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: 01.07.2019 – 30.06.2020

Following the suggestion by the Wissenschaftlicher Lenkungsausschuss, who highlighted the severe strain on DKRZ resources in their reply to our last proposal for computational resources, we have kept use of computational resources within the project as low as practically feasible. This involved rescheduling simulations, and focusing on most essential work. We have succeeded to perform most of our computational work based on alternative computational resources, prepared additional boundary conditions, and have analyzed a large set of simulation output from a predecessor model, the latter of which culminated in a publication (Stepanek et al., 2020) that is currently in review. In the ensuing analysis of model output in the DKRZ project, respective information on climate characteristics with a predecessor model of low resolution, but high climate sensitivity, will be valuable in understanding the impact of increased spatial resolution, in both ocean and atmosphere, on the simulated climate of the Mid-Piacenzian.

Based on previous work and results, for the upcoming allocation period we will largely focus our work on three topics (see proposal for details):

- finalizing simulations of the proposed simulation ensemble; we will apply for a modest amount of computing time for additional simulations, and for a small amount of resources for previously proposed simulations, as we are able to partly cover resources for unfinished simulations from other sources
- analyzing already acquired model data, focusing our research in particular on the importance of resolution in the ocean for the establishment of Mid-Piacenzian ocean surface temperature anomalies, that have been reconstructed from the geologic record; these are, in particular, high positive temperature anomalies in the North Atlantic to Arctic Ocean realm and in the Benguela upwelling system; models generally have the tendency of simulating too cold temperature anomalies also in PlioMIP2, although the bias has been reduced with respect to the predecessor iteration of PlioMIP, partly owed to updated boundary conditions by Haywood et al. (2016) and Dowsett et al. (2016) for PlioMIP2 (Haywood et al., 2020); our hypothesis is that increased ocean resolution of AWI-ESM1/2 in critical regions (coasts, gateways) might reduce this mismatch
- running three additional simulations where we test the impact of higher spatial model resolution in gateway and coastal regions on the efficacy of Mid-Piacenzian gateway changes to reduce model-data mismatch in the models employed in this project (MPI-ESM-1-2-LR, AWI-ESM-1-LR, AWI-ESM-2-LR); such gateway changes have been shown, based on our analysis in the current allocation period, to impact on the model data agreement in a predecessor model, but have been inconclusive: adapting gateways to the Mid-Piacenzian gateway configuration increases the AMOC as expected, but only leads to a modestly improved model-data-agreement (Figure 1; Stepanek et al., 2020); the simulated warming patterns are spatially separated from locations where large temperature anomalies are reconstructed – the aim of the

additional simulations with the state-of-the-art models is to test whether increased detail of ocean bathymetry in their comparably high resolution ocean components can further increase the contribution of Mid-Piacenzian ocean gateway states to reduced model-data-discord

- CMORizing based on the published DKRZ CMIP6 data request, and publishing our modelling results on ESGF and in peer reviewed journals; we will need a sufficient amount of disk space towards data processing and CMORizing of model output

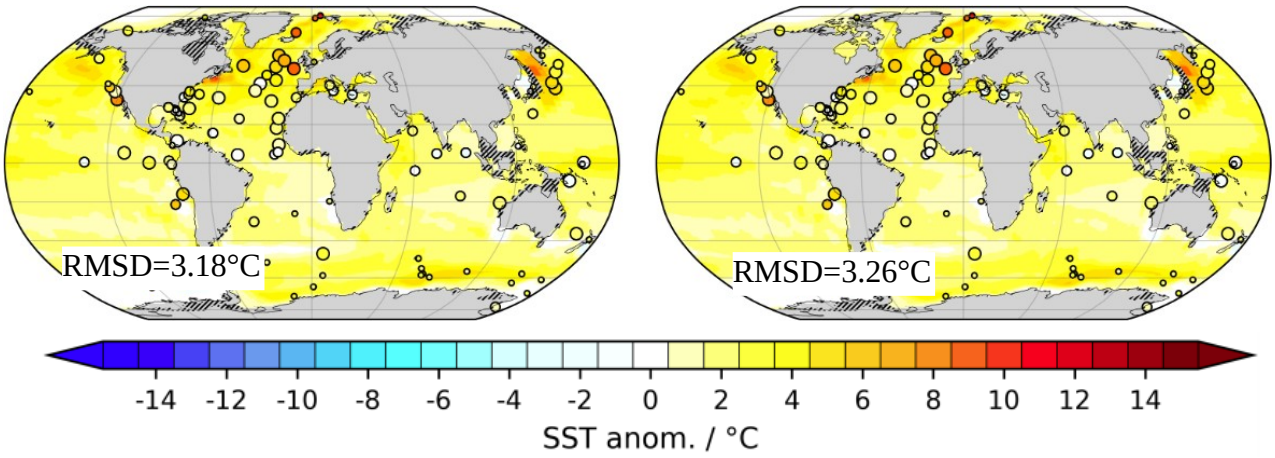

Figure 1: Simulated and reconstructed Mid-Piacenzian sea surface temperature (SST) with a predecessor model for a simulation considering all Mid-Piacenzian boundary conditions including all gateway changes (left) and with selected gateways in their modern configuration (right). While the simulation with the full set of Mid-Piacenzian conditions reproduces expected higher Atlantic Meridional Ocean Circulation and reduced root mean square deviation (RMSD) of reconstructed/ modelled SST in the Atlantic to Arctic Ocean than the setup with modern gateways, warming patterns are dislocated with respect to reconstructed warming in the Atlantic to Arctic Ocean.

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