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Quality Assessment for HATPRO Microwave Radiometer Measurements and Calibrations

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The atmospheric boundary layer (ABL) is the most important under-sampled part of the atmosphere. ABL monitoring is crucial for short-range forecasting of severe weather within highly resolving numerical weather predictions (NWP). Top-priority atmospheric variables for NWP applications like temperature (T) and humidity (H) profiles are currently not adequately measured. Ground-based microwave radiometers (MWRs) like HATPRO (Humiditiy And Temperature PROfiler) are particularly well suited to obtain T-profiles in the ABL as well as coarse resolution H-profiles; yet MWR data are not assimilated by any operational NWP system. The HATPRO measures in zenith and other angles throughout the troposphere over an area with ~10 km radius and has a temporal resolution on the order of seconds. Measured brightness temperatures (TB) are used to retrieve the T- and rudimentary H-profiles. Path integrated values like IWV (Integrated Water Vapor) and LWP (Liquid Water Path) are more reliable with excellent uncertainties up to 0.5 kg/m^2 and 20 g/m^2, respectively.

Driven by the E-PROFILE program, a recent proposal was accepted by EUMETNET, to continuously provide suited MWR data to the European meteorological services. Also, the European Research Infrastructure for the observation of Aerosol, Clouds, and Trace gases ACTRIS or the European PROBE (PROfiling the atmospheric Boundary layer at European scale) COST action currently focus on establishing continent-wide quality and observation standards for MWR networks for research as well as for NWP applications. The German Weather Service (DWD) also investigates the potential of HATPRO networks for improving short-term weather forecasts.

For all this it is important to obtain an overview of what HATPROs are capable of in regard to their measurement uncertainty. This is done by conducting coordinated experiments at JOYCE (Jülich Observatory for Cloud Evolution) and the FESSTVaL (Field Expermient on Submesoscale Spatio-Temporal Variability at Lindenberg) campaign in 2021. The goal is to develop a standard procedure for error characterization that can be applied to any HATPRO network instrument.

During FESSTVaL, there are 4 HATPROs on site which presents the unique opportunity to assess calibration procedures and measurements in order to characterize systematic errors and random uncertainties for each channel. Important error components are absolute calibration errors (biases), drifts (instrument stability, leaps between calibrations), radiometric noise and radio frequency interference. For the absolute calibration with liquid nitrogen, the repeatability, the duration, and the time between calibrations are essential. Differences between two consecutive calibrations should be minimal, the right duration of a calibration and the right amount of time between calibrations are to be defined, as are the magnitudes of the drifts. For the determination of noise levels for each channel, covariance matrices of measured brightness temperatures from the cold- and hot-load are necessary. With these matrices, the correlated noise of each channel with itself and which each other are studied.