NOAA Satellite Plans

2016 Tropical Cyclone Operations and Research Forum

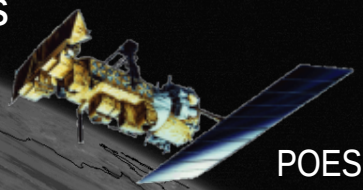
John Pereira, Deputy Director
Office of Projects, Planning, and Analysis (OPPA)
National Environmental Satellite, Data, and Information Service (NESDIS)

March 16, 2016

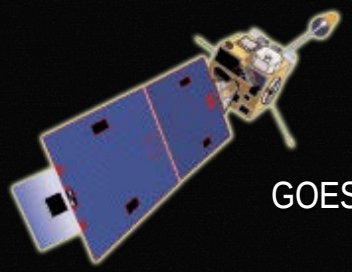
NESDIS Principal Activities

Currently Providing 24/7 On-Orbit Satellite Operations

- Geostationary satellites (GOES)
- Polar-orbiting satellites (POES)
- Defense Meteorological Satellite Program (DMSP)
- Jason Altimetry Satellite
- Suomi National Polar-orbiting Partnership (S-NPP)
- DSCOVR



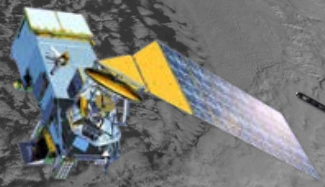
POES



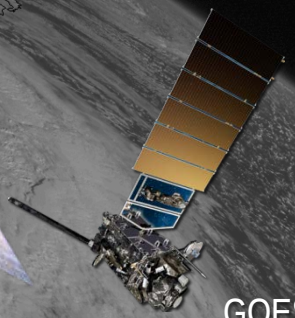
GOES

Acquiring Next Generation Satellites

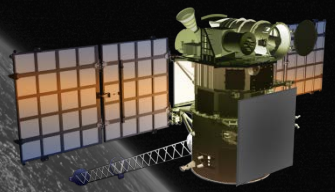
- COSMIC-2 Radio Occultation
- GOES–R Satellite Series
- Joint Polar Satellite System



JPSS



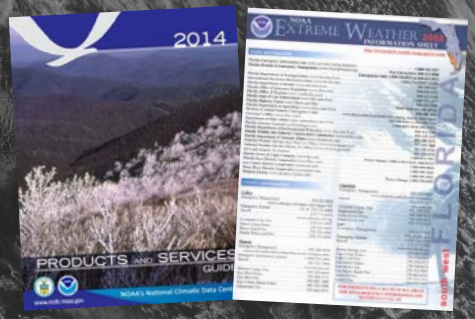
GOES-R



DSCOVR

Providing Long Term Data Stewardship

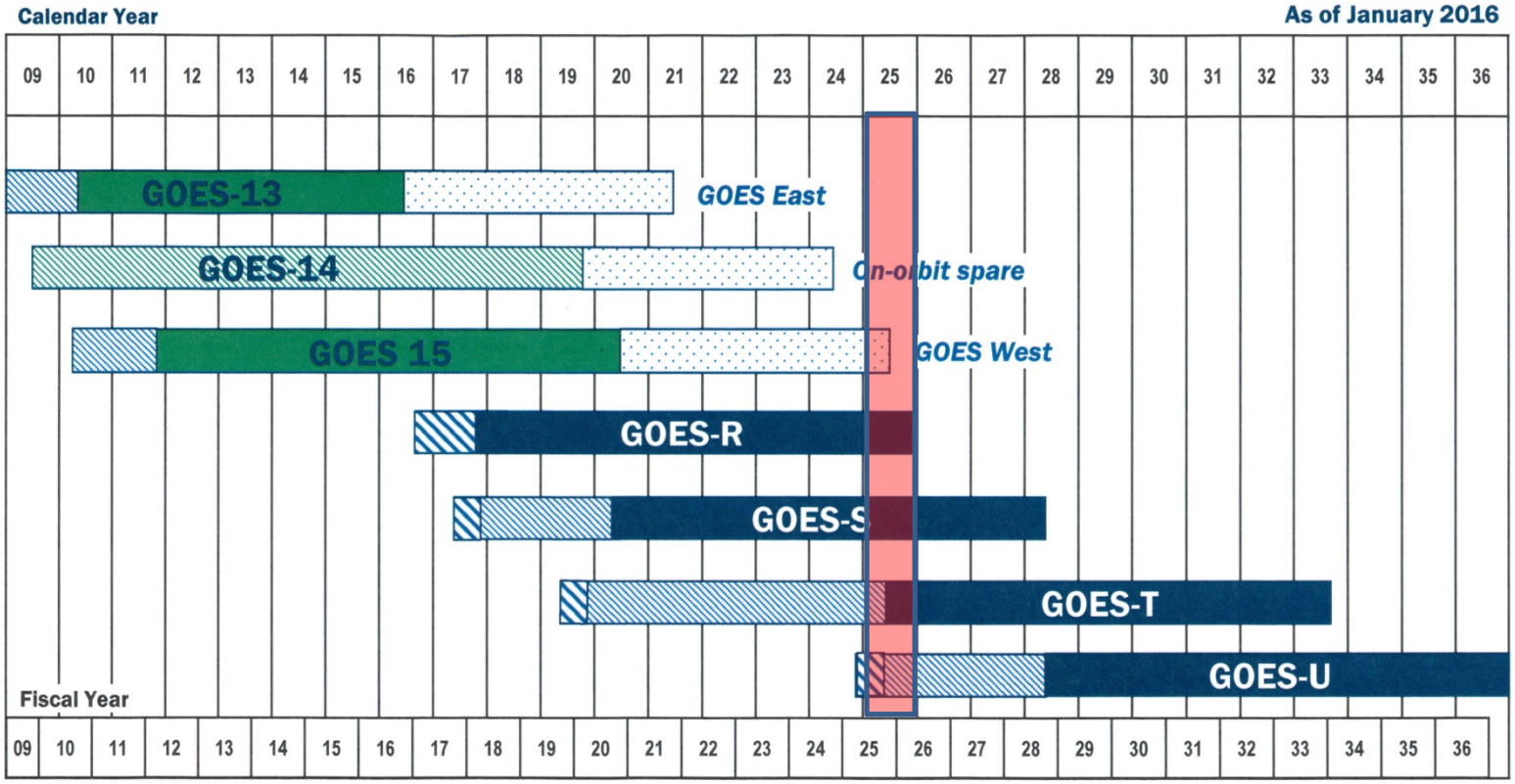
Conducting Research and Developing Products



NCEI/STAR

NOAA/JMA

NOAA Geostationary Satellite Programs
Continuity of Weather Observations



Approved: _____
Assistant Administrator for Satellite and Information Services

- In orbit, operational
- In orbit, storage
- Fuel-Limited Lifetime Estimate
- Planned On-orbit Storage
- Test & Checkout
- Planned Mission Life

GOES-R Instruments

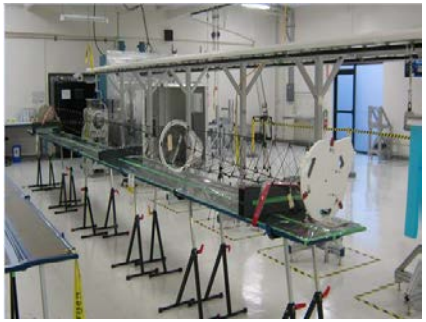
Earth Pointing

Advanced Baseline Imager (ABI)

Geostationary Lightning Mapper (GLM)

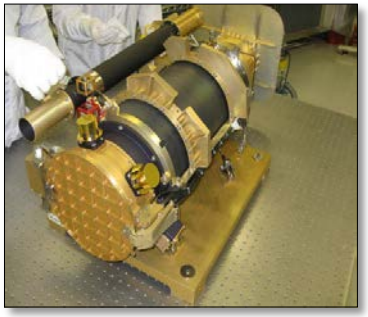
In-Situ

Space Environment in-Situ Sensor Suite (SEISS)

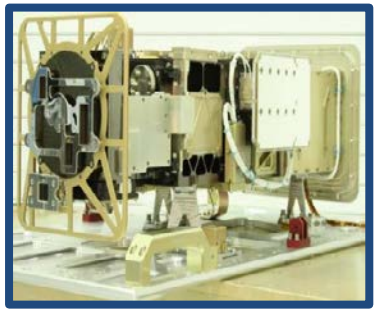


Magnetometer

Sun Pointing



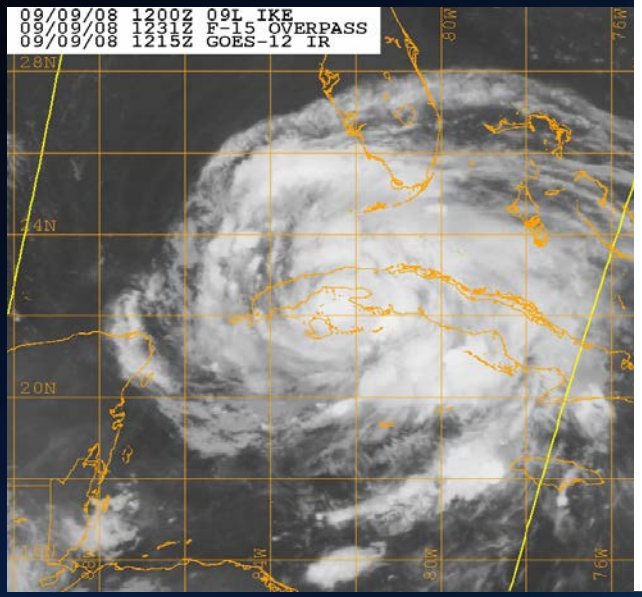
Solar UV Imager (SUVI)

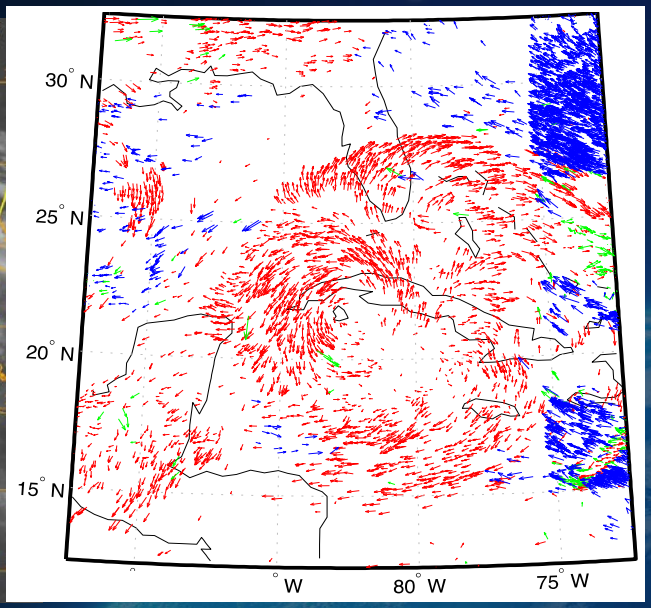


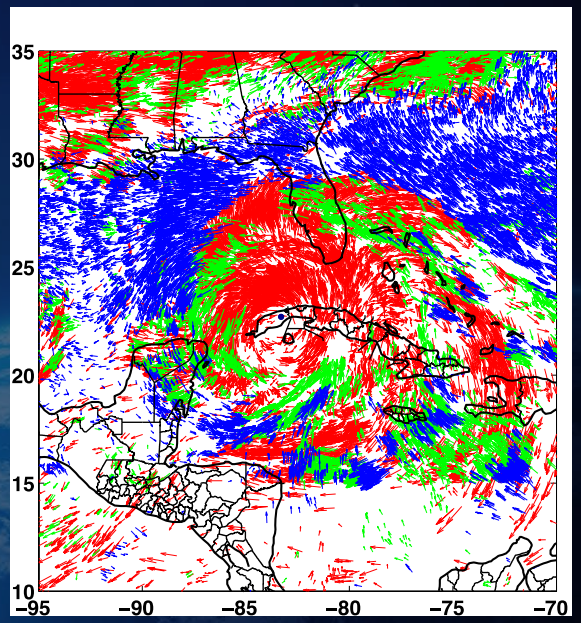
Extreme UV and X-ray Irradiance Sensors (EXIS)

Assimilating High-resolution Satellite-Derived Winds Improves Mesoscale Analyses and Forecasts of Tropical Cyclones

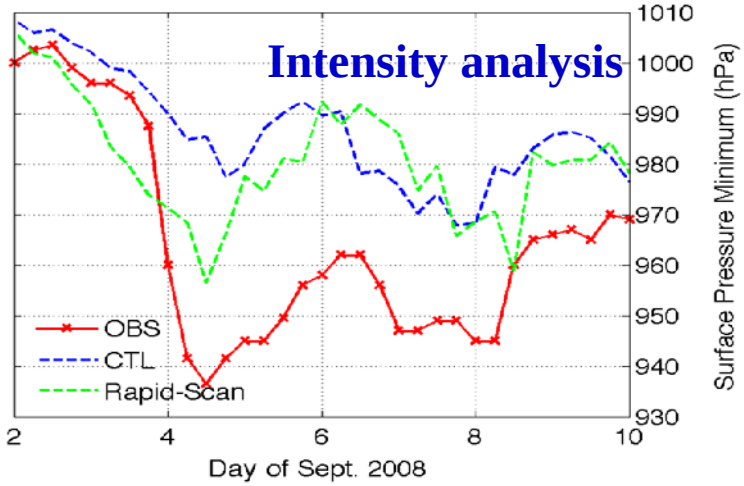
-- Example: Hurricane Ike (2008) --







P ≤ 350 hPa 350 < P ≤ 800 hPa P > 800 hPa

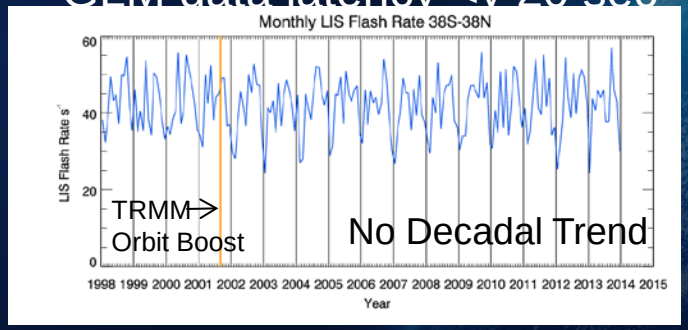


Above: As a proxy for GOES-R 5-minute imagery, GOES-East rapid-scan imagery (7-min) is used to derive winds. The coverage vs. normally-available winds is substantially increased over Hurricane Ike.

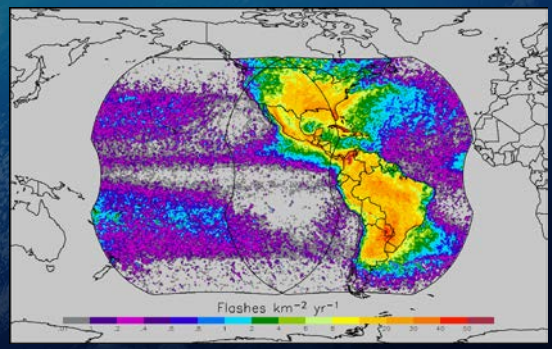
Left: Assimilation of the rapid-scan winds into the mesoscale DART/WRF system produces superior analyses of Hurricane Ike's intensity (OBS) over a Control (CTL) without the winds. *C. Velden, CIMSS*

GLM Mission Benefits

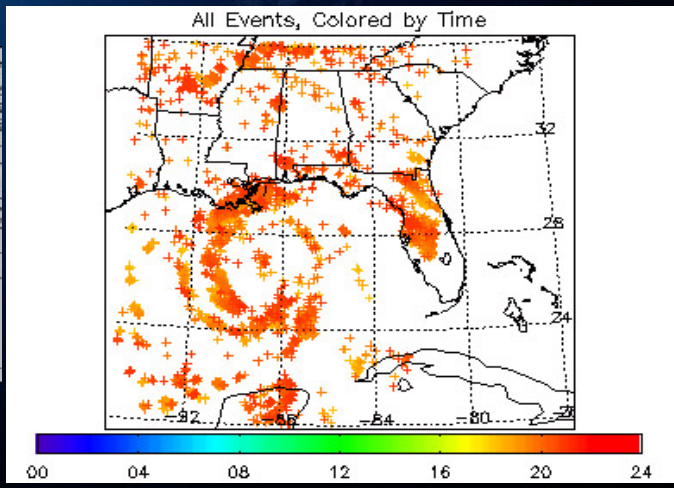
- Detects total lightning (in-cloud and cloud-to-ground)
- Improved forecaster situational awareness and confidence resulting in more accurate nowcasting and severe storm warning decision-making to save lives and property
- Diagnosing convective storm structure and evolution
- Aviation and marine convective weather hazards
- Tropical cyclone intensity change
- Decadal changes of extreme weather – thunderstorms/ lightning intensity and distribution
- GLM data latency <y 20 sec



Global flash rate from LIS/OTD (1995-2014)



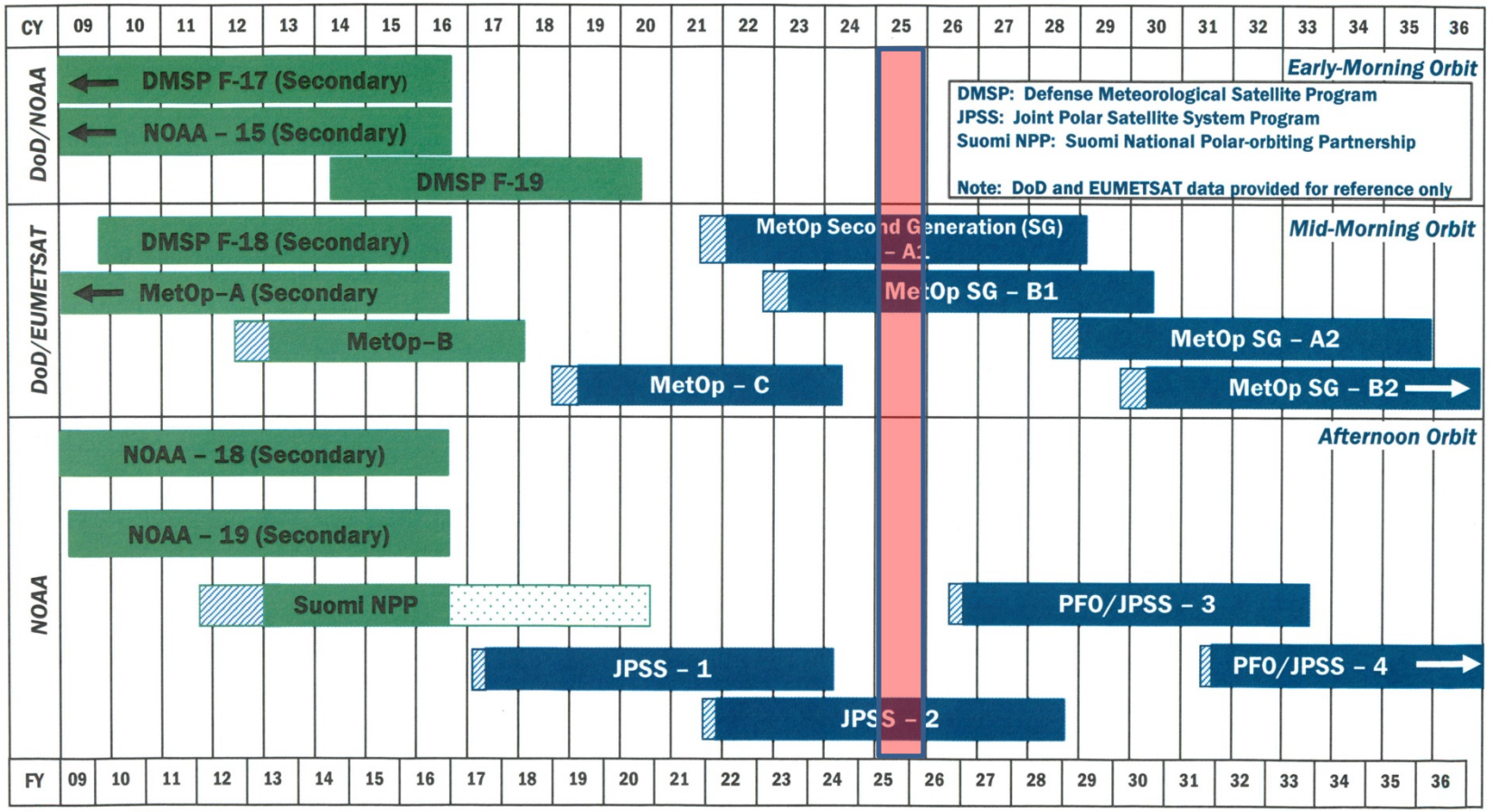
Lightning Climatology



Katrina Lightning

NOAA & Partner Polar Satellite Programs
Continuity of Weather Observations

As of January 2016



Approved: Stephen Volz

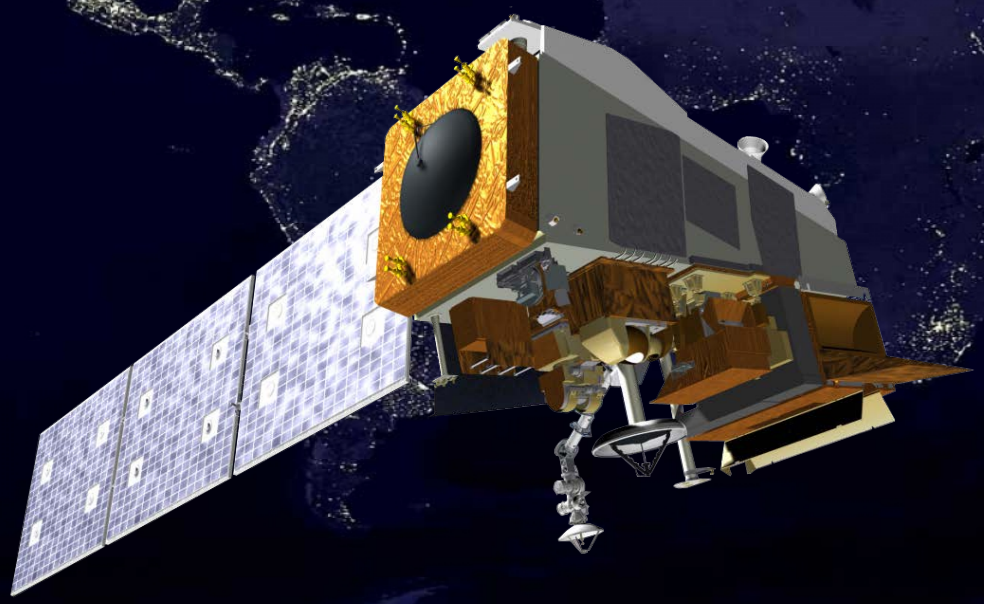
Assistant Administrator for Satellite and Information Services

Note: Extended operations are reflected through the current FY, based on current operating health.

In orbit	Post Launch Test
Fuel-Limited Lifetime Estimate	Planned Mission Life, from Launch Readiness Date
Launched before Oct 2008	Operational beyond Dec 2036

Joint Polar Satellite System (JPSS)

Polar Environment and Space Observations
NOAA Weather and Climate Observations



JPSS Instruments
ATMS - Advanced Technology Microwave Sounder
CrIS - Cross-track Infrared Sounder
VIIRS – Visible Infrared Imaging Radiometer Suite
OMPS - Ozone Mapping and Profiler Suite
CERES - Clouds and the Earth's Radiant Energy System

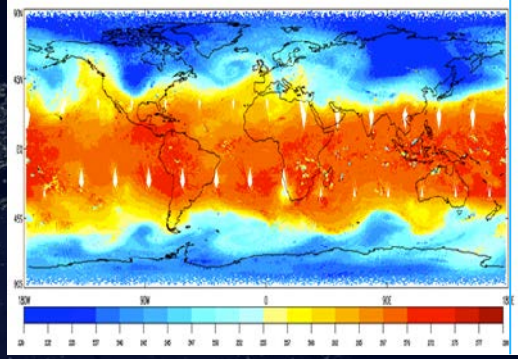
www.jpss.noaa.gov

JPSS Applications Advancements

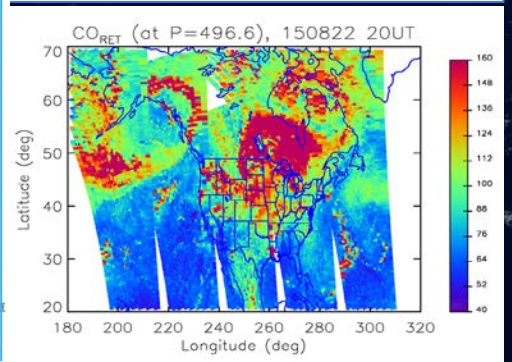
Sounding Products

- Demonstrations with operational forecasters
- Support storm watches and warnings
- CO product for tracking smoke emissions from forest fires

NUCAPS Temperature retrieval @ 500mb
(January 5th 2014 Polar Vortex Anomaly)

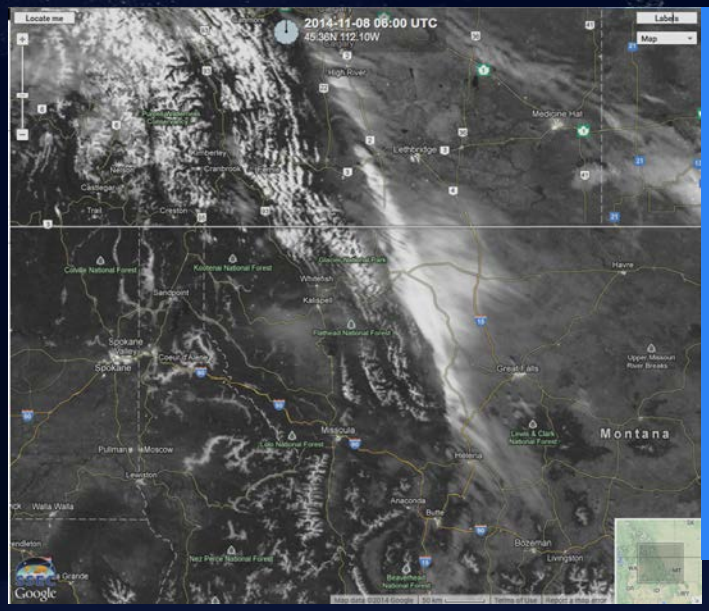


Carbon Monoxide @500mb
August 22, 2015



Day Night Band

- Sea Ice
- Storm tracking at night
- Ground Fog
- Active fires and smoke
- Socio / Economic / Impact assessment



Area Forecast Discussion
National Weather Service
Missoula MT
334 AM MST SAT NOV 8 2014

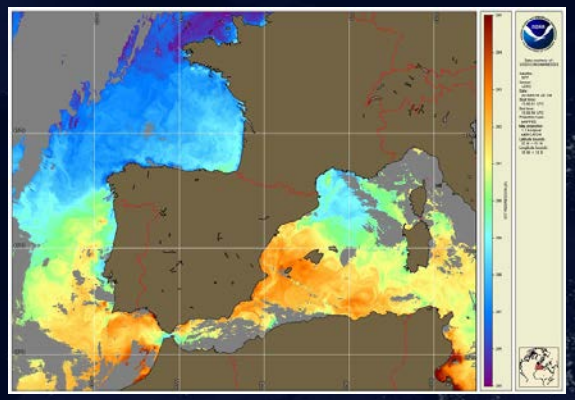
...

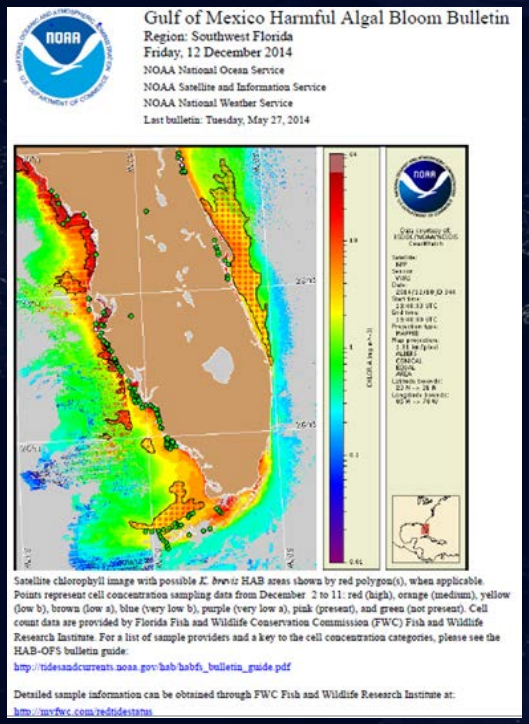
.AVIATION...Moderate high pressure situated over the area will bring a chance for fog to develop at KGPI, KMSO and KSMN. ***The VIIRS night-time visible satellite image at 08/1010z revealed some valley fog across Clearwater County, Idaho and also north across the Idaho Panhandle.*** Any fog that develops near the aforementioned terminals will dissipate by noon. Expect light and variable surface winds at all the terminals.

JPSS Applications Advancements

Oceanography

- Improved sea surface temperature
- Highly calibrated global ocean color



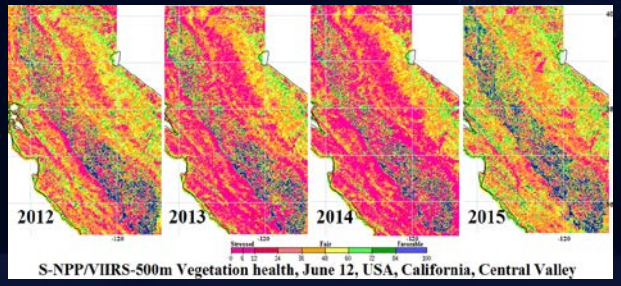


Hydrology

- Ice blockage
- Flood prediction / monitoring

Land

- Green Vegetation Fraction
- Vegetation Stress



Jason Continuity of Altimetry Measurements

Courtesy of Parag Vaze, JPL

Jason-3 Mission Overview

Science Measurements

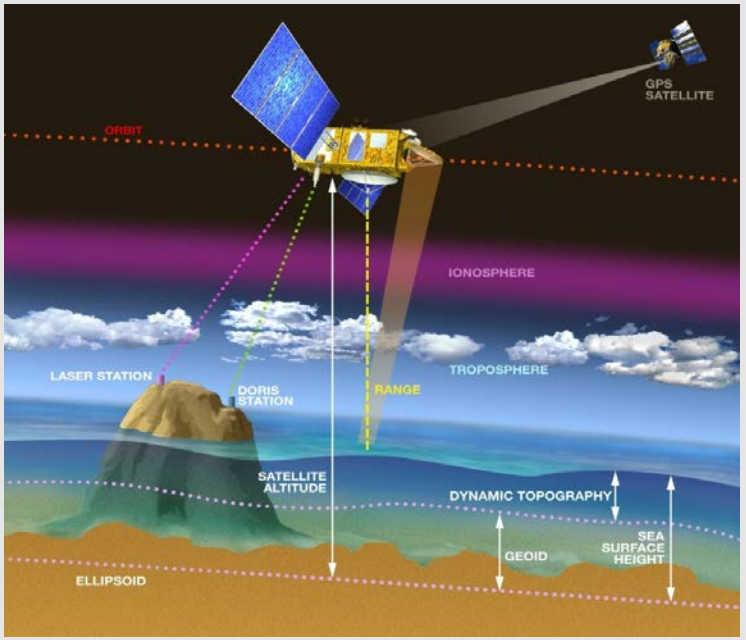
Global sea surface height to an accuracy of ≤ 4 cm every 10 days, for determining ocean circulation, climate change and sea level rise

Mission Objectives

- **Operational ocean altimetry mission to enable the continuation of multi-decadal ocean topography measurements achieved through TOPEX/Poseidon, Jason-1 and OSTM/Jason-2**
- **NOAA and EUMETSAT are lead agencies with CNES and NASA/JPL providing implementation support**

Instruments

- **Core Mission:**
  - **Poseidon-3B Altimeter**
  - **DORIS (Precise Orbit Determination System)**
  - **Advanced Microwave Radiometer (AMR)**
  - **GPS Payload (GPSP)**
  - **Laser Retro-reflector Array (LRA)**
- **Passengers (Experiments):**
  - **JRE (Carmen3 + LPT)**



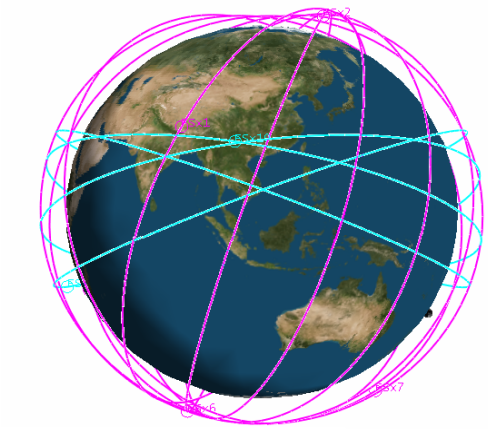
Mission Overview

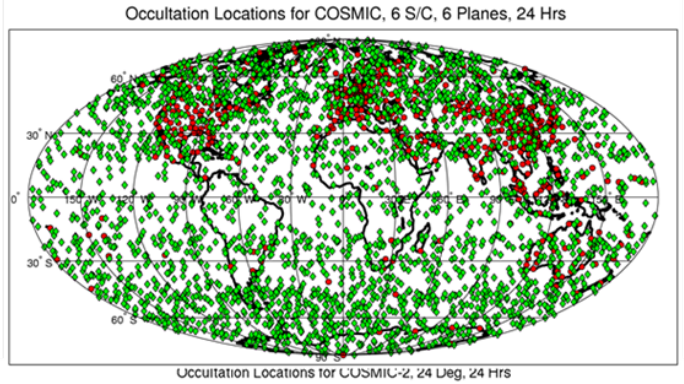
- **Launched: January 17, 2016**
- **Launch Vehicle: Falcon-9.1**
- **Proteus Spacecraft Bus provided by CNES**
- **Mission life of 3 years (goal of 5 years)**
- **1336 km Orbit, 66º Inclination**

NOAA funded items in BLUE

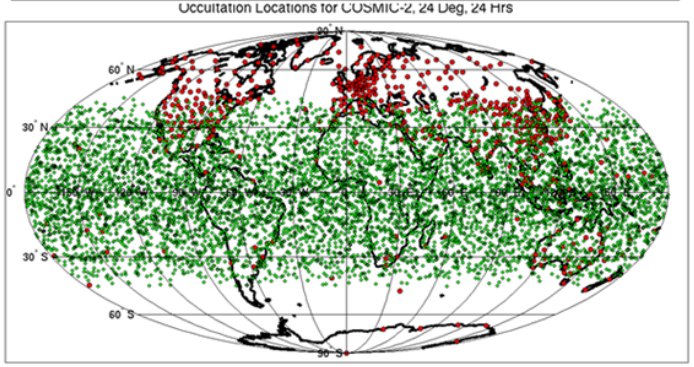
Continuity of GNSSRO Observations COSMIC-1 and COSMIC-2

- First launch of 6 satellites to 24 deg
- Second launch of 6 satellites to 72 deg
- Both launches -> parking orbit, deployment period of 15-18 months for 6 satellites to reach operational orbit
- Design life of 5 years

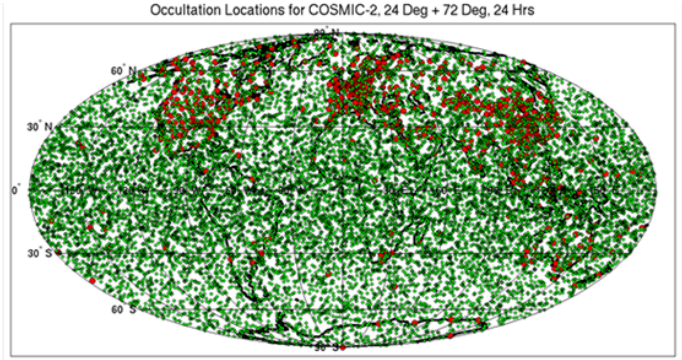




COSMIC-1
6 spacecraft
(72 degree)



COSMIC-2A
6 spacecraft
(24 degree)

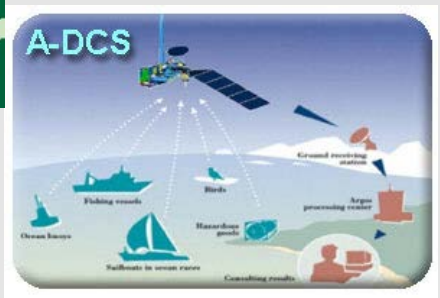


COSMIC-2B
6 spacecraft
(72 degrees)
Plot shows
12 spacecraft (C2A & C2B)

CDARS Mission Overview

Mission Objectives

- Continue the operation of the SAR instruments as part of the international COSPAS-SARSAT system designed to detect and locate Emergency Locator Transmitters (ELTs), Emergency Position-Indicating Radio Beacons (EPIRBs) and Personal Locator Beacons (PLBs)
- Continue the operation of the Argos Data Collection System obtaining a wide variety of data from platforms used for both environmental study and non-environmental uses



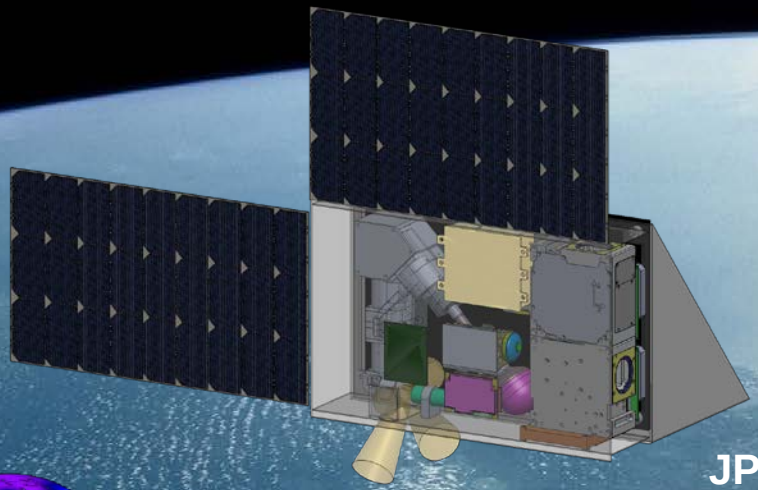
Mission Overview

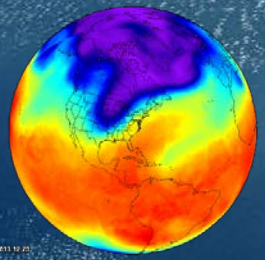
- Integrate A-DCS, SARR and SARP onto Commercially Hosted Payload, LRD: 2020
- Commercially Hosted Payload: USAF HoPS Contract
- Ground Support: HoPS contractor
- Mission Operations: HoPS Contractor

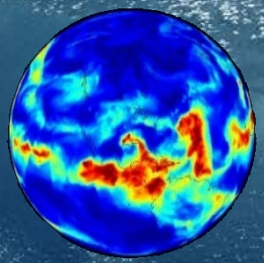
Instruments

- Search and Rescue Repeater (SARR), Canada/Com Dev
- Search and Rescue Processor (SARP), CNES / France / Thales
- Advanced Data Collection System (A-DCS), CNES / France / Thales

An Instrument Concept Study for an Advanced Imager-Sounder: Final Design Review







JPL Task Manager: Thomas S. Pagano
NOAA COTR: David Furlong

Jet Propulsion Laboratory,
California Institute of Technology, CA, USA

February 25, 2016

The CubeSat Infrared Atmospheric Sounder (CIRAS) Selected for Development at NASA JPL

- Hyperspectral infrared sounders provide 2nd highest impact to operational forecast
- Infrared complements microwave by "sharpening" the vertical and horizontal resolution. (Microwave sees through clouds while IR is limited)
- CIRAS selected by NASA ESTO InVEST program in Sept. 2015
  - Objective: To demonstrate IR sounding technologies in a CubeSat: HOTBIRD Detectors, Immersed Grating, MPT Cooler
  - PI: Thomas S. Pagano
    Jet Propulsion Laboratory,
    California Institute of Technology
- CIRAS measures the infrared spectrum of temperature and water vapor in the lower troposphere
- Retrieval accuracy similar to AIRS/CrIS in lower troposphere
- CIRAS selected by the CubeSat Launch Initiative to fly in 2018/2019
- NOAA participation in requirements definition and design studies for future EON-IR based on CIRAS

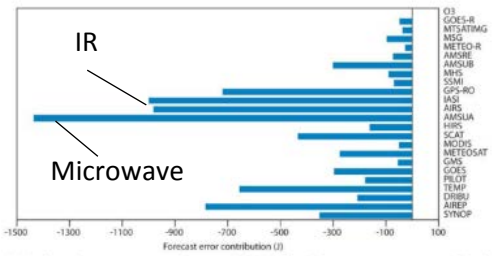
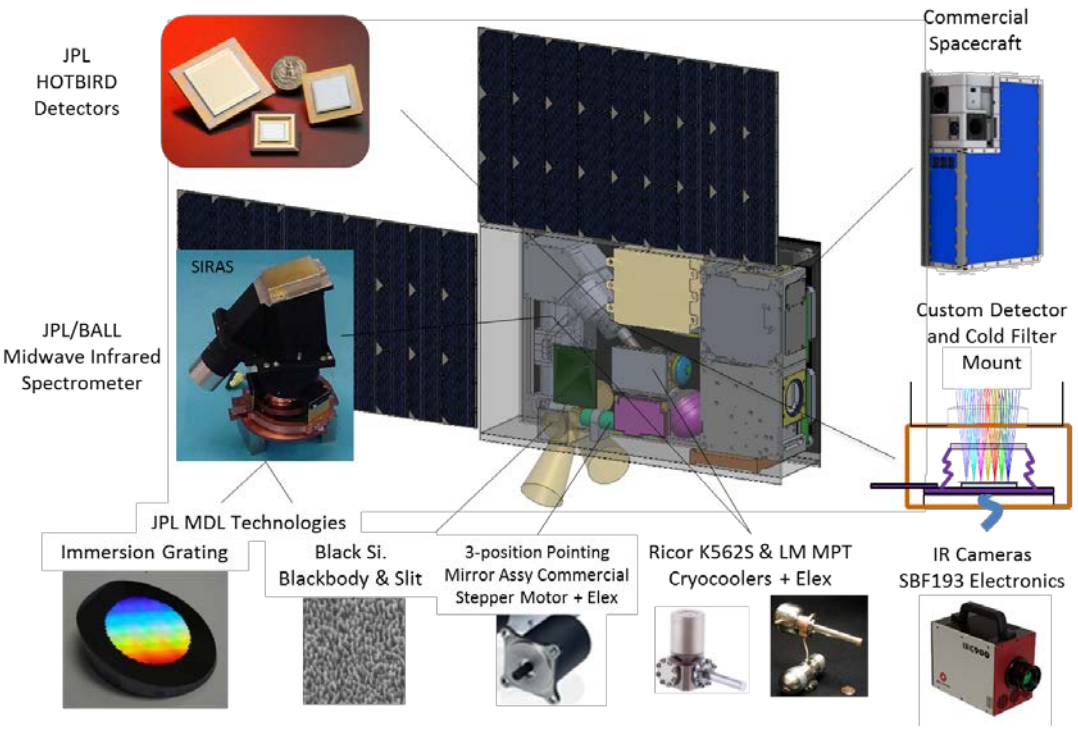


Figure 11. 24-hour forecast error contribution (Joule10^{-4}) of the components (types) of the observing system during September, October, November and December 2008. Negative (positive) values correspond to a decrease (increase) in the energy norm of forecast error.*

From Cardinali (ECMWF Tech. Memo. 599, 2009)

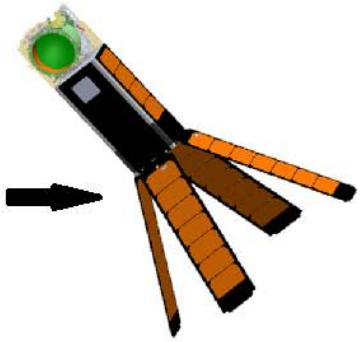
Parameter	Legacy (CrIS) Performance	CBE
Orbit	824 km	450 km
Vertical Range	1000-50mb	1000-300 mb
Temperature Profile	≤1.5 K/km	≤1.2 K/km
Humidity Accuracy	15%/2km	15%/2km
Spatial Res. (nadir)	13.5 km	13.5 km
Scan Range	2040 km	165 km
Spectral Range	3.9-15.4μm	4.78-5.09μm
Spectral Resolution	0.625 cm^{-1}	0.5 cm^{-1}
NEdT	<0.25 K	<0.25K



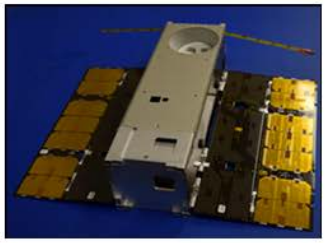
EON-MW Overview

- Earth Observing Nanosatellite - Microwave (EON-MW): Miniaturized microwave sounder technology demonstration developed by MIT Lincoln Laboratory (MIT/LL)
- EON uses innovative, proven CubeSat technology to greatly reduce cost of construction and launch compared to traditional space systems
- EON is next evolutionary step in MIT/LL's CubeSat microwave sounder series

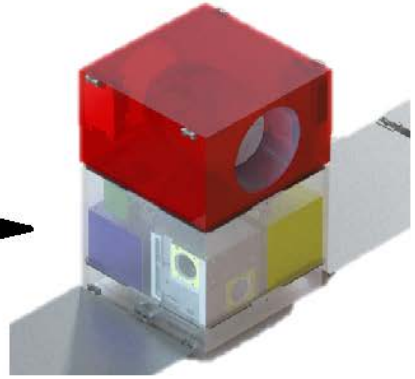
MicroMAS (2015)



MicroMAS-2 (2017)



MiRaTA (2017)



EON-MW (2020)

- Goal is to be operationally equivalent to 4-band, 22-channel ATMS on S-NPP
- Low cost polar-orbit microwave sounding gap mitigation. Could lead to low cost source of operational microwave soundings after JPSS Program

Observing System Simulation Experiments (OSSEs)

Motivation for Performing OSSEs

- Costs of developing, maintaining & using new space-based observing systems typically exceed $100-500M / instrument
- Significant time lags between instrument deployment and eventual operational NWP use
- OSSEs can provide quantitative information on observing system impacts
  - New instruments
  - Alternative mix of current instruments
  - Data assimilation system diagnosis and improvement
- Information from OSSEs can lead to better planning and decisions

OSSE Objectives:

1. To provide a *QUANTITATIVE* assessment of the potential impact of proposed observing systems on data assimilation, and numerical prediction.
2. To evaluate and/or develop new methodology for the processing and assimilation of new types of data.
3. To evaluate tradeoffs in the design and configuration of proposed observing systems (e.g. coverage, resolution, accuracy and data redundancy).
4. To optimize the global observing system for weather, climate or other mission goal.

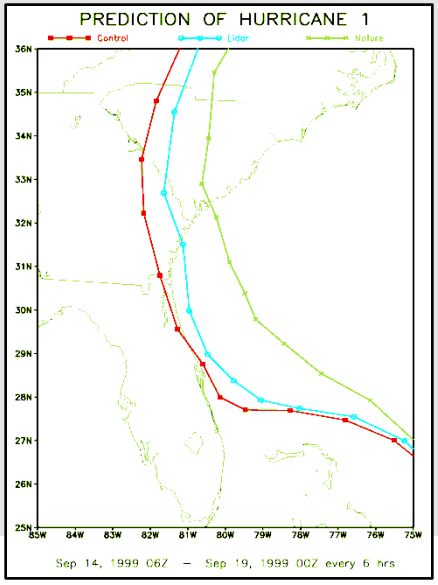
OSSE Example:
Simulated Doppler Wind Lidar Impact on a Hurricane Track Forecast

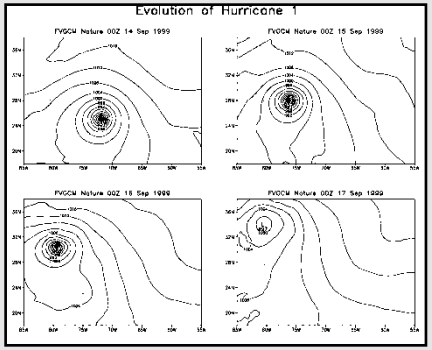
Green: Actual track

Red: Forecast beginning 63 hours before landfall with current data

Blue: Improved forecast for same time period with simulated DWL data

Note:
A significant positive impact was obtained for both of the land falling hurricanes in that year's data; the average impact for 43 oceanic tropical cyclone verifications was also significantly positive.





[Robert Atlas et al., NOAA/AOML]

Doppler Wind Lidar (DWL)

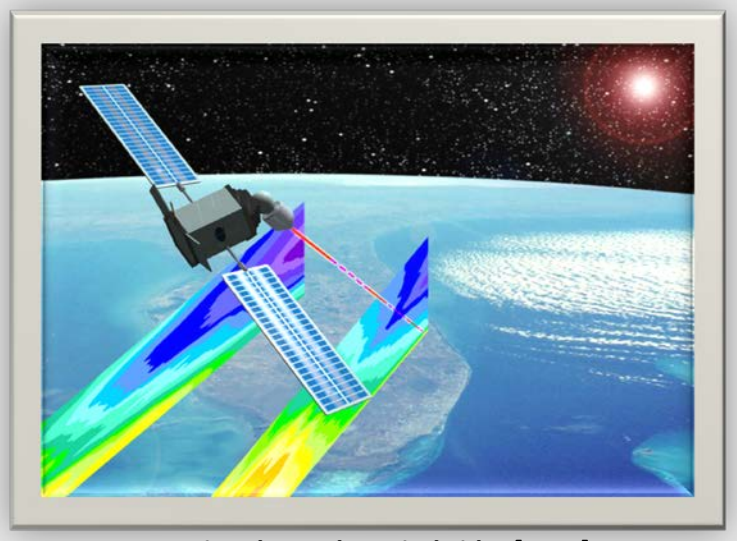
Independent modeling studies at NOAA/NCEP, NOAA/ESRL, NASA and the European ECMWF show **tropospheric wind profiles** to be the **single most beneficial measurement** **now absent** **from the Global Observing System**.

Global Wind Profiles are NOAA's # 1 Unmet observational need for its **meteorological NWP mission**. Global Wind Profiles would support achieving NOAA's strategic goals of a Weather Ready Nation and Understanding Climate Variability and Change.

Space-based **Doppler Wind Lidar [DWL] observations** can provide measurements of **Global Wind Profiles** in the troposphere and lower stratosphere.

The first **National Research Council (NRC) Decadal Survey** report for Earth Sciences and Applications from Space recommended **a global wind mission**.

The NRC Weather Panel determined that a **hybrid Doppler Wind Lidar (DWL)** in low Earth orbit could make a **transformational** impact on global tropospheric wind analyses and NWP.



Notional Doppler Wind Lidar [DWL]

DWL Observations / Measurements

Wind profile observations (speed and direction as a function of height) in the earth's troposphere using lidar backscatter measurements from aerosols in the earth's atmosphere.

Wind profile observations (speed and direction as a function of height) in the earth's upper troposphere and lower stratosphere using lidar backscatter measurements from molecules in the earth's atmosphere.

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- From the depths of the ocean to the surface of the sun and from million-year-old sediment records to near real-time satellite images
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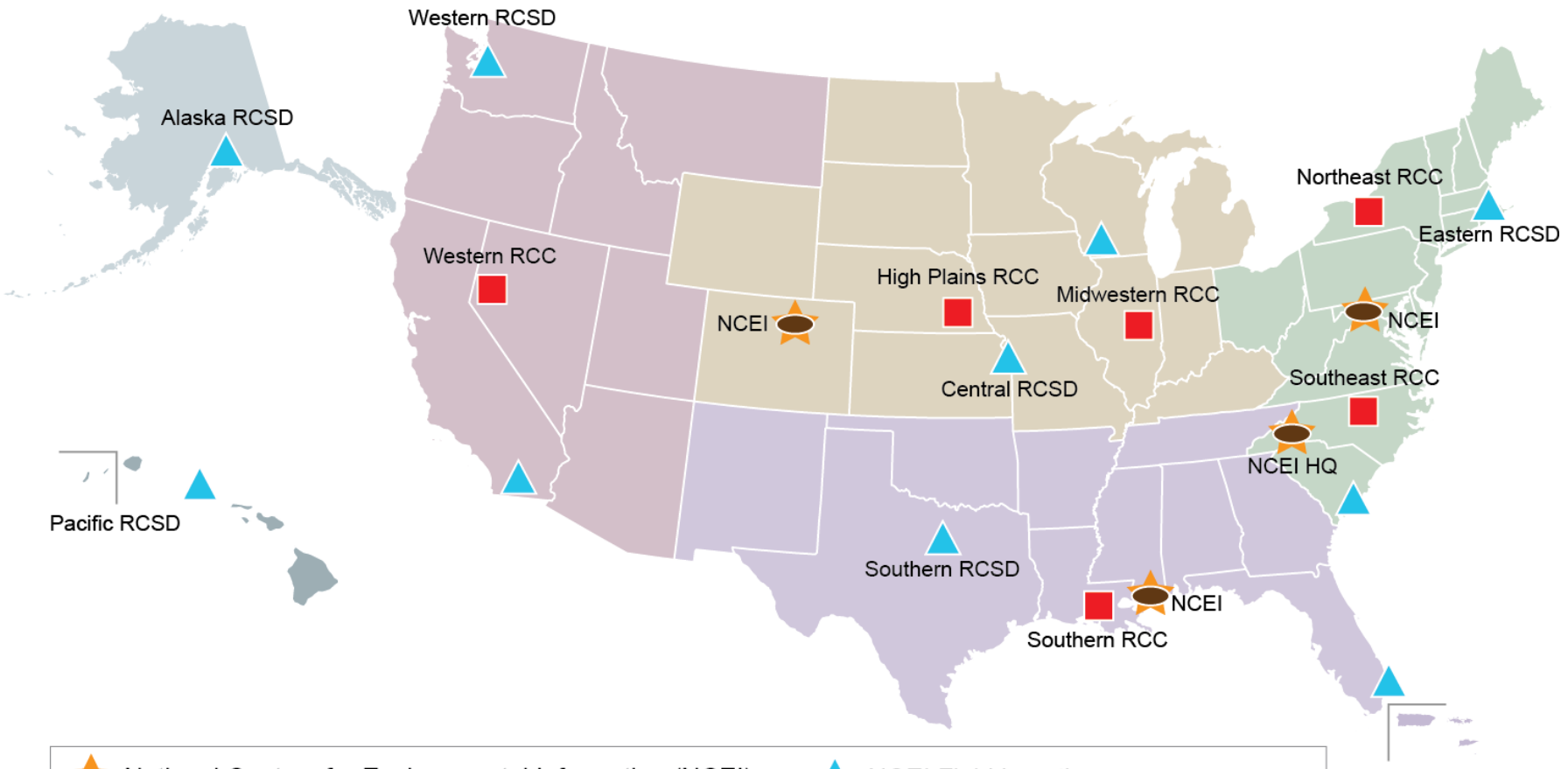

Thank you!