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ABSTRACTS (MASTER THESIS)

Development of rotational Raman lidar with a multispectral detector for profiling atmospheric temperature

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Temperature profiling in the atmosphere is essential for studying atmospheric processes such as thermodynamics and cloud physics. Rotational Raman (RR) lidar can conduct continuous observation of the spatial distribution of atmospheric temperature. 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 RR signals.

The spectral detection component of the temperature lidar consists of a grating and a photomultiplier (PMT) tube array with 32 channels. To remove the leakage effect caused by strong elastic scattering in the detector, we attempted two methods. First, we covered one PMT cathode strip of the elastic scattering channel to reduce the crosstalk effect. Second, we blocked the major portion of elastic scattering with the polarization beam splitter by using the polarization properties for spherical particles. The ideal settings for multispectral observations were determined by the theoretical simulation of accurate temperature projection based on the effects of both spectral resolution and spectral range, which influence the statistical error in temperature values of the lidar signals.

We constructed the temperature lidar with an MSD with 0.5nm spectral resolution at a laser wavelength of 532 nm. Simultaneous measurements with the proposed RR lidar and radiosonde were conducted at the middle and upper (MU) radar observatory in Shigaraki, Japan under clear sky conditions on the nights of November 5–8, 2013. The difference in photon detection efficiency at each MSD channel was calibrated using the radiosonde data. We found good agreement between the temperature profiles in the free troposphere between the lidar and radiosonde observations when both stokes branch (528.65 nm–531.65 nm) and anti-stokes branch (533.15 nm–536.15 nm) of RR lidar signals were used. The statistical error of the temperature values with an observation time of 4 h and a height resolution of 800m was 1.1K at an altitude of 7 km.

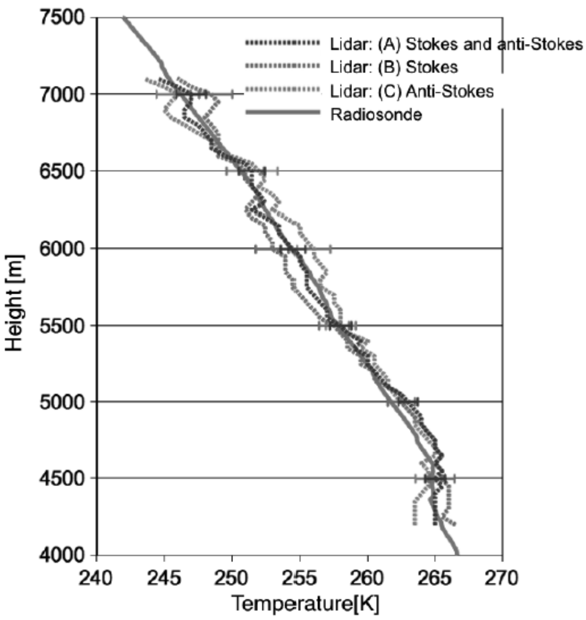

Figure 1. Temperature profiles measured with the rotational Raman (RR) lidar on 5 November 2013, 19:32 - 23:31 Japan standard time (JST). Radiosonde data at 20:29 JST is shown for comparison. Lidar data were smoothed with sliding average length 800 m. Error bars show the 1-σ statistical uncertainty of the RR temperature measurements using the photon-counting signals. The temperature retrievals were applied for the observed RR signals for three data types: (A) both Stokes and anti-Stokes lines, (B) Stokes lines, and (C) anti-Stokes lines.