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solar cycle influence on the North Atlantic Oscillation

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The influence of the pathway of the solar cycle on the North Atlantic Oscillation (NAO) from the upper stratosphere to the surface was examined through lagged regression analyses using recent observations, historical observations covering 194 years, and an earth system model simulation covering 165 years. The propagation of the solar signal was well explained by a top-down mechanism modulated by the ocean: The solar signal first appears in the subtropical upper stratosphere as a temperature signal, the associated zonal wind signal propagates downward to the surface through the activity of the Polar-night Jet Oscillation, and finally the NAO is driven at the surface centered around February of the solar activity peak years. This signal is further modulated in such a way that the positive NAO signal tends to appear earlier in the winter as the number of years after the solar activity peak increases; this modulation can be attributed to an oceanic effect. The fluctuations and amplitude modulation of the solar–NAO relationship on a 50-year time scale also suggest that nonlinear interactions occur between solar forcing and ocean dynamics.

In fact, the oceanic effect can be seen on the monthly solar–NAO map, where the NAO tends to appear earlier in winter as the lag in years increases. If the only mechanism were a top-down mechanism, the asymmetry between positive and negative lag years would not appear. This asymmetry is likely due to the thermal inertia of the ocean. The other indication of an oceanic effect is the drift of the peak NAO timing relative to solar maximum years on a 50-year timescale. This drift suggests the existence of a strong nonlinear interaction between the solar cycle and ocean dynamics. The amplitude modulation of the decadal component of the NAO also suggests such an interaction.