Update on the GOES-R AWG Hurricane Intensity Estimation (HIE) Algorithm

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Tropical Storms/Hurricanes

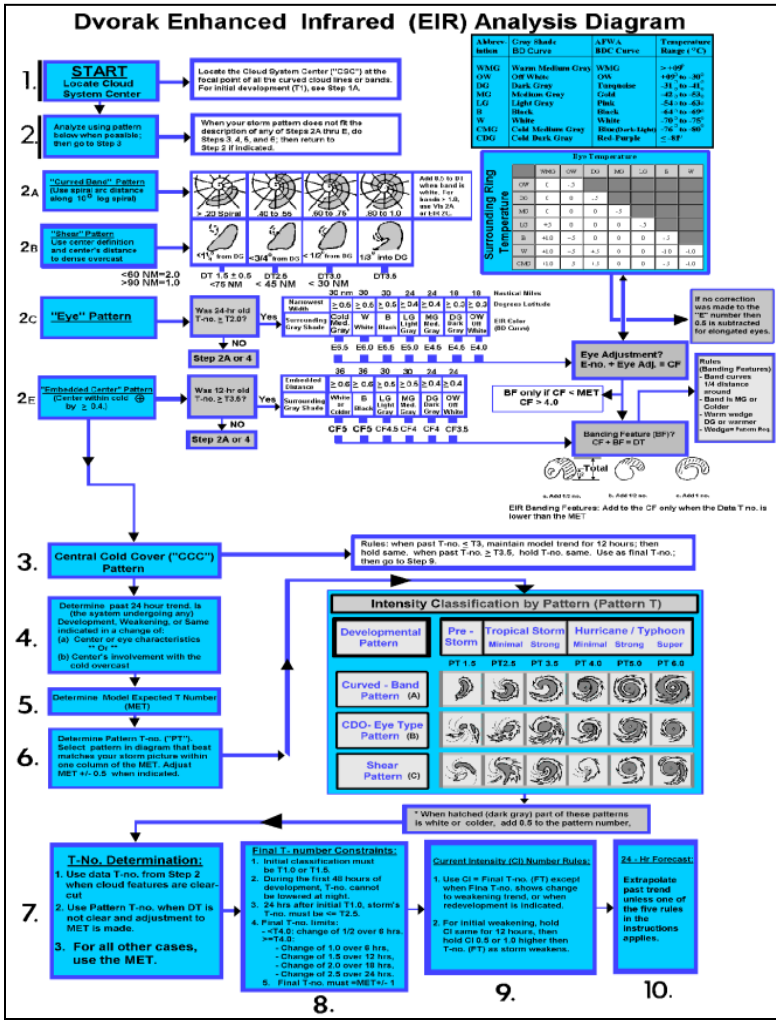
AWG and Proving Ground

Introduction

- The purpose of the GOES-R **Hurricane Intensity Estimation (HIE)** algorithm is to provide tropical cyclone (TC) forecasters with a completely objective and operationally-proven tool to estimate TC intensity using the new GOES-R ABI infrared imagery.

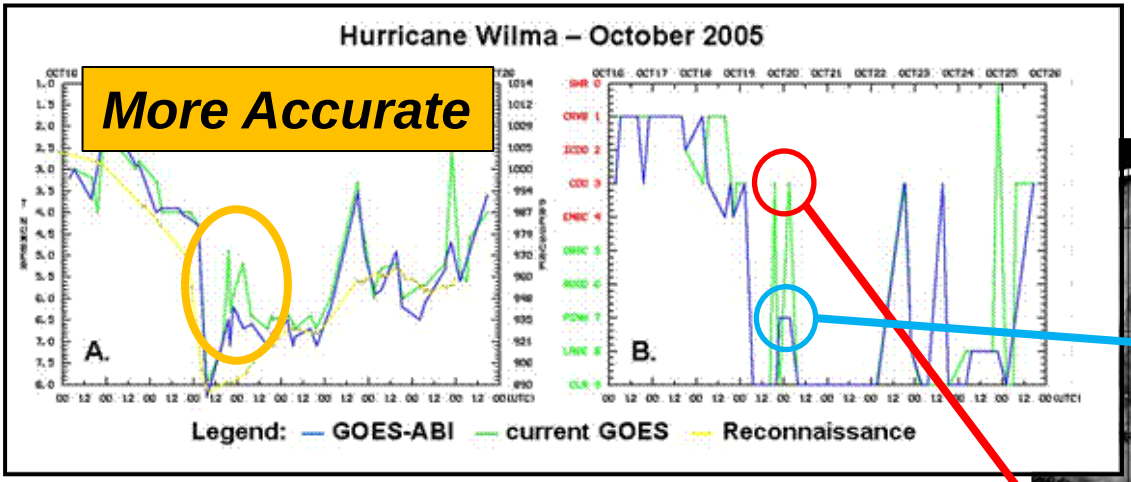
Background

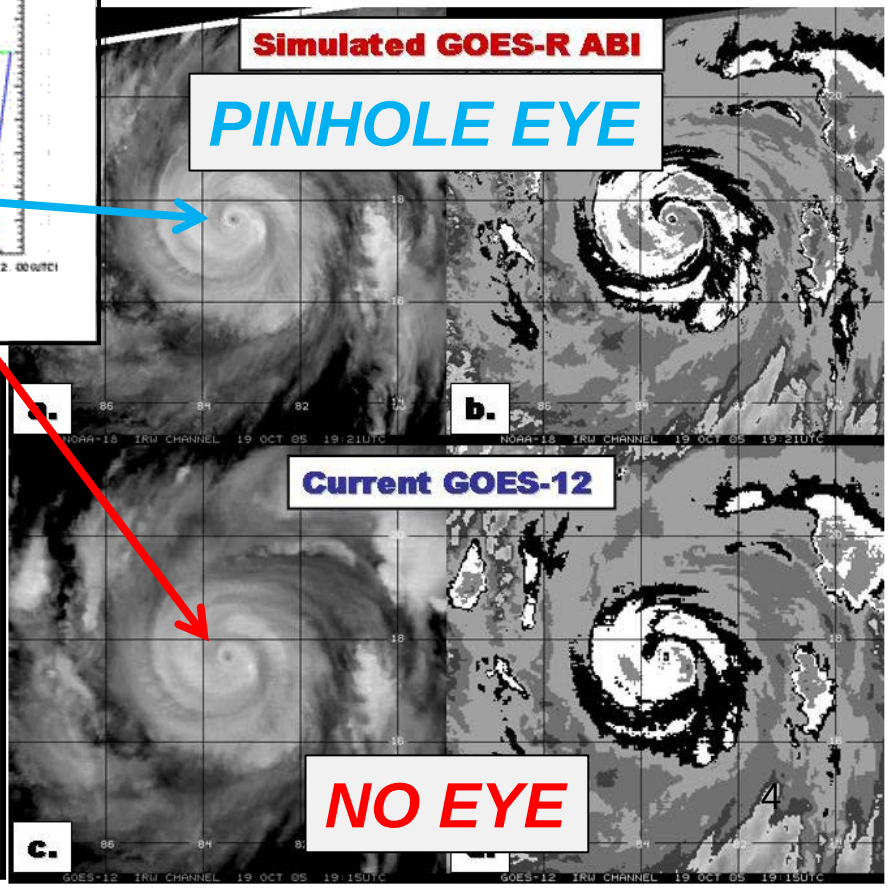
- The **HIE** has its heritage as a version of the UW-CIMSS Advanced Dvorak Technique (ADT), which was developed to closely mimic the “enhanced infrared” segment of the operational Subjective Dvorak Technique (SDT, right), developed by NOAA/NESDIS scientist Vern Dvorak in the 1970’s/1980’s.
- The ADT has been in development since the mid-1990’s and has progressed beyond the scope of the SDT by implementing new analysis techniques and integrated satellite information.
- The ADT now provides TC forecasters with an objective tool to help check their SDT intensity classifications, and this will be the objective of the **HIE** in the GOES-R era.



Methodology/Expected Outcomes

- The superior spatial and temporal resolution provided by GOES-R will improve the ADT/HIE "scene type" selection process and provide more accurate automated storm center determinations, which are vital to accurate objective TC intensity analysis.





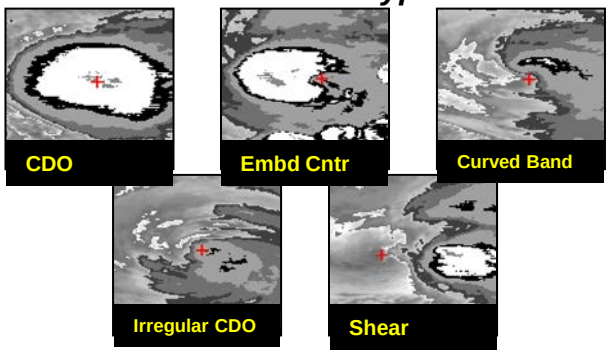
Simulated GOES-R ABI infrared window (IRW) imagery with a.) black/white contrast stretch and b.) "BD-curve" enhancement versus current GOES-12 IRW imagery with c.) black/white contrast stretch and d.) "BD-curve" enhancement for Hurricane Wilma on 19 October 2005 (19:21 and 19:15UTC, respectively). Contrast stretch/enhancement shows improved capability to capture small eye feature.

- Scene type selection
  - Improved ability to identify **small eye features** (such as seen in Hurricane Wilma (2005), right).

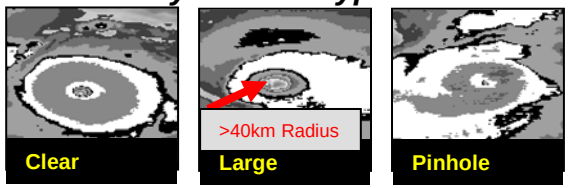
Methodology/Expected Outcomes

– Scene type selection
  - Provide better low-level and **cloud-top temperature and structure information** to aid the analysis of selected scene types.

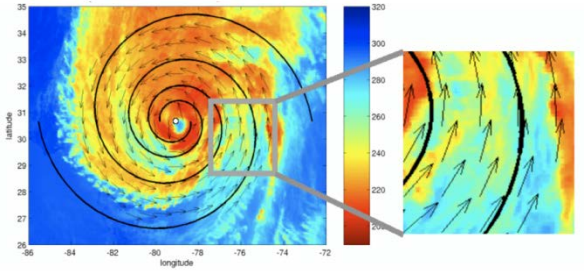
Cloud Scene Types



Eye Scene Types



– Automated storm center determination
  - The **HIE** will more accurately identify spiral structures in rainbands and the eyewall region through improved objective methods to retrieve center positions.

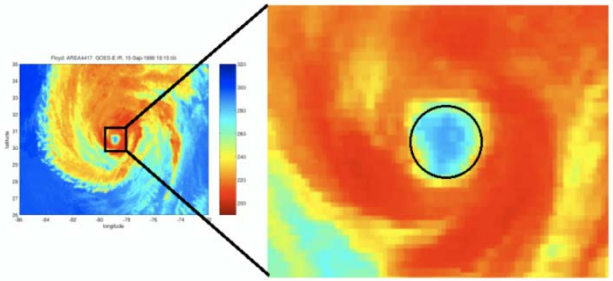


Spiral Centering

- **Fits 5° log spiral vector field to the IR image**
- **Calculates a grid of scores that indicates the alignment between the spiral field and the IR Tb gradients (maximum at the spiral center)**

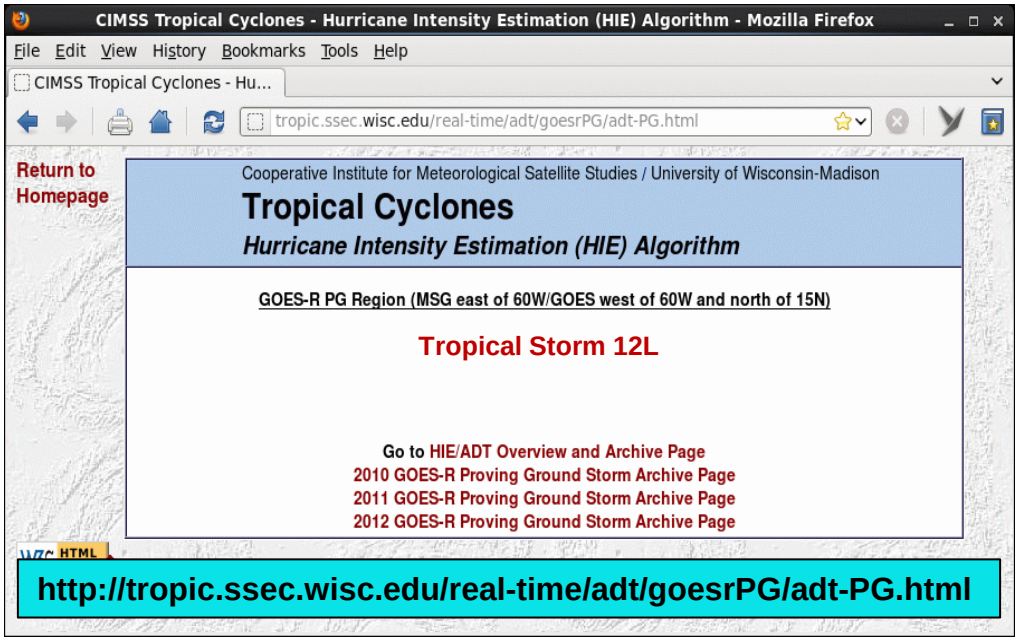
Ring Fitting

- **Calculates a grid of scores that identifies a ring (eyewall), and indicates the best fit to a range of possible ring positions and diameters (maximum at the analyzed eye center)**



Methodology/Expected Outcomes

- **The HIE has been demonstrated to NHC/TAFB specialists within the GOES-R Proving Ground since the 2010 Atlantic TC season.**
  - As proxy data for GOES-R, the **HIE** employs 15-minute IR imagery from Meteosat-9/10 and GOES-East (CONUS sector).
  - **Dedicated HIE web site** was developed for the Proving Grou demonstrations (top)



http://tropic.ssec.wisc.edu/real-time/adt/goesrPG/adt-PG.html

- **Example feedback/use of the HIE by NHC during the GOES-R Proving Ground**

WTNT43 KNHC 060845 2012250 0845
TCDAT3

HURRICANE MICHAEL DISCUSSION NUMBER 13
NWS NATIONAL HURRICANE CENTER MIAMI FL AL132012
500 AM AST THU SEP 06 2012
MICHAEL HAS CONTINUED TO INTENSIFY OVER THE PAST SEVERAL HOURS WITH THE EYE BECOMING WARMER AND THE EYEWALL CONVECTION STAYING STRONG. WHILE SUBJECTIVE ESTIMATES WERE NEAR 90 KT AT 0600 UTC**...OBJECTIVE ESTIMATES FROM ADT AND THE GOES-R HIE PRODUCT HAVE RECENTLY BEEN BETWEEN 107 AND 110 KT.** A BLEND OF THESE DATA GIVE AN INITIAL WIND SPEED OF 100 KT...MAKING MICHAEL THE FIRST MAJOR HURRICANE... CATEGORY THREE OR HIGHER...OF THE SEASON.

Results

Independently analyzed performance analysis conducted after the 2011 TC season (Atlantic Basin only) comparing real-time intensity estimates from the ADT8.1.3 and HIE algorithms. *(courtesy Jack Beven – NOAA/NHC)*

	MSW (kts)			CI#			FT#			
	Bias	Stdv	AvErr	Bias	Stdv	AvErr	Bias	Stdv	AvErr	NUM
HIE	**-1.2**	**6.7**	**9.0**	**-0.08**	**0.32**	**0.44**	**-0.33**	**0.38**	**0.51**	**1890**
ADT	**-2.0**	**6.4**	**9.2**	**-0.12**	**0.32**	**0.46**	**-0.35**	**0.36**	**0.53**	**1890**

MSW = Maximum Sustained Winds; CI# = Current Intensity Number; FT# = Final T-number. Verification: NHC Best Track intensity analysis

Comparatively, the **HIE** performs on par with the latest version of the CIMSS **ADT**.

Path to Operations

- **The ADT is already used operationally by various TC forecast centers worldwide, including NOAA/NHC & CPHC, NOAA/NESDIS/SAB, and DoD/JTWC.**

- **Integration and testing of the HIE is underway through the GOES-R Algorithm Working Group program, for "Day-1" readiness after launch and operational activation of GOES-R.**

Future Plans

- The current version of the **HIE** that is being integrated into the GOES-R processing system framework is “frozen” code. The final version for operational use will integrate and include all upgrades contained in the most recent version of the ADT at the time of GOES-R activation. Some of these upgrades will include:
  - Direct ingest and use of polar-orbiter microwave data within the HIE algorithm (self-contained)
  - Adjustments to the intensity determination routine based on new science and positive performance impacts (such as new regression equations and various rules used within the algorithm)
  - Possible use of visible and shortwave-IR channel
  - Improved automated storm centering based on ARCHER algorithm
  - Ability to operate on pre-Depression systems
  - Development of a scene type for TCs transitioning to Extra-Tropical or Post-Tropical systems

References/Publication List

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• Wimmers, A. and C. S. Velden, 2012: Hurricane center-fixing with the Automated Rotational Center Hurricane Eye Retrieval (ARCHER) method: From microwave to infrared and visible application**,** Conference on Satellite Meteorology, Oceanography and Climatology, 18th, and Joint AMS-Asia Satellite Meteorology Conference, 1st, New Orleans, LA, 22-26 January 2012. American Meteorological Society, Boston, MA, 2012

• Wimmers, A. J., and C. S. Velden, 2010: Objectively determining the rotational center of tropical cyclones in passive microwave satellite imagery. *J. App. Meteor*, **49**, 2013-2034.