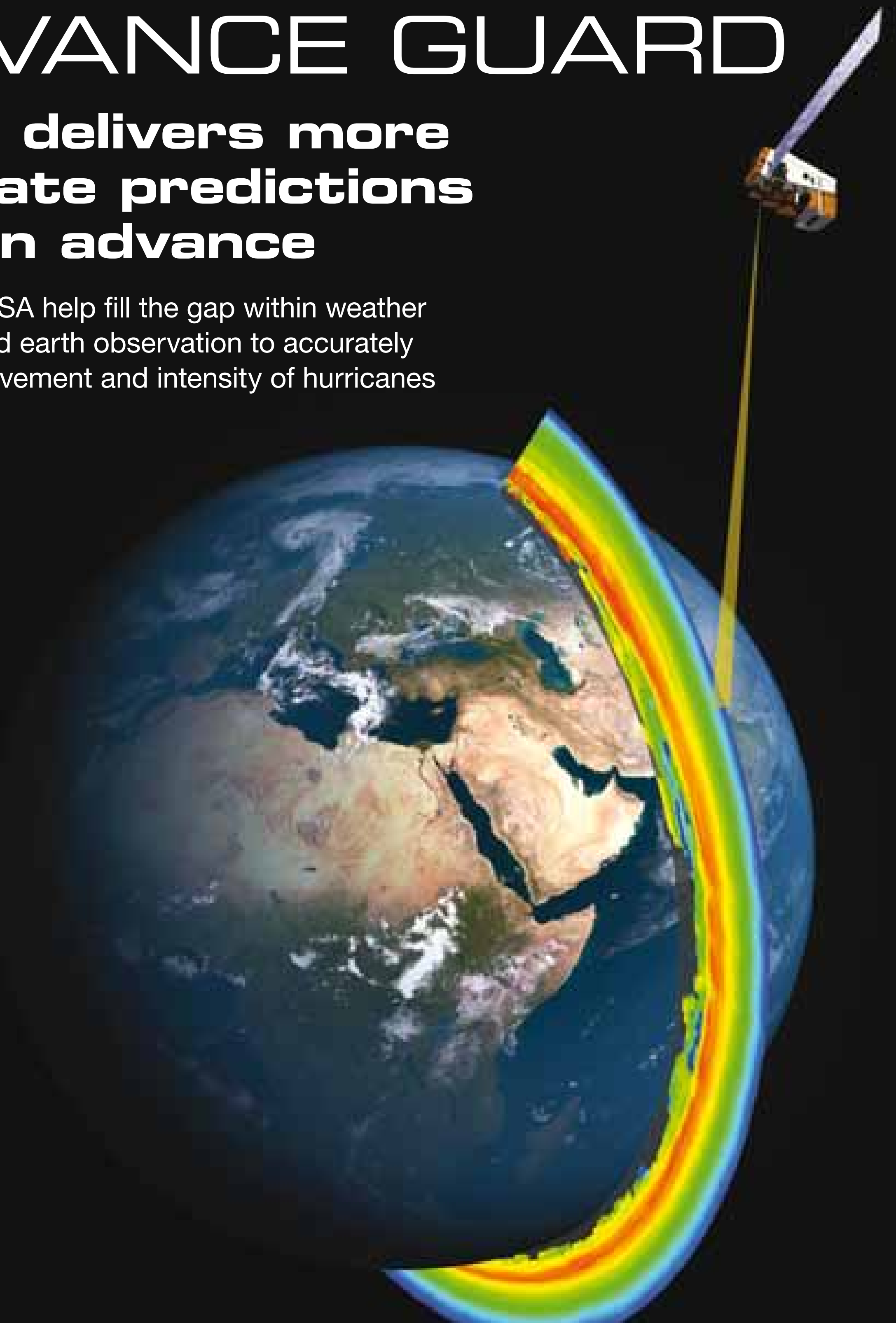
by Scott C. Asbury

ADVANCE GUARD

JPSS delivers more accurate predictions days in advance

NOAA and NASA help fill the gap within weather forecasting and earth observation to accurately predict the movement and intensity of hurricanes



Picture credit: NASA/NOAA

A new generation of Earth-observing satellites is making a dramatic difference in the ability of scientists to predict short and long duration weather events and long-term climate change. The Joint Polar Satellite System (JPSS) is the next generation polar-orbiting operational environmental satellite system for the USA. JPSS is a collaborative program between NOAA and its acquisition agent NASA.

In August 2011, when Hurricane Irene stormed up the US eastern seaboard, weather forecasting technology predicted Irene would directly hit New York City as a category 1 hurricane. Weather prediction models used at the time considered wind strength, distance and time, resulting in a plan to deploy millions of dollars of resources to deal with the effects of severe weather on a large metropolitan area. However, between its origination in the Caribbean and landfall, Irene weakened considerably. By the time Irene made final landfall in Brooklyn, New York, it had been downgraded to a tropical storm. While meteorologists were able to accurately predict the track of Irene five days in advance, they were not able to predict Irene's intensity accurately or in a timely manner, in part because they were working with limited data that was delivered and assimilated too slowly.

Improved forecasts

On October 28, 2011, a significant step towards improved weather forecasts occurred with the launch of the Suomi National Polar-orbiting Partnership (S-NPP) satellite. S-NPP is the first of NOAA's next generation of polar-orbiting environmental satellites. S-NPP represents major advances in meeting the most pressing needs for operational weather forecasting and climate change studies.

S-NPP showed its forecasting capabilities when Hurricane Sandy hit the east coast in November 2012. Most numerical weather prediction models showed Sandy going harmlessly out to sea, but one model was ingesting data from the satellite faster and was able to give more accurate predictions, days in advance. The convergence of several different models indicates a more reliable weather forecast. While Sandy was near Cuba, the forecasting models converged and meteorologists learned more than five days in advance that Sandy would take the infamous "left hook" into southern New Jersey. There was more time to prepare, which saved lives and made a significant difference in how resources were deployed and evacuations planned.

The advance planning for Hurricane Sandy is just one example of how polar-orbiting satellites such as S-NPP contribute vital information for national forecasts, severe weather warnings, search and rescue operations, disaster response preparations, military contingency planning and environmental monitoring.

A rendering of the JPSS-1 spacecraft. Credit: Ball Aerospace & Technologies Corp

This image of Hurricane Sandy was acquired by the Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi NPP satellite around 2:11 a.m. Eastern Daylight Time (06:11 Universal Time) on October 29, 2012. Credit: NASA Earth Observatory

Data continuity

S-NPP also provides continuity of environmental data records from NOAA's Polar-orbiting Operational Environmental Satellite (POES) spacecraft – the precursor to JPSS – and also from NASA's aging Earth Observing System (EOS), a group of satellites that provide critical insights into how Earth's systems interact, including clouds, oceans, vegetation, ice and the atmosphere. Continuing uninterrupted the long-term environmental data records gathered by these satellites is critical to understanding fluctuations in Earth's climate system and provides more accurate and timely data for weather forecasting.

Ball Aerospace designed and built the S-NPP spacecraft for NASA's Goddard Space Flight Center, and was responsible for integrating the instruments and for performing satellite-level testing and launch support. Ball also designed and built one of S-NPP's instruments, the Ozone Mapping and Profiler Suite (OMPS).

Five instruments

The S-NPP spacecraft carries five instruments designed to provide operational continuity of satellite-based observations and products. These instruments trace their heritage to those on NASA's Terra, Aqua and Aura missions, on NOAA's POES spacecraft, and on the Department of Defense's Defense Meteorological Satellite Program (DMSP).

S-NPP's five instruments are the Advanced Technology Microwave Sounder (ATMS), the Cross-track Infrared Sounder (CrIS), the OMPS, the Visible Infrared Imaging Radiometer Suite (VIIRS), and Clouds and the Earth's Radiant Energy System (CERES).

CrIS and ATMS work together to measure global high-resolution profiles of temperature and moisture. These two sensors provide the majority of data used as input to Numerical Weather Prediction (NWP) models. Higher spatial, temporal and spectral resolution and more accurate sounding data from CrIS and ATMS support continuing advances in NWP models and data assimilation systems to improve short- to medium-range weather forecasts.

CrIS is a spectrometer with 1,305 spectral channels providing the ability to measure three-dimensional, high-resolution temperature profiles with greater accuracy than previous instruments. CrIS will also provide data that will help scientists understand phenomena such as El Niño and La Niña, which impact global weather patterns. NOAA is using CrIS data in its numerical weather prediction models as a test for the upcoming longer-life CrIS instrument that will fly on NOAA's JPSS spacecraft, JPSS-1.

ATMS operates in both clear and cloudy conditions, providing high spatial resolution microwave measurements of temperature and moisture. ATMS, a 22-channel passive microwave radiometer, has two more channels than previous instruments. When ATMS takes measurements inside the eye of a hurricane, it provides a clearer picture of the hurricane's warm core and the intensity of its rainfall.

VIIRS's 22 channels contribute to improved weather forecasting by measuring clouds and the nature of cloud content, which helps better predict rainfall. Along with its abilities to track long-term data on land vegetation and ocean surface features such as sea surface temperature and sea ice concentration, VIIRS tracks fires, flooding and drought as they happen. When combined with ATMS, and CrIS data, VIIRS's data on hurricanes gives scientists improved weather prediction capabilities.

For long-term climate monitoring, VIIRS continues critical data records of vegetation, clouds, aerosols, sea and land surface temperatures, the health of the biosphere, and changes in land cover. VIIRS extends the widely used data records of NASA's Moderate Resolution Imaging Spectroradiometer (MODIS), which was launched aboard NASA's Terra and Aqua spacecraft in 1999 and 2002.

VIIRS's day/night band also allows it to detect low levels of visible/near-infrared light at night to detect and discriminate between low clouds, fog, snow, ice and blowing dust/sand lit by moonlight and lightning. This represents a significant advance over previous instruments because it will provide calibrated visible observations of clouds and other phenomena at night.

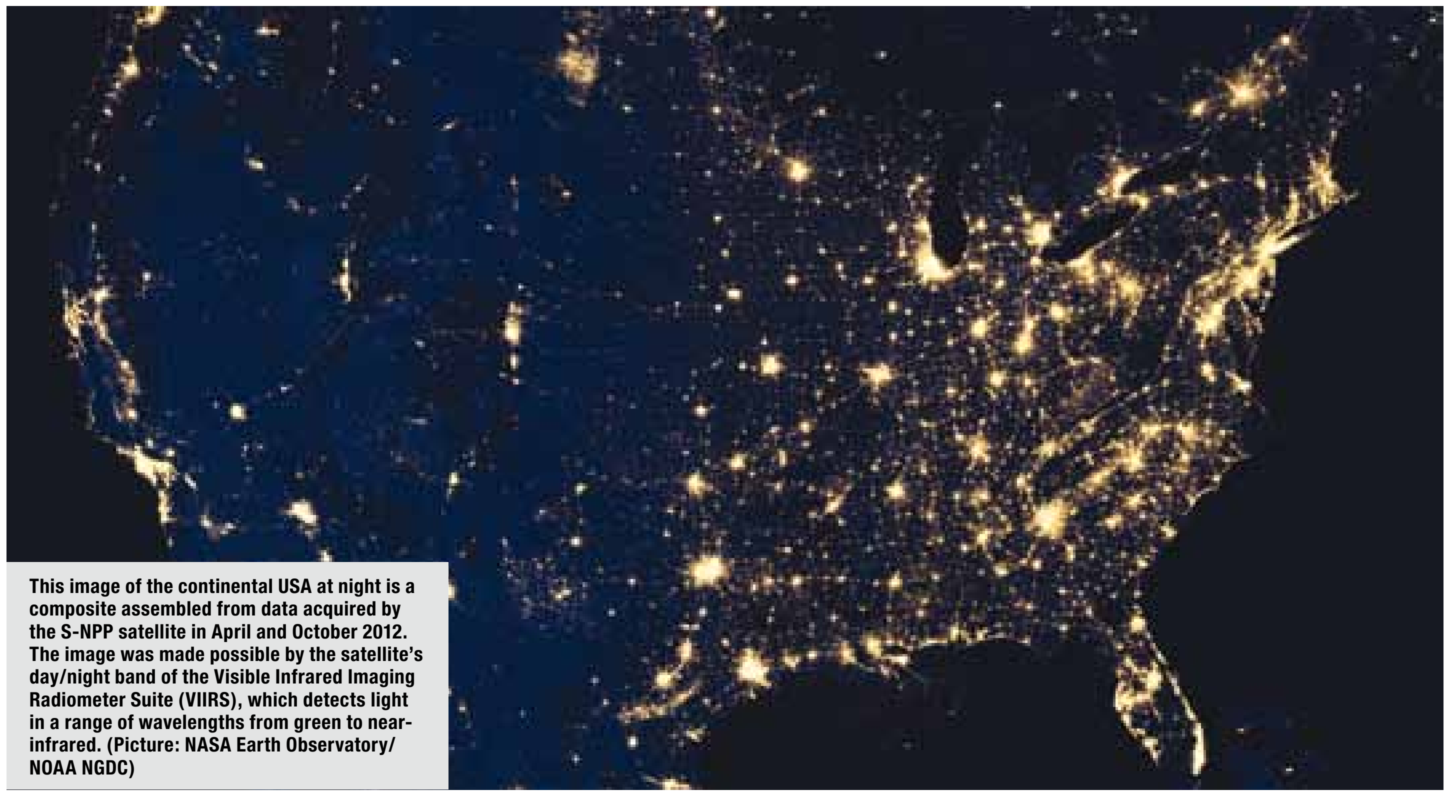
The three-channel radiometer CERES measures the balance of sunlight and the heat in the Earth's system and how it changes over time, continuing the Earth radiation budget data record of other CERES instruments on Terra, Aqua and other satellites. CERES data can be used for evaluating the effects and climatic impact of natural disasters, such as volcanic eruptions and major floods and droughts.

With improved vertical resolution, OMPS takes accurate long-term measurements of the Earth's ozone layer and builds on decades of ozone observations made most recently by a predecessor instruments on NOAA's series of POES spacecraft. When combined with cloud predictions, OMPS data helps create the Ultraviolet Index, a guide to safe levels of sunlight exposure.

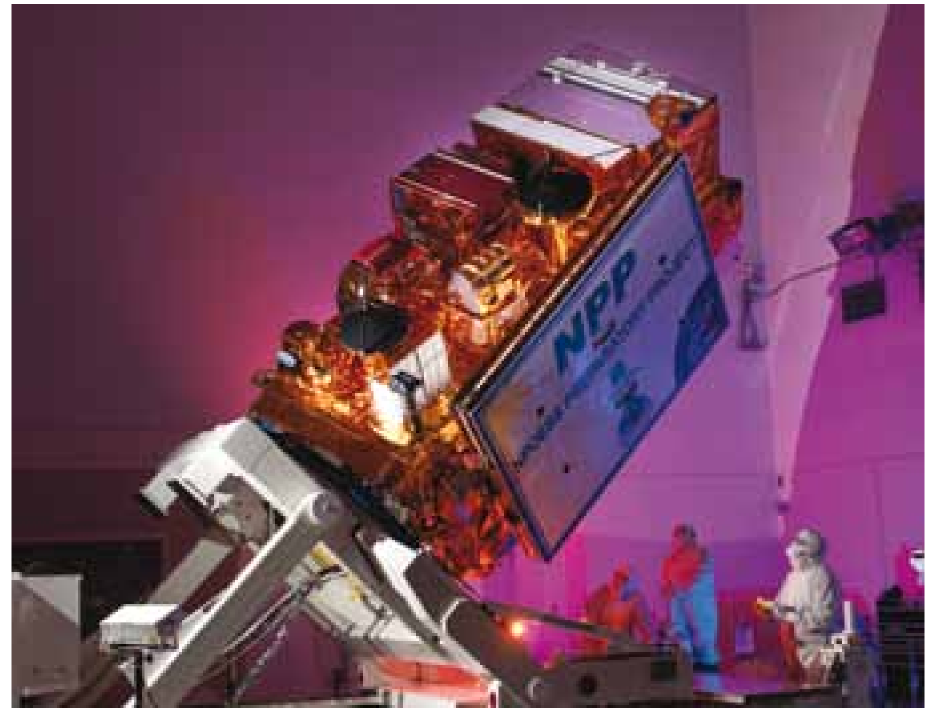
Greater detail

These S-NPP instruments offer higher spatial and spectral resolution than their predecessors, which translates to greater detail on spectra and atmospheric parameters. S-NPP orbits the Earth about 14 times each day, every 102 minutes, flying 512 miles above the surface and always crossing the equator locally after noon. It has a five-year design life and is the eighth of 11 spacecraft built by Ball Aerospace on the Ball Configurable Platform, a core architecture designed for cost-effective remote sensing applications. The spacecraft transmits data from its five instruments to a ground station in Svalbard, Norway, and also broadcasts sensor data directly to remote users in real time. From Norway, the data is routed via communication networks to end users.

After a demanding and accelerated evaluation period, S-NPP data was in use by May 22, 2012, just seven months after launch – almost three times faster than previous missions. The data contributes to all public and private weather forecasts in the USA. Development of the software used in advanced weather models was accelerated through a partnership between NASA, NOAA and the Department of Defense, enabling the ATMS data to flow to scientists in record time.



This image of the continental USA at night is a composite assembled from data acquired by the S-NPP satellite in April and October 2012. The image was made possible by the satellite's day/night band of the Visible Infrared Imaging Radiometer Suite (VIIRS), which detects light in a range of wavelengths from green to near-infrared. (Picture: NASA Earth Observatory/ NOAA NGDC)



The S-NPP spacecraft is prepared for launch at Vandenberg AFB, California (Picture: Ball Aerospace & Technologies Corp)

JPSS-1 spacecraft

S-NPP serves as the bridge between NOAA's POES and NASA's EOS satellites to the next generation JPSS spacecraft, JPSS-1, scheduled to launch in 2017. JPSS-1 will take advantage of lessons learned from S-NPP and also utilize the advances in technology that have taken place in the 10 years since the S-NPP satellite build began. JPSS-1 will fly in the same orbit with the same five instruments, which are being improved to provide the reliability needed for a seven-year mission life.

The S-NPP spacecraft is installed in its rocket housing, a United Launch Alliance Delta II-7920-10 launch vehicle. Credit: Ball Aerospace & Technologies Corp

A key difference between the S-NPP and JPSS-1 spacecraft is the enhanced data delivery capability built into JPSS-1. To stream its stored mission data faster and more efficiently, JPSS-1 will have two deployable, steerable Ka-band antennas in place of the single fixed X-band antenna on S-NPP. The primary JPSS-1 Ka-band antenna will broadcast to ground stations, while the secondary or 'back-up' Ka-band antenna will broadcast data to the Tracking and Data Relay Satellite System (TDRSS), a constellation of nine satellites flying 22,300 miles above the Earth that transmit voice, television and data between spacecraft and ground stations. This JPSS-1 capability will deliver data more quickly, with no more than 80 minutes from observation to ground user. The TDRSS antenna will offer the ability to further reduce data latency should mission needs demand more rapid data delivery.

JPSS-1 will also have an updated onboard data handling system that reduces development risk and replaces the obsolete IEEE 1394 serial databus. Spacewire will be used for the high data rate transmissions required by the VIIRS and CrIS instruments. ATMS, OMPS and CERES will use a MIL-STD-1553 serial databus due to their lower data rate requirements. The JPSS-1 spacecraft and instruments are being designed for a longer mission life than S-NPP, so the part requirements and component qualification processes are necessarily more stringent. The core spacecraft architecture is the same Ball Configurable Platform 2000, which is designed to accommodate a wide variety of Earth-observing payloads that require precision pointing control, flexible high data rate throughput and downlinks and controlled re-entry.

In December 2012, the JPSS-1 spacecraft passed a delta Critical Design Review, which delineated the design differences between JPSS-1 and S-NPP and allowed JPSS-1 fabrication to begin. JPSS-1 is currently in full-scale production and will enter integration and test in early 2014.

When launched in 2017, JPSS-1 promises to deliver the most advanced satellite weather technology and further increase the efficiency and speed of data delivery. Preserving the continuity and value of long-term environmental data records, JPSS-1 will deliver life-saving information to the world's weather forecasters. ▮

Scott C Asbury is program management professional (PMP), senior program manager, Joint Polar Satellite System Spacecraft, Ball Aerospace & Technologies Corp