Aerosol Absorption Measurements with MODIS

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Introduction: Atmospheric aerosols play an important role in the Earth's energy budget and climate change through their direct, indirect, and semi direct effects. In particular, aerosol absorption deserves special attention since it can warm up atmospheric layers, cool the surface, affect cloud formation and lifetime, change the planetary albedo, and affect the hydrological cycle.
In this work we are testing a remote sensing technique to retrieve aerosol single scattering albedo (SSA) by applying the "critical reflectance" technique on MODIS data over the Amazon and South Africa regions, where the aerosol absorption from biomass burning is significant. Here we show results of the comparison between SSA retrieved from MODIS reflectance measurements and co-located AERONET SSA. We also show the sensitivity of this algorithm to uncertainty in aerosol optical depth.

(I) "Critical Reflectance" Calculation

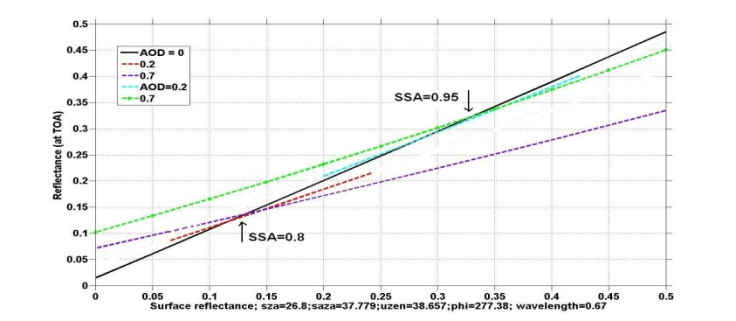

Figure 1: "Critical Reflectance" is determined by comparing the reflectances at the top of the atmosphere (TOA) on two different days with distinct AOD loadings. Here, we use radiative transfer simulation result to show thatt "critical reflectance" is different for different SSA.

(II) AOD Sensitivity Study

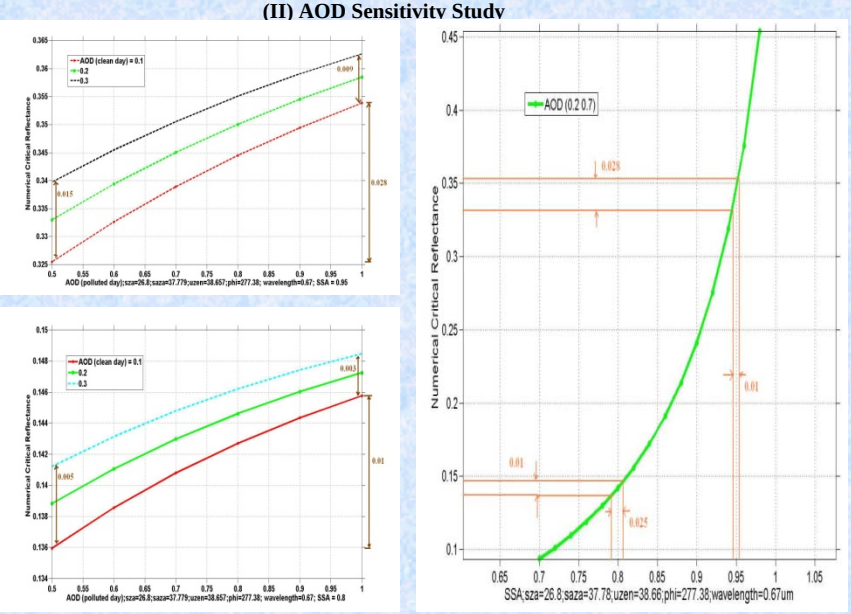

Figure 2: Uncertainty of AOD leads to small uncertainty of critical reflectance, and therefore small uncertainty of SSA

(III) Describe algorithm of SSA Retrieval from MODIS

MODIS reflectance (level 1, collection 5) with 16 days (clean day and polluted day respectively) apart are picked based on the chosen AERONET site. After applying cloud mask, 60*60km (centered at AERONET site) range is divided into 9 (3*3) cells, with each cell 20*20km. Critical reflectance for each cell is determined by comparing MODIS reflectances in the cell, which is used to retrieve SSA for this cell (20*20km).

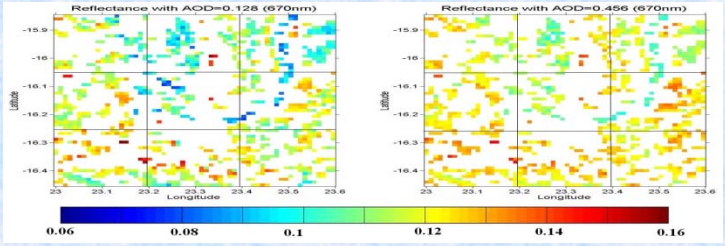

*Figure 3. An example of MODIS reflectance in 60*60 km range with cloud mask on; the image on the left side is the MODIS reflectance on the clean day; ; the image on the left side is the MODIS reflectance on the polluted day;*

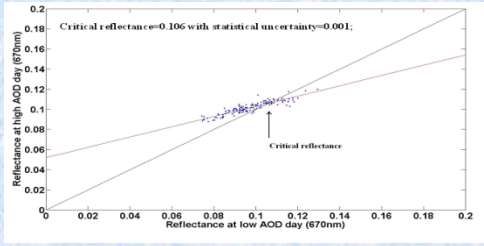

*Figure 4. The scatter plot of MODIS reflectance in the 1st cell cell (20*20km) on the polluted day vs on the clean day.*

(IV) Compare SSA Retrieved from MODIS and AERONET SSA

AERONET sites in South Africa	AERONET SSA (level 2) at the closest time with uncertainty 0.03	Time difference between the closest time AERONET and MODIS overpass time	MODIS SSA in 60*60km (total 9 cells with each cell 20*20km) after data quality assurance with each cell at maximum uncertainty 0.03		
			min (SSA)	max (SSA)	Number of cells left after applying data quality assurance
Mongu in 2000	0.87	1h 59min	0.85	0.86	9
	0.89	2h 13min	0.86	0.89	8
	0.87	2h 43min	0.87	0.88	9
	0.88	2h 8min	0.83	0.87	8
	0.84	3h 10min	0.83	0.87	9
	0.88	3h 56min	0.85	0.86	8
	0.88	3h 58min	0.81	0.86	8
	0.87	6h 4min	0.85	0.87	9
Mongu in 2001	0.87	1h 58min	0.85	0.88	9
	0.83	2h 20min	0.81	0.84	3
	0.83	2h 32min	0.84	0.88	7
	0.83	2h 37min	0.83	0.85	9
Mongu in 2002	0.89	1h 33min	0.79	0.83	9
	0.89	1h 33min	0.72	0.78	4
	0.78	4h 50min	0.81	0.83	9
Senanga in 2000	0.83	1h 38min	0.84	0.87	9
	0.84	1h 59min	0.86	0.87	9
	0.84	1h 59min	0.85	0.85	9
	0.84	1h 59min	0.86	0.87	8
	0.84	2h 24min	0.86	0.91	9
	0.84	2h 9min	0.83	0.87	6
	0.86	3h 36min	0.86	0.91	9
Mwinilunga in 2000	0.85	1h 45min	0.84	0.85	9
	0.91	2h 22min	0.82	0.88	8
	0.90	2h 26min	0.82	0.87	9

AERONET sites in South America	AERONET SSA (level 2) at the closest time with uncertainty 0.03	Time difference between the closest time AERONET and MODIS overpass time	MODIS SSA in 60*60km (total 9 cells with each cell 20*20km) after data quality assurance with each cell at maximum uncertainty 0.03		
			min (SSA)	max (SSA)	Number of cells left after applying data quality assurance
Alta Floresta in 2004	0.92	5h 3min	0.78	0.84	8
	0.94	5h 21min	0.88	0.91	9
	0.90	2h 24min	0.83	0.89	6
	0.93	3h 15min	0.86	0.91	7
	0.96	4h 56min	0.89	0.93	6
Alta Floresta in 2005	0.93	1h 46min	0.85	0.97	9
	0.85	1h 40min	0.89	0.92	6
	0.95	1h 50min	0.86	0.88	8
	0.95	1h 25min	0.77	0.97	8
	0.90	1h 55min	0.81	0.95	6
	0.96	1h 46min	0.77	0.93	8
Alta Floresta in 2006	0.94	2h 3min	0.86	0.89	9
	0.93	1h 49min	0.82	0.93	9
	0.94	1h 40min	0.89	0.97	9
	0.93	1h 53min	0.85	0.87	9
Alta Floresta in 2007	0.86	1h 52min	0.76	1.00	7
	0.83	1h 21min	0.92	0.97	2
	0.92	1h 32min	0.90	0.92	6
	0.86	1h 54min	0.84	0.90	7
	0.86	2h 22min	0.77	0.92	8
	0.89	1h 42min	0.77	0.96	8
	0.89	1h 42min	0.77	0.96	8
Alta Floresta in 2005	0.87	1h 42min	0.72	0.99	8
	0.93	1h 45min	0.84	0.91	8
	0.84	1h 42min	0.83	0.86	9
Cuiba in 2007	0.96	1h 45min	0.86	0.92	8

*Table 1: Compare SSA retrieved from MODIS images (60*60km range, centered at AERONET site) and SSA retrievd from AERONET at time that is the closest to MODIS overpass time, with AERONET sites in South Africa on the left side and AERONET sites in South America on the right side. All the cases are picked with condition that detector zenith angle smaller than 40 degree and the AOD difference in clean day and in polluted day is bigger than 0.2.*

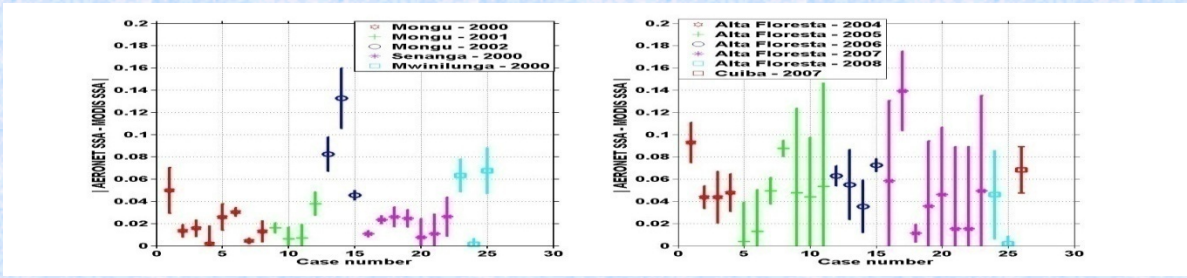

*Figure 5: Compare the averaged SSA (with standard deviation in 60*60km range centered at AERONET site) retrieved from MODIS images and SSA (level 2) from AERONET*

Results: MODIS reflectance measurements are used to determine the "critical reflectance" parameter, which is used to retrieve the aerosol single scattering albedo. The AOD sensitivity study shows that this technique is insensitive to uncertainties in AOD. Furthermore, MODIS SSA standard deviation shows that aerosol is more homogeneously distributed in South Africa than in South America. In addition, the averaged MODIS SSA in 60*60km range agrees better with AERONET SSA in South Africa than in South America.