NESDIS
PSDI

KEY NESDIS RESEARCH AND R2O INTENDED TO IMPROVE HURRICANE FORECASTS

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NOAA Center for Satellite Applications and Research
Fort Collins, Colorado

2015 NHC PG Demo Plan
GOES-R Demonstrations

Proving Ground Product	Category	Evaluation Goals
GOES-R natural color (Future Capability)	Mature	Included in NHC PG for several years Continue to obtain feedback, time permitting
RGB air mass (Future Capability)		
RGB dust (Future Capability)		
Saharan Air Layer (Future Capability)		
Pseudo natural color (Future Capability)		
Super rapid scan imagery (Baseline)		
Hurricane Intensity Estimate (HIE) (Baseline)	Quantitative	Continue to obtain feedback, quantitative verification
Rapid Intensification Index (RII) (Risk Reduction)		
Derived motion winds (Baseline)	Introductory	Emphasize and obtain feedback on tropical applications – first two or new this year, last four were introduced in late 2013, little exposure
RGB daytime microphysics (Future Capability)		
RGB nighttime microphysics (Future Capability)		
RGB convective storms (Future Capability)		
CIRA RGB DEBRA-Dust (Future Capability)	Comparison	Encourage forecasters to display comparison products w/ originals, provide strengths and weaknesses
Lightning density (Baseline)		
Tropical overshooting tops (TOT) (Future Capability)	Underutilized	Continue to be included, modified, or given less emphasis?

The 2016 plan is being developed.

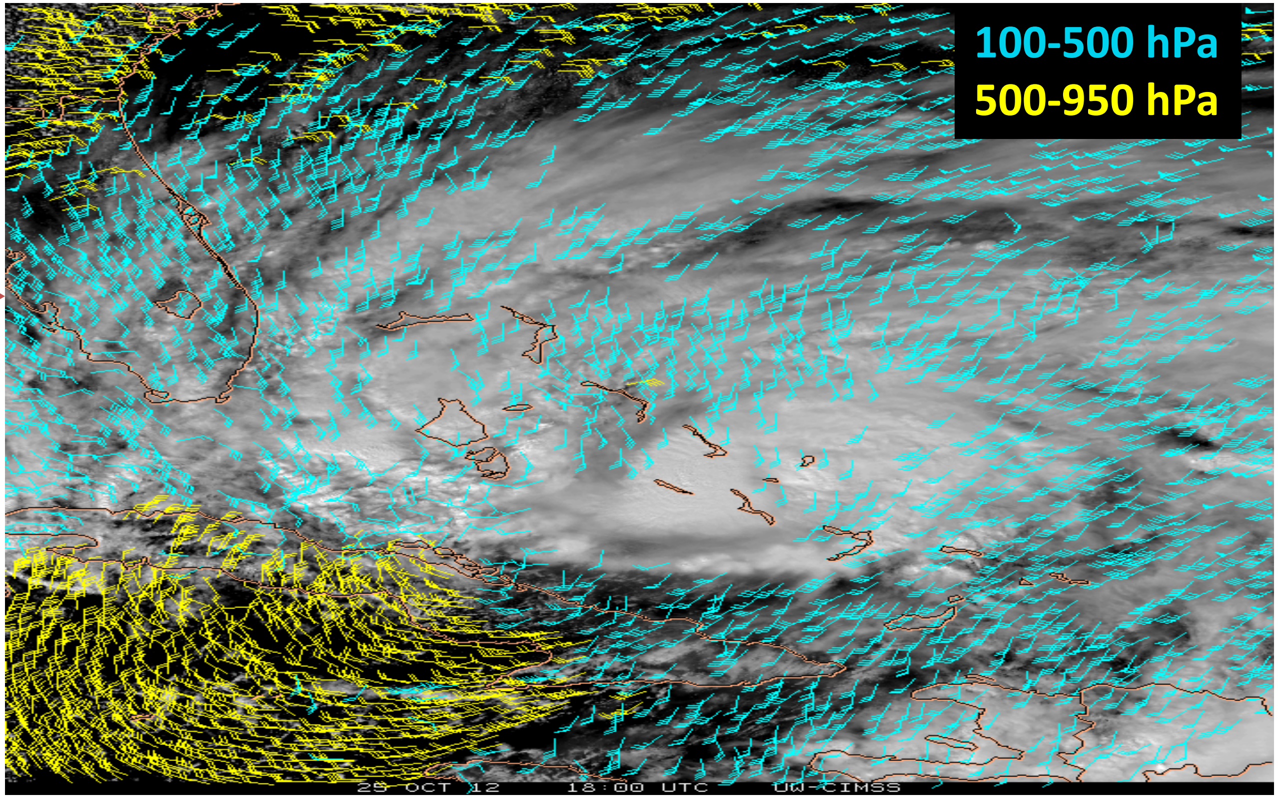
GOES-R Derived Motion Winds (DMV)

PIs: Jaime Daniels (NESDIS/STAR) and Chris Velden (CIMSS)

- **Features of the GOES-R DMV algorithm and processing**
  - Completely automated; Novel tracking and vector height assignment methods
  - Adapted to operate with GOES-R LW and SW IR, WV and VIS rapid-scan imagery
  - Will provide rapid-refresh, real-time tropical cyclone wind fields
  - R&D and R2O supported by GOES-R AWG and HFIP

1800 UTC 25 Oct, 2012

VIS/IR DMVs from GOES-14 super-rapid-scans during Hurricane Sandy



HWRF data assimilation experiments to optimize the DMV information for improving TC predictions are underway

Real-time hybrid Windspeed Probabilities

Data & Methods

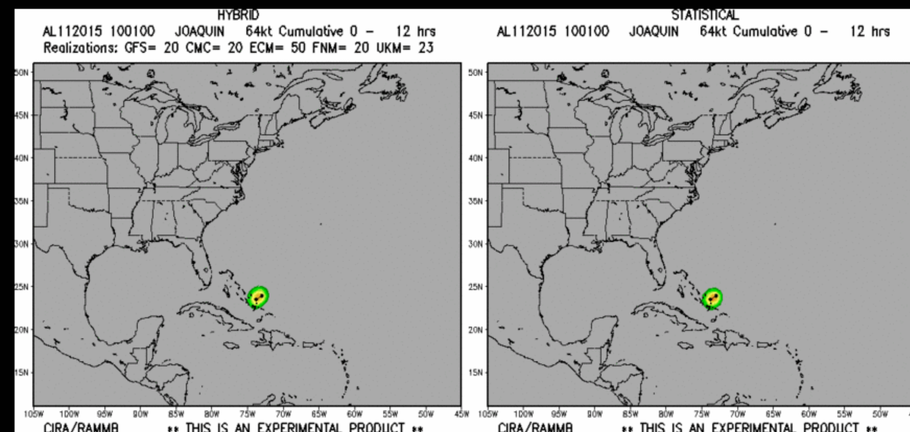
Data:

- TC Information
  - a-decks, b-decks and e-decks
- Global forecast ensembles
  - GFS (n=20),CMC (n=20),ECMWF (n=50),FNMOC (n=20), UKMET (n=23)
  - 133 model total track forecasts

Methodology:

- Use 133 global model ensemble tracks realizations in place of 1000 MC tracks
- Intensity and radii same as statistical version
- Atlantic, NE Pacific, NW Pacific basins
- Runs on numbered invests (not verified)

Example: Joaquin



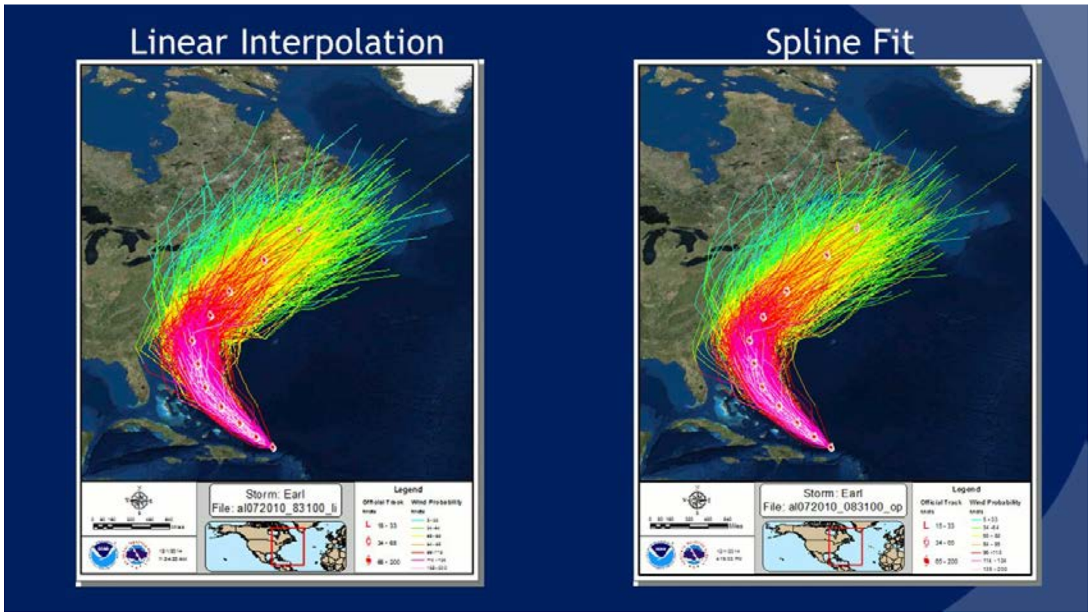
- Latency ~ 6-12 hrs
  - Runs as soon as first ensembles are available
  - Keeps updating until all are available
- Runs at 0 and 12 UTC

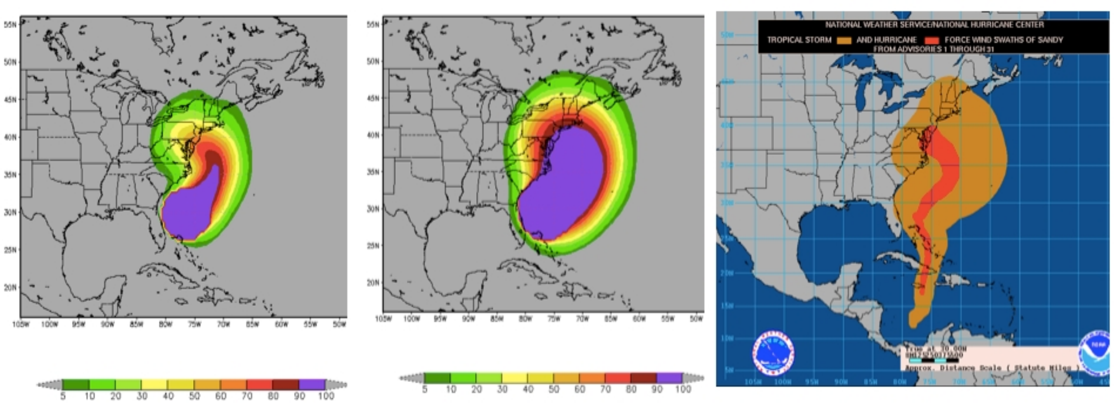
http://www.hfip.org/data/
Display of: Ensemble probability
Select model: Windspeed probability thresholds

Sponsor: HFIP/NHC
PI: Andrea Schumacher

Upgrades to the Monte Carlo Wind Speed Probability Program – JHT

Andrea Schumacher, CSU/CIRA





- Improved interpolation
  - replaced linear interpolation with spline
  - smoother, more realistic realization tracks (left, top)
- Standardized error statistics to match NHC official
- Radii bias correction
  - Uses official radii forecasts, when available
  - Improved probabilities for very small and very large TCs (e.g., left bottom)

Joint Hurricane Testbed

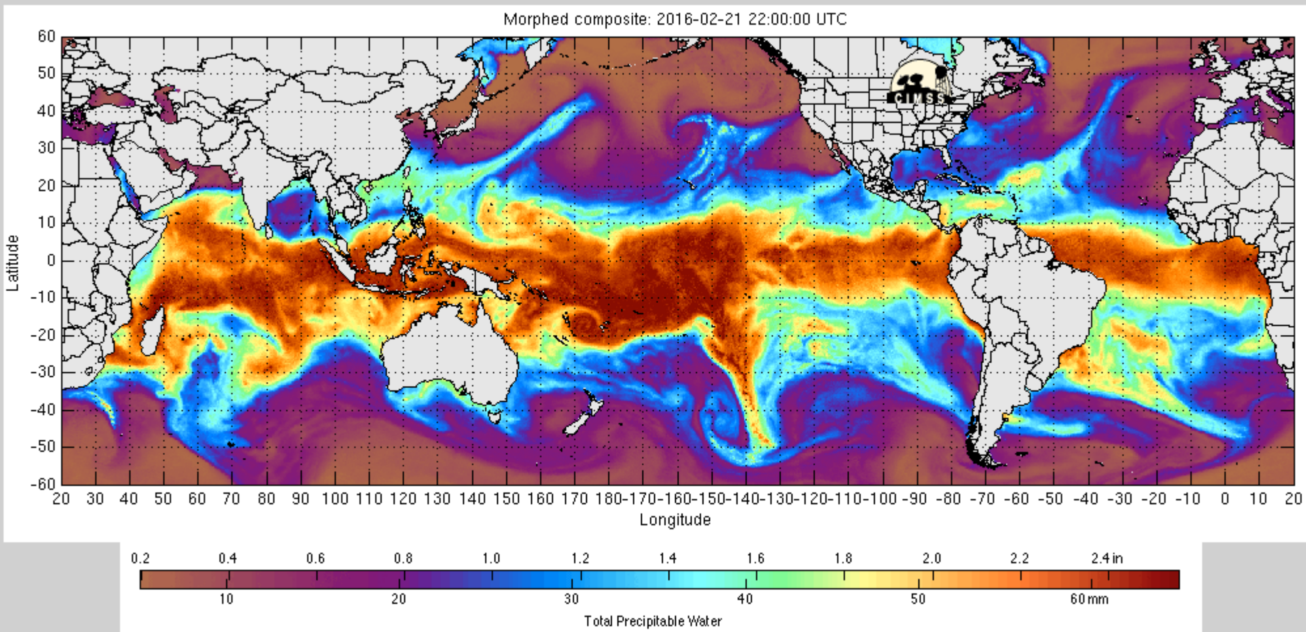
MIMIC-TPW

Morphed Integrated Microwave Imagery at CIMSS - Total Precipitable Water (MIMIC-TPW)

Global | Global-2 | North Atlantic | West Pacific | East Pacific | Indian Ocean | Australia/Fiji

SSMI/SSMIS/AMSR2-derived Total Precipitable Water - Global

Current time: Mon, 22 Feb 2016 17:54:03 GMT



View: Animated Gif / HTML5 | Animations: Recent / FTP archive | Images: Recent / FTP archive | Product Description

- Real-time morphological composites of satellite-derived Total Precipitable Water
- Used routinely by the Pacific Region, Key West, TAFB; Distributed over AWIPS-2
- R2O supported by JPSS-RR and Proving Ground

PIs: Tony Wimmers and Chris Velden

Verification of large-scale HWRF synthetic total precipitable water

Purpose:

- Environmental moisture plays a critical role in TC evolution
- Validate HWRF synthetic total precipitable water using the NESDIS operational blended product (Kidder & Jones 2007)

Metrics:

- Mean absolute error (MAE)
- Mean bias
- Mean square error (MSE) skill score (SS) with climatology as a reference

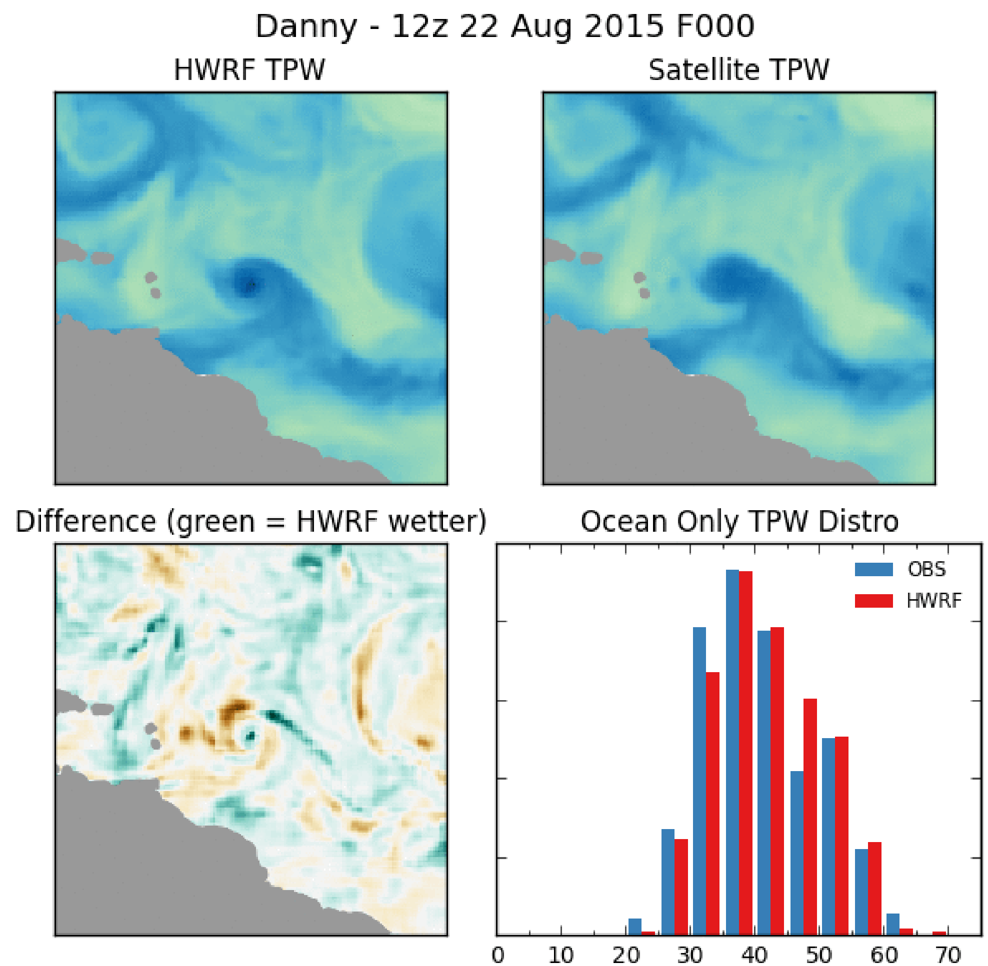
Potential extensions to work:

- Correlate MSE SS from the analysis to 24/48 hour intensity error
- Perform outlier analysis

Sponsor HFIP/NHC

PI: Kate Musgrave

Personnel: Chris Slocum, John Knaff



Comparison and difference plots and normalized histograms for each forecast.

Kidder, S. Q., and A. S. Jones, 2007: A Blended Satellite Total Precipitable Water Product for Operational Forecasting. J. Atmos. Oceanic Technol., 24, 74–81.

R2O Projects: Hurricane Intensity and Wind Structure Forecasting

- Eyewall Replacement Cycles (ERCs): Two models have recently been transitioned into operations at the National Hurricane Center as part of the NOAA **Joint Hurricane Testbed (JHT)** Project:

    1. The PERC-model provides probability of an ERC event.
    2. E-SHIPS provides intensity forecasts during ERCs.

Satellite data utilized: Microwave and GOES data during R&D period of the projects, GOES infrared-based predictors in the operational models.

A third model is in the R&D phase of the R20 JHT project. This model adds operational microwave data to the existing models.

- Rapid Intensification (RI): Development of probabilistic models to forecast RI. Presently in transition to NHC operations.

Satellite data utilized: Microwave and GOES data during R&D and operational periods.

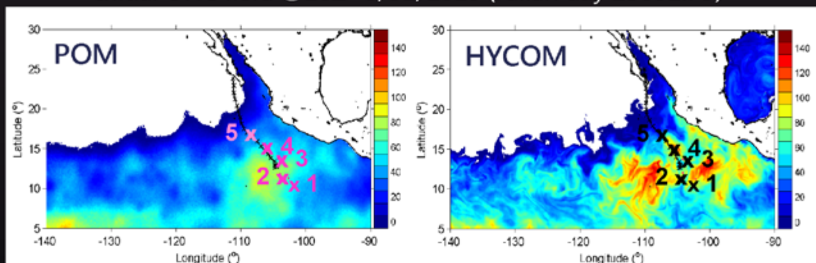
Personnel: Jim Kossin[1], Chris Rozoff[2], Tony Wimmers[2], Derrick Herndon[2], Chris Velden[2], Tim Olander[2], Mark DeMaria[3], John Kaplan[4], John Knaff[5]

[1] NOAA National Centers for Environmental Information, Center for Weather and Climate
[2] Cooperative Institute for Meteorological Satellite Studies
[3] NOAA National Hurricane Center
[4] NOAA Hurricane Research Division
[5] NOAA Center for Satellite Applications and Research

Blanca (2015) OHC/SSHA

Hurricane Blanca (2015): Ocean Heat Content (OHC)

Initial OHC field @18Z 5/31/2015 (Julian day 23891.75)



	Argo					POM			HYCOM		
#	ID	Julian day	Lon. (°W)	Lat. (°N)	OHC ±1.5	Lon. (°W)	Lat. (°N)	Δ OHC	Lon. (°W)	Lat. (°N)	Δ OHC
1	4901510	23891.45	102.66	11.79	**123.0**	102.70	11.86	**-54.4**	102.64	11.91	**5.6**
2	4901509	23890.34	104.33	12.23	**118.2**	104.33	12.20	**-38.3**	104.32	12.23	**0.0**
3	4901511	23889.79	104.38	14.41	**105.1**	104.33	14.38	**-58.9**	104.40	14.41	**8.2**
4	4900842	23885.86	106.03	15.67	**84.7**	106.06	15.63	**-35.9**	106.00	15.64	**4.0**
5	4901638	23893.26	108.30	16.56	**29.2**	108.26	16.55	**8.9**	108.32	16.56	**2.8**

Mean difference ($kJcm^{-2}$) = -35.5 (POM) vs. 4.1 (HYCOM)
RMS difference ($kJcm^{-2}$) = 24.0 (POM) vs. 2.7 (HYCOM)

With the recent launch of Jason-3 and Sentinel-3a, we will have possibly as many as 5 altimeters operating in 2016.

Hurricane coverage may be greatly improved.

Jason-3 and Sentinel-3a were recently launched

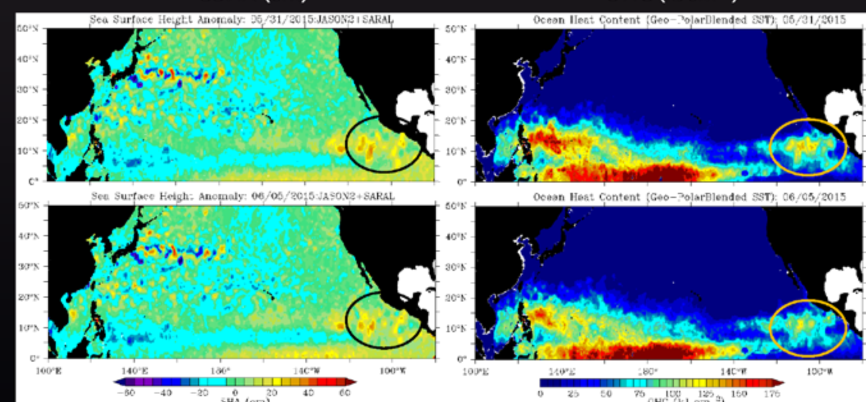
Provided by Hyun-Sook Kim and Laury Miller

Contacts: Eileen Maturi
Developed by Nick Shay

SSHA and OHC for Hurricane Blanca (2015)

Before (May 31) and after the 1st intensification (June 5)
ΔSSHA ~46 cm
ΔOHC ~51 $kJcm^{-2}$

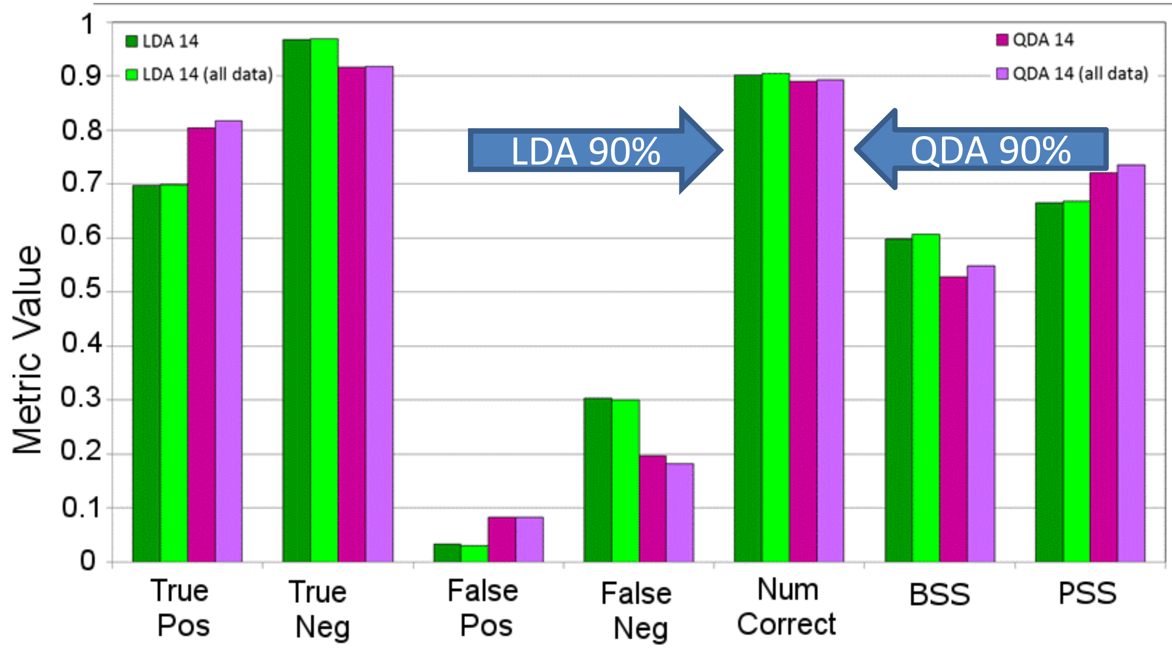
SSHA (cm) OHC ($kJcm^{-2}$)

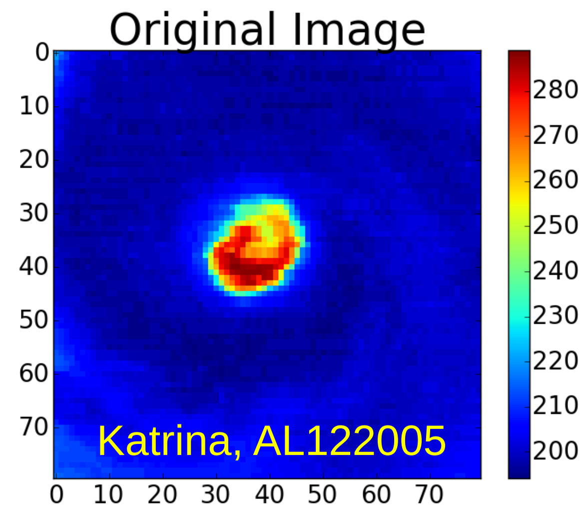


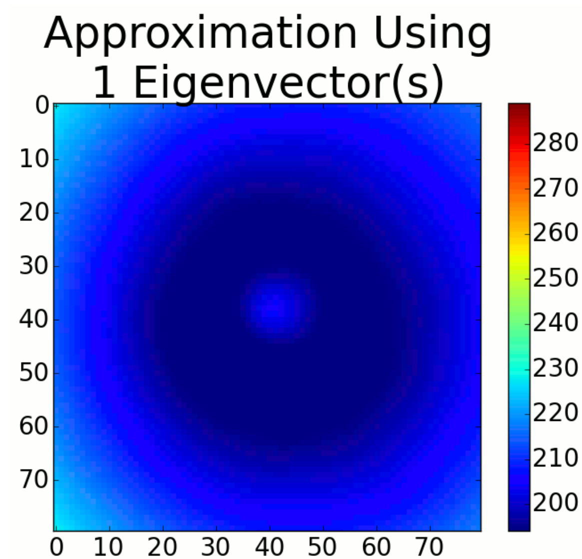
The NESDIS operational N. Pacific OHC product
developed by Nick Shay (univ of Miami, RSMAS)
Contact for access to this operational product is Eileen Maturi 301-683-3347.

Eye-Detection Algorithm for SHIP/LGEM/RII (HIE ?)

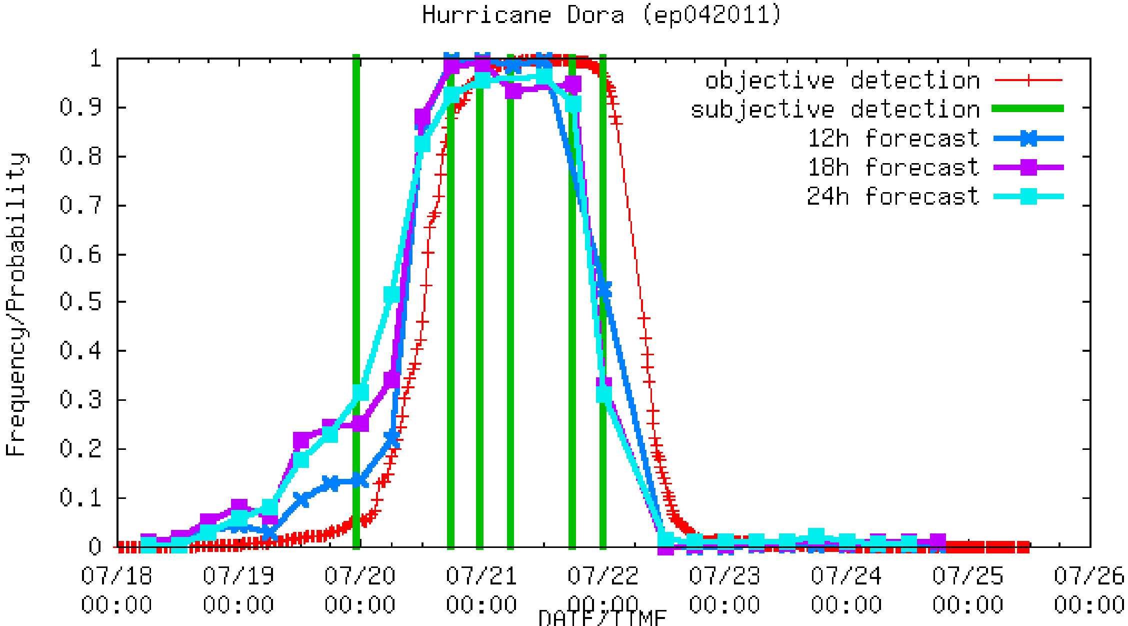
- TC eye formation is often associated with RI
- Developed preliminary **automated objective eye-detection algorithm**:
  - Uses PCA and Linear and Quadratic Discriminant Analysis (QDA and LDA)
  - Has **85-90% success rate**
  - Will be **improved** and used to **develop new RII/SHIPS/LGEM predictor**







Sponsor: JPSS PI: Galina Chirokova Personnel: R. DeMaria, J. Knaff



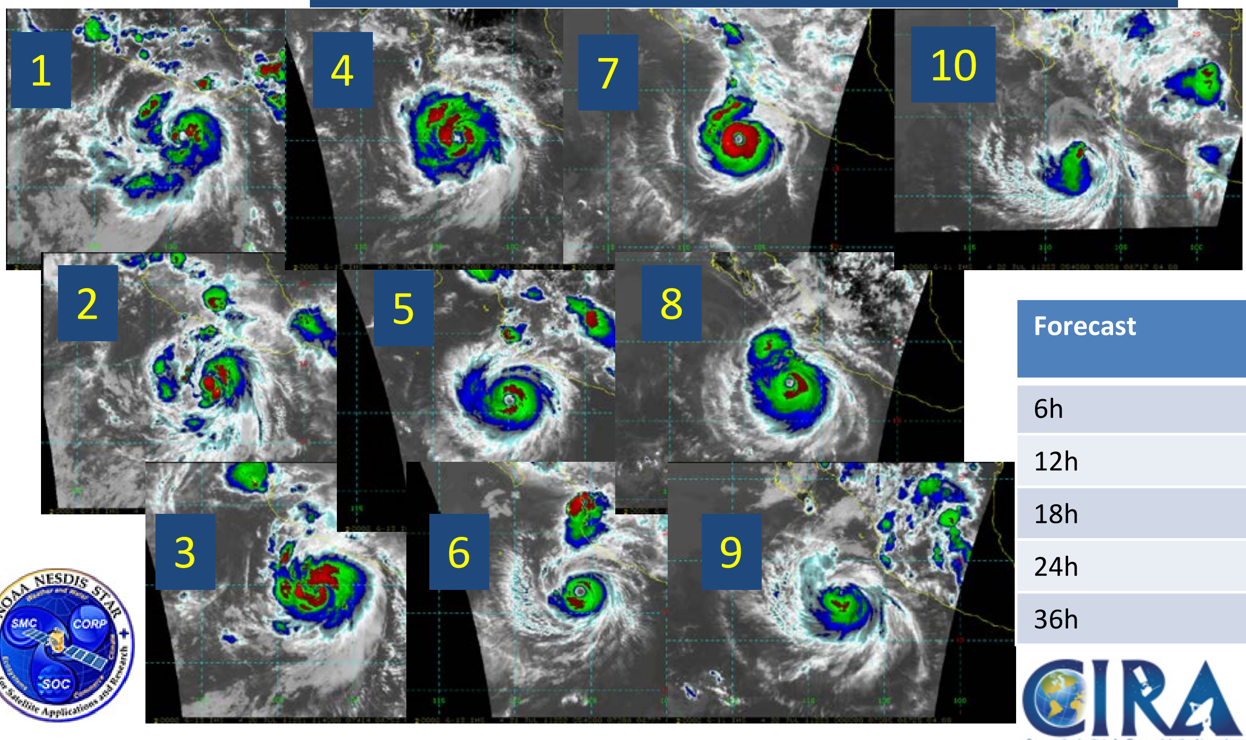
Probabilistic Eye Anticipation

PI's: Kate Musgrave & John Knaff
Sponsor: GOES-R Risk Reduction

Subjective estimates from Operational Dvorak estimates

Objective detection is based on IR PCs, Vmax, latitude (R. DeMaria, 2015)

1 2 3 4 5 6 7 8 9 10 6-hourly staring 7/20 UTC

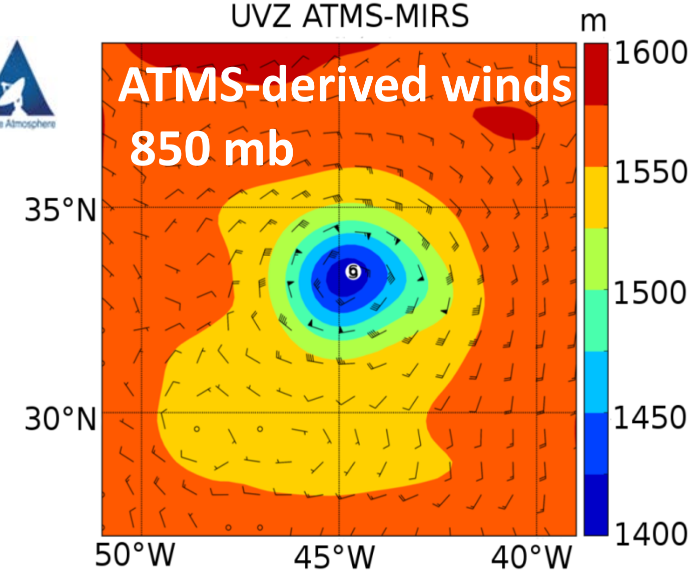


Forecasts developed using Atlantic TC cases (1996-2013)

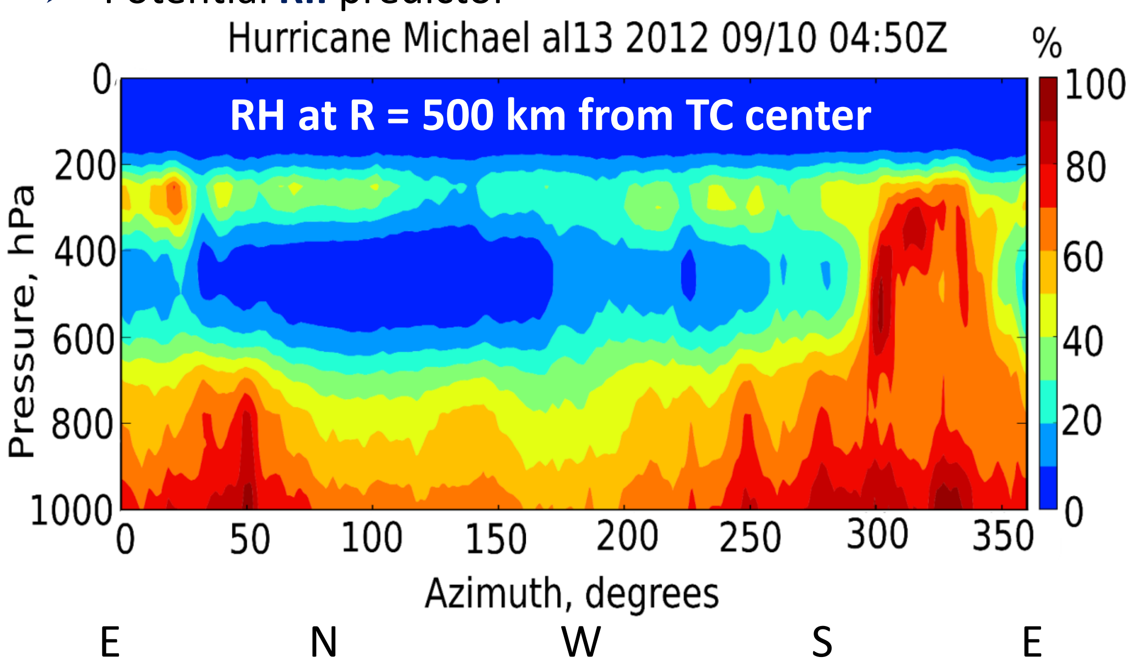
Results shown are based on East Pacific TCs (1996-2013) (i.e., independent stats)

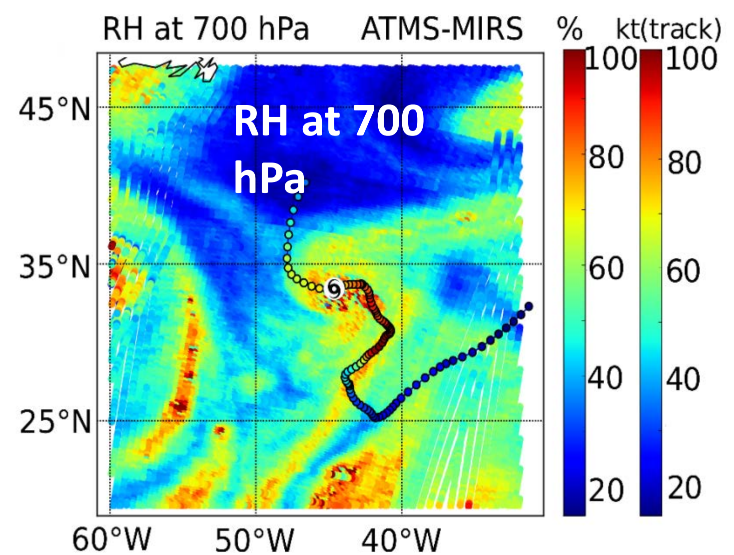
Forecast	BSS (persistence)	BSS(climatology)
6h	-0.14468	0.887362
12h	0.352624	0.804435
18h	0.466596	0.708896
24h	0.469752	0.576138
36h	0.497027	0.375371

MIRS-based Moisture Flux Application for RI Improvements



- Magnitude, direction of moisture flux at a given radius R from the TC center can be estimated from ATMS AMSU and/or NUCAPS
- Relative Humidity (**RH**): **ATMS-MIRS/NUCAPS q profiles**
- **Winds**: **derived from ATMS/NUCAPS T, q profiles** using CIRA operational microwave wind algorithm or use **GFS**
- Potential **RII** predictor

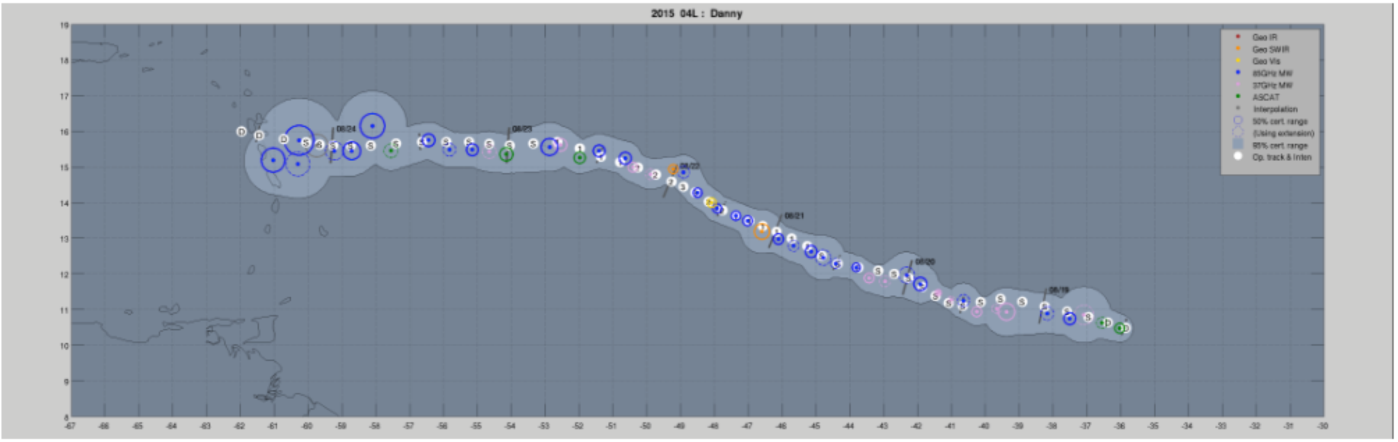


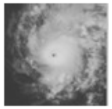
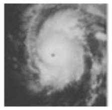
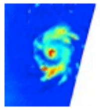
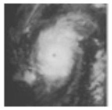
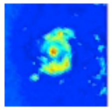


Hurricane Michael al132012

Sponsor: JPSS PI: Galina Chirokova Personnel: R. DeMaria, J. Knaff

ARCHER – Automated Rotational Center Hurricane Eye Retrieval

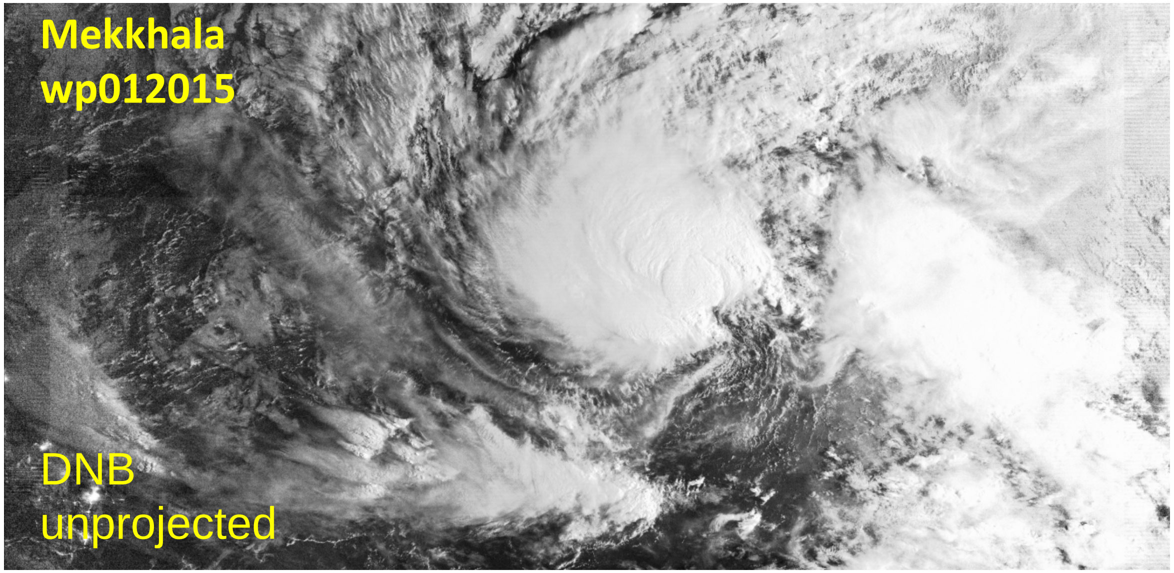


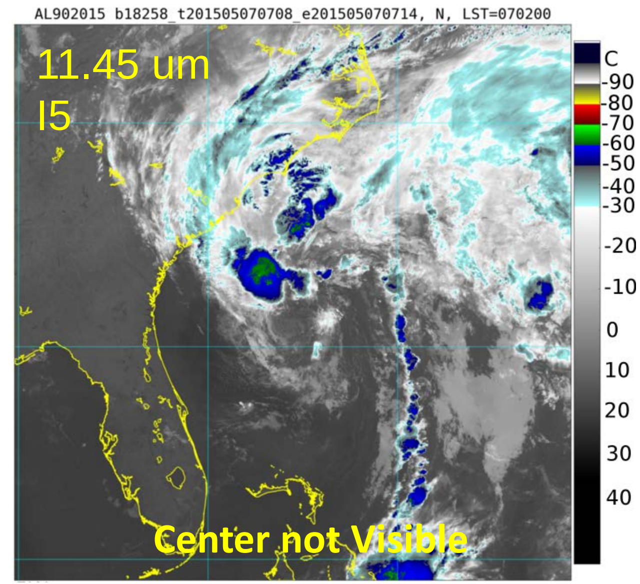
Geo IR	85-92GHz	Date/Time (UTC)	Source	Sensor	Vmax(kts)	ARCHER Lat	Lon	Geo-ref Lat	Lon	50% cert. rad.	95% cert. rad.	Eye diam (deg)	% cert. of eye
		**20150821 14:45:00 ***	**Geo**	**Vis**	**91.9**	**14.00**	**-48.08**	**14.00**	**-48.08**	**0.13**	**0.37**	**0.10**	***
		20150821 14:45:00	Geo	NearIR	91.9	13.92	-48.19	13.92	-48.19	0.27	0.75	0.10	***
		20150821 14:45:00	Geo	IR	91.9	***	***	***	***	***	***	0.10	***
		20150821 13:06:00	Metop-B	ASCAT	86.8	13.72	-48.05	13.63	-47.87	0.16	0.45	***	***
		20150821 12:15:00	Metop-A	ASCAT	85.4	13.51	-47.88	13.48	-47.82	0.20	0.55	***	***
		20150821 12:12:00	Metop-A	ASCAT	85.3	13.51	-47.88	13.48	-47.82	0.20	0.56	***	***
		20150821 11:45:00	Geo	Vis	84.6	13.81	-47.66	13.81	-47.66	0.45	1.28	0.20	***
		20150821 11:45:00	Geo	NearIR	84.6	13.69	-47.79	13.69	-47.79	0.35	0.98	0.10	***
		20150821 11:45:00	Geo	IR	84.6	13.74	-47.82	13.74	-47.82	0.14	0.40	0.10	100.0
		20150821 11:09:48 *	**SSMIS-18**	**85-92GHz**	**83.6**	**13.80**	**-47.84**	**13.84**	**-47.92**	**0.13**	**0.37**	**1.30**	**58.4**
		20150821 09:29:41	SSMIS-19	85-92GHz	80.8	13.72	-47.47	13.68	-47.37	0.15	0.43	1.00	34.5
		20150821 09:23:10	SSMIS-17	85-92GHz	80.6	13.76	-47.45	13.73	-47.37	0.14	0.39	1.10	52.2
		20150821 08:45:00	Geo	NearIR	79.6	13.56	-47.39	13.56	-47.39	0.20	0.57	0.10	***
		20150821 08:45:00	Geo	IR	79.6	13.61	-47.34	13.61	-47.34	0.21	0.58	0.10	84.6
		20150821 07:41:01 *	**SSMIS-16**	**85-92GHz**	**77.8**	**13.58**	**-47.22**	**13.63**	**-47.37**	**0.13**	**0.36**	**1.10**	**61.3**

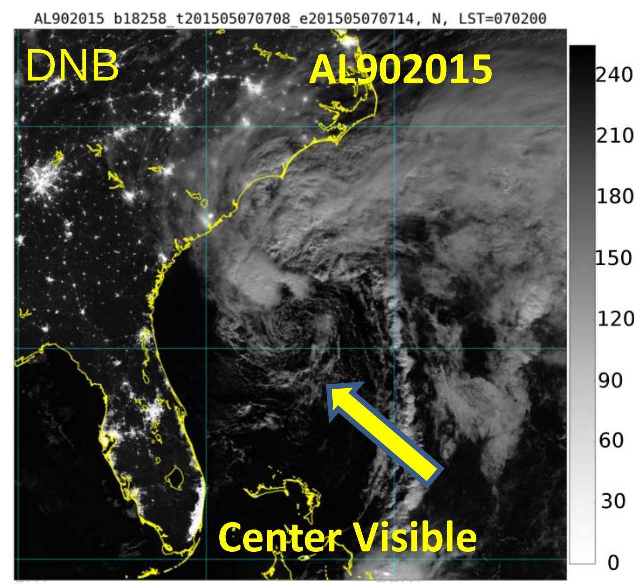
- Real-time, objective tropical cyclone center-finding from geostationary, polar microwave and scatterometer
- Used by National Hurricane Center and soon by Central Pacific Hurricane Center
- R2O supported by the NOAA Joint Hurricane Testbed

PI's: Tony Wimmers and Chris Velden

Improving the Utility of VIIRS TC Imagery







- VIIRS DNB imagery provides unique data that could be critical for TC forecasting
- Near real-time the IR, Visible, and DNB images of the global tropical cyclones is available at RAMMB-CIRA TC Real Time Page: http://rammb.cira.colostate.edu/products/tc_realtime/

- Next:
  - Create improved VIIRS TC DNB imagery for wider range of conditions

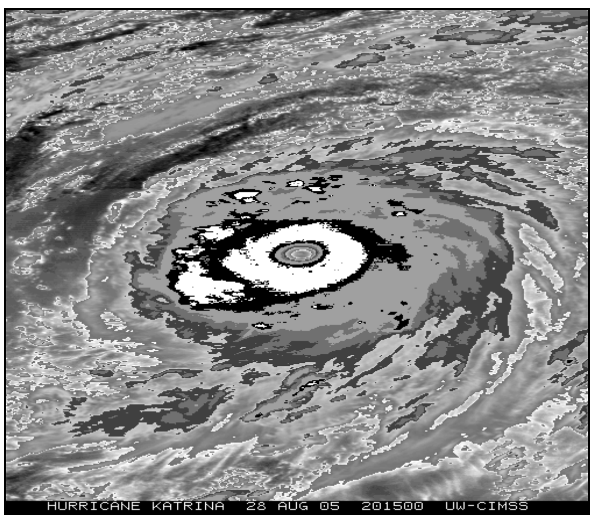
Sponsor: JPSS PI: Galina Chirokova
Personnel: R. DeMaria, J. Knaff, K. Micke

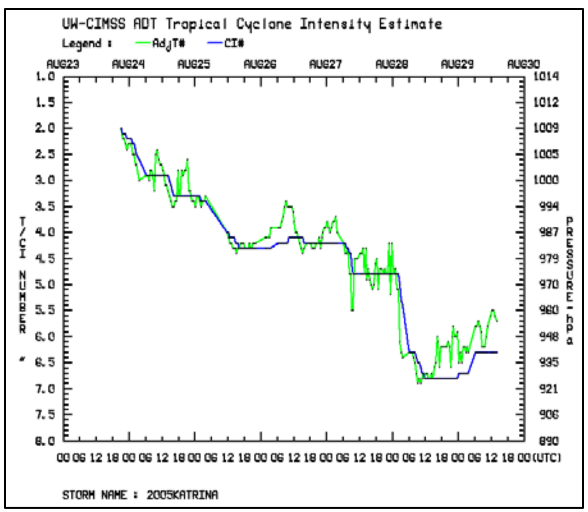
GOES-R Hurricane Intensity Estimation (HIE) Algorithm

PIs: Tim Olander and Chris Velden (CIMSS)

- **Features of the HIE**
  - Based on the operational Advanced Dvorak Technique (ADT)
  - Utilizes GEO Longwave IR imagery, enhanced with LEO microwave data
  - Completely automated and objective
  - Adapted to operate on GOES-R imagery
  - Will provide rapid-refresh (10-min) real-time tropical cyclone intensity estimates

R2O supported by GOES-R AWG and Proving Ground



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                 UW - CIMSS
          ADVANCED DVORAK TECHNIQUE
              ADT-Version 8.1.5
     Tropical Cyclone Intensity Algorithm

           ----- Current Analysis -----
   Date :  28 AUG 2005     Time :   154500 UTC
    Lat :   26:14:25 N      Lon :   88:20:05 W

              CI# /Pressure/ Vmax
              6.8 / 926.0mb/134.8kt

           Final T#  Adj T#  Raw T#
              6.7     6.7     6.7

   Latitude bias adjustment to MSLP :  -0.6mb

 Estimated radius of max. wind based on IR : 33 km

 Center Temp : +20.2C    Cloud Region Temp : -69.9C

 Scene Type : EYE

 Positioning Method : RING/SPIRAL COMBINATION

 Ocean Basin : ATLANTIC
 Dvorak CI > MSLP Conversion Used : ATLANTIC

 Tno/CI Rules : Constraint Limits : NO LIMIT
                    Weakening Flag : ON
           Rapid Dissipation Flag : OFF

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New Microwave Intensity and Structure Estimates (NESDIS)

Description

- Uses the Microwave Integrated Retrieval System (MIRS)
- NOAA -18, -19, Metop-A,-B, ATMS
- Follows previous methodology (Demuth et al. 2004, 2006)
  - Create radial/height profiles
  - Calculate gradient winds
  - Statistically bias correct to provide intensity and structure.
- Available from
  - AMSU: ftp://satepsanone.nesdis.noaa.gov/TCFP/AMSUTC/
  - ATMS: ftp://satepsanone.nesdis.noaa.gov/TCFP/NPPTC/

Statistics (JTWC/NHC/CPHC best)

ATMS

	Vmax (kt)	Pmin (hPa)	R34 (nmi)	R50 (nmi)	R64 (nmi)
ATMS	**11.1**	**7.0**	**20**	**12**	**12**
Required (≤)	***13.5***	***10.0***	***32***	***18***	***10***
Bias	0.0	0.7	-3.1	0.3	4.5
N	*1565*	*1565*	*344*	*215*	*134*

AMSU

	Desired Accuracy	MIRS
Vmax (kts)	13.5	13.2 (4346)
Pmin (hPa)	9	8.4 (4347)
R34 (nmi)	32	24.9 (1044)
R50 (nmi)	18	10.6 (601)
R64 (nmi)	10	8.9 (336)

Sponsor: PSDI

PIs: J. Knaff & J. Dostalek, A. Schumacher

PROVIDING WIND RADII ESTIMATES TO ROUTINE DVORAK INTENSITY FIXES

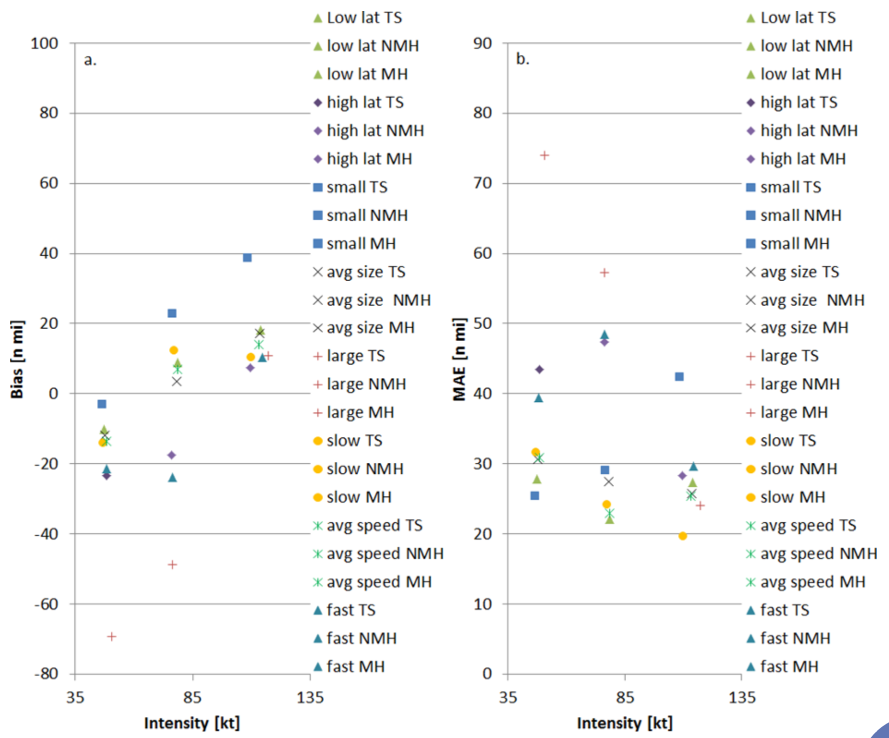
Description

- Inputs: TC intensity *, TC location*, TC motion*, matching IR image
- TC size is estimated from the IR image (Knaff et al. 2014)
- TC size is related to average wind radii (Knaff et al. 2016)
- Asymmetries are based on climatology and the motion vector (Knaff et al. 2007)
- Fixes (text) will be generated at CIRA and JTWC and available from the fdecks and the CIRA TC-Realtime web page.

* Based on Dvorak fixes

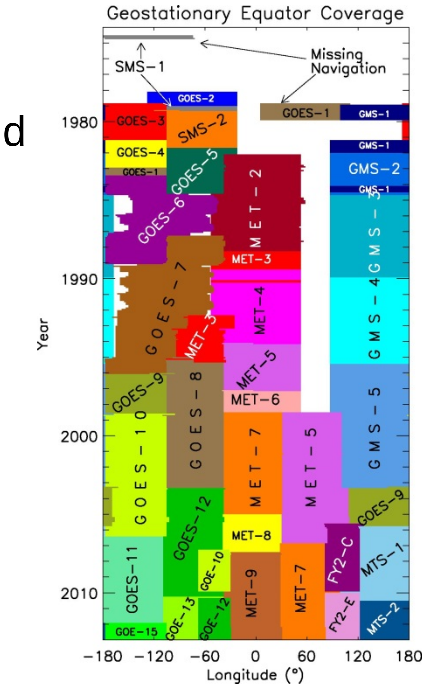
Sponsor: GOES-R Risk Reduction
PI's: Kate Musgrave, John Knaff

R34 Performance given size and intensity



Errors largest for large, weak, fast and high-latitude systems

Climate Data Records Hurricane Applications



- The HURSAT data record: Global tropical cyclone-centric satellite data record derived from the ISCCP-B1 CDR (1979 to present). Reanalyzed and recalibrated for temporal and spatial homogeneity.
- The ADT-HURSAT data record: Application of the Advanced Dvorak Technique (ADT) to the HURSAT record creates global homogeneous tropical cyclone intensity record.
- The Cyclone Center Project: Application of crowd-sourcing methods to the HURSAT data record.
- The International Best Track Archive for Climate Stewardship (IBTrACS): Compilation of global tropical cyclone best track data.

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Current Joint Hurricane Testbed Projects

Next… Many of these involve NESDIS and NESDIS CI personnel

JHT Project 1: Guidance on Observational Undersampling over the Tropical Cyclone Lifecycle – Dave Nolan (UM/RSMAS)
JHT Project 2: Passive Microwave Data Exploitation via the NRL Tropical Cyclone Webpage – Josh Cossuth (NRL)
JHT Project 3: Improvements in Operational Statistical Tropical Cyclone Intensity Forecast Models – Galina Chirokova (CSU/CIRA)
JHT Project 4: Improvements to the Tropical Cyclone Genesis Index (TCGI) – Jason Dunion (UM/CIMAS/AOML)
JHT Project 5: Improvement and Implementation of the Probability-based Microwave Ring Rapid Intensification Index for NHC/JTWC Forecast Basins – Haiyan Jiang (FIU)
JHT Project 6: Probabilistic Prediction of Tropical Cyclone Rapid Intensification Using Satellite Passive Microwave Imagery – Chris Rozoff (U of Wisc./CIMSS)
JHT Project 7: Improved Eyewall Replacement Cycle Forecasting Using a Modified Microwave-Based Algorithm (ARCHER) – Tony Wimmers (U of Wisc./CIMSS)
JHT Project 8: Transition of the Coastal and Estuarine Storm Tide Model to an Operational Model for Forecasting Storm Surges - Yuepeng Li (FIU)