Societal Benefits from NOAA Environmental Satellites

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Topics

- Overview of NESDIS and how our information drives decisions
- The latest generation of NOAA satellites including JPSS, GOES-R and international partnerships
- Examples of how using satellite data benefits agriculture, weather forecasting, and monitoring ice, fires, volcanic eruptions, oceans, coasts and flooding

Our Mission

NOAA'S MISSION

Science, Service, Stewardship

- To understand and predict changes in climate, weather, oceans and coasts
- To share that knowledge and information with others
- To conserve and manage coastal and marine ecosystems and resources

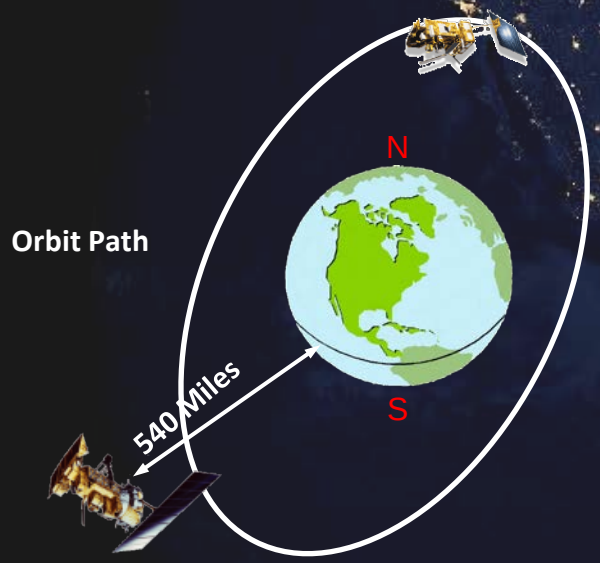
NESDIS MISSION

Dedicated to providing timely access to global environmental data from satellites and other sources to promote and enhance the Nation's economy, security, environment and quality of life:

- Acquires and manages the Nation's environmental satellites
- Operates the NOAA National Data Centers
- Provides data and information services including Earth system monitoring
- Performs official assessments of the environment and conducts related research

Two Orbits, One Mission

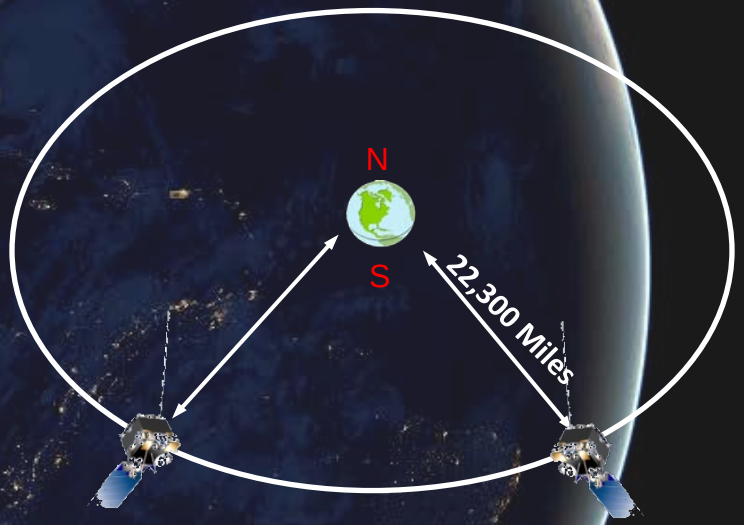
Polar-orbiting Operational Environmental Satellites



Each satellite covers the Earth twice per day

- Pole-to-pole orbit is 102 minutes and views each location at the same time of day
- Global coverage every 12 hours with one satellite
- Information is used for mid-range, 3-7 day advanced warnings of severe weather, and environmental imaging and monitoring for short term polar weather and global ocean and atmosphere forecasting/monitoring

Geostationary Operational Environmental Satellites

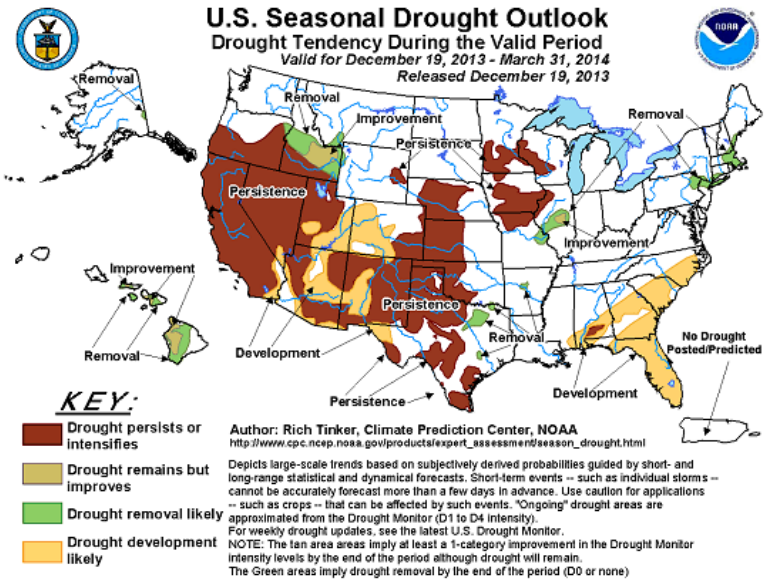


Continuously monitors the Western Hemisphere

- Same geographic image over time
- Full image every 30 minutes and Northern Hemisphere images every 15 minutes
- Usable images between 60ºN and 60ºS
- Information is used for short-term weather forecasting and severe storm warning/tracking

Information drives decisions

- A bad environmental decision can impact lives, property and segments of the economy for years.
- What if there were no weather warnings or forecasts, tsunami and flood alerts, fire and drought reports and predictions, ice monitoring or harmful algal bloom assessments?
- Better information is usually tied to better observations, modeling and computer resources.
- Decision support tools are essential and information must be easy to comprehend.



From Satellites to Agricultural Decisions

Satellite Products that Support Agricultural Decisions

- Vegetation health products
- Soil moisture, land surface temperature
- Land type
  - arid vs. semi arid
- Snow cover and snow water equivalent
  - water resources
- Precipitation
  - especially important for areas without radar
- Global assessments and historical perspective

Drought affects Global Food Security by reducing agricultural production below consumption. Since 2000, this occurred 8 years out of 13.

Examples of Decisions from Drought Assessments and Predictions

Farmers

- When and what to plant
- Plant density
- Irrigation timing and amount
- Pesticides and fertilization
- Expected yield and harvesting decisions
- Impacts on livestock

Buyers

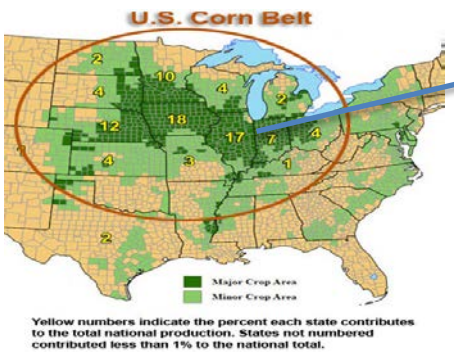
- Anticipate productivity
- Global, Regional vs. local purchasing

Humanitarians

- Anticipated drought regions
- Impact on communities
- Planning relief efforts

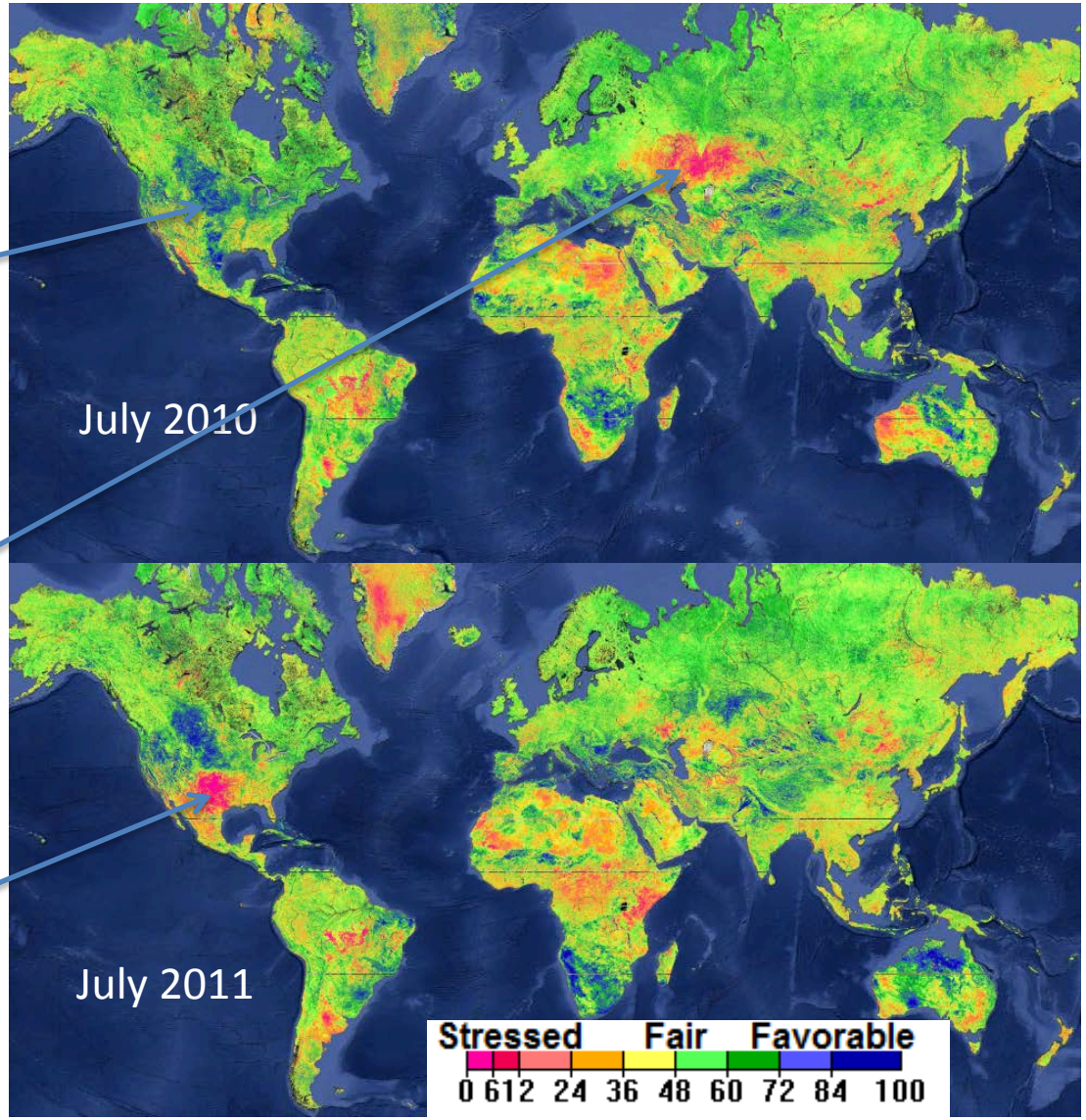
Vegetation Health from AVHRR

IMPACTS:
U.S. corn production in 2010
Hit a record high.



Wheat was down 27% in **Russia**, 32% in **Kazakhstan**, and 19% in the **Ukraine**.

Texas cotton production fell by more than half, from 7.84 million bales in 2010 to 3.5 million in 2011.



Next-Generation JPSS and GOES-R Advantages

JPSS

- **CrIS:** significantly improved temperature and water vapor information than POES HIRS
- **ATMS:** improved global coverage and spatial resolution than AMSU
- **VIIRS:** superior imagery and more spectral bands than AVHRR
- **OMPS:** improved spatial resolution, coverage and vertical profiling than SBUV
- **CERES and TSIS:** for fundamental energy budget climate measurements

JPSS-1 Launch: 2Q FY2017
JPSS-2 Launch: 1Q FY 2022

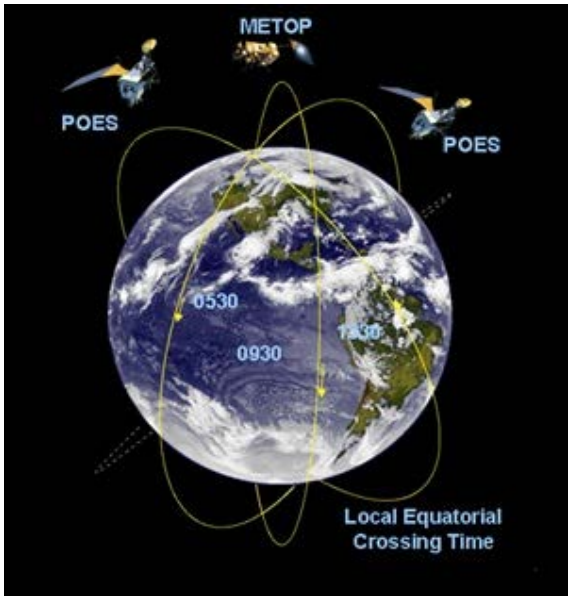
GOES-R

- **ABI:** superior imagery and more spectral bands than the GOES imager
  - Improved temporal sampling, CONUS every 5 minutes, full disk every 15 minutes and selected 1000 x 1000 km area at 30 seconds
- **GLM:** first ever geostationary lightning mapper
- **SEISS/SUVI/EXIS:** significantly improved space weather coverage
  - Monitors solar radiation, locates solar flares and coronal mass ejections, detects solar irradiance

GOES-R Launch: 2Q FY2016
GOES-S Launch: 3Q FY2017

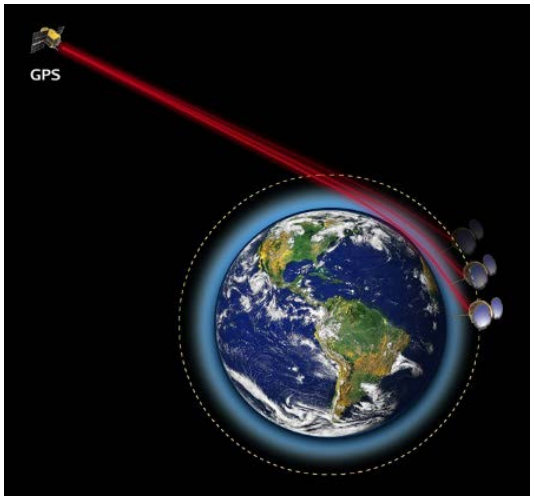
With new instruments comes an increase in data and changes in data distribution.

Other NOAA/Partner Satellite Contributions



JPSS and Metop: Complementary Orbits

JPSS program (next-gen POES satellites) implements U.S. civil commitment, interagency and international agreements to afford 3-orbit global coverage.



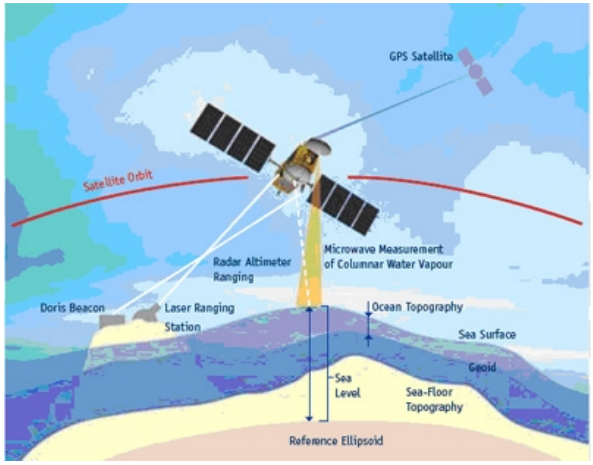
GNSS-RO Launch: 2015/2016

Following COSMIC, the GNSS-RO mission will provide global radio-occultation measurements of ionosphere, temperature and water vapor information for weather and climate applications.

DSCOVR Launch: 2014/2015

JASON-3 will continue the legacy of altimetry measurements of sea-level, along with supporting ocean circulation modeling and hurricane intensity predictions.

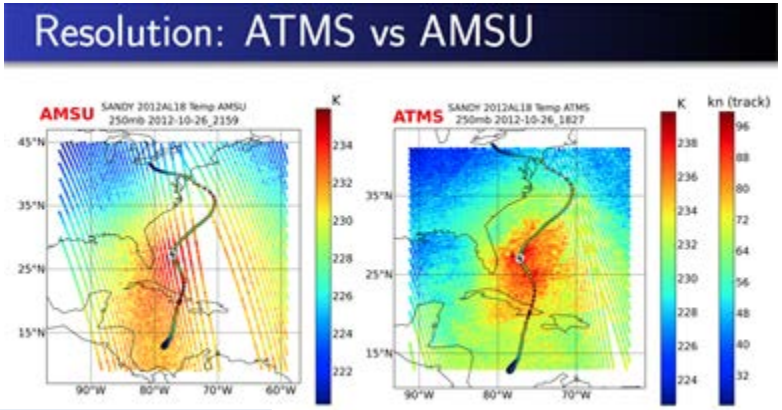
DSCOVR will provide space weather observations from L1 orbit for up to 60 minute lead time and maintain the nation's solar wind observations.



Jason-3 Launch: March 2015

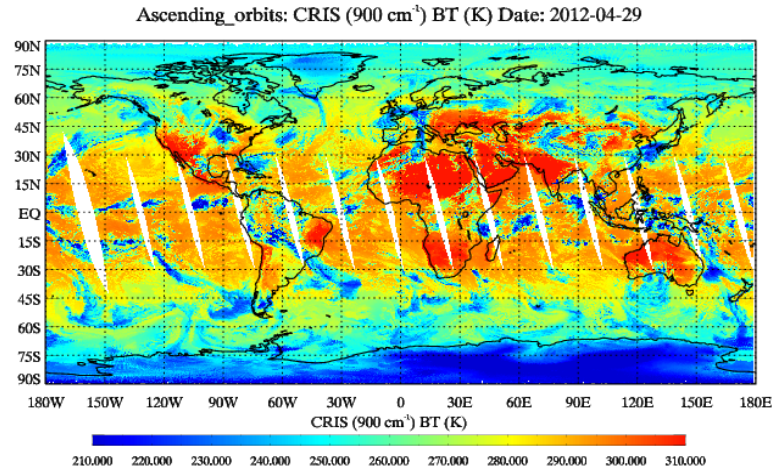
JPSS Next Generation Instruments

Advanced Technology Microwave Sounder



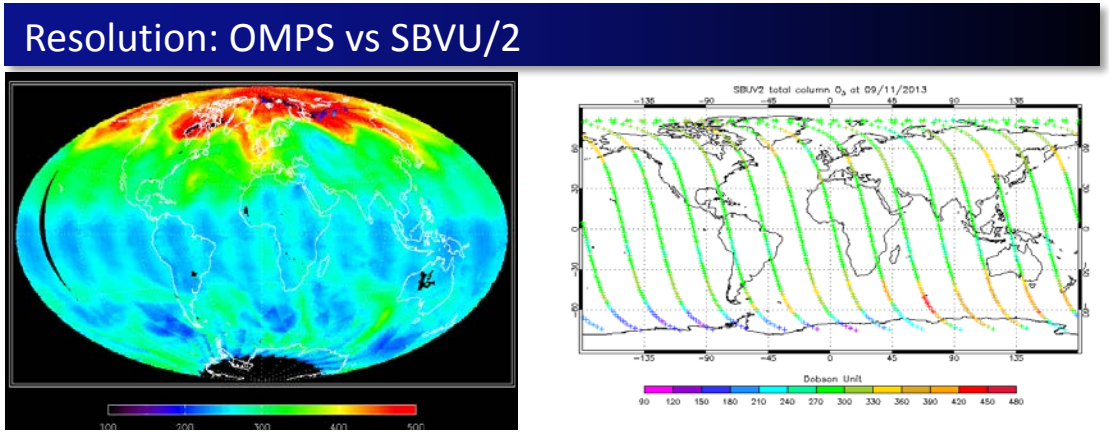
Higher resolution, wider swath, smaller gaps

Cross-track Infrared Sounder



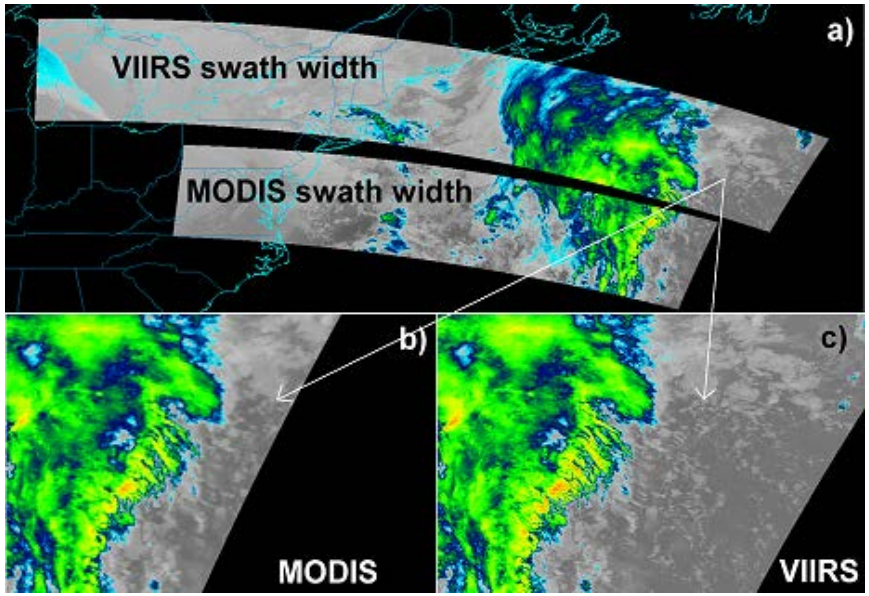
6x more vertical resolving power

Ozone Mapping Profiler Suite

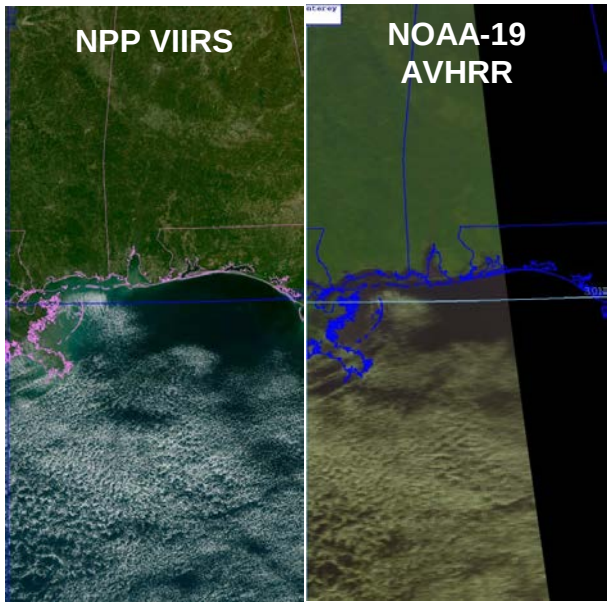


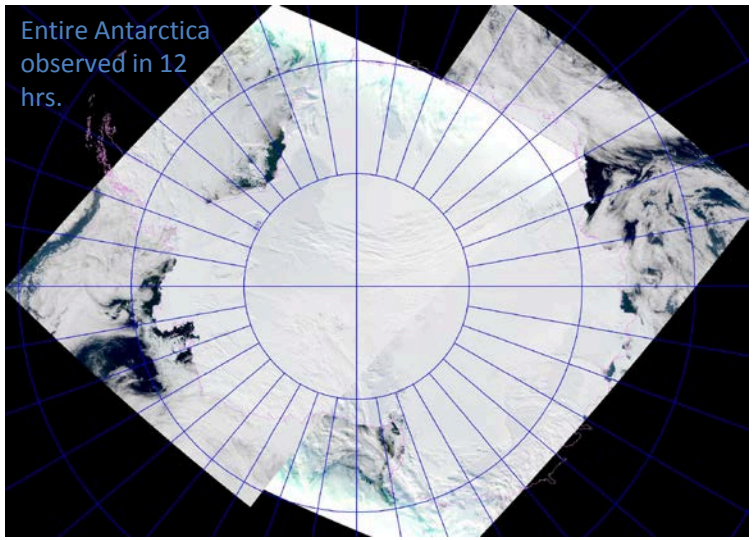
Provides global coverage ozone monitoring

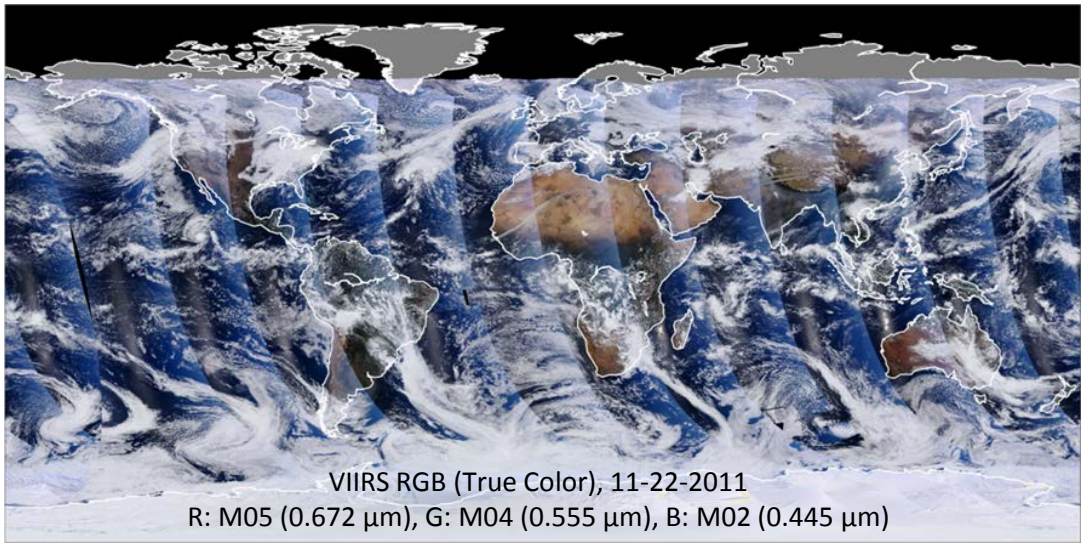
JPSS Next Generation Instruments



The Visible Infrared Imaging Radiometer Suite offers more spectral bands, higher resolution, wider swath and greater accuracy, resulting in a large number of products.



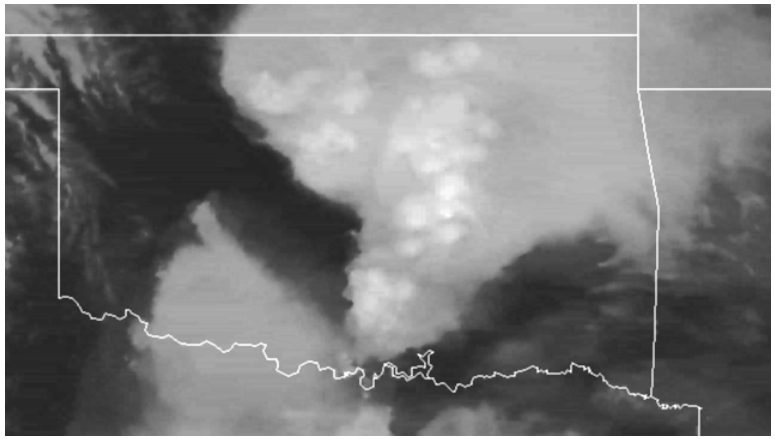




GOES-R Next Generation Instruments

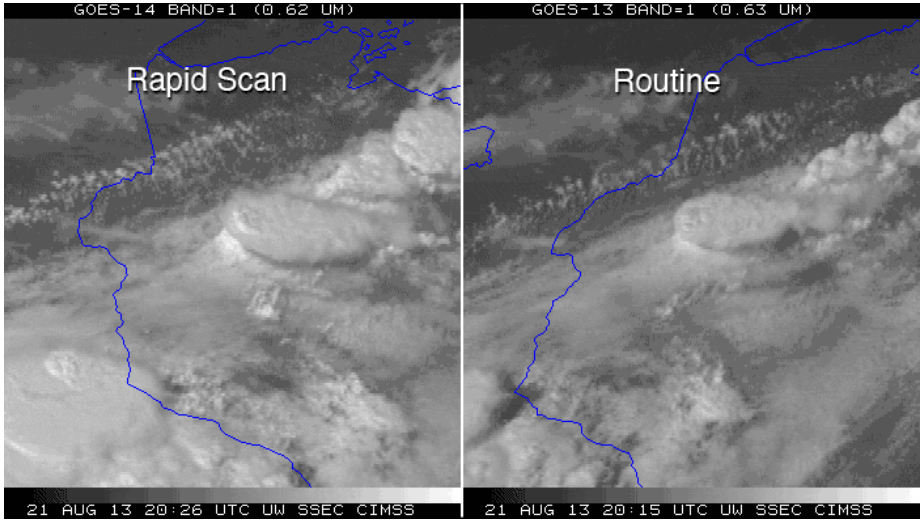
Geostationary Lightning Mapper

- GLM is a near-infrared instrument that maps total lightning
- For the first time, scientists will be able to detect cloud-to-cloud lightning
- Rapid increase in cloud-to-cloud lightning, called a "jump signature," has been shown to precede severe weather on the ground
- Lightning observations will enable meteorologist to better track storm development and intensification



Simulation of GLM lightning detection capabilities during tornado outbreak in Oklahoma

Advanced Baseline Imager



NOAA operated GOES-14 in an experimental rapid scan one-minute mode to simulate ABI capabilities in 2012 and 2013

- Primary instrument on GOES-R
- Five times faster imaging
- Four times the spatial resolution
- More accurate calibration
- New products for severe weather forecasting, volcanic ash advisories and fire and smoke monitoring

Both JPSS and GOES-R support improved weather forecasting—weather forecasting impacts decision making.

Immediate impacts

- Saving lives and property through warnings and preparation
- Ranges from imminent warnings (tornadoes) to 7 day forecasts of extreme weather events (hurricanes)
- Emergency preparations, hazard response and evacuations
- Support to FEMA
- Support to the American Red Cross and their decision makers
- General commerce, transportation, tourism, etc.

Potential long-term impacts

Historical data, decisions and impacts can be used to improve preparations of future events.

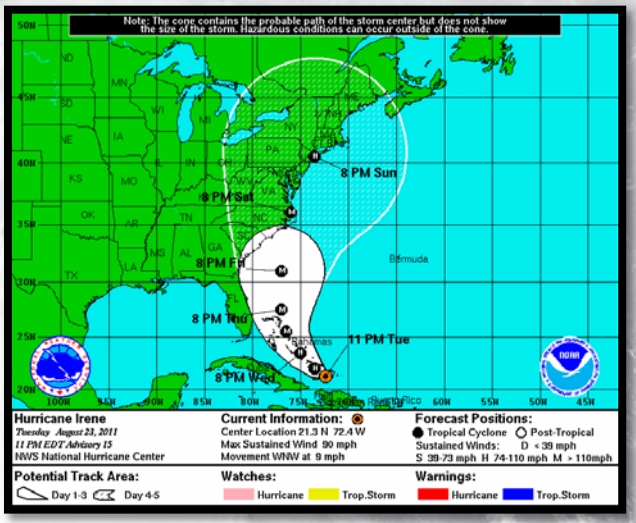
Hurricane force winds blast a walker off his feet on Bournemouth beach in the UK

Satellite data resolution (spatial and vertical) must keep pace with improvements in forecast model resolution

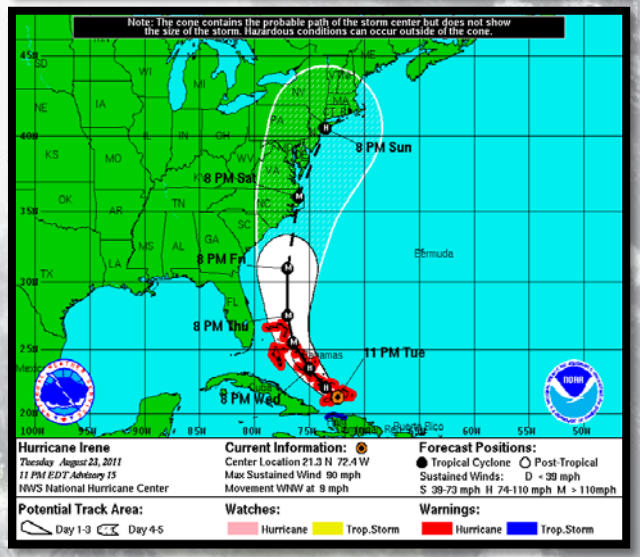
Decisions from accurate hurricane forecasts

- Evacuations
  - Improving "cone" of uncertainty reduces evacuation areas and costs
  - Each coastal evacuation mile is about $1M
- Preparing for damage and keeping lives and property safe
- Moving ships out of area to prevent damage
- More accurate forecasts result in fewer false alarms
  - A study by Considine et al. 2004, *Journal of Applied Meteorology and Climatology*, noted that the value of existing 48 hour hurricane forecast information to oil and gas producers in the Gulf of Mexico averaged $8M per year during the 1990s, which exceeds the NHC annual budget by about a factor of 2.
  - An improvement of 50% in forecasting hurricane tracks would increase the value to about $15M per year.

NOAA satellites support advanced forecast enterprise: Observations – Models – Supercomputers – Expert Forecasters



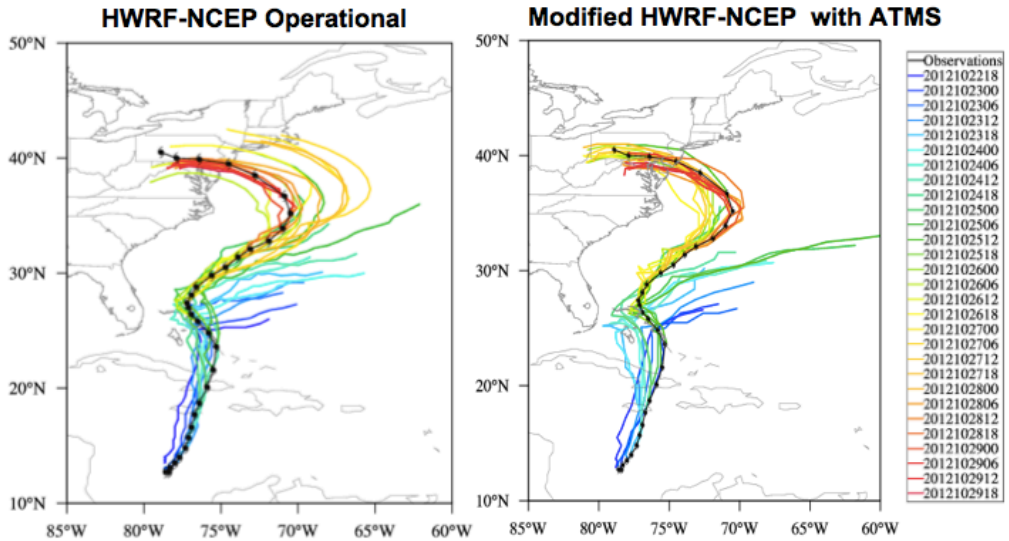
"2001" Irene Forecast



2011 Irene Forecast

Sandy Simulation Experiment

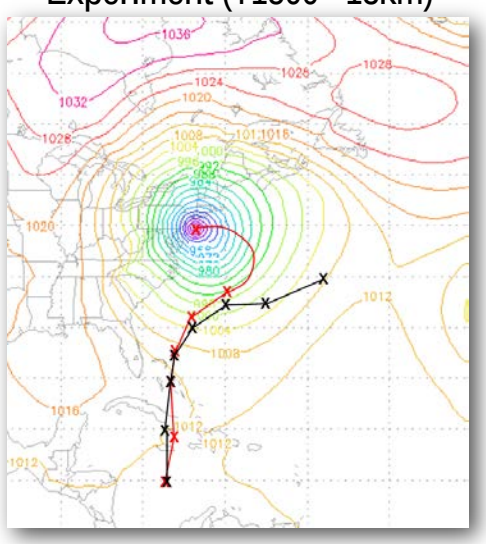
Experimental results showing improvements in Sandy track forecasts from Hurricane Weather Research Forecast model with ATMS



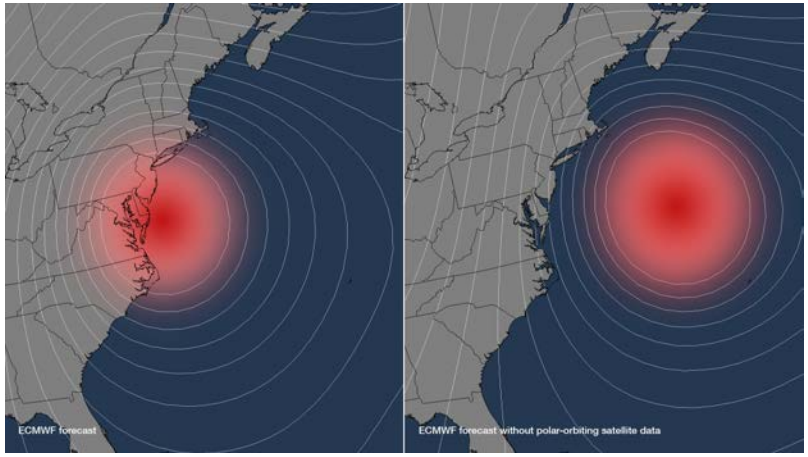
A study by the European Centre for Medium-Range Weather Forecasts (ECMWF) showed that forecasts of Hurricane Sandy's track would have been hundreds of miles off without information from polar-orbiting satellite data. Rather than identifying the New Jersey landfall location within 30 miles five days before landfall, the models would have shown Sandy remaining at sea.

Next-generation satellite instruments will continue to support improved data, modeling and forecasting.

Experiment (T1500~ 13km)



Experiment: Is the 7 day forecast of Sandy improved by increasing model resolution from 27 km (black) to 13 km (red)?
Hypothesis: Increased horizontal resolution resolves complicated Atlantic blocking pattern, slows simulated hurricane, and allows it to curve toward the East Coast.

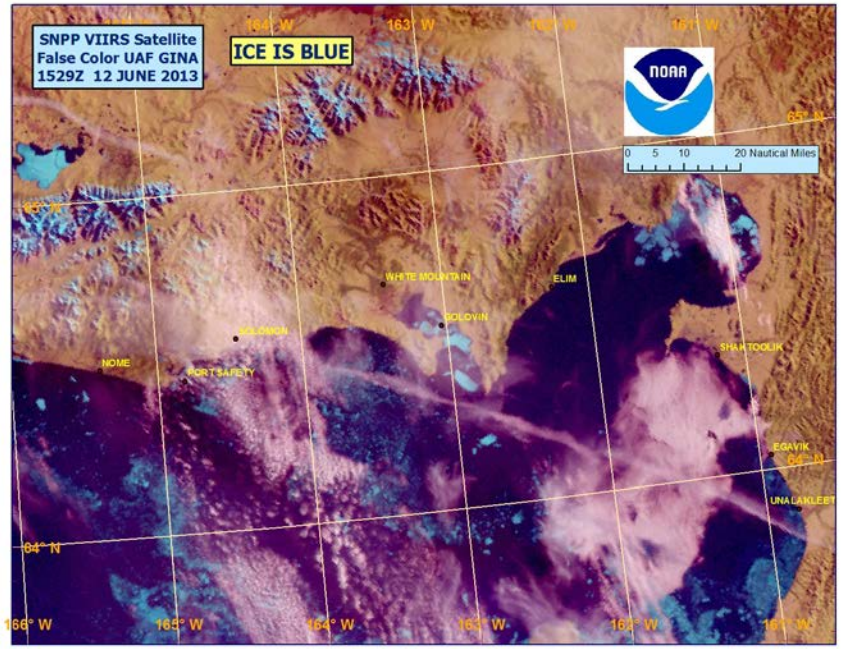


ECMWF with and without polar-orbiting satellite data

Decisions from ice monitoring

Immediate impacts

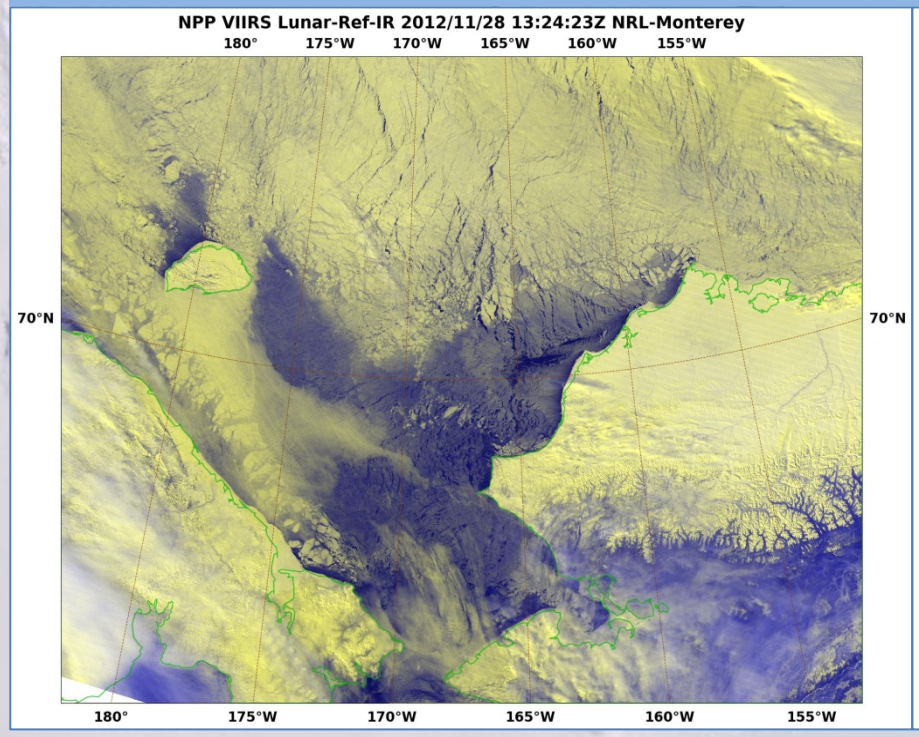
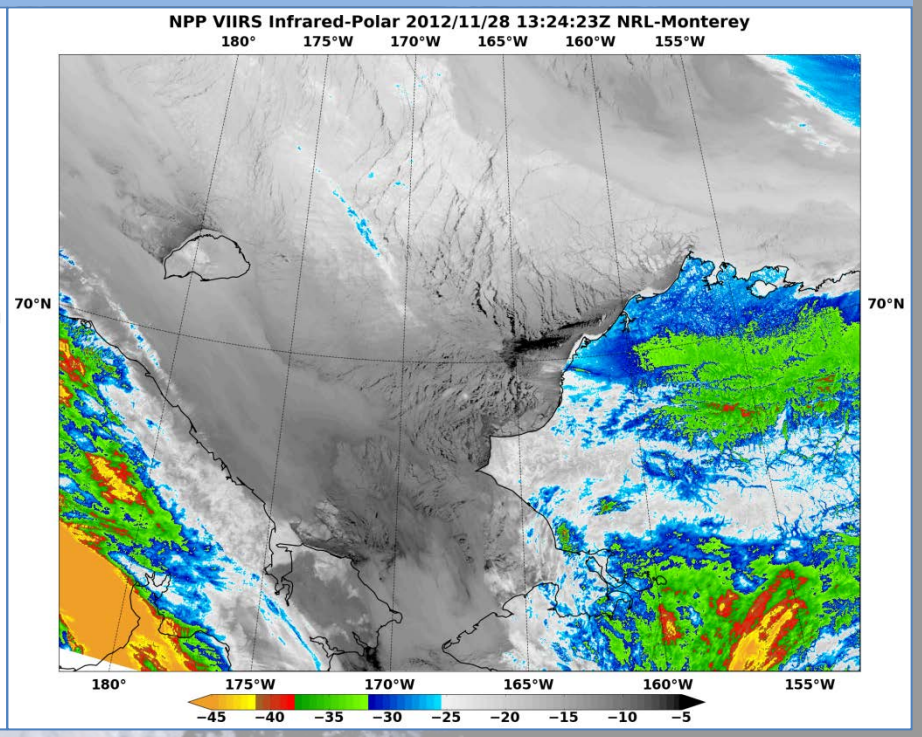
- Shipping routes
- Keeping clear of potential ice hazards – getting stuck in ice, ship damage, delays in supply deliveries and general commerce
- River ice flooding and evacuations – impact local communities



Potential long-term impacts

- Shrinking arctic ice pack increases future navigation routes and potential new discoveries of natural resources
- Potential melting of Greenland ice will cause sea-level rise impacting coastal communities
- Melting permafrost will release trapped methane potentially accelerating global warming
- Impact on general weather circulation

VIIRS enhancements for night-time monitoring of polar sea ice

VIIRS Day Night Band	VIIRS Infrared
	

Credit: NRL

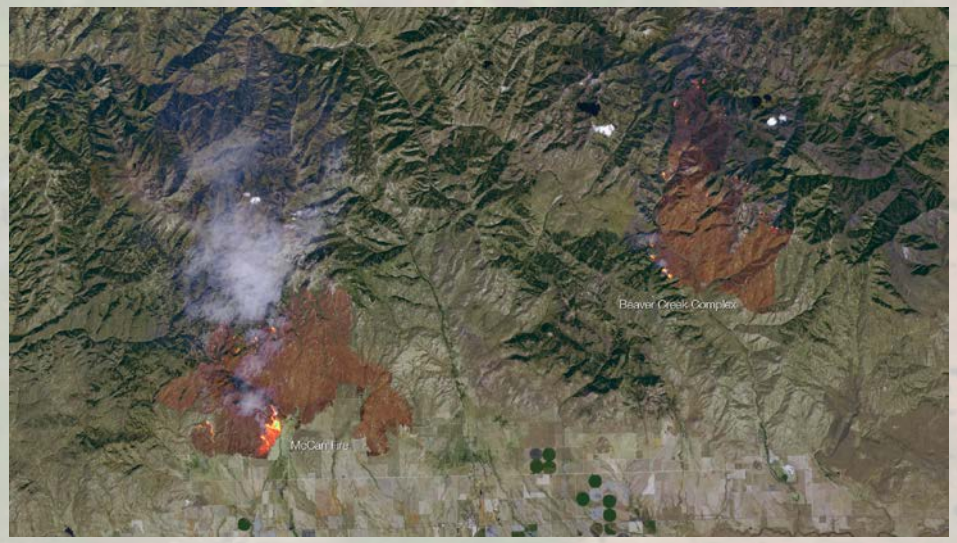
Decisions from fire monitoring and prediction

Immediate impacts

- Lives and property
- Fire control and behavior
- Health impacts due to smoke inhalation
- Visibility impacts on transportation
- Local economies and employment
- Tourism, commerce

Potential long-term impacts

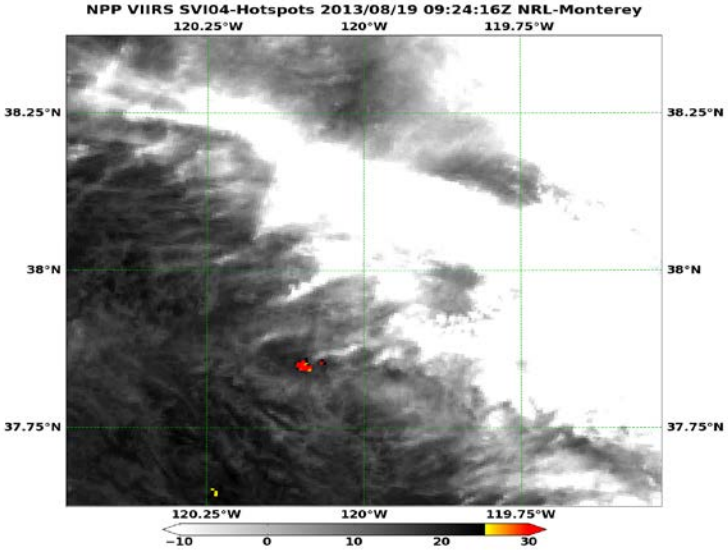
- Burn scar will cause larger flooding runoff events due to heavy precipitation and less ground cover



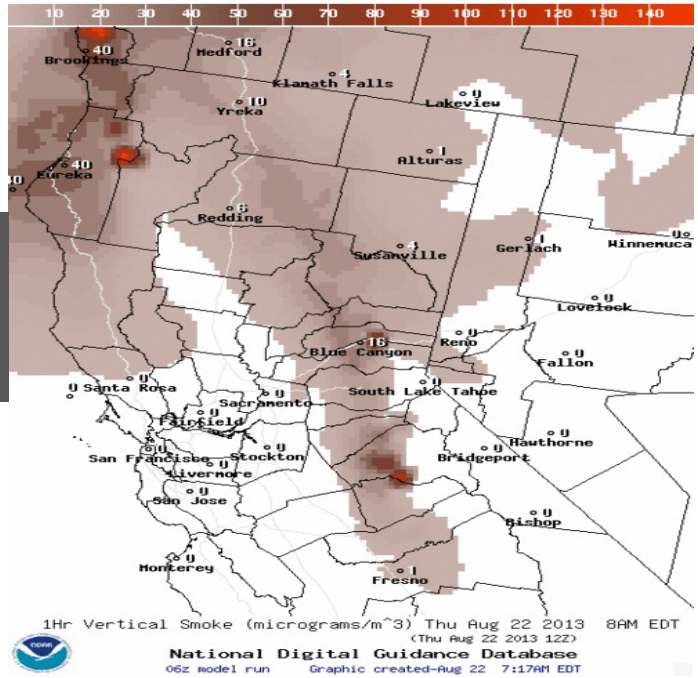
McCan & Beaver Creek, Idaho, 2013, burn scar from Landsat 8

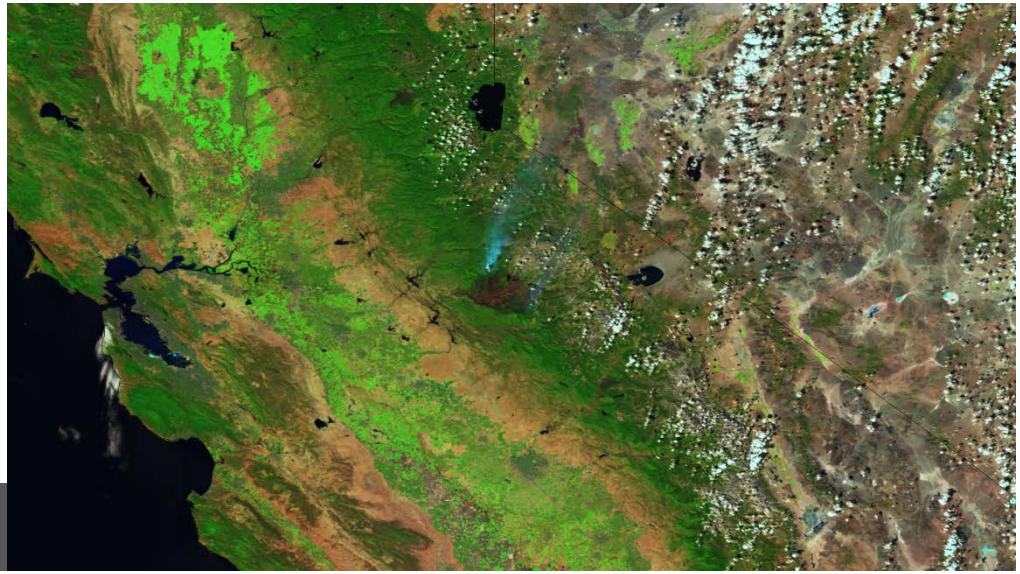
RIM Fire as viewed from VIIRS

Hot spot/intensity from VIIRS



Fire locations used by NOAA for operational smoke plume predictions





80% contained and burn scar – Sept 5, 2013

Decisions from monitoring ocean and coastal ecosystems

Immediate impacts

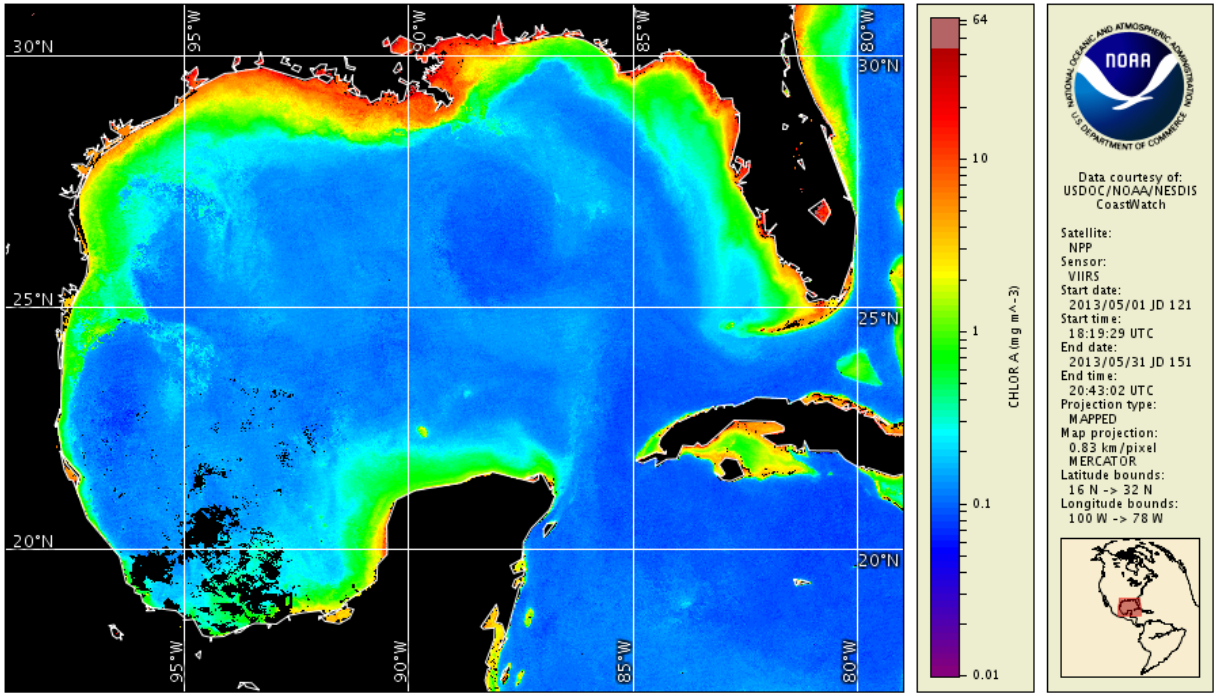
- Aquaculture, fishing and tourism
- Health/respiratory impacts due to brevetoxin emissions from harmful algal blooms
- Fishing restrictions due to harmful water quality
- More effective fishing practices
- Stock assessments
- Local economies and employment

Potential long-term impacts

- Fishing industry
- Water quality
- Ecosystem decadal impacts
- Monitoring provides verification of regulatory decisions

Harmful algal blooms caused by agricultural runoff due to soluble phosphorous from fertilizers.

VIIRS Ocean Color is used by NOAA to monitor health of ocean, coastal and large lake ecosystems



Credit: NOAA Coastwatch

The New York Times **Environment** April 6, 2013

Florida Algae Bloom Leads to Record Manatee Deaths

A manatee off Peanut Island, Fla.

The state's annual red tide affects a wide range of aquatic animals and can cause problems in people. The algae contain a nerve poison known as brevetoxin that is not only found underwater but that is also blown through the air when waves break open the algae's outer casing.

Manatees, birds, dolphins and other animals can be killed by consuming the poison, either by accidentally eating the algae or by ingesting small organisms clinging to sea grass that have soaked up the poison while filtering seawater.

Residents and tourists regularly have respiratory problems after inhaling brevetoxins while strolling on beaches near red tides. People can also become ill after eating oysters and clams that have absorbed the toxin.

Decisions from monitoring volcanic eruptions

Immediate impacts

- Lives and property
- Aviation industry
- Tourism
- Health from ash inhalation
- Visibility
- Local economies and employment

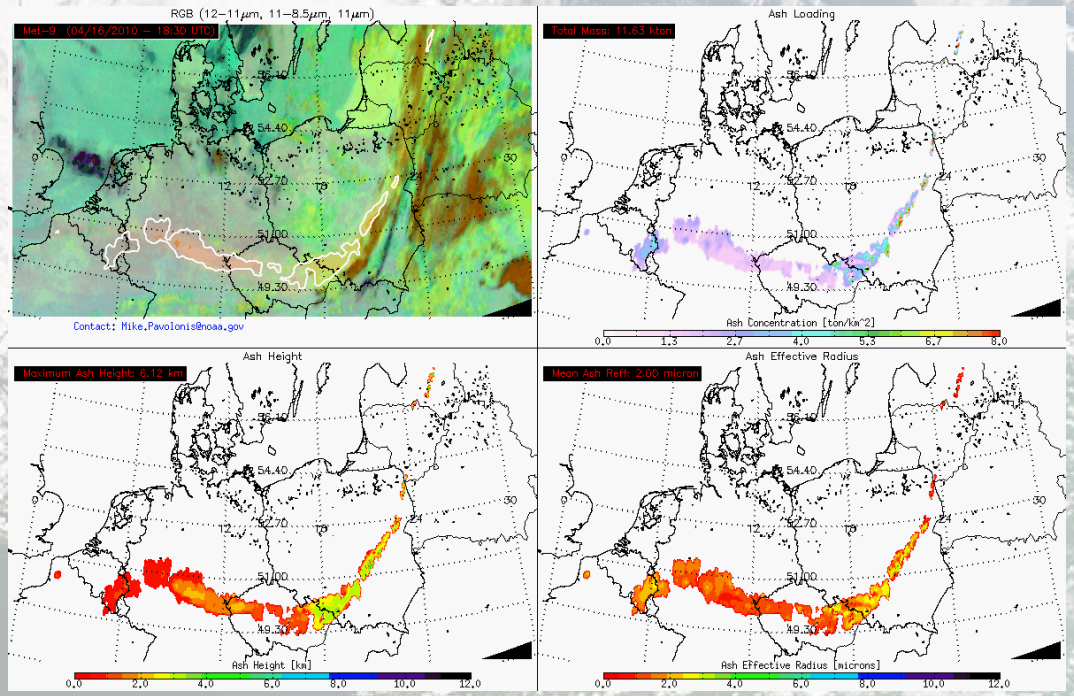
Summary of Volcano Impact Findings

- Global aviation sector losses in the first week tallied US$2.6 billion. However, when factoring in deferred business and leisure travel, the net aviation sector impact was US$2.2 billion.
- The visitor spending impact realised by destinations around the world is estimated at US$1.6 billion in lost revenues, primarily to hospitality sectors.
- Productivity losses stemming from stranded workers are estimated at US$490 million.
- International trade has also been severely disrupted as a result of the flight restrictions—particularly for perishable goods and for just-in-time production processes (e.g. high-value items which are also low-weight such as electronic parts and machine components).
- The total impact on global GDP caused by the first week's disruption amounts to approximately US$4.7 billion.
- Since the massive airspace shutdown in the first week, another 5,000 flights have been sporadically cancelled. This would add an additional 5% to the first week impacts, bringing the total cost to US$5.0 billion lost GDP through 24 May, 2010.

Economic impact from Iceland's Eyjafjallajokull volcano

– from Oxford Economics report

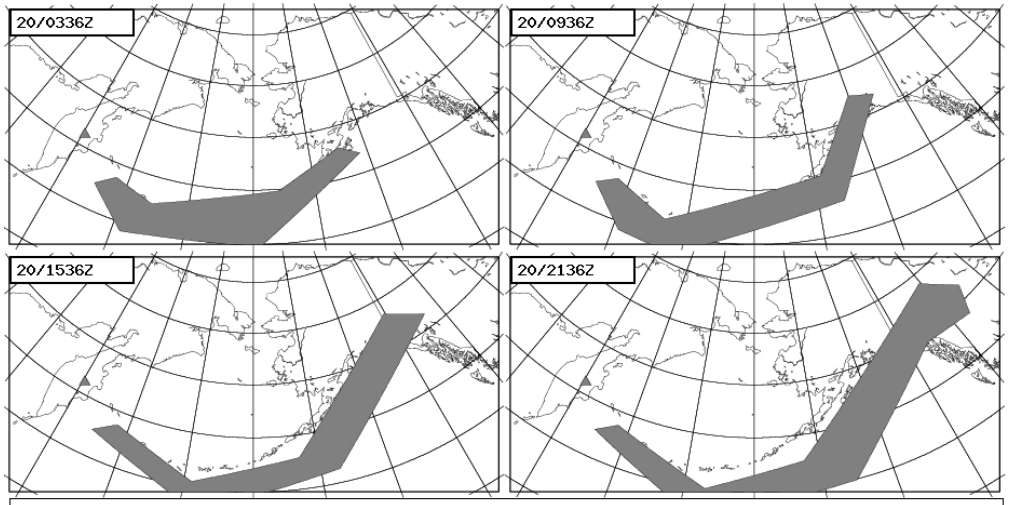
Iceland's Eyjafjallajokull volcano impacting Europe as observed from Meteosat-9



(a) Ash cloud imagery; (b) Ash loading; (c) Ash height and (d) Ash effective radius

The volcano first began to erupt on 14 April 2010, resulting in massive flight cancellations and delays over most of Europe, which had serious global impacts

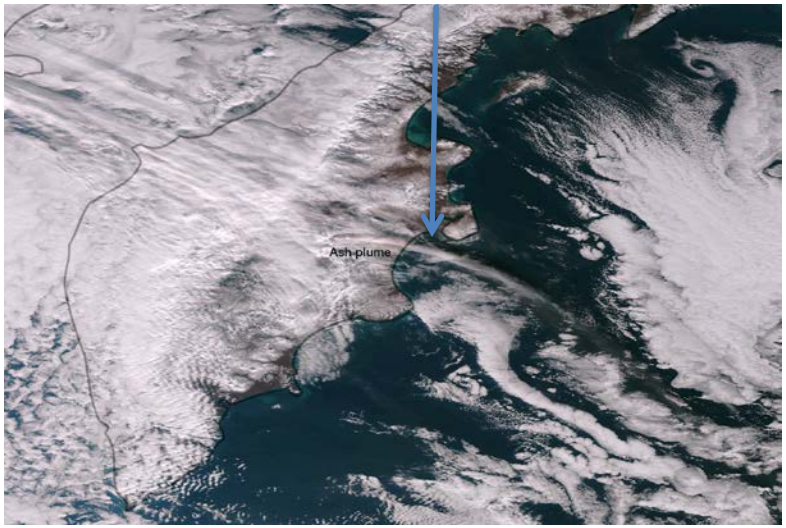
Volcanic Ash is detected and monitored by both polar and geostationary satellites; the data are used to issue official volcano advisories.



VOLCANIC ASH ADVISORY
DTG: 20131020/0336
VAAC: ANCHORAGE
VOLCANO: KLYUCHEVSKOY 1000-26
AREA: KAMCHATKA
SUMMIT ELEV: 15584ft (4750m)
ADVISORY NUM: 2013/015

INFO SOURCE: MT-SAT/GOES/POES/AVO/KVERT/PILOT REPORT
ERUPTION DEAILS: ERUPTION CONTINUING
REMARKS: TOKYO VAAC IS ISSUING VAA FOR VA IN THEIR AREA OF RESPONSIBILITY. SEE FVFE01 RJTD ISSUED BY TOKYO VAAC WHICH DESCRIBES CONDITIONS NEAR THE ANCHORAGE VAAC AREA OF RESPONSIBILITY.
NEXT ADVISORY: WILL BE ISSUED BY 20131020/0936Z

Ash cloud estimated at 10 km altitude from VIIRS



Aviation Color Codes

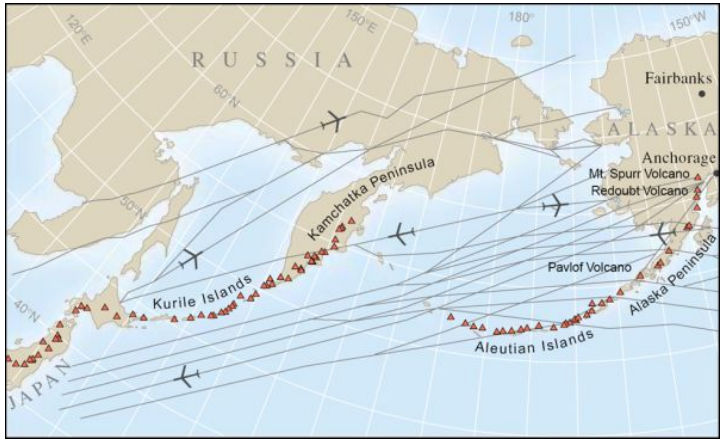
GREEN
Volcano is in typical background, noneruptive state or, *after a change from a higher level*, volcanic activity has ceased and volcano has returned to noneruptive background state.

YELLOW
Volcano is exhibiting signs of elevated unrest above known background level or, *after a change from a higher level*, volcanic activity has decreased significantly but continues to be closely monitored for possible renewed increase.

ORANGE
Volcano is exhibiting heightened or escalating unrest with increased potential of eruption, timeframe uncertain, **OR** eruption is underway with no or minor volcanic-ash emissions [ash-plume height specified, if possible].

RED
Eruption is imminent with significant emission of volcanic ash into the atmosphere likely **OR** eruption is underway or suspected with significant emission of volcanic ash into the atmosphere [ash-plume height specified, if possible].

Klyuchevskoy (Russia): Code red, Oct. 20, 2013



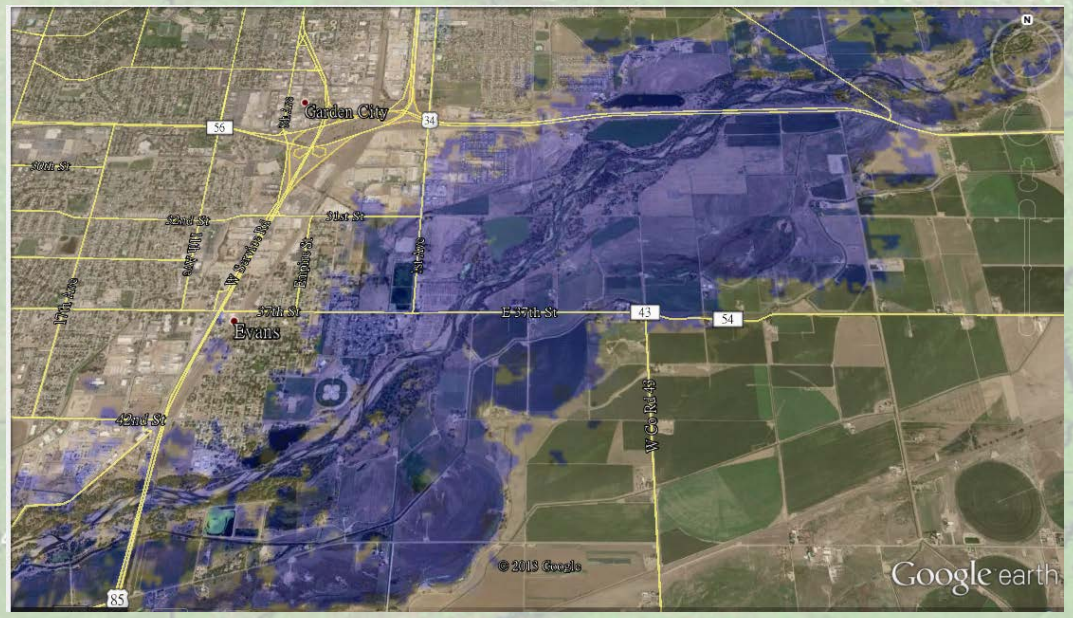
Decisions from monitoring extent of floods

Immediate impacts

- Recovery efforts
- Warnings
- Health impacts due to standing water
- Insurance claims
- Local economies and employment

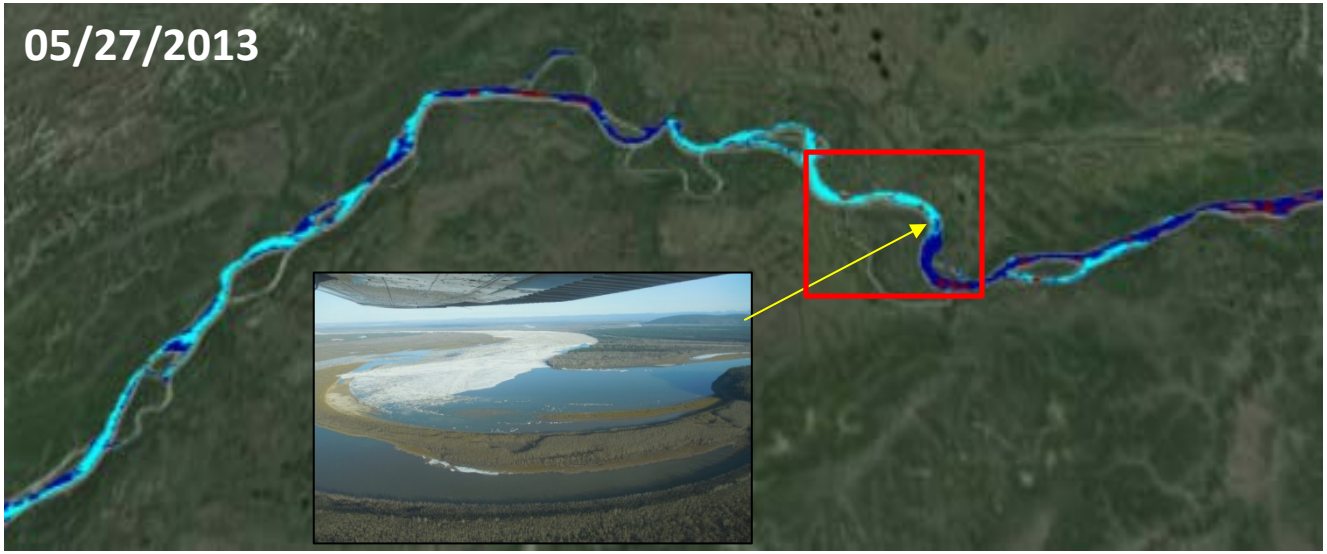
Potential long-term impacts

Historical data and modeling can be used to predict episodic impact and action



Flood near Evans and Garden City, Colo., Sept. 17, 2013 – VIIRS spatial resolution is enhanced with use of 30 meter digital elevation map

VIIRS River Ice and Flood Products



VIIRS can identify river ice jams which can lead to large flood events

- Cyan is mixed ice/water
- Blue is water
- Red is cloud
- Yellow is solid ice

Galena, Alaska on May 28, 2013

Flooding from ice jams can occur in a very short time

Other societal benefits from satellite data

- Communication and electrical grids
  - Space Weather instruments provide early warnings (GOES-R and DSCOVR)
- Energy
  - Wind measurements and cloud cover
- Health
  - Vegetation conditions for vector-borne disease such as malaria from mosquitos
- New international initiative on socio-economic benefits
  - Coordination Group on Meteorological Satellites (CGMS) Socio-Economic Tiger Team (SETT)
  - Established July 2013: Representatives from NOAA, NASA, EUMETSAT, ESA, JMA, WMO
  - Purpose: To develop a credible methodology and common terminology for articulating the socio-economic benefit of satellite observing systems; to explore the most effective ways to communicate this information to desired stakeholders

CGMS SETT

Activities for 2013–15

- Review relevant socio-economic benefit and return on investment studies and activities
- Identify relevant socio-economic expertise in CGMS members, the WMO and related institutions
- Identify key application areas and gather examples – case studies in such areas that can illustrate the benefit – for communications purposes
- Evaluate approaches and methodologies used to understand the value of satellite observing systems among all observing systems and satellite observing systems in the entire value chain
- Review terminology for accuracy, consistency and accessibility to non-technical audiences

SETT Facilitator: Charles Wooldridge NOAA/NESDIS

Summary

- NOAA's satellite programs contribute to the global observing system and provide decision-driving information.
- Interagency and international partnerships are essential to NOAA's satellite missions.
- Observations coupled with modeling, data fusion and the underpinning research are essential for transforming observations to the products, applications and services needed to address environmental impacts on society and improve decisions.