Simple Dynamical and Stochastic Models of Annular Patterns of Variability and the North Atlantic Oscillation

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We present a hierarchy of simple models for the basic spatial and temporal structure of the large scale modes of intraseasonal variability in the extra-tropical atmosphere and associated variations of the zonal index. We focus on those patterns characterized by a meridional dipole structure of zonal wind and geopotential height, specifically the North Atlantic Oscillation (NAO) and a more zonally symmetric pattern known as the annular mode. Such patterns may be produced by momentum fluxes associated with large-scale mid-latitude stirring, such as that provided by baroclinic eddies. We probe the potential effects of this stirring with three models of varying complexity.

The spatial structure of the variability is illustrated with two stochastic models. The first is purely stochastic, an idealized, analytic model of the zonal wind. The second is dynamical, a barotropic model where midlatitude stirring is represented by a simple stochastic forcing. Both suggest that the NAO and annular modes are produced by the same mechanism, and thus are manifestations of the same phenomenon. While the time behavior of the low frequency patterns in the barotropic model captures the basic structure observed, the nature of the stochastic forcing precludes feedback from the low frequency modes on the high frequency stirring. A simplified three-dimensional primitive equation model allows for two way interaction between the the stirring - now baroclinic instability - and the variability, providing a richer context for understanding the temporal structure.