EGU2020-22454
https://doi.org/10.5194/egusphere-egu2020-22454
EGU General Assembly 2020

Finding Dynamical Modes of Atmospheric Variability Using Conservation Properties

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It is evident that persistent large-scale weather phenomena are an important factor in extreme seasonal climate; this has been especially true in boreal summers over the last two decades. Large, relatively slowly changing modes of variability on the mid-latitude jet are key to understanding high impact weather events. High monthly precipitation totals in the summer, for example, are linked to stationary Rossby wave patterns; stationary winter jet patterns can direct North Atlantic cyclones towards the UK and Europe. These wave patterns are often diagnosed but without a link to their phase speeds or dynamics.

To examine these slow modes we define an atmospheric background state as a function of isentropic and materially conserved co-ordinates (potential temperature and PV), resulting in a slowly changing, zonally symmetric background state. We then extract patterns of variability from the set of perturbations by employing an alternative Empirical Orthogonal Function (EOF) technique which utilizes a conserved wave activity as a weighted covariance. This results in statistical (EOF) patterns which possess an intrinsic dynamical phase speed and frequency, which are predicted from the conservation properties pseudomomentum and pseudoenergy. These statistical modes are a recombination of the dynamical normal modes in a system with quasi-linear dynamics.

We examine long runs with relaxation to unstable background jets but without orography, diurnal or seasonal effects, where large amplitude wave activity emerges. These simplified situations are used to test whether or not the predicted phase speeds from theory (given the structures found) matches with the observed phase speeds deduced from the principal component time series of the ENMs. Our hypothesis is that slow wave motion is explained by the structure and conservation properties of the modes. We are able to explore the dependence on the structures by varying the background state.