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Correlation Study of Water Vapor and Aerosol Distributions in Troposphere Using Scanning Raman Lidar

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Aiming at the study of water vapor and aerosol distributions in the lower atmosphere from the Otlica observatory, Slovenia (45.93ºN, 13.91ºE, elevation 945 m above sea level), we have built a new Raman lidar in parallel to the existing Mie lidar. The new system is oriented towards the Adriatic coast with a fixed azimuth angle of 235.1º and shares the transmitter (tripled Nd:YAG pulsed laser at 355 nm with pulse energy of 100 mJ and repetition rate of 20 Hz) and mechanical support with scanning functionality in zenith angle with the Mie lidar.

The receiver part of the Raman lidar employs custom optics using a low f-number aspheric lens, designed to maximize the coupling of lidar returns collected by a parabolic mirror with a diameter of 800 mm and focal length of 410 mm and the 1000 μm core multi-mode optical fiber used to transport the light to the polychromator for spectral analysis. In the polychromator, 5-nm bandwidth interference filters combined with dichroic beam splitters were used to separate the vibrational Raman signals of nitrogen and water wapor molecules. The three return signals were detected by photo-multiplier tubes and sampled by transient recorders in photon-counting mode.

System functionality was assessed in a number of preliminary experiments, where water vapor concentrations were calibrated using radiosonde data. During the nights of 24-25 August 2011 a series of measurements of water vapor and aerosol distributions along the lidar line of sight were performed at various elevation angles. In the vertical measurements, two layers with larger water vapor content were visible at altitudes of 1.5 km and 4.0 km with relative humidity in both cases exceeding 75%. Aerosol extinction decreased linearly between the altitudes of 2 km and 4.5 km, with aerosol layers appearing at 4.0 km, 4.7 km and 5.6 km. In horizontal measurements, the water vapor mixing ratio and the relative humidity were found to be almost constant in the range of 1.5 km to 4.5 km with a sudden drop in close range (at 0.7 km), which corresponds to the variation in the terrain configuration along the line of sight. Between 2.5 km and 5.0 km the atmospheric extinction was also found to be constant with values of about 0.15 km-1. The measurements at an inclination of 25º showed linear decrease of water vapor concentration between the ranges of 1.5 km and 5.0 km with a number of indistinct peaks, while a linear increase of aerosol extinction was found in the same range with several aerosol layers between the altitudes of 2.2 km and 2.8 km. The correlation between water vapor and aerosol distributions was investigated by comparing the aerosol extinction to the water vapor mixing ratio. As no correlation was found, we conclude that the aerosols detected in the study region were predominantly non-hygroscopic.