Environmental Products from NOAA Satellites

Stacy L. Bunin

People are accustomed to seeing weather satellite imagery on the news. Learn about the wide variety of other environmental products generated from satellites.

The National Oceanic and Atmospheric Administration (NOAA) operational environmental satellite system consists of two types of satellites. The Geostationary Operational Environmental Satellites (GOES) orbit at an altitude of 35,800 km over fixed locations relative to Earth's surface, allowing for continuous monitoring of environmental phenomena. The Polar-orbiting Operational Environmental Satellites (POES) orbit Earth 14 times per day at an altitude of 830 to 870 km, giving environmental information for the entire globe. Together, data from the GOES and POES satellites provide for a global environmental monitoring system. Oceanic, atmospheric, and land surface products are derived on a variety of temporal and geographic scales. These products are used for short-term warnings, long-term forecasting, and climate and hydrological applications, both domestically and internationally. Satellite-derived products are critical to the user community. Each product provides a data point for understanding, explaining, and predicting weather and environmental phenomenon.

Ocean products

Sea surface temperature

The oceans play a major role in the global climate. Satellite measurements give important information about conditions over ocean areas lacking in widely available surface observations. Sea surface temperature observations are used as input to weather forecasting and climate models. Specific features can be used for understanding the impact of hurricanes, the prime locations for tracking marine life, and for identifying temperature gradients in the ocean, such as El Niño and La Niña events and the Atlantic Gulf Stream.[1]

Inside Track

- Environmental data from NOAA's satellites include ocean, atmosphere, and land surface products.
- Meteorological, hydrological, marine, agricultural, and transportation user communities all use NOAA's environmental satellite products.
- Environmental products provide information for understanding, explaining, and predicting weather and environmental phenomenon.
- Improved future technologies will enhance the products for the benefit of all users.

Sea surface temperature observations are generated from each POES orbit and are used to produce a daily global product, bi-weekly regional products that cover the coastal US with fields such as the East Coast, bi-weekly local products with fields including the Great Lakes and Gulf of Mexico, and a global monthly mean product. Coastal sea surface temperature products are generated from higher resolution data, which provide more detailed sea surface temperature information for environmental uses along the US coastlines. POES data are used to generate sea surface temperature anomalies. The anomalies are calculated by determining the difference between the sea surface temperature and the climatic norms, which are based on the monthly mean observations from 1984–1993. (Data from 1991 and 1992 are excluded from these calculations because the significant amount of aerosols in the atmosphere following the eruption of Mt. Pinatubo affected the accuracy of sea surface temperature retrievals.) These anomalies are used to gauge the development of El Niño, to monitor ocean temperature cooling conditions following the passage of a hurricane, and determine the extent of coral reef bleaching.[2]

GOES sea surface temperature images for the full Earth disk are provided every three hours, while regional analyses are provided hourly. The frequent imaging allows for a higher chance to obtain cloud-free images to give a complete understanding of current sea surface temperature.[2]

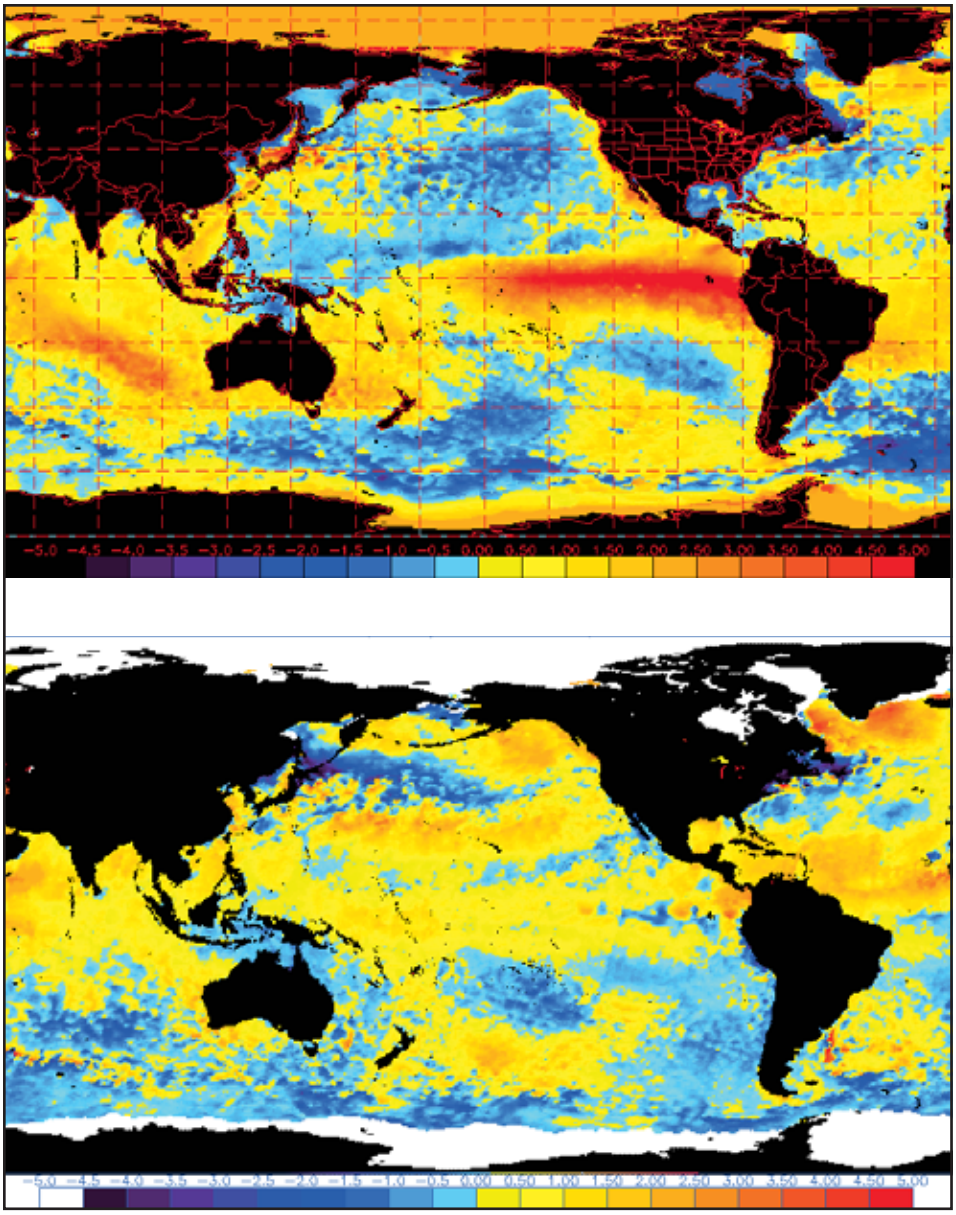

Figure 1. The higher than normal temperatures associated with El Niño off the western coast of South America are evident in this sea surface temperature anomaly image (top) from January 5, 1998. The image on the bottom shows the anomalies from May 31, 2005 when no El Niño is present. Credit: NOAA.

Coral reef bleaching

Coral reefs are sensitive ecosystems that support a vast array of animal and plant species. Coral reef bleaching can occur with the thermal stress associated with above average sea surface temperatures. Corals that might become damaged or die as a result of severe bleaching events can be located by tracking and analyzing sea surface temperature data.

Coral bleaching early warning products such as coral reef bleaching hotspots and tropical ocean coral bleaching indices are generated using the sea surface temperature anomalies. Degree heating weeks are also generated from the anomalies and indicate the amount of thermal stress that a coral reef has experienced over the last 12 weeks.

Ice cover

Sea ice forms in the higher latitudes of the oceans in the Arctic and Antarctic and fresh water ice forms over lakes and rivers in the continental US, notably in the Great Lakes, Chesapeake and Delaware Bay systems, and over important ports and transportation arteries along the East Coast. Studying sea and lake ice and its changes is important for scientists, as it is a factor in global change. As ocean and surface temperatures increase or decrease, the coverage of sea ice can change drastically over a short period of time.[3] This makes frequent observations important to many industries, including those that rely on shipping and maritime services, since the lack of information on the changes in sea ice or fresh water ice boundaries or the locations of icebergs on the open seas could lead to disastrous accidents.[1]

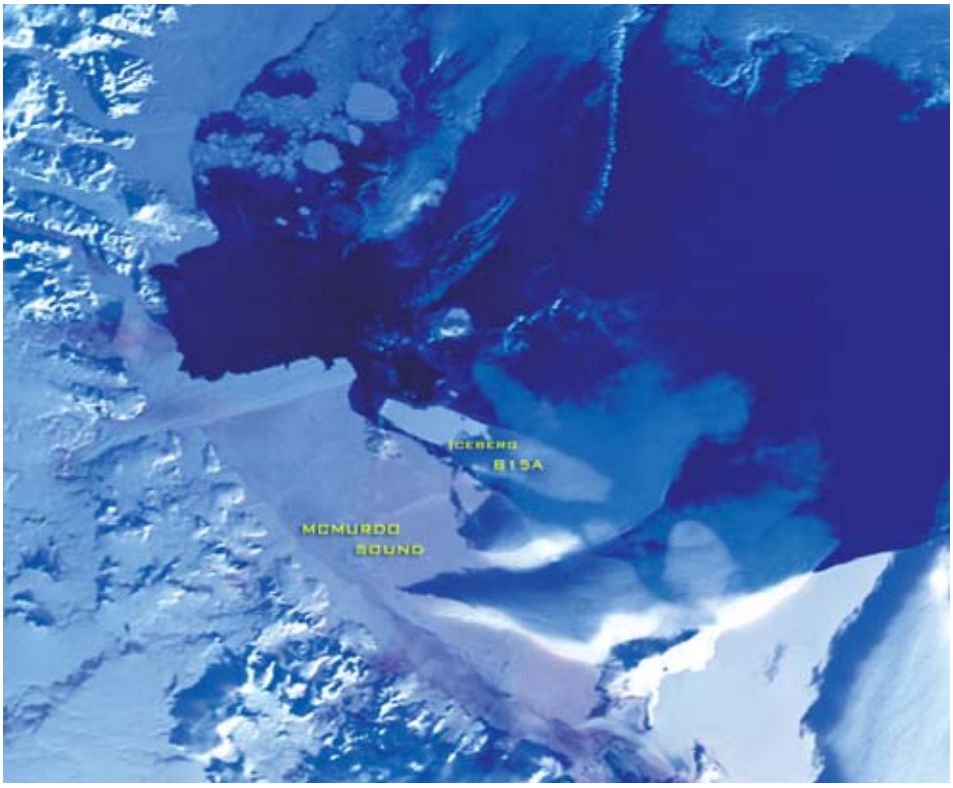

Figure 2. On December 12, 2004, a POES satellite observed Iceberg B15A in McMurdo Sound, Antarctica, which was reportedly blocking access to penguin colony feeding grounds and potentially blocking shipping access to scientific stations in the sound. Credit: NOAA.

Atmosphere products

Aerosol

Aerosols are particles in the atmosphere including dust, ash, and smoke. They are created by dust storms, volcanic eruptions, and smoke from fires and have an effect on aircraft, air quality, and health. The tracking of aerosols is useful for climate studies, the aviation sector, and atmospheric circulation research. Total column aerosol optical thickness products are generated from the POES satellites over the global oceans. The orbital observations are used to generate weekly and monthly products.

Atmospheric moisture and temperature soundings

When forecasting weather, meteorologists use numerical weather prediction models as a guide. These models often make use of atmospheric temperature and moisture profiles. Satellite observations provide meteorologists with a source of global information on the atmosphere. POES satellites provide approximately 300,000 retrievals of atmospheric temperature and 1,400,000 moisture retrievals on a daily basis.[4] Atmospheric temperature and moisture soundings from GOES and POES are provided for specific pressure levels throughout the atmosphere between 1,000 and 0.1 millibars.

Atmospheric imagery

Cloud imagery is used to detect weather systems and forecast their movement. Imagery is utilized to support the hazards missions of severe weather, heavy precipitation, smoke, and tropical cyclone and volcanic ash analyses. Atmospheric imagery includes visible, infrared, and water vapor images. Visible images are only available during daylight hours and represent the amount of sunlight being scattered back into space by the clouds, aerosols, atmospheric gases, and the Earth's surface. Thicker clouds have a higher reflectivity and appear brighter than thinner clouds on a visible image. Infrared satellite measurements are related to the brightness temperature, where warmer objects appear darker than colder objects. Clouds appear as white, while the warmer ground or ocean surface appears darker. Water vapor images help to determine the amount of moisture in the atmosphere. Darker colors indicate drier air, while brighter shades of white indicate progressively moister air.[5]

Visible and infrared images are generated daily from POES satellite data for the entire globe. Imagery from POES is particularly important to the northern latitudes, which are beyond the range of GOES coverage. The GOES satellites provide infrared, visible, and water vapor imagery in full disk coverages and for selected sectors. In addition, fog and low cloud imagery are available for the aviation community to help identify ceilings below 1,000 feet.

Earth radiation budget

Radiation budget products describe the distribution of the incoming and outgoing radiation at the top of the atmosphere and are used to study global climate change. Radiation is emitted by the Earth into space, and the outgoing long wave radiation (OLR) products provide this information for the climate community. Short wave absorbed solar radiation (SWAR) is a measure of how much solar radiation is absorbed and is calculated as the difference between the incoming and outgoing solar radiation at the top of the atmosphere. OLR and SWAR products are generated from POES data. Orbital radiation budget observations are used to create products on a variety of time scales, including daily analyses and monthly, seasonal, and annual means.

Ozone

A layer of ozone occurs naturally in the upper atmosphere and helps to keep damaging ultraviolet radiation from reaching the Earth's surface. Scientists use satellite measurements to identify changes in stratospheric ozone levels, particularly over the southern hemisphere's ozone hole. Using these satellite measurements, scientists study the long-term changes in the ozone levels to measure the extent of climate change.[2]

Precipitation

Rain rate products are generated in order for scientists and forecasters to determine the location and intensity of rainfall across

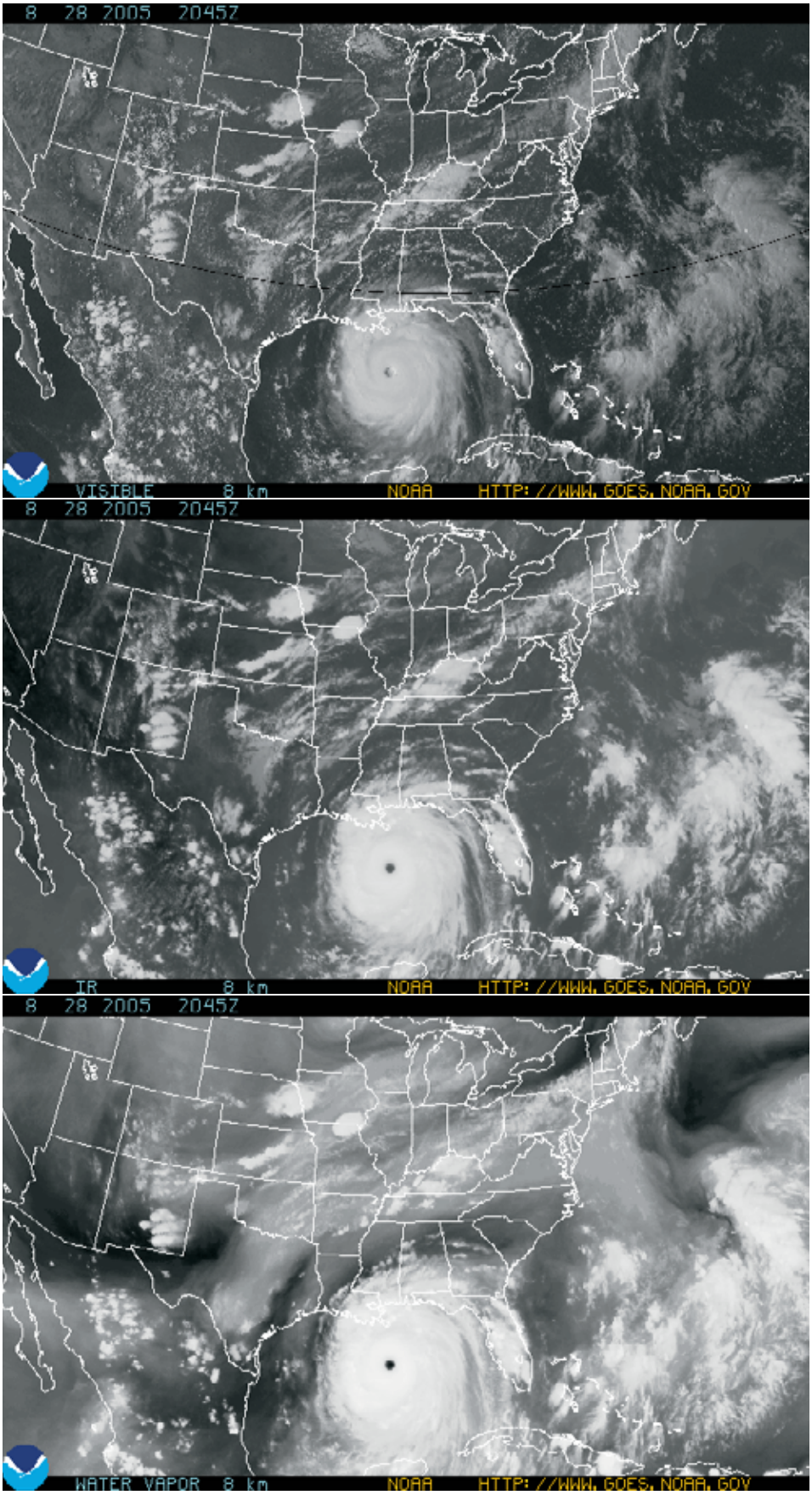

Figure 3. Visible (top), infrared (center), and water vapor (bottom) imagery shows Hurricane Katrina from the GOES East satellite. Credit: NOAA.

the globe. The products are also used to estimate rainfall potential for tropical systems. Rain rate estimates are used by forecasters as guidance for weather systems, such as tropical cyclones, having the potential for flooding prior to making landfall. Rain rates from each POES orbit are used to estimate short-term rainfall, while the GOES satellite data provide estimates of heavy precipitation amounts during convective storms, winter storms, and lake effect snow events.

Stability

Stability products provide information about the state of the atmosphere and are indicators of where convection may occur. They include products such as lifted index, convective available potential energy, maximum expected hail size, and the freezing level. Tracking stability parameters gives a user the opportunity to see dynamic changes within weather events. Stability products are generated from GOES satellites on an hourly basis. Their coverage includes the Continental US and adjacent ocean areas.

Volcanic ash

Volcanic ash poses a risk to people in the vicinity of an eruption as well as to aircraft thousands of miles away during major eruptions. The detection and tracking of volcanic ash plumes are particularly useful to the air traffic industry since volcanic ash can cause damage to jet engines which could result in engine shutdowns.[6] Volcanic ash plumes are monitored from both POES and GOES satellites. While the data from polar-orbiting satellites is important for detecting ash in the higher latitudes, their less frequent capture rate means a volcanic eruption might not be detected immediately, making them more useful for ongoing volcanic events.[7]

Atmospheric winds

Atmospheric wind products are used by numerical weather prediction modeling centers across the globe. Wind data are useful for forecasters in understanding the motion of weather systems and tropical storms. Infrared and water vapor imagery from GOES data are used to derive wind velocity estimates at multiple levels throughout the atmosphere, as well as indications of the vertical wind shear.

Land surface products

Fire analyses

Large fire events, such as forest fires, can be detected from environmental satellites. Analyses are used by forestry services and emergency managers. Some fire events attract the attention of the media, which occasionally uses satellite images to relay additional information on the fires to the public. Fire potential areas show where weather conditions exist that are conducive to wild fires.

Scientists use infrared POES data to detect the high temperatures of large fires and to track fire and smoke events. A trained analyst manually integrates data from various automated fire detection algorithms to create a quality-controlled display of fire locations and their smoke plumes. GOES data is used to detect significant fire and smoke events. In addition, it is used to detect and monitor fires and smoke, prescribed burns, deforestation, and other agricultural applications throughout the Western Hemisphere related to biomass burning.

Snow cover

By detecting changes in snow cover, it is possible to better understand cloud and storm patterns, the hydrologic cycle, surrounding surface and air temperatures, and areas that have the potential of having disastrous flooding.[8] Snow cover data and snow maps are critical inputs for numerical weather prediction models and can be used for climate studies. Snow water equivalent is beneficial for hydrological applications by providing information related to the melting of snow pack. Visible imagery from both GOES and POES are analyzed to detect the snow and ice fields and to create a daily snow and ice chart.

Vegetation

By measuring vegetation using satellite data, seasonal and climatic variations can be determined. Areas with the potential for drought conditions or wildfires can be detected by measuring the health and moisture content of the vegetation. Daily vegetation products are generated from POES and are used to create a weekly product. Because vegetation does not change significantly over a seven day period, this method helps to accumulate more vegetation data than can be obtained on a daily basis because areas obscured by clouds on one day will likely not be cloudy for the whole week.[2]

Looking ahead

The data from POES and GOES has become a significant tool for weather forecasting, climate studies, and understanding the Earth's environment. Plans are in place for future polar-orbiting and geostationary environmental satellite systems that will continue to provide data on the oceans, atmosphere, and land surface. Future instruments will provide more data as well as new types of data. New product areas will include ocean surface wind vectors for better understanding of tropical cyclones and for providing the maritime industry with additional data to supplement surface-based buoys; ocean color for monitoring red tides and other potentially dangerous biological events that can threaten human health; sea surface height and topography useful for estimating both hurricane intensity and small- to large-scale ocean circulations and for studying global change; and direct measurement of tropospheric winds for the improvement of weather forecasts. Higher resolution imagery and more accurate atmospheric moisture and temperature soundings from hyperspectral instruments will also be available. These new and improved products will ultimately have a positive impact on forecasting agencies, researchers, and the public. ❖

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Additional resources

- NESDIS Center for Satellite Applications and Research, http://www.orbit.nesdis.noaa.gov.
- NESDIS Office of Satellite Data Processing and Distribution, http://www.osdpd.noaa.gov.
- NESDIS Satellite Products Overview Display, http://satprod.osd.noaa.gov.

Stacy L. Bunin is a principal meteorologist at Mitretek, where she primarily supports the National Environmental Satellite, Data, and Information Service. She is currently determining requirements for operational product generation and distribution continuity during the next era of polar-orbiting weather satellites. She received her master's degree in space studies from the University of North Dakota. Contact her at sbunin@mitretek.org.