Sea-ice ocean interactions in a high-resolution global climate model

The physical processes regulating the stratification of the Southern Ocean are poorly understood in nature and important to global climate: the production of Antarctic Bottom Water (AABW) is important in moderating the global meridional circulation and ocean heat uptake; the rate of transport of Circumpolar Deep Water (CDW) onto the continental shelf is important in regulating the mass balance of the Antarctic Ice Sheet.

Here, we seek to understand how the explicit resolution of oceanic eddies affects simulation of the Southern Ocean. To do so, we compare water mass production and stratification between standard (1 degree) and high (1/10 degree) resolution of ocean and sea ice in 150-year integrations of the Community Climate Model Version 3.5 (CCSM 3.5). The atmosphere and land components are at 0.5 degree resolution in both cases. High resolution generally improves the agreement in temperature and salinity between simulation and observations in the Southern Ocean, as several key features emerge in the eddy-resolving integration that are not captured at coarser resolution. At high resolution, the water mass similar to AABW is colder and more saline, sinks along steeper isopycnals, and contributes to a more vigorous deep overturning. At mid-depths, water comparable to CDW upwells at greater rates, and extends closer to the continent. We argue that resolving localized sea ice formation regions has improved the production of AABW, driving a more vigorous deep overturning circulation at high resolution.

In addition to considering the effect of resolution on the unforced ocean mean state, preliminary results are presented from two perturbed experiments branching from the same control simulation. In one, integrations at peak (1960's) and minimal (2000) ozone levels are contrasted. In the other, CO_2 is ramped by 1% per year until it doubles. Fine resolution alters how the ocean evolves when perturbed, especially at depth. Irrespective of resolution, however, ozone depletion and CO_2 ramping cause an increase in surface westerlies, a warming of the surface waters and a decrease in sea ice.