Geophysical Research Abstracts
Vol. 13, EGU2011-11074, 2011
EGU General Assembly 2011

Chaotic and deterministic variability of the meridional overturning circulation on subannual to interannual timescales

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The first 5 years of observations of the meridional overturning circulation (MOC) at 26.5°N have shown that the MOC exhibits a large subannual to seasonal variability. The origins of this variability is only partly understood. In particular it is not clear how much of the observed MOC variability is due to chaotic (unpredictable) processes such as mesoscale eddies (and to a lesser extent external waves). Here we use a 1° and a 1/4° (eddy permitting) global ocean model (NEMO) as well as a simple box-model to illustrate how to isolate the chaotic MOC. The 1° and 1/4° NEMO runs consist of two passes through the 1958 to 2001 forcing. After an initial model adjustment with strong drifts during the first pass the model reaches a quasi steady-state. To extract the chaotic MOC component we only use the 1976 to 2001 period of both passes. Since the surface forcing is the same, the instantaneous differences between passes 1 and 2 are most likely due to different eddy (and to a lesser extent internal wave) fields. For the 1/4° model, the standard deviation of the differences between passes 1 and 2 is between 5 Sv (equator) and typically 1 - 2Sv at mid-latitudes. This corresponds to about 20 to 30% of the total MOC variability. For the coarser resolution of 1° mesoscale eddies are not resolved and the chaotic MOC component is 10% or less. Despite the differences due to eddies and internal waves, the correlation between the MOC values of the two passes of the eddy-permitting run is high, suggesting that on subannual to interannual timescales the MOC variability is mainly determined by the atmospheric forcing.

Interestingly, the ratio between chaotic and total MOC variability does not change much when the subannual and interannual MOC components are considered separately. This suggests that oceanic eddies (with a typical lifetime of a few months) can also trigger intrinsic MOC variability on longer (interannual and maybe even longer) timescales.