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The Dynamics and Structure of the Baroclinic Annular Mode

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As first explored by Thompson and Barnes (2014), hemispheric mean storm activity (or related quantities, such as the meridional eddy heat flux) exhibits periodicity on 20-30 day time scales. They characterized this variability with the so-called Baroclinic Annular Mode, or BAM, a ring of enhanced eddy activity which is present in both hemispheres, but most pronounced in the south, which is less perturbed by zonal asymmetries relative to the north. The mechanism behind this internally generated periodicity, however, has remained elusive. We probe the dynamics and structure of the BAM on two fronts. To understand the mechanism, we develop a minimal model that captures the essential dynamics: 2 layer quasi-geostrophic flow in a channel. By varying the geometry of the channel and the thermal and frictional forcing, we tease out the parameters that control the period and amplitude of the BAM. The resulting changes in the BAM support the general framework of the charge-discharge mechanism proposed by Thompson and Barnes, but demand a more detailed explanation for the coupling between eddies and the mean baroclinicity that generates enhanced variability on subseasonal time scales. On a second front, we apply dynamical mode decomposition (DMD) to atmospheric reanalyses of the Southern Hemisphere to quantify the structure of the southern BAM. DMD captures BAM variability, providing additional information on relationships between the eddy kinetic energy and other mean and eddy quantities. It suggests that moisture plays a fundamental role in the relationship between the eddy activity and baroclinicity, and that changes in stratification are more important than horizontal temperature gradients in the dynamics. In this sense, the underlying BAM dynamics of vacillation between eddy and potential energy are remarkably robust, active in our moist atmosphere and in dry quasi-geostrophic systems where only the meridional temperature gradient can capture the available energy.