Project: **1006**

Project title: **Simulations of the Mid-Piacenzian Warm Period (~3.3-3.0 Ma BP) using MPI-ESM 1.2.00 in the framework of the Pliocene Model Intercomparison Project Phase 2 (PlioMIP2)**

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Report period: 01.07.2017 – 30.06.2018

We report on our modelling efforts in DKRZ project 1006 on HLRE3/Mistral during the first 9 months of the allocation period 2017 – 2018. Our modelling approach so far has been based on MPI-ESM-LR. We have updated our plans and would like to now also include a legacy model (COSMOS, based on ECHAM5 / JSBACH / MPIOM at a lower resolution of T31) and – if the Wissenschaftlicher Lenkungsausschuss approves our request – an additional CMIP6 model (AWI-CM, based on ECHAM6 / JSBACH / FESOM1.4) for the production of climate states of the Mid-Piacenzian Warm Period (MPWP) as outlined in our current project proposal. During previous allocation periods we already prepared model simulations for PlioMIP2 based on the MPI-ESM 1.2.00, that was initially announced as the official CMIP6 model. Various carbon dioxide sensitivity studies were completed based on this model.

During the course of the project it became apparent that the model version 1.2.00 will be updated to account for some deficiencies, and that the model version so far used by us will not be the actual CMIP6 model with which simulations will be prepared by the Max-Planck-Institute for Meteorology (MPI-Met) and the Deutsches Klimarechenzentrum. A new model version, MPI-ESM 1.2.01, was published end of October last year and announced as the updated and official CMIP6 version. Consequently, we have continued our modelling effort in DKRZ project 1006 based on this updated model and prepared new spinups utilizing the already equilibrated ocean model states that were produced with the predecessor version MPI-ESM 1.2.00.

Yet, shortly after the publication of the updated model also in that version problems were detected, and a pending update to the final CMIP6 version was announced. Reason for the pending model update is the discovery of an indexing problem in the ocean model. We expect that the fix in the updated model will lead to a significant change in the ocean model states and, due to the coupling of ocean and atmosphere, to the overall climate states simulated by us in this DKRZ project. This expectation is based on our information that some re-tuning of the updated model has been necessary. To our information, this re-tuning also caused the waiting time for the release of the updated model. Our most recent information is that this model version will be available sometime during May 2018.

Until the announcement of the pending CMIP6 model update, the intermediate “CMIP6-version” has been utilized to further equilibrate the model states for the various simulations derived with the previous version MPI-ESM 1.2.00. Upon learning that our modelling efforts will not directly lead to climate data that can be submitted to the CMIP6/PMIP4/PlioMIP2 model-intercomparison, as has been promised by us for our work within DRKZ project 1006, we strongly reduced our modelling effort in order to not overly consume DKRZ resources – this explains why the project lost a significant amount of computational resources at the end of some quarters. We continued to equilibrate MPI-ESM simulations, the ocean states will be used as a starting point in order to speed up equilibration with the updated CMIP6 model. Furthermore, in order to utilize a bit more computing time of the project in a scientifically sensible way, we set up two test simulations in order to identify the utility of the AWI-CM for our work with PlioMIP2. The result of this approach is that we now request additional resources to also prepare MPWP simulations with the AWI-CM for PlioMIP2.

In the mean time, we have also extended our modelling work outside of DKRZ project 1006 on AWI’s own high performance computers to using the COSMOS climate model, which is the legacy model employed by us for the first phase of PlioMIP (PlioMIP1). The use of the old PlioMIP1 model in addition to the state-of-the-art models will enable us to enrich the PlioMIP2 model database with model data from low (COSMOS), intermediate (MPI-ESM), and high (AWI-CM) model resolution in the ocean. The COSMOS furthermore bridges the gap to PlioMIP1 in that it will enable us to judge the influence of the updates to model boundary conditions in PlioMIP2 on the modelled climate states. Our analysis of climate sensitivity of COSMOS and

MPI-ESM (Fig. 1) illustrates that for a given level of carbon dioxide a much warmer climate is computed by the COSMOS. Hence, our approach to employ both the COSMOS and the MPI-ESM for the PlioMIP2 will provide simulations of both a low- and a high-climate-sensitivity model for the model intercomparison. In this way, we consider the uncertainty in the estimated climate sensitivity of the earth system in our work.

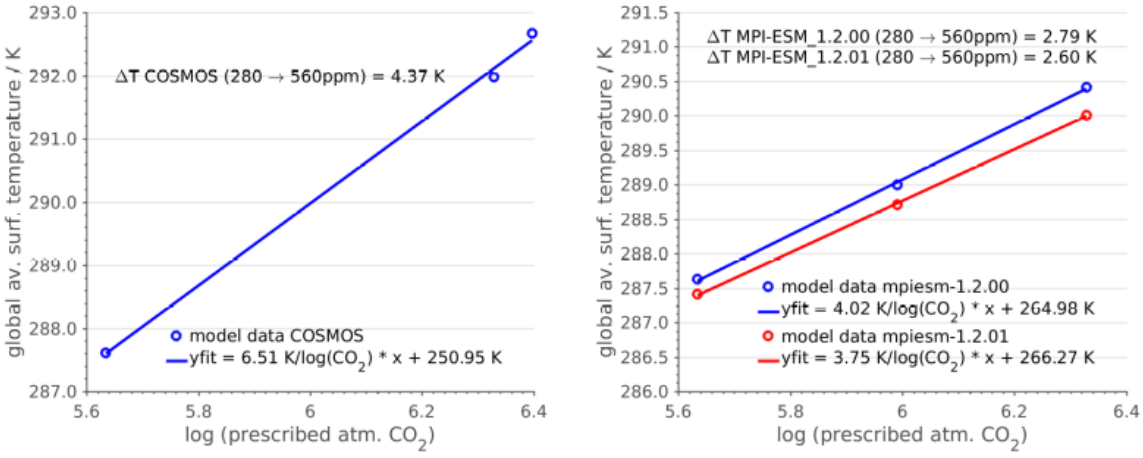

Fig. 1: Climate sensitivity of the Community Earth System Models (COSMOS, ECHAM5/JSBACH/MPIOM; left) and the Max Planck Institute Climate Model (MPI-ESM, ECHAM6/JSBACH/MPIOM; right). The data is based on equilibrium-integration of the COSMOS for a pre-Industrial geography, but with differing levels of carbon dioxide in the atmosphere (280 ppm, 560 ppm, 600 ppm; simulations were performed on AWI's own computers); for MPI-ESM a similar simulation approach has been used within project 1006 on the HLRE3, but for the carbon dioxide levels of 280 ppm, 400 ppm, and 560 ppm.

We highly value efforts by the MPI-Met to prepare a CMIP6 model and would like that our contributions to PlioMIP2 will give the MPI-ESM CMIP6 model as much impact in the model-intercomparison as possible. Hence, we deem it necessary to re-equilibrate and (re)-run all our MPI-ESM simulations with the updated CMIP6 model as soon as it becomes available. This includes the simulations E^{400} and E^{560} as well as the production of the Mid-Piacenzian Warm Period (MPWP) simulations with various volume mixing ratios of carbon dioxide, Eoi^{280}, Eoi^{350}, Eoi^{400}, and Eoi^{450}. The orography and land ice forcing factorization simulations, proposed for the current allocation period, have been delayed in order to wait for the availability of the updated CMIP6 version of the model. These simulations will only be prepared if time and computational resources allow.

The WLA suggested in reply to our last proposal for DKRZ project ba1006 that our work is important for CMIP6 and PlioMIP2, but that sensitivity experiments concerning the model bug may be shortened and computed within the AWI-share. In this sense we will aim at performing some parts of our simulations, as outlined in our current project proposal, with the AWI-share, and in this manner we will reduce the computational load that will be caused by our project within the BMBF share. Yet, it is foreseeable, that the time after publication of the CMIP6 model update and the allocated computational resources both in DKRZ project 1006 and in the AWI-share are not sufficient to fully perform this task. Hence, we request for additional resources for the following allocation period to partly redo and finish the PlioMIP2 simulations of this project.

It is foreseeable that we will not be able to complete all simulations proposed for PlioMIP2 by Haywood et al. (2016) until the end of this year, which is the time when PlioMIP2 shall proceed from the production to the analysis and model-intercomparison phase. Hence, we would like to focus on those simulations that are most important for a successful contribution to PlioMIP2, which are the MPWP CORE simulation and the Tier 1 simulations with various levels of atmospheric carbon dioxide.

References:

Haywood, A. M., Dowsett, H. J., Dolan, A. M., Rowley, D., Abe-Ouchi, A., Otto-Bliesner, B., Chandler, M. A., Hunter, S. J., Lunt, D. J., Pound, M. and Salzmann, U.: The Pliocene Model Intercomparison Project (PlioMIP) Phase 2: scientific objectives and experimental design, Clim. Past, 12, 663–675, doi:10.5194/cp-12-663-2016, 2016.