Validation and uncertainty characterization of the water vapor mixing ratio measured by the MeteoSwiss Raman lidar and advanced experiments towards operational assimilation.

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The Raman Lidar for Meteorological Observations (RALMO) is operated at the MeteoSwiss station of Payerne (Switzerland) and provides, amongst other products, continuous measurements of temperature since 2010 and water vapor mixing ratio since 2008. We retrieve temperature profiles from the pure rotational Raman signals detected around the 355 nm Cabannes line. The humidity profiles are obtained from the Raman ro-vibrational Q-branch signals backscattered from the atmospheric Nitrogen and water vapor molecules. The temperature and humidity profiles have been validated against the reference operational radiosounding systems (ORS) co-located with RALMO (currently, the Vaisala RS41). The ORS in combination with the measurement of the solar background by RALMO, are used to automatically calibrate RALMO temperature and humidity during clear-sky periods. The focus of this study is on the retrieval of the water vapor mixing ratio (WVMR) and the description and validation of the uncertainty budget. We apply Gaussian error propagation through the WVMR equation and account for the main sources of uncertainty, which are measurement noise and the calibration coefficient. Measurement noise and atmospheric variability are efficiently separated using the temporal autocorrelation function. The analytical uncertainty is assessed by looking at the distribution of differences between the Vaisala RS41 and RALMO WVMR, which lie within the *k*-sigma intervals based on the Gaussian distribution. The results of a four-month statistics of RS41 vs RALMO WVMR are shown in terms of bias and standard deviation for daytime and nighttime cases. Within the measurement range, we find a bias smaller than 0.5 g/kg and a standard deviation smaller than 0.9 g/kg for daytime and nighttime .

The high-quality WVMR data from RALMO are assimilated for test experiments into the 1-km mesh-size ensemble data assimilation system KENDA-1. The results of the assimilation of RALMO show a positive impact of the RALMO observations on the forecasts of humidity and precipitation during a summertime convective period. MeteoSwiss is working towards an operational assimilation in 2022.