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Eastern-boundary baroclinic variability and the meridional overturning circulation at 26.5°N

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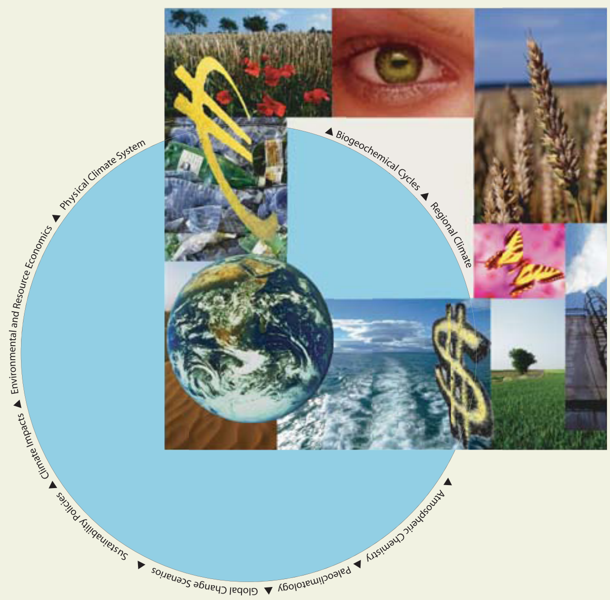

Abstract

We study the contribution of eastern-boundary density variations to sub-seasonal and seasonal anomalies of the strength and vertical structure of the Atlantic Meridional Overturning Circulation (AMOC) at 26.5° N, by means of the RAPID/MOCHA mooring array between April 2004 and April 2008. The major density anomalies are found in the upper 500 m, and they are often coherent down to 1400 m. The densities have 13-day fluctuations that are apparent down to 3500 m. The two strategies for measuring eastern-boundary density – a tall offshore mooring (EB1) and an array of moorings on the continental slope (EBH) – show little correspondence in terms of amplitude, vertical structure, and frequency distribution of the resulting basin-wide integrated transport fluctuations, implying that there are significant transport contributions between EB1 and EBH. Contrary to the original planning, measurements from EB1 cannot serve as backup or replacement for EBH: density needs to be measured directly at the continental slope to compute the full-basin density gradient. Fluctuations in density at EBH generate transport variability of 2 Sv rms in the AMOC, while the overall AMOC variability is 4.9 Sv rms. There is a pronounced deep-reaching seasonal cycle in density at the eastern boundary, which is apparent between 100 m and 1400 m, with maximum positive anomalies in spring and maximum negative anomalies in autumn. These changes drive anomalous southward upper mid-ocean flow in spring, implying maximum reduction of the AMOC, and vice-versa in autumn. The amplitude of the seasonal cycle of the AMOC arising from the eastern-boundary densities is 5.2 Sv peak-to-peak, dominating the 6.7 Sv peak-to-peak seasonal cycle of the total AMOC. Our analysis suggests that the seasonal cycle in density may be forced by the strong near-coastal seasonal cycle in wind stress curl. The transport anomalies which dominate the seasonal cycle of the basinwide upper ocean transports do not correspond to basin scale coherent flows but are concentrated at the eastern boundary between EB1 and EBH. As the deep seasonal anomalies at EBH (and the lack thereof at EB1) suggest, the seasonal flow takes place near the African coast rather than being broadly distributed over the more than 1000 km wide section between EB1 and EBH. The seasonal surface elevations inferred from altimetry can not be related to seasonal upper mid ocean transport variability at 26.5° N. The results presented here indicate that it is essential to observe the deep vertical density structure at the eastern boundary of the mid-ocean section as part of an AMOC monitoring strategy at 26.5° N.