Et-005 Room: C513 Time: June 7 10:00-10:15

First measurements with the RASC rotational Raman lidar at Shigaraki (34.8 deg N, 136.1 deg E)

Andreas Behrendt[1], Takuji Nakamura[1], Michitaka Onishi[2], Toshitaka Tsuda[1]

[1] RASC, Kyoto Univ., [2] RASC,Kyoto Univ

Measurement parameters of the new Raman lidar of the Radio Science Center for Space and Atmosphere (RASC) at Kyoto University are optical particle properties, temperature (with rotational Raman and with Rayleigh integration technique), and humidity (rotational vibrational-rotational technique). The system is located at Shigaraki (34.8 deg N, 136. deg E), where also the RASC middle and upper atmosphere radar (MU radar) with a unique set of high-technology radar instruments is operated. Main scientific topics of our lidar are the study atmospheric wave phenomena from the ground up to the mesosphere, the validation of lidar and radar data by comparison, and synergetic effects of simultaneous measurements with lidar and radar. First measurements with this system are presented.

The remote, height-resolved measurement of atmospheric parameters with lidar offers a number of exciting features to the atmospheric science community such as, e.g., the possibility of continuous observation and of measurements in height regions which are difficult to access with other instruments.
Measurement parameters of the new Raman lidar of the Radio Science Center for Space and Atmosphere (RASC) at Kyoto University are optical particle properties, temperature (with rotational Raman and with Rayleigh integration technique), and humidity (rotational vibrational-rotational technique). The system is located at the RASC observatory at Shigaraki (34.8 deg N, 136. deg E), where also the RASC middle and upper atmosphere radar (MU radar) with a unique set of high-technology radar instruments is operated. Main scientific topics of our lidar are the study atmospheric wave phenomena from the ground up to the mesosphere, the validation of lidar and radar data by comparison, and synergetic effects of simultaneous measurements with lidar and radar.

In the present stage, 5 channels are operated: 2 elastic channels (for low and high altitude signals, res.), 2 pure-rotational Raman channels (for the detection of low- and of high-quantum-number transitions, res.), and a channel for the vibrational Raman signal of water vapor. The lidar transmitter is a doubled Nd:YAG laser emitting radiation at a wavelength of 532.1 nm with 30 W output power. The receiving telescope is of Cassegrainian type with a primary mirror diameter of 0.82 m. The same telescope also detects the backscatter signals of the collocated Na fluorescence lidar of Shinshu University, which is used to study the density of the mesospheric Na layer and whose backscatter signal is separated with a dichroic beamsplitter.

The Rayleigh integration method is the lidar technique which is most widely used for temperature determination from the middle stratosphere to the mesosphere. High temporal and spatial resolution of the measurements and a relatively simple experimental setup are its main features. However, below the top of the stratospheric aerosol layer (about 30 km height), where elastic scattering is partly caused by particles, the Rayleigh integration method is not applicable. Also the data are derived under the assumption that the atmosphere is locally in hydrostatic equilibrium. Both these limitations are overcome with rotational Raman lidar.

The intensity of low- and high-quantum number transitions of the pure rotational Raman spectrum decreases and increases, respectively, when the temperature increases. Rotational Raman lidar exploits this effect for temperature determination by detecting atmospheric backscatter signals in two spectral regions of different temperature dependence.

Our setup utilizes multi-cavity interference filters mounted sequentially with small angles of incidence. Advantages of this design are high signal throughput, high out-of-band blocking and spectral adjustability of the center wavelengths, combined with a stable experimental setup. The elastic backscatter contribution to the rotational Raman signals are reduced to such low values that temperature data are reliable even in clouds. Nighttime temperature measurements from the ground to the stratopause with high temporal resolution of typically a few minutes at the height of the tropopause became possible with this technique [1].

Usually, Raman lidar takes vibrational-rotational Raman backscatter of nitrogen as reference signal for the measurement of optical particle properties and humidity. In contrast to this, our system makes use of the approximately 10-times stronger pure-rotational Raman signals also for this purpose.

At the conference, we will present and discuss the first measurements of this system.

Reference:

[1] A. Behrendt and J. Reichardt, Applied Optics, 39, 1372 - 1378, 2000.