Project: **988**

Project title: **CMIP6**

Principal investigator: **Martin Schupfner**

Report period: **2020-11-01 to 2021-08-31**

Activities MPI-M

In early 2021, the ICON-ESM DECK experiments in low resolution (LR, 160 km atmosphere and 40 km ocean), which were performed at the end of 2020, went through further postprocessing and quality-testing, and were prepared for the cmorization by DKRZ.

The evaluation of the ICON-ESM DECK experiments was continued and the model documentation paper (Jungclaus et al., "The ICON Earth System Model Version 1.0", to be submitted in August 2021) was finalized.

ICON-ESM-V1 is, to our knowledge, the first climate/earth system model that is based on unstructured grids in the atmosphere (ICON-A, Giorgetta et al., 2018) and ocean (Korn, 2017) components. The model evaluation concentrated on comparison between the late 20th/early 21st century climate simulated in the historical ensemble and observational and reanalyses-based data. We also compare the quality of coupled ocean-atmosphere simulations with AMIP-type experiment using ICON-A.

Notable achievements of the ICON-ESM-LR simulations are well-balanced top-of-atmosphere radiation, stable key climate quantities in the control simulation, and a good representation of the historical surface temperature evolution. The model has overall biases, which are comparable to those of other CMIP5 or CMIP6 models, but ICON-ESM performs less well than its predecessor, the Max Planck Institute for Meteorology Earth System model at comparable resolution. Problematic biases are diagnosed in ICON-ESM in the vertical cloud distribution and the mean zonal wind field. In the ocean, sub-surface temperature and salinity biases are of concern as is a too strong seasonal cycle of the sea-ice cover in both hemispheres. ICON-ESM has a higher equilibrium climate sensitivity than MPI-ESM (3.7 vs. 3.0^{0}C).

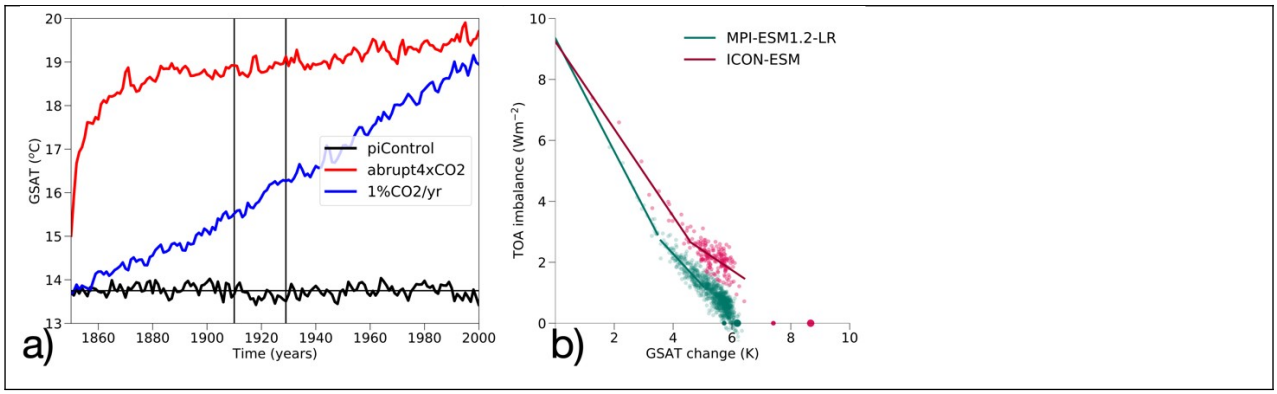

Figure 1: *Estimating the transient climate response (left) and equilibrium climate sensitivity ECS from idealized DECK experiments: a) evolution of global surface temperature in the 1pctCO2 (blue) and abrupt4xCO2 (red) experiments together with the piControl run (black). B) Gregory-style regression method to estimate ECS for ICON-ESM (dark red) and MPI-ESM (green).*

Computing time report AWI

In 2021 no new simulations were performed in this project. Postprocessing has been applied to the model data that have been produced in 2020. In addition, a few more data have been published at ESGF. Evaluation of the simulations has resulted in an interesting aspect regarding AWI-CM compared to MPI-ESM. The transient climate response to idealized 1%CO2 per year forcing is around 20% larger in AWI-CM compared to MPI-ESM and the equilibrium climate sensitivity 10% larger in AWI-CM compared to MPI-ESM. This difference manifests in different projections for this century according to AWI-CM compared to MPI-ESM - see Fig. 2. A paper on this is published in ESSOAR and is in the review process for JGR Oceans.

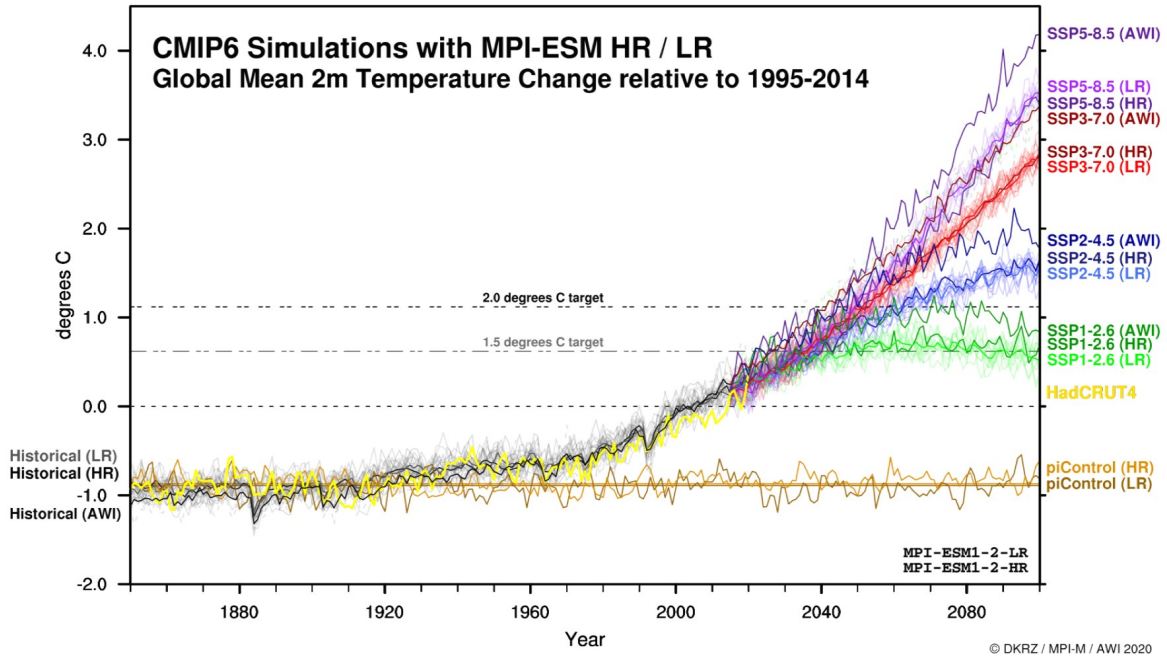

Figure 2: *Development of global mean 2 m temperature anomaly (°C) relative to 1995-2014 according to historical and scenario simulations from AWI-CM-MR, MPI-ESM-LR, and MPI-ESM-HR.*

References

Giorgetta, M. A., Brokopf, R., Crueger, T., Esch, M., Fiedler, S., Helmert, J., . . . Stevens, B. (2018). ICON-A, the Atmosphere Component of the ICON Earth System Model: I. Model Description. Journal of Advances in Modeling Earth Systems, 10(7), 1613-1637. doi:10.1029/2017ms001242

Korn, P. (2017). Formulation of an unstructured grid model for global ocean dynamics. Journal of Computational Physics, 339, 525-552. doi:10.1016/j.jcp.2017.03.009

Semmler, T., Jungclaus, J. H., Danek, C., Goessling, H., Koldunov, N. V., Rackow, T., & Sidorenko, D. (2021). Ocean model formulation influences transient climate response. Earth and Space Science Open Archive ESSOAr.