The Influence of Polar Vortex Edge Thickness On Rossby Wave Breaking

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We consider the three-dimensional dynamics of a breaking Rossby wave on the edge of a cylindrical, axisymmetric vortex, as a representation of breaking planetary waves on the winter stratospheric polar vortex. A complete understanding of the mechanisms involved is not only important for, e.g., applications to the confinement of chemical species within the stratospheric vortex, but also provides insight into possible ways in which the dynamics of the perturbed vortex may influence the troposphere below.

Here, we extend the work of Dritschel and Saravanan (1994), who considered wave breaking on a vortex with zero edge width, to a vortex with a nonzero edge width, represented in our contour-dynamical framework by a series of small discontinuities (contours) in the quasigeostrophic potential vorticity (PV). The edge width, as well as the lower boundary wave forcing amplitude, is varied as an external parameter. Two cases are considered: the first, with constant Coriolis parameter, corresponds to a polar f-plane, the second, retaining the first order correction to the variation of the Coriolis parameter with latitude, corresponds to a polar gamma-plane.

In each case we examine the wave propagation and breaking as a function of the edge width and forcing amplitude over a range of parameter values, focussing on the onset of wave breaking and the quasi-equilibrium state reached after significant vortex destruction. The greater upward channeling of wave propagation on the sharp vortex edge compared to that on the smooth edge is demonstrated. Finally, in the gamma-plane case, we consider the extent to which wave activity leaks away from the vortex region by wave propagation to low latitudes on the background PV gradient associated with the variable Coriolis parameter.

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