CHILL Radar Data - Version 1

1. Data Set Description

This dataset contains radar moments data in CfRadial format, collected by the CHILL radar during the Preparatory Rockies Experiment for the Campaign In the Pacific (PRE-CIP). During PRE-CIP, CHILL collected data from Greeley, CO (40.4464 N, 104.637 W, 1.432 km altitude) and collected data from July 25 to August 22, 2021. This release contains both Level 2 and Level 3 products.

2. Instrument description

The CSU-CHILL National Weather Radar Facility, located in Greeley, CO, is an advanced, transportable dual-polarized dual-wavelength (S- and X-band) weather radar system. The facility is operated by Colorado State University, under the sponsorship of the National Science Foundation and the University.

For more information on CHILL, please visit http://www.chill.colostate.edu/w/CSU_CHILL.

CHILL Radar Characteristics	
Transmitter	2.725 GHz
Pulse Width	
PRF	1000 Hz
Peak Power	1 MW
Receivers	
Noise Power	-113 dBm @ 1 MHz bandwidth
Radar Noise Figure	3.4 dB
Dynamic Range	80 dB
Bandwidth	
Minimum detectable signal	-38 dBZ at 1 km
Polarization Switching	HV
Gain	43 dBi (including feed loss)
Diameter	8.5 m
Beamwidth	1.0°
First sidelobe	-27 dB
Scan rate	1.8°/s for RHIs, 8°/s for PPIs

Wind Limit	
Number of range gates	960
Gate Spacing	0.15 km
Number of Samples	
Clutter filter	Selectable Chebyshev/Elliptic notch filter, Spectral filters
Time Series (I/Q) capability	Yes

3. Data collection and processing

CHILL scanned on a 12-minute cycle that coordinated with CHIVO and ran nearly continuously over the project. Data collection began in earnest on 15 July 2021. The 12-minute cycle consisted of a curtain RHI scan beginning at 281º and ending at 101º, a surveillance scan that consisted of elevation angles from 0.5º to 15º, a dedicated RHI scan pattern that scanned over the cardinal directions and CSU Atmospheric Science/Christman Field, and a user-selected scan that consisted either of RHI scans centered on nearby precipitation or a shallower surveillance scan.

Raw radar files were converted to CfRadial by RadxConvert.

Two QC procedures were performed to 1) remove the lowest quality signal and correct any measurement errors (Level 2) and 2) remove low-quality and non-weather echoes from the data and add value-added products (Level 3).

3.1 Level 2: high-quality radar measurements retained

To remove the lowest-quality signal, any gates where smoothed NCP < 0.2 were removed. This QC was applied to all variables using Python.

We identified an average ZDR bias of 0.3 dB after examination of SUR scans above the melting level and select birdbath scans. This bias is corrected and saved to the ZDR data. CHILL has a wet radome problem in rainfall - hours where rainfall at the nearby Greeley airport surpassed 0.1 in/hour were removed from ZDR bias estimation analysis.

Level 2 data contain bias-corrected and high-quality radar signals, which include both meteorological and non-meteorological echoes. These data are for experienced radar users who want access to the full radar measurements. For most meteorological applications, users should consider using the Level 3 data.

3.2 Level 3: high-quality meteorological data, including value-added products

Low-quality echoes were removed from the dataset based on polarimetric values, the CSU RadarTools despeckling algorithm (Lang et al. 2019), and non-weather categories from the PID algorithm in RadxRate. Polarimetric variables used for thresholding included RHOHV, smoothed NCP (using a 2D Gaussian smoother), LDRH, and the standard deviation of PHIDP. Soundings for the PID were obtained from the RAP model analysis and the wet bulb temperature was used to identify the melting level.

KDP was calculated using RadxRate, with a FIR filter length of 10 gates and using the Hubbert and Bringi (1995) method to handle phase shift on backscatter. KDP is only considered valid in regions where the standard deviation of PHIDP is less than 20 and RHOHV is above 0.9.

The NCAR PID was used to identify hydrometeor types. Soundings for the PID were obtained from the 6-hourly GFS model analysis.

Attenuation-corrected DBZ and ZDR are calculated using the default S-band coefficients available in RadxRate. These Level 3 products are labeled DBZ and ZDR in the final dataset; the variables prior to attenuation correction are referred to as DBZ_ATTEN_UNCORRECTED and ZDR_ATTEN_UNCORRECTED.

Rain rates are estimated using the RATE_HYBRID method available in RadxRate. Coefficients for R(Z), R(Z, ZDR), and R(KDP) were taken from Ryzhkov et al. (2022).

These Level 3 products have removed the majority of non-meteorological echoes and are recommended for general use. Users who want more control over the quality control processing are recommended to use the Level 2 data.

Processing scripts and parameter files are available on GitHub.

4. Data Format

The moments data described here are available at <link> in CfRadial format. For more information on CfRadial see https://www.eol.ucar.edu/system/files/CfRadialDoc-v2.0-20180430.pdf.

The primary data products for scientific use are listed in the table below.

Variable	**Dimensions Unit**	**Long Name**
time	time s	Seconds since volume start
range	range m	Range from instrument to center of gate

azimuth	time deg	Ray azimuth angle
elevation	time deg	Ray elevation angle
DBZ_L2	n_points dBZ	Level 2 Reflectivity
VEL_L2	n_points m/s	Level 2 Doppler velocity
WIDTH_L2	n_points m/s	Level 2 Spectrum width
ZDR_L2	n_points dB	Level 2 Bias-corrected differential reflectivity
PHIDP_L2	n_points deg	Level 2 Differential phase
DBZ	n_points dBZ	Level 3 Attenuation-corrected reflectivity
ZDR	n_points dB	Level 3 Attenuation-corrected and bias-corrected differential reflectivity
DBZ_ATTEN_UNCORRECTED	n_points dBZ	Level 3 Reflectivity
ZDR_ATTEN_UNCORRECTED	n_points dB	Level 3 Bias-corrected differential reflectivity
VEL	n_points m/s	Level 3 Doppler velocity
WIDTH	n_points m/s	Level 3 Spectrum width
PHIDP	n_points deg	Level 3 Differential phase
KDP	n_points deg/km	Level 3 Specific differential phase
RHOHV	n_points none	Level 3 Cross correlation ratio
PID	n_points	Hydrometeor particle ID from RadxRate
RATE_HYBRID	n_points mm/h	Hybrid precipitation rate from RadxRate

5. Known problems

The ZDR bias was considered as a system bias over the entire field project. If examining case studies or an event where rain was occurring (or had occurred recently), an additional ZDR bias correction may be necessary. CHILL has a wet radome problem during and after periods of rainfall, which produces temporary biases in ZDR that are unaccounted for in our ZDR bias correction.

A time series of median CHILL ZDR values in SUR scans above the melting level that met data quality requirements with the Greeley airport rain rates is shown in Fig. 1. The wet radome problem was visible at the end of July 2021 where median ZDR values became negative as rain fell nearby at the Greeley airport. This bias, and any other short term biases in ZDR, will need to be corrected by the user. Additionally, biases in ZDR will require the user to re-run the PID and rain rate. Files after September 1st are included in the image, but not in the final dataset.

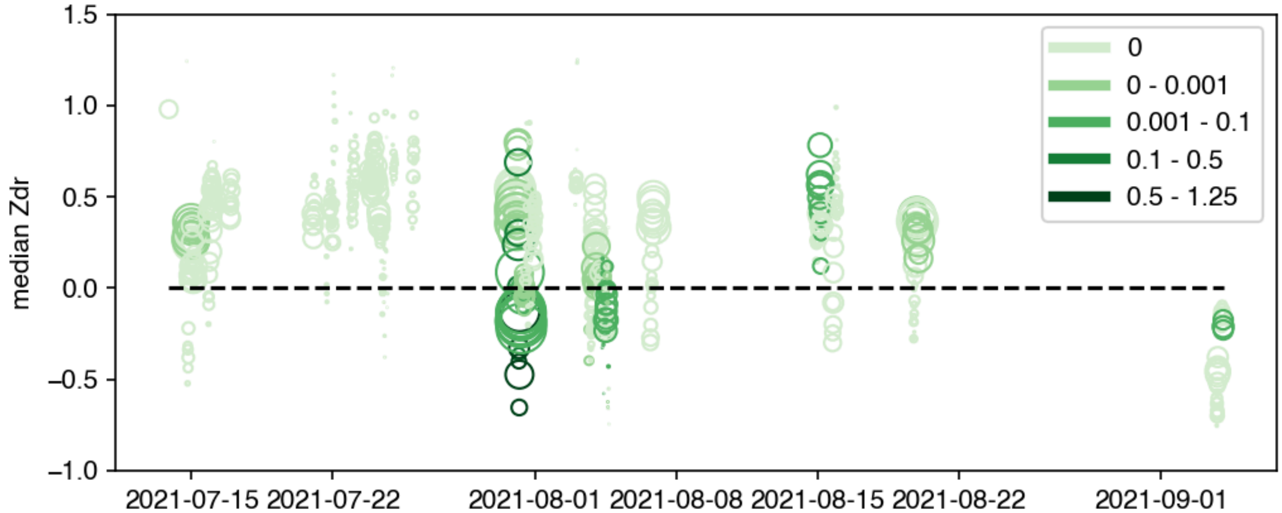

Fig. 1: Median ZDR for CHILL SUR files above the melting level, where size indicates the number of data points and color indicates the hourly rain rate at the Greeley airport.

Specific periods around which the user should exercise caution are shown in the table below.

Hour (UTC)	**Hourly Precipitation (in)**
2021-07-31 04:00	0.50
2021-07-31 05:00	1.04
2021-08-06 22:00	0.17
2021-09-03 20:00	0.14

6. Citation

6.1 Data Citation

Colorado State University Radar Team: Michael Bell, V. Chandrasekar, Jennifer DeHart, Brenda Dolan, Jim George, Francesc Junyent, EunYeol Kim. 2023. PRECIP: CHILL_S radar moments data. Version 1.0. Colorado State University. https://doi.org/. Accessed <insert data download date>.

6.2 References

Hubbert, J., V. Chandrasekar, V. N. Bringi, and P. Meischner, 1993: Processing and Interpretation of Coherent Dual-Polarized Radar Measurements. *J. Atmos. Oceanic Technol.*, **10**, 155–164, https://doi.org/10.1175/1520-0426(1993)010<0155:PAIOCD>2.0.CO;2.

Lang, T., Dolan, B., Guy, N., Gerlach, C., and Hardin, J. (2019). CSU-Radarmet/CSU_RadarTools: CSU_RadarTools v1.3 (v1.3). Zenodo. https://doi.org/10.5281/zenodo.2562063

Ryzhkov, A., Zhang, P., Bukovčić, P., Zhang, J., and Cocks, S., 2022: Polarimetric Radar Quantitative Precipitation Estimation. *Remote Sens.*, **14**, 1695. https://doi.org/10.3390/rs14071695.

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