Using the NASA GEOS-5 MERRAer Aerosol Reanalysis
to Understand the OMI OMAERUV Aerosol Products

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Introduction
The Ozone Monitoring Instrument (OMI) onboard the NASA Aura spacecraft provides wide-swath, near-global daily coverage of the distributions of climatically important absorbing aerosols over both land and ocean.

We have simulated OMI observations using the NASA GEOS-5 Earth system model produced MERRAer aerosol reanalysis. The objectives of this work are to:

- Understand the distributions of climatically important absorbing aerosols
- Evaluate and improve our ability to simulate the distributions and properties of absorbing aerosols
- Understand the sensitivities of OMI retrievals of aerosol quantities to the distributions of aerosols

At right we review previous work on the first two bullet points. Below we show progress toward a study on the information content of the OMI retrievals.

Information Content of OMI Retrievals

Our objective is to compare MERRAer and OMI (OMAERUV) retrievals for the same input radiances and assess algorithm differences. As a first exercise (and shown here), we address the following question: given the same radiances, do OMAERUV and MERRAer derive the same aerosol index? And if not, why not?

Our approach is:

- Ignore the presence or absence of clouds
- Using the MERRAer aerosols and atmosphere, simulate the radiances and AI for the full OMI swath using the OMI viewing geometry and surface reflectivities
- Provide simulated radiances as input to the OMI retrieval algorithm and computed retrieved products to those directly calculated by the model

Why does OMAERUV return a different Aerosol Index than MERRAer for same input radiances?

Recall the definition of the Aerosol Index:

\[ AI = 100 \log_{10} \frac{I_{354}^{\text{Model}}}{I_{354}^{\text{Ray}}} = 100 \log_{10} \left( \frac{R_{388}^\text{Model}}{R_{388}^\text{Ray}} \right) \]

MERRAer is the proxy for the observed radiances, and so provides the \( I_{354}^{\text{Ray}} \) term. Other terms in the expression require additional ancillary calculations assuming a molecular-only atmosphere. These calculations are done independently for the MERRAer fields and in the OMAERUV algorithm, using somewhat different assumptions and different radiative transfer codes. Possible residual differences in the resulting AI thus include:

- Formation differences (e.g., definition of AI)
- Details of radiative transfer (e.g., codes, streams, etc.)
- Atmospheric profile and treatment of molecular scattering (e.g., pressure and temperature)

Results

The residual AI difference between MERRAer and OMAERUV (above, far right) looks a lot like the pressure field difference between MERRAer and what is assumed for OMAERUV (right). In particular, the largest differences in AI correlate with pixels where the pressure differences are the largest (far right)

When OMAERUV AI calculation is redone assuming the MERRAer pressure field, the AI difference is greatly reduced (both plots at the bottom right)

Hypothesis: Differences in the assumed pressure profile explain the differences in the respective AIs. The atmospheric profile of pressure and temperature have a large effect on the simulation of the molecular-only atmosphere required for the AI calculation. OMAERUV assumes a time-independent field for the surface pressure (with adjustment for topography), while MERRAer assumes a pressure field consistent with the MERRA atmospheric analyses, and so is variable in time and unrelated to the pressure field OMAERUV assumes

Next Steps:
Once the differences between OMAERUV and MERRAer AI are established and accounted for, a similar comparison will be carried by comparing MERRAer derived AOD and SSA with the same parameters retrieved by OMAERUV. The figures on the right show the OMAERUV AOD retrievals and MERRAer for the same case study. A first sight, both algorithms retrieve AODs in the dust cloud exiting NW Africa. It is clear that MERRAer derives AODs everywhere whereas OMAERUV in retrievals an AOD when it determines there is absorbing aerosol in the pixel and it is clear sky

Acknowledgements
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References

Comparison of MERRAer and OMI

We have simulated the global aerosol distributions using the NASA GEOS-5 Earth system model produced MERRAer aerosol reanalysis:

- Global 0.5° x 0.625° latitude-longitude, 72 vertical levels to 85 km
- GOCART aerosol module simulates dust, sea salt, sulfate, and carbonaceous aerosols
- Meteorology is constrained by MERRA analyses
- Aerosol optical depth (AOD) is constrained by MODIS-derived AODs

Simulated aerosol distributions and atmospheric profile are used to calculate the OMI radiances at 354 and 388 nm using the OMI viewing geometry and surface reflectivity at clear-sky pixels. The simulated radiances are used to calculate the OMI aerosol optical depth (AAOD) for comparison to the OMI retrievals from the OMAERUV algorithm.

These comparisons show MERRAer is able to capture many of the absorbing aerosol features found by OMI. Results recently published in Buchard et al., ACP, 2015.