Effects of Data Quality on the Characterization of Aerosol Properties from Multiple Sensors

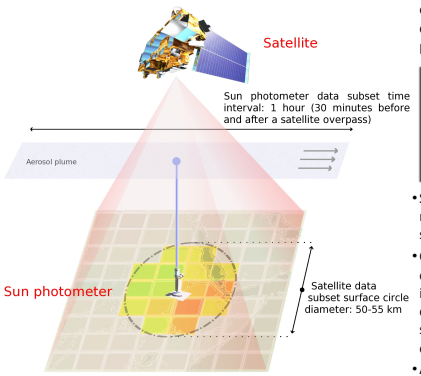
Maksym.Petrenko@nasa.gov (ESSIC, University of Maryland), Charles Ichoku, Gregory Leptoukh (NASA Goddard Space Flight Center), AG Giovanni team

Abstract

Cross-comparison of aerosol properties between ground-based and spaceborne measurements is an important validation technique that helps to investigate the uncertainties of aerosol products acquired using spaceborne sensors. However, it has been shown that even minor differences in the cross-characterization procedure may significantly impact the results of such validation. Of particular consideration is the quality assurance / quality control (QA/QC) information – an auxiliary data indicating a "confidence" level (e.g., Bad, Fair, Good, Excellent, etc.) conferred by the retrieval algorithms on the produced data. Depending on the treatment of available QA/QC information, a cross-characterization procedure has the potential of filtering out invalid data points, such as uncertain or erroneous retrievals, which tend to reduce the credibility of such comparisons. However, under certain circumstances, even high QA/QC values may not fully guarantee the quality of the data. For example, retrievals in proximity of a cloud might be particularly perplexing for an aerosol retrieval algorithm, resulting in an invalid data that, nonetheless, could be assigned a high QA/QC confidence.

In this poster, we study the effects of several QA/QC parameters on cross-characterization of aerosol properties between the data acquired by multiple spaceborne sensors. We utilize the Multi-sensor Aerosol Products Sampling System (MAPSS) that provides a consistent platform for multi-sensor comparison, including collocation with measurements acquired by the ground-based Aerosol Robotic Network (AERONET). The multi-sensor spaceborne data analyzed include those acquired by the Terra-MODIS, Aqua-MODIS, Terra-MISR, Aura-OMI, Parasol-POLDER, and Calipso-CALIOP satellite instruments.

MAPSS framework and sensors



- Sample data from multiple sensors over uniform areas of 55km centered around AERONET sun photometer ground stations

- Sample AERONET data within ±30 minutes of each overpass of the satellites
- Compute a range of statistics characterizing the samples, including mean, mode, standard deviation, the total number of sampled data points and number of sampled points with valid data
- Also, compute **mode of QA** flags of the pixels in the sample

Sensor	Platform	Spatial Resolution (Level 2)	Equator Crossing Time*	Data period	Features	QA summary
AERONET	Ground-based	N/A	N/A	Varies with sites	High accuracy	No QA flags, data at Level-2 is quality assured manually
T-MODIS A-MODIS	Terra Aqua	10x10 km	10:30 am 1:30 pm	Jan'00- Jul'02-	High spatial coverage	Integer flags, 0..3: (0=Bad, 3=Good)
MISR	Terra	17.6x17.6 km	10:30 am	Jan'00-	Multiple viewing angles	Integer flag, 0..3: (0=Good, 3=Bad)
OMI	Aura	13.7x23.7 km	1:38 pm	Oct'04-	Absorption SSA	Integer flag, 0..7: (0=Good, 3..7=Bad)
POLDER	ADEOS ADEOS-2 PARASOL	19x19 km	1:30 pm	Oct'96-Jun'97 Apr'03-Oct'03 Mar'05-	Polarization	Combination of several real numbers, [0..1]: [Bad .. Good]
CALIOP	CALIPSO	5x0 km	1:32 pm	Jun'06-	Vertical profile	Combination of several real numbers, [0..1]: [Bad .. Good]
SeaWiFS	SeaStar	13.5x13.5 km	12:00 pm	Jan'98-Dec'10	Longest time span, precise calibration	Integer flags, 0..3: (0=Bad, 3=Good)

Enhancing data quality based on regional QA trends

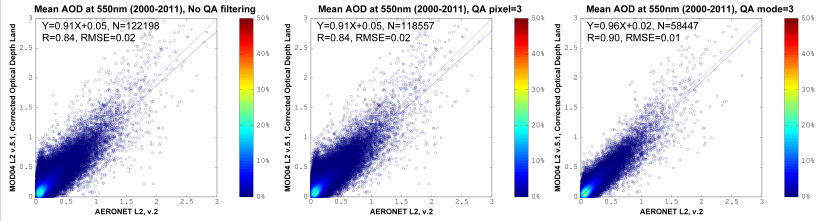
Experiment design

- Compare means of satellite-derived AOD over 55km areas to means of AERONET AOD (interpolated) within ±30 minutes of satellite overpasses
- Filter satellite data based on QA:
  - No filtering (left column)
  - Compute mean AOD based only on pixels with Best QA (central column)
  - Compute mean AOD based on all pixels in the sample, but only if mode of QA over the whole sample is Best (right column)

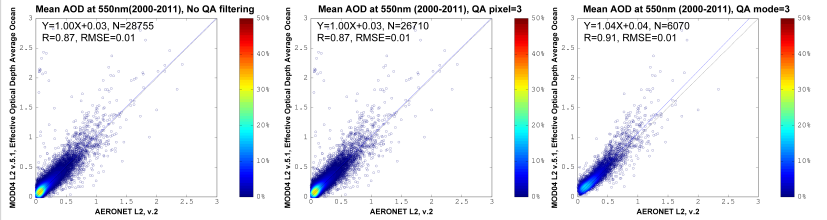
Observations

- For MODIS products, considering the overall data quality in the observation region produces a more accurate (but smaller) subset of the data
- Applying QA filtering to individual pixels in MODIS Land or Ocean products discards certain data points, but does not change the overall character of the data
- For OMI, pixel-based filtering produces somewhat better results, perhaps because of higher variability of measurement error in sampling areas (e.g., subpixel cloud contamination)

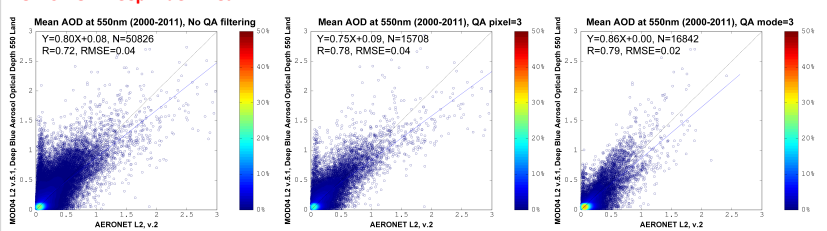
MODIS AOD Land Corrected - mean



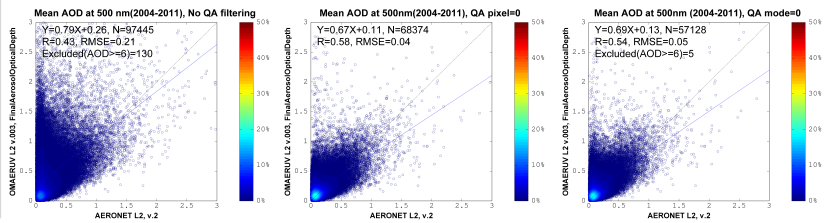
MODIS AOD Ocean Average - mean



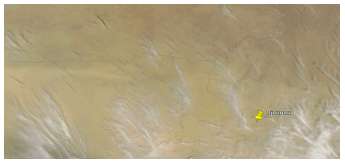
MODIS AOD Deep Blue - mean



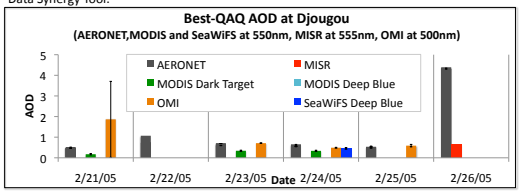
OMI AOD Mean



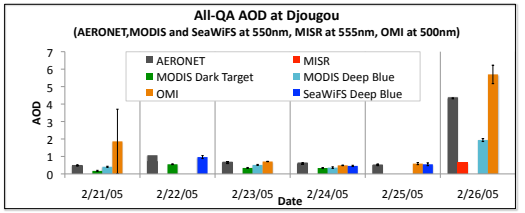
Data with the Less-than-Best QA and its applications



Dust storm at Djougou, Benin, 2/26/2005. Source: MODIS Rapid Response, AERONET Data Synergy Tool.



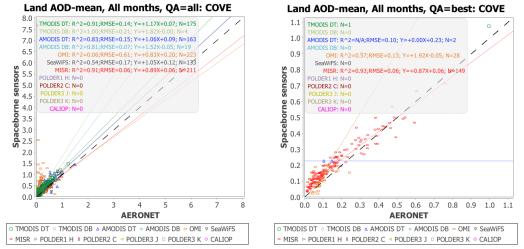
- The event was observed by multiple sensors, but most Best-QA measurements underestimated the AOD value measured by AERONET
- Notably, there were no best-QA Deep Blue AOD retrievals from MODIS, but there were some from SeaWiFS, despite both products using the similar algorithm



- A significantly larger number of lower-QA observations indicates the conditions (i.e., bright surface, high aerosol loading) were hard for most sensors
- Deep Blue AOD from MODIS and SeaWiFS seem to be the most accurate in these conditions, however they should be used with caution because of the low QA
- AOD retrieved by OMI on Feb.26 was the closest to the peak AERONET AOD, but was also indicated as having a low QA

Potential of QA misrepresentation

- Under extreme or uncertain conditions, retrieval algorithms might have difficulty assigning the correct QA flags, and even valid data might be marked as "Bad"
- Analysis of long-term data can help to reveal areas with systematic uncertainties in QA values, e.g. coastal areas
- For example at COVE region (coast line of Virginia), most of the sensors retrieve AOD in a close agreement to AERONET (left plot). However, only a small portion of these data has Best QA (right plot, please note a changed scale)



ACKNOWLEDGMENT: Support for the development of the MAPSS system has been provided by NASA HQ through the ROSES 2006 ACCESS program under the grant number NNX08AN39A. WEB interface for MAPSS has been developed within the AeroStat online platform for statistical intercomparison of aerosols, NASA ROSES grant ACCESS-09-0035. In addition, we would like to thank Giovanni team for developing and hosting the WEB MAPSS. We thank various support teams of MODIS, MISR, OMI, POLDER, CALIOP and AERONET teams for making available the respective aerosol products and quality assurance efforts, as well as for providing assistance while developing MAPSS sampling for these products. We also thank PIs of the individual AERONET sites for the provided data.