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On the Formation and Maintenance of the Interannual Variability of the North Atlantic Oscillation

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Motivated by the observation that the interannual variability of the North Atlantic Oscillation (NAO) is associated with the ensemble emergence of individual NAO events occurring on the intraseasonal time scale, one naturally wonders how the intraseasonal processes cause the interannual variability, and what the dynamics are underlying the multiscale interaction. Using a novel time-dependent and spatially localized multiscale energetics formalism, this study investigates the dynamical sources for the NAO events with different phases and interannual regimes. For the positive-phase events (NAO^+), the intraseasonal-scale kinetic energy (K^1) over the North Atlantic sector is significantly enhanced for NAO^+ occurring in the negative NAO winter regime (NW), compared to those in the positive winter regime (PW). It is caused by the enhanced inverse cascading from synoptic transients and reduced energy dispersion during the life cycle of NAO^+ in NW. For the negative-phase events (NAO^-), K^1 is significantly larger during the early and decay stages of NAO^- in NW than that in PW, whereas the reverse occurs in the peak stage. Inverse cascading and baroclinic energy conversion are primary drivers in the formation of the excessive K^1 during the early stage of NAO^- in NW, whereas only the latter contributes to the larger K^1 during the decay stage of NAO^- in NW compared to that in PW. The barotropic transfer from the mean flow, inverse cascading and baroclinic energy conversion are all responsible for the strengthened K^1 in the peak stage of NAO^- in PW.