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Subpolar Gyre – AMOC – Atmosphere Interactions on Multidecadal Timescales in a Version of the Kiel Climate Model

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There is a controversy about the nature of multidecadal climate variability in the North Atlantic (NA) region, concerning the roles of ocean circulation and atmosphere-ocean coupling. Here we describe NA multidecadal variability from a version of the Kiel Climate Model, in which both subpolar gyre (SPG)-Atlantic Meridional Overturning Circulation (AMOC) and atmosphere-ocean coupling are essential. The oceanic barotropic streamfuntions, meridional overturning streamfunctions, and sea level pressure are jointly analyzed to derive the leading mode of Atlantic variability. This mode accounting for about 23.7 % of the total combined variance is oscillatory with an irregular periodicity of 25-50 years and an e-folding time of about a decade. SPG and AMOC mutually influence each other and together provide the delayed negative feedback necessary for maintaining the oscillation. An anomalously strong SPG, for example, drives higher surface salinity and density in the NA's sinking region. In response, oceanic deep convection and AMOC intensify, which, with a time delay of about a decade, reduces SPG strength by enhancing upper-ocean heat content. The weaker gyre circulation leads to lower surface salinity and density in the sinking region, which eventually reduces deep convection and AMOC strength. There is a positive ocean-atmosphere feedback between the sea surface temperature and low-level atmospheric circulation over the Southern Greenland area, with related wind stress changes reinforcing SPG changes, thereby maintaining the (damped) multidecadal oscillation against dissipation. Stochastic surface heat-flux forcing associated with the North Atlantic Oscillation drives the eigenmode.