# 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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During the first 9 months of allocation period 2018 – 2019 we have furthered our modelling based on MPI-ESM-LR and AWI-ESM (AWI-CM with dynamic vegetation) and, as an addition independently of DKRZ resources, on a predecessor to MPI-ESM. Like many other computing projects (e.g. ba1066 at our work group) that depend on CMIP6 versions of climate models, we are still delayed with respect to our schedule.

Our delay in finalizing the proposed simulations with MPI-ESM-LR is related to model upgrades of the official CMIP6 model that were published during allocation period 2018 – 2019 on the one hand side, and to a delay in the provision of the CMIP6 data request for the DKRZ's ESGF data node on the other hand side. Updates to MPI-ESM-LR, published since our last proposal for computing time in DKRZ-project ba1006, encompass the upgrade to: a) mpiesm-1.2.01p1 towards the end of last year, where, among other changes, the cloud parameterization has been modified (see Table 1) and fixes have been applied to the nitrogen-cycle, changes that break binary compatibility to the previous CMIP6-version of MPI-ESM-LR; b) the recent upgrade to mpiesm-1.2.01p3 (not yet officially released on <a href="https://code.mpimet.mpg.de/projects/mpi-esm-users/files">https://code.mpimet.mpg.de/projects/mpi-esm-users/files</a>), where CMOR information is updated to the current controlled vocabulary for CMIP6 and errors in the generation of CMIP6 output have been fixed.

Finalizing our proposed work with AWI-ESM was prevented by the lack of a finalized CMIP6 data request and the related uncertainty in properly defining model-output-streams for the generation of CMIP6-conform model data. Colleagues from AWI's Climate Dynamics are currently in contact with DKRZ towards publication of the first official CMIP6 piControl data sets produced with AWI-CM. Based on their experience we are optimizing our namelist settings towards CMIP6-conformity of the model output produced by us.

cloud parameter	mpiesm-1.2.01	mpiesm-1.2.01p1
crs (critical humidity at surface)	0.968	0.973

Table 1: Changed cloud parameter in the official CMIP6 version of MPI-ESM. Various cloud parameters changed between mpiesm-1.2.01 and mpiesm-1.2.01p1, the changes depend on the employed model resolution. Here, only the change in critical humidity at surface is mentiones as this is the only change that is active in LR-resolution of MPI-ESM, that is the resolution employed in this project.

Clouds are an important feature for climate sensitivity and hence for the overall global climate. As we are bound to use the official CMIP6 models we have integrated the simulations already performed with mpiesm-1.2.01 with the upgraded model version further. Unfortunately, waiting for model upgrades and finalization of the CMIP6 data request has again led to expiration of a significant amount of computing time, for which we apologize to the WLA. Knowing that the DKRZ's infrastructure is already under strain due to the various MIP-simulations we refrained from utilizing computational resources for producing the final PMIP4 simulation output when it became foreseeable that this likely has to be redone, at least in part.

Remaining computational resources for allocation period 2018 – 2019 will be employed to finalize our modelling work with MPI-ESM-LR and AWI-ESM. As the timeframe is tight we will focus on those simulations that are absolutely necessary for taking part PlioMIP2 (i.e. the Mid-Pliocene simulation with the best estimate of 400 ppmv of carbon dioxid) for both models. If computational resources remain we will prepare as much other model output as possible based on the remaining resources in the project. In this respect we will follow the suggestion regarding a reduced set of model simulations that has been offered by the WLA as an answer to our previous request. It is likely that we will not completely finish the generation of CMOR-conform output and generation of CMORized data sets within the current allocation period. Therefore, we request a limited amount of computational resources to finish these tasks in the third quarter of 2019 (see proposal). For the upcoming allocation period we would like to continue our work by preparing

Mid-Pliocene simulations also with the AWI-ESM2 (see proposal). As AWI-ESM2 simulations will not be immediately contributed to CMIP6, our work with this model is less subjected to time pressure but will certainly provide a first step towards future MIPs within and outside the paleoclimate context. Furthermore, the AWI-ESM2 enhances throughput and reduces computational expense by a factor of 3-4 in comparison to AWI-ESM, hence causing less strain on the DKRZ's computing resources.

Based on analyses of simulations from our extended model toolbox, that, besides MPI-ESM and AWI-ESM, also contains a predecessor to the MPI-ESM (see the proposal for allocation period 2018-2019 for details), we find that our choice to exclusively employ model versions that are equipped with dynamic vegetation leads to a major improvement of the simulation of Mid-Pliocene climate with respect to previous efforts in PlioMIP (Stepanek and Lohmann, 2012), where a fixed vegetation, that is - in contrast to dynamic vegetation - not necessarily consistent with the simulated climate, has been employed. Improvements of the model simulation are in particular present in regions where Mid-Pliocene climatic conditions are very different from the Preindustrial. Changes in ambient climatic conditions impose constrains on vegetation, that responds via a changed regional composition of plant cover. This is particularly obvious for today's Sahel and for high latitude regions of the Russian Federation and of North America. The already finalized model simulations with the predecessor model of MPI-ESM (Stepanek et al., in prep.) show that dynamic vegetation creates the expected large spatial vegetation shifts in these regions if the model is exposed to Mid-Pliocene paleogeography (Figure 1). These vegetation shifts impact on climate via the vegetationrelated feedbacks albedo and evaporation. Sensitivity of vegetation dynamics, in combination with the simulated climate state, to the employed model version (MPI-ESM-LR and AWI-ESM, and as well AWI-ESM2 if approved by the WLA) will be analysed in the framework of our contribution to PlioMIP2.



Figure 1: Simulated vegetation distribution for pre-industrial (a,b) and Mid-Pliocene (c,d) for forest (a,c) and grass (b,d), shown here for the finalized simulations with the predecessor model of MPI-ESM. Position of the tree line (defined as the 10%-isoline of forest cover) indicated by blue contours (a,c).

### **References:**

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