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Observed latitudinal coherence of the North Atlantic Meridional Overturning Circulation

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Ocean models show that, while the North Atlantic Meridional Overturning Circulation (AMOC) only becomes completely coherent across latitudes on multidecadal time scales, there is a coherent component to the circulation on shorter time scales. Coherence is generally explained by basin-scale coupling mechanisms with the atmosphere, by gyre-scale adjustments, or by coastally-trapped waves propagating transport anomalies along the western and eastern boundaries. This latitudinal coherence, and the dynamics associated with it, are important predictions because they are linked to our ability to monitor climate variability on various time scales, and to detect trends, from current observation programs.

Here we measure the latitudinal coherence of the overturning circulation, from different sources of observations at three latitudes, and attempt to identify the responsible mechanisms. The approach is to focus on the lower limb of the AMOC, by using estimates of the volume transport at depths between 1000 m and 4000 m approximately. For these estimates, we consider the western boundary contributions to the zonally-integrated meridional transport, as model results and observations show that this is the dominant contribution to the total meridional transport. We form and use times series of deep transports arising from the western boundary at three latitudes. At 26.5N, we use data from the Rapid/MOCHA array. At approximately 39N we use data from the Woods Hole line W, and at approximately 42N, data from the Rapid-WAVE array. At these last two observation sites, the estimates of the meridional transport are based on the theory of using boundary bottom pressure to determine transport. Bottom boundary pressure is determined by either using direct bottom pressure measurements or by reconstructing the pressure gradient using the novel "step" method which utilizes density and velocity measurements along the slope.

The overlapping time series across the three sites are about 3.7 years long so far, and will continue to lengthen. The cross-spectral analysis between the two northern time series show that the transports are coherent at monthly to seasonal time scales and approximately in phase. The cross-spectral analysis between the northern time series and the time series at 26.5N show evidence of coherence at frequencies corresponding to 10-day time scale to monthly and seasonal time scales. In some frequency bands, the coherence is associated with a constant phase, interpreted in terms of basin-scale coupling mechanisms, and in others with an approximate linear phase, or constant lag, which could be representative of southward propagating coastal waves mediating the zonally-integrated transports.