

**2010 National Hurricane Center (NHC) GOES-R Proving Ground
Final Report March 8, 2011**

1. Introduction

The NHC GOES-R Proving Ground (PG) was held during a portion of the 2010 Hurricane Season to provide feedback on GOES-R data and products generated from proxy data. Table 1 lists the primary activities leading up to, during and following the 2010 NHC PG. The primary participants are listed in the Appendix.

Table 1. 2010 NHC Proving Ground Time Table

Mar 2010	Initial planning meeting at the Interdepartmental Hurricane Conference (IHC)
Jun 17, 2010	Operations Plan completed
Jul 28, 2010	Product training via conference call to NHC
Aug 1, 2010	Proving Ground begins
Sep 9, 2010	Mid-project review at NHC
Nov 30, 2010	Proving Ground ends
Jan 13, 2011	De-briefing conference call with NHC
Mar 1, 2011	Project summary at the IHC (presented by Jack Beven)
Mar 1, 2011	Planning meeting at the IHC for the 2011 PG
Mar 8, 2011	2010 Final Report completed

2. GOES-R Data and Products

Table 2 lists the products being evaluated. The preliminary discussion of products began at a meeting at the IHC in March of 2010, and was later finalized by e-mail correspondence in the preparation of the Operations Plan, which was completed in June of 2010. The Hurricane Intensity Estimate is one of the baseline GOES-R products being developed by the Algorithm Working Group (AWG). The others are experimental products being developed in the GOES-R Risk Reduction program or applications of imagery. The product set was chosen based on availability of proxy data, algorithm readiness, and NHC forecaster interest.

Table 2. GOES-R Products in the 2010 NHC Proving Ground.

Product	Proxy Data Sources
1. Hurricane Intensity Estimate	SEVIRI Imagery for ABI
2. RGB Air Mass Product	SEVIRI Imagery for ABI
3. RGB Dust Product	SEVIRI Imagery for ABI
4. RGB Saharan Air Layer Product	SEVIRI Imagery for ABI
5. Super Rapid Scan Operations Imagery	GOES-15 imagery for ABI
6. Lightning-based Rapid Intensity Index (RII)	Vaisala GLD-360 lightning network for GLM, GOES-east and -west for ABI

3. Product Feedback

As described in the Operations Plan, the mechanism chosen for product feedback was for two NHC Hurricane Specialists (Michael Brennan and Jack Beven) to serve as project focal points and to collect forecaster feedback during the season. Feedback from them and from other participants was provided at the mid-year review in September 2010, and at a de-briefing conference call in January 2011. Most of the product comments were qualitative, but some quantitative information on the HIE and the lightning based Rapid Intensity Index was also obtained. This information is summarized below for each product.

3.1. HIE product

The HIE was routinely consulted for storms east of about 50°W, and was routinely compared to the ADT values and the subjective Dvorak estimates from NHC's Tropical Analysis and Forecast Branch (TAFB). Comments included the following.

- a. The HIE and Automated Dvorak Technique (ADT) maximum wind estimates are generally comparable, but the minimum sea level pressures of the HIE can be unrealistically low at times. The product providers at CIMSS recognized this problem, and a new version of the HIE has already been created. CIMSS has re-run the HIE for the 2010 season and provided the results to NHC for additional evaluation.
- b. A quantitative comparison of the HIE with other intensity estimates is underway by NHC, led by Jack Beven. This evaluation should be completed before the 2011 Hurricane Season. Figure 1 shows an example of a minimum sea level pressure estimates from the HIE and other techniques for Hurricane Igor.

- c. The HIE evaluation data set could be significantly expanded if the algorithm can run using 15-min CONUS sector data from the GOES-EAST satellite. The feasibility of this will be explored during 2011.

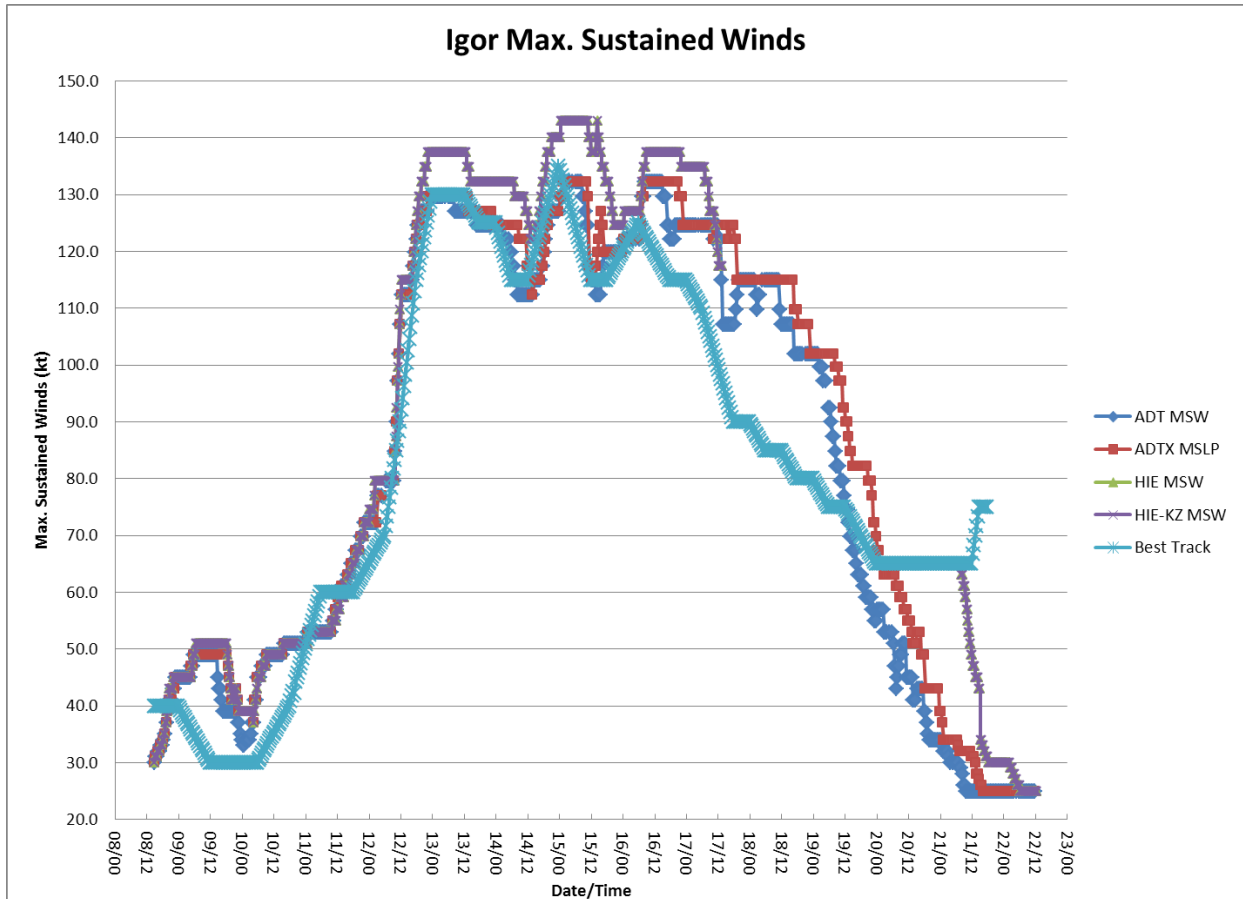


Figure 1. Comparison of the HIE minimum sea-level pressure estimates from two versions of the HIE product, the NHC best track, and two versions of the operational Automated Dvorak Technique for Hurricane Igor from the 2010 Atlantic Hurricane Season. Because the HIE uses SEVIRI data from Meteosat, the values are only available for the portion of the storm track that was in the eastern Atlantic.

3.2. RGB Air Mass Product

- a. This product is a useful complement to the dust product, and in some ways, better separates the dry and moist air regions.

- b. This product may be helpful for monitoring extratropical transition. A late season tropical cyclone (Otto) began extratropical transition in the field of view of Meteosat. The Air Mass Product for that case will be extracted from the archive for later evaluation and training.
- c. The delivery method by Google Earth was okay, but requires full reloading of the loop whenever changes are made to the time interval of the loop. This comment applies to all the Google Earth Products. A modification was made at CIRA following the mid-project review to alleviate that problem. However, even with this change, the products would be much more useful in AWIPS or N-AWIPS format.
- d. Sometimes the product indicates polar air at very low latitudes. This cause of this is not clear.
- e. There are limb effects that perhaps could be corrected as function of zenith angle.

3.3 Dust Product

- a. This product was generally considered very useful and it complements the use of visible imagery to detect dust. The product was mostly viewed by the Hurricane Specialist Unit but has some TAFB applications as well.
- b. Similar to the air mass product, the Google Earth delivery method should be replaced by N-AWIPS next season.
- c. There may be some cloud contamination problems near stratocumulus fields.
- d. There may be some false alarms in very low latitudes.

3.4 SAL Product

- a. The forecasters have been using a similar product for several years, but found the animated version to be an improvement over the static images used previously.
- b. Transition the product to N-AWIPS for 2011.
- c. There may be some contamination near stratocumulus fields.

3.5 SRSO data

- a. Due to the GOES-15 Science Test in the most active part of the 2010 Atlantic Hurricane Season, many valuable SRSO and RSO cases were obtained. This included one minute data for Hurricanes Danielle, Earl, Igor and Karl. Extended periods of five minute data were also obtained.
- b. No hurricane landfall SRSO data was obtained. This will be a high priority for follow-on Proving Ground activities.
- c. The SRSO and RSO data were very valuable for testing NHC's operational ingest and display capabilities.
- d. The SRSO and RSO data were very valuable for comparing data obtained via land line versus direct ingest. The land line option might be needed in the GOES-R era.

3.6 Lightning-Based RII

- a. The lightning data tends to have only a moderate impact on the RII probabilities.
- b. Time series of the inner-core and rainband lightning might be a useful complement to the probability of rapid intensification provided by the product. Plots of this data from 2010 will be made available for evaluation and training and in real time in 2011.
- c. A quantitative evaluation of the RII product was performed after the season. Three metrics were considered, as shown in Table 3. Figure 2 shows the percent improvement in each of these three metrics due to the lightning input. The lightning input improved all three metrics in the east Pacific, but only improved the Bias in the Atlantic.
- d. The real-time RII in 2010 was run using input from the Vaisala GLD-360 data. However, the RII algorithm was developed from lightning data from the World Wide Lightning Location Network (WWLLN). Simple correction factors were applied to convert the GLD-360 data to their WWLLN equivalent based on a three-month overlap at the end of 2010. Inaccuracies in this conversion may have impacted the product evaluation. The WWLLN data for 2010 were obtained following the 2010 season. A slightly modified version of the RII algorithm was re-run for all cases from 2009 and 2010. These two years represent an independent sample because the algorithm was developed from data from 2008 and prior. Figure 3 shows the percent improvement of the RII algorithm run with the WWLLN input. For this sample, the lightning improved all metrics in both basins except for a small degradation in the Atlantic Threat Score. This result suggests that a longer period of overlap is needed between the Vaisala and WWLLN data to properly account for the differing properties in these two networks.

Table 3. Metrics Used to Evaluate the Rapid Intensity Index Without and With Lightning Input

Multiplicative Bias – The sample sum of all forecasted probabilities of rapid intensification (RI). For a perfect score, the summed probability would exactly equal the number of times RI actually occurred in the following 24 hr. The percentage improvement in the bias of the RI forecasts with the lightning was calculated relative to the bias without the lightning input.

Brier Score – The sum of the square of the forecast probability minus the verification probability, where the verification probability equals 1 if the event occurred or 0 if it did not. A value of zero is a perfect Brier Score. The percent improvement is the reduction in the Brier Score due to the inclusion of the lightning data.

Threat Score – The probability of RI is converted to a yes-no binary forecast by assigning a threshold value. The Threat Score is the number of times RI was forecasted and observed, divided by the sum of the number of times RI was forecasted and observed, forecasted but not observed and observed but not forecasted. A perfect score is 1. This can be interpreted in terms of the percentage area of overlap between the forecasts and observations of RI. The Threat Score was calculated for a range of probability thresholds, and the threshold that optimized the Threat Score was chosen. The percent improvement is the increase in the Threat Score due to the lightning input. The optimal probability thresholds were about 40% for the Atlantic and 60% for the east Pacific.

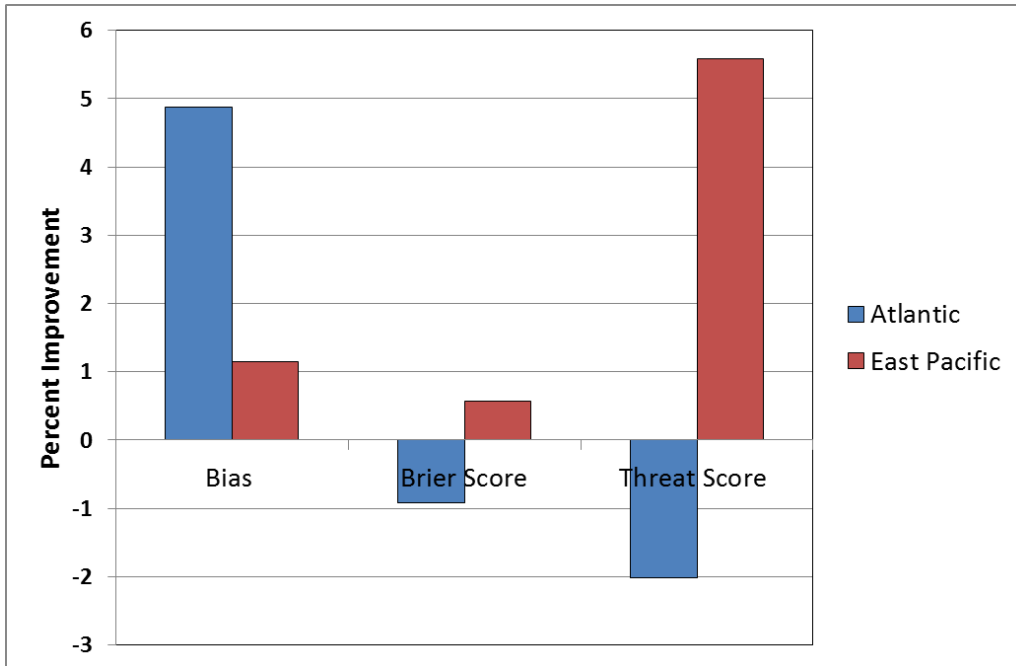


Figure 2. Improvements in the Bias, Brier Score and Threat Score due to the inclusion of the Vaisala lightning input in the experimental Rapid Intensity Index for the 2010 season.

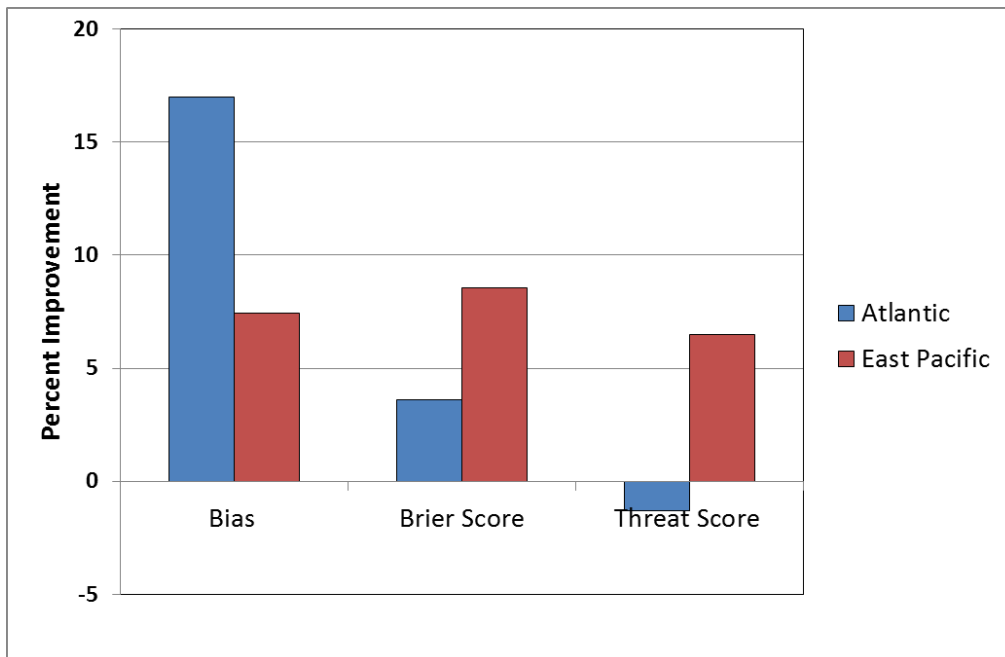


Figure 3. Improvements in the Bias, Brier Score and Threat Score due to the inclusion of the WWLLN lightning input in the experimental Rapid Intensity Index for the 2009-2010 seasons.

4. Lessoned Learned and Preliminary Plans for 2011 NHC Proving Ground

The 2010 season provided an initial introduction of GOES-R data and products to the NHC forecasters, as well as initial experience with the Proving Ground. A meeting is planned at the Interdepartmental Hurricane Conference in March to begin discussion on a follow-up GOES-R Proving Ground at NHC in 2011. Below are some lessoned learned from 2010 and preliminary suggestions for the 2011 Proving Ground.

1. 2010 provided initial familiarity with the Proving Ground. Additional years will be needed to adequately prepare for GOES-R.
2. A quantitative evaluation of the HIE should be performed and a follow-on test should be done in 2011.
3. The possibility of running the HIE off of the GOES-East CONUS sector should be considered in 2011 to increase the sample size.
4. The RGB products are fairly new and it will take several seasons for the forecasters to gain experience with these.
5. The RGB products would be much more useful if they can be provided in N-AWIPS format, rather than Google Earth on a separate PC.
6. It might be useful to "tune" the RGB products more to the tropical regions.
7. Super Rapid Scan Imagery for a U.S landfalling hurricane should be obtained if possible.
8. More experience is needed to determine the value of the lightning input both for the quantitative RII product and for qualitative use for intensity prediction. The algorithm should be tested again in 2011, but using the same lightning network in real time that the algorithm was developed from, if possible.
9. An RGB product developed specifically to aid in TC center fixing might be of use.
10. The AWG version of the GOES-R true color imagery application might be demonstrated from MODIS in 2011.
11. After preliminary research, the GOES-R overshooting tops algorithm might be evaluated during the 2011 season.
12. A product to discriminate between thin and thick cirrus over tropical cyclones would be useful. There are AWG products for that, so proxy versions of those might be considered for the 2011 season.

Appendix

2010 NHC Proving Ground Primary Participants and Their Roles

NOAA/National Hurricane Center

Michael Brennan, Hurricane Specialist
Jack Beven, Hurricane Specialist
John Cangialosi, Hurricane Specialist
Dan Brown, Hurricane Specialist
Marshall Huffman, Tropical Analysis and Forecast Branch forecaster
Jiann-Gwo Jiing, Technical Support Branch chief
Dan Mundell, Tropical Analysis and Forecast Branch forecaster
Chris Sisko, Technical Support Branch

NOAA/NESDIS/STAR Regional and Mesoscale Meteorology Branch

Mark DeMaria, project management, lightning products
John Knaff, lightning products, RGB products, training
Debra Molenaar, technical support

Cooperative Institute for Meteorological Satellite Studies/University of Wisconsin

Tim Olander, Hurricane Intensity Estimate product, training
Chris Velden, Hurricane Intensity Estimate product, RGB products, training

Cooperative Institute for Research in the Atmosphere/Colorado State University

Renate Brummer, project coordination, training
Kevin Micke, technical support, Google Earth products

Cooperative Institute for Marine and Atmospheric Studies/University of Miami

Jason Dunion, Saharan Air Layer product, RGB products, training

GOES-R Program Office

Steve Goodman, Project Coordination, lightning products
Bonnie Reed, Project Coordination
Dick Reynolds, Project Coordination