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Wintertime response of the coupled stratosphere/troposphere system to the large-scale Atlantic decadal variability

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The multidecadal trends of the North Atlantic Oscillation (NAO) and coupled stratosphere/troposphere Northern Annular Mode (NAM) has been mostly considered in the framework of anthropogenic climate. The historical multidecadal variation and recent reversal of the NAO and NAM trends occurred in association with the Atlantic Multidecadal Variability (AMV), which is believed to result from low frequency Ocean circulation changes.

Here we first show, through observational analysis and standalone atmospheric model experiments, that large-scale Atlantic warming associated with AMV drives high-latitude precursory stratospheric warming in early to mid winter that propagates downward resulting in a negative tropospheric NAO in late winter. The mechanism involves stratosphere/troposphere dynamical coupling, and can be simulated to a large extent, but only with a stratosphere-resolving model (i.e., high-top). Further analysis shows that this precursory stratospheric response can be explained by the shift of the daily extremes toward more major stratospheric warming events.

We also show that the observed and simulated results are supported by long-term atmosphere/Ocean/Sea-ice coupled model simulation and sensitivity experiments performed with the standalone atmospheric component and boundary conditions taken from the coupled model.

Our results requires the consideration of the AMV in interpreting the multidecadal tropospheric and stratospheric trends associated with NAO or NAM.

As AMV has been shown to be predictable on seasonal-to-decadal timescales, these results have important implications for the predictability of the extratropical-coupled stratosphere/troposphere-system on these time-scales.