Improvements to the SHIPS Rapid Intensification Index (RII)

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This NOAA JHT project is being funded by the USWRP in NOAA/OAR's Office of Weather and Air Quality, with elements of the research funded by the GOES-R Risk Reduction Program

Background and Motivation

Predicting episodes of tropical cyclone (TC) rapid intensification (RI) has recently been ranked as one of NHC's top forecast priorities. Hurricanes Charley (2004) and Humberto (2008) are good examples of recent U.S. landfalling storms whose RI just prior to landfall was poorly forecast by model guidance.

To aid in the forecasting of RI, a statistically-based probablistic rapid intensification index (RII) was developed that uses large-scale predictors from the SHIPS model (Kaplan and DeMaria 2003, Kaplan et al 2010). This model is now operational, although the skill is rather limited (particularly in the Atlantic basin).

However, results from an experimental version of the RII that was developed during a recently completed JHT project are encouraging (Kaplan et al. 2011).

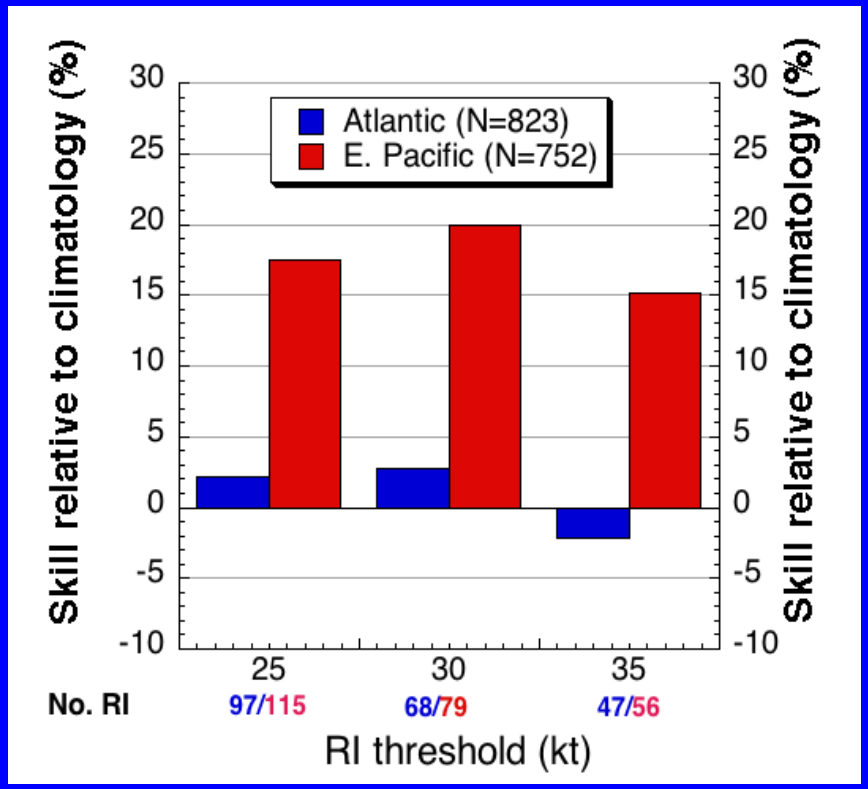
Current JHT Goals

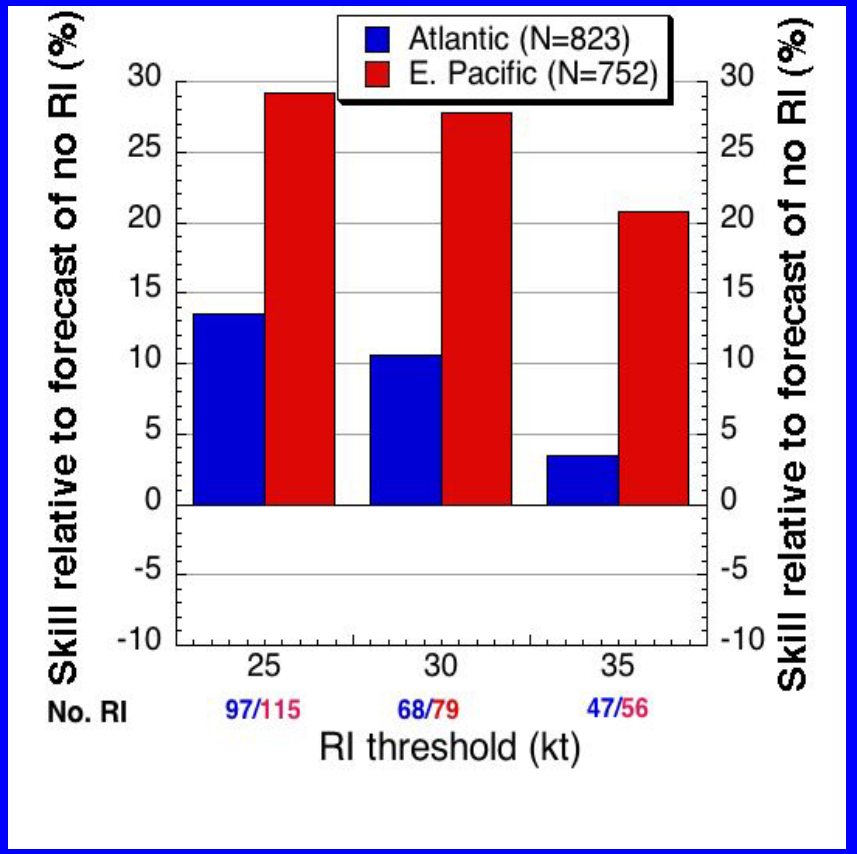
Our current project seeks to improve upon the operational RII model by testing and transitioning new versions of the RII. Specifically our project seeks to:

- **Explore additional forecast lead-times out to 48-h**
- **Employ a multi-model ensemble-based approach**
- **Incorporate satellite microwave information as additional predictors**

Skill of the Operational RII forecasts for 2008-2011

Verification rules: All 24-h over-water RII forecasts for tropical and subtropical systems (including unnamed depressions) verified using final NHC best track data.
N = number of forecast cases





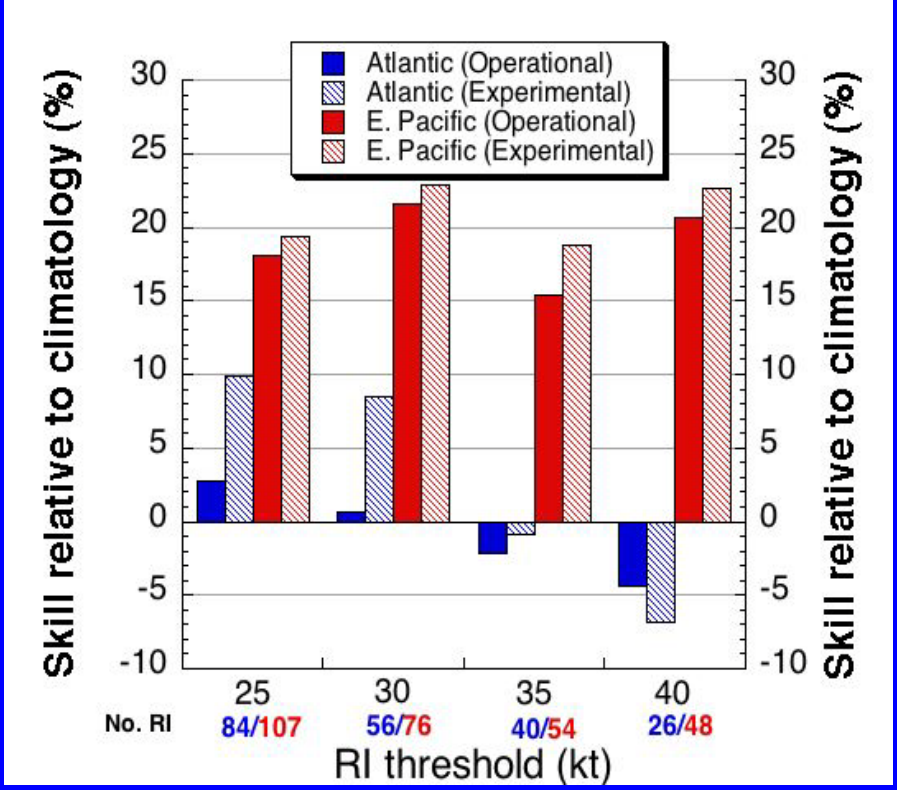
Experimental RII

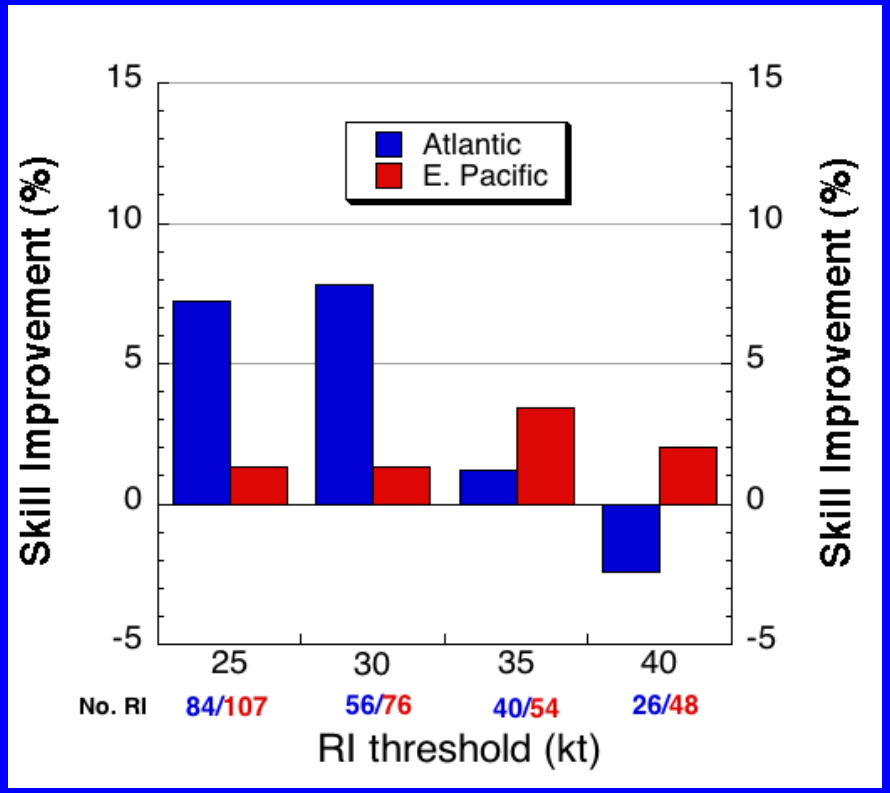
- **10 total RI predictors**
  - **6 original operational RI predictors (vertical shear, upper-level divergence, low-level relative humidity, potential intensity, ocean heat content, and persistence)**
- **2 replacement RI predictors**
  - **Total precipitable water (replaces 850-700 mb relative humidity)**
  - **2nd principle component of GOES infra-red imagery(replaces infra-red pixel count of -30 °C temperatures)**
- **2 new RI predictors**
  - **Inner-core dry-air predictor**
  - **Initial (t=0-h) maximum sustained wind**

Skill of the Experimental and Operational RII for the 2008-2011 seasons

Verification rules: All 24-h over-water RII forecasts for tropical and subtropical systems (including unnamed depressions) verified using final NHC best track data.

N = number of forecast cases

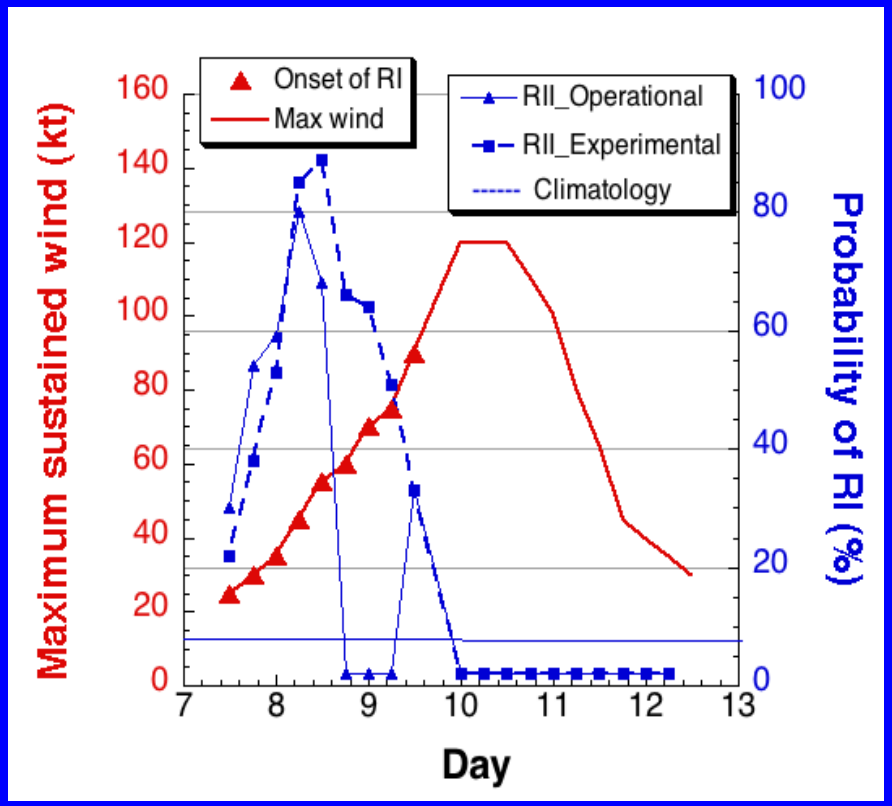




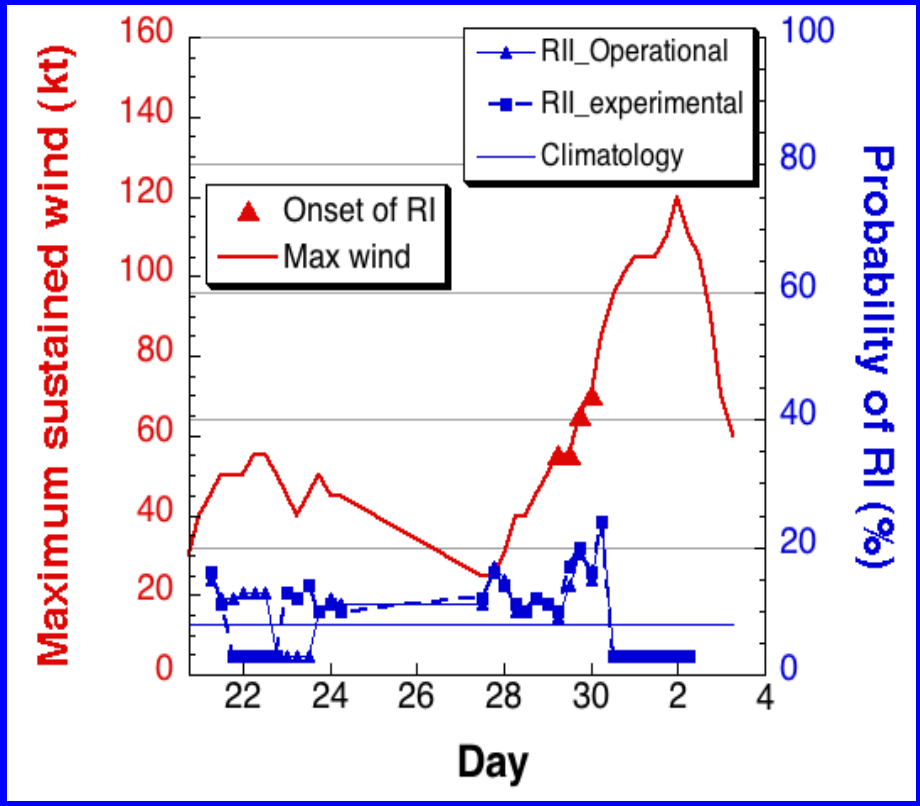
(Atlantic N=768, E. Pacific N=707)

Examples of Experimental vs. Operational RII peformance for the 30-kt RI threshold

Adrian (2011)



Ophelia (2011)



Current JHT Project Goals

Test versions of the experimental RII for the added lead times of 12-h, 36-h, and 48-h for both the Atlantic and E. Pacific basins.

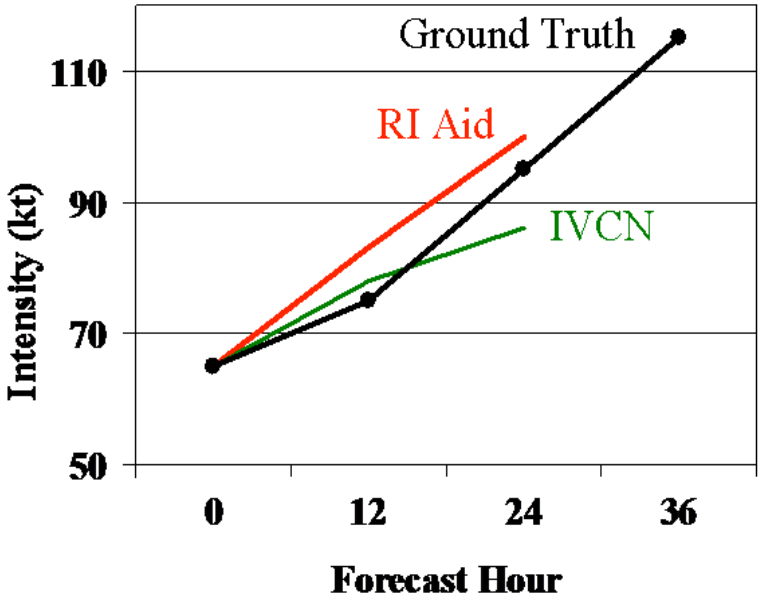
At each lead time (12-h, 24-h, 36-h, and 48-h) and basin, test ensemble-based versions of the RII utilizing new RI approaches/models.

Explore the impact on RII performance with the incorporation of satellite microwave-based predictors.

Generate improved deterministic RI guidance using the newly advanced RII models described above.

Deterministic RI Aid (AL and EP Basins)

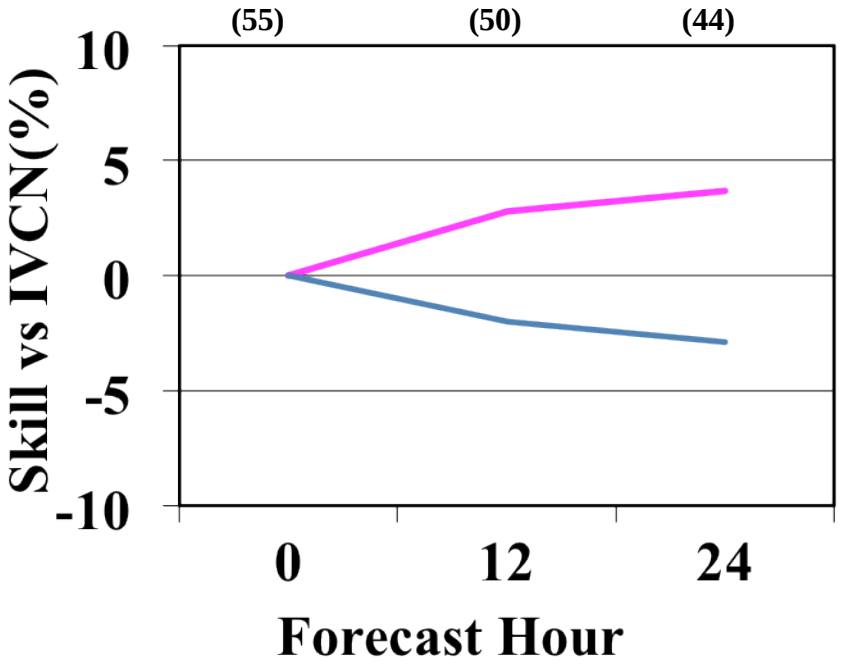
1. **Uses 24-h probabilistic RI thresholds for 25-40 kt**
2. **Assigns intensification rate when threshold exceeded**
3. **Can be displayed directly on ATCF**
4. **Reduces IVCN bias ~2 kt (~30%) and mean error (~5%) for 2011 sample.**
5. **N=50 cases at 12-h and N=44 at 24-h**

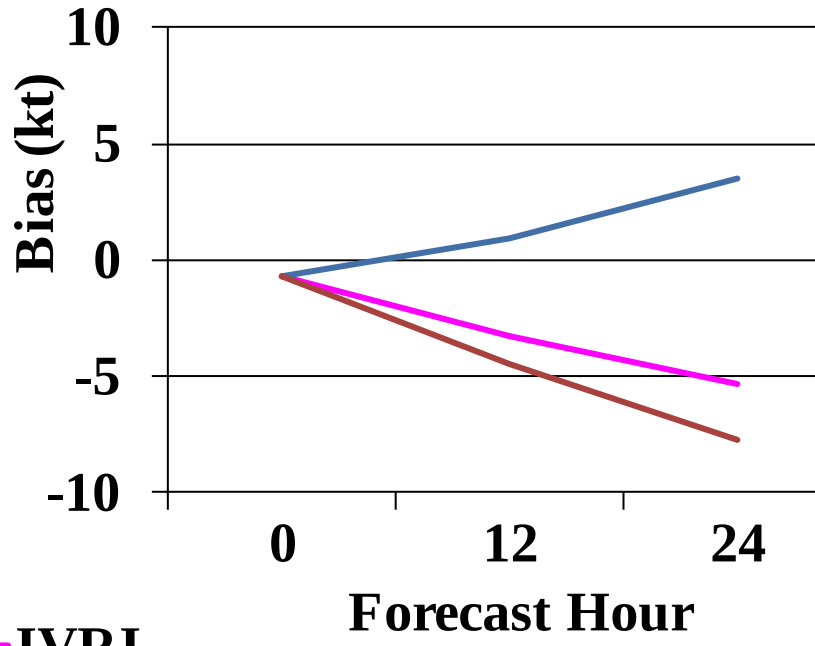


Sampson, C. R., J. Kaplan, J. A. Knaff, M. DeMaria, C. A. Sisko, 2011: A deterministic rapid intensification aid, **Wea. Forecasting, 26**, 579-585.

2011 NHC Consensus with RI Aid Included (IVRI)

(AL and EP 2011)





IVRI
RI25
IVCN

An intensity consensus (IVRI) that includes the deterministic RI aid and uses only the operational RI guidance was run post-season and showed improved skill and bias over IVCN (the operational NHC consensus). RI25 is the deterministic RI guidance for a 25-kt RI event, which had reasonable skill and less bias.

Testing of ensemble-based versions of RII

Combine discriminant (Experimental version), bayesian, and logistic versions of RII at each of 4 lead-times (12-h, 24-h, 36-h and 48-h) for both the Atlantic and E. Pacific basins utilizing cases from the 1995-2010 SHIPS database (Rozoff and Kossin 2011).

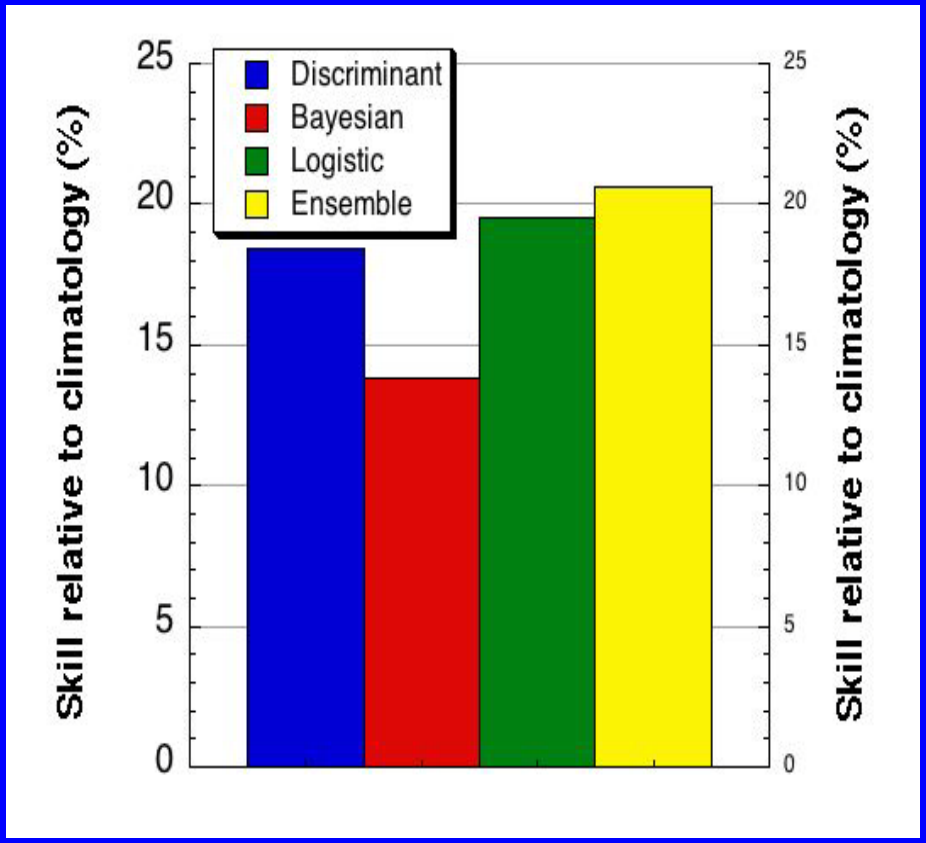
Average cross-validated RI probabilities (i.e. leave one year out) from each of the above three RI models to compute the final ensemble-based RI probability values.

Ensemble-based versions of the RII were generated for RI thresholds equivalent to about the 95th percentile of over-water intensity change at each lead time.

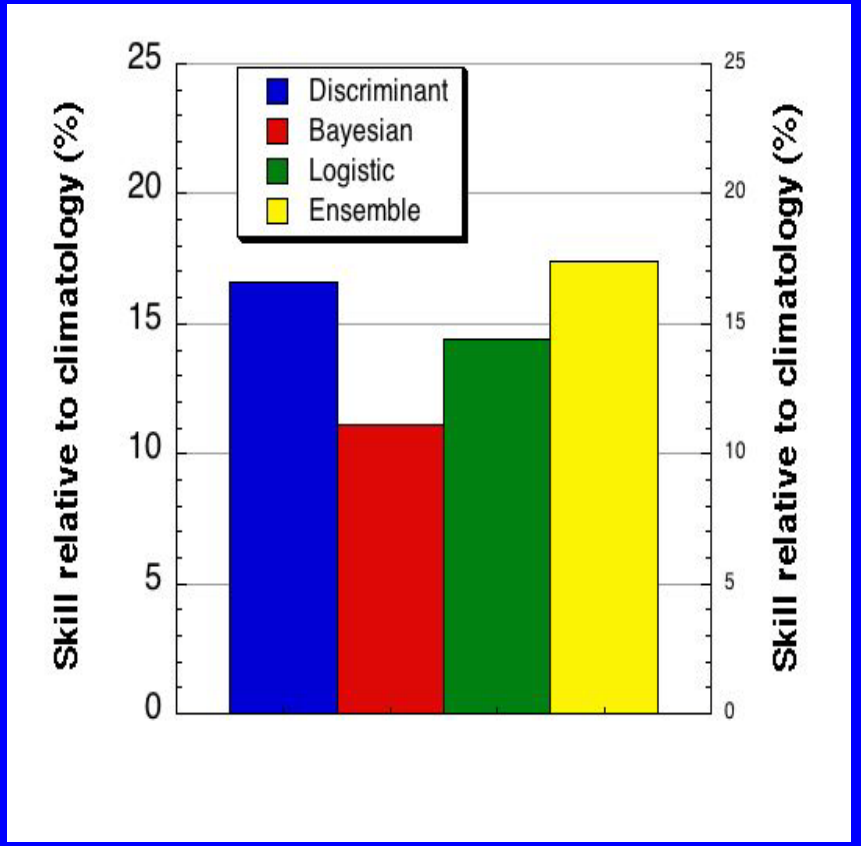
However, for consistency with the earlier RII, the 24-h lead time ensemble-based forecasts were obtained for all of the current operational RII thresholds (25-kt, 30-kt, 35-kt and 40-kt).

Atlantic basin ensemble RII methodology for 24-h lead time (1995-2010)

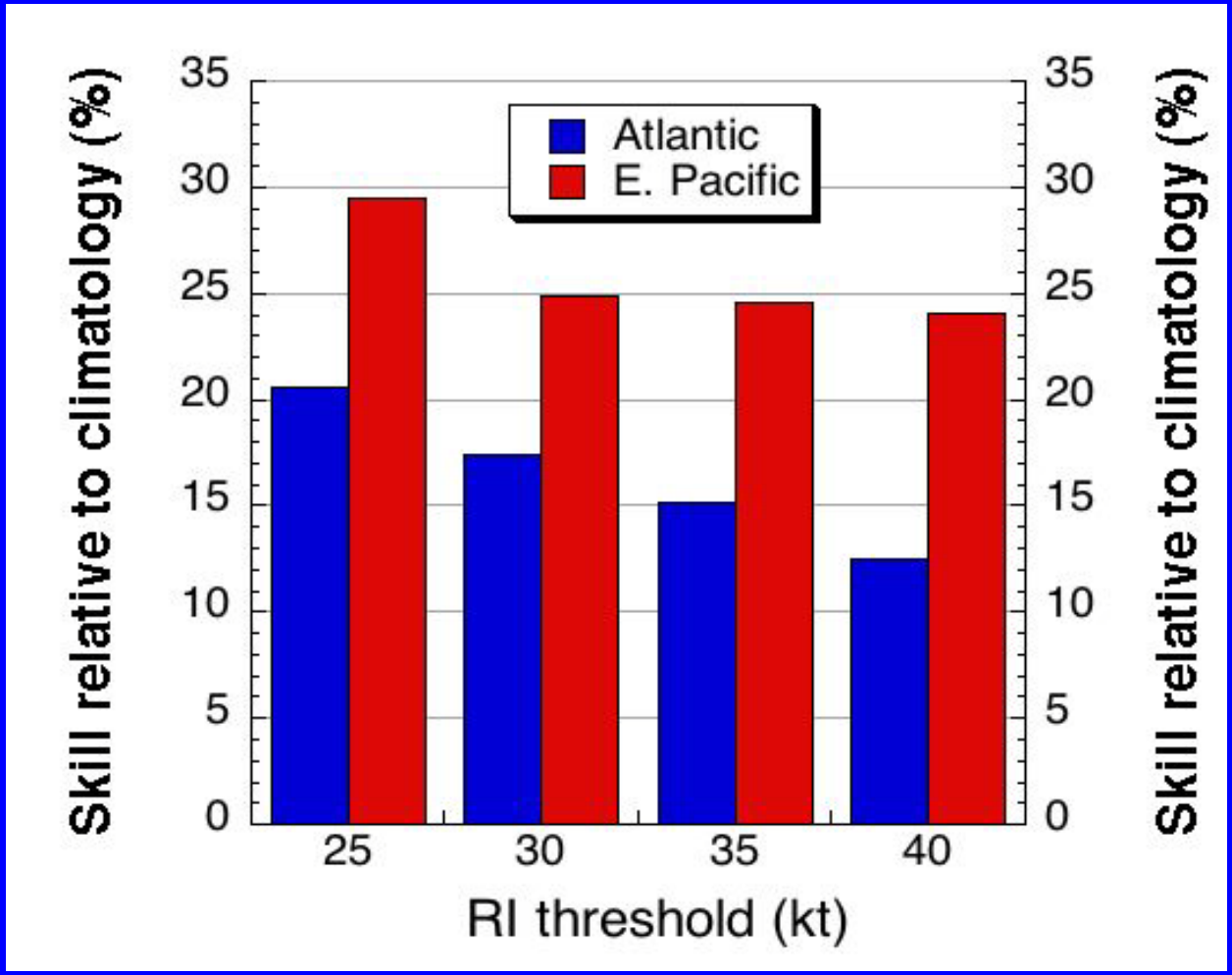
25-kt RI threshold



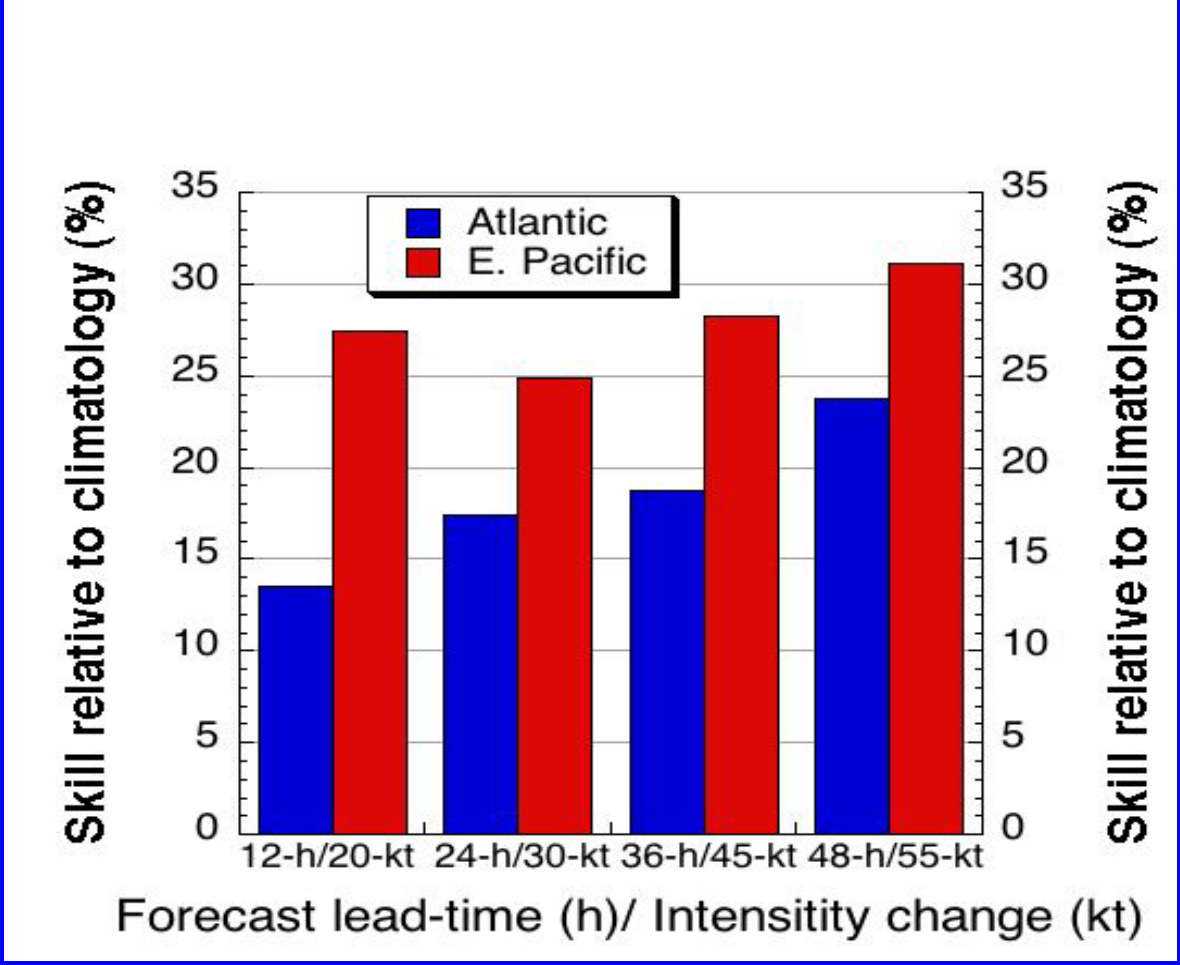
30-kt RI threshold



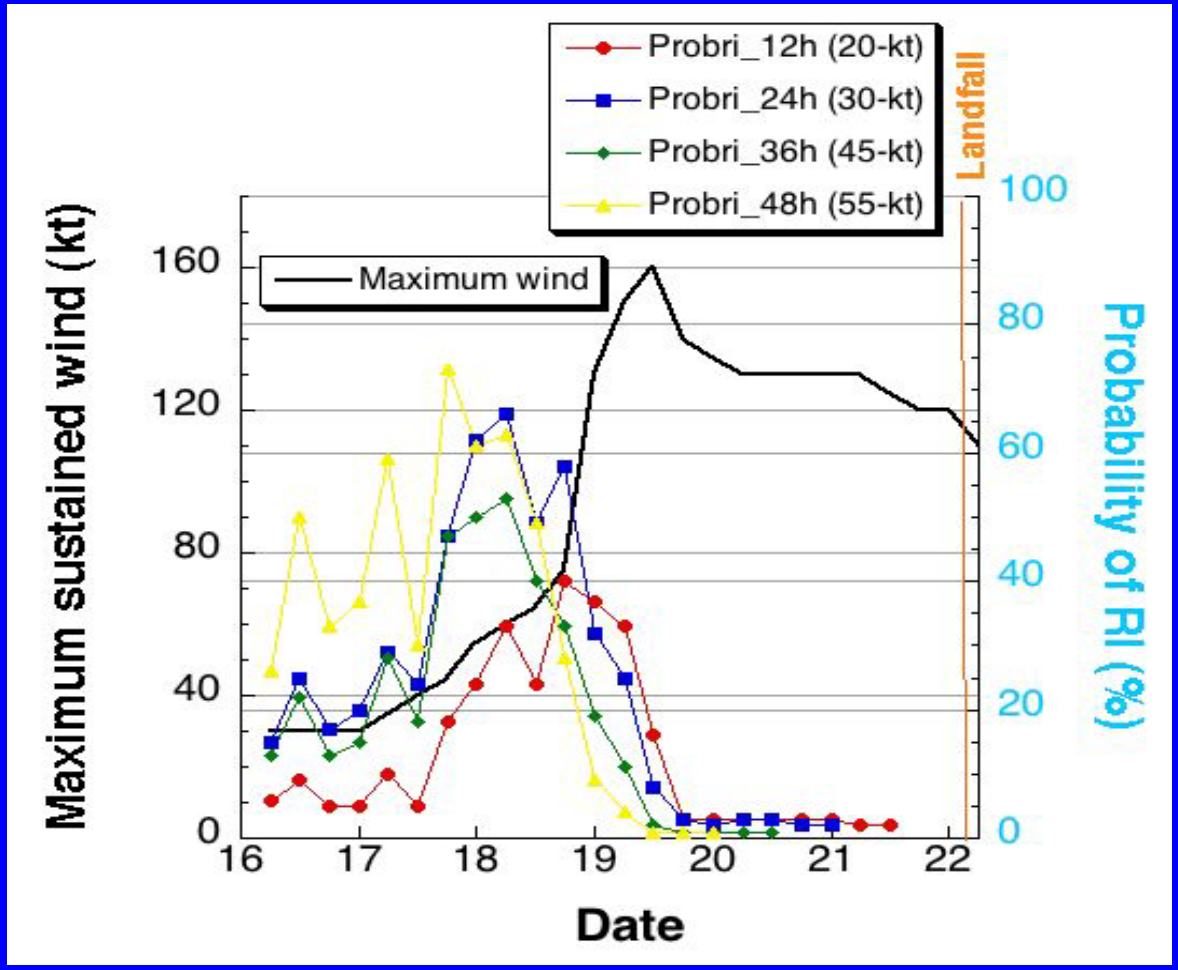
Skill of the 24-h ensemble-based RII for the 1995-2010 cross-validated sample



Skill of the ensemble-based RII for the 1995-2010 cross-validated samples as a function of forecast lead-time for the 95th percentile of intensity change



Example of Ensemble-based RII forecast for Hurricane Wilma (2005)



Summary

The operational RII was generally skillful for the period 2008-2011, but skill was limited particularly for the Atlantic basin.

A recently developed experimental version of the RII shows average skill improvements of 2% (E. Pacific) to 4% (Atlantic), with improvements as large as 8% observed for the Atlantic basin.

A new ensemble-based version of the RII was tested in the Atlantic and E. Pacific basins for the 12-h, 24-h, 36-h, and 48-h lead-times. Verification of the cross-validated forecasts indicate that they are skillful at all lead times in each basin, with skill as high as 24% (31%) observed for the 48-h lead time in the Atlantic (E. Pacific) basins.

A deterministic RI aid based on the RII model probabilities showed improvements in skill of up to 5% and a reduction in bias of ~30% over operational NWP-based consensus (IVCN) for the combined Atlantic and E. Pacific samples for the 2011 season.

New satellite microwave predictors have been tested and show promise (see presentation by Rozoff et al.)

Future Work

Continue to refine the newly developed ensemble-based version of the RII at the 12-h, 24h, 36-h and 48-h lead-times and conduct near real-time tests of this guidance during the 2012 hurricane season.

Utilize the new ensemble-based RII guidance to refine/improve the deterministic rapid intensity aid and conduct near real-time tests during the 2012 hurricane season.

Continue to test and refine new satellite microwave-based predictors for the RII, and test the new microwave-based version in near real time.