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Horizon 2020

Call: H2020-MSCA-IF-2018

(Marie Skłodowska-Curie Individual Fellowships)

Topic: MSCA-IF-2018

Type of action: MSCA-IF-EF-ST

(Standard European Fellowships)

Proposal number: 838078

Proposal acronym: PERIDoT

Deadline Id: H2020-MSCA-IF-2018

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How to fill in the forms

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

1 - General information

Topic	MSCA-IF-2018	Type of Action	MSCA-IF-EF-ST
Call Identifier	H2020-MSCA-IF-2018	Deadline Id	H2020-MSCA-IF-2018

Acronym: PERIDoT

Proposal title: Predictability of glaciERs, Ice caps and snow on Decadal Timescales

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

Duration in months: 24

Scientific Area: ENV - Environmental and Geosciences (ENV)

Please select up to 5 descriptors (and at least 3) that best characterise the subject of your proposal, in descending order of relevance.

Descriptor 1: Climatology and climate change

Descriptor 2: Cryosphere, dynamics of snow and ice cover, sea ice, permafrost and ice sheets

Descriptor 3: Meteorology, atmospheric physics and dynamics

Descriptor 4: Numerical analysis, simulation, optimisation, modelling tools

Descriptor 5: Statistics

Free keywords: *decadal climate prediction; long-term climate projections; prediction skill; natural variability; anthropogenic forcing; AMV; IPO; downscaling; evaluation; forecast calibration and bias correction*

Please choose the scientific area and descriptors carefully, and in order of importance, since this will guide the REA in the selection of experts for proposal evaluation and the allocation of proposals to experts. To help you select the most relevant area for your proposal, please consult the Guide for Applicants which provides a breakdown of each scientific area into a number of descriptors.

Abstract

Glaciers, ice caps and snow fields are important components of the human socio-ecosystem. In many regions of the world, they represent an important source of water for domestic, agricultural and hydro-power use. They can also have large societal impacts through their major contribution to sea-level rise and glacier-related hazards such as avalanches or glacial lake outburst floods. Moreover, they play a role in mountain and polar tourism and provide cultural or spiritual services. Up to now, the evolution of glaciers and ice caps around the world has been mainly assessed through the impact of long-term climate change mainly related to anthropogenic forcings. However, the socio-environmental impacts of glacier and snow evolution are also strongly dependent on the climate variability at shorter timescales ranging from a year to a decade, that involves mainly the internal variability of the climate system. This project aims to bridge the gap between long-term changes of glaciers and snow fields and their variability at shorter timescales, with the challenging objective to design a forecast system able to predict their evolution homogeneously and continuously from annual to centennial timescales. Using retrospective forecasts (hindcasts) of temperature and precipitation, the predictability of the glacier surface mass balance and snow depth will be assessed for a few glaciers, ice caps and snow sites featuring long observational time series. By providing scenarios of the evolution of glaciers, ice caps, and snow, we expect in particular to narrow the uncertainty especially large at decadal timescales in the projections currently available for the cryosphere. The final objective of this project is to produce real-time forecasts of the glacier surface mass balance and snow depth providing continuous information from the annual to the multi-decadal timescale relevant for socio-environmental applications.

Remaining characters 69

Has a similar proposal in terms of research objectives been submitted to a Horizon 2020 Marie Skłodowska-Curie Individual Fellowship call? ○ Yes ◉ No

Declarations

1) The applicant (future beneficiary) declares to have the explicit consent of all partner organisations (if applicable) 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 applicant (future beneficiary) hereby declares:

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

The applicant (future beneficiary) is only responsible for the correctness of the information relating to his/her own organisation. Where the proposal to be retained for EU funding, the applicant (future beneficiary) 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	BARCELONA SUPERCOMPUTING CENTER - CENTRO NACIONAL DE SUPERCOMPUTACION	Spain	

2 - Administrative data of participating organisations

Future Host Institution

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

Specific Legal Statuses

Research and Innovation legal statuses

Legal person ..... yes

Non-profit ..... yes

International organisation ..... no

International organisation of European interest ..... no

Secondary or Higher education establishment ..... no

Research organisation .....yes

Small and Medium-sized Enterprises (SMEs) .....no

Public body .....yes

Academic Sector ..... yes

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

If the location of the Department carrying out the proposed work is not the same as the location of the Host Institute, please note that although the proposal submission system calculates the budget of the project based on the location of the Host Institute, the budget of the project for the grant agreement will be calculated by using the country coefficient of the location of the Department carrying out the proposed work.

Researcher

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

Last Name*	Verfaillie	Last Name at Birth	
First Name(s)*	Deborah	Gender*	○ Male ◉ Female
Title	Dr.	Country of residence*	Spain
Nationality*	Belgium	Nationality 2	
Date of Birth (DD/MM/YYYY)	01/11/1988	Country of Birth*	Belgium
		Place of Birth	Braine-l'Alleud

Contact address

Current organisation name	Barcelona Supercomputing Center		
Current Department/Faculty/Institute/ Laboratory name	Earth Sciences		
☐ Same as organisation address			
Street	Calle Jordi Girona, 29		
Postcode/Cedex	08034	Town	Barcelona
Phone	+33642863071	Country	Spain
Phone2 / Mobile	+xxx xxxxxxxxx		
E-Mail*	deborah.verfaillie@bsc.es		

ORCID ID	0000-0003-0603-0780	
Researcher ID		*The maximum length of the identifier is 11 characters (ZZZ-9999-2010) and the minimum length is 9 characters (A-1001-2010).*
Other ID	*Please enter the type of ID here*	*Please enter the identifier number here*

Qualifications

Doctorate Date of (expected) award	Select the exact date (DD/MM/YYYY)	24/11/2014
Doctorate start date	Select the exact date (DD/MM/YYYY)	01/10/2011
University Degree giving access to PHD	Date of award (DD/MM/YYYY)	01/07/2011

Place of activity/place of residence (previous 5 years - most recent one first)

Indicate the period(s) and the country/countries in which you have legally resided and/or had your main activity (work, studies, etc) during the last 5 years up until the deadline for the submission of the proposal.

Please fill in this section without gaps. Short stays (as defined in the Guide for Applicants) shall not be listed in this box.

Period from	Period to	Duration (days)	Country
16/04/2018	12/09/2018	150	Spain
01/09/2010	15/04/2018	2784	France
	Total	2934	

Proposal ID **838078** *Acronym* **PERIDoT** *Short name* **BSC**

Supervisor

The name and e-mail of the Researcher and Supervisor are read-only in the administrative form, only additional details can be edited here. To give access rights and 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*: **Francisco J.** Last name*: **Doblas-Reyes**

E-Mail*: **francisco.doblas-reyes@bsc.es**

Position in org.: Earth Sciences Department Director

Department: Earth Sciences

[ ] Same as organisation address

Street: Calle Jordi Girona, 29

Town: Barcelona Post code: 08034

Country: Spain

Website: https://www.bsc.es/doblas-reyes-francisco-j

Phone: +34 934137719 Phone 2: *+xxx xxxxxxxxx* Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Dorota	Chmielewska	dorota.chmielewska@bsc.es	*+34 934134082*

3 - Budget

Is the Researcher eligible for family allowance? (•) Yes ( ) No

Participant Number	Organisation Short Name	Country	Country Coefficient	Number of Months	Researcher Unit Cost			Institutional Unit Cost		Total
					Living Allowance	Mobility Allowance	Family Allowance	Research, training and networking costs	Management and Overheads	
1	BSC	ES	0,954	24	111732,48	14400,00	12000,00	19200,00	15600,00	172932,48
Total					111732,48	14400,00	12000,00	19200,00	15600,00	172932,48

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	
5. ANIMALS		**Page**
Does your research involve animals?	○ Yes ◉ No	
6. THIRD COUNTRIES		**Page**
In case non-EU countries are involved, do the research related activities undertaken in these countries raise potential ethics issues?	○ Yes ◉ No	
Do you plan to use local resources (e.g. animal and/or human tissue samples, genetic material, live animals, human remains, materials of historical value, endangered fauna or flora samples, etc.)?	○ Yes ◉ No	
Do you plan to import any material - including personal data - from non-EU countries into the EU?	○ Yes ◉ No	
Do you plan to export any material - including personal data - from the EU to non-EU countries?	○ Yes ◉ No	
In case your research involves low and/or lower middle income countries, are any benefits-sharing actions planned?	○ Yes ◉ No	
Could the situation in the country put the individuals taking part in the research at risk?	○ Yes ◉ No	
7. ENVIRONMENT & HEALTH and SAFETY		**Page**

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

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

How to Complete your Ethics Self-Assessment

5 - Call specific questions

Eligibility Researcher (future fellow)

1. Were you in the last 5 years in military service? ○ Yes ◉ No

2. Did you spend time on procedures for obtaining refugee status (according to the 1951 Geneva Refugee Convention and the 1967 Protocol) in a Member State or Associated Country? ○ Yes ◉ No

Other Questions

1. For communication purposes only, the European Commission REA asks for permission to publish the name of the researcher (future fellow) should the proposal be retained for funding. Does the researcher (future fellow) give this permission? ◉ Yes ○ No

2. Some national and regional public research funding authorities run schemes to fund MSCA applicants that score highly in the MSCA evaluation but which cannot be funded by the MSCA due to their limited budget. In case this proposal could not be selected for funding by the MSCA, do the researcher and supervisor consent to the European Commission disclosing to such authorities the results of its evaluation (score and ranking range) together with their names and contact details, non-confidential proposal title and abstract, proposal acronym, and host organisation? ◉ Yes ○ No

3. Is there a secondment in Member States or Associated Countries envisaged in Part B of this proposal? ◉ Yes ○ No

In which sector is the secondment in Member States / Associated Countries foreseen?

☒ Academic ☐ Non Academic

Do you already know the organisation to which this secondment will be? ◉ Yes ○ No

Name: Institut des Géosciences de l'Environnement - UMR 5001

Country: France

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.*

1. Excellence

1.1 Quality and credibility of the research/innovation project; level of novelty, appropriate consideration of inter/multidisciplinary and gender aspects

1.1.1 Introduction

Glaciers, ice caps and snow fields around the world represent an important component of the human socio-ecosystem. Most mountain glaciers act as seasonal and long-term "water towers", providing water for domestic use as well as agricultural use and hydropower to mountain and lower-lying cities[1]. More than one billion people rely on freshwater at least partially originating from snow and glacier melt, especially in China and the Himalaya-Hindu Kush region, which represent the third largest glacier area after the Arctic and Antarctica[2]. In many parts of the South American Andes, populations also rely heavily on meltwater from glaciers and snow for domestic consumption and hydropower[2], especially during the dry season when it can be the **only source of fresh water**[3]. This is the case for example of the Bolivian capital city of La Paz, where inhabitants rely almost exclusively on drinking water supplied by the surrounding glaciers and snow fields in summer. Moreover, glaciers and the large ice sheets of Greenland and Antarctica represent **major contributors to current and future sea-level rise**[4,5]. **Glacier-related hazards**[6] (snow/ice avalanches and landslides/floods associated with glacial lake outbursts) as well as **glacier, snow and polar region tourism or cultural/spiritual services** are also paramount for society. In the context of climate change, most of the cryosphere is retreating fast, with strong consequences in terms of glacier-related risks and service[1-4]. It is therefore necessary to **assess their short-to-mid-term (a few years to a few decades) evolution in response to future projected climate change and natural variability in order to better evaluate the upcoming impacts** linked to water scarcity, sea-level rise and the evolution of glacier-related hazards and related services **on society**.

Glaciers and ice caps are **reliable climate indicators**, as they react rather rapidly (within a few days to a few years) to changes in climate[1]. They are mostly sensitive to changes in air temperature (influencing their melt rate) and solid precipitation (influencing the amount of snow accumulated, which later transforms into ice), but other factors can come into play, such as radiation (through their energy balance), wind speed and direction (re-distributing snow), or sea surface temperatures (SST) for marine-terminating glaciers (influencing the iceberg discharge rate, or calving rate, and/or the position of the grounding line, which is the line where the glacier marine margins cease to be in contact with the seafloor)[1]. One of the widely used metrics to measure the evolution of glaciers and ice caps over time is the evolution of their **mass balance** (MB). The MB can be defined as the sum of all ablation (mass removal) and accumulation processes occurring on a glacier over a given time period. The **surface mass balance** (SMB) only includes processes occurring at the surface of the glacier: ablation through surface melt, sublimation and wind erosion, and accumulation through solid precipitation (snow), refreezing or wind deposition[1]. SMB measurements have been carried out at regular intervals (seasonally or annually) for some glaciers through field measurements, for whole glaciers or ice caps through digital elevation model (DEM) differentiation, and globally through satellite gravimetry[1,7]. Field measurements typically feature more accuracy than remote sensing measurements and can provide **continuous annual data as far back as the beginning of the 20th century** (for example, the Claridenfirn glacier in Switzerland displaying SMB observations since 1914)[1,7]. However, they only cover a small proportion of all existing glaciers and ice caps. Additionally, snow depth measurements have been carried out in the French Alps and the Pyrenees since the 1960s (for example at the Col de Porte observatory in the French Alps[8]).

The recent worldwide decline in glaciers and ice caps has been mainly attributed to atmospheric warming[e.g.,1,9-12] and in some regions to declining precipitation[13,14], and oceanic warming through ice-ocean interactions[1,15,16]. Thus **most of the recent negative mass balance of glaciers worldwide has been attributed to anthropogenic forcing**[17]. However, **natural variability** also plays a role in glacier evolution, even though that aspect is not as well understood. This is especially true for the ice sheets in Greenland and Antarctica, since regional climate variability is an important driver of

1. Vaughan, D. G. et al., 2013. *In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. **2.** Barnett, T. P. et al., 2005. *Nature*, 438 (7066), 303–309, doi:10.1038/nature04141. **3.** Bradley, R. S., et al., 2006. *Science*, 312 (5781), 1755-1756, doi: 10.1126/science.1128087. **4.** Church, J. A. et al., 2013. *In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* **5**. Shepherd, A. et al., 2018. *Nature*, 556, 219-222, doi: 10.1038/s41586-018-0179-y. **6.** Website of the Glacier and Permafrost Hazards in Mountains (GAPHAZ) scientific working group: https://www.mn.uio.no/geo/english/research/projects/gaphaz/. **7.** World Glacier Monitoring Service (WGMS) website: https://wgms.ch/. **8.** Morin, S. et al., 2012. Earth Syst. Sci. Data, 4, 13–21, doi: 10.5194/essd-4-13-2012. **9.** Rignot, E. et al., 2003. Science, 302, 434–437, doi: 10.1126/science.1087393. **10.** Willis, M. J. et al., 2012. Geophys. Res. Lett., 39, L17501, doi: 10.1029/2012GL053136. **11.** Berthier, E. et al., 2010. Nat. Geosci., 3, 92–95, doi: 10.1038/ngeo737. **12.** Moholdt, G. et al., 2012. Geophys. Res. Lett., 39, L10502, doi: 10.1029/2012GL051466. **13.** Favier, V. et al., 2016. Sci. Rep., 6, 32396, doi: 10.1038/srep32396. **14.** Salerno, F. et al., 2015. *Cryosphere*, 9 (3), 1229-1247, doi: 10.5194/tc-9-1229-2015. **15.** O'Leary, M. and Christoffersen, P., 2013. *Cryosphere*, 7 (1), 119-128, doi: 10.5194/tc-7-119-2013. **16.** Straneo, F. et al., 2016. *Oceanography*, 29 (4), 34-45, doi:10.5670/oceanog.2016.97. **17.** Marzeion, B. et al., 2014. *Science*, 345 (6199), 919-921, doi: 10.1126/science.1254702.

ice sheet accumulation, melt, and ice-ocean interactions[18,19]. For example, in Greenland, some significant part of the natural climate variability, including the Atlantic Multidecadal Variability (AMV), impacts the ice sheet[18,20,21]. Similarly, in Antarctica, attribution of ice sheet and glacier changes to either anthropogenic forcing or natural variability is challenging[22] because ice-ocean interactions remain poorly understood[e.g.,23,24]. Moreover, a combination of different processes, including the increase in greenhouse gases, stratospheric ozone depletion[25] and tropical Pacific sea surface conditions[26-29], drive atmospheric changes. For mountain glaciers, recent changes are categorically attributed to anthropogenic warming[30], while studies concerning the impact of natural climate variability are rather scarce. Consequently, **most studies of future projections of glacier and ice cap evolution have focussed on their long-term (more than 30 years) evolution**, which is driven primarily by greenhouse gases[4 and refs therein]. However, **substantial uncertainty remains**, which is partly linked to the poor knowledge of natural variability. Moreover, while national governments are interested in the time scales covered by long-term climate projections, **most stakeholders are much more interested in the shorter-term time horizons** (from a few years to a few decades), as this is the horizon over which they plan and operate. However, **those are generally not addressed by glaciologists**, even though new initiatives are emerging (e.g., the recently proposed "Near-term Variability and Prediction of the Antarctic Climate System (AntClimnow)" Scientific Committee on Antarctic Research programme), because at those timescales the natural (internally-generated) variability of climate is about as large as the externally-forced component (due to greenhouse gases and aerosols)[31]. **The understanding of glacier and snow evolution at decadal timescales and the possibility to predict it in real time would benefit many stakeholders**, in particular government agencies and companies managing hydro-power plants, water resources and economic activities related to tourism in mountainous and polar areas. For example, ski resorts, which attract more than 10 million customers every year in France, providing around 1.2 billion € yearly revenue and sustaining more than 120,000 jobs[32] would benefit greatly from such forecasts. In addition, it could provide some early warning of climate change and glacier-related impacts such as glacial lake outburst floods.

Moreover, **glacier evolution is a crucial issue for the scientific community when engaging with the topic of climate change**, because it is such a (visually) strong symbol of the human pressure on the climate system. Anticipating glacier evolution at decadal timescales could reinforce the message of the scientific community since society is highly sensitive to the climate variation at this time scale, whereas it is much harder to mobilise social action for longer-term horizons. Additionally, specific users might be interested in receiving information on glacier and snow evolution at different time horizons, depending on their application. It is therefore crucial to provide them with **a continuous source of information from the annual to the multi-decadal timescales**.

Predicting the climate evolution at decadal timescale is a rather recent area of research called **decadal climate prediction**[33] (DCP). Pioneering studies of DCP[33-35] investigated the capacity of different decadal prediction systems to accurately "predict" past climate variability in retrospective experiments called hindcasts. At the decadal timescale, the observed climate variability can be understood as the superimposition of an anthropogenically-driven trend on natural fluctuations. While the trend is driven by changes in anthropogenic emissions, the natural fluctuations are generated internally by the interactions of the different components of the climate system (atmosphere, ocean and sea ice) or externally by other factors such as volcanic eruptions and solar activity. Provided that these different modes of variability operate on a sufficiently long timescale (multinannual or longer) and can be estimated with a sufficient level of accuracy, they can potentially be a source of skill in a decadal prediction context. Significant skill has been found for surface air temperature over large areas of the globe, and particularly over the ocean [36 and refs therein], since the ocean is the primary driver of decadal variability[37]. Skill was also found for precipitation over land in specific regions. Lately, studies have started looking at the skill of other variables and drivers of the climate variability, such as sea ice, the stratosphere, aerosols, and some land surface components (soil moisture, vegetation, snow and permafrost)[36,38].

18. Wouters, B. et al., 2013. *Nat. Geosci.*, 6, 613, doi: 10.1038/ngeo1874. **19.** Turner, J. et al., 2017. *Rev. Geophys.*, 55 (1), 235-276, doi: 10.1002/2016RG000532. **20.** Ding, Q. et al., 2014. *Nature*, 509 (7499), 209-12, doi:10.1038/nature13260. **21.** Ding, Q. et al., 2017. *Nat. Clim. Change*, 7, 289, doi:10.1038/nclimate3241. **22.** Turner, J. et al., 2016. *Nature*, 535, 411-415, doi: 10.1038/nature18645. **23.** Dutrieux, P. et al., 2014. *Science*, 343 (6167), 174-178, doi:10.1126/science.1244341. **24.** Hellmer, H. H. et al., 2017. *J. Climate*, 30 (12), 4337-4350, doi:10.1175/jcli-d-16-0420.1. **25.** Waugh, D. W. et al., 2015. *J. Climate*, 28 (16), 6581-6586, doi:10.1175/jcli-d-15-0138.1. **26.** Schneider, D. P. et al., 2015. *J. Climate*, 28 (23), 9350-9372, doi:10.1175/jcli-d-15-0090.1. **27.** England, M. R. et al., 2016. *Geophys. Res. Lett.*, 43 (15), 8207-8213, doi:10.1002/2016gl070055. **28.** Raphael, M. N. et al., 2016. *B. Am Meteorol. Soc.*, 97 (1), 111-121, doi:10.1175/bams-d-14-00018.1. **29.** Clem, K. R., 2017. *Clim. Dynam.*, 49 (1-2), 113-129, doi:10.1007/s00382-016-3329-7. **30.** Roe, G. H. et al., 2017. *Nat. Geosci.*, 10 (2), 95-99, doi:10.1038/ngeo2863. **31.** Doblas-Reyes, F. J. et al., 2013. *Nat. Commun.*, 4, 1715, doi:10.1038/ncomms2704. **32.** DSF, 2017. http://www.domaines-skiables.fr/fr/publications/observatoire/. **33.** Smith, D. M. et al., 2007. Science, 317, 796–799, doi:10.1126/science.1139540. **34.** Keenlyside, N. S. et al., 2008. Nature, 453, 84–88, doi:10.1038/nature06921. **35.** Pohlmann, H. and Jungclaus, J. H., 2009. *J. Climate*, 22, 3926–3938, doi: 10.1175/2009JCLI2535.1. **36.** Kirtman, B. et al., 2013. *In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. **37.** Bjerknes, J., 1964. *Adv. Geophys.*, 10, 1-82, doi: 10.1016/S0065-2687(08)60005-9. **38.** Bellucci, A. et al., 2015. *Rev. Geophys.*, 53, 165–202, doi:10.1002/2014RG000473.

However, to our knowledge, the predictability of glaciers and ice caps at decadal timescales has never been investigated, even though we could expect some skill to arise at least for those under the influence of important **modes of variability** in addition to the influence of anthropogenic warming. **The main objective of this project will thus be to assess the question of the predictability of glaciers, ice caps and snow at decadal timescale**, focussing on specific regions where some skill can be expected, as well as **merging long-term projections of their evolution with short-to-mid term predictions to obtain a continuous source of information**. The **quantification of uncertainties in glacier and snow evolution** will also be an important common-thread aspect of this project.

To reach those objectives, the present project is organised in 3 work packages (WP), each addressing a specific goal:

- Evaluate the predictability of specific glaciers, ice caps and snow sites and the added-value of decadal predictions compared to climate projections (**WP1**)
- Produce real-time decadal forecasts of glacier SMB and snow depth at those sites (**WP2**)
- Merge decadal prediction of glacier and snow evolution with longer-term projections (**WP3**)

1.1.2 Research methodology and approach

WP1: Evaluate the predictability of specific glaciers, ice caps and snow sites and the added-value of decadal predictions compared to climate projections (M1-M12)

Task 1.1: List specific glaciers, ice caps and snow sites of interest, based on established or potential sensitivity to modes of variability and the existence of long-enough observational time series (M1-M2)

In this task, we will establish a list of a limited number (4 to 7) of glaciers, ice caps and snow sites that could present some skill on decadal timescales. This selection will be based on two criteria:

- The glacier/ice cap/snow field should be sensitive (established or expected sensitivity) to some modes of variability with skill on multi-annual to decadal timescales, such as the AMV, the Pacific Decadal Oscillation (PDO) [39]/Interdecadal Pacific Oscillation (IPO)[40], the Southern Annular Mode (SAM)[41] or the El Niño Southern Oscillation (ENSO)[42]. The focus will be primarily on glaciers, ice caps and snow sites potentially sensitive to modes of variability, additionally to the predictability that arises from global warming for all cryospheric bodies.
- The time series of observed SMB/SD at each site should be long enough (i.e., at least around 30 years) and continuous (one observation per year needed), to enable the computation of skill metrics on decadal timescales.

Based on those criteria, potential candidates for the glaciers and ice caps include the Jakobshavn Isbrae glacier in Greenland and some alpine glaciers such as Argentière or Saint-Sorlin (influenced by the AMV), glaciers in the Andes such the Antizana, the Zongo or glaciers in the Patagonian Icefields (ENSO, the South Pacific IPO, the SAM), the Chhota Shigri glacier in India or the Mera Peak in Nepal (PDO/IPO and the monsoons), or glaciers of the Antarctic Peninsula (SAM). Long-term snow observatories in the French Alps and the Pyrenees will also be investigated.

Task 1.2: Collect observational time series at the selected sites and evaluate their uncertainty (M3-M4)

Once the glaciers, ice caps and snow sites have been selected, the corresponding SMB and SD observational time series will be collected and quality controlled. Depending on the sites, different sources of information might be used (e.,g. worldwide glacier SMB databases, such as the World Glacier Monitoring Service[7] or from ref. 17), but we will try to favour the use of data coming directly from the team/institution that made the measurements. This task will mainly be achieved through a secondment of two months at the Institut des Géosciences de l'Environnement (IGE) in Grenoble, which is one of the leading institutes on glacier research worldwide. Moreover, it is the provider of many observational datasets on glacier SMB and snow depth, some of which are available through the GLACIOCLIM (Les GLACIers, un Observatoire du CLIMat) national observation service[43]. It will also involve assessing the observational uncertainty associated with these datasets.

Task 1.3: Collect and analyse multi-model hindcasts of cryosphere-relevant climate variables (M5-M8)

Glacier SMB and SD are not variables that are directly available from decadal prediction systems, they will have to be estimated based on hindcasts of temperature and precipitation. We will use the new hindcasts from different contributing decadal prediction systems, made available in 2019 through the Decadal Climate Prediction Project[44]

39. Mantua, N. J. et al., 1997. *B. Am Meteorol. Soc.*, 78, 1069–1079, doi:10.1175/1520-0477(1997)078,1069:APICOW.2.0.CO;2. **40.** Power, S., T. et al., 1999. *Clim. Dynam.*, 15, 319–324, doi: 10.1007/s003820050284. **41.** Thompson, D. W. J. et al., 2011. *Nat. Geosci.*, 4, 741–749, doi: 10.1038/ngeo1296. **42.** Rasmusson, E. M. and J. M. Wallace, J. M., 1983. *Science*, 222, 1195–1202, doi: 10.1126/science.222.4629.1195. **43.** GLACIOCLIM national observation service website: https://glacioclim.osug.fr/. **44.** Boer, G. J. et al., 2016. *Geosci. Model Dev.*, 9, 3751–3777, doi:10.5194/gmd-9-3751-2016.

(DCPP) as a contribution to the 6th Coupled Model Intercomparison Project [45] (CMIP6). Some of the DCPP multi-model temperature and precipitation hindcasts will be performed as part of the H2020 EUropean Climate Prediction system (EUCP, 2018-2021) project[46] in which the candidate is currently involved. Here a selection of the cryosphere-relevant variables and their evaluation in terms of multi-annual skill will be carried out. Their evaluation will provide an estimate of the contribution of the climate prediction system to the final total uncertainty in SMB and SD.

Task 1.4: Multi-model forecast quality estimates of SMB and SD hindcasts on decadal timescales at the sites and assessment of their added value compared to non-initialised projections (M9-M12)

Traditional forecast quality estimates used in decadal prediction, such as the anomaly correlation coefficient (ACC)[47], the reliability or the ranked probability skill score (RPSS)[48], compare ensemble hindcasts with the corresponding observational time series. The latter will be collected from existing datasets (Task 1.2), but the former needs to be estimated for cryospheric variables. This can be achieved through the use of rather simple positive degree-day (PDD) models[49], that calculate daily SMB as the sum of daily snow or ice melt (representative of ablation) and daily accumulation through snow precipitation on the surface of the glacier. Such a PDD model was developed at IGE and applied over different glaciers, such as the Cook Ice Cap on the Kerguelen Islands[13,50]. In this project we plan to use this PDD model, which only requires daily temperature and precipitation anomaly data, to produce hindcasts of SMB on the selected glaciers and ice caps and SD for specific sites in the French Alps and Pyrenees. This represents a first unprecedented approach to investigate to what extent temperature and precipitation provide cryosphere-relevant information at the decadal timescale. Becoming familiar with the model and its calibration will be carried out at IGE during the second half of the secondment mentioned above. Degree day factors for snow and ice, accounting for the amount of snow-covered/bare ice that melt per degree per day, will be estimated for each glacier from refs 49,51,52. For snow sites, daily snow melt and accumulation on bare soil instead of ice using the same model will be considered.

As glacier response through SMB integrates climate evolution on multiple years, skill could be calculated over rather long time periods, such as 2-9 years after initialisation[48], which would provide higher skill than if integrated on shorter time scales. The mean snow depth over multiple years will also be considered. Once multi-model hindcasts of SMB and SD have been estimated, the forecast quality metrics mentioned above will be calculated to assess the forecast quality at decadal time scales. Also, their added value with respect to a benchmark taken from the climate-change projections will be estimated in a comparison over the same period of validity of the decadal predictions. Additionally, the contribution of the glaciological model to the overall uncertainty in SMB and SD will be assessed.

WP2: Produce real-time decadal forecasts of glacier SMB and snow depth at those sites (M13-M16)

Task 2.1: Produce multi-model real-time forecasts of climate variables relevant for the cryosphere (M13-M14)

Forecasts correspond to the actual future predictions of climate models, initialised at a given date and run for a few years (as opposed to hindcasts, which are retrospective runs of the same models). To produce decadal forecasts (2020-2029) of temperature and precipitation, we will run the EC-Earth prediction system[53] developed at the Barcelona Supercomputing Center (BSC), one of the World Meteorological Organization (WMO) recognised near real-time producing centre, using current observations. Additionally, we will make use of other near real-time decadal forecasts available through the Multi-model decadal forecast exchange[54] coordinated by the UK Met Office in which BSC participates. All of these forecast systems have corresponding hindcasts developed for the DCPP and CMIP6 projects (used in Task 1.3). Forecasts will be calibrated to account for any bias or lack of reliability identified in the hindcasts.

Task 2.2: Compute multi-model decadal forecasts of SMB and SD for the selected sites (M15-M16)

Similarly to the work done in Task 1.4, multi-model decadal forecasts of SMB and SD for the selected sites will be carried out using the PDD model previously calibrated and used for producing hindcasts. In doing so, we make the (rather reasonable) hypothesis that the sensitivity of SMB/SD to climate (and especially to temperature through the degree day factors for snow and ice) will not change in the coming decade. Moreover, **the probability of reaching a given societally critical SD, SMB or glacier extent threshold** (to be determined based on each case, e.g., total glacier disappearance, or snow-free areas for multiple years) **in the future will be estimated** in the calibrated forecasts.

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45. Eyring, V. et al., 2016. *Geosci. Model Dev.*, 9, 1937–1958, doi:10.5194/gmd-9-1937-2016. **46.** Website of the EUCP project: https://www.eucp-project.eu/. **47.** Knight, J. R. et al., 2014. *J. Climate*, 27, 7550–7567, doi: 10.1175/JCLI-D-14-00069.1. **48.** Goddard, L. et al., 2013. *Clim. Dynam.*, 40, 245-272, doi: 0.1007/s00382-012-1481-2. **49.** Radic, V. and Hock, R., 2011. *Nat. Geosci.*, 4, 91–94, doi: 10.1038/ngeo1052. **50.** Verfaillie, D. et al., 2015. *J. Geophys. Res. Earth Surf.* 120(3), 637–654, doi: 10.1002/2014JF003329. **51.** Braithwaite, R. J., 1995. *J. Glaciol.*, 41, 153–160, doi: 10.3189/S002214300001784. **52.** Hock, R., 2003. *J. Hydrol.*, 282, 104–115, doi: 10.1016/S0022-1694(03)00257-9. **53.** Hazeler, W. et al., 2010. *B. Am Meteorol. Soc.*, 91, 1357–1364, doi: 10.1175/2010BAMS2877.1. **54.** Website of the Multi-model decadal forecast exchange: https://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/long-range/decadal-multimodel.

WP3: Merge decadal prediction of glacier and snow evolution with longer-term projections (M17-M24)

Task 3.1: Estimate SMB and SD from historical simulations and climate projections (M17-M20)

SMB and SD estimates will be produced from historical climate simulations and climate projections using the same PDD model (Tasks 1.4 and 2.2). Temperature and precipitation available through the CMIP6 project will be used as forcings. To sample the scenario uncertainty range, the two most extreme future scenarios (combination of radiative forcing scenarios and Shared Socio-economic Pathways) [55] considered in CMIP6 will be used, although for the time ranges considered in this study (up to 2050) the differences in scenarios are small. Again, if we use the same degree day factors for snow/ice for future projections as in the hindcasts, we make the assumption that the response of glaciers and snow to climate is stationary over multi-decadal timescales. The sensitivity of future SMB and SD projections to those degree day factors will be assessed by using different scenarios of time-varying factors.

Task 3.2: Merge the information from decadal forecasts and long-term projections of SMB and SD (M21-M24)

Merging the information from decadal forecasts and long-term projections is becoming increasingly called for, as illustrated by the coming 6th Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC), in which near-term prediction and long-term projections are reviewed in the same chapter and the need for their merging is addressed. This challenging task will also be carried out for climate variables in the EUCP project. In the present project, we plan to merge the information from decadal forecasts and projections of SMB and SD in order to provide a continuous source of information for specific glaciers, ice caps and snow sites.

For consistency, we will use forecasts and long-term projections obtained from the same models. Nevertheless, there will be some discontinuities between the decadal predictions and the long-term projections, due to the fact that initialised predictions will inevitably drift from the observed climate, requiring a drift adjustment (while projections are not initialised with observations) and predictions and projections will feature a different spread of possible SMB/SD values at a given date. These discontinuities are what makes this task challenging, although some of those aspects will already be treated for climate variables through the EUCP project. The methods considered for the merging are expert judgement, simple linear combination after calibration and Bayesian regression. The information about the added value of decadal prediction compared to climate projections obtained in Task 1.4 will be used here to assess the time horizon until which decadal predictions provide more information than projections with respect to glacier SMB and SD.

1.1.3 Originality and innovative aspects of the research program

To our knowledge, this is the first time that decadal prediction of glacier/ice cap SMB and SD will be attempted. Decadal prediction of climate is itself a rather new research topic, and decadal climate forecasters and glaciologists have not yet started to work together, despite the obvious interest that there could be in such a collaborative approach (relevance for the study of glacier and snow impacts on society and provision of user-relevant information at those timescales). Moreover, predicting SMB and SD in an operational way is also innovative. Besides, the challenging goal of providing a continuous prediction from annual to multi-decadal timescales by merging climate predictions and climate-change projections has not yet been attempted either, neither for climate variables (which is the main research goal of one of the work packages in the new EUCP project), nor for its impacts on glacier/snow variations. This will provide a continuous source of information on glacier and snow evolution from the annual to the multi-decadal timescales to specific users, such as officials whose town is at risk of running out of water or of being impacted by glacier-related risks, companies involved in the renewal of hydroelectric fleets, or tourism operators (e.g., those involved in ski resorts), who might be interested in this information at different time horizons.

1.1.4 Interdisciplinary aspects

This project is very interdisciplinary, bringing together glaciological/snow sciences, climate sciences, mathematics and socio-economics. Indeed, it merges glaciology/snow research and climate forecasting, climate forecasting and climate change studies, and climate forecasting and local infrastructure and/or social factors. Glaciology and snow sciences involve many aspects of geophysics, through the study of climate-glacier-snow interactions, thermodynamics and the rheology of ice and snow. Climate prediction includes atmospheric sciences, oceanography and climatology, and requires statistical tools for forecast verification and calibration. Additionally, the outcomes of this project will provide relevant information for different socio-economic sectors at different timescales.

55. O'Neill, B. C. et al., 2016. *Geosci. Model Dev.*, 9, 3461–3482, doi: 10.5194/gmd-9-3461-2016.

1.2 Quality and appropriateness of the training and of the two way transfer of knowledge between the researcher and the host

Both the candidate and the BSC will benefit from the implementation of this project in the Earth Sciences Department (BSC-ES). Indeed, the candidate will gain relevant knowledge through the BSC expertise on climate prediction (seasonal to decadal), including data assimilation, initialization, forecast drift, bias adjustment and calibration methods, and post-processing tools. She will also be trained in the use of highly collaborative tools employed at BSC-ES (e.g., gitlab), as well as handling and visualising the large amounts of data involved in multi-model, multi-member decadal forecasts. Other training activities will include proposal writing, project management and statistical programming, including the collaborative development of an R package for forecast verification (s2dverification [56]). The department hosts the Computational Earth Sciences (CES) group devoted to ensuring efficient computational resources and providing data services to BSC researchers, and regular hands-on training sessions are organised, e.g. for programming or data visualisation. The expertise in social sciences of the Earth System Sciences (ESS) group will be useful for identifying relevant problems to investigate, interacting with stakeholders and communicating results to users, especially regarding the identification and the probability of reaching future societally critical SMB thresholds (Task 2.2). Some training in communication to non-specialists will also be scheduled in order to convey results to a large audience.

On the other hand, the expertise the candidate acquired on glaciology during her PhD and snow sciences during her postdoctoral stages will be very useful to the BSC. She is the first member of the Climate Prediction (CP) group with previous experience in glacier/snow observation and modelling and glacier-snow-climate interactions. This will promote the creation of a new line of research within the CP group and BSC-ES, and allow for new collaborations between glaciologists and climate forecasters. In particular, new collaboration opportunities will arise between researchers at the BSC and IGE in Grenoble as a result of the secondment planned in this project. Moreover, the applicant's strong background in long-term climate projection, regional climate modelling and downscaling and bias adjustment techniques will be complementary assets for her work at the BSC. Finally, her experience in computing and scripting languages such as Fortran and python will be useful for the community.

1.3 Quality of the supervision and of the integration in the team/institution

Qualifications and experience of the supervisors

Prof Francisco J. Doblas-Reyes is Research Professor at ICREA (Institució Catalana de Recerca i Estudis Avançats) and head of the BSC-ES department. He is very highly regarded in the field of climate prediction and services development, having received the 2006 Norbert Gerbier-MUMM International Award of the WMO. He was a lead author of the chapter 'Near-term Climate Change: Projections and Predictability' of the Fifth Assessment report (AR5) of the IPCC and coordinating lead author of the chapter "From global to regional climate information" of the AR6. He is a member of numerous international scientific committees e.g. co-chair of the Modelling Advisory Council (WMAC) of the World Climate Research Programme (WCRP) and member of the Decadal Climate Prediction Panel (DCPP). He was co-chair of the Working Group on Seasonal-to-Interannual Prediction (WGSIP) and member of the Polar Prediction Project (PPP) of the World Weather Research Programme. Prof Doblas-Reyes is experienced in the fields of climate dynamics, services and prediction with outstanding proven supervision and project management skills. In addition to a long list of more than 100 scientific peer-review papers with high citation impact (h-index of 40), his experience is also confirmed by the fact that he led or is currently leading numerous projects, among others the FP7 SPECS (308378) and H2020 EUCP (776613) projects as well as of a number of contracts with the Copernicus Climate Change Service. Finally, it is worth noting that four of the MSC Individual Fellowships have been awarded under his supervision: DPETNA (655339), INCLIDA (275505), CLIM4CROP (740073) and SPFireSD (748750).

Dr Vincent Favier is glaciologist and climate scientist at IGE. He manages the GLACIOCLIM observatory in Antarctica aiming at performing long term glaciological measurements and developing regional-scale modelling approaches of the SMB and heat budget. He has supervision and project management skills (PI of several projects with more than 1M€ of funding over the last 10 years) as reflected by his position as co-head of the "GLACE" team at IGE (20 permanent and 30 non-permanent members). From 2005 to 2007 he also was head of the Glaciology Group at the CEAZA (Centro de Estudios Avanzados en Zonas Áridas), La Serena, Chile. He is French national representative in the standing scientific group on physical sciences of the SCAR (Scientific Committee on Antarctic Research). Since 2004, Dr Favier co-authored 43 peer-reviewed publications (8 as first author, h-index=24, citations>2000) in glaciology, hydrology, climate and paleoclimate, including 2 articles in Nature. He supervised 6 PhD theses including the candidate's.

56. Manubens, N. et al., 2018. *Environ. Modell. Softw.*, 103, 29-42, doi: 10.1016/j.envsoft.2018.01.018.

Dr Martin Ménégoz is a climate scientist with 12 years of experience, who recently joined the Centre National de la Recherche Scientifique (CNRS, France) at IGE. Expert in climate variability from annual to centennial timescales, he has also a strong knowledge on the cryosphere and hydrosphere and in aerosol science. Active in the development of global and regional climate models, and in particular of the European model EC-Earth, he uses them to investigate the natural and anthropogenic sources of climate variability. He is also involved in the management of GLACIOCLIM. He is currently part of several French national projects that aim at understanding the climate response to external forcings, greenhouse gases and pollution, as well as its socio-environmental consequences, e.g. water resource and sea-level changes. He is largely involved in BSC activities where he worked from 2014 to 2017, through a Spanish project and European initiatives. Dr Ménégoz has 21 articles in peer-review journals (8 as first author, h-index=12), one highlight in Nature Climate Change and 764 citations. He regularly reviews papers for international journals and supervised several master students and two post-doctorates. His scientific background and skill in modelling and observational approaches coupled to his large international network of collaborations are solid basis to support this MSC project.

Hosting Arrangements

BSC will facilitate the integration of the candidate by providing access to a personal workstation, laptop, BSC's High Performance Computing (HPC) facilities, BSC and UPC facilities such as library, conference rooms and several services (internal trainings/seminars, language classes, health insurance, entry permits). BSC has made a Declaration of Endorsement to the principles of the "European Charter for Researchers" and "The Code of Conduct for the recruitment of researchers" and was awarded with the "HR Excellence in research" category. The candidate will be part of the CP group in BSC-ES and will carry out her project in close collaboration with both the computational earth sciences (CES) and the earth system services (ESS) groups. The CP group undertakes advanced research to forecast climate variations from one month to several years into the future (seasonal-to-decadal prediction) and from regional to global scales. It is a highly productive scientific entity that has published more than 100 research articles in peer-reviewed journals over the last 5 years, some of them in prestigious high-impact journals. The CES group provides help and guidance to the scientists with technical issues relating to their work and develops a framework for the most efficient use of HPC resources. The candidate will benefit from technical help (tool development and optimization, installation and upgrade of various software) and training (e.g., through hands-on sessions) from members of the CES group. Finally, the ESS group aims to bridge the gap between climate information and end users in key sectors of society via tailored services to societal actors. They develop these non-profit services in-house in collaboration with public administrations, private companies or funding agencies, and spin-off companies that could exploit operational opportunities. Their tight link to social sciences will provide key guidance for the candidate as part of this project.

IGE is a public research laboratory in Earth and Environmental Sciences, created on 1 January 2017 by the merging of LGGE (Laboratory of Glaciology and Geophysics of the Environment) and LTHE (Laboratory of Transfers in Hydrology and Environment). One of the main strengths of IGE is the diversity of the geographical zones they investigate, which requires the long-term monitoring, and an understanding, of the processes related to global changes, their interfaces and their interactions. In particular, the institute has a long expertise in glacier observation and modelling, and is host to several national observation services, among others, the GLACIOCLIM observatory.

1.4 Potential of the researcher to reach or re-enforce professional maturity/independence during the fellowship

The candidate has a strong multidisciplinary background, acquired through her PhD on glacier-climate interactions in the sub-Antarctic region and her study of climate projections and their impact on snow in the French mountain regions carried out during her previous post-doctoral positions. During the latter, she also gained knowledge on operational aspects of climate predictions, climate services and user-targeted studies. She has published 11 articles (4 as first author), which were cited 163 times, and has contributed to a book chapter on climate change and adaptation in France. Her h-index is 5. She has had 11 oral presentations and 3 posters in international conferences and workshops and gave 2 public presentations to non-specialist audiences. She has some experience in teaching at the university, has supervised 5 different students over the last 6 years and took part in 2 field campaigns as part of her PhD.

Her previous work also allowed her to develop a large contact network in the glaciological, snow and climate research communities, which will be further extended to the climate prediction research community through the implementation of this project at the BSC. It will additionally offer her the opportunity to collaborate in European projects (such as H2020 EUCP-776613). Building on the host institution's expertise on climate prediction in general, and at decadal timescales in particular, and her own expertise in glaciology, snow sciences and climate projections, the candidate will develop a new research line within the CP group. She will receive substantial guidance in this respect from her supervisor and from BSC's Project Management staff, mainly through the drafting of a Career Development Plan before the beginning of the project, which will include short and long-term objectives as well as training requirements.

Developing this new research line at the BSC will enable the candidate to establish herself as an expert in the host institution but also at the international level, and ultimately as the leader of a small research team on this topic. Furthermore, this highly novel project will also allow her to gain further scientific visibility in the international community and to develop her own independent research. During this fellowship, the candidate will gain more experience in leadership, project management and multidisciplinary collaborative research at the European level.

2. Impact

2.1 Enhancing the future career prospects of the researcher after the fellowship

Through her work at the BSC and secondment at IGE, the researcher will broaden her scientific knowledge in a research field - decadal prediction - that is new to her, and acquire new competences and skills that will enhance her future career prospects. In particular, she will benefit from the BSC's highly collaborative environment to further develop her statistical and computing skills, and the training she will receive on leadership, project management and communication will serve her throughout her scientific career. Her participation in different European projects and the collaborations she will develop through her secondment will help her to build a broad international research network.

The development of a new research line within BSC-ES could ultimately lead to the development of a small research team in the subject, led by the candidate. It will therefore provide her with the skills necessary to produce her own research and lead an independent research group. The researcher will presumably become an international leading expert on decadal prediction of glacier and snow evolution, relevant for the impacts of cryospheric changes on society, such as water scarcity, sea-level rise, evolution of glacier-related hazards and services. The simple approach considered in this project (PDD model using only precipitation and temperature as input) could ultimately develop into a more complex one, building on (and contributing to) the future efforts on seasonal to decadal prediction of snow and glaciers (e.g., through the H2020 PROSNOW-730203 project or the AntClimnow SCAR programme). Finally, as beneficiary of the MSC fellowship and through the development of the different competencies outlined above, the candidate will be in an advantageous position to apply for future grants (e.g., the ERC Starting grants), national or international projects (e.g., H2020 projects) and permanent positions in research centres around the world.

2.2 Quality of the proposed measures to exploit and disseminate the project results

The results obtained through this project will be disseminated to the wider scientific community through publications in international peer-reviewed journals. Considering the highly innovative aspect of the research proposed here, high-impact journals such as Science or Nature will be a target. Four publications are foreseen. The first one will provide a review of glaciers/snow sites of interest for decadal prediction and evaluate their sources of predictability (WP1). A complementary publication will focus on the added-value of decadal prediction compared to climate projections in terms of cryosphere-relevant climate information (Task 1.4). A third publication will present the new real-time decadal forecasts of glacier SMB and SD (WP2). The fourth publication will address the merging of decadal prediction and long-term projections of glacier and snow evolution (WP3). In order to guarantee open access to all peer-reviewed scientific publications related to the project, BSC will provide open access and will deposit all the papers in a repository (UPCommons institutional repository: https://upcommons.upc.edu/) to ensure they are preserved in the long term.

Additionally, the project activities and results will be presented in high-level international conferences. The European Geoscience Union (EGU) and American Geoscience Union (AGU) hold general assemblies every year and are attended by climate prediction, climate projection specialists and glaciologists alike. The International Glaciological Society (IGS) also organises several symposia per year, in which the candidate could participate. Some punctual conferences on climate and decadal prediction, such as the CMIP6 conference organised at BSC in March 2019, have already been considered. Attending several of these conferences will allow disseminating results to key researchers and end-users as well as expanding the candidate's contact network and increase her knowledge on cutting-edge climate prediction and cryospheric research. The candidate will also present her results to scientific partners at IGE, inviting also any stakeholders identified during the life of this grant, at the end of the project.

Moreover, in order to benefit society, the results of this project must be communicated to specific users such as government officials, institutions and companies managing hydro-power plants, water resources and economic activities related to tourism in mountainous and polar areas. This will be especially relevant for the "early warning" aspects of glacier evolution and the probability of reaching a given future societally critical SD, SMB or glacier extent threshold. In order to disseminate those results efficiently to the users, the project will be conducted in tight collaboration with the ESS group. The BSC visualization group has already been involved in developing websites to disseminate climate prediction products such as tropical cyclone prediction (www.seasonalhurricanepredictions.org). A similar website will be built to broadcast the EC-Earth decadal forecasts for DCPP and glaciological/snow predictions produced in this project.

2.3 Quality of the proposed measures to communicate the project activities to different target audiences

One of the priorities of the fellowship will be to seek public engagement through the active and effective communication of results to non-specialized audiences and students. The applicant will have the support of the BSC communication group, the ESS group and the CNRS communication service for the following planned activities:

- Inclusion of the project information, progress and results in several dissemination activities of the BSC (e.g., website, presentations, leaflets, brochures, videos),
- Development and maintenance of BSC and GLACIOCLIM webpages to disseminate the glacier/snow forecasts,
- Participation in MareNostrum open day events, aimed at high school, graduate students, and general public, among others through the "We are young women researchers" project aimed at bridging the gender gap in the science and technology field, as well as in DataBeersBCN events and European Researchers' Night (ERN) events,
- Academic cooperation with universities in Barcelona and their PhD and MSc programs (in particular the Meteorology or the Soil and Water Management MSc programs at Universitat de Barcelona, or the Modelling for Science and Engineering MSc program of the Universitat Autònoma de Barcelona).
- As much as possible, the researcher will also publish highlights of her research to less specialised scientific journals like CLIVAR Exchanges, or through press releases on publicly accessible websites such as the CNRS journal (in France, https://lejournal.cnrs.fr/) or GlacierHub (http://glacierhub.org/).

3. Quality and Efficiency of the Implementation

3.1 Coherence and effectiveness of the work plan, including appropriateness of the allocation of tasks and resources

The project is divided into the following work packages, with the following milestones, deliverables and secondments (Table 1). The planning of the project in terms of person-months has been carefully thought out and accounts for delays and re-planning if necessary (WP2 and WP3 are independent and could be switched in case the decadal forecasts were delayed). All three WPs have been designed to fully benefit from the expertise of the BSC on climate prediction, the candidate's expertise on glacier-snow-climate interactions and climate projections, and IGE's expertise on glacier observation. Task 1.1 and 1.2 will be attained with the help of co-supervisors at IGE. Task 1.3 will be made possible by taking advantage of climate simulations available through the DCPP and EUCP projects. For Task 1.4, the PDD model used to calculate SMB and SD is already available and has been tested on various glaciers. The candidate will further benefit from the expertise on forecast evaluation at the BSC. Task 2.1 and 2.2 will be reached using the EC-Earth model developed at BSC (and its computing resources) as well as through collaboration with other forecasting groups through the the multi-model decadal forecast exchange. Additionally, the candidate will benefit from the assistance of the visualization group at BSC for her webpages. Task 3.1 will be made possible thanks to the expertise of the candidate on climate projections and glaciers/snow, and using the same PDD model as for Task 1.4. Finally, for Task 3.2, the candidate will benefit from the innovative work planned within the EUCP project on this topic. Deliverables will be available on the date planned in the form of BSC-ES technical memoranda.

Work Packages (WP)

WP1: Evaluate the predictability of specific glaciers, ice caps and snow sites and the added-value of decadal predictions compared to climate projections (M1-M12)
WP2: Produce real-time decadal forecasts of glacier surface mass balance and snow depth at those sites (M13-M16)
WP3: Merge decadal prediction of glacier and snow evolution with longer-term projections (M17-M24)

Milestones (M)

M0 Career Development Plan drafted (M1)
M1.1 List of specific glaciers, ice caps and snow sites of interest (M2)
M1.2 Observational time series of SMB and SD at selected sites and uncertainty quantification (M4)
M1.3 Multi-model hindcasts of cryosphere-relevant climate variables (M8)
M1.4 Multi-model skill estimates of SMB/SD hindcasts and added value compared to non-initialised projections (M12)
M2.1 Multi-model real-time forecasts of climate variables relevant for glaciers and snow (M14)
M2.2 Multi-model decadal forecasts of SMB and SD and first version of webpages (M16)
M3.1 SMB and SD from historical simulations and climate projections (M20)
M3.2 Merged information from decadal forecasts and long-term projections of SMB and SD (M24)

Deliverables (D)

D1.1 Article on glaciers and snow sites of interest for decadal prediction and their predictability submitted (M10)
D1.2 Article on the added-value of decadal prediction compared to climate projection in terms of cryosphere-relevant climate information submitted (M12)

D2.1 Article on the new decadal forecasts of glacier SMB and snow depth submitted and press release (M16)
D3.1 Article on the merging of decadal prediction and long-term projection of SMB/SD submitted, press release (M24)
D0.1 Final project report (M24)

Secondments/Visits

Visits are planned at IGE in Grenoble, in collaboration with the Centre d'Etudes de la Neige (CEN), to collect SMB and SD observational time series (Task 1.1, M3) and to become familiar with the PDD model and its calibration (Task 1.4, M4). A short visit is also planned there at the end of the project to present results to the scientific partners (M23).

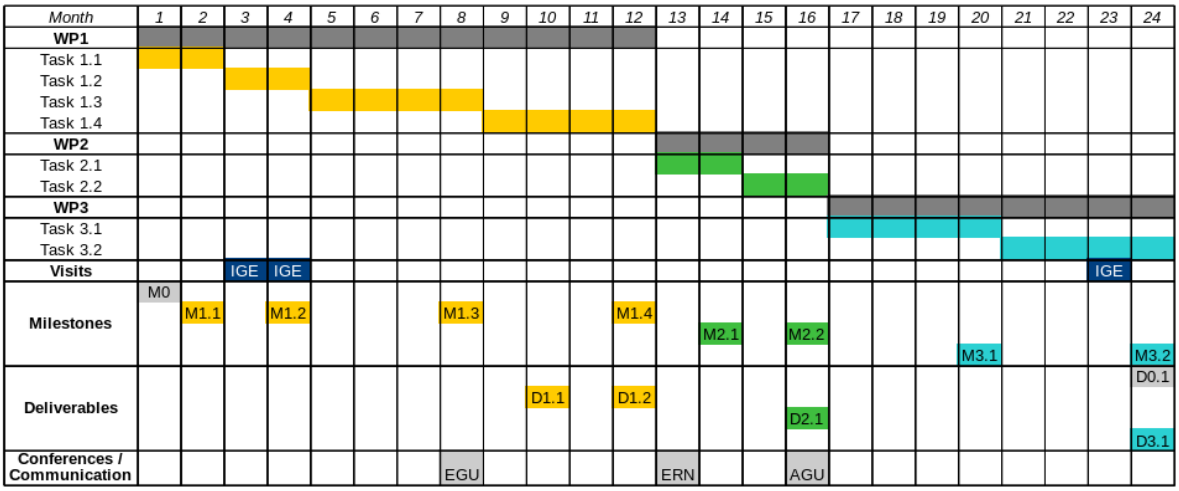

Table 1: Gantt chart of the PERIDoT project. Only events for which the approximate dates are already known are indicated.

3.2 Appropriateness of the management structure and procedures, including risk management

A project manager will support the researcher in all the legal, financial and administrative arrangements needed and work in close contact with the Education, Human Resources and Communications groups for all training arrangements and dissemination and outreach activities. As a result of its effort to foster research careers and strengthen internal training, based on the principles of the European Charter for Researchers and on the Code of Conduct for Recruitment, the BSC was awarded with the badge of Human Resources Excellence in Research (HRS4R) in 2015. Finances of the project will be managed according to MSC funding rules signed at the grant agreement and will follow the already established processes in the centre. Moreover, the financial management strategy will try to maximize the impact of travels by associating each conference participation to short visits or research talks at other institutions. The applicant will work in close contact with the supervisor of this project, scheduling fortnightly meetings to discuss progress and results. Results will also be presented to the scientific staff on a regular basis through participation in the CPG meetings and internal seminars of the BSC-ES. This will allow the evaluation of her progress against the work plan and Career Development Plan and to identify any risks, to implement contingency plans in a timely and periodic manner if the need arises. The potential risks identified at this stage do not pose a threat to the successful implementation of the project goals. Nonetheless, we list below the minor risks and mitigation measures associated.

Task	**Risk**	**Mitigation measure**
Task 1.1/1.2	Not long-enough data on SMB available at specific sites	Use glacier length data instead, which go back further in time
Task 1.3/3.1	Decadal simulations from DCPP/climate projections from CMIP6 are delayed	Use CMIP5 simulations instead, which are already available

3.3 Appropriateness of the institutional environment (infrastructure)

The BSC provides outstanding HPC infrastructures, computational resources, and IT support to perform and analyze the climate model simulations of this project (cf. Section 5). The BSC-ES has a high-quality IT support team - optimizing computational codes, developing tools to launch, monitor and process experiments as well as strong experience in forecast verification tools - who is ready to assist the applicant in computational and technical issues. The secondment at IGE will provide the candidate with support regarding the choice and collection of glacier and snow observational data and with SMB modelling. The BSC has extensive experience in hosting fellows, always providing them with the best project management support. The combination of outstanding HPC facilities, high quality user support, training opportunities, an exciting collaborative research environment and experience in hosting fellows will provide the candidate a perfect environment to guarantee a successful completion of the proposed research.

4. CV of the experienced researcher

Personal information

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Research interests

- Climate variability : observations, models, forecasts and long-term projections
- Mountain and polar cryosphere
- Glacier-climate and snow cover-climate interactions

Education

24/11/2014	PhD degree - Joseph Fourier University - LGGE laboratory (Grenoble) *Monitoring and modelling of the mass balance of the Cook Ice Cap, Kerguelen Islands – link with climate change* - Supervisors: Hubert Gallée & Vincent Favier
01/07/2011	Master degree in Sciences, Technology, Health - Joseph Fourier University Grenoble - Earth and Environment Sciences, speciality Ocean, Atmosphere, Hydrology, hydraulic Engineering and Environment. Master 2 internship: *Snow accumulation variability in Adelie Land (East Antarctica) derived from radar and ice core data. A transect from Dome C to Dumont-d'Urville*
01/07/2009	Bachelor degree in Geosciences and Environment - Lille 1 University Master 1 internship: *Mineralogical characterisation of aerosols collected in the South Atlantic Ocean aboard Marion-Dufresne*

Positions

16/04/2018 - present	Research Scientist – Barcelona Supercomputing Center *H2020 EUCP project*: Forecast evaluation, calibration and bias adjustment. Methods to provide seamless climate information for 1-40 year time scales
01/10/2016 – 31/03/2018	Beginner Researcher – Météo France - Centre d'Etudes de la Neige (Grenoble) *INTERREG POCTEFA Clim'Py project*: Characterisation of climate evolution and provision of information for adaptation in the Pyrenees
01/04/2015 – 30/09/2016	Engineer in meteorology - CNRS - Centre d'Etudes de la Neige (Grenoble) *GICC ADAMONT project*: Downscaling of climate change in mountain regions and simulation of its impact
01/10/2014 – 28/02/2015	Engineer in scientific calculation - CNRS - LGGE laboratory (Grenoble) *LEFE-KCRuMBLE and IPEV GLACIOCLIM-KESAACO projects*: Kerguelen climate regionalization and mass and energy balance modeling.

Metrics (Researchgate)

Publications	11 (+4 under review)
Citations	163
h-index	5

Peer-reviewed publications

Articles under review:

- G. Evin, B. Hingray, J. Blanchet, N. Eckert, S. Morin, and **D. Verfaillie**: Partitioning uncertainty components of an incomplete ensemble of climate projections using data augmentation, Journal of Climate.
- **D. Verfaillie**, V. Favier, H. Gallée, X. Fettweis, C. Agosta, and V. Jomelli: Regional modeling of surface mass balance on the Cook Ice Cap, Kerguelen Islands (49ºS, 69ºE), Climate Dynamics.
- H. Lievens, R.H. Reichle, M. Girotto, L. Brucker, E. Kim, C. Marty, T. Jonas, M. Olefs, M. Dumont, **D. Verfaillie**, J. Schöber, and G. J. M. De Lannoy: Mapping snow water equivalent in the European Alps with Sentinel-1, Water Resources Research.
- P. Sielenou, N. Eckert, P. Naveau, S. Morin, G. Giraud, M. Dumont, and **D. Verfaillie**: Combining random forests and class-balancing to discriminate low, moderate and high avalanche activity days in the French Alps, Cold Regions Science and Technology.

Published articles:

1. **D. Verfaillie**, M. Lafaysse, M. Déqué, N. Eckert, Y. Lejeune, and S. Morin, 2018: Multi-component ensembles of future meteorological and natural snow conditions for 1500 m altitude in the Chartreuse mountain range, Northern French Alps, The Cryosphere, 12, 1249-1271 (citations: 3).
2. V. Jomelli, I. Schimmelpfennig, V. Favier, F. Mokadem, A. Landais, V. Rinterknecht, D. Brunstein, **D. Verfaillie**, C. Legentil, G. Aumaitre, D. Bourlès, and K. Keddadouche, 2018: Glacier extent in sub-Antarctic Kerguelen Archipelago from MIS 3 period: Evidence from 36 Cl dating, Quaternary Science Reviews, 183, 110-123 (citations: 0).
3. **D. Verfaillie**, M. Déqué, S. Morin, and M. Lafaysse, 2017: The method ADAMONT v1.0 for statistical adjustment of climate projections applicable to energy balance land surface models, Geoscientific Model Development, 10, 4257-4283 (citations: 3).
4. V. Jomelli, F. Mokadem, I. Schimmelpfennig, E. Chapron, V. Rinterknecht, V. Favier, **D. Verfaillie**, D. Brunstein, C. Legentil, E. Michel, D. Swingedouw, A. Jaoen, G. Aumaître, D.L. Bourles, and K. Keddadouche, 2017: Sub Antarctic glacier extensions in the Kerguelen region (49°S, Indian Ocean) over the past 23 000 years constrained by 36Cl moraine dating, Quaternary Science Reviews, 162, 128-144 (citations: 1).
5. V. Favier, **D. Verfaillie**, E. Berthier, M. Ménégoz, V. Jomelli, J.E. Kay, L. Ducret, Y. Malbéteau, D. Brunstein, H. Gallée, Y.-H. Park, and V. Rinterknecht, 2016: Atmospheric drying as the main driver of dramatic glacier wastage in the southern Indian Ocean, Scientific Reports, 6, 32396 (citations: 4).
6. V. Jomelli, T. Lane, V. Favier, V. Masson-Delmotte, D. Swingedouw, V. Rinterknecht, I. Schimmelpfennig, D. Brunstein, **D. Verfaillie**, K. Adamson, L. Leanni, F. Mokadem, and ASTER Team, 2016: Paradoxical cold conditions during the medieval climate anomaly in the Western Arctic, Scientific Reports, 6, 32984 (citations: 5).
7. **D. Verfaillie**, V. Favier, M. Dumont, V. Jomelli, A. Gilbert, D. Brunstein, H. Gallée, V. Rinterknecht, M. Ménégoz, and Y. Frenot, 2015: Recent glacier decline in the Kerguelen Islands (49°S, 69°E) derived from modeling, field observations and satellite data, Journal of Geophysical Research Earth Surface, 120, 637-654 (citations: 4).
8. D.A. Hodgson, A.G.C. Graham, S.J. Roberts, M.J. Bentley, C. Ó Cofaigh, E. Verleyen, W. Vyverman, V. Jomelli, V. Favier, D. Brunstein, **D. Verfaillie**, E.A. Colhoun, K.M. Saunders, P.M. Selkirk, A. Mackintosh, D.W. Hedding, W. Nel, K. Hall, M.S. McGlone, N. Van der Putten, W.A. Dickens, and J.A. Smith, 2014: Terrestrial and submarine evidence for the extent and timing of the Last Glacial Maximum and the onset of deglaciation on the maritime-Antarctic and sub-Antarctic islands, Quaternary Science Reviews, 100, 137–158 (citations: 31).
9. The RAISED Consortium, M.J. Bentley, C. Ó Cofaigh, J.B. Anderson, H. Conway, B. Davies, A.G.C. Graham, C.-D. Hillenbrand, D.A. Hodgson, S.S.R. Jamieson, R.D. Larter, A. Mackintosh, J.A. Smith, E. Verleyen, R.P. Ackert, P.J. Bart, S. Berg, D. Brunstein, M. Canals, E.A. Colhoun, X. Crosta, W.A. Dickens, E. Domack, J.A. Dowdeswell, R. Dunbar, W. Ehrmann, J. Evans, V. Favier, D. Fink, C.J. Fogwill, N.F. Glasser, K. Gohl, N.R. Golledge, I. Goodwin, D.B. Gore, S.L. Greenwood, B.L. Hall, K. Hall, D.W. Hedding, A.S. Hein, E.P. Hocking, M. Jakobsson, J.S. Johnson, V. Jomelli, R.S. Jones, J.P. Klages, Y. Kristoffersen, G. Kuhn, A. Leventer, K. Licht, K. Lilly, J. Lindow, S.J. Livingstone, G. Mass, M.S. McGlone, R.M. McKay, M. Melles, H. Miura, R. Mulvaney, W. Nel, F.O. Nitsche, P.E. O'Brien, A.L. Post, S.J. Roberts, K.M. Saunders, P.M. Selkirk, A.R. Simms, C. Spiegel, T.D. Stolldorf, D.E. Sugden, N. van der Putten, T. van Ommen, **D. Verfaillie**, W. Vyverman, B. Wagner, D.A. White, A.E. Witus, and D. Zwartz, 2014, 2014: A community-based geologi-

cal reconstruction of Antarctic Ice Sheet deglaciation since the Last Glacial Maximum, Quaternary Science Reviews, 100, 1–9 (citations: 96).

10. **D. Verfaillie**, M. Fily, E. Le Meur, O. Magand, B. Jourdain, L. Arnaud, and V. Favier, 2012: Snow accumulation variability derived from radar and firn core data along a 600 km transect in Adelie Land, East Antarctic plateau, The Cryosphere, 6, 1345–1358 (citations: 16).

Non-Peer-Reviewed Publications/Book chapters

1. G. Evin, N. Eckert, B. Hingray, **D. Verfaillie**, S. Morin, M. Lafaysse, and J. Blanchet, 2018: Traiter l'incertitude des projections climatiques, Schweizerische Zeitschrift fur Forstwesen, 169 (4), 203-209.
2. D'Amico et al., 2018: Massifs montagneux – Les Pyrénées. in Comité Scientifique Régional AcclimaTerra sous la direction de Hervé Le Treut, Anticiper les changements climatiques en Nouvelle-Aquitaine. Pour agir dans les territoires, Éditions Région Nouvelle-Aquitaine, 488 p., ISBN 978-2-9564516-0-0.

Presentations at scientific meetings

1. 2nd Workshop on Bias Correction in Climate Studies, Santander (Spain), 14-16/05/2018. Talk: The ADAMONT method for statistical adjustment of climate projections and seasonal-to-decadal predictions applicable to energy balance land surface models. **D. Verfaillie**, M. Déqué, S. Morin, M. Lafaysse, J.M. Soubeyroux, S. Bernus, V. Gouget, R. Samacoits, P. Lassègues, P. Etchevers, A.L. Gibelin, L. Batté, C. Viel, L.P. Caron, F.J. Doblas-Reyes.
2. Clim'Py workshop, Andorra-la-vella (Andorra), 31/01/2018. Talk : Pyrenean-wide reanalysis and climate projections of meteorological and snow conditions. **D. Verfaillie**, J.-M. Soubeyroux, S. Morin.
3. EGU General Assembly, Vienna (Austria), 24-28/04/2017. Talk: Projections of meteorological and snow conditions in the Pyrenees using adjusted EURO-CORDEX climate projections. **D. Verfaillie**, M. Déqué, S. Morin, J.-M. Soubeyroux, M. Lafaysse.
4. EGU General Assembly, Vienna (Austria), 24-28/04/2017. Poster: A statistical adjustment approach for climate projections of snow conditions in mountain regions using energy balance land surface models. **D. Verfaillie**, M. Déqué, S. Morin, M. Lafaysse.
5. Journées Glaciologie-Nivologie-Hydrologie de Montagne de la SHF, Grenoble, 22-23/03/2017. Talk (in French): Projections de l'enneigement dans les Alpes et les Pyrénées obtenues à partir de projections climatiques EURO-CORDEX ajustées par la méthode ADAMONT. **D. Verfaillie**, M. Déqué, S. Morin, M. Lafaysse, J .-M. Soubeyroux
6. 1st SURFEX users workshop, Toulouse, 27/02-01/03/2017. Talk: Numerical simulations of snow on ski slopes using SURFEX/ISBA-Crocus-RESORT. P. Spandre, S. Morin, **D. Verfaillie** (presenting), H. François, M. Lafaysse, E. George-Marcelpoil
7. 2nd INARCH workshop, Grenoble, 17-19/10/2016. Talk: Projections of meteorological and snow conditions at Col de Porte (French Alps) using downscaled and adjusted EURO-CORDEX climate projections. **D. Verfaillie**, M. Déqué, S. Morin, M. Lafaysse
8. Journées R&D, Toulouse, 15/06/2016. Talk (in French): Descente d'échelle et correction de projections climatiques – application aux conditions d'enneigement dans les Alpes françaises. **D. Verfaillie**, M. Déqué, S. Morin, M. Lafaysse
9. 1st MAR workshop, Liège (Belgium), 08-09/06/2016. Talk: Monitoring and modelling of the mass balance of the Cook Ice Cap, Kerguelen Islands –link with climate change. **D. Verfaillie**, V. Favier, H. Gallée
10. ICRC-CORDEX conference, Stockholm (Sweden), 17-20/05/2016. Talk: A downscaling and bias-correction approach for climate projections of snow conditions in mountain regions using energy balance land surface models. **D. Verfaillie**, M. Déqué, S. Morin, M. Lafaysse
11. Journées Glaciologie-Nivologie-Hydrologie de Montagne de la SHF, Grenoble, 08-09/03/2016. Talk (in French): Descente d'échelle et correction de projections climatiques – application aux conditions d'enneigement dans les Alpes françaises. **D. Verfaillie**, M. Déqué, S. Morin, M. Lafaysse
12. IGS conference 2014: Contribution of Glaciers and Ice Sheets to Sea-Level Change, Chamonix (France), 26-30/05/2014. Poster: Sub-Antarctic dryness causes among the largest glacier wastage on Earth. V; Favier, **D. Verfaillie**, E. Berthier, J.E. Kay, V. Jomelli, M. Ménégoz, L. Ducret, Y. Malbéteau, D. Brunstein, H. Gallée, Y.-H. Park
13. EGU General Assembly, Vienna (Austria), 07-12/04/2013. Talk: Recent glacier retreat over Kerguelen archipelago (49°S, 69°E) derived from field data, satellite imagery and modelling. **D. Verfaillie**, V. Favier, M. Dumont, V. Jomelli, A. Gilbert, D. Brunstein, and Y. Frenot

14. SCAR Open Science Conference, Portland (USA), 16-19/07/2012. Poster: Interpreting field observation to assess the causes for glacier retreat on Kerguelen archipelago. **D. Verfaillie**, V. Favier, V. Jomelli, D. Brunstein, and A. Gilbert

Presentations to non-specialist audiences

1. Restitution of the ADAMONT project, Autrans (France), 07/12/2017. Talk (in French) : Les principales tendances du changement climatique passé et futur - Focus sur Vercors à 1500m. **D. Verfaillie**, S. Morin.
2. Journée de formation Rectorat / COP21-UGA "Autour du 2°C", Grenoble, 15/10/2015. Talk (in French): L'avenir du tourisme lié à la neige. **D. Verfaillie**, P. Spandre, S. Morin

Participation in research projects

Ongoing projects

- H2020 EUCP: EUropean Climate Prediction system
- ERA4CS MEDSCOPE: MEDiterranean Services Chain based On climate PrEdictions
- INTERREG POCTEFA Clim'Py: Characterisation of climate evolution and provision of information for adaptation in the Pyrenees

Past projects

- GICC ADAMONT: Downscaling of climate change in mountain regions and simulation of its impact
- LEFE-INSU GLACEPREKER: Past and recent glacier evolution in the Kerguelen Islands
- LEFE-INSU KCRuMBLE: Kerguelen Climate Regionalization and Mass Balance modEling
- IPEV-1048 GLACIOCLIM-KESAACO: KErguelen Surface Ablation, Accumulation and Climate Observation

Funding/Grants

2011-2014	PhD funded by the French Ministry for Education and Research. 72,890€ gross.
2012	Fellowship awarded by the French National Committee for Arctic and Antarctic Research (CNFRA) to participate in the SCAR Open Science Conference, Portland (USA), 16-19/07/2012. 1,350€
2010	Grant awarded by the International Students and Scholars Office of the Joseph Fourier University in Grenoble to attend the second year of MSc. 8,000€

Reviewer of scientific journal

Géomorphologie - relief, processus, environnement

Teaching Activities and Mentoring

2018	Supervision of a 3rd year bachelor intern at LGP, Meudon (1 month). Deglaciation at Kerguelen: GIS cartography of moraine ensembles.
2017	Supervision of 3 interns of the National School of Meteorology (ENM, 6 weeks) at CEN, Grenoble. Evaluation and improvement of snow climatologies in the French mountain regions.
2011-2014	Complementary teaching mission - Joseph Fourier University Grenoble (192h). Tutorials, practical and classes in Glaciology, Numerical Analysis, Remote Sensing, Introduction to Geosciences, Chemistry of environmental water (BSc to MSc 1).
2012	Supervision of a 3rd year bachelor intern at LGGE, Grenoble (1 month). Retrieval and analysis of MODIS satellite images for the computation of albedo on Cook Ice Cap, Kerguelen Islands.

Field work experience

2013	Field work on Ampere Glacier, Kerguelen (1 month). Maintenance of a glaciological stake network and meteorological and hydrological stations.
2011-2012	Field work on the Kerguelen Islands (4 months). Installation and maintenance of a glaciological stake network and meteorological and hydrological stations, GPS measurements, moraine sampling for cosmogenic dating.

Technical skills

Languages

- French (mother tongue)
- English: bilingual (writing of scientific articles)
- Dutch: read, spoken, written (second national language in Belgium)
- Spanish: read, spoken, written
- Italian: basic knowledge

Computer

- Windows and Linux environments
- Good programming and scripting skills (Fortran, bash, Python, R, Matlab, CDO, NCO)
- Use of collaborative versioning tools: git (gitlab), svn
- Knowledge of specific software (Ferret, Quantum GIS, …)
- Daily use of office software (Word, Excel, Powerpoint, …)

5. Capacity of the Participating Organisations

List of participating organisations

Participating organisations	Legal Entity Short Name	Country	Supervisor	Role of partner organisation
Beneficiary				
BARCELONA SUPERCOMPUTING CENTER	BSC	Spain	Prof. Francisco J. Doblas-Reyes	
Partner Organisation				
INSTITUT DES GÉOSCIENCES DE L'ENVIRONNEMENT, UMR 5001	IGE	France	Dr. Vincent Favier, Dr. Martin Ménégoz	Hosting secondment

Beneficiary: Barcelona Supercomputing Center (BSC), Spain	
General description	The **Barcelona Supercomputing Center** (BSC) combines unique high performance computing facilities and in-house research departments on computer, life, and Earth sciences, and computational applications, counting more than 486 researchers and students from more than 45 different countries. BSC-CNS has been accredited as one of the first eight Severo Ochoa Centers of Excellence. This award is given by the Spanish Government as recognition for leading research centers in Spain that are internationally well known institutions in their respective areas. The **Earth Sciences Department** of the BSC (BSC-ES) was established in 2006 and focused initially on atmospheric composition modelling. Since tthe merging of the department with the Climate Forecast Unit of the Institut Català de Ciències del Clima (IC3-CFU) the BSC-ES has become, in a short time, a main European actor in the development of climate predictions and climate services. The department is structured around 4 groups, with more than 80 employees, including technical and support staff. It is a highly productive scientific entity that has published more than 180 research articles in peer-reviewed journals over the last five years (2014-2018), some of them in prestigious high-impact journals (https://earth.bsc.es/wiki/doku.php?id=publications:publications). The **Climate Prediction Group** aims at developing a climate forecast system based on the EC-Earth model and performs regular assessments of the characteristics of this forecast system compared to all other operational and quasi-operational systems available in the world. This group participates currently in 10 European projects and 5 national projects. BSC is one of the world leaders in the development of climate prediction and climate services. This is achieved by expanding the understanding of the climate predictability mechanisms through tailored and comprehensive forecast quality assessment, developing the EC-Earth climate forecast system through the testing of new model parameterisations/components and the development of innovative initialization strategies.
Academic organisation	Yes
Role and profile of key persons (supervisor)	ICREA Research Prof. Francisco J. Doblas-Reyes is the director of BSC-ES. He is a worldwide expert in the development of seasonal-to-decadal climate prediction systems and has more than 20 years of experience in weather and climate modelling, climate prediction, as well as the development of climate services. Prof. Doblas-Reyes serves on scientific panels of the World Climate Research Programme (WCRP) and the World Weather Research Programme (WWRP) and has authored and co-authored more than 100 peer-reviewed papers on climate modelling and prediction, as well as on climate services. He is a member of the European Network for Earth System modelling HPC Task Force and has participated in numerous national and European FP4 and FP7 projects. Prof. Doblas-Reyes is also involved in 4 Horizon 2020 Collaborative projects and 2 C3S contracts as a Principal Investigator and has supervised or is currently supervising 4 Marie Skłodowska-Curie Individual Fellowships.
Dept./Division / Laboratory	Earth Sciences Department/Climate Prediction Group
Key research facilities, Infrastructure and Equipment	BSC hosts and manages a range of HPC systems, including MareNostrum 4, with 148,176 cores and 13.7 PFlops capacity. Additionally, BSC manages Minotauro, a Sandy Bridge's cluster with NVIDIA GPUs, providing more than 100 TFlops.
Independent research premises?	Yes. All key research facilities, infrastructure and equipment will be available for the fellow.
Previous and current involvement in research and training programmes	BSC-ES is a highly productive scientific institution that has been granted 24 EU Horizon 2020 projects, 6 EU FP7 projects, 10 Copernicus contracts, 11 national projects and 4 European Space Agency projects in the last 5 years. The most important projects for this MSC proposal that the CPG currently participates in, are H2020 projects: **PRIMAVER**A: PRocess-based climate sIMulation: AdVances in high-resolution modelling and European climate Risk Assessment; H2020-SC5-01-2014-641727 **MEDSCOPE:** MEDiterranean Services Chain based On climate PrEdictions; ERA-Net ERA4CS project **EUCP**: European Climate Prediction system; H2020-SC5-2016-776613 Previous European project: **SPECS:** Seasonal-to-decadal climate prediction for the improvement of European Climate Services; FP7-ENV-2012-308378. The BSC is also the beneficiary of Marie Skłodowska-Curie Action COFUND program for postdoctoral fellows (**STARS**; H2020-MSCA-COFUND-754433). The BSC-ES is currently awarded 6 postdoctoral fellowships (5 Juan de la Cierva, 1 Beatriu de Pinos), 5 senior research grants (4 Ramon y Cajal, ICREA) and hosts 7 MSCA-IF research projects: NeTNPPAO, ACRoNNim, SPFireSD, DUST.ES, PROTECT, INADEC and CLIM4CROP.
Relevant publications and/or research/innovation products	Turco et al., 2018. Nature Communications, 9, 2718, doi: 10.1038/s41467-018-05250-0. Merryfield et al., 2017. EOS, 98, doi:10.1029/2017EO086891. Boer, G. J. et al., 2016. Geoscientific Model Development, 9, 3751–3777, doi:10.5194/gmd-9-3751-2016. Massonnet et al., 2016. Science, 6311, 452-455, doi: 10.1126/science.aaf6369. Doblas-Reyes et al., 2013. Nature Communications, 4, 1715, doi: 10.1038/ncomms2704.

Partner organisation for secondment: Institut des Géosciences de l'Environnement (IGE), UMR 5001, France	
General description	The Institut des Géosciences de l'Environnement (IGE) is a public research laboratory in Earth and Environmental Sciences, created on 1 January 2017 by the merge of LGGE (Laboratory of Glaciology and Geophysics of the Environment) and LTHE (Laboratory of Transfers in Hydrology and Environment). The IGE is a joint research unit supervised by CNRS/INSU, IRD, Université Grenoble Alpes (UGA) and Grenoble-INP. The IGE is one of the main laboratories of the Grenoble Observatory (OSUG) which is a federative body of INSU. The staff of the laboratory is around 240 people, of whom 145 permanent members (researchers, lecturers and professors, engineers, technicians and administrative staff) and about 95 doctoral students, post-doctoral fellows and staff on fixed-term contracts. The laboratory also hosts several dozens of trainees and scientific visitors each year. One main strength of IGE is reflected by the diversity of the geographical zones under investigation, which require the establishment of long-term observing systems to monitor and understand processes related to global changes, their interfaces and interactions. In particular, the institute has a long expertise in glacier observation and modelling, and is the host of several national observation services. Major research fields are the Alps, the polar regions, the global ocean and inter-tropical zones.
Academic organisation	Yes
Role and profile of key persons (supervisors)	Dr. Vincent Favier is a glaciologist and climate scientist at IGE. He manages the French glacier observatory (GLACIOCLIM) in Antarctica, aiming at performing long term glaciological measurements and developing regional-scale modelling approaches of the surface mass and heat budgets. He has been the PI of several projects with more than 1M€ of funding over the last 10 years, and is currently co-head of the GLACE team at IGE (20 permanent and 30 non-permanent members). Between 2005 and 2007 he also was head of the Glaciology Group at the CEAZA (Centro de Estudios Avanzados en Zonas Áridas), La Serena, Chile. He is French national representative in the standing scientific group on physical sciences of the SCAR. Since 2004, Dr Favier co-authored 43 peer-reviewed publications (8 as 1st author, h-index=24, citations>2000) in the field of glaciology, hydrology, climate and paleoclimate, including 2 articles in Nature. He has supervised 6 PhD theses including the one of the candidate. Dr. Martin Ménégoz is a CNRS researcher, who joined the IGE in 2018. He is part of two teams at IGE: GLACE (http://www.ige-grenoble.fr/recherche/equipes/glace/?lang=en), a team developing models and observational networks to investigate the interactions between the cryosphere and the climate at high latitudes; and a second one, CYME (http://www.ige-grenoble.fr/recherche/equipes/cyme/?lang=en) which investigates the climate of the mountainous areas with a special focus on the response of the cryosphere in high altitude areas. Using models and observations, he investigates the climate sensitivity to external forcings like greenhouse gases and aerosol particles. In close collaboration with the BSC where he worked from 2014 to 2017, he develops forecast systems to produce quasi operational predictions at seasonal to decadal timescales, with particular attention on the simulation of the aerosol forcing in climate models. He supervised several master students and one post-doc researcher, and developed a large network of collaborations within national and European projects.
Dept./Division / Laboratory	GLACE & CYME teams
Key research facilities, Infrastructure and Equipment	Through the Grenoble Observatory, IGE runs several national observation services and is involved in modelling and instrumental platforms labelled by INSU, among others the GLACIOCLIM observatory. The IGE is structured around eight research teams, a technical department, an information systems department and an administrative department, which can provide relevant support to the candidate. Additionally, researchers at IGE have access to the collaborative CIMENT High Performance Computing platform (https://ciment.ujf-grenoble.fr/wiki-pub/index.php/Welcome_to_the_CIMENT_site!), with 6,528 cores and 136 TFlops.
Previous and current involvement in research and training programmes	Previous European project: **ice2sea**, FP7-ENV-2008-1-226375. Ongoing European projects: **ENVRIplus**, H2020-INFRADEV-4-2014-2015-654182; **LTER-Europe**. Ongoing international project: **CliC** (Climate and Cryosphere core project of the WCRP). Ongoing national project: **GLACIOCLIM** national observation service.
Relevant publications and/or research/innovation products	Ménégoz et al., 2018. Environmental Research Letters, 13, 064022, doi: 10.1088/1748-9326/aac4db. Favier et al., 2016. Scientific Reports, 6, 32396, doi: 10.1038/srep32396. Verfaillie et al., 2015. Journal Of Geophysical Research-Earth Surface, 120(3), 637–654, doi: 10.1002/2014JF003329. Favier et al., 2013. The Cryosphere, 7(2), 583–597, doi: 10.5194/tc-7-583-2013. Vincent et al., 2005. Comptes Rendus Geoscience, 337(1-2), 97–106, doi: 10.1016/j.crte.2004.08.010.

6. Ethical Issues

The present project involves research in climate sciences and glaciology. Therefore, as detailed in Part A of the present proposals, there are no potential ethical issues identified for PERIDoT.

7. Letter of commitment

The following letter of support has been provided by Dr. Vincent Favier and Dr. Martin Ménégoz from Institut des Géosciences de l'Environnement.

Grenoble, 16th August 2018

Subject: Letter of commitment for Dr. Deborah Verfaillie's MSCA application

Dear Sir or Madam,

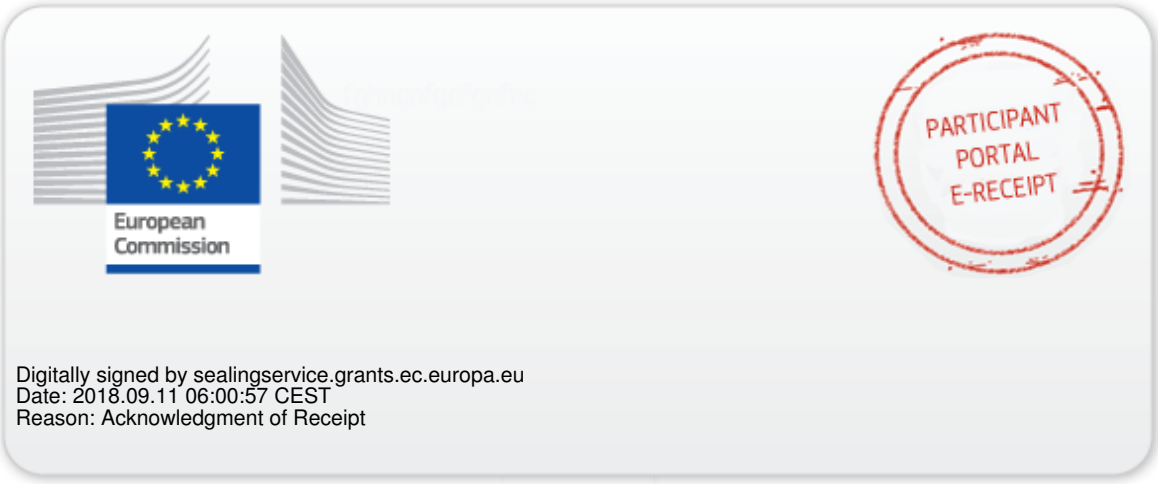
This letter has been written to support the scientific objectives and the work organisation of the Marie Sklodowska-Curie Action IF-EF entitled "PERIDoT" submitted by Dr. Deborah Verfaillie (BSC). It is also to express our personal commitment to advise Dr. Deborah Verfaillie in her work and to host her at the Institute for Geosciences of the Environment (IGE, Grenoble, France) as part of her research project.

The IGE is an internationally recognised group hosting around 250 people including 150 permanent members, and a large number of experts in the interactions between the climate system, the hydrosphere and the cryosphere. The reputation of the IGE relies on its double ability to set up long-term observational networks and to develop modelling approaches to study the environment in a large number of regions of the world. In the field of glaciology, the IGE is famous for having drilled ice-cores in ice caps and large glaciers to rebuild the atmospheric composition and estimate the temperature variability over the last 700,000 years. The IGE developed also a strong expertise in the cryosphere sensitivity to climate variability, by providing a complete understanding of the processes driving the mass of mountain glaciers and ice caps, from the equilibrium between snow accumulation and melting at the surface to the dynamical downstream flow of ice finally supplying water in the rivers and the oceans. Precipitation variability, as well as snow cover and glacier changes are a central point of interest for many IGE researchers. Their activity concerns the climate change at the regional scale, with socio-environmental applications like water resources, biodiversity, local economy, but also at the global scale, with crucial scientific issues like the climate feedbacks related to snow cover or major societal challenges such as sea-level change. Both global and regional climate models are developed and used at the IGE that is largely involved in the CMIP and IPCC activities. Such models have been used to understand the variations of the climate in the previous century, as well as during glacial or interglacial periods, but also to investigate future scenarios for the coming centuries. The IGE benefits from a strong collaboration with the Snow Research Center (CEN, Météo-France, Grenoble), the French institute that is in charge of surveying the snowpack and forecasting its evolution.

Dr. Deborah Verfaillie would be very welcome to work with us in this fruitful environment. We think that her innovative research project will participate into filling the gap between meteorological and climate timescales concerning the links between the climate and the cryosphere. Her project would allow to merge the expertise of the IGE in climate and cryosphere sciences with the innovative approaches developed at BSC to provide seasonal to decadal forecasts. This context will be a perfect opportunity for Dr. Deborah Verfaillie to achieve the goals of her project.

Martin Ménégoz

Vincent Favier



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