Sensitivity of North Atlantic deep ocean biases to increasing ocean resolution in a hierarchy of prototype CMIP6 simulations

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We study a hierarchy of five century-long multi-resolution simulations with the AWI Climate Model (AWI-CM). The ocean grid sizes range from a nominal resolution of ~1° –in the coarse CMIP5-type setup– up to locally eddy-resolving. The main goal is to understand the sensitivity of dominant biases to increasing ocean resolution on multi-decadal timescales and to inform the choice of optimal ocean grids for AWI-CM to be used in phase 6 of the 'Coupled Model Intercomparison Project' (CMIP6) and in the flagship simulations of the related 'High Resolution Model Intercomparison Project' (HighResMIP).
Biases at the ocean surface are immediately apparent and, therefore, comparatively well known and studied. However, climate models also suffer from large biases in the deep ocean, which are often neglected, and which vary on longer timescales. Those biases impact, e.g., the storage of heat by the ocean, which is especially relevant for projections of the transient climate response performed in the framework of CMIP. A major bias identified in previous studies with the coarse resolution AWI-CM is a warm and saline anomaly in the deep North Atlantic Ocean (~1000 m) compared to observations. This bias is also observed in other climate models, with different hypothesized explanations, including a lack of spatial resolution in that area.
To test the latter hypothesis, we gradually increase the number of ocean grid points in the remaining four, otherwise identical, AWI-CM configurations. It is shown that the dominating 'deep bias' in the North Atlantic successively fades with higher resolution to a rather small amplitude that is typical for the remaining –relatively small– biases in the other ocean basins. Together with a competitive throughput of 5–6 simulated years per day for the highest analyzed resolutions, this gives a strong case to aim for a (locally) eddy-resolving configuration not only in HighResMIP, but already for AWI's CMIP6 workhorse. It remains to be seen whether the strong improvements seen over the 100yr-timescale will last on multi-centennial timescales.