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Zonal-index persistence in the two-layer model

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The dominant mode of variability of the zonal-mean zonal wind consists of a meridional displacement of the extratropical jet about its mean position. This type of variability is often referred to as 'the zonal index' and may be regarded as the zonal-wind signature of the annular mode phenomenon, with which it is strongly correlated. The zonal index variability is driven by changes in the eddy momentum flux but tends to occur on significantly longer time scales than that of the forcing eddies. Because the zonal index variability is also associated with meridional shifts in stormtracks and precipitation it is very important to understand what controls the persistence of the zonal index.

There is still not a clear answer to this question. Although the slower agents in the climate system might play a role in enhancing the persistence of the zonal index, it is noteworthy that idealized models without ocean or stratosphere tend in fact to be more persistent than the actual atmosphere. At least in those models, the enhanced persistence of the zonal index should thus be driven dynamically through a positive feedback mechanism (i.e. the perturbed eddy fluxes tend to maintain the perturbed jet). Some observational studies have suggested that the same might be true for the actual atmosphere and a few dynamical mechanisms for the positive feedback have been proposed that seem consistent with observations and modeling results. However, the existing evidence in support of these mechanisms is only qualitative at present.

In this work we analyze the zonal-index variability in arguably the simplest model that can produce this type of variability: the two-layer quasigeostrophic model. We assess the relevance of 'self-maintenance' for the enhanced persistence by considering the lagged relation between the zonal-mean barotropic and baroclinic anomalies and the characteristic lifecycles of these anomalies over different frequency ranges. We also study the sensitivity of persistence to the frictional and thermal forcing timescales and perform idealized experiments that underscore the dynamical mechanisms at work.