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Water mass variability in the Atlantic Subtropical Gyre reveals the mechanisms of recent Meridional Overturning changes

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Interannual variability in the volumetric water-mass distribution within the North Atlantic subtropical gyre (STG) is described in relation to the recent reported changes in the Atlantic Meridional Overturning Circulation (AMOC). Using an Argo based gridded climatology and a high-resolution ocean state estimate (ECCO), we project the ocean into thermohaline coordinates as volumes of water defined by their temperature and salinity. We compare monthly time-series of the volumetric distribution to the volume changes implied by the water mass transformations due to air/sea fluxes of heat and freshwater over the STG, and the divergence of advective transports across the latitudinal boundaries of the STG. Coinciding with the reported AMOC changes during the winters of 2009/10 and 2010/11, in both the observations and the state estimate, the total STG volume above the thermocline decreases while the volume below increases in compensation. During the winter of 2009/10, this redistribution is equivalent to a transport of 25 Sv (1 Sv==10^6 m^3s^{-1}) over 3 months. A comparison to two air-sea flux re-analyses products shows that this variability cannot be explained by anomalous cooling over the STG, which suggests the volumetric redistribution is caused by changes in the transport divergence between 26 and 45°N. In ECCO, we see a reduction in the zonal circulation of the STG and divergence of transport above the thermocline. Below the thermocline we see an increase in the southward transport at 45°N and a decrease at 26°N. Using two wind-stress products, we present evidence that the observed changes are a barotropic response to anomalous wind-stress curl over the STG.