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Agenda Item: E.1

USA Support for the WMO Tropical Cyclone Program

This paper provides a summary of the USA support for the WMO Tropical Cyclone Program.

USA Support for the WMO Tropical Cyclone Program

1. Introduction.

Due to the lack of in-situ observations over the tropical and sub-tropical oceans, tropical cyclone (TC) analysis and forecasting relies heavily on satellite observations. These data are used directly for TC analysis (position and intensity estimation, wind field diagnosis, etc), as input to numerical tropical cyclone forecast models and to support the WMO Tropical Cyclone Program. NOAA uses a combination of geostationary and polar-orbiting satellites to monitor tropical cyclones. NOAA's two operational geostationary satellites are primarily restricted to the western hemisphere. NOAA's polar orbiting satellites can be used for global tropical cyclone analysis. Tropical cyclone applications of NOAA's current and planned spacecrafts are briefly described.

2.0 Geostationary Operational Environmental Satellite (GOES).

Using modern 3-axis stabilization for orbit control, *GOES-12* at 75□W and GOES-10 at 135□W support the operational two-GOES constellation. Independent imager and sounder instruments eliminate the need to time share, yielding an increase in spatial coverage of image and sounder data at more frequent scanning intervals. The GOES also provides higher resolution and additional spectral channels than its predecessor, affording the hydrometeorological community improvements in detection, monitoring, and analysis of developing tropical cyclones. From 135□W and 75□W, routine GOES satellite data coverage is extensive, stretching from the central Pacific through the Americas to the eastern Atlantic, including the vital breeding grounds for tropical cyclones.

Routinely, each GOES schedule provides two views of the continental US (CONUS) (GOES-10 view is termed PACUS) every 30 minutes. More frequent interval scans can be employed to support NOAA's warning programs, including the tracking of tropical and subtropical cyclones. Government agencies and the private sector have access to digital data transmissions directly from NOAAPORT *or directly from GOES*.

The current series of GOES satellites provide satellite data generated from full resolution, and imager and sounder data. Imagery at 1, 4, and 8 km resolution is available for daytime and nighttime applications. The increased resolution of the satellite imagery is a vast improvement from previous satellites. Visible data are available at 1 km, "near infrared" (channel 2 data) as well as the infrared channels 4 and 5 are available at 4 km resolution, and water vapor (channel 3) is available at 8 km resolution *on GOES-10 and 4 km resolution on GOES-12*. Channel 2 data are valuable for the detection of low clouds, fog, stratus, and surface hot spots; channel 5 data, *available on GOES-10*, in combination with data from channels 2 and/or 4 are useful for detecting volcanic ash in the atmosphere. *On GOES-12, channel 5 is replaced by a new 13.3*

micron channel 6 that detects the presence of CO_2. Channel 6 improves the measurement of the height of clouds and volcanic ash, thus improving computer model forecasts and ash warnings to the aviation community. The digital data may be enhanced to emphasize different features as desired. A suite of digital data and products is available to users in the National Weather Service (NWS), the National Environmental Satellite, Data, and Information Service (NESDIS), other Federal agencies, the academic community, and many private agencies, both national and international. These data are made available through NOAAPORT, RAMSDIS, the Internet, and other means such as local networks.

2.1 GOES-12

GOES-12, *launched July 23, 2001,* supports the GOES-East station at 75□W and serves NOAA operations, to include the TPC/NHC, other Federal agencies, and the private sector. Various imager channels at higher resolutions are being utilized to monitor the intensification and movement of tropical cyclones over the Atlantic Ocean and a portion of the East Pacific. In particular, greater detail in the imagery facilitates tropical cyclone monitoring and analysis, and the use of the 3.9 micron channel to the GOES imager has vastly improved the detection of low-level circulation centers at night to assist in storm positioning. Retrievals from the GOES sounder are now being incorporated into NCEP's numerical models to improve model output. In addition, sounder data are being exploited to generate derived product imagery such as total precipitable water, atmospheric stability indices, and surface and cloud temperatures.

During the 1996 hurricane season, NESDIS instituted a specialized *GOES-East* sounder schedule consisting of four sectors covering distinct areas of the Atlantic Ocean. Of the four sounder sectors, the CONUS sector is scanned every hour and covers the northern Gulf of Mexico and the east coast of the United States. During routine scanning operations, of the other 3 sounder sectors (the Gulf of Mexico, North Atlantic, and the East Caribbean) the Gulf of Mexico sector is designated as the “primary OCONUS” (off CONUS) sector and is scanned 4 times in a 6 hour period, while the other two sectors are only scanned once in every 6 hour period. Event driven, this “primary OCONUS” sounder sector can be changed by the TPC/NHC. The "primary" OCONUS sector provides frequent scans over the area of interest to generate experimental sounder winds (identifies steering currents) and provide moisture and temperature retrievals. Sounder winds are made available to TPC/NHC as a forecasting tool by the Cooperative Institute for Mesoscale Meteorological Studies (CIMSS), University of Wisconsin.

2.2 GOES-10

GOES-10, a clone of GOES-8, was launched on April 24, 1997, and supports the GOES-West station at 135□W. The spacecraft carries the same specified imager and sounder instruments as GOES-8 and GOES-9. *Due to failure of GOES-9 described below*, GOES-10 was declared operational in July 1998 and was moved to 135□W. The routine scanning mode of GOES-10 provides coverage of the Northern and Southern Hemisphere eastern Pacific Ocean as well as the western United States. The GOES-West satellite also supports the missions of both the TPC/NHC and the CPHC, and provides coverage of developing tropical cyclones over the East

and Central Pacific. The DOD and other Federal agencies are also supported.

2.3 GOES-9

GOES-9, launched May 23, 1995, was replaced by GOES-10 as the operational satellite located at 135□W due to its imminent failure. *While the satellite has some momentum wheel problems, GOES-9 is capable of performing operations and replaced the Japanese Meteorological Society's (JMA) GMS-5 over the west Pacific in April 2003.*

2.4 GOES-11

GOES-11 was launched on May 3, 2000. GOES-11 is also a clone of GOES-8 and carries the same imager and instrumentation capabilities as GOES-8 and GOES-10. GOES-11 is stored on orbit until required to replace either of the older operational satellites.

2.5 GOES-8

GOES-8 was launched on April 13, 1994 and is stored on orbit as a secondary backup to the operational satellites.

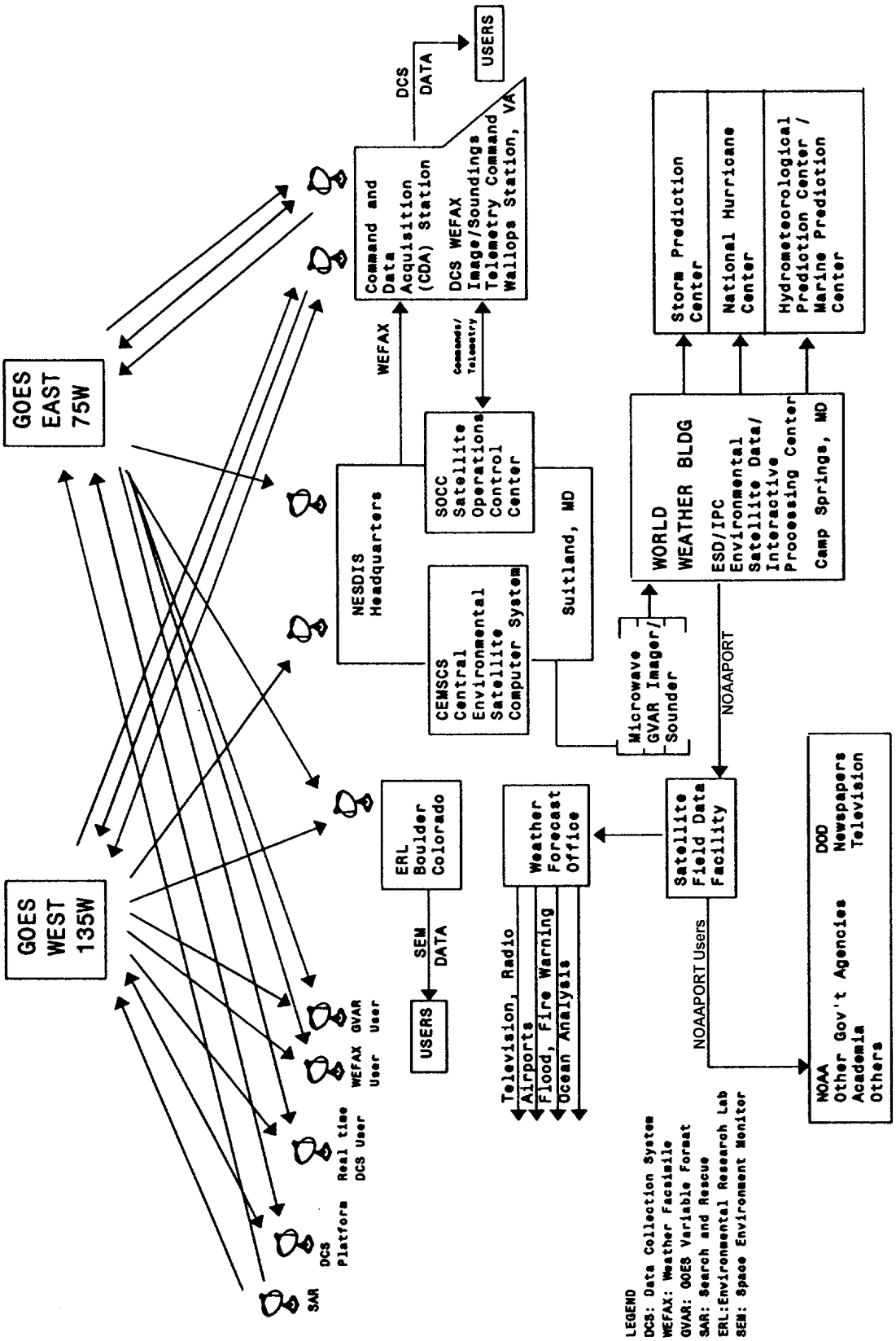
GOES EAST 75W
GOES WEST 135W
Command and Data Acquisition (CDA) Station
DCS WEFAX Image/Soundings Telemetry Command Wallops Station, VA
DCS DATA
USERS
WEFAX
Commands/ Telemetry
NESDIS Headquarters
SOCC Satellite Operations Control Center
CEMSCS Central Environmental Satellite Computer System
Suitland, MD
Microwave GVAR Imager/ Sounder
WORLD WEATHER BLDG
ESD/IPC Environmental Satellite Data/ Interactive Processing Center
Camp Springs, MD
Storm Prediction Center
National Hurricane Center
Hydrometeorological Prediction Center / Marine Prediction Center
NOAAPORT
ERL Boulder Colorado
SEM DATA
USERS
Weather Forecast Office
Television, Radio
Airports
Flood, Fire Warning
Ocean Analysis
Satellite Field Data Facility
NOAAPORT Users
NOAA
Other Gov't Agencies
Academia
Others
DOD
Newspapers
Television
SAR
DCS Platform
Real time DCS User
WEFAX User
GVAR User
LEGEND
DCS: Data Collection System
WEFAX: Weather Facsimile
GVAR: GOES Variable Format
SAR: Search and Rescue
ERL:Environmental Research Lab
SEM: Space Environment Monitor

Figure 1. The GOES satellite system

Satellites and Satellite Data Availability for the Current Hurricane Season. Table 1 lists satellite capabilities for the current hurricane season.

Table 1. Satellite and satellite data availability for the current hurricane season

SATELLITE	TYPE OF DATA	LOCAL TIME	PRODUCTS
GOES-8 *(on-orbit storage)* GOES-9 located at *155□E to replace GMS-5* GOES-11 at 112□W *GOES-12* at 75□W	Multispectral Imager and Sounder 5 Channels for Imager 19 Channels for SOUNDER	Every 30 min, in Routine Scan Mode, provides 3 sectors with prescribed coverages: Northern Hemisphere (NH) or Extended NH; CONUS or PACUS; and Southern Hemisphere. Exception is transmission of full disk every 3 hours. (Available Rapid Scan Operations yield increased transmissions to 7.5 minute intervals to capture rapidly changing, dynamic weather events).	1. 1, 2, 4, and 8 km resolution visible standard sectors. 2. 4 km equivalent resolution IR sectors. 3. Equivalent and full resolution IR enhanced imagery. 4. Full disk IR every 3 hours. 5. 8 km water vapor sectors. 6. Quantitative precipitation estimates; high density cloud and water vapor motion wind vectors; and experimental visible and sounder winds. 7. Operational moisture sounder data (precipitable water) in four levels for inclusion in NCEP numerical models. Other sounder products including gradient winds, vertical temperature and moisture profiles, mid-level winds, and derived product imagery (precipitable water, lifted index, and surface skin temperature). 8. Tropical storm monitoring and derivation of intensity analysis.

3. Future Geostationary Satellites

3.1 Introduction and Overview

NOAA's next-generation Geostationary Operational Environmental Satellite (GOES) beginning with GOES R is the follow-on to the GOES N-P series. GOES R is being developed for launch in the 2012 time frame. Proposed GOES R improvements in environmental sensing instruments include an Advanced Baseline Imager (ABI); a Hyperspectral Environmental Suite (HES), capable of providing soundings and imagery; a Solar Instrument Suite (SIS); a Space Environment In Situ Suite (SEISS); and a GOES Lightning Mapper (GLM). Improved spatial, spectral and temporal resolution and decreased latency will enable GOES R to provide better, near real time monitoring of hazards such as hurricanes, floods, severe storms, volcanic eruptions, and forest fires.

3.2 Goals

The GOES R system goals are to:

- Maintain continuous and reliable operational environmental satellites to protect life and property.

- Monitor and predict changes in the Earth and Space environment; conserve and manage coastal and marine resources to meet our Nation's economic, social, and environmental needs.

- Introduce improved atmospheric and oceanic observations and data dissemination capabilities (increased spatial, temporal and spectral resolution)

- Develop and provide new and improved applications and products for a wide range of federal agencies, state and local governments, and private users

- Move NOAA into the 21st Century scientifically and operationally, while recognizing the link between our global economy and our planets environment.

3.3 Mission Continuity

Replacement satellites are required to sustain US geostationary capabilities and coverage beyond 2012. Expected mean mission duration for the GOES N-P series should support full mission availability through ~2018. GOES R must be launched by 2012 to serve as on orbit replacement by 2018. Currently available instrument capabilities are also inadequate to meet many of the emerging requirements, necessitating the development of new technologies.

3.4 Data Losses

With the current GOES system, data losses occur for several hours each day during the weeks around the spring and fall equinox (eclipse). The reason is the viewing geometry of the current geostationary satellites, which allows sunlight impingement on the optical path of the sensing instruments. This direct sunlight may cause a degradation of the radiometric response accuracy and potential permanent damage to the Earth-viewing detectors. To avoid such damage, data are not sensed nor provided during these periods – termed the "keep out zones." The combined impact on the current GOES I-M and GOES N-P series is a 3 to 4 hour loss of data for 10 to 12 days before and after each eclipse

During these periods, there is significant loss of data for all customers. In addition, the fall eclipse and keep-out zone coincides with the peak of the Atlantic Hurricane season (see figure 2).

Periodic spacecraft maneuvers are required to adjust the drift and orbit of the geostationary satellites and to counteract the gravitational forces from the sun and the moon. The time needed for the current GOES I-M satellites and the GOES N-P series to return to normal operations after such maneuvers may be up to 9 hours. This excessive delay is unacceptable for forecast and modeling operations that require and depend upon timely satellite data input.

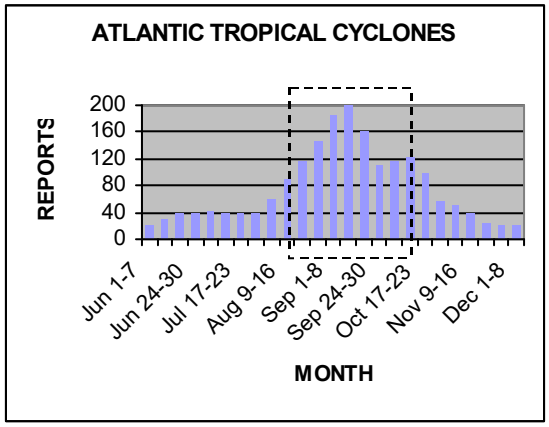

Figure 2. Hurricane season and Fall Eclipse (dashed).

3.5 Data Latency (Timeliness)

Product delivery must be done in near real-time to capture rapidly changing, relatively short-term events, (e.g., severe weather, thunderstorms, and flash floods). The usefulness (forecast value) of the current GOES imagery is greatly diminished if the images are not available for analysis by the forecaster before the start of the next image, i.e. in near real-time. Data latency sometimes

exceeds two hours from the time measured until available for use at national forecasting centers. Reducing data latency will allow more timely and accurate warnings and forecasts.

3.6 GOES R Improvements

The GOES R system is planned to operate for a period of at least 14 years, providing a remote sensing capability to acquire and disseminate regional environmental imagery and specialized meteorological, climatic, terrestrial, oceanographic, solar-geophysical and other data to central processing centers and distributed direct users. GOES R will operate with improved latency, full hemispheric coverage and during periods of eclipse. This section provides a description of the proposed system.

Key Performance Parameters (KPPs)

- GOES-R instruments must operate continuously during eclipse
- GOES-R must improve the temporal resolution of the imager over the full disk from 30 minutes to 15 minutes or fewer
- GOES R must meet "simultaneous" global/synoptic/ mesoscale imaging needs by providing temporally interspersed images that meet the following schedule: 15-minute (or faster) full disk coverage, 5-minute CONUS coverage, and when commanded 30 second mesoscale coverage
- GOES-R must improve spatial resolution of the imager in the infrared from 4 km to 2 km
- GOES-R sounding must improve the sounding coverage rate by factor of 4 compared to the current GOES-I and –N series sounders, accounting appropriately for any spatial resolution differences
- GOES-R sounding must improve the rms temperature error from 2° K to 1° K over the region from 800 mb to 400 mb and rms relative humidity error from 20% to 11 % or smaller.

Federal, state and local agencies, academia, and industry, on a worldwide basis, will be able to access GOES R series real-time rebroadcast data. Broadcast capabilities of the GOES R series are currently under study. The potential use of commercial communications satellites and the use of landlines are also being considered for GOES R real-time rebroadcast.

3.7. Sensor Improvements

3.7.1 Advanced Baseline Imager (ABI)

The Advanced Baseline Imager is a new state of the art, 16-channel imager covering 2 visible bands (0.47 μm & 0.64 μm) and 14 IR bands (0.86 μm to 13.3 μm). Spatial resolution is band dependent, 0.5 km at nadir for visible, 1.0 km for near IR, and 2.0 km for IR. ABI will provide three imaging sectors; Full Disk (FD), CONUS, and Mesoscale. Full Disk includes the full Earth view from space. The CONUS sector covers a 5000 kilometer (km) x 3000 km area, and

Mesoscale covers a 1000 km x 1000 km square at nadir. Figure 3 depicts ABI and HES coverage from GOES R constellations. *ABI coverage is shown as the outer ellipses and HES coverage is shown as circles.*

ABI has two imaging modes; Mode 3 and Mode 4. Mode 3 imaging can provide 1 Full Disk Image, 3 CONUS and 30 Mesoscale images, every 15 minutes. Mode 4 can provide 30 Mesoscale images every 15 minutes as well as a Full Disk every 5 minutes.

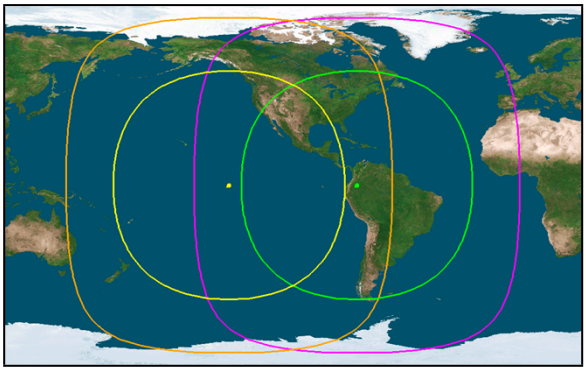

Figure 3. GOES R ABI and HES coverage

Figure 4 compares current GOES Full Disk coverage against GOES R Mode 4. Current GOES (I-P) provides a Full Disk every 30 minutes. GOES R will provide six times the temporal coverage of current GOES.

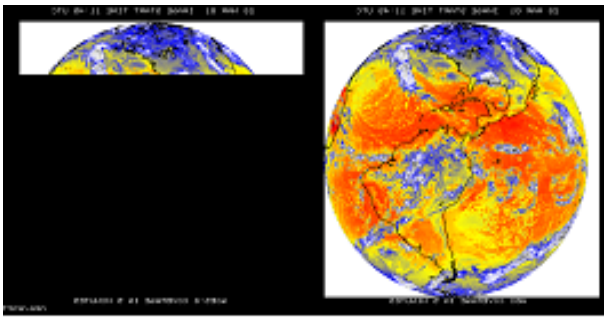

Figure 4. Five-Minute Coverage from GOES vs. GOES R

3.7.2 Hyperspectral Environmental Suite (HES)

The HES is a hyperspectral sounder and multi channel imager suite with three threshold tasks. HES will provide high-resolution Hemispheric Disk Soundings (DS) and Severe Weather Mesoscale (SW/M) soundings and Coastal Waters (CW) imaging.
The current GOES sounder cannot see the United States and ocean areas for hurricanes and winter storms simultaneously. The sounder on the GOES-R Hyperspectral Environmental Suite will sense the GOES full disk, enabling views of multiple events at the same time (see Fig. 5.).

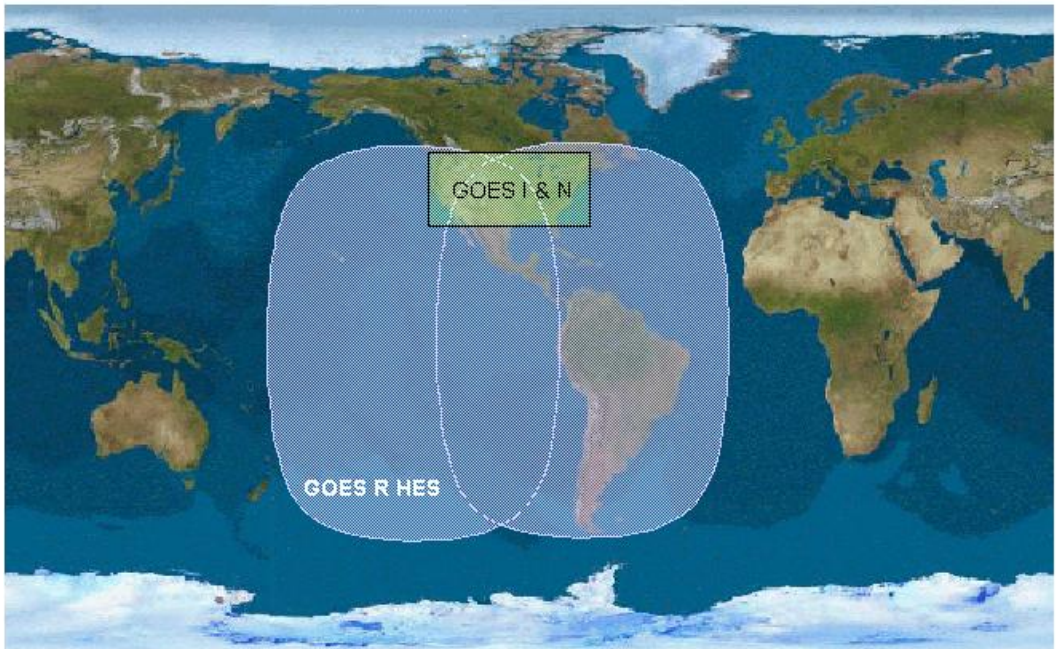

Figure 5. GOES Sounder Coverage. GOES-R HES compared to sounder on GOES I-M and N Series.

HES DS provides 10 km IR resolution from 3.7 μm to 15.4 μm with a one-hour refresh rate covering almost the full Earth disk with a 62° local zenith angle. SW/M will cover a 1000 x 1000 km square at a 4 km resolution for IR and 1 km for visible, from a single broadband channel for cloud detection. DS and SW/M may utilize the same IR and Visible focal planes. The total number of channels is still TBD.

HES CW task will provide at least 14 channels coverage from 0.4 μm to 1.0 μm, with a 300 m visible resolution and a 3-hour refresh rate. CW has a goal resolution of 2 km for IR imagery. Coastal Waters are defined as the 400 km zone adjacent to CONUS and waters surrounding Hawaii.

3.7.3 GOES Lightning Mapper (GLM)

The GLM on GOES R will continuously map the intensity, frequency and location of lightning discharges over both hemispheres and CONUS. A GLM with high spatial resolution and detection efficiency will be an invaluable tool in tropical cyclone prediction. GLM can detect storm formulation and determine maturity/severity over both land and oceans. Threshold hemisphere horizontal resolution shall be 10 km (with a objective of 1 km). The mapper will image 500 frames per second and capable of detecting in excess of 50 lightning strikes per second. The GLM should detect lightning strikes lasting longer than 1 microsecond (ms). The mapping accuracy should be 1 km (goal: 100 meter). The measurements would be disseminated

in real time (within 1 minute) and could thus be related on a continuous basis to other observable data, such as radar returns, cloud images, and other meteorological variables.

3.8 Tropical Cyclone and Other Hazards Monitoring

The increased resolutions of GOES R (spatial, spectral and temporal) and continuous near-real time imaging will benefit monitoring of tropical cyclones and other hazards. Improved data latency and faster refresh rates will also provide increased storm detection and warnings. GOES R will provide cloud and moisture imagery every 5 minutes with 5 minute refresh rates. Mesoscale refresh rates and data latency will both be 30 seconds. These rates represent six-fold increase in temporal resolution. Figure 9 illustrates the improvements in hurricane detection expected with GOES R.

HES will improve water vapor depiction by identifying small-scale features vertically and horizontally. HES will likewise characterize the complete life cycle of clouds, as well as distinguish between ice and water clouds.

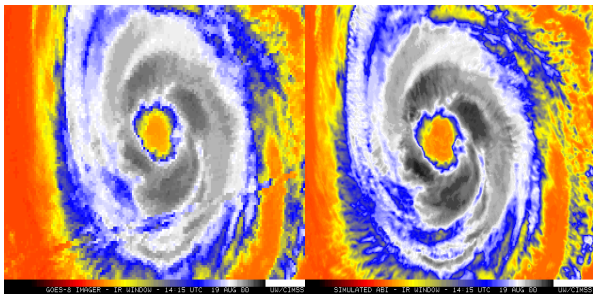

Figure 6. Hurricane Coverage From GOES vs. GOES R

The combination of GOES R ABI and HES will benefit hazards management on various levels.

Table 2 summarizes the observational requirements satisfied with GOES ABI and HES.

Table 2. GOES R Observational Requirements

ABI	HES
Hurricane Intensity	Atmo Vertical Moisture
Flood/Standing Water	Atmo Vertical Temperature
Oil Spill Monitoring	Total Precipitable Water
Fire/Hot Spot Imagery	Mositure Flux
All Weather Day Night Imagery	Aircraft Icing Threat
Cloud/Moisture Imagery	SO_2 Concentration
Aerosol Detection	CO & CO_2 Concentrations
Aerosol Loading	Ozone Layers
Suspended Matter	Microburst Winds
Volcanic Ash	Radiances
Cloud Top Height	Cloud Top Height
Derived Motion Winds	Cloud Base Height
Ocean Currents	Sea and Lake Ice Conditions
Sea Surface Temperatures	Ocean Color
Sea and Lake Ice Conditions	Ocean Optical Properties
Snow Cover/Snow Depth	Ocean Turbidity
Absorbed Shortwave Radiation	Surface Emissivity

GOES Product Improvements

- Severe storm and flood warnings
- Tropical cyclone (hurricane reconnaissance and warnings)
- Hydrologic forecasts and water resources management
- Short-term and mesoscale forecast
- Ocean surface and internal structures forecasts
- Medium range forecast outlook (out to fifteen days)
- Solar and space environmental forecasts
- Aviation forecasts (domestic, military, and international)
- Ice conditions forecasts
- Seasonal and inter-annual climate forecasts
- Decadal-scale monitoring of climate variability
- Environmental air quality monitoring and emergency response
- Fire and volcanic eruption detection and analysis
- Long-term global environmental change assessment
- Nowcasting capabilities

3.9 Summary

The GOES R system will transition from and begin replacing the GOES N series in approximately 2012. Based on new architecture concepts and system designs, the GOES R series will continue to meet and exceed GOES mission goals.

Sensor improvements will enable more timely land, atmospheric and ocean forecasts, including vast improvements in hurricane track and intensity predictions. GOES R will operate during eclipses, and provide simultaneous mesoscale and full hemispheric coverage. The increase in GOES R latency will improve forecasts and climate/hydrology monitoring. The inclusion of a GLM will provide continuous lightning detection over land and water. Storm severity, maturity and advanced warning will be improved by the ability to track lightning intensity, frequency and location from space. For additional information, please visit NOAA's GOES R webpage at http://www.osd.noaa.gov/goes_R/index.htm.

4.1 National Oceanic and Atmospheric Administration (NOAA) Polar-Orbiting Satellites.

Two primary operational NOAA polar orbiting satellites, *NOAA-16 and NOAA-17*, provide image coverage four times a day over a respective area in *6* spectral channels *(however only 5 channels can be supported at one time; channel switching is used to support the 6th channel)*. These satellites cross the U.S. twice per day at 12-hour intervals for each geographical area near the Equatorial crossing times listed in Table 2. *NOAA-16 and NOAA-17* provide the same capabilities as previous NOAA satellites, except for the addition of an Advanced Microwave Sounder Unit (AMSU). Data are available via direct readout--high resolution picture transmission (HRPT) or automatic picture transmission (APT)--or central processing. The POES instruments useful for tropical cyclone analysis and forecasting as follows.

Advanced Very High Resolution Radiometer:

Channel 1, 0.58-0.68 μm: Daytime position and Dvorak intensity estimation
Channel 3B, 3.55-3.93 μm: Nighttime position estimation
Channel 4: Position and Dvorak intensity estimation, sea surface temperature analysis, precipitation estimation

Advanced Microwave Sounding Unit (AMSU):

AMSU is useful for tropical cyclone warm core identification, temperature (AMSU-A) and moisture (AMSU-B) soundings in storm environment, identification of convective organization below IR cloud top (AMSU-A), and precipitation estimation.

High resolution Infrared Radiation Sounder (HIRS):

HIRS provides temperature and moisture soundings in the storm environment, and is often used in combination with AMSU.

WINDSAT:

As part of the development effort for the next generation NOAA polar-orbiting satellites described in the next section, NOAA is participating in a project to develop advanced methods

for estimating ocean surface wind speed and direction. The Coriolis/WINDSAT satellite was successfully launched in January of 2003. This platform can provide useful information about the tropical cyclone surface wind circulation, particularly with regard to size of the storm.

The Command and Data Acquisition (CDA) stations at Fairbanks, AK, and Wallops, VA, acquire recorded global area coverage data, and then route the data to NESDIS computer facilities in Suitland, MD, where the data are processed and distributed to the NOAA, the DOD, and private communities. Ground equipment installed at various NWS regions including Kansas City and Miami (TPC), enable direct readout and data processing of AVHRR data from *NOAA-16 and NOAA-17.* The high resolution polar data and products generated at TPC complement other satellite data sources to support tropical mission objectives.

4.2 NOAA-15

NOAA-15 is *used as a backup satellite; however, it continues to provide imagery and products*. *Once NOAA-17 became operational, some users had continued requirements for some specific NOAA-15 data. NOAA-15 has an AMSU and an AVHRR shortwave channel at 1.6 microns, which NOAA-17 does not. Some sounder-based derived products include rain rate and total precipitable water.*

4.3 NOAA-16

NOAA-16 is in full operational use with the same capabilities as NOAA-15.

4.4 NOAA-1

NOAA-17, launched June 24, 2002, is in full operational use with the same capabilities, except as described above, as NOAA-15 and NOAA-16.

Table 2. Satellite and satellite data availability for the current hurricane season (continued)

SATELLITE	TYPE OF DATA	LOCAL TIME	PRODUCTS
NOAA-17 NOAA-16 NOAA-15	AVHRR; GAC and LAC (recorded); HRPT (direct); AMSU; HIRS	*1010D*[1]*/2210A*[2] 0159D/1359A 0655D/1855A	1. 1 km resolution HRPT and Local Area Coverage (LAC) data. 2. 4 km resolution APT and Global Area Coverage (GAC) data. 3. Mapped imagery. 4. Unmapped imagery (all data types) at DMSP sites. 5. Sea-surface temperature analysis. 6. Soundings. 7. Moisture profiles. 8. Remapped GAC sectors. 9. Sounding-derived products--total precipitable water, rain rate, and surface winds under sounding 10. Daily northern hemisphere snow cover analysis. 11. Twice daily fire and smoke analysis over specific areas within CONUS.

[1] D - descending

[2] A – ascending

Table 3. Satellite and satellite data availability for the current hurricane season (continued)

SATELLITE	TYPE OF DATA	LOCAL TIME	PRODUCTS
DMSP F-12	OLS Imagery (direct only), SSM/I (non-functional), SSM/T-1 (non-functional), SSM/T-2 (direct only)	*0635D/1835A*	1. 0.3 nm (regional) and 1.5 nm (global) resolution (visual and infrared) imagery available via stored data recovery through AFWA. 2. Regional coverage at 0.3 nm and 1.5 nm resolution (visual and infrared) imagery available from numerous DOD tactical terminals. 3. SSM/T-1, SSM/T-2, SSM/I data transmitted to NESDIS and FNMOC from AFWA
DMSP F-13	OLS Imagery (recorded and direct), SSM/I, SSM/T-1	*0620D/1820A*	
DMSP F-14 DMSP F-15	OLS Imagery (recorded and direct), SSM/I, SSM/T-1 (inop), SSM/T-2	*0805D/2005A*	
	OLS Imagery (recorded and direct), SSM/I, SSM/T-1, SSM/T-2	*0930D/2130A* *Note: Times are accurate to +/- 5 minutes*	

5.0 NOAA's Future Polar-Orbiting Satellites

Over the next decade, the NOAA/NESDIS POES program is being merged with the U.S. Department of Defense polar satellite program to produce the National Polar-orbiting Operational Environmental Satellite System (NPOESS). The first launch is planned for early in the next decade. To prepare for these new capabilities, a subset of the planned instruments will be available in the 2005-2006 time frame in the NPOESS Preparatory Project (NPP). Several instruments will be available for tropical cyclone analysis and forecasting from NPP and NPOESS, as described below.

NPP

Visible/Infrared Imager Radiometer Suite (VIIRS):

VIIRS can be used for tropical cyclone position and intensity estimation, and high spatial resolution sea surface temperature analysis. VIIRS will provide observations at higher spatial resolution that the POES/AVHRR.

Advanced Technology Microwave Sounder (ATMS):

ATMS can be used for tropical cyclone warm core identification, temperature and moisture soundings in storm environment, identification of convective organization below IR cloud top, and precipitation estimation. The ATMS will provide some advancement relative to the current AMSU instrument.

Cross-track Infrared Sounder (CrIS):

CrIS will provide temperature and moisture soundings in the storm environment, and will likely be used in combination with ATMS.

NPOESS

In addition to the NPP instruments described above, NPOESS will likely include instrumentation to measure ocean surface winds, similar to that described above for WINDSAT, and a satellite altimeter that can measure ocean heights. The ocean height measurements will be useful for estimation of oceanic heat content, which has been shown to be important for prediction tropical cyclone intensification.

6.0 Data Access

The current POES data and future NOAA polar satellite data will be available by two primary mechanisms. Direct readout systems can obtain the data directly from the satellites over specific regions. Data can also be obtained via land lines from regional ingest locations such at the NESDIS Office of Satellite Data Processing and Distribution (OSDPD).