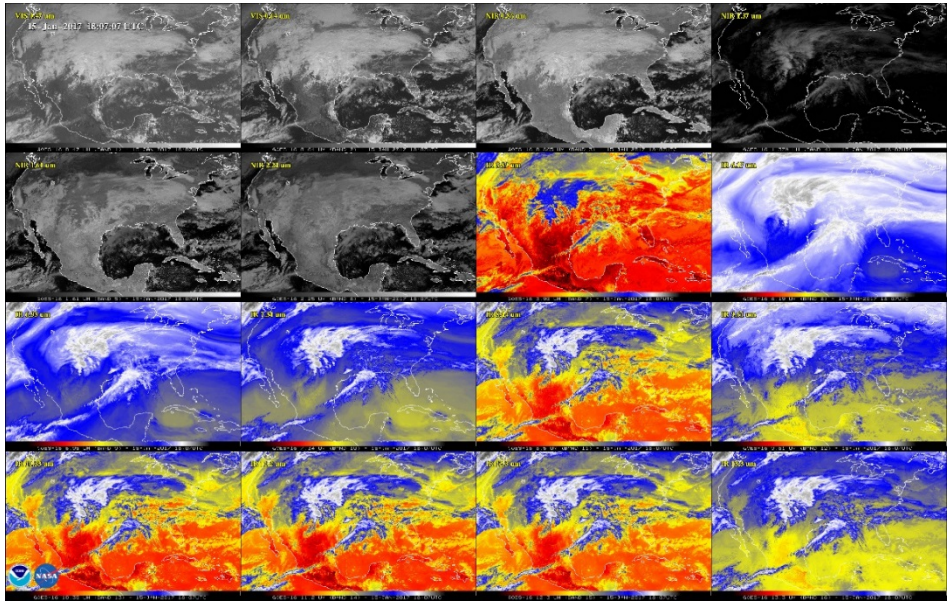
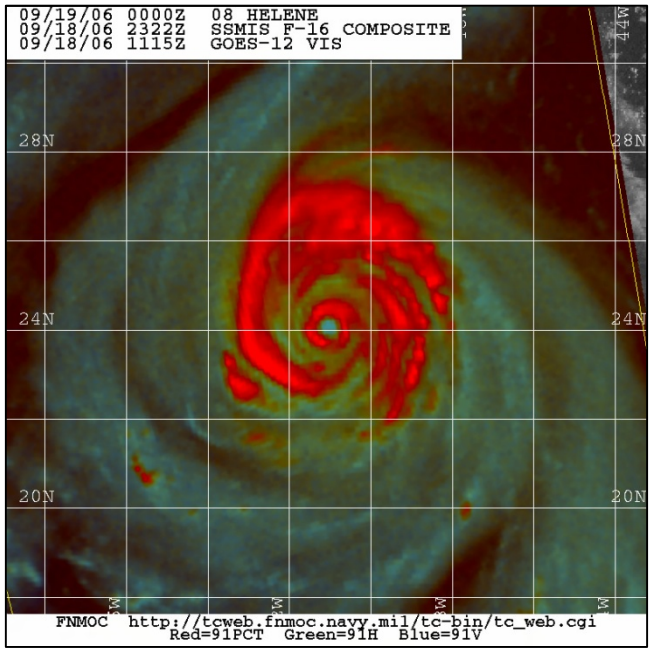
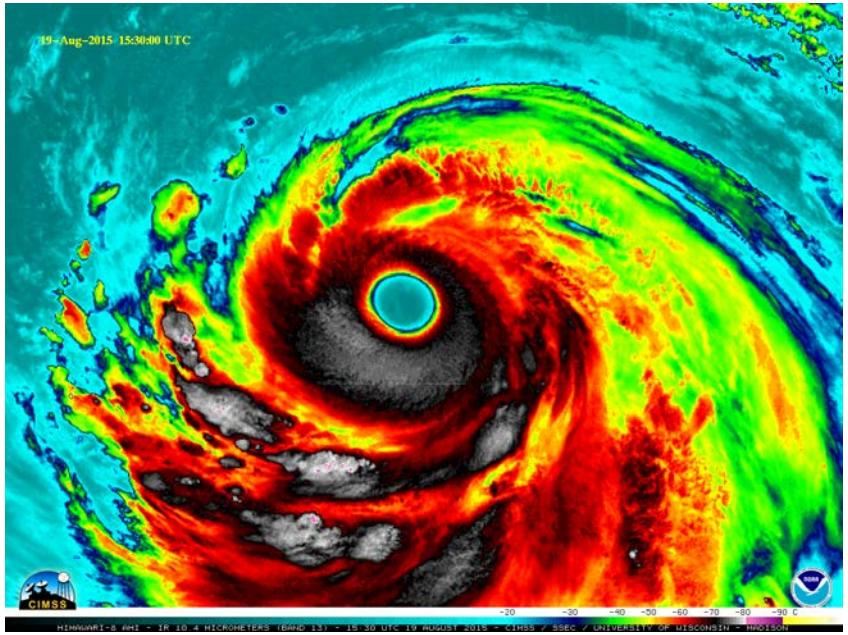
Satellite Remote Sensing at NHC







Hurricane History Session

Michael Brennan

National Hurricane Center

18 April 2017

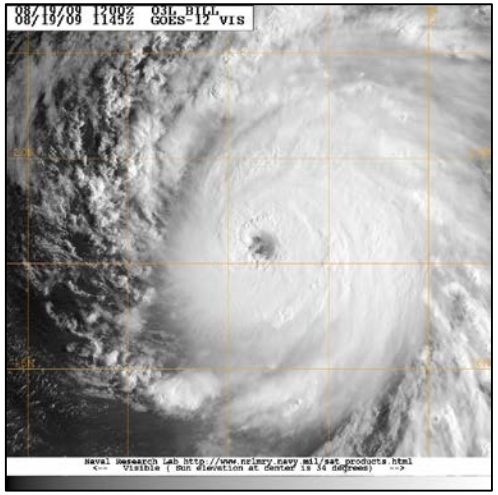
Outline

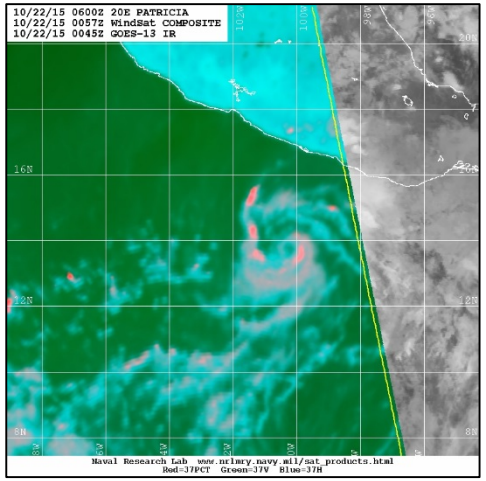
- History of satellites and NHC operations
- Current status of NOAA geostationary satellites
- GOES-16 overview
- Capabilities compared to current GOES
- Uses for tropical cyclone analysis and forecasting

Tropical Cyclone Analysis

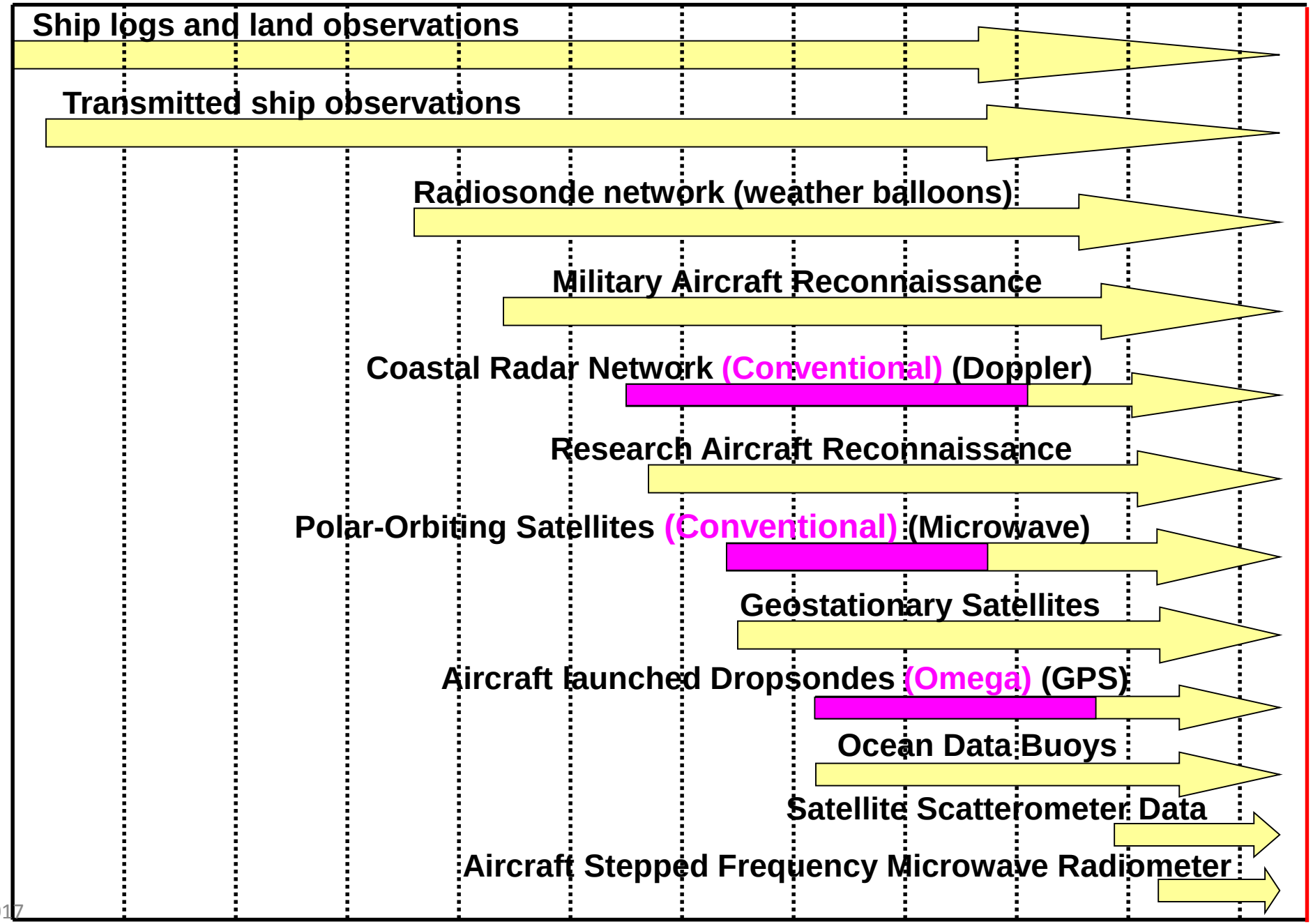
Questions the Forecaster Must Answer

1. Where is the storm located?
   - Determines initial motion
   - Critical to initializing model guidance and making track forecast
2. How strong is the storm?
   - Initial intensity and intensity change important for model guidance and intensity forecast
3. How big is the storm?
   - Extent of tropical-storm and hurricane-force winds
   - Forecasting structure is critical for watch/warning placement and timing and storm surge



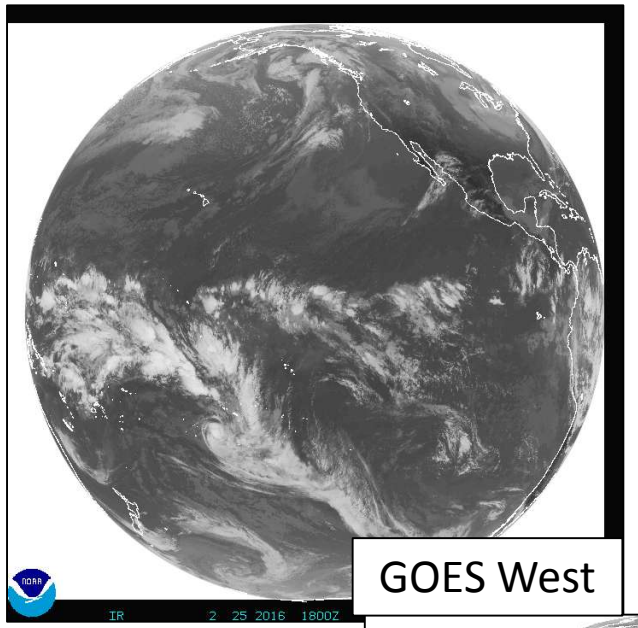


Tropical Cyclone Observational Platforms since 1900

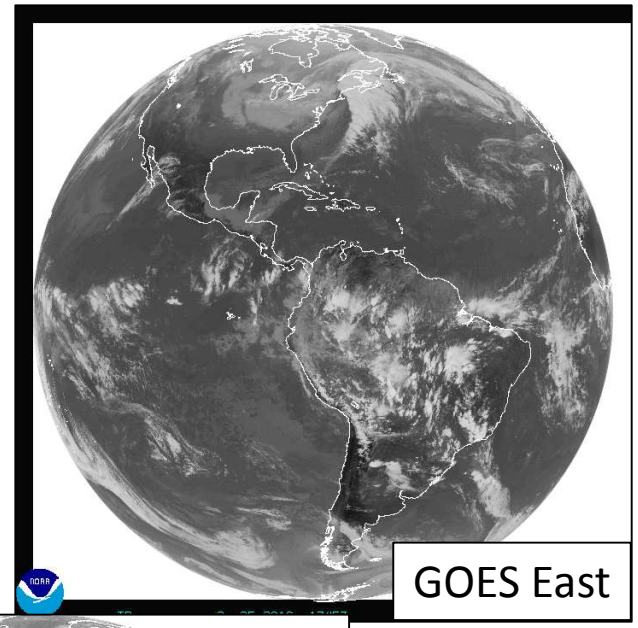


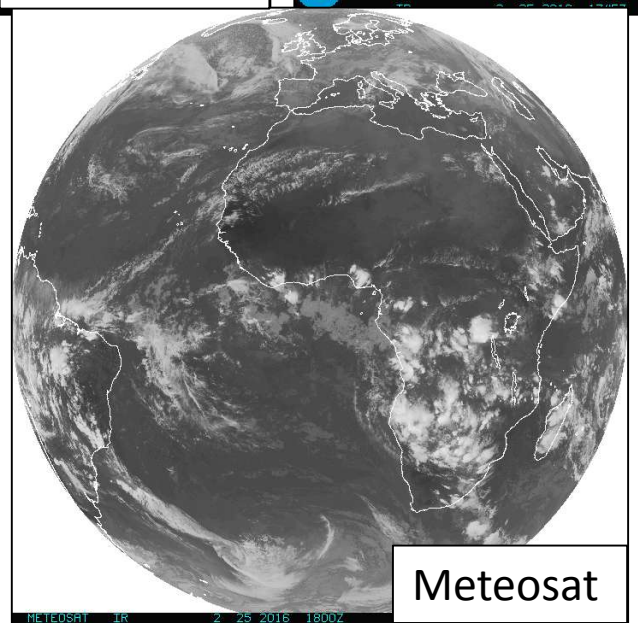
Satellite Data at NHC

- Geostationary satellite imagery is the single most important tool in NHC's observational toolkit
  - Allows for continuous monitoring of weather in NHC's AOR, which is otherwise largely data void
  - Provides intensity estimates (through the Dvorak technique) of tropical cyclones through their entire life cycle
- NHC routinely uses data from 3 geostationary satellites – GOES East, GOES West, and Meteosat – to monitor its AOR



GOES West

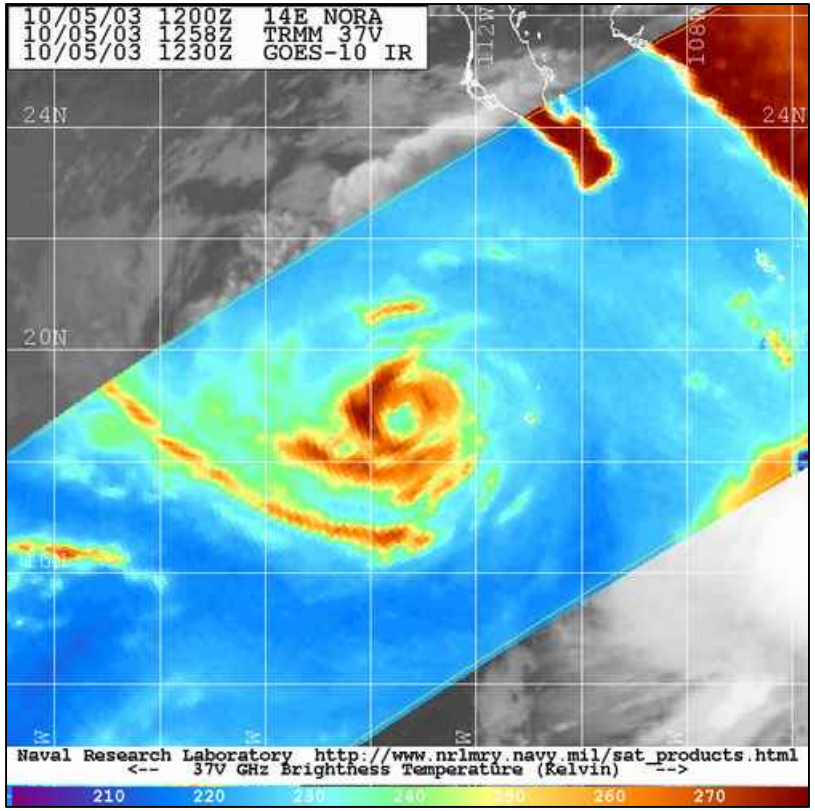

GOES East

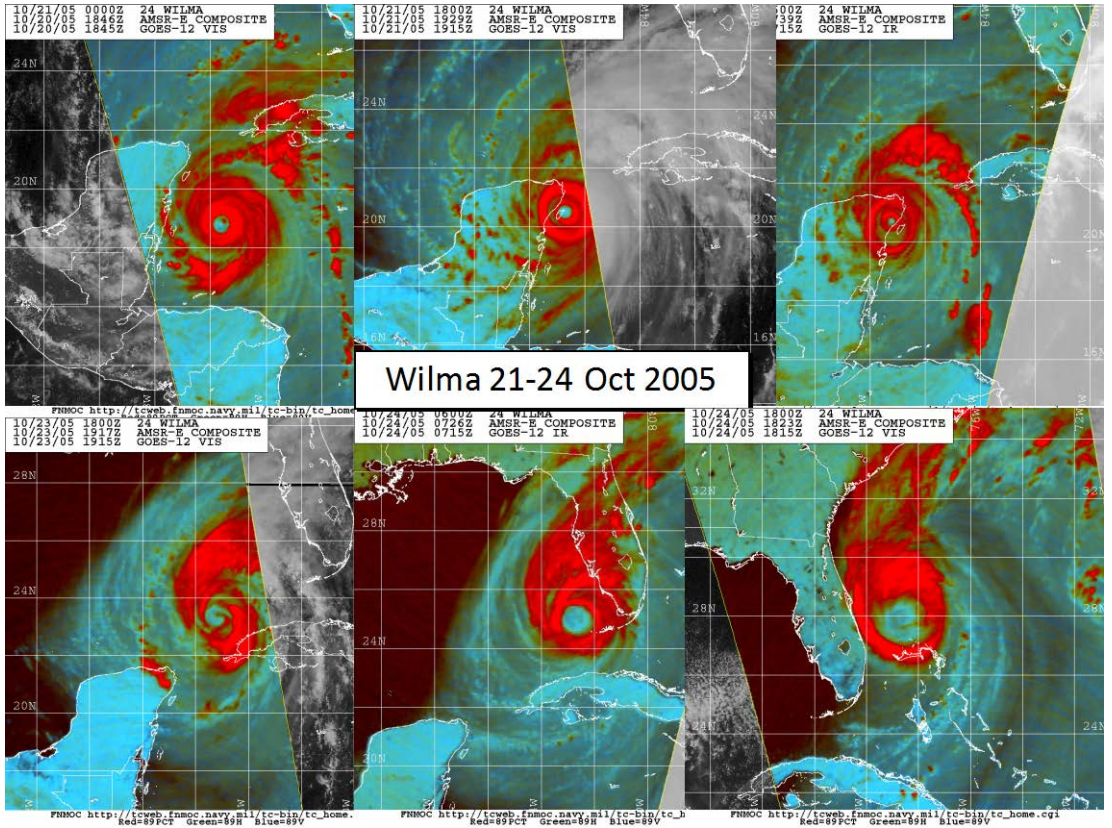


Meteosat

Satellite Data at NHC

- Passive microwave imagery from low-earth orbiting satellites (GPM, AMSR-2, SSMI) assists in locating TC centers and monitoring TC structural evolution, such as eyewall replacement cycles

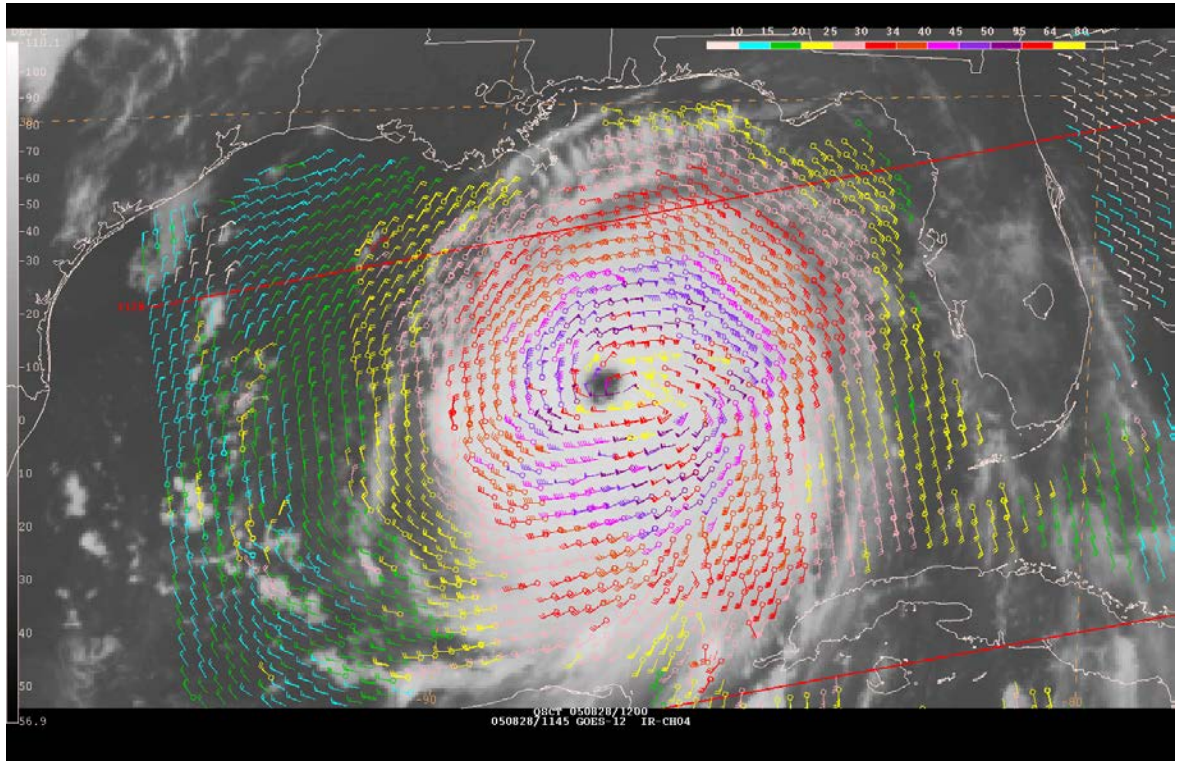


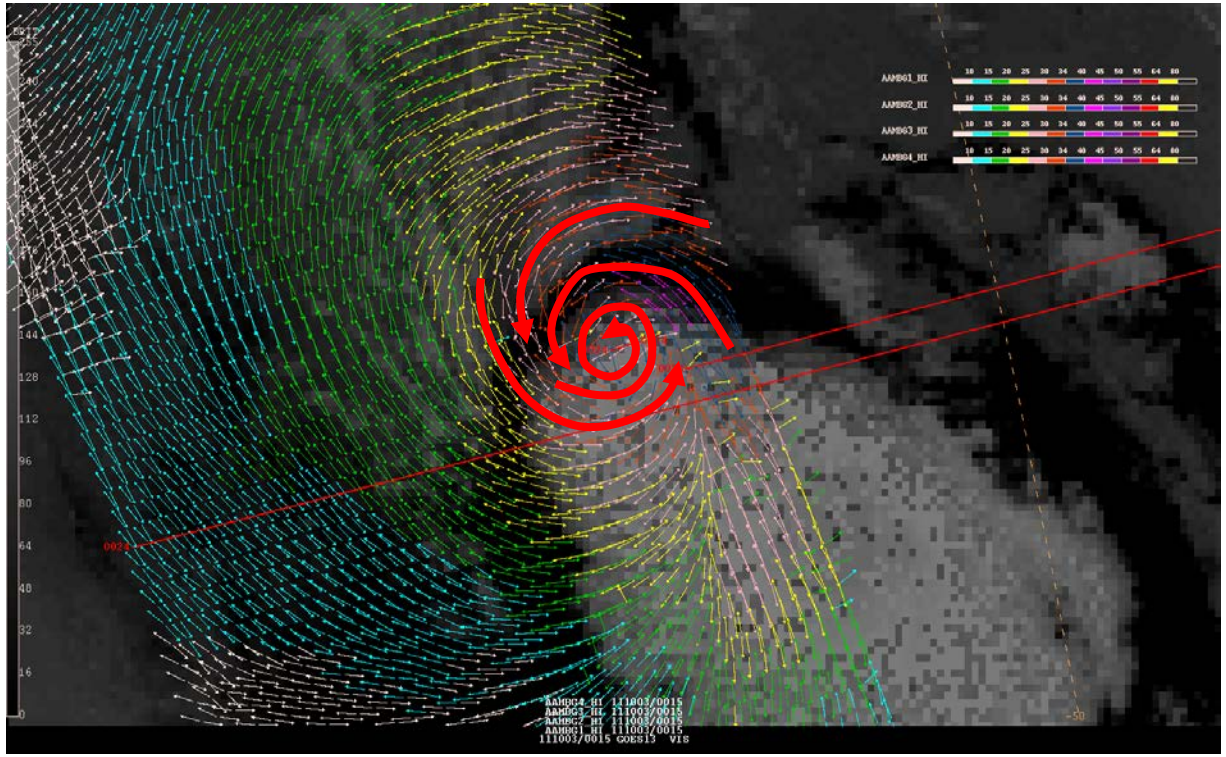


Images courtesy NRL TC Webpage

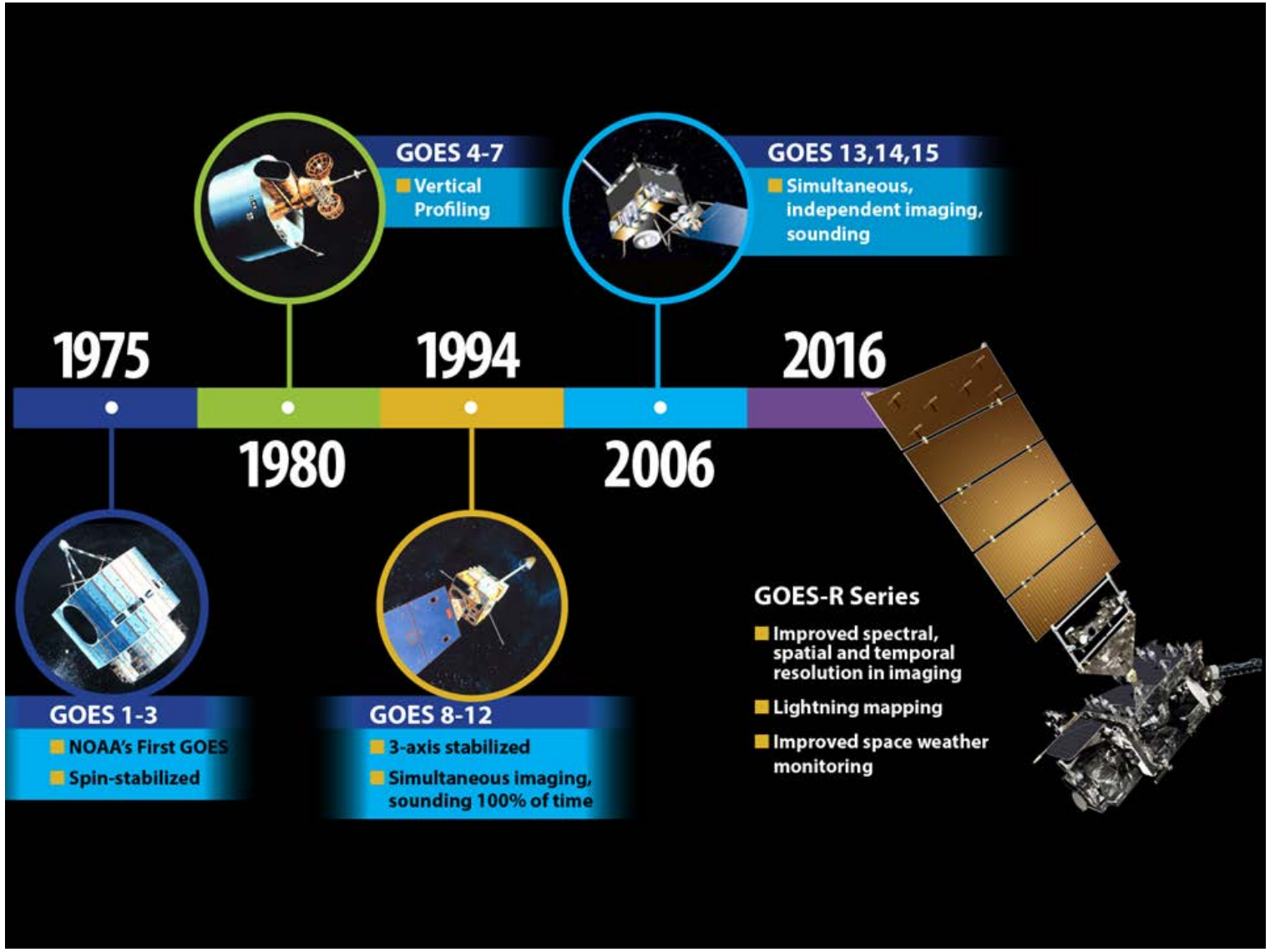
Satellite Data at NHC

- Satellite ocean surface vector winds from scatterometers (ASCAT) are also important in monitoring TC development, center location, intensity and wind field structure

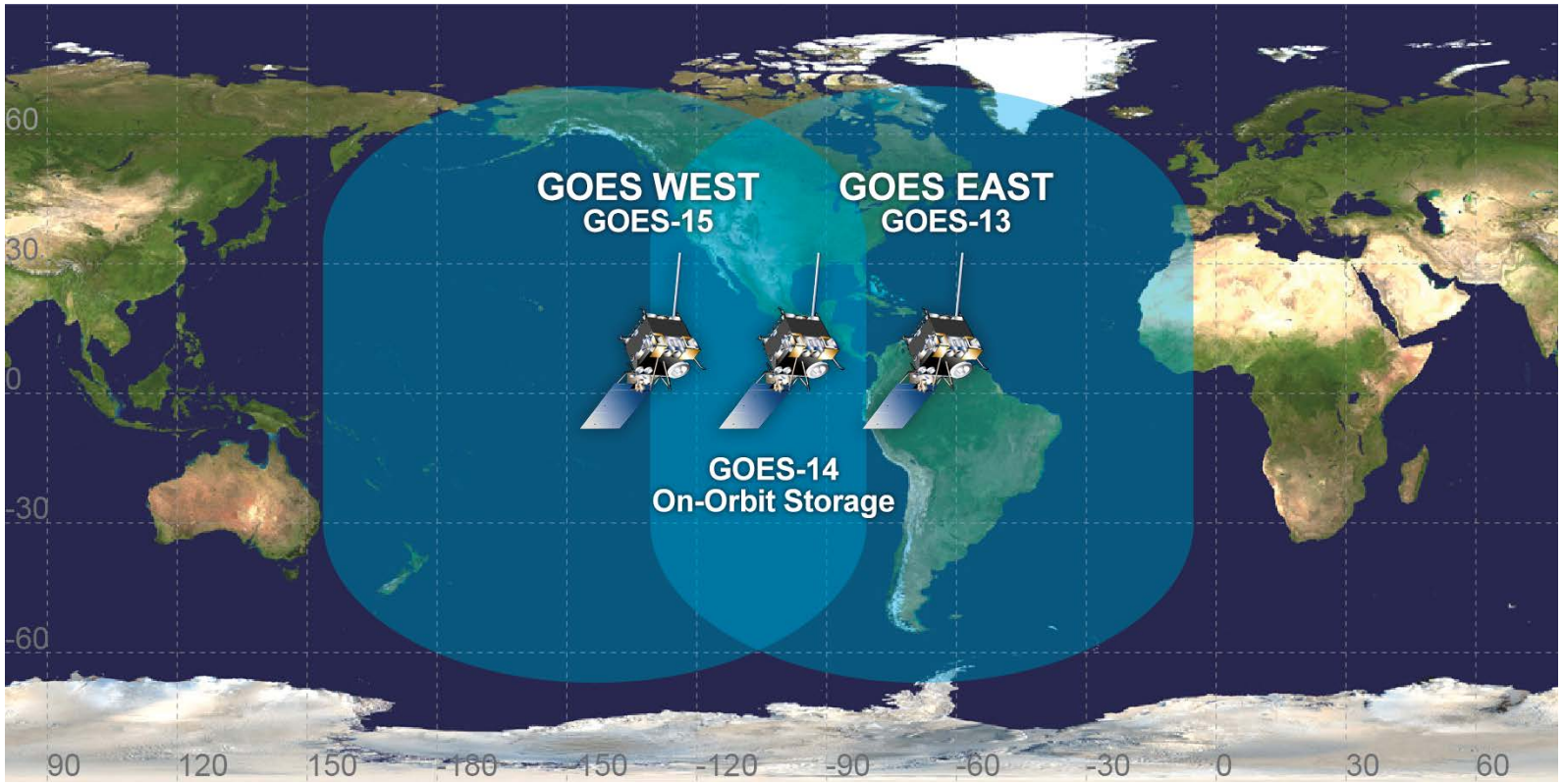




History of NOAA Geostationary Satellites

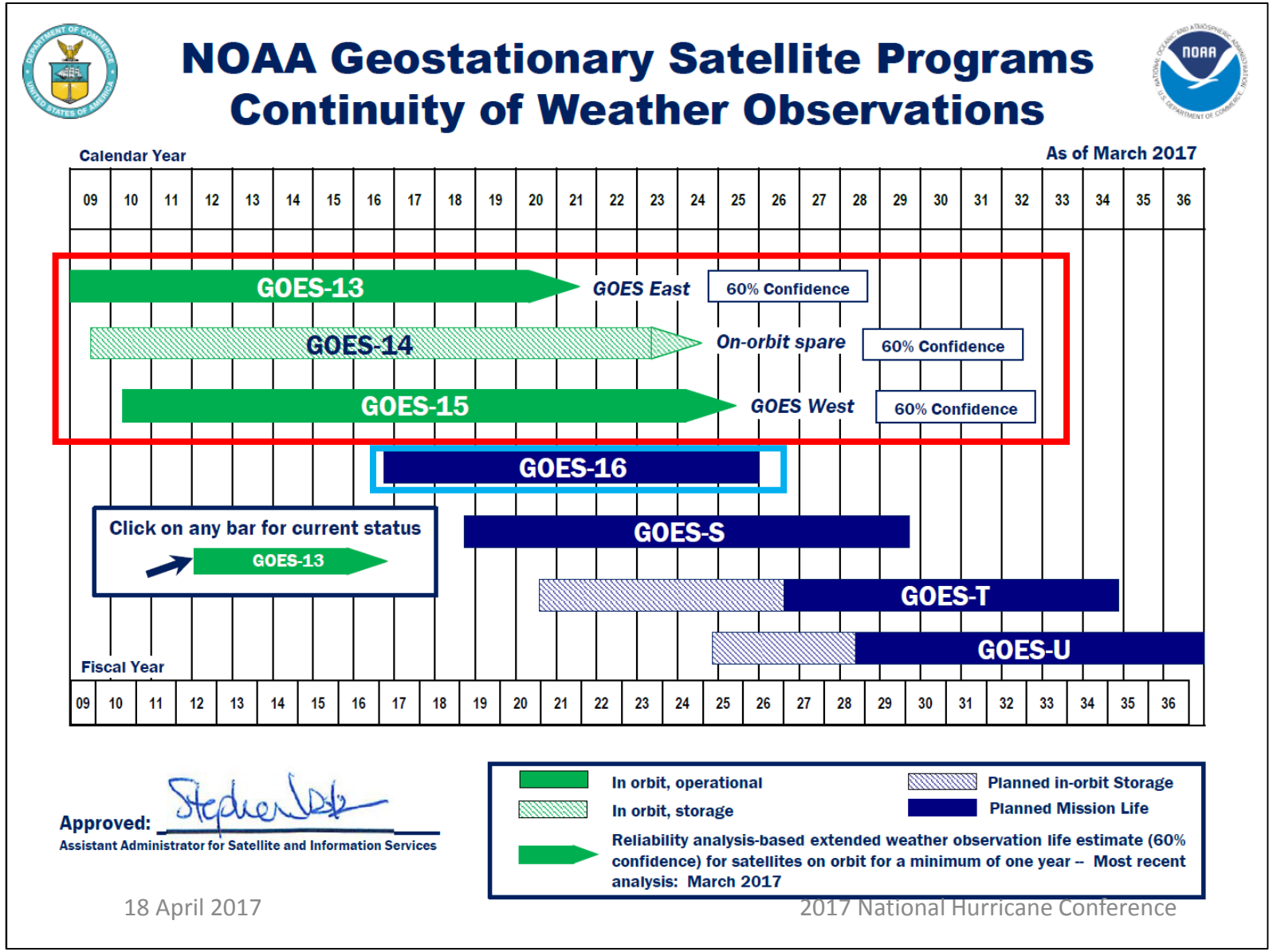


Status of GOES Constellation



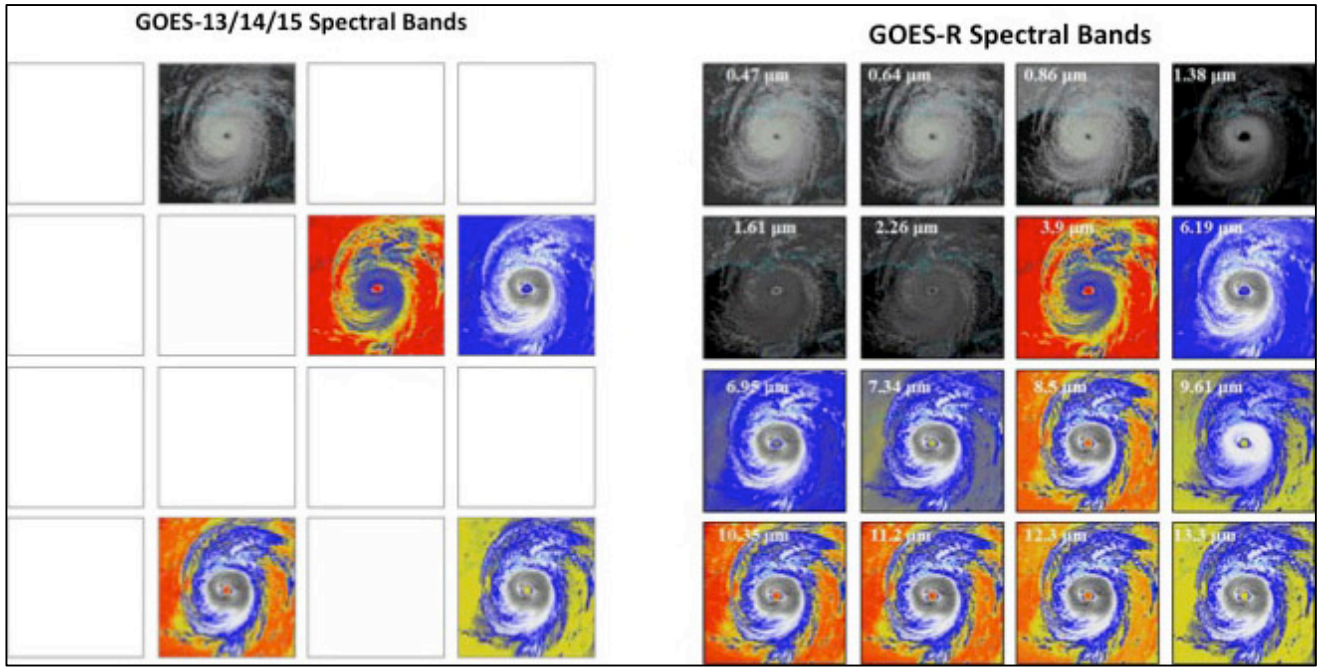
- NOAA currently has four geostationary satellites on orbit:
  - GOES-13 (GOES East 75°W)
  - GOES-15 (GOES West 137°W)
  - GOES-14 (On-orbit spare)
  - GOES-16
- GOES-16 currently at 89.5°W undergoing calibration/ validation
  - Will become operational GOES East or West by November 2017
  - Planned location will be announced in May 2017

Status of GOES Constellation



- NOAA currently has four geostationary satellites on orbit:
  - GOES-13 (GOES East 75°W)
  - GOES-15 (GOES West 137°W)
  - GOES-14 (On-orbit spare)
  - GOES-16
- GOES-16 currently at 89.5°W undergoing calibration/ validation
  - Will become operational GOES East or West by November 2017
  - Planned location will be announced in May 2017

GOES-16 Spectral Bands



5 channels

16 channels

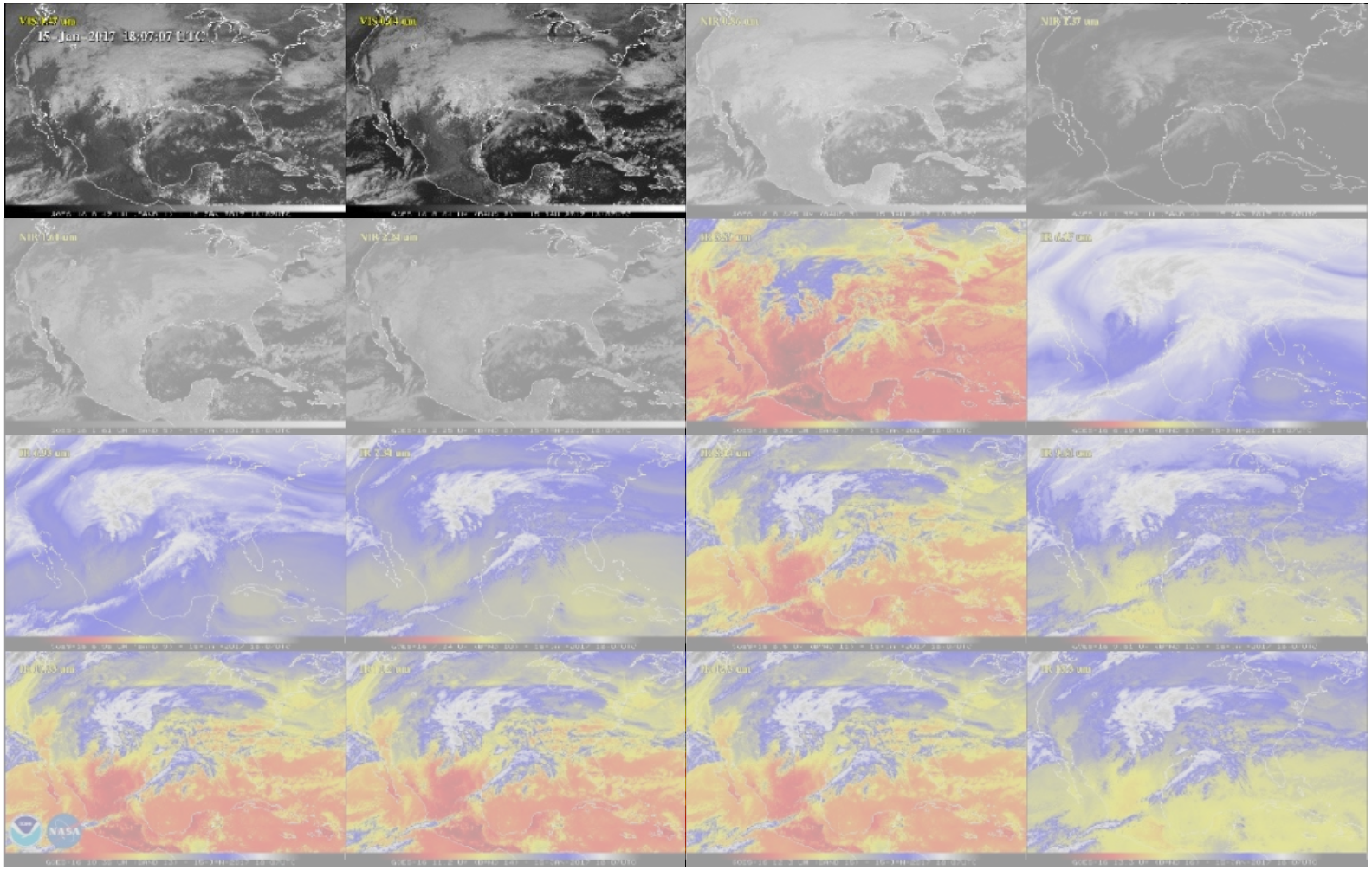
GOES-16 has an Advanced Baseline Imager (ABI) with 16 channels

- 2 visible
- 4 near infrared
- 10 infrared (including 3 water vapor channels)

Legacy GOES imager has 5 channels

- 1 visible
- 4 infrared

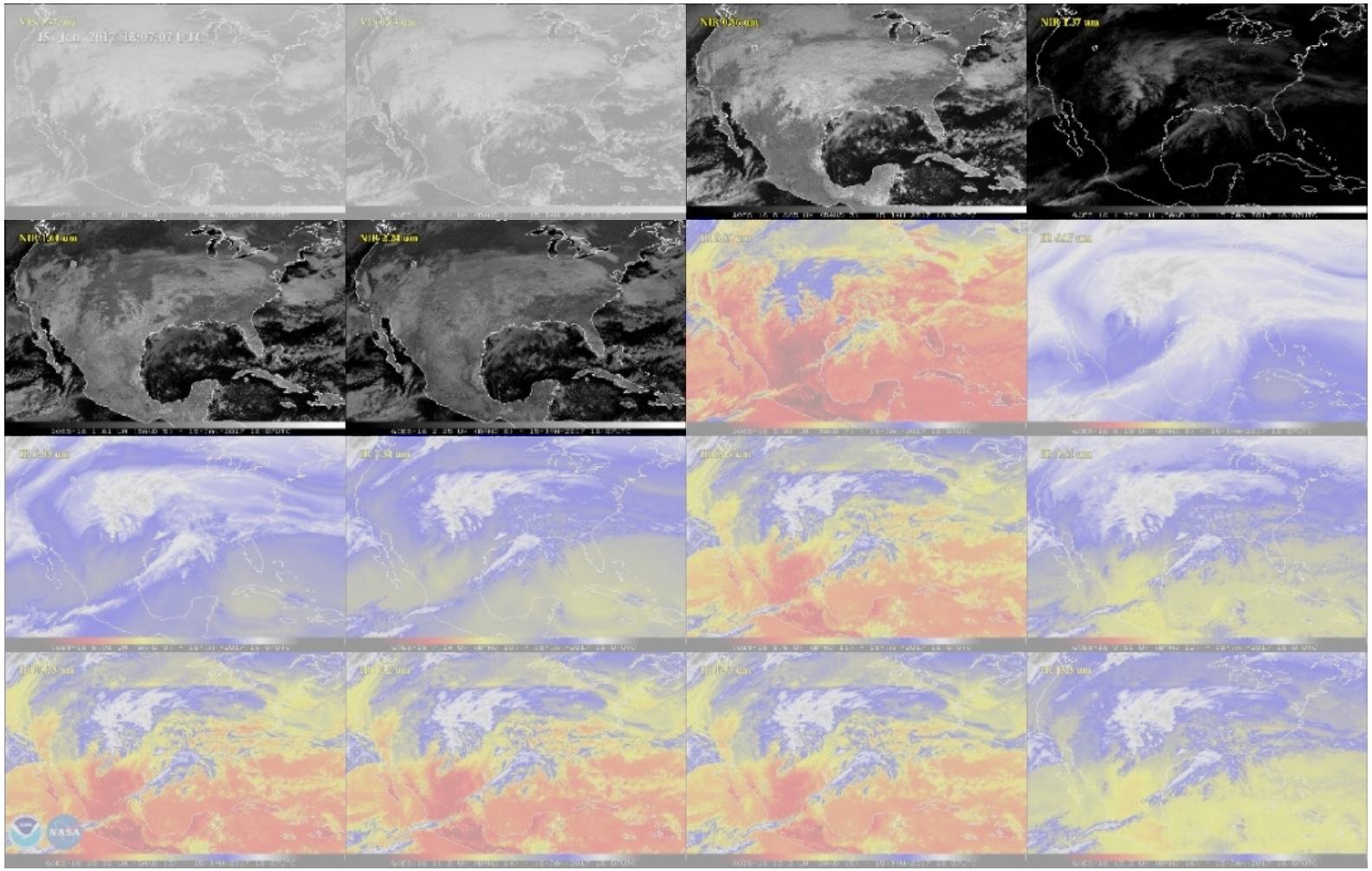
GOES-16 Spectral Bands



Visible Channels

- Band 1: Blue (0.47 µm)
  - Resolution: 1 km
- Band 2: Red (0.64 µm)*
  - Resolution: 0.5 km
  - Legacy GOES Resolution: 1 km

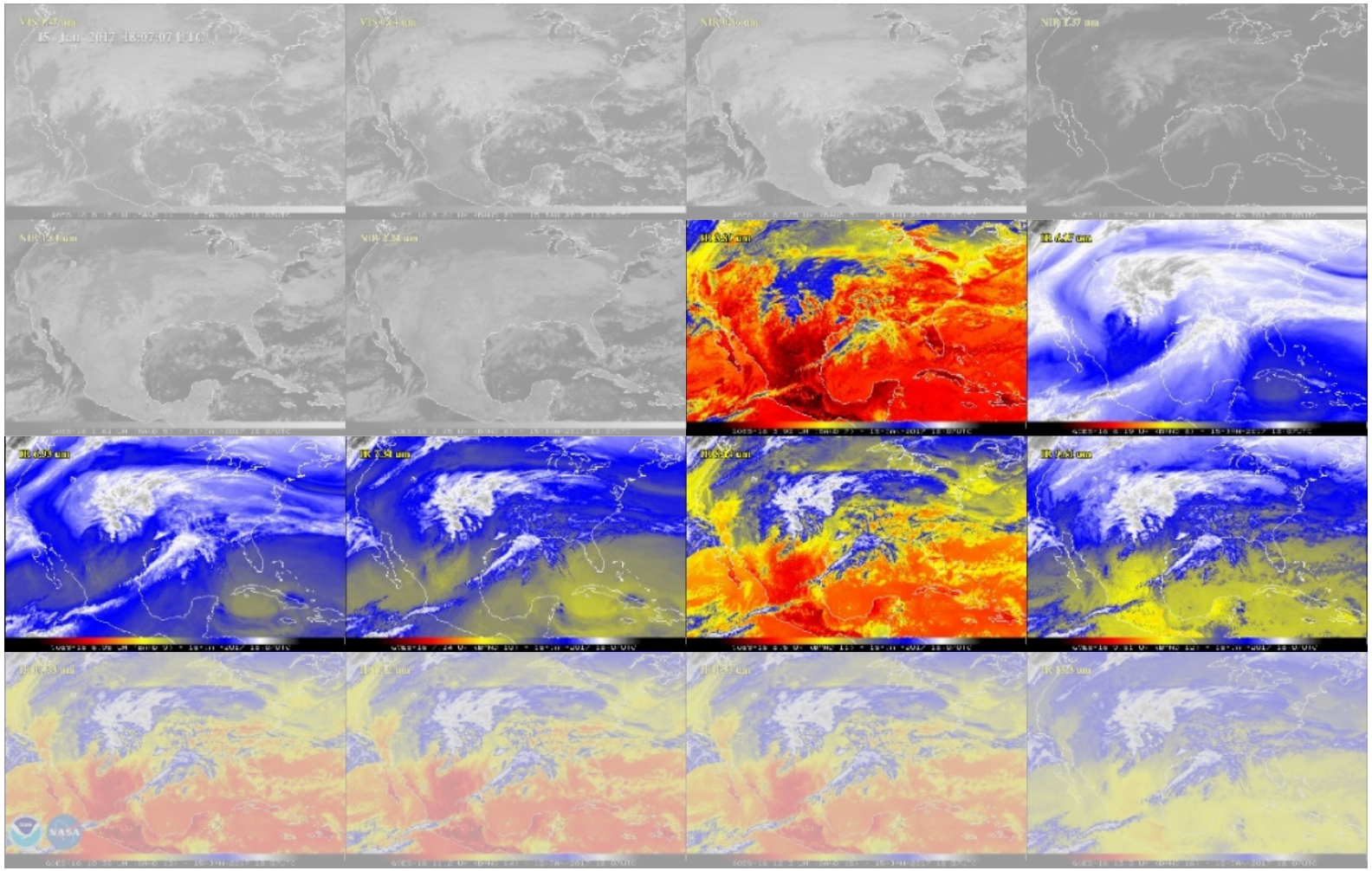
GOES-16 Spectral Bands



Near IR Channels

- Band 3: Veggie (0.86 µm)
  - Resolution: 1 km
- Band 4: Cirrus (1.37 µm)
  - Resolution: 2 km
- Band 5: Snow/Ice (1.6 µm)
  - Resolution: 1 km
- Band 6: Cloud Particle Size (2.2 µm)
  - Resolution: 2 km

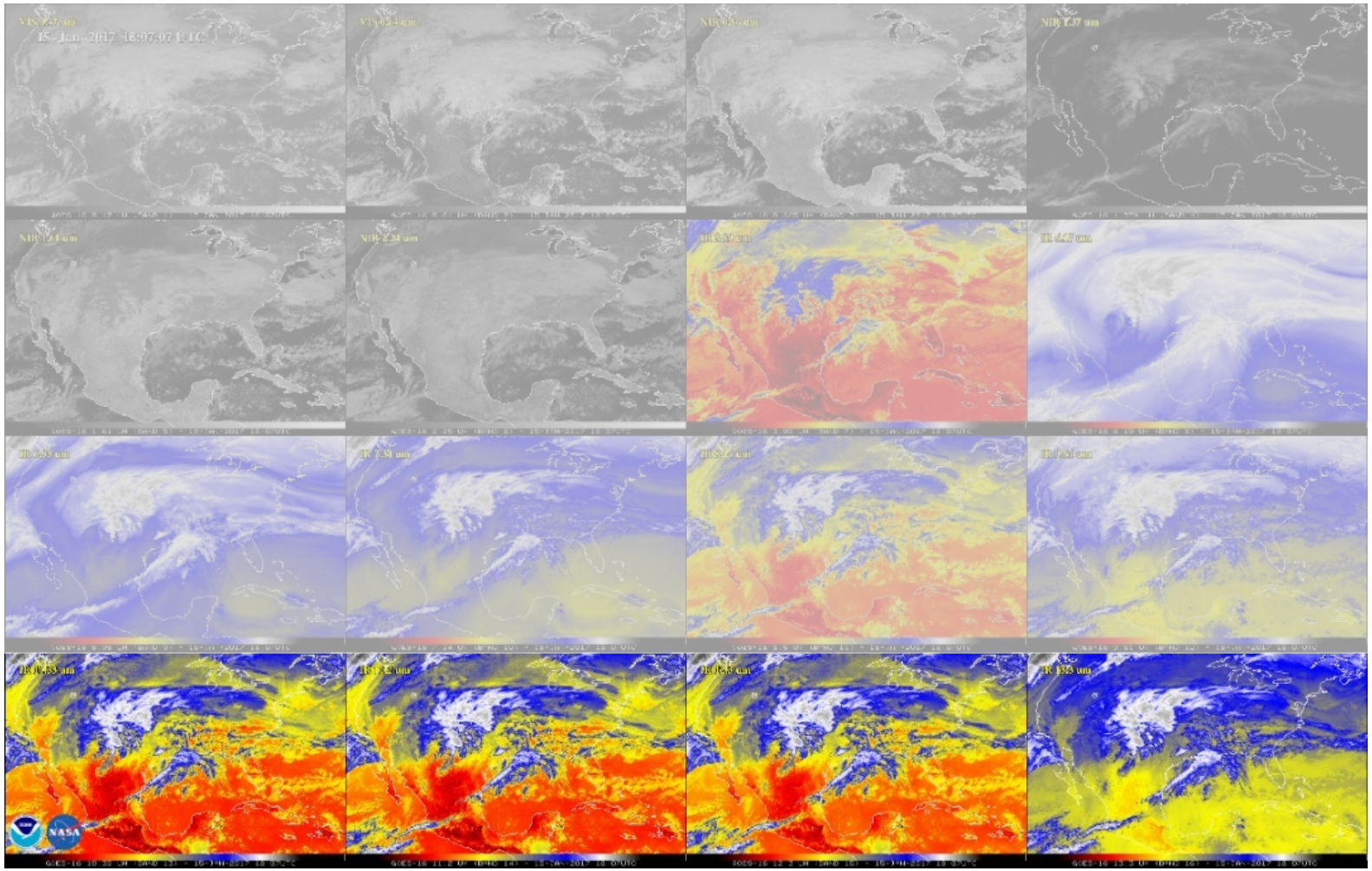
GOES-16 Spectral Bands



IR Channels (2-km resolution)

- Band 7: Shortwave Window (3.9 µm)*
  - Legacy GOES - 4-km resolution
- Band 8: Upper-level Water Vapor (6.2 µm)
- Band 9: Mid-level Water Vapor (6.9µm)*
  - Legacy GOES - 4-km resolution
- Band 10: Low-level Water Vapor (7.3 µm)
- Band 11: Cloud Top Phase (8.4 µm)
- Band 12: Ozone (10.3 µm)

GOES-16 Spectral Bands

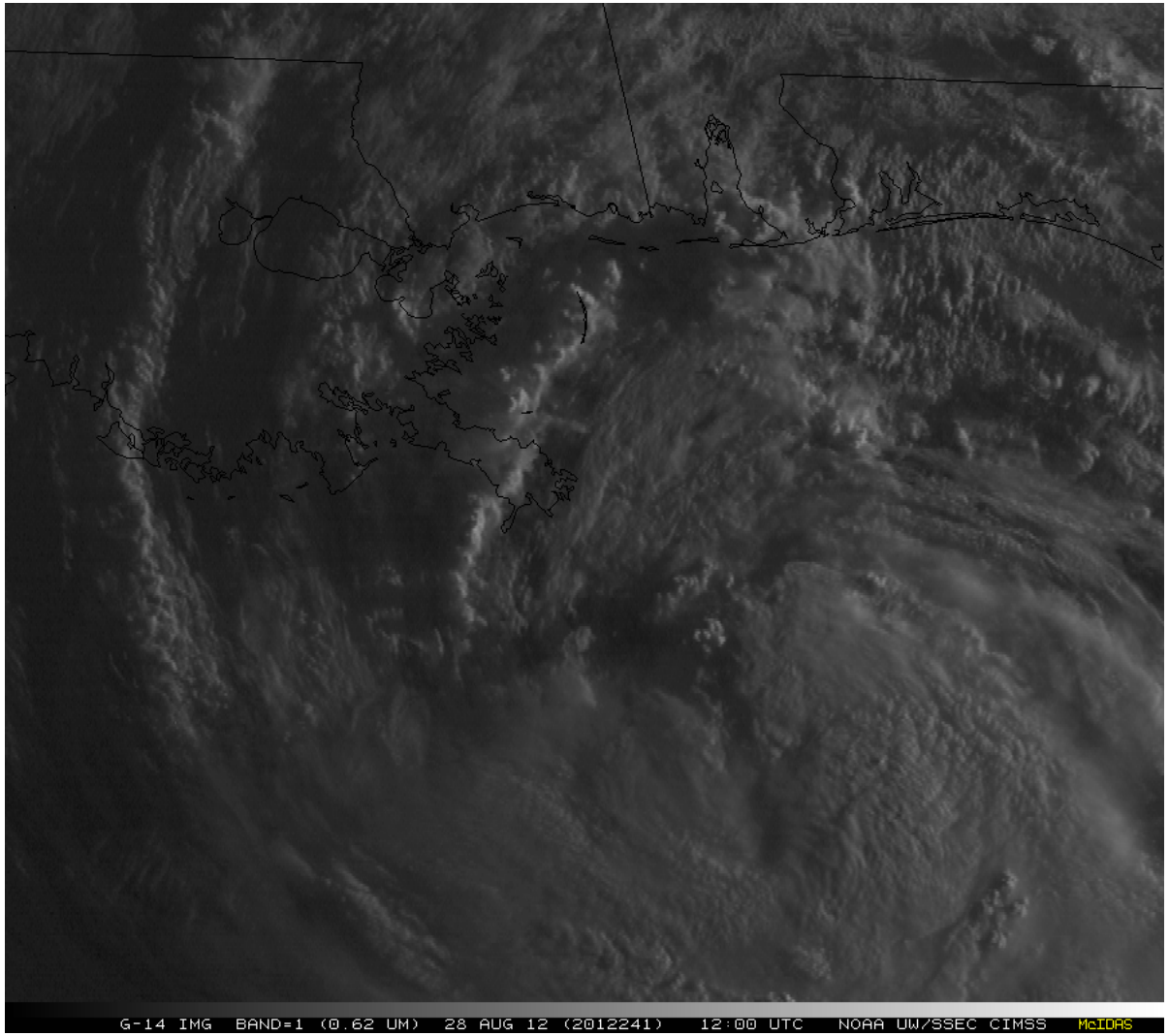


IR Channels (2-km resolution)

- Band 13: Clear IR Longwave Window (10.3 µm)*
  - Legacy GOES - 4-km resolution
- Band 14: IR Longwave Window (11.2 µm)*
  - Legacy GOES - 4-km resolution
- Band 15: Dirty Longwave Window (12.3 µm)
- Band 16: CO_2 Longwave Window (13.3 µm)

GOES-16 Scan Strategy

- Flex Mode:
  - Full disk every 15 min
  - CONUS every 5 min
  - 2 Meso sectors every 60 sec or 1 Meso every 30 sec
- Full Disk Mode:
  - Full disk every 5 minutes
  - No Meso sectors

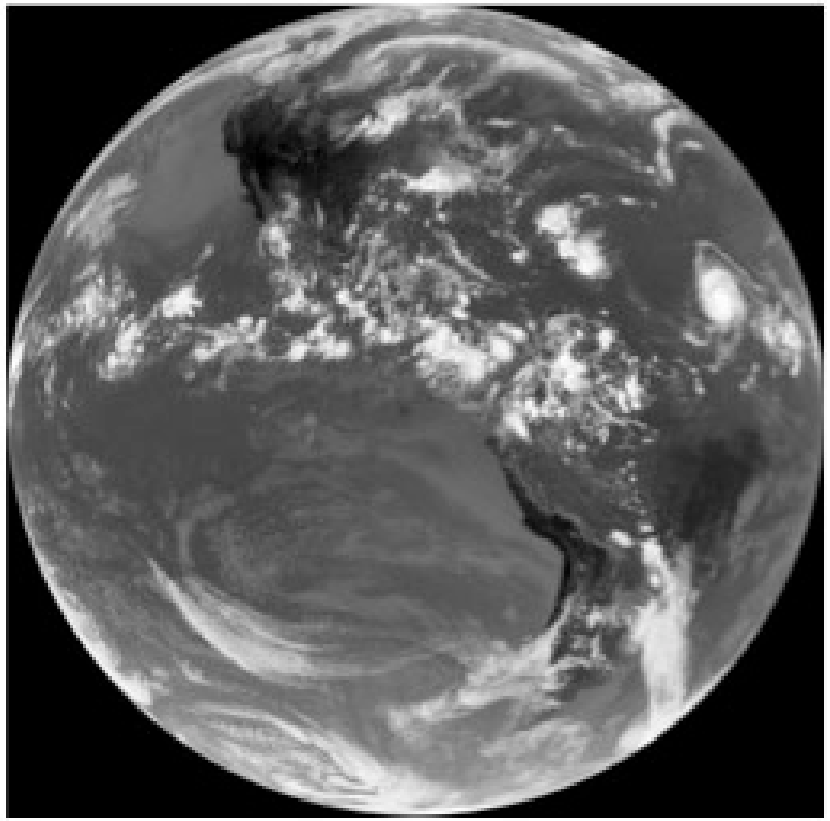


GOES-14 SRSO 1-min visible imagery over Hurricane Isaac

GOES-16 Scan Strategy

Current GOES

5-minute Capability

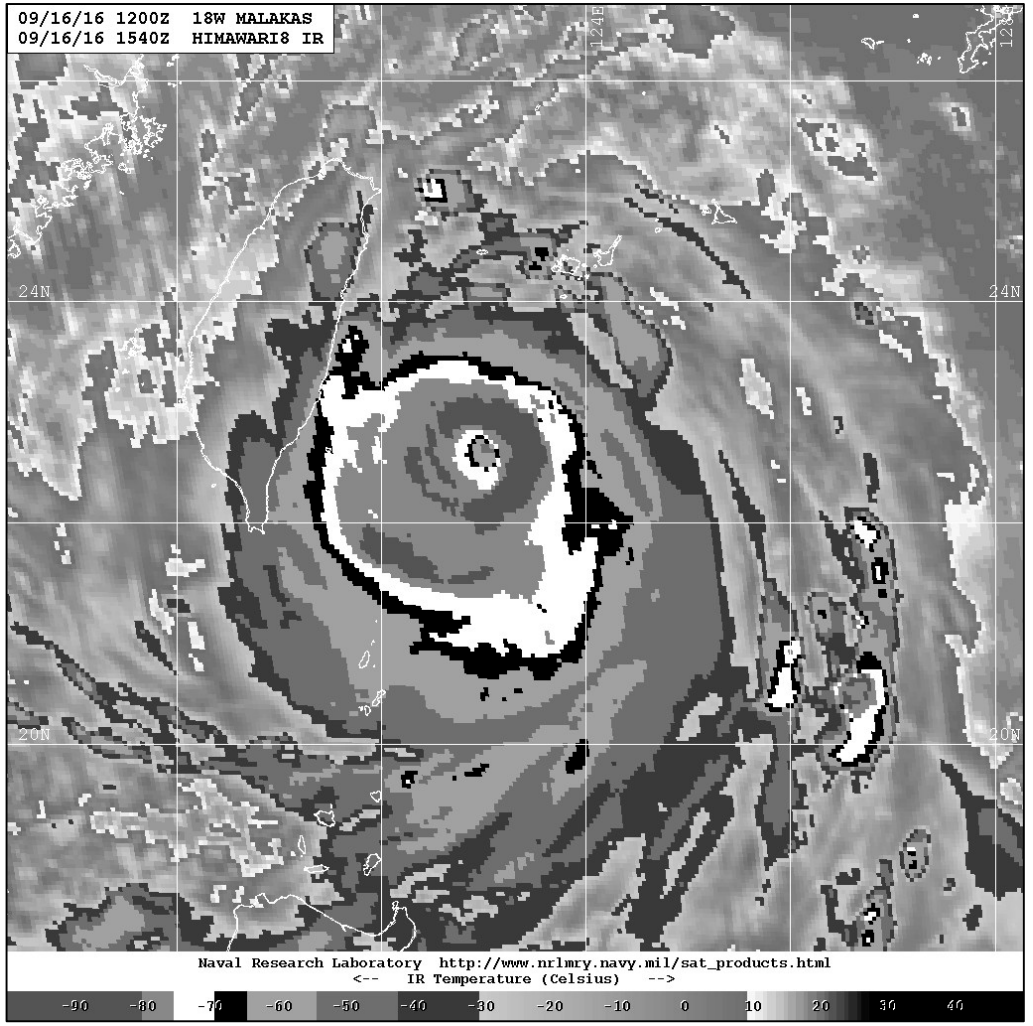


GOES-R

5-minute Capability

GOES-16 Utility in Tropical Cyclone Analysis

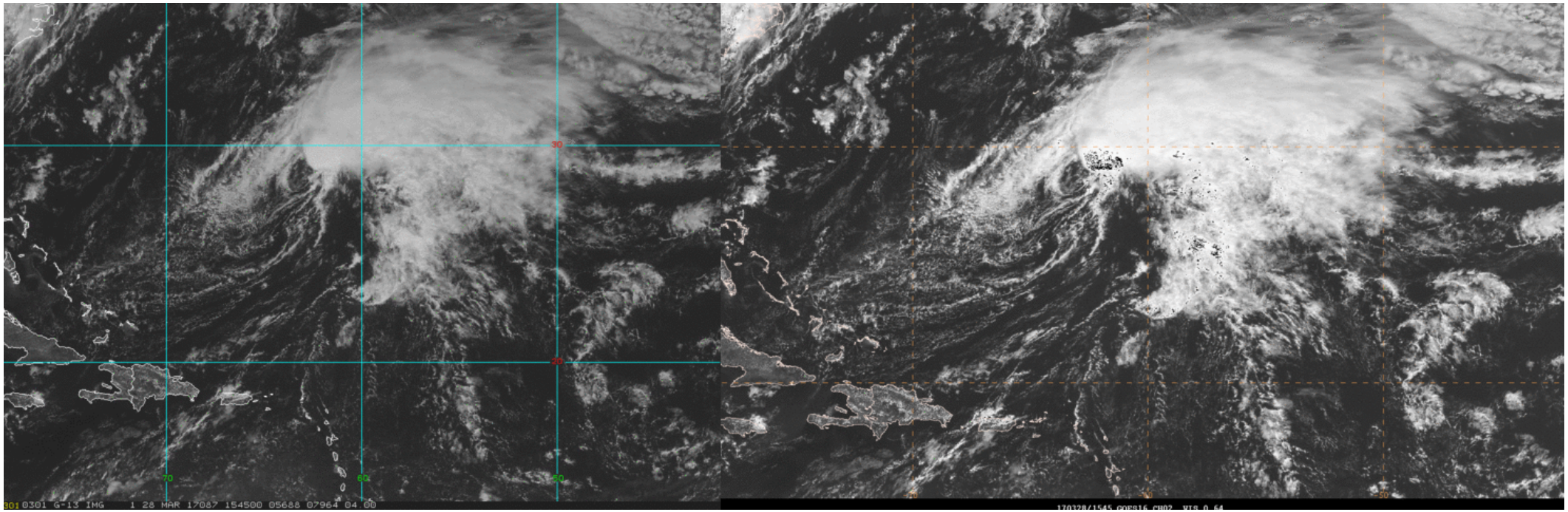
- Forecast process begins with analysis
  - **Cyclone location and initial motion**
  - **Intensity (maximum winds)**
  - Size (34, 50, and 64-kt wind radii)
- Geostationary satellite imagery critical in determining location and intensity through the Dvorak technique
  - Proper analysis critical to initializing model guidance and making a successful forecast
- Geostationary imagery and data also used to analyze the environment and other critical features
  - Imagery, cloud track winds, etc.



Himiwari IR image of Typhoon Malakas
1540 UTC 16 Sep 2016

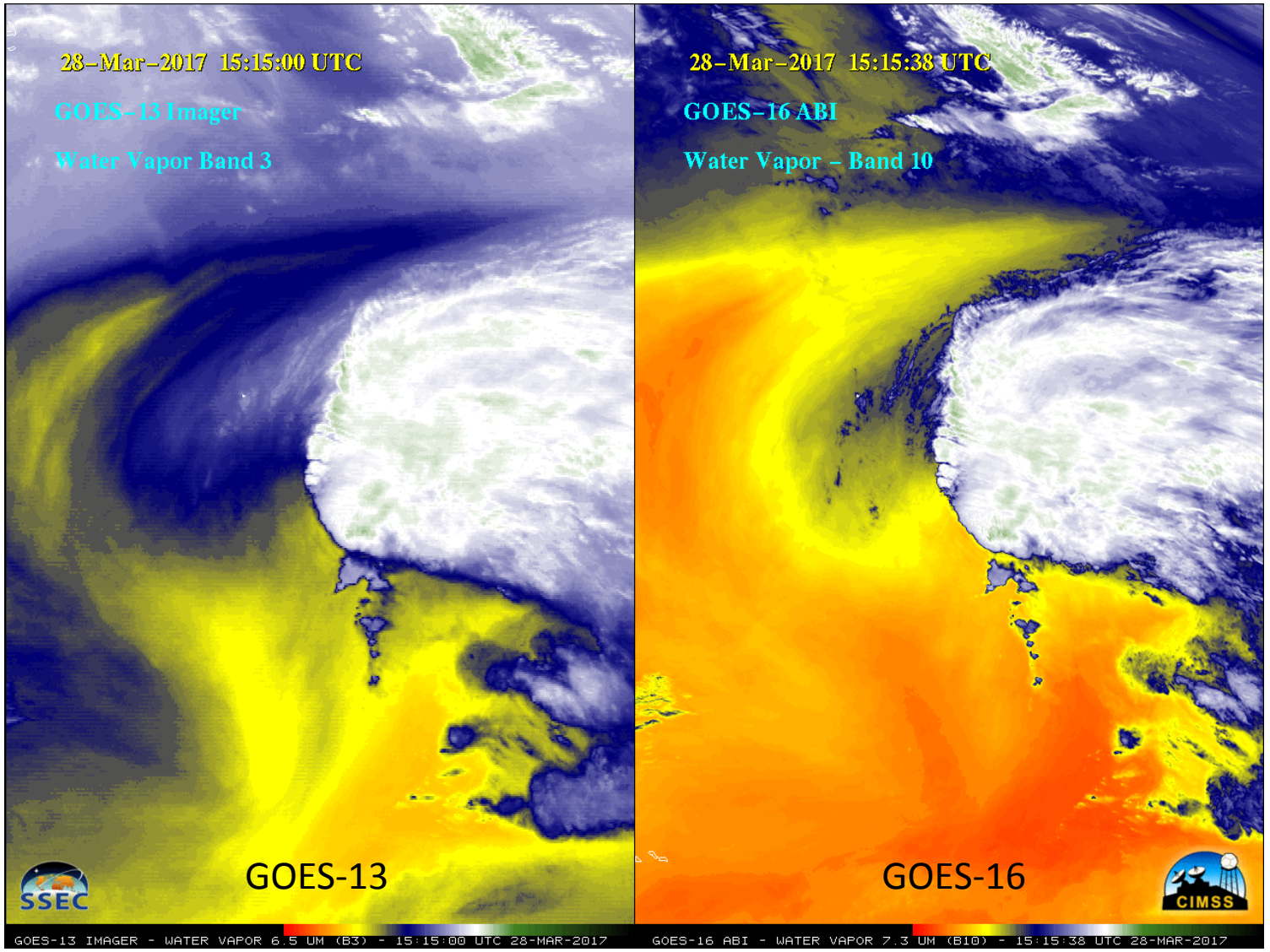
Improvements over Current GOES

- More frequent imagery will help with analysis of center location and identification
- High-frequency visible imagery will make it easier to identify and track the low-level center of developing systems in the low cloud lines
- Could be useful at sunrise to quickly assess weak/developing systems to make decisions about deploying aircraft reconnaissance



Improvements over Current GOES

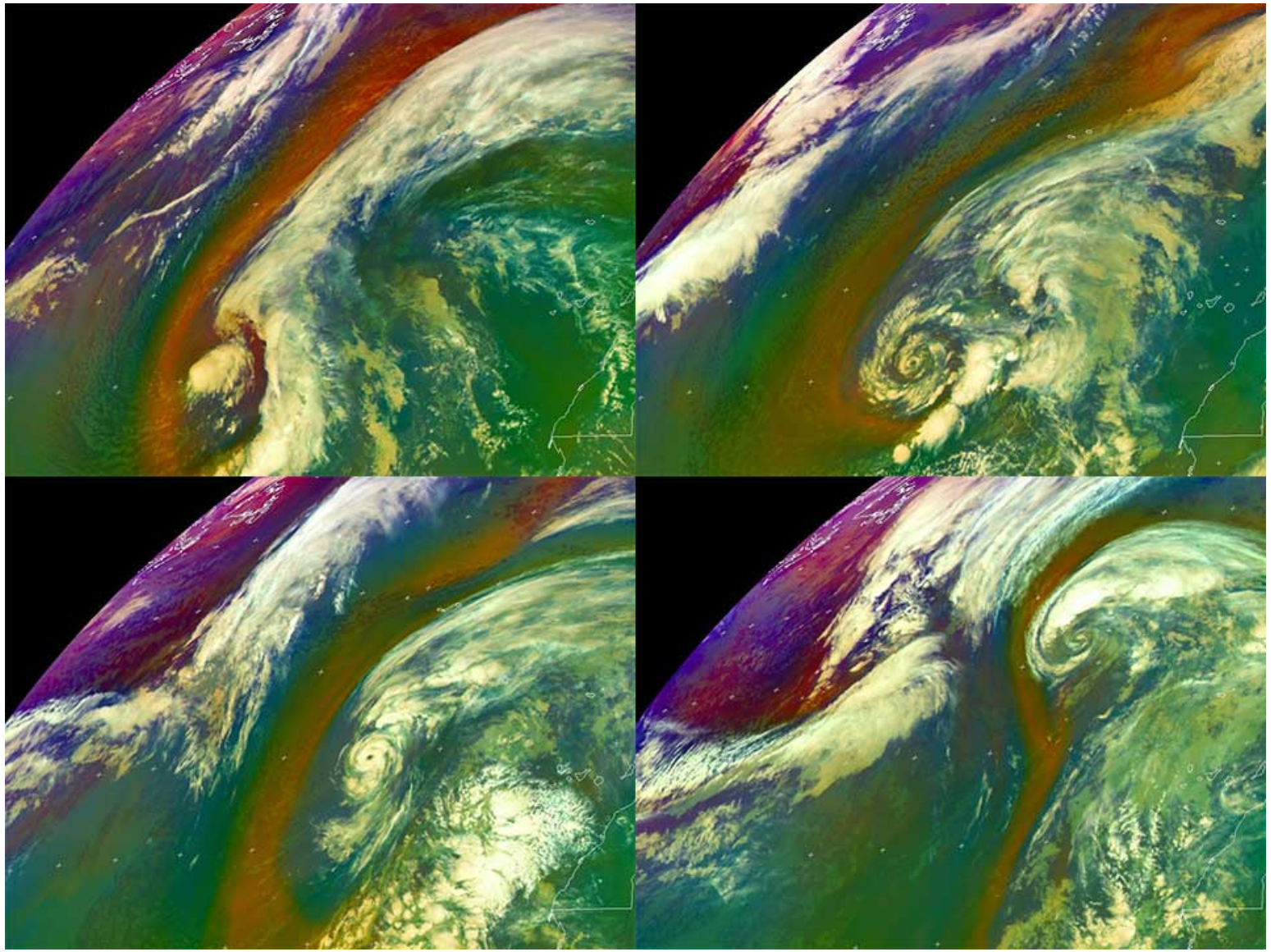
- Multiple water vapor channels with different weighting functions will allow assessment of atmospheric moisture through deeper layers of the troposphere
- GOES-16 7.3-µm imagery (right) shows mid-level moisture west of AL90 invest that wasn't seen in GOES-13 6.5-µm imagery (left) that is more sensitive at higher levels



RGB Airmass Images of Hurricane Alex (2016)

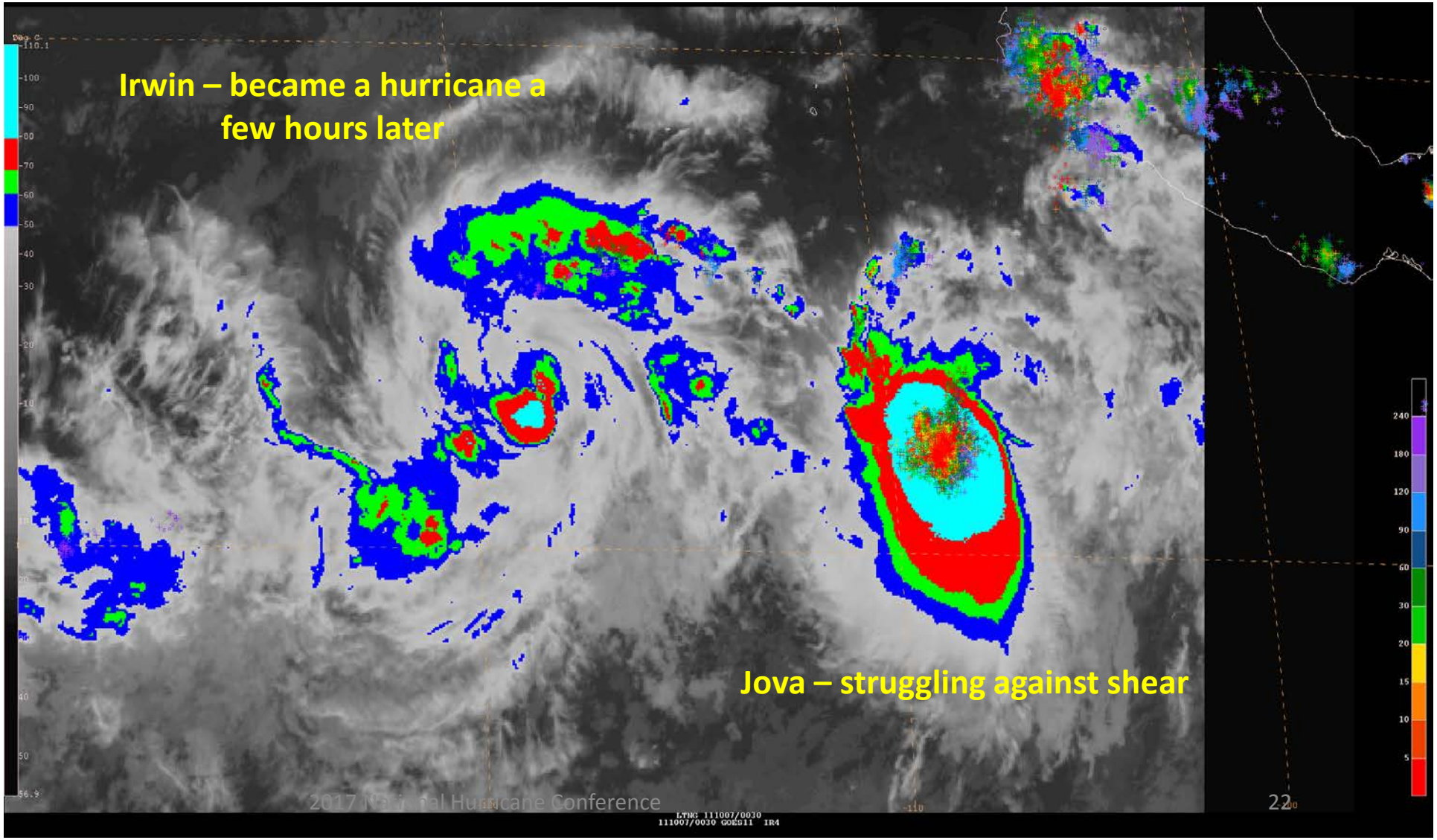
- RGB Airmass Product combines imagery from 4 different channels (2 WV, 2 IR) to highlight different cloud heights and airmass differences, including tropopause folds

- Useful to monitor extratropical and tropical transition events



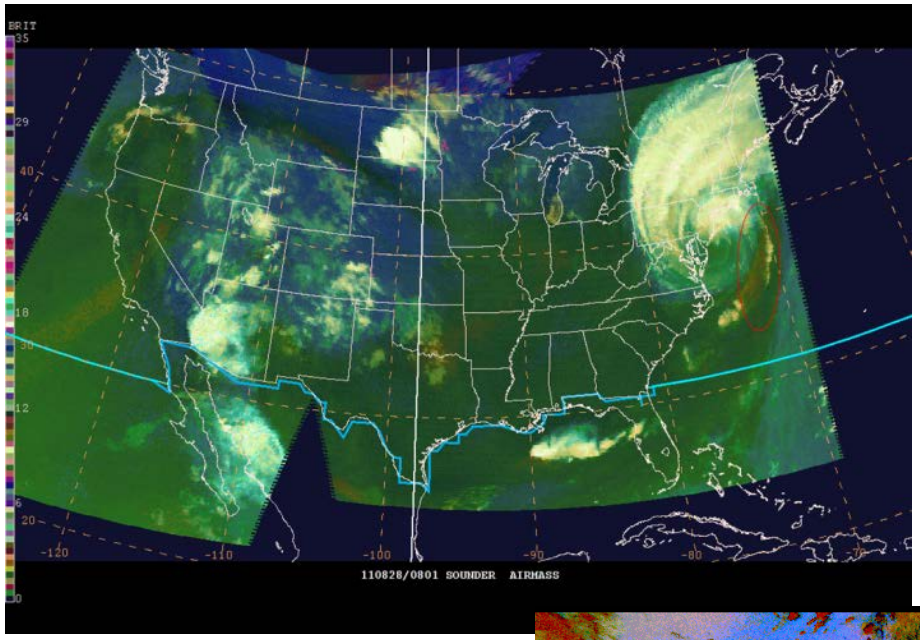
Lightning in Tropical Cyclones

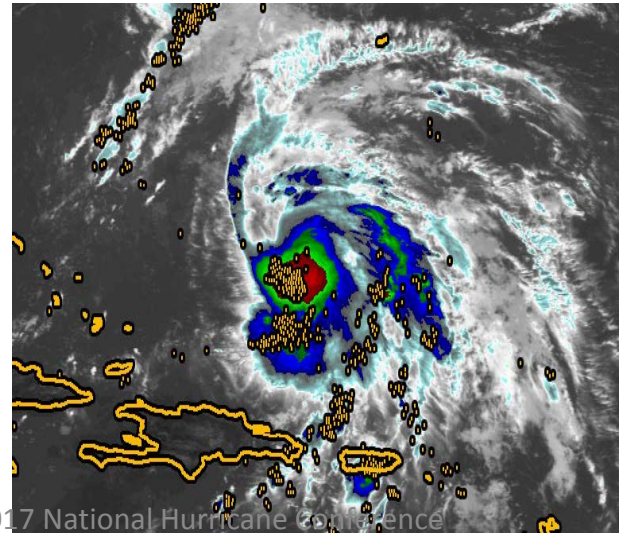
- GOES-16 lightning mapper will allow investigation of the relationship between lightning trends and TC intensity change
- Current research is mixed on the role that lightning plays in identifying intensity trends

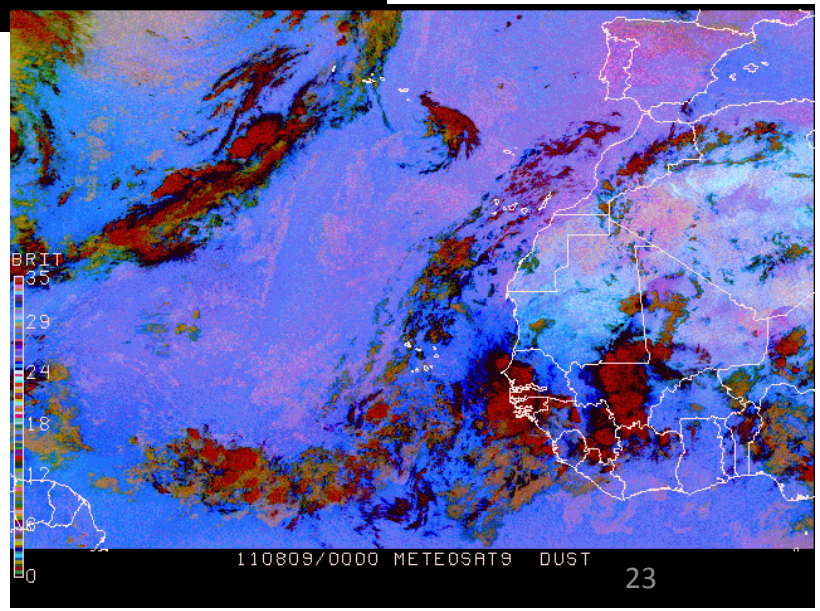


GOES-R Proving Ground

- NHC has several years of experience using proxy GOES-R products from METEOSAT and other sources
- Allowed forecasters to become familiar with GOES-R capabilities and new products, such as RGBs, and to provide feedback to product developers







Summary

- NHC forecasters will have access to GOES-16 imagery during the 2017 hurricane season
- Initially, GOES-16 will be located at 105°W, providing imagery over the western part of the Atlantic basin and the eastern part of the eastern Pacific basin
  - Will be moved to GOES East or GOES West position by November
- NHC and other users will provide feedback to satellite product developers and document utility of new capabilities