Revisiting the oceanography of the southern end of the overturning: Transient and standing eddy heat transports across an idealized Southern Ocean

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Abstract

To the south and connecting with the deep flows of the Atlantic, the Southern Ocean has been singled out as a region in which transient mesoscale eddies are especially important. When effects of bathymetry on the flow are considered, however, the transient eddies alone need not generate the entire poleward heat transport that compensates the equatorward heat transport forced by the prevailing westerly winds. Instead, topographically fed meanders, or standing eddies, can deliver much of this poleward component of the heat transport.

The meridional transports, when decomposed as time-mean and transient eddy (either resolved or parameterized), are puzzlingly different between two different configurations of the model:

1. In the strongly eddying 0.1◦ resolution, the Eulerian mean component (first term on the right hand side of Equation 1) shows a poleward heat transport, rather than the equatorward heat transport that would be associated with the Deacon Cell. In an 0.01 resolution version of the model, with parameterized eddy transport of mixing, the Eulerian mean component does indeed show an equatorward heat transport over more than half of the latitude range, with the parameterized eddy transport (labeled GM Bolus) and mixing (Redi) providing the dominant poleward heat transport; for qualitatively similar results in the Southern sector of a realistic global configuration see Danabasoglu and McWilliams (1995) and Gent et al. (1990). To understand this discrepancy, we further decompose the heat transport, considering also the standing eddy contribution.

2. In the strongly eddying 0.1◦ resolution, the eddies of the model (second term on the right hand side of Equation 2) show a poleward heat transport, rather than the equatorward heat transport that would be associated with the Deacon Cell. In an 0.01 resolution version of the model, with parameterized eddy transport of mixing, the Eulerian mean component does indeed show an equatorward heat transport over more than half of the latitude range, with the parameterized eddy transport (labeled GM Bolus) and mixing (Redi) providing the dominant poleward heat transport; for qualitatively similar results in the Southern sector of a realistic global configuration see Danabasoglu and McWilliams (1995) and Gent et al. (1990).

The meridional transports from four simulations, integrated from western edge of ridge, into the region of the northward excursion. This heat is lost by a divergent heat flux into the mean flow, with the strongest values of transient eddy transport occurring at the northward excursion. These heat flux divergences are shown in green, while the red Eulerian Mean line, since its Transient Eddy transport is essentially zero.

In Summary

The standing eddy dominates poleward heat transport at all resolutions, when the eddy parameterization is not used.

A Stream Coordinate Perspective

Here, from time-averaged fields, one sees the equatorward deviation of the flow as it crosses the ridge. One also sees a remarkable intensification of the flow that occurs in the lee of the ridge.

Sea surface temperature (shaded) and barotropic stream function (contoured), averaged over five years from the strongly eddying 0.1◦ simulation. Contour interval is 5 Sv (negative contours dashed). The volume we analyze, in order to determine the relative importance of surface heat, mean and transient eddy fluxes in the net delivers of heat poleward, is bounded by bold contours at 3 and 25 Sv. The ridge is centered around a longitude of 17◦. Note that the flow intensifies remarkably in the lee of the ridge.

Our analysis of heat flux divergence into the volume bounded by barotropic stream function values of 5 and 25 Sv confirms that the mean flow accounts for more of the heat flux divergence than do the transient eddies.

References