REQUEST FOR A SPECIAL PROJECT 2018–2020

MEMBER STATE: Germany

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Project Title:

Understanding linkages between the Arctic and mid-latitudes using relaxation experiments

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** ________________	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2018	
Would you accept support for 1 year only, if necessary?	YES ☐	NO ☐

Computer resources required for 2018-2020: (To make changes to an existing project please submit an amended version of the original form.)		**2018**	**2019**	**2020**
High Performance Computing Facility	(SBU)	25.970.000	×	×
Accumulated data storage (total archive volume)[2]	(GB)	77.200	×	×

***An electronic copy of this form must be sent via e-mail to**:* *special_projects@ecmwf.int*

Electronic copy of the form sent on (please specify date):

30 June 2017

Continue overleaf

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project's activities, etc.

[2] If e.g. you archive x GB in year one and y GB in year two and don't delete anything you need to request x + y GB for the second project year.

Principal Investigator: Prof Dr Thomas Jung

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Extended abstract

All Special Project requests should provide an abstract/project description including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used.

Requests asking for 1,000,000 SBUs or more should be more detailed (3-5 pages).

Following submission by the relevant Member State the Special Project requests will be evaluated by ECMWF as well as the Scientific and Technical Advisory Committees. The evaluation of the requests is based on the following criteria: Relevance to ECMWF's objectives, scientific and technical quality, disciplinary relevance, and justification of the resources requested. Previous Special Project reports and the use of ECMWF software and data infrastructure will also be considered in the evaluation process.

Large requests asking for 10,000,000 SBUs or more will receive a detailed review by members of the Scientific Advisory Committee.

All accepted project requests will be published on the ECMWF website.

Introduction

The weather and climate of the Arctic have been changing rapidly in recent years and these profound transformations are projected to continue in the decades to come. Rapid Arctic changes have taken many by surprise, including the scientific and operational forecasting communities. It is therefore no coincidence that our predictive capacity in the Arctic across time scales is still limited; hampering effective decision-making processes (Jung et al. 2016). The fast pace of Arctic change may also explain why our understanding of the impact of Arctic climate change on mid-latitude weather and climate, including high-impact events, is still at a pre-consensus stage (e.g. Jung et al. 2015).

Recognizing the importance of this topic, in 2015 the European Commission issued a dedicated call entitled *Impact of Arctic changes on the weather and climate of the Northern Hemisphere*. A European consortium[2] responded to this call by submitting a proposal called APPLICATE, which was selected in 2016 for funding. APPLICATE, which is coordinated by the PI of the proposed special project, aims "to develop enhanced predictive capacity for weather and climate in the Arctic and beyond, and to determine the influence of Arctic climate change on Northern Hemisphere mid-latitudes, for the benefit of policy makers, businesses and society".

Central to the APPLICATE project is a work package entitled *Atmospheric and Oceanic Linkages*. As part of this WP, it is planned to carry out a coordinated suite of novel multi-model experiments designed to identify the oceanic and atmospheric linkages between the Arctic region and the northern mid-latitudes. In this application for a special project we ask for HPC resources allowing us to study the influence of the Arctic atmosphere on mid-latitude weather and climate from a prediction perspective. More specifically, seasonal forecast experiments will be carried out in which the atmosphere is relaxed towards ERA-Interim data in certain regions, leaving the model run freely elsewhere. This approach, which has been successfully applied by Jung et al. (2014) for medium-range and subseasonal predictions during boreal winter, provides insight into the potential that enhanced predictive capacity in the Arctic has on mid-latitude forecast skill and vice versa. Furthermore, it allows to "verifiy" teleconnections. Here, previous work will be extended by carrying out coordinated experiments with two different coupled models (ECMWF coupled model and CNRM-CM) to explore sensitivity to model formulation. Furthermore, the forecasts horizon will be extended to include seasonal time scales; and spring, summer and autumn seasons will also be considered. All relaxation experiments will be thoroughly analysed, including the verification of teleconnections, the diagnosis of mechanisms including storm tracks, the investigation of a possible flow-dependence of the atmospheric linkages, and the origin of recent Arctic Amplification.

[2] The consortium includes a total of 16 partner including AWI (coordination), Meteo-France and ECMWF.

Experimental design and motivation

We plan to carry out experiments using the ECMWF seasonal forecasting system (cycle 43r3). For the atmospheric component the same resolution as used for ERA-Interim will be employed (T255L60). Given that the model will be relaxed towards ERA-Interim, hence, no interpolation of the relaxation fields will be required. All seasonal experiments will be run for 6 consecutive months starting on 1st November (May) for extended winters (summers) of the period 1979–2017. For each forecast date and experiment a total of 10 ensemble members will be run. This choice represents a compromise between limiting the computational costs and maximizing the signal-to-noise ratio.

The coupled control experiments (**Control**) comprises the baseline for all relaxation experiments. Its setup is consistent with "Stream 1" experiments employed the APPLICATE project. Hence, the evaluation of these experiments will also contribute to establishing a baseline of polar prediction skill in state-of-the-art seasonal forecasting systems[3].

Prior to starting the hindcast experiments with relaxation it is planned to carry out some testing (**Tests**) regarding relaxation regions and parameters being relaxed.

To understand the influence of the Arctic atmosphere on the weather and climate of the lower latitudes, coupled seasonal forecasting experiments will be carried out in which the Arctic troposhere (north of 70^{o}N) will be relaxed towards ERA-Interim data (**Arctic**). The use of the coupled system allows to represent coupled atmosphere-ocean processes in the mid-latitude and possibly tropical response. This approach accounts for recent evidence suggesting that atmoshere-ocean interaction can enhance the atmospheric response in mid-latitudes to Arctic changes (Blackport and Kushner 2017).

There is strong evidence that mid-latitude weather is a strong driver of the Arctic atmosphere (e.g. Jung and Leutbecher 2007). It is important, thus, to consider experiments in which the mid-latitudes are relaxed, while running the Arctic freely (**MidLat**). Here, we are planning to relax the mid-latitude troposphere in the belt 35^o–50^{o}N. Such an approach allows to use the same experiments to also explore the influence of mid-latitudes atmospheric processes on the coupled tropical system.

Like in the results from previous special projects using atmosphere-only models (e.g. Jung et al. 2014, Semmler et al. 2016, Semmler et al. 2017) we are proposing to carry out additional *coupled* experiments with tropical (**Tropical)** and and stratospheric relaxation (**Stratosphere**) (see also Hansen et al. 2016) in order to put possible remote responses into context.

Finally, we are planning to explore the relative role of local vs remote mid-latitude processes in explaining Arctic Amplification (AA). It is commonly believed that sea ice-albedo feedback, Planck feedback and lapse rate feedback are critical for explaining recent AA. However, recently it has been argued that a significant part of AA may actually be driven by atmospheric circulation anomalies originating in the mid-latitudes and tropics (e.g. Ding et al. 2014, Gong et al. 2017). In order to address this issue, we propose to carry out additional **Control** and **MidLat** experiments in which the initial conditions for the sea ice-ocean system are randomized. This approach will allow to impose the lower-latitude forcing and study the relative impact on recent AA.

A summary of all proposed experiments with estimated resource requirements is given in Table 1. For the coupled model integrations, estimates are based on the assumption that 1 month of integration with the coupled model will require 740 SBUs and 2.2 Gb of data storage in MARS (6-hourly atmospheric and monthly-mean ocean data). A subset of these experiments (**Control**, **Arctic** and **MidLat**) will also be carried out with CNRM-CM6 by the APPLICATE partner Meteo-France (HPC resources at Meteo-France will be used) using the same relaxation approach. This multi-model relexation approach is novel and allows to identify possible dependencies of remote responses on model formulation.

[3] This is a contribution to WP5 in APPLICATE entitled *Improved predictive capacity*.

Table 1: Summary of the experiments planned in 2018. See text for details.

Experiment	Forecast months[1]	SBU (kilo units)	Archive (Gb)	Notes
Control	39×2×6×10=4680	3.463	10.296	No relaxation
Control-Rand	39×2×6×10=2340	3.463	10.296	No relaxation with randomly chosen initial conditions
Tests	2340	3.463	10.296	Testing of different relaxation configurations prior to starting the full hindcast experiments
Arctic	39×2×6×10=4680	3.463	10.296	Arctic relaxation
MidLat	39×2×6×10=4680	3.463	10.296	Relaxation of the troposphere in mid-latitudes of the Northern Hemisphere
MidLat-Rand	39×2×6×10=2340	3.463	10.296	Relaxation of the troposphere in mid-latitudes of the Northern Hemisphere; randomly chosen initial conditions
Tropical	39×2×6×10=4680	3.463	10.296	Relaxation of the tropical atmosphere
Stratosphere	39×1×6×10=4680	1.732	5.148	Relaxation of the stratosphere over the Northern Hemisphere

[1] *Years×Seasons×Simulation months×ensemble members*

Dissemination

We anticipate the proposed experiments to be of interest for a wide range of researcher. Hence, we are planning to make a subset of the data (selected variables) publicly available exploiting the dissemination approach used in the APPLICATE project.

References

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