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Assessing variability in the size and strength of the North Atlantic subpolar gyre

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Recent studies on the size and strength of the North Atlantic subpolar gyre (SPG) offer contrasting assessments of the gyre's temporal variability: studies that use the leading empirical orthogonal function (EOF) mode of satellite sea-surface height (SSH) in the North Atlantic report a rapid decline in SPG size and strength since 1992 (∼20% per decade), while concurrent in situ observations from moorings, hydrographic sections and profiling floats report either no trend or a slight decline (8% per decade). Here we investigate this discrepancy by analyzing the size and strength of the SPG with satellite SSH from January 1993 to September 2015 with two separate methods: indirectly via an EOF analysis and more directly through measurements of the gyre center and boundary. We define the boundary of the gyre as the largest closed contour of SSH, the center as the minimum SSH, and the strength as the difference between the SSH at the boundary and at the center. We find that the size and strength of the SPG co-vary at monthly (r = 0.81) and annual (r = 0.68) time scales and that both variables have seasonal cycles that peak in the winter. We identify a linear decline over the study period in the SPG strength (5.1% per decade) but the decline in SPG area (1.2% per decade) is not statistically significant. Both trends are weaker than the EOF-based trends and are most likely below the level of detection of the in situ measurements. We conclude that the variability previously identified as a sharp decline in SPG circulation can be more appropriately attributed to basin-wide sea level rise (0.21 cm per year in the North Atlantic) due to an increase in ocean heat content during the satellite altimetry period.