MRR-2

Micro Rain RADAR

User Manual

10.2010 Valid for MRR Service Version ≥ 5.2.0.9

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1 Safety Precautions

To operate the MRR-2 a mains voltage of 210-240 VAC is needed for the power supply. An improper handling can be dangerous to you. Only competent and instructed persons should work with this system or with parts of it.
The outdoor installation must not be performed in case of an approaching thunderstorm, to avoid a possibly endangering of personnel by lightning.

There are not known any health hazards originating from the emitted electromagnetic radiation of about 50 mW. Nevertheless you should take care that everybody keeps out of the beam above the antenna (parabolic dish) when it is in operation.

All connecting cables, plugs, and couplings of the MRR-2 are not interchangeable to prevent any erroneous assembly. This safety precaution is disabled if other types of plugs are installed by the user. Therefore any guarantee explicitly expires and METEK accepts no responsibility for injuries to persons, damage of equipment or other consequences connected with not authorized changing of connectors, cables or other parts of the system.

Depending on regional rules for the use of electromagnetic transmitters frequency permission might be necessary. The operator of the system will be liable for the achievement of such permission. However METEK will be of help with providing adequate information. Copies of the certifications for Germany can be found in chapter 6 of this manual.

2 How to use this manual

The delivered hardware items are described in section 4. Make sure that the delivery is complete and free of damage. Consult section 5 for setting up the hardware. In section 6 the installation and use of the control software is described. The technical specifications are listed in section 8.

Section 7 contains more detailed information which is not needed for standard operation.

All auxiliary information marked by a grey vertical line on the left margin may be skipped at first reading as it is not needed for standard setting up and operation.

3 Measuring Principle

The Micro Rain Radar MRR-2 retrieves quantitative rain rates, drop size distributions, radar reflectivity, fall velocity of hydro meteors and other rain parameters simultaneously on vertical profiles up to several kilometers above the radar.

It operates with electromagnetic radiation at a frequency of 24,230 GHz with a modulation of 0.5 – 15 MHz according to the height resolution (e.g. 300 m – 10 m). The radiation is transmitted vertically into the atmosphere where a small portion is scattered back to the antenna from rain drops or other forms of precipitation.

Due to the falling velocity of the rain drops antenna there is a frequency deviation between the transmitted and the received signal (Doppler frequency). This frequency is a measure for the falling velocity of the rain drops. Since drops with different diameters have different falling velocities the backscattered signal consists of a distribution of different Doppler frequencies. The spectral analysis of the received signal yields a power spectrum which is spread over a range of frequencies lines corresponding to the Doppler frequencies of the signal.

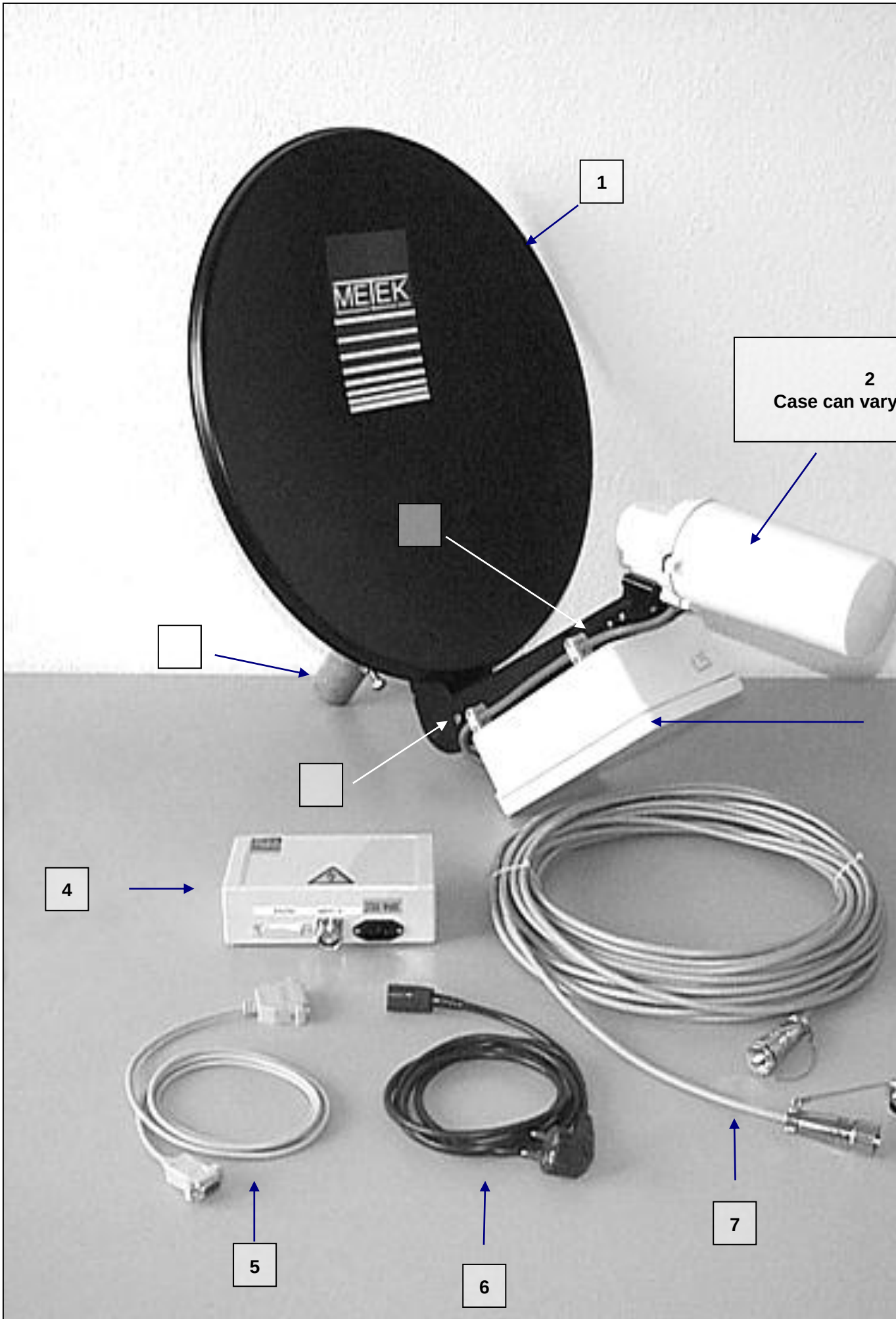
The RCPD determines this power spectrum with a high time resolution (25 per second) and sends mean power spectra every 10 s to the connected control and data acquisition system, where the reflectivity spectrum is calculated considering the calibration parameters of the RADAR module. Using known relations between fall velocity, rain drop size and scattering cross section the drop spectrum (or drop size distribution) is derived. The integration over the entire drop size distribution, considering further correction terms, followed by further averaging over 10 to 3600 seconds, results in rain rate and liquid water content.

The output signal of the RADAR is transmitted continuously (CW mode), a linearly decreasing saw tooth modulation of the transmit signal (FM mode) makes it possible to perform profile measurements with selectable range resolution.

The RADAR antenna is an offset parabolic dish with vertical beam orientation. This antenna design allows rainwater to drain without building ponds. In order to avoid disturbances from snow, which could cover the antenna dish, optional antenna heating is offered.

4 System Description

4.1 Overview


1
METEK
2
Case can vary
4
5
6
7

The Control- and Evaluation Computer, a commercial PC, (not part of delivery) must be ordered separately. The operating system must be Windows® 2000 or XP. (Windows® Vista and Windows 7 is not supported).

4.2 Description of the Components

4.2.1 Parabolic Dish

The antenna is used for the transmission of the RADAR signals and the receiving of backscattered signals. It is designed as an offset parabolic dish (1). Its largest diameter is 70 cm, the beam width is 2°. Due to the offset-design of the parabolic dish rainwater can drain off.

For antenna mounting the tube socket (10) (inner Ø = 49.4 mm, outer Ø = 54.4 mm) is to be plugged onto a pole with an outer diameter of max. 49 mm. The socket is fastened with an M10 screw (10 mm Ø).
Connect a ground wire to this screw which serves as a surge protector.

The pivot (9) is factory-adjusted, so that vertical orientation of the mounting tube socket results in a vertical orientation of the antenna beam. (Ignore the scale on the pivot).

The parabolic dish must not be moved in its pivot (9), because this would cause beam deviations from vertical and would result in erroneous measurements.

The transmitting and receiving properties of the antenna affect the radar calibration. Therefore the reflector surface should be clean (e.g. free from leaves or wet snow). For the same reason any mechanical deformation of the parabolic dish must be avoided. If nevertheless obvious deformation occurred, the reflector must be replaced.

4.2.2 Antenna Heating (Option)

+

Figure 2: Antenna Heating

The back side of the reflector is optionally equipped with a heating coil. It is covered and sealed with a molded lid (11) which provides also extra stability for the reflector. The energy consumption increases with decreasing temperatures and amounts to maximum 500 W. The heating is activated when the temperature falls below a threshold which can be adjusted in the heating-junction box (13). The heating coil works with 230 VAC voltage supply and needs an extra power cable which is connected to (1).

4.2.3 RADAR Control and Processing Device and Transceiver

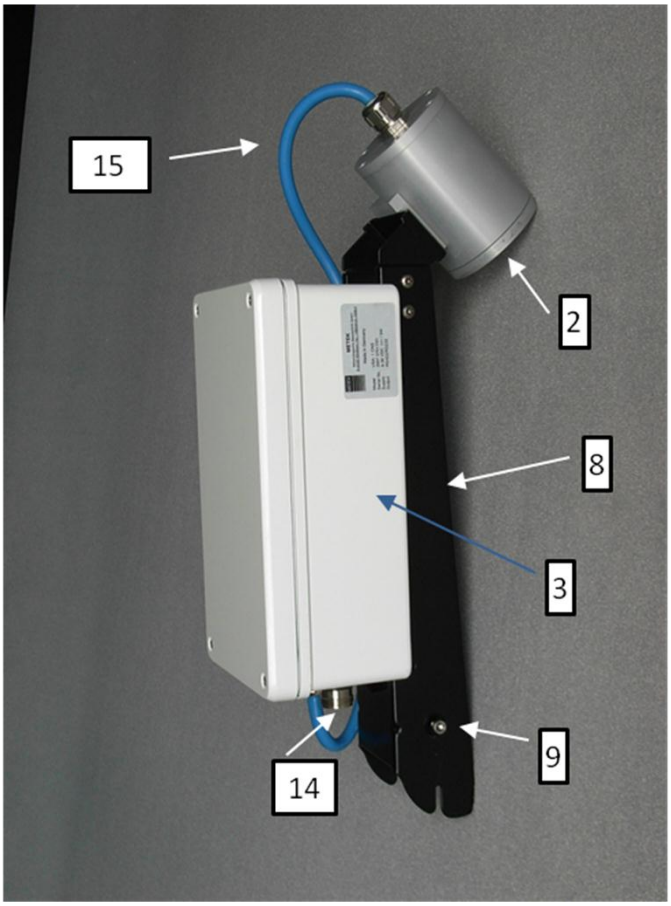


Figure 3: RCPD and Transceiver

The RCPD (3) generates the RADAR transmit modulation signal and passes it to the transceiver (2) through cable (15). It analyses the backscattered receiver signal, calculates Doppler spectra and transfers average power spectra (referred to as “raw data”) to the control and evaluation PC, where these spectra are interpreted. The RCPD is located in a water protected IP65 housing, which is fixed to the antenna arm (8). At the bottom side of the RCPD is the socket (14) for cable (7). The electronic components inside the housing don’t need any service. As far as possible the RCPD should not be opened by the user.

4.2.4 Junction Box / Power Supply

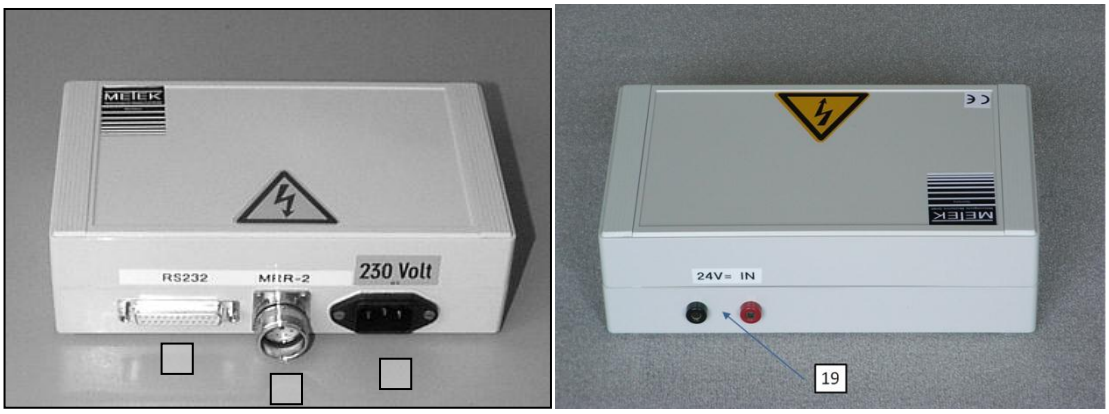


Figure 4: Junction Box Left:Front Side, Right: Back Side

The junction box is used to pass through the communication between the PC and the RCPD. For this purpose it has a 25-pin D-sub-miniature socket, (16) for the data cable (5) to the PC and a flanged socket (17) for the cable (7) to the RADAR RCPD (3).

The power supply for the RCPD and Transceiver is also integrated in the junction box. An IEC connector for the mains supply of 230 VAC (17) is on the front side of the case. On the back side are two sockets for banana plugs for the connection of an alternative external DC power supply (19). The power supply (24 VDC) for the RCPD and Transceiver is also passed through cable (7).

Note : The junction box is not appropriate for outdoor operation.

4.2.5 Cable RCPD-Junction Box

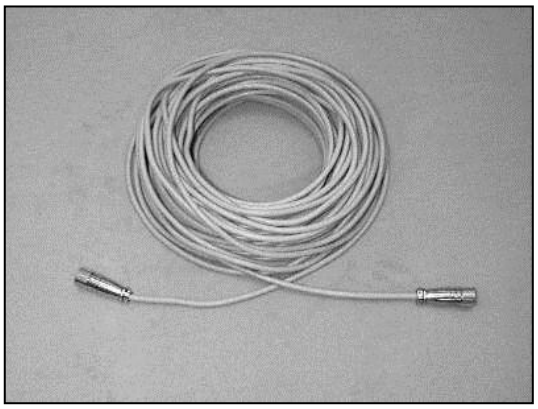


Figure 5: Cable between Junction Box and RCPD

The cable has a length of 25 m, on both ends are screwed plugs (male and female respectively). They must be screwed onto the matching plugs at the junction box (cable has pins) and at the RCPD (cable has sockets).

4.2.6 Cable Junction Box-PC

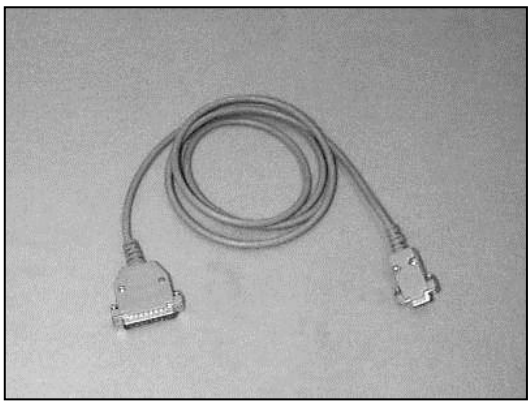


Figure 6: Cable Junction Box-PC

Data cable with a 9-pin (female) and a 25-pin (male) plug and a length of 1.5 m is delivered. This cable is not appropriate for outdoor applications.

4.2.7 Control- and Evaluation Computer (PC)

A personal computer (PC) with the operating system Windows® 2000 or XP serves for setting the operation parameters and data evaluation of the MRR. (Windows® Vista and Windows® 7 are not supported).

The PC must have at least one serial port which will be configured by the control program as follows:

57600 baud,
8 data bits, no parity,
software protocol (XON/XOFF), no hardware protocol (handshake).

Pinning (D-Sub-25-socket at the device) :

Pin 2	RD	*received data*	to the device
Pin 3	TD	*transmitted data*	from the device
Pin 7	GND	*ground*	

The control program which is needed to operate the MRR-2 is part of delivery. Its installation and operation is described in section 6 *Control Program* page 18.

5 Hardware Installation

5.1 General Provisions

- Before you start the system, all cable connections must be set up**.**
- Only the antenna unit including RCPD, Transceiver and cable (7) are designed for outdoor operation. All other components, e.g. the junction box and PC, must be installed in a weather protected environment with temperatures within 5 - 50 °C.
- The electronic cases may be opened only in dry environment. Especially in outdoor area you risk damage by moisture.
- If cables are laid on free field, a cable conduit is recommended.
- All cable connections should be protected by strain-reliefs.
- Use only the original connectors. Guarantee is void, if other connectors are installed.

5.2 Site Conditions

Before actual installation the site must be checked for its suitability for rain measurements.

There must be free view of at least 10° zenith angle over the radar.

Nearby transmitters (base stations of mobile phones, broadcast towers, radars) can cause interference although they operate nominally at different frequency bands. If such neighborhood is necessary, a simple metallic screen or larger object (container) obscuring the direct line of sight to the interfering source can help.

The vicinity of electric machines (e.g. drive of elevators) should be avoided, since they can create interfering signals which are difficult to screen.

If measurements at very low heights are planned, (with appropriate settings the MRR-2 allows measurements from a minimum height of 20 m above ground) take care that the wind field in this level is not disturbed by nearby buildings, trees, masts etc., because strong turbulence could falsify the data.

In contrast with in-situ rain sensors the exposure of the antenna to the free wind field is not detrimental but favorable.

Figure 7 shows various examples of MRR installations: On ground, on top of containers and on top of buildings.

Figure 7: Examples of MRR installations

5.3 Installation Procedure

Preparations:
A fixed vertical pole (Ø max. 49 mm, length min. 30 cm) is required for attaching the antenna. Operating of the MRR-2 requires a 230 VAC mains supply, with a fuse protection of 8 A (slow) minimum. To prevent disturbance of the device by variations or breaks of the power supply we recommend the use of a no-break power supply (UPS).

Required Tools: A wrench with 17 mm opening.

Installation Steps:

1. Install the control and evaluation computer (PC) according to the documents of the manufacturer.
2. Plug the tube socket (10) of the RADAR antenna over the attachment pole and clamp it with the M10 fixing bolt.
3. Check the vertical alignment of the antenna with the built in bubble level (see Figure 8)

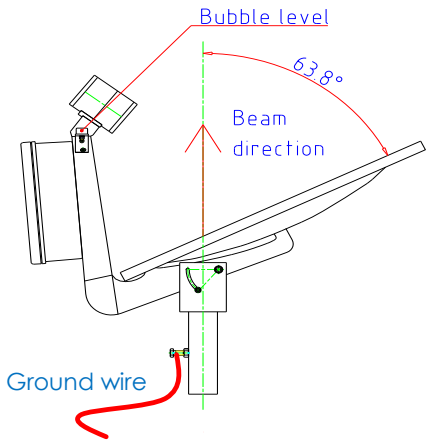


Figure 8: Vertical alignment of the radar beam

4. Attach a ground wire to the fixing bolt for lightning protection.
5. Connect cable (7) between RCPD and Junction Box after mounting of the antenna.
6. Connect cable (5) to that serial interface of the computer, which was selected in the operating system for the connection of the MRR-2. If this serial port is unknown, it can be looked up in the administration of the "services" in the operating system of the computer and it can be changed accordingly there. See also installation of the control program page 18 ff.
7. Connect cable (6) of the Junction Box to the mains voltage of 230 VAC (cable (6)).
8. Establish the communication between the control program „MRR-2 Control" and the RCPD-firmware.
9. Check the correct data transmission and recording.

6 Control Program

If the PC for controlling the MRR-2 with was not ordered separately the programs for controlling the MRR-2 and for data recording are delivered on a CD-ROM and must be installed on a PC with operating system **Windows® 2000 or Windows® XP. (**Older Windows® versions, Windows® Vista, or Windows® 7 are not supported.)

If the PC was configured and delivered by METEK (optional) 6.1 **Installation** may be skipped.

6.1 Installation

For installing the Control Program:

- Insert the CD-ROM.
- Login as administrator.
- Open the program group `my computer` (icon on the desktop).
- Open the folder for the CD-ROM device.
- Change to the folder `METEK\MrrCtrl.`
- With the right mouse key click on the file `Mrr`***`xxxxxx`***`.inf`.
- Activate the install menu. The files are copied and the registry of the PC is updated.
- When the copy process has finished, reboot the PC.

Note: The data flow rate from the MRR to the PC requires that the PC response time does not exceed certain limits. If the PC was configured and delivered by METEK (optional), meeting of this request is warranted. Any modern PC with medium performance is basically sufficient to run the Control Program without flaws, if there are not too many other tasks running simultaneously. Particularly virus scanning programs may slow down the PC below the minimum possible value. In that case the data records are corrupted. Check the integrity of recorded data by visual inspection or by some automated procedure.

6.2 Using the Control Program

After login to the operating system open a command line window and enter the command `MrrCtrl.exe`. The following dialogue window appears (The screenshots in this manual were taken from a Windows® 2000 system.):

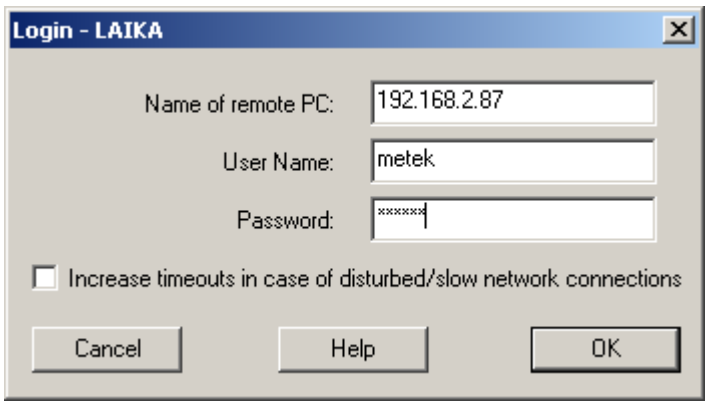


Figure 9: Login Screen

If you are sitting at the PC which is directly connected to the MRR-2 leave the entry at ***Name of the Remote PC*** empty (or type a period or the name of the local PC). If you are sitting at another PC, enter the name of that PC to which the MRR-2 is connected directly and where the communication service (`MrrCtrl.exe`) was started.
The User Name is generated automatically and the Password is usually not needed (see below for exceptions).

The ***Password*** entry field is useful if the remote computer is a member of another Windows domain, because in this case a connection can be built up only if a user name and the matching password is given. The user name is set automatically (see the header of the dialog window).

The network connection to the remote computer usually is a LAN- or a RAS connection. RAS connections using the public telephone net are mostly not very efficient, especially connections with mobile phone radio nets. Considering that, the login dialog provides the use of time-out-values which are adjusted to the maximum delay times for the responses from the remote PC. Using a direct LAN or a local login, this feature is not needed.

If the program was started by a command line input, the information concerning the login window can be handed over as a parameter. Example:

```
C:\METEK\MrrCtrl hostname secret /t
```

This entry would try to build a connection to a computer with the name `\\hostname`. The password is `secret`, the time-out-values are set for slow WAN connections (`/t`). The parameter `/t` is optional, the computer name and the password however must be given always. This is also valid for local logins (the password will not be checked).

If the connection to the communication service could be built up, the entire status of the MRR-2 is read out first. This can take some seconds, on RAS connections even some minutes.

Click the OK button
The MRR-2 status is read out which takes some seconds (in case of slow remote communication even some minutes). Then the Main Menu will appear.

6.2.1 Main Menu

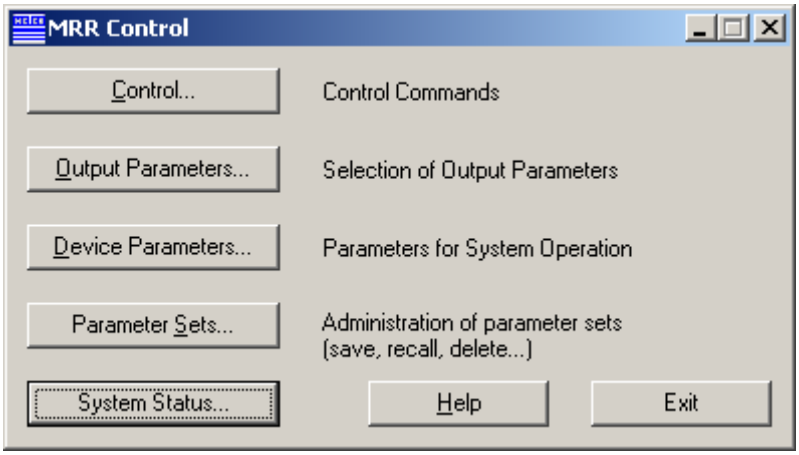


Figure 10: Main Menu

The main menu shows buttons for the menus

Control	chapter 6.2.2 on page 22
Output Parameters	chapter 6.2.3 on page 22
Device Parameters	chapter 6.2.4 on page 25
Parameter Sets	chapter 6.2.5 on page 27
System Status	chapter 6.2.6 on page 29

You can leave the program with the ***Exit*** button.
The ***Help*** button provides a Windows conforming help text.

6.2.2 Control Commands Menu

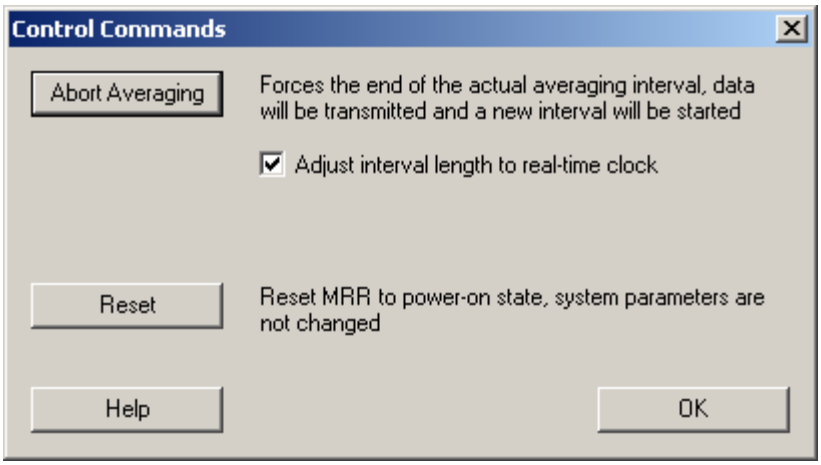


Figure 11: Control Commands

Abort Averaging

The current averaging interval is stopped. Data, collected since the begin of the averaging interval, are processed and a new averaging interval is started regardless of elapsed averaging time.

Adjust interval length to real time clock

This checkbox activates the synchronization of measuring intervals to the actual time of day. This means every output of averaged data will occur at 'round' times. Example:
If the measuring time has been set to 600 seconds, output will be generated at every full 10 min.

Reset

Pressing this button will perform a reset of the RCPD firmware. There is no influence on the MRR-2 parameters. It has the same effect as an interruption of the power supply.

6.2.3 Output Parameters Menu

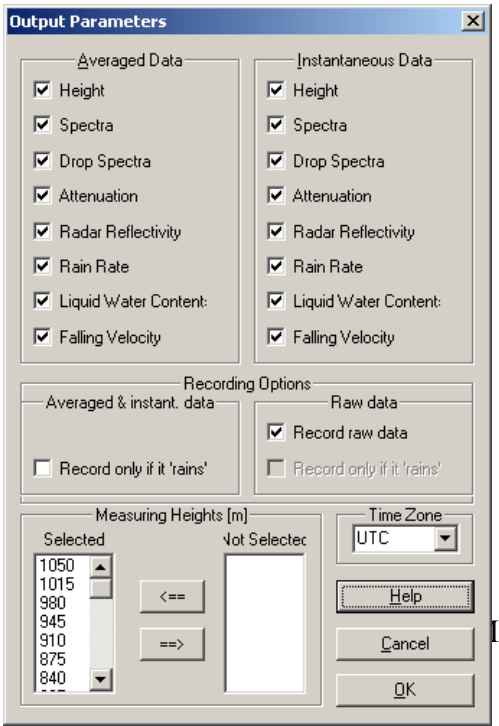


Figure 12: Output Parameters

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The two upper panels shown in Figure 12 contain check boxes for configuring selections of *averaged data* and *instantaneous data* separately for recording. *Instantaneous data* are processed on the basis of one raw spectrum[1]. *Averaged Data are processed* on the basis of an average of multiple raw spectra, depending on the selected averaging time. The selectable variables are described in the table below.

Selection of	**causes the recording of**
Height[2]	Measuring height above ground
Spectra	Spectral volume reflectivity
Drop Spectra	Drop diameter and number of drops per volume and diameter
Attenuation	Two way path integrated attenuation
Radar Reflectivity	Radar reflectivity factor and attenuated radar reflectivity factor
Rain Rate	Vertical volume flux of liquid water per unit area
Liquid Water Content	Mass of liquid water per volume
Falling Velocity	Doppler velocity (1. moment of the spectrum)

[1] Since the raw spectra and the instantaneous data represent already averages over 10
[2] The output variable*Height* should always be selected, as this facilitates further processing of recorded data.

Recording Options

Raw data

By checking “Record raw data” the raw spectra including metadata are written in addition to other selected data to a separate log-file. The path name of these log-files is defined by the parameters RawDataFile , RawDataPath.

Conditional recording

By checking “Record only if it rains” no data are recorded, if the evaluation software does not detect precipitation in any measuring height during the measuring (averaging) interval. This condition can be activated separately for averaged/instantaneous data and raw data respectively.

Measuring Height(s)

A subset of measuring heights can be selected for recording. This subset is used for both kinds of data output, instantaneous and averaged data. The selection of measuring heights for output is done with two lists containing the selected and unselected height steps. To move items (sets of height steps) between the lists they must be marked in the source list. The movement will be performed when the arrow button pointing to the other target list is pressed.
(The *height resolution* (step-width) can be adjusted with the device parameters menu (see chapter 6.2.4 on page 25)).

Time Zone

The time zone can be selected which is used for the time stamps of the recorded data.

All changes in the Output Parameters Menu become effective by clicking the “Ok” button. Then the corresponding commands are transmitted to the RCPD firmware. Clicking the “Cancel” button cancels all changes.

6.2.4 Device Parameters Menu

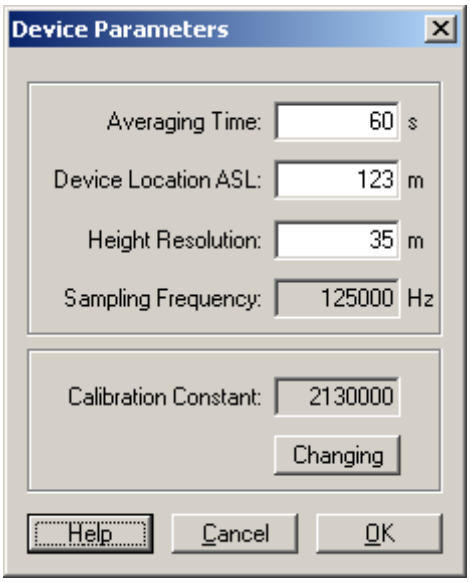

Figure 13: Operation Parameters

Averaging Time

Here you define the averaging time for the *averaged data*.
The adjustable range is 10 .. 3600 s

After each averaging time, an *averaged data* set is generated and recorded and a new averaging interval starts. Instantaneous data are generated and recorded independently in 10 s time intervals within each averaging interval.

Device Location ASL

Enter the height of the MRR-2 location above sea level.
The adjustable range is 0 ... 9999 m.
This parameter is used for the density correction of the fall speed versus drop size relation.

Height Resolution

Enter the desired distance between adjacent measuring heights (step width).
The adjustable range is 10 - 1000 m. Typical values are 30 – 100 m.
The measuring heights are integer multiples of the height resolution. The maximum number of height steps is 31.

Sampling Frequency

Number of samples per second of the analogue input signal of the MRR-2. This parameter can't be changed by the user.

Calibration Constant

This constant is needed for converting the engineering units of the receiver signal (raw data) into physical units (instantaneous and averaged data). See Physical Basis for details. The calibration constant is factory set. Nevertheless it can be changed by the experienced user. Before a new calibration constant can be entered the "changing" button must be pressed. It should be only done, if there is clear evidence for a miss-calibration of the MRR. This can be inferred for example from rain rates measured with the MRR (R_{MRR}) and a rain gauge (R_{RG}) respectively. If C_{old} is the old calibration constant, the new calibration constant C_{new} can be calculated according

$$C_{new} = C_{old} \frac{R_{RG}}{R_{MRR}}$$

It should be kept in mind that comparisons of rain rates measured aloft with the MRR and a rain gauge are not straightforward due to the strong inhomogeneity of rain. MRR data should be taken from range gates not below the 3rd range gate, because approximations in the radar equation cause larger biases at lower range gates. On the other hand the measuring height should not exceed 200 m in order to keep attenuation effects small (they are only eliminated in case of correct calibration) and to keep the correlation with surface precipitation at a useful level. Further make sure that the MRR rain retrieval is not affected by the ice phase or melting processes. Strong winds should also be avoided since rain gauges tend to unreliable under such conditions.

OK

All changes in the Device Parameters Menu become effective by clicking the "OK" button. Then the corresponding commands are transmitted to the RCPD firmware. Clicking the "Cancel" button cancels all changes.

6.2.5 Parameter Storage

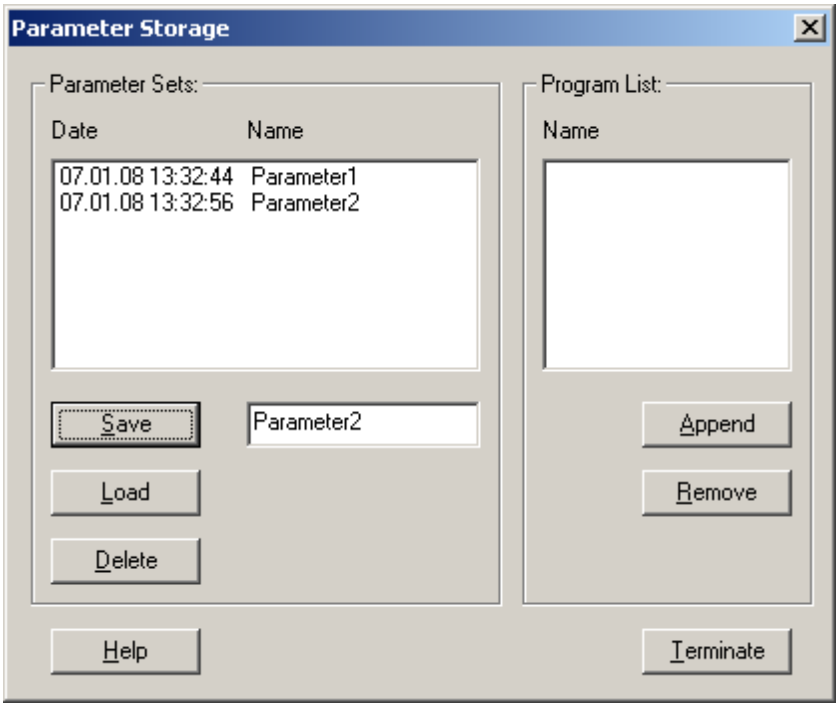

Figure 14: Parameter Storage

Parameter Sets

The parameter memory of the MRR-2 is used for convenient saving and loading of complete parameter settings.

A parameter set consists of
- the device parameters (except calibration constant) and
- the selected output parameters

Saving a parameter set:

- Type a name in the field right of the ***Save***-button or select a name of the Parameter Sets list.
- Click the ***Save***-button.

Loading a parameter set:

- Type a name of the Parameter Sets list in the field right of the ***Save***-button or select a name of the Parameter Sets list.
- Click the ***Load***-button.

Deleting a parameter set:

- Type a name of the Parameter Sets list in the field right of the ***Save***-button or select a name of the Parameter Sets list.
- Click the ***Delete***-button.

Program List

Previously defined parameter sets can be added to a program list. All sets, which are included in this list, will be processed successively. This means every time the averaging interval has finished, the next entry will be loaded from the list. After reaching the end of this list, the program starts over with the first entry.

Creating a Program List

- Select a parameter set in the Parameter Sets list
- Click the ***Append*** button. The parameter set is inserted in the empty Program List or added to the end of the non-empty Program List.

As soon as the Program List is not empty, it becomes active.

Removing entries from the Program List

- Select the entry from the Program List
- Click the ***Remove***-button

Note:

1. Parameter sets, which appear in the Program List can neither be changed nor deleted.
2. The same parameter set name may appear at several places in the Pram List.

6.2.6 Status messages and time-axis control

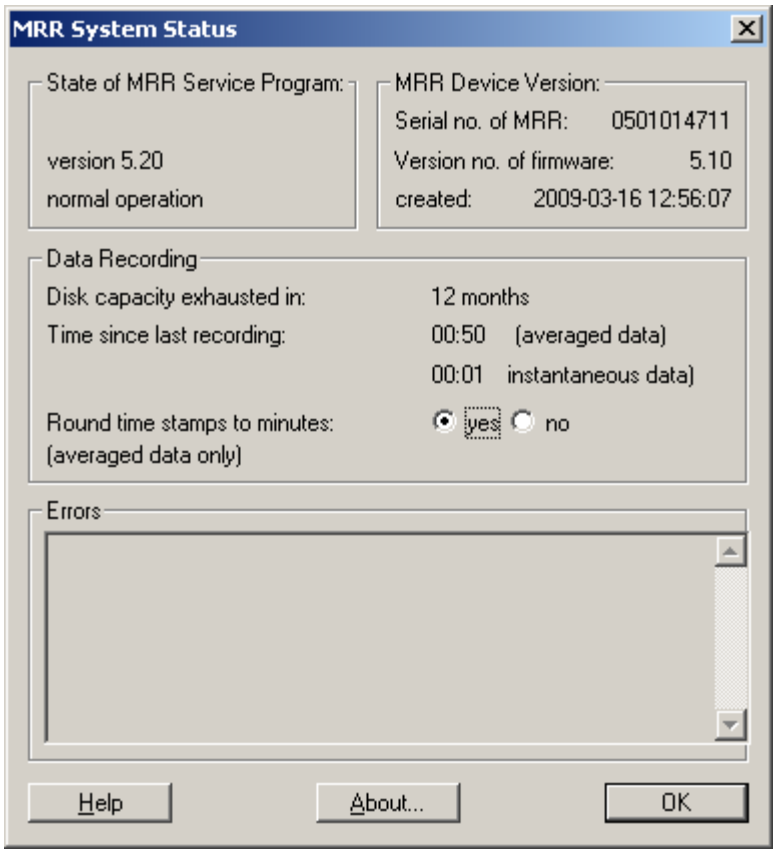

Figure 15: System Status

Sub-Panel: "State of the MRR Service Program"

The version number of the MRR service program is shown.

The operation state is shown:

- *normal operation*
  No problems occurred.
- *erroneous operation*
  One component of the service could not be installed. Either a hardware error or a conflict between programs occurred (Example: Two programs attempt to access the same port.)

Sub-Panel: "MRR Device Version"

The serial number, the firmware version number and the firmware creation date of the connected MRR are shown.

Sub-Panel: “Data Recording”

Disk capacity exhausted in The remaining time for data recording is shown. The calculation is based on the average sizes of the last received measuring protocol and the actual free disk space (Initially **???** appears until the first data set is stored).

Time since last recording The time elapsed, since the last averaged and instantaneous data sets were written to disk, is shown (Initially **???** appears until the first data set is stored).

Round time stamps to minutes Time stamps are rounded to integer values. This can be useful under the following condition: If the "Adjust interval length to real time clock" (see chapter 6.2.2 **Control Commands Menu**) was selected, the time stamps should be integer multiples of 10 seconds, minutes or ten minutes. Nevertheless small deviations from these integers may occur due to variable processing time. If this is disturbing for subsequent data analysis programs, the recorded time stamps can be rounded. The selection *yes* or *no* is activated by pressing the *ok* button.

Sub-Panel “Errors”

This panel shows a list of errors which occurred during the measuring operation. Errors which occurred before the control program was started can be retrieved from the Windows® 2000- or Windows® XP-event log.

About Button

Figure 16: This panel appears after clicking the *About*-button

6.3 Instantaneous and averaged data

6.3.1 Format description

Instantaneous and averaged data are archived in two separate directory structures (see chapter 7.1.2 Data Recording on page 42). Optional recording of so called raw data, which represent the unprocessed measuring data of the MRR-2, is only useful for special purposes.

The data format is human readable ASCII text. Each data set consists of one line. The order of the data lines and the used identifiers are listed below:

Identifier	**Meaning**	**Unit**	**Remark**
MRR	*Header Line*	n.A.	
H	*Height*	m	
TF	*Transfer Function*	dimensionless	
F*nn*	*Spectral Reflectivities*	dB	$10 \cdot \log \eta_{nn}$ with η_{nn} in m^{-1} *nn* from min(*h*) to max(*h*) [3]
D*nn*	*Drop Size*	mm	Center of size class
N*nn*	*Spectral Drop Densities*	$m^{-3}mm^{-1}$	$N(D_{nn})$ [3]
PIA	*Path Integrated Attenuation*	dB	
Z	*Radar Reflectivity*	dBZ	$10\log\left(\sum_{nn=\min(h)}^{nn=\max(h)} N(D_{nn})D_{nn}^6\right)$ *nn* from min(*h*) to max(*h*)
z	*Attenuated Radar Reflectivity*	dBZ	Z-PIA
RR	*Rain Rate*	mm h^{-1}	
LWC	*Liquid Water Contents*	g m^{-3}	
W	*Fall Velocity*	m s^{-1}	

[1)] *See MRR-Physical Basics for details*.

The measured data are displayed in lines following the header. For each measured variable there is one line starting with a 3-character identifier of the variable. Each line represents a profile of this variable, i.e. a function versus height. Each data entry is 7 characters wide. Height is running from left to right

[3] *See MRR-Physical Basics for details*.

in increments according to the chosen height resolution of the MRR. Invalid or not calculable values are coded as 7 consecutive space characters. Space characters at the end of a line are omitted in order to save disk space. So lines can have different lengths although representing the same number of height steps.

MRR – Header Line

The header line marks the beginning of a data set. It starts with the identifying string ”MRR“, a space character and a date/time stamp.

The date/time stamp consists of 12 digits (format *YYMMDDhhmmss*), a single space character and the name of the time zone. This name starts with the string „UTC“ and is optionally followed by an offset value (format ±*hh* or ±*hhss*).

Averaging time in seconds (“AVE”), (Not in instantaneous data).

height resolution in meters (“STP”),

height of the ground level above sea level in meters (“ASL”),

sampling rate (“SMP”) of the RADAR signal in the time domain (unit: Hz),

parameters for the automatic noise level adjustment (“NF0” and “NF1” without unit),

version number of the MRR Service (“SVS”),

version number of the MRR firmware (“DVS”),

serial number of the MRR (“DSN”)

calibration constant (“CC”)

data quality parameter consisting of the identifying string “MDQ”, a single space character and a 3digit number between 0 and 100. It is the percentage of valid spectra collected during the averaging interval. Spectra can be invalid due to saturation of the AD converter – caused either by extreme precipitation or by some interference

Each of the parameters in the header line starts with a delimiting space character, the 3-character identifier as shown above in the parentheses and a field of 6 characters for the numerical value (except of the serial number, which can consist of up to 10 numeric characters between 0 and 9).

Example (Each entry of the header line is shown in a separate line of the table) :

MRR*090612040200 UTC	The header line dates from June 12th, 2009, 4:02 AM, UTC.
AVE****60	Averaging time is 60 seconds.
STP****35	Height resolution is 35 meters.
ASL***147	The radar is sited 147 meters above sea level.
SMP*125e3	Sampling rate is 125,000 Hz.
NF0*1.000	Noise level 0 set to 1.000 (used only in older versions).
NF1*0.000	Noise level 1 set to 0.000 (used only in older versions).
SVS*5.2.0.9	Version number of the MRR Service is 5.2.0.9
DVS*5.13	Version number of the MRR firmware is 5.13.
DSN*020704	Serial number of the MRR is 020704.
CC*2066000	Calibration constant is 2066000.
MDQ 100	Percentage of valid spectra is 100

H - Height

Argument of the following data profiles corresponding to the settings described in chapter 6.2.3, page 22, and chapter 6.2.4, page 25. The units are meters above the radar system.

TF - Transfer Function

To each height step a value of the Transfer Function is assigned by which raw data are divided.

Fnn with nn from 0 to 63 - FFT Spectra

Each line represents a profile of spectral reflectivity corresponding to the spectral bin *nn*. As **Fnn** is corrected for the receiver noise floor negative values can occur, if the signal to noise ratio is low. These entries cannot be presented in the logarithmic domain and are replaced by space characters.

Dnn with nn from min(h) to max(h) - Drop Sizes

The drop size is described by the diameter of an equivolumic sphere. The spectral bins of drop numbers are of variable width in the size domain (in contrast with spectral bins in the frequency- and velocity-domain). In addition, the widths of the size bins are slightly height dependent. Therefore the assignment

of frequency-bin-index nn to diameter D is listed explicitly for each bin and height. The center of each size class is displayed.

Nnn with nn from min(h) to max(h) - Spectral Drop Densities

With the knowledge of the frequency of the Doppler-shift the calculation of the corresponding drop fall velocity is possible (equation 1.4.3.2 in MRR Physical Basics). Thus each FFT-line stands for a drop size interval. Chapter 2 in the Physical Basics shows how to derive from the received spectral power the number of drops for this drop size class, and finally – by divison through the variable class width – the spectral drop densities.
Only a sub-set of all 64 spectral bins is considered for the calculation. The lower (min(h)) and upper limit (max(h)) depends on the height as described in MRR Physical Basics (Fig. 7).
In case of negative values of Fnn negative drop number densities are calculated. Although they have no physical meaning they are retained in order to avoid statistical biases.

PIA - Path Integrated Attenuation [1)]

The two-way Path integrated attenuation by rain drops is calculated as described in chapter 3.2 MRR-Physical Basis and is used for correction of Nnn, Z, RR and LWC.

z - Attenuated Radar Reflectivity[2)]

z is the radar reflectivity factor (see chapter 3.1 MRR-Physical Basics) without attenuation correction

Z - Radar Reflectivity[2)]

Z is the radar reflectivity factor (see chapter 3.1 MRR-Physical Basics)

RR - Rain Rate[2)]

RR is the rain rate (see chapter 3.3 MRR-Physical Basics)

LWC - Liquid Water Content[2)]

LWC is the liquid water content (see equation 3.2.1 MRR-Physical Basics)

[2)] *In case of low signal to noise ratio negative values can occur. Although they have no physical meaning they are retained in order to avoid statistical biases*.

W - Fall Velocity

W is the characteristic falling velocity.
(First Moment of the Doppler spectrum, see chapter 3.4 MRR-Physical Basics).

The width of velocity-bins can be derived from the maximum number of height steps, the sampling rate (as shown in the header line) and the wave length of the RADAR signal. 32 height steps and 64 lines per step are calculated. For a sampling frequency of 125 kHz and a transmit frequency of 24.23 GHz, the resolution of the fall velocity can be calculated as:

$$\frac{125\ \mathrm{kHz}}{2}\,\frac{1}{32\cdot 64}\,\frac{299700\ \mathrm{km/s}}{2\cdot 24\ \mathrm{GHz}} = 0{,}1887\ \mathrm{m/s}$$

6.3.2 Example

Instantaneous and **averaged data** files have the same structure including the header lines, except of the entry AVE, which is missing in the instantaneous data.

```
MRR 090612040200 UTC AVE    60 STP    35 ASL     0 SMP 125e3 NF0 1.000 NF1 0.000 SVS 5.20 DVS 5.10 DSN 020704 CC 2066000 MDQ 100
H      35    70   105   140   175   210   245   280   315   350   385   420   455   490   525   560   595   630   665   700   735   770   805   840   875   910   945   980  1015  1050  1085
TF  0.0115 0.0420 0.0999 0.1756 0.2542 0.3340 0.4255 0.5324 0.6030 0.6757 0.7565 0.7942 0.8366 0.8778 0.8914 1.0000 0.9683 0.9243 0.8838 0.8904 0.9040 0.8759 0.8538 0.8433 0.8346 0.7807 0.7749 0.7524 0.6890 0.6406 0.4225
F00 -65.29 -74.53 -82.05 -87.75 -90.83 -91.33 -91.50 -94.20             -106.26        -90.26 -89.09 -89.00 -91.35 -92.31             -97.45 -98.65        -91.66 -89.67 -82.65 -82.43 -83.39 -82.92 -82.32 -87.28 -83.34
F01 -66.94 -76.22 -84.02 -89.60 -92.92 -90.74 -90.22 -91.96 -98.48 -93.34 -92.11 -94.45 -86.71 -86.55 -86.06 -87.13 -86.23 -86.12 -87.00 -87.60 -89.90 -89.54 -83.82 -83.08 -80.77 -80.17 -79.91 -80.16 -80.55 -85.48 -84.48
F02 -72.75 -81.78 -88.82 -93.49 -95.53 -90.61 -89.73 -90.07 -91.23 -89.44 -88.96 -88.11 -84.14 -84.20 -83.97 -84.47 -83.51 -82.95 -83.39 -83.78 -85.48 -82.83 -80.38 -80.66 -79.75 -79.03 -78.00 -77.93 -79.20 -84.64 -84.43
F03 -82.02 -88.54 -91.72 -95.03 -94.67 -90.35 -89.07 -89.06 -89.11 -88.73 -87.65 -86.96 -83.49 -83.15 -83.76 -84.45 -83.31 -82.42 -82.31 -81.95 -82.49 -80.82 -79.11 -79.94 -79.96 -78.79 -77.68 -78.09 -79.97 -85.73 -84.42
F04 -88.10 -89.28 -91.25 -93.59 -93.01 -89.24 -88.55 -88.52 -87.96 -87.75 -86.36 -86.62 -83.91 -83.20 -84.08 -84.65 -83.34 -82.21 -81.64 -81.08 -80.83 -80.01 -78.92 -79.43 -79.85 -78.92 -78.32 -79.59 -81.30 -87.44 -89.43
F05 -87.30 -88.16 -90.08 -91.37 -90.76 -87.91 -87.93 -88.12 -87.23 -86.03 -85.55 -85.93 -83.96 -83.56 -83.46 -83.48 -83.08 -81.79 -80.80 -80.48 -80.31 -80.04 -79.39 -79.69 -79.70 -79.05 -79.05 -80.49 -81.83 -92.29
F06 -86.28 -87.67 -89.08 -89.78 -89.56 -87.00 -86.86 -87.26 -86.60 -84.90 -84.87 -85.42 -83.82 -83.16 -81.80 -81.73 -82.05 -81.64 -80.52 -80.39 -80.10 -80.05 -79.87 -79.89 -79.57 -79.54 -79.82 -80.68 -81.55 -91.37
F07 -85.61 -87.55 -87.62 -87.87 -88.59 -86.53 -85.65 -85.65 -85.22 -84.25 -84.12 -84.48 -83.35 -82.33 -80.94 -80.79 -81.24 -81.80 -81.09 -80.80 -80.21 -79.90 -80.26 -80.11 -80.14 -80.32 -80.92 -81.36 -80.73 -86.27 -90.26
F08 -85.09 -86.74 -85.56 -85.78 -87.12 -85.88 -84.82 -84.31 -83.53 -83.16 -83.51 -83.70 -82.61 -81.83 -80.95 -80.77 -81.04 -81.61 -81.21 -81.00 -80.65 -79.74 -80.34 -80.91 -81.45 -81.12 -81.86 -83.43 -80.90 -83.80 -86.63
F09 -83.82 -85.29 -84.11 -84.49 -85.50 -84.67 -83.86 -83.45 -82.85 -82.34 -82.85 -83.29 -82.07 -81.43 -80.82 -80.91 -81.09 -81.14 -80.36 -80.60 -80.82 -79.78 -79.96 -80.97 -81.79 -81.54 -81.74 -85.51 -83.05 -86.41 -87.24
F10 -81.72 -83.85 -83.09 -83.53 -84.12 -83.04 -82.34 -82.48 -82.97 -81.99 -81.72 -82.26 -81.23 -80.89 -79.95 -80.47 -80.97 -80.60 -79.69 -80.18 -80.62 -80.34 -80.30 -80.81 -81.04 -81.24 -81.55 -86.03 -87.40        -86.95
F11 -80.23 -82.49 -81.94 -82.30 -82.87 -81.75 -81.02 -81.68 -82.53 -81.59 -80.59 -80.79 -80.37 -80.35 -79.23 -79.76 -80.65 -80.37 -79.30 -79.57 -80.19 -80.93 -79.99 -80.16 -80.66 -80.97 -82.35 -85.89 -84.87-101.37 -83.71
F12 -79.40 -81.17 -80.57 -81.10 -81.90 -80.83 -80.14 -80.97 -81.54 -80.92 -79.88 -79.77 -79.65 -79.78 -79.11 -79.41 -79.88 -79.90 -78.92 -79.10 -79.78 -80.83 -79.01 -78.79 -80.08 -80.50 -82.59 -84.83 -81.59 -86.14 -78.92
F13 -78.57 -79.85 -79.34 -80.17 -80.79 -79.95 -79.19 -79.97 -80.56 -79.90 -79.10 -79.05 -78.80 -78.77 -78.83 -79.30 -79.17 -79.27 -78.68 -79.00 -79.44 -80.03 -78.76 -78.40 -79.50 -80.26 -81.78 -83.31 -80.78 -81.78 -74.26
F14 -77.86 -78.66 -78.36 -79.29 -79.47 -79.02 -78.43 -79.04 -79.33 -78.74 -78.19 -78.20 -77.69 -77.59 -78.06 -78.72 -78.69 -78.80 -78.75 -79.12 -79.01 -79.18 -78.82 -78.63 -79.50 -80.22 -80.71 -81.93 -79.66 -76.73 -69.46
F15 -77.06 -77.59 -77.41 -78.22 -78.28 -77.92 -77.74 -78.16 -78.00 -77.48 -77.22 -77.24 -76.68 -76.54 -76.80 -77.43 -77.98 -78.33 -78.52 -78.87 -78.50 -78.60 -78.48 -78.32 -79.13 -79.11 -78.99 -80.89 -77.10 -71.53 -65.20
F16 -75.62 -76.37 -76.39 -77.05 -77.13 -76.54 -76.42 -77.07 -76.64 -76.07 -76.25 -76.30 -75.84 -75.36 -75.42 -76.32 -77.01 -77.52 -77.90 -78.21 -77.66 -77.64 -77.62 -77.52 -77.96 -77.19 -77.11 -78.89 -73.66 -66.92 -61.51
F17 -74.28 -75.27 -75.46 -76.15 -76.17 -75.52 -75.10 -76.04 -75.61 -74.93 -75.36 -75.26 -74.86 -74.28 -74.56 -75.66 -76.04 -76.46 -76.79 -77.19 -76.41 -76.18 -76.40 -76.50 -76.91 -76.00 -75.74 -76.16 -70.42 -63.54 -58.70
F18 -73.30 -74.28 -74.44 -75.24 -75.17 -74.85 -74.28 -75.21 -74.97 -74.16 -74.31 -74.12 -73.73 -73.29 -73.78 -74.76 -75.05 -75.41 -75.66 -76.02 -75.32 -74.98 -75.23 -75.52 -75.95 -75.31 -74.85 -73.83 -67.66 -61.18 -56.98
F19 -72.19 -73.25 -73.11 -73.83 -73.90 -73.99 -73.53 -74.48 -74.45 -73.55 -73.39 -73.38 -73.07 -72.71 -73.02 -73.69 -74.16 -74.47 -74.70 -74.94 -74.59 -74.35 -74.37 -74.39 -74.76 -74.30 -73.62 -71.82 -65.18 -59.40 -56.03
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F21 -70.02 -70.51 -70.34 -71.50 -71.71 -71.55 -71.83 -73.00 -72.18 -71.17 -71.48 -71.86 -71.54 -71.43 -71.38 -71.83 -72.46 -72.42 -72.58 -73.05 -73.21 -72.67 -72.50 -72.30 -72.43 -71.97 -70.28 -67.47 -61.00 -56.68 -55.21
F22 -68.79 -69.29 -69.18 -70.49 -70.98 -70.52 -70.58 -71.37 -70.74 -69.96 -70.42 -70.53 -70.18 -70.11 -70.08 -70.71 -71.41 -71.50 -71.35 -71.96 -72.40 -72.07 -71.61 -71.21 -71.26 -70.44 -68.25 -65.05 -59.54 -55.98 -55.17
F23 -67.82 -68.28 -67.92 -69.21 -70.09 -69.44 -69.18 -69.79 -69.44 -68.87 -69.17 -69.15 -69.06 -68.89 -69.10 -69.83 -70.32 -70.70 -70.43 -71.05 -71.55 -71.38 -70.36 -69.87 -69.98 -69.02 -66.26 -62.66 -58.11 -55.69 -55.47
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F25 -66.05 -66.05 -65.20 -66.62 -67.44 -66.85 -66.12 -67.10 -66.86 -66.14 -66.49 -67.01 -67.58 -66.93 -66.97 -68.14 -68.35 -68.74 -69.28 -69.68 -69.55 -69.24 -68.32 -67.77 -67.46 -65.57 -62.26 -58.67 -55.36 -54.98 -56.32
F26 -64.87 -64.49 -64.33 -66.00 -66.29 -65.55 -64.75 -65.61 -65.58 -65.09 -65.48 -65.65 -66.37 -66.03 -65.95 -67.03 -67.47 -67.83 -68.44 -68.75 -68.79 -68.39 -67.40 -66.55 -65.95 -63.88 -60.49 -57.31 -54.80 -55.01 -56.92
F27 -63.97 -63.27 -63.33 -64.91 -64.92 -64.37 -63.66 -64.41 -64.32 -64.00 -64.29 -64.24 -64.95 -64.87 -64.77 -65.51 -66.43 -67.06 -67.47 -67.73 -68.02 -67.71 -66.55 -65.37 -64.70 -62.52 -59.00 -56.22 -54.55 -55.34 -57.81
F28 -62.71 -62.26 -62.06 -63.11 -63.14 -63.15 -62.71 -63.46 -63.21 -62.75 -62.88 -62.91 -63.54 -63.48 -63.52 -64.01 -65.01 -65.98 -66.46 -66.83 -67.19 -67.08 -65.77 -64.46 -63.50 -61.06 -57.75 -55.43 -54.59 -59.16
F29 -61.64 -61.26 -60.96 -61.81 -61.73 -61.97 -61.99 -62.76 -62.47 -61.77 -61.73 -61.70 -62.10 -62.06 -62.24 -62.73 -63.41 -64.36 -65.13 -65.81 -66.21 -66.35 -64.87 -63.37 -61.92 -59.25 -56.59 -54.95 -54.97 -57.05 -60.88
F30 -60.93 -60.35 -60.19 -61.05 -60.86 -60.96 -61.18 -61.97 -61.69 -61.04 -60.94 -60.69 -60.86 -60.90 -61.05 -61.64 -61.97 -62.66 -63.51 -64.45 -64.83 -65.13 -63.87 -62.14 -60.43 -57.72 -55.79 -54.73 -55.43 -58.37 -62.82
F31 -60.03 -59.37 -59.43 -60.18 -60.14 -60.01 -60.14 -60.97 -60.75 -60.35 -60.31 -60.02 -59.96 -59.90 -60.10 -60.78 -60.95 -61.23 -61.88 -62.84 -63.17 -63.41 -62.83 -60.99 -59.02 -56.61 -55.45 -54.90 -56.19 -59.79 -64.76
F32 -59.11 -58.53 -58.62 -59.27 -59.40 -59.14 -59.28 -59.96 -59.81 -59.68 -59.59 -59.39 -59.37 -59.20 -59.25 -60.04 -60.05 -60.02 -60.45 -61.27 -61.84 -62.14 -61.81 -59.77 -57.60 -55.84 -55.46 -55.47 -57.31 -61.23 -66.56
F33 -58.30 -57.67 -57.79 -58.49 -58.75 -58.35 -58.59 -59.22 -59.21 -59.17 -58.87 -58.61 -58.78 -58.71 -58.53 -59.24 -58.93 -58.97 -59.41 -59.93 -60.69 -61.07 -60.77 -58.72 -56.67 -55.39 -55.52 -56.25 -58.70 -63.05 -68.60
F34 -57.80 -56.89 -57.20 -57.92 -58.22 -57.85 -58.24 -58.94 -59.08 -58.76 -58.23 -57.84 -57.96 -58.08 -58.04 -58.52 -57.94 -58.13 -58.72 -58.96 -59.58 -59.66 -59.47 -57.95 -56.27 -55.16 -55.58 -57.07 -60.24 -65.50 -71.44
F35 -57.42 -56.24 -56.86 -57.55 -57.72 -57.51 -58.11 -58.85 -58.89 -58.22 -57.86 -57.50 -57.42 -57.61 -57.79 -58.16 -57.49 -57.70 -58.21 -58.35 -58.95 -58.50 -58.10 -57.14 -56.13 -55.45 -56.09 -58.00 -61.53 -67.89 -74.75
F36 -56.94 -55.77 -56.65 -57.23 -57.32 -57.16 -57.70 -58.51 -58.44 -57.78 -57.74 -57.62 -57.39 -57.47 -57.60 -58.10 -57.66 -57.67 -57.74 -57.92 -58.48 -57.74 -57.13 -56.53 -56.19 -56.33 -57.35 -59.65 -63.32 -70.14 -77.61
F37 -56.69 -55.63 -56.60 -57.12 -57.06 -56.75 -57.22 -58.05 -58.10 -57.75 -57.78 -57.68 -57.46 -57.58 -57.64 -58.24 -57.98 -57.69 -57.39 -57.61 -57.87 -57.20 -56.69 -56.39 -56.33 -57.10 -59.08 -61.94 -65.92 -73.07 -79.88
F38 -56.67 -55.72 -56.69 -57.05 -56.76 -56.40 -57.05 -58.02 -58.14 -57.81 -57.68 -57.48 -57.26 -57.65 -57.86 -58.40 -58.14 -57.68 -57.27 -57.43 -57.40 -56.86 -56.47 -56.32 -56.65 -57.86 -60.77 -64.24 -68.62 -76.39 -79.07
F39 -56.58 -55.70 -56.72 -56.83 -56.50 -56.32 -57.00 -58.12 -58.25 -57.82 -57.61 -57.50 -57.41 -58.01 -58.17 -58.60 -58.28 -57.69 -57.41 -57.59 -57.37 -56.97 -56.52 -56.49 -57.48 -59.27 -62.61 -66.56 -71.30 -79.54 -76.80
F40 -56.55 -55.55 -56.81 -56.91 -56.53 -56.46 -57.22 -58.28 -58.27 -58.02 -57.95 -58.08 -58.12 -58.80 -58.66 -58.87 -58.48 -57.97 -57.80 -57.88 -57.47 -57.25 -56.90 -57.31 -58.89 -61.33 -64.92 -69.09 -74.26 -83.17 -75.03
F41 -56.89 -55.67 -57.11 -57.27 -56.97 -56.99 -58.04 -58.77 -58.39 -58.35 -58.53 -58.80 -58.80 -59.51 -59.20 -59.27 -58.81 -58.50 -58.21 -57.93 -57.60 -57.46 -57.54 -58.66 -60.71 -63.69 -67.55 -71.56 -77.12 -85.09 -73.43
F42 -57.52 -56.04 -57.47 -57.79 -57.82 -57.92 -59.14 -59.37 -58.68 -58.82 -59.16 -59.36 -59.52 -60.21 -59.90 -60.08 -59.64 -59.43 -58.76 -58.03 -57.94 -57.98 -58.53 -60.31 -62.99 -66.36 -70.55 -74.53 -80.29 -87.09 -71.92
F43 -58.26 -56.73 -58.05 -58.54 -58.84 -58.97 -59.94 -59.65 -59.01 -59.55 -59.95 -60.18 -60.69 -61.38 -61.18 -61.53 -61.07 -60.72 -59.64 -58.63 -58.55 -58.81 -59.96 -62.45 -65.57 -69.27 -73.72 -78.57 -85.37 -86.62 -70.68
F44 -59.10 -57.69 -59.07 -59.52 -59.97 -60.19 -60.63 -59.75 -59.37 -60.31 -61.03 -61.53 -62.18 -63.08 -63.22 -63.39 -62.74 -62.17 -60.75 -59.75 -59.63 -59.86 -61.45 -65.00 -68.31 -72.24 -77.02 -84.21 -91.70 -83.35 -69.50
F45 -60.47 -58.85 -60.52 -60.79 -61.00 -61.15 -61.35 -60.21 -59.91 -60.90 -62.30 -63.19 -63.86 -65.27 -65.92 -65.61 -64.60 -64.07 -62.39 -61.15 -61.03 -61.28 -63.17 -67.59 -71.56 -75.81 -81.46        -92.25 -81.10 -68.44
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D04 0.2456 0.2454 0.2452 0.2450 0.2448 0.2447 0.2445 0.2443 0.2441 0.2439 0.2437 0.2436 0.2434 0.2432 0.2430 0.2428 0.2426 0.2424 0.2423 0.2421 0.2419 0.2417 0.2415 0.2413 0.2411 0.2410 0.2408 0.2406 0.2404 0.2402 0.2400
D05 0.2817 0.2814 0.2812 0.2809 0.2807 0.2805 0.2802 0.2800 0.2798 0.2795 0.2793 0.2791 0.2788 0.2786 0.2783 0.2781 0.2779 0.2776 0.2774 0.2772 0.2769 0.2767 0.2765 0.2762 0.2760 0.2757 0.2755 0.2753 0.2750 0.2748 0.2746
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D10 0.4747 0.4742 0.4737 0.4731 0.4726 0.4721 0.4716 0.4710 0.4705 0.4700 0.4694 0.4689 0.4684 0.4678 0.4673 0.4668 0.4663 0.4657 0.4652 0.4647 0.4641 0.4636 0.4631 0.4625 0.4620 0.4615 0.4609 0.4604 0.4599 0.4594 0.4588
D11 0.5162 0.5156 0.5150 0.5144 0.5138 0.5132 0.5126 0.5120 0.5114 0.5108 0.5102 0.5096 0.5090 0.5084 0.5078 0.5072 0.5066 0.5060 0.5054 0.5048 0.5042 0.5036 0.5030 0.5024 0.5018 0.5012 0.5006 0.5001 0.4995 0.4989 0.4983
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D16 0.7405 0.7395 0.7385 0.7375 0.7365 0.7355 0.7345 0.7335 0.7325 0.7315 0.7306 0.7296 0.7286 0.7276 0.7266 0.7256 0.7246 0.7236 0.7226 0.7216 0.7206 0.7197 0.7187 0.7177 0.7167 0.7157 0.7147 0.7137 0.7127 0.7117 0.7108
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D23 1.1159 1.1141 1.1123 1.1105 1.1087 1.1069 1.1052 1.1034 1.1016 1.0998 1.0980 1.0963 1.0945 1.0927 1.0909 1.0892 1.0874 1.0856 1.0839 1.0821 1.0803 1.0786 1.0768 1.0750 1.0733 1.0715 1.0698 1.0680 1.0662 1.0645 1.0627
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D43 3.2480 3.2361 3.2242 3.2124 3.2006 3.1890 3.1774 3.1659 3.1545 3.1431 3.1318 3.1206 3.1094 3.0983 3.0873 3.0764 3.0655 3.0547 3.0439 3.0333 3.0226 3.0121 3.0016 2.9911 2.9808 2.9705 2.9602 2.9500 2.9399 2.9298 2.9198
D44 3.4796 3.4655 3.4516 3.4377 3.4240 3.4104 3.3968 3.3834 3.3701 3.3569 3.3437 3.3307 3.3178 3.3049 3.2922 3.2795 3.2669 3.2544 3.2421 3.2297 3.2175 3.2054 3.1933 3.1814 3.1695 3.1577 3.1459 3.1343 3.1227 3.1112 3.0998
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D46 4.0694 4.0485 4.0279 4.0075 3.9873 3.9674 3.9477 3.9282 3.9089 3.8898 3.8710 3.8523 3.8338 3.8156 3.7975 3.7796 3.7619 3.7443 3.7270 3.7098 3.6928 3.6759 3.6592 3.6427 3.6263 3.6101 3.5940 3.5781 3.5623 3.5467 3.5312
D47 4.4672 4.4402 4.4135 4.3873 4.3615 4.3360 4.3109 4.2862 4.2618 4.2378 4.2140 4.1906 4.1676 4.1448 4.1223 4.1001 4.0782 4.0566 4.0352 4.0141 3.9933 3.9727 3.9523 3.9322 3.9123 3.8927 3.8732 3.8540 3.8350 3.8162 3.7977
D48 4.9907 4.9530 4.9161 4.8800 4.8447 4.8100 4.7761 4.7427 4.7101 4.6780 4.6466 4.6156 4.5853 4.5555 4.5262 4.4973 4.4690 4.4411 4.4137 4.3867 4.3601 4.3339 4.3082 4.2828 4.2578 4.2331 4.2088 4.1848 4.1612 4.1379 4.1149
D49 5.7582 5.6977 5.6392 5.5826 5.5279 5.4749 5.4235 5.3736 5.3252 5.2781 5.2322 5.1876 5.1441 5.1017 5.0603 5.0199 4.9804 4.9419 4.9042 4.8673 4.8312 4.7958 4.7612 4.7273 4.6940 4.6614 4.6294 4.5980 4.5672 4.5369 4.5071
D50                                                                                                            5.7853 5.7220 5.6610 5.6022 5.5453 5.4903 5.4370 5.3854 5.3353 5.2866 5.2393 5.1933 5.1486 5.1050 5.0624 5.0210
D51                                                                                                                                                                                                                   5.7677
N04 1.7e+7 1.3e+7 8.3e+6 4.9e+6 5.6e+6 1.3e+7 1.6e+7 1.6e+7 1.8e+7 1.9e+7 2.7e+7 2.5e+7 4.7e+7 5.6e+7 4.6e+7 4.1e+7 5.5e+7 7.2e+7 8.2e+7 9.4e+7 1.0e+8 1.2e+8 1.6e+8 1.4e+8 1.3e+8 1.6e+8 1.8e+8 1.4e+8 9.3e+7 2.3e+7 1.4e+7
N05 8.9e+6 7.3e+6 4.7e+6 3.5e+6 4.1e+6 7.9e+6 7.9e+6 7.6e+6 9.4e+6 1.2e+7 1.4e+7 1.3e+7 2.0e+7 2.2e+7 2.3e+7 2.3e+7 2.5e+7 3.4e+7 4.3e+7 4.7e+7 4.9e+7 5.3e+7 6.1e+7 5.8e+7 5.8e+7 6.7e+7 6.8e+7 4.9e+7 3.6e+7 3.3e+6-5.7e+6
N06 5.2e+6 3.8e+6 2.8e+6 2.4e+6 2.5e+6 4.6e+6 4.7e+6 4.3e+6 5.1e+6 7.6e+6 7.7e+6 6.8e+6 9.9e+6 1.2e+7 1.6e+7 1.6e+7 1.5e+7 1.7e+7 2.2e+7 2.3e+7 2.4e+7 2.5e+7 2.6e+7 2.6e+7 2.8e+7 2.8e+7 2.7e+7 2.2e+7 1.8e+7 1.9e+6-2.7e+6
N07 3.1e+6 2.0e+6 1.9e+6 1.9e+6 1.6e+6 2.5e+6 3.1e+6 3.2e+6 3.5e+6 4.4e+6 4.6e+6 4.2e+6 5.5e+6 7.0e+6 9.8e+6 1.0e+7 9.2e+6 8.2e+6 9.7e+6 1.0e+7 1.2e+7 1.3e+7 1.2e+7 1.3e+7 1.2e+7 1.2e+7 1.1e+7 9.6e+6 1.1e+7 3.1e+6 1.3e+6
N08 1.8e+6 1.2e+6 1.6e+6 1.6e+6 1.2e+6 1.6e+6 2.0e+6 2.3e+6 2.7e+6 3.0e+6 2.8e+6 2.7e+6 3.5e+6 4.2e+6 5.2e+6 5.4e+6 5.1e+6 4.5e+6 5.0e+6 5.3e+6 5.8e+6 7.2e+6 6.3e+6 5.5e+6 4.9e+6 5.4e+6 4.5e+6 3.2e+6 5.7e+6 3.0e+6 1.6e+6
N09 1.3e+6 964959 1.3e+6 1.2e+6 937657 1.1e+6 1.4e+6 1.5e+6 1.8e+6 2.0e+6 1.8e+6 1.6e+6 2.2e+6 2.5e+6 3.0e+6 2.9e+6 2.8e+6 2.8e+6 3.4e+6 3.2e+6 3.1e+6 3.9e+6 3.8e+6 3.0e+6 2.5e+6 2.7e+6 2.6e+6 1.1e+6 1.9e+6 907918 754334
N10 1.3e+6 768728 923905 840020 739504 953753 1.1e+6 1.1e+6 991462 1.2e+6 1.3e+6 1.2e+6 1.5e+6 1.7e+6 2.1e+6 1.9e+6 1.7e+6 1.8e+6 2.3e+6 2.0e+6 1.9e+6 2.0e+6 2.0e+6 1.8e+6 1.7e+6 1.7e+6 1.6e+6 564613 414979 -20941 465284
N11 1.0e+6 621685 711679 660284 583135 760609 906342 785129 649938 813113 1.0e+6 993357 1.1e+6 1.1e+6 1.5e+6 1.3e+6 1.1e+6 1.1e+6 1.5e+6 1.4e+6 1.2e+6 1.0e+6 1.3e+6 1.3e+6 1.1e+6 1.1e+6 780067 348279 443056 9440.2 584411
N12 767281 512404 592273 528738 442943 570640 675093 561459 496654 577079 739843 764211 793363 775179 913108 858995 776754 780217 986458 952714 821772 650838 997461 1.1e+6 793431 725081 451939 272152 577617 202885 1.1e+6
N13 576843 431121 488397 407029 355461 435667 522800 439910 387910 454876 551636 562480 601123 609885 607535 550143 571359 563326 650526 610362 555522 489453 661070 724471 567980 480128 341375 241834 436064 347849 2.0e+6
N14 429862 359385 388558 316192 306202 342264 395556 346791 326425 377830 432588 434691 493647 509447 461112 400309 406449 399950 407624 377887 391822 379743 416047 439166 362189 309788 278832 212242 360912 713077 3.8e+6
N15 333126 296551 311766 260891 259418 284571 299414 273867 286966 326201 349637 350815 402810 420326 398697 348319 309816 288807 279012 259424 285359 281594 292512 306142 256370 259686 269250 175144 422713 1.5e+6 6.7e+6
N16 304136 257262 258238 223607 221747 256341 265884 231201 257144 295662 286649 285947 321365 361754 360112 295804 255063 228728 211731 199175 228346 231565 234804 242549 221228 266613 274303 183597 616336 2.9e+6 1.0e+7
N17 274365 219690 212223 182470 183544 214996 239070 194280 216859 255903 233828 241443 267754 309082 292567 229114 212046 194450 182086 167784 202771 216297 207422 204869 188392 234147 251193 229915 868205 4.3e+6 1.3e+7
N18 230314 184889 179919 151115 154855 168328 194066 157963 168707 204982 200254 211194 233224 260683 235570 189852 179433 166845 159144 148261 176056 191974 183249 173401 158738 185544 208667 265910 1.1e+6 5.0e+6 1.3e+7
N19 200924 158461 165180 141569 140788 138946 155985 126885 128839 160355 167831 169881 184631 202743 190770 165220 149847 141021 135056 129349 141758 151370 152190 153406 142244 159680 189023 288862 1.3e+6 5.1e+6 1.1e+7
N20 177710 146166 157718 131888 128235 126181 127211  98728 107621 136431 138665 132461 142528 151358 148113 137367 122667 121660 116416 112057 113413 125454 129319 138858 132724 143312 188068 323311 1.6e+6 4.9e+6 8.7e+6
N21 155008 139360 146398 113302 109202 114436 108330  83714 102135 130385 122737 113699 123647 128248 131122 119569 104688 106867 104113  94707  92357 105815 111147 117728 115660 129991 194264 375062 1.7e+6 4.6e+6 6.5e+6
N22 140816 126587 130999  98039  88663  99512  99203  83721  97790 118412 107914 106361 116653 119810 122141 106879  92034  91345  95763  84141  77016  84087  94614 105036 105269 128586 215446 455662 1.6e+6 3.8e+6 4.6e+6
N23 121124 109708 120646  90688  74869  87859  94385  83104  91132 105060  99072 100957 104094 109677 105738  90670  81853  76030  81973  71983  64860  68398  87586  99317  98064 123893 236655 549438 1.6e+6 2.8e+6 3.0e+6
N24  97263  93412 116639  86789  69463  80716  91907  76905  84704 100005  96142  89549  84413  96036  92550  75247  71525  64792  65056  58016  56647  60266  79499  89018  89371 124299 262051 630792 1.6e+6 2.2e+6 1.9e+6
N25  86051  86804 106888  77970  65343  75784  90697  73448  78559  93855  87626  78806  70042  82398  82805  64096  61947  57441  51361  47551  49606  54121  67806  78042  85081 133052 289222 670890 1.5e+6 1.6e+6 1.2e+6
N26  77397  85316  89612  61831  58577  70302  85628  71149  72620  82428  76274  74484  63873  70000  72325  57200  52484  49014  43238  40833  41059  45691  58164  71944  83760 136817 302889 639047 1.2e+6 1.1e+6 727434
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N27	65034	77233	77047	54277	54943	63194	75355	64328	66657	72639	68916	70825	60905	62989	65385	56005	46039	40390	37312	35709	33954	36990	49099	65355	77473	129939	296993	572692	851860	718282	412021
N28	59026	66127	70259	55971	56345	57046	63899	54558	58683	66137	65170	65792	57746	59388	59866	54314	43849	35604	32366	30234	28302	29523	40584	55745	70727	126182	274944	475678	584131	428478	209074
N29	50985	56198	61063	51006	52755	50587	51158	43541	47225	56325	57750	59052	54748	56087	54753	49673	43251	35350	30083	26158	24278	23919	34233	49233	69992	131766	246784	364771	367922	231057	96781
N30	40194	46466	48851	40735	43229	42916	41426	35106	38049	44885	46703	50271	49188	49603	48721	43339	40800	35474	29685	24365	22737	21626	29404	44669	67396	128169	202369	262097	225946	116619	42418
N31	32791	38667	38739	33112	33966	35632	35121	29527	31592	35190	36132	39297	40590	41861	40777	35522	34810	33220	29146	23816	22513	21731	25332	39495	63409	112091	148329	170767	128777	57111	18438
N32	26779	30998	30818	27021	26688	28794	28357	24711	26040	27304	28354	30252	31003	32845	33046	28087	28609	29383	27140	22956	20519	19565	21557	35231	59064	89797	99531	101029	67060	27643	8231.6
N33	21174	24803	24561	21294	20373	22734	21943	19334	19721	20283	22167	23937	23517	24379	25869	22460	24626	24905	22963	20825	17844	16721	18303	29935	48723	66532	65672	56417	32615	12167	3448.5
N34	15543	19429	18430	15880	15100	16759	15610	13544	13375	14668	16884	18871	18722	18590	19172	17529	20454	20027	17849	17282	15318	15391	16430	23729	35545	46676	43087	31116	15240	4622.4	1196.3
N35	11074	14746	13021	11318	11080	11857	10535	9071.8	9153.5	10891	12100	13423	13959	13631	13374	12554	14989	14600	13282	13155	11733	13308	14872	18890	24295	28910	25386	16667	7517.4	1769.8	372.01
N36	8063.7	10718	8927.8	7966.0	7954.2	8413.8	7584.7	6429.2	6668.3	7912.6	8156.4	8572.4	9241.6	9262.2	9187.0	8380.0	9491.1	9687.6	9774.1	9585.0	8641.0	10461	12281	14376	15828	15629	12579	7542.3	3299.7	699.22	127.95
N37	5579.9	7232.0	5896.5	5342.4	5529.4	6050.6	5548.5	4679.9	4724.6	5237.0	5312.6	5556.1	5978.6	5945.9	6001.2	5351.7	5813.2	6361.6	6982.7	6806.1	6566.6	7816.2	8969.7	9791.1	10116	8644.9	5594.9	2947.6	1201.5	236.46	50.288
N38	3660.6	4631.9	3782.0	3554.0	3882.1	4301.2	3788.2	3094.7	3073.3	3388.5	3572.4	3826.3	4115.9	3848.7	3753.9	3401.1	3693.0	4212.3	4742.4	4694.6	4822.6	5578.4	6223.4	6570.3	6224.6	4805.3	2510.5	1149.9	428.02	73.016	40.260
N39	2451.6	3052.0	2462.6	2454.8	2701.9	2879.9	2516.2	1986.3	1970.7	2224.8	2389.8	2510.6	2621.3	2340.3	2308.5	2145.4	2363.8	2776.2	3040.2	2991.0	3206.6	3590.5	4066.8	4184.1	3400.7	2300.2	1089.4	447.38	153.45	23.465	45.138
N40	1619.3	2074.6	1583.4	1582.6	1763.5	1834.0	1574.2	1260.2	1294.3	1402.1	1458.3	1450.0	1468.7	1288.6	1363.3	1331.0	1495.8	1722.1	1838.6	1847.8	2074.7	2231.3	2468.2	2294.7	1631.5	949.15	424.41	166.03	51.607	6.7670	45.100
N41	982.38	1326.3	973.26	959.24	1050.9	1068.5	858.33	744.14	829.82	857.60	842.94	812.12	831.79	723.97	797.48	805.01	917.07	1012.8	1109.3	1210.2	1333.5	1407.9	1414.7	1116.5	712.05	366.94	154.27	62.599	17.781	2.8902	43.531
N42	559.59	801.97	590.94	560.59	570.14	570.07	441.00	428.44	513.44	509.34	483.11	472.63	466.78	408.14	449.80	443.00	503.02	542.48	648.21	783.12	818.78	829.53	748.08	508.35	280.57	132.16	51.527	21.089	5.7216	1.2082	41.131
N43	311.72	452.26	341.63	311.89	298.49	296.60	243.05	266.12	315.43	285.84	267.08	259.91	236.88	207.13	222.80	211.03	240.93	268.09	351.68	453.51	472.69	455.83	358.53	206.85	103.39	45.136	16.576	5.5499	1.1879	0.9027	36.637
N44	169.68	239.35	178.44	164.85	152.13	148.30	137.29	172.38	192.97	159.46	138.54	126.42	111.82	93.173	92.717	91.467	109.10	127.54	181.10	233.85	246.11	239.27	169.73	76.829	36.747	15.236	5.1847	1.0163	0.1858	1.2911	32.235
N45	81.786	121.41	84.666	81.660	79.681	78.907	77.345	103.17	113.45	92.542	68.828	57.519	50.597	37.522	33.149	36.609	47.387	54.895	82.849	112.99	119.13	115.14	76.344	28.340	11.652	4.4790	1.2523	-0.1501	0.1087	1.4566	27.688
N46	34.401	57.447	38.938	39.926	41.450	43.409	45.297	54.983	60.493	52.144	33.413	25.366	20.018	12.808	11.334	13.548	17.845	20.532	31.125	48.032	53.157	48.112	29.404	9.4621	3.2046	1.0200	0.1508	-0.1471	0.2992	1.2458	21.402
N47	14.599	25.105	17.415	18.311	18.017	21.264	26.064	29.209	30.549	26.836	16.089	11.018	7.6411	4.1295	3.6462	4.5463	5.7951	6.7475	9.5651	16.130	19.956	17.000	9.3864	2.6096	0.7768	0.2122	0.0214	-0.0118	0.3312	0.8860	14.571
N48	6.0655	10.083	6.7792	6.7683	6.5345	9.1416	12.917	15.288	15.165	12.710	7.4520	4.6330	3.0609	1.3756	0.9208	1.3419	1.6967	1.8734	2.5597	4.3964	6.1000	4.8768	2.2767	0.5247	0.0722	-0.0227	9.6e-4	-0.0267	0.2702	0.6419	8.2911
N49	2.5061	3.6136	2.2706	1.9711	2.0213	3.5677	5.5743	7.8399	7.7926	5.9892	3.3414	1.7142	0.9998	0.3713	0.1577	0.3096	0.3850	0.3988	0.6132	1.0605	1.5677	1.1634	0.4705	0.1001	-0.0409	-0.0489	0.0142	0.0276	0.2706	0.4230	4.0321
N50																0.0510	0.0522	0.0533	0.1262	0.2087	0.3256	0.2438	0.1037	0.0316	0.0116	0.0055	0.0252	0.0680	0.2527	0.3298	1.8604
N51																															0.7945
PIA	0.000	0.028	0.054	0.076	0.097	0.120	0.143	0.162	0.182	0.204	0.226	0.248	0.270	0.292	0.315	0.334	0.354	0.374	0.395	0.414	0.433	0.453	0.475	0.500	0.528	0.565	0.610	0.667	0.743	0.833	0.939
z	32.52	33.54	32.65	32.07	31.98	32.17	31.91	31.51	31.60	31.57	31.22	31.08	30.90	30.59	30.51	30.04	30.24	30.28	30.36	30.40	30.31	30.37	30.39	30.55	30.90	31.57	32.08	32.73	33.37	33.36	33.33
Z	32.52	33.56	32.69	32.14	32.07	32.29	32.05	31.67	31.77	31.77	31.43	31.32	31.16	30.87	30.82	30.37	30.59	30.65	30.75	30.82	30.75	30.83	30.87	31.06	31.44	32.15	32.69	33.40	34.10	34.18	34.25
RR	2.93	3.25	3.09	2.58	2.52	2.71	2.69	2.31	2.41	2.68	2.69	2.72	2.74	2.79	2.81	2.49	2.47	2.42	2.41	2.30	2.24	2.35	2.62	3.00	3.46	4.53	5.96	8.08	12.16	16.29	20.79
LWC	0.17	0.18	0.17	0.14	0.14	0.15	0.16	0.14	0.14	0.16	0.17	0.17	0.18	0.19	0.19	0.17	0.17	0.18	0.19	0.18	0.18	0.20	0.22	0.23	0.25	0.31	0.40	0.50	0.76	1.07	1.49
W	6.57	6.73	6.57	6.66	6.68	6.81	6.84	6.95	6.90	6.72	6.57	6.51	6.53	6.42	6.45	6.48	6.58	6.68	6.83	6.99	7.09	7.10	7.00	6.77	6.50	6.20	5.88	5.53	5.11	4.61	4.16

6.4 Raw data

6.4.1 Format Description

Each data block in a **raw data** file begins with a header line which contains the date, the time and the time zone of the following data block. This line is preceded by the letter T and a colon (T means time). The format of the date/time stamp is YYMMDDhhmmss, which means year, month, day, hour, minute and second with 2 digits each. Date, time and time zone are separated by a space character. The header line is supplemented with the version number of the MRR firmware (following the identifier DVS), the serial number (of the MRR (following the identifier DSN), the calibration constant of the MRR (following the identifier CC) and the percentage of valid spectra, number of valid spectra and number of total spectra (following the identifier MDQ).

The next data lines contains the measuring heights. It begins with the capital letter M, a colon, the small letter h, two space characters, and an equals sign (M means measured value, h means height). The following numbers (9 digits decimal each) represent the measuring heights in meters.

The height line is followed by the line of the transfer function. It starts with the capital character M, a colon, the capital letters T and F and one space character. The rest of that line represents the values of the transfer function for each height step (9 digits decimal each).

The line of the transfer function is followed by 64 data lines. Each one starts with the capital character M, a colon, the small letter f, and a 2-digit number of the spectra line (0 to 63). The rest of these lines represent the received spectral signal power in engineering units for each height step (9 digits decimal each).

The raw spectra include the receiver noise floor.

6.4.2 Example

```
T:090612024311 UTC DVS 5.10 DSN 020704 CC 2066000 MDQ 100 58 58
H:h  =     0     35     70    105    140    175    210    245    280    315    350    385    420    455    490    525    560    595    630    665    700    735    770    805    840    875    910    945    980   1015   1050   1085
M:TF = 0.003292 0.011523 0.041975 0.099863 0.175583 0.254184 0.334019 0.425514 0.532373 0.603018 0.675720 0.756516 0.794239 0.836626 0.877778 0.891358 1.000000 0.968313 0.924280 0.883813 0.890398 0.903978 0.875857 0.853772 0.843347 0.834568 0.780658 0.774897 0.752401 0.689026 0.640604 0.422497
M:f00=  4798   2205    166     46     22     20     20     20     19     18     18     23     24     24     19     15     15     18     16     15     18     15     12     12     10     10     11     10      7      6      6      4
M:f01=  2780   1272    107     33     19     20     25     23     22     20     22     28     29     27     22     18     18     20     18     21     25     21     15     14     12     12     12     12     11      8      7      5
M:f02=   541    246     33     20     22     22     27     27     26     25     26     32     34     32     28     23     25     25     24     28     30     25     17     17     16     13     13     14     15     10      8      6
M:f03=    39     22     17     20     25     24     27     28     28     26     26     31     35     33     28     24     29     28     25     27     28     25     19     21     19     14     14     14     13     11      8      6
M:f04=     4      9     18     22     25     24     27     30     29     26     24     26     30     27     24     27     34     30     25     24     25     24     20     20     22     20     14     15     14     12     12      9      6
M:f05=     3      9     19     26     27     24     26     30     29     31     26     21     25     22     20     30     36     31     26     23     23     22     18     19     17     12     13     13     11     12     11      7
M:f06=     3      9     20     32     32     24     24     28     30     33     27     22     27     24     21     30     35     30     27     23     23     19     18     16     14     11     11     11     12     13     12      7
M:f07=     3      9     21     38     38     27     24     25     27     30     27     25     30     27     24     31     33     33     31     29     26     24     20     20     16     13     11     13     13     11     12     12      7
M:f08=     3     10     23     49     48     32     26     24     22     29     30     27     29     30     31     34     32     31     32     28     25     22     24     16     13     13     16     15     10     10     11      6
M:f09=     4     11     28     61     54     36     29     25     24     30     33     28     29     35     38     35     36     33     32     27     24     21     23     15     15     17     17     15     10      9     10      6
M:f10=     5     13     34     70     56     38     34     30     32     32     34     34     33     33     43     46     38     41     37     30     25     24     19     19     17     20     20     17     14     12     12      9      5
M:f11=     4     16     44     85     60     39     38     35     37     34     35     39     36     47     54     48     47     39     30     24     22     19     20     21     26     20     16     14     13     14      8      4
M:f12=     5     18     55    107     71     48     47     42     42     41     40     43     37     46     57     54     55     45     30     24     21     20     20     23     29     21     16     15     14     13      7      4
M:f13=     7     19     65    137     93     75     60     46     47     52     51     47     38     47     56     52     61     52     34     23     23     24     21     29     33     28     21     18     17     13      6      5
M:f14=     9     23     84    198    141    127     88     49     53     61     56     48     39     53     62     59     68     60     42     29     28     29     26     37     40     38     31     24     21     15      9      6
M:f15=    12     34    139    329    220    182    124     60     62     75     64     54     45     65     80     78     80     71     52     39     34     35     41     47     49     41     36     29     24     17     12      7
M:f16=    15     52    236    522    336    215    136     69     74     88     74     65     59     78     92     93     91     84     63     49     42     46     65     64     57     42     37     31     28     19     12      8
M:f17=    24     75    325    698    485    275    150     81     85     90     85     79     83     99    100    101    101    102     83     58     54     61     78     72     61     48     41     33     31     22     12      7
M:f18=    48    120    374    710    569    364    199    116    115    112    105     94    106    132    127    108    112    125    106     71     68     70     77     73     61     48     42     32     30     23     12      7
M:f19=    98    215    526    747    595    418    242    166    178    168    133    115    126    152    157    123    132    157    136    101     88     78     71     73     63     44     38     29     27     25     15      9
M:f20=   177    377    803    915    652    452    268    217    240    236    188    149    155    169    192    159    168    182    170    139    115    101     76     65     63     43     36     29     27     29     19     11
M:f21=   290    582   1054   1084    739    488    303    257    276    295    262    195    187    206    243    201    190    179    179    150    125    121     96     67     71     52     40     36     36     38     24     12
M:f22=   492    873   1270   1406   1049    557    352    281    293    305    310    266    234    259    267    222    207    171    152    125    117    124    111     93     91     66     50     47     49     48     31     16
M:f23=   814   1437   1629   1947   1531    666    418    340    355    315    349    369    345    329    261    225    224    178    142    109    122    129    116    125    114     88     80     64     62     61     40     22
M:f24=  1103   2015   2193   2970   2137    816    526    473    506    421    509    486    480    405    278    248    249    225    176    140    141    135    131    158    147    131    124     91     91     88     88     55     33
M:f25=  1215   2304   3049   4586   3012    973    722    714    711    661    829    608    523    405    287    289    322    323    257    222    179    161    194    220    207    195    176    129    133    130     81     48
M:f26=  1202   2861   4088   5698   3567   1012    867    906    952   1013   1097    733    513    352    284    358    464    482    382    369    262    252    330    337    297    270    243    192    179    162    106     61
M:f27=  1692   3945   4978   5726   3427    893    775    923   1093   1218   1081    731    502    394    351    445    628    732    577    586    405    437    516    481    421    367    299    263    248    200    124     79
M:f28=  3428   4611   6013   6285   3599    883    731   1024   1164   1418   1153    719    516    513    543    565    807   1059    830    791    549    632    668    614    557    452    349    317    349    282    146     97
M:f29=  6270   5873   8179   7200   3957   1145    965   1395   1737   2134   1536    855    663    639    762    756   1113   1595   1225    983    714    817    814    673    573    450    403    404    446    355    166    105
M:f30=  9754   9622  11394   7165   4522   2175   1524   2165   2896   2947   1902   1066    893    830    948    934   1443   2246   2014   1453   1080   1073   1003    695    466    385    471    517    487    369    204    128
M:f31= 13520  15729  15559   7632   6648   4740   2698   3354   4341   3500   2201   1344   1043   1018   1095   1059   1805   2799   3242   2339   1587   1295   1095    675    317    315    525    557    425    331    251    187
M:f32= 15274  23192  21914  10788  11365   9077   5307   4776   5807   3976   2625   1708   1151   1200   1387   1756   2922   3657   4269   3481   2313   1409    825    465    161    207    414    451    340    289    266    227
M:f33= 13520  26471  25550  15241  18222  15080  10203   7315   7471   4865   3160   2005   1326   1568   2126   3210   4680   4528   4170   3876   2687   1273    441    202     62     92    211    307    320    276    245    176
M:f34=  9754  21874  22408  17097  22023  19192  16351  12855  11468   7592   4160   2636   2145   2913   3740   4692   5560   4499   3363   2929   1955    825    194     64     26     34     99    235    324    273    218    116
M:f35=  6270  15310  16602  15558  19843  18169  19653  18327  16854  11037   5469   4241   4229   5146   5376   5022   4785   3691   2351   1622    952    415     84     22     17     18     56    191    289    237    211    110
M:f36=  3428   9683  12461  12216  15018  13796  16298  18613  17631  10864   6094   6075   6527   6463   5080   3520   2864   2397   1243    674    375    171     40     15     15     16     36    163    246    176    178    103
M:f37=  1692   5905  11128  10153   9887   8186   9553  13447  12424   7651   5677   6779   7882   7002   3872   1817   1248   1158    474    212    126     64     24     16     16     18     31    136    175    119    114     68
M:f38=  1202   4727  11416  11332   6377   3700   4043   6282   5638   4052   4089   5560   6861   5684   2461    776    450    449    161     64     42     31     19     16     16     18     27     87     93     64     53     32
M:f39=  1215   4582  11578  12064   4531   1380   1280   1967   1806   1531   1950   2962   3602   2693   1117    307    172    177     65     28     22     22     18     14     15     17     19     37     35     25     21     16
M:f40=  1103   4033  10911  10304   2914    545    423    572    558    463    597    958   1075    770    369    128     84     80     33     19     16     18     18     13     15     18     17     17     17     15     14     10
M:f41=   814   3225   9611   8782   1958    260    208    227    195    151    155    230    224    179    115     60     50     38     23     20     16     17     17     13     15     18     16     15     16     14     13      9
M:f42=   492   2421   7508   7183   1576    130     97     97     79     64     65     76     66     62     51     37     34     24     22     20     19     18     17     14     14     16     14     13     14     12     12      8
M:f43=   290   1436   4351   4426   1007     58     41     42     38     38     43     39     36     41     34     29     25     21     23     21     21     20     18     16     15     15     13     12     12     12     13      7
M:f44=   177    675   2171   2315    502     33     25     28     32     33     33     26     26     33     29     25     23     21     22     22     23     22     20     19     16     16     13     11     11     13     14      8
M:f45=    98    318   1386   1407    254     30     24     24     31     31     27     21     22     27     26     24     23     20     19     22     24     23     20     20     15     14     13     12     11     14     12      7
M:f46=    48    149    828    804    135     27     23     21     27     29     25     22     23     23     24     25     23     18     18     23     24     23     18     18     13     11     12     14     12     13     11      7
M:f47=    24     60    332    325     67     25     22     19     25     29     25     24     26     25     27     27     26     22     19     25     25     21     17     16     12     11     12     14     13     11     11      7
M:f48=    15     21     96    101     35     27     24     19     22     29     26     25     28     27     30     27     25     23     19     23     23     19     15     15     12     11     13     14     13     10     10      8
M:f49=    12     10     33     38     23     27     25     18     20     28     24     21     25     25     25     21     19     18     19     22     21     19     16     16     12     10     12     14     13     10      9      7
M:f50=     9      8     19     24     22     26     23     20     24     29     25     19     21     20     19     18     16     17     20     23     22     21     18     17     13      9     11     14     14     11     10      7
M:f51=     7      7     14     22     26     27     23     22     27     31     27     18     21     20     18     18     18     17     20     25     23     21     20     16     14     10     12     14     12     11     11      6
M:f52=     5      7     12     20     27     28     26     27     28     31     28     20     23     24     21     18     18     14     19     26     22     20     20     16     13     11     11     13     12     13     13      7
M:f53=     4      6     11     17     24     26     26     28     29     33     29     26     27     24     20     19     20     14     19     23     22     20     18     16     14     13     13     14     13     13     14      8
M:f54=     5      8     13     19     24     23     24     26     30     33     31     30     27     22     20     22     23     17     18     20     20     20     18     16     16     15     14     15     14     14     10      8
M:f55=     4     10     15     21     26     23     23     26     28     30     33     32     25     20     22     25     25     20     20     19     17     19     18     16     18     16     13     14     13     12      9      6
M:f56=     3      9     15     21     25     22     22     22     22     25     32     34     27     22     23     24     24     21     23     21     18     19     16     14     17     17     14     15     12     11     10      6
M:f57=     3     10     19     25     24     21     22     20     21     24     31     35     31     26     22     22     24     22     26     24     20     19     14     13     16     17     14     17     12     11      9      6
M:f58=     3     11     24     30     26     22     23     23     22     22     28     28     30     29     22     19     24     24     26     25     21     17     14     15     17     17     14     17     12      9      8      6
M:f59=     3     10     24     31     26     23     23     25     24     20     25     23     26     29     21     18     21     22     24     24     21     17     15     17     18     18     15     16     12     10      8      6
M:f60=     4      9     21     28     25     22     21     26     26     21     25     24     25     28     21     21     21     20     20     20     19     17     16     18     17     17     16     15     11     10     10      6
M:f61=    39     25     18     24     24     20     18     24     29     25     25     25     27     27     22     23     21     20     19     18     17     17     16     18     18     16     17     15     10     10     11      6
M:f62=   541    254     29     20     24     21     18     24     30     28     22     24     29     28     22     22     21     19     19     16     15     16     16     17     16     16     18     14     10     11     10      6
M:f63=  2780   1279     95     32     23     21     18     22     24     23     19     23     27     27     21     18     18     19     18     15     15     14     14     14     12     12     14     11      9     10      8      4
```

6.5 Removing of the Software

If you want to remove the program from your PC you must be logged in as administrator. If still active you must stop the MRR-2 data-, error- & communication service using the `services` program in the program group `control panel/Administrative Tools`.

Then activate the folder `software`, select the entry `METEK MRR Software` and press the button `Add/Remove`. Finally you must manually remove the empty directory (`C:\METEK`) and possibly some data files and directories.

7 Detailed description of the MRR-2 control program

The MRR-2 generates Doppler spectra at 31 height ranges. The data processing is performed by a DSP which is located in the Radar Control and Processing Device (RCPD) at the antenna. The measured data are transmitted by a serial RS-232 port. This port is also used for the device control. If the MRR-2 is connected to a PC, the control, the calculation of further values, and the recording of the data can be done with the MRR-2-control program described below.

The software is divided into two components :

- Communication-, Data-, and Error- Service (CDES)
- Control Program User Interface (CPUI)

DCES communicates directly with the connected MRR-2, and CPUI performs the operational control of the MRR-2 using CDES. By means of this the user can interrogate or change the system status in a comfortable way.

Windows® Service Programs

Service programs are software components, which are started automatically when the machine is turned on and the operating system boots. They offer their ‘services’ e.g. control functions and data to other programs. The management of those programs must be provided by the operating system. The starting of a service program needs no manual operation. Only take care that the corresponding service is not deactivated.

Various details of the usage of services depend on the operating system. For this reason the used operating system must be Windows® 2000 or XP. (Windows® Vista and Windows 7 are not supported).

7.1 Communication-, Data-, and Error-Service (CDES)

7.1.1 Communication Service

This service is needed for the communication between the control program user interface (CPUI) and the control port of the MRR-2, which is implemented as a serial interface. With CDES the system settings of the MRR-2 can be retrieved and any changes entered by the user are translated to the corresponding commands and transmitted to the MRR-2. (Factory setting of the serial port of the MRR-2 is 57600 baud, 8 bit, no parity, XON/XOFF handshake protocol.)

7.1.2 Data Recording

The second function of CDES is the recording of the “averaged” or “instantaneous” measured data of the MRR-2. The data is ASCII formatted, so that it is directly readable.

CDES creates one file each day, whose name is constructed from the actual month, the day (2 characters each) and an additional extension. The boundary between two days is defined as 0:00 (selected time zone including UTC). The file name extension is `.MRR` .

All files of a month are stored in a separate directory which will be created automatically if it is not already existing. The names of the directories are constructed from the actual year (4 digits) and the respective month (2 digits).

The path names for the data registration and the port settings may be changed with the MS registry editor regedit.exe at the key

```
HKEY_LOCAL_MACHINE\
   System\
      CurrentControlSet\
         Services\
            MrrSrvc\
               Parameters
```

The variables of this key are shown with their default settings. Change the underlined values, if necessary :

```
Port                  REG_SZ         COM1
BaudRate              REG_DWORD      57600
AveragedDataFile      REG_EXPAND_SZ  %MetekRoot%\ActData\Data%s
AveragedDataPath      REG_EXPAND_SZ  %MetekRoot%\Data
InstantaneousDataFile REG_EXPAND_SZ  %MetekRoot%\ActData\InstData%s
InstantaneousDataPath REG_EXPAND_SZ  %MetekRoot%\InstData
```

The common root directory is defined by the environmental variable

MetekRoot

It also can be changed with the registry editor at the following key :

```
HKEY_LOCAL_MACHINE\
   System\
      CurrentControlSet\
         Control\
            Session Manager\
               Environment
```

The variable is :

MetekRoot REG_SZ **C:\METEK**

The default settings are :

C:\METEK\Data	for averaged data
C:\METEK\ActData	for actual data(raw, instantaneous and averaged)
C:\METEK\Instdata	for instantaneous data
C:\METEK\Rawdata	for raw data, not processed, only for testing purposes
C:\METEK	as the common root directory

The file C:\METEK\Data\200506\0611.MRR e.g. would contain the averaged data from June, 11th of 2005.

7.1.3 Error Protocol

The third function of CDES is the recording of all error messages which are caused by the operation of the MRR-2 (except messages which are generated from user input errors).

The error recording is done by the event logging function of the operation system. At the item application you find a chronologically sorted list of error messages, which occurred during the operation. Use the Windows event viewer to look at the messages or to store them in other formats. You also can define, how the system shall act if more than the storable number of errors occur. The event viewer is located in the program group Programs/Administrative Tools.

7.2 Control Program User Interface (CPUI)

CPUI provides the user access to the MRR-2 through CDES. The correct installation and the automatic start of the service program are required for a successful start of CPUI. CPUI allows controlling the MRR-2 also by PCs which are not connected directly to the MRR-2.

It is only necessary that there is a network connection to that PC, on which CDES was started. This network connection may be either a local connection (ethernet) or a remote access connection (RAS) which is built up using the public telephone. (Make sure that you have purchased the required number of program licenses.)

For this remote operation a login at the remote CDES is necessary when you start the program (e.g. by a mouse click on a program icon you created before, or by the command line `C:\METEK\MrrCtrl`). This ensures that only one user is accessing the MRR-2.

There are no special network installations needed, because no network protocol dependent functions are used between the service and the user interface.

The following picture shows an example for a remote access, where the network connection is performed by a RAS connection. The communication of the user interface on PC #2 with the MRR-2 uses the network and the communication service program on PC #1. The data recording and the event logging is executed on PC #1 which is connected directly to the MRR-2:

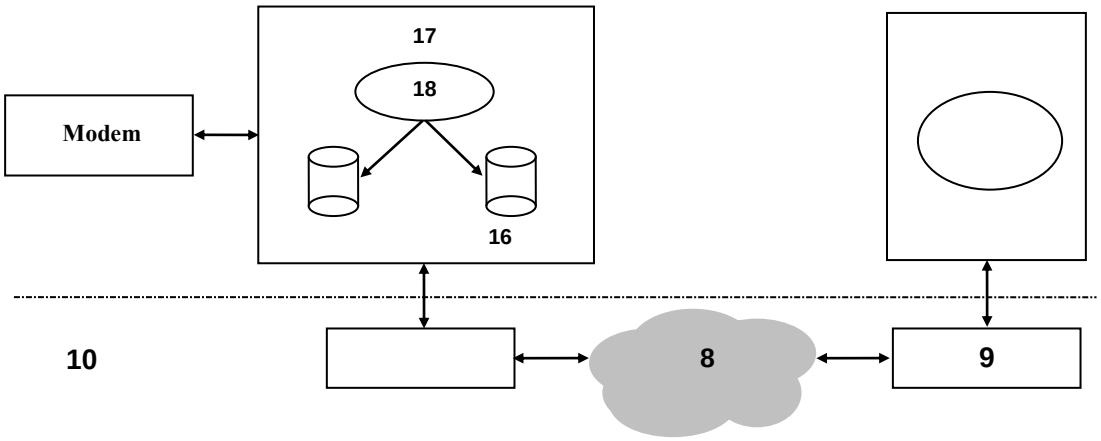

Figure 17 Remote Acces

The software is supplied on a CD-ROM with the following files:

`MrrSrvc.exe`	the service program
`MrrCtrl.exe`	control program (GUI)
`Messages.dll`	used for error messaging
`MFC71.dll`	used for runtime environment
`msvcr71.dll`	used for runtime environment
`Mrr`***`XXXXXX`***`.inf`	installation file (***XXXXXX*** stands for the serial number of the MRR)
`MrrCtrl_D.hlp`	help file German
`MrrCtrl_E.hlp`	help file English
`MrrCtrl_D.cnt`	help file German
`MrrCtrl_E.cnt`	help file English
`MrrView.bat`	
`sbsize.exe`	
`setcolor.exe`	
`gzip.exe`	data compression tool
`tail.exe`	data viewer

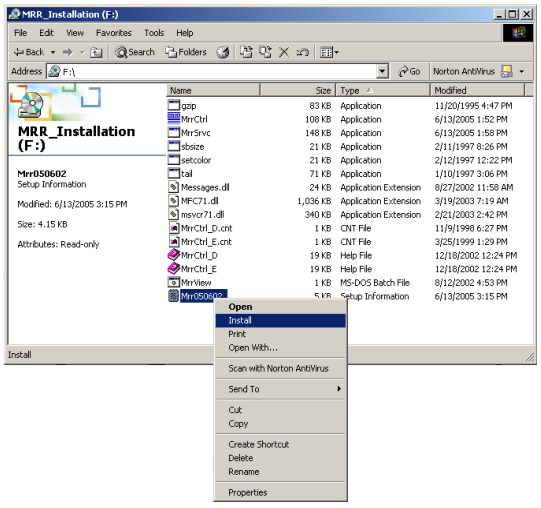

Figure 18 Directory Listing of the Installation CD-ROM

After installation of the MRR software the port settings may be changed with the MS registry editor regedit.exe at the key

```
HKEY_LOCAL_MACHINE\
   System\
      CurrentControlSet\
         Services\
            MrrSrvc\
               Parameters
```

The port variables of this key are shown with their default settings. Change the underlined values, if necessary :

Port	REG_SZ	COM2
BaudRate	REG_DWORD	57600

(You must be logged in with administration rights to change Windows® Registry parameters)

Every time when you change one ore more MRR parameters in the Windows® Registry you have to restart the MRR service because these parameters are only read from the Registry when the service starts.

Open the `Start/Settings/Control Panel/Administrative Tools/Services` menu in Windows® 2000. After selecting the MRRService, stop and start it directly with the short cuts or open the **Properties menu** and use the **Stop** and **Start** buttons.

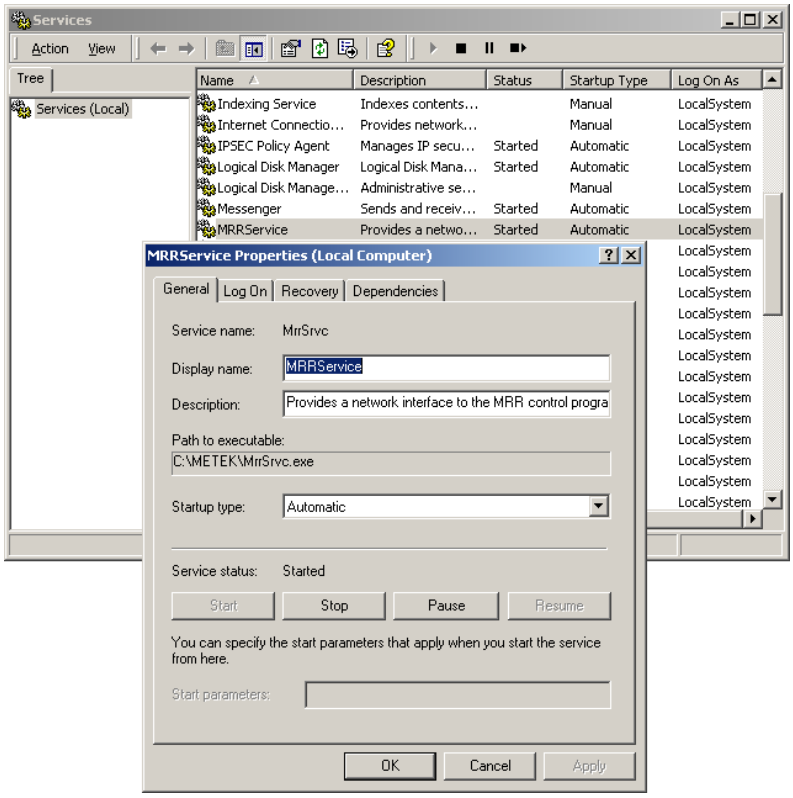

Figure 19 Administrative Tools / Services – Menu (Windows® 2000)

8 MRR-2 Specifications

RCPD with Radar module

Operating Frequency:	24.230 GHz
Operating Mode:	FMCW
Modulation:	1.5 - 15 MHz
Output Power:	50 mW (+17 dBm) (antenna foot point)
OoB and Spurious Emission:	< -80 dBm/MHz (antenna foot point)
2nd Harmonic:	-37 dBm
ITU-Designation:	30M0N0N
Power Supply:	24 VDC / 1A

Antenna

Type:	parabolic offset antenna
Diameter:	600 mm
3 dB Beamwidth:	approx. 1.5 °
Gain:	40.1 dBi

Junction Box / Power Supply:

Input Voltage:	230 VAC or 24 VDC
Output Voltage	24 VAC / 1.5 A
Dimensions:	205 x 145 x 65 mm
Weight:	1.3 Kg

Antenna Heating (Option)

Power Supply:	230 VAC
Power Output:	approx. 200 W

Complete System:

Weight:	17.5 Kg
Dimensions:	800 x 600 x 850 mm

CETECOM ICT Services GmbH

EC Identification number 0682

authorized by the German Government

to act as Notified Body in accordance with the R&TTE Directive 1999/5/EC of 09. March 1999.

CERTIFICATE
EXPERT OPINION

Registration-No.: **E814169R-EO**

Certificate Holder: **METEK**
Meteorologische Meßtechnik GmbH
Fritz-Straßmann-Str. 4

D-25337 Elmshorn

Product Designation: **Mikro-Regen-Radar (MRR) / PreWeS24**

Product Description: **Radar System**

Product Manufacturer: **METEK**
Meteorologische Meßtechnik GmbH
Fritz-Straßmann-Str. 4

D-25337 Elmshorn

Essential requirements	Specifications / Standards	Submitted documents	Result
Radio spectrum (R&TTE, Article 3.2)	EN 300 440-1 V1.3.1 (2001-09) EN 300 440-2 V1.1.1 (2001-09)	Test Report	conform

Marking: **The product shall be signed with CE, our notified body number and the Class II identifier (Alert sign) as shown right hand.**

CE 0682 !

The scope of this evaluation relates to the submitted documents only.
The certificate is only valid in conjunction with the following **number** of annexes.

Number of annexes: **1**

Saarbrücken, 18.10.2004
Place, Date of Issue

Signed by Ernst Hussinger
Notified Body

GERMAN NOTIFIED BODY
DEUTSCHE BENANNTE STELLE

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