Geophysical Research Abstracts
Vol. 17, EGU2015-10834, 2015
EGU General Assembly 2015

Predicting global overturning from meridional density gradients

Edward Butler (1), Kevin Oliver (1), and Joel Hirschi (2)

(1) National Oceanography Centre Southampton, University of Southampton, United Kingdom (k.oliver@noc.soton.ac.uk),
(2) National Oceanography Centre, Southampton, United Kingdom

Numerous attempts have been made to scale the strength of the meridional overturning circulation (MOC), principally in the North Atlantic, with large-scale, basin-wide hydrographic properties. In particular, various approaches to scaling the MOC with meridional density gradients have been proposed, but the success of these has only been demonstrated under limited conditions. Here we present a scaling relationship linking overturning to twice vertically-integrated meridional density gradients via the hydrostatic equation and a “rotated” form of the geostrophic equation. This provides a meridional overturning streamfunction as a function of depth for each basin. Using a series of periodically forced experiments in a global, coarse resolution configuration of the general circulation model NEMO, we explore the timescales over which this scaling is temporally valid.

We find that the scaling holds well in the upper Atlantic cell (at 1000m) on decadal and longer timescales, explaining at least 94% of overturning variance for timescales of 128 to 2048 years and accurately predicting the relative magnitude of the response for different frequencies. Despite the highly nonlinear response of the Antarctic cell in the abyssal Atlantic, over 77% of the observed variability at 4000m is predicted on timescales of 32 years and longer. The scaling law is also successful in the Indo-Pacific, thus demonstrating its generality. This analysis is extended to a higher resolution, stochastically forced simulation for which correlations of at least 0.79 are obtained with upper Atlantic MOC variance on all timescales greater than 25 years. These results demonstrate that meridional density gradients and overturning are linked via meridional pressure gradients, and that both the strength and structure of the MOC can be predicted from hydrography on multi-decadal and longer timescales provided that the link is made in this way.