Please check our wiki for help on navigating the form.

Horizon 2020

Call: H2020-INFRAEDI-2018-2020
(European Data Infrastructure)

Topic: INFRAEDI-02-2018
Type of action: RIA

Proposal number: SEP-210494560

Proposal acronym: ESiWACE2

Deadline Id: H2020-INFRAEDI-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.

Proposal Submission Forms

Proposal ID **SEP-210494560**	*Acronym* **ESiWACE2**

1 - General information

Topic	INFRAEDI-02-2018	Type of Action	RIA
Call Identifier	H2020-INFRAEDI-2018-2020	Deadline Id	H2020-INFRAEDI-2018-1

Acronym ESiWACE2

Proposal title Excellence in Simulation of Weather and Climate in Europe, Phase 2

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 *weather, climate, exascale, HPC, scalability, portability, simulation, profiling and optimisation, workflow, computer science, data middleware, large data volume*

Abstract

The path towards exascale computing holds enormous challenges for the community of weather and climate modelling regarding portability, scalability and data management that can hardly be faced by individual institutes. ESiWACE2 will therefore link, organise and enhance Europe's excellence in weather and climate modelling to (1) enable leading European weather and climate models to leverage the performance of pre-exascale systems with regard to both compute and data capacity as soon as possible and (2) prepare the weather and climate community to be able to make use of exascale systems when they become available. To achieve this goal, ESiWACE2 will (a) improve throughput and scalability of leading European weather and climate models and demonstrate the technical and scientific performance of the models in unprecedented resolution on pre-exascale EuroHPC systems, (b) evaluate and establish new technologies such as domain specific languages and machine learning for use in weather and climate modelling, (c) enhance HPC capacity via services to the weather and climate community to optimize code performance and allow model porting, (d) improve the data management tool chain from weather and climate simulations at scale, (e) foster co-design between model developers, HPC manufacturers and HPC centres, and (f) strengthen interactions of the community with the European HPC Eco-system. ESiWACE2 will deliver configurations of leading models that can make efficient use of the largest supercomputers in Europe and run at unprecedented resolution for high-quality weather and climate predictions. This will be a beacon for the community in Europe and around the world. ESiWACE2 will develop HPC benchmarks, increase flexibility to use heterogeneous hardware and co-design and provide targeted education and training for one of the most challenging applications to shape the future of HPC in Europe.

Remaining characters   91

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 <u>European Code of Conduct for Research Integrity</u> — 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 <u>http://ec.europa.eu/research/participants/portal/desktop/en/organisations/lfv.html</u> 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 <u>privacy statement</u>. 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 <u>Privacy statement for the EDES Database.</u>

| Proposal ID | **SEP-210494560** | *Acronym* | **ESiWACE2** |

2 - Participants & contacts

#	Participant Legal Name	Country	Action
1	DEUTSCHES KLIMARECHENZENTRUM GMBH	DE	
2	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	FR	
3	EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS	UK	
4	BARCELONA SUPERCOMPUTING CENTER - CENTRO NACIONAL DE SUPERCOMPUTACION	ES	
5	MAX-PLANCK-GESELLSCHAFT ZUR FORDERUNG DER WISSENSCHAFTEN EV	DE	
6	SVERIGES METEOROLOGISKA OCH HYDROLOGISKA INSTITUT	SE	
7	CENTRE EUROPEEN DE RECHERCHE ET DE FORMATION AVANCEE EN CALCUL SCIENTIFIQUE	FR	
8	NATIONAL UNIVERSITY OF IRELAND GALWAY	IE	
9	MET OFFICE	UK	
10	FONDAZIONE CENTRO EURO-MEDITERRANEO SUI CAMBIAMENTI CLIMATICI	Italy	
11	THE UNIVERSITY OF READING	UK	
12	SCIENCE AND TECHNOLOGY FACILITIES COUNCIL	UK	
13	BULL SAS	FR	
14	SEAGATE SYSTEMS UK LIMITED	UK	
15	EIDGENOESSISCHE TECHNISCHE HOCHSCHULE ZUERICH	CH	
16	THE UNIVERSITY OF MANCHESTER	UK	
17	STICHTING NETHERLANDS ESCIENCE CENTER	NL	
18	EIDGENOESSISCHES DEPARTEMENT DES INNERN	CH	
19	DATADIRECT NETWORKS FRANCE	FR	
20	MERCATOR OCEAN	FR	

2 - Administrative data of participating organisations

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 | Applications Department   ☐ 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*	
Is controlled by	MAX-PLANCK-GESELLSCHAFT ZUR FORDERUNG DER WISSENSCHAFTEN E	

Proposal Submission Forms

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 **Joachim**   Last name **BIERCAMP**

E-Mail **biercamp@dkrz.de**

Position in org. | Head of the Unit for Applications |

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 | www.dkrz.de |

Phone | +4940460094314 | Phone 2 | +4940460094415 | Fax | *+xxx xxxxxxxx* |

Other contact persons

First Name	Last Name	E-mail	Phone
Chiara	Bearzotti	chiara.bearzotti@gmail.com	*+xxx xxxxxxxx*
Philipp	Neumann	neumann@dkrz.de	*+xxx xxxxxxxx*
Joerg	Behrens	behrens@dkrz.de	*+xxx xxxxxxxx*
Kerstin	Fieg	fieg@dkrz.de	*+xxx xxxxxxxx*
Niklas	Roeber	roeber@dkrz.de	*+xxx xxxxxxxx*
Christiane	Melzer	melzer@dkrz.de	*+xxx xxxxxxxx*

Proposal Submission Forms

PIC

999997930

Legal name

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 | IPSL/ Laboratoire des Sciences du Climat et de l'Environnement | ☐ not applicable

☐ Same as proposing organisation's address

Street   Orme des Merisiers, Bat 712, CE Saclay

Town   Gif sur Yvette

Postcode   91191

Country   France

Dependencies with other proposal participants

Character of dependence	*Participant*	

Proposal Submission Forms

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. Directeur de Recherche au CNRS

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

☐ Same as proposing organisation's address

Street Orme des Merisiers, Bat 712, CE Saclay,

Town Orme des Merisiers, Bat 712, CE Saclay,   Post code 91191

Country France

Website

Phone +33169085674   Phone 2 *+xxx xxxxxxxx*   Fax *+xxx xxxxxxxx*

Other contact persons

First Name	Last Name	E-mail	Phone
Francesca	Guglielmo	francesca.guglielmo@lsce.ipsl.fr	*+xxx xxxxxxxx*

Proposal Submission Forms

Proposal ID **SEP-210494560**		*Acronym* **ESiWACE2**		*Short name* **ECMWF**	

PIC
999916741

Legal name
EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

Short name: ECMWF

Address of the organisation

Street SHINFIELD PARK

Town READING

Postcode RG2 9AX

Country United Kingdom

Webpage www.ecmwf.int

Legal Status of your organisation

Research and Innovation legal statuses

Public body ....yes

Non-profit ....yes

International organisation ....yes

International organisation of European interest ....yes

Secondary or Higher education establishment ....no

Research organisation ....yes

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 | Research Department | ☐ not applicable

☒ Same as proposing organisation's address

Street | SHINFIELD PARK

Town | READING

Postcode | RG2 9AX

Country | United Kingdom

Dependencies with other proposal participants

Character of dependence	*Participant*	

Proposal Submission Forms

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 **Peter**   Last name **Bauer**

E-Mail **peter.bauer@ecmwf.int**

Position in org. Head of Model Division

Department Research Department   ☐ Same as organisation name

☒ Same as proposing organisation's address

Street SHINFIELD PARK

Town READING   Post code RG2 9AX

Country United Kingdom

Website

Phone +44 118 9499080   Phone 2 +44 118 949 9216   Fax *+xxx xxxxxxxxx*

Other contact persons

First Name	Last Name	E-mail	Phone
Peter	Dueben	peter.dueben@ecmwf.int	*+44 118 949 9024*
Daniel	Thiemert	daniel.thiemert@ecmwf.int	*+44 118 949 9024*

PIC

999655520

Legal name

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 | Computational Earth Sciences - Earth Sciences Department | ☐ not applicable

☐ Same as proposing organisation's address

Street | Nexus II - Planta 1 C/ Jordi Girona, 29

Town | Barcelona

Postcode | 08034

Country | Spain

Dependencies with other proposal participants

Character of dependence	*Participant*	

Proposal Submission Forms

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 **Kim**   Last name **Serradell**

E-Mail **kim.serradell@bsc.es**

Position in org. COMPUTATIONAL EARTH SCIENCES GROUP COORDINATOR

Department BARCELONA SUPERCOMPUTING CENTER - CENTRO NACIONAL DE SU   ☒ Same as organisation name

☐ Same as proposing organisation's address

Street Nexus II - Planta 1 C/ Jordi Girona, 29

Town Barcelona   Post code 08034

Country Spain

Website https://www.bsc.es

Phone +34 934134051   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
999990267

Legal name
MAX-PLANCK-GESELLSCHAFT ZUR FORDERUNG DER WISSENSCHAFTEN EV

Short name: MPIM

Address of the organisation

Street   HOFGARTENSTRASSE 8

Town   MUENCHEN

Postcode   80539

Country   Germany

Webpage   www.mpg.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..05/04/2016 - no

SME self-assessment ....05/04/2016 - no

SME validation sme...31/10/2008 - no

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

Proposal Submission Forms

Department(s) carrying out the proposed work

Department 1

Department name | Max Planck Institute for Meteorology | ☐ not applicable

☐ Same as proposing organisation's address

Street | Bundesstraße 53 |

Town | Hamburg |

Postcode | 20146 |

Country | Germany |

Dependencies with other proposal participants

Character of dependence	*Participant*	
Controls	DEUTSCHES KLIMARECHENZENTRUM GMBH	

Proposal Submission Forms

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 **Reinhard**   Last name **Budich**

E-Mail **reinhard.budich@mpimet.mpg.de**

Position in org. Group Leader Strategic IT Partnerships (SIP)

Department Scientific Computing Laboratory   ☐ Same as organisation name

☐ Same as proposing organisation's address

Street Bundesstraße 53

Town Hamburg   Post code 20146

Country Germany

Website http://mpimet.mpg.de/

Phone +494041173369   Phone 2 *+xxx xxxxxxxx*   Fax *+xxx xxxxxxxx*

Other contact persons

First Name	Last Name	E-mail	Phone
Chenbo	Guo	chenbo.guo@mpimet.mpg.de	*+xxx xxxxxxxx*

PIC
999507983

Legal name
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*	

Proposal Submission Forms

Proposal ID **SEP-210494560**		*Acronym*	**ESiWACE2**	*Short name*	**SMHI**

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 +46114958104   Fax *+xxx xxxxxxxxx*

Other contact persons

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

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   Legal person ....yes

Non-profit ....no

International organisation ....unknown

International organisation of European interest ....unknown

Secondary or Higher education establishment ....no   Industry (private for profit).................yes

Research organisation ....no

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 Modelling and Global Change team | ☐ 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*	

Proposal Submission Forms

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 **Dominique**   Last name **Roffi**

E-Mail **roffi@cerfacs.fr**

Position in org. Grant manager

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

Phone +xxx xxxxxxxx   Phone 2 +xxx xxxxxxxx   Fax +xxx xxxxxxxx

Other contact persons

First Name	Last Name	E-mail	Phone
Michele	Campassens	campasse@cerfacs.fr	+xxx xxxxxxxx
Sophie	Valcke	sophie.valcke@cerfacs.fr	+33561193076

Proposal Submission Forms

PIC	*Legal name*
999978045	*NATIONAL UNIVERSITY OF IRELAND GALWAY*

Short name: ICHEC

Address of the organisation

Street   UNIVERSITY ROAD

Town   GALWAY

Postcode

Country   Ireland

Webpage   www.nuigalway.ie

Legal Status of your organisation

Research and Innovation legal statuses

Public body ....yes   Legal person ....yes

Non-profit ....yes

International organisation ....unknown

International organisation of European interest ....unknown

Secondary or Higher education establishment ....yes   Industry (private for profit).................no

Research organisation ....unknown

Enterprise Data

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

SME self-assessment ....19/05/2016 - no

SME validation sme...02/12/2008 - 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 | Irish Centre for High End Computing | ☐ not applicable

☐ Same as proposing organisation's address

Street | IT302, IT Building, NUI Galway

Town | Galway

Postcode | 000000

Country | Ireland

Dependencies with other proposal participants

Character of dependence	*Participant*	

Proposal Submission Forms

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 **Alastair**   Last name **McKinstry**

E-Mail **alastair.mckinstry@ichec.ie**

Position in org. Environmental Sciences Activity Leader

Department NATIONAL UNIVERSITY OF IRELAND GALWAY   ☒ Same as organisation name

☒ Same as proposing organisation's address

Street UNIVERSITY ROAD

Town GALWAY   Post code

Country Ireland

Website http://www.ichec.ie/about_us/contact

Phone *+XXX XXXXXXXX*   Phone 2 *+XXX XXXXXXXX*   Fax *+XXX XXXXXXXX*

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

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*	

Proposal Submission Forms

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 **Paula**　　　　　　　　　Last name **Newton**

E-Mail **paula.newton@metoffice.gov.uk**

Position in org. `Senior grant manager`

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 ``

Phone `+xxx xxxxxxxx`　Phone 2 `+xxx xxxxxxxx`　Fax `+xxx xxxxxxxx`

Other contact persons

First Name	Last Name	E-mail	Phone
Mick	Carter	mick.carter@metoffice.gov.uk	+xxx xxxxxxxx

Proposal Submission Forms

PIC
999419422

Legal name
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.

Proposal Submission Forms

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 | ODA - Ocean modeling and Data Assimilation Division | ☐ not applicable

☐ Same as proposing organisation's address

Street | Viale Carlo Berti Pichat 6/2

Town | Bologna

Postcode | 40127

Country | Italy

Dependencies with other proposal participants

Character of dependence	*Participant*	

Proposal Submission Forms

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
Sandro	Fiore	sandro.fiore@cmcc.it	*+390832297332*
Silvia	Mocavero	silvia.mocavero@cmcc.it	*+390832297304*
Giulia	Galluccio	giulia.galluccio@cmcc.it	*+390283623433*
Laura	Conte	laura.conte@cmcc.it	*+390832297304*
Simona	Masina	simona.masina@cmcc.it	*+xxx xxxxxxxxx*

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

Short name: UREAD

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   Legal person ....yes

Non-profit ....yes

International organisation ....no

International organisation of European interest ....no
                                                                                       Industry (private for profit).................no
Secondary or Higher education establishment ....yes

Research organisation ....yes

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   National Centre for Atmospheric Science- Dept of Meteorology   ☐ not applicable

☐ Same as proposing organisation's address

Street   Early Gate

Town   Reading

Postcode   RG66BB

Country   United Kingdom

Dependencies with other proposal participants

Character of dependence	*Participant*	

Proposal Submission Forms

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 **EU-Unit**   Last name **Reading**

E-Mail **eu-unit@reading.ac.uk**

Position in org. `Dr Elena Koukharenko EU Research Development Manager and EU Liaison`

Department `EU Research Development Manager and EU Liaison Officer | Themes– Envi`   ☐ Same as organisation name

☐ Same as proposing organisation's address

Street `Whiteknights House, Whiteknights`

Town `Reading`   Post code `RG6 6AH`

Country `United Kingdom`

Website ` `

Phone `+44 118 378 8844`   Phone 2 `+xxx xxxxxxxx`   Fax `+xxx xxxxxxxx`

Other contact persons

First Name	Last Name	E-mail	Phone
Bryan	Lawrence	bryan.lawrence@ncas.ac.uk	+44 118 378 6507

PIC
999980179

Legal name
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.

Proposal Submission Forms

Proposal ID **SEP-210494560**		*Acronym*	**ESiWACE2**	*Short name*	**STFC**

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*	

Proposal Submission Forms

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 **Rupert**   Last name **Ford**

E-Mail **rupert.ford@stfc.ac.uk**

Position in org.   Computational Scientist

Department   SCIENCE AND TECHNOLOGY FACILITIES COUNCIL   ☒ Same as organisation name

☒ Same as proposing organisation's address

Street   Polaris House North Star Avenue

Town   SWINDON   Post code   SN2 1SZ

Country   United Kingdom

Website

Phone   *+xxx xxxxxxxx*   Phone 2   *+xxx xxxxxxxx*   Fax   *+xxx xxxxxxxx*

Proposal ID **SEP-210494560**	*Acronym* **ESiWACE2**	*Short name* **BULL**

PIC	*Legal name*
996058081	BULL SAS

Short name: BULL

Address of the organisation

Street   RUE JEAN JAURES 68

Town   LES CLAYES SOUS BOIS

Postcode   78340

Country   France

Webpage   www.bull.com

Legal Status of your organisation

Research and Innovation legal statuses

Public body ....no

Non-profit ....no

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).................yes

Enterprise Data

SME self-declared status...08/11/2017 - 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 | Bull BDS - Center for Excellence in Parallel Programming | ☐ not applicable

☐ Same as proposing organisation's address

Street | 1, rue de Provence |

Town | Echirolles |

Postcode | 38432 |

Country | France |

Dependencies with other proposal participants

Character of dependence	*Participant*	

Proposal Submission Forms

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 **Xavier**   Last name **Vigouroux**

E-Mail **xavier.vigouroux@atos.net**

Position in org. Director of Center for Excellence in Parallel Programming

Department Center for Excellence in Parallel Programming   ☐ Same as organisation name

☐ Same as proposing organisation's address

Street 1, rue de Provence

Town Echirolles   Post code 38320

Country France

Website www.bull.com

Phone +33686285081   Phone 2 *+xxx xxxxxxxxx*   Fax *+xxx xxxxxxxxx*

Other contact persons

First Name	Last Name	E-mail	Phone
Erwan	Raffin	erwan.raffin@atos.net	*+xxx xxxxxxxxx*
Medur	SRIDHARAN	medur.sridharan@bull.net	*+33130803024*

PIC	*Legal name*
999728076	*SEAGATE SYSTEMS UK LIMITED*

Short name: SEAGATE

Address of the organisation

Street   LANGSTONE ROAD

Town   HAVANT

Postcode   PO9 1SA

Country   United Kingdom

Webpage

Legal Status of your organisation

Research and Innovation legal statuses

Public body ....no

Non-profit ....no

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).................yes

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

No department involved

Department name   ☒ not applicable

Name of the department/institute carrying out the work.

☐ 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*	

Proposal Submission Forms

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 **Sai**   Last name   **Narasimhamurthy**

E-Mail **sai.narasimhamurthy@seagate.com**

Position in org. `Scientist`

Department `SEAGATE SYSTEMS UK LIMITED`   ☒ Same as organisation name

☒ Same as proposing organisation's address

Street `LANGSTONE ROAD`

Town `HAVANT`   Post code `PO9 1SA`

Country `United Kingdom`

Website ` `

Phone `+xxx xxxxxxxx`   Phone 2 `+xxx xxxxxxxx`   Fax `+xxx xxxxxxxx`

Proposal Submission Forms

PIC	*Legal name*
999979015	EIDGENOESSISCHE TECHNISCHE HOCHSCHULE ZUERICH

Short name: ETH Zurich

Address of the organisation

Street   Raemistrasse 101

Town   ZUERICH

Postcode   8092

Country   Switzerland

Webpage   www.ethz.ch

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...06/01/2009 - no

SME self-assessment .... unknown

SME validation sme..06/01/2009 - 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 | Swiss National Supercomputing Centre | ☐ not applicable

☐ Same as proposing organisation's address

Street | Via Trevano 131

Town | Lugano

Postcode | 6900

Country | Switzerland

Dependencies with other proposal participants

Character of dependence	*Participant*	

Proposal Submission Forms

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 Ms

Sex ○ Male ⦿ Female

First name **Katarzyna** Last name **Pawlikowska**

E-Mail **kasia@cscs.ch**

Position in org. Research Collaboration Coordinator

Department Swiss National Supercomputing Centre ☐ Same as organisation name

☐ Same as proposing organisation's address

Street Via Trevano 131

Town Lugano Post code 6900

Country Switzerland

Website www.cscs.ch

Phone +41 91 610 8257 Phone 2 +xxx xxxxxxxxx Fax +41 91 610 8282

Other contact persons

First Name	Last Name	E-mail	Phone
Lucas	Benedicic	benedicic@cscs.ch	+41 91 610 8220
Will	Sawyer	wsawyer@cscs.ch	+41 91 610 8229

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

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	

Proposal Submission Forms

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. Scientist

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 +xxx xxxxxxxx   Phone 2 +xxx xxxxxxxx   Fax +xxx xxxxxxxx

Other contact persons

First Name	Last Name	E-mail	Phone
Liz	Fay	liz.fay@manchester.ac.uk	+xxx xxxxxxxx
Natalia	Stefanovic	researchsupportcsm@manchester.ac.uk	+xxx xxxxxxxx
Su	Smith	su.smith@manchester.ac.uk	+xxx xxxxxxxx

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

Short name: NLeSC

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   Legal person ....yes

Non-profit ....yes

International organisation ....no

International organisation of European interest ....no

Secondary or Higher education establishment ....no   Industry (private for profit)..................no

Research organisation ....yes

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*	

Proposal Submission Forms

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 **Ben**   Last name **Vanwerkhoven**

E-Mail **b.vanwerkhoven@esciencecenter.nl**

Position in org. `Scientist`

Department `STICHTING NETHERLANDS ESCIENCE CENTER`   ⊠ Same as organisation name

⊠ Same as proposing organisation's address

Street `SCIENCE PARK 140`

Town `AMSTERDAM`   Post code `1098 XG`

Country `Netherlands`

Website ` `

Phone `+xxx xxxxxxxx`   Phone 2 `+xxx xxxxxxxx`   Fax `+xxx xxxxxxxx`

Proposal Submission Forms

PIC
990186089

Legal name
EIDGENOESSISCHES DEPARTEMENT DES INNERN

Short name: MeteoSwiss

Address of the organisation

Street Inselgasse 1

Town BERN

Postcode 3003

Country Switzerland

Webpage www.edi.admin.ch

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

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*	

Proposal Submission Forms

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 **Daria**   Last name **Wanner Stamm**

E-Mail **daria.wannerstamm@meteoswiss.ch**

Position in org. Grant manager

Department EIDGENOESSISCHES DEPARTEMENT DES INNERN   ☒ Same as organisation name

☒ Same as proposing organisation's address

Street Inselgasse 1

Town BERN   Post code 3003

Country Switzerland

Website

Phone +xxx xxxxxxxx   Phone 2 +xxx xxxxxxxx   Fax +xxx xxxxxxxx

Proposal Submission Forms

PIC
911849083

Legal name
DATADIRECT NETWORKS FRANCE

Short name: DDN

Address of the organisation

Street   10-12 rue Andras Beck

Town   Meudon la foret

Postcode   92360

Country   France

Webpage   ddn.com

Legal Status of your organisation

Research and Innovation legal statuses

Public body ....unknown

Non-profit ....unknown

International organisation ....unknown

International organisation of European interest ....unknown

Secondary or Higher education establishment ....unknown

Research organisation ....unknown

Legal person ....yes

Industry (private for profit).................unknown

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

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	

Proposal Submission Forms

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 **Jean-Thomas**   Last name **Acquaviva**

E-Mail **jacquaviva@ddn.com**

Position in org. | Scientist |

Department | DATADIRECT NETWORKS FRANCE | ☒ Same as organisation name

☒ Same as proposing organisation's address

Street | 10-12 rue Andras Beck |

Town | Meudon la foret | Post code | 92360 |

Country | France |

Website | |

Phone | +xxx xxxxxxxx | Phone 2 | +xxx xxxxxxxx | Fax | +xxx xxxxxxxx |

PIC	*Legal name*
974300496	*MERCATOR OCEAN*

Short name: MO

Address of the organisation

Street   RUE HERMES 8-10 PARC TECHNOLOGIQUE

Town   RAMONVILLE SAINT AGNE

Postcode   31520

Country   France

Webpage   www.mercator-ocean.fr

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...04/06/2010 - 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

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   Ms   Sex   ○ Male ● Female

First name   **Laura**   Last name   **Cherdel**

E-Mail   **laura.cherdel@mercator-ocean.fr**

Position in org.   Grant Manager

Department   MERCATOR OCEAN   ☒   Same as organisation name

☒ Same as proposing organisation's address

Street   RUE HERMES 8-10 PARC TECHNOLOGIQUE DU CANAL

Town   RAMONVILLE SAINT AGNE   Post code   31520

Country   France

Website

Phone   *+xxx xxxxxxxx*   Phone 2   *+xxx xxxxxxxx*   Fax   *+xxx xxxxxxxx*

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	Deutsches Klimarechenze ntrum Gmbh	DE	790000	325500	0	0	0	278875,00	0	1394375,00	100	1394375,00	1394375,00
2	Centre National De La Recherche	FR	414800	24250	0	0	0	109762,50	0	548812,50	100	548812,50	548812,50
3	European Centre For Medium-range	UK	683100	30000	0	0	0	178275,00	0	891375,00	100	891375,00	891375,00
4	Barcelona Supercomputi ng Center -	ES	180000	10750	0	0	0	47687,50	0	238437,50	100	238437,50	238437,50
5	Max-planck-gesellschaft Zur Forderung	DE	343200	16000	0	0	0	89800,00	0	449000,00	100	449000,00	449000,00
6	Sveriges Meteorologisk a Och	SE	120600	4500	0	0	0	31275,00	0	156375,00	100	156375,00	156375,00
7	Centre Europeen De Recherche Et	FR	138000	20500	0	0	0	39625,00	0	198125,00	100	198125,00	198125,00
8	National University Of Ireland Galway	IE	40038	1500	0	0	0	10384,50	0	51922,50	100	51922,50	51922,50
9	Met Office	UK	210748	11550	0	0	0	55574,50	0	277872,50	100	277872,50	277872,50
10	Fondazione Centro Euro-mediterraneo	IT	378000	29250	0	0	0	101812,50	0	509062,50	100	509062,50	509062,50

Proposal ID **SEP-210494560**   *Acronym* **ESiWACE2**

11	The University Of Reading	UK	402720	65569	0	0	0	117072,25	0	585361,25	100	585361,25	585361,25
12	Science And Technology Facilities	UK	372000	25000	0	0	0	99250,00	0	496250,00	100	496250,00	496250,00
13	Bull Sas	FR	317240	23000	0	0	0	85060,00	0	425300,00	100	425300,00	425300,00
14	Seagate Systems Uk Limited	UK	187500	4500	0	0	0	48000,00	0	240000,00	100	240000,00	240000,00
15	Eidgenoessische Technische Hochschule	CH	208800	11000	0	0	0	54950,00	0	274750,00	100	274750,00	274750,00
16	The University Of Manchester	UK	127106	12000	0	0	0	34776,50	0	173882,50	100	173882,50	173882,50
17	Stichting Netherlands Escience	NL	281400	18500	0	0	0	74975,00	0	374875,00	100	374875,00	374875,00
18	Eidgenoessisches Departement	CH	320680	16000	0	0	0	84170,00	0	420850,00	100	420850,00	420850,00
19	Datadirect Networks France	FR	210000	5500	0	0	0	53875,00	0	269375,00	100	269375,00	269375,00
20	Mercator Ocean	FR	45000	2250	0	0	0	11812,50	0	59062,50	100	59062,50	59062,50
	Total		5770932	657119	0	0	0	1607012,75	0	8035063,75		8035063,75	8035063,75

Proposal ID **SEP-210494560**	*Acronym* **ESiWACE2**

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	

Proposal Submission Forms

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.*

	Title of Proposal:	**Excellence in Simulation of Weather and Climate in Europe, Phase 2**

Title of Proposal: **Excellence in Simulation of Weather and Climate in Europe, Phase 2**

Acronym: **ESiWACE2**

Work Programme: **Horizon 2020 Work Programme 2018-2020;**
European research infrastructures (including e-Infrastructures)

Call: **INFRAEDI-02-2018: HPC PPP – Centres of Excellence on HPC**

List of participants

No*	Participant organisation name	Acronym	Country
1 **COORDINATOR**	Deutsches Klimarechenzentrum GmbH	DKRZ	Germany
2	Centre National de la Recherche Scientifique	CNRS-IPSL	France
3	European Centre for Medium-Range Weather Forecasts	ECMWF	United Kingdom
4	Barcelona Supercomputing Center	BSC	Spain
5	Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V./ Max-Planck-Institut für Meteorologie	MPIM	Germany
6	Sveriges meteorologiska och hydrologiska institut	SMHI	Sweden
7	Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique	CERFACS	France
8	National University of Ireland Galway (Irish Centre for High End Computing)	ICHEC	Ireland
9	Met Office	METO	United Kingdom
10	Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici	CMCC	Italy
11	The University of Reading	UREAD	United Kingdom
12	Science and Technology Facilities Council	STFC	United Kingdom
13	BULL SAS	BULL	France
14	Seagate Systems UK Limited	SEAGATE	United Kingdom
15	ETH Zürich	ETH Zurich	Switzerland
16	The University of Manchester	UNIMAN	United Kingdom
17	Netherlands eScience Center	NLeSC	Netherlands
18	Federal Office of Meteorology and Climatology	MeteoSwiss	Switzerland
19	DataDirect Networks	DDN	France
20	Mercator Océan	MO	France

*Same participant numbering as that used in the administrative proposal forms.

Table of Content

1 Excellence

The Centre of **Excellence in Simulation of Weather and Climate in Europe** (ESiWACE) leverages two established European networks, namely the European Network for Earth System modelling (ENES), representing the European climate modelling community and the world-leading European Centre for Medium-Range Weather Forecasts (ECMWF), which is an independent European organisation supported by 34 member and cooperating states.

Numerical weather prediction and climate modelling are highly dependent on the available computing power and the ability to produce, store and analyse large amounts of simulated data. All of these points directly impact the achievable spatial resolution and the completeness of physical processes that can be represented in the models.

ESiWACE2 is demonstrating and improving scalability of some of Europe's leading weather and climate models on world class HPC systems and is prototyping new tools and methods for management of climate and weather data in the exascale era.

With this proposal we request funding for the second phase of this Centre of Excellence (CoE) as ESiWACE2.

The first phase of ESiWACE (ESiWACE1) is setting the stage for a joint climate and weather community engagement in research and service provision. ESiWACE2 will extend and focus this engagement towards the delivery of accurate and computationally efficient Earth system modelling systems suited for the seamless simulation of weather and climate at (pre-)exascale. This capability is particularly relevant with respect to the prediction of extreme events in a changed climate.

In view of drastically changing paradigms in HPC architectures and programming models, the ESiWACE2 consortium has been strengthened by adding partners with leading expertise in innovative software development for climate and weather codes, and world class expertise in supercomputing.

ESiWACE2 will leverage the potential of the envisaged EuroHPC[1] pre-exascale systems to push European climate and weather codes to world-leading spatial resolution for production-ready simulations, including the associated data management and data analytics workflows. For this goal, the portfolio of climate models supported by the project has been extended with respect to the demonstrators of ESiWACE1. Additionally, we will set up training and dedicated services to enable the wider community to efficiently use upcoming pre-exascale and exascale supercomputers.

While the central focus of this project lies on achieving our scientific performance goals with HPC systems that will become available within the next four years, we will also target our research and development to prepare the community for the systems of the exascale era.

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[1] https://ec.europa.eu/digital-single-market/en/eurohpc-joint-undertaking

1.1 Objectives

The principal objectives of ESiWACE2 are to:

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(1) Enable leading European weather and climate models to leverage the available performance of pre-exascale systems with regard to both compute and data capacity in 2021.

(2) Prepare the weather and climate community to be able to make use of exascale systems when they become available.

To achieve these high-level objectives, the ESiWACE2 consortium has set a number of specific objectives, which lay the foundation for the work plan of this proposal.

(a) Boost European climate and weather models to operate in world-leading quality on existing supercomputing and future pre-exascale platforms

We will improve throughput and scalability of leading European weather and climate models and demonstrate the technical and scientific performance of the models in unprecedented resolution on pre-exascale EuroHPC systems. (WP1)

(b) Establish new technologies for weather and climate modelling

We will develop and establish domain-specific languages (DSLs) for community models and evaluate the potential of innovative technologies such as machine learning to explore new methodologies in Earth system modelling. (WP2)

(c) Enhance HPC capacity of the weather and climate community

We will provide support and training to the community to profile and optimise code performance, and to port models to existing and upcoming exascale supercomputers. (WP3, WP6)

(d) Improve the toolchain to manage data from climate and weather simulations at scale

We will develop tools to mitigate the effects of the data deluge from high-resolution simulation: ensemble tools to minimise data output, storage middleware to handle IO performance, and improved tools for post-processing data analytics and visualisation. (WP4, WP5)

(e) Strengthen the interaction with the European HPC ecosystem

We will reach out to the European HPC initiatives, in particular to related FET projects, to PRACE and to EuroHPC and we will provide platforms for dedicated interactions between the climate and weather community and the HPC stakeholders. (WP6)

(f) Foster co-design between model developers, HPC manufacturers and HPC centres

Co-design will in particular be supported through the High-Performance Climate and Weather benchmark (HPCW; WP3) but also by all of the above. (all WPs)

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Why are these objectives crucial for the future success of weather and climate modelling?

Weather and climate simulations have been intimately connected with progress in supercomputing since the first numerical forecast was made about 65 years ago. Operational prediction centres currently run single ten-day forecasts at 9 km, ensembles of global model forecasts down to 18 km resolution into the medium range (3-30 days), at 36 km resolution up to one month ahead, and climate simulations at 100 km resolution for decades and centuries. Weather and climate model development is a long-term effort. Current models have evolved over decades, shaped by hundreds of person-years of work. The spatial resolution, a crucial parameter to improve the quality and reliability of the simulations, has been continuously refined over decades, exploiting the continuing increase in available compute power. However, the fact that today's increase in theoretical peak performance of available HPC systems is mainly achieved by increasing parallelism has led to a challenging situation. The major limiting factor for very high-resolution models is no longer the theoretical peak performance of available HPC systems. It is rather a) the scalability of the models and the associated data management workflows and b) the achievable throughput, i.e. the "time-to-solution". The next significant step in refining the reliability of Europe's leading climate and weather models by enhancing resolution and model complexity requires a coordinated and joint effort between model owners, software experts, and HPC providers.

The first objective is to take this step, and to

> **prepare Europe's leading weather and climate prediction models for operation on Europe's upcoming pre-exascale systems.**

A key target for the next decade is to reach spatial resolutions with global models of at least 1 km. This resolution enables the explicit representation of convective clouds and small-scale ocean eddies. It will therefore decrease errors and uncertainties in both weather and climate predictions significantly since processes of immense importance for the global circulation, namely deep convection and orographic wave drag, can be represented explicitly, avoiding crude parameterisation schemes. As a consequence, these "cloud-resolving" simulations will yield better predictions of trends and provide much more fidelity in the representation of high-impact regional events. This is clearly not achievable today and will require at least exascale computing, significantly improved data handling capability and innovative software techniques.

Today's models represent many components of the complex Earth system including the atmosphere, oceans, sea-ice and the land surface. However, many important subgrid-scale processes remain unresolved due to a lack of computational power that would allow simulations at higher resolution and increased complexity. In the future, weather and climate prediction models are expected to converge towards so-called Earth system models (ESMs) representing all relevant physical and (bio-)chemical processes at their native scales. Just like weather forecasting models, ESMs will be run in ensemble mode to produce predictions of future states and their uncertainties. Today's high-resolution models generate tens of terabytes of data per forecast, and are likely to produce petabytes in the next decade – and these numbers scale linearly with ensemble size.

Simulations with coupled atmosphere and ocean require a throughput rate of at least 1 simulated model year per day of integration (SYPD) to be useful for operational weather and climate predictions. In the first period of the Centre of Excellence in Simulation of Weather and Climate in Europe and in collaboration with other initiatives (such as the German project HD(CP)^2)[2], it was shown that it is technically possible to run global atmosphere-only simulations with up to 1 km nominal horizontal resolution[3]. However, neither models nor the

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[2] www.hdcp2.eu

[3] https://www.esiwace.eu/results/achievements

available supercomputing platforms were sufficient to achieve a performance that would enable weather and climate predictions to run within the required time-to-solution standards and at full complexity.

Being able to run Earth system simulations at 1 km global resolution at an acceptable throughput rate with full model IO is still a long-term challenge for the community that will require significantly more resources with regard to hardware, i.e. true extreme-scale platforms as well as revolutionary model development approaches. To keep up with the radical and rapid changes of hardware and corresponding programming models, for example, has always been a major challenge for weather and climate modellers. Until today, only very few weather and climate models make efficient use of heterogeneous hardware architectures and accelerators such as GPUs, which is mainly due to the complexity of the models that have millions of lines of code. The FET-HPC project ESCAPE[4] has pioneered the assessment of such architectures with selected model components, so-called weather and climate dwarfs, and concluded that significant code adaptation and investment in new programming models is needed to extract additional performance. ESiWACE2 will investigate how novel software techniques (such as domain-specific languages and machine learning) that appear to be attractive for weather and climate prediction may help to solve the aforementioned issues.

Thus, the second objective aims at

> **defining a strategy for Europe's leading weather and climate prediction models to achieve 1 km resolution and 1 simulated year per day, and to make first steps in this direction.**

The ESiWACE1 model demonstrators confirmed that with current model codes and hardware, time-to-solution falls short by about a factor of 100 for fully coupled atmosphere-ocean models including IO at a nominal resolution of 1 km. The nominal resolution refers to the grid spacing defined in the model set up. This does not imply that processes at 1 km scale will be resolved, so that the actual shortfall factor is likely to be at least one order of magnitude larger.

Achieving a 10^4-fold increase in efficiency with affordable electrical power footprints of the HPC system will require an investment at all levels, namely scientific algorithms, programming models and heterogeneous hardware solutions. This investment has to simultaneously account for the requirement of performance and portability across HPC architectures and models. The magnitude of this challenge as well as the need to intimately couple weather and climate models with impact prediction and risk assessment systems has motivated the concept of the *ExtremeEarth*[5] Flagship proposal in response to the FETFLAG-01-2018 call issued by the EC. While *ExtremeEarth* is aiming for a complete multi-disciplinary science-technology solution for addressing the challenges of environmental extremes in the next decades, ESiWACE2 will focus on the weather and climate-specific issues required to efficiently operate existing models on near-term EuroHPC type infrastructures. Building on developments from other FET-HPC projects (in particular ESCAPE and ESCAPE-2), ESiWACE2 will be crucial for defining the weather and climate community's strategy for the period leading towards and for *ExtremeEarth* itself.

While the clear goal of ESiWACE2 is to seize the opportunity provided by extreme-scale computing capabilities through very high-resolution modelling (reducing the necessity for parameterising physical processes), we believe the project will yield benefits for all of weather and climate science. The technical challenges associated with performance portability and data deluge apply to large ensembles and complex models as much as to high resolution, and the science requires us to compare and contrast all available approaches to understand the Earth system.

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[4] www.hpc-escape.eu; (grant agreement for ESCAPE-2 is in preparation)

[5] www.extremeearth.eu

1.2 Relation to the work programme

ESiWACE2 is set out as a centre of excellence in the environmental sciences, addressing elementary infrastructure, research and innovation actions in weather and climate simulation. Its main focus is on the call area 2 "Environmental sciences: climate and weather simulation, natural hazards forecast and prevention".[6]

Text of call INFRAEDI-02-2018	Targeted by ESiWACE2 through:
Specific Challenge:	
Promote the use of upcoming exascale and extreme performance computing capabilities in areas where user communities in collaboration with other HPC stakeholders can develop or scale up existing parallel codes towards exascale and extreme scaling performance, resulting into tangible benefits for addressing scientific, industrial or societal challenges	• Delivery of selected very high-resolution weather and climate models, based on existing leading community codes that require pre-exascale capability to be used in production and for producing world class science • Provision of services to the community to optimise and scale up existing weather and climate codes • Exploiting a consortium of leading European institutions in weather prediction, climate research, HPC-centres and the HPC-industry
Scope (Points to be addressed by the proposal):	
Research in HPC applications towards highly scalable, optimised codes and the path to exascale performance (both computing and extreme data)	• Research on scalability and code optimisation (at algorithmic and implementation level) for European, world-leading weather and climate models towards exascale computing and data handling capability (WP1, WP2) • Research on DSLs and other novel technologies to enhance programmability for European models on future processor technologies (WP2) • Research on innovative data middleware and tools to efficiently handle exascale weather and climate data (WP4, WP5)

The provision of services supporting different usage models for the community needs, and contributing to the potential convergence of HPC, high-throughput computing (HTC), and high-performance data analytics (HPDA). This includes developing, maintaining, optimizing (if needed re-design) and scaling HPC application codes, addressing the full scientific/industrial workflow, particularly covering data aspects; testing and validating codes and	• Delivery of production-ready weather and climate prediction models, comprising the whole simulation workflow, designed for high throughput to be scientifically useful. This will be done by
	   ○ Scaling, optimising and partially refactoring selected existing and proven models (WP1)
	   ○ Providing services to the community to analyse, optimise, redesign and/or scale additional models
	• Including the full data management workflow (WP4) and in-situ compression, visualisation and analytics of very large amounts of weather and climate simulation data (WP5) into production-ready codes of WP1
	• Quality assurance (scientific) through cooperation with national and international domain experts (WP1, Task 1.4 and WP6, WP7,

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[6] *NOTE: this proposal has its main focus of work on the Call Area 2 "Environmental sciences: climate and weather simulation, natural hazards forecast and prevention". We are aware that another proposal (ChEESE) has been submitted in Call Area 9 ("Other domains") which will address early warning and forecasting of geohazards. Both proposals are complementary, since they cover weather and climate-related hazards (ESiWACE2) and geohazards (ChEESE) with no overlap.*

quality assurance	see also section 3.5.1, Scientific Advisory Board) • Quality assurance (technical) through continuous integration and end-to-end testing (WP4, Task 4.6)
Commitment to the co-design approach (hardware, software, codes), including the identification of suitable applications relevant to the development of HPC technologies towards exascale	• Involving partner BULL in services on performance optimisation (WP3) and partners DDN and SEAGATE in development of the IO stack (WP4) • Dissemination of the HPCW benchmark suite relevant to HPC technology development and performance benchmarking (WP3, Task 3.4) • Application of co-design on programmability between computer science and weather and climates science to the DSL development (WP2) • See also section 1.3.2.2, Co-design aspects, and section 2.1)
In collaboration with PRACE, address the skills gap in computational science in the targeted domain by specialised training and capacity building measures to develop the human capital resources for increased adoption of advanced HPC in industry (including SMEs) and academia	• Crossing the chasm in education between computational science and weather and climate modelling with regard to extreme-scale computing by supporting and organising specialised trainings, workshops and summer schools on HPC software engineering, IO, HPDA, containerisation, DSLs, etc., with a focus on (pre-)exascale challenges for weather and climate applications (WP6) • Synchronisation of training with PRACE via CSA for CoE (WP6, WP7) • Interactions with the European HPC ecosystem (WP6)
Data management and long-term data stewardship, in particular towards exascale	• Development of a data management plan (WP7) • Infrastructure (including output data management) for global high-resolution simulations (in cooperation with the international DYAMOND[7] initiative) (WP1) • Development of a semantic storage layer and Earth system data middleware to manage exascale data (WP4) • Cooperation with well-established data services via consortium partners, which will, in the long term, facilitate downstream provision of data; e.g. Earth System Grid Federation (ESGF), World Data Center for Climate (WDCC), UK Centre for Environmental Data Analysis (CEDA), and Meteorological Archival and Retrieval System (MARS)
Widening the access to codes and fostering transfer of know-how to user communities, including specific and targeted measures for industry and SMEs	• Enhanced sharing of code, best practices and corresponding expertise through ESiWACE2 community services (WP3) • Knowledge transfer on evolving new technologies (exascale hardware, heterogeneous computing, machine learning, containerisation) via workshops and white papers (WP2) • Sharing improved tools, such as OASIS and XIOS, by the entire community (WP1,WP6) • Fostering exchange of know-how on data management requirements between the weather and climate community and storage vendors (SEAGATE, DDN) (WP4) • Selected measures for industry provided through key performance indicators (WP7)

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[7] https://www.esiwace.eu/services/dyamond

Business plans for long-term sustainability embracing a wide range of service models and funding options	• Sustainability planning taking into account related community activities as briefly laid out in section 2.2, a2) (WP7, deliverable D7.8) • Long-term strategies of consortium partners to support the models selected by WP1 • Involvement of model consortia (e.g., the NEMO- and EC-Earth consortia) to guarantee uptake of ESiWACE2 developments • Prototyping novel service models for weather and climate codes (WP3)
In collaboration with the support action foreseen for CoEs (specific challenge (b) of this topic), addressing the fragmentation of HPC activities for excellence in applications, and fostering the widening of the use of HPC codes in the EU	• Bi-directional support for dissemination of training activities and other events, with ESiWACE2 focusing on the weather and climate case (WP6) • Willingness to share outreach material and participation in the support action for CoEs, in particular offering a seat on the ESiWACE2 Scientific Advisory Board to the CSA-CoE • Liaising with the European HPC ecosystem (such as other CoEs, ETP4HPC, PRACE, EuroHPC) (WP6) • Strong focus on dissemination of ESiWACE2 results and activities to other communities (WP7)

Expected impacts (For a more detailed answer **see section 2.1**):

European leadership in exascale and extreme-scale-oriented codes and innovative algorithms/solutions that address societal challenges or are important for key scientific and industrial applications	Leading role of European climate and weather models
Improved access to computing applications and expertise that enables researchers and industry to be more productive, leading to scientific excellence and economic and social benefit	Provision of full-blown scientifically useful applications
Improved competitiveness for European companies and SMEs through access to CoE expertise and services	Help the industry to understand computational and data requirements and thus be internationally competitive
Federating capabilities and integrating communities around computational science in Europe	Integrate a large base of direct and indirect users
A large number of scientists and engineers, in particular female and young ones, trained in the use of computational methods and optimisation of applications	Provide trainings and support

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1.3   Concept and methodology

1.3.1   Concept

Europe's numerical prediction models have evolved over decades. They have contributed to Europe's leading position in weather and climate science and to their close link to service provision to citizens via national meteorological-hydrological centres, ECMWF and Copernicus[8] services. The associated computer codes represent substantial financial and intellectual investments and their adaptation to the evolving HPC architectures continually occupies significant resources. While substantial progress has been made in improving the efficiency and scalability of these codes, it is not obvious how the ambitious 1 km resolution goal, in both atmosphere and ocean, can be reached. This goal is expected to eliminate key sources of model error, for example, those associated with parameterised processes such as clouds and convection (Schneider et al. 2017)[9] and those associated with ocean-atmosphere interactions (Hewitt et al. 2017)[10]. It is also expected to deliver benefits for all other facets of weather and climate modelling, including lower resolution, large ensembles and long duration paleoclimate runs (Mitchell et al, 2012)[11].

Already today, numerical weather and climate prediction centres and their dedicated computing facilities face substantial challenges due to the rising cost of energy associated with running complex high-resolution forecast models on more and more processors as, with the end of Dennard scaling and Moore's law, microprocessor density (and performance) no longer doubles every two years. But the biggest challenge to state-of-the-art computational weather and climate prediction services arises from their own software productivity shortfall. The application software at the heart of all services throughout Europe is not equipped to efficiently adapt to the rapidly evolving heterogeneous hardware provided by the supercomputing industry. The sustained performance of operational models only reaches 5% of peak performance on present-day CPU technology. If this challenge is not addressed, weather and climate prediction and the associated European service infrastructure will not advance much beyond current capabilities. This is clearly not sufficient, for example, to meet the need for much enhanced skill for predicting environmental extremes in the context of climate change (Marotzke et al, 2017)[12].

The first phase of ESiWACE has quantified, for the first time, the computability of such high-resolution simulations performed with European global operational forecast models using existing technology. The result is a shortfall in computational speed by at least three orders of magnitude[13].

The solution to this grand science-technology challenge needs to account for at least two key requirements of European service infrastructures:

(1)   the need to evolve today's forecasting systems to operate on the next generation of HPC systems within the next 5 years allowing operational centres and services to continue business as seamlessly as possible.

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[8] https://climate.copernicus.eu

[9] Schneider, T et al. Earth system modeling 2.0: A blueprint for models that learn from observations and targeted high-resolution simulations. Geophysical Research Letters, 44, 12, 396-12,417, https://doi.org/10.1002/2017GL076101, 2017

[10] Hewitt, HT et al. Will high-resolution global ocean models benefit coupled predictions on short-range to climate timescales? Ocean Modelling, 120, 120-136, DOI: 10.1016/j.ocemod.2017.11.002, 2017

[11] Mitchell, J et al. Infrastructure strategy for the European Earth System Modelling community 2012-2022, ENES Report Series 1, https://doi.org/10.5285/ca90b281d6ff4cffb9a9bbdeb5fa63f3, 2012

[12] Marotzke, J et al. Climate research must sharpen its view. Nature Climate Change 7, 89-91. doi:10.1038/nclimate3206, 2017

[13] https://www.esiwace.eu/results/achievements

(2) the need to radically change scientific methodologies, codes and workflows through co-design with future infrastructures within the next 10-15 years to fully overcome the above shortfalls.

ESiWACE2 will be instrumental to effectively realise both pathways at the same time.

As Figure 1 shows, ESiWACE2 will drive the efforts to adapt the leading European weather and climate forecasting models to the emerging EuroHPC platforms with support from novel research projects contributed by FET-HPC on algorithms and numerical methods (ESCAPE[14], ESCAPE-2), precision and concurrency (ESiWACE1), programming models (ESiWACE1, EuroEXA[15], EPiGRAM-HS, ESCAPE-2), and data handling (NextGenIO[16], MAESTRO). This fulfils requirement (1) and will ensure operational production capability with EuroHPC technology. ESiWACE2 will further allow establishing the baseline for achieving requirement (2) at the same time. The project will provide input to the strategy for a much more radical reformulation of entire forecasting systems. The preparation of such a strategy is currently foreseen under the European Flagship proposal *ExtremeEarth*[17] that promises substantially advanced predictive capabilities providing the European society with a qualitatively different level of information on environmental extremes in the entire Earth system enabled by novel technologies.
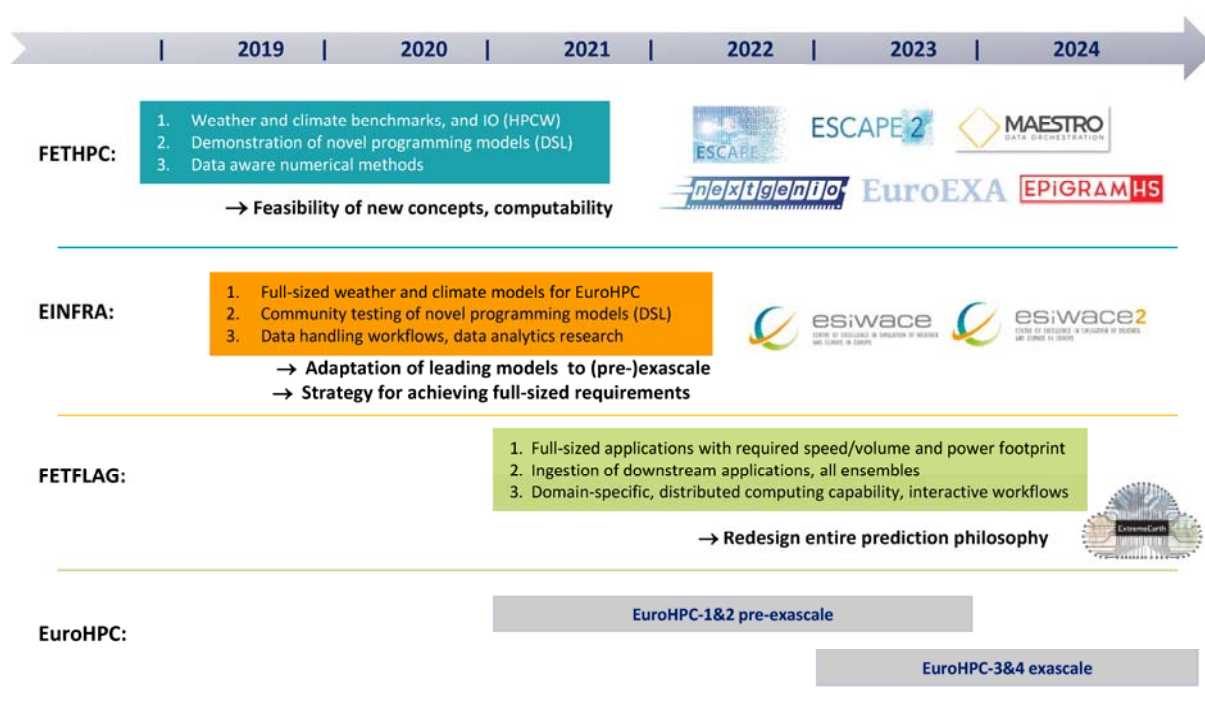
Figure 1: Weather and climate community roadmap for advancing prediction systems to meet scientific challenges of the next decades, in concert with EuroHPC: Existing FET-HPC projects providing advanced methods for computing and data for existing models – to be extended and disseminated by ESiWACE2. Breakthrough redesign of environmental prediction capabilities are targeted by the ExtremeEarth Flagship proposal. (The projects MAESTRO, EPIGRAM-HS and ESCAPE-2 are selected but have not yet started)

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[14] www.hpc-escape.eu

[15] euroexa.eu

[16] www.nextgenio.eu

[17] www.extremeearth.eu

1.3.2 Methodology

ESiWACE2 will pursue its objectives along two time scales. Within project life time we will deliver world-class applications to be deployed on the most powerful European supercomputers available in this time frame. On the longer time scale, we will prepare the European community of weather and climate modellers to cope with exascale computing (Figure 2).
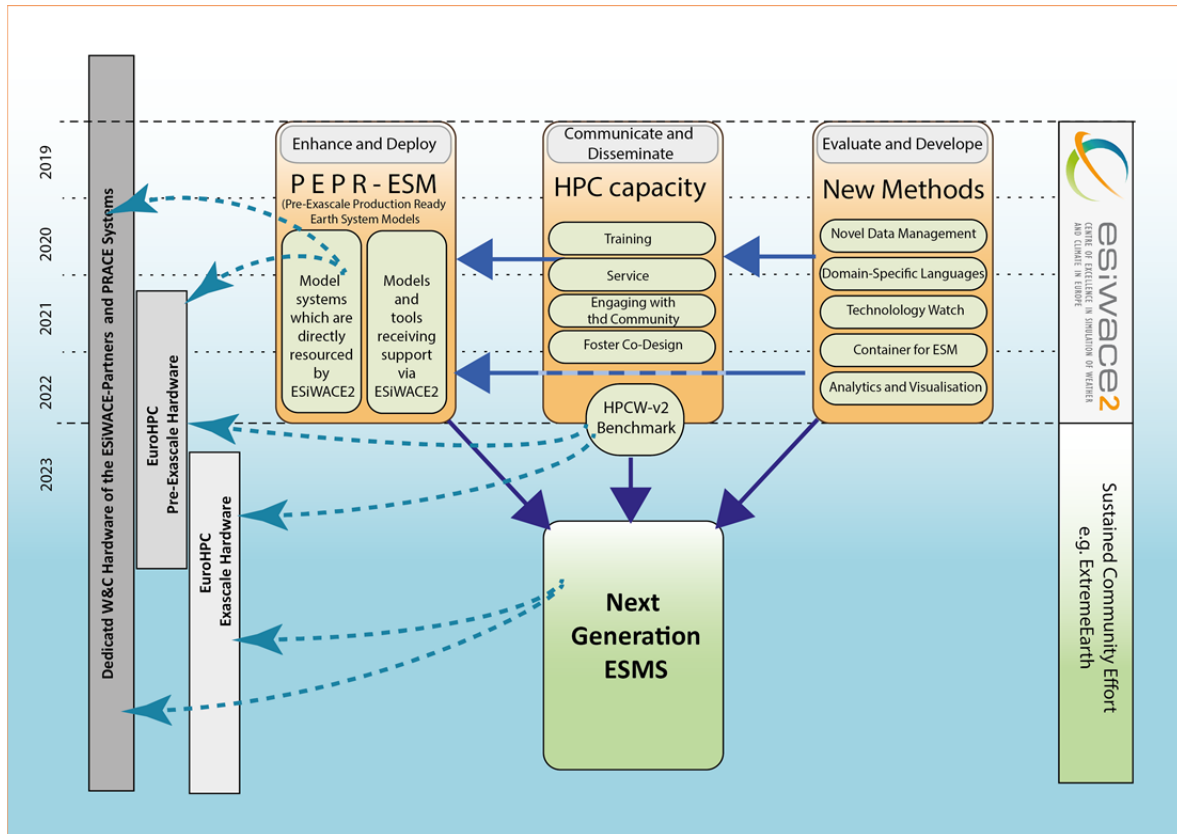
Figure 2. The central ESiWACE2 deliverables are pre-exascale production-ready model systems including data management and post-processing workflows and version 2 of the HPCW benchmark. Both will be deployed on existing systems and on the EuroHPC systems. Training and support to enhance the HPC capacity of the community and research into new methods will a) enable further models and b) feed into the development of next generation ESMs to leverage exascale capabilities.

1.3.2.1 Providing real pre-exascale applications

The central activity of ESiWACE2 will be the development of climate and weather models that are designed to deliver **scientific results in unprecedented detail and quality** and that will require pre-exascale compute and storage capabilities to run with sufficient performance and handle the data produced ("pre-exascale production-ready model systems").

We will denote the minimal scientifically useful performance by achievable time-to-solution of the models, which, for high-resolution models, is approximately 1 SYPD. For a given model and application scenario (which will be defined in cooperation with supporting climate scientists, see section 3.6.2), we will then push the resolution as far as possible to sustain the required throughput on at least one of the pre-exascale systems

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to be acquired via the European High-Performance Computing Joint Undertaking (EuroHPC JU)[18]. On such infrastructures, we expect to achieve spatial resolutions down to at least 5 km depending on the architecture and performance of the eventually implemented hardware (WP1). We hope to influence the choice of architectures by means of the High-Performance Climate and Weather benchmarks, which will be developed in the project ESCAPE-2, and extended and disseminated by ESiWACE2 (see WP3).

The models will be implemented and tested on the supercomputing systems available to the project partners (see section 3.6.2, Table 3). The computational aspects of the models will be enhanced with modern concepts to improve performance, portability, and programmability that have proven valuable in existing projects. Using container technologies, the models will be prepared for **fast and easy deployment** on new systems, in particular the EuroHPC pre-exascale systems once these are available. The containers thus complement the portability efforts started in ESiWACE1 via SPACK[19]-based software stack installations. The model codes will include new middleware to enhance the exploitation of multiple tiers of storage from on-node disk to nearline tape. The technical implementation will greatly benefit from the experience gained through the demonstrator exercise in ESiWACE1.

ESiWACE2 works primarily with four world-class model configurations. (1) **EC-Earth**[20] and (2) the weather **forecast model of ECMWF** have a long history and are considered to be among the best climate and weather models in the world. The (3) **ICON model** is currently developed to become the leading German climate model, and it is already used for operational weather predictions at the German Weather Centre. (4) At **IPSL, a model** is currently being developed with the aspiration to become the leading model for simulations of the Earth system in France. All model configurations will be used in coupled mode with both atmosphere and ocean running at very high resolution. Including the ocean model in simulations is certainly required for climate simulations. Experience has shown that the coupling to the ocean also has a very beneficial impact on global weather prediction already from the first forecast day. Three of the four models include the **NEMO** ocean model. Therefore, NEMO will also be enhanced to improve resolution for global simulations.

Raw simulation speed is only one half of the problem associated with producing and exploiting very high-resolution simulations. The data volumes at high resolution yield additional challenges. Model data shall be written without slowing down the actual model. Downstream archiving and data re-use need to be accomplished efficiently. Computing tasks must not wait for input/output by making the best use of heterogeneous tiered storage – both at run-time and in post-processing. These problems are particularly problematic when the use of other data as input or for comparison is required since this may involve moving large amounts of data over wide-area networks.

ESiWACE2 will address these issues by providing the necessary toolchain to handle data at scale. It will integrate and extend existing community software to reduce the amount of written data and to exploit the heterogeneous tiered storage landscape (NVM, local storage, shared storage, object storage) anticipated for future large-scale systems. This will be achieved by adjusting workflows towards more sophisticated experimental planning that can then be exploited by intelligent data placement and processing, as well as improved diagnostic and visualisation tools. The entire toolchain will be demonstrated using the high-resolution simulations in production mode that are described above.

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[18] https://ec.europa.eu/digital-single-market/en/eurohpc-joint-undertaking

[19] https://spack.io/

[20] https://www.ec-earth.org/

In summary, ESiWACE2 will provide model configurations that comply with the performance baseline of 1 SYPD for world-class European weather and climate models, including computation and data management, achievable on existing supercomputers and future EuroHPC pre-exascale systems.

1.3.2.2 Preparing for exascale and beyond

The **global 1 km simulation target** is expected to be only achievable through a fundamental redesign of the entire prediction system and a domain-specific co-design of software and hardware. ESiWACE2 proposes a number of activities to support this process. ESiWACE2 will support several community models in Europe to make sure that the gene pool of Europe's weather and climate models is preserved during the step to exascale computing. However, the close collaboration of leading modelling groups within ESiWACE2 will foster synergies between the groups to face the challenges of future HPC and to achieve this step as soon as possible.

Preparing the models for exascale

Traditional climate and weather models have a development time of more than 25 years and incorporate tremendous amounts of investment and valuable experience that needs to be protected. Today, the community has to face the fact that these models are not yet ready to efficiently exploit upcoming exascale systems. New methods need to be developed to optimise scalability and to minimise data communication overheads. However, given the enormous complexity of Earth system models, the potentially disruptive development of new methods has to be conducted simultaneously to the use of proven models. ESiWACE2 will prepare the weather and climate community for the exascale era by extending previous efforts in particular from the first ESiWACE phase and the projects ESCAPE and ESCAPE-2.

Exascale systems will exhibit an even higher degree of parallelism to achieve higher performance. Some, if not all, of these machines will also make use of heterogeneity within a node via accelerators (featuring, for example, both CPUs and GPUs). Unfortunately, different architectures such as CPUs and GPUs require the use of different programming models like OpenMP, OpenACC. In general, it has been shown that it is not possible to attain a single source code that is performance-portable across multiple architectures. With weather and climate models consisting of up to millions of lines of code, maintaining different source codes that run efficiently on heterogeneous architectures is not a viable option. DSLs are a promising solution to address the problem of performance portability on (pre-exascale) systems. ESiWACE2 will evaluate and start to adapt and to apply some of the most outstanding DSL solutions for weather and climate models and additionally integrate solutions for concurrent execution of different component models on hybrid architectures.

In order to prepare for the future of exascale systems, ESiWACE2 will also keep watch on future technologies such as machine learning methods to replace certain components of weather models as well as new programming models and new developments for future hardware.

Preparing data handling for exascale

Data handling is already a major bottleneck in state-of-the art weather and climate modelling. At 1 km resolution and with 100 vertical levels, one 64-bit field from a model at one time step will require 400 GB of storage – and existing approaches typically require dozens (to hundreds) of such variables to be stored at regular intervals (at 1 SYPD, 10-100 times per real day, or up to 4 PB/day). Ensembles of lower resolution models using the same amount of compute resources will write even more data (since at high resolution, more of the compute cycles are spent on shorter time steps). Once written, exploitation can be even more difficult, requiring vast amounts of scratch storage, fast tape systems, and tier2 level compute to carry out the analysis.

Three key activities are necessary to address these issues for weather and climate at exascale; (1) instead of writing all this data, other methods need to be introduced to reduce data archiving; (2) once written, the

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storage environment needs to be easier to exploit; (3) diagnostic tools need to be parallelised for a variety of possible hardware environments (GPUs etc.). ESiWACE2 will address all these points: developments for "in flight" data processing are planned (diagnostics/statistics and compression across simulations and ensembles); the complexity of the storage environment will be hidden in middleware that will at the same time exploit the throughput of the fast tiers and the capacity of the slow tiers; basic diagnostic and visualisation tools will be enhanced for exascale.

Preparing the community for exascale

We will set up a prototype **service activity** to help developers and users of weather and climate models to deploy their applications on current and upcoming tier0 systems. The goal of this service is to create small collaborative projects that provide guidance, engineering, and advice to prepare weather and climate applications for exascale. In this pilot phase, we will concentrate on profiling and performance prediction, porting of compute-intensive code elements to accelerators, assistance in the deployment of community tools for coupling, scheduling and IO on pre-exascale hardware and guidance on usage of DSLs. The provision of the services will be based on a peer review process to be set up during the first year of ESiWACE2. The service itself should run from year two to year four. Based on the experiences, we will set up a business plan to sustain relevant services (see section 2.2, a2)).

In addition to the service activity, which targets selected projects, we will provide trainings on exascale-relevant issues of tools and methods for the weather and climate community. We will offer trainings in the different HPC areas of ESiWACE2 expertise, i.e. IO, computation (DSLs, C++ and coupling software), data analytics and containerisation. Additionally, we will organise two summer schools to train scientists in the efficient usage of supercomputers for high-resolution Earth system modelling.

Co-design aspects

Co-design between developers of weather and climate applications, hardware manufactures and tier1/0 computing centres will be facilitated by the HPCW benchmarks that provide a hierarchy of key elements from the weather and climate workflow. The benchmarks will be developed and a first version will be implemented by the project ESCAPE-2 to represent key elements of the models ICON, IFS and NEMO. ESiWACE2 will extend, maintain and disseminate the benchmarks to cover a wider range of community models. The benchmarks will be ported to different hardware to identify performance bottlenecks and differences in the accuracy of results.

In terms of the IO stack, a co-design approach already started in ESiWACE1. Several vendors are involved on the low-level storage landscape and a software stack is being created, tailored to the needs of weather and climate applications and the community. Indeed, we managed to integrate top-class software products from European stakeholders into a vision of a coherent software stack that will lift the capabilities and performance to the next level. Starting from this advanced stack, further transformations, that are necessary for exascale, will be easier to be accomplished. The models and tool infrastructure will be adapted and will benefit from this software stack.

ESiWACE2 will investigate the use of DSLs in weather and climate models. Once DSLs will have been introduced, it will be much easier to port models to different hardware via the introduction of different hardware back-ends. Furthermore, the use of DSLs will facilitate the application of performance models as well as performance tuning. DSLs will therefore be very beneficial for co-design approaches in the future.

ESiWACE2 will also watch new technologies and in particular, development projects for exascale hardware in Europe and elsewhere. The potential impact of new hardware on the weather and climate community will

be evaluated and it will be considered whether specific requirements will imply adjustments in model development. Findings will be communicated to hardware developers to foster co-design.

Already in the actual funding phase of ESiWACE we plan to contribute use cases to proposals targeting the H2020 ICT-14-2019: Co-designing Extreme Scale Demonstrators (EsD). ESiWACE2 (WP6), if funded, will seek to co-operate with any EsD, if funded, in a co-design spirit.

1.3.2.3   The gender dimension

We currently consider the gender dimension of ESiWACE2 as neutral. Nevertheless, the consortium is ready to contribute to surveys and investigations fostered by the European Commission.

1.4   Ambition

The vision of ESiWACE2 is to take a significant step towards production-ready weather and climate models at (pre-)exascale based on existing software on the one hand, and to significantly advance weather and climate simulation technology as well as the community as a whole—in terms of HPC-awareness and HPC-capabilities—on the other hand. The latter aspects are particular prerequisites for future weather and climate forecasting at exascale with improved reliability. The fact that this needs to be achieved, even as the community exploits existing models to address existing operational and scientific requirements (see section 2.1), is one of the drivers for the collaborative centre-based approaches in ESiWACE1 and ESiWACE2.

With these objectives, ESiWACE2 has the concrete plan to deliver world-leading global coupled Earth system models, ready to use for scientific research, in yet unprecedented accuracy in terms of spatial resolution of climate and weather events. Given a) the enormous complexity of these models, b) the still undetermined hardware architecture of the supercomputers that will be available towards the end of this project and c) the fact that we target increase in computational throughput by at least one order of magnitude within project life time (and by a factor of 1000 on the longer run), **this endeavour is indeed very ambitious** and requires a coordinated, multi-disciplinary approach.

1.4.1   State-of-the-art and main limitations

In recent years, the need to increase efficiency and parallelism of Earth science applications has been addressed at various levels. Model components have been ported to accelerator architectures (e.g. Gysi et al. 2015)[21], mixed-precision arithmetic has been investigated (Vana et al. 2017)[22], substantial changes in numerical algorithms and respective discretisation schemes on the sphere have been undertaken to reduce communication overheads (e.g. Zängl et al. 2015[23]; Müller et al. 2015[24]), and so forth.

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[21] Gysi, T et al., STELLA: A Domain-specific Tool for Structured Grid Methods in Weather and Climate Models, in: Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis, SC '15, 41:1-12, https://doi.org/10.1145/2807591.2807627, 2015

[22] Váňa, F et al. Single Precision in Weather Forecasting Models: An Evaluation with the IFS. Mon. Wea. Rev., 145, 495-502, https://doi.org/10.1175/MWR-D-16-0228.1, 2017

[23] Zängl, G et al. The ICON (ICOsahedral Non-hydrostatic) modelling framework of DWD and MPI-M: Description of the non-hydrostatic dynamical core. Q.J.R. Meteorol. Soc., 141:563-579, doi:10.1002/qj.2378, 2015

[24] Müller, A et al. "Strong scaling for numerical weather prediction at petascale with the atmospheric model NUMA", (submitted to the International Journal of High Performance Computing Applications), 2015

Despite all these initiatives, many crucial parts of Earth system models are still limited in parallelism, the handling of an increasing amount of data towards higher resolution will become a serious bottleneck for future progress, and the inability to port models efficiently to heterogeneous hardware represents a serious risk for the efficient use of future HPC architectures. It is likely that accelerators such as GPUs will play a significant role in pre-exascale supercomputers. Yet, only a very small number of existing weather and climate models can make efficient use of accelerator hardware.

1.4.2   Moving beyond the state-of-the-art

There is an urgent need for more accessibility to different hardware architectures, abstaining from expert-level programming, through source-to-source translation and a high-level DSL front-end to translate code that is close to the equations into code that is HPC-optimal. This is likely to be achievable in a domain-specific way only. **ESiWACE2 has the ambition to establish domain-specific languages in Earth system modelling**, looking for optimal configurations across existing community models. "Optimal" is meant in the sense of (1) being acceptable with regard to model code adaption and the integration of the DSL, (2) delivering optimal code performance, and (3) determining the most useful language specification for the two most promising DSL candidates (GridTools, Psyclone-CLAW).

ESiWACE2 will transform the approach to data handling. Instead of writing, storing, extracting from tape, and handling files on file systems, users will handle *fields* that are defined semantically via interfaces with high performance and low user-facing complexity. This will facilitate and improve diagnostic systems, visualisation, and the handling of data "in-flight" and across ensembles. ESiWACE2 will also prepare the ground for active storage via the development of diagnostic kernels and schedulers that could be deployed within an appropriately configured storage system.

To be in a position to make efficient use of exascale computing, groups within the weather and climate community will have to approach each other even more closely than it has already been the case over the last decade. **The services and support actions that ESiWACE2 will provide have exactly this ambition. ESiWACE2 will foster co-design and the exchange of model codes, exploit software-defined storage, evaluate DSL approaches in various models, establish code optimisation techniques and share know-how from one group to another.** The services are a joint effort between researchers in weather or climate modelling and computational science as well as supercomputing centres and hardware or storage vendors.

Concluding, **it is crucial to overcome the aforementioned performance barriers for Earth system models. This is not a matter of simply increasing computing power measured in theoretical FLOP rates.** Addressing Europe's grand challenges, especially under continued budgetary constraints for many European countries, with limited energy availability for computing and complex storage environments, it is imperative to identify, apply and implement flexible, HPC-aware software engineering design principles for current and future weather and climate models.

1.4.3   Innovation potential

Creating production-ready global high-resolution simulations of weather and climate (WP1) at unprecedented resolution will yield **novel insight into computability that is possible at (pre-)exascale for the most recent and established models in Europe.** ESiWACE2 will answer the question "Which resolution is accessible at (pre-)exascale with 1SYPD throughput?" and develop real (pre-)exascale applications. The production-ready model configurations will enable new science at exascale and bring the community much closer to the long-term goal of performing global cloud-resolving simulations at km-scale resolution. Global simulations at 1 km resolution are expected to **decrease errors and uncertainties in both weather and climate predictions**

significantly since important processes such as deep convection and orographic wave drag can be represented explicitly. With regard to the computational requirements at exascale, **new findings at the algorithmic level will be derived from concurrency considerations across model components** (WP2, Task 2.2).

The **work towards Earth System Data Middleware (ESDM) (WP4) has the potential to feed into storage vendor software technology** to improve data handling performance also beyond Earth system modelling. In particular, the **co-design with SEAGATE and DDN bares potential to influence their product lines** (including novel Flash and NVRAM technology), thus widening market opportunities and, potentially, **feeding back into storage and corresponding software employed in pre- and exascale systems**.

The shortcomings of currently well-established benchmarks such as HPL (High-Performance LINPACK) for the prediction of a real system's performance have been widely recognised. ESiWACE2 will **improve HPCW benchmarks for weather and climate models** (WP3, task 3.4) that will facilitate performance evaluations among systems and implementations as well as for hardware vendors. HPCW will allow a more accurate, yet facilitated, evaluation of new HPC systems for climate and weather applications. HPCW is therefore particularly **attractive for testing new HPC architectures and for HPC procurements** to increase future efficiency and productivity beyond the time scope of ESiWACE2.

Increasing programmability via **domain-specific languages will substantially simplify efficient weather and climate model programming**. This **increases HPC market opportunities for SMEs and productivity of modelling groups** by enabling accelerated hardware adaptation, e.g. when transitioning "from lab to market" and "from prototype to production". By spreading the application of the DSL approach to various European models (via WP2, Task 2.4 and the services in WP3), these innovations are made accessible to modelling groups across Europe.

The services offered through WP3 will boost exchange and drive innovation among modelling groups, computer science groups, and hardware and storage vendors. The realisation of the services in the scope of ESiWACE2 will demonstrate if and how these services shall be continued as a service/business concept in the long term.

ESiWACE2 will **boost innovation beyond its time frame via trainings on relevant aspects for exascale model development** (WP6). It is recognised that well-educated and trained personnel is required in the future, with interdisciplinary backgrounds covering a wide range in weather and climate modelling, algorithms, and programming. ESiWACE2 will **ensure that Europe's innovation potential remains world-leading in weather and climate forecasting in the exascale era**.

2 Impact

2.1 Expected impacts

ESiWACE2 will strongly impact European excellence, efficiently employing exascale high-performance computing to support one of the largest societal impact areas, namely weather and climate forecasting.

Impacts listed in the Work Programme

European leadership in exascale and extreme-scale-oriented codes and innovative algorithms/solutions that address societal challenges or are important for key scientific and industrial applications:

European climate and weather models have taken a world-leading role since the very first operational forecasts have been issued more than 50 years ago. Their capabilities and developments continue to be linked to supercomputing ever since. Establishing production-ready models for European pre-exascale systems until 2021 and preparing the models and the community for exascale systems is essential for Europe to stay competitive and remain leading in weather and climate modelling. Enabling high-resolution, that is kilometre-scale, simulations at exascale will increase fidelity in climate and weather predictions and thus will have strong impacts on society and industry as outlined above.

Improved access to computing applications and expertise that enables researchers and industry to be more productive, leading to scientific excellence and economic and social benefit:

Future improvements in predictive skill for both weather and climate will originate from comprehensive coupled Earth system models with significantly enhanced spatial resolution, run as ensembles to better characterise forecast uncertainty. This implies moving computing applications from the present-day tera- and peta-scale to exascale computing. This is an endeavour that, given the architectural constraints in supercomputer design, is outside the realm of individual research institutions or operational services and requires internationally coordinated effort.

ESiWACE2 addresses this need and thus significantly contributes to the provision of (pre-)exascale computing applications and related expertise of paramount economic and social importance. Weather and climate related disasters have caused $2.4 trillion in economic losses and nearly 2 million deaths globally since 1971 as a result of hazards such as droughts, extreme temperatures, floods, tropical cyclones and related health epidemics, according to a new report by the World Meteorological Organization[25]. Notably, the United Nation's Global Assessment Report on Disaster Risk Reduction 2013[26] concluded that direct and indirect losses from natural hazards of all kinds have even been underestimated by at least 50%. More precise forecasts and their uncertainty bounds in both time and space are critical for human activities and concerns such as travel, health, work, and safety. A new risk is the changing characteristics (frequency, location, severity) of weather and climate related hazards since natural climate variability is now exacerbated by long-term, human-induced climate change. The socio-economic impact of disasters given climate change is likely to be escalating because of their increasing frequency and severity and the growing vulnerability of human societies.

Investment in systems that provide reliable simulations of these phenomena is therefore critical. The above economic assessments conclude that these investments pay for themselves many times over.

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[25] http://newsroom.unfccc.int/nature-s-role/wmo-report-the-escalating-impacts-of-climate-related-natural-disasters/

[26] http://www.unisdr.org/we/inform/publications/33013

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Improved competitiveness for European companies and SMEs through access to CoE expertise and services:

Weather and climate prediction centres form a big and influential community for HPC that is closely monitored by the entire HPC technology ecosystem (e.g.: processing, memory, storage, networks, etc.). European companies will benefit from the excellence of the ESiWACE2 consortium which involves major European actors in this field. ESiWACE2 will open substantial HPC market opportunities for European industry and SMEs as well as companies addressing specifically weather and climate such as early warning services. Mentoring service providers and preparing applications to reach their best performance by taking advantage of future HPC systems will open up new application domains, for example high-resolution, local forecasting tailored to energy, food and health users. This will impact a very large part of European industry. Regarding HPC vendors such as BULL, the knowledge acquired in the centre of excellence will enhance the quality of the company's services dedicated to the weather and climate prediction community and beyond.

The services on the HPCW benchmark, which aim to become the most relevant benchmark for the weather and climate prediction community, will provide a clear framework for the realistic testing of new technologies and procurements. This offers European companies a competitive advantage.

The weather and climate community will impact both the HPC and the Big Data market, as recent workshops and interlock activities (ETP4HPC + BDVA) have shown – indicating that the climate and weather use case provides a particular challenge and good example for joint HPC + Big Data activities in Europe. ESiWACE2 will look at some of the Big Data-oriented themes such as post-processing and analytics. This will help industrial consortium partners, such as Seagate and DDN, to harness their technologies in both the HPC and the Big Data verticals. Moreover, entirely new market perspectives are expected to arise from this interplay. Giving industry the opportunity to build technology prototypes that are suited for the weather and climate community and verticals, the time-to-market for upcoming products will be positively affected – not only for this community, but also for other related verticals in data-intensive computing. Storage currently evolves towards software-defined storage. As a consequence, new extreme-scale architectures need to be thought of as a service with a well-designed pairing of software and hardware. An output of ESiWACE2 will be a storage architecture which is optimised for large-scale weather and climate simulation. This will help Europe's local engineering workforce to grow and increase attractiveness of Europe as a scientific hotpot for future computing technologies.

Federating capabilities and integrating communities around computational science in Europe:

ESiWACE2 assembles and integrates leading European weather and climate scientists, computer and computational scientists, as well as industrial partners from HPC and data technology to develop the next generation of scalable weather and climate community models. The direct users of ESiWACE and ESiWACE2 span the model developers and HPC architects who are preparing for future heterogeneous multi-core HPC developments and those responsible for the current and near-term software infrastructure (the operational weather centres and the ENES infrastructure [27] supporting operational aspects of climate modeling). The work of these direct users will allow partner institutions to exploit these next generation tools to deliver scientific results relevant to the policy and security of their nations and the global community. Future users could also include any private sector companies that arise to exploit climate and weather services. Other indirect users include the supranational bodies such as the World Meteorological Organisation (WMO), the World Climate Research Programme (WCRP), the World Weather Research

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[27] https://is.enes.org/

[ESiWACE2]   template WP18-20 v20171006

Programme (WWRP) and future exercises of the Intergovernmental Panel on Climate Change (IPCC), see Figure 3. At highest level, the economic and societal benefits due to more accurate weather forecasts and climate projections are wide-ranging, affecting both our safety and efficiency – turning the whole society into a beneficiary of our work.

Furthermore, ESiWACE2 will exploit synergies with other Centres of Excellence either through direct collaboration, for example with a centre of excellence on performance optimisation (such as the CoE POP in phase1; if funded) or through the coordinating services provided by the CoE Coordination and Support Action (CSA) planned under call INFRAEDI-02-2018.
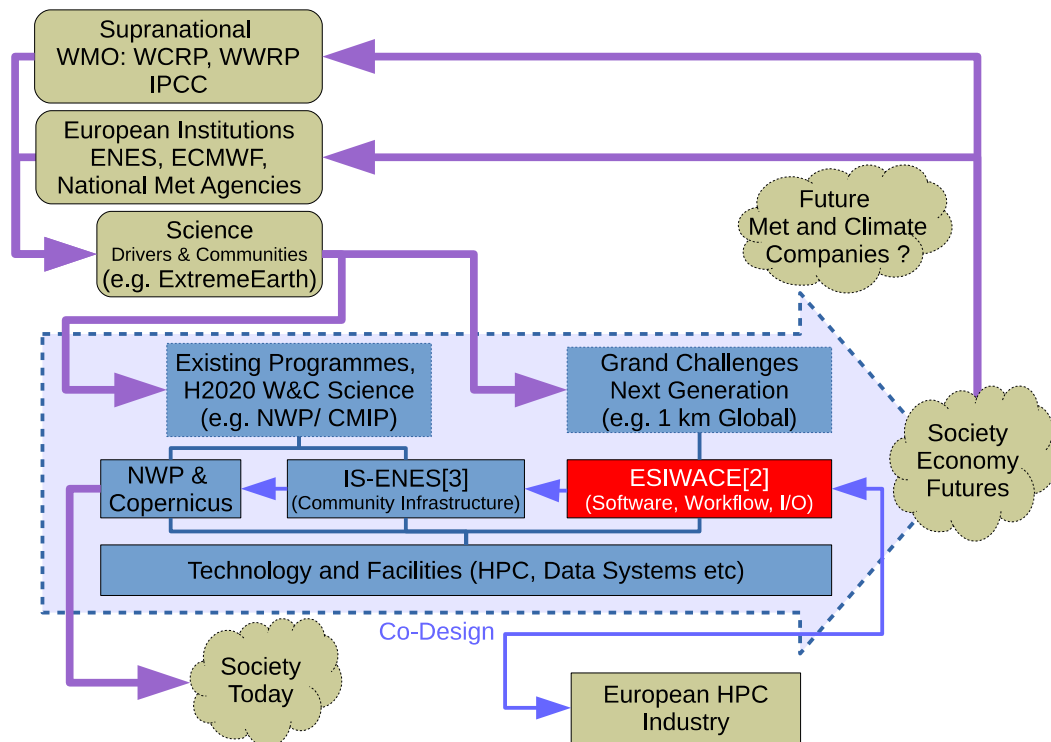
Figure 3: The relationship between science drivers, ESIWACE2 and other key software projects, facilities and downstream impacts, including feedbacks to new scientific and societal objectives via national and supranational programmes.

A large number of scientists and engineers, in particular female and young ones, trained in the use of computational methods and optimization of applications:

ESiWACE2 will offer diverse training programmes on pre-exascale HPC software engineering, methods and tools for engineers and scientists in the domain of weather/climate. Indeed, running (pre-)exascale applications on the most advanced supercomputers asks for well-trained and highly-qualified staff ensuring sound programming of the applications and expert use of all components in the ecosystem. Attention will be specifically paid to attracting female and young people to participate. Face-to-face and online trainings (WP6) will constitute the transfer of general knowledge from ESiWACE2 experts to the community while the services from WP3 will constitute a precise and individual answer to user-specific problems that are encountered by developer groups on their path to exascale. The trainings will be coordinated with the ones offered by the PRACE Advanced Training Centres (PATCs) in cooperation with the CoE CSA.

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Conditions that may determine whether and to what extent the expected impacts will be achieved

Performance and scalability of weather and climate models depend on the underlying HPC architecture. The trend to more parallelism, particularly utilising many "weak" compute cores (e.g. GPUs), has drastically decreased the efficiency of these codes in terms of the ratio of theoretical peak performance (in FLOPS) to sustained performance. To what extent the expected impacts will be achieved therefore crucially depends on the procurement of the EuroHPC systems, in particular if and how the requirements of weather and climate codes, are considered, e.g. by using the HPCW as benchmark for these systems.

On the longer time scale, our goal is to mitigate the influence of the hardware architecture on performance by implementing DSLs for climate and weather codes. The impact of this effort crucially depends on a) the success in developing efficient DSLs for this type of codes and b) the degree to which the DSLs are adopted by the climate modellers, which in turn will be determined by the ease of use of the DSLs themselves.

Given the growing complexity of weather and climate models, the long time frame necessary to develop them and the need to continuously adapt them to new HPC systems, the long-term impacts of ESiWACE2 and related projects mandate a growing and sustained community effort. The community has addressed this via the ExtremeEarth proposal, but would need to follow other funding routes, if this is not successful.

Key performance indicators and targets

To measure the **project's success in achieving each of the expected impacts specified above**, we defined the following sets of key performance indicators (KPIs). For each of these sets, we define a number of metrics, which will be refined during the first three months of the project (D7.7). Detailed statistics and measurements will be carried out at least annually. The results and the deduced progress will be reported in detail in the periodic reports and review meetings:

- **How close are we to exascale?** This will be measured by the number of compute nodes utilised when sustaining our key target of 1 SYPD with the highest resolution we can achieve at the time of measurement. This will be done for all models used by WP1. The final targets for the resolution of the different models are defined in WP1, task 1.2. The target for the number of utilisable nodes is 50% of the computer available at time of measurement. To compare this FLOPS-based performance with scientific performance of the models, we will also evaluate the metrics for "real" performance of climate models as defined by Balaji et al, 2017[28].

- **How much did we improve the data workflow?** This will be measured by the efficiency enhancement achieved with methods developed in WP4 with respect to vanilla system performance for disk, object store and tape. Final target is an efficiency increase by at least 50%.

- **How many groups and people of our target audience did we reach through trainings, dissemination, and other interactions?** This will be measured through the number of trainings, the number of attendees to the trainings, the number of ESiWACE2 services, etc. Goal is to increase all of these numbers continuously over the project life time, in line with and extending ESiWACE1 targets.

- **How much did ESiWACE2 impact industry and foster co-design?** This will be measured through new service projects, products, and product features that industrial partners of ESiWACE2 will develop. The final goal is to have 2 new products/services by the end of the project per industrial partner. The impact of co-design on weather and climate codes will be measured by evaluating the performance of the HPCW benchmark on different HPC systems over time. The target is to evaluate the codes of the benchmark suite on at least 3 different HPC-architectures.

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[28] Balaji, V. et al. 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, 2017.

2.2 Measures to maximise impact

a) Dissemination and exploitation of results

In order for ESiWACE2 to realise its full potential, and to achieve all of the expected impacts, considerable effort will be made to enable effective engagement with all relevant target audiences, ranging from the scientific community, HPC industry and decision/policy-makers. Appropriate methods of dissemination, communication and exploitation of the project results to these target audiences have been identified.

Several work packages across the project will have responsibility for establishing processes for:

- **Engagement** with the weather and climate community (WP6), with the European HPC ecosystem (WP6, but also WP1-5), with the HPC industry (WP2, WP3, WP6), and with decision and policy makers (WP7)
- **Dissemination of the project results** to the weather and climate community (WP6), European HPC ecosystem (WP6, but also WP1-5), HPC industry (WP2, WP3, WP6), decision and policy makers (WP7)
- **Facilitating exploitation of the project results by** the weather and climate community (WP6), the European HPC ecosystem (WP6, but also WP1-5), the HPC industry (WP2, WP3, WP6)
- **Communicating** the overall project and its results to the European HPC ecosystem (WP6, but also WP1-5), decision and policy makers (WP7) and to the public and society at large (WP7).

a 1) Draft plan for dissemination and exploitation

ESiWACE2 follows the definition of dissemination provided by the European Commission, with dissemination defined as "*the public disclosure of the results by any appropriate means (other than resulting from protecting or exploiting the results), including by scientific publications in any medium*"[29]. Project results are going to be disseminated throughout the course of the project **and** after its completion. In Table 1, we show the multi-layered dissemination strategy to be followed, which identifies clearly delineated strategies for each target audience. This is the draft version of our first '**Plan for the Dissemination, Engagement and Communication of ESiWACE2 results'**. All partners will be actively involved. Coordination will be provided by the Project Office.

During the project, this *draft* plan is going to be used as the basis on which to develop separate plans: a detailed **Dissemination, Engagement and Communication Plan** (D7.3), and an **Exploitation Plan** (D7.5). These plans provide more details on specific requirements, target audiences, deadlines, methods, procedures and evaluation measures and ensure effective management of these activities and their integration into the project.

Dissemination and Communication:

The **Dissemination, Engagement and Communication Plan** (D7.3) contains more details about targeted audiences and activities, and it includes monitoring and evaluation measures. These measures will be reported against when updates are provided to EC as part of the periodic reports. The results are likely to be of interest to the media: in coordination with the press and media offices of the consortium partners, and in line with Open Data principles, the project will decide how to manage ad hoc media enquiries, routine communication of research results and negative media coverage, amongst others. The plan is going to be regularly updated with each progress report in month 18, 36 and 48. More information on the communication activities, goals and contents is provided in section 2.2, **b) "Communication activities".**

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[29] https://www.iprhelpdesk.eu/glossary/dissemination-horizon-2020

Engagement:

The end-users listed in Table 1 are central to the work done and provide the expert sector knowledge which determines the way in which their project develops. They assist in determining the most effective dissemination and communication methods, enabling maximum exploitation and ensuring that their feedback is incorporated in decision making.

Exploitation:

The variety of outlined dissemination and communication measures will aid in the exploitation of ESiWACE2 results, in particular for utilisation in research activities which are not part of the project, as well as for utilisation for further development, creation and marketing of products/services and processes. Potentially, the following exploitation measures can be adopted: transfer of results, open access to peer-reviewed publications and research data, organisation of clustering activities with the European HPC ecosystem, the climate and weather community (WP6) and together with the CSA for the Centre of Excellence[30].

The **Exploitation Plan** (D7.5) is the strategy for *knowledge management, protection and for the exploitation of results*, defining procedures and responsibilities within the consortium. All partners will be actively involved in the exploitation activities.

a 2) Sustainability

As detailed in section 2.1, the long-term impacts of ESiWACE2 mandate a growing and sustained coordinated effort. WP7 will develop a plan for long-term sustainability embracing a wide range of service models and funding options (D7.8). This plan will be based on the ESiWACE1 business plan which is due end of 2018.

A particular aspect of the ESiWACE2 business plan will be a concept to evolve the prototype service activity set up in WP3 into a full-blown and sustained service for the weather and climate modelling community.

The ESiWACE2 business plan will very much depend on whether and how the ExtremeEarth initiative will be funded. If ExtremeEarth is successful, we expect the ESiWACE2 successor activities to merge with this larger and comprehensive initiative. If ExtremeEarth is not successful as a H2020 flagship, the community will have to develop new strategies to pursue its goals. Since all leading ESiWACE2 partners are involved in the ExtremeEarth planning, this will directly impact on our business plan.

a 3) Management of research data generated/collected during the project

The consortium agreement (CA) regulates the ownership and access to key knowledge (IPR, data etc.), open access to research data collected and generated during the project, and scientific foreground. The CA is set up after the communication of the approval of the project by the European Commission and before the signature of the Grant Agreement. For the management of research data refer to task 7.3. The relevance and corresponding management of data per work package is detailed in the following.

WP1: High-resolution model output will be generated for testing purposes and inter-comparison. Parts thereof are anticipated to be made available and shared publicly (for example in the scope of the project DYAMOND, see WP 1, Task 1.1). Output is based on community standards (NetCDF, grib). Data are provided and preserved through consortium partners (e.g., DKRZ); no cost will apply. Besides, performance data are generated and shared among the consortium.

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[30] Reference Coordination & support action [CSA], call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC

Table 1. Draft Plan for the dissemination and exploitation of ESiWACE2 results.

Target Audience	Relevant Area	Objectives	Content / Message	Tools	Expected frequency	Responsibility
Business sector end users (emerging actors and established actors)	• Weather and climate • HPC • Data science	Ensure project outcomes are relevant and in a useable format, ensure that direct and indirect users (see 2.1) quickly understand the project objectives and potential impacts, exchange knowledge, ensure maximum benefit	Services available, project progress and results, relevant end user documentation, events, literature and/or publications	Website, public presentations, newsletter, specific symposia at established events	See WP6 planned deliverables	WP6
European HPC ecosystem	• Weather and climate • HPC • Data science	Exchange knowledge, maximise impact and exploitation, integration of the project with other projects	Project progress and results	Scientific conferences, project annual meetings, peer-reviewed journal articles	Regular publication of scientific findings (open access), annual project meetings	WP6, WP7
National and European governments, policy makers, European Commission services, national services	• Weather and climate • HPC • RTD, Clima, REGIO, CONNECT	Inform HPC policy, provide means for greater understanding of the impact of very high-resolution weather and climate modelling, fostering use of results for policy action	Project progress and results, contribution to international committees	Briefing of the target audience using established communication channels via direct and in-direct users (see 2.1, Figure 3)	Inform future climate policy, provide tools for greater understanding of impacts of climate change, fostering use of results for policy action	WP6, WP7
Project partners	• Weather and climate • HPC • Data science	Ensure an effective and integrated project, keep all partners actively involved in the project, timely identify and protect any Intellectual Property	Communication and Dissemination Plan (internal communication section), progress	Intranet, web and teleconferencing, project meetings, work package meetings	Regular updates to intranet and email communications, annual project meeting, quarterly	WP7

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Target Audience	Relevant Area	Objectives	Content / Message	Tools	Expected frequency	Responsibility
			and results of WP, complementary research / project results		video/tele-conference	
European and, international initiatives and projects such as ETP4HPC, IS-ENES, ExtremeEarth, DYAMOND FET and CoE	• Weather and climate • HPC • Data science	Share resources, ensure synchronisation of activities for addressing open science questions, develop a shared understanding of the project and results, demonstrate the value added through collaborative working	Project progress and results, feedback from the communities involved	Two-way flow of information with existing projects: Joint activities planned in the CSA project and contribution to specific deliverables	Quarterly meetings of HPC Task Force, several interactions with target groups per year	WP6
Higher education course leaders and other **facilities** delivering HPC and climate science	• Weather and climate • HPC • Data science	Ensure knowledge is passed on through education, improve the professional skills and competencies of those working in the specific topic areas covered by the project, tackling skills gap of workforce	Project progress and results, open access to publications and data	Training sessions and webinars, annual meetings, webinars, training modules, summer schools, existing European training networks	See WP6 tasks and deliverables	WP6
Public and wider society interested in science projects and results, and/or climate research		Ensure the project visibility, raise awareness, achieve visibility for the project and its results	Project results and implications tailored for a broader non-specialist audience	Website, social media, public lectures and presentations, press releases and media coverage	Monthly updates secured via WP7, task 7.4	WP7

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WP2: This WP aims at technology watch and does not generate numerical or other relevant data sets.

WP3: This WP provides services and therefore does not generate numerical or other relevant data sets.

WP4: This WP is not expected to be collecting data which needs long-term curation. Any data collected will either be performance data of specific codes on specific hardware (and thus have little/no likelihood of re-use), or it will be incorporated into performance models which will be made available in software repositories. If data is collected for longer-term use, NetCDF standards will be used; data will be deposited in CEDA archives (http://www.ceda.ac.uk). CEDA is a partner via STFC; no cost for curation will apply.

WP5: This WP will investigate implementations and methods for post-processing, visualisation and data analytics at scale. No numerical or other relevant data sets are expected to be created or collected. Rather, tools and applications that will allow weather and climate data post-processing, analysis and visualisation at scale will be provided. NetCDF will be the standard data format for data sets managed in WP5.

WP6: Teaching OER material (task 6.2) will be created and made available under a permissive CC-by licence. No cost will apply.

WP 7: This WP takes care of project management and does not create numerical or other relevant data sets.

a 4) Outline strategy for knowledge management and protection and measures to provide open access

It is anticipated that the value of the Intellectual Property (IP) produced by ESiWACE2 lies in the ability to produce a number of diverse tools/products for the scientific community. The strategic use and management of IP is essential for strengthening the European scientific leadership, boosting innovation, and ensuring growth in the EU. The impact of the project is dependent on an informed and consistent approach to the management of IP generated by the different teams. The strategy will be modulated to cover the entire lifecycle of the project: before the start of the project, during its implementation phase, and after its closure.

Before the start of the project:

A **Consortium Agreement** (CA) will be prepared by DKRZ[31] in parallel with the preparation of the grant agreement. The partners have agreed to adopt the **DESCA** Model Consortium Agreement for Horizon 2020 projects. The CA will regulate the relation between consortium members and 1) **regulate Intellectual Property Rights** (IPR); responsibilities for the internal management of IP, additional rules on future exploitation and dissemination of results, access rights to Background IP and results; 2) contain a list of the **identified background IP:** in the CA the partners will identify the background in writing i.e. tangible or intangible inputs such as data, knowhow, information which is held by the project partners prior to their accession to the CA; 3) **regulate use of Foreground generated and ownership of results,** indicating appropriate measures to properly manage ownership issues, such as keeping documentary evidence (e.g. a properly completed Invention Disclosure Form) and how to regulate joint ownership, should the situation arise; 4) regulate liability, indemnification and confidentiality arrangements**;** 5) indicate how to settle possible internal disputes.

Each project partner has the right to request access rights to the other project partner's background and results as long as it **needs** them in order to carry out its work under the project or to use its own results (**minimum access rights**). To avoid conflicts, partners agree in the CA on a common interpretation of what is "needed". Access rights are granted throughout the duration of the project for exploitation needs. Once requested, access rights may be exercised as long as they are needed for exploiting the results (e.g. until the background patent expires). Access to **background IP** and to the **results** needed for the project implementation are granted **royalty-free** to the partners.

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[31] The CA will be drafted in compliance with the European Commission Guidance on "How to draw up your consortium agreement". V2.0, 23 February 2015

During the implementation phase:

As indicated in section 2.2, the **Exploitation Plan** (D7.5) is defined for the entire consortium in month 6 with the focus on practical development and exploitation, and taking into account the legitimate interests of the beneficiaries. The strategy will be based on the following **principles: 1) disseminate and share**: project partners will be obliged to disseminate the results swiftly (i.e. to scientific community, HPC industry) by any appropriate means and including the publication of results in any medium. A dissemination checklist will be developed in the early stage (WP7) for the use of the partners to remind them of the steps and actions to be undertaken for dissemination of results; 2) **exploit and protect: w**e will set up clear and efficient procedures for rapidly protecting new results and agreeing on dissemination, hereby ensuring that no information is published which could be detrimental to the protection of some results. Project partners will be supported by the Project Office in examining the possibility of protecting their results and must adequately protect them — for an appropriate period and with appropriate territorial coverage — if (a) the results can reasonably be expected to be commercially or industrially exploited and (b) protecting them is possible, reasonable and justified (given the circumstances); 3) **identification and collaboration with potential users** for multiplying the effects of exploitation.

The choice of the most suitable form for protection of IP will be made on the basis of the specificities of the results. Indicatively, potential measures could be confidential information, copyright, patents, trademarks and utility models. In some cases we might need to keep the information confidential for allowing further development while avoiding the negative consequences related to premature filing. Income generated by exploiting the results of the project (e.g. the IPR) is not considered a receipt since successfully exploiting the results is one of the main objectives of the action[32]. Applications for protection will include mentioning of the reference to the EU funding set out in the Grant Agreement.

At the end of the project and after its closure:

The final report of the project will include a plan for the use and dissemination of foreground, to demonstrate the added value and positive impact of the project on the European Union. A final publishable summary of the results will be made available to the European Commission for dissemination in the public domain including information on expected results, and their wider societal implications. After the official end of the project, the foreground of the project will be available as a web-based archive for all interested actors. Each beneficiary must – *up to four years after the project completion* – take measures aiming to ensure 'exploitation' of its results (either directly or indirectly, in particular through transfer or licensing by: (a) using them in further research activities (outside the action); (b) developing, creating or marketing a product or process; (c) creating and providing a service, or (d) using them in standardisation activities (**General obligation to exploit).** Each beneficiary may **transfer ownership of its results** within the EC rules. A beneficiary that intends to transfer ownership of results must give at least 45 days advance notice to the other beneficiaries that still have (or may request) access rights to the results. Unless agreed otherwise, any other beneficiary may object within 30 days of receiving notification, if it can show that the transfer would adversely affect its access rights. In this case, the transfer may not take place until agreement has been reached between the beneficiaries concerned.

Open Access measures:

The Europe H2020 strategy for a smart, sustainable and inclusive economy underlines the central role of knowledge and innovation in generating growth. As stated by the European Commission, "*Modern*

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[32] Annotated Grant Agreement, Art. 30

research builds on extensive scientific dialogue and advances by improving earlier work"[33]. Fuller and wider access to scientific publications and data therefore helps to build on previous research results (improved quality of results); foster collaboration and avoid duplication of effort (greater efficiency); accelerate innovation (faster to market = faster growth); involve citizens and society (improved transparency of the scientific process).

Measures to provide open access to peer-reviewed scientific publications:

Peer-reviewed scientific publications will be made freely available to anyone as soon as possible and in all cases **no later than six months after publication.** We will privilege Open Access journals for publishing our articles and avoid signing any copyright agreements with publishers that do not allow them to fulfil the EC Open Access requirement. If our scientists prefer to publish their articles in journals which are not Open Access journals, we will pay the **Golden OA option**. If this is too expensive, the **Green OA option** will be applied. Authors will first retain their copyright and provide the publisher with a license to publish, instead of signing a simple copyright transfer agreement (CTA). Articles will be made available: 1) in the **institutional repository** of the institutes where the authors work; 2) in the **subject repository for the specific topic of the article**, when available; 3) in **OpenAIRE** www.openaire.eu.

Measures to provide open access to research data:

Openly accessible research data can typically be accessed, mined, exploited, reproduced and disseminated free of charge for the user. **We agree to participate in the Open Access to Data Pilot established by the European Commission on a voluntary basis and agree to include the Art. 29.3 in the Grant Agreement.** The Data Management Plan (D7.4) will be established in project month 6 and will document how the research data collected or generated will be handled during and after the project.

b) Communication activities

Communication goals of ESiWACE2 are to:

- **Show how European collaboration in the consortium has achieved more than would have otherwise been possible**, notably in achieving scientific excellence, and contributing to competitiveness;
- **Make better use of the results, by making sure they are taken up** by the scientific community and by industry and to ensure their follow-up.

Our communication activities start at the outset of the action and continue throughout its entire lifetime: we identify and set clear communication objectives, choose pertinent messages targeting and adapting them to audiences that go beyond the project's own community, by using relevant medium and means.

Communication covers 1) **internal communication** (e.g. collaboration platforms, etc): an intranet (D7.1) ensures smooth and timely communications between the project partners, allows them to capture and share the project outputs, and also ensures that the project maintains scientific excellence and all partners remain abreast of new developments in the sector; 2) **communication of the project**: making the project visible (D7.2); 3) **communication of project results (e.g. dissemination)**: the tools previously outlined in the Draft Plan in section 2 are going to be used for disseminating project results.

WP7 will update the **Dissemination, Engagement and Communication plan** (D7.4) on a regular basis during the project lifetime.

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[33] Guidelines to the Rules on Open Access to Scientific Publications and Open Access to Research Data in Horizon 2020

Information of EU funding: In compliance with the Grant Agreement (Art. 27, 29.4 and 38), all partners will ensure that every dissemination result will display the EU emblem and indicate clearly that the project has received funding from the Horizon 2020 research and innovation programme.

3 Implementation

3.1 Brief presentation of the overall structure of the work plan

The work plan and structure of work packages closely follows the concept and methodology as laid out in chapter 1.3. There are seven work packages. Each work package has a leader and a co-leader.

WP1 will develop coupled weather and climate models in unprecedented technical quality and performance as well as the organisational framework to assess their scientific performance. (Peter Bauer ECMWF; Joachim Biercamp, DKRZ)

WP2 will establish, evaluate and watch new technologies to prepare climate and weather simulation for the exascale era. (Rupert Ford, STFC; Carlos Osuna, MeteoSwiss)

WP3 will develop and provide services to improve performance and portability of climate codes with respect to existing and upcoming tier1 and tier0 computers. (Ben van Werhoven, NLeSC; Erwan Raffin, Bull)

WP4 will provide the necessary toolchain to handle data at pre-exa-scale and exa-scale, for single simulations, and ensembles. (Bryan Lawrence, UREAD; Julian Kunkel, UREAD)

WP5 will enhance the tools to analyse and visualise these data (Sandro Fiore, CMCC; Niklas Röber, DKRZ)

WP6 will link ESiWACE2 to the weather and climate community it serves on the one hand and to the European HPC ecosystem on the other hand (Sylvie Joussaume, CNRS-IPSL; Sophie Valcke, CERFACS)

WP7 ensures an effective and smooth high-quality implementation of the project and puts strong emphasise on dissemination of ESiWACE2 achievements (Joachim Biercamp, DKRZ; Peter Bauer, ECMWF)

Table 3.1a: List of work packages.

Work package No	Work Package Title	Lead Participant No	Lead Participant Short Name	Person-Months	Start Month	End month
WP1	Cutting Edge Resolution in Earth system modelling	3	ECMWF	198	1	48
WP2	Establish and watch new technologies for the community	18	MeteoSwiss	150	1	48
WP3	HPC services to prepare the weather and climate community for the pre-exascale	17	NLeSC	120	1	48
WP4	Data Handling at Scale	11	UREAD	163	1	48
WP5	Data post-processing, analytics and visualisation	10	CMCC	68	1	48
WP6	Community engagement and Training	2	CNRS-IPSL	57	1	48
WP7	Coordination, Management and Dissemination	1	DKRZ	52	1	48
				808		

3.2 Timing of the different work packages and their components

Project month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
WP1																																																
Deliverables																				1.2																1.1												1.3
WP2																																																
Deliverables												2.8							2.6			2.10														2.3 2.5						2.7						2.1 2.2 2.4 2.9
WP3																																																
Deliverables																							3.1																					3.3	3.2			3.4 3.5
WP4																																																
Deliverables																							4.1																			4.2						4.3
WP5																																																
Deliverables																																				5.1						5.2						5.3
WP6																																																
Deliverables																		6.3																		6.1 6.4				6.2								
WP7																																																
Deliverables	7.1	7.2		7.3		7.4 7.7 7.5																														7.8												7.6
Annual meetings																		A						A												A												A
Reporting periods						Period 1																	Period 2															Period 3										
Progress reports (activities & finances preparation)																			🟧																			🟧										🟥
EC Reviews																							R															R										
Milestones												5.1				1.1 4.1								2.1 3.1												1.2 4.2										5.2	1.3 2.2 3.2

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3.3 Detailed work description

Table 3.1b: Work package description.

Work package number	1					Lead beneficiary			ECMWF	
Work package title	Production runs at unprecedented resolution on pre-exascale supercomputers									
Participant number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**9**	**10**	**20**
Short name of participant	DKRZ	CNRS-IPSL	ECMWF	BSC	MPIM	SMHI	CERFACS	METO	CMCC	MO
Person months per participant	30	36	36	30	12	18	6	12	9	9
Start month	1					End month		48		

Objectives

WP1 is directly related to **principal objective (1) and specific objective (a) of ESiWACE2** to enable leading European weather and climate models to leverage the available performance of pre-exascale systems with regard to both compute and data capacity in 2021. WP1 will provide configurations of European climate and weather models that are real pre-exascale applications and that can make efficient use of a significant fraction of existing national and future EuroHPC infrastructures while running at full model complexity and with full model output at a performance that will allow operational weather forecasts and climate predictions.

WP1 will improve throughput, scalability, coupling and the data-handling toolchain to enable unprecedented scientific investigations of global simulations at very high resolution and will also support scientific assessments of model quality and predictive skill as well as model comparisons. WP1 will have strong interactions with **WP2, WP3, WP4 and WP5**.

Description of work [Lead: ECMWF. Co-lead: DKRZ]

ESiWACE1 could show that it is technically possible to run leading European models at global horizontal resolution up to 1 km. However, simulations were uncoupled, model output was minimal or switched off, and execution times were much too slow for operational use. This work package will be based on previous results and push resolution towards unprecedented levels for coupled simulations in production mode that show a performance that would allow operational weather and climate predictions (at least 1 SYPD) with realistic model output. During this exercise, resolution will be pushed to levels as high as possible. To reach this aim, coupling and IO efficiency will be improved and infrastructure to compare results of coupled simulations at very high resolution will be developed. The model configurations that are developed will be ported to the European pre-exascale EuroHPC systems planned for 2021. The scaling behaviour of the models will be diagnosed and documented. The following models will participate:

1. EC-Earth: Fully coupled Earth system model that is used for climate simulations. EC-Earth will be used in the GCM configuration and couple OpenIFS for the atmosphere, NEMO for the ocean and further components via the OASIS coupler.
2. ECMWF: IFS atmosphere model based on cycle 45R1 is coupled in line to the NEMO ocean model version 3.4. The model is used for operational weather forecasts at ECMWF.
3. ICON-ESM: The ICON model is used for both weather and climate simulations. For ICON-ESM, ICON-Atmosphere is coupled to ICON-Ocean via the YAC coupler.
4. The IPSL model: DYNAMICO-LMDZ is a new atmosphere model that is coupled to the NEMO ocean model via OASIS or XIOS.

Task 1.1: Develop infrastructure for production-mode configurations [Lead: BSC. Partners: CERFACS, CMCC, MetO, MO]

To enable production-mode simulations at the highest resolution possible, to be able to fill a significant fraction of a pre-exascale EuroHPC system, and to allow a scientific comparison of results some infrastructure needs to be developed.

Coupling infrastructure: There is work required to advance the coupling infrastructure OASIS-MCT for production-mode simulations at very high resolution. This will support production-mode simulations with EC-Earth and the IPSL model (The task will contribute to D1.1).

Improvement of IO: There is work required to improve model IO for production simulations. The ensemble enhanced version of XIOS developed in WP4 (and also based on work on the UK Met Office Unified Model) will be introduced into the EC-Earth model and used in pre-exascale ensemble simulations at the highest practical ensemble resolutions. If XIOS is able to cope with ensemble output of high resolution simulations, this will add another dimension to scale the EC-Earth and the IPSL model (The task will contribute to D1.1).

NEMO for high-resolution coupled simulations: The NEMO ocean model is used in three of the four models above. Stand-alone global simulations with NEMO at 1/12 degree (~8 km) resolution are already possible in production mode today. This project will start to use this level of resolution in coupled production-mode simulations (see below). To further improve the NEMO model in high-resolution simulations work will be performed to enable simulations at 1/36 degree (~3 km) global resolution. However, at this stage it is not clear whether these simulations will reach a performance of 1 SYPD until the end of this project (The task will contribute to D1.1).

Infrastructure for high-resolution data: A major goal of ESiWACE2 is the seamless integration of pre-exascale and exascale model development with production-ready global climate and weather simulation at the highest resolution possible. This task aims at this integration at the level of sharing and comparing ESiWACE2-models with international efforts on highest-resolution modelling, such as the DYAMOND initiative on global high-resolution model inter-comparison. For this purpose, ESiWACE2 will provide the infrastructure for the use and provision of high-resolution data, input scripts etc. for selected models and a corresponding website, incorporated into the ESiWACE portal, to publish results (D1.2).

Task 1.2: Develop production-mode configurations [Lead: ECMWF. Partners: BSC, CNRS-IPSL, DKRZ, MPI-M, SMHI, CERFACS]

Model configurations that can run in production mode will be developed for the four models listed above. It will be demonstrated that the models can run at 1 SYPD with full model IO (D1.1). For development and testing supercomputing facilities available to the partners, including those at DKRZ, ECMWF, BSC, ETH Zurich will be used. In addition, we expect PRACE to provide some resources to the CoEs that can be used to test further simulations at large scale.

We aim for the following levels of resolution for the different models in global production-mode simulations:

- EC-Earth: 16 km (TL1279) atmosphere coupled to a 1/12 degree (~8 km) ocean
- ECMWF: 5 km (TCo1999) atmosphere coupled to a ¼ degree (25 km) ocean
- ICON-ESM: 5 km atmosphere coupled to a 5 km ocean, aiming at higher resolutions for the ocean
- The IPSL model: 10 km atmosphere coupled to a 1/12 degree (~8 km) ocean

These goals where set based on previous experience. E.g. during the first funding period of ESiWACE it was shown that both ICON and IFS (atmosphere only, no IO) scale very reasonably when running with up to 1000 Broadwell nodes, reaching 0.1 and 0.3 SYPD respectively at 2.5 km resolution and a very high resolution version of ICON showed very good scaling behaviour on 500000 BlueGene Q cores recently.

Task 1.3: Port models to pre-exascale EuroHPC systems [Lead: DKRZ. Partners: BSC, CMCC, CNRS-IPSL, ECMWF, MetO, MPI-M, SMHI]
The production-mode configurations of task 1.2 will be ported to at least one of the pre-exascale EuroHPC systems that will be available in 2021 towards the end of ESiWACE2. The maximal resolution that is possible to reach for production-mode simulations on these machines will be diagnosed and compared to the resolution that was possible on the computing facilities of the partners.   Porting to new systems: Port all production-mode configurations from task 1.2 to the new computing systems. WP2, task 2.4, will evaluate the potential of containers to prepare and thus speed up the porting.   Scalability: Evaluate strong scaling for different levels of model resolution on the machine.
Deliverables   **D1.1 Simulations of global high-resolution climate and weather models in production mod**e   Present and compare production-mode configurations that were developed in task 1.1. Discuss the major challenges for high-resolution simulations, coupling and model IO. Provide information on scalability and performance at different horizontal resolution when running the models on local supercomputing systems. Report on IO and storage aspects. Due at month 36; PU; R; Lead: ECMWF   **D1.2 Model inter-comparison for global high-resolution simulations.** A webpage that presents guidelines for model inter-comparison including data management, sharing of input files as well as the conversion of output files to standard file formats will be published. Due at month 24; PU; DEC; Lead: DKRZ   **D1.3 Scalability on pre-exascale EuroHPC systems.** Discuss challenges encountered when porting the models of task 1.1 to the new supercomputing systems. Discuss scalability of all models when running on the new systems with different horizontal resolution. Extrapolate performance and data requirements to exascale and discuss potential resolutions that could be realised on future exascale machines when perfect scalability is assumed. Due at month 48; PU; R; Lead: DKRZ

Work package number	2				Lead beneficiary				MeteoSwiss		
Work package title	Establish, evaluate and watch new technologies for the community										
Participant number	1	3	4	5	9	10	11	12	15	16	18
Short name of participant	DKRZ	ECMWF	BSC	MPIM	METO	CMCC	UREAD	STFC	ETH Zurich	UNIMAN	MeteoSwiss
Person months per participant	8	11	3	12	7	14	3	31	8	17	36
Start month	1				End month				48		

Objectives

WP2 is related to **both principal objectives of ESiWACE2** to enable leading European weather and climate models to leverage the available performance of pre-exascale systems and to prepare the weather and climate community to make use of exascale computing when it becomes available. The WP is directly related to **specific objective (b)** to establish new technologies for the weather and climate case and to **specific objective (f)** to foster co-design between model developers, HPC manufacturers and HPC Centres.

In this work package we will establish, evaluate and watch new technologies for the community that have the potential to play a crucial role to port and run weather and climate models on exascale supercomputers in the future. WP2 will have strong interactions with **WP1 and WP3**.

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Description of work [Lead: MeteoSwiss. Co-lead: STFC]

The work package will **establish** the use of domain-specific languages (DSLs) for the community that have been used successfully in two separate efforts: PSyclone in the LFric model and GridTools in the COSMO model. This work package will compare, evaluate and interoperate the two approaches in benchmark tests. It will make both approaches usable for a wider community and demonstrate their use on the main weather and climate models used in this project.

The work package will **evaluate** whether concurrency and containers will be useful approaches for the community. Concurrency can help to significantly speed-up simulations when scaling to peta-scale and beyond and when using heterogeneous hardware. Containers would provide large benefits in the deployment of model workflows in multiple supercomputing systems if the performance penalty is found to be small.

The work package will **watch** and communicate how machine learning, exascale hardware developments and alternative programming models will influence future developments of weather and climate models. Machine learning has the potential to improve performance or model quality of parts of simulations while speeding-up model performance at the same time.

Task 2.1: Establish DSLs in the community [Lead: STFC. Partners: MeteoSwiss, DKRZ, ECMWF, UNIMAN, ICHEC, CMCC, METO, UREAD]

The objective of this task is to extend and prepare existing DSLs developed for weather and climate models to pre-exascale system models. The main DSLs to be adopted and extended to support the main demonstrators of ESiWACE2 are the GridTools ecosystem, and the PSyclone-CLAW DSL.

Enable community use: Extend and adapt the two existing DSL projects to serve a larger community. The GridTools ecosystem will be adapted for demonstrators on irregular grids models to be used in ICON and IFS. PSyclone-CLAW will be enabled to support the NEMO model such that unmodified NEMO code can run on many-core CPUs and GPUs (D2.1).

Benchmark extraction: A set of representative benchmarks will be extracted from the models of WP1. Different aspects of the DSL approaches such as performance portability, performance improvements, developer productivity, safety, and acceptance will be compared. The benchmarks will be ported to the DSLs GridTools, PSyclone-CLAW. In a second step, the benchmarks will be extended to demonstrate the usability of DSLs for real models on pre-exascale machines: the use of PSyclone will be demonstrated in NEMO and LFRic, and the use of GridTools will be demonstrated in ICON and IFS (D2.1, D2.2).

Interoperability of DSLs: The different DSL approaches explored in this work package expose different languages with different characteristics. In order to interoperate the different solutions and reuse tools and optimisers, the project ESCAPE-2 will develop a standard high-level intermediate representation (HIR) for weather and climate models. This task will demonstrate the use of the HIR by interoperating the PSyclone-CLAW DSL with the GridTools toolchain. HIR concepts will be extended to support aforementioned benchmarks and the interoperability of the DSLs will be demonstrated by generating HIR from the PSyclone-CLAW DSL that is later processed by GridTools toolchain (D2.3).

Optimisation: The performance optimisation phase space is large and optimisation decisions will depend on the numerical methods, type of grid and size, underlying parallel model and target computing architecture. For the pre-exascale systems and models proposed in this project new optimisations (like strong scaling optimisations) which operate on the extended HIR will be explored. Performance of advanced optimisations will be compared with hand-tuned solutions (D2.4).

Task 2.2: Evaluate concurrent components to improve performance [Lead: MPIM. Partners: DKRZ, MeteoSwiss]

The goal of this task is to test approaches to improve scalability and performance of a model via high-level functional parallelism. The target is to improve scalability on homogeneous architectures and to allow efficient operations on hybrid architectures, where different tasks can run concurrently on different devices.

The performance benefit and cost of running different components of a model on three different classes of architectures (CPU/CPU, CPU/GPU and GPU/GPU) will be analysed and the feasibility of generalising this approach to other models in a maintainable way will be evaluated.

Solution strategies: Explore technological solutions to incorporate concurrency into ESiWACE2 models that address maintenance issues. Two approaches will be evaluated: 1. A model independent library-only solution which provides a model with the required functionality to work as a concurrent radiation component. 2. A driver program that can be executed as a radiation component in a "multiple program - multiple data" run. A suitable numerical error metric will also be defined (D2.5).

Application in ICON: Apply the concurrent radiation implementation to the ICON model as a prototype. The concurrent radiation will be verified on CPUs using scientific criteria. Test cases and configurations for different hybrid architectures will be developed and evaluated for CPU-CPU, CPU-GPU and GPU-GPU configurations at the strong scaling limit. Performance benefits will be analysed, documented and discussed with interested modelling groups in the project (D2.5).

Task 2.3: Evaluate containers to port Earth system models to new hardware [Lead: ETH Zurich. Partners: MeteoSwiss, CMCC, UREAD, BSC]

Atmosphere and ocean models are characterised by complex dependencies, external configurations, and performance requirements. The objective to containerise such software stacks is to provide a consistent environment to ensure security, portability and performance. Since the container is built only once, but then can be deployed on multiple platforms, productivity is increased. ETH Zurich will provide subsequent Docker/Shifter support for the teams to complete the containerisation of their models.

Hackathon: ETH Zurich will organise a 3-day Docker "hackathon" for all the partners of this task who have committed to containerise their climate models (D2.8).

Containerisation of Earth system models: Create containerised versions of Earth system models (e.g., COSMO, ICON, Nemo, OpenIFS, EC-Earth) using a Docker-compatible technology like Shifter. Identify representative test cases in order to evaluate performance when containers are used. Adapt containers to improve performance figures (D2.9).

Deployment: Deploy the ported Earth system models from the hackathon on different supercomputers (ETH Zurich) using a Docker-compatible format and collect the performance figures from the representative test cases (D2.9).

Task 2.4: Watch emerging technologies [Lead: CMCC. Partners: UNIMAN]

The purpose of this task is to track developments in a number of key areas relevant to future very high-resolution weather and climate models, the associated massive data processing/data analytics activities and their execution on future HPC systems.

Machine learning: Machine Learning is recognised as a potentially disruptive technology, which may have a huge positive impact on both the computational and data management activities associated with (very) high-resolution ESMs. The most relevant efforts regarding the use of machine learning techniques and frameworks in the climate and weather domains will be tracked and evaluated (D2.6, D2.7).

Exascale hardware: There are a number of development projects for exascale hardware in Europe and elsewhere exploring new processors - including various hardware acceleration devices, memory system and interconnect technologies. This task will track the key developments of these projects in order to (i) help the community assess progress and accordingly (ii) plan future activities, regarding (very) high-resolution Earth system models and high-performance data analytics applications (D2.6, D2.7).

Programming models and hardware interplay: It is widely acknowledged that "MPI + X" is not a future-proofed programming model for high productivity programming of exascale systems. The DSL approach proposed in this WP is designed to provide flexibility in the choice of underlying programming models and hardware targets. This task will track developments in both programming models and hardware, as well as in

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DSL developments in other fields. Initial targets (for pre-exascale machines) will be existing technologies such as MPI, OpenMP, OmpSs and OpenCL for CPU-based systems with GPGPUs (D2.6, D2.7).

Two scientific workshops will be organised (M18 and M42) on the three areas applied to climate and weather applications. The workshops will gather computational scientists, application domains scientists, and vendors to explore and foster a co-design approach across the communities.

Deliverables

D2.1 Report summarising the adaptation of the proposed DSLs and the evaluation of the benchmarks and models proposed in this project. Due at month 48; PU; R; Lead: STFC.

D2.2 Demonstration of the DSLs in the proposed models. Due at month 48; CO; DEM; Lead: STFC

D2.3 Demonstration of PSyclone-CLAW using the GridTools toolchain with the proposed benchmarks, making use of the HIR. Due at month 36; CO; DEM; Lead: MeteoSwiss

D2.4 Report on the performance of DSL compilers with the proposed models. Due at month 48; PU; R; Lead: UNIMAN

D2.5 Report and demonstration of the concurrency of model components, evaluating the impact in performance and comparison of technologies employed. Due at month 36; CO; R; Lead: MPIM

D2.6 First white paper on community guidelines on the use, value and applicability of emerging technologies in climate and weather applications. Due at month 20; PU; R; Lead: CMCC

D2.7 Second white paper on community guidelines on the use, value and applicability of emerging technologies in climate and weather applications. Due at month 44; PU; R; Lead: UNIMAN

D2.8 Material and summary of the hackathon experiences (derived from individual reports by each of the attending partners). Due at month 12; PU; R; Lead: ETH Zurich

D2.9 Report summarising porting the different models to containers, including evaluation of the performance on the supercomputer where the containers are deployed. Due at month 48; PU; R; Lead: ETH Zurich

D2.10 Machine learning workshop. Due at month 24; PU; OTHER; Lead: UNIMAN

Work package number	3				Lead beneficiary				NLeSC
Work package title	HPC services to prepare the community for the pre-exascale								
Participant number	1	2	3	4	7	9	13	15	17
Short name of participant	DKRZ	CNRS-IPSL	ECMWF	BSC	CERFACS	METO	BULL	ETH Zurich	NLeSC
Person months per participant	6	2	6	4	6	6	44	4	42
Start month	1			End month			48		

Objectives

WP3 is directly related to **principal objective (2) and specific objective (c) of ESiWACE2** to prepare the weather and climate community to be able to make use of exascale computing when it becomes available. WP3 is also directly related to **specific objective (f)** to foster co-design between model developers, HPC manufacturers and HPC centres. WP3 is designed to provide support to the community in terms of HPC

services to groups in weather and climate modelling both within and outside of the ESiWACE2 consortium. It is the aim to improve model efficiency and to enable to port models to existing and upcoming European tier0 systems. WP3 will also improve efforts to develop and diagnose benchmarks for weather and climate modelling to foster co-design between model developers and HPC centres. WP3 will have strong interactions with **WP1 and WP2**.

Description of work [Lead: NLeSC. Co-lead: BULL]

This work package represents the outward engagement of the project and integrates ESiWACE2 with the Earth system modelling communities in Europe. Weather and climate models are large and complex applications that experience a tension field between investments to enhance certain features, for example increasing fidelity, spatio-temporal resolutions, or resolving more physical processes, and investments to adapt the software to the latest hardware architectures. The way forward in preparing weather and climate simulations for exascale is to involve the community in making better use of the collective resources, utilising components developed elsewhere. The services do exactly that, they bring together experts in different fields to create real impact in Earth system models.

We create open services to the Earth system modelling community in Europe. The goal of the services is to create collaborations that provide guidance, engineering, and advice to support exascale preparations for weather and climate models. All groups developing and maintaining weather and climate codes - not only the ESiWACE2 partners - can apply. Proposals for such collaboration projects will be peer-reviewed and when found eligible will be granted in-kind support by one of the partners involved. For Service 1, we aim for a duration of three up to nine person-months per project, and for the Services 2 and 3, we aim for one to three person-months. These durations ensure that significant steps can be made within a collaboration, while guaranteeing that multiple models from different groups can benefit from the services.

Task 3.1: Coordinate HPC services [Lead: NLeSC. Partners: BULL, CERFACS, DKRZ, BSC, METO, ECMWF, IPSL]

The goal of task 3.1 is to setup and coordinate the services for collaboration projects. This task will contribute to D3.1 and 3.5.

Setup and coordination of service call: Setup and coordinate the open call for service requests to organise support for existing Earth system models that target the European pre-exascale systems planned for 2021. Communicate the nature of the services that are provided to modelling groups in Europe. Coordinate the peer-review process of service requests by establishing an external committee, with members from both inside and outside of the consortium, but external to the partners involved in providing the services. The committee takes the final granting decisions based on peer-reviewed assessments on the relevance and importance to the weather and climate modelling community as a whole. Identify the need for support and make sure that all service projects are started within a reasonable timeframe from the granting decision.

Service review: Review the service project achievements, progress and performance, both for scientific and technical relevance as well as for schedule and cost. Report on the work done, identify achievements, and describe possible directions for future developments.

Task 3.2: Service 1: Model portability and refactoring [Lead: NLeSC. Partners: BULL]

Achieving high performance on modern processors requires porting and refactoring in a way that reconsiders choices that were made at higher levels in the code. This stresses the need for co-design of high-level routines and their algorithmic implementations, requiring experts from both weather and climate modelling as well as from HPC. Service 1 provides collaboration projects between these groups. This task feeds into WP2 by recognising opportunities for using Domain-specific languages (DSLs) in weather and climate codes and is complemented by the DSL training offered in WP6. This task will contribute to D3.2.

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Porting to accelerators: Provide support and guidance in porting model components to accelerators such as GPUs and novel architectures.

Exascale preparations: Provide guidance and advice to enable and support exascale preparations for their models.

Task 3.3: Service 2: Coupling, IO and workflows [Lead: CERFACS. Partners: IPSL, METO]

Service 2 offers weather and climate modelling groups the support they need to optimally use the coupling, IO, and workflow infrastructure available. It will strengthen Earth system modelling software with the integration and optimal use of existing infrastructure components, in particular with libraries developed by the community and tools such as the OASIS3-MCT coupler, the XIOS IO server, and the Cylc workflow engine. Results are summarised in D3.3.

Optimisation of coupling: The services will ensure that the groups who are using (or want to use) the OASIS3-MCT coupler can take full advantage of the coupler to allow the optimal coupling of multi-component systems. The service will optimise coupled systems depending on the coupled configuration and on the user's objective

Optimisation of IO: The services will help modelling groups to optimally use the XIOS IO server. XIOS provides powerful online data treatment before output, such as time integration, combined with arithmetic operators, interpolation, remapping, reduction. The linkage of these operations and the distribution of XIOS client and server processes has a crucial impact on the overall IO performance.

Support for Cylc: The services will provide support in using Cylc for workflow orchestration. Cylc orchestrates complex distributed suites of interdependent tasks. It was originally designed for environmental forecasting systems at NIWA.

Task 3.4: Service 3: Weather and climate benchmarking [Lead: DKRZ. Partners: BULL, BSC, ECMWF, ETH Zurich]

Service 3 is focussing on the in-depth performance analysis and benchmarking of weather and climate codes. The project ESCAPE-2 will develop a benchmark suite called HPCW that isolates key elements in the workflow of weather and climate prediction systems to improve performance and to allow a detailed performance comparison for different hardware. These benchmarks will be based on the ICON, IFS and NEMO models. ESiWACE2 extends the HPCW suite to represent a wider range of community models, tests the performance of HPCW benchmarks on different computing systems, including the pre-exascale EuroHPC systems of the EU, and covers production-mode simulations from WP1 on machines with pre-exascale and exascale dimension. Results are reported and published in D3.4.

Extension of benchmarks: Develop, support and add further HPCW benchmarks for model configurations and model components that are not covered by ESCAPE-2 to the HPCW benchmark suite. The decision which components will be picked and supported will be based on a peer-reviewed process.

Hardware and compilation uncertainties: Measure hardware and compilation uncertainties for HPCW benchmarks. Benchmarks will be run on the supercomputing facilities of the partners (at DKRZ, BSC, ECMWF, ETH Zurich, and BULL). Results will be compared in terms of performance and accuracy, which will be measured, documented and published.

Benchmarking on pre-exascale systems: Port the HPCW benchmarks from ESCAPE-2 onto the pre-exascale EuroHPC systems, diagnose performance and provide advice on how to boost performance on these specific hardware configurations. These services will be aligned with optimisation and productivity services of the CoE to be funded under focus area 8 'performance optimisation' of this call (INFRAEDI-02-2018) using common tools and methodologies to reinforce collaboration between both CoEs.

Kronos for production mode at exascale: Kronos is a benchmarking tool that was developed in the NextGenIO project to generate a model of a "real-life" HPC workload by analysing profiling data. In

ESCAPE-2, Kronos will be used to simulate and analyse the workload generated by HPCW benchmarks. ESiWACE2 will enhance Kronos to be able to deal with production-mode simulations on machines with pre-exascale and exascale dimension. Model configurations of models from WP1 will be taken into account.

Deliverables

D3.1 Mid-term assessment of the services
Report on the service project achievements, progress and performance, both for scientific and technical relevance as well as for schedule and cost. Due at month 24; CO; R; Lead: NLeSC

D3.2 Report on services in portability and refactoring
Summarise results from porting applications. Discuss how to move forward and advance the codes towards exascale. Due at month 46; PU; R; Lead: BULL

D3.3 Report on services offered on IO, coupling and workflow
A document summarizing the services offered on IO, coupling and workflow to the different modelling groups, analysing the benefits and the long-term sustainability of the improvements achieved during the service period. Due at month 44; PU; R; Lead: CERFACS

D3.4 Report on services offered on weather and climate benchmarks
Provide documentation of new benchmarks and publish benchmark codes (where applicable). Summarise typical performance measures and accuracy levels for different benchmarks on different hardware. Due at month 46; PU; R; Lead: DKRZ

D3.5 To make Europe's Earth system models fit for the exascale
Summarise the work done, identify achievements and describe possible future developments. Discuss the main bottlenecks for Europe's models towards exascale simulations and how to address them. Due at month 48; PU; R; Lead: NLeSC

Work package number	4			Lead beneficiary				UREAD		
Work package title	Data systems for scale									
Participant number	1	2	3	8	9	10	11	12	14	19
Short name of participant	DKRZ	CNRS-IPSL	ECMWF	ICHEC	METO	CMCC	UREAD	STFC	SEAGATE	DDN
Person months per participant	15	12	1	6	12	9	48	24	16	20
Start month	1				End month			48		

Objectives

WP4 will contribute to both **principal objectives (1) and (2)** of the project and will in particularly meet **specific objective (d)** – to mitigate the effects of the data deluge from high-resolution simulations, this work package specifically addresses ensemble tools and storage middleware. Specifically, WP4 will

1. Support data reduction in ensembles and avoid un-necessary subsequent data manipulations by providing tools to carry out ensemble statistics "in-flight" and compress ensemble members on the way to storage.
2. Provide tools to: a) transparently hide complexity of multiple-storage tiers from applications at run time by developing middleware that lies between the familiar NetCDF interface and storage, and prototype commercially credible storage appliances which can appear at the backend of such middleware, and; b) support manual migration of semantically important content between primary storage on disk, tape, and

object stores, including appropriate user-space caching tools (thus allowing some portable data management within weather and climate workflows).

Description of work [Lead: UREAD (B. Lawrence). Co-lead: UREAD (J. Kunkel)]

The primary approach is to extend and exploit existing tools and interfaces which are in common use in the community and/or with which we have previous experience. In doing so, the key philosophy is "Maximum Impact from a Minimum Change Surface" insofar as ESiWACE2 data handling solutions need to

- Maximise their impact on data handling, by minimising the impact of increasing volumes of data from multiple sources, particularly within and between large-scale ensembles,
- have minimal interference with existing working practice and codes, and
- have minimal requirements of the system environment.

The best way to achieve this is by modifying existing tools, developing a minimum of new tools and, where possible, exploiting middleware which can be deployed easily, hiding complexity from end-users. The heart of the middleware approach is to insert software layers in the stack between the model IO code and the files it produces which have traditionally been placed on (parallel) file systems. Two key layers will be involved:

1. Between model ensemble members and the NetCDF library interface
2. Between the HDF library, which itself sits inside the NetCDF stack, and the underlying storage.

The proposed work will build on a number of developments in ESiWACE1, in particular:

1. Semantic Storage Layers (SemSL). "Intelligent knowledge" about the data held in NetCDF and other formats depends on semantics which exploit the format syntax (e.g. variable attributes) but link them in complex ways. The SemSL exploits the NetCDF CF aggregation conventions to fragment NetCDF files into sub-files which can then be managed (using SemSL or other traditional NetCDF tools) across different storage providers whether local or remote.
2. Earth System Data Middleware (ESDM). Existing scientific software formats provide libraries that provide syntactical support for four-dimensional datasets on disk. ESDM targets the widely used HDF library (upon which NetCDF4 depends) to intercept read/writes via HDF to provide more sophisticated, and higher-performance, use of storage.

These two approaches – "above the data format" and "below the data format" – share a common conceptual design philosophy (since they were developed together), but have been developed to address different parts of the problem space. ESDM has been developed to provide performance in simulation and is expected to evolve to provide an "active storage" system which is "weather and climate-aware". SemSL has been developed to assist in data analysis and data management, and is expected to provide "manual control of storage tiering". One of the goals of ESiWACE2 will be to further integrate these parts and further differentiate around the distinctive roles ("smart/performant/active", "simple/performant/manual").

Together, they represent the recognition that the efficient execution of workflows and individual applications within a workflow must be able to harness the different characteristics of a site's storage systems, and that the balance of services between active and manual can and will differ. Both need to address efficiency, performance portability, manageability, data reduction, and robustness (fault tolerance) of workflows.

There is one management task to coordinate and oversee six separate interlocking tasks within this WP. Internal WP milestones will be used to help cross-task control and to synchronise with project-level control points and milestones. All software products will be formally described in D4.3, building on the interim deliverable D4.1 (covering software delivered by tasks 4.2 and 4.3) at month 24. The scope for commercial products will be evaluated by a description of appliance prototypes in D4.2.

Task 4.1: Design and leadership [Lead: UREAD]

Manage the inter-locking tasks, develop an overall architecture, and provide a final report which covers what has been done and provides a roadmap (D4.3) which takes input from other IO and storage projects targeting exascale computing.

Task 4.2: Ensemble services [Lead: UREAD. Partners: CNRS-IPSL, ECMWF]

Develop and deploy support for controlling an ensemble of model instances within one executable feeding data output via an "active" IO server to storage. The IO server will be configurable to support "ensemble diagnostic kernels" which will include simple diagnostics (e.g. maxima, minima, averages) as well as "ensemble compression" – the ability to write out a compressed ensemble (building on work from ESiWACE1). This work will extend an initial prototype developed with UK national funding which exploits the XIOS IO server developed by ESiWACE1 and French national funding, making it more robust and suitable for wider deployment in other models. A key task will be developing support in the ensemble controller to handle failures in any one-ensemble member so that the ensemble system will not crash if one member fails. The initial software, available at the end of year two (described in D4.1), will be used in WP1 and continually improved thereafter.

Task 4.3: Earth System Data Middleware [Lead: UREAD. Partners: DKRZ, Seagate, CMCC, STFC, DDN, Seagate]

Middleware to interface standard IO libraries (NetCDF/HDF) and storage – whether it be a file system or a combination of burst-buffer, file system, or object store – to support active migration of data within workflows. The effort made in ESiWACE will be more tightly integrated with existing software, hardened and productised, and finally enhanced with several new capabilities that are needed to deal with the growing needs of the scientists: 1) the existing middleware is hardened and performance of the POSIX back-end is further optimised; 2) the current data systems performance model is enhanced to predict back-end behaviour more accurately; 3) we explore a direct NetCDF integration instead of providing a HDF5 VOL driver – we aim to provide a HPC NetCDF back-end driver; 4) we optimise and integrate better compression capabilities as prototyped in the AIMES project into the software stack and make it available in NetCDF; 5) we provide and optimise the storage back-ends which exploit the vendor-specific protocols for Clovis, WOS, IME; 6) we develop and deploy a generic S3 interface to support portability; 7) we provide an optimised ESDM interface for analytics tools using Ophidia as the prototype. A formal software deliverable (D4.1) at the end of year two will be used as input to task 4.7 and WP1 and published for wider distribution – with software support and testing (task 4.6) continuing throughout the remainder of the project.

Task 4.4: Semantic Storage Layer tools (SemSL) [Lead: STFC. Partners: UREAD]

User-space tools suitable for deployment without system administrator interaction so that datasets can be spread across multiple storage tiers (tapes, POSIX disk, object stores) in multiple files that can be accessed through one semantic master file. Includes support for caching and metadata interaction via standard (NetCDF) queries without the need of having underlying data online. The effort made in ESiWACE will be more tightly integrated with existing software, in particular schedulers and workflow managers. Specifically: 1) the performance of the S3NetCDF software will be improved, and it will be more closely integrated into other libraries (including the ESDM itself); 2) the cache subsystem will be improved to support a wider range of tape back-ends with a cleaner management interface. An internal software deliverable at month 30 will make this software available for deployment on tier0 machines, with the resulting experience feeding into D4.3.

Task 4.5: Workflow enhancements [Lead: DKRZ. Partners: UREAD, DDN, METO]

Add explicit support within the SLURM scheduler and the Cylc workflow management software to support the efficient scheduling of the data-intensive workloads with active staging of data products through storage tiers with or without the use of the ESDM and/or Semantic Storage Tools. Specifically: 1) a co-design phase to capture scientific requirements and the data life cycle and to map script-based workflows to directed graphs enriched with IO dependencies, performance needs and information about data lifecycle and user intervention (enabling users to describe the execution of their experiments and the data interaction in detail);

2) enrich the workflow scheduler Cylc that is used to schedule NWP/climate compute workflows with the capabilities to deal with data dependencies and lifecycle information, and to interface with ESDM to query information about data locality and to announce intended data usage to ESDM; 3) to enrich the workflow scheduler SLURM to honour the data dependencies and query information from ESDM about data locality; 4) ESDM is extended with a workflow interface and service that implements the needs of the data lifecycle, e.g., allowing to migrate/copy data between storage back-ends, and to clean out-dated or redundant data. The Cylc enhancements available in month 36 will be made available for use in WP1 and the resulting experience will feed into D4.3.

Task 4.6: Testing [Lead: ICHEC. Partners: All WP partners]

Carry out continuous integration, component level, and end-to-end testing. This will require: 1) setting up and managing a continuous integration testing environment; 2) component level quality control assessments (for each of XIOS ensemble branch, ESDM, Semantic Storage Tools, SLURM and Cylc branches, and the analytics kernel libraries); 3) scheduler support for the testing environment, and 4) regular end-to-end testing. While all development will involve testing, formal cross-task testing will begin from month 24, and experience with testing will be reported as part of D4.3.

Task 4.7 Industry proof of concept [Lead: SEAGATE. Partners: DDN]

The ESDM software is designed to work with a range of storage environments, but it is anticipated that for wide uptake, many sites may want to purchase an appliance which has vendor support for the storage sub-system. To that end, both Seagate and DDN will create a prototype appliance package which exposes the complete ESDM implementation and includes client libraries that can be deployed by users on the local compute systems. This work will build on the ESDM release at month 24 (D4.1) and result in D4.2.

Deliverables

D4.1 Advanced software stack for Earth system data
Documentation and design description, along with formal code release of the ensemble code and hardened ESDM software and various back-end implementations. Due at month 24; PU; R; Lead: UREAD

D4.2 Report on appliances available for testing
Report on appliance configurations and performance. Due at month 42; PU; R; Lead: SEAGATE

D4.3 Software documentation and roadmap
Formal documentation of software produced, description of any on-going issues discovered during this work, with a forward-looking data handling roadmap. Due at month 48; PU; R; Lead: UREAD

Work package number	5		Lead beneficiary		CMCC	
Work package title	Data Post-Processing, Analytics and Visualisation					
Participant number	1	2	5	10	11	16
Short name of participant	DKRZ	CNRS-IPSL	MPIM	CMCC	UREAD	UNIMAN
Person months per participant	15	7	24	15	4	3
Start month	1		End month	48		

Objectives

WP5 is directly linked to **principal objectives (1) and (2)** and in particular to **specific objective (d)**.
The main objective of this work package is to provide a consistent view regarding the support for data post-processing, analytics and visualisation at scale in the weather and climate domain by building, on top of the

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ESDM module developed by WP4, the proper ESDM extensions.

In particular, the tasks in WP5 are to a) design the ESDM interface extensions to support in-flight analytics kernels for post-processing, analysis and visualisation (PAV) needs; b) identify, prioritise, implement, and validate a set of common analytical kernels starting from a set of community-based tools; c) develop a high-performance support to enable ESDM data parallelisation for in-flight analytics; d) validate the ESDM post-processing, analytics and visualisation support on a set of representative case studies regarding community-based weather and climate applications.

All software products will be formally described in D5.1 (ESDM PAV runtime), D5.2 (analytical kernels) and D5.3 (ESDM-enabled PAV applications) building on the architectural report described in M5.1. The final software release of the ESDM-enabled PAV case study application will be documented in M5.2.

Description of work [Lead: CMCC. Co-lead: DKRZ]

Task 5.1 Design of the ESDM interface for data post-processing, analytics and visualisation (PAV) [Lead: CMCC. Partners: DKRZ, UREAD]

This task addresses the design of the ESDM interface API to support data-intensive *post-processing*, *analytics*, and *visualisation* (PAV) applications and case studies in the weather and climate domain. Starting from a set of key scientific applications, this task will identify, gather, analyse, and prioritise the key requirements to properly address the design of the ESDM PAV API (M5.1).

Task 5.2 Implementation of the ESDM PAV runtime extensions [Lead: CMCC. Partners: MPIM]

High volume workflows require IO and compute parallelisation in post-processing, analytics and visualisation. There are multiple routes to parallelisation, from on-node support for accelerators, GPUs and threading, single-executable MPI jobs exploiting multiple nodes, to task based parallelisation using simple batch jobs or complex graph-based task scheduling – all could benefit from improved parallel data access exposed via the ESDM and/or the Semantic Layer Tools to perform on-the-fly analytics while data are being transferred from the storage back-ends to the applications built on top of the ESDM module. This task is to support PAV applications, by exploring and prototyping efficient *in-flight analytics* ESDM extensions. Additionally, the support for remote execution via DASK or SLURM for data-driven workflows to reach high degrees of parallelism will be explored. The initial software, available at M18 will be used to test the first analytical kernels in task 2 and will be ready for integration in task 4 and task5 at M24, and continually improved thereafter. The ESDM PAV runtime and related parallelisation strategies will be comprehensively documented in D5.1 and will be ready to be deployed on tier0 with a finale release at M36.

Task 5.3 ESDM PAV analytical kernels [Lead: MPIM. Partners: DKRZ]

In this task, we will develop the core libraries (plug-ins for the EDSM PAV runtime) needed to properly interface and support, from an analytical point of view, the ESDM module to existing community post-processing tools, analytics frameworks, and visualisation applications.

A comprehensive set of key common candidates for analytical kernels, which can exploit semantic metadata, will be established via an iterative evaluate/prioritise/design phase.

More specifically, the supported analytical kernels include, among others, statistical and arithmetic operators, data transformation operators, as well as correlation, regression and interpolation operators, that will benefit from the parallelisation support available from the ESDM runtime. They will be either exposed by the ESDM interface, or made available directly via suitable APIs to applications. To further address performance, the task also targets analytics on massively parallel architectures, by including GPU-based implementation of key analytical kernels. The first software release of the analytical kernels will feed into task 4 and 5 to start with the PAV applications porting to the ESDM at M24; intermediate releases at M30 and M36 will be deployed on tier0 and tested on the prototypes of the ESDM-enabled PAV tools/applications; the final release will be comprehensively documented in D5.2 and delivered at M42.

Task 5.4 Interfacing data post-processing and analytics applications to ESDM [Lead: MPIM. Partners: CMCC, UNIMAN, UREAD]

In this task, we will interface a set of community processing tools and analytics frameworks to the ESDM. As such, a set of key applications (e.g. CDO) will be considered as case studies to test and validate the entire ESDM software stack.

More specifically, work in this task comprises: upgrading the CDO operators via the ESDM PAV interface, also including GPU support; interfacing existing community tools (e.g. CF-Python, Ophidia) to the ESDM PAV; additionally, validation feedback will be provided to, respectively, the output of (i) task 5.3 in terms of functional (e.g. supported analytical kernels) and non-functional requirements (e.g. usability, performance) and (ii) task 5.2 from the ESDM PAV runtime point of view.

An initial release of the ESDM-enabled tools/applications for post-processing and analytics is planned at M30 to be deployed on tier0, whereas the prototypes at M36 will be tested for first integration into tier0 simulations. During the last year, the activity on the tools/application will continue thus leading to the final release at M48, which will be reported in detail in D5.3. The final software implementation of key selected post-processing and analytics tools/applications will be documented in M5.2.

Task 5.5 ESDM-enabled data visualisation case studies [Lead: DKRZ. Partners: CNRS-IPSL]

Depending on the actual size of the data produced by high-resolution weather and climate models, the conventional post-processing and post-visualisation pipeline finally encounters a barrier that can only be overcome with alternative approaches to access, store, analyse and visualise it.

One of which is in-situ visualisation, which analyses and visualises the data alongside the simulation process while the simulation is still running.

In this regard, a choice of different setups exists, that allow a loose or tight coupling between the simulation model and the visualisation software to either perform an on-the-fly data visualisation that shows how the simulation progresses, or to store images, animations and even geometry using a predefined script onto the disk. Other data reduction and transformation techniques, such as compression and decomposition are also possible and may also be explored. Especially interesting is thereby the data decomposition using wavelets with an associated (lossy/lossless) compression. This approach would allow transforming the data into several Level-Of-Detail versions, which can be accessed progressively.

The main goal of this task is to analyse how key approaches, like those mentioned above, can be implemented on top of the ESDM interface for some key visualisation applications (e.g. ICON and DYNAMICO) (M5.2, D5.3).

More specifically the task focuses on: analysing suitable rendering solutions in the light of a pre-exascale HPC system (i.e. GPU vs. CPU); implementing an in-situ visualisation framework using ParaView/Catalyst and exploring the different setups (i.e. in-transit vs. in-situ); exploring the possibilities for an in-situ created image based rendering approach that can be used as preview to the data (i.e. the ParaView Cinema extension); implementing an in-situ wavelet decomposition and compression for a later progressive data access and visualisation using Vapor; exploring lossy data compression and its impact to the data.

As for task 4, an initial release of the ESDM-enabled visualisation applications is planned at M30 to be deployed on tier0; prototypes at M36 will be tested with tier0 simulations. Development will continue during the fourth year. The final release delivered at M48 will be described in D5.3. The final software implementation of selected visualisation applications will be documented in M5.2.

Deliverables

D5.1: Report on the ESDM runtime extensions for parallel in-flight analytics
Formal documentation of the ESDM parallel runtime strategies and software implemented (final release). Due at month 36; PU; R; Lead: CMCC

D5.2: Report on the implementation of the ESDM PAV analytical kernels for post-processing, analysis and visualisation

Formal documentation of the implemented ESDM PAV analytical kernels (final release). Due at month 42; PU; R; MPIM

D5.3: Report on the final implementation of key selected post-processing, analytics and visualisation applications and main outcomes

Report on the main technical porting-to-ESDM aspects, outcomes and guidelines related to key community applications. Due at month 48; PU; R; Lead: MPIM

Work package number	6				Lead beneficiary						CNRS-IPSL		
Work package title	Community Engagement and Training												
Participant number	1	2	3	4	7	9	10	11	12	14	15	18	19
Short name of participant	DKRZ	CNRS-IPSL	ECMWF	BSC	CERFACS	METO	CMCC	UREAD	STFC	SEAGATE	ETH Zurich	MeteoSwiss	DDN
Person months per participant	6	4	6	3	11	1	7	5	2	1	6	4	1
Start month	1					End month					48		

Objectives

WP6 objectives are linked to **principal objective (2)** and in particular to **specific objectives (c) and (e)** of ESiWACE2.

WP6 focuses on the further engagement of ESiWACE2 with the community by strengthening the ties between climate and weather modellers, exploiting possible synergies with other relevant community activities (FETs, flagships, Centres of Excellence, …), fostering the efficient use of HPC resources in particular through the interaction with PRACE, with the European HPC industry and with ETP4HPC, and networking with the Big Data community.

WP6 will in particular offer diverse training programmes on pre-exascale HPC software engineering, methods and tools for engineers and scientists in the domain of weather/climate. Indeed running (pre-) exascale applications on the most advanced supercomputers asks for well-trained and highly-qualified staff ensuring sound programming of the applications and expert use of all components in the ecosystem. Attention will be specifically paid to attract female and young people to participate. These trainings will constitute a first transfer of general knowledge from ESiWACE2 experts to the community while the services from WP3 will constitute a precise and individual answer to user specific problems encountered with their code on the path to exascale. These trainings will be coordinated with the ones offered by the PRACE Advanced Training Centres, preferably in cooperation with the CoE Coordination and Support Action (CSA) planned under call INFRAEDI-02-2018.

Description of work [Lead: CNRS-IPSL. Co-lead: CERFACS]

Task 6.1: Community engagement in ESiWACE2 [Lead: CNRS-IPSL. Partners: DKRZ, CERFACS, ECMWF, BSC]

Task 6.1 will engage with the community by:

- Addressing HPC issues relevant for the ESM community, in particular cross-cutting issues, through discussions at the General Assembly and HPC workshops as well as through feedback from the HPC Task Force, Scientific Advisory Board and supporting partners.

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- Liaising with other European projects involving ESM and HPC and deploying this interaction as a source of user feedbacks.
- Organising regular interactions with the ExtremeEarth preparatory action (ExtremeEarth.eu) initiative and any follow-on activities.

1. High-Performance Computing Task Force: **A**n active platform on organisation and coordination issues related to HPC will be maintained through the HPC Task Force (HPC-TF). This task force will update on a regular basis the scientific case for climate and NWP, contribute to the strategy on co-design activities in link with the ExtremeEarth initiative, coordinate use of, and access to, potential EU extreme-scale demonstrators. The HPC-TF will report to the General Assembly and minutes of meetings will be published on the ESiWACE2 website.

2. HPC workshop: A community workshop will be organised to help engage with the community on latest developments related to HPC (D6.3). This workshop will be organised by DKRZ and will be prepared with the HPC Task Force. It will be an opportunity to invite contributors from other related projects and from outside Europe. This workshop will be complemented by the biannual workshops organised by ECMWF and dedicated to NWP. In addition ESiWACE2 will continue the tradition of ESiWACE1 to contribute minisymposia and BOF-sessions to established conferences, in particular PASC, ISC, SC and EGU.

Dedicated PRACE allocation: A potential, dedicated computing allocation from PRACE to the CoEs will be managed, ensuring that this resource is used by project partners for developments in the framework of the ESiWACE2. Further allocations will be negotiated or applied for if necessary for the work in WP1.

3. Strategic interaction with HPC ecosystem and HPC industry: Liaising with the European HPC and Big Data ecosystems is planned, linking a) to relevant FET projects, Extreme Scale Demonstrators (EsD, H2020 call ICT-14-2019), and other CoEs, e.g. through active participation to European summit week; b) to the ETP4HPC, in particular by contributing to updates of the Strategic Research Agenda; c) to HPC-related hard- and software industry and foster their involvement in ESiWACE2 activities, in particular their participation to the HPC workshops; d) on the technical level with PRACE and other HPC centres, in particular with respect to the requirements arising from the developments in WP1 and WP4; e) with HPC Europa3 and similar initiatives granting use HPC resources; f) to the European BDVA, in particular by providing use-cases.

Task 6.2: Training and schools on HPC software engineering, methods and tools [Lead: CERFACS. Partners: ECMWF, BSC, METO, CMCC, UREAD, STFC, SEAGATE, ETH Zurich, MeteoSwiss, DDN, CNRS-IPSL, DKRZ]

This task organises the trainings offered in different HPC areas of ESiWACE2 pre-exascale expertise i.e. IO, computation (DSLs, C++ and coupling software), data analytics and containerisation. It also organises two summer schools to train scientists in these matters.

For all trainings, we embrace the creation of online digital media as *Open Educational Resources (OER)* material (https://www.oercommons.org) that will be available under a permissive CC-by licence and can be reused by teachers and researchers outside the consortium. Resulting material will be presented during the summer schools. All trainings also propose online sessions or face-to-face sessions at the partner's institution (Deliverable D6.2). Additionally, we will explore the collaboration with the international effort of the Universität Hamburg to establish an HPC certificate programme for scientists (https://www.hhcc.uni-hamburg.de/en/hpc-certification-program.html).

These trainings will result in a larger number of scientists and engineers with higher qualifications in the use and optimisation of climate and weather applications on tier-0 machines, increasing HPC awareness in that community. Ultimately, training will allow climate and weather research to be more productive, favouring European scientific excellence in that field.

1. Training on IO and HPC awareness: This task covers training on the IO hardware and software stack.

Delivered material will target scientists accessing data on storage and developers that aim to utilise storage APIs efficiently.

We will create descriptive course material covering the co-designed software stack of WP4 as a standardised and efficient platform for IO (Cylc, XIOS, ESDM, NetCDF, HDF5) and how the analysis stack fits into this (in-depth analysis workflows are part of training on high-performance data analytics, see below), training on the underlying storage APIs and file systems (e.g., Mero/Clovis, Lustre), efficient creation of IO dominated workflows, performance and efficiency considerations when dealing with file systems, NVM, tape or object storage, and cost-considerations in storage architectures.

Material will cover roughly 8 hours course work in the form of presentations and a summarising paper covering the individual aspects. Webinars that present the created OER material and blog entries describing issues will be organised. Finally, we will harness existing community approaches like the Virtual Institute of IO (https://www.vi4io.org/) for promoting this training.

2. Training on DSL: The rapid changes in the multiple supercomputing architectures used to run weather and climate codes and the different programming models used seriously affect the development productivity and the ability to retain a single source code running efficiently everywhere. Domain-specific languages provide a solution to portability of these codes. In this training, we provide insights on DSLs considered in ESiWACE2 (PSyclone, CLAW and GridTools ecosystem) and demonstrate how to apply them to weather and climate models.

The training will be organised in the form of a 5-day face-to-face training workshop in spring of year 2 for about 25 people. Participants will theoretically and practically learn how to use the DSL languages to implement PDE operators. During a hands-on session, participants will be encouraged to implement some of the benchmark models defined by WP2 using DSLs and to build their own toy models, followed by an in-depth evaluation of generated optimised implementation and performance benefits.

3. Training on C++ for HPC: ETH Zurich organises an advanced course for C++ in HPC as part of its regular trainings. Up to 12 domain scientists can further improve their software-engineering skills by participating in the autumn 2021 three-day course on "Advanced C++ programming for HPC". This course will present advanced tools for effective C++ programming in the context of HPC, such as generic programming techniques, API development, specific C++-11/14 constructs, rather than treating parallel programming primitives, such as OpenMP or MPI, a subject of widely available courses.

4. Online training course for code coupling with OASIS3-MCT: The objectives of this task is to create an online course that teaches the participants basic concepts in code coupling, focussing on the ocean-atmosphere context, and help them learn on how to use OASIS3-MCT. This training course is for engineers, physicists, and computer scientists wishing to use this code coupling software in their own coupled model.

The training course will be delivered once per year during the 2nd, 3rd and 4th year of the project, over 4 consecutive weeks with learning activities delivered each week and requiring about 2 hours of work per week from the participants. The material will cover theoretical concepts about code coupling, instructions on how to download, install and compile OASIS3-MCT and finally implementation of the coupling between two toy models in a hands-on tutorial session.

5. Training on High-Performance Data Analytics: The objective of this task is to increase scientists' expertise on scientific data analysis at scale applied to climate and weather domains, using high-performance data analytics tools available from the open source market (e.g., Ophidia). It will address several vertical training levels (e.g., intermediate, expert) from different horizontal perspectives (e.g., end-user, developer, administrator), covering from simple analytics tasks to workflows and applications (e.g., Python-based) and providing best practices and guidelines on dealing with massive scientific datasets on HPC architectures.

Delivered material, using aforementioned material on IO and HPC awareness as background, will include 8 hours of theoretical and practical aspects on big data (both introductory and advanced topics), high-performance data management (including performance and optimisation aspects), scientific data analytics at

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scale, and analytics workflows. As for the training on code coupling with OASIS3-MCT, the online training course (e.g. webinar) will be delivered once per year, during 2nd, 3rd and 4th year of the project, over 4 consecutive weeks, with 2 hours of work per week from the participants.

6. Training on Docker containerisation: Docker is an open software technology for developers to build, ship, and run distributed applications in containers. This is achieved by describing the software environment and build instructions allowing the creation of a container that can be executed on different environments and does not depend on system-wide software packages. Consisting of a rich ecosystem, Docker enables applications to be quickly assembled from components and eliminates the friction between development, QA, and production environments. As a result, software can ship faster and run the same unchanged stack on laptops, data centres, and virtual machines. With Docker, developers can build any application in any language using any toolchain; "dockerised" applications are completely portable and can run anywhere.

A 4-hour introductory tutorial followed by a 2-hour hands-on session on Docker containers will be produced, condensing the experiences from WP2, task 2.4. A recording of the material presented at the summer schools will be made available online in order to reach a wider audience.

7. Summer school in HPC for weather and climate: In this task, we will organise two summer schools for Earth system scientists, including PhD students and postdocs, covering the HPC aspects to run scientific workflows on large scale HPC environments efficiently. A five day summer school will take place in year 2 and 3 of the project and support about 30 students each year and fund their attendance. The selection procedure for subsidising students will be established 6 months before the summer school taking into account the experience gained with summer schools held within the IS-ENES projects. It will prioritise diversity and internationality and fund students depending on the financial support possible by their home institution.

Theoretical courses and hands-on sessions will be organised on IO, HPC computation (DSLs, C++ and coupling software), data analytics, containers, efficient programming and usage of data Centre resources, using the teaching material created in this WP, but we will also invite external experts to give tutorials about selected topics. Selected presentations will be recorded and made available online after the summer school for a wider audience. A survey will be conducted to evaluate the feedback of participants about the content of the tutorial itself (D6.1).

Deliverables

D6.1 Report on summer school and its material
Report covering the teaching material and discussing the result of the conducted survey regarding the quality and effectiveness of the summer school and the individual OER materials. Due at month 36; PU; R; Lead: UREAD

D6.2 Report on the different trainings
Report describing the different online or face-to-face training on IO, DSLs, C++, coupling, HPDA, containerisation held during the project. Due at month 42; PU; R; Lead: CERFACS

D6.3 6th ENES HPC-workshop in Hamburg
Three day Workshop continuing the successful series of HPC workshops (Hamburg, Toulouse (2x) and Lecce (2x)) on weather and climate-related subjects. Due at month 18; PU; OTHER; Lead: DKRZ

D6.4 Training OER material made available under a permissive CC-by licence
Report describing the OER material. Due at month 36; PU; R; Lead: CERFACS

Work package number	7				Lead beneficiary				DKRZ	
Work package title	Scientific Coordination, Management and Dissemination									
Participant number	1	3	12	18	17	13	11	10	2	7
Short name of participant	DKRZ	ECMWF	STFC	MeteoSwiss	NLeSC	Bull	UREAD	CMCC	CNRS-IPSL	CERFACS
Person months per participant	38	6	1	1	1	1	1	1	1	1
Start month	1				End month		48			

Objectives

The general objective of this work package is to ensure an effective and smooth high-quality implementation of the project and delivery of innovation actions, and impacts. This includes scientific coordination and project management, and administrative and financial management, in particular:

- to set up and maintain a structure, procedures and tools that will allow a coherent and efficient technical and administrative management of the project;
- to apply controlling and make sure the project delivers on time and in line with the assigned budget;
- to prevent, identify and manage risks;
- to identify opportunities and procedures for fostering the uptake of results by partners and stakeholders;
- to assure quality management;
- to ensure that requirements for open access of data and publications are fulfilled;
- to establish and coordinate relevant dissemination measures to reach out for all stakeholders;
- to ensure efficient innovation management and adequate exploitation of project results;
- to coordinate the communication and interactions between work packages and partners;
- to coordinate the communication processes between the governance bodies of the project;
- to coordinate the communication processes between ESiWACE2, the European Commission and other European bodies and EU/international initiatives and projects;
- to ensure sound data management coordination in the project.

The management structure and procedures of the project are extensively described in section 3.2. More on innovation management (section 3.2.4), dissemination and exploitation measures as well as communication activities is described in section 2.2. **That information is not repeated in here.**

Description of work [Lead: DKRZ. Co-lead: ECMWF]

Task 7.1 Scientific Coordination and Management [Lead: DKRZ. Partners: ECWMF, Work Package-Leaders and co-leaders]

Scientific coordination: The Coordinator, the Co-coordinator and the Scientific Programme Manager carry out the coordination and monitoring of scientific excellence within the project; this includes regular discussion with the Steering Board and the Scientific Advisory Board. The scientific coordination ensures that the planned work is carried out on time and within budget, monitors the scientific review of reports and deliverables, ensures that any necessary scientific aspects are incorporated into the project, liaise with the EC to seek advice and a solution, if there are any major difficulties within the project that cannot be resolved using the appropriate management structure. The Work Package-Leaders ensure that the progress of activities is actively monitored, expected results are achieved and deliverables are on time. The management processes are described in more detail in section 3.2.

Management: The Project Office ensures the implementation of the consortium agreement, ensures compliance with project obligations from the Grant Agreement, provides administrative, financial and legal support to all partners involved during the implementation of the project, including administrative tasks for

the preparation, execution and post-processing of annual project meetings and review meetings, and of meetings of decision-making, advisory and executive bodies, and of official reports to the EC. It ensures effective communication within the consortium (via intranet D7.1) and with the EC (EC Portal). See section 3.2 for details on the composition of the Project Office.

7.2 Risk Management [Lead: DKRZ; Partners: ECMWF, all WP leaders and co-leaders]

The Scientific Coordination will be responsible for management of the risks within the project. Day-to-day maintenance of the risk registers via regular meetings of the SB will be undertaken by the SPM (for more details refer to section 3.2). Critical risks to project implementation, which have the potential to impact the project objectives being achieved, have been identified and described in the Table 3.2.a. The General Assembly is responsible for taking decisions on how to deal with risks and issues in the project, see section 3.2.5 for details.

Task 7.3 Exploitation of results [Lead: DKRZ. Partners: ECMWF, all WP leaders and co-leaders]

Management of knowledge and innovation: **Management of knowledge and innovation** is an integral part of ESiWACE2. We focus on the role and synergies between partners' experiences, competences, capabilities, and on how partners protect, share, manage IPR capital actual exploitation. Detailing of the exploitation plans and preparation for innovation activities will be continuously followed up throughout the project. The innovation management is well integrated in the management structure of the project and in the work plan (see section 3.2.3).

Consortium agreement: The consortium agreement regulates the ownership and access to key knowledge (background) and scientific results.

Exploitation: A **strategy for the knowledge management, protection and for the exploitation of results, the Exploitation Plan (D7.5),** is going to be based on the principles explained extensively in section 2.2. A Strategy for the Intellectual Property exploitation (D7.6) is going to be drafted at the end of the project for providing best practices in capturing and assessing the Intellectual Property and providing measures for exploitation after the end of the project.

Data management: ESiWACE2 provides open access **to peer-reviewed scientific publications** through a combination of golden open access and green open access, and it is voluntarily taking part in the European Commission **Open Access Data Pilot for Research Data** (see section 2.2): a **Data Management Plan (D7.4)** which oversees data generated throughout the project is planned for project month 6 and drafted in compliance with the "Guidelines on FAIR Data Management in Horizon 2020" and the "Guidelines to the Rules on Open Access to Scientific Publications and Open Access to Research Data in Horizon 2020". Updates of D7.4 will be submitted to the EC as an integral part of the Project Periodic Reports.

Task 7.4 Dissemination [Lead: DKRZ. Partners: All partners]

The dissemination activities of the project will involve **all consortium partners** and their respective staff, including researchers. They are coordinated by DKRZ, during the lifetime of the project, in its closing phase and after formal closure of the project. The **Dissemination, Engagement and Communication Plan (D7.3)** explains the strategy behind the project for disseminating to relevant stakeholders and communicating to the society at large. Updates are submitted to the EC as an integral part of the Project Periodic Reports, and include a record of past and planned activities related to dissemination and exploitation. Project results and dissemination materials will be made available in open access in **ZENODO** www.zenodo.org.

Task 7.5 Communication [Lead: DKRZ. Partners: All partners]

The communication activities of the project will involve **all consortium partners** and their respective staff, including researchers and will be coordinated by DKRZ. We have identified different levels of communication activities: 1) **Communication activities to promote the project and its findings** mostly targeting non-scientific audiences. 2) **Coordination of internal communication within the consortium,**

with the supporters and the advisory bodies. As indicated in section 2.2, we have already foreseen tools for the implementation of our communication strategy; and update of the table in section 2.2 is foreseen with D7.3. Project progress reports to the EC include a record of the completed and planned communication activities. (Months 18, 36, 48). See the Gantt chart, section 3.2.

Task 7.6 Sustainability [Lead: DKRZ. Partners: All partners]

During the first phase of the project, we will refine the KPIs which measure success and impact (D7.7). Based on these KPIs and on the business plan of ESiWACE1 and taking into account also the evolvement of other coordinated community activities like ExtremeEarth, we will develop a sustainability plan (D7.8).

Deliverables (brief description and month of delivery)

D7.1: Design and implementation of the intranet
The intranet is a web-based tool for the project, legal, financial and administrative management of the project. Due at project month 2; CO; DEC; Lead: DKRZ

D7.2 Project Public website
The website of ESiWACE2 will be based on the existing website of ESiWACE1 (www.esiwace.eu). Modifications and extensions with regard to the description of both projects on this website will be carried out. Due at project month 2; PU; DEC; Lead: DKRZ

D7.3 Dissemination, Engagement and Communication Plan
It explains the strategy behind the project for disseminating to relevant stakeholders and communicating to the society at large. Due at project month 4; PU; R; Lead: DKRZ

D7.4 Data Management Plan (DMP)
DMP sets up the requirements of the "Guidelines on FAIR Data Management in Horizon 2020". Due at project month 6, PU; R; Lead: DKRZ

D7.5 Exploitation Plan
Plan identifying types of potential pathways of market-oriented exploitation, converting or transforming knowledge will be identified, together with key factors for a successful innovation management. Due at project month 6; PU; R; Lead: DKRZ

D7.6 Strategy for the Intellectual Property Exploitation
Strategy for defining measures for exploitation "after the project" phase, providing evidence of best practices in capturing and assessing, Due at project month 48; PU; R; Lead: DKRZ

D7.7 Refined set of KPIs
Set of detailed metrics and targets based on four sets of basic KPIs. Due at project month 7; CO; R; Lead: DKRZ

D7.8 Sustainability Plan
Defines the long-term strategy for sustainability. Due at project month 36; PU; R; Lead: DKRZ

Table 3.1c. List of deliverables.

Deliv. no.	Deliverable name	WP no.	Lead	Type	Dissem. level	Delivery date (in month)
1.1	Simulations of global high-resolution climate and weather models in production mode	1	ECMWF	R	PU	36
1.2	Model inter-comparison for global high-resolution simulations	1	DKRZ	DEC	PU	24
1.3	Scalability on pre-exascale EuroHPC systems	1	DKRZ	R	PU	48
2.1	Report summarising the adaptation of the proposed DSLs and the evaluation of the benchmarks and models proposed in this project	2	STFC	R	PU	48
2.2	Demonstration of the DSLs in the proposed models	2	STFC	DEM	CO	48
2.3	Demonstration of PSyclone-CLAW using the GridTools toolchain with the proposed benchmarks, making use of the HIR	2	MeteoSwiss	DEM	CO	36
2.4	Report on the performance of DSL compilers with the proposed models	2	UNIMAN	R	PU	48
2.5	Report and demonstration of the concurrency of model components, evaluating the impact in performance and comparison of technologies employed	2	MPIM	R	CO	36
2.6	First white paper on community guidelines on the use, value and applicability of emerging technologies in climate and weather applications	2	CMCC	R	PU	20
2.7	Second white paper on community guidelines on the use, value and applicability of emerging technologies in climate and weather applications	2	UNIMAN	R	PU	44
2.8	Material and summary of the hackathon experiences	2	ETH Zurich	R	PU	12
2.9	Report summarising the porting of the different models to containers, including evaluation of the performance on the supercomputer where the containers are deployed	2	ETH Zurich	R	PU	48
2.10	Machine learning workshop	2	UNIMAN	OTHER	PU	24

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3.1	Mid-term assessment of the services	3	NLeSC	R	CO	24
3.2	Report on services in portability and refactoring	3	BULL	R	PU	46
3.3	Report on services offered on IO, coupling and workflow	3	CERFACS	R	PU	44
3.4	Report on services offered on weather and climate benchmarks	3	DKRZ	R	PU	48
3.5	To make Europe's Earth system models fit for the exascale	3	NLeSC	R	PU	48
4.1	Advanced software stack for Earth system data	4	UREAD	R	PU	24
4.2	Report on appliances available for testing	4	SEAGATE	R	PU	42
4.3	Software documentation and roadmap	4	UREAD	R	PU	48
5.1	Report on the ESDM runtime extensions for parallel in-flight analytics	5	CMCC	R	PU	36
5.2	Report on the implementation of the ESDM PAV analytical kernels for post-processing, analysis and visualisation	5	MPIM	R	PU	42
5.3	Report on the final implementation of key selected post-processing, analytics and visualisation applications and main outcomes	5	MPIM	R	PU	48
6.1	Report on summer school and its material	6	UREAD	R	PU	36
6.2	Report on the different trainings	6	CERFACS	R	PU	42
6.3	6th ENES HPC-workshop in Hamburg	6	DKRZ	OTHER	PU	18
6.4	Training OER material made available under a permissive CC-by licence	6	CERFACS	R	PU	36
7.1	Design and implementation of the intranet	7	DKRZ	DEC	CO	1
7.2	Project public website	7	DKRZ	DEC	PU	2
7.3	Dissemination, Engagement and Communication Plan	7	DKRZ	R	PU	4
7.4	Data Management Plan	7	DKRZ	R	PU	6
7.5	Exploitation Plan	7	DKRZ	R	PU	6
7.6	Strategy for the Intellectual Property Exploitation	7	DKRZ	R	PU	48
7.7	Refined set of KPIs	7	DKRZ	R	CO	7
7.8	Sustainability Plan	7	DKRZ	R	PU	36

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3.4 Graphical presentation of the components showing how they interrelate
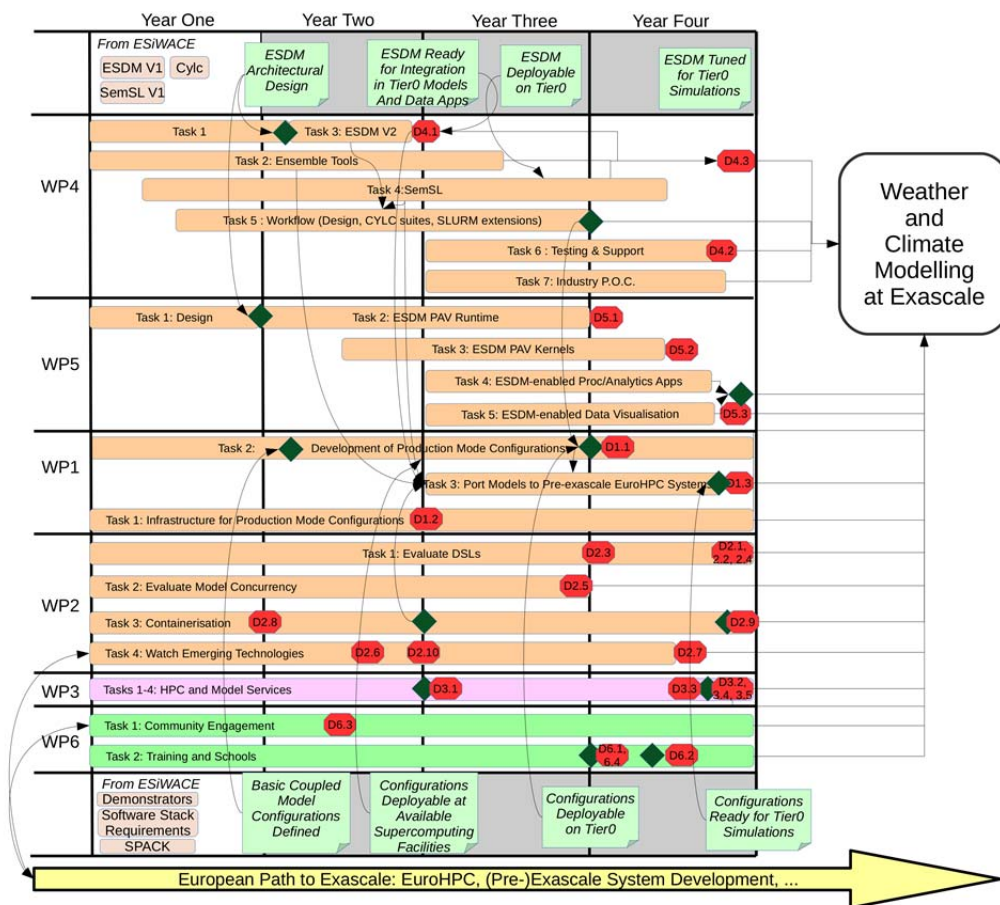
Figure 4. Path to weather and climate modelling at exascale via ESiWACE2. The arrows show approximate time dependencies, with basically all paths (1) feeding the production-ready models on EuroHPC systems, or (2) impacting modelling in the exascale era in the long term. The green-colored diamonds show the WP-internal milestones (Table 3.2a). The diagram illustrates how tasks and milestones are aligned to define four overarching control points for ESiWACE2 which will be monitored by the project management: Year 1: Architectural design and target configurations ready. Year 2: Deployment of developed software on existing supercomputing facilities. Year 3: Deployment of final systems (model and data) on EuroHPC ("tier-0") systems. Year 4: The final goal of production-ready configurations on EuroHPC systems.

3.5 Management structure, milestones and procedures

3.5.1 Organisational structure and decision-making

The consortium consists of 20 beneficiaries from science and industry from 9 countries. A number of institutions, called supporters, have committed to support the project throughout its funding period.

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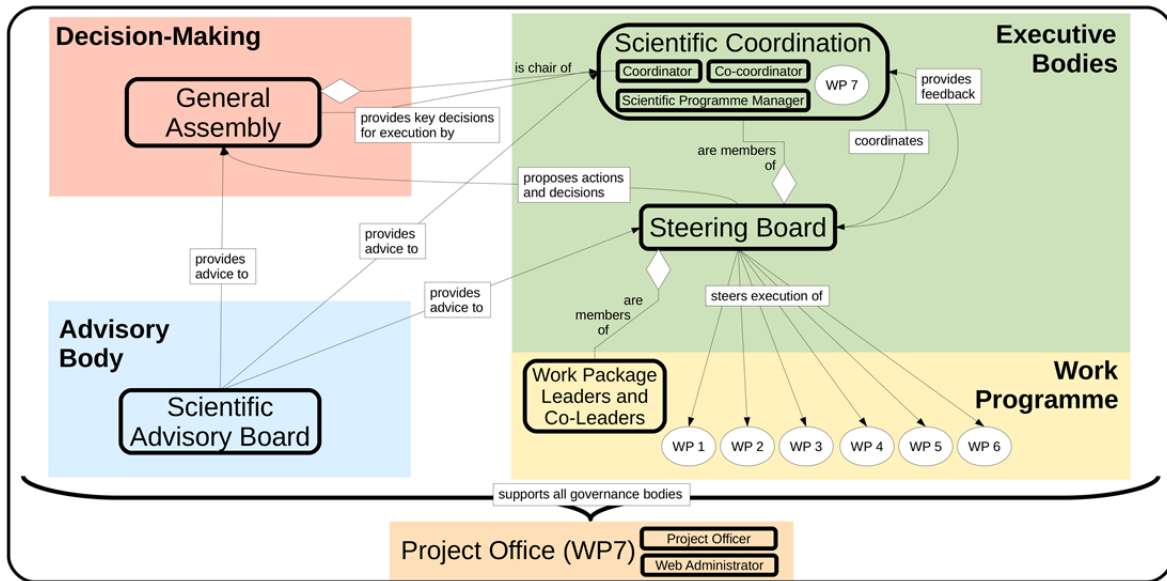
Figure 5. Organisational structure of ESiWACE2

The organisational structure (Figure 5) is set up as follows:

- Decision-making: the General Assembly (GA)
- Executive Bodies: the Coordination and the Steering Board (SB)
- Advisory Body: the Scientific Advisory Board (SAB)

Decision-making

The ultimate decision-making body of the consortium is the **General Assembly (GA).** The GA is responsible for making key decisions for the project as a whole, on the basis of issues raised by the Executive Bodies and the Advisory Body. This includes strategic decisions on the project progress, decisions on public relations and dissemination activities, modifications of the Grant Agreement, and modifications of the Consortium Agreement.

The GA consists of one representative per consortium partner (beneficiaries). It is chaired by the Coordinator. Each consortium member has one right to vote on decisions. Decisions of the GA have to be made at least by simple majority. Formal meetings of the GA are held during the annual project meetings, and via monthly teleconferences. The supporters might attend the GA meetings in their advisory role. Representatives of the EC are invited to attend as observers.

Executive Bodies

The Executive Bodies consist of:

- The **Scientific Coordination,** comprising the Coordinator (Dr. Joachim Biercamp, DKRZ), the Co-coordinator (Dr. Peter Bauer, ECMWF) and the Scientific Programme Manager (SPM). They are responsible for the following tasks: overall scientific coordination, liaising with the European Commission and European initiatives (i.e. ETP4HPC, EuroHPC, PRACE), execution of the decisions taken by the GA, monitoring of the project progress (including time schedule, quality and risk management), proposal of corrective and proactive actions for the scientific coordination of the project. The Coordinator and Co-coordinator are supported in their tasks by the SPM who is located at DKRZ: the SPM is in charge of the day-to-day management of the project, ensures that ESiWACE2 is

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implemented coherently with the project agenda, keeps close contact with all consortium partners, overlooks the overall progress towards the ESiWACE2 goals in terms of deliverable and milestone control, is in charge of risk and quality management, and supports the planning and coordination of corporate activities.

- The **Steering Board (SB)** is responsible for the execution of the project. It proposes decisions to the GA and monitors their execution. It consists of the Scientific Coordination and the Work Package Leaders and Work Package Co-leaders. The Work Package Leaders and Co-leaders are responsible for the fulfilment of the work package objectives, corresponding deliverables and the achievement of the project milestones. They manage the actual project work at WP level and report to the GA and SPM on a frequent basis on the WP progress.

Advisory Body

The **Scientific Advisory Board (SAB)** provides independent scientific evaluation of the project, gives advice on the scientific approach and orientation taken by ESiWACE2 by liaising with the executive and decision-making bodies, and supports the project by establishing links to other relevant initiatives and programmes at international and European level. The SAB comprises experts on climate and weather simulation and on HPC for covering the broad interdisciplinary range addressed in ESiWACE2.

The following experts have already committed, in their personal capacity, to act as advisors:

- Prof. Dr. Thomas Jung, Alfred-Wegener-Institute for Polar and Marine Research,
  Head, Climate Dynamics Section
  Core expertise related to ESiWACE2: Earth system model development

- Prof. Dr. Venkatramani Balaji, Princeton University and NOAA/Geophysical Fluid Dynamics Laboratory
  Head, Modeling Systems Group
  Core expertise related to ESiWACE2: Earth system model development, software engineering

- Dr. Rudolf Fischer, NEC Deutschland GmbH
  Director Core Technology
  Core expertise related to ESiWACE2: Optimising scientific applications, HPC architectures

- Dr. Michèle Weiland, EPCC - University of Edinburgh
  Project Manager
  Core expertise related to ESiWACE2: HPC software and hardware

- Prof. Dr. Peter Fox, Tetherless World Constellation
  Lead Professor for Environmental Informatics Application Theme
  Core expertise related to ESiWACE2: environmental informatics, computational and computer science, semantic data frameworks

The pool of advisors will be further enhanced with additional experts during the course of the project to ensure high quality science and engagement with other communities and relevant initiatives. This will include:

- Scientific representatives of the **community models involved in ESiWACE2** to enable an immediate feedback loop on ESiWACE2 service and support procedures (WP3)
- A representative of the European HPC ecosystem, preferably directly related to **EuroHPC**

- A representative of the **Coordination & support action [CSA]** responding to the call **INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC** to enable a stable dialogue and flow of information to/from the CSA.

Participation of advisors to ESiWACE2 annual meetings and workshops will be ensured on the basis of a rotating mechanism and according to the needs for expertise in the ESiWACE2 community.

Support to the governance bodies

In support to the governance bodies mentioned above, a **Project Office (PO)** will be established at DKRZ to make sure that financial and legal requirements set by the grant and the consortium agreements are met by the partnership and the governance bodies and to set up the tools for internal communication (redmine, our intranet) and for web visibility of the project (website/portal).

For this, the following roles have been defined:

- The **Project Officer** is located at DKRZ and is in charge of monitoring the financial and legal implementation of the project, supporting the partners in the implementation of the requirements set by H2020 and the requirements derived from the Grant and the Consortium Agreement, Open Science and Open Access, IP protection. The Project Officer supports the consortium in implementing its exploitation strategy and in innovation management. The Project Officer is also in charge of preparing amendments to the contracts, supporting the partners in the financial reporting, liaising with the EC for matters related to the financial/legal implementation of the project, tracking of dissemination activities in the EC portals and in Zenodo, supporting the entire consortium in the preparation of progress reports and reviews, and in monitoring the use of resources at project level.
- The **Web Administrator** is located at DKRZ and is in charge of the project intranet (redmine), the website and the web-based dissemination activities. The Web Administrator will support the partners in the use of tools for internal communication.

3.5.2 Appropriateness of organisational structure to ESiWACE2

The chosen organisational structure is relatively flat and allows for flexibility, e.g., in terms of optimal ESiWACE2 services and support structures, tailored to the needs of the community.

The **General Assembly and Scientific Advisory Board** ensure close links to science, technology, and actual weather and climate applications, reach out to the European weather and climate community to prepare it for exascale, and foster close interaction of ESiWACE2 with the European HPC landscape, European projects (FET projects, centres of excellence) and related initiatives such as PRACE, ETP4HPC, EuroHPC, EXCDI.

Through the **General Assembly,** all partners are intimately involved in the decision-making processes of ESiWACE2. This yields transparency at all levels, e.g., decisions within consortium and in the interactions with the EC and other projects/initiatives.

The **Steering Board** enables rapid communication with all relevant initiatives on an everyday basis and synchronises actions with the GA, acts as hub for synchronisation with centres of excellence of type (b) (Coordination and Support Actions): it will direct coordinating and support actions, that ESiWACE2 can contribute, to the corresponding persons/ESiWACE2 bodies in charge.

The **Scientific Coordination and Steering Board** ensure high quality and coherence in the implementation of the project and prompt risk, quality and conflict management. In case of arising conflicts, the conflicts are first handled internally at work package level by the WP Leader and WP Co-leader in charge. For inter-work package conflicts or in case that a conflict at work package level cannot be resolved, it is discussed with the members of the SB to find a solution. If this does also not resolve the conflict, the conflict is taken to the GA, including potential exchange with the SAB to deliver valuable input for conflict resolution.

Finally, the **Project Office** ensures a safe environment for operations, provides support in the implementation of legal requirements set by the contracts with the EC and between the partners, and enhances effective information flow between all ESiWACE2 partners through adequate tools (redmine, Zenodo, web portal).

3.5.3   List of milestones

The milestones in Table 3.2a are aligned in time to define four overarching control points for the project which will be monitored by the project management (WP7) as illustrated in section 3.4, Figure 4.

Table 3.2a: List of milestones.

Milestone number	Milestone name	Related work package(s)	Partner in charge	Due date (in month)	Means of verification
M1.1	Target configuration for coupled systems (ICON-ESM, ECMWF, EC-Earth, IPSL model) specified	WP1	ECMWF	15	Documentation of specifications
M1.2	Production-mode simulation with NEMO, ICON-ESM, ECMWF, EC-Earth, IPSL model	WP1	ECMWF	36	Up and running
M1.3	Production-mode simulation with NEMO, ICON-ESM, ECMWF, EC-Earth, IPSL model on EuroHPC systems	WP1	ECMWF	48	Up and running
M2.1	Containers 1	WP2	CSCS	24	1 model ported using containers
M2.2	Containers 2	WP2	CSCS	48	3 models ported using containers
M3.1	Service coordination 1	WP3	NLeSC	24	5 service projects up and running
M3.2	Service coordination 2	WP3	NLeSC	48	9+ service projects up and running
M4.1	Architecture	WP4	UREAD	15	Report
M4.2	Workflow extensions	WP4	UREAD	36	Code release
M5.1	Architecture	WP5	CMCC	12	Architecture delivered to consortium partners
M5.2	ESDM-based CDOs, data tools and visualisation applications	WP5	MPIM	46	Software released, validated and deployed on tier0

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3.5.4 Innovation management

The Consortium Agreement (CA) is going to be signed before the signature of the Grant Agreement with the European Commission: it is the internal agreement establishing the rights/obligations of the partners with respect to the implementation and organisation of the action, and regulates items not regulated in the EC Grant Agreement, such as project management procedures, joint ownership, use of background and Intellectual Property Rights (IPR). Based on the agreement outlined in the CA, a strategy for the protection of intellectual property arising from the project is going to be updated and implemented at regular stages in the project (D7.5, D7.6). Effective innovation management requires an overview of the project in its entirety. For this reason, the **SB will be in charge of innovation management.** The SB 1) ensures the development of a strategy and concrete actions of the consortium for the protection, exploitation and dissemination of the results of the project; 2) addresses technical, scientific and application aspects of innovation emerging in the project; 3) provides effective management and therefore exploitation of project results; 4) tracks and proposes commercialisation and exploitation strategies (i.e patents, publications, copyrights, etc.) with the support of the Project Officer. **Early in the project,** procedures for innovation management are going to be described in D7.5. **At a more mature stage** of the project, this plan will be adapted to take into account best practice methods of maximising the value of intellectual property, for dealing with technology transfer/exploitation/protection, and with the assessment of IP and research results (D7.6).

3.5.5 Risks and risk management strategy

The **Scientific Coordination** is in charge of the risk management, with the **SPM** controlling the project progress in order to keep track of any deviations from the work plan and to quantify the probability and impact of the risks. Inputs on potential risks will be collected via the SB members. The GA will be responsible to decide on proposed preventive and corrective actions. A detailed list of critical project risks, that may impact project objectives, is found below in Table 3.2b. At the present stage, all these risks have been identified and analysed by the partners. The list will be updated throughout the project and regularly monitored by the **Scientific Coordination** for the General Assembly consideration.

Table 3.2b. Critical risks for implementation

Description of risk (indicate level of likelihood: Low/Medium/High)	Work package(s) involved	Proposed risk-mitigation measures
Unable to reach target resolution/throughput for all weather and climate models (Medium)	WP1	Any development towards reaching resolution/throughput improves the model performance and mitigates the risk.
Unable to use pre-exascale systems due to non-CPU or exotic hardware (Medium)	WP1, WP4	Work towards GPU portability is carried out via ESiWACE2 services (WP2). Close interaction with European HPC ecosystem (WP6) will keep community updated on pre-exascale developments.
Performance reduction due to containerisation (Low)	WP2	Studies on simpler problems have shown that performance reduction is not significant. However, if the performance reduction is considered significant then more lightweight containers could be investigated.

Lack of domain-specificity of DSLs due to supporting too many models (Medium)	WP2	Specialised DSL front-ends will be supported which can remain specific, but a common back-end is expected. However, multiple back-ends could be supported if necessary.
Performance gains in ESDM are not as great as expected (Low)	WP4	Continuous testing and optimisation and comparison with other technical options, exploiting best ideas as they appear.
Configuring models to exploit ESDM and/or ensemble tools proves more difficult than expected (Medium)	WP4	Concentrate on fewer models and ensure we demonstrate capability and advantages in those which can be used (based on the ESiWACE1 developments).
Higher than expected complexity of the ESDM PAV runtime module and related parallelisation strategies (Medium)	WP5	ESiWACE2 involves computational science experts on scientific data management and HPC from the early design phase on.
Delays in the software releases related to the ESDM PAV runtime and kernels could impact on the implementation of the application case studies (Medium)	WP5	The development of the key components will be closely monitored. Agile methods and release cycles will be exploited.
Application case studies are too complex to be ported on the ESDM PAV back-end during the project time frame and the effort needed is underestimated (Medium)	WP5	ESiWACE2 partners have a deep scientific knowledge and are main contributors of several key PAV community applications.
Lack of engagement of community outside the ESiWACE2 partners, for example in workshops, trainings and schools (low)	WP6	Fostering close interaction with the community (WP6), for example through interactions with the ESiWACE2 supporters, and with the Scientific Advisory Board will mitigate the risk.

3.5.6   Quality management

The quality management involves the product description and quality expectations of key deliverables and attainment of milestones, and an internal review and acceptance procedure. As soon as deliverables/ milestones are ready for review, they undergo the review by the **Scientific Coordination**, checking the coherence/compliance with highest possible scientific standards and contractual obligations. Should there be any IP emerging from reported activities, the Project Officer will get in touch with the legal advisors of the partners involved, to make sure that IP will be protected before going for disclosure and full dissemination. Dissemination of the achievements described in the deliverable are taken up by the lead of the dissemination and communication task (WP 7, tasks 7.4 and 7.5). Deliverables are made available to the SAB and the supporters to ensure wider dissemination and benefits for the community and beyond.

3.5.7   Financial and administrative management

The Project Officer is in charge of the financial and administrative management of the project and provides the Coordination with relevant data on the **use of resources.** Interim financial reports (6-month basis) will be established in the consortium. **Distribution of the EC contribution** (pre-financing and interim payments) to the beneficiaries will be implemented in compliance with the requirements set by the Grant Agreement, Consortium Agreement, and General Assembly's decisions. Regular formal reporting to the EC (**progress reports**) is planned in **months 18, 36 and 48**. Progress reports will be made

available in Zenodo, [www.zenodo.org,](http://www.zenodo.org) in full open access. Integral part of the progress reports due in months 18, 36 and 48 is the **track record of dissemination/engagement/ communication activities** performed in the project in the period covered by the reporting. The lead of tasks 7.4 and 7.5 will be in charge of these activities (see WP7 description for more details).

3.6 Consortium as a whole

3.6.1 Consortium description

The expertise of the scientific partners optimally matches our objective to develop solutions for cross-cutting HPC issues particular to the weather and climate domain. In particular, we want to emphasise the scientific and technical expertise related to weather and climate research software as well as high-performance computing. The consortium comprises world-leading climate research institutions, operational weather services, supercomputing centres including three PRACE members and experts in computer science including university members. Within ESiWACE1, the partners showed high communication, collaboration, adaptation and team-working skills, which paved the way for a successful project and shall be transported into a second phase.

The consortium is led by two topical supercomputing centres each operating one of the largest computing facilities in Europe. The Coordinator, the German Climate Computing Centre (DKRZ), has provided for more than three decades high-performance computing and data management facilities and services tailored to the need of climate modelling. The Coordinator will in its management and dissemination efforts be supported by ECMWF running an operational service, producing and disseminating numerical weather predictions.

For the second phase (for which we apply here) the consortium has been extended by additional partners to reinforce the expertise in software engineering, computer science skills and provision of services related to research software. Table 2 lists the partners and indicates the areas of expertise they contribute to project.

3.6.2 Contribution to the project

As can be seen from Table 2, most of the partners bring expertise in a number of areas relevant to the objectives of ESiWACE2 to the project and consequently are involved in a number of tasks. But, more importantly, each of the partners plays **a crucial and unique role** in the project (indicated by dark green boxes in the table).

Ownership of ESiWACE2 pre-exascale production-ready codes

The model configurations to be prepared for and ported to pre-exascale systems by ESiWACE2 build on four European Earth system models. For each of these configurations, the institutions leading its development is resourced with 36 person months – i.e the equivalent of 1 FTE for 3 years to support the necessary enhancements and tests: **ECMWF** for IFS/NEMO, **MPIM** and **DKRZ** for ICON-ESM, **CNRS-IPSL** for DYNAMICO/NEMO and **BSC and SMHI** (representing the EC-Earth consortium) for the EC-Earth model.

We would like to point out that the funding we apply for within this context is requested for **technical** model development. The institutions listed above will **in addition provide scientific guidance** in configuring and testing the models **as in-kind contribution**. To underpin this, leading scientists from these institutions will be nominated as members of the scientific advisory group as detailed in section 3.5.

	DKRZ	ECMWF	CNRS-IPSL	BSC	MPIM	SMHI	CERFACS	ICHEC	METO	CMCC	UREAD	STFC	BULL	SEAGATE	ETH zurich	UNIMAN	NLeSC	MSwiss	DDN	Mercator
Climate research			L		L				L	L										
Weather forecast		L																L		
Development of W&C Models	D	D	D	D	D	D				D		L								D
Development and support of tools	L		L	L			D		D											
Computer science				L				D								D	L			
Development of DLSs												D						D		
Data management	L										D			D					D	
Operation of HPC facilities																				
HPC related support and services								L					D		D		D			
Design and Deliverery of HPC facilities													L						L	
Project Management	L	L																		

Table 2: Table of expertise.

Support of common infrastructure

The model configurations listed above share a number of components. ESiWACE2 has allocated sufficient resources to the institutions which own or develop these tools to support them with respect to the ESiWACE2 objectives: **CNRS-IPSL** for the XIOS IO library**, CERFACS** for the OASI-MCT coupler and **MO** together with **CMCC** for a very high-resolution version of the NEMO ocean model. Furthermore, **CMCC** brings strong experience in high-performance data analytics to the project, as does **DKRZ** for visualisation of large data sets on irregular grids.

HPC services

The Netherlands eScience Center (**NLeSC**) provides technical expertise in the development and application of research software. The **BULL** Center of excellence in parallel programing supports its customers in HPC applications. Coming from scientific and industrial areas respectively, these two institutions complement each other. ESiWACE2 assigns the task to set up a service activity for European Earth system modellers to these experienced institutions.

Expertise in data management and analytics

In ESiWACE1, some of the most experienced European institutions with respect to data management for climate and weather applications are developing an innovative middleware for handling Earth system data: **University of Reading** together with **STFC, DKRZ** and industry partner **Seagate.** This development will be continued in ESiWACE2 to be deployed in connection with production codes on pre-exascale and later exascale system. The end-to-end testing of this software will be led independently by **ICHEC** who are not involved in the development. Two industry partners, **SEAGATE** and the new partner **DDN,** will carry out a proof of concept for commercial applicability.

Domain-specific languages

[ESiWACE2]   template WP18-20 v20171006

Domain-specific languages are a promising method to separate the scientific model development from (changing) underlying hardware. Two groups in Europe have a high reputation in research and development in applying this technique to weather and climate applications. **MeteoSwiss** and **ETH Zurich** in Switzerland and **STFC** supported by **METO** in the UK. ESiWACE2 brings these groups together to exploit synergies between the approaches and to establish the wider use of DSLs in weather and climate applications.

Expertise in innovative technologies

One objective of ESiWACE2 is to foster application of innovative HPC technologies in weather and climate modelling. UNIMAN has decades of experience and also strong links with industry in these areas.

Provision of resources for development and testing

The partners ECMWF, METO and DKRZ operate the most advanced facilities dedicated to weather and climate simulation in Europe. Additionally, a number of PRACE sites (namely CSCS (via ETH Zurich) and BSC) and industry partner BULL contribute resources to the project. Table 3 lists the resources available for developing and testing the ESiWACE2 pre-exascale production-ready models (PEPR-ESM, see Figure 2) as well as the HPCW benchmark and other software components delivered by ESiWACE2.

Table 3. HPC resources within consortium.

Partner	HPC or other architecture
ECMWF	Cray XC-40, 2x 3550 Intel Broadwell nodes, 36 cores/node, 2.1 GHz + 32 KNL 7210 nodes, 64 cores/node, 1.3 GHz 34 Intel Haswell nodes, 24 cores/node, 2.6 GHz + 2x NVIDIA K80/nodes
METO	3 Cray XC40 systems, 12,932 nodes, 460,672 cores with a mixture of Haswell and Broadwell CPUs and a total of 1,620 terabytes of memory and 24 petabytes of disk storage
DKRZ	bullx DLC 720 (Mistral), 1550 Intel Haswell nodes 24 cores/node, 2.5 GHz + 1750 Intel Broadwell nodes 36 cores/node 2.1 GHz 21 nodes (Broadwell/Haswell) with NVidia Kepler and Maxwell GPUs
BSC	Mare Nostrum 4: 3456 nodes, Intel Xeon Platinum 8160 CPU with 24 cores each, 2.10 GHz, for a total of 48 cores per node, 100 Gbit/s Intel Omni-Path Future Emerging Technologies clusters (part of Mare Nostrum 4). Available during 2018-2019: cluster IBM POWER9 processors and NVIDIA Tesla GPUs and cluster Intel Knights Hill processors
ETH Zurich (via CSCS)	Cray XC-40/50 (Piz Daint) 5320 hybrid nodes (Intel® Xeon® E5-2690 v3 @ 2.60GHz (12 cores, 64GB RAM) and NVIDIA® Tesla® P100 16GB) and 1431 multi-core nodes (Intel® Xeon® E5-2695 v4 @ 2.10GHz (18 cores, 64/128 GB RAM) Cray XC-40 (Grand Tavé) 164 hybrid nodes (64 cores Intel(R) Xeon Phi(TM) CPU 7230 @ 1.30GHz) CS Storm (Piz Kesch) 24 fat hybrid nodes (2x Intel Haswell E5-2690v3 2.6 GHz 12-core plus 8x NVIDIA Tesla K80)
BULL	Genji: medium scale system based on standard x86 CPUs, Nvidia GPUs, Intel Xeon Phis, ARM; one large in-memory server MESCA-2 Manny: large scale system based on last generations of CPUs and possibly accelerators

3.6.3 Industrial/commercial involvement in the project to ensure exploitation

Seagate: Seagate is working closely to understand the requirements of weather and climate use cases in ESiWACE2 continuing from the early work in ESiWACE1. Seagate hopes to exploit the results of the project by building storage technologies (and associated interfaces) suited for the weather and climate community as we head towards exascale. The technology that will be assessed within the project will also be

used in other market verticals in data-intensive computing. Seagate's work will specifically target object storage software infrastructure for data-intensive extreme-scale computing where existing parallel file systems such as Lustre, GPFS, etc. reach performance and scalability limitations. Seagate's involvement in the CoE will also help to understand some of the lower level requirements for extreme-scale computing on base storage technology (e.g. disk drives, Flash, NVMs, etc.) which are important Seagate product lines. Where applicable and if deemed suitable, publications on the work will be pursued. As part of the overall engagement strategy (and part of exploitation), the work will look at working very closely with other CoEs and FET-HPC projects (e.g.: SAGE) as well as communities outside of HPC (e.g.: Big Data Value Association, or BDVA) to synergise the activities in building storage systems suitable at extreme scale.

DDN: In terms of scale, weather and climate is one of the peculiar applications in which an exascale system has a strong scientific meaning. For instance, the ability to simulate the weather at the European scale will require a system of this size. Furthermore, weather applications are generating a large volume of data, thus for DDN, ESiWACE2 is the perfect vehicle to assess what will be data-intensive exascale platforms.

Additionally to these quantitative aspects, ESiWACE2 offers important research opportunities for a storage company such as DDN. Regarding the interface between software and hardware, ESiWACE2 is very aggressive in the sense that this CoE is not only focused on the algorithmic side, but addresses as well the data layout and the data format itself. The ability to control the data layout and access pattern is of specific interest due to the byte-addressable capabilities of storage media such as NVMs and NVRAM. The data format investigation proposed in ESiWACE2 will pave the way to new products and new data layout able to leverage Flash and NVRAM technological specificities.

BULL: As an HPC actor, BULL involvement in ESiWACE2 will provide important reference results for the weather and climate community and other HPC actors that will be disseminated to as proposed in plan for the exploitation of the results: transfer of results to the largest community including industrials through public deliverables, open access publications and dedicated workshops. BULL will ensure exploitation of the results by involving its Center for Excellence in Parallel Programming (CEPP) as follows: a) providing to CoE users its expertise at different levels, from processor micro-architecture to many-node systems, to prepare their application for pre-exascale HPC systems; b) porting applications and discuss how to advance the codes towards exascale; c) in-depth performance analysis, accuracy, and benchmarking on various state-of-art hardware using the HPCW benchmark.

3.6.4   The supporters of ESiWACE2

ESiWACE2 will disseminate its achievements to the weather and climate science community and also in a co-design spirit to the European HPC ecosystem. To foster and organise this process we formed a group of supporters and asked for continued support. We have received numerous Letters of Support (Table 4) from consortia and institutions which underline the importance attached to ESiWACE2 by the climate and weather community as well as HPC centres and vendors. Among the supporters, there are in particular large organisations such as the World Climate Research Program (WCRP) and the World Weather Research Program (WWRP), consortia like EC-Earth and ExtremeEarth, PRACE centres and research institutions.

The supporters of ESiWACE2 are legal national and international entities which are not beneficiaries, but wish to support ESiWACE2 through complementary activities. Most of them commit explicitly to specific supporting activities, amongst others:

- Active participation in ESiWACE2 annual meetings
- Supporting ESiWACE2 in disseminating results in supporting institution
- Contributing to strategic discussions on software and high-performance computing

- Nomination of a dedicated contact person to interact with ESiWACE2
- Support of the dissemination of ESiWACE2 results and outcomes

Table 4. Signatories of letters of support, including affiliation and dedicated contact persons.
Weather and Climate

Signatories	Affiliation / Federation / Network	Named contact person
Thomas Jung Head, Climate Dynamics Section	Alfred-Wegener-Institute for Polar and Marine Research	Bernadette Fritsch, Dmitry Sidorenko
Tony Hirst General Manager of the Science to Services Program	Bureau of Meteorology, Australia	-
Peter Huszár Deputy-Head of Department of Atmospheric Physics	Charles University	Michal Belda
Veronika Eyring Chair of Coupled Model Intercomparison Project (CMIP) Panel	CMIP	Veronika Eyring
Theodoros Christoudias Assistant Professor	Cyprus Institute	Theodoros Christoudias
Marianne Thyrring Director General	Danish Meteorological Institute	-
Sarah Jones Head of Business Area Research and Development	Deutscher Wetterdienst	Florian Prill
Christopher Bretherton Organiser of US participation in DYAMOND project	DYAMOND	Christopher Bretherton
Masaki Satoh Professor of Atmosphere and Ocean Research Institute, Japan participation in DYAMOND project	DYAMOND, University of Tokyo	Masaki Satoh
Erin Robinson Executive Director	Earth Science Information Partners	Erin Robinson
Ralf Döscher Chair of EC-Earth Steering Committee, Head of Global Climate Modelling unit at SMHI	EC-Earth, Sveriges Meteorologiska och Hydrologiska Institute (SMHI)	Uwe Fladrich
Florence Rabier Director-General ECMWF, on behalf of ExtremeEarth consortium	ExtremeEarth (ECMWF)	-
Juhani Damski Director General	Finnish Meteorological Institute	-
Gerard van der Steenhoven Director General	Royal Netherlands Meteorological Institute (KNMI)	Bart van den Hurk
Marc Pontaud Director of Research	Météo-France	Ludovic Auger
Patrick Jöckel Speaker of MESSy consortium	Modular Earth Submodel System (MESSy) consortium	Patrick Jöckel
Stephen Mobbs Director	National Centre for Atmospheric Science	-
Michael Uddstrom National eScience Infrastructure (NZ) HPC Platforms Manager, NIWA Programme Leader for the Multi-Hazards Forecasting System research programme	National Institute of Water and Atmospheric Research (NIWA)	Hilary Oliver

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Lars-Anders Breivik Director of Research	Norwegian Meteorological Institute	Øyvind Seland
Angela Hatton Director of Science and Technology	National Oceanography Centre	Adrian New
Tim Palmer Royal Society Research Professor	University of Oxford	Tim Palmer
Venkatramani Balaji Head, Modeling Systems Group	Princeton University, NOAA/Geophysical Fluid Dynamics Laboratory	Venkatramani Balaji
Peter Fox Lead Professor for Environmental Informatics Application Theme	Tetherless World Constellation	Peter Fox
Thierry Fichefet Professor, Georges Lemaître Centre for Earth and Climate Research	Université catholique de Louvain	-
Deon Terblanche World Climate Research Programme	World Meteorological Organization	Michel Rixen
Paolo Ruti World Weather Research Programme	World Meteorological Organization	-

Computing Centers and HPC Infrastructure

Signatories	Affiliation / Federation / Network	Named contact person
Sanzio Bassini Director of Supercomputing Applications and Innovation department	CINECA	Piero Lanucara
Mark Parsons Director of Supercomputing centre at the University of Edinburgh (EPCC)	EPCC	Michèle Weiland
Thomas Lippert Head of Jülich Supercomputing Centre	Jülich Supercomputing Centre	Lars Hoffmann
Serge Bogaerts Managing Director, Chair of the Board of Directors	PRACE	-

HPC Industry

John Goodenough VP Technology & Collaboration	arm	Oliver Perks
Dominik Ulmer Vice-President of Business Operations EMEA	CRAY	Adrian Tate
Stéphane Negre Président Intel Corporation SAS (France)	Intel	Marie-Christine Sawley
Yuichi Kojima CEO of NEC Germany, Vice President HPC for Europe	NEC	Rudolf Fischer
Stefan Kraemer Director Business Development HPC-EMEA	NVIDIA	Stan Posey

3.7 Resources to be committed

Table 3.4a. Summary of staff effort. WP leaders are represented in bold, Co-leaders in italics.

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	Total Person Months per Participant
1/ DKRZ	*30*	8	6	15	*15*	6	**38**	**118**
2/CNRS-IPSL	36		2	12	7	**4**	1	**62**
3/ECMWF	**36**	11	6	1		6	*6*	**66**
4/BSC	30	3	4			3		**40**
5/MPIM	12	12			24			**48**
6/SMHI	18							**18**
7/CERFACS	6		6			*11*	1	**24**
8/ICHEC				6				**6**
9/METO	12	7	6	12		1		**38**
10/CMCC	9	14		9	**15**	7	1	**55**
11/UREAD		3		*48*	4	5	1	**61**
12/STFC		*31*		24		2	1	**58**
13/BULL			*44*				1	**45**
14/SEAGATE				16		1		**17**
15/ETH Zurich		8	4			6		**18**
16/UNIMAN		17			3			**20**
17/NLeSC			**42**				1	**43**
18/MeteoSwiss		**36**				4	1	**41**
19/DDN				20		1		**21**
20/MO	9					0		**9**
Total Person Months	198	150	120	163	68	57	52	**808**

Table 3.4b. 'Other direct cost' items (travel, equipment, other goods and services, large research infrastructure): The table below is completed for each participant whose sum of the costs for' travel', 'equipment', and 'goods and services' exceeds 15% of the personnel costs for that participant (according to the budget table in section 3 of the proposal administrative forms): this is the case for DKRZ and UREAD only in our consortium.

1/ DKRZ	Cost (€)	Justification
Travel	275.000	Travels to workshops, annual conferences, review meetings for coordination/WPL/staff/Advisory Board members/guest speakers. Travels for dissemination.
Equipment	0	//
Other goods and services	50.500	Organisation of meetings, project workshops, other project events, audit costs (8K), print cost for dissemination materials, organisation of HPC workshops/summer schools (25k)
Total	**325.500**	

11/UREAD	Cost (€)	Justification
Travel	20.250	Travels to workshop, annual conferences, review meetings for WPL/staff/guest speakers. Travels for dissemination for staff.
Equipment		
Other goods and services	45. 319	audit costs (5,3k) ,organisation of HPC summer schools (40k)
Total	65.569	

Glossary

BDVA	Big Data Value Association	IO	Input/Output
CA	Consortium Agreement	IP	Intellectual Property
CoE	Centre of Excellence	IS-ENES	Infrastructure for the European Network of Earth System Modelling
CSA	Coordination and Support Action		
DMP	Data Management Plan	NVM	Non-volatile memory
DSL	Domain-specific language	NVRAM	Non-volatile random access memory
DYAMOND	DYnamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains		
		NWP	Numerical weather prediction
		OER	Open educational resources
ENES	European Network for Earth System Modelling	PATC	PRACE Advanced Training Centres
EsD	Extreme scale Demonstrator	PAV	Post-processing, analysis and visualisation
ESDM	Earth System Data Middleware		
ESiWACE1	ESiWACE, phase 1	PO	Project Office
ESM	Earth system model	SAB	Scientific Advisory Board
ETP4HPC	European Technology Platform for High-Performance Computing	SB	Steering Board
		SemSL	Semantic Storage Layer
		SME	Small and medium-sized enterprise
EuroHPC	European High-Performance Computing		
		SPM	Scientific Programme Manager
EuroHPC JU	European High-Performance Computing Joint Undertaking	SYPD	Simulated years per day
		WP	Work package
GA	General Assembly		
GPU	Graphics Processing Unit		
HIR	High-level intermediate representation		
HPC	High-performance computing		
HPCW	High-Performance Climate and Weather Benchmark		
HPDA	High-performance data analytics		
HPL	High-Performance LINPACK		
HTC	High-throughput computing		

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Section 4: Members of the consortium

1/ Deutsches Klimarechenzentrum GmbH (DKRZ)

About the institute

DKRZ, the German Climate Computing Centre, is a national service provider which constitutes an outstanding research infrastructure for model-based simulations of global and regional climate and the investigation of the processes in the climate system. DKRZ's principal objectives are provision of adequate computer performance, data management, and service and support to use these tools efficiently. DKRZ operates one of the largest supercomputers in Germany and 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. This also includes training and support for related application software and data processing issues. DKRZ participates in many national and international projects aiming to improve the infrastructure for climate modeling. Through its research group on scientific computing DKRZ is linked to the Department of Informatics of the University of Hamburg.

DKRZ is a non-profit and non-commercial limited company with four shareholders. MPG holds 55% of the shares of DKRZ (see http://www.dkrz.de/about-en/Organisation/gesellschafter for more references). The dependency relationship has been declared in the administrative forms in the EC portal.

Contribution to the specific project

In ESiWACE2, DKRZ will coordinate the entire project, lead WP7, co-lead WP1, co-lead in WP5 and having important contributions to all the other work packages.

Joachim Biercamp (male) holds a PhD in Physical Oceanography and has a long standing experience in supporting data intensive climate simulations. He is leading the Application department of DKRZ. His responsibilities include the organization of user support and the interaction with DKRZ's user group and scientific steering committee. He coordinated the procurement and benchmarking of the previous three generations of DKRZ super computers (a NEC SX6, IBM Power6, bullx), all ranked within the TOP 35 of the TOP500 list. Joachim is involved in several national and international projects dealing with infrastructure for climate modeling. In particular he is member of the steering committees of two large German framework projects: HD(CP)2 is aiming at development and operation of a cloud resolving version of the ICON model which is used for both, climate research and numerical weather prediction. PALMOD is setting up Earth System Models to understand climate system dynamics and variability during the last glacial cycle. He is the coordinator of ESiWACE and will also coordinate ESiWACE2.

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.

Thomas Ludwig (male) is the director of DRKZ and leader of the research group Scientific Computing of the DKRZ. His research activity is in the fields of high volume data storage, energy efficiency, and performance analysis concepts and tools for parallel systems. At DKRZ Thomas takes

the responsibility for accomplishing its mission: to provide high performance computing platforms, sophisticated and high capacity data management, and superior service for premium climate science.

Joerg Behrens (male) received his Diploma in Physics from the University of Goettingen, Germany and now works in the Application department of DKRZ mainly on performance optimization of climate models. He has 20 years of experience with developing scalable parallel Fortran applications in material and climate science. He is one of the authors of the YAXT library which simplifies efficient MPI communication. Using YAXT he improved the scalability of several communication patterns in various climate models. He has experience with ICON model development especially with communication and radiation aspects. As an active model developer he is aware of the usability requirements on DSLs for climate model developers. Joerg will contribute to WP2.

Niklas Roeber (male) joined DKRZ in 2009 as a member of the scientific staff. He received a Master's degree and a Ph.D. in computer science from the University of Magdeburg, and an MBA from the University of Wales. His research interests are centered around the visualization and analysis of climate model data, especially the visualization of extremely large and unstructured climate simulations. Currently he is working on implementing an in-situ visualization for the ICON model using ParaView/Catalyst, as well as experiments with wavelets for ICON for a Level-of-Detail decomposition and a progressive rendering using the software Vapor. Niklas will contribute to WP5.

Panagiotis Adamidis (male) holds a PhD in Mechanical Engineering. He has more than 18 years of experience in the area of High Performance Computing with emphasis on parallel numerical algorithms and parallel programming models. Since 2006 he has been working for DKRZ, dealing with the development of parallel algorithms for earth system models and optimization issues at application level. He participates in the project HDCP2 (High Definition Clouds and Precipitation for Climate Prediction) where his focus is on enhancing scalability of the ICON model for future generation supercomputers. Panos will contribute to several WPs where DKRZ is involved.

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. Kerstin will contribute to the WP7.

Publications, and/or products or other achievements

- Crossing the Chasm: How to develop weather and climate models for next generation computers? Lawrence, B. N., Rezny, M., Budich, R., Bauer, P., Behrens, J., Carter, M., Deconinck, W., Ford, R., Maynard, C., Mullerworth, S., Osuna, C., Porter, A., Serradell, K., Valcke, S., Wedi, N., and Wilson, S.: , Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2017-186, in review, 2017.

- A major achievement is the successful coordination and management of the EU H2020 ESiWACE project, funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No 675191.

Projects, and/or activities, services

- ESiWACE Centre of Excellence in Simulation of Weather and Climate in Europe. This project is coordinated by Joachim Biercamp at DKRZ.
- EU FP7 IS-ENES Infrastructure for the European Network for Earth-SystemModelling, EU FP7 Project fostering simulations with global earth system models
- EU FP7 EUDAT: European Data Infrastructure; building and supporting a collaborative data infrastructure
- ScalES: Scalable Earth System Models, funded by BMBF (https://www.dkrz.de/Klimaforschung/dkrz-undklimaforschung/infraproj/scales/scales).

- C3-Grid & C3-INAD: Collaborative Climate Community Data and Processing Grid, funded by BMBF
- HD(CP)2: "High definition clouds and precipitation for advancing climate prediction" focusing on cloud resolving models, funded by BMBF
- ICOMEX: ICOsahedral-grid Models for EXascale earth system simulations (http://wr.informatik.uni-hamburg.de/research/projects/icomex/)
- Scalus: SCALing by means of Ubiquitous Storage (http://www.scalus.eu/) • SIOX: Scalable I/O For Extreme Performance (http://www.hpc-io.org/)
- A full list of projects led or participated by DKRZ is available here: http://www.dkrz.de/Klimaforschung-en/projects

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 (http://www.dkrz.de/daten-en/wdcc) .

- IPCC AR4: Simulations for the Fourth Assessment Report of the Intergovernmental Panel on Climate Change
- IPCC AR5: Simulations within the frame of the international climate model comparison project CMIP5 and for the 5th climate assessment report of the United Nation
- Climate simulations for Europe with CLM: the regional climate model CLM, which is based on the weather forecast model "LM" by the German Weather Service, was used for ensemble simulations of regional climate changes in Europe.
- STORM - development of a high resolution climate model: STORM is a consortium project by several German climate research institutes with the common goal of developing a climate model with very high spatial resolution. The impact of small scale processes on the quality of climate simulations is planned to be evaluated on the basis of a 21st century simulation with the model
- Climate Simulations for Europe with CLM: the regional climate model CLM, which is based on the weather forecast model "LM" by the German Weather Service DWD, was used for ensemble simulations of regional climate changes in Europe.

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, an IBM Power6 computer with 8500 processor cores and a peak performance of 160 TFLOPS will be replaced by a new BULL system in March 2015. The new system will be installed in two stages, starting with 36000 processor cores and a peak performance of 1.5 PetaFLOPS to be upgraded to ca 8000 cores and 3.2 PetaFLOPS in spring 2016.

The file system will be based on lustre and will initially have a net storage capacity of 20 PetaBytes in 2015 which will be upgraded to 50 PetaBytes in 2016.

For long term archiving of data DKRZ runs a tape library with the capacity to 75 PetaByte of data annually.

A data nodes and data portal of the Earth System Grid Federation (ESGF) are run by DKRZ (http://esgf-data.dkrz.de

2/ Centre National de la Recherche Scientifique (CNRS-IPSL)

About the institute

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. Main laboratories from IPSL involved in EASIWACE2 are Laboratoire des Sciences du Climat et de l'Environnement (LSCE), Laboratoire d'Océanographie et du Climat (LOCEAN), Laboratoire de Météorologie Dynamique (LMD). 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 EASIWACE, 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). CNRS with the Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA) have developed a new dynamical core DYNAMICO adapted to massively parallel computing and XIOS, a software library dedicated to efficient IO management for climate models.

Contribution to the specific project

In ESiWACE2, CNRS-IPSL will be involved in WP1 with the new coupled IPSL climate model based on DYNAMICO coupled with the LMDZ physics and the NEMO ocean model. CNRS-IPSL will be in charge of activities related to the XIOS software: with service in WP3, with developments in WP4 and WP5 on ensemble services and post-processing and analytics, and with training in WP6. CNRS-IPSL will also lead WP6 on governance and community engagement.

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 will lead WP6.

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, has co-developed the DYNAMICO dynamical core 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 WP1, and will be in charge of activities related to XIOS in WP3, WP4, WP5 and WP6.

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. He will be involved in WP3, WP5, WP5, WP6.

Thomas Dubos (male) is a researcher in geophysical fluid dynamics and applied mathematics at Ecole Polytechnique (EP) within the LMD joint unit. Thomas Dubos is co-leading the development of the DYNAMICO dynamical core and is an expert in theoretical and numerical aspects of atmospheric modelling. He will be involved in WP1 on the very high resolution version of the coupled IPSL model.

Frédéric Hourdin (male) 52-year old, h-index 36, 65 citations / publication on average, is a researcher in climate modelling at CNRS within the LMD joint research unit. He is leading the development of the atmospheric climate model at IPSL for about 15 years and is deeply involved in coupled modeling. He is an expert in the parameterization of boundary layer and clouds, in the representation of tracer transport modeling and in climate model tuning. He will be involved in WP1 on the very high resolution of the coupled IPSL model.

Sébastien Masson (male) is a researcher in oceanography and climatology at Université Pierre et Marie Curie (UPMC) within the LOCEAN joint unit. With more than 20-year experience on NEMO, he is member of the NEMO system team since 2005. His specific fields of expertise encompass air-sea interactions from basin-scale to eddy-scales, frontier ocean-atmosphere coupled simulations and high performance computing. He will be involved in WP1 on the very high resolution of the coupled IPSL model.

Publications, and/or products or other achievements

1. Dubos, T., Dubey, S., Tort, M., Mittal, R., Meurdesoif, Y., and Hourdin, F.: DYNAMICO-1.0, an icosahedral hydrostatic dynamical core designed for consistency and versatility, Geosci. Model Dev., 8, 3131-3150, https://doi.org/10.5194/gmd-8-3131-2015, 2015.
2. E. Kritsikis, M. Aechtner, Y. Meurdesoif, T. Dubos (2017) Efficient, geometrically-exact, conservative remapping between spherical meshes Geosci. Mod. Dev. 10, 425-431, 2017
3. XIOS code is available at http://forge.ipsl.jussieu.fr/ioserver. The web site also includes the software documentation, user guide and tutorials.
4. Hourdin F., Mauritsen T., Gettelman A., Golaz J.C., Balaji V., Duan Q., Folini D., Ji D., Klocke D., Qian Y., Rauser F., Rio C., Tomassini L., Watanabe M., and Williamson D., The art and science for climate modelling tuning, BAMS, PP 589-602, 2017. https://doi.org/10.1175/BAMS-D-15-00135.1
5. Hourdin, F., M.-A. Foujols, F. Codron, V. Guemas, J.-L. Dufresne, S. Bony, S. Denvil, L. Guez, F. Lott, J. Ghattas, P. Braconnot, O. Marti, Y. Meurdesoif, and L. Bopp, Impact of the LMDZ atmospheric grid configuration on the climate and sensitivity of the IPSL-CM5A coupled model, Clim. Dyn., 40, 2167–2192, 2013a.
6. Hourdin, F., J.-Y. Grandpeix, C. Rio, S. Bony, A. Jam, F. Cheruy, N. Rochetin, L. Fairhead, A. Idelkadi, I. Musat, J.-L. Dufresne, A. Lahellec, M.-P. Lefebvre, and R. Roehrig, 2013b, LMDZ5B: the atmospheric component of the IPSL climate model with revisited parameterizations for clouds and convection, Clim. Dyn., 40, 2193–2222, 2013b
7. Oerder, V., Colas, F., Echevin, V., Masson, S., & Lemarié, F. (2018). Impacts of the mesoscale ocean-atmosphere coupling on the Peru-Chile ocean dynamics: The current-induced wind stress modulation. Journal of Geophysical Research: Oceans, 123. https://doi.org/ 10.1002/2017JC013294
8. Samson, G., Masson, S., Durand, F., Terray, P., Berthet, S., et al. 2017. Roles of land surface albedo and horizontal resolution on the Indian summer monsoon biases in a coupled ocean–atmosphere tropical-channel model. Climate Dynamics, Springer Verlag, 2016, 10.1007/s00382-016-3161-0.
9. 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

10. Joussaume S., Lawrence B., Guglielmo F., Update of the ENES infrastructure strategy 2012-2022, 2017, goo.gl/iyDqh9

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** Centre of Excellence in Simulation of Weather and Climate in Europe.
- **ANR HEAT,** national project (2015-2019), which aims at modelling an efficient global atmospheric model based on the DYNAMICO dynamical core.
- **AIMES international project,** under ANR (2014-2018), which supports new dynamical cores from Europe and Japan.
- **GENCI Grand challenge 2018** on 10 km simulation with the DYNAMICO-LMDZ atmospheric model
- **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.

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 datanode 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/).

3/ European Centre for Medium-Range Weather Forecasts (ECMWF)

About the institute

The European Centre for Medium-Range Weather Forecasts (ECMWF) is an international organization supported by 34 States: 22 Members (Austria, Belgium, Croatia, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Serbia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom) and 12 Co-operating Members (Bulgaria, Czech Republic, Estonia, the former Yugoslav Republic of Macedonia, Hungary, Israel, Latvia, Lithuania, Montenegro, Morocco, Romania and Slovakia). ECMWF's principal objectives are the preparation, on a regular basis, of medium-range and long-range weather forecasts for distribution to the meteorological services of the Member States, the development of scientific and technical research directed to the improvement of these forecasts, and the collection and storage of appropriate meteorological data ECMWF's strategy includes the principal goals to provide reliable forecasts of severe weather across the medium-range and high-quality, near-surface forecast products focusing on areas such as precipitation, wind and temperature. ECMWF's computer facility includes supercomputers, archiving systems and networks.

In 2013, ECMWF initiated a Programme on Scalability that aims at developing the next-generation forecasting system addressing the challenges of future exascale high-performance computing and data management architectures. The Programme is required to optimize system performance allowing ECMWF to fulfil its strategy within the expected resource constraints.

Contribution to the specific project

In ESiWACE2, ECMWF will lead WP1. Moreover, ECMWF will contribute to WP2, WP3, WP4, WP6 and WP7.

Peter Bauer (male) - joined ECWMF in January 2000. Before becoming Deputy Director of Research he headed the Model Division that comprises the physical and numerical aspects of numerical weather prediction and the Satellite Section at ECMWF. Before joining ECMWF, he was leading a DLR research team on satellite meteorology in Cologne, Germany. His background covers physical modelling, data assimilation and satellite remote sensing. During his career, he was awarded research fellowships by NOAA and NASA, and a science award by DLR. He is the author and co-author of 100 peer-reviewed scientific journal papers, and his publications have an h-index of 41. He is a member of several scientific advisory committees at the international level (WMO, ESA, EUMETSAT) and has extensive experience with managing international research projects. At ECMWF, his current duties also include the management of the transition of new model cycles from research to operations and he is the manager of the recently launched Scalability Programme. He coordinates the ESCAPE project and co-coordinates the ESiWACE Centre of Excellence.

Peter Dueben (male) is a Royal Society University Research Fellow with ECMWF as his host organisation. Peter is working on the use of reduced numerical precision arithmetic and uncertainty quantification in weather and climate simulations. He is currently developing a single precision version of the Integrated Forecast System at ECMWF that allows to reduce runtime of forecast simulations by 40% while keeping meteorological quality of forecasts at a level that is almost indistinguishable compared to double precision simulations. Peter wrote his PhD thesis at the Max Planck Institute for Meteorology in Hamburg on the development of dynamical cores for Earth System models and worked for several years as PostDoc with Tim Palmer at the University of Oxford before joining ECMWF in October 2016.

Tiago Quintino (male) is the Team Leader for Data Handling within the Forecast Dept. at ECMWF. He and his team develop software for data encoding and decoding, pre and postprocessing of meteorological products, storage and perpetual archival of weather observations and forecast data. Tiago develops the meteorological archival software (MARS) and the high performance I/O middleware (FDB). Previously, he worked for the Von Karman Institute for Fluid Dynamics on high

performance CFD software for aerospace applications and contributed to multiple EU funded projects. He is also the author of 25 journal publications and book chapters in the area of high performance scientific computing.

Publications, and/or products or other achievements

1. Energy-efficient SCalable Algorithms for weather Prediction at Exascale, Bauer, Peter; Wedi, Nils; Baldauf, Michael; Benard, Pierre; Fuhrer, Oliver; Kulczewski, Michal; McKinstry, Alastair; Messmer, Peter; New, Nick; HansenSass, Bent; Szmelter, Joanna; Termonia, Piet; Vigouroux, Xavier, Source: Impact, Volume 2017, Number 1, January 2017, pp. 69-71(3).

2. Representing the Earth surfaces in the Integrated Forecasting System: Recent advances and future challenges, G Balsamo, A Agustì-Panareda, C Albergel, A Beljaars, S Boussetta, E Dutra, T Komori, S Lang, J Muñoz-Sabater, F Pappenberger, P de Rosnay, I Sandu, N Wedi, A Weisheimer, F Wetterhall, E Zsoter, ECMWF Research Department Technical Memorandum 729, ECMWF Reading, UK, 2014.

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Projects, and/or activities, services

- Collaborative Research into Exascale Systemware, Tools & Applications (CRESTA). FP7-287703, 2011-2014.
- PantaRhei. FP7/2012/ERC Advanced Grant agreement no. 320375, 2013-2018.
- Energy-efficient SCalable Algorithms for weather Prediction at Exascale (ESCAPE). H2020-671627, 2015-2018 **(Coordinator)**

- Excellence in SImulation of Weather and Climate in Europe (ESIWACE), H2020=675191, 2015-2019
- Co-designed Innovation and System for Resilient Exascale Computing in Europe: From Applications to Silicon (EuroExa), H2020-754337, 2017-2021
- Energy-efficient SCalable Algorithms for weather and climate Prediction at Exascale (ESCAPE-2), H2020-800897, 2018-2020 **(Coordinator)**

Significant infrastructure, and/or major items of technical equipment

ECMWF maintains a multi-petaflops supercomputer facility which is designed for operational resiliency featuring two Cray XC40 systems and independent Cray Sonexion storage systems. Each subsystem consists of 20 Cray XC40 cabinets equipped with Intel Broadwell processors and around 3,600 dual-socket compute nodes per system, a number of Cray Development and Login nodes and around 10 petabytes of Lustre storage with the ability to cross mount the Lustre file systems between the halls

4/Barcelona Supercomputing Center – Centro Nacional de Supercomputación (BSC)

About the institute

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. PRACE provides competitive computing time on world-class supercomputers to researchers in the 25 European member countries.

The Center houses Mare Nostrum 4, one of the most powerful supercomputers in Europe with 165,888 cores and 13.7 Pflops capacity. 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 Center has been extremely active in the EC Framework Programs 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 (CIMP5) 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. The ES-BSC is already active in the planning and design of the future coupled climate model intercomparison project, CIMP6, and is preparing to make key contributions including the ground-breaking high-resolution climate simulations with EC-Earth.

Contribution to the specific project

BSC will participate in the project WP1, WP2, WP3, WP6 in the following:
- Improving the performance and developing new configurations for EC-Earth model
- Developing the integration of XIOS server in EC-Earth model
- Defining and analysing benchmarks and assessing their performance

Kim Serradell (male) - Kim Serradell is the manager of the Computational Earth Science (CES) group at the Earth Sciences department in the Barcelona Supercomputing Center (BSC-CNS). The CES group is a multidisciplinary team of 21 members with different IT profiles that interacts closely with all the other groups of the Earth Sciences Dept. The group has among its tasks providing help and guidance to the scientists with the technical issues related to their work and developing a framework for the most efficient use of HPC resources. In recent years he has been in charge of the system administration of all the computational resources of the department and he was also responsible of supervising the operational runs of the NMMB/BSC-Dust model and CALIOPE Air Quality System in the HPC infrastructures of the BSC.

Mario Acosta (male) - Mario C. Acosta is a post-Doctoral fellow in the Computational Group of the Earth Sciences Department at the Barcelona Supercomputing Center. He received his PhD in

Computer Science (related to High Performance Computing applied to Earth System Modelling) from University of Granada in 2015. His research interests and expertise include wide knowledge in numerical models (governing equation, numerical algorithms and computational implementation), performance analysis to highlight the main bottlenecks of the models and how to adapt and optimize them efficiently to actual and new High Performance Platforms.

Miguel Castrillo (male) - Computer Scientist in the Computational Earth Sciences group: Miguel holds an MSc in computer science from the University of León. Having more than nine years of experience as software analyst and developer, he has worked for different associations (XBRL Spanish Association) and companies (Municipia SL, Grupo TEVA), combining his full-time work with a degree in Geography and History by the Univesidad Nacional de Educación a Distancia (UNED). He currently works in the Computational Earth Sciences group at the Earth Sciences department of the Barcelona Supercomputing Center (BSC). His extensive expertise in HPC ranges from HPC data management and visualization tools, to parallel applications performance. He has been working on the performance optimizations for the NEMO 3.6 alpha version, and all of his contributions are now part of the 3.6 official version. Miguel is currently a permanent member of the NEMO HPC WG and EC-Earth technical group.

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. Paper Accepted.
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Projects, and/or activities, services

FP7 IS-ENES2 project Infrastructure for the European Network for Earth System modelling phase 2 (IS-ENES2-312979) 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. –

H2020 project ESiWACE Excellence in SImulation of Weather and Climate in Europe (GA 675191): will substantially improve efficiency and productivity of numerical weather and climate simulation on high performance computing 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. –

H2020 project: PRIMAVERA PROcess-based climate sIMulation: AdVances in high resolution modelling and European climate Risk Assessment (PRIMAVERA-641727) the main objective 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 governments, business and society in general –

H2020 project SPECS Seasonal-to-decadal climate Prediction for the improvement of European Climate Services (SPECS-308378) will undertake research and dissemination activities to deliver a new generation of European climate forecast systems, with improved forecast quality and efficient regionalization 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.

Significant infrastructure, and/or major items of technical equipment

BSC is the National Supercomputing Facility of Spain and hosts a range of high-performance computing (HPC) systems including Mare Nostrum IV the new supercomputer, 12.4 times more powerful than the previous Mare Nostrum 3 with a performance capacity of 13.7 Petaflop/s. The general-purpose element, has 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 Mare Nostrum 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. It will include PowerPC 9 and ARM clusters.

The BSC 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 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.

A data node of the Earth System Grid Federation (ESGF) with EC-Earth model outputs is run by BSC.

5/ Max-Planck-Gesellschaft zur Förderung der Wissenschaften E.V. (MPIM)

About the institute

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 (MPIM, http://www.mpimet.mpg.de) is dedicated to fundamental climate research. The overall mission of MPIM 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.

Contribution to the specific project

In ESiWACE2, MPIM will participate in WP1, 2,and 5.

Bjorn Stevens (male) is a director at the Max Planck Institute for Meteorology where he leads the Atmosphere in the Earth System Department and is a professor (§17) at the University of Hamburg. Prior to moving to Hamburg Dr. Stevens was a full professor of Dynamic Meteorology at the University of California of Los Angeles. He received a PhD in Atmospheric Science in 1996 from the Colorado State University in Ft Collins CO, and holds a Bachelor and Masters of Science in Electrical Engineering from Iowa State University. Prof. Stevens' research blends modeling, theory and field work to help articulate the role of aerosols, clouds and atmospheric convection in the climate system. He has made pioneering contributions to both understanding and modelling of mixing and microphysical processes and their impact on the structure and organization of clouds. Likewise, his contribution to an understanding of how clouds respond to warming, and how radiative forcing responds to aerosol perturbations, has proven fundamental to the present comprehension of the susceptibility of Earth's climate to perturbations. Prof. Stevens served as a lead-author of Chapter 7, "Cloud and Aerosols" for the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. He is the lead principal investigator for the HD(CP)2 project, High Definition Clouds and Precipitation for Climate Prediction, a national project supported by the Germany Ministry of Education and Research. He serves on a number of international advisory boards, has served as editor of leading journals in his field and has been honored by a number of awards, and fellowships.

Reinhard Budich (male) is an Oceanographer active in Climate Modelling and related infrastructures for over 25 years. He was the Technical Coordinator of the FP7 project IS-ENES1, and work package leader in ISENES2. He was running the COSMOS network as a project manager, and was Director of the FP5 PRISM project. From 2001 to 2015 he has also been running the ENES office in Hamburg, Germany. He is also involved in the ESiWACE and ESCAPE-2 projects. He is ICT-Representative of MPIM and responsible for the HPC strategy of this institute as the leader of the group "Strategic IT partnerships" within MPIM's Scientific Computing Laboratory.

Ralf Mueller (male) is a Theoretical Physicists now working as a scientific programmer in the Scientific Computing Lab of the MPI for Meteorology. After five year in industry he joined the MPIM working on IS-ENES1 in 2009. Since 2014 he is a member of the Computational Infrastructure and Model Development Group at MPI mainly focusing on ICON. This involves close collaboration with DWD, KIT and CSCS dealing with topics like IO, performance and its portability.

Publications, and/or products or other achievements

1. P. Korn, Formulation of an unstructured grid model for global ocean dynamics, J. Comp. Phys. 339 (2017), 525-552
2. P. Korn, S. Danilov, Elementary dispersion analysis of some mimetic discretizations on triangular C-grids, J. Comp. Phys. 330 (2017), 156-172
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6. Crueger, T., Giorgetta, M. A., Brokopf, R., Esch, M., Fiedler, S., Hohenegger, C., ... Stevens, B. (2018). ICON-A, the atmosphere component of the ICON Earth System Model. Part II: Model evaluation, Journal of Advances in Modeling Earth Systems, submitted.
7. Giorgetta, M. A., Brokopf, R., Crueger, T., Esch, M., Fiedler, S., Helmert, J., ..., Stevens, B. (2018). ICON-A, the atmospheric component of the ICON Earth System Model. Part I: Model Description, Journal of Advances in Modeling Earth Systems, submitted.

Projects, and/or activities, services

- EU H2020 ESiWACE Centre of Excellence in Simulation of Weather and Climate in Europe
- PRISM - EVR1-CT-2001-40012 – to share the development, maintenance and support of a comprehensive Earth System Modelling software environment
- EU FP7 IS-ENES, GA228203 –
  - The integration of the European climate and Earth system modelling community;
  - The development of Earth System Models for the understanding of climate change;
  - High-end simulations enabling better understanding and prediction of future climate change;
  - The application of Earth system model simulations to better predict and understand future climate change impacts.
- Continued in EU FP7 IS-ENES2, GA 312979
  - Foster the integration of the European Climate and Earth system modeling community
  - Enhance the development of Earth System Models for the understanding of climate variability and change
  - Support high-end simulations enabling us to better understand and predict climate variations and change
  - Facilitate the application of Earth system model simulations to better predict and understand climate change impacts on society
- EU H2020 ESiWACE substantially improves efficiency and productivity of numerical weather and climate simulation on high-performance computing platforms by supporting the end-to-end workflow of global Earth system modelling in High Performance Computing environments
- EU FP7 EUDAT: European Data Infrastructure; building and supporting a collaborative data infrastructure (http://www.eudat.eu)
- C3-Grid: Collaborative Climate Community Data and Processing Grid, funded by BMBF
- HD(CP)2: "High definition clouds and precipitation for advancing climate prediction" focusing on cloud resolving models, funded by BMBF

- ICOMEX: ICOsahedral-grid Models for EXascale earth system simulations (http://wr.informatik.uni-hamburg.de/research/projects/icomex/)
- IPCC AR4: Simulations for the Fourth Assessment Report of the Intergovernmental Panel on Climate Change
- IPCC AR5: Simulations within the frame of the international climate model comparison project CMIP5 and for the 5th climate assessment report of the United Nation
- Climate simulations for Europe with CLM: the regional climate model CLM, which is based on the weather forecast model "LM" by the German Weather Service, was used for ensemble simulations of regional climate changes in Europe.
- STORM - development of a high resolution climate model: STORM is a consortium project by several German climate research institutes with the common goal of developing a climate model with very high spatial resolution. The impact of small scale processes on the quality of climate simulations is planned to be evaluated on the basis of a 21st century simulation with the model
- Climate Simulations for Europe with CLM: the regional climate model CLM, which is based on the weather forecast model "LM" by the German Weather Service DWD, was used for ensemble simulations of regional climate changes in Europe.

Significant infrastructure, and/or major items of technical equipment

Easy access to computing and support resources of DKRZ.

Large programming department for software infrastructure development tasks.

To satisfy the extensive computational needs of the MPI-M, the institute built strategic partnership with the German Climate Computing Centre (DKRZ), the German collaborator of the Earth System Grid Federation (ESGF). MPG is also the major shareholder of the DKRZ.

The MPIM has for a long time benefited from a close integration of its systems with those of DKRZ, offering the MPIM seamless access to the DKRZ-managed machines such as the Bull machine "mistral", a supercomputer with a peak performance of 3.14 Petaflops consisting of approx. 3,000 compute nodes, 100,000 compute cores, 240 Terabytes of memory, and 54 Petabytes of disk. "Mistral" will also be used for CMIP6 simulations.

6/ Swedish Meteorological and Hydrological Institute (SMHI)

About the institute

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 to the specific project

In ESiWACE2, SMHI will be active in WP1 by contributing to the development of a very-high resolution, production mode configuration for EC-Earth. Particularly, SMHI will contribute experience from earlier high-resolution configuration development. Furthermore, SMHI will be using its coordinating role within the EC-Earth consortium to make sure the very-high resolution configuration of the model will be aligned, to a large degree, with the community versions.

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.

Publications, and/or products or other achievements

1. Jiang, X., et al. (2015), Vertical structure and physical processes of the Madden-Julian oscillation: Exploring key model physics in climate simulations, J. Geophys. Res. Atmos., 120, 4718–4748. doi:10.1002/2014JD022375.
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5. 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. Climate Dynamics, 49(1-2), 471-492. https://doi.org/10.1007/s00382-016-3354-6
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10. Koenigk, T., Brodeau, L., Graversen, R.G. et al. rctic climate change in 21st century CMIP5 simulations with EC-Earth. Clim Dyn (2013) 40: 2719. https://doi.org/10.1007/s00382-012-1505-y

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 IMPREX Improving Predictions and Management of Hydrological Extreme
- EU H2020 PRIMAVERA Process-based climate simulation: advances in high resolution modelling and European climate risk assessment
- EU H2020 Climateurope
- EU H2020 INTAROS Integrated Arctic Observation System
- EU H2020 EUCP European Climate Prediction system
- NordForsk ARCPATH Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies
- FORMAS Interdec The potential of seasonal-to-decadal-scale inter-regional linkages to advance climate predictions
- FORMAS REGTREND Quantifying uncertainties in regional climate trends and its implications for adaptation decision-making
- FORMAS LUCSNE4C Land Use, Carbon Sinks and Negative Emissions for Climate targets

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.

7/ Centre Européen de Recherche et de formation Avancée en Calcul Scientifique (CERFACS)

About the institute

CERFACS (http://www.cerfacs.fr), 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 (2009-2012) and IS-ENES2 (2012-2016) projects as leader and co-leader of work packages. CERFACS currently participates actively in ESiWACE as co-leader of the work package 2, into which a more performant and multi threaded version of OASIS was recently developed, and 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 (Task leader).

Contribution to the specific project

In ESiWACE2, CERFACS is co-leading WP6 and will contribute to WP1, WP3 and WP7.

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 and had 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, such as the USA-led ESMF or the NCAR Community Earth System Model (CESM). 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 (http://earthsystemcog.org/projects/iwcct/). In ESIWACE2, S. Valcke will co-lead WP6 and participate to CERFACS activities in WP1 and WP3.

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 be involved in the optimisation of the OASIS coupler in WP1 and will provide expert services on the coupler in WP3.

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 alos contributes to European projects focused on high-resolution climate simulations

(H2020 PRIMAVERA and ESiWACE) and massive data projects (H2020-EUDAT). M.-P. Moine will provide the expert services on XIOS in WP3.

Publications, and/or products or other achievements

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2. 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.
3. **S. Valcke,** R. Ford, M. Hobson, G. Jonville, A. Porter, G. Riley. IS-ENES Coupling Technology Benchmarks. Platform for Advanced Scientific Computing (PASC) 2017, Minisymposium "Earth System Modeling: HPC Bringing Together Weather and Climate Prediction", Lugano, Switzerland
4. Bessières, L., Leroux, S., Brankart, J.-M., Molines, J. M., **Moine, M.-P**., Bouttier, P.-A., Penduff, T., Terray, L., Barnier, B. and Serazin, G. (2017) Development of a probabilistic ocean modelling system based on NEMO 3.5: application at eddying resolution, Geoscientific Model Development, pp. 1091-1106, doi:10.5194/gmd-10-1091-2017
5. Monerie, P.-A., Coquart, L., **Maisonnave, E., Moine, M.-P.,** Terray, L. and **Valcke, S.** (2017) Decadal prediction skill using high-resolution climate model, Climate Dynamics, 49 (9-10), pp. 3527–3550, doi:10.1007/s00382-017-3528-x
6. Voldoire, A., Decharme, B., Pianezze, J., Lebeaupin Brossier, C., Sevault, F., Seyfried, L., Garnier, V., Bielli, S., **Valcke, S.,** Alias, A., Accensi, M., Ardhuin, F., Bouin, M.-N., Ducrocq, V., Faroux, S., Giordani, H., Léger, F., Marsaleix, P., Rainaud, R., Redelsperger, J.-L., Richard, E., Riette, S.: SURFEX v8.0 interface with OASIS3-MCT to couple atmosphere with hydrology, ocean, waves and sea-ice models, from coastal to global scales, Geosci. Model Dev., 10, 4207-4227, https://www.geosci-model-dev.net/10/4207/2017/, DOI =10.5194/gmd-10-4207-2017, 2017.
7. **S. Valcke**, G. Jonville, R. Ford, M. Hobson, A. Porter and G. Riley (2017), Report on benchmark suite for evaluation of coupling strategies, UMR 5318 CECI, CERFACS/CNRS, TR-CMGC-17-87, Toulouse, France (http://cerfacs.fr/wp-content/uploads/2017/05/GLOBC-TR-IS-ENES2_D10.3_MAI2017.pdf)
8. **S. Valcke**, T. Craig and L. Coquart, 2015. OASIS3-MCT User Guide, OASIS3-MCT_3.0, Technical Report TR/CMGC/15/38, Cerfacs, France.
9. Dunlap, R., M. Vertenstein, **S. Valcke**, and T. Craig, 2014. Second Workshop on Coupling Technologies for Earth System Models, Bull. Amer. Meteor. Soc., 95, ES34–ES38, doi:10.1175/BAMS-D-13-00122.1.
10. **Valcke, S.**, V. Balaji, A. Craig, C. Deluca, R. Dunlap, R. Ford, R. Jacob, J. Larson, R. O'Kuinghttons, G. Riley, M. Vertenstein (2012): Coupling technologies for Earth System Modelling, Geosci. Model Dev., 5, 1589-1596, doi:10.5194/gmd-5-1589-2012. http://www.geosci-model-dev.net/5/1589/2012/gmd-5-1589-2012.pdf

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.

8/Irish Centre for High-End Computing (ICHEC)

About the institute

The Irish Centre for High-End Computing (ICHEC) is legally a centre within the National University of Ireland, Galway; PIC code 999978045.

ICHEC, founded in 2005, is Ireland's national high performance computer centre. Its mission is to provide High-Performance Computing (HPC) resources, support, education and training for researchers in third-level institutions and through technology transfer and enablement to support Irish industries large and small to contribute to the development of the Irish economy. ICHEC works on code optimisation and development of climate and weather codes wirth academia and public organisations, in particular the EC-Earth climate model, where it is a consortium

member, and the 'Harmonie' weather model with Met Éireann in the Hirlam consortium. ICHEC has experience providing operational services for Met Éireann, the national weather service, since 2007. This involves redundant compute and computational scientist support as part of a scientific collaboration, where ICHEC scientists optimise and develop weather and climate codes on next-generation systems. This has recently expanded to include emergency dispersion modelling for the EPA (Environmental Protection Agency) and RPII (radiation), and Dept. of Agriculture (foot and mouth, disease dispersion); Met Éireann and ICHEC have also demonstrated flood forecasting for the Irish Office of Public Works.

ICHEC manages an Earth System Grid Federation (ESGF) portal for climate model data on behalf of the EC-Earth consortium, publishing data on behalf of 14 organisations; we have developed processing workflows and data management systems for this.

Contribution to the specific project

ICHEC will contribute to WP4 in ESiWACE2.

Alastair McKinstry (male) is a computational scientist with more than 15 years' experience in HPC and Unix code optimization, originally in industry (Digital, Compaq, Oracle) and weather and climate code development. He has worked on XIOS development within PRACE 2IP, leading development of the GRIB output, and memory caching to enable XIOS scaling on large low-memory-per-node HPC systems, and adding XIOS to the IFS atmosphere model within EC-Earth. At ICHEC Alastair leads environmental activities, optimizing user and community codes.

Publications, and/or products or other achievements

•   Ovadnevaite, Giovanni Martucci, Jakub Bialek, Ciaran Monahan, Harald Berresheim, Aditya Vaishya, Zachary McGraw Grigas, Alastair McKInstry S Gerard Jennings, Baerbel Langmann, Tido Semmler, Ray McGrath (2011): The Eyjafjallajökull Ash Plume–Part 2: Simulating ash cloud dispersion with REMOTE Atmospheric environment

•   J Donners, C Basu, A McKinstry, M Asif, A Porter, Eric Maissonave, Sophie Valcke, Uwe Fladrich Performance Analysis of EC-EARTH 3.1, PRACE technical report, 2012

•   P.Nolan, A. McKinstry, Scaling Coupled Climate Models to Exascale: OpenACC-enabled EC-Earth3 Earth System Model, 2013, PRACE technical report

•   Shiyu Wang, Ray McGrath, Alastair McKinstry, Recent Irish Weather Extreme and

Change of Extreme Precipitation Due to Climate Change, EPA Climate Change report, 2010

Projects, and/or activities, services

- EU FP7 PRACE: ICHEC was WP co-leader for climate code development in PRACE2IP
- CMIP5 EC-EARTH: ICHEC managed the data publication for CMIP5 for the EC-Earth climate model in CMIP5, doing code development and optimization, running ensemble runs

with Met Éireann, and post-processing ocean data from EC-Earth partners.

Significant infrastructure, and/or major items of technical equipment
ICHEC's primary HPC facility is "Fionn", a 7680-core SGI ICE X / SGI UV 2000 system (147 Tflop peak) with additional accelerator and high-memory regions. This has 560 TB formatted Lustre storage, and multiple login nodes, including dedicated nodes for NWP and emergency service use • ICHEC is also part of the eINIS collaboration, managing an Earth System Grid Federation (ESGF) node managing climate model data on 1 PB of storage based at DIAS in Dublin.

9/ Met Office (METO)

About the institute

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 to the specific project

In ESiWACE2, METO will contribute to WP1, WP2, WP3, WP4, WP6.

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 led effort in both IS-ENES2 and ESiWACE around the Cylc meta-sheduler.

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.

Publications, and/or products or other achievements

1. Crossing the Chasm: How to develop weather and climate models for next generation computers?
2. 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

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
- EU H2020 EUSTACE – Met Office coordination - EU Surface Temperature for All Corners of Earth
- EU H2020 ATLANTOS - Optimizing and Enhancing the Integrated Atlantic Ocean Observing System

The Met Office provides the Monsoon service which has been providing a collaborative HPC and post-processing environment for approved Natural Environment Research Council (NERC) and Met Office users since 2010. There have been around 200 registered users and 30 ongoing projects throughout this period. This collaboration is managed under the auspices of the Joint Weather and Climate Research Programme. Monsoon ensures the UK has access to internationally competitive tools for weather and climate science and enables close collaboration between Met Office and NERC scientists in a common environment.

Funded by the Engineering and Physical Sciences Research Council (EPSRC) and joining with the GW4 alliance and Cray, MetO also hosts the Isambard service for UK-based scientists to provide multiple advanced architectures within the same system in order to enable evaluation and comparison across a diverse range of hardware platforms. Isambard is set to be the world's first production ARM-powered supercomputer based on Cray's XC50 Arm-based product line, consisting of over 160 dual socket Cavium ThunderX2 nodes, and >10,000 cores, networked by Cray's Aries interconnect.

Met Office contributes to the IPCC AR4, AR5 and AR6: Simulations for the successive Assessment Report of the Intergovernmental Panel on Climate Change

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 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 systems 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.

10/ Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC)

About the institute

The Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici (Fondazione CMCC) is a non-profit research institution (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 (www.cmcc.it/publications-type/annual-report)

Contribution to the specific project

In ESiWACE2, CMCC will lead WP5 on Data Post-Processing, Analytics and Visualization and it will contribute to WP1, WP2, WP4, WP6, WP7. More specifically, CMCC will contribute to: WP1 regarding the development of infrastructure for ocean production mode configurations and their porting to pre-exascale systems; WP2, by leading the task on watching emerging technologies and by contributing to the application of DSLs to ocean models; WP4 by contributing to the ESDM implementation and testing activities; WP5, by leading the WP and contributing to the design and implementation of the ESDM PAV runtime, as well as its interface to post-processing and analytics applications; WP6 by leading the training on HPDA tools and frameworks.

Giovanni Aloisio (male). He is full professor of Information Processing Systems at the Dept. of Innovation Engineering of the University of Salento, Lecce, Italy, where he leads the HPC laboratory. Former director of the Scientific Computing and Operations (SCO) Division at CMCC, he is now the Director of the CMCC Supercomputing Center and a member of the Strategic Council. His expertise concerns high performance computing, grid & cloud computing and distributed data management. He was strongly involved in EU grid projects such as GridLab, EGEE, IS-ENES1, EUBrazilCC, IS-ENES2, CLIP-C and the G8 ExArch. As CMCC, he is also the coordinator of the OFIDIA2 (Operational FIre Danger preventIon plAtform) project in the context of Interreg V-A Greece Italy Programme 2014-2020 and he is currently coordinating the CMCC activities in the ESiWACE project. He has been in charge of the EU-FP7 EESI (European Exascale Software Initiative) project for ENES as well as the EU-FP7 EESI 2 project for the University of Salento (as PRACE Third Party). In both

cases, he has also chaired the WCES (Weather, Climate and solid Earth Sciences) European Working Group. He is a member of the ENES HPC Task Force and one of the key experts of the IESP project (International Exascale Software Project), whose main goal is the definition of the roadmap for a common, open source software infrastructure for scientific computing at exascale. He is the author of more than 100 papers in referred journals on high performance computing, grid computing and distributed data management.

Sandro Fiore (male) Ph.D., Director of the Advanced Scientific Computing (ASC) Division of the Euro-Mediterranean Centre on Climate Change Foundation. His research activities focus on parallel and distributed computing, in particular on scientific data management, big data, data analysis, mining and high performance data analytics. He has been Visiting Scientist at Lawrence Livermore National Laboratory (LLNL) working at PCMDI in the context of the Earth System Grid Federation (ESGF). Since 2004, he has been involved in several national and international projects, such as: EGI-InSPIRE, IS-ENES, EUBRAZILCC, ExArch, ORIENTGATE, TESSA, OFIDIA, CLIP-C, INDIGO-DataCloud, EUBra-BIGSEA and ESIWACE, working on data management topics. Since 2010, he has been the Principal Investigator of the Ophidia project, a research project on high performance data analytics, mining, and diagnostics for eScience. He is the author and co-author of more than 60 papers in refereed books/journals/proceedings on parallel and distributed computing and holds a patent on data management. He is the editor of the book "Grid and Cloud Database Management" (Springer, 2011). He is an ACM Member.

Silvia Mocavero (female) Ph.D., is scientist at the "Advanced Scientific Computing" (ASC) Division of the "Euro-Mediterranean Center on Climate Change" (CMCC), where she leads the "High End Computing" research group. Her skills include parallel programming on hybrid architectures, distributed environments, and a long experience in several parallel programming models: message passing, shared memory, many-threads programming with accelerators. She is currently exploring new computing issues, such as exascale computing. She works on the performance analysis and optimisation of climate models with a particular focus on the NEMO ocean framework. She has been Visiting Scientist at Barcelona Supercomputing Center (BSC) and at Argonne National Laboratory (ANL) 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 and national projects like FIRB Grid.it and TESSA. She is currently involved in the ESIWACE, working on models scalability. She is co-author of more than 25 papers in journals/proceedings on high-performance, distributed and grid computing.

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. Her scientific interests focus on the understanding of the ocean role in the global climatic system. 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 to set up the basis of a NEMO based high-resolution ocean forecasting system which is now operational at CMCC. She has been involved in several EU project (among the latest MyOcean and CRESCENDO) 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. She teaches the course "Ocean Dynamics" at the Università di Venezia Ca' Foscari, in the "Science and Management of Climate Change" Ph.D. Programme and is member of the Faculty Board since 2006. She is member of the CLIVAR Panel on Ocean Model Development and representative at the "Commissione Oceanografica Italiana" (Italian IOC-UNESCO).

Dorotea Iovino (female) holds a Ph.D. in physical oceanography from the Geophysical Institute, University of Bergen (Norway). She expanded her knowledge and experience in oceanography and numerical modelling during the post-doctorate at the Laboratoire d'Océanographie et du Climat: Expérimentations et Approches Numériques (LOCEAN) in Paris (France), and is currently a scientist at the Euro-Mediterranean Centre on Climate Change (CMCC), in Bologna, where she coordinates the research activities of Ocean and Sea-Ice Modelling group within the Ocean Modeling and Data Assimilation Division since 2015. 2015. She has been involved into several national and international projects, with more than 10 years of experience working on ocean and sea ice modelling, both on the technical and scientific aspects, with particular interest in the high-resolution ocean/sea ice modelling. She was involved in high-resolution ocean modelling within ENS4OCEAN, PRACE funded project, and now coordinates the PRACE project ROMEO. Since 2017, she is member of the CLIVAR/CliC Northern Oceans Regional Panel (NORP). As NEMO Officer, she leads the CMCC effort within the NEMO System Team in developing the model system, member of the NEMO sea ice Working Group since 2016. Since 2012, she teaches in Ph.D. programme in Science and Management of Climate Change at Ca' Foscari University in Venice.

Publications, and/or products or other achievements

1. 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, International Journal of High Performance Computing Applications, SAGE Publications, ISSN 1094-3420, Online ISSN: 1741-2846, DOI: 10.1177/1094342016684930

2. Sandro Fiore, Marcin Plóciennik, Charles M. Doutriaux, Cosimo Palazzo, J. Boutte, Tomasz Zok, Donatello Elia, Michal Owsiak, Alessandro D'Anca, Z. Shaheen, Riccardo Bruno, Marco Fargetta, Miguel Caballer, Germán Moltó, Ignacio Blanquer, Roberto Barbera, Mário David, Giacinto Donvito, Dean N. Williams, V. Anantharaj, Davide Salomoni, Giovanni Aloisio: Distributed and cloud-based multi-model analytics experiments on large volumes of climate change data in the earth system grid federation eco-system. BigData 2016: 2911-2918

3. Iovino, D., S. Masina, A. Storto, A. Cipollone, and V.N. Stepanov, 2016. A 1/16° eddying simulation of the global NEMOv3.4 sea ice-ocean system. Geosci. Model Dev. 9 (8), pp. 2665-2684 - doi:10.5194/gmd-2015-268.

4. J. Dongarra, P. Beckman, T. Moore, P. Aerts, G. Aloisio, J. C. Andre, D. Barkai, J. Y. Berthou, T. Boku, B. Braunschweig, F. Cappello, B. M. Chapman, X. Chi, A. N. Choudhary, S. S. Dosanjh, T. H. Dunning, S. Fiore, A. Geist, B. Gropp, R. J. Harrison, M. Hereld, M. A. Heroux, A. Hoisie, K. Hotta, Z. Jin, Y. Ishikawa, F. Johnson, S. Kale, R. Kenway, D. E. Keyes, B. Kramer, J. Labarta, A. Lichnewsky, T. Lippert, B. Lucas, B. Maccabe, S. Matsuoka, P. Messina, P. Michielse, B. Mohr, M. S. Mueller, W. E. Nagel, H. Nakashima, M. E. Papka, D. A. Reed, M. Sato, E. Seidel, J. Shalf, D. Skinner, M. Snir, T. L. Sterling, R. Stevens, F. Streitz, B. Sugar, S. Sumimoto, W. Tang, J. Taylor, R. Thakur, A. E. Trefethen, M. Valero, A. van der Steen, J. S. Vetter, P. Williams, R. Wisniewski, K. A. Yelick (2011). The International Exascale Software Project roadmap, International Journal of High Performance Computing Applications, 25(1): 3-60 (2011), ISSN 1094-3420, doi: 10.1177/1094342010391989

5. Epicoco I., Mocavero S., Macchia F., Vichi M., Lovato T., Masina S., Aloisio G. (2016). Performance and results of the high-resolution biogeochemical model PELAGOS025 v1.0 within NEMO v3.4. Geosci. Model Dev., 9, 2115-2128, doi:10.5194/gmd-9-2115-2016, 2016.

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Projects, and/or activities, services
- EU H2020 Project 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 participates to several activities including: enhancing community capacity in HPC; scheduling and workflow capabilities; implementation of new storage layouts for Earth System Data to be evaluated on fast (in-memory) data analytics frameworks for scientific data management.
- EU FP7 Project IS-ENES (2009-2013) and its follow on 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 was involved in technology tracking activities towards next generation climate models and on the data node monitoring infrastructure.
- EU H2020 Project 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 contributed to requirements gathering from the user communities and dissemination as well as to libraries and toolkits for user interfaces and big data workflows support (WaaS) for eScience.
- EU H2020 Project CRESCENDO (2015-2020). CRESCENDO brings together 7 European Earth System Modelling (ESM) teams and 3 European Integrated Assessment Modelling groups to improve the process realism and future climate projection reliability of ESMs, while evaluating and documenting the performance quality of these models using a project-developed and openly-available community ESM evaluation tool (ESMValTool). CMCC is involved principally in the application of the CMCC Earth System Model v2 (CMCC-ESM2) to investigate the changes in the fully coupled system considering improvements in the marine and terrestrial biochemical processes and contributes to the development of the necessary tools to evaluate model performance quality and projections reliability.
- EU H2020 Project 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. The ODA division contributes to WP2 and WP3, assessing the effect of model resolution on the performances of global climate models, and developing physical parameterisations specifically designed for use in combination with high-resolution meshes. The ASC division of the CMCC Foundation will work in WP9 addressing HPC and Data management challenges.
- EU FP7 Project EESI1 (2010-2011). The goal of the project was the production of the European Roadmap on Exascale. CMCC chaired the WP3/Task3.2 on Weather, Climatology and solid Earth Sciences.

- PRACE Ens4Ocean (ENSemble-based approach for global OCEAN forecasting, 2014-2015). 13M core hours on the high performance computing infrastructure of MareNostrum which allowed CMCC to provide the eddy-resolving global implementation of the NEMO model (1/16° horizontal resolution and 100 vertical levels). A 10-year hindcast simulation was produced and validated within the project.
- PRACE ROMEO (understanding the ROle of Mesoscale Eddies in the global Ocean, 2018). 67M core hours on the high performance computing infrastructure of MARCONI KNL (based at CINECA, Bologna, Italy) available for CMCC to produce a long-term simulation of the global ocean domain at eddying resolution in order to properly characterise mesoscale dynamics and better understand their role in governing the time-mean ocean and ocean variability.

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. Each node is a dual Intel E5-2670 processor working at 2,6 GHz. Athena has a computing capability of 160TFlops (160,000 billion operations per second). The design of the computing architecture, comprised of the IBM dx360M4 server cluster, the InfiniBand interconnection network and the storage subsystem, accelerates research activities and improves the quality of the scientific research for the development of future climate change scenarios and impacts. The huge amount of data produced by CMCC researchers is managed by a DLM system based on a hierarchical storage management solution (HSM). HSM allows data storage on different tiers based on specific policies, enabling administrators to migrate and store data on the most appropriate tier and enabling transparent data access. The CMCC Supercomputing Center is the only computational facility in Italy specializing in Climate Change research.

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 climate simulations datasets in the CMIP5 federated data archive related to CMCC models. Moreover, CMCC runs a dedicated big data analytics cluster with 5 fat nodes, 100 cores, 1.3 TB RAM, 56 TB GFS that will be used during the project for testing activities related to the ESDM. Such infrastructure is expected to be further upgraded with additional nodes (from 2 to 4) and storage (from 20TB to 40TB) during 2018.

11/ The University of Reading (UREAD)

About the institute

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 change, 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 EsiWACE2, awarded to its staff in their host institutions.

Contribution to the specific project

In ESiWACE2, UREAD will provide the core leadership in data systems across all work packages (the "data theme") and specifically lead WP4. Both the WPL leader and the co-lead of the WP4 are working for UREAD. UREAD will also support WP2, WP5, WP6, and WP7.

Bryan Lawrence (male), 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, 10000 core) JASMIN data analysis facility. He has over thirty years' 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 storage work package, recently led a work package in IS-ENES2, and is leading related JASMIN/CEDA projects aimed at high-performance tiered storage. He will be leading the data theme and co-leading WP4 with Dr Julian Kunkel.

Julian Kunkel (male), Lecturer in Computer Science: joined the University of Reading in 2018 as one of three academic founder members of the ACES group in computer science. Previously, he had a post-doctoral position at DKRZ where he worked on a range of projects, as well as teaching at the University of Hamburg Informatics Department where he was also a member of the scientific computing group. His interests include I/O tracing and tools for client and server I/O, data reduction techniques, performance analysis of parallel applications and I/O, cluster management, cost-efficiency and software engineering. His doctorate (2013) was on the monitoring and simulation of parallel programs on the application and system level. Julian is a member of various program committees and his community support activity has included organising I/O workshops and contributing several years of birds-of-a-feather sessions for several years at SC and ISC. He was a member of the steering committee in the former Exascale10 activity, and in 2015, with a number of international colleagues founded the Virtual Institute of I/O (VI4IO) which provides a "storage equivalent" of the HPC Top500 utilising the IO-500 benchmarks. Currently, he is focusing on optimization of parallel I/O and on novel I/O interfaces for Exascale, and he will be co-leading WP4.

Publications, and/or products or other achievements

1. Lawrence, B. N., Rezny, M., Budich, R., Bauer, P., Behrens, J., Carter, M., … Wilson, S. (2018). Crossing the Chasm: How to develop weather and climate models for next generation computers. *Geoscientific Model Development Discussions*. https://doi.org/10.5194/gmd-2017-186

2. 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

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Projects, and/or activities, services

The UREAD has a strong track record of working in European projects and has received awards for over 150 EU projects across FP7 and H2020 resulting in nearly 64M EU Contribution.

- EU H2020 ESiWACE Centre of Excellence in Simulation of Weather and Climate in Europe
- EU FP7 IS-ENES2 Infrastructure for the European Network for Earth-System Modelling, EU FP7 Project fostering simulations with global earth system models

In addition, UREAD Meteorology provides leadership for many other large collaborative coordinated projects in climate and environment focused research under EU FP7 and EUH2020 (e.g., FIDUCEO; PRIMAVERA; MELODIES; WINDSURFER). It has received 5 ERC Starting/Consolidator grant awards and 7 ERC Advanced grant awards. UREAD also has around 40 FP7 Marie Curie People/ H2020 MSCA projects (over 10M EU Contribution), which include 14 Initial/Innovative Training Networks (ITN), 1 International Research Staff Exchange Scheme (IRSES), 1 Researchers' Night award and over 20 individual fellowships.

NCAS at the University of Reading includes the NCAS Computational and Modelling Services, http://cms.ncas.ac.uk/ unit providing software engineering, workflow, HPC resource management, and infrastructure support for UK academic weather and climate research.

Significant infrastructure, and/or major items of technical equipment

Professor Lawrence is the Principle Investigator and Director of the JASMIN facility, and will be providing access to JASMIN in support of ESIWACE2 from his Director's resource allocation. JASMIN is undergoing a significant expansion in Q2 2018, which will result in excess of 40 PB of disk and 10,000 cores. Alongside a large tape library, disk will be provided in number of tiers, including traditional parallel file system, software defined POSIX storage, and object stores. The compute cores are delivered in a batch cluster and a private community cloud providing both infrastructure as a service and platform as a service. A small test cluster is provided for file system testing.

12/ Science, Technology and Facilities Council, UK (STFC)

About the institute

STFC is one of seven UK research councils under the UK government's Department for Business, Energy and Industrial Strategy. It is responsible for supporting and enabling UK research, particularly in the fields of particle physics, nuclear physics and astronomy. In its support role, it also runs two national UK laboratories (Daresbury and Rutherford Appleton) which provide both experimental and computational facilities to UK researchers and their collaborators. Support for the computational sciences is provided by the Scientific Computing Department (which has a more academic focus) and the Hartree Centre which hosts and runs the third largest UK supercomputer outside of dedicated meteorological centres. STFC also plays a significant role in data archival – it runs the UK Hub (tier 1 archive) for the Large Hadron Collider and provides data storage for the Centre for Atmospheric Data Archival (CEDA). As well as providing facilities for computation and data management, STFC employs around 150 computational scientists who work to develop and optimise the full range of scientific applications as well as providing training in software engineering and optimisation. The Hartree Centre has a continuing involvement in both national and European projects aiming to develop or support weather, climate and ocean models on future computer architectures.

Contribution to the specific project

In ESiWACE2, STFC will co-lead WP2 and contribute to WP4, 6, and 7.

Neil Massey (male) - Senior Software Engineer. Neil joined CEDA in 2016 after working on the climateprediction.net (CPDN) and weather@home (w@h) projects at the University of Oxford for over 10 years. Using Volunteer Distributed Computing, CPDN and w@h computes very large ensembles of global and regional climate models, producing a corresponding large amount of data. Neil used this data to study the influence of climate on extreme events, including heatwaves, floods and European winter wind storms, for historical, future and non-anthropogenic climate scenarios.
At CEDA Neil is using his experience of large datasets to develop solutions to storing and accessing the very large archive of data held at CEDA and to ensure that CEDA is ready to migrate the archive to the next generation of storage hardware. This includes new methods of using tape and exploiting object stores via semantic file-fragmentation.
Neil holds a BSc. in Computing Science and Mathematics from the University of Newcastle-Upon-Tyne, an MSc. in Cognitive Science from the University of Birmingham and a DPhil. in Atmospheric Physics from the University of Oxford.

Rupert Ford (male) – Computational Scientist Rupert Ford received a BSc(Hons) in Physics in 1989 and followed this with an MSc in Computer Science in 1990, both from the University of Manchester, U.K. He then became a founding member of the Centre for Novel Computing, a High Performance Research Group based in the School of Computer Science, at the University of Manchester, where he stayed for over 20 years. In 2012 he moved to STFC Daresbury Laboratory where he continues to pursue his interests in performance engineering and flexible frameworks for code maintainability and

performance portability within the High-Performance-Software Engineering Group of the Hartree Centre. The majority of his research over the past 15 years has been undertaken in the Earth System Modelling and Integrated Assessment domains in which he has developed the BFG coupling system and the PSyclone code generation system, the latter which is in use by the Met Office in their prototype next generation model.

Andrew Porter (male) – Computational Scientist. Andrew is a member of the High-Performance-Software Engineering Group within the Hartree Centre at STFC's Daresbury Laboratory, UK. Beginning with his first degree in Computational Physics, Andrew has 25 years experience of developing technical and scientific software. In his ten years with STFC, Andrew has specialised in the optimisation of atmospheric and oceanographic simulation software for HPC platforms. He has been heavily involved with optimizing the NEMO ocean model which has included the introduction of dynamic memory and a novel domain decomposition scheme as well as investigating the suitability of NEMO for hardware such as GPUs and the Intel Xeon Phi. This experience has led to an interest in achieving portable performance for models such as NEMO. Andrew is currently working on PSyclone, a Domain-Specific Compiler for finite-element/difference models in the earth-system domain. PSyclone is a part of the build system for the UK Met Office's LFRic model (the successor to the Unified Model). Andrew holds an MPhys in Computational Physics from the University of York, UK and a PhD in Electronic-Structure Theory from the University of Cambridge, UK.

Publications, and/or products or other achievements

1. Andrew Porter, Jeremy Appleyard, Mike Ashworth, Rupert Ford, Jason Holt, Hedong Liu and Graham Riley, "Portable Multi- and Many-Core Performance for Finite Difference Codes; Application to the Free-Surface Component of NEMO.", Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2017-150, in review, (2017).

2. Porter, R. W. Ford, S. Mocavero, S. Fiore and G. Aloisio, "Application of the PSyKAl approach to the NEMO ocean model", report for Task 3.2 of IS-ENES2, https://portal.enes.org/ISENES2/documents/na2-working-documents/application-of-the-psykal-approach-to-the-nemo-ocean-model/view (2017)

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J., Riley G., Schapoff S., Slavin P., Vielle M., Wallace C., "Producing Policy-relevant Science by Enhancing Robustness and Model Integration for the Assessment of Global Environmental Change", Submitted to Environmental Modelling and Software (2016)

9. Modani M, Ford R.W., Johnson J., Evangelinos C., Evaluating Stencil Codes at Scale, Proceedings of the 3rd International Conference on Exascale Applications and Software, (2015), ISBN: 978-0-9926615-1-9

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Projects, and/or activities, services

• EU H2020 EuroEXA: European co-design for exascale applications. STFC is to host and run the testbed machine (WP5) as well as working on the porting of the NEMO ocean model (WP2).

• EU H2020 ESiWACE Centre of Excellence in Simulation of Weather and Climate in Europe

• EU FP7 IS-ENES Infrastructure for the European Network for Earth-SystemModelling, EU FP7 Project fostering simulations with global earth system models.

• EU FP7 EUDAT: European Data Infrastructure; building and supporting a collaborative data infrastructure (http://www.eudat.eu)

Significant infrastructure, and/or major items of technical equipment

STFC runs two major national computing facilities:

- Scafell Pike is an Atos Sequana X1000 system consisting of 846 dual Intel Xeon (Skylake) nodes and 840 Intel Xeon Phi (Knights Landing) nodes connected using a Mellanox EDR interconnect. It has a peak performance of 4.3 PetaFLOPS. The filesystem is GPFS with long-term data archival provided for with a tape library. Thirty of the Xeon Phi nodes are equipped for large-scale data processing and have 384GB of high-performance memory and locally-connected NVMe drives.

- JADE (owned by the University of Oxford) is the UK's largest GPU-based machine and is hosted by STFC's Hartree Centre. It has 22 NVIDIA DGX-1 deep-learning servers, each with eight Tesla P100 GPUs and 4 TB of SSD. It has over 1 PB of Seagate ClusterStor storage and Mellanox EDR interconnect between nodes.

The Hartree Centre also runs a variety of smaller, more novel machines (ARM based, Maxeler, oil-cooled etc.) for experimental purposes.

13/ BULL SAS (BULL)

About the company

Bull is the Atos brand for its technology products and software, which are today distributed in over 72 countries worldwide. With a rich heritage of over 80 years of technological innovation, 2,000 patents and a 700 strong R&D team supported by the Atos Scientific Community, it offers products and value-added software to assist clients in their digital transformation, specifically in the areas of Big Data and cyber security.

Bull is the European leader in High Performance Computing (HPC) and its products include the energy-efficient supercomputer that is based on a system patented by the company; bullion, one of the most powerful x86 servers in the world developed to meet the challenges of Big Data. Bull has become an ATOS company since January 2015. ATOS is a leading information technology services company generating annual revenues of EUR 12 billion and employing 100,000 people in 72 countries. Serving a global client base, the Group provides Consulting & Systems Integration services, Managed Services & BPO, Cloud operations, Big Data & Cyber-security solutions, as well as transactional services. With its deep technology expertise and industry knowledge, the Group works with clients across different business sectors: Defense, Financial Services, Health, Manufacturing, Media, Utilities, Public sector, Retail, Telecommunications, and Transportation.

In recent years, the Bull R&D labs have developed many major products that are recognized for their originality and quality. These include the Sequana supercomputer which concretes the first results of the "Bull Exascale Program" announced during SuperComputing 2014, bullion servers for the private Clouds and Big Data, the Shadow intelligent jamming system designed to counter RCIEDs, the libertp tool for modernization of legacy applications and hoox, the first European smartphone featuring native security. To explore new areas and develop tomorrow's solutions, today, Bull R&D is investing heavily in customers – with whom it has forged many successful technological partnerships – as well as in institutional collaborative programs (such as competitiveness clusters and European projects) and in partnerships with industry (Open Source, consortiums). Bull is involved with the strategy towards HPC in Europe with the active leadership of ETP4HPC and contribution to the Strategic Research Agenda.

Contribution to the specific project

In ESiWACE2, BULL will co-lead WP3 and support WP7.

Xavier Vigouroux (male), after a Ph.D. from Ecole Normale Supérieure de Lyon in Distributed computing, worked for several major companies in different positions. He has now been working for bull for more than 10 years. He led the HPC benchmarking team for the first five years, then was in charge of the "Education and Research" market for HPC at Bull, he is now managing the "Center for Excellence in Parallel Programming" of Bull. He will co-lead WP3.

Erwan Raffin (male) obtained his PhD degree in computer science in 2011 from the University of Rennes1, France in the framework of collaboration between Technicolor and the INRIA/IRISA laboratory. During his PhD, he has focused his research on compilation and synthesis aspects of multimedia application acceleration on coarse-grained reconfigurable architectures using constraint programming. From 2011 to 2014, he was a research and development engineer at CAPS entreprise, which developed and commercialized innovative software for high performance application tuning in the domains of HPC. He then worked at INSA Rennes, IETR, UMR CNRS 6164, UEB in the Image Group as a research engineer on low power video decoder. He joined the Center for Excellence in Parallel Programming (CEPP) of Bull in 2016 focusing on Weather and Climate community and its HPC application domain. He will be involved in WP3 and also co-lead this WP.

David Guibert (male) is senior HPC Expert in the "Center for Excellence in Parallel Programming" of Bull, an Atos company. Degree in Applied Mathematics and Modelling at the Engineer School Institut des Sciences et Techniques de l'Ingénieur de Lyon (ISTIL/EPUL) in 2004, he received his Ph.D. in Applied Mathematics in 2009 from the University of Lyon1, France. During his PhD, he has focused his research on the parallelisation of stiff differential equations arising mainly in CFD

problems. He got the label of Expertise C3I (Certificat de Compétences en Calcul Intensif) delivered by the GENCI in 2009. He led the HPC development of a meshless code for complex fluid dynamics around complex geometries in a SME from 2010 till 2016. He is now working as a HPC applications and performance expert, especially on CFD codes and weather and climate applications. David will be involved in WP3.

Publications, and/or products or other achievements

Our keywords are digital transformation, innovation and value creation, both for our own company and for our clients. We have cemented our position as the trusted partner for our clients' digital transformation, with the resources, the scale and the know-how that our clients need. With more than 80 years of technology innovation expertise, the brand Bull is the hub of technology development at the heart of the Atos Business Technologist family. Bull has developed a complete vertical HPC offer containing Hardware and Software technologies dedicated to scalable HPC systems:

- **Bull Sequana: The open exascale-class supercomputer**

With the Bull Sequana X range of supercomputers, Atos confirms its strategic commitment to the development of innovative high performance computing systems – the systems needed to meet the major challenges of the 21st century. Designed by Atos R&D in close cooperation with major customers, Bull Sequana X supercomputer leverages the latest technological advances, so as to guarantee maximum performance for a minimized operation cost. The race to exascale calls for technological breakthroughs. With Bull Sequana, Atos delivers an innovative solution that matches the exascale technological challenges. The Atos R&D designed Bull Sequana around the following guidelines:

- Open and multi-technology
- Ultra-dense and scalable
- Ultra-energy efficient
- Easy administration

- **Bull Sequana S series**

To tackle enterprise IT challenges and enable businesses to take full advantage of Artificial Intelligence (AI), Atos brings to the market a new generation of x86 servers, BullSequana S, optimized for machine-learning, business critical computing applications and in-memory environments. BullSequana S reaches the highest level of quality of service, performance, availability and scalability to meet IT departments' existing and emerging demands. Based on a very flexible architecture, the BullSequana S server range consists of 5 complementary models, based on the Intel® Xeon® Scalable processor. Each model can be smoothly upgraded to another one, preserving investments and applicative environments. This easy upgrade path is made possible thanks to a very modular design:

- A server scales from 2 to 32 processors, up to 32 GPUs with a maximum memory capacity of 48 TB RAM and 64 TB NV-RAM. All those components within a server are hosted within 1 to 4 Compute boxes;
- The Compute box is the base element of a server, with 3 different form factors (2U/4U/8U) hosting 1 module per 2U;
- The interconnections are performed within a single Compute box by a Connecting box. Above 8 CPUs, a Ubox is added, hosting the new generation of Atos eXternal Node Controller (XNC).

The UBox enables to interconnect up to 4 Compute boxes, to form an SMP system (Symmetric Multi-Processor) with up to thirty-two processor sockets in a CC-NUMA architecture. The UBox is a 5U chassis. This VLSI-type (Very Large Scale Integration) integrated circuit is derived from technologies developed for mainframe servers and tuned for High Performance Computing. Up to 8 CPUs, BullSequana S scales in glueless mode; to reach 16 CPUs, a UBox is added to interconnect 2 Compute boxes (2*8 CPUs) and 2 UBoxes are necessary to reach 32 CPUs.

- **Bull Sequana M series**

Atos mainframe servers have always been able to evolve in order to integrate the latest technologies, especially to take into account the processing of very large data volumes, to integrate into the Cloud or to deploy Big Data applications.

BullSequana M is the new range of mainframe class servers with unmatched features. Designed by Atos engineers, based on the latest Intel® Xeon® Scalable processors and a highly flexible and modular architecture, BullSequana M servers benefit from the latest technological features such as virtualization.

BullSequana M servers are available in two series:

- BullSequana M7000 series for GCOS 7, Windows® and Linux® applications,
- BullSequana M9000 series for GCOS 8, Windows and Linux applications.

Both of them propose a virtualized version in addition to a "classical" one.

- **Bull eXascale Interconnect (BXI)**

Exascale entails an explosion of perfor-mance, of the number of nodes/cores, of data volume and data movement. At such a scale, optimizing the network that is the backbone of the system becomes a major contributor to global performance. The interconnect is very likely going to be a key enabling technology for exascale systems. This is why one of the cornerstones of Bull's exascale program is the development of our own new-generation interconnect. The Bull eXascale Interconnect or BXI introduces a paradigm shift in terms of performance, scalability, efficiency, reliability and quality of service for extreme workloads. The BXI fabric is highly scalable (up to 64.000 nodes for the first version), it features:

- High-speed links (100 Gb/s/s)
- High message rate (>100 M msg/s)
- Minimal memory footprint and low latency components.

The BXI fabric relies on two types of ASICs as its building blocks, a Network Interface Controller (NIC) and a switch, and comes with its complete software suite. BXI switches are managed through a distributed and out-of-band fabric management suite allowing to scale up to 64K nodes. Out-of-band management eliminates any interference of the management traffic with the applications traffic.

- **Bull supercomputer suite, or SCS**

Bull supercomputer suite introduces a new approach to extreme computing software solutions. Bull SCS is a scalable, open, and robust software suite that meets the requirements of even the most challenging high performance computing (HPC) environments, which also require enhanced security. Bull SCS is the result of Atos's long experience in deploying large-scale supercomputers, combined to continued efforts in Research & Development.

Bull supercomputer suite is designed for every HPC need, from small supercomputers with just a few hundred cores to supercomputers with tens of thousands of nodes. It is cut out to reach performance targets of the order of up to 100 PFlops, based on new-generation CPUs and GPUs. The main goal of Bull SCS is to provide a global high performance supercomputing environment. It includes:

- a standardized and scalable installation process with an enhanced update solution; mechanisms to ease integration of new hardware;
- default security with on-time fixes;
- and support for several user development and execution environments with top performance.

This new generation HPC software suite is a further step towards Exascale computing.

Projects, and/or activities, services

Bull is involved with the strategy toward HPC in Europe with the active leadership of ETP4HPC and contribution to the Strategic Research Agenda.

Bull participated to the following cooperative projects connected to the subject of this proposal:

- EU H2020 Mont-Blanc 3 - European scalable and power efficient HPC platform based on low-power embedded technology.
- EU H2020 SAGE - Percipient StorAGe for Exascale Data Centric Computing.
- EU H2020 CompBioMed Centre of Excellence in Computational Biomedicine.
- EU H2020 ESCAPE Energy-efficient Scalable Algorithms for Weather Prediction at Exascale.
- EU H2020 ESiWACE Centre of Excellence in Simulation of Weather and Climate in Europe.

Significant infrastructure, and/or major items of technical equipment

Atos CEPP has got access to two computing clusters hosted in Bull France facilities. Both are continuously upgraded to the latest technologies (network, CPU, memory…).

The 1st one, called genji, is a medium scale system dedicated to experimentation bed. It is heterogeneous and its resources are evolving quickly in order to test early upcoming technologies. Thus it is equipped with standard x86 CPUs, Nvidia GPUs including dedicated to IA, Intel Xeon Phis, as well as with ARM processors. One large in-memory server MESCA2 is also mounted to genji-. This platform can be tuned. So depending on the needs its fabric could be either EDR IB-2, OPA or BXI, and different types of parallel filesystems may be available.

The 2nd one, called manny, is a large scaled system based on systems in delivery testing. It is designed for performance and is continuously equipped with several hundreds of nodes embedding last generations of CPUs and possibly accelerators.

With these platforms partners can bring their data and then install, test and validate their developments throughout the project whether they are technology providers or applications developers.

14/ Seagate (SEAGATE)

About the organisation

Seagate is the world's leading provider of Data Storage devices, equipment and services. The organisation is a worldwide multi-national registered in Ireland (Seagate Technology plc) with more than 50,000 employees. Seagate operates two primary divisions within its corporate operations, Seagate Technology develops and produces data storage devices including disk drives, solid state drives and solid state storage for integration within servers, a large facility is located in Northern Ireland. Seagates' Cloud Systems and Silicon Group provides enterprise data storage solutions and core silicon technologies. Key within its portfolio are storage systems targeted at the High Performance Computing marketplace. The division of the organisation responsible for this project is Seagate Systems UK Ltd which is part of the CSSG organisation. The HPC products from Seagate consist of fully engineered data storage systems with all hardware, file systems software and system management provided. Systems are provided through our OEM or business partnerships including with ATOS, which features a ~60PB installation at DKRZ, Germany, and major installations at CEA in France. Seagate HPC systems in general support some of the world's most powerful supercomputers including NCSA Bluewaters where the storage system achieved the world's first 1TByte / second performance. Skills in all technology disciplines are needed to create these diverse range of products from molecular scientists to systems software and Seagate Systems will draw upon the knowledge and skills of the whole Seagate organisation to ensure the success of the project bringing knowledge on fundamental storage devices and techniques alongside methods to harness the huge capacity of systems for the HPC as well as accelerating their performance to future needs. Within Seagate Systems (UK) the Emerging Technology Group manages collaborative research activities within Europe and will work in concert with development engineering groups based in UK. The group has experience with H2020, FP7 and UK National collaborative projects.
Current projects include:
- H2020 SAGE - Percipient storage for Extreme scale era of which Seagate is project coordinator and technical lead
- H2020 ESiWACE - Climate and Weather centre of excellence where Seagate is working to optimise access to the vast databases of these communities
- H2020BigStorage - a European Training program (ETN) of convergence of HPC storage and Data Science.
- EXDCI: European Extreme Data and Computing Initiative[1]The skills of the team and the wider Seagate Systems organisation have been harnessed to create a next generation object storage platform (Mero) which will be further leveraged as one of the backend storage software platforms for EsiWACE2 on top of which the middleware extensions will be built. The Mero platform has been a 'ground up' development explicitly considering, from its outset, the needs of Extreme scale storage for the exascale era.

In June 2017 Seagate signed a strategic partnership with Cray wherein Cray takes ownership of service and support for one of Seagate's legacy product lines (ClusterStor). Seagate is now focussed on solutions and technologies that truly work for Extreme scale computing and data storage (through Mero as a foundation). Seagate is also heavily involved in setting the strategic direction of EU HPC Research through its steering board membership in the ETP4HPC Organisation and its active role in defining the ETP4HPC's Strategic Research Agenda updates.

Contribution to the specific project
In ESiWACE2, Seagate will work on WP4 and WP6.

The main motivation for Seagate involvement in the project is to provide a next generation object storage backend for the ESDM. Seagate will be involved in developing the Earth Systems Data Middleware extensions as needed for the updated Clovis API for its Mero Object store. This extends some of the work already done in ESiWACE which provided early Clovis API support for ESDM. Seagate will also be involved in providing a proof of concept storage system (with Mero and Clovis) suitable for ESiWACE use cases which demonstrates the value of ESDM with Clovis/Mero.

Hua Huang (male) is currently a senior software engineer at Seagate working on Research and Development for next generation storage systems. Hua Huang received his Ph.D in Computer Science in 2005 from Institute of Computing Technology, Chinese Academy of Sciences, a leading institute in computer architecture and HPC research in China. There, he joined the Blue Whale file system research and development team as a PhD student and was one of the main contributers. Since 2005 he worked on Lustre in ClusterFS (later acquired by Sun) as a senior software engineer. Leaving in March 2009 to join EMC, he continued to work on file system development for EMC storage platform. Leaving in late 2009, he joined a start-up company Clusterstor to design and implement an Exascale storage system, this technology was acquired by Xyratex (now part of Seagate) and forms the basis of the core SAGE system.

His main experience on file system and storage system research and development includes cluster file system metadata management, large-scale distributed storage system performance analysis and optimization, etc. Hua Huang's role within ESiWACE2 will be Seagate's involvement in WP4 and WP6.

Sai Narasimhamurthy (male) is currently Sr. Staff Engineer, Seagate Research (formerly Lead Researcher, Emerging Tech, Xyratex) working on Research and Development for next generation storage systems (2010-). Sai currently also holds the position of vice-chair of industry for the ETP4HPC organisation and leads the storage and I/O working group for developing ETP4HPC's Strategic Research Agenda (SRA). He has also actively led and contributed to many European led HPC and Cloud research initiatives on behalf of Xyratex (2010-) currently coordinating and providing technical leadership for SAGE. Previously(2005 - 2009) , Sai was CTO and Co-founder at 4Blox, inc, a venture capital backed storage infrastructure software company in California addressing IP SAN(Storage Area Network) performance issues as a software only solution. During the course of his doctoral dissertation at Arizona State University (2001-2005), Sai has worked on IP SAN protocol issues from the early days of iSCSI(2001). Sai also worked with Intel R&D and was a contributing participant in the first stages of the RDMA consortium (put together by IBM, Cisco and Intel) for IP Storage and 10GbE (2002). Sai's main role within ESiWACE2 will be to coordinate the work required within Seagate and inputs into the project for WP4 and WP6.

Publications, and/or products or other achievements

As a commercial organisation Seagate does not generally take the lead in submitting material for publication in academic journals or to conferences. However they do present publicly on selected technical aspects of the systems and solutions with presentations at major events such as Super Computing and ISC.

Seagate is solution provider for storage systems suitable for Cloud and HPC. More information can be obtained here: (http://www.seagate.com/products/enterprise-servers-storage/enterprise-storage-systems).

Projects, and/or activities, services

- Seagate is involved in the H2020 through the **SAGE** project (http://www.sagestorage.eu) as co-ordinator and lead.
- The SAGE project has introduced the base Object storage platform and the base storage API and a repertoire of ecosystem components (Hierarchical Storage Management, Programming models, etc.) that works on top of the API.
- Seagate is involved also in H2020 Big Storage (http://bigstorage-project.eu/) and ESiWACE(https://www.esiwace.eu/). Seagate is developing a next generation multi-tiered active storage system in SAGE, assessing the storage needs of SKA (https://www.skatelescope.org/sdp/) in Big Storage which is a MCITN (http://www.cipris.eu) and providing object storage interfacing solutions for the Climate and Weather community in ESiWACE (https://ec.europa.eu/programmes/horizon2020/en/news/eight-new-centres-excellence-computing-applications) .
- Seagate is also actively involved in the ETP4HPC activities that helps to define the direction of European HPC research and is on the board(http://www.etp4hpc.eu/) .
- Seagate Systems has been involved in a number of FP7 projects including IRMOS

(http://www.irmos.eu); creating Quality of Service capability for storage in 'real time' cloud systems and currently is a member of the DEEP-ER(http://www.deep-er.eu) project particular focused on improved IO guidance mechanisms.

- The organisation also has involvement in a number of Research projects in the area of Optical Interconnects including PHOXTROT (http://phoxtrot.eu).
- Seagate Systems has also involved in UK funded research initiatives (eg : http://www.avatar-m.org.uk/Avatarm/) as Xyratex.

Significant infrastructure, and/or major items of technical equipment
None.

15/ Eidgenössische Technische Hochschule Zürich (ETH Zurich)

About the institute

In 1991 **Eidgenössische Technische Hochschule Zürich** / Swiss Federal Institute of Technology in Zurich, founded the Swiss National Supercomputing Centre (CSCS). CSCS partners with Swiss universities and research institutions on all issues related to High Performance Computing. Headed by Prof. Thomas Schulthess, CSCS provides scientists with the computing infrastructure and expertise they need, from cutting-edge super-computers to a full range of services delivered by an international team. CSCS is an autonomous unit of the ETH Zurich and it is located in Lugano in the Italian-speaking region of Switzerland. CSCS also caters for users from business and industry and works with the world's leading computing centres and hardware manufacturers to guide and develop the state of the art.

Contribution to the specific project

In ESiWACE2, ETH Zurich will be involved in WP2, WP3, WP6.

Thomas C. Schulthess (male) received his PhD in physics from ETH Zurich in 1994. He is a professor for computational physics at ETH Zurich and Director of the Swiss National Supercomputing Centre in Lugano, Switzerland. Thomas holds a visiting distinguished professor appointment at ORNL, where he was group leader and researcher in computational materials science for over a decade before moving to ETH Zurich in 2008. His current research interests are in development of efficient and scalable algorithms for the study of strongly correlated quantum systems, as well as electronic structure methods in general. He is also engaged in the development of efficient tools and simulations systems for other domain areas, such as meteorology/climate and geophysics. Thomas will oversee ETH Zurich involvement in ESiWACE2.

Lucas Benedicic (male) received the M.Sc. and Ph.D. degrees in Computer Science from the University of Primorska in 2009 and the Jožef Stefan International Postgraduate School in 2013, respectively. He joined the Swiss National Supercomputer Center (CSCS) in 2014. He is a member of the HPC Operations unit where he leads the development and deployment of software-defined platforms on top of heterogeneous systems and hybrid architectures. This effort currently incorporates technologies enabling container runtimes, interactive HPC and web-oriented compute and storage services.

William Sawyer (male) received his Doctorate of Science from ETH Zurich in 2007. He is a senior computational scientist at the Swiss National Supercomputing Centre (CSCS), in Lugano, Switzerland. He works in the Scientific Community Engagement group as a liaison between CSCS's customers – researchers from a variety of scientific disciplines, in particular from Geosciences – and the system engineers and computer scientists who support current and emerging high performance computing solutions. He has more than 20 years of experience in numerical analysis for HPC, and has been active in research at NASA Goddard Space Flight Center, the University of Maryland.

Publications, and/or products or other achievements

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Projects, and/or activities, services

- PRACE – First, Second, Third, Fourth and Fifth Implementation Phase Project (PRACE-1IP, 2IP, 3IP, 4IP, 5IP) - PRACE, the Partnership for Advanced Computing in Europe, aims to create a pan-European high performance computing (HPC) service and enable high impact scientific discovery and engineering research and development across all disciplines to enhance European competitiveness for the benefit of society.
- The Human Brain Project (HBP) - The Human Brain Project is part of the FET Flagship Programme, the goal is to encourage visionary, "mission-oriented" research with the potential to deliver breakthroughs in information technology with major benefits for European society and industry.
- Interactive Computing E-Infrastructure for the Human Brain Project (ICEI)
- Exa2Green: Energy-Aware Sustainable Computing on Future Technology – Paving the Road to Exascale Computing, the European Commission project under the 7th Framework Programme.

Significant infrastructure, and/or major items of technical equipment

CSCS, the Swiss National Supercomputing Centre, develops and provides the key supercomputing capabilities required to solve important problems in science and society. The centre operates the very latest supercomputers and works with the world's leading computing centers and hardware manufacturers. Piz Daint, a hybrid Cray XC40/XC50 system, is the flagship system for national HPC Service. In 2017, CSCS becomes fifth PRACE (Partnership for Advanced Computing in Europe) hosting member. Piz Daint is the most powerful system in the PRACE pool of resources with 5320 hybrid nodes with NVIDIA P100 GPUs and 1431 dual-socket Intel Xeon CPU nodes. CSCS storage services include a high bandwidth scratch file system for Piz Daint and site-wide storage of over 10 PetaBytes. Recently, a new tape library has been installed with an initial capacity of 120 PetaBytes. Additional services include a cloud environment using OpenStack technology. MeteoSwiss weather forecasts systems are hosted at CSCS. In 2016, MeteoSwiss operational numerical weather prediction services were moved to a hybrid multi-GPU compute-node system. To support scientific workflows, CSCS offer 100 Gbps connectivity Swiss academic and research network and is part of the PRACE network.

16/ University of Manchester (UNIMAN)

About the institute

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 to the specific project
In ESiWACE2, UNIMAN will participate in WP2 and WP5.

Graham 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 Informatics Ltd. for several years.

Publications, and/or products or other achievements

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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 includes ESM and it is anticipated that the final demonstrator will be available for use in EU projects.

See: https://ec.europa.eu/digital-single-market/en/news/euroexa-european-co-design-exascale-applications

17/ Netherlands eScience Center (NLeSC)

About the institute

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 to the specific project

In ESiWACE2, NLeSC will lead WP3 and contribute to WP6.

Ben van Werkhoven (male) holds a PhD in High-Performance Distributed Computing, specifically GPU Computing. He works as an eScience Research Coordinator at the Netherlands eScience Center, where he is the leading GPU Computing expert. His responsibilities include leading a group of (postdoc-level) eScience Research Engineers. As a senior researcher, Ben is involved in accelerating scientific research using GPUs in many collaborations with national and international partners, across many disciplines, including Microscopy, Oceanography, and Radio Astronomy. Ben has been the main developer of a GPU port of the Parallel Ocean Program, and has published on methods for porting large scientific applications to GPUs. He also developed performance models for modelling computation and communication overlap for GPU programs, and developed Kernel Tuner, a software development tool for testing and auto-tuning GPU code. In ESiWACE2, he will coordinate WP3, and lead WP3 T1 & T2.

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. In ESiWACE2, he will be involved in WP3 (T1 & T2).

Rob van Nieuwpoort (male) hold a PhD in High-Performance Distributed Computing from VU University Amsterdam. Rob is Director eScience Technology at the Netherlands eScience Center and an endowed professor of Efficient Computing for eScience at the University of Amsterdam. He is responsible for eScience Technology development in all projects at the eScience Center, project leader of the eScience technology platform, and manager of the research staff. Rob performs research on radio astronomy algorithms and pipelines for LOFAR and the exascale SKA telescope. His latest

research focuses on the use of many-core architectures such as GPUs. In ESiWACE2, he will be involved in WP3 (T2).

Inti Pelupessy (male) obtained his PhD in Astrophysics from Leiden University. He developed the astrophysical multi-purpose software environment (AMUSE) to facilitate coupled multi-physics and multi-scale numerical simulations. AMUSE is used by students and researchers worldwide to formulate and conduct numerical experiments in astrophysics. His interest in the development of methods for coupled simulations led him to head a cross-disciplinary effort to apply the AMUSE technology to the Oceanography and Climate Sciences. This effort resulted in the development of the OMUSE coupling framework. Inti's main expertise lies in the field of scientific computing, with extensive knowledge about parallel HPC methods, distributed computing and numerical simulation methods. In ESiWACE2, he will be involved in WP3 (T2).

Gijs van den Oord (male) holds a PhD in Particle Phenomenology from the Radboud University and Nikhef, where he developed expertise in high-performance computing, numerical simulation and the Monte Carlo method. He has worked on the DeltaShell framework at Deltares, embedding hydrological computational codes into object-oriented wrappers to facilitate visualization and coupling. He has also contributed to D-Flow Flexible Mesh, a shallow-water equation solver on unstructured grids. Gijs is working on Primavera, a project with KNMI to study the EC-Earth climate model at high resolution, and a project with CWI and KNMI that aims to couple cloud-resolving large-eddy simulations to global atmospheric climate codes. In ESiWACE2, he will be involved in WP3 (T2).

Publications, and/or products or other achievements

1. **B. van Werkhoven**, J. Maassen, M. Kliphuis, H. A. Dijkstra, S. E. Brunnabend, M. van Meersbergen, F. J. Seinstra, and H. E. Bal. "A distributed computing approach to improve the performance of the Parallel Ocean Program (v2.1)" Geosci. Model Dev., 7, 267-281, https://doi.org/10.5194/gmd-7-267-2014

2. 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)". Geosc. Model Dev., 9, 4185-4208, https://doi.org/10.5194/gmd-9-4185-2016

3. **Inti Pelupessy**, **Ben van Werkhoven**, Arjen van Elteren, Jan Viebahn, Adam Candy, Simon Portegies Zwart, and Henk Dijkstra. "The Oceanographic Multipurpose Software Environment (OMUSE v1.0)." Geoscientific Model Development 10, no. 8: 3167–87. https://doi.org/10.5194/gmd-10-3167-2017

4. Brunnabend, S.-E., H. A. Dijkstra, M. A. Kliphuis, H. E. Bal, F. Seinstra, **B. van Werkhoven**, J. Maassen, and M. van Meersbergen. "Changes in Extreme Regional Sea Level under Global Warming." Ocean Science 13, no. 1: 47–60. https://doi.org/10.5194/os-13-47-2017

5. **Ben van Werkhoven** and Pieter Hijma. "An integrated approach to porting large scientific applications to GPUs" IEEE 11th International Conference on e-Science 2015, 57-66. https://doi.org/10.1109/eScience.2015.23

6. **Gijs van den Oord**, and Rena Bakhshi. "Parallel Post-Processing of the Earth Climate Model Output." Procedia Computer Science 108 (2017): 2473–77. https://doi.org/10.1016/j.procs.2017.05.146

7. 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

Projects, and/or activities, services

- EU H2020 PROCESS - PROviding Computing solutions for ExaScale challengeS
- EU H2020 Blue-Action – Blue Action: Arctic Impact on Weather and Climate
- EU H2020 EOSCpilot - The European Open Science Cloud for Research Pilot Project
- EU H2020 EUCP – European Climate Prediction System
- EU H2020 PRIMAVERA - Process-based climate simulation: Advances in high-resolution modelling and European climate risk assessment. NLeSC is involved as subcontractor.
- 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
- Stochastic Multiscale Climate Models – https://www.esciencecenter.nl/project/stochastic-multiscale-climate-models
- Data mining tools for abrupt climate change – https://www.esciencecenter.nl/project/data-mining-tools-for-abrupt-climate-change
- TWEX - Translating Weather Extremes into the Future – a case for Norway – https://www.esciencecenter.nl/project/twex
- Towards Large-Scale Cloud-Resolving Climate Simulations – https://www.esciencecenter.nl/project/towards-large-scale-cloud-resolving-climate-simulations
- NLeSC is currently involved in over 90 projects, for the full list please see: https://www.esciencecenter.nl/projects

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.

18/ Federal Institute of Meteorology and Climatology MeteoSwiss (MeteoSwiss)

About the institute

The Federal Office of Meteorology and Climatology MeteoSwiss is by federal mandate the national provider for weather and climate services in Switzerland. In this role, it serves the general public, authorities, research and industry. MeteoSwiss monitors the atmosphere over Switzerland and operates the corresponding networks, it issues weather forecasts, warns the authorities and the general public of dangerous weather conditions and also monitors the Swiss climate. The legal duties include the provision of climate information and climatological

services for the benefit of the general public. MeteoSwiss provides generic and tailor-made datasets and services for customers, and conducts research on themes from weather and climate to high-performance computing. Weather and climate in the Alpine region is one of its core competences. MeteoSwiss hosts the national GCOS office and is the official representative of Switzerland in various

international organisations (WMO, ECMWF, EUMETSAT, EUMETNET etc.) and member of the Swiss Centre for Climate Systems Modelling (C2SM). In its research MeteoSwiss collaborates with academia (e.g. ETH Zurich and Swiss National Supercomputing Centre CSCS), with other governmental offices (e.g. hydrology) and the private sector (e.g. reinsurance). In the framework of the Swiss HP2C and PASC Initiatives, MeteoSwiss has led the adaption of the regional weather and climate model (COSMO) to hybrid high-performance computing systems and has spearheaded the application of domain-specific languages in operational atmospheric codes. On the basis of its numerical weather forecasting models, MeteoSwiss has issued weather and climate forecasts to commercial customers for over ten years now and has also a profound experience in the communication of such forecasts to the public and media.

Contribution to the specific project

In ESiWACE2, DKRZ will lead WP2 and contribute to WP6 and WP7.

MeteoSwiss has significant expertise in the domain of developing DSLs for weather and climate. It has lead the development of the STELLA DSL (Gysi et al. 2015) which is running in the operational implementation of the regional numerical weather prediction model COSMO (Fuhrer et al. 2014; Lapillonne and Fuhrer, 2014). Together with the Swiss National Supercomputing Centre (CSCS) and the computer science department of the ETH Zurich, MeteoSwiss is leading the development of the GridTools ecosystem of libraries for weather and climate models, which will supersede and extend STELLA with new functionality. This work has also been the basis for the development of the DSL work on global models on unstructured meshes within the ESCAPE project. More specifically, MeteoSwiss is leading the development of high-level DSLs and toolchains for GridTools within the Swiss Platform of Advanced Scientific Computing (pasc.org), which will be extended as a high-level DSL and toolchain for global models in ESCAPE-2 project. Further, MeteoSwiss has developed the CLAW compiler, a directives based source-to-source translator that can be applied to the physical parametrizations.

Oliver Fuhrer (Male) – holds a PhD in Physics and has many years of experience in developing and deploying weather and climate models. Currently, he is leading the model development group at MeteoSwiss and a lecturer at ETH Zurich. His group is responsible for both improvements in model quality as well as the high-performance computing aspects of the model development. Over the past 7 years, he has attracted the funding for multiple
research projects focusing on the adaption of weather and climate codes to emerging and future hardware architectures. A main thrust has been the development of novel programming models and DSLs. His team at MeteoSwiss has been awarded the Swiss ICT Award in 2016 for having implemented the first operational weather model fully running on a Cray CS Storm cluster with fat GPU nodes.

Carlos Osuna (Male) – has a PhD in Particle Physics which he obtained in 2009. Since then he has been working in the field of high-performance computing with large scientific codes. In 2011 he joined, as a Post-Doctoral at ETH, the HP2C project to develop a new GPU capable version of the numerical weather and climate model prediction COSMO, which significantly improved the performance and energy efficiency of the model used in production at MeteoSwiss and ETH institutions. Since then he has been involved in the development of novel domain specific languages (STELLA and GridTools) for numerical methods used in atmospheric sciences. Currently he is co-PI of the PASC PASCHA project that aims at developing a universal toolchain for high-level DSLs that increase the productivity of model developments in heterogeneous architectures.

Xavier Lapillonne (Male) – is a senior scientist in the model development group at the Federal Office of Meteorology and Climatology MeteoSwiss, Zurich since 2015. He is working in the field of high performance computing, in particular on hybrid system, and is currently the project leader of the Performance On Massively Parallel Architectures project for the Consortium for Small-scale Modeling (COSMO). He received a PhD in physics from EPF Lausanne in 2010, where he worked on

massively parallel codes to simulate turbulence in hot plasmas. In 2010-2015 he was Post-doctoral researcher at ETH Zurich working on the development of a new GPU capable version of the numerical weather prediction code COSMO used at MeteoSwiss for weather prediction and at several universities for climate research. He was the lead developer for porting several parts of the model using OpenACC compiler directives, including physical parameterization and data assimilation. He has experience in developing and running scientific models on many supercomputers, including hybrid architectures (IBM blue gene, Bull NovaScale, Cray XT-4/5, XE6, XK7, XC30, CS-Storm)

Publications, and/or products or other achievements

1. Fuhrer, O., Chadha, T., Lapillonne, X., Leutwyler, D., Lüthi, D., Osuna, C., Schär, Ch., Schulthess, T. C., Vogt, H., Höfler, T., Kwasniewski, G.: Near-global climate simulation at 1 km resolution on a GPU-accelerated supercomputer: establishing a performance baseline with COSMO 5.0, Geosci. Model Dev., submitted

2. Fuhrer, O., Osuna, C., Lapillonne, X., Gysi, T., Cumming, B., Arteaga, A., and Schulthess, T. C.: Towards a perfor-mance portable, architecture agnostic implementation strategy for weather and climate models, Supercomp. Front. Innov., 1, doi:10.14529/jsfi140103, 2014.

3. Gysi, T., Osuna, C., Fuhrer, O., Bianco, M., and Schulthess, T. C.: STELLA: A Domain-specific Tool for Structured Grid Methods in Weather and Climate Models, in: Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis, SC'15,41:1–41:12,doi:10.1145/2807591.2807627, 2015.

4. Lapillonne, X. and Fuhrer, O.: Using Compiler Directives to Port Large Scientific Applications to GPUs: An Example from Atmospheric Science, Parallel Process. Lett., 24, 1450003, doi:10.1142/S0129626414500030, 2014. ESCAPE-2 Part B section 4-6, page 9

5. Leutwyler, D., Fuhrer, O., Lapillonne, X., Lüthi, D., and Schär, C.: Towards European-scale convection-resolving climate simulations with GPUs: a study with COSMO 4.19, Geosci. Model Dev., 9, 3393-3412, https://doi.org/10.5194/gmd-9-3393-2016, 2016.

6. Clement, V., Ferrachat, S., Fuhrer, O., Lapillonne, X., Osuna, C., Rood, R., Sawyer, W.: The CLAW DSL: Abstractionsfor performance portable weather and climate models, submitted to PASC18 conference, 2018.

Projects, and/or activities, services

- EU H2020 ESCAPE-2 Energy-efficient SCalable Algorithms for weather and climate Prediction at Exascale
- HP2C COSMO – development of a version of COSMO fully capable of running on GPU-accelerated hybrid HPC architectures based on the STELLA DSL
- PASC GridTools – development of the GridTools DSL, which will supersede the STELLA DSL
- PASC Pascha – Portability and Scalability of COSMO on Heterogeneous Architectures
- PASC ENIAC – Portability and performance portability for the ICON atmospheric model.

Significant infrastructure, and/or major items of technical equipment

MeteoSwiss is running the operational workflow in a GPU-based (with K80 NVIDIA GPUs), tightly packed Cray CS-Storm supercomputer at CSCS.
As part of the collaborations with CSCS and the informatics deparment of ETHZ, MeteoSwiss has access for development projects to all major computing systems at CSCS, including Piz Daint, currently ranked #3 worldwide in computational capacity, and other hybrid systems with different computing architectures like Intel XeonPhi.

19/DATADIRECT NETWORKS FRANCE (DDN)

About the organization

For almost 20 years, DDN has designed, developed, deployed and optimized systems, software and solutions which enable enterprises, service providers, universities and government agencies to generate more value and accelerate time to insight from their data and information, on premise and in the cloud. DDN systems are now powering more the 70% of the Top500 companies. With around 2/3 of its work force in R&D DDN is a company leading innovation in the field of high performance storage. The past 3 years DDN Storage has established an R&D Center in Meudon, close to Paris, France. This facility is hosting the core development team of the Software Defined Storage group with more than 20 engineers, a large fraction of them holding a Ph.D. DDN is active in the European R&D ecosystem with participation in the ETP4HPC, involvement in teaching HPC I/O in European Universities (Versailles, Trieste, Evry). DDN Storage is an associated member of the Energy oriented Center of Excellence (EoCoE) DDN Storage is owning several facilities with HW prototypes in Europe, one in Paris, one in Dusseldorf.

DDN Storage is an active open source actor as illustrated by its numerous contributions to the Lustre High Performance File System

Contribution to the specific project

In ESiWACE2, DDN will contribute to WP4 to the new Earth Ssytem Data Middleware, workflow optimization for data movement, and industry proof-of-concept.

Jean Thomas Acquaviva (male) is a Research Engineer in the Emerging Tech Department of Data Direct Networks (France). Jean-Thomas has obtained his Ph.D. in 2000 from CEA, DAM (French Atomic Commission, Military Dept.) and University of Versailles (France). After spending 2 years at Intel Compiler group in Santa Clara, he joined the University of Versailles as a Research Engineer, and afterwards joined CEA (civilian department) still as a Research Engineer. Jean-Thomas was one of the founding members of the Exascale Research Centre, a joint lab between Intel, CEA and UVSQ, where he took the head of the performance group. He's now actively participating to the development of DDN's newly set Advanced Technology Center in France. Jean-Thomas is chairing two workshop focused on parallel file systems and performance scalability of file systems. He has authored or co-authored around 20 international publications. Jean-Thomas will be involved in the Task 4 and 5 WP4.

Sebastien Buisson (male) is a Research Engineer in the Emerging Tech Department of Data Direct Networks (France). A graduate of the École Nationale Supérieure d'Informatique et de Mathématiques Appliquées of Grenoble (ENSIMAG), he started working in the High Performance Computing field in 2007 for the Bull company, where he assumed the role of technical leader on the Parallel File Systems aspects. In 2015, he decided to move to one of the HPC storage leaders, namely DDN company, where he is now in charge of the security aspects for the Lustre file system included in the EXAScaler software product. Sébastien will be involved in the task 9, WP4.

Publications, and/or products or other achievements

1. Yingjin Qian, Xi Li, Shuichi Ihara, Lingfang Zeng, Jürgen Kaiser, Tim Süß, André Brinkmann: A Configurable Rule based Classful Token Bucket Filter Network Request Scheduler for the Lustre File System. Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis (SC), Denver, Co, USA, November 12-17, 2017.
2. ExSeisPIOL: Extreme-Scale Parallel I/O for Seismic Workflows, Cathal Ó Broin, Ruairi Short, Seán Delaney, Steven Dagg, Gareth O'Brien, Jean-Thomas Acquaviva and Michael Lysaght, RICE OGHPC 2017.

3. ExSeisPIOL: A Seismic Parallel I/O Library for Increasing Developer Productivity. Authors: Cathal O'Brien, Ruairi Short Meghan Fisher, S. Delaney, S. Dagg, G. O'Brien, J.T. Acquaviva, M. Lysagth, EAGE Workshop on High Performnace Computing for Upstream, October 2017

Projects, and/or activities, services

- DDN is an active member of the ETP4HPC, an associated member of the EoCoE Center of Excellence, part of the DASH ANR (French research project)
- DDN is an active open source contributor to several projects: the file system Lustre, the high performance communication library MPI-IO, the network libraries CCI and OpenFabrics
- DDN organises or co-organises several workshop dedicated to I/O, scalability and performance management
- DDN has been involved in the design and installation of the JCAHPC's Oakforest storage architecture. Oakforest is the largest HPC system installed in Japan and the number 7 in the world (Top500 – June 2017). This system is of particular interest for the project due to its scale and the emphasis put on QoS. JCAPHC is #1 at the IO500 IO performance ranking initiative.
- Notably on the Lustre part of the storage. This system is also one of the largest tier storage in the world with more than 1TB/s of burst buffer coupled to 500 GB/s Lustre.
- DDN is present in more the 70% of the Top500 HPC systems

EXAScaler is a product consisting of the integration of a storage architecture with Lustre parallel file system and targetting HPC. EXAScaler combines a powerful storage architecture with DDN Enterprise Lustre Distribution, DDN integration tools, system monitoring tools and deep bench of Lustre experts across engineering, pre-sales and support. The result is the industry's fastest, most advanced Lustre appliance, proven in the most demanding environments in HPC.
Infinite Memory Engine (IME) 53 is a scale-out flash native I/O. IME is a software layer able to cope with a discrete number of I/O servers and provides a unified system view. By design load balancing and fault tolerance are natively supported across all servers. IME can be seen as a scale-out, flash-native, software-defined, storage cache that streamlines the data path for application I/O. IME interfaces directly to applications and secures I/O via a data path that eliminates file system bottlenecks
Lustre Monitoring Tool: A tool for dynamically monitoring the status of Lustre file system.

http://www.ddn.com/products/lustre-file-system-exascaler/
http://www.ddn.com/products/ime-flash-native-data-cache/

Significant infrastructure, and/or major items of technical equipment
DDN will contribute to the experimentation and validation of the software stack developed during ESIWACE2. In order to do so, the company commits to leverage its World Wide Benchmarking Center which is located in Düsseldorf, Germany.

20/ Mercator Ocean (MO)

About the institute

Between observation infrastructures and users, Mercator Ocean is a non-profit company employing a team of 60 persons which ensures the continuity from research to oceanographic operational services. Mercator Océan has nine research and operational governmental shareholders (Centre National de la Recherche Scientifique (CNRS), Institut pour la Recherche et le Développement (IRD), Météo-France (the French Meteorological office), Naval Hydrographic and Oceanographic Service (SHOM), Institut Français de Recherche pour l'Exploitation de la MER (IFREMER), the Euro-Mediterranean Center on Climate Change (CMCC s.r.l.), Met-Office (the UK Meteorological office), National Energy Research Scientific Computing Center (NERSC), and Puerto Del Estado. Over the last 15 years, Mercator Ocean has been playing a leading role in operational oceanography at international level and European level. After having successfully coordinated the European MyOcean projects since 2009, Mercator Ocean was officially appointed by the European Commission on November, 2014 to define, manage, implement and operate the "Copernicus Marine Environment Monitoring Service" (CMEMS) (as part of the European Earth observation program, Copernicus) on its current multi-annual financial framework 2014-2020. Mercator Ocean also defines and manages the service evolution and user uptake of the CMEMS activities.

Contribution to the specific project

In ESiWACE2, MO will be involved in WP1 and WP6. It will develop a global high resolution ocean configuration based on NEMO OGCM at 1/36° horizontal resolution and will perform first simulation with this ocean model.

Romain Bourdallé-Badie (male) has been engineer at Mercator Ocean since the year 2000. Within the R&D team, he is in charge of developing, tuning and validating the high-resolution oceanic and ice model of the future Mercator Ocean prototype. In this context, he has developed the global 1/12° model and he participates to the NEMO developments.

Clément Bricaud (male) has been Ocean engineer at Mercator Ocean since 2006. He is the Mercator Ocean NEMO officer i.e. he represents Mercator Ocean inside the NEMO consortium. As such he is deeply involved in the development and testing of the code. He works also on Mercator's ocean model development and he is the main developer of the online coarsening for Biogeochemistry model.

Yann Drillet (male) is the head of R&D department and scientific director deputy at Mercator Océan, the French global scale operational oceanography center. He is a member of DRAKKAR and NEMO consortiums and leader of the global monitoring and forecasting centre in Copernicus Marine Services. He is an expert on ocean modelling and operational forecasting design.

Publications, and/or products or other achievements

- Gary Brassington, MJ Martin, HL Tolman, S Akella, M Balmeseda, CRS Chambers, E Chassignet, JA Cummings, **Y Drillet**, PAEM Jansen, P Laloyaux, D Lea, A Mehra, I Mirouze, H Ritchie, G Samson, PA Sandery, GC Smith, M Suarez and R Todling. Progress and challenges in short- to medium-range coupled prediction. GODAE OceanView Special Issue publication in the Journal of Operational Oceanography. Volume 8, supplement 1, May 2015
- E. Dombrowsky, L. Bertino, **J. Chanut, Y. Drillet**, V. Huess, A. Misyuk, J. Siddorn and M. Tonani, 2012, NEMO in MyOcean Monitoring and Forecasting Centers (MFCs). Mercator Quarterly Newsletter#46, Oct 2012, pp 31-45

- **Y. Drillet**, J. M. Lellouche, B. Levier, M. Drévillon, O. Le Galloudec, G. Reffray, C. Regnier, E. Greiner, and M. Clavier. Forecasting the mixed layer depth in the north east Atlantic: an ensemble approach, with uncertainties based on data from operational oceanic systems Ocean Sci. Discuss., 11, 1435-1472, 2014

- Lellouche, J.M., O. Le Galloudec, M. Drévillon, C. Régnier, E. Greiner, G. Garric, N. Ferry, C. Desportes, C.-E. Testut, **C. Bricaud, R. Bourdallé-Badie**, B. Tranchant, M. Benkiran, **Y. Drillet**, A. Daudin, C. de Nicola, Evaluation of real time and future global monitoring and forecasting systems at Mercator Océan, Ocean Science Discussions ; 9(2):1123-1185, 2013.
- Hewitt, H. T., Roberts, M. J., Hyder, P., Graham, T., Rae, J., Belcher, S. E., **Bourdallé-Badie, R**., Copsey, D., Coward, A., Guiavarch, C., Harris, C., Hill, R., Hirschi, J. J.-M., Madec, G., Mizielinski, M. S., Neininger, E., New, A. L., Rioual, J.-C., Sinha, B., Storkey, D., Shelly, A., Thorpe, L., and Wood, R. A.: The impact of resolving the Rossby radius at mid-latitudes in the ocean: results from a high-resolution version of the Met Office GC2 coupled model, Geosci. Model Dev., 9, 3655-3670, https://doi.org/10.5194/gmd-9-3655-2016, 2016.
- Maraldi, C., **Chanut, J.**, Levier, B., Ayoub, N., De Mey, P., **Reffray, G.**, Lyard, F., Cailleau, S., Drévillon, M., Fanjul, E. A., Sotillo, M. G., Marsaleix, P., and the Mercator Research and Development Team: NEMO on the shelf: assessment of the Iberia–Biscay–Ireland configuration, Ocean Sci., 9, 745-771, doi:10.5194/os-9-745-2013, 2013.
- Reffray, G., **Bourdalle-Badie, R.**, and Calone, C.: Modelling turbulent vertical mixing sensitivity using a 1-D version of NEMO, Geosci. Model Dev., 8, 69-86, https://doi.org/10.5194/gmd-8-69-2015, 2015.

- Marina Tonani, Magdalena Balmaseda, Laurent Bertino, Ed Blockley, Gary Brassington, Fraser Davidson, **Yann Drillet**, Pat Hogan, Tsurane Kuragano, Tong Lee, Arichal Mehra, Francis Paranathara, Clemente A. S. Tanajura, Hui Wang. Status and future of global and regional ocean prediction systems. GODAE OceanView Special Issue publication in the Journal of Operational Oceanography. Volume 8, supplement 1, May 2015

Projects, and/or activities, services

- Mercator Ocean was the coordinator of the EC/FP7 MyOcean, MyOcean2 and MyOcean FO projects (Copernicus Marine Service).
Mercator Ocean is a member of the NEMO consortium. Mercator Ocean participates of the road map elaboration (parameterizations, technical choices,…), of the developments and of the supports of NEMO. The participation of is up to one man/year.
- Participation to the ERA-CLIM2 (FP7): a collaborative research project funded by the European Union, with the goal of preparing input data and assimilation systems for a new global coupled reanalysis of the 20th century. Mercator Ocean will contribute on sea-ice assimilation and Physical Ocean and bio-geo-chemical model coupling.
- Participation in ANR COMODO: COMODO (COmmunauté de Modélisation Océanique) is a research project supported by the French national research agency (ANR), which regroups the whole French ocean modeling community. This common effort will be directed towards two main objectives: improvement of existing models and numerical methods, guidelines for the development of future generation ocean models.
- Mercator Ocean is involved in ALBATROS project, on of objectives is to derive a simplified model of the marine atmospheric boundary layer which would have the ability to represent key processes associated to air/sea interactions at the characteristic scales of the oceanic mesoscale. This model called SIMBAD (SIMplified Boundary Atmospheric layer moDel) is of intermediate complexity between a bulk parameterization and a full three-dimensional atmospheric model. The goal is improving the CMEMS forecast by improving the interactions ocean/atmosphere.

Significant infrastructure, and/or major items of technical equipment
Mercator Ocean performs operational ocean forecast and ocean reanalysis on High Performance Computers at Meteo-France, for research and development activities we have access to High Performance Computers at Meteo-France, ECMWF and internal computing facilities

Section 4.2 Third parties involved in the project (including use of third party resources)

4.2.1 Subcontracting

	Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	Description of subcontracting	Value (€) *(Figures below are indicative)*
1/ DKRZ	No	//	//
2/CNRS-IPSL	No	//	//
3/ECMWF	No	//	//
4/BSC	No	//	//
5/MPIM	No	//	//
6/SMHI	No	//	//
7/CERFACS	No	//	//
8/ICHEC	No	//	//
9/METO	No	//	//
10/CMCC	No	//	//
11/UREAD	No	//	//
12/STFC	No	//	//
13/BULL	No	//	//
14/SEAGATE	No	//	//
15/ETH Zurich	No	//	//
16/UNIMAN	No	//	//
17/NLeSC	No	//	//
18/MeteoSwiss	No	//	//
19/DDN	No	//	//
20/MO	No	//	//

4.2.2 Work is performed by linked third parties (Art.14 of the Grant Agreement)

	Does the participant envisage that part of its work is performed by linked third parties	Description of third party and link to the participant	Description of tasks	And estimate of the costs: provide the breakdown of the costs: • Staff • other direct costs • indirect costs • total direct plus indirect costs
1/ DKRZ	No	//	//	//
2/CNRS-IPSL	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 WP1, WP3 and WP5 for tasks concerning the I/O server XIOS and the DYNAMICO dynamical core. 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 (estimate 3 PM)
		Ecole Polytechnique (EP) is associated with CNRS within the Joint Research Unit LMD, which is part of IPSL.	EP is involved in WP1 on the coupling with the DYNAMICO dynamical core through Thomas Dubos.	No transfer of money from CNRS to EP but EP permanent personnel costs will be justified (estimate 3 PM)
		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 NEMO system team.	UPMC is involved in WP1 on the ocean component of the coupled IPSL model through through Dr Sébastien Masson.	No transfer of money from CNRS to UPMC but UPMC permanent personel costs will be justified (estimate 3 PM

3/ECMWF	No	//	//	//
4/BSC	No	//	//	//
5/MPIM	No	//	//	//
6/SMHI	No	//	//	//
7/CERFACS	No	//	//	//
8/ICHEC	No	//	//	//
9/METO	No	//	//	//
10/CMCC	No	//	//	//
11/UREAD	No	//	//	//
12/STFC	No	//	//	//
13/BULL	No	//	//	//
14/SEAGATE	No	//	//	//
15/ETH Zurich	No	//	//	//
16/UNIMAN	No	//	//	//
17/NLeSC	No	//	//	//
18/MeteoSwiss	No	//	//	//
19/DDN	No	//	//	//
20/MO	No	//	//	//

4.2.3 Third Parties providing in-kind contributions (Article 11 and 12)

	Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)
1/ DKRZ	No
2/CNRS-IPSL	YES **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 NEMO system team. As a third party to the beneficiary, UPMC will in-kind contributions free of charge to the beneficiary (**Article 12 Grant Agreement**) through the development of the coupled IPSL model at very high resolution in WP1 through Dr Sébastien Masson.
3/ECMWF	No
4/BSC	No
5/MPIM	No
6/SMHI	No
7/CERFACS	No
8/ICHEC	No
9/METO	No
10/CMCC	No
11/UREAD	No
12/STFC	No
13/BULL	No
14/SEAGATE	No
15/ETH Zurich	No
16/UNIMAN	No
17/NLeSC	No
18/MeteoSwiss	No

19/DDN	No
20/MO	No

Section 5: Ethics and Security

5.1 Ethics

Not applicable.

5.2 Security

Our project **will not** involve activities or results raising security issues

Our project **will not** involve 'EU-classified information' as background or results

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

Alfred Wegener Institute, PO Box 12 01 61, 27515 Bremerhaven, Germany

Joachim Biercamp
Coordinator of ESiWACE2
Coordinating institution: DKRZ, Hamburg

Prof. Dr. Thomas Jung
Head of Climate Dynamics
Alfred Wegener Institute
Klußmannstraße 3
D-27570 Bremerhaven
T +49 471 4831 1761
F +49 471 4831 1797
thomas.jung@awi.de

February 26, 2018
Letter of support

Dear Dr. Biercamp,

with this letter we express our full commitment to engage in the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.

I am the head of the Climate Dynamics section at the Alfred Wegener Institute[1] and strongly believe that many important insights will be obtained from this project, which will help us to understand more clearly the system requirements in support of future projects on high-resolution modelling. Drs Bernadette Fritsch and Dmitry Sidorenko will be dedicated points of contact from our side for ESiWACE2.

We would be interested in engaging in the following ways:
- Participation ESiWACE2 annual meetings
- Supporting ESiWACE2 in disseminating project outcomes in our institution
- Contributing to ESiWACE2 workshops on HPC for weather and climate modelling
- Regular roadmap updates on hardware and system software relevant to ESiWACE2

Alfred Wegener Institute
Helmholtz Centre for
Polar and Marine Research

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Commerzbank AG,
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IBAN DE12292400240349192500
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---

[1] The Alfred Wegener Institute is one of the world leading polar research institutions, and it develops and runs high-resolution climate models with a special emphasis on sea ice-ocean models on unstructured meshes.

HELMHOLTZ

- Contribution to strategic discussions on software, high-performance computing and data management developments
- Interest in support of ESiWACE2 on model development, especially IFS and the atmospheric component of ICON
- Interest in support of ESiWACE2 on tools such as the OASIS coupler

Personally, I am also delighted to support the project as a member of the scientific advisory board, should the application be successful.

We are happy to provide any additional information regarding our commitment to the project upon your request or request of the European Commission.

We are looking forward to working together with you in this important project!

Yours sincerely,

(Thomas Jung)

HELMHOLTZ

In reply please quote

To:

Joachim Biercamp

Coordinator of ESiWACE2

Coordinating institution: DKRZ, Hamburg

Letter of support

Dear Dr. Biercamp,

With this letter we express our enthusiastic support for the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.

I am the acting General Manager of the Science to Services Program at the Australian Bureau of Meteorology and I believe that many keen insights are likely to be derived from this project that will help the Bureau of Meteorology understand more clearly the system requirements to support this community with future projects.

The Bureau of Meteorology is in partnership with the U.K. Met Office and other Unified Model (UM) Partners in a comparable Exascale Project. As this Project develops, we expect to engage broadly with other, similar, projects. In particular, in coordination with other UM Partners, we would expect to engage with ESiWACE2 in some of the following ways:

- Participation ESiWACE2 annual meetings
- Supporting ESiWACE2 in disseminating results in our institution
- Contributing to ESiWACE2 workshops on HPC for weather/climate modelling
- Contribution to strategic discussions on software, high-performance computing and data management developments
- Interest in support of ESiWACE2 on tools (e.g., OASIS coupler)

We are looking forward to working together with you in this exciting project!

Yours sincerely,

Tony Hirst
A/GM Science to Services Program

Peter Huszár, Deputy-head

Department of Atmospheric Physics, Faculty of Mathematics and Physics

Charles University

Prague, Czech Republic

To:

Joachim Biercamp

Coordinator of ESiWACE2

Coordinating institution: DKRZ, Hamburg

Letter of support

Dear Dr. Biercamp,

with this letter we express our enthusiastic commitment to engage in the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.

I am the deputy-head of the Deptartment of Atmospheric Physics at the Faculty of Mathematics and Physics, Charles University and I believe that many keen insights are likely to be derived from this project and will help us to understand more clearly the system requirements to support this community with future projects. Michal Belda will be a dedicated contact person from our side for EsiWACE2.

The research at our department is focusing on highly topical issues of high societal impact - the main issues include climate and climate change, modelling weather phenomena, modelling of atmospheric chemistry and air quality, turbulent flow modelling in small scale research or gravitational waves and their impact on global circulation. We participated in numerous international modelling activities and projects and contributed to model development. We are aware of the importance of both integrating weather and atmospheric chemistry modelling to form a coupled system and to increase model resolutions in order to resolve the detailed structure of meteorology and chemistry interactions, especially for areas such as Europe, where due to urbanization, landuse and emissions are highly variable. Our engagement in ESiWACE2 would therefore perfectly match our long terms perspectives in research.

In particular, we would expect to engage in some of the following ways:

- Participation ESiWACE2 annual meetings

- Supporting ESiWACE2 in disseminating results in our institution
- Contribution to strategic discussions on software, high-performance computing and data management developments
- Interest in support of ESiWACE2 on data management
- Interest in support of ESiWACE2 on model benchmarking
- Interest in links of ESiWACE2 results to other modelling activites, eg. limited area models or impact models

We are happy to provide any additional information on our commitment to the project upon your request or request of the European Commission.

We are looking forward to working together with you in this exciting and important project!

Your sincerely

Peter Huszár

Prague, March 2nd , 2018

**Deutsches Zentrum
für Luft- und Raumfahrt e.V.**

in der Helmholtz-Gemeinschaft

German Aerospace Center

DLR Institute of Atmospheric Physics Oberpfaffenhofen, Postfach 11 16, 82230 Weßling, Germany	Your reference Germany Your letter Our reference

**Dr Joachim Biercamp
Coordinator of ESiWACE2
Deutsches Klimarechenzentrum GmbH (DKRZ)
Bundesstraße 45a
20146 Hamburg
Germany**

Your correspondent	Prof. Dr. habil. Veronika Eyring
Telephone +49 8153 28-	2533
Telefax +49 8153 28-	
E-mail	veronika.eyring@dlr.de
	5 March 2018

Dear Dr Biercamp,
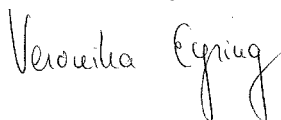
I am writing to you as chair of the Coupled Model Intercomparison Project (CMIP) Panel to confirm my strong support for the proposal ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC. Earth System modelling activities are internationally coordinated through CMIP which has characterized the evolution and progress of climate science since the World Climate Research Programme (WCRP) Working Group on Coupled Models (WGCM) organized the first CMIP phase in the mid-1990s. The objective of CMIP is to document and provide understanding of past, present and future climate variability and change through a coordinated international multi-model experiment design.

CMIP activities are international and require the broad support of the international community if they are to succeed. Overall, the CMIP5 simulations were performed by more than 40 different models or versions of models. This multi-model community ensemble has created an enormous resource and enabled a large amount of science. It is because of this international scope that CMIP initiatives have provided such critical input into the IPCC Assessment Report processes.

At this moment the climate community is actively engaged in the 6th Phase of CMIP (CMIP6) which will feed into the next round of assessments. There is now a growing number of Earth System Models (ESMs) participating in CMIP that can simulate a large range of physical and biogeochemical climate feedbacks. The growing complexity and data production of ESMs and the needs of the CMIP user community call for further infrastructure improvements supporting data services and management as well as model development and benchmarking. Ongoing support is required to maintain the existing infrastructure framework and to enhance it to meet CMIP's new demands towards production-ready coupled weather and climate models that can be deployed on European pre-exascale systems.

I will therefore work together towards a strongly cooperative exchange between your group and CMIP so that the goal of a sustained and improved infrastructure for CMIP6 and future phases can be reached.

Yours sincerely,

Veronika Eyring
(*Senior Scientist at DLR and Chair of Climate Modelling at the University of Bremen*)

THE CYPRUS INSTITUTE

RESEARCH·TECHNOLOGY·INNOVATION

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To:
Joachim Biercamp
Coordinator of ESiWACE2
Coordinating institution: DKRZ, Hamburg

Letter of support

Dear Dr. Biercamp,

With this letter we express our enthusiastic commitment to engage in the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.

I am Assistant Professor at the Cyprus Institute and I believe that many keen insights are likely to be derived from this project and will help CaSToRC Climate Modeling group understand more clearly the system requirements to support this community with future projects. I will serve as contact person from our side for ESiWACE2.

In particular, we would expect to engage in some of the following ways:
- Participation ESiWACE2 annual meetings (depending on funding availability)
- Supporting ESiWACE2 in disseminating results in our institution
- Contributing to ESiWACE2 workshops on HPC for weather/climate modelling
- Contribution to strategic discussions on software, high-performance computing and data management developments
- Interest in support of ESiWACE2 on model development (ICON)
- Interest in support of ESiWACE2 on data management
- Interest in support of ESiWACE2 on model benchmarking

We are happy to provide any additional information on our commitment to the project upon your request or request of the European Commission.

We are looking forward to working together with you in this project.

Sincerely,

T. Christoudias

Theodoros Christoudias

1 March 2018

Danish
Meteorological
Institute
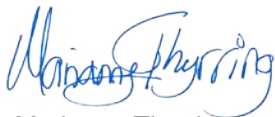
Dr. Peter Bauer
ECMWF
Shinfield Park
RG2 9AX Reading
United Kingdom

ESiWACE-2 project

Dear Peter

With this letter DMI would like to express its strong support for ESiWACE2 as a continuation of current efforts to keep Europe in the forefront of HPC technology for simulations of Weather and Climate. DMI is involved in both climate modelling and regional weather prediction and is participating in the ESCAPE project (Energy-efficient Scalable Algorithms for Weather Prediction at Exascale) and in the upcoming ESCAPE-2 project. We are therefore happy to support related activities in the European community to promote future HPC infrastructure in Europe.

Yours sincerely

Marianne Thyrring
Director General of DMI

**Danish
Meteorological
Institute**

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DANISH MINISTRY OF
CLIMATE, ENERGY AND BUILDING

Deutscher Wetterdienst - Postfach 10 04 65 - 63004 Offenbach

Dr. Joachim Biercamp
Coordinator of ESiWACE2
Coordinating institution: DKRZ
Hamburg

Abteilung Zentrale Meteorologische Fachverfahren

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UST-ID: DE221793973

Offenbach, 14. März 2018

Letter of Support

Dear Dr. Biercamp,

With this letter we express our enthusiastic commitment to engage in the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.

The German Weather Service (DWD) is of the firm opinion that many important insights will be derived from this project and will help DWD to make efficient use of the advancing progress of supercomputer performance in its operational forecast system.

Dr. Florian Prill will be the dedicated contact person from our side for ESiWACE2.

Since 2015 DWD, Germany's National Meteorological Service, has integrated the ICON grid point model into its operational numerical weather prediction (NWP) system. Being a joint development of the German Weather Service and the Max-Planck-Institute for Meteorology, ICON has become prerequisite for the provision of seamless weather and climate services, spanning global and regional applications as well as ensemble forecasts. Therefore DWD has particular interest in the objectives of ESiWACE2, which aim at keeping the ever-increasing technical complexity of the software infrastructure (e.g. I/O, parallelization) manageable.

In particular, we expect to engage in some of the following ways:

- Participation in ESiWACE2 annual meetings
- Supporting ESiWACE2 in disseminating results in our institution
- Contributing to ESiWACE2 workshops on HPC for weather/climate modelling
- Interest in support of ESiWACE2 on ICON model development, including regular feedback on the DSL work packages during the design and development process
- Interest in support of ESiWACE2 on model benchmarking

We are happy to provide any additional information on our commitment to the project upon your request or request of the European Commission.

www.dwd.de
Dienstgebäude: Frankfurter Str. 135 - 63067 Offenbach am Main, Tel. 069 / 8062 - 0
Kontoverbindung: Bundeskasse Trier - Deutsche Bundesbank, Filiale Saarbrücken - Kto-Nr.: 59001020 - BLZ: 590 000 00
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Zertifikat seit 2011
audit berufundfamilie

We are looking forward to working together with you in this exciting project!

Yours sincerely

Prof. Dr. Sarah Jones
Head of Business Area Research and Development
Member of the Executive Board

Atmospheric Sciences
University of Washington

Department of Atmospheric Sciences
Box 351640
University of Washington
Seattle, WA 98195-1640
Email: breth@washington.edu
4 March 2018

Joachim Biercamp
Coordinator, ESiWACE2
Coordinating institution: DKRZ, Hamburg

Dear Dr. Biercamp,

This is a **letter of support** expressing our commitment to engage in the ESiWACE2 project submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.

I am organizing the participation of four U. S. global cloud resolving models in the DYAMOND (DYnamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains) project, in collaboration with Prof. Dr. Bjorn Stevens of MPI-Meteorology and Prof. Masaki Satoh of U. Tokyo. DYAMOND will rely on the ESiWACE2 infrastructure for data storage and analysis. The U. S. groups are led by S.-J. Lin of the Geophysical Fluid Dynamics Laboratory in Princeton, NJ, Falko Judt of the National Center for Atmospheric Research in Boulder, CO, Marat Khairoutdinov of Stony Brook University in NY, and Bill Putnam of NASA's Goddard Space Flight Center. I can serve as a contact for ESiWACE2 for these groups.

DYAMOND will compare 40-day global weather simulations with a grid of finer than 5 km and about 75 vertical levels made by a set of models from around the world, including MPI, Japan, and the USA. Three-dimensional arrays from these very large simulations (e.g. temperature, humidity, winds) will be stored with the help of ESiWACE2 every 3 hours, with a set of two-dimensional arrays (e. g. surface rainfall) stored every ten minutes. Each model has a slightly different grid structure, yet we need to compare their results. The required data storage and analysis will be a formidable challenge at the cutting edge of atmospheric computational ambition. This project will help us decide whether global atmospheric simulations with a grid fine enough to resolve individual cumulonimbus (rain) clouds can greatly improve forecasts of rainfall and cloud distribution.

Sincerely yours,

Christopher Bretherton,
Professor, Atmospheric Science and Applied Mathematics

To:

Joachim Biercamp

Coordinator of ESiWACE2

Coordinating institution: DKRZ, Hamburg

Letter of support

Dear Dr. Biercamp,

With this letter we express our enthusiastic commitment to engage in the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.

I am Professor of Atmosphere and Ocean Research Institute, The University of Tokyo, and engaged in researches with high-resolution atmospheric modelling in Japan and I believe that many keen insights are likely to be derived from this project and will help the Japanese atmospheric modelling community understand more clearly the system requirements to support this community with future projects.

In particular, we would expect to engage in some of the following ways:

- Participation ESiWACE2 annual meetings

- Supporting ESiWACE2 in disseminating results in our institution

- Contributing to ESiWACE2 workshops on HPC for weather/climate modelling

- Contribution to strategic discussions on software, high-performance computing and data management developments

- Interest in support of ESiWACE2 on model development, e.g. ICON

- Interest in support of ESiWACE2 on tools, e.g. coupler

- Interest in support of ESiWACE2 on data management

- Interest in support of ESiWACE2 on model benchmarking

- Support for international framework for model intercomparison, e.g. DYAMOND

We are happy to provide any additional information on our commitment to the project upon your request or request of the European Commission.

We are looking forward to working together with you in this exciting project.

Your sincerely,

2. March 2018

Masaki Satoh

Professor, Atmosphere and Ocean Research Institute, The University of Tokyo

To:
Joachim Biercamp
Coordinator of ESiWACE2
Coordinating institution: DKRZ, Hamburg

Dear Dr. Biercamp,

With this letter we express our enthusiastic commitment to engage in the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.

I am the Executive Director of ESIP and I believe that many keen insights are likely to be derived from this project and will help ESIP and the Earth science informatics community at large, understand more clearly the system requirements to support this community with future projects. I, Erin Robinson, will be a dedicated contact person from our side for ESiWACE2.

The ESIP Federation is an open networked community that brings together science, data and information technology practitioners. In this forum, practitioners work together on interoperability efforts across Earth and environmental science allowing self-governed and directed groups to emerge around common issues, ebbing and flowing as the need for them arises. These efforts catalyze connections across organizations, people, systems and data allowing for improved interoperability in distributed systems. By virtue of working in the larger community, ESIP members experience the network effect, which enables more coordinated cyberinfrastructure across domain-specific communities.

In particular, we would expect to engage in some of the following ways:
- Participation ESiWACE2 annual meetings
- Supporting ESiWACE2 in disseminating results in our institution
- Contributing to ESiWACE2 workshops on HPC for weather/climate modeling
- Interest in support of ESiWACE2 on containerisation
- Interest in support of ESiWACE2 on data management

We are happy to provide any additional information on our commitment to the project upon your request or request of the European Commission.

We are looking forward to working together with you in this exciting project!

Sincerely,

Erin Robinson
Executive Director
Earth Science Information Partners

Letter of Support

Ralf Döscher
Rossby Centre/SMHI
601 76 Norrköping
ralf.doescher@smhi.se

To:
Dr Joachim Biercamp
Coordinator of EsiWACE2, Coordinating institution: DKRZ, Hamburg

March 12, 2018

Dear Dr. Biercamp,

with this letter we express our commitment to engage in the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.
As the chair of the EC-Earth SG and head of the global climate modelling unit at SMHI/Rossby Centre I believe that many key insights are likely to be derived from this project and will help EC-Earth and SMHI to better understand the system requirements to support the climate modelling community with future projects. Dr. Uwe Fladrich will be a dedicated contact person from our side for EsiWACE2.
EC-Earth aims at studying relevant climate processes and to improve climate projections and predictions. In particular, we would expect to engage in some of the following ways:

- Participation ESiWACE2 annual meetings
- Supporting ESiWACE2 in disseminating results in our institution
- Contributing to ESiWACE2 workshops on HPC for weather/climate modelling
- Contribution to strategic discussions on software, high-performance computing and data management developments
- Interest in support of ESiWACE2 on model development (EC-Earth/ IFS/ NEMO)
- Interest in support of ESiWACE2 on tools (OASIS coupler, XIOS, Cylc, Kronos)
- Interest in support of ESiWACE2 on containerisation
- Interest in support of ESiWACE2 on data management
- Interest in support of ESiWACE2 on model benchmarking

We are happy to provide any additional information on our commitment to the project upon your request or request of the European Commission.

We are looking forward to working together with you in this exciting project!

Sincerely yours,

Dr. Ralf Döscher
Chair of the Steering Committee of EC-Earth, head of globale climate modelling at Rossby Centre/SMHI

ECMWF

EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

Europäisches Zentrum für mittelfristige Wettervorhersage | Centre européen pour les prévisions météorologiques à moyen terme

Our ref: DG/18-063
Date: 27 February 2018

Direct line: +44 118 9499001
E-mail: florence.rabier@ecmwf.int

Dr Joachim Biercamp
DKRZ
Bundesstrasse 45a
20146 Hamburg
Germany

Dear Dr Biercamp

On behalf of the European Centre for Medium-Range Weather Forecasts (ECMWF) I would like to express our strong support for the ESiWACE-2 project.

ECMWF is the acknowledged world leader in medium-range weather prediction and is running complex weather analysis and forecasting suites along time-critical product delivery schedules for its 34 member and cooperating states as well as partners and commercial customers. It is expected that the associated computing and data handling tasks will reach exascale dimensions from implementing upgrades of model resolution, model complexity, observational data growth and larger ensembles in the next 5-10 years.

Already at today's scale ensuring the performance and resilience of the forecasting system as well as the timely product delivery is a major challenge. In the transition period to exascale it will thus be crucial to prepare the existing operational weather and climate prediction models for new technologies and software environments, which we can expect from the EuroHPC infrastructures. ESiWACE-2 is key for achieving this target for the weather and climate community.

This challenge goes well beyond the capabilities of single centres or national efforts and requires true international collaboration at European scale. While ECMWF is a partner in the ESiWACE-2 project proposal it represents the interests of more than a single institute, namely of most of the European Member States. Further, ECMWF coordinates a grand-scale European effort, the ExtremeEarth Flagship proposal, in response to the FETFLAG-01-2018 call for CSA. ExtremeEarth thinks even further ahead into the post-EuroHPC area aiming to address the truly grand challenge of fundamentally advancing the quality of prediction enabled by technology for the benefit of European society and economy.

This letter of support therefore goes well beyond ECMWF's involvement in the project. It reflects the support of ECMWF's mission to advance the capabilities of its Member States, and to realize the grand vision of addressing fundamental socio-economic challenges in a changing world by a concerted European effort with research projects, a centre of excellence and the ambitious Flagship programme.

Yours sincerely

Dr Florence Rabier
Director-General

FINNISH METEOROLOGICAL INSTITUTE

Dr. Peter Bauer
Deputy Director
Research Department
European Centre for Medium-Range Weather Forecasts
Shinfield Park, Reading RG2 9AX, UK

2 March 2018

Subject: Letter of Support

Dear Dr. Peter Bauer

With this letter, the Finnish Meteorological Institute (FMI) wishes to express its strong support for the project ESiWACE-2. The project follows in the footsteps of the ESiWACE project. It will be an important step towards supporting weather and climate centres in Europe to cope with future High Performance Computer, HPC infrastructures provided by the EuroHPC effort.

Yours Sincerely,

Prof. Juhani Damski

Director General

**Royal Netherlands
Meteorological Institute
Ministry of Infrastructure
and Water Management**

> Return address PO Box 201 3730 AE De Bilt

To: Dr. Joachim Biercamp, Coordinator of the ESiWACE-2 project

KNMI

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Contact

Date   March 7, 2018
Subject   Letter of Support for the ESiWACE-2 project

**Our reference
KNMI-2018/572**

Your reference

Enclosure(s)

Dear Dr Biercamp,

I am writing this letter to express my support for the proposed ESiWACE-2 project. As Director General of the Netherlands' public weather service, I attach great value to the realization of this project. Let me explain why.
As national weather service, KNMI makes use of the best weather and climate models to inform Dutch society about the changes in the weather, climate and related subject. KNMI has a particular interest in early warning concepts, as climate change leads to extreme weather events that occur more frequently than in the past. Good forecasts of hazardous weather and solid scenarios of the climate in a given region or country are essential to save life and property. Predictions of extreme weather events rely on very advanced numerical models. The skill of these models to predict extremes is limited by computing capabilities. The development of applications for novel digital infrastructures is therefore essential to KNMI, and the future development of the services my institute intends to deliver to society.
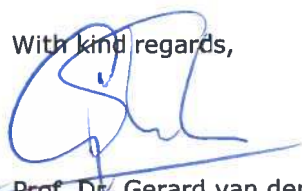
The ESIWACE2 Center of Excellence proposal addresses these issues with an excellent group of research partners. Many of these groups are closely related to KNMI, in particular ECMWF. They will pave the way towards new exascale computing platforms. Projects like ESIWACE2 will make a crucial link between the scientific and computing needs of KNMI and the European Commissions' ambitions towards exascale computing. This will be essential to further develop reliable and trustworthy meteorological and climate services by KNMI.

More explicitly, the biggest value of ESiWACE2 is to be found in the preparation and porting of Europe's leading forecast models (IFS, ICON - ideally coupled with ocean models) at high resolution onto the upcoming HPC systems that EuroHPC will provide. In contrast to the ExtremeEarth project, this will be done with the existing codes and rather minor adaptations. The project also invests in selected novel developments (like DSL) that complement similar efforts in ESCAPE-1&2 and those performed at MeteoSwiss and the UK Met Office. Another large investment is in new work flows for dealing with large model output volumes.

It is for these reasons that I would like to express my strong support for the approval of the ESiWACE-2 project. The realization of this project will not only be beneficial for a national weather service like KNMI in the Netherlands, but for all European weather services. It will lead to a safer and more resilient Europe in times of climate change.

If further contacts between the future ESiWACE-2 consortium and KNMI need to be established please liaise with prof. dr. Bart van den Hurk, who is heading the weather and climate modeling department of KNMI.

With kind regards,

Prof. Dr. Gerard van der Steenhoven
Director General KNMI, The Netherlands and Faculty of Geo-Information
Science and Earth Observation (ITC), University of Twente

Météo-France, Direction of Research

42 avenue G. Coriolis

31057 Toulouse cedex

France

To:

Joachim Biercamp

Coordinator of ESiWACE2

Coordinating institution: DKRZ, Hamburg

Letter of support

Dear Dr. Biercamp,

with this letter we express our enthusiastic commitment to engage in the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.

I am the Director of Météo-France Research and I believe that many keen insights are likely to be derived from this project and will help Météo-France understand more clearly the system requirements to support this community with future projects. Dr. Ludovic Auger, head of the numerical section in the NWP research group, could be a dedicated contact person from our side for ESiWACE2.

This section is in charge of the evolution of the current operational dynamical core, a fully compressible version of the currently hydrostatic IFS core. It is also in charge of the technical environment within which Météo-France NWP systems are run and it is heavily involved in the Météo-France high performance computer procurement. Current research trends are to try to improve the current algorithm by performing most or all computations in grid-point space. In particular, a new horizontal scheme that keeps the current computational grids, in particular with the spherical geometry is being developed. Other areas of research are semi-implicit solvers, HEVI schemes for mass-based vertical coordinates as well as using the quasi-elastic equation set as an alternative to the fully compressibleone. The section has also developed the current IO server used in IFS (as well as our own models), post-processing and geometry changing software, etc.

In particular, we would expect to engage in some of the following ways:

- Participation ESiWACE2 annual meetings
- Supporting ESiWACE2 in disseminating results in our institution

- Contributing to ESiWACE2 workshops on HPC for weather/climate modelling
- INCLUDE OR DELETE Interest in support of ESiWACE2 on model benchmarking

We are happy to provide any additional information on our commitment to the project upon your request or request of the European Commission.

We are looking forward to working together with you in this exciting project!

Your sincerely

Toulouse, March 7th, 2018

Météo-France,
Director of Research

Marc Pontaud

MESSy Consortium
Münchner Strasse 20
82234 Weßling
Patrick Jöckel (speaker of the consortium)

Phone: +49-(0)-8153 282565
Fax: +49-(0)-8153 281841
E-mail: Patrick.Joeckel@dlr.de

To:
Joachim Biercamp
Coordinator of ESiWACE2
Coordinating institution: DKRZ, Hamburg

Letter of support

Dear Dr. Biercamp,

with this letter we express our enthusiastic commitment to engage in the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.

I am the speaker of the MESSy Consortium (see http://www.messy-interface.org) and I believe that many keen insights are likely to be derived from this project and will help our consortium to understand more clearly the system requirements to support this community with future projects. I myself will be a dedicated contact person from our side for ESiWACE2.

The MESSy Consortium (http://www.messy-interface.org) comprises currently 19 research institutions and universities and aims at integrating the by now distributed knowledge and methodologies of the earth system science and climate research communities into a joint Earth System Model of flexible complexity, which combines a global and a limited area model two-way nested into the global model coupled to an ocean model, different algorithmic approaches and various alternative process formulations. By this, the MESSy Consortium builds up and applies a continuously growing, comprehensive but consistent chemistry-climate model system enabling numerical modelling of different atmospheric processes over different scales and considering all atmospheric layers from the troposphere up to the thermosphere. To achieve this goal, the MESSy Consortium makes use of the MESSy infrastructure.

ESiWACE2 appears to be a suitable platform to continuously further develop and improve our model infrastructure.
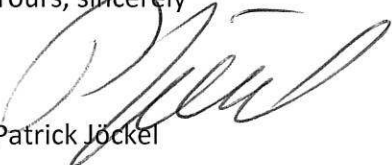
In particular, we would expect to engage in some of the following ways:

- Participation ESiWACE2 annual meetings
- Supporting ESiWACE2 in disseminating results in our consortium
- Contributing to ESiWACE2 workshops on HPC for weather/climate and atmospheric chemistry modelling
- Contribution to strategic discussions on software, high-performance computing and data management developments
- Consultancy for ESiWACE2 in the field of HPC challenges, which are specific for atmospheric chemistry and aerosol modelling, i.e. "chemistry integrated systems"
- Interest in support of ESiWACE2 on model development (e.g., IFS and ICON)
- Interest in support of ESiWACE2 on tools (e.g., OASIS coupler, XIOS)
- Interest in support of ESiWACE2 on model benchmarking

We are happy to provide any additional information on our commitment to the project upon your request or request of the European Commission.

We are looking forward to working together with you in this exciting project!

Yours, sincerely

Patrick Jöckel   Oberpfaffenhofen, March 13, 2018

National Centre for Atmospheric Science

School of Earth and Environment
University of Leeds
Leeds LS2 9JT

Telephone (0113) 3435158/6408
Email s.d.mobbs@ncas.ac.uk
http://www.ncas.ac.uk

Professor Stephen Mobbs
Director

20 March 2018

Dr Joachim Biercamp
Coordinator: ESiWACE2
DKRZ, Hamburg

Dear Dr Biercamp,

ESiWACE2

I write to express the enthusiastic commitment of the UK National Centre for Atmospheric Science (NCAS) to engage in the project ESiWACE2 to be submitted to the EC under the call INFRAEDI-02-2018: HPC PPP – Centres of Excellence on HPC. NCAS has very active research programmes on
- the science of climate change, including modelling and predictions;
- atmospheric composition, including air quality;
- weather, including hazardous weather, and
- technologies for observing and modelling the atmosphere.

We also provide scientific facilities, including computer models and facilities for managing data.

We have recognised exascale software and computing issues as significant targets for investment within our long-term science programme. This work will complement that planned within ESiWACE. In doing so, we expect some of our activities will be aligned with ESiWACE2 in order to maximise our research investments. This will be aided by the fact that our Director of Models and Data, Professor Lawrence, is leading ESiWACE2 work package 4. He will be combining both the NCAS investments and the intended commitment by the European Commission in order to meet our joint goals.
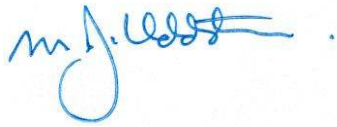
In particular, we would expect to engage by:
- participation ESiWACE2 annual meetings,
- supporting ESiWACE2 in disseminating results,
- contributing to ESiWACE2 workshops on HPC for weather/climate modelling,
- co-funding of some activities at our base within the University of Reading, and
- contributing to ESiWACE2 workshops on HPC for weather/climate modelling

I would be happy to provide any additional information on our commitment to the project upon your request or that of the European Commission.

NCAS is looking forward to working together with you in this exciting project and I wish your application every success.

Yours sincerely,

Professor Stephen Mobbs
NCAS Director

To:

Joachim Biercamp

Coordinator of ESiWACE2

Coordinating institution: DKRZ, Hamburg

Letter of support

Dear Dr. Biercamp,

With this letter we express our enthusiastic commitment to engage in the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.

I am the National eScience Infrastructure (NZ) HPC Platforms Manager, and NIWA Programme Leader for the Multi-Hazards Forecasting System research programme, and I believe that many keen insights are likely to be derived from this project and will help NIWA understand more clearly the system requirements to support this community with future projects. Hilary Oliver will be a dedicated contact person from our side for ESiWACE2.

NIWA is a core partner in the Unified Model Consortium and is actively engaged in meteorological research, weather and environmental forecasting, climate research, and earth system modelling. The Cylc Workflow Engine (which enjoyed some support from ESiWACE1) originated at NIWA and we continue to lead its ongoing development. NIWA also has recent experience in creating self-contained full-workflow HPC benchmark packages that may be of interest to ESiWACE2 partners.

In particular, we would expect to engage in some of the following ways:

- Participation ESiWACE2 annual meetings
- Supporting ESiWACE2 in disseminating results in our institution
- Contributing to ESiWACE2 workshops on HPC for weather/climate modelling
- Contribution to strategic discussions on software, high-performance computing and data management developments
- Interest in support of ESiWACE2 on DSLs
- Interest in support of ESiWACE2 on tools (OASIS coupler, XIOS, Cylc, Kronos)
- Interest in support of ESiWACE2 on model benchmarking

We are happy to provide any additional information on our commitment to the project upon your request or request of the European Commission.

We are looking forward to working together with you in this exciting project!

Your sincerely

Michael Uddstrom

Principal Scientist, Environmental Forecasting
National Institute of Water and Atmospheric Research
301 Evans Bay Parade
Greta Point
Wellington 6021
New Zealand

Letter of support , **ESiWACE 2**

Dear Dr. Biercamp,

with this letter we express our enthusiastic commitment to engage in the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding. Dr. Øyvind Seland will be the contact person from our side for ESiWACE2.

The project is of significant interest to the Norwegian Earth system modelling community, in which the Norwegian Meteorological Institute is a core partner. The topics as addressed by the proposal are of key relevance also to the NorESM (Norwegian Earth System Model) which we maintain and further develop together with several other institutions.

Should the proposal be funded, we would be interested in participating in the project activities depending on resources available and direction of future model development Examples for such activities are

- Contributing to ESiWACE2 workshops on HPC for climate modelling
- Contribution to strategic discussions on software, high-performance computing and data management developments
- Interest in support of ESiWACE2 of Cylc.
- Interest in support of ESiWACE2 on model benchmarking
- Interest in support on how to obtain and utilize resources on shared European HPC resources

Yours sincerely

Lars-Anders Breivik
Director of Research

Oslo 26. February 2018

Professor Angela Hatton
Director of Science and Technology
National Oceanography Centre
European Way, Southampton
SO14 3ZH
United Kingdom
Tel +44 (0) 23 8059 6017

Prof. Joachim Biercamp
Coordinator of ESiWACE2
DKRZ, Hamburg

Letter of support

Dear Dr. Biercamp,

I would like to express our support for the ESiWACE2 project submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.

I am the Director of the Science and Technology Directorate at the National Oceanography Centre (NOC) and the project will strongly benefit the objectives of our centre and in particular of our modelling group as described further below. Professor Adrian New will be a dedicated contact person from our side for ESiWACE2.

ESiWACE2 will build on ESiWACE1 as a centre of excellence for the simulation of weather and climate in Europe, and will further develop high resolution demonstrator simulations towards production-ready coupled atmosphere-ocean weather and climate models that can be deployed on the recently announced pre-exascale High Performance Computing (HPC) systems in Europe, and on the longer term exascale systems (which will include cloud resolving and eddy resolving ocean-atmosphere models). The Marine Systems Modelling (MSM) group at NOC are experts in high resolution ocean modelling with the NEMO ocean model and are now (through a close partnership with the UK Met Office and other NERC centres in the UK) building, running, and analysing our own high resolution climate models. The direction of travel planned for ESiWACE therefore strongly complements the interests of the MSM group, will enhance their abilities in this regard, and lead to a deeper understanding of climate system dynamics and mechanisms. The NOC are already partners in the funded H2020 PRIMAVERA project (high resolution climate modelling), in the recently submitted H2020 proposal IMMERSE (to build the next generation of the NEMO ocean model), and are associated with the Extreme Earth project (for next generation climate modelling at the exascale). Our interests are therefore closely aligned with those of ESiWACE.

We would expect to engage in the following ways:

- Participation in ESiWACE2 annual meetings
- Supporting ESiWACE2 in disseminating results in our institution
- Contributing to ESiWACE2 workshops for weather/climate modelling
- Supporting ESiWACE2 in terms of model development (climate and earth system models including the NEMO ocean component).

I am happy to provide any additional information on our interest in the project upon your request or the request of the European Commission.

We look forward to working together with you on this exciting project.

Yours sincerely

Angela Hatton

Dr Joachim Biercamp
Deutsches Klimarechenzentrum
20146
Germany

02 March 2018

Dear Dr Biercamp

I am writing in strong support of the ESiWACE-2 proposal led by the German DKRZ.

As I write these words, Europe is in the grip of a cold blast of air from the East. At the same time the Arctic and other neighbouring parts of the world are experiencing unprecedented warmth. Is this a signal of things to come, national media are asking, as part of human-induced climate change?

We cannot presently answer this question with any confidence. The redistribution of temperature is associated with a large-scale blocking anticyclone. However, despite being large in scale, this circulation pattern is maintained over periods of days and weeks by small-scale processes that the current generation of climate models only poorly resolve. As a result, the current generation of models do not simulate long-lived blocking anticyclones accurately.

As a result, there is a strong desire from the climate community to develop a new generation of climate models with 1km horizontal grid. With such models, we will be able to eliminate a number of semi-empirical parametrisations which limit the accuracy of current generation climate models. We expect to be able to simulate blocking anticylones accurately with this new generation of climate model. However, even with the expected development in supercomputer hardware, it will be impossible to run such 1km models in ensemble mode and over sufficiently many years to generate statistically reliable results, without dramatically improving the efficiency of the software that encodes the laws of physics in these models.

More generally, to allow society become more resilient to changes in climate we need higher resolution models. But in order to make this a reality, we need much greater software efficiency and productivity than is currently possible. Without these improvements in efficiency, we will not be able to run high-resolution models effectively on next-generation (exascale) computer hardware e.g. as provided by the EuroHPC effort. This is what ESiWACE-2 will deliver. It is therefore an absolutely vital part of a much larger programme of work in climate modelling to benefit European business and society.

Yours faithfully

T.N.Palmer
Royal Society Research Professor, University of Oxford.
Professorial Fellow, Jesus College, Oxford

Princeton University

Princeton University
NOAA/GFDL
201 Forrestal Road
Princeton NJ 08540
USA

9 March 2018

To: Joachim Biercamp
Coordinator of ESiWACE2
Coordinating institution: DKRZ, Hamburg

Dear Dr. Biercamp,

I am writing to express my enthusiastic commitment to engage in the project **ESiWACE2** submitted to the EC under the call *INFRAEDI-02- 2018: HPC PPP - Centres of Excellence on HPC*, should the project be selected for funding.

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. I have served on National Academies panels providing modeling expertise in fields other than my own, and serve on Scientific Advisory Boards to diverse institutions, including US National labs and overseas research institutions. Here is my homepage: https://www.gfdl.noaa.gov/v-balaji-homepage/.

Here at NOAA/GFDL and Princeton University, we are undertaking work along similar lines. ESiWACE1 partners at ECMWF and NOAA/GFDL have previously collaborated on common scientific and performance benchmarks under the NGGPS Phase I and NGGPS Phase II efforts to define the US's Next Generation Global Prediction System.

Should ESiWACE2 be funded, which would be of great benefit to the entire community, Princeton University and NOAA/GFDL would like to continue common efforts to refine and contribute results to a set of common scientific and performance benchmarks for exascale-class weather and climate prediction models. We would also be willing serve on common steering committees or scientific advisory bodies, if requested. We have been in regular attendance at workshops organized by ESiWACE1 and will continue to do so. We look forward to being in touch with you at the commencement of your project.

1

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

March 7, 2018

Dr. Joachim Biercamp
Coordinator of ESiWACE

Letter of Commitment

Dear Dr. Biercamp,

with this letter we express our enthusiastic commitment to engage in the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.

I am the lead professor for our environmental informatics application theme and I believe that many keen insights are likely to be derived from this project and will help Rensselaer Polytechnic Institute understand more clearly the system requirements to support this community with future projects. Prof. Peter Fox will be the dedicated contact person from our side for ESiWACE2.

The Tetherless World Constellation (TWC) at Rensselaer Polytechnic Institute (RPI) is a constellation of multidisciplinary researchers who study the scientific and engineering principles that underlie the Web, to enhance the Web's reach beyond the desktop and laptop computer, and develops new technologies and languages that expand the capabilities of the Web under three research themes: Future Web, Xinformatics and Semantic Foundations; and three application themes: Environmental Informatics, Government Data and Health Care and Life Sciences. Our specific interest in ESIWACE surrounds our long-standing efforts in climate and environmental informatics applications and a long-standing involvement with the Earth System Grid Federation, and attention to the U.S. Global Change Information System that provides access to the 3rd and 4th U.S. National Climate Assessments, and the Marine Biodiversity Virtual Laboratory.

In particular, we would expect to engage in some of the following ways:
- Participation ESiWACE2 annual meetings
- Supporting ESiWACE2 in disseminating results in our institution
- Contributing to ESiWACE2 workshops on HPC for weather/climate modelling
- Contribution to strategic discussions on software, high-performance computing and data management developments
- Interest in support of ESiWACE2 on tools (OASIS coupler, XIOS, Cylc, Kronos)
- Interest in support of ESiWACE2 on containerisation
- Interest in support of ESiWACE2 on data management
- TWC has extensive experience in provenance and explanation systems, as well as providing the traceable accounts for the U.S. National Climate Assessment. As such, we are very willing to share experience and provide development expertise for members of ESiWACE2.

Tetherless World Constellation, Rensselaer Polytechnic Institute
110 8th Street, Troy, NY 12180-3590 | Winslow
Email: pfox@cs.rpi.edu, foxp@rpi.edu, Phone (518) 276-4862 | Fax (518) 276-4464 tw.rpi.edu/web/Person/PeterFox

We are happy to provide any additional information on our commitment to the project upon your request or request of the European Commission.

We are looking forward to working together with you in this exciting project!

Science Advisory Board:
- Professor Peter Fox declares his availability to act as member of the scientific advisory board of ESiWACE. In this capacity he would bring expertise in the field(s) of ocean and environmental informatics, computational and computer science, and semantic data frameworks to the project. More details on Dr. Fox are available at: http://tw.rpi.edu/web/person/PeterFox.

Sincerely,

Peter A. Fox
Professor of Earth and Environmental Science,
 Computer Science and Cognitive Science
Tetherless World Constellation Chair
Director, IT and Web Science Program

UCL Université catholique de Louvain

UCL
Université
catholique
de Louvain

Earth and Life Institute

Georges Lemaître Centre for Earth and
Climate Research

Université catholique de Louvain (UCL)
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Fax: +32-474722
E-mail: thierry.fichefet@uclouvain.be

To
Dr. Joachim Biercamp
Coordinator of ESiWACE-2
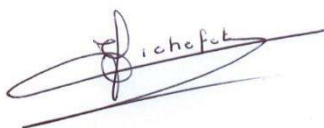
Letter in support of ESiWACE-2

Dear Dr. Biercamp,

Weather and climate models lead to predictions and services that provide significant and wide-ranging
benefit to society from the protection of life and property through to strategic infrastructure planning and
policy development. A recent set of case studies shows that weather and climate modelling on HPC
systems lead to a 20 times return on investment. That is approximately £2 Billion present value over 5
years in the areas of civil aviation, renewable energy, food production, flooding, and travel and the
benefits of climate policy. This was based on a subset of possible case studies in the UK alone, so the real
figure in Europe will be significantly higher.

Exascale systems will give us the opportunity to run models at higher resolution that also incorporate
more of the physical processes that impact our weather and climate, in particular through coupling of the
atmosphere with the ocean and sea ice. Further, we will be able to run more ensemble members and this
will allow us to provide probabilistic predictions and to better represent inherent uncertainties due to
imperfect observations of initial conditions and the inherent chaotic nature of weather.

Hence, the adaptation of our models to exascale HPC systems is a fundamental requirement for ensuring
Europe stays at the cutting-edge of weather and climate prediction. It is increasingly important that such
systems are developed in partnership with the developers of applications that will use them, in a co-
design process. To be successful, such a process has to be wider than a single application domain, such as
our community. ESiWACE already achieved great progress in supporting the scalability of weather and
climate models, and it will need ESiWACE-2 to make the step towards the exascale for the European
community.

Sincerely yours,

Prof. Thierry Fichefet

World Climate Research Programme
c/o World Meteorological Organization
7 bis, avenue de la Paix – Case postale N° 2300
CH-1211 Geneva 2 – Switzerland

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wcrp@wmo.int

Ref.: 08314/2018- L3 RES-WCRP

Our ref.:   08314/2018-Modelling/WCRP/RES

Dr Joachim Biercamp
Coordinator of ESiWACE2
Abteilungsleiter Anwendungen
Department Head Applications
Deutsches Klimarechenzentrum GmbH (DKRZ)
Bundesstraße 45 a
D-20146 Hamburg
Germany

Geneva, 21 March 2018

Dear Dr Biercamp,

On behalf of the World Climate Research Programme (WCRP), I express my strong support to the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.

The World Climate Research Programme (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 state of the Earth's climate in response to various forcing factors, including human activities.

This proposal is addressing key challenges at the heart of the Earth System modelling enterprise. Exascale computing is required to bring weather and climate simulations into a new era. In particular, it is expected that cloud resolving models will significantly improve prediction skill and will also advance our fundamental understanding of climate sensitivity.

The focus of this proposal is very well aligned with the new WCRP strategy, currently in development and is nicely complementing other crucial EU projects on innovation for exascale computing (EuroEXA), next-generation IO concepts (NEXTGenIO) and new mathematical concepts (ESCAPE-2).

We will therefore be extremely happy to engage actively in ESiWACE2 activities and help disseminating results in our networks.

Dr Michel Rixen will be our contact person from WCRP for ESiWACE2.

We look forward to working together with you on this exciting project.

Your sincerely

(Deon Terblanche)
Acting Director
WCRP Joint Planning Staff

Our ref.:   RES/ARE/WWR   Geneva, 9 March 2018

Subject: Support letter for "Excellence in Simulation of Weather and Climate in Europe"
(ESiWaCE2)

Dear Dr Biercamp,

It is my pleasure writing a letter in support of the proposal for "Excellence in Simulation of Weather and Climate in Europe" (ESiWaCE2) proposed by the DKRZ. If implemented, the research done through this project will provide valuable contribution to the World Weather Research Programme (WWRP) of the World Meteorological Organization (WMO).

ESiWaCE2 is expected to make unique and defining contributions to the Global Framework for Climate Services in further developing the infrastructure to support Earth System modelling for the benefit of both weather and climate communities in Europe, leveraging two well established entities, namely the European Network for Earth System modelling (ENES) and the European Centre for Medium-Range Weather Forecasts (ECMWF) together with a well-selected set of partner organizations, thereby ensuring the development of an end-to-end workflow from HPC infrastructures to Copernicus services for atmospheric monitoring (CAMS) and climate change (CCCS).

Joint training activities and workshops proposed by ESiWaCE will ensure the widest visibility of Europe's investment in the critical field, the congruence of global and European governance regarding Earth System Modelling initiatives, and the global exposure of ESiWaCE outcomes to both weather and climate communities.

WWRP, working in partnership with other international initiatives, will ensure that the outcomes of this project will feedback into the implementation of WMO research strategy towards the seamless prediction of the Earth system from minutes to months.

In conclusion, I fully support the proposal, and I am looking forward to the contribution of this program to the activities of WWRP.

Yours faithfully,

P. Ruti
World Weather Research Programme
Research Department

CINECA

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www.cineca.it

Codice Fiscale
00317740371

Partita IVA
00502591209

Registro delle imprese
C.C.I.A.A di Bologna
n. 00317740371

Dr. Joachim Biercamp
Coordinator of ESiWACE2
DKRZ, Hamburg

Casalecchio di Reno, 8 March, 2017

Letter of Support the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence

Dear Dr. Biercamp,

I am writing in my capacity as the Director of the SuperComputing Applications and Innovation (SCAI) Department of CINECA, to express my strongest support for the proposed proposal ESiWACE.

CINECA is the largest Italian computing center, one of the world-class supercomputing infrastructures in Europe. My department, SCAI, provides high performance computing resources, data processing and large volume storage systems, tools and HPC services, and expertise at large, aiming to develop and promote technical and scientific services related to high-performance computing for the Italian and European research community.

I believe that many keen insights are likely to be derived from this project and will help CINECA and its research ecosystem to understand more clearly the system requirements to support the meteo climate and environment community with future projects. Dr. Piero Lanucara will be a dedicated contact person from our side for ESiWACE2.

CINECA has a long tradition in supporting the weather and climate community acting also as operational center for weather forecast for Italian Civic Protection and involved in many Copernicus projects.

In particular, we would expect to engage in some of the following topics:

- Participation ESiWACE2 annual meetings
- Supporting ESiWACE2 in disseminating results in our institution
- Contributing to ESiWACE2 workshops on HPC for weather/climate modeling
- Contribution to strategic discussions on software, high-performance computing and data management developments
- Interest in support of ESiWACE2 on containerization and data management.
- Interest in support of ESiWACE2 on data management
- Interest in support of ESiWACE2 on model benchmarking

We are interested to provide any additional information on our commitment to the project upon your request or request form the European Commission.

I therefore strongly support the upgrade of ESiWACE as a CoE and look forward to future collaborations and clustering partnership between DKRZ and CINECA.

Therefore, as the Director of SCAI at CINECA, I very much welcome and strongly support this timing proposal for the reinforcing of a Center of Excellence in weather and climate simulation.

Yours Faithfully.

Director of SuperComputing Applications
and Innovation Department - CINECA

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Dr Joachim Biercamp
Project Coordinator for ESiWACE2
Deutsches Klima Rechenzentrum
Bundesstraße 45a
D-20146 Hamburg

Tuesday, 06 March 2018

Dear Dr Biercamp,

I am the Director of **EPCC, the supercomputing centre at the University of Edinburgh**, and I would hereby like to express our full commitment to engage with the project ESiWACE2, submitted to the EC under the call *INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC*, should it be selected for funding.

ESiWACE2 will be addressing the Exascale computing and data challenges faced by the European weather and climate community. As one of the leading European supercomputing centres, EPCC will support the project by offering its expertise in HPC and data science. **Dr Michèle Weiland** will represent EPCC on the **Scientific Advisory Board** for ESiWACE2.

EPCC is deeply involved in Exascale research and led the CRESTA project, which laid the groundwork for further research around programming models, energy efficiency, as well as storage and I/O. EPCC believes that the community served by ESiWACE2 has a particularly strong need for Exascale computing capabilities and is keen to provide expertise wherever possible to help with the transition.

In addition to our engagement via the Scientific Advisory Board, EPCC will:

- Participate in all ESiWACE2 annual meetings, and contributing to ESiWACE2 workshops on HPC for weather/climate modelling;

- Contribute to strategic discussions on software, high-performance computing and data management developments

- Offer ESiWACE2 early and privileged access to the cutting edge **NEXTGenIO hardware prototype**, allowing project partners to evaluate the impact of non-volatile memory of weather and climate workloads.

We are happy to provide any additional information on our commitment to the project upon your request or request of the European Commission.

We are looking forward to working together with you in this important and exciting project.

Your sincerely

Professor Mark Parsons,
EPCC Director

Institute for Advanced Simulation
JSC: Jülich Supercomputing Centre
Direktor des Instituts:
Prof. Dr. Dr. Thomas Lippert

Forschungszentrum Jülich GmbH · JSC · 52425 Jülich

Dr. Joachim Biercamp
Coordinator of ESiWACE2
Coordinating institution: DKRZ, Hamburg

Ihr Zeichen:
Ihre Nachricht vom:
Unser Zeichen:
Unsere Nachricht vom:

Ansprechpartner: Prof. Thomas Lippert
Organisationseinheit: JSC

Telefon: 02461 61-6402
Telefax: 02461 61-6656

E-Mail: th.lippert@fz-juelich.de

Jülich, 5 January 2018

Letter of support

Dear Dr. Biercamp,

With this letter we express our strong commitment to engage in the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, given the project will be selected for funding.

As head of the Jülich Supercomputing Centre (JSC), I believe that many keen insights are likely to be derived from this project and will help JSC understand more clearly the system requirements to support this community with future projects. Dr. Lars Hoffmann, team leader of the Simulation Laboratory 'Climate Science' at JSC, will be a dedicated contact person from our side for ESiWACE2.

The Jülich Supercomputing Centre operates supercomputers of the highest performance class. We enable scientists and engineers to solve highly complex problems by simulations. Supporting climate simulations at extreme scale is a key element of JSC's research portfolio. Recent joint efforts, e.g., within the German research initiative 'High Definition Clouds and Precipitation for Advancing Climate Prediction – HD(CP)^{2}' ensure that we can foster our successful collaborations within ESiWACE2 and beyond.

Mitglied der Helmholtz-Gemeinschaft

50.03.001/18.01

In particular, we would expect to engage in some of the following ways:

- Participation at ESiWACE2 annual meetings
- Supporting ESiWACE2 in disseminating results in our institution
- Contributing to ESiWACE2 workshops on HPC for weather/climate modelling
- Provide access to nominal seed hardware of latest generation
- Regular roadmap updates on hardware and system software relevant to ESiWACE2
- Contribution to strategic discussions on software, HPC and data management
- Interest in support of ESiWACE2 on model benchmarking

We are happy to provide any additional information on our commitment to the project upon your request or request of the European Commission. We are looking forward to working together with you in this exciting project!

Your sincerely

Prof. Dr. Dr. Thomas Lippert

Dr. Philipp Neumann
ESiWACE 2
Abteilung Anwendungen
Department Application Support
Deutsches Klimarechenzentrum GmbH
(DKRZ)
Bundesstraße 45a
D-20146 Hamburg
GERMANY

neumann@drkz.de
biercamp@drkz.de
peter.bauer@ecmwf.int

Brussels, 12 March 2018

Subject: Letter of Support

Dear Dr. Neumann,
Dear Dr. Biercamp,
Dear Dr. Bauer,

I am writing to you in your capacity as co-ordinators of a proposal to be submitted to the **INFRAEDI-02-2018 "HPC PPP - Centres of Excellence on HPC"** call for projects.

PRACE would like to express our strong support for all project proposals under this call for new Centres of Excellence.

We are deeply convinced that the Centres of Excellence are corner stones to the development of the European HPC ecosystem, especially in the framework of the current challenge to reach exa-scale

We are looking forward to collaborate with all Centres of Excellence via:
- The dedicated share of PRACE resources under our Calls for Proposals for Projects Access.
- The soon to start EXDCI-2 project.
- The other project proposals in preparation under "coordination and support action" calls for proposals.
- Possible new and innovative avenues of co-operation and creation of synergies.

I am looking forward to hearing the – hopefully positive – result of your project application in the near future.

Yours sincerely,

Serge Bogaerts
Managing Director
Chair of the Board of Directors

PRACE | Partnership for Advanced Computing in Europe AISBL
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BE 0826 890 059

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This proposal version was submitted by **Chiara BEARZOTTI** on **22/03/2018 12:34:46** Brussels Local Time. Issued by the Participant Portal Submission Service.

arm

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09/03/2018

Department of Application Support.
German Climate Computing Centre (Deutsches Klimarechenzentrum, DKRZ),
Bundesstraße 45a
20146 Hamburg
Germany

Dear Dr. Joachim Biercamp,

Thank you for providing me with details of "ESiWACE2", a proposal to be submitted targeting the EC call: "INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC". I am very pleased to be able to write this letter of support.

Arm is the world's largest provider of semiconductor IP and is the architecture of choice for more than 90% of the smart electronic products being designed today. Arm designs and found their way into more than 17Bn devices in 2016 alone. As well as our 32 and 64-bit CPU cores, our hardware products extend to GPUs, DSP cores, cell libraries, memory compilers and system components. We also supply software tools and stacks; reference de-signs and OS ports to enable our customers to create functional systems as quickly and reliably as possible. Though we do not fabricate anything ourselves, our customers do. To maintain our value proposition, it is essential that we are aware of the developing needs from the markets and the opportunities presented by emerging technologies.

I believe that many keen insights are likely to be derived from this project and will help Arm understand more clearly the system requirements to support this community with future projects. Oliver Perks will be a dedicated contact person from our side for ESiWACE2.

The earth simulation and modelling community is very active within high performance computing, driving the technology forward in terms of both software and hardware. Arm has a key interest in the adaption of ESM applications – and the associated software stacks – to multicore architectures. By better understanding the requirements of the community Arm can improve the software offering (compilers, maths libraries and tools) in addition to leveraging our position within the community to further HPC capability.

In particular, we would expect to engage in some of the following ways:
- Participation ESiWACE2 annual meetings
- Supporting ESiWACE2 in disseminating results in our institution
- Contributing to ESiWACE2 workshops on HPC for weather/climate modelling

- Contribution to strategic discussions on software, high-performance computing and data management developments
- Interest in support of ESiWACE2 on DSLs
- Interest in support of ESiWACE2 on tools (OASIS coupler, XIOS, Cylc, Kronos)
- Interest in support of ESiWACE2 on data management
- Interest in support of ESiWACE2 on model benchmarking

We are happy to provide any additional information on our commitment to the project upon your request or request of the European Commission. We are looking forward to working together with you in this exciting project.

Yours sincerely,

3/19/18

Dr John Goodenough
VP Technology & Collaboration ARM

CRAY

Joachim Biercamp

Coordinator of ESiWACE2

Coordinating institution: DKRZ, Hamburg

Basel, 28 February 2018

Dear Dr. Biercamp,

With this letter we express our enthusiastic commitment to engage in the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.

I am the Vice-President of Business Operations EMEA and I believe that many keen insights are likely to be derived from this project and will help Cray understanding more clearly the system requirements to support this community with future projects. Adrian Tate, Director of the Cray EMEA Research Lab, will be a dedicated contact person from our side for ESiWACE2. He will be supported by Ilene Carpenter, segment lead for climate and weather modelling at Cray.

Cray considers climate and weather simulation to be one of our key segments, combining the most demanding challenges for supercomputer architectures, mathematical and parallel programming methodologies, application software engineering, data management, and analytics with operational requirements for daily production that are unmatched in other supercomputing segments.

In particular, we would expect to engage in some of the following ways:

- Participation ESiWACE2 annual meetings
- Supporting ESiWACE2 in disseminating results in our institution
- Contributing to ESiWACE2 workshops on HPC for weather/climate modelling
- Contribution to strategic discussions on software, high-performance computing and data management developments
- Interest in support of ESiWACE2 on DSLs
- Interest in support of ESiWACE2 on containerisation
- Interest in support of ESiWACE2 on data management
- Interest in support of ESiWACE2 on model benchmarking
- Interest in support of ESIWACE2 on work- and dataflow management

Dominik Ulmer, VP EMEA Business Operations
Cray Computer GmbH, Technologiepark Basel
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CRAY

We are happy to provide any additional information on our commitment to the project upon your request or request of the European Commission.

We are looking forward to working together with you in this exciting project!

Your sincerely

Dominik Ulmer

Dominik Ulmer, VP EMEA Business Operations
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+41 91 266 7080
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Dr Joachim Biercamp.
DKRZ
Bundesstraße 45a
D-20146 Hamburg
Germany

Dear Dr Biercamp,

With this letter we express our strong support for the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.

As President of Intel SAS Corporation, I believe that many interesting insights are likely to be derived from this project and will help our company understand more clearly the system requirements to support your community with future projects. Marie-Christine Sawley will be the dedicated point of contact from our side for ESiWACE2.

Intel as a leader in HPC technology is committed to develop and build Exascale HPC systems and software, and to engage with initiatives ensuring multi-disciplinarity. Therefore, we would be interested to serve as an external expert or consultant on topics such as:

- strategic discussions on software, high-performance computing and data management developments
- open source libraries of particular interest for Earth science and Weather codes
- open source tools contributing to exploit efficiently future exascale architectures, in particular for enhanced numerical accuracy, energy management and best usage of new volatile memory capacities
- characterization of application performances on Intel architectures and development of publicly available performance models of ESIWACE2 applications; Interest in guidance of ESiWACE2 on model development (EC-Earth/ IFS/ ICON/ NEMO/ DYNAMICO) on extreme scaling capabilities

We would support ESIWACE2 to facilitate the dissemination of best practices and reports, articles and events that can be made public, like for example within the IXPUG community. We would contribute to ESiWACE2 workshops on HPC for weather/climate modelling on topics of common relevance.

The terms of this Letter of Support are non- binding and do not create any legal rights or obligations. Intel will ask the project partners to enter into non-disclosure agreements before exchanging any confidential information.

We wish the ESIWACE2 consortium a great 2018 year and success in their proposal.

Sincerely yours,

Stéphane NEGRE
Président
Intel Corporation SAS (France)

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Dr. Joachim Biercamp
Coordinator of ESiWACE2
Coordinating Institution: DKRZ, Hamburg

Düsseldorf, 1. März 2018

Letter of Support

Dear Dr. Biercamp,

with this letter we express our enthusiastic commitment to engage in the project ESiWACE2 submitted to the European Commission under the call "INFRAEDI-02-2018: HPC PPP – Centres of Excellence on HPC", should the project be selected for funding.

I am the CEO of the NEC Deutschland GmbH and Vice President HPC for Europe, and I believe that many important insights would emerge from this project, which will help the NEC Corporation, Tokyo, to understand more clearly the system requirements for us to support this community for future projects by the provision of better products and better services.

Dr. Rudolf Fischer, Director Core Technology, will be the dedicated contact person from our side for ESiWACE2 and will be available to serve as a member of the Scientific Advisory Board of the project.

The HPC-division is supporting European research and business with complete HPC-solutions, and for that reason strongly depends on detailed feedback from the market to understand the requirements of high-end users. What users need, where the pain-points are, in which directions applications are heading, what the bottlenecks are and how one could resolve them, these are all necessary ingredients for NEC to shape our product- and business-strategy.

In particular, we would expect to engage in the following ways:

- Participation in the annual meetings of ESiWACE2
- Supporting ESiWACE2 in disseminating results in our institution
- Contributing to ESiWACE2 workshops on HPC for weather and climate modelling, as far as our competencies and qualifications are sufficient
- Contributing to strategic discussions on software directions, programming paradigms, high performance computing in general and data management developments

NEC

- We might be able to at least comment on the design and development of DSLs, not in terms of the scientific necessity but from the perspective of a vendor who has to develop compilers and tools to support those

Naturally our competencies are insufficient to directly support scientific aspects of the model development, but we should be able to provide feedback as far as implementation and performance aspects are concerned. That way this project is fully in line with our mission to support scientific users.

We are happy to provide any additional information regarding our commitment to the project upon your request or a request of the European Commission.

We are looking forward to working together with you in this exciting project!

Yours sincerely

Yuichi Kojima
CEO NEC Deutschland GmbH
VP HPC

Letter of Support

To:
Joachim Biercamp
Coordinator of ESiWACE2
Coordinating institution: DKRZ, Hamburg

Dear Dr. Biercamp,   27th of February 2018

With this letter NVIDIA Corporation express our enthusiastic commitment to engage in the project ESiWACE2 submitted to the EC under the call INFRAEDI-02-2018: HPC PPP - Centres of Excellence on HPC, should the project be selected for funding.
I am the Director of Business Development for HPC in EMEA, and I believe that many keen insights are likely to be derived from this project that will help NVIDIA to understand more clearly the system requirements for support of this community with future projects. Mr. Stan Posey, Program Manager for the Earth System Sciences Domain, will be a dedicated contact person from the NVIDIA side for ESiWACE2.
With the introduction of the general purpose Graphics Processing Unit (GPU) in 2004, NVIDIA set a milestone in HPC. Since then, NVIDIA expertise developed in GPU technology has led to breakthroughs in parallel computing, while also providing cost-effective solutions in HPC and artificial intelligence. NVIDIA would like to offer this expertise and other resources you may require to ensure success in ESiWACE2.

In particular, NVIDIA would expect to engage and support ESiWACE2 in some of the following ways:

- Participation in ESiWACE2 annual meetings.
- Support for ESiWACE2 in disseminating results within our organisation.
- Contribute to ESiWACE2 workshops on HPC for weather/climate modelling.
- Provide nominal seed hardware of latest generation GPUs for HPC.
- Provide technical guidance on applications engineering.
- Provide regular roadmap updates on hardware and system software relevant to ESiWACE2.
- Contribute to strategic discussions on directions for accelerated HPC.
- Support for ESiWACE2 HPC model development (EC-Earth/IFS/ICON/NEMO/DYNAMICO).
- Support for other ESiWACE2 HPC topics: DSLs, containerisation, and model benchmarking.
- Provide technical guidance on HPC implementation of relevant applications in AI.

We are happy to provide any additional information on our commitment to the project upon your request or request of the European Commission.
We are looking forward to working together with you in this exciting project!
Yours sincerely,

Stefan Kraemer
Director Business Development HPC-EMEA
Enterprise Solutions
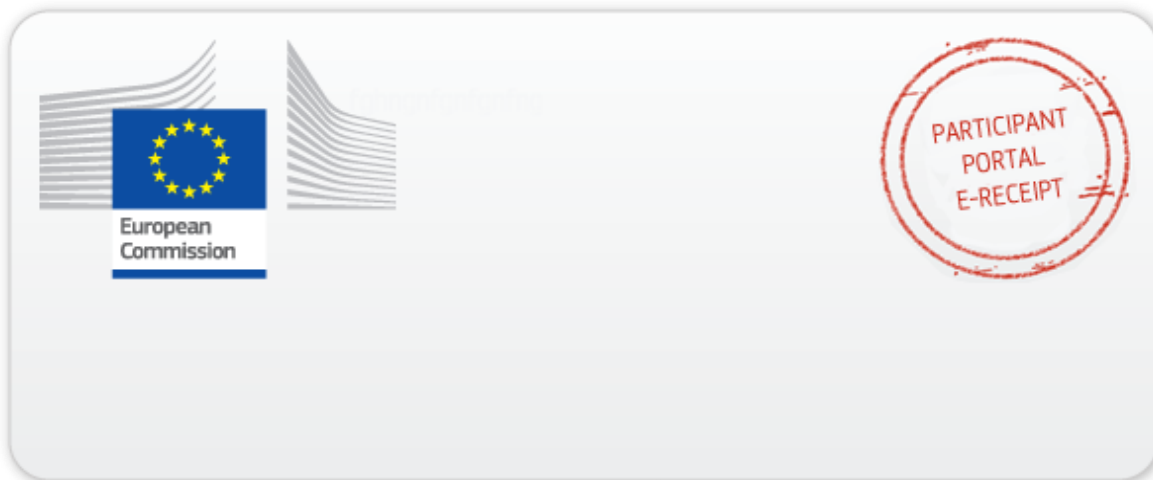**NVIDIA**
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