The Surface-Forced Overturning of the North Atlantic: Estimates from Modern Era Atmospheric Reanalysis Datasets

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Estimates of the recent mean and time varying water mass transformation rates associated with North Atlantic surface-forced overturning are presented. The estimates are derived from heat and freshwater surface fluxes and sea surface temperature fields from six atmospheric reanalyses (JRA, NCEP-1, NCEP-2, ERA-I, CFSR and MERRA) together with sea surface salinity fields from two globally gridded data sets (World Ocean Atlas and EN3). The resulting twelve estimates of the 1979-2007 mean surface-forced streamfunction all depict a sub-polar cell, with maxima north of 45 ºN, near σ =27.5 kg m^{-3}, and a sub-tropical cell between 20 ºN and 40 ºN, near σ =26.1 kg m^{-3}. The mean magnitude of the sub-polar cell varies between 12-18 Sv, consistent with estimates of the overturning circulation from sub-surface observations. Analysis of the thermal and haline components of the surface density fluxes indicate large differences in the inferred low latitude circulation are largely due to the biases in reanalysis net heat flux fields, which range in the global mean from -13 Wm^{-2} to 19 Wm^{-2}. The different estimates of temporal variability in the sub-polar cell are well correlated with each other. This suggests the uncertainty associated with the choice of reanalysis product does not critically limit the ability of the method to infer the variability in the sub-polar overturning. In contrast, the different estimates of sub-tropical variability are poorly correlated with each other, and only a subset of them capture a significant fraction of the variability in independently estimated North Atlantic Sub-Tropical Mode Water volume.