REQUEST FOR A SPECIAL PROJECT 2014–2016

MEMBER STATE: Denmark ……………………………………………………………...…

Principal Investigator[1]: Peter L. Langen ……………………………………………….……

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E-mail: pla@dmi.dk…………………………………………………..……

Other researchers: Rasmus Anker Pedersen, Ph.D. student, Danish Meteorological Institute and University of Copenhagen …………………………..……

Shuting Yang, Danish Meteorological Institute ……………….……

Project Title: Modelling interglacial climate……………………………………..……

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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.)	2014	
Would you accept support for 1 year only, if necessary?	YES ☐	NO ☐

Computer resources required for 2014-2016: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2016.)	**2014**	**2015**	**2016**
High Performance Computing Facility (units)	1,100,000	1,100,000	-
Data storage capacity (total archive volume) (gigabytes)	1,750	1,750	-

*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):

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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.

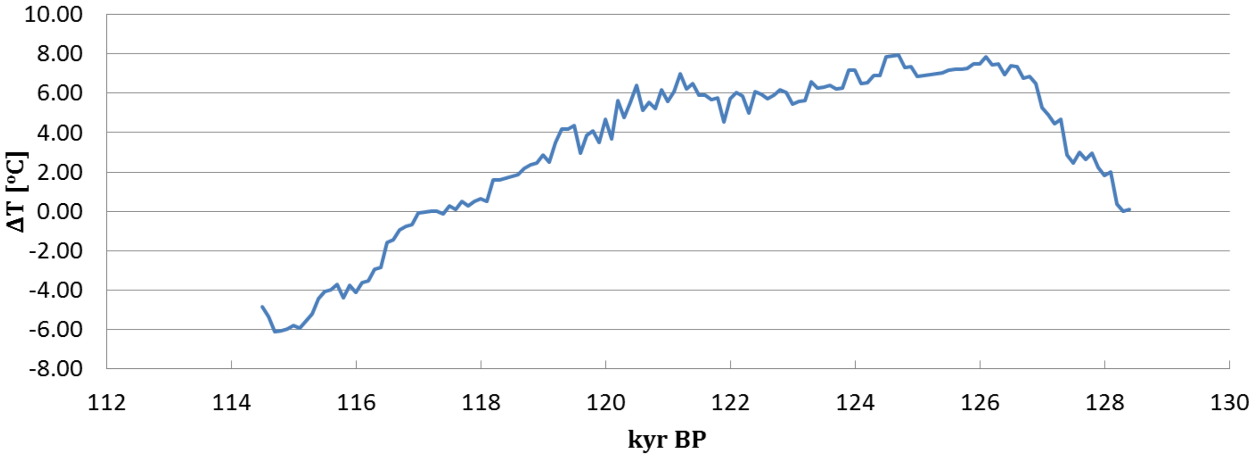
Principal Investigator: Peter L. Langen ………………………………………………

Project Title: Modelling interglacial climate …………………………………

Extended abstract

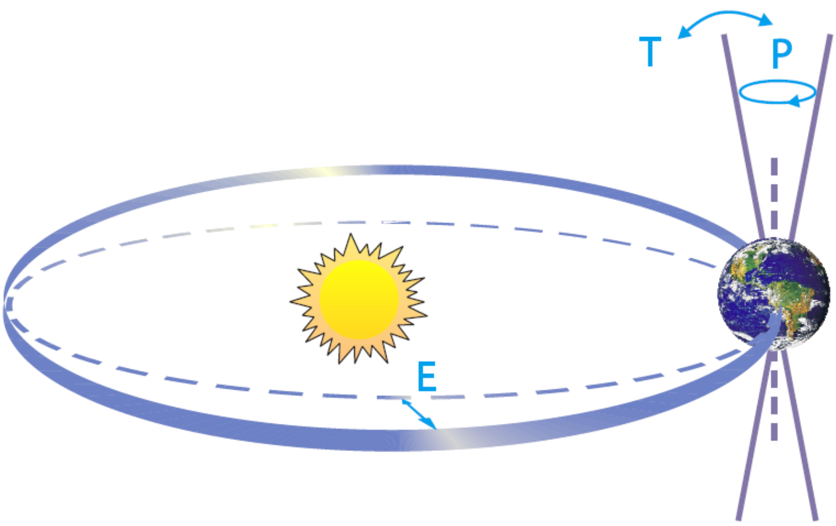
It is expected that Special Projects requesting large amounts of computing resources (500,000 SBU or more) should provide a more detailed abstract/project description (3-5 pages) including a scientific plan, a justification of the computer resources requested and the technical characteristics of the 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.

The special project entitled Modelling interglacial climate will be a part of the Ph.D. project by Rasmus Anker Pedersen, which aims to investigate the current and especially the last interglacial climate state using GCM simulations with EC-Earth. The warm Eemian period (also known as Marine Isotopic Stage MIS5e, approximately 115-130,000 years ago) has been proposed as an analogue to future climate, which may not be appropriate due to the different forcing mechanisms. It is thus important to investigate the difference between driving climate change with a greenhouse gas increase, compared to changes in the insolation. The regionally different changes in insolation may produce an entirely different warming response compared to a globally uniform forcing from a greenhouse gas increase [van de Berg et al., 2011].



Temperature reconstruction of the Eemian period from the NEEM ice core based on stable water isotopes and air content records. ΔT indicates temperature change at the site compared to the last millennium. Based on [NEEM community members, 2013, suppl. mat.]

The main experiment will be a simulation of the Eemian climate. This simulation must be driven by changes in the insolation, and thus an extension to the EC-Earth model is needed, in order to modify the insolation to correspond to a different orbital configuration. A module that allows for orbital changes will be developed and implemented in the initial phase of the project, and will be used as basis for the simulation. This new module will calculate the insolation at a given latitude using the solar zenith angle, which can be derived from values of the obliquity, eccentricity, and precession (following Berger [1978]).



Sketch of the orbital parameters that decide the insolation: the obliquity (or axial tilt, *T*), the eccentricity (*E*), and the precession (*P*). Taken from IPCC AR4 [Jansen et al., 2007]

Bosmans et al. [2012] have worked with insolation changes in EC-Earth in their study of the mid-Holocene. Their experiment, however, focuses on the short-term response of the monsoon patterns, where this experiment will investigate long-term effects and variability of the climatic changes in the Eemian period.

The Eemian experiment will simulate a single “time-slice” equilibrium climate state, which will be based on a boundary dataset incorporating knowledge from different proxy data sources. The orbital parameters, atmospheric composition, insolation, ice sheet configuration, and vegetation patterns will all be based on state-of-the-art research, to ensure the best possible estimate of the Eemian climate. The Ph.D. project is shared with the Centre for Ice and Climate at the Niels Bohr Institute, University of Copenhagen, which has been involved in drilling and analysis of several Greenlandic ice cores, and it is thus obvious to include data from ice cores as boundary conditions – e.g. the atmospheric composition estimated from ice core gas measurements [NEEM community members, 2013]).

The results will be compared to the proxy data in order to assess the performance of the model in simulating this warmer climate state – e.g. temperature reconstructions derived from ice cores, deep sea cores, and pollen proxies. This comparison may also indicate how the model will perform in simulations of future, warmer climate projections [Otto-Bliesner et al., 2006].

When comparing the last interglacial to the current, Greenland ice cores suggest that the Eemian period may have been significantly less stable than the Holocene. The model simulation of the Eemian will thus also be used to analyse the stability of the climate, and to assess the processes that help stabilize or destabilize the climate states. If possible within the scope of this project, a simulation of the mid-Holocene period will be done, to allow for direct comparison of the two interglacial climates in terms of stability and climate sensitivity.

Additionally specific sensitivity studies might reveal how the properties of the Eemian climate have changed. Sensitivity studies are based on the main experiment, and start from the obtained equilibrium climate state, where the response to a perturbation in a climatic parameter is simulated – the focus here will be on changes in CO_2 level, ice sheet configuration, sea ice cover, and vegetation patterns. Such simulations will be made for the Eemian climate, and if possible also the mid-Holocene.

The analysis will have a special focus on the climatic changes in the Arctic, and especially the response of the Greenland Ice Sheet (GIS) to the induced forcings. Changes in temperature and precipitation (amount, distribution, and form) over Greenland will thus be analysed. A central topic will be an assessment of the difference in the response of GIS to warming from a greenhouse gas increase (as expected in the future) and to insolation changes (as in the Eemian). To investigate this, and to make a more general comparison of Eemian and possible future climate conditions, the simulations will be compared to existing projections of future climate (EC-Earth simulations based on the RCP scenarios [van Vuuren et al., 2011]). A possible extension of this project is to incorporate an ice sheet model in the simulation of the Eemian climate. The Danish Meteorological Institute currently has the ice sheet model PISM coupled to the EC-Earth model.

Hence a range of EC-Earth simulations forms the basis for this project, and computational time at the ECMWF HPC system would be very beneficial. The planned experiments are the simulation of the Eemian climate state, and the related sensitivity experiments. If possible, a mid-Holocene climate experiment (equilibrium, and perhaps sensitivity studies) will be added. This will be coordinated with the special project of Shuting Yang (also DMI) entitled “Last Glacial Maximum and Mid-Holocene Climate in EC-Earth”.

The main experiment will require a relatively comprehensive simulation, as the climate system will have to spin up, i.e. adjust to the Eemian conditions. Hence this experiment will consist of approximately 500 model years, of which the climatic spin-up will cover the initial 300 years. This will – by far – be the most demanding experiment, but it should be noted that the 500 model years is a realistic, yet conservative estimate of the requirements.

In the subsequent sensitivity experiments changes in CO_2 concentration, sea ice, and vegetation will be induced, and the resulting climate will be compared to the main experiment, indicating the response of the model climate to the induced change – i.e. the sensitivity to changes in that particular parameter. These simulations will not require the same degree of spin-up, as they are initiated from the simulated Eemian climate. The induced changes are not as radical as the insolation changes, and 150 model years should be sufficient to cover the spin-up period, and ensure a good statistical basis for the following analysis of the new quasi-equilibrium state.

Due to the time frame of the Ph.D. project, this special project will extend over a two-year period, in which the main experiment will be performed within the first year, and the sensitivity study in the second. The two years will thus be approximately equal in terms of both billing units and storage requirements. The table below summarises the total requirements of the project – i.e. the combined values for the two years.

2 year project 2014-15	
Sum of model years:	1,000 years
Billing units pr. model year:	2,200 units
Total billing units:	2,200,000 units
Storage pr. model year:	3.5 GB
Total storage:	3.5 TB

References

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