

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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We report on project progress during the first 8 months of allocation period 2021 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). First of all, we would like to thank the WLA for the positive evaluation of our last proposal. During the year of 2020 and 2021 the AWI-ESM2 model has experienced significant further development in the framework of project ba0989. That development has lead to appreciable changes in the setup of the ocean model (non-linear free surface, cavities, updates to the coupling of ocean and ice sheets), the concurrent-radiation setup, and inclusion of stable isotopes in AWI-ESM2's components. As these updates imply changes to model physics with regard to the version previously employed in project ba1066, we would like to re-request for allocation period 2021/2022 resources for CMIP6 simulations that will then be performed with the updated model (see request document). Further development of the model components in project ba0989 took longer than expected, which shifted our work plan for simulations in 2021. Since many parts of our future modelling work will be based on AWI-ESM2 with interactive ice sheets, this work will be performed with that model version. This ensures that synergies with DKRZ project ba0989 will still be available.

We are glad that model output generated by means of resources from project ba1066 has been used towards publication of a number of peer-reviewed manuscripts that have become available over the last two years. The publication record proves that our modelling efforts are contributing to the overall progress of science in the framework of CMIP and PMIP. Below we present an updated manuscript overview that includes updates of manuscript records, we also list manuscripts that have been published since the last report on our project progress. These manuscripts relate to the models AWI-ESM1, AWI-ESM2, and MPI-ESM1.2, whose model output has been evaluated in the framework of various model-model and model-data intercomparison studies for various time periods since the Last Interglacial. In addition, the data sets produced by us have been considered for published research beyond the CMIP6/PMIP4-related model intercomparison, suggesting the general usefulness of our work beyond CMIP/PMIP.

In addition to the analysis of the MPI-ESM1.2 Last Interglacial (LIG) simulation *lig127k* by Scussolini et al. (2019), that was aiming at a model-data comparison of precipitation during the LIG, a follow up publication by Scussolini et al. (2020) has employed the precipitation data for a study of floods and global river discharge during the LIG. The model-intercomparison of LIG large scale climate features by Otto-Bliesner et al. (2021), that considers MPI-ESM1.2 simulation output for *lig127k* and *piControl*, has been accepted and published after revisions. Lohmann et al. (2020) employed high resolution ocean output to study the impact of different meltwater routes on ocean circulation for their study on abrupt climate change. Brown et al. (2020) considered model output in an evaluation of the El Nino Southern Oscillation across interglacial and glacial climates. Arctic sea ice, as simulated by AWI-ESM2 in simulation *lig127k*, has been compared to that simulated by other models in a publication by Kageyama et al. (2021a). Brierley et al. (2020) consider the AWI-ESM-1 in an analysis of large-scale climate features and in an evaluation of PMIP4-CMIP6 *midHolocene* simulations. The AWI-ESM1 *piControl* and *historical* simulations have been utilized towards a study of AMOC recovery in a set of experiments that have been conducted with and without interactive Northern Hemisphere ice sheets (Ackermann et al., 2020). The authors found that interactive ice sheets are important towards resolving decadal variability of surface runoff into the North Atlantic Ocean. AWI-ESM model output has also been employed towards studying the climate sensitivity in PMIP (Renoult et al., 2020), characterization of the climate of the Early Holocene (Shi et al., 2020a), the shift of ocean gyres towards the poles (Yang et al., 2020a), the impact of poleward advancing meridional temperature gradients on tropical expansion (Yang et al., 2020b) and for the study of sea ice dynamics at the Bransfield Strait (Vorrath et al., 2020). So far, model output of this project has been published in two data sets that are available via the Earth System Grid Federation (Shi et al., 2020b; Danek et al., 2020).

Further publications, to which model output of DKRZ project ba1066 contributed, have become available during 2021. Kageyama et al. (2021b) compare the PMIP4 Last Glacial Maximum experiments. Our model output has been considered for this publication via a collaboration with DKRZ project ba0989. Furthermore, simulated changes in stratospheric ozone and water vapour from 1850 to 2100 contributed to the study by

Keeble et al., (2021). Their analysis shows that AWI-ESM-1-1-LR captures the observed water vapor volume mixing ratio within the CMIP6 ensemble relatively well (Fig. 1). The impact of orbital forcing since the mid-Holocene on the amplitude of ENSO has been analyzed by Carré et al. (2021).

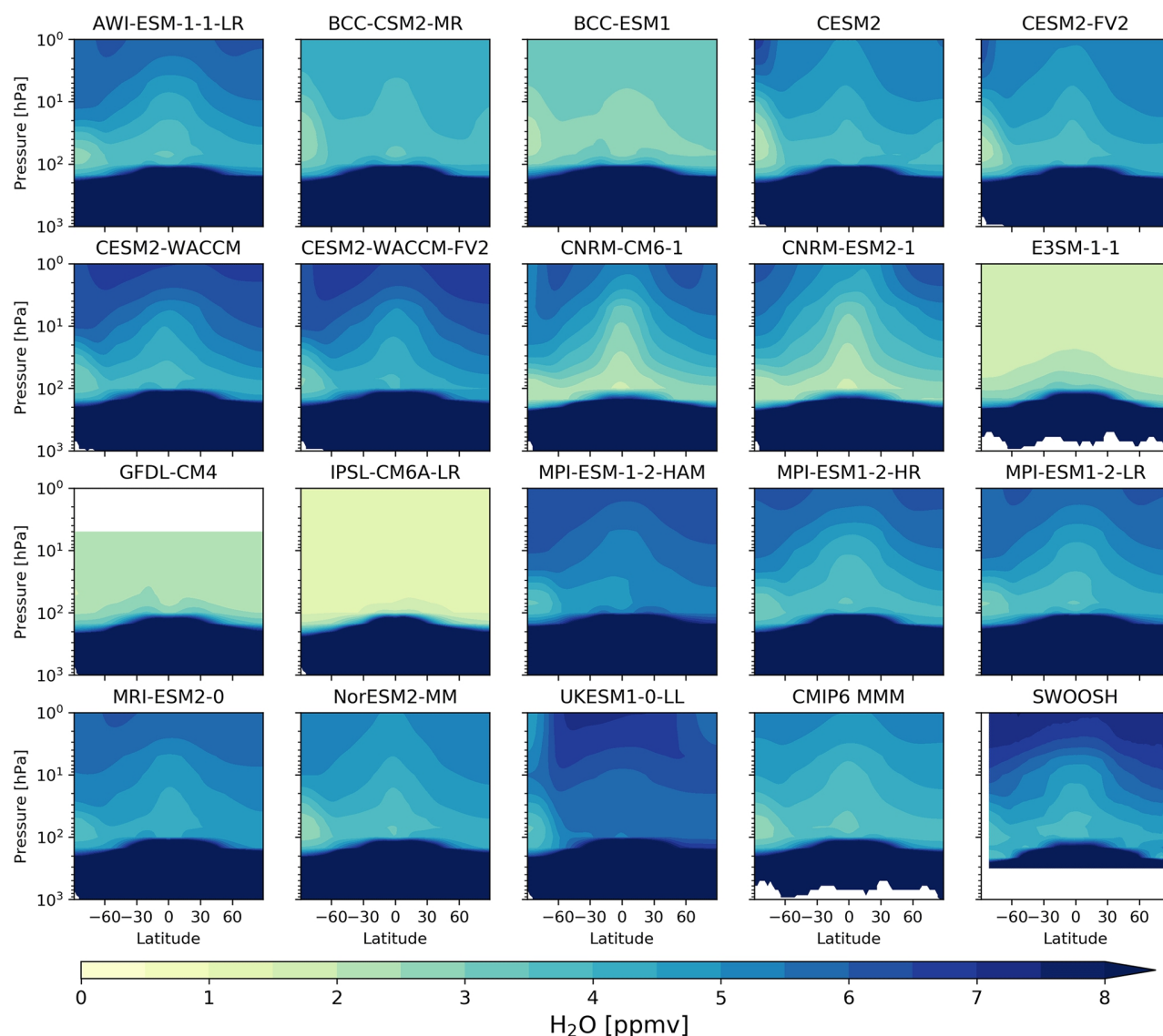


Fig. 1: Analysis of CMIP6 model's zonal mean annual mean water vapour mixing ratio by Keeble et al. (2021). Shown is a comparison of individual models, the CMIP6 multi model mean (CMIP6 MMM), as well as observational data (SWOOSH).

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