HIAPER Cloud Radar (HCR) moments data, Version 1.0

Overview
This dataset contains HIAPER Cloud Radar (HCR) data collected during the MEOW (Make Everything Operate Well) project. During MEOW HCR was operated on the ground in the GV pod. It was located in the parking lot of the Foothills Lab 1 building of the NCAR campus in Boulder, Colorado, USA. The testing took place from May 10 to June 27, 2024 and consisted of 11 Intensive Operation Periods (IOPs). For more information on MEOW, see https://www.eol.ucar.edu/field_projects/meow.

IOP	Start date	Start time UTC	End date	End time UTC
IOP01	2024-05-10	16:25	2024-05-10	21:15
IOP02	2024-05-20	20:00	2024-05-21	00:35
IOP03	2024-05-21	18:25	2024-05-22	01:35
IOP04	2024-05-29	18:25	2024-05-29	20:40
IOP05	2024-05-30	21:10	2024-05-30	22:25
IOP06	2024-06-07	21:00	2024-06-07	23:20
IOP07	2024-06-10	20:45	2024-06-10	23:50
IOP08	2024-06-14	18:20	2024-06-14	22:20
IOP09	2024-06-20	20:50	2024-06-20	23:20
IOP10	2024-06-24	20:20	2024-06-24	23:15
IOP11	2024-06-27	15:30	2024-06-27	17:00

Instrument description
HCR is a polarimetric, millimeter-wavelength (W-band) radar that serves the atmospheric science community by providing cloud remote sensing capabilities to the NSF/NCAR G-V (HIAPER) aircraft and on the ground. HCR detects drizzle, and ice and liquid clouds, and collects Doppler radial velocity measurements, which at vertical incident include the vertical wind speed and particle fall speed.

A single lens antenna is used for both transmit and receive. The transceiver uses a two-stage up and down conversion superheterodyne design. The transmit waveform, from a waveform generator, passes through the two-stage up-conversion to the transmit frequency of 94.40 GHz. It is then amplified by an extended interaction klystron amplifier (EIKA) to 1.6 kW peak power. System performance on transmit and receive paths are closely monitored using a coupler and a noise source. Raw in-phase and quadrature information are archived in HCR. For more information, see www.eol.ucar.edu/instruments/hiaper-cloud-radar-hcr

Data description
During MEOW we tested a new Dual-PRT mode which alternates 100 pulses of length 256 ns with a PRT of 0.1 μs (short pulse) with 66 pulses of length 512 ns with a PRT of 0.15 μs (long

pulse). The short pulse provides higher range resolution while the long pulse provides 6 dB better sensitivity. The two pulses combined result in a nyquist velocity of 15 m/s.

The 10 Hz moments data described here are available at https://data.eol.ucar.edu/dataset/647.002 in CfRadial format.

The primary data products for scientific use are listed in the table below. The radar moments in the table contain merged long and short pulse data. The individual short and long pulse fields are also available in the dataset (e.g., DBZ_long or DBZ_short).

Variable	**Dimensions**	**Unit**	**Long Name**
time	time	seconds	Time in seconds since volume start
range	time	meters	Range from instrument to center of gate
latitude	time	deg	Latitude
longitude	time	deg	Longitude
altitude	time	meters	Altitude of radar
DBZ	time, range	dBZ	Reflectivity
VEL	time, range	m/s	De-aliased Doppler velocity
WIDTH	time, range	m/s	Spectrum width
SNRVC	time, range	dB	Signal to noise ratio
DBMVC	time, range	dBm	Log power co-polar v transmit, v receive
DBMHX	time, range	dBm	Log power cross-polar v transmit, h receive
NCP	time, range		Normalized coherent power
LDR	time, range	dB	Linear depolarization ratio (V/H)
PRESS	time, range	hPa	Air pressure from HRRR
TEMP	time, range	C	Air temperature from HRRR
RH	time, range	%	Relative humidity from HRRR
SST	time	C	Sea surface temperature from HRRR
U	time, range	m/s	U wind component from HRRR
V	time, range	m/s	V wind component from HRRR
FLAG	time, range		See Romatschke et al. (2021) Flag field to classify reflectivity (to mask unwanted data): 1 Cloud 2 Speckle (contiguous 2D echo areas of < 100 pixels) 3 Extinct (signal completely attenuated) 4 Backlobe echo (reflection from the land/sea surface when zenith pointing and flying low) 5 Out of range (second trip echo from land/sea surface

			when flying too high) 6 Transmitter pulse (echo from within the radar itself) 7 Water surface echo 8 Land surface echo 9 Below the surface 10 Noise source calibration 11 Antenna in transition (e.g. from nadir to zenith or vice versa) 12 Missing (not transmitting)
ANTFLAG	time		Flag field to indicate the status of the antenna: 1 Down (nadir pointing) 2 Up (zenith pointing) 3 Pointing (pointing to an angle different from nadir or zenith) 4 Scanning (e.g. sea surface calibration) 5 Transition (e.g. from nadir to zenith) 6 Failure
MELTING_LAYER	time, range		See Romatschke (2021) but note changes described in the next section 9 warm 11 melting warm 19 melting cold 21 cold
ECHO_TYPE_2D	time, range		See Romatschke and Dixon (2022) 14 stratiform low 16 stratiform mid 18 stratiform high 25 mixed 30 convective 32 convective elevated 34 convective shallow 36 convective mid 38 convective deep
ECHO_TYPE_1D	time		As ECHO_TYPE_2D

Data processing and quality control

A detailed description of the data processing and quality control procedures can be found in Romatschke et al. (2021). The basic principle of the melting layer detection algorithm is described in Romatschke (2021) but significant changes have been made since then (see below). The algorithm that separates radar echo into convective and stratiform types and calculates convectivity is described in Romatschke and Dixon (2022). Changes made since the publication of these papers are described in the following.

Melting layer detection

A new melting layer detection algorithm has been developed which identifies the whole vertical extent of the melting layer based on a fuzzy logic methodology. The output has been simplified from what is described in Romatschke (2021). The MELTING_LAYER field now has the following flag values: 9 - warm (below the melting layer), 11 - melting warm (in the melting layer but below the altitude of maximum melting), 19 - melting cold (in the melting layer but above the altitude of maximum melting), 21 - cold (above the melting layer). Values of MELTING_LAYER are set to “missing” outside of regions with cloud echo (i.e., in regions where FLAG does not equal 1). Note that in some cases the reanalysis HRRR temperature was significantly higher than what the algorithm expected. In those cases, the melting layer product is unreliable.

Stratiform/convective echo type

In the advanced echo classification, where the troposphere is separated into the low, mid, and high region, we do no longer allow the separation boundary between the low and the mid region to fall below 2 km above the ground, and the separation boundary between the mid and the high region to fall below 4 km above ground. This way, we always retain all three regions and the associated cloud classifications, even when the melting layer intersects the ground. See Romatschke (2023) for details.

References

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