NOAA'S TRANSITION TO OPERATIONS OF NDE S-NPP PRODUCTS

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1. INTRODUCTION

The launch of the National Oceanic and Atmospheric Administration (NOAA) Suomi National Polar-orbiting Partnership (S-NPP) satellite in October 2011 brought opportunities for meteorological, oceanic, terrestrial, cryogenic, and climate users to utilize new and enhanced environmental, sensor, and temperature data records. NOAA's NPP Data Exploitation (NDE) system, situated within the National Environmental Satellite, Data, and Information Services (NESDIS) Environmental Satellite Processing Center (ESPC), is the data processing system that serves near-real time S-NPP data to the civilian operational user community. A product generation tool within the NDE system enables the tailoring of data records to better satisfy user requirements. Tailoring examples include conversion into alternative data formats, aerial coverages, frequencies, and map projections. NDE also has the ability to apply science algorithms to S-NPP data records enabling the generation of additional unique atmospheric, oceanic, and land surface products required by NOAA's users. This paper will describe the status of the transition of NDE products to operations.

2. NDE SYSTEM

NDE's primary mission is to provide near-real time products, derived from S-NPP instrument observations, to NOAA's operational and climate communities and other civilian and U.S. Government users. The NDE system receives data that is observed from the following suite of instruments onboard the S-NPP satellite:

- 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

The data sets and products generated from S-NPP instrument observations are critical, providing gap mitigation between the current on-orbit NOAA-19 satellite and the future JPSS-1 satellite. Maintaining the continuity of capabilities that exist from legacy POES, DMSP, and EOS satellite constellations is a high priority for NOAA. Through the NDE system, NOAA services the S-NPP products in near-real time and enables exploiting of new sensing capabilities by providing a computing framework capable of developing new and enhanced products to satisfy NOAA user requests.

3. NDE PRODUCTS

A suite of environmental, temperature, sensor, and select application-related data records (xDRs) from S-NPP are provided to the NDE system and made available by subscription to real-time operational end users. NDE receives xDR products in Hierarchical Data Format 5 (HDF5) and reformats them into NetCDF4 prior to distribution. The system is capable of integrating product processing algorithms within its framework. Through coordination and various processes, algorithms are developed and integrated within the NDE system, enabling generation of NESDIS Unique Products (NUPs). NUPs and their associated metadata are delivered to users and will soon be made available to the NOAA Comprehensive Large Array-data Stewardship System (CLASS) for long-term archiving.

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The Low-earth Orbiting Requirements Working Group (LORWG), in collaboration with the NOAA Line Offices, has developed S-NPP product priorities and data latency thresholds for specific NDE products NDE. The NOAA Observing System Council (NOSC) is the approval authority which has approved the priorities and latencies. Both of these requirements are documented in the JPSS Level 1 Requirements Document (L1RD) and associated Supplement.

3.1 *Radiances*

Microwave (ATMS) and infrared (CrIS) radiances were among the first S-NPP products to be made available by the NDE system. Prior to transitioning the NDE system from development into operations, these products were made available to the National Weather Service (NWS) and other Numerical Weather Prediction (NWP) centers as test products and consequently only monitored on a best effort basis. Due to the measureable impact microwave and infrared radiances have on global weather prediction, providing such data to NWP for early assimilation efforts is critical and eventually enabled NWS to successfully promote both radiance sets into operational.

ATMS and CrIS radiances are provided to NWS and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) in Binary Universal Form for the Representation of meteorological data (BUFR) format, which is the desired format for many NWP applications. The NDE system provides the ATMS radiance data in 15 km resolution granules, each comprised within a single data file. The CrIS radiance data being distributed to EUMETSAT and NWS differ in that a subset of 399 channels are being made available to the NWS while all 1305 channels are being made available to EUMETSAT. EUMETSAT produces a 399-channel CrIS BUFR product and places it on GTS. EUMETSAT uplinks both the ATMS and CrIS 399-channel BUFR datasets onto various shared networks or systems such as the Global Telecommunication System (GTS), the Regional Meteorological Data Communication Network (RMDCN), and EUMETcast. NDE provides the ATMS granules at a resolution of 15 km.

3.2 *Imagery*

NWS forecast offices in Alaska require high-resolution imagery from polar-orbiting satellites due to their high latitude, which exceeds much of the geostationary satellite coverage. S-NPP products from the VIIRS instrument satisfy this need. Currently VIIRS visible (I1 band) and infrared (I4 and I5 bands) imagery data over Alaska are sent to the NWS where they are uplinked to their Satellite Broadcast Network (SBN). NWS Offices and Centers which have SBN access have the capability to ingest, and display these VIIRS data sets on NWS AWIPS II workstations. These products are generated with a 375m resolution.

The NDE system tailoring functions for NWS imagery products include sectorizing (based on NWS spatial domain requirements), merging of geolocation info and data info into one file, file compression using GZIP, and filtering of unneeded data parameters to reduce the file sizes. Figure 1 below shows a sample AWIPS II workstation display of VIIRS imagery over Alaska.

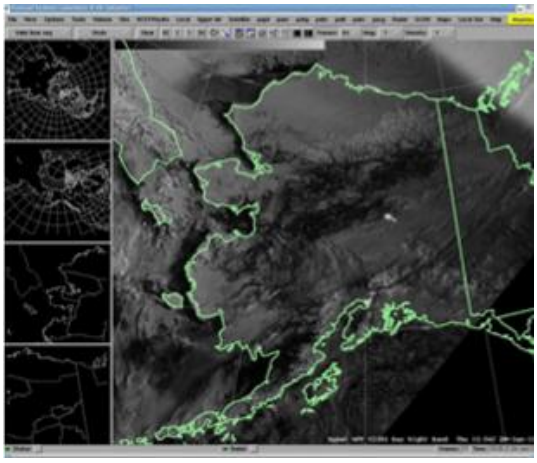

Figure 1. VIIRS Imagery over Alaska

3.3 *Atmospheric Soundings*

Atmospheric soundings include vertical moisture, temperature, and pressure profiles. They significantly improve the knowledge of Earth's atmosphere, benefiting weather and climate applications. Soundings are generated from the CrIS and ATMS instruments with a 50km resolution and are provided in NetCDF4 format. This product

will soon be made available to NWS field offices and NCEP centers and displayable on AWIPS II software. Figure 2 provides an illustration of a sample pop-up Skew-t Log-p graphing capability that is being developed and tested for AWIPS II.

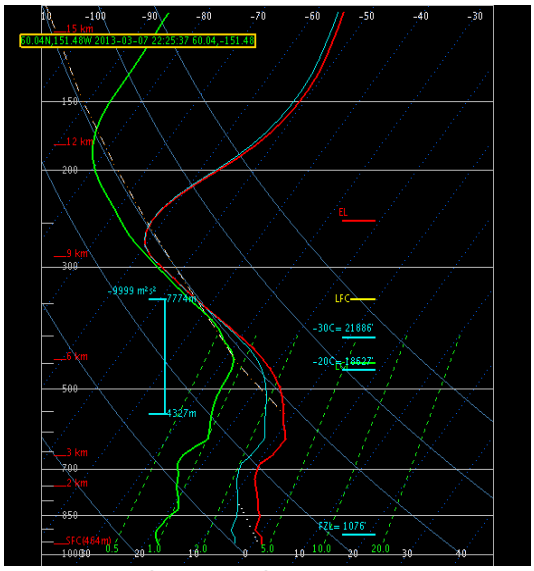

Figure 2. Skew-t Log-p

3.4 *Ozone*

The S-NPP OMPS instrument contains the nadir and limb sensor and 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. Ozone products monitor and assess the ozone hole in the short term. Long-term ozone data is used in ozone layer recovery efforts and to determine impacts due to climate variability and change.

Currently, OMPS profile and total column ozone are generated operationally in BUFR format for National Center for Environmental Prediction's (NCEP) Climate Prediction Center (CPC).

Additional ozone products being developed by NDE include a blended total ozone analysis. This analysis uses infrared ozone and ultraviolet measurements to provide a full-coverage global map of ozone.

Figure 3 provides an illustration of a total ozone image generated from the OMPS instrument.

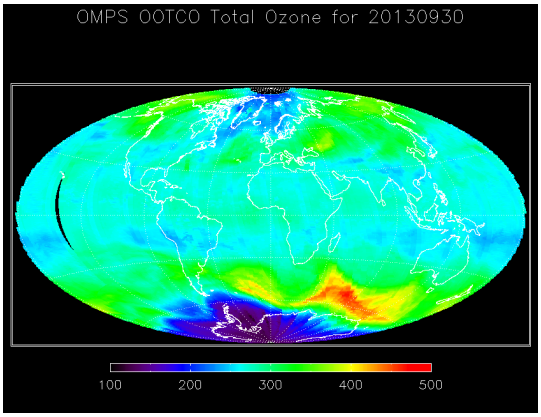

Figure 3. OMPS Total Ozone

3.5 *Microwave Integrated Retrieval System*

The Microwave Integrated Retrieval System (MIRS) processes products over all weather conditions and for different surface types. The algorithm contains one executable using microwave sensors from a variety of geostationary and polar-orbiting satellites.

MIRS products derived from ATMS observations are generated and made available in NetCDF format and include the following observational parameters: temperature profiles, moisture profiles, land surface temperature, land surface emissivity, snow water equivalent, snow cover, sea ice concentration, cloud liquid water, total precipitable water, and rainfall rate.

Products are used by forecasters to assist in the detection of precipitation potential and to enhance NOAA's climate monitoring capability. Figure 4 provides an illustration of a MIRS-generated total precipitable water image using ATMS data.

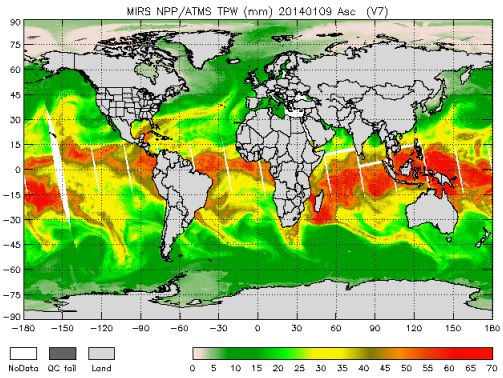

Figure 4. MIRS Total Precipitable Water

3.6 *Advanced Clear-Sky Processor for Oceans Sea Surface Temperature*

The Advanced Clear-Sky Processor for Oceans (ACSPO) Sea Surface Temperature (SST) product is derived from VIIRS observational data and is or will be assimilated into weather and ocean forecast models. ACSPO SST will provide critical data for monitoring ecosystems, such as coral reef habitats. The ACSPO SST product is generated in NetCDF4 format containing a 750m resolution. It is available globally; however, the NDE system is capable of tailoring the product into specific spatial domains. Currently, NDE performs spatial tailoring and generates aggregated ACSPO SST granules for various CoastWatch regions.

NDE is also developing a blended SST product, which combines higher spatial resolution products from an array of polar-orbiting satellites with higher temporal resolution products from geostationary satellites.

3.7 *Aerosol Optical Thickness*

Aerosols are solid or semi-solid suspended matter such as smoke, dust, sea salt, volcanic ash, sulfate, nitrate, and a combination of organic or inorganic particles. The aerosol optical thickness (AOT) product is a measure of atmospheric aerosol loading. AOT products will be assimilated into regional and global NWP models to improve forecast accuracy. NDE will reformat the AOT Environmental Data Record (EDR) into BUFR format for NCEP and EUMETSAT NWP utility.

Figure 5 is a global image of aerosols for the time period of June–August 2013.

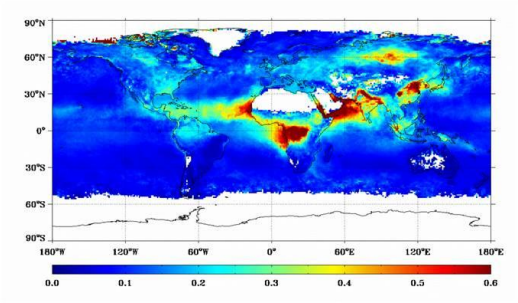

Figure 5. Aerosol Optical Thickness

3.8 *VIIRS Polar Winds*

NWP centers use cloud-tracked atmospheric wind vectors over the poles, called polar winds, to improve model forecasts for the extratropics of both hemispheres. The polar tropospheric wind products include wind speed, direction, and height at high latitudes (over 65 degrees). VIIRS-based wind speed, direction, and height over the Arctic and Antarctic regions will be generated in NetCDF and BUFR formats.

3.9 *Tropical Cyclone Products*

Tropical cyclone intensity products are used to estimate and forecast the radii of winds to give guidance to hurricane forecasters. Products include maximum winds, minimum sea-level pressure, and radii of 34-, 50-, and 64-knot winds. They are generated globally from ATMS data and distributed in text format every six hours for the north Atlantic and northeast Pacific tropical cyclone basins. S-NPP tropical cyclone products are planned to be made available from the NDE system in mid-2014.

3.10 *Green Vegetation Fraction*

Green vegetation fraction (GVF) products are used as an input to land surface models to provide enhanced characterization of the surface, resulting in improved forecasts of near-surface winds, temperature, and humidity. In addition to NetCDF4 format, GVF products from VIIRS data will be generated in GRIB2 format. The weekly product will be updated daily and will be available globally with 4-km resolution and regionally with 1-km resolution.

3.11 *Blended Snow and Sea Ice*

A blended snow and sea ice cover analysis uses data from geostationary and polar-orbiting satellites, as well as non-satellite sources. Data from the S-NPP VIIRS instrument is being added to the algorithm. The snow and ice cover product is used as an input into NWP models and for climate prediction. Snow and ice cover analyses are produced globally once per day and over North America twice per day in GRIB2 format. Figure 6 illustrates a blended snow and ice cover analysis for North America on February 13, 2014.

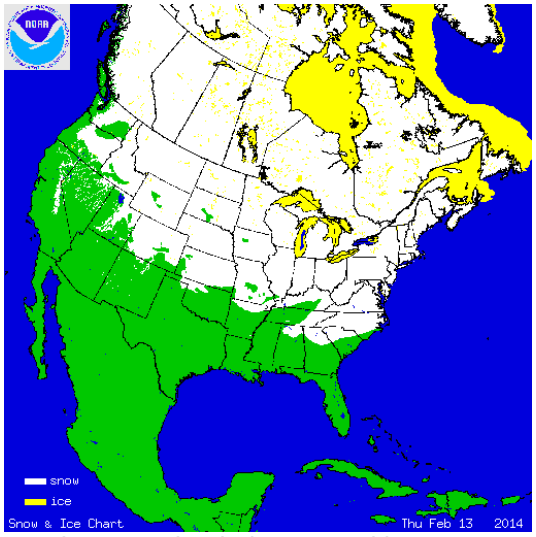

Figure 6. Blended snow and ice cover

3.12 *Vegetation Health*

Vegetation health products are used by CPC for U.S. drought monitoring. The product is also used in global climate impact assessments. Other government agencies use vegetation health products to determine global crop production, fire risk, disaster mitigation, and food security.

Vegetation health products are currently under development and will be derived using VIIRS data. Products include the vegetation health index (VHI), which characterizes total health conditions in response to weather impacts, the vegetation condition index (VCI), which characterizes moisture, and temperature condition index (TCI), which characterizes temperature. Vegetation health products will be made available in HDF and GeoTiff formats on a weekly basis with a resolution of 4-km.

3.13 *Cloud Products*

Various S-NPP VIIRS derived cloud products are generated by the Joint Polar Satellite System's (JPSS) ground system, the Interface Data Processing Segment (IDPS), and are distributed to the NDE system for near-real time user access. VIIRS cloud product EDRs include cloud cover/layers, cloud mask, cloud effective particle size, cloud optical thickness, cloud top height, cloud top temperature, cloud top pressure, and cloud base height.

The NDE system currently provides EUMETSAT with a single cloud test product combining VIIRS cloud top height, cloud cover/layers, and associated geo-referencing information. This information is used to populate various cloud parameters within the CrIS SDR data NDE provides. This product is an example of how the NDE system can tailor data to satisfy user requirements.

3.14 *Ensemble Tropical Rainfall Potential*

The Ensemble Tropical Rainfall Potential (eTRaP) product provides an estimate of rain rates from land-falling tropical cyclones. The eTRaP products blend a variety of polar-orbiting and geostationary satellite data. ATMS instrument data is currently being added to the algorithm responsible for this product generation. The eTRaP products are, and will continue to be, provided in ASCII text and McIDAS area formats.

4. SUMMARY

NESDIS has successfully transitioned the NDE system capabilities from development to operations and is in the process of developing additional satellite products from S-NPP instrument data. The new and enhanced products satisfy user requirements, resulting in improved weather forecasts and assisting in the monitoring of Earth's climate and oceans.

New and enhanced products will continue to be generated as user requirements are

identified, validated, and product development resources are identified.

5. REFERENCES

JPSS Level 1 Requirements Document, June 2013.

JPSS Level 1 Requirements Supplement, June 2013.

Suomi National Polar-orbiting Partnership, http://jointmission.gsfc.nasa.gov/

T. Schott, S.L. Bunin, J. Silva, and K. Berberich: “NOAA’s Product Processing from Future Polar-orbiting Operational Environmental Satellites,” *Seventh Annual Symposium on Future Operational Environmental Satellite Systems* in Seattle, WA, January 2011.