AEROSOL OPTICAL DEPTH RETRIEVAL OVER LAND USING MODIS DATA AND ITS APPLICATION IN DETECTION OF DUST EVENT

Linlu Mei[1,3], *Yong Xue*[1,2*], *Jie Guang*[1,3], *Yingjie Li*[1,3], *Ying Wang*[1,3], *Hui Xu*[1,3], *Jianwen Ai*[1,3]

[1]State Key Laboratory of Remote Sensing Science, Jointly Sponsored by the Institute of Remote Sensing Applications of Chinese Academy of Sciences and Beijing Normal University, Institute of Remote Sensing Applications, Chinese Academy of Sciences, Beijing 100101, China

[2]Department of Computing, London Metropolitan University, 166-220 Holloway Road, London N7 8DB, UK

[3]Graduate University of the Chinese Academy of Sciences, Beijing 100049, China

{Email: meilinlu@163.com; yxue@irsa.ac.cn}

ABSTRACT

Atmospheric remote sensing offers us a view to estimate atmospheric environment in describing the aerosol distribution either for a local or global coverage. Physically speaking, atmospheric turbidity is a significant indicator of dust events, which has a good relationship with atmospheric aerosol content [1]. AOD is a vitally important physical parameter of aerosol which can be retrieved from satellite remote sensing data.

Dust storms are a kind of natural disaster occurring most frequently over deserts and regions of dry soil, where particles are loosely bound to the surface [2]. As a kind of tracer in the atmosphere, dust aerosol plays an important role in people's life, especially during the dust episode. Remote sensing is an established method for the detection and mapping of dust events due to the high spatial variability of the dust plume characteristics along its transport and has been used to identify the dust-source locations with a varying degree of success [3]. Many events such as the heavy dust events crossed the Pacific to affect North America were discussed in detail by comparing satellite images, a regional-scale meteorological model [4], and ground observations exchanged through the Internet by the Asian Dust Network. Former studies show a significant positive association between AOD and Angstrom exponent causing by dust episode was found [2, 5].

Since the dust storms have more serious influence over the urban area, people pay more attention to the atmospheric parameters such as AOD and Angstrom exponent during the episode. The current MODIS aerosol estimation algorithm over land is based on the DDV approach, which works only over densely vegetated surface. Many algorithms or methods have already been applied by previous researchers to improve the accuracy of retrieving AOD [6-8]. However; Retrieving AOD over land still remains a difficult task because the measured signal is a composite of reflectance of sunlight by the variable surface covers and back scattering by the semitransparent aerosol layer. The key problems addressed here is how to retrieve the aerosol information from remotely sensed data over high reflective land surface, make the operational aerosol remote sensing possible over various land surface.

[*] Corresponding author

In this paper, an approach using bi-angle with MODIS data was presented. This new method is based on the operational bi-angle approach [9-10] to retrieve the AOD from MODIS data, which can describe the real characteristics of the surface structure more completely. Further more, the derived AOD is compared to AERONET observations in the Washington State area. Moreover, a dust episode in Washington State during October 4th, 2009 was presented; we have analyzed the advection and dispersion of this event to get the possible source areas for the episode using backward air trajectories and signature tracing methods and its influence in the next day under the meteorological conditions. MODIS AOD 550nm showed high values on October 4th, 2009 with low values of Angstrom exponent (a), suggesting coarse model particle loading in the atmosphere.

Fig.1 shows satellite-retrieved AOD compared with the AOD obtained in Washington State area AERONET ground-based remote sensing stations for a number of day during October 3-5th, 2009. The real line stands for the regression line with R^2 =0.8278, The error bars in x-axis and y-axis represent the standard deviation of the AOT among the SYNTAM value and AERONET value, that is 0.0255.

We have analyzed the advection and dispersion of Washington State dust event on October 4th, 2009 using MODIS data with backward air trajectories and meteorological conditions. Fig. 2 reveals the strong spatial contrast of AOD. In particular, two areas are distinct with high AOD, ranging approximately from 0.5 to 1.0: dust episode area (the red circle), and an unknown area. Fig.3 shows that the Angstrom exponent (a) around dust area is much lower than other areas that mean AODs are governed by coarse-mode particles which are dominant in desert or soil-originated dust loaded atmospheres. In Fig.4, the backward trajectories ending at the storm area was presented, which demonstrated that the dust source comes from North and Northwest direction. According to Fig.5, we can easily get that the red circle area is the dust source area in October 3th, 2009, which fully in line with Fig.4.

Since The dust aerosol properties were strongly influenced by meteorological conditions. Satellite observations of AOD variations suggested increased aerosol loading in October 4th, 2009 due to dust storm. With the meteorological conditions, especially the wind direction, the distribution on October 5th 2009 can be described as Fig.6 since the main wind direction is northwest and southwest. The dust can be transport to the East and Northeast area, as showed in the red circle area in Fig.6.

Index Terms**—**Aerosol Optical Depth (AOD), MODIS, Dust episode

REFERENCES

[1]G. R. Liu, A. J. Chen, T. H. Lin and T. H. Kou, "Applying Spot data to estimate the aerosol optical depth and air quality," *Environmental Modelling & Software*, vol. 17, no. 1, pp. 3–9, Dec. 2001.

[2] A. R. Sharma, S. K. Kharol and K V.S. Badarinath, “Satellite observations of unusual dust event over North-East India and its relation with meteorological conditions,” *Journal of Atmospheric and Solar-Terrestrial Physics*, vol. 71, no.17-18, pp.2032-2039, Sep. 2009.

[3]M. C. Baddock, J. E. Bullard and R. G. Bryant, “Dust source identification using MODIS: A comparison of techniques applied to the Lake Eyre Basin, Australia,” *Remote Sensing of Environment,* vol. 113, no. 7, pp. 1511–1528, Aug.2009.

[4]I. Uno, H. Amano, S. Emori, K. Kinoshita, I. Matsui and N. Sugimoto, “Trans-Pacific yellow sand transport observed in April 1998: A numerical simulation,” *Journal of Geophysical Research*, vol.106, no.D16, pp. 18331–18344, Oct.2000.

[5]S. W. Kim, S. C. Yoon, A. Jefferson, J.A. Ogren, E. G. Dutton, J.G. Won, Y.S. Ghim, .I. Lee and J.S. Han, “Aerosol optical, chemical and physical properties at Gosan, Korea during Asian dust and pollution episodes in 2001,” *Atmospheric Environment*, vol. 39, no.1, Jan. 2005.

[6] J. P. Veefkind, G. D. Leeuw and P. A. Durkee, **“**Retrieval of aerosol optical depth over land using two-angle view satellite radiometry during TARFOX,” *Geophysical Research Letters*, vol. 25, no.16, pp. 3135-3138, Aug. 1998.

[7]S. L. Liang, B. Zhang and H. L. Fang, “Improved estimation of aerosol optical depth from MODIS imagery over land surface,” *Remote Sensing of Environment*, vol.104, no.4, pp. 416–425, May.2006.

[8]E. I. Kassianov and M. Ovtchinnikov, “On reflectance ratios and aerosol optical depth retrieval in the presence of cumulus clouds,” *Geophysical Research Letters,* vol. 35, no. 6, pp. L06807-L06842**,** March.2008.

[9]J. Tang, Y. Xue, T. Yu and Y. Guan, “Aerosol optical thickness determination by exploiting the synergy of TERRA and AQUA MODIS,” *Remote Sensing of Environment*, vol.94, no.3, pp. 327–334, Feb.2005.

[10]Y. Xue and A. P. Cracknell, “Operational bi-angle approach to retrieve the Earth surface albedo from AVHRR data in the visible band,” *International Journal of Remote Sensing*, vol.16, no.3, pp. 417-429, Feb.1995.

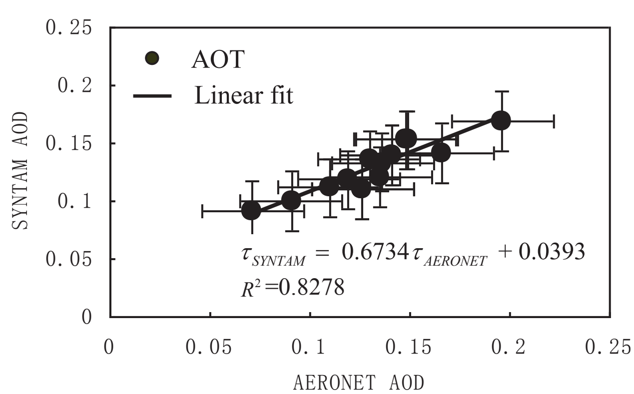

Fig.1.Linear correlation of SYNTAM Value and AERONET value.

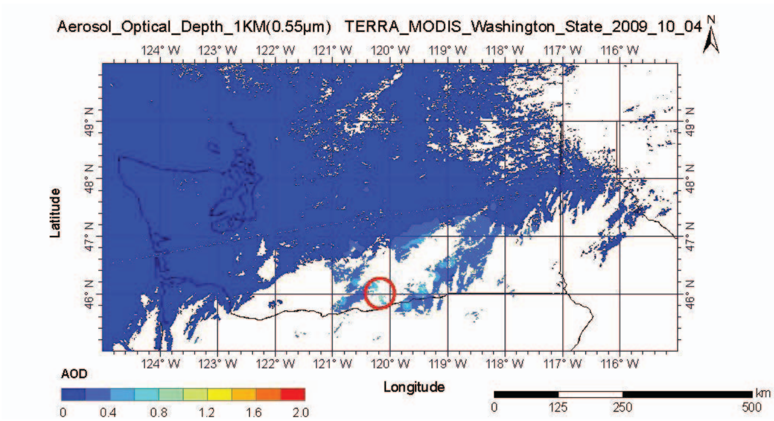

Fig.2. Aerosol optical thickness derived at 550nm of TERRA overpass by SYNTAM,2009_10_04.

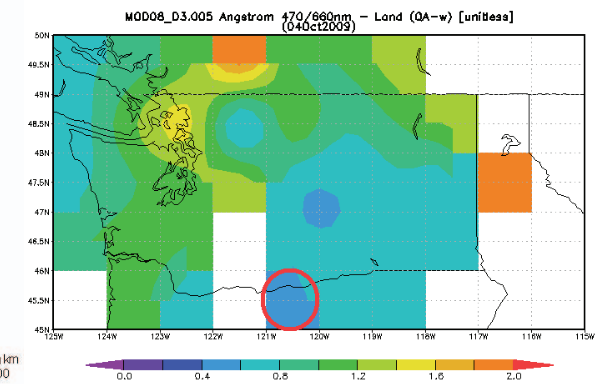

Fig.3. Angstrom 470/660nm - Land (QA-w), 2009_10_04.

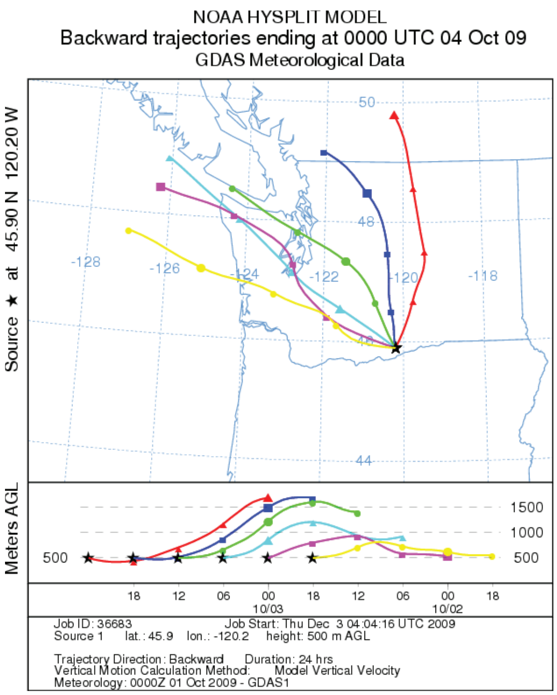

Fig.4. Backward trajectories ending at (102.2°W, 45.9°)), 2009_10_04.

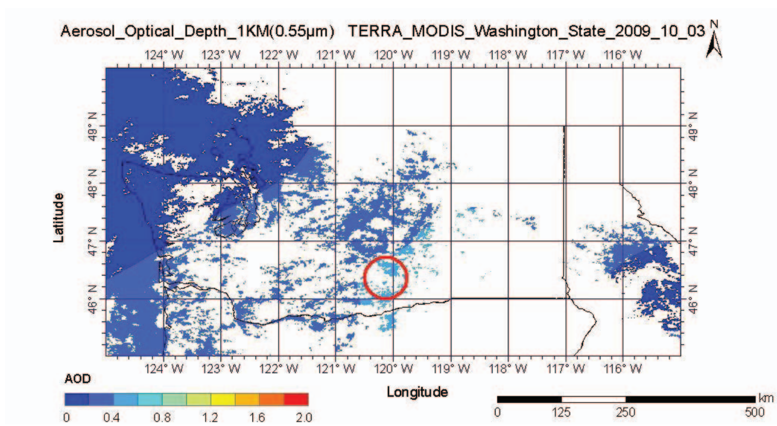

Fig.5. Aerosol optical thickness derived at 550nm of TERRA overpass by SYNTAM,2009_10_03.

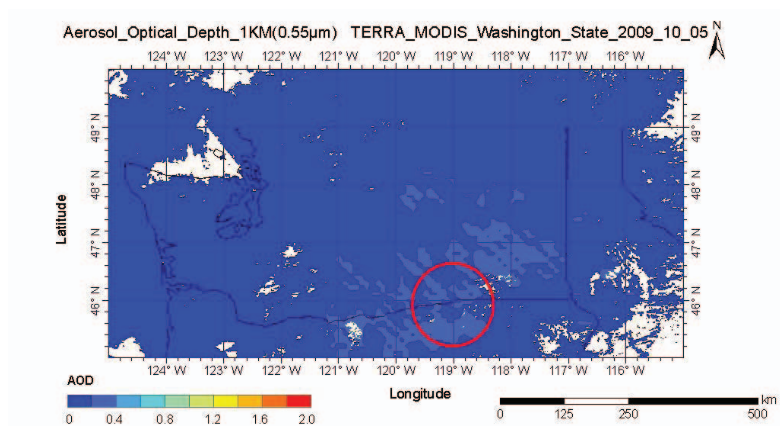

Fig.6. Aerosol optical thickness derived at 550nm of TERRA overpass by SYNTAM,2009_10_05.