The Construction and Application of Effective Coefficient for Aerosol Size Distribution

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Abstract: Due to the fact that the composition and variability of aerosols is considered rather complex, it is difficult to employ a simple and straightforward physical model in calculating the aerosol size distribution in the absence of actual data. This complicates the already difficult retrieval of various atmospheric parameters from remotely sensed data. Thus, the main purpose of this study is trying to find an effective aerosol size coefficient that is stable, and can depict the particle size distribution. This paper also attempts to construct an "effective aerosol size coefficient" database for each respective season, where it can quickly and effectively supply pertinent information of the atmosphere's opacity.

Keywords: Aerosol size distribution, Effective coefficient, Remote sensing

1. Introduction

By using actual aerosol optical depth (AOD) data from ground-based sun photometers, the regional aerosol optical depth can be calculated from remotely sensed data [3,4,5]. With this information in hand, it could be of great help in the procedure of atmospheric corrections for remotely sensed images and providing data regarding the air quality. As long as the particle size distribution and aerosol optical depth are known, the calculation of the atmospheric turbidity which corresponds to the concentration of aerosols within the atmosphere, can be done using the turbidity law [1]. However, because of the complicated nature of aerosols [2], without actual data, it is extremely difficult to calculate the particle size distribution merely with a simple physical model. Consequently, this paper tries to analyze and classify the characteristics of aerosols from actual ground measured data by introducing an effective parameter of the aerosol size distribution (effective aerosol size coefficient) to serve as an indicator in the monitoring of the atmospheric turbidity.

2. Methodology

From the Ångström turbidity formula,

$$\tau_{a\lambda} = \beta\lambda^{-\alpha} \quad (1)$$

where τ_a is the aerosol optical depth, λ the wavelength, β the Ångström turbidity coefficient, it is clearly seen that it enjoys a positive correlation with the atmospheric turbidity. α is basically used to describe the size and distribution of aerosols.

Due to the fact that the composition of these particles is susceptible to various influences, the value of α is not always a constant [2]. Therefore, this paper attempts to overcome this difficulty by combining the α value with the wavelength, or in other words, using the λ**(- α) term in describing the local aerosol particle coefficient. With the problem simplified, a more stable coefficient should theoretically be derived in each season.

An effective aerosol size coefficient A is defined in this paper as:

$$A = 1/[\lambda **(-\alpha)] \quad (2)$$

Thus, the Ångström turbidity equation can be rewritten as:

$$\beta = A\tau_{a\Delta\lambda} \quad (3)$$

where $\tau_{a\Delta\lambda}$ is the respective bandwidth (Δλ) of the aerosol optical depth. If a representative local aerosol particle size parameter can be formed, along with employing satellite data in calculating the atmospheric turbidity from the aerosol optical depth, real time data on the air quality can be provided.

3. Analysis and Result

Regarding the calculation of the local particle size distribution, it was performed by obtaining data from the sun photometer located at the National Central University from May to August in the year 1998, where the aerosol size distribution coefficient or α could be analyzed. The procedure is first done by calculating the aerosol optical depth and atmospheric turbidity coefficient using the bandwidth of 500 ~ 590 nm (SPOT/HRV/XS1) from the sun photometer's measurements. Results show that the extent of the atmospheric turbidity opacity increases with the aerosol optical depth, where a linear relationship clearly exists (Fig. 1(a)). By using a linear regression model, the average α value reaches 1.33, which is extremely close to the value of 1.3 suggested by Ångström, indicating that the atmospheric conditions was in a normal state. Furthermore, if a α value of 0.8 is used for distinction (roughly equaling to one standard deviation), the aerosol optical depth is positively proportional with the atmospheric turbidity, where the R-squared value can be over 0.98. Fig. 1(b) shows that the average smaller aerosol particles accounts for 86% of the entire dataset, where the average α value is 1.44. The α value can be used in representing the aerosol particle coefficient of the test area, and the regression line can be employed in calculating the atmospheric turbidity. Fig. 1(c) represents the average larger particles occupying the remaining 14%, with the average α value being 0.36. Larger particles originated mostly from smoke, haze or dust storm.

4. Discussions

The introduction of the effective aerosol size distribution proves to be stable under normal atmospheric conditions. This effectively overcomes the drastic changes brought forth when analyzing the particle size distribution. If more long-term data can be collected, it would further improve the calculation of the atmospheric opacity and the local aerosol particle coefficient.

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References

[1] Ångström A. K., 1929: On the atmospheric transmission of sun radiation and on dust in the air. Geogr. Ann., vol. 11, pp. 156-166.

[2] Cachorro V. E., A. M. de Frutos, and J. L. Casanova, 1987: Determination of the Ångström turbidity parameters. Applied Optics, Vol. 26, No. 15, pp. 3069-3076.

[3] Lin, T.-H., A. J. Chen, G.-R. Liu, and T.-H. Kuo, 2002: Monitoring the Atmospheric Aerosol Optical Depth with SPOT Data in Complex Terrain. International Journal of Remote Sensing, Vol. 23, No. 4, 647-659.

[4] Liu, G.-R., A. J. Chen, Tang-Huang Lin and Tsung-Hua Kuo, 2002: Applying SPOT Data to Estimate the Aerosol Optical Depth and Air Quality. Journal of Environmental Modeling and Software, Vol. 17, Issue 1, pp. 3-9.

[5] Tanre D., P. Y. Deschamps, C. Devaux, and M. Herman, 1988: Estimation of Saharan aerosol optical depth from blurring effects in Thematic Mapper data. J. Geophys Res., Vol. 93, No. D12, pp 15955-15964.

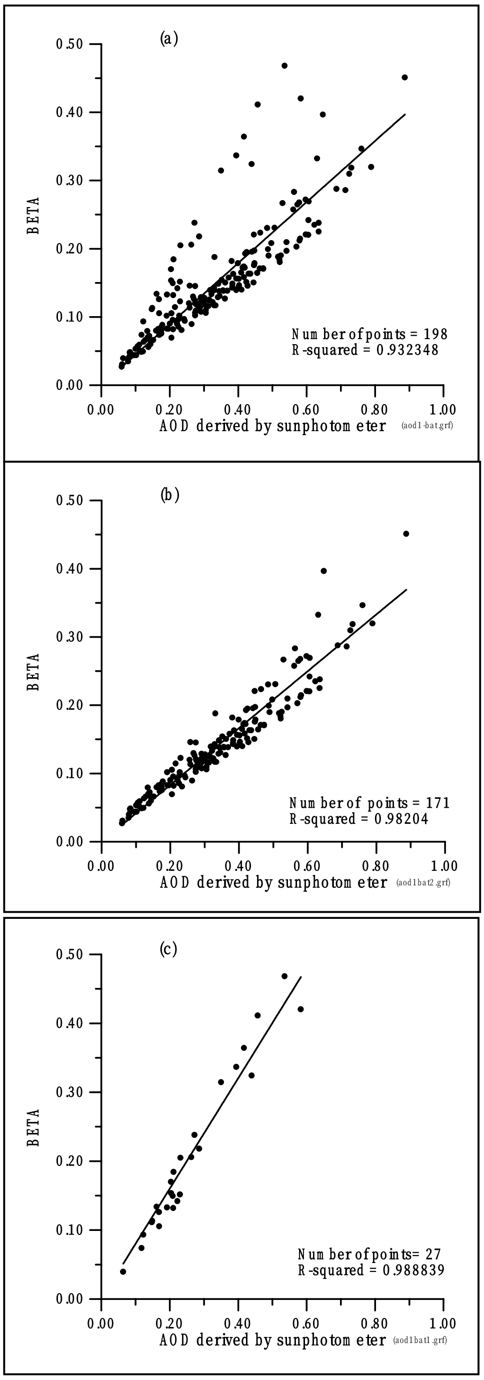

Fig. 1 (a) The relationship between β and AOD in SPOT/HRV/XS1 band, (b) Portion of smaller particles in Fig. 1(a), (c) Portion of larger particles in Fig. 1(a).