Standard Operating Procedures

Microwave radiometer

This document describes the **Standard Operating Procedures (SOPs)** that must be applied to all Microwave radiometers contributing measurements to the ACTRIS Cloud Remote Sensing Data Centre.

Version 2, October 2023

I. Site requirements

1	Operation area : environment surrounding the instrument	Open view to horizon (no obstacles >3° elevation angle), preferably in northern direction to perform elevation scans
2	Specific points of attention	Easy access for site visits (esp. for liquid nitrogen calibrations and radome exchange) is required If a scanning radar is operated nearby, interferences can occur and tests are recommended while setting up the radiometer.
3	Reliability of internet and power	
4	Comply with local safety and security rules	Respect safety regulations when handling liquid nitrogen. Follow
5	Radio frequency interference (RFI)	Disturbances due to RFI that are caused by external radio sources (e.g. mobile phone links, military, etc.) may occur. To check whether RFI is present, we recommend to perform test measurements (azimuth and elevation scans).

II. Operation modes

1	Stability	Keep instrument always on power. This ensures permanent temperature stabilization.
2	Scanning modes	• Standard operation: Vertical pointing • Recommended repetition rate of elevation (boundary layer) scans is every 15 minutes. • Perform at least one boundary layer scan every 30 minutes (HATPRO: 100 seconds integration time). • Optional azimuth scanning possible

		• All scans (elevation+azimuth) should account for less than 50% of the hour (see also general CCRES-SOPs for scanning) • Contact CCRES for checking other scan patterns.
3	Ensure collection of data	Data collection according to section IV/4.
4	Ensure collection metadata and housekeeping data	Keep all housekeeping data (see below) and check them regularly. Take warning messages from the instrument software seriously.
5	Continuity	Data should be collected 24/7, with a temporal resolution of 1 second. Always perform data backup on radiometer.
6	Ensure accurate system clock and location	Most instruments ensure accurate time and location by attached GPS receiver (UTC time!)
7	Ancillary measurements to be performed	Weather station, Video camera, Infrared pyrometer
8	Recommendations to maximize good working order of the instrument	A device to dry the radome after precipitation events is highly recommended to maximize uptime

III. Monitoring of system parameters

1	Instrument status dashboard(s) and (automatic) alert systems (applied on data and housekeeping data)	Centralized housekeeping data for all CCRES instruments in development
2	Housekeeping data threshold and available variability	To be defined for each instrument type
3	Web sites to access QLs	Cloudnet data portal
4	Visual inspection of instrument (e.g. remotely controlled camera)	Advised
5	Routine on-site control	Radome cleaning (preferably 1x per week using a soft towel). At remote and unattended sites, a surveillance camera is recommended.

IV. Data types and database connection

1	Temporal resolution of the data	Store data with 1 second temporal resolution (or highest possible) Generate files with maximum 1 hour of data (HATPRO: default for unlimited observations).
2	Temporal resolution of the metadata	Same as above
3	Range resolution of the data	not applicable
4	Raw data and metadata flow (including housekeeping data) implementation to the data centre	Store all raw data (voltages, brightness temperatures, calibration data) and transfer them to the CLU database (at least once **HATPRO:** BRT, BLB/BLS, HKD, IRT, MET, (SPC), LOG-files CAL.LOG* *in the current RPG software versions a new CAL.LOG file is created every 1-2 weeks. The old file is then automatically copied to a file named “CAL YYYY-MM-DD to YYYY-MM-DD.LOG”. These files need to be transferred manually from the radiometer to the Host-PC.

V. Calibration

1	Retrieval of Calibration Parameters	**HATPRO Calibration parameters include:** • Gain (G) • System Noise Temperature (T_{sys}) • Noise Diode Temperature (T_n) • Non-linearity factor (α) **For HATPRO G5:** ● Gain is automatically updated with 50Hz ("noise switching") ● T_{sys} is updated by the hotload calibration (automatic, every 5-10 minutes) ● T_n and α are updated at absolute calibration **For HATPRO G4 and older:** ● Gain is updated by the hotload calibration (automatic, every 5-10 minutes) ● T_{sys} is updated by the noise diode calibration (automatic, every 30 minutes) ● T_n and α are updated at absolute calibration
2	Characterization of measurement uncertainties	**HATPRO:** Covariance matrix is automatically saved during each absolute calibration
3	Calibration schedule (automatic and hands-on)	● Absolute calibration with liquid nitrogen every 6 months: ○ only during dry weather conditions (RH preferably < 70%) to reduce the risk of condensation on cold target. ○ It is recommended to turn off the cloud radar during the absolute calibration procedure to avoid potential interferences. ○ **For details, please refer to calibration guideline document**. ● Relative calibrations are automatically performed in the routine observations program ● Sky tipping calibration not recommended as a standard calibration method, except for sites with low water vapor and difficult access (e.g. polar or alpine regions)
4	Azimuth and elevation pointing accuracy	Ensure horizontal adjustment of instrument. For azimuth scanning instruments, make sure to provide north position relative to the instrument
5	Detecting systematic errors during instrument operation	In CCRES various checks are performed: - Spectral consistency check of measured brightness temperatures

		- Monitoring of instrument stability (receiver temperature) - Drifts will be analysed by O-B statistics (comparison of clear-sky brightness temperatures with model analysis/forecast)

VI. Maintenance schedule

1	Preventive maintenance	**CHANGE MATERIAL**: Radome: every 6-12 months depending on site. The quality of the hydrophobic coating can be checked by pouring some water on it. If the water is not blown away, a radome change is necessary.
2	Likely component replacements	Weather station sensors (every 2-4 years)
3	Likely software issues, software upgrades	Software version numbering crucial, perform regular upgrades (after advice from CCRES)

VII. Documentation

1	Synthesis of technical actions (e.g. on-line log book)	A log book must include the following actions: • Changes of instrument location and/or alignment • Changes of MDF/MBF files (provide all operational MDF files!) • Software updates • Absolute calibration • Radome changes • Reason for data gaps of > 1 day • Malfunction of instrument components (e.g. blower, heater, weather station,…) • Any repair or exchange of components
2	Procedure and technical documents	Manual of manufacturer Processing readme
3	Web form	
4	Training guides	Liquid nitrogen Calibration document Instrument software guideline
5	Recording of maintenance actions	See VII/1

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