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Accuracy assessment of water vapour measurements from in-situ and remote sensing techniques during the DEMEVAP 2011 campaign

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The Development of Methodologies for Water Vapour Measurement (DEMEVAP) project aims at assessing and improving humidity sounding techniques and establishing a reference system based on the combination of Raman lidars, ground-based sensors and GPS. Such a system may be used for climate monitoring, radiosonde bias detection and correction, satellite measurement calibration/validation, and mm-level geodetic positioning with Global Navigation Satellite Systems. A field experiment was conducted in September-October 2011 at Observatoire de Haute Provence (OHP). Two Raman lidars (IGN mobile lidar and OHP NDACC lidar), a stellar spectrometer (SOPHIE), a differential absorption spectrometer (SAOZ), a sun photometer (AERONET), 5 GPS receivers and 4 types of radiosondes (Vaisala RS92, MODEM M2K2-DC and M10, and Meteolabor Snow-White) participated in the campaign. A total of 26 balloons with multiple radiosondes were flown during 16 clear nights. This paper presents preliminary findings from the analysis of all these datasets. Several classical Raman lidar calibration methods are evaluated which use either Vaisala RS92 measurements, point capacitive humidity measurements, or GPS integrated water vapour (IWV) measurements. A novel method proposed by Bosser et al. (2010) is also tested. It consists in calibrating the lidar measurements during the GPS data processing. The methods achieve a repeatability of 4-5 %. Changes in calibration factor of IGN Raman lidar are evidenced which are attributed to frequent optical re-alignments. When modelling and correcting the changes as a linear function of time, the precision of the calibration factors improves to 2-3 %. However, the variations in the calibration factor, and hence the absolute accuracy, between methods and types of reference data remain at the level of 7 %. The intercomparison of radiosonde measurements shows good agreement between RS92 and Snow-White measurements up to 12 km. An overall dry bias is found in the measurements from both MODEM radiosondes. Investigation of situations with low RH values (< 10 %RH) in the lower and middle troposphere reveals, on occasion, a lower RH detection limit in the Snow-White measurements compared to RS92 due to a saturation of the Peltier device. However, on other occasions, a dry bias is found in RS92, instead. On average, both RS92 and Snow-White measurements show a slight moist bias at night-time compared to GPS IWV, while the MODEM measurements show a large dry bias. The IWV measurements from SOPHIE (night-time) and SAOZ (daytime) spectrometers, AERONET photometer (daytime) and calibrated Raman lidar (night-time) showed excellent agreement with the GPS IWV measurements.