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On the impact of large-amplitude fluctuations in deep integrated transports over sloping bathymetry on the vertical structure of the Atlantic Meridional Overturning Circulation

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The time-variable barotropic flow over the continental rises of the eastern and western boundaries of the Atlantic projects on the vertical structure of the Atlantic meridional overturning circulation (AMOC) streamfunction. This AMOC component is invisible to density measurements, and is therefore difficult to quantify by observations. The RAPID/MOCHA array has provided daily estimates of the vigor of the AMOC at 26.5°N since April 2004, based on simultaneous observations of (i) Gulf Stream transports using cable measurements across the Straits of Florida, (ii) Ekman transports inferred from satellite scatterometry, and (iii) mid-ocean baroclinic transports derived from density profiles taken at the Moroccan and Bahamas continental slopes. Time-variable reference transports for the baroclinic mid-ocean transports - required to estimate the daily strength of the AMOC – have previously been estimated indirectly, via the imposition of a physically plausible, integral zero-net-transport constraint at each time step (Cunningham et al., 2007). This constraint has been implemented in the form of a spatially uniform compensation velocity field. Using geostrophic reference transports inferred from deep bottom pressure measurements carried out on the eastern and western boundaries at 26.5°N, Kanzow et al. (2007) showed that the AMOC strength was highly correlated with that using the integral transport constraint. At the same time AMOC related abyssal, basin-wide integrated meridional rms transport fluctuations using the former approach exceeded those relying on the transport constraint by a factor 3.

Based on an analysis of bottom pressure records collected between April 2004 and October 2007 we show that abyssal, zonally integrated transport variations at 5000 m show pronounced seasonal variability, and that the amplitude of the observed fluctuations exceeds that at any other level below the thermocline, in contrast to the transport constraint solution. The reason for this are intense time-variable flows over the eastern continental rise, as revealed by the bottom pressure 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. The presence of the large-amplitude abyssal transport variability is puzzling from an energetics point of view, as it clearly exceeds the level of variability required for a barotopic compensation of Gulf Stream and Ekman transports. Overall, our results reveal that the external mode exhibits a pronounced zonal structure. This suggests that a modification of the spatially invariant compensation flow field (required to estimate mid-ocean reference transports) to incorporate a simple approximation to the zonal structure inferred from the bottom pressure measurements, yields a much more realistic representation of the deep, time-variable, vertical structure of the AMOC.