# Progress towards a GRUAN MWR product

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### Why a GRUAN MWR product?

Microwave Radiometer (MWR) provides:

- Low-resolution Temperature and Humidity profiles
- Total water vapor + liquid water column (TWVC, TLWC)
- Continuous measurements at
  - ~1 min temporal resolution
  - ~all weather

#### With respect to radiosondes

- Highly redundant (though much lower vertical resolution)
- Independent (e.g. RS80 dry bias)
- Complement diurnal cycle
- Complement TLWC (no other GRUAN instrument)

# **MWR GRUAN Data Product progression (B5)**

- Update on MWR GRUAN Data Product (GDP) Tech Doc (TD)
  - Status reviewed by new TT GB members
  - It was decided that it makes more sense to update the TD only once the MWR GDP is more established.

#### • Europe:

- EUMETNET is establishing a MWR network; cooperation with
  - PROBE (short-term cooperation action)
  - ACTRIS (long-term research infrastructure)
- It seems natural to follow that development (2021-2023)
- Monitor the development keeping in mind GRUAN requirements
- This development may be extended elsewhere (TBC)
  - USA: ARM could provide their MWR data files (calibrated brightness temperature) without special dedicated processing

## **Progress since ICM-12**

- Calibration monitoring (PROBE)
- Calibration uncertainty (ACTRIS)
- MWR networking (E-PROFILE)

# **Online MWR calibration monitoring**

- Continuous Observation minus model Background (O-B) stats
  - Suitable in clear-sky conditions
  - Simulate observations with RTTOV-gb from NWP output
  - Calculate daily differences, monthly means and variances
- AROME
  - Developed at Meteo France, hosted by U. Cologne (P. Martinet, U. Löhnert)
  - 4 sites, including GRUAN sites Lindenberg, Paris, Payerne for ~1 year
- WRF/ECMWF
  - Developed and hosted at CNR-IMAA (N. Cimini, S. Gentile, F. Madonna)
  - 3 sites, including GRUAN site in Potenza for 2 years
- Demonstrated successful in monitoring calibration jumps

#### **Online MWR calibration monitoring**

#### ~2 years of MWR O-B in Potenza (June 2019 – June 2021)



MWR Obs(CNRIMAA) vs Sim(WRF) from 2019/06 to 2021/06 3482 MATCHUPS AVAILABLE FOR OBS vs SIM COMPARISON WITH SSI <= 0.4 COR BIAS STDRMS P(1)P(2) SDEF(GHz) SMPL 22.235 3482 -0.63 3.37 3.42 0.96 0.95 2.20 3.32 -0.54 3.21 3.26 0.96 1.86 3.18 23.035 3482 0.96 2.77 23.835 3482 -0.54 2.82 0.96 0.94 2.28 2.71 26.235 3482 0.06 1.81 1.81 0.94 0.92 1.43 1.76 2.32 2.29 30.000 3482 -1.01 2.53 0.85 1.10 -0.64 0.45 2.30 51.250 3482 2.25 0.90 1.17 -16.48 2.16 52.280 3482 2.41 1.90 3.07 0.95 1.18 -27.15 1.74 53.850 3482 1.09 -23.70 0.71 0.90 1.15 0.99 0.70 -0.16 0.73 0.74 0.68 54.940 3482 0.99 1.04 -11.76 56.660 3482 0.36 0.86 0.93 0.99 1.02 -4.80 0.85 57.290 3482 0.38 0.91 0.98 0.90 0.99 1.01 -3.82 0.20 1.01 1.03 1.01 58.800 3482 0.99 -2.02 1.01









### **ACTRIS Cloud Remote Sensing**

- ACTRIS (Aerosol, Cloud and Trace Gases Research Infrastructure) is currently being established.
- MWR are an essential part of the Centre for Cloud Remote Sensing (CCRES) within ACTRIS.
- Currently ~ 20 MWR are operational at ACTRIS sites, until 2025 > 30 MWR will be installed
- University of Cologne and JOYCE (Jülich Observatory for Cloud Evolution) are hosting the MWR centre of expertise within CCRES



### **MWR quality assessment in ACTRIS**

- Common data processing and level2 data generation within ACTRIS
- Long-term quality control and quality assurance through monitoring of calibration parameters, noise levels, etc.
- Recent calibration campaign at Lindenberg (May 2021) including 4 HATPRO MWR for assessment of
  - Uncertainties/Biases of absolute calibrations
  - Repeatability of calibrations
  - Drifts between calibrations
  - Random errors (incl. channel covariances)
- Goal: For every MWR in ACTRIS these uncertainties will be given in the data files
- First results have been presented at latest EMS general assembly (Böck et al, https://doi.org/10.5194/ems2021-162).

### **Results from Lindenberg calibration campaign**



# Correlated radiometric noise via channel covariances

Diagonal elements are variances of single channels (random noise). Will be determined regularly within ACTRIS

#### Brightness temperature Biases/offsets:

2 hours of clear sky zenith obs on 06 May Offset between freshly calibrated MWR of new generation <0.02 K

Blue and yellow: HATPRO G5 (new generation), red and black G1/G2 (>10 years old)



### **Results from Lindenberg calibration campaign**



#### Repeatability of liquid nitrogen calibrations: Three subsequent calibrations show max. 0.15 K difference in V-Band (similar in K-Band)

#### Long-term drifts:

Calibrations of HATPRO at JOYCE between 2019 and 2021. Drifts can be determined at every LN2 calibration, will be monitored in ACTRIS For most channels <0.3 K over 6 months

in K-Band



### **Results from Lindenberg calibration campaign**

#### Summary of uncertainties and mitigation potential

Type of Error	Typical Error Values K-band	Typical Error Values V-band	Determined via	Error influenced by handling?	How to reduce error?
Biases/Offsets	usually ≤ 0.3 K (up to 0.48 K)	usually ≤ 0.5 K (up to 1.1 K)	Zenith measurement differences between two MWRs	yes	Quality of calibration
Drifts (over 6 months)	usually ≤ 0.3 K (up to 0.6 K)	usually ≤ 0.8 K (up to 1.3 K)	Leaps at coldload after calibration	no	Frequency of calibration
Calibration Repeatability	≤ 0.12 K	≤ 0.24 K	Leaps to zenith reference measurements after two immediate consecutive calibrations	yes	Quality of calibration
Noise Levels (coldload – hotload) (1s)	≤ 0.11 K – 0.18 K	≤ 0.27 K – 0.35 K	Standard deviation of hot/coldload observations	no	Not possible, instrument specific

- EUMETNET is establishing a MWR network within its E-PROFILE observation programme until 2023
- close cooperation with PROBE (short-term cooperation action) and ACTRIS (long-term research infrastructure)

#### E-PROFILE

- profiling observations of the atmosphere for meteorology
- current networks
  - wind profiling (Doppler radar and lidar)
  - aerosols and clouds (Automatic lidars and ceilometers)
- visualisation: https://e-profile.eu









#### why?

- user requirements
  - ABL observation gap: top priority for NWP and meteorological stakeholders in general
  - continuous availability for nowcasting and short range forecasting
- mature technology
  - many years of experience
  - recent advances in instruments, calibration targets, procedures
    - easier to operate for non-experts
  - forward operators for Tb assimilation available

#### what products?

- brightness temperatures (assumption-free)
  - ideal for assimilation (e.g. with RTTOV-gb)
- liquid water, water vapour, temperature (L2)
  - strong user requirement (mainly forecasting)
- Continuous forecast indices (FI)
  - high relevance e.g. for convectivity/severe weather



#### how?

- distribution of observations in near real-time
- central processing hub
  - common data format (shared with ACTRIS)
  - central retrieval
- central monitoring
  - automated near real-time O-B
  - semi-automated daily
  - monthly statistics
- central near real-time visualisation and archiving



#### where?

- Based on existing infrastructure
  - EUMETNET will not buy instruments
  - benefits:
    - thorough monitoring
    - central processing
    - visualisation & archive
    - community
  - operators can submit data in native format
  - participation welcome



#### more info:

https://doi.org/10.1007/s42865-021-00033-w Rolf.Ruefenacht@meteoswiss.ch



### Perspectives

- ACTRIS MWR quality assessment (2021-2023)
  - Uncertainty characterization
- E-PROFILE networking (2021-2023)
  - L1 and L2 data format
  - Data flow and online monitoring
- WMO campaign in Lindenberg (2022)
  - Two MWR (HATPRO and MP3000), 4 RS operational + extra RS

## **Summary and conclusions**

- Ongoing activities towards characterization of MWR uncertainty
  - Calibration monitoring
  - Calibration uncertainty

Thanks much for your attention!

- Perspectives are looking good
  - MWR calibration center (ACTRIS CCRES)
  - E-PROFILE MWR networking

Best practices could be extended to other GRUAN sites (TBC)