CFI Climate Sentinels Icing Detector Data

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1 Data Set Description

1.1 Introduction: This dataset contains ice thickness data collected by ice detectors installed at various climate sentinels within the Saint Lawrence River Valley. The names of four stations for which ice accretion data are available in 'CFI_Climate_Sentinels_Icing_Detector_Data.nc' are given in *Table 1* below, along with their corresponding four-letter identifiers as indicated in the column 'Station'.

1.2 Data version: v1.0. June 2022

1.3 Time period covered by the data: Given in *Table 1*. Note that times herein are specified in the format 'HH:MM:SS dd.mm.yyyy'.

Station full name	Station	Start date/time (UTC)	End date/time (UTC)
Gault	GAUL	00:00:00 01.11.2021	23:59:00 31.03.2022
Arboretum	ARBO	00:00:00 01.11.2021	23:59:00 31.03.2022
UQAM	UQAM	00:01:00 12.02.2022	23:59:00 31.03.2022
Trois-Rivières	TROI	20:46:00 08.12.2021	23:59:00 31.03.2022

Table 1: Time period of availability for ice detector data.

1.4 Physical location data: Given in *Table 2*.

Station	Latitude (degrees North)	Longitude (degrees East)	Elevation above mean sea-level (m)
GAUL	45.535021	-73.149006	132
ARBO	45.430065	-73.942156	49
UQAM	45.508594	-73.568741	69*
TROI	46.349835	-72.581354	47

Table 2: Physical location data for stations containing ice detector data.
** UQAM station platform is 69 m above mean sea-level. It is on a building whose ground floor is 39 m above mean sea-level.*

1.5 Data frequency: minutely.

1.6 Data source: The raw data from these climate sentinels that were used to construct this dataset are part of the Adaptable Earth Observation Systems (AEOS) project.

1.7 Website address references:

Gault: https://eos.meteo.mcgill.ca/stations/1/live-data

Arboretum: https://eos.meteo.mcgill.ca/stations/1/live-data

(None for Trois-Rivières and UQAM)

1.8 Dataset restrictions: Please refer to the WINTRE-MIX data policy (https://www.eol.ucar.edu/content/wintre-mixdata-policy) as well as the WINTRE-MIX data management plan (https://www.eol.ucar.edu/system/files/Data_Management_Plan-1Dec2021.pdf) for more information regarding dataset restrictions and dissemination.

2 Instrument Description

2.1 Instrument information: Given in *Table 3*.

Station	Instrument name	Elevation of detector above ground-level (m)	Link to the manual
GAUL	Ice detector	3.0	https://s.campbellsci.com/documents/ca/manuals/0872f1_man.pdf
ARBO	Ice detector	3.0	https://s.campbellsci.com/documents/ca/manuals/0872f1_man.pdf
UQAM	Ice detector	2.0*	https://s.campbellsci.com/documents/ca/manuals/0872f1_man.pdf
TROI	Ice detector	2.0	https://s.campbellsci.com/documents/ca/manuals/0872f1_man.pdf

Table 3: Instrument information
**UQAM height is above the platform level.*

2.2 Instrument operation:

According to the manual above, an ice detector consists of a probe with characteristic natural frequency of oscillation. When exposed to icing conditions, ice bonds onto the probe and the mass increases, resulting in a decrease in this frequency. Frequency changes are related directly to ice accretion levels. Frequencies are averaged over one minute to give minutely accretion data.

A detector can measure tiny ice accretion increments on their surfaces. However, to constitute an actual measurement, the accretion must exceed a pre-determined threshold, called 'min_meas_thresh". Detector thresholds at the individual sentinel stations are listed in *Table 4*. Below this threshold, ice levels are considered noise (e.g. fluctuations due to temperature, pressure, and other precipitation).

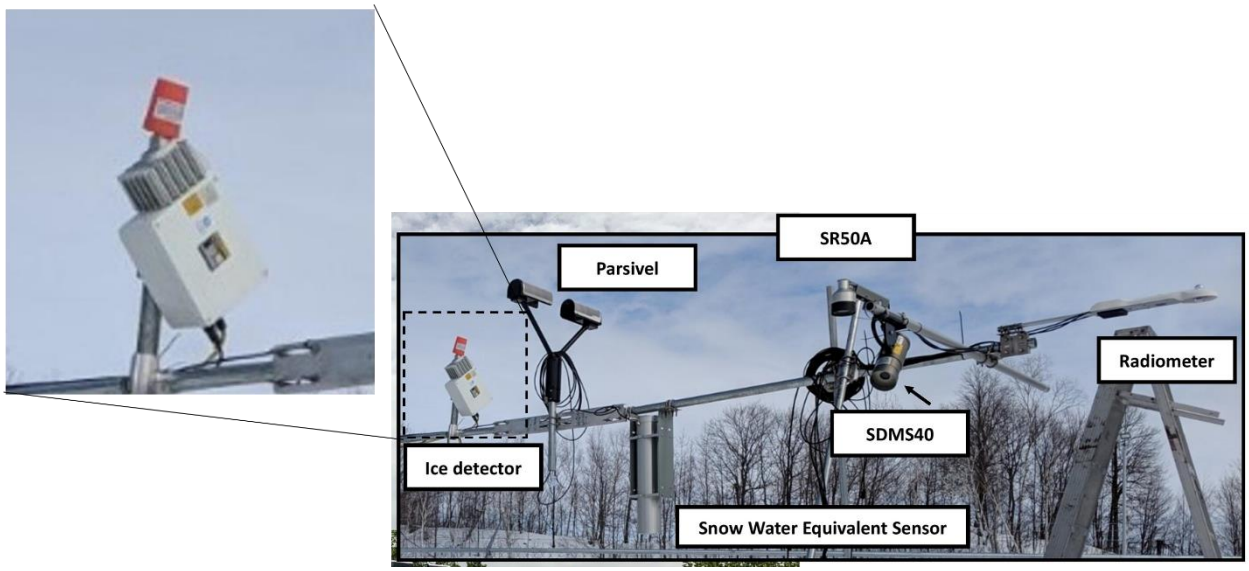
Once a pre-determined thickness of ice has been reached on the surface of a detector, called 'heat_thresh', the heaters are activated for a sufficient, internally-calculated time to promptly melt the ice. These values are also indicated in *Table 4* for the individual sensors. Once the ice is melted and the surface is cooled, ice may accrete again on the surface until the heater threshold is reached. This cycle continues as long as ice accretion is being recorded by the detector. All the following thresholds were in place for the entire duration of operation / measurement period (see *Table 1*). For more, please see the manual https://s.campbellsci.com/documents/ca/manuals/0872f1_man.pdf.

Station	min_meas_thresh (mm)	heat_thresh (mm)
GAUL	0.13	0.10
ARBO	0.13	0.10
UQAM	0.13	1
TROI	0.13	1

Table 4:Various pre-programmed thresholds set for the ice detectors.

2.3 Instrument photos

Gault



Arboretum
(No photo available)

UQAM

Trois-Rivières

More information about the detector can be found at https://www.campbellsci.ca/0872f1. Please see the instrument manual for a detailed description of operation. The manual for *0872F1 - Ice Detector (2400 BAUD Output)* can be accessed by visiting https://s.campbellsci.com/documents/ca/manuals/0872f1_man.pdf.

3 Data Collection and Processing

3.1 Data collection: For each sentinel, raw ice thickness data is recorded in real-time by a data logger and appended to the end of a '.dat.' file. One file is produced per day. Data for the 'GAUL' and 'ARBO' ice sensors were obtained directly from the dataset address specified in *Section 1.7*. Data for the 'UQAM' and 'TROI' ice sensors were obtained from Co-author Hadleigh D. Thompson. Ice detector data from all four stations were combined into a single multidimensional array. Please see *Section 4* for additional details.

3.2 Data processing: Data from 'UQAM' and 'TROI' were filtered to remove noise below a level of 0.02 mm prior to data acquisition and combining with data from the other stations. Please contact Co-author Hadleigh D. Thompson for details on this pre-processing step. Data was not fileted for 'GAUL' and 'ARBO' for the reasons specified in *Section 5*.

3.3 Derived parameters: The original raw daily datasets contain several string variables that have unique values describing the status of the ice detector and occurrences of errors. The 'ice_status' variable, as described in *Section 4.4* and whose values take those as indicated in *Table 7*, was derived by compiling this information into a single string variable. 'ice_status' effectively summarizes the functionality of the ice detector at each time step and also serves as a flag for suspect data.

4 Data Format

4.1 Data structure and naming conventions: The data format is netCDF-4 (.nc). One file is produced, called 'CFI_Climate_Sentinels_Icing_Detector_Data.nc'. This file contains ice data collected by the respective detectors at the four sentinels/locations.

4.2 Data format and layout: The dataset has variables with dimensions as shown in *Table 5*.

Dimension	Size	Description
time	217440	The number of minutely observations between the start and end dates.
station	4	The number of stations.
string4	4	The number of characters composing the station identifier.

Table 5: Dimensions of ice detector variables and their meanings.

4.3 Variables: List of dataset variables and their properties, as given in *Table 6*.

Variables	Dimensions	Data Type	Units	Frequency	Range
time	time	double	min	minutely	--
station	station × string4	char	--	--	--
ice	station × time	double	mm	minutely	0 to 2.5
heater_status	station× time	boolean	--	minutely	0 or 1
ice_status	station× time	char	--	minutely	See *Table 7*
lat	station × 1	double	˚N	--	--
lon	station × 1	double	˚E	--	--
elev	station × 1	double	m	--	--

Table 6: List of ice detector variables and their properties.

Description of variables and constants in the dataset:

"time": The time of an observation expressed in the following format: minutes since 00:00:00 01.11.2021. The proleptic_gregorian calendar is used.

"station": The station identifier for the station at which there is an observation.

"ice": The ice accretion[1] on the detector. The ice thickness is based on one-minute averages of probe oscillation frequency data.

"heater_status": Indicates whether the heater is activated or not. If it is (is not) activated, the variable returns 1 (0). When the thickness of ice on a detector surface exceeds 'heat_thresh', the values of which are tabulated in *Table 3* for the various stations, then the "heater_status" variable is subsequently changed to '1' and the "ice_status" variable changed to 'Y' (unless an error is present) to indicate the activation of the heater upon detection of approximately 'heat_thresh' thickness of ice on the detector, respectively.

"lat": Latitudes of the stations to six decimal places.

"lon": Longitudes (in the range -180 to +180) of the stations to six decimal places.

"elev": Elevation of the ice detectors above ground-level. Values for these last three constants are also given in the third column of *Table 2*.

4.4 Flag variables: "ice_status": This variable describes the operating status of the ice detector. It takes on several values, as illustrated in *Table 7* below.

Value	**Meaning**
'Y'	Ice has been detected on the ice detector. This occurs when the estimated accretion exceeds the pre-determined threshold 'heat_thresh'. See *Table 4* for these values.
'N'	Ice has not been detected on the ice detector.
'M'	Datapoint is missing. This indicates data loss at the specified time. Periods with significant data gaps (one-hour) are given in *Table 8*. This usually occurs when there is an outage at the sentinel or with the sensor.
'E'	Error detected with the ice detector. It is not operating properly and so data is unavailable.

[1] Note that the terms 'accretion' and 'thickness' are used interchangeably herein to indicate the thickness of ice accumulated on the detector surface.

‘O’	Ice detector is not yet in operation at the station. This is only relevant for the ‘UQAM’ and ‘TROI’ detectors because they began operating after Nov. 1, 2021.
‘Q’	Data that has been flagged after inspection. These points are suspect and should be treated with caution. Flagged periods are illustrated in *Table 9*.

Table 7: Values for the 'ice_status' variables and their meanings.

Meaning of NaN elements: NaN values are produced for the ‘ice’ variable when ‘ice_status’ takes on any of the following values: ‘M’, ‘E’, ‘O’, or ‘Q’.

5 Data Remarks

Note: As can be seen in *Table 4*, for the ice detectors at the ‘GAUL’ and ‘ARBO’ sentinels, the heater was initially programmed to activate at an ice accretion level below the minimum measurement threshold. Unfortunately, this implies that significant periods of ice accretion may have been missed throughout their operation. Given the programming technicalities for ‘GAUL’ and ‘ARBO’, filtering is not applied to those respective stations. **Please be aware of this issue when viewing ice data from these sensors**.

5.1 Missing data periods: See *Table 8*. Only major gaps, defined as at least one consecutive hour of missing data, are shown.

Station	Start of gap	End of gap
GAUL	23:55 18.12.2021	06:01 19.12.2021
	23:55 21.12.2021	14:08 22.12.2021
	23:55 14.01.2022	01:10 15.01.2022
ARBO	12:25 30.11.2021	18:08 30.11.2021
	04:20 12.12.2021	05:39 12.12.2021
UQAM	None	None
TROI	None	None

Table 8: Occurrences of significant data gaps in the ice detector variables.

5.2 Flagged data: See *Table 9*.

Station	Start time	End time	Explanation/reason
UQAM	00:02 23.02.2022	02:49 23.02.2022	The ice detector heater appears to be stuck on continuously for about two hours, during which period the ice thickness exceeds

			the maximum range (2.5 mm) of the detector.

Table 9: Flagged ice detector data.

6 References

Financial support was provided by Canada Foundation for Innovation (CFI), Canada Research Chair (CRC), Natural Sciences en Engineering Research Council (NSERC) of Canada, Department of Atmospheric and Oceanic Sciences at McGill University, Département des Sciences de la Terre et l'atmosphère de l'UQAM, and the Fonds de Recherche du Québec Nature et Technologie (FRQNT). We also thank Calin Giurgiu, Guillaume Dueymes, George Huard and Frédéric Toupin who provided technical support. This README was largely inspired from NYSM Chazy, NY Parsivel Disdrometer Data (Minder et al. 2022).

7 References

Minder, J., N. Bain, W. Bartolini, Jr., K., and S. McKim, 2022: NYSM Chazy, NY Parsivel Disdrometer Data. Version 1.0. https://doi.org/10.26023/KRFX-TMZW-JJ0W .

8 Appendix

Some GCMD science keywords to describe dataset.

- Total freezing rain accumulation
- Ice storms
- Liquid precipitation
- Rain
- Freezing drizzle
- Frozen precipitation
- Snow storms
- Extratropical cyclones