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ACTRIS
Centre for Cloud Remote Sensing

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Microwave radiometer data processing and quality control framework for network operation

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Introduction and Network Overview

Ground-based microwave radiometers (MWR) are passive remote sensing instruments providing valuable insights in **thermodynamics**, including liquid water **clouds**, in the atmospheric **boundary-layer**.

Profiles of temperature and humidity, as well as the **integrated quantities** cloud liquid water path (LWP) and integrated water vapor (IWV), are retrieved from inferred brightness temperature (TB) observations at a high temporal resolution.

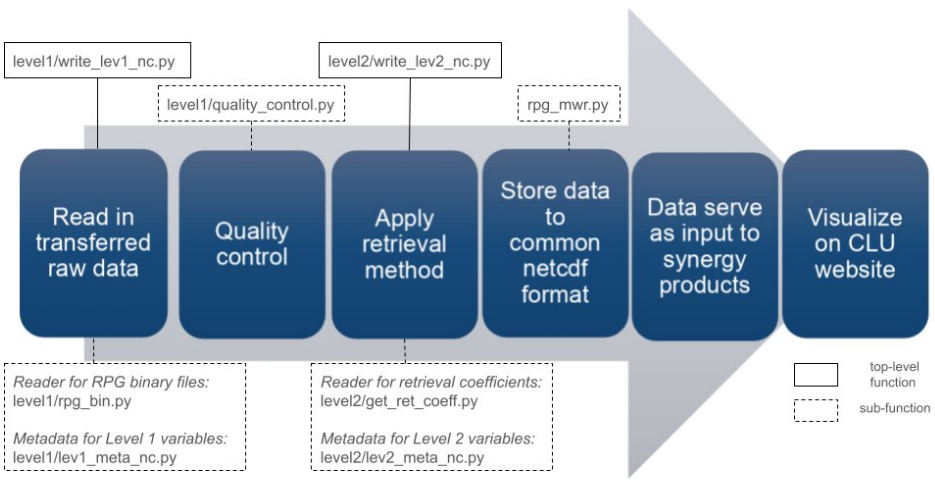
The MWR network is part of the ACTRIS **Centre for Cloud Remote Sensing** (CCRES) and currently hosts more than 20 instruments worldwide.

The **Jülich ObservatorY for Cloud Evolution** (JOYCE), jointly operated by the University of Cologne and the Research Centre Jülich, is part of CCRES as NF and operates the MWR **central unit** (CCRES-DE).

To ensure high quality and consistent long-term operation, **Standard Operating Procedures** (SOP) were established in close collaboration with other units and networks (e.g. CARS, E-PROFILE).

Centralized Processing – MWRpy

A framework for centralized MWR data processing has been developed and implemented at the CCRES data center unit (CLU) to achieve standardization of meteorological variables:



- Based on **raw files** uploaded by the station operators (currently only for RPG instruments; product support for Radiometrics)
- Python software package **MWRpy** (Marke et al., 2024) outputs Level 1 and Level 2 data products, including derived quality flags
- Embedded in **Cloudnet** to further utilize other ACTRIS-CCRES instruments, like lidar, cloud radar, for deriving synergy products

Cloudnet
cloudnet.fmi.fi

References

Böck, T., Löffler, M., Marke, T., Pospichal, B., Knist, C., and Löhnert, U.: Instrument uncertainties of network-suitable ground-based microwave radiometers: overview, quantification, and mitigation strategies, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2025-1727, 2025.

Marke, T., Löhnert, U., Tukiainen, S., Siipola, T., & Pospichal, B.: MWRpy: A Python package for processing microwave radiometer data, Journal of Open Source Software, 9, 6733, https://doi.org/10.21105/joss.06733, 2024.

Data and Calibration Monitoring

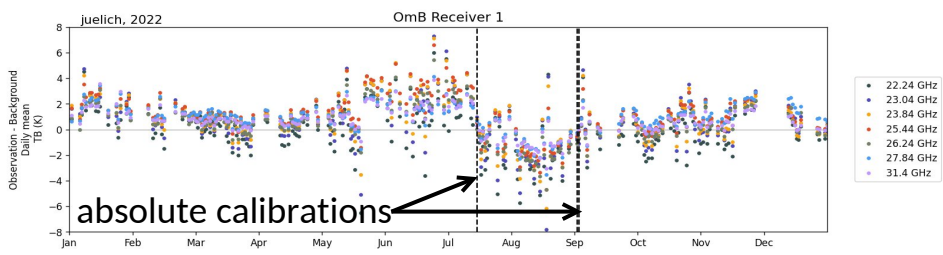
Spectral consistency check:
- Part of routine processing (level 1)
- Compares retrieved and observed spectrum
- Detection of rain, interference, and faulty channels

Housekeeping data monitoring in Grafana:
- Efficient instrument failure detection
- Help with instrument maintenance
- Automatic alerting system will be set up

Analysis of absolute calibration parameters:
- Characterize uncertainties and instrument noise characteristics (from covariance matrix)
- Track history of performed calibrations

Long-Term Quality Control

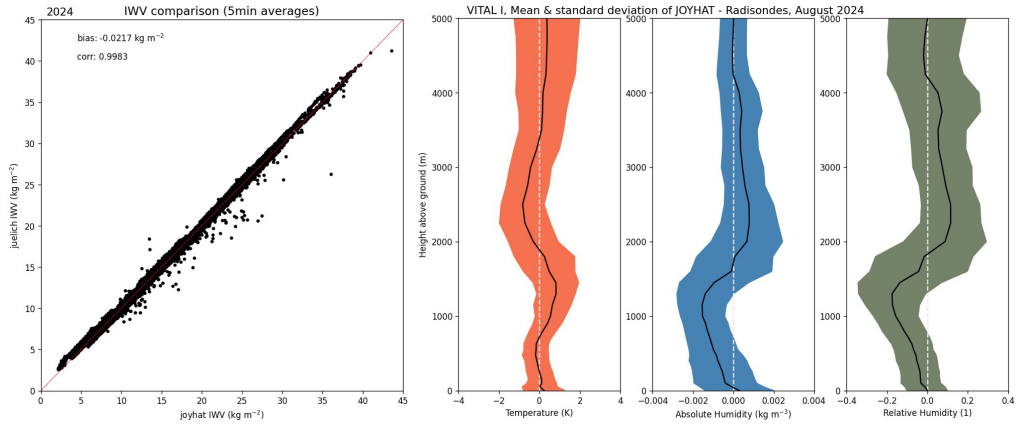
- **Stability** of MWR receiver temperatures (maintained by IPSL; https://ccres.aeris-data.fr/en/data-visualization-mwr/)
- Monthly **reports** to assess statistics on data availability, instrument status and geophysical data quality
- **Observation minus background** analysis (for clear sky cases)
  - Identify faulty calibrations or larger TB drifts/jumps
  - Requires radiative transfer calculations based on model data
  - Existing infrastructure needs to be implemented
  - More details and an assessment of MWR uncertainties can also be found in Böck et al. 2025 (in discussion)



Outlook on Retrieval Development

Currently: retrievals from manufacturers are used
Planned retrieval **setup**:
- **Statistical** retrieval (Neural Network including auxiliary information)
- Training with **ERA5** climatology (comparison with radiosondes)
- Rosenkranz 2024 absorption model for radiative transfer
- MWR + IRT **synergy** retrieval for LWP
- Include 89 GHz channel of cloud radar / radiometer for improvements in LWP

Reference MWR and radiosondes are used to evaluate retrieval algorithms, as well as calibrations.



Comparison of IWV between 2 MWR (left) and profile comparison MWR vs. radiosondes (right)