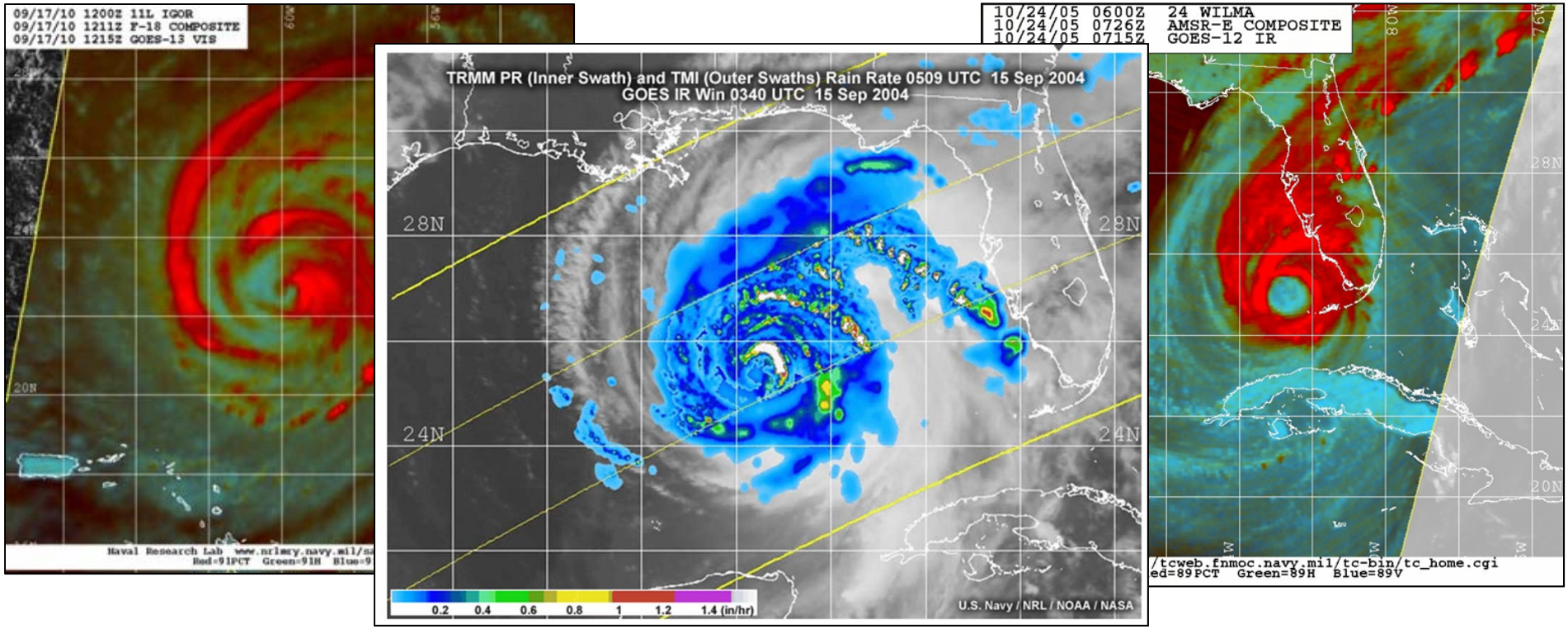
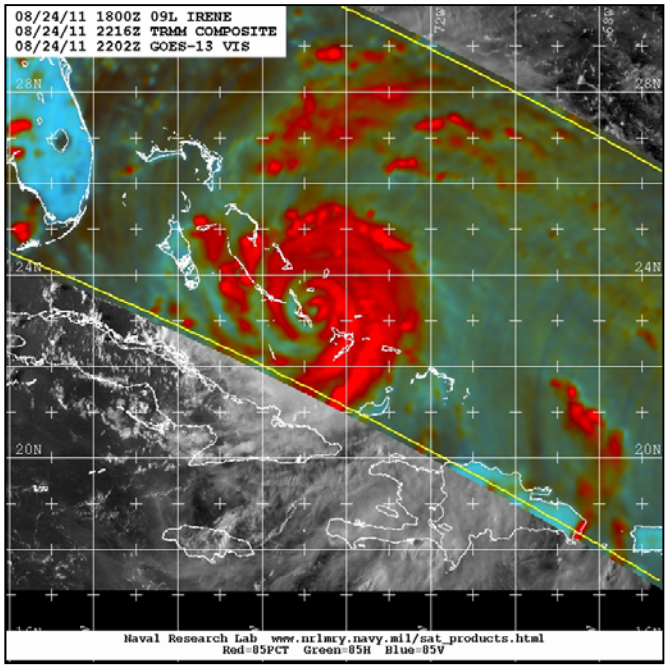
The Use of GPM Data and Products at NHC

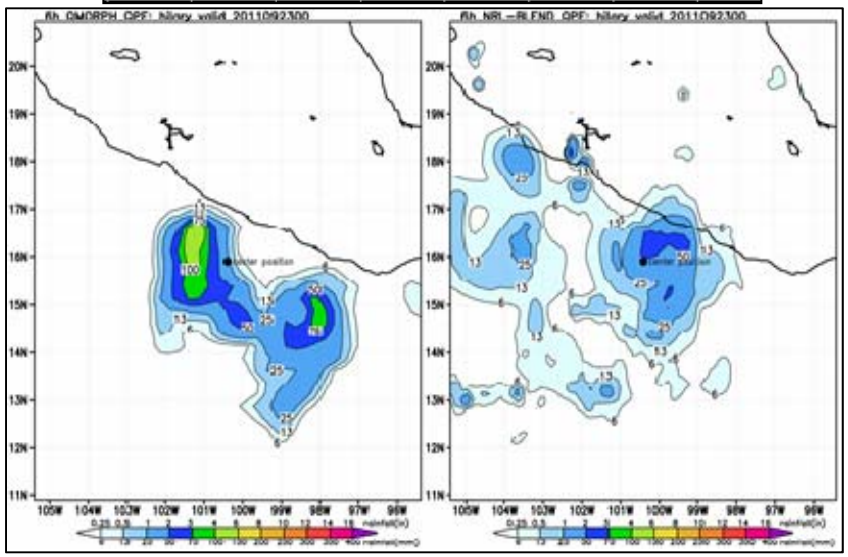


Michael Brennan and Jack Beven
National Hurricane Center, Miami, FL
April 2, 2013

GPM Use

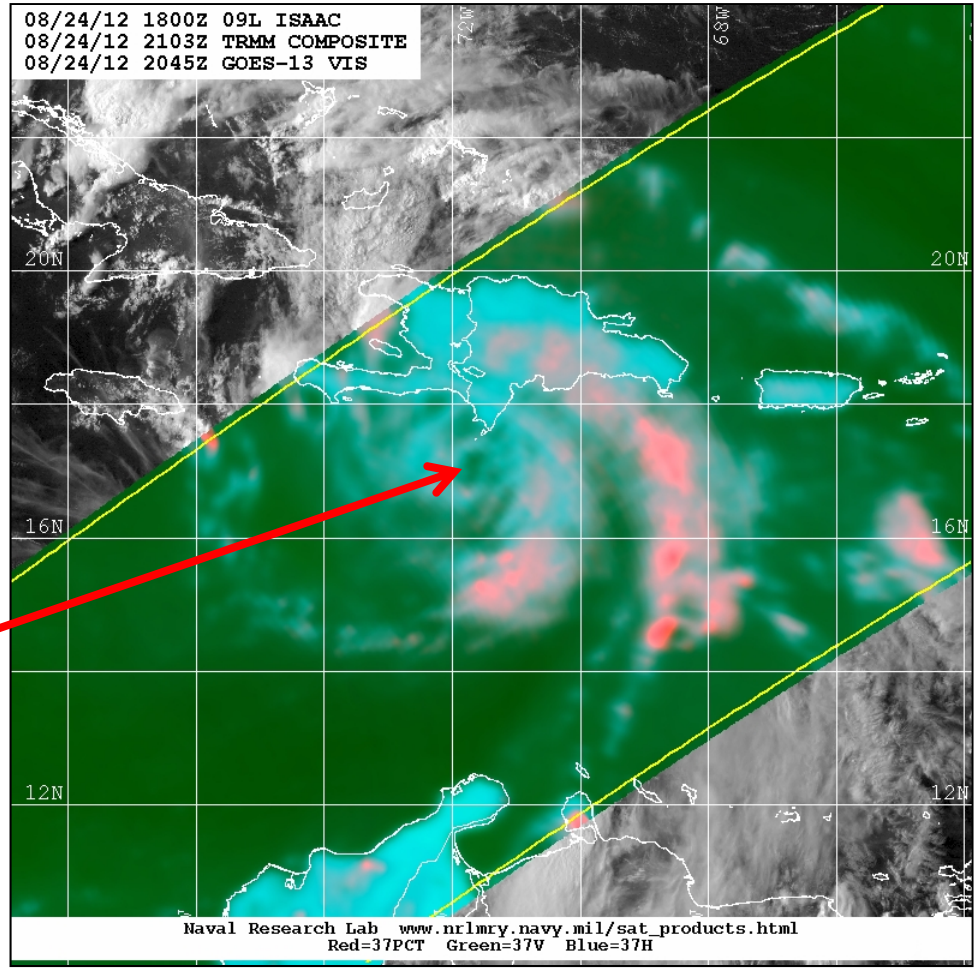
- GPM data/imagery will be used ***subjectively*** by forecasters at NHC for tropical cyclone analysis
- Quantitative use includes rainfall estimates for tropical cyclones and other precipitation systems in the NHC AOR





GPM Data and Products at NHC

- GPM offers continuity of important products provided for many years from TRMM Microwave imagery at 37 and 91-GHz give a “radar-like” view of tropical cyclone rainbands and inner-core structure
  - In particular, high-resolution imagery at the lower frequency provides the best look at the low-level rainband structure and low-level center, particularly in weak and developing systems
  - As this capability is currently only available from LEO platforms, its critical to have many MW imagers on orbit to increase the number of looks at a given TC



Tropical Storm Isaac – 2103 UTC 24 Aug. 2012

GPM is One Tool in the Toolbox

- Tropical cyclone analysis uses a large number of tools to estimate the position (i.e., center), intensity, and structure of a given TC
  - Geostationary satellite imagery, microwave imagery, aircraft data, scatterometry, in-situ observations, radar, microwave sounders, cloud track winds, raobs, dropsondes, etc.
- Getting the best estimate of the initial state of the TC and the environment is critical to forecaster understanding of the current situation and proper initialization of TC model guidance

Current Microwave Imagers

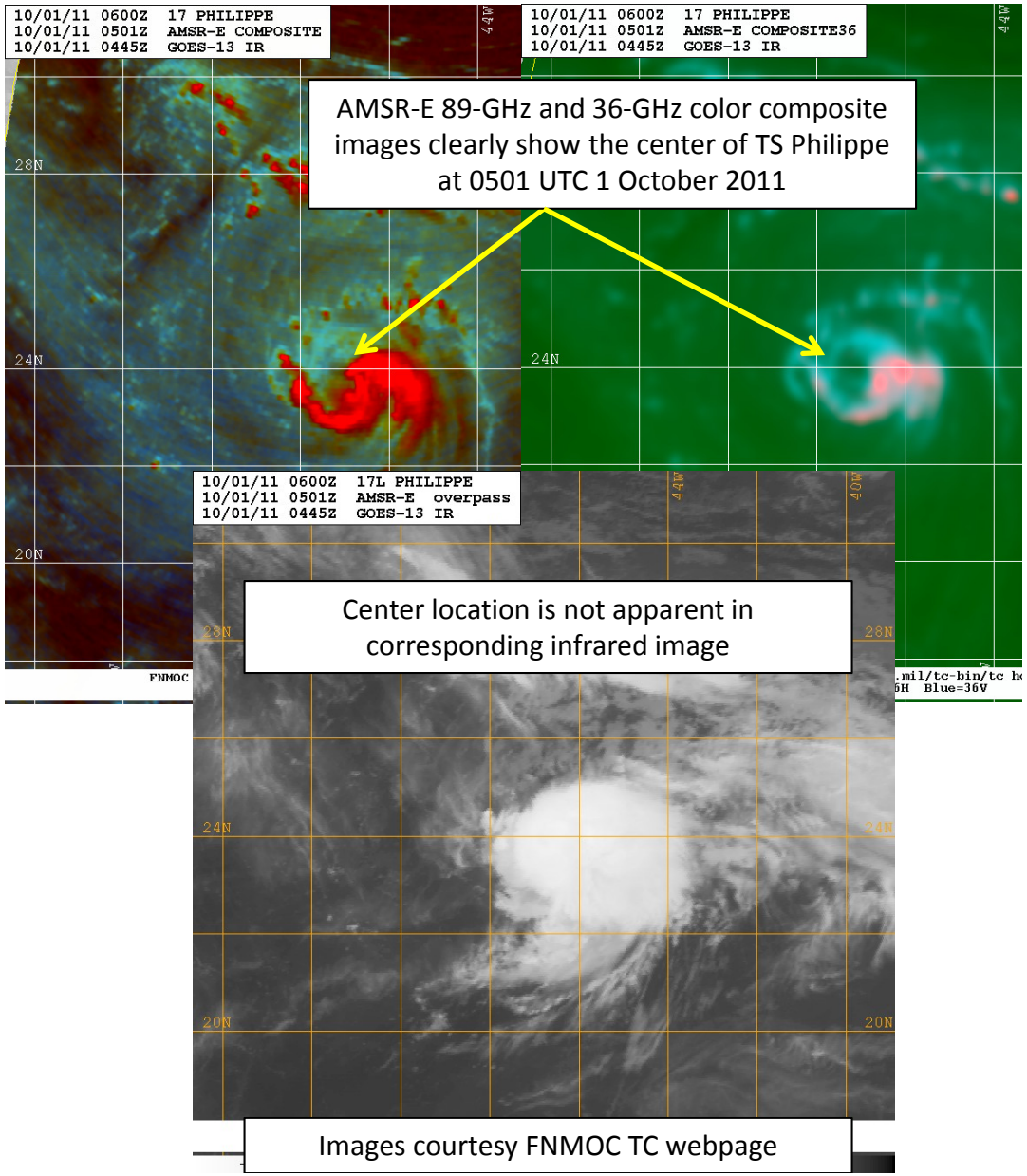
- AMSU-A/B – 6 satellites (89 GHz only, low-res)
  - NOAA 15, 16, 18, 19
  - MetOP-A, B
- SSM/I – 1 DMSP satellites (F-15) (low-res)
- SSMIS – 3 DMSP satellites (F-16, F-17, F-18) (**hi-res at 91 GHz**, lo-res at 37 GHz)
- TRMM – NASA/Japan (**hi-res at 91 and 37 GHz)**
- WindSat – Navy NRL (**hi-res** but only 37-GHz)

- Coming Soon?
  - GPM (36.5 and 89 GHz, polar orbit)
  - AMSR2 on GCOM-W (36.5 and 89 GHz, polar orbit)
  - MADRAS on Megha-Tropiques (36.5 and 89 GHz, 20° inclination orbit)

Impact of Microwave Imagery

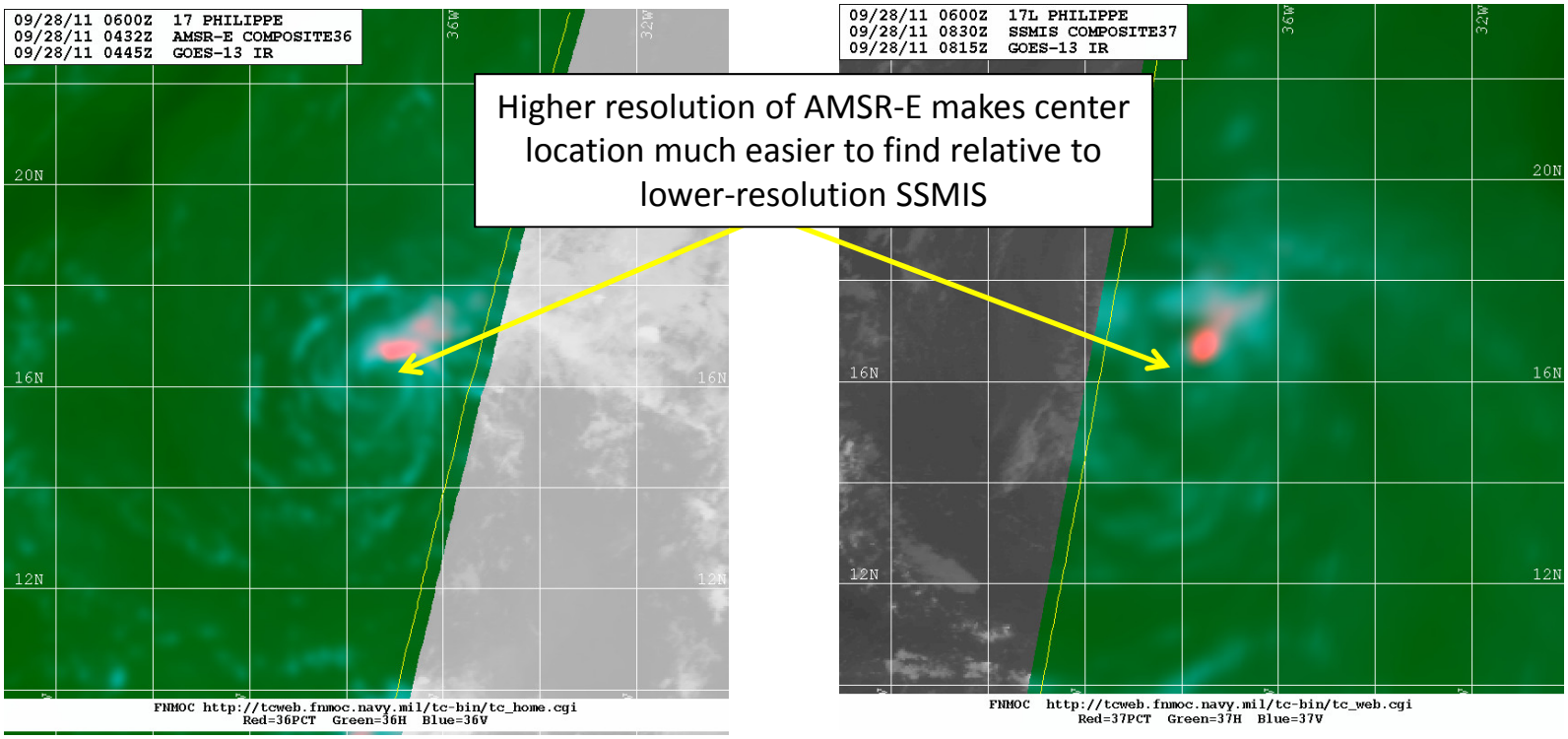
Overview

- Highest-resolution sensors that provide microwave imagery of tropical cyclones and their precursors are critical components of ***subjective*** forecaster analysis
- Microwave imagery is extremely useful for:
  - Determining if a formative system has a well-defined center, a requirement to initiate advisories
  - Locating the center of tropical cyclones when the center location is not readily apparent in conventional visible or infrared imagery, especially for weaker systems at night
  - Assessing trends in TC structure that provide qualitative information on TC intensity, such as eyewall formation and eyewall replacement cycles



Impact of Resolution

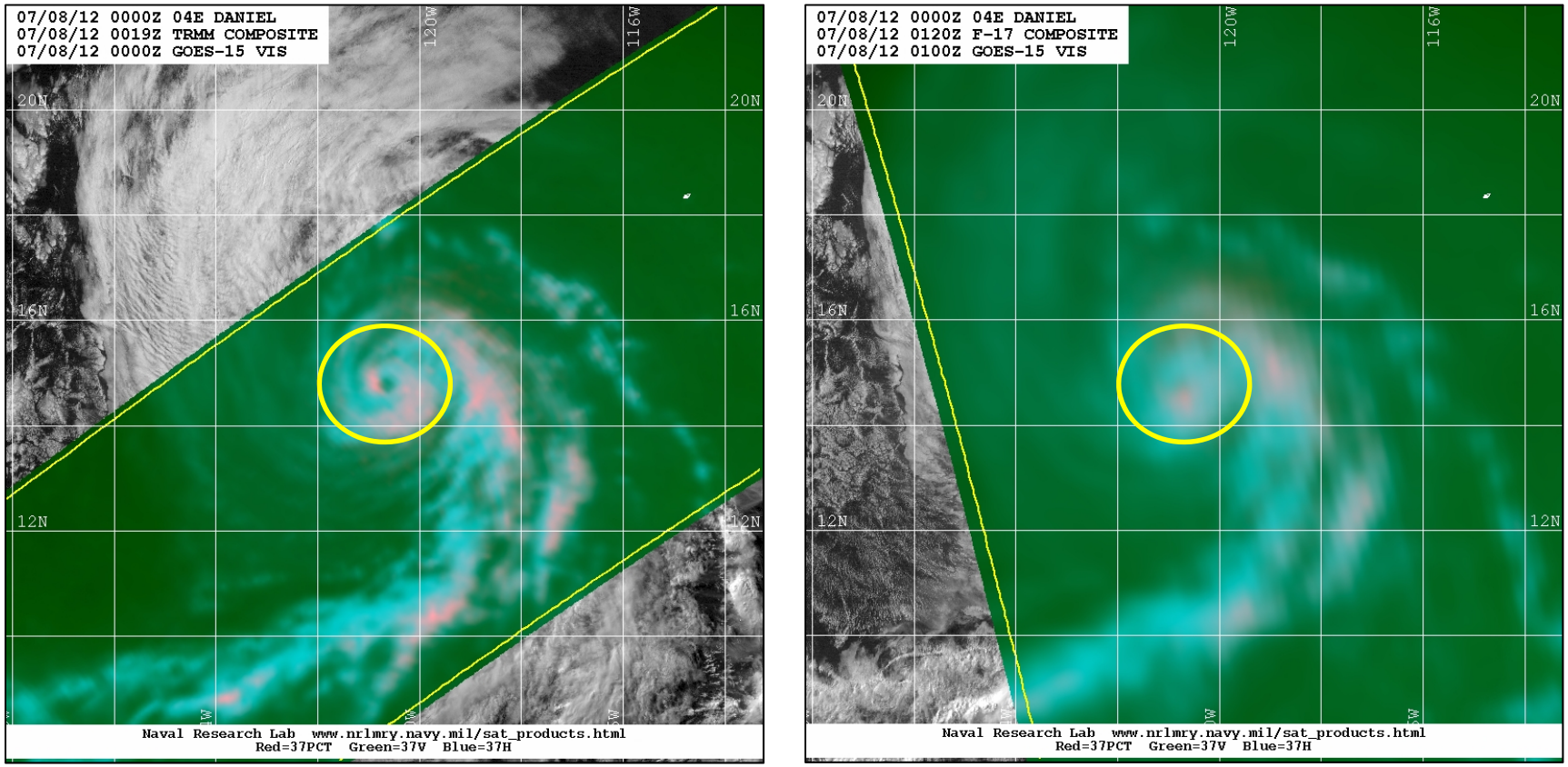
- Higher-resolution imagery, particularly for lower frequency channels, are best for locating the low-level center



Comparison of 36/37-GHz color composite imagery over TS Philippe from AMSR-R (left) and SSMIS (right) at 0432 UTC and 0830 UTC 28 September 2011, respectively – Images courtesy FNMOC TC webpage

Impact of Resolution

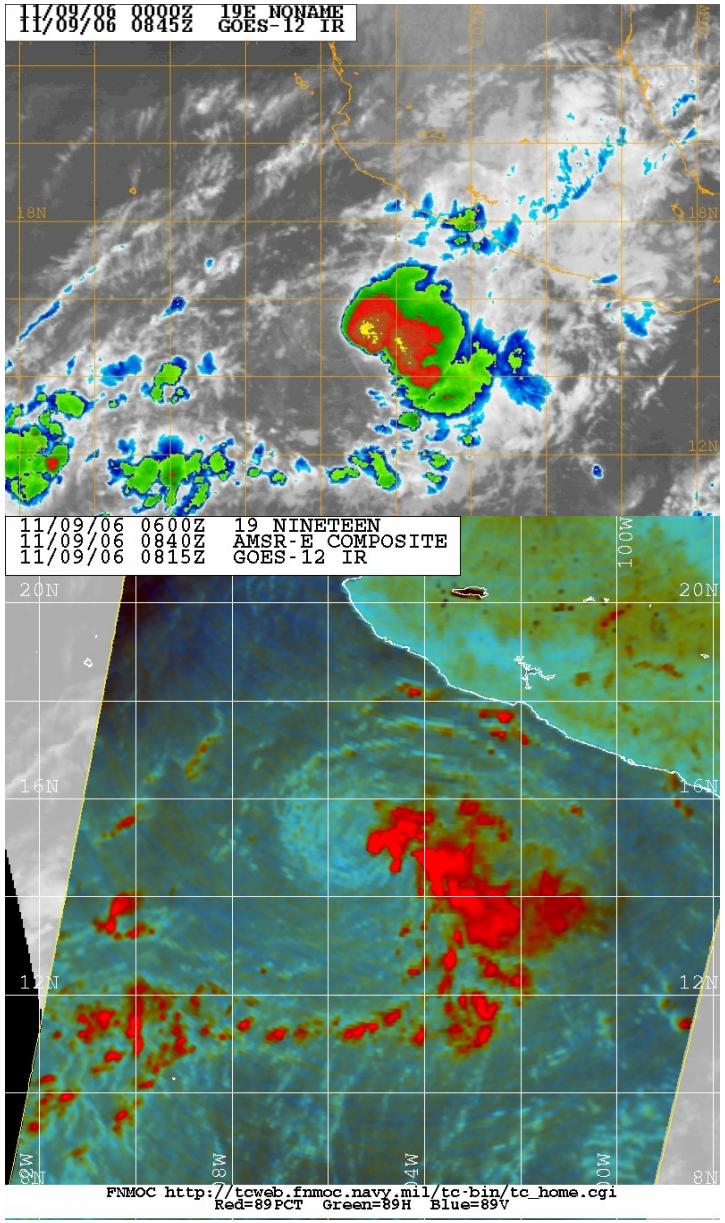
- Resolution differences also affect the ability to resolve low to mid-level eyewall structure

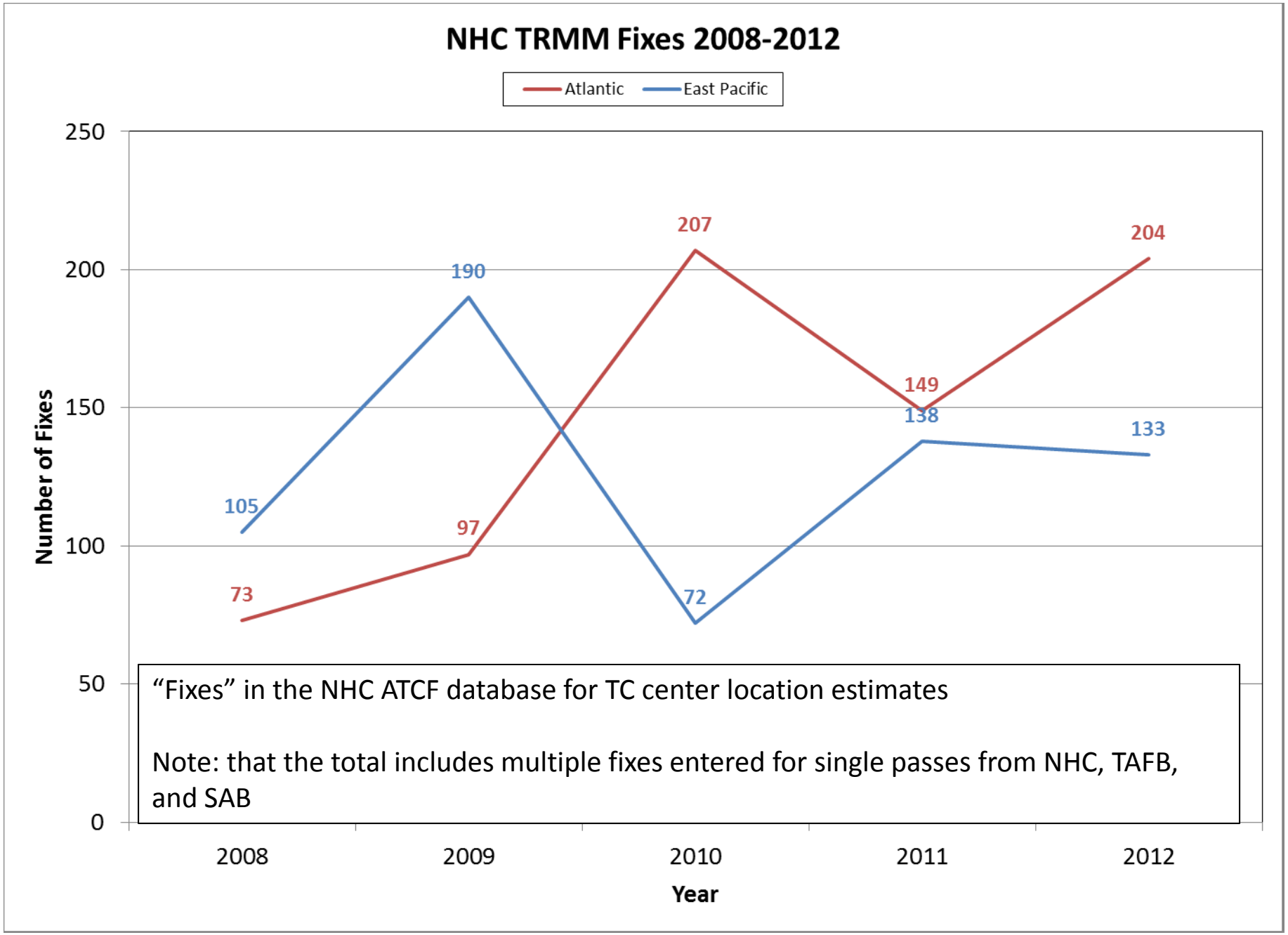


Comparison of 37-GHz color composite imagery over Hurricane Daniel from TRMM (left) and SSMIS (right) at 0019 UTC and 0120 UTC 8 July 2012, respectively (Images courtesy NRL TC webpage)

Impact of Center Location

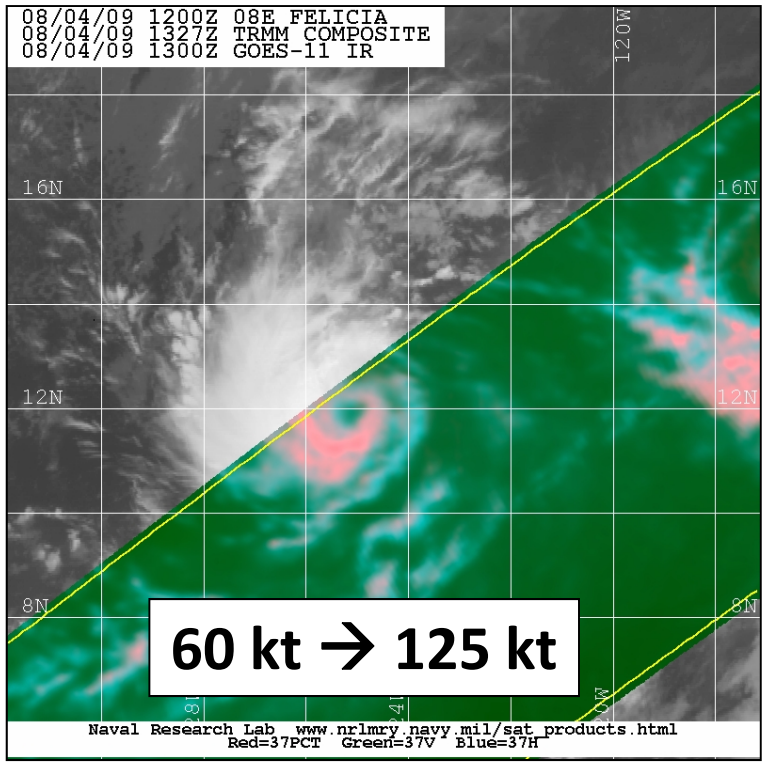
- Locating the center of a tropical cyclone is critical to establishing initial motion, initializing model guidance, and assessing the organization and intensity of the cyclone
- Microwave imagery, especially at the 36/37-GHz channels, helps improve position estimates for Dvorak intensity estimates
- Dvorak estimates are very sensitive to incorrect center locations at certain stages of development, especially for sheared systems

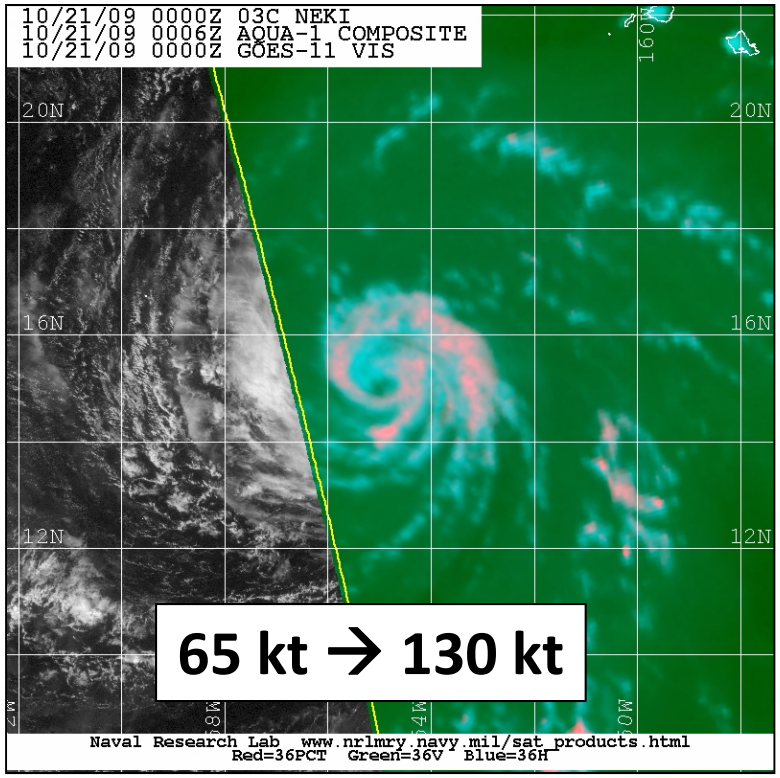



NHC TRMM Fixes 2008-2012
Atlantic
East Pacific
250
200
150
100
50
0
Number of Fixes
105
190
72
138
133
73
97
207
149
204
2008
2009
2010
2011
2012
Year
"Fixes" in the NHC ATCF database for TC center location estimates
Note: that the total includes multiple fixes entered for single passes from NHC, TAFB, and SAB

TC Core Evolution

Rapid Intensification



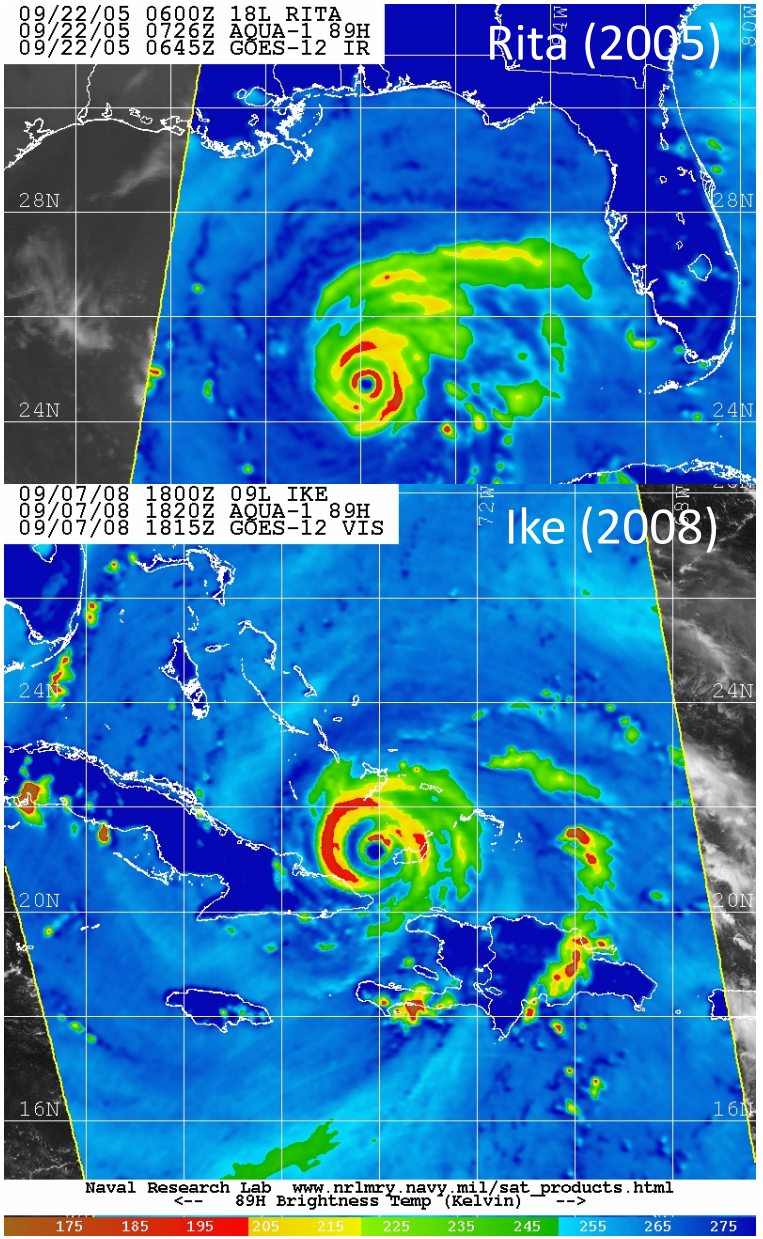


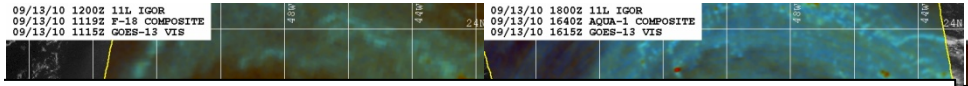
- Research suggests that a closed low-level ring of convection is a precursor signal to rapid intensification
- Microwave imagery is currently the only way to observe this is the vast majority of TCs

TC Core Evolution

Eyewall Replacement

- Occur in ~1/3 of major hurricanes in Atlantic and East Pacific basins (Sitkowski and Kossin 2009)
- Linked with rapid changes to TC intensity and wind field
  - Critical to wind and surge impacts
  - Andrew (1992) intensified after it completed eyewall replacement cycle prior to landfall near Miami
- Poorly understood
- Can observe these changes, but not forecast them

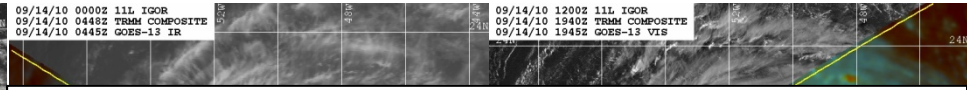




HURRICANE IGOR DISCUSSION NUMBER 32
NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL AL112010
1100 PM AST WED SEP 15 2010

BASED ON RECENT MICROWAVE DATA...IGOR APPEARS TO BE COMPLETING AN EYEWALL REPLACEMENT. IN ADDITION... INFRARED GEOSTATIONARY SATELLITE IMAGERY SHOWS THE INNER CORE CONVECTION DIMINISHING WITH AN OUTER RING OF CONVECTION BECOMING MORE PROMINENT.

THIS DEGRADED APPEARANCE AND A BLEND OF SATELLITE INTENSITY ESTIMATES...THE INITIAL WIND SPEED IS LOWERED TO 125 KT.



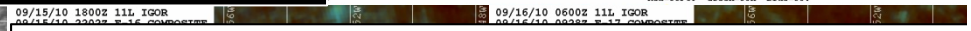
HURRICANE IGOR DISCUSSION NUMBER 33
NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL AL112010
500 AM AST THU SEP 16 2010

MICROWAVE AND INFRARED SATELLITE IMAGERY SUGGEST THAT THE EYEWALL REPLACEMENT WITH IGOR IS COMPLETE. THE NEW EYEWALL APPEARS TO BE CONSOLIDATING AT A RADIUS OF ABOUT 30-35 N MI AND IS PRODUCING RATHER DEEP CONVECTION... SUGGESTING THE INTENSITY IS INCREASING AGAIN.

ORGANIZATION OF THE INNER CORE.

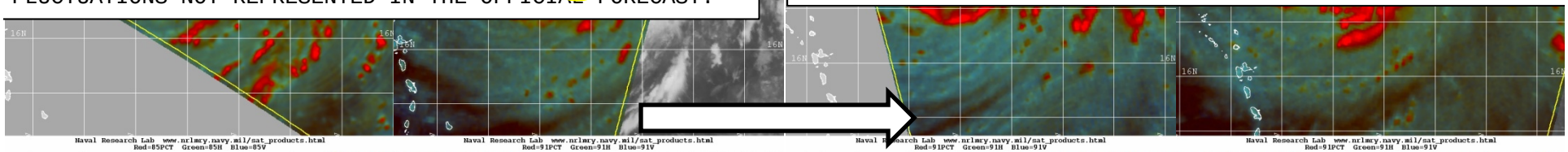
HURRICANE IGOR DISCUSSION NUMBER 23
NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL AL112010
500 PM AST MON SEP 13 2010

WHILE A 1640 UTC AMSR-E PASS DOES NOT SHOW ANY EVIDENCE OF A SECONDARY EYEWALL YET...IT IS POSSIBLE THAT AN EYEWALL REPLACEMENT CYCLE WILL OCCUR IN THE FIRST COUPLE OF DAYS...WHICH COULD RESULT IN SOME INTENSITY FLUCTUATIONS NOT REPRESENTED IN THE OFFICIAL FORECAST.



HURRICANE IGOR DISCUSSION NUMBER 26
NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL AL112010
1100 AM AST TUE SEP 14 2010

RECENT MICROWAVE OVERPASSES DO NOT YET SHOW AN OUTER EYEWALL...BUT DO SHOW THAT A LARGE RAIN-FREE MOAT HAS FORMED BETWEEN THE EYEWALL AND THE OUTER CONVECTIVE BANDS.



HURRICANE IGOR DISCUSSION NUMBER 42
NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL AL112010
1100 AM AST SAT SEP 18 2010

RECENT MICROWAVE OVERPASSES SUGGEST THE HURRICANE IS UNDERGOING AN EYEWALL REPLACEMENT CYCLE...WITH THE 20 NM WIDE INNER EYE SEEN IN THE PREVIOUS AIRCRAFT MISSION GRADUALLY WEAKENING.

HURRICANE IGOR DISCUSSION NUMBER 38...CORRECTED
NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL AL112010
1100 AM AST FRI SEP 17 2010

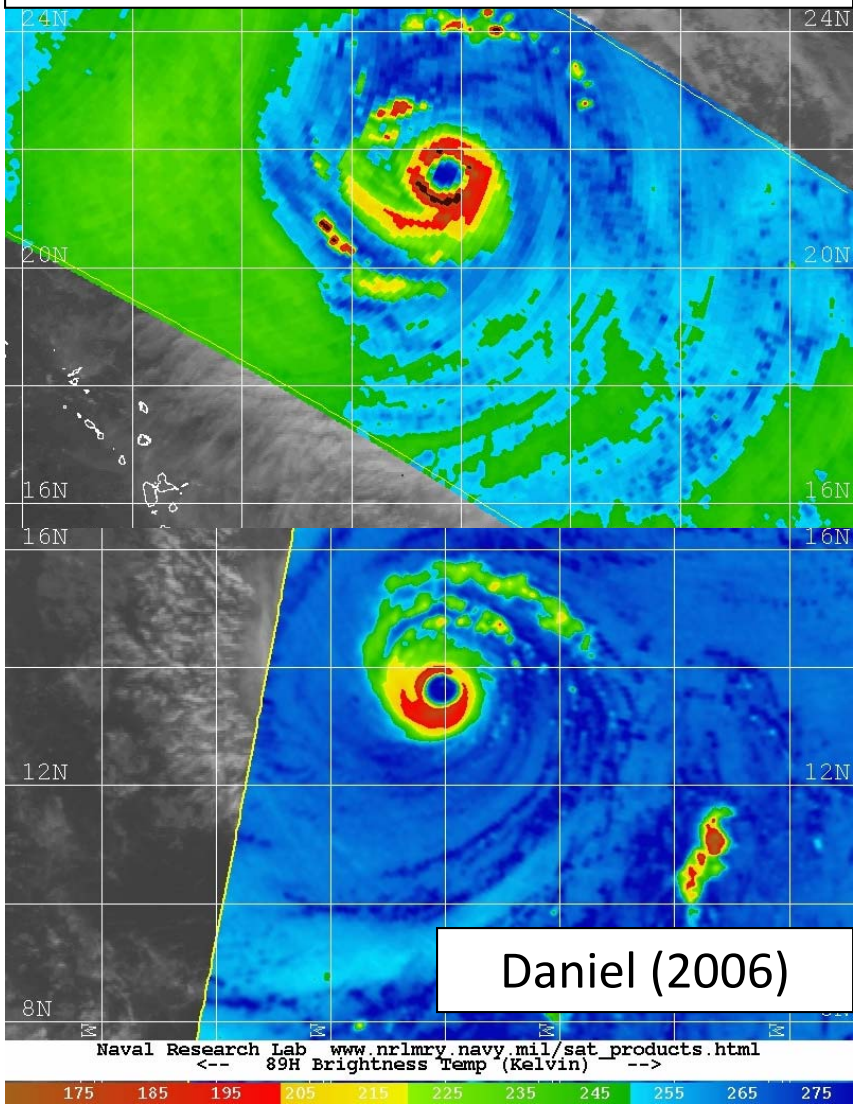
AN 0915 UTC SSMIS OVERPASS SHOWED THE EXISTENCE OF A NEW OUTER WIND MAXIMUM AT ABOUT 90 NMI RADIUS...WITH AN INNER EYEWALL PARTIALLY BROKEN TO THE WEST.

TC Core Evolution

Annular Hurricanes

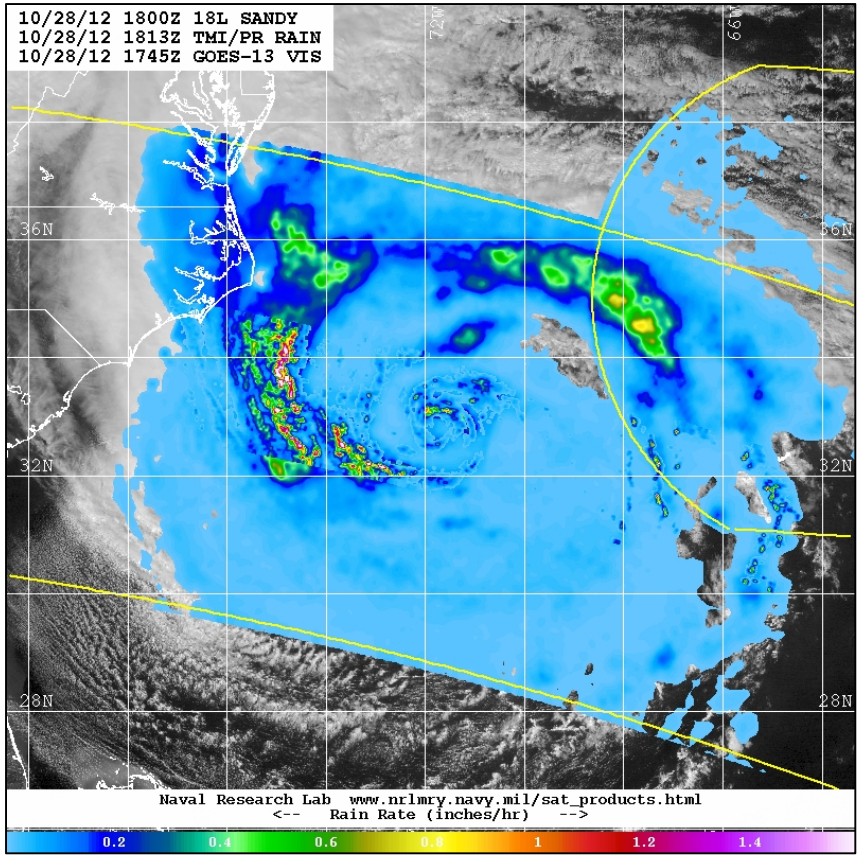
- Other TC core structure challenges include annular hurricanes – develop large, stable eye configurations
- Stronger, maintain peak intensity longer, and weaken more slowly than average TCs (Knaff et al. 2003)
- Have larger than average forecast intensity errors (Knaff et al. 2008)
- Ability to examine wind field with imagery of TC core structure would provide insights into evolution

Isabel (2003) maintained major hurricane intensity for almost 8 days



Rainband Evolution

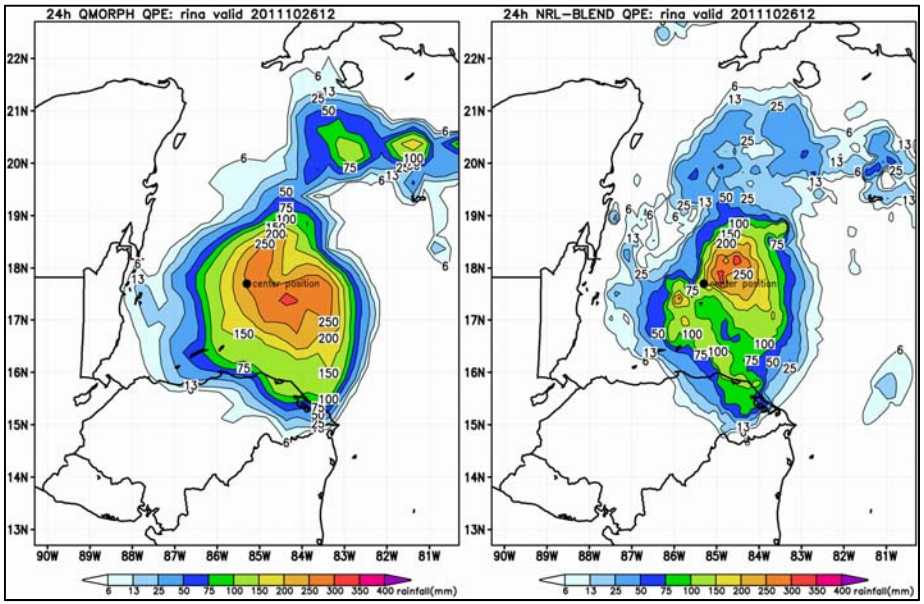
- TC rainband structure and evolution plays a role in initial TC organization, intensity and wind field structure through diabaitc PV redistribution



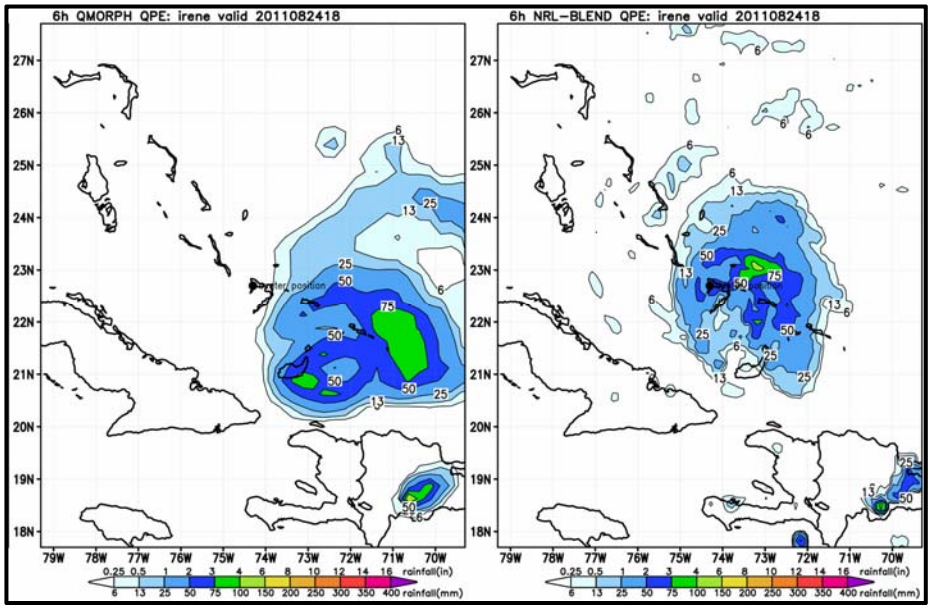
Hurricane Sandy – 1813 UTC 28 Oct. 2012

Precipitation Monitoring

- Several microwave sensors currently serve as input into an experimental rainfall monitoring and forecast product NHC is generating
- QMORPH and NRL-Blend are used for QPE for tropical cyclones, invests, and other significant rainfall systems in the NHC AOR



QPE for Hurricane Irene in the western Caribbean Sea 26 October 2011



QPE for Hurricane Irene in the Bahamas 24 August 2011

Lessons from Ongoing Proving Grounds

- Ensuring that data are available in the operational decision support platform (NAWIPS →AWIPS2) is critical
- Providing training on product details and interpretation, including comparisons to imagery and data from other platforms, will facilitate adoption and use by forecasters