SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year ……2014……..……

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

Computer Project Account: …… SPDKLANG ……..……

Principal Investigator(s): ……..……

…… Peter L. Langen ……..……

Affiliation: DMI, Copenhagen, Denmark ……..……

Name of ECMWF scientist(s) collaborating to the project (if applicable) ……..……

……..……

Start date of the project: Jan 1 2014 ……..……

Expected end date: Originally: Dec 31 2015, but we may have to apply for an extension (see below) ……..……

Computer resources allocated/used for the current year and the previous one (if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)			1,100,000	97,827.47
Data storage capacity	(Gbytes)			3500	~0

Summary of project objectives
(10 lines max)

The project is 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. 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. Using this module, the main experiment will be a simulation of the Eemian climate. 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.

Summary of problems encountered (if any)
(20 lines max)

Implementation of the orbital changes into EC-Earth ver 2 proved more difficult than first anticipated. The addition of the insolation modules affects several parts of the code involving radiation calculations. In addition to the task of setting up routines and physics for the insolation changes, several technical challenges arose during the implementation, which prolonged the model modification. Ensuring consistency across all the affected model parts proved to be a cumbersome task. We had originally planned to carry out the experiments with ver 2, since we have made numerous other additions (such as interactive ice sheets) to our setup with ver 2 here at DMI. It now turns out, however, that porting this model version to the new ECMWF Cray might be so time consuming that we have decided to do the majority of the experiments with ver 3. We are collaborating with the group from INK at Stockholm University (Qiong Zhang et al.) on setting up this on the new machine.

The combination of difficulties in implementation of the orbital changes and in porting the ver 2 code have set us back some months compared to our initial timeline. It is hard to say at this point, what it will mean for the end of the project, but there is a risk that we will have to apply for an extension next year.

Summary of results of the current year (from July of previous year to June of current year)

This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

We have implemented the orbital changes in EC-Earth ver 2 and the Stockholm group has implemented similar modules in ver 3. We therefore have two model versions in which we can experiment with orbital changes. While the future plan is to continue primarily with ver 3, the first simulation of Eemian climate is currently ongoing in ver 2 of the model. The now modified ver 2 is still being actively used in various projects, as DMI has several add-ons to this model version – e.g. coupling to an ice sheet model. Additionally, the now modified model provides a good basis for comparison for paleo-simulations done in the newer setup in ver 3.

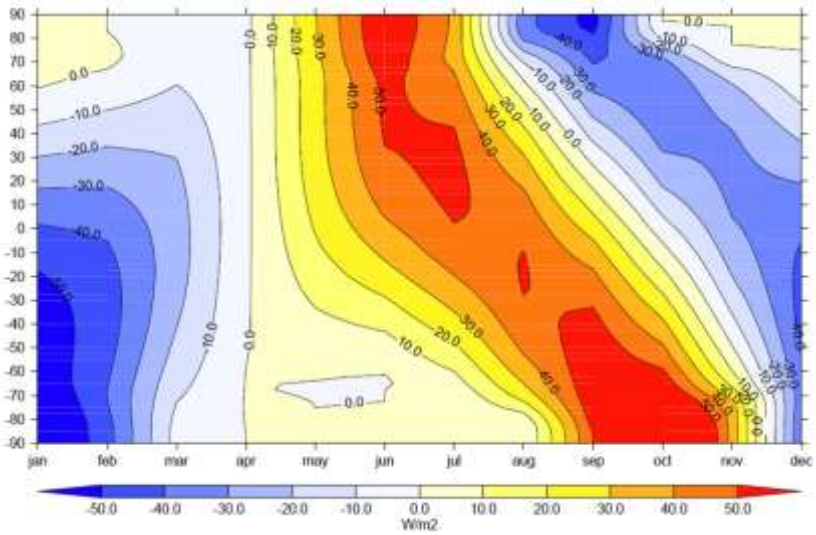

Figure 1: Eemian (125 ka before present) insolation anomalies. From [Lunt et al. 2013]

The initial results from the Eemian run already indicate that the model modifications work as desired, and provide excellent illustrations of how the model climate responds to the radiative forcing from the changed insolation pattern (Figure 1). Even though the forcing is added instantaneously the evolution of the Arctic surface air temperature (Figure 2) clearly indicates that the climate responds in a very gradual manner. This fully coupled model setup has several parameters contributing to this "delay" in the response; but the main contributor is the ocean. In a short run like this, only the very upper ocean can be expected to have responded to the forcing, and the deeper ocean is likely still responsible for a significant heat-uptake. While the ocean is responding to the changes (the so-called spin-up period), we are expecting to see a gradual stabilization of the temperature, corresponding to the equilibrium climate state, as it could have been 125 thousand years ago.

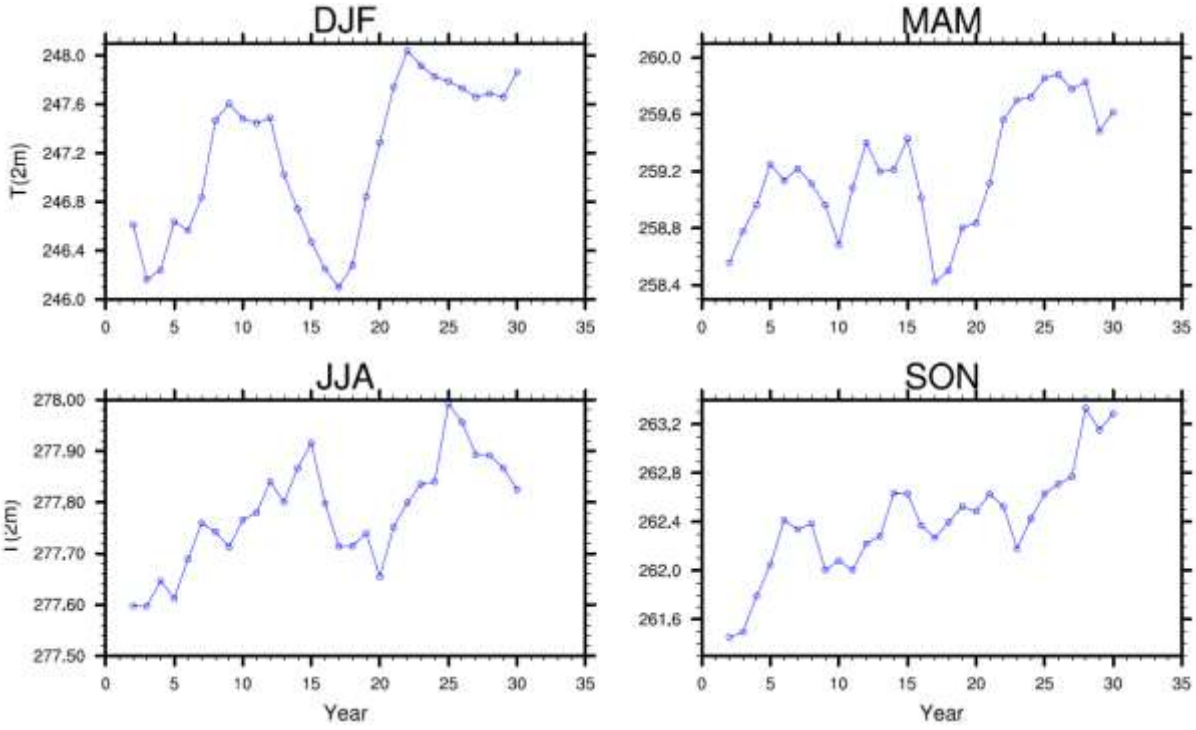

Figure 2: 3-year running seasonal means of Arctic surface air temperature (2-meter temperature).

From the evolution surface air temperature in Figure 2 it is clear that this coupled model exhibits relatively large interannual variability, but it does appear that the temperature is increasing in all seasons. To further substantiate this observed climate change from the Arctic mean temperature, other parameters have been investigated in a similar manner. The sea ice in the polar regions is very sensitive to warming, and thus a good indicator of climate change. In Figure 3 below, it is clearly evident that the Eemian insolation pattern is causing a significant sea ice reduction in the Arctic throughout the year – even though the insolation is only increased during summer.

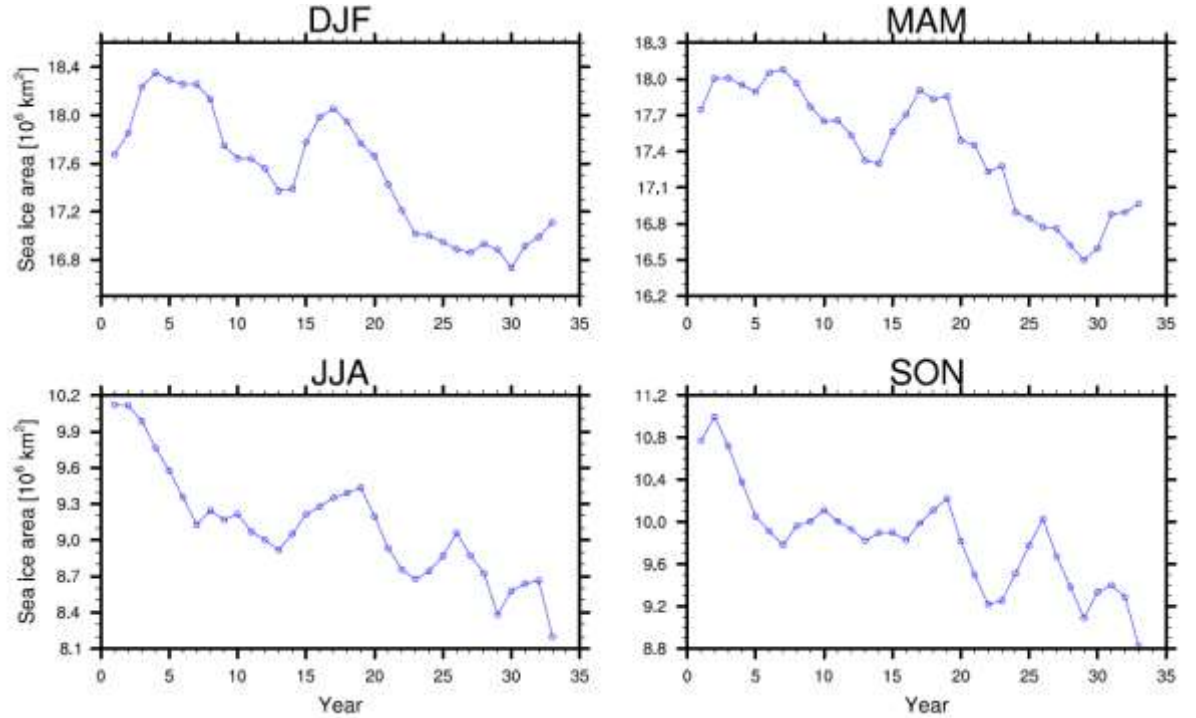

Figure 3: 3-year running seasonal means of Arctic (60-90^{o}N) sea ice cover (in 10^6 km^2).

List of publications/reports from the project with complete references

None

Summary of plans for the continuation of the project

(10 lines max)

We have started a run with ver 2 on the IBM (c2a) that we plan to continue to run for a few hundred years over the summer. This will not provide us with a fully spun up climate system, as the deep ocean will still be drifting. It will, however, give a good indication of the surface climate changes. As we are ready with the setup of ver 3 on the Cray (cca), we will setup an Eemian simulation continuing from the ocean conditions at the end of the ver 2 run. The first hundreds of years of this experiment will provide a good comparison of the two model versions' responses to the orbital changes. The remainder of the project will then be carried out with ver 3 on the Cray and we intend to implement an acceleration scheme for the ocean, if we can find a suitable and efficient setup, to allow a faster equilibration of the climate system.