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Simulated response of the Southern Ocean to wind changes: towards the role of mesoscale eddies

Lavinia Patara, Claus Böning, and Arne Biastoch
Helmholtz-Zentrum für Ozeanforschung Kiel (GEOMAR), Germany (lpatara@geomar.de)

The role of ocean mesoscale eddies in the Southern Ocean response to recent wind changes is explored with a suite of realistic global ocean simulations at increasing horizontal resolution. Southern Ocean mesoscale eddies are known to be critical in the meridional redistribution of tracers, and are suggested to affect how the Southern Ocean responds to wind changes, takes up heat, and exchanges CO_2 with the atmosphere. By employing the ocean general circulation model NEMO-LIM, ocean simulations with horizontal resolutions of 1/2°, 1/4°, and 1/12°, i.e. ranging from non-eddying to eddy-resolving, are performed and compared. In particular, a "two-way" nesting technique is used to refine the ocean grid up to 1/12° in the Southern Ocean. The ocean models are forced with the CORE v.2 atmospheric reanalysis during the period 1948-2007, and companion experiments under a repeated-annual-cycle forcing are used to detect model spurious drifts. First, we assess the effect of explicitly simulated eddies on ocean mean properties. Mesoscale eddies are shown to modify the mixed layer depth and the upper-ocean density, with potential effects on the formation properties of Subantarctic Mode Waters. Second, we explore the role of mesoscale eddies in affecting the ocean circulation sensitivity to the sustained increase of Southern Hemisphere winds during the past decades. Whereas the non-eddying simulations exhibit large increases of the Antarctic Circumpolar Current transport, the 1/4° and 1/12° models are less sensitive to the wind increase, in better agreement with available observations. These results show a clear effect of model resolution on the Southern Ocean response to climate variability and change.