16.5 NOAA/NESDIS PREPARATION FOR THE NPOESS ERA

Stacy L. Bunin* and Diane Holmes
Mitretek Systems, Inc., Falls Church, Virginia

Tom Schott and H. James Silva
NOAA/NESDIS, Washington, D.C

1. INTRODUCTION

Since the 1970s, the Polar-orbiting Operational Environmental Satellite (POES) system has been utilized to provide continuous daily global observations of weather patterns and environmental measurements of the Earth's atmosphere, its surface and cloud cover, and the proton and electron flux at satellite altitude. The National Environmental Satellite, Data, and Information Service (NESDIS), part of the National Oceanic and Atmospheric Administration (NOAA), has operated the current POES system since 1978, with a two satellite constellation in circular, near-polar, sun synchronous morning (730 and 1000) and afternoon (1400) orbits.

The launch of National Polar-orbiting Operational Environmental Satellite (NPOESS) Preparatory Program (NPP) and the first operational NPOESS will begin a new phase in NOAA's operational polar program. NPOESS will replace the current POES and Defense Meteorological Satellite Program (DMSP) programs, meeting both civilian and military environmental data requirements.

2. CURRENT SATELLITE STATUS AND PLANS

NOAA currently operates a morning and an afternoon polar-orbiting series of weather satellites as part of the POES program. In the current series, NOAA-16 and NOAA-17 are the afternoon and morning satellites respectively. NOAA-N and N' are scheduled for launch in September 2004 and March 2008 and are planned to be in afternoon orbits. Metop-1 and Metop-2 will take over the role of the operational morning satellites with launches scheduled for September 2005 and May 2010. NESDIS also generates data from two operational DMSP satellites.

NPP is a joint project between the National Aeronautics and Space Administration (NASA) and the Integrated Program Office (IPO) that is scheduled for launch in October 2006 in order to prepare for the next generation of polar-orbiting weather satellites. It is intended to provide a risk reduction demonstration for five of the NPOESS sensors and their algorithms, the NPOESS ground segment architecture, and the data processing necessary to derive improved atmospheric moisture and temperature soundings, sea surface temperature, land and ocean biological productivity, cloud and aerosol properties, total column ozone and ozone profile of the atmosphere, and radiation flux of the Earth's atmosphere. The first NPOESS satellite is scheduled for launch in 2010.

3. NPP INSTRUMENTS

Product development efforts will initially focus on the NPP instruments to take full advantage of their risk reduction benefits. The NPP satellite will carry the following instruments.

- Advanced Technology Microwave Sounder (ATMS): used for generating global observations of temperature and moisture profiles. It is used in conjunction with CrIS to derive enhanced short-medium term weather forecasts and improve warnings.
- Cross-Track Infrared Sounder (CrIS): used for generating global observations of temperature and moisture profiles.
- Visible Infrared Imaging Radiometer Suite (VIIRS): used for generating global observations of land, ocean, and atmosphere parameters, including clouds, aerosols, sea surface temperature, ocean color, low light visible imagery, vegetation health, and marine phytoplankton activity.

* *Corresponding author address*: Stacy L. Bunin, Mitretek Systems; 3150 Fairview Park Drive South; Falls Church, Virginia 22042; e-mail: sbunin@mitretek.org.

- Ozone Mapping and Profiler Suite (OMPS): used for generating total ozone and ozone profiles.
- Clouds and the Earth's Radiant Energy System (CERES): monitors solar energy reflected from the Earth and heat energy emitted from the Earth.

4. NESDIS RESPONSIBILITIES

The NPP and NPOESS systems will require numerous changes to the current POES ground system, focusing on data processing capabilities, product generation and distribution systems, as well as product science applications and data archive and access systems. These new capabilities will support the development of new products as well as improvement to the existing suite of products.

As the interface to the civilian user community, NESDIS must be capable of receiving, processing, and distributing all NPP/NPOESS data and products. The NPOESS Data Exploitation (NDE) Program has been established to identify and implement all changes within the NESDIS architecture required to support NPP and NPOESS data. NDE activities have been identified to support the NDE priorities defined as follows:

1) Ensure the continuity of the existing POES product suite and avoid any degradation of service to its user community
2) Allow for the earliest use of NPP data
3) Prepare for use of NPOESS data as soon as possible after C1 launch
4) Enhance the quality of existing NESDIS Polar products
5) Create new products

The NPOESS program will provide many new opportunities and technologies to exploit information from polar-orbiting satellites. NPP will provide a risk reduction opportunity for a subset of NPOESS capabilities. Changes and impacts on the current NESDIS ground system introduced by the NPP/NPOESS satellites and architecture are identified below.

Data format: Data received from the NPP and NPOESS satellites will be in Hierarchical Data Format 5 (HDF5) format. This format, which supports increased storage requirements as well as improved throughput processing requirements, differs from the current formats provided by NESDIS, which include Binary Universal Form for the Representation of meteorological data (BUFR), gridded/mapped, etc. NESDIS will develop a tool set to process HDF5 data into other formats. NESDIS will use this tool set to repackage data for end users. NESDIS may also make this tool set available to end users so they can more easily ingest data into various applications.

Data volume: NPOESS will provide a 1200 times increase in data volume over the current POES system. Although NPP will provide a subset of the NPOESS instrument complement, NPP will still provide 1000 times the amount of satellite data received per day over current data volumes. This massive increase of data volume requires major upgrades to the existing communication infrastructure and development of techniques to reduce the volume of disseminated information. In addition, data storage capacity will need to be increased to handle the NPP/NPOESS data as well as the new NOAA-unique products generated from these data.

After distribution of products to NOAA's near-real time users, the greater volumes will require a more efficient archive and access capability, including greater storage capacity, improved data management, and enhanced telecommunications to distribute the immense data volume to users on request.

Data content: Pre-defined NPP/NPOESS data sets will be delivered to NESDIS for use in its product processing systems. The data provided in these data sets will differ from data received from the current POES satellites in numerous ways. New instruments, more instrument data, and better resolution will impact the current NESDIS product suite as well as make new products available. Integrating these new data sets into existing POES products, producing higher level products as well as blended products (derived from both polar-orbiting and geostationary satellites) is critical to maintain product continuity. All of these product related activities require new algorithms, new or enhanced processing software, and enhanced processing tools.

Data processing: NESDIS will develop a common set of data processing tools that can be shared by many internal applications. These

enterprise-processing tools will include capabilities to combine orbital data sets to derive daily, weekly, monthly, etc. products and to combine various imagery channels to derive new imagery based products such as fog and status detection imagery.

5. PRODUCTS

Prior to generating and distributing NOAA-unique products, NESDIS will receive three types of data sets from the NPP and NPOESS Interface Data Processor Segment (IDPS):

- Raw Data Records (RDRs) will be full resolution, unprocessed sensor data that have been time referenced and earth located. Calibration coefficients will be appended to the data.
- Sensor Data Records (SDRs) will be full resolution sensor data that have been time referenced and earth located. Calibration coefficients are applied to the data. SDRs also include calibration, ephemeris, and any ancillary data required to convert the sensor units back to raw data.
- Environmental Data Records (EDRs) will be fully processed sensor data that contain atmospheric, land, oceanic, or solar geophysical environmental parameters or imagery and ancillary data.

Collectively these are known as xDRs. There will be 55 EDRs for NPOESS and 27 EDRs for the NPP mission. As part of NDE, NESDIS will receive all the data records, will perform quality control of all the records required for further processing, and provide for further processing according to the needs of the operational user community. This will allow users such as NOAA's National Weather Service (NWS), National Ocean Service, National Marine Fisheries Service and the Office of Oceanic and Atmospheric Research to conduct impact assessments to their operational missions. The provision of NPP satellite products to the user community promises to help the users realize the potential of the data prior to NPOESS and to minimize the impact to their processing systems when the NPOESS satellite data is declared operational. By satisfying a large portion of the NPOESS requirements with the NPP satellite, users will be able to prepare their systems for the improved products soon after the launch of the first operational NPOESS at lower cost and with less risk than would otherwise be possible.

The current NPP product development efforts are expected to cover several areas. NESDIS will support all areas with algorithm research, developing and maintaining product generation systems, reformatting products for specific users, and providing a user interface for product selection. Scientists will also conduct real-time quality control and science validation. Products that will be available for users include heritage products that are generated from current POES systems, blended products from polar-orbiting and geostationary satellite data, hazard support such as fire and smoke detection and volcanic ash detection, and new products developed from NPP's new sensor data.

Science support to the development of xDRs will include calibration and validation, algorithm upgrades, product enhancements, and new product development.

The NESDIS Product Processing Activities are summarized in Figure 1.

5.1 *Thinned radiances from CrIS/ATMS*

Because the CrIS has over 1000 channels and the data volume is too large for timely distribution, the radiance data needs to be spatially and spectrally thinned before it is provided to Numerical Weather Prediction (NWP) centers. Developments for this product will be based on the experience gained from processing for the Atmospheric Infrared Sounder (AIRS) instrument data on NASA's Aqua satellite and for the Infrared Atmospheric Sounding Interferometer (IASI) instrument data on EUMETSAT's Metop satellites.

5.2 *Microwave-only products*

Microwave only products such as cloud liquid water, precipitation rates, land surface temperature, snow cover, sea ice, and surface emissivity are currently derived from the Advanced Microwave Sounding Unit-A and -B (AMSU-A and AMSU-B) aboard the POES satellites. Similar products will be generated from the ATMS instrument on NPP.

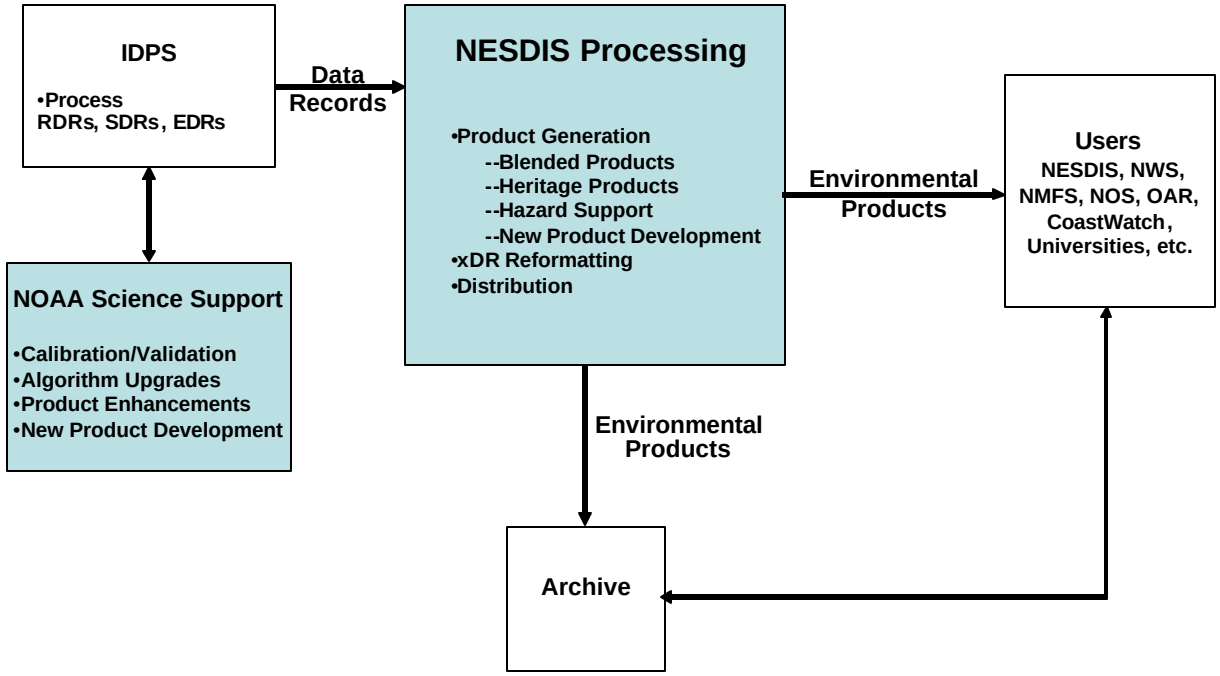

Figure 1. NESDIS Processing Activities during the NPP/NPOESS era

5.3 *Climate data records for ozone*

The OMPS instrument will provide atmospheric long-term ozone data from satellite, similar to the data derived from the NOAA/POES Solar Backscatter Ultra Violet Spectral Radiometer (SBUV/2) and the NASA Total Ozone Mapping Spectrometer (TOMS) sensors. NESDIS scientists will implement ozone algorithms and provide for any necessary reprocessing capabilities. In addition, total ozone products will be generated from the CrIS instrument. These are similar to those currently generated from the POES High-resolution Infrared Radiation Sounder (HIRS) instrument and are important because the products will provide ozone coverage during the dark portion of the orbit. Ozone profile data are also used to initiate the NWP models for generating short-medium term weather forecasts and warnings..

5.4 *Land surface data*

The VIIRS instrument will provide the EDR for vegetation index by measuring biomass greenness in Normalized Difference Vegetation Index (NDVI) units. NESDIS intends to create more specific vegetation products for users, including real-time green vegetation fraction, leaf area indices, drought indices, and vegetation health. These additional products will ensure the continuation of the vegetation product datasets generated from the Advanced Very High Resolution Radiometer (AVHRR) on the POES satellites.

Snow cover products will also be generated from VIIRS data, as well as blended products from the VIIRS, ATMS, and Geostationary satellite data. Data from the Conical-scanning Microwave Imager Sounder (CMIS) instrument on NPOESS will be added to the blended product when it is launched.

5.5 *Ocean products*

Ocean product development efforts are expected to focus in two areas: sea surface temperature and ocean color. Sea surface temperature products beyond the EDR level will include daily, bi-weekly, and monthly analyses as well as products that are generated in support of coral reef bleaching events and sea

surface temperature anomalies. A blended product using data from NPP and the Geostationary Operational Environmental Satellite (GOES) system will also be produced. The EDR products will also be reformatted for users, including NWS and CoastWatch users. Sea surface temperature development for NPP will use the VIIRS instrument although products will also be derived using the CMIS instrument on NPOESS. The sea surface temperature products derived from the POES AVHRR will serve as heritage to those generated from NPP.

The ocean color EDR contains information on water leaving radiances and chlorophyll-*a*. NESDIS will generate additional ocean color products such as particulate organic carbon and will derive information on harmful algal blooms. These products will also be tailored for CoastWatch users. Algorithm development for ocean color products will build on that being done for the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument aboard NASA's Aqua and Terra and the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) instrument.

5.6 *Hazards*

NPP satellite data will be used in support of hazard monitoring. Fire and smoke plume detection and aerosols from volcanic eruptions will be derived from the VIIRS. Tropical rainfall potential and other tropical cyclone parameters will be generated from ATMS data. Many of these products will be generated using Geographic Information System (GIS) technologies.

5.7 *Atmospheric soundings*

Atmospheric moisture and temperature soundings such as layer precipitable water, total precipitable water, layer temperatures, and level temperatures will be provided to the NWS field units via the Advanced Weather Interactive Processing System (AWIPS).

5.8 *Radiation budget*

Radiation budget parameters such as outgoing longwave radiation are currently generated orbitally. Other products include daily analyses, monthly mean, seasonal mean, and annual mean. NESDIS will generate these products using CrIS and CERES data on NPP.

6. CONCLUSION

The NDE program will ensure that changes are made to the NESDIS product processing and distribution systems prior to the launch of NPP. NPP data will impact the NESDIS ground systems through an increase in data volume and the need for data formatters and additional product processing to maintain product continuity for atmospheric, oceanic, and land-based products. By taking advantage of the early availability of NPOESS-era data from the NPP satellite, NESDIS and its users will be able to better prepare for the next generation of polar-orbiting satellite products.

7. REFERENCES

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