Climate model biases in ocean stratification in the vicinity of Antarctica: origins and impacts

C. O. Dufour[1,2], S. M. Griffies[3], A. Adcroft[3], J. Dunne[3], M. Winton[3], R. Hallberg[3].

[1]*Program in Atmospheric and Oceanic Sciences, Princeton University, Princeton, New Jersey, USA*
[2]*Department of Atmospheric and Oceanic Science, McGill University, Montreal, Quebec, Canada*
[3]*NOAA/Geophysical Fluid Dynamics Laboratory, Princeton, New Jersey, USA*

In the vicinity of Antarctica, large amounts of heat stored in the ocean subsurface can potentially access the atmosphere and the ice shelves, with important implications for climate warming and sea level rise. Model representation of stratification and water mass properties in this region is thus key to climate projections. However, climate models generally do poorly in polar regions due to the lack of observations and the complex coupling between atmosphere, ocean, sea ice and ice sheet. Studies have suggested that some improvement in model performance could be obtained through increasing oceanic resolution. Here, we examine the effect of refining the ocean resolution in climate models on the stratification in the Weddell Sea. We also discuss the impact of other model choices, like eddy parameterization and vertical coordinate, on stratification.

To do so, we use two GFDL eddy-permitting climate models of differing resolutions in the ocean. We find that the coarser model version (CM2.5; 0.25°) simulates unrealistic continuous deep convection in the open-ocean region of the Weddell Sea, while the finer model version (CM2.6; 0.10°) simulates two large polynya events over the course of the 200 year simulation, similar to that observed in the 1970s. We attribute the occurrence of the continuous deep convection in the 0.25° model to weak stratification, that we link, among other factors, to the poor representation of mesoscale eddy activity and of dense shelf water overflows. In addition, we inferred higher rates of spurious diapycnal mixing in the 0.25° model to be another contributor to the weak stratification, and to cause Antarctic Bottom Water properties to erode rapidly. Further analyses are carried out with the new GFDL climate model (CM4; 0.25°) to explore the impact of the use of a hybrid vertical coordinate and mesoscale eddy transport parameterization on the stratification of the Weddell Sea.