Upper tropospheric water vapor profiles derived from IPRAL Lidar over SIRTA

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Reliable water vapor data are required to evaluate the humidity content as one of the main uncertainties to understand and investigate contrail formation in the upper troposphere at cruise altitude. IPRAL (IPSL Hi-Performance multi-wavelength Raman Lidar) system which is originally dedicated for aerosol and cirrus cloud investigations, has also capability to provide promising water vapor profiles with contrail detection. This system was developed thanks to the expertise acquired with the previous systems developed in France at Observatory of Haute-Provence, at Puy-de-Dôme and at La Réunion (Southern tropic). IPRAL was designed with a bi-axial configuration, with a 22 j.m^2 lidar power and a ND:YAG laser emission at 355 nm.

Water vapor mixing ratio as a physical parameter is proportional to the ratio of the H_2O and N_2 Raman channels signals. The calibration process is conducted to give a geophysical meaning of this ratio to be converted on a real water vapor mixing ratio (WVMR) profile by a constant scale factor with altitude. Lidars probe the atmosphere to get a humidity content measurement that drastically decreases with altitude up the tropopause domain (less than 1g/kg). Being particularly sensitive to atmospheric variability with altitude, WVMR measurements require a robust calibration of the lidar instrument. The Calibration efforts often rely on co-located external measurements, to ensure accuracy and reliability. For IPRAL, a non-axial lidar, a calibration method was developed to be applied on any Raman lidar. It is based on meteorological analysis ERA5 data from the European center ECMWF due to their wide availability and their fine temporal resolution.

8 years of co-located and simultaneous lidar water vapor mixing ratio (WVMR) hourly profiles from cleaned and smoothed signals are calibrated using hourly ERA-5 reanalysis data that assimilate radiosondes, scale factors are retrieved from altitudes between 3 & 5 km. The collocated 37 pressure levels reference is considered allowing a maximal spatial drift of 0.1° and the best temporal coincident. One Hourly full profile calibration factor is hence calculated as average of the 3-5 km range coefficients. A full night calibration factor is estimated then from all night hour calibration factors. Daily calibrations are inspected to detect any instrumental effect on the calibration coefficient. Final coefficients are then calculated for quasi stationary periods.

The plus-value of IPRAL system is performed by the regular balloon launches with well calibrated water vapor measurements performed within GRUAN Network which can help as a validation reference to evaluate lidar calibrated humidity levels and those simulated by ERA5 analysis product. This new software will improve the accuracy of lidar-based water vapor measurements, to evaluate numerical weather models and to better understand contrails formation, their persistence and the potential management of this issue in future air traffic regulation as part of European project BeCoM.