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Meridional heat transport across the Antarctic Circumpolar Current by the Antarctic Bottom Water overturning cell

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The lower limb of the meridional overturning circulation of the Southern Ocean is likely to play a role in transporting heat meridionally. Cold Antarctic Bottom Water flows on average northward at the sea bed, and is replaced by warmer, saltier circumpolar mid-depth water flowing southward. Both provide a poleward heat transport. However, across the Southern Ocean, the heat transport by this deep cell is commonly held to be negligible, in comparison with the meridional heat transport effected by eddies higher in the water column.

Observationally it is very difficult to determine the heat fluxed by the deep overturning cell, because to calculate a meaningful value requires a zero volume flux. Previous estimates have been made for the contribution of the mean flow by integrating along streamlines, but these excluded the deep overturning contribution. Determining the contribution in numerical models has awaited models that are of sufficiently high resolution, have sufficiently good topography, and have a sufficiently good sea ice model, to produce a reasonably realistic volume flux of Antarctic Bottom Water. Happily, we have now reached the stage where first estimates can be made, and we present calculations here from the OCCAM one twelfth degree global model.

Using the annual mean field for 1994 yields a value for the strength of the lower limb of the overturning circulation of 6.1 Sv at 56S, on the northern side of the Antarctic Circumpolar Current. The heat fluxed by this Antarctic Bottom Water cell is 0.033 PW. Use of the annual mean however does not give a true picture of the overturning, because it does not include the effect of eddies and other transients; variations in temperature and volume transport may well be correlated. Calculating the mean results for all the 5-day mean fields in 1994 yields a larger strength of the lower limb of the

overturning circulation at 56S of 8.1 Sv and a larger southward heat flux of 0.063 PW. At 60S, the heat fluxed by the Antarctic Bottom Water cell is smaller at 0.022 PW using the 5 day fields; using the annual mean field reduces the heat flux to only 0.009 PW. For comparison, the total meridional heat flux at 60S in FRAM, a rigid-lid ancestor of OCCAM, is quoted as 0.20 PW (Saunders & Thompson, Journal of Physical Oceanography, 1993), so the Antarctic Bottom Water cell would contribute 10% of this.

Thus the eddy field is adding considerably to the heat fluxed poleward by the Antarctic Bottom Water overturning cell. The results imply that this component of the meridional heat flux, although small, may not be as negligible as has been supposed.