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Role of mesoscale dynamics in Southern Ocean heat uptake and storage

Mathias Zeller and Torge Martin
GEOMAR, Ocean Dynamics, Germany (mathias-zeller@gmx.net)

Mesoscale eddies play a key role in Southern Ocean dynamics, upwelling and transformation of water masses, the surface heat flux and therefore in storage of heat at deeper layers. To better understand local processes but also basin-scale implications, we apply regional ocean grid refinement to the entire region south of 28˚S in the fully coupled climate model FOCI. This two-way nesting configuration (FOCI-ORION10X) enables us to resolve the entire Southern Ocean at 0.1˚ yielding an eddy-rich simulation in this region whereas eddies are parameterized in the remainder of the global ocean running on a 0.5˚ grid. We contrast our high-resolution simulation with the non-eddying pre-industrial control run of FOCI. Heat uptake and redistribution in mean states of three pre-industrial simulations with FOCI-ORION10X are investigated: one 100 years after starting the model from rest, and two branching off from two different FOCI reference runs without and with regular open ocean deep convection in the Weddell Sea.

Net surface heat fluxes are significantly enhanced by up to 50% in the eddy-rich nested simulations compared to the non-eddying reference simulations. In our simulations, eddy kinetic energy (EKE) is largest in the Brazil–Malvinas Confluence Zone and the Agulhas Current system, regions of large upward surface heat flux, i.e. ocean heat loss. Heat uptake occurs farther south in the region of the Antarctic Circumpolar Current associated with a broad band of enhanced EKE between 45˚S and 55˚S. Explicitly simulating instead of parameterizing eddies also impacts Southern Ocean upwelling and heat convergence at mid-latitudes. We explore and quantify the associated impact on heat storage in three mean states representing different states of Southern Ocean mean temperature and bottom water volume, which affects the meridional overturning circulation strength.