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A water vapor Raman lidar as part of the Swiss meteorology service

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Vertical water vapor profiles with high time resolution are necessary for improved numerical weather prediction (NWP). Meteorological services rely, in part, on NWP models for short to mid-term weather forecasting. Typically vertical water vapor profiles are acquired from twice a day radiosonde observations which have time resolution insufficient to resolve rapidly changing meteorological phenomena. New operational instruments with near real-time sampling of the water vapor field are needed. Raman LIDARs can provide vertical humidity profiles within the troposphere with time and range resolution suitable for NWP model assimilation and validation. That is why in 2004 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 build an automated Raman lidar for day and night vertical profiling of tropospheric water vapor and aerosol properties.

Currently RALMO (Raman Lidar for meteorological observations) is operational at MeteoSwiss aerological station at Payerne. It is fully automated, self-contained, eye-safe instrument for day and night-time vertical profiling of water vapor mixing ratio, aerosol backscatter, and extinction within the troposphere. The lidar profiles of water vapor mixing ratio have vertical resolution from 15 m (boundary layer) to 100–450 m (free troposphere) and time resolution of 2 min (boundary layer) to 30 min (free troposphere). The range resolved aerosol extinction and backscatter coefficients are measured with similar resolution. The lidar operational range is from ∼50 m to 5 km during daytime (detection limit of 0.2 g/kg), and from ∼50 m to 10 km night-time. LabView based software allows continuous fully automated operation. Automated data treatment software reads the accumulated lidar data, derives vertical profiles of water vapor mixing ratio (grams per kilogram of dry air) estimates statistical error, and stores the result for upload to MeteoSwiss. The operational time resolution is 30 min whereas the vertical resolution is 30 m; it is decreased if needed by steps of 30 m to keep the relative mixing ratio error below 10 %. Aerosol backscatter and extinction retrieval algorithms are available as well.

In order to study the range independence and long term stability of the lidar calibration constant we carried out several intercomparisons of operationally retrieved lidar profiles with collocated radiosondes. We used Vaisala RS 92 and Snow-White chilled mirror hygrometer radiosondes attached to single balloon. In all cases there is excellent agreement of the lidar derived mixing ratio profiles with the radiosondes.