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The ECCO Consortium: Importance of general circulation changes to Atlantic Ocean heat storage rates

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The Atlantic meridional overturning circulation and its associated variability have been the subject of much attention. This is partly due to the notion that overturning circulation changes can exert a direct influence on Atlantic sea surface temperatures and consequently could affect Northern Hemisphere climate. However, because the causal links between ocean circulation and heat transport variability, sea surface temperature variations and ocean heat storage remain to be established, the potential impacts of overturning circulation changes on climate cannot presently be anticipated. In this study, we explore how changes in ocean circulation influence variable ocean heat storage rates. To this end, ocean heat budgets and transports are diagnosed for the case of the tropical and subtropical Atlantic Ocean on seasonal and interannual timescales. We use an estimate of the ocean state over 1993-2004, produced by the Estimating the Circulation and Climate of the Ocean (ECCO) group, generated by a coarse-resolution general circulation model, and optimized via assimilation of millions of ocean observations. Meridional heat transports are first decomposed into contributions from time-mean and -variable velocity and temperature, and second from various components of the circulation. Next, exploiting the dynamical consistency of the state estimate, closed heat budgets are used to ascribe changes in heat storage rates to ocean-atmosphere heat exchanges, diffusive mixing, and advective processes related to the various components of the meridional heat transport. Results reveal that a combination of surface heat fluxes, shallow overturning (including Ekman flows) above c. 500 meters, and overturning of intermediate waters (below c. 500 meters) accounts for seasonal and interannual heat storage rates near the equator as well as for interannual rates of heat storage at most tropical and subtropical latitudes, while overturning of deep waters (below c. 2000 meters) probably is not important on these timescales. A relationship between interannual heat storage rates in the equatorial Atlantic's top 100 meters and overturning heat transport is observed; however, due in part to the role of shallow advective processes at these latitudes, any direct link between sea surface temperature variability and heat transport changes associated with intermediate or deep meridional overturning circulations is not clear. Lack of a clear connection between sea surface temperature and intermediate and deep circulation changes would seem to apply at other latitudes as well.