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Forced finite-time barotropic Instability: An Application to atmospheric Blocking

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The modifications of the finite time barotropic instability problem that are implied by the addition of a forcing term are presented. In particular a method is developed to maximize the response of a perturbation with fixed initial kinetic energy to a prescribed temporal constant forcing field. These perturbations can be described as optimal, in the sense that they maximize linear disturbance growth (with respect to the kinetic energy) over a chosen integration period (optimization time). The perturbations are found by calculating the roots of a polynomial, which represents the auxiliary condition of the optimization problem. The degree of this polynomial depends on the model truncation.

In order to construct a forcing field we investigated the intraseasonal wintertime statistical relationship between streamfunction anomalies and the vorticity forcing due to synoptic-scale (bandpass filtered) eddies. From the results we concluded that the bandpass eddy vorticity forcing can act as a possible mechanism for the barotropic re-enforcement during Atlantic blocking episodes. We examined the impact of this forcing on the development of Atlantic blocking highs in terms of forced finite time barotropic instability.

For the numerical experiments a barotropic model triangularly truncated with global domain is used. The model is linearized about a 300 hPa climatological flow. The calculated finite-time barotropic instabilities at initial time are located upstream of the forcing. During the evolution the perturbations dispersed downstream. At optimization time a stationary dipol like structure similar to an observed blocking anomaly arise over the eastern North Atlantic. The sensitivity of this mode with respect to the strenght of the forcing is also investigated.