AEROSOL OPTICAL DEPTH RETRIEVAL BASED ON LAND SURFACE SPECTRA MODELING

Bo Zhong[1], Qinhuo Liu[1], Qiang Liu[1]

[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, Beijing 100101,China

Email: bzhong1@gmail.com

1. INTRODUCTION

The radiation from the sun to satellites in the sky is always modulated twice by atmosphere. Aerosol is one of the dramatically changing components in atmosphere and it usually contaminates the remotely sensed imagery severely. Thus, many researches have been done to correct the atmospheric effects, such as dark objects and contrast reduction methods. However, in order to completely eliminate the atmospheric effects, it is necessary to retrieve accurate enough aerosol information, like Aerosol Optical Depth (AOD), the aerosol phase function, asymmetric index, and so on. Many researchers have developed different algorithms to retrieve AOD from remotely sensed imagery, such as Densely Dark Vegetation (DDV) method [1], contrast reduction method [2], and the algorithm base on long time series MODIS imagery [3][4]. Although these methods retrieved accurate AOD in some land surface conditions like areas with dense vegetation and desert areas, it is difficult or even impossible to apply these methods to one whole satellite imagery so that these methods are seldom applied to researches like global change and urban air quality monitoring because these methods mainly extract information from remotely sensed imagery only which couples the signatures of land surface and atmosphere.

Consequently, in order to retrieve accurate AOD from remotely sensed imagery, we develop a land surface spectra model based on physical mechanism of land surface radiative transfer model. This land surface spectra model modified the linear mixing spectral model [5] in taking consideration of the signature attenuation caused by the shadow effects and multiple scattering between soil and vegetation. This method is used to retrieve AOD of North China Plain and the results shows good agreement with the in-situ measurement by sun-photometer in Beijing, China.

2. METHODOLOGY

The land surface reflectance usually can be expressed by a linear spectra model as follows:

$$\rho(\lambda)=A\ \rho_l(\lambda) + (1-A)\ \rho_s(\lambda) \tag{1}$$

$\rho(\lambda)$, $\rho_l(\lambda)$, $\rho_s(\lambda)$ express the land surface reflectance, vegetation reflectance and soil reflectance respectively. A is the vegetation area ratio. Practically, the signature attenuation caused the shadow effects and the multiple scattering between soil and vegetation needs to be considered, so a deviation term, $\delta\rho(\lambda)$, is added to correct the attenuation. Thus, equation (1) changed to

$$\rho(\lambda)= A\rho_l(\lambda) + (1-A)\ \rho_s(\lambda)+\delta\rho(\lambda) \tag{2}$$

The surrounding dense vegetation reflectance $\rho_l(\lambda)$ can be calculated from 2.1μm channel and the soil reflectance $\rho_s(\lambda)$ can be calculated from the dry soil reflectance by the equation [6] as follows:

$$R= R_s*\exp(- V_{ws}.\alpha_{ws}) \tag{3}$$

R -- reflectance of soil with water, R_s --reflectance of dry soil, V_{ws} --volume water content of soil, α_{ws}--water absorption coefficient. R_s can be retrieved from spectra database and α_{ws} can be simulated from ground measurements. 2.1μm channel is less contaminated by aerosol and it can therefore used to retrieve V_{ws} accurately. The vegetation area ratio A is closely related with vegetation index like NDVI; consequently, the land surface reflectance $\rho(\lambda)$ can be calculated.

In addition, for more accurate AOD inversion results, the MODIS water vapor content products are used to correct the water vapor effects of 2.1μm channel which is severely compacted by atmospheric water vapor (see figure 1).

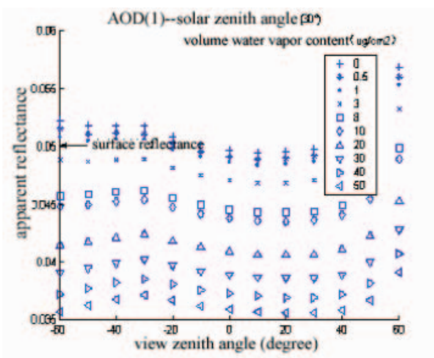
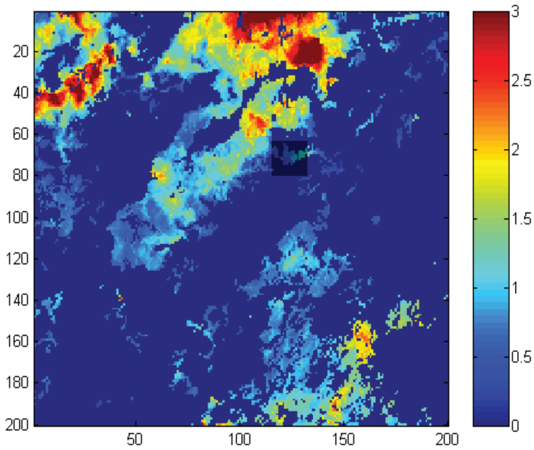


Figure 1. Atmospheric water vapor effect in 2.1μm channel

3. PRELIMINARY RESULTS

Based on the method above, the AOD of North China Plain is calculated and the in-situ measurements in Beijing, China has been used to validate this method. The validation shows a very good agreement between the results from the proposed method and the in-situ measurements.



0.61502	0	0	0	0	0	0	0	1.1463	0	0	0
0.6175	0	0	0	0	0	0	0	0	0	0	0
0.5406	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0.422	0	0	0	0	0
0.54947	0	0	0	0	0	0.40731	0.42862	0	0	0	0
0.56907	0	0.58477	0	0	0	0	0.54274	0.51939	0	0	0
0.58177	0.74934	0.63054	0.46028	0	0	0	0.56415	0.51889	0	0	0
0.38753	0.509	0.58587	0.45464	0	0	0.54251	0.56371	0.61708	0	0.57399	0.65624
0.33375	0.33363	0.51682	0.51818	0	0	0.56363	0.61697	0.66096	0.57444	0.80807	0.75416
0	0	0.4253	0.53541	0	0	0.4742	0.6609	0.57101	0.63812	0.71903	0.90714
0	0	0.42515	0.50082	0.53571	0.44328	0.45097	0.49659	0.64021	0.56976	0.90753	0.90814
0	0	0	0	0	0.61663	0.5545	0.55853	0.54089	0.50024	0.91197	1.0161
0	0	0	0	0	0	0.50809	0.43831	0.58093	0.55186	0.69	0.96258
0	0	0	0	0	0	0.47888	0.427	0.52038	0	0.69897	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0.51871	0.53839	0	0	0	0	0	0	0	0	0	0

Figure 2. The retrieved AOD

Figure 2 shows the retrieved AOD of North China Plain in Mar. 4, 2001by using MODIS imagery. The left graph is the AOD distribution and the table on the right is the AOD values of the dark patch within the left graph. The retrieved AOD in 550nm in the measurement site is 0.45097 and is agree with the in-situ sun-photometer measurement, 0.4924.

4. CONCLUTION

The retrieved AOD based on the land surface spectra model proposed in this paper has very good agreement with the in-situ sun-photometer measurements. Furthermore, this method mainly based on the physical mechanism of land surface radiative transfer model; that is, it has the potential to be applied to most of the land surface conditions; the retrieved AOD can therefore be used to researches like global change and urban air quality monitoring.

5. REFERENCES

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