

A Blended, Multi-Platform Tropical Cyclone Rapid Intensification Index

Leads:

John Knaff, NESDIS/STAR/RAMMB

Chris Velden and Chris Rozoff, CIMSS/UW

John Kaplan, OAR/AOML Hurricane Research Division

Other Participants:

Mark DeMaria, NESDIS/STAR/RAMMB

Jonathan Vigh, NCAR MMM Division

Andrea Schumacher, CIRA/CSU



NOAA Satellites and Information

National Environmental Satellite, Data, and Information Service



Project Summary

1) Explore the utility of multi-sensor, multi-platform information to forecast tropical cyclone rapid intensification

- Long range lightning detection (proxy for GLM)
- LEO passive microwave observations of convective organization
- Convective asymmetries and modes from GOES IR (proxy for ABI)
- SST, OHC (satellite based products)
- GFS observations and forecast of environment

2) Develop experimental versions of the operational Rapid Intensification Index (RII)

- Use new predictors from lightning, microwave , IR observations
- Use different statistical techniques (Discriminant analysis, Logistic regression, & Naïve Bayes classifier)
- Leverage other funded projects.

Justification

- Improved forecasts of tropical cyclone rapid intensification is a high priority NWS and NOAA goal (i.e., one of the justifications of HFIP)
- Several datasets with potential to improve rapid intensification are not fully utilized
- A diversity of statistical methods has yet to be used for the rapid intensification problem

Methodology

- Combine the talents and expertise at CIRA/RAMMB, CIMSS and AOML/HRD
- Better use of satellite data
 - GOES, Microwave, lightning
- Develop complimentary statistical techniques to estimate the probability of RI
 - LDA, Logistic Regression, Bayesian
 - Test the concept of consensus RI forecasting
- Demonstrate real-time capabilities that can combine lightning, MI and GOES predictors.

6. FY11 Milestones

- CIRA/RAMMB will provide to AOML and CIMSS
 - July 2011: Storm relative IR predictors and lightning Atlantic and E./C. Pacific
 - Summer 2011: Further testing of lightning-based correction models developed for Atlantic & E. Pacific
 - Coordinate effort among the groups for potential real-time testing in 2011.
- CIMSS data provided to AOML and CIRA
 - August 2011: Develop improved 37 GHz MW predictors. (refined center finding and ring identification plus RGB (polarized Tb and PCTs.)
 - October 2011: provide storm relative 19, 37 (corrected) and 85-92 GHz MI predictors for the Atlantic to AOML/HRD (1995 – 2009).
 - November 2011: provide storm relative 19 and 85-92 GHz MI predictors for the Eastern Pacific to AOML/HRD (1995 – 2009).
 - December 2011: Initial code developed for real-time testing (at CIMSS) of 37 GHz predictors in RI prediction schemes and ensemble-mean forecasts.

6. FY11 Milestones (Cont.)

- Summer 2011: AOML will develop experimental versions of RII that use MI predictors Atlantic and E./C. Pacific
- ALL
 - Develop a set of statistical techniques that make use of the same
 - Developmental datasets for consensus forecasting tests
 - Develop a data repository for real-time testing in 2011/2012 for possible Proving Ground testing.

Results (MW predictors)

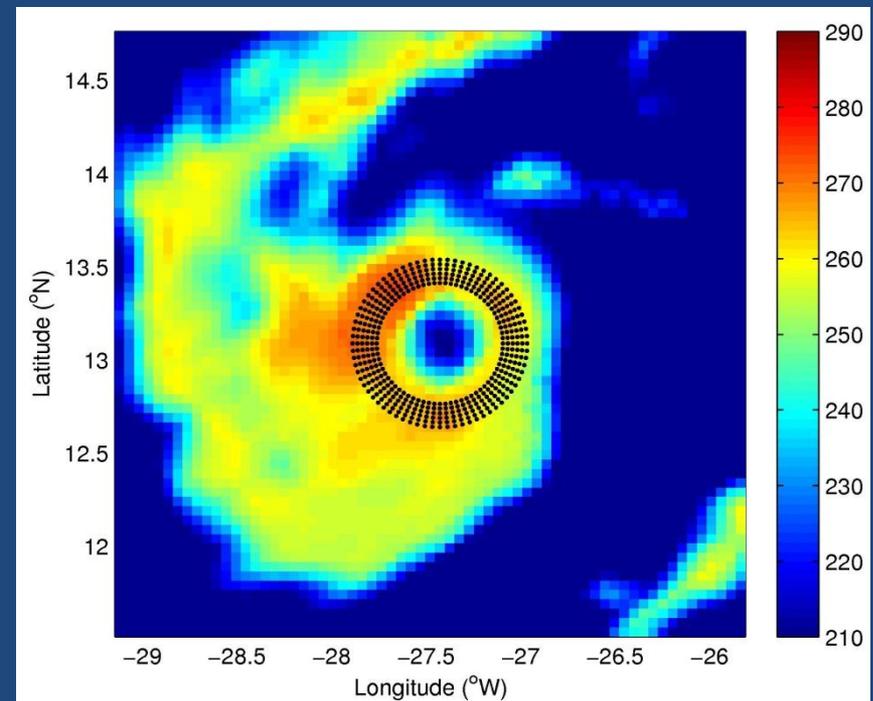
- Start with operational RII (LDA version)
 - Produces forecasts at 00, 06, 12 and 18 UTC
- 19, 37, and 85 GHz MW imagery database created for 1995-2009 (T_b ; V and H pol. and PCT) from multiple sensors
 - SSM/I, TRMM-TMI, AMSU-B, AMSR-E, and WINDSAT
- Automated center location methods leveraged from other projects
- MW predictor selections evaluated using a logistic regression model (Rozoff and Kossin 2011; *WAF*)
- the predictors also being tested in logistic regression, Bayesian, and LDA versions

Results (MW predictors)

Automated Center Finding

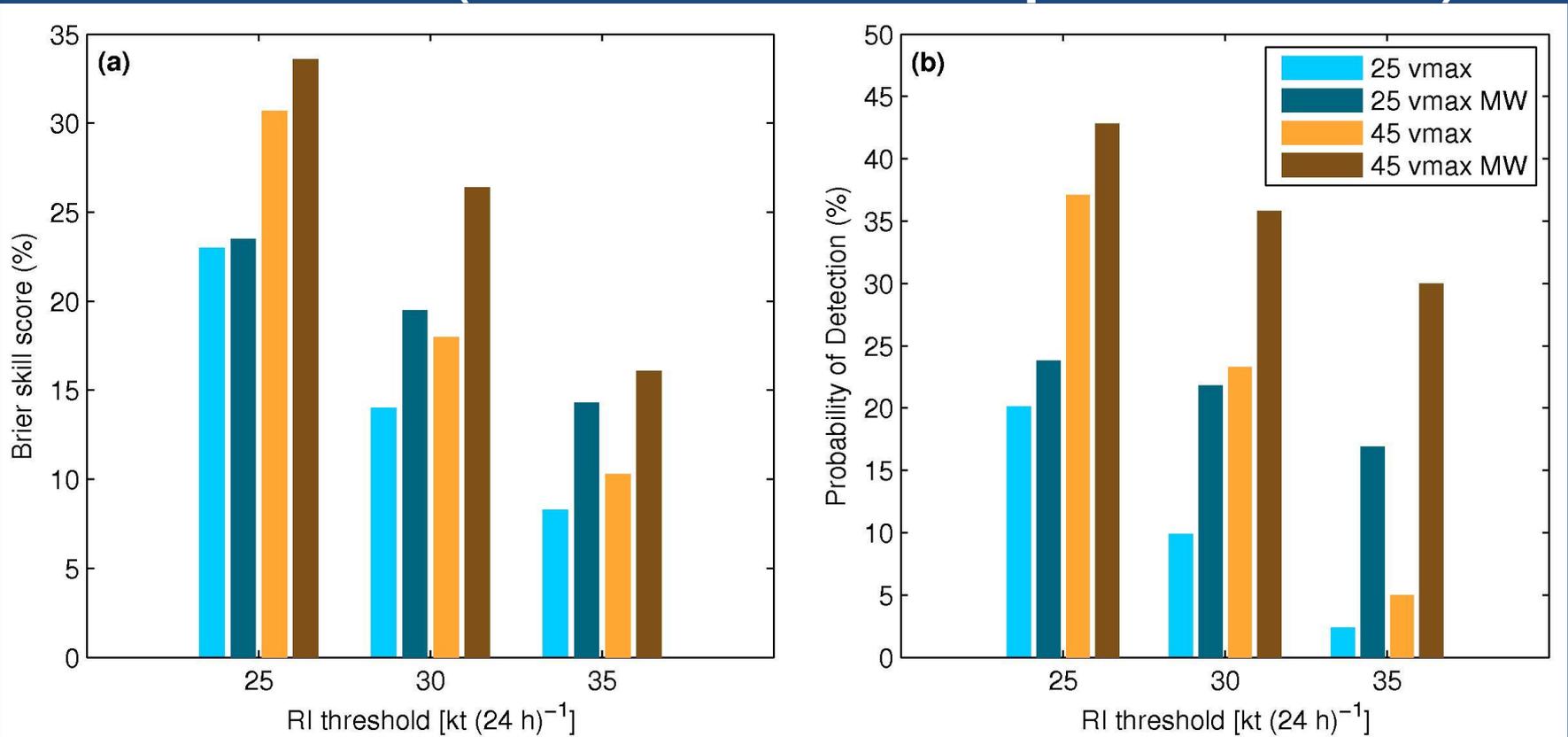
- Using ARCHER (Automated Regional Center Hurricane Eye Retrieval)
 - Wimmers and Velden (2010)
- An objective ring detection scheme has been recently implemented that improves earlier results

Example



Caption: Horizontally polarized T_b (37 GHz) and objective ring [TMI; Danielle (2004)]

Results (37-GHz MW predictors)



Improvements to the logistic RI model for the Atlantic (Rozoff and Kossin 2011; WAF) by incorporating improved microwave predictors. The forecasts are made at satellite passage times for all storms and also only for storms containing an intensity of at least 45 kt. Here, $N = 2720$ for all storms and $N = 2050$ for storms at least 45 kt in intensity. The skill scores are determined from independent testing over 1998 – 2008. These results include SSMI, WINDSAT, TMI, and AMSRE.

Results (TPW and IR PCs)

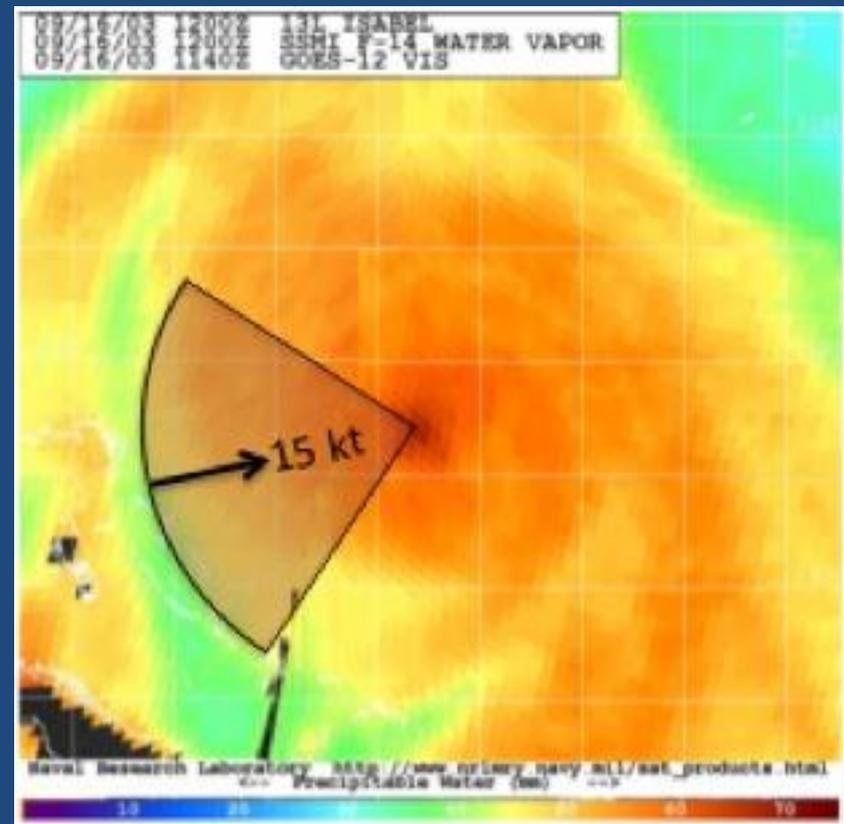
- Start with operational RII
- Leverages Joint Hurricane Testbed research and testing
- Leverages TPW historical and operational datasets
 - RSS TPW (SSM/I)
 - NESDIS Blended (SSM/I, SSM/IS, AMSU)
- Identified two new potential predictors
 - one TPW-based
 - one IR PC-based

Results (TPW and IR PCs)

TPW Predictor Description

- Percentage of TPW pixels <45 mm
- radius=0-500 km
- 90 deg quad centered up-shear of the vertical wind shear vector (200-850 hPa)

Example

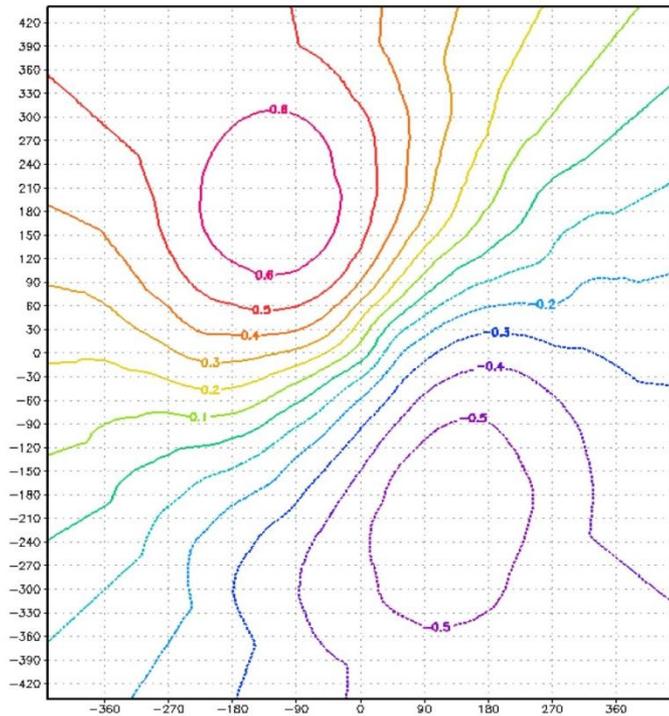


Results (TPW and IR PCs)

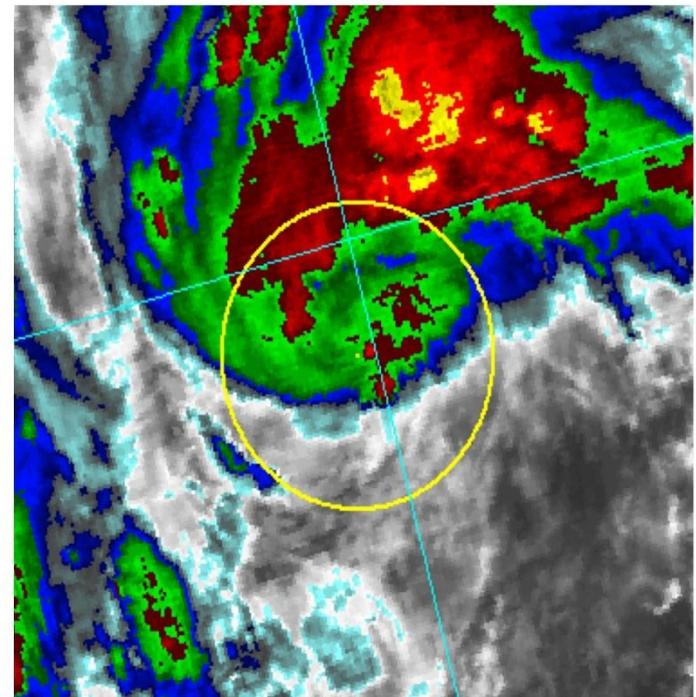
- Principle components (PCs) for direction relative imagery calculated from CIRA IR image archive (1995-2010)
- IR brightness temperatures are analyzed on a cylindrical grid
- Standard EOF analysis was performed and first nine PCs were examined
- PC #2 (wave # 1 asymmetry) found to precede RI

GOES IR Principle Component (PC) RII Predictor

Wilma 10/17/05 18 UTC



Storm
Motion

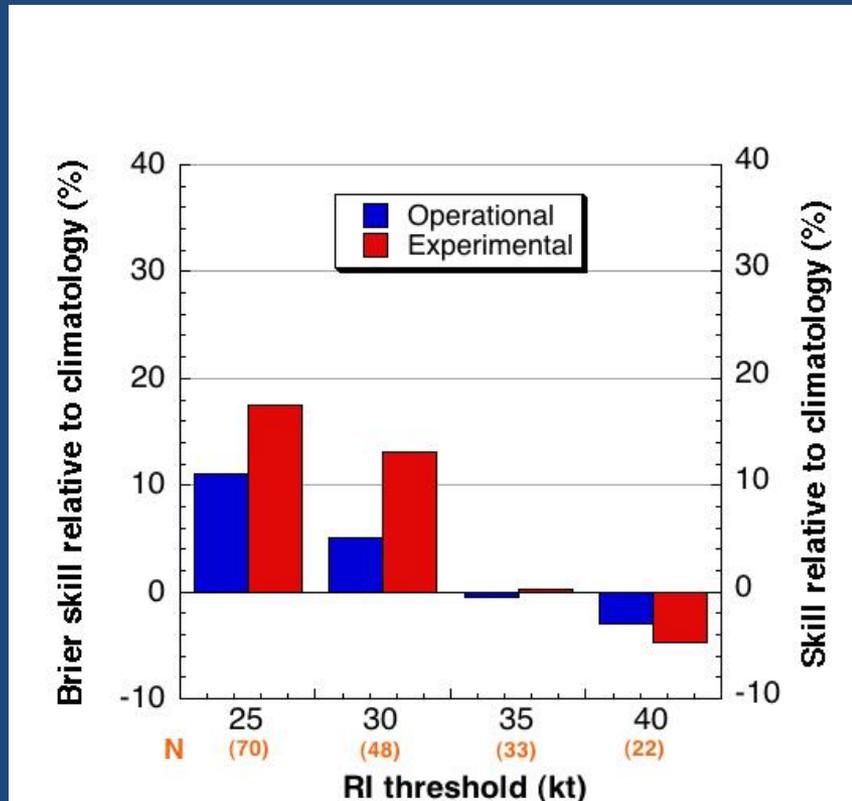


PC2 = -1.32

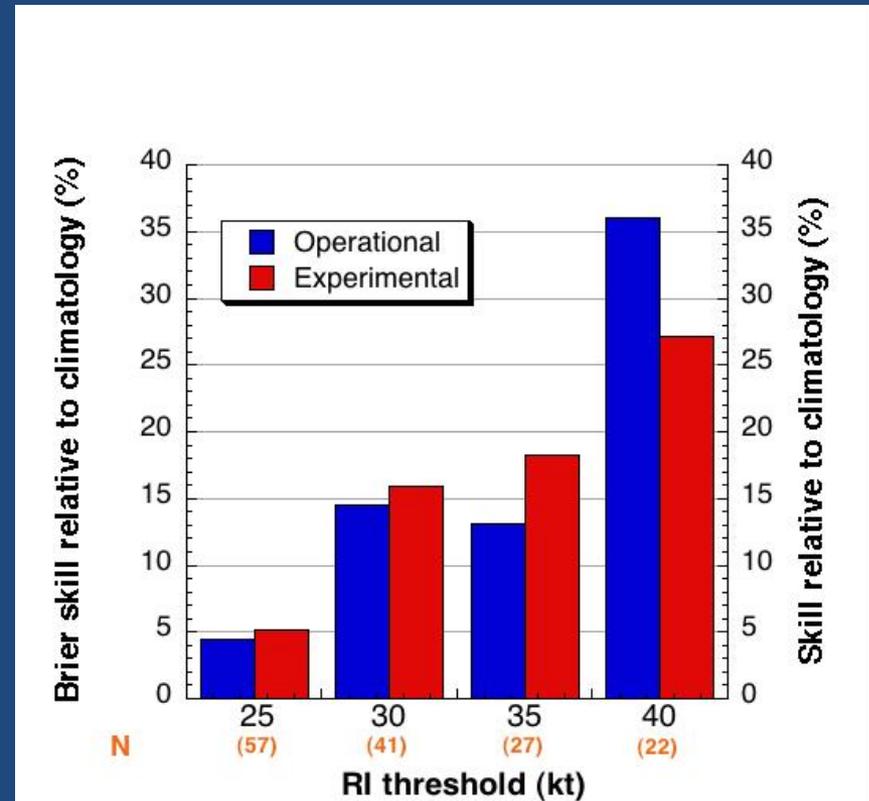
Spatial Weightings of EOF 2

Results (TPW and IR PCs)

Atlantic



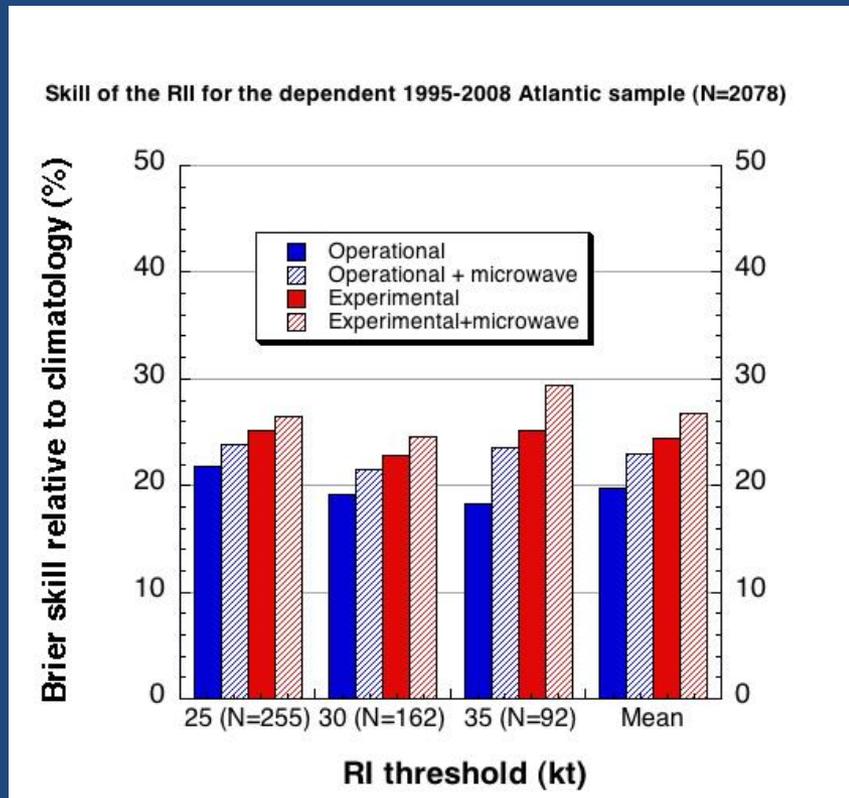
East Pacific



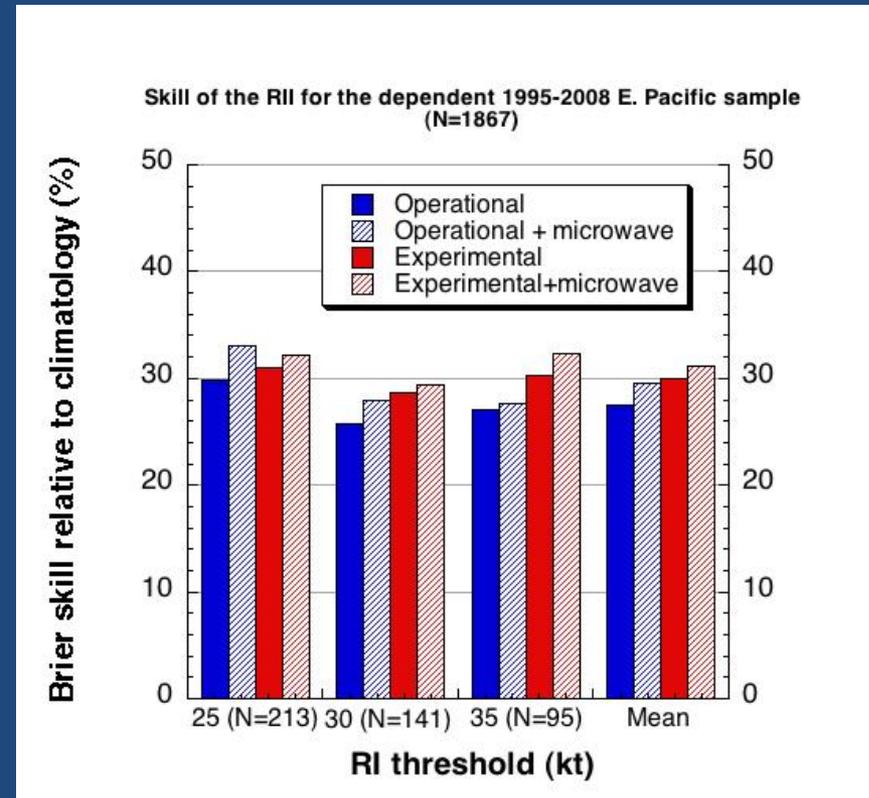
Comparison of the skill of the current operational RII (Kaplan et al. 2010) against that of the new experimental version that uses TPW and IR PCs for the independent 2008-2010 sample (leveraged from JHT work at AOML)

Results (TPW, IR PCs, & MW)

Atlantic



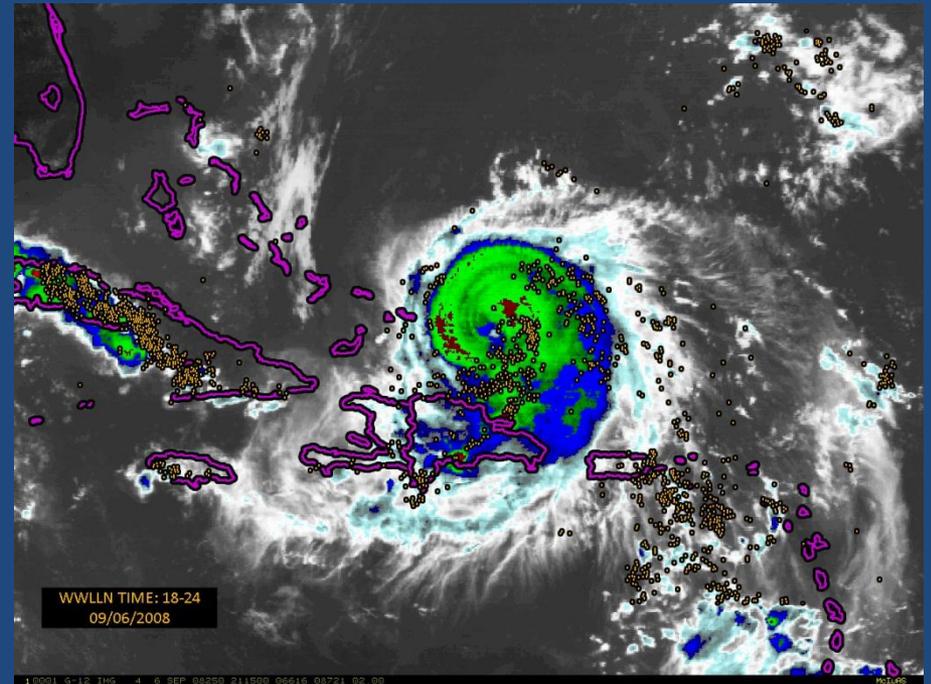
East Pacific



Results used MW data at operational times, use linear discriminant analysis and are comparable to the logistic regression model output $v_{max} > 25$. **MW improves all forecasts at all thresholds.**

Lightning and Rapid Intensity Change

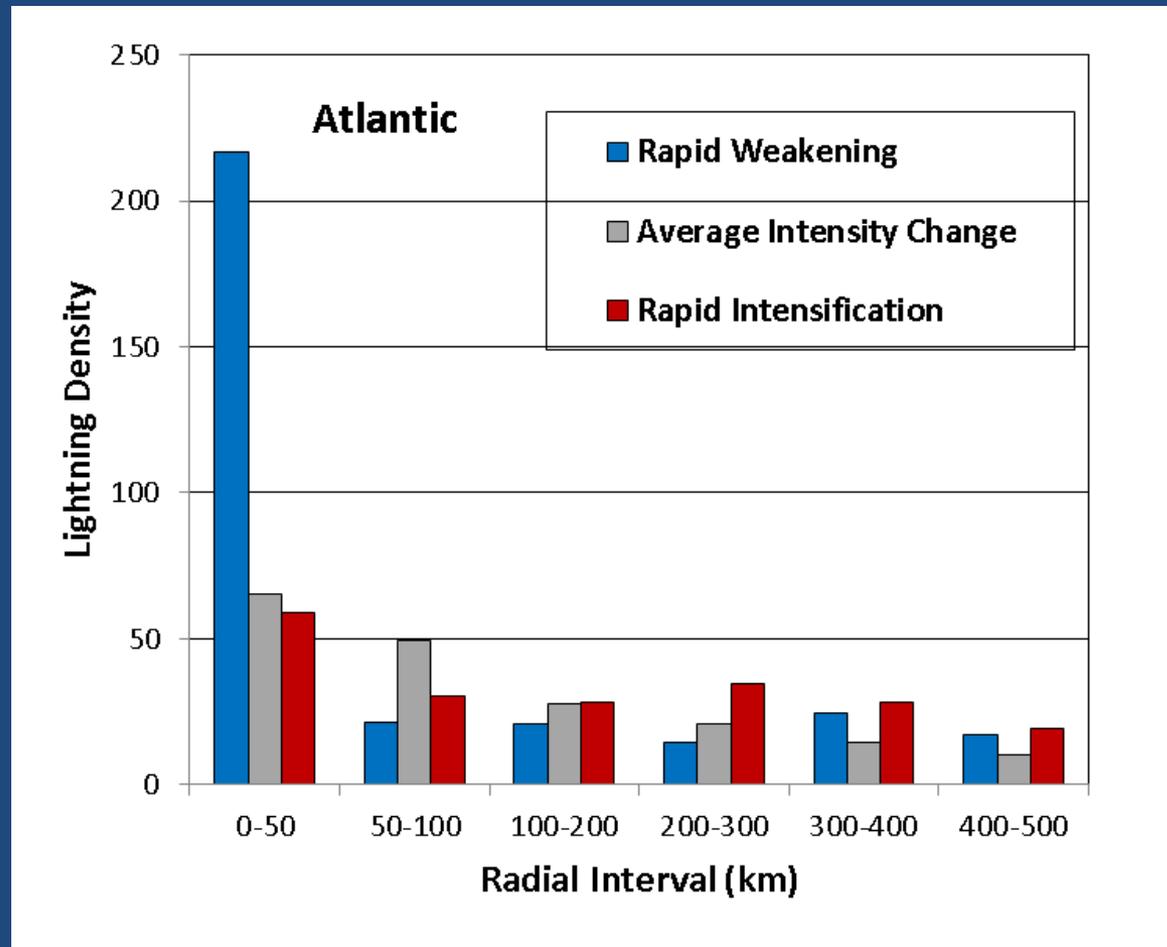
- WWLLN data is GLM proxy
- Large data sample (2005-2010 cases) for algorithm development
- Experimental Rapid Intensity Change algorithms



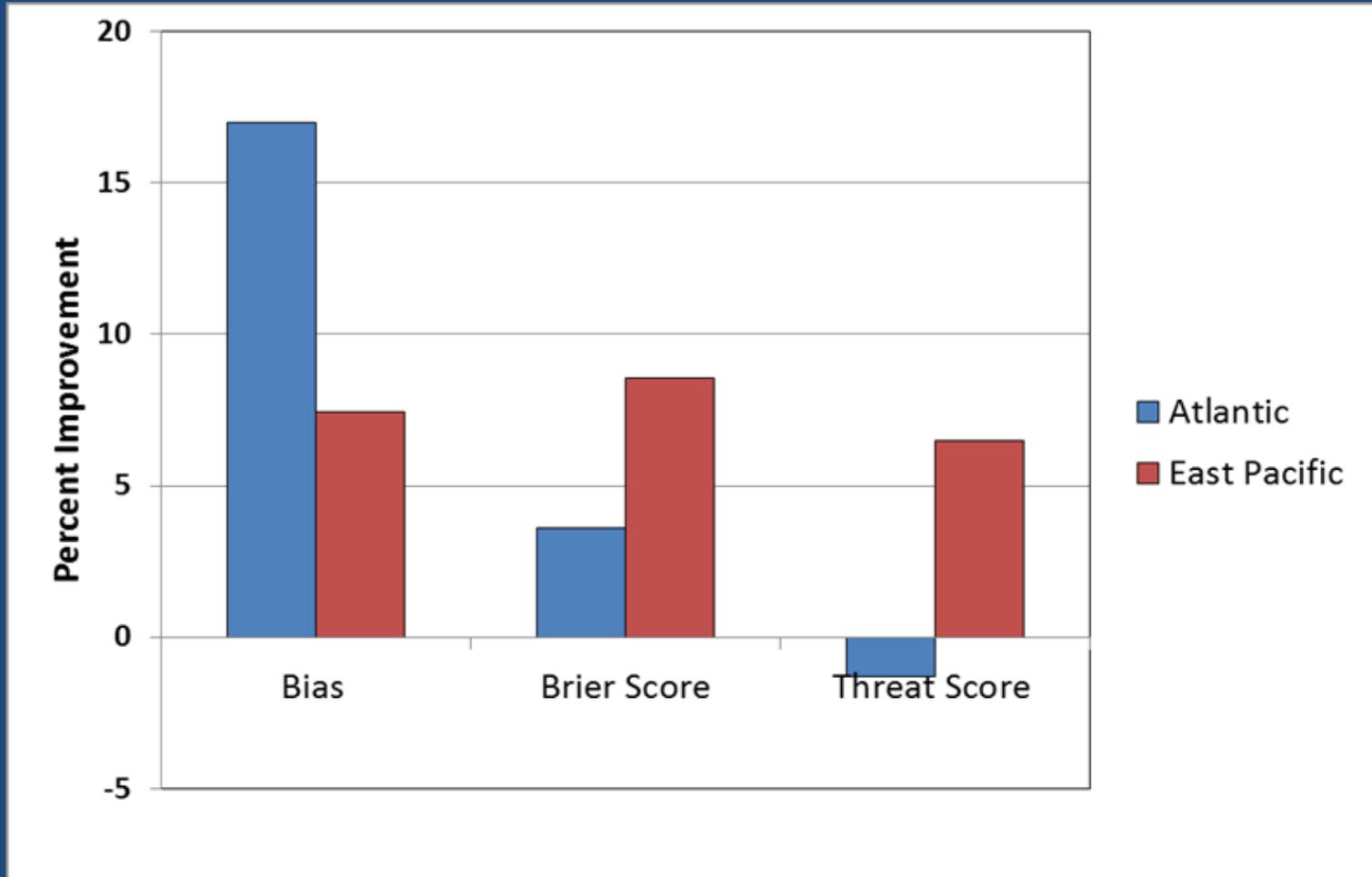
Results (Lightning)

- Increased lightning in the rainband region of the storm tends to precede RI
- Increased lightning in the TC core often indicates peaking in intensity
- Experimental rapid intensification scheme with lightning tested in 2010 and 2011 NHC proving ground
 - 2011 version includes new rapid weakening index
- Paper submitted to MWR

Lightning Density versus Radius Stratified by Intensity Change in the next 24 hr



Forecast improvements due to lightning input during 2010 Proving Ground at NHC



Plans (TPW, MW, IR PCs, & Lightning)

- RII with TPW and IR PCs run in Joint Hurricane Testbed in 2011
 - NHC will make operational transition decision before 2012 season
- New JHT project in 2012-2013 to transition MW version of RII
 - Will be added to TPW - IR PC version
- Lightning data tests will continue in NHC Proving Ground
- Could be added to TPW, IR PC, MW version
- All versions will use ensemble approach
 - LDA, Logistic Regression, Bayesian

QUESTIONS?



NOAA Satellites and Information

National Environmental Satellite, Data, and Information Service

