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Salinity changes relative to the response to anthropogenic forcing and internal variability in the North Atlantic

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Over the past few decades, surface waters in the subpolar North Atlantic have experienced substantial fluctuations, including periods of rapid cooling and freshening alternating with the periods of enhanced warming, salinification, and decreased circulation of the gyre. Since these waters feed the North Atlantic thermohaline circulation, such changes have the potential to impact the global ocean circulation and future climate states. A number of potential causes for the observed changes have been suggested, including those related to the strength of the ocean circulation and heat transports, as well as other factors, such as anthropogenic aerosol forcing or changes in surface fluxes.

Here we assess how the observed warming/salinification events fit into the long-term picture, focusing on variations in upper-ocean salinity. Salinification of the subpolar North Atlantic may seem counter-intuitive to the reported long-term increase in freshwater supply to the region from river discharge and ice melting, sparking debates about whether the freshening of the subpolar gyre has ceased, and whether the recent salinification, if continued, will be able to forestall the projected slowdown of the overturning circulation. Using a suite of in situ salinity observations spanning the last 60 years, modern satellite salinity observations from Aquarius and SMOS missions, and multi-decadal realizations from global climate models, we estimate the likelihood of such salinity changes in the context of the historical record, contemporary estimates, and future projections. Results are discussed in terms of the probability of occurrence of a decade-long salinification in the presence of the background freshening in response to anthropogenic forcing. In particular, computed probabilities suggest that such “unusual” salinification events are plausible under the strong influence of internal, decadal-to-interdecadal variability.