Description of the MRR data for ICE-POP 2018

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1. Introduction

MRR-2 (Micro Rain Radar-2; MRR) operated during the ICE-POP 2018 (International Collaborative Experiment for Pyeongchang 2018 Olympics and Paralympics winter games) are deployed in Pyeongchang and Gangneung city, Gangwon province, South Korea from 2016-2017 winter until 2017-2018 winter.

Seven MRRs (BWO, CPO, DRO, JBO, ODO, SJO, and YPO) were operated by National Institute of Meteorological Sciences (NIMS) and Four MRRs (KNU (1), CCU (1), and NASA (2)) were operated by Kyungpook National University (KNU).

The post-processing is done by Kyungpook National University.

2. Deployment

A. 2016-2017 winter: 8 MRRs, Pre-ICEPOP IOP (20161101 – 20170317)

1) GWU / KNU
2) BWO / NIMS
3) CPO / NIMS
4) JBO / NIMS
5) ODO / NIMS
6) SJO / NIMS
7) YPO / NIMS
8) DGW / CCU

NOTE) CCU MRR was intentionally stopped on Feb 25, 2017 and went back to Taiwan.

B. 2017 summer: 4 MRRs, Inter-comparison IOP (20170327 – 20170822)

1) DGW / KNU MRR
2) DGW / NASA(MRR03)
3) DGW / NASA(MRR04)
4) DGW / CCU MRR

NOTE) NIMS MRRs will not be uploaded during this period because they were not in DGW site for inter-comparison.

NOTE) CCU MRR started to operate from May 31, 2017.

NOTE) NASA MRRs started to operate from July 17, 2017.

NOTE) Each MRR was at least 20 m apart from each other.

C. 2017-2018 winter: 11 MRRs, ICE-POP 2018 IOP (20170901 – 20180431)

1) GWU / KNU

2) BWO / NIMS

3) CPO / NIMS

4) DRO / NIMS

5) JBO / NIMS

6) ODO / NIMS

7) SJO / NIMS

8) YPO / NIMS

9) DGW / CCU

10) BKC / NASA(MRR03)

11) GWU / NASA(MRR04)

3. Site

Site (3-digit)	Site	Longitude (°E)	Latitude (°N)	Height (m, MSL)
BKC	BoKwang1-ri Community center	128.805847	37.738157	175
BWO	BalWang cloud physics Observatory	128.6715	37.6111	1433
CPO	Cloud Physics Observatory	128.758636	37.686953	855
GWU	Gangneung-Wonju national University	128.866858	37.770897	36
JBO	JinBu cloud physics Observatory	128.5645	37.6479	541
MHS	MayHills Supersite	128.699611	37.665208	789
ODO	O-Dae cloud physics Observatory	128.612303	37.765679	963
PCO	PyeongChang Observatory	128.3946	37.3779	303
SJO	Ski Jumping center cloud physics Observatory	128.679653	37.660483	839
YPO	YongPyong cloud physics Observatory	128.670494	37.643342	772
DGW	DaeGwallyeong Weather office	128.718825	37.677331	773

4. Directory/File naming

The directories are named with the site name during 2017-2018 winter:

/DATA/ICE-POP/OBSD_DATA/MRRD/${SITE}/${FORMAT}/${YYYYMM}/${DD}/${FILENAME}

where,

${SITE}: YPO/SJO/PCO/ODO/MHS/JBO/GWU/CPO/BWO/BKC

${FORMAT}: RAW/PRO/AVE/NC

${YYYYMM}: the year and month of the data

${DD}: the day of the data

${FILENAME}: ${MMDD}.(raw/pro/ave) if RAW, PRO and AVE, or ${YYYYMMDD}.nc if NC.

If datasets obtained from 2016-2017 winter or 2017 summer experiment are needed, following directories should be easier to use.

NIMS BWO: /DATA/ICE-POP/OBSD_DATA/NIMS/MRR/BWO/${FORMAT}}/${YYYYMM}/${DD}/${FILENAME}

NIMS CPO: /DATA/ICE-POP/OBSD_DATA/NIMS/MRR/CPO/${FORMAT}}/${YYYYMM}/${DD}/${FILENAME}

NIMS DRO: /DATA/ICE-POP/OBSD_DATA/NIMS/MRR/DRO/${FORMAT}}/${YYYYMM}/${DD}/${FILENAME}

NIMS JBO: /DATA/ICE-POP/OBSD_DATA/NIMS/MRR/JBO/${FORMAT}}/${YYYYMM}/${DD}/${FILENAME}

NIMS ODO: /DATA/ICE-POP/OBSD_DATA/NIMS/MRR/ODO/${FORMAT}}/${YYYYMM}/${DD}/${FILENAME}

NIMS SJO: /DATA/ICE-POP/OBSD_DATA/HIWRC/SJO/MRR/${FORMAT}}/${YYYYMM}/${DD}/${FILENAME}

NIMS YPO: /DATA/ICE-POP/OBSD_DATA/NIMS/MRR/YPO/${FORMAT}}/${YYYYMM}/${DD}/${FILENAME}

KNU MRR: /DATA/ICE-POP/OBSD_DATA/KNU/MRR/${FORMAT}}/${YYYYMM}/${DD}/${FILENAME}

CCU MRR: /DATA/ICE-POP/OBSD_DATA/CCU/MRR/${FORMAT}}/${YYYYMM}/${DD}/${FILENAME}

NASA MRR03: /DATA/ICE-POP/OBSD_DATA/NASA/MRR/03/${FORMAT}}/${YYYYMM}/${DD}/${FILENAME}

NASA MRR04: /DATA/ICE-POP/OBSD_DATA/NASA/MRR/04/${FORMAT}}/${YYYYMM}/${DD}/${FILENAME}

5. Observational strategy

A. 2016-2017 winter: Identical (200-m vertical / 10-sec temporal resolution)

B. 2017 summer: Identical (100-m vertical / 10-sec temporal resolution)

C. 2017-2018 winter: Identical (150-m vertical / 10-sec temporal resolution)

NOTE) JBO site is in resolution of 200 meters during 2017-2018 winter.

NOTE) The dates which resolution was changed are different (MHS: 11/3~, PCO: 11/18~, BKC and GWU: 11/20~, SJO: 12/1~, CPO, YPO, DRO and ODO: 12/8~, BWO: 1/4~). Before the changes, the resolution was mostly 200 meters.

NOTE) Please let us (KNU) know via email if any information is wrong.

6. Data description and data format

A. RAW: This data is stored by manufacturer (METEK, 2012a) software and provides Doppler spectra (in linear unit). This is in ASCII format.

B. PRO: This data is processed by manufacturer (METEK, 2012b) software and provides Doppler spectra (in dB unit), radar moments and drop size distribution (DSD). Please note that the moments and DSD are calculated by assuming ‘rain’. This is in ASCII format.

C. AVE: This data is same as PRO except for averaged over adjustable time interval. This provides Doppler spectra (in dB unit), radar moments and drop size distribution (DSD). Please note that the moments and DSD are calculated by assuming ‘rain’. This is in ASCII format.

D. NC: This data is processed by Maahn and Kollias (2012) algorithm (IMProToo; Improved Mrr Processing Tool). Please see below table for provided variables. This data does not contain drop (particle) size distribution. This is suitable for only snow or light rain rather than heavy rain. This is in classic Netcdf format.

NOTE) Please see http://dx.doi/10.5194/amtd-5-4771-2012 or https://github.com/maahn/IMProToo for further information regarding IMProToo algorithm.

E. Data format

1) RAW

Identifier	Variable	Unit	Dimension	Description
MRR	N/A	N/A	Time	The beginning of a data set
	Time	UTC	Time	Measurement time (YYMMDDHHIISS)
	DVS	N/A	Time	Version number of the MRR firmware (Device version)
	DSN	N/A	Time	Device serial number of the MRR
	BW	N/A	Time	Bandwidth
	CC	N/A	Time	Calibration constant
	MDQ	%, #, #	Time	Micro Rain Radar Data quality: percentage of valid spectra, number of valid spectra and number of total spectra
	TYP	N/A	Time	Identifier for data type (raw)
H	Height	meter	Time, range	Height above the radar system
TF	TF	dBZ	Time, range	Transfer function
Fnn	FFT spectra	engineering unit	Time, range, spectral bin	The received spectral signal power in engineering units for each height step. The nn represents number of spectra line

2) PRO and AVE

Identifier	Variable	Unit	Dimension	Description
MRR	N/A	N/A	Time	The beginning of a data set
	Time	UTC	Time	Measurement time (YYMMDDHHIISS)
	AVE	sec	Time	Averaging time
	STP	meter	Time	Height resolution
	ASL	Meter	Time	Height of the ground level (ASL)
	SMP	Hz	Time	Sampling rate of the radar signal in the time domain
	SVS	N/A	Time	Version number of the MRR service (Service version number)
	DVS	N/A	Time	Version number of the MRR firmware (Device version)
	DSN	N/A	Time	Device serial number of the MRR
	CC	N/A	Time	Calibration constant
	MDQ	%, #, #	Time	Micro Rain Radar Data quality: percentage of valid spectra, number of valid spectra and

				number of total spectra
	TYP	N/A	Time	Identifier for data type (pro or ave)
H	Height	meter	Time, range	Height above the radar system
TF	TF	dBZ	Time, range	Transfer function
Fnn	FFT spectra	dB	Time, range, spectral bin	FFT spectra, Fnn with nn from 0 to 63. Each line represents a profile of spectral reflectivity corresponding to the spectral bin nn
Dnn	Drop sizes	mm	Time, range, spectral bin	Drop sizes (diameter of an equivolumic sphere), Dnn with nn from min(h) to max(h)
Nnn	Spectral drop densities	m^{-3} mm^{-1}	Time, range, spectral bin	Spectral drop density, Nnn with from min(h) to max(h)
PIA	PIA	dB	Time, range	Two-way path integrated attenuation by rain drops
z	z	dBZ	Time, range	Attenuated radar reflectivity (without attenuation correction)
Z	Z	dBZ	Time, range	Radar reflectivity (with attenuation correction)
RR	RR	mm h^{-1}	Time, range	Rain rate
LWC	LWC	g m^{-3}	Time, range	Liquid water content
W	W	m s^{-1}	Time, range	Fall velocity

3) NC

Variable	Unit	Dimension	Description
time	sec	Time	Measurement time (since 1970-01-01)
range	#	Range	Range bins
velocity	m s^{-1}	Velocity	Doppler velocity bins. If dealiasing is applied, the spectra are triplicated
velocity_noDA	meter	Velocity_noDA	Original, non dealiased, Doppler velocity bins.
height	meter	Time, range	Height above instrument
eta_noDA	mm^6 m^{-3}	Time, range, velocity_noDA	Spectral reflectivities NOT dealiased
etaMask_noDA	bool	Time, range, velocity_noDA	Noise mask of eta NOT dealiased, 0: signal, 1: noise
eta	mm^6 m^{-3}	Time, range, velocity	Spectral reflectivities. if dealiasing is applied, the spectra are triplicated, thus up to three peaks can occur from -12 to +24 m/s. However, only one peak is not masked in etaMask
etaMask	Bool	Time, range, velocity	Noise mask of eta, 0: signal, 1: noise
quality	#	Time, range	**A) Usually, the following erros can be ignored (no. is position of bit)** 1) spectrum interpolated around 0 and 12 m/s 2) peak streches over interpolated part 3) peak is dealiased 4) first Algorithm to determine peak failed, used

			backup 5) dealiasing went wrong, but is corrected **B) reasons why a spectrum does NOT contain a peak** 8) spectrum was incompletely recorded 9) the variance test indicated no peak 10) spectrum is not processed due to according setting 11) peak removed since not wide enough 12) peak removed, because too few neighbors show signal, too **C) thinks went seriously wrong, don't use data with these codes** 16) peak is at the very border to bad data 17) in this area there are still strong velocity jumps, indicates failed dealiasing 18) during dealiasing, a warning was triggered, applied to whole column
TF	N/A	Time, range	Transfer Function (see Metek's documentation)
Ze_noDA	dBZ	Time, range	Reflectivity of the most significant peak, not dealiased
Ze	dBZ	Time, range	Reflectivity of the most significant peak
spectralWidth_noDA	m s^{-1}	Time, range	Spectral width of the most significant peak, not dealiased
spectralWidth	m s^{-1}	Time, range	Spectral width of the most significant peak
skewness_noDA	m s^{-1}	Time, range	Skewness of the most significant peak, not dealiased
skewness	m s^{-1}	Time, range	Skewness of the most significant peak
kurtosis_noDA	m s^{-1}	Time, range	Kurtosis of the most significant peak, not dealiased
kurtosis	m s^{-1}	Time, range	Kurtosis of the most significant peak
peakVelLeftBorder_noDA	m s^{-1}	Time, range	Doppler velocity of the left border of the peak, not dealiased
peakVelLeftBorder	m s^{-1}	Time, range	Doppler velocity of the left border of the peak
peakVelRightBorder_noDA	m s^{-1}	Time, range	Doppler velocity of the right border of the peak, not dealiased
peakVelRightBorder	m s^{-1}	Time, range	Doppler velocity of the right border of the peak
leftSlope_noDA	dB m^{-1} s	Time, range	Slope at the left side of the peak, not dealiased
leftSlope	dB m^{-1} s	Time, range	Slope at the left side of the peak
rightSlope_noDA	dB m^{-1} s	Time, range	Slope at the right side of the peak, not dealiased
rightSlope	dB m^{-1} s	Time, range	Slope at the right side of the peak
W_noDA	m s^{-1}	Time, range	Mean Doppler Velocity of the most significant peak, not dealiased
W	m s^{-1}	Time, range	Mean Doppler Velocity of the most significant peak
etaNoiseAve	mm^6 m^{-3}	Time, range	Mean noise of one Doppler Spectrum in the same units as eta, never dealiased
etaNoiseStd	mm^6 m^{-3}	Time, range	Std of noise of one Doppler Spectrum in the same units as eta, never dealiased
SNR	dB	Time, range	Signal to noise ratio of the most significant peak, never dealiased!

Note) Dimensions: time, range, velocity, velocity_noDA

Note) _FillValue = -9999.f for all variables

Note) Please see global attribute 'properties' for detailed configuration used in processing data

7. References

Maahn, M., and P. Kollias, 2012: Improved Micro Rain Radar snow measurements using Doppler spectra post-processing. *Atmos. Meas. Tech.*, **5**, 2661–2673, doi:10.5194/amt-5-2661-2012.

METEK, 2012a: MRR Physical Basics, Version of 13 March 2012, 20 pp.

______, 2012b: MRR User Manual, Version of 01 March 2012, 53 pp.