Satellite Remote Sensing at NHC

Webinar
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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
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/watching placement and timing and storm surge
Tropical Cyclone Observational Platforms since 1900

- Ship logs and land observations
- Transmitted ship observations
- Radiosonde network (weather balloons)
- Military Aircraft Reconnaissance
- Coastal Radar Network (Conventional) (Doppler)
- Research Aircraft Reconnaissance
- Polar-Orbiting Satellites (Conventional) (Microwave)
- Geostationary Satellites
- Aircraft launched Dropsondes (Omega) (GPS)
- Ocean Data Buoys
- Satellite Scatterometer Data
- Aircraft Stepped Frequency Microwave Radiometer

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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
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.
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

- **1975**: GOES 1-3
  - NOAA’s First GOES
  - Spin-stabilized
- **1980**: GOES 8-12
  - 3-axis stabilized
  - Simultaneous imaging, sounding 100% of time
- **1994**: GOES 4-7
  - Vertical Profiling
- **2006**: GOES 13, 14, 15
  - Simultaneous, independent imaging, sounding
- **2016**: GOES-R Series
  - Improved spectral, spatial and temporal resolution in imaging
  - Lightning mapping
  - Improved space weather monitoring
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
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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 \( \mu \text{m} \))
  - Resolution: 1 km
- Band 4: Cirrus (1.37 \( \mu \text{m} \))
  - Resolution: 2 km
- Band 5: Snow/Ice (1.6 \( \mu \text{m} \))
  - Resolution: 1 km
- Band 6: Cloud Particle Size (2.2 \( \mu \text{m} \))
  - 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 \( \mu m \))*(
  - Legacy GOES - 4-km resolution
- Band 14: IR Longwave Window (11.2 \( \mu m \))*(
  - Legacy GOES - 4-km resolution
- Band 15: Dirty Longwave Window (12.3 \( \mu m \))
- Band 16: CO\(_2\) Longwave Window (13.3 \( \mu m \))
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.

Himawari 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.

Irwin – became a hurricane a few hours later.

Jova – struggling against shear.
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