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)**

Project lead: **Gerrit Lohmann**

Report period: **2019-01-01 to 2019-12-31**

We report on our modelling efforts with MPI-ESM-LR and AWI-ESM (i.e. AWI-CM with vegetation dynamics and related climate-vegetation feedbacks) during the first 10 months of allocation period 2019 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. We replied to the WLA's comments via the online form where we provide a detailed explanation for the technical and principal reasons that prevented us from using more tape archive storage while overusing our disk storage share, leading to reduced effectiveness of our use of computational resources in the first 10 months of 2019. As outlined in our response via the online form, reasons for overuse of disk storage were largely beyond our control. Generation of output after model spinup for CMIP6/ PMIP4 is subject to CMORization, which itself depends on availability of a finalized DKRZ CMIP6 data request. The latter was until very recently still subject to significant development, delaying CMORization of model output and prompting us to store much more data on disk than what would have been necessary if a finalized data request had been available at an earlier time during the current allocation period. Yet, we are currently progressing with CMORizing already available model output and hope that by the end of 2019 disk space will not be a bottle neck anymore for your ongoing work in project ba1066.

We acknowledge that resources at HLRE-3 are still under strain during the allocation period of 2019 because of the ongoing CMIP6 modelling efforts. Following the suggestion by the reviewers to focus on tier 1 simulations we consequently tried to limit utilization of resources at HLRE-3 in the framework of DKRZ-Project ba1066 also during 2019 as much as possible. We are happy that various simulations proposed during the two last allocation periods have now been finalized from the viewpoint of climate modelling (Table 1). For these simulations only CMORization is still ongoing. The respective model output already has undergone initial scientific evaluation. In case of the simulation of Last Interglacial climate with MPI-ESM our work already provided useful model output for a multi-model- / proxy-data-intercomparison in the framework of PMIP4 that led to a scientific study that will be published in Science Advances shortly (Scussolini et al., in press).

Table 1: Model simulations that have been finished except for CMORizing. *****Produced based on DKRZ resources by other computing projects and listed here to provide a complete overview of our contribution to PMIP4. ******We propose to prolong the run period to year 2100 in the upcoming allocation period (see proposal for details).

no.	model	MIP-affiliation	simulation	run period
1	AWI-ESM	PMIP4	midHolocene_AWI-ESM*****	complete
2	AWI-ESM	PMIP4	lgm_AWI-ESM*****	complete
3	AWI-ESM	PMIP4	lig127k_AWI-ESM	complete
4	AWI-ESM	PMIP4	hol9.5k_AWI-ESM	complete
5	AWI-ESM	CMIP6	piControl_AWI-ESM	complete
6	AWI-ESM	CMIP6	historical_AWI-ESM	complete
7	AWI-ESM	CMIP6	1pctCO2_AWI-ESM	1850-2000******
8	AWI-ESM	CMIP6	abrupt-4xCO2_AWI-ESM	1850-2000******
9	MPI-ESM-LR	PMIP4	lig127k_MPI-ESM-LR	complete

The list of finished model simulations (Table 1) is only a subset of those proposed for 2019. Reasons for this are delays in CMORization of already produced model output (as described above and via the online form) and the WLA's suggestion to focus on tier 1 PMIP4 simulations for this allocation period. For 2020 we will request resources for a subset of the still missing model simulations as outlined in our request document.
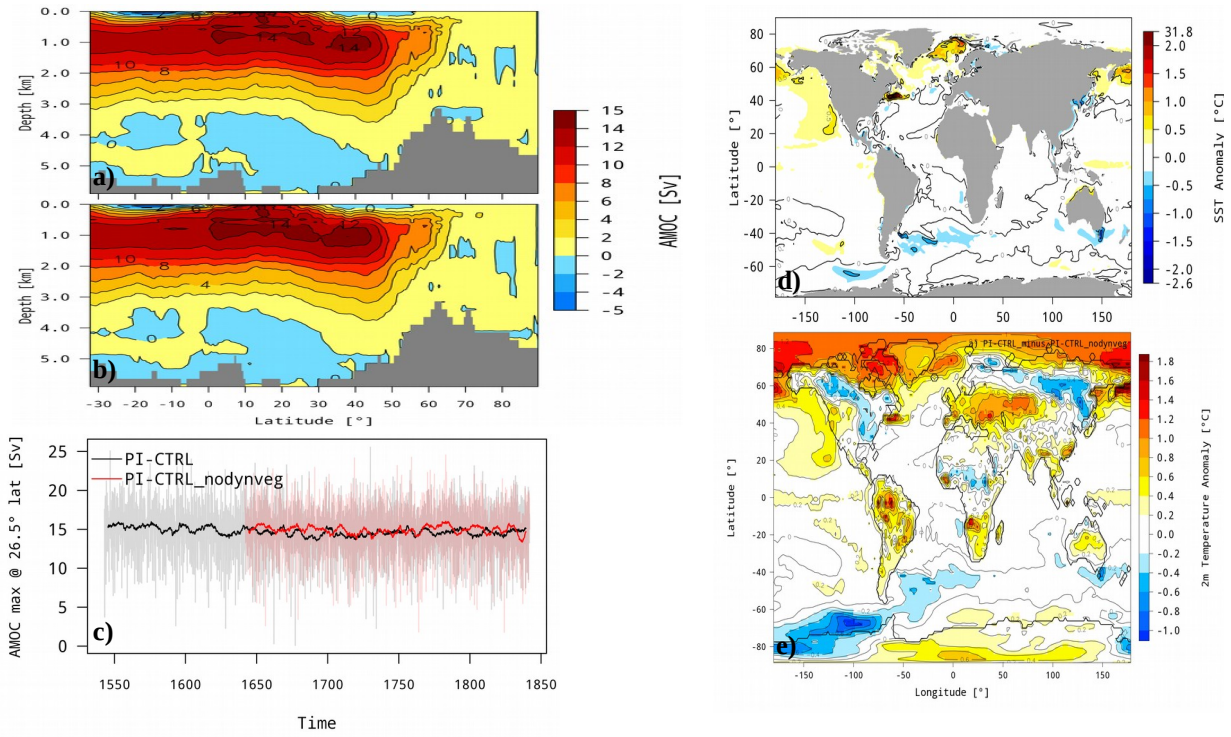
Fig. 1: Pre-industrial climate patterns simulated with AWI-ESM in comparison to AWI-CM. Absolute Atlantic Ocean Meridional Overturning (AMOC) streamfunction (a,b) and maximum AMOC at 26.5°N (c). Anomaly of sea surface temperature (SST, d) and air temperature 2 m above the ground (e), AWI-ESM minus AWI-CM.

One aim of your work in project ba1066 is the characterization of the AWI-ESM's climate patterns and performance in comparison to other models in the framework of paleoclimatological research in CMIP6/PMIP4. Our contribution of DECK simulations with AWI-ESM to CMIP6/PMIP4 is motivated by the need to consider vegetation dynamics on orbital time scales as a key climate-relevant model system. Dynamic vegetation is present in AWI-ESM, contrary to AWI-CM for which CMIP6/PMIP4 contributions are provided by colleagues of the AWI's department for Climate Dynamics. Comparison of pre-industrial climate of AWI-ESM in comparison to AWI-CM highlights that, while the Atlantic Ocean Meridional Overturning streamfunction as a large scale oceanographic parameter is not strongly influenced by presence/absence of vegetation dynamics, regional climate indeed depends on vegetation dynamics and climate-vegetation feedbacks (Fig. 1).

Based on our work in DKRZ-project ba1066 in collaboration with DKRZ-projects ba0989 and ba1021 we provide an AWI-ESM-based set of climate states to CMIP6/PMIP4 that so far characterizes three distinct climate states during the last glacial cycle (Fig. 2): two interglacials (Mid-Holocene, Last Interglacial) and one glacial (Last Glacial Maximum). We emphasize the scientific value of collaboration between ba1066 and other CMIP6/PMIP4 related DKRZ-projects. Our choice of a novel climate model with dynamic vegetation and a finite-element ocean, improving spatial resolution in various regions, provides the opportunity to characterize and study global climate dynamics at key periods of the last 130,000 years without ignoring regional patterns.
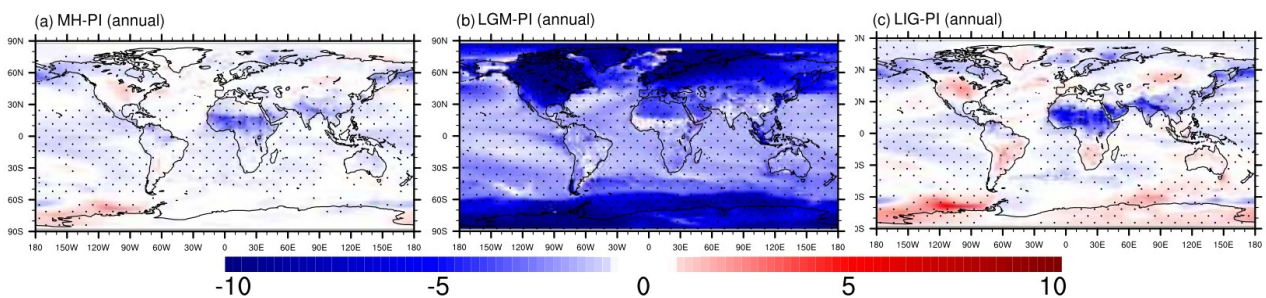

Fig. 2: Annual mean surface air temperature anomalies with respect to pre-industrial (PI) in units of °C as modelled with AWI-ESM: a) Mid-Holocene (MH), b) Last Glacial Maximum (LGM), and c) Last Interglacial (LIG). a) and b) have been computed based on DKRZ projects ba1021 and ba0989.

Reference:

Scussolini, P., Bakker, P., Guo C., Stepanek, C., Zhang, Q., Braconnot, P., Cao J., Guarino, M.-V., Coumou, D., Prange, M., Ward, P.J., Renssen, H., Kageyama, M., Otto-Bliesner, B., and Aerts, J.C.J.H. (in press, Sci. Adv.): Agreement between reconstructed and modeled boreal precipitation of the Last Interglacial.