Geophysical Research Abstracts
Vol. 17, EGU2015-3168-2, 2015
EGU General Assembly 2015

Modelling the Seasonal Overturning Circulation in the Red Sea

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The overturning circulation in the Red Sea exhibits a distinct seasonally reversing pattern and is studied using 50-year, high-resolution MIT general circulation model simulations. The seasonal water exchange in the Strait of Bab el Mandeb is successfully simulated, and the structures of the intruding subsurface Gulf of Aden intermediate water are in good agreement with summer observations in 2011.

The model results suggest that the summer overturning circulation is driven by the combined effect of the shoaling of the thermocline in the Gulf of Aden resulting from remote winds in the Arabian Sea and an upward surface slope from the Red Sea to the Gulf of Aden set up by local surface winds in the Red Sea.

For the winter overturning circulation, the climatological model mean results suggest that the surface inflow intensifies in a western boundary current in the southern Red Sea that switches to an eastern boundary current north of 24°N. The overturning is accomplished through a cyclonic recirculation and a cross-basin overturning circulation in the northern Red Sea, with major sinking occurring along a narrow band of width about 20 km along the eastern boundary and weaker upwelling along the western boundary. The northward pressure gradient force, strong vertical mixing, and horizontal mixing near the boundary are the essential dynamical components in the model's winter overturning circulation.