SPECIAL PROJECT FINAL REPORT

All the following mandatory information needs to be provided.

Project Title:	Simulating the climate in Last Millennium using EC-Earth
Computer Project Account:	spdkyang
Start Year - End Year :	2017 - 2018
Principal Investigator(s)	Shuting Yang
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Other Researchers (Name/Affiliation):	Ida Ringgaard (nhr), DMI Peter Langen (nhy), DMI Christian Rodehacke (nhc) DMI Qiang Li (suzk), Stockholm University

The following should cover the entire project duration.

Summary of project objectives

(10 lines max)

The aim of the project is to develop the transient climate in the last millennium (850-1849 CE) using climate model EC-Earth in response to mainly natural forcing (i.e., solar variations, volcanic aerosols, orbital parameters and the atmospheric concentration of well mixed greenhouse gases) as well as to a less extent the land use/land cover changes. The experiment will contribute to the CMIP6 endorsed Paleoclimate Modeling intercomparison Project phase 4 (PMIP4), as well as to be used to study the characteristics and mechanisms of decadal to centennial climate variability.

Summary of problems encountered

(If you encountered any problems of a more technical nature, please describe them here.)

We unfortunately ended up not being able to carry out the experiments as planned. The problem was not at all due to technical difficulties with the ECMWF system but rather a model development issue. As a result we only used a small fraction of the granted computing resources.

Our intention has been to perform the Last Millennium (LM) climate simulation using the same model as CMIP6 (at low resolution T159). Using the CMIP6 model version is important in order to ensure our simulations can be integrated to the CMIP6 process (including the PMIP paleoclimatic runs thereunder), as well as a meaningful comparison with the resulting present and pre-industrial climates which are simulated following the CMIP6 protocol. The release of the fully tuned CMIP6 model version, EC-Earth3, is delayed tremendously and not until at the end of 2018. We thus have not been able to start the production simulations.

Experience with the Special Project framework

(Please let us know about your experience with administrative aspects like the application procedure, progress reporting etc.)

It is pleasant to work under the Special Project framework. Application and reporting are straight forward and easy. We also appreciate the ECMWF computation environment and staffs, who provide fast, friendly and extremely competent technical support.

Summary of results

(This section should comprise up to 10 pages, reflecting the complexity and duration of the project, and can be replaced by a short summary plus an existing scientific report on the project.)

While we are waiting for the release of the final CMIP6 version EC-Earth3.3, we had worked on the configuration of the low resolution (T159L62), EC-Earth3-LR, on cca using the intermediate model version EC-Earth3.2.3, with the expectation that the setup for EC-Earth3.3 is fairly close to that of EC-Earth3.2. We also used this configuration to perform a “pseudo spin-up” run of 500 years under the pre-industrial condition. This pseudo spin-up fostered an ocean state close to equilibrium which can then be served as the initial state for the production model version in order to shorting the spinning up time when EC-Earth3-LR v3.3 is released.
Figure 1 illustrates the evolution of the Atlantic Meridional Overturning Circulation (AMOC) in the 500 year simulation. After an initial rapid slow down, the AMOC gradually stabilizes at around 14 Sv with some interannual variations. The level of the AMOC strength is slightly low compared to the observed state. Taking into account that the forcing condition at the pre-industrial level, the sea ice in Arctic and Antarctic simulated well as shown in Figure 2.

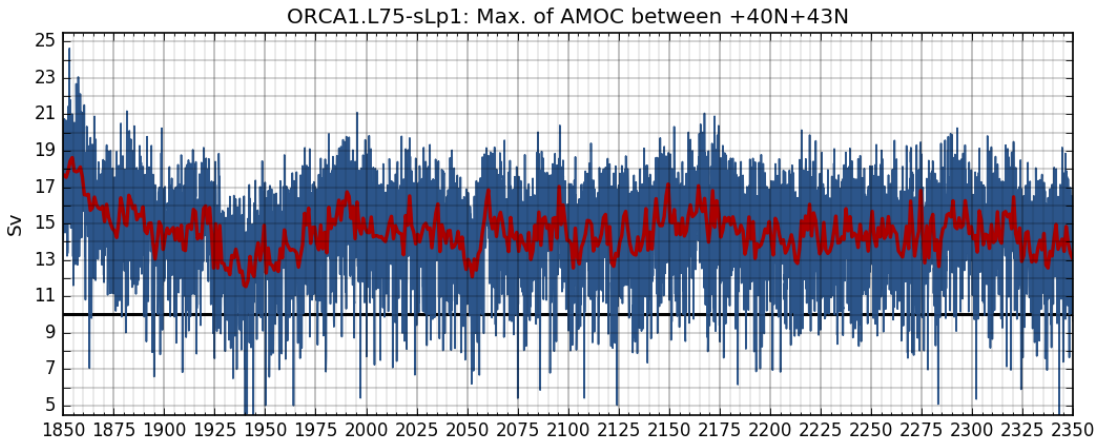

Figure 1. The time series of the annual Atlantic Meridional Overturning Circulation maximum between 40°N to 43°N (blue line) as simulated by an intermediate model version (EC-Earth3-LR, v3.2) under pre-industrial condition. The red line shows the five-year running mean. Unit: Sv.

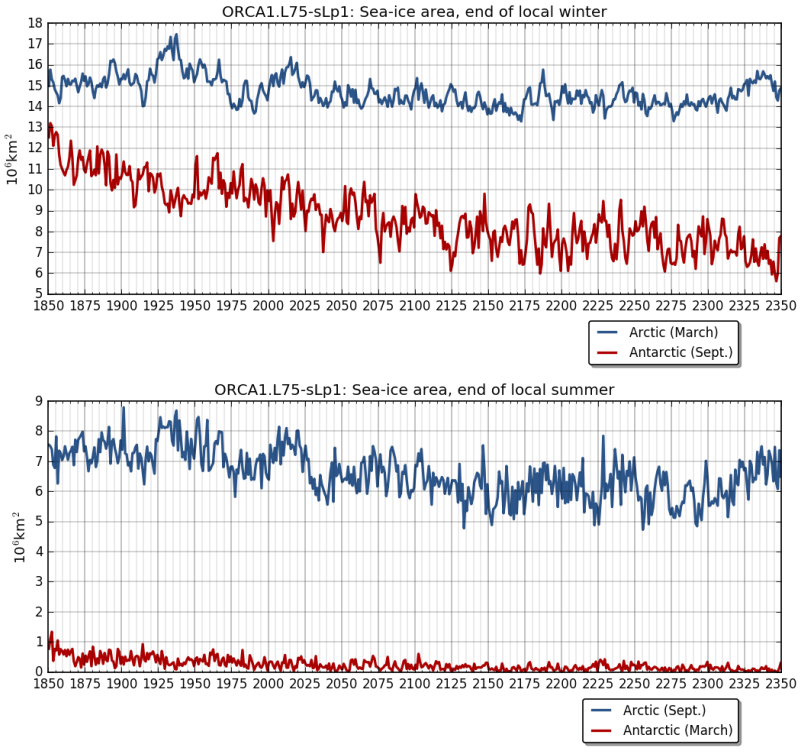

Figure 2. As Figure 1 but for area mean Arctic sea ice (blue) and Antarctic sea ice (red) at local winter (top panel) and local summer (bottom panel). Unit: 10^6 km^2.

This intermediate model version also simulates a reasonable present-day climate. Figure 3 shows the 30-tear averaged SSTs distribution toward the end of a 100 year long present-day (left) and its difference with the HadISST average (right). In comparison with the HadISST data set, the SSTs demonstrate a similar pattern as the observation but somewhat too warm in most of the mid-latitude and eastern part of the ocean, except over North Atlantic where the SSTs are generally too cold. The global averaged bias is small and about 0.85°C. We are therefore confident that the final version of EC-Earth3-LR will simulate recent climate reasonably well.

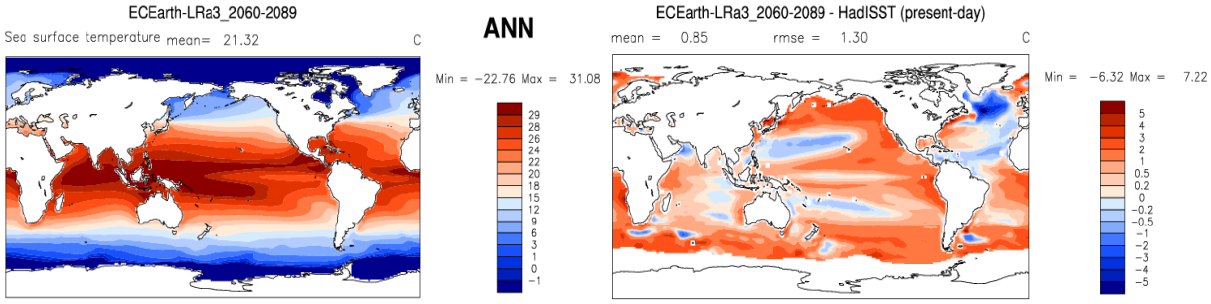

Figure 3. The simulated 30-year mean SSTs after an initial spin-up of 70 years in the control run under present-day condition (left) and its difference with the HadISST average for present day (right). Unit: °C.

List of publications/reports from the project with complete references

None to come out of this project as we were not able to perform the planned experiments.

Future plans

(Please let us know of any imminent plans regarding a continuation of this research activity, in particular if they are linked to another/new Special Project.)

Unfortunately the supporting project of ERC ice2ice project is ending this summer, so we are lack of funding to continue this particular experiment in the imminent future. But we seeking resource to eventually finish the experiment sometime in late 2019 or 2020.