Wavelike asymmetries are an intriguing aspect of Tropical Cyclone (TC) dynamics. Previous work hypothesized that some of them are Vortex Rossby Waves (VRWs) that propagate on the radial gradient of mean-flow relative vorticity (e.g., Guinn and Schubert, 1993, Montgomery and Kallenbach 1997, Montgomery and Enagonio 1998, Möller and Montgomery 1999).

MacDonald (1968) first proposed that spiral rain bands in hurricanes are Rossby waves. They rotate cyclonically within the hurricane and wrap around the vortex. Depending upon the size of the vortex itself, these bands can extend hundreds of kilometers from the eyewall (Romine and Wilhelmson 2006). They appear to propagate outward as they are advected cyclonically downwind by the axially symmetric mean flow with velocities lower than the mean tangential wind. One theory of their genesis is linked to energy released by the exchange of potential vorticity anomalies within the symmetric vortex (Guinn and Schubert 1993). Accordingly, spiral bands can be interpreted as Vortex Rossby Waves.

The purpose of this research is to offer a different perspective and present a computationally and conceptually simpler formulation. The simulated VRWs resemble spiral rain bands observed in Tropical Cyclones, for example in Eastern Pacific Hurricane Olivia 1994 (Black et al. 2002).

In this theory VRWs are initiated by convection in the TC eyewall, propagate wave energy outward, and converge angular momentum inward at the locus of forcing. The VRWs thus “pump” cyclonic angular momentum into the eyewall wind maximum (Figure 1). Because of their slow tangential phase velocity and the narrow interval between the Rossby-wave cut-off frequency where the radial wavenumber is locally zero and zero frequency where it is locally infinite, their radial propagation is limited to a relatively narrow annular waveguide (Figure 2).

Their wave energy is absorbed at an outer critical radius where their Doppler-shifted frequency approaches zero. Angular momentum flux divergence and vorticity convergence at the critical radius decelerate the mean flow there. The waves converge angular momentum...
from the critical radius to the locus of forcing and accelerate the mean flow there. The vorticity perturbations that accumulate near the critical radius stretch into narrow cyclonic and anticyclonic bands that become filamented as they wrap around the vortex (Figure 3). This mechanism may initiate outer wind maxima by weakening the mean swirling flow just inside the critical radius (e.g., Qiu et al. 2010).

In the present simulations, the VRWs are forced intermittently so that wave energy accumulates near the critical radius where the waves become filamented and are ultimately absorbed.

REFERENCES


