Winter Precipitation Type Research Multi-Scale Experiment (WINTRE-MIX) Manual Observation Dataset

Version 1.0

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1. Dataset Description

1.1 Introduction

Manual observations were conducted to support the Winter Precipitation Type Research Multi-Scale Experiment (WINTRE-MIX) during 11 intensive observation periods (IOPs) between 01 Feb – 15 March 2022. Manual observations primarily include precipitation type, ice accretion thickness, and snowboard sampling measurements. These observations were conducted by research teams from the University at Albany, University of Colorado Boulder, Université du Québec à Montréal (UQAM), and McGill University. The research teams usually collected their manual observations throughout each IOP. Typically, the manual observations were conducted every 10 minutes at the same site as the soundings. Manual observations were often accompanied by manual hydrometeor photography, which is provided in a separate dataset (https://doi.org/10.26023/D0SE-720B-K60J). The following sections provide the information on the instruments, methods, and file format of the manual observations, as well as limitations associated with the data. For more information on the meteorological conditions of each IOP, please refer to the mission summaries on the WINTRE-MIX field catalog (http://catalog.eol.ucar.edu/wintre-mix/missions).

1.2 Data Version and Date

Version 1.0, 7th July 2022

DOI:
https://doi.org/10.26023/68S9-0EBB-5A0D

1.3 Observation Locations

Manual observations were conducted at a variety of locations across the Saint Lawrence Valley in southern Quebec and the Champlain Valley in northern New York throughout the WINTRE-MIX field campaign. Based on the forecast conditions of targeted weather systems, the specific sites were chosen for the ground observations. For more information on the selection of sites for each IOP, please refer to the mission summaries (http://catalog.eol.ucar.edu/wintre-mix/missions). A list of the sites used for WINTRE-MIX operations is provided below, partitioned by the research teams that operated at each site. A map showing all the locations is provided in Fig. 1.

University at Albany:
- DOW-US-N (Champlain, NY): 44.9554328°, –73.3878575° (elev: 46 m)
- DOW-US-Plattsburgh: 44.684823°, –73.526291° (elev: 109 m)
- ESSX (Essex Farm): 44.308028°, –73.374444° (elev: 67 m)

University of Colorado Boulder:
- DOW-CAN-N (NW of Acton Vale, QC): 45.704814°, –72.644103° (elev: 69 m)
- DOW-CAN-SE (St. Blaise-sur-Richelieu, QC): 45.2129313°, –73.2854085° (elev: 47 m)
- DOW-CAN-S (Noyan, QC): 45.085246°, –73.271936° (elev: 37 m)
- COW-CAN (St. Pie, QC): 45.478247°, -72.936154° (elev: 31 m)
- JEAN (St. Jean-sur-Richelieu, QC): 45.324880°, –73.266880° (elev: 37 m)

UQAM:
- Sorel, QC: 46.030244°, –73.110328° (elev: 13 m)
- Trois-Rivières, QC: 46.349836°, –72.581353° (elev: 52 m)
- JEAN (St Jean-sur-Richelieu, QC): 45.324880°, –73.266880° (elev: 37 m)

McGill University:
- Gault (Mont St. Hilaire, QC): 45.535022°, –73.149006° (elev: 132 m)

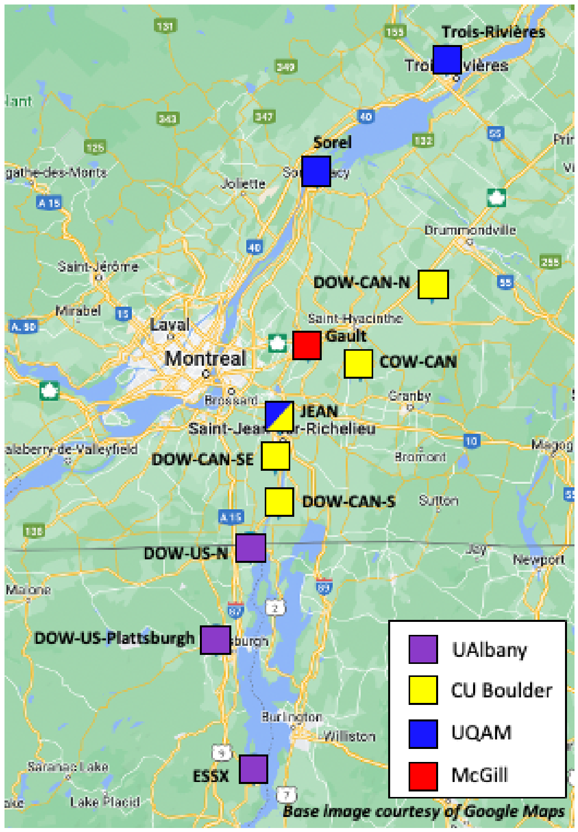

Figure 1. Manual observation locations used throughout the WINTRE-MIX field campaign

1.4 Observation Summary

A total of 11 IOPs were conducted throughout the field campaign. The summary of manual observations for each IOP is listed in the table below:

IOP	IOP Duration	Locations	Hydrometer photography*	Ice/snow measurement*
1	2100 UTC 2 Feb – 0900 UTC 3 Feb 2022	Sorel Gault DOW-CAN-S DOW-US-Plattsburgh	Yes No No No	No No No No
2	0800 UTC 10 Feb – 1330 UTC 10 Feb 2022	Sorel Gault DOW-CAN-N DOW-US-N	Yes No No No	No No No No
3	2200 UTC 11 Feb – 0630 UTC 12 Feb 2022	Sorel	No	No

		Gault	No	No
		DOW-CAN-N	No	No
		DOW-US-N	No	No
4	2300 UTC 17 Feb – 1000 UTC 18 Feb 2022	Sorel	Yes	Snow only
		Gault	Yes	Yes
		COW-CAN	No	No
		DOW-CAN-S	Yes	Ice only
		DOW-US-Plattsburgh	Yes	Ice only
5	2000 UTC 22 Feb – 0530 UTC 23 Feb 2022	Sorel	Yes	Yes
		Trois-Rivières (TR)	Yes	Ice only
		Gault	No	Ice only
		COW-CAN	No	Ice only
		DOW-CAN-N	No	Ice only
		DOW-US-N	No	Ice only
6	0900 UTC 25 Feb – 2000 UTC 25 Feb 2022	ESSX	Yes	Snow only
7	1600 UTC 01 Mar – 0200 UTC 02 Mar 2022	Sorel	Yes	Snow only
		Gault	Yes	Snow only
		DOW-CAN-SE	Yes	Snow only
		DOW-US-N	Yes	Snow only
8	0600 UTC 06 Mar – 1730 UTC 06 Mar 2022	Sorel	Yes	Yes
		Trois-Rivières (TR)	No	No
		Gault	No	No
		DOW-CAN-N	No	No
		DOW-US-N	No	No
9	1400 UTC 07 Mar – 0200 UTC 08 Mar 2022	Sorel	Yes	Snow only
		Gault	Yes	Snow only
		DOW-CAN-SE	Yes	No
		DOW-US-Plattsburgh	No	No
10	0000 UTC 12 Mar – 0900 UTC 12 Mar 2022	Sorel	Yes	Snow only
		Gault	Yes	Snow only
		JEAN	Yes	No
		DOW-US-Plattsburgh	No	No
11	0000 UTC 15 Mar – 0700 UTC 15 Mar 2022	Gault	Yes	No
		JEAN	No	No
		DOW-US-Plattsburgh	No	No

*Hydrometeor photography taken: Yes or No
*Ice/snow measurements included: Yes (both ice accretion and snowboard measurements), ice only (ice accretion only), snow only (snowboard sampling only) or No

1.5 Web Address

Preliminary manual observation datasheets in PDF format for each IOP can be accessed on the WINTRE-MIX field catalog (http://catalog.eol.ucar.edu/wintre-mix/reports).

1.6 Data Restrictions

Please refer to the websites below for more information regarding the dataset restrictions and dissemination.
WINTRE-MIX data policy:
https://www.eol.ucar.edu/content/wintre-mix-data-policy
WINTRE-MIX data management plan:

https://www.eol.ucar.edu/system/files/Data_Management_Plan-1Dec2021.pdf

2. Instrument Description

The research teams reported precipitation type by both filling in a digital form and using the mPING app on their smartphones (Elmore et al., 2014; https://mping.ou.edu/). mPING is a crowd-sourcing application in which the observers report the instantaneous precipitation type they observe at their location. Only ice- and snow-related measurements need instruments to conduct the observations. Descriptions of the instrumentation/equipment used by each research team are provided below.

2.1 University at Albany

Ice accretion measurements conducted by the research team from the University at Albany were performed with a metal rod attached to a large metal plate on a tripod. The rod was fixed onto a wooden board. After it was deployed onto the metal plate vertically, the rod had a 30-degree angle relative to the horizontal level (Figure 2.1). The mounting height was approximately 90 cm above the ground. When the tripod was extended, the mounting height was approximately 150 cm above the ground. The rod diameter was 21.8 mm. A vernier digital caliper with 0.01 mm precision was used to measure the full thickness of the rod at each observational interval. Snow depth and snow water equivalent (SWE) were measured by sampling on a 41 cm x 41 cm x 1.25 cm Snowmetrics plastic snowboard (Figure 2.2a), and using a Snowmetrics 12” snow tube and a Snowmetrics spring scale with 0.1 mm precision (Figure 2.2b). For more information on the snowboard sampling equipment, please refer to the Snowmetrics website (https://snowmetrics.com/product-category/snow-board-equipment/).

Figure 2.1 The ice accretion equipment used by the UAlbany research team

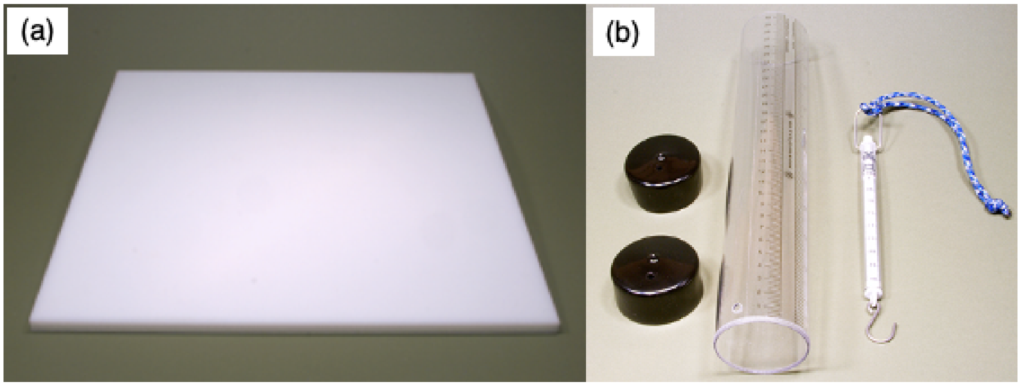

Figure 2.2 The snowboard sampling equipment used by the UAlbany research team

2.2 UQAM

2.2.1 Sorel site

Ice accretion measurements conducted by the research team from UQAM at the Sorel site were performed with an aluminum rod attached to a tripod. The rod was fixed by 2 clamps at approximately 80 cm above the ground. The rod had a 30-degree angle relative to the horizontal level (Figure 2.3). The rod diameter was 21.5 mm. A vernier digital caliper with 0.01 mm precision was used to measure the full thickness of the rod at each observational interval. Snow depth and snow water equivalent (SWE) were measured by sampling on a 38 cm x 42 cm x 2 cm white wooden snowboard, and using a Snowmetrics 12” snow tube and a Snowmetrics spring scale with 0.1 mm precision (Figure 2.2b).

Figure 2.3 Sorel manual observation site with ice accretion rod.

2.2.2 Trois-Rivières site

Ice accretion was only measured at Trois-Rivières site during IOP #5. The measurement was done on a copper rod. In the absence of a tripod, the rod was directly put in the snow at an angle of 30°. The rod diameter was 21 mm. During IOP #5, the ice was removed from the rod after each hourly measurement. No snow depth measurements were performed at Trois-Rivières throughout the field campaign.

2.3 University of Colorado Boulder

Ice accretion measurements conducted by the research team from the University of Colorado Boulder (excluding those conducted at COW-CAN) were performed with a hollow, aluminum metal rod that was attached to the trunk of the vehicle used by the research team to commute to the observing site. The rod was 12.7 mm in diameter and 91.44 cm long, and positioned at approximately a 30-degree angle relative to the horizontal for the duration of an IOP. The University of Colorado Boulder team did not have access to a digital caliper, so all ice accretion measurements were made using a ruler. Snow depth was measured by sampling snow depth with a ruler on a plastic snowboard identical to that shown in Fig. 2.2a. No snow water equivalent measurements were made by the University of Colorado Boulder team during the field campaign.

The COW-CAN team did not have access to a metal rod with which to conduct ice accretion measurements or a snowboard. Ice accretion measurements were made by measuring the amount of ice on a vertical pole that was attached to the Parsivel disdrometer that was located at the COW-CAN site. The pole used for ice accretion measurements featured a diameter of 45.5 mm and measurements were made with a manual vernier caliper. No snow depth measurements were performed at COW-CAN throughout the field campaign.

2.4 McGill University

Ice accretion measurements conducted by the research team from McGill at the Gault site were performed with an aluminum rod placed at a 30 deg angle in the snow (measured using the angle gradient inclinometer app on our phone), as close to the ground as possible and at least 20 feet from the nearest building/structure. The rod diameter was 50.8 mm. A vernier digital caliper with 0.01 mm precision was used to measure the full thickness of the rod at each observational interval after IOP5, all prior events used a standard ruler. Snow depth and snow water equivalent (SWE) were measured by sampling on a white 30” x 30” plastic snowboard and using a Snowmetrics 12” snow tube and a Snowmetrics spring scale with 0.1 mm precision.

3. Data Collection and Processing

During each IOP, the observers identified the precipitation type and weather, and conducted the hydrometeor photography and ice/snow measurement, if applicable. After that, the observers filled out a Google form. The answers were automatically recorded into a Google spreadsheet. The questions in the Google form are listed below (and the example form is included as a supplemental file):

Part 1 - Basic information:

(a) Observer initials; (b) Location; (c) Date & time (UTC)

***Part 2 - Precipitation type and weather*:**

(a) Primary precipitation type; (b) Secondary precipitation type; (c) If a frozen p-type was identified, was it visibly wet/melting? (d) If PL was identified, does it have a liquid core? (e) mPING report submitted? (f) Fog present? (g) Blowing snow? (h) Primary cloud type; (i) Sky cover; (j) Weather/p-type comments

***Part 3 - Hydrometeor photography*:**

(a) Hydrometeor photos taken? (b) Camera settings; (c) Photo comments

***Part 4 - Snow and ice amount*:**

(a) Snow/ice measurements collected? (b) Interval snow depth (mm); (c) Interval snow water equivalent (mm); (d) Snowboard interval (hr); (e) Ice accretion caliper reading (mm); (f) Ice accretion period (hr); (g) Snow and ice amount comments

Throughout the field campaign, each group could utilize the mPING app to report the identified precipitation type at the observation sites by smartphones. For more information on mPING reports, please refer to Elmore et al. (2014).

After each IOP, the current Lead Sounding and Hydrometeor Observation Scientist (the author of the “Sounding Coordinator Summary” report) reviewed each group’s manual observation spreadsheet. The sheets were checked for any possible errors (p-types inconsistent with automated weather observations, incorrect timestamps, ambiguous comments, etc.). If potential errors were identified, the manual observation team leader was contacted to investigate and, if appropriate, revise the spreadsheet to make a correction.

The radial ice accretion was calculated after the field campaign rather than reported in the field. The methods to collect ice and snow measurements by each research team are provided below.

3.1 University at Albany

During each IOP, when freezing rain was expected, the observers deployed a rod for measuring ice accretion. The rod was typically deployed at the start of the IOP. It was transported and stored in the unheated storage compartment of a box truck. The observer used a digital caliper to measure the full thickness of the rod (including the rod diameter) and recorded the reading averaged over three different locations on the rod. The observational interval of ice accretion was typically 10 or 20 minutes.

The snowboard was also typically deployed at the start of the IOP. When there was ice pellet accumulation, the observer took depth of ice pellets on the ground. When the precipitation type was snow, the observer held the tube vertically and pushed it from the snow surface down to the snowboard, and recorded the snow depth. After that, the observer put a spatula under the tube, lifted the spatula along with the tube, and turned the tube upside down. The scale hook was then placed in the hole on the tube to weigh the tube and the SWE reading from the scale was recorded. The observational interval of snow depth and SWE was typically 2 or 3 hours. After each measurement, the snowboard was cleaned off.

3.2 UQAM

3.2.1 Sorel site

A metal rod was installed on a tripod for the duration of the field campaign. Snow or ice accretion was cleared from the rod at the beginning of every IOP. The observer used a digital caliper to measure the full thickness of the rod (including the rod diameter) and recorded the reading averaged over three different locations on the rod. The observational interval of ice accretion was typically 20 minutes during freezing precipitation.

The snowboard was also typically deployed at the start of the IOP. When there was ice pellet accumulation, the observer took depth of ice pellets on the ground. When the precipitation type was snow, the observer held the tube vertically and pushed it from the snow surface down to the snowboard, and recorded the snow depth. After that, the observer put a spatula under the tube, lifted the spatula along with the tube, and turned the tube upside down. The scale hook was then placed in the hole on the tube to weigh the tube and the SWE reading from the scale was recorded. The observational interval of snow depth and SWE was typically 2 or 3 hours. After each measurement, the snowboard was cleaned off.

3.2.2 Trois-Rivières site

Ice accretion was only measured at Trois-Rivières site during IOP #5. The measurement was done on a copper rod. In the absence of a tripod, the rod was put directly in the snow at an angle of 30°. The rod diameter was 21 mm. During IOP #5, the ice was removed from the rod after each hourly measurement. A digital caliper was used for the measurements.

No snow depth measurements were performed at Trois-Rivières throughout the field campaign.

3.3. University of Colorado Boulder

The aluminum metal rod that was used for ice accretion measurements was typically set up at the start of an IOP whenever freezing rain conditions were expected. The rod was transported in a heated vehicle to the observing site. By setting up the rod at the start of the IOP, the temperature of the rod quickly adjusted to the ambient air temperature. It is unlikely that this methodology had any undue influence on observations, given that ice accretion at the University of Colorado Boulder sites never started within 1-2 hours of the beginning of an IOP. The Parsivel at the COW-CAN site was positioned permanently outdoors for the duration of the field campaign, such that the pole that was used for ice accretion measurements was always adjusted to the ambient air temperature. Ice accretion measurements were typically conducted at intervals of 1–2 hours depending on the IOP, and multiple manual caliper measurements were taken of the ice accretion and averaged together to determine the amount that was entered into the manual observation form.

The snowboard was also typically deployed at the start of an IOP whenever snow or ice pellet accumulation was expected. Snowboard measurements were taken with a ruler every 2–3 h, depending on the IOP. Snow and ice pellets was cleaned off the snowboard after measurements were taken.

3.4 McGill University

The aluminum ice accretion rod was typically set up at the start of an IOP. The rod was stored in the Earth Observing System Building at room temperature, and quickly adjusted to the outdoor temperature at the start of the IOP. It is unlikely that this methodology had any undue influence on observations, given that ice accretion at the McGill site never started within 1-2 hours of the beginning of an IOP. The Parsivel at the Gault site is positioned permanently outdoors at the climate sentinel location. Ice accretion measurements were typically conducted at intervals of

1–2 hours depending on the IOP. The snowboard was also typically deployed at the start of an IOP. Snowboard measurements were taken with a ruler every 2–3 h, depending on the IOP. Snow was cleared off the snowboard after measurements were taken.

4. Data Format

Manual observations were originally recorded in a Google spreadsheet and were converted to CSV format. All the research teams share the same spreadsheet to record the data throughout the field campaign. The name convention of each file is as follows:

*surface.manobs.IOP[**number**].[**site name**].csv*

where [**number**] indicates the number of IOP, and [**site name**] represent the observation location name provided in section 1.3. Missing data is denoted by empty fields in the files. Each file contains the reports as in the table below:

Header	Description
Observer initials	The name initials of the observer
Data & time (UTC)	The observation time in UTC
Primary p-type	The primary precipitation type reaching the ground*
Secondary p-type	The secondary precipitation type reaching the ground*
Wet/melting p-type	Whether the frozen p-type was wet/melting (Yes, No or Uncertain)
Liquid-core IP	Whether the identified ice pellets had a liquid core (Yes, No or Uncertain)
mPING report	Whether the mPING report was submitted (Yes or No)
Cloud type	The primary cloud type at the observation site*
Sky cover	The sky cover (0-8) at the observation site
Weather/p-type comments	Comments on the weather/p-type
Hydrometeor photos	Whether the hydrometeor photos were taken (Yes or No)
Camera settings	Camera settings for taking the hydrometeor photos
Photo comments	Comments on the hydrometeor photos
Snow/ice measurements	Whether the snow/ice measurements were collected (snowboard and ice accretion, snowboard only, ice accretion only, or none)
Interval snow depth (mm)	Snow depth measured on snowboard
Interval SWE (mm)	Snow water equivalent measured on snowboard
Snowboard interval (hr)	Time since the snowboard was deployed or cleared.
Ice accretion caliper reading (mm)	The recording data for ice accretion in full thickness measured by the caliper
Radial ice accretion (mm)	The radial ice accretion thickness calculated by subtracting the object diameter and dividing by 2
Ice accretion period (hr)	Time since the ice accretion rod was deployed
Snow and ice comments	Comments on the ice/snow measurement

* Abbreviations are used to record the precipitation type and cloud type. The meaning of each abbreviation is listed below:

Precipitation type:

RA=rain; FZRA=Freezing rain; DZ=Drizzle; FZDZ=Freezing Drizzle; SN=Snow; SG=Snow grains; IC= Ice crystals (diamond dust); PL= Ice pellets; GS= Snow pellets (graupel)

Cloud type:
Cb=Cumulonimbus; Cu=Cumulus; St=Stratus; Ns=Nimbostratus; Sc=Stratocumulus; As=Altostratus; Ac=Altocumulus; Ci=Cirrus; Cc=Cirrocumulus; Cs=Cirrostratus

The identification guides that the observer used are listed as below:
Precipitation type: https://cloudatlas.wmo.int/en/hydrometeors-other-than-clouds-falling.html
Cloud type: https://cloudatlas.wmo.int/en/cloud-identification-guide.html

5. Data Remarks

A preliminary assessment of the manual observations is provided in this section. Each subsection describes the factors that should be considered when using the data.

5.1 University at Albany Data Limitations

Precipitation type, as well as cloud type and amount were subjectively determined by the observer following the identification guides. Cloud type and sky cover were left blank in the file if the observer could not determine them, especially when the IOP was conducted during night. The preparation of soundings and dealing with communication issues between the radiosonde and the receiver could lead to a longer observational interval when there was limited staffing. When there was no precipitation (e.g., IOP2) or rain/drizzle only (e.g., IOP1), the observer at times submitted the report at a longer time interval.

5.2 UQAM Data Limitations

At times, the Sorel snowboard was not cleaned off after the SWE measurement. Make sure to consult the “Snow and ice comments” before using snow and ice measurements. In general, cloud type and sky cover fields were left empty during night time. Blowing snow was a big issue for snow measurement at Sorel site.

5.3. University of Colorado Boulder Data Limitations

Precipitation type, as well as cloud type and amount, were subjectively determined by the observer following the identification guides. Cloud type and sky cover were left blank in the file if the observer could not determine them, especially when the IOP was conducted during night. While every effort was made to conduct manual observations every 10 minutes, staffing issues typically resulted in delays whenever a radiosonde launch was performed. Longer observational intervals were also used when there was either light precipitation or no precipitation.

Ice accretion measurements during IOP5 were estimated based on the amount of ice that had accumulated on top of a layer of snow near the observing site. During this event, temperatures warmed enough such that ice was not accreting to the aluminum metal rod attached to the research team’s vehicle. Snowboard measurements during IOP7 are strong underestimates of the snowfall totals at the DOW-CAN-SE site. This site was subject to considerable blowing and drifting snow throughout the IOP, which led to only trace amounts of accumulation on the snowboard itself. Last, ice accumulations at COW-CAN are not included for IOP4 due to technical issues and flooding at the COW, which required the COW-CAN team to cease operations early.

5.4 McGill University Data Limitations

Important notes for the Gault site manual observations are that the ice accretion rod and snowboard material are different from those used at other stations (at Gault we used an aluminum rod for ice accretion. Until IOP4, plywood was used as a snowboard. After that, a hard plastic material was used for the remainder of the IOPs). As mentioned in previous statements, cloud type and precipitation type are somewhat subjective at times, and discussions were held after the fact to make important distinctions between e.g. FZRA and RA. These post-IOP changes are listed carefully in the comments.

6. References

Elmore, K. L., Z. L. Flamig, V. Lakshmanan, B. T. Kaney, V. Farmer, H. D. Reeves, and L. P. Rothfusz, 2014: MPING: Crowd-sourcing weather reports for research. *Bull. Amer. Meteor. Soc.*, 95, 1335–1342, https://doi.org/10.1175/BAMS-D-13-00014.1.

Links to external documentation and websites are embedded within each of the aforementioned subsections.

7. Appendix

Suggested GCMD keywords to accompany this dataset are provided below in no particular order:

- Hydrometeors
- Liquid precipitation
- Solid precipitation
- Ice storms
- Snow storms
- Cloud types
- Cloud amount

The example form used by all the research teams for reporting the manual observations during WINTRE-MIX field campaign is provided as a supplemental file.

8. Acknowledgments

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