THE INTER-COMPARISON OF AATSR AEROSOL OPTICAL DEPTH RETRIEVALS FROM VARIOUS ALGORITHMS

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ABSTRACT

The project aerosol-CCI as part of European Space Agency (ESA) Climate Change Initiative (CCI) has provided three aerosol retrieval algorithms for the Advanced Along-Track Scanning Radiometer (AATSR) aboard on ENVISAT. For the purpose of estimating different performance of these three algorithms in Asia, in this paper we compared the Aerosol Optical Depth (AOD) of L2 data (10km × 10km) including FMI AATSR Dual-view ADV algorithm, the Oxford RAL Aerosol and Cloud retrieval (ORAC) algorithm and the Swansea University AATSR retrieval (SU) algorithm with the AErosol RObotic NETwork (AERONET) and the China Aerosol Remote Sensing Network (CARSNET) data separately. The result shows that the algorithms of ADV and SU have good performance on the retrieval of AOD, and the ORAC algorithm has relative lower precision than other two algorithms.

Index Terms—aerosol optical depth (AOD), validation, satellite remote sensing, AATSR

1. INTRODUCTION

Solid or liquid particles with radius varying from 100nm to 100μm suspended in the atmosphere compose atmospheric aerosol. The source of atmospheric aerosols can be natural or not. Various types of aerosol change the Earth's radiation budget by both affecting radiation transfer directly and affecting cloud properties [1]. However, the average compositions vary with time, size, location and the bulk compositions of individual particles, leading to unavoidable uncertainties in measurements of spatial and temporal properties. [2]

Anthropogenic aerosol is the largest uncertainty in climate forcing constituent (IPCC, 2013), which calls for further work to improve all types of available observation [3]. Conventional ground-based observation can't be used to detect entire properties of aerosols. Since the launch of Landsat, satellite data have been used to retrieve properties and distribution of aerosol. The Advanced Along-Track Scanning Radiometer (AATSR) aboard on ENVISAT is using to observe the Earth by dual-view. The data of AATSR can be used to retrieve aerosol optical depth (AOD) both over land and ocean, which is an important merit in the characterization of aerosol properties [4].

Using AATSR data, several effective algorithms have been developed, including the FMI AATSR retrieval algorithm (ADV/ASV), the Oxford RAL Aerosol and Cloud retrieval (ORAC) and the Swansea University AATSR retrieval (SU). The ADV/ASV algorithm over land is based on the so-called k assumption, where the ratio (k) of the ground reflectance for the two views is assumed to be independent of wavelength [7]. Using 1.61μm wavelength to compute the k, ADV/ASV algorithm assumes that aerosols are negligible when compared to ground reflectance. The ORAC algorithm is based on an optimal estimation method [6] and the SU algorithm is based on iterative optimization of AOD and aerosol model subject to multiple constraints [3].

Ground-based sunphotometer has been used to take sun and sky measurement directly [10]. Both AERONET and CARSNET have high precision in observing AOD. In this paper, we evaluated performance of AATSR algorithm for AOD of L2 (10km x 10km) aerosol products using the AERONET and the CARSNET data. In section 2, we give the introduction of main method and processing procedure briefly. The result is presented in section 3. The result analysis is presented in Section 4.

2. METHOD

2.1. Validation

AERONET or other ground-based network provides accurate measurements without influence of land surface reflection (Holben et al., 1998), compared with ground-

based measurements is the basic method. AOD of L2 data sets were compared with AERONET/CARSNET data using scatter plots and linear-regression to the data. The comparisons were made for collocated satellite and AEROENT/CARSNET observations (Ichoku, 2002), i.e. AOD pixels were selected within a spatial extent of +/−50 km and a time range of +/−30 min from AERONET/CARSNET measurements.

2.2. Statistics

Several statistics are selected to estimate different performances:

(1) Mean bias error (MBE) and Mean absolute error (MAE) represent the degree of deviation satellite retrieved AOD and AERONET/CARSNET observed AOD.

(2).Correlation coefficient (CC) represents the linear relationship between AATSR AOD and ground-based observation.

(3) Root mean square error (RMSE) represents the average deviation of uncertainty in satellite-retrieved AOD.

$$MBE = \frac{1}{n} \Sigma_{i=1}^{n} \left(\tau_{sat,i} - \tau_{aero,i} \right) \qquad (1)$$

$$MAE = \frac{1}{n} \Sigma_{i=1}^{n} \left| \left(\tau_{sat,i} - \tau_{aero,i} \right) \right| \qquad (2)$$

$$CC = \frac{\Sigma_{i=1}^{n} \left(\tau_{aero,i} - \overline{\tau_{aero}} \right) \left(\tau_{sat,i} - \overline{\tau_{sat}} \right)}{\sqrt{\Sigma_{i=1}^{n} \left(\tau_{aero,i} - \overline{\tau_{aero}} \right)^2} \sqrt{\Sigma_{i=1}^{n} \left(\tau_{sat,i} - \overline{\tau_{sat}} \right)^2}} \qquad (3)$$

$$RMSE = \sqrt{\frac{1}{n} \Sigma_{i=1}^{n} \left(\tau_{sat,i} - \tau_{aero,i} \right)^2} \qquad (4)$$

Where, i means the number of each AOD pixel, $\tau_{aero,i}$ means the value of AERONET AOD for site i, $\tau_{sat,i}$ means the corresponding satellite-retrieved AOD.

3. DATA AND RESULTS

3.1. Study Area and Data

The study area is in mainland China and a part of middle Asia, the spatial range as 35º-150ºE, 15º-60ºN. The data we used are AATSR aerosol products 2008 over the study area. We selected AATSR L2 AOD, which has the resolution of 10km x 10km. The ancillary data are AERONET and CARSNET ground-based observed data.

The details of these three aerosol products are shown in table1.

3.2. Results

After preprocessing, we matched AATSR AOD with ground-based observed AOD using the method depicted above. The ORAC L2 product has largest coverage, which makes validation result with most collocation pairs, 323 pairs, 350 pairs with AERONET and CARSNET respectively. The ADV and SU L2 products have similar validated results with same amount of collocation pairs. The numbers of ADV validation pairs are 201, 115 with AERONET and CARSNET respectively. The SU has 200, 129 pairs respectively.

Table 1. Details of AATSR aerosol Products

algorithm	version	sensor	Main parameters	Resolution coverage
ADV/ASV	1.42	AATSR	AOD,ANG	10km,1 ° global
SU	4.2	AATSR	AOD,ANG	10km,1 ° global
ORAC	2.02	AATSR	AOD, aerosol type	10km,1 ° global

4. RESULT ANALYSIS

Comparing different statistics in table 2, we can see that the ADV L2 product and SU L2 product have same accuracy with high CC and low RMSE as fig.1~fig.4 show, however, fig.5 and fig.6 show that the performance of ORAC L2 product is not good as the other two products. Obviously, ORAC L2 product has the largest coverage at the cost of accuracy. Both ADV and SU L2 products have good performance on AOD retrieval over study area, mainly because these two aerosol products have strict quality control. That's why the ADV and SU L2 products have relative low coverage than ORAC L2 product.

Table 2. Validation results: statistics

		N	MBE	MAE	CC	RMSE
SU	AERONET	200	0.004	0.089	0.855	0.120
	CARSNET	129	0.091	0.102	0.880	0.117
ADV	AERONET	201	0.062	0.090	0.878	0.100
	CARSNET	115	0.153	0.158	0.784	0.130
ORAC	AERONET	323	-0.041	0.146	0.568	0.250
	CARSNET	350	0.026	0.201	0.647	0.334

5. CONCLUSION

These three AATSR aerosol products provided by aerosol-CCI have different performance in study area. Even though the statistics and scatterplots show ORAC product has low accuracy, we can't determine which product has best performance in Asia.

For the AOD retrieval on the base of satellite, the coverage and accuracy are competing. Therefore, when estimating different algorithms' performance on AOD retrieval, we need take both their coverage and accuracy into account.

7. REFERENCES

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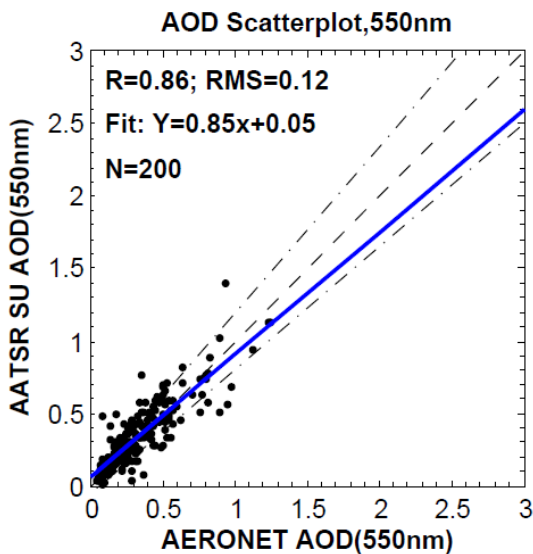
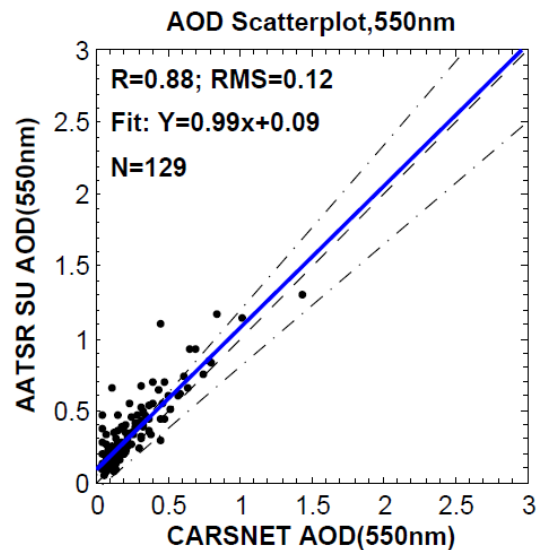Fig.1. Comparison between AATSR SU AOD and AERONET data in 2008

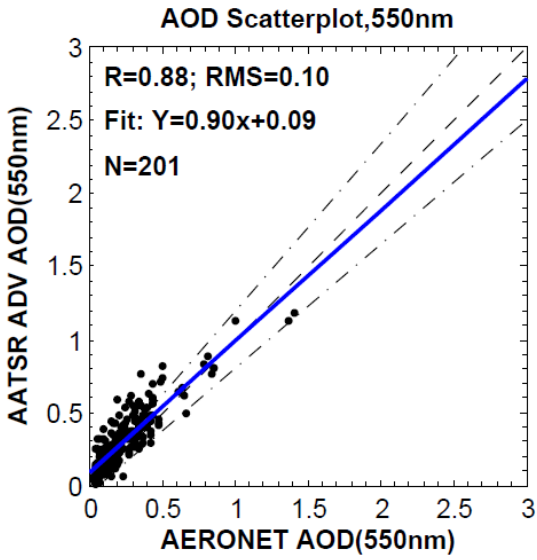Fig.2. Comparison between AATSR SU AOD and CARSNET data in 2008

AOD Scatterplot,550nm
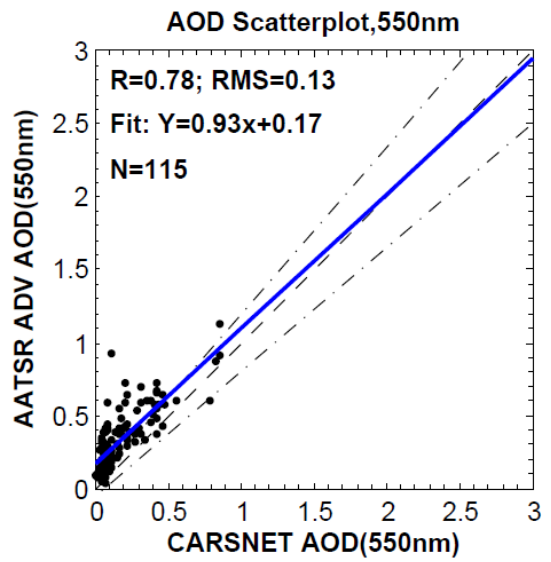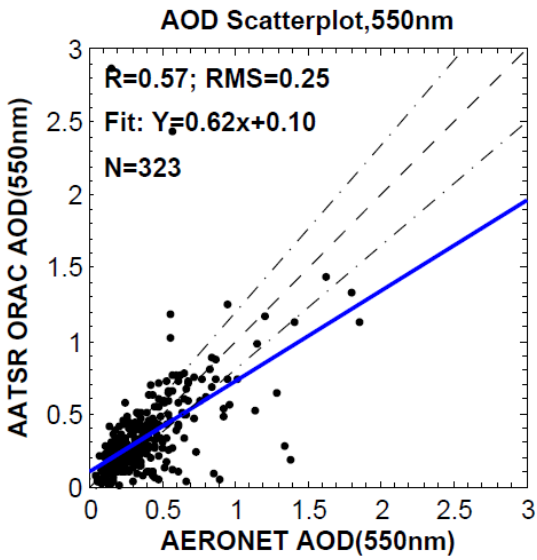
R=0.88; RMS=0.10

Fit: Y=0.90x+0.09

N=201

AATSR ADV AOD(550nm) vs *AERONET AOD(550nm)*

Fig.3. Comparison between AATSR ADV AOD and AERONET data in 2008

AOD Scatterplot,550nm

R=0.78; RMS=0.13

Fit: Y=0.93x+0.17

N=115

AATSR ADV AOD(550nm) vs *CARSNET AOD(550nm)*

Fig.4. Comparison between AATSR ADV AOD and CARSNET data in 2008

AOD Scatterplot,550nm

R=0.57; RMS=0.25

Fit: Y=0.62x+0.10

N=323

AATSR ORAC AOD(550nm) vs *AERONET AOD(550nm)*

Fig.5. Comparison between AATSR ORAC AOD and AERONET data in 2008

AOD Scatterplot,550nm

R=0.65; RMS=0.24

Fit: Y=0.47x+0.21

N=350
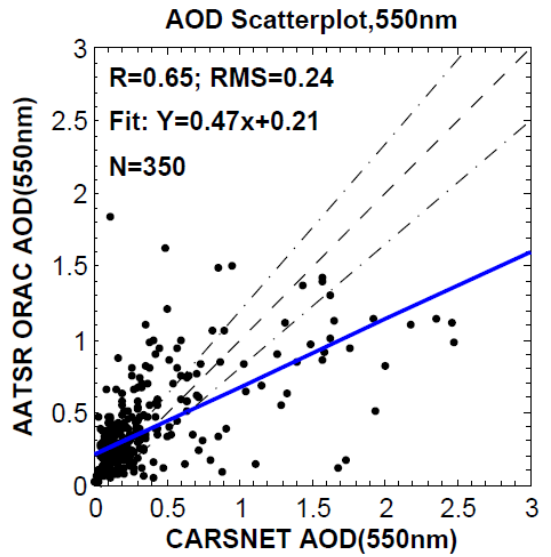
AATSR ORAC AOD(550nm) vs *CARSNET AOD(550nm)*

Fig.6. Comparison between AATSR ORAC AOD and CARSNET data in 2008