Author's Response

April 22, 2024

Reviewer 1

Thank you for your work in helping us improve the manuscript. We have made changes to the manuscript for your consideration. We have responded to all R1 comments below and outlined changes in the manuscript (via tracked changes).

- Information on the environment in which the observation equipment is installed should be added. Photographs of the observation equipment and its location should be included to show the conditions at the observation site. The installation and surrounding environments are important factors in meteorological observation data. Depending on the environment, the interpretation of the data may change. In this manuscript, each meteorological observation site is described a little in the text, but that is not enough. Please include photographs of the observation equipment in the text, Appendix, or Supplement.
    - The description of each site has been significantly increased. In particular, seven new detailed Tables (Tables 4-10) outlining all of the instruments, their manufacturers, accuracy, operating configuration, temporal resolution, and quality control at each site is now included. Note these Tables are extensive (several pages long) so we would also suggest having them in an Appendix instead. We have noted in the manuscript that the information in these tables is also documented in the attributes of the MODFs themselves. Photographs of each site, including the surrounding topography, are now included as well (Figures 2-8). Additional photographs of several key instruments at each site, as an example of the operating conditions, are also included. Combined, this enables the user to better understand the surrounding environment, equipment, relative locations of instruments, and surface conditions.
    - The new Tables and Figures are provided at the end of this response, in the Appendix.
- Fig. 2 should be replaced with a clearer photo or image for the same reason. The photo in Fig. 2 hints at the cover information around the installation site but does not provide other important information, such as the specific surface cover type or topographic information. The reader needs to interpret the meteorological data, so the figure should be changed to include such information.
    - Seven new Figures (Figures 2-8 in the new manuscript) have been added to the manuscript to address this. The new figures clearly illustrate each site's topography and cover information at and around the site, showing the specific surface cover type and other topographic information. Note these new Figures are numerous (several sub-figures were requested to show instruments as well as the surrounding area), so we suggest having them in an Appendix instead.
    - The original Figure 2 (now Figure 9) has been mostly left as-is to provide a "zoomed out" perspective of the synoptic region, km-scale land cover, and the NWP model grid points that fall within this region; it also appears later in the paper when NWP models are discussed.
- Please describe the QC, even briefly. Related to Major Comment 1, without a description of the environment in which the data was processed, data users cannot determine whether they can fully rely on this dataset. In an appropriate observing environment, a simple QC can make the dataset more complete, but in a complex or harsh observing environment, the reliability of the dataset will depend on how carefully the QC was performed. Although there is a brief description of the QC method in this

manuscript, it should be explained more carefully in this paper (rather than just citing the method) due to the aim of data description papers. Since it is difficult to judge the usability of the overall dataset at present, authors should describe how the QC was performed, even briefly, along with a description of the surrounding environment (also related to Major Comment 1).

  - The discussion about QC has been significantly increased and expanded in the paper. The new Tables 4-10 are extensive and provide a dedicated quality control column including a full description of how QC was applied for every single instrument at each site (i.e., all measured variables). The QC method is no loner just cited but now explained in detail with references provided. There also exists an in-depth discussion of QC in Section 4 to highlight processing and QC differences between some of the sites. Details pertaining to how the QC was performed, thresholds and metrics used, etc., is now included in the new Tables 4-10. A description and pictures of the surrounding environment is now provided in seven new Figures 2-8 (see previous two comments) to improve context of the observations and their conditions.

- Lack of information on observation sensors and data processing. Whether or not information on the type of meteorological sensor is specified is an important aspect in interpreting the validity of the observation data, along with information on the observation environment. Depending on the characteristics of the sensor, the observed data may not faithfully reflect the surrounding meteorological conditions. The lack of easy access to the list of observation items and sensors used at different sites is a major obstacle to the main goal of organizing observation data at the super sites in a unified manner. Although information is provided in fragments in the text, it would be easier for readers to read if the information were systematically organized in tables.
  - Seven new Tables (4-10) have been added to the paper which describes each individual instrument that was used in the MODF for each site. Details about each site's instruments, including the make, model, accuracy, uncertainty, processing technique, and QC are now provided in full detail. Where possible, references to the manufacturer's datasheets and other reference material is provided in the text, including additional comments on methodologies and relevant intricacies of each instrument's dataset. This long list of instruments at each site is quite extensive and detailed; as such it may also be suitable as an Appendix. Overall, these new Tables improve the organization and clarity regarding the source of each observation in a clear and standardized manner.
- There is a lack of information on the sensor installation environment. For example, whether the air temperature sensor is installed in a forced or natural ventilation shelter, whether the shelter heating effect is corrected for natural ventilation, whether the humidity is corrected in a sub-freezing environment, whether the flux measured by the eddy correlation method eliminates the influence of the surrounding environment, etc. It is important to specify whether or not the data set has been corrected for the factors mentioned above in addition to QC to ensure data availability.
  - The new Tables (4-10) added to the manuscript now provide this information (see previous comment). Details regarding the setup, environment, and configuration for each instrument is now provided in full detail to clearly indicate the precise observing configuration as well as the level of QC that was / was not performed. The new Figures 2-8 have photographs of several of these instruments (as an example) and the surrounding area; they provide visual context of their operating configuration and surrounding environment.
- L55 Polar prediction: What prediction?

    - The text now reads "Polar weather forecast prediction" to clarify this.
- L128 super site: Is "super site" defined somewhere? If not, mentioning "super site" every time is redundant, so it should be rewritten as just "site".
    - L71 now provides a brief description to distinguish 'supersite' from 'site': "in general, the suite of several additional instruments that enable an enhanced measurement program, including remote sensing, radiation, and other meteorological sensors, is what distinguishes a 'supersite' from a typical weather site."
    - The text now reads 'supersite (hereafter referred to as "sites")' in the Introduction immediately following this sentence, with "sites" being used for the remainder of the text to reduce redundancy.
- L128 the Canadian Arctic Weather Science (CAWS) project: please add a brief description of the purpose of the CAWS project.
    - CAWS was initiated to evaluate upper air observing technologies that can complement and improve Polar forecasts, perform satellite calibration / validation over Arctic terrain, and to provide recommendations to optimize the Canadian Arctic observing network. This text is now included in the manuscript.
- L135, 149 etc. roughness length: what is the intention of including roughness length? Roughness varies greatly depending on the surface condition (snow cover, vegetation, bare ground, etc.), so simply showing the average roughness value has less meaning. If there is an intention, please modify it so that the intention is clear; otherwise, consider deleting it as it is redundant.
    - This has been removed from the text to reduce redundancy.
- L139 average monthly precipitation: it should be stated in terms of annual total precipitation rather than monthly average precipitation. Temperature and precipitation amounts as climatic values are important and valuable data, and their inclusion is strongly recommended. However, they are generally presented as annual mean temperature and total precipitation as climate values. It is acceptable to include monthly averages, but it would be better to include them as additional information to the annual precipitation totals.
    - The total annual precipitation is now provided for each site, as well as the annual average temperature. This information is now reported for all sites in a systematic manner, following R2's comment on the structure of the site descriptions.
- L251 snowfall of 60.3 cm: would this "snowfall of 60.3 cm" be 46.6 mm w.e. in water equivalent? It should be stated in terms of water equivalent to describe precipitation as a climatic value. That information can be listed if the authors want to list the snow depth.
    - In order to standardize the site descriptions (standard statements for precipitation, temperature, etc.) and improve clarity, the reported snowfall amount for Eureka has been removed from the text, in response to R2's comments.
- L296 The radiation flux observations were processed using the eddy correlation and bulk method: this statement is inappropriate since the eddy correlation and bulk methods are related to heat fluxes due to atmospheric turbulence and have nothing to do with radiation. I did not fully understand the author's intention to refer to the heat balance method, but please correct this part.
    - The text has been changed to "heat flux;" the use of "radiation flux" with respect to using EC and bulk was an error, thank you for catching this error.

- L374 (such as snow/frost deposition…): the content of the parentheses is too long and instead impairs readability. I request that the text be revised.
    - The parentheses have been moved to a new sentence to improve clarity: "These sources of error may include snow/frost deposition on radiation and temperature sensors or absorption of solar radiation by unsheltered temperature sensors."
- L403 assessed by the site scientist/data quality office: I do not understand what is intended by this expression. Please revise the wording specifically to describe it more.
    - The sentence has been changed to "A second level of manual QC was performed whereby data was reviewed by instrument mentors and visually assessed by the site scientist/data quality office" to improve clarity. This assessment is conducted manually via visual inspection by the instrument / site PI as a means to verify the QC process.
- Table1: it is difficult to understand what "Measured Variable" means, starting with "All" in "Measured Variable" at Whitehouse and Iqaluit, "Total precipitation of water" at other sites, "all wind", "all radiation", "all wind," and "all radiation" and so on, at other locations. Please consider correcting the element names, including correcting the terminology pointed out in the Minor Comment to L280.
    - "All" refers to the entire list of the measured variables in Table 3, whereas "All radiation" refers to all radiation-relevant measured variables (for instance, all upward/downward longwave/shortwave radiation observations). This description is now included in the Table caption to clarify what 'all' refers to and which particular subsets (e.g., "all wind" refers to all the wind speed and direction observations) are being referred to. Using the short form "all" is required to significantly shorten the length of the table, reduce redundancy, and improve readability. The terminology regarding wind (minor comment to L280) has been resolved; the text now reads "wind speed and direction" here and elsewhere throughout the manuscript.
- Table3: (1) Please cite the H-K table or add a brief explanation in the caption. The explanations of figures and tables should be in a style that can be understood to some extent without reading the paper by looking at the figures and captions. (2) Please correct the superscripts of the units in "Measured variable" as they are not superscripted. (3) Please explain what you mean by "EC" and "bulk" in the Table for the method of Flux measurement.
    - (1) The reference for the H-K table is now provided in the caption.
    - (2) Missing superscripts of the units in "measured variable" are now fixed, thank you for catching this.
    - (3) "EC" and "bulk" are now explained in the Table caption.
- Figure 1: please increase the resolution of the figures in both (a) and (b). Also, it cannot be understood what the 1000 km scale in (b) means. In the notation of figure (b), the distance in the figure should not be constant. The scale should not be notated on such a diagram. Please delete it.
    - The resolution for Figure 1 has been increased to its maximum. The length scale in (b) has been removed.
- Figures 3-6: please include the time step of the data in the caption. Daily? Hourly?
    - The time step of the data used for these Figures is 30 minutes. This is now stated in their Figure caption.
- Figure 3: I do not understand what the mean and spread indicate. Please add an explanation.
    - The Sodankylä site conducts more than one measurement of the downward surface long-wave radiation at several locations (see the site description in Sect 2). Instead of plotting just one of

these timeseries, this plot provides their mean (black line) and their spread (min – max) as the grey shaded area. The Figure caption's text has been clarified to indicate that the spread is the min to max value of these observations.

- L55 Jung et al., 2014: I could not find this reference in the reference section.
  - The text should read "2016" – it has been fixed in the manuscript. Thank you for catching this error.
- L148, L217, L281, L292 "/s" -> "s–1"
  - Resolved throughout the manuscript as suggested.
- L198 NOAA: since "NOAA" has already appeared in L178, there is no need to write the official name in parentheses.
  - The official name no longer appears here and instead the acronym is defined at L178 during the first instance of NOAA.
- L237 The CAnadian Network…: I understand the intention of capitalizing the first letter of the abbreviation, but it should be "Canadian..." as the official name.
  - Changed to "Canadian" as suggested.
- L243, L253, L264, L309, L384, L392, L407, L412, L413, L417 "＆＆″ -> "and"
  - All instances of "&" have been replaced with "and"
- L280, L292 wind: does it mean "wind speed and direction"?
  - The text has been clarified to "wind speed and direction."
- L280, L292 pressure: does it mean "atmospheric pressure"?
  - Yes; this is now clarified in the manuscript.
- L301 "/m2" -> m–2
  - Resolved as suggested
- L301 "µV/W/m2" -> µV/(W/m–2)–1
  - Resolved as suggested
- L327 CMPI6: CMIP6? Please confirm and correct if necessary.
  - The text has been changed to CMIP6. Thank you for catching this typo.
- L357 Huang et al., 2023b; 2023a -> Huang et al., 2023a; 2023b
  - Resolved as suggested.
- L367 missing_value -> "missing_value": I understood that "missing_value" is a flag indicating a missing value. I think it is better to enclose it with " in the text to distinguish it from a flag with a proper noun role and an ordinary word.
  - "missing_value" is now enclosed with quotes in the text, as suggested.
- L394 Cook et al. (2008) と Fuehrer and Friehe (2002): Cook et al. (2008) and Fuehrer and Friehe (2002) were not on the list of cited references. Please add them.
  - These two missing references have been added to the reference list, thank you for catching this oversight.
- Reference formatting is not standardized. For example, the following points. Please again check the submission policies and correct them to the prescribed format. (1) The format of "doi" is not unified. (2) The word [dataset] is not written in the dataset's reference. (3) The following points should be corrected as required: L413 Younkin & Long, 2004 -> Is 2003 wrong? Please check; L413 Maturilli, 2020a, 2020b, 2020c, 2022 -> Maturilli (2020a, 2020b, 2020c, 2022).

    - The reference formatting has been manually checked and modified to adhere to the journal's standards.
      (1) Doi format is now standardized, where possible, as much as possible.
      (2) The word dataset is now written in the dataset's reference,
      (3) 2003 is correct for Younkin; this typo is now fixed. The Maturilli reference is now fixed with parentheses, as suggested.
- All Tables: (1) The caption of the Table should be written at the top of the Table. Please modify it. (2) The Tables do not include vertical lines. Please remove the vertical bars and modify them to a refined appearance.
    - (1) Table captions have been moved to the top of the Table.
      (2) We have removed the vertical lines in all the Tables. Further formatting will be achieved during the typesetting process, particularly for the new and lengthy Tables.
- Table2 -> "and"
    - All instances of "&" have now been replaced with "and."

Reviewer 2

Thank you for your work in helping us improve the manuscript. We have made changes to the manuscript for your consideration. We have responded to all R2 comments below and outlined changes in the manuscript (via tracked changes).

- The abstract contains long sentences (ex: Lines 30-33; line 37-42) and the aim of improving numerical weather prediction (NWP) is also mentioned twice. The abstract should be improved for clarity and to summarize the material presented in the manuscript.
  - The abstract has been revised to improve the flow and clarity overall. The abstract has been shortened and the material presented in the manuscript is now clearly summarized towards the end of the abstract. The long sentences were adjusted (broken into multiple sentences) to improve flow of the text. NWP improvement is now only mentioned once in the text.
- The goal of the study should be clarified. While reading the manuscript, I thought that the dataset also included the model outputs, but it is only the field measurements. To improve this, the paragraph starting at line 89, could be divided into 2. One paragraph about the MODF files and a shorter paragraph stating the goal of the manuscript. Also, is a little long and could be shorten. The first few sentences 107-111 seemed to be out of place. Should it be justifying the need to describing such database and, therefore, placed before stating the goal of the study. Additionally, when reading the conclusion, it seems that the authors are doing 2 things: 1) describing a new database and 2) describing a new way to organize/compress data. The goal should probably reflect this because there is a section in the manuscript describing the type of file.
  - This paragraph is now divided into two, as suggested. The first paragraph focuses on the description of the MODFs and their contents. The second paragraph focuses on the goal of the manuscript and the motivation for developing the MODFs. This second paragraph was revised to improve clarity regarding the goal of this study and the purpose of the MODFs. The goals stated in the Introduction (and abstract) now more closely reflect the statements made in the conclusion to help emphasize the goals and achieved outcomes of the study.
- Description of the sites (section 2). I suggestion to use a standard structure for the description of each site. For example, the first sentence of the Whitehorse site is about the platform and instruments while not other site description has this information, at least at the beginning of the section. For each site, 1) there should be a photo of the site with the instruments used, 2) short geographical description, 3) the climatology and 4) other relevant information about the site. Since that the manuscript describe field data, photos of the sites/instruments should come before the grid points used by NWP.
  - The description for each site has been significantly changed to be more systematic, with a standardized structure, as suggested. In the revised version, each site now follows the suggested structure of (1) photos and list of instruments, (2) geographical description, (3) climatology, and (4) other relevant information. Seven new Figures (2-8) containing photos for each site, including the site's topography and individual sensor configurations, are now included prior to the Figure with grid points used by NWP (now Figure 9) with seven new Tables to provide this information for each site.
- Figure 2 should probably be later in manuscript when the authors describe the structure of the datasets in sections 4 and 5 to not confuse the field data and the model data.

    - Figure 2 has been moved to later in the manuscript, as suggested. After the addition of the new requested Figures (photos of the sites and instruments in Figures 2-8), this is now Figure 9 in the revised manuscript.
    - The new Figures and Tables are provided at the end of this response, in the Appendix.
- The authors should carefully double check the use of full name/acronyms. These are most of the minor comments below.
    - Acronyms and names have been double-checked and inconsistencies and/or typos have been fixed.
- Line 119: The sentence can start with "To properly..." and "It is important" can be deleted.
    - The sentence now starts with "to properly" as suggested.
- Line 177: Add DOE in parenthesis after "Department of energy" and one can use the acronym later.
    - Resolved as suggested
- Line 178: Define NOAA here and use the acronym later.
    - Resolved as suggested
- Line 193: Use NOAA instead of the full name.
    - Resolved as suggested
- Line 194: FMI is already defined.
    - FMI is no longer re-defined, as suggested
- Line 271: I wonder if the author should add a Table to describe these. Then, the reader does not have to download the data to get the information.
    - A series of new detailed Tables (4-10) is now provided in the manuscript for each site, as suggested by R1. We have noted in the manuscript that the information in these tables is also documented in the attributes of the MODFs themselves.
- Lines 338 and 339: Use "m" instead of "meters".
    - 'm' is now used instead of 'meters,' as suggested
- Line 340: Add commas between "respectively".
    - Resolved as suggested
- Line 341: Change "2" for "two".
    - Resolved as suggested
- Line 347: The beginning of the sentence is awkward. Just start the sentence with "The present phase..." and add "used" after "concept"?
    - The sentence has been revised, as suggested. It now reads "The present phase of the MODF concept is to use standardized…"
- Line 385: DOE/ARM already defined no need to write the full name.
    - DOE, ARM, and GML are no longer re-defined, as suggested.
- Line 464: I suggest removing "excellent".
    - "Excellent" is now removed from the text, as suggested.
- Line 522: Use the acronym because they are already defined.
    - DOE and ARM are no longer re-defined, as suggested
- Line 549: Delete "see" in front of Figures 3 to 6 and use e.g. instead? One can also delete "as an example".

  - “see” is now replaced with e.g., and “as an example” has been deleted, as suggested
- Line 550: Delete “see”.
  - “See” is now removed, as suggested.

Appendix: New Tables and Figures

Table 4. List of the instruments that contributed to the Whitehorse MODF, including details about the instrument manufacturer, measured variables, configuration, temporal resolution, measurement uncertainty, and quality control applied. Unless otherwise stated in the instrument configuration column, all instruments were deployed at 2 m a.g.l. The MODF featureType timeSeries variables are listed first, with timeSeriesProfile and timeSeriesProfileSonde variables listed last. * Denotes a variable NOT included in the H-K Table.

Measured variables	Instrument	Manufacturer	Instrument Configuration	Temporal Resolution	Uncertainty (+/-)	Quality Control
Atmospheric pressure (Pa)	WXT520	Vaisala	Solid-state, all-in-one weather instrument in standard aspirated configuration mounted on a pole.	1 min	0.5 hPa	Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., >20 hPa/hr change).
Total precipitation of water in all phases per unit area (kg m^{-2} s^{-1})			No bird spike kit was used.		5%	Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 10 mm/hr change). No corrections for solid precipitation under-catchment were performed (the dataset is raw in the MODF); where appropriate, users are recommended to process under-catchment corrections via Kochendorfer et al. (2020).
Eastward Wind (m s^{-1})					0.3 ms^{-1}	Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 10 m/s/hr change).
Northward Wind (m s^{-1})						
Temperature (K)					0.3 K	The shelter heating effect is uncorrected. Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 5 K/hr change).
Relative Humidity (1 or %)					3%	The humidity is not corrected in a sub-freezing environment. Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 30 %/hr change).
Dew-point Temperature (K)					0.5 K	The shelter heating effect is uncorrected and humidity is not corrected in a sub-freezing environment. Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 5 K/hr change).
Cloud Base Height (m)	CL51	Vaisala	Proprietary algorithm determines the lowest cloud base height	1 min	~10 m	No additional QC performed.
Atmospheric pressure	RS92 / DFM-	Vaisala /	Standard radiosonde launch	6 hr	0.5 hPa	Data were binned into 10-meter intervals of geopotential height and all measurements

(Pa)	09	GRAW		within each bin were averaged.
Eastward Wind (m s^{-1})			0.15 ms^{-1}	No additional QC performed.
Northward Wind (m s^{-1})				
Temperature (K)			0.15 K	
Dew-point Temperature (K)			0.5 K	

Table 5. Same as Table 4, except for the Iqaluit MODF.

Measured variables	Instrument	Manufacturer	Instrument Configuration	Temporal Resolution	Uncertainty (+/-)	Quality Control
Pressure (Pa)	PTB110	Vaisala	Installed within a naturally vented protective enclosure.	1 min	0.3 hPa	Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., >20 hPa/hr change).
Total precipitation of water in all phases per unit area (kg m^{-2} s^{-1})	Pluvio2	OTT	Single Alter shield		5%	Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 10 mm/hr change). No corrections for solid precipitation under-catchment were performed (the dataset is raw in the MODF); where appropriate, users are recommended to process under-catchment corrections via Kochendorfer et al. (2020).
Eastward Wind (m s^{-1}) **Northward Wind (m s^{-1})**	Wind monitor 5103	RM Young	Four-blade helicoid propeller in standard configuration with a wind vane to measure wind direction		0.3 ms^{-1}	Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 10 m/s/hr change).
Temperature (K)	HMP35D	Vaisala	Sensor installed in shaded, naturally vented shelter.		0.1 K	The shelter heating effect is uncorrected. Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 5 K/hr change).
Dew-point Temperature (K)					0.2 K	The shelter heating effect is uncorrected and humidity is not corrected in a sub-freezing environment. Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 5 K/hr change).
Relative Humidity (1 or %)					0.8%	The humidity is not corrected in a sub-freezing environment. Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 30 %/hr change).
Snow thickness (m)	SR50A	Campbell Scientific	Sonic distance sensor at 50KHz with a perforated flat target base levelled at the surface (0 m a.g.l.)		1 cm	Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 20 cm/hr change).
Upward Short-wave Radiation (W m^{-2}) **Downward Short-wave Radiation (W m^{-2})**	CMP10L (285 to 2800 nm)	Kipp and Zonen	Integrated levelling included, dome, RM Young radiation shield (6 plate), and a CVF4L Ventilation System with Integrated Heater running when temperatures where near zero to prevent		7 W m^{-2}	Data is raw and no additional QC was performed. No additional QC was performed on these observations to account for potential frost or snow deposition on the sensors. Data should be treated with caution since they typically require additional QC processing prior to analysis.
Upward Long-wave Radiation	CGR4L (4.5 to 42	Kipp and			7 W m^{-2}	

(W m^{-2})	μm)	Zonen	frost.			
Downward Long-wave Radiation (W m^{-2})			Installed on the flux tower crossbeam arms.			
***Horizontal East-facing Long-wave Radiation (W m^{-2})**						
***Horizontal West-facing Long-wave Radiation (W m^{-2})**						
***Horizontal South-facing Long-wave Radiation (W m^{-2})**						
***Horizontal North-facing Long-wave Radiation (W m^{-2})**						
Cloud Base Height (m)	CL51	Vaisala	Proprietary algorithm determines the lowest cloud base height		5 m	No additional QC was performed.
Atmospheric pressure (Pa)	WXT520	Vaisala	Solid-state, all-in-one weather instrument in standard aspirated configuration mounted on a pole at 10 m a.g.l.		0.5 hPa	Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., >20 hPa/hr change).
Total precipitation of water in all phases per unit area (kg m^{-2} s^{-1})			No bird spike kit used.		5%	Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 10 mm/hr change). No corrections for solid precipitation under-catchment were performed (the dataset is raw in the MODF); where appropriate, users are recommended to process under-catchment corrections via Kochendorfer et al. (2020).
Eastward Wind (m s^{-1})					0.3 ms^{-1}	Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 10 m/s/hr change).
Northward Wind (m s^{-1})						
Temperature (K)					0.3 K	Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 5 K/hr change).
Relative Humidity (1 or %)					3%	The humidity is not corrected in a sub-freezing environment. Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 30 %/hr change).
Atmospheric pressure (Pa)	RS92 / DFM-09	Vaisala / GRAW	Standard radiosonde launch	6 hr	0.5 hPa	Data were binned into 10-meter intervals of geopotential height and all measurements within

Eastward Wind (m s^{-1})		0.15 ms^{-1}	each bin were averaged. No additional QC performed.
Northward Wind (m s^{-1})			
Temperature (K)		0.15 K	
Dew-point Temperature (K)		0.5 K	

Table 6. Same as Table 4, except for the Sodankylä MODF.

Measured variables	Instrument	Manufacturer	Instrument Configuration	Temporal Resolution	Uncertainty (+/-)	Quality Control
Temperature (K)	PT100	Vaisala	Sensor installed in shaded, naturally vented shelter.	10 min	0.1 K	The shelter heating effect is uncorrected. Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 5 K/hr change).
	PT100	Generic			0.3 K	
	PT100	Pentronic			0.3 K	
	HMP155	Vaisala			0.1 K	
Relative Humidity (1 or %)	HMP155	Vaisala	Sensor installed in shaded, naturally vented shelter.		1%	The humidity is not corrected in a sub-freezing environment. Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 30 %/hr change).
	HMP35D	Vaisala			0.8%	
	HMP45D	Vaisala			2% (0-90 %RH) 3% (90-100 %RH)	
Snow thickness (m)	SR50	Campbell Scientific	Sonic distance sensor at 50KHz with a perforated flat target base levelled at the surface (0 m a.g.l.)		1 cm	Observations were checked against site-based climatology ranges, routine manual observations, and the rate of change thresholds, which were based on hourly criteria. Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 20 cm/hr change).
Total precipitation of water in all phases per unit area (kg m^{-2} s^{-1}) **Snowfall flux unit area (kg m^{-2} s^{-1})**	Distrometer Model: 5.4110.01.200	Thies Clima	Model with extended heating	1 min	5%	Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 10 mm/hr change).
Snow water equivalent (m)	SSG 1000	Sommer Messtechnik	Sensor consists of seven perforated panels having a total measuring surface of 2.8 x 2.4 m with the measurement being made on the centre plate,		0.3%	Data is raw and no additional QC was performed.
Downward Short-wave Radiation (W m^{-2})	CMA11 (285 to 2800 nm)	Kipp and Zonen	Integrated levelling included, dome, RM Young radiation shield (6 plate), and a CVF4L Ventilation System with Integrated Heater running when temperatures where near zero to prevent frost	10 min 1 min	7 W m^{-2} 7 W m^{-2}	Data is raw and no additional QC was performed. No additional QC was performed on these observations to account for potential frost or snow deposition on the sensors. Data should be treated with caution since they typically require additional QC processing prior to analysis.
	CMP3 (300 to 2800 nm)	Kipp and Zonen	Installed on a pole, naturally vented	10 min	15 W m^{-2}	
	CNR4 (300 to 2800 nm)	Kipp and Zonen	Integrated 4-component system with temperature sensor		7 W m^{-2}	
Downward Long-wave Radiation	CNR4 (4500 to 42000 nm)	Kipp and Zonen	Integrated 4-component system with temperature		7 W m^{-2}	

(W m^{-2})			sensor			
Upward Short-wave Radiation (W m^{-2})	CMA11 (285 to 2800 nm)	Kipp and Zonen	Integrated levelling included, dome, RM Young radiation shield (6 plate), and a CVF4L Ventilation System with Integrated Heater running when temperatures where near zero to prevent frost		7 W m^{-2}	
	CMP3 (300 to 2800 nm)	Kipp and Zonen	Installed on a pole, naturally vented		15 W m^{-2}	
	CMP11 (285 to 2800 nm)	Kipp and Zonen			7 W m^{-2}	
	CNR4 (300 to 2800 nm)	Kipp and Zonen	Integrated 4-component system with temperature sensor		7 W m^{-2}	
Upward Long-wave Radiation (W m^{-2})	CNR4 (4500 to 42000 nm)	Kipp and Zonen	Integrated 4-component system with temperature sensor		7 W m^{-2}	
Net Short-wave Radiation (W m^{-2})	NR-Lite (0 to 100 µm)	Kipp and Zonen	Single-component thermopile net radiometer		25 W m^{-2}	
	NR-Lite2 (0 to 100 µm)				15 W m^{-2}	
Photosynthetic Photon Flux density (mol m^{-2} s^{-1})	PAR Lite	Kipp and Zonen	Quantum sensor		10%	
	PQS1	Kipp and Zonen			5%	
	LI190SZ	Licor			5%	
Pressure (Pa)	PTB201A	Vaisala	Installed within a naturally vented protective enclosure. Deployed at 10 m a.g.l.		0.3 hPa	Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., >20 hPa/hr change).
Surface horizontal visibility (m)	FD12P	Vaisala	Optical forward-scatter sensor installed on a pole at 10 m a.g.l.		10%	Data is raw and no additional QC was performed.
Eastward Wind (m s^{-1})	WA25 (WAA25 and WAV25)	Vaisala	Cup anemometer and vane designed for Arctic conditions with integrated heaters to prevent ice buildup. Deployed at 10 m a.g.l.		0.3 m s^{-1}	Observations that fell outside of the 3-sigma normal climatological range were rejected, as were observations that had a rate of change greater than a seasonal-dependant threshold (e.g., > 10 m/s/hr change).
Northward Wind (m s^{-1})						
Eastward Wind (m s^{-1})	UA2D	Thies Clima	2-D sonic anemometer deployed at 10 m a.g.l.		2%	Data is raw and no additional QC was performed.
Northward Wind (m s^{-1})						
Eastward Wind (m s^{-1})	USA-1	Metek	3-D sonic anemometer deployed at 10 m a.g.l.		0.1 m s^{-1}	Data is raw and no additional QC was performed.
Northward Wind (m s^{-1})						
Vertical velocity (m s^{-1})						

Surface friction velocity (eddy covariance method) ($m\ s^{-1}$)					0.1 $m\ s^{-1}$	No additional QC performed. Additional filtering of output from eddy covariance processing not performed.
Surface turbulent latent heat flux (eddy covariance method) ($W\ m^{-2}$)					20%	
Surface turbulent sensible heat flux (eddy covariance method) ($W\ m^{-2}$)					20%	
Surface momentum flux (eddy covariance method) ($W\ m^{-2}$)					25%	
Ground heat flux ($W\ m^{-2}$)	HFP01	Huseflux	Thermopile buried in soil		3%	Data is raw and no additional QC was performed
Bulk soil temperature (K)	QMT103	Vaisala	Thin steel sheath incorporating sensor, buried in soil		0.3 K	
	Hydra Probe II	Stevens	4-needle sensor buried in soil		0.3 K	
Average layer soil moisture ($kg\ m^{-2}$)	Hydra Probe II	Stevens	4-needle sensor buried in soil		5%	
Bulk soil temperature (K)	GS3	Decagon Devices	Sensor encapsulated in an epoxy body with stainless steel needles. Buried in soil.		1 K	
	GTE	Decagon Devices	Sensor encapsulated in an epoxy body with stainless steel needles. Buried in soil.		1 K	
	109-L	Campbell Scientific	Thermistor encapsulated in an epoxy-filled aluminum housing and buried in soil.		0.3 K	
	CS655	Campbell Scientific	Two 12-cm-long stainless steel rods connected to a printed circuit board encapsulated in epoxy attached to a shielded cable. Buried in soil.		0.3 K	
	PT100	Pentronic	Thin steel sheath incorporating sensor, buried in soil.		0.3 K	
	IKES PT100	Nokeval	Thin steel sheath incorporates a Pt100 sensor with double insulation moulded in solid rubber with the cable. Buried in soil.		0.3 K	
Average layer soil moisture ($kg\ m^{-2}$)	ThetaProbe ML2x	Delta-T Devices	4-needle sensor buried in soil		5.00%	Data is raw and no additional QC was performed
Snow temperature (K)	107-L	Campbell Scientific	Thermistor encapsulated in an epoxy-filled aluminum housing and		0.5 K	

			buried in snow			
Air temperature (K)	PT100	generic	Sensor installed in shaded, naturally vented shelter. Deployed at 40 m a.g.l.		0.3 K	
Relative Humidity (1 or %)	HMP	Vaisala	Sensor installed in shaded, naturally vented shelter. Deployed at 40 m a.g.l.		0.80%	
Wind speed ($m\ s^{-1}$)	WAA25	Vaisala	Cup anemometer with integrated heater to prevent ice buildup. Deployed at 40 m a.g.l.		0.17 $m\ s^{-1}$	
Atmospheric pressure (Pa)	RS41	Vaisala	Standard radiosonde launch	6 hr	0.5 hPa	No additional QC was performed. Output is directly from Vaisala processing.
Eastward Wind ($m\ s^{-1}$)					0.15 ms^{-1}	
Northward Wind ($m\ s^{-1}$)						
Temperature (K)					0.3 K	
Relative Humidity (1 or %)					4%	

Table 7. Same as Table 4, except for the Utqiaġvik MODF.

Measured variables	Instrument	Manufacturer	Instrument Configuration	Temporal Resolution	Uncertainty (+/-)	Quality Control
Pressure (Pa)	PTB-220	Vaisala	The Barrow meteorology station (BMET) obtains barometric pressure, visibility, and precipitation data from sensors at the base of the tower. https://www.arm.gov/capabilities/instruments/twr	1 min	0.15 hPa	Observations were checked against other instrumentation on the tower and compared with the surface meteorological instruments and the energy balance bowen ratio to remove outliers and nonphysical values. Data was also compared with the SONDE data that was launched from the tower: https://www.arm.gov/publications/tech_reports/handbooks/twr_handbook.pdf
Near-surface (2m) eastward wind (m s^{-1})	WS425	Vaisala	Sensors are aspirated. The Barrow meteorology station (BMET) uses mainly conventional in situ sensors; these are mounted at 2 m a.g.l. See: https://www.arm.gov/capabilities/instruments/twr		0.135 ms^{-1}	
Near-surface (2m) northward wind (m s^{-1})						
Near-surface (2m) air temperature (K)	HMT337 (previously HMP35D/ HMP45D)	Vaisala			0.2 K	
Near-surface (2m) dew point temperature (K)					0.2 K	
Near-surface (2m) relative humidity (%)					1.7 %	
Ozone concentration in air (mole fraction)	TEI 49i	Thermo Scientific	Inlet line samples air from roof of station through filter, while instrument is housed inside station building. This data set contains continuous UV photometric data of surface level ozone collected at 6m above ground level.		1 ppb	Manual inspection of the data to ensure nonphysical values are filtered. See: https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.ncdc:C00894
Surface snow thickness (m)	Toughsonic 30	Senix	Instrument is located on broadband radiation albedo rack		n/a	Data is compared against meteorological and global radiation data to verify accuracy; data values not physically possible are removed. Pollution/technical events are flagged and/or removed from data set.
Surface (skin) temperature (K)	IRT	Apogee	Data collected from US Climate Reference Network (CRN) per standard operating configuration (see https://www1.ncdc.noaa.gov/pub/data/uscrn/documentation/program/ManualMonitoringHandbook.pdf)		0.5 K	Inter-comparison of the 3 temperature sensors: Sensors should be within 0.3° C of one another. An hourly flag message is generated for any departure greater than 0.30° C (i.e., 0.301° C and greater). IR max should exceed the ambient temperature, and IR min should be less than ambient temperature, otherwise data is filtered. See : https://www1.ncdc.noaa.gov/pub/data/uscrn/documentation/program/ManualMonitoringHandbook.pdf
Upward surface short-wave radiation	GNDRAD (0.3 to 3	PSP	Standard operating configuration, see: https://www.arm.gov/capabilities/		2.0 W m^{-2}	SIRS Instrument mentors review the Data Quality Office's (DQO) weekly Data Quality Assessment Reports

(W m^{-2})	µm)		instruments/gndrad		(DQAR). If a problem is detected, a Data Quality Problem Report (DQPR) is issued. The DQPR system is a web-based system by which the mentor, local site operations staff, and the DQO are informed and communicate to resolve a data quality problem (e.g., instrument failure, data collection issue, etc.). A DQPR is typically initiated by the DQO or instrument mentor during data review. This process filters and removes erroneous data. Data Quality Reports (DQR) are prepared by instrument mentors as needed to close out corresponding DQPRs. See: https://www.arm.gov/capabilities/instruments/gndrad and https://www.arm.gov/capabilities/instruments/skyrad
Downward short-wave radiation at the surface (W m^{-2})	SKYRAD (295 to 3000 nm)	PSP	Standard operating configuration, see: https://www.arm.gov/capabilities/instruments/skyrad	4.0 W m^{-2}	
Upward surface long-wave radiation (W m^{-2})	GNDRAD (4 to 50 µm)	PIR	Standard operating configuration, see: https://www.arm.gov/capabilities/instruments/gndrad	2.0 W m^{-2}	
Downward surface long-wave radiation (W m^{-2})	SKYRAD (3.5 to 50 µm)	PIR	Standard operating configuration, see: https://www.arm.gov/capabilities/instruments/skyrad	4.0 W m^{-2}	
Surface turbulent latent heat flux (eddy covariance method) (W m^{-2})	Windmaster Pro Anemometer	Gill	Standard ARM site arrangement is sonic sensor "North" mark pointing along the boom to the tower; the boom is usually pointing due south; u wind component is north-south with positive toward the north; v wind component is east-west with positive toward the west. No correction is made to convert u and v component into meteorological "north" and "east" wind components when tower boom is not aligned to south; u wind component is "along boom", v wind component is "cross boom https://www.arm.gov/publications/tech_reports/doe-sc-arm-tr-223.pdf	<1.5%	The QCECOR VAP currently contains two variables: surface latent heat flux (LH) and sensible heat flux (SH), together with their QC flags. When SEBS are collocated with ECOR, the wetness measurements from SEBS are used to flag the LH that may be incorrect due to hydrometeors such as precipitation, dew, or frost. An indeterminate flag is given to those that fail the wetness test. See: https://www.arm.gov/publications/tech_reports/doe-sc-arm-tr-223.pdf
Surface turbulent sensible heat flux (eddy covariance method) (W m^{-2})					
Ground heat flux (W m^{-2})	HFT-3, SMP1, STP-1	Radiation and Energy Balance Systems, Inc.	Soil measurements are performed by three sets of soil heat flow (5 cm depth), soil temperature (0–5 cm average), and soil moisture (centered at 2.5 cm) probes. Soil heat flow is adjusted for the effect of soil moisture above the soil heat flow plate. The storage of energy in the soil above the soil heat flow plate is determined from the change in soil temperature with time.	10 mV	Instrument mentor routinely views graphic displays that include plots (day courses) of all calculated quantities and comparison plots (time series or scatter plots) of relevant parameters with data from collocated ECOR, SEBS, EBBR (SGP CF and EF39 only), and surface meteorological instrumentation (MET) (Cook et al. 2006). See: https://www.arm.gov/publications/tech_reports/handbooks/sebs_handbook.pdf
Eastward wind component (m s^{-1})	WS425	Vaisala	Sensors are aspirated. The Barrow meteorology station (BMET) uses mainly conventional in situ sensors mounted at four different heights (2m, 10m, 20m and 40m) on a 40 m tower to obtain profiles of wind speed, wind direction, air temperature, dew point and humidity. https://www.arm.gov/capabilities/	0.135 ms^{-1}	Observations were checked against other instrumentation on the tower and compared with the surface meteorological instruments and the energy balance bowen ratio to remove outliers and nonphysical values. Data was also compared with the SONDE data that was launched from the tower: https://www.arm.gov/publications/tech_reports/handbooks/twr_handbook.pdf
Northward wind component (m s^{-1})					
Air temperature (K)	HMT337 (previously HMP35D/	Vaisala		0.2 K	

Dew-point temperature (K)	HMP45D)		instruments/twr		0.2 K	
Relative humidity (%)					1.7 %	
Soil temperature profile (K)	PT100	in-house	Soil measurements are performed by three sets of soil heat flow (5 cm depth), soil temperature (0–5 cm average), and soil moisture (centered at 2.5 cm) probes. Soil heat flow is adjusted for the effect of soil moisture above the soil heat flow plate. The storage of energy in the soil above the soil heat flow plate is determined from the change in soil temperature with time.		n/a	Data is compared against meteorological and global radiation data to verify accuracy; pollution/technical events are flagged and/or removed from data set; data values not physically possible are removed
Snowfall flux per unit area	KAZR	KAZR	Installed on top of the ARM facility roof. See: https://doi.org/10.1525/elementa.2021.00101		n/a	Threshold-based flags to remove outliers and unphysical values. See: https://doi.org/10.1525/elementa.2021.00101 and: https://www.arm.gov/publications/tech_reports/handbooks/kazr_handbook.pdf
Atmospheric pressure (Pa)	RS41	Vaisala	Standard radiosonde launch. The SONDE system originally located at Barrow was an old CLASS-type that was originally operated by NOAA's Climate Measurements and Diagnostics Laboratory on TWP's Manus site.	6-12 hr	1 hPa	The manufacturer defines the cumulative sensor uncertainty at the 2-sigma (95.5%) confidence level. Repeatability is estimated from the standard deviation of differences between two successive repeated calibrations (2-sigma). Reproducibility is estimated from the standard deviation of differences in twin soundings. See: http://dx.doi.org/10.5439/1595321.
Eastward wind component ($m\ s^{-1}$)					0.15 ms^{-1}	
Northward wind component ($m\ s^{-1}$)						
Temperature (K)					0.5 K	
Dew-point temperature (K)					0.5 K	
Relative humidity (%)					5%	

Table 8. Same as Table 4, except for the Tiksi MODF.

Measured variables	Instrument	Manufacturer	Instrument Configuration	Temporal Resolution	Uncertainty (+/-)	Quality Control
Surface pressure (Pa)	PTB110	Vaisala	Located on the fluxtower at 5m a.g.l.	1 min	0.3 hPa	Data are manually QC'd to identify and eliminate instrument malfunction; outliers are filtered out if values are physically impossible. Values are compared to other local variables if/when possible by manual inspection via the instrument mentor.
Near-surface (4m) eastward wind (m s^{-1})	3001	RM Young	Located on the fluxtower at 4m a.g.l.		0.5 m s^{-1}	
Near-surface (4m) northward wind (m s^{-1})						
Near-surface air temperature (K)	HMT330	Vaisala	Located on the fluxtower		0.2 K	
Near-surface relative humidity (%)					1.5 + 0.015 × reading	
Surface snow thickness (m)	SR50A	Campbell Scientific	Located on the albedo rack		1 cm	
Surface (skin) temperature (K)	SI-111	Apogee	Located on the fluxtower		0.2 K	
Upward surface short-wave radiation (W m^{-2})	PSP (295-2800 nm)	Eppley	Located on the albedo rack		2.0 W m^{-2}	
Downward surface short-wave radiation (W m^{-2})	CM22 (200 to 3600 nm)	Kipp & Zonen	Located on the tracker at the MET station building		5.0 W m^{-2}	
Upward surface long-wave radiation (W m^{-2})	PIR (4 to 50 µm)	Eppley	Located on the albedo rack		2.0 W m^{-2}	
Downward surface long-wave radiation (W m^{-2})			Located on the tracker at the MET station building		4.0 W m^{-2}	
Ground heat flux (W m^{-2})	HPF01	Hukseflux	Located at the base of the fluxtower at 5cm depth		3 %	
Air temperature (K)	HMT330, HMP155	Vaisala	Located on the fluxtower at 2m, 6m, 10m a.g.l.		0.2 K	
Relative humidity (%)					1.5 + 0.015 × reading	
Soil temperature profile (K)	TP-101	MRC	Located at albedo rack at depths: 5cm, 10cm, 15cm, 20cm, 25cm, 30cm, 45cm, 70cm, 95cm, 120cm		n/a	
Atmospheric pressure (Pa)	RS41	Vaisala	Standard radiosonde launch. See: https://www.ncei.noaa.gov/pub/data/igra/data/data-por/	12 hr	1 hPa	No additional QC was performed. See: https://www.ncei.noaa.gov/pub/data/igra/data/data-por/
Eastward wind component (m s^{-1})					0.15 ms^{-1}	
Northward wind component (m s^{-1})						
Temperature (K)					0.5 K	
Dew-point temperature (K)					0.5 K	
Relative humidity (%)					5%	

Table 9. Same as Table 4, except for the Ny-Ålesund MODF.

Measured variables	Instrument	Manufacturer	Instrument Configuration	Temporal Resolution	Uncertainty (+/-)	Quality Control
Pressure (Pa)	Digiquarz 6000-16B	Paroscientific, Inc.	Installed within a naturally vented protective enclosure.	1 min	0.08 hPa	Observations were checked against site-based climatology ranges and the rate of change thresholds. Flagged data was filtered.
Total precipitation of water in all phases per unit area (kg m^{-2} s^{-1})	Pluvio2	OTT	Single Alter shield. Operated and analysed by the University of Cologne.		5%	No additional QC was applied; data is raw and should be treated with caution.
Eastward Wind (m s^{-1})	Combined Wind Transmitter 4.3324.32.073	Thies Clima	Opto-electronically scanned three-cup anemometer with low starting speed. The position of the wind vane is detected opto-electronically.		0.4 ms^{-1}	Instrument is checked on a daily basis manually by the instrument mentor. Observations were checked against site-based climatology ranges, the rate of change thresholds, and redundant measurements in close proximity if/when possible. Erroneous or unphysical observations were filtered.
Northward Wind (m s^{-1})						
Temperature (K)	Ventilated air temperature transmitter 2.1265.20.000	Thies Clima	The sensor is protected by a double thermal radiation shield. A built-in ventilator provides for the necessary air flow.		0.1 K	
Relative Humidity (1 or %)	HMP155	Vaisala	The sensor with additional temperature sensor is installed in a vented radiation shelter.		0.80%	
Upward Short-wave Radiation (W m^{-2})	CMP22 (200 to 3600 nm)	Kipp and Zonen	Sensor installed in an Eigenbrodt ventilation system to prevent from icing.		5 Wm^{-2}	Instrument is checked on a daily basis manually by the instrument mentor. Data quality check is performed according to BSRN requirements.
Downward Short-wave Radiation (W m^{-2})			Sensor installed in an Eigenbrodt ventilation system to prevent from icing.			
Upward Long-wave Radiation (W m^{-2})	PIR (4 to 50 µm)	Eppley	Sensor installed in an Eigenbrodt ventilation system to prevent from icing.		5 Wm^{-2}	
Downward Long-wave Radiation (W m^{-2})			Sensor is shaded and installed in an Eigenbrodt ventilation system to prevent from icing.			
Cloud Base Height (m)	CL51	Vaisala	Proprietary algorithm determines the lowest cloud base height		~10 m	Operated with the standard Vaisala proprietary algorithm that retrieves cloud base height. Additional check for unphysical outliers was manually performed by the instrument mentor.
Atmospheric pressure (Pa)	RS41	Vaisala	Standard radiosonde launch	6 hr	0.5 hPa	No additional QC was performed.
Eastward Wind (m s^{-1})					0.15 ms^{-1}	
Northward Wind (m s^{-1})						
Temperature (K)					0.3 K	

Relative Humidity (1 or %)	4%

Table 10. Same as Table 4, except for the Eureka MODF.

Measured variables	Instrument	Manufacturer	Instrument Configuration	Temporal Resolution	Uncertainty (+/-)	Quality Control
Surface pressure (Pa)	PTB220	Vaisala	Located on Flux Tower at 2 m a.g.l.	1 min	0.3 hPa	Data are manually QC'd to identify and eliminate instrument malfunctions by the instrument mentor. Outliers are filtered out if values are physically impossible. Values are compared to other local variables if/when possible by the instrument mentor.
Near-surface (6m) eastward wind (m s^{-1})	VENTUS-UMB Ultrasonic	Lufft	Located on Flux Tower at 6 m	1-10 s	0.1 ms^{-1}	
Near-surface (6m) northward wind (m s^{-1})						
Near-surface (2m) air temperature (K)	HMT-337	Vaisala	Located on Flux Tower	1 min	0.2 K	
Near-surface (2m) relative humidity (%)					1.5 + 0.015 × reading	
Surface Snow Thickness	SR50A	Campbell Scientific	Located on Flux Tower		1 cm	
Surface (skin) temperature (K)	IRTS-P	Apogee	Located on Flux Tower		0.2 K	
Upward surface short-wave radiation (W m^{-2})	PSP (295-2800 nm)	Eppley	Located on Flux Tower at 11 m a.g.l.		2.0 W m^{-2}	Processed through Long QCRad; Historical Quality Control Techniques: Long, C. N., & Shi, Y. (2008). See: doi: 10.2174/1874282300802010023
Downward surface short-wave radiation (W m^{-2})	CMP22 (200 to 3600 nm)	Kipp and Zonen			5.0 W m^{-2}	
Upward surface long-wave radiation (W m^{-2})	PIR (4 to 50 μm)	Eppley			4.0 W m^{-2}	
Downward surface long-wave radiation (W m^{-2})						
Ground heat flux (W m^{-2})	HPFO1	Hukseflux	Depth 3 cm		3 %	Manually QC'd to identify and eliminate instrument malfunctions or non physical values by the instrument mentor.
Air temperature (K)	HMT-337	Vaisala	Located on Flux Tower at 2, 6, 10 m.		0.2 K	Data are manually QC'd to identify and eliminate instrument malfunctions by the instrument mentor. Outliers are filtered out if values are physically impossible. Values are compared to other local variables if/when possible, by the instrument mentor.
Relative humidity (%)					1.5 + 0.015 × reading	
Soil temperature profile (K)	TP-101	MRC	Depth: 5cm, 10cm, 15cm, 20cm, 25cm, 30cm, 45cm, 70cm, 95cm, 120cm		n/a	
Eastward wind component (m s^{-1})	VENTUS-UMB Ultrasonic	Lufft	Located on Flux Tower at 6 m and 11 m	1-10 s	0.1 ms^{-1}	
Northward wind component (m s^{-1})						
Atmospheric pressure (Pa)	RS41	Vaisala	Standard radiosonde launch	6 hr	0.5 hPa	No additional QC was performed.
Eastward Wind (m s^{-1})					0.15 ms^{-1}	
Northward Wind (m						

s^{-1})	
Temperature (K)	0.3 K
Relative Humidity (1 or %)	4%

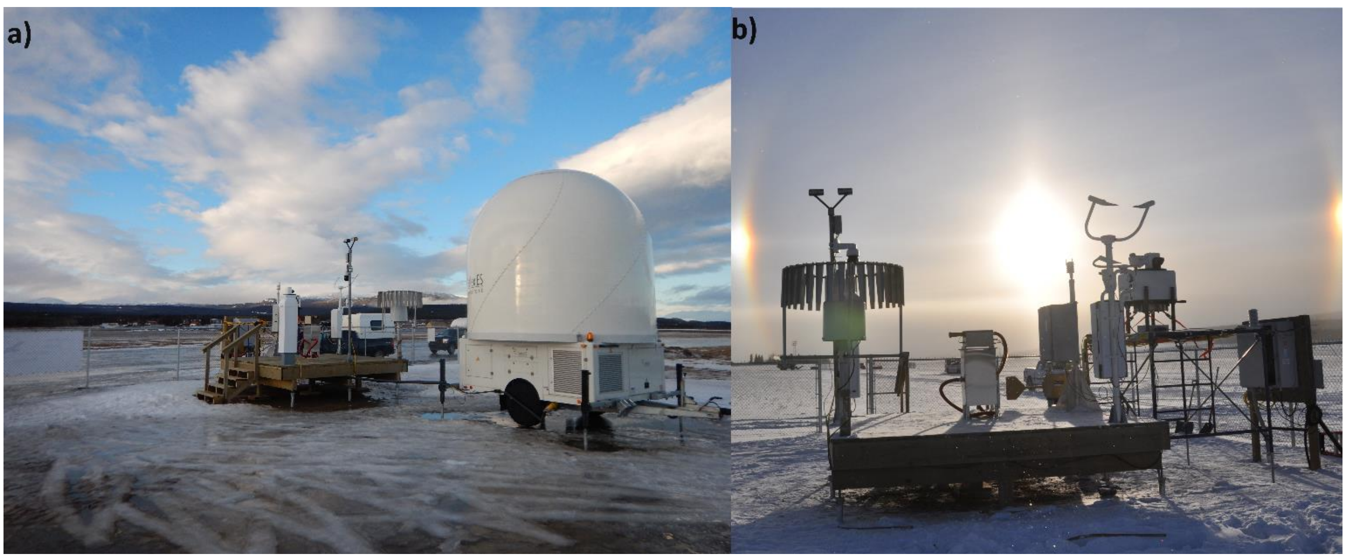

Figure 2. The Whitehorse site and the surrounding airfield in early spring 2018 with an X-band radar (white dome) in the foreground (a), and the main instrument platform, including a Pluvio2, Parsivel, FS11P, WXT520, and CL51 ceilometer (from left to right) with a sundog in the background (b). Photos adapted from Figure 5 in Mariani et al. (2022).

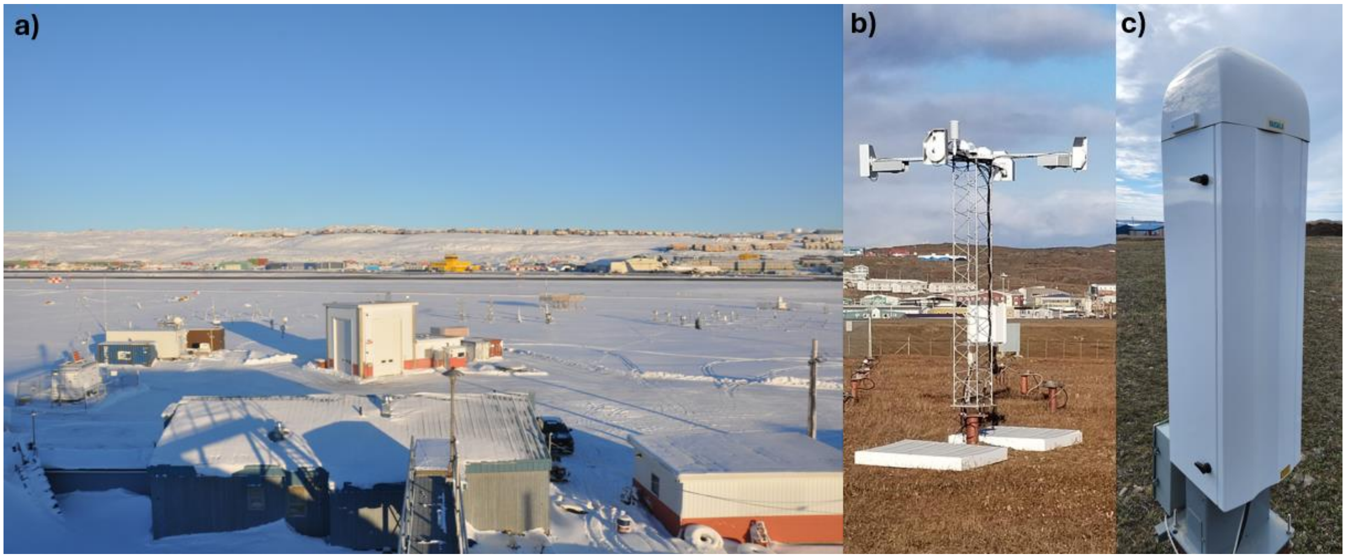

Figure 3. The Iqaluit site surroundings taken in winter 2018 with the Iqaluit airport in the background (a), the radiation flux sensor suite during the summer, consisting of several CMP10Ls, CGR4Ls, and SR50As (b), and the CL51 ceilometer during the summer (c). Photos adapted from Figure 2 (Mariani et al., 2022).

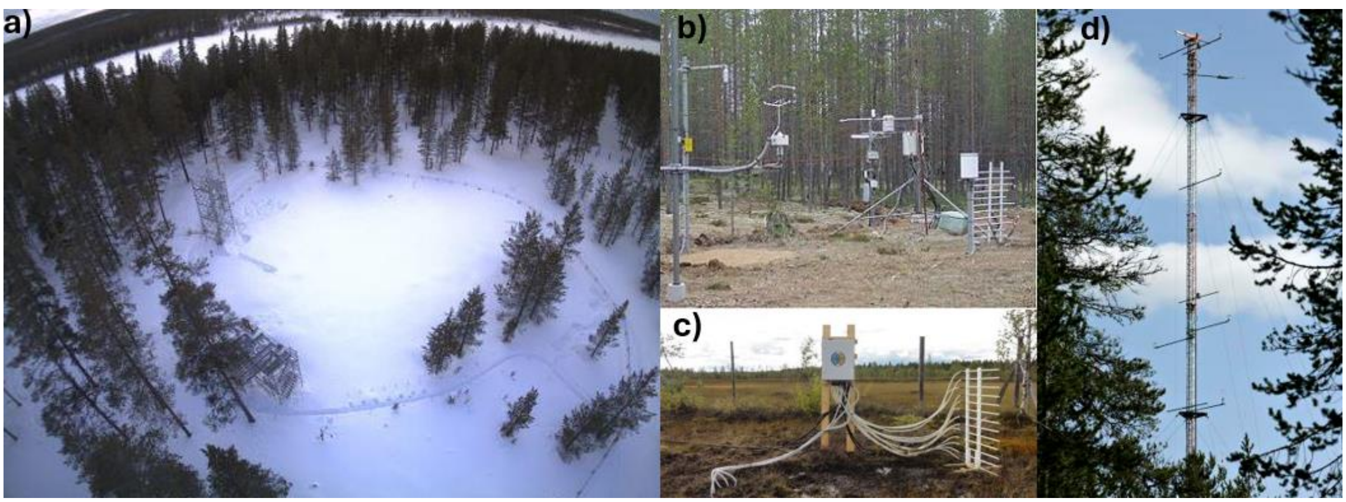

Figure 4. The Sodankylä site surroundings during the winter at the Intensive Observation Area, IOA, in the boreal forest (a), snow, soil and meteorological measurements in the MET measurement field (b), multi-level snow and soil measurements at the Peatland site, SUO, (c) and the meteorological tower with meteorological and radiation sensors (d). Photos: FMI (litdb.fmi.fi).

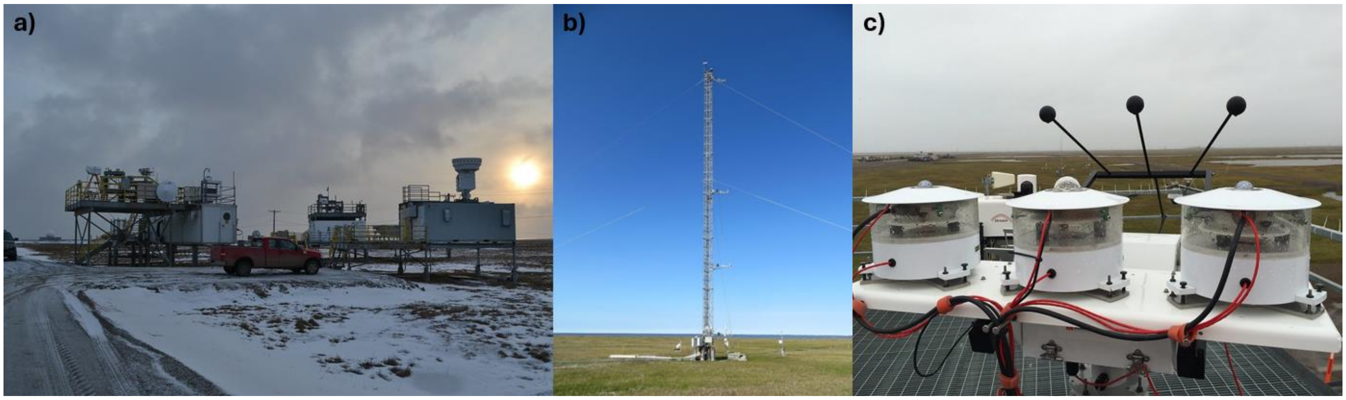

Figure 5. The Utqiaġvik site surroundings during the winter, including the main observation stations and their rooftop instrument suites (a), the meteorological tower with radiation flux sensors deployed in the summer (b), and the SKYRAD downward longwave radiation sensor deployed on the roof in the spring (c). Photos: www.arm.gov.

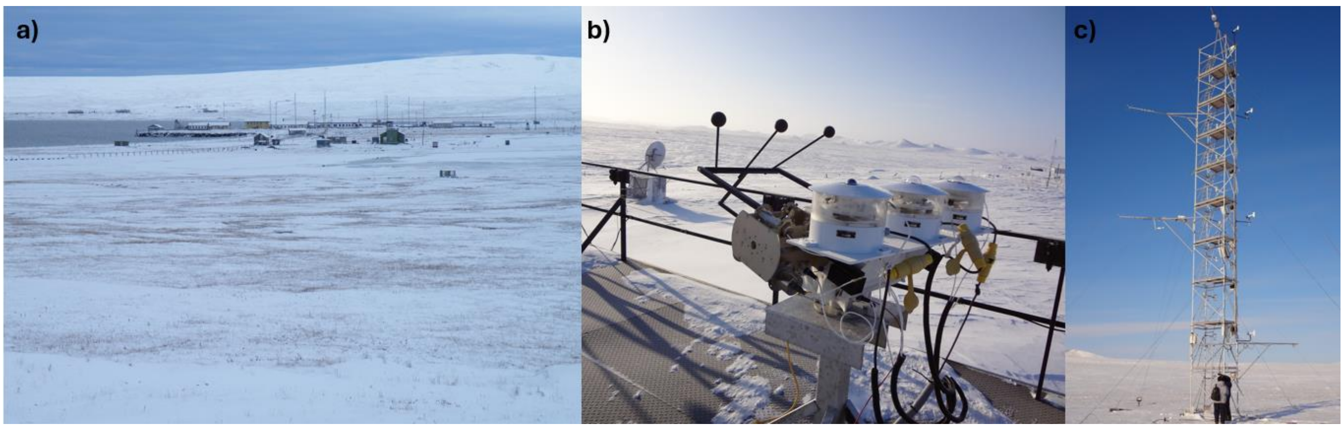

Figure 6. The Tiksi site surroundings, taken from afar in the winter (a), the SKYRAD downward longwave radiation sensor deployed on the roof of the Tiksi observation building (b), and the meteorological tower equipped with radiation flux sensors (c). Photos: Taneil Uttal (NOAA).

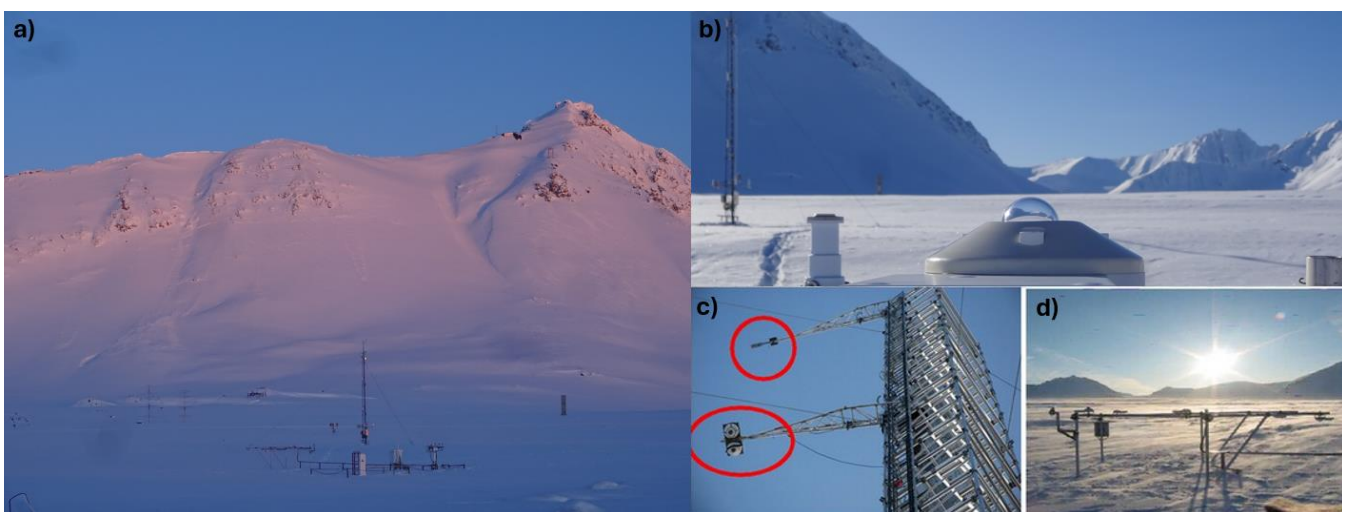

Figure 7. The Ny-Ålesund site surroundings taken in the winter with the meteorological sensors and radiation tower in the foreground (a), the CMP22 downward shortwave radiation sensor at the site (b), the meteorological tower with the radiation flux sensors circled (c), and several surface meteorological and albedo-measuring sensors at the BSRN station (d). Photos (c-d) are adapted from Figure 1 in Becherini et al., 2021.

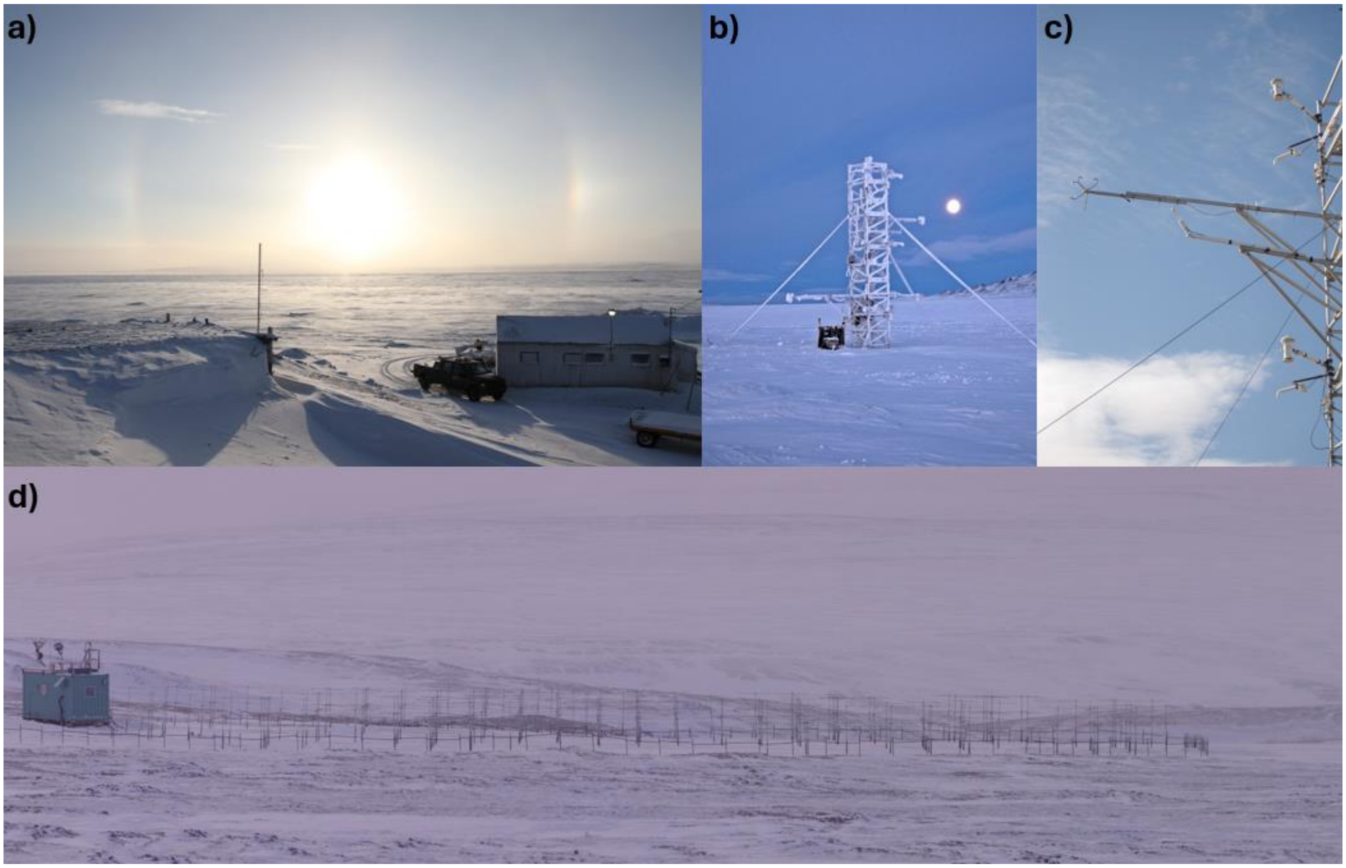

Figure 8. The Eureka site surroundings in the winter, facing south from the Eureka Weather Station (EWS) looking over the frozen fjord with a sundog in the background (a), the meteorological tower at the Surface and Atmospheric Flux Irradiance Extension (SAFIRE) (b) with radiation flux (e.g., PSP) and meteorological sensors deployed (c), and the SAFIRE site surroundings taken from afar (d).