JP8.9 NOAA-GENERATED OPERATIONAL PRODUCTS AVAILABLE FROM THE METOP SATELLITE

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1. INTRODUCTION

The launch of the MetOp-A satellite on October 19, 2006 provided the opportunity for NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) to generate a suite of new products using MetOp's new instruments and capabilities. As part of the Initial Joint Polar-orbiting Operational Satellite System (IJPS) agreement, NOAA receives data from MetOp's instruments from the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT). MetOp-A's new instruments include the Infrared Atmospheric Sounding Interferometer (IASI), Advanced Scatterometer (ASCAT), and Global Ozone Monitoring Experiment (GOME). In addition, higher resolution products are now generated using the global 1-km Advanced Very High Resolution Radiometer (AVHRR) data. Since the launch of MetOp-A, NOAA has been developing new products and transitioning them to an operational environment. New products that have recently been declared operational include cloud cleared radiances, carbon trace gases, and ozone profiles from IASI; ocean surface wind vectors and radar backscatter measurements from ASCAT; and total ozone and magnesium II index products from GOME. This paper will provide information on the new products available to the NOAA user community from the MetOp-A satellite.

2. PRODUCT PROCESSING FROM METOP

Because of the increased volume of data and transmission capabilities the MetOp data is delivered to NOAA and processed in a granule (pipeline) format, or small subsets of the orbit versus the entire orbit. Data is accrued into 8-minute files called granules before being processed, which allows products to be distributed to meet user timeliness requirements. Level 1b data from the MetOp satellite, as well as from the NOAA-18, are available in both orbital and pipeline formats.

The products generated from the MetOp unique instruments, as well as some of the global 1-km products, all use pipeline processing of granules. Figure 1 describes the time savings of using pipeline processing for a sample area of interest. In this example, processing of the area of interest begins approximately 45 minutes earlier than waiting for the orbital file to become available.

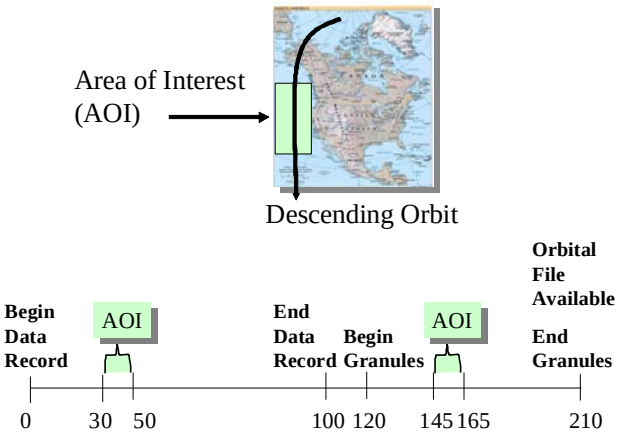

Figure 1. Granule processing versus orbital processing.

Several existing products were also upgraded to use pipeline processing and take advantage of the improved product time latency.

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3. NEW PRODUCTS FROM METOP

MetOp and POES contain similar instruments such as the Advanced Very High Resolution Radiometer (AVHRR/3), High Resolution Infrared Radiation Sounder (HIRS/4), Advanced Microwave Sounding Unit-A (AMSU-A), Microwave Humidity Sounder (MHS), and Space Environment Monitor (SEM-2). Shortly after MetOp replaced the morning satellite in the POES constellation, products from those instruments were declared operational as a continuity of mission. New products from MetOp's unique instruments and datastreams have recently moved into operations.

3.1 *ASCAT*

Monitoring the air-sea interaction is very important for daily and long-term weather forecasting and global climate studies and observing ocean surface winds is an important factor for understanding this interaction. The ASCAT sensor aboard MetOp-A provides global coverage of ocean surface wind vectors and allows NOAA users to have access to a suite of wind vector products previously only available from the QuikSCAT instrument. While the ASCAT instrument does not replace QuikSCAT, it does provide an additional data source in the large and mostly data void ocean regions.

ASCAT uses radar to measure the electromagnetic backscatter from the ocean surface and is used to derive ocean surface wind vectors at 50-km and 25-km resolution at a nominal height of 10 m. ASCAT retrievals are based on the C-band radar cross-section measurements of the ocean surface at three different azimuth angles. Products are generated in BUFR format and are assimilated into NWP models and are also used by NWS field offices. Wind vector products from ASCAT are also used to track tropical cyclones and winds that are centered on tropical storms are also available.

Figure 2 shows an ASCAT image of 50-km near real-time winds surrounding Hurricane Ike in September 2008.

In the future higher resolution wind products and a daily sea ice product will be generated, as well as normalized radar cross-section images, which depict ice in the polar regions.

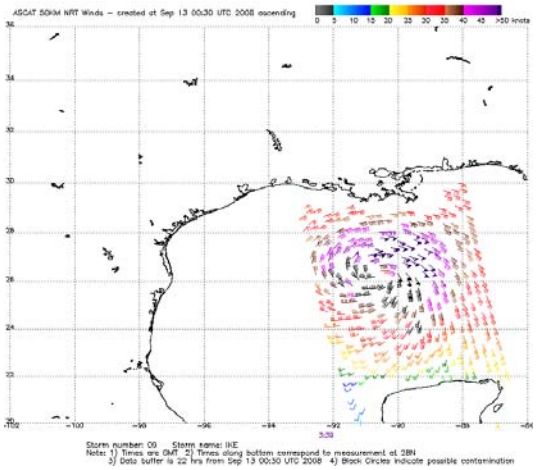

Figure 2. ASCAT 50-km winds.

3.2 *GOME*

Satellite measurements are used to monitor stratospheric ozone levels in order to determine long-term changes in ozone levels and measure the extent of climate change. Total ozone products are used in environmental modeling and to monitor the ozone hole and ozone trends. The GOME-2 instrument on MetOp-A measures atmospheric ozone, with near global-coverage on a daily basis. GOME-2 total ozone products are based on the SBUV/2 version 8 algorithm, which has varying ozone and temperature climatology based on latitudes and seasons, an improved forward model, corrections for aerosol contamination, and an inverse model that uses measurements at ten wavelengths ranging from 273-331 nm. The total ozone product is available in binary and BUFR formats. Aerosol indices and reflectivity values are included in the total ozone binary product. A gridded total ozone product with a 1 x 1.25 degree grid is available on a daily basis in ASCII and GRIB2 formats. Figure 3 shows an example of the total ozone product from GOME-2.

A new product is also available from GOME-2. The Magnesium II (MgII) index is used by the solar and space community for space density calculations and is a key to computing satellite drag and de-orbits. The MgII index is extracted from GOME-2 data as soon as a new solar measurement is available. The product includes a 61-wavelength subset of the daily solar spectrum and a core-to-wing ratio for the spectrum. The MgII index uses the average of

irradiance values in the wavelengths from 276.82 nm to 283.17 nm. MgII index is the ratio of the irradiance values at the three core wavelengths to the values at the four wavelengths at each of the two wings. It is generated daily in ASCII format for solar and space users.

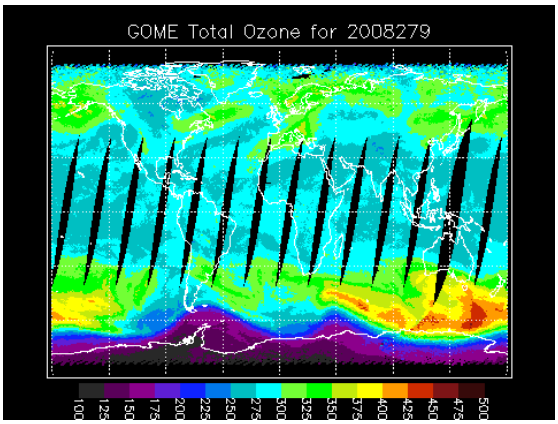

Figure 3. Total Ozone from GOME-2.

Future product plans from GOME-2 include the generation of air quality products. Trace gases such as nitrogen dioxide, sulfur dioxide, and formaldehyde will be generated, as well as aerosol products that will provide the ability to distinguish between dust/smoke and urban/industrial aerosols.

3.3 *IASI*

Hyperspectral measurements are used to improve knowledge of temperature, moisture, and ozone, for both weather and climate applications. The IASI instrument, used in conjunction with the AMSU-A and MHS for cloud clearing capabilities, provides highly accurate data for assimilation into NWS numerical weather models. The IASI instrument has 8461 channels with a total of 29 GB per day of data making it necessary to subset the data for users. Thinned radiances are generated for a set of selected channels. Principal component scores and cloud cleared radiances are also generated. These products are all available in NetCDF, BUFR, and gridded/binary formats.

Level 2 IASI products include total ozone and trace gases such as carbon dioxide (CO2), carbon monoxide (CO), methane (CH4), and nitric acid (HNO3), which are useful to the climate community. Trace gases are important drivers for climate change and can indicate areas of burning of biomass and fossil fuels. Level 2 IASI products are available in NetCDF and gridded/binary formats.

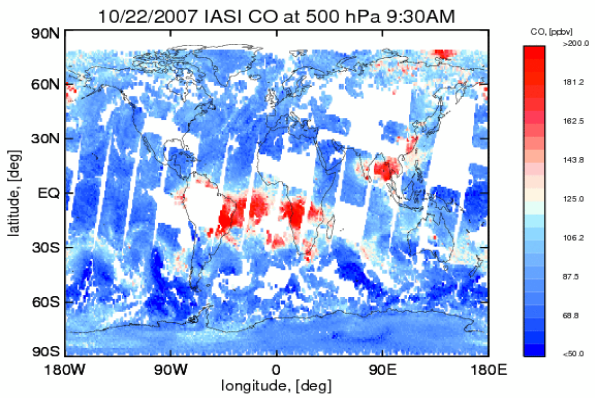

Figure 4. Carbon Monoxide from IASI.

Future products from IASI include atmospheric temperature and moisture profiles.

3.4 *Global 1-km AVHRR*

The Advanced Very High Resolution Radiometer (AVHRR/3) is the same instrument about both the NOAA and MetOp satellites. MetOp uses solid state recorders and an X-band link, which provides a much greater downlink capacity than NOAA's L-band, yielding much more data in the acquisition window. For these reasons, the MetOp satellite provides full resolution global 1-km data.

Products that use the 1-km MetOp data include sea surface temperature, clear sky radiances, and aerosol optical depth. Sea surface temperature products and clear sky radiances are assimilated into operational forecast models. Sea surface temperature products are also used to determine an accurate assessment of coral reef heat stress and prediction of bleaching events; to provide locations of critical temperature fronts and eddies; to assess development of El Niño and La Niña; and to help search and rescue missions to estimate survival time. Aerosol optical depth is used to flag areas contaminated with atmospheric dust to give

more accurate sea surface temperature retrievals.

For each of these products the 8-minute granules are aggregated into 10-minute granules with duplicate data removed. In the future, level 2 product granules will be used to generate the level 3 and 4 products, which are daily, bi-weekly, and weekly products. Each of the level 2 sea surface temperature, clear sky radiances, and aerosol optical depth products are generated in HDF format.

Global vegetation index products are also generated using MetOp's 1-km data in order to monitor the density and health of green vegetation. Applications include classifying land cover, estimating crop coverage, and detecting plant stress. Vegetation products are generated from daily maps, which are used to make the weekly composite product in HDF. They are in the testing phase to be integrated into numerical weather models. Vegetation products do not have strict time requirements and therefore do not use pipeline processing. Figure 5 shows an example of the normalized density vegetation index generated from MetOp's global 1-km AVHRR data generated in December 2008.

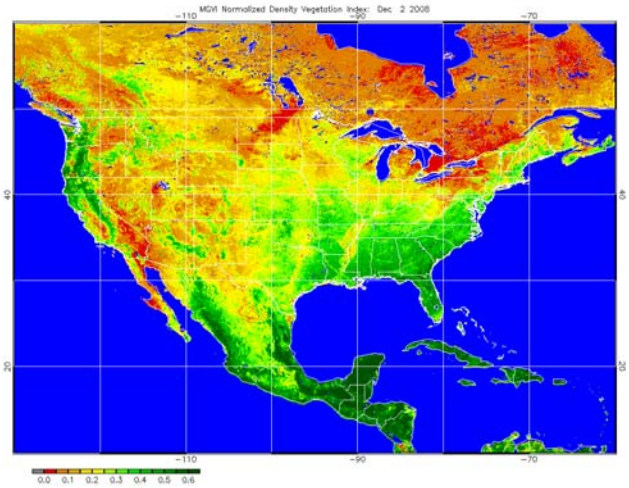

Figure 5. NDVI from MetOp 1-km data

Cloud products are generated daily from the Extended Clouds from AVHRR (CLAVR-x) processing system using MetOp's 1-km data. Pixel-level products include cloud amount, cloud type (water, cirrus, opaque ice, and multi-layer cirrus), cloud emissivity, cloud liquid water path, and cloud ice water path. Each of these products is generated from MetOp's 1-km data. The CLAVR-x cloud products use pipeline processing to increase latency requirements for time-critical users.

Table 1 shows a summary of the new operational products that NOAA generates from the unique instruments on the MetOp satellite, as well as the improved products from the global 1-km AVHRR data.

4. SUMMARY

Products from the MetOp satellite have recently moved from research to operations. They are being used in numerical weather prediction for improved forecasts and in support of climate prediction, prediction of coral reef heat stress and bleaching events, and to more accurately predict ocean temperature fronts for fishery monitoring. Many of the new products now being generated from MetOp will help with the preparations for generating products from NPOESS Preparatory Project (NPP) data. Product development work is currently being done to generate products from NPP's hyperspectral sounder, as well as sea surface temperature products, in order to provide continuity of data.

5. REFERENCES

http://manati.orbit.nesdis.noaa.gov/doc/oceanwinds1.html

http://manati.orbit.nesdis.noaa.gov/ascat/

http://www.osdpd.noaa.gov/ml/air/gome.html

http://www.osdpd.noaa.gov/ml/land/vegetation.html

http://www.star.nesdis.noaa.gov/smcd/spb/iosspdt/iosspdt.php

http://www.osdpd.noaa.gov/ml/air/clavr-x.html

Product	Sensor	Horizontal Resolution	Vertical Resolution	Coverage	Formats
Ocean Surface Wind Vectors	ASCAT	25 and 50 km	N/A	Global Oceans	BUFR
Sigma-0 Radar backscatter	ASCAT	25 and 50 km	N/A	Global Oceans	BUFR
Level 2 Total Ozone	GOME-2	40x80 km	Total Column	Global	Binary, BUFR
Level 3 Gridded Total Ozone	GOME-2	1x1.25 degrees	Total Column	Global	ASCII, GRIB 2
MgII Index	GOME-2	N/A	Total Column	N/A	ASCII
Thinned Radiances	IASI with AVHRR for cloud clearing	50 km	N/A	Global	BUFR, NetCDF, Binary
Principal Components	IASI with AVHRR for cloud clearing	50 km	N/A	Global	NetCDF, Binary
Cloud Cleared Radiances	IASI with AVHRR for cloud clearing	50 km	N/A	Global	BUFR, NetCDF, Binary
Total Ozone	IASI, AMSU-A, MHS, with AVHRR for cloud clearing	50 km	Total Column	Global	NetCDF, Binary
Carbon Dioxide	IASI, AMSU-A, MHS, with AVHRR for cloud clearing	50 km	Mid troposphere	Global	NetCDF, Binary
Carbon Monoxide	IASI, AMSU-A, MHS, with AVHRR for cloud clearing	50 km	Mid/upper troposphere	Global	NetCDF, Binary
Methane	IASI, AMSU-A, MHS, with AVHRR for cloud clearing	50 km	Lower stratosphere	Global	NetCDF, Binary
Nitric Acid	IASI, AMSU-A, MHS, with AVHRR for cloud clearing	50 km	Lower Stratosphere	Global	NetCDF, Binary
Sea Surface Temperature	AVHRR	1 km	N/A	Global	HDF 4.2
Clear Sky Radiances	AVHRR	1 km	N/A	Global	HDF 4.2
Aerosol Optical Depth	AVHRR	1 km	N/A	Global	HDF 4.2
Normalized Difference Vegetation Index	AVHRR	4 km	N/A	Global	HDF
Total Cloud Fraction	AVHRR	1 km	N/A	Global	HDF
High Cloud Fraction	AVHRR	1 km	N/A	Global	HDF
Cloud Type	AVHRR	1 km	N/A	Global	HDF
Cloud Emissivity	AVHRR	1 km	N/A	Global	HDF
Cloud Liquid Water Path	AVHRR	1 km	N/A	Global	HDF
Cloud Ice Water Path	AVHRR	1 km	N/A	Global	HDF

Table 1. Summary of new products being generated from MetOp.