Installation and Maintenance Guide

Setup, Operation, Maintenance of
RPG standard single-polarization radiometers

Applicable for
HATPRO, LHATPRO, TEMPRO, HUMPRO, LHUMPRO,
LWP, LWP-U90, LWP-U72-82, LWP-90-150,
Tau-225, Tau-225-350

Document Change Log

Date	Issue/Rev	Change
07.07.2011	00/01	Work
20.07.2011	01/00	Release

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1 Scope of this document

This document describes all processes needed for installing and setting up the standard RPG radiometer models. The target audience is mainly the engineering and support personnel who are in charge of the initial installation, maintenance, station supervision, calibration, cleaning and repairs. All the technical aspects of such tasks are covered. In addition, the basic operations of how to start a pre-defined measurement and how to stop a measurement and shut down the instruments are explained.

The procedures in this document apply to single-polarization radiometers of HATPRO types (profiling radiometers RPG-XXXPRO series), LWP multi-channel radiometers (RPG-LWP-XXX series) and Tau/Tipping radiometers (RPG-Tau-XXX).

What is not covered here (but in other manuals for standard radiometers) is:

- Theory of operation, scientific background (→Operational Manual)
- Software details and how to define a measurement (→ Software Manual)
- Measurement Examples
- Deployment Examples

Furthermore, all dual-polarization instruments (RPG-XCH-DP) are not described here, but in a separate set of manuals.

2 Setup and Installation

This chapter covers the complete installation of the radiometer up to the point of starting operations.

2.1 Choice of location

The location for a radiometer installation needs to comply with several requirements in order to guarantee successful recording of valid data. The following list of requirements shall be matched:

- Flat and stable grounds to support 100 kg of weight (plus personnel), preferably a concrete base plate or a flat rooftop.
    - If vegetation covered soil or bare soil is chosen, then some extra provision is needed to prevent the radiometer stand from sinking into the ground.
    - If the surface does not allow the mounting of steel cables to tie the radiometer to the ground, then the radiometer stand needs to be loaded with extra weight
- The view to the horizon should be unobstructed by trees, fences, and buildings into at least one direction (for radiometers without azimuth positioner it needs to coincide with the main scan direction indicated by orange arrows on the housing).
- For sky scanning, a significant distance from obstacles like houses and trees is beneficial.
- The distance from the radiometer to (a) power outlets and (b) the location of the controlling host PC should match the length of the cables ordered with the radiometer
- A safe routing option for the cables (outdoor →indoor) should exist. The power cable diameter is 12 mm, the data cable is a fibre optical cable which needs to be handled with great care. The fibre optics connectors are even bigger (up to 10cm). Pushing and pulling the cables can lead to a malfunction of the cable performance.

- To avoid in-band RFI, the user may want to check for radars and telecommunication links directly in the observation bands (22 GHz to 32 GHz, and 51 GHz to 59 GHz).

2.2 Unpacking the radiometer and accessories

The following standard components are delivered in addition to the radiometer:

- Host computer with installed operating software (desktop computer, laptop or industrial PC)
- Instrument stand with adjustable feet
- External absolute calibration target (cold load)
- Air flow reduction for winter operation of thermal stabilisation system
- Connector protectors
- Interconnecting cables (main power, fibre optics data interface cable), 60 m long (default)
- Powerful dew blower system + heater module
- CD-ROM with retrieval algorithms based on customer's radiosonde data (if provided)
- An optional infrared radiometer (or dual IR twin system)
- An optional azimuth positioner + azimuth driver power supply unit

2.2.1 Radiometer Box

The radiometer system is shipped in two wooden boxes. One contains the radiometer and blower while the other contains all accessories needed to operate and calibrate the instrument. The radiometer case is fastened to the container by two straps as indicated in Fig.2.2.1. The dew blower is also included in the radiometer transportation box as well as rain sensor and GPS-clock (usually already mounted).

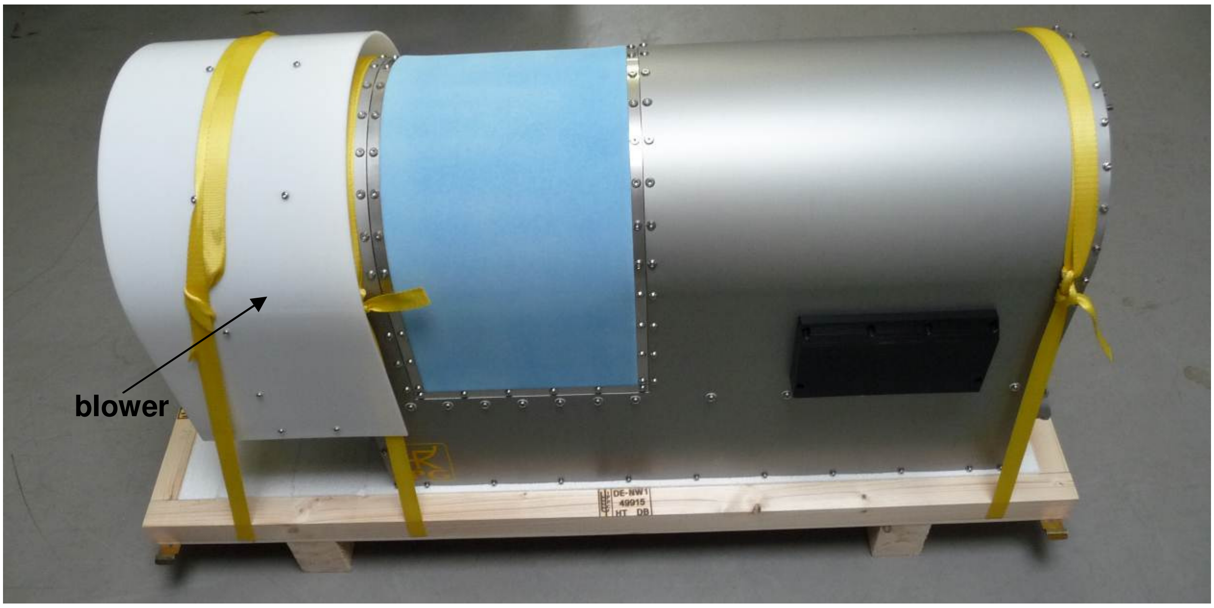


Fig.2.2.1: Radiometer and blower packed to the transport container's base plate.

2.2.2 Accessories

Fig.2.2.2: Accessory box with radiometer stand, calibration target, heater module, cables, IR Radiometer, azimuth drive and host PC (including monitor, keyboard).

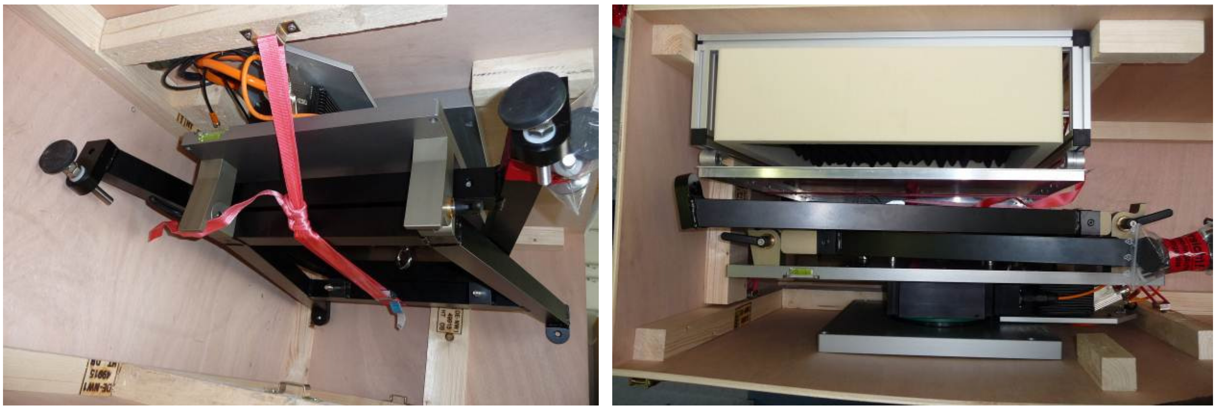


Fig.2.2.3: Folded stand fastened to the side wall and packing of calibration target

The radiometer stand and calibration target are both fastened to the box' side walls with ribbons as indicated in Fig.2.2.3.

2.3 Setup the Instrument Stand

The instrument stand is packed folded without the four feet mounted to the stand's legs. Among the radiometer's accessories you will find a plastic bag with the four stainless steel feet as shown in Fig. 2.3.1a):

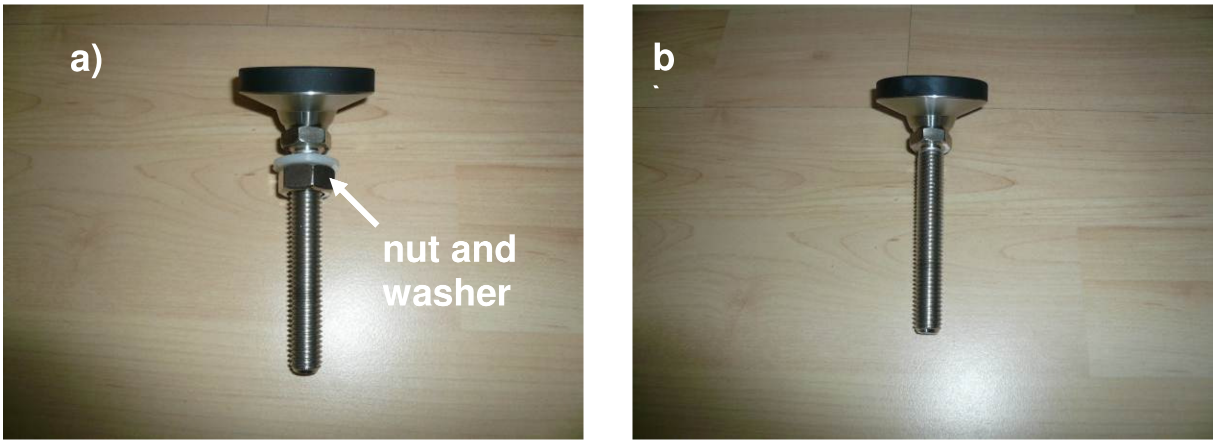


Fig.2.3.1: One of the four stand's feet.

A nut and washer is screwed on the thread rod. Remove both from the thread bar as indicated in Fig.2.3.1b). Then screw the four bolts on the stand's legs (Fig.2.3.2a)) and mount the washers and nuts from the top as indicated in Fig.2.3.2b).

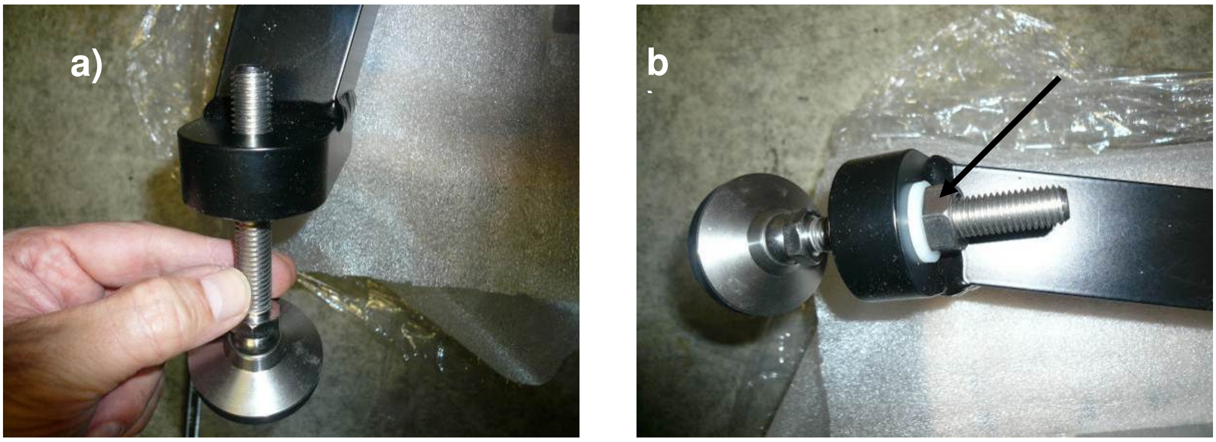


Fig.2.3.2: Mounting the feet to the stand's legs.

Lay the folded stand on the top side of the table plate (Fig.2.3.3). Please use a soft underground or matte to prevent the table surface from being scratched.
The two leg pairs are clamped by two clamps with black steel handles each. Open the clamps to turn the two leg pairs into upright position. The leg pairs should be pushed outside as much as possible (see Fig.2.3.4b)). Then fasten the clamps firmly (Fig.2.3.4a)) and turn the stand to its normal orientation, with the table surface pointing upwards.
Unpack the two black stabilizing bars (Fig.2.3.5a)) and the four mounting nuts (Fig.2.3.5b)). Then push the two bars onto the stand's cross-beam threaded bolts as in Fig.2.3.6a) and fasten them with four special nuts (Fig.2.3.5b)). There are no special tools needed to set up the stand.

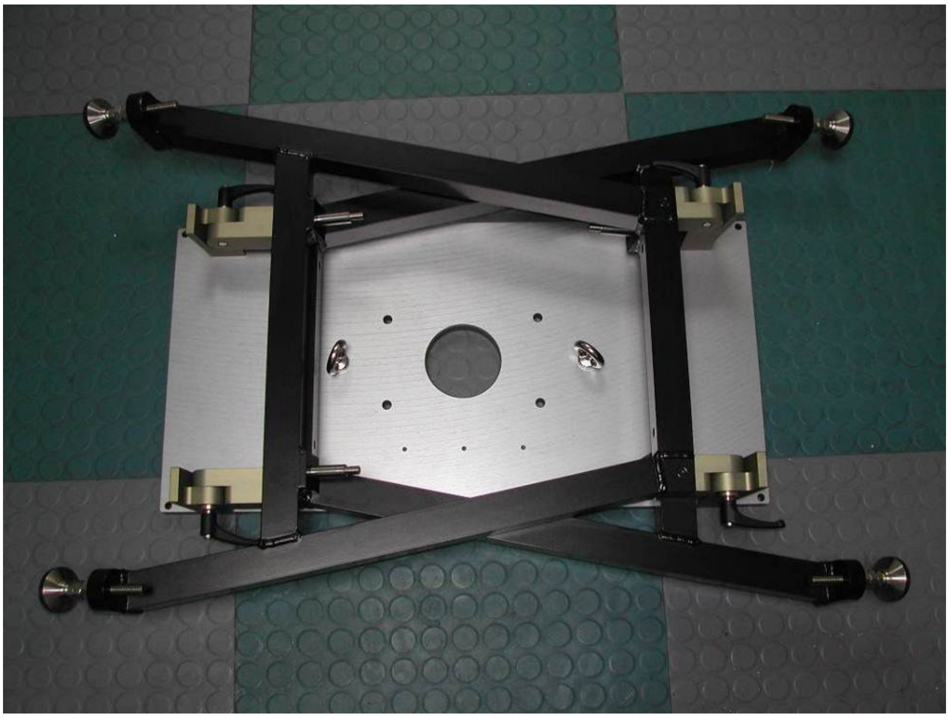


Fig.2.3.3: The folded stand.

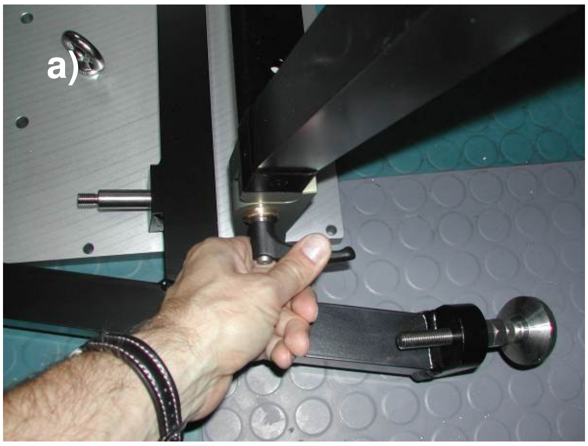


Fig.2.3.4: Open clamps and turning legs into upright position.

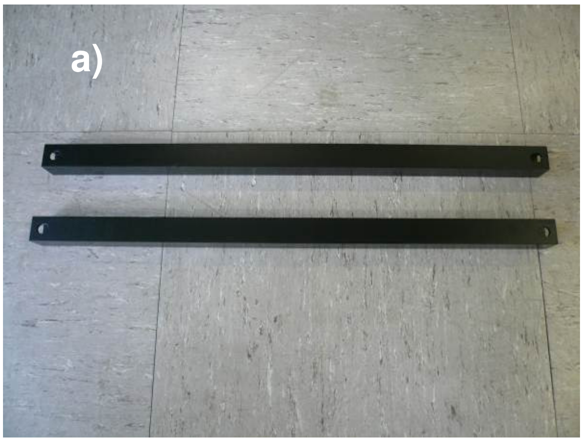


Fig.2.3.5: Stabilizer bars and mounting nuts.

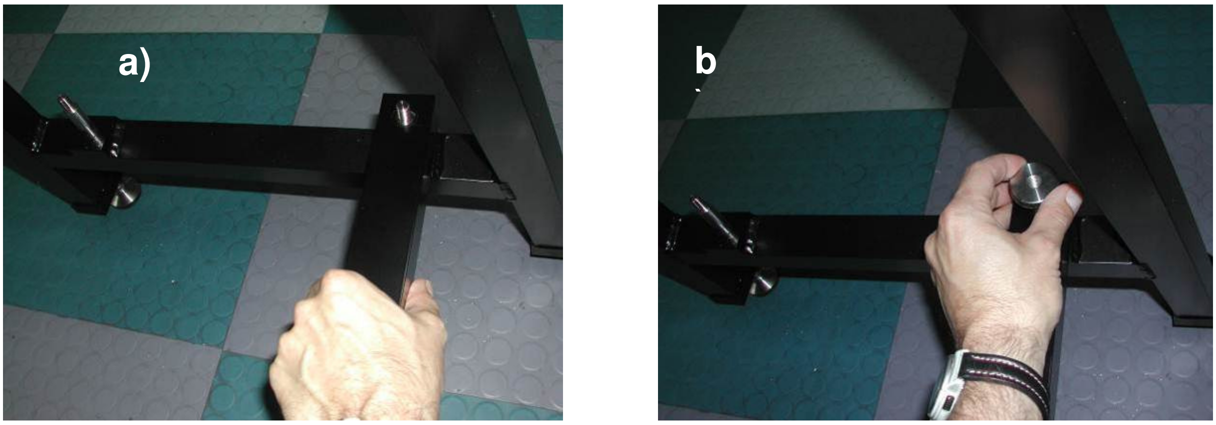


Fig.2.3.6: Mounting the horizontal stabilizer bars.

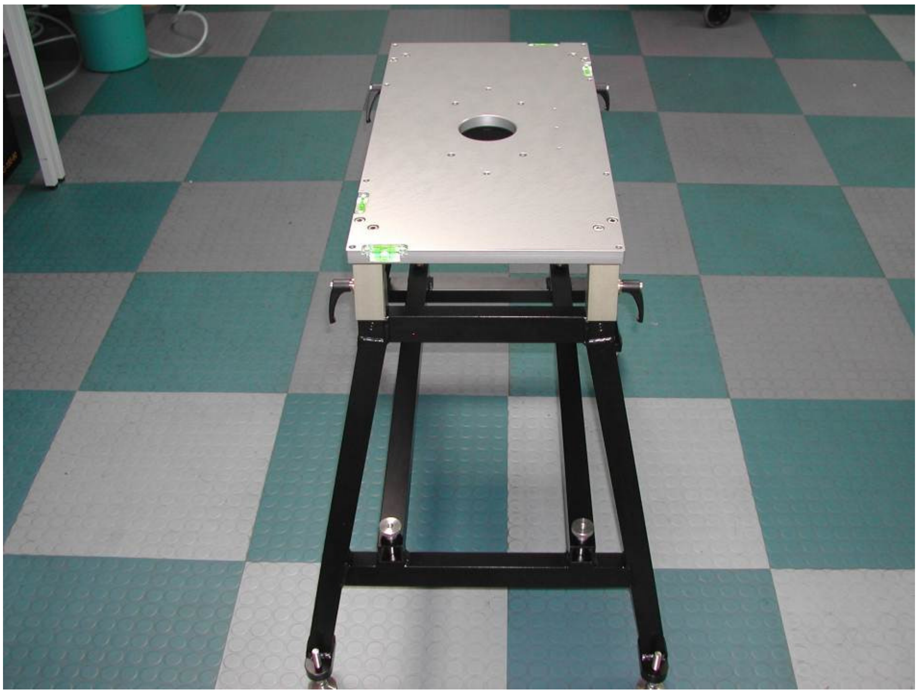


Fig.2.3.7: Completely mounted stand.

Finally, the stand should be horizontally aligned. For this purpose, 4 spirit levels are located on the table plate's edges (Fig.2.3.8a)). Adjust the feet as indicated in Fig.2.3.8b) for horizontal alignment.

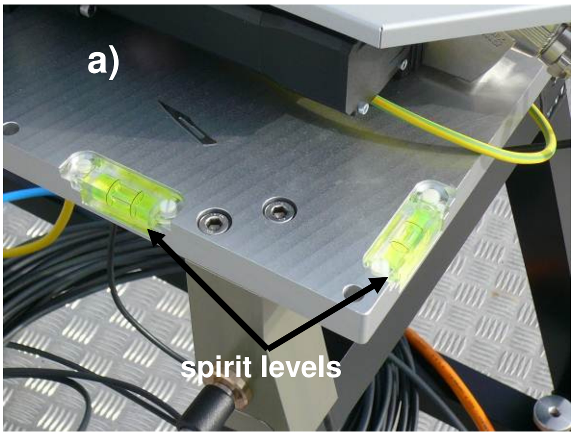


Fig.2.3.8: Spirit levels on table base plate for horizontal adjustment of the stand.

Without this adjustment, the reading of the elevation axis during measurements is not equivalent to the real observation elevation angle. The inclination angles of the elevation axis and the direction normal to it are adjusted by inspecting the spirit levels attached to the stand's table and changing the stand's 4 individual feet lengths (M19 wrench required).

2.4 Setup of the Azimuth Positioner (Optional)

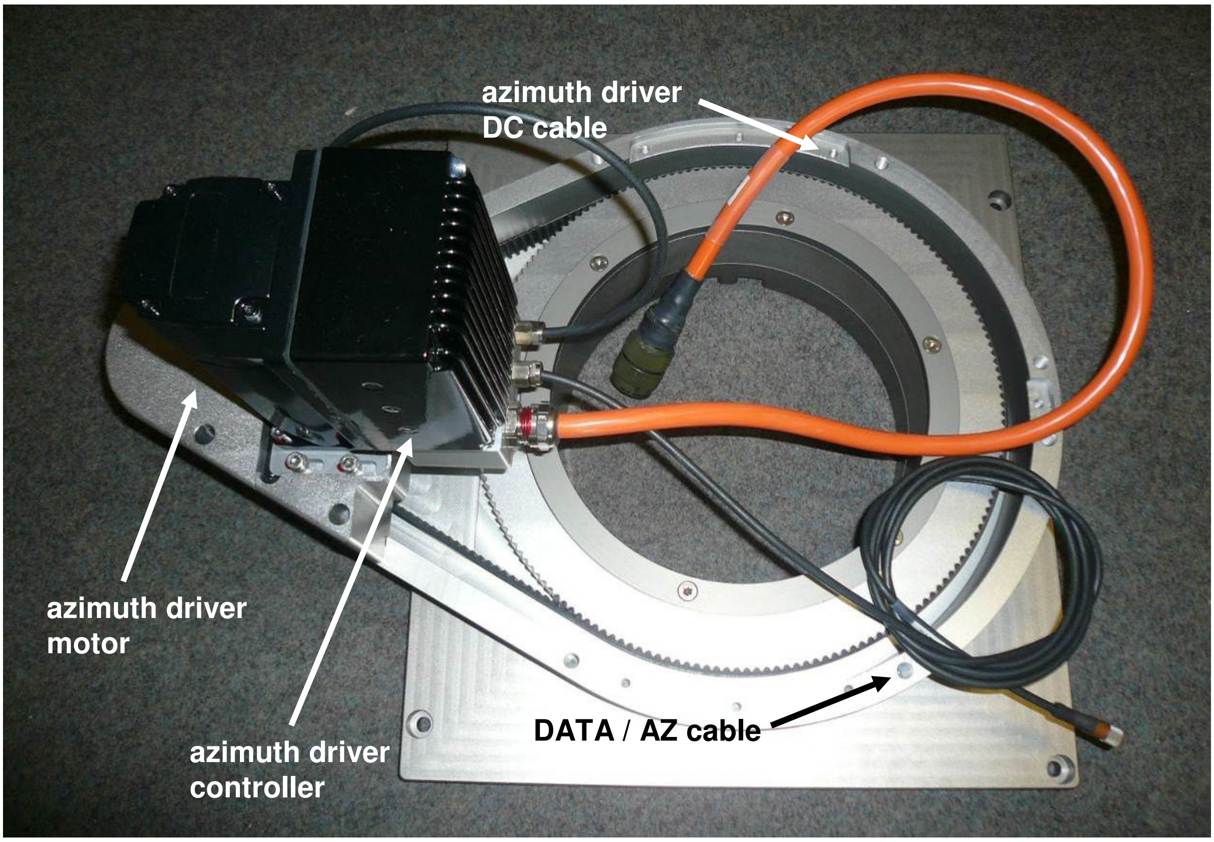


Fig.2.4.1: Azimuth positioner

The azimuth positioner is an optional equipment which is required when the radiometer shall perform full sky scanning or other scanning patterns.

After unpacking the azimuth drive and laying it on its table plate, the sub-unit looks like in Fig.2.4.1. Two cables are important for the later installation steps: The driver's DC power cable (orange) and the controller's RS-232 interface cable (black), labelled 'DATA / AZ'.
When the azimuth drive is mounted on top of the stand, it is important that the two red arrows, as indicated in Fig.2.4.2, are located on the same side.
Fix the azimuth drive with 6 screws (M8, 20 mm thread length) from the bottom side of the stand's plate (see Fig.2.4.3).
The next step is to mount the azimuth drive power supply (Fig.2.4.4) to the bottom side of the table (see Fig.2.4.5), using 6 M6 screws (20 mm thread length). The power supply has two cables attached to it: AC1 (blue) and AC2 (yellow).
Plug in the azimuth driver's DC power connector to the socket on the right side of the power supply box (Fig.2.4.6).

If a radiometer is installed without the optional azimuth drive, the power supply in Fig.2.4.4 is replaced by the power splitter in Fig.2.4.7, which is also mounted to the bottom side of the table.

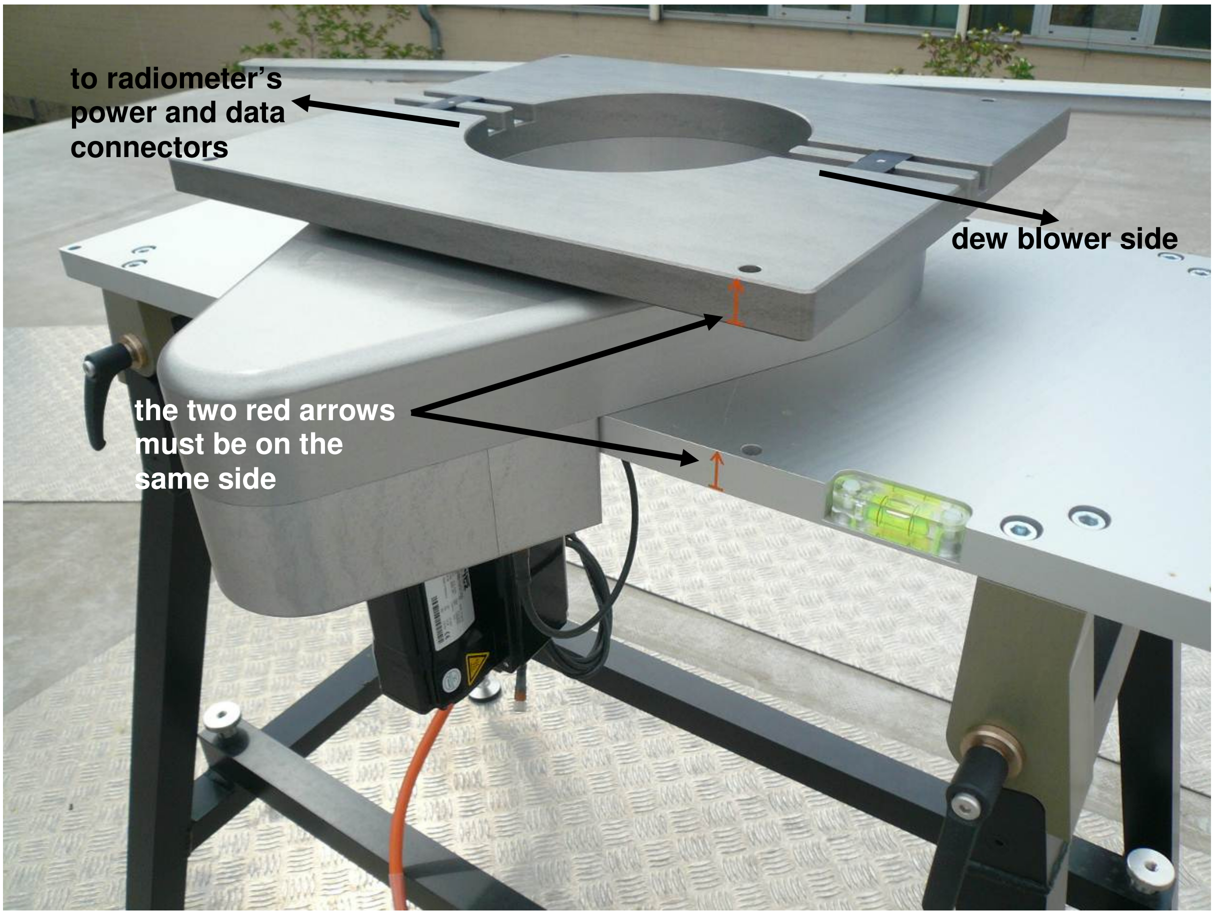


Fig.2.4.2: Azimuth positioner on the stand's table plate.

Fig.2.4.3: Fixing the azimuth drive with 6 M8x20 screws.

Fig.2.4.4: 6 M6x20 screws for mounting the azimuth drive power supply (on the right).

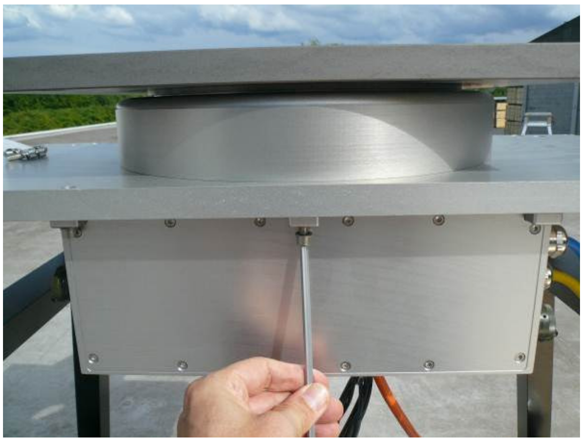


Fig.2.4.5: Mounting the azimuth drive power supply.

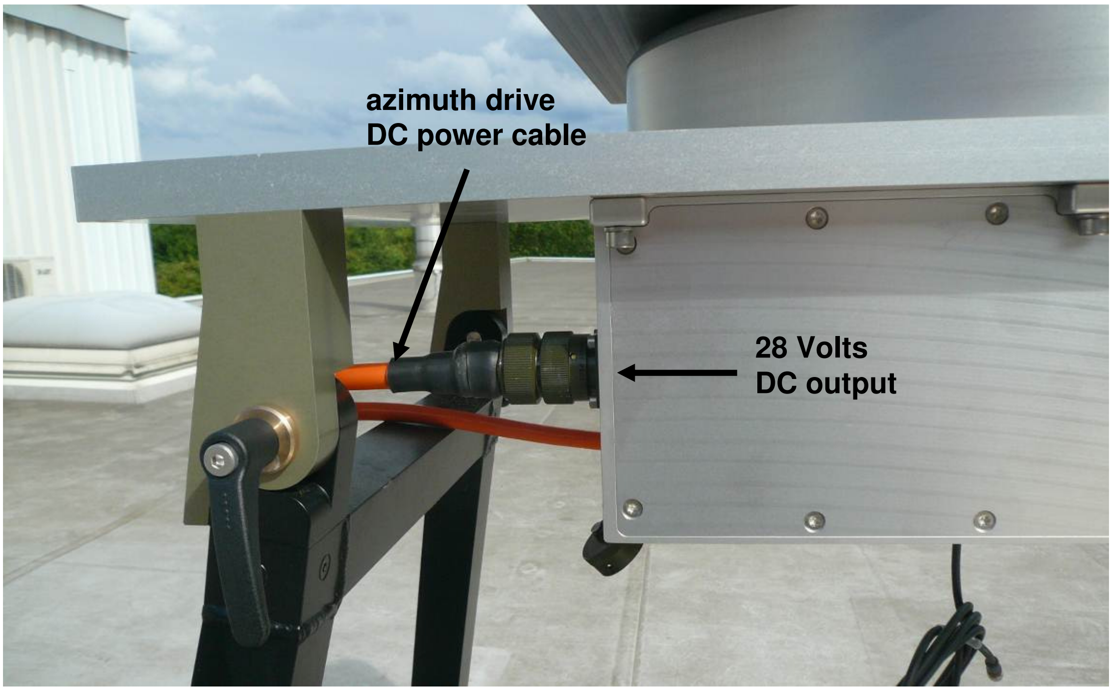


Fig.2.4.6: Plug in the azimuth drive DC power connector.

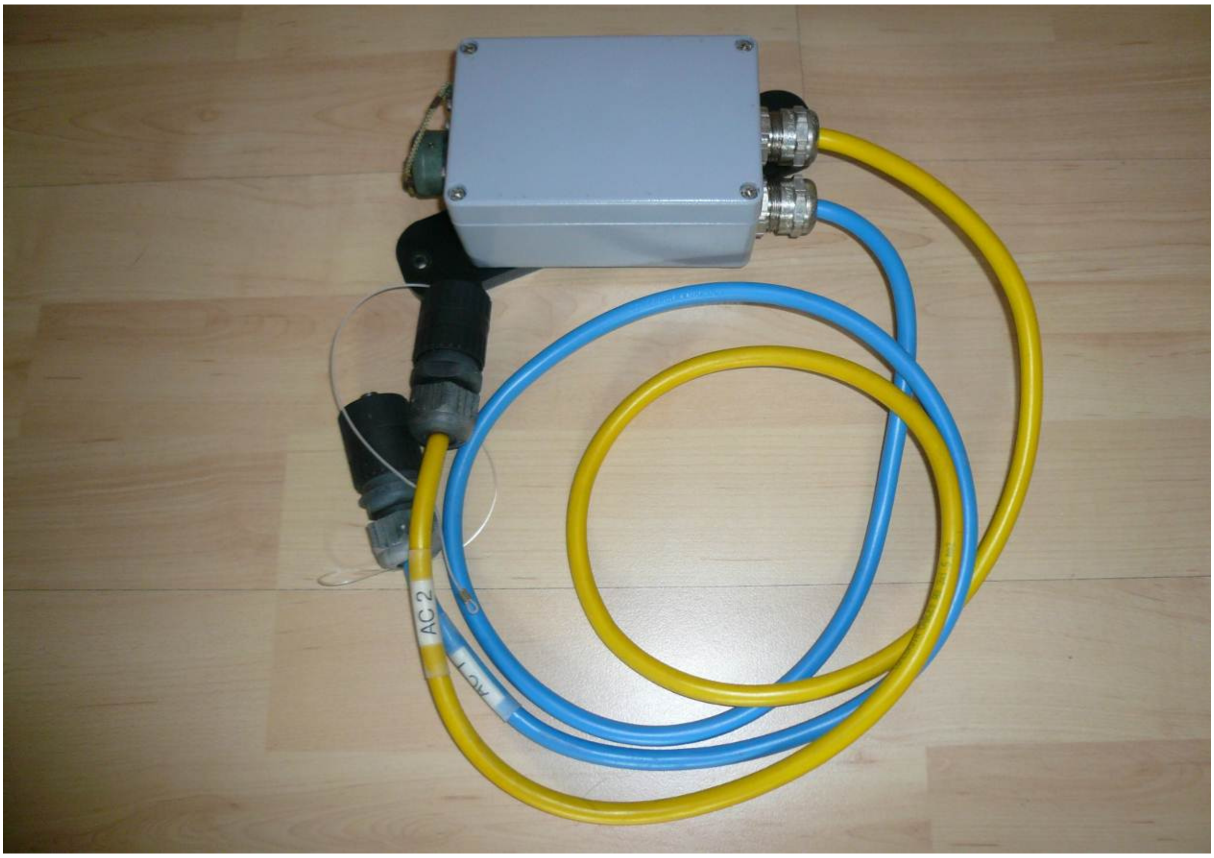


Fig.2.4.7: Power splitter unit used instead of the power supply in Fig.2.4.4, if no azimuth positioner option is installed.

Unscrew the black plastic brackets (Fig.2.4.8) on the top of the azimuth table. The cable channels are labeled with the cable designations as shown in Fig.2.4.9a),b).

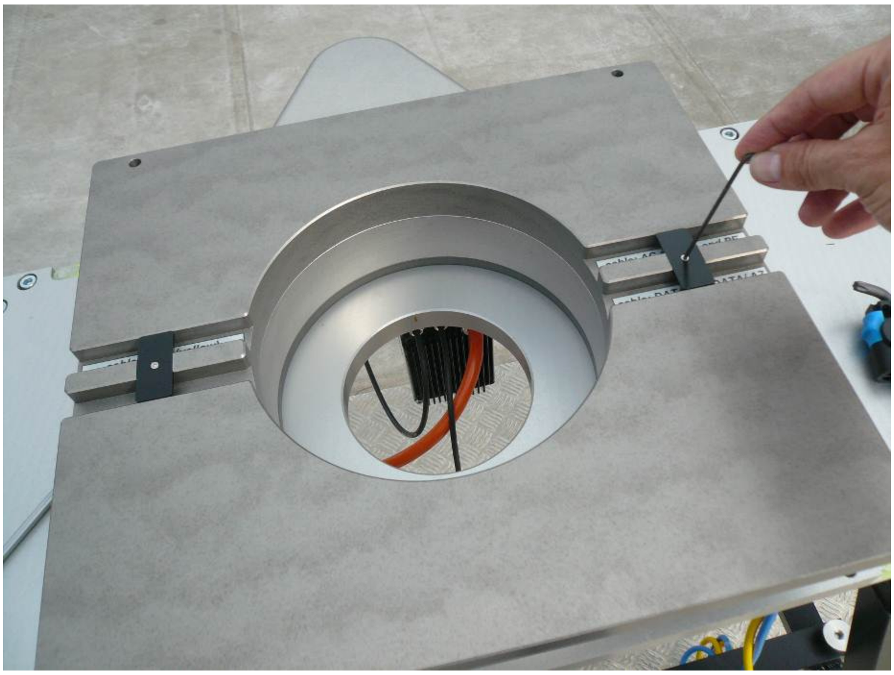


Fig.2.4.8: Plastic brackets on cable channels.

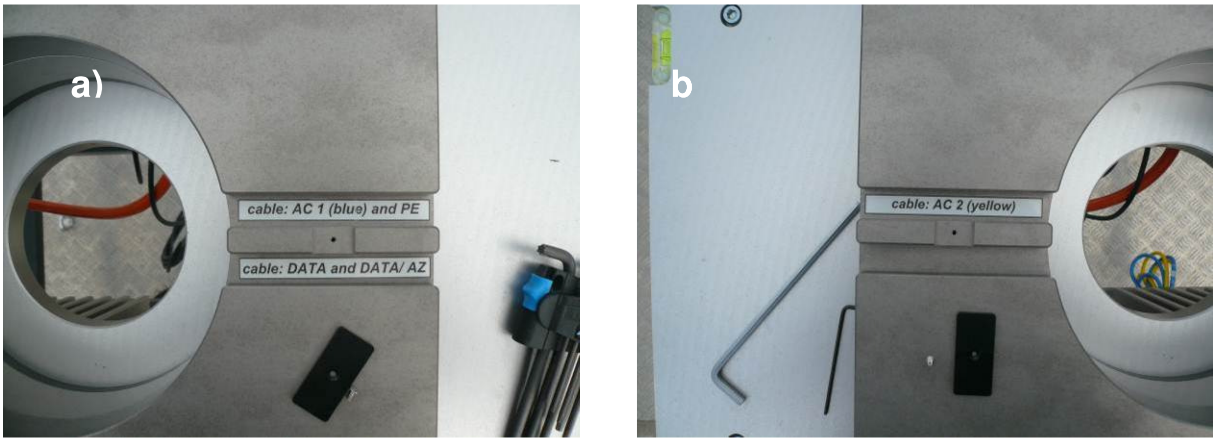


Fig.2.4.9: Labeled cable channels for a): AC1 cable (blue), DATA/AZ cable (black), fiber optics DATA cable (black) and b): AC2 cable (yellow).

Now feed the AC1 cable (blue), AC2 cable (yellow), the DATA/AZ cable (black) and the fiber optics data cable (see Fig.2.4.10a) and Fig.2.4.10b)) through the central azimuth drive hole from the bottom table side to the top.

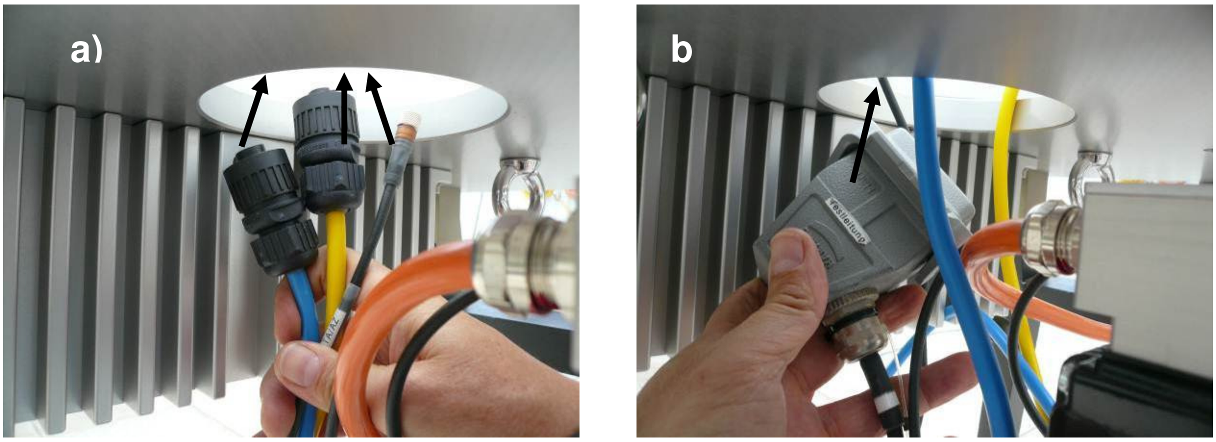


Fig.2.4.10: Feeding AC1, AC2, DATA/AZ and fibre optics data cable through centre hole.

Thread the different cables into their associated channels and mount the black plastic brackets (Fig.2.4.11).

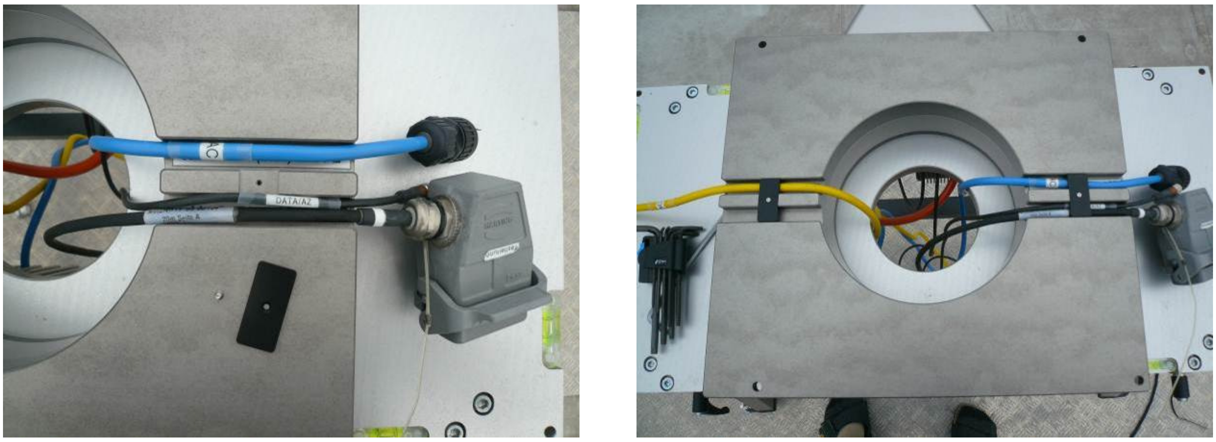


Fig.2.4.11: Mounting the cables into the cable channels.

2.5 Mounting of Radiometer Box

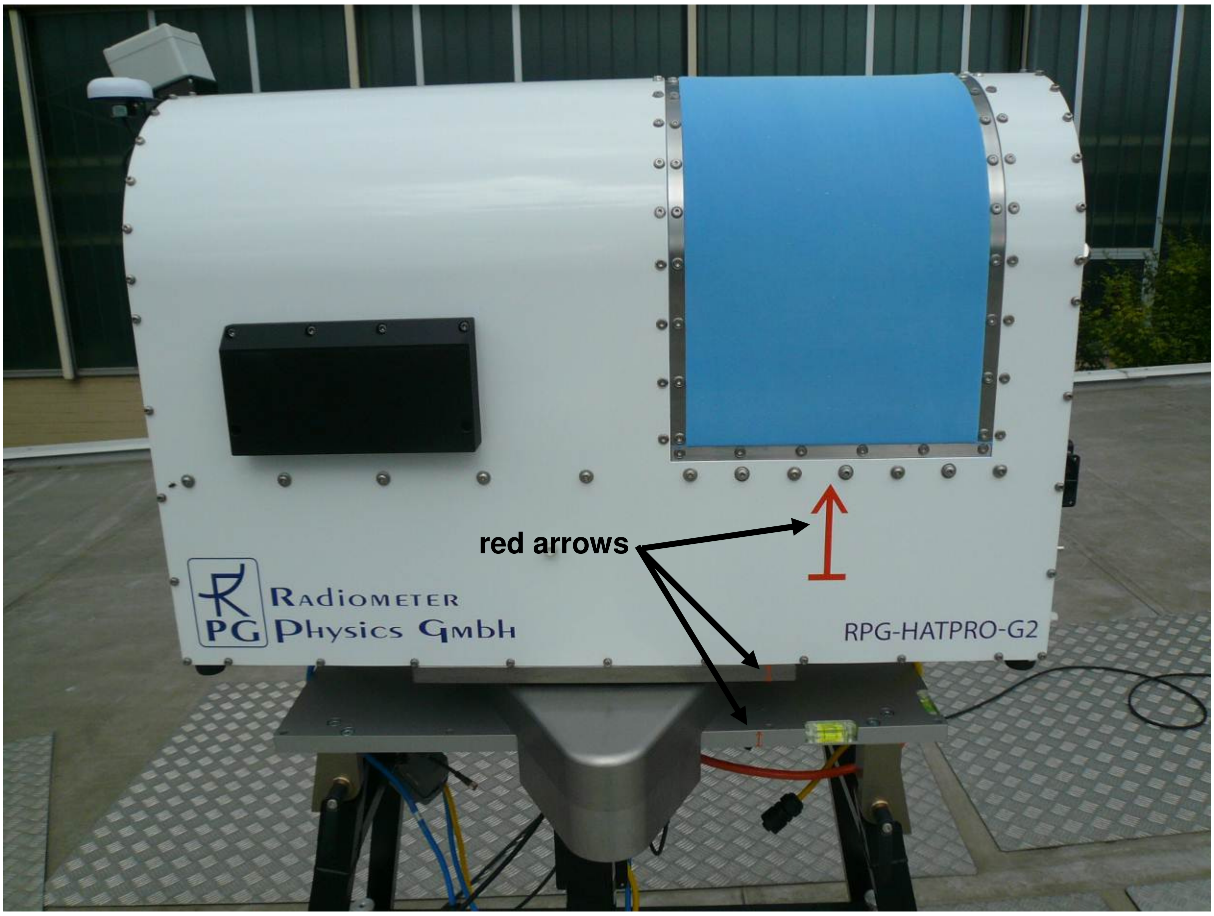


Fig.2.5.1: Radiometer box on azimuth turn table.

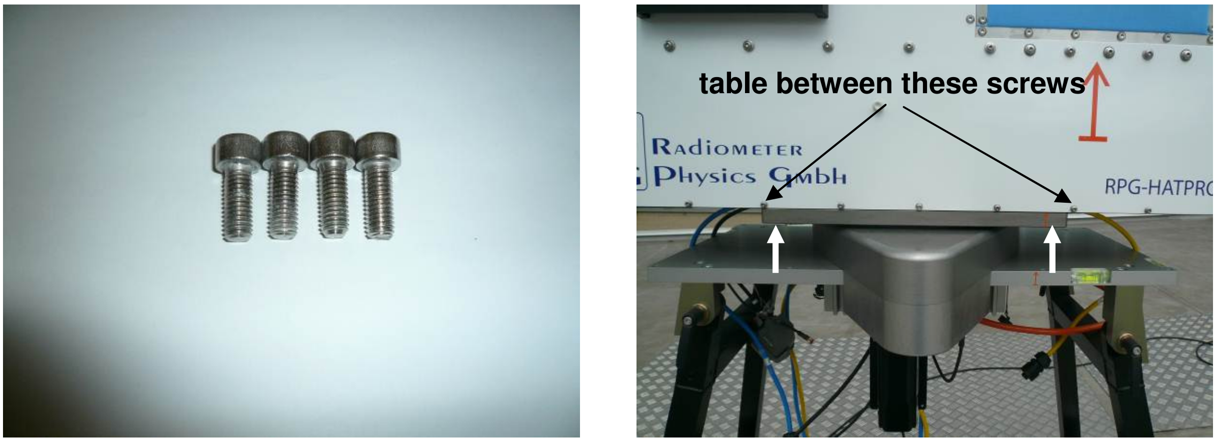


Fig.2.5.2: Four M8x20 screws for fixing the radiometer box on the azimuth driver table.

After the installation and adjustment of the instrument stand and optional azimuth positioner, the radiometer box has to be lifted on the azimuth table (Fig.2.5.1) if the optional azimuth drive is installed, or directly on the stand's top plate, if no azimuth positioner is used. The radiometer box has to be oriented, so that all red arrows are on the same side. Before lifting

the radiometer box, the dew blower (Fig.2.2.1) must be removed from the radiometer (see section 2.6).
For fixing the radiometer box on the azimuth table, four M8 screws (20 mm thread length) are used. If the radiometer box is directly mounted on top of the stand, eight M8 screws (30 mm thread length) are used.

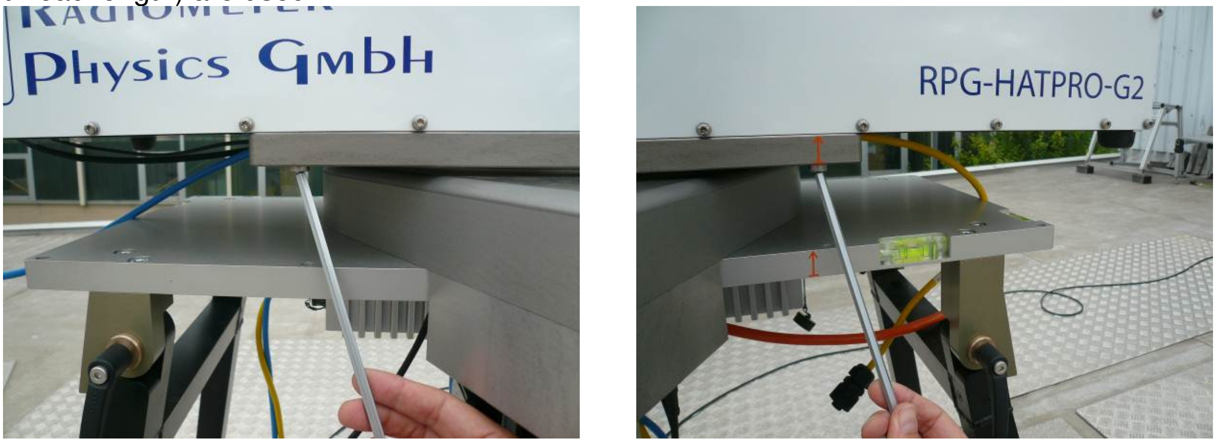


Fig.2.5.3: Use Allen key to fasten the box with four M8 screws.

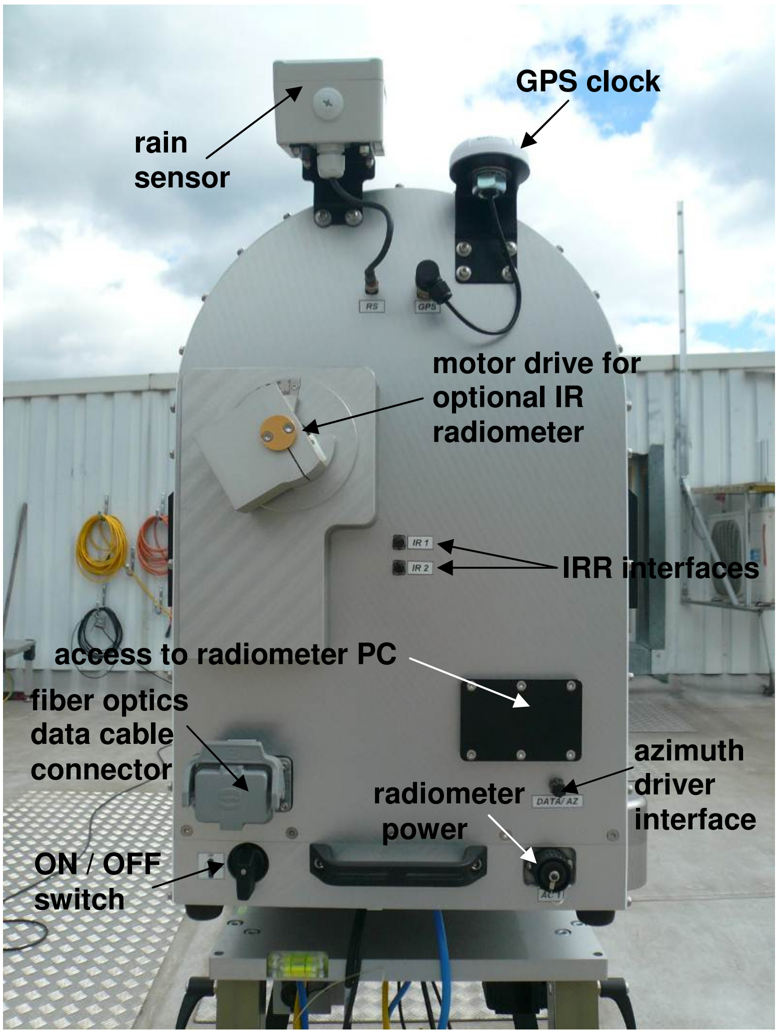
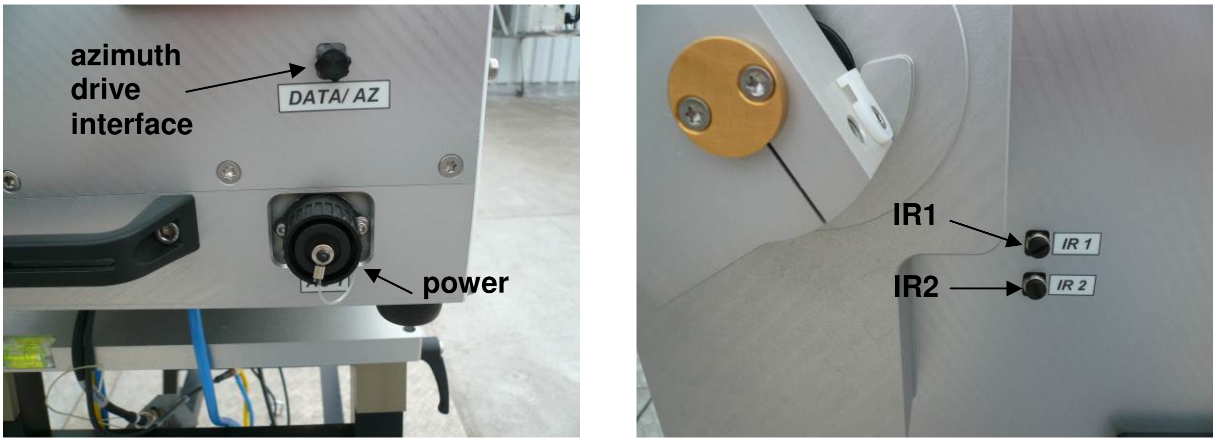


Fig.2.5.4: Connectors on the side wall.

Fig.2.5.4 shows the different connectors, switches and sensors on one of the two side walls. For transportation, all connector sockets are protected by caps (See Fig.2.5.5).



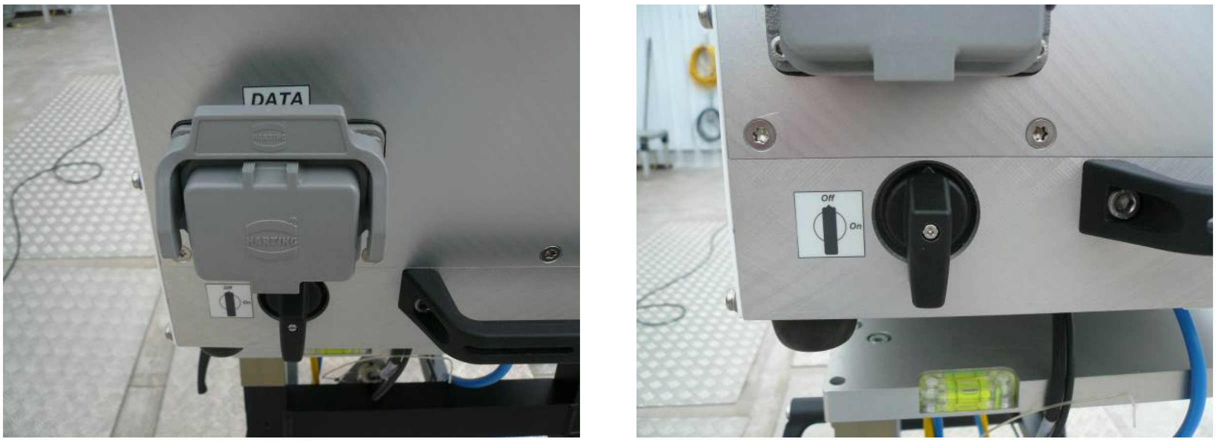


Fig.2.5.5: Connector protection caps and ON / OFF switch.

Before connecting the AC1, DATA/AZ and fiber optics cable, the connector socket protection caps must be removed. Keep these protection caps for future transportation use. If a socket is left unprotected during transportation, condensation water may accumulate inside the connector, which may lead to malfunctioning of the radiometer.

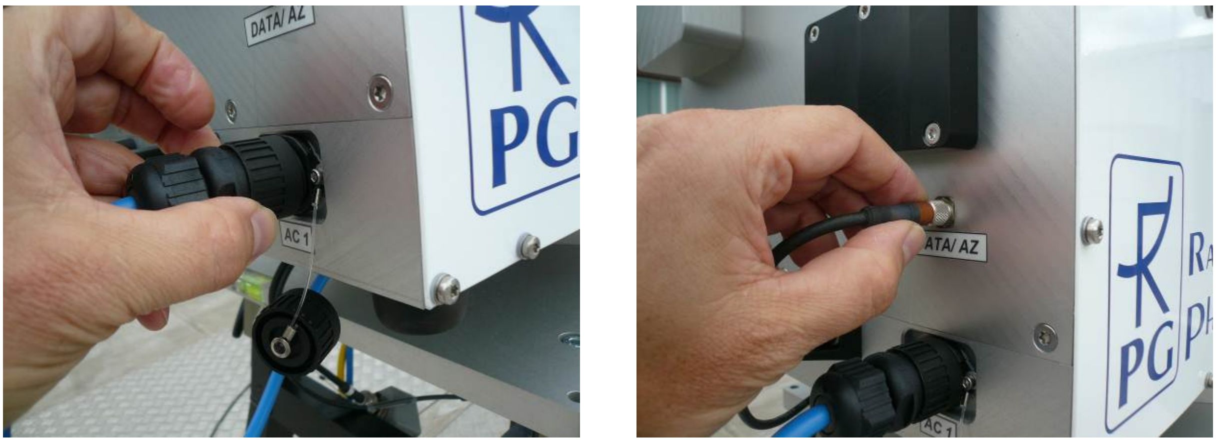


Fig.2.5.6: Connecting the blue AC1 cable and the black azimuth driver interface cable (DATA/AZ).

The fibre optics connector contains 6 fibre optics pins that have to be precisely aligned (see Fig.2.5.7).

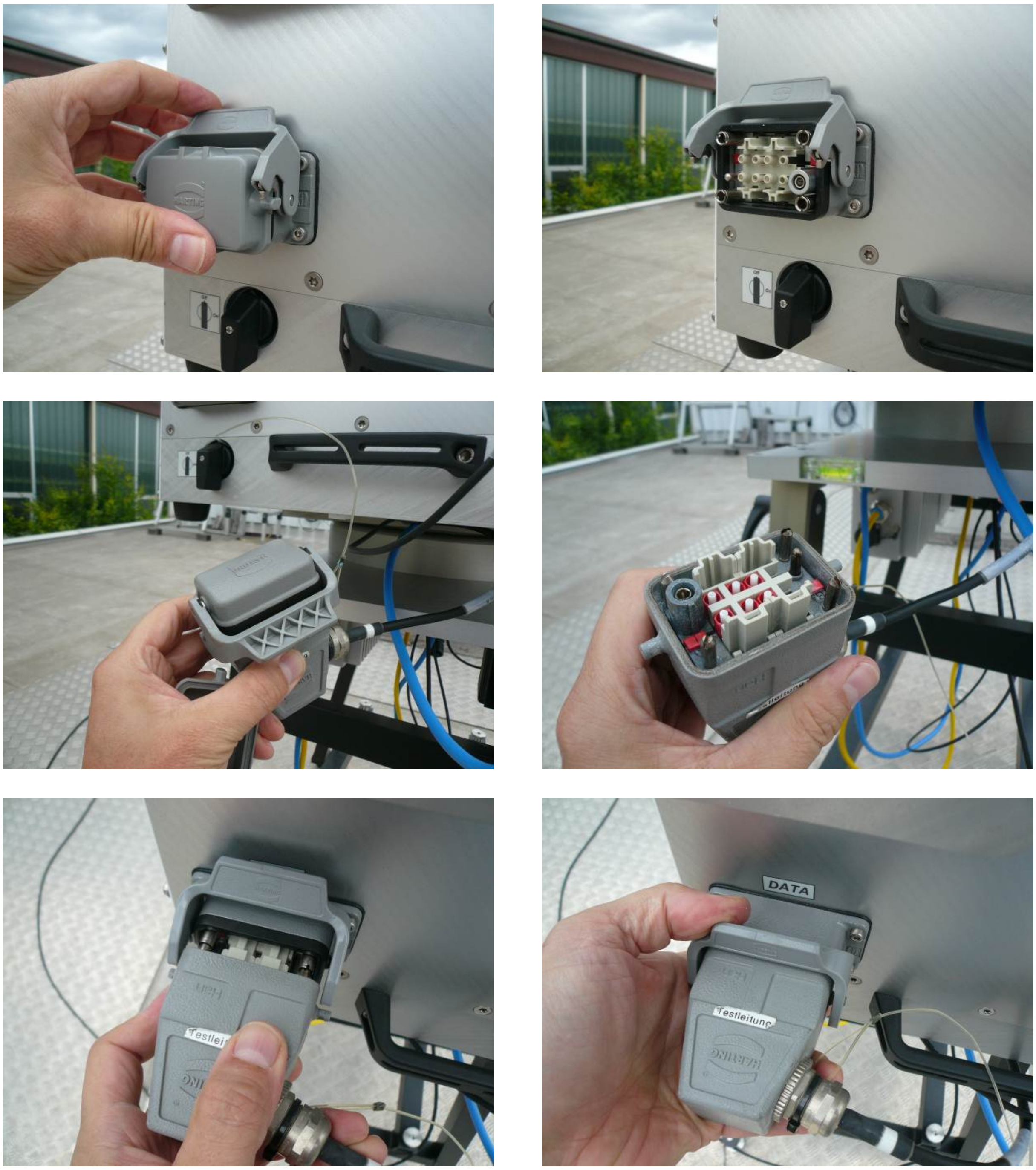


Fig.2.5.7: Sequence for connecting the fibre optics data cable.

After these connections have been performed (Fig.2.5.8), the cables should be pulled back to get the right length on the side wall (Fig.2.5.9). Finally they are fixed to the radiometer's bottom plate by one or two cable ties (Fig.2.5.10).

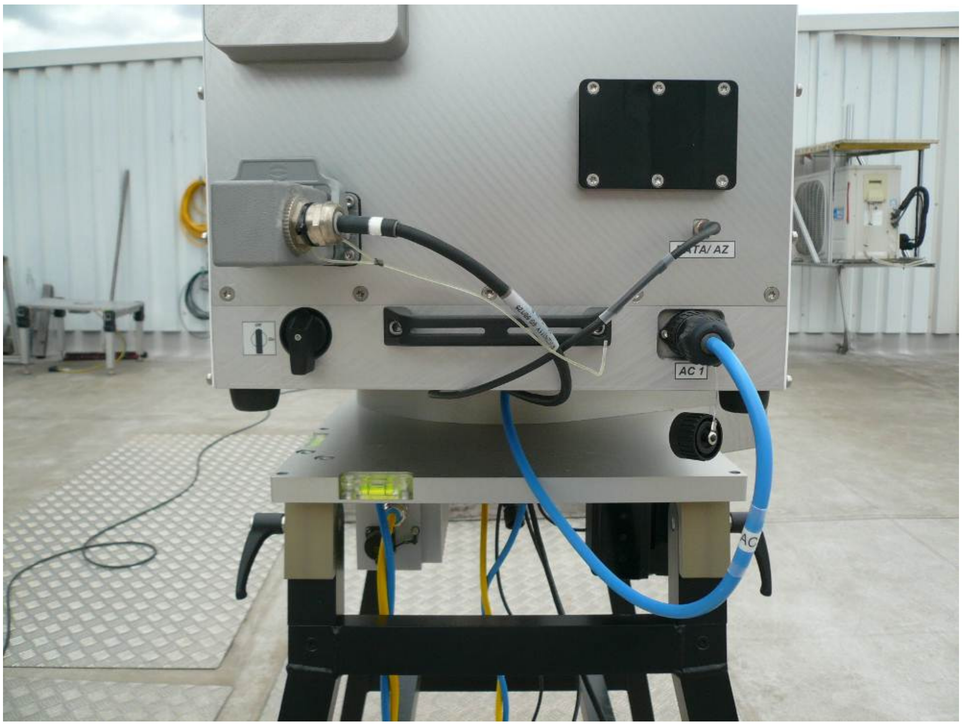


Fig.2.5.8: All cables connected to the radiometer.

Fig.2.5.9: Pulling back the cables to adjust the cable lengths.

Fig.2.5.10: Fastening cables on the radiometer's bottom plate.

2.6 Mounting of Externals (Blower, Heater, IRR, Weather Station)

2.6.1 Dew Blower

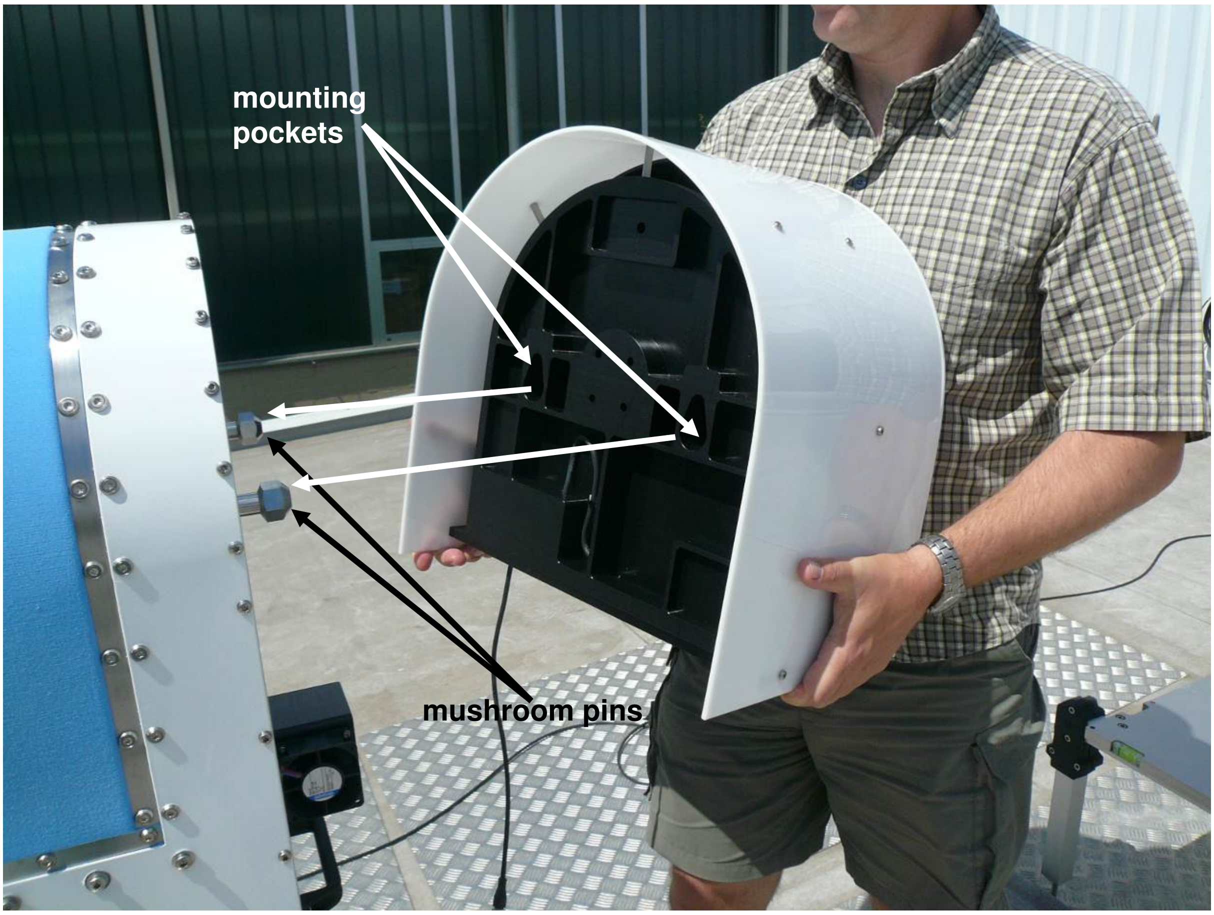


Fig.2.6.1: Dew blower with mounting pockets.

Fig.2.6.1 shows the dew blower with its mounting pockets. When attaching the blower to the radiometer, the mushroom pins have to slide into these pockets.

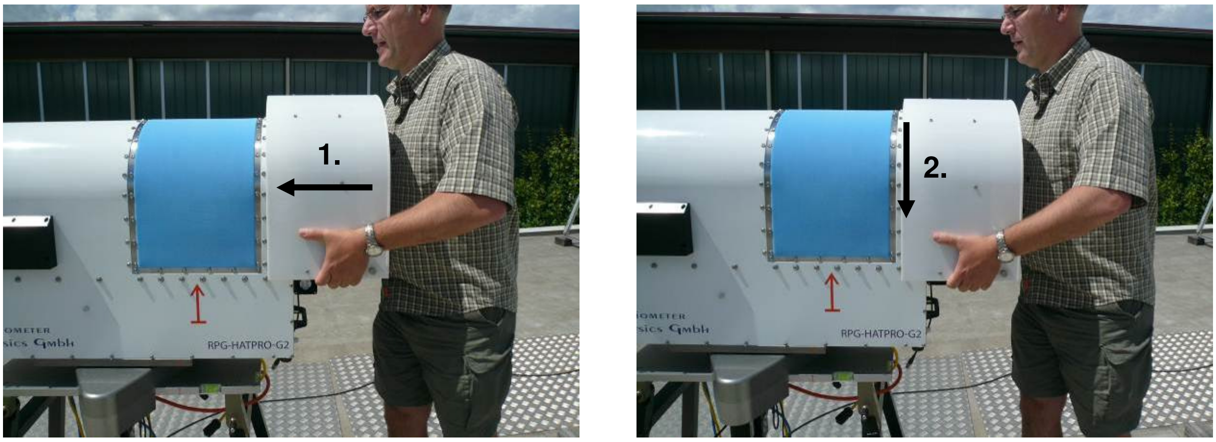


Fig.2.6.2: Sequence of movement.

The first step is to push the blower against the radiometer housing so that the mushroom pins slide into the blower's mounting pockets (1. in Fig.2.6.2). In the second step, the blower is released to slide downwards (2. in Fig.2.6.2), so that the mushroom pins get locked inside the pockets.
In order to dismount the blower, the inverse movement is required, e.g. when unpacking the radiometer box (Fig.2.2.1), the blower has to be removed from the radiometer housing in order to lift the radiometer onto the instrument stand. Each time the instrument is packed or unpacked, the blower has to be mounted or dismounted in this way.

2.6.2 Heater Module

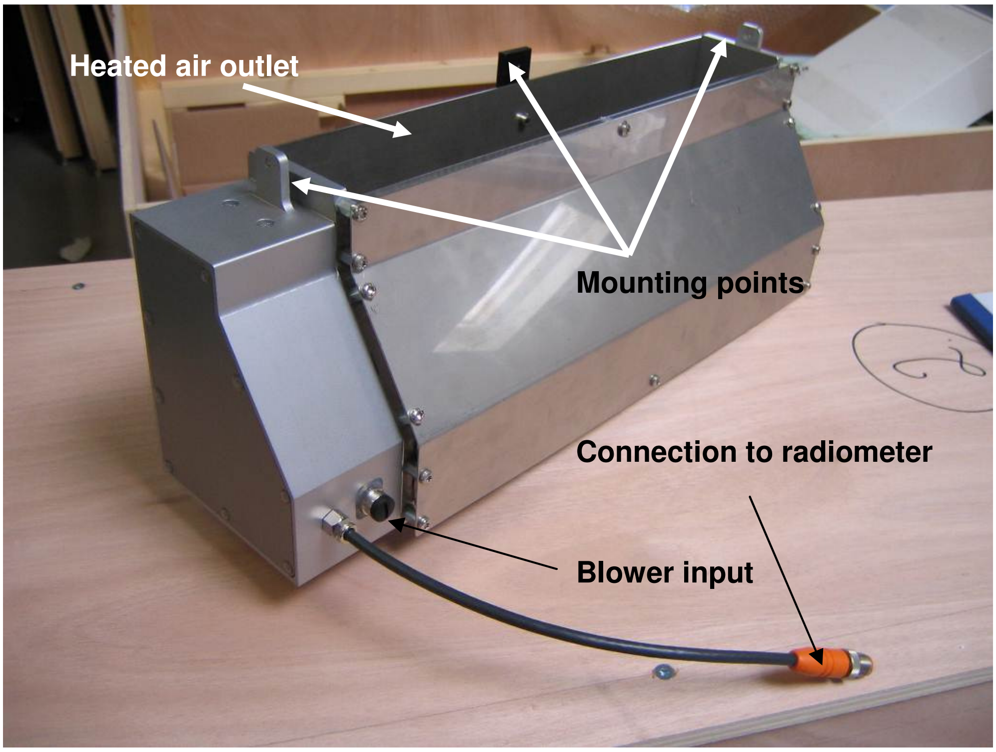


Fig.2.6.3: Dew blower heater module with mounting points.

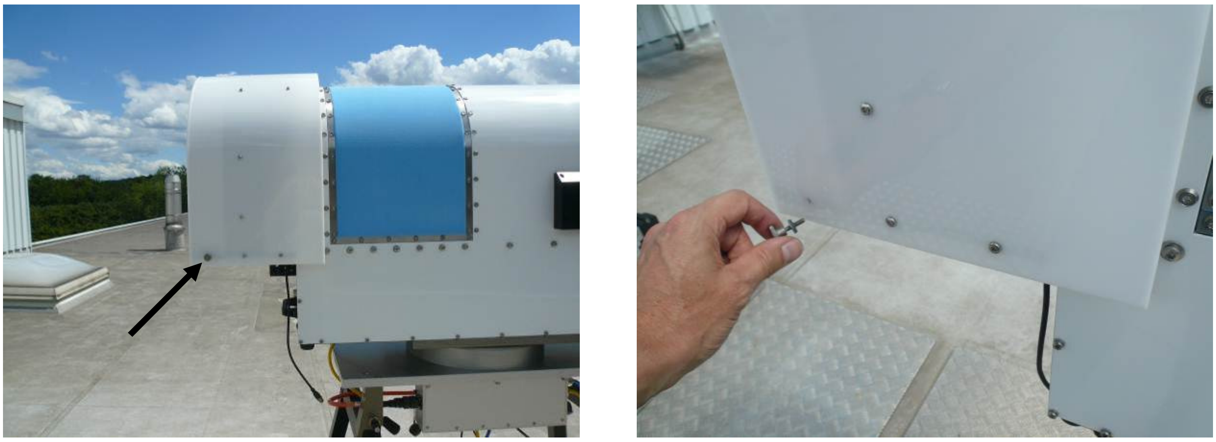


Fig.2.6.4: Remove heater mounting screws from the blower.

Fig.2.6.5: Shift the heater module underneath the blower's air inlet and fasten the mounting screws as indicated.

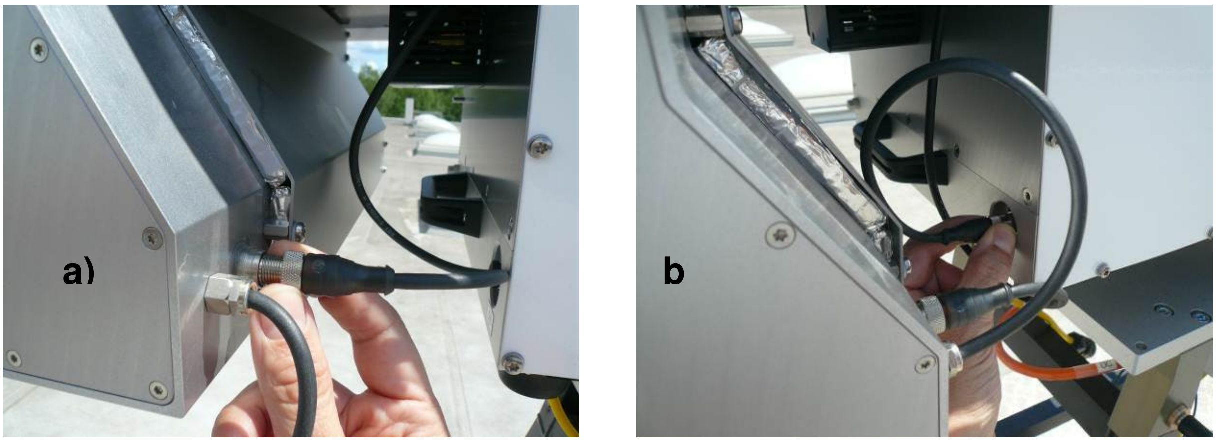


Fig.2.6.6: Connect blower supply to heater module (a)) and then connect heater module to radiometer (b), 'DB' connector socket).

Fig.2.6.7: Connection of AC2 cable (yellow) to the heater module AC input.

Finally, the AC2 cable is fixed at the radiometer bottom plate (Fig.2.6.8) with cable ties.

Fig.2.6.8: Fixing AC2 cable on radiometer bottom plate.

2.6.3 Mounting of IR Radiometer (Optional)

The infrared radiometer data is used as an additional information for retrievals dealing with cloud base height, humidity profiling, LWC profiling, etc. In order to protect the IR optics the system is operated in a tilted position (see Fig.2.7.1a)). The IR beam is reflected by a gold plated mirror to sky directions between 0° (horizontal) and 90° (zenith). This is useful when the IR data shall be combined with microwave observations under elevation angles other than zenith.
The customer may select from a broad band single IR radiometer (10-12 µm bandwidth), range +100℃ to -80℃, or a dual narrow band twin system (10-11 µm, 11-12 µm), range +100℃ to -60℃, which is beneficial for the retrieval accuracy of low LWP clouds (< 100 g/m^2).

2.6.3.1 Manually Adjustable IRR Elevation Axis

The standard version is a manually adjustable IR radiometer mount (Option IRR-A) as shown in Fig.2.6.9b).

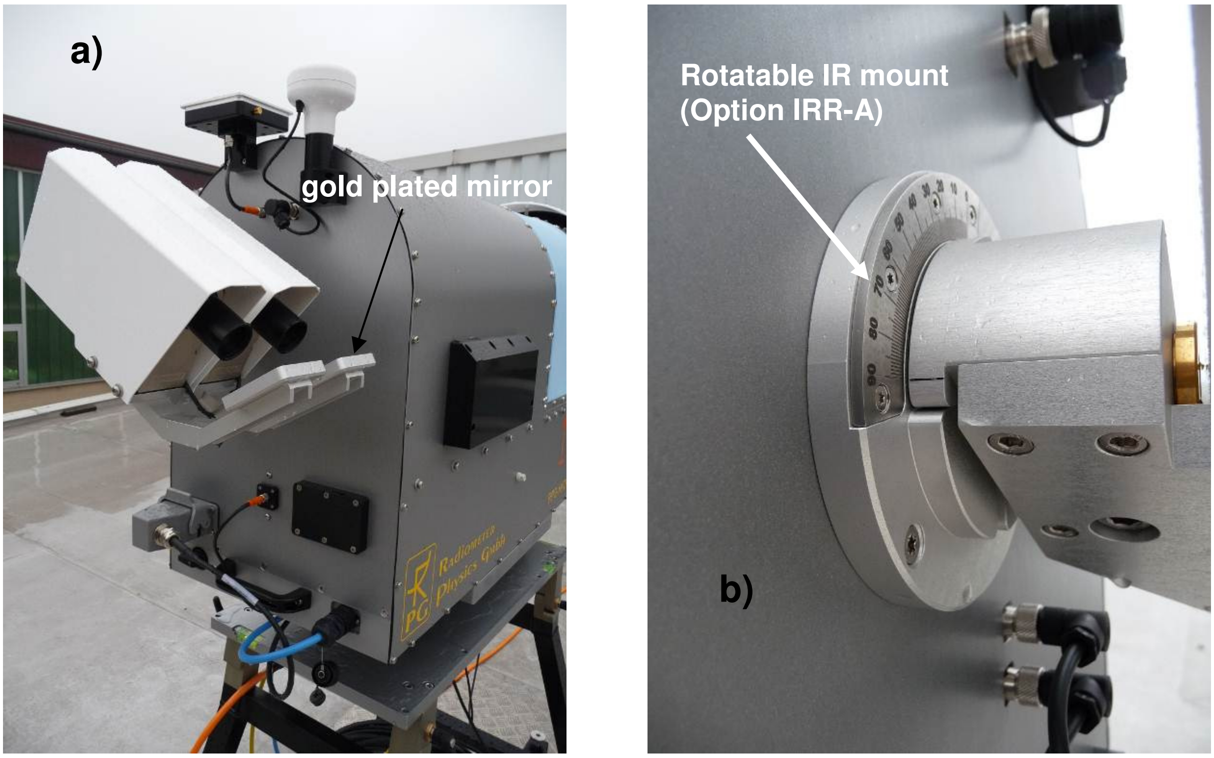


Fig.2.6.9: Infrared radiometer mounted to the radiometer side wall on manually adjustable elevation axis. Because of an axial mount the IR radiometer viewing angle can be changed between 0° and 90° and fixed at an arbitrary angle in this range.

Fig.2.6.10: Connecting the IRRs to their interface ports (IR1 and IR2).

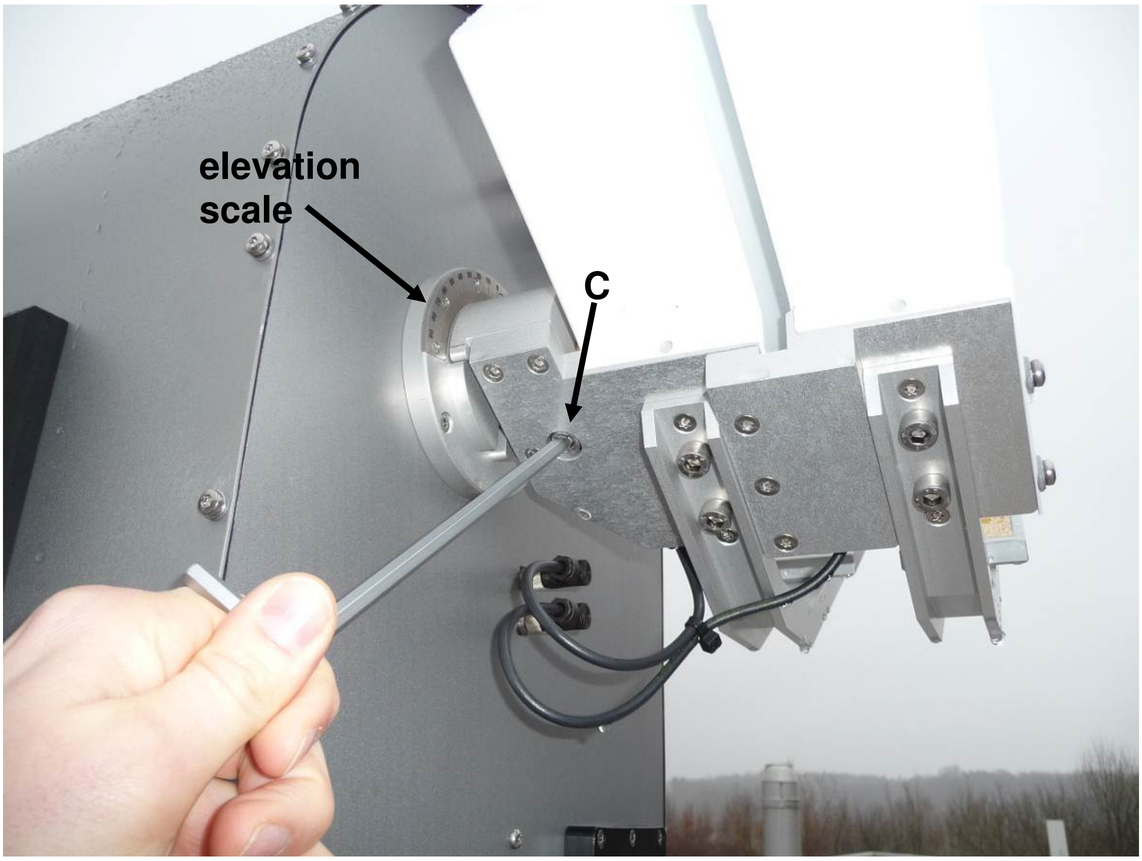


Fig.2.6.11: The manual adjustment is performed by loosening the clamp (C), rotating the IRRs to the desired elevation position (use the elevation scale) and fastening the clamp again.

2.6.3.2 Motorized IRR Elevation Axis (Optional)

If arbitrary scan patterns (e.g. volume scans) shall be performed with automatically synchronized elevation pointing of the microwave and IR beams, a motor driven mount is available (Option IRR-B). This option is not a plug-and-play extension and requires a modification of the radiometer housing and electronics. If desired, this feature should be ordered together with the radiometer in order to avoid additional costs in a later upgrade.

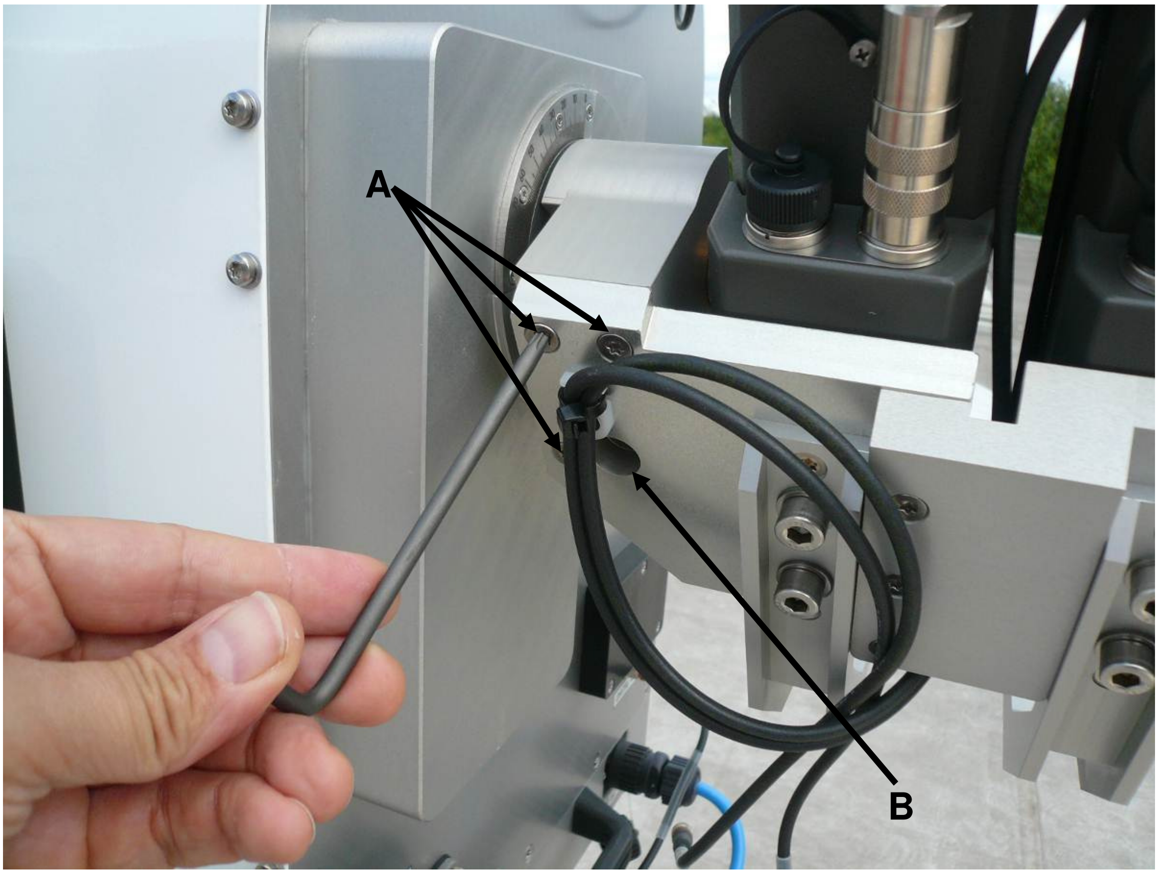


Fig.2.6.12 For the motorized IR-Option (Option IRR-B), the IR radiometers are mounted with three M4 screws (A). NEVER touch the screw in (B). It has been adjusted to an elevation axis tilt accuracy of 0.3°. By loosening (B), this adjustment is lost.

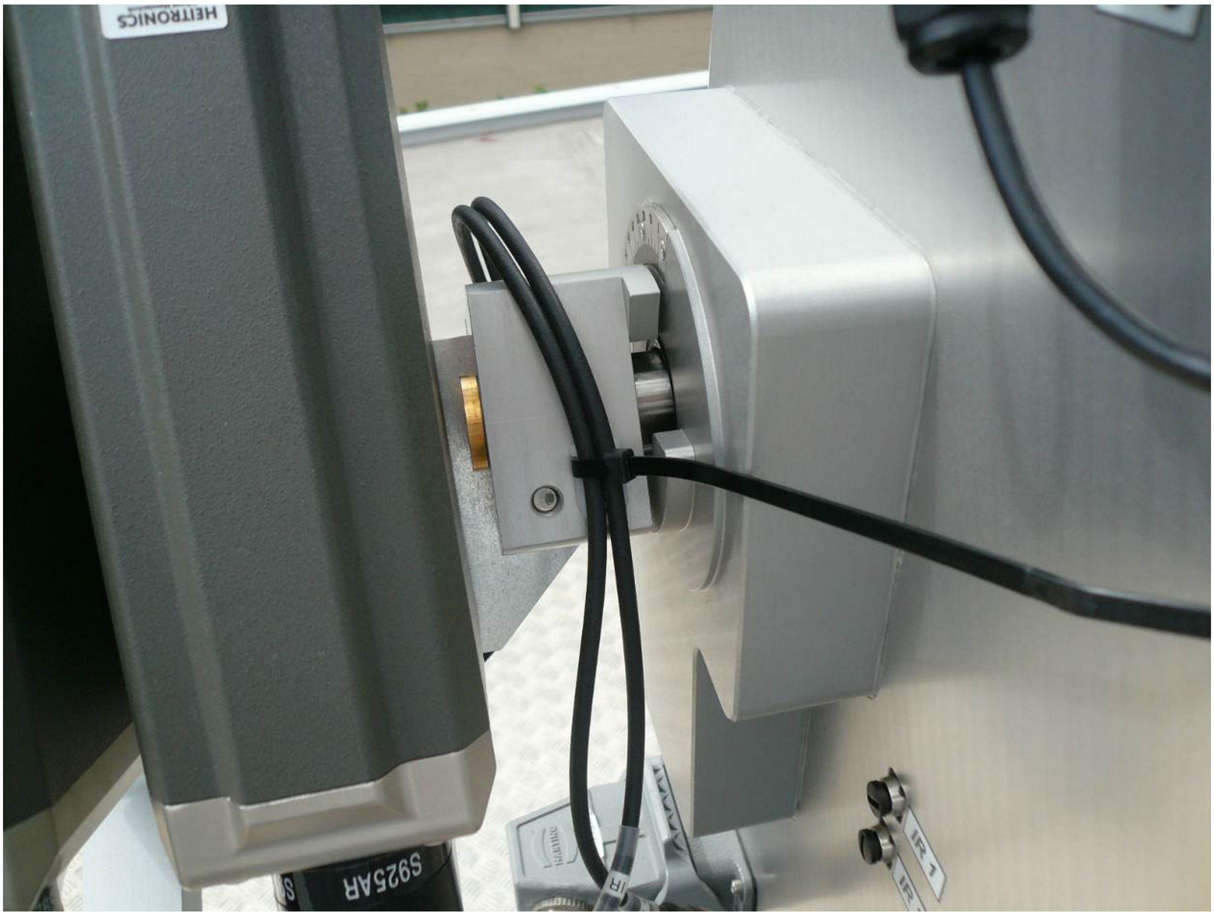


Fig.2.6.13: Also fasten the IR-interface cables with a cable tie.

2.6.4 Rain Sensor and GPS Clock

The rain sensor and GPS clock are not dismounted for transportation.

2.7 Fibre Optics Converter

2.7.3 Old Version (6 Lines)

The fibre optics data cable has a 6 way Harting connector on the radiometer end (see Fig.2.5.7) and 6 single ended fibre lines on the Host PC end (Fig.2.7.1)

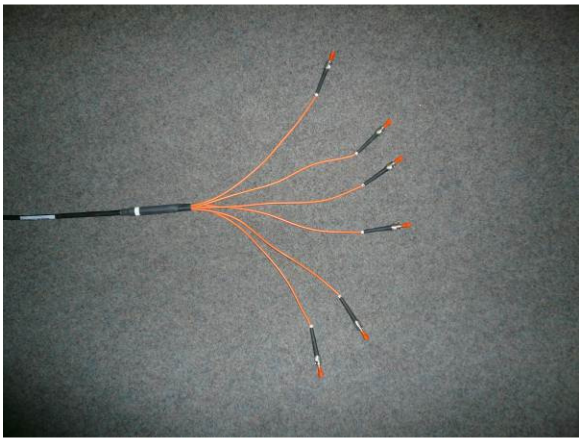


Fig.2.7.1: 6 line fibre optics cable on the host PC end.

A fibre optics to RS-232 converter interfaces the glass fibre cable to the host PC's RS-232 interface.

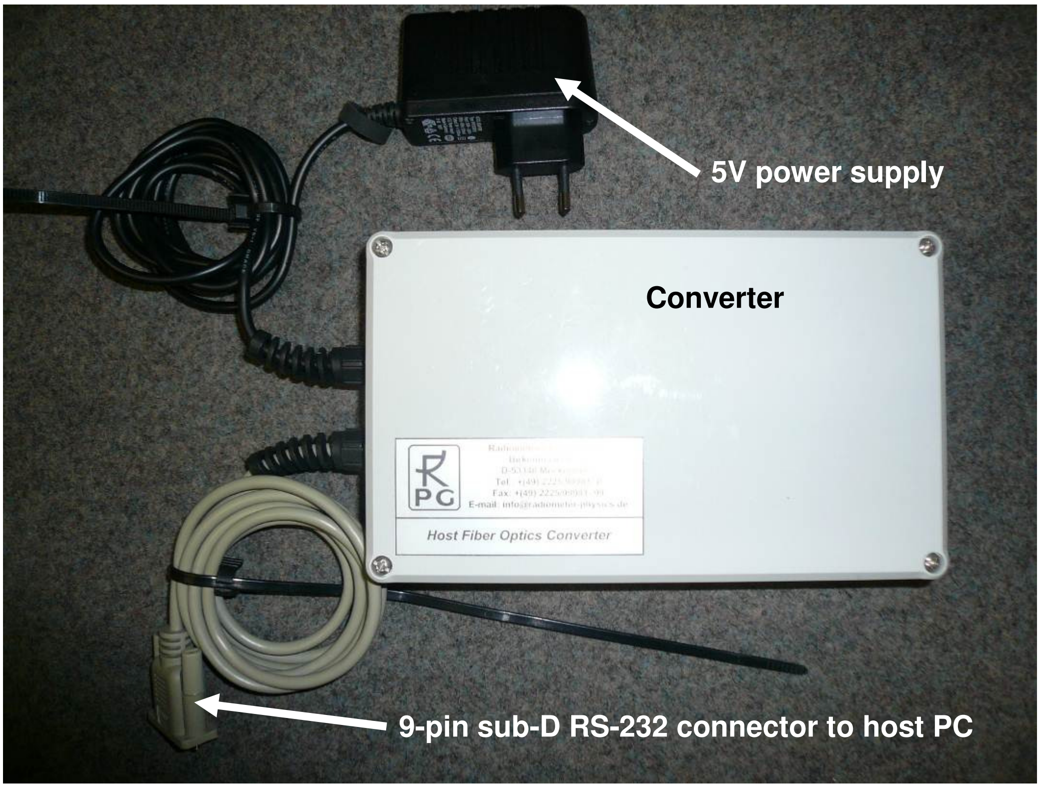


Fig.2.7.2: Fiber to RS-232 converter module.

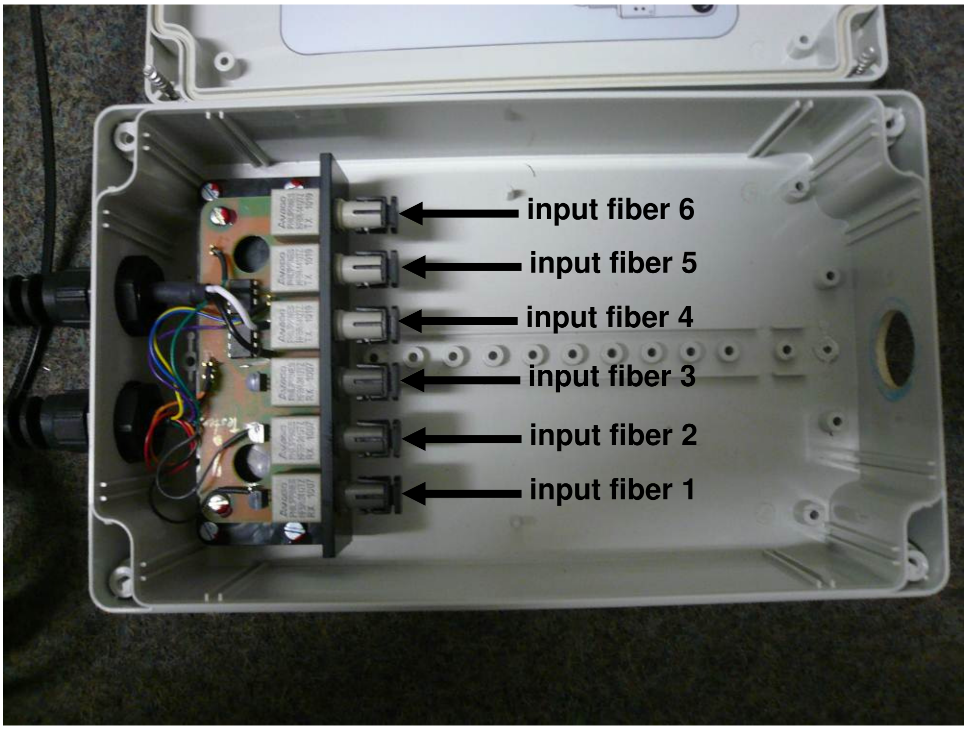


Fig.2.7.3: Fibre to RS-232 converter module from inside.

The active fibre optics line is only 50 µm in diameter, embedded into a glass matrix (white, see Fig.2.7.5).

Fig.2.7.4: Red protection cap on fibre tip.

The fibre connector has a nose (see Fig.2.7.5) which has to fit into a slit in the fibre socket (see Fig.2.7.6).
After the connector is sliding into the socket (the nose guided by the slit), the bayonet coupling has to be pushed against a spring inside the coupling and then turned clockwise.
After all fibre lines have been connected, close the converter with its lid and fasten the lid by its 4 screws.
Connect the converter's 5 V power supply (Fig.2.7.2) to a 110-220 V/AC power outlet and the 9-pin sub-D connector to the COM1-interface of the Host PC.

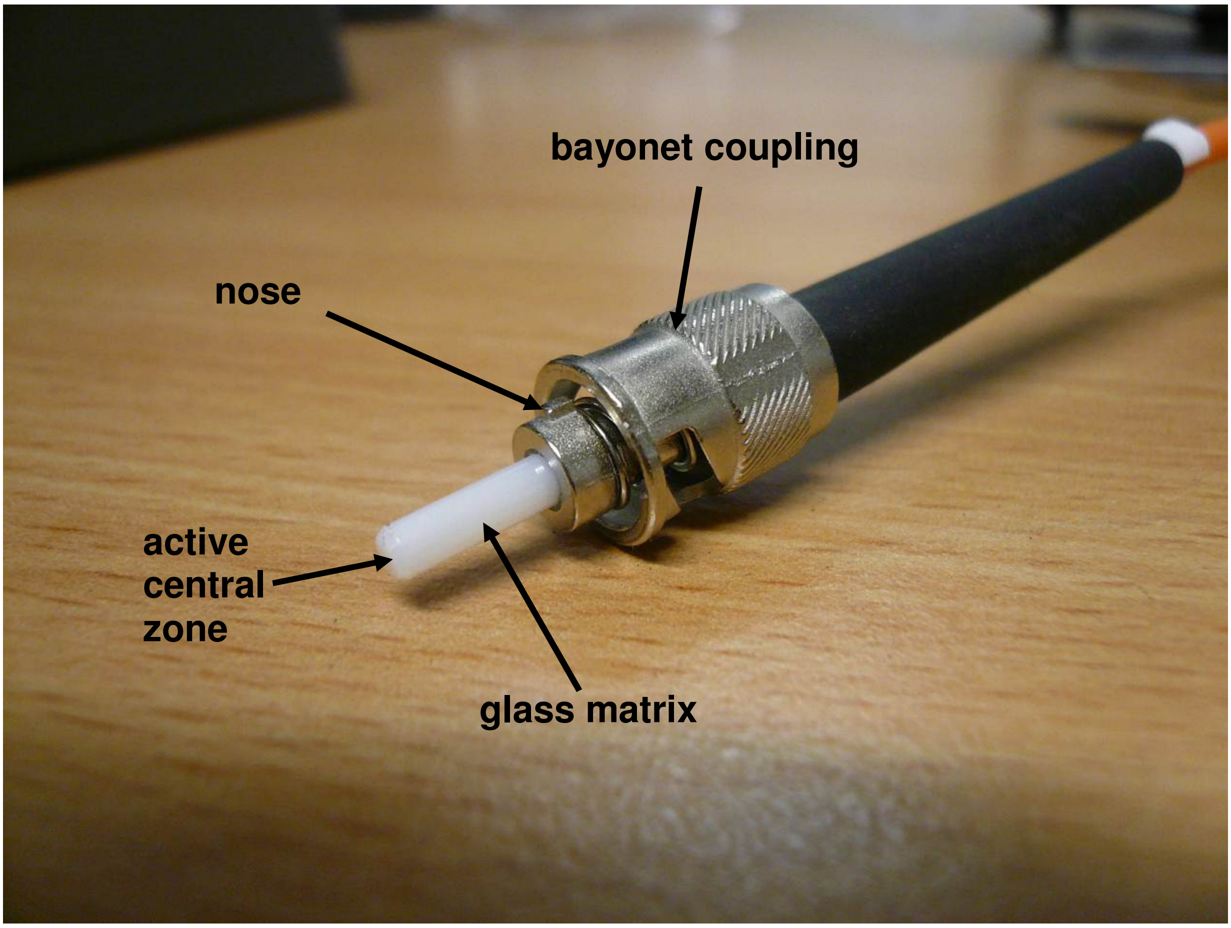


Fig.2.7.5: Details of the glass fibre connector.

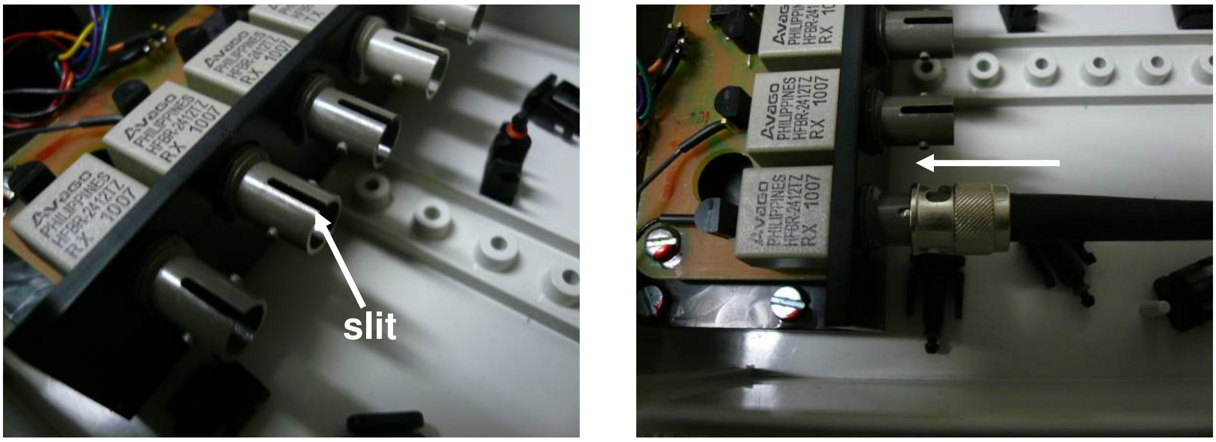


Fig.2.7.6: Socket slit and connector pushed into the socket.

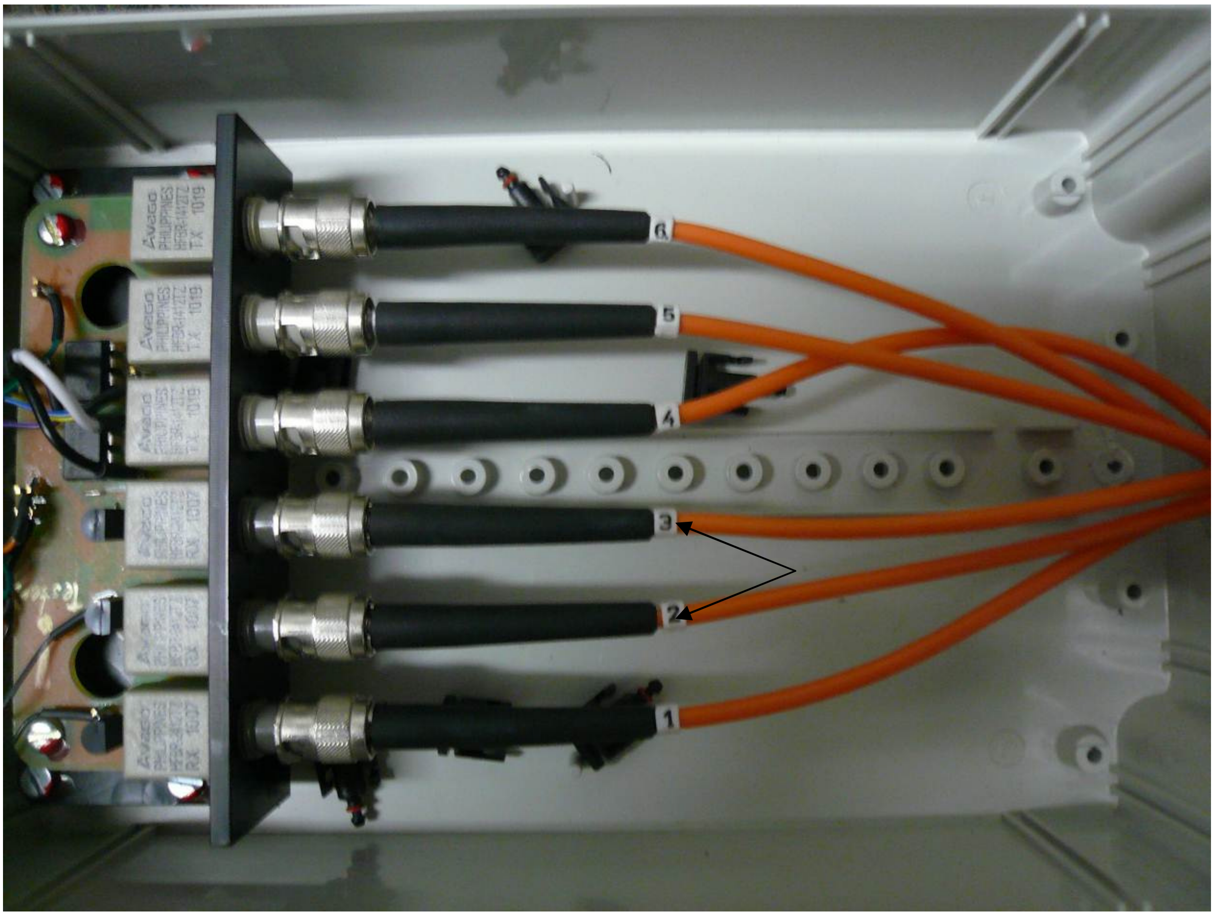


Fig.2.7.7: All 6 glass fibre lines connected with the converters sockets. Notice the numbering on each of the lines.

2.8. Electrical Connections

The radiometer power cable is split into AC1 (supply for radiometer, blue) and AC2 (supply for blower heater module, yellow). AC1 can be buffered via a UPS system (see Fig.2.8.1) in the range 100-240 A/AC, 50-60 Hz. AC2 must be connected directly to a power outlet at 220 V/AC or via a 110-to-220 V transformer to a 110 V/AC power outlet. The heater will not be damaged if it is connected to a 110 V/AC line, but the heater power is reduced from its standard 1800 Watts down to 450 Watts in this case. 450 Watts of heater power is not efficient enough for drying the microwave window. For 110 V/AC outlets, it is therefore recommended to use a transformer to produce 220 V/AC to power the heater.
The fibre optics data cable is more sensitive to mechanical stress than a usual copper cable and in the case of damaging, it needs to be repaired by a specialist. Certain treatments of the fibre optics cable should be avoided in order to maintain the functionality of the cable (see Fig.2.8.2), like pulling the cable with strong force or like stepping on it. Older radiometer versions are equipped with a 6-line cable which has to be connected to a special RPG-FO-RS-232 converter box (see section 2.7). The new version is a 2-line fibre cable which is connected to the host PC via a commercially available converter.

Fig.2.8.1: Summary of Connections

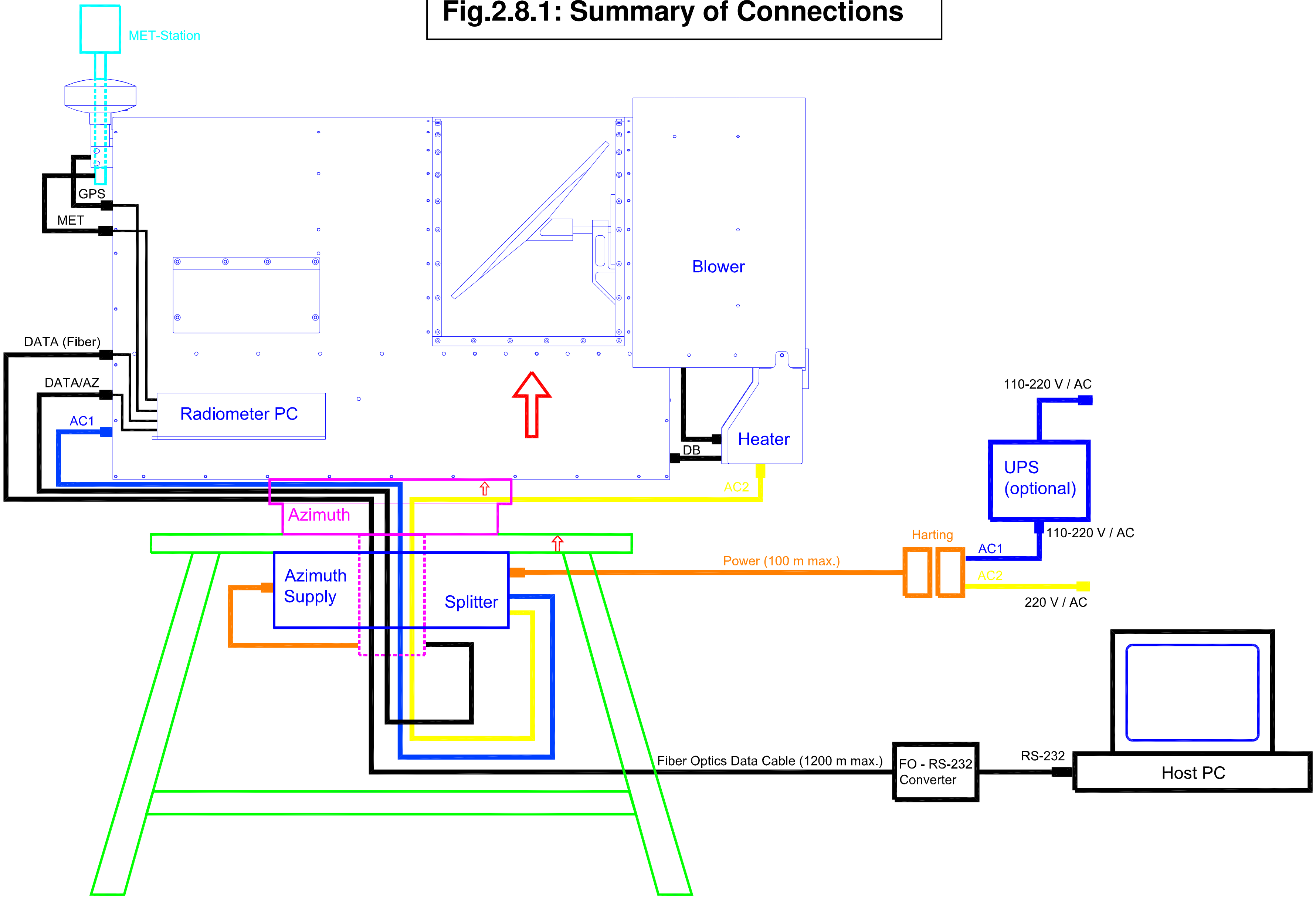



Fig.2.8.2: Avoid loops in the fibre optics cable. The curvature radius should not be less than 5 cm. Crossings of cables can lead to cable damage when stepping on it.

2.9 Recommendations for Viewing Directions and Angles

Fig.2.8.1 and 2.8.2 show the requirements for the free viewing ranges. When sky-dip (tip curve) calibration is enabled, the radiometer performs an elevation scan from zenith to 20° elevation. No obstacles should be in that viewing range to ensure a good calibration.

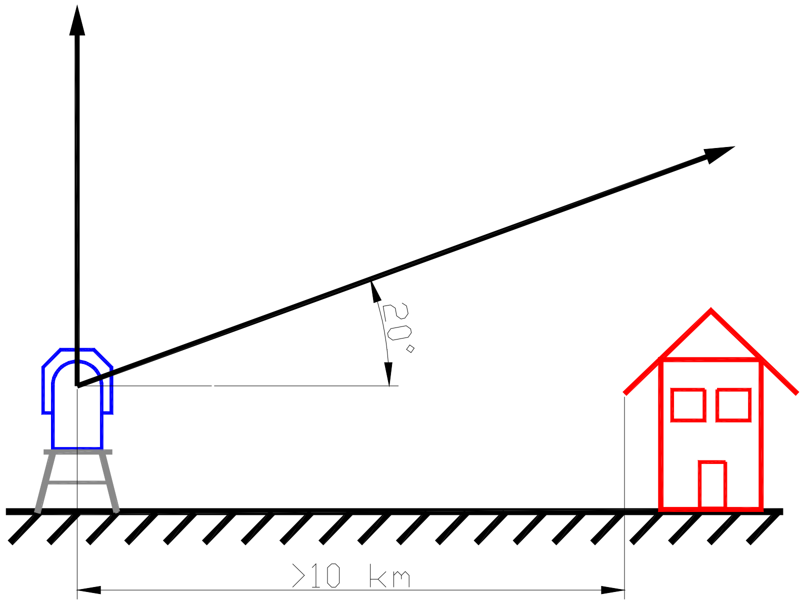


Fig.2.8.1: Tip curve calibration viewing range.

For boundary layer temperature profiling the instrument performs an elevation scan between zenith and 5° elevation angle. No obstacles should block the beam within a distance of 1 km.

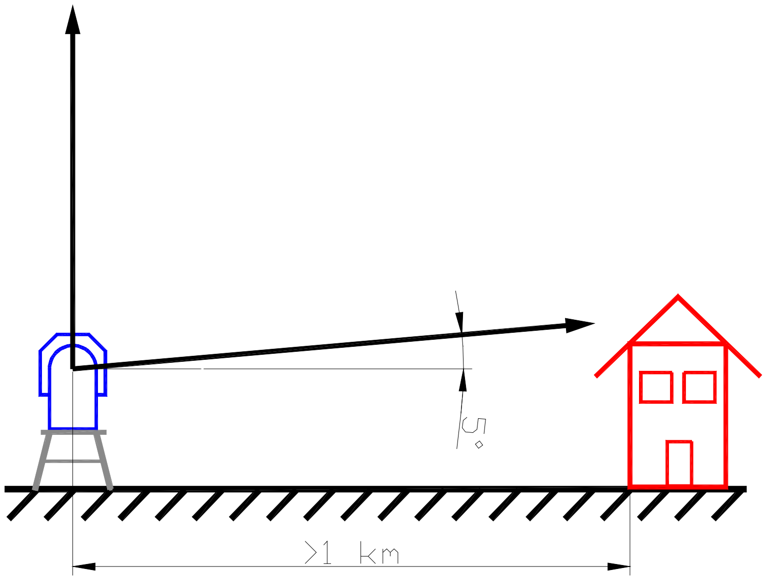


Fig.2.8.2: Boundary layer scan viewing range.

3 Quick Start Guide

This guide is meant to explain how to switch on the instrument and execute pre-defined measurements, and reversely terminate measurements and switch off the radiometer.

All details about how to define measurement modes, using the operating software, handling the data etc. is beyond the scope of this manual and will be covered in the software reference manual.

3.1 Safety precautions

Before powering up any part of the hardware, it is important to consider guidelines for safe operation (meaning the instrument as well as the operators). In addition to the guidelines given here, the user should use **common sense** precautions to prevent damages to personnel and equipment.

3.1.1 Safety of the instrument

The radiometer should be handled with the same care as other electronic equipment. The radiometer shall be protected from fire, over voltages (e.g, lightning or malfunctions in the electric networks), falling/flying objects (debris during hurricanes, typhoons, and tornados), physical forces, shock and vibration at levels which would be harmful to computer hardware or other sensitive electronic lab equipment.

The safe environmental parameters for **transport and storage** are:

Parameter	Range
Temperature	-40 °C to +50 °C
Humidity	1% to 100% relative humidity
Pressure	300 hPa to 1300 hPa
Vibration	< 10 g acceleration
Shock	< 20 g acceleration

The safe environmental parameters for **operation** are:

Parameter	Range
Temperature	-40 °C to +50 °C
Humidity	1% to 100% relative humidity
Pressure	300 hPa to 1300 hPa
Vibration	< 1 g acceleration
Shock	< 10 g acceleration

The warranty of the instrument is void if the instrument will be opened, or if the electronics parts inside the instruments are modified, or if the cables are not handled properly, or if the connection to power supply and data interfaces is not according to the specified standards (the power supply should be 100 V to 230 V/AC with 50 to 60 Hz).

Any malfunctions and failures arising from operating the radiometer and its accessories (including cables and controlling host PC) outside of the specified environments, are not covered by the instrument warranty. Damages (and consequential damages) from either violating the radiometers physical and electrical integrity, or arising from third parties (including animals, e.g. bird attack to the microwave window) are not covered by the radiometer warranty.

3.1.2 Safety during liquid nitrogen calibrations

During liquid nitrogen (LN2) calibrations, all persons handling the LN2

- shall be trained in the handling of LN2
- shall wear suitable protective gloves
- shall wear protective glasses / goggles
- shall wear a protective apron

Failures to comply with these safety measures result in a significant risk of freezing injuries from the cold temperature of liquid nitrogen (close to -200 °C).

3.1.3 Safety considerations with moveable parts (azimuth, elevation)

In addition to the normal common-sense precautions when handling electric equipment and heavy equipment, the user needs to avoid injuries from moving parts. If the radiometer is equipped with the optional azimuth positioner, which allows rotating the whole instrument from 0° to 360°, all persons should stay away from the radiometer by at least one meter. This safety distance ensures that no one get his hands or similar in between the moving radiometer and the non-rotating instrument stand.

3.2 Power up

After successful installation (including the wiring, power and data connection), the instrument needs to be turned on. The main switch is located In the lower left corner of the radiometer's side wall, see Fig.3.2.1.

Fig.3.2.1: Radiometer power switch in OFF position.

After turning the switch to the ON-position, the radiometer initializes all interfaces. If an azimuth positioner is installed, the table will turn to its zero index position. Also the microwave mirror inside the radiometer box is adjusted. The motor movement can usually be heard when standing close to the radiometer. The blower, which can run on two speeds, will shortly be switched to full power mode during the initialization phase.

Once powered up, the radiometer enters into the temperature control loop for stabilizing the receiver board temperatures. It is recommended to keep the radiometer switched on and thus in temperature stabilized conditions at all times. The hardware is designed in such a way that we expect it to operate for years uninterrupted. The only reason for switching it off is a severe damage, water in the radiometer, problems with the power supply or for transportation purposes.

3.3 Connect Host to Radiometer

After switching on the radiometer, the control software needs to be started on the host PC.

When clicking on the desktop icon  to start the host software, the following introduction window appears:

It displays the current version number, a few examples of instrument deployments, a list of supported RPG radiometer models and (in red) a hint to press <ESC> if you want to change some of the starting configuration settings (black arrow). By pressing <ESC> during software start, the user enters a menu where he can overwrite some settings of the automatically loaded configuration file ***R2CH.CFG***. This can be very useful, e.g. when the host software is configured for 'Auto Connect' in auto start mode (see below) but the user wants to change a serial port or the radiometer has been turned off.

The program first tries to locate a free RS-232 host serial port and a data cable connected to one of them. If it does not find a data cable, the message ***The specified port in 'R2CH.CFG' has no data cable connected to it!*** is displayed as shown in Fig. 3.3.1. This message refers to the file ***R2CH.CFG*** (located in ***MY_DIRECTORY\RPG-XXX***) which is a configuration file that is loaded by ***the host software*** at program start. This file contains information (among other data) about the standard serial interface port used for the communication link to the radiometer.

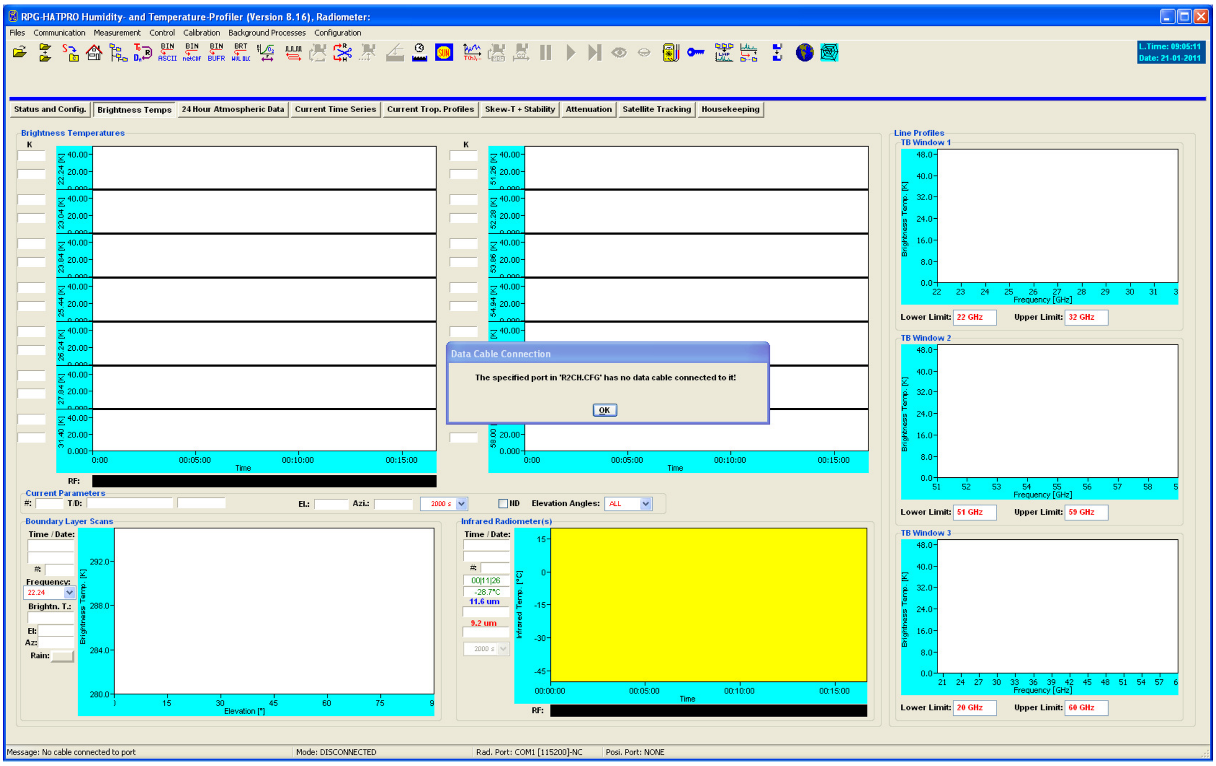


Fig.3.3.1: Starting host software without a data cable connected to any of the RS-232 interfaces.

If a data cable is installed between the host and the radiometer and the radiometer is turned on, the user has to define the serial interface parameters for the communication. This is done by clicking  (***Define Serial Interface***). This command opens the menu in Fig.3.3.2. The selectable COM-ports are enabled in the upper button list. The user can only select one of the available ports for interconnection with the radiometer.

The baud rate parameter defines the communication speed. For copper cable lengths up to 50 m and for fibre optic cables, the highest baud rate should be used (***115200***). Select the COM1 port in the ***Master COM Port*** box if you have connected the fibre optics cable converter to COM1 of the host.

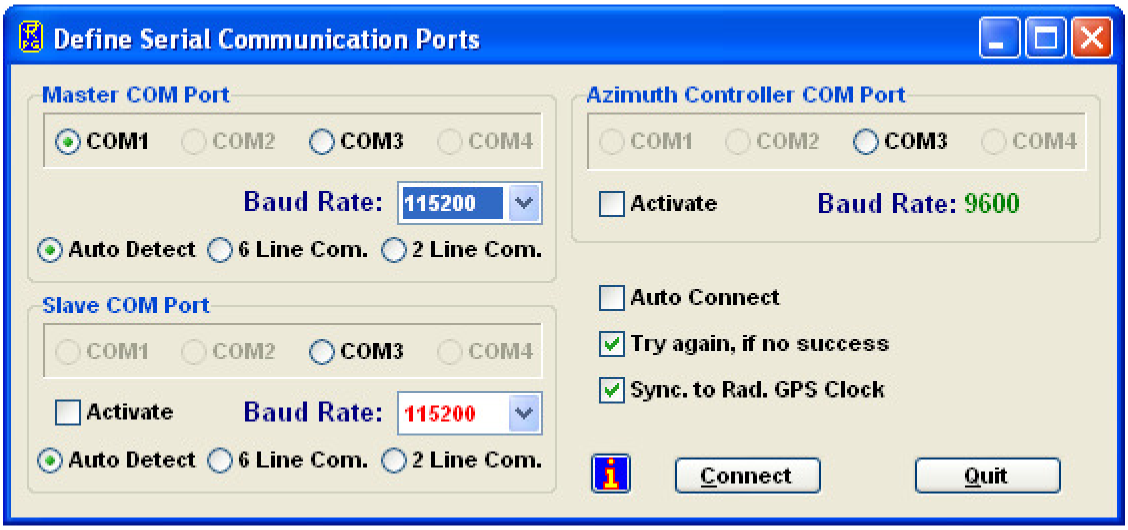


Fig.3.3.2: Serial interface menu.

If ***Auto Connect*** is checked, the host software automatically attempts to connect to the radiometer during the starting phase (if a data cable is detected). This feature enables an auto-start up function after a power failure of the host PC.
Fibre optics cables are available in two versions:

- ***6 line fibre optic cable***: This cable provides double hardware handshaking for maximum transfer speed. A special RPG made RS-232 to fibre converter has to be implemented with this cable type. A disadvantage is that commonly available RS-232 to USB converters cannot be used on the host, because such devices only offer poor speed grades for handshaking lines. Instead, if the host motherboard does not provide a serial port, an extension card must be installed (e.g. PCMCIA or Express Card on laptops) that connect to the 6 line RS-232 to fibre converter. Maximum cable length is 2000 m.
- ***2 line fibre optic cable***: No hardware handshaking is implemented for these cables, only TX / RX in combination with an optimized software handshaking. The communication with the radiometer is only slightly slower compared to the 6 line version which can be neglected. An advantage of the 2 line cable is that it can be interfaced with any type of commonly available serial converters (e.g. USB, PCMCIA, Express Card) and commercially available serial to fibre converters (most of them only support TX / RX communication).

For new radiometer installations, check the radio button ***2 Line Com.***, no matter which type of cable you have installed. Even with a 6-Line cable, the radiometer is then only using two lines of it.

The sequence for setting up a communication link to the radiometer is the following:

- Install the interface cable between host PC and radiometer.
- Turn on the radiometer power.
- Wait for 1 minute until the radiometer PC has booted up and the elevation mirror has moved to its index position (the mirror movement is quiet, but easily audible).
- Start the host software (if not already done) and define the serial interface parameters as described above (if not already done in a previous session).

- The next step is to initiate the communication between the host and radiometer PC by pressing (***Connect to Radiometer***). If successful, the message ***Connection to radiometer successfully established. Baud Rate adjusted.*** is displayed. Otherwise the message ***Radiometer does not respond! Connection could not be established...*** appears. In this case try the following to handle the problem:
    - Repeat the command.
    - If not successful, check the data cable (is it properly connected to host and radiometer?).
    - Check that the radiometer power is turned on.
    - Repeat the turn on procedure.
    - If not successful, contact RPG.

3.4 Sending a Measurement Definition File

The details of how to define a measurement definition file (MDF) are not explained in this manual. Please refer to the software manual for more information about MDFs.
In the following, we assume that a valid MDF file is already defined and stored to a directory on the Host PC.

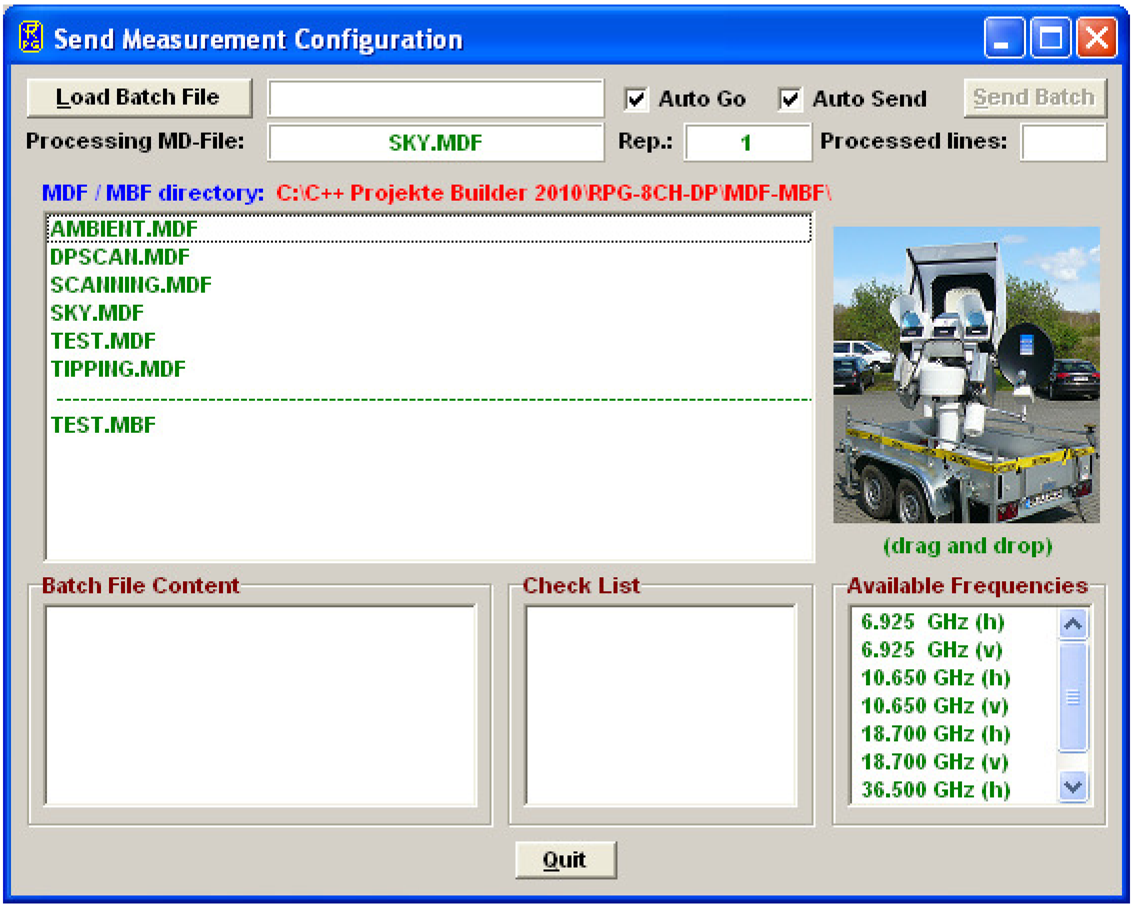


Fig.3.3.3: Menu for sending an MDF to the radiometer.

In order to send a MDF to the radiometer, click the button (***Send Measurement Configuration***). The menu in Fig.3.4.1 is shown.
Check the two checkboxes ***Auto Go*** and ***Auto Send*** and mark one of the MDF files listed in the MDF list. Drag and drop it to the radiometer image on the right. The measurement will automatically start.

When an MBF is loaded (***Load Batch File***) its contents and repetition factor are displayed. In addition some pre-checks are performed, e.g. correct radiometer configuration, frequency list consistency, etc. A variety of other checks ensure that no erroneous command data is sent.
When the consistency check of a MDF is finished, the test result is displayed in the ***Check List***. The batch can only be sent to the radiometer if all consistency checks have finished with the status OK. Then the MBF is transmitted with ***Send Batch to Radiometer***.

3.5 Browsing Through the Measurement Displays

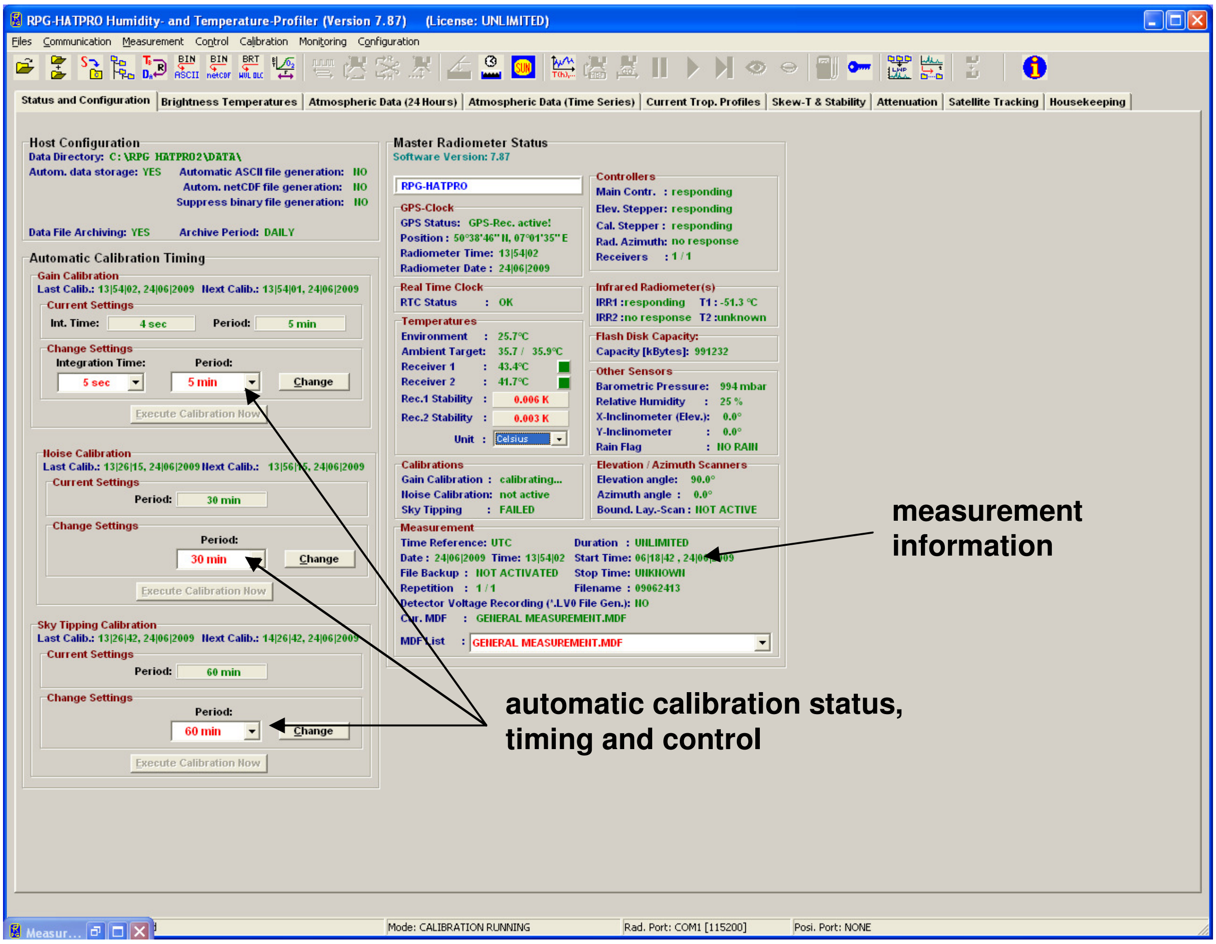


Fig.3.5.1: Radiometer status, measurement configuration and automatic calibration display.

The monitoring of the products that were selected in the MDF is automatically activated and the measured data is displayed. Since the data is transmitted online from the radiometer to the host, no additional file transfer is required afterwards.

The data display is grouped into different tag fields that can be freely selected.

Status and Configuration**:** This group includes the status display of the radiometer and measurement information like the current processed MDF, current data filename, activation status of file backup and level 0 data storage, start and end time, etc. In a second box, the settings for the automatic calibrations are displayed (**Automatic Calibration Timing**). These settings, like calibration period and integration time, can be changed ‘on the fly’. Each calibration is performed automatically but there is the possibility to enforce a calibration by clicking the associated ***Execute Calibration*** button.

Brightness Temperatures: All brightness temperatures, at both microwave and IR frequencies, are displayed in this group.

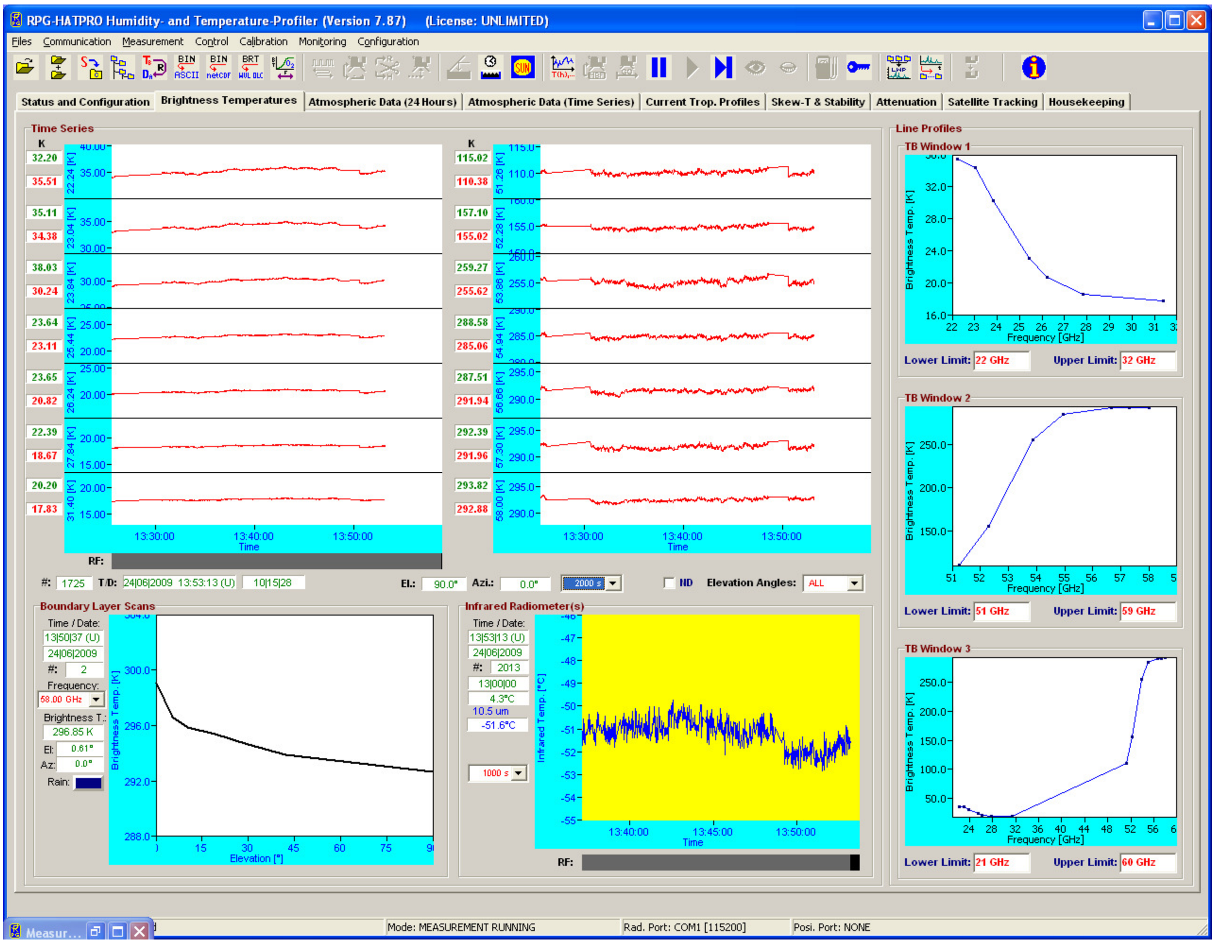


Fig.3.5.2: Brightness temperature information.

The display includes the time series of each available microwave and IR channel, the boundary layer scan information and the line profiles, if applicable (e.g. the water vapour and oxygen lines). The three **TB Windows 1-3** each show a subset of the microwave channels that is defined by entering the Low Limit and High Limit of the displayed frequency range.

Time series graphs can be changed by selecting a different time axis period from the time axis selection box.

Atmospheric Data (24 hours): A 24 hour history of IWV, LWP, meteorological sensors and profiles is continuously updated in this group. The IWV, LWP and sensor data displays can be individually changed to a 3, 6, 12 or 24 hour history. In the profiles boxes, color scales, vertical axis limits and contour values may be changes for the data monitoring. The humidity profile window has a selection button for displaying absolute or relative humidity.

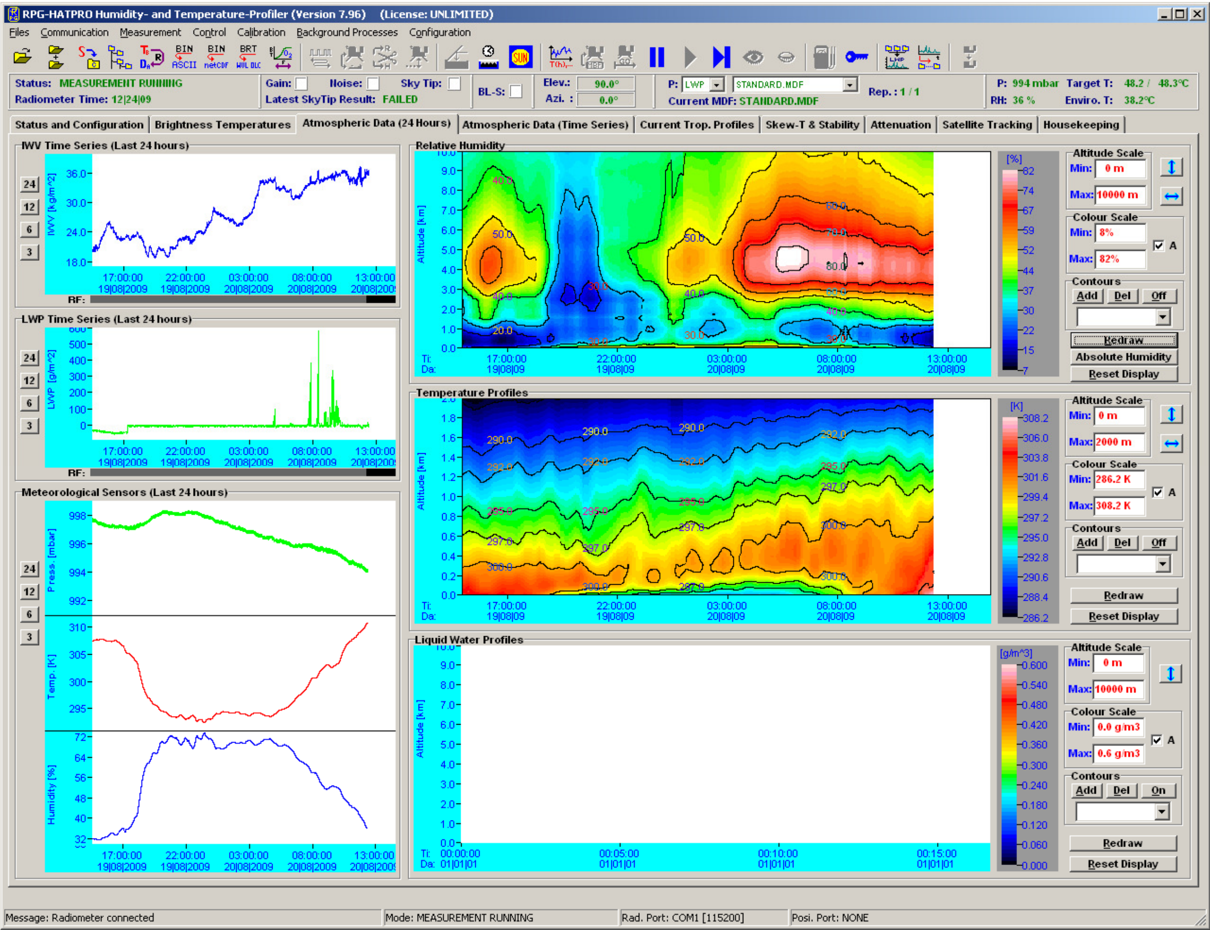


Fig.3.5.3: 24 hour data history display.

Atmospheric Data (Time Series): This group includes time series of liquid water path (LWP), integrated water vapour (IWV), cloud base height (CBH) information and the surface sensors (temperature, rel. humidity and barometric pressure). CBH data is vailable for all temperature profiling radiometer models (RPG-HATPRO, RPG-TEMPRO, RPG-TEMP90) if the IRR option is installed. LWP, IWV and CBH are retrieved data products and are therefore quality checked. The quality level (High, Medium, Low) and the possible reason for reduced data quality is shown below the time series charts. All time series include a rain flag display. Each window displays the current reference time, date, sample number, sample value, retrieval type (if applicable) and cursor position (when the mouse cursor is moved into the display area).

Current Trop. Profiles: The group summarizes all available profiles. There are three temperature profile displays, one for the boundary layer scan (TPB) with high vertical resolution (range 0-2000 m), one for the zenith observation (TPC, full troposphere profile with coarser resolution in the boundary layer) and one for the composite profile (CMP.TPC). The composite temperature profile is a combination of the high vertical resolution boundary profile and the full troposphere profiles. Both profiles are linked together at the 1200 m altitude level by applying a cubic spline fit. The temperature profiles are in blue color while the dew point temperature profiles are in green. Dew point information is only available (and displayed), if the radiometer is equipped with a humidity profiler. Absolute humidity and dew point temperature are only different versions of the same information content. Like with all temperature displays, the temperature axis can be scaled to Celsius, Fahrenheit or Kelvin.

On the bottom of the screen the diagrams for absolute humidity (HPC), relative humidity and the liquid water profile (LPR) are shown. The LPR data product is automatically generated when the products LWP, IWV and IRT are selected in the MDF product list and a retrieval for the maximum LWC is installed in the LWP retrieval directory (must have the same retrieval filename as the LWP retrieval but starting with 'LWM' instead of 'LWP'). X-axis: LW-density [g/m^3], Y-axis: altitude [m].

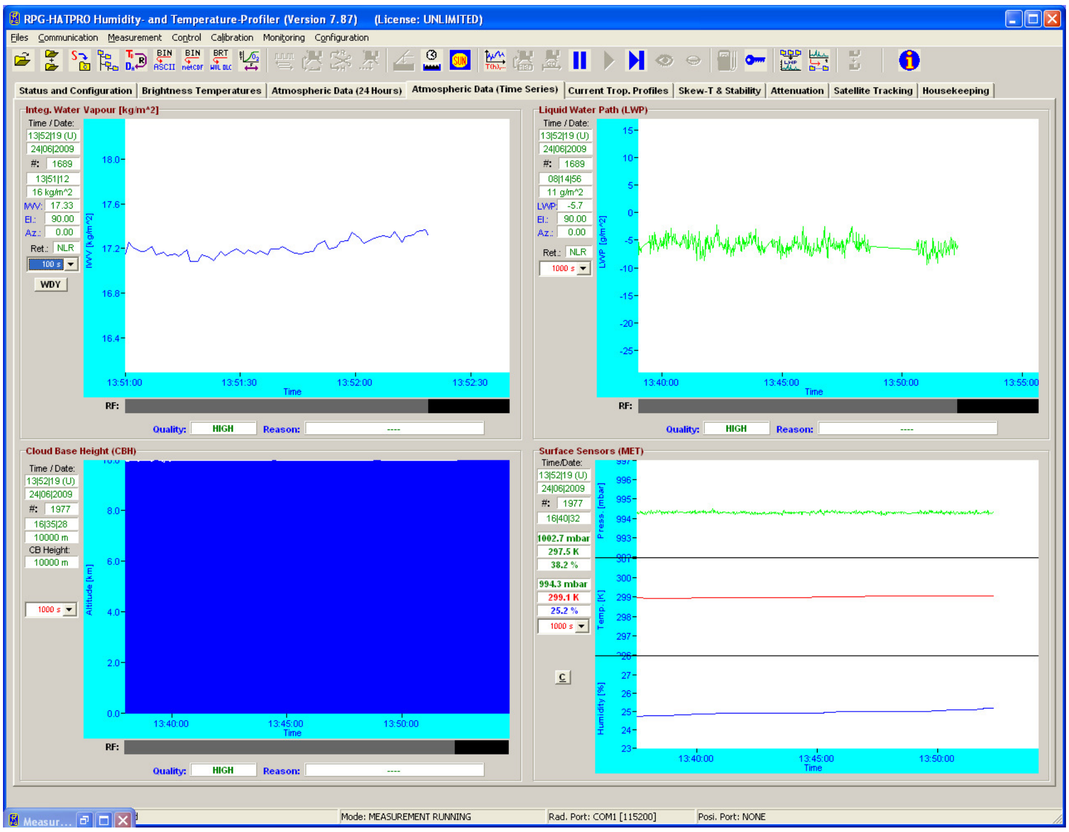


Fig.3.5.4: Time series of atmospheric data like IWV, LWP cloud base height and sensor data.

Scew-T & Stability: This group includes a skew-T and a stability index display. Six of the most common stability indices (lifted index, K-index, KO-index, Showalter index, CAPE index, total totals index) are monitored. X-axis: measurement time, Y-axis 1: [K] index, Y-axis 2: CAPE index [J/m^3].

The skew-T plot is automatically generated when temperature and humidity profiles are sampled. Also the stability indices are computed and stored in files of extension '.STA'. The displayed temperature and dew-point profiles can be analyzed graphically by using the cursor on the skew-T chart. The cursor coordinates, P and T, are monitored as the cursor is moved across the diagram. Other useful information like the LCL (Lifted Condensation Level) and LFC (Level of Free Convection) is marked on the Skew-T.

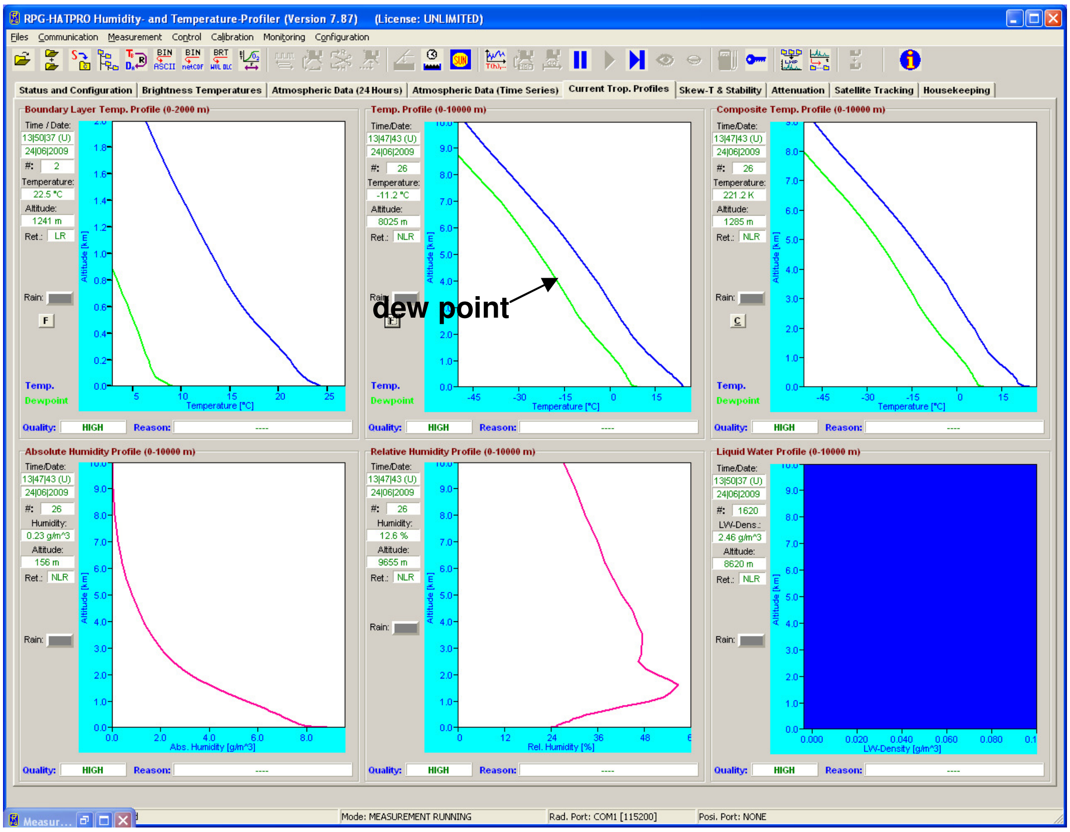


Fig.3.5.5: Atmospheric profiles display.

Attenuation: This display is similar to the brightness temperature diagram and monitors the time series of atmospheric attenuation. The vertical axis unit is dB as the standard unit for damping parameters. The attenuation is only calculated for the microwave channels. The standard attenuation retrievals are applicable for all elevation angles and can be used in scanning mode.

Satellite Tracking: If satellite tracking is enabled in the running MDF, the scanned satellite information, like satellite number, navigation file, satellite elevation and azimuth position, wet path delay and LWP along line of sight and atmospheric attenuation are listed for each scan.

Housekeeping: Data like GPS position, receiver stability, system temperatures (ambient target, receiver temperatures), flash memory capacity, quality flags and system status flags are monitored. By clicking the ***Legend*** button, the colour codes for the different flags are listed. An ALARM indicator warns the user if a systematic problem with the radiometer has occurred. A detailed description of housekeeping flags is given in appendix A18 of the software manual.

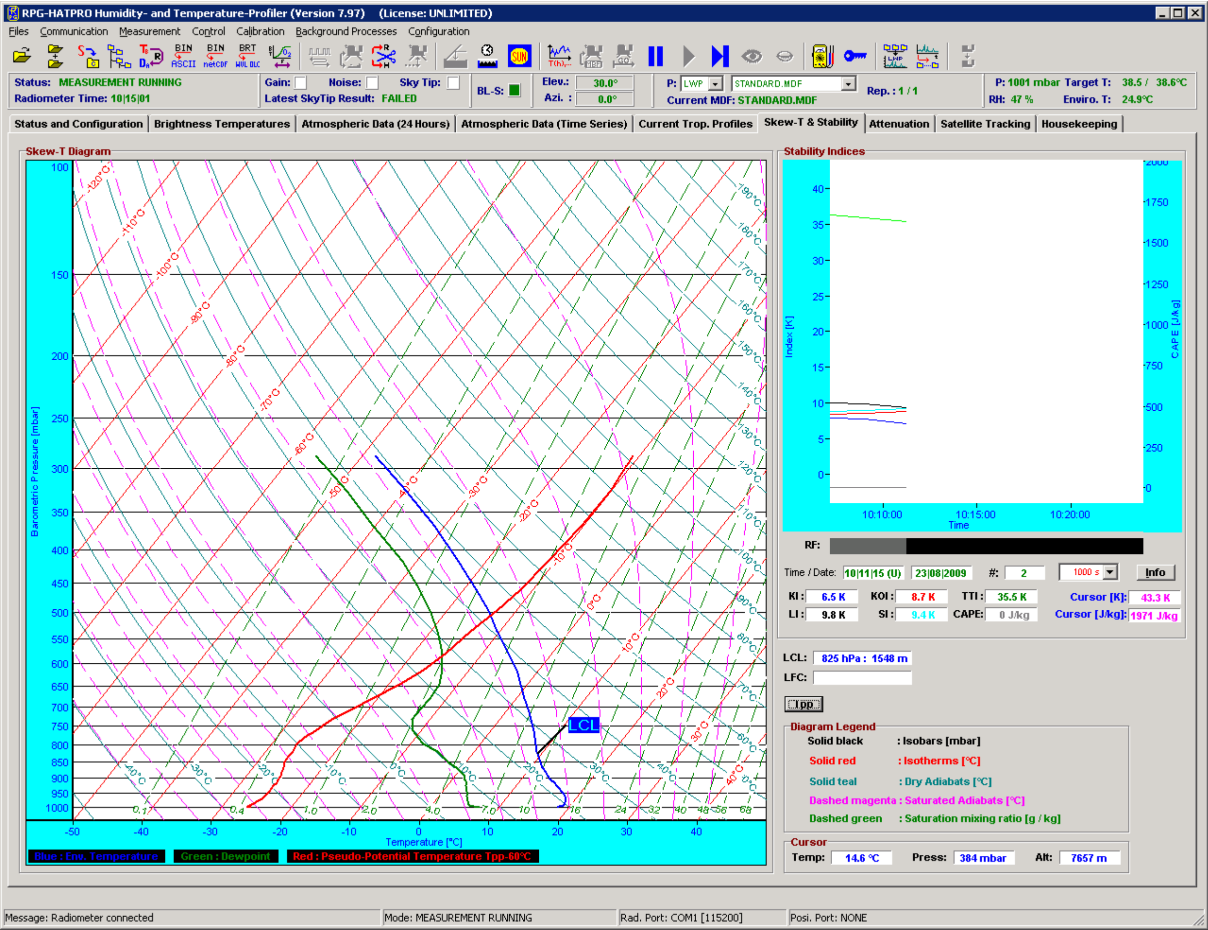


Fig.3.5.6: Skew-T diagram and Stability Indices display.

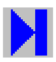
3.6 Starting/Stopping Measurements

 (***Halt Running Batch***)

A running measurement can be halted any time. This might be useful when e.g. the user wants to change the elevation angle manually. The status bar display changes to “MEASUREMENT HALTED”.

 (***Continue Interrupted Batch***)

Used to continue a halted measurement. The status bar display changes back to “MEASUREMENT RUNNING” and the manual control button is disabled.

 (***Terminate Running Batch***)

This command terminates the execution of the currently running batch. The radiometer switches to STANDBY mode and is ready to receive a new MBF.

4 Maintenance

4.1 Cleaning

RPG radiometers are designed to withstand all kind of weather and climate conditions. However, it is a good practice to prevent accumulations of dust, dirt, debris, salt (if located close to the sea), and other pollutants. Such cleaning is best done

- With pure fresh water (no chemical detergents, soap, solvent etc.)
- Without applying mechanical force, especially to the microwave window
- Just by watering and spraying gently to wash away the accumulated pollutants (and thus simulating a rain shower…)

The air inlets to the radiometer (at sidewalls of main housing) and the inlet of the dew-blower/heater device need to stay clear from larger scale size of debris.

In areas with extreme snow amounts and ice-rain, the radiometer needs to be checked for snow/ice obstacles which would prevent the moveable parts (if any, depending on the selected options) from rotating. This affects the azimuth positioner and the IR elevation scanner.

All these cleaning activities need to be carried out according to the demand generated by the specific local environmental conditions. The intervals vary from twice a year (during the recommended LN2 calibrations) to weekly or daily (on ships).

4.2 Software Upgrades

Assumption: You want to install a new radiometer software version (2CH.EXE) on the embedded radiometer PC and a new version of R2CH.EXE on the host PC.

1. Step: Save the old software versions

a) Create a directory to save the old software versions (e.g. C:\MyPath \SAVE).

b) Connect the host to the radiometer and enter the File Transfer Menu (, Fig.4.2.1). On the right side (Host) browse to the directory for saving the files (e.g. C:\MyPath\ SAVE) and on the left side (Radiometer) in the System Files Directory mark the 2CH.EXE file. Then drag and drop the 2CH.EXE file to the C:\MyPath\ SAVE directory to initiate the copy process.
c) locate the R2CH.EXE file in the MyPath\ RPG-HATPRO directory and copy this file to the C:\MyPath \SAVE directory (by using the Operating System Explorer).

2. Step: Overwrite the old versions by the new ones

a) Copy the new version of 2CH.EXE (the radiometer PC software) on an arbitrary directory on your hard disk (e.g. MyPath\RPG-HATPRO\Radiometer PC). Then enter the file transfer menu in Fig.4.2.1 and browse to that directory. Mark the 2CH.EXE file in the Files-list and drag and drop it to the System Files Directory list. Because you are now going to overwrite a file in the System Files Directory (which is password protected for write access) a password entry window pops up. Please enter the following password in exactly the way as it is printed here:

theringsofsaturn

Press OK and the 2CH.EXE on the radiometer PC will be overwritten by the new 2CH.EXE version. Exit the File Transfer Menu after that.

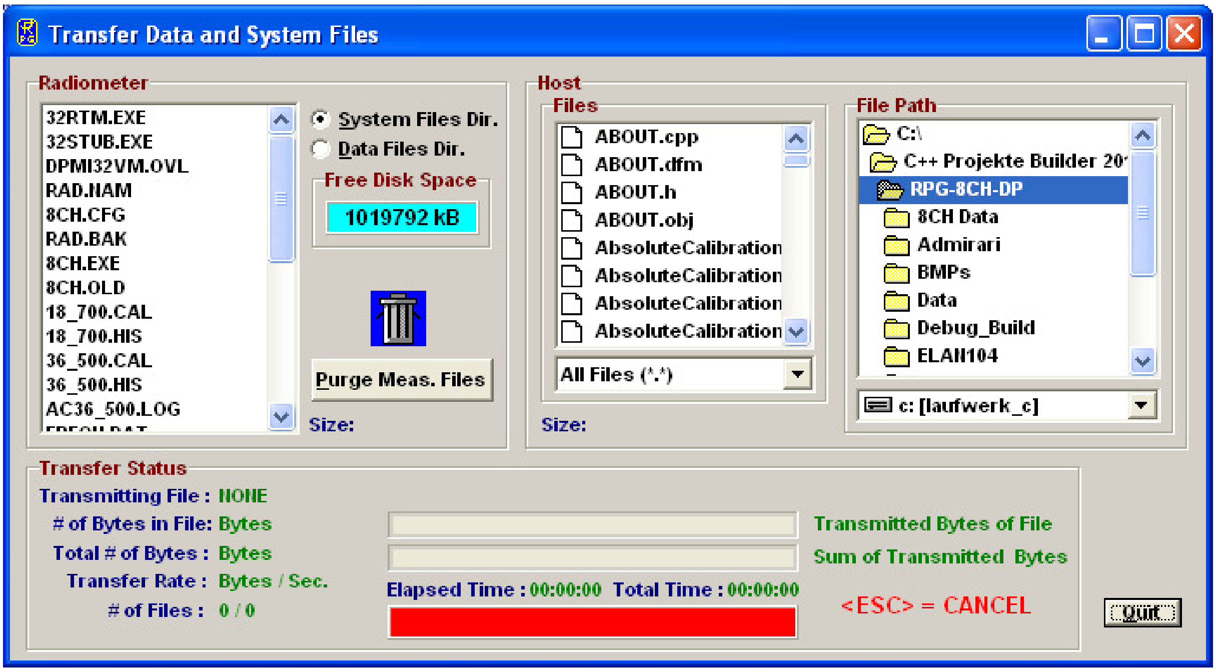
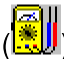


Fig.4.2.1: File Transfer Menu

b) Boot the radiometer PC to make the new 2CH.EXE the running version. You can do this by entering the Manual Control Menu () and selecting the “Radiometer System” tag. Press the “Reset Radiometer PC” button and confirm the command with YES. Wait for about 2 minutes to give the boot process time enough to finish.

c) Terminate R2CH.EXE and overwrite the old R2CH.EXE in MyPath\ RPG-HATPRO with the new version.

d) Execute R2CH.EXE to start the new host version and reconnect to the radiometer with .

The software upgrade is finished. You can confirm the successful upgrade by reading the software version numbers of both, the embedded radiometer PC (see main window radiometer status display) and the host PC (see main window caption).

4.3 Absolute Calibration Procedure

For the radiometer models RPG-15-90, RPG-HALO-KV, RPG-HALO-119-90 and RPG-HALO-183 an external ambient temperature target is used. Its physical temperature is measured by a certified thermometer, pushed into the foam pyramidal absorber.

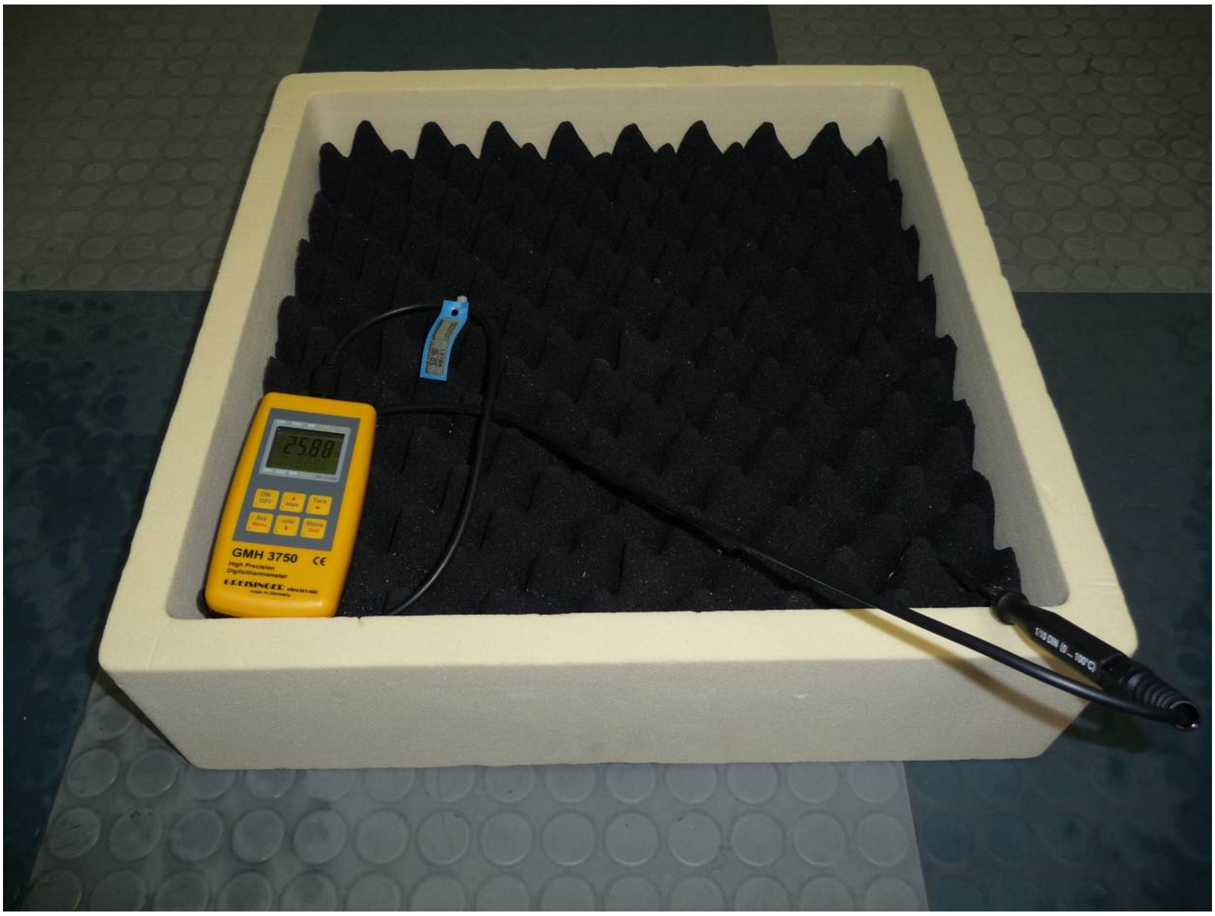


Fig.4.3.1: External ambient temperature target for models RPG-15-90, RPG-HALO-KV, RPG-HALO-119-90 and RPG-HALO-183.

4.3.1 External Liquid Nitrogen Cooled Calibration Target

An absolute calibration standard is the liquid nitrogen cooled target that is attached externally to the radiometer box (see Fig.4.3.2). This standard - together with the internal ambient load - is used for the absolute calibration procedure. The cooled load is stored within a 40 mm thick polystyrene container. 25 litres of liquid nitrogen is needed for one filling.

The described cold target is used for all profiling, LWP and Tipping radiometers. All other models are shipped with a target similar to the one for the ambient temperature calibration point shown in Fig.4.3.1.

4.3.1.1 Assembly and Mounting of the LN Cooled Target

The external absolute calibration target consists of a frame that holds the liquid nitrogen container and a 90° planar reflector.
The 90° planar mirror rests on two supports that have to be mounted to the target frame as is shown in Fig.4.3.3.

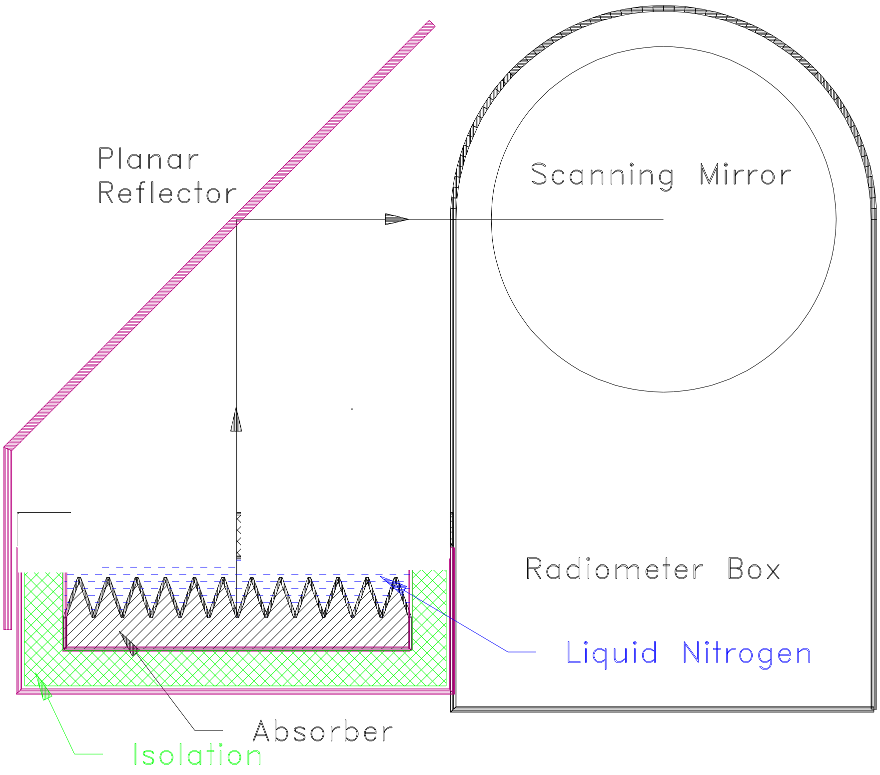


Fig.4.3.2: External cold load attached to the radiometer box.

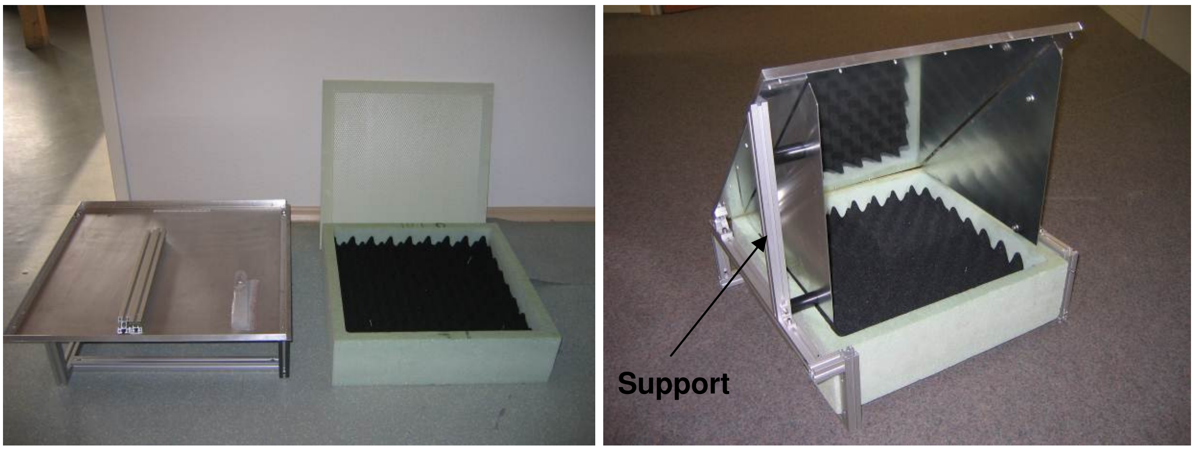


Fig.4.3.3: External absolute calibration target (cold load).

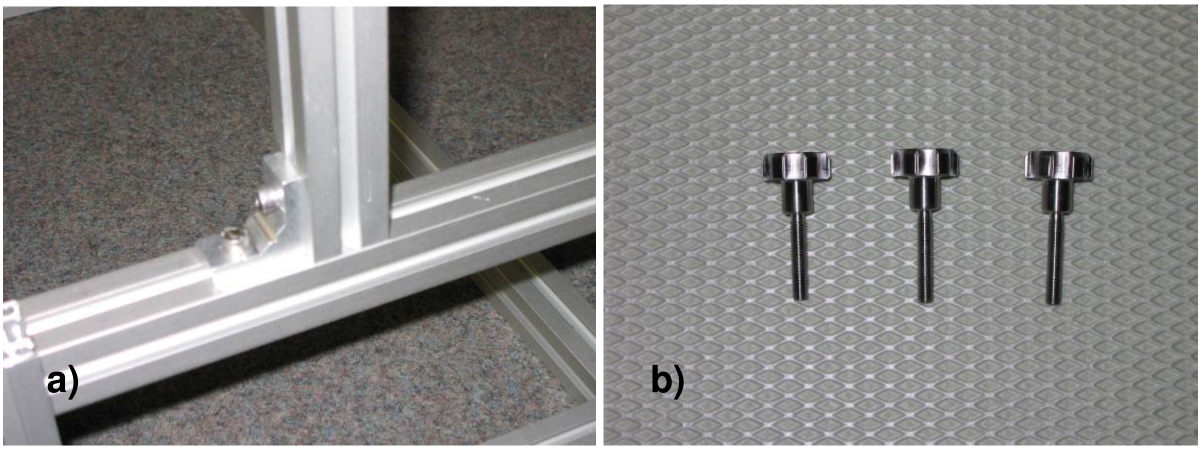


Fig.4.3.4: a) mounting the support posts to the target frame. b) Screws for mounting target to radiometer housing.

Fig.4.3.5: location of mounting screws for the target frame.

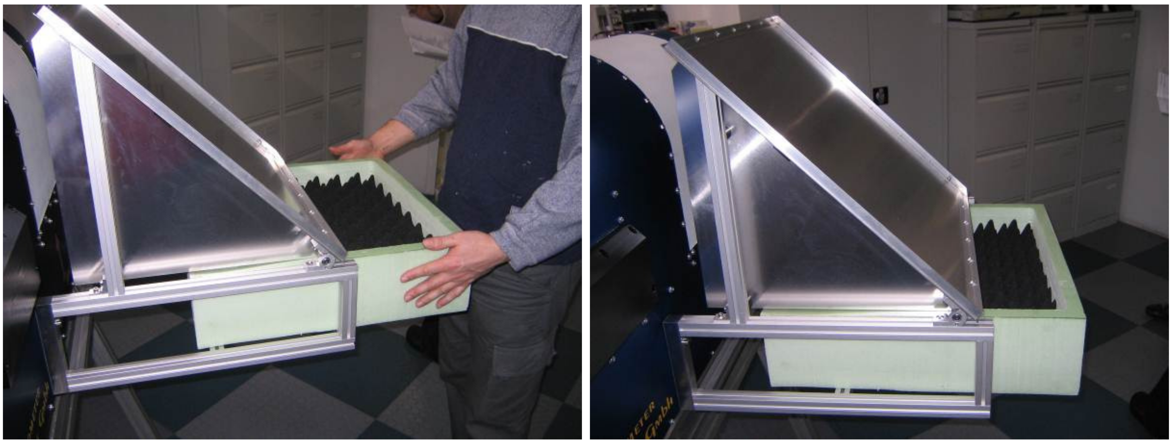


Fig.4.3.6: Pushing the target into the frame.

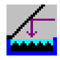
Once the target frame is set up it can be fastened to the radiometer housing. The target frame is mounted on the radiometer side marked with a red arrow (observation side). Two hand screws (from accessory box) are needed to do this (Fig. 4.3.5).

The styro-foam container is then pushed into the frame. Do not push the target completely into the frame to allow for filling the LN2 into it (Fig. 4.5.b). For filling the target with liquid nitrogen the following procedure is recommended:
Start with pouring the liquid nitrogen into the small Styrodur container included in the accessories. Then use the container to fill the target as indicated in Fig. 4.5.c. This is repeated 2-3 times until the target is filled to a level where the absorber tips disappear in the liquid. The target must then be pushed into the frame until it touches the radiometer housing (Fig.4.5.d).

Fig.4.3.7: Filling the target step by step.

Note: Handling liquid nitrogen without protection like gloves, goggles, aprons etc. is riskful and can lead to serious injuries. We strongly recommend to wear these protection items while doing the calibration. Only trained personal should be allowed to handle LN. Without wearing gloves, goggles and aprons the user is acting on his own risk.

Fig.4.3.7: Push the target to its final position.

After setting up the external cold target, an absolute calibration is initiated by clicking  (***Perform Absolute Calibration***) on the host PC. The menu in Fig.4.3.8 is shown, if the connected instrument is a profiling, LWP or tipping radiometer.

Start Calibration starts the absolute calibration procedure. During calibration the current activity is displayed in the message line. When the integration cycles have completed, the message *Calibration successful! Save?* is displayed and the user has to confirm to save the calibration with *Continue*. The absolute calibration parameters are then stored on the radiometer PC. Leave the calibration menu by pressing *Quit*.

Fig.4.3.8: Absolute calibration menu (profiling, LWP and tipping radiometers).

If the error message *No response to cold load. Calibration terminated!* appears, the cold target was probably not filled with liquid nitrogen or was not installed at all.

No noise diode response. Calibration terminated! indicates a malfunction of one of the noise sources. Contact RPG for help in this case.

For the radiometer models RPG-15-90, RPG-HALO-KV, RPG-HALO-119-90 and RPG-HALO-183 the absolute calibration menu looks slightly different:

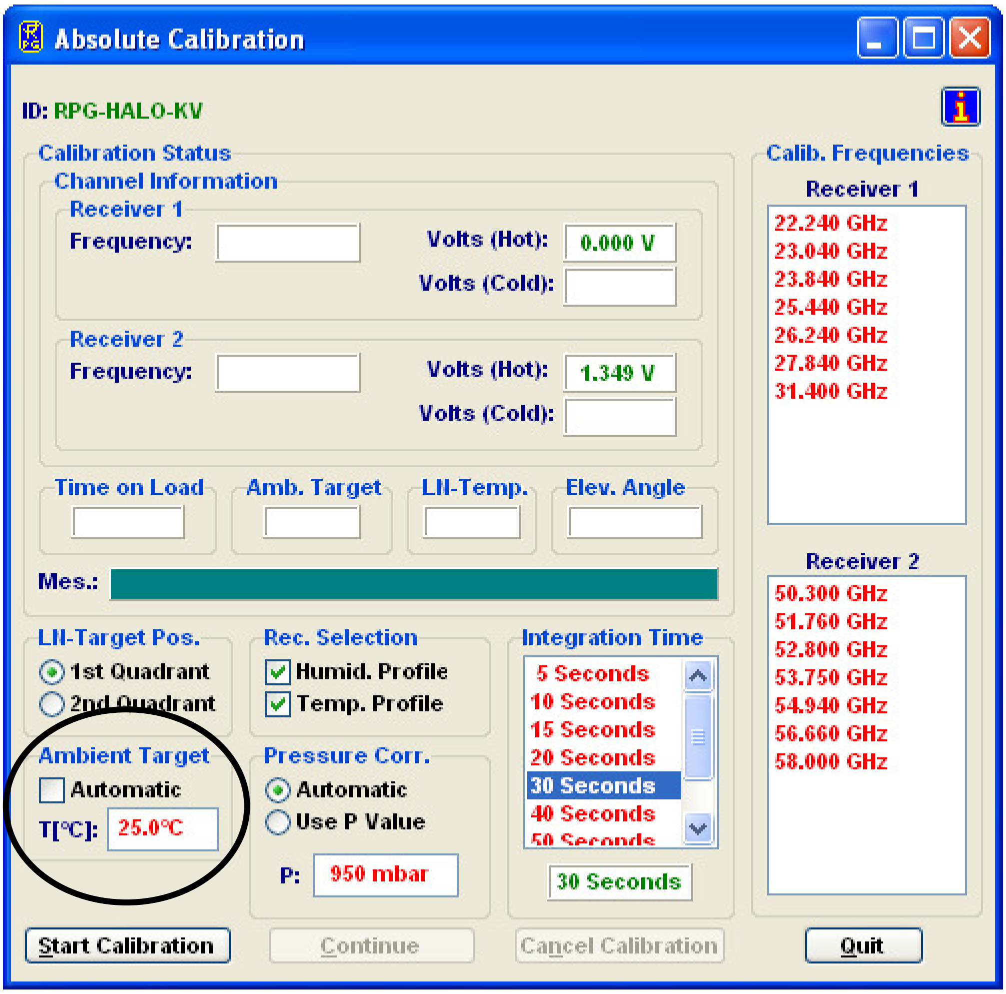


Fig.4.3.9: Absolute calibration menu (RPG-15-90, RPG-HALO-KV, RPG-HALO-119-90 and RPG-HALO-183 models).

It contains the additional box ***Ambient Target*** as indicated in Fig.4.3.9. As discussed in section 4.3, an external calibration target is used for models RPG-15-90, RPG-HALO-KV, RPG-HALO-119-90 and RPG-HALO-183, shown in Fig.4.3.1. The target temperature is measured manually by a precision thermometer and its value has to be entered in the edit box labelled ***T[°C]***. It is important that the checkbox ***Automatic*** remains unchecked. During the calibration, messages in the message box are displayed that prompt the user to change the targets from ambient to cold target.

When the calibration is finished and the target frame is removed do not forget to screw the protector caps into the open threads (Fig.4.3.10).

Fig.4.3.10: After the target frame has been unscrewed the open threads should be protected by plastic caps.

Except for the automatic calibrations performed by the instrument (following the settings of the measurement definition file (MDF)) a manual absolute calibration (using LN2) is required when the system is transported or turned off for a longer period (> several days). The calibration is started by pressing (***Perform Absolute Calibration***) from the host software (see Software Manual).

The absolute calibration should be repeated every 6 month to maintain measurement accuracy of the built-in noise standards.

4.4 Exchange/Replacement of Parts

The instrument user is expected to exchange spare parts, which are accessible from the outside (without opening the radiometer housing), by himself. These parts are:

- **Rain sensor**
- **GPS receiver**
- **External RH and T sensors or Weather-Station**
- **Radome window sheets**
- IR radiometers (if available, optional hardware)
- Weather station (if available, optional hardware)
- Azimuth positioner (if available, optional hardware)
- Dew blower unit
- Heater unit for dew blower
- Cables

Those parts not printed in boldface in the above list were handled during the installation process and are covered in the appropriate section of chapter 2. In the following, this maintenance guide will explain how to exchange those parts which are usually not handled during a standard installation procedure.

4.4.1 Changing the Rain Sensor

The sensor data connection needs to be dismounted by

1. loosening the connector screw of the cable connection
2. loosening the M4 mounting screws with a Torx tool (size 20)
3. detach the sensor

The replacement part is mounted by reversing the sequence of steps. In order to prevent damage to the cable connector, please comply with these rules:

- The pins usually fit easily into the socket of inside the radiometer wall. Do not apply force! If it does not go in easily, then there is some misalignment, canting, etc. Using force will destroy the pins and/or damage the socket
- The screw on the cable should only be fastened by hand, not with a tong

4.4.2 Changing the GPS Receiver

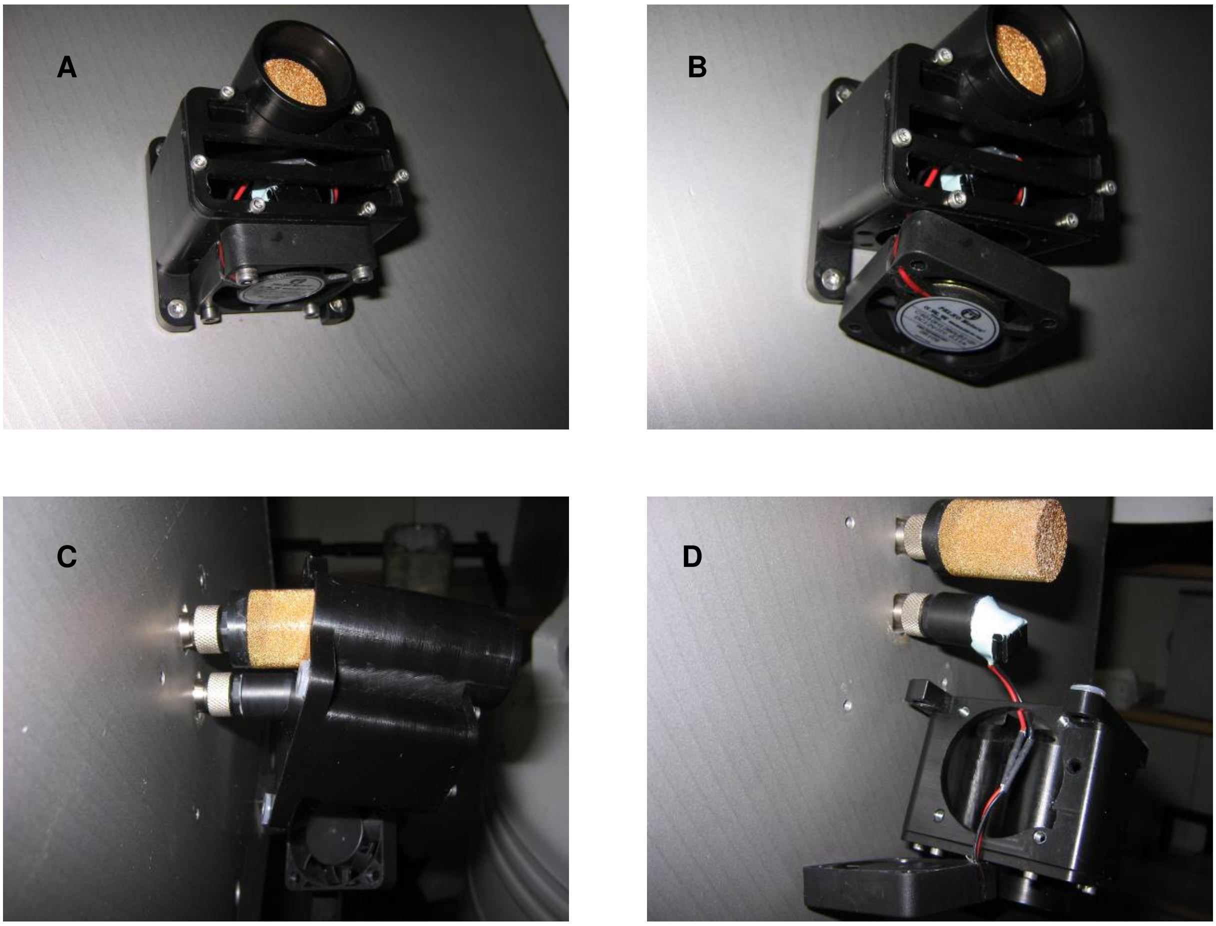
The sensor data connection needs to be dismounted by

1. loosening the connector screw of the cable connection
2. loosening the M4 mounting screws with a Torx tool (size 20)
3. detach the sensor

The replacement part is mounted by reversing the sequence of steps. In order to prevent damage to the cable connector, please comply with these rules:

- The pins usually fit easily into the socket of inside the radiometer wall. Do not apply force! If it does not go in easily, then there is some misalignment, canting, etc. Using force will destroy the pins and/or damage the socket
- The screw on the cable should only be fastened with the hand, not with a tong

4.4.3 Changing the Temperature and Humidity Sensors



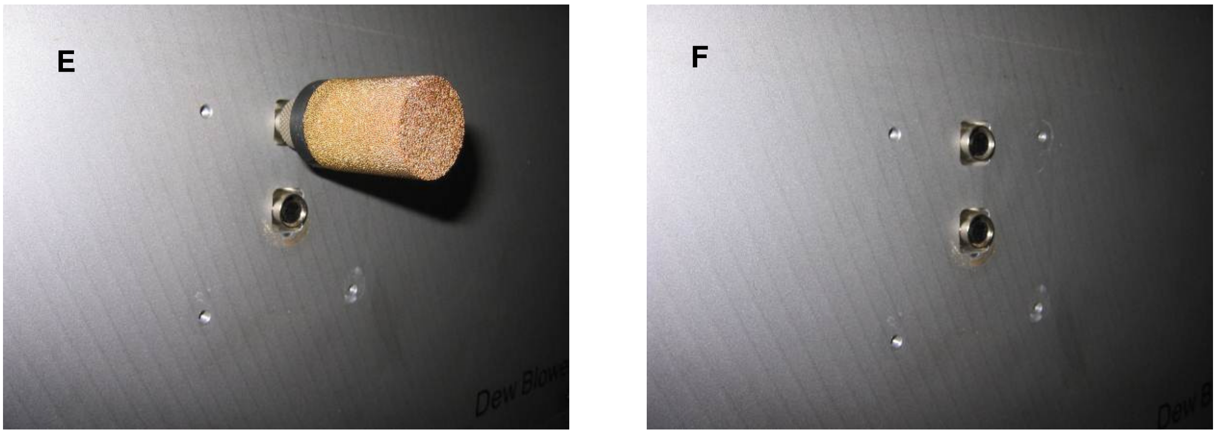


Fig.4.4.1: Dismounting the external surface sensors: A) Sensor cage below the dew blower. B) Unscrewing the T-sensor fan. C) Unscrewing the sensor cage housing. D) The humidity sensor (with gold plated cap) and the temp. sensor can be unscrewed by hand. E) Temperature sensor removed. F) Humidity sensor removed.

The external relative humidity and temperature sensors are field replaceable. In the following the process of how to exchange these sensors is described. New radiometer models are only equipped with a Meteorological Station and do not have extra temperature and humidity sensors.
Fig.4.4.1 describes how to take off the sensor cage and sensors. The replacement temperature sensor comes together with the sensor fan connected to it.

4.4.4 Changing the Microwave Window Sheets

4.4.4.1 Purpose of the Microwave Window

The microwave window sheets are made from a plastic foam material which is transparent in the microwave region to allow the reception of electromagnetic radiation in the otherwise metallic shielding of the instruments housing. The material has a thickness of 10 mm and serves as a rain protection and also thermal insulation layer. The sheets are covered with a hydrophobic coating which lets water drops roll off easily (in conjunction with the airflow provided by the blower system).

4.4.4.2 When to Change the Microwave Window

If one of the two functions of the window (protection from water, and avoidance of drops staying on the window) is no longer working because the window sheet is either physically damaged, or the coating has been worn off (by aging, salt and dust coverage, UV radiation…), then the window sheet needs to be changed.
Since 2006, all profiling and LWP type radiometers facilitate a radiometer shell with a window mounting which allows changing the window without disassembling the complete radiometer housing.

4.4.4.3 Window Changing Procedure

Before changing the window, make sure that you are equipped with sufficient tools. We recommend a Torxs-M4 (size 20) tool, a thread cutter, an Allen key (hexagon socket screw key) with a round hat, some lubricant/grease, and a carpet cutter.

In a first step, the old window has to be removed. Therefore, all M4 Torxs screws at the inside rows of screws (closer to the blue window, not the line of screws closer to the metal housing) have to be removed (Fig. 4.4.2 b). This way, the metal bands which press and hold the window sheet can be removed. If a screw brakes off, it has to be removed later by drilling it out.
In a second step, the threads inside the housing frame need to be prepared for re-mounting: All threads need to be cleaned from debris and lubricated with grease. A thread cutter is dipped into oil (WD-40) and then turned into each of the threads (Fig. 4.4.2 c)

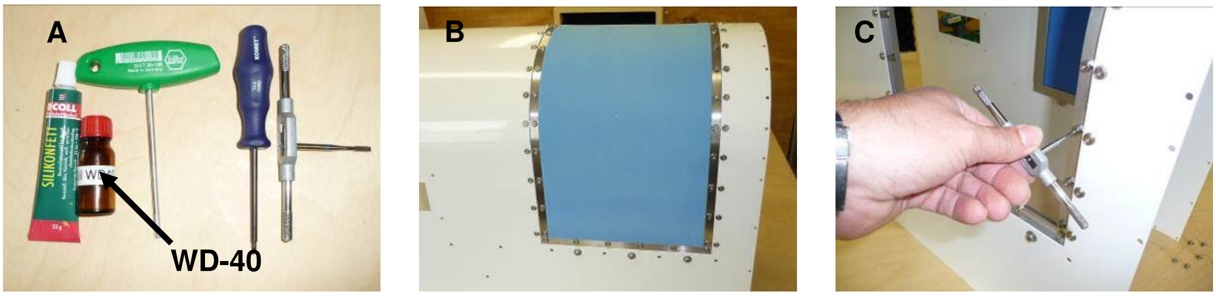


Figure 4.4.2 a, b, c

The metal bands for re-mounting the window sheet need to be arranged carefully to their respective positions since they are **not symmetric!** Figures 4.4.2 (d, e, f) show that the **smaller distance** between the holes and the edge of the strip located in the side of the **window**, the larger distance to the side of the metal housing.

Figure 4.4.2 d, e, f

The mounting procedure starts with placing the replacement windows with the already existing triple set of holes symmetrically over the topmost thread in the radiometer housing (Fig. 4.4.2 g). The metal strips are placed over the window sheet and fixed by fastening the Torx screws as shown (Fig. 4.4.2 h and i).

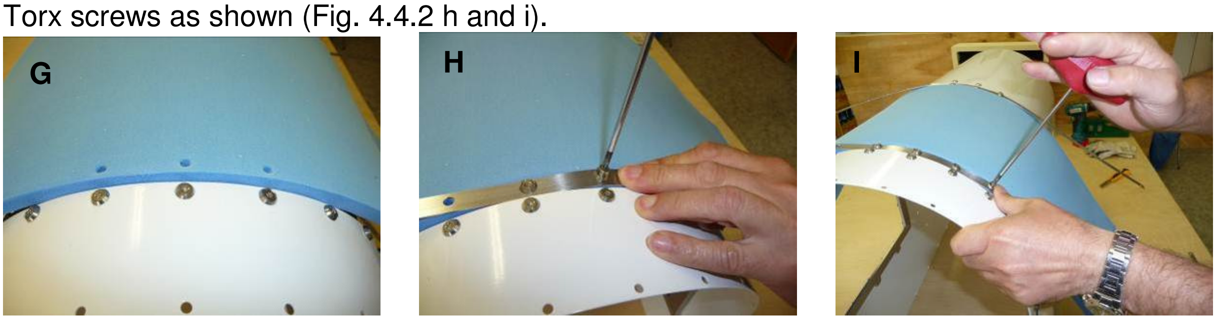


Figure 4.4.2 g, h, i

A small Allen wrench (size M3) is used to punctuate the window sheet material at the position of the next holes (Fig. 4.4.2 L). While working from screw to screw from top down to the lower side of the housing, some force needs to be applied to pull the metal bands tight and apply enough pressure to squeeze the window material into position (Fig. 4.4.2 m, and o).

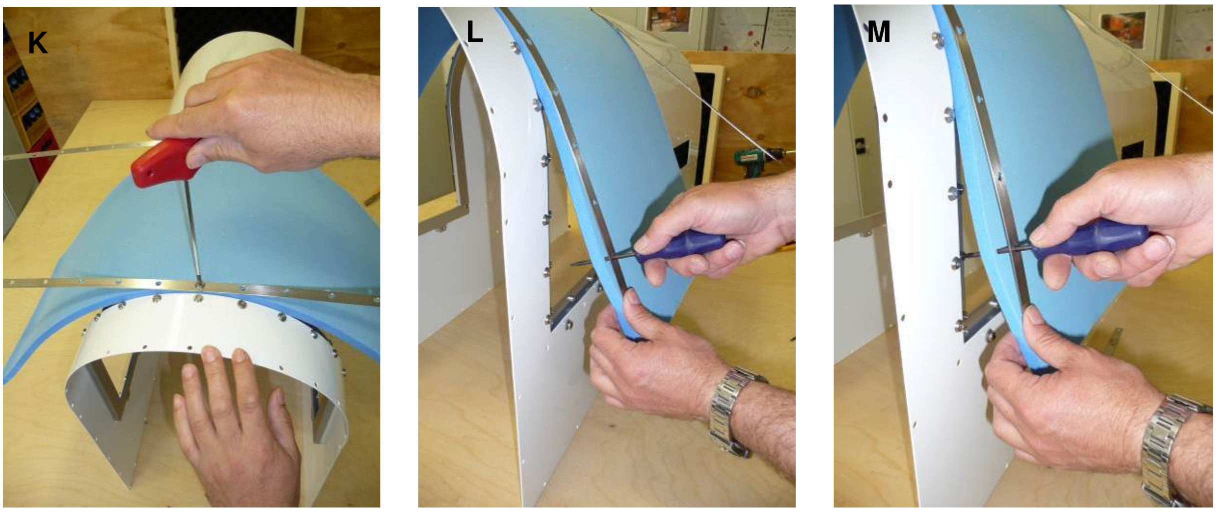


Figure 4.4.2 k, l, m

This pulling of the metal bands is best done with a small Allen wrench, putting the head into the holes of the mounting threads as a counter bearing (as a toe hold). The tool should have a round head, so that the thread is not damaged.

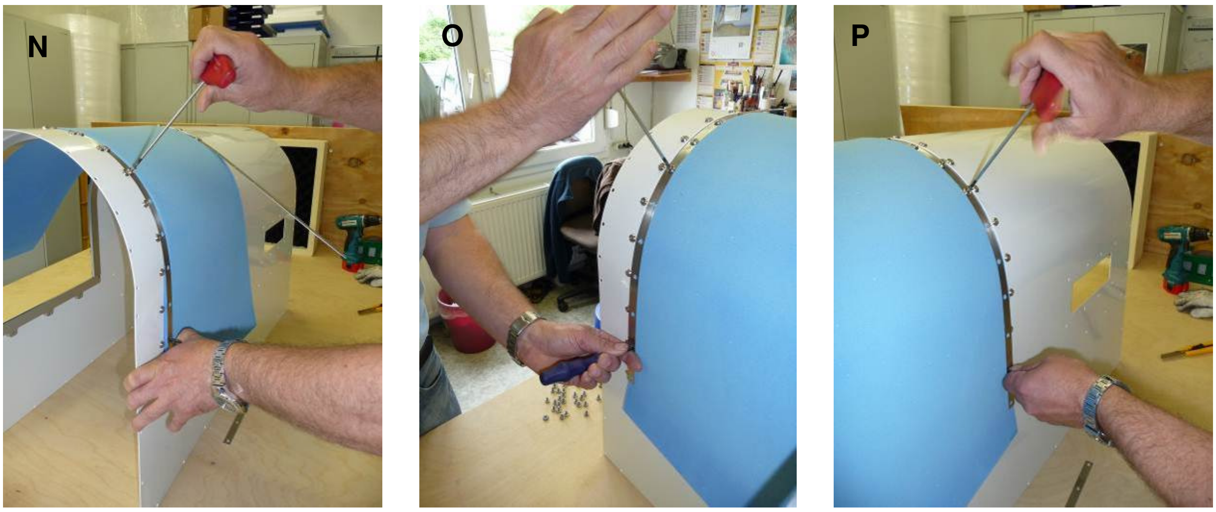


Figure 4.4.2 n, o, p

After applying the two longer metal strips over the arch of the radiometer housing (Fig. 4.3.2 p)., there will be extra material of the window sheet at both lower side which needs to be cut off and removed. Figures 4.3.2 q, r, and s show how to use the remaining shorter metal bands for marking and cutting the surplus material with a carpet cutter.

Figure 4.3.2 q, r, s
After cutting the excess material, the window sheet is finally fixed with the short metal bands at the lower sides.

Figure 4.4.2 t, u, v

In the end, the window material should be firmly pressed to the metal housing frame, without leaving any gaps (Fig. 4.4.2 u, v).

4.5 Preventive maintenance

In the table below the given maintenance intervals are average periods. Depending on the deployment site these intervals should be optimized. For instance required cleaning intervals strongly depend on climate zones (arctic, sub-tropic, etc.), the vicinity to polluted areas (cities, sand deserts, airports etc.) or the abundance of insects or other animals (e.g. spider webs).

Activity	Recommended Service Interval
Cleaning of rain sensor	6 month
Cleaning of dew blower	6 month
Cleaning of radiometer housing	12 month
Cleaning of microwave window	6 month
Cleaning of cooler slits	24 month
Cleaning of external sensor cage	6 month
Absolute calibration with liquid nitrogen	6 month
Inspection of cables	12 month
Exchange of microwave window	24 month

5 Trouble Shooting

problem	possible cause	what to do
host connection to radiometer cannot be established	A) bad cable inter-connection B) radiometer PC software has crashed C) host PC serial interface damaged D) radiometer PC serial interface damaged E) radiometer not turned on	check all connectors for cleanliness and correct fitting, data cable(s) damaged? Fibre optics cable connected correctly? reset radiometer PC (turn on/off or use reset button) replace host PC or use different serial port contact RPG turn on radiometer power and wait one minute for booting
message "The specified port in 'R2CH.CFG' has no data cable connected to it"	the host serial port specified in the configuration file exists, but the data cable is not connected to it	connect the data cable to the right host PC serial interface or change the serial port number for the connection to the radiometer (see Software Manual)
measured LWP and IWV values unrealistically high	wet radome (microwave window)	dry radome, eventually renew hydrophobic coating or replace window set lower humidity threshold for heater module switching (see Software Manual)
interference (RFI) on one of the reception channels	external high frequency source (e.g. radar, data link, etc.)	use retrievals for level 2 data that are not including the disturbed channel (contact RPG)
brightness temperatures show strong drift	A) receivers are not thermally stabilized B) thermal control system malfunction	wait for a warmup period of 45 minutes check receiver temperatures in diagnostics menu (see Software Manual), contact RPG
brightness temperatures show spikes	A) external RFI source B) external obstacle (person, bird, etc…) C) channel malfunction	remove external source or scan to different direction remove external obstacle contact RPG
message "Measurement finished" in UNLIMITED mode	A) radiometer power failure and radiometer's recovery mode is turned off B) someone manually terminated measurement	activate radiometer recovery mode (see Software Manual)
rain flag always on or off	A) rain sensor malfunction B) dirty rain sensor	replace rain sensor (contact RPG) cleaning of rain sensor
surface temperature sensor shows unrealistic temperature	sensor malfunction	replace temperature sensor (field replaceable)
surface humidity sensor shows unrealistic	sensor calibration parameters not correct	contact RPG for sending new SENSOR.SCL file for installation on

problem	possible cause	what to do
readings		radiometer PC
damaged microwave window	birds, ice, vandalism…	replace microwave window (ask RPG for replacement window sheets)
blower always on high speed	humidity threshold for blower high speed and activated heater module too low	increase rel. humidity threshold (see Software Manual)
blower does not move	A) blower not correctly connected to radiometer B) radiometer power off C) blower malfunction	check blower connecting cable turn on radiometer power contact RPG
sky tipping always fails	A) clear sky conditions, inhomogeneous humidity field B) RFI in one of the transparent channels	wait for better atmospheric tipping conditions try other azimuth angles for the elevation tipping, delete the elevation angle (where the disturbance occurs) from tipping list (see Software Manual)
message “No response to cold load” after absolute calibration	A) no liquid nitrogen in external target or no target attached to radiometer box B) one of the receiver channels has failed	install external cold target and fill with liquid nitrogen. Repeat calibration check channel responses in diagnostics menu (see Software Manual), contact RPG
message “No response to noise diode” after absolute calibration	A) one of the channels has low signal level B) the noise diode of one of the calibrated receivers has failed	check channel responses in diagnostics menu (see Software Manual), turn on/off noise diode manually, contact RPG contact RPG

6 Spare part list

– To be edited –

Spare part	Interval (if preventive)	Reason for change

7 Radiometer dimensions