# Characterizing the nature and evolution of asymmetric structures in idealized simulations of rapidly intensifying tropical cyclones

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## Overview

- Do asymmetric structures contribute to, or interfere with tropical cyclone rapid intensification?
- Hypothesis – Direct influences: wave-mean flow interactions, indirect influences: structural modification
- Approach – Idealized Simulation in CM1: Analyze symmetric, low- and high-wavenumber evolution

## Vortex evolution

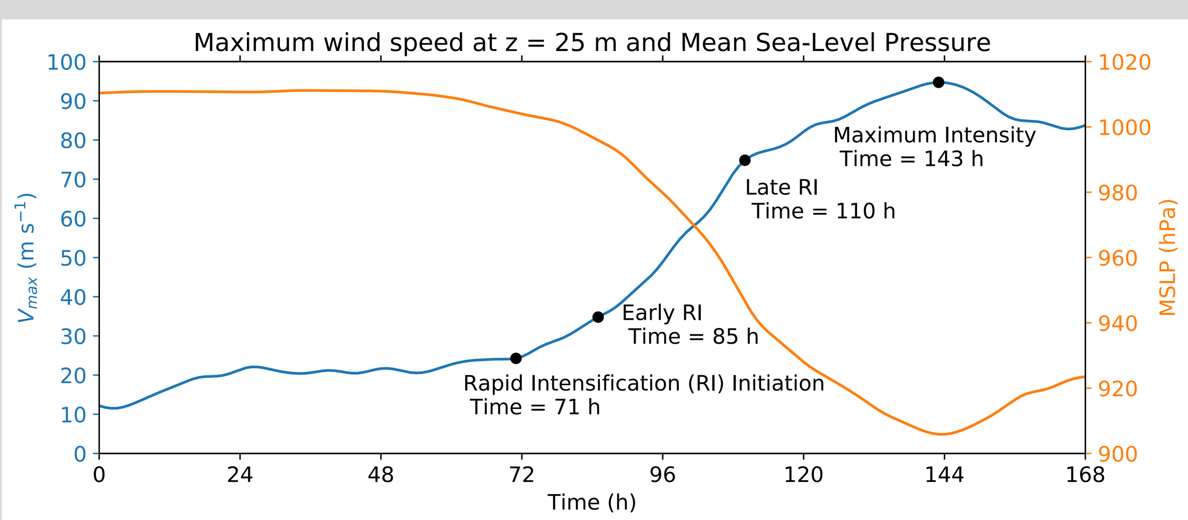


Fig. 1. Maximum azimuthally averaged wind speed at the lowest model level (50 m) and mean sea-level pressure. Each time series is smoothed using a 12-h low-pass Lanczos filter with nine weights.

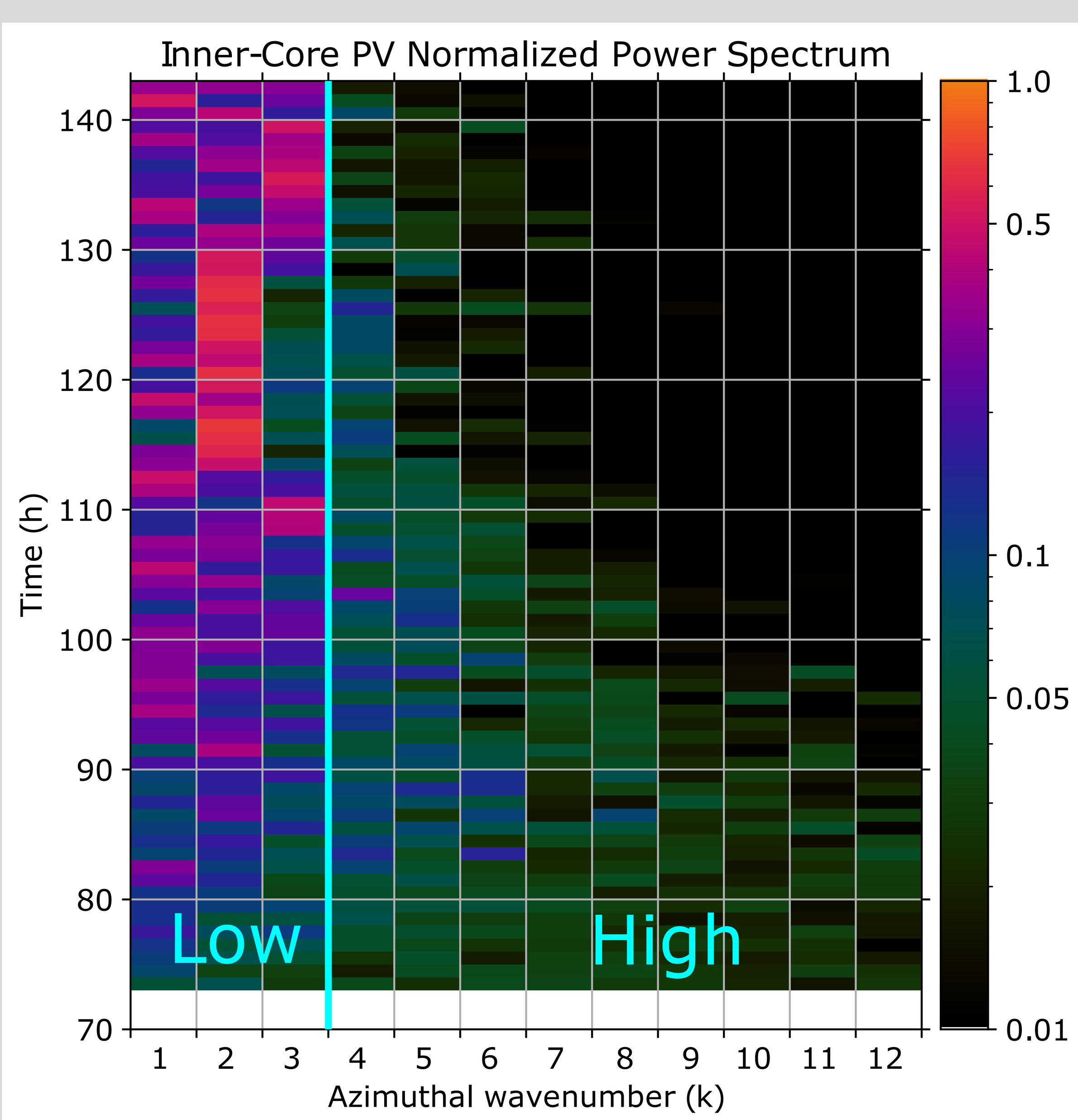


Fig. 2. Dry potential vorticity (PV) normalized power spectrum. Normalized power spectrum for z = 1-3 km mass-weighted PV is averaged for each radius circuit within 1.5 × radius of maximum tangential velocity at z = 2 km.

## Early Rapid Intensification (Time = 85 h)

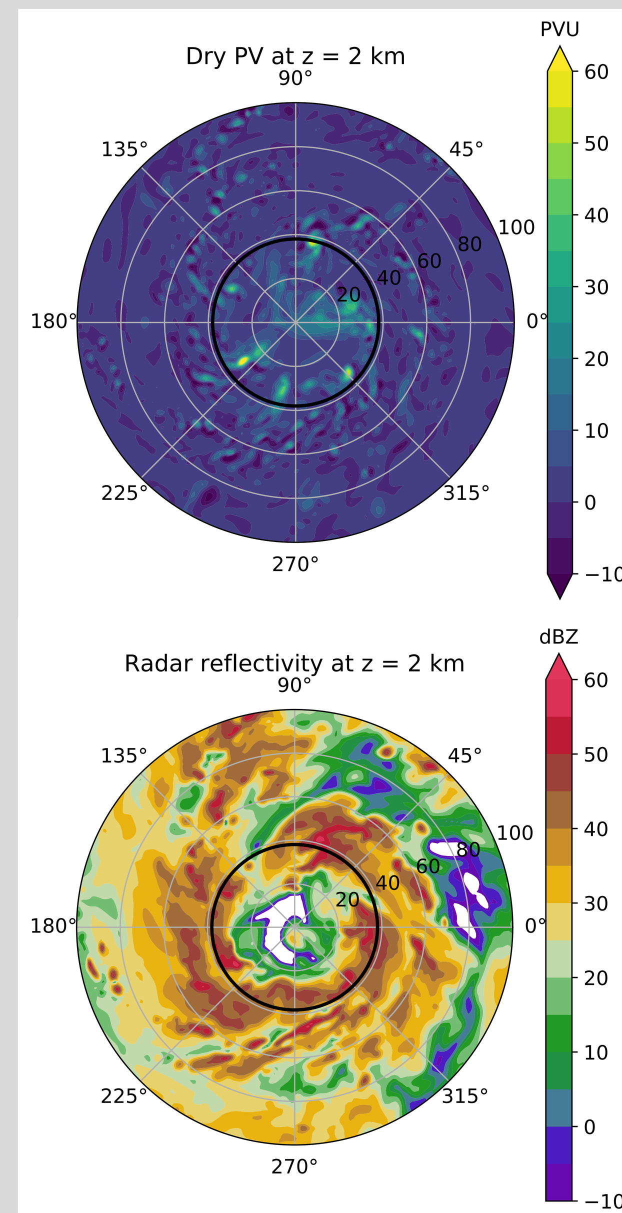


Fig. 3. (Top) Dry potential vorticity (PV) (and bottom) radar reflectivity (dBZ) at 2-km altitude. Black ring is the radius of maximum tangential velocity.

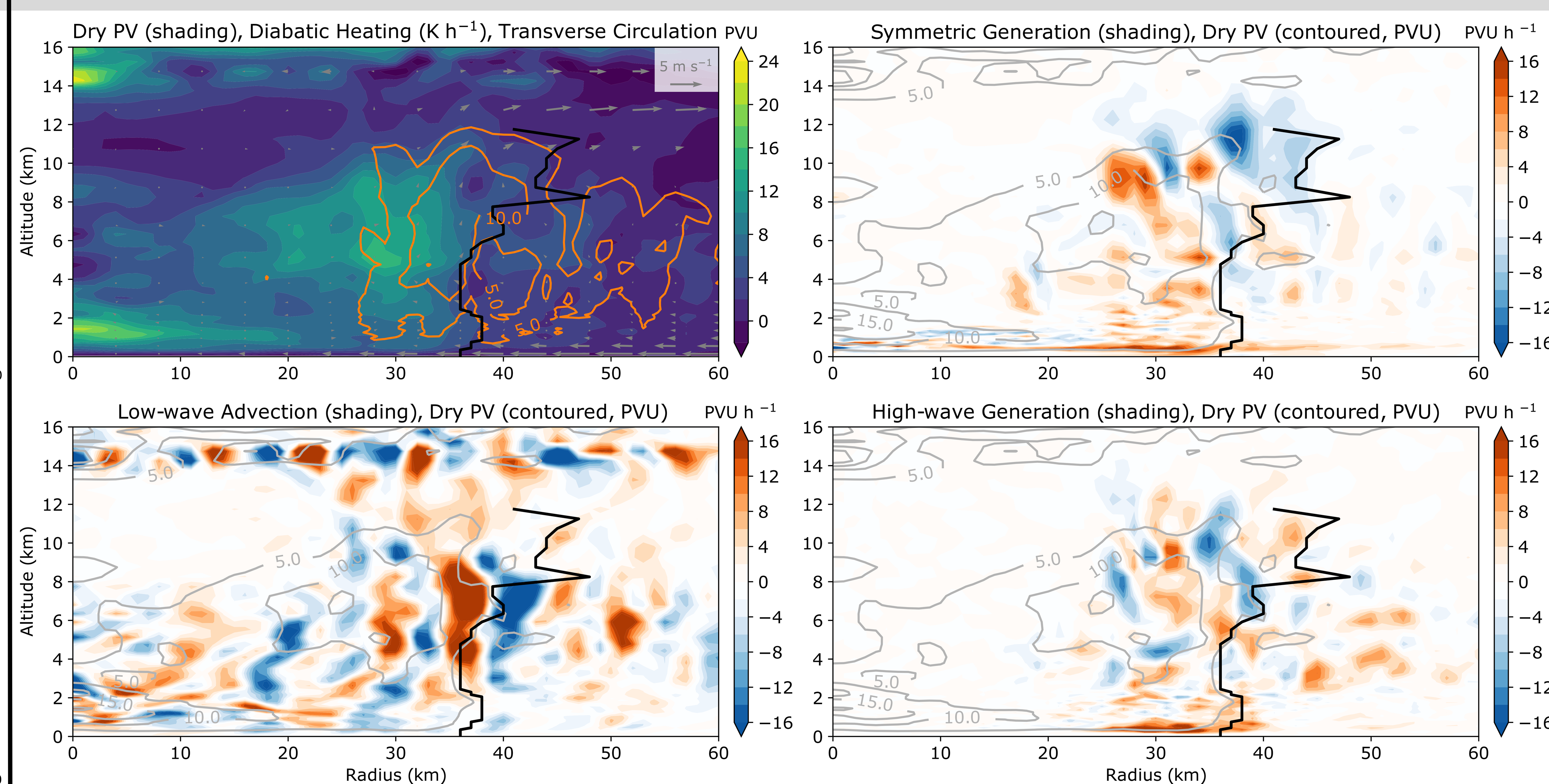


Fig. 4. Early rapid intensification analysis (time = 85 h). (Top Left) Axisymmetric dry PV (shading, PVU), diabatic heating (orange contours, K h$^{-1}$), and transverse circulation vectors. (Top right) Symmetric generation of PV (shading, PVU h$^{-1}$) and axisymmetric dry PV (gray contours, PVU). (Bottom left) Low-wavenumber advection of dry PV (shading, PVU h$^{-1}$) and axisymmetric dry PV (gray contours, PVU). (Bottom right) High-wavenumber generation of dry PV (shading, PVU h$^{-1}$) and axisymmetric dry PV (gray contours, PVU). Black line denotes the azimuthal average radius of maximum tangential velocity.

- High-wavenumber asymmetries located near RMW
- Low-wavenumber PV advection concentrates PV near axis of rotation
- Symmetric and high-wavenumber PV generation contribute to PV tower development
- Symmetric and asymmetric terms are same order of magnitude

## Late Rapid Intensification (Time = 110 h)

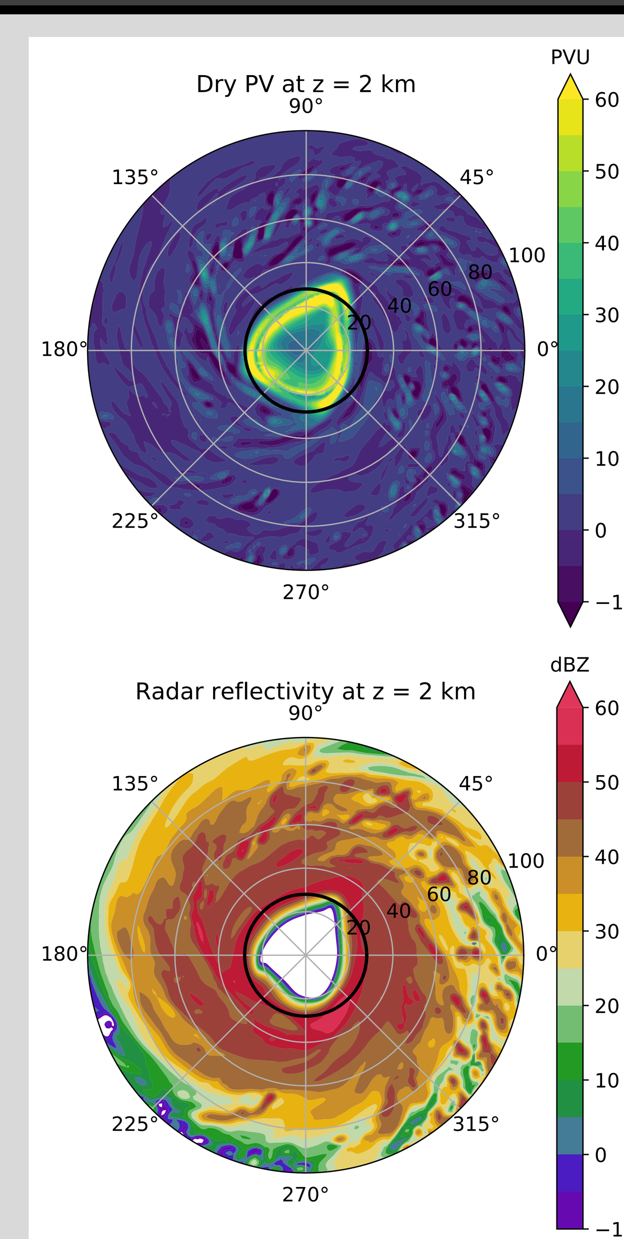


Fig. 5. (Top) Dry potential vorticity (PV) (and bottom) radar reflectivity (dBZ) at 2-km altitude. Black ring is the radius of maximum tangential velocity.

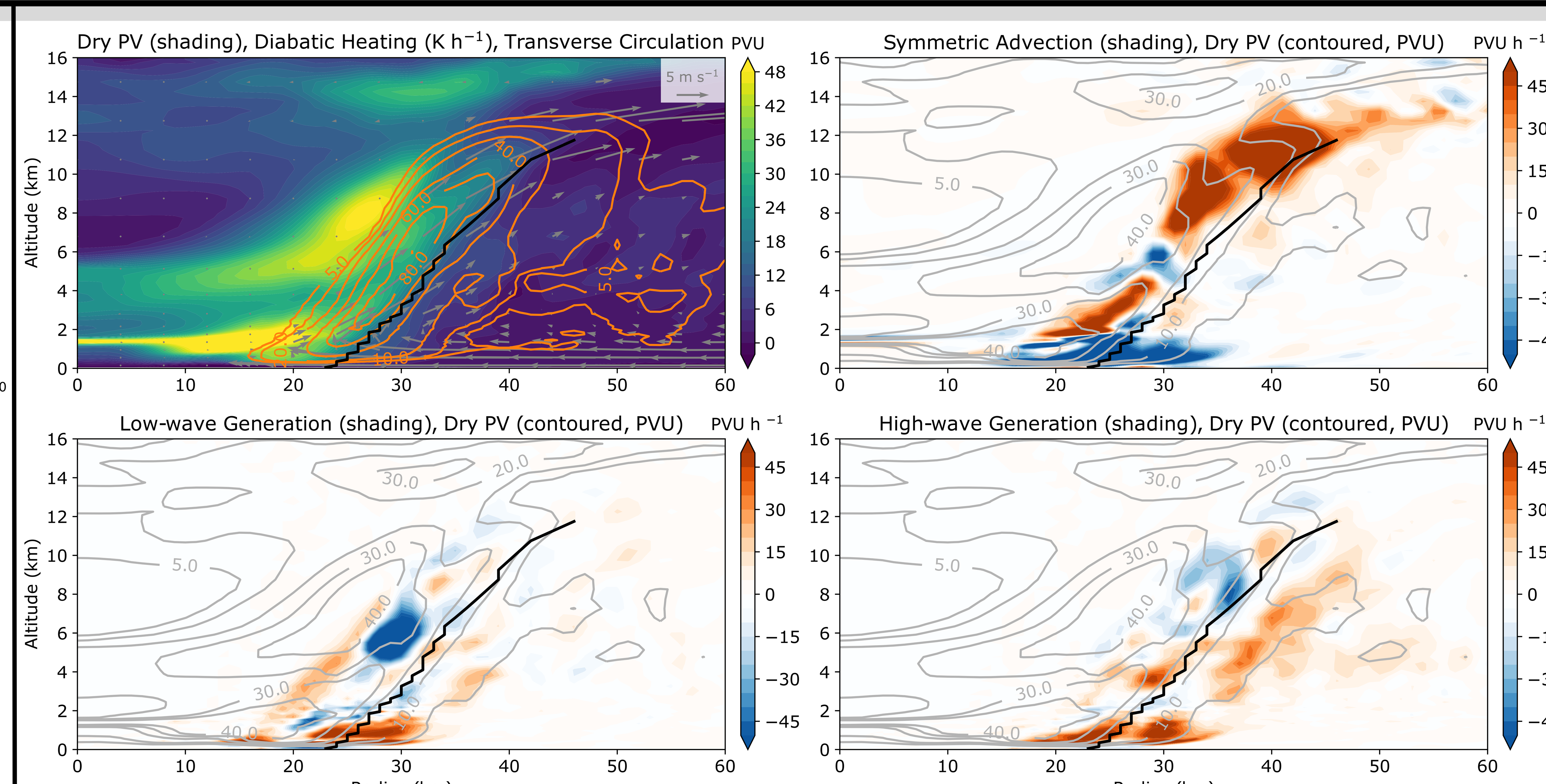


Fig. 4. Early rapid intensification analysis (time = 110 h). (Top Left) Axisymmetric dry PV (shading, PVU), diabatic heating (orange contours, K h$^{-1}$), and transverse circulation vectors. (Top right) Symmetric advection of PV (shading, PVU h$^{-1}$) and axisymmetric dry PV (gray contours, PVU). (Bottom left) Low-wavenumber generation of dry PV (shading, PVU h$^{-1}$) and axisymmetric dry PV (gray contours, PVU). (Bottom right) High-wavenumber generation of dry PV (shading, PVU h$^{-1}$) and axisymmetric dry PV (gray contours, PVU). Black line denotes the azimuthal average radius of maximum tangential velocity.

- Hollow PV tower accompanied by wavenumber-3 structure
- Symmetric PV advection contributes to upper-level PV tower
- Low- and high-wavenumber PV generation enhance hollow PV tower
- Symmetric terms are ~twice larger than asymmetric terms

- This study is funded by NSF Grant AGS-1701225 and ONR Grant N000141613033