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)

Progress since ICM-11

1. Investigation of systematic uncertainty (absorption model)

2. Online calibration monitoring

1) Investigation of systematic uncertainty

- Current MW absorption models are affected by systematic uncertainty
  - e.g. speed-dependence (SD) of line shapes is currently not considered

- Theory for SD line shapes has been developed and tested
  - Lines at 22 and 118 GHz (Rosenkranz & Cimini, TGRS 2020)
  - Line at 183 GHz (Koshelev et al., submitted to JQSRT, 2020)

- Non-negligible systematic errors are introduced if SD is neglected
  - ~1-2%

2) Online MWR calibration monitoring

- Continuous Observation minus model Background (O-B) stats
  - Check for 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

- WRF/ECMWF
  - Developed and hosted at CNR-IMAA (N. Cimini, S. Gentile, F. Madonna)
  - 3 sites, including GRUAN site in Potenza

- Demonstrated successful in monitoring calibration jumps

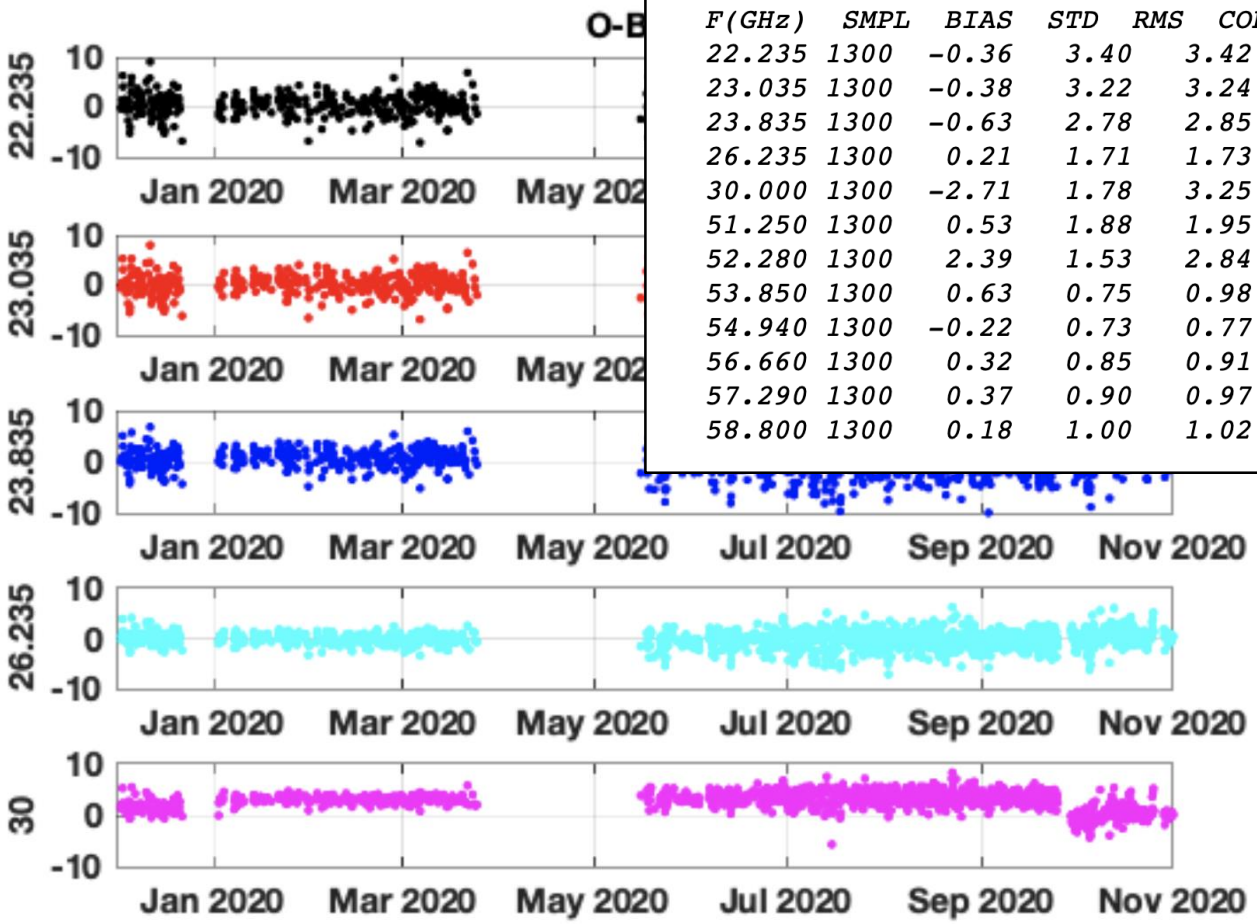
2) Online MWR calibration monitoring

~1 year of MWR O-B in Potenza (Dec 2019 – Oct 2020)

MWR Obs(CNRIMAA) vs Sim(WRF) from 2019/12 to 2020/10

1300 MATCHUPS AVAILABLE FOR OBS vs SIM COMPARISON WITH SSI <= 0.4

F(GHz)	SMPL	BIAS	STD	RMS	COR	P(1)	P(2)	SDE
22.235	1300	-0.36	3.40	3.42	0.96	0.96	1.85	3.36
23.035	1300	-0.38	3.22	3.24	0.96	0.97	1.28	3.20
23.835	1300	-0.63	2.78	2.85	0.96	0.94	2.37	2.72
26.235	1300	0.21	1.71	1.73	0.95	0.91	1.45	1.65
30.000	1300	-2.71	1.78	3.25	0.90	1.06	1.69	1.77
51.250	1300	0.53	1.88	1.95	0.93	1.17	-17.00	1.77
52.280	1300	2.39	1.53	2.84	0.96	1.16	-24.26	1.38
53.850	1300	0.63	0.75	0.98	1.00	1.08	-20.78	0.58
54.940	1300	-0.22	0.73	0.77	0.99	1.04	-11.24	0.69
56.660	1300	0.32	0.85	0.91	0.99	1.01	-4.51	0.85
57.290	1300	0.37	0.90	0.97	0.99	1.01	-3.98	0.89
58.800	1300	0.18	1.00	1.02	0.99	1.01	-2.89	1.00



Prospectives

- Task Team on Ground-Based Remote Sensing Measurements (TT-GB)
  - New members, highly MWR-qualified
    - Maria Cadeddu, ANL, USA: MWR mentor for ARM
    - Christine Knist, DWD, DE: MWR responsible for GRUAN LC
- MWR data and calibration center
  - To be established by University of Cologne & Research Centre Jülich (DE)
  - Part of the Center for Cloud Remote Sensing (CCRES) of ACTRIS
  - ACTRIS – Aerosols, Clouds and Trace gases Research Infrastructure
- EU MWR network
  - EUMETNET will soon decide on the proposal to include MWR in E-PROFILE (part of EUCOS - EUMETNET Composite Observing System)
- All sound very beneficial for the establishment of GRUAN MWR products

Summary and conclusions

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

Thanks much for your attention!

- Prospectives are looking good
  - New highly MWR-qualified TT-GB members
  - MWR calibration center (ACTRIS CCRES)
  - Possible inclusion of MWR within E-PROFILE

Back-up slides

Next slides are from ICM-10/11, including open issues

- GRUAN MWR Program Guide
- GRUAN product requirements
- What's missing for a GRUAN MWR product?
- What's missing for full SI-traceability?
- More on absorption model uncertainty

GRUAN MWR Program Guide

STATUS:

- Following the GRUAN Guide (GCOS-171)
- First draft delivered (15 April 2016)

- **GRUAN MWR Program Guide TD-N.1.0**
  1. Introduction
  2. Instrumentation
  3. Reference Measurements
  4. Measurement Uncertainty
  5. Measurement Scheduling
  6. Data Management
  7. Post-processing Analysis and Feedback
  8. Quality Management
  9. Site Assessment and Certification
  - Appendix 1 - Acronyms
  - Appendix 2 - Examples of MWR lv1 and lv2 data files
  - References

GRUAN MWR Program Guide

- **V1.0 touches all sections**
  - but it's only a first draft (by no means complete)
- **V1.0 is a living document**
  - continuous updates following TOPROF/GAIA-CLIM activities
- **Drafting stopped when**
  - MWR TD-N.1.0 ↔ MWR Product 1.0

GRUAN product requirements

- Data and metadata available
- Open and transparent processing
- Treaceble to SI
- Uncertainty estimate

What's missing for a GRUAN MWR product?

- Implementation of automatic MWR data product
  - Who shall/could develop this?
  - Centralized data processing facility?

- Current observation accuracy corresponds to >10-year old technology
  - much better characterization of new generation instruments
  - not currently available at GRUAN sites

What's missing for full SI-traceability?

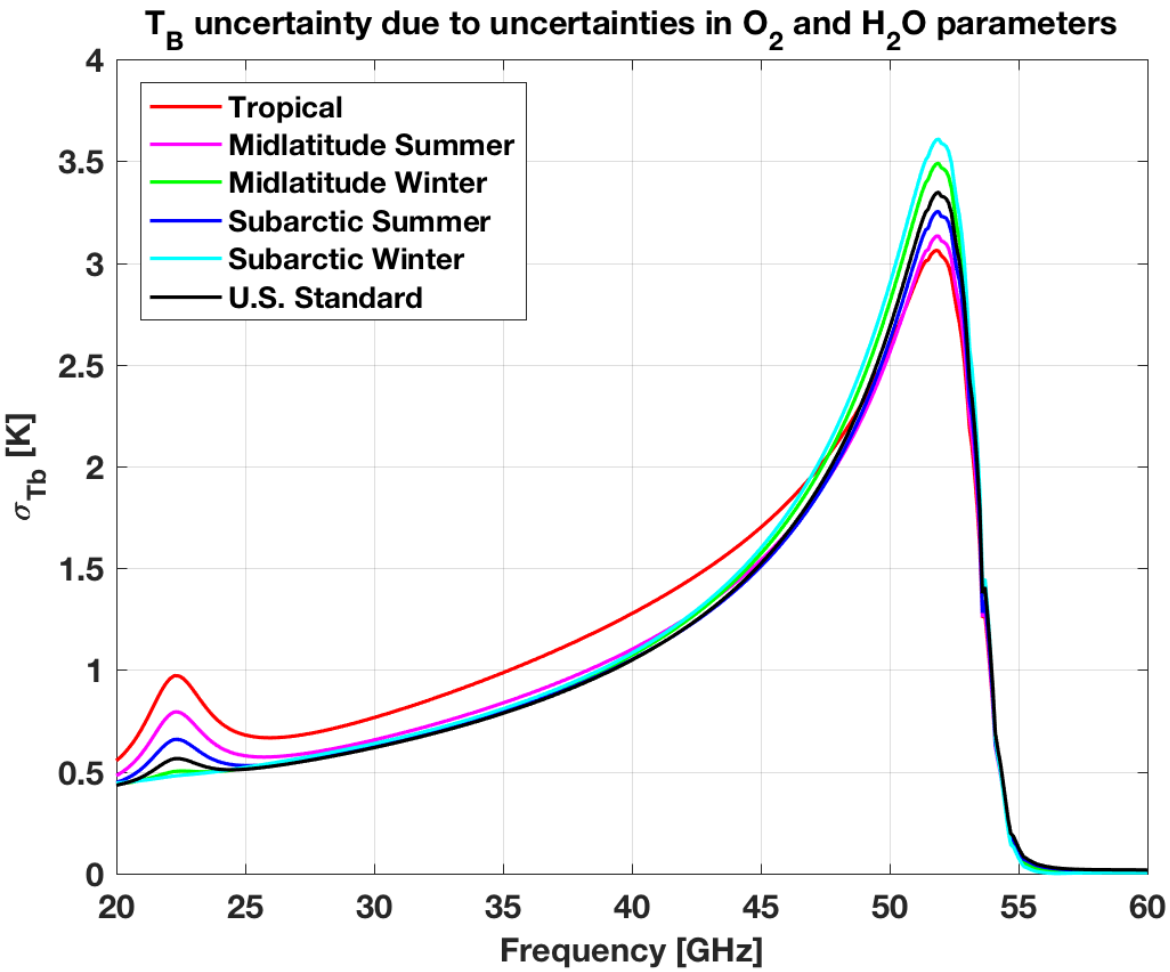
1. MW transfer standard calibration targets
   - NIST is working on this development

2. Certified internal temperature sensors
   - Manufacturers should provide certifications

3. Uncertainties on *a priori* model background and radiative transfer model are not SI-traceable

2) Absorption model uncertainty

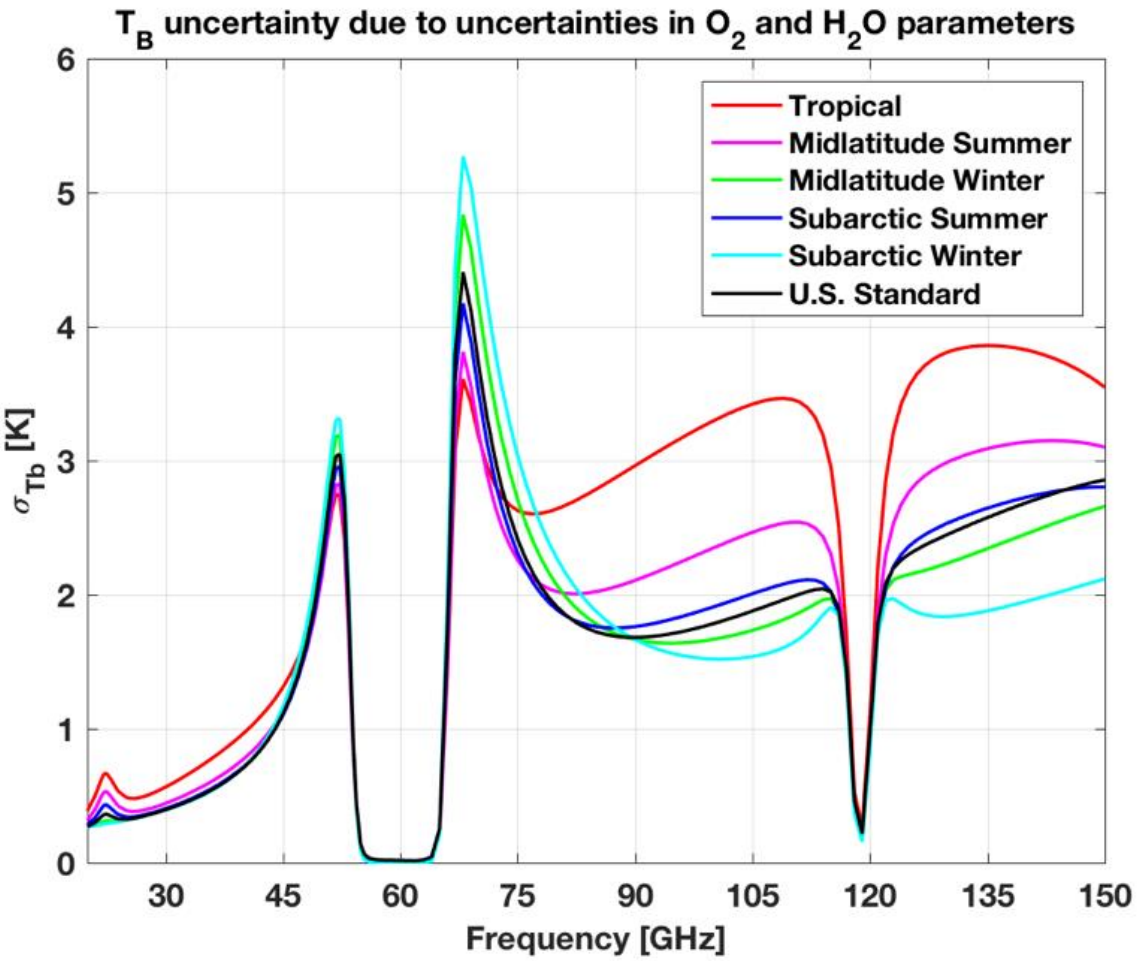
- Efforts started within GAIA-CLIM
- Completed for 20-60 GHz range within GAIA-CLIM



Cimini et al, ACP 2018

2) Absorption model uncertainty

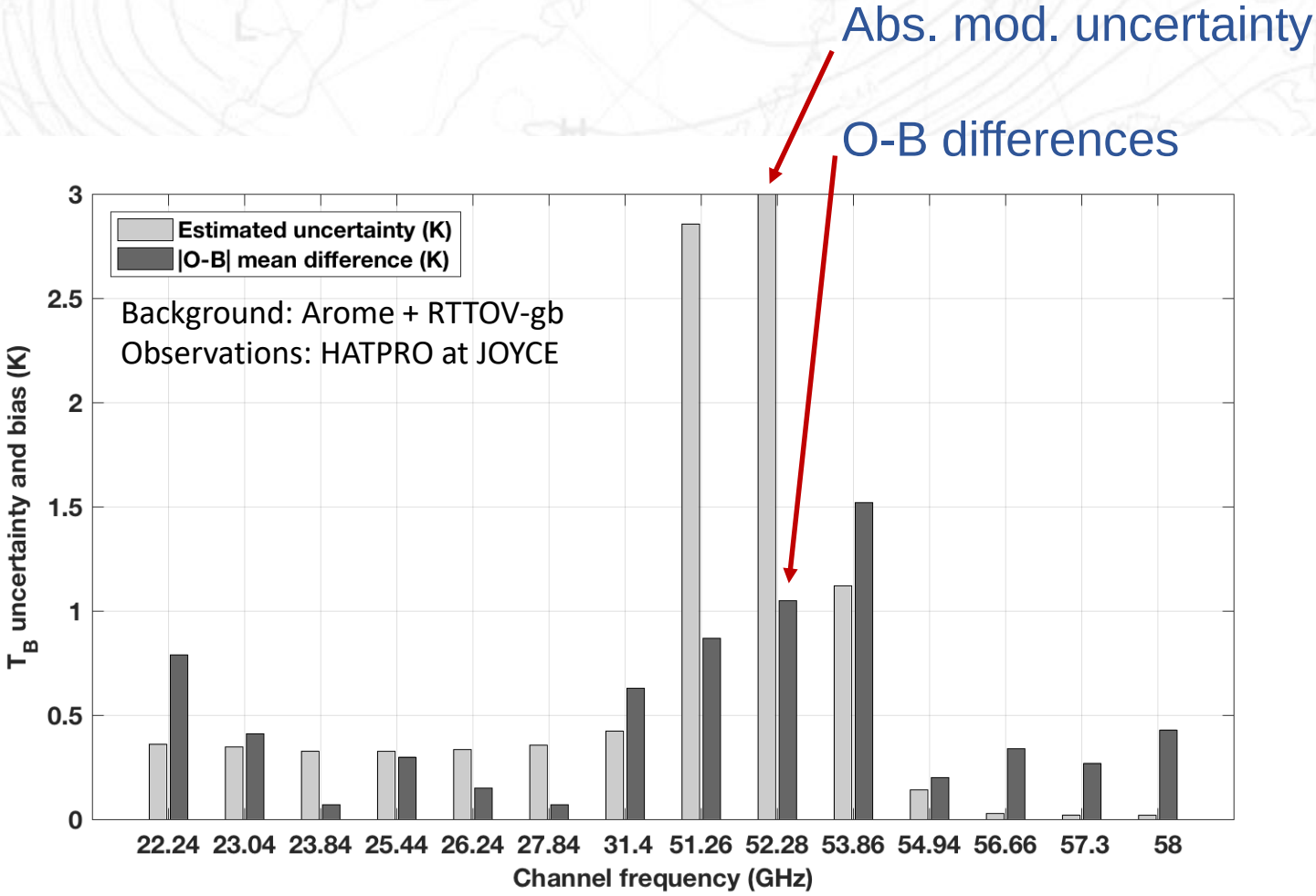
- Extended to higher frequency (up to 150 GHz)
  - To include 70-150 GHz MWR used for CLW retrievals



Cimini et al, GMD 2019

2) Absorption model uncertainty

- For a well maintained MWR, absorption model uncertainty explains most of O-B differences



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