Please check our wiki for help on navigating the form.

Horizon 2020

Call: H2020-INFRAIA-2018-2020

(Integrating and opening research infrastructures of European interest)

Topic: INFRAIA-01-2018-2019

Type of action: RIA

Proposal number: SEP-210499769

Proposal acronym: IS-ENES3

Deadline Id: H2020-INFRAIA-2018-1

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How to fill in the forms

The administrative forms must be filled in for each proposal using the templates available in the submission system. Some data fields in the administrative forms are pre-filled based on the steps in the submission wizard.

1 - General information

Topic	INFRAIA-01-2018-2019	Type of Action	RIA
Call Identifier	H2020-INFRAIA-2018-2020	Deadline Id	H2020-INFRAIA-2018-1

Acronym	IS-ENES3
Proposal title	Infrastructure for the European Network for Earth System modelling - Phase 3

Note that for technical reasons, the following characters are not accepted in the Proposal Title and will be removed: < > " &

Duration in months	*48*
Free keywords	*Earth system modelling, climate change, model data repository, WCRP international experiments, high-performance computing*

Abstract

IS-ENES3 will deliver the third phase of the distributed e-infrastructure of the European Network for Earth System Modelling (ENES). IS-ENES3 will be initiated as the European climate modelling community faces the challenges of contributing to the next assessment report of the Intergovernmental Panel on Climate Change through the 6th phase of the Coupled Model Intercomparison Project. IS-ENES3 will address these challenges by developing, documenting and deploying new and advanced models and tools, standards and services to deal with unprecedented data volumes and model complexity. IS-ENES3 will stimulate collaboration, disseminate software and data, and further integrate the European climate science community. IS-ENES3 will support climate research, climate impact science, and the climate services industry. It will bring down barriers of access, and expand the community who can exploit the data and knowledge produced by state-of-the-art climate models. In doing so, it will find innovative ways of working with the Copernicus programme, other parts of the European data infrastructure, and with the high performance computing and data analytics industries. IS-ENES3 will be delivered by partners combining expertise in climate modelling, computational science, data management, climate impacts and climate services, with proven ability to increase the influence of European science internationally. It will deliver the European part of the Earth System Grid Federation and a central point of entry to services providing access to new data, software, models and tools. Joint research will support a new community sea ice model, promote efficient use of high-performance computing, improve the European common model evaluation framework, and develop and enhance services on data. Networking will grow the user base, increase the cohesion of the climate modelling community, promote innovation and prepare for a long term sustainable infrastructure in support of climate modelling.

Remaining characters 6

Has this proposal (or a very similar one) been submitted in the past 2 years in response to a call for proposals under Horizon 2020 or any other EU programme(s)? ○ Yes ◉ No

Please give the proposal reference or contract number.	
xxxxxx-x	

Declarations

1) The coordinator declares to have the explicit consent of all applicants on their participation and on the content of this proposal.	☒
2) The information contained in this proposal is correct and complete.	☒
3) This proposal complies with ethical principles (including the highest standards of research integrity — as set out, for instance, in the European Code of Conduct for Research Integrity — and including, in particular, avoiding fabrication, falsification, plagiarism or other research misconduct).	☒

4) The coordinator confirms:

- to have carried out the self-check of the financial capacity of the organisation on http://ec.europa.eu/research/participants/portal/desktop/en/organisations/lfv.html or to be covered by a financial viability check in an EU project for the last closed financial year. Where the result was "weak" or "insufficient", the coordinator confirms being aware of the measures that may be imposed in accordance with the H2020 Grants Manual (Chapter on Financial capacity check); or	○
- is exempt from the financial capacity check being a public body including international organisations, higher or secondary education establishment or a legal entity, whose viability is guaranteed by a Member State or associated country, as defined in the H2020 Grants Manual (Chapter on Financial capacity check); or	◉
- as sole participant in the proposal is exempt from the financial capacity check.	○

5) The coordinator hereby declares that each applicant has confirmed:

- they are fully eligible in accordance with the criteria set out in the specific call for proposals; and	☒
- they have the financial and operational capacity to carry out the proposed action.	☒

The coordinator is only responsible for the correctness of the information relating to his/her own organisation. Each applicant remains responsible for the correctness of the information related to him and declared above. Where the proposal to be retained for EU funding, the coordinator and each beneficiary applicant will be required to present a formal declaration in this respect.

According to Article 131 of the Financial Regulation of 25 October 2012 on the financial rules applicable to the general budget of the Union (Official Journal L 298 of 26.10.2012, p. 1) and Article 145 of its Rules of Application (Official Journal L 362, 31.12.2012, p.1) applicants found guilty of misrepresentation may be subject to administrative and financial penalties under certain conditions.

Personal data protection

The assessment of your grant application will involve the collection and processing of personal data (such as your name, address and CV), which will be performed pursuant to Regulation (EC) No 45/2001 on the protection of individuals with regard to the processing of personal data by the Community institutions and bodies and on the free movement of such data. Unless indicated otherwise, your replies to the questions in this form and any personal data requested are required to assess your grant application in accordance with the specifications of the call for proposals and will be processed solely for that purpose. Details concerning the purposes and means of the processing of your personal data as well as information on how to exercise your rights are available in the privacy statement. Applicants may lodge a complaint about the processing of their personal data with the European Data Protection Supervisor at any time.

Your personal data may be registered in the Early Detection and Exclusion system of the European Commission (EDES), the new system established by the Commission to reinforce the protection of the Union's financial interests and to ensure sound financial management, in accordance with the provisions of articles 105a and 108 of the revised EU Financial Regulation (FR) (Regulation (EU, EURATOM) 2015/1929 of the European Parliament and of the Council of 28 October 2015 amending Regulation (EU, EURATOM) No 966/2012) and articles 143 - 144 of the corresponding Rules of Application (RAP) (COMMISSION DELEGATED REGULATION (EU) 2015/2462 of 30 October 2015 amending Delegated Regulation (EU) No 1268/2012) for more information see the Privacy statement for the EDES Database.

2 - Participants & contacts

#	Participant Legal Name	Country	Action
1	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	FR	
2	THE UNIVERSITY OF READING	UK	
3	DEUTSCHES KLIMARECHENZENTRUM GMBH	DE	
4	CENTRE EUROPEEN DE RECHERCHE ET DE FORMATION AVANCEE EN CALCUL SCIENTIFIQUE	FR	
5	MET OFFICE	UK	
6	BARCELONA SUPERCOMPUTING CENTER - CENTRO NACIONAL DE SUPERCOMPUTACION	ES	
7	KONINKLIJK NEDERLANDS METEOROLOGISCH INSTITUUT-KNMI	NL	
8	FONDAZIONE CENTRO EURO-MEDITERRANEO SUI CAMBIAMENTI CLIMATICI	IT	
9	SCIENCE AND TECHNOLOGY FACILITIES COUNCIL	UK	
10	SVERIGES METEOROLOGISKA OCH HYDROLOGISKA INSTITUT	SE	
11	DEUTSCHES ZENTRUM FUER LUFT - UND RAUMFAHRT EV	DE	
12	STICHTING NETHERLANDS ESCIENCE CENTER	NL	
13	UNIVERSIDAD DE CANTABRIA	ES	
14	METEOROLOGISK INSTITUTT	NO	
15	METEO-FRANCE	FR	
16	THE UNIVERSITY OF MANCHESTER	UK	
17	NATIONAL CENTER FOR SCIENTIFIC RESEARCH "DEMOKRITOS"	EL	
18	STICHTING WAGENINGEN RESEARCH	NL	
19	UNIVERZITA KARLOVA	CZ	
20	FACULTY OF PHYSICS OF THE UNIVERSITY OF BELGRADE	RS	
21	UNI RESEARCH AS	NO	

22	LINKOPINGS UNIVERSITET	SE	

2 - Administrative data of participating organisations

PIC	***Legal name***
999997930	*CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS*

Short name: CNRS-IPSL

Address of the organisation

Street RUE MICHEL ANGE 3

Town PARIS

Postcode 75794

Country France

Webpage www.cnrs.fr

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....18/11/2008 - no

SME self-assessment ..... unknown

SME validation sme.....18/11/2008 - no

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Institut Pierre Simon Laplace ☐ not applicable

☐ Same as proposing organisation's address

Street: 1 place Aristide Briand

Town: Meudon

Postcode: 92195

Country: France

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: ○ Male ◉ Female

First name: **Sylvie** Last name: **Joussaume**

E-Mail: **sylvie.joussaume@lsce.ipsl.fr**

Position in org.: Research Director

Department: Laboratoire des Sciences du Climat et de l'Environnement ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: Orme des Merisiers (Bât 712)

Town: Gif-sur-Yvette Post code: 91191

Country: France

Website: http://www2.cnrs.fr/en/35.htm

Phone: +33 1 69 08 56 74 Phone 2: +xxx xxxxxxxxx Fax: +xxx xxxxxxxxx

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Cédric	Adam	cedric.adam@cnrs.fr	*+33169823287*
Marie	PARINET	marie.parinet@lsce.ipsl.fr	*+33169088595*
Marie-Hélène	Papillon	dr04_spv-europe@dr4.cnrs.fr	*+33169823262*

PIC	***Legal name***
999984156	*THE UNIVERSITY OF READING*

Short name: UREAD-NCAS

Address of the organisation

Street WHITEKNIGHTS CAMPUS WHITEKNIGHTS H

Town READING

Postcode RG6 6AH

Country United Kingdom

Webpage http://www.reading.ac.uk

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....yes

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....17/03/1926 - no

SME self-assessment ..... unknown

SME validation sme.....17/03/1926 - no

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: NCAS, Department of Meteorology ☐ not applicable

☒ Same as proposing organisation's address

Street: WHITEKNIGHTS CAMPUS WHITEKNIGHTS HOUSE

Town: READING

Postcode: RG6 6AH

Country: United Kingdom

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Prof.

Sex: (•) Male ( ) Female

First name: **Bryan**

Last name: **Lawrence**

E-Mail: **bryan.lawrence@ncas.ac.uk**

Position in org.: Professor of Weather & Climate Computing and NCAS Director of M&D

Department: NCAS, Department of Meterology

☐ Same as organisation name

☐ Same as proposing organisation's address

Street: Earley Gate , Whiteknights campus, PO Box 243

Town: Reading

Post code: RG6 6BB

Country: United Kingdom

Website:

Phone: +xxx xxxxxxxxx

Phone 2: +xxx xxxxxxxxx

Fax: +xxx xxxxxxxxx

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
EU-Unit	Reading	eu-unit@reading.ac.uk	+xxx xxxxxxxxx

PIC	***Legal name***
998692310	*DEUTSCHES KLIMARECHENZENTRUM GMBH*

Short name: DKRZ

Address of the organisation

Street BUNDESSTRASSE 45A

Town HAMBURG

Postcode 20146

Country Germany

Webpage http:/www.dkrz.de

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....03/11/2008 - no

SME self-assessment ..... unknown

SME validation sme.....03/11/2008 - no

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Data Management ☐ not applicable

☒ Same as proposing organisation's address

Street: BUNDESSTRASSE 45A

Town: HAMBURG

Postcode: 20146

Country: Germany

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: (•) Male ( ) Female

First name: **Stephan** Last name: **Kindermann**

E-Mail: **kindermann@dkrz.de**

Position in org.: Group Leader Data Infrastructure

Department: DEUTSCHES KLIMARECHENZENTRUM GMBH ☒ Same as organisation name

☒ Same as proposing organisation's address

Street: BUNDESSTRASSE 45A

Town: HAMBURG Post code: 20146

Country: Germany

Website: http:/www.dkrz.de

Phone: +49 40 460094 343 Phone 2: +xxx xxxxxxxxx Fax: +xxx xxxxxxxxx

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Christiane	Melzer	melzer@dkrz.de	*+49 40 460094 161*
Michael	Lautenschlager	lautenschlager@dkrz.de	*+49 40 460094 118*
Kerstin	Fieg	fieg@dkrz.de	*+49 40 460094 137*
Chiara	Bearzotti	chiara.bearzotti@gmail.com	*+xxx xxxxxxxxx*

PIC	***Legal name***
999940118	*CENTRE EUROPEEN DE RECHERCHE ET DE FORMATION AVANCEE EN CALCUL SCIENTIFIQU*

Short name: CERFACS

Address of the organisation

Street Avenue Gaspard Coriolis 42

Town TOULOUSE

Postcode 31057

Country France

Webpage www.cerfacs.fr

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....no

Non-profit .....no

International organisation .....unknown

International organisation of European interest .....unknown

Secondary or Higher education establishment .....no

Research organisation .....no

Legal person .....yes

Industry (private for profit).....yes

Enterprise Data

SME self-declared status.....19/05/2016 - no

SME self-assessment ..... unknown

SME validation sme.....22/09/2008 - no

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Climate modeling and Global change (GLOBC) ☐ not applicable

☒ Same as proposing organisation's address

Street: Avenue Gaspard Coriolis 42

Town: TOULOUSE

Postcode: 31057

Country: France

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: ○ Male ◉ Female

First name: **Sophie** Last name: **Valcke**

E-Mail: **valcke@cerfacs.fr**

Position in org.: Research engineer

Department: CENTRE EUROPEEN DE RECHERCHE ET DE FORMATION AVANCEE EN ☒ Same as organisation name

☒ Same as proposing organisation's address

Street: Avenue Gaspard Coriolis 42

Town: TOULOUSE Post code: 31057

Country: France

Website: https://cerfacs.fr/

Phone: +33 (0) 561193131 Phone 2: +33 (0) 561193076 Fax: +33 (0) 561193030

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Dominique	Roffi	roffi@cerfacs.fr	*+33 (0) 561193003*

PIC	***Legal name***
999892685	*MET OFFICE*

Short name: MetO

Address of the organisation

Street FitzRoy Road

Town EXETER

Postcode EX1 3PB

Country United Kingdom

Webpage www.metoffice.gov.uk

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....no

International organisation .....unknown

International organisation of European interest .....unknown

Secondary or Higher education establishment .....unknown

Research organisation .....no

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status..... unknown

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Met Office ☐ not applicable

☒ Same as proposing organisation's address

Street: FitzRoy Road

Town: EXETER

Postcode: EX1 3PB

Country: United Kingdom

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Mr. | Sex: (•) Male ( ) Female

First name: **Mick** | Last name: **Carter**

E-Mail: **mick.carter@metoffice.gov.uk**

Position in org.: Head (Climate Science IT Applications)

Department: MET OFFICE ☒ Same as organisation name

☒ Same as proposing organisation's address

Street: FitzRoy Road

Town: EXETER | Post code: EX1 3PB

Country: United Kingdom

Website: www.metoffice.gov.uk

Phone: +44 1392 884003 | Phone 2: *+xxx xxxxxxxxx* | Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Paula	Newton	paula.newton@metoffice.gov.uk	*+44 1392 884834*

PIC	***Legal name***
999655520	*BARCELONA SUPERCOMPUTING CENTER - CENTRO NACIONAL DE SUPERCOMPUTACION*

Short name: BSC

Address of the organisation

Street Calle Jordi Girona 31

Town BARCELONA

Postcode 08034

Country Spain

Webpage www.bsc.es

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....01/03/2005 - no

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Earth Science department ☐ not applicable

☐ Same as proposing organisation's address

Street: NEXUS II building, Jordi Girona 29

Town: Barcelona

Postcode: 08034

Country: Spain

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: (•) Male ( ) Female

First name: **Mario** Last name: **Acosta**

E-Mail: **mario.acosta@bsc.es**

Position in org.: Researcher

Department: Earth Science department ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: NEXUS II building, Jordi Girona 29

Town: Barcelona Post code: 08034

Country: Spain

Website: www.bsc.es

Phone: +34 934134049 Phone 2: *+xxx xxxxxxxxx* Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Mar	Rodriguez	mar.rodriguez@bsc.es	*+34934137566*

PIC	***Legal name***
999518944	*KONINKLIJK NEDERLANDS METEOROLOGISCH INSTITUUT-KNMI*

Short name: KNMI

Address of the organisation

Street UTRECHTSEWEG 297

Town DE BILT

Postcode 3731 GA

Country Netherlands

Webpage www.knmi.nl

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....15/05/2008 - no

SME self-assessment ..... unknown

SME validation sme.....15/05/2008 - no

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: R&D Observations and Data Technology ☐ not applicable

☒ Same as proposing organisation's address

Street: UTRECHTSEWEG 297

Town: DE BILT

Postcode: 3731 GA

Country: Netherlands

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Mr. Sex: (•) Male ( ) Female

First name: **Wim** Last name: **Som de Cerff**

E-Mail: **wim.som.de.cerff@knmi.nl**

Position in org.: Senior researcher

Department: R&D Observations and Data Technology ☐ Same as organisation name

☒ Same as proposing organisation's address

Street: UTRECHTSEWEG 297

Town: DE BILT Post code: 3731 GA

Country: Netherlands

Website:

Phone: +31302206871 Phone 2: *+xxx xxxxxxxxx* Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	*Last Name*	*E-mail*	*Phone*
Priscilla	Wittenberg	priscilla.wittenberg@knmi.nl	*+xxx xxxxxxxxx*

PIC	***Legal name***
999419422	*FONDAZIONE CENTRO EURO-MEDITERRANEO SUI CAMBIAMENTI CLIMATICI*

Short name: CMCC

Address of the organisation

Street VIA A IMPERATORE 16

Town LECCE

Postcode 73100

Country Italy

Webpage www.cmcc.it

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....no

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....11/05/2005 - no

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: ASC - Advanced Scientific Computing Division ☐ not applicable

☒ Same as proposing organisation's address

Street: VIA A IMPERATORE 16

Town: LECCE

Postcode: 73100

Country: Italy

Department 2

Department name: REMHI - Regional Models and geo-Hydrological Impacts ☐ not applicable

☐ Same as proposing organisation's address

Street: via Maiorise

Town: Capua (CE)

Postcode: 81043

Country: Italy

Department 3

Department name: ODA - Ocean modeling and Data Assimilation ☐ not applicable

☒ Same as proposing organisation's address

Street: VIA A IMPERATORE 16

Town: LECCE

Postcode: 73100

Country: Italy

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Prof. Sex: (•) Male ( ) Female

First name: **Giovanni** Last name: **Aloisio**

E-Mail: **giovanni.aloisio@cmcc.it**

Position in org.: Director of the CMCC Supercomputing Center and member of the Strategic C

Department: ASC - Advanced Scientific Computing Division ☐ Same as organisation name

☒ Same as proposing organisation's address

Street: VIA A IMPERATORE 16

Town: LECCE Post code: 73100

Country: Italy

Website: www.cmcc.it

Phone: +390832297221 Phone 2: +xxx xxxxxxxxx Fax: +390832277603

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Giulia	Galluccio	giulia.galluccio@cmcc.it	*+390283623433*
Sandro	Fiore	sandro.fiore@cmcc.it	*+390832297332*
Laura	Conte	laura.conte@cmcc.it	*+390832297304*
Silvia	Mocavero	silvia.mocavero@cmcc.it	*+390832297304*

PIC	***Legal name***
999980179	*SCIENCE AND TECHNOLOGY FACILITIES COUNCIL*

Short name: STFC

Address of the organisation

Street Polaris House North Star Avenue

Town SWINDON

Postcode SN2 1SZ

Country United Kingdom

Webpage www.scitech.ac.uk

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....unknown

International organisation of European interest .....unknown

Secondary or Higher education establishment .....unknown

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....01/04/2007 - no

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: RAL Space ☐ not applicable

☐ Same as proposing organisation's address

Street: Rutherford Appleton Laboratory

Town: Didcot

Postcode: OX11 0QY

Country: United Kingdom

Department 2

Department name: Hartree Centre ☐ not applicable

☐ Same as proposing organisation's address

Street: STFC Daresbury Laboratory

Town: Sci-Tech Daresbury

Postcode: WA4 4AD

Country: United Kingdom

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: (•) Male ( ) Female

First name: **Martin** Last name: **Juckes**

E-Mail: **martin.juckes@stfc.ac.uk**

Position in org.: Deputy Division Head

Department: RAL Space ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: Rutherford Appleton Laboratory

Town: Didcot Post code: OX11 0QY

Country: United Kingdom

Website: www.ceda.ac.uk

Phone: +44 1235445124 Phone 2: +xxx xxxxxxxxx Fax: +xxx xxxxxxxxx

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Caroline	Gore	caroline.gore@stfc.ac.uk	*+44 1235 445697*
Nick	Pickering	nick.pickering@stfc.ac.uk	*+44 1235 446998*

PIC	***Legal name***
999507983	*SVERIGES METEOROLOGISKA OCH HYDROLOGISKA INSTITUT*

Short name: SMHI

Address of the organisation

Street Folkborgsvaegen 1

Town NORRKOEPING

Postcode 601 76

Country Sweden

Webpage www.smhi.se

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....no

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status..... unknown

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Rossby Centre, Research Department ☐ not applicable

☒ Same as proposing organisation's address

Street: Folkborgsvaegen 1

Town: NORRKOEPING

Postcode: 601 76

Country: Sweden

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: (•) Male ( ) Female

First name: **Uwe** Last name: **Fladrich**

E-Mail: **uwe.fladrich@smhi.se**

Position in org.: Senior Scientist

Department: Rossby Centre, Research Department ☐ Same as organisation name

☒ Same as proposing organisation's address

Street: Folkborgsvaegen 1

Town: NORRKOEPING Post code: 601 76

Country: Sweden

Website: http://www.smhi.se/en/research/research-departments/climate-resea

Phone: +46114958351 Phone 2: +46114958000 Fax: +xxx xxxxxxxxx

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Monica	Wallgren	monica.wallgren@smhi.se	*+46114958104*

PIC	***Legal name***
999981731	*DEUTSCHES ZENTRUM FUER LUFT - UND RAUMFAHRT EV*

Short name: DLR

Address of the organisation

Street Linder Hoehe

Town KOELN

Postcode 51147

Country Germany

Webpage www.dlr.de

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....no

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....28/10/2008 - no

SME self-assessment ..... unknown

SME validation sme.....28/10/2008 - no

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Institute of Atmospheric Physics ☐ not applicable

☐ Same as proposing organisation's address

Street: Münchener Straße 20

Town: Wessling

Postcode: 82234

Country: Germany

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Prof. Sex: ○ Male ◉ Female

First name: **Veronika** Last name: **Eyring**

E-Mail: **veronika.eyring@dlr.de**

Position in org.: Senior researcher

Department: Institute of Atmospheric Physics ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: Münchener Straße 20

Town: Wessling Post code: 82234

Country: Germany

Website: www.dlr.de

Phone: +49 8153 282533 Phone 2: +xxx xxxxxxxxx Fax: +xxx xxxxxxxxx

Other contact persons

First Name	*Last Name*	*E-mail*	*Phone*
Stephanie	König	stephanie.koenig@dlr.de	+49 8153 283119

PIC	***Legal name***
946813800	*STICHTING NETHERLANDS ESCIENCE CENTER*

Short name: NIeSC

Address of the organisation

Street SCIENCE PARK 140

Town AMSTERDAM

Postcode 1098 XG

Country Netherlands

Webpage www.esciencecenter.nl

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....no

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....14/06/2016 - no

SME self-assessment .....14/06/2016 - no

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

No department involved

Department name: *Name of the department/institute carrying out the work.* ☒ not applicable

☐ Same as proposing organisation's address

Street: *Please enter street name and number.*

Town: *Please enter the name of the town.*

Postcode: *Area code.*

Country: *Please select a country*

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Prof. Sex: (•) Male ( ) Female

First name: **Wilco** Last name: **Hazeleger**

E-Mail: **w.hazeleger@esciencecenter.nl**

Position in org.: Director

Department: STICHTING NETHERLANDS ESCIENCE CENTER ☒ Same as organisation name

☐ Same as proposing organisation's address

Street: Science Park 140 (Matrix I)

Town: Amsterdam Post code: 1098 XG

Country: Netherlands

Website: www.esciencecenter.nl

Phone: +31 20 4604770 Phone 2: *+xxx xxxxxxxxx* Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Aletta	Debernardi	a.debernardi@esciencecenter.nl	*+31 649944007*
Otto	Van Rhee	o.vanrhee@esciencecenter.nl	*+xxx xxxxxxxxx*

PIC	***Legal name***
999880075	*UNIVERSIDAD DE CANTABRIA*

Short name: UC

Address of the organisation

Street AVENIDA DE LOS CASTROS S/N

Town SANTANDER

Postcode 39005

Country Spain

Webpage www.unican.es

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....yes

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....02/02/2009 - no

SME self-assessment ..... unknown

SME validation sme.....02/02/2009 - no

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Applied Mathematics and Computer Science ☐ not applicable

☒ Same as proposing organisation's address

Street: AVENIDA DE LOS CASTROS S/N

Town: SANTANDER

Postcode: 39005

Country: Spain

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: (•) Male ( ) Female

First name: **Antonio Santiago** Last name: **Cofiño**

E-Mail: **antonio.cofino@unican.es**

Position in org.: Lecturer

Department: Santander Meteorology Group ☐ Same as organisation name

☒ Same as proposing organisation's address

Street: AVENIDA DE LOS CASTROS S/N

Town: SANTANDER Post code: 39005

Country: Spain

Website: http://www.meteo.unican.es/en/main

Phone: +34942201731 Phone 2: *+xxx xxxxxxxxx* Fax: +34942201103

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Maria	Herrero	maria.herrero@unican.es	*+34942203904*
Juan José San Miguel	Roncero	miguelj j@gestion.unican.es	*+34942200968*

PIC	***Legal name***
999510893	*METEOROLOGISK INSTITUTT*

Short name: Met.no

Address of the organisation

Street HENRIK MOHNS PLASS 1

Town OSLO

Postcode 0313

Country Norway

Webpage www.met.no

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....12/03/1995 - no

SME self-assessment ..... unknown

SME validation sme.....12/03/1995 - no

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Research and Development ☐ not applicable

☒ Same as proposing organisation's address

Street: HENRIK MOHNS PLASS 1

Town: OSLO

Postcode: 0313

Country: Norway

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: (•) Male ( ) Female

First name: **Oyvind** Last name: **Seland**

E-Mail: **oyvind.seland@met.no**

Position in org.: Senior Scientist

Department: RTD ☐ Same as organisation name

☒ Same as proposing organisation's address

Street: HENRIK MOHNS PLASS 1

Town: OSLO Post code: 0313

Country: Norway

Website: www.met.no / yr.no

Phone: +47 22 96 33 23 Phone 2: *+xxx xxxxxxxxx* Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Per Helmer	Skaali	per.helmer.skaali@met.no	*+ 47 94 79 53 79*

PIC	***Legal name***
999578890	*METEO-FRANCE*

Short name: MF-CNRM

Address of the organisation

Street AVENUE DE PARIS 73

Town SAINT MANDE CEDEX

Postcode 94165

Country France

Webpage www.meteo.fr

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....18/06/1993 - no

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: CNRM - Centre National de Recherches Météorologiques ☐ not applicable

☐ Same as proposing organisation's address

Street: Avenue Gaspard Coriolis 42

Town: Toulouse cedex 01

Postcode: 31057

Country: France

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr.

Sex: (•) Male ( ) Female

First name: **David**

Last name: **Salas y Melia**

E-Mail: **david.salas@meteo.fr**

Position in org.: Researcher

Department: CNRM/GMGEC - Groupe de Météorologie Grande Echelle et Climat

☐ Same as organisation name

☐ Same as proposing organisation's address

Street: Avenue Gaspard Coriolis 42

Town: Toulouse cedex01

Post code: 31057

Country: France

Website: http://www.meteo.fr

Phone: +33561079665

Phone 2: +xxx xxxxxxxxx

Fax: +xxx xxxxxxxxx

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Lydie	Romet	lydie.romet@meteo.fr	*+33561079915*
Cellule	Partenariat Projets de R	ppr@meteo.fr	*+33561079636*
Chantal	Lehacaut	chantal.lehacaut@meteo.fr	*+xxx xxxxxxxxx*
Claire	DOUBREMELLE	claire.doubremelle@meteo.fr	*+xxx xxxxxxxxx*
Marc	PONTAUD	marc.pontaud@meteo.fr	*+xxx xxxxxxxxx*

PIC	***Legal name***
999903840	*THE UNIVERSITY OF MANCHESTER*

Short name: UNIMAN

Address of the organisation

Street OXFORD ROAD

Town MANCHESTER

Postcode M13 9PL

Country United Kingdom

Webpage www.manchester.ac.uk

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....yes

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....31/07/2015 - no

SME self-assessment .....31/07/2015 - no

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: School of Computer Science ☐ not applicable

☒ Same as proposing organisation's address

Street: OXFORD ROAD

Town: MANCHESTER

Postcode: M13 9PL

Country: United Kingdom

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: (•) Male ( ) Female

First name: **Graham** Last name: **Riley**

E-Mail: **graham.riley@manchester.ac.uk**

Position in org.: Lecturer at School of Computer Science

Department: THE UNIVERSITY OF MANCHESTER ☒ Same as organisation name

☒ Same as proposing organisation's address

Street: OXFORD ROAD

Town: MANCHESTER Post code: M13 9PL

Country: United Kingdom

Website:

Phone: +44 0161 275 5724 Phone 2: +xxx xxxxxxxxx Fax: +xxx xxxxxxxxx

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Natalia	Stefanovic	researchsupportcsm@manchester.ac.uk	*+44 0161 306 3572*
Liz	Fay	liz.fay@manchester.ac.uk	*+xxx xxxxxxxxx*

PIC	***Legal name***
999978239	*NATIONAL CENTER FOR SCIENTIFIC RESEARCH "DEMOKRITOS"*

Short name: NCSR-D

Address of the organisation

Street END OF PATRIARCHOU GRIGORIOU E AND

Town AGIA PARASKEVI

Postcode 15341

Country Greece

Webpage www.demokritos.gr

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....12/05/2016 - no

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Institute of Informatics and Telecommunications (IIT) ☐ not applicable

☐ Same as proposing organisation's address

Street: PATR. GRIGORIOU E' & 27 NEAPOLEOS ST.

Town: AGIA PARASKEVI

Postcode: 15341

Country: Greece

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: (•) Male ( ) Female

First name: **Vangelis** Last name: **Karkaletsis**

E-Mail: **vangelis@iit.demokritos.gr**

Position in org.: Research Director

Department: Institute of Informatics and Telecommunications (IIT)/ SKEL ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: PATR. GRIGORIOU E' & 27 NEAPOLEOS ST.

Town: AGIA PARASKEVI Post code: 15341

Country: Greece

Website: www.iit.demokritos.gr

Phone: +302106503197 Phone 2: *+xxx xxxxxxxxx* Fax: +302106532175

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Maria	Markouli	markouli@iit.demokritos.gr	*+302106503204*

PIC	***Legal name***
999547365	*STICHTING WAGENINGEN RESEARCH*

Short name: WENR

Address of the organisation

Street DROEVENDAALSESTEEG 4

Town WAGENINGEN

Postcode 6708 PB

Country Netherlands

Webpage http://www.wur.nl

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....no

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....09/12/1997 - no

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Wageningen Environmental Research ☐ not applicable

☐ Same as proposing organisation's address

Street: Droevendaalsesteeg 3

Town: Wageningen

Postcode: 6708PB

Country: Netherlands

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: ○ Male ◉ Female

First name: **Judith** Last name: **Klostermann**

E-Mail: **judith.klostermann@wur.nl**

Position in org.: Senior Researcher

Department: Wageningen Environmental Research ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: Droevendaalsesteeg 3

Town: Wageningen Post code: 6708PB

Country: Netherlands

Website: www.wur.nl/environmental-research

Phone: +31 317486427 Phone 2: *+xxx xxxxxxxxx* Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Patricia	Vanderkooij	patricia.vanderkooij@wur.nl	*+31 317483337*

PIC	***Legal name***
999923434	*UNIVERZITA KARLOVA*

Short name: CUNI

Address of the organisation

Street OVOCNY TRH 5/3

Town PRAHA 1

Postcode 11636

Country Czech Republic

Webpage www.cuni.cz

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....yes

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....22/04/1998 - no

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Dept. of Atmospheric Physics, Fac. of Mathematics and Physics ☐ not applicable

☐ Same as proposing organisation's address

Street: V Holesovickach 2

Town: Prague

Postcode: 180 00

Country: Czech Republic

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Prof. Sex: (•) Male ( ) Female

First name: **Tomáš** Last name: **Halenka**

E-Mail: **tomas.halenka@mff.cuni.cz**

Position in org.: Associate Professor

Department: Department of Atmospheric Physics ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: V Holesovickach 2

Town: Prague Post code: 180 00

Country: Czech Republic

Website:

Phone: +420 951552514 Phone 2: +420 728778513 Fax: +420 951552533

PIC	***Legal name***
999859220	*FACULTY OF PHYSICS OF THE UNIVERSITY OF BELGRADE*

Short name: FPUB

Address of the organisation

Street Studentski trg 12-16

Town BELGRADE

Postcode 11001

Country Serbia

Webpage www.ff.bg.ac.yu/nanoscience

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....unknown

International organisation of European interest .....unknown

Secondary or Higher education establishment .....yes

Research organisation .....unknown

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status..... unknown

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Institute of Meteorology ☐ not applicable

☐ Same as proposing organisation's address

Street: Dobracina 16

Town: Belgrade

Postcode: 11000

Country: Serbia

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Prof. Sex: (•) Male ( ) Female

First name: **Vladimir** Last name: **Dj**

E-Mail: **vdj@ff.bg.ac.rs**

Position in org.: Associate Professor

Department: Institute of Meteorology ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: Dobracina 16

Town: Belgrade Post code: 11000

Country: Serbia

Website: www.ff.bg.ac.rs

Phone: +381 117158152 Phone 2: +381 641948240 Fax: +381 2638919

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Vesna	Napijalo	vesna.napijalo@ff.bg.ac.rs	*+381 117158152*

PIC	***Legal name***
999419616	*UNI RESEARCH AS*

Short name: UniRes

Address of the organisation

Street NYGARDSGATEN 112

Town BERGEN

Postcode 5008

Country Norway

Webpage www.uni.no

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....no

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....17/06/2003 - no

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Uni Research Climate ☐ not applicable

☐ Same as proposing organisation's address

Street: Jahnebakken 5

Town: Bergen

Postcode: 5007

Country: Norway

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Dr. Sex: (•) Male ( ) Female

First name: **Mats** Last name: **Bentsen**

E-Mail: **mats.bentsen@uni.no**

Position in org.: Senior Researcher

Department: Uni Reserach Climate ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: Jahnebakken 5

Town: Bergen Post code: 5007

Country: Norway

Website: www.uni.no

Phone: +47 22963385 Phone 2: +xxx xxxxxxxxx Fax: +xxx xxxxxxxxx

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Erik	Sandquist	erik.sandquist@uni.no	+4793002873

PIC	***Legal name***
999852236	*LINKOPINGS UNIVERSITET*

Short name: LiU

Address of the organisation

Street CAMPUS VALLA

Town LINKOPING

Postcode 581 83

Country Sweden

Webpage www.liu.se

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....yes

Research organisation .....yes

Legal person .....yes

Industry (private for profit).....no

Enterprise Data

SME self-declared status.....28/10/2008 - no

SME self-assessment ..... unknown

SME validation sme.....28/10/2008 - no

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Climate Data Infrastructure and Services at NSC ☐ not applicable

☐ Same as proposing organisation's address

Street: Olaus Magnus väg 42-44

Town: Linkoping

Postcode: 58183

Country: Sweden

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

The name and e-mail of contact persons are read-only in the administrative form, only additional details can be edited here. To give access rights and basic contact details of contact persons, please go back to Step 4 of the submission wizard and save the changes.

Title: Mr. Sex: (•) Male ( ) Female

First name: **Hamish** Last name: **Struthers**

E-Mail: **struthers@nsc.liu.se**

Position in org.: Application expert

Department: NSC ☐ Same as organisation name

☒ Same as proposing organisation's address

Street: CAMPUS VALLA

Town: LINKOPING Post code: 581 83

Country: Sweden

Website: Website: http://docs.snic.se/wiki/User:Hamish_Struthers_%28NSC%2

Phone: +4613281072 Phone 2: +xxx xxxxxxxxx Fax: +xxx xxxxxxxxx

Other contact persons

First Name	*Last Name*	*E-mail*	*Phone*
Jan-Olov	Holm	jan-olov.holm@liu.se	*+46 13 281937*
Victoria	Westling	victoria.westling@liu.se	*+46 13 286969*

3 - Budget

No	Participant	Country	(A) Direct personnel costs/€	(B) Other direct costs/€	(C) Direct costs of sub-contracting/€	(D) Direct costs of providing financial support to third parties/€	(E) Costs of inkind contributions not used on the beneficiary's premises/€	(F) Indirect Costs / € (=0.25(A+B-E))	(G) Special unit costs covering direct & indirect costs / €	(H) Total estimated eligible costs / € (=A+B+C+D+F+G)	(I) Reimburse-ment rate (%)	(J) Max.EU Contribution / € (=H*I)	(K) Requested EU Contribution/ €
1	Centre National De La Recherche	FR	1202865	260800	104400	0	0	365916,25	0	1933981,25	100	1933981,25	1933981,25
2	The University Of Reading	UK	836864	85619	40000	0	0	230620,75	0	1193103,75	100	1193103,75	1193103,75
3	Deutsches Klimarechenzentrum Gmbh	DE	636180	28500	0	0	0	166170,00	0	830850,00	100	830850,00	830850,00
4	Centre Europeen De Recherche Et	FR	650268	64800	0	0	0	178767,00	0	893835,00	100	893835,00	893835,00
5	Met Office	UK	476362	38800	0	0	0	128790,50	0	643952,50	100	643952,50	643952,50
6	Barcelona Supercomputing Center -	ES	342000	42400	0	0	0	96100,00	0	480500,00	100	480500,00	480500,00
7	Koninklijk Nederlands Meteorologisc	NL	491837	29900	0	0	0	130434,25	0	652171,25	100	652171,25	652171,25
8	Fondazione Centro Euro-mediterraneo	IT	483000	50400	0	0	0	133350,00	0	666750,00	100	666750,00	666750,00
9	Science And Technology Facilities	UK	427603	46967	0	0	0	118642,50	0	593212,50	100	593212,50	593212,50
10	Sveriges Meteorologisk a Och	SE	326400	24600	0	0	0	87750,00	0	438750,00	100	438750,00	438750,00

11	Deutsches Zentrum Fuer Luft - Und	DE	306634	15300	0	0	0	80483,50	0	402417,50	100	402417,50	402417,50
12	Stichting Netherlands Escience	NL	140000	6800	0	0	0	36700,00	0	183500,00	100	183500,00	183500,00
13	Universidad De Cantabria	ES	60000	17000	0	0	0	19250,00	0	96250,00	100	96250,00	96250,00
14	Meteorologisk Institutt	NO	106000	5100	0	0	0	27775,00	0	138875,00	100	138875,00	138875,00
15	Meteo-france	FR	77200	6300	0	0	0	20875,00	0	104375,00	100	104375,00	104375,00
16	The University Of Manchester	UK	50209	6500	0	0	0	14177,25	0	70886,25	100	70886,25	70886,25
17	National Center For Scientific	EL	30000	56000	0	0	0	21500,00	0	107500,00	100	107500,00	107500,00
18	Stichting Wageningen Research	NL	46697	39200	0	0	0	21474,25	0	107371,25	100	107371,25	107371,25
19	Univerzita Karlova	CZ	18000	39200	0	0	0	14300,00	0	71500,00	100	71500,00	71500,00
20	Faculty Of Physics Of The University	RS	29580	23200	0	0	0	13195,00	0	65975,00	100	65975,00	65975,00
21	Uni Research As	NO	47025	4600	0	0	0	12906,25	0	64531,25	100	64531,25	64531,25
22	Linkopings Universitet	SE	43260	6600	0	0	0	12465,00	0	62325,00	100	62325,00	62325,00
	Total		6827984	898586	144400	0	0	1931642,50	0	9802612,50		9802612,50	9802612,50

4 - Ethics

1. HUMAN EMBRYOS/FOETUSES		Page
Does your research involve Human Embryonic Stem Cells (hESCs)?	○ Yes ◉ No	
Does your research involve the use of human embryos?	○ Yes ◉ No	
Does your research involve the use of human foetal tissues / cells?	○ Yes ◉ No	
2. HUMANS		**Page**
Does your research involve human participants?	○ Yes ◉ No	
Does your research involve physical interventions on the study participants?	○ Yes ◉ No	
3. HUMAN CELLS / TISSUES		**Page**
Does your research involve human cells or tissues (other than from Human Embryos/ Foetuses, i.e. section 1)?	○ Yes ◉ No	
4. PERSONAL DATA		**Page**
Does your research involve personal data collection and/or processing?	○ Yes ◉ No	
Does your research involve further processing of previously collected personal data (secondary use)?	○ Yes ◉ No	
5. ANIMALS		**Page**
Does your research involve animals?	○ Yes ◉ No	
6. THIRD COUNTRIES		**Page**
In case non-EU countries are involved, do the research related activities undertaken in these countries raise potential ethics issues?	○ Yes ◉ No	
Do you plan to use local resources (e.g. animal and/or human tissue samples, genetic material, live animals, human remains, materials of historical value, endangered fauna or flora samples, etc.)?	○ Yes ◉ No	
Do you plan to import any material - including personal data - from non-EU countries into the EU?	○ Yes ◉ No	
Do you plan to export any material - including personal data - from the EU to non-EU countries?	○ Yes ◉ No	
In case your research involves low and/or lower middle income countries, are any benefits-sharing actions planned?	○ Yes ◉ No	
Could the situation in the country put the individuals taking part in the research at risk?	○ Yes ◉ No	

7. ENVIRONMENT & HEALTH and SAFETY		Page
Does your research involve the use of elements that may cause harm to the environment, to animals or plants?	○ Yes ◉ No	
Does your research deal with endangered fauna and/or flora and/or protected areas?	○ Yes ◉ No	
Does your research involve the use of elements that may cause harm to humans, including research staff?	○ Yes ◉ No	
8. DUAL USE		**Page**
Does your research involve dual-use items in the sense of Regulation 428/2009, or other items for which an authorisation is required?	○ Yes ◉ No	
9. EXCLUSIVE FOCUS ON CIVIL APPLICATIONS		**Page**
Could your research raise concerns regarding the exclusive focus on civil applications?	○ Yes ◉ No	
10. MISUSE		**Page**
Does your research have the potential for misuse of research results?	○ Yes ◉ No	
11. OTHER ETHICS ISSUES		**Page**
Are there any other ethics issues that should be taken into consideration? Please specify	○ Yes ◉ No	

I confirm that I have taken into account all ethics issues described above and that, if any ethics issues apply, I will complete the ethics self-assessment and attach the required documents. ☒

How to Complete your Ethics Self-Assessment

5 - Call-specific questions

Extended Open Research Data Pilot in Horizon 2020

If selected, applicants will by default participate in the Pilot on Open Research Data in Horizon 2020[1] , which aims to improve and maximise access to and re-use of research data generated by actions.

However, participation in the Pilot is flexible in the sense that it does not mean that all research data needs to be open. After the action has started, participants will formulate a Data Management Plan (DMP), which should address the relevant aspects of making data FAIR – findable, accessible, interoperable and re-usable, including what data the project will generate, whether and how it will be made accessible for verification and re-use, and how it will be curated and preserved. Through this DMP projects can define certain datasets to remain closed according to the principle "as open as possible, as closed as necessary". A Data Management Plan does not have to be submitted at the proposal stage.

Furthermore, applicants also have the possibility to opt out of this Pilot completely at any stage (before or after the grant signature). In this case, applicants must indicate a reason for this choice (see options below).

Please note that participation in this Pilot does not constitute part of the evaluation process. Proposals will not be penalised for opting out.

We wish to opt out of the Pilot on Open Research Data in Horizon 2020.	○ Yes	◉ No

Further guidance on open access and research data management is available on the participant portal: http://ec.europa.eu/research/participants/docs/h2020-funding-guide/cross-cutting-issues/open-access-dissemination_en.htm and in general annex L of the Work Programme.

[1] *According to article 43.2 of Regulation (EU) No 1290/2013 of the European Parliament and of the Council, of 11 December 2013, laying down the rules for participation and dissemination in "Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)" and repealing Regulation (EC) No 1906/2006.*

RIA Research and Innovation action
INFRAIA-01-2018-2019: Integrating Activities for Advanced Communities

Topic:
Environmental and Earth Sciences
Research infrastructures for Earth's climate system modelling

Infrastructure for the European Network for Earth System modelling –Phase 3
IS-ENES3

Coordinator: Sylvie Joussaume

Participant no.	Participant organisation name	Participant short name	Country
1	Centre National de la Recherche Scientifique – Institut Pierre Simon Laplace	**CNRS-IPSL**	France
2	The University of Reading - National Centre for Atmospheric Science	**UREAD-NCAS**	United Kingdom
3	Deutsches Klimarechenzentrum GmbH	**DKRZ**	Germany
4	Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique	**CERFACS**	France
5	The Met Office	**MetO**	United Kingdom
6	Barcelona Supercomputing Centre	**BSC**	Spain
7	Koninklijk Nederlands Meteorologisch Instituut	**KNMI**	Netherlands
8	Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici	**CMCC**	Italy
9	Science and Technology Facilities Council	**STFC**	United Kingdom
10	Sveriges Meteorologiska och Hydrologiska Institut	**SMHI**	Sweden
11	Deutsches Zentrum Für Luft- und Raumfahrt in der Helmholtz Gemeinschaft	**DLR**	Germany
12	Stichting Netherlands eScience Center	**NleSC**	Netherlands
13	Universidad de Cantabria	**UC**	Spain
14	Norwegian Meteorological Institute	**met.no**	Norway
15	Météo France - Centre National de Recherches Météorologiques	**MF-CNRM**	France
16	University of Manchester	**UNIMAN**	United Kingdom
17	National Centre of Scientific Research "Demokritos"	**NCSR-D**	Greece
18	Stichting Wageningen Research, Wageningen Environmental Research	**WENR**	Netherlands
19	Charles University	**CUNI**	Czech Republic
20	Faculty of Physics of the University of Belgrade	**FPUB**	Serbia
21	Uni Research AS	**UniRes**	Norway
22	Linköpings Universitet	**LiU**	Sweden

Abstract

IS-ENES3 will deliver the third phase of the distributed e-infrastructure of the European Network for Earth System Modelling (ENES). IS-ENES3 will be initiated as the European climate modelling community faces the challenges of contributing to the next assessment report of the Intergovernmental Panel on Climate Change through the 6th phase of the Coupled Model Intercomparison Project. IS-ENES3 will address these challenges by developing, documenting and deploying new and advanced models and tools, standards and services to deal with unprecedented data volumes and model complexity.

IS-ENES3 will stimulate collaboration, disseminate software and data, and further integrate the European climate science community. IS-ENES3 will support climate research, climate impact science, and the climate services industry. It will bring down barriers of access, and expand the community who can exploit the data and knowledge produced by state-of-the-art climate models. In doing so, it will find innovative ways of working with the Copernicus programme, other parts of the European data infrastructure, and with the high performance computing and data analytics industries.

IS-ENES3 will be delivered by partners combining expertise in climate modelling, computational science, data management, climate impacts and climate services, with proven ability to increase the influence of European science internationally. It will deliver the European part of the Earth System Grid Federation and a central point of entry to services providing access to new data, software, models and tools. Joint research will support a new community sea ice model, promote efficient use of high-performance computing, improve the European common model evaluation framework, and develop and enhance services on data. Networking will grow the user base, increase the cohesion of the climate modelling community, promote innovation and prepare for a long term sustainable infrastructure in support of climate modelling.

Key words

Earth system modelling, climate change, model data repository, WCRP international experiments, high-performance computing

1. Excellence

Integrating Activity for Advanced Communities (INFRAIA-01-2018-2019)

Biological and Medical Sciences

☐ Microbial Resource Centres.
☐ Facilities for high throughput DNA sequencing.
☐ Centres for replacement, reduction and refinement (3 Rs) of non-human primate testing.
☐ High throughput facilities for proteome analysis.

Energy

☐ Research Infrastructures for solar energy: concentrating solar power.
☐ Research Infrastructures for solar energy: photovoltaic.

Environmental and Earth Sciences

☐ Research infrastructures for forest ecosystem and resources research.
☐ Natural history collections.
☐ Research aircrafts for environmental and geo-science research.
☐ Research vessels.
☒ **Research infrastructures for Earth's climate system modelling.**
☐ Sites, experimental platforms and data collections of anthropogenic impacts for ecosystem functioning and biodiversity research.

Mathematics and ICT

☐ Visualisation facilities.

Material Sciences and Analytical facilities

☐ Electron Microscopies for advanced imaging, diffraction, spectroscopy and metrology of materials.
☐ High and low energy ion beam labs.
☐ Infrastructures for Neutron Scattering and Muon Spectroscopy.
☐ Facilities for research on materials under extreme temperature conditions.
☐ Infrastructures for studying turbulence phenomena and applications.

Physical Sciences

☐ Research Infrastructures for hadron physics.
☐ Research Infrastructures for high resolution solar physics.

Social Sciences and Humanities

☐ Research infrastructures for the assessment of science, technology and innovation policies.
☐ Digital archives and resources for research on European history.
☐ Archaeological data infrastructures for research.

1.1 Objectives

IS-ENES3 is the third phase of the infrastructure project of ENES, the European Network for Earth System modelling (https://enes.org). ENES gathers the European community developing and using climate models of the Earth system and their data. Collectively, ENES has a mandate to better understand past and present-day climate and to project future variability and changes under anthropogenic and natural forcing. This community is a key player in the assessments of the Intergovernmental Panel on Climate Change (IPCC) and provides the multi-model climate projections on which EU mitigation and adaptation policies are built.

Since 2009, IS-ENES (https://is.enes.org) (i) fosters collaboration among the modelling groups to speed-up the development of models of the complex Earth's climate system, namely "Earth System models" (ESMs); (ii) delivers common strategies for research infrastructures; and (iii) facilitates the sharing of data archives and high-performance computing facilities.

The ENES community faces new challenges as a result of increased model complexity, the challenges of emerging computing platforms and the need to exploit ever-increasing volume and complexity of data by new, multi-disciplinary audiences, to address the climate change societal challenge. IS-ENES3 tackles these challenges through a distributed e-infrastructure of shared models components, tools and data infrastructures. ENES activities support the World Climate Research Program (WCRP, *See Letter of Support in Appendix of Section 4*) as well as contributing to the standards for data and metadata required for WCRP's international repository - the Earth System Grid Federation (ESGF).

During its first phase (2009-2013), IS-ENES supported the 5th Coupled Model Intercomparison Project (CMIP5), the results of which have been extensively used in the 5th IPCC Assessment Report. In its second phase, IS-ENES2 (2013-2017) extended its data infrastructure support to include results from regional climate models within the WCRP Coordinated Regional Downscaling Experiments (CORDEX, *See Letter of Support in Appendix of section 4*) covering Europe and Africa. In both phases, IS-ENES facilitated access to climate model results for the research community studying impacts of climate change; this led to the development of the climate4impact platform[1]. IS-ENES and IS-ENES2 have also facilitated the sharing of expertise on software tools needed to develop, run and exploit climate models. A first ENES community infrastructure strategy for the period 2012-2022 was developed and published (*Mitchell et. al. 2012*)[2] and updated during IS-ENES2 (*Joussaume et al, 2018*)[3].

IS-ENES3 will be initiated as the European climate modelling community faces the challenges of contributing to the next IPCC assessment report (*See letter of Support from IPCC Working Group I in Appendix of Section 4*) through the 6th phase of CMIP (CMIP6). IS-ENES3 will address these by developing, documenting and deploying new and advanced tools and services for models, model evaluation and data distribution to deal with unprecedented large data volumes. The solid experience acquired in previous phases of IS-ENES will be a strong asset for IS-ENES3.

The current project is organised around three main objectives with the overall goal of providing the infrastructure to **better understand and project climate variability and change** through technical excellence**.**

Objective 1: IS-ENES3 will pursue the integration of the Earth's climate system modelling community and will prepare the sustainability of its infrastructure. It will:

Establish stronger ties with parties either underrepresented within, or relatively new to, the ENES community, in particular through training and schools (e.g. groups in Eastern Europe and the impact modelling community);

- Build on existing governance and communication activities to prepare a sustainable infrastructure by developing a robust stakeholder consensus on downstream user requirements;
- Strengthen existing collaborations with third parties, and developing new relationships and synergies with other infrastructures, projects, initiatives, and communities, particularly those where IS-ENES

[1] https://climate4impact.eu/impactportal/general/index.jsp

[2] Mitchell J., Budich R., Joussaume S., Lawrence B. and Marotzke J. (2012), "Infrastructure strategy for the European Earth System Modelling community 2012-2022", ENES Report Series 1, 33 pp. doi.org/10.5285ca90b281d6ff4cffb9a9bbdeb5fa63f3

[3] Joussaume S., Lawrence B., Guglielmo F., Update of the ENES infrastructure strategy 2012-2022, 2018, goo.gl/iyDqh9

knowledge and/or services will bring wider impact;
- Develop a strategy for the infrastructure needed by the ENES community in the next decade seeking opportunities for interoperability among infrastructures.

Objective 2: IS-ENES3 will foster the common development of models and tools, and the efficient use of HPC. It will:

- Create sustainable communities through the coordination of network and joint research activities;
- Develop common, sustainable model infrastructure, including support for relatively new software tools evaluated in previous phases;
- Where possible, share development of common model components, with a focus on developing a common European sea ice model and on improving the computational performance of the European ocean platform;
- Promote the use of new metrics for evaluating model computational performance aimed at understanding the relative efficiency of codes and how best to use available HPC;
- Provide community leadership and knowledge exchange, aimed at responding to the existing strategy, and improving the exploitation of HPC both nationally and internationally (e.g. ENES use of PRACE);
- Explore new avenues and tools, such as Machine Learning (ML) and Artificial Intelligence (AI).

Objective 3: IS-ENES3 will support the exploitation of model data by the Earth system science community, the climate change impact community and the climate service community. It will:

- Maintain and develop the European component of the global Earth System Grid Federation with the aim of supporting the 6th phase of the Coupled Model Intercomparison Project (CMIP6), expected to require storing and supporting access to tens of petabytes of data;
- Develop a new service to ease multi-model data analytics;
- Put the infrastructure and governance of key metadata and data standards (e.g. Climate Forecast conventions for NetCDF, documentation of models and simulations) onto a sustainable footing
- Raise the standard for Earth system model evaluation by gathering more detailed understanding of user requirements, by promoting standards for the science provenance, and by developing a state-of-the-art community European model evaluation framework;
- Invest in the operation and development of the climate4impact platform and the underlying services to enable customised access to data, documentation, and information about model evaluation to the climate impact community as well as climate service businesses and consultancies.

1.2 Relation to the work programme

IS-ENES3 as a key research infrastructure for climate modelling

The Earth system modelling community requires access to efficient customised software, running on leading HPC platforms, and long-term access to the resulting tens of petabytes of data. This will support evaluation of the models themselves, advance the understanding of the climate system, and support the needs of users in other scientific domains, including the impact and climate service community, for the benefit of society. Following the legacy of FP7 IS-ENES and IS-ENES2, IS-ENES3 will continue to foster European community access to all aspects of the necessary software, hardware and human infrastructure.

The three IS-ENES3 objectives target these goals specifically: integrating and widening the scope of community support for both academia and industry; developing community access to software and HPC infrastructure via shared model components development and documentation; and maintaining data facilities based on national resources which are exposed both within the international ESGF global federation and transnational service. Delivering on these objectives will serve not only the scientific community, but provide an optimal route to maximising the European investment in understanding, and adapting to, climate change.

Added value of IS-ENES3

IS-ENES3 will strengthen the culture of networking and cooperation developed and established in IS-ENES and IS-ENES2 in an even more pervasive way.

These previous FP7 Integrating Activities have demonstrated the added value of working together at the

European scale to support the WCRP internationally coordinated experiments at global and regional scale and the climate impacts community, to share tools and expertise, and to develop and deploy the ESGF to manage and distribute data products. Whereas the main development of codes and parameterizations is carried out at national level, IS-ENES has fostered sharing of best practice, coordinated common development of key software and tools with a focus on improving performance, coordinated the support necessary for major scientific projects, and promoted standard methodologies for comparing model performance. The IS-ENES community was instrumental in identifying the need for a new approach to simulation on future computing platforms, and instigated the coordinated preparation of the Centre of Excellence for HPC application on Weather and Climate (ESiWACE).

IS-ENES3 will go beyond current achievements. It will not only support the European contribution to CMIP6, and associated regional projections within CORDEX, but will also prepare for long-term sustainability. It will expand its services towards additional software tools, as well as open a service on data processing for multi-model analyses. IS-ENES3 will support new common model components development, building a new sea-ice platform. IS-ENES3 will also support a new infrastructure for model evaluation based on the community European evaluation tool, the ESMValTool. Moreover, IS-ENES3 will widen its user base through a series of interdisciplinary training and schools. IS-ENES3 will also focus on social innovation, promoting the use of climate data by climate services through improvements in data services and training events. IS-ENES3 will in particular further elaborate a common strategy with the emerging Copernicus Climate Change Service (C3S) on the dissemination of climate projection data. IS-ENES3 will also facilitate exchange of knowledge with software and HPC industry.

IS-ENES3 mobilises a comprehensive consortium

IS-ENES3 brings together software infrastructure for modelling, data distribution infrastructure, and access to services for models and data. The consortium includes national climate modelling centres, computing and data centres as well as expert teams from universities, research organisations and national meteorological services. Together they cover a rich diversity of skills: climate modelling, computational science, data management, climate impact science, and climate services (development and provision). This group closely interacts with other research infrastructures through both national and international interfaces (e.g. ESFRI environmental infrastructures, like Euro-ARGO or ICOS on observations, and e-infrastructures like PRACE). IS-ENES3 will also widen its user base, in particular towards Eastern Europe thanks to the help of two University teams well embedded in science networks in Central and South-eastern Europe. Across the partnership, there are connections to the key stakeholders in both private and public sectors.

IS-ENES3 integrated activities

IS-ENES3 is a holistic synthesis of networking, virtual and transnational access and joint research activities as described in section 1.3(b). The networking activities are targeted at governance and widening impact; building new and maturing existing communities, revisiting requirements; developing models and tools in a sustainable way for the benefit of as wide a community as possible; and improving the IS-ENES access services. The service activities are built on the requirements and strategic objectives identified in IS-ENES and IS-ENES2, and consist of information services and expert assistance on models and tools. A substantial effort is also devoted to model data infrastructure services, which include storage, data documentation and delivery, and computational services, as well as community support services for data standards. The joint research activities (JRA) cover model software development, model evaluation, and data systems. The IS-ENES community has a track record of migrating requirements gathered in networking activities to services, through JRA developments.

IS-ENES3 follows the principles and guidelines of the "*European Charter for Access to Research Infrastructures*" being based on digital services, with data open to all and new open access software. IS-ENES3 contributes to integrate national and European activities and facilitates international cooperation of science within WCRP modelling activities. IS-ENES3 supports science on the global societal challenge of climate change, by promoting climate model developments and providing access to data from reference climate model simulations. These reference simulations form the basis of the science leading to IPCC reports and are used to improve the understanding of climate process. IS-ENES3 has a new focus to provide knowledge transfer for innovation, mainly to climate services and the ICT industry.

IS-ENES3 support to global standards and Open Research Data

IS-ENES3 activities will be an essential part of the development of global standards on both data and metadata.

IS-ENES3 will continue to lead the international Earth System Documentation (ES-DOC) activity on documenting models and model simulations for CMIP. IS-ENES3 will also support, for the first time, the Climate and Forecast convention[4] for metadata. This international convention enables tools to be developed with value across all users of the data from multiple models. IS-ENES3 will also propose a new standard for describing model evaluation scientific provenance. IS-ENES3 will also propose a new standard for describing model evaluation scientific provenance. IS-ENES3 will make all European CMIP6 model data available using the creative commons open-access license, which will be embedded in the data files. IS-ENES3 will also interact with other actors on data policy in Europe and internationally (e.g. Research Data Alliance).

IS-ENES3 collaboration with the European landscape of research infrastructures

IS-ENES3 will interact with other European environmental research infrastructures in the frame of the ENVRI community, where IS-ENES has started to bring an expertise on data management within the ENVRIPlus project. IS-ENES3 will strengthen current links with other actors of the European landscape for data (EUDAT, EGI), in particular with European Open Science Cloud Initiatives EOSC initiatives (H2020 EOSC-Pilot, EOSC-Hub, DARE projects), and HPC (PRACE, GEANT, COEs and FET projects, flagship initiatives) and will explore opportunities for establishing new ones. It will also continue to collaborate with the ESiWACE Centre of Excellence, the Copernicus initiative and the Flagship proposal "*ExtremeEarth*"[5].

1.3 Concept and methodology

(a) Concept

Overall concept

The climate modelling infrastructure relies on three main pillars (Figure 1): the climate models themselves, the high-performance computing (HPC) and the data and metadata components. Earth's climate models are large numerical codes (million line codes) composed of different model components and developed through time (representing typically at least a thousand person years of effort, often over at least a decade). High performance computing is necessary to run simulations, and large-scale archive and data analysis systems are needed to exploit and distribute the model data. More emphasis is given to increasingly complex workflow to run simulations, process and access model results. Also, the physical network required to exchange data and all the diagnostic software needed to analyze model results and evaluate their quality are required. All these components rely on the expertise of people in climate science, model, and data and software development.

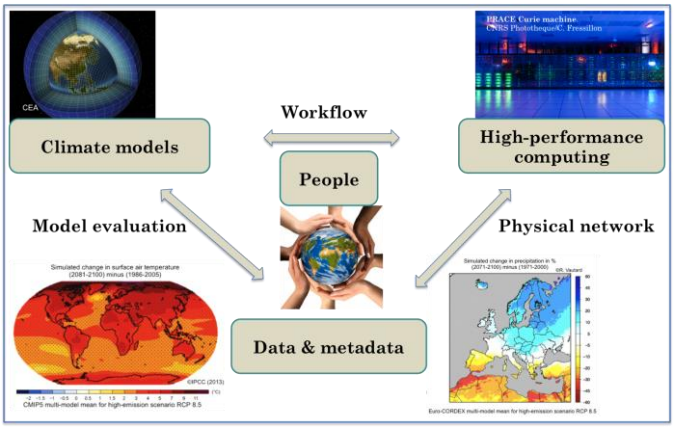


Figure 1*: the main components of climate modelling infrastructures*

During the IS-ENES2 project, the ENES infrastructure strategy was updated (Joussaume et al., 2018) and is the basis for IS-ENES3. It also describes the two streams the community has to deal with (Figure 2). The first one is addressed by IS-ENES. It is aimed at supporting the current generation of climate models, fostering community approaches to improve models and share tools, and supporting international coordinated experiments which serve as a reference to the international community not only working on climate modelling

[4] http://cfconventions.org/
[5] ExtremeEarth proposal http://www.extremeearth.eu/home

but also more largely on climate change. The second one is to prepare for exascale computing architectures and this is the main objective of the Centre of Excellence on HPC applications for Climate and Weather ESiWACE, which has been fostered by IS-ENES and is supported by DG-Connect.

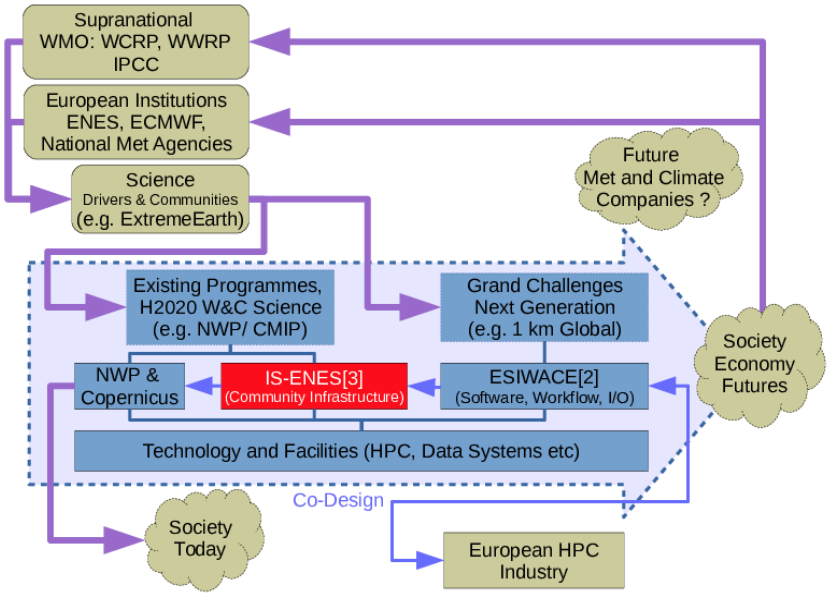


Figure 2. The relationship between IS-ENES3 and other major science projects from existing programmes, other community initiatives such as ESiWACE (possibly followed by ESiWACE2), and the underlying technology and facilities. Together they deliver solutions for societal requirements and have feedbacks onto future science drivers.

The internationally coordinated experiments from the Coupled Model Intercomparison Project (CMIP), under WCRP, form a set of reference simulations important for model evaluation, understanding of processes, and provision of scenarios for future climate change. The climate research community extensively uses the data from these simulations and the Coordinated Regional Downscaled Experiments, CORDEX, which are downscaled from the CMIP experiments, either dynamically or statistically. These are references for communities studying the impacts of climate change on different sectors (e.g. agriculture, energy, insurance, health), and increasingly for climate services informing decision-making. They are also a key reference basis for IPCC assessment reports. IS-ENES3 will support CMIP6 in its main phase of distribution and analyses of model results as well as paving the way for CORDEX and next phase of CMIP. So far IS-ENES has demonstrated the added value of working together at the European scale to support CMIP and CORDEX and contributed to developing and deploying, with US colleagues, the international ESGF federated data archive, needed to manage and distribute model data and which has 14 000 registered users. CMIP is a long-term activity that requires a sustainable infrastructure. Together with other international stakeholders, IS-ENES3 will address this requirement by defining and preparing a sustainable infrastructure to be implemented at the end of the project. Moreover, in line with its community integration objective, IS-ENES3 will further emphasise the role of user feedback and involve partners from geographical regions so far underrepresented in the infrastructure, namely Eastern and South-eastern Europe.

Seven major European climate models form the main European contribution to CMIP experiments. In theory, diversity is needed to infer uncertainties related to the model representation of processes. However, in practice, not all the current diversity leads to understanding of uncertainty, and so IS-ENES facilitates common model development when relevant, such as the new European sea ice platform, and triggers sharing of expertise in software tools to avoid duplication of effort. It will also set up for the first time an infrastructure for (i) model evaluation, by supporting and extending functionalities of a common evaluation tool developed through European science projects and (ii) data analysis, by consolidating ongoing efforts in the community regarding server-side analytics approaches.

Interdisciplinary dimension

IS-ENES3 activities toward common goals rely on a blend of skills including climate and computational sciences through to climate services and climate impact sciences. IS-ENES3 will collaborate with experts in

high-performance computing to improve existing model performance on the current generation of massively parallel computers. It will also explore using emerging technologies such as big data and artificial intelligence techniques for possible use in climate applications, in collaboration with other European projects (e.g. H2020 DARE project).

IS-ENES3 will widen its user base in particular towards the wide community investigating climate change impacts as well as the emerging climate service providers in the public and private sector for the benefit of various societal sectors.

Integration of European research infrastructures in Europe

IS-ENES3 integrates models and data via tools managed in workflows. The underlying computing layer is beyond what can be managed by an I3 project and is delivered by national and European computing centres, including PRACE.

IS-ENES3 integrates the seven major European global climate model families contributing to CMIP6 as well as the NEMO European platform for ocean modelling. IS-ENES3 also includes the ESMValTool evaluation tool as well as several other shared software tools covering coupling, I/O and workflow.

IS-ENES3 integrates the European distributed data centres contributing to the international ESGF federated data archive. A new compute service layer will be added by exploiting interoperable remote data processing capabilities. IS-ENES3 is fully integrated in the international infrastructure with scientific oversight via membership of the WGCM Working Group on Coupled Models Infrastructure Panel (WIP, *see Letter of Support in Appendix in Section 4*) as well as the ESGF Steering and Executive groups. IS-ENES3 also supports, and plays a leading role in, international data and metadata standards, especially through the Earth System Documentation (ES-DOC) initiative.

Impact on European research area

By sharing infrastructure, expertise and developments, IS-ENES3 will continue to strengthen, collaborations within the European climate modelling community. This approach is needed to increase the overall efficiency of the community and its international influence. The climate modelling community is better developed in Western Europe; IS-ENES3 will target strengthening the involvement of Eastern and South-eastern Europe and will benefit from existing networks dealing with impacts of climate change. Moreover, with a work package dedicated to widening the user base and better linking with user requirements, IS-ENES3 will enhance the European impact on climate research.

European activities

IS-ENES3 is also integrated with other ENES-initiated H2020 scientific projects relying on IS-ENES infrastructure, such as CRESCENDO (*Coordinated Research in Earth Systems and Climate: Experiments, Knowledge, Dissemination and Outreach*) and PRIMAVERA (*PRocess-based climate sIMulation: AdVances in high resolution modelling and European climate Risk Assessment*), which both support simulations for CMIP6, and the EUCP (*EUropean Climate Prediction system*) project supporting new CORDEX simulations over Europe and Mediterranean regions. All these connections strengthen the IS-ENES European and international dimension (*See letters of support in Appendix of Section 4*).

IS-ENES3, as an e-infrastructure, will endeavour to collaborate with, and possibly contribute to, the world-class "*European Data Infrastructure*" planned by the European Commission to offer high-performance computing and data facilities, and fast connectivity. Indeed, climate models use the European HPC infrastructure PRACE and the ENES HPC task force ensures that the community influences and is influenced by PRACE. On the application side, IS-ENES3 is complementary to ESiWACE, which aims at preparing climate models for exascale computing architectures. For data, IS-ENES3 will follow the EU recommendations for open access to data and continue to collaborate with the EUDAT data infrastructure. Moreover, IS-ENES3 partners are involved in several European Open Science Cloud projects: the EOSC-pilot demonstrator that links IS-ENES data with the observation European infrastructure on carbon observations ICOS, the DARE project that provides researchers and users with programmable methods and tools making use of data and infrastructures as transparently as possible, the EOSC-Hub that contributes to the EOSC common service catalogue.

IS-ENES2 has developed collaboration with the new Copernicus climate change service (C3S) at global and regional scale. C3S will serve a large range of users through the distribution of climate data, in particular results from the reference CMIP and CORDEX simulations. C3S has decided to rely on ESGF and IS-ENES3

has an important role to provide access to new results, with CMIP6 and next CORDEX simulations, and to sustain the related backbone infrastructure ESGF. IS-ENES3 partners are leading five C3S projects developing the climate data store for global and regional projections: CP4CDS, MAGIC, CRECP, CORDEX4CDS, and PRINCIPLES. IS-ENES3 will continue to work closely with C3S (*see letter of support in Appendix of Section 4*), and develop links with other future Copernicus projects related to CMIP and CORDEX.

IS-ENES3 will liaise with coordination actions such as the H2020 project ClimatEurope on climate modelling, observations and services, with JPI Climate as well as with other Research infrastructures via the ENVRI community, and via the mapping initiative RISCAPE at international level.

International activities

IS-ENES3, as its predecessors, will maintain and further pursue its international dimension. As described above, all the activities of IS-ENES3 associated with CMIP experiments are fundamentally international. IS-ENES3 is fully integrated in the international activities of the different CMIP6 related panels and initiatives. IS-ENES3 will continue to be a member of the international ESGF governance: the Executive Committee co-chaired by IS-ENES, working on the development and implementation of ESGF and the Steering Committee chaired by the US Department of Energy, with participation from NASA, NOAA and the Australian National Computational Infrastructure, governing ESGF. IS-ENES3 will also continue to lead the international ES-DOC project on the standards for model and simulation documentation. IS-ENES3 partners also participate to the Working Group on Coupled Models Infrastructure Panel (WIP). These committees ensure the overall governance of the data infrastructure and related standards in support to CMIP.

IS-ENES3 will continue to collaborate with the Lawrence Livermore PCMDI (*the Program for Climate Model Diagnosis and Intercomparison*) (*See letter of support in Section 4 appendix*), which supports the WCRP CMIP experiments at the international level. This collaboration will be enhanced within IS-ENES3 through the model evaluation framework and its associated standards.

IS-ENES3 will also further collaborate on software at the international level through its services on models and tools, for example on the Cylc workflow engine co-developed in New Zealand and used in USA, Australia, Korea and India.

(b) Methodology

IS-ENES3 is organised in complementary Networking, Access, and Joint Research activities to improve the quality, sustainability and adoption of the infrastructure - models and tools, HPC, and data (Figure 3). All these activities will contribute in a consistent and coordinated way to the **overall project objectives** of sustainable communities and infrastructure with the widest adoption as follows:

Pursuing the integration of the Earth's climate system modelling community and preparing the sustainability of its infrastructure

This objective will mainly be addressed through networking activities. WP2/NA1 will provide the ENES infrastructure strategy for next decade, integrating global and regional climate modelling. It will also support the overall governance of the community and, overseeing WP4/NA3 and WP5/NA4, prepare for sustainability at the end of the 3rd phase. Other network activities will also contribute to the integration of the community. WP3/NA2 will both widen and strengthen the interactions with the users of the infrastructure, namely through training, and actively collect user requirements. Schools will be an opportunity to train the early career researchers in interdisciplinary approaches, on the use of climate model data for a range of different applications and on new computational technologies to address the big data challenge in climate science. These actions will provide material and context to WP2/NA1 to prepare sustainability.

Fostering the common development and evaluation of models and tools, and the efficient use of HPC,

IS-ENES3 will foster sharing of community tools and common developments of model components. WP4/NA3 and WP8/JRA1 will initiate the new community development of a unified European platform for sea ice. WP6/VA1 and WP8/JRA1 will support use and further improvements of common coupling, I/O and workflow software tools crucial for the development and efficient use of climate models. WP6/VA1 will also contribute to further extending the use of European ESMs, and of the European NEMO ocean model.

WP4/NA3 will apply and integrate new metrics developed in IS-ENES2 to compare the computational

performance of complex coupled Earth Systems Models while WP8/JRA1 will improve the computational performance of the common European ocean platform NEMO. WP4/NA3 will also consider new ways to exploit available hardware and software technologies for HPC applications and beyond, in new areas such as machine learning and artificial intelligence and promote innovation with HPC and ICT software vendors. The HPC Task Force in WP2/NA1 will continue to be the focal point of engagement by the community with PRACE, establishing community requirements for HPC and coordinating community-scale bids.

Supporting the exploitation of model data by the Earth system science community, the climate change impacts community and the climate service community,

IS-ENES3 will support model data access in WP7/VA2, supported by new developments in WP10/JRA3 and networking in WP5/NA4 and short introductions and trainings all over Europe in WP3/NA2. WP7/VA2 will provide virtual access to CMIP and CORDEX data, through ESGF and the climate4impact platform, but also set new services providing access to data processing through virtual access via TNA applications. WP10/JRA3 will drive the evolution of the IS-ENES climate data infrastructure software stack addressing data distribution, processing, vocabulary management, documentation, and impact study tools as well as both data access/processing for the climate impact research and modelling community, and the interface to the Copernicus Climate Services. WP5/NA4 will build worldwide connections around data, metadata and related computing.

WP9/JRA2 will contribute to technically improving the community developed Earth System Model Evaluation Tool (ESMValTool) to enable an efficient evaluation of CMIP models with observations. In order to accommodate externally developed diagnostics, WP3/NA2 will define user-driven standard interfaces.. ESMValTool will be adapted to efficiently run alongside the ESGF infrastructure at selected nodes in order to ensure a stable service in WP7/VA2. Complex workflows will be better supported and easier to replicate through the use of the Rose and Cylc suite and workflow management tools in WP8/JRA1 and WP6/VA1.

Coordination

IS-ENES3 will be steered by a Coordination and Management Work Package WP1. This will oversee a new approach to Innovation for IS-ENES3, based on previous experience, which will be run as a virtual Work Package across all NA WPs to maximise scope and impact (see section 1.4 on Innovation).

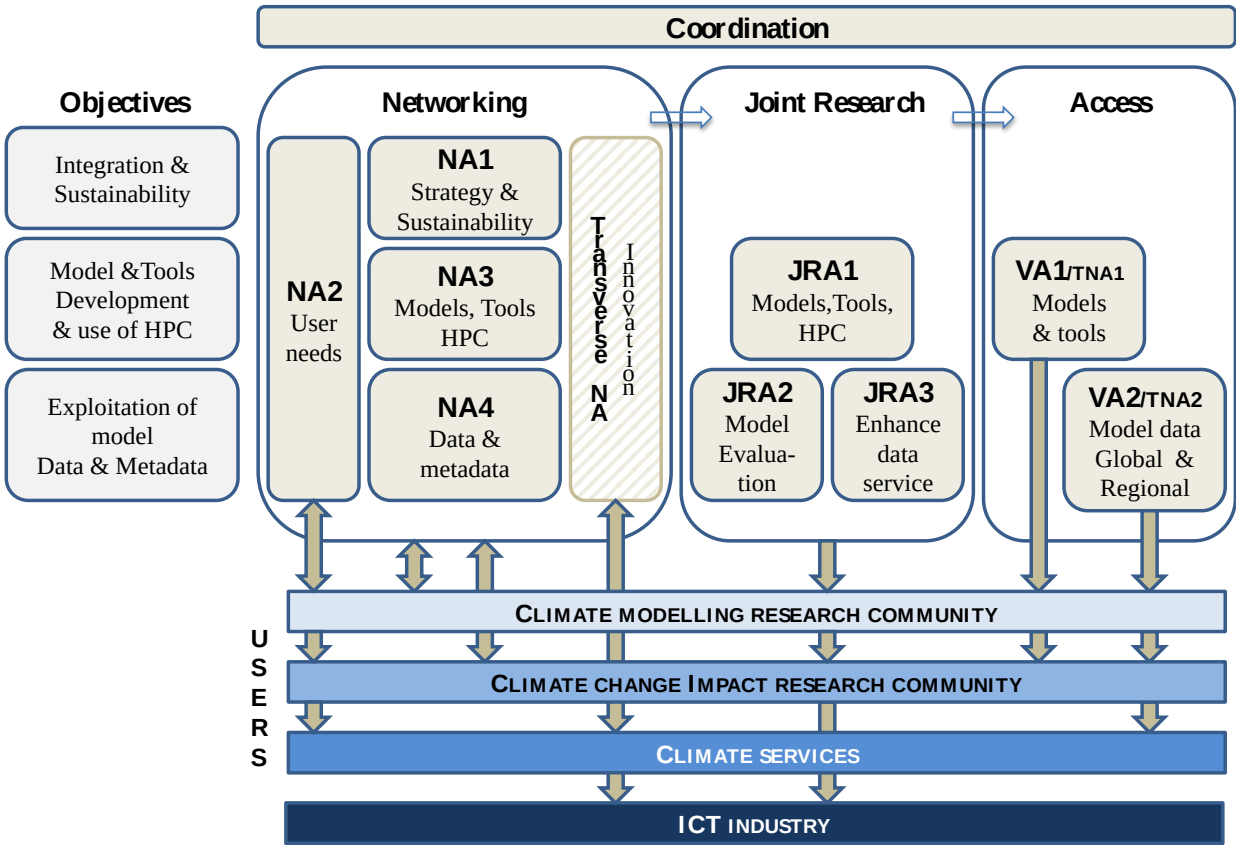


***Figure 3**: Overview of IS-ENES3 work packages and how they relate to the 3 project objectives*

Gender dimension in IS-ENES3 research activities

After careful consideration, we conclude that sex and gender differences will not affect in any way IS-ENES3 activities in developing concepts and technical solutions, formulating research questions, collecting and analysing data and using the analytical tools that are specific to our scientific area and stakeholder and target communities. Gender assumptions will not influence IS-ENES3 scientific priorities, research questions, or methods. Our results will moreover not affect sexes and genders differently.

1.4 Ambition

IS-ENES is the distributed infrastructure of the European Network for Earth System modelling (ENES) that serves the European modelling community working on understanding and predicting climate variability and change.

State of the art, assets from previous IS-ENES phases

Over previous IS-ENES projects, considerable progress on integration infrastructure has been achieved. Nevertheless, new challenges and opportunities arise. ESMs' scientific and technical complexity is increasing, the amount of data generated grows exponentially and the international CMIP experiments add stronger operational requirements on the infrastructure (see international background). The infrastructure is further developing in its European and international dimension in terms of disciplines, user communities and geographic outreach. Moreover, and as recommended in the latest ENES infrastructure strategy, sustainable community-based cooperation would put both climate modelling research and long-term future development activities on a firmer footing.

By providing access to CMIP5 and CORDEX model results, IS-ENES 1 and 2 achieved a key step in the integration of global and regional climate models. This led to the recognition of the European contribution to ESGF through IS-ENES in the ESGF international governance, with half of the working teams led by European experts from IS-ENES2[6]. IS-ENES2, building on the former METAFOR EC project, also played a leading role in the evolution of metadata standards and in the development of the metadata services in collaboration with US institutions in the frame of ES-DOC, an international collaboration documenting climate model simulations and compliance with MIP protocols. There is a strong expectation from both the European and international community that IS-ENES3 will maintain and strengthen this strategic contribution to CMIP6.

IS-ENES has developed the climate4impact portal giving access to climate model data for the climate impacts community. Moreover, the expertise of IS-ENES in ESGF enabled the use of ESGF by the Copernicus Climate Change Service to access global and regional climate model simulations as well as the use of the climate4impact platform in Copernicus projects. These call for a sustained research infrastructure.

IS-ENES1 and 2 support services for modelling and related environmental software emphasized the importance of supporting common developments as well as sharing experience and best practices. Sustaining long term collaboration and sharing is crucial for common software.

The climate modelling community has always been facing the challenge of ensuring that models will be able to follow the fast evolution of computer architectures. ESiWACE will lead on the Exascale challenge and the next generation models, but in the immediate future we need to improve the situation of increasing complexity and resolution of the current models on HPC platforms that deliver capacity when we need capability. IS-ENES3 will address this need.

International background

The climate modelling community is working on the 6th phase of CMIP, defining and running the simulations and preparing data compliant with CMIP format to be accessible through ESGF. CMIP6[7] will provide a basis

[6] L. Cinquini, D. Crichton, C. Mattmann, J. Harney, G. Shipman, F. Wang, R. Ananthakrishnan, N. Miller, S. Denvil, M. Morgan, Z. Pobre, G. M. Bell, C. Doutriaux, R. Drach, D. Williams, P. Kershaw, S. Pascoe, E. Gonzalez, S. Fiore, R. Schweitzer, The Earth System Grid Federation: An open infrastructure for access to distributed geospatial data, *Future Generation Computer Systems*, Volume 36, 2014, Pages 400-417, ISSN 0167-739X, https://doi.org/10.1016/j.future.2013.07.002.

[7] Eyring, V., Bony, S., Meehl, G. A., Senior, C. A., Stevens, B., Stouffer, R. J., and Taylor, K. E.: Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization, Geosci. Model Dev., 9, 1937-1958, doi:10.5194/gmd-9-1937-2016, 2016.

for the 6th IPCC Assessment Report due in 2021. CMIP6 will address important scientific questions in climate science: How does the Earth system respond to forcing? What are the origins and consequences of systematic model biases? And how can we assess future climate changes given internal climate variability, predictability, and uncertainties in scenarios? It will also support many studies on climate change after the IPCC AR6. The example from the previous CMIP5 phase shows that more than 1000 publications were published based on the 2 PBytes (PB) CMIP5 data repository (4 PB with replicas) and that CMIP data are extensively used after the publication of IPCC Assessment Reports.

IS-ENES3 will commence in time to support the peak exploitation phase of CMIP6 data, with key simulations completed and data being made available via the ESGF nodes, but with more runs and data to come. 20 to 40 PB of data will be made available (and much more produced by the models) and this requires robust infrastructures to deliver the data to the archives and to make them accessible to the widest possible audience.

In Europe, the seven climate modelling groups that participated to CMIP5 will contribute to many of the projects composing CMIP6 (the "MIPs"). The PRIMAVERA and CRESCENDO H2020 projects support the science on some of CMIP6 experiments. The H2020 EUCP project, just starting, will support Euro-CORDEX and Med-CORDEX downscaling experiments from CMIP6. All these projects will rely on IS-ENES3 infrastructure (*See Letters of Support in Appendix of Section 4*).

Ambition of IS-ENES3

After its first two phases, IS-ENES3 has the ambition to make its services, infrastructure and community sustainable, widen its user base, especially towards the large community working on climate change impacts and towards Eastern Europe. It will also exploit new opportunities such as an emerging community infrastructure for model evaluation, and further strengthen its international leadership on standards for data and metadata.

Networking Activities

Networking activities will connect experts within the community developing the ENES infrastructure and also ensure that IS-ENES3 is driven by the needs of both climate scientists and all climate data users. Networking activities will feed into the Joint research activities with community requirements, thus driving the design and helping in the priorities. In detail, IS-ENES3 will reach beyond the previous two phases as follows:

WP2/NA1 Governance, Sustainability and Innovation

Improving the complex infrastructure requires proactive planning and joint development. WP2/NA2 will ensure relationships with internal and external community members and users, and with European and international opportunities, such as PRACE, EOSC, ESGF. In addition, IS-ENES3 will deliver a cross-institutional approach to broaden innovation throughout the whole project, by addressing the interface with major external organizations (such as Copernicus Climate Service) and industry.

Reflecting its standing of a mature, advanced community, IS-ENES3 will deliver plans for maintenance of the ENES infrastructure after the end of the project. The formulation of a sustainable approach requires a well-defined pathway to be followed within the project to achieve a clearer understanding of what needs to be sustained, how it might be done, and preliminary steps towards its implementation.

To inform this essential activity, IS-ENES3 will produce a new strategic foresight document for the Earth system modelling infrastructure for 2022-2032, in the legacy of previous efforts (Mitchell et al. 2012, Joussaume et al. 2018), reflecting the evolving needs of a dynamic community and taking into account upcoming major challenges coming from changes in underlying technology, new European facilities alongside the evolution of scientific aspirations for the benefit of society.

WP3/NA2 Community engagement

WP3/NA2 will give service beneficiaries a prominent role in informing IS-ENES governance in order to make sure that an ever-growing number of users see their needs and requirements satisfied by the infrastructure. This will create deeper links and mutual understanding between service developers and users, within and beyond academic community: climate researchers, vulnerability, impact and adaptation researchers, climate service providers and related public/private spin-off initiatives, thus strengthening the innovation dimension of the infrastructure. Regular training will be an opportunity to widen the user base, especially towards the impact

community, and to consult users. To reach these communities many short events will be organized all over Europe (close to the potential users), with 4 out of 10 in Eastern Europe.

WP3/NA2 will also further engage with the younger generation. Interdisciplinary approaches will be favoured on two streams. One stream will gather, in two one-week schools, climate modellers with impact modellers to enable a better use of climate model data in impact studies at regional scale (one in Eastern Europe, one in Western Europe). This will inform on the strengths and weaknesses of approaches to downscale climate model data. The second stream will gather climate modellers with ICT experts to explore big data new technology opportunities to analyze large climate model data.

WP3/NA2 will also focus on the co-development of standards. It will, in the first place, evaluate the usability of current climate research standards and then contribute to the development of further ones, by better reflecting the whole range of its users (including e.g. impact researchers) and providing dedicated space for the necessary community consultation and related training.

All these exchange activities targeting user feedback will inform project coordination and governance and reflect into cross-WPs actions and prioritisation.

WP4/NA3 Networking on Models, Tools, and efficient use of HPC resources

WP4/NA3 will promote the necessary exchange to support Joint research activities on models, tools and HPC. On community model developments, main focus will be on the NEMO European ocean platform. Indeed, the continuous integration of software developed at several European institutes requires the infrastructure to ensure a rigorous and extensive quality control for both technical and scientific activities. Making this a continuous process will leave a legacy of sustainable, community-driven development. IS-ENES3 will also support the new initiative within the NEMO consortium that develops a common sea ice model aiming at integrating and replacing the three current ocean sea ice models (LIM, CICE, GELATO). WP4/NA3 will support the elaboration of a common roadmap and buy-in by the community around this new common sea ice platform.

Efficient use of HPC is a critical issue for climate modelling By comparing the computational performance of European ESMs, using and extending the metrics developed within IS-ENES2 in collaboration with US, WP4/NA3 will improve the methodology of load balancing across climate model components. International workshops on coupling technologies and HPC, in the legacy of its previous two phases, will tackle emerging technical challenges and contribute to community building around them.

Technology tracking on ICT is needed to ensure best use of new technologies and enhance computation efficiency. Artificial Intelligence and Machine Learning open new ways of optimizing data analytics. WP4/NA3 will investigate interdisciplinary approaches, especially those provided by the industry to inform the ENES community.

These activities will translate into a common understanding about potential innovation with the hardware and software technologies industry in the field of climate modelling.

WP5/NA4 Networking on data and model evaluation

WP5/NA4 will build synergies around data, metadata and data-centric compute activities in Europe and worldwide, in order to get a scalable, robust, easy-to-operate and cost-effective infrastructure, built on top of state-of-the-art technologies and standards, and an architectural design driven by scientific user needs and requirements. Interoperability with other research infrastructures will represent a key aspect on the work package. For this, WP5/NA4 will strengthen existing relationships at single-institution, European or international level, for example with WGCM Infrastructure Panel (WIP), IPCC Working Groups, Copernicus Climate Change Service projects, EOSC projects, Environmental research infrastructure community. WP5/NA4 will strengthen the European contribution to the development of the international ESGF data infrastructure influencing priorities on replication strategies, support and access metrics. WP5/NA4 will ensure metadata standards can be sustained within ES-DOC. Coding sprints and hackathons for development groups will develop services and compute-based applications.

Community model evaluation is expected to play an increasingly important role in the ESM model development process. WP5/NA4 will collect current and future requirements over the next decade towards a fast and scalable model evaluation tool. The activity will provide the definition, delivery, documentation, and dissemination of common protocols and standards covering modularity for existing packages, new community diagnostics, and investigation of (re-) usability and of efficient interfaces to map among different languages.

This will be instrumental to inform related work in WP9/JRA2.

Access activities

Access activities are at the core of the IS-ENES3 infrastructure. They provide models and tools in WP6/VA1 and access to data and metadata in WP7/VA2. There are new services and all but two trans-national services are by virtual, open access to software and data.

WP6/VA1 Services and Training on European ESMs and Software Tools

WP6/VA1 will provide an easy access to European Earth system model information and software. Beyond information on the European ESMs participating to CMIP5/6 and their documentation, IS-ENES3 will provide access and service on three European ESMs and the NEMO European ocean model, platform all used beyond their national groups.

WP6/VA1 will continue to provide access to OASIS and CDO software tools. The OASIS coupler software, used by more than 40 climate modelling groups in Europe, USA, Canada, Australia and Asia, allows synchronized exchanges of coupling information between components of the climate system. The Climate Data Operators (CDOs), used by around 150 groups worldwide, are a collection of functions for handling and analyzing data produced by a variety of climate and NWP models. WP6/VA1 will also provide access to new services on XIOS and Cylc. XIOS is an HPC library dedicated to data flow management for ESM models, developed in the previous two phases of IS-ENES, and it is beginning to be more widely used in Europe. Cylc ("silk") is a workflow engine for cycling systems, which orchestrates complex distributed suites of interdependent cycling tasks, with users internationally and increasing adoption in Europe. In addition to virtual access, a new TNA service, based on a selection procedure, will be set up to allow on-site OASIS support. This service was experienced with success through networking activity in IS-ENES.

WP7/VA2 Data standards, distribution and processing services

WP7/VA2 will provide access to the new CMIP6 data as via the ESGF European data nodes. The infrastructure will continue to provide access to the whole ESGF database, including previous CMIP5 and CORDEX data but also observations under the Obs4MIPs project and reanalyzes under the Ana4MIPs project. Basic functions will support discovery, download, documentation, and support services to users. The climate4impact platform will provide an easier access to a subset of ESGF data, including advanced services on visualization, computation of indices and downscaling needed by the wider community working on climate impacts. For the first time, four European ESGF large data nodes will include pre-assigned processing services, providing access to a specific set of emerging data analytics capabilities as well as routinely processed model evaluation results through virtual access. A trans-national access (TNA) service will also be offered under a selection procedure to support various flexible data processing and analytics on virtual workspaces. The wider user community will continue to benefit from IS-ENES3 documentation services for scientific provenance of model data (VA). These activities will be complemented by statistic on utilization, improved documentation and bespoke responses to user enquirers. To promote efficiency and interoperability of the data products a service on data standards will also be offered, providing the tools to support implementation of standards and services to translate community requirements into data specifications.

Joint research activities

The infrastructure will be improved through JRA activities. These will focus on models, tools and efficient use of HPC and on data, metadata and model evaluation infrastructure.

WP8/JRA1 Models & Tools developments

WP8/JRA1 will improve the NEMO computational performance, mainly for the execution of new high-resolution and complex simulations. It will enhance code scalability by reducing the communication overhead, identifying parts of the code that could be run using single precision while preserving accuracy, and improving I/O performance. WP8/JRA1 will also support the development of the unified European modelling platform for sea ice to be implemented within NEMO by performing in-depth testing, improving modularity and providing documentation.

WP8/JRA1 will further develop community tools: the coupler OASIS3-MCT, the XIOS data flow management

tool and the Cylc/Rose tool for the automation of suites of tasks. Developments will improve functionality and performance. Networking and governance will feed back on these activities and inform additional developments and/or slightly re-orient priorities for the maximal benefit of the users.

WP9/JRA2 Earth System Model Evaluation developments

In IS-ENES2, a strategy towards routine evaluation of ESMs in CMIP has been developed[8]. In order to achieve this goal, WP9/JRA2 plans to further develop the European community evaluation tool, the Earth System Model Evaluation Tool (ESMValTool)[9]. The tool gathers diagnostics and performance metrics to evaluate the models with respect to observations developed and gathered through a range of European science projects (e.g. EMBRACE, CRESCENDO).

Through coordinated developments, the ESMValTool will be extended to evaluate regional climate models. A standard interface will be developed to ease the addition of new diagnostics. The ESMValTool will be coupled to ESGF to provide access to new evaluation products for CMIP6 within WP7/VA2.

WP10/JRA3 ENES Climate Data Infrastructure software stack developments

Driven by requirements and needs gathered by WP5/NA4, these activities will provide sustainable, streamlined, and scalable foundation for the climate data infrastructure software stack that will be run in production in WP7/VA2. WP10/JRA3 will include data distribution, processing, vocabulary management, documentation and impact study tools, also taking into consideration ongoing efforts in the wider European data ecosystem and will look forward to the EOSC roadmap and evolution as well as to the Copernicus landscape.

WP10/JRA3 will develop an interoperable and flexible computing layer supporting scientific data analysis and processing within the infrastructure providing an integrated set of processing related services for end users. WP10/JRA3 will also provide advanced data processing services for the climate4impact platform in order to deliver to impact researchers new user-friendly interfaces for climate data analytics.

WP10/JRA3 will also maintain and develop the ES-DOC international documentation infrastructure to support CMIP6 and other MIPs as well as expand the scope of documentation to new areas for climate modelling process, including model evaluation.

Innovation potential

Innovation within IS-ENES3 will grow the user base beyond the research community and transfer knowledge that will enable growth in specific markets in Europe. Dedicated innovation tasks will be distributed across the Network Activities and coordinated in WP2/NA1 Task 2.

IS-ENES3 is mainly concerned with two different approaches in innovation: on one side, social innovation proposing the use of reference climate model data for climate services and supporting further dissemination through the Copernicus Climate Change Service (C3S), to inform society on climate change; on the other side, innovation around ICT technology, either as users of hardware solutions (e.g. computers, data cloud solutions) or as providers of software tools of interest to companies (e.g. meta-scheduler Cylc).

IS-ENES3 strategy to innovation: WP2/NA1 will deal with the strategic aspects of innovation. This mainly concerns the Copernicus Climate Change Service as downstream users of IS-ENES3 expertise (see social innovation) and the IS-ENES3 strategy with regards to the cloud, through the European Open Science Cloud (EOSC), or even possible solutions using public or private cloud providers. Both aspects provide routes for exploitation and impact beyond IS-ENES3 itself. WP2/NA1 will strongly link with the more technical aspects of innovation developed in WP3/NA2, WP4/NA3 and WP5/NA4.

Widening the data user base for social innovation: The need to adapt to climate change raises the challenge

[8] Eyring, V., Gleckler, P. J., Heinze, C., Stouffer, R. J., Taylor, K. E., Balaji, V., Guilyardi, E., Joussaume, S., Kindermann, S., Lawrence, B. N., Meehl, G. A., Righi, M., and Williams, D. N.: Towards improved and more routine Earth system model evaluation in CMIP, *Earth Syst. Dyn.*, 7, 813-830, 2016a.

[9] Eyring, V., Righi, M., Lauer, A., Evaldsson, M., Wenzel, S., Jones, C., Anav, A., Andrews, O., Cionni, I., Davin, E. L., Deser, C., Ehbrecht, C., Friedlingstein, P., Gleckler, P., Gottschaldt, K. D., Hagemann, S., Juckes, M., Kindermann, S., Krasting, J., Kunert, D., Levine, R., Loew, A., Mäkelä, J., Martin, G., Mason, E., Phillips, A. S., Read, S., Rio, C., Roehrig, R., Senftleben, D., Sterl, A., van Ulft, L. H., Walton, J., Wang, S., and Williams, K. D.: ESMValTool (v1.0) – a community diagnostic and performance metrics tool for routine evaluation of Earth system models in CMIP, *Geosci. Model Dev.*, 9, 1747-1802, 2016b.

of providing society reliable and tailored information. The resulting "climate services" encompasses a chain from the science, providing reference climate simulations and observations, to the downstream services providing tailored information to end-users[10]. IS-ENES3 contributes to the overall chain, by providing the backbone infrastructure to deliver access to the climate model and observational data. The Copernicus Climate Change Service (C3S) recognizes this role through its decision to provide access to climate projections by brokering on the research ESGF data infrastructure, which will be developed in IS-ENES3. It will be important for the sustainability of IS-ENES to engage with C3S on the strategy for long-term collaboration.

Several activities of WP3/NA2 will be undertaken in IS-ENES3 to reinforce the links with users. This will not only target impact research communities but will be open to climate service communities, including both public and private initiatives. These activities will facilitate innovations through the transfer of climate knowledge to SMEs and larger companies providing such climate services. Practically all data for CMIP6, especially all from Europe, will be in open access with no restriction for commercial use. New groups, Europe wide, will be reached via short events and webinars, and dedicated workshops accompanied by hands-on sessions.

Innovating with software and HPC industry: IS-ENES3 promotes opportunities to bring climate science knowledge and information on models, tools and HPC (WP4/NA3 and WP8/JRA1) to the attention of industry. The results from HPC performance evaluation activities of complex coupled systems and all research on the development of models and modelling tools will allow the project to interact at different levels with vendors of HPC and related software. Requirements from users and developers of the HPC applications used by the climate modelling community will be collected, creating a common understanding about future mutual needs. This information can be exploited by the HPC industry so that the market can produce better performance tools for the applications developed and used by climate modellers, but also by other communities/parties with similar challenges.

Besides, new technologies will be also explored in WP4/NA3. Companies involved in Machine Learning and Artificial Intelligence will be exposed to opportunities for exploiting climate data to provide new services, reach a wider market, and encourage co-design. Further, appropriate industry experts will be engaged and also invited to attend the community workshops to encourage exploration of community expertise on coupling, I/O and complex workflow management, eventually leading to products a wider community will benefit from. Contacts have already been made with the Altair Company showing a clear interest in the Cylc workflow engine for their HPC solutions.

As cloud computing is a consolidated trend for data centres from an infrastructural standpoint, during IS-ENES3, WP5/NA4 will investigate how the cloud solutions, private or public, may impact or improve some of our services.

2. Impact

2.1 Expected impacts

The IS-ENES3 infrastructure is a research infrastructure for climate science and the users of climate data (such as the impacts community). This direct impact has a path to many socio-economic sectors (energy, agriculture, transport, water management, health, safety…) through climate services, as well as national and international policy makers.

2.1.1 IS-ENES3 will provide wider, simplified and more efficient access to its climate modelling research infrastructure

IS-ENES serves several research communities: the Earth climate system modeling community, developing and using climate models, the climate research community interested in analyzing model results from CMIP reference simulations, and the wider community working on impacts of climate change using climate projections produced within CMIP and CORDEX coordinated experiments. For all users and in addition to the continued access to CMIP5, IS-ENES3 will provide access to the new set of coordinated experiments from the 6th phase of CMIP. These new experiments provide both updated and improved projections of future climate

[10] Street R., Parry M., Scott J., Jacob D., Runge T., A European research and innovation roadmap for climate services, EC Directorate General for Research and Innovation, 2015

using newer and more sophisticated models, and a more comprehensive set of simulations aimed at better understanding the climate system itself. The CMIP6 experiments have been defined through a wide consultation of the community. IS-ENES3 underpins the entire CMIP6 activity, providing and maintaining crucial parts of the necessary software infrastructure as well as deploying the data services necessary to exploit the European investments in the simulations themselves. More specifically:

The Earth climate system modelling community will benefit from wider access to more efficient models and tools. IS-ENES3 will provide a new European platform for sea ice modelling available to all modellers within the NEMO European ocean consortium - NEMO is already used in 184 projects worldwide. The computational performance of NEMO will be enhanced, and new metrics on computational performance will allow better understanding of how to exploit HPC. Modellers will also have access to new software tools, such as the new Python interface for the OASIS coupler that will facilitate its use, the XIOS data flow management and the Cylc workflow engine. IS-ENES3 will also offer a new service on model evaluation using the European ESMValTool common software, and further develop it during the project, while acquiring further user requirements, and defining and promoting a new standard interface for diagnostics to support easier integration of community science. All these developments will target a wider user base and extend to regional climate models.

The Earth climate system research community will benefit from enhanced model data services. As well as developing and maintaining the Earth System Grid Federation software, IS-ENES3 will provide the data access service for European CMIP6 data hosted on ESGF. CMIP6 data are expected to reach more than 20 PB (currently CMIP5 is ~2 PB in volume). IS-ENES3 will lead the climate data operations team, and be responsible for maintaining a high-quality and efficient ESGF service. The project will support both data providers and users. For the first time, IS-ENES3 will offer a unique data processing service to analyse multi-model ensembles, preventing bulk data downloads. IS-ENES3 users will also benefit from advanced model and simulation metadata through the international IS-ENES led ES-DOC developments.

The climate change impacts community will benefit from enhanced services through the climate4impact platform. The research community studying impacts of climate change use simulations from global and regional climate models to force their impact models. Impact modellers require easy access model variables from both different future climate scenarios and from different climate models - the former to address possible futures, the latter to address uncertainty arising from the models themselves. IS-ENES3 will continue and further improve this service through the climate4impact platform with new data processing and user-friendly interfaces for analytics designed. The platform will also benefit from the cooperation with other projects, such as pre-Copernicus CLIPC project and the C3S MAGIC project to reach a wider climate services community.

2.1.2 IS-ENES3 will widen the user base, mainly towards the impact climate modelling community and towards Eastern Europe.

IS-ENES3 will gather feedback from users, especially those from potential new communities, via surveys, training, schools, and workshops. This will improve the project awareness of existing user requirements, and allow it to respond to the needs of new communities from the wide climate impacts community. A set of workshops will explicitly target the vulnerability, impact and adaptation scientists, including hands-on training activities and fruitful two-ways dialogue. Training will also aim at enlarging the user base in Eastern Europe, benefitting from existing connections established within previous initiatives, e.g. the FP6 CECILIA project[11] Central and Eastern Europe network and the network on South-eastern Europe the "*South East Europe Virtual Climate Change Center*"[12].

2.1.3 IS-ENES3 will strengthen synergies between infrastructures, further easing the data flow.

IS-ENES works to avoid duplication of effort within the European infrastructures for climate modelling. IS-ENES3 will enhance the number of software tools shared among the community to reduce overheads and develop a strategy for the replication of ESGF data in Europe, sharing the replica among different centres. IS-ENES3 will also offer a complementary access service for data processing. :

IS-ENES3 will also pursue collaboration with other research infrastructures in order to strengthen

[11] CECILIA: Central and Eastern Europe Climate Change Impact and Vulnerability Assessment http://www.cecilia-eu.org/

[12] South-Eastern Europe Virtual Centre on Climate Change http://www.seevccc.rs/

interoperability and reusability of data. Collaboration will be further extended with EOSC and EUDAT for data and PRACE, GEANT, current and future COEs, FET projects and flagship initiatives for HPC. In particular, IS-ENES3 will interact with the Centre of Excellence on HPC for weather and climate ESiWACE, which complements IS-ENES3 by targeting future generation of climate models able to run on exascale computer architectures. IS-ENES3 will also continue to interact with other environmental research infrastructures within the ENVRI community, where IS-ENES3 brings its advanced expertise on metadata.

2.1.4 IS-ENES3 will advance innovation in the field of climate modelling.

IS-ENES3 will open its training and school activities to climate service providers, which are translators of climate model data into tailored information to societal sectors affected by climate change. IS-ENES3 will in particular foster collaboration with SMEs, such as TCDF and TEC Conseil (*See letters of support, Appendix of Section 4*). IS-ENES3 will also further collaborate with the Copernicus Climate Change Service (*See letter of support*), which aims at providing access to climate projections by brokering on ESGF.

IS-ENES3 will strengthen its dialogue with the ICT hardware and software industry, both as users of hardware solutions (e.g. computers, data cloud solutions) and as providers of software tools. Altair, a software and consultancy firm will be working with IS-ENES3 on the workflow scheduler Cylc in a two-way exchange of information, experience, and code. Collaboration with vendors within ESiWACE, such as Bull/ATOS, and at institutional level (e.g. IBM, CRAY…) will facilitate this dialogue and will benefit from work done on the efficient use of HPC.

2.1.5 IS-ENES3 will foster inter-disciplinary fertilization, especially within the young generation of researchers.

IS-ENES3 will provide opportunities to further develop interactions between the climate and climate impact modelling communities on efficient use of model results from international reference simulations. IS-ENES3 will run dedicated training workshops in different parts of Europe for impact modellers. Two one-week schools, initially targeting early career members of the two communities, one in Western Europe, one in Eastern Europe will be organised for the first time; the objective is to bridge the gaps between the two communities and improve the use of model data for increasing understanding of climate change impacts. Hand-on sessions will be an opportunity for the two communities to work together.

Also, IS-ENES3 will further develop interactions between climate modellers and computational scientists. A particular focus will be on big data science and emerging technologies associated with artificial intelligence and machine learning. A new school on big data science for climate will be organised in collaboration with experts in data science in order to train young generations on these new aspects and trigger further collaboration between the two communities.

2.1.6 IS-ENES3 will prepare a sustainable infrastructure

As recommended in the 2018 mid-term update of the ENES infrastructure, a sustained long-term infrastructure is necessary. This impacts most prominently the ESGF data delivery infrastructure, but software efficiency and optimization efforts also tremendously benefit from sharing of knowledge and tools and reduced redundancy. The whole community acknowledges the achievements and the overall efficiency and synergies gained arising from these European collaborations. Building on the interaction with its main stakeholders, the project will revisit the usefulness and usability of existing services in order to define the resources and structures required to sustain them. Scientific, technical, political and funding opportunities will be investigated. The existing infrastructure strategic roadmap and partner management insights will be instrumental toward the preparation of and initial implementation of the necessary sustainability plan.

2.1.7 IS-ENES3 will impact on policy (IPCC) and Copernicus

WCRP-CMIP global experiments, complemented by the downscaled CORDEX simulations, serve as a reference basis for the IPCC assessment reports. IS-ENES3 will continue to serve as European storage infrastructure for these activities, supporting CMIP6 in its main phase of distribution and analyses of model results as well as paving the way for CORDEX and next phase of CMIP.

Access to these projection data is also an integral requirement of the Copernicus programme, within its Climate Data Store (CDS). Supporting CDS is an additional route to supporting the European climate services industry. IS-ENES3 will continue to ensure that the requirements of the Copernicus programme are understood, and where possible supported from within IS-ENES3. Copernicus requirements will form part of the background for the long-term sustainability plans as well.

2.1.8 Indicators for IS-ENES3 impacts

In line with IS-ENES3 objectives, we propose to employ the following quantitative indicators to show the advancement of key aspects/activities toward the achievement of the project impacts as follows:

- Number of external parties involved (per community and career stage) in IS-ENES3 workshops/trainings/schools;
- Number and type of applications for Trans National Access;
- For services on software in WP6/VA1: number of downloads, discussions on forums, emails exchanged, query tickets solved;
- For the new European sea ice model: number of developments committed, and institutions involved, uptake within IS-ENES3, NEMO consortium and NEMO user community.
- For services on data in WP7/VA2: statistics on ESGF data node usage (data download volumes, data file downloads, active users per data node, answers to user queries with IS-ENES3 contribution), statistics on use of the Climate4Impact Platform, statistics on use of ES-DOC documentation (search and compare tool use, number of publications acknowledging this service);
- Estimate of IS-ENES3 partners (jointly or on single partner basis) participating in European interoperability initiatives;
- Number of national and international science projects relying on IS-ENES infrastructure;
- For the new model evaluation infrastructure: number and diversity of active ESMValTool users, number of modelling groups using the tool in-house, number of publications acknowledging this service;
- For widening the community, number of institutions and companies engaging across all IS-ENES3 services. Registry of engagements with Industry;
- For engagement with Copernicus, EOSC, and other European infrastructure. Number of meetings, and a registry of any tangible outcomes.

2.1.9 Barriers and obstacles to the achievement of IS-ENES3 impacts

The benefits listed above may have some dependence on conditions *external* to IS-ENES3's scope, influence and objectives, which may determine whether, and to which extent, the expected impacts will be achieved. Some of these barriers are:

- Poor feedback from complex or emerging communities with different modes of governance and interaction;
- Feedback from users not comprehensive enough to detect all opportunities and problems;
- Divergence in science goals and openness policies between evolving national research infrastructures;
- Tension between cross-disciplinary national infrastructure and trans-national discipline based infrastructure objectives.
- Unexpected challenges to cyber security in a distributed system with a broad portfolio of services;
- Limits to interoperability determined by difficulties in cross-domain mapping among community-specific standards.
- Evolving requirements from key societal users, e.g. Copernicus;
- Technical knowledge gaps in the user community;
- Rapid evolution in ICT, with limited influence from climate modelling community;
- Difficulties in recruiting and retaining suitable staff, particularly computational science;
- Lack of suitable legal instruments increasing complexity in the preparation of a sustainable infrastructure.

While these barriers could exist with different degrees of severity, IS-ENES3 will attempt to mitigate their influence by exploiting solid governance, an unprecedented effort in collecting user requirements and feedback

throughout the project, and maximising the use of advice from the Stakeholder Board and the Science Advisory Board. The continuous monitoring of reliable and adjustable indicators will offer opportunities to anticipate and contain the effects of such hurdles. Past IS-ENES experience also demonstrates the capacity of the Consortium to cope with external impact-limiting factors – examples, which occurred during IS-ENES2, included adapting to the launch of the Copernicus programme and providing temporary solutions to mitigate a major ESGF security breach. We do not foresee any other framework condition that could impede the achievement of IS-ENES3 impacts. For risks related to the project implementation, please refer to section 3.2.4.

2.2 Measures to maximise impact

We provide below a draft "*Plan for the dissemination and exploitation of IS-ENES3's results*" (2.2.a) and indications for *communication of IS-ENES3's results* (2.2.b) that respectively provide measures to achieve expected impacts of the project and communicate the project's results. Considering the different impacts of such an infrastructure project (see 2.1) together with the heterogeneity of the IS-ENES target communities, we propose, for the sake of efficiency, different actions tailored for different audiences. The measures will involve all consortium partners and their staff and will be coordinated by WP1.

2.2.a Dissemination and exploitation of results

Draft plan for dissemination and exploitation of IS-ENES3's results

This plan will be further developed during the lifetime od IS-ENES3 and will be expanded to contain a strategy to manage knowledge management (ownership, access), protection and for the exploitation of results, defining procedures and responsibilities within the consortium throughout the project and indications on how this issue will be dealt with once IS-ENES3 has ended. A confirmed version of this Plan will be prepared at the start of the project and updated in both the periodic and final reports.

Target communities: IS-ENES3 directly serves: the Earth climate system modelling community (developing and using climate models); the climate research community (interested in analysing model results from CMIP reference simulations); and the wider community working on impacts of climate change using climate projections produced within CMIP and CORDEX coordinated experiments, including climate service providers. Furthermore the project has impacts on HPC industry and climate service providers, in particular C3S, and provides the storage and curation infrastructure for simulation results that inform global decision making at policy level.

Strategic aspects for knowledge management, protection, exploitation and dissemination of results: In line with the project's overall objectives, IS-ENES3 puts together measures to address specific needs. In first place, each target community should benefit from tailored presentation of results: modellers need open access to well-documented codes and to evaluation information, data providers and users from the global and regional modelling communities clear procedures to ingest/extract data in the infrastructure and meaningful, up-to-date reference standards, impact scientists and climate service providers need reliable, usable interfaces and transparent documentation on downscaling, indicators, and associated uncertainties. IS-ENES3 offers a blend of services to satisfy these needs, contributing to the optimization of the modelling workflow and of the downstream exploitation of data.. IS-ENES3 results are available to all but a specific emphasis will be given on Eastern Europe. IS-ENES3 will also widen its user base, in particular towards regional modelling groups, climate impact scientists and climate service providers. Due to the non-profit vocation of the science and knowledge advancement activities, no risk of competition among users is foreseen. There is no foreseen risk that the output of IS-ENES3 will be substantially ignored in favour of other solutions, as there are no viable alternatives being developed for most of the infrastructure. In some example, such as Machine Learning and AI, IS-ENES3 will bring external opportunities to our community so that we can select the most effective approaches together.

In terms of access policy, all project results will be open to no-profit exploitation; no patents will be registered and no industrial co-design foreseen, even if exchange with HPC vendors lead to directly or indirectly innovation.

Dissemination measures: IS-ENES3 will support the dissemination of data, software and knowledge. Data and its rich metadata will be made accessible through IS-ENES3 ESGF data nodes, whose access and services are advertised on the ENES Portal (See below). Software made available through open repositories, typically

github. Scientific publications, technical, strategic and recommendation reports, tutorials, documentation, white papers, deliverables and milestones will be made available via the ENES portal and website. Dissemination measures of all this will be formulated according to the different target communities/audiences and will often be integrated with the support activities.

Workshops, training events, task forces actions, and community building activities will also be used to create and disseminate project output. As EC grant recipient, IS-ENES3 will ensure that electronic copies of peer-reviewed scientific publications become freely available to anyone as soon as possible and in all cases no later than six months after publication.

The ENES portal (https://portal.enes.org) is already a sustainable central information gateway for the European Earth System Modelling community, including up-to-date community news and announcements, links to other complementary and adjacent initiatives, task forces material, documentation training material, and a unified access point to all IS-ENES services. As part of the infrastructure sustainability plan, the ENES portal will be maintained as well after IS-ENES3. The IS-ENES3 website (https://is.enes.org) will host all project related content (technical and scientific reports in milestone or deliverable form, periodic reports, newsletters), host tweets (see communication), and mirror relevant community news. Both ENES and IS-ENES3 will rely on dedicated twitter accounts. Peer-reviewed publications will also be made available via the European platform OpenAIRE and non-peer-reviewed material will be uploaded to ZENODO. Both platforms are connected and indexed by grant agreement number and provide long-term preservation.

In the table below, we list the foreseen results of the joint research and (selected) networking activities and connect them with the expected project impacts (*cf Section 2.1*), formulating for each appropriate measures to maximize such impact. Eventually, we propose dissemination measures, during and after the project, to maximize them. The following table links a results, impact targets and dissemination approach for appropriate activities.

Results of JRA/NA	***Expected Impact (2.1)***	***Dissemination measures***
NEMO version with enhanced performance and updated quality assurance package. Unified European modelling platform for sea ice for NEMO. Improved Environment tools (OASIS3-MCT, XIOS, Cylc/Rose).	Wider, simplified and more efficient access to climate modelling research infrastructure	*Target community:* **Global Earth climate system modellers** Technical reports (D4.2, D4.4, D4.5, D8.1, D8.2, D8.3, D8.4, D8.5) Peer reviewed publications Software available at institutional repositories and through the ENES portal.
Improved and enhanced ESMValTool: for regional climate models and different timescales, unstructured grids, to incorporate new diagnostics, to achieve better performance. Work towards standardized model evaluation: definition and delivery of common protocols and standards on modularity and new diagnostics. Investigation of (re-) usability and of efficient interfaces to map among languages. Coupling ESMValTool to ESGF.	Wider, simplified and more efficient access to climate modelling research infrastructure Dedicated focus on user requirements. Enhanced service on model data.	*Target community:* **Global and regional Earth climate system modellers, impact modellers and climate service providers** Technical and recommendation reports (D9.1, D9.2, D9.3, D9.4, D9.5, D3.3, D3.4) and peer reviewed publications. Software available on a github repository and through the ENES portal.

Evolution of the ENES Climate Data Infrastructure software stack: • Interoperable and flexible compute layer supporting CMIP6 and CORDEX data analysis and processing. • Developments on data distribution, processing, vocabulary management, documentation. • Climate4impact platform: advanced data processing and new user-friendly interfaces for data analytics. • Maintenance and development of ES-DOC to support CMIP and new areas for climate modelling process, including model evaluation. Defining an architecture for future data services. Defining European priorities for ESGF. Defining technical standards and an architecture for plugin diagnostic tools for model evaluation workflow.	Enhanced service on model data. Stronger synergies between infrastructures. Impact on policy (IPCC) and Copernicus. Preparation of a sustainable infrastructure. Enhanced services through the climate4impact platform. Widen the user base, mainly towards the impact climate modelling community and towards Eastern Europe. Dedicated focus on user requirements.	*Target community:* **Global and regional Earth climate system scientists (modellers, data providers, data users, engineers), climate impacts scientists (modellers, data providers, data users), other infrastructures.** Technical and strategic reports (D5.1, D5.2, D5.3, D5.4, D5.5, D5.6, D10.1, D10.2, D10.3, D10.4, D10.5) Recommendation reports (D3.5) Publications Software documentation available on ESGF and ESMValtool github repositories and accessible through the ENES portal. ES-DOC software components available on ES-DOC github repository (https://github.com/ES-DOC). ES-DOC documentation (https//:es-doc.org).
Training events (short events and schools)	Widen the user base, mainly towards the impact climate modelling community and towards Eastern Europe. Advance social innovation	*Target community:* **Climate impact scientists, climate and data scientists, climate service providers** Recommendation reports (D3.2) Training tools and documentation available through the ENES Portal.
Comparison of the computational performance of European models. Investigation of coupling technologies and HPC. ICT Technology tracking for computation efficiency and investigation of approaches on big data, AI, machine learning for data analytics.	Advance innovation in the field of climate modelling. Preparation of a sustainable infrastructure.	*Target Community:* **Global Earth climate system modellers, Industry** Technical reports (D4.3, D4.5) Workshop reports (D4.1) Report on innovation activities (D2.3)
Plans for sustainability of the IS-ENES infrastructure. Elaboration of the ENES infrastructure strategy 2022/2032	Dedicated focus on user requirements. Preparation of a sustainable infrastructure	*Target community:* **Earth climate system scientists, climate change impact scientists** Strategic reports (D2.1, D2.2) available on the ENES portal.

Exploitation measures

We briefly list how IS-ENES3 results could be exploited *outside* the consortium and related measures to facilitate them.

Newly developed and or enhanced:

- The NEMO, NEMO Sea-Ice model, OASIS, XIOS, Cylc software will be exploited by ESM users to improve their models and their capacity to perform projections, predictions, and process studies, in particular for their participation in CMIP experiments.
- ESMValTool developments and their coupling to ESGF results will be exploited by global and regional

ESM developers, and data users, to better evaluate models and support data exploitation, respectively.

- Provision and support of data distribution, replication, processing, vocabulary management, documentation, analysis, the Climate4Impact platform and ES-DOC standards will be exploited by ESM Data providers and data consumers. Impact scientists/modellers and other RIs members (to develop interoperability solutions) will be able to better exploit model data for their research.
- Computational performance metrics and improvements will help climate modellers better exploit available HPC.

The results of:

- Consultations, e.g. on strengths and weaknesses of downscaling approaches, will also serve the impact scientists and service providers.
- Evaluation on usability of current climate research standards will trigger community (climate and impact modellers) co-design.
- Workshops on coupling technologies and HPC will enable ICT technology tracking for computation efficiency and investigation of approaches on big data, AI, machine learning for data analytics, helping modellers and industry.
- Innovation activity reporting and the plans for sustainability of the IS-ENES infrastructure after the end of the project will inform EC policies.

Finally, the ENES new strategic document for the future of the infrastructure and the sustainability plan will inform the whole user community, the EC and the WCRP as well.

The blend of proposed dissemination (*Section 2.2.b*) measures will support all these ways of exploitation of IS-ENES3 results. In order to facilitate outreach in underrepresented geographic areas, workshops and community building events will take place in Eastern and South-Eastern Europe. Open access will be granted to all peer-reviewed scientific publications resulting from IS-ENES3, to all software produced following different licensing schemes and to all data collected and or produced by the project.

Indicators: In order to assess the efficacy of the planned measures with respect to the project objectives, IS-ENES3 will periodically verify that:

- Published material is accessible and accessed (e.g. counting downloads from the IS-ENES3 website)
- Codes are accessible and accessed (see also project KPIs);
- All different target communities are satisfied with the information they receive via surveys.
- The scientific stakeholders and the advisory bodies are engaged;

This will be proactively managed by WP1 with support from work-package leads.

Business plan

The IS-ENES3 Consortium will leverage significant national investment, alongside that of the Commission, to deliver services, which will be free at the point of use by all consumers, whether academic, government or industry. The primary concern then is the sustainability of this activity, which is addressed in WP2/NA1, where Task 3 specifically addresses the scientific, technical, legal and financial issues, which will need on-going agreement and governance. This will result in D2.2, the "ENES-RI Sustainability Plan" which will be published in the final year of the project, outlining a candidate proposal plan, the state of stakeholder agreement, and any progress on implementation. It will build on an earlier sustainability scoping report (M2.3 at the end of the second year).

Draft of Data Management Plan

IS-ENES3 plans to take part in the Pilot in Open Research Data and will adopt a Data Management Plan. At the core of the data management plan are the "FAIR" principles (findable, accessible, interoperable and reusable) applied to output from experiments, measurements, observations resulting from fieldwork, survey results, interview recordings and images, focusing on research data that is available in digital form.

The three objectives of IS-ENES3, characterized as 1) community integration, 2) software and HPC, and 3) facilitating exploitation of data will yield software and documents, none of which easily fit into the scope described above. Nonetheless, there is a significant amount of activity which we will cover within our data

management plan, however, the scope will be different from a traditional data management plan. This can be understood by considering the data handling associated with objective 3. IS-ENES3 is responsible for the infrastructure for accepting, describing, storing and providing data to data consumers. It is not responsible for production of the data. In these senses the IS-ENES3 Data Management Plan will be primarily orientated towards describing the standards, conventions, documentation and tools, being developed and deployed, and how IS-ENES3 itself is delivering the mechanism by which the data producers can deliver on the FAIR principles for their data. IS-ENES3 will also be facilitating the curation of some climate model data, as described below.

Timing and Responsibility: The formal data management plan, DMP, will be delivered by project month 6 (D1.1). The Project Coordinator will be formally responsible for the DMP and be supported by the Scientific Officer. The plan will be updated as part of the periodic assessments based on new understandings about data being collected, or changes in consortium policies, composition etc.

Scope, target audience and contributors: The bulk of the data being handled by the project will consist of climate model data being published into, and consumed from, the ESGF, although we do expect some data will be collected on software and system performance, including testing data. Given the expected emphasis on ESGF data, the target audience will primarily be the producers of data for, and the consumers of data from, the ESGF – although all project participants will be made aware of their responsibilities with respect to any other data which might be collected via the Project Leadership Team and the regular reviews.

In the remainder of this section we provide some of the headlines elements in draft format for the IS-ENES3 DMP before identifying the key steps to develop the DMP.

Draft Recommendations - Climate: All data entering the ESGF must conform to the requirements promulgated by the WGCM Infrastructure Panel (WIP, the IS-ENES3 team currently includes several members of the WIP). These include requiring data to conform to the CMOR[13] extensions to the CF conventions for NetCDF, file identifiers and naming to conform to the ESGF standards, and provenance information to include descriptions of models, simulations and conformance to CMIP protocol, using the ES-DOC standards. The IS-ENES funded ESGF nodes will be responsible for FAIR access to data they hold for the duration of the project, with longer-term plans for data management forming part of the sustainability plan.

Draft Recommendations – Testing and Systems Data: Where quantitative data on software or systems performance is collected during the project, and used as input to a deliverable or publication, it should either be included as supplementary material, or deposited with an appropriate repository. Work package leaders should keep a list of any such data, and when data is published or deposited, they should appear with a short description in a project data registry on the project website.

Draft Recommendations - Qualitative Data: It is possible that the networking activities will involve surveys, at workshops, or via email or the web. Where numbers allow, anonymized data summarizing key results should form part of relevant workshop reports/milestones or deliverables. Work package leaders should keep a list of any such data, and when data is published or deposited, they should appear with a short description in a project data registry on the project website.

Keys steps towards developing the formal DMP, include:

1. Establishing a project-level register of expectations around both data collection, and data handing on a task by task basis (this will need to be updated as each task starts, since not all tasks start within the first six months of the project).
2. Ensuring that each of the datasets exposed by this register are handled within an expanded and more detailed set of DMP guidelines based on those above.
3. Establishing the public project data registry on the project website (not to include ESGF datasets and documentation, which are discoverable via ESGF itself).

2.2.b Communication activities

Draft Communication plan of IS-ENES3 activities and results

The intention of these communication measures is to promote the project and to provide tailored information

[13] CMOR : Climate Model Output Rewriter software

for all target communities. This will improve impact and illustrate the success, relevance and benefits of the enhanced European research infrastructure to research, science, industry, and society.

The range of planned communication activities is very diverse, covering development activities (e.g. announcements of software releases or of new services), operational services, recommendations, and training opportunities, on a wide range of time scales. IS-ENES3 will provide a comprehensive overview of all these activities to ensure that the broadest spectrum of audiences can take full advantage of the investment Europe is making in the climate modelling infrastructure and in the associated development of services. In this heterogeneous consortium internal communication is also essential to ensure coherent progress toward sustainability.

IS-ENES3 may be of interest to the media: the project coordination will plan opportunities and how to manage appropriately media enquiries following Open Data principles. Press Offices and/or communication departments of the partner institutions will also support the project public communication activities, including the exploitation of social media. IS-ENES3 (as will be the case with ENES) will rely on a dedicated twitter account and will evaluate other channels such as ResearchGate, LinkedIn and Facebook.

At project submission stage, a number of distinct target audiences have been identified and the proposed communication measures for promoting IS-ENES3 activities during the period of the grant are presented below. WP1 will provide an update as part of the Project Dissemination and Exploitation Plan in project month six, and in periodic reports thereafter. The Communication Strategy within this will identify the challenges, audiences and communication methods in higher detail.

Communication measures: The following measures address the needs of different target audiences: partners, external modelling groups and data users, climate change impact scientists and modellers, climate service providers, early career scientists, other projects/initiatives/infrastructures, the European Commission and the general public.

Within the Consortium:

General Assemblies will facilitate exchange among project partners and to the project management.

Regular Conference calls within and across work-packages will facilitate exchange in particular for the management of the execution of the project (*see Section 3.1*).

IS-ENES3 intranet website will host internal communications.

IS-ENES3 Deliverables, Milestones, Workshop reports KPI reports and progress reports (following project timeline) will communicate project results, allow assessment of progress and services efficacy for the Consortium and EC policy officer.

Within and outside the Consortium:

IS-ENES3 mailing will advertise project news to project partners, collaborators and advisory board but also other interested parties upon registration. It will be used to announce project news, diffuse IS-ENES3 Newsletters and diffuse various internal (and external upon demand) announcements, publish calls for TNA

Newsletters (3-4 per year) will present on-going project related activities and services, results, announce events, inform on collaborations and synergies with external projects/initiatives, and on external projects/initiatives. They will be disseminated through the IS-ENES3 mailing list but also to the ENES mailing list and other related projects mailing lists.

IS-ENES3 website regular updates (weekly) will present on-going project related activities and services, results, announce events and training opportunities, publish calls for TNA.

ENES Portal (weekly) will present community news and joint statements, advertise the catalogue of IS-ENES services, inform on community and external projects and initiatives; inform on HPC and Data Task Forces activities; and mirror ENES tweets.

IS-ENES3 Deliverables, Milestones, Workshop reports (upon project timeline) will promote networking and exchange on innovation.

IS-ENES3 tweets (weekly to potentially daily) will inform on IS-ENES3 activities and promote networking.

ENES tweets (weekly to potentially daily) will inform on ENES community news, initiatives, science and infrastructure projects (e.g. IS-ENES3, ESiWACE, EUCP…), promote community building and networking.

3. Implementation

3.1 Work plan — Work packages, deliverables

3.1.1 Presentation of the overall work plan

The work plan is organised in ten work packages, with WP1 on coordination, four NA work packages, two Access activities, mainly composed of virtual access, and three JRA work packages.

As described in the methodology section, the structure of work packages addresses the objectives of IS-ENES3 for the different components of the climate modelling infrastructure: models and software tools, including efficient use of HPC, and exploitation of data and metadata from reference model simulations and for model evaluation. How the different work packages contribute to the overall objectives and innovation is described in the table below.

Objectives	1	2	3	Innov-ation (*)
WP1 Coordination, Dissemination and Management WP1 will coordinate and manage the project and conduct the dissemination and communication of model results.				
WP2/NA1 Governance, Sustainability and Innovation Will drive the governance of the infrastructure, prepare for its sustainability at the end of IS-ENES3 and drive innovation strategy.	X			X
WP3/NA2 Community engagement Widens the user base, especially for social innovation around climate services, by stimulating interdisciplinary approaches and community building of the early careers researchers, by supporting the community dimension of standards, while ensuring a better knowledge on user requirements and feedback to services.	X	X	X	X
WP4/NA3 Networking on Models, Tools and efficient use of HPC Will network on a new community sea ice model, on HPC performance measurements and technology tracking on machine learning technologies, and on innovating with hardware and software ICT industry.		X		X
WP5/NA4 Networking on data and model evaluation Networks on data and metadata, ensuring consistency with other related initiatives in Europe and at the international level on open access data, on sustaining long-term standards on metadata, and networks on a common interface for model evaluation.			X	X
WP6/VA1 Services on European ESMs and Software Tool Will support the access services on models and tools, essentially through virtual access to models and community tools, including the common evaluation tool. A new TNA offers an opportunity to support coupling of models		X		
WP7/VA2 Data standards, distribution and processing services Supports the access services on model data and metadata from the WCRP coordinated experiments. It offers a range of service for different communities as well as a new TNA service for data processing.			X	
WP8/JRA1 Models & Tools developments Will further develop models and tools services, enhancing computational efficiency of the NEMO ocean model, supporting the development of the new sea ice model and further improvements of community software		X		
WP9/JRA2 Earth System Model Evaluation developments Will further develop the European common evaluation tool ESMValTool in order to enlarge its functionalities for a wider community			X	
WP10/JRA3 ENES Climate Data Infrastructure software stack developments Will further develop data and metadata access services, improving the international ESGF, ES-DOC and the climate4impact platforms, and global standards.			X	

(*) INNOVATION: WP2/NA1 Task 2 will ensure the integration of the dedicated innovation tasks from the different NA work packages into a common strategy on innovation. This solution has been chosen in order to better embed innovation across all IS-ENES3 activities

3.1.2 Timing of the different work packages

RP	RP1									RP2									RP3					
mth	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
	WP1																							
T1	M1.1		D1.2					M1.3									M1.4						M1.5	
T2																								
T3		M1.2	D1.3																					
T4		D1.1																						
	WP2																							
T1						M2.1																		D2.4
T2						M2.2															D2.3			
T3												M2.3									D2.2			
T4												M2.4						D2.1						
	WP3																							
T1												M3.3	M3.5										D3.5	
T2										M3.2								D3.2						
T3									D3.1			M3.4						D3.3						
T4									M3.1									D3.4					D3.6	
	WP4																							
T1																				D4.4				
T2						M4.1							D4.2											
T3																		D4.3						
T4												M4.2												
T5									D4.1														M4.3	
T6																						D4.5		
	WP5																							
T1																							D5.6	
T2									M5.1									D5.3						
T3									M5.2									D5.4						
T4						D5.1												M5.4						
T5										M5.3		D5.2						D5.5						
	WP6																							
T0									M6.2			D6.2								D6.5				
T1									M6.1									M6.3						M6.4
T2									D6.1									D6.3						D6.6
T3																		D6.4						
	WP7																							
T0						M7.2						D7.2								D7.4				
T1				M7.1					D7.1			M7.3						D7.3					M7.4	D7.6
T2																								
T3																								
T4																								
T5																					D7.5			
	WP8																							
T1												M8.4										D8.5		
T2												D8.1			M8.2									
T3												M8.3						D8.2						
T4						M8.1														D8.3				
T5						M8.2														D8.4				
	WP9																							
T1																	M9.1/ M9.2							D9.5
T2																								
T3									D9.1															
T4																		D9.4						
T5												D9.2												
T6																								
T7																								
T8															D9.3									
	WP10																							
T1							M10.1		D10.1			D10.2						D10.3						D10.5
T2																								
T3																								
T4																								
T5																							D10.4	
T6									M10.2			M10.3												M10.4

3.1.3 Detailed work description

Table 3.1a: List of work packages

Work package No	Work Package Title	Lead Participant No	Lead Participant Short Name	*Co-Lead Participant Short Name*	Person-Months	Start Month	End month
WP1	MGT	1	CNRS-IPSL	*UREAD-NCAS (2)*	**58**	1	48
WP2	NA1	2	UREAD-NCAS	*DKRZ (3)*	**80**	1	48
WP3	NA2	1	CNRS-IPSL	*KNMI*	**86**	1	48
WP4	NA3	5	MetO	*BSC (6)*	**97**	1	48
WP5	NA4	1	CNRS-IPSL	*SMHI (10)*	**67**	1	48
WP6	VA1	10	SMHI	*CERFACS (4)*	**67**	1	48
WP7	VA2	3	DKRZ	*KNMI (7)*	**184**	1	48
WP8	JRA1	4	CERFACS	*CMCC (8)*	**135**	1	48
WP9	JRA2	11	DLR	*BSC (6)*	**115**	1	44
WP10	JRA3	8	CMCC	*CERFACS (4)*	**174**	1	48
				Total person-months	**1063**		

Description of WPs Tables 3.1.b are provided below for the 10 WPs.

WP1/MGT Coordination, dissemination and management

Work package number	1	**Lead beneficiary**			CNRS-IPSL		
		Co-Lead beneficiary			UREAD-NCAS		
Work package title	Coordination, dissemination and management						
Participant number	1	2					
Short name of participant	CNRS-IPSL	UREAD-NCAS				**Total**	
Person months per participant	**54**	**4**				**58**	
Start month	1			End month	48		

Objectives

The main objective of this work package (WP) is to ensure an effective, smooth and high-quality implementation of the project's work plan. More specifically, the following tasks aim to implement the appropriate practices regarding administrative, financial, legal and managerial issues accordingly to the scale of the project. The management structure relies on strong previous experiences of the consortium and has been specifically thought to meet the requirements of EU funded projects.

WP1 will also ensure dissemination of IS-ENES3 results both internally and externally by using the most relevant tools such as the internet website, social networks or publications (see also *section 2.2b*)

Links with other work packages

WP1 is strongly articulated with the other work packages composing the work plan – it will ensure WP leaders and co-leaders in every task deliver on the relevant management, coordination and dissemination, including meeting all requirements on reporting, open-access, and data management.

Description of work

IS-ENES3's organization is extensively described in section *3.2.* This work package "Management" will benefit from the close supervision of the Project Coordinator on behalf of the Coordinator Legal Entity. The Project Coordinator will be assisted by the Project Lead Scientist to ensure an effective scientific and technical coordination of the project and by the European Project Manager for management and financial related tasks.

The main tasks are:

Task 1: Ensure the overall management of the consortium
CNRS-IPSL (26 pm)

The Project Coordinator, on behalf of the Coordinator, with the assistance of the European Project Manager and CNRS administration will finalise the Consortium Agreement between partners (D1.2).

During the lifetime of the project, they will also ensure:

- Administrative and financial management, assistance to the consortium for administrative and financial aspects, reporting to the European Commission;
- Overall coordination and communication with the European Commission, through the Scientific Officer;
- Organisation of consortium meetings (kick-off and final meetings, General Assembly meetings, Project Leadership Team meetings...) in collaboration with partners (M1.1 to M1.5).
- Management of the budget allocated to develop international collaboration with scientific groups outside the IS-ENES consortium

Task 2: Ensure the scientific coordination of IS-ENES3
CNRS-IPSL (16 pm), UREAD-NCAS (3 pm)

The Project Coordinator and the Project Lead Scientist will:

- Ensure the coordination of scientific work within the consortium: follow up the project's work plan, meet the deadlines to generate the project's deliverables and take appropriate actions in case of deviations;

- Manage the Project Leadership Team, which gathers the work package leaders and the Coordination Team in order to follow the execution of the work plan;
- Ensure regular interaction with the Scientific Advisory Board and the Stakeholders Board;
- Deliver the periodic reports and the final report linked to the project execution.

Task 3: Dissemination
CNRS-IPSL (12 pm), UREAD-NCAS (1 pm)

Through this task, IS-ENES3 will update the project website to provide general information on on-going activities of the project. This website will in particular advertise the IS-ENES3 access activities platform (https://enes.org/). IS-ENES3 website will be accessible through the existing IS-ENES website (https://is.enes.org/) in order to ensure a wider dissemination level.

The Project Coordinator, with the European Project Manager will ensure communication and dissemination activities described in the *2.2 section* of this proposal. To that extent they will:

Coordinate the **internal communication** between the partners through web and regular teleconference in order to facilitate the exchanges between partners, especially on the progress of results. Provide the appropriate work documentation to the consortium members through the internet section of the project's website.

Coordinate the **external communication** in order to disseminate information by:

- Maintaining the IS-ENES website to provide general information on on-going activities of the project, in particular give access to presentations at project workshops and to public deliverables and milestones;
- Producing regular newsletters presenting on-going activities, in particular workshops, services and results obtained;
- Launching and animating a twitter account to widen dissemination in networks related to Earth system modeling.

A section related to completed and planned communication activities will be added in the periodic and final reports.

Ensure the **accessibility of project results and conditions for their exploitation**. The draft '*plan for the dissemination and exploitation of results'* in *section 2.2a* will be completed in first months of the project (D1.3). It will be regularly presented at General Assembly meetings and updated in both the periodic and final reports. Following recommendations of the Work Programme, it will include:

- A record of activities related to dissemination and exploitation that have been undertaken and those still planned;
- Dissemination of access opportunities and of the resulting use of the research infrastructure;
- Measures to assess or improve the innovation potential of the infrastructure.

Data Management Plan

The Coordination Team with the help of WP leaders and co-leaders will prepare a more detailed version of the "Data Management Plan" (D1.1) further explaining what types of data will be collected or generated, their associated standards and the measures to be implemented for their exploitation and possible re-use, as well as for their curation and preservation. It will be updated over the course of the project if any significant changes arise, or as a minimum in time with the periodic assessment of the project.

Deliverables

D1.1 (Task 3, mo 4): **Data Management Plan**
A more elaborate version of the draft Data Management Plan included in the proposal will be created. This plan will describes the data management life cycle for the data to be collected, processed and/or generated by IS-ENES3. It will include information on how to make IS-ENES3 research data findable, accessible, interoperable and re-usable (FAIR), as asked to the participants of the Pilot on Open Research Data in Horizon 2020 (UREAD-NCAS).

D1.2 (Task 1, mo 6): **Consortium Agreement**
A comprehensive Consortium Agreement (CA) will be established, overseeing the structure, function, and management of the project. The CA will include, if applicable, any intellectual property issues that may arise. All partners will be asked to contribute to the definition of the content of this document and to sign it within the first 6 months of the project (CNRS-IPSL).

D1.3 (Task 3, mo 6): Dissemination and Exploitation Plan
The draft in section 2.2a will be complemented by a detailed analysis per work package and deliverables in order to guide its implementation during the course of the project (CNRS-IPSL).

Milestones

M1.1 (Task 1, mo 1)	Kick-off meeting (CNRS-IPSL)
M1.2 (Task 3, mo 3)	First version of IS-ENES3 website (CNRS-IPSL)
M1.3 (Task 1, mo 16)	First General Assembly meeting (CNRS-IPSL)
M1.4 (Task 1, mo 34)	Second General Assembly meeting (CNRS-IPSL)
M1.5 (Task 1, mo 46)	Final General Assembly meeting (CNRS-IPSL)

WP2/NA1 Governance, Sustainability and Innovation

Work package number	WP2		**Lead beneficiary**			UREAD-NCAS	
			Co-Lead beneficiary			DKRZ	
Work package title	Governance, Sustainability, and Innovation						
Participant number	2	1	3	9	4	5	
Short name of participant	UREAD-NCAS	CNRS-IPSL	DKRZ	STFC	CERFACS	MetO	**Total**
Person months per participant	**42**	**5**	**18**	**8**	**6**	**1**	**80**
Start month	1		**End month**		48		

Objectives

WP2/NA1 addresses the objective for IS-ENES3 to purse integration of the community and prepare for sustainability through relationships with stakeholder partners and governance and leading the IS-ENES3 strategy on innovation.

More specifically, WP2/NA1 addresses these issues with four interlocking tasks:

Governance and Task Forces will ensure that the project has a route to obtaining independent advice and communications with both stakeholders and other major projects and infrastructures. It will involve replacing the existing ENES board with two new bodies: a Stakeholders Board representing both the infrastructure providers and the infrastructure users, and an independent Science Advisory Board. The existing task forces will continue to retain the responsibility for the two task forces which provide interfaces to key European organisations (such as PRACE and the EOSC) as well as to existing major international projects (such as ESGF) and which coordinate community actions (such as shared bids for resources).

Innovation is focused on the strategic aspects of widening the exploitation of the IS-ENES infrastructure, both in terms of innovative uses of the infrastructure, and innovation around the technology used (e.g. by working with cloud providers). It will involve developing strategic metrics of innovation, coordinating pull-through from individual innovation activities in NA2-NA4, and addressing the interfaces with major external organisations (such as Copernicus).

Sustainability addresses how the community can establish and maintain an infrastructure which can evolve in response to requirements without ad-hoc project funding such as that delivered via I3 investments from the commission. Some investigation on possible mechanisms was carried out in IS-ENES2, and the mid-term foresight update stressed the strategic importance of a sustainable approach to the European climate science community. This task will deliver a clearer understanding of what needs to be sustained, how it might be done, and initial steps towards the implementation of an ENES-Research Infrastructure (ENES-RI).

Strategy will revise the ten-year ENES Infrastructure Strategy for 2022-2032. During the course of IS-ENES3 we will see major changes in underlying technology (e.g. increased heterogeneity in computing, further uptake of cloud, new storage paradigms), new European facilities (e.g. the European Open Science Cloud) alongside the normal ongoing evolution of scientific aspirations – it will be time to revisit from first principles a European strategic approach to Earth System simulation infrastructure.

Together with the community engagement in WP3/NA2, the project leadership team, and the internal governance processes associated with the software components, this WP will provide the primary scientific integration of the shared European infrastructure. The "ENES Scientific Officer" will support all four tasks and help link between the governance, the tasks of the WP, and the wider project.

Links with other work packages

WP2/NA1 has strong links with the project leadership activities in WP1, with the community engagement in WP3/NA2, and with innovation tasks in WP3/NA2, WP4/NA3, and WP5/NA4.

Description of work:

Task 0: Coordination of WP2/NA1
UREAD-NCAS (WP leader, 2 PM), DKRZ (WP co-leader, 2 PM), Total 4 PM

Task 0 provides the effort required for effective work package coordination, including management of resources, quality, risks, provision of periodic reports for the WP and managing the delivery of milestones and deliverables. Task 0 will also ensure the interface between the WP and the rest of the project.

Task 1: Governance and Task Forces
UREAD-NCAS (Scientific Officer, SO, 18PM), CERFACS (4 PM), DKRZ (4 PM), Total 26 PM

The primary goal of the governance task (led by UREAD-NCAS) is to establish scientific oversight and coordination for the activities of the ENES community, by exploiting the newly formed Science Advisory Group and establishing a new Stakeholders Board, as well as the other tasks established here. The Stakeholders Board will be focused on providing advice to the project on the expected difficult issues of prioritisation around funding, expectations, and opportunities in the light of all the inputs received by the project. The Stakeholders Board will evolve from the existing ENES Board. With this new focus, new terms of reference and new membership will be necessary. With membership from partner stakeholders, key project representatives and community representation – including from the chairs of the two task forces - it will meet annually. The first meeting will be held within the first six months after the appointment of the scientific officer (who will provide the Board secretariat).

The HPC Task Force (led by CERFACS) will continue to be the primary point of engagement by the community with PRACE, establishing community requirements for HPC, and coordinating community-scale bids. It will convene workshops, both directly under the auspices of IS-ENES3, and in partnership with other projects – where possible – such as ESiWACE2 (if funded). Activities will include: using, and coordinating access to, European supercomputers; exchanging best practice and quantifying resources needed for modelling activities; maintaining coordinated relationships with vendors of hardware and software; maintaining working relationships with other European initiatives (other FET projects, PRACE, Commission activities etc.).

The Data Task Force (led by DKRZ) will promulgate common standards for European data sharing, and coordinate the computing and services necessary to exploit data and information produced by and/or acquired by the community. It will provide the coordination for the European components of the global Earth System Grid Federation – and representatives of the Data Task Force will provide the European contribution to global ESGF governance activities. Responsibilities include advising on, and where possible, organizing computing and network infrastructure, software tools, procedures, standards, related quality control and assurance, and data citation, as these apply to European collaboration and European participation in global activities. Most of the work within with IS-ENES3 will be spent in: Coordination of support for CMIP6 and CORDEX; Technical cooperation with ESGF; Coordination of the ENES contributions to ESGF ("EuroESGF"), and; the relationship between EuroESGF and other data infrastructure in Europe.

Task 2: Innovation
STFC (6PM), UREAD-NCAS (SO, 6 PM) Total 12 PM

Alongside the use and engagement of SMEs, the innovation opportunities in IS-ENES3 arise primarily from four opportunities: exploiting tools and techniques developed in IS-ENES3 outside the research community; developing and/or fostering new climate service opportunities; developing new tools and/services within IS-ENES3 to serve external communities; and working with the ICT companies. All these opportunities have both strategic and tactical aspects - the latter are identified in the other NA work packages, the focus here is on pulling this through into strategic engagement, with a specific emphasis on innovation via potential partner organisations identified by, or working through, the task forces, beginning with the Copernicus Programme and the exploitation of Cloud Computing and the European Open Science Cloud (EOSC) both of whom provide routes for exploitation and impact beyond IS-ENES3 itself. In addition, this task is responsible for measuring and reporting on the success of innovation across the project.

Task 3: Sustainability
DKRZ (12PM), UREAD-NCAS (SO, 12 PM), CERFACS (2PM), CNRS-IPSL (1 PM), METO (1PM), STFC 2PM) Total 20 PM

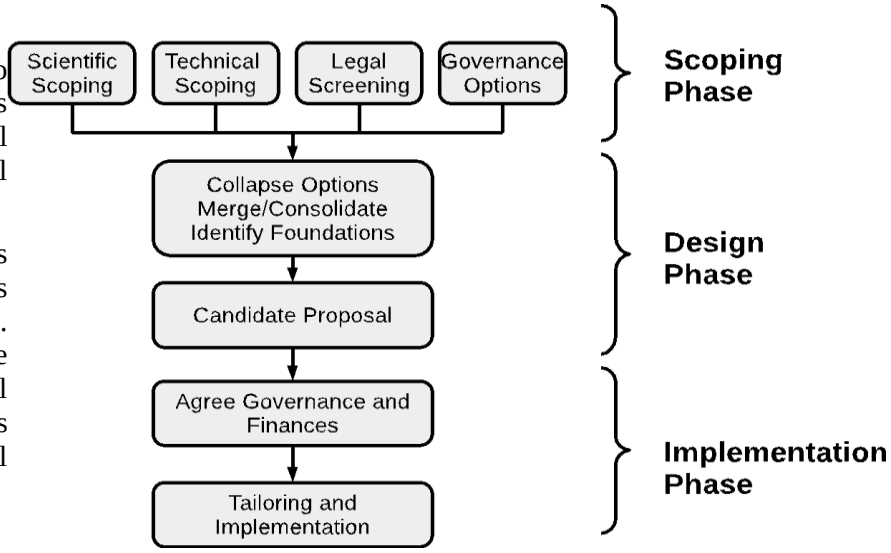
Establishing a sustainable research infrastructure (the ENES-RI) requires three phases: an initial scoping activity, a design phase, and an implementation phase.

The initial scoping phase requires a thorough, iterative analysis of scientific needs and corresponding technical requirements and solutions. At the same time the possible legal and organizational opportunities and solutions need to be evaluated alongside possible governance structures.

The design phase involves developing a range of options and iterating through them with the Advisory Board and the likely funders (host institutions, national agencies etc), and collapsing them into a feasible contour (scope), identifying who needs to be involved in delivering the foundational infrastructure, and merging and consolidating the evaluation and options onto a proposal.

Implementation will only be able to proceed once the foundation partners have agreed the governance model and any ongoing financial commitments.

There will be significant interactions between this and the other tasks as well as the other work packages. Consultation and discussion will be performed in bilateral and multilateral exchanges, workshops and discussions in project workshops and general assemblies.



Task 4: Strategy
UREAD-NCAS (4 PM and SO 6 PM), CNRS/ISPL (4 PM), Total 14 PM

The relationship between the scientific aspirations of the community, and the underlying infrastructure is always evolving. For example, within the last decade we have seen the increasing prominence of WCRP grand challenges, an enhanced emphasis on research to support climate services, and an ever-increasing scope for Earth climate system simulation" – now including more processes and communities and a closer relationship with numerical weather prediction. At the same time, the computational demands (for more compute, storage, bandwidth etc.) have grown even as the ability of most of the relevant systems to deliver growth has slowed – and new opportunities for service delivery are or will become available, from the EOSC to the proposed new European exascale computing initiatives. It has become necessary to revisit anew the community aspiration for shared infrastructure - and provide a vision that is representative of not only the IS-ENES partners, but the wider community and suitable for input to wider European infrastructure planning. This new shared vision will be established by inviting wide participation to two workshops: the first will be a scoping meeting, gathering input from both self-nominated and invited speakers – after which a draft strategy will be prepared. This will be used as input to another community workshop, whereupon recommendations can be agreed. A final text will be prepared, and a final phase of community input via an electronic forum will be used to preserve not only consolidated recommendations but also recommendations from those areas where there is not agreement on the best joint ways forward.

Deliverables:

D2.1 (Task 4, mo 36): Infrastructure Strategy for Earth System Modelling for 2022-2032
Following the second community workshop, a formal technical document will be published to the community outlining an infrastructure strategy for the next decade (UREAD-NCAS)

D2.2 (Task 3, mo 42): The "ENES-RI Sustainability Plan" will be published in the final year of the project, outlining the candidate proposal, the state of stakeholder agreement, and any progress on implementation (DKRZ)

D2.3 (Task 2, mo 42): The "Final Report on Innovation Activities" will outline what the project has achieved in terms of cross-disciplinary fertilisation and wider participation (STFC)

D2.4 (Task 1, mo 48): The "Final Report on Governance Activities" will summarise four years of advisory group input and the key outcomes of the task force activities over the duration of the project. It will identify on-going issues for community governance for infrastructure for input into both formal ongoing activities (such as those covered by the sustainability plan) and informal community-wide activities (such as future shared software and service development) (UREAD-NCAS)

Milestones:

M2.1 (Task 1, mo 12): New Advice Structures Active. Short report marking the completion of the first meeting of the new Stakeholders Board, and include the terms of reference, the method of establishing the membership, the initial members, and the minutes of the first meeting (UREAD-NCAS).

M2.2 (Task 2, mo12): **Innovation Plan.** Short report summarising the development of a shared project-wide approach to innovation and reporting on cross-disciplinary fertilisations and a wider sharing of information, knowledge and technologies across fields and between academia and industry (STFC).

M2.3 (Task 3, mo 24): **Sustainability Scoping Report**. Short report on results of a discussion workshop of the results of the ENES-RI scoping phase. Workshop audience is the IS-ENES3 project consortium and ENES-RI partner candidates (DKRZ).

M2.4 (Task 4, mo 24): **First Strategy Workshop.** Short report providing an outline of the key points which were brought up at the community-wide strategy workshop (which will subsequently be fleshed out into a complete draft strategy for discussion at the second community workshop (UREAD-NCAS).

WP3/NA2 Community engagement

Work package number	WP3	**Lead beneficiary**			CNRS-IPSL		
		Co-Lead beneficiary			KNMI		
Work package title	**Community engagement**						
Participant number	1	7	9	4	18	8	
Short name of participant	CNRS-IPSL	KNMI	STFC	CERFACS	WENR	CMCC	
Person months per participant	**16**	**13**	**4**	**6**	**6**	**1**	
Participant number	3	10	17	2	11	6	
Short name of participant	DKRZ	SMHI	NCSR-D	UREAD-NCAS	DLR	BSC	
Person months per participant	**6**	**5**	**3**	**6**	**5**	**1**	
Participant number	20	19	13				
Short name of participant	FPUB	CUNI	UC			Total	
Person months per participant	**6**	**6**	**2**			**86 PM**	
Start month	1			**End month**	48		

Objectives

WP3/NA2 aims at further engaging with the community of users of IS-ENES services. This will be done through widening the user base through training, engaging the community in co-constructing standards and expressing needs, and engaging the younger generation in interdisciplinary approaches. Target users will be the climate researchers and the vulnerability, impacts and adaptation (VIA) researchers. WP3/NA2 will also target societal innovation through the emerging climate service providers.

The first objective of this WP is to **widen the IS-ENES user community** especially toward new science, as well as towards industry and societal users, strengthening the innovation dimension of the IS-ENES3 project. A two-way dialogue is sought, aimed at enhancing the responsiveness of IS-ENES3 to communities and developing wider participation, particularly outside of academia. Prominent targets include VIA researchers, the Copernicus Programme and the fast developing climate services industry.

The second objective is **to nurture the existing ENES users/stakeholders community** creating deeper links and mutual understanding between users and developers via a number of co-construction actions such as workshops and training. One key goal will be to train the younger generation of scientists and climate service experts (keeping the gender balance in mind) via schools, furthering the successful cross-disciplinary network of expertise promoted by ENES for the last 15 years.

The third objective is to **expand community standards** which serve the ENES community. Standards in Earth system science are numerous and it is key to evaluate which can be used or adapted for IS-ENES use and which need to be developed. The existing standards used by ENES are not necessarily the same as the standards in user communities (e.g. impacts) and a venue for exchanging on these standards is needed to collect user requirement and provide training.

The final integrating goal is to collect user feedback and requirements both from actions in this WP and other WPs as well as dedicated actions to provide a synthesis of technical and services requirements to the project coordination.

Links with other work packages

By essence, this WP is cross-cutting throughout the project. WP3/NA2 will ensure exchange of user feedback and requirements with the other WP's (WP5/NA4, WP7/VA2, WP8/JRA1, WP9/JRA2, WP10/JRA3). WP3 will also exchange and work with other WPs (WP2/NA1, WP4/NA3, WP6/VA1, WP10/JRA3) on demonstration, training and guidance of infrastructure, tools and data to a broader community (younger generation and new users within climate and VIA research and Climate Services Industry).

Description of work

Task 0: Coordination of WP3/NA2
CNRS-IPSL (WP leader, 2 PM), KNMI (WP co-leader, 2 PM), Total 4 PM

Task 0 provides the effort required for effective work package coordination, including management of resources, quality, risks, provision of periodic reports for the WP and managing the delivery of milestones and deliverables. Task 0 will also ensure the interface between the WP and the rest of the project.

Task 1: Widening the user base for science and societal innovation
KNMI (4 PM), WENR (3 PM), SMHI (3 PM), CERFACS (2 PM), FPUB (6 PM), CUNI (3 PM), Total 21 PM

Several activities will be undertaken to reach a wider community, focussing on different user groups. These activities are clearly linked with the activities on user requirements, since it is important to know what makes the tools and climate information useful and usable to them.

Short events and webinars will be organised to reach new user groups especially within the VIA community, Climate Services, all over Europe, including 4 events in Eastern Europe. A total of 10 short trainings/introductions (0.5-2 days, 2/3/3/2 in years 1/2/3/4) and 5 webinars (1/1/2/1 in years 1/2/3/4) are planned. Short events, closer to the potential new users, will make it easier for them to attend. The climate4impact (C4I) portal will be used to demonstrate the possibilities on how to access climate model data and compute indices. The webinars are meant as a follow up to answer questions and discuss what is needed to use the tools (also through newsletters, and other social media, as organised by WP1). This task will actively seek to leverage from existing networks (Young Earth Science Scientists, ISIMIP community for VIA research, Climate-KIC for climate services industry, etc.). Organised by WENR, KNMI, CERFACS, SMHI, FPUB, CUNI.

A special workshop will be organized in Eastern Europe on Climate indices requirements (mo 24). Used by a broad user community for many applications outside the climate modelling community, these indices provide compact information on key physical parameters. A reference specification of the indices has been developed by joint CCl/CLIVAR/JCOMM Expert Team (ET) on Climate Change Detection and Indices (ETCCDI), and these have been implemented in the ICCLIM tool. A workshop will evaluate the existing indices and explore the need for new ones in these broader and new communities. Organized by: SMHI, CERFACS, FPUB.

Task 2: Training and resources: nurturing the community
WENR (3 PM), KNMI (2 PM), CERFACS (2 PM), CMCC (1 PM), DKRZ (5 PM), NCSR-D (3 PM) CUNI (3 PM), SMHI (2 PM) Total 21 PM

Schools will be organized in order to provide training for the younger generation scientists. These schools will be an opportunity to foster interdisciplinary approaches on data, focusing on gathering climate and impact modellers and climate scientists with computer and data scientists.

Schools on the interface between climate and impact models. Climate and impact modelling communities show little overlap, as typical intercomparison experiments concentrate on one of these realms. However, proper climate change impact analysis governed by projections require a good understanding of the propagation of uncertainty, predictability and information content through the chain between climate drivers, climate projections, downscaling activities and impact assessments. Two interdisciplinary schools (1 week each and about 30 persons per school, mo18 and mo30) concentrating on this chain of model assessments with the help of realistic case studies will contribute to building a network of experts that can oversee and connect this chain. After the first school the setup will be evaluated. Organised by WENR, KNMI, CERFACS, CUNI.

School on Climate Data Science. The aim of this school (2 weeks, M34) is to increase expertise and skills on theoretical and practical concepts of Data Science, building upon and mainly targeting how to accelerate scientific discovery from data. Young scientists will learn how to analyse, visualize and report on massive datasets, in the scientific domain as well as how to apply data-intensive and data-oriented paradigms and solutions to address scientific discovery in climate science. Driven by the theoretical background provided by domain, data and computer science experts, the school will adopt a hands-on approach for maximizing results focusing on the usage of datasets linked to the IS-ENES data services. The school will strengthen the individual

expertise of the participating climate and computer scientists, as well as, leverage and emphasize the need of collaboration between them, helping early career scientists with different backgrounds to meet and network. Organised by NCSR-D, CMCC, DKRZ

ENES portal. Update the existing ENES portal with information on workshops, trainings, documentation and dissemination of training material, background information on e.g. standards, model evaluation, options for stakeholders to provide feedback/user requirements from all tasks in this WP and other WPs (DKRZ, KNMI).

Task 3: Community standards
STFC (2 PM), KNMI (3 PM), CNRS-IPSL (6 PM), DLR (4 PM), DKRZ (1 PM), UREAD-NCAS (2 PM), UC (2PM), CERFACS (1 PM), Total 21 PM

Task 3.1: Advancing existing community standards via workshops

Vocabularies and standards for CMIP [mo 9] (WCRP Coupled Model Inter-comparison Project). Building on the CMIP6 data request combined requirements (technical and community engagement from 22 international consortia), the workshop will review the challenges and achievements of CMIP6 and provide recommendations for CMIP7 (STFC, DKRZ).

Data Standards for Climate Indices [mo 15]: Bring together technical experts on the specific metadata standards and on climate indices defined by ETCCDI and ET-SCI to review the achievements made in IS-ENES2 and CLIP-C, to solve key issues and to make recommendations for additions and extensions to existing community standards, e.g. the Climate and Forecasting Conventions, ES-DOC. The outcome of this workshop will inform the development of the tools and software building blocks of the C4I portal in WP10/JRA3, thus enabling production and dissemination of climate indices to be integrated into the IS-ENES infrastructure (SMHI, CERFACS, KNMI).

Climate and Forecast Convention (CF) [mo 19]: this standard underpins interoperability of climate model data by providing a rich framework for detailed, machine-operable, technical information about the data products. The CF Convention is maintained by a community network to support the international climate research community. The workshop will review the status and outlook of CF and formulate recommendations for next steps (UC, UREAD-NCAS).

Task 3.2: New standard on scientific provenance of model evaluation

Documenting and providing information on the origin and post-processing stages of model evaluation is key to build trust, allow for a consistent scrutiny and comparison of evaluation products and increase use of a model evaluation software (data provenance) for users. It also provides a framework for climate expert groups to provide and govern the complete definition of metrics and diagnostics (computation, observations used, documentation, etc.), which can then be used "as is" by a variety of model evaluation tools. A framework will be defined for the propagation of documentation and provenance information, in order to ensure that the evaluation process is traceable and fully reproducible. This task will seek to utilize and extend existing approaches where possible, such as ES-DOC, S-PROV from CLIP-C, METACLIP from C3S,...). This task will work in collaboration with other international efforts and the WGCM/WGNE climate diagnostics and metrics panel (CNRS-IPSL, KNMI, DLR)

Task 4: User feedback and requirements
KNMI (2 PM), CNRS-IPSL (8 PM), BSC (1 PM), STFC (2 PM) CERFACS (1 PM), UREAD-NCAS (4 PM), DLR (1 PM), Total 19 PM with subcontracting

Task 4.1: Project wide user requirements (data, models, tools)

During tasks 1, 2, 3 and other interactions with users in other WPs (e.g. access activities) feedback will be collected and a synthesis of related technical and services requirements will be provided to the rest of the project (e.g. working with the C4I portal in tasks 1 and 2 will provide indirect information about requirements, challenges and questions for various user groups). This will be supplemented with desk research on information from other projects or from institutional sources (e.g. IS-ENES2, CLIPC, ERA4CS, WCRP/CMIP, Copernicus climate Change Service,...). Where needed, targeted interviews will help refine the technical and services requirements (KNMI, CNRS-IPSL, CERFACS).

Task 4.2: Specific user requirements

Model evaluation is a major new development for IS-ENES3. We will conduct a community survey to review the needs and expectations of a variety of end users both existing and future (climate model developers, VIA researchers, climate service providers). This survey will cover the science needs, the related services and the different user workflows (CNRS-IPSL, UREAD-NCAS, DLR, BSC and subcontracting).

CMIP documentation for climate modelling (models, simulations, ensembles conformance…): After CMIP5 a revised version was established under ES-DOC supported by IS-ENES2 for CMIP6 (https://es-doc.org). Here we will organise a community review of the science contents of this documentation using both targeted interviews of climate modellers and users of the documentation and feedback from IS-ENES3 schools and workshops in which the documentation will be presented. Future ES-DOC services and extension of documentation scope will also be assessed (UREAD-NCAS, STFC, CNRS-IPSL).

A synthesis of the resulting science and technical requirements for the IS-ENES infrastructure from this WP will be provided to the project coordination (WP1) before each general assembly, providing information to service and research activities, and to the sustainability action (NA1) (CNRS-IPSL, KNMI).

Deliverables

D3.1 (Tasks 3.2, 4.2, mo 18): Initial requirements on model evaluation.
Report on science requirements on model evaluation and related architectural requirements for IS-ENES3 developments (CNRS-IPSL)

D3.2 (Task 2, mo 36): **Synthesis on climate and impact and climate data schools**.
Will contain the material used during the schools, the case study results, feedback and requirements of participants and recommendations for follow up (WENR)

D3.3 (Tasks 3.1, 3.2, mo 36): Standards synthesis.
Synthesis of the workshops on standards including recommendations. It will also include final report on scientific provenance for model evaluation (task 3.2) (STFC)

D3.4 (Task 4.2, mo 36): CMIP documentation requirements.
Report on CMIP documentation user requirements for existing and future ES-DOC services and scope (UREAD-NCAS)

D3.5 (Task 1, mo 46): Synthesis on activities to broaden community.
Description of which user groups were reached and recommendations for future actions (KNMI)

D3.6 (Task 4.1, mo 46): Overview of user requirements, how these requirements were taken into account and recommendations for beyond the project (KNMI)

Milestones
M3.1 (Task 4, mo 18): Report on user requirements.
Synthesis of the project wide science and technical requirements will be made, providing information to the other WPs (KNMI)
M3.2 (Task 2, mo 20): First school on climate and impacts.
Report on first school will contain the material used during the schools, the case study results, feedback and requirements of participants and recommendations for the second school (WENR)
M3.3 (Task 1, mo 24): Synthesis of first 5 short events to broaden community.
The report will contain a description of the events, feedback and requirements of participants and recommendations to increase their effectiveness (KNMI)
M3.4 (Task 3, mo 24): Summary of workshops on standards.
Synthesis of the workshops on standards including recommendations (STFC)
M3.5 (Task 1, mo 26): Workshop on climate indices.
A report will describe the evaluation of existing indices, requirements for new ones from the various user groups and related technical requirements for the IS-ENES infrastructure (FPUB).

WP4/NA3 Networking on Models, Tools and efficient use of HPC

Work package number	4	**Lead beneficiary**			MetO	
		Co-Lead beneficiary			BSC	
Work package title	Networking on Models, Tools and efficient use of HPC					
Participant number	6	4	1	8	15	5
Short name of participant	BSC	CERFACS	CNRS-IPSL	CMCC	MF-CNRM	MetO
Person months per participant	**13**	**11**	**20**	**17**	**6**	**13**
Participant number	16	2	17	9		
Short name of participant	UNIMAN	UREAD-NCAS	NCSR-D	STFC		**Total**
Person months per participant	**7**	**6**	**3**	**1**		**97**
Start month	1			**End month**	48	

Objectives

For the climate research community in Europe, models and tools make up the main research infrastructure for pushing forward the boundaries of climate science. This networking work-package is required to ensure that the partners develop those models and tools in a sustainable way for the benefit of as wide a community as possible based on user requirements. This IS-ENES3 Networking Activity differs compared with the objectives of IS-ENES2 both through a new work-package structure and through a greater emphasis on Networking Activities supporting the Joint Research Activities.

WP4/NA3 will look to find **new ways to exploit available hardware and software technologies**, not only for HPC applications, but also in new areas such as machine learning and artificial intelligence (AI). Another new opportunity is to provide networking support to **develop a new community infrastructure for modelling sea ice** that will be adopted by the members of the NEMO consortium. For the NEMO ocean model, the consortium will be strengthened through investment in an improved testing infrastructure to encourage wider adoption.

The challenges of achieving good computational performance in complex coupled Earth Systems Models (ESMs) are stretching the community and the work-package will coordinate approaches and knowledge across this community. Workshops are another important opportunity for community building around our significant technical challenges. We will continue with the highly successful international workshops on coupling technologies and HPC as well as new workshops.

A specific task around innovation is included to ensure that we are bringing climate science knowledge and information to the attention of industry. The requirements from users and developers of the HPC applications used by our community will be collected through this task, creating a common understanding about future needs from HPC vendors. Moreover, interacting with industry on AI and machine learning could provide new services based on available data. Lastly, solution providers in the HPC market, such as Altair, will be encouraged to exploit opportunities around complex workflow management by interaction with our Cylc activities in WP8/JRA1.

Links with other work packages

Task 1 on QA in NEMO will support the quality aspects of the developments in WP8/JRA1 Task 1 on NEMO performance improvement. Task 2 on community building for the new sea-ice model will underpin WP8/JRA1 Task 2. Task 3 on coupled performance metrics will be supported by work in WP8/JRA1 Task 3 on OASIS and inform WP8/JRA1 Task 1 and Task 3. Tasks 3, 4 and 5, together with WP8/JRA1 Task 5 (Cylc) will feed into the Innovation activity in this work-package (Task 6).

Description of work:

Task 0: Coordination of WP4/NA3
MetO (WP leader 2 PM), BSC (WP co-leader 2 PM), Total 4 PM

Task 0 provides the effort required for effective work package coordination, including management of resources, quality, risks, provision of periodic reports for the WP and managing the delivery of milestones and deliverables. Task 0 will also ensure the interface between the WP and the rest of the project.

Task 1: Development of a new Quality assurance approach for the NEMO consortium
CNRS-IPSL (12 PM), Total 12 PM

The continuous integration within the NEMO European ocean platform of software development originating from several European institutes requires a rigorous and extensive quality control for both technical and scientific activities. This task will contribute to improve unit and regression test frameworks (Trusting tools) and promote their uptake and effectiveness in the community through improved modularity, documentation and installation procedures. Working with the community and understanding their needs across varied computing platforms, WP4/NA3 will make continuous quality control available to the full development community leaving a legacy of sustainable, community-driven development. The scientific quality control of NEMO outputs is based on idealised test cases. Within this task, new test cases will be used to validate and demonstrate the benefit of existing and new features. For example, idealised tests will be performed on NEMO advection schemes through a systematic illustration of their behaviour and comparisons with other ocean models. The approach will also be applied to the new compensated time-space schemes, before final implementation. Community defined approaches (Python notebook, validation criteria, etc…) will be used to ensure buy-in by the developers.

Task 2: Building a new community around a European Platform for Sea Ice modelling in NEMO
MetO (8 PM), CNRS-IPSL (7 PM), CMCC (6 PM), MF-CNRM (6 PM), UREAD-NCAS (6 PM), Total 33 PM

The NEMO consortium has recently agreed to expand the community approach to include sea ice through the collaborative development of a unified NEMO sea ice (NEMSI) model. This will include functionality from the existing models currently used with NEMO (CICE, GELATO, and LIM). This activity, coordinated by the NEMO Sea Ice Working Group (SIWG), will support development of this NEMO sea ice model by building the required developer and user community, and the creation of a sustainable development strategy for NEMO sea ice. Regular networking activities will be required to build the community, and provide interaction with other international sea ice model development groups and external experts outside the NEMO community. In particular, the task will network to: (i) create a new integrated sea ice model development community from the individual sea ice specialists and development groups within the NEMO community; (ii) proactively ensure the exchange of knowledge; (iii) negotiate community code design principles and quality standards; (iv) negotiate common goals and scientific priorities.

The task will maximise effective adoption by: (i) development of new working practices for a unified ice model (CNRS-IPSL & MetO); (ii) development of a suite of test configurations and protocols (All); (iii) creation and delivery of developer training materials at multiple sites (CNRS-IPSL, MetO) (iv) support of developer teams to adapt their development systems and processes to the new standard (CMCC, UREAD-NCAS, MF-CNRM); (v) building developer expertise through mentoring and consultancy (CMCC, UREAD-NCAS, MF-CNRM); and (vi) creation of a technical development strategy (MetO & CNRS-IPSL).

Task 3: Complex Coupled Systems HPC performance evaluation
BSC (8 PM), CERFACS (8 PM), CMCC (8 PM), Total 24 PM

Earth System Models (ESMs) represent a variety of coupled components running independently on HPC systems at the same time as Multiple Data, Multiple Program applications. WP4/NA3 will perform for the first time a complete computational and energy performance analysis of CMIP6 models using the CPMIP (Computational Performance Model Intercomparison Project) computational metrics developed within IS-ENES2. Such analyses are required to reduce the cost of each component independently and as a whole. Advise on applying profiling

tools and interpreting the results will be provided.

The task will move beyond traditional metrics and expand the database with a systematic collection of performance results from IS-ENES3 partners. This will be facilitated by the use of the LUCIA (Load-balancing Utility and Coupling Implementation Appraisal) performance tool integrated and improved (attending new requirements) in the OASIS3-MCT coupler in task 4 of WP8/JRA1 for wider adoption. We will use existing BSC tools in OASIS3-MCT to provide per-component results and new metrics for energy consumption will be evaluated using low-level utilities.

Load-balancing of coupled models is one of the greatest computational performance challenges for the ESM community. A load balancing and affinity/binding distribution study will be done in order to provide recommendations to minimize the idle-time in a range of OASIS-based coupled components covering irregular time steps, varied and wide range of component speeds and sequencing constraints. The results will differentiate load-balancing, component-interaction and single component issues.

Task 4: Machine Learning and Technology Tracking
UNIMAN (4 PM), CMCC (3 PM), NCSR-D (3 PM), MetO (2 PM), Total 12 PM

Vendors are developing hardware and software technologies that are likely to prove useful to the climate community. Machine learning, artificial intelligence and Big data together represent one such area with a wealth of specialist hardware platforms available (Deep Neural Networks, Tensor Processing Units, GPUs and other low power technologies). These are supported by software frameworks (TensorFlow, Caffe2, MXNet, Kera, Pytorch etc). Solutions such as IBM's Infosphere Streams, Cray's Urika, Apache Hadoop and Spark will be compared. This task will build on expertise on big data, analytics, e-infrastructure platforms and past and present scientific piloting actions (e.g. H2020 BDE and DARE projects)

These technologies may be exploitable in the following areas: (i) improving code efficiency by developing emulation models for physics routines (interest at MetO, ECMWF, CMCC, BSC, U. Oxford & Meteo Swiss); (ii) analysis of large climate datasets to inform model development (interest at: DLR, UREAD-NCAS, BSC, CMCC, DKRZ, CNRS-IPSL, CERFACS).

Task 5: Community Workshops
CERFACS (2 PM), BSC (2 PM), Total 4 PM

Cerfacs will organize a 5th in a series of successful International Workshop on Coupling Technologies for Earth System Models, gathering researchers and engineers from Europe, North America and Asia. Topics will include sharing example use and interfaces in ESMs, performance aspect, science of coupling, and coupling strategies. By sharing experience and knowledge, the workshop will promote increased convergence of solutions in the community, in particular between OASIS and XIOS (raising community interest, see WP8/JRA1).

BSC will organise the 7th ENES HPC workshop which aims to continue to be influential in the development of the ENES strategy on HPC and to strengthen our links with HPC vendors, PRACE and the relevant projects and Centres of Excellence available in Europe. The workshop will seek invited speakers from our internationally collaborators both to demonstrate the strength in Europe around HPC in climate science but also to learn from initiatives elsewhere. The workshop will be informed by and supported by the ENES HPC taskforce.

Task 6: Innovating with software and HPC industry
UNIMAN (3 PM), MetO (1 PM), BSC (1 PM), CERFACS (1 PM), CNRS-IPSL (1 PM), STFC (1 PM), Total 8 PM

This is a cross-cutting task to promote opportunities for innovation across WP4/NA3 and WP8/JRA1 on models, tools and HPC.

We will interact with HPC and related software vendors around results from Task 3 and all WP8/JRA1. The work planned in these tasks is representative of a wide range of HPC applications used by the climate community, creating a comprehensive database of computational efficiency on different HPC platforms. This information can be exploited by the HPC industry so that the market can produce better performance tools for the

applications developed and used by our community and others with similar challenges.

New technologies will be also explored, companies involved in Machine Learning and AI (Task 4) will be exposed to opportunities for exploiting climate data to reach a wider market and to encourage co-design in the new area of machine learning and AI for climate science. Further, appropriate industry experts will be engaged and also invited to attend the community workshops to encourage exploration community expertise on coupling (Task 5 and JRA1 Task 3), I/O (Task 5 and JRA1 Task 4) and complex workflow management (JRA1 task 5) leading to products that would benefit a wider community.

Deliverables

D4.1 (Task 5, mo 17): Coupling workshop report
A report from the coupling workshop with recommendations that will influence the OASIS governance activities for improved sustainability and convergence particularly with XIOS (CERFACS).

D4.2 (Task 2, mo 26): Development Strategy for Sea Ice modelling toolset
A development strategy for sea ice in NEMO: including updating Chap 8 of the NEMO development strategy document (2020) (MetO).

D4.3 (Task 3, mo 35): CPMIP performance metrics and community advice.
A summary of the CPMIP metrics and a database results from all the models and benchmarks tested, providing a guide with main results and conclusions. Additionally, a community best practice guide providing practical advice of optimising performance for complex coupled climate models based on CPMIP metrics (BSC).

D4.4 (Task 1, mo 40): NEMO QA update
Update of the trusting tool package, now distributed with NEMO source code, to enable better portability and supported by web pages and test cases (CNRS-IPSL).

D4.5 (Task 3, 4 and 6, mo 44): White paper on innovation on tools, platforms and techniques.
A white paper consolidating the finding within the Innovation task highlighting the opportunities within the Market to exploit climate science (Task 6) and the opportunities for climate science to exploit new technologies focusing on software and HPC (Task 4 & Task 3) (UNIMAN).

Milestones

M4.1 (Task 2, mo 12): Development strategy workshop for European Platform for Sea Ice modelling
A community workshop (2019) focused on the NEMSI long-term development strategy, involving the SIWG members, plus a series of NEMO and external experts (30 participants) (MetO).

M4.2 (Task 4, mo 24): New technical opportunities workshop in ML and AI.
A workshop bringing climate scientists and industry together to share knowledge and experience and to identify new opportunities in the area of machine learning, artificial intelligence and big data techniques (UNIMAN).

M4.3 (Task 5, mo 45): HPC workshop report
A report from the HPC workshop with a focus on the needs to the HPC task-force, updates to the ENES strategy and links to the innovation task within this work-package (BSC).

WP5/NA4 Networking on data and model evaluation

Work package number	5		**Lead beneficiary**			CNRS-IPSL	
			Co-lead beneficiary			SMHI	
Work package title	Networking on data and model evaluation						
Participant number	3	1	9	2	8	7	4
Short name of participant	DKRZ	CNRS-IPSL	STFC	UREAD-NCAS	CMCC	KNMI	CERFACS
Person months per participant	**5**	**17**	**4**	**4**	**5**	**7**	**7**
Participant number	6	22	12	10	11		
Short name of participant	BSC	LiU	NleSC	SMHI	DLR		**Total**
Person months per participant	**9**	**2**	**3**	**3**	**1**		**67**
Start month	1			**End month**	48		

Objectives

IS-ENES3 third objective requires the dissemination of, and timely access to, data and information of all kinds relevant for the climate research community and a broad portion of the impact community. To that end, WP5/NA4 aims at identifying and when possible defining connections around the data, metadata and "data centric compute" activities in Europe and worldwide.

Task 1 will organise the governance and the networking of ES-DOC. ES-DOC is our documentation engine for climate models and climate simulations.

Because we need scalable, resilient, easy to operate and cost effective infrastructure to support the climate modelling endeavour in Europe, task 2 will build upon existing activities and requirements to inform strategic decision in WP2/NA1. Our data lake is findable, accessible, interoperable and reusable thanks to ESGF and the associated activities ESGF has been built upon.

Task 3 will make sure the European agenda is taken into account in the ESGF roadmap. Defining requirements and establishing the roadmap for the IS-ENES compute service is a difficult question which Task 4 will address.

Rapid and seamless model evaluations are key for many use cases. To support this we need Technical Standards and architecture for plugin diagnostic tools that are being developed intensively within Europe and Internationally. Task 5 will address this question.

The combination of Tasks 2, 3, 4 and 5 will provide us with an updated architectural design for the IS-ENES RI, with different scenarios on how the architectural design can be built in support or on top of existing infrastructures in Europe and abroad.

Links with other work packages

WP5/NA4 will benefit from user requirements obtained in WP3/NA2. WP5/N4 will provide input to guide developments in WP10/JRA3. Architecture design plans and strategies with regards to involvement in ESGF and ES-DOC and on compute services will all inform WP2/NA1 to develop the long-term research infrastructure.

Description of work:

Task 0: Coordination of WP5/NA4
CNRS-IPSL (WP leader, 2 PM), SMHI (WP co-leader, 2 PM), Total 4 PM

Task 0 provides the effort required for effective work package coordination, including management of resources, quality, risks, provision of periodic reports for the WP and managing the delivery of milestones and deliverables. Task 0 will also ensure the interface between the WP and the rest of the project.

Task 1: Project management of ES-DOC
CNRS-IPSL (8 PM), UREAD-NCAS (4 PM), Total 12 PM

This task will organise the coordination of ES-DOC, including project management and the governance with the

WGCM/WIP panel and other community stakeholders. It will also ensure proper resources are pulled together, beyond IS-ENES3 (see tasks in WP3/NA2 and WP10/JRA3), to sustain the ES-DOC standards, tools and services (see WP2/NA1). The outreach and user documentation of services will also be organised.

Task 2: Defining an Architecture for Future of Data Services
CNRS-IPSL (2 PM), DKRZ (2 PM), STFC (1 PM), CMCC (1 PM), KNMI (2 PM), CERFACS (2 PM), BSC (1 PM), SMHI (1 PM), Total 12 PM

Networking with related communities as well as organizational bodies is necessary also from the architectural requirements point of view. There are many ways to architect an infrastructure and we need to understand the depth and breadth of all the necessary knowledge required to provide insight in designing and enhancing our infrastructure. The following five categories encompass the very core of our audience and we can't take any design decisions affecting our infrastructure without explaining the technical impact for this audience.

- Ongoing support for WCRP/WGCM/CMIP through the WIP (DKRZ, STFC, CNRS-IPSL)
- Ongoing support for CORDEX (SMHI)
- IPCC WGs and DDC Support (STFC, DKRZ)
- Wider impact community (KNMI, CERFACS, SMHI)
- Copernicus Climate Change Service (STFC, CNRS-IPSL, KNMI)

Also important when evolving an European e-infrastructure is the capacity to synergistically take advantage of existing services. Several high impacts e-infrastructure are operating in Europe that we need to articulate with. IS-ENES partners are already involved in EOSC related projects (EOSC-hub, ENVRI+, ECAS pilot). Additionally specific IS-ENES data service infrastructure components are developed in close collaboration with international initiatives and bodies (WDS, DataCite, RDA…). Networking activities with respect to EOSC as well as these parties will ensure the definition of a roadmap for the evolution of sustainable data services that will feed the sustainability work package.

- Networking with respect to EOSC partner institutes will be taken care of by DKRZ and CNRS-IPSL.
- Networking with respect to WDS, Scholix partners esp. DataCite, RDA, persistent identifiers (ePic) will be taken care of by DKRZ.
- Networking with respect to EGI and EUDAT CDI will be taken care of by CERFACS and CMCC.
- IS-ENES3 Data services integration in EOSC-hub (service repo) will be taken care of by DKRZ, CMCC and CNRS-IPSL.
- Coordinate with other RIs based on ENVRI+ experiences will be taken care of by DKRZ and CNRS-IPSL.
- Evaluation of data management against EU Guidelines on FAIR Data Management in H2020, will be overseen by DKRZ, STFC and CNRS-IPSL.

Task 3: Defining and communicating European priorities for ESGF
DKRZ (1 PM), CNRS-IPSL (1 PM), STFC (1 PM), CMCC (2 PM), KNMI (1 PM), CERFACS (1 PM), LiU (2 PM), Total 9 PM

The IS-ENES partners have an essential influence on the development and evolution of the international ESGF data infrastructure. WP5/NA4 will define the European priorities to be brought into the ESGF working groups as well as committees.

- Coordinate all IS-ENES/ESGF contributions, involvement
- ENES/ESGF project management (CNRS-IPSL, DKRZ, STFC)
- Replication strategy (CNRS-IPSL, DKRZ, STFC)
- User support organization (1st, second Level etc.), coordinate European contribution to overall ESGF support (DKRZ, KNMI, LiU, CERFACS)
- Metrics collection consolidation (CMCC).

Task 4: Defining requirements and establishing the roadmap of an innovative IS-ENES compute service
CMCC (2 PM), DKRZ (2 PM), CNRS-IPSL (2 PM), STFC (2 PM), KNMI (4 PM), CERFACS (4 PM), BSC (2 PM), Total 18 PM

This task will focus on:

(i) The strategic roadmap of the new IS-ENES compute service, taking into account on-going efforts both in the community and in other research infrastructures, as well as the European vision & landscape, (KNMI, DKRZ, CMCC, CNRS-IPSL)

(ii) Training, dissemination, and outreach activities targeting scientific end users, (BSC, CMCC, CERFACS, KNMI)

(iii) Coding sprint events for development groups working on downstream services and compute-based applications. (CERFACS, BSC, STFC)

This task will take into account the current complementary approaches taken by IS-ENES partners in different contexts (e.g. ESGF, Copernicus, EOSC) as well as the ones provided in the context of other European Research Infrastructures (e.g. EGI, EUDAT).

This activity will foresee the organization of a workshop to discuss user requirements, gaps, and challenges for the IS-ENES compute service, as well as the definition of its long-term strategic roadmap. CMCC and CERFACS will both co-organize the workshop on compute service and will co-lead the preparation of the main outcome of the workshop (D5.1), with contributions from the workshop participants.

Task 5: Technical standards and an architecture for plugin diagnostic tools
BSC (6 PM), CNRS-IPSL (2 PM), DLR (1 PM), NleSC (3 PM), Total 12 PM

In this task, we will define the requirements for a fast and scalable evaluation workflow that meets the requirements of ESM developments over the next decade (by means of a workshop with community members). In this network activity, current and future requirements (like time and spatial chunking, memory footprint, I/O management and aware parallel programming strategy, among others) from all the partners involved will be gathered, producing a complete set of specifications. This will include feedback from the users from WP3/NA2 to provide requirements on the existing packages, usability and needs. Standardized model evaluation is expected to play an increasingly important role in the model development process, as evidenced by the considerable interest in WP9/JRA2. For this reason, the special requirements for model development oriented diagnostics and metrics will be assessed and inform the development of WP9/JRA2.

We will also define the technical architecture required to plug other diagnostic packages to existing evaluation software frameworks (such as ESMValTool), in order to foster contribution and acceptance of new diagnostics developed by the community. These requirements will be selected to allow a wide range of diagnostics to interact with the tools in a modular and structured implementation. To facilitate coupling to the tools, a common set of protocols will be used, delivered and documented [D5.2], fostering the uptake of new diagnostics.

Special attention will be kept in coupling different technologies providing efficient interfaces between different languages (i.e. R2Python, F2Py…). Clear documentation of the procedures (in agreement with provenance standards defined in Task 2) and codes will be required, as are standards for all key interfaces, with a special focus on input and output data structures.

We will also develop a framework for coding standards, which will be defined to improve code integration, code distribution between developers, reusability, maintenance and readability. Standards will be distributed to the community through dissemination activities and support material like a style guide [D5.5]. These new standards will be implemented in the ESMValTool in WP9/JRA2.

Deliverables:

D5.1 (Task 4, mo 12): Compute service requirements and state of the art approaches
This report provides a collection of user requirements, gaps, and challenges on computing aspects for analysis and processing, as well as a collection of state of art approaches on compute service from the workshop organized in Task 4 (CERFACS).

D5.2 (Task 5, mo 24): Technical standards for diagnostic tools
Report on the technical standards defined after gathering all the requirements. The document will emphasize on technical solutions chosen to improve the compatibility between tools (BSC).

D5.3 (Task 2, mo 36): Architecture design plans
Produce high level architectural plan design diagrams enabling *scalable, resilient, easy to operate and cost effective infrastructure highlighting IS-ENES connexion with European e-infrastructure* (CNRS-IPSL).

D5.4 (Task 3, mo 36): IS-ENES3 involvement in ESGF
This document will summarize the contributions from IS-ENES 3 partners in the international ESGF effort. Additionally priorities of involvement agreed on in the ENES data task force are defined. Finally a roadmap for the last year of IS-ENES 3 and future ESGF roadmap is set up (DKRZ).

D5.5 (Task 5, mo 36): Style guide on coding standards
This document will gather and present technical details on how to plug other diagnostic packages to existing evaluation tools. It will help users to adapt their new diagnostics to be used by the community (NleSC).

D5.6 (Task 1, mo 46): ES-DOC governance
Report on ES-DOC governance, including project management, funding, outreach and plans for sustainability beyond IS-ENES3 (CNRS-IPSL).

Milestones:

M5.1 (Task 2, mo 18): Draft architecture design
Produce and communicate a draft architectural plan design diagrams enabling scalable, resilient, easy to operate and cost effective infrastructure highlighting IS-ENES connexion with European e-infrastructure. (CNRS-IPSL).

M5.2 (Task 3, mo 18): ESGF CMIP6 summary
A summary of the status of ESGF involvement from ENES partners to establish the operational CMIP6 ESGF infrastructure is provided. A priority list of involvement areas is summarized, which are seen critical with respect to future sustainability of the ESGF effort and European ESGF infrastructure (DKRZ).

M5.3 (Task 5, mo 20): Requirements for technical standards for diagnostic tools
Gather all the requirements from the community and produce a list. This list will be the basis to build the technical architecture for the diagnostics plugin (BSC).

M5.4 (Task 4, mo 36): Compute service roadmap
M5.4 will report on the IS-ENES3 compute service roadmap describing the long-term strategic view about this architectural component (CMCC).

WP6/VA1 Services on European ESMs and Software Tools

Work package number	6			**Lead beneficiary**		SMHI	
				Co-lead beneficiary		CERFACS	
Work package title	Services for European ESMs and Infrastructure Software Tools						
Participant number	4	10	5	1	21	14	11
Short name of participant	CERFACS	SMHI	MetO	CNRS-IPSL	UniRes	met.no	DLR
Person months per participant	**17**	**12**	**17**	**8**	**3**	**3**	**3**
Participant number	6	12					
Short name of participant	BSC	NleSC				**Total**	
Person months per participant	**2**	**2**				**67**	
Start month	1			**End month**	48		

Objectives

Building on previous work and structures established in the past two phase of IS-ENES, this activity will further maintain, extend, and improve services around the main European ESMs, and the NEMO ocean model, and their respective development and user communities. The overarching objectives for all services are to give easy access to information, to provide interfaces between ESM developers and users, and to define processes (such as for feedback) for model development and usage.

Beside the climate models, a number of critical infrastructure software tools have been identified in previous IS-ENES projects and by the community at large. This work package will provide access to, and services around, those components, because they are crucial for the development and efficient use of climate models, as well as for the exploitation of climate model data. Services around the OASIS coupler and the CDO data post-processing tool were already offered in IS-ENES 2, while new services on the Cylc meta-scheduler and the XIOS I/O server are added in this project. The user's need to extend services to new tools proves that the networking efforts devoted to increasingly sharing tools and leveraging other group's developments across the ENES community are slowly, but surely, succeeding.

Provision of access to the following infrastructure(s):

Description of the infrastructure

Name of the infrastructure: **ENES Earth System Model Resources ("ENES ESM" in tables)**

Location (town, country) of the infrastructure:

The ENES ESM Resources is a distributed infrastructure with a centralised entry point at the ENES Portal. The ENES Portal gathers access to expert services provided by European research institutes and is operated by DKRZ (Hamburg, Germany).

The individual groups providing the services are located at: Toulouse, France (CERFACS); Paris, France (CNRS-IPSL); Norrköping, Sweden (SMHI); Exeter, UK (MetO); Bergen, Norway (met.no); Bergen, Norway (UniRes); Barcelona, Spain (BSC); Amsterdam, The Netherlands (NleSC), Munich, Germany (DLR).

Web site address: **ENES Portal** https://portal.enes.org

Annual operating costs (excl. investment costs) of the infrastructure, for the services requesting access costs (€):

- Installation 1: HadGEM and UK-ESM level2 access by MetO: **554 400 €/year**
- Installation 2: EC-Earth level 2 access by the EC-Earth Consortium: **408 000 €/year**
- Installation 3: NorESM level 2 access by met.no and UniRes: **216 000 €/year**
- Installations 4 & 5: OASIS support by CERFACS: **79 000 €/year**; mainly through the VA installation (4) and more limited on the TNA installation (5)
- Installation 6: XIOS access service by CNRS-IPSL and CERFACS: **94 160 €/year** (CNRS-IPSL & CERFACS 72 960 and 21 200 resp.)
- Installation 7: Cylc/Rose access service by MetO: **113 202 €/year**
- Installation 8: ESMValTool access service by DLR, BSC and NleSC: **305 000 €/year** (DLR & BSC, 210 000 and 95 000 resp.)

Two other access services, also accessed through the ENES Portal, will be given without requesting access costs:

- NEMO Ocean code, since it is a sustained service taken in charge by the NEMO Consortium, represented here by CNRS-IPSL who coordinates the NEMO System Team. Only 1 PM will be requested to provide statistics.
- CDO post-processing tool, since it is a sustained service offered free of cost by the Max Planck Institute for Meteorology (no cost requested- collaboration with MPI-M) (*See Letter of Support, Section 4 appendix*).

The total annual operating cost of the infrastructure is estimated at **1 769 762 €/year**. The total access cost requested amounts to **483 031 € for 4 years** (120 k€/year), i.e**. 7%** of the total operating costs.

Description of the infrastructure:

WP6/VA1 is largely run through virtual access on a set of distributed web services and is based on a network of experts located at research institutes in Europe. There is one central web service (the ENES Portal), which acts as a "landing site" for users of WP6/VA1 and WP7/VA2 services. The ENES Portal links the individual web sites and provides forwarding to the appropriate services asked for by the users. The individual services on models and tools are operated at the partner institutes and comprise web services as well as human resources for training and dedicated user support.

Services currently offered by the infrastructure:

The services offered by the infrastructure described above are threefold: Services on ESMs, services on infrastructure tools, and a central access point with an up-to-date overview and basic information about the individual services. The overall services are targeted at users of European ESMs and ESM data, having varying expertise and individual needs.

Services on ESMs

For European ESMs participating in the CMIP6 exercise, basic services (level 1) will continue to be provided by the infrastructure. This includes easy access to continuously updated information about the climate models, which is important for users -- particularly new users -- of the ESMs and the model data produced. The information can be accessed through a central web service, the ENES Portal.

For a subset of ESMs, advanced services will be provided (service level 2), which supports model developers, model users, and model data users in their work. Again, a central access point to these services will be provided via links at the ENES Portal, but the individual services will be made available by model development groups through their separate web sites. Service level 2 includes standard software development support activities (such as releases, issue tracking) as well as specific information provision for climate models (e.g. via documentation and discussion forums).

Services on ENES community tools

Expert services will also be available for the most important community tools developed and used in ENES: OASIS coupler, XIOS I/O server, CDO data postprocesser, Cylc/Rose workflow engine and the Earth System Model Evaluation Tool (ESMValTool). Services on some of these tools have already started in IS-ENES phases 1 and 2 and their further development is actively going on (see WP8/JRA1, task 3 for OASIS, task 4 for XIOS, task 5 for Cylc/Rose and WP9/JRA2 for ESMValTool).

Description of work:

Task 0: Coordination of WP6/SA1
SMHI (2 PM), CERFACS (2 PM), Total 4 PM

Task 0 will ensure the effort required for effective work package coordination, including management of resources, quality, risks, provision of periodic reports for the WP and managing the delivery of milestones and deliverables. Task 0 will also provide the interface between the WP and the rest of the project.

Task 1: Level 1 services: Maintaining and monitoring the ENES ESM resources
SMHI (4 PM), Total 4 PM

It will be ensured that the following, minimal set of information for CMIP5 and CMIP6 ESMs is easily and centrally accessible for the whole community: Short model description (including current version); Contact point,; Model website; Description of access to level 2 services, where applicable.

It will be ensured that the information is regularly updated and available through the ENES Portal. Regular reports will document availability and coverage of the ENES ESM resources.

Task 2: Level 2 services for European ESMs
MetO (6 PM), CNRS-IPSL (1 PM), SMHI (6 PM), met.no (3 PM), UniRes (3 PM), Total 19 PM

An advanced set of services (level 2) will be offered to allow researchers to make effective and efficient use of a subset of ESMs and the NEMO ocean platform. Most of all, access to up-to-date model versions and associated documentation will be provided together with essential functional communication channels between model users and developers are essential to address any problems while working with the model.

It will be ensured that users and developers of European ESMs have access to the following services: Regular releases; Documentation and Issue tracking.

For the following European ESMs and component:

- HadGEM/UKESM (MetO)
- EC-Earth (SMHI)
- NorESM (met.no and UniRes)
- NEMO (CNRS-IPSL)

These services will be regularly monitored and reports provided.

Task 3: Services for European infrastructure tools
CERFACS (15 PM), CNRS-IPSL (7 PM), MetO (11 PM), DLR (3 PM), BSC (2 PM), NleSC (2 PM), Total 40 PM

Active user support (AUS), including web services (e.g. on-line download, installation information, tutorial, FAQs, hints for best practices, forum) and assistance through e-mails, will be offered for the 5 tools: OASIS, XIOS, Cylc and ESMValtool, as well as CDO.

In addition, trainings at the developers' site will be provided by tool developers and expert users of OASIS and XIOS (VA). These services include a guided installation and interfacing of API routines in toy models. For OASIS, a dedicated support at user site will be given through TNA.

- OASIS (CERFACS 12 PM). In addition to AUS, will provide trainings on the developers' site and a dedicated user support offered at the user site (TNA service) to implement new coupled models or consolidate existing interfaces at regional and global scales.
- XIOS (CNRS-IPSL 7 PM, CERFACS 3 PM). In addition to AUS: will provide trainings on the developers' site [CNRS-IPSL] and support to use the dr2xml tool (see WP8/JRA1) within the CMIP framework and beyond [CERFACS]
- Cylc/Rose (MetO 11PM): The AUS on Cylc & Rose will support sites which are already using or in the process of adopting Cylc/Rose as well as any new adopters. The service will include (i) support in initial decision making and planning – the adoption of Cylc (and optionally Rose) is best achieved at the corporate level to gain the widest benefit, (ii) remote support via email or the cylc online forum and hands-on remote problem analysis where this is possible, (iii) consultancy to encourage best practice and support adoption of good suite design and (iv) enhancements to the documentation (including training material) based on community feedback.
- ESMValTool (DLR 3PM, BSC 2PM, NleSC 2PM): AUS on ESMValTool software means (i) as is already the case today, free download of up-to-date versions of the software via github as provided by WP9/JRA2, (ii) access to relevant information about installation and use, (iii) documentation with SPHINX that will be enhanced and automated so that the user guide can be kept up to date [DLR], (iv) tutorials (including video presentations), (v) FAQs (vii) user forums and hints for best practices [DLR, BSC, NleSC], (viii) personal help to efficiently use the software and the diagnostic portal via direct user support by experts from the development team, available to answer specific questions and provide guidance on how to use the software

on specific platforms and in particular configurations, including proof of this user support statistics [BSC, NleSC].

- CDO (MPI-M 0PM): standard AUS will be provided

Modality of access under this proposal:

ENES distributed services on ESMs, component models and tools, will be free of charge and accessible to the general user community of European ESMs through the ENES Portal. Access restrictions will only be applied where required by software license terms.

OASIS dedicated support (TNA): Nine one month long dedicated support periods will be offered to any climate research laboratory in Europe. As in IS-ENES1 (tested within NA activities), a call will be opened every year (published on the official OASIS website, sent to OASIS user and other Climate Modelling related mailing lists). The selection will be validated by the OASIS Advisory Board[14] and three grants allocated every year (M3, M15 and M27)

OASIS and XIOS trainings: OASIS: 2 sessions; XIOS: 4 sessions, during 2 days.

Support offered under this proposal:

Support offered for each of the participating ESMs and infrastructure tools is described in detail above. During the dedicated support to OASIS, a code coupling expert will visit the granted laboratories to help designing, upgrading or enhancing the implementation of the OASIS library and set up a tailored and computationally efficient coupled system.

Outreach to new users:

The services on ESMs and infrastructure tools will be promoted to new users accessing the ENES Portal. Particularly, the level 1 services on models and the training services for tools have a dedicated focus on new users.

Review procedures under this proposal:

Access services review: A review board will be established for services on models and tools and given the task to report on the quality of the services offered. The review board will include experts on ESMs and tools, mainly from the ENES network (outside IS-ENES Consortium), but also possibly from the international community. The reviews will be published through deliverables D6.2 and D6.5.

OASIS dedicated support (TNA): The peer-review procedure will be assigned to a selection panel consisting of 5 members of the OASIS Advisory Board, representing the main ENES institutions using the OASIS coupler, and 3 experts from outside the ENES community, chosen for their ability to provide valuable inputs and advices about OASIS developments. The OASIS Advisory Board will assess all proposals received based on agreed selection criteria and will recommend a short-list of the user groups that should benefit from dedicated support. The evaluation will be based on the following criteria:

- Originality of the problem: e.g. new physics (ice sheets, hydrology, atmosphere/ocean boundary layer...), increased task parallelism (extraction and concurrent running of sub-components e.g. sea-ice) …
- Quality of the methodology proposed
- Development of cooperation with communities outside ENES (regional modelling...)
- Potential training aspects for new or young users
- Synergy with OASIS development plan

Priority will be given to participants who have not previously used the coupling library (new users). During the IS-ENES1, 6 out of the 12 granted laboratories were already coming from outside the ENES community.

[14] https://portal.enes.org/oasis/metrics/images-and-documents/2017_OASIS_AdvisortBoard.pdf

Deliverables:

D6.1 (Tasks 2 and 3, mo 18): First periodical report on service statistics for models and tools (M18)
D6.1 will report on the service KPIs for models and tools, reported half-yearly. It will document the number of releases, the number of downloads as well as information on user support through the number of support interactions (mails, tickets, forum) and the number of change sets (SMHI).

D6.2 (Task 0, mo 24): First external review of model and tools services (M24)
This deliverable will present the results of the first external review of the models and tools access services (SMHI).

D6.3 (Tasks 2 and 3, mo 36): Second periodical report on service statistics for models and tools (M36)
D6.3 will update D6.1 on same KPIs (CERFACS).

D6.4 (Task 3, mo 36): Report on new OASIS coupled models/interfaces (M36)
This report will describe the results of the TNA activity on the OASIS coupler, presenting implementation details and best practices, as well as the new needs for OASIS improvements identified by this activity (CERFACS).

D6.5 (Task 0, mo 40): Second external review of model and tools services (M40)
This deliverable will present the results of the second external review of the models and tools access services (CERFACS).

D6.6 (Tasks 2 and 3, mo 48): Third periodical report on service statistics for models and tools (M48)
D6.6 will update D6.3 on same KPIs (SMHI).

Milestones:

M6.1 (Task 1, mo 18): ENES ESM resources updated, RP1 (SMHI)

M6.2 (Task 0, mo 18): Reviewer for services appointed (CERFACS)

M6.3 (Task 1, mo 36): ENES ESM resources updated, RP2 (SMHI)

M6.4 (Task 1, mo 48): ENES ESM resources updated, RP3 (SMHI)

WP7/VA2 Data standards, distribution and processing services

Work package number	7		**Lead beneficiary**			DKRZ	
			Co-lead beneficiary			KNMI	
Work package title	Data distribution and processing services						
Participant number	6	1	8	3	11	7	
Short name of participant	BSC	CNRS-IPSL	CMCC	DKRZ	DLR	KNMI	
Person months per participant	**3**	**35**	**8**	**44**	**4**	**12**	
Participant number	22	12	10	9	2		
Short name of participant	LIU	NleSC	SMHI	STFC	UREAD-NCAS		**Total**
Person months per participant	**3**	**4**	**8**	**29**	**34**		**184**
Start month	1			**End month**		48	

Objectives

Users from the climate modeling community, the climate impact community as well as interdisciplinary research domains rely on stable and consistent services to access and to process high volume climate model data from the WCRP reference simulations from CMIP and CORDEX, hosted in distributed repositories in Europe. ENES Climate Data Infrastructure (ENES CDI) provide access services on data from ESGF, from the archival system WDCC, from the climate4impact portal, as well as processing services and services on data documentation and standards. Services are mainly offered through VA, except the possibility to access virtual workspaces through TNA. Goal of these Service Activities is to provide operational support to the climate and climate impact research communities and other communities using the data and tooling provided by IS-ENES3. The VA/TNA activities will also provide support for communities that are new to using climate data.

Provision of access to the following infrastructure(s):

Description of the infrastructure

Name of the infrastructure (and its installations, if applicable): **ENES Climate Data Infrastructure (CDI)**

The ENES CDI is composed of 11 installations (described below), hosted by DKRZ, STFC, CNRS-IPSL, CMCC, LiU, BSC and KNMI.

Location (town, country) of the infrastructure:

The infrastructure provides a consistent and integrated set of services hosted by installations at:

Paris, France (CNRS-IPSL), Barcelona, Spain (BSC), Hamburg, Germany (DKRZ); Rutherford, England (STFC); Lecce, Italy (CMCC); Linköping, Sweden (LIU); De Bilt, The Netherlands (KNMI). A single sign on is provided to end users and integrated into the distributed data portals which provide a consistent overall data search and data download experience to users. During the IS-ENES3 the infrastructure will be extended by installations supporting data near climate data analysis.

Web site address: **ENES Portal**, https://portal.enes.org/data/is-enes-data-infrasctructure

Annual operating costs (excl. investment costs) of the infrastructure (€):

The total annual operating cost of the infrastructure is estimated at **2913 k€/year** with:

- Installation 1: DKRZ-WDCC-ESGF-Comp1 (VA) hosted by DKRZ with contributions of DLR and NleSC Has an annual operating cost of **1012 k€ /year** (760 staff cost for archive services at DKRZ-WDCC, 210 for DLR and 42 for NleSC)
- Installation 2: STFC-ESGF-Comp1-CFDR (VA) hosted by STFC with contributions of UREAD-NCAS and SMHI, has an annual operating cost of **792 k€ /year** (537 for staff costs of open archive services at STFC CEDA, 195 for UREAD-NCAS, 60 for SMHI)
- Installation 3: CNRS-ESGF-ESDOC-Comp1 (VA) hosted by CNRS-IPSL with contribution of UREAD-

NCAS, has an annual operating cost of **182 k€ /year** (115 for archive services at CNRS, 67 for UREAD-NCAS)

- Installation 4: CMCC-Comp1- (VA) has an annual operating cost of **16 k€ /year**
- Installation 5: LiU-ESGF (VA) hosted by LiU with a contribution from SMHI, has an annual operating cost of **183 k€ /year** (53 for LiU and 130 for SMHI)
- Installation 6: BSC-ESGF (VA) hosted by BSC has an annual operating cost of **53 k€ /year**
- Installation 7: KNMI-C4I-Comp1 (VA) hosted by KNMI has an annual operating cost of **75 k€ /year**
- Installation 8: DKRZ-Comp2 (TNA) hosted by DKRZ has an annual operating cost of **220 k€ /year** for staff costs for flexible and compute facility
- Installation 9: STFC-Comp2 (TNA) hosted by STFC has an annual operating cost of **248 k€ /year** for staff costs for cloud service at CEDA
- Installation 10: CNRS-Comp2 (TNA) hosted by CNRS has an annual operating cost of **97 k€/year** for flexible and compute facility
- Installation 11: CMCC-Comp2 (TNA) hosted by CMCC has an annual operating cost of **35 k€/year**

The service cost requested to the EU for WP7/VA2 is 1 435.6 k€ for 4 years (i.e. 358.9 k€/year) corresponding to **12% of the total operating costs**.

Description of the infrastructure: **ENES CDI**

The infrastructure currently serves more than 4 Petabytes (PB) of data and will grow to more than 30 PB during IS-ENES3 (CMIP6). The ENES CDI is the primary source for climate model data in Europe (originating from European modeling groups as well as international groups).

Available storage and processing facilities:

- DKRZ: 5 PB of fast disk storage pool for CMIP5, CMIP6 as well as CORDEX data. The disk space is associated to the DKRZ HPC system as well as a dedicated data analysis compute cluster. Users of the DKRZ compute resources are mainly associated to national projects, yet dedicated compute services (see VA task 4) as well as direct access to virtual workspaces (see TNA task 5) will open up these resources for European researchers. The World Data Center for Climate (WDCC) is hosting more than 2 PB of data (in multiple copies for security reasons) and providing ~1000 DOIs for data collections (mostly CMIP5). In addition to the specifically curated data in the WDCC, DKRZ provides a long term data archive with a capacity of over 50 PB.
- STFC: 5 PB of fast disk storage for CMIP6, together with tape archive. The data will be held in the CEDA archive with secure backup. The archive is held within the JASMIN high performance analysis system which provides user-accessible servers with low-latency, high-capacity links to the data archive. The users also have access to collaborative workspaces (26 PB) which they can use to store additional data files needed for or generated by their calculations. 11,500 compute cores are available for data analysis via a batch cluster, or a community cloud. The users of JASMIN servers come primarily from the UK research community, but European researchers will be able to gain access through the TNA activity in task 5. There are currently 1700 users registered for access to JASMIN.
- CNRS-IPSL: 7 PB of fast disk storage for CMIP5, CMIP6, CORDEX data as well as a very diverse repository of reference observational datasets classically used for climate model evaluation. The disk space is associated to the IPSL high performance analysis system which provides high capacity links to the data archive. Users of the IPSL analysis system are mainly associated to national projects, yet dedicated compute services (see VA task 4) as well as direct access to virtual workspaces (see TNA task 5) will open up these resources for European researchers.
- CMCC: ESGF data node with 100 TB disk storage for CMIP experiments, connected to the DKRZ ESGF index node. A dedicated compute service facility with about 100 cores, 50 TB of online storage and 10 Gbit fast network connection, that will be used by climate scientists for data analysis (both at national and EU level) through the VA Task4 and TNA Task5 services.
- LiU: 240 TB of fast disk storage for CMIP5, CMIP6 as well as CORDEX data, together with tape archive.
- BSC: ESGF data node with 600 TB disk storage for CMIP6 experiments (PRIMAVERA) connected to the CEDA ESGF index node.
- KNMI: ESGF datanode with 60 TB diskstorage for CMIP6, connected to the DKRZ ESGF index node. The climate4impact portal, with 20 TB local (temporary) disk space for storing user data (calculation results). Perfsonar node for bandwidth monitoring (http://perfsonar.knmi.nl/)

Services currently offered by the infrastructure:
(in " " are short names used to describe the services available in the different installations)

ESGF data access and data publication services "ESGF"

Data access and data publication services (Task 3) are based on ESGF data node installations at DKRZ, STFC, CNRS-IPSL, CMCC as well as LiU, BSC and KNMI. DKRZ, CNRS-IPSL as well as STFC operate so called "Tier1" ESGF sites with specific international responsibilities in the context of CMIP5 and CMIP6 with respect to data portal provisioning as well as data replication. Additionally BSC, LiU, CMCC, KNMI host "Tier2" ESGF sites with specific national and project specific support activities. Currently more than 3000 users are registered at the distributed European data portals with about 800 active users per year. Support functions are distributed among partners, with central contact addresses connected to the institutional request tracking systems. Additionally documentation and FAQs are provided as part of the ENES portal (hosted at DKRZ) as well as the ESGF portals at DKRZ, CNRS-IPSL as well as STFC.

Long term data archival, persistent data identification and the WDCC service for IPCC data "WDCC"

Long term data accessibility, persistent data identification and long term data archival related services are provided by DKRZ, as part of the World Data Center for Climate (WDCC). Persistent data identification services are integrated into the ESGF data federation to support CMIP6 data versioning, annotation and replication. In addition data citation services on archived data collections are provided to support the citation of model data in scientific literature. The WDCC as well as STFC additionally contribute to the IPCC DDC. A data replication strategy agreed among the three European tier1 nodes (STFC CEDA centre, DKRZ, CNRS-IPSL) will improve data access for the European climate community (e.g. with respect to data security and availability). The WDCC is a certified member of the ICSU World Data System (WDS) and thus supports in particular the goal of providing universal and equitable access to quality-assured scientific data. In addition, the WDCC is especially linked to the metadata services of the emerging European Open Science Cloud (EOSC), and thus contributes to a strong interdisciplinary scientific dialogue with other research communities. More than 1000 users downloaded more than 3.5 Petabytes (in more than 1.4 million individual file downloads) from WDCC in 2017 mostly relying on services which are integrated into the European ESGF infrastructure (75 % of users relied on ESGF portals to access the data). Around ¼ of users are located in Europe, ¼ in north America whereas about 50% were located in Asia, South America and Africa.

Climate4impact service for the climate impact research community "C4I"

The climate4impact portal (https://climate4impact.eu) and associated services are provided by KNMI. Climate4impact, developed within IS-ENES1 and 2, aims to support climate change impact modellers, impact and adaptation consultants, as well anyone else wanting to use climate change data. The portal offers web interfaces for searching, visualizing, analyzing, processing and downloading datasets from ESGF and thus the portal is closely interlinked with the ESGF installations described above. Climate4impact has a steadily growing user community now at 2150 unique visitors each month on average in 2017 (1600 unique visitors on average in 2016). User support is provided by up-to-date documentation (background topics, user guidance, connection to ES-DOC/ENES portal), FAQs and a contact address with request tracker for questions.

New Processing services associated to large data pools and climate evaluation diagnostics "Comp1" & "Comp2)

At the sites at DKRZ, STFC, CNRS-IPSL as well as CMCC, the ESGF installations are supplemented by large data storage pools supporting climate data analysis activities at a national level. IS-ENES3 offers for the first time new services to European climate researchers to support analysis of large climate data volumes (CMIP5, CMIP6 and CORDEX). These compute services are responding to a growing user need to enable efficient data analysis activities at the large data centers thus avoiding the download of huge amounts of data to their home institutes.

"Comp1" (VA): A new emerging set of specific web accessible compute services will be hosted at DKRZ, CNRS-IPSL, STFC and CMCC (Task 4) initially concentrating on the processing of climate evaluation diagnostics based on the ESMValTool as well as multi-model data analysis. These service activities will be aligned with related activities in the context of the Copernicus Climate Change Service and (ii) EOSC-related initiatives to ensure consistency of products offered and appropriate exploitation of synergies in software and hardware deployments. The distribution of diagnostics to users is supported by a new diagnostics portal

installation at DKRZ as well as KNMI.

"Comp2" (TNA): Data near processing capabilities at the centers DKRZ, CNRS-IPSL, STFC and CMCC will be made accessible via TNA (Task 5) to a broader user community. These processing capabilities support multi-model data analyses through direct access to large data pools including replicated data from the European as well as non-European ESGF data nodes.

New service on data and metadata standards "CFDR"

Data community data standards provide an essential framework for data services. These standards are supported by services run at STFC and UREAD-NCAS, and fall into two broad areas. Firstly, the **Climate and Forecast Convention ("CF")** for file metadata which is used both across the climate science community, ensuring interoperability of data files from different actors in the community, and in related domains such as atmospheric science and Earth Observation. Secondly, the WCRP Coupled Model Intercomparison Project (CMIP) uses a structured **Data Request ("DR")** to precisely specify data requirements for CMIP. STFC provides a moderation service for the CF Standard Name list, supporting the community discussions which feed new names into the list. STFC is also supporting the CMIP6 Data Request: this includes running community discussions to clarify definitions of 2000 configured model output diagnostics and providing access to the consolidated CMIP6 data request and associated software. UREAD-NCAS runs complementary services supporting the CF Conventions through maintenance of the CF Data Model and associated software and by providing editorial effort to complete updates to the CF Conventions reference document.

Services on model documentation "ESDOC"

CNRS-IPSL and UREAD-NCAS will provide support for model documentation based on ES-DOC is essential for providing scientific provenance information for the data distributed based on the ENES CDI. This includes support actions for all European modelling groups described in Task 5 below. Documentation will be provided by ES-DOC search and compare web services available from https://es-doc.org as well as the further-info-URL dynamic entry point to documentation, an URL stored in each CMIP6 data file.

Description of work:

Task 0: Coordination of WP8/VA2
DKRZ (WP leader, 2 PM), KNMI (WP co-leader, 2 PM), Total 4 PM

The service activities are coordinated by DKRZ and KNMI ensuring the timely collection of service access statistics as well as the regular service reviews by an external board. Based on the reviews the planning of service related activities is initiated to expand the usage and uptake of services by a growing user community.

Task 1: ESGF Data Dissemination, Long Term Archival and User Support (VA) – "ESGF-WDCC-C4I"
DKRZ (28 PM), CNRS-IPSL (4 PM), STFC (6 PM), KNMI (5 PM), BSC (3 PM), LiU (3 PM), SMHI (4 PM), Total 53 PM

This task focuses on the ENES CDI data distribution (ESGF), data archival related (WDCC) and climate impact services (C4I). User support functions will be provided based on consistently maintained end user documentation (accessible via the ENES portal, the ESGF portals as well as the climate4impact portal) as well as a distributed help desk. DKRZ, CNRS-IPSL and STFC acting as first level support with respect to ESGF related data provisioning and KNMI acting as first level support for the impact community oriented services. SMHI provides support functions with respect to CORDEX and the regional climate modelling community. DKRZ and KNMI will be responsible to collect and provide up-to-date documentation, FAQs and contact addresses, connected with the support functions (e.g. request tracker systems) at the installations.

Task 2: Compute Services (VA) - "Comp1"
KNMI (5 PM), DKRZ (9 PM), CNRS-IPSL (2 PM), STFC (2 PM), CMCC (3 PM), DLR (4 PM), NleSC (4 PM), Total 29 PM

Comp1 will provide a set of compute services and access to derived data products. The services are based on the software stack evolved in WP10/JRA3 as well as WP9/JRA2. A new service will be established to generate and distribute an up to date collection of climate model evaluation data products based on the ESMValTool. The routine statistics generation and related web interface is provided at DKRZ relying on automatic processes

ensuring the replication of newly published (or modified) CMIP6 data collections as input for the ESMValTool. The web based interface, maintained by NleSC, will be hosted at DKRZ and also integrated into the portal frameworks hosted at KNMI. Scientific support for the ESMValTool is provided by DLR, technical support is provided by KNMI and DKRZ. Diagnostics portal related documentation will be provided and made accessible as part of the diagnostics portal as well as interlinked from the other related IS-ENES infrastructure portal deployments (e.g. the ESGF portals).

Stepwise, additional compute services will be made available at specific IS-ENES3 data centers. Compute services will be directly accessible for users as well as indirectly e.g. via the climate4impact portal, which delegates some computations to specific data centers. Access is provided free of charge for registered users of the IS-ENES3 data infrastructure, yet data centers will apply resource management actions to prevent the overloading of available resources if necessary.

Task 3: Virtual workspaces (TNA) - "Comp2"
STFC (5PM), DKRZ (5 PM), CNRS-IPSL (5 PM), CMCC (5 PM), Total 20 PM

Based on the transnational access mechanism (TNA) users are provided with virtual workspaces at DKRZ, CNRS-IPSL, STFC (at CEDA) and CMCC to flexibly support data near analysis activities. The individual data centers provide access to a (center specific) set of compute and storage resources. Compute facilities have direct access to locally maintained large climate data pools. The data pools at the resource providers are integrated into the ENES CDI replication infrastructure. A selection committee will supervise the selection of applications for virtual workspace access. Results from user groups enabled through the virtual workspaces access will be disseminated under the project.

Task 4: Support for CF convention and Data Request - "CFDR"
STFC (16 PM), UREAD-NCAS (22 PM), SMHI (4 PM), Total 42 PM

Task 4 supports the CF convention and Data Request (DR) standards. UREAD-NCAS is responsible for maintaining the standards document itself and for providing the CF Data Model, which provides a robust semantic structure for the complex rules expressed in the convention. STFC moderates the discussion of the CF Standard Names and maintains the table of approved names. STFC provides the CMIP6 data request (w3id.org/cmip6dr), the CORDEX data request will be provided by SMHI by adapting the solution for CMIP for regional scale climate modelling.

Task 5: ES-DOC operational support for CMIP6/7 - "ESDOC"
CNRS-IPSL (24 PM), UREAD-NCAS (12 PM), Total 36 PM

Operational support for the 30+ modelling groups participating in CMIP will be provided by CNRS-IPSL and UREAD-NCAS. This will include setting up institutional accounts and storage for groups (on github), automated generation of simulation and ensembles documents following ESGF publishing (cdf2cim), support and tools (ipython notebook, spreadsheets, quality control, training, helpdesk) for liaison people within modelling groups, maintenance of the CIM database and related view/search/compare tools and services.

Modality of access under this proposal:

Users will be given free web based access to data and derived data products distributed via the ENES CDI data portals and data nodes as well as compute nodes (ESGF portals and ESGF nodes, climete4impact portal, evaluation portal). Access statistics are collected regularly and summarized in deliverables.

As part of the new TNA service, admitted user groups (admission based on vote of a selection panel, see below) will be provided direct access to compute and storage resources at DKRZ, CNRS-IPSL, STFC or CMCC ("virtual workspaces"). The centers will provide site specific access mechanisms, where (a) compute loads scheduled into the operational compute loads at the centers based on their established resource management solutions; (b) specific resources can be allocated on demand to user groups, based on specific requirements; or (c) dedicated servers and disk space assigned in a cloud environment for the duration of the TNA project. All installations will declare costs on the basis of actual costs as there is considerable variation with respect to project requirements. The costs cover configuration of servers and storage required by the project as well as support for project coordinators. The unit access for the offerings at the installations at DKRZ, CNRS-IPSL,

STFC and CMCC are as follows:

DKRZ, CNRS-IPSL, CMCC: Users/project groups will be offered a specific amount of cpu-time and associated storage associated to dedicated project accounts. These project accounts will allow access to a dedicated compute facility (CMCC) and to shared or dedicated servers or allow the submission of batch jobs for the DKRZ "mistral" HPC system and the CNRS-IPSL system. Direct (read-) access to the 5PB CMIP data pool (DKRZ, CNRS-IPSL) will be provided. Disk space allocation for derived data products or transient results vary from a few TB to 10s of TB. The Unit of Access will be based on a reference tenancy of compute/storage resources.

STFC: The JASMIN facility at STFC includes a private cloud and batch processing cluster. Research projects can gain access to shared or dedicated servers in the cloud, and make use of a reserved allocation of disk space within which the project team can organise and share results. Project disk space allocations vary from a few TB to 500TB. Projects also have access to the x000 core LOTUS batch processing cluster. The Unit of Access will be a Reference Tenancy, based on representative requirements.

Support offered under this proposal:

- Scientific and technical support with respect to access to data and to derived data products is provided via a first level (basic level: contact points)/second level (advanced: developers' contact) support infrastructure across the ENES-CDI. This support is integrated with the global ESGF support as well as the institutional request tracking systems. Non-technical data queries are forwarded to the corresponding scientific contact persons at the modeling centers or derived data product generators (e.g. the ESMValTool contacts).
- Trans-national access to virtual workspaces is mostly based on remote usage of centralized compute and storage resources at the providers DKRZ, STFC, IPSL and CMCC. Site specific support is available and will enable users to perform high data volume data analysis, which is not feasible based on the limited resources accessible at their home institutes. This site specific support is already routinely provided to national research groups and will be extended as part of this activity.
- Operational support for the scientific documentation of CMIP6 models is provided as part of Task 2
- Support for the evolution of the CF standard as well as the CMIP data request is provided as part of Task 1
- Support for CORDEX will be organised in collaboration with the International Project Office for CORDEX (IPOC) located at SMHI. A helpdesk for responding to users' requests for information and support regarding CORDEX data standards and supporting tools developed within IS-ENES3, e.g. for data re-formatting and quality controls to enable publication to ESGF.
- Support for impact research community will be organized together with WP3/NA2 Community and WP5/NA4 Data and evaluation. The workshops and trainings will deliver valuable output and insights in usage of the ENES services. Material created and lessons learned will be used to improve support infrastructure.

Outreach to new users:

Based on the experiences with CMIP5 and CORDEX the provisioning of the new CMIP6 results will attract a strongly growing user base. Additionally the provisioning for access to processing capabilities and the offering of processing related services is directly responding to requests from users various research groups. Additionally the services will be announced as part of the ENES portal and community conferences attracting new user groups. In cooperation with WP3/NA2, community activities will be deployed to actively engage with new user communities from the impact research and outscaling of the provided services towards SMEs to encourage innovation. Specific attention will be given to users from Eastern Europe by joining specific events in Eastern Europe (WP3/NA2), add examples and use cases of specific interest for Eastern Europe and provide access to ENES services (WP7/VA2).

Every year the International Project Office for CORDEX is involved in organising and otherwise supporting several workshops in the different CORDEX domains worldwide. At these events there are typically opportunities and demand for information regarding solutions, both for data producers to publish their results, and data users on how to access and master ESGF and other portal services provided by IS-ENES. As such these workshops offer excellent opportunities to disseminate the results of IS-ENES and promote the infrastructure solutions and supporting tools for building efficient workflows.

Review procedure under this proposal:

Access services review: A review board will be established for services on data and given the task to report on

the quality of the services offered. The review board will include experts on climate data in Europe and worldwide. The reviews will be published through deliverables D7.2 and D7.4.

Review procedure for TNA: All proposals for transnational access will directed in a first step to an ENES CDI access management contact address associated to a board with representatives from the ENES CDI resource centers at DKRZ, IPSL, STFC as well as CMCC. This resource provider board forwards the proposal to the (scientific) selection panel together with a recommendation for a resource center handling the TNA request. The user selection panel is representing international experts in the climate model community as well as downstream communities (especially the climate impact community) and evaluates the proposal based on the following criteria: objectives, impact, expected results, originality and scientific quality, technical expertise to exploit the platform to produce the results in the described time frame, scientific excellence and quality of methodology, and innovation potential

Deliverables

D 7.1 (Task 1-5, mo 18): First KPI and TNA report for ENES CDI services.
First access statistics with respect to data access (including data replication) (Task1) as well as processing service access (Task2 and Task3). The access statistics will summarize the detailed usage profile of the data and as well as compute services of the ENES CDI. It also summarizes the service provisioning for data standards (Task4) and model documentation (Task5) (DKRZ).

D 7.2 (Task 0,mo 24): First external review report for ENES CDI services.
A summary report is produced with respect to the services of the ENES CDI and the review results of the external advisory board. Expected steps to address the issues pointed at by the advisory board are included (KNMI).

D7.3 (Task 1-5,mo 36): Second KPI and TNA report for ENES CDI services
Update of D7.1 for second period (DKRZ).

D7.4 (Task 0, mo 42): Second external review report for ENES CDI services
Update of D7.2 (KNMI)

D7.5 (Task 5, mo 42): Report on operational support for CMIP documentation
Report on ES-DOC operational support to CMIP (CNRS-IPSL).

D7.6 (Task1-5, mo 48): Third KPI an TNA report for ENES CDI services
Final access statistics and service usage report for ENES CDI services (DKRZ).

Milestones*:*

M7.1 (Task 1, mo 8): ENES CDI help desk. Support infrastructures for data, compute and for climate4impact are integrated, connected to institutional request tracking systems and contact addresses are published at ENES CDI portals.

M7.2 (Task 0, mo 12): Set up of review committee and user selection panel. A user selection panel for the transnational access to virtual workspaces is established consisting of representatives of resource providers as well as international experts. Additionally a review panel for the service activities is established.

M7.3 (Task 2, mo 24): Improved version of evaluation portal. An improved version of the evaluation portal is integrated with the climate4impact portal. The DKRZ evaluation portal concentrates its services towards the modeling community, while the climate4impact integration at KNMI supports the wider down-stream communities.

M7.4 (Task 1, mo 46): Complete ENES-CDI long term archival for CMIP6. The core CMIP6 data collections are archived as part of the WDCC (with data citation enabled) and integrated in the ESGF data infrastructure. A clear justification on "core" collections is given based on the needs of the climate modeling and climate impact community on one hand side and available storage resources on the other side.

WP8/JRA1 Models & Tools developments

Work package number	8	**Lead beneficiary**				Cerfacs	
		Co-lead beneficiary				CMCC	
Work package title	WP8/JRA1 Model & Tools developments						
Participant number	4	8	6	5	1	15	2
Short name of participant	CERFACS	CMCC	BSC	MetO	CNRS-IPSL	MF-CNRM	UREAD-NCAS
Person months per participant	**28**	**14**	**20**	**33**	**31**	**1**	**2**
Participant number	9						
Short name of participant	STFC						**Total**
Person months per participant	**6**						**135**
Start month	1			**End month**		44	

Objectives

One of the IS-ENES strategic goals is to promote and further develop community models and tools in order to produce more accurate and reliable simulations of the Earth climate system. Phases 1 & 2 of IS-ENES have successfully initiated this strategy by investing significant efforts in the NEMO ocean model and in the OASIS coupler. IS-ENES3 will give remarkable further impetus toward this community goal with the development of a unified European platform for Sea Ice to be implemented within NEMO, and with the identification and development of additional community tools, i.e. XIOS for data flow management and Cylc/Rose for the automation of suites of tasks. These community-coordinated activities will open new possibilities for more technically robust and diverse code base and shared developments within Europe.

Improving NEMO computational performance

One of the key points for the NEMO community is improving the model computational performance, mainly for the execution of new high-resolution and complex simulations. The plans regarding NEMO are to improve the scalability of the code with particular focus on the communication overhead reduction, define a methodology useful to understand which parts of the code could be safely integrated in single precision without impacting on the accuracy of the model, and improve I/O operations, one of the main bottlenecks for model execution when the number of parallel processes increases.

Developing the unified European platform for sea ice modelling

Fully in line with IS-ENES strategic goal, the NEMO consortium has recently decided to expand the scope of the consortium to include a unified community sea ice model for use with NEMO. This activity is coordinated by the NEMO Sea Ice Working Group (SIWG). The development of the new model will be focused around a coordinated merging of the best aspects from the existing models used with NEMO (CICE, GELATO & LIM).

Developing community software tools

IS-ENES3 will devote a significant effort to further develop its community software tools, either already well established like the OASIS3-MCT coupler, or being progressively adopted by more and more groups like XIOS or Cylc/Rose. Few key developments are proposed here increasing the tool functionalities or improving their performance. Through the community governance, additional developments might be considered or priorities slightly re-oriented for the maximal benefit of the users.

Links with other work packages

In order to maximise the benefits for the whole community, the developments in this work package will be driven by i) networking activities described in WP4/NA3 (see Tasks 1, 2 and 5 therein), ii) feedbacks from the services offered on models and tools in WP6/SA1, and iii) the community governance structures, either already established (for NEMO and OASIS) or in discussion in WP2/NA1 (for XIOS and Cylc/Rose).

Description of work:

Task 0: Coordination of WP8/JRA1
CERFACS (WP Leader, 2 PM), CMCC (WP co-leader, 2 PM), Total 4 PM

Task 0 provides the effort required for effective work package coordination, including management of resources, quality, risks, provision of periodic reports for the WP and managing the delivery of milestones and deliverables. Task 0 will also ensure the interface between the WP and the rest of the project.

Task 1: Improving Nemo computational performance
CMCC (11 PM), BSC (20 PM), MetO (5 PM), Total 36 PM

CMCC and BSC will use state-of-the-art performance tools to trace the scalability at routine level. Communication impact studies will allow the assessment of the model sensitivity to the network latency, revealing the impact of inter-node messages over the model scalability (M8.4). Strategies to reduce inter-node communication time and frequency will be developed and implemented to limit the communication overhead, which inhibits scalability since, unlike computing time, it does not usually decrease with the number of parallel processes. Moreover, the balance between the number of messages and the packet size as well as the optimal distribution of the model subdomains according to the computing resources and network topology will also be taken into account (D8.5).

Today, there is a general consensus that more attention needs to be paid to the floating-point precision in scientific software, in order to wisely use the resources without losing the necessary accuracy on a case-by-case basis. A method to understand the precision required by each process of a climate model in general, and by NEMO in particular, will be developed by BSC through an emulator. Reducing the precision only where it won't impact on the model accuracy will preserve the quality of the results (D8.5).

Finally, the latest version of NEMO includes writing and reading capabilities through XIOS. However, greater understanding and tuning of the I/O performance at high core count is still required. The evaluation of XIOS for NEMO and profiling on high-resolution configurations (e.g. 1/12° and 1/16°) will be performed by MetO and CMCC (M8.4). Depending on these results, we will consider the extension of XIOS for reading and writing other data (sea ice and biogeochemistry) (D8.5).

Task 2: Developing the unified European platform for sea ice modelling
MetO (4 PM), CNRS-IPSL (4 PM), CMCC (1 PM), MF-CNRM (1 PM), UREAD-NCAS (2 PM), Total 12 PM

Task 2 will consolidate and support the work of the SIWG by performing in-depth technical testing and through documentation of the new sea ice code (M8.5). In parallel, the modularity of the code will be improved to increase the flexibility, and ease of use, of the new model. The outcome of this activity will be a new sea ice model developed specifically for use with NEMO and made freely available through the NEMO code repository (D8.1). This new model will be technically robust, thoroughly documented and will adhere to NEMO coding and design standards. The code will be modular and more flexible than the existing crop of sea ice models used with NEMO.

Task 3: OASIS3-MCT development
CERFACS (23 PM), STFC (6 PM), Total 29 PM

Within IS-ENES3, CERFACS plans to produce a further version, OASIS3-MCT_5.0 (D.8.2), that will include the high-priority and some of the medium-priority developments (M8.3) identified in the latest Development Plan accepted by the OASIS Advisory Board (see https://portal.enes.org/oasis/users/oasis-governance for details), among which major ones are:

- Parallel and higher-accuracy library for the calculation of the interpolation weights.

Different interpolation libraries (e.g. ESMF and XIOS) other than the sequential SCRIP library currently available in the coupler will be evaluated and performant higher-quality interpolation routines will be interfaced by CERFACS in the initialisation phase of the coupler, so to allow an efficient on-line calculation of the interpolation weight file. This can be seen as a first step toward the evolution, on the longer term, toward a

dynamic coupler supporting component with masks or grids evolving with time.

- Further development of LUCIA, the load balance analysis tool.

LUCIA, delivered with OASIS3-MCT, is a post-processing tool that analyses OASIS online time measurements to evaluate the load balance between the coupled components. We will widen its applicability to more diverse configurations, for example components with irregular duration of their coupling time step or one-way coupled components. CERFACS also plans to include LUCIA analysis directly in OASIS finalisation step (instead of using it in a post-processing phase), and to unify LUCIA and the standard OASIS timer result presentation.

- Diagnostics and pre- and post-processing transformations.

CERFACS will include more diverse diagnostics on coupling fields (e.g. for intensive variables or for fields with fractional masks) and additional post-processing transformations (e.g. combination with other fields coming from disk files or user-defined transformations) as asked by users.

- Development of Python bindings.

STFC will use Fortran 2003 C iso bindings to create a portable FORTRAN to C interface to start with (which means that C bindings will also be provided to couple C model through OASIS3-MCT); a Python to C interface library will then be used (e.g. SWIG or Cython) to realize the final Python bindings. This innovation will allow a much wider community, less advanced in HPC, to more easily use the OASIS coupler for new couplings.

Task 4: XIOS development
CNRS-IPSL (27 PM), CERFACS (3 PM), Total 30 PM

CNRS-IPSL will deliver a new version of XIOS version (D8.3) offering a full and efficient data flow infrastructure for climate models that combines online data treatment, model coupling and data input/output from/to files, using both MPI and OpenMP parallelism. In addition to the current functionality, the following developments will be achieved:

- Additional spatial transformations: some simple (still missing) remapping operators, such as bilinear or nearest-neighbor interpolations, and more complex operators, such as curl or divergence, will be implemented.
- Time interpolation: currently data can be output only at a period corresponding to an entire number of model time steps and data can be read in only at the frequency defined by the input file. Time interpolation will ensure, for example, that a monthly file could be read in and will automatically provide interpolated daily values.
- Restartability: the possibility of restarting a model using XIOS at any time without losing part of information (for example if the model stopped in the middle of a time averaging period) will be implemented.
- Robustness and reliability: a set of unit tests based on continuous integration concept, which could be automated by Jenkins tools, will be developed; more explicit error diagnostics will be included for easier resolution of problems (M8.1).
- Multithreading and coupling: these functionalities, developed at a prototype stage in ESiWACE, will be further tested and validated at an operational level. Gathering I/O and coupling functionalities into the same tool is extremely innovative; even though it has been a matter of discussion in the community for many years, it is the first time that such integration is effectively proposed.

CERFACS will also extend the dr2xml package. The dr2xml is a python package that exploits the CMIP6 Data Request API to automatically generate XIOS XML configuration files so that output NetCDF data files generated by XIOS meet the CMIP6 format and metadata requirements without further post-processing. Dr2xml will be adapted for the forthcoming CMIP7 exercise and extended to produce XIOS configuration files also for experiments outside the CMIP framework.

Task 5: Cylc/Rose development
MetO (24 PM), Total 24 PM

Cylc and Rose will be further developed by MetO to ensure they continue to meet user requirements increasing their usability, responding to changing technologies and improving performance (M8.2). These developments will make it feasible to tackle new and more complex problems and are essential to maintain confidence in the long-term viability of the tools and to encourage wider adoption (D8.4). Development priorities will be community driven, supported by the governance activities in WP2/NA1 and informed by the service activity in

WP6/SA1, but the scope is likely to include:

1. Improvements to the performance and scalability of Cylc to address the needs of increasingly complex workflows. Even today, we have seen explosive adoption of Cylc stretch the scalability of the system. These challenges will grow over time as increased model output resulting from increased HPC capacity drives the need for research and production activities to scale out to use more resource through increased parallelism at every level.
2. Addressing new requirements resulting from emerging applications (e.g. Machine Learning and Data Analytics workflows), new platforms and schedulers, new data storage architecture (e.g. Object Storage) or from the need to become more fault tolerant in emerging HPC environments.
3. Adoption of new GUI technologies to replace the deprecated GTK+ 2 based GUIs. This work will then allow new requirements to be addressed which are not possible with the current technologies.
4. Migration from Python 2 to 3. With the end of life of python 2 expected in 2020 this work is essential to ensure long term support.

Deliverables:

D8.1 (Task 2, mo 24): NEMO sea ice model code
Provision of the new NEMO sea ice model code through the NEMO code repository. The code will be modular, technically robust and will adhere to NEMO coding and design standards (MetO)

D8.2 (Task 3, mo 36): OASIS3-MCT_5.0 release
A new official release of OASIS3-MCT named OASIS3-MCT_5.0 including the developments described in Task 3, publicly available through OASIS SVN repository (CERFACS)

D8.3 (Task 4, mo 40): XIOS new release
A new official release of XIOS, including the developments described in Task 4, will be publicly available through XIOS SVN repository (CNRS-IPSL)

D8.4 (Task 5, mo 40): Cylc / Rose development summary
Report on the main developments to Cylc & Rose delivered from Task 5. An outline roadmap of planned future developments will also be included (MetO)

D8.5 (Task 1, mo 44): Update of the NEMO code
Integration into the NEMO model of code changes suggested by the analysis and the optimizations delivered from Task 1. The integration process will respect the development practices of the NEMO Consortium (CMCC).

Milestones:
M8.1 (Task 4, mo 12): A set of unit tests for XIOS
A set of automated unit tests based on continuous integration concept implemented for XIOS (CNRS-IPSL)

M8.2 (Task 5, mo 12): Cylc/Rose development priorities agreed
A list of the high level development priorities for Cylc/Rose will be agreed which will guide the developments undertaken in task 5 (MetO)

M8.3 (Task 3, mo 24): Final list of developments for OASIS3-MCT_5.0
An update of the 2017 OASIS development plan (see https://portal.enes.org/oasis/users/oasis-governance) describing the new developments planned for OASIS3-MCT_5.0 release (CERFACS).

M8.4 (Task 1, mo 24): Definition of NEMO optimization strategy
Report on the analysis of NEMO computational performance. The document will summarise the main outcome of the analysis process and the planned optimization strategy with regard to scalability, mixed-precision, I/O (CMCC).

M8.5 (Task 2, mo 30): Documentation of the NEMO sea ice model
The new NEMO sea ice model will be thoroughly documented within the NEMO online documentation and described within a peer-reviewed scientific journal article (MetO).

WP9/JRA2 Earth System Model Evaluation developments

Work package number	9		**Lead beneficiary**			DLR	
			Co-lead beneficiary			BSC	
Work package title	Earth System Model Evaluation developments						
Participant number	11	6	8	3	1	7	14
Short name of participant	DLR	BSC	CMCC	DKRZ	CNRS-IPSL	KNMI	met.no
Person months per participant	**26**	**25**	**5**	**3**	**4**	**2**	**7**
Participant number	5	12	10	21	2		
Short name of participant	MetO	NleSC	SMHI	UniRes	UREAD-NCAS		**Total**
Person months per participant	**13**	**11**	**8**	**2**	**9**		**115**
Start month	1			**End month**	48		

Objectives

WP9/JRA2 aims at further developing the Earth System Model Evaluation Tool (ESMValTool). The ESMValTool is a community-development that aims at facilitating model evaluation within CMIP and at individual modelling centres. It consists of a *backend* that performs common pre-processing operations such as extraction, reformatting, regridding, and masking of the input data and a *diagnostic part* that includes tailored diagnostics and performance metrics for specific scientific applications. The ESMValTool is developed in several projects which have enhanced synergies in this important research area in Europe. However, these projects focus mainly on enhancements of the *diagnostic part*. Although some technical developments are covered that we will built on, a focused infrastructural effort is required to enhance the capability of the tool. The objectives of **WP9/JRA2** are:

- **Improving ESMValTool technically:** IS-ENES3 will devote a significant effort to further develop the tool so that it can efficiently handle the large amount of data expected in CMIP6 and in future phases of CMIP together with the observational data required for model evaluation while ensuring efficiency, provenance, automated testing, and proper documentation.
- **Extending ESMValTool features to attract users:** IS-ENES3 will also further advance the tool in terms of its applicability towards a seamless evaluation tool that can be consistently applied to output from global and regional climate models (RCMs) and across timescales. Furthermore, the tool will be adapted to enhance the coupling of externally developed new diagnostics via common standard interfaces and will enhance the application for model development also for irregular grids. Developments will also allow calculations by user demands.
- **Coupling of ESMValTool to other infrastructures:** One of the key points, when developing a community tool, is to foster its adaptation to other existing community infrastructures, such as ESGF. This task will ensure that the ESMValTool can be run efficiently alongside the ESGF infrastructure at selected nodes in order to ensure a stable service in **WP7/VA2** Data.

Links with other work packages: These developments will use the user survey and requirements coming from WP3/NA2 [mo 18]. User requirements and standards will be defined in **WP3/NA2 /Community**. A service with the ESMValTool will be provided in VA activities. WP7/VA2 will include those parts of the service on model evaluation that relate to ESGF; these are the systematic production of ESMValTool results at ESGF nodes and the Diagnostics Portal. WP6/SA will include the user support to the ESMValTool. The coupling to the ESGF (Task 7) and distributed computing (Task 8) have links with the corresponding data WPs.

Description of work:

Task 0: Coordination of WP9/JRA2
DLR (2 PM), BSC (2 PM), Total 4 PM

Task 0 provides the effort required for effective work package coordination, including management of resources, quality, risks, provision of periodic reports for the WP and managing the delivery of milestones and deliverables. Task 0 will also ensure the interface between the WP and the rest of the project.

Task 1: Coding Workshops and Coordination of ESMValTool activities
DLR 2 PM, BSC 1 PM, Total 3 PM

This task will prepare and run coding workshops on the ESMValTool where people come together to improve certain aspects of the tool across different projects. It will coordinate activities on the ESMValTool within IS-ENES3 and across projects.

Task 2: Technical Improvements of the ESMValTool [M3-M42]
DLR (11 PM), MetO (9 PM), BSC (8 PM), NleSC (8 PM), UREAD-NCAS (5 PM), Total 41 PM

This task will contribute to the continuous technical development of the ESMValTool by improving and extending the current capabilities and performance of the ESMValTool backend so that the requirements defined in WP3/NA2/Community are met. This work is important to ensure an efficient processing with the ESMValTool as the data volume is steadily growing, and to ensure provenance.

Enhance and improve automated testing (BSC 2 PM, NleSC 1 PM): The ESMValTool development is following an agile code development approach which makes use of modern code development techniques, based on continuous integration (CI) services. A key aspect to ensure the maturity of the code is the capability to be tested automatically. In-depth testing will be therefore implemented in the ESMValTool with a test-driven development approach. This will ensure that the code performs correctly even if different components are changed and will therefore significantly help to increase the code quality [D9.5].

Improving the performance of the ESMValTool backend (DLR 9 PM, BSC 1 PM, MetO 9 PM, NleSC 3 PM, UREAD-NCAS 3 PM). The ESMValTool backend is currently being rewritten in Python using the Iris library, but further work will be required to improve its performance, flexibility and stability. Enhancements will include the possibility to execute multiple namelists of the ESMValTool at the same time and parallelization capabilities. The multiple elements of an ESMValTool process allow for multiple opportunities for optimization - principally through increased concurrency. Significant scope arises for parallelization of data acquisition through partitioning of data requests to execute on multiple nodes (i.e. chunking). The underlying Iris functionality lends itself to several possible optimization strategies, including use of Dask, Spark, myi4py, Python threads and processes. Individual components of the ESMValTool backend workflow will be benchmarked and analysed to determine the appropriate optimization approach and initial implementations of improved versions will be developed. Task parallelism over-arches the functional approach outlined above and is naturally achieved by incorporation of ESMValTool into a workflow management system with a job scheduling engine which enables and runs asynchronous processes [D9.5].

Improve the modularization of the code (NleSC 1 PM, BSC 1 PM). Better modularization will allow more flexibility and customization in the pre-processing steps to the users. This improved modularization will also make future developments, such as parallelization, easier. It will also facilitate to plug in newly developed diagnostics and performance diagnostics that follow the standards defined in WP3/NA2 [D9.5].

Containerization (UREAD-NCAS 2 PM, BSC 1 PM, NleSC 1 PM). We will include an installation package and installation testing to improve user friendliness of the tool for installations on machines with different configurations. Deployment of complex software frequently presents barriers to its use on multiple diverse platforms Containerization of ESMValTool will significantly reduce the effort required to port the software to multiple platforms - either to central facilities or to user local compute resources. The containerized ESMValTool will package all its dependencies in a single object for easy installation on different hardware platforms. Several container technologies or automatic installation frameworks (e.g. Spack, EasyBuild) with differing limitations and capabilities are available; this work will evaluate these and emerging schemes and prototype a solution based on the evaluation [D9.5].

Implementation of standard interfaces, provenance and coding guidelines as defined in WP3/NA2 (BSC 3 PM, DLR 2 PM, NleSC 2 PM). This will include information on e.g. input data, diagnostics, software versions, PIDs, and dois in the output files as well as other metadata. We will follow standards that are developed for example as part of Copernicus and will implement them into the ESMValTool [D9.5].

Task 3: Data preprocessing and reformatting [M1-M18]
met.no (4 PM), BSC (4 PM), DLR (1 PM), KNMI (2 PM), UniRes (2 PM), Total 13 PM

In this task we will enhance data preprocessing and reformatting capabilities of the ESMValTool.

Pilot support for ocean data on original grids (UniRes 2 PM): A current need for the ESMValTool is to improve the handling of curvilinear and unstructured ocean grids and models with Lagrangian vertical coordinate (e.g. MICOM of NorESM, MOM6 of GFDL (and soon NCAR), HYCOM of FSU and GISS, AWI-CM, ICON), as ESMValTool does currently not support them. Pilot support shall be added to the Iris based preprocessor, and made usable from ESMValTool via the backend that is developed in Task 1 [D9.1].

Providing observations to the user (BSC 4 PM, DLR 1 PM, met.no 3 PM, KNMI 2 PM). Despite the recent efforts (e.g., obs4mips, ana4mips) to deliver observations and reanalyses in CMIP format, the vast majority of observations are still released without compliance to any specific standard. The ESMValTool provides the user with reformatting routines but users still need to manually download the data from the corresponding sources and apply the reformatting routines. The goal of this task is to automate the process of accessing the original data source, downloading and processing the observational data in the correct format. The design of this automated procedure should also allow adding new observation sources in an easy way [D9.1].

Version documentation of utilized observations (met.no 1 PM). Reprocessing of observational data is motivated by better data understanding but creates moving targets for model evaluation. Increasingly DOIs, better metadata and other data tagging mechanisms are implemented to allow for transparent model evaluation by attaching version information to observational datasets. These version numbers need to be carried through from the data source to the diagnostics and diagnostic products of the ESMValTool [D9.1].

Task 4: Seamless Evaluation with the ESMValTool [M6-M36]
BSC (5 PM), CMCC (5 PM), CNRS-IPSL (1 PM), met.no (1 PM), SMHI (5 PM), Total 17 PM

Application to Regional Climate Models (SMHI 5 PM, CMCC 5 PM, met.no 1 PM): RCMs supplement coarser-resolution global models providing high-resolution climate simulations necessary for impact assessment and adaptation planning at regional and local scale. Additionally, in CMIP6 some global simulations will start to reach these high resolutions. We will extend ESMValTool so that it can be applied to output from both RCMs and ESMs. To this end, we will tackle the challenges posed by a range of different curvilinear coordinate systems that are common in RCMs and by limited domains. Furthermore, we will devise solutions to deal with the vast amounts of data that stem from high-resolution RCM simulations (e.g. 1-2km). Using the same tool for both RCMs and ESMs unifies analysis and simplifies the intercomparison of climate data generated by global and regional climate models considerably. To achieve these goals we will leverage our prior experience in the CORDEX project and, consequently, ESMValTool is likely to play an important role in the future evaluation in CORDEX. To overcome the computational challenges, this task will depend on the performance improvements developed in Task 2. The increased availability of observational data sets resulting from Task 3 will further help with the evaluation of the high-resolution RCM output [D9.4].

Flexible use across different types of experiments and timescales (BSC 5 PM, CNRS-IPSL 1 PM): The ESMValTool is mainly developed to analyse historical simulations and projections and, although possible, it is not easy to adapt it for other types of experiments such as decadal predictions. It will be further developed to simplify application across different types of experiments and to add the functionalities required by the new use cases [D9.4].

Task 5: Enhancing the use of the ESMValTool for model development [M1-M24]
MetO (4 PM), BSC (1 PM), CNRS-IPSL (2 PM), met.no (2 PM), SMHI (3 PM), Total 12 PM

Quicklook system for online diagnostics (SMHI 2 PM, met.no 1 PM): Based on previous work we will further enhance the quicklook capability of the ESMValTool that allows monitoring simulations while they are running in the machine. This capability has already been developed for the MPI-ESM and EMAC, and will be enhanced here in terms of diagnostics shown and models it can be applied to. More concretely, we will develop a new component for the coupling scheme that allows the application of ESMValTool as an online analysis tool [D9.2].

Incorporation of ESMValTool into modelling or stand-alone workflow (MetO 4 PM, CNRS-IPSL 2 PM, met.no 1 PM, BSC 1 PM, SMHI 1 PM): A requirement for using the tool for model development is to be able to assess a test model against a control. Bringing in this functionality requires processing of model output in its native format. This will increase the use of ESMValTool within model development centers and will also be a

step towards bringing in additional metrics/diagnostics from other tools which are currently used for model development (e.g. Auto-assess) as these other tools will then be merged with / replaced by ESMValTool [D9.2].

Task 6: Coupling of externally developed diagnostics and metrics to the ESMValTool
DLR (6 PM), BSC (2 PM), Total 8 PM

We will enhance the ESMValTool with new diagnostics and performance metrics as they become available from the community via pull requests in the ESMValTool github repository. The service activity in WP7/VA2 will be enhanced accordingly. The main task here is to work with the external developers to ensure that standards and coding rules defined for ESMValTool and in WP3/NA2 and WP5/NA4 are met before the externally developed diagnostics are merged to the master branch and integrated into the next official release of the tool. It will also be ensured that automatic documentation and provenance for WP7/VA2 is fully working. As is currently already the case for example for the NCAR Climate Variability Diagnostic Package, the scientific functionality itself sometimes resides in the external library. The activity will be restricted to support of community consensus developed packages such as the ENSO metrics package or packages that might be developed by individual CMIP6-Endorsed MIPs or international panels [D9.5].

Task 7: Coupling of ESMValTool to the ESGF
UREAD-NCAS (4 PM), DKRZ (3 PM), DLR (2 PM), Total 9 PM

We will enhance the ESMValTool so that it can be executed quasi-operationally in WP6/SA1 to produce a broad assessment of model performance as part of the ESGF publishing workflow [D9.3], as could documentation and visual displays of the evaluation results with records of provenance. This requires acquiring and potentially caching data as needed for the ESMValTool. Tools such as esgf-pyclient and synda exist which allow interrogation of local and distributed node data, and which could transfer the necessary data into either a cache or the ESGF replica storage. OPeNDAP could also be used without the necessity for a cache. The task will include: (a) efficient scalable storage integration, scalable parallel processing support; (b) data replication integration; (c) exposure of ESMValTool functionalities as ESGF WPS services (thus integration of the efforts into the IS-ENES3 data near compute efforts and European contribution to the ESGF compute team activities as well as integration of Copernicus efforts), and (d) support of provenance tracking of generated data products: Automatic PID assignment, PID collection assignment for input data, in general provenance support building a bridge to automatic DOI assignment for specific activity results, for citation in literature.

Task 8: Distributed ESMValTool computing and calculations on user demand
NleSC (3 PM), BSC (2 PM), DLR (2 PM), CNRS-IPSL (1 PM), Total 8 PM

We regard the option to host all required data as replicas and to run diagnostic alongside an ESGF node as practical in the CMIP6 timeframe, but a possibly more promising option on the long-term that we will work on is to distribute the processing of diagnostics at different ESGF nodes [D9.3]. One possibility is to make use of WPS calls to remote sites, running the ESMValTool preprocessor at each ESGF node, and run all diagnostics at a single location, gathering up all data enabling calculations by user demands.

Deliverables

All deliverables of WP9/JRA2 will consist of the release of an enhanced ESMValTool version in the ESMValTool github repository and a corresponding report. The enhanced versions of each deliverable will be accompanied by documentation for the user's and developer's guide following ESMValTool guidelines.

D9.1 (Task 3, mo 18). ESMValTool version supporting irregular and unstructured grids. This report will include a list of new models supported and examples of application will be provided. A new release of the ESMValTool will be provided (met.no).

D9.2 Task 5, mo 24). ESMValTool version enabling model development usage. This deliverable will track the developments done to allow ESMValTool to work as modelling support tool. It will include examples of usage from modelling teams and quicklook capabilities**.** A new release of the ESMValTool will be provided (MetO).

D9.3 (Task 7 and 8, mo 30). ESMValTool version with ESGF coupling and distributed computation

features: Use cases provided by community users and an evaluation of the execution in production nodes will be included. A new release of the ESMValTool will be provided (UREAD-NCAS).

D9.4 (Task 4, mo 36). ESMValTool version supporting regional climate models and different timescales: This version will include the extension of the ESMValTool for decadal simulations. Examples of application will be provided. A new release of the ESMValTool will be provided (BSC).

D9.5 Tasks 1, mo 48). Final IS-ENES3 ESMValTool version. At the end of the project, a final version of the code will be released as open source code, including all the developments performed during the project. A paper, describing all the features developed in the context of the project will be published (DLR).

Milestones*:*

M9.1 (Task 1, mo 36): Release of enhanced ESMValTool documentation for VA1 activity. Release on ESMValTool github repository (DLR)

M9.2 (Task 1, mo 36): Release of enhanced ESMValTool version for VA2 activity. Release on ESMValTool github repository (BSC).

WP10/JRA3 ENES Climate Data Infrastructure software stack developments

Work package number	10		**Lead beneficiary**			CMCC	
	10		**Co-lead beneficiary**			CERFACS	
Work package title	ENES Climate Data Infrastructure software stack developments						
Participant number	6	4	8	3	1	7	22
Short name of participant	BSC	CER-FACS	CMCC	DKRZ	CNRS-IPSL	KNMI	LiU
Person months per participant	**3**	**36**	**19**	**7**	**21**	**37**	**2**
Participant number	10	9	13	2			
Short name of participant	SMHI	STFC	UC	UREAD-NCAS			**Total**
Person months per participant	**12**	**17**	**10**	**10**			**174**
Start month	1			**End month**	48		

Objectives

This WP will evolve and consolidate the ENES climate data infrastructure software stack according to the overall project objective #3, *IS-ENES3 will support the exploitation of model data by both the earth system science community and the climate change impacts community*. Driven by user requirements gathered in WP5/NA4, this WP will design and develop the software stack regarding the key services offered by the ENES CDI in WP7/VA2 and deployed at European data centers.

The involved software components are developed and maintained as open source efforts by the IS-ENES partner institutes as well as the international ESGF developer community. This WP will address key software components related to the data infrastructure like data distribution, processing, vocabulary management, documentation and impact study tools. It will also address the data access/processing for the climate impact research and modeling community, ensuring significant societal impacts. The activities will be performed by also taking into consideration efforts ongoing in the wider European 'data' ecosystem and will look forward to the EOSC roadmap and evolution as well as to the Copernicus landscape.

The main goals of this WP are to:

- Systematically improve and consolidate the IS-ENES CDI software stack as a basis for a sustainable, streamlined and scalable climate model data distribution solution for users in the climate modeling as well as climate impact research and modeling communities;
- Provide an interoperable and flexible computing layer supporting scientific data analysis and processing within the infrastructure, by evolving existing solutions towards an integrated set of processing related service offerings for end users (from climate researchers to climate impact research and modeling community including long tail end users);
- Support interoperability of data files and archives for automated data processing through improved and extended standards and metadata;
- Evolve the climate4impact platform (C4I http://climate4impact.eu) towards a climate data analytics portal for impact scientists. This is done by providing advanced data processing services and data access services in the C4I portal. The functionalities will be made available through user friendly interfaces (e.g., tailored search interfaces, guided wizards, Jupyter notebooks with use case examples);
- Maintain and develop the ES-DOC international documentation infrastructure to support CMIP6 and other MIPs as well as expand the scope of documentation to new areas for the climate modelling process, including model evaluation.

Links with other work packages:

All WP10/JRA3 activities will be informed from WP5/NA4 and WP3/NA2 networking activities and will improve WP7/VA2 IS-ENES3 data services. WP10/JRA3 activities will also be informed by WP5/NA4 on the interoperability with existing e-infrastructures (e.g. EGI/EUDAT), Copernicus C3S, as well as EOSC and related initiatives (e.g. EOSC-hub) focusing on distributed computing aspects. Activities on climate indices will furthermore be informed by the workshops

Description of work:

Task 0: Coordination of WP10/JRA3
CMCC (WP leader, 2 PM), CERFACS (WP co-leader, 2 PM), Total 4 PM

Task 0 provides the effort required for effective work package coordination, including management of resources, quality, risks, provision of periodic reports for the WP and managing the delivery of milestones and deliverables. Task 0 will also ensure the interface between the WP and the rest of the project.

Task 1: Core data distribution services
CNRS-IPSL (7 PM), DKRZ (4 PM), STFC (4 PM), CMCC (7 PM), BSC (3 PM), LiU (2 PM), UC (6 PM), Total 33 PM

The ENES CDI is based on integrated service deployments at European data centers. The underlying software components are developed and maintained based on open source efforts by IS-ENES partner institutes as well as the ESGF developer community. The goal of Task 1 is to systematically improve the data storage and distribution of Climate Model data infrastructure components as a basis for a sustainable, streamlined and scalable climate model data distribution solution for users in the climate and climate impact research communities. The focus is in the establishment of a sustainable software testing, installation and deployment process of core data infrastructure components across IS-ENES data centers as well as consistent metrics collection. This will improve the maintenance of existing installations and simplifying the deployment of new ENES CDI data nodes, thus contributing to a sustainable distributed service infrastructure.

By close collaboration with associated networking activities (WP5/NA4) this work will reflect the requirements and needs of the climate community as a whole and will be done in close collaboration with ESGF. This activity integrates the components developed in the other tasks of WP10 (e.g. data processing, workflows, vocabulary management, documentation) providing the proper connection and user interfaces to the entire climate community.

Task 2: Develop a compute layer for processing and analytics for CMIP6 and CORDEX
CMCC (10 PM), DKRZ (3 PM), STFC (3 PM), KNMI (6 PM), CERFACS (3 PM), Total 25 PM

This task will target the core part of the scientific data analytics and processing layer in order to fully address computing needs and move forward a sustainable and integrated data analytics and processing model. The compute software stack will be designed to efficiently support end-user needs (e.g. multi-model analytics experiments, climate indicators, etc.) thus serving a large user base in IS-ENES, also including the long tail of climate research. The access to the climate datasets will be ensured by designing a strong and seamless link to the data services set up in the Task 1. Close collaboration with the related networking activity (WP5/NA4) ensures that the various requirements from end-user side as well as service provider and emerging service infrastructure side are properly taken into account. This task will also implement the software components and interfaces needed to support the integration of processing/analysis codes into IS-ENES CDI processing services.

External access to hosted services will require an appropriate solution for access control and proper extensions at the processing service level interface, to ensure legitimate use of the computing resources at the host facility by external users. The ESGF access control system has recently been enhanced to support the widely adopted OAuth 2.0 framework; this includes functionality for user delegation which can be used to address the complex access control scenarios associated with processing services.

Task 3: Improve the user interface and functionalities of the climate4impact platform for the impact communities
CERFACS (17 PM), KNMI (11 PM), UC (4 PM), Total 32 PM

This task will work on consolidating and extending the climate4impact front-end, incorporating lessons learned from current interface and user communities. The user communities will be engaged for requirements and regular evaluations in close cooperation with WP3/NA2 Task 4. Task 3 will:

- Deliver better data search interfaces and services, using the vocabulary services build in Vocabulary Management, ESGF faceted search and ES-DOC.

- Develop a reusable wizard and workflow interface components for climate indicators calculations.
- Consolidate and automate monitoring of KPI's.
- Update and improve user documentation and use cases, integrating the use of the provided vocabularies.
- Focus on a data-oriented interaction with a THREDDS single point of access to hide the ESGF data nodes file structure organization to end users, and modify the User Interface accordingly in consultation with user requirements.
- Improve usability of the provided user interfaces from user feedbacks. Regular user evaluation on usability in coordination with WP3/NA2.

Task 4: Integrate the newly developed data compute services for data analytics into the climate4impact platform
KNMI (20 PM), CERFACS (12 PM), SMHI (6 PM), Total 38 PM

This task will work on integrating into climate4impact the newly developed data compute services for data analytics. It will also take into account the newly developed Copernicus C3S tools and platform. The work is divided in the following specific subtasks:

- Evaluate feasibility of going toward dockerization of climate4impact self-containing services using a micro-services approach, that can be easily deployed and configured.
- Consolidation and improvements on the underlying software ICCLIM, providing on-demand ECA-D[15] and ETCCDI[16] climate indices calculations, preparing for CMIP6/7 data. Integration of model diagnostics (ESMValtool, VA2/task4). Will coordinate with Task 6.
- Integration of metadata, provenance and DRS standards for calculated indices and user data processing results (using results from the WP3/NA2 workshop).
- Delegation of compute calculations using the ESGF Computing Nodes (CWT API), the Ophidia framework, and investigate the feasibility of delegating to the EUDAT/EGI FedCloud (EOSC) e-infrastructures. Coordinate with the Copernicus C3S tools and platform (with WP3/NA2).

Task 5: ES-DOC extensions for CMIP and other community projects
CNRS-IPSL (11 PM), STFC (4 PM), UREAD-NCAS (8 PM), Total 35 PM and subcontracting

The main goal of this task is to address future capabilities of ES-DOC. Beyond the CMIP6 documentation on models, simulations, experiments, conformance to protocol, (https://es-doc.org/cmip6) we will extend the scope of the ES-DOC documentation to new community projects. These were identified during IS-ENES2 and include Obs4MIPs, the downscaling description integration (linked to task 1), seasonal to decadal forecasting specific requirements and model evaluation support. This will require revisions to the standard information model (CIM) [UREAD-NCAS, CNRS-IPSL], new specialisations and vocabularies [STFC, UREAD-NCAS] and new functionalities in the ES-DOC ecosystem [CNRS-IPSL]. Related community requirements will be gathered from the WP3/NA2 activity.

Task 6: Tools, services, information models for data standards
STFC (6 PM), CNRS-IPSL (3 PM), SMHI (6 PM), UREAD-NCAS (2 PM), CERFACS (2 PM), Total 19 PM

Vocabulary management tools should support the lifecycle of the vocabularies used in the data service infrastructure, from the development of the vocabularies to community engagement and distribution for use in tools. The tools should enable the community to support a range of model intercomparison projects. Different vocabularies have different governance and management structures: the aim here is to create a clearing house with vocabularies from different system components (e.g. ES-DOC, CF, ESGF).

The CMIP Data Request specifies details of thousands of physical parameters and the specifications for hundreds of numerical experiments tailored to the requirements of multiple user communities. Variable lists may be filtered by priority, scientific objective, and a range of model configuration options. The schema is designed to promote automated processing of the request so that modelling groups can streamline the effort required to

[15] European Climate Assessment & Dataset <https://www.ecad.eu//indicesextremes/index.php>
[16] CCl/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices <https://www.wcrp-climate.org/data-etccdi>

configure their models to generate the required output. The Data Request is distributed as a structured document with a supporting python library providing programming interface. The requirements for the data request schema and tools will be reviewed through a dedicated workshop in WP3/NA2. [STFC, IPSL]

This task will draw on user/community input from a dedicated workshop in WP3/NA2 to develop schema (including extension to CF standard) and tools for handling requirements for climate indicators (i.e. WCRP/JCOM/CCl ETCCDI, WMO/CCl ET-SCI[17], and ECAD climate indices) and for configuration of metadata used in workflows and data publication, with implementation in ICCLIM. The schema will facilitate the generation of climate index data sets with comprehensive metadata, enabling efficient distribution and exploitation of these datasets. This work will be strongly coordinated with Task 4. [SMHI, CERFACS, UREAD-NCAS]

Deliverables:

D10.1 (Tasks 1 to 6, mo 18): Architectural document of the ENES CDI software stack
The report will provide a formal documentation about the software design document of the ENES CDI software stack (CMCC).

D10.2 (Tasks 1 to 6, mo 24): First release of the ENES CDI software stack
D10.2 will provide the first release of the ENES CDI software stack (software repositories, licensing information, change logs, link to technical documentation). The deliverable will report about the implementation of the core data distribution services, climate4impact, ES-DOC, compute services and their integration with downstream applications, data request schema & tools for MIPs, and file metadata specifications for climate indices. The deliverable will also review and refine the technical requirements and provide an update of the software architecture (KNMI).

D10.3 (Tasks 1 to 6, mo 36): Second release of the ENES CDI software stack
D10.3 will provide a second release of the ENES CDI software stack, updating D10.2. The report will present the release and update the D10.2 report, based on the third year activity (CNRS-IPSL).

D10.4 (Task 5, mo 46): CMIP6 documentation
CMIP6 documentation on climate models, simulations and ensembles, experiments and conformance to experimental protocol, delivered via web services and tools developed in IS-ENES3 (CNRS-IPSL).

D10.5 (Tasks 1 to 6, mo 48): Final release of the ENES CDI software stack
D10.5 will provide the final release of the ENES CDI software stack. It will also report on the final implementation of the ENES CDI software stack. This report will provide an update of D10.3 based on the last year activity (CERFACS).

Milestones:
M10.1 (Tasks 1 to 6, mo 14): Technical requirements on the software stack
Report providing a comprehensive list of technical (both functional and non-functional) requirements for the ENES CDI software stack (CMCC).
M10.2 (Task 6, mo 18): CMIP data request schema 2.0
The data request schema used for CMIP6 will be upgraded and released to support CMIP7. The schema will propose an information model to be used for the CMIP7 Data Request (STFC).
M10.3 (Task 6, mo 24): Climate indicators/indices and file metadata specifications and tools
Short report on internationally agreed standards for metadata and DRS specifications for climate indices and indicators. List and description of compliant tools. Description of the integration of a provenance model for processing (SMHI).
M10.4 (Task 6, mo 48): Update of the climate indicators/indices and file metadata specifications and tools
Update of the M10.3 report on internationally agreed standards for metadata and DRS specifications for climate indices and indicators. List and description of compliant tools. Description of the integration of a provenance model for processing (SMHI).

[17] WMO Commission on Climatology Expert Team on Sector-specific Climate Indices <http://www.wmo.int/pages/prog/wcp/ccl/opace/opace4/ET-SCI-4-1.php>

3.1.4 List of Deliverables

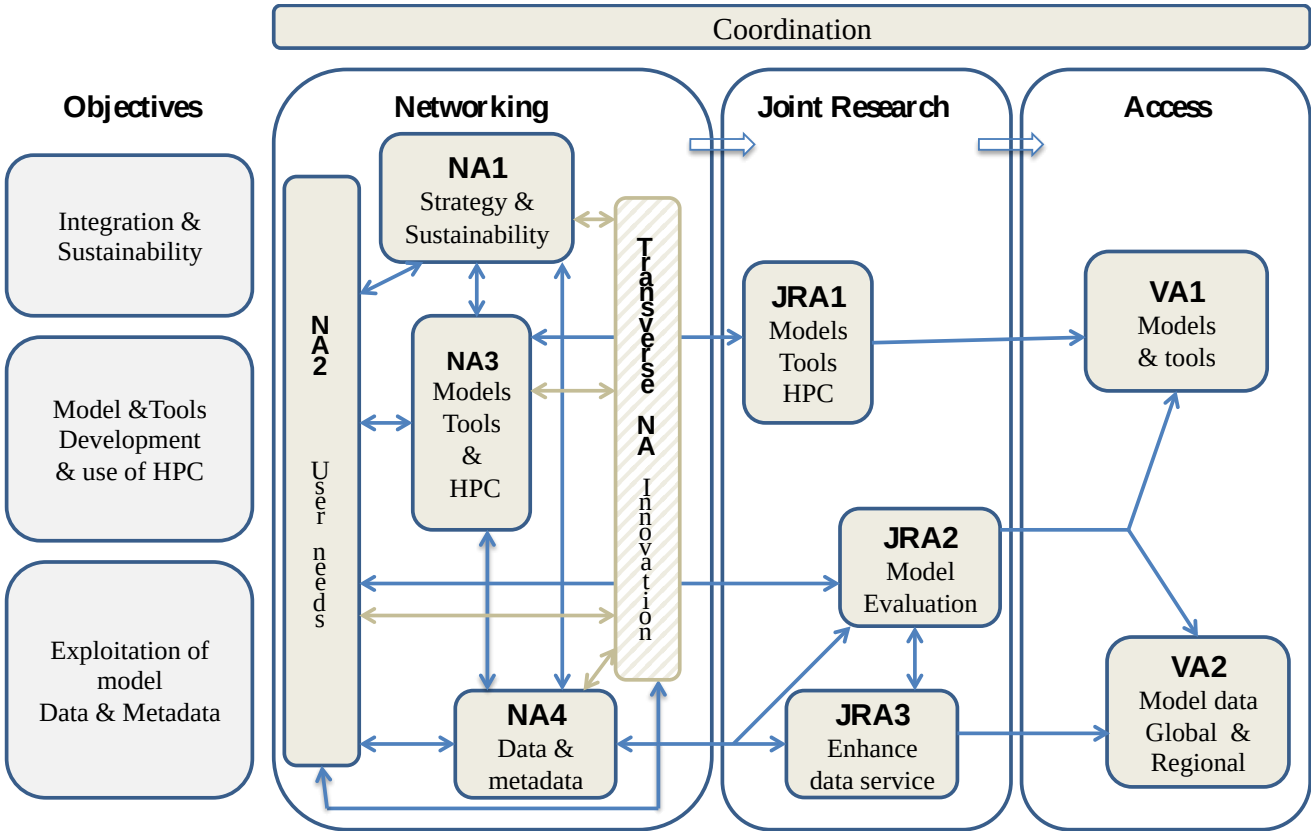
Table 3.1c: List of Deliverables

Deliverable (number)	Deliverable name	Related WP and task number	Lead partner	Type	Dissemi-nation level	Delivery date (in months)
D1.1	Data Management Plan	WP1, T4	UREAD-NCAS	R	PU	M4
D1.2	Consortium agreement	WP1, T1	CNRS-IPSL	R	CO	M6
D1.3	Dissemination and Exploitation Plan	WP1, T3	CNRS-IPSL	R	CO	M6
D2.1	Infrastructure Strategy for Earth System Modelling for 2022-2032	WP2, T4	UREAD-NCAS	R	PU	M36
D2.2	ENES-RI Sustainability Plan	WP2, T3	DKRZ	R	PU	M42
D2.3	Final Report on Innovation Activities	WP2, T2	STFC	R	PU	M42
D2.4	Final report on Governance Activities	WP2, T1	UREAD-NCAS	R	PU	M48
D3.1	Initial requirements on model evaluation	WP3, T3 and T4	CNRS-IPSL	R	PU	M18
D3.2	Synthesis on climate and impact and climate data schools	WP3, T2	WENR	R	PU	M36
D3.3	Standards synthesis	WP3, T3	STFC	R	PU	M36
D3.4	CMIP documentation requirements	WP3, T4	UREAD-NCAS	R	PU	M36
D3.5	Synthesis on activities to broaden the community	WP3, T1	KNMI	R	PU	M46
D3.6	Overview of user requirements	WP3, T4	KNMI	R	PU	M46
D.4.1	Coupling workshop report	WP4, T5	CERFACS	R	PU	17
D.4.2	Development Strategy for Sea Ice modelling toolset	WP4, T2	MetO	R	PU	26
D 4.3	CPMIP performance metrics and community advice.	WP4, T3	BSC	R	PU	35
D.4.4	NEMO QA update	WP4, T1	CNRS-IPSL	Other	PU	40
D.4.5	White paper on innovation on tools, platforms and techniques.	WP4, T3, T4,T6	UNIMAN	R	PU	44
D5.1	Compute service requirements and state of the art approaches	WP5, T4	CERFACS	R	PU	12
D5.2	Technical standards for diagnostic tools	WP5, T5	BSC	R	PU	24
D5.3	Architecture design plans	WP5, T2	CNRS-IPSL	DEM	CO	36
D5.4	IS-ENES3 involvement in ESGF	WP5, T3	DKRZ	R	PU	36
D5.5	Style guide on coding standards	WP5, T5	NleSC	R	PU	36
D5.6	ES-DOC governance	WP5, T1	CNRS-IPSL	R	CO	46

D6.1	First periodical report on service statistics for models and tools	WP6, T2, and T3	SMHI	R	PU	18
D6.2	First external review of model and tools services	WP6, T0	SMHI	R	PU	24
D6.3	Second periodical report on service statistics for models and tools	WP6, T2 and T3	CERFACS	R	PU	36
D6.4	TNA report on new OASIS coupled models/interfaces	WP6, T3	CERFACS	R	PU	36
D6.5	Second external review of model and tools services	WP6, T0	CERFACS	R	PU	40
D6.6	Third periodical report on service statistics for models and tools	WP6, T2, and T3	SMHI	R	PU	48
D7.1	First KPI and TNA report for ENES CDI services	WP7, all tasks	DKRZ	R	PU	18
D7.2	First external review report for ENES CDI services	WP7, T0	KNMI	R	PU	24
D7.3	Second KPI and TNA report for ENES CDI services	WP7, all tasks	DKRZ	R	PU	36
D7.4	Second external review report for ENES CDI services	WP7, T0	KNMI	R	PU	40
D7.5	Report on operational support for CMIP documentation	WP7, T5	CNRS-IPSL	R	PU	42
D7.6	Third KPI an TNA report for ENES CDI services	WP7, all tasks	DKRZ	R	PU	48
D.8.1	NEMO sea ice model code	WP8, T2	MetO	Other	PU	24
D 8.2	OASIS3-MCT_5.0 release	WP8, T3	CERFACS	Other	PU	36
D 8.3	XIOS new release	WP8, T4	CNRS-IPSL	Other	PU	40
D8.4	Cylc / Rose development summary	WP8, T5	MetO	R	PU	40
D8.5	Update of the NEMO code	WP8, T1	CMCC	Other	PU	44
D9.1	ESMValTool version supporting irregular and unstructured grids	WP9, T3	met.no	R	P	18
D9.2	ESMValTool version enabling model development usage	WP9, T5	MetO	R	P	24
D9.3	ESMValTool versionwith ESGF coupling feature and distributed computing capabilities	WP9, T7, and T8	UREAD-NCAS	R	P	30
D9.4	ESMValTool version supporting regional climate models and different timescales	WP9, T4	BSC	R	P	36
D9.5	Final IS-ENES3 ESMValTool version	WP9, T1	DLR	R	P	48
D10.1	Architectural document of the ENES CDI software stack	WP10, T1 to T6	CMCC	R	PU	18
D10.2	First release of the ENES CDI software stack	WP10, T1 to T6	KNMI	R	PU	24
D10.3	Second release of the ENES CDI software stack	WP10, T1 to T6	CNRS-IPSL	R	PU	36
D10.4	CMIP6 documentation	WP10, T5	CNRS-IPSL	Other	PU	46
D10.5	Final release of the ENES CDI software stack	WP10, T1 to T6	CERFACS	R	PU	48

3.1.5 Graphical presentation of work packages and their interdependencies

Interdependencies between work packages are described in each WP description (*section 3.1.3*). A graphical representation of their interdependencies is given below, expanding the graphical representation of Figure 3.



3.2 Management structure, milestones and procedures

3.2.1 Organisational structure and the decision-making

The IS-ENES consortium is composed of 22 partners from 11 European countries and delivers infrastructure which supports a much larger constituency, including universities, other research organisations, and public bodies. As such it needs to deal with two layers of decision-making: working with the community it supports to establish infrastructure requirements and priorities; and responding to both external and internal priorities within the project, its partners and collaborators. The project structure reflects both the delivery of the project, and engagement with the community.

IS-ENES3 manages external requirements by identifying two routes of engagement: top-down via stakeholders, and bottom up, by working directly with the community in workshops and training events etc. The project itself is managed by a leadership team with an external independent science advisory board, and the project structure is designed to deliver the necessary infrastructure, and work with these two lines of input.

WP1 delivers the key elements of project management and coordination, WP2/NA1 delivers the "top-down" interface to the community, WP3/NA2 delivers the "bottom-up" engagement with the "user" community, and WP4/NA3, and WP5/NA4 network more directly with the model and data "provider" communities.

The following entities deliver the requisite management for the Consortium:

1. The **Partie**s are the contractors who form the Consortium
2. The **Coordinator** will be the legal entity acting as the intermediary between the Parties and the European Commission. The Coordinator will, in addition to its responsibilities as a Party, perform the tasks assigned to it as it is described in the Grant Agreement and the Consortium Agreement.

3. The **Coordination Team** will be responsible for ensuring that the Coordinator can deliver on its responsibilities. It consists of
    a. The **Project Coordinator** – who is ultimately responsible to the Coordinator for the project delivery.
    b. The **Project Lead Scientist** – who provides additional scientific and technical leadership with a particular focus on technical futures and sustainability.
    c. The **Scientific Officer** – who will support the Project Leader and the Project scientist in strategic tasks including the key liaison roles required with other projects and consortia and national and international bodies.
    d. The **European Project Manager** – who will aid the Coordinator and Project Leader in delivering their coordination responsibilities.
4. The **Project Leadership Team** (PLT) – consists of the work package leaders, their co-leads and the coordination team. The **Work Package Leaders** are responsible for the activities within their work packages, including their deliverables and the project milestones.
5. The **Stakeholders Board** consists of representatives of the key users and providers of the IS-ENES infrastructure, including the major modelling groups and representatives of large funded science projects.
6. The **Science Advisory Board** consists of independent external experts who can provide scientific advice and reflection from an alternative perspective.
7. The **General Assembly** consisting of a representative of each of the Parties, will be the ultimate decision making body of the Consortium.

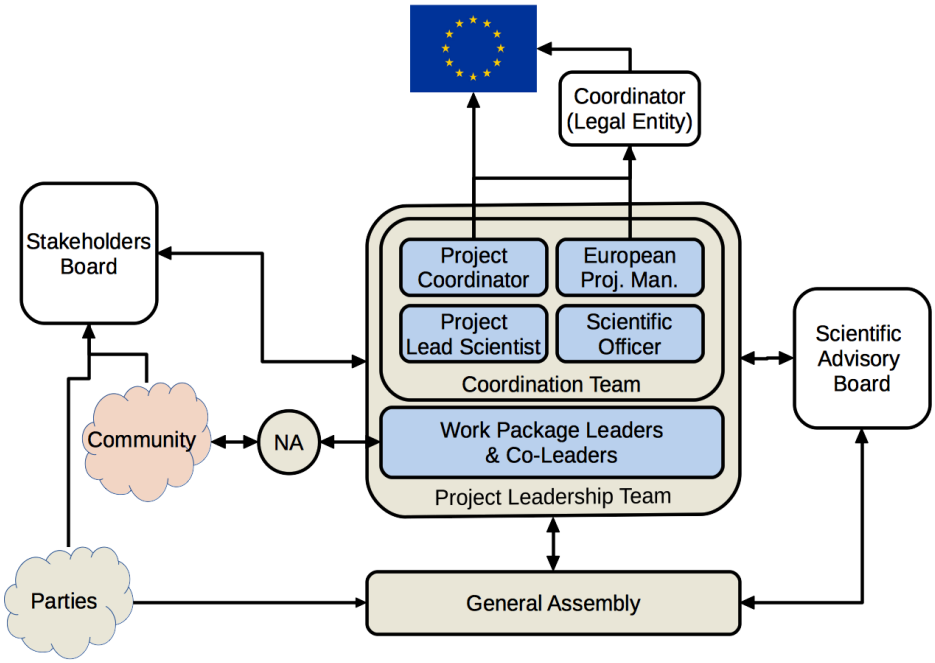


Figure 5: Overview of IS-ENES3 Management structure.

The Coordinator

Responsibility: The Coordinator is responsible for the adherence to the contractual obligations in all activities of the Project, including prompt delivery of all reports and deliverables required by the European Commission.

The coordinator will:

- Monitor the work progress of the consortium to ensure that the milestones and deliverables are being achieved in time and within budget.
- Report to the EC on the progress of the consortium by providing all scientific reports requested.
- Represent the Consortium.
- Anticipate any problems which can affect the implementation of the project.

- Lead the consortium in order to ensure a good cooperation and communication between partners.
- Promote and monitor gender equality in the project

CNRS, on behalf of the Institut Pierre Simon Laplace, will act as the technical, financial and administrative coordinator for the IS-ENES3 project. The Coordinator will manage the project with the help of a full time European Project Manager (EPM). The Coordinator will be assisted by the CNRS administrative and legal administration.

The Administrative Management Department from CNRS will provide a strong support to the Coordination Team. Indeed, CNRS has a long experience in the management of European projects, and dedicates staff on financial, legal, and administrative issues. CNRS has a European contracts unit, especially dedicated to financial reporting for EU projects.

Key Individual Roles

Dr Sylvie Joussaume will be the **Project Coordinator**. She is a senior scientist within CNRS. She has a long experience in project management. She has been the Coordinator of the two first phases of IS-ENES (2009-2017) and has been Chair of the ENES Scientific Board since 2007. She has been laureate from the French 5th edition of the "*Etoiles de l'Europe*" in december 2017[18] for her IS-ENES2 coordination. She is an expert in climate modelling and has involved in IPCC assessment reports since the third report. Previously she was appointed as director of the Institut National des Sciences de l'Univers (INSU) (http://www.insu.cnrs.fr/) which coordinates national research in the fields covering Earth sciences, from the Earth interior to the surface, astronomy and astrophysics as well as space research. She has also led an interdisciplinary consortium of laboratories around Paris aiming at developing interdisciplinary researches on climate change and its impacts (http://www.gisclimat.fr/). She has been involved in the Climate KIC of EIT and is a member of the Governing Board of JPI Climate (http://www.jpi-climate.eu/). In France, she coordinates the national research infrastructure on climate modelling (https://climeri-france.fr/).

Professor Bryan Lawrence will be the **Project Lead Scientist**. He holds a chair in Weather and Climate Computing at the University of Reading (UREAD-NCAS) and is the Director of Models and Data in the UK National Centre for Atmospheric Science. He is the HPC technical advisor for the UK Natural Environment Research Council, responsible for the JASMIN data intensive supercomputer, and the specification for, and the use of, national HPC platforms by the environmental science community. Amongst other commitments, he is on the Science Advisory Board of the Barcelona Supercomputer Centre, the Advisory Board of the US NCAR Computational and Information Systems Laboratory (CISL), the board of the UK CMIP6 project, the Independent Advisory Board for the NZ Deep South Climate Challenge, and has recently provided independent science assurance for the German Helmholtz Association.

The European Project Manager (EPM) will be the right-hand of the Coordinator. He/she will ensure the day-to-day management of the project, focusing on the administrative, financial, legal and communication aspects. In close cooperation with the Coordinator, the EPM will be the direct interface of the European Commission team to fulfil any contractual obligations and be responsible for the communication of all management information to and from the consortium to the EC, including to

- Ensure the follow up of the contractual terms (deliverables, activities and financial reports).
- Coordinate and/or contribute to administrative, financial reports considering the deadlines.
- Ensure the follow up of the implementation of the Consortium Agreement.
- Coordinate the internal communication of the project (implementation of tools in order to facilitate the exchanges between partners especially on the progress of results).
- Coordinate the external communication of the project (implementation of a website, organisation of workshops, seminars).
- Organise any consortium meetings (the kick-off and final meetings General assembly meetings...) in collaboration with the partners.

The ENES Scientific Officer will focus on the key external individuals, EU and other projects and CoEs and

[18] http://www.horizon2020.gouv.fr/cid123638/cinquieme-edition-des-etoiles-de-l-europe-les-chercheurs-recompenses-pour-leur-engagement-europeen.html

activities with which the project must work. She/he will work with the science advisory board, the stakeholder board, and the HPC and Data task forces (see WP2/NA1) to understand and reflect high-level requirements to the leadership team. She/he will work on the strategy and sustainability of the infrastructure, and be responsible alongside the WP2/NA1 task leader for innovation, and the co-leads for WP3/NA2 for bringing together a project-wide approach to innovation, impact, and a wider user-base.

The Work Package Leaders. Each Work Package Leader is in charge of the coordination of activities inside their Work Package and achieving the goals set in the work plan. They report to the Coordination Team and the other WP leaders, within the Project Leadership Team. IS-ENES3 has also designated WP Co-Leaders that will help the Work Package leaders in the coordination of their activities. They will also supplement the WP leaders at meetings or teleconference if they are available, help with the reports, and ensure the links within and between the work packages. The Work Package Leaders and co-Leaders will:

- Track and monitor the progress in their respective WP.
- Prepare the deliverables, milestones and any requested reports in cooperation with the participants of their respective WP.
- Ensure a good communication within and between WPs.
- Contact the coordinator for specific assistance.
- Exchange regularly on the progress results with the WP Leaders.
- Report to the coordinator any problems, conflicts which cannot be solved within the WP.

WP number	WP Leader Participant short name	WP Leader	WP Co-Leader Participant Short name	WP Co-Leader
1	CNRS-IPSL	Sylvie Joussaume (F)	UREAD-NCAS	Bryan Lawrence (M)
2	UREAD-NCAS	Bryan Lawrence (M)	DKRZ	Michael Lautenschlager (M)
3	CNRS-IPSL	Eric Guilyardi (M)	KNMI	Janette Bessembinder (F)
4	MetO	Mick Carter (M)	BSC	Mario Acosta (M)
5	CNRS-IPSL	Sébastien Denvil (M)	SMHI	Klaus Zimmermann (M)
6	SMHI	Uwe Fladrich (M)	CERFACS	Eric Maisonnave (M)
7	DKRZ	Stephan Kindermann (M)	KNMI	Wim Som de Cerff (M)
9	CERFACS	Sophie Valcke (F)	CMCC	Silvia Mocavero (F)
10	DLR	Veronika Eyring (F)	BSC	Kim Serradell (M)
11	CMCC	Sandro Fiore (M)	CERFACS	Christian Pagé (M)

Key Project Bodies

The General Assembly is the ultimate decision-making body of the Consortium and takes decision supported by the Project Leadership Team. It will oversee the work of the project. It is composed of one representative from each participant empowered to making decisions on behalf of his/her organization. The Coordinator chairs the General Assembly, unless otherwise decided by the General Assembly.

The General Assembly will decide on all important issues, including:

- Implementation or modification of the Consortium Agreement;
- Approval of reports by the Coordinator;
- Research strategies, following the expression of requirements from Stakeholder Board, and the wider community, and with advice from the Scientific Advisory Board;
- Any significant modification of the work-plan (including any consequential budget changes);
- Acceptance and/or exclusion of new participants;
- Any other matters brought to it by the Coordinator, the Project Leadership Team, or by any individual Party representative.

Decision making procedure: The decision-making procedure within the General assembly will be based on the principle of one party-representative, one vote. Where possible consensus decisions will be made to avoid voting. Decision making procedures, which regroup voting rules and quorum, veto rights and minutes of meetings, will be regulated by the Consortium Agreement signed by each of the beneficiaries.

General operational procedures: The coordinator shall convene ordinary meetings of the General Assembly at least once for each Reporting Period and shall also convene extraordinary meetings as needed, or at any time upon written request of any Member. Where possible any interstitial meetings that may be necessary will utilize video or telephone conference calls.

The Project Leadership Team shall prepare the meetings, propose decisions and prepare the agenda of the General Assembly, respecting the objective to reach consensus before making proposals. It will be responsible for the proper execution and implementation of the decisions of the General Assembly. It will monitor the effective and efficient implementation of the Project itself, including progress against milestones and deliverables. In doing this, it shall collect information at least every six months on the progress of the Project from each work package and examine that information to assess compliance with the work plan and, if necessary, propose modifications of the work plan to the General Assembly. Specifically, it will:

- Initiate and coordinate the Work Packages;
- Support the Coordinator and the Coordination Team in preparing meetings with the European Commission and in preparing related data and deliverable materials;
- Prepare the content and timing of press releases and joint publications by the Consortium or proposed by the European Commission.

In the case of abolished tasks as a result of a decision of the General Assembly, the Project Leadership Team will advise the General Assembly on ways to rearrange tasks and budgets of the Parties concerned. Such rearrangement will take into consideration the legitimate commitments taken prior to the decisions, which cannot be cancelled. The Project Leader, or her nominee if she is unavailable, shall normally chair all meetings of the Project Leadership Team, unless decided otherwise by the General Assembly.

The Stakeholder Board responsibilities include representing both the institutional providers of the infrastructure, and the key users of the IS-ENES infrastructure, including the major modelling groups and representatives of large funded science projects. It will provide a forum for engagement around strategic scientific objectives, their infrastructural consequences, and the long-term sustainability of the infrastructure. The stakeholders board will be appointed during Year 1 (see Task 1, WP2/NA1) and provide annual input into the PLT. Of necessity the stakeholder's board will include some individuals from Parties to the Consortium, but in such cases the members will be expected independent of their Parties in the General Assembly.

The Scientific Advisory Board will provide general independent guidance to the project. In particular, it will advise the General Assembly, the Project Leadership Team and the Coordination Team on the overall programme of activities and their relationship to key European and International programmes (including the Copernicus programme, the World Climate Research Programme and the International Geosphere-Biosphere Programme). The following experts have confirmed their agreement (*see letters in annex of section 4*). List is given in alphabetic order:

1. **Dr Ben Evans** (M), Associate Director of the National Computational Infrastructure, Australian National University, is involved in ESGF Steering Committee

2. **Dr Peter Gleckler** (M), Research Scientist at PCMDI (USA), Lawrence Livermore National Laboratory, chairs the WCRP Climate model Metrics Panel of the Working Group on Coupled Models

3. **Pr Gunilla Svensson** (F), Bert Bolin Centre (Sweden), Stockholm University, is the climate modelling coordinator of the Bert Bolin Research Centre and is strongly involved in the Swedish e-science Research Centre
   https://www.su.se/english/profiles/gsven-1.182452

4. **Dr Claas Teichmann** (M), Researcher at GERICS, the Climate Service Center in Germany, co-chairs the CMIP6 Advisory Board on Vulnerability, Impacts, Adaptation and Climate Services (VIACS)
   http://www.climate-service-center.de/about/team/062567/index.php.en

5. **Dr Mariana Vertenstein** (F), Senior Software Engineer at the National Center for Atmosphreic Research (USA), former head of the CESM Software Engineering Group
   https://www.researchgate.net/profile/Mariana_Vertenstein

6. **Gabriella Zsebeházi** (F), Hungarian Meteorological Service (Hungary), responsible for the activities

of the Regional Climate Modelling Group of the Hungary Meteorological Service

Adequacy of the organisational structure and decision-making

The management and advice structure is based on experience from the first two phases of IS-ENES.

The complexity of the project means that the European Project Manager role is crucial to the ability of the Coordinator and Project Leader to deliver the contracted material and provide timely and full reports to the Commission.

The ENES Scientific Officer post was included for the first time during IS-ENES2, and has proved invaluable in delivering on scientific liaison and coordination tasks.

The only new role is that of the Project Lead Scientist, where the ever-widening scope, technical depth, and number of activities has meant that the project leadership needs strengthening; reinforcing the Coordination Team with the Project Lead Scientist is aimed at addressing these issues to support in delivering and sustaining the infrastructure.

We have found that

- Organising work packages with both a Leader and a Co-Leader has delivered significant efficiency, and that it is also an opportunity to grow the community of leaders.
- Regular (approximately every second month) meeting of the Project Leadership Team by phone and/or video conferencing is necessary to ensure cross work package and task synchronization, and to address strategic issues.
- Face to face meetings with partners at General Assembly once per Reporting Period is appropriate for dealing with major issues and to trigger extra collaborative work.
- Whenever needed, consultation by email firstly with the Project Leadership Team, and then with the General Assembly membership, is appropriate to deal with most interstitial issues.

The Consortium Agreement

The Consortium Agreement will define more specifically the general administrative and legal aspects: management structure, decision process, liabilities of the Contractors, defaults and remedies, confidentiality, severability, disputes, intellectual property rights provisions. Through specific annexes, it will address the specific technical and financial content of the project (list of affiliates, project plan, allocation of resources and background). This agreement will benefit from the experience of IS-ENES1 and 2 Consortium Agreements.

The IS-ENES3 Consortium will promote and guarantee **gender equality** in the project and will be ready to contribute to surveys and investigations fostered by the European Commission. The Consortium is aware of the importance of attracting more high quality female researchers into the sphere of research and innovation and management, stimulating and promoting the progress of women in scientific careers. 26% of IS-ENES3 work package leaders/co-leaders are women, including the project coordinator. IS-ENES3 will support gender balance among the personnel primarily responsible for carrying out the research and innovation activities and in the implementation of the actions, including supervisory and managerial levels (ref. Art. 33 of the Grant Agreement). Promotion and monitoring of gender equality throughout the project will be responsibility of the coordinator.

3.2.2 Project Milestones

The Project Leadership Team will follow closely the execution of Deliverables, including an internal review process. Milestones (Table 3.2a) will be used to check key steps in the implementation of work with oral progress reports at the bimonthly project leadership team meetings.

Table 3.2a: List of milestones

Milestone (number)	Milestone name	Related WP and task number	Lead partner	Delivery date (in months)	Means of verification
M1.1	Kick-off meeting	WP1, T1	CNRS-IPSL	1	Meeting advertised on website
M1.2	First version of IS-ENES3 website	WP1, T3	CNRS-IPSL	3	Screen shots of website updates
M1.3	First General Assembly meeting	WP1, T1	CNRS-IPSL	16	Meeting advertised on website
M1.4	Second General Assembly meeting	WP1T1	CNRS-IPSL	34	Meeting advertised on website
M1.5	Final General Assembly meeting	WP1T1	CNRS-IPSL	46	Meeting advertised on website
M2.1	ENES Advisory Board Underway	WP2, T1	UREAD-NCAS	12	Short report on initial meeting
M2.2	Innovation Plan	WP2, T2	STFC	12	Plan published
M2.3	Sustainability Scoping Report	WP2, T3	DKRZ	24	Report available
M2.4	First Strategy Workshop	WP2, T4	UREAD-NCAS	24	Key point report available
M3.1	Report on user requirements	WP3, T4	KNMI	18	Report available
M3.2	First school on climate and impacts	WP3, T2	WENR	20	Report available
M3.3	Synthesis of first 5 short events to broaden community	WP3, T1	KNMI	24	Report available
M3.4	Summary of workshops on standards	WP3, T3	STFC	24	Report available
M3.5	Workshop on climate indices	WP3, T1	FPUB	26	Report available
M.4.1	Development strategy workshop for European Platform for Sea Ice modelling	WP4, T2	MetO	12	Workshop summary report
M 4.2	New technical opportunities workshop in ML and AI.	WP4, T4	UNIMAN	24	Workshop summary report
M.4.3	HPC workshop report	WP4, T5	BSC	45	Workshop summary report
M5.1	Draft architecture design	WP5, T2	CNRS-IPSL	18	Report reviewed by scientific experts and delivered to the community
M5.2	ESGF CMIP6 summary	WP5, T3	DKRZ	18	Same as for M5.1
M5.3	Requirements for technical standards for diagnostic tools	WP5, T5	BSC	20	Same as for M5.1
M5.4	Compute Service Roadmap	WP5, T4	CMCC	36	Same as for M5.1

M6.1	ENES ESM resources updated, RP1	WP6, T1	SMHI	18	Validate information on ENES Portal
M6.2	Reviewer for services appointed	WP6, all T	CERFACS	18	List of reviewers available on intranet
M6.3	ENES ESM resources updated, RP2	WP6, T1	SMHI	36	Validate information on ENES Portal
M6.4	ENES ESM resources updated, RP3	WP6, T1	SMHI	48	Validate information on ENES Portal
M7.1	ENES CDI help desk	WP7, T1	DKRZ	8	Consistent help contact info at all ENES portals
M7.2	Set up of review committee and user selection panel	WP7, T0	KNMI	12	Review committee participants confirmed.
M7.3	Improved version of evaluation portal	WP7, T2	KNMI	24	Evaluation portal integrated with C4I portal
M7.4	Complete ENES-CDI long term archival for CMIP6	WP7, T1	DKRZ	46	Full archival of agreed upon core (multi-petabyte) CMIP6 data collections
M8.1	A set of unit tests for XIOS	WP, T4	CNRS-IPSL	12	Report on the implementation of the unit tests
M8.2	Cylc / Rose development priorities agreed	WP8, T5	MetO	12	Responses from IS-ENES3 partners to the proposal document
M8.3	Final list of developments for OASIS3-MCT_5.0	WP8, T3	CERFACS	24	Plan approved by OASIS Advisory Board
M8.4	Definition of NEMO optimization strategy	WP8, T1	CMCC	24	Report on NEMO analysis and optimization plan
M8.5	Documentation of the NEMO sea ice model	WP8, T2	MetO	30	Sea ice model documentation available online
M9.1	Release of enhanced ESMValTool documentation for VA1 activity	WP9, T1	DLR	36	Release in the ESMValTool github repository
M9.2	Release of enhanced ESMValTool version for VA2 activity	WP9, T1	BSC	36	Release in the ESMValTool github repository
M10.1	Technical requirements on the software stack	WP10, all T	CMCC	14	Short report delivered to the consortium
M10.2	CMIP data request schema 2.0	WP10, T6	STFC	18	New information model reviewed by user group
M10.3	Climate indicators/indices and file metadata specifications and tools	WP10, T6	SMHI	24	Specifications agreed and accepted by community representatives
M10.4	Update of the climate indicators/indices and file metadata specifications and tools	WP10, T6	SMHI	48	Specifications agreed and accepted by community representatives

3.2.3 Innovation management

Innovation actions exist throughout the IS-ENES3 work plan, integrated into the networking, service and development work-packages. A dedicated activity in WP2/NA1 (Task 3: Innovation) will oversee the innovation activities and outcomes across the project and provide a link between individual tasks and the strategic level activities conducted through the management and governance structures.

The project-wide approach to innovation will be established in the first year, delivered by a range of interactions at the task level and the work of the Project Leadership Team (marked by M2.2, month 12, "Innovation Plan"). This will cover not only the opportunities arising from the novel technology and data assets delivered through IS-ENES3, but also the barriers to exploitation outside academia and the mechanisms for facilitation of exploitation.

Task 3 of WP2 will also organise two cross-cutting innovation workshops focused towards climate services and cloud infrastructure respectively, each of which touch on many aspects of the project work-plan. The first workshop will focus on the relationship between the ENES Data Service Infrastructure and the Copernicus Climate Change Service (C3S), a relationship which has gained strength through participation of IS-ENES3 partners in the C3S pre-operational phase, but which remains complex as both C3S and the research infrastructure evolve. The second workshop will explore the relationship between the extensive use of cloud technology in the IS-ENES infrastructure portfolio and the development of the European Open Science Cloud.

Other external innovation opportunities will be primarily mediated by the Networking Activities, in particular, the specific external innovation tasks within each of the other networking activity work packages (WP3/NA2 Task 1: Widening the user base for science and societal innovation; WP4/NA3 Task 6: Innovating with software and HPC industry; WP5/NA4 Task4: Defining requirements and establishing the roadmap for an innovative IS-ENES compute service). Along with opportunities arising internally, these activities will generate input for the project leadership, which will promulgate requirements on one or more of services, the architecture of tools and software or systems, or scientific activities including training. Such requirements will need to be delivered within existing activities or added to the plans for sustainability or the strategy. A final review of innovation activities will be provided in Deliverable D2.3 (Month 42).

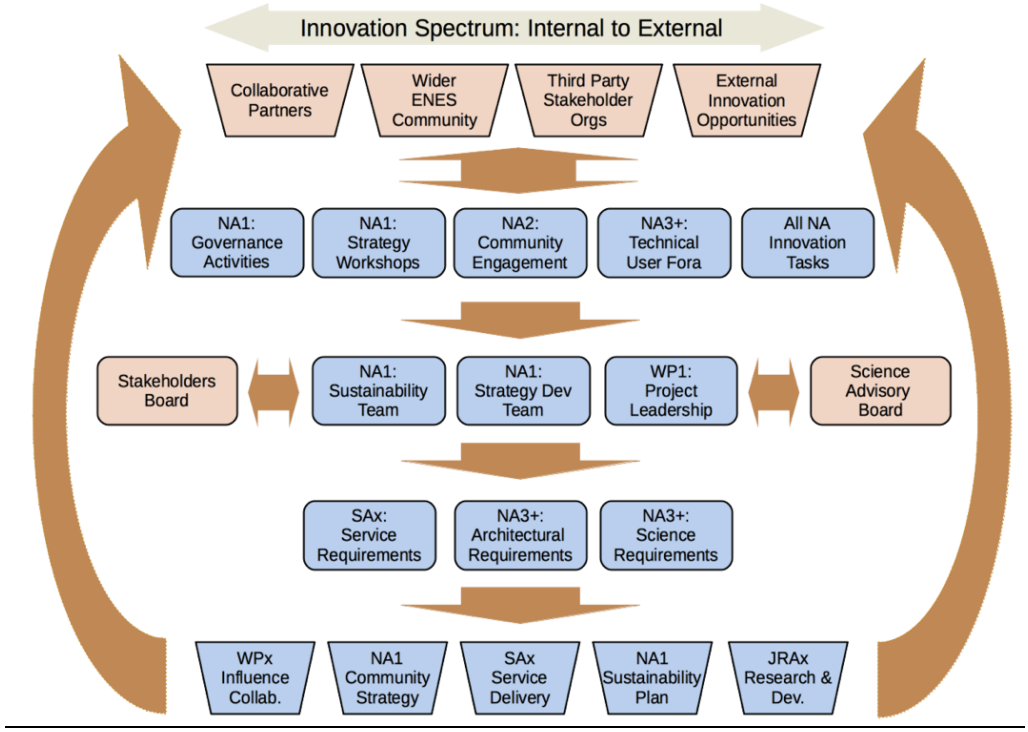


Figure: The innovation spectrum, and the relationship to its management within IS-ENES3.

3.2.4 Critical risks for implementation and mitigation measures

The Coordination Team and the Project Leadership Team will follow the execution of the project and ensure that risks identified below in Table 3.2b, as well as risks that may appear during the course of the project, will be identified at their earliest possible stage, so that efficient mitigation measures will be taken in time.

Table 3.2b: Critical risks for implementation

WP1 Coordination, dissemination and management & common risks

Description of risk (indicate level of likelihood: Low/Medium/High)	WPs	Proposed risk-mitigation measures
High: Delays or deviations of the project plan.	WP1 & all WPs	Close monitoring and escalation to the Coordination Team and ultimately the Commission.
Low: A WP/task leader decides to leave the consortium, which would interfere with the efficient follow-up and coordination of the associated WP activities.	WP1 & all WPs	The Coordination Team will replace the WP/task leader by the co-leader (WP) or nominate a suitable colleague.
Low: A partner decides to leave the consortium, which could jeopardize the implementation of the planned work.	WP1	The Coordination Team, together with the General Assembly will decide to reallocate the budget and workload to new or existing partners.

WP2/NA1 Governance, Sustainability and Innovation

Medium: Difficulty with establishing agreed interfaces and methods of engagement around innovation with third party organisations (e.g. EOSC, Copernicus).	WP2	Improve information flow at a high level: We will aim to get suitable "IS-ENES3-aware individuals" placed on the boards/advisory groups of external projects and vice-versa (identify key third party individuals for our Stakeholders Board).
Medium: Difficulty with establishing a community innovation engagement with third parties.	WP2	We will work to ensure that key individuals in the project are placed on the boards/advisory groups of key external activities (e.g. EOSC, Copernicus projects).
High: Difficult to establish a cross-community sustainability plan with institutional and stakeholder buy in.	WP2	It may be necessary to develop sustainability plans at a smaller level of granularity.

WP3/NA2 Community engagement

Medium: Lack of participation from new users.	WP3	Due to costs for travelling and time investment: more and short events closer to the new users (in Eastern-Europe, VIA community, CS providers), use of webinars and linking up with activities of these user communities.
Medium: Drop out of new users after first contact.	WP3	Webinars to continue contact with users. Website and newsletter to keep on informing new users. User support for C4I (WP10). Evaluation of contact strategy in M3.3 to see whether strategy should be revised.
Medium: Lack of feedbacks and requirements from other WPs	WP3	Regular communication with the other work packages and with the Coordination will ensure that

workshops and meetings.		any issues are identified in a timely manner. Use cross-cutting and coordination arrangements.

WP4/NA3 Networking on Models, Tools and efficient use of HPC

Medium: Ineffective engagement with industry leads to weak innovation.	WP4	Inclusion of a specific resources task on innovation linking to other tasks and work-packages. Seek industry engagement in advance of project initiation.
Medium: Being new, the sea-ice model development carries more risk than more established codes.	WP4	A comprehensive and well-resourced networking activity to complement WP8/JRA1 will maximise the chances of building a strong community model. Maintain close links to the well-established NEMO consortium.
Medium: Incomplete or insufficient CPMIP metrics measurements.	WP4	Maintain a strong communication and link with other IS-ENES3 partners to coordinate analyses of simulation runs. Communicate clearly and actively the importance of including CPMIP measurements before selected simulations.

WP5/NA4 Networking on data and model evaluation

Low: Inappropriate representation of requirements.	WP5	The requirements gathered are not understandable to extract meaningful information to build a technical draft. More iterations with partners will be proposed until a clear list is produced.

WP6/VA1 Services on European ESMs and Software Tools

Low: Operation of web services discontinued by some service provider (typically computing centre).	WP6	Keep services distributed. Use standard software stacks for service operations.
Low: Substantially increased workload for services on models/tools due to disruptive hardware landscape changes.	WP6	Coordinate services with innovation tasks in WP4/NA3 to prepare for potential changes in user needs.

WP7/VA2 Data standards, distribution and processing services

Low: Data distribution services shutdown because of security incident.	WP7	Security incident prevention mechanisms are established: regular scan of software components. Installation supervised by CDNOT team.
Low: TNA offering to access virtual workspaces does not meet user needs.	WP7	The TNA service will be announced directly to user groups who already announced interest based on various means (portal, conferences, international meetings,..).
Low: Provisioning of ESMValTool based climate evaluation results delayed, because of unavailability of replicated CMIP6 data.	WP7	Give ESMValTool data requirements a high priority in ENES CDI replication.. Close collaboration with network providers as part of international ICNWG working group as well as at European level.

WP8/JRA1 Models & Tools developments

Medium: NEMO optimisations introduce new coding rules for the NEMO developers team, making the integration process more complex.	WP8	Maintaining close links to the NEMO developers team in order to design transparent and less invasive optimisation solutions and to have a continuous feedback from the developers.
High: Python bindings for OASIS3-MCT does not lead to a wider adoption of the coupler by communities less	WP8	Leverage interactions with new users through WP3, workshops in WP4 and WP6 services so to make sure that this new OASIS3-MCT development gets

advanced in HPC.		publicized to new users.
Medium: Adding coupling functionalities into XIOS adds undesirable complexity.	WP8	Further enforce good engineering practices in XIOS development, developing appropriate unit tests and strictly testing each code modification before including it in the official sources
Medium: Lack of engagement in Cylc/Rose from new users making the identification of development priorities difficult.	WP8	Seek interactions with new users through WP3, workshops in WP4 and WP6 services to ensure that Cylc and Rose get publicized to new users.

WP9/JRA2 Earth System Model Evaluation

Low: User adoption.	WP9	Increase proactive actions to reach users from different modelling groups and address the issues preventing them to use the tool (with WP3/NA2).
Medium: Difficulties in implementing some new features.	WP9	Some proposed features can be harder to deploy than expected. Increasing the work between development partners (taking advantage of different skills) to identify blocking issues.
Medium: Low performance when dealing with expected increases in resolution.	WP9	Identify partners with strong Computer Science background to apply novel solutions to overcome the issue.

WP10/JRA3 Evolving and consolidating the ENES Climate Data Infrastructure software stack

Medium: Requirements for software components (e.g. services, tools, and interfaces) related to operational data archives are not well defined.	WP10	Work closely with WP5/NA4 and WP7/VA2 to ensure that requirements are consistent with experience in operational data archives.
Medium: New software components (e.g. compute services) could not meet users expectations and/or could not be adopted by a large user base.	WP10	By working closely with WP5/NA4, WP7/VA2 and WP3/NA2, users needs will be prioritised and regularly evaluated. Start from already existing community based efforts.

3.2.5 Summary of virtual and trans-national access provided

Table 3.2c: Summary of trans-national/virtual access provision

Access provider short name	*Short name of infrastructure*	*Installation*		*Instal-lation Country code*	*Type of access*	*Unit of access*	*Unit cost UC (€)*	*Min. quantity of access to be provided*	*Access costs*		*Estimated number of users*	*Estimated number of user projects*
		Nr	*Short name*						*On the basis of UC*	*As actual costs*		
MetO	ENES ESM	1	HadGEM/UKESM	UK	VA	n/a	n/a	n/a	n/a	38 978		
SMHI	ENES ESM	2	EC-Earth	SE	VA	n/a	n/a	n/a	n/a	51 000		
met.no	ENES ESM	3	NorESM	NO	VA	n/a	n/a	n/a	n/a	39 750		
UniRes	ENES ESM	3	NorESM	NO	VA	n/a	n/a	n/a	n/a	34 094		
CERFACS	ENES ESM	4	OASIS-VA	FR	VA	n/a	n/a	n/a	n/a	25 125		
CERFACS	ENES ESM	5	OASIS-TNA	FR	TA-ac	n/a	n/a	n/a	n/a	63 000	9	9
CNRS-IPSL	ENES ESM	6	XIOS	FR	VA	n/a	n/a	n/a	n/a	66 500		
CERFACS	ENES ESM	6	XIOS	FR	VA	n/a	n/a	n/a	n/a	19 875		
MetO	ENES ESM	7	Cylc/Rose	UK	VA	n/a	n/a	n/a	n/a	86 475		
DLR	ENES ESM	8	ESMValTool	DE	VA	n/a	n/a	n/a	n/a	29 484		
BSC	ENES ESM	8	ESMValTool	ES	VA	n/a	n/a	n/a	n/a	11 250		
NleSC	ENES ESM	8	ESMValTool	NL	VA	n/a	n/a	n/a	n/a	17 500		
DKRZ	ENES CDI	1	DKRZ-WDCC-ESGF-Comp1	DE	VA	n/a	n/a	n/a	n/a	330 350		
DLR	ENES CDI	1	DKRZ-WDCC-ESGF-Comp1	DE	VA	n/a	n/a	n/a	n/a	39 312		
NleSC	ENES CDI	1	DKRZ-WDCC-ESGF-Comp1	NL	VA	n/a	n/a	n/a	n/a	35 000		
STFC	ENES CDI	2	STFC-ESGF-Comp1-CFDR	UK	VA	n/a	n/a	n/a	n/a	165 109		
UREAD	ENES CDI	2	STFC-ESGF-Comp1-CFDR	UK	VA	n/a	n/a	n/a	n/a	202 344		
SMHI	ENES CDI	2	STFC-ESGF-Comp1-CFDR	SE	VA	n/a	n/a	n/a	n/a	34 000		
CNRS-IPSL	ENES CDI	3	CNRS-ESGF-ESDOC-Comp1	FR	VA	n/a	n/a	n/a	n/a	176 490		
UREAD	ENES CDI	3	CNRS-ESGF-ESDOC-Comp1	UK	VA	n/a	n/a	n/a	n/a	111 460		
CMCC	ENES CDI	4	CMCC-Comp1	IT	VA	n/a	n/a	n/a	n/a	26 563		
LiU	ENES CDI	5	LiU-ESGF	SE	VA	n/a	n/a	n/a	n/a	23 175		
SMHI	ENES CDI	5	LiU-ESGF	SE	VA	n/a	n/a	n/a	n/a	34 000		
BSC	ENES CDI	6	BSC-ESGF	ES	VA	n/a	n/a	n/a	n/a	16 875		
KNMI	ENES CDI	7	KNMI-C4I	NL	VA	n/a	n/a	n/a	n/a	88 290		
DKRZ	ENES CDI	8	DKRZ-Comp2	DE	TA-ac	n/a	n/a	n/a	n/a	40 000	50	10
STFC	ENES CDI	9	STFC-Comp2	UK	TA-ac	n/a	n/a	n/a	n/a	30 351	80	4
CNRS-IPSL	ENES CDI	10	CNRS-Comp2	FR	TA-ac	n/a	n/a	n/a	n/a	38 875	40	4
CMCC	ENES CDI	11	CMCC-Comp2	IT	TA-ac	n/a	n/a	n/a	n/a	43 438	40	8

3.3 Consortium as a whole

3.3.1 IS-ENES3 Consortium

The IS-ENES3 consortium has been assembled to cover the necessary spectrum of activities from Earth climate system modelling - with both global and regional models on high-end computing – to the necessary common software and data support services, including data centres, for both the modelling community itself, and to support and engage with downstream users in impact modelling and climate services.

Foster the integration of the climate modelling community – global and regional

Expertise on Global Earth Climate System modelling groups

IS-ENES3 includes the main Earth System modelling groups in Europe. While they have a long history of collaboration (since before the beginning of the European Research Framework Programmes on Environment), there are demanding new challenges to meet together. Intensified collaboration is necessary to address the evermore demanding challenges resulting from increased complexity in different dimensions of the climate problem: science, technology, governance, and collaboration – especially with the impacts community.

MetO and UREAD-NCAS (UKESM model), CNRS-IPSL (IPSL-ESM model), MF-CNRM and CERFACS (CNRM-CERFACS model), CMCC (CMCC-ESM model), met.no and UniRes (NorESM model), KNMI, SMHI and BSC (EC-Earth model), DLR (EMAC model) all bring an important expertise on climate modelling. DKRZ, responsible for optimising and running the MPI-ESM model, provides strong link to MPIM (*see also section 3.3.3*). They are all involved in CMIP6 and together represent the major European contribution to CMIP6. They are all heavily involved not only in simulations and data distribution, but in the science as well: DLR hosts the Chair of the CMIP Panel, MetO and UREAD-NCAS are leading the PRIMAVERA project for the simulation of high-resolution simulations and NCAS/MetO is coordinating the CRESCENDO project on simulations with Earth System Models. Together they bring the science focus on requirements, since they all rely on the IS-ENES infrastructure.

Expertise on regional climate modelling and downscaling approaches

IS-ENES3 will further integrate the global and regional climate modelling communities by supporting the joint dissemination of results from CMIP6 and CORDEX. Consortium members involved in leading these activities include SHMI and MetO: SMHI, one of the two leaders of CORDEX, will ensure consistency of IS-ENES3 activity with the international coordination of CORDEX, and via the International Project Office for CORDEX (IPOC), reach out to modelling groups to help reduce the initial difficulties of publishing CORDEX data on the ESGF. SMHI is also leading the C3S PRINCIPLES project that will complement the Euro-CORDEX simulations based on CMIP5. MetO will be coordinating the EUCP project, which will provide the regional climate simulations for Euro-CORDEX and Med-CORDEX based on CMIP6. Several additional IS-ENES3 groups are participating in Euro-CORDEX and Med-CORDEX. Alongside SMHI and MetO, CNRS-IPSL, CMCC, MF-CNRM will all contribute, and UC will contribute their expertise in statistical downscaling.

Foster the development of common models and software tools

Expertise on common software tools

CERFACS plays an important role in the development of coupled Earth System models through the provision of the OASIS coupler. CNRS-IPSL develops the XIOS software used in the NEMO platform and more and more used by other models in Europe. MetO is working with NIWA in New Zealand develop and support the Cylc workflow engine.

Several partners of IS-ENES3 are linked through formal trans-national institutional agreements:

CNRS-IPSL, MetO and CMCC work together within the NEMO Consortium to develop the NEMO platform for ocean modelling. They will ensure the dissemination of improvements of the NEMO ocean platform and the new NEMO sea ice model. KNMI, SMHI and BSC are collaborating within the EC-Earth Consortium.

Foster efficient use of High-performance computing

Expertise on high- performance computing, computational science and technology

UNIMAN, STFC and CMCC bring strong expertise in computational science for HPC, they will help to improve the computing efficiency of the common European NEMO platform and contribute to OASIS and technology tracking. UREAD-NCAS, STFC, and CNRS-IPSL will contribute their proven skills in e-technologies associated with metadata production. NCSR-D, new to ENES, brings expertise in data science, including Artificial Intelligence and Machine Learning. NCSR-D leads the EOSC project DARE. They will strengthen the interdisciplinary dimension of the climate data school. NleSC brings multidisciplinary expertise in applying research and software development. They will bring that expertise to bare on the interface to users for the model evaluation tool.

IS-ENES3 also includes expertise from supercomputing centres. Three national supercomputing centres dedicated to climate research issues are involved: DKRZ (Germany) and CMCC (Italy) provide HPC and data systems and STFC (UK) hosts a dedicated data intensive supercomputer for environmental science. They will be complemented by engagement by general purpose centres having a strong interest in climate research: BSC (Spain) and LIU (Sweden). BSC is involved in PRACE and will help to integrate the ENES community into PRACE. All modelling centres have expertise in HPC procurement and/or exploitation. DKRZ, STFC, CNRS-IPSL and CMCC all bring expertise in data management and data systems.

Raising the standard of Earth system model evaluation

Expertise on community-developed evaluation tools

IS-ENES3 will raise the standard for routine model evaluation by developing a common evaluation tool (ESMValTool) to be fully integrated into the ESGF, which can be routinely applied to CMIP data as soon as the output reaches the archive. DKRZ, STFC, and UREAD-NCAS have, together with DLR, developed the strategy towards that integration. DLR is leading the development, hosts the source repository, and brings long-term experience in the evaluation of CMIP models with observations. BSC will co-lead WP9/JRA2 together with DLR. BSC, NleSC, and UREAD-NCAS are all core developers of the ESMValTool, bringing complementary technical expertise to enhance the capabilities and the user interface.

CMCC, IPSL, KNMI, MetO, met.no, and SMHI all develop and run Earth system models, with long-term expertise in evaluating the model's performance with observations. They will enhance the ESMValTool so that it can be applied for the evaluation of single models during model development. MetO brings expertise in the Iris library that is used in ESMValTool that implements a data model to create a data abstraction layer which isolates analysis and visualisation code from data format specifics of CF-NetCDF.

Foster the exploitation of model data

DKRZ, STFC and CNRS-IPSL are Tier 1 data centres within ESGF. They will be complemented with expertise by Tier 2 centers at BSC, CMCC, KNMI and LIU. DKRZ runs the World Data Centre for Climate, with an extensive archive of climate model data. STFC hosts the Centre for Environmental Data Analysis (CEDA), which is the designated data centre for the UK earth observation, and atmospheric, polar and climate science. These two centres host, in partnership with the Center for International Earth Science Information Network (Columbia University, New York), the IPCC Data Distribution Centre.

STFC, CNRS-IPSL, DKRZ, CMCC, CERFACS, NleSC and NCSR-D will ensure the link with EOSC. CNRS-IPSL, DKRZ, NleSC are involved in demonstrators for the EOSC-Pilot project. CMCC and DKRZ are involved in the EOSC-hub project as ENES representatives, by proposing a case study on climate data analysis focusing on workflows, provenance and distributed computing aspects. They also contribute to the EOSC-hub service portfolio through the ENES climate analytics service. NCSDR coordinates the DARE EOSC project with an application for climate impacts led by CERFACS.

Foster model data dissemination and their use by the impact community and climate service providers

KNMI, SMHI and WENR have a strong expertise in climate impact modelling as well as climate services. They are involved in several impact and climate services projects, e.g. SMHI leads the SWICCA C3S project on developing impact information for water, KNMI led the FP7 ECLISE project on impacts. They will play a key role in widening the user base through training and schools targeting the impact community.

CUNI and FPUB will play a strong role in widening the user base in Eastern, Central and South-eastern Europe. CUNI has led the CECILIA "Central and East European Climate Change Impact and Assessment Vulnerability" project (http://www.cecilia-eu.org/) and FPUB is a major participant in the activities of the

South East European Virtual Climate Change Center (http://www.seevccc.rs/) and PannEx (Pannonian Experiment - Regional Hydroclimate Project of the WCRP/GEWEX[19]).

CERFACS and KNMI will contribute to widen this use base through the use of the climate4impact platform dedicated to a wider community. STFC will bring expertise from their leadership of the pre-Copernicus Climate Information Portal for Copernicus project (http://www.clipc.eu/).

Foster Social Innovation

KNMI, SMHI and CERFACS will bring their expertise to climate service providers on tailoring climate information to provide information and products more adapted to end users. Training and workshops will be open to climate service providers. KNMI and CNRS-IPSL will help link with the ClimatEurope (https://www.climateurope.eu/) network which links science and society on climate and gathers a large network on climate modelling, observations and climate services.

Cooperation with Copernicus Climate Change Service will be further developed during the course of IS-ENES3 (*See Letter of Support, section 4 appendix*). CNRS-IPSL, KNMI, SMHI and STFC are strongly involved in the Copernicus Climate Change Service and will ensure that IS-ENES3 service complement C3S services. STFC is leading the CP4CDS project, KNMI the MAGIC project, both ensuring the exploitation of global projections for C3S. CNRS-IPSL leads the CORDEX4CDS project and SMHI the PRINCIPLES project that both ensure the exploitation of regional projections for C3S.

Partners have also link with SMEs in the field of climate information. STFC and CNRS-IPSL have links with TEC, partner of the CLIPC project. CNRS-IPSL collaborates with TCDF, a spin-off from IPSL on the distribution of downscaled climate data (*See Section 3.3.3*). They will help better link with private climate services.

Foster Innovation with HPC and software industry

MetO is in contact with Altair (*See Section 3.3.3*) a leading provider of enterprise-class engineering software enabling innovation, reduced development times, and lower costs through the entire product lifecycle from concept design to in-service operation. Altair has recently been working to develop a holistic solution for HPC workload and workflow management in an innovative way using PBS Professional and the Cylc workflow engine. This collaboration offers the opportunity to influence the development of this integrated solution for the benefit of the climate community, particularly in the area of seasonal and decadal prediction that underpins the expansion of climate services.

3.3.2 Involvement of third-parties

CNRS-IPSL will involve third parties through its joint research units: CEA "Commissariat à l'Energie Atomique et aux Energies Alternatives" and UPMC (Université Pierre et Marie Curie"). See also section 4 for CNRS-IPSL.

3.3.3 Associated partners

IS-ENES3 will collaborate with several institutions considered for the project as Associated Partners, with no legally binding agreement. These collaborations are shown through *letters of support in Appendix, Section 4*.

The Max Planck Institut for Meteorology in Hamburg (DE) (https://www.mpimet.mpg.de/en/) will collaborate with IS-ENES3, both through modelling work via DKRZ, and in to support the WP6/VA1 access to CDO post-processing tool.

PCMDI, the Program for Climate Model Diagnosis and Intercomparison at the Lawrence Livermore National Laboratory (USA) (https://pcmdi.llnl.gov/) will continue to collaborate with IS-ENES3. PCMDI has a strong leading role in supporting the international PMIP and this collaboration is very important to ensure common developments.

Altair enterprise (https://www.altair.com/), as discussed above, will collaborate with IS-ENES3 on the Cylc

[19] https://www.gewexevents.org/wp-content/uploads/GHP2016_Lakatos_Pannex.pdf

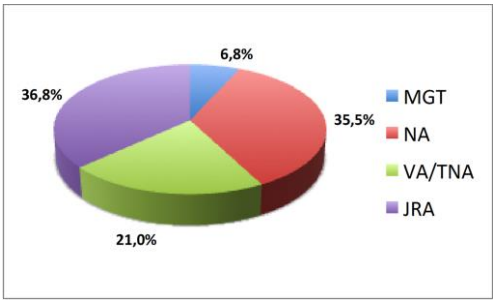
workflow software.

TEC Conseil is an SME in France working on services on climate change mitigation and adaptation through consulting, study, research and innovation and training (http://www.tec-conseil.com/). TEC has been involved in several EU projects, e.g. CLIPC.

TCDF, The Climate Data Factory (https://theclimatedatafactory.com/) is an SME collaborating with CNRS-IPSL on providing ready-to-use climate information.

3.4 Resources to be committed

The total EU funding requested for IS-ENES3 is **9 802 613 €** including Management, (MGT) NA, VA/TNA and JRA. The graph shows the percentage for each type of activity. The table below presents the split between personnel costs, travel, workshops and other direct costs, within total costs. Most of the budget is allocated to personal costs except in NA and Management, which require workshops and training costs.



	Personnel/ Access costs	Sub-contracting	Travel	Workshops	others	TOTAL
MGT	3,8%	0,0%	0,4%	0,8%	1,8%	**6,8%**
NA	28,7%	0,4%	2,6%	3,8%	0,0%	**35,5%**
VA/TNA	20,7%	0,0%	0,2%	0,0%	0,0%	**21,0%**
JRA	33,8%	1,1%	1,8%	0,1%	0,0%	**36,8%**
TOTAL	**87,1%**	**1,5%**	**5,0%**	**4,7%**	**1,8%**	**100,0%**

Description by type of activity:

Management

WP1/Management: 662 622 € EU funding with 298 k€ (58 PM), 60 k€ workshops, 35 k€ travel, 137 k€ other costs, 132 k€ indirect costs

The personnel resources cover the costs associated to the Coordination Team. Workshop costs cover costs the Kick-off meeting and General Assemblies. Travel costs are for the Coordination team. Other costs include a provision for travel costs for the Scientific Advisory Board and invitations of scientists outside the Consortium members, audit costs, dissemination costs. It also includes 50 k€ to fund collaboration with our US collaborators to allow exchange of researchers and engineers, especially with PCMDI.

Networking Activities

WP2/NA1 to WP5/NA4: 3 482 427 € EU funding with 2 251 k€ (330 PM), 201 k€ for travel, 302 k€ for workshops, 688 k€ indirect costs, 40 K€ of subcontracting

Costs in NA are mainly associated with personnel costs, workshops and travel costs. Travel costs have been computed with a base of 500 €/PM (exceptions See Table 3.4.b). Workshops are particularly needed in NA to develop the network. Most of them will include the possibility to invite experts outside the IS-ENES3. Travel costs to workshops for IS-ENES3 partners are included in their own travel costs, not in workshop costs. The relatively high number of PMs (80, 86, 91, 67 respectively, *see Table 3.4.a*), is due to the ENES Scientific Officer in WP2 (36/80 PM), all tasks in WP3 to widen user base, the networking on the new sea ice model in WP4 (33/97 PM), all tasks in WP5. All innovation tasks amount to 59 PM. Subcontracting is planned for the survey on model evaluation in WP3/NA2 (*see Section 4.2*).

Access activities

WP6/VA1 & WP7/VA2: 2 054 762 € EU funding with 1 625 k€ (251 PM), 18 k€ for travel for TNA in WP7, 411 k€ indirect costs

Access services costs are associated to personnel costs to provide VA and TNA. WP6/VA1 access costs amount to 483 k€ including 63 k€ TNA (*see Table 3.2.c*). This TNA also requires travel (*see Table 3.4.b* for CERFACS). WP7/VA2 access costs amount to 1 436 k€ with 153 k€ for TNA (*see Table 3.2.c*).

Joint research activities

WP8/JRA1 to WP10/JRA3: 3 602 802€ EU funding with 2 653 k€ (424 PM), 141 k€ for travel, 5 k€ for workshops, 700 k€ indirect costs, 104 K€ of subcontracting

Costs in NA are mainly associated with personnel costs and travel costs. Travel costs have been computed with a base of 300 €/PM (exceptions See Table 3.4.b). Workshops are very limited. Subcontracting is associated with the work on the model and simulation documentation (ES-DOC) *(See Section 4.2)*.

Table 3.4a: Summary of staff effort

Number of person/months over the whole duration of the planned work, for each work package, for each participant (**WP leader**, **WP co-leader)**

Participant no./short name	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	WP10	Total Person Months
1/ CNRS-IPSL	**54**	5	**16**	20	**17**	8	35	31	4	21	**211**
2/UREAD-NCAS	**4**	**42**	6	6	4	0	34	2	9	10	**117**
3/ DKRZ	0	**18**	6	0	5	0	**44**	0	3	7	**83**
4/ CERFACS	0	6	6	11	7	**17**	0	**28**	0	**36**	**111**
5/ MetO	0	1	0	**13**	0	17	0	33	13	0	**77**
6/ BSC	0	0	1	**13**	9	2	3	**20**	**25**	3	**76**
7/ KNMI	0	0	**13**	0	7	0	**12**	0	2	37	**71**
8/ CMCC	0	0	1	17	5	0	8	14	5	**19**	**69**
9/ STFC	0	8	4	1	4	0	29	6	0	17	**69**
10/ SMHI	0	0	5	0	**3**	**12**	8	0	8	12	**48**
11/ DLR	0	0	5	0	1	3	4	0	**26**	0	**39**
12/ NleSC	0	0	0	0	3	2	4	0	11	0	**20**
13/ UC	0	0	2	0	0	0	0	0	0	10	**12**
14/ met.no	0	0	0	0	0	3	0	0	7	0	**10**
15/MF-CNRM	0	0	0	6	0	0	0	1	0	0	**7**
16/ UNIMAN	0	0	0	7	0	0	0	0	0	0	**7**
17/ NCSR-D	0	0	3	3	0	0	0	0	0	0	**6**
18/ WENR	0	0	6	0	0	0	0	0	0	0	**6**
19/ CUNI	0	0	6	0	0	0	0	0	0	0	**6**
20/ FPUB	0	0	6	0	0	0	0	0	0	0	**6**
21/ UniRes	0	0	0	0	0	3	0	0	2	0	**5**
22/ LiU	0	0	0	0	2	0	3	0	0	2	**7**
Total	**58**	**80**	**86**	**97**	**67**	**67**	**184**	**135**	**115**	**174**	**1063**

Table 3.4b: 'Other direct cost' items (travel, equipment, other goods and services)

Partners with' travel', 'equipment', and 'goods and services' costs exceeding 15% of personnel costs

1/ CNRS-IPSL	Cost (€)	Justification
Other Travel	65 800	**20 k€** for WP1 to ensure the coordination and promotion of the project. **45,8k€** other travel costs, following the standard rule of multiplying a flat rate*PM (applied to all partners, see above).
Other goods and services	195 000	**60k€** dedicated to organisation of 4 general assemblies and other overall project events, including costs for invitations (outside partners) **20k€** in WP2 for organization a large strategy workshop (ca 80 participants, with invitations) **115k€** dedicated to: dissemination/communication activities (30 k€), to ensure invitation of SAB, of Associated partners and external experts to IS-ENES3 events (35 k€), and to ensure the collaboration between IS-ENES3 and PCMDI and facilitate exchange with US colleagues (50 k€).
Total ODC	**260 800**	

13/ UC	Cost (€)	Justification
Other Travel	7000	In addition to the **4 k€** standard travel allocation, **3 k€** were added to make sure UC can come to IS-ENES3 general assemblies, even if UC has a small amount of PMs and less than 4 k€ standard travel.
Other goods and services	10 000	**10k€** Covering the organisation of the Climate and Forecast Convention (CF) workshop (about 40 participants with some invitations), as part of Task 3 Community standards of WP3.
Total ODC	**17 000**	

17/ NCSR-D	Cost (€)	Justification
Other Travel	6000	In addition to the **3 k€** standard travel allocation, **3 k€** were added to make sure NCSR-D can come to IS-ENES3 general assemblies (same rule as UC).
Other goods and services	50 000	**50 k€** covering the organisation of the school on Climate Data Science as described in WP3, Task 2 (rooms, lodging and catering of students and lecturers, travels of lecturers; about 30 students for 2 weeks).
Total ODC	**56 000**	

18/ WENR	Cost (€)	Justification
Other Travel	9000	In addition to the **3 k€** of standard travel allocation, **3 k€** were added to make sure WENR can come to IS-ENES3 general assemblies (same rule as UC) **3k€** were also added to ensure WENR can travel to two training short events and to one school in WP3 (other than the one they organize).
Other goods and services	30 200	**5,2 k€** covering the organization of two training short events to widen the user base for science and societal innovation (WP3, Task 1; each workshop is estimated at 2,6 k€; short 1 to 1.5 days events on site with 15 to 20 participants) **25 k€** for the organisation of one of the school on Climate Data Science (WP3, Task2; same as NCSR-D but for a week school).
Total ODC	**39 200**	

19/ CUNI	Cost (€)	Justification
Other Travel	9000	In addition to the **3 k€** of standard travel allocation, **3 k€** were added to make sure CUNI can come to IS-ENES3 general assemblies (same rule as UC). **3 k€** were also added to ensure CUNI can travel to some of the short events and to the school in WP3.
Other goods and services	30 200	**5,2 k€** covering the organization of two short events to widen the user base for science and societal innovation (WP3, Task 1; same as WENR) **25 k€** for the organisation of one of the schools on the interface between climate and impact models (WP3, Task2; same as WENR
Total ODC	**39 200**	

20/ FPUB	Cost (€)	Justification
Other Travel	8000	In addition to the **3 k€** of standard travel allocation, **3 k€** were added to make sure FPUB can come to IS-ENES3 general assemblies (same rule as UC). **2 k€** were also added to ensure FPUB travel to 2 other short training events in WP3.
Other goods and services	15 200	**5,2 k€** Covering the organization of two short training events to widen the user base for science and societal innovation (WP3, Task 1) **10 k€** covering the organisation of the workshop on Climate indices requirements (WP3, Task 1, M3.5; 40 participants, 3 days, conference room and catering, some travel for experts external to IS-ENES3).
Total ODC	**23 200**	

22/LiU	Cost (€)	Justification
Other Travel	6 600	In addition to the **1.6 k€** of standard travel allocation, **5 k€** were added to make sure LiU can come to IS-ENES3 general assemblies (3 k€) (same rule as UC) and can participate in WP5/NA4 meetings, even with main PMs in WP7/VA2 with no travel costs associated (2 k€).
Total ODC	**6 600**	

Partners providing trans-national access and foreseeing costs for travel and subsistence needed to support the visits of the selected users

In this case travel covers the costs or the OASIS expert to travel on the site of the users selected for TNA

4/CERFACS	Cost (€)	Justification
Travel & subsistence for trans-national access (if applicable)	18 000	**18 k€** are requested to cover the accommodation and travel of the expert in charge of the OASIS dedicated support TNA activity (WP6, Task 3), when visiting the granted laboratories during a total of 9 months (9 * 1 month). This includes travel and lodging.
Total ODC for TNA	**18 000**	

Glossary

ANA4MIPs: Reanalysis for MIPs, to provide collocated reanalysis data sets, with common format, for more ready access and use (https://esgf.nccs.nasa.gov/projects/ana4mips/).
BDE: Big Data Europe, H2020 project *(*https://www.big-data-europe.eu/*)*.
CECILIA: Central and Eastern Europe Climate Change Impact and Vulnerability Assessment (http://www.cecilia-eu.org/).
CDO: Climate Data Operators - collection of functions for handling and analyzing data produced by a variety of climate and NWP models - (http://www.mpimet.mpg.de/cdo).
CICE: The Los Alamos Sea Ice model (http://oceans11.lanl.gov/trac/CICE).
CIM: Common Information Model - The FP7 METAFOR project has developed this standard.
CLIMATE4IMPACT: ENES Portal for Climate Impact Communities (http://climate4impact.eu) developed within IS-ENES and IS-ENES2 to ease access to model data for the climate impact research communities.
CLIMATEUROPE: linking science and society, H2020 project (https://www.climateurope.eu/).
CLIP-C: Climate Information Portal for Copernicus, FP7 project (http://www.clipc.eu/).
CMIP5/6: Coupled Model Intercomparison Project Phase 5/6, under the auspices of WCRP to prepare IPCC AR5/6 **(**http://cmip-pcmdi.llnl.gov/cmip5/**).**
COPERNICUS C3S: Copernicus Climate Change Service (https://climate.copernicus.eu/).
CORDEX: Coordinated Regional downscaling Experiments, under WCRP auspices (http://wcrp.ipsl.jussieu.fr/SF_RCD_CORDEX.html).
CORDEX4CDS: Access to CORDEX simulations for the European domain, Copernicus C3S funded activity (http://meteo.unican.es/jobs/201801).
CP4CDS: Climate Projections for Climate Data Store, Copernicus C3S funded activity.
CRECP: Copernicus Roadmap for European Climate projections, Copernicus C3S funded activity (https://climate.copernicus.eu/copernicus-roadmap-european-climate-projections).
CRESCENDO: Coordinated Research in Earth Systems and Climate: Experiments, Knowledge, Dissemination and Outreach (https://www.crescendoproject.eu/).
Cylc: workflow engine for cycling systems (https://cylc.github.io/cylc/).
DARE: Delivering Agile Research Excellence, H2020 project (http://project-dare.eu/).
EGI: E-infrastructure providing advanced computing services for research (https://www.egi.eu/).
ENVRI: Community of the Environmental research infrastructures, projects and networks as well as other diverse stakeholders interested in the environmental research infrastructure matters **(**http://envri.eu/**).**
ENVRIPlus: Cluster of Environmental and Earth System Research Infrastructures, projects and networks, H2020 project (http://www.envriplus.eu/).
EOSC: European Open Science Cloud (http://ec.europa.eu/research/openscience/index.cfm?pg=open-science-cloud).
EOSC Pilot: The European Open Science Cloud for Research Pilot Project (https://eoscpilot.eu/).
EOSC-Hub: Services for the European Open Science Cloud (http://www.eosc-hub.eu/).
ES-DOC: Earth System Documentation (http://es-doc.org).
ESGF: Earth System Grid Federation, international data repository for WCRP CMIP and related data (http://www.earthsystemgrid.org/).
ESiWACE: Centre of Excellence in Simulation of Weather and Climate in Europe, H2020 project (https://www.esiwace.eu/*)*.
ESM(s): Earth System Model(s).
EUCP: EUropean Climate Prediction system, H2020 project (https://www.bsc.es/research-and-development/projects/eucp-european-climate-prediction-system).
EUDAT: European Data Infrastructure, FP7 project (http://www.eudat.eu/).
EURO-Argo: European Research Infrastructure Consortium, European contribution to the Argo programme (http://www.euro-argo.eu/).
EURO-CORDEX: European branch of the international CORDEX initiative (http://www.euro-cordex.net/).
FET: Future and Emerging Technologies, EU H2020 action.
GEANT: Europe's leading collaboration on e-infrastructure and services for research and education (https://www.geant.org/).
GELATO: Global Experimental Leads and *ice* for ATmosphere and *Ocean (*http://www.umr-cnrm.fr/gmgec-old/site_engl/gelato/gelato_en.html*)*.
HPC: High Performance Computing

I/O: Input/Output is the generic process of exchanging data during a simulation, either as input to the model or as output of model simulations.
ICOS: European Research Infrastructure Consortium, Integrating Carbon Observation System (https://www.icos-ri.eu/).
ICT: Information & Communication Technology
IPCC: Intergovernmental Panel on Climate Change (http://www.ipcc.ch).
JPI-CLIMATE: Joint Programming Initiative "Connecting Climate Knowledge for Europe" **(**http://www.jpi-climate.eu/home**).**
LIM: Louvain-la-Neuve sea ice model (http://www.astr.ucl.ac.be/index.php?page=LIM Description).
MAGIC: Metrics and Access to Global Indices for Climate Projections, Copernicus C3S funded activity.
MCT: The Model Coupling Toolkit, USA set of open source software tools to create coupled models **(**http://www.mcs.anl.gov/research/projects/mct/**).**
Med-CORDEX*:* coordinated contribution to CORDEX that is supported by HyMeX and MedCLIVAR international programs (https://www.medcordex.eu/).
METAFOR: Common Metadata for Climate Modelling Digital repositories, FP7 project under ENES (http://ncas-cms.nerc.ac.uk/METAFOR/).
NASA: National Aeronautics and Space Administration, USA *(*https://www.nasa.gov/*)*
NCAR: National Center for Atmospheric Research in Boulder, USA (http://www.ncar.ucar.edu/).
NEMO: Nucleus for European Modelling of the Ocean (http://www.locean-ipsl.upmc.fr/NEMO/).
NetCDF: network Common Data Form (http://www.unidata.ucar.edu/software/netcdf/).
NOAA: National Oceanographic and Atmospheric Organisation, USA (http://www.noaa.gov/).
OASIS: Ocean Atmosphere Sea Ice and Soil coupler (https://portal.enes.org/oasis).
Obs4MIP: Observations for Model Intercomparisons Project, to make observational products more accessible on ESGF for climate model intercomparison (https://www.earthsystemcog.org/projects/obs4mips/).
PRIMAVERA: PRocess-based climate sIMulation: AdVances in high resolution modelling and European climate Risk Assessment, H2020 project (https://www.primavera-h2020.eu/).
PRINCIPLES: Producing RegIoNal ClImate Projections Leading to European Services, Copernicus C3S funded activity.
PCMDI: Program for Climate Model diagnosis and Intercomparison, at Lawrence Livermore National Laboratory, USA (http://www-pcmdi.llnl.gov/).
PRACE: Partnership for Advanced Computing in Europe (http://www.prace-project.eu/).
ROSE: Framework for managing and running meteorological suites (http://metomi.github.io/rose/doc/rose.html).
RISCAPE: European Research Infrastructures in the International Landscape, H2020 projec**t** (http://www.riscape.eu/).
WCRP: World Climate Research Programme (http://www.wmo.ch/pages/prog/wcrp).
WIP: WGCM Infrastructure Panel (https://www.earthsystemcog.org/projects/wip/).
WGCM: Working Group on Coupled Models (http://www.clivar.org/organization/ wgcm/wgcm.php).
XIOS: XML-IO-SERVER, parallel I/O and "in situ "post-treatment software for big data in climate modelling.
XML: Extensible Markup Language

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Section 4-5 and Appendix

Section 4: Members of the consortium

4.1. Participants (applicants)

1. Centre National de la Recherche Scientifique (CNRS-IPSL)

About the partner

The Centre National de la Recherche Scientifique (CNRS) is the main French public research institution under the responsibility of the French Ministry of Education and Research. CNRS acts here in the name of the Institut Pierre Simon Laplace (IPSL), which is a federal institute located in Paris and composed of 9 research laboratories working on global environmental and climate studies. IPSL gathers about 1000 scientists and represents more than a third of the French research potential in atmospheric and oceanic sciences. Laboratories from IPSL involved in IS-ENES3 are Laboratoire des Sciences du Climat et de l'Environnement (LSCE), Laboratoire d'Océanographie et du Climat (LOCEAN), Laboratoire Atmosphère, Milieux, Observations Spatiales (LATMOS) and the IPSL federative unit. One of the main objectives of IPSL is to understand climate variability and change, from both natural and anthropogenic origin, at global and regional scales. Climate modelling relies on the development of the IPSL Earth system model, which participates to the WCRP CMIP international experiments. IPSL has coordinated the IS-ENES phases 1 and 2 projects, and is involved in several European projects such as ESiWACE and CRESCENDO. CNRS was a pioneer in developing since the 1980s a numerical model of the global physical ocean taking into account the HPC issues from the very beginning. This led to the NEMO Consortium involving different research/operational oceanography centres in Europe, which join efforts for the sustainable development of NEMO (www.nemo-ocean.eu). IPSL has expertise on data and metadata and is strongly involved in the development of the international ESGF and ESDOC. CNRS with the Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA) have developed XIOS, a software library dedicated to efficient IO management for climate models.

Contribution of partner to the specific project

In IS-ENES3, CNRS-IPSL will coordinate the project, be involved in WP2 on strategy, lead WP3/NA2 on community engagement and WP5/NA4 on networking on data and model evaluation. CNRS will also be involved in data and metadata service and developments (WP7/SA2 and WP10/JRA3), on the new community sea ice model (WP4/NA3 and WP8/JRA1), on the XIOS software (WP6/SA1 and WP8/JRA1), and on model evaluation (WP3/NA2 and WP9/JRA2).

Curriculum Vitae of responsible for carrying out the proposed activities

Dr Sylvie Joussaume (female) is a researcher at CNRS since 1983. She is an expert in climate modelling. She has been coordinating IS-ENES (EU FP7) phases 1 and 2 since 2009 and is Chair of the ENES Scientific Board. She has been involved in IPCC since the third assessment report. She is involved in the Governing Board of JPI Climate. She has been vice-chair (2011-2014) and chair (2015) of the PRACE scientific committee. She is chair of the evaluation committee of the national supercomputing facilities under GENCI. She is representing the ENES network and its infrastructure in the ClimatEurope H2020 coordinated action. She is IS-ENES3 scientific coordinator.

Marie-Alice Foujols (female) is a research engineer at CNRS. She is in charge of coordinating technical aspects of the Earth system model at IPSL, and the head of the IPSL engineers group working across the IPSL laboratories. She has an expertise in high performance computing since 20 years. She will participate in WP7.

Dr Yann Meurdesoif (male) is an engineer at CEA within the LSCE joint unit and has a PhD in theoretical physics. He has been working for several years as a consultant for high performance computing at the CEA supercomputing centre and has then acquired a strong background on

parallelism, code porting, and optimization on a large variety of supercomputer. He has developed the parallel versions of several components of the IPSL Earth system model and is responsible at IPSL for the development of XIOS, a software library dedicated to efficient IO management for climate models. He will be involved in WP4, WP6, and WP8.

Arnaud Caubel (male) has been working as engineer at LSCE (CEA) since 2003. He has expertise on High Performance Computing, especially on coupling and I/O aspects. He is in charge of the technical aspects of the IPSL Earth System model and its environment: assembling, porting and optimization on HPC centres. He is also involved in the development and integration of XIOS library in climate components (WP6 and WP8).

Dr Jérôme Servonnat (male) is a CEA IT-researcher since 2011. He works on climate model evaluation (focus on the IPSL coupled model) and climate model evaluation tools (co-developer of the python library CliMAF, contributor of the PCMDI Metrics Package). He has been a contributor of IS-ENES 1 and 2 and is looking for implication in the development of the future version of the ESMValTool (WP3).

Sébastien Denvil (male), is a research engineer at CNRS, holds a *diplôme d'études supérieures spécialisées* in "Information treatment and data processing". He joined the global climate modelling group at IPSL where he is responsible for the long IPCC-type simulations and for the distribution of model outputs. Sébastien Denvil is a member of ESGF Executive Committee, of the WGCM Infrastructure Panel and of ESDOC. He will lead the data networking activity (WP5/NA4) and will be involved in the services activities WP7/SA2 and developments WP10/JRA3.

Dr Guillaume Levavasseur (male) is a data scientist at UPMC, working on climate data management at the IPSL since 2012. With a broad general knowledge in geosciences and a PhD in climate modelling, he is involved in climate engineering through data publication on ESGF platform, user support for data access and analysis and lead on development of ESGF key tools for data preparation and errata service. He will be involved in activities of WP7 and WP10.

Dr Eric Guilyardi (male) is a researcher at CNRS on climate variability, climate model development and software infrastructures for Earth System Models. He contributed over 45 publications in peer-reviewed journals. He is Lead Author for IPCC-AR5. He has been coordinating the FP7 METAFOR project. He will be involved in the model evaluation and metadata activities. He will lead the community WP3/NA2 and contribute to some other WPs.

Dr Martin Vancoppenolle (male) wants to understand the role of sea ice in the Earth system. To do that, he studies sea ice physical, biological and chemical processes from observations and numerical models. He has contributed to the development of LIM, the sea ice model of NEMO, the European ocean modelling system, used in several Earth System Models used as a basis for IPCC reports and co-leads the sea ice working group. He also (within the international team BEPSII) has gathered and analyzed databases of Antarctic sea ice biogeochemical parameters and taken part to several missions on the field. He will work on the Sea Ice activities in WP4 and WP8.

Simona Flavoni (female) holds her degree in mathematics at Rome University. She is engineer at CNRS since 2009, she is the CNRS NEMO Officer i.e. she represents CNRS in NEMO consortium and she's responsible of the CNRS Annual Workplan. She executed various climate model experiments for CMIP5 exercise, she was involved in IS-ENES1 and IS-ENES2 European Projects and she took part in COMODO ANR project. She leads the Robustness & Test Cases working group. She is interested in numerical analysis; she is strongly involved in development of idealized configurations in NEMO. She will be involved in the NEMO activity of WP4.

Nicolas Martin (male) is an engineer in Programming and Information Technology within Sorbonne University since 2014. Inside the NEMO System Team, he oversees the web presence of the project and rolls out the collaborative environment for the NEMO community (users and developers). Nicolas is in

charge of the institutional website, the distribution/development platform of the source code and the mailing lists for internal/external communications. He will work on the activities related to NEMO in WP4 and WP6.

Karim Ramage (male) is a geoscience physicist working as a computer scientist in the field of geospatial data management since 2002. He is responsible for a data archive and processing facility at IPSL/CNRS. He works on the development of software applications for observational data and model simulations processing and distribution in the scope of international field campaign experiments databases. He is currently the chair of the database working team of the HyMeX project which supports the Med-Cordex contribution to CORDEX.

Philippe Weill (male) is a research engineer at CNRS with a master on network and system administration. He is a specialist in file system, networking, linux and HPC environment administration at IPSL within the joint research unit LATMOS since 1991. He will participate to the VA and TNA activities of WP7/VA2.

Up to 5 relevant Publications, and/or products or other achievements

1. Dufresne J.L., M.A. Foujols, S. Denvil, and 57 other authors including S. Joussaume, S. Masson, Y. Meurdesoif, 2013: Climate change projections using the IPSL-CM5 Earth System Model: from CMIP3 to CMIP5. Clim Dyn, 40, 2123–2165, https://doi.org/10.1007/s00382-012-1636-1.
2. Rousset, C., Vancoppenolle, M., Madec, G., Fichefet, T., Flavoni, S., Barthélemy, A., Benshila, R., Chanut, J., Levy, C., Masson, S., and Vivier, F. , 2015: The Louvain-La-Neuve sea ice model LIM3.6: global and regional capabilities, Geosci. Model Dev., 8, 2991-3005, https://doi.org/10.5194/gmd-8-2991-2015.
3. Bellenger, H., Guilyardi, E., Leloup, J., Lengaigne, and Vialard J. ENSO representation in climate models: from CMIP3 to CMIP5. Clim. Dyn., 42, 1999-2018, https://doi.org/10.1007/s00382-013-1783-z.
4. Mitchell J, Budich R, Joussaume S, Lawrence B and Marotzke J (2012), "Infrastructure strategy for the European Earth System Modelling community 2012-2022", ENES Report Series 1, 33 pp. https://doi.org/10.5285ca90b281d6ff4cffb9a9bbdeb5fa63f3
5. Joussaume S., Lawrence B., Guglielmo F., Update of the ENES infrastructure strategy 2012-2022, 2017, goo.gl/iyDqh9

Up to 5 relevant Projects, and/or activities, services

EU FP7 IS-ENES phase 1 (2009-2013), phase 2 (2013-2017), Infrastructure for European Network for Earth System Modelling, coordinated by CNRS-IPSL. IS-ENES projects have fostered the integration of the European Climate and Earth system modelling community, enhanced the development of Earth system models for the understanding of climate variability and change, supported high-end simulations, and facilitated model applications to better predict and understand climate change impacts on society (https://is.enes.org).

EU H2020 ESiWACE (2015-2019), Centre of Excellence in Simulation of Weather and Climate in Europe. ESiWACE contributes to prepare climate model applications for future computer architectures.

ANR Convergence project (2013-2017), aimed at developing a platform capable of running large ensembles of simulations with a suite of models, to handle the complex and voluminous datasets generated, to facilitate the evaluation and validation of the models and the use of higher resolution models. The project has in particular extended the use of XIOS on all model components in France.

H2020 CRESCENDO (2015-2020) stands for "Coordinated research in Earth Systems and Climate: Experiments, kNowledge, Dissemination and Outreach". The project aims to improve the representation of key processes in European Earth System Models (ESMs) (i), evaluate thoroughly the scientific

performance of these models (ii), use the models to generate a new set of Earth system projections for the coming century and coordinate the European contribution to CMIP6 (iii), and ensure that knowledge developed in the project is communicated to key stakeholder communities in an engaging and understandable form (iv).

H2020 CLIMATEUROPE CSA (2015-2020) coordinates activities on Earth system modelling, observations and climate services. CNRS-IPSL coordinates the WP on forward looking.

Significant infrastructure, and/or major items of technical equipment

CNRS-IPSL is running the coupled Earth's climate system model IPSL-ESM. This model has contributed to the CMIP3, CMIP5 and CMIP6 international WCRP coordinated experiments. CNRS-IPSL uses the GENCI national supercomputing facilities and manages a data node within the international ESGF database. CNRS-IPSL coordinates the national research infrastructure on climate modelling CLIMERI-France, which supports the French contribution to international coordinated experiments (https://climeri-france.fr/).

2. The University of Reading - National Centre for Atmospheric Science (UREAD-NCAS)

About the partner

The University of Reading was established in 1892 and is now a world-class university with campuses in the UK and Malaysia. The proposed work will be carried out in the School for Mathematical, Physical and Computational Sciences, with contributions from the Department of Computer Science alongside substantial engagement from the UK National Centre for Atmospheric Science (NCAS) based in the Department of Meteorology.
The Department of Meteorology is the only UK university department to offer a full range of undergraduate and postgraduate courses in meteorology. The department is internationally renowned for excellent research and teaching in atmospheric, oceanic and climate science. The Department of Computer Science has been recently established as part of a reorganisation of what was the School of Systems Engineering. As part of the reorganisation, and partly in response to the training and skills needs identified in IS-ENES2 and ESiWACE, the department has hired three new academics to provide the kernel for a new "Advanced Computing in Environmental Sciences" group intended to work at the intersection of Meteorology and Computer Science.
NCAS is an organisation distributed amongst several UK universities and the Science and Technology Facilities Council (STFC). As well as world class research in climate science, atmospheric composition, and atmospheric physics, NCAS provides scientific facilities for researchers' right across the UK to enable excellent atmospheric science on a national scale. These include a world-leading research aircraft, a ground-based instrumentation pool, access to computer models and facilities for storing and analysing petascale data (JASMIN). NCAS carries out research using its own resources and via projects such as IS-ENES3, awarded to its staff in their host institutions.

Contribution of partner to the specific project

In IS-ENES3, UREAD will contribute to the project coordination, lead WP2/NA1 on governance, sustainability and innovation (including managing the project scientific officer in partnership with IPSL), contribute to the work on metadata standard and model documentation in WP3/NA2, WP7/SA2, and WP10/JRA3, provide software engineering support for technical improvements to ESMValtool in WP9/JRA2, and contribute to the development of the European Sea Ice platform in WP3/NA4 and WP8/JRA1.

Curriculum Vitae of responsible for carrying out the proposed activities

Professor Bryan Lawrence (male) is a Professor of Weather and Climate Computing at the University of Reading. He has a dual position between Computer Science and Meteorology, is Director of the Models and Data Division of NCAS, and the leader of the new university Advanced Computing in Environmental Sciences (ACES) group. He was responsible for identifying the need for a UK and European data analysis facility, and for procuring and specifying all the phases of what is now the (40+PB, 11000 core) JASMIN data analysis facility. He has over thirty years of experience in atmospheric science and computing with over one hundred relevant publications. He has successfully supervised eleven completed doctoral students. He is on many national and international committees for climate science and climate related infrastructure. He holds a formal visiting scientist position at the STFC to facilitate the management and direction of JASMIN. He is currently co-leading the ESiWACE "Exploitability" work package, recently led a work package in IS-ENES2, and is leading related JASMIN/CEDA projects. He will be leading WP2/NA1 and supporting Dr Joussaume (IPSL) in coordination.

Professor Danny Feltham (male) is Professor of Climate Process Physics in the Department of Meteorology in the University of Reading and a founding member of the NERC Centre for Polar Observation and Modelling, where he directs Sea ice modelling. Danny is Chair of the Joint Sea Ice Model Panel advising on NERC-Met Office National Capability sea ice effort. Danny won a 2006 Philip Leverhulme Prize for excellence in research and his expertise is in the construction and analysis of new mathematical models of physical processes in the cryosphere. This research combines the development of fundamental new theory and numerical simulations with laboratory experiments, field measurements and remotely-sensed observations. He has provided the principal supervision for 11 PhD students and 8 Postdoctoral Research Assistants and has co-supervised many others. Danny has published over 70 papers in the following research areas: interaction of ice with the polar ocean, including deep water formation and export, ice-ocean interface dynamics, water mass modification, marine ice deposition; sea ice dynamics, especially sea ice rheology and the role of form drag; and sea ice thermodynamics including melt pond formation and frazil ice. Many of these studies have led to sea ice physics parameterisations included into the sea ice components of climate models.

David Hassell (male) was previously a senior scientist for regional climate modelling in the Met Office, since 2011 Hassel has been a computational scientist in NCAS. He is the designer and lead developer of cf-python, a software library for the data manipulation and analysis written for the Python programming language. This library is unique in that it makes full use of a data model of the CF conventions used for storing climate and forecast datasets. He has been coordinating elements of the evolution of the CF conventions for some years, and has been a key individual in the development of the ES-DOC systems and tools for the creation, analysis and dissemination of documentation for numerical models and research workflows.

Up to 5 relevant Publications, and/or products or other achievements

1. Balaji, V., Maisonnave, E., Zadeh, N., Lawrence, B. N., Biercamp, J., Fladrich, U., … Wright, G. (2017). CPMIP: Measurements of Real Computational Performance of Earth System Models in CMIP6. *Geosci. Model Dev.*, *10*(1), 19–34. https://doi.org/10.5194/gmd-10-19-2017
2. Hassell, D., Gregory, J., Blower, J., Lawrence, B. N., & Taylor, K. E. (2017). A Data Model of the Climate and Forecast Metadata Conventions (CF-1.6) with a Software Implementation (CF-Python v2.1). *Geosci. Model Dev.*, *10*(12), 4619–4646. https://doi.org/10.5194/gmd-10-4619-2017
3. Heorton, H. D. B. S., Radia, N. and Feltham, D. L. (2017) A model of sea ice formation in leads and polynyas. J Phys Oceanogr, 47 (7). pp. 1701-1718. ISSN 0022-3670 doi: https://doi.org/10.1175/jpo-d-16-0224.1
4. Mitchell J, Budich R, Joussaume S, Lawrence B and Marotzke J (2012), "Infrastructure strategy for the European Earth System Modelling community 2012-2022", ENES Report Series 1, 33 pp. https://doi.org/10.5285ca90b281d6ff4cffb9a9bbdeb5fa63f3

5. Joussaume S., Lawrence B., Guglielmo F. Update of the ENES infrastructure strategy 2012-2022, 2017, goo.gl/iyDqh9

Up to 5 relevant Projects, and/or activities, services

EU FP7 IS-ENES phase 2 (2013-2017), Infrastructure for European Network for Earth System Modelling, coordinated by CNRS-IPSL. IS-ENES projects have fostered the integration of the European Climate and Earth system modelling community, enhanced the development of Earth system models for the understanding of climate variability and change, supported high-end simulations, and facilitated model applications to better predict and understand climate change impacts on society (https://is.enes.org). UREAD provides work package leadership.

EU H2020 ESiWACE (2015-2019), Centre of Excellence in Simulation of Weather and Climate in Europe. The main goal of ESiWACE is to substantially improve efficiency and productivity of numerical weather and climate simulation by supporting the end-to-end workflow of global Earth system modelling in current and future high performance computing environments - especially those which will require the next generation of pre-exascale and then exascale computers. UREAD provides work package leadership.

NCAS Computational Modelling Service (http://cms.ncas.ac.uk) provides HPC resource management and software engineering support for the UK atmospheric and polar science community and delivers key underpinning infrastructure including Unified Model software repositories, configured versions of key climate models, and relevant training courses. UREAD hosts NCAS-CMS within Professor Lawrence's division of NCAS.

UKCMIP6. The UK-CMIP6 project is a joint Met Office NERC activity aimed at delivering the UK contributions to CMIP6. NCAS-CMS is providing modelling and workflow support, and Professor Lawrence is on the UKCMIP6 board.

3. Deutsches Klimarechenzentrum GmbH (DKRZ)

About the partner

DKRZ, the German Climate Computing Centre, is a national service provider, providing state-of-the-art super-computing, data service and other associated services to the German and international scientific community to conduct top of the line Earth System and Climate Modelling. DKRZ operates a fully scalable supercomputing system designed for and dedicated to Earth system modelling including mass storage systems to a capacity of more than 190 PBs. It provides its more than 1000 scientific users with the technical infrastructure needed for the processing and analysis of huge amounts of data from climate simulations, also covering training and support for related application software and data processing. DKRZ participates in numerous national and international projects aiming to improve the research infrastructure for climate modelling. It is partner in ENES (European Network for Earth System Modelling) and is one the representatives of the Earth system research community in the EUDAT project. DKRZ is operating with its ICSU World Data Center Climate (WDCC) a community specific long-term data archive. Connected with its WDCC DKRZ provides best practise examples in scientific data life cycle management for the Earth system research community (federated data infrastructures, long-term archiving service, grid-based data processing workflows). Through its research group on scientific computing DKRZ is linked to the Department of Informatics of the University of Hamburg.

Contribution of partner to the specific project

In IS-ENES3, DKRZ will lead WP7/SA2 on data and compute services, co-lead WP2/NA1 on governance, sustainability and innovation and is leading the IS-ENES data task force in this context. DKRZ will be involved in community engagement and networking on data and evaluation (WP3/NA2

and WP5/NA4). DKRZ will also be involved in developments with respect to data and data evaluation (WP10/JRA3 and WP9/JRA2).

Curriculum Vitae of responsible for carrying out the proposed activities

Dr Stephan Kindermann (male) holds a PhD in computer science from the University of Erlangen (1997). He leads the "data infrastructure" group at DKRZ responsible for e-infrastructure operation, integration and research activities. He is computer scientist with more than 10 years of experience in parallel and distributed processing infrastructures and more than 10 years experience in big data management in the context of climate model data. Since 2004 he is working at DKRZ, involved in many national and international data infrastructure projects (EGEE, C3Grid, ESGF, EUDAT2020, IS-ENES, IS-ENES2, ENVRI+, COPERNICUS). Currently he act as data infrastructure group leader at DKRZ responsible for the operations of the ESGF DKRZ infrastructure as well as the development and integration efforts (local, national, international) related to the Earth System Grid Federation (ESGF) and IS-ENES. In the context of COPERNICUS he leads the activities establishing a (data near) compute service for climate projections (CP4CDS: global climate projections, CORDEX4CDS: regional climate projections, in negotiation). Within the IS-ENES3 project he will take lead of the work package data (WP7).

Dr Michael Lautenschlager (male) is leading the Data Management Department at DKRZ (German Climate Computing Centre) and is also director of the ICSU World Data Center Climate at DKRZ. He started his career at MPI-M (Max-Planck-Institute for Meteorology) in Earth system modelling. Since 1991 he is active in scientific data management at DKRZ and MPI-M. He is member of the WGCM Infrastructure Panel and co-chair of ESGF Executive Board. Within the IS-ENES3 project he will take lead of the sustainability work task in WP2/NA1.

Dr Martina Stockhause (female) holds a PhD in Meteorology (2000). Her main responsibilities within DKRZ are the co-ordination of the long-term archival for climate intercomparison projects, and DataCite DOI Data Publication. She contributed this expert knowledge within several national and international projects and initiatives. Within CMIP6 she leads the evolving data citation and the long-term data archival services. She is managing the IPCC DDC (Data Distribution Centre) and is an ex-officio member of IPCC TGICA. Within the IS-ENES3 project Martina will contribute to WP7/SA2.

Hannes Thiemann (male) is Deputy Head of department Data Management at DKRZ. He holds a degree in geophysics and works as a senior scientist at DKRZ with more than 25 years of experience in data management. His current main activity is the management of the long term data archive (CERA) at DKRZ. He has been involved in many national and international projects like PRISM and IS-ENES. Moreover he was participating in different roles in the EU funded projects EUDAT and EUDAT2020. At the European level, he is currently involved in the projects SeaDataCloud and EOSC-hub. Hannes will contribute to WP5/NA4 within the IS-ENES3 project.

Dr Tobias Weigel (male) holds a PhD in computer science from Hamburg University (2015) and is working since 2010 at DKRZ in the area of e-infrastructures, with participation in the previous H2020 projects IS-ENES, IS-ENES2 and EUDAT. In the EOSC-hub project, Tobias leads the ENES Climate Analytics Thematic Service task and B2HANDLE subtask. He is responsible for PID service development in ESGF. He is also a member of the Research Data Alliance (RDA) Technical Advisory Board, has co-chaired multiple RDA Working Groups related to PIDs and is an Editorial Board member of the CODATA Data Science Journal. In IS-ENES3 project he will contribute to the data work package WP7

Katharina Berger (female) holds a diploma in Computer Science and is working in the Datamanagement Department of DKRZ since 2013. Her main activity is the administration, development and support for the ESGF. Within the IS-ENES3 project Katharina will contribute to the work packages WP/SA1, WP7/SA2 and WP10/JRA3.

Dr Kerstin Ronneberger (female) works in the Application Department of DKRZ. She holds a PhD in Earth System Research. Since 2005 she worked in several projects dealing with grid software, data-access and workflow in Earth-System Modelling. She is technically maintaining the ENES portal for the community and thus contributing to WP3/NA2.

Dr Kerstin Fieg (female) works in the Application department of DKRZ as work package leader in third-party funding projects. She holds a PhD in Meteorology has 20-year experience in supporting data intensive climate simulations and project management. She worked in the field of development, coupling and performance optimization of Earth System Models and has contributed to procurement and management of several HPC systems. Kerstin was engaged in the projects CMIP5, IS-ENES and IS-ENES2 and currently involved in several national and international funded projects (like HDCP2, ESiWACE) dealing with infrastructure to support climate modelling. Kerstin will support the WP3.

Up to 5 relevant Publications, and/or products or other achievements

1. V. Eyring, M. Righi, A. Lauer, M. Evaldsson, S. Wenzel, C. Jones, A. Anav, O. Andrews, I. Cionni, E. Davin, C. Deser, C. Ehbrecht, P. Friedlingstein, P. Gleckler, K. Gottschaldt, S. Hagemann, M. Juckes, S. Kindermann, J. Krasting, D. Kunert, R. Levine, A. Loew, J. Mäkelä, G. Martin, E. Mason, A.S. Phillips, S. Read, C. Rio, R. Roehrig, D. Senftleben, A. Sterl, L.H. van Ulft, J. Walton, Jeremy S. Wang, K.D. Williams, (2016) ESMValTool (v1.0) – a community diagnostic and performance metrics tool for routine evaluation of Earth system models in CMIP. Geosci.Model Dev.., 9, Seiten 1747-1802. https://doi.org/10.5194/gmd-9-1747-2016 ISSN 1991-959X
2. V. Eyring, P. Gleckler, C. Heinze, R.J. Stouffer, K.E. Taylor, V. Balaji, E. Guilyardi, S. Joussaume, S. Kindermann, B. Lawrence, G.A. Meehl, M. Righi, D.N. Williams (2016) Towards improved and more routine Earth system model evaluation in CMIP. Earth Syst Dynam, https://doi.org/10.5194/esd-7-813-2016 ISSN 2190-4979
3. S. Kindermann: Data Discovery: Identifying, Searching and Finding Data, in: Earth System Modelling - Volume 6, pp. 21-32, SpringerBriefs in Earth System Sciences, Springer Berlin Heidelberg, ISBN 978-3-642-37243-8, https://doi.org/10.1007/978-3-642-37244-5_4
4. T. Weigel, M. Lautenschlager, F. Toussaint, S. Kindermann (2013): A Framework for Extended Persistent Identification of Scientific Assets., Data Science Journal, Vol. 12, p. 10-22, https://doi.org/10.2481/dsj.12-036

Up to 5 relevant Projects, and/or activities, services

COPERNICUS: DKRZ is one of the three partners (besides CEDA - UK and IPSL - France) providing global climate projections to the Copernicus climate data store (C3S) as part of the CP4CDS project. DKRZ also leads the work package establishing a "compute node" to provide data near processing functionality based on standardized (OGC WPS) interfaces. DKRZ is also a partner in the regional climate projections project (currently in negotiation phase) also with the responsibilities to provide regional projections data and to provide a data near compute solution. Additionally DKRZ will integrate persistent data identification services for regional projections data.

ENVRIPlus: Harmonizing approaches for data identification, citation, data processing and data workflows for environmental research infrastructures. DKRZ contributes to the data identification and citation work package as well as the data curation and data processing related work packages ensuring the future consistency of ENES community developments with the overall ENVRI+ framework developments and thus the wider earth science related initiatives and e-infrastructures in Europe.

EU H2020 project SeaDataCloud: A focus of this project, involving 55 partners from 34 countries, is the further development of existing services and standards for research data from the SeaDataNet network, in which more than hundred oceanographic data centers have been organized. The DKRZ, together with four other partners from the EUDAT network, is involved in developing and operating services for the SeaDataCloud community on the basis of current IT infrastructures and technologies. These services are based on developments by EUDAT like the data storage services B2SAFE or

B2SHARE and are the basis for the further growth of the SeaDataNet network.

EU H2020 project EOSC-hub: The EOSC-hub project brings together providers from the EGI Federation, EUDAT CDI, INDIGO-DataCloud and other major research infrastructures that provide services, software and data for advanced data-driven research and innovation. These resources are offered through the Hub - the integration and management system of the European Open Science Cloud - which acts as a central contact point for all relevant actors. In cooperation with the Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC), the DKRZ brings the "ENES Climate Analytic Service" (ECAS) into EOSC-hub, which enables end users to carry out data analyses on large amounts of climate data based on a PID-enabled and server-side approach. In addition, DKRZ lead the activities related to data discovery and access and is responsible for the EOSC-hub services B2HANDLE and B2FIND.

EU H2020 CoE ESiWACE: European Center of Excellence in Simulation of Weather and Climate in Europe, DKRZ acts as project coordinator, WPL in WP4 and WP5 and co-WPL in WP1.

Significant infrastructure, and/or major items of technical equipment

DKRZ is running one of Germany's most powerful high performance computers and world class data storage and archiving hardware. The current system is a BULL system with 80000 cores and 3.2 PetaFLOPS. The file system is based on lustre and will initially have a net storage capacity of 50 PetaBytes. For long term archiving of data DKRZ runs a tape library with the capacity to store more than 190 PetaByte of data.
As for services, DKRZ supports complex and compute intensive national and international collaborative projects: simulations are carried out and resulting data are managed and made available through the World Data Center Climate (WDCC) operated by DKRZ. Data nodes and data portal of the Earth System Grid Federation (ESGF) run are run by DKRZ.

4. Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique (CERFACS)

About the partner

The Centre Européen de Recherche et de formation Avancée en Calcul Scientifique (CERFACS), established in 1987 in Toulouse (France), is currently one of the world's leading research institutes working on efficient algorithms for solving large-scale scientific problems. The CERFACS Climate Modelling and Global Change team conducts basic scientific research and high-level technical developments in the field of climate studies. In particular, the team develops the OASIS coupler currently used by more than 45 climate-modelling groups in Europe and around the world. CERFACS activities in high performance computing encompass assembling high-resolution coupled climate based on state-of-art component models, porting and optimising them on a variety of platforms. Together with Météo-France, CERFACS is participating in CMIP6 and one of its main scientific objectives is to make significant contributions to the understanding of the world climate variability on regional to global scales and to climate impact studies at seasonal-to-decadal time scales. CERFACS is getting also involved in building new approaches to deal with large data volumes produced in climate science together with large data centres in Europe. Thanks to its strong expertise in code coupling and the central role played by the OASIS coupler in the European climate community, CERFACS was heavily involved in the set-up and realisation of the IS-ENES1 and IS-ENES2 projects as leader and co-leader of work packages. CERFACS currently participates actively in ESiWACE Centre of Excellence1 as WP2 co-leader and as leader of the HPC task force. CERFACS is also involved in several other e-infrastructure and scientific FP7 European projects: EUDAT2020 2015-2018 (Task leader), PRIMAVERA 2016-2019 (WP leader); APPLICATE 2017-2020 (participant), DARE 2018-2021 (WP & Task leader).

Contribution of partner to the specific project

In IS-ENES3, CERFACS will lead WP8/JRA1 on model and tool developments, in particular conducting the work on the OASIS3-MCT coupler. CERFACS will co-lead WP6/SA1 offering services on the OASIS3-MCT coupler and on the XIOS server, and WP10/JRA3 on the data service software infrastructure leading the development of the Climate4Impact platform. CERFACS will also be involved in the following work packages: WP2/NA1 on the governance and sustainability tasks; WP3/NA2 on community engagement; WP4/NA3 in particular with the performance evaluation of complex coupled systems and with the organisation of the 5th International Workshop on Coupling Technologies for Earth System Models; WP5/NA4 on coordination for data distribution and processing with other e-infrastructures.

Curriculum Vitae of responsible for carrying out the proposed activities

Eric Maisonnave (male) is a research engineer at CERFACS since 1999 specialised in HPC, parallelisation and code coupling for sustainable climate models. He has developed a strong expertise to configure and optimise OASIS-based coupled models. He was involved in IS-ENES1 & 2 European projects working on Earth System Model assembling, porting and optimisation and providing OASIS dedicated support to several European laboratories. E. Maisonnave will co-lead WP6/SA1 and will be involved in WP4/NA3 and WP8/JRA1.

Dr Christian Pagé (male) holds a "highly qualified" research engineer position at CERFACS. He has been active in research and development since 1995, covering a large spectrum of atmospheric sciences. He has been involved in many large projects. He is currently involved in improving access to large data volumes for use within the climate community. He has been involved in several European projects, notably FLYSAFE, EUDAT/EUDAT2020, IS-ENES/IS-ENES2, CLIPC, SPECS, DARE, often as a work package leader. He is also involved in the Earth System Grid Federation (ESGF) Compute Working Expert team, on providing data processing near the data storage for large data volumes in a federated infrastructure. He also leads the work on the interfaces and workflows with respect to the delegation of computations from the EUDAT CDI to the EGI FedCloud. C. Pagé will co-lead WP10/JRA3 and will be involved in WP3/NA2 and WP5/NA4.

Dr Sophie Valcke (female) holds a "highly qualified" research engineer position at CERFACS where she is working on high-resolution atmosphere-ocean-ice coupled modelling and is leading a team of 4 engineers developing the OASIS coupler. Thanks to her expertise in HPC for climate, Dr Valcke currently sits on the EXDCI Weather, Climate & Earth Sciences Working Group and was a member of the PRACE Access Committee from 2012 to 2016. Dr Valcke is CERFACS Principal Investigator for ESiWACE CoE and played this role also for IS-ENES2, IS-ENES1 and METAFOR infrastructure projects. These projects favour Dr Valcke's interaction with many climate modelling groups in Europe and with other groups internationally developing coupling frameworks. Dr Valcke also played a key role in the set-up of the International Working Committee on Coupling Technologies that organizes global efforts on the characterization, comparison, and benchmarking of Earth system model coupling technologies and related workshops. S. Valcke will lead WP8/JRA1 and will be involved in WP2/NA1, WP4/NA3, and WP6/SA1.

Dr Marie-Pierre Moine (female) is a research engineer at CERFACS, graduated in Atmospheric Physics in 2001. Since 2007, she is working in the context of national, European and international projects dealing with climate modelling and data management, from production (in particular with the XIOS server) to user accessibility through dedicated networks (ESGF). Currently involved in the realisation of CMIP6, she also contributes to European projects focused on high-resolution climate simulations (H2020 PRIMAVERA and ESiWACE CoE) and massive data projects (H2020-EUDAT). M.-P. Moine will contribute to WP6/SA1 and WP8/JRA1.

Up to 5 relevant Publications, and/or products or other achievements

1. Balaji, V., Maisonnave, E., Zadeh, N., Lawrence, B. N., Biercamp, J., Fladrich, U., Aloisio, G., Benson, R., Caubel, A., Durachta, J., Foujols, M.-A., Lister, G., Mocavero, S., Underwood, S., and Wright, G., 2017: CPMIP: Measurements of Real Computational Performance of Earth System Models in CMIP6 , Geosci. Model Dev., 46, 19-34, https://doi.org/10.5194/gmd-10-19-2017
2. Craig, A., S. Valcke, L. Coquart, 2017: Development and performance of a new version of the OASIS coupler, OASIS3-MCT_3.0, Geosci. Model Dev., 10, 3297-3308, https://doi.org/10.5194/gmd-10-3297-2017, 2017.
3. Lawrence, B. N., M. Rezny, R. Budich, P. Bauer, J. Behrens, M. Carter, W. Deconinck, R. Ford, C. Maynard, S. Mullerworth, C. Osuna, A. Porter, K. Serradell, S. Valcke, N. Wedi, and S. Wilson: Crossing the Chasm: How to develop weather and climate models for next generation computers?, Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2017-186, in review, 2017.
4. Monerie, P.-A., Coquart, L., Maisonnave, E., Moine, M.-P., Terray, L. and Valcke, S. (2017) Decadal prediction skill using high-resolution climate model, Clim. Dyn., 49 (9-10), pp. 3527–3550, https://doi.org/10.1007/s00382-017-3528-x
5. Déandreis, Céline, Christian Pagé, Pascale Braconnot, Lars Bärring, Edoardo Bucchignani, Wim Som de Cerff, Ronald Hutjes, Sylvie Joussaume, Constantin Mares, Serge Planton, Maarten Plieger, 2014. Towards a dedicated impact portal to bridge the gap between the impact and climate communities: lessons from use cases. Clim Change, 125 (3-4), 333-347, https://doi.org/10.1007/s10584-014-1139-7.

Up to 5 relevant Projects, and/or activities, services

CERFACS provides advanced HPC training in code coupling for PhD & post-doctoral students and engineers (see http://www.cerfacs.fr/19-25708-Home.php).

CERFACS is currently involved in the current EU and national projects:

EU H2020 ESiWACE Centre of Excellence in Simulation of Weather and Climate in Europe

EU H2020 EUDAT2020: European Data Infrastructure

EU H2020 APPLICATE: Advanced prediction in Polar regions and beyond

EU H2020 PRIMAVERA PRocess-based climate sIMulation: AdVances in high resolution modelling and European climate Risk Assessment

EU H2020 DARE: Data Reliability in Networks and Storage Memories

French ANR COCOA COmprehensive Coupling approach for the Ocean and the Atmosphere

Significant infrastructure, and/or major items of technical equipment

The NEMO cluster provides CERFACS with a peak capacity of about 276 Tflop/s. It includes 288 compute nodes, each of them with two Intel E5-2680 processors (12 cores haswell processor at 2.5 Ghz) and 64 GB DDR4 memory. The 288 node of this “compute partition” are completed by 11 post-processing nodes with 256 GB memory and one node with 512 GB memory used for large mesh generation. The interconnection network is a non-blocking FDR Infiniband network. An internal GPFS file system offers to users a 0.5 PO scratch directory capacity. Software environment includes intel development compilers, libraries and tools; TotalView and DDT debuggers; and SLURM job manager. Integrated by Lenovo and serviware, this cluster has been inaugurated on September 30th, 2015.

5. The Met Office (MetO)

About the partner

The Met Office is the UK National Meteorological Service (NMS) and is one of the world's leading providers of climate and weather-related service. The Met Office was formed in 1854 with the primary aim to research the possibilities of forecasting the weather, mainly to protect the safety of ships and their crew at sea. As well as being the first NMS, the Met Office has continued to lead the field in the development of weather and climate services. The Met Office provides essential services 24/7, 365 days a year, in many aspects of business, social and political life in the UK.

The Met Office is a Trading Fund within the Department for Business Innovation and Skills, operating on a commercial basis under set targets. We are recognised as one of the world's most accurate forecasters, using more than 10 million weather observations a day, an advanced atmospheric model and a high performance supercomputer to create 3,000 tailored forecasts and briefings a day. These are delivered to a huge range of customers from the Government, to businesses, the general public, armed forces, and other organisations. This includes the Public Weather Service (PWS), which provides forecasts for the public to help them make informed decisions about their day-to-day activities. The National Severe Weather Warning Service is also a part of this, providing advance notice of weather which could affect public safety.

The Met Office provides the Met Office Hadley Centre Climate Programme which is supported by Department for Business, Energy & Industrial Strategy (BEIS) , and the Department for Environment, Food and Rural Affairs (Defra). Their investment provides the core science on which Government can make decisions to help the UK become resilient to climate variability and change, benefit from opportunities for growth, and engage in international climate negotiations. For example, research findings from the programme help ensure cost-effective deployment of renewable energy, and a resilient future for the nation's infrastructure. To achieve this, the Hadley Centre needs a large production facility to run complex multi-model integrations and ensembles of integrations as well as a resource for research and development. These models can run over periods of months and are time critical to meet deadlines for the customer and for the International Panel for Climate Change (IPCC) producing significant output that needs analysis over long periods of time.

The Met Office has a long experience in developing successful software infrastructures to support both Weather and Climate scientists and models including archive systems, user interfaces, build and configuration management systems.

Contribution of partner to the specific project

In IS-ENES3, MetO will lead WP4/NA3 (Networking on models, tools and HPC), lead Task 2 of WP4/NA3 (community Sea Ice Model), Task 3 of WP8/JRA1 (Rose and Cylc) and Task 5 of WP9/JRA2 (enhancing ESMValTool). It is also involved in WP2/NA1 working on sustainability, Task 4 of WP4/NA3 on machine-learning, Tasks 2 and 3 of WP6/SA1 (ESM support and Rose/Cylc support), Task 1 WP8/JRA1 (NEMO performance) and Task 2 WP9/JRA2 (ESMValTool improvements).

Curriculum Vitae of responsible for carrying out the proposed activities

Mick Carter (male): Mr Mick Carter (male) has 36 years of experience working in Scientific Software Engineering for the Weather and Climate Communities at the Met Office (MetO). Mick is currently the Strategic Head of Scientific Software for the Met Office Hadley Centre for Climate Prediction with a team of 20 staff. He is also the chair of the Technical Advisory Group for the Unified Model Partnership and a member of the HPC Taskforce for ENES. Mick has been a member of the technical team procuring HPC and mass storage systems for 22 years and is the project executive for the LFRic project board and sits on the Met Office's Exascale programme board. Mick is currently a work-package co-leader in ESiWACE and has jointly led work-packages for IS-ENES2 and prior EU funded projects.

David Matthews (male): has 22 years of experience working in Scientific Software Engineering at the Met Office (MetO). He leads the Modelling Infrastructure team containing 4 developers who contribute to development and support the CYLC meta-scheduler and are the primary developers of the Rose and

FCM systems. Dave sits on the technical team that has procured processing platforms for research activities. Dave has has led effort in both IS-ENES2 and ESiWACE around the Cylc meta-scheduler.

Dr Mike Bell (male): Fellow in Ocean Dynamics, Mike led the operational implementation of daily global ocean forecasts at the Met Office in 1997. He has been Head of the National Centre for Ocean Forecasting, leader of the Implementation and Production WP in MERSEA Integrated Project, a member of the MyOcean Board, and joint chair of the Global Ocean Data Assimilation Experiment (GODAE) International Science Team. He played a key role in initiating the NEMO consortium. He is currently in a research position working on the detailed numerics of the NEMO model. He leads the NEMO Kernel Working Group (WG) and, jointly with Silvia Mocavero, the NEMO HPC WG.

Dr Ed Blockley (male): manages the Polar Climate Group of the Met Office Hadley developing and evaluating sea ice climate models and understanding climate change in polar regions. Ed leads development of the Global Sea Ice (GSI) configurations that are used within all Met Office/Hadley Centre physical models and the UK Earth System Model for forecasting and prediction across all time-scales. Ed is also co-chair of the NEMO Sea Ice Working Group and co-leads development of the NEMO sea ice model. Ed has 10 years' experience developing and evaluating ocean-sea ice systems based upon NEMO within the framework of the Met Office's operational short-range and seasonal forecasting systems and global climate models. During this time he was heavily involved with the (EU) MyOcean series of projects including as work package leader.

Bill Little (male): has 22 years of experience as a Software Engineer in industry. He has been working as a Software Engineer within the Analysis, Visualisation and Data (AVD) Team at the Met Office (MetO) since 2009. Bill is a core developer of the SciTools open source Python packages Iris and Cartopy, and has contributed to many other open source community based Python packages. He is the (shared) technical lead of the AVD Team containing 7 developers who contribute to developing and supporting SciTools: https://github.com/SciTools.

Dr Paul Earnshaw (male): has been a member of the Global Model Evaluation and Development Group at the Met Office since he joined in 2002. He is the configuration manager of the Global Atmosphere (GA) series of global model configurations used for both NWP and climate prediction, and is also the code owner for AutoAssess (the Met Office software tool for Climate Model Assessment). During his period in the Met Office he has become an experienced user and developer of the Unified Model, contributing to numerous operational configuration upgrades. He also has interests in idealised modelling and is currently working with Professor Geoff Vallis at the University of Exeter on simplified modelling frameworks and model hierarchies.

Dr George Pankiewicz (male): manages the Unified Model partnership which includes a team supporting UM partners in Australia, India, Korea, New Zealand, Philippines, Poland, South Africa and the US. This support allows organisations in those countries to use the UM for NWP and climate applications. Together with his team, he facilitates contributions to joint scientific and technical programmes including global and regional model evaluation and development, and technical infrastructure including UM partner contributions to the exascale programme. George implemented the first machine learning system at the Met Office based on satellite imagery in the 1990s. He is a work package leader for Weather and Climate Science to Services Partnership for South Africa, and chairs the Technical Advisory Group of the Natural Hazard Research Platform for New Zealand.

Up to 5 relevant Publications, and/or products or other achievements

1. Crossing the Chasm: How to develop weather and climate models for next generation computers? Configuration Management Best Practice Guide for Climate Science. https://portal.enes.org/ISENES2/documents/milestones/is-enes2_ms4-5_configuration-management-best-practice-guide-for-climate-science/view
2. Blockley, E. W., Martin, M. J., McLaren, A. J., Ryan, A. G., Waters, J., Lea, D. J., Mirouze, I., Peterson, K. A., Sellar, A., and Storkey, D.: Recent development of the Met Office operational

ocean forecasting system: an overview and assessment of the new Global FOAM forecasts, Geosci. Model Dev., 7, 2613-2638, https://doi.org/10.5194/gmd-7-2613-2014, 2014

Up to 5 relevant Projects, and/or activities, services

EU H2020 ESiWACE Centre of Excellence in Simulation of Weather and Climate in Europe

EU FP7/H2020 IS-ENES and ISENES2 Infrastructure for the European Network for Earth-SystemModelling, EU FP7 and H2020 Projects fostering simulations with global earth system models.

EU FP7 CLIPC – CLimate Information Platform for Copernicus

EU H2020 PRIMAVERA - PRocess-based climate sIMulation: AdVances in high resolution modelling and European climate Risk Assessment

EU H2020 CRESCENDO - Coordinated Research in Earth Systems and Climate: Experiments, kNowledge, Dissemination and Outreach

Significant infrastructure, and/or major items of technical equipment

MetO has been at the cutting edge of supercomputing for several decades providing HPC systems for both weather and climate ranging from real-time operations, through production activities such as CMIP-6 to research activities. The current three XC40 systems total 12,932 nodes, 460,672 cores and 15,600 TFlops peak performance. There is 1,620 Tbytes of memory and 24 Pbytes of disk storage dileivering IO rates of 730 GBytes/s. A tape-based system is used to provide users access to data that grows at a rate of more than 210 TBytes a day and currently holds 120 PBytes. More data is accessed each data than is archived from this system and on some days, more than a PByte of data is accessed.

6. Barcelona Supercomputing Centre (BSC)

About the partner

The Barcelona Supercomputing Center (BSC) was established in 2005 and is a key element of and coordinates the Spanish Supercomputing Network, which is the main framework for granting competitive HPC time to Spanish research institutions. Furthermore, BSC-CNS is one of six hosting nodes in France, Germany, Italy and Spain that form the core of the Partnership for Advanced Computing in Europe (PRACE) network. The mission of BSC is to research, develop and manage information technologies in order to facilitate scientific progress. BSC combines HPC service provision and R&D into both computer and computational science (life, earth and engineering sciences) under one roof and currently has over 450 staff from 44 countries. BSC has collaborated with industry since its creation, and participates in various bilateral joint research centers with companies such as IBM, Microsoft, Intel, NVIDIA and Spanish oil company Repsol. The centre has been extremely active in the EC Framework Programmes and has participated in over 100 projects funded by it. BSC is a founding member of HiPEAC, the ETP4HPC and other international fora. The ES-BSC activities with the focus on global climate modelling and prediction are based on research, development and predictions with the EC-Earth climate forecast system. EC-Earth is the state-of-the art coupled climate model that is being developed and used for climate predictions and projections by the European consortium of more than 20 research and operational institutions from European Centre for Mid-range weather Forecasts (ECMWF is provider of the atmospheric and land components) to ES-BSC. Beside contributing to the 5th phase of the Coupled Model Intercomparison Project (CMIP5) critical for the UN IPCC Fifth Assessment Report (AR5), global climate research activities at ES-BSC enable provision of various historical reconstructions and initial conditions to the EC-Earth community for analysis of climate dynamics and for seasonal to decadal climate predictions. The ES-BSC is a contributor to the IS-ENES FP7 European project fostering the integration of the European climate modelling community and the development of

Earth System Models (ESM) for advancing the understanding and predictions of climate variability and change. BSC is also involved in other European projects as ESiWACE, Montblanc or PRIMAVERA. The ES-BSC is already active in the planning and design of the future coupled climate model intercomparison project, CMIP6, and is preparing to make key contributions including the groundbreaking high-resolution climate simulations with EC-Earth.

Contribution of partner to the specific project

In IS-ENES3, BSC will co-lead WP4/NA3 on HPC networking and WP9/JRA2 on model evaluation. BSC will also be involved in data (WP5/NA4 and WP10/JRA3) and models (WP7/SA2 and WP10/JRA3) with additional representation in other WPs.

Curriculum Vitae of responsible for carrying out the proposed activities

Dr Mario Acosta (male) is a postdoctoral researcher and the leader of the HPC Performance Team in the Computational group at the BSC (Barcelona Supercomputing Center) Earth Science Department. He obtained his PhD from University of Granada (Spain) in 2015, on High Performance Computing applied to Earth System Modeling. This expertise includes wide knowledge in numerical models (governing equations, numerical algorithms and computational implementation) and how to adapt them efficiently to actual and new HPC resources. In the last years he has being involved in the IS-ENES2, ESiWACE and PRIMAVERA European projects and collaborating with the IFS, EC-Earth and NEMO models development teams. Being a member of the NEMO HPC working group and EC-Earth technical group.

Pierre-Antoine Bretonnière (male), holds a Masters Degree in "Mathematical and Mechanical Modelling" from the Matmeca engineer school in Bordeaux (France). Graduated in 2010, he has worked in several climate research institutes (CERFACS-Toulouse-France, Catalan Institute of Climate Sciences-Barcelona-Spain and the Earth Sciences Department of the Barcelona Supercomputing Center). His work focuses on climate models outputs and diagnostics, data management and model coupling. He was the person in charge of the data management plan and data conventions definitions in the SPECS FP7 project and has participated in several other European projects. He is also involved in the Research Data Alliance (RDA) framework as chairman of the "Weather, climate and air quality" interest group.

Miguel Castrillo (male), holds an MSc in computer science from the University of León. Having more than five years of experience as software analyst and developer for different companies in the private sector, he joined the Computational Earth Sciences group at the Earth Sciences department of the Barcelona Supercomputing Center (BSC) in 2012, where he has been specializing in HPC and Earth Sciences modelling. His extensive expertise in the sector ranges from HPC data management and visualization tools, to parallel applications performance. He developed the CALIOPE air quality system mobile application, winner of the European Commission MYGEOSS project (2015-2016) for innovative applications using open data. In the last five years he has been intensely focused on HPC performance and model workflows, being involved in the IS-ENES2 and ESiWACE European projects and collaborating with the EC-Earth and NEMO models development teams. Currently he is head of the Models and Workflows Team in the Earth Sciences Department, as well as permanent member of the NEMO HPC working group and EC-Earth technical group.

Dr Alicia Sánchez Lorente (female), holds a PhD in “High-Precision Gamma and X-Ray Spectroscopy” from the Johannes Gutenberg University, Mainz, (Germany). After working at the Helmholtz Institute Mainz (Germany) in the Nuclear Physics Division as a research manager, she joined the Barcelona Supercomputing Center Earth-Sciences co-leading the computational Earth Sciences group. She has a long experience in developing computational techniques as well as data analysis algorithms to deal with huge amount of data (Big Data) and improve Signal-to-Noise Ratio. She has participated on several international Scientific Collaborations worldwide and has helped with her interdisciplinary knowledge to consolidate important European research projects within the framework of High Precision Energy technologies. Currently, her interest focuses on developing Big Data and Machine Learning techniques in the field of earth sciences.

Kim Serradell Maronda (male), holds a Bachelor (2005) in Computer Sciences for the Facultat d'Informàtica de Barcelona (FIB-UPC) and for the Grande école publique d'ingénieurs en informatique, mathématiques appliquées et télécommunications de Grenoble (ENSIMAG). Since 2014 is also Master on High Performance Computing from the Facultat d'Informàtica de Barcelona (FIB-UPC). Currently, he is the manager of the Computational Earth Science (CES) group at the Earth Sciences department in the Barcelona Supercomputing Center (BSC). At present, he is in charge of the computational resources of the department and he was also responsible of the operational runs of the NMMB/BSC-Dust model for BDFC and CALIOPE Air Quality System. He has been involved in European projects like IS-ENES(1&2), ESiWACE, SDS-WAS, BDFC or CONSOLIDER.

Up to 5 relevant Publications, and/or products or other achievements

1. Tinto, O., M. Castrillo, M.C. Acosta., A. Cortes, A. Sanchez, K. Serradell, F.J. Doblas-Reyes (2017). Finding, analyzing and optimizing MPI communication bottlenecks in Earth System models. J Comput Sci-Neth (Paper accepted)
2. Tinto, O., M.C. Acosta., M. Castrillo, A. Cortes, A. Sanchez, K. Serradell, F.J. Doblas-Reyes (2017). Optimizing domain decomposition in an ocean model: the case of NEMO. Procedia Comput. Sci. http://www.sciencedirect.com/science/article/pii/S1877050917308888
3. Tintó Prims, O., M. Castrillo, K. Serradell, O. Mula-Valls and F.J. Doblas-Reyes (2015). Optimization of an ocean model using performance tools. BSC-CES Technical Memorandum 2015-002, 16 pp. https://earth.bsc.es/wiki/lib/exe/fetch.php?media=library:external:bsc-ces-2015-002.pdf
4. Yepes-Arbós, X., M. C. Acosta, K. Serradell, A. Sanchez Lorente, F.J. Doblas-Reyes (2017). Simulation-based performance analysis of EC-Earth 3.2.0 using Dimemas. BSC-CES Technical Memorandum 2017-001, 30 pp. https://earth.bsc.es/wiki/lib/exe/fetch.php?media=library:external:bsc-ces-2017-001-dimemas_performance_analysis_report.pdf
5. Acosta, M.C., X. Yepes-Arbós, S. Valcke, E. Maisonnave, K. Serradell, O. Mula-Valls and F.J. Doblas-Reyes (2016). Performance analysis of EC-Earth 3.2: Coupling BSC-CES Technical Memorandum 2016-006, 38 pp. https://earth.bsc.es/wiki/lib/exe/fetch.php?media=library:external:technical_memoranda:bsc-ces-2016-001-scalability_ec-earth.pdf

Up to 5 relevant Projects, and/or activities, services

EU FP7 IS-ENES phase 1 (2009-2013), phase 2 (2013-2017), Infrastructure for European Network for Earth System Modelling, the integration of the European Climate and Earth system modelling community, enhanced the development of Earth system models for the understanding of climate variability and change, supported high-end simulations, and facilitated model applications to better predict and understand climate change impacts on society.

EU H2020 ESiWACE (2015-2019), Centre of Excellence in Simulation of Weather and Climate in Europe. It will substantially improve efficiency and productivity of numerical weather and climate simulation on HPC platforms by supporting the end-to-end workflow of global Earth system modelling in HPC environment. This will be obtained by improving and supporting (1) scalability of models, tools and data management on state-of-the-art supercomputer systems (2) Usability of models and tools throughout the European HPC eco-system, and (3) the Exploitability of the huge amount of resulting data.

EU H2020 APPLICATE (2016-2020), (Advanced Prediction in Polar regions and beyond: Modelling, observing system design and LInkages associated with a Changing Arctic climaTE) is an EU H2020 project. Its main objective is to improve the understanding of processes involved in polar climate variability and teleconnections with the mid-latitudes. This goal will be achieved through novel model developments, a wide variety of ambitious sensitivity experiments, the exploitation of new polar observations and improved understanding of polar climate and linkages predictability. This project gathers experts from 16 research centers across Europe.

EU H2020 PRIMAVERA (2015-2020), (Process-based climate siMulation: AdVances in high resolution modelling and European climate Risk Assessment). The goal of PRIMAVERA is to deliver novel, advanced and well-evaluated high-resolution global climate models capable of simulating and predicting regional climate with unprecedented fidelity, out to 2050. Sector-specific end-users in policy and business are engaged individually, with iterative feedback, to ensure that new climate information is tailored, actionable and strengthen societal risk management decisions.

H2020 project ESCAPE-2 (2018-2022), (Energy-efficient SCalable Algorithms for weather and climate Prediction at Exascale). ESCAPE-2 will develop world-class, extreme-scale computing capabilities for European operational numerical weather and climate prediction, and provide the key components for weather and climate domain benchmarks to be deployed on extreme-scale demonstrators and beyond.

Significant infrastructure, and/or major items of technical equipment

BSC-CNS is the National Supercomputing Facility of Spain and hosts a range of high-performance computing (HPC) systems including MareNostrum IV the new supercomputer that have a performance capacity of 13, 7 Petaflop/s. The general purpose element have 48 racks with more than 3,400 nodes with next generation Intel Xeon processors and a central memory of 390 Terabytes. The second element of MareNostrum 4 is formed of clusters of three different technologies that will be added and updated as they become available. These are technologies currently being developed in the US and Japan to accelerate the arrival of the new generation of pre-exascale supercomputers.

The BSC-CNS is a key element of and coordinates the Spanish Supercomputing Network, which is the main framework for granting competitive HPC time to Spanish research institutions. Furthermore, BSC-CNS is one of six hosting nodes in France, Germany, Italy and Spain that form the core of the Partnership for Advanced Computing in Europe (PRACE) network. PRACE provides competitive computing time on world-class supercomputers to researchers in the 25 European member countries.

BSC-CNS is also part of the HPC technical working group of NEMO, member of the EC-Earth consortium and collaborating with other developer groups as IFS, OASIS and Xios teams.

7. Koninklijk Nederlands Meteorologisch Instituut (KNMI)

About the partner

The Royal Netherlands Meteorological Institute (KNMI) is the Dutch national weather service. It is an agency of the Ministry Infrastructure and Water management. Primary tasks are weather forecasting and the monitoring of weather, climate, air quality and seismic activity. KNMI is the national research and information centre for meteorology, climate, air quality, and seismology.
KNMI focuses on monitoring and warning for risks with an atmospheric or seismic origin. In addition, KNMI offers advice and strategy prospects for both acute and future dangers. We strive to make our high-quality knowledge and information in the area of weather, climate, and seismology operationally available 24 hours a day, seven days a week. In addition, we continuously extend and deepen this knowledge in cooperation with research institutes, universities and businesses. As a scientific institute, KNMI contributes to the international climate research and contributes to the process and reports of the Intergovernmental Panel on Climate Change (IPCC).
KNMI has a long record of activities related to climate services, both on the national as well as the European to global scale. It has been involved in several EU-funded projects, which provide users (policy makers, the scientific community, commercial partners) with tailored science-based assessments through our Climate Services activities as well as detailed state-of-the-art datasets. It provides these assessments and datasets using sustained and operational IT based services (ECA&D, Climate Explorer (climexp.knmi.nl), KNMI Data Center (data.knmi.nl), IS-ENES (climate4impact.eu).
KNMI has a long tradition in climate modelling and providing access to climate model output and has been involved in several projects of some with directly relevance to IS-ENES3.

Contribution of partner to the specific project

In IS-ENES3, KNMI will co-lead WP3/NA2 on community and WP7/SA2 on Data. KNMI will also be highly involved in data and metadata community, services and development (WP5/NA4, WP7/NA2, WP10/JRA3) on climate4impact development and Computation for CMIP6 and CORDEX. KNMI also supports model evaluation (JRA2/WP9) by contributing its knowledge on observations.

Curriculum Vitae of responsible for carrying out the proposed activities

Wim Som de Cerff (male) is a senior researcher at the R&D Observations and Data Technology division of KNMI (RDWD). He has seven years' experience leading Agile software development in R&D projects. His main expertise is in research, development and running of data services. He has been work package leader and developer in several EU research projects in the last 15 years, most recently in SPECS, EUPORIAS, CLIPC and ISENES2. Currently Wim is work package leader of the data dissemination work package in the H2020 EUNADICS-AV (Natural Airborne Disaster Information and Coordination System for Aviation) project. Wim is project leader of the Copernicus C3S 32a lot2 Magic project, developing the C3S software for data analysis from climate models and member of the advisory board of C3S 32a lot1 CP4CDS project. Within KNMI Wim is Product Owner of the KNMI Data centre (data.knmi.nl), providing open data and INSPIRE compliant data services. He is responsible for transition towards Agile software development at KNMI RDWD and wider in KNMI. Wim will be co-leading WP7/SA2 Data and contributing to WP5/NA4, WP9/JRA2 andWP10/JRA3.

Maarten Plieger (male) is Software Engineer GEO-ICT at the Royal Netherlands Meteorological Institute (KNMI). In 2008 he obtained his Master in Physical Geography from Utrecht University. He has over eight years of experience in web visualization and processing. His expertise is software development and implementing standards. Maarten is team lead of the ADAGUC GIS data visualization and dissemination software. He is an excellent developer and is highly skilled in C++, Java and JavaScript. In the IS-ENES climate4impact project he builds web processing services to calculate climate indices and continues developments on the ADAGUC software. Maarten has experience with security mechanisms like OpenID, Oauth2 and x509 which are applied in ESGF, climate4impact and EUDAT. Currently Maarten is part of the Scrumteam building the KNMI next generation meteorological workstation (GeoWeb) and of the team building the C3S 34a MAGIC webservices infrastructure. Maarten will contribute to WP5/NA4, WP7/NA2 and WP10/JRA3.

Alessandro Spinuso (male) is a senior researcher at the R&D Observations and Data Technology division of KNMI. He is involved in a number of EU initiatives and projects, focusing on the deployment of an e-science infrastructure for Solid Earth Science research in Europe (NERA, VERCE, EPOS). He has been leading the design and the implementation of the VERCE Science Gateway and chaired the VERCE Project Executive Board. He is currently responsible for the Computational Earth Science activities conducted by the EPOS project. His main expertise is on production and exploitation of data provenance in HPC and Data intensive platforms. Alessandro will be contributing to WP5/NA4, WP7/NA2 and WP10/JRA3.

Bernadet Overbeek (female) is working for KNMI since 2009 on projects about bridging the gap between climate scientists, users of climate information and policymakers. E.g. in 2012 she organized a 3 day school for PhD students about dealing and communicating uncertainties in climate- and socio-economic scenarios, in impact models and in the decision making process. The result of the course was a common frame of reference for the use of scenarios and dealing with uncertainties. From 2009-2014 she worked as communication officer for the project "High quality climate projections" of the national "Knowledge for Climate" research programme. From 2012-2014 she was involved in the user interaction for the KNMI'14 climate scenarios for which she organised several interactive workshops with a broad range of users, she led a user feedback group and took care of the coordination and editing of the newsletters, brochures and website. Since 2015 she is working at the Weather- and Climate Services division on products in which weather and climate are brought together. In the EU-project Climateurope, which is about linking supply and demand of climate information, she worked on

communication and dissemination. She is coordinating the stakeholder involvement for the new KNMI climate scenarios to be published in 2021.Bernadet will be contributing to WP3/NA2.

Dr Janette Bessembinder (female) is working for KNMI since 2005 and involved in climate services development, inventories of users' requirements related to climate (change) data and information, and tailoring of climate data for users ranging from impact/adaptation researchers, companies to policy makers. Since 2009 she has led several climate services tailoring projects and she was work package leader of "Climate services" in the project "High quality climate projections" of the national "Knowledge for Climate" research programme. She has been involved in the development of the KNMI'06 and KNMI'14 climate scenarios, especially in the communication and tailoring of climate scenarios for a broad range of users. Currently she is involved in work packages, mostly as WP-leader, on user interaction and dissemination of the European projects EUSTACE, Climateurope, PRIMAVERA and WATCH and smaller tailoring projects in the Netherlands among others for adaptation to climate change and spatial planning. She is also involved in the stakeholder involvement for the new KNMI climate scenarios to be published in 2021. Janette will be co-leading WP3/NA2.

Up to 5 relevant Publications, and/or products or other achievements

1. Spinuso, J. Cheney, M. Atkinson. Provenance for seismological processing pipelines in a distributed streaming workflow. In EDBT/ICDT Workshops, 2013, pp. 307–312. https://doi.org/10.1145/2457317.2457369.
2. H. Goosen, H., M.A.M. de Groot-Reichwein, L. Masselink, A. Koekoek, R. Swart, J. Bessembinder, J.M.P. Witte, L. Stuyt, G. Blom-Zandstra, W. Immerzeel, 2014. Climate Adaptation Services for the Netherlands: an operational approach to support spatial adaptation planning. Reg. Environ. Change, June 2014, Volume 14, Issue 3, pp 1035-1048 https://doi.org/10.1007/s10113-013-0513-8
3. Berkhout, F., B. Van den Hurk, J. De Boer, M. Van Drunen, B. Bregman, J. Bessembinder, 2014. Framing climate uncertainty: socio-economic and climate scenarios in vulnerability and adaptation assessments. Reg. Environ. Change, June 2014, Volume 14, Issue 3, pp 879-893 https://doi.org/10.1007/s10113-013-0519-2.
4. Kotova, L., M. Manez Costa, M. Rodríguez Pérez, F. Whiffin, N. Garrett, J. Bessembinder, M. Buonocore, P. Newton, Ch. Hewitt, 2017. The first Climateurope Festival: climate information at your service. Climate Services, Volume 6, Pages 80-81 https://doi.org/10.1016/j.cliser.2017.07.005.
5. W. J. Som de Cerff, M. Petitdidier, A. Gemünd, L. Horstink, H. Schwichtenberg. Earth science test suites to evaluate grid tools and middleware - Examples for grid data access tools, Earth Sci. Inform. 2 (1), pp. 117-131, 2009, https://doi.org/10.1007/s12145-009-0022-y.

Up to 5 relevant Projects, and/or activities, services

EU FP7 IS-ENES phase 1 (2009-2013), phase 2 (2013-2017), Infrastructure for European Network for Earth System Modelling, coordinated by CNRS-IPSL. IS-ENES projects have fostered the integration of the European Climate and Earth system modelling community, enhanced the development of Earth system models for the understanding of climate variability and change, supported high-end simulations, and facilitated model applications to better predict and understand climate change impacts on society (https://is.enes.org).

Copernicus C3S 34a lot 2 (MAGIC), 2016-2018 The Copernicus Climate Change Service is developing solutions that will help users assess Global Climate Models (GCMs) projections using well-established metrics and manipulation tools and receive outputs tailored to their needs. In particular, the project aims to provide products that address the needs of the coastal, water, insurance and energy sectors. The system will allow users to access, visualize and manipulate the large data sets that are produced by climate models without having to download them to their own machine. It will combine software that have been developed by partners, either individually or within earlier European projects, into one single system. The software will contain modules to calculate standardized metrics and indices for each model, so that the models' performance can be assessed quickly. The lead contractor is the Royal Netherlands Meteorological Institute (KNMI).

EU H2020 DARE Delivering Agile Research Excellence on European e-Infrastructures, 2018-2029 (http://project-dare.eu/) H2020 project aims to provide scientific communities with a unifying hyper-platform and development context to allow for user-friendly and reproducible carrying out of huge data-driven experiments, and rapid prototyping. DARE specifically addresses the requirements of innovating teams of research developers and scientists, who work on the intersection of software engineering and scientific domains, and on data, complexity and computing extremes. Building on extensive experience in research e-infrastructures, semantification and the handling of metadata, and on big-data technologies and domain applications, DARE will equip teams of innovators with meaningful abstractions and tools allowing for rapid prototyping of reproducible and efficient research solutions. DARE will improve further and integrate tried and tested programmatic dataflow specification APIs, big-data technologies and provenance/datalineage solutions to address the requirements of European RIs, initially of EPOS, on Earth science, and IS/ENES2, on climate. KNMI leads WP3 which will deliver solutions for "Large-scale Lineage and Process Management".

EU FP7 CLIPC (www.clipc.eu) Climate Information Portal for Copernicus, precursor project for C3S, has been developed to provide data and information on climate change and climate impact to users. Main users in focus are the climate scientists, impact researchers and consultants. Important features of the portal are a solid list of climate impact indicators and tool (a toolkit) to work with these indicators and make assessments of climate impact in a certain region. KNMI has been responsible for the developments as part of the Architecture Team, as well as the main developer for processing, visualization discovery and download services (based on the climate4Impact platform).

EU FP7 EUPORIAS (http://www.euporias.eu/) The project EUPORIAS aimed at improving the ability to maximize societal benefit from seasonal to decadal climate predictions. In close collaboration with stakeholders, a set of fully functioning prototypes of climate services were developed in the sectors of energy, agriculture, transport and water management. KNMI lead the Data Dissemination work package and supported the development of one of the showcases (Land Management Tool).

Significant infrastructure, and/or major items of technical equipment

KNMI is running the climate4impact portal (www.climate4impact.eu). The aim of Climate4impact is to enhance the use of climate research data. It has been developed within the European projects IS-ENES, IS-ENES2 and CLIPC. Climate4impact is connected to the Earth System Grid Federation (ESGF) infrastructure, using certificate based authentication, ESGF search, openid, opendap and thredds catalogs. The portal aims to support climate change impact modellers, impact and adaptation consultants, as well anyone else wanting to use climate change data. The portal offers web interfaces for searching, visualizing, analyzing, processing and downloading datasets.

8. Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC)

About the partner

The Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici (Fondazione CMCC) is a non-profit research institution (http://www.cmcc.it). CMCC's mission is to investigate and model our climate system and its interactions with society to provide reliable, rigorous, and timely scientific results, which will in turn stimulate sustainable growth, protect the environment, and develop science driven adaptation and mitigation policies in a changing climate. CMCC collaborates with experienced scientists, economists, and technicians, which work together in order to provide full analyses of climate impacts on various systems such as agriculture, ecosystems, coasts, water resources, health, and economics. CMCC also supports policymakers in setting and assessing costs, mitigation, and adaptation policies. CMCC benefits from the extensive applied research experience of its members and institutional partners: Istituto Nazionale di Geofisica e Vulcanologia (INGV); Università del Salento; Centro Italiano di Ricerche Aerospaziali (CIRA S.c.p.a.); Università Ca' Foscari Venezia; Università di Sassari, Università della Tuscia, Politecnico di Milano. CMCC research activities are distributed among eight research divisions that share different knowledge and skills in the field of climate science: Advanced Scientific Computing (ASC) Division; Climate Simulation and Prediction (CSP) Division;

Economic analysis of Climate Impacts and Policy (ECIP) Division; Impacts on Agriculture, Forests and Ecosystem Services (IAFES) Division; Ocean modeling and Data Assimilation (ODA) Division; Ocean Predictions and Applications (OPA) Division; Risk Assessment and Adaptation Strategies (RAAS) Division; Regional Models and geo-Hydrological Impacts (REHMI) Division. CMCC acquired portfolio of research projects includes 250 funded projects: 37 funded projects in FP6 and FP7, 37 funded projects in H2020 and 176 funded projects under other EU and international research grants. In about a half of the implemented projects, CMCC acted as the coordinator. For further information on CMCC please see Annual Reports and CMCC Strategic Plan (http://www.cmcc.it/publications-type/annual-report).

Contribution of partner to the specific project

In IS-ENES3, CMCC will contribute to WP3/NA2 on community, WP4/NA3 on networking on models and WP5/NA4 on networking on data. CMCC will also be involved in data and metadata service (WP7/SA2), and co-lead both models & tools developments (WP8/JRA1) and data & metadata developments (WP10/JRA3). Finally, CMCC will also contribute on model evaluation (WP9/JRA2).

Curriculum Vitae of responsible for carrying out the proposed activities

Giovanni Aloisio (male). He is full professor of Information Processing Systems at the Dept. of Innovation Engineering of the University of Salento, Italy. Former director of the Scientific Computing and Operations Division at CMCC, he is the Director of the CMCC Supercomputing Center (SCC) and member of the CMCC Strategic Council. His expertise concerns HPC, cloud computing and scientific data management. He has been strongly involved into several EU projects in FP6, FP7 and now H2020. He is also the scientific coordinator of the OFIDIA2 project (Interreg V-A Greece Italy Programme 2014-2020). In the EU EESI and EESI2 projects he chaired the WG on Weather, Climate and solid Earth Sciences, as ENES representative. He is a member of the ENES HPC Task Force and one of the key experts of the International Exascale Software Project. He is the author of more than 100 papers in referred journals on high performance computing, cloud and distributed computing. He will be involved in WP4/NA3, WP8/JRA1, and, as Director of the CMCC SCC, he will supervise the service activity performed at the CMCC SCC in WP7/SA2.

Dr Sandro Fiore (male), senior Scientist and Director of the Advanced Scientific Computing (ASC) Division of CMCC Foundation. His research activities focus on scientific data management, big data and High Performance Data Analytics (HPDA). He has been Visiting Scientist at LLNL working at PCMDI in the context of the ESGF. Since 2004, he has been involved in several EU FP6, FP7 and H2020 projects working on scientific data management topics. He is the P.I. of the Ophidia project, a research effort on HPDA. He is author of more than 60 papers in refereed journals/proceedings on parallel and distributed computing and holds a patent on data management. He is member of the ENES Data Task Force. He will contribute to WP3/NA2, WP5/NA4, WP7/SA2 and WP10/JRA3.

Dr Silvia Mocavero (female) scientist at the "Advanced Scientific Computing" (ASC) Division of CMCC Foundation, where she leads the "High End Computing" research group. Her skills include parallel programming on hybrid architectures, performance analysis and optimisation of climate models with a particular focus on the NEMO ocean framework. She has been Visiting Scientist at BSC and at Argonne National Laboratory working on NEMO benchmarking on large HPC systems. Since 2012, she has been a member of the NEMO System Team and, since 2014, member of the HPC group of the NEMO Consortium. She has been strongly involved in several EU projects such as GridLab, CoreGRID, IS-ENES1, IS-ENES2. She is currently involved in the ESiWACE CoE, working on models scalability. She is co-author of more than 25 papers in journals/proceedings on high-performance, distributed and grid computing. She will be involved in WP4/NA3 and WP8/JRA1.

Dr Simona Masina (female) Ph.D. Princeton University, Director of the Ocean Modelling and Data Assimilation Division of the Euro-Mediterranean Centre on Climate Change Foundation and Senior Researcher at the National Institute of Geophysics and Volcanology. She has more than 20 years of experience in global ocean modelling and ocean data assimilation. In 2014 she coordinated the first

PRACE project awarded to CMCC. She has been involved in several EU project and more recently in the COPERNICUS Marine Environment Monitoring Service (CMEMS) and Climate Change Service (C3S) for the provision of NEMO based global ocean reanalyses. She is author of more than 100 scientific papers in refereed journals and member of the CLIVAR Panel on Ocean Model Development. She will be involved in WP4/NA3 and WP8/JRA1.

Paola Mercogliano (female) Director of the REgional Models and Hydrogeological Impacts Division of CMCC Foundation and head of the meteorology laboratory of C.I.R.A. (Italian Aerospace Research Centre). She is a senior researcher with more than 15 years of experience. She is member of the COSMO Consortium for development of the NWP (Numerical Weather Prediction) COSMO LM (local model) and also member of the CLM Assembly for the development of the RCM (Regional Climate Model) COSMO CLM (climate local model). She was involved in several projects concerning implementation and analysis of RCMs and also for their correct application for impact analysis. Moreover, she is involved in the activity of MENA-CORDEX, EURO-CORDEX and in the CORDEX flagship pilot studies (FPS) LUCAS (Land Use & Climate Across Scales) and CPM (convection-permitting model). She will be contribute to WP9/JRA2.

Dr Doroteaciro Iovino (female) - Ph.D. in physical oceanography - is a scientist at CMCC. She coordinates the activities of the Ocean and Sea Ice Modelling group. She has been involved into several international projects, with ~15 years of experience on ocean and sea ice modelling, both on the technical and scientific aspects. She is involved in high-resolution ocean modelling (within PRACE projects: ENS4OCEAN and ROMEO). Since 2017, she is member of the CLIVAR/CliC Northern Oceans Regional Panel. She leads the CMCC effort within the NEMO System Team in developing the model system, and is member of the NEMO Sea Ice Working Group. She teaches in Ph.D. programme in Science and Management of Climate Change at Ca' Foscari University. She will be involved in WP4/NA3 and WP8/JRA1.

Alessandro D'Anca (male) is a Junior Scientist at CMCC Foundation (laurea degree in Computer Engineering from the University of Lecce). From 2008 to 2011 as Junior Computer Systems Analyst he was involved in the management of the CMCC SCC HPC cluster infrastructure, tuning of batch queuing systems and job schedulers, analysis, profiling, and performance optimization of HPC software. In 2011 he joined the Scientific Computing Division at CMCC, working in the Scientific Data Management (SDM) research group, which he is now leading since 2015. His research activities focus on HPC, distributed data management, high performance data analytics. He is responsible for the operational set up and maintenance of the CMCC Compute Service facility (WP7/SA2). He will be involved in the WP3/NA2, WP5/NA4, WP7/SA2 and WP10/JRA3.

Mauro Tridici (male) is a BSc student. Since October 2011 he is a Senior Research Associate at the CMCC SuperComputing Center (SCC) and he is a member of the HSM (High Performance Computing Systems Management) group. From 2008 to 2011 he worked on ensuring the operation of the HPC systems available at the CMCC SCC and the full data life cycle management. Since 2008, he takes care of the data backup/archive services available at the CMCC SCC. He also provides support to the HPC systems users (helpdesk service, problem solving, etc.) and the definition of the CMCC SCC security policies. He contributes to the system administration, operational maintenance and networking activities of the CMCC Compute Service facility (WP7/SA2).

Dr Giuseppe Calò (male) received the Dr. Eng. degree in Computer Engineering at the University of Salento in 2008. Since 2008, he held a Junior Computer Systems Analyst position working at the CMCC Supercomputing Center (SCC). His expertise concerns the setup, configuration, management, administration of the high performance mass storage subsystems and high-performance parallel file systems deployed at the CMCC SCC. He is also responsible for the CMCC SCC private cloud platform, technical maintenance and update of the CMCC ESGF data node as well as of the related CMIP data publication activity. He will be involved in the WP7/SA2.

Up to 5 relevant Publications, and/or products or other achievements

1. Balaji V., Maisonnave E., Zadeh N., Lawrence B. N., Biercamp J., Fladrich U., Aloisio G., Benson R., Caubel A., Durachta J., Foujols M-A., Lister G., Mocavero S., Underwood S., Wright G. (2017) CPMIP: measurements of real computational performance of Earth system models in CMIP6, Geosci. Model Dev., 10, 19-34, https://doi.org/10.5194/gmd-10-19-2017
2. Epicoco I., Mocavero S., Porter A. R., Pickles S. M., Ashworth M., Aloisio G. (2017). Hybridisation strategies and data structures for the NEMO ocean model, High Performance Computing Applications, SAGE Publications, ISSN 1094-3420, Online ISSN: 1741-2846, https://doi.org/10.1177/1094342016684930
3. L. Cinquini, D. Crichton, C. Mattmann, J. Harney, G. Shipman, F. Wang, R. Ananthakrishnan, N. Miller, S. Denvil, M. Morgan, Z. Pobre, G. M. Bell, C. Doutriaux, R. Drach, D. Williams, P. Kershaw, S. Pascoe, E. Gonzalez, S. Fiore, R. Schweitzer, The Earth System Grid Federation: An open infrastructure for access to distributed geospatial data, Future Gener. Comput. Syst.., Volume 36, 2014, pp. 400-417, ISSN 0167-739X, https://doi.org/10.1016/j.future.2013.07.002.
4. Uotila, P., Iovino, D., Vancoppenolle, M., Lensu, M., and Rousset, C.: Comparing sea ice, hydrography and circulation between NEMO3.6 LIM3 and LIM2, Geosci. Model Dev., 10, 1009-1031, https://doi.org/10.5194/gmd-10-1009-2017, 2017
5. Bucchignani, E., Mercogliano, P., Panitz, H.-J., Montesarchio, M., Climate change projections for the Middle East - North Africa domain with COSMO-CLM at different spatial resolutions, Adv. Clim. Change Res. (2018), https://doi.org/10.1016/j.accre.2018.01.004

Up to 5 relevant Projects, and/or activities, services

EU H2020 ESiWACE (Centre of Excellence in Simulation of Weather and Climate in Europe; 2015-2019). ESiWACE is a user-driven Centre of Excellence in Simulation of Climate and Weather in Europe. In particular, CMCC Foundation contributes to enhancing community capacity in HPC, scheduling and workflow capabilities, storage middleware.

EU FP7 IS-ENES (2009-2013) and its follow-up IS-ENES2 (2013-2017). The goal of IS-ENES has been the development of a common climate and Earth system modelling distributed research infrastructure in Europe. IS-ENES2 further integrated the European climate modelling community, stimulated common developments of software for models and their environments, fostered the execution and exploitation of high-end simulations and supported the dissemination of model results to the climate research and impact communities. CMCC coordinated the technology tracking activity towards next generation climate models.

EU H2020 PRIMAVERA (PRocess-based climate sIMulation: AdVances in high resolution modelling and European climate Risk Assessment; 2015-2019). The goal of PRIMAVERA is to deliver novel, advanced and well-evaluated high-resolution global climate models (GCMs), capable of simulating and predicting regional climate with unprecedented fidelity, out to 2050. CMCC contributes to data management activities as well as to assessing the effect of model resolution on the performance of global climate models, and developing physical parameterisations specifically designed for use in combination with high-resolution.

EU H2020 INDIGO-DataCloud (INtegrating Distributed data Infrastructures for Global ExplOitation; 2015-2017). INDIGO-DataCloud has focused on the development of a data/computing platform targeted at scientific communities, deployable on multiple hardware, and provisioned over hybrid (private or public) e-infrastructures. CMCC mainly contributed to data analytics workflow support for ENES and other scientific communities.

EU H2020 EUCP (European Climate Prediction system project, 2017-2021). Among the main objectives of the project there is to develop an innovative ensemble climate prediction system based on high-resolution climate models for Europe for the near-term including improved methods used to characterize uncertainty in climate predictions, regional downscaling, and evaluation against

observation. CMCC REMHI division is involved the development of a very high-resolution configuration (~3 km) including urban parameterization.

Significant infrastructure, and/or major items of technical equipment

The CMCC's Supercomputing Center provides the technological infrastructure and the computational capabilities needed in order to develop simulations and models able to provide more accurate, detailed and better defined results. The main facility of the Supercomputing Center is the Athena system based on 482 IBM iDataPlex compute nodes (dual Intel E5-2670 processor working at 2,6 GHz). Athena has a computing capability of 160TFlops. The HPC infrastructure includes also the IBM dx360M4 server cluster, the InfiniBand interconnection network, the GPFS parallel file-system and a Hierarchical Storage Management (HSM) solution. The CMCC Supercomputing Center is the only computational facility in Italy specialized in Climate Change research. Additionally, a data node of the Earth System Grid Federation (ESGF) is maintained at the CMCC SuperComputing Centre. The ESGF data node at CMCC publishes about 100TB of CMCC climate simulations datasets in the CMIP5. Finally, CMCC SCC operates a big data analytics cluster with 5 fat nodes, 100 cores, 1.3 TB RAM, 56 TB GFS that will be exploited by end-users as compute infrastructure to run data analysis experiments in WP7/SA.

9. Science and Technology Facilities Council (STFC)

About the partner

STFC is a Research Council that runs research funding programmes and also operates National Laboratories which provide research facilities and capabilities that, because of their scale, complexity, strategic character or cost, are appropriately operated as a national research resource. The primary mission of the laboratories is to facilitate national research capability in ways which complement and support the university research base. The teams from STFC involved in IS-ENES3 are in the Centre for Environmental Data Analysis (CEDA) and the High Performance Software Engineering Group. CEDA, situated in the RAL Space department, provides environmental data services for the Natural Environment Research Council (NERC). The services are divided between the environmental data archive and the JASMIN high performance data analysis facility. CEDA works closely with University research scientists, particularly with the researchers of the National Centre for Atmospheric Sciences, and with the UK Met Office, to maintain a comprehensive archive and an extensive range of services. In the last 5 years the JASMIN facility has transformed the use and exploitation of climate data in the UK. At the end of 2017, the facility hosts 6Pb of CEDA archive data on high speed disk and also provides a further 14Pb for use by users, who have access to substantial computing resources enabling flexible processing of the archive and their own data products. The start of 2018 will see the total capacity expanded to 44Pb. The current archive includes large volumes of both climate model simulations and satellite observations, as well as thousands of smaller data collections. A substantial expansion of the facility is under way, which will make it possible to allocate an additional 5Pb of disk for the CMIP6 archive. The High Performance Software Engineering Group is located in the Hartree centre.

Contribution of partner to the specific project

In IS-ENES3, STFC will contribute to several areas of data service development, and will also be involved in development work for the OASIS coupling system (WP8). The data service work includes work on vocabularies and standards (WP3, WP7, WP10), on climate model documentation (WP6, WP11), providing data services for replication, access and processing of climate model archives (WP7), and development work on data services, standards management and climate model documentation systems (WP10).

Curriculum Vitae of responsible for carrying out the proposed activities

Martin Juckes (male) is an Atmospheric Scientist at CEDA, where he currently provides the scientific leadership for CEDA. His publication record covers a range of topics from atmospheric dynamics to assimilation of satellite data on ozone and methane into a tracer advection model. He currently manages

the UK contribution to the IPCC Data Distribution Centre. He has lead a work packages in each of the EU FP7 projects IS-ENES and ISENES2, and is lead FP7 project CLIPC (a Climate Information Platform for Copernicus) and the G8 Research Initiative project "ExArch: Climate analytics on distributed exascale data archives".

Ag Stephens (male) is the Head of Partnerships at the STFC Centre for Environmental Data Analysis. Ag has extensive experience of working on a range of environmental and big data problems. These range from data and system management in the CMIP5 project through to project management of the UKCP09 User Interface delivery. He has a comprehensive knowledge of the data standards relevant to the environmental sciences and has a detailed technical understanding of managing large datasets – using both database and file-based approaches. He is the lead developer of the CEDA Web Processing Service (WPS) and Data Catalogue service.

Dr Ruth Petrie (female) has been working as data scientist at CEDA since 2015. She has a PhD in Meteorology and has expertise in climate modelling and the management of climate model data. In particular, she has expertise in the use of controlled vocabularies for the management of large volumes of structured data through the use of data reference syntax and the quality control of metadata. She has worked in the CLIPC and CP4CDS projects.

Dr Charlotte Pascoe (female) is a senior data scientist at the STFC Centre for Environmental Data Analysis. She has extensive experience of the development and application of data models for climate science in her work with the METAFOR the Earth System Documentation Projects which have supported model documentation for CMIP5 and CMIP6 respectively. She is an associate member of the IPCC Task Group for Impacts and Climate Analysis (TGICA) and works on the IPCC Data Distribution Centre where the focus of her work is making climate data available to the wider climate science community.

Alison Pamment (female) is an environmental data scientist at the Centre for Environmental Data Archival (CEDA). Between 1995 and 2003 Alison worked on climate model validation and studies of the water vapour feedback at the Met Office Hadley Centre. She joined CEDA as a research scientist in 2003 and since 2006 has managed the development and maintenance of the controlled vocabularies that are a key component of the CF (Climate and Forecast) metadata conventions.

Phil Kershaw (male) is Technical Manager, Centre for Environmental Data Analysis and is responsible for the delivery of information and computing systems in support of the CEDA Earth Observation and Atmospheric Science strategy. Technical vision authority for CEMS (facility for Climate and Environmental Monitoring from Space), technical lead on a number of EC and ESA funded projects

Matt Pryor (male) joined CEDA in 2015 as DevOps (software development and operations role). He is responsible for making the JASMIN data analysis facility more readily accessible and easy to use for the scientific user community and provides operational support to users.

Rupert Ford (male) is a Computational Scientist in the High Performance Software Engineering Group within STFC's Hartree Centre. He has been working in the area of High Performance Computing for over 25 years and in the area of Climate and Weather modelling infrastructure for 20 years. He is the author of the BFG coupling system and PSyclone code generation system, the latter being used by the Met Office for their prototype next generation atmospheric model. He will be involved in WP8 developing Python bindings for the OASIS coupling system.

Up to 5 relevant Publications, and/or products or other achievements

1. Lawrence, B. N., Bennett, V. L., Churchill, J., Juckes, M., Kershaw, P., Pascoe, S., Pepler, S., Priitchard, M. and Stephens, A. (2013) Storing and manipulating environmental big data with JASMIN. In: IEEE Big Data, October 6-9, https://doi.org/10.1109/BigData.2013.6691556, 2013
2. Eyring, V., Righi, M., Lauer, A., Evaldsson, M., Wenzel, S., Jones, C., Anav, A., Andrews, O., Cionni, I., Davin, E. L., Deser, C., Ehbrecht, C., Friedlingstein, P., Gleckler, P., Gottschaldt, K.-D.,

Hagemann, S., Juckes, M., Kindermann, S., Krasting, J., Kunert, D., Levine, R., Loew, A., Mäkelä, J., Martin, G., Mason, E., Phillips, A. S., Read, S., Rio, C., Roehrig, R., Senftleben, D., Sterl, A., van Ulft, L. H., Walton, J., Wang, S., and Williams, K. D.: ESMValTool (v1.0) – a community diagnostic and performance metrics tool for routine evaluation of Earth system models in CMIP, Geosci. Model Dev., 9, 1747-1802, https://doi.org/10.5194/gmd-9-1747-2016, 2016.

3. Bennett, V., Kershaw, P., Pritchard, M., Churchill, J., Del Cano Novales, C., Juckes, M., Pascoe, S., Pepler, S., Stephens, A., Lawrence, B., Muller, J.-P., Kaharbouche, S., Latter, B. and Styles, J. (2014) EO science from big EO data on the JASMIN-CEMS infrastructure. In: 2014 conference on Big Data from Space (BiDS'14), 12-14 November 2014, Frascati, pp. 53-55.

Up to 5 relevant Projects, and/or activities, services

EU FP7 IS-ENES phase 1 (2009-2013), phase 2 (2013-2017), Infrastructure for European Network for Earth System Modelling, coordinated by CNRS-IPSL. IS-ENES projects have fostered the integration of the European Climate and Earth system modelling community, enhanced the development of Earth system models for the understanding of climate variability and change, supported high-end simulations, and facilitated model applications to better predict and understand climate change impacts on society (https://is.enes.org).

EU FP7 CLIPC, Climate Information Platform for Copernicus, coordinated by STFC, developed a climate information portal (www.clipc.eu) built on a solid foundational platform of data standards and web services.

C3S CP4CDS, the Climate Projections for the Climate Data Store project, funded by the Copernicus Climate Change Service and led by STFC, is building systems to feed climate projections into the C3S services.

EU H2020 PRIMAVERA, a European Union Horizon2020 project, deploying a new generation of advanced and well-evaluated high-resolution global climate models, producing simulations and predictions of regional climate with unprecedented fidelity, for the benefit of governments, business and society in general. STFC is providing archive and analysis space.

Intergovernmental Panel on Climate Change Data Distribution Centre (IPCC DDC): STFC jointly hosts the IPCC DDC (www.ipcc-data.org) with DKRZ and the Center for International Earth Science Information Network (CIESIN).

Significant infrastructure, and/or major items of technical equipment

JASMIN provides the UK and European climate and earth-system science communities with an efficient data analysis environment. Many datasets, particularly model data, are too big to be easily shipped around: JASMIN enables scientists to bring their processing to the data. A significant upgrade at the end of 2017 brings the infrastructure capacity up to 44PB of disk storage with 11,500 computational cores on 588 nodes. Scientists can make use of the computational power through shared servers or by configuring their own server in the JASMIN cloud. The internal network is configured to give fast non-blocking access to the storage park, so that multi-processor data analysis jobs can run without encountering IO blockages. The disk park is complemented by a tape archive used for back-up and archive of infrequently used data.

10. Sveriges Meteorologiska och Hydrologiska Institut (SMHI)

About the partner

SMHI (http://www.smhi.se) is a government agency under the Swedish Ministry of Environment. SMHI offers products and services that provide organisations with important environmental information to support decision-making. The main fields include weather and climate forecasts/projections, industry-specific services, simulations and analyses. SMHI has a strong R&D focus. With climate research

involving all of six research sections, including the Rossby Centre that is responsible for the development and application of regional and global climate models. In particular the Rossby Centre is active in the development of EC-Earth, being responsible for the development and release of the most recent generation, EC-Earth 3. The Rossby Centre also has extensive experience in the development and application of advanced regional climate models.

Contribution of partner to the specific project

In WP3/NA2 SMHI will organise a technical workshop on meta-data for climate indices and otherwise contribute to networking activities.
SMHI will co-lead WP5/NA4, which will identify and define connections and standards around data, metadata, and data centric computing activities in Europe and around the world. Additionally, SMHI will contribute to the definition of an Architecture for future data services.
SMHI will co-lead WP6/SA1, which provides services around European ESMs and related infrastructure software tools. Furthermore, SMHI will provide the services for EC-Earth, one of the ESMs covered by the work package.
In WP7/SA2 SMHI will provide support services to the international CORDEX community, both in terms of organising and maintaining the CORDEX data requests and helping supporting CORDEX data producers get their data published on ESGF as well as supporting users of the data. These service activities will draw on the International Project Office for CORDEX.
In WP9/JRA2 SMHI will contribute to the development of ESMValTool in two critical ways: First, ESMValTool will be extended to be applicable for Regional Climate Models; second, it will be integrated into the model development workflow as an online diagnostic tool.
SMHI will in WP10/JRA3 develop tools for managing data requests for climate indices and related meta-data, and further develop and extend the climate4impact portal back-end tool (ICCLIM) for standardised calculation of climate indices and contribute to its integration into the portal.

Curriculum Vitae of responsible for carrying out the proposed activities

Dr Lars Bärring (male) is a senior scientist at SMHI, with ~20 years experience working in regional climate change and climate change impacts. He has worked extensively in the overlap area between regional climate modelling and climate impacts and adaptation and was a lead contributor to the Swedish National Assessment on Climate Vulnerability.

Dr Uwe Fladrich (male) is scientific software developer (education in applied mathematics and computer science) and one of the core developers of the EC-Earth model. His focus lies on efficient software development processes and numerical aspects of climate models. He is appointed the role of the EC-Earth release manager and will coordinate the ESiWACE developments with the roadmap of the EC-Earth consortium.

Michael Kolax (male) is a senior IT developer coordinating data management at Rossby Centre (SMHI). He has been involved in processing and quality assessment of CMIP5, CORDEX, SPECS and other data. He has been active in meta data standards as well as infrastructure related activities like IS-ENES the ESGF and CLIPC. His expertise covers even workflow setup on distributed resources as done for the Swedish contribution to CORDEX. His previous activities include technical responsibility for operational forecasting systems at SMHI.

Dr Grigory Nikulin (male) has a PhD in atmospheric physics and extensive experience in the analysis of large climate data sets. He has been extensively involved in defining the format and data standards for the WCRP CORDEX project.

Klaus Zimmermann (male) is a research scientist at Rossby Centre, SMHI, working on model evaluation for both regional and global earth system models. He is currently involved in CRESCENDO, and PRIMAVERA, focusing his work on improvements of the community driven model evaluation tool ESMValTool. A trained physicist, he joined the climate research community recently after research

activities in Freiburg, Germany, and Trieste, Italy, where he worked on computational aspects of large open quantum systems.

Up to 5 relevant Publications, and/or products or other achievements

1. Koenigk, T., & Brodeau, L. (2017). Arctic climate and its interaction with lower latitudes under different levels of anthropogenic warming in a global coupled climate model. Clim. Dyn., 49(1-2), 471-492. https://doi.org/10.1007/s00382-016-3354-6
2. Caian, M., Koenigk, T., Döscher, R., & Devasthale, A. (2018). An interannual link between Arctic sea-ice cover and the North Atlantic Oscillation. Clim. Dyn., 50(1-2), 423-441. https://doi.org/10.1007/s00382-017-3618-9
3. Haarsma, R. J., Roberts, M. J., Vidale, P. L., Senior, C. A., Bellucci, A., Bao, Q., Chang, P., Corti, S., Fučkar, N. S., Guemas, V., von Hardenberg, J., Hazeleger, W., Kodama, C., Koenigk, T., Leung, L. R., Lu, J., Luo, J.-J., Mao, J., Mizielinski, M. S., Mizuta, R., Nobre, P., Satoh, M., Scoccimarro, E., Semmler, T., Small, J., and von Storch, J.-S.: High Resolution Model Intercomparison Project (HighResMIP v1.0) for CMIP6, Geosci. Model Dev., 9, 4185-4208, https://doi.org/10.5194/gmd-9-4185-2016, 2016.
4. Bärring, L. & Strandberg, G., (2018). Does the projected pathway to global warming targets matter? Environ. Res. Lett., 13, 024029, https://doi.org/10.1088/1748-9326/aa9f72
5. Kjellström E., Bärring L., Nikulin G., Nilsson C., Persson G., Strandberg G. (2016). Production and use of regional climate model projections – A Swedish perspective on building climate services. Climate Services, ISSN2405-8807, https://doi.org/10.1016/j.cliser.2016.06.004.

Up to 5 relevant Projects, and/or activities, services

EU H2020 ESiWACE Centre of Excellence in Simulation of Weather and Climate in Europe

EU H2020 CRESCENDO Coordinated Research in Earth Systems and Climate: Experiments, Knowledge, Dissemination and Outreach

EU H2020 PRIMAVERA Process-based climate simulation: advances in high resolution modelling and European climate risk assessment

EU H2020 EUCP European Climate Prediction system

EU FP7 CLIP-C Climate Impact Portal for Copernicus

Significant infrastructure, and/or major items of technical equipment

SMHI is providing the technical infrastructure for developer-developer and developer-user interaction for the EC-Earth model (the EC-Earth Development Portal).

SMHI is one of the key laboratories developing and performing large model inter-comparison exercises, such as CMIP5 and CMIP6.

SMHI is hosting the WCRP International Project Office for CORDEX (IPOC)

11. Deutsches Zentrum Für Luft- und Raumfahrt in der Helmholtz Gemeinschaft (DLR)

About the partner

DLR is the German national research establishment for aeronautics, astronautics, and energy technology within the Helmholtz-Gemeinschaft der Forschungszentren (HGF). In IS-ENES3, DLR is represented by the Institute of Atmospheric Physics (DLR-IPA). DLR-IPA has long-term experience in several research areas that are of relevance for IS-ENES3, in particular global Earth system modelling and evaluation, the analysis of multi-model ozone and climate projections, in situ air-borne measurements,

and processing and analysis of satellite data. DLR-IPA is the PI of the Earth System Model Evaluation Tool (ESMValTool, http://www.esmvaltool.org/) that is developed in collaboration with other partners. The modelling group at DLR-IPA develops the ECHAM/MESSy Atmospheric Chemistry (EMAC) model in collaboration with other partners and supports international activities such as the CMIP with simulations that serve as a basis for ozone and climate assessments. The Coupled Model Intercomparison Project (CMIP) Panel is currently chaired by DLR-IPA.

Contribution of partner to the specific project

In IS-ENES3, DLR-IPA will lead WP9/JRA2 on Earth System Model Evaluation. DLR-IPA will also be involved in the definition of community standards and a a community survey on model evaluation (WP3/NA2/Community and WP5/NA4: Data and Evaluation) and on services for European infrastructure tools around the ESMValTool (WP6/SA1: Models and WP7/SA2: Data).

Curriculum Vitae of responsible for carrying out the proposed activities

Prof Dr Veronika Eyring (female) is Senior Scientist and Head of the Earth system model evaluation group at DLR-IPA. She is Professor of Climate Modelling at the University of Bremen and maintains a strong collaboration with the National Center for Atmospheric Research (NCAR, USA) as Affiliate Scientist. Her research focuses on Earth system modeling and evaluation with observations. She has authored many peer-reviewed journal articles and has contributed to the Intergovernmental Panel on Climate Change (IPCC) climate and World Meteorological Organization (WMO) ozone assessments since 2004. Veronika is the PI of the ESMValTool development and is involved in the World Climate Research Programme (WCRP) through her roles as Chair of the CMIP Panel and member of the scientific steering committees for the Working Group on Coupled Modeling (WGCM), the WCRP Data Advisory Council's (WDAC) Observations for Model Evaluation Task Team, and the Working Group on Numerical Experimentation (WGNE)/WGCM Climate Model Diagnostics and Metrics Panel.

Dr Axel Lauer (male) is a Research Scientist at DLR-IPA and member of the Earth system model evaluation group. Before joining the Earth system model evaluation group at DLR, Axel spent five years as a researcher at the International Pacific Research Center in Honolulu (U.S.) studying clouds, aerosols and their interactions and two years at the Institute for Advanced Sustainability Studies in Potsdam (Germany). His main research interests are aerosols, clouds and cloud-climate feedbacks as well as their interactions. He has a long standing experience in evaluating and analysing climate model results and coordinates the technical ESMValTool development together with Dr Mattia Righi as core developer.

Dr Mattia Righi (male) is Research Scientist at DLR-IPA and member of the Earth system model evaluation and aerosol groups. His research focuses on global aerosol modelling and evaluation, in particular on aerosol-cloud and aerosol-radiation interactions, and on the quantification of aerosol impacts from specific sources. He has a long standing experience in evaluating and analysing climate model results and coordinates the technical ESMValTool development together with Dr Axel Lauer as core developer.

Up to 5 relevant Publications, and/or products or other achievements

1. Eyring, V., Bony, S., Meehl, G. A., Senior, C. A., Stevens, B., Stouffer, R. J., and Taylor, K. E.: Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization, Geosci. Model Dev., 9, 1937-1958, 2016a. https://doi.org/10.5194/gmd-9-1937-2016
2. Eyring, V., Gleckler, P. J., Heinze, C., Stouffer, R. J., Taylor, K. E., Balaji, V., Guilyardi, E., Joussaume, S., Kindermann, S., Lawrence, B. N., Meehl, G. A., Righi, M., and Williams, D. N.: Towards improved and more routine Earth system model evaluation in CMIP, Earth Syst. Dynam., 7, 813-830, 2016b. https://doi.org/10.5194/esd-7-813-2016
3. Eyring, V., Righi, M., Lauer, A., Evaldsson, M., Wenzel, S., Jones, C., Anav, A., Andrews, O., Cionni, I., Davin, E. L., Deser, C., Ehbrecht, C., Friedlingstein, P., Gleckler, P., Gottschaldt, K. D., Hagemann, S., Juckes, M., Kindermann, S., Krasting, J., Kunert, D., Levine, R., Loew, A., Mäkelä,

J., Martin, G., Mason, E., Phillips, A. S., Read, S., Rio, C., Roehrig, R., Senftleben, D., Sterl, A., van Ulft, L. H., Walton, J., Wang, S., and Williams, K. D.: ESMValTool (v1.0) – a community diagnostic and performance metrics tool for routine evaluation of Earth system models in CMIP, Geosci. Model Dev., 9, 1747-1802, 2016c. https://doi.org/10.5194/gmd-9-1747-2016

4. Lauer, A., V. Eyring, M. Righi, M. Buchwitz, P. Defourny, M. Evaldsson, P. Friedlingstein, R. de Jeuf, G. de Leeuw, A. Loew, C.J. Merchant, B. Müller, T. Popp, M. Reuter, S. Sandven, D. Senftleben, M. Stengel, M. Van Roozendael, S. Wenzel, and U. Willén: Benchmarking CMIP5 models with a subset of ESA CCI Phase 2 data using the ESMValTool, Remote Sens. Environ., 203, 9-39, doi: 10.1016/j.rse.2017.01.007, 2017. https://doi.org/10.1016/j.rse.2017.01.007
5. Wenzel, S., Cox, P. M., Eyring, V. & Friedlingstein, P. Projected land photosynthesis constrained by changes in the seasonal cycle of atmospheric CO2. Nature 538, 499-501, https://doi.org/10.1038/nature19772 (2016).

Up to 5 relevant Projects, and/or activities, services

BMBF CMIP6-DICAD (2016-2020), German national project to coordinate and fund CMIP6 activities in Germany, responsible for enhancements of the ESMValTool with additional diagnostics and metrics and for establishing a first version of the ESMValTool coupling to the ESGF infrastructure at DKRZ.

Copernicus C3S-MAGIC (2016-2019), C3S - Metrics and Access to Global Indices for Climate Projections, work package leader for the development of performance metrics in the ESMValTool (https://climate.copernicus.eu/development-c3s-software-data-analysis-climate-models).

Copernicus C3S-511 (2017-2021), Scientific Quality Assessment and Report for ECVs, responsible for the scientific quality assessment of observations related to cloud properties, aerosol, carbon dioxide, and methane with the ESMValTool.

EU FP7 IS-ENES Phase 2 (2013-2017), Infrastructure for European Network for Earth System Modelling, responsible for the development of a strategy towards routine evaluation of Earth System Models (https://is.enes.org).

EU H2020 CRESCENDO (2015-2020), Coordinated Research in Earth Systems and Climate: Experiments, kNowledge, Dissemination and Outreach, responsible for the research theme Earth System Model Evaluation (https://www.crescendoproject.eu/).

Significant infrastructure, and/or major items of technical equipment

To facilitate the development by multiple users and institutions, the development of the ESMValTool is conducted at GitHub, using an open repository that is available to the public (https://github.com/ESMValGroup/ESMValTool) and a private repository that is restricted to the ESMValTool Development Team. The ESMValTool is based on open-source software, such as Python and the NCAR Command Language (NCL), which are available on most computer facilities, including the DLR-IPA Linux Cluster. DLR-IPA runs global simulations with the EMAC model and the ESMValTool at supercomputing centers such as the German Climate Computing Center (DKRZ, Hamburg) and the Leibniz Supercomputing Center (LRZ, Garching). In addition to these resources, DLR-IPA has also access to a local Linux-cluster.

12. Stichting Netherlands eScience Center (NleSC)

About the partner

The Netherlands eScience Center (NLeSC) is the national hub for the development and application of domain overarching software and methods for the scientific community. The eScience Center is a permanent research institute, funded by the Dutch national research council (NWO) and the Dutch organisation for ICT in education and research (SURF). Each year, NLeSC publishes several calls for research proposals to fund new projects and balances its effort among all research disciplines. NLeSC

has an annual budget of between 3-4M€ to fund collaborative research projects with Dutch academia. These projects are provided with both in-cash and in-kind funding. The in-cash part is used to hire a PhD student or Postdoc at the PI's organization. The in-kind part consists of eScience Research Engineers, employed by the NLeSC. Together, they form a project team that will work on the collaborative research project. The eScience Research Engineers are researchers that typically hold a PhD, and have expertise on state-of-the-art computational technologies, as well as a keen interest in developing of research software. NLeSC is involved in more than 90 collaborative research projects, spanning many different research disciplines and application domains, of which 11 currently projects are in the Climate Sciences.

Contribution of partner to the specific project

In IS-ENES3, NLeSC will be involved in multiple aspects of model evaluation in the form of standards (WP5/NA4), support services (WP6/SA1) compute services (WP7/SA2) and development (WP9/JRA2).

Curriculum Vitae of responsible for carrying out the proposed activities

Prof Dr Wilco Hazeleger (male) is the Director of the Netherlands eScience Center and endowed professor in Climate Dynamics at Wageningen University. He holds a PhD in Physical Oceanography from Utrecht University. He initiated and led the EC-Earth project, a European Earth system modelling consortium that develops a state-of-the-art Earth system model based on ECMWF's numerical weather prediction model. Until 2014, Wilco led climate research divisions at KNMI. In 2013 he served as Acting Director of a research department on Climate and Seismology Research at KNMI. Wilco currently serves on a number of international and national science committees on meteorology, climate and data science, including the SRG of the UK Met Office and the advisory committee of the Swedish eScience Center, and he leads the Big Data national science initiative in the Netherlands.

Dr Niels Drost (male) holds a PhD in High-Performance Distributed Computing from VU University Amsterdam. He works as an eScience Research Engineer at the Netherlands eScience Center, where he coordinates technical development on workflows and orchestration. As a senior engineer Niels has led technical work done in a number of projects and disciplines, including Astrophysics, Climate Sciences, Hydrology, and Archaeology. Niels is currently the technical lead of the MAGIC project on climate model evaluation, funded by the Copernicus European Union Programme. In addition, he is Co-PI of the eWaterCycle II project on the structural evaluation of Hydrological models. In ES-ENES3, he will work on WP5/NA4 and WP7/SA2.

Bouwe Andela (male) holds an MSc degree in Theoretical Physics and an MSc degree in Astronomy. At the moment he works as an eScience Research Engineer on developing the next version of ESMValTool, a community tool for evaluating earth system models, as well as on a project for urban land cover classification based on satellite data. For ESMValTool he has recently implemented a parallel workflow with completely revised interfaces, creating a much faster and simpler user experience. Previously he has been involved in developing and running software during the on-ground calibration of the Sentinel 5P Tropomi instrument for KNMI and the in-flight calibration of the Sentinel 3A optical instruments at ESA. At ESA he improved several algorithms, leading to higher accuracy and greatly reduced processing time for level 1 products.

Up to 5 relevant Publications, and/or products or other achievements

1. Haarsma, R. J., Roberts, M. J., Vidale, T. L., Senior, C. A., Bellucci, A., Bao, Q., Chang, P., Corti, S., Fuckar, N. S., Guemas, V., von Hardenberg, J., Hazeleger, W., Kodama, C., Koenigk, T., Leung, L. R., Lu, J., Luo, J. J., Mao, J., Mizielinski, M. S., Mizuta, R., Nobre, P., Satoh, M., Scoccimarro, E., Semmler, T., Small, J. and von Storch, J. S., 2016: "High Resolution Model Intercomparison Project (HighResMIP)". Geosci. Model Dev., 9, 4185-4208, https://doi.org/10.5194/gmd-9-4185-2016

2. Nathalie Schaller, Jana Sillmann, Malte Müller, Dag Bjørge, Timo Kelder, Gijs van den Oord, Rein Haarsma, and Wilco Hazeleger. Translating the October 2014 flood event in western Norway into the future. Geophysical Research Abstracts Vol. 20, EGU2018-4780, 2018 https://meetingorganizer.copernicus.org/EGU2018/EGU2018-4780.pdf
3. Hazeleger, W. et al (2015): Tales of Future Weather. Nature Climate Change, 5, 107-114. https://doi.org/10.1038/nclimate2450
4. Hazeleger, W. Wang, X. Severijns, C., S. S_tef_anescu, R. Bintanja, A. Sterl, K. Wyser, T. Semmler, S. Yang, B. van den Hurk, T. van Noije, E. van der Linden, and K. van der Wiel. EC-Earth V2.2 (2012): Description and validation of a new seamless earth system prediction model. Clim. Dyn., 39(11):2611{2629}. https://doi.org/10.1007/s00382-011-1228-5
5. Hut, R., Drost, N., van Meersbergen, M., Sutanudjaja, E., Bierkens, M., and van de Giesen, N.: eWaterCycle: a hyper-resolution global hydrological model for river discharge forecasts made from open source pre-existing components, Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2016-225, 2016.

Up to 5 relevant Projects, and/or activities, services

EU H2020 Blue-Action – Blue Action: Arctic Impact on Weather and Climate. NLeSC performs high resolution atmospheric and coupled model simulations to address the impact of Arctic climate change on mid-latitudes and vice versa

EU H2020 EOSCpilot - The European Open Science Cloud for Research Pilot Project. NLeSC is partner in two science demonstrator projects, on Hydrology and on Radio Astronomy, both focussing on FAIR data as well as FAIR software.

EU H2020 EUCP – European Climate Prediction System, developing an innovative ensemble climate prediction system based on high-resolution climate models for Europe for the near-term.

EU H2020 PRIMAVERA: Coordinated high resolution climate modelling. The Netherlands eScience Center was subcontracted by KNMI to optimise and perform high resolution global simulations by EC-Earth.

Copernicus C3S MAGIC project funded by the Copernicus European Union Programme. The lead contractor is the Royal Netherlands Meteorological Institute (KNMI). NLeSC is in charge of the technical work done in the project.
http://climate.copernicus.eu/development-c3s-software-data-analysis-climate-models

Significant infrastructure, and/or major items of technical equipment

The Netherlands eScience Center does not own computing facilities. Instead, NLeSC is a participant in the DAS-5 (The Distributed ASCI Supercomputer 5). DAS-5 is a six-cluster wide-area distributed system designed by the Advanced School for Computing and Imaging (ASCI). DAS-5 is funded by NWO (the Netherlands Organization for Scientific Research), and the participating universities and organizations. As one of its distinguishing features, DAS-5 employs a number of HPC Accelerators (e.g., currently various GPU types, FPGAs) and an internal wide-area OpenFlow interconnect based on light paths. The goal of DAS-5 is to provide a common computational infrastructure for researchers, who work on various aspects of parallel, distributed, grid and cloud computing, and large-scale multimedia content analysis. DAS-5 is intended for developing parallel and distributed (GPU) applications, not for long production runs.

13. Universidad de Cantabria (UC)

About the partner

Universidad de Cantabria is a modern public institution whose main purpose is to contribute to social progress through teaching and scientific excellence. It consists of around 1,600 researchers and 13,500

students (out of which 653 are PhD students), 3 research centres (joint initiatives with the Spanish Research Council CSIC), 4 associated research institutes, and 157 R&D groups from 32 departments. Moreover, UC is one of the 9 Spanish universities selected in the "Campus of International Excellence" Programme, promoted in 2009 by the Spanish Government. UC is equipped with a modern infrastructure for data and IT management, logistics and general services. UC participated in 49 FP7 and is currently managing around 3 Million € in new H2020 projects every year. In addition, UC actively participates and coordinates 22 projects in other European funding schemes, such as LIFE+ (3), INTERREG (5), INFRAVATION (2) and RFCS (3). Regarding the present proposal, UC has leading research groups at European and International level in environmental sciences, including climate science (the UC Meteorology Group).

The **UC Meteorology Group** (**UC-MG**, http://www.meteo.unican.es) is formed by 15 researchers and conducts research on various topics related to regional climate modelling (including dynamical and statistical downscaling methods) and information technologies applied to data and metadata processing (including user community portals and services for data access and post-processing). In particular, this group is specialized in data/metadata management, statistical and dynamical (WRF) downscaling and applications in different impact sectors (tourism, forest fires, health, critical infrastructures, energy). UC-MG is currently involved in several EU-funded projects, such as IS-ENES2, EUPORIAS, SPECS and INTACT and is actively involved in international initiatives, such as CORDEX, VALUE and ENES. It is also involved in the COPERNICUS C3S tender QA4Seas for seasonal forecast evaluation, responsible of the task related to bias corrected and downscaled products. The group has also an agreement with FAO-ONU to provide tools, consulting and capacity development services for different food security initiatives developed worldwide. In the framework of these activities, the group has developed public user tools for accessing climate information (e.g. ECOMS-UDG; http://www.meteo.unican.es/ecoms-udg) and to perform statistical downscaling (ENSEMBLES Downscaling Portal http://meteo.unican.es/downscaling, which has been recently integrated in IS-ENES Climete4Impact: http://climate4impact.eu).

Contribution of partner to the specific project

In IS-ENES3, UC will involved in data service development (WP10/JRA3), community engagement (WP3/NA2) and governance and sustainability (WP2/NA1).

Curriculum Vitae of responsible for carrying out the proposed activities

Dr Antonio S. Cofiño (male) is Associate Professor of the University of Cantabria (UC) at the Department of Applied Mathematics and Computating Sciences, head of the UC Climate Data Service (CDS), and responsible of the Distributed Computing in Earth Science research line of the Santander Met. Group and the Earth System Grid Federation (ESGF) node of the UC. He has obtained the PhD in Mathematics and Computing at the Universidad de Cantabria in 2004. He has been involved as research in 7 European projects, including topics such metadata definition (e.g. METAFOR, IS-ENES2) and data publication for climate services (e.g. CLIM-RUN, EUPORIAS). His research activities are mainly related with the development and deployment of services to support the access and publication of data and metadata through the CDS, including the definition of standards for the data and metadata publication. This activity is currently giving support to several international initiatives, including CORDEX and VALUE, and projects (e.g. SPECS or EUPORIAS from the FP-7).

Ezequiel Cimadevilla (male) is a software engineer at UC. He is working as a *dev-ops* engineer providing technical support in the development of climate data access services and maintaining the ESGF node at the UC. He has participated in H2020 european projects (PROTEUS), FP7 (INSIDDE) and Spanish R+D national (INSIGNIA) projects and has experience developing web applications with *JEE* and *Spring*, working with data access protocols and administrating Unix systems. He has knowledge of the *Hadoop ecosystem*, relational databases, automatic deployment and configuration, continous integration and source control management.

Up to 5 relevant Publications, and/or products or other achievements

1. Cofiño, A. S., J. Bedia, M. Iturbide, M. Vega, S. Herrera, J. Fernández, M. D. Frías, R. Manzanas, and J. M. Gutiérrez. 2017. "The ECOMS User Data Gateway: Towards Seasonal Forecast Data Provision and Research Reproducibility in the Era of Climate Services." Climate Services, July. https://doi.org/10.1016/j.cliser.2017.07.001.
2. Fernández-Quiruelas, V., C. Blanco, A. S. Cofiño, and J. Fernández. 2015. "Large-Scale Climate Simulations Harnessing Clusters, Grid and Cloud Infrastructures." Future Generation Computer Systems, Special Section: A Note on New Trends in Data-Aware Scheduling and Resource Provisioning in Modern HPC Systems, 51 (October): 36–44. https://doi.org/10.1016/j.future.2015.04.009.
3. Fernández-Quiruelas, V., J. Fernández, A.S. Cofiño, L. Fita, and J.M. Gutiérrez. 2011. "Benefits and Requirements of Grid Computing for Climate Applications. An Example with the Community Atmospheric Model." Environ. Modell. Softw. 26 (9): 1057–69. https://doi.org/10.1016/j.envsoft.2011.03.006.
4. Frías, M. D., M. Iturbide, R. Manzanas, J. Bedia, J. Fernández, S. Herrera, A. S. Cofiño, and J. M. Gutiérrez. 2018. "An R Package to Visualize and Communicate Uncertainty in Seasonal Climate Prediction." Environ. Modell. Softw.. 99 (Supplement C): 101–10. https://doi.org/10.1016/j.envsoft.2017.09.008.
5. Manzanas, R., J. M. Gutiérrez, J. Fernández, E. van Meijgaard, S. Calmanti, M. E. Magariño, A. S. Cofiño, and S. Herrera. 2017. "Dynamical and Statistical Downscaling of Seasonal Temperature Forecasts in Europe: Added Value for User Applications." Climate Services, June. https://doi.org/10.1016/j.cliser.2017.06.004.

Up to 5 relevant Projects, and/or activities, services

EU FP7 IS-ENES2 (2013- 2017): InfraStructure for the European Network for Earth System Modelling - Phase 2. IS-ENES2 is the second phase project of the distributed e-infrastructure of models, model data and metadata of the European Network for Earth System Modelling (ENES). This network gathers together the European modelling community working on understanding and predicting climate variability and change. ENES organizes and supports European contributions to international experiments used in assessments of the Intergovernmental Panel on Climate Change. This activity provides the predictions on which EU mitigation and adaptation policies are built. IS-ENES2 further integrates the European climate modelling community, stimulates common developments of software for models and their environments, fosters the execution and exploitation of high-end simulations and supports the dissemination of model results to the climate research and impact communities. IS-ENES2 implements the ENES strategy published in 2012 by: extending its services on data from global to regional climate models, supporting metadata developments based on the FP7 METAFOR project, easing access to climate projections for studies on climate impact and preparing common high-resolution modeling experiments for the large European computing facilities. IS-ENES2 also underpins the community's efforts to prepare for the challenge of future exascale architectures.

EU FP7 SPECS (2012 -2017): Seasonal-to-decadal climate Prediction for the improvement of European Climate Services. SPECS will undertake research and dissemination activities to deliver a new generation of European climate forecast systems, with improved forecast quality and efficient regionalisation tools to produce reliable, local climate information over land at seasonal-to-decadal time scales, and provide an enhanced communication protocol and services to satisfy the climate information needs of a wide range of public and private stakeholders.The improved understanding and seamless predictions will offer better estimates of the future frequency of high-impact, extreme climatic events and of the prediction uncertainty. New services to convey climate information and its quality will be used. **UC-MG** led the workpackage for local prediction and statistical downscaling.

EU FP7 EUPORIAS (2012-2017): European Provision Of Regional Impacts Assessments on Seasonal and Decadal Timescales. EUPORIAS intends to improve our ability to maximise the societal benefit of the new climate forecast technologies working in close relation with a number of European stakeholders. The project want to develop a few fully working prototypes of climate services addressing

the need of specific users. The time horizon is set between a month and a year ahead with the aim of extending it towards the more challenging decadal scale.

EURO-CORDEX (WCRP sponsored initiative, ongoing**):** Coordinated Downscaling Experiment - European Domain. EURO-CORDEX is the European branch of the international CORDEX initiative, which is a program sponsored by the World Climate Research Program (WRCP) to organize an internationally coordinated framework to produce improved regional climate change projections for all land regions world-wide. The CORDEX-results will serve as input for climate change impact and adaptation studies within the timeline of the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) and beyond. UC-MG co-coordinates the statistical downscaling workpacage. José M. Gutierrez is PoC for CORDEX-ESD in Europe.

FAO-MOSAICC (GCP/GLO/243/EC, ongoing): Linking information and decision making to improve food security: Module for regional projection of climate. R+D research project funded by FAO in order to contribute to the development of the FAO tool MOSAICC (for MOdelling System for Agricultural Impacts of Climate Change), which is a system of models and utilities designed to carry out inter-disciplinary climate change impact assessment on agriculture through simulations. The main components of the system are one statistical downscaling portal, one hydrological model for estimating water resources for irrigation in major basins, two water balance-based crop models to simulate crop yields under climate change scenarios and finally one Computable General Equilibrium model (CGE) to assess the effect of changing yields on national economies.

Significant infrastructure, and/or major items of technical equipment

UC hosts one of the nodes of the Spanish National Supercomputing Network (the node Altamira), which reserves 30% of the computing time to UC research groups. Moreover, the Meteorology Group maintains the UC Climate Data Service, which provides support for climate data storage and access using a variety of services tailored to different end users, including services to access standard predictors for statistical downscaling from seasonal (e.g. ECOMS) and climate change initiatives (e.g. VALUE).

14. Norwegian Meteorological Institute (met.no)

About the partner

Met Norway is the national meteorological service in Norway. In addition to national and aviation weather forecasting, and climate monitoring for Norway and adjacent sea areas, the institute represents Norway in ECMWF, EUMETSAT, EUMETNET, WMO and other international fora, and takes part in national and international research projects (e.g. EU) on climate, atmospheric and marine research, and air pollution. The number of employees is around. 400, with nearly 100 scientists doing research relevant for weather prediction, ocean and sea ice, climate, air pollution, instrumentation, and remote sensing. Met Norway has extensive experience in operational applications for innovation and added value in private and public sectors. Met Norway is together with the universities in Oslo and Bergen the main developer of the Norwegian Earth System model NorESM, providing results for CMIP and IPCC. The scientific contributions particularly emphasize the interactions between aerosols, clouds, atmospheric composition, climate dynamics, variability, and change. Results were delivered to CMIP5 based on NorESM1. Final preparations for the new NorESM2 to be used for CMIP6 are underway.

Contribution of partner to the specific project

In IS-ENES3 METNO will be involved in WP9/JRA2 on model evaluation using the knowledge and measurements in the AeroCom project and WP6/SA1 by providing service functions for NorESM.

Curriculum Vitae of responsible for carrying out the proposed activities

Michael Schulz (male): Deputy Head Climate Modelling and Air Pollution Section with responsibility for atmospheric chemistry, aerosols, climate and earth system modeling. He si the leader of AeroCom, with internationally leading contributions to the understanding of aerosol-climate interactions.He is the PI in EU FP7 project ECLIPSE, ACTRIS2 and in eSTICC. He leads and contributes to IPCC AR4 and AR5. He co-chairs AerChemMIP of CMIP6. He is the co-coordinator of the Norwegian Infrastructure proposal INES on the NorESM model starting in 2018.

Jan Griesfeller (male): Senior Engineer with model data handling and model evaluation background. Contributed largely to ESA's Aerosol_CCI projects and is currently project leader for the Met Norway contribution to the Copernicus C3S_312a_Lot5 project. Main Author of the aerocom evaluation software.

Dirk Olivie (male): researcher in earth system modelling with emphasis on atmospheric chemistry and climate. He brings key contributions to NorESM-development in EVA, and to chemistry-climate experiments in EU FP7 ECLIPSE. He contributes to advancing the chemistry-aerosol interactions in NorESM and their evaluation.

Øyvind Seland (male): Senior researcher with expertise on aerosol modelling in NorESM, model tuning, and production runs. PI in EVA, EU FP7 PEGASOS and ACCESS, and in CRAICC and eSTICC. He is a key contributor to the preparatory and production-runs for CMIP6.

Up to 5 relevant Publications, and/or products or other achievements

1. Kirkevåg, A. et al. (2013): Aerosol–climate interactions in the Norwegian Earth System – NorESM1-M., Geosci. Model Dev., 6, 207–244, 2013. https://doi.org/10.5194/gmd-6-207-2013
2. Bentsen, M. et al. (2013): The Norwegian Earth System Model, NorESM1-M – Part 1: Description and basic evaluation of the physical climate, Geosci. Model Dev., 6, 687–720, https://doi.org/10.5194/gmd-6-687-2013
3. Iversen, T. et al (2013): The Norwegian Earth System Model, NorESM1-M – Part 2: Climate response and scenario projections, Geosci. Model Dev., 6, 389–415, https://doi.org/10.5194/gmd-6-389-2013.
4. Collins, W. J., Lamarque, J. F., Schulz, et al.: AerChemMIP: quantifying the effects of chemistry and aerosols in CMIP6, Geosci. Model Dev., 10, 585-607, 2017. https://doi.org/10.5194/gmd-10-585-2017
5. Myhre, G., Samset, B. H., Schulz, M., et al.: Radiative forcing of the direct aerosol effect from AeroCom Phase II simulations, Atmos. Chem. Phys., 13, 1853-1877, https://doi.org/10.5194/acp-13-1853-2013, 2013.

Up to 5 relevant Projects, and/or activities, services

Norwegian Research Council -INES: National infrastructure project for support of technical development of NorESM. Starts 1. July 2018

EU FP7 IS-ENES phase 2 (2013-2017), Infrastructure for European Network for Earth System: HPC intercomparison

EU H2020 CRESCENDO, Coordinated Research in Earth Systems and Climate: Experiments, Knowledge, Dissemination and Outreach project

EU H2020 APPLICATE, Advanced Prediction in Polar regions and beyond: modelling, observing system design and LInkages associated with a Changing Arctic climaTE project.

15. Météo France - Centre National de Recherches Météorologiques (MF-CNRM)

About the partner

MF-CNRM is a research center affiliated to CNRS and Météo-France (the French national weather service). Primarily oriented towards the needs of public utility in the domain of meteorology, CNRM's research actions encompass the atmosphere, extending to, and including, closely related fields such as climate, stratospheric ozone chemistry, upper ocean, physics and dynamics of the snow cover, surface hydrology etc. To carry out its missions, CNRM hosts approximately 230 permanent positions (one third being research scientists) and 60 students and visitors, working in specialised departments. The department of CNRM that is involved in IS-ENES3 is the Large Scale and Climate Meteorology Department (GMGEC). The main research activities of GMGEC are climate modelling and simulation at global and regional scales, climate variability including detection and attribution of climate change, climate change impacts, atmospheric chemistry including air quality and ocean-air interactions. GMGEC has participated in phases 3 and 5 of CMIP and is currently contributing to CMIP6 with its coupled climate system model CNRM-CM6 and Earth system model CNRM-ESM. It currently participates in IS-ENES2, CRESCENDO, APPLICATE, EUCP european projects.

Contribution of partner to the specific project

In IS-ENES3, as a participant to the NEMO Sea Ice Working Group (SIWG), CNRM will be involved in WP4/NA3, contributing to building the scientific community using and developing NEMO's new sea ice model SI^3.

Curriculum Vitae of responsible for carrying out the proposed activities

Dr David Salas y Mélia (male) leads CNRM's research group in charge of climate and atmospheric composition (staff of about 85). He has more than 20 years of experience in sea ice and coupled climate modelling, with a particular interest in the Arctic climate system and sea level changes. David Salas y Mélia is the author of the sea ice model included in CNRM-CM and CNRM-ESM. David Salas y Mélia is the co-director of the French national research infrastructure on climate modelling CLIMERI-France (https://climeri-france.fr/) and is a member of the NEMO-SIWG. He is the author or co-author of 50 peer-reviewed articles.

Dr Matthieu Chevallier (male)
Matthieu is a researcher at Meteo France/Centre National de Recherches Meteorologiques (CNRM). His research mainly focuses on understanding coupled processes at the air-ice-sea interface, including processes related to sea ice, and improving their representation in coupled models used for seasonal predictions and climate projections. He leads the research team in charge of the development and evaluation of the CNRM-CM atmosphere-ocean global coupled model, which contributed to the last phases of CMIP. He is a member of the Steering Group of the Polar Prediction Project (WWRP), a member of Year Of Polar Prediction Modelling Task Team, and participates in the NEMO-SIWG.

Up to 5 relevant Publications, and/or products or other achievements

1. Chevallier, M., D. Salas y Mélia, A. Voldoire, M. Déqué and G. Garric (2013). Seasonal forecasts of the pan-Arctic sea ice extent using a GCM-based seasonal prediction system, J. Climate https://doi.org/10.1175/JCLI-D-12-00612.1
2. Voldoire, A., E. Sanchez-Gomez, D. Salas y Mélia, B. Decharme, C. Cassou, S.Sénési, S. Valcke, I. Beau, A. Alias, M. Chevallier, and 16 co-authors (2013). The CNRM-CM5.1 global climate model: description and basic evaluation, Clim. Dyn., 40(9-10): 2091-2121, https://doi.org/10.1007/s00382-011-1259-y
3. Séférian, R., C. Delire, B. Decharme, A. Voldoire, D. Salas y Mélia, M. Chevallier, D. Saint-Martin, O. Aumont, J.-C. Calvet, D. Carrer, H. Douville, L. Franchistéguy, E. Joetzjer, and S. Sénési (2016). Development and evaluation of CNRM Earth system model – CNRM-ESM1, Geosci. Model Dev., 9, 1423-1453, https://doi.org/10.5194/gmd-9-1423-2016.

4. Wang, Q., Mehmet Ilicak, Rüdiger Gerdes, Helge Drange, and 35 co-authors including D. Salas y Mélia (2016). An assessment of the Arctic Ocean in a suite of interannual CORE-II simulations. Part I: Sea ice and solid freshwater. Ocean Model., 99, 110-132. https://doi.org/10.1016/j.ocemod.2016.02.004

Up to 5 relevant Projects, and/or activities, services

EU FP7 IS-ENES phase 2 (2013-2017), Infrastructure for European Network for Earth System Modelling, coordinated by CNRS-IPSL. IS-ENES projects have fostered the integration of the European Climate and Earth system modelling community, enhanced the development of Earth system models for the understanding of climate variability and change, supported high-end simulations, and facilitated model applications to better predict and understand climate change impacts on society (https://is.enes.org).

French ANR Convergence project (2013-2018), aimed at developing a platform capable of running large ensembles of simulations with a suite of models, to handle the complex and voluminous datasets generated, to facilitate the evaluation and validation of the models and the use of higher resolution models. The project has in particular extended the use of XIOS on all model components in France.

EU H2020 CRESCENDO (2015-2020) primarily aims at improving the representation of key processes in European Earth System Models (ESMs) by thoroughly evaluating the scientific performance of these models. These models will be used to generate a new set of Earth system projections for the coming century and coordinate a European contribution to CMIP6. Another important goal of CRESCENDO is to ensure that knowledge developed in the project is communicated to key stakeholder communities in an engaging and understandable form.

EU H2020 APPLICATE (2016-2020) : The goal of the project APPLICATE is to improve weather and climate predictions in the Arctic, and to investigate atmospheric and oceanic linkages between Arctic climate change and mid-latitude weather and climate. Model improvements planned in WP2 (co-led by M. Chevallier) include better representation of sea ice surface features (melt ponds, roughness, snow), more consistent representation of atmosphere-sea ice-ocean coupling in coupled models and enhanced horizontal resolution of the ocean and sea ice components in 5 european climate models (AWI-CM, CNRM-CM, EC-Earth, HadGEM and NorESM).

EU H2020 EUCP (2017-2021) : The European Climate Prediction system project (EUCP) has the following four main objectives: 1. Develop an innovative ensemble climate prediction system based on high-resolution climate models for Europe for the near-term (about 1-40 years); 2. Use the climate prediction system to produce climate information co-designed with users to support climate related risk assessments and climate change adaptation programs; 3. Demonstrate the value of this climate prediction system through high impact extreme weather events in the near past and near future translated into risk information for, and with, targeted end users; 4. Develop, and publish, methodologies, good practice and guidance for producing and using authoritative climate predictions for the 1-40 year timescale.

Significant infrastructure, and/or major items of technical equipment

CNRM develops and uses the global coupled climate system model CNRM-CM (in collaboration with CERFACS) and the Earth System Model CNRM-ESM. CNRM-CM has contributed to the CMIP3 and CMIP5 international intercomparison, and both models are currently contributing to CMIP6. CNRM mainly uses supercomputing facilities from Météo-France (two 72,000-core Bull hpc machines) and from the European Centre for Medium-Range. It also operates a data node of the international Earth System Grid Federation.

16. University of Manchester (UNIMAN)

About the partner

The University of Manchester is one of the top research-led universities and can lay claim to 25 Nobel Prize winners amongst its current and former staff and students, including 4 current Nobel laureates. The School of Computer Science plays important roles in the two EU FET flagship projects (Graphene and Human Brain Project) and collaborates with the Square Kilometer Array (SKA) experiment headquartered in the university's Jodrell Bank Observatory.

The school also has a long and distinguished research record, including the development of the first stored program computer the late '40s, and the development of virtual memory among a range of innovations in the Atlas computer in the early '60s (the UK first supercomputer). The school retains strong activities in computer systems and engineering (indeed, graphene, the discovery of which led to the Nobel Prize for Physics in 2010, was first observed using a microscope in our engineering and nanotechnology labs). The Advanced Processor Technologies group (APT) continues the excellent record in high performance low-power computer systems, and encompasses a range of research activities addressing the formidable complexity of both software and hardware for the many-core systems of the future. The APT group brings together more than 60 researchers (faculty, fellows, PhD students) and is one of the few centers of excellence able to design complex silicon as demonstrated by SpiNNaker; a one million ARM cores massively parallel architecture. APT has helped the EU competitive position with commercialization examples such as the ICL Goldrush Database server, Amulet processors (Low-power architectures) bought by ARM Ltd., Transitive Corporation (Virtualization and Binary Translation) bought by IBM and Silistix Ltd (Networks-on-Chip).

Contribution of partner to the specific project

In IS-ENES3, UNIMAN will participate in WP4. In WP4, UNIMAN will lead Task 4 on Machine Learning and Technology Tracking and Task 6 Innovating w**ith software and HPC industry.**

Curriculum Vitae of responsible for carrying out the proposed activities

Grahm Riley (male) is a Lecturer in the Advanced Processor Technologies group (APT) in the School of Computer Science at the Universty of Manchester with contributions in High Performance Computing - including Performance Control and the software engineering aspects of flexible coupled modelling, primarily in the field of Earth System Modelling (ESM) He also has research interests in performance aspects related to the acceleration of Deep Learning on low-power heterogeneous systems. He has a long association with the UK Met Office and was a consultant on their FLUME project and more recently led Manchester's involvement in the UK NERC/Met Office-funded Next Generation Weather and Climate Prediction project (GungHo) which prototyped a new, scalable dynamical core suited for the emerging many-core architectures on the road to exascale computing. He led Manchester's participation in the EU-funded IS-ENES and IS-ENES2 projects (Infrastructure for the European Network for Earth System Modelling). He is a co-investigator on the EU-funded pre-exascale machine project, EuroEXA where he is leading Manchester's contribution to research in application development, with a focus on ESM, for the proposed FPGA-accelerated EuroEXA architecture. He has around 50 publications in international journals and conferences. Graham has good links with industry and was the part-time Managing Director of the School's exploitation company, Manchester Info**rmatics Ltd. for several years.**

Mike Ashworth (male) is a senior researcher in the APT group. He has worked for many years on the development and optimisation of large-scale scientific applications for high-performance computers, with a focus on novel architecture systems. For 13 years he led the Applications Performance Engineering Group at STFC Daresbury Laboratory, being responsible for the initiation and delivery of projects across a wide range of scientific disciplines and including a number of novel and emerging computer technologies. He specialises in environmental models such as atmospheric and oceanic

models for weather and climate simulations, and was one of the founders of the GungHo project, which laid the groundwork for the UK Met Office new LFRic model. As a senior manager in STFC, he was one of the team which successfully attracted £56.5 million funding to establish the Hartree Centre. At the University of Manchester, he is currently working on the EuroExa project, investigating and optimising the LFRic model for the EuroExa FPGA-based architecture. He has participated in many EC-funded projects including leading STFC's contribution to all six PRACE projects and to the two projects of the European Exascale Software Initiative. He has around 50 publications in international journals and conferences.

Up to 5 relevant Publications, and/or products or other achievements

1. Dufresne J.L., M.A. Foujols, S. Denvil, and 57 other authors including S. Joussaume, S. Masson, S Valcke, A Craig, R Dunlap, G.D Riley. Sharing Experiences and Outlook on Coupling Technologies for Earth System Models. Bulletin of the American Meteorological Society 97 (3), 2016. https://doi.org/10.1175/BAMS-D-15-00239.1
2. Porter, A., Ford, R., Ashworth, M., Riley, G. & Modani, M. Towards Compiler-Agnostic Performance in Finite-Difference Codes. Parallel Computing 2015 (ParCo), Edinburgh 1-4 September, 2015: Parallel Computing: On the Road to Exascale. Joubert, G. R., Leather, H., Parsons, M., Peters, F. & Sawyer, M. (eds.). IOS Press, Vol. 27, p. 647-658 (Advances in Parallel Computing), 2016. https://doi.org/10.3233/978-1-61499-621-7-647
3. Valcke, S., Balaji, V., Craig, A., DeLuca, C., Dunlap, R., Ford, R.W., Jacob, R., Larson, J., O'Kuinghttons, R., Riley, G.D., and Vertenstein, M.: Coupling technologies for Earth System Modelling, Geosci. Model Dev., 5, 1589-1596, https://doi.org/10.5194/gmd-5-1589-2012 , 2012.
4. Armstrong, C, Ford, R. W., Riley, G. D. Coupling integrated Earth System Model components with BFG2, Concurrency Computat. Pract. Exper. , Vol. 21, pp. 767-791, 2009. https://doi.org/10.1002/cpe.1348.
5. R.Warren, R.Ford, G. Riley et.al. Development and illustrative outputs of the Community Integrated Assessment Model (CIAS), a multi-institutional modular integrated assessment approach for modelling climate change. In J. Environ. Modell. Softw., Vol. 23, No. 5, pp. 592-610, May 2008. Elsevier, ISSN: 1364-8152, https://doi.org/10.1016/j.envsoft.2007.09.002. (Prize winning paper).

Up to 5 relevant Projects, and/or activities, services

EU H2020-FETHPC EuroEXA, Co-designed Innovation and System for Resilient Exascale Computing in Europe: From Applications to Silicon.

EU FP7 IS-ENES 2, Infrastructure for the European Network for Earth-SystemModelling, EU FP7 Project fostering simulations with global earth system models.

EU FP7 IS-ENES, Infrastructure for the European Network for Earth-SystemModelling, EU FP7 Project fostering simulations with global earth system models.

NERC-Met Office-STFC-funded NGWCP project, developing the next generation dynamical core for the UK Met Office ("GungHo").

Met Office FLUME project, designing a Flexible Unified Model Environment.

Significant infrastructure, and/or major items of technical equipment

The APT group is a lead partner in the EU H2020-FETHPC project, EuroEXA. This project is developing demonstrators towards an FPGA-accelerated pre-exascale machine over the next three years of so. The application areas being addressed include ESM and it is anticipated that the final demonstrator will be available for use in EU projects.

17. National Centre of Scientific Research "Demokritos" (NCSR-D)

About the partner

National Center for Scientific Research "Demokritos" (NCSRD) is the largest Greek self-governing research organisation under the supervision of the General Secretariat for Research and Technology (GSRT) of the Greek Government. NCSRD will participate with the Software and Knowledge Engineering Lab (SKEL, http://skel.iit.demokritos.gr) of its Institute of Informatics and Telecommunications (IIT).
SKEL has participated in and coordinated numerous national and European projects (H2020, FP7, bilateral) and has very substantial expertise in the areas of big data management, content analysis, e-infrastructure, personalization and human-machine interaction. Additionally, SKEL is very active within the standardization processes of the World Wide Web Consortium (W3C) where SKEL researchers contributed to several Working Groups.

Contribution of partner to the specific project

In IS-ENES3, NCSRD participates in WP3, Task 4 “Machine learning and technology tracking”, where it will build on its big data, analytics and e-infrastructures experience to provide ways to climate experts to exploit current technological trends in machine learning in order to improve their models and gain statistical insights from their data. It will also participate in WP4, where as part of Task 2 it will help to organise a School of Climate Data Science bringing together climate and computer scientists, emphasizing the need of collaboration between them, and helping early career scientists with different backgrounds to meet and network.

Curriculum Vitae of responsible for carrying out the proposed activities

Dr Vangelis Karkaletsis (male) is Research Director at NCSRD, and head of SKEL at IIT. His research interests are in the areas of big data management, content analysis, natural language interfaces, ontology engineering, and personalization. He was Technical/scientific manager of the FP7-ICT project SemaGrow on the efficient discovery of web resources, the FP7-ICT project C2Learn on computational tools fostering human creativity. He was also the Site Manager of the CLARIN-EL infrastructure, the Greek part of the European CLARIN e-infrastructure, and currently of the follow-up project APOLLONIS. He was Scientific Manager of the H2020 project Your Data Stories on the analysis of open governmental data and their linking to social web, site manager for the H2020 Big Data Europe project for the development of a Big Data Integrator platform. Currently he is coordinator of the H2020 Radio project on the use of robots in assisted living environments, and the H2020 DARE project on big data management to support large-scale European e-infrastructures. He is also responsible for the two Google Digital News Initiative projects, Storybot and Open Journalism. He has organized international summer schools, workshops and conferences. He is director of the MSc program on Data Science which runs jointly with the University of Peloponnese.

Dr Iraklis Klampanos (male) holds a PhD in Computing Science from the University of Glasgow. He is a research associate with experience in big data, data science, data-intensive computing and information retrieval. He currently manages the technical work in the H2020 DARE project. He has previously worked in the Data-Intensive Research group of the University of Edinburgh, leading development work in the FP7 project VERCE. He also led technical work of the H2020 Big-Data-Europe pilot addressing SC5 on Environment. He has participated in a number of industrial, national and European projects in Greece and Scotland.

Antonis Koukourikos (male) holds a BSc in Computer Science from the University of Crete and is a PhD candidate in the Department of Digital Systems of the University of Piraeus. He is a member of the Software and Knowledge Engineering Laboratory (SKEL) at the Institute of Informatics Telecommunications (IIT) of the National Center of Scientific Research "Demokritos" (NCSRD) for the last 10 years, having participated in more than 8 EU research and development projects. He is currently WP leader in the H2020 DARE project. His main scientific interests are in the areas of Ontology

Matching and Evolution, Linked Data Management, and Natural Language Processing. He is a member of the Association for Computational Linguistics (ACL), the Hellenic Association of Artificial Intelligence (EETN), and of the Hellenic Association of Computer & Information Technology Scientists (GCS).

Up to 5 relevant Publications, and/or products or other achievements

1. I. Klampanos, A. Davvetas, S. Andronopoulos, C. Pappas, A. Ikonomopoulos, & V. Karkaletsis (2018). Autoencoder-driven weather clustering for source estimation during nuclear events. Environ. Modell. Softw., 102. http://doi.org/10.1016/j.envsoft.2018.01.014
2. I. Klampanos, D. Vlachogiannis, S. Andronopoulos, A. Cofiño, A. Charalambidis, Rob Lokers, S. Konstantopoulos, and V. Karkaletsis, "Towards Supporting Climate Scientists and Impact Assessment Analysts with the Big Data Europe Platform." In Proceedings of European Geosciences Union General Assembly 2016 (EGU 2016), Vienna, 17-22 April 2016. Geophysical Research Abstracts vol. 18, Session ESSI3.3 Earth science on Cloud, HPC and Grid.
3. S. Albani, M. Lazzarini, M. Koubarakis, E. K. Taniskidou, G. Papadakis, V. Karkaletsis, G. Giannakopoulos, "A pilot for Big Data exploitation in the Space and Security domain", proceedings of 2nd Big Data from Space Conference, 15-17 March, Santa Cruz de Tenerife (2016).
4. A. Charalambidis, A. Troumpoukis, S. Konstantopoulos. SemaGrow: Optimizing federated SPARQL queries, In Proceedings of the 11th International Conference on Semantic Systems (SEMANTiCS 2015), Vienna, Austria, 15-18 September 2015. https://doi.org/10.1145/2814864.2814886.
5. R. Lokers, S. Konstantopoulos, A. Stellato, R. Knapen, S. Janssen. Exploiting Innovative Linked Open Data and Semantic Technologies in Agro-environmental Modelling, Proceedings of the 7th International Congress on Environmental Modelling and Software (iEMSs 2014), San Diego, California, 15-19 June 2014.

Up to 5 relevant Projects, and/or activities, services

EU H2020 DARE - Delivering Agile Research Excellence on European e-Infrastructures (H2020-EINFRA, 2018-2020): The size and complexity of scientific data, as well as the difficulty in formulating domain-specific solutions in reproducible and reusable ways, may often lead to throw-away, unsustainable end-user products, or long release cycles. This complexity increases exponentially with the size and diversity of input and produced data. Furthermore, widely used big-data technologies and analytics, while they are known to lead to increased productivity in commercial settings, they are often not taken advantage of in scientific. The requirement to deal with diverse exascale data resources dictates the need to ensure and increase productivity through the controlled disruption of the current modus operandi of European RIs. DARE aims to be the technological pivot for this transition, while providing transparent, traceable and developer-friendly bridges over existing infrastructures and services. Building on extensive experience in research e-infrastructures, semantification and the handling of metadata, and on big-data technologies and domain applications, DARE will equip teams of innovators with meaningful abstractions and tools allowing for rapid prototyping of reproducible and efficient research solutions. DARE will improve further and integrate tried and tested programmatic dataflow specification APIs, big-data technologies and provenance/data- lineage solutions to address the requirements of European RIs, initially of EPOS, on Earth science, and IS/ENES2, on climate.

EU H2020 BigDataEurope - Integrating Big Data, Software & Communities for Addressing Europe's Societal Challenges (H2020, 2015-2018). To push the use of data technologies within selected European societal key sectors, BigDataEurope will provide support mechanisms for all the major aspects of a data value chain, in terms of the employed data and technology assets, the participating roles and the established or evolving processes. It aims to develop an adaptable, easy to deploy and use solution, which will allow interested user groups to extend their Big Data solutions or introduce Big Data technologies to their business processes. All European stakeholders will be able to use a platform based on a concrete methodology for producing technically sound solutions and maximizing their outreach to their relevant communities. To reach this aim, BigDataEurope focuses on creating a network of stakeholders and designing, realising and evaluating a Big Data Aggregator Platform

infrastructure. The effectiveness of the provided solution will be assessed in different domains pertaining to the seven identified European societal key sectors, with respect to the needs and requirements of the related communities. (http://www.big-data-europe.eu/)

EU FP7 SemaGrow - Data intensive techniques to boost the real-time performance of global agricultural data infrastructures (FP7-ICT, 2012-2015): As the trend to open up data and provide them freely on the Internet intensifies, the opportunities to create added value by combining and cross-indexing heterogeneous data at a large scale increase. To seize these opportunities, infrastructure is needed that is not only efficient, real-time responsive and scalable but is also flexible and robust enough to welcome data in any schema and form and to transparently relegate and translate queries from a unifying end-point to the multitude of data services that make up the open data cloud. To address these challenges, SemaGrow carries out fundamental databases research and develops methods and infrastructure that are rigorously tested on three large-scale current use cases as well as on their projected data growth beyond the project's end. (www.semagrow.eu)

EU H2020 datACRON - Big Data Analytics for Time Critical Mobility Forecasting (H2020, 2016-2018) is a research and innovation collaborative project introducing novel methods for threat and abnormal activity detection in very large fleets of moving entities spread across large geographical areas. Specifically, datACRON aims to develop novel methods for real-time detection and prediction of trajectories and important events related to moving entities, together with advanced visual analytics methods, over multiple heterogeneous, voluminous, fluctuating, and noisy data streams from moving entities, correlating them with archived data expressing, among others, entities' characteristics, geographical information, mobility patterns, regulations and intentional data (e.g. planned routes), in a timely manner. Technological developments are validated and evaluated in user-defined challenges focusing on increasing the safety, efficiency and economy of operations concerning moving entities in the Air-Traffic Management and Maritime domains.

Significant infrastructure, and/or major items of technical equipment

NCSRD participates in IS-ENES3 with its substantial experience in big data management and analytics, data science. For the organisation of the School of Climate Data Science NCSRD can contribute its dedicated development and testing cluster recently used for the Big Data Europe pilots.

18. Stichting Wageningen Research, Wageningen Environmental Research (WENR)

About the partner

Wageningen Environmental Research (WENR, previously Alterra, https://www.wur.nl/en/Expertise-Services/Research-Institutes/Environmental-Research.htm) is a leading European research and development organisation offering a combination of practical, innovative and interdisciplinary scientific research across many disciplines related to sustainable use of the living environment. WENR offers a combination of practical and scientific research in a multitude of disciplines, and has a long-standing experience in climate change modelling (we have four Nobel Prize laureates), sustainable agriculture, crop monitoring and the use of remote sensing and GIS. WENR has been involved in a large number of national and international projects directly relevant to user requirements in Copernicus Climate Services.
WENR has all facilities required to execute this work, in terms of stakeholder involvement, knowledge brokering and the science-policy-society interface. We have a wide range of experience in working in complex projects; professional support staff for project management, and administrative accounting. WENR is certified under ISO 9001:2008 for our Quality Management System as well as for our environmental management system conforming ISO 14001:2004. An internal auditing system is established to verify if applied quality activities comply with the agreed quality system and contribute to the quality objectives.

Contribution of partner to the specific project

In IS-ENES3, WENR will be involved in WP3/NA2 on community.

Curriculum Vitae of responsible for carrying out the proposed activities

Dr Judith Klostermann (female) Judith Klostermann (PhD) is senior researcher at WENR. She is working on climate change adaptation, adaptive capacity of institutions, and involving stakeholders. She is work package leader in an H2020 project on urban climate (http://urbanfluxes.eu/). She is also working on the evaluation of the European Adaptation Strategy. She was involved in work for the European Topic Centre Climate Adaptation for the report on adaptation in cities (2011) and for monitoring of adaptation at national level (2015). Other projects include the Delta Alliance toolbox for adaptive management, several projects for the Dutch Delta Program, and a Scoping Mission to Guyana on waterlogging problems in Georgetown. In 2003 she acquired a PhD in social sciences and she has a Master's degree in Biology from the University of Utrecht. She will be involved in WP3.

Dr Annemarie Groot (female) is a senior researcher at WENR. Her areas of expertise include science-policy-practice interaction, governance and stakeholder participation. She finished a PhD in the facilitation of multi stakeholder learning processes. She has more than 20 years of experience in dealing with complex change processes in the field of water resources management and climate change adaptation for which she uses transdisciplinary approaches. Her research interests lie in methodologies that enable knowledge co creation processes involving scientists, citizens and policy makers. Recently she has been involved in the FP7 BRIDGE and HighNoon projects.

Dr Ronald Hutjes (male) is senior scientist at Wageningen Environmental Research. He specializes in fundamental and applied, experimental and modelling research on land - atmosphere interactions in the context of climate change, including water cycle processes and greenhouse gas exchanges. He applies his knowledge in climate change impact and adaptation studies with respect to water resources and land use, on seasonal to decadal and centennial time scales. Furthermore he is involved in Climate Services on climate variability, climate change for hydrology and agriculture. He is involved in WP3 (two schools on exchange between climate models and impact studies).

Up to 5 relevant Publications, and/or products or other achievements

1. Klostermann, J.E.M. ; Sandt, K. van de; Harley, M. ; Hilden, M. ; Leiter, T. ; Minnen, J. van; Pieterse, N. ; Bree, L. van (2018) Towards a framework to access, compare and develop monitoring and evaluation of climate change adaptation in Europe. Mitig Adapt Strateg Glob Change (2018) 23: 187. https://doi.org/10.1007/s11027-015-9678-4
2. Turnhout, E. ; Stuiver, M. ; Klostermann, J.E.M. ; Harms, B. ; Leeuwis, C. (2013) New roles of science in society: Different repertoires of knowledge brokering. Sci.Public Policy 40 (3). - p. 354 – 365 https://doi.org/10.1093/scipol/scs114.
3. Swart, R.J. ; Bruin, K. de; Dhenain, S. ; Dubois, G. ; Groot, Annemarie ; Forst, E. von der (2017) Developing climate information portals with users: Promises and pitfalls. Climate Services 6 . - p. 12 – 22, https://doi.org/10.1016/j.cliser.2017.06.008.
4. Gonzalez, A. ; Donnelly, A. ; Jones, M. ; Klostermann, J.E.M. ; Groot, A.M.E. ; Breil, M. (2011) Community of practice approach to developing urban sustainability indicators. J. Env. Assmt. Pol Mgmt. 13 (4). - p. 591 – 617, https://doi.org/10.1142/S1464333211004024.
5. Ogutu, Geoffrey E.O. ; Franssen, Wietse H.P. ; Supit, Iwan ; Omondi, P. ; Hutjes, Ronald W.A. (2017) Skill of ECMWF system-4 ensemble seasonal climate forecasts for East Africa. Int. J. Climatol. 37 (5). - p. 2734 – 2756, https://doi.org/10.1002/joc.4876.

Up to 5 relevant Projects, and/or activities, services

EU FP7 EUPORIAS (2012-2017) develops end-to-end impact prediction services and demonstrates their value in informing decision making to stimulate a market for these new tools. A number of sectors have been addressed, water, energy, agriculture-food security, land management, etc. Both scientific assessments of predictive skill at seasonal time scales of climate and its sectorial impacts were part of

the project, as well analysis and development of communication and visualisation strategies and of typical workflows and operational service prototypes. Leading the respective work packages WENR for seasonal impact prediction development for hydrology in Europe and for agriculture in E-Africa.

EU FP7 CLIP-C (2013-2016) developed a pre-operational information portal for the Copernicus Climate Change Service. Led by STFC with scientific and technological coordination and support provided by WENR, CLIPC provides access to climate information of direct relevance to a wide variety of users, from scientists to policy makers and private sector decision makers. The platform complements existing GMES/Copernicus pre-operational components and focuses on datasets which provide information on climate variability on decadal to centennial time scales from observed and projected climate change impacts in Europe. CLIP-C also provides a toolbox to generate, compare and rank key indicators.

Copernicus C3S 411 Lot1 (Service for Water Indicators in Climate Change Adaptation), will bridge the gap between institutes who provide climate-impact data on one side, and water managers and policy makers on the other side. The project will add value to data and ensure that available information is useful for water management at local and regional scale across Europe. WENR lead the stakeholder engagement and training activities in addition to making available hydrological model based water indicators for various CMIP5 scenarios.

Copernicus C3S 52 SECTEUR (Evaluation and Quality Control Function for the Sectoral Information System) translating European User Requirements (2016-2017) also part of C3S, brings together organisations with vast expertise in climate and business, to engage directly with end-users and analyse their requirements, identify gaps and deliver recommendations on future needs to support better decision-making. The Sectors covered are Agriculture & Forestry, Coastal areas, Health, Infrastructure, Insurance and Tourism. WENR was sector lead for the agriculture sector.

EU FP7 IS-ENES2 (2012-2015), InfraStructure for the European Network for Earth System Modelling. EU project in which WENR was one the partners responsible for Assessment of climate data needs in support of the EU Climate Adaptation Strategy; Design of user interface, guidance and documentation of the climate4impacts portal; and Dissemination to stakeholders, consultants in particular.

Significant infrastructure, and/or major items of technical equipment

WENR has access to and availability of relevant data sets and literature information through past projects in the region, knowledge of publicly available data sources and Wageningen UR Library.

19. Charles University (CUNI)

About the partner

Charles University (CUNI) founded in 1348 is one of the oldest universities in Europe and nowadays belongs to the most eminent educational and scientific establishments in the Czech Republic. Management. It is public a university, represented for this project by the Department of Atmospheric Physics at the Faculty of Mathematics and Physics. The department provides training to students in subject field of meteorology and climatology in all degree programmes – bachelor, master and doctorate. In addition to training of experts in the field of atmospheric physics, the department contributes significantly to research focused on the weather, climate system and air quality. One of the main objectives of CUNI in the field of climate is to understand climate variability and climate change as well as its impacts, both of natural and anthropogenic origin, with emphasis to the regional scales using dynamical downscaling of CMIP global data with RegCM and WRF models. In this direction we participate in CORDEX activity, namely EuroCORDEX, we coordinated FP6 project CECILIA on climate change impacts modelling using RCMs for Central Europe, we participated in other FP6 projects ENSEMBLES and QUANTIFY as well as in FP7 project MEGAPOLI with application of RCM downscaling. We were in connection to the IS-ENES phases 1 projects. Within our activities we worked with ESGF both downloading the data for further analysis or downscaling, and preparing our EuroCORDEX results for uploading to the system.

Contribution of partner to the specific project

In IS-ENES3, CUNI is supposed to participate in WP3/NA2 contributing to the networking and outreach of data handling and maintenance at ESGF as well as of practices in CMIP data use, with emphasis on Central Europe region.

Curriculum Vitae of responsible for carrying out the proposed activities

Dr Tomas Halenka, CSc. (male) has been working at CUNI since 1985, from 2006 as Associate Professor of meteorology. He is an expert in regional climate modelling, climate change and impacts analysis, recently with urban effects as well. He coordinated the FP6 project CECILIA, he was leader of WP and a member of Steering Committee in FP6 project QUANTIFY and ATTICA, he was a leader of CUNI in other EC projects like ENSEMBLES, MEGAPOLI, SOLICE, Operational Program UHI, now coordinating big local project under Operational Program for City of Prague. He participated in a few meetings of IS-ENES (EU FP7) phase 1 project. He will be involved in WP3 contributing to the workshops organizing, planning and running.

Dr Michal Belda, (male) is an academic research worker at CUNI, his PhD is in meteorology and climatology. He has been working for several years in RCMs adaptation and scripting for CUNI applications in climate change and impacts studies, as well as in results analysis and assessment. He is an expert of the Department for high performance computing, he has acquired a strong background on parallelised runs, code porting and optimization on a large variety of computers, including supercomputer of the National HPC Centre of the Czech Republic, as well as the expertise in handling and postprocessing big data. He will be involved in WP3 contributing to the workshops organizing, planning and running.

Up to 5 relevant Publications, and/or products or other achievements

1. Vautard, R., Gobiet, A., Jacob, D., Belda, M., Colette, A., Deque, M., Fernandez, J., Garcia-Diez, M., Goergen, K., Guttler, I., Halenka, T., Karacostas, T., Katragkou, E., Keuler, K., Kotlarski, S., Mayer, S., van Meijgaard, E., Nikulin, G., Patarcic, M., Scinocca, J., Sobolowski, S., Suklitsch, M., Teichmann, C., Warrach-Sagi, K., Wulfmeyer, V., Yiou, P. (2013): The simulation of European heat waves from an ensemble of regional climate models within the EURO-CORDEX project. Clim. Dyn., 41, 2555-2575, https://doi.org/10.1007/s00382-013-1714-z.
2. Belda, M., Holtanova, E., Halenka, T., Kalvova, J. (2014): Climate classification revisited: From Köppen to Trewartha. Clim. Res., 59, 1, 1-13, https://doi.org/10.3354/cr01204.
3. Skalak, P., Deque, M., Belda, M., Farda, A., Halenka, T., Csima, G., Bartholy, J., Caian, M., Spiridonov, V. (2014): CECILIA regional climate simulations for the present climate: validation and inter-comparison. Clim. Res., 60, 1, 1-12, https://doi.org/10.3354/cr01207 .
4. Belda, M., Holtanova, E., Halenka, T., Kalvova, J., Hlavka, Z. (2015): Evaluation of CMIP5 present climate simulations using the Koppen-Trewartha climate classification. Clim. Res., 64, 3, 201-212, https://doi.org/10.3354/cr01316
5. Belda, M., Holtanova, E., Kalvova, J., Halenka, T. (2017): Global warming-induced changes in climate zones based on CMIP5 projections. Clim. Res., 71, 1, 17-31. https://doi.org/10.3354/cr01418

Up to 5 relevant Projects, and/or activities, services

EU FP6 ENSEMBLES (2004-2009), regional climate modelling in RT3

EU FP6 CECILIA (2006-2009), Central and Eastern Europe Climate Change Impact and Vulnerability Assessment, based on high resolution RCM simulations.

EuroCORDEX (2011-now), contributing with simulations using RegCM, participating in new FPSs on convection as well as land-use changes.

EU FP7 IS-ENES phase 1 (2009-2013), following, participating in a few meetings

EU H2020 ESiWACE (2015-2019) Centre of Excellence in Simulation of Weather and Climate in Europe, support letter, following

Significant infrastructure, and/or major items of technical equipment

Not applicable.

20. Faculty of Physics of the University of Belgrade (FPUB)

About the partner

The Faculty of Physics (FP) is the national oldest and leading educational and research institution in the field of physical science in Serbia. Faculty of Physics, is a legally independent public institution but under the responsibility of the University of Belgrade (UB) and Ministry of Education, Science and Technological Development of the Republic of Serbia. Faculty is a part of the University, together with other 31 faculties, many institutes, centres and libraries. FP is composed of two institutes, Institute of Physics and Institute of Meteorology. Total number of employees on Faculty of Physics is 134, of which 57 professors and assistants and 25 scientific researchers. Main research objectives of the Institute of Meteorology are in the fields of meteorology and climatology, and majority of research is related to the numerical modelling of the geophysical processes, from numerical weather prediction (NWP) to climate scales. Research in area of numerical modelling started in the beginning of 1970's. In that period Institute of Meteorology together with Federal hydrometeorological institute (of ex Yugoslavia) starts to develop numerical weather prediction model, which become known as *Eta model*, and which in 1990's became operational model for NWP in NOAA/NCEP in the US. Today, research related to climate modelling, within Institute, relies on the development of the coupled regional climate model EBU-POM (combination of Eta model and Princeton Ocean Model), which participates to the Med-CORDEX initiative. Researchers from Institute of meteorology currently participate in two EU H2020 projects, ClimatEurope and Geo-Cradle project (as third party), and in two international initiatives, Med-CORDEX initiative and Pannex - Pannonia basin Regional Hydroclimate Project of the World Climate Research Programme (WCRP) Global Energy and Water Exchanges Project (GEWEX). Institute of Meteorology during last several years participated/contributed to many national relevant climate related projects, but also in preparation of national policy relevant documents such as, national communications to the UNFCC (for several countries in the region) and Adaptation action plan for the City of Belgrade.

Contribution of partner to the specific project

In IS-ENES3, FPUB will be involved in WP3/NA2 contributing in organization of short events and webinars that will be organized to reach new user groups especially within Eastern Europe. Also, FPUB will contribute in special workshop on climate indices requirements for end users in eastern Europe.

Curriculum Vitae of responsible for carrying out the proposed activities

Dr Vladimir Djurdjevic (male) is an employee of the FPUB since 1999. In 2017 he received position of Associate Professor. He is an expert in climate modelling and climate data analysis. He is main contributor to the development of coupled regional climate model EBU-POM. He is involved in international initiative Med-CORDEX and he is member of international planning committee of the Pannex hydroclimate project (with in WCRP/GEWEX). He is co-leader of the largest national project in Serbia related to climate change (Studying climate change and its influence on the environment: impacts, adaptation and mitigation – grant number 43007). He was visiting scientist in NOAA/NCEP (UAS) and CMCC (Italy). He is external associate of the Republic hydrometeorological service of Serbia (RHMSS) and SEEVCCC regional climate change center.

Dr Ivana Tosic (female) is an employee of the FPUB since 1992. She is a full professor in the Faculty of Physics, Institute of Meteorology, at the University of Belgrade. She is a project leader of the fundamental national project in Serbia (Meteorological extremes and climate change in Serbia – grant number 176013). Her research interests are in statistics in climatology, numerical modelling in meteorology and climatology. She has published over 100 peer reviewed articles in scientific journals and conference papers in these fields.

Aleksandra Krzic (female) is a graduate meteorologist. She works in the National Climate Center at RHMSS and she is PhD candidate on FPUB. She has participated in several international projects (ORIENTGATE, DMCSEE, SEERISK, ECRAN), and in operative and research work carried out in the RHMSS.

Up to 5 relevant Publications, and/or products or other achievements

1. Ruti P.M., Somot S., Giorgi F., and 50 other authors including Djurdjevic V. (2015) MED-CORDEX initiative for Mediterranean Climate studies. *Bull. Amer. Meteor. Soc.* doi: https://doi.org/10.1175/BAMS-D-14-00176.1
2. Dell'Aquila A., Mariotti A., Bastin S., Calmanti S., Cavicchia L., Deque M., Djurdjevic V., Dominguez M., Gaertner M., Gualdi S. (2016) Evaluation of simulated decadal variations over the Euro-Mediterranean region from ENSEMBLES to Med-CORDEX, *Clim. Dyn.*, https://doi.org/10.1007/s00382-016-3143-2
3. Petric M., Lalic B., Ducheyne E., Djurdjevic V., Petric D. (2017) Modelling the regional impact of climate change on the suitability of the establishment of the Asian tiger mosquito (Aedes albopictus) in Serbia, *Climatic Change*, https://doi.org/10.1007/s10584-017-1946-8
4. Krzic A., Tosic I., Djurdjevic V., Veljovic K. and Rajkovic B. (2011) Changes in some indices over Serbia according to the SRES A1B and A2 scenarios. *Climate Research*, 49, 73-86. https://doi.org/10.3354/cr01008
5. Djurdjevic, V. and Rajkovic, B. (2008) Verification of a coupled atmosphere-ocean model using satellite observations over the Adriatic Sea. *Ann. Geophys.*, 26(7): 1935-1954, https://doi.org/10.5194/angeo-26-1935-2008

Up to 5 relevant Projects, and/or activities, services

EU H2020 CLIMATEUROPE (2015-2020) (as a linked third party) Climateurope is the Europe-wide network for researchers, suppliers and users of climate information; a place to share best practices, gaps and recommendations and discover the state of the art about climate observations, modelling and services; an opportunity to actively interact with users and suppliers of climate information. Climateurope project main objective is to coordinate and support Europe's knowledge base to enable better management of climate-related risks and opportunities, thereby creating greater social and economic value. Institute of meteorology participate in WP3 (Mapping and analysis of current Earth system modelling and climate service activities) and WP4 (Forward-looking recommendations). (www.climateurope.eu)

EU H2020 GEO-CRADLE (2016-2018) (as a linked third party) GEO-CRADLE brings together key players from Balkans, N. Africa and M. East, region and the complete EO value chain with the overarching objective of establishing coordination network that will (i) support the effective integration of existing EO capacities, (ii) provide the interface for the engagement of the complete ecosystem of EO stakeholders, (iii) promote the concrete uptake of EO services and data, (iv) contribute to the improved implementation of and participation in GEO, GEOSS, and Copernicus in the region. Institute of meteorology participate in WP4 - Pilots towards regional challenges (feasibility studies on adaptation to climate change) (geocradle.eu/en/).

SINTA (SImulations of climate chaNge in the mediTerranean Area**)** (2006-2008). SINTA Project established a scientific cooperation between the scientific institution form Italy (INGV/CMCC) and Serbia (Republic Hydrometeorological Service (RHMSS) and the Faculty of Physics, University of Belgrade (FPBU)). One of the main objectives of this project was to perform a set of regional

simulations with the Regional Climate Model EBU-POM forced by boundary conditions from the GCM (INGV/CMCC) simulations. The Italian Ministry for the Environment, Land and Sea financed this project. (http://www.earth-prints.org/handle/2122/4675)

CCIAM (Studying climate change and its influence on the environment: impacts, adaptation and mitigation in Serbia) (2011-2018). Largest national project in Serbia related to the studying of climate change, which integrates more then 30 research institutions and universities in Serbia. FPBU is responsible for regional climate model runs, climate data analysis, and data dissemination for use in many different sartorial studies. The Republic ministry of education, science and technology od Serbia finances this project.

PANNEX (Pannonian experiment) (2015-ongoing) PannEx is community driven initiative, supported by the experts and institutions from the Pannonian region. PannEx is in its way (currently in initiation phase) to become a Regional Hydroclimate Project (RHP) of the World Climate Research Programme (WCRP) Global Energy and Water Exchanges Project (GEWEX). The almost closed structure of the Pannonian basin makes it a very good natural laboratory for the study of the water and energy cycles, focusing on the physical processes of relevance. Institute of Meteorology contributed to several activates: workshop organization, drafting of the White Book and drafting of the Implementation Science Plan. (sites.google.com/site/projectpannex/)

Significant infrastructure, and/or major items of technical equipment

FPUB is running the coupled regional climate model EBU-POM. This model has contributed to the Med-CORDEX international WCRP downscaling coordinated experiments. FPUB uses several multi-processors workstations, and has remote access to the Republic hydrometeorological Service (of Serbia) HPC infrastructure. FPUB also has remote access to the European Centre for Medium-Range Weather Forecasts (ECMWF) infrastructure as a regular user and participates in one ECMWF's Special Project. FPUB is also running Eta/NCEP numerical weather prediction model, Non-hydrostatic Multi-scale Model on the B grid - NMMB model (developed in NOAA/NCEP), The Advanced Regional Prediction System - ARPS model for storm-scale simulations, and Hydrology surface-runoff prognostic model HYPROM.

21. Uni Research AS (UniRes)

About the partner

Uni Research AS (UniRes) is part of the research group NORCE that also consists of the research institutes Christian Michelsen Research AS, International Research Institute of Stavanger AS, Agderforskning AS and Teknova AS. Uni Research Climate is the climate research division of UniRes. Uni Research Climate has particular strengths in understanding climate dynamics across multiple spatial and temporal scales, dynamical modelling of the climate system and understanding past-future climate variability and change. Uni Research Climate has extensive experience coordinating and leading large national and international projects. Uni Research Climate is also one of four partners in the Bjerknes Centre for Climate Research (BCCR). The BCCR is the largest climate research centre in the Nordic countries with a focus on the natural science aspects of climate change and established expertise in complex research projects (e.g. BCCR Centre of Excellence; EVA, the national Norwegian Earth System Modelling project). Uni Research Climate has a leading role in Norway for the use and further development of the Norwegian Earth System Model (NorESM), with expertise in global climate, atmosphere and ocean modelling, decadal prediction, regional downscaling and climate dynamics. Uni Research Climate played an instrumental role in delivering future earth system model (ESM) experiments to the CMIP5 project with a similar role in the next phase, CMIP6. Uni Research Climate is coordinating the Infrastructure for Norwegian Earth System modelling (INES), starting 2018, that will upgrade NorESM for participation in CMIP7 and provide services related to the use of the model and data sharing.

Contribution of partner to the specific project

In IS-ENES3, UniRes will contribute with level 2 services related to NorESM in WP6/VA1 and improved ESMValTool support for ocean data on original grids in WP9/JRA2.

Curriculum Vitae of responsible for carrying out the proposed activities

Dr Mats Bentsen (male) is a senior research scientist at UniRes since 2010. He has been strongly involved in the development of coupled climate modelling capability in Norway and had an active role in the development of the NorESM. Bentsen is the main developer of the NorESM ocean component that is one of a few CMIP models using isopycnic vertical coordinate. He is leading the crosscutting model development activity at BCCR. Bentsen is a member of the CLIVAR Ocean Model Development Panel and responsible for the Norwegian contribution to the CMIP6 endorsed Ocean Model Intercomparison Project (OMIP). He will coordinate the national research infrastructure project INES. He has extensive experience in the simulation and interpretation of North Atlantic and Arctic climate state, circulation and variability. Bentsen will be involved in services related to NorESM in WP6/VA1 and improved ESMValTool support for ocean data on original grids WP9/JRA2.

Dr Alok Kumar Gupta (male) is a scientific programmer at UniRes since 2013. His expertise includes high performance computing, parallel computing and I/O, numerical analysis and load balancing of coupled models. In addition to in-depth knowledge of NorESM and CESM, he has experience with EC-Earth and MPI-ESM. He was involved in IS-ENES2 providing information about data archiving and modelling workflow related to NorESM and benchmarking high resolution configurations of NorESM targeted for the CMIP6 endorsed HighResMIP. In IS-ENES3, Gupta will be involved in services related to NorESM in WP6/VA1 and improved ESMValTool support for ocean data on original grids WP9/JRA2.

Up to 5 relevant Publications, and/or products or other achievements

1. Bentsen, M., I. Bethke, J. B. Debernard, T. Iversen, A. Kirkevåg, Ø. Seland, H. Drange, C. Roelandt, I. A. Seierstad, C. Hoose, and J. E. Kristjánsson, 2013: The Norwegian Earth System Model, NorESM1- M – Part 1: Description and basic evaluation of the physical climate. Geosci. Model Dev., 6, 687–720, https://doi.org/10.5194/gmd-6-687-2013.
2. Iversen, T., M. Bentsen, I. Bethke, J. B. Debernard, A. Kirkevåg, Ø. Seland, H. Drange, J. E. Kristjánsson, I. Medhaug, M. Sand, and I. A. Seierstad, 2013: The Norwegian Earth System Model, NorESM1-M—Part 2: Climate response and scenario projections. Geosci. Model Dev., 6, 389–415, https://doi.org/10.5194/gmd-6-389-2013 .
3. Tjiputra, J. F., C. Roelandt, M. Bentsen, D. M. Lawrence, T. Lorentzen, J. Schwinger, Ø. Seland, and C. Heinze, 2013: Evaluation of the carbon cycle components in the Norwegian Earth System Model (NorESM). Geosci. Model Dev., 6, 301–325, https://doi.org/10.5194/gmd-6-301-2013 .
4. Ilıcak, M., H. Drange, Q. Wang, R. Gerdes, Y. Aksenov, D. Bailey, M. Bentsen, A. Biastoch, A. Bozec, C. Böning, C. Cassou, E. Chassignet, A. C. Coward, B. Curry, G. Danabasoglu, S. Danilov, E. Fernandez, P. G. Fogli, Y. Fujii, S. M. Griffies, D. Iovino, A. Jahn, T. Jung, W. G. Large, C. Lee, C. Lique, J. Lu, S. Masina, A. J. G. Nurser, C. Roth, D. Salas y Mélia, B. L. Samuels, P. Spence, H. Tsujino, S. Valcke, A. Voldoire, X. Wang, and S. G. Yeager, 2016: An assessment of the Arctic Ocean in a suite of interannual CORE-II simulations. Part III: Hydrography and fluxes. Ocean Model., 100, 141–161, https://doi.org/10.1016/j.ocemod.2016.02.004
5. Counillon, F., N. Keenlyside, I. Bethke, Y. Wang, S. Billeau, M. L. Shen, and M. Bentsen, 2016: Flow-dependent assimilation of sea surface temperature in isopycnal coordinates with the Norwegian Climate Prediction Model. *Tellus*, 68A, 32 437, https://doi.org/10.3402/tellusa.v68.32437

Up to 5 relevant Projects, and/or activities, services

EU FP7 IS-ENES2 (2013-2017), Infrastructure for European Network for Earth System Modelling; UniRes provided information about data archiving and modelling workflow related to NorESM and benchmarking high-resolution configurations of NorESM.

NICEST (2017-2019), Nordic Infrastructure Collaboration on Earth System Tools, a project funded by the Nordic e-Infrastructure Collaboration hosted by NordForsk under the Nordic Council of Ministers. The project will strengthen the Nordic ESM community by supporting their efficient use of various e-infrastructures through competence building, and sharing and exchanging knowledge. The major ESMs involved are EC-Earth and NorESM.

OMDP, CLIVAR Ocean Model Development Panel. Objectives of the panel include stimulating the development and validation of ocean models in the climate modelling community and promoting interaction within the community. OMDP is responsible for the forcing protocol of the CMIP6 endorsed OMIP and the definition of CMIP6 ocean model output. Mats Bentsen, UniRes, is a panel member since 2015.

EU H2020 APPLICATE (2016-2020), Advanced Prediction in Polar regions and beyond: Modelling, observing system design and LInkages associated with ArctiC ClimATE change. UniRes is involved in developing ocean metrics for the Arctic and implementation in ESMValTool; improve the representation of ocean circulation and sea ice conditions in the Arctic Ocean; and assess the impact of future Arctic sea ice depletion in coupled model experiments.

INES (2018-2028), Infrastructure of Norwegian Earth system Modelling, a project funded by the Research Council of Norway. The project will upgrade and maintain a cutting-edge and verified ESM; provide an infrastructure for efficient model simulations, storage, analysis and validation; and for efficient sharing of model data, provide and infrastructure that connects to international data grids and ensure that model data complies with established standards of the climate community. UniRes is coordinating INES.

Significant infrastructure, and/or major items of technical equipment

UniRes has a key involvement in the development and application of NorESM that has contributed to CMIP5 and will contribute to CMIP6. UniRes coordinates the national research infrastructure project INES on NorESM upgrade, maintenance, efficient use and data sharing. UNINETT Sigma2 AS manages the Norwegian infrastructure for providing high performance computation and data storage resources to research and education. UniRes is eligible to apply for computing and storage resources from UNINETT Sigma2 and UNINETT Sigma2, and is also assisting the national NorESM consortium to interface with the Earth System Grid Federation (ESGF) for efficient sharing of earth system model output.

22. Linköpings Universitet (LiU)

About the partner

The National Supercomputer Centre in Sweden (NSC) provides leading edge high performance computing resources, storage solutions and support to users throughout Sweden. NSC is an independent center within Linköping University and is primarily funded by the Swedish Research Council via SNIC (Swedish National Infrastructure for Computing). NSC also has two partner collaborations with SAAB (the aerospace and defense company) and SMHI (the Swedish Meteorological and Hydrological Institute).
NSC's partnership with SMHI dates back to 1996. Activities within this partnership include hardware procurement, cluster operations and usage support, development and operation of storage solutions and development and deployment of data publishing services. Since 1997, NSC has taken primary responsibility on behalf of SMHI for procuring, hosting, and operating the Swedish hpc infrastructure required for NWP operations as well as their research and development. From 2013, this NWP activity

has grown with NSCs inclusion in the MetCoOp project, a joint effort between SMHI and MET Norway to develop a common operational high-resolution NWP system with ensemble predictions.

Contribution of partner to the specific project

In IS-ENES3, LIU will be involved in operating a CMIP5/CMIP6 and CORDEX Tier-1 ESGF Index Node, under the WP7/SA2. LIU is also involved in development activities in ESGF, leading the Installation Working Team (IWT), under WP10/JRA3. LIU is also involved in networking activities and assisting with conducting workshops under the networking activity WP5/NA4.

Curriculum Vitae of responsible for carrying out the proposed activities

Prashanth Dwarakanath is a software engineer who has worked at NSC since January 2013. He has more than 10 years experience in deploying and operating scientific e-infrastructure. He is responsible for ESGF deployment and management of production environments at NSC and is Co-chair of the ESGF Installation and Node Manager Working Teams. Prashanth has received the annual ESGF award for 'outstanding contributions to the success of ESGF' for 2014 and 2015.

Dr Kai Lu has a PhD in Information Technologies in the field of Grid computing. He has more than five years experience in data management and sharing, in particular with experience in managing operational data access services in NSC/LiU for the Earth System Grid Federation (ESGF), publishing CORDEX datasets into ESGF and support to the users of ESGF community. He has also three years experience in supporting the climate and earth system models.

Up to 5 relevant Publications, and/or products or other achievements

1. Acosta Navarro, J. C., V. Varma, I. Riipinen, Ø. Seland, A. Kirkevåg, H. Struthers, T. Iversen, H.-C. Hansson, A. M. L. Ekman: Amplification of Arctic warming by past air pollution reductions in Europe. Nature Geoscience, 9, 277-282. https://doi.org/10.1038/ngeo2673
2. P. Dwarakanath, H. Ramthun, K. Berger, S Pascoe, S. Legutke, C. Blanco: IS-ENES2 Datanode Administrators' Reference Manual, https://github.com/snic-nsc/datanode-mgr-doc/raw/master/ro/Datanodemgr-doc.pdf
3. P. Dwarakanth: Setting up a Virtual Testbed for ESGF, http://esg-dn2.nsc.liu.se/virtualtestbed/checklist.pdf

Up to 5 relevant Projects, and/or activities, services

EU FP7 IS-ENES and IS-ENES2: NSC has been a partner in both the modelling related IS-ENES work packages as well as the data infrastructure activities. NSC has participated in WP10 with the role of performing benchmarking of the fully coupled version of EC-Earth. NSC was also involved in the data infrastructure activities, WP8 and WP11. This includes involvement in the ESGF Installation and ESGF Node Management working groups and acting as release manager for ESGF software.

EU FP7CLIP-C: CLIP-C developed services for access to climate information of direct relevance to a wide variety of users, from scientists to policy makers and private sector decision makers. NSC participates in WP5 (Climate Data Access), specifically Task 5.1 (Climate data for impacts toolkit) and Task 5.4 (Dynamic tape-archive extraction and post-processing).

PRACE: NSC has participated in all phases of the PRACE project, through provision of expertise in code analysis, optimization, and parallelization.

Significant infrastructure, and/or major items of technical equipment

LIU operates the SMHI-NSC-LIU ESGF Tier-1 Index node esg-dn1.nsc.liu.se, and currently hosts over 80TiB of CORDEX, CMIP5, SPECS, and CLIPC project data, and is in the process of capacity enhancement to offer fast storage upto 500 TiB.

Section 4.2 Third parties involved in the project (including use of third party resources)

1. Centre National de la Recherche Scientifique – Institut Pierre Simon Laplace

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	**YES**
CNRS-IPSL wishes to use outsourcing in WP10/JRA3 for matters for which CNRS-IPSL does not have enough skill and man power. Indeed, recruiting people on fixed-term contracts has shown in the past several drawbacks: recruitment difficulties, long initial training period requiring strong supervision, limited time duration of the contract duration reducing attraction. Over the last decade, a number of research projects have been funded at the national or the European level to bring out software ecosystem and cloud technologies related to information technology. Subsequently, a number of these projects were able to aggregate a large community following an Open Source development model. Currently these projects or part of these communities are changing again and give birth to companies specialized in information technology and semantic web. The generalisation of the software ecosystem developed in WP10/JRA3 Task 5 will benefit from existing technology available from public cloud provider solutions. Using cloud provider, we will be able to rapidly prototype new ideas using various NoSQL databases and Graph databases. There is a pool of innovative companies of very different sizes specialized on these issues and able to bring a high added value in a timely manner.	
Does the participant envisage that part of its work is performed by linked third parties	**YES**
Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA) is associated with CNRS within the Joint Research Unit LSCE which is part of IPSL. CEA will be involved in WP5, WP6, WP8 for tasks concerning the I/O server XIOS. CEA will be involved through two engineers Yann Meurdesoif and Arnaud Caubel. No transfer of money will be done from CNRS to CEA but CEA permanent personnel costs will be justified (around 15 PMs for a direct cost of 115 k€). **Université Pierre et Marie Curie** (UPMC) is associated with CNRS within the Joint Research Unit LOCEAN which is part of IPSL. UPMC is involved with CNRS in the IPSL data team and will contribute to WP7/SA2 through Guillaume Levavasseur. No transfer of money will be done from CNRS to UPMC but UPMC permanent personnel costs will be justified (around 15 PMs for a direct cost of 80 k€).	
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	**NO**
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	**NO**

2. The University of Reading - National Centre for Atmospheric Science

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	**YES**
WP2 will subcontract a survey on needs for model evaluation in Task 4. Model evaluation is a major new development for IS-ENES3. This community survey will review the needs and expectations of a variety of end users both existing and future ones (climate model developers, VIA researchers, climate service providers). It will be realised by a sub-contractor. As an example, we could benefit from the experience of the potential sub-contractor ASSIMILA Ltd, who provided highly professional surveys for the JPI-Climate. A sub-contractor will also ensure neutrality on a topic which is sensitive in the different modelling groups.	
Does the participant envisage that part of its work is performed by linked third parties	**NO**
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	**NO**
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	**NO**

3. Deutsches Klimarechenzentrum GmbH

No third parties involved

4. Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique

No third parties involved

5. The Met Office

No third parties involved

6. Barcelona Supercomputing Centre

No third parties involved

7. Koninklijk Nederlands Meteorologisch Instituut

No third parties involved

8. Centro Euro-Mediterraneo sui Cambiamenti Climatici

No third parties involved

9. Science and Technology Facilities Council

No third parties involved

10. Sveriges Meteorologiska och Hydrologiska Institut

No third parties involved

11. Deutsches Zentrum Für Luft- und Raumfahrt in der Helmholtz Gemeinschaft

No third parties involved

12. Stichting Netherlands eScience Center
No third parties involved

13. Universidad de Cantabria
No third parties involved

14. Norwegian Meteorological Institute
No third parties involved

15. Météo France - Centre National de Recherches Météorologiques
No third parties involved

16. University of Manchester
No third parties involved

17. National Centre of Scientific Research "Demokritos"
No third parties involved

18. Stichting Wageningen Research, Wageningen Environmental Research
No third parties involved

19. Charles University
No third parties involved

20. Faculty of Physics of the University of Belgrade
No third parties involved

21. Uni Research AS
No third parties involved

22. Linköpings Universitet
No third parties involved

Section 5: Ethics and Security

5.1 Ethics

Not applicable to IS-ENES3.

5.2 Security

Please indicate if your project will involve:
- activities or results raising security issues: **NO**
- 'EU-classified information' as background or results: **NO**

Appendix: Letters of support to IS-ENES3

Letters of support from international and European programs
WCRP
WCRP-CORDEX International Project Office
WGCM Infrastructure Panel
IPCC Working Group I Technical Support Unit
Copernicus Climate Change Service

Agreement of members of the IS-ENES3 SAB
Dr Ben Evans
Dr Peter Gleckler
Prof Gunilla Svensson
Dr Claas Teichmann
Dr Mariana Vertenstein
Gabriella Zsebeházi

Letters of support for collaboration
Max Planck Institute for Meteorology
PCMDI
Altair company
The Climate Data Factory
TEC Conseil

Letters of support of H2020 projects supporting CMIP6 and CORDEX
PRIMAVERA
CRESCENDO
EUCP

Letters of support from international and European programs
World Climate Research Program

World Climate Research Programme
c/o World Meteorological Organization
7 bis, avenue de la Paix – Case postale N° 2300
CH-1211 Geneva 2 – Switzerland

Tel.: +41 (0)22 730 82 40
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wcrp@wmo.int

Ref.: 07442/2018-1.5 RES-WCRP

Our ref.: 07442/2018-RES-WCRP

Ms Sylvie Joussaume
CNRS-IPSL
LSCE, Orme des Merisiers Bat 712
CE Saclay
91191 Gif sur Yvette Cedex
France

13 March 2018

Subject: Letter of Support to the IS-ENES3 Project

Dear Ms Joussaume,

On behalf of the World Climate Research Programme (WCRP), I express our strong support to the project "Infrastructure for the European Network for Earth System modelling – third phase".

WCRP coordinates the efforts of thousands of climate scientists worldwide engaged in climate research. It facilitates observation and process experiments, the development and use of state-of-the-art climate models and data analyses to describe and understand the past, current and future states of the Earth's climate in response to various forcing factors, including human activities. It also contributes to disseminating climate science knowledge to policy and decision-makers involved in adaptation and mitigation of climate change impacts. Today, there is an unprecedented demand in many socio-economic sectors for relevant and authoritative climate information. WCRP has taken the lead in supporting and coordinating the global climate research community to develop the scientific basis to meet this demand in the context of improving society's resilience to climate variability and change. As such, data infrastructures play an absolute vital role in the success of the WCRP.

The proposed IS-ENES3 project contributes to the development and sharing of model outputs, super-computing software tools and model documentation necessary for the Coupled Models Intercomparison Project (CMIP6) and the Coordinated Regional Downscaling Experiment (CORDEX), which are both expected to contribute very significantly to the Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC). IS-ENES3 represents a major contribution to the Earth System Grid Federation effort (ESGF), the central data infrastructure for the WCRP enterprise.

WCRP is pleased to note that many of the participating groups in this proposed project are actively involved in WCRP research and have contributed significantly to promote it. The WCRP is pleased to support this proposai as it will clearly further integrate the European climate modelling community, and network this project with the rest of organizations and scientists participating in WCRP related activities from around world.

Yours sincerely,

(D. Terblanche)
Acting Director, WCRP

WCRP-CORDEX International Project Office

Sylvie Joussaume

Directeur de Recherche au CNRS
IPSL/ Laboratoire des Sciences du Climat et de l'Environnement
Orme des Merisiers, Bat 712, CE Saclay
91191 Gif sur Yvette Cedex, FRANCE
Tel: 33 1 69 08 56 74 - Email: sylvie.joussaume@lsce.ipsl.fr
Coordinator IS-ENES

The Coordinated Regional Climate Downscaling Experiment (CORDEX) is a global collaborative initiative aiming to develop and provide high-resolution, regional climate simulations necessary for vulnerability, impact and adaptation studies at local and regional levels. CORDEX is working to meet the increasing need for reliable regional climate information communicated in a manner enabling effective impact and adaptation planning. This global framework has led to common protocols for the development and inter-comparison of high-resolution projections and for how to archive and make accessible the results.

Whereas CORDEX has contributed vastly to the development and production of high-resolution regional climate data and information there are still both knowledge gaps and coverage gaps, which is why further development of models, infrastructure, tools and knowledge exchange are needed. In this respect CORDEX recognizes the value that IS-ENES1 and IS-ENES2 have provided to developing and establishing the CORDEX data infrastructure, which is vital for archiving and disseminating CORDEX output through the ESGF. CORDEX strongly supports IS-ENES3 and the efforts of IS-ENES to further support the CORDEX data infrastructure.

Yours sincerely,

Iréne Lake Iréne

Director of the International Project Office for CORDEX

SMHI / Swedish Meteorological and Hydrological Institute

SE - 601 76 NORRKÖPING

Sweden

www.smhi.se, www.cordex.org

E-post / Email: irene.lake@smhi.se, ipoc@cordex.org

Tel / Phone: +46 (0)11 495 83 19

Besöksadress / Street address: Folkborgsvägen 17

WIP: Working Group on Coupled Models Infrastructure Panel

Princeton University

CICS Cooperative Institute for Climate Science

Princeton University
NOAA/GFDL
201 Forrestal Road
Princeton NJ 08540
USA

21 March 2018

To: Sylvie JOUSSAUME
CNRS-IPSL
LSCE, Orme des Merisiers Bat 712
CE Saclay
91191 Gif sur Yvette Cedex
France

Dear Dr. Joussaume,

On behalf of the Working Group on Coupled Modeling (WGCM) Infrastructure Panel (WIP), the co-chairs Karl Taylor of Lawrence Livermore National Laboratories and myself, are writing to express our enthusiastic support for the project "Infrastructure for the European Network for Earth System modelling third phase (IS-ENES3)".

I am V. Balaji, Head of Modeling System Group, Atmospheric and Oceanic Sciences at US National Oceanic and Atmospheric Administration (NOAA)/Geophysical Fluid Dynamics Laboratory (GFDL) and Princeton University, and along with Karl Taylor, co-chair of the WIP. Its parent organization WGCM oversees climate science and modeling activities under the World Climate Research Programme (WCRP).

The WIP has been instrumental in coordinating the development of a global data infrastructure for the support of WGCM's coordinated international scientific campaigns such as the Coupled Model Intercomparison Project (CMIP). The WIP provides design oversight for the international cyberinfrastructure in support of CMIP and related campaigns. Members of the IS-ENES community are essential partners in this activity. IS-ENES members underpin climate model development at IS-ENES partner institutions, and share the goal of coordinated climate simulation experiments. IS-ENES supports international standards for data and metadata and provides the European contribution to the WCRP international database, the Earth System Grid Federation (ESGF). We note that IS-ENES has supported the participation of several active members of the WIP.

We are writing to express formal support for a continuation of IS-ENES, and look forward to continued collaboration with IS-ENES in its third phase.

Please do not hesitate to get in touch if you, or the European Commission, have any questions.

Yours sincerely,

V. Balaji
Head, Modeling Systems Group
Cooperative Institute for Climate Science
Princeton University and NOAA/GFDL
Tel: +1-609-452-6516

Intergovernmental Panel on Climate Change
Technical Support Unit of Working Group I

ipcc
INTERGOVERNMENTAL PANEL ON climate change

Working Group I (WG I) – The Physical Science Basis

To the attention of **Sylvie JOUSSAUME**
CNRS-IPSL
LSCE, Orme des Merisiers Bat 712
CE Saclay
91191 Gif sur Yvette Cedex
France

Tuesday, 20th March 2018

Subject: Letter of Support to the IS-ENES3 project

Dear Sylvie Joussaume,

I am writing as Head of the Technical Support Unit of the IPCC Working Group I (WGI) to express strong support of the *Infrastructure for the European Network for Earth System modelling – third phase (IS-ENES3)*".

The Intergovernmental Panel on Climate Change (IPCC) is the international body for assessing the science related to climate change and its potential environmental and socio-economic impacts. The Working Group I (WGI) contribution to the Sixth Assessment Report (AR6) is on understanding the physical basis of climate change and includes the assessment of climate modelling, model evaluation, predictions, scenarios and projections, and detection and attribution on global and regional scales. The comprehensive assessment of CMIP6 model outputs will be an integral part of the WGI contribution to the AR6.

The IS-ENES3 project is expected to support the core infrastructure needed to distribute the CMIP6 model results from European Earth system models for climate research as well as for climate impact studies, including in collaboration with the IPCC Data Distribution Centre and through relevant training activities. Moreover, it will support further development of European climate models and common model evaluation which are important to understand and represent climate processes and feedbacks. To this end, I fully support the IS-ENES3 project as a critical and urgently needed contribution from the international climate science community, from which the IPCC, WGI in particular, will need to draw from in its assessment of the state of knowledge on climate change information.

I very much look forward to hearing positive outcomes from this research project.

Yours sincerely

(Anna Pirani)
Head, TSU of the IPCC Working Group I

WGI Technical Support Unit · c/o Université Paris-Saclay
Immeuble Discovery · Route de l'Orme des Merisiers · 91190 Saint-Aubin · France · +33 (0)1 69 33 77 23
tsu@ipcc-wg1.universite-paris-saclay.fr · **www.wg1.ipcc.ch**

WMO UNEP

Copernicus Climate Change Service

Date 14/03/2018

Sylvie JOUSSAUME
CNRS-IPSL
LSCE, Orme des Merisiers Bat 712
CE Saclay
91191 Gif sur Yvette Cedex
France

Subject: Letter of Support to the IS-ENES3 project

Dear Sylvie Joussaume,

with this letter, I, Jean-Noël Thépaut, Head of the Copernicus Climate Change Service at ECMWF, express my support to the project "Infrastructure for the European Network for Earth System modelling – third phase".
As coordinator of the Copernicus Climate Change Service (C3S), mandated by the European Commission to provide a wide range of users (policy makers, practioners, scientists, ..) with access to sustained and authoritative global and regional climate projection information, ECMWF (European Centre for Medium-range Weather Forecasts) is interested in benefiting from the IS-ENES3 project.
C3S is operational by nature, and aims at improving reliability in the access to climate projection data through the Climate Data Store, the architectural backbone of C3S. To achieve this, C3S is supporting a sustainable infrastructure to broker CMIP and CORDEX simulations on the Earth System Grid Federation (ESGF).
These sustainability needs will grow in the future, in particular in view of updating C3S future climate projections information with state-of-the-art science coming from the CMIP6 initiative, which IS-ENES3 ambitions to champion.

For the reasons mentioned above, I wish every success to the IS-ENES3 project.

Yours sincerely,

Dr. Jean-Noël Thépaut
Head, Copernicus Climate Change Service
Deputy Director, Copernicus Services
E-mail: jean-noel.thepaut@ecmwf.int

ECMWF Shinfield Park, Reading RG2 9AX, UK
Tel: +44 (0) 118 949 9000 | Fax: +44 (0) 118 986 9450 |Email: first.initial.surname@ecmwf.int
climate.copernicus.eu | copernicus.eu | ecmwf.int

Agreement of members of the IS-ENES3 SAB

Dr Ben Evans

Australian National University

15 March, 2018

Dr Ben Evans
Associate Director (Research Engagement and Initiatives)
National Computational Infrastructure

Canberra ACT 2602 Australia
www.nci.org.au

CRICOS Provider No. 00120C

Attention: **Sylvie JOUSSAUME**
CNRS-IPSL
LSCE, Orme des Merisiers Bat 712
CE Saclay
91191 Gif sur Yvette Cedex
France

Subject: Participation in the Scientific Advisory Board of the IS-ENES3 project

Dear Sylvie,

I would like to express my agreement to participate in the Scientific Advisory Board of the project "*Infrastructure for the European Network for Earth System modelling – third phase*".

I am the Associate Director, Research Engagements and Initiatives, at NCI Australia, hosted at the Australian National University. NCI is the leading Australian computational and data infrastructure hosting and developing high performance computing, data management and data analysis, which underpins merit based research and other priority driven programs. NCI is underpinned by its partners: the Australian National University and three major national science agencies; the Bureau of Meteorology, CSIRO, and Geoscience Australia, as well as funding support from the Australian Government through the National Research Infrastructure Strategy, NCRIS. NCI provides particular support for Climate and Weather research, Earth systems, Earth observation, water management and geophysics.

NCI activities are closely aligned with the IS-ENES3 program. In particular, the Australian Community Climate and Earth Systems Simulator (ACCESS) is developed and run at NCI; one of a large suite of collaborative climate and weather model and analysis activities. In particular, these generate the datasets that are used for the Coupled Model Intercomparison Project (CMIP). Like other participants in the IS-ENES3 program, notably IPSL and CEDA, NCI is a major node of the Earth Systems Grid Federation (ESGF), an international collaboration that supports both the CMIP data dissemination and subsequent data analysis. NCI manages major infrastructure, including: a top100 supercomputer, and by 2019 will be within the top 30 supercomputers; 10's of petabytes of high performance reference datasets on high speed filesystems; and a tightly integrated compute cloud used for securely managing data services and selected virtual research environments.

Yours Sincerely,

Dr Peter Gleckler

Lawrence Livermore National Laboratory

PCMDI
Program for Climate Model Diagnosis and Intercomparison

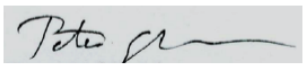
To the attention of **Sylvie JOUSSAUME**
CNRS-IPSL
LSCE, Orme des Merisiers Bat 712
CE Saclay
91191 Gif sur Yvette Cedex
France

05 March, 2018

Subject: Participation to the Scientific Advisory Board of the IS-ENES3 project

Dear Sylvie Joussaume,

I express my agreement to participate to the Scientific Advisory Board of the project "*Infrastructure for the European Network for Earth System modelling – third phase*". Our mutual interest to make systematic model evaluation a more routine part of the Coupled Model Intercomparison Project (CMIP) compels us to collectively advance methods, standards and tools necessary to meet this goal. In addition to model evaluation, it is imperative that we continue working together to further advance the connectedness between ESGF, ESDOCs and obs4MIPs. IS-ENES3 will be critical to ensure the success of these important activities.



Peter J. GLECKLER, PCMDI staff scientist
05 March, 2018

Prof Gunila Svensson

STOCKHOLM UNIVERSITY
Department of Meteorology
Gunilla Svensson, Professor

To the attention of **Sylvie JOUSSAUME**
CNRS-IPSL
LSCE, Orme des Merisiers Bat 712
CE Saclay
91191 Gif sur Yvette Cedex
France

March 16, 2018

Subject: Participation to the Scientific Advisory Board of the IS-ENES3 project

Dear Sylvie Joussaume,

I express my agreement to participate in the Scientific Advisory Board of the project "*Infrastructure for the European Network for Earth System modelling – third phase*".
I am Professor of Meteorology with expertise in numerical modeling from process scale to global scale with specific interests in atmospheric turbulence and clouds. My group have been involved in various parts of the Coupled Model Intercomparison project in development of models, executing the simulations, evaluating the performance as well as analyzing the results. I have taken a leading role in the development of the climate modeling research of two Swedish Strategic Research Centres, the Bolin Centre (bolin.su.se) and the Swedish e-Science Research Centre (SeRC, e-science.se) and am currently leading the Nordic ESM network.

Through my research and coordinating roles, I have interests that aligns well with many of the points in the proposed project and also acknowledge the importance of the work done in the first two phases of IS-ENES. In particular, I am interested in the planned work on sustainability infrastructure for ESM and the encouraging role for tool sharing. Of particular interest for my research group is the plans on developing a common European sea-ice model since we are involved in several research projects concerning the Arctic Climate change.

Gunilla Svensson
Professor

Department of Meteorology
Stockholm University
S-106 91 Stockholm
SWEDEN
http://www.misu.su.se

Phone + 46 - 8 - 16 43 37
Fax + 46 - 8 - 15 71 85

E-mail address gunilla@misu.su.se

Dr Claas Teichmann

GERICS | Fischertwiete 1 | 20095 Hamburg

To the attention of **Sylvie JOUSSAUME**
CNRS-IPSL
LSCE, Orme des Merisiers Bat 712
CE Saclay
91191 Gif sur Yvette Cedex
France

Dr. Claas Teichmann
GERICS
Chilehaus, Eingang B
Fischertwiete 1, 20095 Hamburg
Tel.: +49 (0) 40 - 226 338-441
Fax +49 (0) 40 - 226 338-163
claas.teichmann@hzg.de
www.gerics.de

Hamburg, 15.03.2018

Subject: Participation to the Scientific Advisory Board of the IS-ENES3 project

Dear Sylvie Joussaume,

I express my agreement to participate to the Scientific Advisory Board of the project "Infrastructure for the European Network for Earth System modeling – third phase".

I am working at the Climate Service Center Germany (GERICS) which bridges the gap between climate research and application. In my research, climate information from global via regional to local scales is created and analyzed focusing on the aspect of its application in practice. Being one of the co-chairs of the CMIP6 endorsed Vulnerability, Impact, Adaptation and Climate Services Advisory Board (VIACS AB) and being one of the organizers of the WCRP CORDEX endorsed EURO-CORDEX effort, I am working closely with the climate service and the regional modeling researchers communities.

Excellent climate models, tools, data and analysis is essential for considering climate information in practical applications. IS-ENES3 is providing the methods, tools and science as well as the frame for international cooperation to assure that the basis for future research and applications of climate information in the Vulnerability, Impact, Adaptation and Climate Services communities are available. Therefore I fully support IS-ENES3 and am looking forward to contribute in the Scientific Advisory Board.

Best regards,

Dr. Claas Teichmann

Dr Mariana Vertenstein

National Center for Atmospheric Research
CGD | Climate & Global Dynamics Laboratory
P.O. Box 3000, Boulder, CO 80307-3000

To the attention of **Sylvie JOUSSAUME**
CNRS-IPSL
LSCE, Orme des Merisiers Bat 712
CE Saclay
91191 Gif sur Yvette Cedex
France

March 15, 2018

Subject: Participation to the Scientific Advisory Board of the IS-ENES3 project

Dear Sylvie Joussaume,

I express my agreement to participate to the Scientific Advisory Board of the project "*Infrastructure for the European Network for Earth System modelling – third phase*".

I am a senior software engineer at the National Center for Atmospheric Research and have been the head of the CESM Software Engineering Group (CSEG) for the last eleven years. I have been technically involved in all aspects of the CESM software engineering process during that time, from being a key contributor to the implementation of the current coupling infrastructure of CESM (cpl7), refactoring the Community Land Model (CLM) to be more modular and extensible and creating the first prototype of the Common Infrastructure of Modeling the Earth (CIME). I am also a member of NOAA Unified Forecast System Steering Committee, the ESMF Change Review Board, the CESM Scientific Steering Committee and a co-chair of the CESM Software Engineering Working Group.

The key objectives of IS-ENES3 are important to address as climate modeling faces new challenges due to increasing model complexity, higher resolution and new disruptive machine architectures. My background will enable me to positively contribute to this effort as a member of the Scientific Advisory Board.

Name, title: Dr. Mariana Vertenstein

Date: March 15, 2018

Signature: Mariana Vertenstein

Gabriella Zsebeházi

Hungarian Meteorological Service

Person of contact: *Gabriella Zsebeházi*
Phone: *+36 1 346 4851*
Fax: *+36 1 346 4669*
E-mail: *zsebehazi.g@met.hu*

To the attention of Sylvie JOUSSAUME

CNRS-IPSL
LSCE, Orme des Merisiers Bat 712
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91191 Gif sur Yvette Cedex
France

Subject: Participation to the Scientific Advisory Board of the IS-ENES3 project

Dear Sylvie Joussaume,

I express my agreement to participate to the Scientific Advisory Board of the project "Infrastructure for the European Network for Earth System modelling – third phase".

Since August 2017 I am responsible for the activities of the Regional Climate Modelling Group of the Hungary Meteorological Service (OMSZ). Our group conducts future climate projections mainly for the Charpatian Basin using two regional climate models, i.e. ALADIN-Climate and REMO adapted at OMSZ. These simulation results were implemented in several impact studies, and also in the National Adaptation ang Geo-Information System, to support adaptation planning and decision making on country level. My personal research focus is urban climate modelling and investigation of climate change in cities.

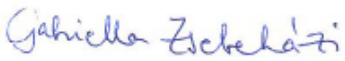
I am especially interested in participating to the Scientific Advisory Board of the IS-ENES3 project for many reason. Our group intensively uses ESGF to access climate model simulations of CMIP5 and Euro-CORDEX initiatives. On the one hand we deeply analyse the different sources of uncertainties in these model sets, on the other we use Euro-CORDEX simulations for investigating future climate change in Hungary. Moreover, one of the goals of IS-ENES3 is establishing user consultation, which is a prior interest of us as well. Therefore, through a wider aspect we could get a better understanding of user needs and may translate the requirements of Hungarian impact researchers to the Scientific Advisory Board as well.

OMSZ – HUNGARIAN METEOROLOGICAL SERVICE
H-1525 Budapest P.O.Box 38.

Finally, I would express my sincere gratitude for inviting me to the Scientific Advisory Board of the IS-ENES-3 project.

Budapest, 14 March 2018

Yours sincerely



Gabriella Zsebeházi

Letters of support for collaboration
Max Planck Institute for Meteorology

Max-Planck-Institut für Meteorologie

MAX-PLANCK-GESELLSCHAFT

Max-Planck-Institut für Meteorologie | Bundesstr. 53 | 20146 Hamburg

Sylvie JOUSSAUME
CNRS-IPSL
LSCE, Orme des Merisiers Bat 712
CE Saclay
91191 Gif sur Yvette Cedex
France

Reinhard G. Budich
Strategische IT Partnerschaften, SCLab
Max-Planck-Institut für Meteorologie
Bundesstr. 53
20146 Hamburg
Deutschland
Tel.: +49 - (0)40 - 41173 - 369
Fax: +49 - (0)40 - 41173 - 298
reinhard.budich@mpimet.mpg.de
www.mpimet.mpg.de/~reinhard-budich

Hamburg, 15. March 2018

Dear Sylvie Joussaume,

The MPI for Meteorology confirms its willingness to collaborate with IS-ENES3 on the matter of the Climate Data Operators.

The Max Planck Society (MPG) is Germany's most successful research organization. It was established in 1948. The 83 Max Planck Institutes and facilities (as of 2017) conduct basic research in the service of the general public in the natural sciences, life sciences, social sciences, and the humanities. Continuous renewal in the institutional structure preserves the scope the Max Planck Society needs to react quickly to pioneering scientific developments. The MPG contributes to the project with the institute for meteorology.

Max Planck Institute for Meteorology (MPI-M, http://www.mpimet.mpg.de) is dedicated to fundamental climate research. The overall mission of MPI-M is to understand how chemical, physical, and biological processes, as well as human behavior contribute to the dynamics of the Earth system, and specifically how they relate to global climate changes. The institute comprises three departments: The Atmosphere in the Earth System; The Land in the Earth System and The Ocean in the Earth System and hosts independent research groups focused on Fire in the Earth System, Forest Management in the Earth System, Sea Ice in the Earth System, Stratosphere and Climate as well as Turbulent Mixing Processes in the Earth System.

Concerning IS-ENES3, MPI-M agrees to collaborate with IS-ENES3 partners on providing the "Climate Data Operator" (cdo) toolset in the way MPI-M also has recently, after the end of (ISENES) EC funding: Maintain the cdo website, provide regular updates, support the community, together with DKRZ, concerning bug fixes, maintenance, and development as MPI-M sees fit, and results from other EC project funding are available, as well as maintaining the user forum. MPI-M will consider input from ISENES3 with special attention and seek interaction on it as MPI-M sees fit.

Reinhard G. Budich

Digital unterschrieben von Reinhard Budich
DN: cn=Reinhard Budich, o=MPI-M, ou=SIP, SCLab, email=reinhard.budich@mpimet.mpg.de, c=DE
Datum: 2018.03.15 08:44:34 +01'00'

2018-03-15

Strategische IT Partnerschaften

PCMDI

Lawrence Livermore National Laboratory

Physical and Life Sciences

March 12, 2018

Dr. Sylvie Joussaume

Directeur de Recherche au CNRS

IPSL/ Laboratoire des Sciences du Climat et de l'Environnement

Subject: Collaboration with the IS-ENES3 project

Dear Dr. Joussaume;

As Interim Project Leader for the Program for Climate Model Diagnosis and Intercomparison (PCMDI), and Climate Program Leader at Lawrence Livermore National Laboratory, I would like to confirm our intention to continue our collaboration started in IS-ENES2 into IS-ENES3.

PCMDI was established in 1989 at the US Department of Energy's Lawrence Livermore National Laboratory (LLNL), located near San Francisco. LLNL's climate program has a multi-disciplinary staff that includes expertise in climate observations; Earth system model development, analysis, diagnostics and metrics; data science, software engineering and computational science. The PCMDI project is primarily funded by the Regional and Global Climate Modeling (RGCM) of the U.S. Department of Energy's Office of Science, Biological and Environmental Research (BER) program.

The PCMDI mission is to engage in cutting-edge climate research and to provide support for community climate modelling activities that advance climate science. As one focus, we develop improved methods and tools for the diagnosis and intercomparison of global climate models. Our ongoing responsibilities associated with the Coupled Model Intercomparison Project (CMIP, now in its sixth phase) include leadership in both experiment planning and design and the development of software infrastructure for operationally serving output from CMIP models. We are charged by the World Climate Research Programme's Working Group on Coupled Modelling to manage many of the practical aspects of the CMIP6 project. For this purpose, we rely on contributions from our internationally federated partners, including those involved in IS-ENES.

From the beginning of IS-ENES we have participated as unfunded collaborators. This has been beneficial in that we share common goals, including implementing software infrastructure for climate modelling and evaluating climate models. This collaboration has helped us avoid duplication of effort and has served to establish a cooperative vision of future development plans. It has ensured that software developed by IS-ENES is compatible with and contributes to the requirements of CMIP. We have been very pleased with our established collaboration, which has included participation in meetings and extended visits to PCMDI by IS-ENES software scientists.

We affirm our strong interest and willingness to collaborate with IS-ENES3 partners on the continued provision of federated archive services for international climate model inter-comparisons, the collection and specification

of user requirements (encompassing both analysts using the archive to access data and modelers using the archive to distribute data), and the development of software to further enhance the archive services. As in the past, our participation could include participation in IS-ENES3 project. In this and other ways, we would hope to build on the advances already made in the earlier phase of IS-ENES.

Sincerely,

David C. Bader, Ph.D.
Climate Program Leader
Physical and Life Sciences Directorate
Lawrence Livermore National Laboratory

Mail Stop L-103
Ph. 925-422-4843
Bader2@llnl.gov

Cc: Peter Gleckler, LLNL
Karl Taylor, LLNL
Dean Williams, LLNL

Altair Engineering

Imperial House, Holly Walk,
Leamington Spa, CV32 4JG

P 01926 468600
F 01926 468601

altairengineering.co.uk

To the attention of **Sylvie JOUSSAUME**
CNRS-IPSL
LSCE, Orme des Merisiers Bat 712
CE Saclay
91191 Gif sur Yvette Cedex
France

09/03/2018

Subject: Collaboration with the IS-ENES3 project

Dear Sylvie Joussaume,

We at Altair are very keen to have the opportunity to be involved in the innovation task in WP4/NA3 of the IS-ENES3 proposal. This is of direct relevance to Altair as we are developing an integrated solution for both workload and workflow management and we see this as a great opportunity to understand the needs of the climate community and to interact and influence with the Cylc development effort within WP8/JRA1 of IS-ENES3.

Altair strongly believes that this more holistic approach across workflow and workload has the potential to bring great benefits to users of HPC and cloud computing systems as workflows become more complex and need to be operationalised to meet the modelling needs for climate services. We are already aware of interest from other communities than weather and science where workflow is challenging. Hence, Altair sees a good alignment between these IS-ENES3 activities and our own development investment in this area.

Many thanks for the invitation to innovate with you in IS-ENES3,

Ian.

Name, title: I.E. LITTLEWOOD

Date: 09/03/2018

Signature: .....

Registered in England: 3051069 Registered Office: As Above VAT Registered: 660 8695 03

The Climate Data Factory

the climate data factory
12 rue de Belzunce
75010 Paris
France

To the attention of Sylvie Joussaume
CNRS-IPSL
LSCE, Orme des Merisiers Bat 712
CE Saclay
91191 Gif sur Yvette Cedex
France

19/03/2018

Subject: Collaboration with the IS-ENES3 project

Dear Sylvie Joussaume,

Our organization gladly confirms its willingness to collaborate with IS-ENES3.

the climate data factory is an online provider of ready-to-use IPCC climate projections data and graphics. We tackle the challenge of getting quick and easy access to actionable information for impact researchers and adaptation practitioners.

We currently offer two types of products on theclimatedatafactory.com for those two types of users: country level data, available at a daily resolution for various climate variables, and city level graphics available for climate variables and indicators. Data from both products are bias adjusted and remapped on a reference grid.

Within IS-ENES3, we agree to collaborate with IS-ENES3 partners on:

The common development and evaluation of European Earth's climate System Models.
In particular by:

- Encouraging common development of model evaluation tools and expanding their use for a wider modeling community.

Enhancing access to model data and widen their application for climate change impacts.
In particular by:

- Maintaining and developing access to know-how: methodologies, data and metadata standards, and tools;
- Maintaining and developing access to data for the climate impact community as well as climate services and consultancies.

H. Loukos

Harilaos Loukos
CEO

TEC Conseil

To the attention of **Sylvie JOUSSAUME**
CNRS-IPSL
LSCE, Orme des Merisiers Bat 712
CE Saclay
91191 Gif sur Yvette Cedex
France

March 19th, 2018

Subject: Collaboration with the IS-ENES3 project

Dear Sylvie Joussaume,

Our organization confirms its willingness to collaborate with IS-ENES3.

TEC developed competences in climate service, delivering long-term climate projections for Climate Change adaptation (www.pro-clim.org). TEC has been involved in several projects on climate services (EU FP7 EUPORIAS, CLIMRUN, CLIPC) and is currently involved in H2020 projects, as co-coordinator of both PROSNOW and SOCLIMPACT projects.

Within IS-ENES3, we agree to collaborate with IS-ENES3 partners, especially on the accessibility to climate services, the visualization of data, the management of uncertainty, and the development of relevant business models, for various sectors.

Name, title: Ghislain DUBOIS, TEC CEO and Founder

Date: 19/03/2018

Signature:

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TEC
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Letters of support of H2020 projects supporting CMIP6 and CORDEX

PRIMAVERA

For the attention of **Sylvie JOUSSAUME**
CNRS-IPSL
LSCE, Orme des Merisiers Bat 712
CE Saclay
91191 Gif sur Yvette Cedex
France

14 March 2018

Subject: Letter of Support to the IS-ENES3 project

Dear Sylvie Joussaume,

On behalf of The PRIMAVERA H2020 research project, we express our support for the "*Infrastructure for the European Network for Earth System modelling – third phase*" project.

PRIMAVERA is a Horizon 2020 project of 19 European partners, led by the Met Office and Reading University in the UK. Its aim is to develop a new generation of advanced and well-evaluated high-resolution global climate models, capable of simulating and predicting regional climate with unprecedented fidelity, for the benefit of society. The results will help answer questions such as: to what extent are recent heat waves, floods and droughts in Europe attributable to natural variability or human influences on the global climate system; and, how will the risk of such high impact climate and weather events change over the next few decades?

The work proposed by ISENES-3 on integrating modelling and data infrastructures for climate research, improving common tools used for coupling model components, developing access to CMIP6 model data infrastructure, and supporting common development of model components would greatly help the PRIMAVERA project (which ends in 2020) to achieve, or exceed its agreed goals. Further it would be good if IS-ENES-3 considered looking at ways of coding standardised diagnostics into climate models to make them more efficient regarding data outputs for diagnostics.

Dr. Malcom Roberts, Manager of High resolution global climate modelling; Met Office, UK.
Coordinator PRIMAVERA

Prof. Pier Luigi Vidale, Professor of Climate System Science; University of Reading, UK.
Coordinator PRIMAVERA

Mr. Paul van der Linden, Science Manager, Met Office, UK.
PRIMAVERA Project Manager

CRESCENDO

National Centre for Atmospheric Science
NATURAL ENVIRONMENT RESEARCH COUNCIL

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Attn: Sylvie JOUSSAUME
CNRS-IPSL
LSCE, Orme des Merisiers Bat 712
CE Saclay, 91191 Gif sur Yvette Cedex
France

20th March 2018

Subject: Letter of Support to the IS-ENES3 project

Dear Sylvie

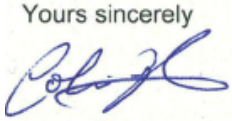
On behalf of the Horizon2020 project CRESCENDO and the UK Earth system modelling project, I wish to express my strong support for the project "*Infrastructure for the European Network for Earth System modelling – third phase*".

CRESCENDO brings together seven leading European Earth system models (ESMs) to make a coordinated contribution to the 6th Coupled Model Intercomparison Project (CMIP6). CRESCENDO emphasizes improving coupled climate-carbon cycle processes in ESMs. We will further apply these improved ESMs to produce a new set of Earth system projections for the 21st century within CMIP6.

Much of the scientific work in CRESCENDO and the UKESM project builds on the highly successful outcomes of is-ENES1 and is-ENES2, where a number of key technical and scientific developments were realized. These include: (i) Improving model performance on European HPC systems. (ii) Increasing the scalability of ESMs. (iii) Developing standardized formats and metadata used in CMIP6 and CORDEX. (iv) Developing and maintaining the European infrastructure and expertise behind the Earth System Grid Federation (ESGF), as well as a number of other key developments. Without the enormous efforts of is-ENES1 and is-ENES2, European Earth system modelling would be far less developed than it is today.

Our collective need for such critical underpinning work has not diminished. On the contrary, it may actually have increased, given the high demand for detailed climate information at a range of future timescales. I therefore view is-ENES3 as of fundamental importance to the science of Earth system modelling, both in Europe and internationally. Many of the necessary developments in both modelling and data management and access would simply not occur without is-ENES to champion these activities and coordinate the necessary expertise. I therefore wholeheartedly support the proposed is-ENES3 project and look forward to working actively with it in the future.

Yours sincerely



Colin Jones
Head of UK Earth System Modeling
Coordinator CRESCENDO Horizon2020 project
Professor, University of Leeds and UK Met Office Hadley Centre
FitzRoy Road, Exeter EX1 3PB, UK
email: colin.jones@metoffice.gov.uk

To the attention of **Sylvie JOUSSAUME**
CNRS-IPSL
LSCE, Orme des Merisiers Bat 712
CE Saclay
91191 Gif sur Yvette Cedex
France

16 March 2018

Subject: Letter of Support to the IS-ENES3 project

Dear Sylvie Joussaume,

On behalf of the Horizon 2020 EUCP project, I express our support to the project "*Infrastructure for the European Network for Earth System modelling – third phase*".

The EUropean Climate Prediction system (EUCP) project aims to develop a European regional ensemble climate prediction system based on a new generation of improved and typically higher-resolution climate models, covering timescales from seasons to decades initialised with observations, designed to support practical and strategic climate adaptation and mitigation decision-taking on local, national and global scales. The objectives and goals of IS-ENES3 are therefore well aligned to the aims of EUCP

Dr Chris Hewitt, EUCP Coordinator

16 March 2018

C Hewitt

IS-ENES3 VA1 tables

Estimation of the Access Costs for Virtual Access

Participant number	5	Organisation short name		METO	
Short name of Infrastructure	ENES ESM	Installation number	1	Short name of Installation	HadGEM/UKESM

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs	Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
	Total A	**0,00**
	of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time	Category of staff[1]	Person-Months	Personnel Costs (€)
	Senior scientist, manager of HadGEM collaborations (MetOffice)	6	31 182,00
	Reporting of user support actions realized by the collaborative team		
	Total B		**31 182,00**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	7 795,50
D. Estimated eligible access costs = A+B+C		38 977,50

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	10	Organisation short name		SMHI	
Short name of Infrastructure	ENES ESM	Installation number	2	Short name of Installation	EC-Earth

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs

Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
Total A	**0,00**
of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time

Category of staff[1]	Person-Months	Personnel Costs (€)
Software engineer and EC-Earth development & support coordinator (SMHI)	6	40 800,00
Reporting of user support actions realized by the EC-Earth consortium (11 countries)		
Total B		**40 800,00**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	10 200,00
D. Estimated eligible access costs = A+B+C		51 000,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	14	Organisation short name		met.no	
Short name of Infrastructure	ENES ESM	Installation number	3	Short name of Installation	NorESM

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs

Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
Total A	**0,00**
of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time

Category of staff[1]	Person-Months	Personnel Costs (€)
Senior scientist, one of the NorESM developers (Met.no)	3	31 800,00
Reporting of user support actions realized by the meteorological agency		
Total B		**31 800,00**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	7 950,00
D. Estimated eligible access costs = A+B+C		39 750,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	21	Organisation short name		UniRes	
Short name of Infrastructure	ENES ESM	Installation number	3	Short name of Installation	NorESM

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs

Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
Total A	**0,00**
of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time

Category of staff[1]	Person-Months	Personnel Costs (€)
Senior scientist, one of the NorESM developers (Uni.research)	3	27 275,00
Total B		**27 275,00**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	6 818,75
D. Estimated eligible access costs = A+B+C		34 093,75

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	4	Organisation short name		CERFACS	
Short name of Infrastructure	ENES ESM	Installation number	4	Short name of Installation	OASIS-VA

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs	virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
	Total A	**0,00**
	of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time	Category of staff[1]	Person-Months	Personnel Costs (€)
	Core developer/manager of OASIS and user support staff (CERFACS)	3	20 100,00
	(team of 2-3 people). Training organized since 2010, see:		
	https://portal.enes.org/oasis/users/training/training-sessions-on-oasis3		
	Total B		**20 100,00**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	5 025,00
D. Estimated eligible access costs = A+B+C		25 125,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Participant number	**4**	**Organisation short name**	**CERFACS**	**Short name of Infrastructure**	**ENES ESM**
Installation number	**5**	**Short name of Installation**	**OASIS-TNA**	**Unit of access**	**n/a**

If access costs are declared on the basis of actual cost or on the basis of a combination[5] of unit cost and actual costs, please use the following table to estimate the actual costs.

Access provision period from: (usually the project life-time)	01/01/2019	**to:**	31/12/2022

A. **Direct eligible costs of providing access to the selected user groups, excluding personnel costs**	selected for support under the action. All contributions to capital investments of the installation are not eligible.		**Eligible Costs (€)**
	Total A		**0,00**
	of which subcontracting (A')		
B. **Personnel direct eligible costs needed to provide access to the selected user groups**	**Category of staff** [6]	**Person-Months**	**Personnel Costs (€)**
	OASIS coupling expert (one engineer previously involved in OASIS dedicated	9	50 400,00
	user supports -IS-ENES1- and OASIS developments)		
	Estimated #users: 3/year * 3 years = 9		
	Estimated #user projects: 9		
	Total B		**50 400,00**
C. Indirect eligible costs: 25% x ([A-A']+B)			12 600,00
D. **Actual Access Cost for the access offered under the project = A + B + C**			**63 000,00**

[5] In case of combination of unit cost and actual costs, only cost categories and cost items that have not been used in the unit cost calculation above may be reimbursed on an actual cost basis.

[6] Personnel costs for the provision of access can only include costs of administrative, technical and scientific staff directly working for the provision of access to the selected users and their support. These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	1	Organisation short name		CNRS-IPSL	
Short name of Infrastructure	ENES ESM	Installation number	6	Short name of Installation	XIOS

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs	virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
	Total A	**0,00**
	of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time	Category of staff[1]	Person-Months	Personnel Costs (€)
	Core developers of XIOS and user support permanent staff (2 permanent staff from IPSL)	7	53 200,00
	Organize training and user support on their tool		
	Total B		**53 200,00**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	13 300,00
D. Estimated eligible access costs = A+B+C		66 500,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	4	Organisation short name		CERFACS	
Short name of Infrastructure	ENES ESM	Installation number	6	Short name of Installation	XIOS

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs

Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
Total A	**0,00**
of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time

Category of staff[1]	Person-Months	Personnel Costs (€)
1 Engineer/co-developer of dr2xml (CERFACS)	3	15 900,00
Ensure user support on the tool		
Total B		**15 900,00**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	3 975,00
D. Estimated eligible access costs = A+B+C		19 875,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	5	Organisation short name		METO	
Short name of Infrastructure	ENES ESM	Installation number	7	Short name of Installation	Cylc/Rose

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs

Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
Total A	**0,00**
of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time

Category of staff[1]	Person-Months	Personnel Costs (€)
Engineers from the Cylc/Rose development and user support staff (MetOffice)	11	69 180,00
from a permanent team of 4 persons.		
Organizer of training and user support on their tools		
Total B		**69 180,00**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	17 295,00
D. Estimated eligible access costs = A+B+C		86 475,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	11	Organisation short name		DLR	
Short name of Infrastructure	ENES ESM	Installation number	8	Short name of Installation	ESMValTool

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs

Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
Total A	**0,00**
of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time

Category of staff[1]	Person-Months	Personnel Costs (€)
Core developer of the ESMValTool development, permanent staff (DLR)	3	23 587,20
Document, update and provide support on this tool		
Total B		**23 587,20**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	5 896,80
D. Estimated eligible access costs = A+B+C		29 484,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	6	Organisation short name		BSC	
Short name of Infrastructure	ENES ESM	Installation number	8	Short name of Installation	ESMValTool

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs

Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
Total A	**0,00**
of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time

Category of staff[1]	Person-Months	Personnel Costs (€)
Engineer from the permanent staff (BSC)	2	9 000,00
Ensure support and training on the tool he co-develops		
Total B		**9 000,00**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	2 250,00
D. Estimated eligible access costs = A+B+C		11 250,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	12	Organisation short name		NIeSC	
Short name of Infrastructure	ENES ESM	Installation number	8	Short name of Installation	ESMValTool

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs

Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
Total A	**0,00**
of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time

Category of staff[1]	Person-Months	Personnel Costs (€)
MSc eScience Research Engineer (NIeSC)	2	14 000,00
Translate expert knowledge of software into clear documentation		
and help for users		
Total B		**14 000,00**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	3 500,00
D. Estimated eligible access costs = A+B+C		17 500,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

IS-ENES3 VA2 tables

Estimation of the Access Costs for Virtual Access

Participant number	3	Organisation short name		DKRZ	
Short name of Infrastructure	ENES CDI	Installation number	1	Short name of Installation	DKRZ-WDCC-ESGF-Comp1

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs		Eligible Costs (€)
	virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	
	Total A	**0,00**
	of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time	Category of staff[1]	Person-Months	Personnel Costs (€)
	technical data infrastructure mangement staff (T.W.)	8	52 000,00
	technical data management staff (K.B)	5	30 000,00
	scientific data management staff (Dr. M. S)	16	128 000,00
	scientific programmer (NN)	8	54 280,00
	Total B		**264 280,00**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	66 070,00
D. Estimated eligible access costs = A+B+C		330 350,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	11	Organisation short name		DLR	
Short name of Infrastructure	ENES CDI	Installation number	1	Short name of Installation	DKRZ-WDCC-ESGF-Comp1

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs	virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
	Total A	**0,00**
	of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time	Category of staff[1]	Person-Months	Personnel Costs (€)
	Research scientist	4	31 449,60
	Total B		**31 449,60**
C. Indirect eligible costs 25% x ([A-A']+B)	**max**		7 862,40
D. Estimated eligible access costs = A+B+C			39 312,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	12	Organisation short name		NIeSC	
Short name of Infrastructure	ENES CDI	Installation number	1	Short name of Installation	DKRZ-WDCC-ESGF-Comp1

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs		Eligible Costs (€)
	virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	
	Total A	**0,00**
	of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time	Category of staff[1]	Person-Months	Personnel Costs (€)
	MSc eScience Research Engineer (NLeSC)	4	28 000,00
	Translate expert knowledge of software into usages in compute services.		
	Total B		**28 000,00**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	7 000,00
D. Estimated eligible access costs = A+B+C		35 000,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	9	Organisation short name		STFC	
Short name of Infrastructure	ENES CDI	Installation number	2	Short name of Installation	STFC-ESGF-Comp1-CFDR

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs		Eligible Costs (€)
	virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	
	Total A	**0,00**
	of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time	Category of staff[1]	Person-Months	Personnel Costs (€)
	Management of services (permanent staff)	3,5	26 563,00
	Science Support	20,5	105 524,00
	including: 1 permanent staff for 4 PM		
	Request services		
	Total B		**132 087,00**
C. Indirect eligible costs 25% x ([A-A']+B)		**max**	33 021,75
D. Estimated eligible access costs = A+B+C			165 108,75

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	2	Organisation short name		UREAD-NCAS	
Short name of Infrastructure	ENES CDI	Installation number	2	Short name of Installation	STFC-ESGF-Comp1-CFDR

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs

Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
Total A	**0,00**
of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time

Category of staff[1]	Person-Months	Personnel Costs (€)
Senior Software Engineer (CF-Checker)	5	37 153,38
Senior Software Engineer (CF_Conventions, CF Data Model)	17	126 321,50
Total B		**163 474,88**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	40 868,72
D. Estimated eligible access costs = A+B+C		204 343,60

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	10	Organisation short name		SMHI	
Short name of Infrastructure	ENES CDI	Installation number	2	Short name of Installation	STFC-ESGF-Comp1-CFDR

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs	Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
	Total A	**0,00**
	of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time	Category of staff[1]	Person-Months	Personnel Costs (€)
	CORDEX Data expert (scientific)	2	13 600,00
	CORDEX Data expert (technical)	2	13 600,00
	Total B		**27 200,00**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	6 800,00
D. Estimated eligible access costs = A+B+C		34 000,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	1	Organisation short name		CNRS-IPSL	
Short name of Infrastructure	ENES CDI	Installation number	3	Short name of Installation	CNRS-ESGF-ESDOC-Comp1

Access provision period (usually the project life-time) from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs	Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
	Total A	**0,00**
	of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time	Category of staff[1]	Person-Months	Personnel Costs (€)
	3 permanent staff scientific programmers (ESGF and Comp1 services)	6	37 320,00
	1 non permanent Research Engineer on ES-DOC service	24	103 872,00
	Total B		**141 192,00**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	35 298,00
D. Estimated eligible access costs = A+B+C		176 490,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	2	Organisation short name		UREAD-NCAS	
Short name of Infrastructure	ENES CDI	Installation number	3	Short name of Installation	CNRS-ESGF-ESDOC-Comp1

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs	Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
	Total A	**0,00**
	of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time	Category of staff[1]	Person-Months	Personnel Costs (€)
	Senior Software Engineer (ES-DOC Operational Support for CMIP)	12	89 168,12
	Total B		**89 168,12**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	22 292,03
D. Estimated eligible access costs = A+B+C		111 460,15

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	8	Organisation short name		CMCC	
Short name of Infrastructure	ENES CDI	Installation number	4	Short name of Installation	CMCC-Comp1

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs	Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
	Total A	**0,00**
	of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time	Category of staff[1]	Person-Months	Personnel Costs (€)
	Senior Scientist, supervisor of the operational service activites in WP7/SA2	0,5	6 250,00
	Senior Scientist (compute service facility operational manager and help desk)	1	8 500,00
	Junior Scientist (admin of the compute service facility and help desk	0,5	2 500,00
	Senior Research Associate (tech resp. of the storage pool/file system)	0,5	2 000,00
	Senior Research Associate (admin, operational maintenance, network activities)	0,5	2 000,00
	Total B		**21 250,00**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	5 312,50
D. Estimated eligible access costs = A+B+C		26 562,50

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	22	Organisation short name	LiU		
Short name of Infrastructure	ENES CDI	Installation number	5	Short name of Installation	LiU-ESGF

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs	Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
	Total A	**0,00**
	of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time	Category of staff[1]	Person-Months	Personnel Costs (€)
	1 Software engineer expert on ESGF	3	18 540,00
	Total B		**18 540,00**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	4 635,00
D. Estimated eligible access costs = A+B+C		23 175,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	10	Organisation short name		SMHI	
Short name of Infrastructure	ENES CDI	Installation number	5	Short name of Installation	LiU-ESGF

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs

Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
Total A	**0,00**
of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time

Category of staff[1]	Person-Months	Personnel Costs (€)
CORDEX Data information/outreach expert	2	13 600,00
CORDEX Data informatics/web expert	2	13 600,00
Total B		**27 200,00**

C. Indirect eligible costs 25% x ([A-A']+B)	**max**	6 800,00
D. Estimated eligible access costs = A+B+C		34 000,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	6	Organisation short name		BSC	
Short name of Infrastructure	ENES CDI	Installation number	6	Short name of Installation	BSC-ESGF

Access provision period (usually the project life-time)	from:	01/01/2019	to:	31/12/2022

A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs	Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.	Eligible Costs (€)
	Total A	**0,00**
	of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time	Category of staff[1]	Person-Months	Personnel Costs (€)
	1 Research Engineer	3	13 500,00
	Total B		**13 500,00**

C. Indirect eligible costs 25% x ([A-A']+B)	max	3 375,00
D. Estimated eligible access costs = A+B+C		16 875,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Estimation of the Access Costs for Virtual Access

Participant number	7	Organisation short name		KNMI	
Short name of Infrastructure	ENES CDI	Installation number	7	Short name of Installation	KNMI-C4I

Access provision period (usually the project life-time)		from:	01/01/2019	to:	31/12/2022
A. Estimated direct eligible costs of providing virtual access during the project life-time excluding personnel costs	Describe the direct eligible costs that will be charged to the grant for the provision of virtual access over the project life-time (e.g. maintenance, utilities, consumable costs). All contributions to capital investments of the infrastructure are not eligible.				Eligible Costs (€)
				Total A	0,00
				of which subcontracting (A')	

B. Estimated personnel direct eligible costs needed to provide virtual access during the project life-time	Category of staff[1]	Person-Months	Personnel Costs (€)
	1 Research scientist expert in software development (permanent staff)	4	30 396,00
	1 Software engineer (permanent staff)	6	40 236,00
		Total B	70 632,00

C. Indirect eligible costs 25% x ([A-A']+B)	max	17 658,00
D. Estimated eligible access costs = A+B+C		88 290,00

[1] Personnel costs for technical and scientific staff directly working for the provision of virtual access, including for the generic support of user (e.g. help desk). These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Participant number	**3**	**Organisation short name**	**DKRZ**	**Short name of Infrastructure**	**ENES CDI**
Installation number	**8**	**Short name of Installation**	**DKRZ-Comp2**	**Unit of access**	**n/a**

If access costs are declared on the basis of actual cost or on the basis of a combination[5] of unit cost and actual costs, please use the following table to estimate the actual costs.

Access provision period (usually the project life-time)	**from:**	01/01/2019	**to:**	31/12/2022

A. **Direct eligible costs of providing access to the selected user groups, excluding personnel costs**	Describe the costs actually and solely incurred for providing access to the user groups selected for support under the action. All contributions to capital investments of the installation are not eligible.	**Eligible Costs (€)**
	Total A	**0,00**
	of which subcontracting (A')	

B. **Personnel direct eligible costs needed to provide access to the selected user groups**	**Category of staff** [6]	**Person-Months**	**Personnel Costs (€)**
	technical data management staff (K.B.)	1	6 000,00
	technical data infrastructure management staff (T.W.)	4	26 000,00
	Total B		**32 000,00**

C. Indirect eligible costs: 25% x ([A-A']+B)	8 000,00
D. **Actual Access Cost for the access offered under the project = A + B + C**	**40 000,00**

[5] In case of combination of unit cost and actual costs, only cost categories and cost items that have not been used in the unit cost calculation above may be reimbursed on an actual cost basis.

[6] Personnel costs for the provision of access can only include costs of administrative, technical and scientific staff directly working for the provision of access to the selected users and their support. These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Participant number	9	Organisation short name	STFC	Short name of Infrastructure	ENES CDI
Installation number	9	Short name of Installation	STFC-Comp2	Unit of access	n/a

If access costs are declared on the basis of actual cost or on the basis of a combination[5] of unit cost and actual costs, please use the following table to estimate the actual costs.

Access provision period (usually the project life-time)	**from:**	01/01/2019	**to:**	31/12/2022

A. Direct eligible costs of providing access to the selected user groups, excluding personnel costs	Describe the costs actually and solely incurred for providing access to the user groups selected for support under the action. All contributions to capital investments of the installation are not eligible.	**Eligible Costs (€)**
	Total A	**0,00**
	of which subcontracting (A')	

B. Personnel direct eligible costs needed to provide access to the selected user groups	**Category of staff** [6]	**Person-Months**	**Personnel Costs (€)**
	Administration	1	6 821,00
	Technical Staff	4	17 460,00
		Total B	**24 281,00**

C. Indirect eligible costs: 25% x ([A-A']+B)	6 070,25
D. **Actual Access Cost for the access offered under the project = A + B + C**	**30 351,25**

[5] In case of combination of unit cost and actual costs, only cost categories and cost items that have not been used in the unit cost calculation above may be reimbursed on an actual cost basis.

[6] Personnel costs for the provision of access can only include costs of administrative, technical and scientific staff directly working for the provision of access to the selected users and their support. These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Participant number	1	Organisation short name	CNRS-IPSL	Short name of Infrastructure	ENES CDI
Installation number	10	Short name of Installation	CNRS-Comp2	Unit of access	n/a

If access costs are declared on the basis of actual cost or on the basis of a combination[5] of unit cost and actual costs, please use the following table to estimate the actual costs.

Access provision period (usually the project life-time)	**from:**	01/01/2019	**to:**	31/12/2022

A. Direct eligible costs of providing access to the selected user groups, excluding personnel costs	Describe the costs actually and solely incurred for providing access to the user groups selected for support under the action. All contributions to capital investments of the installation are not eligible.	**Eligible Costs (€)**
	Total A	**0,00**
	of which subcontracting (A')	

B. Personnel direct eligible costs needed to provide access to the selected user groups	**Category of staff** [6]	**Person-Months**	**Personnel Costs (€)**
	3 permanent staff scientific programmers (Comp2 services)	5	31 100,00
		Total B	**31 100,00**

C. Indirect eligible costs: 25% x ([A-A']+B)	7 775,00
D. **Actual Access Cost for the access offered under the project = A + B + C**	**38 875,00**

[5] In case of combination of unit cost and actual costs, only cost categories and cost items that have not been used in the unit cost calculation above may be reimbursed on an actual cost basis.

[6] Personnel costs for the provision of access can only include costs of administrative, technical and scientific staff directly working for the provision of access to the selected users and their support. These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).

Participant number	8	Organisation short name	CMCC	Short name of Infrastructure	ENES CDI
Installation number	11	Short name of Installation	CMCC-Comp2	Unit of access	n/a

If access costs are declared on the basis of actual cost or on the basis of a combination[5] of unit cost and actual costs, please use the following table to estimate the actual costs.

Access provision period from: (usually the project life-time)	01/01/2019	**to:**	31/12/2022

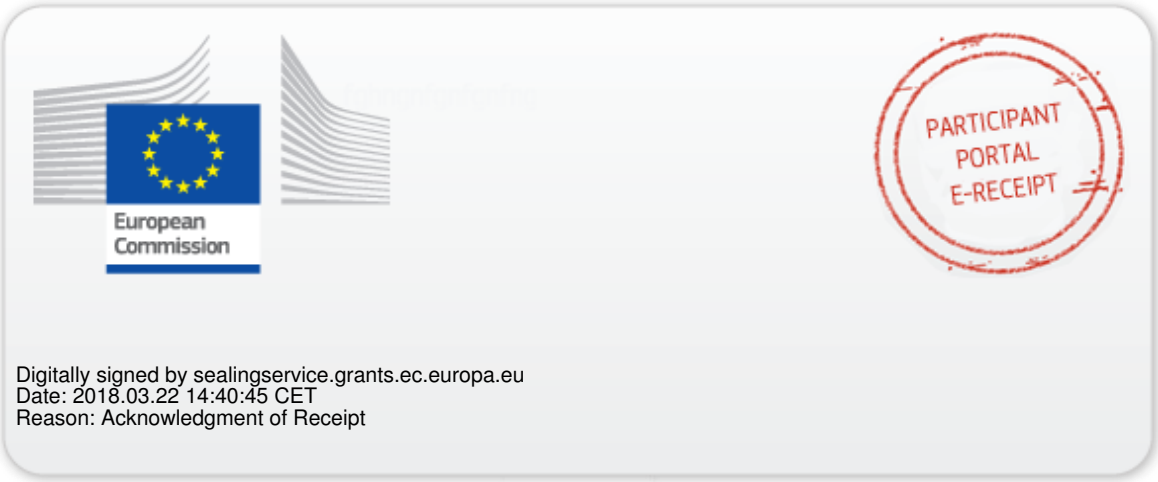
A. Direct eligible costs of providing access to the selected user groups, excluding personnel costs	Describe the costs actually and solely incurred for providing access to the user groups selected for support under the action. All contributions to capital investments of the installation are not eligible.	**Eligible Costs (€)**
	Total A	**0,00**
	of which subcontracting (A')	

B. Personnel direct eligible costs needed to provide access to the selected user groups	**Category of staff [6]**	**Person-Months**	**Personnel Costs (€)**
	Senior Scientist (supervisor of the operational service activites in WP7/SA2)	1,5	18 750,00
	Senior Scientist (compute service facility operational manager and help desk)	0,4	3 400,00
	Junior Scientist (admin of the compute service facility and help desk)	0,2	1 000,00
	Senior Research Associate (tech resp. of the storage pool/file system)	1,5	6 000,00
	Senior Research Associate (admin, operational maintenance, network activities)	1,4	5 600,00
	Total B		**34 750,00**

C. Indirect eligible costs: 25% x ([A-A']+B)	8 687,50
D. **Actual Access Cost for the access offered under the project = A + B + C**	**43 437,50**

[5] In case of combination of unit cost and actual costs, only cost categories and cost items that have not been used in the unit cost calculation above may be reimbursed on an actual cost basis.

[6] Personnel costs for the provision of access can only include costs of administrative, technical and scientific staff directly working for the provision of access to the selected users and their support. These costs will be charged to the grant as direct personnel costs (hours worked for the grant must be recorded).



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