66th Interdepartmental Hurricane Conference, Charleston, SC
March 5-8, 2012

FIU FLORIDA INTERNATIONAL UNIVERSITY

Enhancement of SHIPS Rapid Intensification Index Using the 37 GHz Ring Pattern

PI: Haiyan Jiang[1]
Postdoc: Tie Yuan[1]
PhD Research Assistant: Margaret Kieper [1]
Collaborators: Edward J. Zipser[2] and John Kaplan[3]
[1]Florida International University
[2]University of Utah
[3]NOAA Hurricane Research Division

Acknowledgements: *This NOAA Joint Hurricane Testbed project was funded by the US Weather Research Program in NOAA/OAR's Office of Weather and Air Quality.*

METEOROLOGY

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

Outline

- Project Overview
- Updates during Yr-1: Evaluations of the ring+SHIPS rapid intensification (RI) Index
- Works in progress

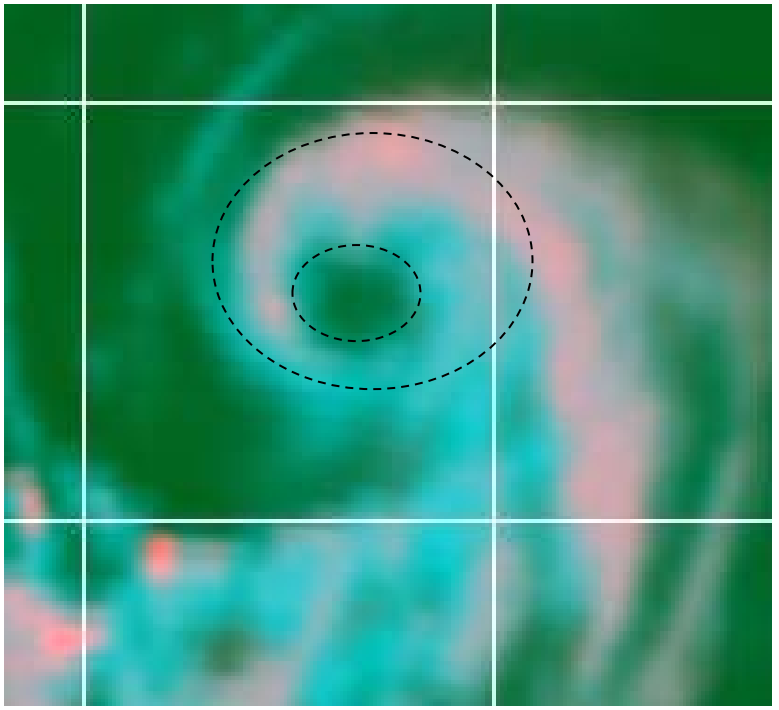
Project Overview: Background

- SHIPS RI index (Kaplan and DeMaria 2003; Kaplan et al. 2010) is a well-established RI index which uses the environmental parameters to predict the probability of RI.
- M. Kieper (AMS presentations 2008; Tech. Doc. for NOAA NHC 2009) found that the first appearance of a cyan color ring (from NRL 37 GHz color product, Lee et al. 2002; Hawkins and Velden 2011) around the eye could be an indicator of RI when environmental conditions are favorable.
- Kieper's subjective RI forecast method has been unofficially tested in real time for 2008, 2009 and 2010 hurricane seasons.

Decoding the 37 GHz color Product

- The NRL 37 GHz color product: 1) combines 37 GHz Polarization Corrected brightness Temperature (PCT), 37 GHz vertically and horizontally polarized TB's; 2) no quantitative information; 3) pink→ deep convection, cyan→low level clouds, green→ sea surface (Lee et al. 2002).

- To automate Kieper's subjective method into an objective method, we have determined quantitative values of the 37 GHz TB's in different color regions using the TRMM Tropical Cyclone Precipitation Feature (TCPF) database (http://tcpf.fiu.edu; Jiang et al. 2011, JAMC).



NRL 37 GHz Color Product for Hurricane Ivan (2004), WindSat overpass at 09/04/2004 2043Z. 55 kt intensity increasing during the next 24 hours.

Forecast method developed

The Objective 37 GHz Ring RI Index

- A ring pattern is detected by the automatic 37 GHz ring pattern identification algorithm.
- Initial TC intensity is between 45 - 100 kt.
- The core of the TC is currently over water and is anticipated to remain over water for 24 hours.

The Combined Ring+SHIPS RI Index

- Satisfy the Ring index definition
- The SHIPS RI probability >= 20%

Updates During Yr-1 Funding Period

Evaluation 1: Using More TMI Data

- TRMM TMI observed TCs from 1998-2010.
- SHIPS RII independent (post-run) dataset (data courtesy: John Kaplan).

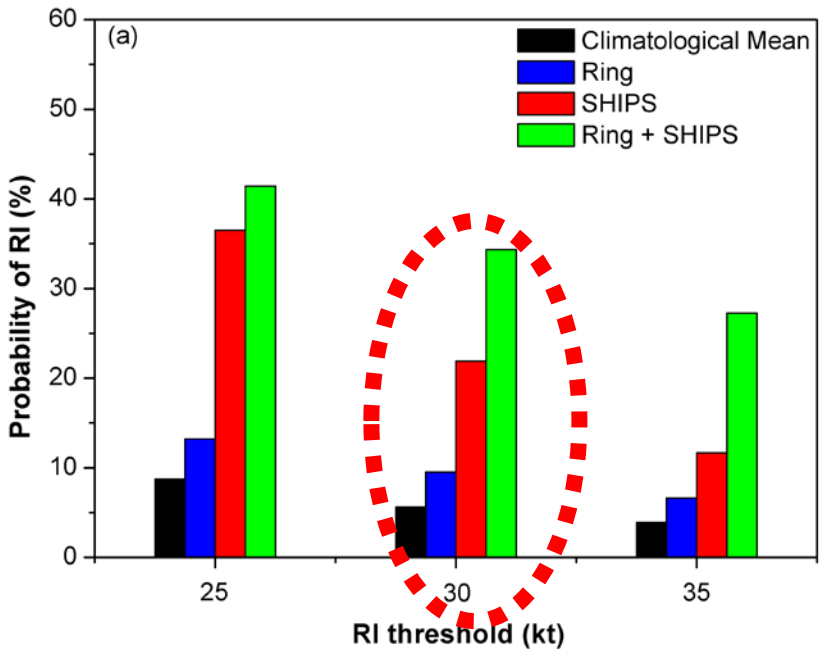
Sample Size (each TMI overpass as one sample)

RI Thresholds For 24-h Intensity Change	25 kt	30 kt	35 kt
ATL (974 total)	85 RI/889 non-RI	55 RI/919 non-RI	38 RI/936 non-RI
EPA (541 total)	55 RI/486 non-RI	39 RI/502 non-RI	27 RI/514 non-RI

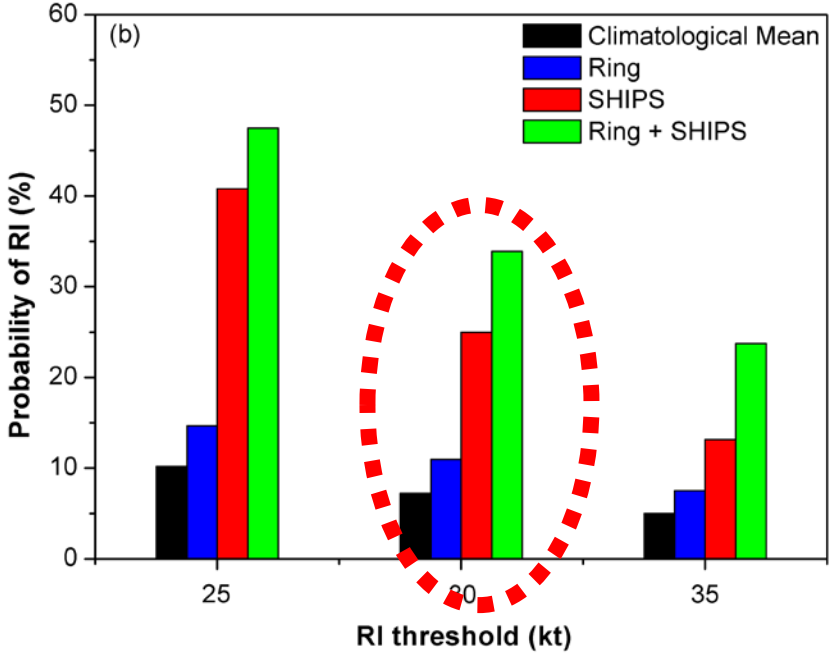
Jiang et al. (2012, to be submitted to WAF)

Probability of RI

Atlantic



Eastern Pacific



Probability of RI for 30 kt RI Threshold	Climatology mean	Ring	SHIPS	Ring+ SHIPS
ATL	6%	10%	22%	34%
EPA	7%	11%	25%	34%

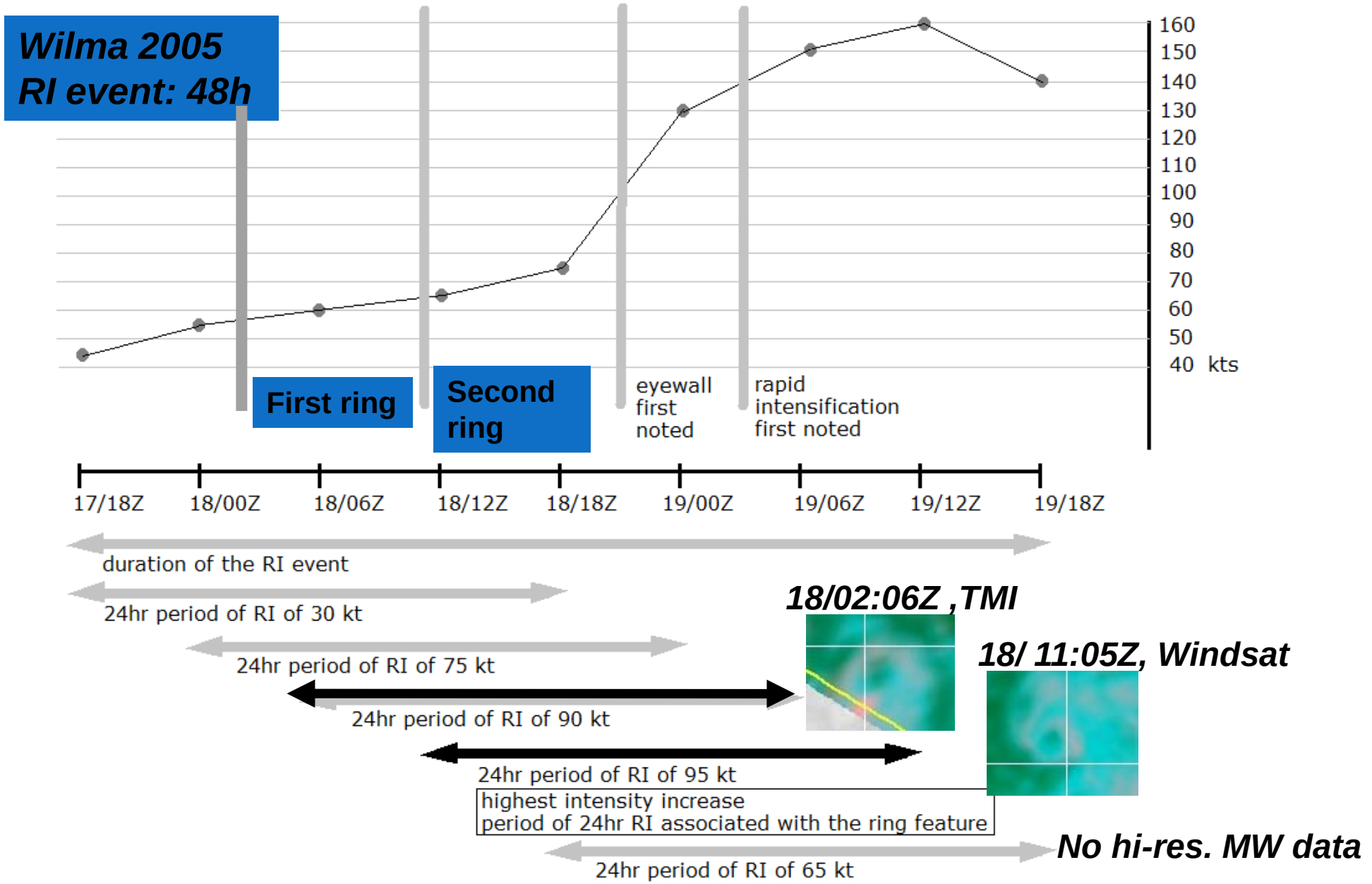
Evaluation 2: Using All Microwave Sensors

- TMI, AMSR-E, Windsat, SSM/I, SSMIS: 2003-2007 Atlantic TCs
- SHIPS RII independent (post-run) dataset
- Each 6-h best track point as one sample: microwave missing data points are removed
- Manually work, only consider 30 kt RI threshold

	Climat. Mean	Ring	SHIPS RII>20%	Ring+ SHIPS
# of total forecasts	**954**	**153**	**163**	**66**
# of correct forecasts	**71**	**39**	**55**	**38**
Probability of RI	**7%**	**25%**	**34%**	**58%**

Kieper and Jiang (2012, GRL, in revision)

Is this type of evaluation fair?



Part of the figure is from Kieper and Jiang (2012, GRL, in revision)

Evaluation 3: RI event-based verification

- Same dataset used in evaluation 2
- Each RI event is defined as the whole RI period for each storm's each intensifying period: more than one RI events for each storm is possible; usually includes several 24-h overlapping RI periods
- Only use the first ring to forecast each RI event

# of total RI events	25
# of total forecasts	25
# of correct forecasts	18 (5 MW late)
# of false alarms	7 (5 MW late)
Probability of detection (POD)	72%
False Alarm Ratio (FAR)	28%

➢*The method may miss the first 6-12 h of the onset of RI, but for most cases, the 37 GHz ring is associated with the highest intensity increase.*

Kieper and Jiang (2012, GRL, in revision)

Summary

- The 37 GHz ring pattern RI index is an independent predictor relative to the SHIPS RI index.
- For the 6 hourly based evaluation, the probability of RI increases about a factor of 3 relative to climatology when a 37 GHz ring pattern is detected, and about a factor of 8 when a 37 GHz ring pattern is detected and the SHIPS RI probability is equal or greater than 20%.
- For the event-based evaluation, the ring is associated with almost every RI event and is associated with the highest intensity increase period.

Works in Progress

- **Preparation for the real-time test at NHC during 2012 Hurricane season:** coding almost completed; TMI real-time data access obtained; need access for SSM/I and SSMIS data. ***(HELP NEEDED!)***
- **Further verification on the automatic algorithm using past AMSR-E, SSM/I, and SSMIS data**
- **Modify the "yes" & "no" type of prediction into "probability" format**
- **Similar RI index for the Western North Pacific basin (Postdoc Tie Yuan leads the work)**

Publications

- Jiang, H., T. Yuan, E. Zipser, and J. Kaplan, 2012: An objective rapid intensification index derived from the 37 GHz microwave ring pattern around the tropical cyclone center. *Wea. Forecasting*, to be submitted.

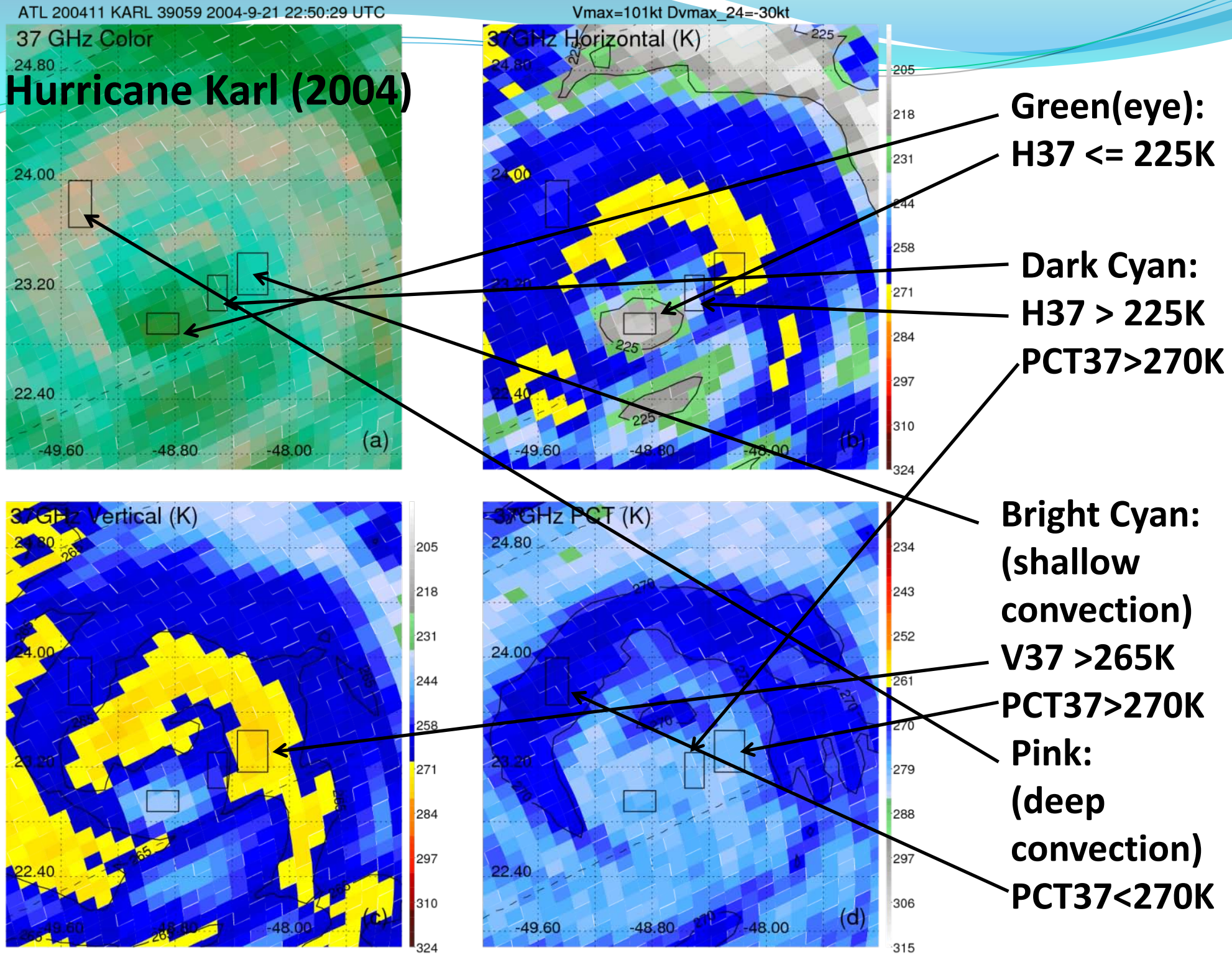
- Yuan T., and H. Jiang, 2012: Forecasting rapid intensification of tropical cyclones in the Western North Pacific using TRMM 37 GHz microwave observations. *Wea. Forecasting*, to be submitted.

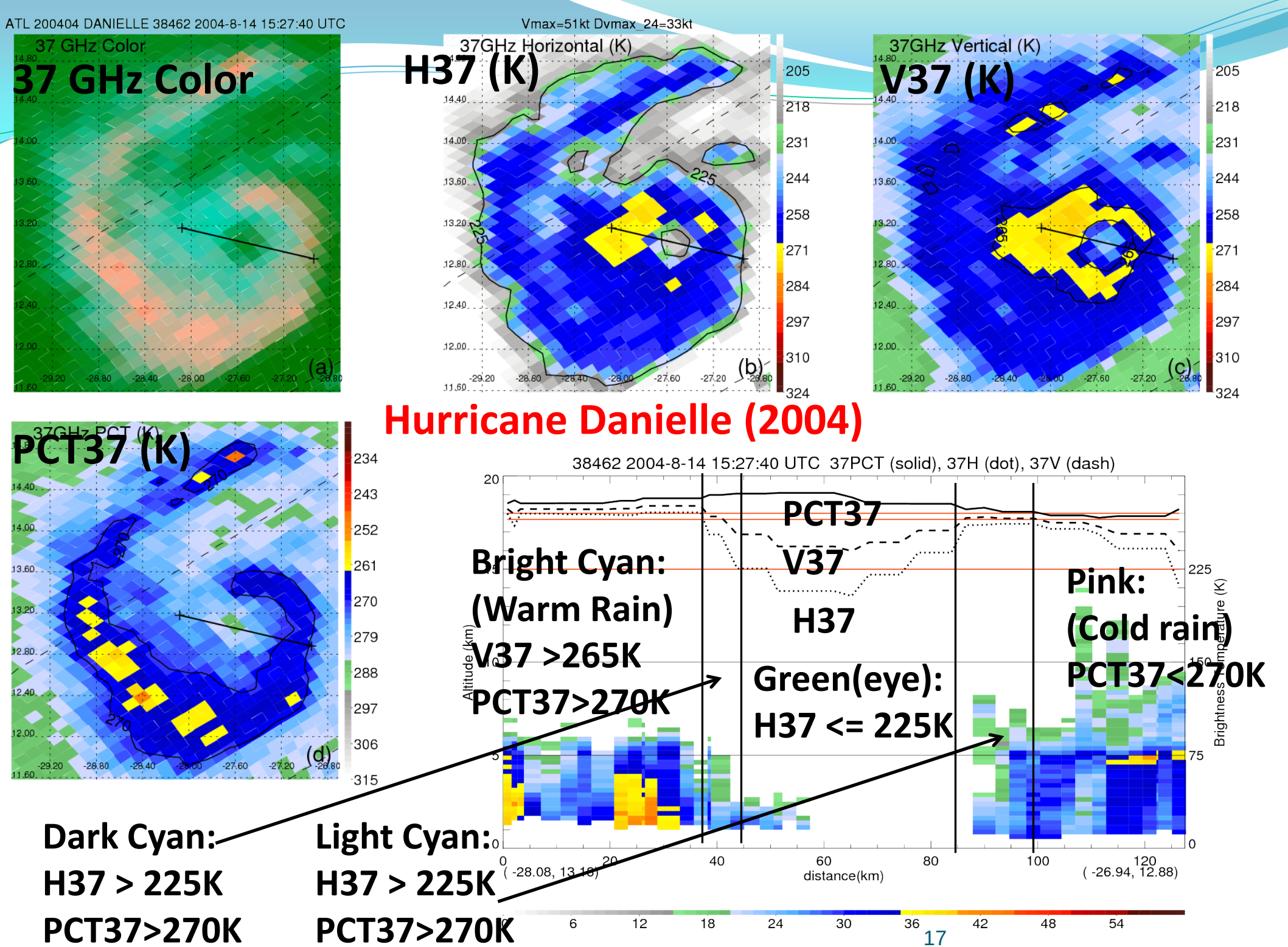
- Kieper, M., and H. Jiang, 2012: Predicting tropical cyclone rapid intensification using the 37 GHz ring pattern identified from passive microwave measurements. *Geophys. Res. Lett.*, in revision.

- Jiang, H., 2012: The relationship between tropical cyclone intensity change and the strength of inner core convection. *Mon. Wea. Rev*., in press.

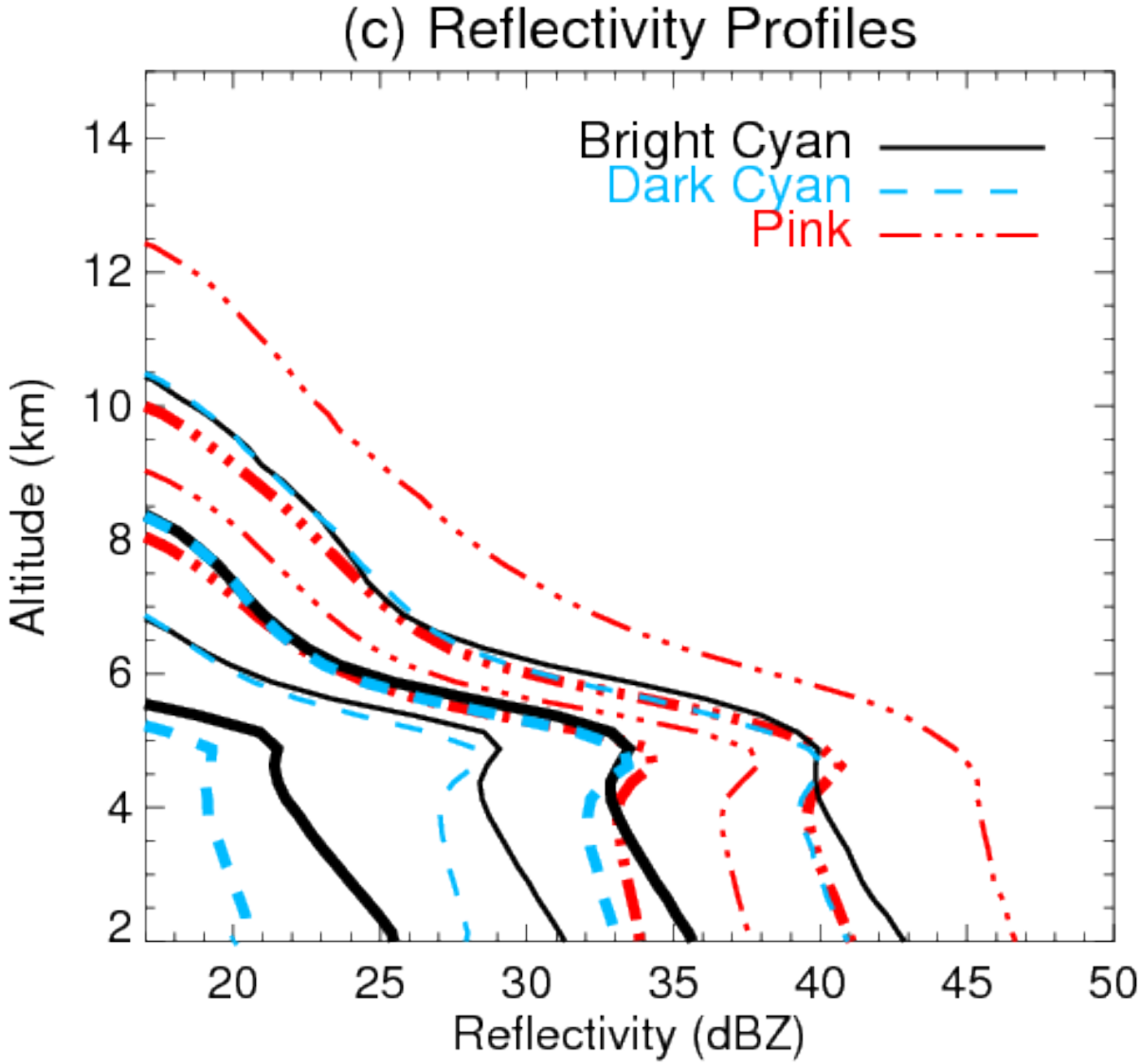
- Jiang, H., C. Liu, and E. J. Zipser, 2011: A TRMM-based Tropical Cyclone Cloud and Precipitation Feature Database. *J. Appl. Meteor. Climatol.*, **50**,1255-1274.

Thanks!


ATL 200411 KARL 39059 2004-9-21 22:50:29 UTC
Vmax=101kt Dvmax_24=-30kt
37 GHz Color
37GHz Horizontal (K)
37GHz Vertical (K)
37GHz PCT (K)
Hurricane Karl (2004)
Green(eye):
H37 <= 225K
Dark Cyan:
H37 > 225K
PCT37>270K
Bright Cyan:
(shallow
convection)
V37 >265K
PCT37>270K
Pink:
(deep
convection)
PCT37<270K


ATL 200404 DANIELLE 38462 2004-8-14 15:27:40 UTC
Vmax=51kt Dvmax_24=33kt
37 GHz Color
37 GHz Color
37GHz Horizontal (K)
H37 (K)
37GHz Vertical (K)
V37 (K)
37GHz PCT (K)
PCT37 (K)
Hurricane Danielle (2004)
38462 2004-8-14 15:27:40 UTC 37PCT (solid), 37H (dot), 37V (dash)
PCT37
V37
H37
Bright Cyan:
(Warm Rain)
V37 >265K
PCT37>270K
Green(eye):
H37 <= 225K
Pink:
(Cold rain)
PCT37<270K
Dark Cyan:
H37 > 225K
PCT37>270K
Light Cyan:
H37 > 225K
PCT37>270K
Altitude (km)
distance(km)
Brightness Temperature (K)
(-28.08, 13.16)
(-26.94, 12.88)

CDFs of PR reflectivity profiles for bright cyan, dark cyan and pink regions in the 37color images in the TC inner core from 45 well-observed PR overpasses for Atlantic TCs during 1998-2009. Contour levels are 50% (bold), 75%, 90% (bold), and 99%

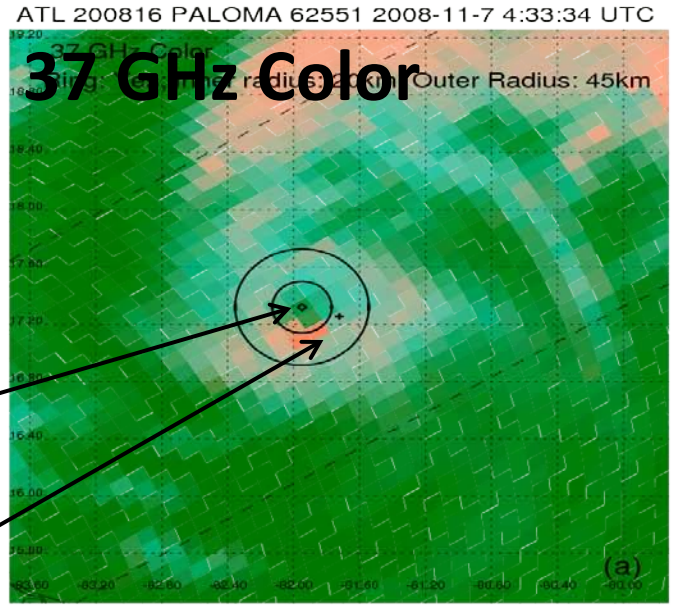


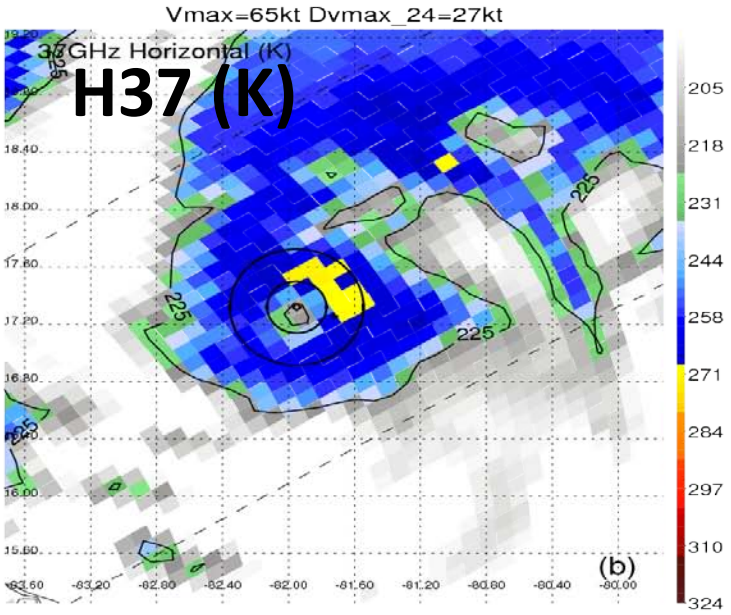
37 GHz ring detection: ATL Hurricane Paloma (2008)

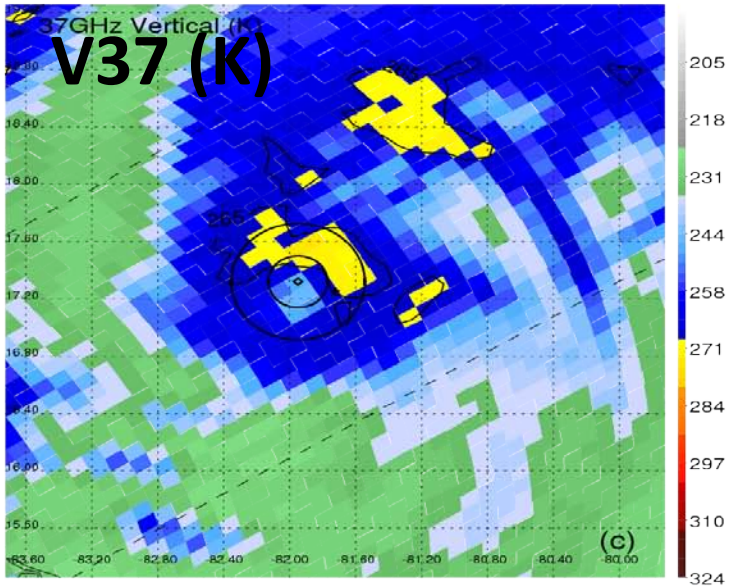
- Best track center is relocated
- The ring meets the minimum thickness requirement
- Solid bright cyan and pink

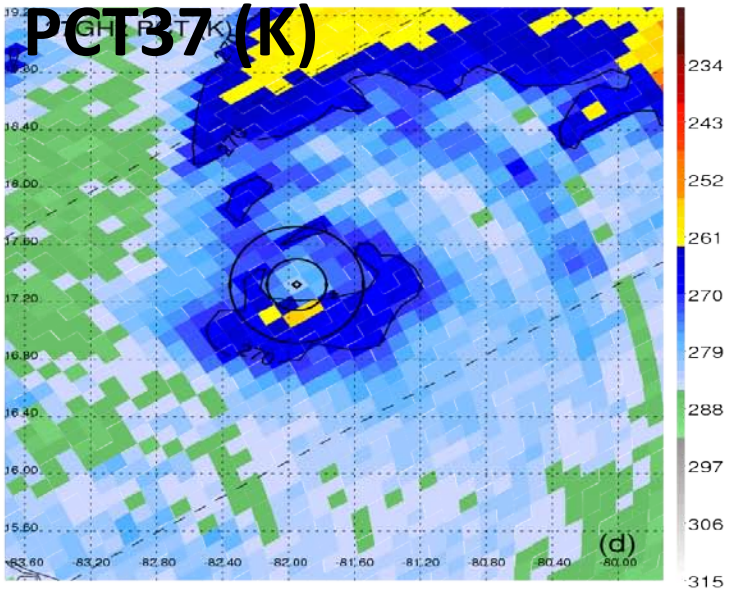
New center

Original center









An Automatic 37 GHz Ring Pattern Identification Algorithm

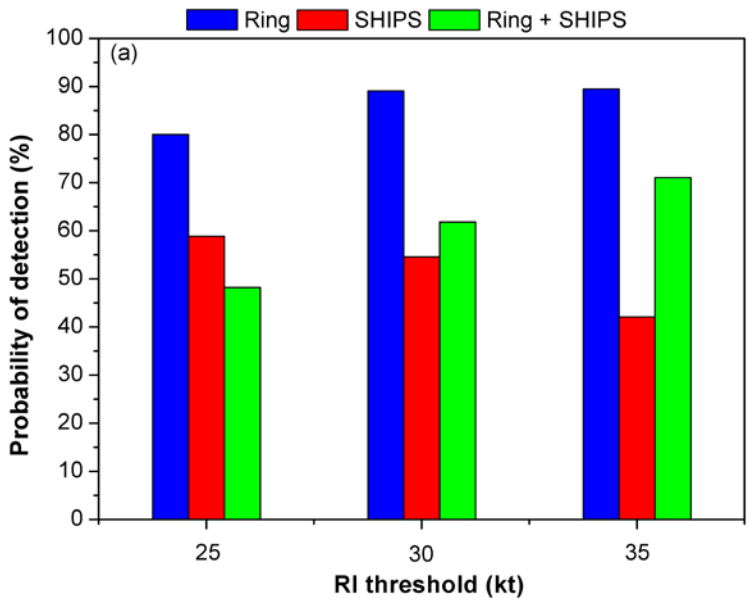
- Relocate the TC center if the best track center is not consistent with 37 GHz pattern
- Search out from the center with 5-km increments to find the inner and outer edges of the ring, if any.
- The ring should be either solid bright cyan or pink.
- The minimum thickness of the ring is ¼ of the diameter of the outer edge.
- The maximum diameter of the ring is 160 km.

13-yr (1998-2010) TRMM Tropical Cyclone Precipitation Feature (TCPF) database webpage:

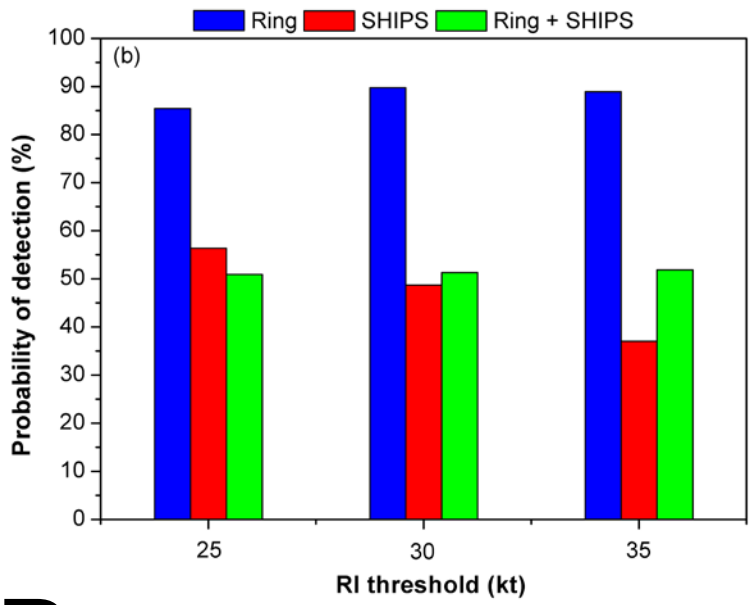
http://tcpf.fiu.edu/

POD

Atlantic



Eastern Pacific



FAR