

Network operability of ground-based microwave radiometers

Calibration and standardization efforts



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Introduction

Ground-based microwave radiometers (MWR) are already widely used by national weather services and research institutions all around the world. Most of the instruments operate continuously and are beginning to be implemented into data assimilation for atmospheric models. Especially their potential for continuously observing boundary-layer temperature profiles as well as integrated water vapor and cloud liquid water path makes them valuable for improving short-term weather forecasts.



Fig. 1: Overview of MWR intercomparison campaign in the frame of TOPROF at LWZ in Lindenberg

However until now, most MWR have been operated as stand-alone instruments. In order to benefit from a network of these instruments, standardization of calibration, operation and data format is necessary. In the frame of TOPROF (COST Action ES1303) several efforts have been undertaken, such as uncertainty and bias assessment, or calibration intercomparison campaigns.

We will present a framework for calibration, data processing and quality control for MWR operators so that these instruments can participate to national and international networks.

Instrumentation

The focus of this work lies on the performance of the two main microwave radiometer types, which are currently used operationally. These are the **HATPRO series** (Rose et al., 2005) by Radiometer Physics GmbH (RPG) as well as the **MP-Profiler series** (Ware et al., 2003) by Radiometrics Corporation as well as . Both instrument types are operating in the same two frequency bands: One along the 22 GHz water vapour line, the other one at the lower wing of the 60 GHz oxygen absorption complex.

Some technical differences between the two systems require separate user recommendations for operation and calibration.



Fig. 2: left: MP-3000 Profiler, right: HATPRO-G4 radiometer, both during the TOPROF campaign in Lindenberg

Benefits of ground-based microwave radiometry

- Observation of integrated atmospheric properties
Liquid Water Path (LWP), Integrated Water Vapour (IWV)
- Temperature and humidity profiles
- Continuous long-term, unmanned observations on temporal scales down to seconds → fill gaps between radiosondes
- Measurements during both clear air and cloudy conditions
- **Unique instrument for high quality boundary-layer temperature profiles as well as cloud liquid water path**

Challenges and limitations

- Limited vertical resolution, declining with height (2-5 degrees of freedom)
 - Absorption modeling
 - **Calibration**
 - **Automatic data quality control**
 - **Coordinated networks**
- } **Focus of this work**

Calibration

MWRs are generally calibrated by so-called hot-cold calibrations, ideally, using two reference points that span the full atmospheric measurement range, assuming the detector behaves linearly.

Ground-based MWRs use a built-in ambient target as hot reference, whereas the cold calibration point is realized either with a liquid nitrogen (LN2) cooled blackbody or with a clear sky zenith measurement which is a so-called Tipping-curve calibration. Tipping-curve calibrations are only useful for channels with low optical depth and can therefore not replace LN2 calibrations completely. Uncertainties have been found to be 0.5 K for tipping-curve calibrations and up to 1.5 K for LN2 calibrations (Maschwitz et al., 2013, Küchler et al., 2016).

For the RPG-HATPRO instruments, a new calibration load has been developed that reduces the errors from Maschwitz et al., 2013 considerably to an estimate of 0.1-0.2 K, by eliminating error sources such as standing waves, refractive index uncertainties or oxygen mixing into the LN2.

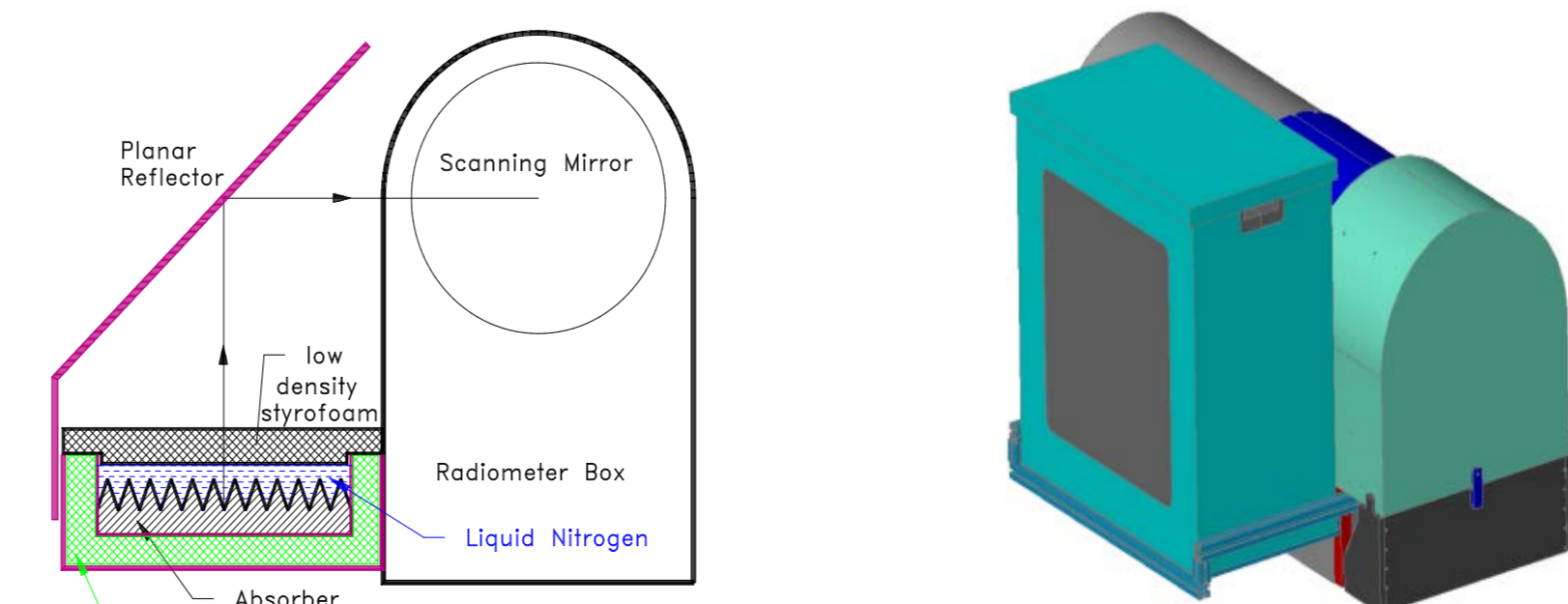


Fig. 3: left: Old LN2 calibration load for RPG-HATPRO, right: new closed load

Coordinated networks

The increasing number of MWR observations makes it possible to perform data assimilation studies or similar coordinated tasks. Caumont et al., 2016 and De Angelis et al., 2017 show that there is potential to improve boundary-layer thermodynamic profiles in models by assimilating MWR data into models. On Fig. 4, the network of current and past MWR stations in Europe shows a rather good distribution. Details can be found at <http://cetemps.aquila.infn.it/mwrnet/>



Fig. 4: Stations with current or past MWR measurements
Source: <http://cetemps.aquila.infn.it/mwrnet/>, Base map from Google maps.

JOYCE: Center for MWR calibration and operation

At the Jülich Observatory for Cloud Evolution (JOYCE) we are currently establishing a center for MWR operation and calibration harmonization. These common standards include calibration control, data quality control and data processing. Calibration and operation recommendations for users as well as quality control tools will be provided.

JOYCE comprises a variety of ground-based remote sensing observations and can benefit from sensor synergies. Details on JOYCE can be found at <http://joyce.cloud> as well as in Löhnert et al., 2015.



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