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Temperature profiling with a rotational Raman lidar using a multispectral detector

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Temperature profiling in the atmospheric boundary layer is essential for understanding atmospheric processes and for meteorological studies, such as precise weather forecasting with particular reference to heat-island phenomena, relative humidity retrievals, and transport characteristics of atmospheric pollutants in urban environments. Lidar has been considered one of the more powerful techniques for remote sensing of atmospheric parameters providing continuous observations with high spatiotemporal resolution. The temperature lidar method detects the temperature dependence of the intensities of the rotational Raman spectrum lines of atmospheric nitrogen and oxygen molecules. The polychromator design for conventional temperature lidar, which is much more complex than that for other lidar techniques, detects the ratio of two rotational Raman lidar signals of opposite temperature dependence using several edge and interference filters. In this study, we developed a temperature lidar with a multispectral detector (MSD), in order to construct a system that is compact, robust, and easy to align for the detection of rotational Raman signals. The multispectral detector enables simultaneous acquisition of multichannel photon counts and it provides spectral and range-resolved data by applying lidar techniques. The multispectral lidar detector can resolve the shape of the rotational Raman spectrum and therefore, temperature estimation can be accomplished by direct fitting of the observed lidar signals to the shape of the theoretical values of rotational Raman spectra that exhibit different dependencies on temperature.

To evaluate the accuracy of temperatures estimated by the proposed method, we constructed the temperature lidar, equipped with a 35-cm receiving telescope, with an MSD that has 0.34-nm spectral resolution at a laser wavelength of 355 nm. Two methods were considered for removing the leakage effects caused by strong elastic scattering in the detector. First, we covered one photomultiplier cathode strip of the elastic scattering channel to reduce crosstalk effects. Second, we blocked the major portion of elastic scattering from the polarization beam splitter using the polarization properties for spherical particles. Simultaneous measurements with the proposed rotational Raman lidar and radiosonde were conducted during January and February 2015 at the middle and upper (MU) radar observatory (34.8 N, 136.1 E) in Shigaraki, Japan. Here, we report the preliminary results of the temperature observations and the calibration process of the photon detection efficiency for each MSD channel.

Keywords: temperature lidar, multispectral detector