The Coherence and Impact of Meridional Heat Transport Anomalies in the Atlantic Ocean Inferred from Observations

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Changes in the meridional transport of heat and in oceanic heat storage are important for understanding climate variability and prediction. Observations of thermosteric sea level (TSL) from hydrographic data (including Argo), equivalent water thickness (EWT) from GRACE gravity data, as well as altimetric sea surface height (SSH) anomalies, are used to construct budgets of heat and mass for the Atlantic Ocean from 31S to 67N and to infer changes in the meridional transport of heat. Time-varying thermosteric and mass contributions to sea level are predicted using surface heat and freshwater flux anomalies in each of seven regions; discrepancies between the modeled and observed sea level components, as well as the total SSH anomaly are used to infer lateral heat and mass convergences. Given reasonable estimates of the model and observation errors, the "unknown control" version of a Kalman filter creates both smooth time series of sea level anomalies and a smooth residual that represents heat and mass convergences. Regional convergences are summed to estimate meridional heat transports for 1993-2010 within estimated errors. The analysis reveals that meridional heat transport (MHT) is coherent between 31S and the separated Gulf Stream and that increases in MHT are accompanied by increases of heat loss through surface fluxes in the subtropical gyre. The inferred MHT reproduces both in timing and in magnitude the 2009 drop and subsequent reversal in 2010 seen in the RAPID/MOCHA observations at 26N. The analysis also reveals previous anomalies, with values as large as 0.5PW in the South Atlantic in 1999. An intensification of MHT anomalies toward the south and a correlation of MHT with the Antarctic Oscillation suggest a southern source for the coherent MHT anomalies.