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Multi-decadal Variability of Atlantic Meridional Overturning Circulation in the Community Climate System Model 3

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Multi-decadal variability of Atlantic meridional overturning circulation (AMOC) is examined from a 700-year present-day control integration of the NCAR Community Climate System Model version 3 with T85 atmospheric resolution (CCSM3). AMOC variability in CCSM3 exhibit two distinct regimes, i.e. periods with very regular and strong decadal (∼20-years) variability versus irregular red-noise-like variability with a persistence longer than 10 years, with an abrupt transition between them. The red noise-like multi-decadal AMOC variability in the last 250 years of the 700 year-long integration is primarily forced by the surface fluxes associated with stochastic changes in the North Atlantic Oscillation (NAO) that intensify and shift northward the deep convection in the Labrador Sea. However, the persistence of the AMOC and the associated oceanic anomalies that are directly forced by the NAO forcing does not exceed about 5 years. The additional persistence originates from anomalous horizontal advection and vertical mixing, which generate density anomalies on the continental shelf along the eastern boundary of the subpolar gyre. These anomalies are subsequently advected by the mean boundary current into the northern part of the Labrador Sea convection region, reinforcing the density changes directly forced by the NAO. On the other hand, the slightly contracted and stronger subpolar gyre in the preceding ∼300 years results in the strong oscillatory AMOC by advecting opposite signed density anomalies from the North Atlantic Current region to the convection site. As a weak atmospheric response is found only in the red-noise regime which reinforces the AMOC variability, the both regimes of the multi-decadal AMOC variability in CCSM3 are suggested to be an ocean-only response to stochastic NAO forcing with opposite delayed feedback caused by the slightly different mean horizontal ocean circulation.