Vortex Rossby Wave Dynamics in Hurricane-Like Vortices

By: Gabriel J. Williams, Jr.

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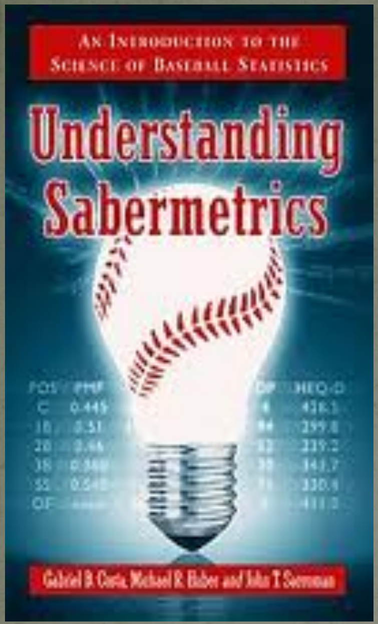

An Introduction to the
Science of Baseball Statistics
Understanding
Sabermetrics
Gabriel B. Costa, Michael R. Huber and John T. Saccoman

Research Projects

- Rearrangement of Hollow PV Towers
  - Adiabatic Rearrangement of PV Towers in Barotropic and Baroclinic Vortices
  - Influence of Non-conservative Effects on Rearrangement of PV Towers
- Spontaneous Imbalance and Radiation in Hurricane-Like Vortices
  - Influence of VRW-IG Radiation on Angular Momentum budget
  - Influence of Non-conservative Effects on VRW-IG Instability
- Development of Shocks in Hurricane Boundary Layer

Vortex Rossby Waves

- The isolines of PV are circles with the highest values of PV found in the center of the cyclone.
- The PV field provides a basic state with a monotonic inward increase of PV on which waves can propagate.
- If the PV pattern is only slightly disturbed from circular isolines, there is a restoring effect and PV wave propagation – vortex Rossby waves.

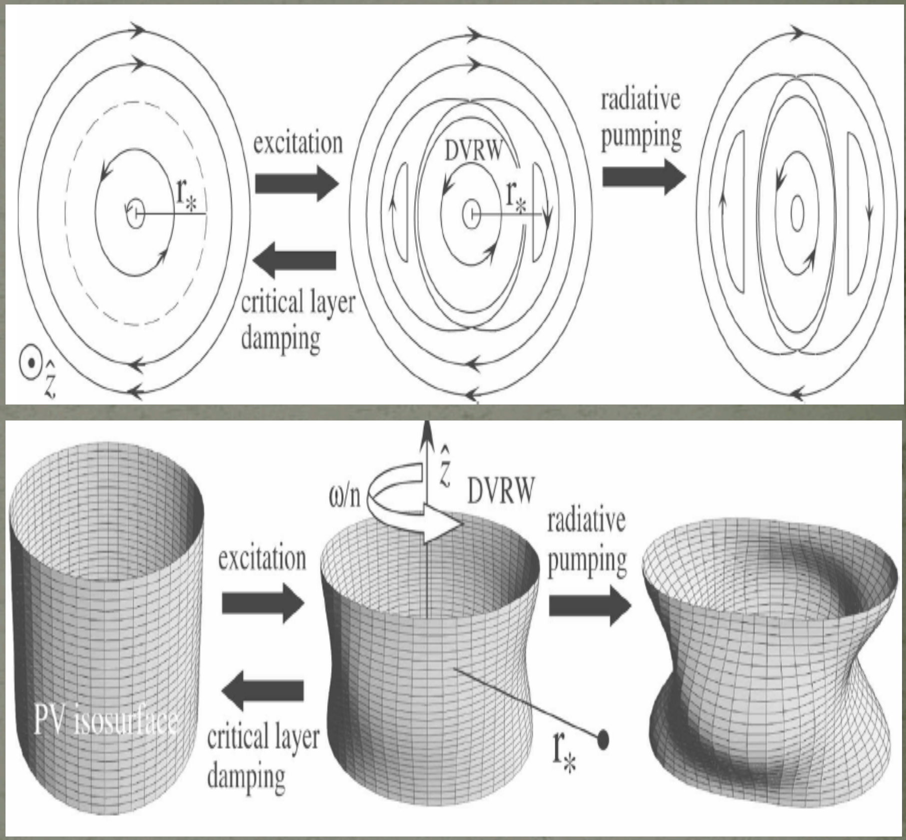


Figure 1: Evolution of a VRW in the core of a stratified monotonic vortex. (Schecter 2008)

Vortex Rossby Waves and Tropical Cyclone Structure

- Vortex Rossby waves (VRWs) play important roles in tropical cyclone structure and intensity changes.
- VRWs may be responsible for initiating spiral rainbands and can intensify the mean vortex. (Montgomery and Kallenbach 1997).
- VRWs with low azimuthal wave numbers dominate the asymmetric structure in the eyewall and play an important role in mixing angular momentum and PV between the eye and the eyewall (Wang 2001).

Figure 2: Mesovortices in Hurricane Isabel. (Kossin and Schubert 2004)

Adiabatic Rearrangement of PV Towers – Barotropic Vortex

- In terms of PV, a mature TC can be visualized as an annual tower of high PV with low PV in the eye.
- This PV configuration is barotropically unstable as counter-propagating VRWs become phase-locked.
- Barotropic instability allows PV transport to the eye and creates mesovortices.

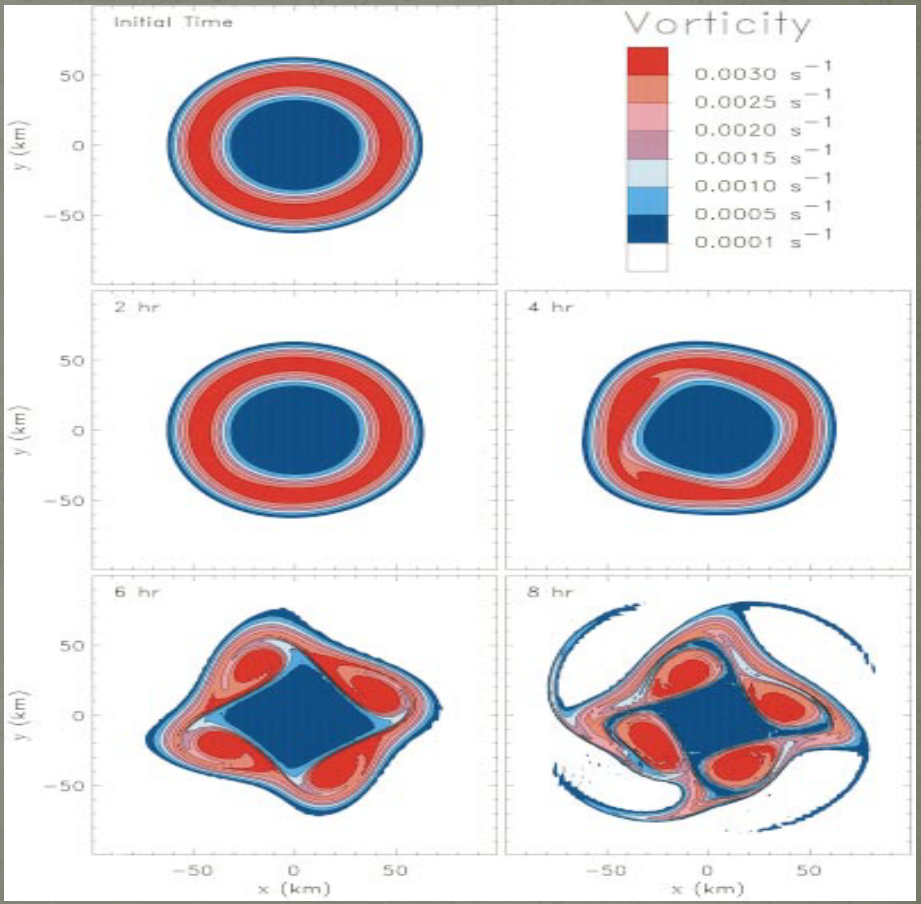
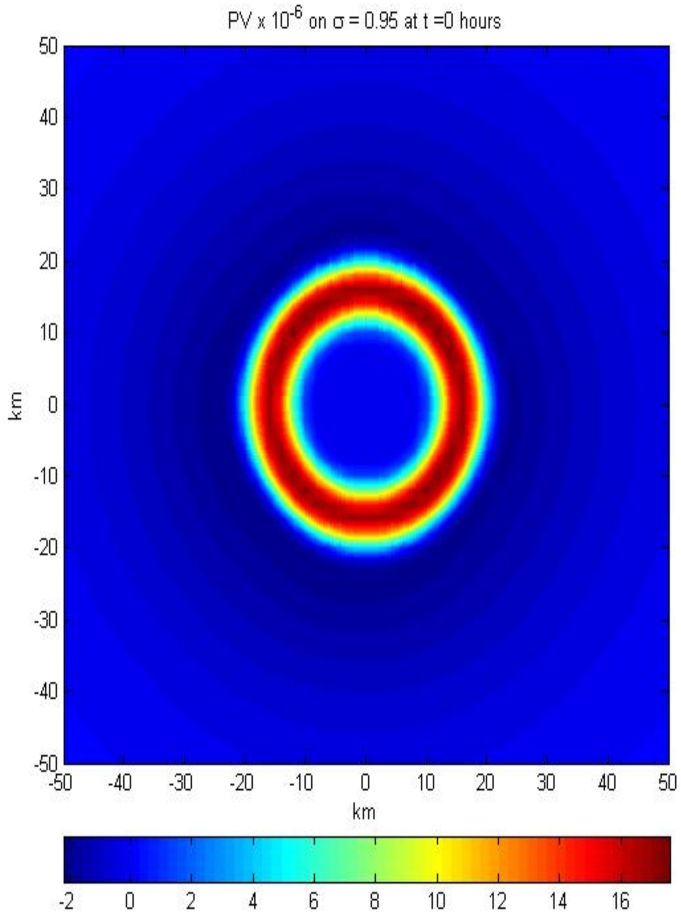
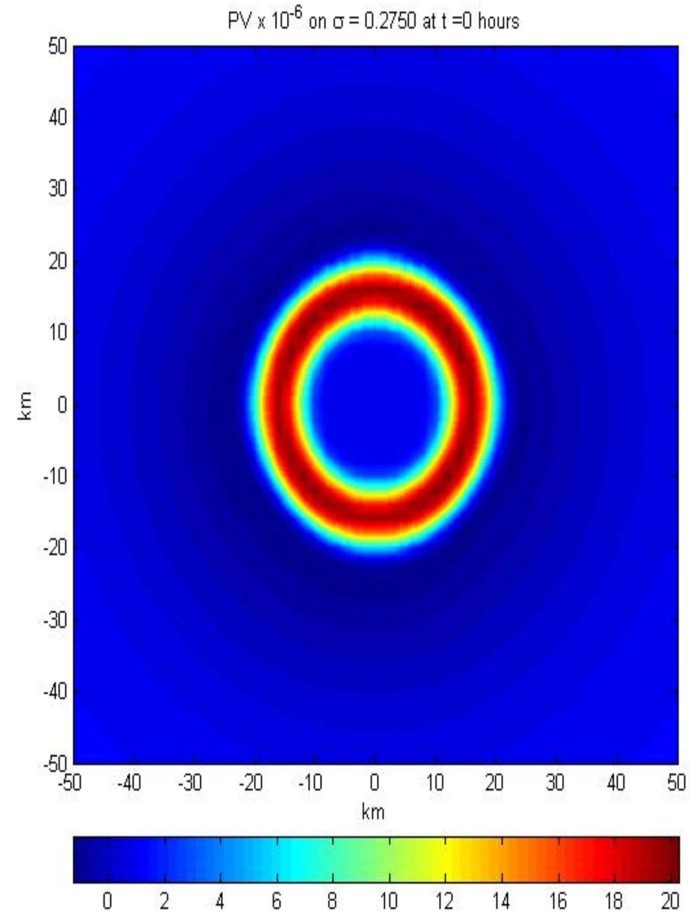


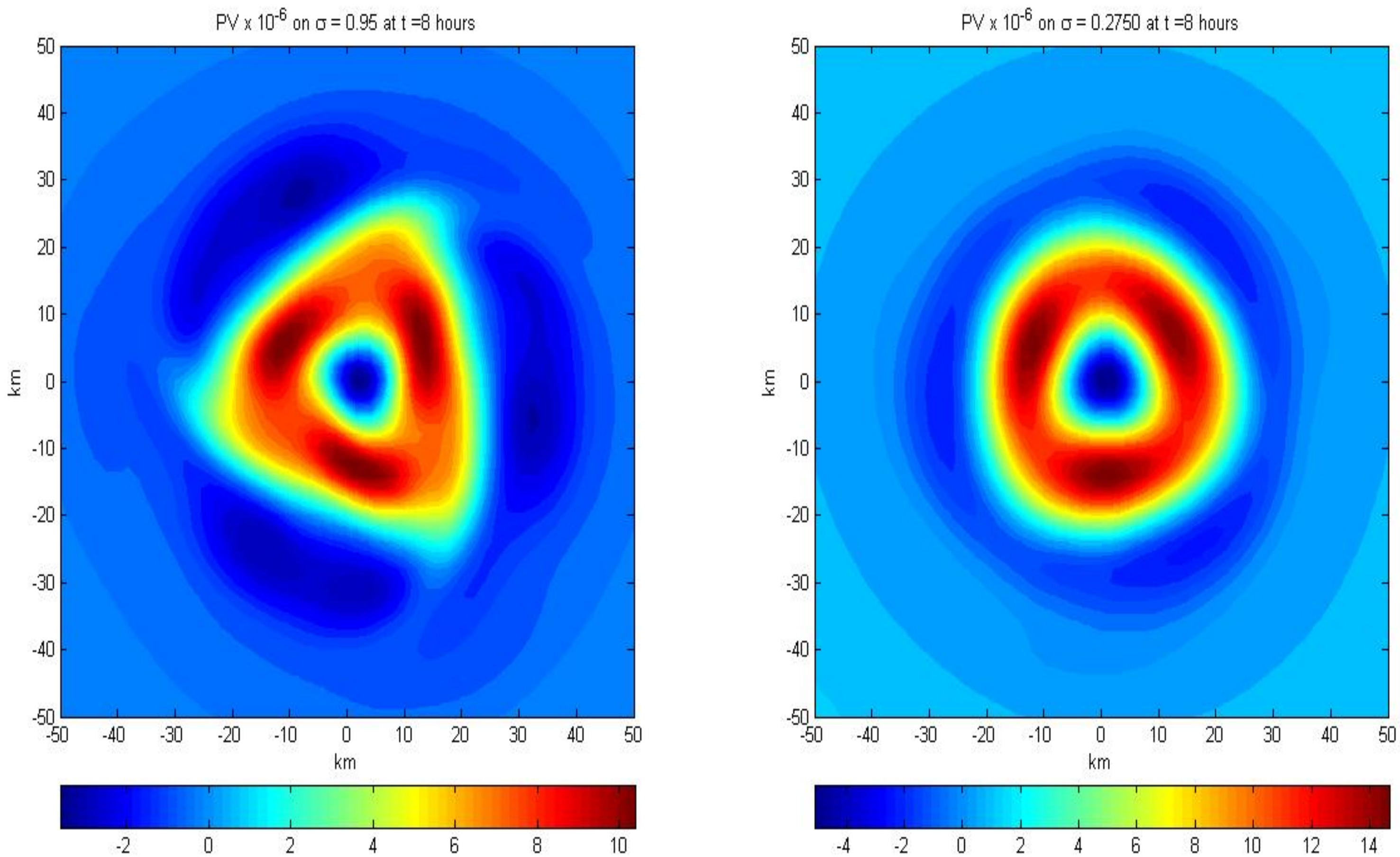
Figure 3: Evolution of Hollow PV Tower of Barotropic Vortex. (Schubert et al. 1999)

Adiabatic Rearrangement of PV Towers – Baroclinic Vortex

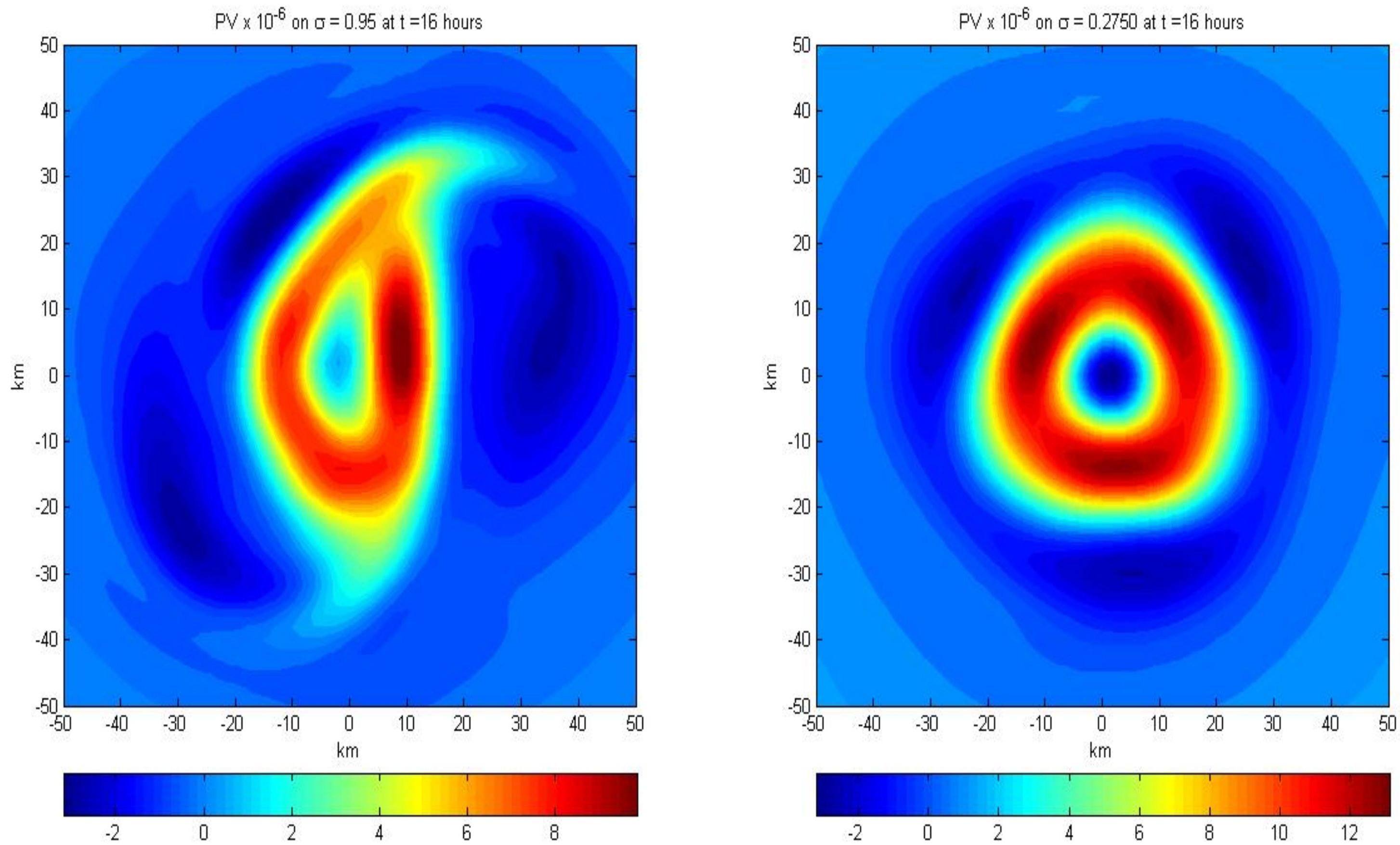




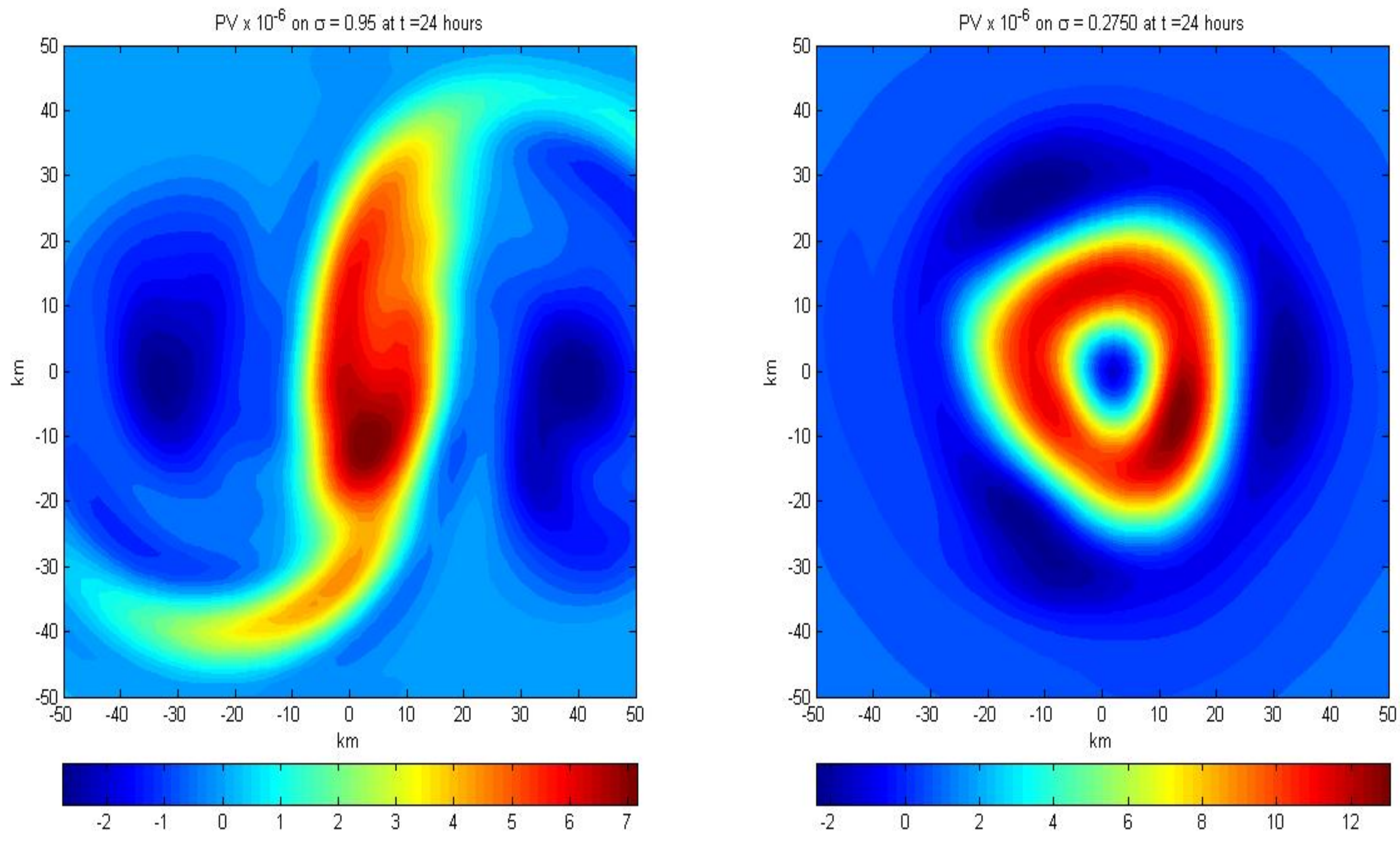
Adiabatic Rearrangement of PV Towers – Baroclinic Vortex



Adiabatic Rearrangement of PV Towers – Baroclinic Vortex



Adiabatic Rearrangement of PV Towers – Baroclinic Vortex



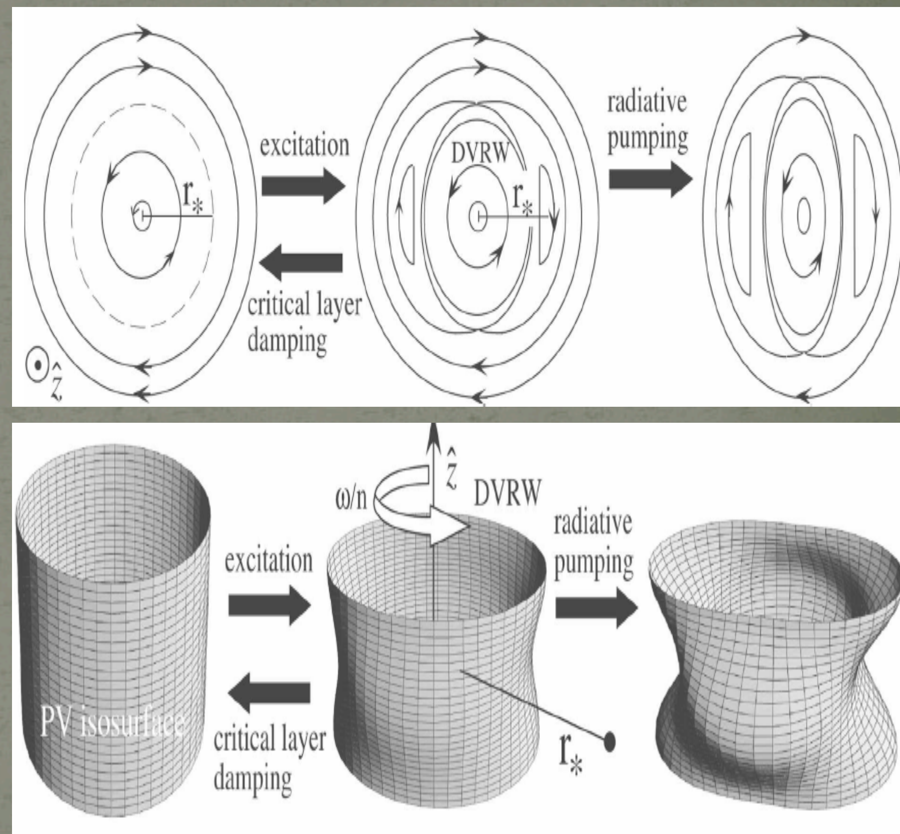
Conclusions and Future Work

- During early evolution, the low level PV ring breaks down with a wavenumber-3 asymmetry, whereas the upper level PV ring remains annular.
- During late evolution, the low level PV ring has nearly symmetrized to a monopole while the upper level ring is beginning to break down with a wavenumber-3 asymmetry.

- Future work includes:
  - Including vertical diffusion and surface friction
  - Including moist diabatic processes
  - Including vertical wind shear and upper level PV forcing

Spontaneous Imbalance for High Rossby Number Vortices

- An asymmetric perturbation on a rapidly rotating, baroclinic vortex excites a VRW.
- The core VRW emits a spiral inertia-gravity (IG) wave into the environment – positive feedback called **radiative pumping.**
- The core VRW also redistributes PV near a critical radius outside the core – negative feedback called **critical layer damping**.
- What is the role of moisture and baroclinity in spontaneous imbalance?



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