Spontaneous Inertia-Gravity Wave Radiation from Vortices: New Theoretical Insights with Possible Relevance to Hurricanes

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A mature hurricane can have Rossby and Froude numbers greater than unity, and therefore "efficiently" radiate spiral inertia-gravity (IG) waves. Some have speculated that IG wave radiation can trigger the formation of outer spiral rainbands [e.g., H.E. Willoughby et al., *J. Atmos. Sci.*, **41**, 3189 (1984)]. Moreover, it might temper the storm by removing angular momentum [e.g., K.C. Chow and K.L. Chan, *J. Atmos. Sci.*, **60**, 2004 (2003)]. Nevertheless, the potential to radiate is not always realized. In this talk, I will discuss conditions that inhibit spiral IG wave radiation from rapidly rotating vortices.

First, I will reexamine the spontaneous radiation of spiral IG waves from a monotonic shallow-water cyclone [D.A. Schecter and M.T. Montgomery, *J. Atmos. Sci.*, **63**, 435 (2006)]. In linear theory, a generic deformation of the cyclone excites discrete vortex Rossby (VR) waves. Each VR wave emits a frequency-matched spiral IG wave into the environment. The emission has positive feedback on the VR wave, causing both to grow. However, the VR wave also deposits wave activity into its critical layer at the radius r_*. If the negative radial gradient of potential vorticity at r_* exceeds a threshold, critical layer absorption suppresses the radiative instability.

On the other hand, numerical simulations show that nonlinear "leveling" of azimuthally averaged PV in the critical layer can revive a damped VR wave and its radiation field after a brief period of decay. For such revival (and the ensuing instability) it suffices that $\Omega_b/|\gamma| \gtrsim 1$. This inequality contains two characteristic frequencies. The denominator γ is the (negative) growth rate of the damped wave. The numerator Ω_b is the nonlinear stirring rate of the critical layer, which is proportional to the square-root of the initial wave amplitude.

In the second part of this talk, I will discuss the spontaneous radiation of internal spiral IG waves from a stratified cloudy cyclone, which might better represent a hurricane [D.A. Schecter and M.T. Montgomery, "Waves in a cloudy vortex," accepted by *J. Atmos. Sci.* after minor revision]. The basic radiation mechanism is the same as in shallow water theory. I will show that heavy cloud coverage inhibits radiation by enhancing the critical layer damping of source VR waves.

Finally, if time permits, I will briefly connect the above results (by analogy) to the problem of spiral acoustic radiation from tornadoes.