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A decomposition of the Atlantic meridional overturning

L. Sime (1,3), D. Stevens (2), K. Heywood (1), and K. Oliver (1)

(1) School of Environmental Sciences, University of East Anglia, Norwich, UK, (2) School of Mathematics, University of East Anglia, Norwich, UK, (3) Now at the British Antarctic Survey, Cambridge, UK (lsim@bas.ac.uk)

We consider a decomposition of meridional overturning circulation (MOC) cells into geostrophic vertical shear, Ekman, and bottom pressure dependent, or external mode, circulation components. The decomposition requires the following information: (1) a density profile wherever bathymetry changes to construct the vertical shear component, (2) the zonal mean zonal wind stress for the Ekman component, and (3) the mean depth-independent velocity information over each isobath to construct the external mode. We apply the decomposition to the model HadCM3 to determine the meridional variability in sensitivity to these individual components within the Atlantic Ocean. The external mode component is shown to be extremely important where western boundary currents impinge on topography, and also in the area of the overflows. The Sverdrup balance explains the shape of the external mode MOC component to first order, but the time variability of the external mode exhibits only a very weak dependence on the wind stress curl. Thus the Sverdrup balance cannot be used to determine the external mode changes when examining temporal change in the MOC. The vertical shear component allows the North Atlantic MOC to be deduced at 25^o S or 50^o N. A stronger dependency on the external mode and Ekman components between 8^o N and 35^o N and in the regions of the overflows means that hydrographic sections need to be supplimented at these latitudes. At the decadal time-scale, variability in Ekman transport is less important than that in geostrophic shears. In the southern hemisphere the vertical shear component is dominant at all time-scales suggesting that unsupplimented hydrographic sections are suitable for deducing change in the MOC at these latitudes.