

The 37-GHz Ring Pattern As An Early Indicator of Tropical Cyclone Rapid Intensification

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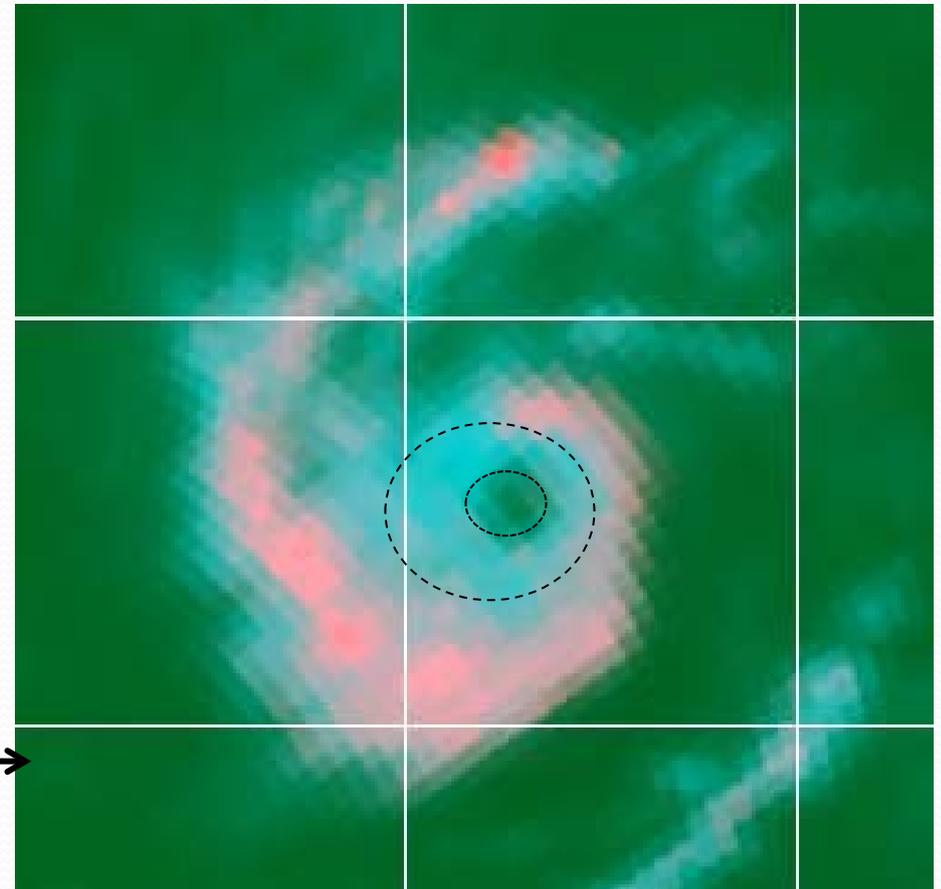
Background

- Both the large-scale environmental conditions and the storm internal processes have influences on Tropical Cyclone (TC) Rapid Intensification (RI).
- SHIPS RI index (Kaplan and DeMaria 2003) is a well-established RI index which uses the environmental parameters to predict the probability of RI.
- Recently Margie Kieper (AMS presentations 2008, 2010; Tech. Doc. for NOAA NHC 2009) found that the first appearance of a cyan color ring (from NRL 37 GHz color product) around the eye could be an early indicator of RI when environmental conditions are favorable.
- Kieper's subjective RI forecast method was tested in real time for 2008, 2009 and 2010 hurricane seasons and turns out to be a successful method.

Background (Cont.)

- In order to translate Kieper's eye-based subjective method into an objective and automatic prediction method, quantitative information is needed.
- However, the NRL 37 GHz color product sacrifices quantitative information.

NRL 37 GHz Color Product for Hurricane Danielle (2004), TRMM TMI overpass at 08/14/2004 1527Z. Ten kt intensity increasing during the next 6 hours.

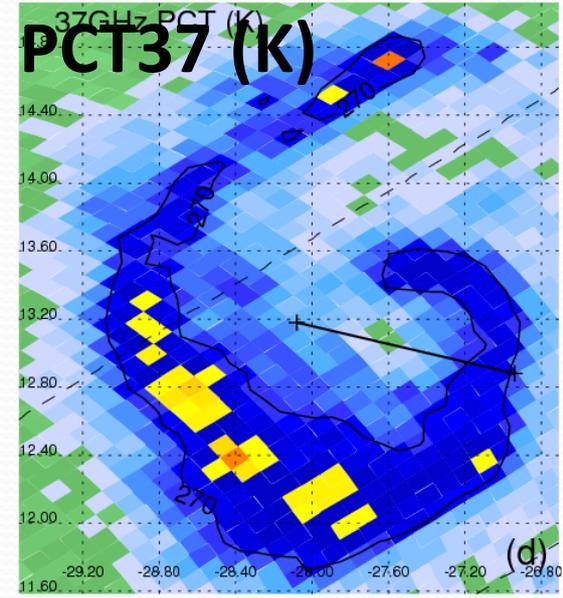
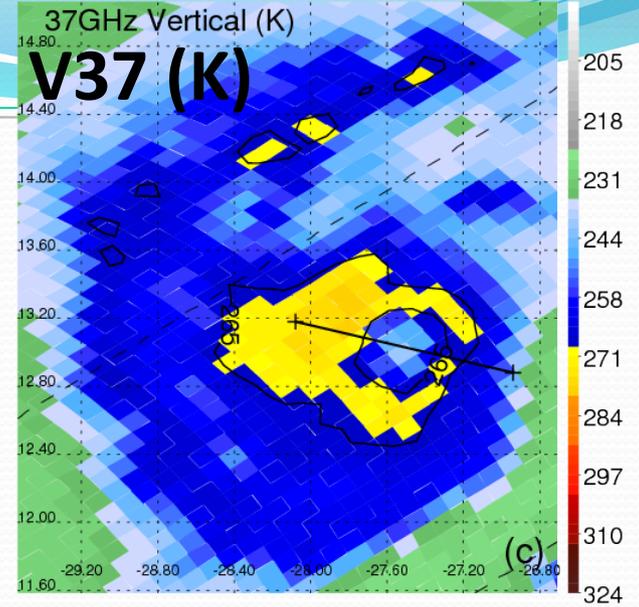
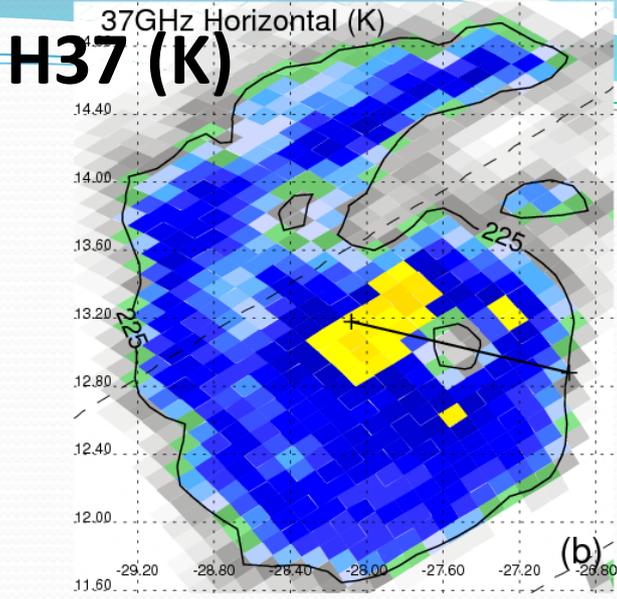
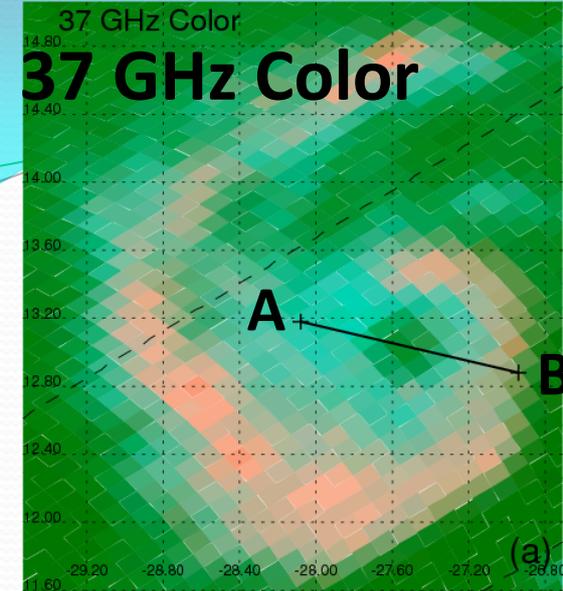


Objectives

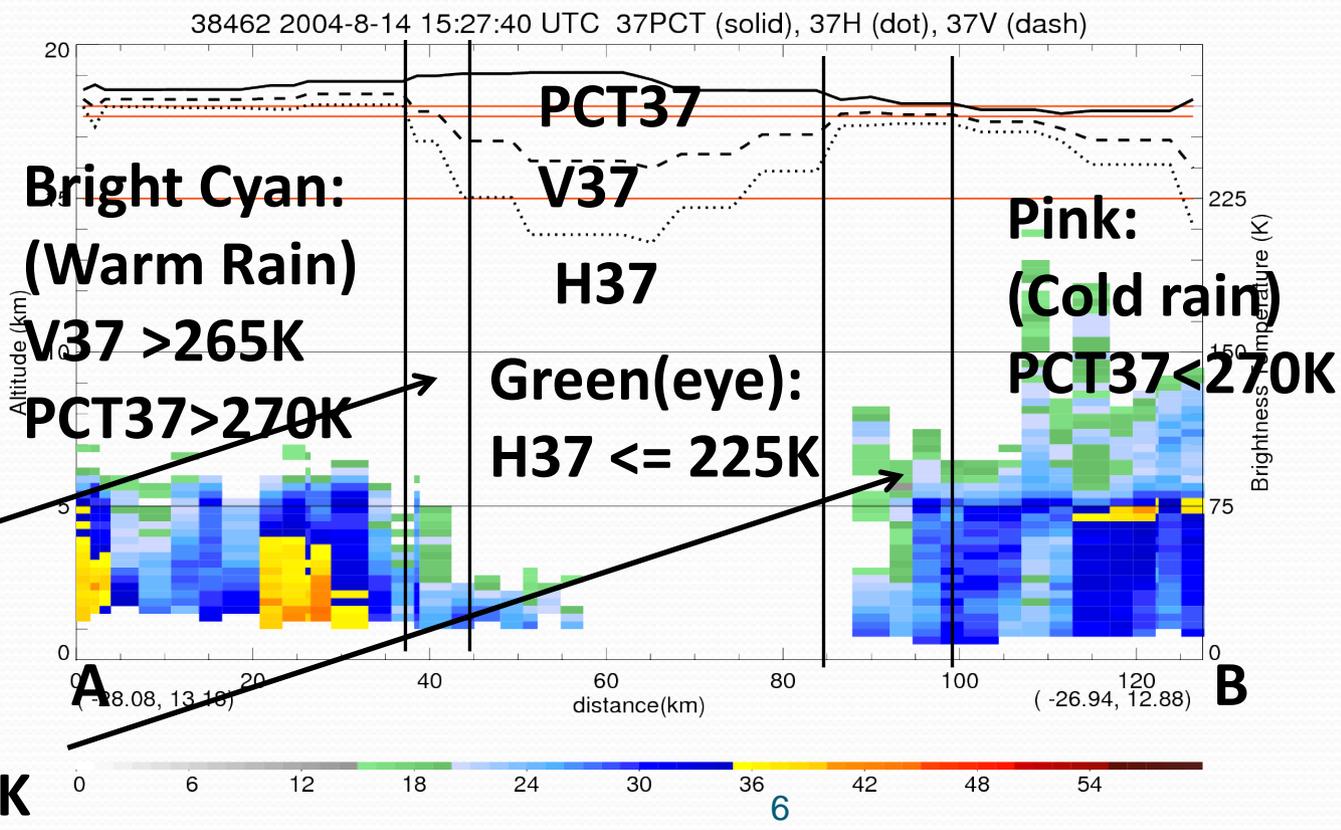
- Determine the 37 GHz quantitative information in the NRL 37 color product by using a 12-yr TRMM based TC precipitation feature (TCPF) database (Jiang et al. 2011).
- Develop an automatic 37 GHz ring pattern identification algorithm.
- Develop an objective 37 GHz ring pattern RI index for Atlantic and Eastern Pacific storms.
- Evaluate the ring RI index by using TRMM observations from 2002 to 2009.
- Evaluate the improvement of the SHIPS RI index by adding the ring RI index.

Determine the Quantitative Information of NRL 37 GHz Color Product

- **Data used:** 12-yr (1998-2009) of FIU/UU TRMM TCPF database.
- **37 GHz parameters:** Polarization Corrected brightness Temperature (**PCT37**), Vertically polarized brightness temperature (**V37**), and Horizontally polarized brightness temperature (**H37**)
- **Method:**
 - 1) Selecting many storms with good cyan rings
 - 2) Using the TRMM collocated dataset to determine the quantitative values of PCT37, V37 and H37 for cyan color regions in the NRL TC images.



Hurricane Danielle (2004)



Dark Cyan:
 $H37 > 225K$
 $PCT37 > 270K$

Light Cyan:
 $H37 > 225K$
 $PCT37 > 270K$

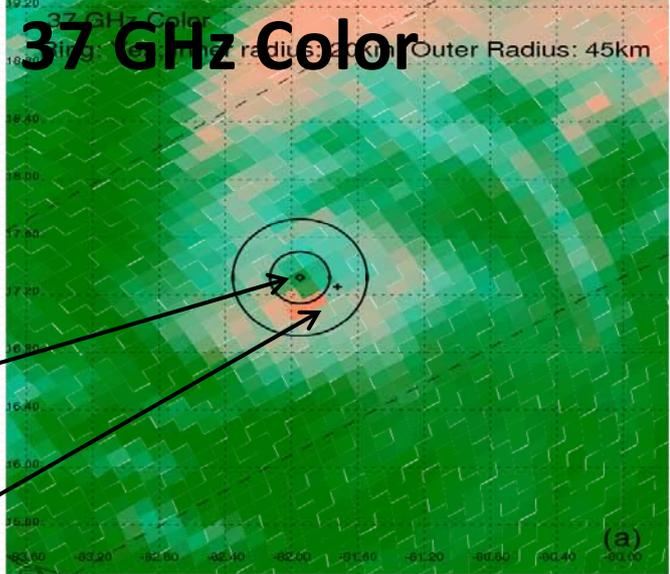
An Automatic 37 GHz Ring Pattern Identification Algorithm

- 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 $\frac{1}{4}$ of the diameter of the outer edge.
- The maximum diameter of the ring is 160 km.

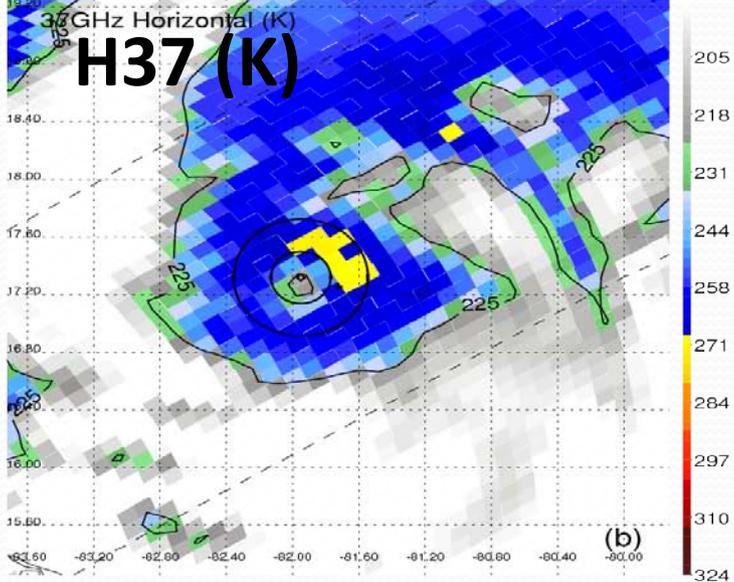
37 GHz ring detection: ATL Hurricane Paloma (2008)

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

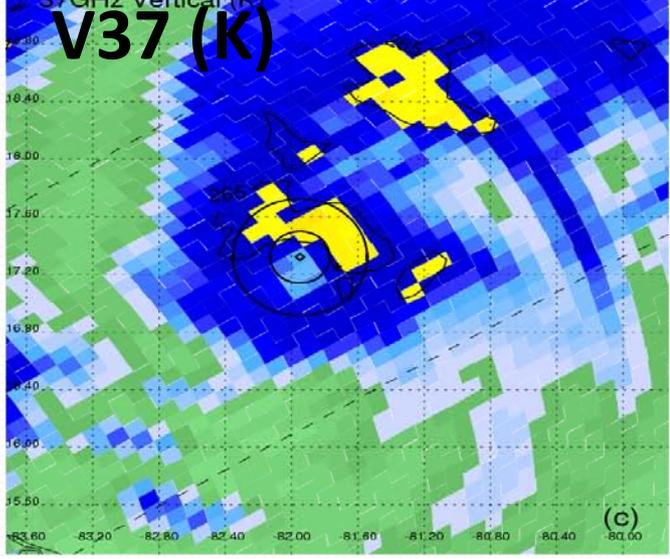
ATL 200816 PALOMA 62551 2008-11-7 4:33:34 UTC



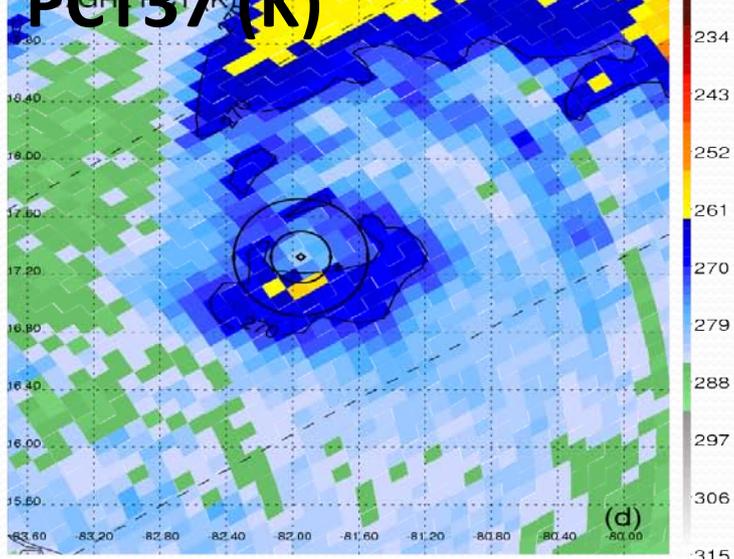
Vmax=65kt Dvmax_24=27kt



37GHz Vertical (K)



37GHz PCT (K)



The Objective 37 GHz Ring Pattern RI Index (Ring Index)

- A ring pattern is detected by the automatic 37 GHz ring pattern identification algorithm.
- Initial TC intensity is between 45 - 135 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 is $\geq 20\%$

Evaluation Dataset

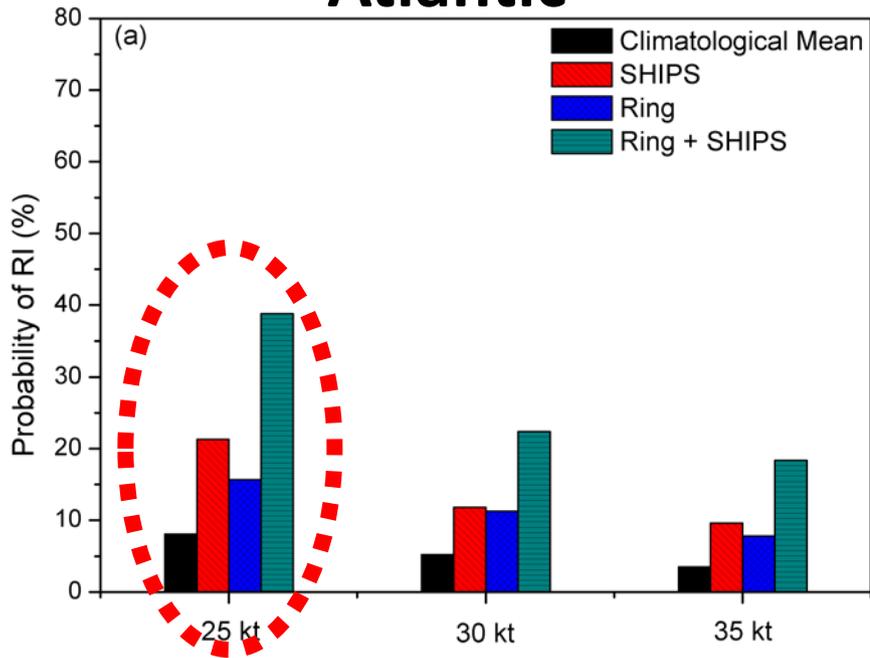
- TRMM TMI observed TCs from 2002-2009.
- SHIPS RI probability data from 2002-2009.

Sample Size

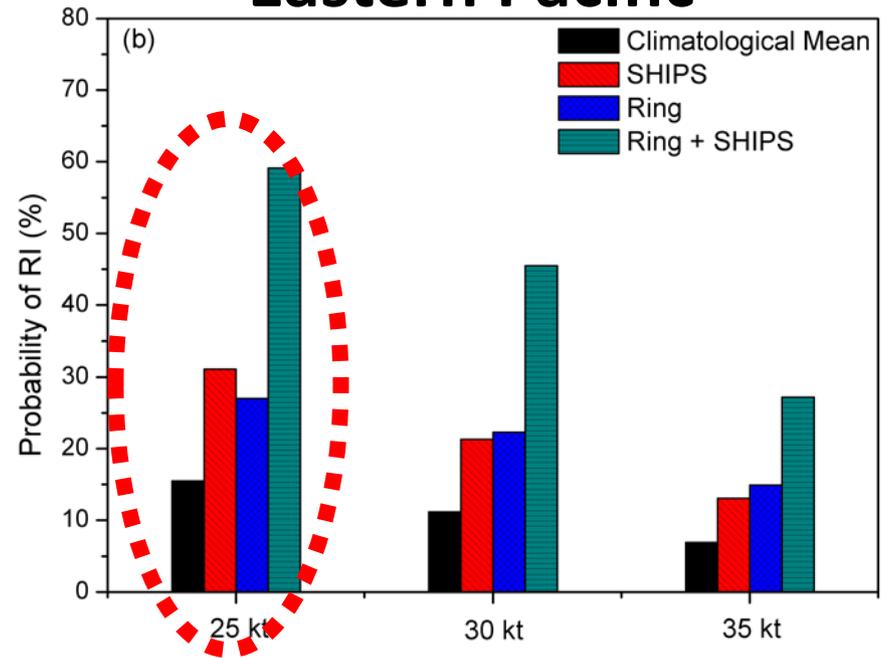
RI Thresholds For 24-h Intensity Change (Kaplan et al. 2010)	25 kt	30 kt	35 kt
ATL (621 total)	50 RI/571 non-RI	32 RI/588 non-RI	22 RI/598 non-RI
EPA (394 total)	61 RI/333 non-RI	44 RI/350 non-RI	27 RI/367 non-RI

Probability of RI

Atlantic



Eastern Pacific

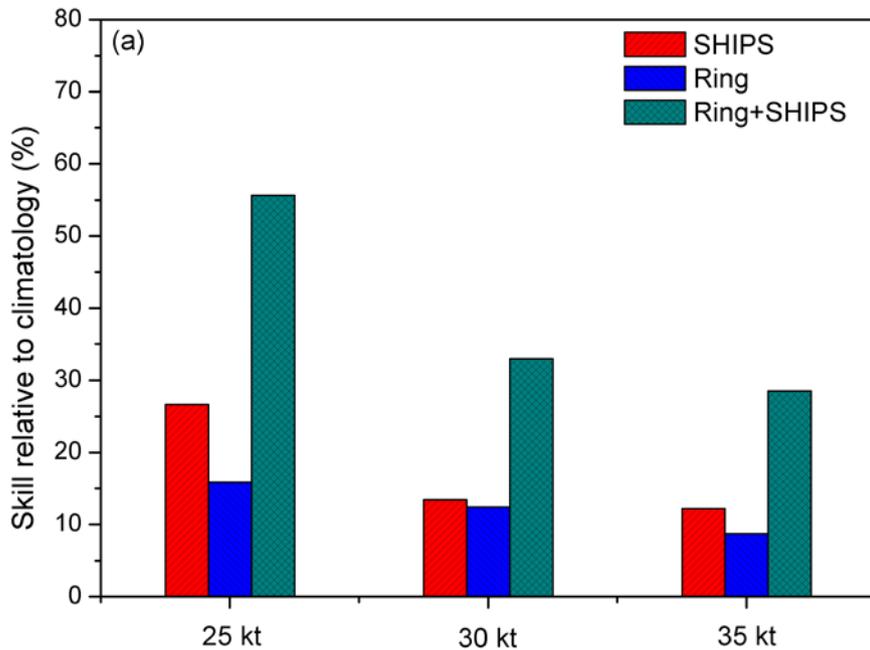


Probability of RI for 25 kt RI Threshold	Climatology mean	Ring	SHIPS	Ring+SHIPS
ATL	8%	16%	20%	39%
EPA	15%	28%	32%	59%

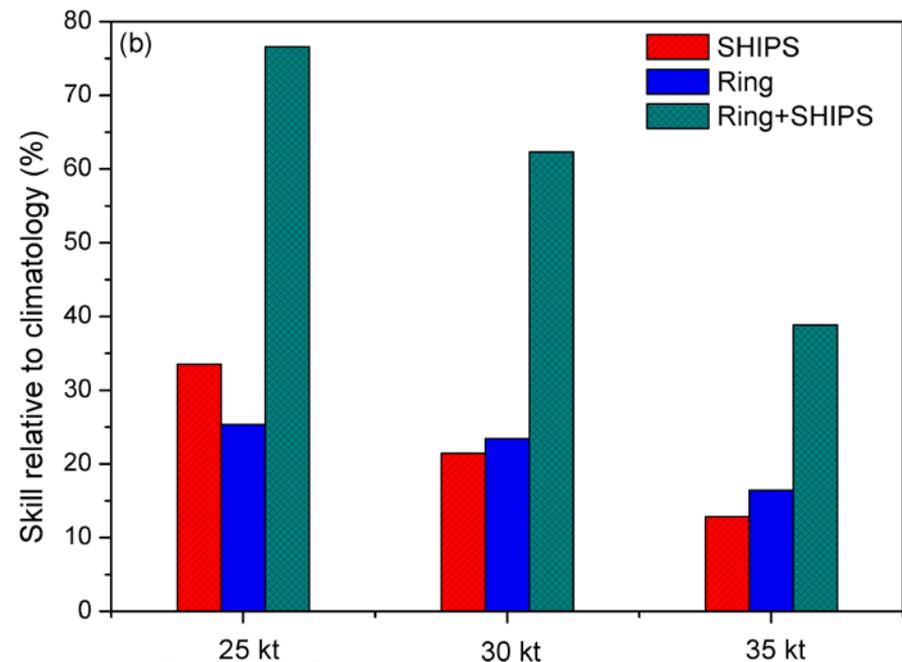
Brier Skill Score

- **Positive** skill score: skillful relative to climatology.
- **100%** means perfect.
- **Negative**: not skillful. (Kaplan et al. 2010)

Atlantic



Eastern Pacific



- Both Ring and SHIPs RI indices are skillful.
- The combined Ring+SHIPS RI index is a factor of 2 more skillful than using one index alone.

Summary

- The quantitative information for the NRL 37 GHz color product has been determined by using the TRMM TCPF database.
- The 37 GHz ring pattern RI index is an independent predictor relative to the SHIPS RI index.
- The probability of RI increases about a factor of 2 relative to climatology when a 37 GHz ring pattern is detected.
- The probability of RI increases about a factor of 4-5 when a 37 GHz ring pattern is detected and the SHIPS RI probability is equal or greater than 20%.



**13-yr (Dec. 1997-Dec. 2010) TRMM
Tropical Cyclone Precipitation Feature
(TCPF) database webpage:**

<http://tcpf.fiu.edu/>



Thanks!