Operational Instrument Description and Data Management Plan for Micro Rain Radar Metek MRR-2, Geophysical Institute, University of Bergen

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Contents

1 Introduction

This document describes the setup and data management of the micro rain radar MRR-2 (Metek GmbH, Germany), which is owned, installed and operated by the Meteorology group at the Geophysical Institute (GFI), University of Bergen (UiB), Norway. It is part of a document series covering all instrumentation used for continuous data acquisition and processing at the Geophysical Institute.

The document serves as a reference for the installation of the hardware and software, for needs when shipping the instrumentation to other locations, to understand and modify the

Table 1: Characteristics of the MRR-2 (from Metek data sheet).

Transmit power	50 mW
Frequency	24 GHz
Averaging interval	10 - 3600 s
Height resolution	10 - 200 m
Number of range gates	up to 30
Antenna heating	230 VAC / 24 VDC, 25 W
Interface	RS232 / RS422 / LAN
Power supply	24 VDC, 25 W
Weight (without power supply and cable)	6 kg
Shipping weight (with stand)	30 kg

data archiving and post-processing if needed, and the file formats and metadata information, and locations used for archiving.

2 Metek Micro Rain Radar MRR-2

2.1 Instrument description and setup

The Micro Rain Radar 2 (MRR-2, Metek GmbH, Germany) is vertically pointing K-band doppler radar operating at wavelengths of 24.23 GHz. From the doppler spectra caused by hydrometeors, the instrument is capable of retrieving reflectivity, drop size distributions, rain rate and liquid water content resolved into effectively 30 range gates at a vertical resolution between 10-200 m (Table 1). This provides a vertical range from 300 m to 6000 m. Profiles are acquired at a sampling rate of 125kHz, and averaged over 10s intervals. The data acquisition software can archive data in addition as time-averaged values. Spectral categories comprise 64 bins for drop size, spectral reflectivity, and spectral drop density (see below on data files).

The instrument has sometimes been operated in a mode with alternating range gate settings for different time intervals. This complicates data post-processing, since data files need to be split manually, and is discouraged. Higher-resolution retrievals are apparently less useful than vertical range for most precipitation situations, as the height of the bright band and other characteristics are missed with too short vertical range.

The instrument is by default installed on the GFI rooftop (45 m a.s.l, Table 3). The MRR-2 is connected to a control box, which in turn is currently connected to a Windows 10 laptop PC (GFI06909x) provided by UiB ITA via a serial/USB connector cable. The MRR-2 data acquisition software (Version number 2.x) is installed as a Windows system service and continuously acquires measurement data after startup of the PC. Operation of instrument can be monitored with MRR Control.exe software available from the desktop. The Metek Viewer software is set up to provide live displays of the acquired data.

Temporal deployment to other locations and field measurements has been done. In this case the MRR-2 is separated into several components for shipping (Table 3). Deployments to Greenland (EastGRIP) and onboard a ship (R/V Allicance during IGP 2018) and at Finse Alpine Research Center (SNOWPACE2020) have been successfully completed (Table 2). The

Table 2: Field deployment of the MRR-2 owned by GFI

Campaign	Location	Time period
EGRIP	EastGRIP ice core drilling site, Greenland	May–August 2017
IGP	R/V Alliance, Iceland-Greenland Sea cruise	February–March 2018
SNOWPACE2020	Finse Alpine Research Center	March–April 2020

Table 3: General instrument parameters for the MRR-2

Parameter	Description
Instrument	Micro Rain Radar 2, Metek GmbH, Germany
Geographical coordinates	5.33E, 60.38N
Installation location	Rooftop of GFI tower (default) and temporal deployment elsewhere during campaigns
Instrument serial number	200607002
Start Date	2015
End Date	ongoing
Funding Source	GFI internal funding
Shipping weight	30 kg
Shipping dimensions	95×69×48 cm aluminium box
Instrument components	Dish, transceiver unit, cable, power/data interface, stand
Mounting setup	53mm tubing, single screw, 13mm hex wrench.
Data owner	Geophysical Institute, University of Bergen, Norway

MRR-2 can be mounted on the provided stand, or on any pole with a suitable diameter (max 53 mm).

The instrument is robust to operate under difficult weather conditions. Icing and snow buildup on the dish will attenuate the received signal, and cleaning is advisable since the dish is without heating (option by the manufacturer). The MRR-2 receiver signal is easily disturbed by other power consumers on the same connection, such as heaters or motors. This has been causing trouble during all previous field deployments. This can be noted by the dropout of profiles during acquisition, e.g. using the MRR Control.exe software. In this case the solution is often to provide a separate power line/socket for the MRR-2 only, or to turn the sender/receiver facing in a different direction.

2.2 Instrument setup and operation

When installing and mounting the instrument, consider the following aspects:

- The instrument shall look straight up, alinged using the libelle on the radar dish. Make sure the instrument does not come loose by wind or other forces over time.
- A green LED is visible in transceiver block (sender/receiver unit) pointing toward the dish, indicating the instrument has power and works correctly.

Table 4: Daily MRR files with naming and files size for ASCII and netCDF format.

File name	File size	Format	Description
`MMDD.raw`	15 MB (60 MB*)	ASCII	raw spectra files
`MMDD.pro`	60 MB (380 MB*)	ASCII	processed spectra files
`mrr_YYYYMMDD.nc`	90 MB	netCDF4	warm rain algorithm (Metek)
`mrr_s_YYYYMMDD.nc`	120 MB snow	netCDF4	snow algorithm (ImProToo)

*without compression

- Remove extensive riming, snow, and ice buildup, if any. Some snow or water will not disturb MRR operations noticeably. Consider heating the dish in strong riming/icing conditions.

- The MRR data acquisition software is run as a system service automatically during login. It hardly ever needs to be restarted once running. Check that data acquision is running by program MRRControl.exe from desktop, then button "System status". A counter will indicate the time since the last succesful retrieval. This should typically be updated every 10s, if power fluctuates the time value is much longer.

- The last profiles appear continuously in the METEK Graphics program window. If many white stripes are apparent besides colored profiles, power fluctuations may cause data acquisition problems. Other causes for error include connections between the modem (backmost USB port on left side, connected to serial cable) and the box to the left of the laptop, other power consumers on the same socket, as well as other remote structures and installations, including high-voltage power lines (landlines).

2.3 Data collection and archiving

Instrument data files are acquired by the MRR Software continuously (every 10 s) and stored in the folder `C:\User\Public\Documents\Data\MRR` on the measurement PC. Two types of files are created, the raw data files (.raw in subfolder `RawSpectra`) and the processed data files (.pro) in folder `ProcessedData` (Table 4).

The python script (`mrr_compress.py`) compress the data using the bzip2 algorithm daily at 01 UTC. Raw files are transferred hourly, *.pro files daily to a network location using a python script (`mrr_archive.py`). Both python scripts are managed by the Windows Task Scheduler. The scripts are located in `C:\User\Public\Documents` on the Windows PC. Copies of the scripts are located on GFI linux file storage `cyclone.hpc.uib.no` at `/Data/gfi/scratch/metdata/scripts/MRR`.

Data files are transferred from the measurement computed to the drive `/Data/gfi/scratch/metdata` via a network mounted drive as volume Y: Nightly mirror backups are maintained for all data on that drive by ITA.

Daily files are located in monthly subfolder, contained within yearly folders within the folders: `/Data/gfi/scratch/metdata/MRR/RawSpectra/YYYY/YYYYMM`
`/Data/gfi/scratch/metdata/MRR/ProcessedData/YYYY/YYYYMM`
`/Data/gfi/scratch/metdata/MRR/netcdf/YYYY/YYYYMM`

Table 5: Measurement parameters recorded by the MRR-2 and contained in ProcessedData netCDF files (mrr_pro_yyyymmdd.nc).

Measurement parameter	Symbol	Unit
Attenuated radar reflectivity	z	dBZ
Radar reflectivity	Z	dBZ
Rain rate	RR	$\mathrm{mm\,h^{-1}}$
Liquid water content	LWC	$\mathrm{g\,kg^{-1}}$
Drop size	D	mm
Spectral reflectivity	F	dB
Spectral drop densities	N	$\mathrm{m^{-3}\ mm^{-1}}$
Doppler (fall) velocity	W	$\mathrm{m\,s^{-1}}$
Path Integrated Attenuation	PIA	dB
Transfer Function	TF	1
Percentage of valid spectra	MDQ1	%

Conversion to netcdf format is done by custom and open source conversion software (see below).

When the instrument is operated in alternating range gate mode, one daily data file is generated containing both range settings. While the pro netcdf files are capable of The snow processing algorithm is not capable to handle data files with alternating range gate settings and requires a splitting step with a separate script (see below). Alternating range settings where only applied in some periods of 2015–2016.

2.4 Processing routines

Processing routines in different programming languages are located in `/Data/gfi/scratch/metdata/scripts/MRR:`

- The tool mrr2c by Peter Kuma (`https://github.com/peterkuma/mrr2c` has been adopted for conversion of the Processed MRR files to netCDF4 format. In its original version, the tool provides only HDF5 output. At GFI, mrr2c is available with a default output in compressed netCDF format (netCDF4). File sizes are only 20% larger than bzipped *.pro files. Input files can be read in while compressed with gzip or bzip2.

- ImProToo python script routines (`https://github.com/maahn/IMProToo`) to process *.raw data files to netcdf format. These routines are specifically applicable for snow retrievals. The IMProToo snow processing routines are only run on demand for specific periods. Data files are named `mrr_s_yyyymmdd_zzzm.nc` instead of `mrr_yyyymmdd.nc`. The datafiles produced by ImProToo do not contain the rain variables produced by the Metek software (Table 5).

- (Deprecated) `MRR-2nc.ncl` NCL script to convert daily *.pro data files to netcdf format.

The processing routines for warm rain conditions are run daily at 2:00 UTC on cyclone. (tbc) NetCDF data files are only archived if precipitation at any elevation was detected within

Table 6: Data file metadata for mrr_s_yyyymmdd_zzm.nc data files produced by IMProToo

```
:calibration_constant = "2707739" ;
:serial_number = "200607002" ;
:firmware_version = "6.10" ;
:service_version = "6.0.0.6" ;
:sampling_rate = "125e3 Hz" ;
:elevation = "0 m" ;
:resolution = "30 m" ;
:averaging_time = "10 s" ;
:creation_date = "Sat Nov  4 02:10:24 CET 2017" ;
:instrument = "Micro Rain Radar 2, Metek GmbH, Germany" ;
:institution = "Geophysical Institute, University of Bergen, Norway" ;
:data_contact = "harald.sodemann@uib.no" ;
:file_creator = "Harald Sodemann" ;
:longitude = "35.9915W" ;
:latitude = "75.6268N" ;
:location_name = "EastGRIP camp, Greenland" ;
:conventions = "NetCDF-CF" ;
:source_file = "1207.pro" ;
:description = "MRR processed data file" ;
```

the time range of one day. The total number of precipitation time is recorded in the log file `/Data/gfi/scratch/metdata/scripts/MRR/MRR_archive.log`

2.5 Quicklooks, plotting routines

Selected quicklooks are located in `/Data/gfi/scratch/metdata/MRR/quicklooks`

Matlab, python and ncl plotting routines are located in the folder `/Data/gfi/scratch/metdata/scripts/MRR`, in their respective subfolders. The matlab routines are currently most up to date:

Filename	Description
read_MRR.m	read MRR data from processed files in netCDF format
aggregate_MRR.m	aggregate MRR data to time interval given in minutes
MRR_overview.m	create quarterly figures of data availability
plot_MRR_weekly.m	create weekly plots of Z, RR and W

When installed at the GFI tower, the instrument data are continuously visualised with a set of plotting routines. To that end, the *.pro files are converted to netCDF format with the modified mrr2c routine once every hour, and then displayed for the last 24 h measurement period in terms of reflectivity and vertical wind speed. A sample plot is shown in Fig. 1.

2.6 Data access, curation, use

Data is available with a Creative Commons license (attribution, access, re-use) after a 2-year carence period. Data are planned to be archived on the Bjerknes Centre Data Base (BCDB,

Table 7: Data file variables and metadata for mrr_yyyymmdd.nc data files produced by mrr2c.

```
:title = "MRR-2 data file" ;
:conventions = "NetCDF-CF" ;
:institution = "Geophysical Institute, University of Bergen, Norway" ;
:file_creator = "Harald.Sodemann@uib.no" ;
:data_contact = "Harald.Sodemann@uib.no" ;
:dataset_version = "1.0" ;
:instrument = "Micro Rain Radar (MRR-2)" ;
:manufacturer = "Metek GmbH, Germany" ;
:creation_date = "2020-04-27 14:41:10 UTC" ;
:creation_note = "Created with modified version of mrr2c V1.0.2 (c) 2017-2020 by Peter Kuma" ;
:calibration_constant = 2707739. ;
:firmware_version = "6.10" ;
:service_version = "6.0.0.6" ;
:sampling_rate = 125000. ;
:height_resolution = 100. ;
:device_serial_number = "200607002" ;
:level = "PRO" ;
:radar_altitude = 58. ;
:time_zone = "UTC" ;
:averaging_time = 10. ;
```

doi tbd). The contact persons for data access are the data collectors stated above.

Data set identifier (DOI): tbd

The data has so far been used in one completed Masters Thesis and one PhD project:

1. Höppler, Lukas C. P.: Characterization of Small-scale Precipitation Variations with Micro Rain Radar Measurements and Radar Data from the Norwegian Meteorological Institute, MSc thesis, Ludwig Maximilian University of Munich, October 2016, 118 pp.

2. Pellaud, Claire: Vertical stable isotope gradients in the Bergen valley, MSc Thesis, Geophysical Institute, University of Bergen, March 2018, 43pp.

3. Weng, Yongbiao, Johannessen, Aina and Sodemann, Harald, 2020: High-resolution stable water isotope signature of a land-falling Atmospheric River in Southern Norway, manuscript in preparation.

4. Weng, Yongbiao, 2020: PhD Thesis, Geophysical Institute, University of Bergen, Norway, to be submitted.

2.7 References

METEK, 2012: MRR-2 Micro Rain Radar User Manual, Meteorologische Messtechnik GmbH, Fritz-Strassmann-Strasse 425337 Elmshorn, Germany.

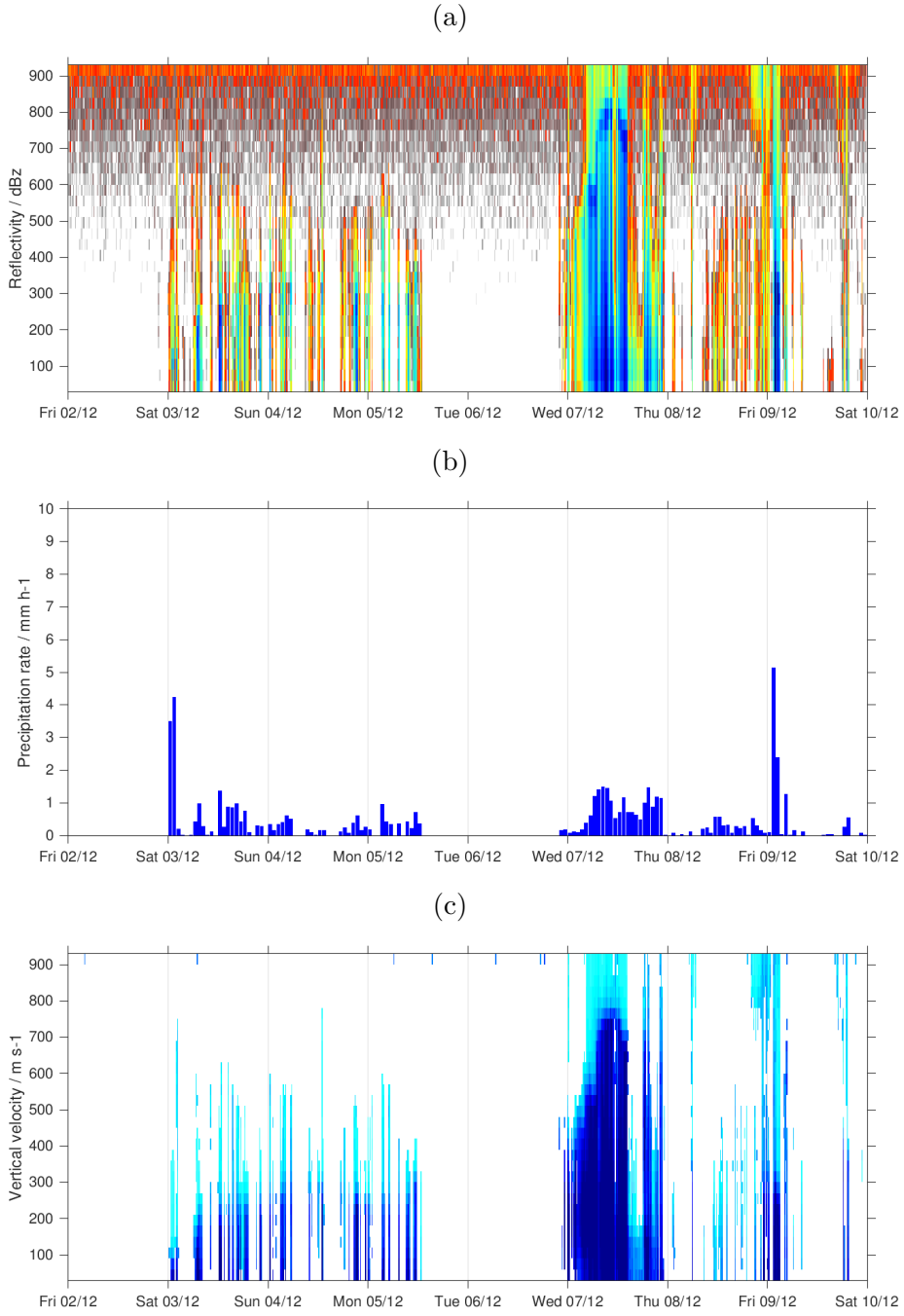

Figure 1: Example of a current measurement visualisation for the MRR data when measuring on the GFI rooftop observatory, aggregated to a 15-min (60-min for RR) time interval. (a) Reflectivity (dBz), (b) Precipitation rate (mm h^{-1}, (c) vertical velocity (m s^{-1}).

3 Data overview

3.1 Events log for 2015

The standardised event log for 2015 is show in Fig. 2.

Table 8: Events log for 2015

07.08.2015	info

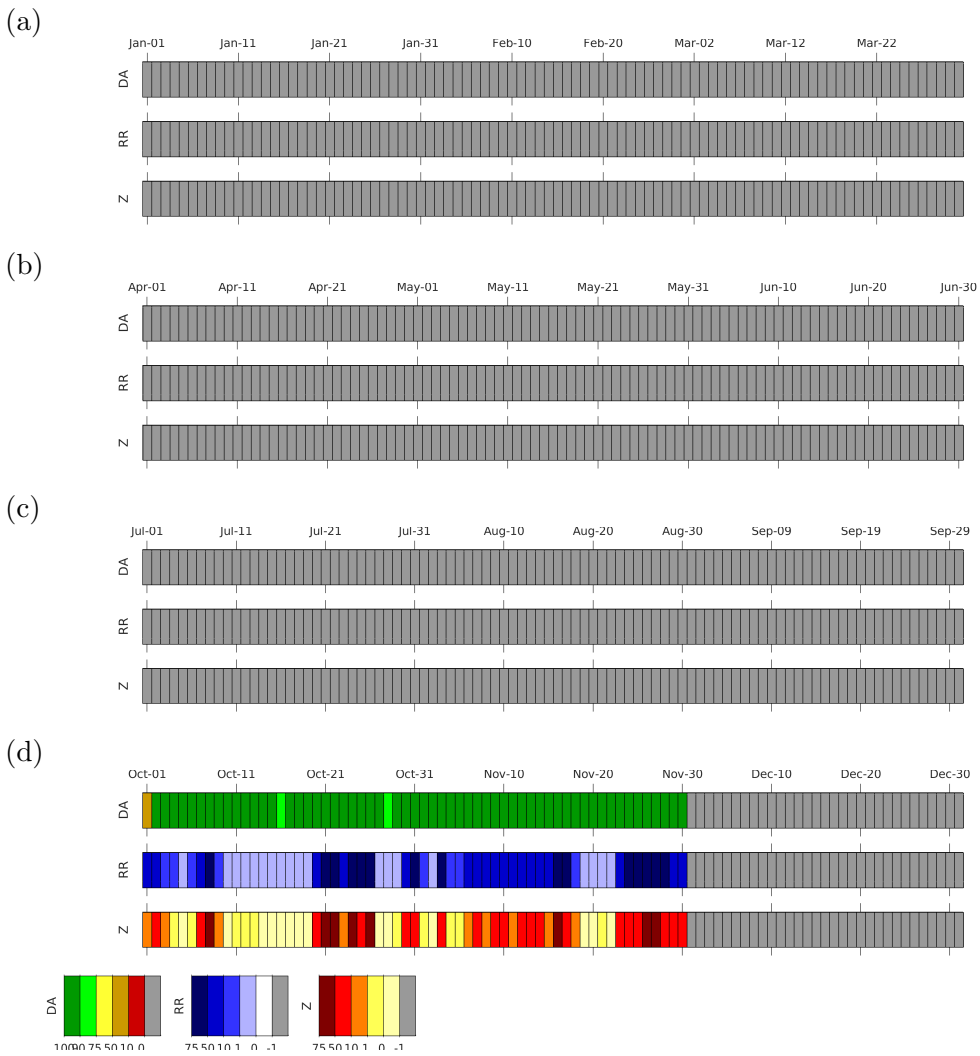

Figure 2: Data availability for the MRR-2 during 2015 for (a) JFM (b) AMJ (c) JAS (d) OND.

3.2 Events log for 2016

The standardised event log for 2016 is show in Fig. 3.

Table 9: Events log for 2016

07.08.2016	comment

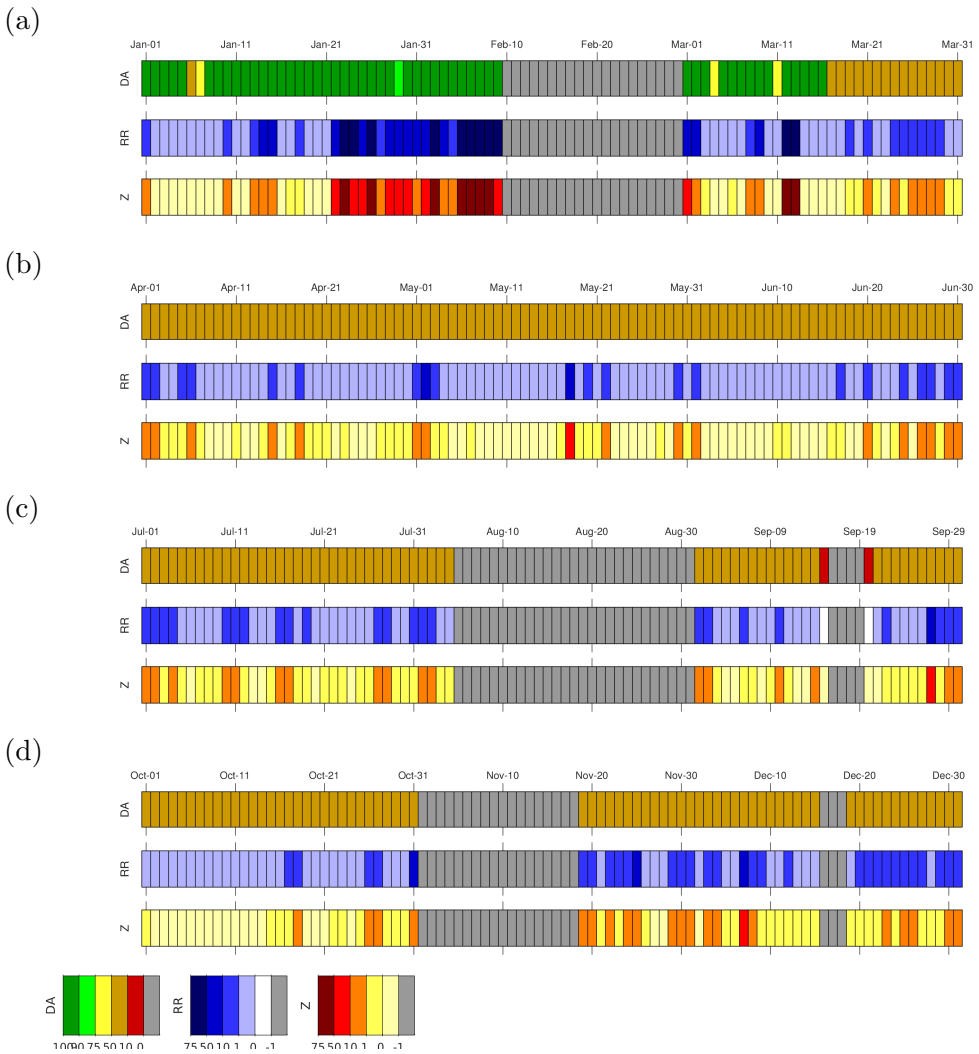

Figure 3: Data availability for the MRR-2 during 2016 for (a) JFM (b) AMJ (c) JAS (d) OND.

3.3 Events log for 2017

The standardised event log for 2017 is show in Fig. 4

Table 10: Events log for 2017

19.05.2017	Instrument installed at EastGRIP
12.08.2017	Instrument deinstalled at EastGRIP
24.08.2017	Instrument reinstalled at GFI

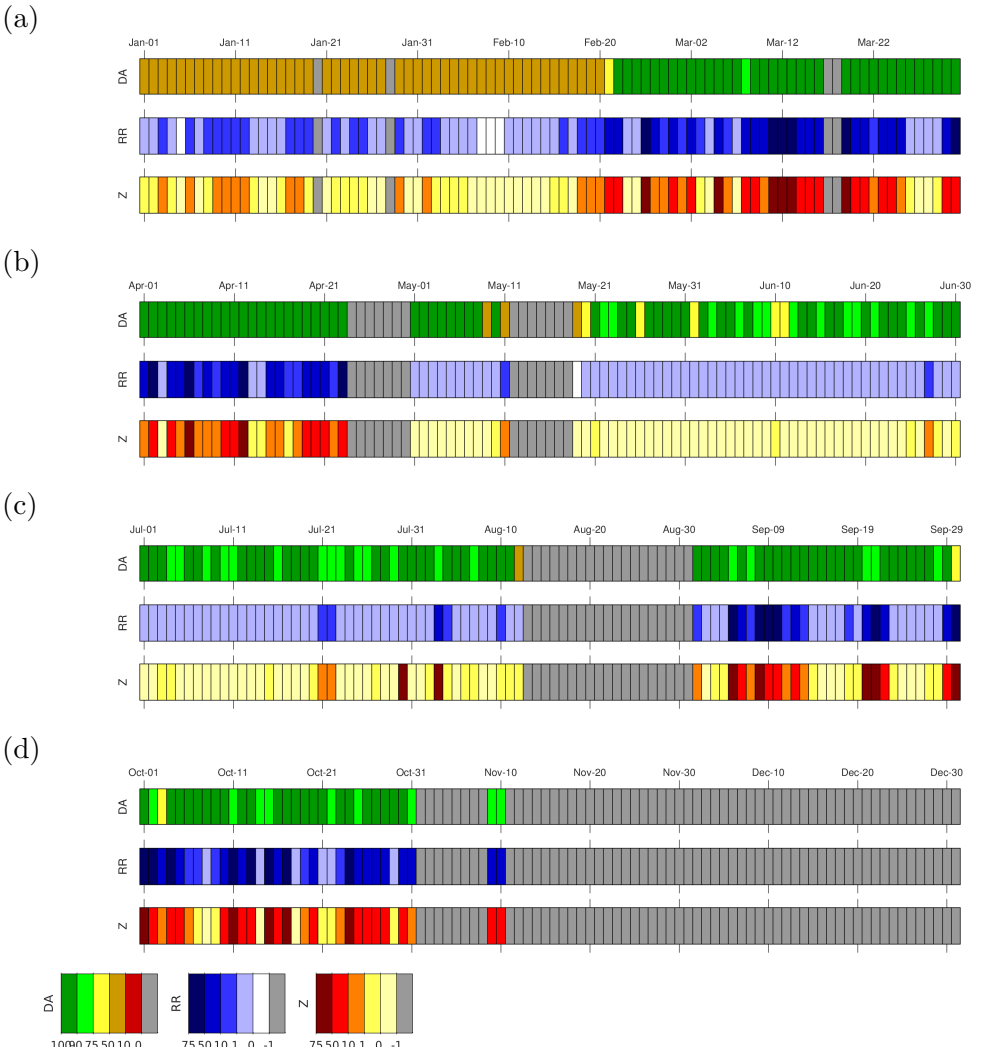

Figure 4: Data availability for the MRR-2 during 2017 for (a) JFM (b) AMJ (c) JAS (d) OND.

3.4 Events log for 2018

The standardised event log for 2018 is show in Fig. 5

Table 11: Events log for 2018

16.05.2018 14:08:00	Instrument data acquisition stopped due to power outage, 13 day data gap
29.05.2018 12:16:57	Instrument data collection restarted

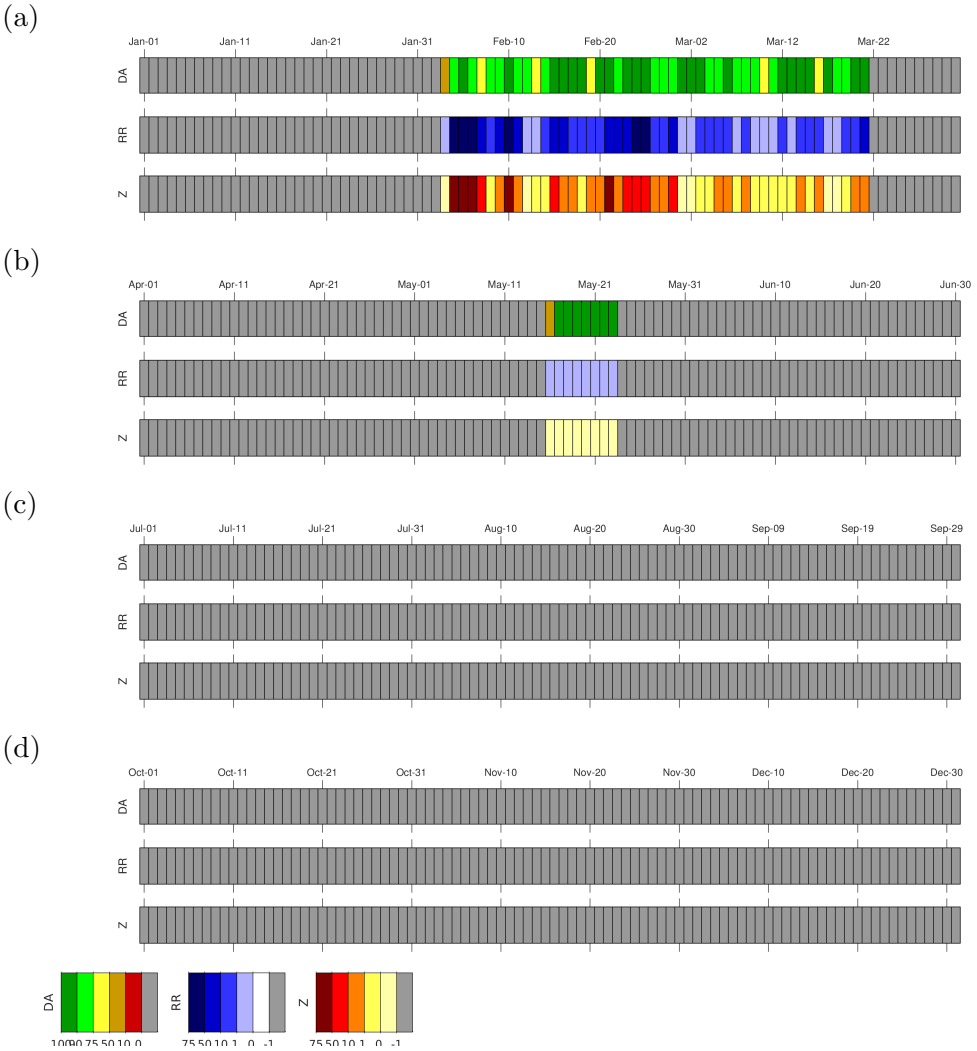

Figure 5: Data availability for the MRR-2 during 2018 for (a) JFM (b) AMJ (c) JAS (d) OND.

3.5 Events log for 2019

The standardised event log for 2019 is show in Fig. 6

Table 12: Events log for 2019

no events logged

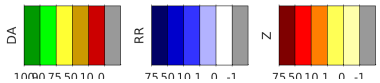

Figure 6: Data availability for the MRR-2 during 2019 for (a) JFM (b) AMJ (c) JAS (d) OND.

3.6 Events log for 2020

The standardised event log for 2020 is show in Fig. 7

Table 13: Events log for 2020

no events logged

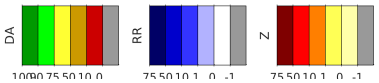

Figure 7: Data availability for the MRR-2 during 2020 for (a) JFM (b) AMJ (c) JAS (d) OND.