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

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Authors:

Andrew C. Winters (Lead)
Assistant Professor
Department of Atmospheric and Oceanic Sciences
University of Colorado Boulder
311 UCB
4001 Discovery Drive
Boulder, CO 80309-0311
E-mail: andrew.c.winters@colorado.edu
Phone: 303-735-5775
ORCID: 0000-0002-1044-3302

Justin Minder (Corr. Author – UAlbany)
Associate Professor
Department of Atmospheric and Environmental Sci.
University at Albany
ETEC 496
1400 Washington Avenue
Albany, NY 12222
E-mail: jminder@albany.edu
Phone: 518-437-3732
ORCID: 0000-0001-7182-7898

Bin Han (Corr. Author – UAlbany)
Postdoctoral Associate
Department of Atmospheric and Environmental Sci.
University at Albany
ETEC 496
1400 Washington Avenue
Albany, NY 12222
E-mail: bhan2@albany.edu
Phone: 518-560-9969
ORCID: 0000-0002-4121-553X

Julie M. Thériault (Corr. Author – UQAM)
Professor
Department of Earth and Atmospheric Sciences
Université du Québec à Montréal
PK-6151, President Kennedy Building
201 President Kennedy Avenue
Montréal, QC, Canada H2X 3Y7
E-mail: theriault.julie@uqam.ca
Phone: 514-987-3000 ext. 4276
ORCID: 0000-0001-6534-5083

Mathieu Lachapelle (Corr. Author – UQAM) Ph.D Candidate/Student
Department of Earth and Atmospheric Sciences
Université du Québec à Montréal
PK-6151, President Kennedy Building
201 President Kennedy Avenue
Montréal, QC, Canada H2X 3Y7
E-mail: lachapelle.mathieu@courrier.uqam.ca
Phone: 438-492-8304

John Gyakum (Corr. Author – McGill) Professor
Department of Atmospheric and Oceanic Sciences
McGill University
Room 945, Burnside Hall
805 Sherbrooke Street West
Montréal, QC, Canada H3A 0B9
E-mail: john.gyakum@mcgill.ca
Phone: 514-398-6076

Juliann Wray (Corr. Author – McGill) Graduate Student
Department of Atmospheric and Oceanic Sciences
McGill University
Room 909, Burnside Hall
805 Sherbrooke Street West
Montréal, QC, Canada H3A 0B9
E-mail: juliann.wray@mail.mcgill.ca
Phone: 613-878-4279

Rebecca Baiman (Corr. Author – CU) Graduate Research Assistant
Department of Atmospheric and Oceanic Sciences
University of Colorado Boulder
584 UCB
4001 Discovery Drive
Boulder, CO 80309-0584
E-mail: rebecca.baiman@colorado.edu
Phone: 708-341-3177
ORCID: 0000-0002-1801-8618

Research Sounding Teams:

University at Albany	University of Colorado Boulder
Bin Han – Team Lead	Rebecca Baiman – Team Lead
Justin Minder	Andrew Winters
Brian Filipiak	Clairisse Reiher
Rachel Eldridge	Theodore Whittock III
John England	Margaux Girouard (UQAM)
Sierra Liotta	Émile Cardinal (UQAM)
Michael Barletta	Christopher Hohman (Wyoming)
Sydney Boschulte	Brian Filipiak (Albany)
Yazmina Rojas	
Erin Potter	
Megan Schiede	
Matthew Brewer	
Yeechian Low (McGill)	
Université du Québec à Montréal	**McGill University**
Mathieu Lachapelle – Team Lead	Juliann Wray – Team Lead
Julie Thériault	John Gyakum
Margaux Girouard	Dustin Fraser
Hadleigh Thompson	Jialin Liu
Émile Cardinal	Henry Carr
Sujan Basnet	Calvin Coulbury
Karel Veilleux	Katie Simzer
	Chris Zhicheng Jing
	Benjamin Ward

1. Dataset Description

1.1. Introduction

Research soundings were conducted in support of the Winter Precipitation Type Multi-Scale Experiment (WINTRE-MIX) during 11 intensive observation periods (IOPs) between 01 February – 15 March 2022. The overarching goal of the WINTRE-MIX campaign is to better understand how multi-scale processes influence the variability and predictability of precipitation-type and amount under near-freezing surface conditions. These mobile soundings were conducted by teams of researchers at the University of Colorado Boulder, University at Albany, Université du Québec à Montréal (UQAM), and McGill University. For all IOPs, initial environmental soundings were conducted at 1 or 2 locations to sample the environment prior to or at the beginning of an IOP. Sites that did not conduct an initial environmental sounding typically began their sounding operations at the start of radar observations and/or manual ground observations. Soundings were conducted at intervals between 1–2 hours at each site, depending on the IOP. The subsections below provide information regarding the instrumentation, format of the files included within this dataset, methods used to conduct soundings during each IOP, and limitations associated with the data. For more information on the meteorological conditions associated with

each IOP described below, the reader is referred 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 0.1 (Preliminary) – 27 April 2022
Version 0.2 (Updated) – 05 July 2022
Version 1.0 (Final) – 12 July 2022

1.3. Sounding Locations

Soundings were conducted at a variety of locations across southern Quebec and the Champlain Valley throughout the field campaign. The specific locations chosen for sounding operations depended on the forecasted conditions during each IOP. For more information on the selection of sites during each IOP, the reader is referred to the mission summaries on the WINTRE-MIX field catalog (http://catalog.eol.ucar.edu/wintre-mix/missions). Below is a list of the sites used for WINTRE-MIX operations, partitioned by the university research team that operated at each site. A map highlighting the locations of all sounding sites is provided in Fig. 1.

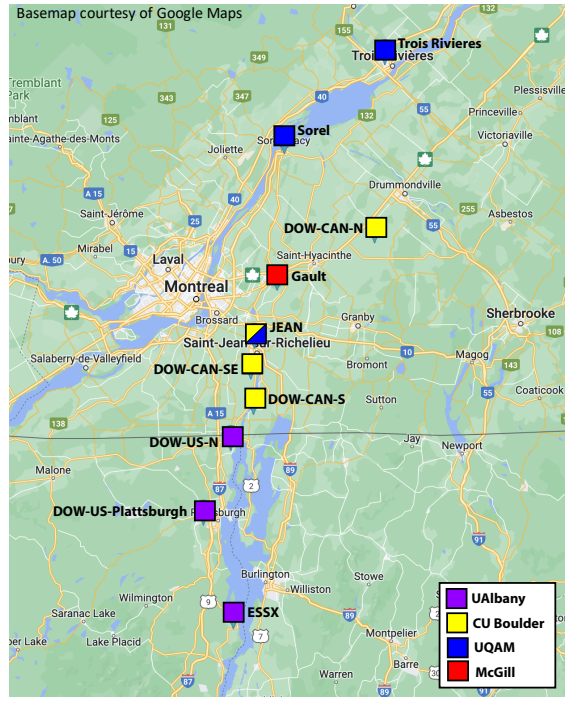


Figure 1. Locations of all WINTRE-MIX sounding sites used throughout the campaign.

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)
- 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)

1.4. Sounding Summary

The WINTRE-MIX campaign was conducted in southern Quebec and the Champlain Valley

between 01 February – 15 March 2022. A total of 11 IOPs were conducted throughout the campaign. A summary of the soundings conducted during each IOP is provided in the table below:

IOP	IOP Duration	Sounding Locations	Sounding Times
IOP 1	2100 UTC 2 Feb – 0900 UTC 3 Feb 2022	Sorel Gault DOW-CAN-S DOW-US-Plattsburgh	2100 UTC 2 Feb (Plattsburgh only) 0100 UTC 3 Feb (all sites except DOW-CAN-S) 0230 UTC 3 Feb (all sites) 0400 UTC 3 Feb (all sites) 0530 UTC 3 Feb (all sites) 0700 UTC 3 Feb (all sites)
IOP 2	0800 UTC 10 Feb – 1330 UTC 10 Feb 2022	Sorel Gault DOW-CAN-N DOW-US-N	0800 UTC 10 Feb (DOW-US-N only) 1000 UTC 10 Feb (all sites except DOW-US-N) 1030 UTC 10 Feb (DOW-US-N only) 1200 UTC 10 Feb (all sites)
IOP 3	2200 UTC 11 Feb – 0630 UTC 12 Feb 2022	Sorel Gault DOW-CAN-N DOW-US-N	2200 UTC 11 Feb (Sorel only) 0100 UTC 12 Feb (all sites) 0230 UTC 12 Feb (all sites) 0400 UTC 12 Feb (all sites) 0530 UTC 12 Feb (Sorel and DOW-CAN-N only)
IOP 4	2300 UTC 17 Feb – 1000 UTC 18 Feb 2022	Sorel Gault DOW-CAN-S DOW-US-Plattsburgh	2300 UTC 17 Feb (Sorel and Gault only) 0100 UTC 18 Feb (all sites) 0300 UTC 18 Feb (all sites except Gault) 0335 UTC 18 Feb (Gault only) 0500 UTC 18 Feb (all sites) 0700 UTC 18 Feb (all sites) 0900 UTC 18 Feb (Plattsburgh only)
IOP 5	2000 UTC 22 Feb – 0530 UTC 23 Feb 2022	Sorel Trois-Rivières (T-R) Gault DOW-CAN-N	2000 UTC 22 Feb (Sorel only) 2200 UTC 22 Feb (all sites except Gault) 2217 UTC 22 Feb (Gault only) 0000 UTC 23 Feb (all sites) 0200 UTC 23 Feb (all sites) 0400 UTC 23 Feb (all sites except Sorel) 0415 UTC 23 Feb (Sorel only)
IOP 6	0900 UTC 25 Feb – 2000 UTC 25 Feb 2022	ESSX	0900 UTC 25 Feb (ESSX only) 1200 UTC 25 Feb (ESSX only)
IOP 7	1600 UTC 01 Mar – 0200 UTC 02 Mar 2022	Sorel Gault DOW-CAN-SE DOW-US-N	1700 UTC 01 Mar (all sites except DOW-US-N) 1725 UTC 01 Mar (DOW-US-N) 1900 UTC 01 Mar (all sites) 2100 UTC 01 Mar (all sites) 2300 UTC 01 Mar (all sites) 0100 UTC 02 Mar (all sites)
IOP 8	0600 UTC 06 Mar – 1730 UTC 06 Mar 2022	Sorel Trois-Rivières (T-R) DOW-CAN-N DOW-US-N	0620 UTC 06 Mar (Sorel only) 0800 UTC 06 Mar (Sorel and Gault only) 1000 UTC 06 Mar (all sites except T-R) 1200 UTC 06 Mar (all sites) 1400 UTC 06 Mar (all sites) 1415 UTC 06 Mar (Sorel only) 1430 UTC 06 Mar (DOW-US-N only) 1440 UTC 06 Mar (Sorel only) 1600 UTC 06 Mar (all sites)

IOP 9	1400 UTC 07 Mar – 0200 UTC 08 Mar 2022	Sorel Gault DOW-CAN-SE DOW-US-Plattsburgh	1400 UTC 07 Mar (Plattsburgh only) 1600 UTC 07 Mar (Sorel and Plattsburgh only) 1800 UTC 07 Mar (all sites) 2000 UTC 07 Mar (all sites) 2200 UTC 07 Mar (all sites) 0000 UTC 08 Mar (all sites) 0100 UTC 08 Mar (Sorel and Gault only)
IOP 10	0000 UTC 12 Mar – 0900 UTC 12 Mar 2022	Sorel Gault JEAN DOW-US-Plattsburgh	0000 UTC 12 Mar (JEAN and Sorel only) 0032 UTC 12 Mar (Gault only) 0200 UTC 12 Mar (all sites) 0400 UTC 12 Mar (all sites) 0600 UTC 12 Mar (all sites) 0800 UTC 12 Mar (all sites except Gault) 0823 UTC 12 Mar (Gault only)
IOP 11	0000 UTC 15 Mar – 0700 UTC 15 Mar 2022	Gault JEAN DOW-US-Plattsburgh	0000 UTC 15 Mar (Gault only) 0010 UTC 15 Mar (JEAN only) 0200 UTC 15 Mar (all sites) 0400 UTC 15 Mar (all sites) 0515 UTC 15 Mar (JEAN only) 0600 UTC 15 Mar (all sites)

1.5. Web Address

Preliminary sounding data associated with each IOP are visualized as "quick look" products on the WINTRE-MIX field catalog (http://catalog.eol.ucar.edu/wintre-mix/missions). Data is available for download via the following URL: https://doi.org/10.26023/DN6Q-VKKE-V002.

1.6. Dataset Restrictions

Please refer to the WINTRE-MIX data policy (https://www.eol.ucar.edu/content/wintre-mix-data-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 Descriptions

Descriptions of the instrumentation, equipment, and software used to facilitate the soundings performed by each research team are provided below.

2.1. University at Albany Instrumentation

Soundings conducted by the research team from the University at Albany were performed with the iMet-3050A sounding system for IOPs 1–4 and the iMet-3150 sounding system for IOPs 6–11, with no soundings collected for IOP5 due to the failure of iMet-3050A sounding system. iMet-4 radiosondes were used and launched using 200-g meteorological balloons. Balloons were filled with helium until lift was achieved using a 750-g counterweight. The balloon was subsequently tied to a balloon flight train consisting of a parachute followed by a 30-m dereeler. The radiosonde was then attached to the dereeler using a zip tie before the launch of the balloon. Before the radiosonde was attached to the balloon flight train, it was left outdoors for 15–20 minutes to achieve an equilibrium state with the ambient conditions. The receiver of the sounding system was used to record the position of radiosondes during their ascent. Data were

collected and processed by the iMetOS-II Meteorological Operating Software with software version 3.133.0C. Data sheets with specifications for the iMet-3050A sounding system, iMet-4 radiosondes are provided below and included as attachments in the appendix (data sheets for the iMet-3150 sounding system are not accessible at this point):

- iMet-3050A Sounding System: https://www.intermetsystems.com/wp-content/uploads/2022/03/202030-11-iMet-3050A-Data-Sheet.pdf
- iMet-4 Radiosondes: https://www.intermetsystems.com/wp-content/uploads/2022/01/202084-12_iMet-4_Technical_Data_Sheet.pdf

2.2. University of Colorado Boulder Instrumentation

Soundings conducted by the research team at the University of Colorado Boulder were performed with the Vaisala MW41 radiosonde system. Vaisala RS41-SG radiosondes were used and launched using 200-g meteorological balloons. Balloons were filled with helium until lift was achieved using a 403-g counterweight. Balloons were subsequently tied to Vaisala RSU411 dereelers using string before the radiosondes were attached to the unwinders. Data were collected and processed by a Vaisala Sounding Processing System with software version MW41 2.11. A Vaisala CG31 antenna was used to track the position of radiosondes during their ascent. Data sheets with specifications for the Vaisala MW41 radiosonde system, RS41-SG radiosondes, and CG31 antenna are provided below and included as attachments in the appendix:

- MW41 Radiosonde System: https://www.vaisala.com/sites/default/files/documents/MW41-Datasheet-B211221EN.pdf
- RS41-SG Radiosondes: https://www.vaisala.com/sites/default/files/documents/WEA-MET-RS41-Datasheet-B211321EN.pdf
- CG31 Antenna: https://www.vaisala.com/sites/default/files/documents/CG31-Datasheet-B210687EN-F.pdf

2.3. UQAM Instrumentation

Soundings conducted by the research team at Université du Québec à Montréal (UQAM) were performed with the iMet-3050A 403 MHz portable radiosonde system. The iMet-4 radiosonde was used and launched with 200-g meteorological balloons. Balloons were filled with 700 g of helium using an iMet-5600 Automatic Balloon Inflator. Balloons were subsequently tied to iMet-54 String dereelers using zip ties before the radiosondes were attached to the dereelers. Data were collected and processed by the iMetOS-II software version 3.133.0. An iMet-3050A Portable 403MHz Antenna/Receiver was used to track the position of radiosondes during their ascent. Data sheets with specifications for the iMet-3050A 403 MHz portable radiosonde system, iMet-4 radiosondes, the iMet-3050A antenna, balloons, and iMet-5600 automatic balloon inflator are provided below and included as attachments in the appendix:

- iMet-3050A 403 MHz Portable Sounding System: https://www.intermetsystems.com/products/imet-3050a-403-mhz-portable/
- iMet-4 Radiosondes: https://www.intermetsystems.com/products/imet-4-radiosonde/

- iMet-3050A Portable 403MHz Antenna/Receiver: https://intermet.co/tracking_stations/imet-3050a/
- Kaymont 200-g Sounding Balloons: https://www.kaymont.com/meteorological
- iMet-5600 Automatic Balloon Inflator: https://intermet.co/balloons/auto-balloon-inflator/

2.4. McGill University Instrumentation

Soundings conducted by the McGill University team were performed at the Gault Nature reserve EOS building with the iMet-3050A 403 MHz portable radiosonde system. The radiosonde used was the iMet-4 radiosonde, which was launched using 200-g meteorological balloons. Balloons were filled with 700 g to 750 g of helium using an iMet-5600 Automatic Balloon Inflator, where the amount of helium depended on meteorological conditions. Balloons were then tied to IMet-54 String dereelers using zip ties before the radiosondes were attached to the dereelers. Data was collected and processed by the iMetOS-II software version 3.133.0. An iMet-3050A Portable 403MHz Antenna/Receiver was used to track the vertical and horizontal position of radiosondes during their ascent. Data sheets with specifications for the iMet-3050A 403 MHz portable radiosonde system and iMet-4 radiosondes are provided below and included as attachments in the appendix:

- iMet-3050A 403 MHz Portable Sounding System: https://www.intermetsystems.com/products/imet-3050a-403-mhz-portable/
- iMet-4 Radiosondes: https://www.intermetsystems.com/products/imet-4-radiosonde/
- iMet-3050A Portable 403MHz Antenna/Receiver: https://intermet.co/tracking_stations/imet-3050a/
- Kaymont 200-g Sounding Balloons: https://www.kaymont.com/meteorological
- iMet-5600 Automatic Balloon Inflator: https://intermet.co/balloons/auto-balloon-inflator/

3. Data Collection and Processing

Soundings across all sites were collected in a variety of near-freezing environments including pre- and post-frontal air masses, snow, drizzle, graupel, rain, freezing rain, ice pellets, strong low-level jets, channeled flow in the St. Lawrence and Champlain Valleys, downsloping flow in the lee of the Adirondacks, and rapid transitions in precipitation type. The spectrum of synoptic-scale systems sampled include weakly forced precipitation events associated with fast-moving clipper systems, well-developed surface cyclones and the passage of their attendant frontal boundaries, and weak frontal waves. In all cases, the specific locations of launches were determined prior to the IOP based on forecasted meteorological conditions.

Launches were coordinated across all sites by the sounding coordinator for each IOP and allowed to ascend until the balloon burst or was manually terminated. To ensure that the frequencies used to communicate with the radiosondes did not interfere across sites, the sounding coordinator initially established a range of frequencies within which each team should operate. If there were difficulties establishing a connection at a particular frequency during the IOP, the team leads and the sounding coordinator would identify a suitable adjustment to that team's

operating frequency to prevent interference with the other teams. In most cases, the balloons were manually terminated after 60–90 minutes, prior to balloon burst, to maintain the temporal consistency of launches across all sites or for operational reasons (i.e., to ensure there was enough time to prepare the next radiosonde for launch). In some cases, as will be discussed in section 5, some balloons were terminated due to a loss of signal or because of potential icing on temperature/humidity sensors. In these cases, the sounding coordinator and operations director made a joint decision whether to proceed with a new launch. Data are included in this dataset for all portions of the soundings that were collected, so long as the data was not determined to be erroneous.

3.1. University at Albany

A total of 42 soundings were successfully conducted by University at Albany researchers across the entire campaign from a mobile platform that was deployed at one of the three sites listed in section 1.3. Sounding data was initially processed by the iMetOS-II Meteorological Operating Software before it was uploaded to the NCAR/EOL Data Archive. Except for the identification of soundings that may be characterized by instrument icing, no quality control has been performed on the data outside of that already performed by the iMetOS-II software system. Prior to the launch of each radiosonde, the antenna of the iMet-3050A sounding system was used to determine the elevation and coordinates of the sounding site while the location information was obtained by the radiosonde itself when operating with the iMet-3150 sounding system. Surface pressure, humidity, and temperature for each sounding were measured from the radiosondes. These measurements were then filled into the iMetOS-II software via choosing the "insert radiosonde measurements" option. Surface wind speed was measured using a Kestrel and read by the operators. Surface wind direction was estimated by the operators. Wind data was manually entered into the iMetOS-II software. The consistency between the radiosonde and Kestrel temperature and relative humidity was checked for some, but not all, launches. For those checked launches, no substantial differences were found.

3.2. University of Colorado Boulder

A total of 36 soundings were successfully conducted by University of Colorado Boulder researchers across the entire campaign from a mobile platform that was stationed at one of the four sites identified in section 1.3. Sounding data was initially processed by the Vaisala MW41 software system and then manually converted to CSV format prior to upload to the NCAR/EOL Data Archive. Except for the identification of soundings that may be characterized by instrument icing, no quality control has been performed on the data outside of that already performed by the MW41 software system. Prior to the launch of each radiosonde, the MW41 software and GC31 antenna were used to determine the elevation and initial location of the sounding site. Surface pressure, humidity, temperature, and wind data for each sounding were manually entered into the MW41 software based on observations taken from the DOW-CAN mesonet station. Some limitations to these surface observations are described in section 5.2.

3.3. UQAM

A total of 58 soundings were successfully conducted by Université du Québec à Montréal researchers across the entire campaign from the Sorel (total of 46), Trois-Rivières (total of 7) and

St. Jean-sur-Richelieu (total of 5) sites. Sounding data was processed by the iMetOS-II software version 3.133.0, which automatically converted them to TXT format prior to upload to the NCAR/EOL Data Archive. Except for the identification of soundings that may be characterized by instrument icing, no quality control has been performed on the data outside of that already performed by the software. Prior to the launch of each radiosonde, the iMetOS-II software and the iMet-3050A Portable 403MHz Antenna/Receiver were used to determine the elevation and initial location of the sounding site. The radiosonde was placed outside and automatically measured the temperature and humidity at the surface. Wind speed and direction data were taken from surface observations at Sorel and entered manually into the iMet sounding software. There were some instances during the first IOP, and during a couple of other UQAM soundings, where station measurements of wind were unavailable. In these instances, the wind is listed as 0 m s^{-1} with a direction of 0°. These instances should be treated as missing data.

3.4. McGill University

A total of 43 soundings were successfully conducted by McGill University researchers across the entire campaign from the Gault Nature Reserve Earth Observatory Site. Sounding data was initially processed by the iMet-3050A 403 MHz software system and then manually converted to TXT format prior to upload to the NCAR/EOL Data Archive. Except for the identification of soundings that may be characterized by instrument icing, no quality control has been performed on the data outside of that already performed by the iMet-3050A software. Prior to the launch of each radiosonde, the iMet-4 radiosonde and iMet-3050A Portable 403MHz Antenna/Receiver were used to determine the elevation and initial location of the sounding site. Surface pressure, humidity, and temperature data for each sounding were automatically entered into the iMet-3050A software based on observations taken from the radiosonde. Wind data was manually input to the software 10 minutes before the time of launch based on Climate Sentinel data at Gault. Data from all soundings were reprocessed during Summer 2022 in order to add latitude and longitude data to the TXT files. Minimal sounding data from 1000 UTC 10 February 2022 during IOP2 was also recovered through these post-processing efforts. Some limitations to the sounding data are described below in section 5.4.

4. Data Format

The following subsections describe the format of the preliminary sounding files that were collected by each research team during the WINTRE-MIX campaign and uploaded to the NCAR/EOL Data Archive.

4.1. University at Albany Soundings

All files collected by the University at Albany research team are in TXT format for the following sites: DOW-US-N, DOW-US-Plattsburgh, and ESSX. The naming convention for these files is as follows:

upperair.sounding.YYYYMMDDHHHH.**[site name]**.txt

Where **[site name]** could be: “Albany_DOW-US_Plattsburgh”, “Albany_DOW-US_N”, or “Albany-ESSX”.

Output data at each timestep are indicated by the rows within each TXT file, with the first row of data representing the initial conditions when the balloon was launched. The columns within each file correspond to the variables output by the iMet sounding software. These variables are as follows:

UTC_Date:	The Month/Day/Year at which the sounding was launched in UTC
UTC_Time:	The time at which the sounding was launched in UTC
FltTime:	The elapsed time in seconds since the sounding was launched
Ascent:	The ascent rate of the sounding in m min^{-1}
GPM_AGL:	The geopotential meters of the sounding above ground level
GPM_MSL:	The geopotential meters above mean sea level
Alt_AGL:	The altitude of the sounding in meters above ground level
Alt_MSL:	The altitude of the sounding in meters above mean sea level
Press:	The pressure measured by the radiosonde in hPa
Temp:	The temperature measured by the radiosonde in degrees Celsius
RelHum:	The relative humidity measured by the radiosonde in %
Mix_Rat:	The mixing ratio measured by the radiosonde in g kg^{-1}
DP:	The dew point measured by the radiosonde in degrees Celsius
WSpeed:	The wind speed measured by the radiosonde in m s^{-1}
WDirn:	The wind direction measured by the radiosonde in degrees (0 degrees corresponds to a northerly wind).
Long/E:	The longitudinal position of the sounding
Lat/N:	The latitudinal position of the sounding

4.2. University of Colorado Boulder Soundings

All files collected by the CU Boulder research team are in CSV format for the following sites: DOW-CAN-N, DOW-CAN-SE, DOW-CAN-S, and JEAN. The naming convention for these files is as follows:

upperair.sounding.YYYYMMDDHHHH.CU_**[site name]**.csv

Where **[site name]** could be: “DOW-CAN_S”, “DOW-CAN_N”, “DOW-CAN_SE”, or “JEAN”.

Output data at each timestep are indicated by the rows within each CSV file, with the first row of data representing the initial conditions when the balloon was launched. The columns within each file correspond to the variables output by the Vaisala MW41 sounding software. These variables are as follows:

/Row/@Altitude:	The altitude of the radiosonde in meters above ground level
/Row/@DataSrvTime:	The data server timestamp in UTC
/Row/@Dropping:	This column is set to 0 if the data is from an ascending radiosonde
/Row/@East:	The distance in meters that the radiosonde is to the east of the launch location
/Row/@Height:	The geopotential height of the radiosonde in meters
/Row/@Humidity:	The relative humidity measured by the radiosonde in %
/Row/@Latitude:	The latitudinal position of the radiosonde

/Row/@Longitude:	The longitudinal position of the radiosonde
/Row/@North:	The distance in meters that the radiosonde is to the north of the launch location
/Row/@Pressure:	The pressure measured by the radiosonde in hPa
/Row/@PtuStatus:	PTU status flags for the launch: 1 = Pressure Interpolated 2 = Height Interpolated 4 = Temperature Interpolated 8 = Humidity Interpolated 16 =Telemetry Break 32 = Adiabatic Check Failed 64 = Pressure From Height - Interpolated
/Row/@RadioRxTimePk:	Radio time in seconds
/Row/@SoundingIdPk:	Randomly generated sounding ID
/Row/@Temperature:	Temperature in Kelvin
/Row/@Up:	Radiosonde vertical distance in meters as measured relative to first time of valid sounding data
/Row/@WindDir:	Wind direction in degrees (0 degrees corresponds to a northerly wind)
/Row/@WindEast:	The zonal component of the wind in m s^{-1}
/Row/@WindInterpolated:	A flag indicating whether the wind has been interpolated by the sounding software
/Row/@WindNorth:	The meridional component of the wind in m s^{-1}
/Row/@WindSpeed:	The wind speed in m s^{-1}

4.3. UQAM Soundings

All files collected by the UQAM research team are in TXT format for the following sites: Sorel, Trois-Rivières, and JEAN. The naming convention for these files is as follows:

upperair.sounding.YYYYMMDDHHHH.**[site name]**.txt

Where **[site name]** could be: “UQAM-Sorel”, “UQAM-Trois-Rivieres”, or “CU_JEAN”.

Output data at each timestep are indicated by the rows within each TXT file, with the first row of data representing the initial conditions when the balloon was launched. The columns within each file correspond to the variables output by the iMet sounding software. These variables are as follows (*Variables that are only available from soundings launched from Trois-Rivières):

FltTime:	The elapsed time in seconds since the sounding was launched
Press:	The pressure measured by the radiosonde in hPa
Temp:	The temperature measured by the radiosonde in degrees Celsius
RelHum:	The relative humidity measured by the radiosonde in %
WSpeed:	The wind speed measured by the radiosonde in m s^{-1}
WDirn:	The wind direction measured by the radiosonde in degrees (0 degrees corresponds to a northerly wind).

UTC_Date: The Month/Day/Year at which the sounding was launched in UTC
UTC_Time: The time at which the sounding was launched in UTC. For Trois-Rivières, the time in UTC is given in AM or PM, rather than in a military time format.
Long/E: The longitudinal position of the sounding
Lat/N: The latitudinal position of the sounding
GPM_MSL: The geopotential meters above mean sea level
GPM_AGL*: The geopotential meters of the sounding above ground level
Ascent*: The ascent rate of the sounding in m min^{-1}
Alt_MSL*: The altitude of the sounding in meters above mean sea level
DP*: The dew point measured by the radiosonde in degrees Celsius

4.4. McGill University Soundings

All files collected by the McGill research team are in TXT format for the following sites: Gault. The naming convention for these files is as follows:

upperair.sounding.YYYYMMDDHHHH.McGill-Gault.txt

Output data at each timestep are indicated by the rows within each TXT file, with the first row of data representing the initial conditions when the balloon was launched. The columns within each file correspond to the variables output by the iMet sounding software. These variables are as follows:

FltTime: The elapsed time in seconds since the sounding was launched
Press: The pressure measured by the radiosonde in hPa
Temp: The temperature measured by the radiosonde in degrees Celsius
RelHum: The relative humidity measured by the radiosonde in %
WSpeed: The wind speed measured by the radiosonde in m s^{-1}
WDirn: The wind direction measured by the radiosonde in degrees (0 degrees corresponds to a northerly wind).
GPM_AGL: The geopotential meters of the sounding above ground level
Long/E: The longitudinal position of the sounding
Lat/N: The latitudinal position of the sounding

5. Data Remarks

A preliminary assessment regarding the quality of the initial sounding data collected during the WINTRE-MIX campaign is offered in the subsections below. In particular, each subsection describes factors that should be considered when evaluating the quality of the data obtained during select IOPs. These factors include an evaluation of the potential for instrument icing that was performed by all groups following the discussion from Waugh and Schuur (2018).

5.1. University at Albany Data Limitations

The iMet-3050A sounding system utilized by the University at Albany team was likely damaged during IOP4 and problems with the receiver were not noticed until the beginning of IOP5. This led to no sounding data being collected for IOP5. A backup hand-held iMet-3150 sounding system was used starting with IOP6. Compared to those soundings collected by the iMet-3050A sounding

system, sounding data from IOP6 onwards shows a limited signal range. The detection range was especially limited when the balloon was launched under windy and/or cloudy conditions. Sounding data was also delayed until 0200 UTC during IOP11 due to issues with the lock on the truck used to launch soundings at the DOW-US-Plattsburgh site. Due to the manual input of surface wind data when initializing soundings, caution should be noted when interpreting the surface wind conditions. Brief notes for sounding data with potential limitations and delayed launches are listed in the table below:

IOP	Sounding	Limitation
IOP2	1030 UTC 10 Feb 2022	The originally scheduled launch at 1000 UTC was not detected by the receiver, resulting in a new launch at 1030 UTC.
IOP3	0400 UTC 12 Feb 2022	Data for this sounding is only available up to ~6 km height due to a software failure. Outliers in temperature and dew point are also present at ~3300m above mean sea level.
IOP4	0500 UTC 18 Feb 2022 0700 UTC 18 Feb 2022	Temperature and dew point data suggest a likely radiosonde icing issue. Temperature and dew point data suggest a potential radiosonde icing issue.
IOP7	1725 UTC 01 Mar 2022 2300 UTC 01 Mar 2022 0100 UTC 02 Mar 2022	The originally scheduled launch at 1700 UTC was ~25 min late because of a communication problem between the radiosonde and the receiver. The originally scheduled launch at 2300 UTC was delayed by ~30 min due to communication problems with the receiver. Data is only available up to a height of ~4.5 km.
IOP8	1000 UTC 06 Mar 2022 1200 UTC 06 Mar 2022 1400 UTC 06 Mar 2022 1430 UTC 06 Mar 2022 1600 UTC 06 Mar 2022	Data is only available up to a height of ~2.7 km. Data is only available up to a height of ~5.0 km. Data is only available up to a height of ~2.2 km. Relaunched one balloon after the previous launch at 1400 UTC terminated at 2.2 km. Data is only available up to a height of ~4.6 km. Data is only available up to a height of ~3.0 km.

5.2. University of Colorado Boulder Data Limitations

Logistical issues prevented the launch of a couple of soundings by the CU Boulder research team during the campaign. During IOP1, there were issues sourcing power for the MW41 sounding system, which prevented a launch until 0230 UTC 03 Feb 2022. During IOP9, there were issues in transporting expendables (balloons, dereelers, radiosondes) to the sounding site. As a result, a sounding was launched from Sorel by the UQAM team at 1600 UTC 07 Mar 2022 rather than at DOW-CAN-SE, as originally scheduled. As discussed in section 1.3, the surface observations that were used as input to the MW41 sounding software were provided by the mesonet station onboard the mast of DOW-CAN. In several instances, meteorological conditions or the local landscape prevented the full extension of the mast to 10-m height. As a result, some caution should be used in evaluating the validity of surface observations due to potential ambient heat from the DOW and or blockage of the wind by nearby trees, power lines, and the DOW cabin itself. Soundings in which the surface observations are particularly spurious are identified in the table below. Surface observations at JEAN were collected using the nearby surface observing station at the St. Jean-sur-Richelieu airport.

IOP	Sounding	Limitation
IOP1	0230 UTC 03 Feb 2022	Altitude, DataSrvTime, Dropping, Latitude, Longitude, PtuStatus, RadioRxTimePk, SoundingIdPk are missing. Height is mistakenly labeled at

		the top of two columns. The first column of data that starts with 32 m in first row is the correct height variable.
IOP2	1000 UTC 10 Feb 2022	Latitude and Longitude coordinates are missing from the data file.
IOP4	0300 UTC 18 Feb 2022	Surface temperature and dew point temperature are likely too warm.
IOP7	1900 UTC 01 Mar 2022	Surface temperature and dew point temperature are likely too warm.
IOP9	2000 UTC 07 Mar 2022 2200 UTC 07 Mar 2022 0000 UTC 08 Mar 2022	Temperature and dew point data suggest a potential radiosonde icing issue. Temperature and dew point data suggest a potential radiosonde icing issue. Surface temperature and dew point temperature are likely too warm. Temperature and dew point data suggest a potential radiosonde icing issue.
IOP10	0600 UTC 12 Mar 2022 0800 UTC 12 Mar 2022	Spurious temperature and dew point temperature just above the surface. Temperature and dew point data suggest a potential radiosonde icing issue.

5.3. UQAM Data Limitations

The sounding dataset has some limitations regarding the height and range at which data could be transmitted from the radiosonde to the antenna. The maximum height at which the radiosonde could be located from the antenna was 25 km and the maximum distance was 250 km. That range can change according to the ground station, the balloon size, and the atmospheric conditions. The biggest problems the UQAM team encountered were with the equipment itself and with the software used for the soundings. For instance, the humidity sensor on the radiosonde could get stuck to a value of 100% sometimes, requiring a relaunch (as described in the table below). There were also three software failures. The first two launches of IOP1 (0100 UTC 03 Feb 2022 and 0230 UTC 03 Feb 2022) used an older version of the software (iMetOS-II version 3.127.5). In both cases, the software froze when the radiosonde reached an altitude of 16 km. A newer computer and software version (iMetOS-II version 3.133.0) were used for the remainder of the field campaign. Due to the manual input of observations when initializing soundings, caution should be noted when interpreting the surface conditions.

IOP	Sounding	Limitation
IOP5	0200 UTC 23 Feb 2022 0415 UTC 23 Feb 2022	Temperature and dew point data suggest a potential radiosonde icing issue at T-R. Launched ~15 min late at Sorel due to spurious humidity data during the original 0400 UTC launch.
IOP8	0620 UTC 06 Mar 2022 1400 UTC 06 Mar 2022 1400 UTC 06 Mar 2022 1415 UTC 06 Mar 2022 1440 UTC 06 Mar 2022	Launched ~20 min late at Sorel due to termination of the 0600 UTC launch at 2000 m. Temperature and dew point data suggest a potential radiosonde icing issue at T-R. Humidity and temperature data are likely unreliable at Sorel due to sensor errors. Humidity and temperature data are likely unreliable at Sorel due to sensor errors above 2000 m. The 1440 UTC sounding data are more reliable at Sorel compared the soundings conducted at 1400 and 1415 UTC.
IOP11	0010 UTC 15 Mar 2022	Sounding launched ~10 min late at St. Jean-sur-Richelieu due to software issues during the 0000 UTC launch.

5.4. McGill University Data Limitations

The sounding dataset collected by the McGill University team has some limitations regarding the quality of surface observations as well as some communication issues between the antenna and

the launched radiosonde. In particular, the initial temperature of the radiosonde thermometer may be characterized by a warm bias due its storage within the EOS building at room temperature up to 5 mins before launch. Initial wind conditions (speed and direction) were collected from the Gault Climate Sentinel site and did not match what the ground team perceived at times. More specifically, the research team believes much stronger gusts were observed than indicated by the Climate Sentinel. Occasionally, the relative humidity readings post-launch would stay at 100% for long periods of time. This appears to have been the case for only one sounding conducted by the McGill University team. There were between 10–15 software failures where the radiosonde signal was not picked up by the antenna after launch, even though the signal appeared to be properly connected pre-launch. The software simply needed to be restarted when this occurred, which solved the issue for subsequent launches. The research team launched one sounding which hit the trees that surround the Gault Nature Reserve EOS due to high winds. The radiosonde was recovered and used in a launch several minutes later and worked just fine. A list of soundings affected by these limitations are provided below.

IOP	Sounding	Limitation
IOP1	0700 UTC 03 Feb 2022	The original 0700 UTC launch at McGill was initially unsuccessful but was relaunched shortly after 0700 UTC. Temperature and dew point data suggest a potential radiosonde icing issue.
IOP2	1000 UTC 10 Feb 2022	Minimal data up to 429 m above sea level is available for this launch due to a software/antenna failure.
IOP4	0335 UTC 18 Feb 2022 0500 UTC 18 Feb 2022 0700 UTC 18 Feb 2022	Multiple attempts at the 0300 UTC launch failed due to popped balloons under windy conditions. A 0335 UTC launch was successful. Temperature and dew point data suggest a potential radiosonde icing issue. Temperature and dew point data suggest a potential radiosonde icing issue.
IOP5	2217 UTC 22 Feb 2022 0400 UTC 23 Feb 2022	The 2200 UTC launch failed due to issues with the radiosonde connecting to the receiver. A launch at 2217 UTC was successful. Temperature and dew point data suggest a potential radiosonde icing issue.
IOP8	1400 UTC 06 Mar 2022	The signal from the radiosonde was lost between 1000–900 hPa, leading to missing data in that layer. Consequently, an adjustment of 0.11 minutes should be added to all latitude values, and an adjustment of –0.82 minutes to all longitude values.
IOP9	2000 UTC 07 Mar 2022 2200 UTC 07 Mar 2022 0100 UTC 08 Mar 2022	Temperature and dew point data suggest a potential radiosonde icing issue. Temperature and dew point data suggest a potential radiosonde icing issue. The initial 0100 UTC launch from Gault was initially unsuccessful but was quickly relaunched shortly after the hour. Temperature and dew point data suggest a potential radiosonde icing issue.
IOP10	0032 UTC 12 Mar 2022 0823 UTC 12 Mar 2022	The receiver initially did not detect the first launch at 0000 UTC, so a second launch was conducted. The 0800 UTC launch failed for unknown reasons, and was relaunched successfully at 0823 UTC.

6. References

Waugh, S., and T. J. Schuur, 2018: On the use of radiosondes in freezing precipitation. *J. Atmos. Ocean. Tech.,* **35**, 459–472, https://doi.org/10.1175/JTECH-D-17-0074.1.

7. Appendix

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

- geopotential height
- tropopause
- atmospheric pressure measurements
- atmospheric stability
- upper air temperature
- water vapor profiles
- upper level winds
- extratropical cyclones
- fog
- ice storms
- snow storms

Data sheets associated with the instrumentation described in section 2 are provided as attachments to this README.

8. Acknowledgments

We thank all the participants that contributed to the WINTRE-MIX field campaign. Support for the CU and UAlbany teams to perform sounding observations as part of the WINTRE-MIX project was provided by the National Science Foundation through grants AGS-2114011 and AGS-2113995. Support for the UQAM and McGill teams was provided by Canada Foundation for Innovation (CFI), the Province of Quebec, McGill University, Canada Research Chair (CRC), Natural Sciences en Engineering Research Council (NSERC) of Canada, Département des Sciences de la Terre et l'atmosphère de l'UQAM, and the Fonds de Recherche du Québec Nature et Technologie (FRQNT).

iMet-3050A

Meteorological Sounding System
403 MHz GPS Portable

- **Low-Cost, High-Performance Design**
- **Integrated Antenna/Receiver/Decoder**
- **Processed Digital Output Direct to PC**
- **35 cm Height, 2.2 Kg Weight (4.9 lbs)**
- **Single Case Deployment**
- **Ideal for Field Use**
- **iMetOS-II and NOAA SkySonde Software**
- **Compatible with all iMet Radiosondes**
- **Innovative, Elegant, Affordable**

Product Overview

The iMet-3050A is InterMet's latest portable sounding system. Designed for maximum ease of use, this compact antenna / receiver / decoder is the most mobile, high-performance sounding system available on the market.

System Overview

Operating Principle	Automatic GPS
Frequency	400.15 – 406 MHz
Operating Mode	Mobile or fixed
Operating Environ.	All-weather
Users Required	1 person
MTBF	> 2400 hours
Useful Life	8+ years
Software	iMetOS-II or NOAA SkySonde

Operating Parameters

Power	Via USB port from PC, 5 VDC
Outside Equip Temp	- 20 to + 40 ° C
Antenna Wt.	2.2 kg
Complete System	< 10 kg, including field case
Antenna Height	35 cm
Tripod	1.5 m – 3 m fully extended

Upper-Air Sounding Performance

Max Slant Range	> 250 Km
Max Altitude	> 35 Km
Reports	WMO, BUFR, Custom MSG
Interfaces	Google Earth, RAOB
Ozone Capable	Standard

403 MHz Antenna

Antenna Type	Quarter-Wave Monopole
Construction	Fiberglass/aluminum
Polarization	Vertical
Impedance	50 Ohm
Gain	2 dBi
Radiation Pattern	Omnidirectional

403 MHz Receiver

Type	Superheterodyne
Frequency Control	Synthesized with AFC
Bandwidth (Narrow)	6 kHz
Modulation	FM / FSK
Sensitivity	-118 dBm
Operational	-110 dBm

Deployment Options

Antenna Assembly	Tripod or fixed mount
Field Case	Pelican Model 1700

System Computer

Processor	Any current model
Operating System	Windows 10
Data Output	USB

International Met Systems is one of the world's leading suppliers of Atmospheric Sensors for synoptic, military and research applications. Since 1997, we have delivered over 400 systems to customers in over 50 countries.

InterMet offers a complete line of sounding systems and sensors to meet customer requirements and budgets. We offer flexible, cost-effective solutions - and the highest level of customer service in the industry.

InterMet
International Met Systems
4767 Broadmoor SE, Ste 7
Grand Rapids, MI 49512
phone: 616-971-1005
e-mail: info@intermetsystems.com

Specifications Subject to Change without Notice
See iMet-4 Data Sheet for Radiosonde Information
Document 202030-11

iMet-4 Radiosonde

403 MHz GPS Synoptic
Technical Data Sheet

Temperature and Humidity

The iMet-4 measures air temperature with a small glass bead thermistor. Its small size minimizes effects caused by long and short-wave radiation and ensures fast response times. A super-hydrophobic coating minimizes wet-bulb effects

The humidity sensor is a thin-film capacitive polymer that responds directly to relative humidity. An integrated temperature sensor minimizes errors caused by solar heating.

Pressure and Height

As recommended by GRUAN[3], the iMet-4 is equipped with a pressure sensor to calculate height at lower levels in the atmosphere. Once the radiosonde reaches the optimal height, pressure is derived using GPS altitude combined with temperature and humidity data.

The pressure sensor facilitates the use of the sonde in field campaigns where a calibrated barometer is not available to establish an accurate ground observation for GPS-derived pressure. For synoptic use, the sensor is bias adjusted at ground level.

Winds

Data from the radiosonde's GPS receiver is used to calculate wind speed and direction.

Data Transmission

The iMet-4 radiosonde can transmit to an effective range of over 250 km*.

A 6 kHz peak-to-peak FM transmission maximizes efficiency and makes more channels available for operational use. Seven frequency selections are pre-programmed - with custom programming available.

Calibration

The iMet-4's temperature and humidity sensors are calibrated using NIST traceable references to yield the highest data quality.

Benefits

- Superior PTU performance
- Lightweight, compact design
- No assembly or recalibration required
- GRUAN[3] qualified (pending)
- Status LED indicates transmit frequency selection and 3-D GPS solution
- Simple one-button user interface

** Subject to ground station, balloon size and atmospheric conditions*
[1] All uncertainties expressed at a 95% confidence level
[2] Primary atmospheric pressure derived by GPS altitude
[3] GECOS Reference Upper-Air Network
Specifications subject to change without notice
Document 202084-12

InterMet
International Met Systems
Grand Rapids, MI USA
www.intermetsystems.com

MEASUREMENTS

Measurement cycle	1 Hz
TEMPERATURE SENSORS	Glass Bead
Manufacturer	Shibaura
Measurement range	+60°C to -90°C
Resolution	0.01°C
Response time: still air/ 5 ms^{-1} (1000 hPa)	2 / < 1 sec
Repeatability in Calibration	0.2 C
Combined Uncertainty/Reproducibility [1]	
> 100 hPa	0.5 C / 0.3 C
< 100 hPa	1.0 C / 0.75 C
Night flight	0.3 C / 0.3 C
Solar correction	≤ 1.2 C
HUMIDITY SENSOR	Capacitive Polymer
Manufacturer	IST
Measurement range	0-100 % RH
Resolution	0.1%
Response time	
@ 25C	0.6 seconds
@ 5C	5.2 seconds
@ -10C	11 seconds
@ -40C	61 seconds
Repeatability in Calibration	5 %
Uncertainty/Reproducibility [1]	
> 0 C	5% / 3%
-40 to 0 C	5% / 5%
PRESSURE [2]	Sensor
Manufacturer	Measurement Specialties
Measurement range	1200 hPa - 10 hPa
Resolution	0.01 hPa
Response time	0.5 milliseconds
Uncertainty/Reproducibility [1]	
Whole range	2.0 / 1.5 hPa
1200 - 400 hPa	1.0 / 0.75 hPa
400 hPa - 10 hPa	2.0 / 1.5 hPa
PRESSURE	GPS derived
Measurement range	SFC to 3 hPa
Resolution	0.1 hPa
Uncertainty/Reproducibility [1]	
1080 - 400 hPa	2.0 / 1.5 hPa
400 hPa - 3 hPa	0.5 / 0.25 hPa

GEOPOTENTIAL HEIGHT	Pressure derived
Measurement range	SFC to 40 km
Resolution	0.1 m
Combined Uncertainty/Reproducibility [1]	
1080 - 400 hPa	15 m / 10 m
400 - 10 hPa	200 m / 150 m
GEOPOTENTIAL HEIGHT	GPS derived
Measurement range	SFC to 40 km
Resolution	0.1 m
Combined Uncertainty/Reproducibility [1]	
1080 - 400 hPa	30 m / 15 m
400 - 3 hPa	60 m / 20 m
WIND SPEED AND DIRECTION	
Resolution	0.1 m/s / 1 degree
Speed	
Combined Uncertainty/Reproducibility [1]	0.5 / 0.25 m/s
Direction	
Combined Uncertainty/Reproducibility [1]	1 degree

TELEMETRY

Transmission type	Synthesized
Maximum Range	> 250 km
Frequency stability	± 3 kHz
Deviation, peak to peak	6 kHz
Output Power	~ 30 – 200 mW
Modulation	AFSK
Data Rate	1200 Baud
Transmission Frequencies	7 Pre-programmed Channels
Custom Frequencies	Available
GPS RECEIVER	
Manufacturer / Type	U-Blox CAM-M8
Cold Start Time	< 60 seconds (typical)

OPERATIONAL DATA

Battery	Lithium
Operating time	> 135 minutes
Weight	120 grams
Dimensions	Body (LWH): 139x67x31
	With boom (LWH): 235x67x31
Calibration Stability	2 years

** Subject to ground station, balloon size and atmospheric conditions*
[1] All uncertainties expressed at a 95% confidence level
[2] Primary atmospheric pressure derived by GPS altitude
[3] GECOS Reference Upper-Air Network
Specifications subject to change without notice
Document 202084-12

InterMet
International Met Systems
Grand Rapids, MI USA
www.intermetsystems.com

iMet-3050A

403MHz Portable Antenna / Receiver

403MHz Antenna

Antenna type	Quarter-wave monopole
Construction	Aluminium / fibreglass composite
Polarization	Vertical
Radiation pattern	Omnidirectional
Gain	2 dBi
Max slant range	> 250 km*
Max altitude	> 40 km*

Receiver

Type	Superheterodyne
Frequency control	Synthesized with AFC
Bandwidth	15kHz
Demodulation	FM, FSK, GFSK
Sensitivity	-118 dBm

System Overview

Radiosonde Compatibility	iMet-1, iMet-2, iMet-4, iMet-50, iMet-54
Frequency	400.15 - 406 MHz
Operating mode	Mobile
Operating Environment	Rain proof
System architecture	Digital
MTBF	> 2400 hours
Useful life	> 8 years
Sounding Software Compatibility	D-Met, iMetOS-II, SkySonde

Computer Requirements

Type	Any current PC
Operating system	Windows
Connection	USB

Operating Parameters

Power	Via USB port from PC
Temperature	-20 to +40 ˚C
Antenna weight	2.2 kg
Antenna length	35 cm
Optional tripod	1.5 m fully extended

Key Features

- Combined antenna and receiver with single USB cable interface
- Integrated GNSS providing accurate station location
- Compatible with all 403MHz InterMet radiosondes
- Small size and light weight
- Ideal for field use
- Compatible with D-Met, iMetOS-II and SkySonde sounding software

This antenna is targeted at users that requires portability and ease of deployment. The compact, integrated, design and simple cabling requirements (USB connection only) makes this antenna a favourite in the research field

InterMet Africa
International Met Systems

33 Estmil Road, Diep River, 7800,
Cape Town, South Africa
Phone: +2721 715 1120
email: info@intermetafrica.com
www.intermetafrica.com

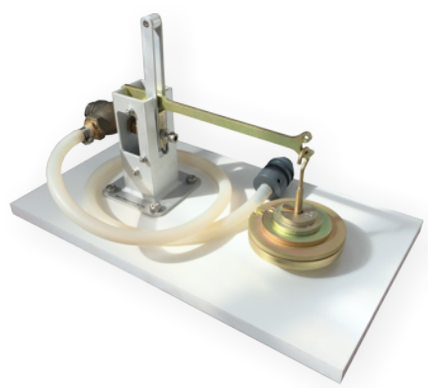
Specifications subject to change without notice
* *Subject to balloon dimensions and atmospheric conditions*

iMet-5600 Automatic Inflation Kit

For Meteorological Balloons

Operating Principle

The automatic inflation kit is connected to the gas supply and allows the meteorological balloon to be automatically inflated to the correct buoyancy by shutting off the gas flow when the balloon is able to lift the counter balance weight. The buoyancy of the balloon can be adjusted according to the payload and ascent rate requirements by adding or removing counterweights from the lift arm.



System Overview

Operating principle	Automatic regulator valve
Capacity	100 - 1000 g balloons
Nozzle size	44 to 70 mm
Compatibility	Helium, non-flammable
Operators required	1 person
Useful life	10 years

Dimensions

Dimensions	47 x 36 x 19 cm
Total weight	5 kg
Counter weights	50, 100, 200, 400 (2), 600 gram

Key Features

- For meteorological balloons
- Suitable for all balloon sizes up to 1000g
- Rugged construction
- Portable
- Easy to use

This automatic inflation kit enables accurate, automatic filling of meteorological balloons with gas to the correct buoyancy. This ensures the correct ascent rates during soundings and helps in achieving consistent burst altitudes.

InterMet Africa
International Met Systems

33 Estmil Road, Diep River, 7800,
Cape Town, South Africa
Phone: +2721 715 1120
email: info@intermetafrica.com
www.intermetafrica.com

Specifications subject to change without notice

Sounding System MW41

Features

- Consistent, high-quality data
- Easy integration to existing soundings network
- Increased flexibility through advanced networking options
- Easy and simple operation
- Quick configuration and modification of station parameters, also remotely

Vaisala Sounding System MW41 supports the world-class performance of Vaisala RS41 radiosonde family. This makes MW41 an excellent choice for both synoptical and research applications.

Vaisala Sounding System MW41 processes, analyses, archives, and relays sounding data. The system consists of a computer that runs MW41 sounding software and is connected to a sounding processing subsystem via a network adapter. MW41 sounding software includes the sounding processing software running as services on a computer and an optional remote client for remote access/use.

Easy to integrate

Upgrading to MW41 from earlier Vaisala sounding systems is smooth and cost-effective. The software is compatible with commonly used Windows operating systems and hardware, making it easy to integrate to most IT bases and helping to minimize maintenance costs. Connectivity with Vaisala Automatic Weather Stations allows using highly accurate surface weather information as reference, which makes operation simpler and less sensitive to human error.

Flexible to use

As MW41 user interface is separated from other software functionalities, it can be operated from anywhere within your network. This allows, for example, managing sounding operations remotely, away from the sounding station. Additionally, all network users can access sounding data, remotely.

The standard MW41 software package includes all features needed to perform synoptic soundings. For more advanced sounding needs, like ozone sounding capability or extended graphics, optional modules are available. The system can be tailored for specific needs of a sounding station.

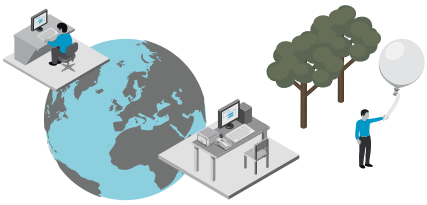
Intuitive to operate

MW41 follows the radiosonde preparation process, minimizing the need for user input and interaction. When the user needs to act, using the system is made easier with clear status indicators and animations, and a software help is available for additional assistance. As operating the system is highly intuitive, training users is faster. Access to specific functionalities can be defined by utilizing user groups and their related privileges.

Quick to configure

Configuring MW41 for operation is easy. The user interface supports quick configuration of station parameters, message creation, and parameter sending. The system can also be configured remotely.

MW41 validates sounding data to make sure it is of high quality. The system can create WMO messages and special text reports using the validated data, and the data is also available in XML format.



Technical data

Compatibility

Radiosonde	• RS41-SG • RS41-SGP • RS41-SGM • RS41-D
Special sensor	Ozone sensors: • ECC-6A ECC • Z ECC

Minimum system requirements for sounding workstation

Computer	PC delivered by Vaisala includes: • Pre-installed MW41 sounding software • System recovery tools, including USB drive with recovery image • Optional Edgeport serial extension Optionally, any PC that fulfills the requirements below can be used.
Operating system	• Windows 10 Pro 64-bit (English)
Web browser	• Microsoft Edge latest version (English) • Mozilla Firefox latest version (English) • Google Chrome latest version (English)
Processor	Intel Pentium Dual Core or equivalent (Quad Core recommended)
Memory	8 GB RAM
Hard disk space	160 GB
Display resolution	1366 × 768 (minimum)
DVD-ROM drive	For the installation media
Optional serial ports	Either integrated or via USB/RS-232 converter. 1 for possible Automatic Weather Station
USB port	For connecting the ground check device
Ethernet adapter	For isolating the sounding system from the internal network
Speakers	Integrated either into computer or display
Remote client PC	Using devices that fulfill the same requirements as for Sounding Workstations is recommended.[1)]

1) It is likely that devices with lower hardware specifications, other operating systems, or other browsers can be used.

Vaisala Sounding Processing Subsystem

Software-defined radio technology
Code-correlating GPS

Operating environment

Indoor equipment	
Operating temperature	+10 ... +40 °C (+50 ... +104 °F) +10 ... +45 °C (+50 ... +113 °F) with rugged laptop
Storage temperature	−40 ... +65 °C (−40 ... +149 °F)
Operating humidity	10 ... 90 %RH
Storage humidity	5 ... 95 %RH
Outdoor equipment	
Operating temperature	−40 ... +55 °C (−40 ... +131 °F)
Storage temperature	−50 ... +71 °C (−58 ... +160 °F)
Operating humidity	0 ... 100 %RH
Storage humidity	0 ... 100 %RH
Operating wind speed	0 ... 65 m/s (0 ... 145 mph)
Operating precipitation	Unlimited

Telemetry

Frequency band	400.15 ... 406 MHz
Tuning step (user-adjustable)	10 kHz
Error detection and correction	Reed-Solomon
Telemetry range (using directional antenna)	Up to 350 km (217.5 mi)

Meteorological messages

TEMP messages	TEMP FM35-XI, TEMP SHIP FM36-XI, TEMP MOBIL FM38-XI
PILOT messages	PILOT FM32-XI, PILOT SHIP FM33-XI, PILOT MOBIL FM34-XI
BUFR messages	BUFR 3'09'050 and BUFR 3'09'051 (for PILOT and High resolution data) BUFR 3'09'052 and BUFR 3'09'057 (for TEMP and High resolution data) BUFR 3'09'056 (for descending sounding after balloon burst)
Advanced option	CLIMAT TEMP FM 75-X BUFR 3'09'053 (DROP BUFR)
Special sensor option	NILU, WOUDC
Defense messages option	METCM STANAG 4082, METB2/METB3 STANAG 4061, METFM STANAG 2103, METSR/METSRX, METTA STANAG 4140, METEO 11

Antennas

Directional UHF antenna (automatic direction control)
Omnidirectional UHF antenna
Portable antenna for UHF and GPS
GPS antenna
Advanced Multipath Rejection GPS antenna

Ground check set

RI41 and RI41-B. See separate datasheets for details.

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Vaisala Radiosonde RS41-SG

Temperature and Humidity Sensors

The Vaisala Radiosonde RS41 temperature sensor is very stable utilizing linear resistive platinum technology. The small size of the sensor results in low solar radiation error and guarantees fast response. The RS41 temperature sensor also incorporates effective protection against evaporating cooling, the phenomenon occasionally encountered when a radiosonde emerges from a cloud top.

The Vaisala Radiosonde RS41 humidity sensor integrates humidity and temperature sensing elements to provide unique features. Prior flight automatic recondition of the humidity sensor effectively removes chemical contaminants and ensures excellent humidity measurement accuracy. Integrated temperature sensor is used to compensate the effects of solar radiation in real time resulting in very precise measurement. The sensor heating function enables an active and effective de-icing method when a radiosonde is flying through layers with freezing conditions. The humidity sensor is very accurate throughout the whole measurement range and has fast response to detect fine structures of the atmosphere.

RS41 Ground Check

RS41 ground check includes several functional checks: temperature check, humidity sensor recondition, humidity check and setting radiosonde parameters. Ground check is performed prior to flight or a radiosonde placed on the Ground Check Device RI41 conveniently operated with MW41 software.

Short range wireless communication link is used in ground check devices for turning radiosonde power on and for data transfer during the ground check. The communication link is based on the RF technique within the range around 4 cm.

In-built temperature sensor check includes comparison of readings from the temperature element of the humidity sensor and the actual temperature sensor giving additional confidence for the functionality check.

Utilizing the new humidity sensor design, the radiosonde is able to generate physical dry humidity reference more consistently than is possible with desiccants. The sensor can measure the deviation of humidity measurement at 0 %RH (physical zero) and fine tune the humidity measurement accordingly.

Wind Data, Height and Pressure

Wind, height and pressure are derived from velocity and location measurements of the RS41 GPS receiver. Height and pressure are calculated from satellite ranging codes, combined with differential corrections from the MW41 ground station. Pressure calculation also uses temperature and humidity from the radiosonde. Wind is calculated independently based on satellite carrier frequency changes.

Data Transmission

The Vaisala Radiosonde RS41-SG has proven data transmission from radiosonde to receiver up to 350 km. This is sufficient for any sounding operations. Data availability during a sounding is guaranteed with digital error correction code transmission and telemetry errors are always detected. Due to narrow band transmission more channels are available in the meteorological frequency band.

RS41 Calibration

The Vaisala Radiosonde RS41's temperature and humidity sensors are calibrated against the references that are traceable to SI standards and measurement uncertainties are estimated according to recommendations of Joint Committee for Guides in Metrology, 100:2008.

Operational Benefits

The RS41's robust and compact design makes it easy to handle during launch preparations.

The status LED indicates when the RS41 is ready to launch, and if there is an error, it is clearly indicated prior to launch.

Unwinder

With the unwinder the radiosonde sensor boom is automatically set in an ideal position for sounding. As the unwinder is separated from the radiosonde, the balloon and unwinder can be prepared in advance to streamline launch preparations.

Vaisala Radiosonde RS41-SG – accuracy and reliability.

Benefits

- Superior PTU measurement performance
- Automated ground check
- Robust and easy to use design
- GPS for continuous wind data availability as well as height and pressure calculation
- Stable narrow band transmission complies with ETSI standard EN 302 054

Add-On Sensor Connector

The RS41 has a serial interface for additional sensors, primarily to connect ozone interface OIF411 to RS41. Also other sensors with Xdata protocol can be connected. The data is transferred either directly or via OIF411 to a RS41 radiosonde and further to the Vaisala DigiCORA® Sounding System MW41.

Technical Data

Measurements

Measurement cycle	1 s
TEMPERATURE SENSOR	TYPE: PLATINUM RESISTOR
Measurement range	+60 °C to -90 °C
Resolution	0.01 °C
Response time (63.2%, 6 m/s flow, 1000 hPa)[1]	0.5 s
Stability (1 year / 3 years)	< 0.05 °C / < 0.1 °C
Accuracy	
Repeatability in calibration	0.1 °C
Combined uncertainty after ground preparation	0.2 °C
Combined uncertainty in sounding < 16 km	0.3 °C
Combined uncertainty in sounding > 16 km	0.4 °C
Reproducibility in sounding > 100 hPa[2]	0.15 °C
< 100 hPa[2]	0.30 °C
HUMIDITY SENSOR	TYPE: THIN-FILM CAPACITOR
Measurement range	0 to 100 %RH
Resolution	0.1 %RH
Response time	
6 m/s, 1000 hPa, +20 °C	< 0.3 s
6 m/s, 1000 hPa, -40 °C	< 10 s
Accuracy	
Repeatability in calibration	2 %RH
Combined uncertainty after ground preparation	3 %RH
Combined uncertainty in sounding	4 %RH
Reproducibility in sounding[2]	2 %RH
PRESSURE	TYPE: CALCULATED FROM GPS
Measurement range	from surface pressure to 3 hPa
Resolution	0.01 hPa
Accuracy	
Combined uncertainty/ Reproducibility[2] in sounding	
> 100 hPa	1.0 hPa / 0.5 hPa
100 - 10 hPa	0.3 hPa / 0.2 hPa
< 10 hPa	0.04 hPa / 0.04 hPa
GEOPOTENTIAL HEIGHT	TYPE: CALCULATED FROM GPS
Measurement range[3]	from surface to 40000 m
Resolution	0.1 gpm
Accuracy	
Combined uncertainty in sounding	10.0 gpm
Reproducibility in sounding[2]	6.0 gpm
WIND SPEED	
Velocity measurement uncertainty[4]	0.15 m/s
Resolution	0.1 m/s
Maximum reported wind speed[3]	160 m/s
WIND DIRECTION	
Directional measurement uncertainty[4]	2 deg
Resolution	0.1 deg
Wind direction range	0 to 360 deg

Telemetry

Transmitter type	Synthesized
Frequency band	400.15 - 406 MHz
Tuning range	400.16 - 405.99 MHz
Maximum transmitting range	up to 350 km
Frequency stability, 90 % probability	± 2 kHz
Deviation, peak-to-peak	4.8 kHz
Emission bandwidth	According to EN 302 054
Output power (high-power mode)	min. 60 mW
Sideband radiation	According to EN 302 054
Modulation	GFSK
Data downlink	4800 bit/s
Frequency setting	Wireless with ground check device

GPS Receiver (SA Off, PDOP<4)

Number of channels	≥ 48
Frequency	1575.42 MHz, L1 C/A code
Cold Start Acquisition Time	35 s (nominal)
Reacquisition Time	1 s (nominal)
Correction	Differential
Reporting resolution of lat, lon position values	1e-8°

Operational Data

Power-up	Wireless with ground check device or with switch
Factory calibration	Stored on Flash memory
Battery	2 pcs AA-size Lithium cells
Operating time	> 240 min
Weight EPS / plastic covers	80 g / 109 g
Dimensions[5]	Body (L x W x H): 155 x 63 x 46 mm
	Sensor boom bent (L x W x H): 282 x 63 x 104 mm

Add-On Sensor Support

Protocol support	Xdata to connect several sensors in the same chain, data transferred either directly or via OIF411 to RS41
Transfer rate	max. 200 bytes/s

Unwinder

Material of the string	Non-UV treated polypropylene
Tenacity	< 115 N
Length of the string	55 m
Unwinding speed	0.35 m/s
Weight	25 g

The performance data is expressed with 2-sigma confidence level (k=2), unless otherwise explicitly specified.
For humidity, the performance data is valid T > -60 °C.

1) After applying time-lag correction, the effect to measurement uncertainty is negligible.
2) Standard deviation of differences in twin soundings, ascent rate above 3 m/s
3) In practice unlimited
4) Standard deviation of differences in twin soundings. Wind speed above 3 m/s for directional measurement uncertainty.
5) For EPS cover; without wire antenna

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Portable Antenna Set CG31

Features

- Easy set up with captive parts
- Long telemetry range - 150 km (93.2 mi) using the RS41 series GPS radiosondes

Vaisala Portable Antenna Set CG31 is a portable antenna designed to be used with GPS wind-finding systems.

The antenna set consists of a Helix UHF antenna with antenna amplifier and GPS antenna on a tripod. The antenna set is painted green as standard. One person can handle and assemble the antenna set. CG31 receives radiosonde signals in 400 MHz meteorological UHF band. The tripod and the antennas fold compactly for transportation. The transport case is made of polypropene and equipped with wheels for ease of transportation. The transport case also holds an equipment bag, which contains foot pads, pegs, and a hammer.

Technical Data

Technical Specifications

UHF Antenna	
Type	Full-wave Quadrifilar Helix
Frequency	400 ... 406 MHz
Gain (Elevation angle 25°)	3.5 dBic
Polarization	Right-Hand Circular
Horizontal pattern	Omni-directional
Telemetry Range	
With RS41 series GPS radiosondes	150 km (93.2 mi)
Amplifier	
Gain	20 dB typical
Noise figure	< 2 dB
Power input	+10 ... 12 VDC, typically 130 mA through RF cable
Output impedance	50 Ω, VSWR < 1.5
GPS Antenna	
Primary power	+5 VDC (±10 %)
Power consumption	22 mA, 0.11 W (nominal)
Output impedance	50 Ω
Frequency	L1 (1575 MHz)
Polarization	Right-Hand Circular Polarization (RHCP)
VSWR	2 : 1
Axial ratio	2 dB at zenith, 10 dB above 10° elevation
Gain	35 dB (nominal)
Noise	2.75 dB (nominal)
Pass-band width	50 MHz
Azimuth coverage	360° (omni-directional)
Elevation coverage	0° to 90° elevation (hemispherical)

Mechanical Specifications

Diameter	Footprint 1133 mm (44.61 in)
Total height assembled	1695 mm (66.73 in)
Transportation case dimensions	1380 × 355 × 385 mm (54.33 × 13.98 × 15.16 mm)
Standard cable length	20 m (65 ft)
Connector	
UHF Antenna	Coaxial N-type female
GPS Antenna	Coaxial TNC-type female
Weight	
With cables	10.5 kg (23.15 lb)
With accessories and transport case	23 kg (50.71 lb)

Operating Environment

Operating temperature range	-40 ... +55 °C (-40 ... +131 °F)
Operating humidity range	0 ... 100 %RH
Operating precipitation	Unlimited
Maximum wind speed	65 m/s (145 mph)
Storage temperature	-50 ... +71 °C (-58 ... +159.8 °F)
Storage humidity	0 ... 100 %RH

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