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: Last Glacial Maximum and Mid-Holocene Climate in EC-Earth

Computer Project Account: SPDKYANG ………………………………………….……

Principal Investigator(s): Shuting Yang ………………………………………….……

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Affiliation: Danish Meteorological Institute …………………….……

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

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Start date of the project: Jan. 2013 ………………………………………………….……

Expected end date: Dec. 2014 ……………………………………………….……

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)	495,000	361,544	495000	456,293
Data storage capacity	(Gbytes)	5000		5000	1700

Summary of project objectives
(10 lines max)

Applying climate models to the palaeoclimate conditions, for which the external forcing are large and relatively well known (from the proxy data) can test the performance and liability of state-of-the-art climate model, and thereby assess the ability of these models to simulate radically different climates other than just the present conditions. This project is to use the EC-EARTH model for simulations for the periods of the Last Glacier Maximum (LGM, about 21ka) and the Mid-Holocene (MH, about 6ka). The aim is to evaluate the capability of the EC-EARTH in simulating the past climate and to investigate the climate response under much different forcing.

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

The implementation of forcing and boundary conditions for the period of LGM and MH were proven to be more difficult than anticipated initially. The modification of the model involved in not only several parts of the codes associated with radiation, the surface physical parameterization of snow and land ice, etc., but also the initial and forcing files. Correct and consistent implementation are complex and has to overcome several technically challenges, and thus was a prolonged process which leads to severe delay of the original project deliverable plan. We initially worked on implementing these changes on the EC-EARTH version for CMIP5 (i.e, version 2.3). However, with the vision of the new EC-EARTH development and the mitigation of the ECMWF HPC, we decided to collaborate with the group led by Qiong Zhang from INK at the Stockholm University and carry out the long simulations with the adopted version of EC-EARTH v3 for the LGM and MH.

As the forcing and boundary conditions for the LGM and MH are very different from the preindustrial-/present day to which the model has been adjusted to, a considerably long spin-up of the model system is needed for the model climate to adjust to the forcings. We have thus already spent all the allocated HPC facility for this year, although we wish to carry out more experiments. We planned to redistribute the un-used resources allocated for other projects to the current one. We may also need to request extra HPC facility for accommodation of the experiments.

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

The primary work in the past year has been on adaptation of the EC-EARTH for the LGM and MH conditions. This includes implementations of (1) the solar insolation change driven by the orbital changes; (2) appropriate topography and land sea mask; (3) appropriate ice sheet coverage and the surface physical process accordingly; (4) appropriate ocean bathymetry; (5) other prescribed boundary conditions according to the PMIP (Paleao-climate Model Intercomparisons Project) experiment protocol; (5) last but not least, consistent initial conditions (especially ocean conditions) for LGM and MH. Some of these modifications were first carried out and tested in EC-EARTH v2.3. And all five required modification have successfully implemented and tested in EC-EARTH v3. Figure 1 shows the zonally averaged annual cycle of the solar insolation as simulated with present day, MH (6 ka) and LGM (21 ka) conditions, respectively. In the MH, the seasonal variation in the solar insolation in the Northern Hemisphere is similar to that in the present day with somewhat stronger amplitude in the summer time, while solar insolation in the Southern Hemisphere is stronger in the spring but weaker in the autumn compared to the present day. The maximum differences with respect to present day occur in the polar regions. The pattern of insolation changes is different for the LGM, with slightly stronger insolation from November through June and slighter weaker from July to October in the mid- and low latitudes, while weaker insolation in the summer half year in polar regions is evident in comparison with the present day period, respectively.

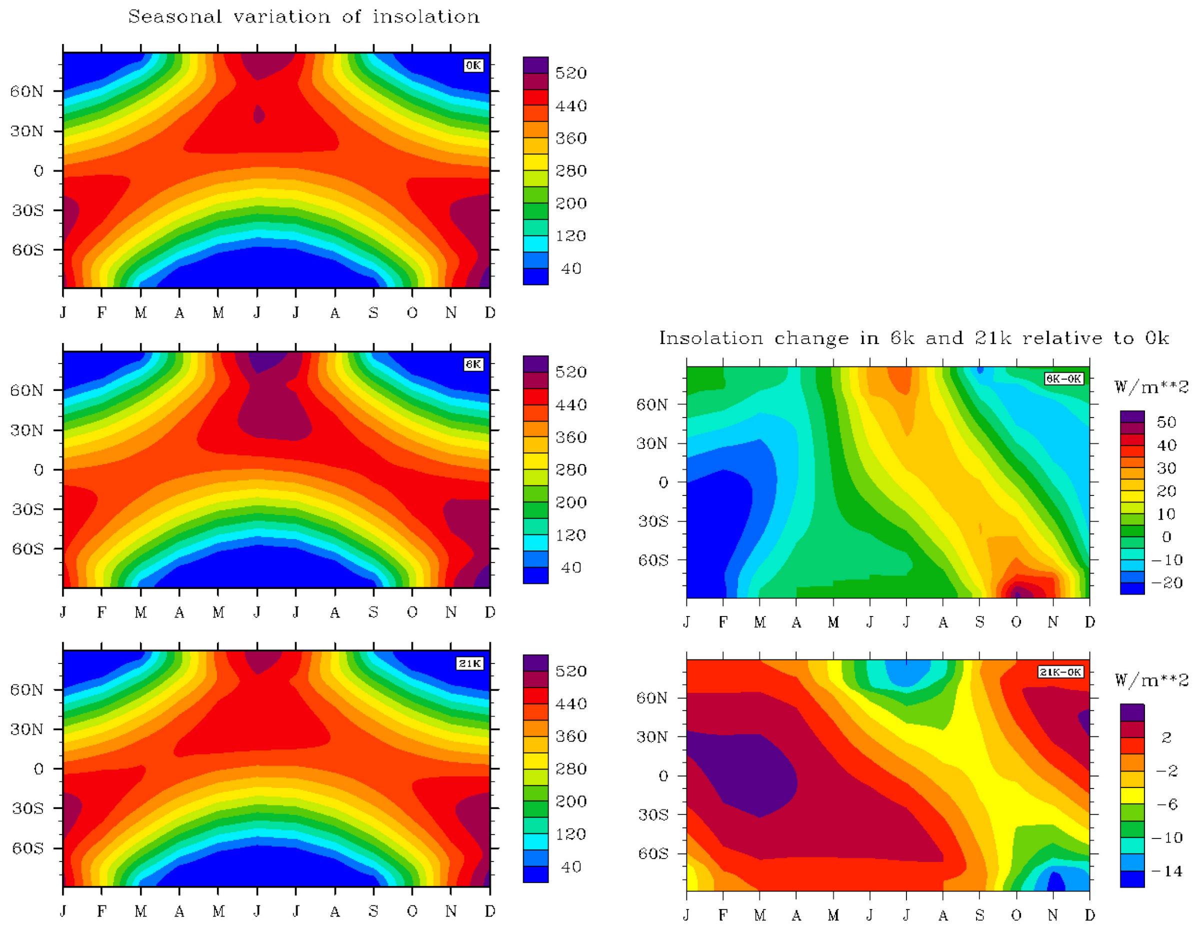

Figure 1. Zonally averaged mean annual cycle of the solar insolation as simulated with present day (0 ka, top left), the MH (6 ka, middle left) and LGM (21 ka, bottom left) condition, and the difference between the MH and the present day (top right), and between LGM and present day (bottom right). Unit: W/m^2. (Courtesy: Q. Zhang)

Sensitivity experiments using the EC-EARTH under MH conditions demonstrate the simulated climate response agrees with the paleo-proxy data. Figure 2 illustrates the mean near surface temperature changes in the two sensitivity experiments, a ‘Green Sahara’ in which the vegetation type is set as shrub over the region 15°W – 35°E and 11 – 33°N, and as desert for a ‘Desert Sahara’. It is evident that Sahara desertification leads to significant local surface cooling over the region. Furthermore, large area cooling is also observed over Arctic, indicating that the North Africa desertification may results in shift of large scale atmospheric circulation and cooling at high latitudes, as suggested by the proxy evidence.

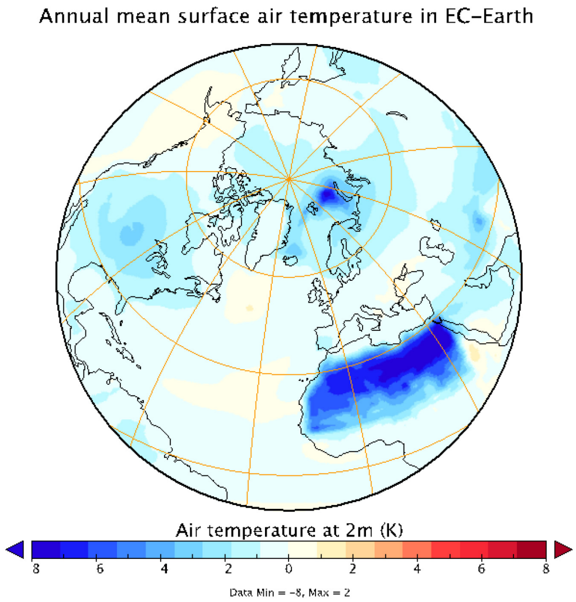

Figure 2. Annual mean near surface temperature difference between the ‘Green Sahara’ and ‘Desert Sahara’ experiments under the MH conditions. Unit: K. (Courtesy: Q. Zhang).

List of publications/reports from the project with complete references

Summary of plans for the continuation of the project

(10 lines max)

Due to the limited time left for the project, we will focus on the LGM period. A long LGM simulation will be carried out to ensure the equilibrium of the climate system. The simulation will then be evaluated against the paleo-proxy data and other PMIP model simulations. The climate response to the forcings, including the mean and variation of the circulation patterns, and the ocean and Arctic sea ice states will be assessed.