Chapter 17
MODIS 500 × 500-m² Resolution Aerosol Optical Thickness Retrieval and Its Application for Air Quality Monitoring

Kwon H. Lee¹, Dong H. Lee¹, Young J. Kim*, and Jhoon Kim²

Abstract Atmospheric aerosol optical thickness (AOT) was retrieved over urban areas using moderate resolution imaging spectroradiometer (MODIS) 500-m resolution calibrated radiance data. A modified Bremen Aerosol Retrieval (BAER) algorithm was used to retrieve AOT over Seoul, Korea. Since the surface reflectance of an urban area is typically brighter than that of vegetation or soil areas in the visible wavelength region, the error associated with aerosol retrieval is higher. Surface reflectance determination using the linear mixing model (LMM) produced values that were smaller (∼0.02) than those obtained using the minimum reflectance technique (MRT). This difference would lead to an overestimated AOT when using the LMM approach. Retrieved AOT data using MRT and standard MODIS 10-km aerosol products (MOD04) were compared to Rotating Shadow-band Radiometer (RSR) observations at Yonsei University, Seoul, Korea. Regression analysis showed that the root mean square error (RMSE) of MODIS AOT and MOD04 AOT was 0.05 in both cases. In addition, MODIS AOT data were compared with ground-based particulate matter data (PM10) from air quality monitoring networks of the National Institute of Environmental Research (NIER). MODIS AOT data showed a relatively low correlation ($r = 0.41$) with surface PM10 mass concentration data due to differences in ground-based and column-averaged data, variability of terrain, and MODIS cloud mask. This result is similar to that of other investigations. The application of fine-resolution satellite data supports the feasibility of local and urban-scale air quality monitoring.

Keywords: AOT, LMM, MODIS, MRT, PM10

¹ Advanced Environmental Monitoring Research Center (ADEMRC), Gwangju Institute of Science & Technology (GIST), 1 Oryong-dong, Buk-gu, Gwangju 500-712, Republic of Korea
² Department of Atmospheric Sciences, Yonsei University, Shinchon-dong 134, Seodaemun-gu, Seoul 120-749, Republic of Korea

*Corresponding author: Tel: + 82-62-970-3401, Fax: + 82-62-970-3404

17.1 Introduction

Satellite remote sensing has provided quantitative information on aerosols with an accuracy comparable to that of surface measurements. The large-scale distribution of aerosol concentration and characteristics, aerosol radiative forcing, and property changes of clouds interacting with aerosols are among the important observations that can be provided by satellite remote sensing. Due to the growing recognition of the importance of aerosol properties for studies of climate and global change, it is indeed fortunate that a number of very significant and greatly enhanced satellite systems are being developed for launch in the next few years. These systems will also provide information on the global distribution, including seasonal and interannual variation, of aerosol sources (forest fires, desert dust and aerosol from the oxidation of SO$_2$ emissions from industrial regions), aerosol loading and optical properties, as well as direct and indirect radiative forcing.

Satellite measurements can also be inverted to yield information on aerosol optical thickness (AOT), angular scattering properties, and size distribution. Satellite measurements clearly have the advantage of being the only set of measurements that provide a wide coverage. The disadvantage of the presently used passive sensors is that they can only be applied under clear-sky conditions, and their application over land is difficult. Furthermore, a number of additional assumptions have to be made regarding atmospheric conditions. In spite of these disadvantages, many researchers have studied global and local-scale aerosol remote sensing using satellites. Techniques associated with satellite observation in the field of atmospheric science are advancing rapidly (Kaufman et al. 1997a; Gordon et al. 1997; King et al. 1999). Total ozone mapping spectrometer (TOMS) measurements are designed to monitor ozone and provide valuable information on aerosol geographical distributions (Herman et al. 1997). Such measurements were used to detect an increase in biomass burning smoke in African savanna regions during the 1990s (Hsu et al. 1999). The Sea-viewing Wide Field-of-view Sensor (SeaWiFS), developed to provide ocean color data products for the study of marine biogeochemical processes, produces an aerosol data product from its atmospheric correction algorithm (Gordon and Wang 1994) through a separate algorithm (von Hoyningen-Huene et al. 2003), and has been used to investigate transport of Asian dust plumes (Lee et al. 2004). The launch of polarization and directionality of the earth’s reflectance (POLDER) on ADEOS II adds greater capabilities (Leroy et al. 1997). Extracting the full potential from the satellite data requires correlative suborbital data to not only validate the satellite measurements (Clark et al. 1997; Fraser et al. 1997; Vermote et al. 1997), but to supply information not obtainable from space. The EOS/Terra and EOS/AQUA satellites and their new instruments, such as the moderate resolution imaging spectroradiometer (MODIS) and multi-angle imaging spectroradiometer (MISR), provide improved measurement capabilities and unprecedented volumes of data regarding the atmosphere, land, ocean, and radiative processes (Tanré et al. 1997; Wanner et al. 1997).