Project: **1066**

Project title: **Simulations of the Last Interglacial and of the Mid-Holocene with MPI-ESM and AWI-CM in the framework of the Paleoclimate Model Intercomparison Project, phase 4 (PMIP4)**

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Report period: **2022-01-01 to 2022-10-31**

We report on project progress during the first 10 months of allocation period 2022 in the framework of simulations for the Paleoclimate Model Intercomparison Project, Phase 4 (PMIP4), that is related to the Climate Model Intercomparison Project, Phase 6 (CMIP6). During the year 2022 the model AWI-ESM2-2, for which we have requested computational resoures, has been subject to intense improvements in the framework of project ba0989 (PalMod2 WG1). The model with coupled ice sheets has shown to provide the correct model sensitivity to forcing (in particular with regard to greenhouse gases) to, in principle, successfully create an inception. Yet, a bias in the mean state of the climate, that is in many regions, that are relevant for ice sheet builtup, too warm, has proven to be too large to actually generate inception of an ice sheet in coupled climate-ice sheet simulations under realistic inception boundary conditions and forcings. The work by Lars Ackermann and colleagues in ba0989 has recently overcome this issue by providing a bias-fix via tuning of the ice sheet model and via removing the bias via an anomaly method that is based on reanalysis data. There, the known model bias with regard to reanalysis data is removed from any atmospheric forcing that is handed over to the ice sheet model.

Simulations, that we have proposed for this year, necessitate to be based on the same setup and tuning as employed in ba0989. It did not make sense for us to start modelling work, that shall produce CMIP6 simulations, based on a model version that has been shown to be not suitable for coupled ice-sheet modelling in the context of glacial-interglacial cycles, and, in particular, in the context of correctly resolving details of the last inception. Consequently, we have waited for finalizing the relevant model improvements. These were underway in project ba0989 and have recently been finished (also see report and allocation document of project ba0989 for 2023). We have not yet run the relevant simulations for which we requested computational resources. During the remainder of the year we aim to finish as much of the proposed work as still possible. We will use where necessary computational resources available to us via other projects.

For the upcoming allocation period we switch focus to a new model version that is planned to become the future work horse of paleoclimate modelling at the AWI, the AWI-CM3. The model has been recently described (Streffing et al., 2022) and has been shown to be comparable in performance to the better CMIP6 models (Fig. 1). Yet, for the use of the model in a paleoclimate setting there is still one important component missing: dynamic vegetation, that has been automatically available via ECHAM6/JSBACH in AWI-ESM2, but that still needs to be tested for its performance in a paleomode in AWI-ESM3, where LPJ-GUESS takes the role of the dynamic vegetation component that is coupled to the atmosphere model openIFS. To this end we propose a set of simulations in the context of CMIP6/PMIP4 where we will spin up the AWI-ESM3 with dynamic vegetation to various climate states. The derived climate and vegetation metrics will then be compared to proxy reconstructions and vegetation distributions derived from other climate models that are likewise employed with dynamic vegetation. As a result we will be able to characterize the performance of the AWI-ESM3 and to improve it, where necessary, for future production work in CMIP/PMIP.

As the dynamic vegetation model LPJ-GUESS has, in the setup coupled to openIFS, so far been used with a focus on the modern climate, we will run additional test simulations for both a colder and a warmer climate state than modern were we test model sensitivity to modified parameters of the dynamic vegetation model. The resulting data sets will also serve to provide a best parameter fit that shall go into a model version that is suitable for simulations across time scales, from colder-than-present to warmer-than-present climate states (see allocation request document for 2023).

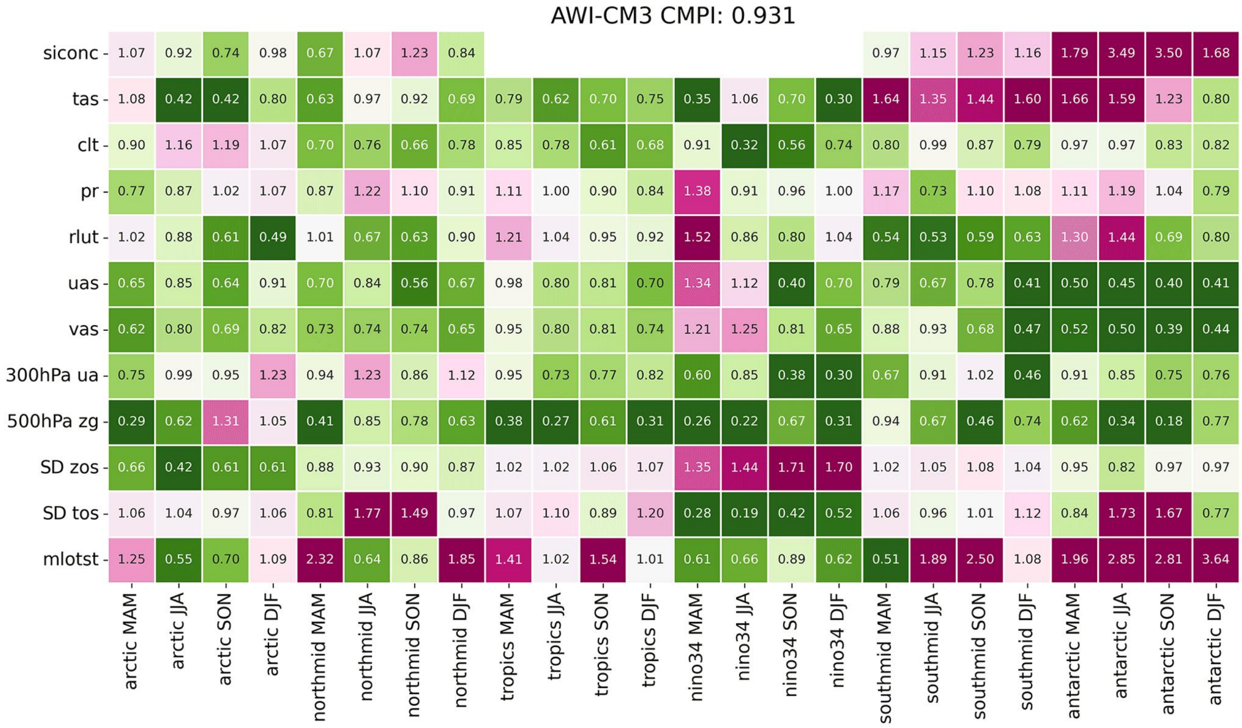

Fig. 1: Climate Model Performance Indicators (CMPI) by Streffing et al. (2022) for the published version of AWI-CM3 (AWI-CM3.0). The CMPI show the model‘s performance in comparison to reanalysis data and to that of other CMIP6 models for various quantities (rows) and various regions and seasons (columns). Where AWI-CM3 performs better than the average CMIP6 model the indicator is below 1 (greenish colors). Where AWI-CM3 performs worse than the average CMIP6 model the indicator is above 1 (redish colors). Note that the current version of AWI-CM3, AWI-CM3.1, has been further improved with respect to the published model version, so that many quantities, in particular those related to high latitude climate, are represented by the model even better than as shown in this figure.

References:

Streffing, J., Sidorenko, D., Semmler, T., Zampieri, L., Scholz, P., Andrés-Martínez, M., Koldunov, N., Rackow, T., Kjellsson, J., Goessling, H., Athanase, M., Wang, Q., Hegewald, J., Sein, D., Mu, L., Fladrich, U., Barbi, D., Gierz, P., Danilov, S., Juricke, S., Lohmann, G., and Jung, T.: AWI-CM3 coupled climate model: Description and evaluation experiments for a prototype post-CMIP6 model, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2022-32, 2022.