HIGH RESOLUTION AOT RETRIEVAL BASED ON MODIS SURFACE REFLECTANCE PRODUCT

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1. INTRODUCTION

The resolution of current MODIS aerosol optical thickness (AOT) product is 10km. This product is suitable for global research, but it faces difficulty in local area research, especially in a city. In order to get detail aerosol distribution in local area or a city, this article mainly discussed how to retrieve 1km resolution AOT and how to estimate surface reflectance in the visible from archived MODIS surface reflectance product. The archived MODIS surface reflectance product is mainly used to build surface reflectance database that is used to estimated surface reflectance in the visible.

2. BASIC THEORY

Surface reflectance estimating in the visible is important in aerosol optical thickness retrieval. Precision in surface reflectance decides final accuracy of AOT. In the paper, a surface reflectance database is built using MODIS surface reflectance product (MOD09) to estimate surface reflectance in the visible, because the MODIS surface reflectance product has a high precision. The total theoretical typical accuracies of this product are 0.005, 0.008 and 0.003 respectively in MODIS band 1, 3 and 7[1].

The method to estimate surface reflectance in the visible using surface reflectance database is based on Geometric Model[2]. In the Geometric Model, the radiance at a downward-looking satellite sensor can be written as

$$S = \frac{A_g}{A} \cdot G + \frac{A_c}{A} \cdot C + \frac{A_z}{A} \cdot Z + \frac{A_t}{A} \cdot T \qquad (1)$$

Where, A_g -- Area of background within A that is both illuminated and viewed; A_c -- Area of crown surface within

A that is both illuminated and viewed, as projected onto the background; A_z -- Area of background within A that is not illuminated but viewed; A_t -- Area of crown surface within A that is not illuminated but view, as projected onto the background; A -- Area of the footprint of sensor's field of view, or pixel size.

A_g, A_c, A_z and A_t are related to solar zenith angle and sensor zenith angle. So, ratio of radiance in two different band is same to each other at the same time, place, solar zenith and sensor zenith. When ignoring the effect of sensor zenith, it is supposed that the ratio remains the same in the same day but different year. As a result, an equation can be written as

$$\frac{\rho_{0.466}^{N}}{\rho_{2.1}^{N}} = \frac{\rho_{0.466}^{O}}{\rho_{2.1}^{O}} \qquad (2)$$

Where $\rho_{0.466}^{N}$ is the surface reflectance to be estimated in the $0.466\mu m$ *(the 3rd band in MODIS)*, $\rho_{2.1}^{N}$ is apparent reflectance in the $2.1\mu m$ *(the 7th band in MODIS)*, the time that $\rho_{2.1}^{N}$ was obtained is same with $\rho_{0.466}^{N}$. $\rho_{2.1}^{O}$ and $\rho_{0.466}^{O}$ are apparent reflectance in the $2.1\mu m$ and surface reflectance in the $0.466\mu m$ in the surface reflectance database respectively.

Although the data was acquired in the same day of different, the time is not exactly same with each other, so the solar zenith angle can be slightly different. Here, solar zenith angle is added into equation 2 as a factor to improve the accuracy of estimated surface reflectance in the $0.466\mu m$. Equation 2 can be rewritten as

$$\rho_{0.466}^{N} = \frac{\rho_{2.1}^{N} \sin(\theta_S^N)}{\rho_{2.1}^{O} \sin(\theta_S^O)} \rho_{0.466}^{O} \qquad (3)$$

Where θ_S^N is the solar zenith angle when $\rho_{2.1}^{N}$ was acquired, θ_S^O is the solar zenith angle when $\rho_{2.1}^{O}$ was acquired.

3. BUILDING SURFACE REFLECTANCE DATABASE

The data used to build the database include MODIS daily products: MOD09GA – surface reflectance, MOD02 – apparent reflectance, MOD35 – cloud mask and MOD03 from the year 2001 to 2008. All the data are first re-projected into same coordinate and then are masked by cloud mask. The data on the same day of different years is deemed as a dataset, thus, there will be 365 datasets. When building the database, the time priority method is used in a dataset. For example, in a dataset, it contains the same day data from the year 2001 to 2008. The data in 2008 is set as the base data, and in the base data, the value under cloud cover area is first filled with data of 2007 in the same area. If there are still some values under the cloud, then the data in the year 2006 will be used. The procedure goes on until all the value under the cloud is filled or the data in 2001 is used. At last, a standard image data without cloud will be got. All others datasets will be processed in the same method. Finally, a database contains 365 image data will be created. Each image data is composed of surface reflectance in 0.466μm, solar zenith angle, sensor zenith angle, solar azimuth angle, sensor azimuth angle and apparent reflectance in 2.1μm.

Surface reflectance in the 0.466μm can be estimated according to equation 3 and the database. In order to check the accuracy of the estimated surface reflectance, the surface reflectance product of MODIS is used. We compare the two datasets in different vegetation cover conditions, the largest absolute error comes out to be 0.0096, and the smallest absolute error is 0.001. The error decreases as the vegetation cover increasing.

4. AOT RETRIEVAL AND VALIDATION

Using the surface reflectance in the visible estimated from equation 3, this article retrieved a series of AOT image of Beijing using DDV[3][4] method. The resolution of AOT is 1km. The observation data of AERONET site in Beijing and Xianghe is used to check the precision of AOT. The largest absolute error of the two datasets is 0.1441, the smallest error is 0.0074 and the average absolute error is 0.06. We also draw a regression line of the two datasets, the slope of the regression is 1.344 and the intercept is -0.026. The slope is a little larger, but the correlation of the two datasets reaches to 0.936. The result can be accepted in 1km resolution.

5. REFERENCE

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