Horizon 2020

Call: H2020-MSCA-IF-2015

Topic: MSCA-IF-2015-EF

Type of Action: MSCA-IF-EF-ST

Proposal Number: 704926

Proposal Acronym: VOLCADEC

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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 previous steps in the submission wizard.

1 - General information

Topic	MSCA-IF-2015-EF	Type of action	MSCA-IF-EF-ST
Call identifier	H2020-MSCA-IF-2015	Acronym	VOLCADEC

Proposal title: Volcanic activity in seasonal to decadal climate forecasts

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

Duration in months: 24

Panel: ENV - Environmental and Geosciences (ENV)

Please select up to 5 descriptors (and at least 1) that best characterise the subject of your proposal, in descending order of relevance.

Descriptor 1	*Climatology and climate change*	Add	
Descriptor 2	*Meteorology, atmospheric physics and dynamics*	Add	Remove
Descriptor 3	*Atmospheric chemistry, atmospheric composition, air pollut*	Add	Remove
Descriptor 4	*Ozone, upper atmosphere, ionosphere*	Add	Remove
Descriptor 5	*Scientific computing and data processing*		Remove

Free keywords: *Climate variability, Seasonal to decadal forecasts, volcanic eruptions, climate models, stratosphere, aerosols, climate dynamics, North Atlantic Oscillation.*

Abstract

At the intermediate timescales between weather forecasts and climate predictions, seasonal to decadal forecasting represents a challenge that requires increased scientific understanding to address a number of societal needs such as agriculture and energy management. The Institut Català de Ciències del Clima (IC3) is one of the main European institutes trying to provide such forecasts in a real-time context, using the best knowledge of climate predictability sources and shaping forecast systems. IC3 recently pointed out the predictability associated with the initialisation of climate models with observations. An open aspect of this activity is linked to the role of the stratospheric particles that strongly impact the climate interannual variability through complex dynamical atmospheric processes. A large part of these particles are emitted by volcanoes. This project named Volcanic activity in seasonal to decadal climate forecasts (VOLCADEC) aims at answering how forecast systems should take into account these particles, an aspect that has not been addressed yet by the community. It focuses on three main challenges: (1) How do the climate conditions modulate the climate response to volcanic eruptions? (2) Can we predict the climate response to a volcanic eruption? (3) How do stratospheric aerosols affect the climate variability outside periods of major eruptions? The final goal of VOLCADEC is to design a protocol to optimally take into account stratospheric aerosols in climate models. Forecast systems implementing this solution will be more helpful in providing climate information, especially in Europe, where stratospheric aerosols substantially impact the climate variability.

Remaining characters 297

Has this proposal (or a very similar one) been submitted in the past 2 years in response to a call for proposals under the 7th Framework Programme, Horizon 2020 or any other EU programme(s)? ○ Yes ◉ No

Has this proposal (or a very similar one) 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) confirms:

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

5) The 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

Your reply to the grant application will involve the recording and processing of personal data (such as your name, address and CV), which will be processed 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 processing of your personal data are available on 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 Warning System (EWS) only or both in the EWS and Central Exclusion Database (CED) by the Accounting Officer of the Commission, should you be in one of the situations mentioned in:
-the Commission Decision 2008/969 of 16.12.2008 on the Early Warning System (for more information see the Privacy Statement), or
-the Commission Regulation 2008/1302 of 17.12.2008 on the Central Exclusion Database
(for more information see the Privacy Statement) .

Proposal ID **704926** *Acronym* **VOLCADEC**

List of participants

#	Participant Legal Name	Country
1	FUNDACIO INSTITUT CATALA DE CIENCIES DEL CLIMA	Spain

2 - Administrative data of participating organisations

Future Host Institution

PIC	***Legal name***
994170073	*FUNDACIO INSTITUT CATALA DE CIENCIES DEL CLIMA*

Short name: IC3

Address of the organisation

Street CARRER DOCTOR TRUETA 203 3R PIS

Town BARCELONA

Postcode 08005

Country Spain

Webpage www.ic3.cat

Legal Status of your organisation

Research and Innovation legal statuses

Public body ..... no

Non-profit ..... yes

International organisation ..... no

International organisation of European interest ..... no

Secondary or Higher education establishment ..... no

Research organisation ..... yes

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

Academic Sector ..... yes

Legal person ..... yes

Nace code 721 -

Does this participant deliver doctoral degrees that are recognised as such by the relevant national authorities? ○ Yes ◉ No

Department(s) carrying out the proposed work

Department 1

Department name	Climate Forecasting Unit
	☒ Same as organisation address
Street	CARRER DOCTOR TRUETA 203 3R PIS
Town	BARCELONA
Postcode	08005
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.

Researcher ID	*If you have a researcher identifier number (e.g. ResearcherID, ORCID) please enter it here.*		
Last Name*	MÉNÉGOZ	Last Name at Birth	
First Name(s)*	Martin	Gender*	◉ Male ○ Female
Title	Dr.	Country of residence*	Spain
Nationality*	France	Nationality 2	
Date of Birth (DD/MM/YYYY)	26/10/1980	Country of Birth*	France
		Place of Birth	Echirolles (38)

Contact address

☒ Same as organisation address

Current organisation name	FUNDACIO INSTITUT CATALA DE CIENCIES DEL CLIMA		
Current Department/Faculty/Institute/ Laboratory name	Climate Forecast Unit		
Street	CARRER DOCTOR TRUETA 203 3R PIS		
Postcode/Cedex	08005	Town	BARCELONA
Phone	+34935679977	Country	Spain
Phone2 / Mobile	*+xxxx xxxxxxxxxxxx*		
E-Mail*	menegozmartin@yahoo.fr		

Qualifications

University Degree		Date of award (DD/MM/YYYY)	13/07/2004
Doctorate (in progress)		Date of award (DD/MM/YYYY)	
Doctorate		Date of award (DD/MM/YYYY)	03/07/2009
Full time postgraduate research experience		Number of months	110
Other Academic qualifications		Date of award (DD/MM/YYYY)	

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

Indicate the period(s) and the country/contries in which you have legally resided and/or had your main activity (work, status, ..) during the last 5 years up until the deadline for the submission of the proposal. Please fill in this section without gaps, until the call deadline (10/09/2015).

Period from	Period to	Duration (days)	Country	
				Add
15/09/2014	10/09/2015	361	Spain	Remove
01/12/2009	14/09/2014	1.749	France	Remove
	Total	2110		

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**

Last name*: **Doblas Reyes**

E-Mail*: **francisco.doblas-reyes@ic3.cat**

Position in org.: Head of the Unit

Department: Climate Forecast Unit

☒ Same as organisation address

Street: CARRER DOCTOR TRUETA 203 3R PIS

Town: BARCELONA

Post code: 08005

Country: Spain

Website: www.ic3.cat

Phone: +34935679977

Phone 2: *+xxx xxxxxxxxx*

Fax: +34933097600

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	IC3	ES	0,976	24	108921,60	14400,00	12000,00	19200,00	15600,00	170121,60
Total				24	108921,60	14400,00	12000,00	19200,00	15600,00	170121,60

Partner Organisation from Third Country does not sign the Grant Agreement, does not recruit the researcher and does not directly claim costs from the action. The entire EC contribution is transmitted to the Host organisation located in Members States or Associated Countries.

4 - Ethics issues table

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 (ii)		**Page**
Does your research involve personal data collection and/or processing?	○ Yes ◉ No	
Does your research involve further processing of previously collected personal data (secondary use)?	○ Yes ◉ No	
5. ANIMALS (iii)		**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.)? (v)	◯ Yes ◉ No	
Do you plan to import any material from non-EU countries into the EU? *For data imports, please fill in also section 4.* *For imports concerning human cells or tissues, fill in also section 3.*	◯ Yes ◉ No	
Do you plan to export any material from the EU to non-EU countries? *For data exports, please fill in also section 4.* *For exports concerning human cells or tissues, fill in also section 3.*	◯ Yes ◉ No	
If your research involves low and/or lower middle income countries, are benefits-sharing measures foreseen? (vii)	◯ 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 See legal references at the end of the section. (vi)		Page
Does your research involve the use of elements that may cause harm to the environment, to animals or plants? *For research involving animal experiments, please fill in also section 5.*	◯ 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? *For research involving human participants, please fill in also section 2.*	◯ Yes ◉ No	
8. DUAL USE (vii)		Page
Does your research have the potential for military applications?	◯ Yes ◉ No	
9. MISUSE		Page
Does your research have the potential for malevolent/criminal/terrorist abuse?	◯ Yes ◉ No	
10. 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

Other Questions

For communication purposes only, the REA asks for permission to publish the name of the researcher (future fellow) should the proposal be retained for funding.

1. Does the researcher (future fellow) give this permission? ◉ Yes ○ No

2. Is there a secondment in Member States or Associated Countries evisaged 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 CERFACS

Country 20000890

Open Research Data Pilot in Horizon 2020

If selected, all applicants have the possibility to 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. Participating in the Pilot does not necessarily mean opening up all research data. Actions participating in the Pilot will be invited to formulate a Data Management Plan in which they will determine and explain which of the research data they generate will be made open.

We wish to participate in the Pilot on Open Research Data in Horizon 2020 on a voluntary basis	○ Yes	◉ No

Participation in this Pilot does not constitute part of the evaluation process. Proposals will not be evaluated favourably because they are part of the Pilot and will not be penalised for not participating.

[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.*

Data management activities

The use of a Data Management Plan (DMP) is required for projects participating in the Open Research Data Pilot in Horizon 2020, in the form of a deliverable in the first 6 months of the project.

All other projects may deliver a DMP on a voluntary basis, if relevant for their research.

Are data management activities relevant for your proposed project?	○ Yes	◉ No

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MARIE SKŁODOWSKA-CURIE ACTIONS

Individual Fellowships (IF)
Call: H2020-MSCA-IF-2015

PART B

- VOLCADEC –

Volcanic activity in seasonal to decadal climate forecasts

This proposal is to be evaluated as:

[Standard EF]

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List of Participants

Participants	Legal Entity Short Name	Academic (tick)	Non-academic (tick)	Country	Dept./ Division / Laboratory	Supervisor	Role of Partner Organisation
Beneficiary Institut Català de Ciències del Clima	IC3	✓		Spain	Climate Forecasting Unit (CFU)	Francisco J. Doblas-Reyes	Host organisation
Partner Organisation Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique	CERFACS	✓		France	Climate Modelling and Global Change	Christophe Cassou	Hosting Secondment

1. Summary

At the intermediate timescales between weather forecasts and climate predictions, seasonal to decadal forecasting represents a challenge that requires increased scientific understanding to address a number of societal needs such as agriculture and energy management. The Institut Català de Ciències del Clima (IC3) is one of the main European institutes trying to provide such forecasts in a real-time context, using the best knowledge of climate predictability sources and shaping forecast systems. IC3 recently pointed out the predictability associated with the initialisation of climate models with observations. An open aspect of this activity is linked to the role of the stratospheric particles that strongly impact the climate interannual variability through complex dynamical atmospheric processes. A large part of these particles are emitted by volcanoes. This project named ***Volcanic activity in seasonal to decadal climate forecasts*** (VOLCADEC) aims at answering how forecast systems should take into account these particles, an aspect that has not been addressed yet by the community. It focuses on three main challenges: (1) How do the climate conditions modulate the climate response to volcanic eruptions? (2) Can we predict the climate response to a volcanic eruption? (3) How do stratospheric aerosols affect the climate variability outside periods of major eruptions? The final goal of VOLCADEC is to design a protocol to optimally take into account stratospheric aerosols in climate models. Forecast systems implementing this solution will be more helpful in providing climate information, especially in Europe, where stratospheric aerosols substantially impact the climate variability.

2. Excellence

2.1 Quality, innovative aspects and credibility of the research

- **Introduction, state-of-the-art, objectives and overview of the action**

Introduction

The scientific knowledge of the climate system is now sufficient to demonstrate the link between the current global warming and the anthropogenic activities. Due to greenhouse gas emissions, surface temperature has increased over the last century, and this warming is expected to continue during the XXIst century, in a way more or less pronounced depending on societal evolutions[1]. Apart from human factors impacting the climate with a time of response of several decades, natural variability induces a strong inter-annual to decadal climate variability that is challenging to forecast[2]. Natural variability is linked to both internal variability and natural forcings[3]. Internal variability is driven by the interactions between the oceans, the continents and the atmosphere. Natural forcings refer to changes of solar energy and natural emissions of gases and aerosols.

There is a strong need for a better understanding of natural variability to design operational models able to provide forecasts for the next years and decades. Initialisation of climate models is fundamental to forecast temperature and precipitation on these timescales[4], but radiative forcings play also a significant role: variations of greenhouse gases, human-made aerosols, volcanic particles and solar irradiance are the main forcings that impact climate decadal variability[5] (Figure 1). Large volcanic eruptions significantly impact climate variability (Figure 1c) by injecting aerosols into the stratosphere[6]. Regional climate impacts of these eruptions are poorly known. Small eruptions also affect the stratospheric aerosol burden[7], and have been used to explain part of the current slowdown of the global warming[8]. **This project aims at developing solutions to predict the regional variability associated with stratospheric aerosols in seasonal to decadal forecasts, by designing a new way to take into account the volcanic forcing in operational forecast systems.**

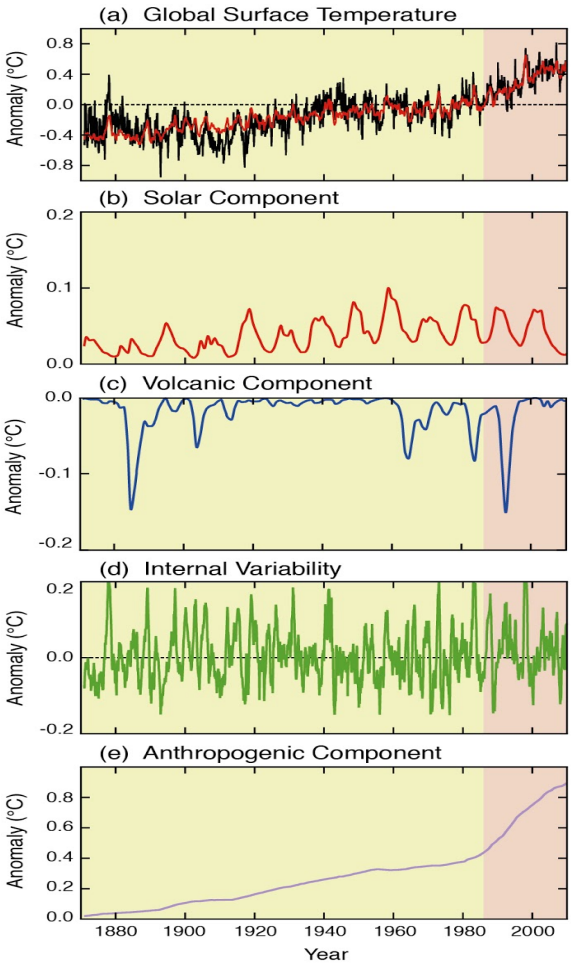

Figure 1: Observed (a, black) and modelled (colour) global surface temperature anomaly and its variability induced by natural and anthropogenic factors (b, c, d, e). IPCC, 2013[1].

[1] *IPCC, Climate Change 2013: The Physical Science Basis, Cambridge Univ. Press, 1552 pp.* [2] *Hawkins, E. et al., 2009, Bull. Am. Meteorol. Soc., 90(8), 1095-1107.* [3] *Deser, C. et al., 2012, Clim. Dyn., 38(3-4), 527-546.* [4] *Doblas-Reyes, F. et al., 2013, Wiley Interd. Rev.: Climate Change, 4(4), 245-268.* [5] *Hansen, J. et al., 2011, Atmos. Chem. Phys., 11, 13421-13449.* [6] *Dutton, E.G. et al., 1992. Geophys. Res. Lett., 19, 2313–2316.* [7] *Ridley, D.A., et al., 2014, Geophys. Res. Lett., 41, 7763–7769.* [8] *Solomon, S. et al., 2011, Science, 333(6044), 866-870.*

Climate and volcanoes: state of the art

During explosive tropical eruptions, large quantities of sulphate particles reach the stratosphere, where they can remain from several months to a couple of years. Strongly reflecting the solar radiation, these particles cool the troposphere, and absorbing the longwave radiation, they warm the stratosphere[9]. This radiative balance induces a general cooling of the surface during one to two years after large eruptions. The cooling is stronger over the continents than over the oceans, particularly during the summer, where it can locally reach -1°C[10]. The most powerful volcanic blast in the recorded history is the Tambora 1815 eruption that produced the "year without a summer" in 1816. This eruption had planetary effects so extreme that many nations and communities sustained drastic fail of crops, waves of famine, disease, civil unrest and economic decline[9]. Eruptions occurring during the XXth century also induced a significant cooling associated to environmental and socio-economical impacts[9]. The summer radiative response can be associated to a dynamical signal, in particular in the Indian subcontinent, where eruptions are generally associated to a decrease of the monsoon circulation[11]. The winter response is more complex to understand, since it is mainly driven by the dynamical response of the atmosphere, and depends on the location of the volcano. Tropical eruptions induce a warming of the stratosphere that leads to an increase of the meridional temperature gradient, intensifying the polar vortex due to the thermal wind relation. In contrast, the meridional temperature gradient decreases close to the surface, leading to a decrease of the planetary wave activity, reinforcing also the polar vortex that is hence less perturbed[9]. Regarding the major tropical eruptions over the last century, it has been observed that such an increase of the polar vortex was generally associated with an increase of the frequency of the positive phases of the North Atlantic Oscillation (NAO) during the two winters following the eruption[12,13]. This response is associated to particularly warm winter temperature over large areas of the Northern Hemisphere continents. This assumption is supported by proxy data analysis that shows positive NAO anomalies the second and the third winter after eruptions for most of the volcanoes that erupted during the last millennium[14]. In contrast with tropical eruptions, particles emitted by high-latitude eruptions remain only several months in the stratosphere [1], leading to little significant dynamical winter response[11]. The volcanic forcing appears to be significant at seasonal to interannual time scales: the atmospheric response is clearly visible in the observations during the 1 to 5 years following one eruption. The oceanic footprint of a large eruption is noticeable during 10 to 20 years[14], with a potential modification of the Atlantic Meridional Overturning Circulation (AMOC[15]).

Context of the proposal and main issues

Agung (1963), El Chichón (1982) and Pinatubo (1991) are the three last eruptions with significant climatic impact, inducing a decrease of the global temperature of several tenths of degrees (Figure 1c), strong enough to attenuate the anthropogenic signal during several years[1]. However, it is challenging to understand the regional climate response to these eruptions, and even more challenging to predict it just after the eruption has taken place. The return period of such eruptions is about 30 years[1]. Due to the low number of observations of both the eruptions and their climate impacts, it is difficult to isolate its signal from the high natural variability of the climate system and, hence, to determine the volcanic impact that should be predicted. In particular, positive phases of the El Niño Southern Oscillation (ENSO) have been suggested to strongly modulate the volcanic signal of these three eruptions[16]. However, it is difficult to state whether these positive phases of the ENSO have been triggered by the eruptions themselves or not. The NAO is one of the main modes of climate variability in the Northern Hemisphere that drives temperature and precipitation, in particular in Europe, both in summer[17] and in winter[18]. As stated before, the dynamical climate response to recent volcanic eruption shows anomalies typical of the positive phase of the winter NAO. However considering the low number of events and the large signal to noise ratio in these latitudes, it is currently not possible to say if such a response would occur during a future eruption. The current generation of Atmosphere Ocean General Circulation Models (AOGCMs) are increasingly more efficient to simulate the radiative response to volcanic eruptions[10,19,20]. However, AOGCMs do not correctly reproduce the dynamical winter response to tropical eruptions, with signals of temperature and pressure strongly under-estimated and even showing in some cases an opposite sign to what has been observed[21]. The modelling experiments trying to reproduce the climate response to tropical eruptions highlighted the relevance of the background conditions of the atmosphere, which could condition the impact of the volcanic aerosol[22,23].

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[9] Robock, A., 2000, Rev. Geophys., 38, 191–219. [10] Man, W. et al., 2014, J. Climate, 27(19), 7394-7409. [11] Oman, L., 2005, J. Geophys. Res., 110, D13103. [12] Smith, D. M. et al., 2014, Q. J. Roy. Meteorol. Soc. [13] *Stenchikov, G. et al., 2002, J. Geophys. Res., 107(D24), 4803. [14] Ortega P. et al., 2015, Nature 523, 71–74. [14] Iwi, A. et al., 2012, J. Climate, 25, 3039–3051. [15] Swingedouw D. et al., 2015, Nature Commun. 6, pages: 6545.* [16] *Yang, F. and Schlesinger, M. E., 2001,* J. Geophys. Res. Atm., *(1984–2012), 106(D14), 14757-14770. [17] Bladé, I. et al., 2011, Climate Dynam., 39, 3-4. [18] López-Moreno, J. I. et al., 2011,* Global Planet. Change*, 77(1), 62-76. [19] Kirchner, I. et al., 1999, J. Geophys. Res., 104, 19,039– 19,055. [20] Schneider, D. P. et al., 2009, J. Geophys. Res., 114, D15101. [21] Driscoll, S. et al., 2012, J. Geophys. Res., 117, D17105. [22] Zanchettin, D., et al., 2013, J. Geophys. Res. Atmos., 118, 4090–4106. [23] Thomas, M. A. et al., 2009, Atmos. Chem. Phys., 9, 3001-3009.*

The climate research community is focusing a large part of its effort on improving seasonal to decadal forecasts to address the requests of decision makers and the industry. Within the fifth phase of the Coupled Model Intercomparison Project[24] (CMIP5), a set of decadal prediction experiments has been performed to investigate how AOGCMs can reproduce the climate observations during one decade after being initialized from an observational state. These experiments have been performed with observed anthropogenic and natural forcings. Therefore, they cannot be considered as "real forecasts". They are very useful to test the ability of AOGCMs to simulate the near-term climate evolution after the initialisation of a climate simulation. However, they cannot give an exact idea of how such forecast systems can be used in real-time forecasts because natural and anthropogenic forcings cannot be known in advance. This difficulty is even more critical when considering volcanic eruptions that are unpredictable in spite of having a fast impact on climate[25]. The problem is equally important for seasonal predictions, which are operational around the world. When the next large volcanic eruption will occur, uncertainties on aerosols emissions will strongly limit our possibility to forecast its regional climate impacts at seasonal to decadal time scales. In addition, recent minor eruptions have been observed to impact the stratospheric aerosol burden, with significant impacts on climate over the past 15 years that had been badly anticipated with current AOGCMs[7]. There is a strong need to design forecast systems able to predict the regional climate response to stratospheric aerosols at seasonal to decadal timescales. This is the aim of the VOLCADEC proposal, which focuses on three major objectives:

(1) Investigating the regional climate impacts of volcanic aerosols;

(2) Checking the ability of forecast systems to predict the regional climate response to volcanic eruptions;

(3) Designing a strategy to describe stratospheric aerosols in climate forecast systems.

- **Research methodology and approach**

The VOLCADEC project will be carried out by Martin Ménégoz at IC3 within the Climate Forecasting Unit (CFU, http://ic3.cat/wikicfu/index.php/Main_Page), under the supervision of Francisco Doblas-Reyes, an expert in near-term climate predictions and head of the CFU team. The VOLCADEC project will involve two internationally recognized French researchers: Christophe Cassou (CERFACS, CNRS, France, expert in decadal climate variability, supervisor of the secondment institution) and Didier Swingedouw (University of Bordeaux, CNRS, France, expert in climate dynamics and its response to volcanic eruptions), as well as Iléana Bladé (University of Barcelona, expert in stratospheric dynamical processes). IC3 is leading the European project *Seasonal to Decadal climate Predictions for the improvement of the European Climate Services* (SPECS, http://www.specs-fp7.eu/) that brings together 20 European institutes investigating the climate predictability at these timescales. The VOLCADEC project will benefit from the collaborations of IC3 with the SPECS partners, in particular Météo-France and CERFACS (France), KNMI (Netherlands), ECMWF and Met Office (UK), and SMHI (Sweden).

Under the Sixth Phase of the *Coupled Model Intercomparison Project* (CMIP6; http://www.wcrp-climate.org/wgcm-cmip/wgcm-cmip6), the *Model Intercomparison Project on the climatic response to Volcanic forcing to investigate the climate response to volcanic eruptions* (VolMIP, http://volmip.org) has been launched in 2015. Martin Ménégoz is the official contact for the component of VolMIP of EC-Earth[26], a climate model developed by a European consortium (http://www.ec-earth.org/). The VolMIP investigations will also contribute to the *Decadal Climate Prediction Project* (DCPP), another component of CMIP6. The VOLCADEC project will be a substantial contribution to CMIP6, supporting the involvement of IC3 in the VolMIP and DCPP exercises.

The three main issues of the VOLCADEC project will be addressed through **three work packages**: the first one aims at understanding the **dynamical response to a tropical volcanic eruption**. The second work package aims at evaluating **the skill of current forecast systems to reproduce the regional climate response to large eruptions when the aerosol concentration is fully specified**. The third work package aims at **defining the best way to take into account stratospheric volcanic aerosols in real-time global forecast systems**, during and outside periods of large eruptions. The following sections describe the methodology planned to carry out these three work packages.

Work Package 1: Understanding and attributing the climate response to volcanoes. Months 1-12

Martin Ménégoz is currently involved in different national and international projects that, among other objectives, investigate the understanding of the global and regional climate impacts of volcanic eruptions. In this context, many simulations have been and will be performed and Martin Ménégoz plans to benefit from the Marie Curie fellowship to analyse this material. Two main sets of simulations will be considered in the two tasks of the Work Package 1 (WP1), each time addressing a specific scientific question:

[24] *Taylor, K. E. et al., 2012, Bull. Amer. Meteor. Soc., 93, 485–498.* [25] *Ammann, C. M., and P. Naveau, 2010, J. Geophys. Res., 115, D05107.*
[26] *Hazeleger, W. et al., 2010, Bull. Amer. Meteor. Soc., 91, 1357–1363.*

Task 1.1: The climate response to large eruptions under different climate conditions in the North Atlantic.

Previous model studies showed that the background climate conditions are not only superimposed to the climate response to volcanic eruptions, but drive also partially this response[22]. Most of the volcanic eruption during the instrumental era occurred during a negative phase of the Atlantic Multi-Decadal Oscillation[27] (AMO), a period with particularly low surface temperature in the North Atlantic area. It was the case in particular for the El Chichón and the Pinatubo eruptions, so that it is natural asking what would have been the climate response to these recent eruptions under a warm phase of the AMO. To answer this question, we will use simulations that have been performed under the project "Mechanisms for climate Oscillations and Retroactions at Decadal tImesCale: Uncertainties and Sensitivity" (MORDICUS, http://www.agence-nationale-recherche.fr/en/anr-funded-project/?tx_lwmsuivibilan_pi2[CODE]=ANR-13-SENV-0002), led by Christophe Cassou and focusing on the understanding of the decadal climate variability. To investigate the climate response to volcanic eruptions under different climate conditions, Christophe Cassou modelled a Pinatubo-like eruption under extreme phases (warm and cold) of the AMO extracted themselves from a 1,000-year CNRM-CM5 model[28] simulation. Martin Ménégoz plans to analyse this ensemble of simulations to understand how the AMO state drives the dynamical response of the atmosphere to a large eruption. This task will be used to check if the positive NAO signal observed the winters following the last major tropical eruptions would have also occurred during a warm phase of the AMO.

Task 1.2: Modulation of the climate response to volcanic eruptions by the background climate conditions.

In this task a new set of simulations will be performed with the EC-Earth model to isolate the volcanic signal from the large internal variability. In contrast with task 1.1 that was focusing only on the NAO, a larger set of modes of climate variability will be considered in task 1.2. Following the VolMIP protocol, five-year ensemble simulations will be performed, including the same volcanic forcing recommended for the 1991 Pinatubo eruption in the context of the CMIP6 historical simulations[29]. These simulations will consist in a large ensemble (25 members) initialised with conditions typical for different states of the dominant modes of climate variability. These different states will be sampled from a long control simulation (200 years) performed under pre-industrial conditions by the EC-Earth consortium for CMIP6. We will extract from this control simulation the extreme phases (negative and positive) of the ENSO, the AMOC, the Quasi-Biennal Oscillation[23] (QBO) and the NAO, that will be used to initialise the sensitivity experiments. The large ensemble of these short-term simulations will be used to investigate the differences of climate responses to tropical eruptions under different background climate conditions. In addition, we will use it to check if the main modes of climate variability that condition the climate response to these eruptions. This set of simulations is one of the experiments planned in the VolMIP project.

<u>Work Package 2: Evaluating the capability of AOGCMs to simulate the climate response to tropical eruptions in a decadal forecast system. Months 7-15</u>

WP1 is devoted to the understanding of the climate response to volcanic eruptions. Work Package 2 (WP2) includes only one task and aims at investigating the ability of the EC-Earth climate forecast system to predict the climate response to tropical eruptions. In contrast with WP1, WP2 will focus on simulations initialised with observations that have been performed under the SPECS project. Preliminary results allowed distinguishing the contributions from initialization and volcanic forcing to the surface temperature anomalies after eruptions in decadal forecasts (Figure 2). Such analysis aims at distinguishing the climate variability induced by internal variability from that induced by the volcanic forcing specified from observations after the eruption.

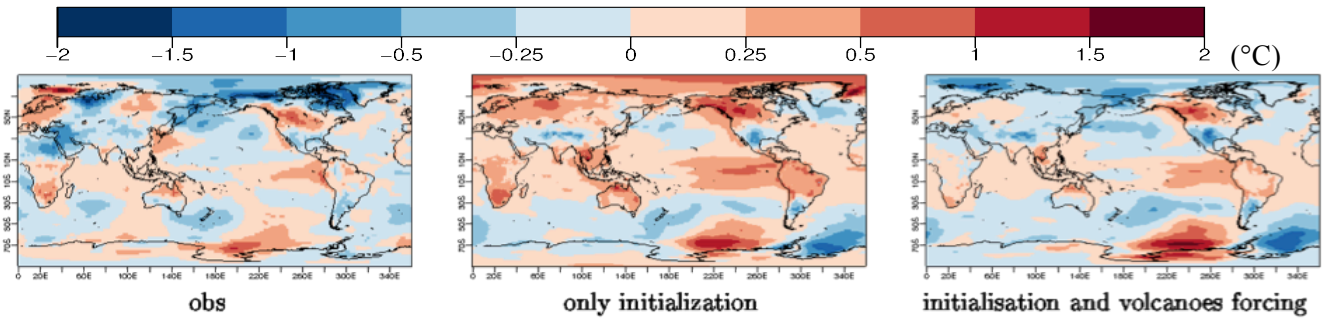


Figure 2: Average of the surface temperature anomalies the first year after the Agung, El Chichón and Pinatubo eruptions. Left: ERA40; simulations including (middle) and excluding (right) including volcanic forcing.

[27] *Knight, J. R. et al., 2005,* Geophys. Res. Lett. *Geophysical Research Letters, 32(20).* [28] *Voldoire, A. et al., 2013, Climate Dynam., 40(9-10), 2091-2121.* [29] *Thomason, L. et al., 2015, in prep. for GMD.*

WP2 is based on a thorough comparison between the SPECS simulations and observations, with a double aim to validate climate forecast systems and to investigate the respective contributions of volcanic forcing and internal climate variability to the climate variations following the last major eruptions. We will use optimal sets of meteorological data and reanalysis that are classically used for verification of forecast systems[4]. The SPECS project aims at investigating the sources of predictability at seasonal to decadal timescales. It is devoted to the design of forecast systems that will be used to provide climate information useful for our society. WP2 of this Marie-Curie project will bring complementary analysis to the SPECS investigations, by considering the increase in skill of forecast systems associated with the volcanic forcing when predicting the evolution of the main modes of climate variability: the NAO[30], the Southern Indian Ocean Dipole[31] (SIOD), the ENSO[32] and the Southern Annular Mode[33] (SAM). These modes of variability can be strongly affected by tropical volcanic eruptions, and WP2 will focus on the ability of forecast systems to anticipate their variations once a volcanic eruption has taken place. This is an essential step to design forecast systems able to predict the climate response to the next major volcanic eruption.

Work Package 3: Accounting for stratospheric aerosols in forecast systems. Months 13-24

Work Package 3 (WP3) aims at improving the representation of stratospheric aerosols in climate forecast systems and will require new sets of EC-Earth experiments. Different model configurations will be tested within two main tasks devoted to (1) the design of an optimal volcanic forcing usable to forecast the climate response to a new eruption, and (2) the improvement of the description of stratospheric background level of aerosols in AOGCMs.

Task 3.1: Defining volcanic forcing of large eruptions in forecast systems.

Two ways can be used to consider the volcanic forcing in seasonal to decadal forecast systems. The first one is to launch an AOGCM simulation considering the satellite-observed stratospheric aerosol concentration at the beginning of the simulation, and thereafter applying an exponential decay of this concentration that would reach the background value after some years. Such an idealised protocol can be used to forecast the climate response just after a new large eruption for which we cannot evaluate the future concentration of stratospheric particles. Such protocol is classically used in different European forecast centres but has never been evaluated. Here, it will be tested thanks to sets of five-member hindcasts for the three last major tropical eruptions (Agung, El Chichón, Pinatubo) that will be compared to the hindcasts performed using estimates of the actual volcanic forcing. Comparing the forecast skill in the two sets of experiments will allow evaluating such an idealised protocol. Under a new eruption, another way to forecast its climate impacts is to use the observed forcing from a past eruption, assuming that this one is more realistic than the idealized forcing tested previously. An additional five-member set of hindcasts will be performed over the three last eruptions, but inverting the volcanic forcing between the different experiments. Again, a forecast quality assessment will be undertaken to evaluate the suitability of such a protocol. The first task of WP3 will be concluded by investigating the potential effect of a new Pinatubo-like eruption occurring in 2015. This experiment will be part of the VolMIP-DCPP joint effort to investigate the sensitivity of the volcanic response to the state of the climate system. Considering together the possible climate responses to volcanic eruptions and the current climate conditions, we will use this forecast to provide detailed information to society on what could be the consequences of a new large volcanic eruption in the short term.

Task 3.2: Defining the stratospheric aerosol load in forecast systems.

There are still many open questions about the small eruptions that clearly impact the climate decadal variability by injecting aerosols in the lower stratosphere[34]. If the current hiatus of global warming has probably been triggered by ocean-atmosphere interactions[35], it is likely that it has been enhanced by a recent increase of small volcanic eruptions[8]. Such an increase of the aerosol burden in the lower stratosphere has never been taken into account in forecast systems, in particular because aerosol optical depth (AOD) used in models is based on satellite observations that underestimate the low stratospheric aerosol burden[7]. Here, we plan to implement in our EC-Earth simulations a new stratospheric aerosol load estimated from *Light and Radar* (LIDAR) observations for the period 1995-2015[7]. With such stratospheric forcing, we will investigate if we improve the coherence of our AOGCMs hindcasts with the observations of the current hiatus of the global surface temperature. We will also test different stratospheric aerosol background levels (upper and lower bounds of the estimations) in further hindcasts that will be performed to estimate the uncertainties associated to this forcing. The final goal of task 3.2 is to define how stratospheric AOD should be specified in operational forecast systems outside periods of large volcanic eruptions.

[30] *Hurrell, J. W., 1995, Science, 269(5224), 676-679.* [31] *Behera, S. et al., 2001, Geoph. Res. Lett. 28(2), 327-330.* [32] *Trenberth, K. E., 1997, Bull. Amer. Meteor. Soc, 78(12), 2771-2777.* [33] *Limpasuvan, V. et al., 1999, Geophys. Res. Lett., 26, 3133–3136.* [34] *Santer, B. D., et al., 2014, Nat. Geosci., 7(3), 185–189.* [35] *Guemas, V. et al., 2013, Nature Climate Change, 3(7), 649-653.*

- **Originality and innovative aspects of the research programme**

As described in Figure 3, the main originality of the VOLCADEC project lies in the prospect to gather the efforts of three different communities: (1) a first one developing operational forecast systems for seasonal to decadal timescales; (2) a second one focusing its attention on understanding the climate response to volcanic eruptions and (3) a third one investigating the climate decadal variability. This Marie-Curie fellowship will favour the interaction between these communities. Martin Ménégoz will carry on this project thanks to his strong background on climate sensitivity to aerosols, involving these communities as follows: (i) IC3 and other SPECS partners will provide an efficient support to optimize and evaluate operational climate forecast systems; (ii) the VOLCADEC project will serve as a base for IC3 and for the EC-Earth consortium to develop a collaboration with the experts of the climate response to volcanoes, in particular trough the VolMIP project that groups more than 70 scientists all over the world; (iii) the CERFACS, the second host institution, will bring its expertise on the natural decadal variability of the climate system.

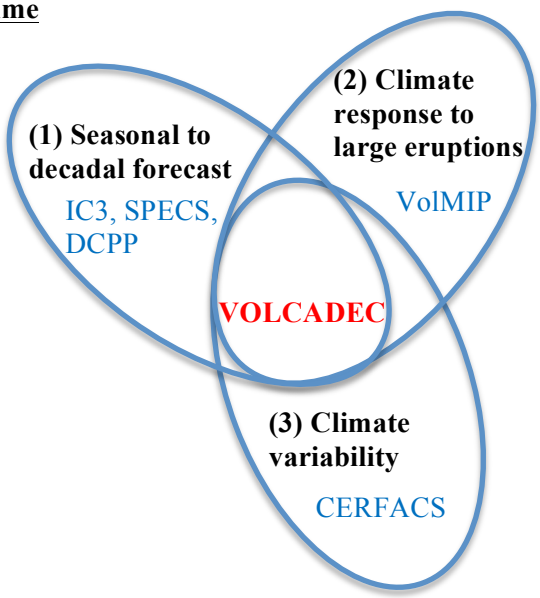


Figure 3: VOLCADEC communities

To address the scientific issues related to the climate response to volcanoes, the VOLCADEC project will use the innovative statistic tools developed by the SPECS community to evaluate operational forecast systems. In return, the VOLCADEC project will serve as the basis to set up new protocols to take into account stratospheric aerosols in climate forecast systems, an effort that is expected to significantly improve their skill. The VOLCADEC project will serve as a base to design AOGCMs able to forecast the climate response to the next large volcanic eruption, but also to anticipate the climate variability induced by variations of the stratospheric aerosol background level. Until now, these two issues have received little attention and they need to be considered to improve the current generation of climate forecast systems. These first order issues should be addressed for a better understanding of the climate variability in Europe, this one being largely driven by dynamical processes, themselves affected by the stratospheric aerosol load. The VOLCADEC project is a unique opportunity for Martin Ménégoz to become an expert in the climate response to volcanic eruptions, a challenging issue that is one of the main priorities of many European climate centres.

2.2 Clarity and quality of transfer of knowledge/training for the development of the researcher

The project is structured in such a way as to offer a unique opportunity to strengthen and widen the competences of the applicant, where he will have to build a bridge between his theoretical background in atmosphere-aerosol interactions and the practical requirements of climate decadal prediction: Martin Ménégoz investigated the climate response to aerosol forcing over the last 10 years, becoming a recognised expert with more than 10 publications in this field. The aerosol description in AOGCMs is one of the main weaknesses faced by the near-term climate prediction community that needs to bring together experts from the aerosol science with experts in decadal forecasts. Bringing his skills on aerosol and climate science, Martin Ménégoz will be fully involved in the community of climate scientists that focus its attention on seasonal to decadal timescales. Funded by the Marie-Curie program, he will further his knowledge in the statistical approaches used to evaluate the performances of the climate forecast systems at these timescales. IC3 has a vast experience in promoting the career of young scientists, by training them in seasonal to decadal forecasting in a go-ahead context of international collaborations. IC3 is also reputed for developing efficient teamwork by providing community analysis tools. Benefiting from the IC3 expertise, Martin Ménégoz will get an extra international recognition in the fields of aerosols and seasonal to decadal climate forecasting. In return, IC3 will benefit from the valuable expertise of Martin Ménégoz in aerosol modelling and understanding, an expertise currently missing in this institute.

2.3 Quality of the supervision and the hosting arrangements

Exposure to the highly dynamic research environment at both IC3 and CERFACS will allow the applicant to mature and diversify his research interests and intellectual curiosity. Particularly at IC3, where most of the fellowship will take place, the mentoring will include not only a thorough training in climate prediction, but have a strong component oriented towards gaining experience in competitive fund- and computing time-raising, and the organization of scientific meetings. The applicant will benefit from the IC3 collaborations opened within the FP7 SPECS and H2020 PRIMAVERA (*Process-based climate simulation: advances in high resolution modelling and European climate risk assessment*) European projects and started respectively in 2012 and 2015.

- **Qualifications and experience of the supervisor(s)**

Prof. Doblas-Reyes, Research Professor at ICREA (Institució Catalana de Recerca i Estudis Avançats) is the leader of the CFU. He is extremely well regarded in the field, having received in 2006 the Norbert Gerbier-MUMM International Award of the World Meteorological Organization (WMO), and being lead author of chapter 11 "Near-term Climate Change: Projections and Predictability" in the fifth assessment report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) Working group I – The Physical Science Basis. He is a member of several international scientific committees: e.g. co-chair of the Working Group on Seasonal-to-Interannual Prediction (WGSIP) and Decadal Climate Prediction Panel (DCPP) of the World Climate Research Programme (WCRP); European Climate, Observations and Modelling for Services panel of the European Commission. Prof. Doblas-Reyes is a prominent researcher in the fields of climate dynamics and climate prediction with excellent proven project management skills: Besides a list of more than 100 scientific peer-reviewed papers, this is also demonstrated by the fact that he is currently leading numerous projects at the CFU, mostly funded by the European Commission, the Spanish Government and private partners. He is collaborating with climate research institutions in three continents, like ECMWF, KNMI, SMHI, Met Office, CERFACS, Météo-France, NOAA, APCC and CPTEC.

Dr. Cassou is a CNRS scientist at CERFACS specialised in climate decadal variability with wide knowledge in atmospheric dynamics and ocean-atmosphere interactions. He leads the Climate Variability and Predictability branch of the Climate Modelling and Global Change team, and has been pursuing mostly modelling research on the above-mentioned themes within several ANR (IRCAAM, ECHO) and European (PREDICATE, DYNAMITE, ENSEMBLES, COMBINE, SPECS) projects; currently, he coordinates the French project MORDICUS and the EPIDOM-GICC initiative that aims at coordinating the decadal prediction efforts at national level between French institutes. Dr. Cassou authored more than 40 peer-review papers, and is member of the DCPP international committee. He is also strongly active in vulgarization projects, e.g. organizing an exhibition on climate change in a train that will cross France (http://messagersduclimat.com/) before the 2015 Paris Climate conference (COP21).

2.4 Capacity of the researcher to reach and re-enforce a position of professional maturity

The applicant has fully demonstrated in the past his proficiency to deal successfully with a wide range of scientific challenges, giving confidence in the realization of this Marie-Curie fellowship. This project will provide him the final expertise needed to become a completely independent scientist able to lead a research group. Martin Ménégoz became a specialist of the climate-atmosphere-aerosol interactions during his PhD at Météo-France. He confirmed his independence aptitude soon after his PhD, spending extended periods in different climate centres (LGGE, LSCE and LMD), focusing his investigations on the cryosphere sensitivity to anthropogenic aerosols, becoming internationally recognised in this field. He recently opened his investigations onto the seasonal to decadal forecast issue, by joining IC3 at the end of 2014. Now, he sees the Marie-Curie grant as the best way to investigate the role of volcanic aerosols in seasonal to decadal forecasts. After an 11-month contract at IC3, he has a solid plan to start leading the research line that deals with the climate response to volcanoes, both in terms of technical developments and theoretical approaches, and by opening collaborations with European partners within the SPECS and the EC-Earth projects. The applicant published 14 scientific papers in peer-review journals and participated in a large number of national and international projects. His curriculum vitae listed therein clearly show how those interactions have been extremely fruitful and have always resulted in publications and dissemination of front-line research. These experiences have allowed the applicant to create a wide network of international collaborations.

3. Impact

3.1 Enhancing research skills to realise the potential of individuals and to provide new career perspectives

The integration in a top-European centre such as IC3 will contribute substantially to enhance the applicant skills and career profile. Particularly effective in this regard will be the clear bottom-up character of the proposed research, its novelty with respect to the applicant previous interests and the high research level of his supervisor. At IC3, the fellow will be involved in advising Master and PhD students in the fields of aerosol impact on climate. These experiences will strengthen his ability to take decisions and to adapt his background to realistic requirements, essential characteristics of a mature researcher. The proposal represents a great opportunity for the applicant to develop project management skills needed to become an accomplished and multidisciplinary researcher. By doing so, he will also create a stream of responsibilities associated with the dependencies created at IC3 and CERFACS and developed within the SPECS European project. The investment in these responsibilities forms a unique training to become an independent researcher. All in all, this fellowship will enable the applicant to guide his research towards cutting-edge, future activities as well as to plan his scientific career in a long-term context. At IC3, the fellow will lead the research line focusing on atmosphere-aerosol interactions. Finally, the applicant is expected to enlarge his record of publications, positioning him at best to reach a tenure-track position.

3.2 Effectiveness of the proposed measures for communication and results dissemination

- **Communication and public engagement strategy of the action**

The results of VOLCADEC will be communicated trough international research activities and publications:

International research activities

CERFACS is leading the MORDICUS French project (2014-2017), devoted to the analysis of internal and externally forced climate variability. Focusing their investigations on the internal variability of climate, CERFACS expects Martin Ménégoz to bring an expertise needed to better understand the variability induced by the volcanic activity. The VOLCADEC results will be disseminated toward the French community thanks to the means of communication developed at CERFACS, targeting both the scientific community and the general public. IC3 is coordinating the SPECS European project (2012-2017) that highlighted the need to improve the way that stratospheric aerosols are taken into account in forecast systems. This issue will be appropriately tackled for the first time in Europe thanks to the VOLCADEC project. The experts involved in SPECS will provide a framework to discuss the VOLCADEC results, and will help to disseminate the findings to the whole European community. IC3 will base a large part of its implication in CMIP6 on activities proposed in VOLCADEC, especially on the VolMIP and the DCPP components. The VOLCADEC project plays therefore a strategic role of the first order for IC3. The research planned here will be of particular interest for the VolMIP community, as it will bring information on background stratospheric aerosol burden, a well-known weakness in the understanding of volcanic impacts on climate. These CMIP6 activities will be particularly useful to communicate the VOLCADEC results.

Expected publications

Three main publications will be submitted under VOLCADEC: (1) the first one will investigate how the climate conditions modulate the climate response to volcanic eruptions; (2) the second one will describe an idealized volcanic forcing that could be used in real-time climate forecasts; (3) the third one will focus on the role of stratospheric aerosols when trying to simulate the current hiatus of the global warming. The participation in other publications is expected thanks to the existing and upcoming international collaborations. The applicant will be involved in particular in a review paper about the climate impacts of volcanoes. The SPECS website is an efficient platform to diffuse information to European partners and the general public that will be used here to publish a fact sheet reviewing the climate impacts of volcanoes. The VOLCADEC results will be presented during international conferences, in particular the European Geophysical Union (EGU) assembly. The Applicant will also share the VOLCADEC results during meetings for the projects SPECS, PRIMAVERA, VolMIP, DCPP and EC-Earth.

- **Dissemination of the research results with the IC3 climate services**

Climate services is a growing topic at IC3 that aims at providing useful, action-oriented climate information to both public and private partners. IC3 is involved in collaborations with several partners in the energy sector in particular with wind farm stakeholders that are interested in the impact of climate variability on their production rates. The results obtained within VOLCADEC will be disseminated through the IC3 climate services. Some stakeholders working with the climate services group have expressed already their interest and provided letters of support.

- **Exploitation of results and intellectual property rights: thorough testing and distribution of a volcanic aerosol protocol for operational forecast systems**

In the last decades, the prediction at near-term time scales has received less attention than weather forecasting and long-term climate change projections. However, the WMO has expressed in clear terms the increasing need for robust climate information covering future periods ranging from several months up to several years for economic, industrial and political planning. The answer to the open questions around the climate impact of volcanoes and their simulation in operational forecast systems is a critical point regarding these societal issues, especially in the framework of the development of operational climate services. Under the VOLCADEC project, a new experimental set up describing the forcing of stratospheric aerosols will be provided to other forecast centres, through the strong implication of the CFU team in the European community. This will be done in particular by reinforcing the IC3 involvement in a recent European project that has been launched to provide real-time, multi-model seasonal to decadal forecasts[37]. Designing optimised forecast systems, we will be able to provide useful climate information, in particular in Europe where the climate variability is highly dependent on dynamical atmospheric processes themselves largely affected by stratospheric aerosols. Likewise, the secondment institution, the CERFACS, having competence in climate decadal variability and a natural user of climate research, will be able to easily take advantage of the technological development derived from the fellowship for specific applications.

[37] *Smith D. M., et al., 2013, Climate Dynam, 41(11-12), 2875-2888, doi:10.1007/s00382-012-1600-0.*

4. Implementation

4.1 Overall coherence and effectiveness of the work plan

As envisaged from its conception, the research project has been designed with the aim of tailoring the applicant's background, the supervisors' expertise and the facilities at the hosting institutions, in order to ensure its successful completion. The work plan reflects this idea, where the scientific program can be tackled from head-to-tail and in autonomy. The project is divided into three WPs that have been detailed in Section 2. Further details follow below, with a Gantt chart showing the schedule of the activities and a list of milestones (Ms) and deliverables (Ds).

Month	M3	M6	M9	M12	M15	M18	M21	M24
WP1 T1.1	MORDICUS							
T1.2	VolMIP experiments							
WP2 T2.1			SPECS					
WP3 T3.1					Idealized forcing experiments			
T3.2						Stratospheric aerosol experiments		
Deliverables		D1.1		D2.1			D3.1	D3.2
Milestones			M1.1		M2.2	M3.1	M3.2	
Secondment				CERFACS				
Meetings								

Gantt chart of the VOLCADEC project: *Each column spans a three-month period with its last month indicated in the second row. T denotes the different tasks of the WPs, appearing in orange when referring to the analysis of existing simulations and in blue when based on new model experiments.*

Timeline of the VOLCADEC project:

WP1 include two tasks: T1.1 is an analysis of the existing simulations provided by the CERFACS under the MORDICUS project. T1.1 will be monitored with a short report (D1.1) due *Month 6*. Part of this report will serve as a base for a review paper about climate and volcanoes that will be submitted by Didier Swingedouw (U. Bordeaux, France). Simultaneously to T1.1, a new set of EC-Earth simulations will be performed following the VolMIP protocol (T2.2). These simulations will be finished *Month 9* (M1.1).

WP2 consists in the analysis of existing initialised experiments performed under the SPECS project. A global analysis of simulations used in T1.1, T1.2 and T2.1 will be done during a secondment at CERFACS, leading to a publication submitted *Month 12* (D2.1). Further analysis of SPECS simulations will serve as a base to publish a fact sheet on the climate response to volcanic eruptions with the aim to improve the public understanding of the impact of volcanic eruptions on climate.

Benefiting from the overview work made during the secondment at CERFACS at the end of WP1, the applicant will come back to IC3 to start **WP3** by implementing a new description of stratospheric aerosol in forecast systems, both for period with large eruptions (T3.1) and for period typical of background aerosols levels (T3.2). These two tasks will be monitored with the completion of hindcasts including idealized volcanic forcing (M3.1) and recent LIDAR observations of the stratospheric aerosol load (M3.2). WP3 will be concluded with two publications, based on the two tasks, submitted respectively *Month 21* and *Month 24*.

The applicant will organize annual meetings with the CERFACS and the IC3 supervisors that will be held during SPECS, DCPP and VolMIP project meetings, with the aim to invite European partners involved in these projects. Didier Swingedouw and Illéana Bladé, both associates to this project, will also be invited at these meetings.

List of milestones:
M1.1: VolMIP experiments completed (Month 9).
M2.1: Fact sheet analysing SPECS hindcasts to be published on the SPECS website (Month 15).
M3.1: Hindcasts including idealised volcanic forcing; forecast of a hypothetical 2015 eruption (Month 18).
M3.2: Hindcasts sensitivity to stratospheric aerosol background (Month 21).

List of deliverables:
D1.1: Report with the results of the MORDICUS simulation analysis (Month 6).
D2.1: Publication investigating how the climate conditions modulate its response to eruptions (Month 12).
D3.1: Publication describing the design of the idealized forcing for large eruptions (Month 21).
D3.2: Publication investigating the climate sensitivity to the stratospheric aerosol load (Month 24).

4.2 Appropriateness of the management structure and procedures, including quality and risk management

- **Project organisation and management structure**

The project will be managed through bi-monthly meetings to ensure full coherence between the applicant's research and the general objectives of IC3. Opening these meetings to the other CFU members when needed, Prof. Doblas-Reyes will provide adequate mentoring in the general background of climate prediction. He will help to adapt the research programme to the difficulties encountered and orientate the project in the most promising aspects of the research undertaken. The applicant will write periodic reports detailing the progress and the issues raised during the development of the research plan.

- **Risks that might endanger reaching project objectives**

No substantial risks have been identified, apart from occasional delays with the milestones/deliverables (due to technical difficulties with code modifications or computer replacements), since the hosting supervisors/institutions have ample competences in the field and all datasets to be analysed are freely available for research purposes.

4.3 Appropriateness of the institutional environment (infrastructure)

- **Description of the main tasks and commitments of the beneficiary and partners**

The host (IC3) and secondment institution (CERFACS) are international leaders for climate research and foster high-level education in the study of climate variability and predictability and its effects on society. Hence, the proposal fits extremely well their goals, ensuring the successful accomplishment of the project. **IC3** undertakes research on the development of dynamical and statistical methods for the prediction of global and regional climate on timescales from a few weeks to several years. The formulation of the predictions includes special efforts to satisfy user needs. It is worth noting that IC3 is the first institute in Spain exclusively devoted to research, education, impact assessment and progress of climate sciences. **CERFACS** has a recognized expertise in climate variability and dynamics, climate change, data assimilation and ocean-atmosphere coupling on both scientific and technical aspects. The team benefits from strong technical support provided by a pool of research engineers who are experts on software/hardware issues.

- **Infrastructure, logistics and facilities offered for the implementation of the action.**

The CFU makes a common effort to develop statistical tools (http://ic3.cat/wikicfu/index.php/Tools/s2dverification) and invests heavily in the development of the EC-Earth AOGCM that will be widely used by the applicant. This one will have at his disposal the computing infrastructures and the support of 20 CFU members. These include the office space and equipment necessary to implement the project, including administrative staff and IT support. The CFU group includes five software engineers that are responsible for maintaining IT, deploying the EC-Earth model at different high performance computing (HPC) platforms, developing tools to process data and assisting CFU members in computing jobs. CFU demonstrated in the past its strong competitive capability in terms of gaining access to the most powerful supercomputer in Spain and in Europe, in particular with the Barcelona Supercomputing Centre platform (BSC, Spain) and with the ECMWF (UK).

4.4 Competences, experience and complementarity of the participating organisations

The elevated level of experience of the applicant and supervisors, together with the high level of excellence at the hosting institutions as well as their match on the project, provide the necessary background for the successful implementation of the proposed research and the continuity of the fellow career development. The scientific challenges in the framework of the fellowship will ensure the two-way transfer of new knowledge reinforcing the skills of all participants. Likewise, the completion of this project will increase their visibility and competitiveness within the research job market in a domain of science attracting significant governmental funds and being at the core of technological and innovative policy in European countries. Finally, the exciting scenario that will bring this fellowship, in addition to be mutually beneficial, could establish a solid base for long-term collaborations among the researchers and lead to pioneering activities in climate prediction.

- **Commitment of beneficiary and partner organisations to the programme**

The first practical arrangement to ensure the implementation of the project is the agreement of IC3 with the CERFACS to invest the necessary effort in the proper development of the work. Several awarded projects currently on-going at the institutions (see Section 6) will be able to provide infrastructure to develop the proposed research. The second arrangement is that the fellow will have access to all the experimental equipment and software required. Third, the two institutions also agree that the fellow will have freedom to manage the fellowship research funds. Finally, the fellow will have full autonomy for applying for projects throughout the fellowship duration.

5. CV of the Experienced Researcher

The CV of the applicants is detailed in the eight following sections: (1) Research interest; (2) Education; (3) Professional experience; (4) Languages and skills; (5) international peer-review publications; (6) Reports; (7) Communications; (8) Supplementary information.

- **Main research interests**

➢ Climate variability and predictability: models and observations

➢ Atmospheric physics and chemistry, aerosols, volcanoes

➢ Glaciers, snow cover and hydrosphere variability

- **Education**

➢ **2006-2009: PhD,** *Atmospheric physics and chemistry, University of Toulouse III, France.*

➢ **2003-2004: Master "Ocean, Atmosphere, Hydrology",** *University J. Fourier, Grenoble*

➢ **2000-2003: École Nationale Supérieure d'Hydraulique et de Mécanique de Grenoble**

- **Professional experience**

➢ **Since 2014, September**: Research fellow at Institut Català de Ciènces del Clima (IC3, Barcelona, Spain).

- Seasonal to decadal climate forecasts.
- Volcanic and anthropogenic aerosols impacts on climate variability.
- Involved in the European "FP7″ project SPECS (Seasonal to decadal climate Predictions for the improvement of the Climate Services) and the french ANR project MORDICUS (Mechanisms for climate Oscillations and Retroactions at Decadal tImesCale: Uncertainties and Sensitivity).

➢ **2013-2014:** Postodctoral fellowship with the Laboratoire de Météorologie Dynamique (LMD, Paris, France) and the Laboratoire de Glaciologie et de Géophysique de l'Environnement (LGGE, Grenoble, France).

- Precipitation and snow cover variability in the Himalaya. From local and remote observations to large-scale climatic simulations.
- Implementing new physical schemes in global and regional climate models for a better representation of snowfall and snowcover in mountainous areas.
- Involved in the European "FP7″ project ic2sea (Estimating the future contribution of continental ice to sea-level rise)

➢ **2012:** Postdoctoral fellowship at the LGGE (France).

- Modelling the impact of black carbon deposition on the himalayan snow.
- Involved in the French national ANR project "PAPRIKA", devoted to the analysis of anthropogenic pressure on the cryosphere in the Himalaya.
- Measuring glacier mass balance and surface energy balance in mountainous areas (French Alps and Himalaya).

➢ **2010-2012:** Postoctoral fellowship with the Laboratoire des Sciences du Climat et de l'Environnement (LSCE, Paris) and the LGGE.

- Estimating the aerosol burden in the Arctic atmosphere, and the snow cover variations induced by aerosol deposition in the Northern hemisphere. Modelling the modern climate and discussing future scenarios with global and regional models.
- Involved in the European "life" project SNOWCARBO, devoted to snow, carbon and climate interactions.
- Lecturer at the University of Joseph Fourier (UJF): atmospheric pollution.

- **2006-2009:** Doctoral fellowship at the « Centre Nationale de Recherche Météorologiques" (CNRM, Météo-France).
    - Global analysis of aerosol-climate interactions. Using and developing the Météo-France chemical-transport model MOCAGE.
    - Involved in the French national ANR project NEEM.

- **2005:** Engineer in HYDRETUDES (Gap, France), private research units in hydraulics.
    - Designing hydraulics networks and river settlements (project management).
- **2004:** Research project with the IRD (Institut de Recherche pour le Développement, French institute), and the Ecuadorian meteorological institute (INHAMI, Quito, Ecuador).
    - Analysis of the climate-cryosphere interactions.
    - Set up of hydrological and meteorological station on a tropical glacier area.
- **2003:** Training period with the IRD → measuring turbulent fluxes over a tropical glacier.
- **2002:** Training period at GÉOLITHE, private research units
    - Sizing protection structures for avalanches.

- **<u>Languages and skills</u>**

- **Languages:**
    - French: mother tongue
    - English and Spanish: spoken and written

- **Computer skills:**
    - Unix, Fortran 90, Ferret, Grads, Nco/Cdo, R, Scilab, Matlab, Python, MSOffice.
    - Using and developing atmospheric chemistry models (MOCAGE, Météo-France, LMDZ-INCA, LSCE) and global and regional climate models (**ARPEGE-Climat**, Météo-France, **LMDZ**, IPSL, **MAR**, LGGE, **EC-EARTH**, European model).

- **Field skills:**
    - Implementation of meteorological and hydrological stations.
    - **High mountain guide** (graduated from ENSA (Ecole Nationale Supérieure de Ski et d'Alpinisme, France, 2012). Manage field campaigns in mountainous areas.

- **<u>International peer-review publications</u>**

14. Jacobi, H.-W., Lim, S., **Ménégoz, M**., Ginot, P., Laj, P., Bonasoni, P., Stocchi, P., Marinoni, A., and Arnaud, Y., 2015: Black carbon in snow in the upper Himalayan Khumbu Valley, Nepal: observations and modeling of the impact on snow albedo, melting, and radiative forcing, The Cryosphere, 9, 1685-1699, doi:10.5194/tc-9-1685-2015.

13. Verfaillie, D, Favier, V., Dumont, M., Jomelli, V., Gilbert, A., Brunstein, D., Gallée, H., Rinterknecht, V., **Ménégoz, M**., Frenot, Y., 2015: Recent glacier decline in the Kerguelen Islands (49°S, 69°E) derived from modeling, field observations and satellite data, JGR, doi: 10.1002/2014JF003329.

12. **Ménégoz, M.**, Krinner, G., Balkanski, Y., Boucher, O., Cozic, A., Lim, S., Ginot, P., Laj, P., Gallée, H., Wagnon, P., Marinoni, A. and Jacobi, H.W., 2014: Snow cover sensitivity to black carbon deposition in the Himalaya: from atmospheric and ice core measurements to regional climate simulations, *Atmos. Chem. Phys*., 14, 4237-4249, doi:10.5194/acp-14-4237-2014; ***Research highlight, Himalayan melt, in Nature Climate Change, 4, 420 (2014), doi:10.1038/nclimate2262***.

11. Krinner, G., Largeron, C., **Ménégoz, M.**, Agosta, C., Parouty, C. and Brutel-Vuilmet, C., 2014: Oceanic forcing of Antarctic climate change: A study using a stretched-grid atmospheric general circulation model, *J. Climate*, **27**, 5786–5800. doi: http://dx.doi.org/10.1175/JCLI-D-13-00367.1.

10. Wagnon, P., Vincent, C., Arnaud, Y., Berthier, E., Vuillermoz, E., Gruber, S., **Ménégoz, M.**, Gilbert, A., Dumont, M., Shea, J. M., Stumm, D., and Pokhrel, B. K., 2013: Seasonal and annual mass balances of Mera and Pokalde glaciers (Nepal Himalaya) since 2007, *The Cryosphere*, 7, 1769-1786, doi:10.5194/tc-7-1769-2013.

9. **Ménégoz, M.**, Gallée, H., and Jacobi, H. W., 2013b: Precipitation and snow cover in the Himalaya: from reanalysis to regional climate simulations, *Hydrol. Earth Syst. Sci*., 17, 3921-3936, doi:10.5194/hess-17-3921-2013.

8. **Ménégoz, M.**, Krinner, G., Balkanski, Y., Cozic, A., Boucher, O., and Ciais, P., 2013a: Boreal and temperate snow cover variations induced by black carbon emissions in the middle of the 21st century, *The Cryosphere*, 7, 537-554.

7. Rabatel, A., […], **Ménégoz, M.**, et al., 2013: Current state of glaciers in the tropical Andes: a multi-century perspective on glacier evolution and climate change, *The Cryosphere*, 7, 81-102.

6. Brutel-Vuilmet, C., **Ménégoz, M.**, and Krinner, G., 2013: An analysis of present and future seasonal Northern Hemisphere land snow cover simulated by CMIP5 coupled climate models, *The Cryosphere*, 7, 67-80.

5. Yasunari, T.J., Tan, Q., Lau, K.-M., Bonasoni, P. Marinoni, A., Laj, P., **Ménégoz, M.**, et al., 2013: What are the true range of black carbon dry deposition and the related snow albedo reduction over Himalayan glaciers during pre-monsoon periods ?, *Atmosph. Env*., doi:10.1016/j.atmosenv.2012.03.031.

4. Gouttevin, I., **Ménégoz, M.** et al., 2012: How the insulating properties of snow affect soil carbon distribution in the continental pan-Arctic area ?, *J. Geophys. Res*., 117, G02020, doi:10.1029/2011JG001916.

3. **Ménégoz, M.** et al., 2012: How does the atmospheric variability drive the aerosol residence time in the Arctic region ?, *Tellus B*, 64, 11596, doi: 10.3402.

2. **Ménégoz, M.** et al., 2010: Winter interactions between aerosols and weather regimes in the North-Atlantic European region, *J. Geophys. Res*., 115, D09201, doi:10.1029/2009JD012480.

1. **Ménégoz, M.** et al., 2009: Equilibrium of sinks and sources of sulphates over Europe: Comparison between a six-year numerical simulation and EMEP observations, *Atmos. Chem. Phys*., 9, 4505-4519.

- **Reports**

- **Ménégoz**, 2013: Simulations avec LMDZ de la sensibilité du couvert neigeux au dépôt d'aérosols. Edited in the journal of the LMD, 2013: http://lmdz.lmd.jussieu.fr/communication/lmdzinfo/lmdzinfo9.pdf/view.
- Bisiaux, M., **Ménégoz, M.**, 2013: Noir sur blanc – l'effet de la pollution sur la fonte des neige en Himalaya, La revue de l'Anena: http://www.anena.org/6333-neige-et-avalanches-n-142.htm.
- **Ménégoz, M.**, 2009: Modélisation globale des interactions atmosphère-aérosols, PhD report, Université Paul Sabatier, Toulouse, 198 p.: http://thesesups.ups-tlse.fr/700/.
- **Ménégoz, M.**, « Étude de la couche limite atmosphérique sur un glacier tropical (Equateur), et estimation des flux turbulents », Master report, 50 p., 2004.
- **Ménégoz, M.**, "Estimation des hauteurs de rugosité et des flux turbulents de chaleur sur un glacier", training period report, 50 p., 2003.

- **Communications**

28. **Ménégoz, M**., Doblas-Reyes, F., Muhammad, A, Massonnet, F.: Volcanic forcing in decadal forecasts (poster), International Union Geodesy and Geophysics (IUGG), Prague, Austria, June 2015.

27. **Ménégoz, M.**, Krinner, G. et al.: Snow cover sensitivity to black carbon deposition in the Himalayas: from ice core measurements to regional climate simulations (poster), International Union Geodesy and Geophysics (IUGG), Prague, Austria, June 2015.

25. Krinner, G., Brutel-Vuilmet, C., **Ménégoz, M**.: An analysis of present and future seasonal Northern Hemisphere land snow cover simulated by CMIP5 coupled climate models (poster), International Union Geodesy and Geophysics (IUGG), Prague, Austria, June 2015.

24. Jacobi, H.-W., **Ménégoz, M**. et al.: Impact of BC and dust on the seasonal snow pack of the high altitude regions of the Himalayas (poster), International Union Geodesy and Geophysics (IUGG), Prague, Austria, June 2015.

23. **Ménégoz, M.**, Doblas-Reyes, F., Guemas, V., Muhammad, A.: Volcanoes and decadal forecasts with the EC-Earth climate model, EC-Earth meeting, Reading, UK, May 2015.

22. **Ménégoz, M.** and Doblas-Reyes, F: Volcanoes and decadal forecasts, SPECS/MIKLIP meeting, Offenbach, Germany, February 2015.

21. Jacobi, Hans-Werner, **Ménégoz, M.**, et al.: Impact of BC and dust on the seasonal snowpack of the high altitude regions of the Himalayas, IGS International Symposium on Glaciology in High Mountain Asia, Kathmandu, Népal, March 2015.

20. **Ménégoz, M.** and Doblas-Reyes, F.: Les éruptions volcaniques dans les prévisions décennales, Ateliers de Modélisation de l'Atmosphère, Toulouse, January 2015.

19. **Ménégoz, M.**, Favier, V., Verfaillie, D., Berthier, E., Jomelli, V, Kay, JE, Ducret, L., Malbéteau, Y., Brunstein, D., Gallée, H., Park, Y.H.: Sécheresse subantarctique et recul spectaculaire des glaciers des îles Kerguelen, Ateliers de Modélisation de l'Atmosphère, Toulouse, January 2015.

18. **Ménégoz, M.**: Investigating snow cover variability with climate models, presentation at the IC3, October, 2014.

17. **Ménégoz, M.**: Appréhender les variations actuelles et futures du couvert neigeux avec un modèle de climat, presentation LTHE-LGGE, February, 2014.

16. **Ménégoz, M.**, Krinner, G., Balkanski, Y., Cozic, A., Boucher, O., Lim, S., Ginot, P., Laj, P. and Jacobi, H.W.: Snow cover sensitivity to black carbon deposition in the Himalaya: from ice core measurements to regional climate simulations (poster), AMA, Toulouse, France, 20th-22th January, 2014.

15. **Ménégoz, M.**, Krinner, G., Balkanski, Y., Cozic, A., Boucher, O., Lim, S., Ginot, P., Laj, P. and Jacobi, H.W.: Snow cover sensitivity to black carbon deposition in the Himalaya: from ice core measurements to regional climate simulations (poster), ISSW, Grenoble, France, 7th-11th October, 2013.

14. **Ménégoz, M.**, Gallée, H. and Jacobi, H.W.: "Precipitation and snow cover in the Himalayas: from reanalyses to climate regional simulations", Geophysical Research Abstracts, Vol. 15, EGU2013-10766, EGU General Assembly 2013.

13. **Ménégoz, M.,** Lim, S., Ginot, P., Balkanski, Y., Cozic, A., Krinner, G. and Jacobi, H.W., Snow cover sensitivity to black carbon deposition in the Himalaya: from ice core measurements to regional climate simulations (poster), Geophysical Research Abstracts, Vol. 15, EGU2013-7486, EGU General Assembly 2013.

12. Dominé, F., Picard, G., Morin, S., Krinner, G., Gouttevin, I., **Ménégoz, M.**, Gallet, J.C., Laurent, A., Dumont, M., Lafaysse, M., Brun, E.: Can snow save us from global warming? (Louis Agassiz Medal Lecture), EGU General Assembly 2013, held 7-12 April, 2013 in Vienna, Austria, p.13913.

11. Jacobi, H.W., **Ménégoz, M.**, et al.: Modeling the impact of black carbon on snowpack properties at an high altitude site in the Himalayas (poster), Geophysical Research Abstracts, Vol. 15, EGU2013-7486, EGU General Assembly 2013.

10. **Ménégoz, M.**, et al.: Variations du couvert neigeux dans l'Hémisphère Nord: Impact des émissions de carbone-suie en régions boréales et tempérées au 21ième siècle, Ateliers de Modélisation de l'Atmosphère, Toulouse, Janvier 2013.

9. **Ménégoz, M.**, et al.: Regional Climate Modelling over Himalaya: An analysis of precipitation and snow cover, presentation at ICIMOD, Kathmandu, Népal, Novembre 2012.

8. **Ménégoz, M.**, Gallée, H., Jacobi, H.W.: Modélisation climatique en Himalaya avec le modèle MAR: apport d'une simulation régionale pour l'analyse des champs de précipitation et de couverture neigeuse (présentation et acte), XXVième colloque de l'association internationale de climatologie (AIC) ; les climats régionaux: observation et modélisation, Grenoble, France, Septembre 2012.

7. **Ménégoz, M.**, Jacobi, H.W. and Gallée, H.: "Modelling precipitation and snow cover in the Himalayas with a regional model MAR" (poster), Symposium on Seasonal Snow and Ice IGS, Lahti, Finland, 2012.

6. Jacobi, H.W., **Ménégoz, M.** and Gallée, H.: "Development of a detailed snowpack model to study the impact of black carbon on the seasonal snow" (poster), Symposium on Seasonal Snow and Ice IGS, Lahti, Finland, 2012.

5. Dominé, F, Krinner, G, **Ménégoz, M.**, Bock, J., Gallet, J-C., Anttila, K.: "Snow-climate feedbacks driven by changes in snow thermal conductivity" (poster), International Polar Year Oslo science conference, June, 2010.

4. **Ménégoz** et al., "A six-years simulation of sulphate aerosol over Europe: analysis and comparison with EMEP observations" (poster), IGAC conference, Annecy, France, 2008.

3. **Ménégoz** et al., "A three-dimensionnal study of sulphates, black-carbon and dust aerosols" (poster), A-train Lille 2007 Symposium aerosol and clouds.

2. **Ménégoz** et al., "A three-dimensionnal study of sulphates, black-carbon and dust aerosols" (poster), EGU, Vienne, 2007.

1. **Ménégoz** et al., "Study of the surface boundary layer on Antizana glacier (Equateur)" (poster), 2nd symposium on mass balance over Andean glaciers, Huaraz, Peru, 2004.

- **Research expeditions that the experienced researcher has led.**

Martin Ménégoz co-supervised three one-month research expeditions in mountainous areas, two in Ecuador (Antizana glacier, 2003 and 2004) and one in Nepal (Mera Peak and Shangri Nup, 2012), devoted to glacier mass balance measurements and surface energy balance observations, by setting up meteorological stations. This work was performed with an IRD team hosted at LGGE investigating the glacier response to climate change in tropical and mid-latitude areas. Martin Ménégoz was also involved in many field campaigns devoted to glaciological observation in the Alps from 2010 to 2013.

- **Supplementary information**

➢ Reviewer for ***The Cryosphere***, ***Environmental Research Letter*** and ***Atmospheric Environment***

➢ Involved in the film "Le doigt de Dieu" devoted to the links between human beings and wilderness around the Meije, an emblematic mountain of the Ecrins (http://www.ledoigtdedieu.fr/index.php).

6. Capacity of the Participating Organisations

Beneficiary - IC3	
General Description	The Institut Català de Ciències del Clima (IC3, Spain) is funded by the Catalan government and aims at developing high-quality research on climate variability and its impacts. The Climate Forecasting Unit (CFU) undertakes research on the development of dynamical and statistical methods for the prediction of global and regional climate.
Role and Commitment of key persons (supervisor)	Prof. Doblas-Reyes is a worldwide expert in the development of seasonal-to-decadal climate prediction systems and the head of CFU. He is involved in the development of the EC-EARTH climate model since its inception. He was involved in the preparation of the IPCC Fifth Assessment Report (Working Group 1) as a lead author, serves in WCRP and WWRP scientific panels, and has participated in more than 20 FP4 to FP7 projects. He is coordinator of the FP7 project Seasonal-to-decadal climate Prediction for the improvement of European Climate Services (SPECS). He is shaping IC3's plans for the development of a climate services capability with a focus on the energy sector and contributes to the international Climate Services Partnership.
Key Research Facilities, Infrastructure	A sizeable allocation in the IC3 linux cluster, as well as competitive computing allocations on a range of supercomputing platforms. Desktops with multi-core processors, fat nodes for post-processing and a mass storage system all under NFS.
Independent research premises?	As an independently managed institution, IC3 headquarters is located in a rented building in Barcelona with more than 700m2 of office space.
Previous Involvement in Research and Training Programmes	IC3 has been playing a relevant national and international role in geosciences, mathematics, climate physics and ecology, as reflected through the participation of IC3 in 7 national projects, 3 private-funded projects, and 4 European projects (FLUXPYR INTERREG 2009, QWECI 243964 FP7-ENV-2009, VIROCLIME 243923 FP7-ENV-2009, INCLIDA 275505 FP7-PEOPLE-2010-IEF supervised by Prof. Doblas-Reyes). Professors at IC3 have been able to provide IC3 researchers with exceptional training support and conditions for their scientific growth in many different ways, including improvements in their scientific and management skills.
Current involvement in Research and Training Programmes	Currently IC3 is participating in 3 national projects, 2 private-funded projects and 10 European projects (CLIMRUN 265192 FP7-ENV-2010, INGOS 284274 FP7-INFRASTRUCTURES-2011, DENFREE 282378 FP7-HEALTH-2011, IS-ENES2 312979 FP7-INFRASTRUCTURES-2012, EUPORIAS 308291 FP7-ENV-2012, EUCLEIA 607085 FP7-SPACE-2013, PREFACE 603521 FP7-ENV-2013), among SPECS (308378 FP7-ENV-2012) and PRIMAVERA 641727 both coordinated by IC3, and 2 FP7-PEOPLE projects (TREE-RINGS & CLIMATE 253277 FP7-PEOPLE-2009-IOF and MEMENTO 300727 FP7-PEOPLE-2011-IOF). IC3 is in close collaboration with several universities (e.g. Universitat de Barcelona, University of Heidelberg, University of Malawi, Universidad Complutense de Madrid) and their Master program and in the near future 6 theses are expected to be defended.
Relevant Publications and/or research/innovation products **(CFU authors appear in bold)**	**F.J. Doblas-Reyes, F.J.**, […], **García-Serrano, J**., **Guemas, V**., 2013: Initialized near-term regional climate change prediction. *Nat. Commun., 4, 1715*. **Guemas, V**., **F.J. Doblas-Reyes, F.J., Andreu-Burillo, I**., **Asif, M**., 2013: Retrospective prediction of the global warming slowdown in the last decade, *Nature Clim. Change, 3, 649-653, doi:10.1038/nclimate1863*. Kirtman, B., […], **Doblas-Reyes, F.J**. et al., 2013: *Near-term climate change: Projections and predictability. Climate Change 2013: The Physical Science Basis*. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Ed. Stocker, Cambridge Univ. Press. **Guemas, V**., […], **García-Serrano, J**., **F.J. Doblas-Reyes**, et al., 2013: The Indian Ocean: the region of highest skill worldwide in decadal climate prediction, *J. Climate, 26, 726-739, doi:10.1175/JCLI-D-12-00049.1.* **Doblas-Reyes, F.J., J. García-Serrano** et al., 2013: Seasonal climate predictability and forecasting: status and prospects. *WIREs Climate Change, 4, 245-268, doi:10.1002/WCC.217*

Partner Organisation - CERFACS	
General description	CERFACS (Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique) is a research organization that aims to develop advanced methods for the numerical simulation and the algorithmic solution of large scientific and technological problems of interest for research as well as industry.
Key Persons and Expertise (supervisor)	Dr. Cassou coordinates the research activities of climate variability and predictability as part of the Climate Modelling & Global Change (CMGC) group. He is involved in many national projects such as the ANR MORDICUS project (coordinator) and international ones. He has coordinated the Météo-France/CERFACS contribution to the near-term CMIP5 exercise. He serves in the WCRP scientific panel.
Key Research facilities, infrastructure and equipment	Indoors computing servers deliver 75 Tflop/s using BULL Intel SandyBridge cluster (BULL B510) and HP AMD MagnyCours cluster (HP C7000). About 360 TO of local storage are distributed. CERFACS benefits as well from Météo-France's infrastructure in terms of computer resources and general facilities.
Previous and Current Involvement in Research and Training Programmes	The CMGC group has been involved in several European projects (e.g. DYNAMITE, COMBINE). Currently, it is participating in 5 European projects (IS-ENES2, EUDAT, SPECS, CLIPC, PREFACE) and 6 national projects, among 2 coordinated by Dr. Cassou. CERFACS participates to several PRACE (Partnership for Advance Computing in Europe) projects in collaboration with many European institutes. CERFACS has also the ambition of reinforcing its position as an actor in High Performance Computing (HPC) training for engineers, PhD and post-doctoral students.
Relevant Publications and/or research/innovation product	Barrier, N., **Cassou, C**., Deshayes, J., Treguier, A.M., 2014: Response of North Atlantic Ocean circulation to atmospheric weather regimes, *J. Phys. Oceanogr., 44, 179-201.* **Cassou, C**., Minvielle, M., Terray, L., Perigaud, C., 2011: A statistical-dynamical scheme for reconstructing ocean forcing in the Atlantic. Part I: weather regimes as predictors for ocean surface variables, *Clim Dyn., 36, 19-39*. **Cassou, C**., 2008: Intraseasonal interaction between the Madden-Julian Oscillation and the North Atlantic Oscillation, *Nature, 455, 523-527*.

7. Ethical Issues

Nothing to declare

8. Letters of support

The next letters in support of the proposal have been signed by the following researchers and managers:

- Dr Claudia Timmreck, senior scientist at the Max Planck Institute for Meteorology (Germany), Co-leader of the VolMIP project, officially endorsed as a CMIP6 activity;
- Dr Tim Stockdale, Head of the Seasonal and Long Range Forecasting Group at ECMWF (UK), coordinator of the SPECS work package devoted to stratosphere and changing radiative forcings;
- Dr Didier Swingedouw, CNRS researcher at University of Bordeaux (France), expert in climate dynamics and in climate response to volcanic eruptions;
- Mr Ignacio Làinez, director of the Energy Assessment Department of the EDP Renewable Europe SL group (Spain), one of the most qualified companies in renewable energy in Europe;
- Dr Matthias Piot, Meteorologist at the ENBW-AG Company (Germany), a large power supplier group in Europe, expert in wind power generation.

Max-Planck-Institut
für Meteorologie

MAX-PLANCK-GESELLSCHAFT

Max-Planck-Institut für Meteorologie | Bundesstr. 53 | 20146 Hamburg

To
Dr. Martin Ménégoz
Lead researcher for Climate and volcanoes group
in the Climate Forecasting Unit (CFU)
at Institut Català de Ciències del Clima (IC3),
Barcelona, Spain

Dr. Claudia Timmreck
VolMIP,Co-leader
Max-Planck-Institut für Meteorologie
Bundesstr. 53
20146 Hamburg
Germany
Tel.: +49 - (0)40 - 41173 - 384
Fax: +49 - (0)40 - 44173 298
claudia.timmreck@mpimet.mpg.de
www.mpimet.mpg.de

Hamburg, den 31/ August 2015

To whom it may concern,

As co-chair of VolMIP, a project devoted to the understanding of the climate response to volcanic eruptions recently endorsed by the Coupled Model Intercomparison project (CMIP6), I would like to offer my enthusiastic support for the proposal of Dr. Martin Ménégoz "Volcanic activity in seasonal to decadal climate forecasts" (VOLCADEC) to the Marie Skłodowska-Curie IF-EF program. Benefiting from this program, Martin Ménégoz will be able to supervise the involvement of IC3 in VolMIP. He will also support substantially the EC-Earth European consortium to contribute to VolMIP, being the only researcher that plans to use the EC-Earth climate model within VolMIP.

Climate response to volcanic forcing is a challenging issue that currently retains the attention of the whole community of climate researchers, because several large eruptions occurred over the last decades, and the volcanic forcing cannot be neglected when evaluating the skill of the current generation of climate models. In addition, it is unclear how such models could be used to simulate the climate response to a new large eruption in real-time forecasts. Such new eruption would be likely to have significant climate impact, in particular in Europe, and these ones need to be better anticipated regarding its potential societal impacts. Overall, both during and out of periods of large eruptions, volcanoes are the main source of stratospheric aerosols, these one significantly impacting the climate decadal variability. Granted by the Marie-Curie program, Martin Ménégoz would be very active in the effort commonly pursued by European institutes to address these questions.

Under the VOLCADEC project, Martin Ménégoz could actively participate in the VolMIP meetings that will be organized over the next years during international events. For these reasons I wish Martin Ménégoz to success with his proposal and hope to collaborate more with him in the near future trough this Marie-Curie project.

Yours sincerely,

Claudia Timmreck

ECMWF European Centre for Medium-Range Weather Forecasts

Europäisches Zentrum für mittelfristige Wettervorhersage • Centre européen pour les prévisions météorologiques à moyen terme

0118 9499117
t.stockdale@ecmwf.int

07/09/2015

Dr. Martin Ménégoz
Lead researcher for Climate and volcanoes group
in the Climate Forecasting Unit (CFU)
at Institut Català de Ciències del Clima (IC3),
Barcelona, Spain

Subject: Letter of support for an application to the European Marie Skłodowska-Curie IF-EF program

As the leader of the relevant work package of the European project *Seasonal to decadal Prediction for the Improvement of the European Climate Services* (SPECS, http://www.specs-fp7.eu/), devoted in particular to the improvement of operational climate forecast systems, and including work on modelling volcanic impact, I would like to offer my enthusiastic support for the Martin Ménégoz proposal "*Volcanic activity in seasonal to decadal climate forecasts*" (VOLCADEC) to the Marie Skłodowska-Curie IF-EF program. Benefiting from this program, Martin Ménégoz will be able to lead the effort made at IC3 to increase the performance of climate forecast systems in terms of processes linking the stratosphere and troposphere dynamics. He will also support substantially the European community that develops the EC-Earth climate model.

Correctly representing the climate response to volcanic forcing is a challenging issue, and although increasing attention is being given to the topic, in my view it remains under-resourced. Large low-latitude volcanic eruptions not only cool the earth's climate, but can also have large impacts on European winter weather via processes which are hard to model. Given the size of the impacts, we are presently in a poor position to respond when (not if) the next large eruption occurs. It will be of great strategic and economic benefit to Europe to invest in research and capacity building before, and not after, the next major volcanic event. It will also be of great scientific benefit to improve our understanding of past variability and the impact of low-level variations in volcanic aerosol background. If granted by the Marie-Curie program, Martin Ménégoz would be very active in the effort commonly pursued by European institutes to address these challenging questions.

As coordinator of the SPECS project work package which includes volcanic impacts, and as a scientist active in operational activities and international research projects, I will be more than happy to collaborate with Martin and facilitate his interaction with the wider scientific community. I wish Martin Ménégoz success with his proposal and hope to collaborate more with him in the near future through this Marie-Curie project.

Yours sincerely,

T. N. Stockdale

Dr Tim Stockdale,
Principal Scientist
Head, Seasonal and Long-range forecasting Group, ECMWF.

ECMWF, Shinfield Park, Reading, RG2 9AX, England
Tel: +44 (0)118 949 9000 • Fax: +44 (0)118 986 9450 • E-mail: first initial.surname@ecmwf.int • Web: www.ecmwf.int

université de BORDEAUX

Dr. Didier Swingedouw
CNRS researcher (CR1)
EPOC, UMR CNRS 5805 -
OASU - Université de Bordeaux
Allée Geoffroy St Hilaire 33615
Pessac, France

Dr. Martin Ménégoz
Lead researcher for Climate and volcanoes
group in the Climate Forecasting Unit (CFU)
Institut Català de Ciències del Clima (IC3),
Barcelona, Spain

Subject: Letter of support to Martin Ménégoz application to the European Marie Sklodowska-Curie IF-EF program

Bordeaux, September, 2nd 2015

Dear Madam, Sir,

As a recognised expert in climate dynamics and in particular concerning the response of the climate system to volcanic eruptions, I would like to offer my enthusiastic support for the Martin Ménégoz proposal "*Volcanic activity in seasonal to decadal climate forecasts*" (VOLCADEC) to the Marie Skłodowska-Curie IF-EF program. Such a project will clearly help the European community to make important contributions on this very challenging issue. Indeed, by benefiting from this program, Martin Ménégoz will support IC3 to increase the performances of European climate forecast systems in terms of atmospheric dynamical processes related to the stratospheric variability. He will support also substantially the European community that develops the EC-Earth climate model, supervising its involvement in VolMIP, an international project devoted to the understanding of the climate response to volcanic eruptions recently endorsed by the Coupled Model Intercomparison project (CMIP6).

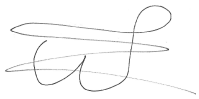
Climate response to volcanic forcing is a challenging issue that currently retains the attention of the whole community of climate researchers, because several large eruptions occurred over the last decades, and the volcanic forcing now appears has a key when evaluating the skill of the current generation of climate models. In addition, it is unclear how such climate models could be used to simulate the climate response to a new large eruption in real-time forecasts. Such a new eruption would have significant climatic impacts, which need to be better anticipated, regarding their potential societal impacts. Overall, both during and out of periods of large eruptions, volcanoes are the main source of stratospheric aerosols, these one significantly impacting the climate decadal variability, especially in Europe where they partly drive the North Atlantic Oscillation, one of the main modes of climate variability affecting temperature and precipitation rates. Granted by the Marie-Curie program, Martin Ménégoz would be at the cutting edge of the effort now pursued by European institutes to address these challenging questions.

Adresse postale
Université de Bordeaux
351 cours de la libération
33405 Talence cedex
www.u-bordeaux.fr

Active in several European projects devoted to the improvements of forecast systems to simulate the climate response to volcanic eruptions, I would be happy to invite Martin Ménégoz to international events to share results. For these reasons I whish Martin Ménégoz to success with his proposal and hope to collaborate more with him in the near future through this very promising Marie-Curie project.

Yours sincerely,

Didier Swingedouw



edp renováveis

Dr. Martin Ménégoz
Lead researcher for Climate and volcanoes group
in the Climate Forecasting Unit (CFU)
at Institut Català de Ciències del Clima (IC3),
Barcelona, Spain

Date: August 20th, 2015

Subject: Letter of support for an application to the European Marie Skłodowska-Curie IF-EF program

EDPR is one of the most qualified companies in renewable energy in Europe. For that reason is paying a lot of attention to the development of climate services in Europe, following with attention the investigations of climate centres involved in this research activity. From an operational point of view, IC3 clearly appears as a qualified group in Spain that is likely to provide seasonal to decadal forecasts in an operational way. We are expecting the possibility to forecast efficiently our energy production rates thanks to seasonal wind predictions that are essential in particular for our wind farm activities. For this reason, I would like to offer my enthusiastic support for the Martin Ménégoz proposal "*Volcanic activity in seasonal to decadal climate forecasts*" (VOLCADEC) to the Marie Skłodowska-Curie IF-EF program. Benefiting from this program, Martin Ménégoz will provide a substantial effort to increase the performances of European climate forecast systems.

Three main reasons encourage me to support his project: (1) IC3 is highly active in the development of climate services, by being involved in several European projects devoted to the valorisation of climate research for applications in the energy sector. Based at IC3, Martin Ménégoz would efficiently share its results with the other European climate centres; (2) I hope its research activities to contribute to the improvement of the forecasts quality in Europe; (3) the IC3 climate services team would support Martin Ménégoz to reach practical applications of its research through an improvement of the climate forecast systems and its dissemination to the users of seasonal forecasts.

EDPR encourages researchers to develop their studies on this field that Mr Ménégoz is working on, hoping to reinforce the links between public and private groups facing together the challenging issue of energy management. For these reasons, I wish Martin Ménégoz to success with his Marie-Curie proposal.

Yours sincerely,

Ignacio Láinez
Director of Energy Assessment Department

www.edpr.com

EDP Renewables Europe SL
Serrano Galvache, 56, Centro Empresarial Parque Norte, Edificio Encina
28033 Madrid - España
T: +34 902 830 700 F: +34 913 997 901

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Hoja nº AS-37659, Inscripción 1º C.I.F. A-74

Dr. Matthias Piot
Meteorologist/Gas Analyst
EnBW Energie Baden-Württemberg AG
Durlacher Allee 93
76131 Karlsruhe, Germany

Date: September 09th, 2015

Subject: Letter of support for an application to the European Marie Skłodowska-Curie IF-EF program

My company EnBW AG is a large power supplier in Europe, with a particular focusing on wind power generation. It is obvious that our company is paying a lot of attention to the development of climate services in Europe, following with attention the investigations of climate centres involved in this research activity. From an operational point of view, IC3 clearly appears as the unique group in Spain that is likely to provide seasonal to decadal forecasts in an operational way. We are expecting the possibility to forecast efficiently our energy production rates thanks to seasonal wind predictions that are essential in particular for our wind farm activities. For this reason, I would like to offer my enthusiastic support for the Martin Ménégoz proposal "*Volcanic activity in seasonal to decadal climate forecasts*" (VOLCADEC) to the Marie Skłodowska-Curie IF-EF program. Benefiting from this program, Martin Ménégoz will provide a substantial effort to increase the performances of European climate forecast systems.

Three main reasons encourage me to support his project: (1) IC3 is highly active in the development of climate services, by being involved in several European projects devoted to the valorisation of climate research for applications in the energy sector. Based at IC3, Martin Ménégoz will efficiently share its results with the other European climate centres; (2) I hope its research activities to contribute to the improvement of the forecasts quality in Europe; (3) the IC3 climate services team will support Martin Ménégoz to reach practical applications of its research trough an improvement of the climate forecast systems and its dissemination to the users of seasonal forecasts.

I would be happy to collaborate more with Martin Ménégoz in the future, hoping to reinforce the links between public and private groups facing together the challenging issue of energy management. For these reasons I whish Martin Ménégoz to succeed with his Marie-Curie proposal.

Yours sincerely,

i.V. JS

Jörg Breitschädel
head of Methods & Models
EnBW AG

ENDPAGE

MARIE SKŁODOWSKA-CURIE ACTIONS

Individual Fellowships (IF)
Call: H2020-MSCA-IF-2015

PART B

- VOLCADEC -

Volcanic activity in seasonal to decadal climate forecasts

This proposal is to be evaluated as:

[Standard EF]

European Commission

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