

Intra-Seasonal Mid- and High-Latitude Circulation Fluctuations Forced by and Coherence with Tropical Heating: Predictability and Prediction

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ABSTRACT

A three-dimensional evolution of Madden–Julian oscillation (MJO) diabatic heating for October–March from satellite data is constructed: the heating propagates eastward for three cycles, modulated by the likelihood for a given MJO phase to occur on a given calendar day. This heating is added to the temperature tendencies of each member of an ensemble of 48 (1 October–31 March) simulations with the Community Earth System Model.

The leading two most predictable modes of the planetary wave vertically integrated total (added plus model generated) heating capture 81% of the ensemble-mean variance and form an eastward-propagating oscillation with very high signal-to-noise ratio. The two most predictable modes of the extratropical Northern Hemisphere 200-hPa height form an oscillation, as do those of the 300-hPa height tendency due to synoptic vorticity flux convergence, the 200-hPa Rossby wave source, and the envelope transient kinetic energy. The North Atlantic Oscillation (NAO+) occurs 15–25 days after the MJO convection crosses the 90°E meridian (see Fig. 1 left panel), supported by synoptic vorticity flux convergence and a distinct pattern of Rossby wave source.

The daily North Atlantic circulation anomalies are categorized into four circulation regimes with a cluster

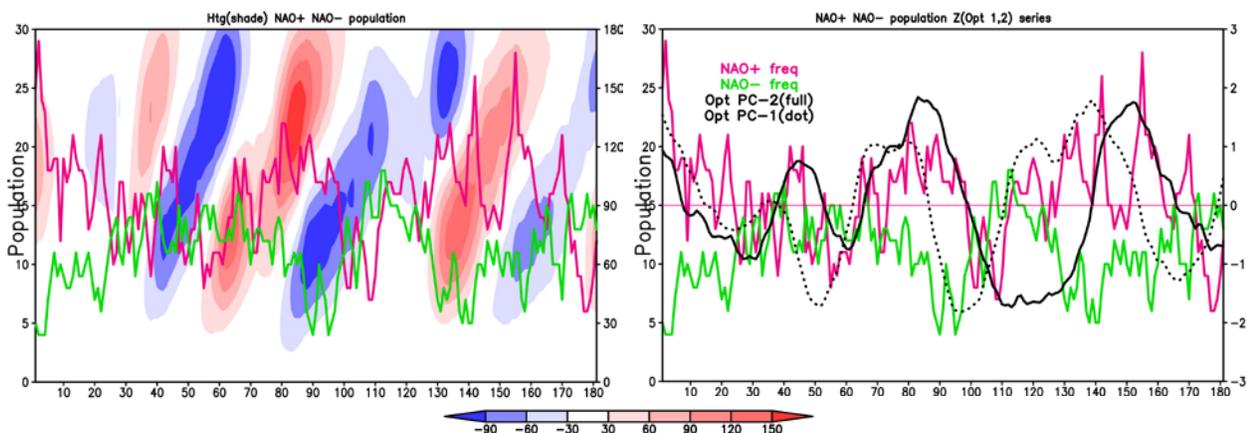


Fig. 1 Number of occurrences of NAO+ regime (red curve) and NAO- regime (green curve) in all ensemble members, as a function of day (see left-hand scale). Shading in left panel is the vertically integrated planetary wave diabatic heating synthesized from the leading two most predictable modes (W m^{-2} , see color bar) as a function of longitude (see right-hand scale). Dotted (solid) curve in the right panel is the ensemble-averaged time series of the first (second) most predictable mode of the extratropical Northern Hemisphere 200 hPa height (see right-hand scale). Time series are normalized to unit variance.

analysis. The NAO+ and NAO− are equally likely in the control model runs, but the NAO+ is 10% more likely in the model runs with heating, compared to a difference of 14% in reanalyses. The daily occurrence of the NAO+ regime in the heating ensemble shows maxima at times when the leading two optimal modes of height also indicate NAO+ but also shows maxima at other times (see Fig. 1 right panel).

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References

Straus D. M., E. Swenson, and C.-L. Lappen, 2015: The MJO cycle forcing of the North Atlantic circulation: Intervention experiments with the Community Earth System Model. *J. Atmos. Sci.*, **72**, 660–681. doi: <http://dx.doi.org/10.1175/JAS-D-14-0145.1>