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A Multi-Year Upper Troposphere/Lower Stratosphere Water Vapour Climatology using Raman Lidar Measurements over Payerne Switzerland

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Water vapour is the most abundant greenhouse gas in Earth's atmosphere and yet it remains difficult to measure accurately due to its large spatial and temporal variability. An accurate long-term water vapour trend analysis requires frequent, well characterized, and high spatial and temporal resolution measurements. One of the few ground-based lidars suitable for studying long-term water vapour trends in the Upper Troposphere/Lower Stratosphere (UTLS) region is the RAman Lidar for Meteorological Observation (RALMO) which is operated by MeteoSwiss and is located in Payerne, Switzerland. The RALMO has one of the longest ground-based lidar water vapour data sets available with almost 50% uptime since late 2007. It has a spatial native resolution of 3.75 meters and is capable of measuring water vapour from 50 m up to 12 - 15 km at night and between 6 to 8 km during the day.The RALMO is also supported by a suite of instruments, including twice-daily radiosondes, occasional Lyman-alpha hygrometer soundings, and a microwave radiometer which offer the possibility of measurement calibration, validation, and redundancy.

We have recently developed a improved calibration technique using radiosonde trajectories and solar background measurements to characterized the evolution of the RALMO system and the optical path over its entire lifetime in order to remove any system bias in the UTLS trend calculations. The first part of this trend analysis involves creating a water vapour climatology using the water vapour lidar Optimal Estimation Method (OEM) presented in Sica and Haefele (2016). Unlike the standard water vapour lidar retrieval, which requires taking the ratio of the water vapour and nitrogen channels and correcting the count profiles for saturation, aerosols, and background this OEM technique is a "first principles" technique and does not require any corrections to the raw measurement. Each individual profile found by using the OEM includes, in addition to the the water vapour mixing ratio, the background for 4 channels, the Ångstrom exponent, the aerosol extinction, and the lidar constants.

The OEM-derived climatology will serve to validate the OEM technique while providing comprehensive uncertainty budget information from several sources including: the system overlap function, the Rayleigh cross-section, the air density, the lidar calibration factor, and the statistical uncertainty. Forecasting and modelers may use the climatology to help understand systemic weather patterns and the uncertainty budget will provide more accurate constraints on climate model solutions. We predict that the OEM uncertainty budget will also lead to better trend resolution and will provide corrections for any cyclical systematic uncertainties that could bias the trend analysis.