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High resolution humidity, temperature and aerosol profiling with MeteoSwiss Raman lidar

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Meteorological services rely, in part, on numerical weather prediction (NWP). Twice a day radiosonde observations of water vapor provide the required data for assimilation but this time resolution is insufficient to resolve certain meteorological phenomena. High time resolution temperature profiles from microwave radiometers are available as well but have rather low vertical resolution. The Raman LIDARs are able to provide temperature and humidity profiles with high time and range resolution, suitable for NWP model assimilation and validation. They are as well indispensible tools for continuous aerosol profiling for high resolution atmospheric boundary layer studies.

To improve the database available for direct meteorological applications the Swiss meteo-service (MeteoSwiss), the Swiss Federal Institute of Technology in Lausanne (EPFL) and the Swiss National Science Foundation (SNSF) initiated a project to design and build an automated Raman lidar for day and night vertical profiling of tropospheric water vapor with the possibility to further upgrade it with an aerosol and temperature channels. The project was initiated in 2004 and RALMO (Raman Lidar for meteorological observations) was inaugurated in August 2008 at MeteoSwiss aerological station at Payerne.

RALMO is currently operational and continuously profiles water vapor mixing ratio, aerosol backscatter ratio and aerosol extinction. The instrument is a fully automated, self-contained, eye-safe Raman lidar operated at 355 nm. Narrow field-of-view multi-telescope receiver and narrow band detection allow day and night-time vertical profiling of the atmospheric humidity. The rotational-vibrational Raman lidar responses from water vapor and nitrogen are spectrally separated by a high-throughput fiber coupled diffraction grating polychromator. The elastic backscatter and pure-rotational Raman lidar responses (PRR) from oxygen and nitrogen are spectrally isolated by a double grating polychromator and are used to derive vertical profiles of aerosol backscatter ratio and aerosol extinction at 355 nm. Set of Stokes and anti-Stokes PRR lines are separated by the polychromator to derive temperature profiles.

The humidity profiles have vertical resolution from 15 m (within the boundary layer) to 100–450 m (within the free troposphere), time resolution of 30 min and 5 km vertical range at daytime and 10 km at night-time. The aerosol backscatter ratio and extinction profiles have similar resolution with vertical range of approximately 10 km. The temperature profiles are derived from PRR lidar signals, simultaneously recorded in analog and photon counting mode, allowing vertical range of approximately 10 km. Vaisala RS-92 and Snow-White chilled mirror hygrometer radiosondes were used for calibration of the water vapor and temperature channels. Continuous temperature profiles were obtained and were coupled with the available water vapor mixing ratio profiles to obtain relative humidity time series. Lidar derived aerosol backscatter ratio profiles will be used for estimation of the boundary layer height and validation of NWP model results. Optical thickness time series are currently compared to independent measurements from a collocated sun photometer to assess the performance of the aerosol channel.