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The forcing of the thermohaline circulation by Agulhas rings

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Agulhas rings put anticyclonic relative vorticity into the Suoth Atlantic subtropical gyre at an annual amount equal to that of the windstress. This induced anticyclonic circulation suffers from a meridional momentum imbalance. The imbalance arises because the Coriolis force acting on the equatorward part of the circulation is smaller than that on the poleward part. The net effect is a northward force. Assuming a multi-year steady state, this force has to be balanced by another one.

The most likely solution is a steady westward flow, which induces a southward Coriolis force to solve the imbalance. This flow then originates south of Africa. In steady state, this flow has to leave the South Atlantic. Given the Malvinas Current, the most likely position to leave the domain is at its northern side.

The zonal momentum balance comes also into play because the northward flowing water experiences a westward Coriolis force. This force can either be balanced by an east-west pressure gradient supported by the continents, or by a compensating southward flow elsewhere. This southward flow is present in the Agulhas retroflection. Since that flow crosses a much smaller meridional distance than the induced northward flow, his has to be much stronger.

Quantifying these ideas gives an overturning transport induced by the anticyclonic nature of the Agulhas rings of 1.5 to 5 Sv, and a retroflecting current with a transport about 10 times as much.

These ideas can also be extended to the Indian Ocean, where the loss of anticyclonic vorticity by the Agulhas rings induces a net southward transport in the upper layer, which might be related to the Indonesian Through Flow. One can also consider the

flow in deeper layers and finds southward transport in the South Atlantic by Agulhas rings. But this might stress a simple theory beyond its limitsĚ