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Barotropic regeneration of upper-level synoptic disturbances in different configurations of the zonal weather regime

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Barotropic dynamics of upper-tropospheric midlatitudes disturbances evolving in different configurations of the zonal weather regime, i.e in different zonal-like large-scale flows, are studied using observational analyses and barotropic model experiments.

The contraction stage of upper-level disturbances that follows their elongation stage leads to an increase of eddy kinetic energy and is called barotropic regeneration process. This barotropic mechanism is studied through the notions of barotropic critical regions (BtCR) and effective deformation. The effective deformation field is equal to the difference between the square of the large-scale deformation magnitude and the square of the large-scale vorticity. Regions where the effective deformation is positive correspond to regions where the large-scale flow tends to strongly stretch synoptic disturbances. A BtCR region is an area separating two large-scale regions of positive effective deformation, one located upstream and on the south side of the jet and the other downstream and on the north side. Such a region presents a discontinuity in the dilatation axes orientation and is a potential area where the barotropic regeneration process may occur.

Winter days presenting a zonal weather regime in the ECMWF 40-year reanalysis data set are decomposed, via a partitioning algorithm, into different configurations of the effective deformation field at 300 hPa. A 6-cluster partition is obtained. Composite maps of the barotropic generation rate for each cluster exhibit a succession of negative and positive values on both sides of the BtCR regions. It confirms statistically that the

barotropic regeneration mechanism occurs preferentially about BtCR regions.

Numerical experiments using a forced barotropic model on the sphere are performed. Each experiment consists in adding a synoptic-scale perturbation initially to one of the zonal-like jet configuration found in the observational part that is maintained fixed with time. The combined effects of the effective deformation and nonlinearities are shown to be crucial to reproduce the barotropic regeneration process about BtCR regions.