The role of a Changing Gulf Stream in Driving Enhanced Exchange between the Deep Western Boundary Current and the Interior

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Previous studies have found interannual-to-decadal shifts in the zonal-mean Gulf Stream latitude downstream of Cape Hatteras. Here we consider a different measure of Gulf Stream variability, the location of a 'path destabilization point' as identified in maps of satellite altimetry. We define this point as the longitude where the variance in monthly-mean Gulf Stream positions first reaches 0.5 degrees^2 latitude. We observe both interannual variability and a longer-term trend which has brought the meandering Gulf Stream closer to the Middle Atlantic Bight shelf and slope as the destabilization point has shifted westward (towards Cape Hatteras).

In situ and remote-sensing observations suggest that the observed changes in the location of this Gulf Stream path destabilization point impact exchange between the abyssal interior and the Deep Western Boundary Current (DWBC) at Line W near 40˚N. Previous observations (from 1988 to 1990) in the region from a moored array in the Synoptic Ocean Prediction (SYNOP) experiment showed that Gulf Stream troughs are associated with the spin-up of deep cyclones. Analysis of shipboard velocity and property data from 18 transects across the DWBC along Line W made between 1994 and 2014 showed that these deep cyclones lead to mixing between the interior and the Denmark Strait Overflow Water (DSOW) component of the DWBC. Gulf Stream meander troughs are associated with high variance in the monthly mean Gulf Stream positions. As these troughs develop in tandem with the spin up of deep cyclones, the deep cyclones draw water off the slope, driving exchange between DSOW, with relatively high CFC concentrations, and interior low-CFC waters. This finding of event-driven exchange inferred from the shipboard data is corroborated by the time series of the offshore-most Line W mooring and the concurrent altimetry observations.

Mooring observations from Line W suggest that the recent westward shift of the Gulf Stream path destabilization point has resulted in an increase in the number of deep stirring events that drive exchange between the DWBC and the deep interior. While the consequences of a shifting Gulf Stream path destabilization point are evident in observational data sets, the cause of the westward shift is more enigmatic. It may be related to remote or local external forcing (whether wind-driven or thermohaline) or it may be related to intrinsic variability in the system at the Gulf Stream/DWBC cross-over by Cape Hatteras.