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A Study on Detection Methods for Atmospheric Small Particles Based of Lidar Techniques

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Knowledge of the aerosol size distribution in the accumulation mode (50-1000 nm) is essential in studies on human health because small particles could even penetrate into lung foam, thus increasing the risk of bronchitis or lung and heart diseases. Optical Remote sensing techniques such as a lidar are effective for monitoring aerosols with high temporal and spatial variations. Aerosol instruments using light of wavelengths 350-1500 nm have been put into practical use, and they are effective for detecting particles with sizes comparable to the wavelength. However, to estimate quantitatively the shape of the particle size distribution, more information of small particles with radii around 100nm is required.

In this study, a lidar analysis method is proposed to derive the aerosol size distribution for a wide range of particle sizes, including 100 nm. The algorithm can be divided into two parts. The first part applies the conventional analysis using the wavelength dependence of aerosol physical parameters based on single scattering lidar techniques. The second part involves the use of multiple scattering via multiple-filed-of-view lidar signals for achieving a probing wavelength less than 350 nm; although such short wavelengths can be used to obtain information on small particles, they have not been used for aerosol measurement owing to the strong light absorption by atmospheric constituents such as ozone. The analysis is accomplished by directly fitting the observed lidar signals and the retrieved aerosol parameters to the theoretical values that are based on the look-up-table which is constructed on the basis of Mie scattering and multiple scattering calculations as a function of the log-normal size distribution.

The retrieved particle mode radii in a range of 50-200 nm agree with the originally assumed parameters in combination of single scattering and multiple scattering algorithms, even if noise is contained. In order to evaluate the noise effect, we simulated a sensitivity analysis. When random errors of 5%, 10%, 20%, and 50% were added to the prepared parameters theoretically calculated by use of the geometric mean radius of 100 nm for the aerosol size distribution, the retrieved mean radius (upper and lower limits) derived from the proposed method were 103 nm (83-128 nm), 100 nm (69-144 nm), 89 nm (48-163 nm), and 84 nm (38-186 nm), respectively.

Keywords: Lidar, Aerosol