MODIS AEROSOL RETRIEVAL IN FINE SPATIAL RESOLUTION FOR LOCAL AND URBAN SCALE AIR QUALITY MONITORING APPLICATIONS

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ABSTRACT:

Remote sensing of atmospheric aerosol using MODIS satellite data has been proven to be very useful in global/regional scale aerosol monitoring. Due to their large spatial resolution of $10km^2$ MODIS aerosol optical thickness (AOT) data have limitations for local/urban scale aerosol monitoring applications. Modified Bremen Aerosol Retrieval (BAER) algorithm developed by von Hoyningen-Huene et al. (2003) and Lee et al. (2005) has been applied in this study to retrieve AOT in fine resolutions of $500m^2$ over Korea. Look up tables (LUTs) were constructed from the aerosol properties based on sun-photometer observation and radiation transfer model calculations. It was found that relative error between the satellite products and the ground observations was within about 15%. Resulting AOT products were correlated with surface PM10 concentration data. There was good correlation between MODIS AOT and surface PM concentration under certain atmospheric conditions, which supports the feasibility of using the high-resolution MODIS AOT for local and urban scale air quality monitoring

KEY WORDS: MODIS, AOT, PM

1. INTRODUCTION

Atmospheric aerosols interact with sunlight and affect the global radiation balance, causing climate change through direct and indirect radiative effects. Recently, it has become evident by estimates from satellite remote sensing data that atmospheric aerosols play an important role in regional air quality and atmospheric chemistry. Air pollution is a widespread problem in Asia. Air quality in this area is the results by a various anthropogenic sources, especially those associated with a rapidly growing economic and population growths. Additionally, the importance of large urban area as sources of regional and global pollution is important [*Akimoto*, 2003]. Satellites are also a valuable tool for urban scale atmospheric remote sensing.

In this paper, we present the results of compositing urban scale aerosol optical thickness maps using MODIS 500m resolution data. To retrieve AOT over the urban area, background surface reflectance and Look-up table (LUT constructed from the DISORT radiative transfer code was used with various aerosol models.

2. METHODOLOGY

The satellite received signal is generally consisted by the both of atmospheric and surface reflected radiation in visible wavelength region. In order to retrieve AOT from MODIS Level 1b (L1b) data the separation technique [*von Hoyningen et al.*, 2003] was used. The aerosol reflectance can be separated from TOA reflectance by subtracting other contributors such as Rayleigh scattering and surface reflectance should be removed from it. Aerosol reflectance, ρ_a can be expressed as

$$\rho_a = \rho_{TOA} - \rho_{Ray}(\lambda, \theta, p(z), M_0, M_S) - \omega_0(\lambda) \cdot \tau_R(\lambda, M_S) \cdot \rho_{Surf}(\lambda, z_0, z_S) \quad (1)$$

where, $\rho_{Ray}(\lambda, \theta, p, M_0, M_S)$ = the normalized Rayleigh path reflectance

θ = multiple scattering for the scattering angle

p = the pressure

M_0 = the air mass factor for illumination

M_S = satellite

$\omega_0(\lambda)$ = the single scattering albedo

τ_R = the transmission for Rayleigh atmosphere

z_S =the zenith distance of satellite

z_0 = the zenith distance of sun

$\rho_{Surf}(\lambda, z_0, z_S)$ =the surface reflectance for sun and satellite geometry

$p(z)$=the pressure at elevation z km.

In case of separation of the surface reflectance from TOA reflectance over land, a linear mixing model of the spectral reflection of 'green vegetation' and 'bare soil' was used to determine the land surface reflectance for a large sized dark pixel. However, bright surface reflectance becomes a problem for aerosol retrieval over urban area with fine spatial resolution. Minimum reflectance selection method was used for background surface reflectance database for MODIS 500m resolution aerosol retrieval. The darkest pixel was chosen with correction of Rayleigh scattering and cloud shadows.

Finally aerosol only signals can be separated from TOA reflectance. The best spectral shape fitting procedure of spectral aerosol reflectances to the corresponding calculated values was done for AOT retrieval. Similar approaches are found from Kaufman and *Tanré* (1998), *Costa et al.* (1999), *Torricella et al.* (1999).

3. RESULTS

Fig. 1. shows surface reflectance in Seoul, Korea calculated by linear mixing model (LMM) and minimum reflectance method(MRM), respectively. The discrepancy between two methods is about 0.02 in 465 nm wavelength. The reflectance by NRM is relatively large due to the man made construction in urban area. This amount of surface reflectance will be error of AOT, ~ 0.2. That can be much increased in longer wavelengths.

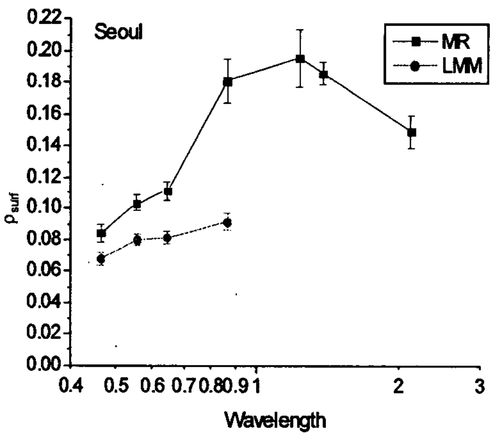

Figure 1. Surface reflectance calculated by linear mixing model (left) and minimum reflectance method (right) on 29 April 2004.

A composite AOT and Angstrom exponent map was produced using MODIS 500m resolution L1B data on 23 April 2004. AOT was retrieved from the cloud-free pixels of the region having a spatial resolution of 500m^2. The AOT was relatively high over Seoul, Korea, indicating a higher aerosol concentration since Asian dust was transported from Chinese desert region. The AOT over these regions was under 0.3 for clear day on 24 April 2004 otherwise about 0.5 to 0.7 for Asian dust case and the Angstrom exponent was under 0.5, indicating the presence of large aerosol particles in the atmosphere.

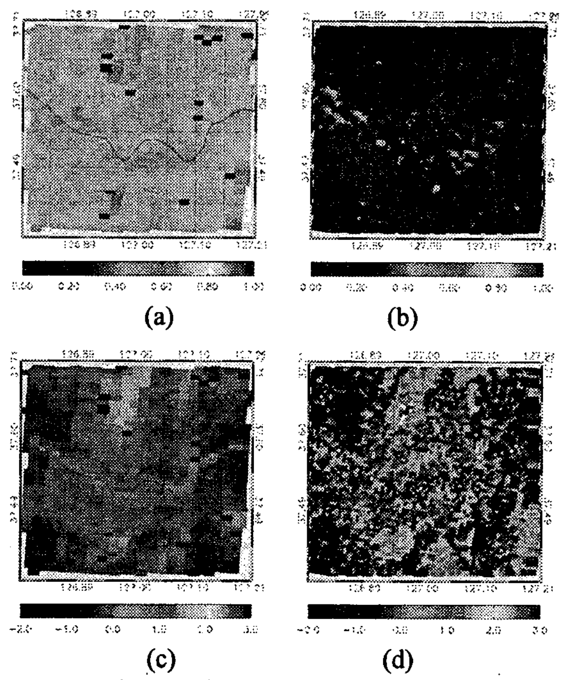

Figure 2. Urban scale composite of MODIS AOT at 465nm for (a) 23 and (b) 24 April 2004, angstrom exponent for (c) 23 and (d) 24 April 2004 at 500m^2 resolution, respectively.

4. CONCLUSION

The fine spatial resolution AOT data over urban area in Korea was analyzed using MODIS 500m resolution data to estimate the urban air quality. For the bright surface reflectance calculation over the urban area, the surface reflectances by LMM and MRM were tested. The surface reflectance by LMM over urban area showed larger error than that by MRM. The AOT and angstrom exponent for case study clearly showed aerosol characteristics for Asian dust and clear day over Seoul, Korea, respectively.

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