An Observational Study of Secondary Eyewall Structure in Hurricane Ivan (2004)

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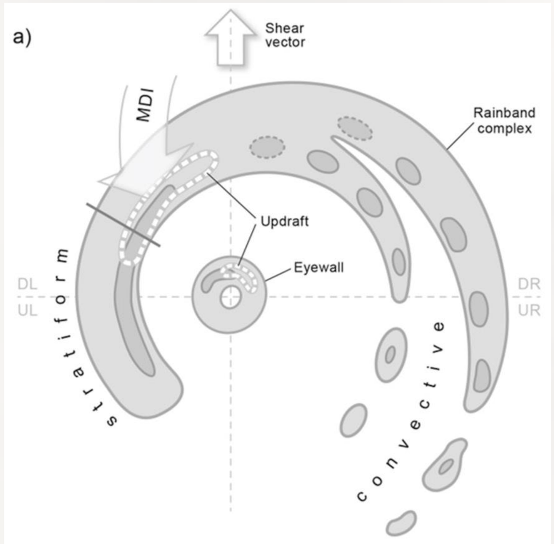
Background and Motivation

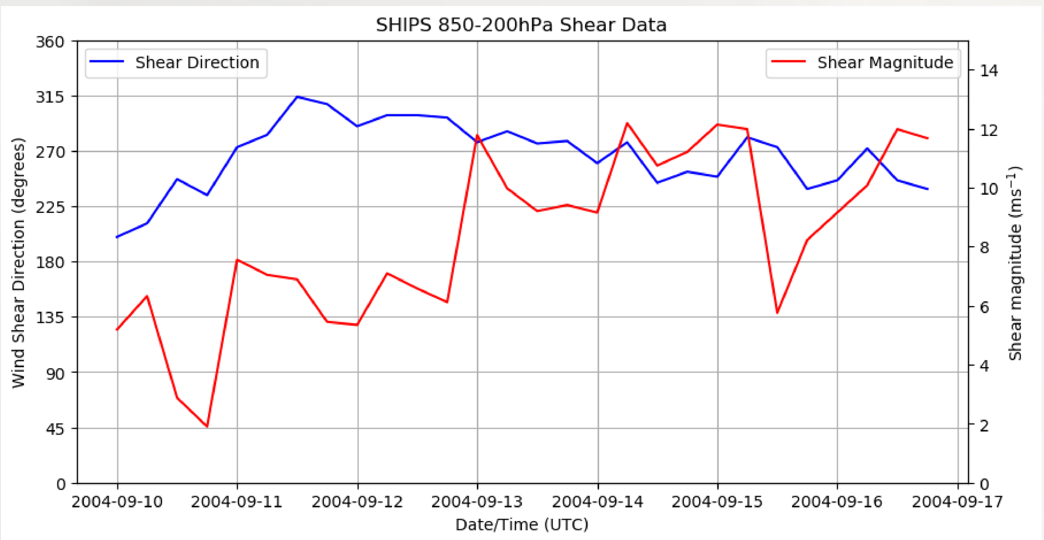
- This study aims to investigate the axisymmetric and asymmetric shear-relative structures during secondary eyewall formation (SEF) and Eyewall replacement cycle (ERC) in Hurricane Ivan (2004) using techniques similar to those in Molinari et al. (2019).
- Didlake et al. (2018) studied the dynamics of SEF and found that the presence of a mesoscale descending inflow (MDI) appears to be dynamically connected to SEF in the downshear left quadrant. Does this mechanism work for the SEF in Hurricane Ivan?
- How well do the current schematics of SEF and ERC hold up for other storms (position and intensity of features), such as in Hurricane Ivan?

Schematic from Didlake et al. (2018) showing plan view, with reflectivity contoured at 20 and 35 dBZ and enhanced updrafts in dashed white contours.

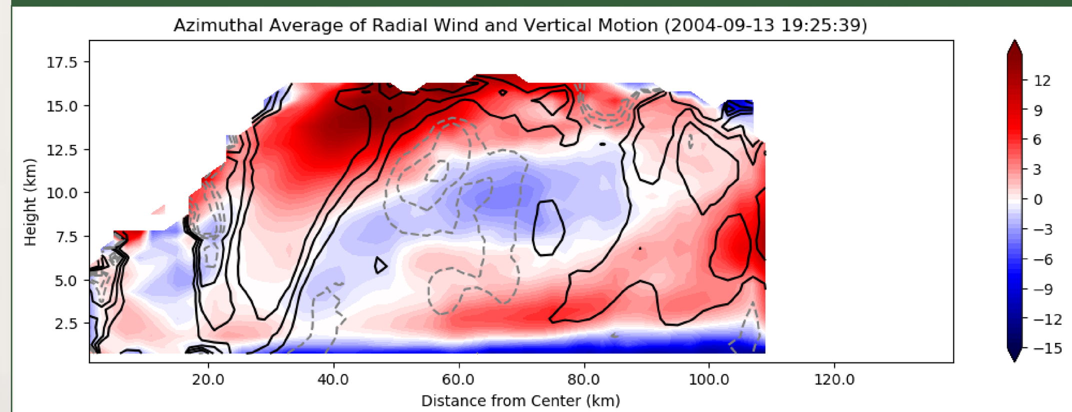


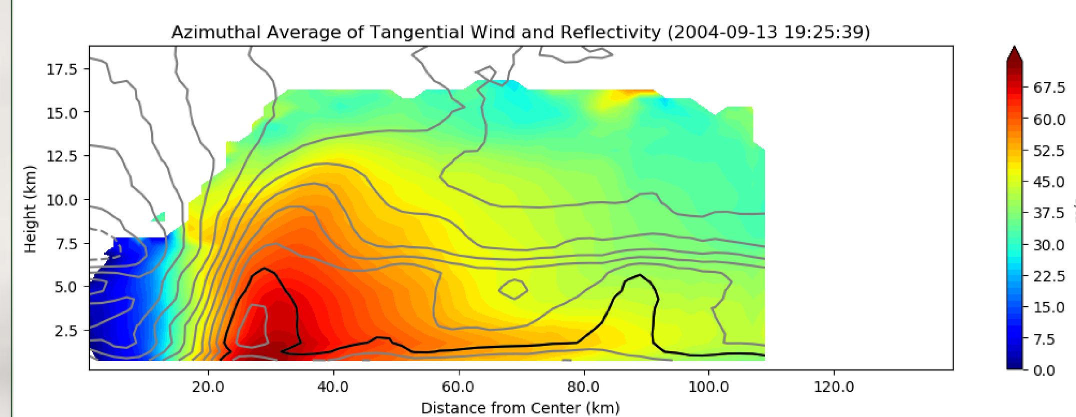
Data and Methodology

- NOAA P3 Tail Doppler Radar data (X-band)
  - 3D winds and reflectivity
  - 2km horizontal resolution, 500m vertical resolution
- USAF and NOAA P3 flight-level data
  - 10 second time resolution from USAF, 1 second resolution from P3
- Passive microwave imagery from various polar orbiting satellite instruments (SSMIS, TMI, AMSRE)
- Statistical Hurricane Intensity Prediction Scheme (SHIPS) Model 0h analysis deep layer environmental shear (0-500km 850hPa-200hPa)

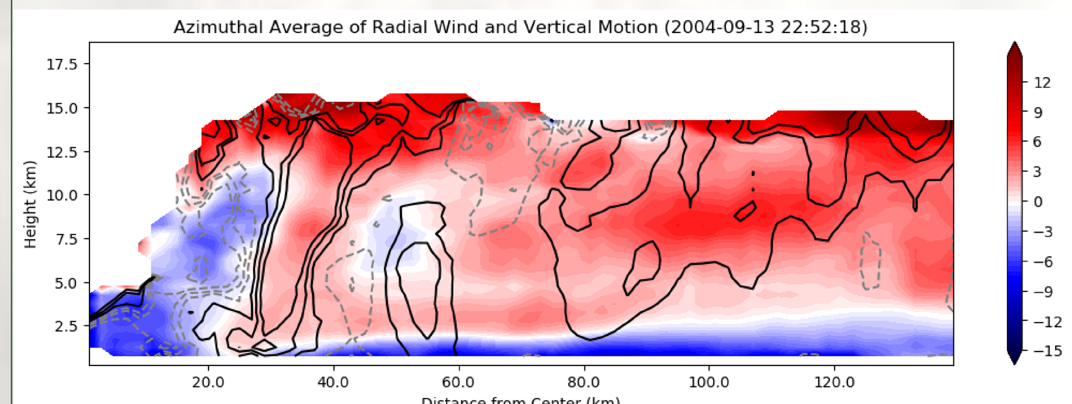


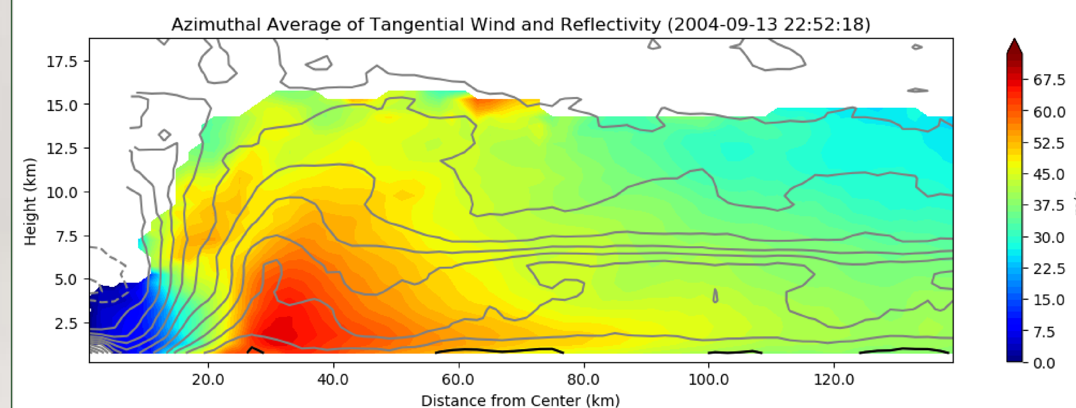
Axisymmetric Analysis

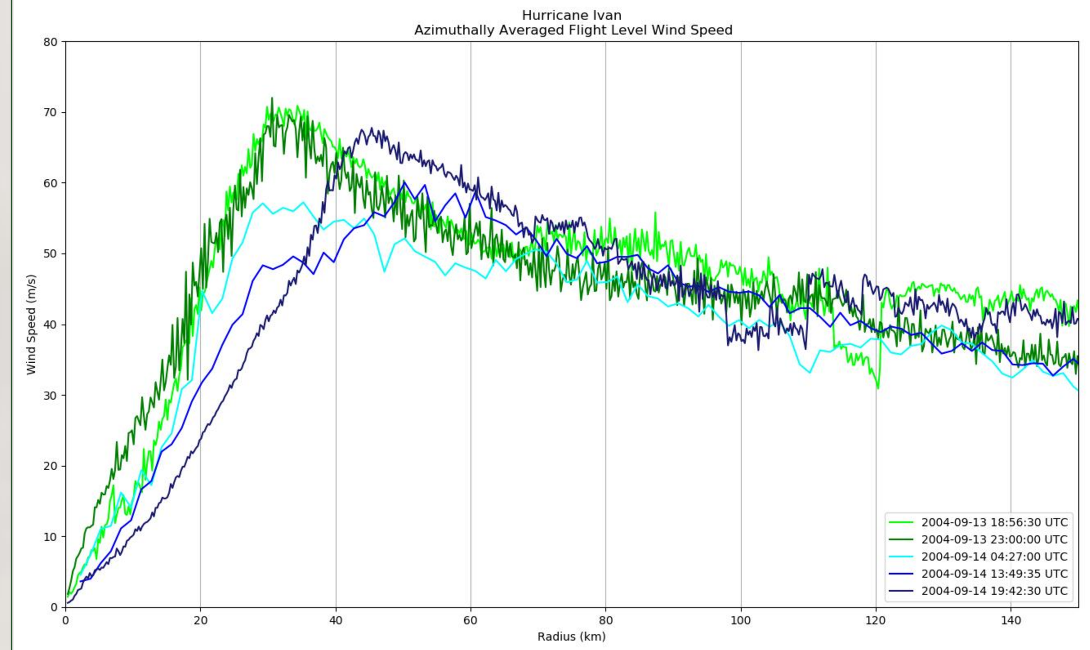




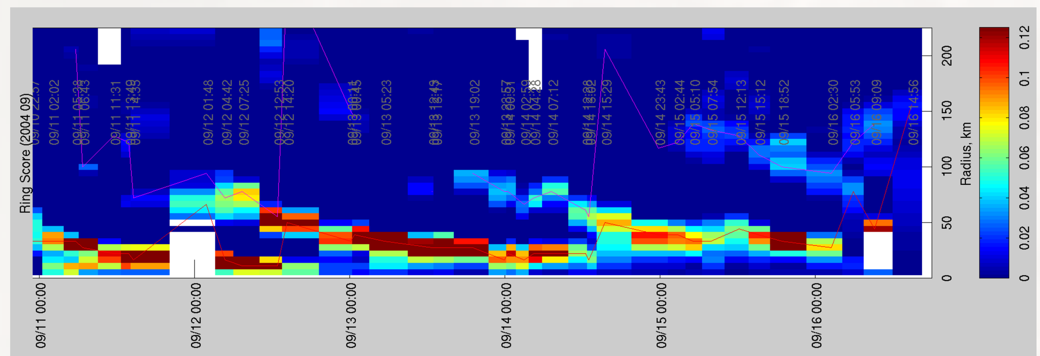
Updrafts contoured at 0.5, 1, 1.5 ms^{-1}
Downdrafts contoured at -0.1, -0.5, -1 ms^{-1}
Reflectivity (dBZ) contoured every 3 dBZ, 30 dBZ contour in black





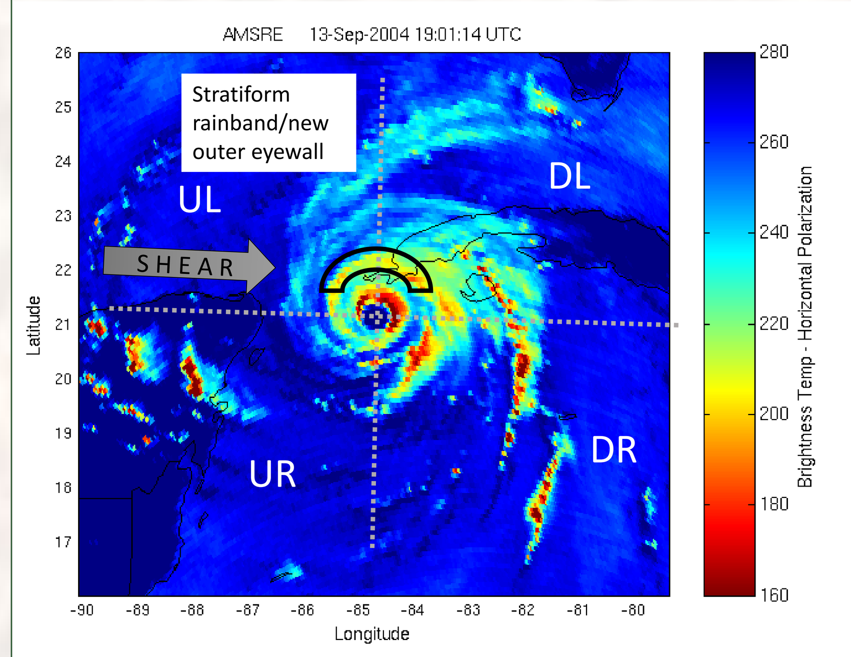


- Expanded tangential wind field in boundary layer, reflexctivity maximum at r = 85 km, local tangential wind maxima near r = 80km.

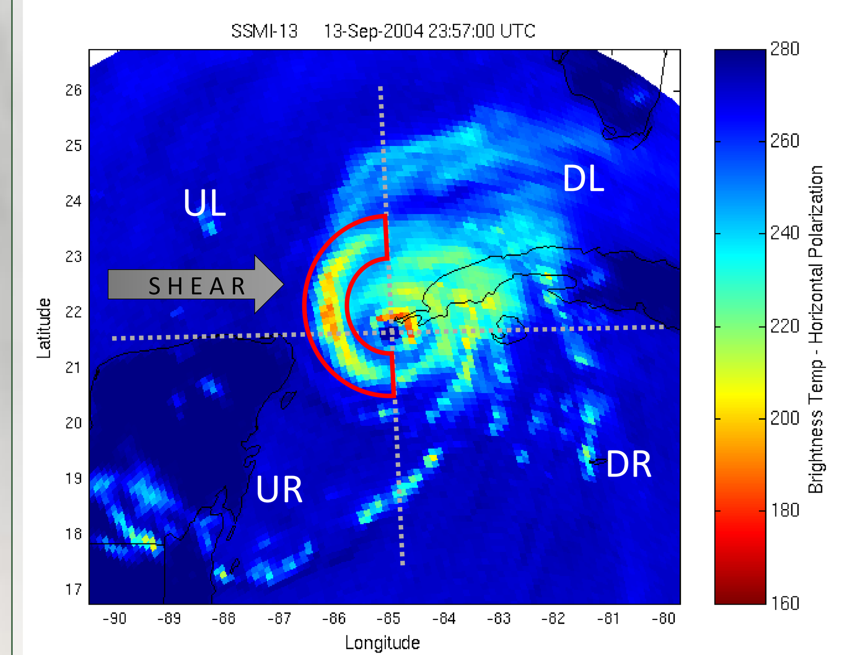


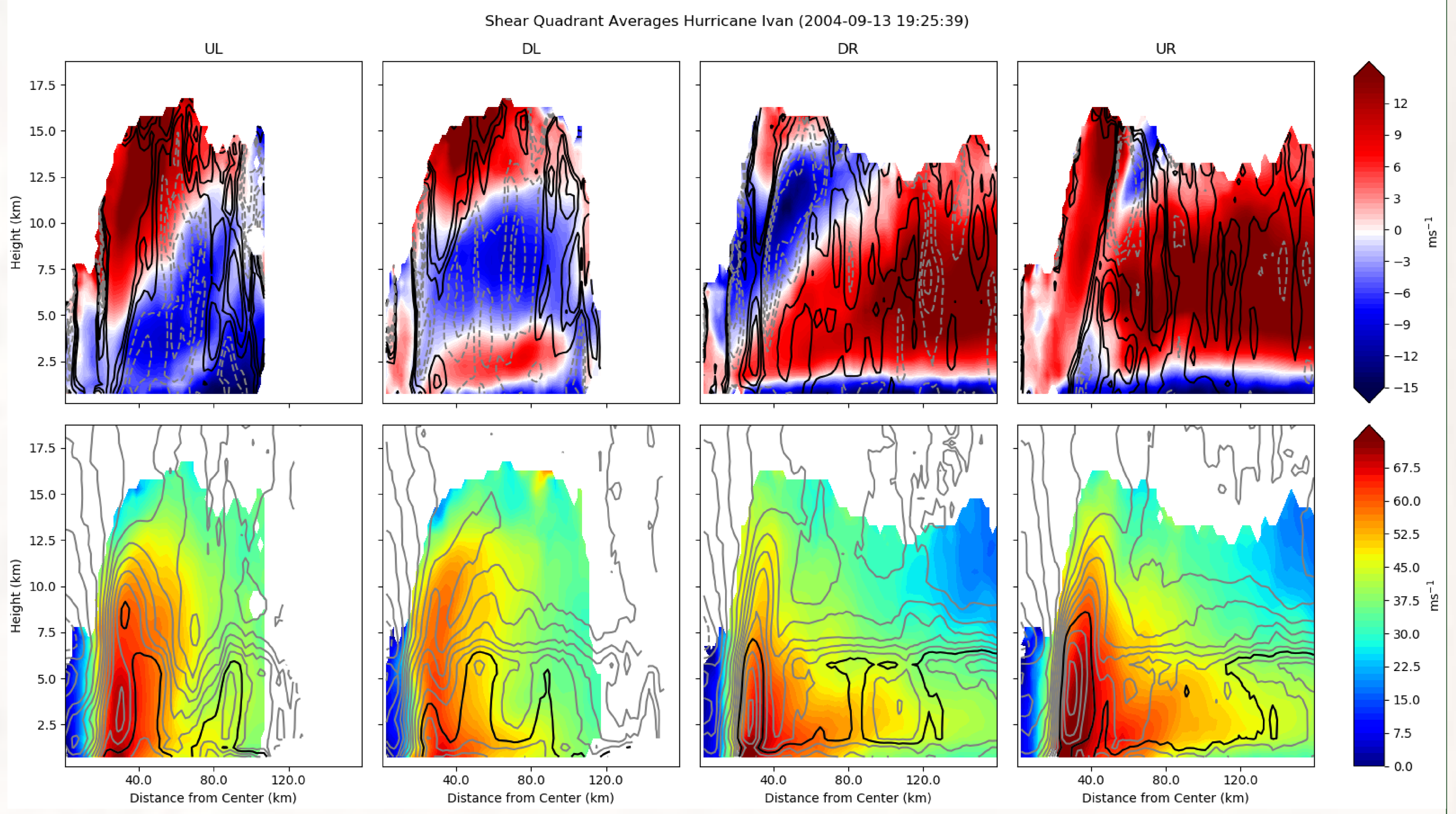
- Successive ERCs for Ivan based on ARCHER ring scores (Wimmers and Velden 2010).

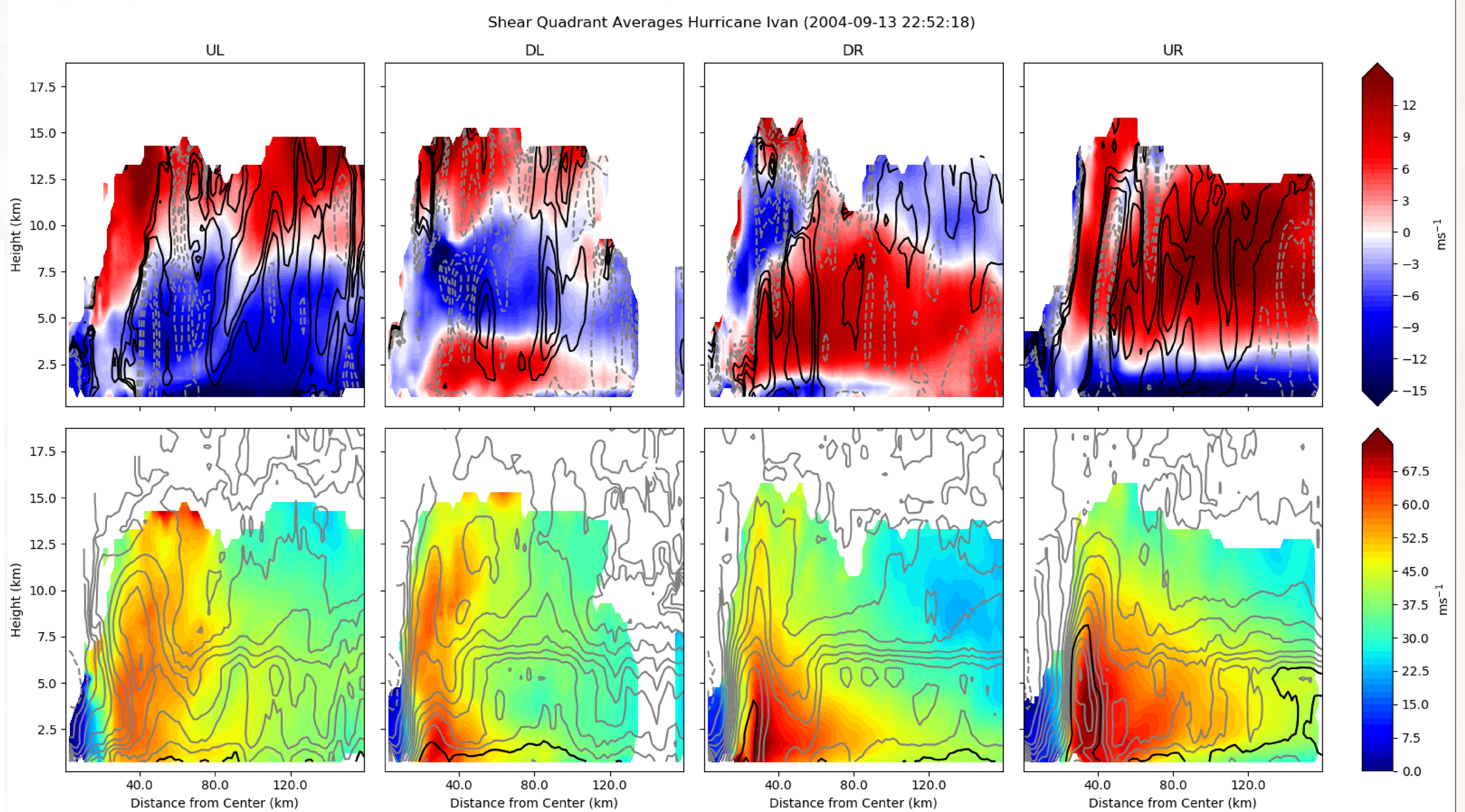
Asymmetric Analysis



Inner eyewall is strongest downshear, consistent with Didlake et al. (2018) at 19Z. Tangential wind max most isolated in UR quadrant.
MDI is at 90 km radius, with a corresponding inflow max at the terminus of the MDI in the UL quadrant.
Updrafts bases are collocated with areas of radial convergence near the MDI.
Outer tangential wind maxima are downwind of the rainband with updrafts upwind.







Conclusions

- Axisymmetric structure analysis revealed expanded tangential wind field, enhanced inflow, and clear maximum in reflectivity and vertical motion during the secondary eyewall formation in Hurricane Ivan.
- Results support the presence of a mesoscale descending inflow (MDI) in the upshear left quadrant of the storm during the ERC of Ivan, indicating that there may be *greater variability in the location of the MDI relative to the shear vector* than that seen by Didlake and Houze (2013) and Didlake et al. (2017).
- Low-level tangential wind maximum is strongest in the UR quadrant in Hurricane Ivan during this SEF, as opposed to the DL quadrant as in Hurricane Earl as documented by Didlake et al. (2018).
- The low-level tangential wind speed did strengthen downwind of the developing secondary eyewall.

References are available by scanning the QR Code here:

Acknowledgments

We thank scientists and crew members that were involved in the aircraft missions into Hurricane Ivan (2004).

Additional thanks to Dr. Steve Skubis and Dr. Michael Veres for insightful discussions, and to Dr. Jake Mulholland for help in designing this poster.