Geophysical Research Abstracts
Vol. 14, EGU2012-11526, 2012
EGU General Assembly 2012

The Dependence of the Atlantic Overturning Circulation on Meridional Density Gradients

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In this study, we seek to elucidate the 3-dimensional force balance governing the Atlantic meridional overturning circulation (MOC). Our approach is based on the observation that when a force is applied to a Boussinesq fluid, such as the ocean, fluid parcels are accelerated both locally by the applied force, and non-locally by pressure gradient forces. The latter are established simply to maintain non-divergence of the resultant motion and to satisfy the kinematic boundary condition. It is only the purely rotational forcing components that are responsible for the evolution of the flow regime.

The rotational forcing can be cleanly separated into components that drive the depth-integrated (mostly wind-driven) circulation and the overturning (mostly buoyancy-driven) circulation. These components are written in terms of scalar forcefunctions. We show that these scalars are powerful diagnostics for ocean general circulation models. We highlight the importance of western boundary buoyancy gradients in predicting changes in the strength and structure of the modelled MOC.