8.3 NOAA's Near-Real-Time Data Products from NPP and NPOESS

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1. INTRODUCTION

NOAA's National Polar-orbiting Operational Environmental Satellite System (NPOESS) Data Exploitation (NDE) project will provide near-real-time operational civilian users of environmental satellite information with data from NPOESS and the NPOESS Preparatory Project (NPP). Through NDE, users can continue to receive polar-orbiting satellite data to maintain their current missions, or take advantage of the improved and expanded suite of products that the NPOESS-era sensors will provide. NDE will receive environmental, sensor, and temperature data records from NPP and NPOESS and tailor them to satisfy user-required attributes such as data format, coverage, frequency of the product (i.e., granule, daily, weekly, etc.), and map projection. NDE will also apply value-added science algorithms to certain data records to generate NOAA-unique products (NUPs) in order to meet NOAA-unique mission requirements. The initial focus of NOAA-unique products will be atmospheric sounding products, microwave surface and precipitation products, and derived sea surface temperature products such as anomalies and coral reef bleaching indices and alerts. Subsequent NUPs will include polar winds, vegetation health, ocean color, and atmospheric chemistry data records.

2. NPOESS DATA EXPLOITATION

The NDE project system objectives are:

- Disseminate NPOESS Data Records to end users
- Generate and disseminate tailored NPOESS Data Records (versions of NPOESS Data Records in previously agreed alternative formats and views)
- Generate and disseminate NOAA-unique products (augmented environmental products constructed from NPOESS Data Records)
- Deliver NOAA-unique products, product processing elements, and associated metadata to the NOAA Long-Term Archive
- Provide services to end users, including NDE product training, product enhancement, and implementation support across NOAA
- Develop a sustainable system that meets end user needs
- Provide software for NPOESS Data Record format translation and other data manipulations

NDE's mission is to assist NOAA and other civilian end users to realize the potential of NPOESS observations. Distribution of NDE products will begin with the NPP satellite.

3. NPP INSTRUMENTS

There are four planned instruments for the NPP satellite that will serve the operational user community. These include the Cross-track Infrared Sounder (CrIS), the Advanced Technology Microwave Sounder (ATMS), the Visible/Infrared Imager/Radiometer Suite (VIIRS), and the Ozone Mapping and Profiler Suite (OMPS). Together, these instruments will collect global atmospheric, land, and ocean data for meteorological and climate change applications. The NDE system is responsible for tailoring Temperature, Sensor, and Environmental Data Records, collectively known as xDRs, as well as generating and tailoring NUPs to meet user requirements and ensure the continuity of legacy Polar-orbiting Operational Environmental Satellite (POES), Earth Observing System (EOS), and Defense Meteorological Satellite Program (DMSP) capabilities. NDE will tailor the xDRs from the native HDF5 format into a variety formats,

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including BUFR, GRIB2, and NetCDF4, and make them available to users. NDE will also exploit new NPP capabilities to address previously unmet NOAA mission needs.

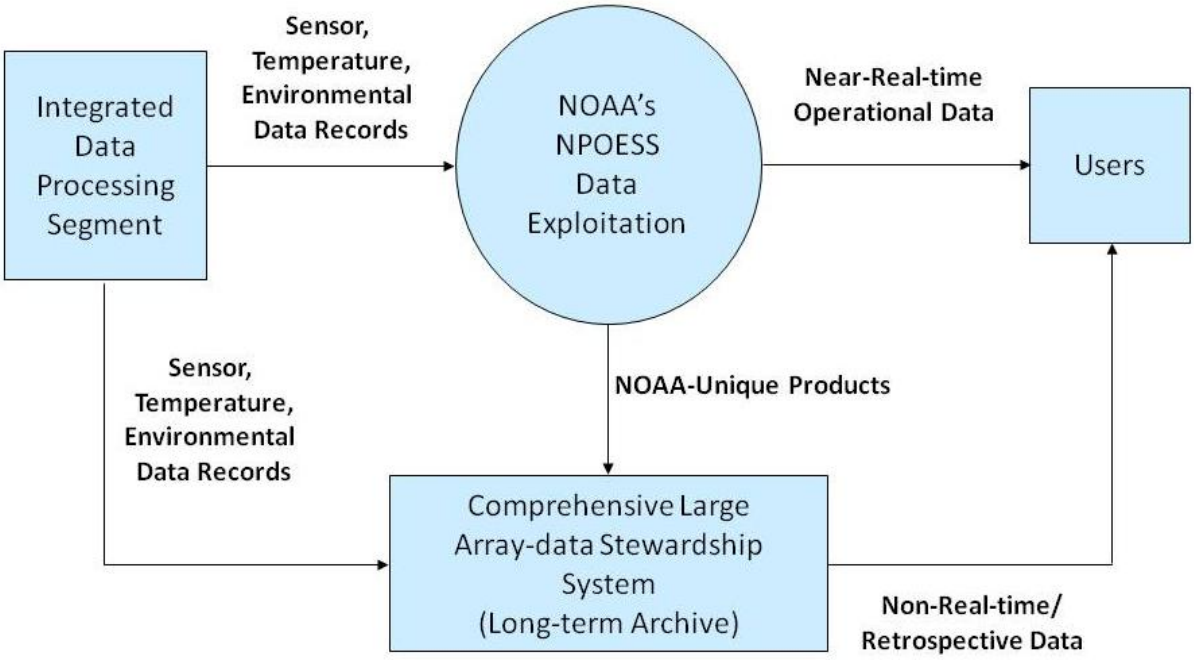

Figure 1. NPOESS Data Exploitation Overview

4. NDE Product Development

NOAA will rely on the Integrated Program Office (IPO), which manages the NPOESS program, to deliver a suite of environmental, sensor, and temperature data records (xDRs). NDE will not create new products unless there is a requirement for a NOAA unique capability. NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) prioritizes product development efforts based upon user needs; priorities are re-evaluated and adjusted annually. A high priority need is the continuation of current capabilities from POES, EOS and DMSP. However, NOAA will also exploit new sensing capabilities from NPP and NPOESS. Sounding and carbon products, microwave hydrological and surface products, and sea surface temperature products that will be generated from NPP instruments have been under development for several years. NESDIS approved new product development efforts for polar winds, green vegetation fraction, and blended total precipitable water. NESDIS will develop additional products if it is technically feasible to satisfy a user request and resources have been secured.

4.1 *CrIS/ATMS*

Hyperspectral measurements are used to improve knowledge of temperature, moisture, and ozone, for both weather and climate applications. NDE will generate hyperspectral products from CrIS data collocated with the ATMS field of regard. NDE will also use the VIIRS instrument for cloud clearing. These products will be continuity from Aqua AIRS/AMSU-A and Metop IASI/AMSU-A data.

CrIS/ATMS products will include principal components (which will compress 1305 channel radiances into approximately 85 independent values), cloud cleared radiances, ozone retrievals, and atmospheric measurements of carbon dioxide, carbon monoxide, methane, and nitric acid. Additional products from CrIS/ATMS will include cloud products such as cloud top pressure and cloud top fraction; stability

products such as convective available potential energy, lifted index, and convective inhibition; and surface emissivity.

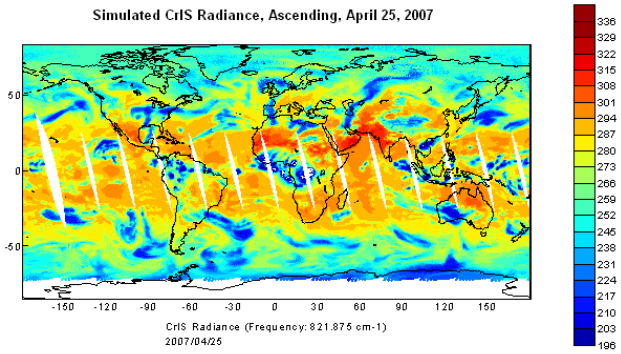

Figure 2. Simulated CrIS radiances.

NDE will distribute CrIS/ATMS products in NetCDF4 and BUFR formats. They will be assimilated into Numerical Weather Prediction (NWP) models and used in climate applications.

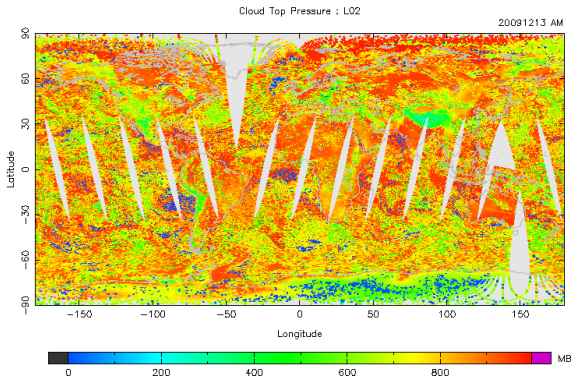

Figure 3. Cloud Top Pressure is generated today from Metop's IASI instrument. A similar product will be available from the CrIS on NPP and NPOESS.

4.2 *MIRS*

The Microwave Integrated Retrieval System (MIRS) provides data products from microwave instruments in all weather and all surface conditions. The MIRS application is adaptable to all microwave sensors to ensure physical consistency and minimal bias for the multitude of microwave sensors. The data generated from the MIRS system is used to improve NWP models, estimations of rainfall, and continuity of climate monitoring for El Niño, water cycle changes, and long-term climate change. NDE will generate MIRS products from the ATMS for continuity with POES and Metop AMSU-A and MHS products.

MIRS products from ATMS will include temperature profiles, moisture profiles, land surface temperature, land surface emissivity, snow water equivalent, snow cover, sea ice concentration, cloud liquid water, total precipitable water, ice water path, instantaneous rain water path, and rain rate. NDE will distribute MIRS products in NetCDF4 and BUFR formats and in pre-defined coverage areas and timeframes, including orbital, area of interest, daily, and monthly. These global products will continue to enhance NOAA's weather forecasting and climate monitoring capabilities.

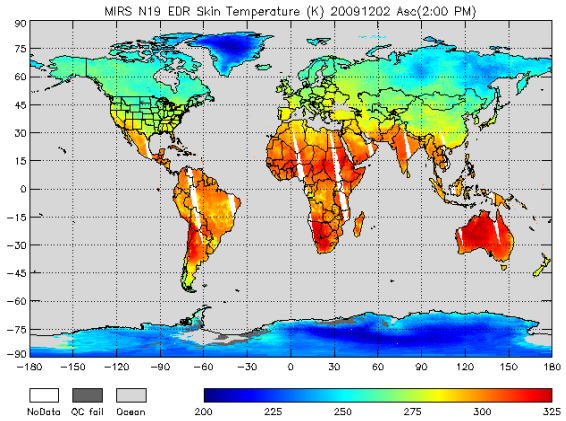

Figure 4. MIRS skin temperature from the NOAA-19 AMSU-A and MHS instruments. A similar product will be generated from ATMS.

4.3 *Sea Surface Temperature*

Sea surface temperature (SST) products are used as an input to environmental models and in climate and ecosystem applications. SST anomaly products provide early warnings of coral bleaching, assessment of El Niño and La Niña development, and monitoring the cooling following the passage of a hurricane.

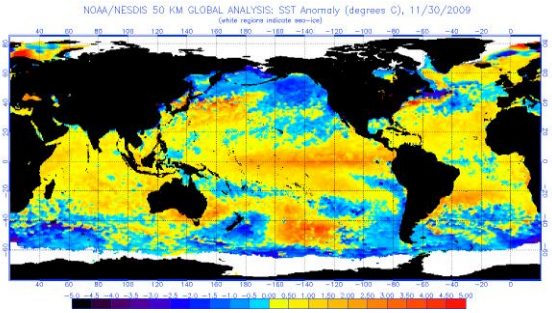

Figure 5. Sea surface temperature anomaly product from the AVHRR. A similar product will be generated from VIIRS.

There are several derived products that will be generated from NPP's VIIRS data, including SST anomalies, hot spots, and degree heating weeks; global and regional SST analyses; global analyses of aerosol optical thickness (AOT); monthly means of SST and AOT; coral bleaching indices and alerts; and blended products using NPP and GOES, POES, and Metop. Coral Reef Watch uses coral bleaching SST products to help pinpoint areas that have higher than normal sea surface temperatures and are at risk for bleaching.

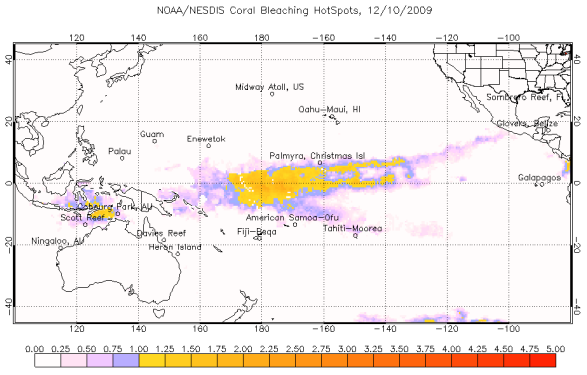

Figure 6. Coral Bleaching Hot Spots are generated from the AVHRR and will be generated from the VIIRS instrument on NPP.

NDE's SST products will provide mission continuity from the AVHRR on POES and Metop. NDE will generate SST products in NetCDF4 format for the National Weather Service, Coral Reef Watch, and CoastWatch/OceanWatch.

4.4 *Polar Winds*

NESDIS measures tropospheric winds in the polar regions by tracking the motion of cloud features in the overlapping region of three successive orbits. A triplet of images is used to facilitate consistency checking and quality control.

Wind products include wind speed, direction, and height at high latitudes. NDE will generate polar winds from VIIRS for continuity with MODIS and AVHRR infrared cloud drift wind products.

The assimilation of polar tropospheric wind data in NWP models has been shown to improve model forecasts for the Northern and Southern Hemispheres. Model impact studies at major NWP centers have demonstrated that forecasts for the extratropics are improved when the MODIS polar winds are assimilated (Key, 2003). A similar impact from the VIIRS product is expected.

NDE will generate polar winds for the Arctic and Antarctic from 65 degrees latitude poleward. NDE will make these products available in BUFR format for NWP centers.

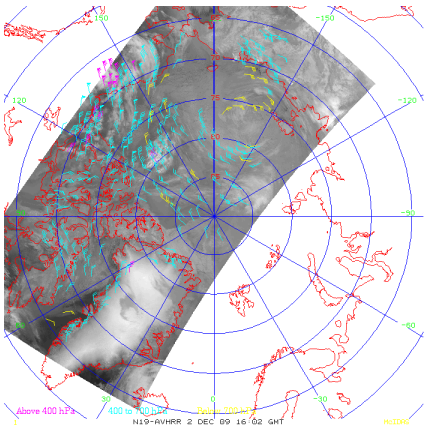

Figure 7. Polar winds from the POES AVHRR. NDE will generate a similar product from the VIIRS.

4.5 *Green Vegetation Fraction*

Green vegetation fraction (GVF) is used as an input to land surface models to provide a better characterization of the surface. NESDIS

currently generates GVF from AVHRR data and will use VIIRS data from NPP.

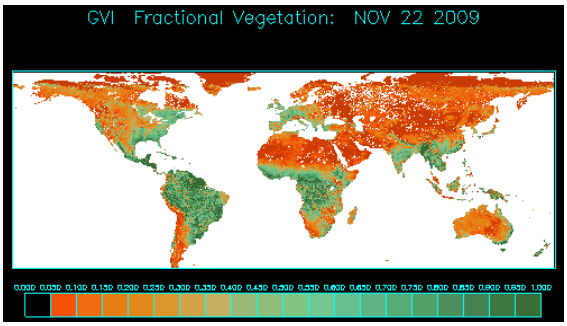

Figure 8. Fractional Vegetation will be generated from VIIRS.

NESDIS will evaluate the vegetation environmental data records, compare VIIRS composites to the AVHRR baseline for consistency, implement algorithm enhancements, and tailor the products for use by NWP models and continuity requirements. NDE will generate GVF products globally on a weekly basis and make them available in NetCDF4 and GRIB2 formats.

4.6 *Blended Total Precipitable Water*

Blending the numerous total precipitable water (TPW) products available from multiple satellites into one product provides a forecaster with a more complete observation of the movement of moisture in the atmosphere and gives the ability to track moisture plumes. This is not possible using individual sensors due to the orbital gaps. The blended TPW product also provides forecasters with continuity on the changing levels of moisture from the ocean areas and helps analysts pinpoint the location of heavy precipitation over the continental United States for use in flood guidance and forecasting. TPW anomaly products show the departure from climatology and help to quickly identify areas where there is a strong flooding potential or the potential for fire hazards.

NDE will generate blended TPW and TPW anomaly products using NPP's ATMS as well as POES AMSU/MHS, DMSP SSM/I and SSMIS, the GOES Sounder, and GPS-Meteorology. These products will be generated globally and will also be sectorized into AWIPS regions.

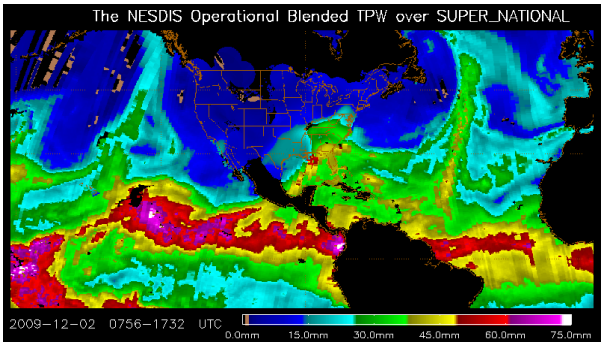

Figure 9. Data from NPP's ATMS will be blended into the current operational TPW product.

4.7 *NetCDF4 Reformatting Tool*

In the past, each individual product application software system was responsible for providing products in specific formats. This led to software redundancy, difficulties in maintenance and increased costs over the long run. To avoid these issues, a project has been started to provide consistency of formats for all NPP and NPOESS products. The project leverages current data translators to design, develop, and create NetCDF4 to BUFR data and NetCDF4 to GRIB2 data. This will allow for an improvement in the maintenance, flexibility, and efficiency of the BUFR and GRIB2 reformatting. The reformatter toolkit will be integrated into the NDE system and will be made available to NOAA's Long Term Archive by NDE.

Table 1 shows the NPP products that will initially be reformatted into BUFR and GRIB2 formats.

Product	BUFR	GRIB2
ATMS Radiances	X	
CrIS Radiances	X	
Nadir Profile Ozone and OMPS Radiances	X	
VIIRS Radiances	X	
Snow Cover		X
Vegetation Index		X
Aerosol Optical Thickness	X	
Sea Surface Temperature	X	
Polar Winds	X	
Green Vegetation Fraction		X

Table 1. Planned BUFR and GRIB products.

5. NDE DATA DISTRIBUTION

NDE users will subscribe to NPP and NPOESS xDRs and NUPs through a web-based interface. The NDE database will contain the definitions of all products, algorithms, product generation rules, files, user profiles, subscriptions, interfaces, and resources. The NDE system will make products available based upon the rules in each user's subscription. The subscription database will contain a list of xDRs and NUPs, along with their pre-defined tailoring options. Optional parameters that may be selected will include limiting the distribution of a product by spatial coverage area and data quality threshold, the type of compression of the delivered file, delivery mechanism, and notification options.

During post-launch testing, NDE will ensure that the NOAA user community, including NWS, NOS, and NMFS, has access to the highest-priority products so that they can evaluate them and prepare to use them in operations.

6. SUMMARY

The NDE Project will begin providing tailored products from NPP to NOAA's user community after the launch and checkout of the satellite. NOAA will use NPP to validate new instruments and to upgrade science processing algorithms prior to the launch of the first NPOESS satellite. For NOAA, NPP is a critical satellite that will provide for mission continuity between the current POES NOAA-19 mission and the future NPOESS C1 mission. NESDIS has started product development projects to prepare for NPP data and is developing capabilities to process and disseminate those products. The primary focus of NDE will be to ensure that legacy capabilities from POES, EOS, and DMSP are maintained and exploited using NPP data. As new user requirements are defined and validated, NDE will develop and implement additional products from NPP and NPOESS.

7. REFERENCES

Key J. R., D. Santek, C. S. Velden, N. Bormann, J.-N. Thépaut, L. P. Riishøjgaard, Y. Zhu, and W. P. Menzel, 2003: Cloud-drift and water vapor winds in the polar regions from MODIS. *IEEE Trans. Geosci. Remote Sens*, **41**, 482–492.

NPOESS Data Exploitation, http://projects.osd.noaa.gov/NDE/

Operational Blended Total Precipitable Water, http://www.osdpd.noaa.gov/bTPW/

Operational Coral Bleaching Products, http://www.osdpd.noaa.gov/ml/ocean/coral_bleaching.html

Operational IASI Products, http://www.osdpd.noaa.gov/IASI/

Operational MIRS Products, http://www.osdpd.noaa.gov/ml/mirs/

Operational Vegetation Products, http://www.osdpd.noaa.gov/ml/land/vegetation.html

Polar Winds Products, http://stratus.ssec.wisc.edu/projects/polarwinds/

8. ACRONYMS

AIRS	Atmospheric Infrared Sounder
AMSU-A	Advanced Microwave Sounding Unit- A
AOT	Aerosol Optical Thickness
ATMS	Advanced Technology Microwave Sounder
AVHRR	Advanced Very High Resolution Radiometer
BUFR	Binary Universal Form for the Representation of meteorological data
CrIS	Cross-track Infrared Sounder
DMSP	Defense Meteorological Satellite Program
EDR	Environmental Data Record
EOS	Earth Observing System
GOES	Geostationary Operational Environmental Satellite
GPS	Global Positioning System
GRIB	Gridded Binary
GVF	Green Vegetation Fraction
HDF	Hierarchical Data Format
IASI	Infrared Atmospheric Sounding Interferometer
IPO	Integrated Program Office
Metop	Meteorological Operational satellite
MHS	Microwave Humidity Sounder
MIRS	Microwave Integrated Retrieval System
NDE	NPOESS Data Exploitation
NESDIS	National Environmental Satellite, Data, and Information Service
NetCDF	Network Common Data Form
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NMFS	National Marine Fisheries Service
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NPP	NPOESS Preparatory Project
NUP	NOAA Unique Product
NWP	Numerical Weather Prediction
OMPS	Ozone Mapping and Profiler Suite
SDR	Sensor Data Record
POES	Polar-orbiting Operational Environmental Satellite
SSMI	Special Sensor Microwave Imager
SSMIS	Special Sensor Microwave Imager and Sounder
SST	Sea Surface Temperature
TDR	Temperature Data Record
TPW	Total Precipitable Water
VIIRS	Visible/Infrared Imager/Radiometer Suite
xDR	Environmental, Sensor, and Temperature Data Records