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The origins of large-scale North Atlantic ocean circulation changes in the late 20th century: implications for decadal prediction

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Surface forcing perturbation experiments performed with an ocean--sea-ice hindcast configuration of the Community Climate System Model, version 4 (CCSM4) reveal that high latitude buoyancy forcing explains most of the large-scale, decadal Atlantic circulation variability of the late 20th century.

NAO-related heat and freshwater forcing variations, and in particular the turbulent buoyancy flux perturbations associated with evaporation and the latent and sensible heat fluxes, account for most of the decadal variability in both the Atlantic meridional overturning circulation (AMOC) and the subpolar gyre circulation, even when applied only over the Labrador Sea region. Year-to-year changes in surface momentum forcing explain most of the interannual AMOC variability at all latitudes as well as most of the decadal variability south of the Equator. The observed strengthening of Southern Ocean westerly winds accounts for much of the simulated AMOC increase south of the Equator, but very little of the signal in the North Atlantic. Ultimately, the multidecadal strengthening of the North Atlantic overturning circulation between the late 1970s and 1990s which contributed to the pronounced SST increase at subpolar latitudes in the late 20th century is explained almost entirely by trends in the atmospheric surface state over the Labrador Sea. These results underscore the significance of the Labrador Sea region for decadal prediction. First, the sea surface height in the Labrador Sea may be a good predictor of subsequent AMOC and associated heat transport variations on decadal timescales; and second, progress in coupled prediction beyond about a decade may hinge on the ability to skillfully forecast atmospheric temperature and humidity variations over this key region.