Application of Aura OMI L2G Products Compared with NASA MERRA-2 Assimilation

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NASA/Goddard Earth Sciences Data and Information Services Center (GES DISC)

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Introduction

- The Ozone Monitoring Instrument (OMI) is one of the instruments aboard NASA's Aura satellite. It measures ozone total column and vertical profile, aerosols, clouds, and trace gases including NO_2, SO_2, HCHO, BrO, and OClO using absorption in the ultraviolet electromagnetic spectrum (280 - 400 nm) . OMI Level-2G (L2G) products are based on the pixel-level OMI granule satellite measurements stored within global 0.25° × 0.25° grids, therefore they conserve all the Level 2 (L2) spatial and temporal details for 24 hours of scientific data in one file.
- The second Modern-Era Retrospective analysis for Research and Applications (MERRA-2) is NASA's atmospheric reanalysis, using an upgraded version of Goddard Earth Observing System Model, version 5 (GEOS-5) data assimilation system. MERRA-2 includes aerosol data reanalysis and improved representations of stratospheric ozone, compared with its predecessor MERRA, in both instantaneous and time-averaged collections. It is found that simply comparing satellite Level-3 products might cause biases, due to lack of detailed temporal and original retrieval information. It is therefore preferable to inter-compare or implement satellite derived physical quantities directly with/to model assimilation with as high temporal and spatial resolutions as possible. This study will demonstrate utilization of OMI L2G daily aerosol and ozone products by comparing them with MERRA-2 hourly aerosol/ozone simulations, matched in both space and time aspects.
- Both OMI and MERRA-2 products are accessible online through NASA Goddard Earth Sciences Data Information Services Center (GES DISC, https://disc.gsfc.nasa.gov/).

Characteristics of OMI L2G

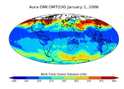
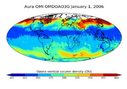
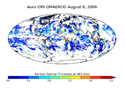
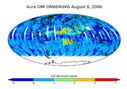
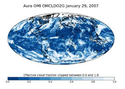
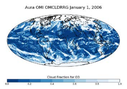
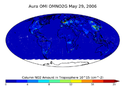
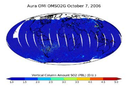
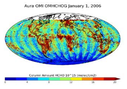
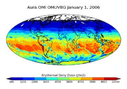
- **Benefits of OMI L2G Product**
  - 24 UTC hours of OMI level-2 data (excluding zoom mode) in one file
  - Global coverage;
  - In grid format with a 0.25°×0.25°resolution, except for OMSO2G whose resolution is 0.125°×0.125°;
  - All data are from "good" scenes;
  - Easy reversal to level 2.

- **What is special about OMI L2G Product?**
  - OMI L2G products are not 'traditional' gridded data.
  - Understanding of Ncandidate: OMI L2G products have a unique dimension of Ncandidate in addition to the dimensions of longitude-grid and latitude-grid, which might cause confusion to new users. Because the candidates in one grid cell of OMI L2G products are sequenced according to their optical paths, they do not correspond temporally, and thus choosing a single level of candidates does not represent the true global spatial distribution of the parameter in time, and should not be used to validate modeled parameters.
  - Comparing OMI L2G products with model simulations such as MERRA-2 is not straightforward.
  - The figures in the next section show the global map of all the candidates with their spatial and temporal signatures collected from the ten OMI L2G products. Each candidate in OMI L2G grid cells is distinguished by specific signatures, including the line number, orbit number, scene number, geolocation, and time stamp.

- **Best Features in OMI L2G Product Applications**
  - Geographic subsetting *ad libitum*
  - Equal or less storage space
  - Reduce file management in coding and loading files
  - With proper algorithms, L2G can be directly compared with model simulations or satellite level 3 products, with regridders such as the NASA GES DISC Level 3/4 Regridder and Subsetter tools.

Acknowledgment: The authors acknowledge the OMI Aerosol Science Teams for the Science Algorithms and the NASA/GMAO MERRA-2 for aerosol data and the GES DISC for its Level 3/4 Regridder and Subsetter tools.

OMI/AURA Daily Gridded Level 2G Products Archived at NASA/GES DISC

OMTO3G	OMDOAO3G	OMAEROG	OMAERUVG	OMCLDO2G	OMCLDRRG	OMNO2G	OMSO2G	OMHCHOG	OMUVBG
▫ O_3 total column (TOMS V8 method) ▫ N-value ▫ UV aerosol index ▫ SO_2 index ▫ LER ▫ Cloud fraction ▫ O_3 below cloud	▫ O_3 total column(DOAS method) ▫ O_3 slant column density ▫ Air mass factor ▫ Scene reflectivity ▫ Cloud fraction and pressure	▫ Aerosol optical depth ▫ Aerosol indexes ▫ Aerosol type ▫ Single scattering albedo ▫ Aerosol layer height ▫ Size distribution	▫ UV aerosol index ▫ Aerosol extinction optical depth ▫ Aerosol absorption optical depth ▫ Single scattering albedo	▫ Cloud fraction and pressure (O_2-O_2 absorption method) ▫ Slant column O_2-O_2 and O_3 ▫ Ring coefficients	▫ Cloud fraction and pressure (Rotational Raman scattering method)	▫ NO_2 total and tropospheric column ▫ Slant column density ▫ Surface reflectivity ▫ Cloud top height	▫ Total SO_2 vertical column in the PBL, lower and middle troposphere, and in lower stratosphere to different sources ▫ LER (UV)	▫ Formaldeheyde total column and slant column abundance ▫ One sigma fitting uncertainties for HCHO and other species	▫ Surface erythemal UV exposure (TOMS algorithm) ▫ Downward spectral irradiance ▫ Erythemally weighted UV irradiance
									
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Optimal Utilization of OMI L2G Products

In order to optimally utilize Aura OMI daily L2G aerosol products that have global coverage, an algorithm has been developed to create hourly OMI gridded data products from L2G data. The hourly aerosol optical thickness (AOT) product can be compared to MERRA-2 hourly aerosol simulations directly, to emphasize the benefit of L2G products.

- Utilize OMI L2G products may not seem as straightforward as level-2 or level-3 products. The major difference between L2G and L3 is that each grid cell of L2G might contain multiple candidates from the level-2 products. The major difference of L2G from L2 is that L2G products no longer have the data at the pixel level. Finding optimal ways to utilize L2G products is critical in order to take full advantage of all the benefits of the L2G format.
- First of all, L2G is basically L2 because it includes all the necessary attributes that define L2 product features, such as pixel-level geographical and temporal elements. As a result, the easiest and most direct method is to treat L2G as L2. Since it will not be representative if only one candidate is chosen from each grid cell, the drawback of this method is that it will lose the benefits of the gridded format, and is time-consuming.
- Another great aspect of L2G is global coverage. Users can easily subset the regions of interest without worrying about the size of the subset areas. This method helps to improve processing speed. Figure 1 demonstrates a dust storm episode which occurred in southwest Africa in July 2007 with a region size of 6º × 4º, showing the OMAERUVG UV aerosol index which can be used to identify aerosol types. Figure 2 shows the OMSO2G product, the vertical column amount of sulfur dioxide in the lower stratosphere, when Mount Agung volcano erupted in the Indonesian island of Bali in late November 2017. One should pay close attention to the missing portion in this OMI swath due to the row anomaly issue which has existed since 2007. This figure also illustrates applying *Quality Flags* is not only for high quality demand, but is also a necessity for data utility.
- The third method to get the best use of L2G products is to fully utilize both the L2 and L3 features in L2G. GES DISC has developed an algorithm to convert the daily L2G product to hourly L2G products, with the purpose of efficiently reducing the candidates in the grid cells, and preparing L2G data in the same format as for model simulations such as the MERRA-2 aerosol hourly reanalysis product M2T1NXAER.
- A proper regridder is required to compare, as accurately as possible, different products with different grid sizes, such as MERRA-2 and OMI L2G. GES DISC has also been developing regridding tools that can be used among various products to meet various purposes.

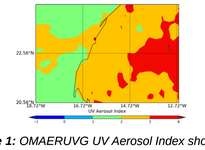

Figure 1: *OMAERUVG UV Aerosol Index shows a dust storm in northwest Africa on July 21, 2017.*

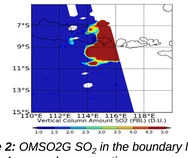

Figure 2: *OMSO2G SO_2 in the boundary layer shows the Mt. Agung volcano eruption.*

Reference: Torres, O., A. Tanskanen, B. Veihelmann, C. Ahn, R. Braak, P. K. Bhartia, P. Veefkind, and P. Levelt (2007), Aerosols and surface UV products from Ozone Monitoring Instrument observations: An overview. J. Geophys. Res., 112, D24S47, doi:10.1029/2007JD008809.

Application Use Cases

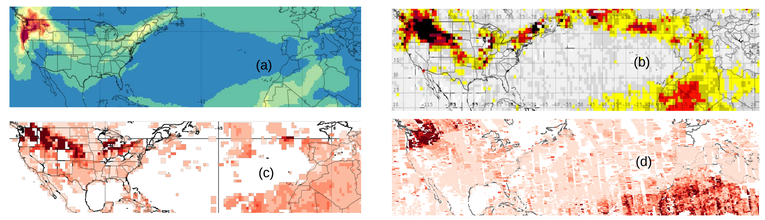

Figure 3: *Wildfires in northwest US and Canada on September 4-8, 2017. (a) MERRA-2 total extinction AOT at 550nm; (b) OMI UV Aerosol Index; (c) OMI Aerosol Optical Depth at 500nm; (d) OMI aerosol absorption optical depth at 500nm.*

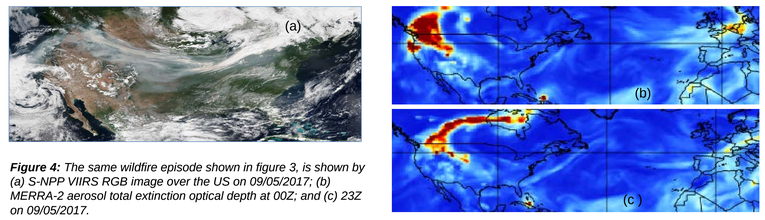

Figure 4: *The same wildfire episode shown in figure 3, is shown by (a) S-NPP VIIRS RGB image over the US on 09/05/2017; (b) MERRA-2 aerosol total extinction optical depth at 00Z; and (c) 23Z on 09/05/2017.*

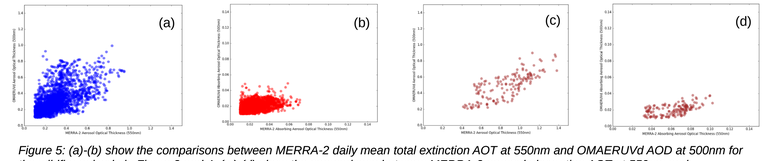

Figure 5: (a)-(b) show the comparisons between MERRA-2 daily mean total extinction AOT at 550nm and OMAERUVd AOD at 500nm for the wildfire episode in Figure 3 and 4; (c)-(d) show the comparisons between MERRA-2 aerosol absorption AOT at 550nm and OMAERUVd absorbing AOD at 500nm for the dust episode in Figure 1.

- Comparisons between MERRA-2 hourly AOT reanalysis vs. OMI L2G hourly AOD product show that the majority of the model grids contain background aerosols with small AOD values in this extensive smoke plume event. When the aerosol loading in the air is very low, the accuracy of aerosol retrieval will be increasing dependingly on the certainties in the surface reflectivity, aerosol types and aerosol height etc. and also on the instrument measurement sensitivity and accuracy.

Summary

- This presentation demonstrates all of the OMI L2G products that are archived at NASA/GES DISC and suggests three ways to utilize OMI L2G optimally.
- The comparisons between daily mean MERRA-2 total extinction/absorption optical thickness and OMAERUVb/OMAEROe show high agreement for both strong biomass burning and dust aerosol events. MERRA-2 simulated larger AOD values, especially large absorption AOD. The closer the data is acquired to the sources of the events, the higher the agreement between products.
- The purpose of generating hourly L2G products is to utilize all the potential that L2G products provide, and to supply relatively more accurate satellite observations varying temporally and spatially. Comparing hourly L2G data to MERRA-2 hourly simulations will, in turn, be helpful to verify model performances in a more accurate way.