Ozone Monitoring Instrument (OMI)
Near Real Time Data User's Guide

OMI-NRT-DUG-0.5 Draft
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Chapter 1 Before You Begin

1.1 Purpose of the Document

Researchers and scientists in atmospheric sciences use this document to understand Ozone Monitoring Instrument (OMI) (Near Real Time) data and data products available. Most readers have with some background in atmospheric physics or chemistry, but not necessarily a strong background in remote sensing.

This guide provides a description of the advantages and limitations of the OMI.Near Real Time Data and how they deviate from the standard products. The data products themselves are more fully described in the OMI Data Users Guide .The sources of information compiled for this document are listed in Chapter 8.

1.2 Overview of the Document

The chapters in this guide are described below:

Chapter 1 is the introduction to the guide.

Chapter 2 gives general information about the OMI.

Chapter 3 describes the algorithm optimizations made for NRT.

Chapter 4 describes. the cluster optimizations made for NRT.

Chapter 5 describes latency of the Level 2 NRT products

Chapter 6 describes the quality differences between NRT and standard science products.

Chapter 7 describes methods of data distribution for the NRT products

Chapter 8 provides a reference list of source documents
Chapter 9 provides a list of common acronyms used in this document.

Chapter 2 The Ozone Monitoring Instrument

2.1 Introduction to the OMI

The Ozone Monitoring Instrument (OMI) is a Dutch-Finnish instrument on board NASA's Aura Satellite, launched in July 2004. OMI is a wide swath, nadir viewing, near-UV and visible spectrograph that measures ozone columns and profiles, aerosols, clouds, surface ultraviolet (UV) irradiance, and the trace gases Nitrogen Dioxide (NO2), Sulfuric Dioxide (SO2), and Formaldehyde (OHCLO)[1]. For this data to be used in forecast models it needs to be processed and sent to customers within 3 hours from the first measurement of a 100 minute orbit , which leaves 80 minutes for processing and distribution. In comparison the OMI "standard" products are usually processed within 6-24 hours on the OMI Science Investigator-led Processing Systems (SIPS) and then made available for distribution. In addition, the NRT data received is raw, unfiltered data from the Spacecraft Contact Session, which is of varying lengths and includes duplicate packets. In order to produce quality data within these time constraints, algorithms need to be tuned to run faster, processing run in parallel, and data distributed to customers in a timely manner. The OMI NRT capability is an element of NASA's Land Atmosphere Near Real-time Capability for EOS (LANCE) system[6]

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Chapter 3 Algorithm Optimization

The OMI Near-Real-Time (NRT) capability is a joint development of NASA and the Royal Netherlands Meteorological Institute (KNMI) . The Level 1B processing software is provided by KNMI and run by NASA. In order to speed up the Level 1B processing, a number of internal algorithms are bypassed in the Level 1 Processor as compared to forward processing. These include spectral calibration, solar stray light corrections, and some dark current corrections. This speeds up the Level 1B software by about 20% as compared to standard processing .The Level 2 software also uses expedited productions rules when selecting ancillary data. During NRT processing these rules use the most recent data available and do not wait for the best data as the production rules used in the standard products do. This usually means using a snow and ice file that is 24-48 hours old rather than on that is within the window of 24 hours of measurements .The OMI NRT Level 1B and Level 2 products are based on space craft contact sessions and estimated orbit definitions. This means the length of a granule can be either larger or smaller than the standard science products. By inferring that the spacecraft contact session intersects with orbit and using predicted orbit definitions, the start and end times can be estimated, thus avoiding another preprocessing step of reading the files to determine the start and end times. Another attribute of the Space Craft contact session is that data is not necessarily be contiguous for 1 orbit. The granule from the contact session may be disjoint; it may start in the previous contact session. In order to not lose data the orbit start time is decremented by 20 minutes. Below is example (Figure 2) of a granule that is disjoint compared to a standard orbit (Figure 1).

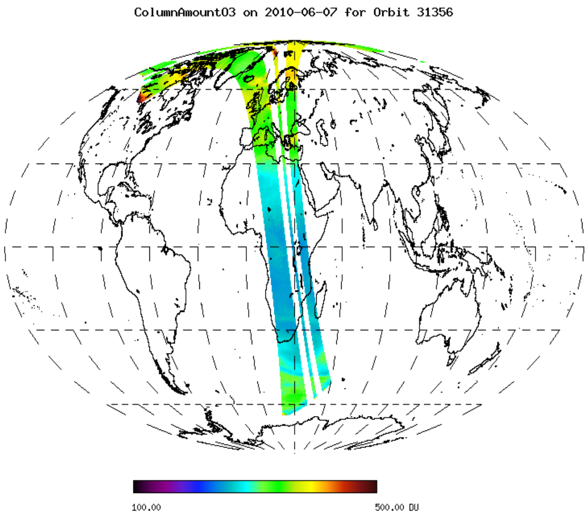

Figure 1 - An example of a normal contiguous granule

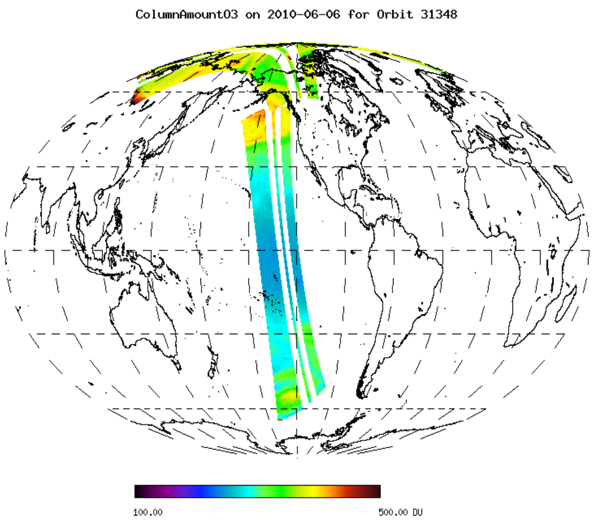

Figure 2 - Example of a disjoint NRT granule

Chapter 4 CLUSTER OPTIMIZATIONS

The OMI team takes advantage of the flexibility and distributed nature of the existing processing system (Atmospheric Composition Processing System[2]) to implement the Near-Real-Time capability. By distributing the workload among processing hosts in the cluster and reserving hosts for jobs at a higher priority, the level 2 algorithms can run in parallel, thus reducing processing time. Additionally, the cluster uses a data driven scheduler to initiate processing upon receipt of the Level 0 data. When a level 0 NRT granule is received, an automated import process ingests the granule into the processing system. This import event triggers the scheduler daemon to plan the Level 1B job which is run on an available processing host.

A redundant processing system is planned for later this summer and will increase the reliability of the system and availability of the products. It will use a separate stream for receipt of the raw level 0 data and will not be depend upon the main processing system. This will enable us to continue to process data during maintenance periods

Chapter 5 LATENCY

One of the challenges of a NRT processing system is to measure and minimize the time it takes to process the NRT data. This latency of the data is measured as the sum of the arrival time from OMI to EOS Data and Operations System (EDOS), the ground system, (E_t) plus the Level 1B processing time ($L1B_t$) plus the sum of the level 2 algorithm and precursor level 2 algorithms processing times ($L2_t$) and any other delays (O_t) , including maintenance) . Thus:

$$\text{NRT Processing Latency} = E_t + L1B_t + L2_t + O_t$$

Table 1 is the results from a typical 2 week period of November 1-14 , 2009. Note that it includes delays due to maintenance .Once the backup NRT is operational we expect these percentages to be close to 99%.

Product	Percentage Delivered under 3 hours
OMCLDO2	96.04
OMDOAO3	94.55
OMNO2A	90.1
OMAERO	85.64
OMCLDRR	96.26
OMAERUV	96.26
OMTO3	93.58
OMSO2	93.58
Total:	92.76

Table 1: Percentage of products delivered in less than 3 hours from first measurement.

Chapter 6 QUALITY DIFFERENCES BETWEEN NRT AND STANDARD SCIENCE PRODUCTS

The quality of OMI NRT Level 2 products compares favorably to the standard products. There appears to be some variances at high latitudes with higher solar zenith angles. In Table 2 we display the maximum differences for a single day and averaged over a week. Note that these are maximum or worst case differences.

Product	**Variable**	**Daily Maximum Percentage Difference**	**Weekly Average Max % Difference**
OMTO3	Total Ozone Column	2.64%	1.40%
OMDOAO3	Total Ozone Column	3.60%	0.30%
OMCLDRR	Cloud Fraction	6.02%	1.42%
	Cloud Pressure	2.82%	0.67%
OMCLDO2	Cloud Fraction	8.83%	1.98%
	Cloud Pressure	3.49%	0.59%
OMAERO	AOD (388 nm)	18.16%	4.56%
OMAERUV	AOD (388 nm)	5.95%	2.31%

Table 2: Maximum differences between NRT and standard products.

As mentioned in section on algorithm optimization, there is a difference in the continuity of the level 2 granules as they are based upon the contact session.

Chapter 7 DATA DISTRIBUTION

OMI data is distributed to a number of customers using both pull and push technology over high speed networks. Originally data was provided to users on a request by request basis. Now data may be downloaded via the FTP protocol as part of NASA's LANCE effort. NRT data is provided by subscription or FTP. Through the subscription based model their is support for scp or sftp pull and FTP or http push. Data is available to any user via FTP pull ; however users must register with ESDIS first (there is no fees or special conditions) . KNMI uses the data for assimilation[3] and provides NRT NO2 maps of Europe through their Tropospheric Emission Monitoring Internet Service (TEMIS) website[4]. Data is also sent to the National Oceanic and Atmospheric Administration (NOAA) for use in volcano monitoring[5]. In addition to other methods of download our Data Downloader (dado) tool offers users a high speed option to pull data to their machines and organize it by user defined metadata using an RSS feed for updates.

Chapter 8 References

[1] P.F. Levelt, E. Hilsenrath, G.W. Leppelmeier, G.H.J. van den Oord, P.K. Bhartia, J. Tamminen, J.F. de Haan, J.P. Veefkind, "Science objectives of the ozone monitoring instrument" , Geoscience and Remote Sensing, IEEE Transactions on Volume 44, Issue 5, Page(s):1199 - 1208 , May 2006.

[2] C. Tilmes, M. Linda, A.J. Fleig, "The Development of Two Science Investigator-led Processing Systems (SIPS) for NASA's Earth Observation

System (EOS)", Geoscience and Remote Sensing Symposium, 2004, IGARSS Proceedings. 2004 IEEE International Volume 3, Issue, Page(s):2190 – 2195, Sept. 2004.

[3] K.F. Boersma, H.J. Eskes, J.P. Veefkind, E.J. Brinksma, R.J. van der A, M. Sneep, G.H.J. van den Oord, P.F. Levelt, P. Stammes, J.F. Gleason, E.J. Bucsela, "Near-real time retrieval of tropospheric NO2 from OMI", Atmospheric Chemistry and Physics Discussions, 6, 12301-12345, 2006.

[4] KNMI, "Regional Tropospheric NO2 columns from OMI" ,Tropospheric Emission Monitoring Internet Service , http://www.temis.nl/airpollution/no2col/no2regioomi_col3.php , December 2009.

[5] NOAA," Latest OMI SO2 Column 5Km - 24-Hour Composite Images", National Environmental Satellite, Data, and Information Service (NESDIS), http://satepsanone.nesdis.noaa.gov/pub/OMI/OMISO2/index.html , December 2009.

[6] NASA, "LANCE Website - and Atmosphere Near-real-time Capability for EOS", NASA Earth Observing System,

Chapter 9 Acronyms

Acronyms, Abbreviations, and Definitions

AAOD Aerosol Absorption Optical Depth

AOD	Aerosol Extinction Optical Depth
AERONET	Aerosol Robotic Network
AQUA	The First Member Satellite in A-Train Series
ATSR	Along Track Scanning Radiometer
BRD	Band Residual Difference
BUV	Backscatter Ultraviolet
CCD	Charge-Coupled Device
DAAC	Distributed Active Archive Center
DEM	Detector Module
DU	Dobson Unit
ELU	Electronics Unit
EOS	Earth Observing System
EP	Earth Probe (satellite)
FOV	Field of View
FWHM	Full Width at Half Maximum
GDPS	Ground Data Processing System
GES DISC	Goddard Earth Sciences Data and Information Services Center
GEOS	Goddard Earth Observing System
GEOS-CHEM	A global three-dimensional model of atmospheric composition driven by assimilated meteorological observations from GEOS
GOME	Global Ozone Monitoring Experiment
HDF	Hierarchical Data Format, current level HDF5
HDF-EOS	The prescribed format for standard data products derived from EOS missions
IAM	Interface Adaptor Module
IFOV	Instantaneous Field of View
L0	Level 0 data are reconstructed, unprocessed instrument and payload data at full resolution, after the removal of all communications artifacts (for example, synchronization frames, communications headers, duplicate data). In most cases, the EOS Data and Operations System (EDOS) provides these data to the DAACs as production datasets for processing by the Science Data Processing Segment (SDPS) or by a SIPS to produce higher level products.

For more specific information about L0 through L3 data, refer to "Error: Reference source not found" beginning on Page Error:

L1A	Level 1A datasets consist of Level 0 data that have been time-referenced and annotated with ancillary information, including radiometric and geometric calibration coefficients and georeferencing parameters (for example, platform ephemeris) computed and appended but not applied to the Level 0 data.
L1B	Level 1B datasets consist of Level 1A data that have been processed to sensor units.
L2	Level 2 datasets contain derived geophysical variables at the same resolution and location as the Level 1 source data.
L2G	Level 2G datasets contain one day's worth of the Level 2 data (typically 14 orbits) ordered by ground position rather than by time.
L3	Level 3 data consists of L2 datasets with the variables mapped on uniform space-time grid scales, usually with some completeness and consistency.
LER	Lambertian-Equivalent Reflectivity
LF	Linear Fit
LIDAR	Light Detection and Ranging
LUT	Look-Up Table
MLER	Mixed Lambertian-Equivalent Reflectivity
MODIS	MODerate resolution Imaging Spectrometer
NRT	Near Real Time
OMI	Ozone Monitoring Instrument
PBL	Planetary Boundary Layer
QF	Quality Flag
RMS	Root-Mean-Square (power measurement)
SBUV	Solar Backscatter Ultraviolet (instrument)
SC	Slant Column
SCO	Slant Column Ozone
SF	Spectral Fit
SIPS	Science Investigator-led data Processing System
SNR	Signal-to-Noise Ratio
SSA	Single Scattering Albedo

SZA	Solar Zenith Angle
TOMS	Total Ozone Mapping Spectrometer
UV	Ultra Violet
UVAI	UV Aerosol Index
VIS	Visible