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A New Look at the Physics and Energy Fluxes of Rossby Waves

Ming Cai (1) and Buhua Huang (2)

(1) Department of Earth, Ocean, and Atmospheric Science, Florida State University, USA, (2) Department of Atmospheric, Oceanic, and Earth Sciences &Center for Ocean-Land-Atmosphere Studies, George Mason University, USA

The presence of the latitudinal variation of the Coriolis parameter serves as a mechanical barrier that causes a mass convergence for the poleward geostrophic flow and divergence for the equatorward flow, just as a sloped bottom terrain does to a crossover flow. Part of the mass convergence causes pressure to rise along the uphill pathway while the remaining part is detoured to cross isobars out of the pathway. This mechanically excited cross-isobar flow, being unbalanced geostrophically, is subject to a “half-cycle” Coriolis force that only turns it to the direction parallel to isobars without continuing to turn it further back to its opposite direction because the geostrophic balance is reestablished once the flow becomes parallel to isobars. Such oscillation, involving a barrier-induced mass convergence, a mechanical deflection, and a half-cycle Coriolis deflection, is referred to as a mechanical-Coriolis oscillation with a “barrier-induced half cycle Coriolis force” as its restoring force. Through a complete cycle of the mechanical-Coriolis oscillation, a new geostrophically balanced flow pattern emerges to the left of the existing flow when facing the uphill (downhill) direction of the barrier in the North(Southern) Hemisphere. The β-barrier is always sloped towards the pole in both hemispheres, responsible for the westward propagation of Rossby waves.

The identification of the physical oscillation mechanism for Rossby waves enables us to recover the well-known “missing” term in energy flux of Rossby waves and reconcile the apparent inconsistency between pressure work and group velocity of Rossby waves.