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Remote sensing of water vapour from the synergy of Raman lidar, GPS and in-situ observations during the DEMEVAP 2011 campaign

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The DEMEVAP (DEvelopment of MEthods for remote sensing of water VAPor) project aims at developing improved reference humidity sounding methods based on the combined used of scanning Raman lidars, ground-based sensors and GPS. The goal is to achieve absolute accuracy better than 3% on the column integrated water vapour (IWV). An intensive observing period was conducted in September-October 2011 at Observatoire de Haute Provence (OHP), France, with the aim of intercomparing several different techniques and instruments. It involved two Raman lidars, four radiosonde measurement systems, five GPS stations, a stellar spectrometer, and several ground-based capacitive and dew-point sensors. Observations were collected over 17 nights during which 26 balloons were released which carried a total of 79 radiosondes. Most of the balloons carried 3 or 4 different sonde types simultaneously (Vaisala RS92, MODEM M2K2-DC and M10, and Meteolabor Snow-White).

The comparison of IWV measurements from the four radiosonde types to GPS reveals biases of -11% to +7%. Comparison of water vapour profiles from the radiosondes to the IGN scanning Raman lidar profiles reveals mostly dry and wet biases in the radiosondes data in dry layers in the middle and upper troposphere. Several Raman lidar calibration methods are evaluated which adjust the lidar measurements either on ground-based capacitive or dew-point sensors measurements, on radiosonde data or on GPS PWV data. Another method adjusts the lidar calibration constant as an extra parameter during GPS processing. All these methods show a good degree of consistency and yield a repeatability of 2 to 5% during the first 3-week period of the experiment. A drift in the calibration constant is observed throughout the full time of the experiment which is partly explained by a temperature-dependent bias in the lidar measurements induced by the progressive cooling of the atmosphere. Modelling and correcting this effect or modifying the Raman lidar detection system should allow achieving a 3% level of accuracy into the long term and make the Raman lidar technique suitable to detect biases or to calibrate data from other techniques (e.g., radiosondes, visible spectrometers and microwave radiometers).