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The decadal variability of the heat and freshwater content of the subpolar North Atlantic

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During the last five decades striking changes occurred in the freshwater and heat content of the subpolar North Atlantic (SNA). The deep and abyssal waters that originate in this region to feed the lower limb of the AMOC experienced a remarkable decrease in salinities after the late 1960s, linked to a progressive dilution of the system of overflows from the Nordic Seas. A rapid reversal of the freshening trend occurred in the mid-1990s, with a pronounced salinification especially in the eastern SNA; at the same time, the freshening of the overflows slowed to a stop. An intriguing feature of the observational record is the tight co-variability of the freshwater and heat content of the SNA: the long-term freshening was accompanied by a progressive decrease in heat content, and both trends reversed simultaneously after 1995. Here we use a sequence of experiments with high-resolution (1/4°, 1/12°, and 1/20°) ocean-sea ice models to identify the dynamical causes of these decadal changes. Hindcast simulations of the oceanic response to the atmospheric variability 1948-2007 (as given by the "CORE" reanalysis) capture the decadal variability in the integral properties of the SNA as reconstructed from historical salinity and temperature data, and reproduce pertinent observational indices of mid-latitude circulation variability. Analysis of the freshwater and heat budgets shows that the largest contribution to the SNA property changes has been due to variations in the inflow of warm, saline water with the subtropical North Atlantic, with only a minor contribution due to variations in the inflow of cold, fresh waters from the northern basins. The subtropical-subpolar flux variability is not directly related to the AMOC; it can conceptually be understood in terms of the "intergyre-gyre" response to the mid-latitude westerlies associated with the NAO.