REQUEST FOR A SPECIAL PROJECT 2017–2019

MEMBER STATE: ……Denmark…..……...…

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Other researchers: ……..……

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Project Title: ……Modeling MIS3: a mild glacial climate state……..……

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If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** _____	
Starting year: (Each project will have a well-defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)	2017	
Would you accept support for 1 year only, if necessary?	YES ☐	NO ☐

Computer resources required for 2017-2019: (To make changes to an existing project please submit an amended version of the original form.)		**2017**	**2018**	**2019**
High Performance Computing Facility	(SBU)	2,250,000	2,250,000	
Accumulated data storage (total archive volume)[2]	(GB)	3000	6000	

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):

…… June 30, 2016 ……

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: ……Peter L. Langen……

Project Title: …… Modeling MIS3: a mild glacial climate state ……

Extended abstract

It is expected that Special Projects requesting large amounts of computing resources (1,000,000 SBU or more) should provide a more detailed abstract/project description (3-5 pages) including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The Scientific Advisory Committee and the Technical Advisory Committee review the scientific and technical aspects of each Special Project application. The review process takes into account the resources available, the quality of the scientific and technical proposals, the use of ECMWF software and data infrastructure, and their relevance to ECMWF's objectives. - Descriptions of all accepted projects will be published on the ECMWF website.

Modeling MIS3: a mild glacial climate state

As part of the efforts under the ERC Synergy Grant project "ice2ice", we aim to perform an EC-Earth simulation of climate conditions during Marine Isotope Stage 3 (MIS3), 25-60.000 years ago. This was the time prior to the Last Glacial Maximum and marks the period with the most pronounced climate shifts recorded in the Greenland ice core records. Abrupt increases in temperature of up to 15C occurred within less than a decade, named Dansgaard-Oeschger events (D-O events). Evidence from paleoclimate studies indicate clearly that these drastic temperature shifts recorded in Greenland had hemispheric implications (Voelker et al. 2002) and coincide with a rapid and almost immediate collapse of sea ice in the Nordic Seas, and an overshoot of temperature rise in the ocean surface layer (Dokken et al. 2013). In light of the ongoing rapid decline of Arctic sea ice and its likely influence on the Greenland Ice Sheet, understanding of previous abrupt reorganizations in the North Atlantic/Arctic climate system is important for a clear mapping of the potential consequences of the current warming.

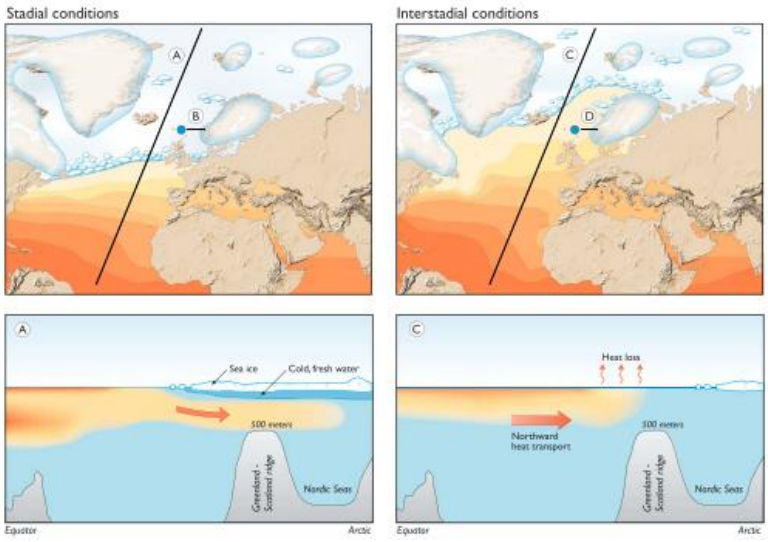

Figure 1:Illustration from Dokken et al. (2013) of a hypothesized difference between stadial (cold D-O phase) and interstadial (mild D-O phase) conditions during MIS3.

A MIS3 - 38 ka coupled model protocol

We have devised a protocol for a coordinated set of experiments between the NorESM (run by ice2ice colleagues in Bergen), HadCM3 (by William Roberts, U Bristol) and EC-Earth models. The main experiment will consist of an equilibrium snap-shot experiment designed to match conditions at 38,000 years before present (38 ka). The protocol addresses the changed land-sea mask and ocean bathymetry (due to 70 m lowered sea level) as well as ice sheet geometries for the Northern Hemisphere. Moreover, the protocol covers settings for atmospheric composition, orbital parameters and changed/extended river routing.

Conditions at 38 ka were characterized by quite extensive ice sheets both in North America and in Fennoscandia, with a sea level lowering relative to present of ~70 m (compare with 120 at Last Glacial Maximum). Nevertheless, the orbital parameters were such that conditions were relatively mild and this may be part of the explanation for why the dramatic D-O events took place with such preference at this time. This makes detailed studies of this period particularly interesting.

Advances of our MIS3 experiment over previous ones (e.g., Van Meerbeck et al. 2009, Brandefelt et al. 2011) are i) that we are part of a coordinated effort, ii) we run at much finer horizontal resolution (T159 vs. T21/T42) and iii) our land-sea mask employs new information on open ocean conditions in the Barents/Kara Seas allowing for a greater import of warm North Atlantic water to the Arctic.

In addition to the main equilibrium experiment, we plan to perform experiments where sea surface temperatures and sea ice conditions are nudged toward a cooler or milder state in an attempt to excite a climate shift. Finally, a set of atmospheric stand-alone experiments may be performed to assess the sensitivity of the atmospheric circulation to changes in the ice sheet geometry.

Requested HPC resources

The requested HPC resources in the following are based on our Eemian experiments with EC-Earth under the special project SPDKLANG (Pedersen et al. 2016a,b). We have not yet set up the latest version of the EC-Earth model in the low-resolution paleoclimatic configuration. Moreover, the latest upgrade of the HPC to Broadwell nodes will also influence the resource usage. Here, we base our estimates on our runs with the EC-Earth v.3.1 at T159 (1 deg ocean) on the CCA cluster where we spent about 4500 SBUs per model year.

Initially the model needs to be spun up to the changed boundary conditions. We estimate that 500 years will suffice for a reasonably equilibrated state. Subsequently, the model will run for 200 years as the main experiment. The nudged sea surface temperature and sea ice experiments will cover

2x100 years. Finally, 250 years atmospheric stand-alone experiments correspond to about 100 years with the coupled system. All in all, this amounts to about 1000 model years corresponding to an estimated usage of 4,500,000 SBUs.

Each model year produces just under 10 GB per year with the level of output we have taken for the Eemian experiments. With more aggressive clean-up during the 500 years of spinup, we estimate a use of 1 TB for the spinup and 1 TB for each of the subsequent 5 centuries. This amounts to a total of 6 TB of storage needs.

2 year project 2017-18	
Sum of model years:	1,000 years
Billing units pr. model year:	4,500 units
Total billing units:	4,500,000 units
Storage pr. model year:	2-10 GB
Total storage:	6 TB

References

Brandefelt et al. 2011. A coupled climate model simulation of Marine Isotope Stage 3 stadial climate. Clim. Past, 7, 649–670´.

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