The Contributions of Ocean Circulation to North Atlantic SST

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The goal of this project is to determine the relative importance of air-sea fluxes and ocean circulation to interannual sea surface temperature anomalies in the North Atlantic Ocean, in particular, whether advection contributes to such large-scale sea surface temperature (SST) patterns as the Atlantic Multidecadal Oscillation (AMO).

Recent results

Low frequency (interannual to decadal) variations in the ocean have typically been characterized by anomalies of SST, which have relatively long climate records. The contributions to SST are numerous: surface fluxes, mixed layer depth, entrainment, vertical mixing, Ekman pumping, and horizontal (geostrophic and Ekman) advection and diffusuion. By comparison, the contributions to the vertical integral of temperature, heat content, are relatively simple: surface fluxes and horizontal advection/diffusion. Because high-quality heat content fields are only available since 2004 (the advent of ARGO), we develop a proxy for heat content using altimetric sea surface height (SSH). Using this proxy we compare the budgets of SST and heat content.

A canonical correlation analysis on low frequency SST and heat content yields three significant modes, which are remarkably similar (not shown here), suggesting a strong correspondence between the budgets. The first mode has the familiar tripole structure, the second mode has a large positive anomaly north of 35°N, and the third mode has the signature of the Gulf Stream.

A straightforward procedure for estimating advection using velocity and gradient fields produces noisy estimates with large errors uncorrelated with observed tendencies of SST or heat content. Therefore we partitioned the budgets into three terms: tendency, surface heating, and all other terms treated as aresidual. Each of these terms was projected onto the canonical correspondence analysis (CCA) spatial modes (Figure 1).

Surface heating accounts for half or more of the first CCA mode, whereas the residual accounts for a larger fraction of the other two modes. For SST the residual is the sum of both vertical and horizontal processes, so both the magnitude and spatial structure of their contributions is difficult to assess. However, the similarity of the SST and heat content budgets suggests that the horizontal terms isolated by the heat content budget dominate the surface signature of SST. Further, this analysis suggests that the dominant contribution to both the low frequency SST and heat content is anomalous ocean circulation, rather than air-sea heat fluxes and that the historical record of SST can be used as a proxy for analyzing ocean heat content anomalies.

Bibliography

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