Linked variations between the Gulf Stream, AMOC and Heat Content

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Understanding the observed changes in the North Atlantic Ocean over the last several decades requires examination of the relationships between different aspects of that change including both circulation and heat content. Using available observational records, we investigate relationship between changes in the Gulf Stream, AMOC at 26°N, wind stress variability and upper ocean heat content. Satellite sea surface height is used as a proxy for upper ocean heat content, while quantification of circulation changes come from cabled Florida Current Transport, Upper Mid-Ocean Transport and total AMOC from the RAPID/MOCHA Array, indices for Gulf Stream path and strength come from satellite sea surface height, while the North Atlantic Oscillation Index (NAO) is used to quantify large scale variability in the Atmosphere.

The Gulf Stream path and strength are found by fitting the across path structure of sea surface height to an error function. To examine changes in upper ocean heat content, the sea surface height is smoothed with a 400km Gaussian filter in order to focus on regional rather than eddy length scales. A continuous record of Florida Current Transport is created by filling a 1.5 year gap with sea surface height difference from the Florida to the Bahamas.

At interannual time scales, we use lagged correlation analysis to examine linked changes in ocean circulation and associated heat content change. We confirm previous studies that have shown that the Gulf Stream path moves to the North after an increase in the NAO index. In addition, we show that this shift occurs all along the Gulf Stream path from 75°W to 50°W. We also find an increase in the NAO results in an increase in the Gulf Stream strength downstream of the New England Seamounts. The Gulf Stream also shifts to the North after an increase in AMOC and the Upper Mid Ocean transport at 26°N. Finally, the strength of the Gulf Stream increases over its entire path after an increase in Florida Current Transport.

We also examine large scale sea surface height and thus heat content changes. We find that an increase in the Florida Current transport leads to an increase in heat content from the Eastern Seaboard to mid basin in a band that is just to the South of the path of the Gulf Stream. However, an increase in Upper Mid Ocean transport is linked to lower heat content along 26°N and an increase in heat content along the path of the North Atlantic Current as far North as Scotland.

The observed downward trend in AMOC and Upper Mid Ocean transport at 26°N can also be linked to a decrease in Gulf Stream strength. The sense of these changes are consistent with what we found interannual times scales. In addition, the large-scale patterns of trends in sea surface height are also consistent with the patterns of

change found at interannual time scales. This suggests that the mechanisms that link changes in North Atlantic Circulation at interannual time scales also hold for trends observed since 2004, and that much of the changes in heat content in the North Atlantic basin are likely linked to changes in AMOC at 26°N.