

NOAA's Product Processing from Future Polar-orbiting Operational Environmental Satellites

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1. INTRODUCTION

Several new polar-orbiting satellites will be in orbit over the next few years and NOAA intends to process the data for operational applications. NOAA's National Polar-orbiting Operational Environmental Satellite System Preparatory Project (NPP) Data Exploitation (NDE) Project will provide operational civilian users of environmental satellite products with data from NPP and the Joint Polar-orbiting Satellite System (JPSS). NOAA will also make products available from Metop-B, which will continue the morning mission started with Metop-A. Potential new sources of data will include Megha-Tropiques and the Global Change Observation Mission (GCOM) satellites. Together these satellites will provide users with new and continuity products such as sea surface temperature, atmospheric soundings, microwave surface and hydrology products, ocean surface winds, atmospheric chemistry, atmospheric radiation, ocean color, snow and ice cover, vegetation products, and smoke and ash tracking.

2. NPP DATA EXPLOITATION

NDE's mission is to assist NOAA and other civilian end users to realize the potential of NPP observations. Distribution of NDE products will begin with the NPP satellite, currently scheduled for launch in October 2011.

A suite of environmental, sensor, temperature, and selected application-related data records (xDRs) from NPP will be provided to NOAA. NDE has additional product development efforts underway to create new products to satisfy user requirements for NOAA-unique capabilities. These products are prioritized by NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) based on user needs and priorities are re-evaluated and adjusted annually.

NOAA currently generates operational products from several polar-orbiting satellites. These include NOAA's Polar-orbiting Operational Environmental Satellite (POES), the Department of Defense's Defense Meteorological Satellite Program (DMSP), and NASA's Earth Observing System (EOS). Products from NPP will be generated from four instruments' data. The NPP instruments are as follows:

- Cross-track Infrared Sounder (CrIS)
- Advanced Technology Microwave Sounder (ATMS)
- Visible/Infrared Imager/Radiometer Suite (VIIRS).
- Ozone Mapping and Profiler Suite (OMPS), including OMPS Limb Profiler

With NPP data, NOAA's high priority need is the continuation of current capabilities from POES, DMSP, and EOS. NOAA will also exploit new sensing capabilities from NPP and will develop these new products to satisfy a user request if it is technically feasible and resources have been secured.

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2.1 CrIS/ATMS

Hyperspectral sounding products are assimilated into numerical weather prediction models and are used for climate applications. These products will be generated from CrIS and ATMS data from NPP and will be modeled from the hyperspectral instruments aboard Aqua and Metop.

CrIS/ATMS products will include principal components (which will compress channel radiances into independent values); cloud cleared radiances; atmospheric moisture and temperature profiles; ozone retrievals; atmospheric measurements of carbon dioxide, carbon monoxide, methane, and sulfur dioxide; cloud products; atmospheric stability products; and surface emissivity. These products will be available globally in NetCDF4 and BUFR formats.

Figure 1 shows the atmospheric temperature for one layer of the atmosphere. This product was generated from IASI data aboard the Metop satellite. Similar products will be generated from CrIS/ATMS data on NPP.

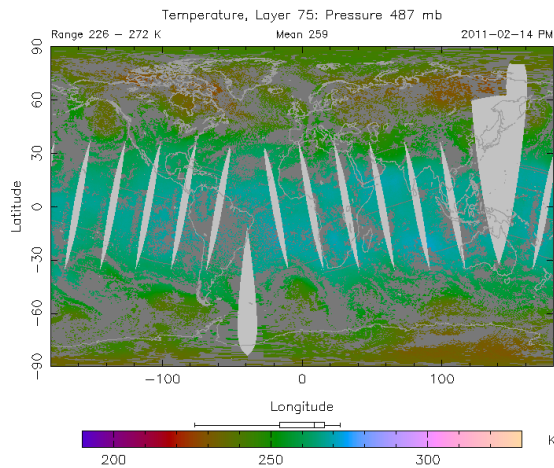


Figure 1. Sample atmospheric temperature image.

Hyperspectral sounding and climate products are expected to be available operationally beginning in 2012.

2.2 MIRS

The Microwave Integrated Retrieval System (MIRS) processes products over all-weather conditions and for different surface types using a microwave sensors from a variety of different satellites. MIRS products from POES, Metop, and DMSP, are already operational and development is now underway to generate products from ATMS data.

MIRS products from NPP will include: ice water path, rain water path, snow water equivalent, snow cover, sea ice concentration, cloud liquid water, temperature and moisture profiles, land surface temperature, land surface emissivity, total precipitable water, and rainfall rate.

NDE will generate MIRS products in NetCDF format. NDE will also generate selected products in BUFR. Additional formats for MIRS products include HDF-EOS and McIDAS.

Figure 2 shows a MIRS snow water equivalent product, which is used in hydrologic forecasting. It was generated from NOAA-19 data and a similar product will be generated from ATMS data on NPP.

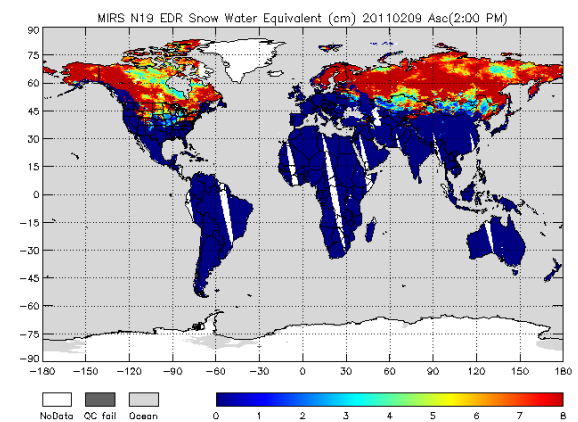


Figure 2. Sample MIRS snow water equivalent product.

MIRS sounding, surface, and hydrological products from NPP data are projected to go operational beginning in 2012.

2.3 Sea Surface Temperature

Sea surface temperature (SST) or its associated derived products are used in operational forecast models, to assess areas with coral reef heat stress and to help predict bleaching events, and to locate oceanic temperature fronts.

Most NDE SST products from NPP's VIIRS will be generated as a continuity of mission, though some will have a higher resolution. NPP products will include:

1. SST anomalies, hot spots, and degree heating weeks at 4-km to 10-km grid spacing.
2. Global SST analyses at 100-km and 50-km and regional analyses at 14-km.
3. Global analyses of aerosol optical thickness (AOT) at 100-km and 50-km
4. A blended SST analyses generated using NPP and GOES data.
5. A blended SST analyses generated using POES and NPP data or Metop and NPP data. This would be a new product in the NPP era since SST products are not currently blended from multiple polar-orbiting satellites.
6. Monthly mean SSTs
7. Monthly mean AOT
8. Coral Bleaching Indices and Alerts

Figure 3 shows an example of the blended SST. This product was generated using POES and GOES data. A similar product will be generated using NPP and GOES data.

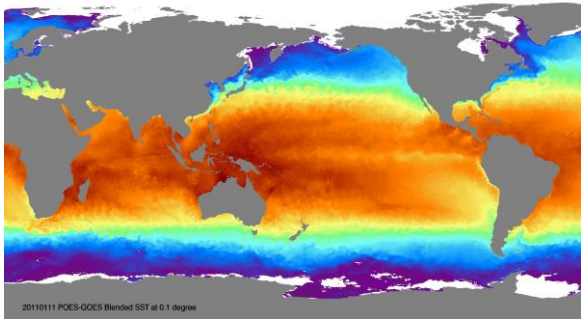


Figure 3. Sample blended sea surface temperature product.

SST products will be generated in NetCDF format and are expected to be produced operationally beginning in early 2013.

2.4 Polar Winds

Polar winds products are used by numerical weather prediction centers to improve model forecasts for the Northern and Southern Hemisphere extratropics. These winds are currently generated using POES and Metop AVHRR data as well as data from Aqua's MODIS. After the launch of NPP, polar winds products will be generated from VIIRS.

Products include wind speed, direction, and height in NetCDF4, BUFR, McIDAS MD, and text for the Arctic and Antarctic.

Figure 4 shows wind vectors over the Arctic. This product was generated using POES AVHRR data. A similar product will be generated from NPP's VIIRS data.

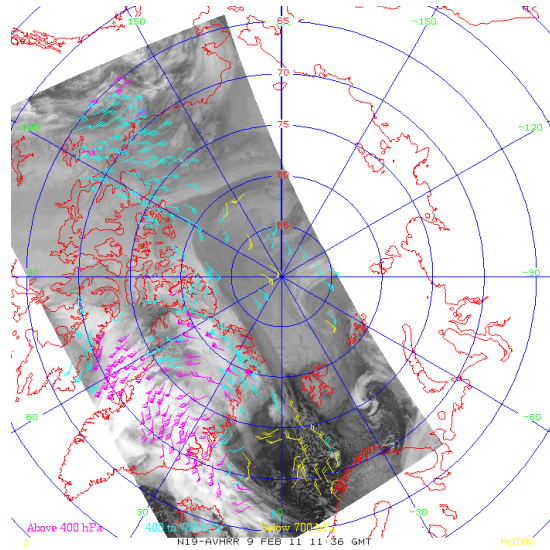


Figure 4. Sample polar winds product.

Polar wind products are expected to be available operationally in 2012.

2.5 Green Vegetation Fraction

Green vegetation fraction (GVF) products help provide a better characterization of the surface for land surface models. They are currently generated using AVHRR data from the POES satellites.

GVF products will be generated weekly with a 4-km resolution from NPP's VIIRS data. Global products will be available in NetCDF and GRIB2 formats. Products will also be generated for the web in additional coverage areas to include North America, South America, Alaska, Europe, Asia, British Isles, Africa, and Oceania.

Figure 5 shows a GVF product, which is currently generated from the AVHRR on POES. A similar product will be generated from the VIIRS data from NPP.

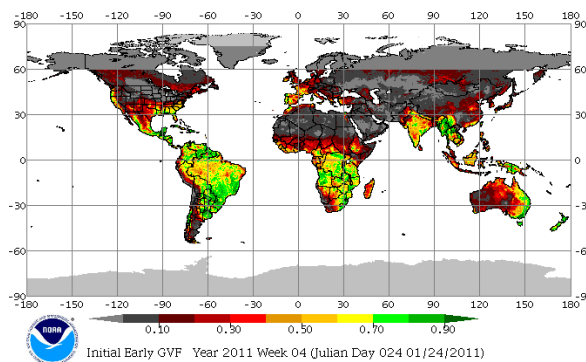


Figure 5. Sample green vegetation product.

GVF products from NPP's VIIRS data are expected to be available operationally in 2012.

2.6 Blended Total Precipitable Water

Total precipitable water (TPW) is derived using multiple sensor data from a variety of satellites. When the data from these sensors are blended to make one total precipitable water product, a forecaster is provided with a more complete observation of the movement of moisture in the atmosphere. The blended TPW product also includes land-based coverage, which can be used to help locate areas of heavy precipitation over the Continental U.S.

TPW anomaly products show the percentage departure from climatology and are used by forecasters to better understand how unusually wet or dry the moisture field is. High percentage values help predict where there is a strong potential for flooding and low values can indicate fire hazards.

The blended TPW products are currently generated using data from POES, Metop, DMSP, the Global Positioning System (GPS) meteorological data, and the Geostationary Operational Environmental Satellites (GOES). Data from NPP's ATMS instrument will be added to the blended TPW products. They are expected to be generated in HDF-EOS and in a format compatible with AWIPS. They will be available globally and for four AWIPS regions, as well as online for 11 different regions.

Figure 6 shows an operational blended TPW product.

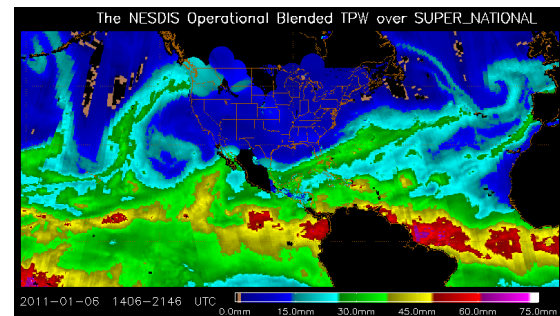


Figure 6. Blended total precipitable water.

Blended total precipitable water and TPW anomaly products are expected to be generated using NPP data beginning in late 2012.

2.7 OMPS Limb Profiles

The OMPS instrument measures the global distribution of total atmospheric column ozone and the vertical distribution of ozone. The nadir instrument measures directly below the satellite and the limb instrument measures ozone at an angle to the Earth's surface. Currently ozone profiles are generated from the SBUV/2 on the POES satellites. The NDE Project will provide new ozone products based on the OMPS Limb Profiler.

Limb ozone profiles will be used as an input to NWP models and will improve on the ultraviolet index prediction and climate trends. The products will include limb scattered radiances, high vertical resolution

ozone profiles, and stratospheric aerosol optical depth. Products will be generated in NetCDF format.

Figure 7 shows a current SBUV/2 ozone profile image. Profiles from the OMPS will be more accurate with higher vertical and horizontal resolutions.

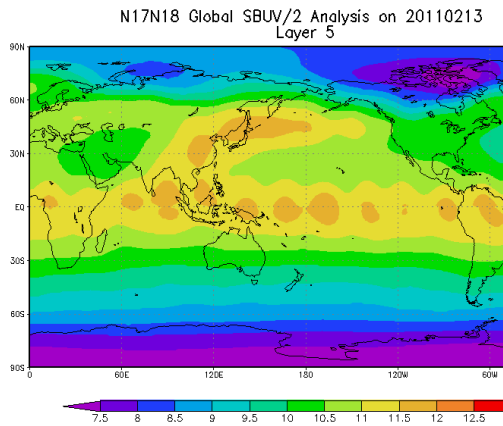


Figure 7. Sample ozone profile image.

OMPS Limb Profile products are expected to be available operationally beginning in 2012.

2.8 Ocean Color

Ocean color products are used to monitor marine and freshwater ecosystems, manage coastal resources, detect the presence of harmful algal blooms, and determine trends related to regional to global climate variability and change. NOAA currently generates ocean color products from NASA's Aqua satellite, as well as from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) on the commercial SeaStar satellite. To provide for continuity of data, NOAA will generate ocean color products from NPP's VIIRS data.

Products using NPP data will include normalized water leaving radiances, chlorophyll-a, chlorophyll frontal product, harmful algal bloom anomaly product, *Emiliania huxleyi* bloom maps, and near coastal ocean color. Ocean color products will be generated in a variety of formats, including NetCDF, CoastWatch HDF, and GeoTIFF.

The chlorophyll concentration in Figure 8 provides an estimate of the live phytoplankton biomass in the surface layer. Similar products will be generated from NPP data.

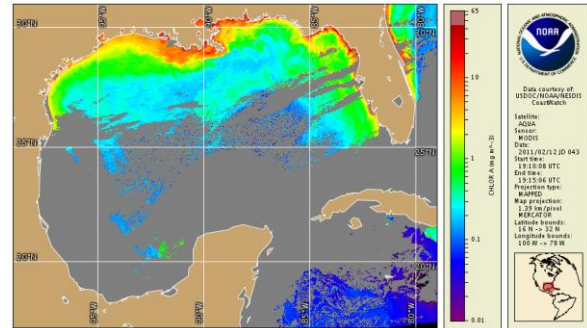


Figure 8. Sample ocean color product.

Ocean color products will be available operationally beginning in 2014.

2.9 Tropical Cyclone Intensity

Tropical cyclone intensity products are used to estimate and forecast the radii of winds to give guidance to hurricane forecasters. They are currently generated using AMSU data from the POES satellites.

Products will include maximum winds, minimum sea level pressure, and radii of 34-, 50-, and 64-knot winds. They will be generated globally from ATMS data and distributed in text format. The tropical cyclone intensity products will be generated every six hours for the north Atlantic and northeast Pacific tropical cyclone basins.

Tropical cyclone intensity and wind radii products from NPP data are expected to be operational beginning in 2013.

2.10 NetCDF Reformatting Tool

NDE will receive xDR products from the IDPS in HDF5 format and will reformat these into NetCDF4 format. Additional NOAA Unique Products will be generated in NetCDF4. Many of the xDRs and NOAA-Unique products will need to be provided to users in additional formats. For instance, radiances and other products in BUFR and GRIB formats are used by NWP centers.

NDE is in the process of generating a toolset that will reformat the NetCDF formats into BUFR and GRIB2.

NOAA is leveraging current data translators to design, develop, and create the NetCDF4 reformat tool. Having one reformatting tool will improve the maintainability, flexibility, and efficiency of product generation systems.

Table 1 lists the NPP products that will use the tool to reformat into BUFR and GRIB2. As more NOAA Unique Products are developed there may be a need for additional products in BUFR and GRIB2 formats. These products will be identified through the annual review of products and will be added to the NetCDF reformatting tool as needed.

Table 1. NPP Reformatted Products.

Prioritized Product	BUFR	GRIB2
ATMS Radiances	X	
CrIS Radiances	X	
Nadir Profile Ozone (OMPS) and OMPS Radiances	X	
VIIRS Radiances	X	
Vegetation Index		X
Aerosol Optical Thickness	X	
Sea Surface Temperature	X	
VIIRS Polar Winds	X	
Green Vegetation Fraction		X
OMPS Limb Profiles	X	

The NetCDF reformat tool will have multiple phases. In each phase, the tool will be designed, developed, and transitioned into

operations for a different set of products. The Phase 1 products will include CrIS, ATMS, VIIRS, and OMPS radiances, nadir ozone profiles, sea surface temperatures, and aerosol optical depth.

The first phase of the NetCDF reformatting tool is expected to be completed in 2011.

3. METOP-B

Metop-A is the first European satellite in the Initial Joint Polar System agreement between NOAA and the European Organization for the Exploitation of Meteorological Satellites. The Metop-B satellite will provide continuity for that mid-morning mission for atmospheric, land surface, oceanic, and space weather products.

The Metop-B instruments will include the following: Advanced Very High Resolution Radiometer (AVHRR/3), Advanced Microwave Sounding Unit (AMSU-A), Microwave Humidity Sounder (MHS), High-resolution Infrared Radiation Sounder (HIRS/3), Infrared Atmospheric Sounding Interferometer (IASI), Advanced Scatterometer (ASCAT), Global Ozone Monitoring Experiment (GOME-2), Space Environment Monitor (SEM-2). NOAA will use the data from these instruments to generate operational products for use in numerical weather prediction for improved forecasts, in support of climate research and prediction, and for weather analysis and forecasting. Products will include atmospheric temperature and moisture soundings, clouds, winds, precipitation, vegetation index, ozone, snow and ice cover, radiation budget, and hazard monitoring such as fires, tropical systems, and volcanic eruptions.

Continuity products from Metop-B are expected to be available operationally in 2012.

4. MEGHA-TROPIQUES

The French-Indian Megha-Tropiques (M-T) satellite mission will study the tropical water and energy cycle. For NOAA it will provide continuity of atmospheric data within the

tropics, which is currently provided by NASA's TRMM satellite.

The M-T satellite will have several instruments onboard. These include the Microwave Analysis and Detection of Rain and Atmospheric Structures (MADRAS), Sounder for Atmospheric Profiling of Humidity in the Intertropics by Radiometry (SAPHIR), and Scanner for Radiation Budget (SCARAB).

Products from M-T will include brightness temperatures, rain rate, cloud liquid water, total precipitable water, ocean surface wind speed, moisture profiles, and net radiation budget. Formats will differ by product but will include NetCDF, McIDAS, and GeoTIFF formats. The products will be used for identifying tropical cyclone attributes (location, intensity, and wind speed), for NWP assimilation and instrument calibration, and for climate data records.

The first M-T products are expected to be available operationally beginning in 2013.

5. GCOM

Japan Aerospace Exploration Agency (JAXA) has planned to carry out the Global Change Observation Mission (GCOM) which will consist of a two satellite series: water (GCOM-W) and climate (GCOM-C). Each satellite mission will include three generations with one year overlap to ensure 10-15 years worth of stable data records. The GCOM missions will provide long-term continuous monitoring and observation of geophysical parameters helping scientists to understand and evaluate climate change and variation.

GCOM-W1 will carry the Advanced Microwave Scanning Radiometer (AMSR2). Products from AMSR2 data will include imagery, cloud liquid water, precipitable water, precipitation (type/rate), sea ice characterization, sea surface temperature, sea surface wind speed, snow cover/depth, snow water equivalent, soil moisture, surface type, and temperature data records.

The details of the GCOM products are still being worked. The operations date for the GCOM-W1 products is to be determined.

6. SUMMARY

As future missions are planned and launched, NOAA will continue to generate and provide satellite products for continuity of several different types of missions. New and enhanced products will also be produced. Together these products will be used to improve weather forecasts and for studying the Earth's climate.

7. REFERENCES

JAXA GCOM-W Mission,
http://www.jaxa.jp/projects/sat/gcom_w/index_e.html

Megha-Tropiques Mission,
<http://smc.cnes.fr/MEGHAT/>

Metop-B Mission,
<http://www.eumetsat.int/Home/Main/Satellites/Metop/MissionOverview/index.htm?l=en>

NOAA/NESDIS Operational Products,
<http://www.osdnp.noaa.gov/ml/index.html>

The NPOESS Preparatory Project,
<http://jointmission.gsfc.nasa.gov/>

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