Powerful Raman-Lidar for water vapor in the free troposphere and lower stratosphere as well as temperature in the upper stratosphere and mesosphere

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A high-power Raman lidar system has been intalled at the high-altitude research station Schneefernerhaus (Garmisch-Partenkirchen, Germany) at 2675 m a.s.l., at the side of an existing wide-range differential absorption lidar (DIAL). Therefore an industrial XeCl laser (350 W, 308 nm) was modified for linearly polarized narrow band single-line operation at an average power of about 180 W. This high power and a receiving telescope with a diameter of 1.5 m allow for a sounding range of up to 25 km for water vapor within a measurement time of just 1 hour, at an uncertainty level of the mixing ratio of 1 to 2 ppm. This was achieved for a vertical resolution varied between just 0.2 and 0.6 km in the stratosphere. The lidar was successfully validated with a balloon-borne cryogenic frost-point hygrometer (CFH). Water vapor profiling has been calibrated with the DIAL, the CFH and radiosondes launched at Munich and Innsbruck (distance 100 km and 40 km). Stratospheric temperature profiles are measured by determining the air density as a function of altitude. Because of the extinction by stratospheric ozone, this cannot be done at the fundamental laser wavelength at 308 nm. The primary plan to use a Raman-shifted fraction of the laser emission from the XeCl laser at a wavelength of 353 nm was discarded. The Raman conversion efficiency using a 3.6 m long hydrogen cell was too weak and unstable. Therefore, the third harmonic from a flash-lamp pumped Nd:YAG laser (3.4 W, 355 nm) was employed. Temperature profiles up to altitudes of around 87 km were demonstrated for 1 h of signal averaging. As the temperature retrieval is an inversion method similar to the Klett inversion, a reference temperature as high as possible is highly valued. At the Schneefernerhaus infra-red soundings of the temperature of the OH-layer in the mesopause (87~km a.s.l) operated by DLR (German Aerospace Center) are available most of the time.