Introduction

Optical A-Train Data Utilization: A Use Case of Aura OMI L2G and MERRA-2 Aerosol Products

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Use Case

OMI flying on NASA’s Aura satellite is a collaborative contribution of the Netherlands Agency for Aerospace Program and the Finnish Meteorological Institute to observe atmospheric components such as ozone, aerosol, NO2, SO2, HCHO, NO, OCO, and cloud with a spectrum range of Ultraviolet and visible band. The push-broom telescope of the hyperspectral imager has a 114°field-of-view corresponding to 2600 km on the ground. The OMI instrument has a 24-hour revisit cycle and is available online at https://ntrs.nasa.gov/search.jsp?R=20170005897

OMI Levelt (2007), Aerosols and surface UV products from Ozone Monitoring Instrument observations: Reference:

Sensor or MERRA-2 matched well in both space and time. The comparison between satellite and model data by simply how to properly handle counterpart pairing is critical considering their spatial and temporal variations. The comparison between satellite and modeled data by simply using Level 3 (L3) products may result biases due to lack of detailed temporal information. It has been proposed to inter-compare or implement satellite derived physical quantity (i.e., Level 2 (L2) Swath type) directly with/to model measurements with higher temporal and spatial resolution as possible. However, this has posed a challenge in the community to handle. Rather than directly handling the L2 or L3 data, there is a Level 2G (L2G) product consisting L2 pixel scientific data quality but in Grid type with the global coverage. In this presentation, we would like to demonstrate the optimal utilization of OMI L2G daily aerosol products by comparing with MERRA-2 hourly aerosol simulations matched well in both space and time.

Data Investigation

OMI

- OMI on NASA’s Aura satellite is a collaborative contribution of the Netherlands Agency for Aerospace Program and the Finnish Meteorological Institute to observe atmospheric components such as ozone, aerosol, NO2, SO2, HCHO, NO, OCO, and cloud with a spectrum range of Ultraviolet and visible band.
- The push-broom telescope of the hyperspectral imager has a 114°field-of-view corresponding to 2600 km on the ground.
- OMI-level-2G (L2G) products contains OMI L2 swath data with all the “good” scenes that are populated the L2G-uniformed longitude-latitude grids. This L2 grid size can be 0.25°×0.25° or 0.125°×0.125°. Currently there are 28 OMI L2G products archived at NASA/GES DISC. Each OMI L2G product defines a “good” scene differently.
- Two aerosol inversion scheme are applied to retrieve OMI aerosol optical thickness (AOT and AOD) and single scattering albedo, producing two L2G products:
  - OMAEROG: The multi-wavelength algorithm uses up to 19 channels from 330nm to 500nm to derive extinction optical thickness.
  - OMAERUVG: The near-UV algorithm uses two UV bands at 348 nm and 380 nm to obtain extinction and absorption AOT.

MERRA-2

- The second Retrospective analysis for Research and Applications (MERRA-2) is NASA’s atmospheric reanalysis data assimilation system. MERRA-2 is enhanced with hourly diagnostic aerosol products of different types such as black carbon, organic carbon, dust, sea salt, SO4, and SO2. The grid size is 0.25°×0.25°.

Advantages of OMI L2G Product

- 24 UTC hours of OMI level-2 data (excluding revision mode) in one file
- Global coverage
- Grid format
- All data are from “good” scenes.

Disadvantages of OMI L2G Product

- OMI L2G products are not commonly gridded data.
- What is Ncondait?
- Core variables of OMI L2G products have all a third dimension of Ncondait in addition to the dimensions of longitude-grid and latitude-grid, which might cause confusing to some users. Figure 1 show OMIOMTG total ozone column amount (DU) of single level candidates versus all-level candidates. Because the candidates in one grid cell of OMI L2G products are sequenced according to their optical paths, choose a single level candidates could not able to represent the true globally spatial distribution of the interest atmospheric composition, thus should not be used to validate modeled parameter.
- The right figure in figure 1 shows the global map of the total column amount of ozone considering all the candidates with their spatial and temporal signatures collected from OMI L2G data. Each candidate in OMI L2G grid cells are distinguished by specific signatures including line number, orbit number, scene number, geolocation and time stamp. Comparing OMI L2G products with MERRA-2 hourly aerosol simulations as

A direct way to compare OMI L2G satellite measurements and MERRA-2 hourly reanalysis simulations

- An algorithm has been developed to create hourly OMI gridded products with all the L2G metadata and OMI L2 spatial and temporal information. See figure 2 for the algorithm flowchart.
- MERRA-2 products are regridded to OMI L2G grids with the GES DISC CDO regrid tool.
- The accuracy of the algorithm will mainly depend on the regridding techniques, which will be further investigated in the future.
- Figure 3 shows an example of the hourly OMAEROG gridded AOT product.

Use Case

In order to optimally utilize Aura OMI daily L2G aerosol products that have a global coverage, an algorithm has been developed to create hourly OMI gridded data products from L2G data. The hourly AOT product will be able to compare to MERRA-2 hourly aerosol simulations directly, thus to emphasize the benefit of O2 products.

The preliminary comparisons to MERRA-2 total extinction and absorption optical thickness are mainly in capability demonstrations not in quantitative match. However, the results do confirm that OMAEROG multi-wavelength algorithm overestimates thick aerosol loading.

In figure 7, the 388 nm AOT dataset combined OMAEROG and OMAERUVG shows good agreement at 3:00 in the eastern region (see figure 8).

In Victoria, Australia, bushes and vegetation had been burned in Great Dividing Range Mountains since December of 2016 due to extremely dry, windy and hot weather. In south America, north of Conception, Chile, a number of agricultural fires caused small smoke plumes. However, the cause of the largest fires near the coast that produced extensive thick smoke plumes could not be identified.

In figure 8 shows the absorbing aerosol thickness comparison between MERRA-2 and OMAERUVG near-UV algorithm retrieval.

Summary

In summary, in the current study we utilized daily aerosol OMI L2G products and the NASA/GSFC MERRA-2 aerosol products to create hourly aerosol products. The data products from both L2G and daily aerosol data have been used to compare with MERRA-2 aerosol products, thus to emphasize the benefit of having daily aerosol products.

Acknowledgment:
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Figure 1: OMI L2G OMTG0G ozone total column amount (DU) on January 1, 2008. The left figure only contains OMI L2G scenes from OMTG0G level 1 candidates that have the shortest optical path among all the candidates in a grid cell. The right figure includes all the candidates from up to 15 levels.

Figure 2: Algorithm flowchart to create hourly OMI gridded products

Figure 3: Total Column Aerosol Optical Depth on January 10, 2007 (13UTC-14UTC) from OMI multi-wavelength Aerosol algorithm retrieval

Figure 4: The smoke plumes over the west coast of Chile are seen from OMAERO multi-wavelength algorithm retrieval (purple circle in Figure 1) but not seen from OMAERUVG retrieval. In the meantime, MERRA-2 reanalysis does show comparitively light aerosol plumes.

Figure 5 illustrates MERRA-2 total extinction AOT mass simulations at 550nm compared to OMI measured AOT retrieved by the Near-UV algorithm (OMAERUVG, red ‘+’) and the Multi-wavelength algorithm (OMAERO), green ‘*’). This analysis confirmed the OMAEROG multi-wavelength algorithm tends to overestimate the high optical thickness loading, especially over land.

Figure 6 shows the absorbing aerosol thickness comparison between MERRA-2 and OMAERUVG near-UV algorithm retrieval.

Table 1: Instrument/Model Specifications for OMI L2G and MERRA-2

<table>
<thead>
<tr>
<th>OMI Product</th>
<th>Spatial Resolution</th>
<th>Temporal Resolution</th>
<th>Data Period</th>
<th>Total Column Aerosol Dataset</th>
</tr>
</thead>
<tbody>
<tr>
<td>OMAEROG</td>
<td>0.25°×0.25° daily</td>
<td>Oct/Nov current</td>
<td>Aerosol Optical Thickness at 324nm, 350nm, 443nm, 468nm, 500nm</td>
<td></td>
</tr>
<tr>
<td>OMAEROG</td>
<td>0.125°×0.125° daily</td>
<td>Oct/Nov current</td>
<td>Aerosol Optical Thickness at 324nm, 350nm, 443nm, 468nm, 500nm</td>
<td></td>
</tr>
</tbody>
</table>

| OMAERUVG             | 0.25°×0.25° daily  | Oct/Nov current     | Absorbing Optical Thickness at 324nm, 350nm, 500nm, 550nm |
| OMAERUVG             | 0.125°×0.125° daily| Oct/Nov current     | Absorbing Optical Thickness at 324nm, 350nm, 500nm, 550nm |

| MERRA-2              | 0.25°×0.25° hourly |                   | Total Column Extinction and Scattering Optical Thickness at 324nm, 350nm, 500nm, 550nm, 750nm |
| MERRA-2              | 0.125°×0.125° hourly|                   | Total Column Extinction and Scattering Optical Thickness at 324nm, 350nm, 500nm, 550nm, 750nm |

| OMAEROG              | 0.25°×0.25° daily  |                   |                                         |
| OMAEROG              | 0.125°×0.125° daily|                   |                                         |

Figure 1: OMI L2G OMTG0G ozone total column amount (DU) on January 1, 2008.

Figure 2: Algorithm flowchart to create hourly OMI gridded products

Figure 3: Total Column Aerosol Optical Depth on January 10, 2007 (13UTC-14UTC) from OMI multi-wavelength Aerosol algorithm retrieval

Figure 4: Visual Parallel Comparisons to Modeled Hourly Forecast

Figure 5: Comparison between MERRA-2 and OMAEROG aerosol optical thickness at 3:00 in the eastern region (see figure 8).