Fourth International Conference on Earth System Modelling
4ICESM-53, 2017

The HAMburg Ocean Carbon Cycle model in the icosahedral general ocean circulation model ICON-O

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The ICON (Icosahedral non-hydrostatic general circulation model) modelling system is a joint initiative of the Max Planck Institute for Meteorology (MPIM) and the German Weather Service (DWD) aiming at a unified framework for climate simulations and weather forecast. The future Earth System Model of MPIM (MPI-ESM2) will be based on ICON. The HAMburg Ocean Carbon Cycle model (HAMOCC) was implemented into the ocean component of ICON (ICON-O). Here, we compare the new ICON-HAMOCC setup to the model configuration consisting of HAMOCC coupled to the ocean component of the current Earth System Model of the MPIM (MPI-ESM1), MPIOM-HAMOCC.

While HAMOCC is identical in the two model setups, both in terms of processes resolved, as well as numerical implementation of the processes, the two physical ocean models differ in several aspects relevant for biogeochemical tracers. For example, the models use different grids, different numerics, different transport schemes, a different sea ice submodel, and ICON-O does not include bottom boundary layer slope convection.

HAMOCC encompasses marine carbonate chemistry, a NPZD-type ecosystem model, air-sea gas-exchange, and a sediment module (see references in Ilyina et al. 2013, Paulsen et al. 2017). In addition to the formulation in Ilyina et al. 2013, alkalinity includes the contributions from silicic and phosphoric acid systems. All parameters used in air-sea gas-exchange and in the solution of the carbonate system are updated according to the recommendations of the biogeochemical protocol for the CMIP6 OMIP (Orr et al. 2016).

In all experiments both ocean models use identical initial conditions and atmospheric forcing. ICON-O runs on the unstructured triangular horizontal grid R2B6 (approx. 40km). MPIOM runs on a structured grid with comparable (w.r.t to grid cell number) horizontal resolution (TP04). HAMOCC is started from basin-scale uniform tracer distributions and an empty sediment. It uses preindustrial CO_2 mixing ratios, climatological N-deposition and Fe-deposition data as atmospheric boundary conditions. Spatial distributions of major state variables, i.e. nutrients, oxygen, dissolved inorganic carbon, and alkalinity are used to illustrate the performance of ICON-HAMOCC in comparison to MPIOM-HAMOCC, as well as in comparison to recent climatological observational data products (WOA13, GLODAPv2). Furthermore, the dynamical behaviour of the models is characterised by comparison of the intra-annual cycle of key tendencies, such as CO_2 surface fluxes and organic matter fluxes.

Both model setups show a consistent and comparable behavior in space and time with differences arising from the different solutions of the physical ocean models.

References

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