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Observed and simulated large-amplitude fluctuations of deep northward volume transports in the subtropical North Atlantic

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Based on simultaneous bottom pressure measurements at different sites along a zonal section in subtropical North Atlantic at 26.5°N from the RAPID/MOCHA array we report on large-amplitude, zonally basin-wide-integrated fluctuations of abyssal northward transports. These transports can be shown to contribute to the compensation for the bulk of upper-ocean basin-wide integrated Gulf Stream, Ekman and upper-mid-ocean transports as part of the Atlantic meridional overturning circulation (MOC). Yet, the abyssal transport variability exceeds the level of rms fluctuations required to compensate for the upper ocean transport by a factor 3. From an energetics point of view the existence of the sea-floor intensified transport variability is therefore puzzling.

Based on an analysis of bottom pressure records collected between April 2004 and October 2007 we show that the abyssal, zonally-integrated geostrophic transport variations at 5000 m show pronounced seasonal variability, and that the amplitude of the observed fluctuations exceeds those at any other level below the thermocline. This can be explained by intense time-variable flows over the western and eastern continental rises and over other topographic feature in the western basin of the Atlantic - as revealed by the bottom pressure and current meter records - that vary out of phase with the integrated transports over the remaining part of zonal extent of the 6000 km wide section, thereby reducing basin-wide integrated transport on shallower levels.

A simluation relying on a numerical model with a horizontal resolution of 1/12°, driven by daily, high-spatial resolution wind forcing, is shown to capture the observed intensification of the near-bottom, zonally-integrated northward flow successfully. Three-daily snapshorts of the zonal and vertical distribution of northward velocities along the 26.5°N section from the model reveal the existence of specific areas of localized, bottom-intensified flow, associated with zonal transitions in the underlying bathymetry. In contrast - in agreement with the observations – the simulated, deep-ocean, time variable flows over the Mid-Atlantic Ridge exhibit rather small rms variability. Overall, the results suggest that the zonal structure associated with the deep compensating flows - as inferred both from the bottom pressure measurements and the model simulation - has a strong impact on the deep and abyssal part of the time-variable, vertical structure of the MOC of 26.5°N.