Improvement and Implementation of the Probability-based Microwave Ring Rapid Intensification Index (PMWRing RII) for NHC/JTWC Forecast– Year 3 Update

Presenter: Yongxian Pei[1]
PI: Haiyan Jiang [1]; Co-PI: Kate Musgrave [2]
Contributors: Jon Zawislak [1,3] and Galina Chirokova [2]
[1]*Florida International University*
[2] *Colorado State University CIRA*
[3] *NOAA HRD/ UM CIMAS*

Acknowledgements:
1) NHC Points of Contact: ***Stacy Stewart, John Cangialosi, and Chris Landsea***
2) JTWC Point of Contact: ***Brian deCicco***
3) This NOAA Joint Hurricane Testbed project was funded by the US Weather Research Program in NOAA/OAR's Office of Weather and Air Quality.

Project Overview

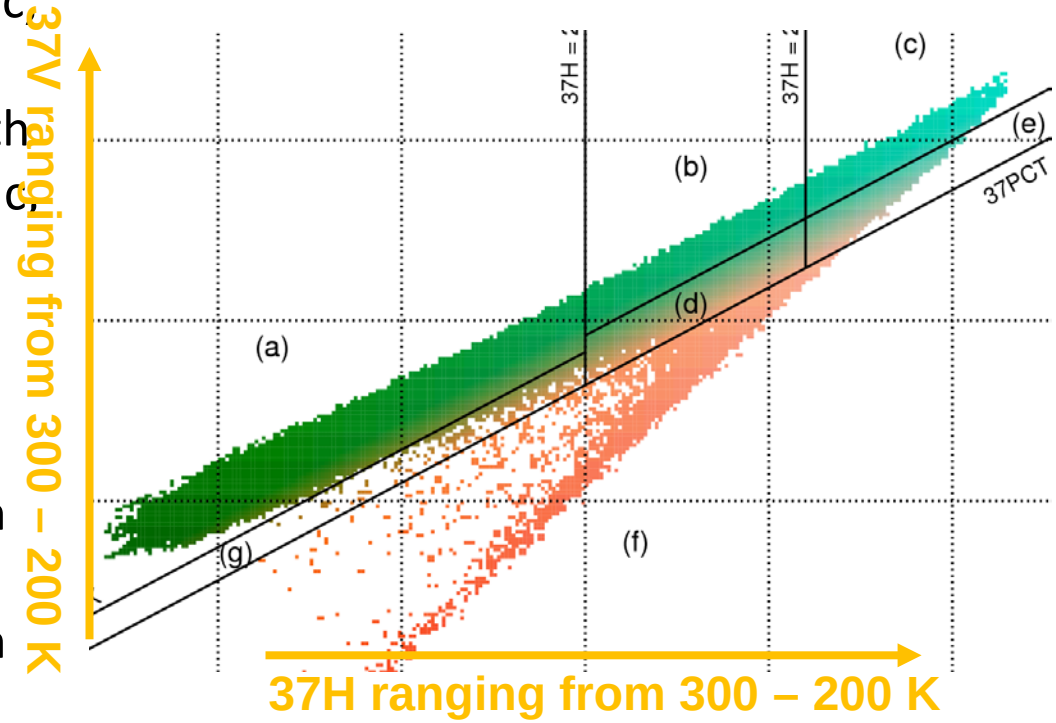
- **Two Parallel Algorithms (Based on inner core rainfall & convection structure)**
  - **1. 37 GHz Ring-Only RI Index (RII, yes & no type)**
    - **The algorithm is mature** after the ARCHER2 code (Wimmer and Velden 2016, JAMC) was implemented better center fixing & ring detection
    - **Algorithm Inputs:**
      - 1) NHC & JTWC A-DECKS TC track
      - 2) Operational SHIPS RII (Environmental Conditions)
      - 3) 37 GHz Microwave Satellite Data from GMI, AMSR-2,SSM/I, SSMIS, and WindSat.
    - **"Yes" RI Forecast Criteria** for 30 kt RI threshold (24-h intensity increase >= 30kt) for all NH & SH basins:
      - 1) A cyan+pink color ring pattern (Kieper and Jiang 2012) is identified from the NRL 37 GHz Color Product (Lee et al. 2002);
      - and 2) The SHIPS RI probability for 30 kt RI threshold >= 10% (environmental conditions are favorable).
  - **Real time testing results for all NH (2017) & SH (2017) basins will be reported here**

Project Overview

- **Two Parallel Algorithms**
  - **2. Probability-based Microwave Ring RI Index (PMWRing RII)**
    - **Task 1: Collecting historical microwave data from AMSR-E, SSM/I, and SSMIS and calibrating their T_B's to be compatible with TMI T_B's**
      - Sensitivity tests show that calibration is not needed for the 37 and 85 PCT thresholds that we chose. (reported in IHC2017)
    - **Task 2: (CIRA) Generating the SHIPS RII developmental dataset**
      - CIRA provided the data for both NH & SH basins (reported in IHC2017)
    - **Task 3: Development of the PMWRing RII for each basin**
      - Completed (will be reviewed here)
    - **Task 4: Real-time testing at NHC and JTWC**
      - NH basins were tested in 2016 & 2017; SH basin was tested in 2017 season (will be summarized here)
    - **Task 5: Evaluate the real-time testing results and refine the index based on lessons learned**
      - All results will be reported here.

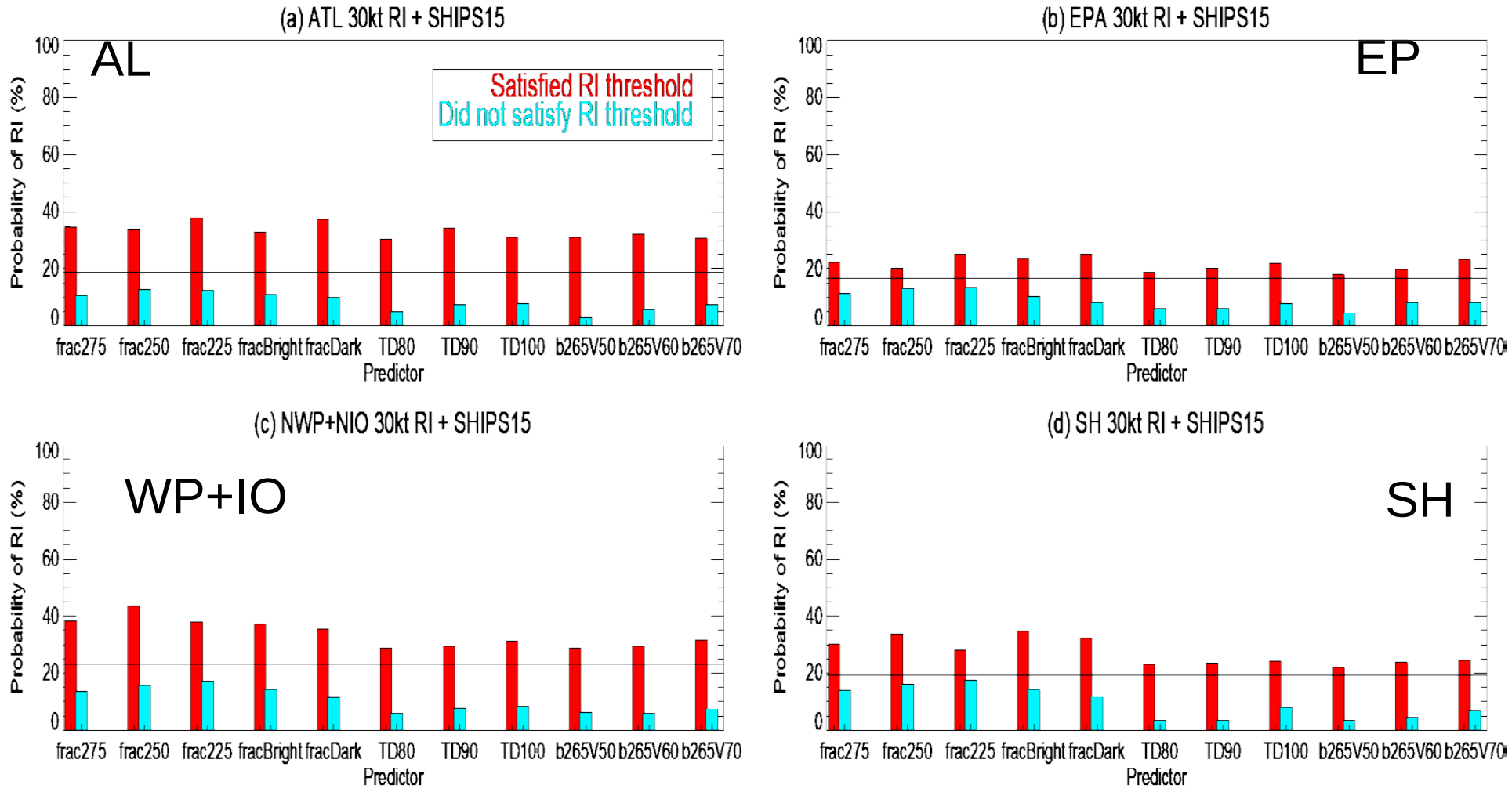
Development of the Probability-based Microwave Ring RI Index (PMWRing RII)

- **Predictors:**
  - **Ring:** 37 GHz cyan+pink ring (regions b, c, d, e, f, g)
  - **FracDark:** Fractional inner core area with 37 GHz color of cyan or pink (regions b, c, d, e, f, g)
  - **FracBright:** Fractional inner core area with 37 GHz color of bright cyan or pink (regions c, d, e, f, g)
  - **Frac275:** Fractional inner core area with 85 GHz PCT<275K
  - **Frac250:** Fractional inner core area with 85 GHz PCT<250K
  - **Frac225:** Fractional inner core area with 85 GHz PCT<225K
- **RI probabilities:** are generated based on a look-up table using all above predictors and SHIPS RII_30kt>= 15%



Scatter plot of real colors in the NRL 37color product as a function of 37H and 37V derived from the inner core region of TCs directly observed by the TRMM PR and TMI during 1998-2011.

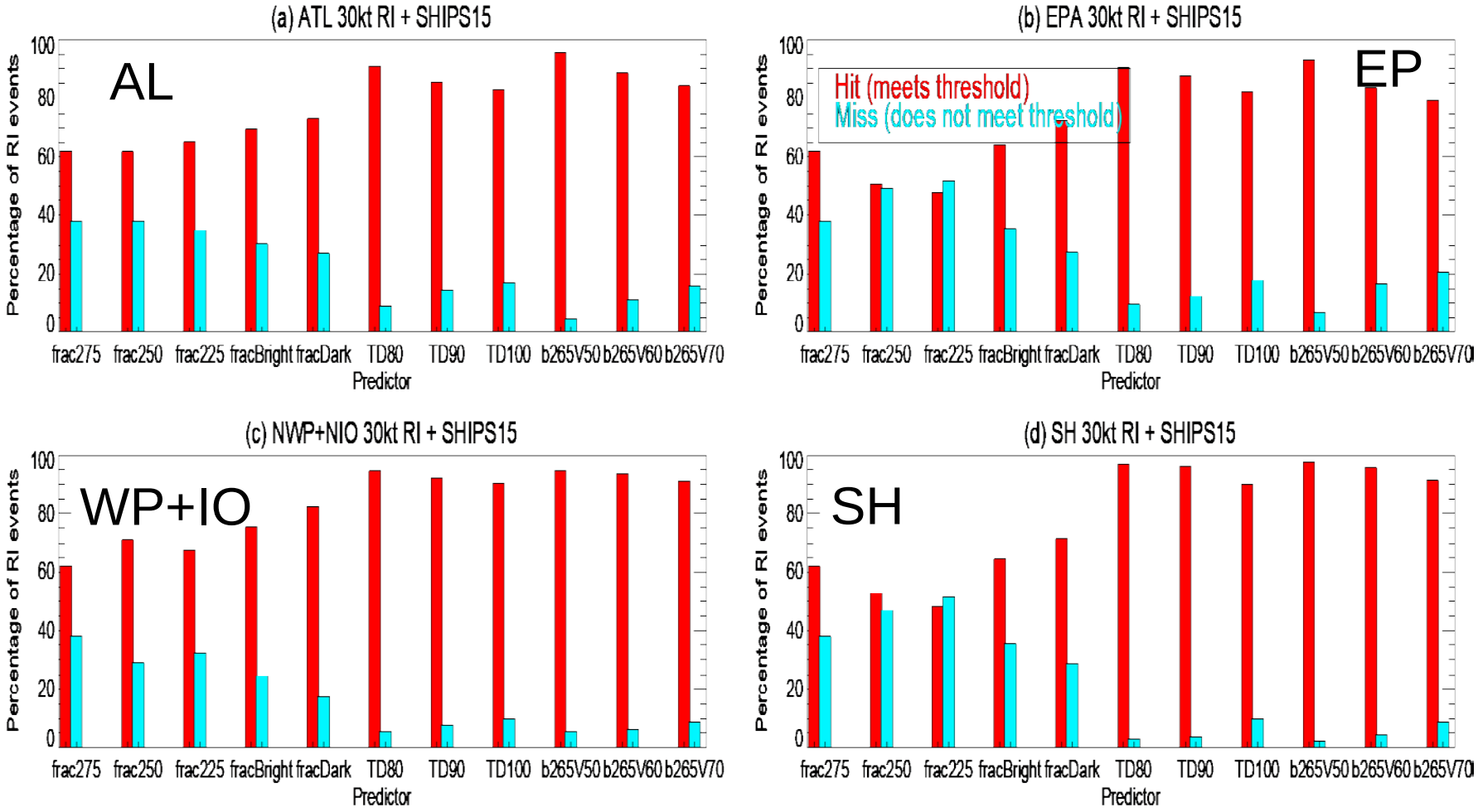
Developmental Results Using Historical Microwave Data:
Probability of RI for predictors satisfying and not satisfying RI threshold (30 kt/day RI; SHIPS_RII_30kt >=15%)



Solid line shows the climatology mean. All predictors are skillful in each basin. Results are similar for 25, 35, 40 kt/day RI categories.

Developmental Results:

% of Hit (POD, red bar) and % of Miss (FAR, blue bar) for 30 kt/day RI; SHIPS_RII_30kt >=15%



- POD is higher than FAR for all predictors in all basins, except frac225 in SH.
- The ring predictor produces the highest POD (nearly 100%) & lowest FAR (as low as less than 10%) in all basins.

PMW-Ring Algorithm Input & Output

- **Algorithm Input**
  - 1) NHC & JTWC A-DECKS TC track
  - 2) SHIPS RII
  - 3) 37 and 85 GHz Microwave Satellite Data from GMI, AMSR-2,SSM/I, and SSMIS (Note that Windsat has no 85 GHz channel; ARCHER2 source code for center fixing is integrated into our algorithm)
- **Output**
  - Probabilities of RI for 25, 30, 35, and 40 kt RI thresholds in AL, EP/CP, WP + IO, and SH basins.
  - Both 6-hourly and satellite overpass centered outputs are generated.

2017 Real-Time Testing

- **For NHC basins (AL and EP/CP) and JTWC basins (WP+IO and SH) : Jun 2017 – Nov 2017**
- **6-hourly forecasts are saved for different basins and different storms: http://tcpf.fiu.edu/JHT/Summary/**
- **Some storms were missed due to FIU server problems and FIU closure during Hurricane Irma**
- **Post-season re-run is done using best track data (Jan 2017-Dec. 2017).**

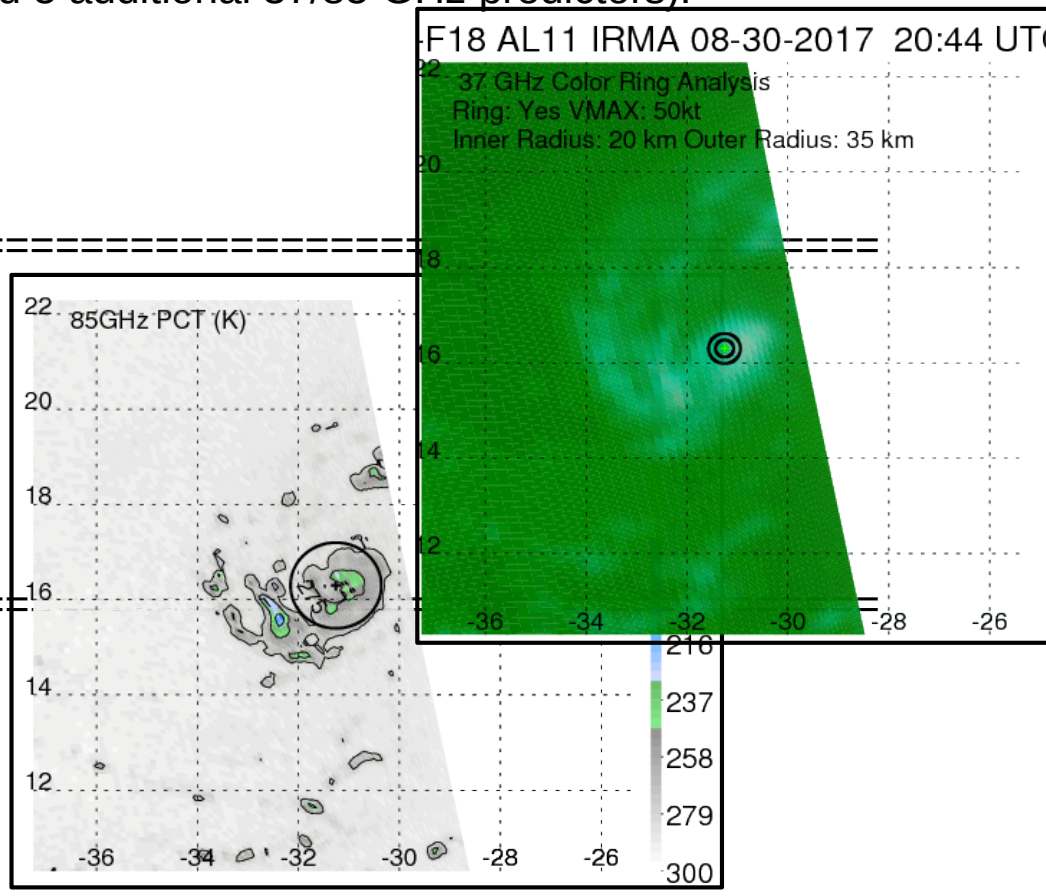
	AL	EP	WP + IO	SH	TOTAL
6 hourly data sample	188	122	198	136	644

2017 Examples: Irma (AL)

- For NHC basins (AL and EP/CP): Jun 2017 – Nov 2017

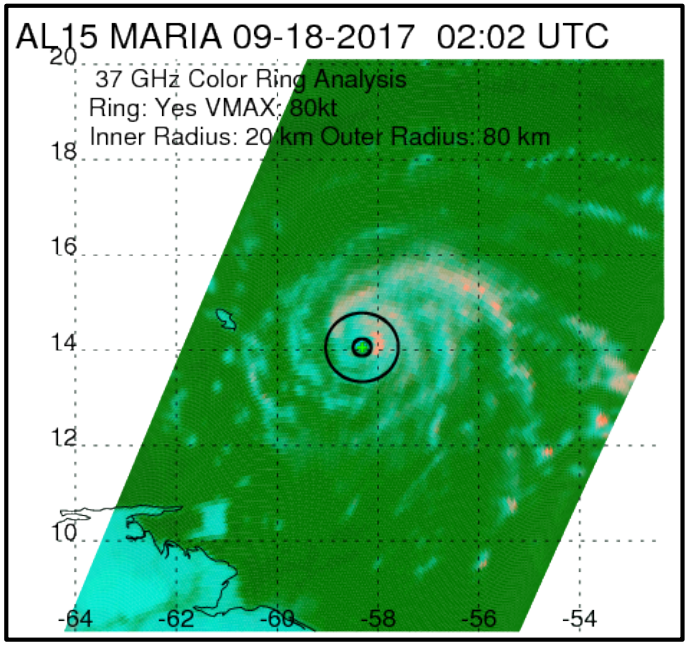
ATLANTIC 37 GHz Ring Only and PMWRing RI INDICES
IRMA AL11 2017 08/31/17 00 UTC
TMI,SSMI,SSMIS,AMSR2 and WINDSAT Total Overpass Orbits: 2
==========RI FORECAST BY THE 37 GHz Ring only and PMWRing RI INDICES DURING PAST 6 HOURS==========
===37 GHz Ring Only RI Forecast:===
FUTURE 24-HOUR INTENSITY INCREASE >= 30 KT (RI): YES
===PMWRing RI Forecast (based on 37 GHz Ring and 5 additional 37/85 GHz predictors):===
PROB OF RI FOR 25 KT RI THRESHOLD= 40%
PROB OF RI FOR 30 KT RI THRESHOLD= 37%
PROB OF RI FOR 35 KT RI THRESHOLD= 29%
PROB OF RI FOR 40 KT RI THRESHOLD= 23%
==========
----------Current SHIPS----------
PROB OF RI FOR 25 KT RI THRESHOLD= 27%
PROB OF RI FOR 30 KT RI THRESHOLD= 17%
PROB OF RI FOR 35 KT RI THRESHOLD= 11%
PROB OF RI FOR 40 KT RI THRESHOLD= 10%
==========

Example RI forecast:
Irma 2017083100
Intensity increase in the future 24 hours: 45 kt

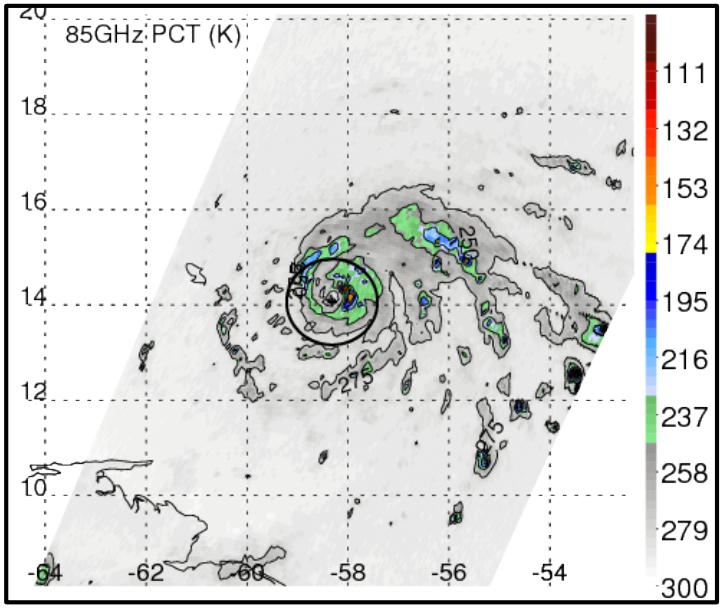


2017 Examples: Maria (AL)

ATLANTIC 37 GHz Ring Only and PMWRing RI INDICES
MARIA AL15 2017 09/18/17 06 UTC
TMI,SSMI,SSMIS,AMSR2 and WINDSAT Total Overpass Orbits: 2
==========RI FORECAST BY THE 37 GHz Ring only and PMWRing RI INDICES DURING PAST 6 HOURS==========
===37 GHz Ring Only RI Forecast:===
FUTURE 24-HOUR INTENSITY INCREASE >= 30 KT (RI): YES
===PMWRing RI Forecast (based on 37 GHz Ring and 5 additional 37/85 GHz predictors):===
PROB OF RI FOR 25 KT RI THRESHOLD= 41%
PROB OF RI FOR 30 KT RI THRESHOLD= 38%
PROB OF RI FOR 35 KT RI THRESHOLD= 25%
PROB OF RI FOR 40 KT RI THRESHOLD= 23%
==========
----------Current SHIPS----------
PROB OF RI FOR 25 KT RI THRESHOLD= 55%
PROB OF RI FOR 30 KT RI THRESHOLD= 49%
PROB OF RI FOR 35 KT RI THRESHOLD= 37%
PROB OF RI FOR 40 KT RI THRESHOLD= 35%
==========

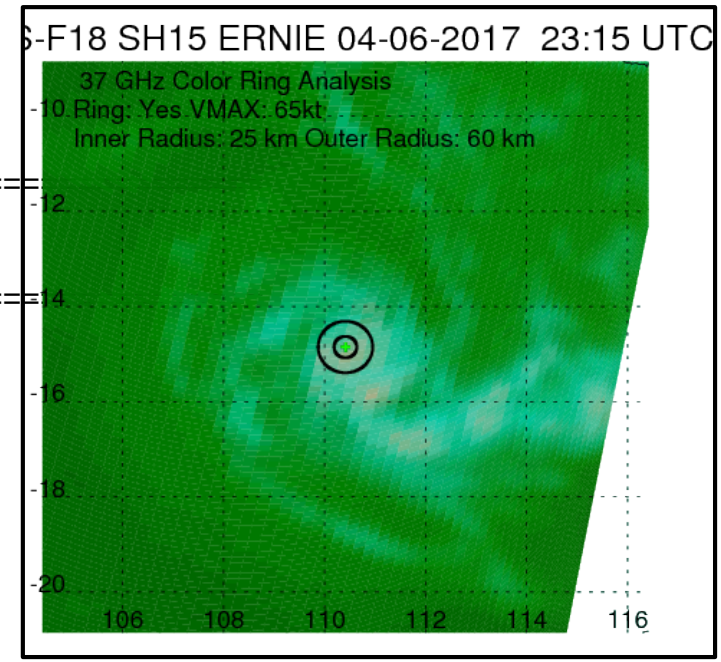


Example RI forecast: Maria 2017091806 Intensity increase in the future 24 hours: 55 kt

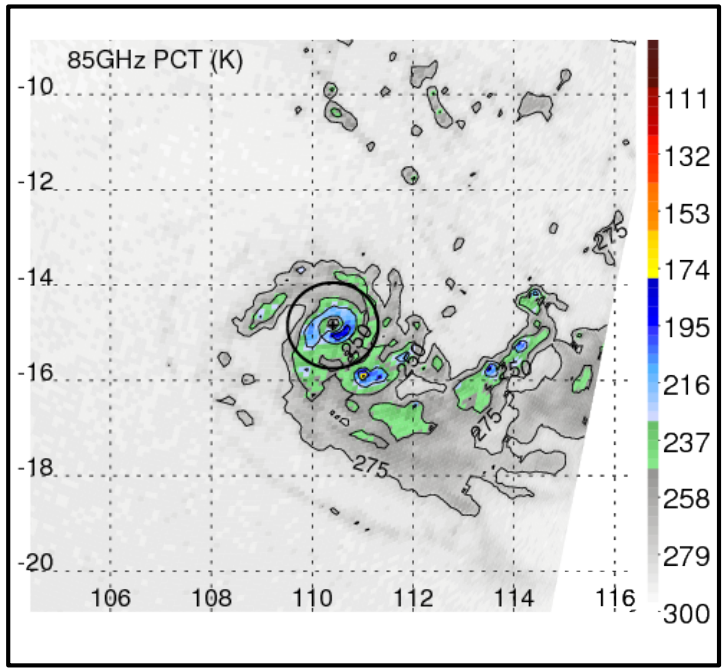


2017 Examples: Ernie (SH)

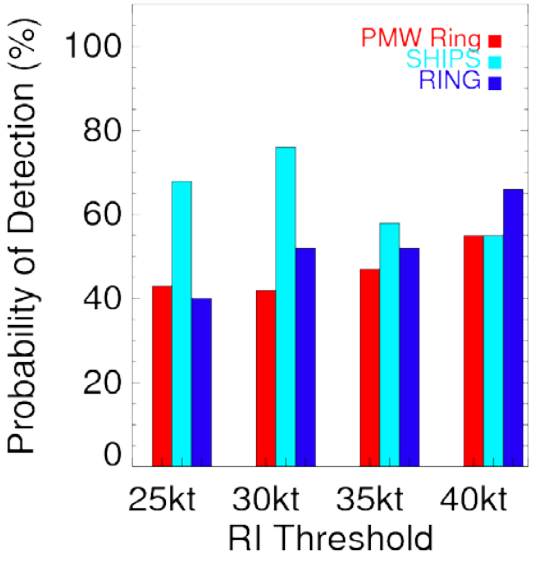
Southern Hemisphere 37 GHz Ring Only and PMWRing RI INDICES
ERNIE SH15 2017 04/07/17 0 UTC
TMI,SSMI,SSMIS,AMSR2 and WINDSAT Total Overpass Orbits: 2
==========RI FORECAST BY THE 37 GHz Ring only and PMWRing RI INDICES DURING PAST 6 HOURS==========
===37 GHz Ring Only RI Forecast:===
FUTURE 24-HOUR INTENSITY INCREASE >= 30 KT (RI): YES
===PMWRing RI Forecast (based on 37 GHz Ring and 5 additional 37/85 GHz predictors):===
PROB OF RI FOR 25 KT RI THRESHOLD= 34%
PROB OF RI FOR 30 KT RI THRESHOLD= 29%
PROB OF RI FOR 35 KT RI THRESHOLD= 20%
PROB OF RI FOR 40 KT RI THRESHOLD= 13%
==========
----------Current SHIPS----------
PROB OF RI FOR 30 KT RI THRESHOLD= 29%
==========

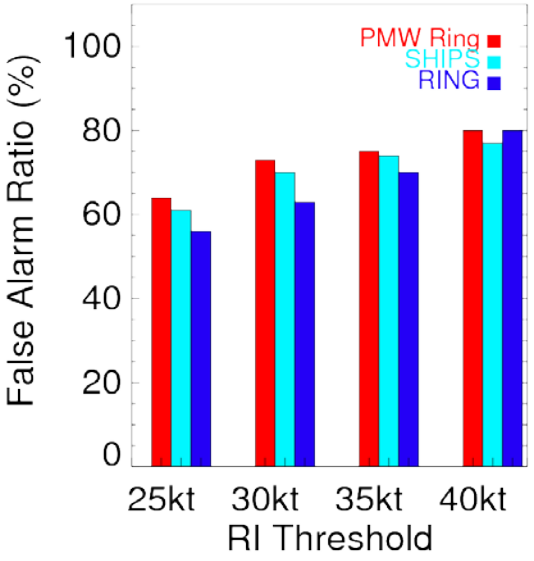


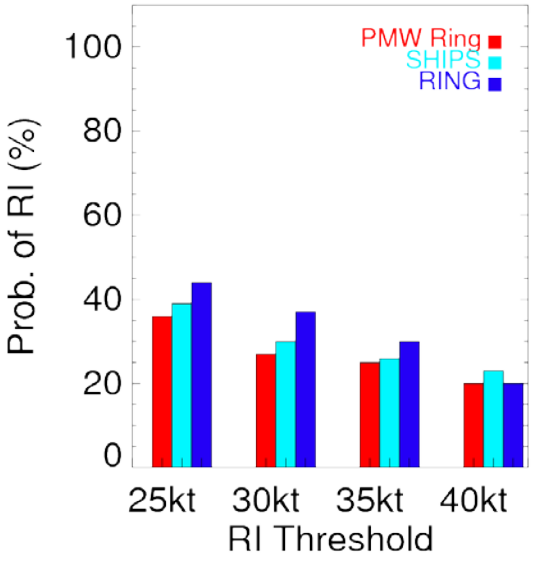
Example RI forecast: Ernie 2017040700 Intensity increase in the future 24 hours: 45 kt

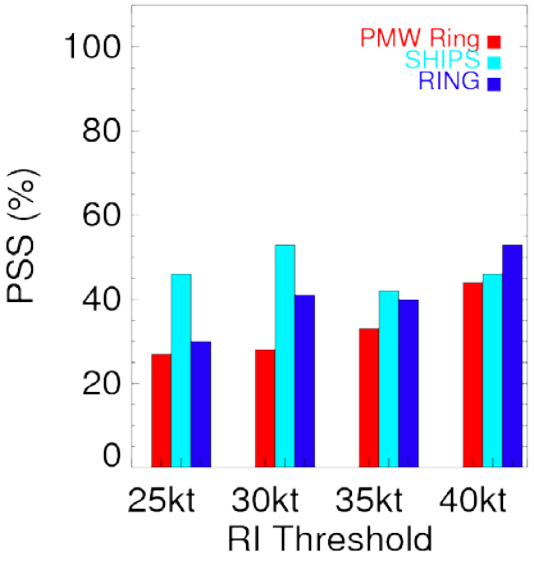


Statistical Results for 2017 Post-Season Re-run: AL





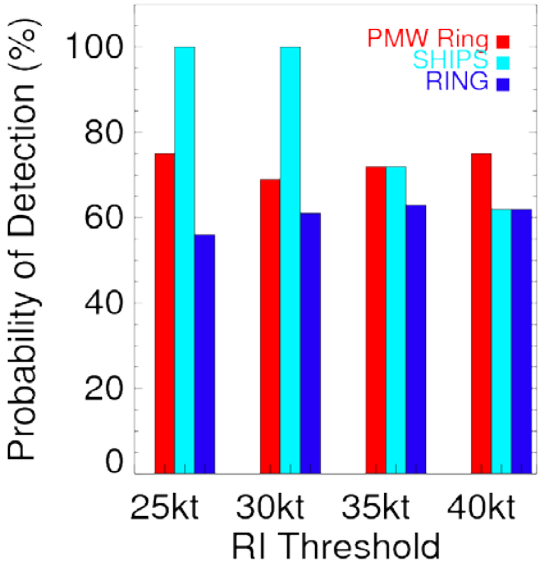


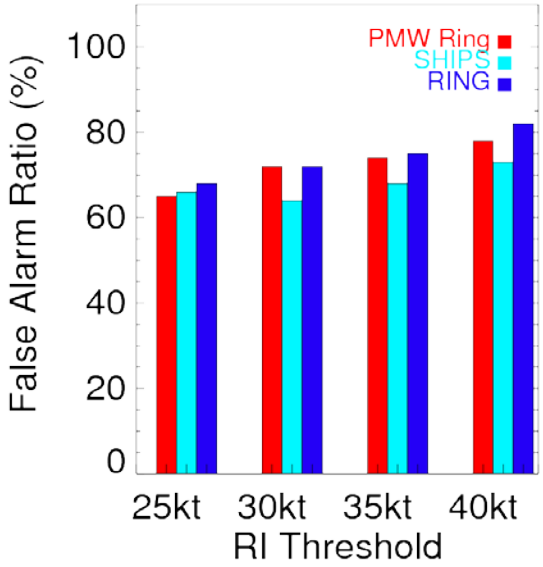


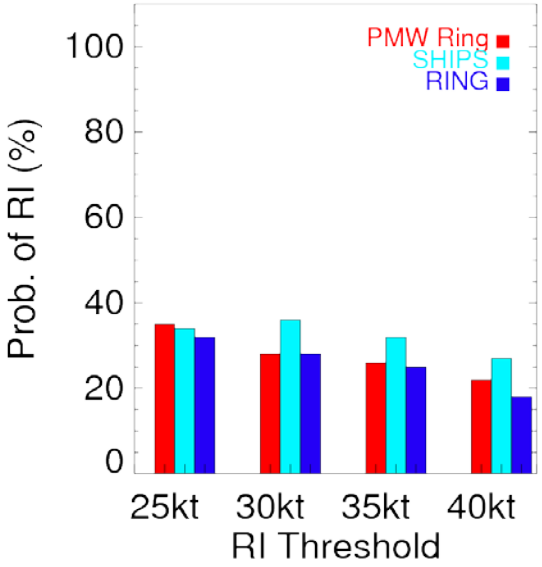
- **SHIPS RI thresholds for each basin were based on Kaplan et al. (2010).**
- **PMWRing RI thresholds were determined similarly as Kaplan et al. (2010).**

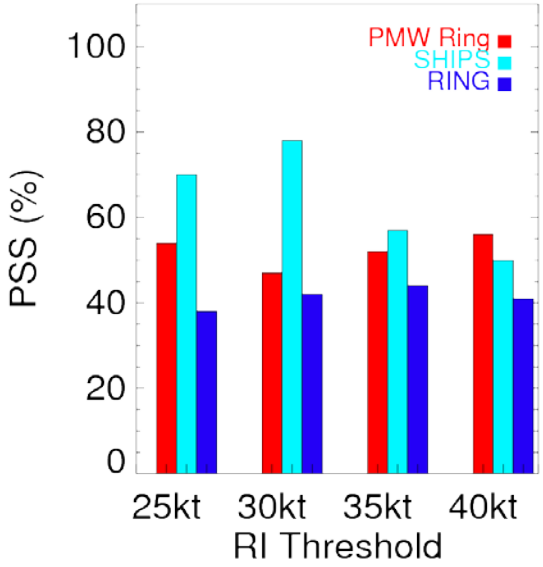
- **SHIPS RII produced the highest POD, lowest FAR, and therefore the best Peirce Skill Score (PSS) for 25, 30, and 35 kt RI thresholds**
- **The 37 GHz-Ring-only RII produced the highest POD and best PSS for the 40 kt RI threshold**

Results for 2017 Post-Season Re-run: EP+CP



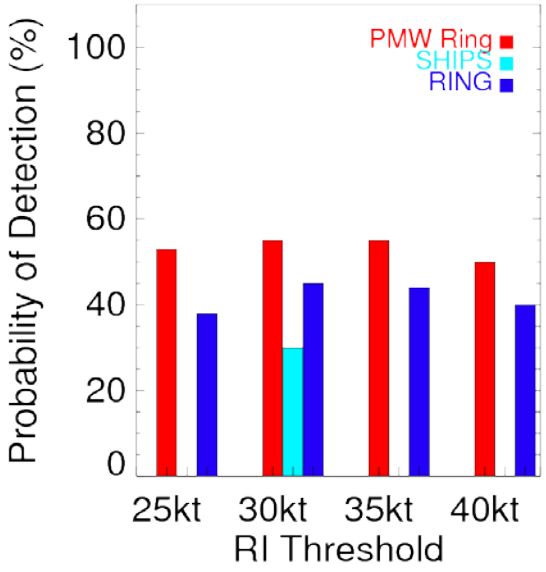


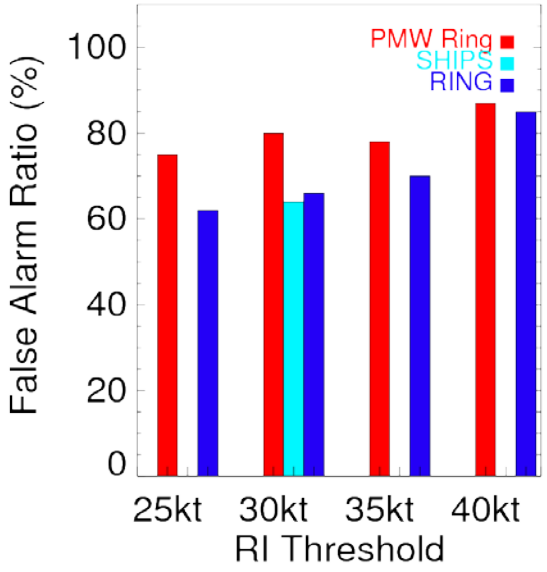


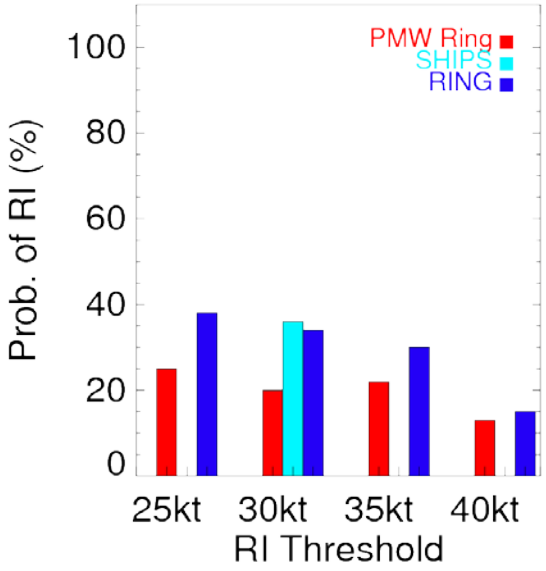


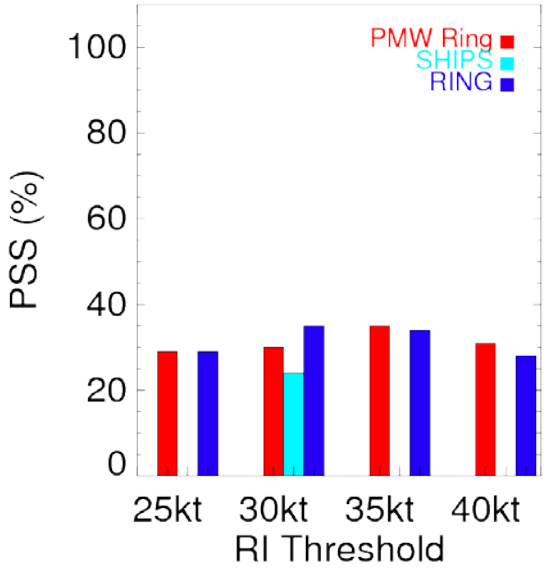
- **SHIPS RII produced the highest POD, lowest FAR, and therefore the best PSS for 25, 30, and 35 kt RI thresholds**
- **PMW-Ring RII produced the highest POD and best Pierce Skill Score (PSS) for the 40 kt RI threshold**

Results for 2017 Post-Season Re-run: WP+IO



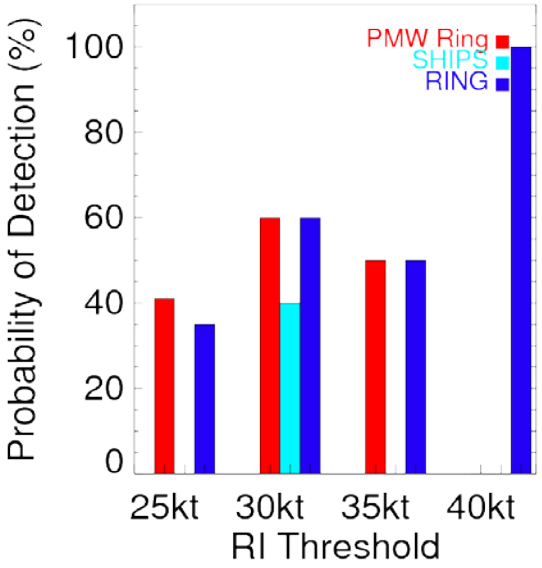


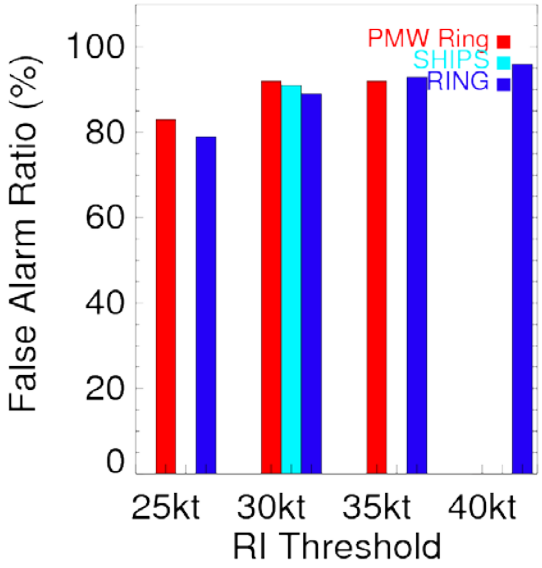


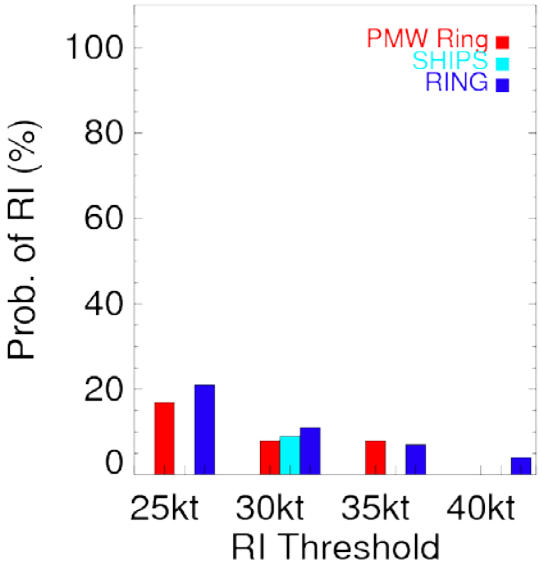


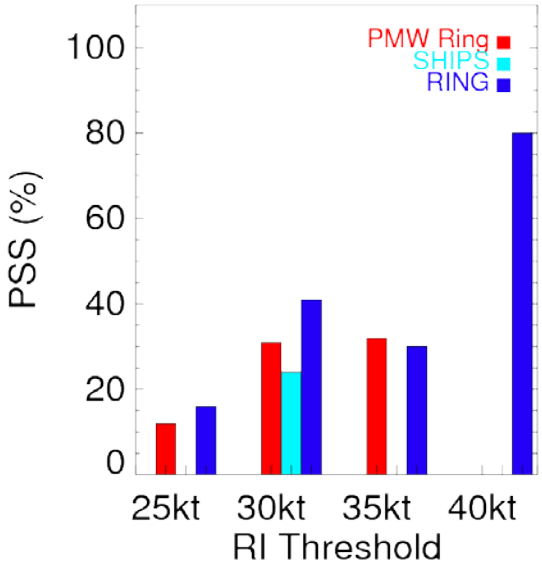
- **SHIPS RII only made forecasts for the 30-kt RI threshold**
- **Both PMW-Ring RII and the 37GHz-Ring-Only RII produced higher POD and higher PSS for the 30 RI threshold**
- **Similar performance between PMW-Ring and the 37GHz-Ring-Only RII for other RI thresholds**

Results for 2017 Post-Season Re-run: SH









- **37GHz-Ring-Only RII produced the highest PSS for the 30 RI threshold, followed by PMW-Ring RII.**
- **Similar performance between PMW-Ring and the 37GHz-Ring-Only RII for 25 and 35 kt RI thresholds**
- **37GH-Ring-Only RII outperformed for the 40 KT RI threshold.**

Summary of Performance in 2017 Season

	PMW-Ring RII	SHIPS RII	37GHz-Ring-Only RII
AL 25, 30, 35 kt RI threshold		Best	Second
AL 40 kt RI threshold		Second	Best
EP+CP 25, 30, 35 kt RI threshold	Second	Best	
EP+CP 40 kt RI threshold	Best		Second
WP+IO 30 kt RI threshold	Second		Best
WP+IO 25, 35, 40 kt RI threshold	Best/Similar	No Data	Best/Similar
SH 30 kt RI threshold	Second		Best
SH 25, 35, 40 kt RI threshold	Second	No Data	Best

Summary of Progress and Next-Step Plan

- **The 37 GHz Ring Only RII algorithm is mature. The PMWRing RII algorithm refinement has also finished for all basins.**

- **Evaluation results for the 2017 season show that the 37 GHz Ring Only RII performed the best, while the PMW-Ring RII had similar skillfulness as the SHIPS RII.**

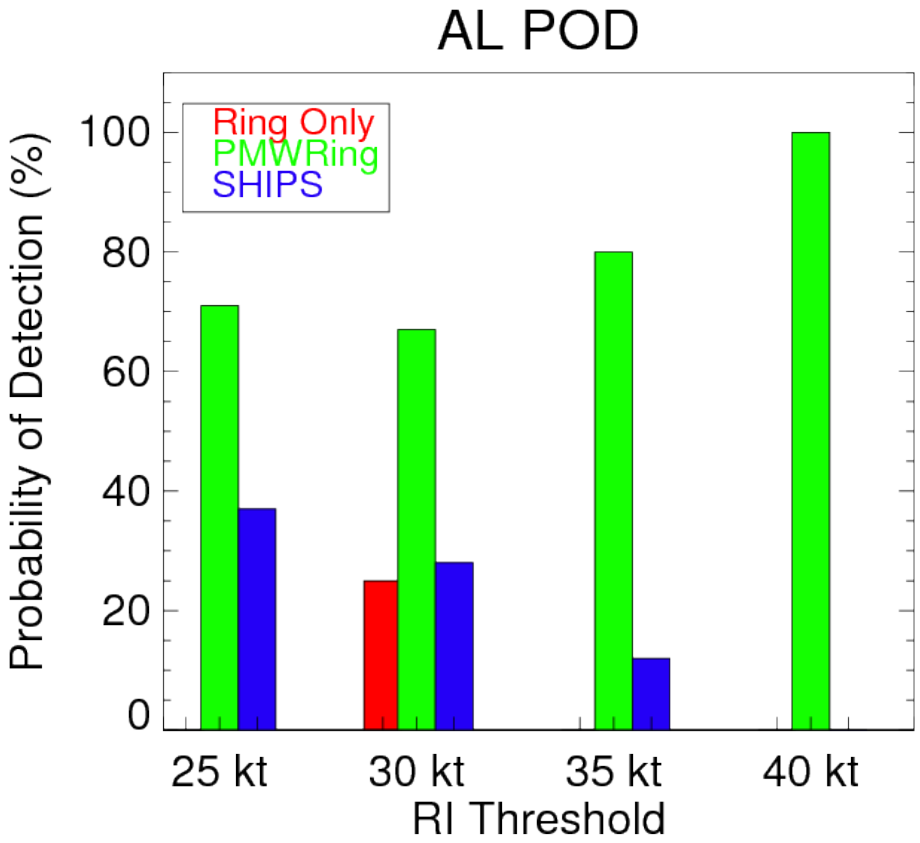
- **R2O Transition recommendations: we strongly recommend that NHC modify SHIPS RII by adding 37 GHz Ring and other 37 & 85 GHz parameters used in this project**

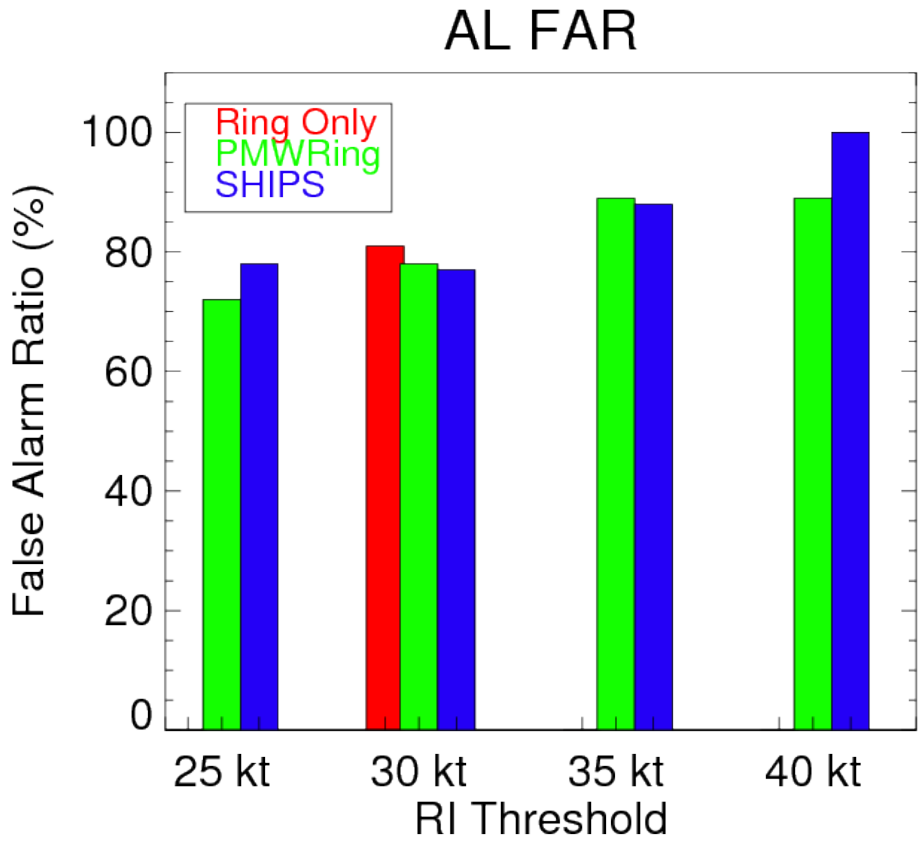
- **Next-step work: summarize the results and prepare for journal paper manuscripts**

Back-up Slides

Preliminary Results for 2016 Post-Season Re-run: AL

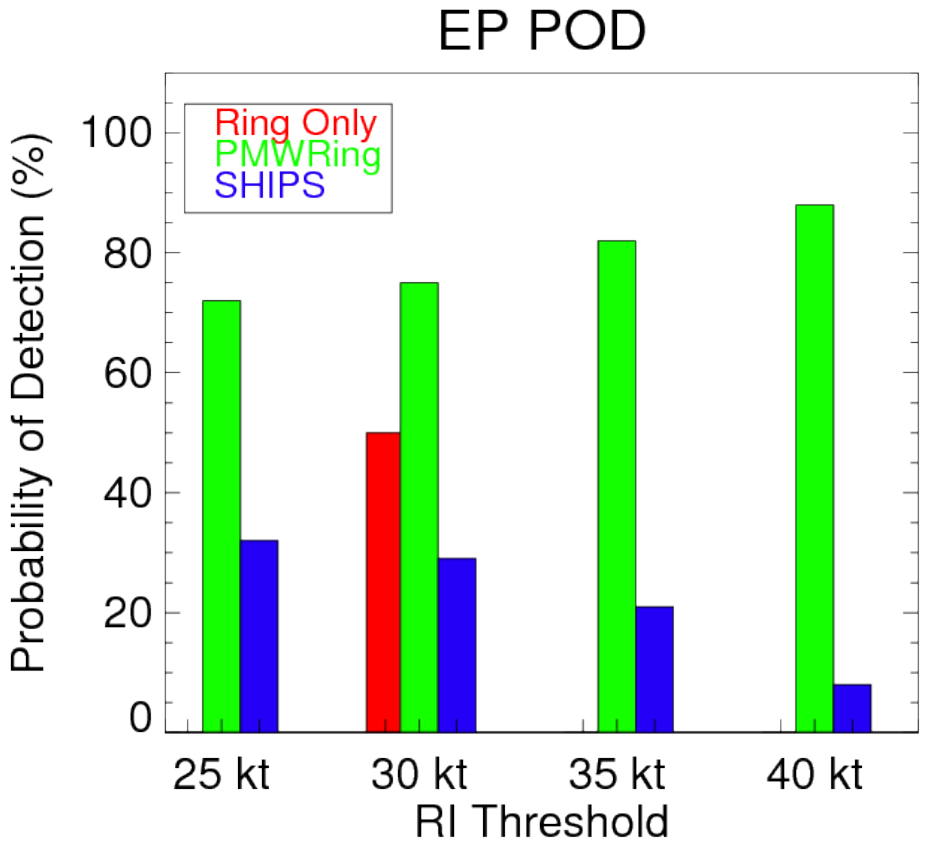
- **SHIPS RI thresholds for each basin were based on Kaplan et al. (2010).**
- **PMWRing RI thresholds were determined similarly as Kaplan et al. (2010).**

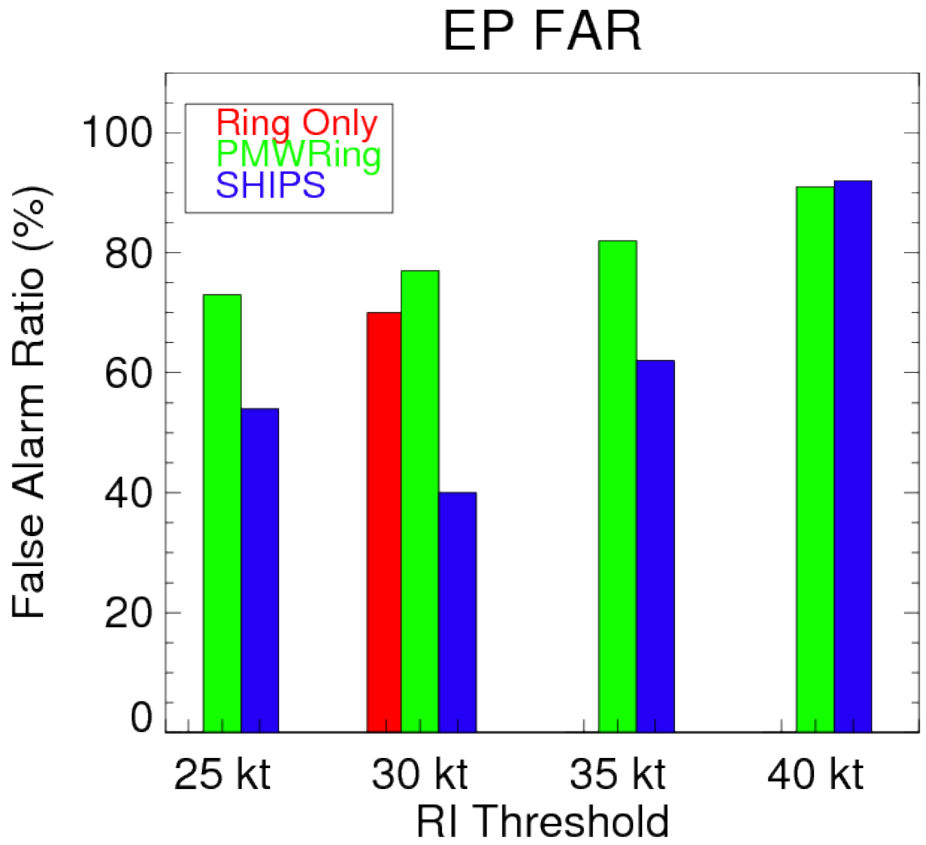




- **AL was tough this year; both ring-only & SHIPS RII had low POD & high FAR**
- **PMWRing RII was better in POD, but not in FAR**

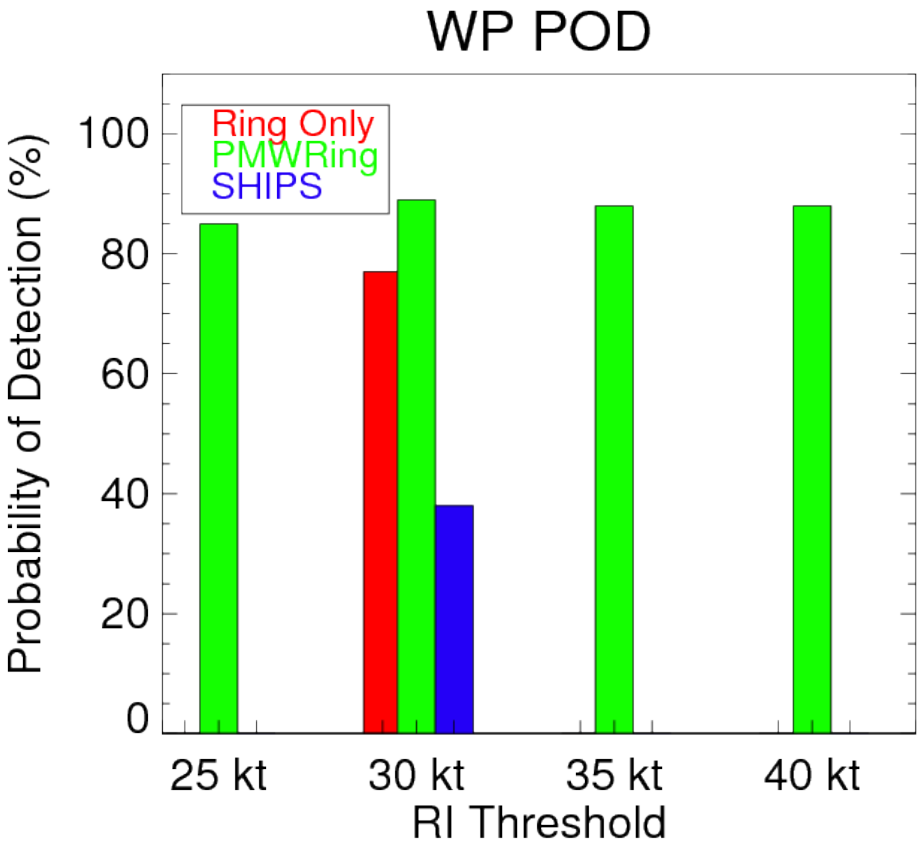
Preliminary Results for 2016 Post-Season Re-run: EP

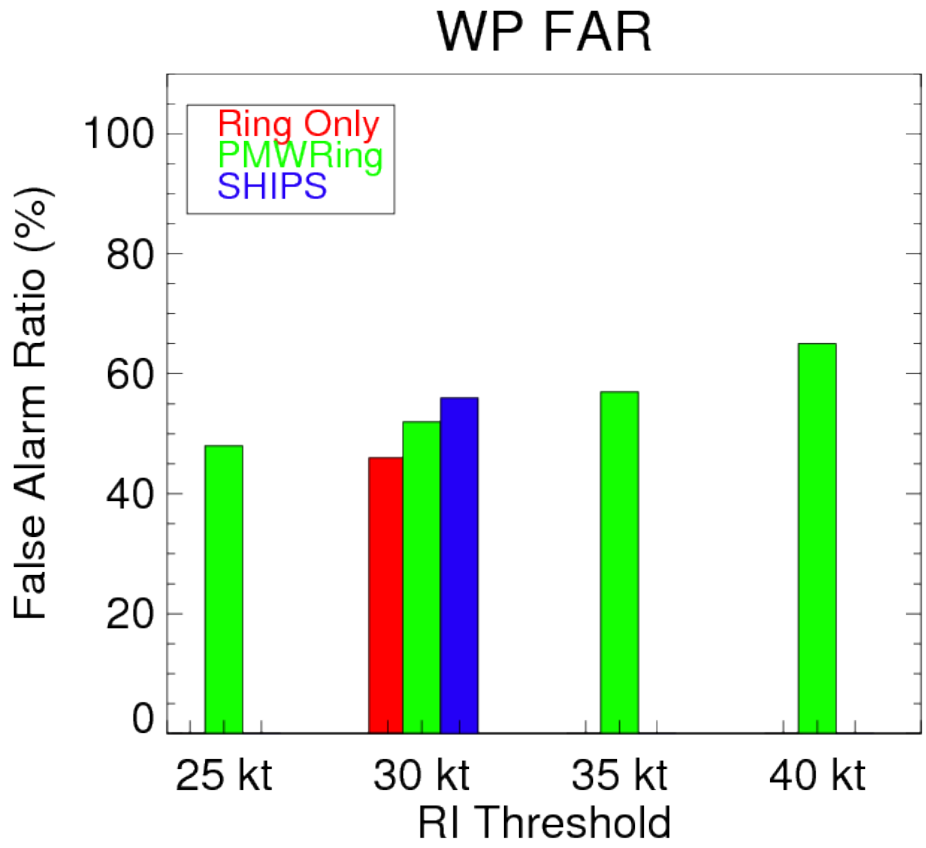




- **SHIPS RII has low POD & low FAR**
- **Ring-only and PMWRing RII has high POD, but also higher in FAR**

Preliminary Results for 2016 Post-Season Re-run: WP





- **Performance in WP was much better**
- **Both ring-only & PMWRing RII had high POD & lower FAR**
- **But SHIPS RII had a low POD and a higher FAR**