GOES-R and JPSS Products and High-Impact Tropical Weather

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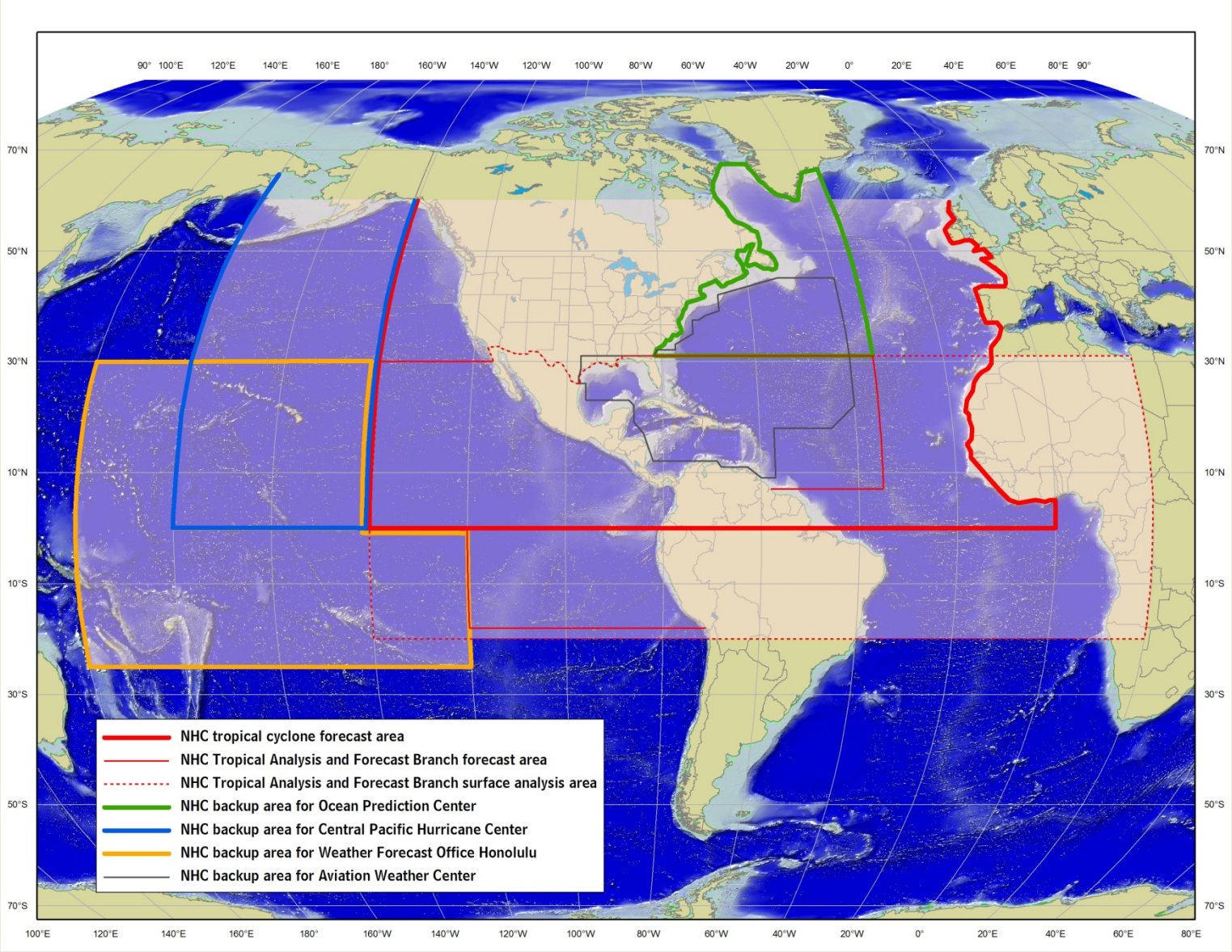
Satellite Science Week March 10-14, 2014

Outline

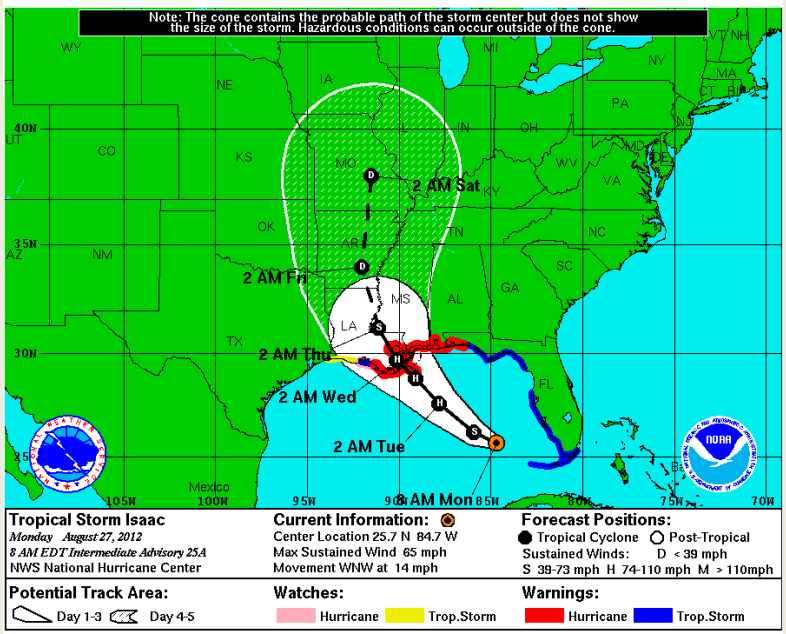
- NHC Forecast Responsibilities
- Satellite Products
  - Qualitative applications
  - Quantitative products for analysis and forecasting
  - Assimilation into numerical models
- The NHC Satellite Proving Ground
- Future plans

NHC AREAS OF RESPONSIBILITY



National Hurricane Center Tropical Cyclone Forecast Parameters

- Genesis
  - Probabilistic forecasts to 48 (120) hr
- Track
  - tropical cyclone positions 0 to 120 hr
- Intensity
  - maximum wind 0 to 120 hr
- Wind Structure
  - Radii of 34, 50 kt winds 0 to 72 hr
  - Radii of 64 kt winds 0 to 36 hr
- Watches
  - Tropical Storm or Hurricane conditions possible within ~48 hr
- Warning
  - Tropical Storm or Hurricane conditions likely in next ~36 hr
- Probabilities of 34, 50 and 64 kt winds 0 to 120 hr
- General guidance on rainfall and storm surge
- *All forecast products updated every 6 hours*



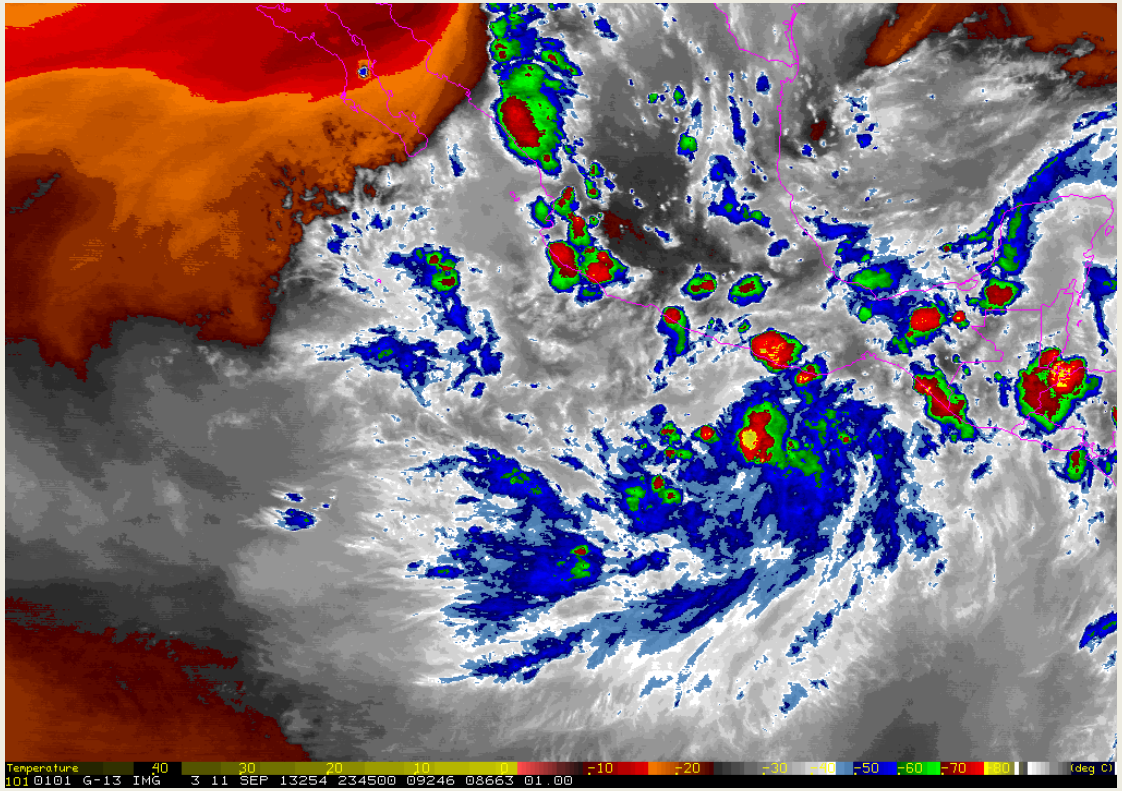
TAFB Responsibilities 365x24x7

- Large domain marine center providing text and gridded Offshore Waters and High Seas forecasts over tropical Atlantic, East and SE Pacific basins – 14 million sq mi
- Tropical/Marine Weather Discussions
- Unified Surface Analysis
- Marine radiofax charts
- Dvorak tropical cyclone intensity estimates
- Extensive backup of three other offices
  - OPC – HSFAT1/OFFNT1 and OFFNT2
  - HFO – HFOHSFSP and HFOSIMHI
  - AWC – FACA and International SIGMETs
- ***100 text/graphical products daily***

Satellite Contributions to Tropical Weather Forecast Improvements

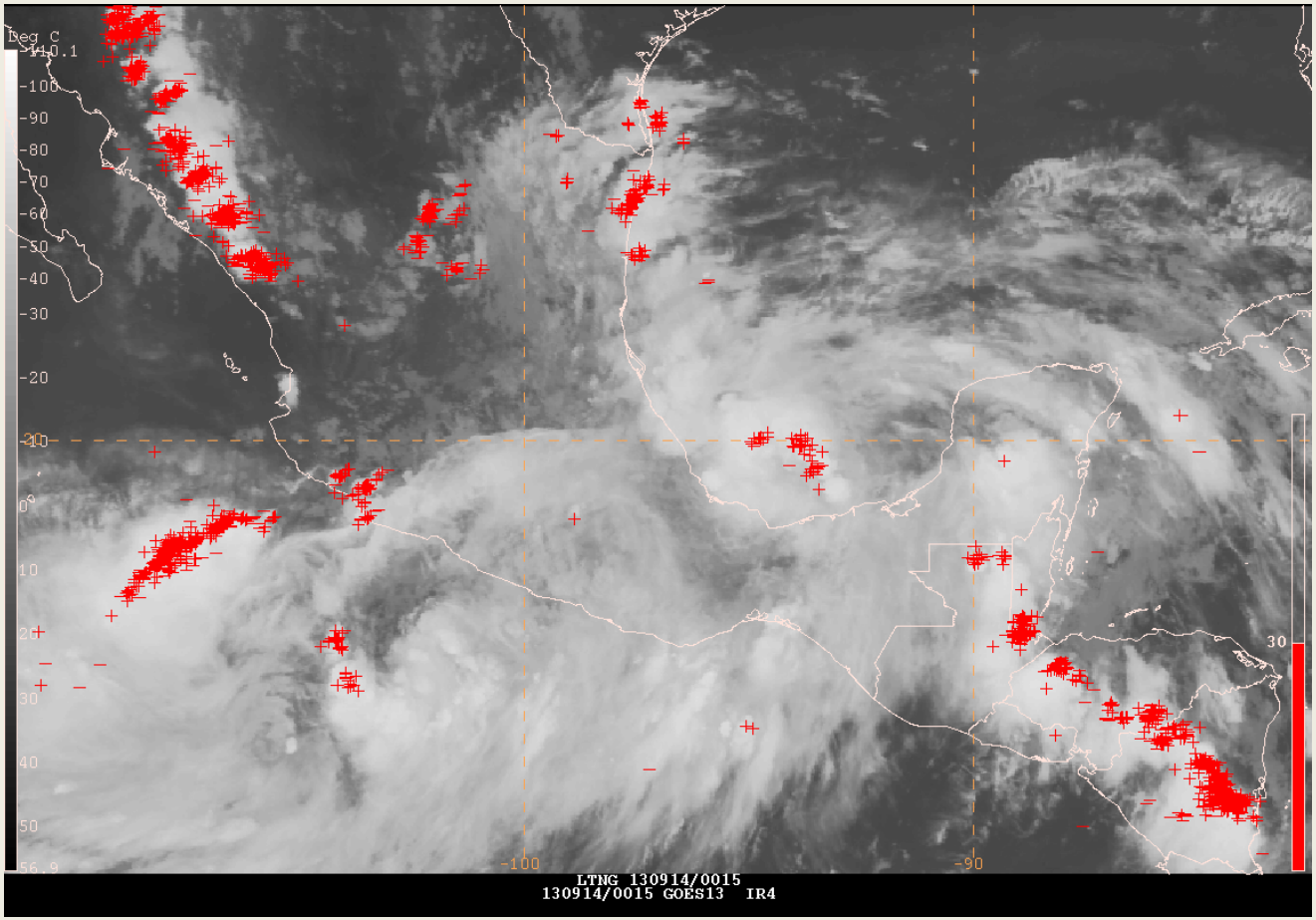
- Qualitative Products for Situational Awareness
  - Individual imagery with color enhancements
  - Multi-spectral products
- Quantitative Products for Analysis and Forecasting
  - Maximum intensity and structure estimation algorithms
  - Center fix algorithm
  - Statistical-dynamical forecast algorithms
- Assimilation into numerical forecast models
  - Global and Regional

GOES Water Vapor Imagery Loop for Hurricane Ingrid



- Improved spectral, spatial, temporal resolution from GOES-R

GLD-360 (GLM Proxy) for Hurricanes Ingrid and Manuel (2013)

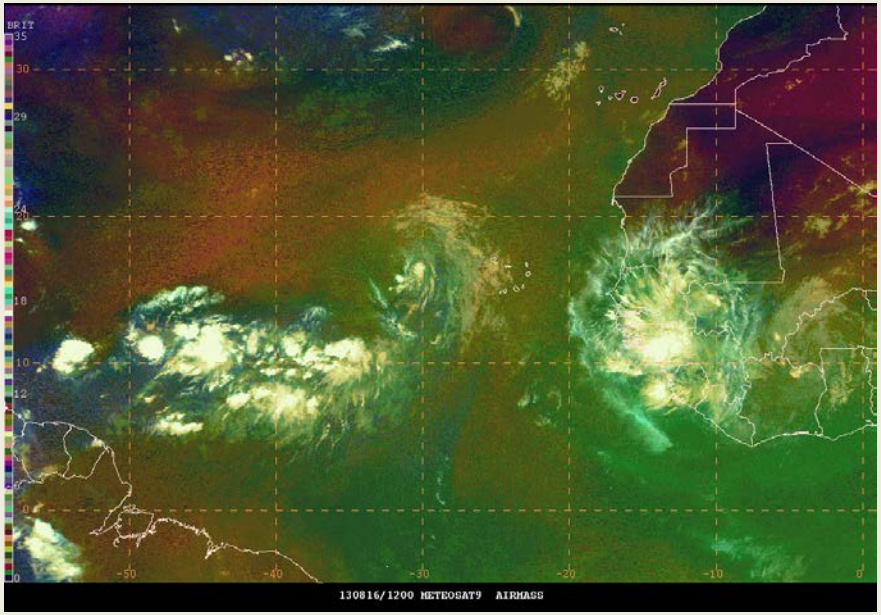


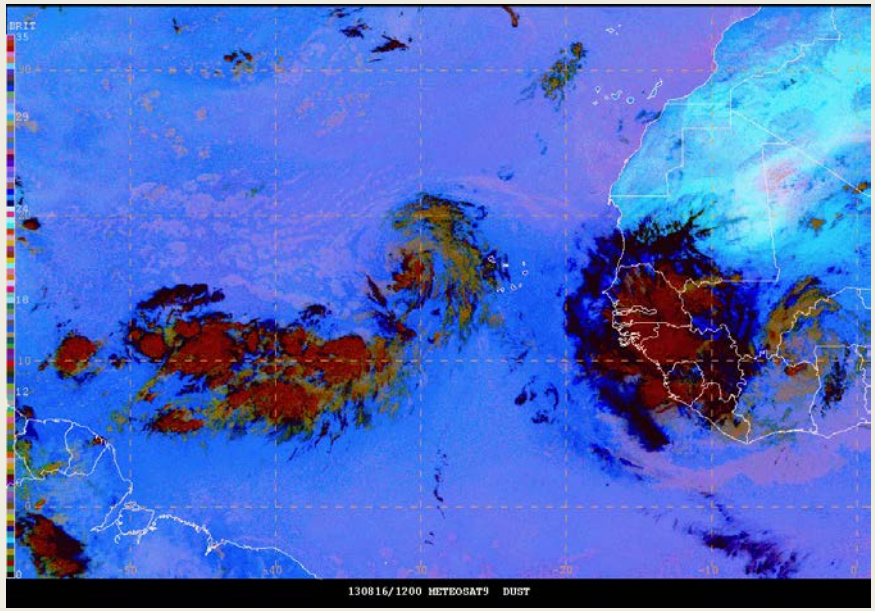
M. Folmer, CICS

RGB Products

- Forecasters will not have time to view all 16 ABI channels
- Greater role for image products focused on specific phenomena
- RGB products load image and image combinations in Red, Green and Blue channels
  - Air Mass
  - Dust
  - Saharan air layer
  - Cloud top microphysics
  - Convective storms
  - Natural color

Air Mass and Dust RGB Products for Tropical Storm Erin (2013)



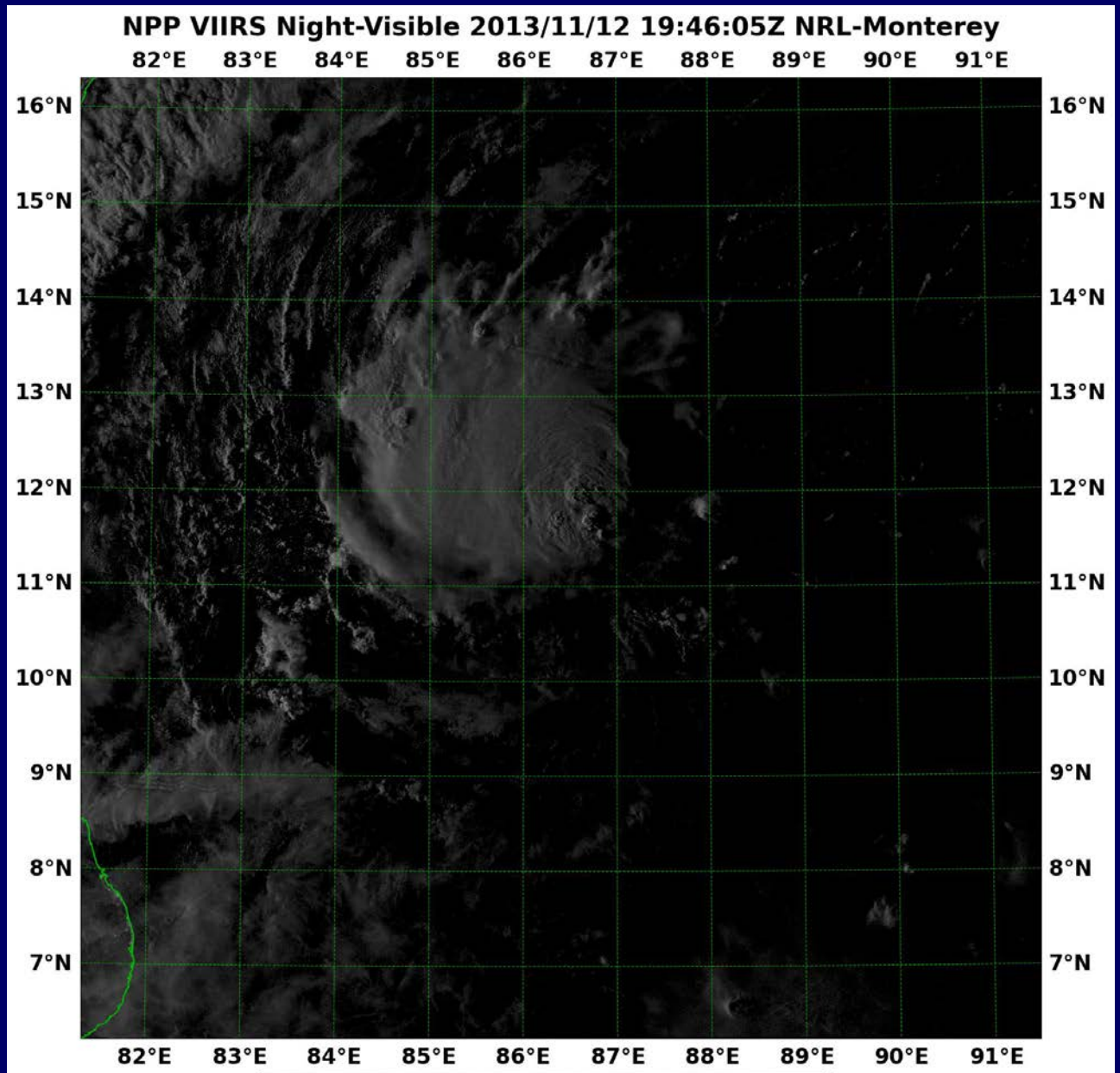


DNB night time radiance imagery

Tropical Depression 30W, 11-12-13 19Z shown here… →

DNB radiance image, overshooting tops near "apparent center", but can't view cloud field reliably on eastern ½ due to lack of illumination

Moon phase: 81%, but moon setting to the west



J. Hawkins, NRL

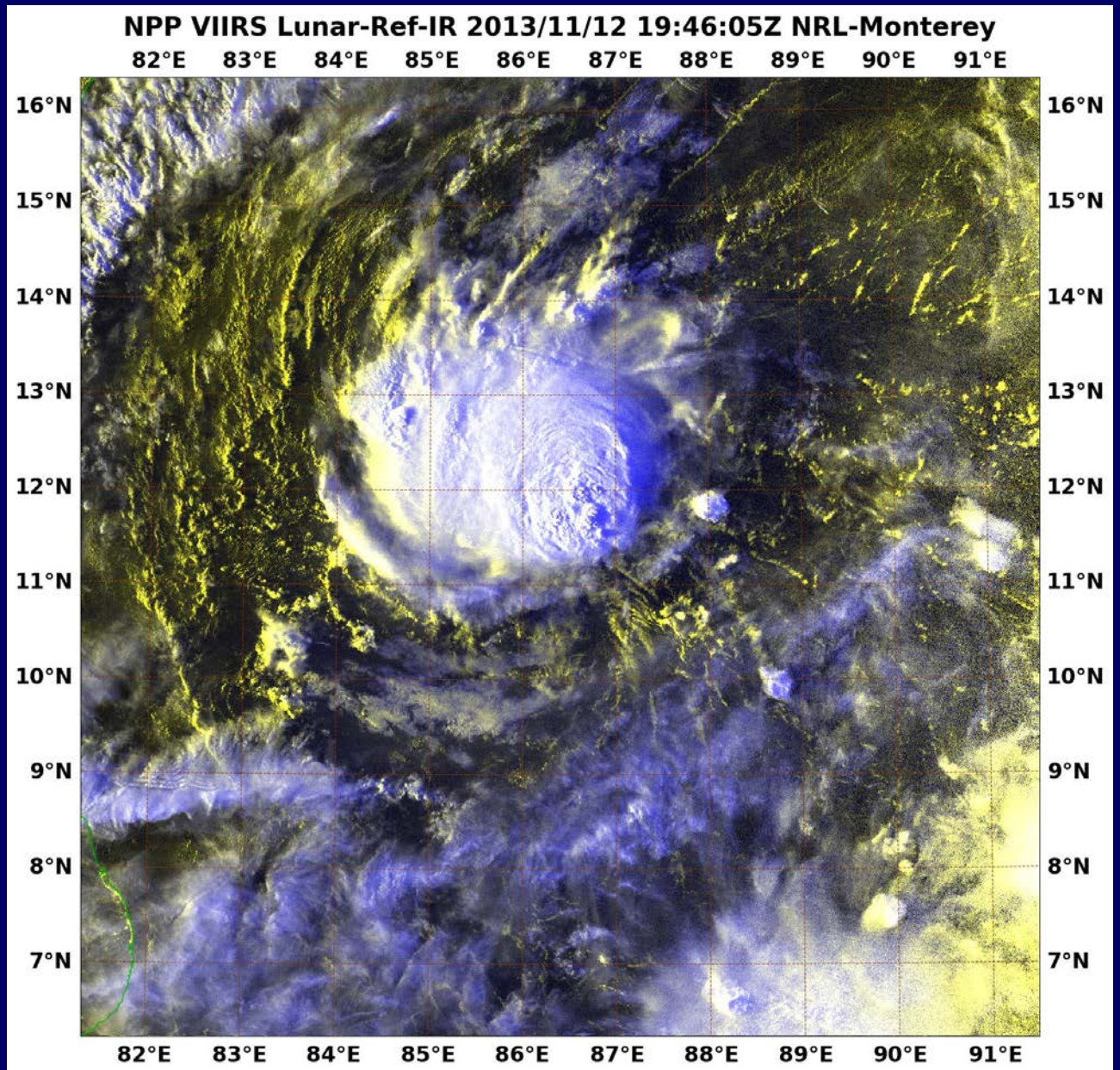
DNB night time radiance imagery

Tropical Depression 30W, 11-12-13 19Z shown here… →

DNB "reflectance", using the NRL-MRY lunar model to convert the radiances + IR

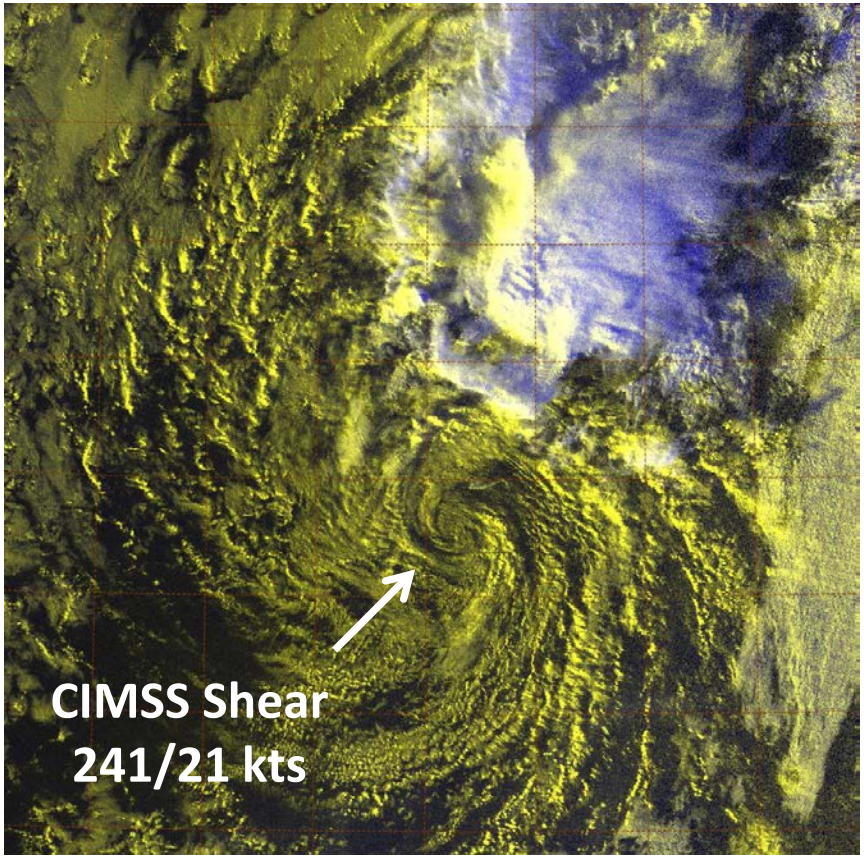
Low clouds – yellow
High clouds – white/cyan

Analyst now able to better comprehend the 3-D cloud structure

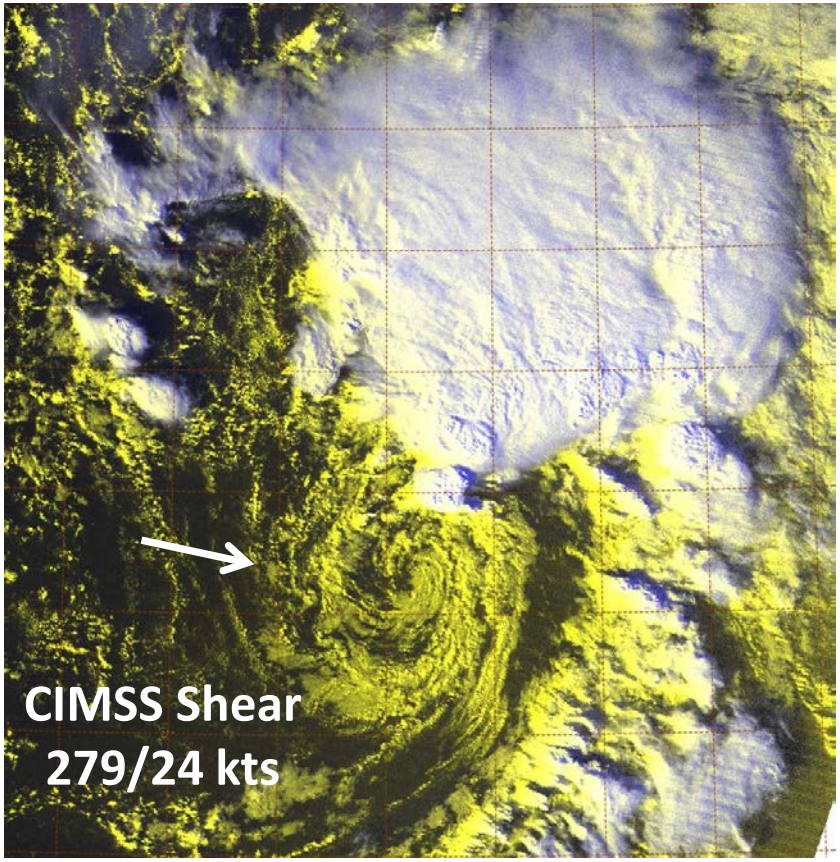


Shear & Low-Level Circulation Centers

05L Erin 08-18-13



09L Humberto 09-17-13



VIIRS DNB reflectance + IR excellent tool for detecting low-level circulation centers (LLCC) due to shear

Quantitative Products for Analysis and Forecasting

- Imager and Sounder data input to quantitative algorithms
  - Hurricane Intensity Estimate
  - Atmospheric Motion Vectors
  - ATMS intensity and wind structure estimation
  - ATMS maximum potential intensity estimations
  - Automated center fixing
    - CIMSS ARCHER technique
    - CIRA Hough Transform
  - Statistical intensity forecast models
  - Rapid Intensification Index

Hurricane Intensity Estimate (HIE)

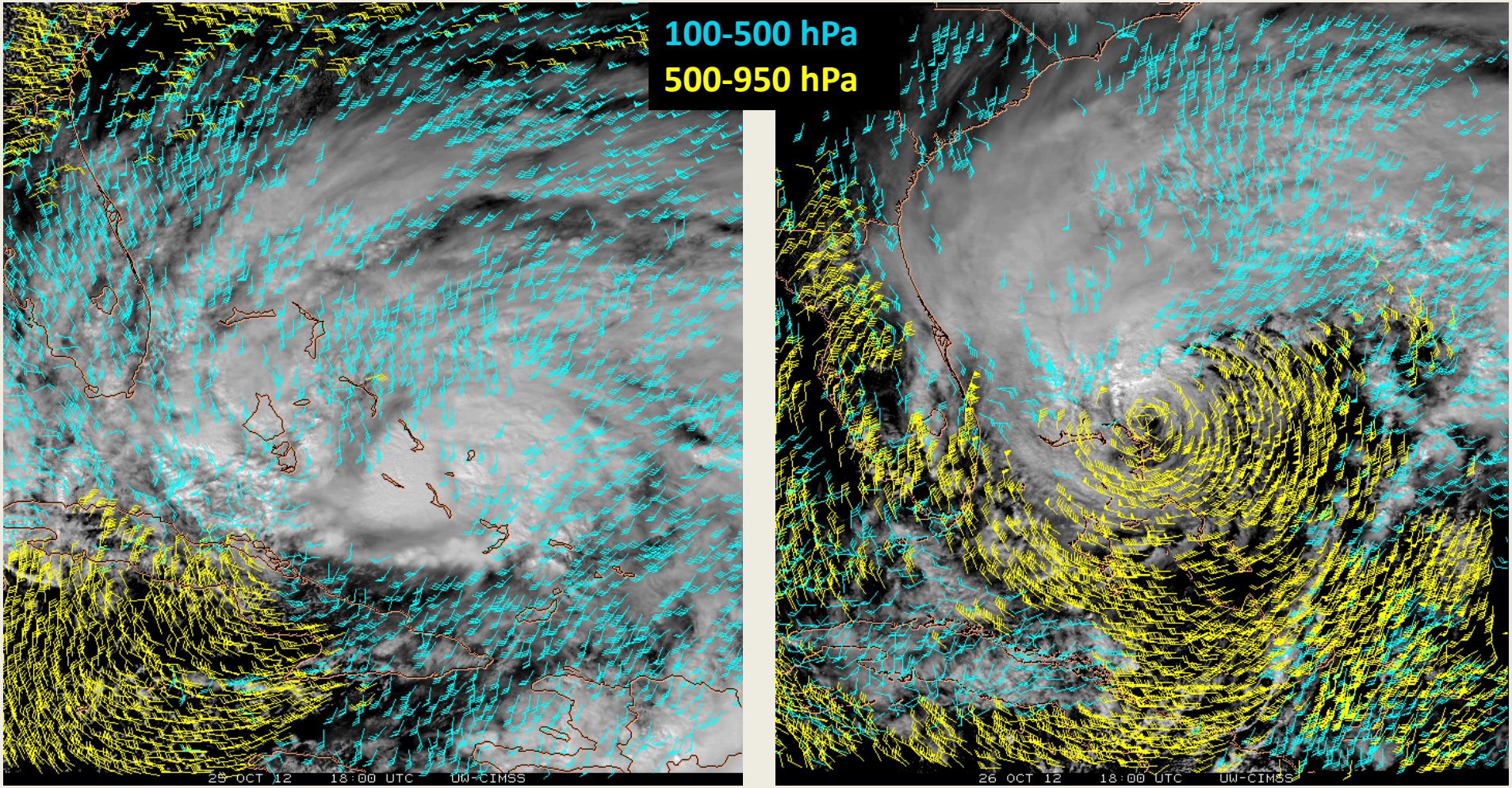
- Provides TC analysts with an objective and operationally-proven TC intensity estimation tool using GOES-R ABI IR imagery.
- Has been demonstrated to NHC/TAFB specialists within the GOES-R Proving Ground since the 2010 Atlantic TC season.
  - As proxy data for GOES-R, employs 15-minute IR imagery from Meteosat-9/10 and GOES-East (CONUS sector)
  - 15 min imagery frequency increases responsiveness
- Algorithm heritage based on the Advanced Dvorak Technique (ADT)
  - Developed by UW-CIMSS, used operationally by NHC
- Systematic verification is underway as part of NHC Proving Ground
- Feedback in 2013
  - Higher refresh rate useful during Humberto…

"Higher refresh rate of RPG HIE allowed for quicker identification of developing eye scene with Humberto, and thus a higher CI than AODT."

-Stripling/DeMaria, TAFB Pacific, Sep 13 2013 1000 UTC

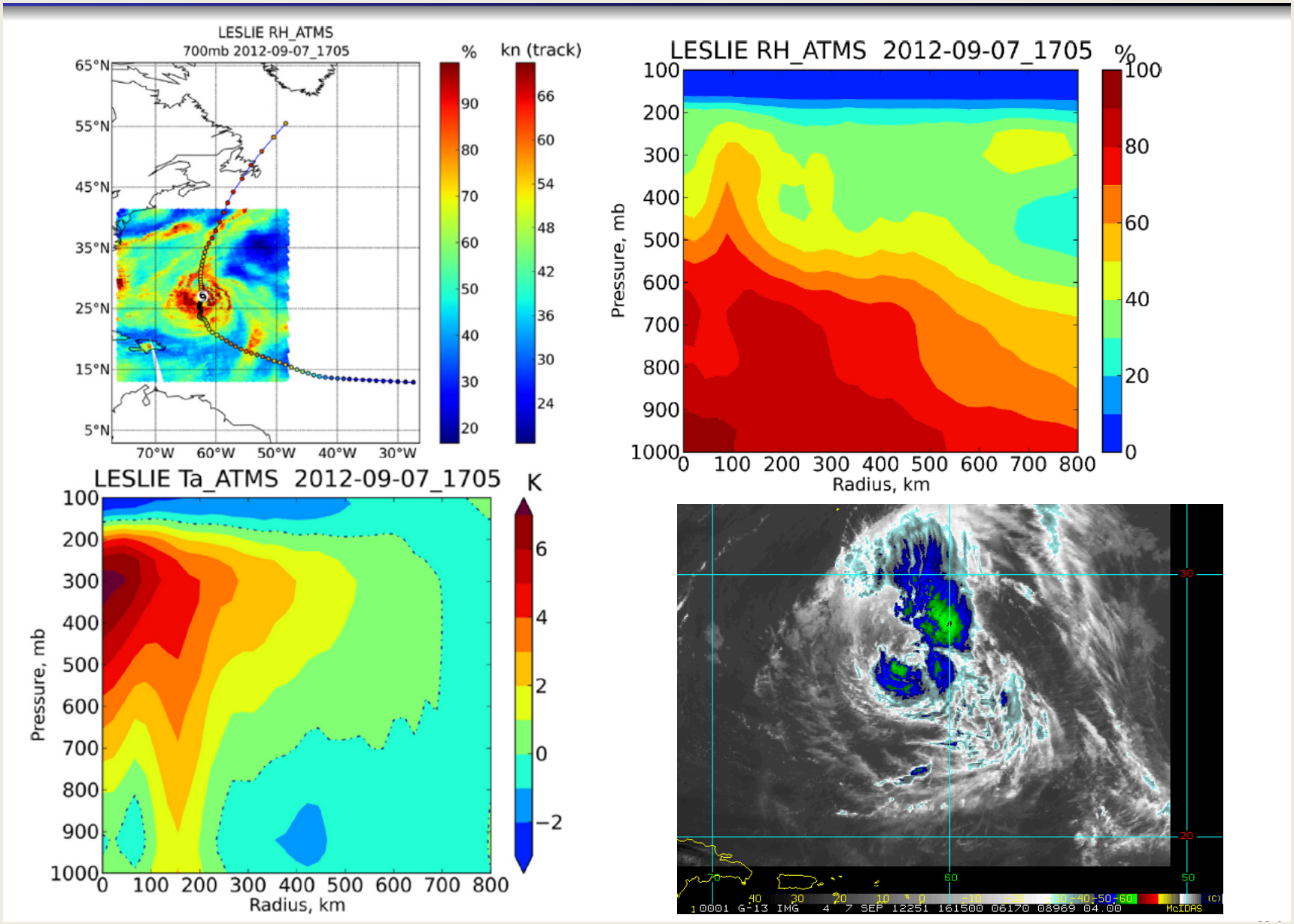
AMVs from GOES 5-min. rapid-scans during Hurricane Sandy

1800 UTC 25 Oct, 2012 | 1800 UTC 26 Oct, 2012



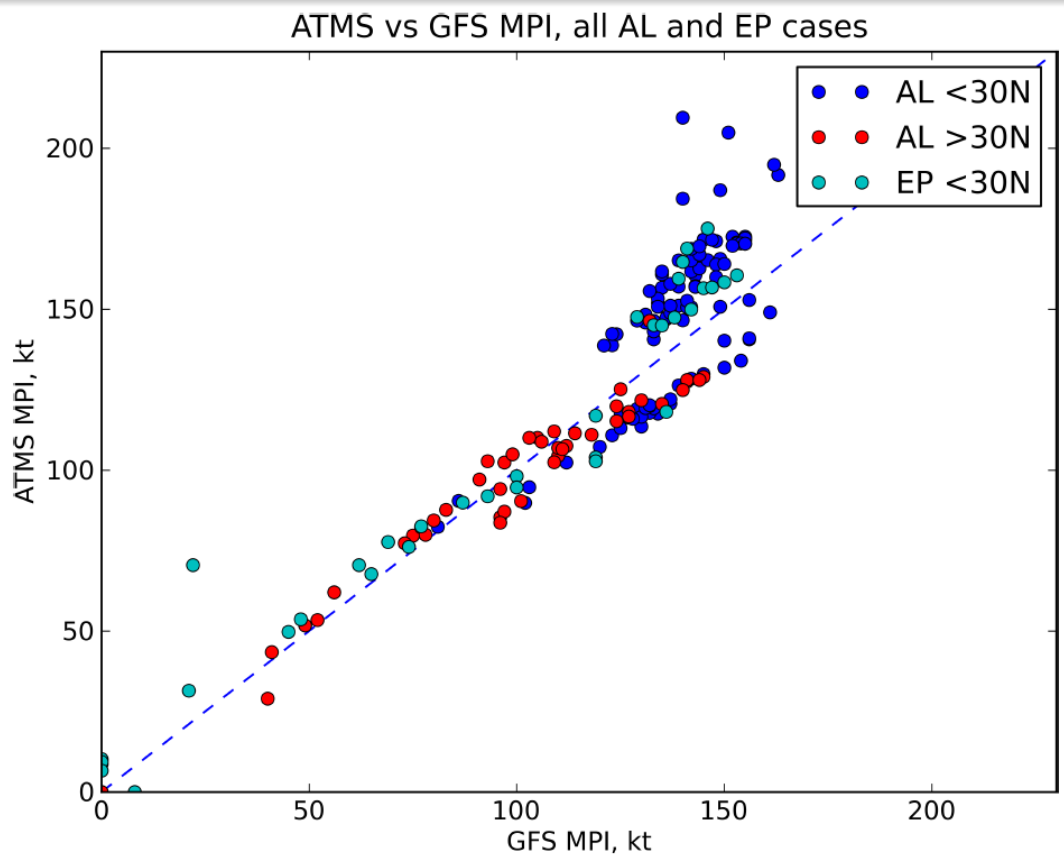
VIS/IR cloud-tracked winds from 5-min image intervals derived using the current NESDIS operational AMV algorithm. Tests using the new GOES-R tracking algorithm in conjunction with data assimilation and model forecast impact experiments are planned. C. Velden, CIMSS

NPP ATMS Products – Hurricane Leslie (2012)



Tropical Cyclone Maximum Potential Intensity Estimates from ATMS

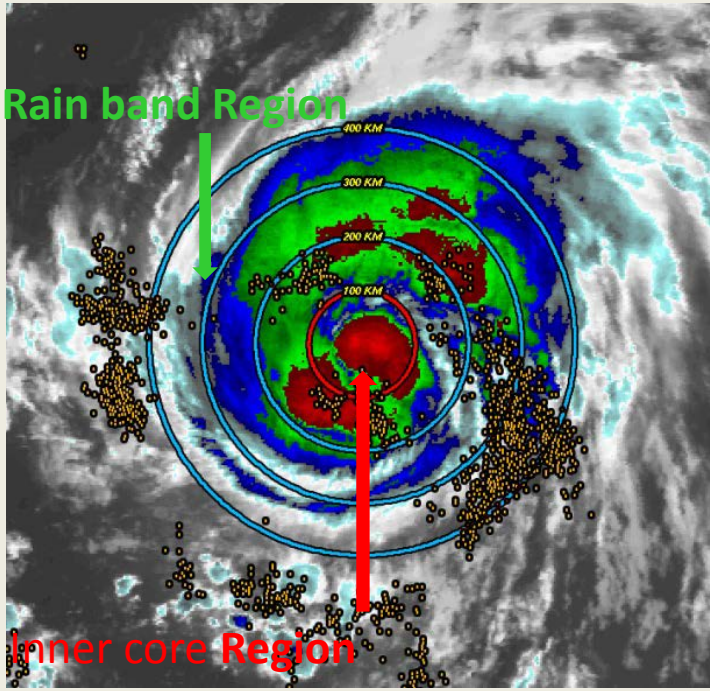
Sounding Input to K. Emanuel Theoretical Formula



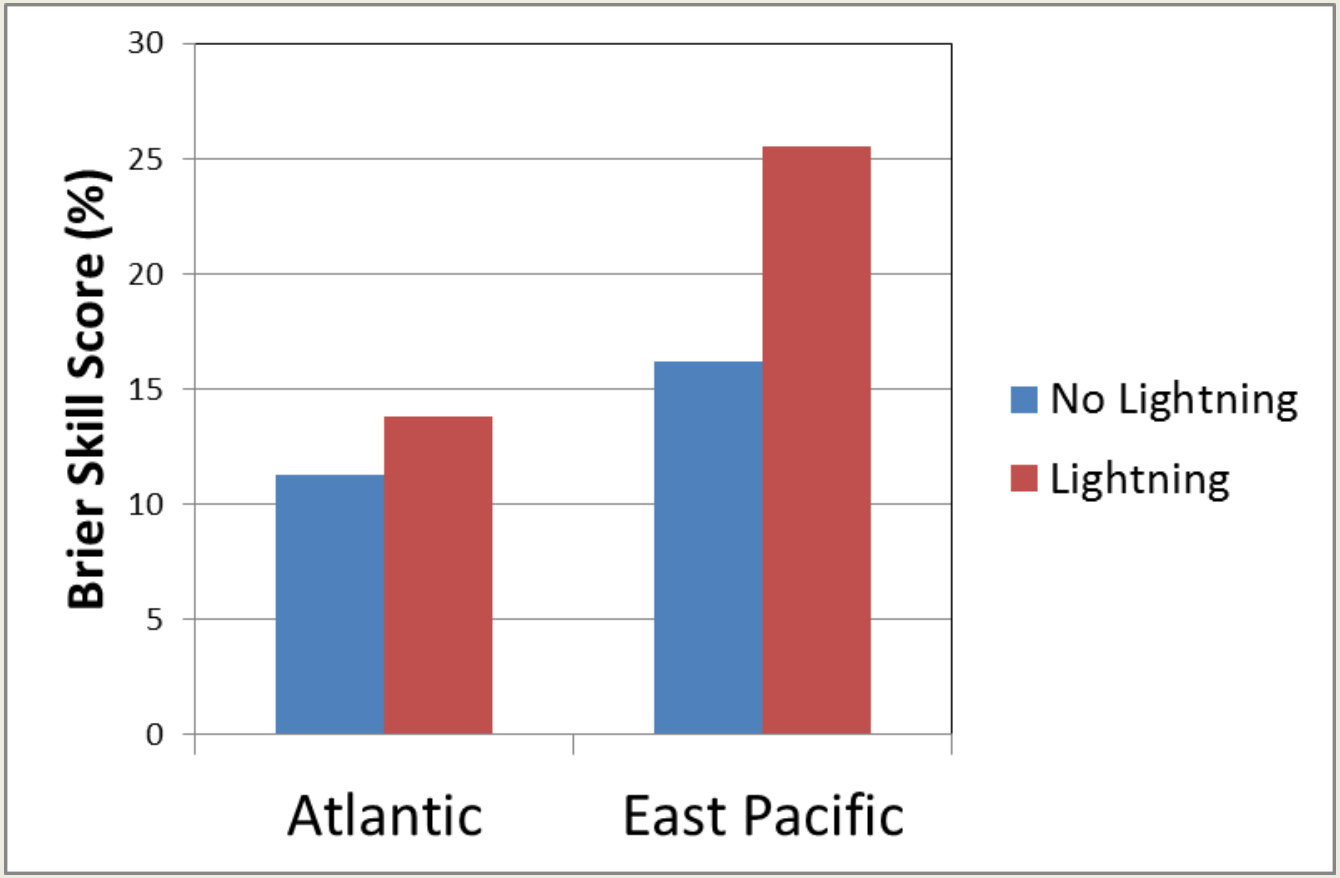
- T,q profiles calculated by azimuthally averaging T,q at 200 ÷ 800km
- ATMS relative to GFS MPI: positive bias for weaker storms for AL and EP

Lightning-based Rapid Intensification Index

- Ground based WWLLN used as proxy for the GLM
- Rapid Intensification Index (RII) algorithm modified to include lightning predictors
  - Rain band lightning favors RI
  - Inner core lightning signals end of RI period
- Large lightning outbreaks for sheared storms
  - Consistent with rapid intensification algorithm
- Systematic verification of 2013 RII underway
- Proving Ground Feedback in 2013
  - Useful for continuity of convective features during GOES outage
  - Lightning outbreak in TD 11 associated with shear and reduced probability of RI
  - Inner core region definition too large for some E. Pac storms, lead to improper reduction of RI probability
  - Quantitative verification of RII with lightning input underway for independent cases



RII Improvements with Lightning Input



2005-2012 Dependent Samples

Lightning Outbreak Indicated Increased Shear in NHC's TD Eleven Forecast Discussion

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WTNT41 KNHC 300840
TCDAT1

TROPICAL DEPRESSION ELEVEN DISCUSSION NUMBER 6
NWS NATIONAL HURRICANE CENTER MIAMI FL AL112013
500 AM AST MON SEP 30 2013

THE CONVECTIVE CLOUD SHIELD REMAINS SHEARED NORTHEAST THROUGH SOUTHEAST OF THE CENTER. THERE HAS BEEN A NOTICEABLE INCREASE IN LIGHTNING ACTIVITY DURING THE PAST COUPLE OF HOURS...WHICH IS OFTEN INDICATIVE OF INCREASING VERTICAL WIND SHEAR. …

$$
FORECASTER STEWART

Products in 2013 NHC Satellite Proving Ground

1. Hurricane Intensity Estimate (HIE)
2. Super Rapid Scan Imagery (SRSO)
3. Tropical Overshooting Tops (TOT)
4. GOES-R Natural Color Imagery
5. Red-Green-Blue (RGB) Air Mass Product*
6. RGB Dust Product*
7. Saharan Air Layer (SAL) Product*
8. Rapid Intensification Index (RII)
9. Pseudo Natural Color Imagery *
10. RGB Cloud Top Microphysics Product*
11. RGB Convective Storms Product*
12. VIIRS Day/Night Band (S-NPP Product)*

*Provided in N-AWIPS format through SPoRT

Plans for the 2014 PG

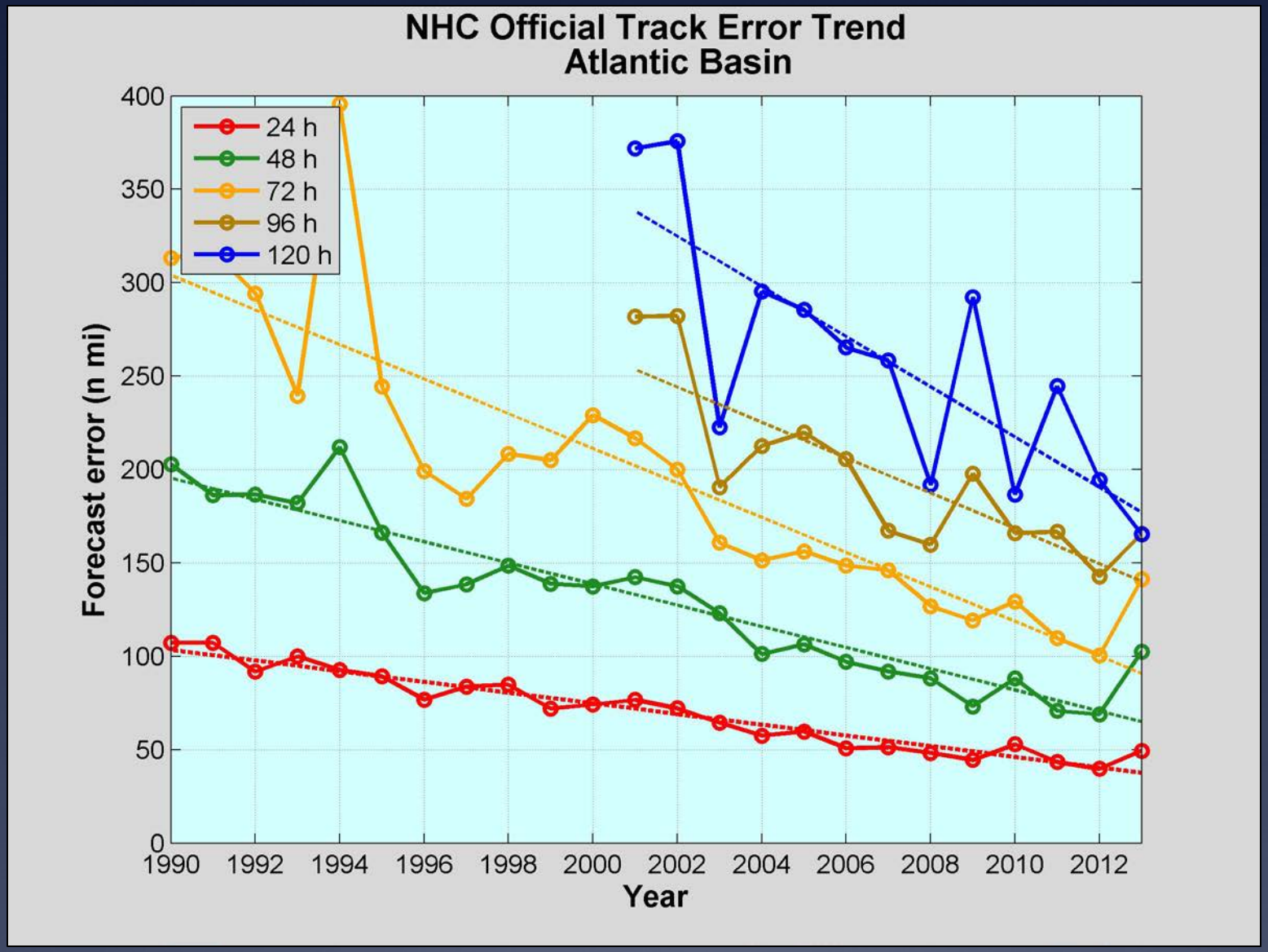
- Andrea Schumacher (CIRA) new part time satellite liaison for NHC/HSU

Continue to look for quantitative evaluations

  - HIE and Lightning RII already have quantitative evaluation methods

- Expand the domain of VIIRS using additional direct readout sites
- Concentrate on a subset for specific forecast desks
  - Rotate in new products
    - ATMS temperature and moisture retrievals
    - GOES-R atmospheric motion vectors
    - Aerosol optical depth

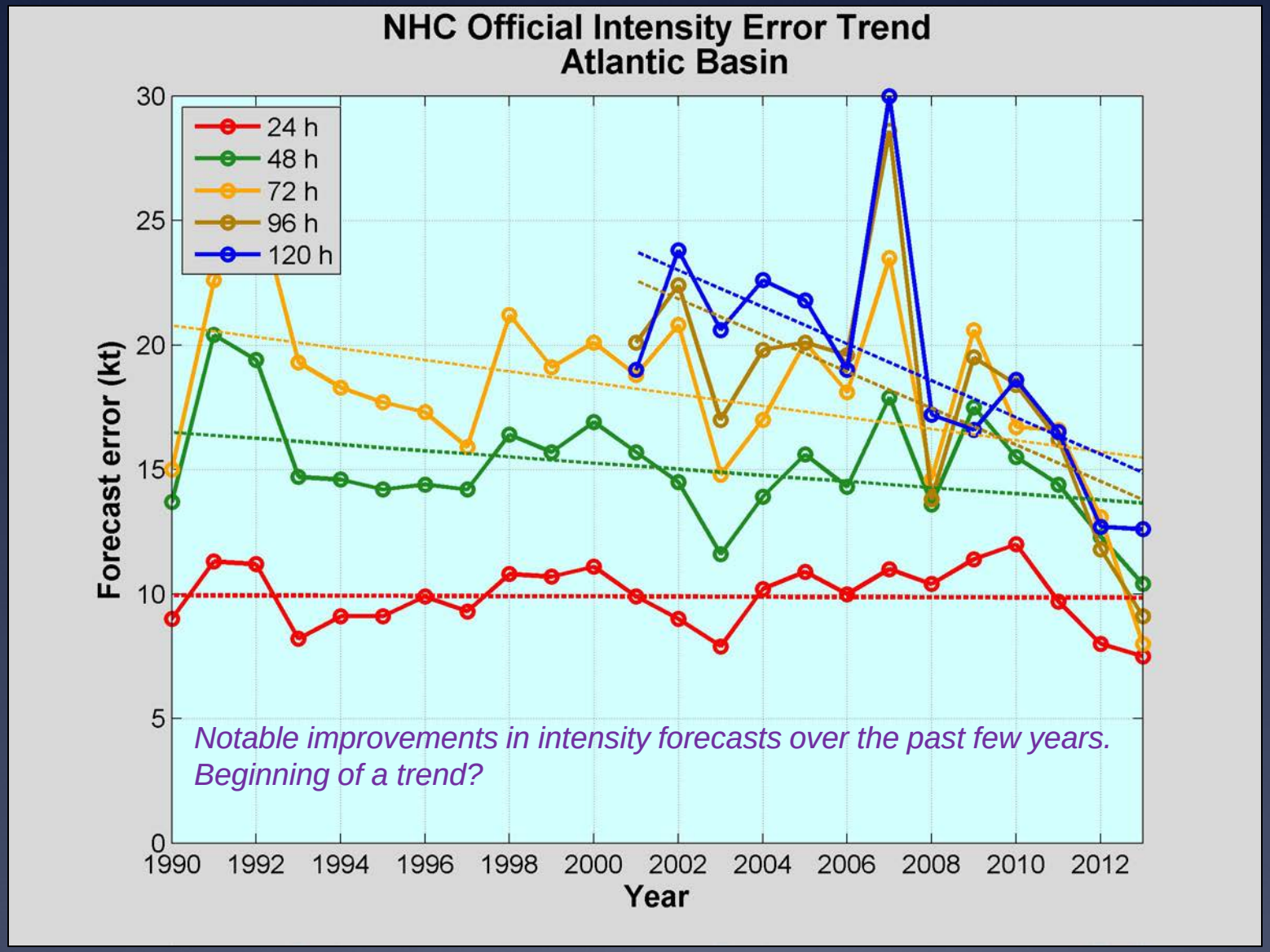
Atlantic Track Error Trends



Track errors increased in 2013 (except at 120 h), but long-term trend shows strong improvements during the past couple of decades.

J. Cangialosi, NHC

Atlantic Intensity Error Trends



J. Cangialosi, NHC

Satellite Data Assimilation

- Improve regional hurricane and global models through data assimilation
- GOES-R
  - Improved AMVs
  - Cloudy radiance assimilation of ABI
  - Total lightning from GLM
  - Improved initial storm position and intensity estimates
- NPP/JPSS
  - Radiance assimilation of ATMS and CrIS
  - Selected VIIRS channels
  - Improved initial storm position and intensity estimates
- See Vijay's presentation and recent JGR paper by Zou et al.

Summary

- Satellite data improving tropical weather forecasting through situational awareness, quantitative products and satellite data assimilation
- RGB products will have greater role in GOES-R era
- VIIRS, especially DNB, is providing new TC analysis capabilities
- Many quantitative TC products under development using JPSS and GOES-R data
- NHC satellite proving providing forecasters with experience with new products
- GOES-R and JPSS have great potential to improve numerical forecast models