Vertical Structure of Tropical Cyclones undergoing Eyewall Replacement Cycles as seen by the TRMM PR

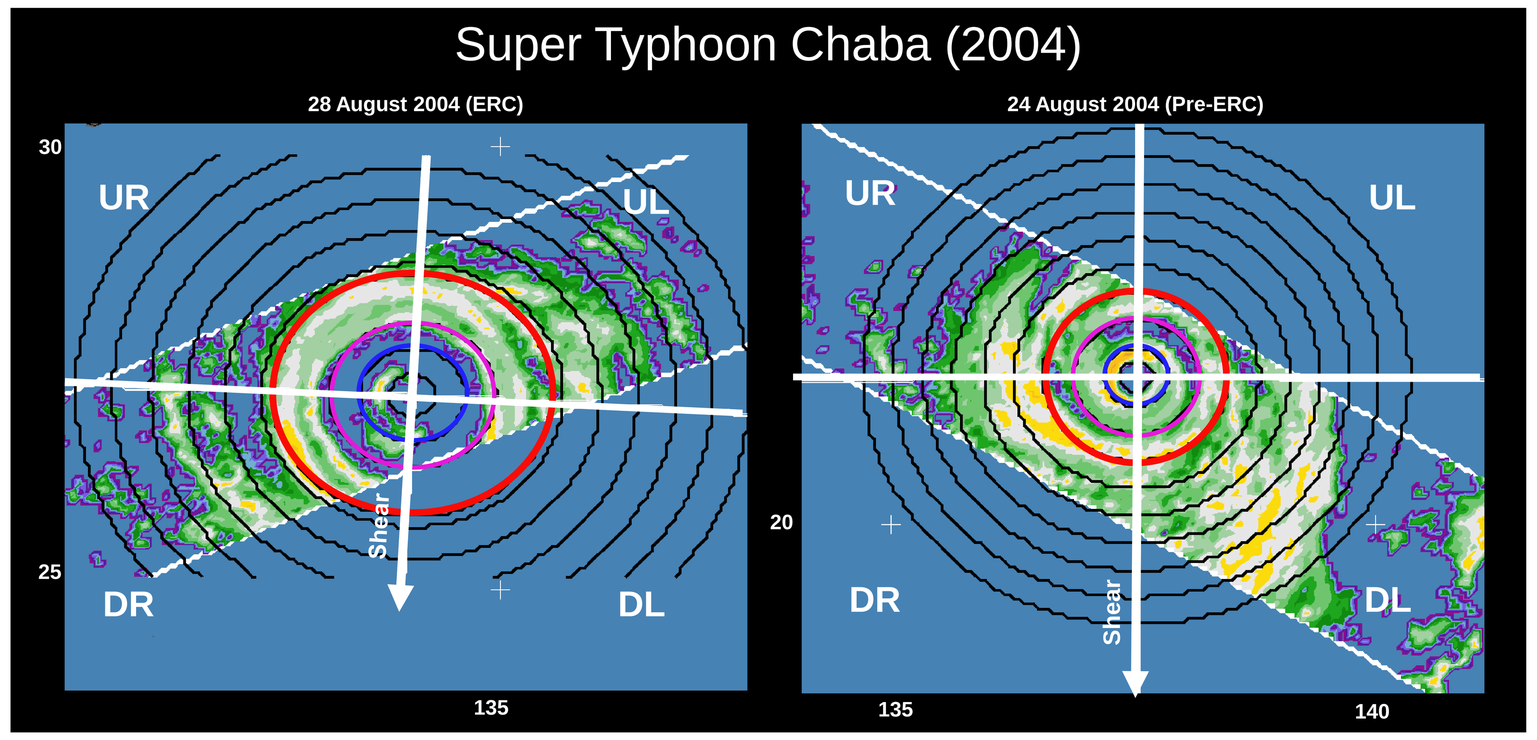
University of Washington
Atmospheric Sciences

Deanna A. Hence, Tia Lerud and Robert A. Houze, Jr.

University of Washington

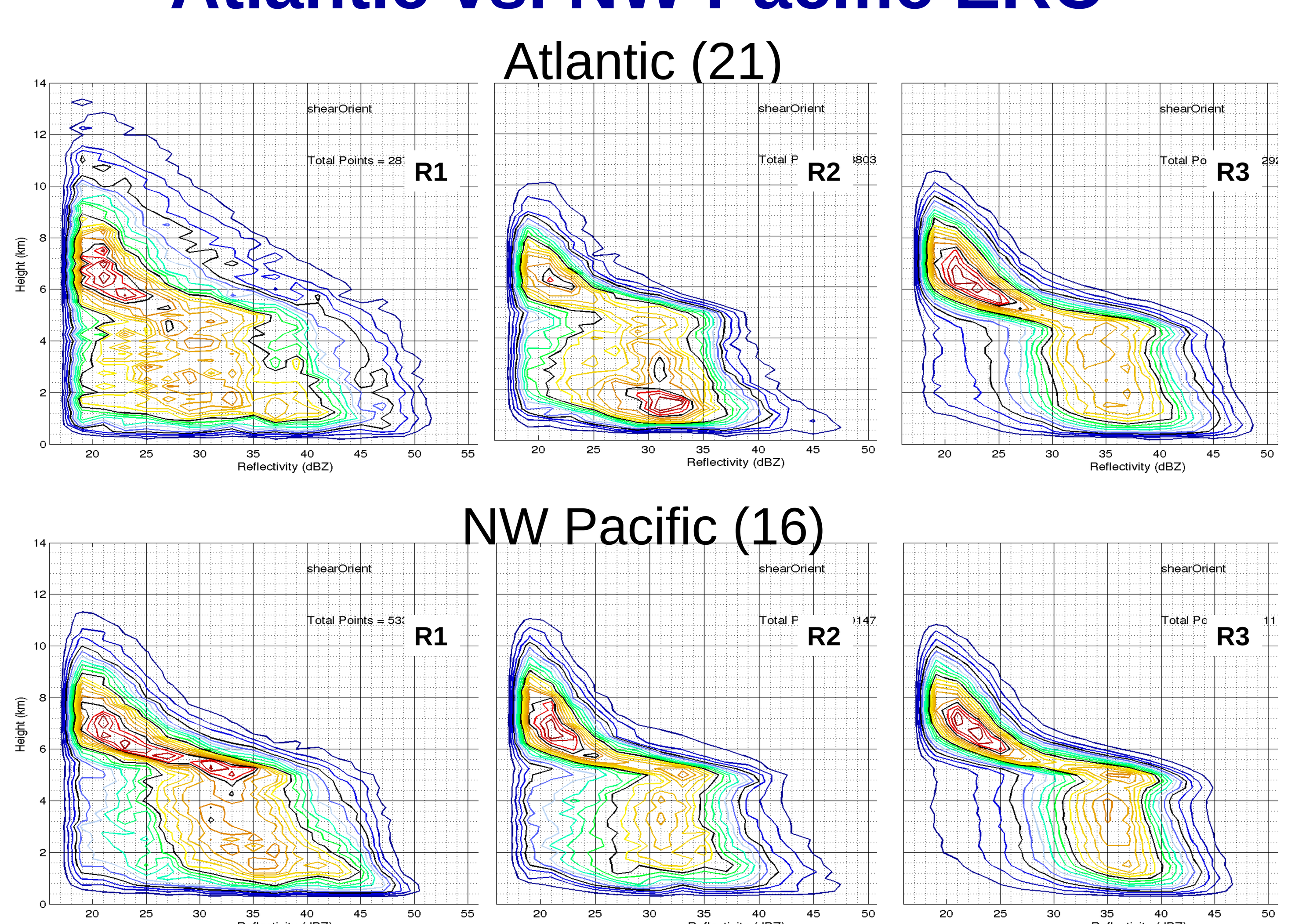
Motivation and Methodology

The eyewall replacement cycle (ERC) within tropical cyclones (TCs) remains one of the more difficult phenomena to study, and yet the processes that govern it are important to understand due to the ERC's role in causing intensity fluctuations within intense storms. Using the TRMM Precipitation Radar (PR), this study aims to examine how the statistical precipitation structure of the primary eyewall, moat region, and secondary eyewall of TCs undergoing an ERC differ from the statistical precipitation structures seen in storms not undergoing an ERC (Non-ERC).



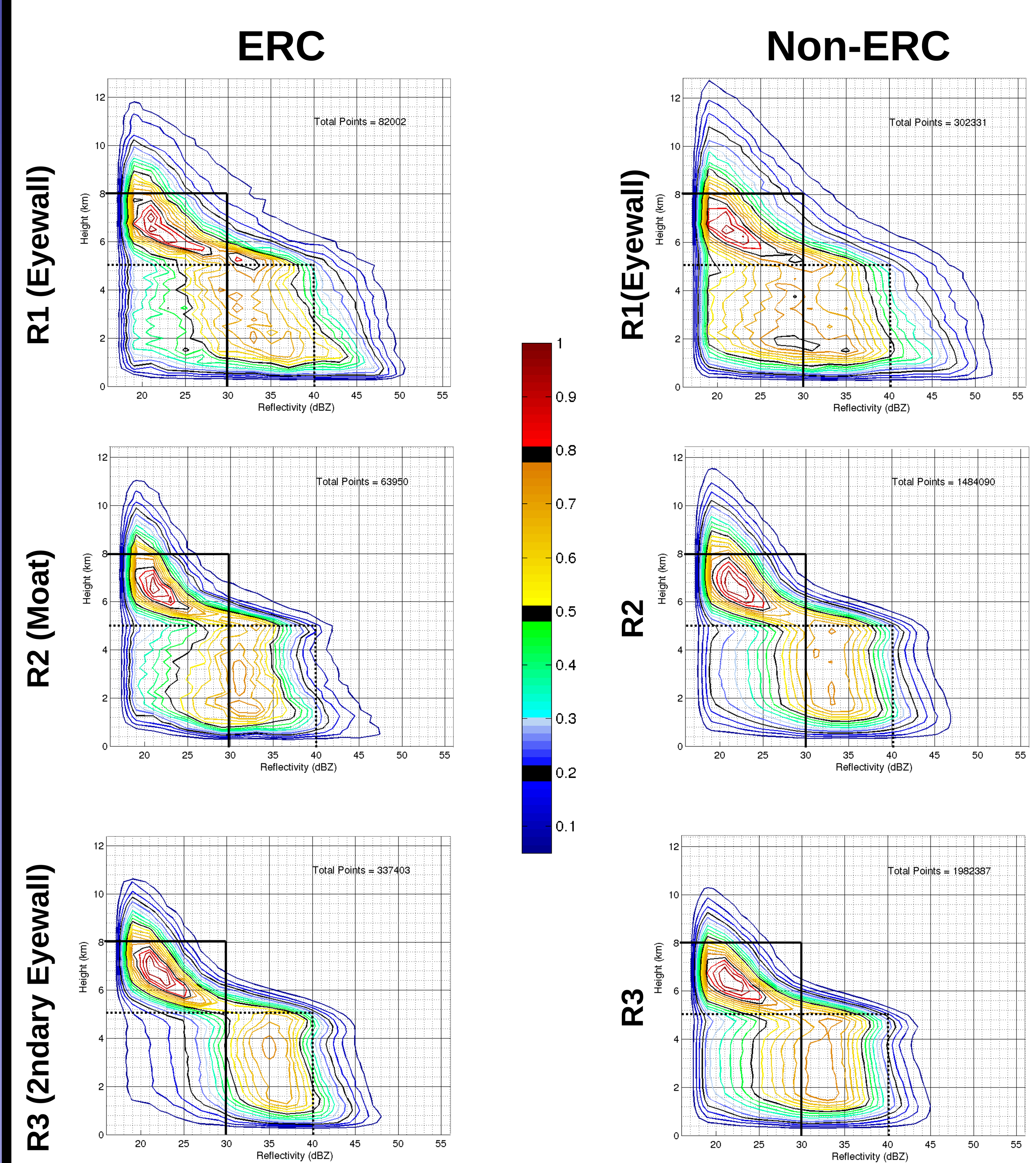
- Contour Frequency by Altitude Diagrams (CFADS) of TRMM PR reflectivity from 1998-2007 tropical cyclones in Atlantic and NW Pacific.
- Non-ERC (352) regions evenly spaced based on eye radius (Re):
  - R1 = Re+ 17 km, R2 =2R1, R3=3R1, etc.
- ERC (37) regions determined subjectively based on PR data:
  - R1 (outer bound blue) eyewall region, R2 (pink) moat region, R3 (red) secondary eyewall region.
- Quadrants (white) counter-clockwise from estimated shear vector

Atlantic vs. NW Pacific ERC



- More uniformly intense primary eyewalls (R1) in NW Pacific, more intense outliers in Atlantic
- More vertical suppression and more low reflectivities in Atlantic moats (R2), similar low-level reflectivities in both basins
- Similar secondary eyewall (R3) distributions in both basins

ERC vs. Non-ERC



- *Primary eyewall (R1):*
  - Intense, deep in modal distribution (yellow) and outliers (blue)
  - More uniformly intense in ERC
  - Outliers deeper in Non-ERC R1
- *Moat (R2):*
  - Vertically limited, narrow distribution, less intense
  - Broader upper-level distribution and more intense low-level distribution in Non-ERC R2
- *Secondary eyewall (R3):*
  - Deep, modal distribution as intense as primary but less intense outliers
  - Non-ERC R3 distribution less intense, less uniform, less deep

Conclusions and Future Work

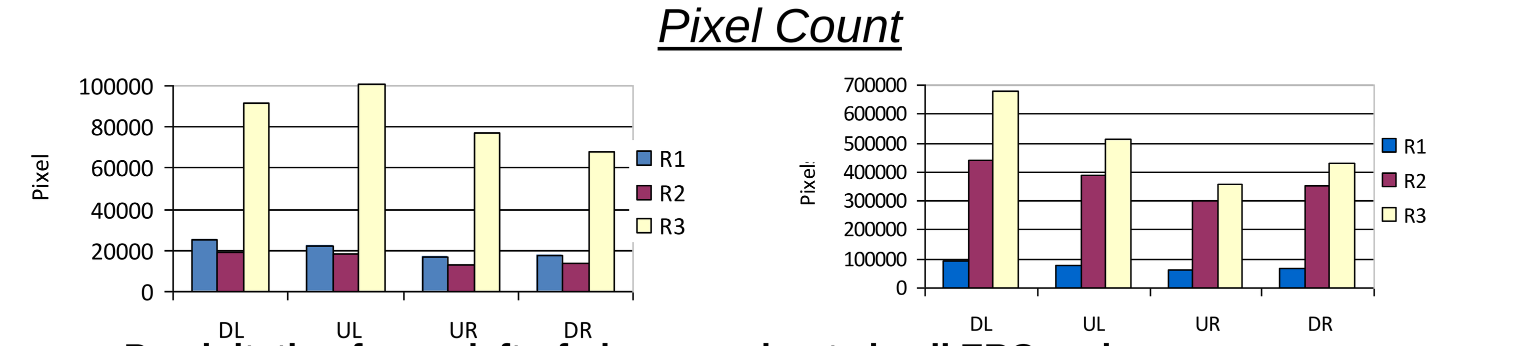
CFAD analysis is used to examine the changes in structure that the tropical cyclone inner core exhibits during an eyewall replacement cycle (ERC). The primary and secondary eyewall regions (R1 and R3) of the ERC cases exhibit a deep, intense vertical distribution. The moat region of the ERC cases (R2), in contrast, exhibits a vertically-limited, sparsely-covered, and less-intense distribution. These features of the distribution are apparent in both the Atlantic and NW Pacific ERC cases, although the moat distribution (R2) is more obviously vertically limited in the Atlantic than the NW Pacific. When compared to the Non-ERC cases, both the primary and secondary eyewalls exhibit a more uniformly intense structure than R1 and R3 of the Non-ERC cases. The moat is more vertically limited and less intense than the R2 region of the Non-ERC cases.

We also explore a preliminary quadrant-by-quadrant analysis of the three ERC regions. The precipitation placement and modal intensity favor the left-of-shear quadrants in the ERC cases, but the echo heights suggest that convective processes differ in each region. The Non-ERC cases indicate a more standard downshear-left asymmetry (Hence and Houze 2010, revised). These quadrant-by-quadrant results require further examination.

Quadrant-by-Quadrant Analysis

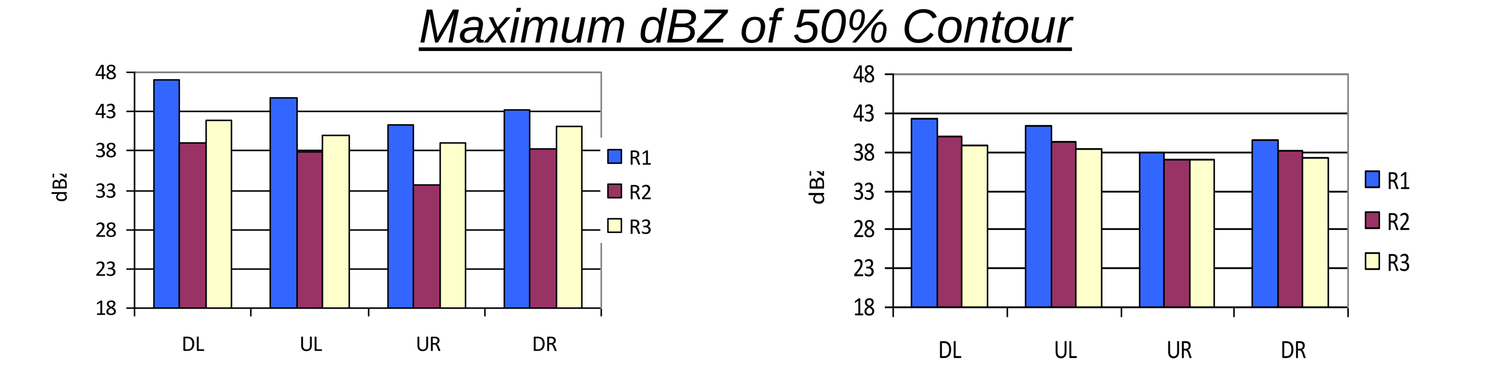
ERC **Non-ERC**

Pixel Count



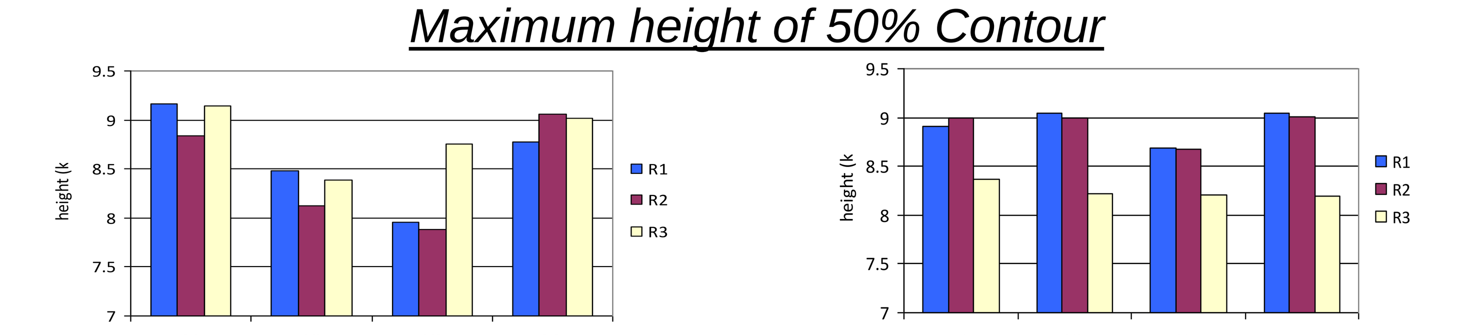
- **Precipitation favors left-of-shear quadrants in all ERC regions**
- **Minimum of precipitation (all quadrants) in the moat region (ERC R2)**
- **Max. precip. in DL, min. in UR, transitional values DR and UL in Non-ERC**

Maximum dBZ of 50% Contour



- **Sharp decrease in precipitation intensity in the moat region in ERC**
- **Non-ERC has steady decrease of precipitation intensity from R1-R3**

Maximum height of 50% Contour



- **Distinct asymmetry in all ERC regions, downshear quadrants have deeper echo**
- **Except for DR, most ERC moat quadrants vertically limited**
- **Non-ERC regions more uniform in height, with sharp decrease in R3**

Acknowledgements

NASA PMM grants NAG5-13654, NNX07AD59G and NNX10AH70G

NASA Earth and Space Science Fellowship NNX06AF17H

National Science Foundation RAINEX grants ATM-0432623 and ATM-0743180

PMM Science Team Meeting, Seattle, WA, 1 November 2010