

Remote Sensing of the Earth
by NASA's Polar Orbiting Satellites

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Note: In PDF format most of the images in this web paper
can be enlarged for greater detail.

The Looming Gap in Earth Satellite Coverage

"The United States is facing a year or more without crucial satellites that provide invaluable data for predicting storm tracks, a result of years of mismanagement, underfunding and delays in launching replacements, according to several recent official reviews. The looming gap in satellite coverage, which some experts now view as almost certain to occur within the next few years, could result in shaky forecasts about storms."

"The endangered satellites fly pole-to-pole orbits and cross the Equator in the afternoon, scanning the whole planet one strip at a time. Along with orbiters on other timetables, they are among the most effective tools used to pin down the paths of major storms around five days ahead." "Experiments show that without this kind of satellite data, forecasters would have underestimated by half the massive snowfall that hit Washington in the 2010 blizzard."

"Experts have grown increasingly alarmed in the past two years because the existing polar satellites are nearing or beyond their life expectancies, and the launching of the next replacement, known as **JPSS-1**, has slipped until early 2017, probably too late to avoid a gap of at least a year."

"What Is JPSS?"

The Joint Polar Satellite System (JPSS) is the Nation's next generation polar-orbiting operational environmental satellite system, procured by the National Oceanic and Atmospheric Administration (NOAA), through the National Aeronautics and Space Administration (NASA). JPSS will provide continuity of critical observations for accurate weather forecasting, reliable severe storm outlooks, **global measurements of atmospheric and oceanic conditions such as sea surface temperatures, ozone, and more.**" Web Reference: <http://www.jpss.noaa.gov/>

"Prodded by lawmakers and auditors, the satellite's managers are just beginning to think through their alternatives when the gap arrives, but these are unlikely to avoid it." **The mismanagement of the \$13 billion program, which goes back a decade**, was recently described as a "national embarrassment" by a top official of the Commerce Department."

"This summer, three independent reviews—by the Commerce inspector general, the Government Accountability Office, and a blue-ribbon team of outside experts—each questioned the government's cost estimates for the program, criticized the program's managers for not pinning down the designs and called for urgent remedies. The project is run by Commerce's National Oceanic and Atmospheric Agency, along with NASA. The outside review team, led by A. Thomas Young, an aerospace industry leader, called the management of the program "dysfunctional."

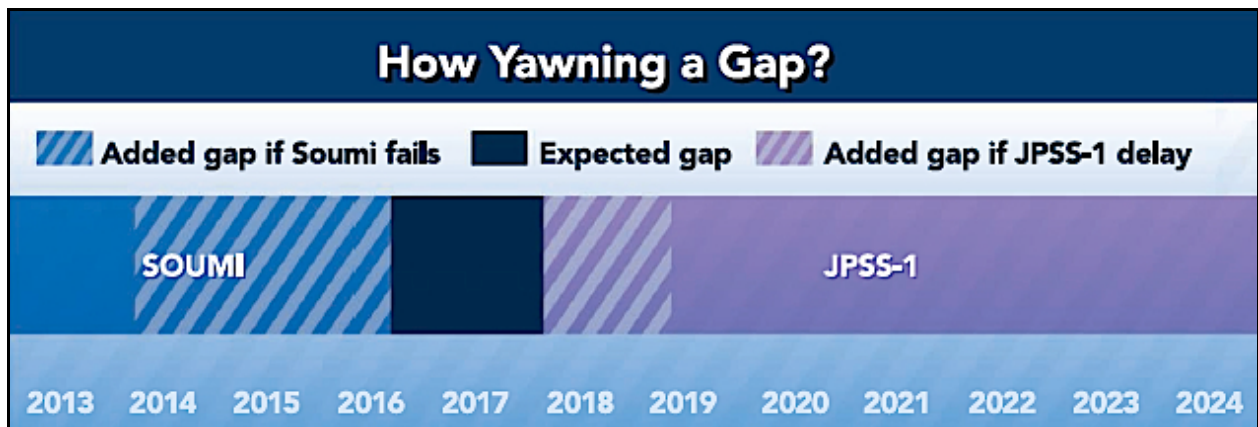
"In response, top Commerce and NOAA officials on Sept. 18 ordered what they called an urgent restructuring—just the latest overhaul of a program that has been troubled for many years. They streamlined the management, said they would fill key vacancies quickly, demanded immediate reports on how the agency might try to cope with the gap. They have moved quickly to nail down the specific designs of the JPSS1's components, many of them already partly built. And they promised to quickly complete a new independent cost estimate to verify the program's budget."

"There is no more critical strategic issue for our weather satellite programs than the risk of gaps in satellite coverage," wrote Jane Lubchenco, the undersecretary of Commerce responsible for NOAA, in her memorandum ordering the changes. Ms. Lubchenco wrote that the administration had been trying all along to fix "this dysfunctional program that had become a national embarrassment due to chronic management problems."

"It is a long, sad history," said Dennis Hartmann, the chairman of a broad review of Earth observing satellite programs released in May by the National Research Council. The report projected a dismal decline in what has been among the crown jewels of modern Earth and atmospheric science. **"The JPSS (for Joint Polar Satellite System) also includes important sensors for studying the global climate, and these too are at risk."**

The above text are excerpts from 2012-10-26 "Aging Satellite Fleet May Mean Gaps in Storm Forecasts" by John H. Cushman Jr., New York Times.

Web Reference: <http://fire.biol.wvu.edu/trent/alles/AgingSatelliteFleetArticle.pdf>



Blind spot. Weather forecasters are facing a 17-month gap in data collection by U.S. polar-orbiting satellites. The gap could be as long as 53 months if the Soumi satellite fails early or the JPSS-1 orbiter is delayed. (See page 16 for article by David Malakoff.)

A Short History of Earth Monitoring from Space



They call it the Blue Marble.

This view of Earth's horizon as the sun sets over the Pacific Ocean was taken by an Expedition 7 crewmember onboard the International Space Station (ISS).

APOD-2008 April 12 - Yuri's Planet
<http://apod.nasa.gov/apod/ap080412.html>

Image Credit: ISS Expedition 7 Crew, EOL, NASA
ISS007-E-10807 (image captured on **21 July 2003**)

Image Record
<http://eol.jsc.nasa.gov/scripts/sseop/photo.pl?mission=ISS007&roll=E&frame=10807>



1968—Earthrise from the Moon taken by the Apollo 8 Mission

Web References

<http://en.wikipedia.org/wiki/Earthrise>

<http://www.nasa.gov/centers/johnson/home/earthrise.html>



1969—Earth from the Moon taken by the Apollo 11 Mission

Web Reference

<http://earthobservatory.nasa.gov/IOTD/view.php?id=4882>



1972—Eastern Hemisphere from Apollo 17

Above is the **Blue Marble**, a famous photograph of the Earth taken on December 7, 1972 by the crew of the Apollo 17 spacecraft at a distance of approximately 45,000 km (28,000 mi) from Earth.

Web Reference

http://en.wikipedia.org/wiki/The_Blue_Marble

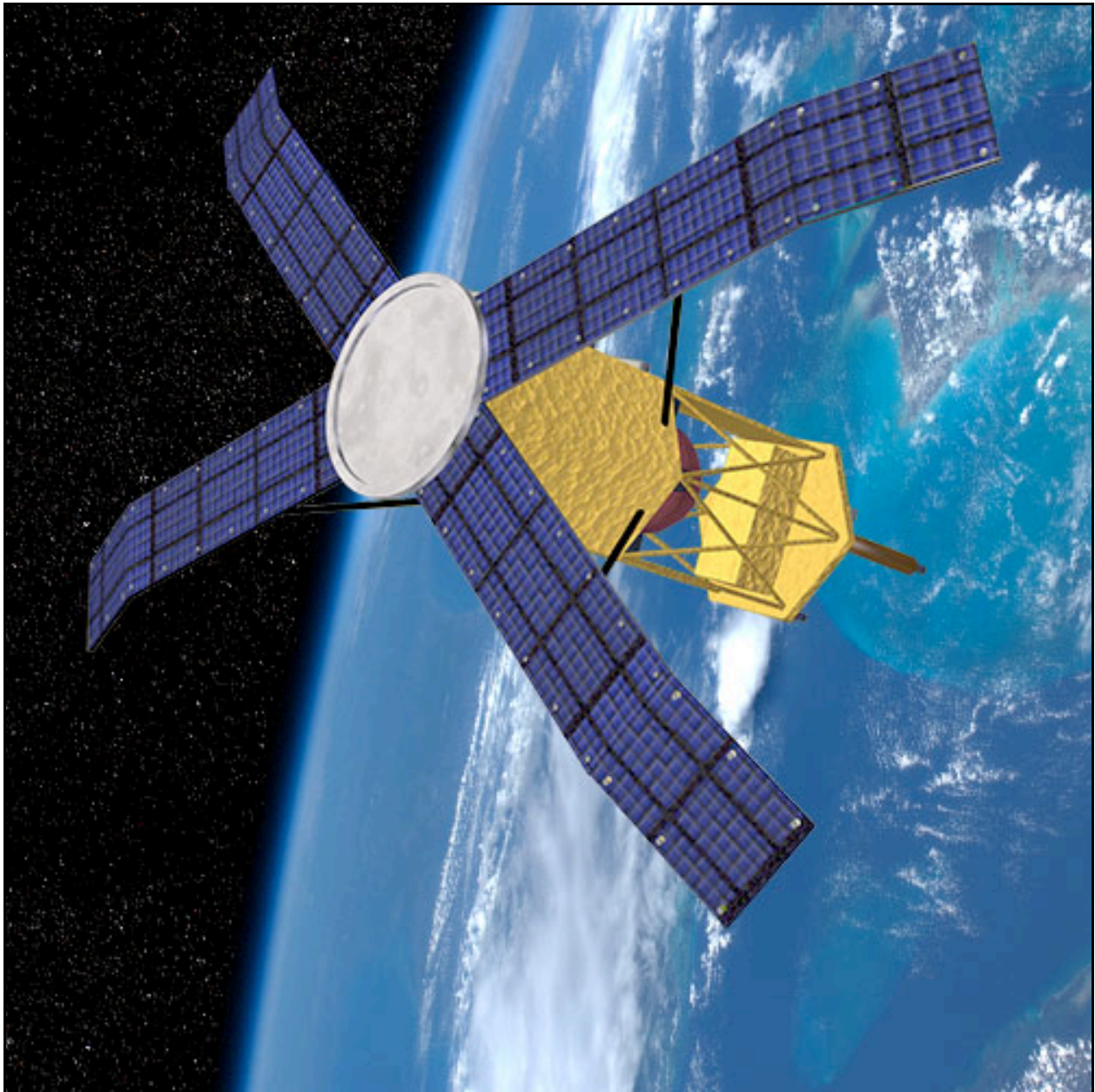


This image of the Earth and Moon was captured by NASA's Galileo spacecraft as it sped away towards Jupiter in **1992**.

Web Reference

<http://www.universetoday.com/14112/photos-of-the-earth-and-moon-from-other-worlds/>

- **SeaWiFS** was launched **August 1, 1997**, and ceased operation in 2010 after a remarkable 13 year long mission.



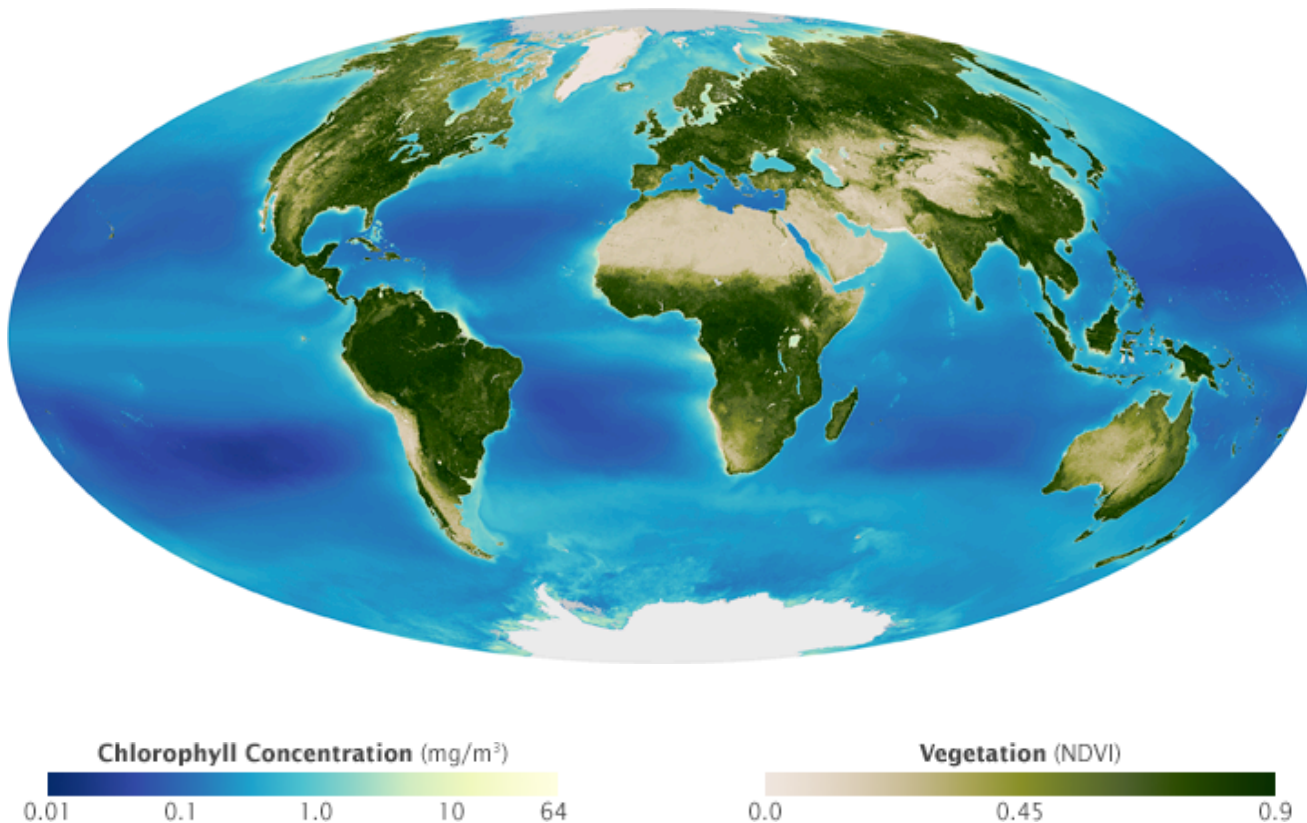
NASA's SeaWiFS Satellite

Web References

<http://oceancolor.gsfc.nasa.gov/SeaWiFS/BACKGROUND/>

<http://oceancolor.gsfc.nasa.gov/SeaWiFS/>

Thirteen Years of Greening from SeaWiFS



“Many people said it would never get off the ground; some said it wouldn’t last a year,” notes NASA ocean scientist Gene Carl Feldman. “The mission was planned for five years. We got 13 years of incredible data out of this amazing little satellite.”

From 1998 to 2010, the Sea-viewing Wide Field-of-view-Sensor, or SeaWiFS, made a simple but elegant measurement: how “green” is the Earth. That is, how much chlorophyll—the pigment that helps turn sunlight into organic energy for plants—is present in the seas and on land. Those measurements offered a window into the planet’s ability to support life. The long, well-calibrated data record also gives scientists one of the best benchmarks to study the planet’s biological response to a changing environment. The image above shows SeaWiFS data as a global average over the entire 13-year record.

For the oceans, the colors represent the concentration of chlorophyll and indicate where phytoplankton most often bloomed since 1998. On the land, data are depicted as a Normalized Difference Vegetation Index (NDVI), which shows the density of green vegetation. An NDVI of zero means no green plants and a high value (0.8 or 0.9) is a thick canopy of green leaves.

SeaWiFS was NASA's first "data buy" mission, in which a private company (Orbital Sciences) designed and built the instrument and spacecraft to NASA specifications and NASA agreed to purchase the data as long as it met certain scientific requirements. (In later years, GeoEye operated the spacecraft.) The OrbView-2 spacecraft, which carried SeaWiFS, stopped communicating with Earth-based data stations in December 2010. After several months trying to revive the link, flight controllers officially ended the mission in February 2011.

SeaWiFS was designed to measure ocean color. This seemingly narrow measurement captures the fundamental biological activity at the ocean surface, the blooming and die-off of the phytoplankton that form the center of the oceanic food web. Its abundance is a direct indicator of the seas' ability to support life. It also plays a central role in the oceans' carbon uptake. SeaWiFS also was used to offer real-time monitoring of red tides and other harmful algae, which can bloom in polluted waters and be deadly to fish and oysters.

Modifications made to SeaWiFS before launch also allowed it to make a similar kind of measurement of plant color on land. This ability to see all of the planet's plant life with a single, well-calibrated instrument produced a first-of-its-kind snapshot of the Earth's biosphere in 1998, similar to the image above.

"There is no question that the Earth is changing," said Feldman, SeaWiFS project manager at NASA's Goddard Space Flight Center. "SeaWiFS enabled us for the first time to monitor the biological consequences of that change—to see how the things we do, and how natural variability, affect the Earth's ability to support life."

Web References

Thirteen Years of Greening from SeaWiFS

<http://earthobservatory.nasa.gov/IOTD/view.php?id=49949>

Phytoplankton: <http://earthobservatory.nasa.gov/Features/Phytoplankton/>

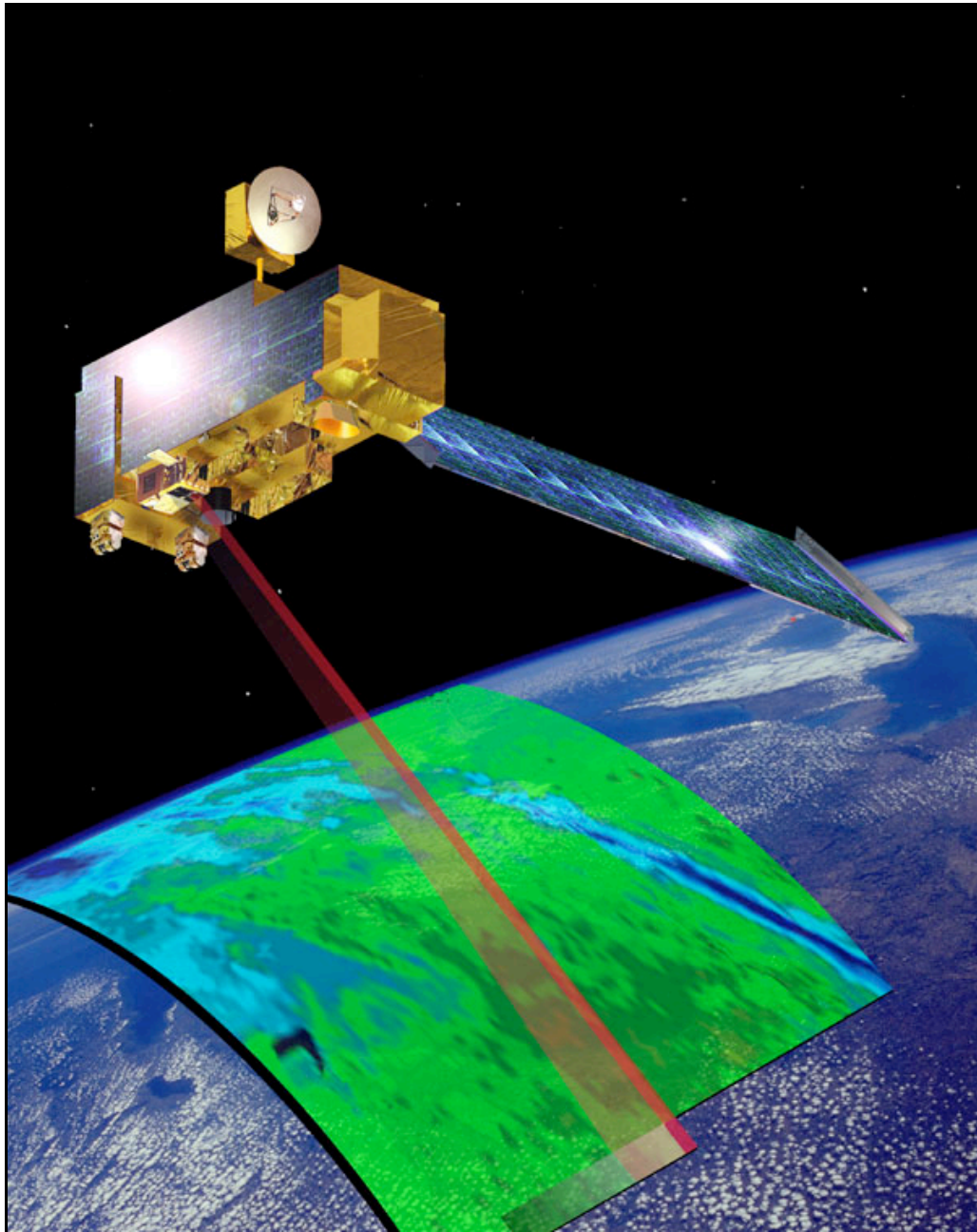
Normalized Difference Vegetation Index (NDVI):

<http://earthobservatory.nasa.gov/Features/MeasuringVegetation/>

Oceans' Carbon Uptake

<http://earthobservatory.nasa.gov/Features/OceanProductivity/>

- NASA's **Terra** satellite was successfully launched on **December 18, 1999**.



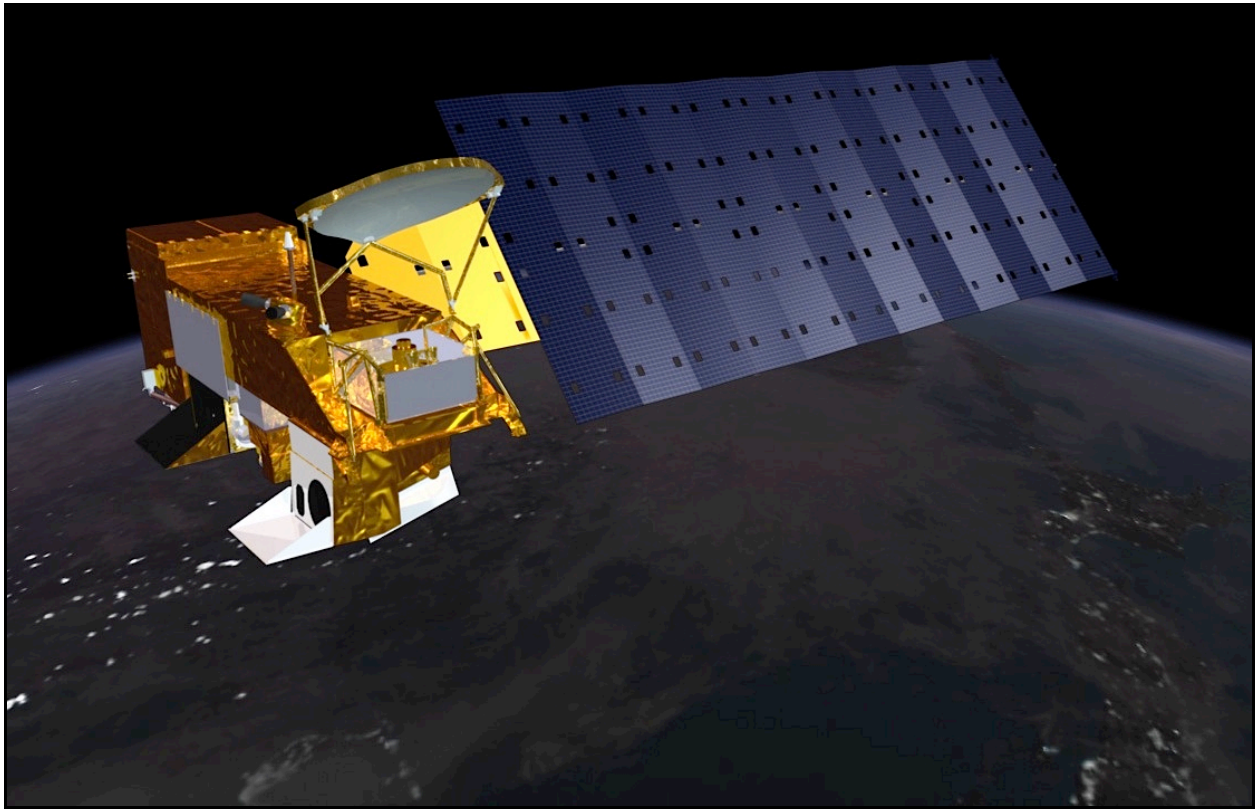
NASA's Earth Monitoring Satellite Terra

As of **June 19, 2013** Terra is still operational.

Web Reference

<http://www2.hawaii.edu/~jmaurer/terra/>

- NASA's **Aqua** satellite was successfully launched **May 4, 2002**.



NASA's Earth Monitoring Satellite Aqua

As of **June 8, 2014**, Aqua is still operational.

Web Reference

[http://en.wikipedia.org/wiki/Aqua_\(satellite\)](http://en.wikipedia.org/wiki/Aqua_(satellite))

For Near Real Time images from both Terra and Aqua go to:
<http://lance-modis.eosdis.nasa.gov/cgi-bin/imagery/realtime.cgi>

For more about the MODIS instrument aboard both Terra & Aqua:
<http://modarch.gsfc.nasa.gov/>



• NASA's **Glory** polar orbital satellite failed to reach orbit after launch at 5:10 EST, **March 4, 2011**. The new Earth-observing satellite was intended to improve our understanding of how the sun and tiny atmospheric particles called aerosols affect Earth's climate.



An artist's representation of Glory if it had reached orbit.

References on Glory's Failure

1. *Mourning Glory*—NASA satellite crash will hamper solar monitoring and aerosol measurements vital to improving climate models. By Jeff Tollefson, *Nature*, Vol. 471, 10 March 2011. For full article go to:

http://fire.biol.wvu.edu/trent/alles/Glory_failure_in_Nature_Journal.pdf

2. *Warning Issued for Looming Data Gap From Fleet of Weather Satellites*—U.S. policymakers are becoming increasingly alarmed about a looming gap in critical weather forecasting data collected by the nation's satellites. By David Malakoff *Science*, Vol. 339, 22 February 2013.

For full article go to: <http://fire.biol.wvu.edu/trent/alles/LoomingDataGap.pdf>

NASA Web References on Glory

Glory Press Releases

<http://glory.gsfc.nasa.gov/>

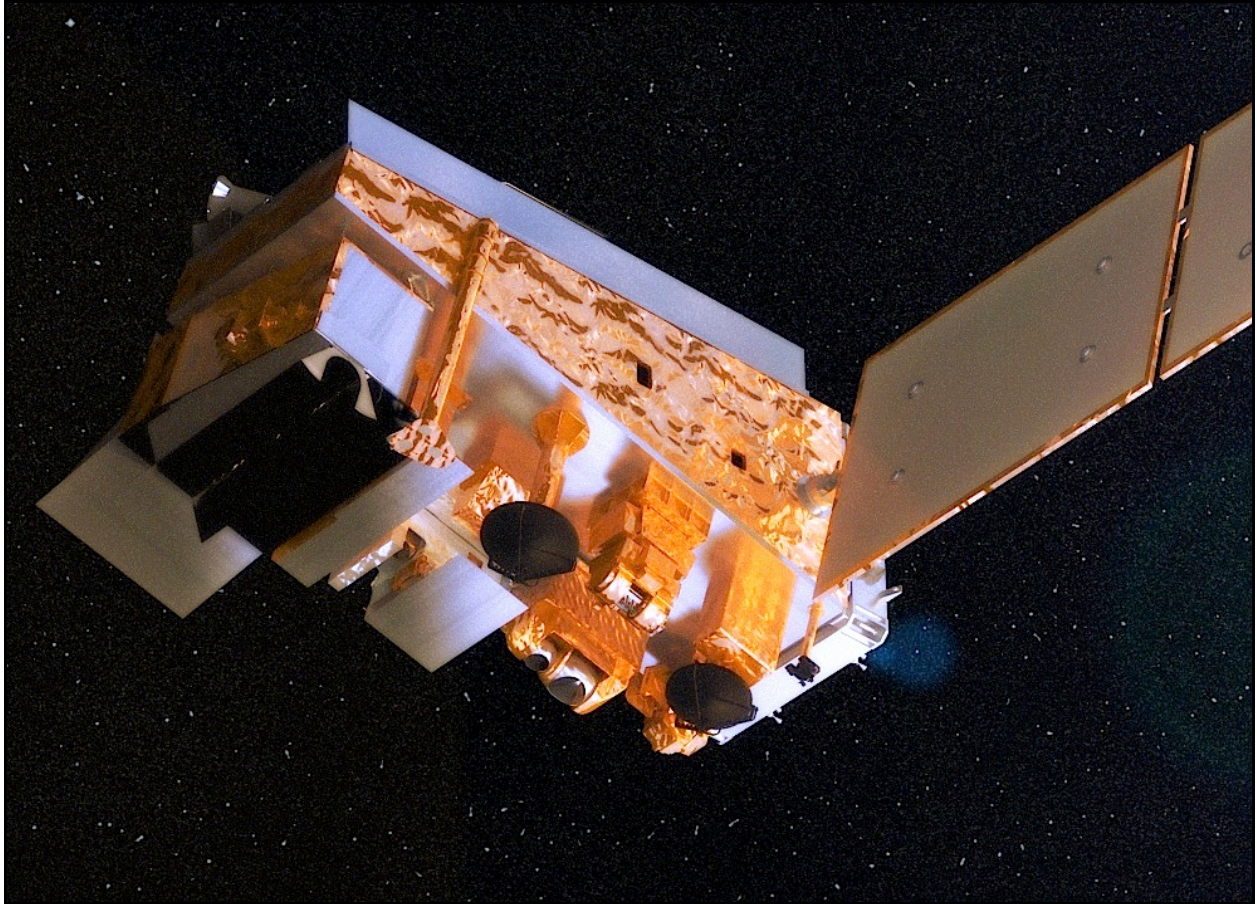
Glory Mission Latest News

http://www.nasa.gov/mission_pages/Glory/main/index.html

Glory Investigation Public Release Summary

http://www.nasa.gov/mission_pages/Glory/news/mishap-board-report.html

<http://glory.gsfc.nasa.gov/history.html>



Suomi National Polar-orbiting Partnership (NPP) Satellite

The Suomi National Polar-orbiting Partnership spacecraft lifted off at 5:48 a.m. EDT on Oct. 28, 2011, to begin its Earth observation mission. The spacecraft was lifted into orbit by a United Launch Alliance Delta II rocket launching from Vandenberg Air Force Base, Calif.

Web Reference

http://npp.gsfc.nasa.gov/mission_details.html



Blue Marble 2002—North America from Space

Image captured by the MODIS instrument aboard the Terra satellite.

Web References

http://earthobservatory.nasa.gov/Features/BlueMarble/Images/globe_west_2048.jpg



Blue Marble 2002—the Eastern Hemisphere from Space

Image captured by the MODIS instrument aboard the Terra satellite.

Web Reference

http://earthobservatory.nasa.gov/Features/BlueMarble/Images/globe_east_2048.jpg



Blue Marble 2005—Western Hemisphere from Space

The 2005 Earth imagery enhanced the Blue Marble legacy by providing a detailed look at an entire year in the life of our planet with twice the level of detail as the original. Blue Marble: Next Generation is a mosaic of satellite data taken mostly from NASA's sensor the Moderate Resolution Imaging Spectroradiometer (MODIS) that flies board NASA's Terra and Aqua satellites.

Web Reference

http://www.nasa.gov/vision/earth/features/blue_marble.html



Blue Marble 2005—the Eastern Hemisphere from Space

Blue Marble 2005: Next Generation offers greater spatial detail of the surface and spans a longer data collection period than the original. The original Blue Marble was a composite of four months of MODIS observations with a spatial resolution (level of detail) of 1 square kilometer per pixel. Blue Marble 2005: Next Generation offers a year's worth of monthly composites at a spatial resolution of 500 meters.

Web Reference

http://www.nasa.gov/vision/earth/features/blue_marble.html



Blue Marble 2012— Western Hemisphere from Space

On **25 January 2012**, NASA released a composite image of the western hemisphere of Earth entitled *Blue Marble 2012*. This and the following image were composed of data obtained by the **VIIRS** instrument on-board the **Suomi National Polar-orbiting Partnership (NPP) satellite**. The data was obtained from six orbits of the Earth on 4 January 2012 by the Suomi NPP over an eight hour period.

Web Reference

<http://www.flickr.com/photos/gsf/6760135001/>



Blue Marble 2012—the Eastern Hemisphere from Space

On **2 February 2012**, NASA released a companion to the previous new Blue Marble, showing a composite image of the eastern hemisphere from data obtained on 23 January 2012 by the **Suomi NPP satellite**.

Web Reference

<http://www.flickr.com/photos/gsf/6806922559/>



Earth at Night Full Disk Western Hemisphere

This new global view of Earth's city lights is a composite assembled from data acquired by the **Suomi satellite**. The data was acquired over nine days in April 2012 and 13 days in **October 2012**. It took 312 orbits to get a clear shot of every parcel of Earth's land surface and islands. This new data was then mapped over existing Blue Marble imagery of Earth to provide a realistic view of the planet.

The image was made possible by the satellite's "day-night band" of the Visible Infrared Imaging Radiometer Suite, which detects light in a range of wavelengths from green to near-infrared and uses filtering techniques to observe dim signals such as city lights, gas flares, auroras, wildfires and reflected moonlight.

The day-night band observed Hurricane Sandy, illuminated by moonlight, making landfall over New Jersey on the evening of Oct. 29. Night images showed the widespread power outages that left millions in darkness in the wake of the storm. *Image credit: NASA's Earth Observator /NOAA/.*

Web Reference

<http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=79787>



October 2012 Larger View

Web Reference

<http://dotearth.blogs.nytimes.com/2012/12/06/the-not-so-dark-side-of-earth/>