Geophysical Research Abstracts, Vol. 9, 07119, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-07119
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Flow compensation associated with the meridional overturning circulation

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The Atlantic meridional overturning circulation (MOC) carries roughly one Petawatt of heat northward through the subtropical North Atlantic. For the first time a continuous one-year-long time series of the meridional overturning volume transports across 25°N in the Atlantic has been computed by combining five components. The Gulf Stream and the zonally integrated Ekman transport are estimated from cable measurements across Florida Strait and space-borne scatterometry, respectively. The three components that combine to give the mid-ocean meridional transports (integrated across the six thousand kilometre wide section below the surface Ekman layer) are derived from eastern to western boundary differences in density and bottom pressure, complemented by direct current measurements.

We present the first direct observational evidence that the zonally integrated meridional flow tends to conserve mass, with the fluctuations of the different transport components largely compensating each other at periods longer than 10 days. We take this as an experimental confirmation for the section end point monitoring approach in this experiment. This enables us to describe several of the most basic and hitherto unobserved characteristics of the MOC. We find its r.m.s volume transport variability to amount to 5.7 million cubic meters per second, of which a large fraction appears to be attributable to bottom-intensified flows, and we present long-sought evidence for barotropic compensation of near surface Ekman flow. The analysis surprisingly reveals that density induced transports contribute as much to the overall MOC variability as the Ekman component. Our results indicate that continuous monitoring of the MOC

is advisable to resolve the large variability it displays over a broad band ranging from daily to seasonal time scales. Understanding the dynamics and spectral distribution of MOC fluctuations is essential for the detection of long-term changes.