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*** McGill vertically pointing radar data ***

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*** Source of data :**

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1.0 Data Set Description

The McGill Radar Observatory operates 2 vertically pointing X-band radars (VertiX) at 2 sites on the island of Montreal. The vertically pointing X-band radars can detect all precipitation targets and some ice clouds. They can also measure the Doppler velocity of precipitation targets. They allow the production of very detailed radar images of weather as it passes overhead. The radar located at the McGill Radar site (JSM) on the west of the Island is dual-polarized while the one on Burnside Hall (BH) downtown is single polarized.
The dual-polarization permits additional information on the variability of shapes of the precipitation targets that the single polarization radar cannot.

Data version: 1.0, 2 Nov 2022

Data Status: Final

Time period: 1 February 2022 - 19 March 2022

Data frequency: 1 ray per 1.5 seconds

Physical locations of 2 stations (ID#, name, lat, lon):

1: JSM McGill Radar site 45°25’26"N, 73°56’16"W

2: BH Burnside Hall site 45°30'17"N, 73°34'30"W

Data source: McGill's J.S. Marshall Radar Observatory

Data source restrictions: None; acknowledgement of McGill Radar Observatory is requested if the data are used in a scientific publication.

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2.0 Instrument Description

Both radars were built in house from transmitters of Racal Decca Bridgemaster
25 kW X-band radars transmitting at 9.41 GHz, Andrew Antennas (4' for BH,
8' for JSM), home-made receivers, and Gage CS14105 digitizer cards.
The radars point vertically only.

For the dual-polarization unit (JSM), X-band pulses are simultaneously
sent and received at two orthogonal horizontal polarizations,
one along and one across the St-Lawrence valley.

The BH radar can be seen at
https://www.radar.mcgill.ca/images/stories/vertix-small.png. A poster that
shows the JSM radar can be seen at
https://web.meteo.mcgill.ca/~frederic/Posters/ERAD2022_243_Fabry_VertiXDP.pdf.
More photos can be obtained on request from frederic.fabry@mcgill.ca.

*** Some hardware specs:**

Nominal transmit frequency: 9.41 GHz

Nominal firing rate: 1750 Hz

Pulse duration used: 0.25 us (37.5-m equivalent)

Antenna size: 1.2 m (BH), 2.4 m (JSM)

Radome: conical (BH), flat with a small angle (JSM)

Gate spacing used: 45 m

*** Raw quantities archived**

Both radars: Lag-0 power, lag-1 power, lag-1 velocity, all at single polarization
JSM: Lag-0 and Lag-1 differential reflectivity and copolar correlation.
Resolution: 1.5 s in time, 45 m in range

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3.0 Data Collection and Processing

Measurements of reflectivity at vertical incidence and vertical Doppler velocity and, for the JSM dual-polarization radar, copolar correlation (measures shape uniformity as seen from below) at ~1.5 s intervals of the weather directly above the instrument. These measurements are derived from averages of 2625 pulses at about 1750 Hz.

Received power is estimated for each range gate from 0 to 19 km (only the first 11 km available here) using lag-0 and lag-1 pulse-pair based estimators.
The ratio of lag-1 to lag-0 power, known as Normalized Coherent Power (NCP) or Signal Quality Index (SQI) is used to threshold estimates that are too contaminated by noise. A minimum of 0.04 SQI is sought for to archive derived parameters.

Doppler velocity are estimated using a traditional pulse pair algorithm. No aliasing correction was performed, nor needed.

For the JSM radar, lag-0 and lag-1 copolar correlation were also computed and archived when SQI was sufficient. We also derived a quantity called depolarization ratio (1 - rho) and archived it in dB units. We found it was better able to illustrate small changes in correlation associated with the presence of targets of varied shapes as seen from below such as 1D crystals. The melting signature at vertical incidence can also be peculiar when both crystals and aggregates are present.

All times are in UTC.

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4.0 Data Format

Data were submitted in NetCDF-4 files following the NCAR CFRadial format

to the best we comprehended them.

Nominally, files are created twice daily for the JSM (every 12h at 0:00 and 12:00UTC) and daily for the BH (starting at 00:00 UTC).

Occasionally, files are interrupted before the end of the file (either every 12h for JSM or day for BH) if the collection program was interrupted, and the next file restarts whenever the program was restarted.

The JSM files contain dual-polarization data while the BH files are at

single polarization.

Each data file is named following the convention:

VertiX_YYMMDDhh00_location.nc where location is either JSM or BH.

Both radars (BH and JSM) will have in their filed:

Radar_Name = VertiX radar name / location

frequency = VertiX radar transmit frequency in GHz, float

radar_beam_width_h = VertiX radar "horizontal" beam width in degrees, float

radar_beam_width_v = VertiX radar "vertical" beam width in degrees, float

Radar_PeakPwr = VertiX radar peak transmit power in dBm, float

pulse_width = VertiX radar transmit pulse width in seconds, float

latitude = radar location latitude where - is south and + is north in degrees, float

longitude = radar location longitude where - is west and + is east in degrees, float

altitude = radar altitude above mean sea level in meters, float

altitude_agl = radar altitude above ground level in meters, float

TimeYear = year of date of data, int32 vector(1,count_rays)

TimeMonth = month of date of data, int32 vector(1,count_rays)

TimeDay = day of date of data, int32 vector(1,count_rays)

TimeHour = hour of date of data, int32 vector(1,count_rays)

TimeMinute = minute of date of data, int32 vector(1,count_rays)

TimeSeconds = second of date of data, int32 vector(1,count_rays)

TimeMsecs = milliseconds of date of data, int32 vector(1,count_rays)

Secs_aftr_midnight = number of seconds after midnight, float vector(1,count_rays)

time = number of seconds since volume start, float vector(1,count_rays)

TimeResol = How the original radials were remapped:

> 0: Average over that many seconds;

0 = all outputs;

< 0: Average over that many radials multiplied by -1, float

Xmit_mode = transmit mode, int32 vector(1,count_rays)

NCP_thresh = NCP value used to threshold radar data, float

Z_correction = Correction offset of Vertix reflectivity compared to McGill S-Band, float

Attenuation_correction = attenuation correction to radar data, float vector(1,count_rays)

Tuning_correction = tuning correction to radar data, float vector(1,count_rays)

Ranges = range from radar in vertical, int32 vector(1,NumRangeBin)

nyquist_velocity = Nysquist velocity, float vector(1,count_rays)

NOISE_REL = relative noise power at far range in linear power units, float vector(1,count_rays)

XMIT_REL = Near range internal reflection power in dBm, float vector(1,count_rays)

V_AFC = automatic frequency control voltage in Volt, float vector(1,count_rays)

DBZ1 = Equivalent reflectivity factor lag1 in dBZ, float matrix(count_rays,NumRangeBin)

DBZ = Equivalent reflectivity factor in dBZ, float matrix(count_rays,NumRangeBin)

NCP = NCP Threshold unitless, float matrix(count_rays,NumRangeBin)

VEL = Vertical doppler Velocity in m/s, float matrix(count_rays,NumRangeBin)

In addition to these, the dual-polarization radar (JSM) will also have:

RHOHV = cross correlation ratio hv with lag 0 unitless, float matrix(count_rays,NumRangeBin)

DR = Depolarization ratio with lag 0 in dB, float matrix(count_rays,NumRangeBin)

RHOHV_lag1 = cross correlation ratio hv with lag 1 unitless, float matrix(count_rays,NumRangeBin)

DR_lag1 = Depolarization ratio with lag 1 in dB, float matrix(count_rays,NumRangeBin)

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5.0 Data Remarks

The downtown VertiX (BH) observe weak ground echoes up to 1.5 km and these may affect reflectivity and Doppler velocity estimates in very weak precipitation. The West Island VertiX (JSM) is essentially free of ground echoes above a few hundred meters.

Several factors influence the quality of reflectivity data and are corrected for:

1) Magnetron aging: As the radars run 24/7 on medium-quality magnetrons (E2V MG5424, https://www.aepmarineparts.com/wp-content/uploads/2016/09/MG5424.pdf), the transmit power gradually decreases;

2) As the transmitters are outside, temperature changes induce slight frequency changes that must be followed by voltage-controlled tuning, and sometimes the tuning gets lost;

3) Especially for the JSM radar, the flat radome sometimes can get very wet, especially when it is covered by snow/ice that starts melting, causing severe attenuation.

As a result, the sensitivity of both radars varied considerably over the course of the experiment.

Hence, in addition to a standard conversion between power and reflectivity, additional corrections are made for the reflectivity.

For the BH radar, primarily sensitive to the magnetron aging issue, we compared estimated reflectivities at different times during WINTREmix with reflectivity derived from the ECCCC Blainville radar as well as the changing strength of ground echoes to roughly establish the gradual degradation rate of the magnetron and of the tuning, and corrected for it, indicating the correction used in the variable Tuning_correction. Data availability for comparison proved more limited than expected; as a result, the correction applied is uncertain. That correction does not affect velocities nor the vertical gradient of reflectivity; over any period, the reflectivities will be off by an uncertain offset.

For the JSM radar, we used the power received from internal reflections (assumed constant) to take care of problems #1 and #2, and the change in the power of noise at far range to measure the emissions of microwaves from the wet radome to estimate the corresponding attenuation to then correct for it. The two corrections used are indicated in Tuning_correction and Attenuation_correction.

Although the VertiX can also measure spectra, their quality was surprisingly poor for most of the experiment especially for the JSM radar. For this reason, we did not include them in the default dataset.

Some peculiar signatures:

- IOP4 (2022/02/18): Marked differences in precipitation type between the two VertiXes in the 0:00-6:00 UTC period.

- IOP5 (2022/02/23): Good ZR. So good flight AC8724 was diverted to YYZ.

- IOP9 (2022/03/07): Evidence of slush at the surface (very low correlation over a deep layer around 23:50) at JSM. A few hours before, the melting observed at BH (16:00) was very incomplete and large fast-falling aggregates were visually observed.

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6.0 References

(among others)

Vogel, J. M., and F. Fabry, 2018. Contrasting Polarimetric Observations of Stratiform Riming and Nonriming Events, Journal of Applied Meteorology and Climatology, 57(2), 457-476. Retrieved Sep 14, 2022, from https://journals.ametsoc.org/view/journals/apme/57/2/jamc-d-16-0370.1.xml

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7.0 Appendix

GCMD science keywords:

VERTICAL POINTING RADAR, VERTICAL WIND VELOCITY/SPEED, RADAR REFLECTIVITY,

DOPPLER VELOCITY, RADAR IMAGERY, PRECIPITATION