Please check our wiki for help on navigating the form.

Horizon 2020

Call: H2020-LC-CLA-2018-2019-2020

(Building a low-carbon, climate resilient future: climate action in support of the Paris Agreement)

Topic: LC-CLA-17-2020

Type of action: RIA

Proposal number: SEP-210645025

Proposal acronym: POLAR-CLIM

Deadline Id: H2020-LC-CLA-2020-2

Table of contents

How to fill in the forms

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

1 - General information

Topic	LC-CLA-17-2020	Type of Action	RIA
Call Identifier	H2020-LC-CLA-2018-2019-2020	Deadline Id	H2020-LC-CLA-2020-2

Acronym	POLAR-CLIM
Proposal title	PROCESS BASED UNDERSTANDING OF THE MECHANISMS DRIVING POLAR AMPLIFICATION AND ITS IMPACTS IN A CHANGING CLIMATE

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

Duration in months	*42*
Fixed keyword 1	Climatology and climate change
Fixed keyword 2	Ocean and Climate Change
Free keywords	*Polar climate, climate change, climate variability, impact, processes, sea-ice, Arctic, Antarctica, Polar Amplification, Linkages*

Abstract

In recent decades, the polar regions have undergone substantial changes, including the rapid decline of Arctic sea ice and major warming over West-Antarctica. Most of these changes can be explained by Polar Amplification (PA) – the amplification of near-surface temperature changes compared to global mean values. It is becoming increasingly clear that PA underlies key societal impacts of climate change. While our understanding of PA and its impacts has increased significantly in recent years, major knowledge gaps remain. POLAR-CLIM will quantify drivers of PA with a focus on improved understanding of the mechanisms, processes and feedbacks governing PA, taking into account possible drivers from lower latitudes. This includes determining the causes of contrasting sea ice changes in the Arctic and Antarctic. POLAR-CLIM will also go beyond changes in mean climate, by understanding changes in climate variability and extreme events in polar regions at the process level. This includes efforts to develop “pictures of the future” to make climate change more tangible to scientists and non-experts. Furthermore, POLAR-CLIM will conduct focussed investigations of major outstanding questions relating to the impact of Arctic and Antarctic climate change on the weather and climate in lower latitudes. Moreover, it will determine the sources of some long-standing systematic model errors in polar regions at the process level and provide guidance in support of future model development activities. To minimize duplication, accelerate progress and increase the scientific and societal impacts, POLAR-CLIM will establish an effective clustering programme with related initiatives. Finally, through a strong user-engagement, dissemination and communication programme, POLAR-CLIM will enable people, policy makers and businesses to make evidence-based decisions regarding adaptation and mitigation in a rapidly warming and highly connected world.

Remaining characters 54

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

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

Declarations

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

4) The coordinator confirms:

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

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

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

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

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

Personal data protection

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

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

2 - Participants & contacts

#	Participant Legal Name	Country	Action
1	ALFRED-WEGENER-INSTITUT HELMHOLTZ-ZENTRUM FUR POLAR- UND MEERESFORSCHUNG	DE	
2	UNIVERSITE CATHOLIQUE DE LOUVAIN	BE	
3	BARCELONA SUPERCOMPUTING CENTER - CENTRO NACIONAL DE SUPERCOMPUTACION	ES	
4	STOCKHOLMS UNIVERSITET	SE	
5	EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS	UK	
6	THE UNIVERSITY OF EXETER	UK	
7	SVERIGES METEOROLOGISKA OCH HYDROLOGISKA INSTITUT	SE	
8	RIJKSUNIVERSITEIT GRONINGEN	NL	
9	UNITED KINGDOM RESEARCH AND INNOVATION	UK	
10	MET OFFICE	UK	
11	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	FR	
12	STICHTING VU	NL	
13	METEOROLOGISK INSTITUTT	NO	
14	FUNDACION TECNALIA RESEARCH & INNOVATION	ES	

2 - Administrative data of participating organisations

PIC	***Legal name***
999497507	*ALFRED-WEGENER-INSTITUT HELMHOLTZ-ZENTRUM FUR POLAR- UND MEERESFORSCHUNG*

Short name: AWI

Address of the organisation

Street AM HANDELSHAFEN 12

Town BREMERHAVEN

Postcode 27570

Country Germany

Webpage www.awi.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.....31/12/2015 - no

SME self-assessment .....17/03/1986 - no

SME validation sme..... unknown

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

Department(s) carrying out the proposed work

Department 1

Department name: Climate Dynamics ☐ not applicable

☐ Same as proposing organisation's address

Street: Bussestraße 24

Town: Bremerhaven

Postcode: 27570

Country: Germany

Department 2

Department name: Atmospheric Physics ☐ not applicable

☐ Same as proposing organisation's address

Street: Telegrafenberg A43

Town: Potsdam

Postcode: 14473

Country: Germany

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

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

Title: Prof. Sex: (•) Male ( ) Female

First name: **Thomas** Last name: **Jung**

E-Mail: **thomas.jung@awi.de**

Position in org.: Professor and Head of Department

Department: Climate Dynamics ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: Bussestraße 24

Town: Bremerhaven Post code: 27570

Country: Germany

Website: www.awi.de

Phone: +49 47148311761 Phone 2: *+xxx xxxxxxxxx* Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Nancy	LANGE	nancy.lange@awi.de	*+49 47148312306*
Luisa	Cristini	luisa.cristini@awi.de	*+49 47148311681*
EU	Grants	eu-grants@awi.de	*+49 47148312306*
Gerlis	Fugmann	gerlis.fugmann@awi.de	*+49 3312882219*
Markus	Rex	markus.rex@awi.de	*+49 3312882127*
Lars	Henning	lars.henning@awi.de	*+xxx xxxxxxxxx*

PIC	***Legal name***
999980664	*UNIVERSITE CATHOLIQUE DE LOUVAIN*

Short name: UCL

Address of the organisation

Street PLACE DE L UNIVERSITE 1

Town LOUVAIN LA NEUVE

Postcode 1348

Country Belgium

Webpage www.uclouvain.be

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 .....yes

Research organisation .....yes

Legal person .....yes

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

Enterprise Data

SME self-declared status.....13/01/2009 - no

SME self-assessment ..... unknown

SME validation sme.....13/01/2009 - 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: Earth & Climate group (ELIC), Earth and Life Institute (ELI) ☐ not applicable

☐ Same as proposing organisation's address

Street: Place Louis Pasteur 3/L4.03.08

Town: Louvain-la-Neuve

Postcode: 1348

Country: Belgium

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

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

Title: Prof. Sex: (•) Male ( ) Female

First name: **François** Last name: **Massonnet**

E-Mail: **francois.massonnet@uclouvain.be**

Position in org.: Professor

Department: ELIC - ELI ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: Place Louis Pasteur 3/L4.03.08

Town: Louvain-la-Neuve Post code: 1348

Country: Belgium

Website: http://www.climate.be/u/fmasson

Phone: +32 10 47 33 04 Phone 2: +xxx xxxxxxxxx Fax: +xxx xxxxxxxxx

Other contact persons

First Name	*Last Name*	*E-mail*	*Phone*
Mahdia	Abdelouahab	mahdia.abdelouahab@uclouvain.be	*+32 10 47 24 80*

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

Short name: BSC

Address of the organisation

Street Calle Jordi Girona 31

Town BARCELONA

Postcode 08034

Country Spain

Webpage www.bsc.es

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

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

Enterprise Data

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

SME self-assessment ..... unknown

SME validation sme..... unknown

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

Department(s) carrying out the proposed work

Department 1

Department name: Earth Sciences ☐ not applicable

☐ Same as proposing organisation's address

Street: Calle Jordi Girona 29

Town: Barcelona

Postcode: 08034

Country: Spain

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

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

Title: Dr. Sex: ○ Male ◉ Female

First name: **Marta** Last name: **Terrado**

E-Mail: **marta.terrado@bsc.es**

Position in org.: Science Communication Specialist

Department: Earth Sciences ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: Calle Jordi Girona 29

Town: Barcelona Post code: 08034

Country: Spain

Website: https://www.bsc.es/

Phone: +34 934137937 Phone 2: *+xxx xxxxxxxxx* Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Dorota	Jouet	dorota.jouet@bsc.es	*+34 934 134 082*

PIC	***Legal name***
999885022	*STOCKHOLMS UNIVERSITET*

Short name: STOCKHOLMS UNIVERSITET

Address of the organisation

Street UNIVERSITETSVAGEN 10

Town STOCKHOLM

Postcode 10691

Country Sweden

Webpage www.su.se

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....yes

Research organisation .....yes

Legal person .....yes

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

Enterprise Data

SME self-declared status..... 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: Meteorology ☐ not applicable

☐ Same as proposing organisation's address

Street: Svante Arrhenius väg 16C

Town: Stockholm

Postcode: 106 91

Country: Sweden

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

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

Title: Prof. Sex: ○ Male ◉ Female

First name: **Gunilla** Last name: **Svensson**

E-Mail: **gunilla@misu.su.se**

Position in org.: Professor

Department: Meteorology ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: Svante Arrhenius väg 16C

Town: Stockholm Post code: 106 91

Country: Sweden

Website: https://www.su.se/english/profiles/gsven-1.182452

Phone: +468164337 Phone 2: +4670255471 Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Albert	de Haahn	adh@misu.su.se	*+468164331*

PIC	***Legal name***
999916741	*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***	

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: **Irina** | Last name: **Sandu**

E-Mail: **irina.sandu@ecmwf.int**

Position in org.: Team Leader Physical Processes

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: www.ecmwf.int

Phone: +441189499730 | Phone 2: *+xxx xxxxxxxxx* | Fax: +44 118 986 9450

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Daniel	Thiemert	daniel.thiemert@ecmwf.int	*+441189499024*

PIC	***Legal name***
999864555	*THE UNIVERSITY OF EXETER*

Short name: UNEXE

Address of the organisation

Street THE QUEEN'S DRIVE NORTHCOTE HOUSE

Town EXETER

Postcode EX4 4QJ

Country United Kingdom

Webpage www.ex.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.....06/08/2014 - 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: Mathematics ☐ not applicable

☐ Same as proposing organisation's address

Street: Laver Building, North Park Road

Town: Exeter

Postcode: EX4 4QE

Country: United Kingdom

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

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

Title: Prof. Sex: (•) Male ( ) Female

First name: **James** Last name: **Screen**

E-Mail: **j.screen@exeter.ac.uk**

Position in org.: Associate Professor in Climate Science

Department: Mathematics ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: 920 Laver Building, North Park Road

Town: Exeter Post code: EX4 4QE

Country: United Kingdom

Website: http://emps.exeter.ac.uk/mathematics/staff/js546

Phone: +44 1392 726408 Phone 2: *+xxx xxxxxxxxx* Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Cathy	Potter	euresearch@exeter.ac.uk	*+44 (0) 1392 7266*

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

Short name: SMHI

Address of the organisation

Street Folkborgsvaegen 1

Town NORRKOEPING

Postcode 601 76

Country Sweden

Webpage www.smhi.se

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....no

Legal person .....yes

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

Enterprise Data

SME self-declared status..... unknown

SME self-assessment ..... unknown

SME validation sme..... unknown

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

Department(s) carrying out the proposed work

Department 1

Department name: Rossby Centre ☐ not applicable

☐ Same as proposing organisation's address

Street: N/A

Town: Norrköping

Postcode: 60167

Country: Sweden

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

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

Title: Dr.

Sex: (•) Male ( ) Female

First name: **Ralf**

Last name: **Doescher**

E-Mail: **ralf.doescher@smhi.se**

Position in org.: Head of Rossby Centre

Department: Rossby Centre, Research Department

☐ Same as organisation name

☐ Same as proposing organisation's address

Street: N/A

Town: Norrköping

Post code: 60167

Country: Sweden

Website: www.smhi.se

Phone: +46114958583

Phone 2: +46114958000

Fax: *+xxx xxxxxxxxx*

Other contact persons

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

PIC	***Legal name***
999989782	*RIJKSUNIVERSITEIT GRONINGEN*

Short name: RIJKSUNIVERSITEIT GRONINGEN

Address of the organisation

Street Broerstraat 5

Town GRONINGEN

Postcode 9712CP

Country Netherlands

Webpage www.rug.nl

Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....yes

Research organisation .....yes

Legal person .....yes

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

Enterprise Data

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

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

SME validation sme.....10/12/2008 - 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: ESRIG Institute Faculty of Science and Engineering ☐ not applicable

☐ Same as proposing organisation's address

Street: Nijenborgh 6

Town: Groningen

Postcode: 9747 AG

Country: Netherlands

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

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

Title: Prof. Sex: (•) Male ( ) Female

First name: **Richard** Last name: **Bintanja**

E-Mail: **bintanja@gmail.com**

Position in org.: Professor in Climate and the Environment

Department: Ocean Ecosystems Dept., ESRIG, Faculty of Science & Engineering ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: Nijenborgh 7

Town: Groningen Post code: 9747 AG

Country: Netherlands

Website: https://www.rug.nl/research/ocean-ecosystems/

Phone: +31 6 37565005 Phone 2: +31 50 3632259 Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Femke	Flederus	findeptfmns@rug.nl	*+31 (0)50 3634137*

PIC	***Legal name***
906446474	*UNITED KINGDOM RESEARCH AND INNOVATION*

Short name: UKRI-BAS

Address of the organisation

Street POLARIS HOUSE NORTH STAR AVENUE

Town SWINDON

Postcode SN2 1FL

Country United Kingdom

Webpage https://www.ukri.org/

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..... 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: NERC - British Antarctic Survey ☐ not applicable

☐ Same as proposing organisation's address

Street: High Cross, Madingley Road

Town: Cambridge

Postcode: CB3 0ET

Country: United Kingdom

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

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

Title: Dr.

Sex: (•) Male ( ) Female

First name: **Thomas**

Last name: **Bracegirdle**

E-Mail: **jbra@bas.ac.uk**

Position in org.: Group Leader Polar Climate and Prediction

Department: NERC - British Antarctic Survey ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: High Cross, Madingley Road

Town: Cambridge Post code: CB3 0ET

Country: United Kingdom

Website: https://www.bas.ac.uk/profile/pahol/

Phone: +44 1223 221571 Phone 2: +xxx xxxxxxxxx Fax: +xxx xxxxxxxxx

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Ana	Pereira-O'Callaghan	anaper@bas.ac.uk	*+44 1223 221558*
Elaina	Ford	eakf@bas.ac.uk	*+44 1223 221453*
Christina	Chatzela	cichat@bas.ac.uk	*+44 1223 221519*

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

Short name: MET OFFICE

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 .....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: Hadley Centre ☐ not applicable

☒ Same as proposing organisation's address

Street: FITZROY ROAD

Town: EXETER

Postcode: EX1 3PB

Country: United Kingdom

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

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

Title: Dr.

Sex: (•) Male ( ) Female

First name: **Ed**

Last name: **Blockley**

E-Mail: **ed.blockley@metoffice.gov.uk**

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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: UMR5318 Climat, Environnement, Couplages et Incertitudes (CECI) ☐ not applicable

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Street: 42 avenue Gaspard Coriolis

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Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

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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 .....yes

Research organisation .....yes

Legal person .....yes

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

Enterprise Data

SME self-declared status.....03/03/2016 - no

SME self-assessment ..... unknown

SME validation sme.....31/12/2011 - 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: Water and Climate Risk ☐ not applicable

☐ Same as proposing organisation's address

Street: De Boelelaann 1111

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Dependencies with other proposal participants

Character of dependence	***Participant***	

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Legal Status of your organisation

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

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

Enterprise Data

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

SME self-assessment ..... unknown

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

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

Department(s) carrying out the proposed work

Department 1

Department name: Development Centre for Weather Forecasting ☐ not applicable

☒ Same as proposing organisation's address

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Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

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Legal Status of your organisation

Research and Innovation legal statuses

Public body .....no

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

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

Enterprise Data

SME self-declared status.....09/07/2018 - no

SME self-assessment ..... unknown

SME validation sme.....09/10/2008 - no

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

Department(s) carrying out the proposed work

Department 1

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3 - Budget

Total requested EU contribution for the proposal/ €	7 998 600

PROCESS-BASED UNDERSTANDING OF THE MECHANISMS DRIVING POLAR AMPLIFICATION AND ITS IMPACTS IN A CHANGING CLIMATE (POLAR-CLIM)

1. Excellence

1.1 Objectives

Mission: POLAR-CLIM will deliver a new level of quantitative process-based understanding of the causes, mechanisms, and impacts of Polar Amplification, enabling a step-change in our understanding of a changing polar climate, and the ability of people, policy makers and businesses to make evidence-based decisions regarding adaptation and mitigation in a rapidly warming and highly connected world.

In recent decades, the polar regions have undergone substantial changes, including the rapid decline of Arctic sea ice and major warming over West Antarctica. These high-latitude changes are influenced by a phenomenon of faster near-surface temperature increase compared to the rest of the world, known as Polar Amplification (PA)[1]. It is becoming increasingly clear that PA leads to key societal impacts of climate change. For example, Arctic sea ice decline associated with PA strongly impacts indigenous communities as well as marine life; and PA has the potential to influence weather patterns over the Northern Hemisphere, including extremes. In the Antarctic, PA was muted during recent decades, but becomes highly influential in climate projections. The loss of land ice in Greenland and Antarctica, leading to significant sea-level rise, is a prominent example of the global consequences of PA. In fact, PA is far more than an abstract concept: it is a major climate phenomenon whose unfolding will significantly affect both polar regions and the rest of the globe.

Although our understanding of climate change in polar regions, and in particular of PA and its impacts, has increased significantly in recent years, it is still mostly qualitative rather than quantitative, and major knowledge gaps remain[2]. Prominent examples of these gaps include our interpretation of observed signals in light of processes governing Arctic and Antarctic climate change (e.g. polar vs. lower-latitude drivers), the nature of the link between mid-latitude weather and climate variability and Arctic sea ice change (e.g. causal vs. incidental), differences in the strength of PA between the two poles, and the causes underpinning the striking differences in simulated (strong decline) and observed (no decline) Antarctic sea ice extent during the satellite era (1979–today).

The specific objectives (**O1-7**) addressed by POLAR-CLIM along with key performance indicators (**KPIs**) are:

O1: ***Drivers of Polar Amplification*** – Deliver an improved understanding of the mechanisms, processes and feedbacks governing PA, taking into account possible drivers from lower latitudes. **KPI-1**: Quantification of the relative importance of polar vs. lower-latitude, atmospheric vs. oceanic, dynamic vs. thermodynamic and physical vs. chemical processes in driving PA in the Arctic and Antarctic.

O2: ***Understanding contrasting sea ice changes*** – Identify the reasons for the mismatch between observed and simulated changes in Arctic and Antarctic sea ice extent over the satellite era based on the latest generation of satellite products and ground-based observations, in particular those from ESA/Europe. Apply this knowledge to improve projections. This includes exploring the possibility that Antarctic sea ice is on the brink of rapid decline. **KPI-2**: Physical explanation for the "Antarctic sea ice paradox" (i.e., stable sea ice conditions in a warming world), which leads to a better understanding of uncertainty in near-term projections.

O3: ***Changes in variability and extreme events: picturing the new Polar Regions*** – Determine the processes governing climate variability and extreme events in polar regions and quantify their projected changes in a warming world. **KPI-3**: Comprehensive, quantitative overview of how climate change will shape extreme events in polar regions in the future. This includes the provision of tangible "pictures" of future weather and environmental conditions in the Arctic and Antarctic regions on pathways to a 1.5°C, 2°C or 4°C warmer world.

O4: ***Understanding impacts of Polar Amplification on lower latitudes*** – Conduct focussed investigations of major outstanding questions relating to the impact of Arctic and Antarctic climate change on the weather and climate in lower latitudes, including impacts on the jet stream, weather regime occurrence, extreme events and ocean circulation through fast (atmospheric) and relatively slow (oceanic) linkages. **KPI-4**: Quantification of

[1] In POLAR-CLIM, PA is considered in a broader sense than just a warming as a function of latitude (zonal-mean) and takes it to also include regional hotspots of change in the polar regions.

[2] Cohen *et al.* (2020): Divergent consensuses on Arctic amplification influence on midlatitude severe winter weather. *Nature Clim. Change.* **10,** 20–29.

sensitivity of lower latitude weather and climate to polar change, including a risk assessment of changes in extreme events.

O5: ***Model error diagnosis*** – Determine the sources of some long-standing systematic model errors (e.g. biases in mixed phase clouds and challenges in representing stable boundary layers) in polar regions at the process level and provide guidance in support of future model development activities. **KPI-5**: Specific recommendations that can be tested by model development groups advancing weather and climate prediction systems.

O6: ***Clustering*** – Establish an effective clustering programme with related initiatives, that minimize duplication, accelerate progress and increase the scientific and societal impacts of POLAR-CLIM research, also beyond the end of the project. **KPI-6**: Regular mutual participation in meetings of related activities, especially for the EU Polar Cluster and associated projects.

O7: ***Maximizing impact*** – Develop an effective user engagement, dissemination, communication and education programme that maximizes the impact of POLAR-CLIM research (O1-5). **KPI-7:** Knowledge exchange with targeted and general stakeholders including co-developed case studies and narratives. Policy briefs with recommendations for policy makers. High impact video to increase outreach. Implementation of a learning environment including a spring school and online courses.

By addressing O1–7, POLAR-CLIM will contribute to combat climate change and its impacts, in line with the objectives of the Paris Agreement. The project will also contribute to sustainable development – especially through SDG13 on Climate Action. By increasing our understanding of the causes and impacts of polar climate change, POLAR-CLIM will contribute to building societies that are more resilient to phenomena such as rapid sea ice loss, wind storms and heat waves. This knowledge will help to underpin the EU Green Deal, an ambitious package of measures addressed to make Europe climate neutral, by providing evidence-based knowledge to decision-makers in a timely manner.

1.2 Relation to the work programme

POLAR-CLIM responds to the topic call LC-CLA-17-2020: "*Polar climate: understanding the polar processes in a global context in the Arctic and Antarctic regions*". It addresses all elements outlined in the specific challenge and scope of the call (relevant objectives (O), as provided under section 1.1, are indicated below in parentheses).

"Understanding the interactive nature and feedbacks of polar processes and addressing their consequences in a global context"

POLAR-CLIM will make a leap forward in this direction by focusing on key processes and interactions in polar regions (e.g. atmospheric heat and moisture transport) (O1-3) and lower latitudes (e.g. atmosphere-ocean interaction and jet stream dynamics), which require improved understanding to determine the impact of polar climate change on lower latitudes (O4) and vice versa (O1-3) through atmospheric and oceanic linkages.

"Benefit the people, policy and businesses well beyond the Polar Regions"

POLAR-CLIM will do so by closing societally relevant knowledge gaps – in polar regions and beyond – that have led to large uncertainties in several previous generations of climate change projections and that have been flagged in previous Intergovernmental Panel on Climate Change (IPCC) reports (O1-5). Examples include the impact of Arctic sea ice decline on weather in mid-latitudes (*medium confidence* according to IPCC Special Report on the Ocean and Cryosphere in a Changing Climate – SROCC), near-term projections of Antarctic sea ice extent (*low confidence* according to IPCC Fifth Assessment Report, AR5) and "picturing" the weather and climate of the future (storyline scenarios[3]). Stakeholders will also benefit from specific recommendations made to modelling groups contributing to upcoming IPCC reports (through the Coupled Model Intercomparison Project, CMIP). Finally, a strong user-engagement and communication component will ensure that critical newly emerging knowledge will effectively reach stakeholders (O7).

"Developing innovative approaches, building on existing data resources and infrastructures, the latest observational products (including in-situ observations), and state-of-the-art climate models, to assess the key physical and chemical processes in the ocean and atmosphere and the key ocean-atmosphere-ice interactions"

[3] Shepherd *et al.* (2018): Storylines: an alternative approach to representing uncertainty in physical aspects of climate change. *Climatic Change*, **151**, 555–571.

POLAR-CLIM will *"**assess the key physical and chemical processes in the ocean and atmosphere and the key ocean-atmosphere-ice interactions**"* using a multi-pronged strategy, *"**developing innovative approaches**"* via a blend of observations and models. Examples include novel Lagrangian diagnostics to determine how air masses are transformed as they enter polar regions from mid-latitudes[4], and machine learning approaches (e.g. causality networks) to interpret the long-range connectivity of climate events, but also feedbacks and other relationships more generally. These analyses will be augmented by novel model experiments in which, for example, certain feedbacks or chemical processes are switched off, or in which the observed evolution of the jet stream is imposed through scale-dependent nudging to separate thermodynamic from dynamic changes. In this context, POLAR-CLIM will exploit "***state-of-the-art climate models***" that have been developed by leading European modelling groups (e.g. EC-Earth and HadGEM3). Research will also be *"**building on existing data resources**",* including the latest reanalysis products (e.g. the Copernicus Climate Change ERA5 reanalysis) and novel model datasets such as the ECMWF-YOPP dataset that includes process tendencies, as well as data from the new Polar Amplification Model Intercomparison Project (PAMIP). Research will also build on *"**existing infrastructures**"* such as high-performance computing resources and the Earth System Grid Federation (ESGF) for sharing some of the model data. POLAR-CLIM will exploit *"**the latest observational products**"* including *"**in-situ observations**"* from the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) and the Year of Polar Prediction (YOPP) initiatives as well as "***satellite observations***" such as those provided through the ESA-Climate Change Initiative (ESA-CCI) and the wealth of satellite data assimilated in reanalysis products (e.g. ERA5).

"Cooperate with relevant projects funded by the ESA Earth Observation Programme"

One focus for cooperation in POLAR-CLIM will be to make best use of existing and upcoming Earth observation data for research carried out in POLAR-CLIM. Another focus will be on identifying areas for improvement of space-borne observations from the ESA Earth Observation Programme; this includes providing feedback on new products and missions. Effective coordination with the ESA Earth Observation Programme, especially through the ESA Polar Science Cluster as well as ESA-CCI and its Climate Model User Group (CMUG), will be developed, implemented and monitored within POLAR-CLIM as part of the clustering programme (O6).

"Join the EU Polar Cluster in order to build synergies and maximise the complementarity of the different actions in the Cluster"

POLAR-CLIM will actively contribute to the EU Polar Science Cluster and its goals: Act as the main entry point into EU funded polar research activities (O6); provide policy-relevant information (O7); and support the EU in implementing its integrated policy for the Arctic, (O7). The Cluster, will also play an important role when it comes to establishing scientific collaboration with relevant projects (e.g. PROTECT for ice sheets and sea level rise, and NUNATARYUK for permafrost).

"Build upon previous actions funded under Horizon 2020 and avoid duplication or overlap"

POLAR-CLIM will do so by using data from previous H2020 projects such as APPLICATE[5] and Blue-Action (especially data from PAMIP and the ECMWF-YOPP data set). Moreover, the state-of-the-art models employed in POLAR-CLIM will benefit from model development efforts in previous projects, especially PRIMAVERA, CRESCENDO and APPLICATE, including the development of coupled single-column models for the polar regions, weather and climate models with enhanced process representations in polar regions as well as novel high-resolution model configurations and protocols (e.g. High-Resolution Model Intercomparison Project) (O1-6).

"International cooperation [...], in particular with countries that took part in the Arctic Science Ministerial (ASM) *meetings"*

Cooperation will be based on direct collaborations (underpinned by letters of intent) as well as joint activities in the context of coordinated international projects, especially those where POLAR-CLIM PIs take leading roles (e.g. YOPP, MOSAiC and PAMIP). Cooperation will build on and strengthen existing collaboration with the following non-European participants of the first two ASMs: Canada (e.g. Environment and Climate Change Canada), Japan (e.g. Japan Agency for Marine Earth Science and Technology), China (e.g. Sun Yet-Sen University), India (e.g. Indian Institute of Tropical Meteorology), New Zealand (e.g. NIWA), Russian Federation (e.g. Shirshov Institute of Oceanology), South Korea (e.g. Korean Polar Research Institute) and the USA (e.g. National Center for

[4] Pithan *et al.* (2018): Role of air-mass transformations in exchange between the Arctic and mid-latitudes. *Nature Geosci.* **11,** 805–812.

[5] The POLAR-CLIM coordinator also led APPLICATE, so that POLAR-CLIM will benefit in its entirety from their activities.

Atmospheric Research). For the other counties, for which no collaboration has been established yet and that are not strongly involved yet in any of the coordinated international projects mentioned above (i.e. Singapore and Greenland), POLAR-CLIM will reach out to a range of potential new partners that have been identified (O6).

1.3 Concept and methodology

(a) Concept

1.3.1 Overall concept underpinning the project

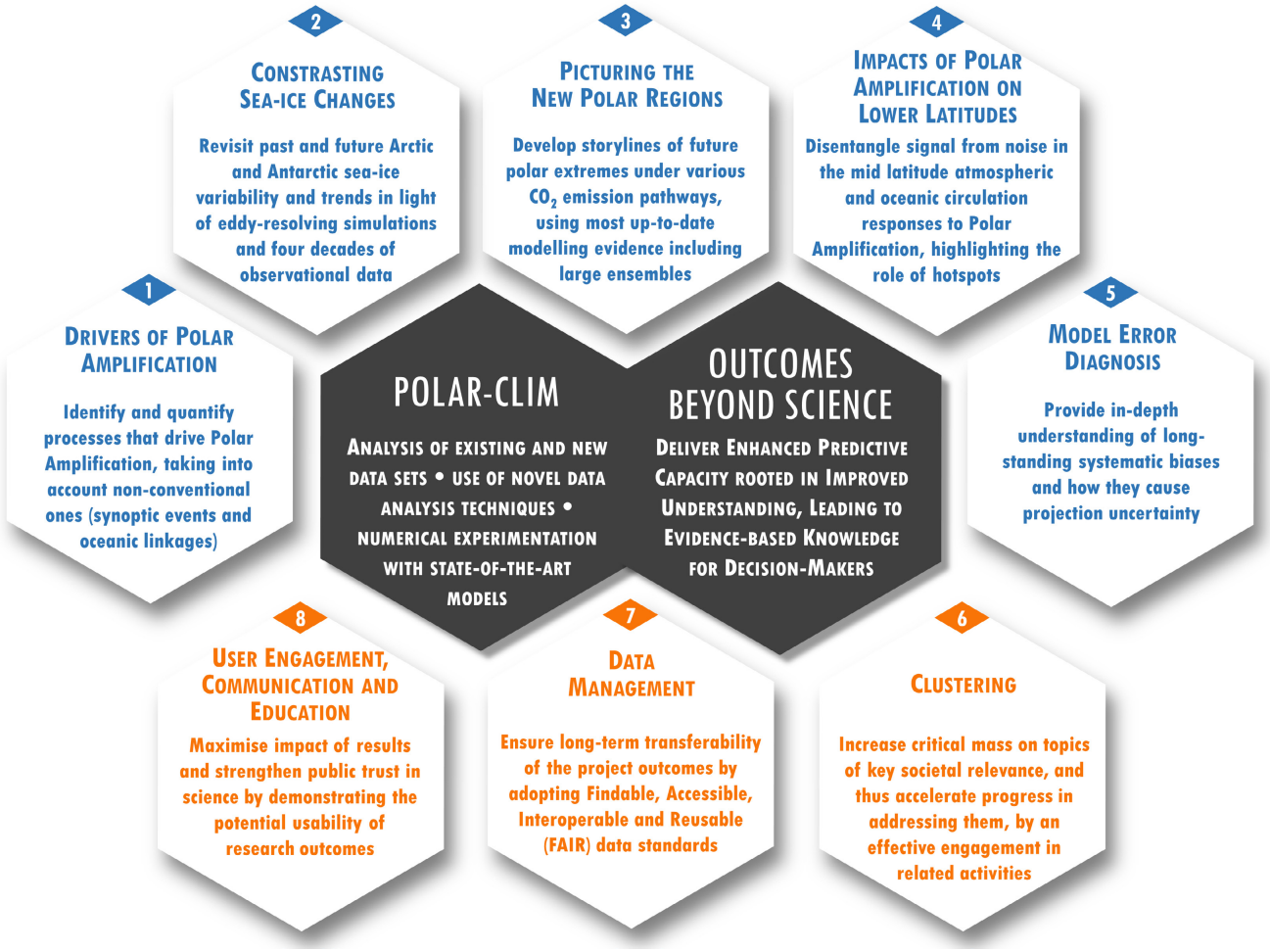


Figure 1: Overview of the key elements of POLAR-CLIM, including the scientific core (blue) and science underpinning activities (orange).

POLAR-CLIM will **focus on identifying and quantifying key processes, feedbacks and interactions that drive PA and that govern changes in weather and climate in lower latitudes**. Those processes, feedbacks and interactions that promise major breakthroughs will be addressed in POLAR-CLIM's scientific objectives (O1-5). These objectives directly translate into five work packages (see Fig. 1, and section 1.3.4 below).

POLAR-CLIM will **use a novel approach to disentangle both the nature and role of key processes, and how they are represented in models**. For example, the separation of thermodynamic from dynamic processes is particularly useful when it comes to climate change, since the thermodynamic (dynamic) processes are usually associated with low (large) uncertainties[6]. Other combinations are polar vs. lower latitude drivers of PA, forced response vs. natural variability, slow (e.g. oceanic) vs. fast (e.g. atmospheric) processes, small-scale (e.g. meso-scale eddies) vs. large-scale processes (e.g. atmospheric planetary waves), changes in mean climate vs. changes in variability, and linear vs. nonlinear responses.

POLAR-CLIM will also **address specific regional hotspots, that are regional manifestations of PA**. For the Arctic, this will be the Beaufort Sea, which is a potential source of freshwater perturbations for the North Atlantic,

[6] Shepherd (2014): Atmospheric circulation as a source of uncertainty in climate change projections. *Nature Geoscience* **7,** 703–708.

as well as the Barents Sea, which is one of the fastest warming regions in the world that is prone to the increased inflow of Atlantic water ('Atlantification') and that could be an important driver of weather patterns across the Northern Hemisphere. For the Antarctic, a focus region will be West Antarctica and adjacent seas (Bellingshausen, Amundsen, Ross). This region has seen large opposing sea ice trends that are central to understanding Antarctic-wide change and the Arctic-Antarctic PA 'mismatch'. These regions are also hotspots for tropical teleconnections, and are of high potential global impact in terms of ongoing and future loss of Antarctic land ice[7].

The **exploration of existing datasets** will be another central element of POLAR-CLIM's strategy. This includes the **use of novel machine learning methods** such as Causal Effect Networks (CEN) to unveil cause-effect relationships in complex climate data[8]. **Data-driven approaches will be augmented by numerical experimentation with state-of-the-art models**. This includes sensitivity experiments in which certain processes will be constrained, or in which CMIP6 protocols will be exploited (e.g. novel high-resolution experiments following the PAMIP protocol).

The objectives addressed by POLAR-CLIM (O1-5) imply the need for a strong focus on the physical climate system, although chemical processes will be taken into account where considered important (especially for O1, O3 and O5). This includes how the transport (polar-lower latitudes linkages) and local emission of anthropogenic and natural aerosol and gases may drive changes in the polar regions either directly or indirectly (e.g. through impact on cloud phase). This also includes interactions between ozone chemistry and stratospheric dynamical processes which may have the potential of modulating teleconnections between polar regions and lower latitudes.

POLAR-CLIM also aims to **understand the origin of some long-standing systemic model errors that affect polar regions** (e.g. SST biases in the Southern Ocean) at the process level. Biases matter since they impact the confidence we have in climate change projections (some of the biases are as large as the expected climate change, which is cause for concern when evaluating strongly non-linear systems like the climate system[9]). Our **concept is based on the notion that processes, feedbacks and interactions that govern PA are also at the heart of several long-standing climate model biases. And vice versa, that understanding of the origin of biases improves our understanding of the functioning of the climate system**. Intrusions of moist and warm air into the polar regions and subduction of heat in the Southern Ocean, for example, are processes that could simultaneously explain the essence of some of the main characteristics of PA as well as long-standing biases in climate models. Finally, POLAR-CLIM recognizes that the existence of large model spread together with advanced physical understanding offers an invaluable chance to refine future projections by the application of emergent constraints.

Clustering with ongoing related activities will be a central element of the concept to avoid duplication and to increase the critical mass on pressing topics of high societal relevance. Clustering will concentrate on PAMIP, YOPP and MOSAiC, for which Principal Investigators of POLAR-CLIM take leading roles (e.g. Doug Smith and James Screen are co-chairs of PAMIP; Thomas Jung leads the planning of YOPP; and Markus Rex is coordinator of MOSAiC) and where POLAR-CLIM can make major contributions (e.g. high-resolution experiments following the PAMIP protocol). Furthermore, there are important topics, to which POLAR-CLIM will contribute *indirectly* (e.g., by sharing data and knowledge). One example is polar sources of sea level rise (Antarctic and Greenland ice sheets), for which changes in the physical system, such as the temperature of water reaching the shelves, are critical. Here, clustering with relevant H2020 projects funded under the topic LC-CLA-07-2019 entitled "The changing cryosphere: uncertainties, risks and opportunities" will be central (e.g. PROTECT project through Paul Holland).

In order to ensure that improved understanding will turn into improved decision making, **POLAR-CLIM will develop a stakeholder engagement strategy** based on the concept of 'institutional intermediaries', which will comprise academic and public centres that will act as liaison between the project research and stakeholders. Target project stakeholders will include the climate research community, European policy makers, the community on standards for climate adaptation, but also public and private stakeholders in the Arctic and beyond. Given that the outcomes will be scientifically complex for non-trained audiences, project results will be leveraged to target communities, showcasing their potential application for decision-making. Involvement of scientists in stakeholder engagement activities will ensure to tap the full potential of scientific results to correctly support and to be readily incorporated into policy and regulatory processes.

[7] Holland *et al.* (2019): West Antarctic ice loss influenced by internal climate variability and anthropogenic forcing. *Nature Geoscience,* **12**:718–724.
[8] Runge *et al.* (2019): Inferring causation from time series in Earth system sciences. *Nature Communications,* **10,** 2553.
[9] Palmer and Stevens (2019): The scientific challenge of understanding and estimating climate change. PNAS, **116,** 24390–24395.

1.3.2. Positioning of the project

In line with the call text, POLAR-CLIM has a strong focus on generating fundamental knowledge, which corresponds to a technology readiness level of 1 (TRL 1 – "basic principles observed"). However, all proposed activities are well embedded in longer-term strategies – and hence value chains – of the different partners, especially those with an operational background, those involved in the development of large European systems like NEMO and EC-Earth, and those contributing to CMIP efforts (specifically the value chain *improved understanding → enhanced models → advanced projections/predictions*).

1.3.3 Related national or international research and innovation activities

There are numerous national and international activities that are related to POLAR-CLIM (many with participation of POLAR-CLIM partners – often in leading roles). In the following, a small number of selected projects will be highlighted that provide relevant input to POLAR-CLIM, keeping in mind, however, that the relationships are often strongly two-way in nature.

Related ***national*** research and innovation activities

National model development activities: High-resolution modelling activities at AWI will benefit from the Pilot Lab Exascale Earth System Modelling, which supports the adaptation of climate models to upcoming HPC platforms (e.g. including GPU boosters at Jülich Supercomputing Centre). Work will also benefit from ongoing developments in the PARAMOUR (Predictability and decadal-to-centennial polar climate variability: The role of multiscale interactions between the atmosphere, the ocean and the cryosphere) Belgian EOS project (http://www.climate.be/paramour).

Related ***European*** research and innovation activities

Previous Horizon 2020 projects: POLAR-CLIM will use (i) PAMIP data, models with enhanced representation of polar processes and the ECMWF-YOPP Dataset from APPLICATE, (ii) PAMIP data from Blue-Action, (iii) HiResMIP simulations from PRIMAVERA, (iv) existing stakeholder networks from Climateurope, **Copernicus Climate Change Services (C3S):** POLAR-CLIM will use reanalysis datasets such as ERA5 and the Copernicus Arctic Regional ReAnalysis (CARRA). These datasets are currently being quality controlled within the C3S 512 contract (lead BSC) to respond to the needs identified in previous contracts using a continuous user-engagement process. C3S SIS (lead Tecnalia) provides data tools and information to support climate sensitive sectors such as infrastructure, transport and associated standards. **EC-Earth:** POLAR-CLIM will benefit from the development of the EC-Earth model by a consortium of 30 institutes from 12 European countries.

Related ***international*** research and innovation activities

CMIP6: POLAR-CLIM will use DECK simulations (especially historical and projection runs, including large ensembles) as well as data from selected model intercomparison projects such as PAMIP (polar amplification and linkages), SIMIP (understanding sea ice through climate model experiments), AerChemMIP (quantifying the role of chemical processes) and DAMIP (detection and attribution of extreme events and disentangling of different processes and drivers to polar climate change). **YOPP:** POLAR-CLIM will use special model data sets such as the ECMWF-YOPP Analysis and Forecast Dataset and YOPPSiteMIP data sets that includes observations from supersites, including MOSAiC. **Belmont-JPI-Climate project** GOTHAM (Globally Observed Teleconnections and their role and representation in Hierarchies of Atmospheric Models): POLAR-CLIM will exploit knowledge gained in applying causal effect networks to large atmospheric data sets.

(b) Methodology

1.3.4 Overall methodology

In the following, a brief description of the activities carried out and methodologies used in each of POLAR-CLIM's work packages (WP) will be given:

WP1: Drivers of Polar Amplification **(O1).** Explore polar processes and feedbacks using novel data provided through MOSAiC and YOPP ● Determine the role of warm and moist air intrusions into polar regions for PA and determine the relative importance of dynamical vs. thermodynamic factors ● Understand the role of local physical processes vs. remote drivers and their interactions through systematic numerical experimentation ● Quantify the impact of lower latitudes on polar climate change through oceanic pathways ● Study the response (and related feedbacks) to local and remote changes of reactive gases and aerosols, by performing sensitivity simulations with chemistry-climate models using well-established CMIP protocols.

***WP2: Understanding contrasting sea ice changes* (O2).** Explore the hypothesis that meso-scale oceanic phenomena such as eddies lead to a delayed decline of Antarctic sea ice extent through high-resolution model experiments and contrast the mechanisms with those operating in the Arctic ● Understand long-term trends and variability of the atmosphere, ocean and sea ice in West Antarctica within a global context by conducting climate model experiments designed to quantify the role of key drivers, such as tropical variability, and ozone depletion ● Produce a new global ensemble sea ice reanalysis (1979–2020) assimilating existing and most recent ESA data (satellite sea ice thickness, snow depth) in the new state-of-the-art European ocean-sea ice model (NEMO4.0-SI3), in collaboration with operational centres (MERCATOR Ocean, ECMWF, national centres) ● Identify case studies that can help understand the causes of recent unusual events like the Weddell polynya or the sudden contraction of Antarctic sea ice since 2014 ● Provide near-real time assessments of sea ice extreme events occurring during the lifetime of the project and contribute to the annual "Explaining Extreme Events from a Climate Perspective" issue of BAMS.

***WP3: Changes in variability and extreme events: picturing the new Polar Regions* (O3).** Determine changes in variability and extreme events that are associated with PA through dedicated climate model simulations and analyses of large ensembles (e.g. CMIP6) ● Use the multi-model CMIP (pre-industrial, historical and scenario) simulations to assess pre-industrial polar climate variability (interannual, decadal), and trends in variability and extremes ● Carry out and analyse novel model simulations (e.g. by constraining certain physical variables through nudging) to identify processes governing changes (e.g. atmospheric rivers) ● Analyse existing large ensembles to quantify both inter- and intra-model uncertainties in variability (trends) ● Estimate how recent high-impact extreme events (e.g. Arctic "heat waves") would have evolved in 1950 and might evolve in 2030, 2050 and 2100 for different emission pathways using scale-dependent nudging (storyline scenarios) ● Analyse the impact of low-probability/high-risk events like a very large Polar Amplification (above 15°C) or strong releases of freshwater from the Beaufort gyre.

***WP4: Impacts of Polar Amplification on lower latitudes* (O4).** Analyse linkages using existing datasets from CMIP6 (e.g. PAMIP) ● Use methods such as emergent constraints and causal effect networks to reduce uncertainties and quantify causality of linkages, respectively ● Explore the impact of possible model and methodological short-comings for existing datasets such as PAMIP (e.g. interactive ozone chemistry, mid-latitude eddy-mean flow interaction, atmosphere-ocean coupling, underestimated signal-to-noise ratio in models and ensemble size) ● Develop PAMIP2 protocol, taking into account lessons learnt from the analysis of existing data (see above) ● Determine the impact of climate hotspots such as the Barents Sea warming on the atmospheric jet stream; and explore how freshening of the Beaufort Gyre influences Arctic outflows into the North Atlantic and hence the Atlantic Meridional Overturning Circulation (AMOC) ● Investigate the emergence of new deep water formation sites in the Arctic along with its remote impacts.

***WP5: Model error diagnosis* (O5).** Carry out process-based model evaluation using causal effect networks, but also comparison with observations (YOPP, MOSAIC) and reanalysis datasets (ERA5, CARRA) ● Create a catalogue of moist- and warm-air intrusions into polar regions, and their counterpart cold air outbreak events, that took place over the past 50 years from the Copernicus Climate Change Service reanalysis ERA5 ● For these events investigate the sources and growth of model error (in different modelling data sets covering a wide range of timescales) through comparison with reanalysis datasets (ERA5, CARRA), observations from YOPP and MOSAiC, and numerical experimentation aimed at disentangling the role of the representation of various processes (e.g. cloud physics, snow over sea ice, sea ice or atmosphere-sea-ice coupling) ● Diagnose the physical origins of systematic model biases in the Southern Ocean (excessive warming and ocean circulation) and Arctic Ocean (biased stratification) by applying data classification approaches to the CMIP6 ensemble.

***WP6: Clustering* (O6).** Engage in the EU Polar Cluster ● Cluster with other EU projects, especially those with close scientific links to POLAR-CLIM, through joint workshops, mutual participation in project meetings, and 'inter-project updates' from researchers involved in multiple projects ● Engage identified potential partners from countries that participated in the Arctic Science Ministerials.

***WP7: Data management* (O7).** Develop a data management plan ● Establish a centralized inventory of the different data sources used during the project (e.g., ESGF DECK simulations, ESA CCI observations, reanalysis) ● For new data, with partial or full dissemination generated within the project, take advantage of existing infrastructures (e.g., ESGF) and share them publicly (e.g., THREDDS server) with transparent access for the users.

***WP8: User engagement, dissemination, communication and education* (O7).** Co-develop case studies and narratives ● Issue policy briefs and strategic notes ● Contribute to the ScienceBrief.org platform (gathering of scientists making sense of the latest evidence in rapidly evolving topics such as climate change) ● Organize stakeholder workshops and policy events ● Prepare project communication and dissemination materials ● Produce a video with high-impact visualizations of weather and environmental conditions on different pathways to a warmer world ● Contribute regularly to EGU blogs ● Plan and implement POLAR-CLIM's education programme

together with the Association of Polar Early Career Scientists (APECS) ● Hold a spring school in 2022 in Abisko, Sweden ● Offer dedicated online courses as well as mentoring activities ● Develop and disseminate educational material for schools and universities in collaborations educators and researchers.

WP9: Project management. Implement effective and proactive project coordination and management.

1.3.5 Gender dimension

Given the strong emphasis of POLAR-CLIM on the physical climate system, we consider our research activities to be gender-neutral. However, gender aspects become relevant when communicating to specific stakeholders. Given that the influence of climate change on human activities will be addressed, there is a gender dimension in how people interact with their environment and how they are affected by changing environmental conditions. To meet this dimension, we will carefully consider how gender aspects are applicable to all stakeholder interactions, including all communication and dissemination aspects of the project.

1.4 Ambition

1.4.1 Advancement beyond the state of the art and ambition

The following table provides (examples for) the status quo related to O1–5, along with POLAR-CLIM's ambition to go beyond the state-of-the-art:

Status quo	Progress beyond the status quo and ambition
Our understanding of Polar Amplification is mostly qualitative and little is known about the relative importance of local feedbacks vs. remote drivers.	Quantify the processes giving rise to Polar Amplification in observations and models, discerning between local feedbacks in polar regions and remote drivers (atmosphere and ocean), dynamic and thermodynamic processes, small-scale and large-scale etc.
There is low confidence in near-term projections of Antarctic sea ice.	Provide an explanation as to why CMIP models – in contrast to satellite data – show a consistent decline of Antarctic sea ice extent. One hypothesis we will test is that explicitly resolving ocean eddies will fundamentally change the response of Antarctic sea ice.
Most of our knowledge about future climate change in polar regions is based on mean climate.	Provide a comprehensive understanding of the processes governing changes in climate variability and extreme events. Make climate change more tangible by illustrating how certain phenomena will change in a warming world ("pictures" of the future and storyline scenarios).
There is still significant controversy whether Arctic climate change impacts weather patterns, and hence extreme events, in lower latitudes.	Reconcile observational and model results through a new level of mechanistic understanding. Revisit the ability of models to correctly represent the response to forcing, accounting for the possibility that important processes might not be captured (e.g. "signal-to-noise paradox" of the North Atlantic Oscillation, NAO).
Despite substantial past model development efforts, climate models still exhibit long-standing systematic model errors in polar regions, which reduce our confidence in regional climate change projection.	Trace the model errors in mean state back to the deficient simulation of processes in specific model components and areas of the world.

1.4.2 Innovation potential

Better processes understanding along with thorough model error diagnosis will lead to recommendations on how to improve long-standing model biases. Better models will lead to improved weather and climate predictions as well as climate change projections in support of upcoming IPCC reports. Furthermore, POLAR-CLIM will explore innovative data analysis approaches, including the use of machine learning techniques. The experience gained with these techniques will be shared with the wider community. Moreover, the "pictures of the future" and storyline approach provides an innovative way of making the impacts of climate change tangible to scientists and society alike. This includes novel visualisations and videos.

2. Impact

2.1 Expected impacts

"Improved understanding of how the changing polar climate systems affect and are affected by lower latitudes through ocean and atmospheric circulation."

POLAR-CLIM will deliver an improved understanding of how changes in polar regions affect lower latitudes and vice versa. In doing so, POLAR-CLIM will build a more connected research community involving scientists that traditionally tended to work isolated from each other (e.g. polar scientists vs. experts on mid-latitude dynamics). Enhanced understanding of teleconnections in the climate system will also provide guidance to model development groups on the origin of biases (i.e. local polar vs. remotely driven). More specifically, POLAR-CLIM will contribute to our understanding of the "signal-to-noise ratio paradox" of the NAO, which will inform modelling groups whether there is something fundamentally wrong with their models in terms of the atmospheric response to forcing. This is expected to benefit climate predictions (sub-seasonal to decadal) and projections alike. The knowledge gained will also consolidate diverging consensuses regarding polar-lower latitude linkages from observational and modelling studies, which has been a matter of considerable controversy in recent years (in the scientific literature and public press). This will also help to convey a clearer message to the public. Finally, the data produced by POLAR-CLIM (e.g. novel PAMIP experiments) will be shared with the scientific community, thus enabling further scientific progress on the linkages theme beyond the lifetime of the project.

"Improved understanding of the key ocean-atmosphere-ice interactions."
"Improved understanding of the fully coupled physical climate system (atmosphere-ocean-ice) on diverse space and time scales."

POLAR-CLIM will facilitate a step-change in our understanding of key interactions in polar regions and thus the fully coupled climate system. This advanced knowledge will provide a new baseline that can be used to confront and thus improve climate models. Given that diverse space and time scales will be addressed, numerical weather prediction (NWP) models, that are becoming increasingly coupled, and climate models will benefit. In this sense, POLAR-CLIM will bring the NWP and climate community closer together. Community building will also benefit from novel collaboration in POLAR-CLIM between experts on Arctic and Antarctic climate (through the comparative assessment). Progress in our understanding of the fully coupled physical climate system will also benefit scientific progress in other fields (enabled through clustering; see WP6). Prominent examples include (i) the future of polar ice sheets, and thus sea level rise, for which atmospheric and oceanic changes are critical drivers, (ii) the future carbon cycle in the Southern Ocean, for which the ocean circulation and ocean-atmosphere-ice interactions are critical, and (iii) thawing permafrost that is related to warming and coastal erosion associated with Arctic sea ice decline. Finally, through its research activities, POLAR-CLIM will contribute to turning high-level international research initiatives such as MOSAiC, YOPP and PAMIP into success stories, thereby demonstrating the added value of international collaboration.

"Improved understanding of key physical and chemical processes in the ocean and in the atmosphere."

POLAR-CLIM will generate improved understanding of key physical processes in the atmosphere (e.g., transport of moist and warm air into polar regions) and ocean (e.g. deep water formation). Furthermore, it will address chemical processes in the atmosphere (e.g. lifecycle of climatically relevant aerosols and gaseous precursors). These advances in understanding will directly feed into the development of the next generation of models. Bringing physicists and chemists together to jointly address important knowledge gaps will also contribute to building a community that can tackle complex problems in climate research. Moreover, through its focus on ocean heat uptake and deep-water formation in high-latitudes, POLAR-CLIM will provide important insights to scientists studying the carbon cycle (i.e. chemical processes in the ocean), especially for the Southern Ocean, which constitutes a key region for carbon uptake. Collaboration in this field will be established through clustering with relevant EU projects (e.g. COMFORT) and international activities such as the CLIVAR/CliC/SCAR Southern Ocean Region Panel (SORP).

"Improved projections of future polar and global climate, including feedbacks and impacts."

POLAR-CLIM will provide the scientific underpinning for an advanced understanding of critical processes (including feedbacks), interactions and phenomena. Projections of the impact of polar climate change on lower latitudes will be delivered on the basis of existing and novel PAMIP experiments. POLAR-CLIM will turn

improved understanding of the origin of model error at the process-level into concrete recommendations on how biases in the next generation of climate models can be reduced and thus projections improved. Moreover, novel projections, such as storyline scenarios and "pictures of the future" (e.g. picturing polar weather and extreme events of the future), will provide new ways of communicating climate change and its uncertainties to scientists and society.

"Improved capability to respond to the impact of climate change on the environment and human activities in the Polar Regions (with a focus on the Arctic), both in the short and longer term."

Improved projections, based on advanced knowledge generated by POLAR-CLIM, will enable a strong evidence-based response to the impact of climate change. By also addressing changes in variability and extreme events, POLAR-CLIM accounts for the fact that risk (i.e. likelihood × impact) is critical to informed decision making. We will explicitly address short and longer-term changes by focussing on strategic time slices (2030, 2050 and 2100) for pathways into 1.5, 2 and 4°C warmer worlds. POLAR-CLIM will also improve capabilities to respond to changes by making the impacts of climate change tangible to stakeholders through effective communication and user-engagement (e.g. "pictures of the future"). By engaging climate change adaptation, disaster risk reduction and standards communities, POLAR-CLIM will help inform the process of building a safer and more resilient society in line with the objectives of the Sendai Framework.

"Contribute to the IPCC scientific assessments."

POLAR-CLIM will contribute to upcoming IPCC reports by addressing critical knowledge gaps, especially those for which society requires trustworthy information, but where previous IPCC reports pointed out limited confidence. This includes projected near-term decreases in Antarctic sea ice (*low confidence,* IPCC AR5) and the influence of changes in Arctic sea ice on mid-latitude weather (*medium confidence*) and specific weather types (*low confidence*) (SROCC). Furthermore, POLAR-CLIM will make major contributions to PAMIP, which has been initiated, and endorsed by CMIP, with the aim to inform IPCC on the impact of polar climate change on lower latitudes. This includes concrete suggestions for a new PAMIP (i.e. PAMIP2). Moreover, in-depth understanding of the origin of long-standing biases in climate models at the process level will translate into better models used in upcoming CMIP activities in support of IPCC reports.

"Contribute to the consolidation phase of the Year of Polar Prediction (YOPP)."

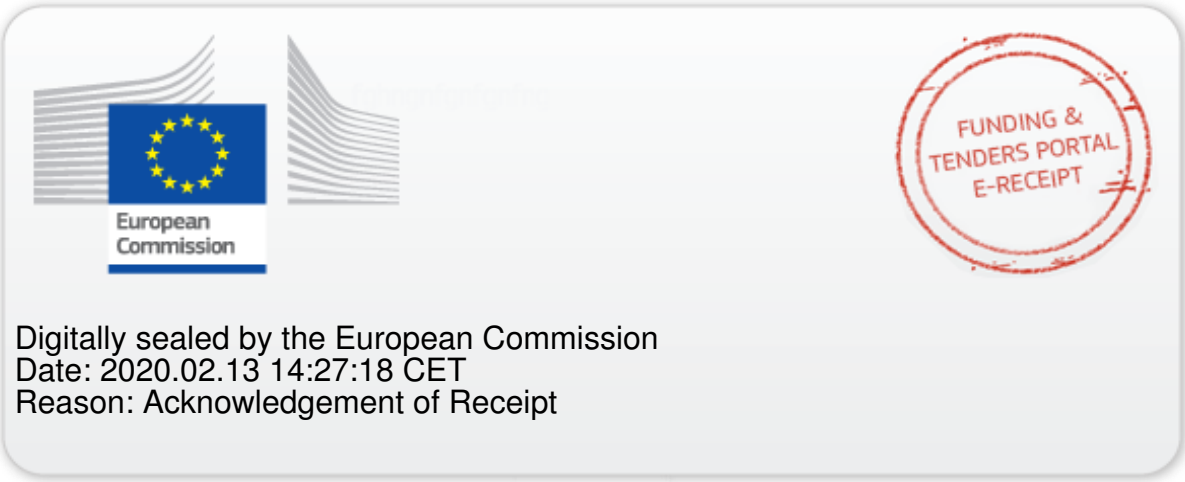
POLAR-CLIM will contribute to YOPP by improving our understanding of polar-lower latitude linkages, which is one of YOPP's flagship activities. Furthermore, POLAR-CLIM will contribute to YOPPSiteMIP, which is key to the YOPP consolidation phase for advancing process understanding and determining the origin of long-standing model errors. Importantly, POLAR-CLIM will contribute to strengthening research on the Southern Ocean, which has been identified – through a gap analysis of YOPP endorsed projects – as a region that is relatively less well studied compared to other parts. POLAR-CLIM will also team up with the YOPP community to hold a joint spring school and to collaborate in user-engagement and communication programmes. Contributions of POLAR-CLIM to YOPP will benefit from the fact that many PIs already assume leading roles in YOPP.

"Contribute to the Copernicus Climate Change Service (C3S)."

POLAR-CLIM will drive enhancements of C3S service provision through advancing (seasonal to decadal) predictions and (climate) projections. It will also improve global and polar reanalyses, as it will be the leading European research project with a special focus on improving the representation of polar processes in models. Only recently, C3S started to include dedicated polar reanalyses with CARRA. However, the holistic approach to coupled, teleconnected process understanding of POLAR-CLIM will reshape the strategy for future polar reanalysis design and help to formulate the observational and data assimilation requirements in both global and regional set-ups. Given the large growth of geo-political and economic activities in polar regions, the polar impact of C3S services will receive significantly more interest in the future, to which POLAR-CLIM will add a new level of confidence in predictive skill.

"Supporting the assessment of regional impacts."

POLAR-CLIM has a strong focus on regional climate change. This holds for the polar regions (e.g. hotspot Barents Sea) as well as for lower latitudes (e.g. Europe as a focus area). POLAR-CLIM will provide boundary conditions that can be used for regional downscaling efforts. However, POLAR-CLIM will also provide direct information on regional impacts to support decision-making (e.g. adaptation of standards to improve resilience to the adverse effects of climate change, and mitigation strategies for sectorial activities such as the renewable energy deployment). This includes information on how Arctic climate change will affect the atmospheric jet stream, and thus extreme events in Europe, as well as the ocean circulation in the North Atlantic, and hence the blue economy.



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