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The Relationship Between the North Atlantic Meridional Overturning Circulation and the Surface-Forced Overturning Stream Function

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The role of surface thermohaline forcing in variability of the Atlantic Meridional Overturning Circulation (MOC) at mid-high latitudes is investigated using output from three IPCC coupled climate models. Following the work of Marsh (2000) we examine the extent that the surface-forced overturning stream function, a measure of the Surface-Forced Overturning Circulation (SFOC), can be used as a proxy for the MOC. Although there is little year on year correspondence between the two indices, the maximum value of the MOC at 48N is found to have a significant lagged relationship with the SFOC in preceding years. This correlation peaks between 2-4 years earlier depending on the coupled model considered. A method for estimating the MOC variability from the past average of the SFOC index over a ten year period is developed and found to capture the inter-decadal variability of the actual model MOC in all three models. The method is then applied with NCEP/NCAR reanalysis surface flux fields for the period 1949-2007 to reconstruct MOC strength over 1958-2007. Like other reconstructions at 48N, our MOC time series shows considerable multi-decadal variability, but no discernible trend over the modern observational era. In addition, we show using a 400 year subset of the HadCM3 coupled model run that the method can be extended from 48N to provide useful estimates of the MOC variability in the range 35–65N. The length of the past averaging interval increases as the latitude decreases from about 6 years at 65N to 15 years at 36N. Values for the correlation coefficient between the HadCM3 SFOC and MOC time series of 0.60, 0.64 and 0.39 are obtained at 60N, 48N and 36N. Thus, the SFOC approach may provide valuable complementary information about MOC variability in the mid-high latitude North Atlantic to that determined from the Rapid array at 26N but it becomes less useful as latitude decreases.