# Standard Operating Procedures

## Doppler Cloud Radar

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

### I. Site requirements

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| 1 | Operation area : environment surrounding the instrument | Surface: stable, solid and easily accessible installation area.<br>Open view within a cone of specified elevation angle from zenith. If scanning : open view to horizon. |
| 2 | Specific points of attention | Reflections on nearby objects may damage the radar. Radar field of view must be clear.<br><br>In addition, local regulations for the use of the RF spectrum should be reviewed before installing an active instrument. |
| 3 | Comply with local Safety and Security Rules | The RF frequency commonly used in cloud radars (above 10 GHz) is absorbed at the skin surface, with very little of the energy penetrating into the underlying tissues.<br><br>Exposure to RF fields above 10 GHz at power densities over 1000 W/m2 are known to produce adverse health effects, such as eye cataracts and skin burns. Commonly used cloud radars operate with a much lower power density (in the order of mW/m2), hence they should represent no danger. However, we recommend to check the recommendations given by the radar manufacturer, and the WHO: |

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| | | https://www.who.int/news-room/q-a-detail/radiation-radar |

## II. Operation modes

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| 1 | Stability | Keep the instrument always on power. This ensures permanent temperature and humidity stabilization. |
| 2 | Scanning modes | - |
| 3 | Ensure collection of data | - |
| 4 | Ensure collection metadata and housekeeping data | - |
| 5 | Continuity | 24/7 |
| 6 | Ensure accurate system clock and location | Use UTC if possible (no changing with Summer Time), use ntpd or GPS reference |
| 7 | Ancillary measurements to be performed | Disdrometer, weather station, video camera |
| 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

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| 1 | Instrument status dashboard(s) and (automatic) alert systems (applied on data and housekeeping data) | Objective : Quasi NRT<br>HKD : radar box temperature and humidity, radar transmitted power, blower ON/OFF,<br>Geophysical data : min/max of reflectivity or Doppler velocity<br>System / data logger : free disk space |
| 2 | Housekeeping data threshold and available variability | To be discussed with manufacturer, different for each cloud radar |
| 3 | Web sites to access QLs | 2D plot : altitude versus time , colorbar = reflectivity or Doppler velocity |
| 4 | Visual inspection of instrument (e.g. remotely controlled camera) | advised |

## IV. Data types and database connection

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| 1 | Temporal resolution of the data | At least one profile every 30 seconds |
| 2 | Temporal resolution of the metadata | Similar to resolution of data |
| 3 | Range resolution of the data | Minimum 60 metres |
| 4 | Maximum range | Site dependent (contact the CF) |
| 5 | Raw data and metadata flow (including housekeeping data) implementation to the data center | Store all raw data (Raw received power, Emitted power, RCS calibration, Z calibration, temperature, voltage, etc)<br>Data to be stored in NetCDF format following CF-1.6. conventions |

## V. Calibration

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| 1 | Retrieval of Calibration Parameters | - Absolute Calibration with targets on masts: Calibration for RCS and radar eq. reflectivity retrievals.<br>- Absolute Calibration with targets on drone: Calibration for RCS and radar eq. reflectivity retrievals.<br>- Absolute Calibration by transfer: Calibration for RCS and radar eq. reflectivity retrievals.<br>- Distance Calibration: Calibration of the distance measurement.<br>- Antenna pattern characterization: Antenna pattern retrieval to calibrate the positioning and gain effects introduced by antenna pointing and parallax using UAVs or targets on masts. |
| 2 | Characterization of measurement uncertainties | ● **Reflectivity Uncertainty Sources:**<br>- Calibration uncertainty, assessed during instrument calibration.<br>- Calibration correction factors used in retrievals, for ex. when measuring radar transmitted power. To be indicated by the manufacturer.<br>- Signal to noise ratio<br>● **Target location uncertainty sources:**<br>- Distance estimation uncertainty<br>- Scanner angles uncertainty<br>● **External Uncertainty Sources:**<br>- Dielectric factor of cloud droplets/ice crystals. Depends on the data treatment protocol.<br>- Attenuation from clouds and rain<br>- Attenuation in case of wet radome |
| 3 | Calibration schedule (automatic and hands-on) | Automatic verification every rain event.<br>Hands-on calibration as frequently as means allow (~ once per year) |
| 4 | Azimuth and elevation pointing accuracy | Study on the scanner angular accuracy and repeatability. |
| 5 | Detecting systematic errors during instrument operation | ● Absolute calibration tracking comparing radar and spectro pluviometer measurements during rain<br>● Absolute calibration tracking using a reference reflector on a mast<br>● Antenna alignment and absolute calibration check with automated UAV flights.<br>● Measurements of transmitted power and of a noise source in the receiver-end to track stability of the radar components gain |

## VI. Maintenance schedule

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| 1 | Preventive maintenance | Radome maintenance as indicated by the manufacturer. |
| 2 | Likely component replacements | Amplifiers degrade gradually during operation. After some years they may need replacement |

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| | | depending on the radar hardware and operating conditions. |
| **3** | Likely software issues, software upgrades | Version numbering is crucial. |
| **4** | Preventive maintenance | Radome maintenance as indicated by the manufacturer. |