Calibration technique for water vapor Raman lidar using GNSS PWV and meso-scale model

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Water vapor is an important component in atmospheric processes, such as thermodynamic influences on convection initiation and localized extreme weather events associated with severe weather disasters. Accurate observations of water vapor in the atmospheric boundary layer are essential for improved weather forecasting. Raman lidar techniques are useful for observing water vapor profiles. However, the calibration factor based on the system constants of both nitrogen and water vapor channels must be determined before estimating the water vapor from Raman signals. Because the calibration factor is usually evaluated by comparing the results of independent measurements (e.g., radiosonde) of water vapor mixing ratio, it is difficult to apply lidar observations at sites where radiosonde observations cannot be carried out.

In this study, we propose a new calibration technique for water vapor Raman lidar using global navigation satellite system (GNSS)-derived precipitable water vapor (PWV) and the Japan Meteorological Agency Meso-Scale Model (MSM). The analysis was accomplished by directly fitting the GNSS-PWV to integrated water vapor profiles combined with the MSM and the results of the Raman lidar observation. This method can be applied to lidar signals under a limited height range due to weather conditions and lidar specifications. For example, Raman lidar using a laser operating in the ultraviolet C (UV-C) region has the advantage of having no daytime solar background radiation in the system. However, the observation range is limited at altitudes lower than 1–3 km because of the strong ozone absorption in the UV-C region. The new calibration method will allow the utilization of various types of Raman lidar systems. In this paper, we will introduce our proposed calibration techniques as well as the preliminary results on the accuracy of the estimated calibration factor based on numerical simulations.

Keywords: water vapor, lidar, GNSS, MSM

