SnowEx20 Airborne SWESARR Brightness Temperature, Version 1

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

Brucker, L., D. Hudson, P. Racette and B. Osmanoglu. 2021. *SnowEx20 Airborne SWESARR Brightness Temperature, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/IIBT502NXDNE. [Date Accessed].

FOR QUESTIONS ABOUT THESE DATA, CONTACT NSIDC@NSIDC.ORG

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SNEX20_SWESARR_TB

National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Parameters

This data set contains airborne microwave brightness temperature observations from the Goddard Space Flight Center SWESARR (Snow Water Equivalent Synthetic Aperture Radar and Radiometer) instrument collected during the SnowEx 2020 campaign at Grand Mesa, Colorado. Brightness temperature (TB) observations were made at three frequencies (10.65, 18.7, and 36.5 GHz; corresponding to X-, K- and Ka-bands, respectively).

1.2 File Information

1.2.1 Format

Data are provided in comma-separated value (.csv) files.

1.2.2 File Contents

The .csv files contain 14 columns with the parameters listed in Table 1.

Table 1. File Content

Parameter	Description	Unit
UTC	Date time in yyyymmdd-hh:mm:ss.ffffff format (e.g. 20200211-18:33:34.382880)	N/A
Longitude (deg)	Radiometer footprint center longitude	degree
Latitude (deg)	Radiometer footprint center latitude	degree
Elevation (m)	Radiometer footprint center elevation	m
TB X (K)	X-band (10.65 GHz) brightness temperature	K
TB K (K)	K-band (18.7 GHz) brightness temperature	K
TB Ka (K)	Ka-band (36.5 GHz) brightness temperature	K
Antenna Longitude (deg)	Antenna longitude	degree
Antenna Latitude (deg)	Antenna latitude	degree
Antenna Altitude (m)	Antenna altitude	m
Antenna Yaw (deg)	Antenna yaw angle	degree
Antenna Pitch (deg)	Antenna pitch angle	degree
Antenna Roll (deg)	Antenna roll angle	degree

Parameter	Description	Unit
Antenna Look Angle (deg)	Antenna look angle	degree

1.2.3 Naming Convention

Data are provided in a one file per pass over a given science line. Files use the following naming convention which is described in Table 2:

```
SNEX20_SWESARR_TB_GRM[TTT]_[BBBRR]_[YYFFF]_[DDD]_[YYMMDD]_XKKa225H_v01.csv
```

Table 2. File Naming Convention

Variable	Description
SNEX20_SWESARR_TB	SnowEx20 Airborne SWESARR Brightness Temperature
GRM	Grand Mesa, Colorado
TTT	3-digit science transect line name (either NT, ST, or CT, signifying North, South, or Cross Transects followed by 1-digit ID)
BBBRR	3-digit aircraft bearing (BBB) followed by 2-digit repeat count (RR). The aircraft bearing is clockwise from 0 degrees due North. The repeat count is auto-incremented for each repeat pass collected on the same flight and reset after each flight.
YYFFF	5-digit flight number. The first two digits are the last two digits of the year of the SWESARR flight, and the next three digits are the flight number by SWESARR counted sequentially from the first flight of the calendar year.
DDD	3-digits indicating the data take count, counted sequentially from the beginning of the flight. The power on the radiometer system is usually turned-on only once and kept on for the entire flight. A data take count of 000 means that the radiometer was running since pre-flight calibrations.
YYMMDD	6-digit date (YYMMDD) of data collection
XKKa225H	Frequency bands, look angle and polarization: Four characters indicating the collected SWESARR frequency bands, followed by a 3-digit look angle and one character polarization. The look angle is defined as 90 degrees for starboard side, 180 degrees for nadir and 270 degrees for port side. Data acquisitions for this data set were conducted with a nominal 45 degree look angle port of nadir resulting in 225 degrees.
v01	2-digit data set version number.
.csv	File extension indicating the data type

Example:

```
SNEX20_SWESARR_TB_GRMCT2_13901_20008_000_200212_XKKa225H_v01.csv
```

1.3 Spatial Information

1.3.1 Coverage

Northernmost Latitude: 39.085º N
Southernmost Latitude: 38.978º N
Easternmost Longitude: 108.097º W
Westernmost Longitude: 108.241º W

1.3.2 Resolution

The field of view and therefore the resolution depends on the frequency of observation and the aircraft altitude. At a nominal altitude of 1500 m the spatial resolutions (across track x along track) are:

- X-band: 496 m x 352 m
- K-band: 282 m x 200 m
- Ka-band: 144 m x 102 m

While the spatial sampling depends on the aircraft speed, the radiometer records a new footprint every 8-10 m along the flight track.

1.3.3 Geolocation

The following table provides information for geolocating this data set.

Table 3. Geolocation Details

Geographic coordinate system	WGS 84
EPSG code	4326
PROJ4 string	+proj=longlat +datum=WGS84 +no_defs
Reference	https://epsg.io/4326

1.4 Temporal Information

1.4.1 Coverage

10 February 2020 to 12 February 2020

1.4.2 Resolution

Snapshot along flight track line

2 DATA ACQUISITION AND PROCESSING

2.1 Background

The Goddard Space Flight Center SWESARR (Snow Water Equivalent Synthetic Aperture Radar and Radiometer) instrument was flown on a Twin Otter International, Limited aircraft during the fall (04-06 November 2019) and a Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) Twin Otter during the winter (10-12 February 2020) NASA SnowEx 2020 campaign at Grand Mesa, CO. Repeated data acquisitions occurred over the three science target lines, named North, South, and Cross (Figure 1). The cross line was recorded from both easterly and westerly flight directions during the winter campaign.

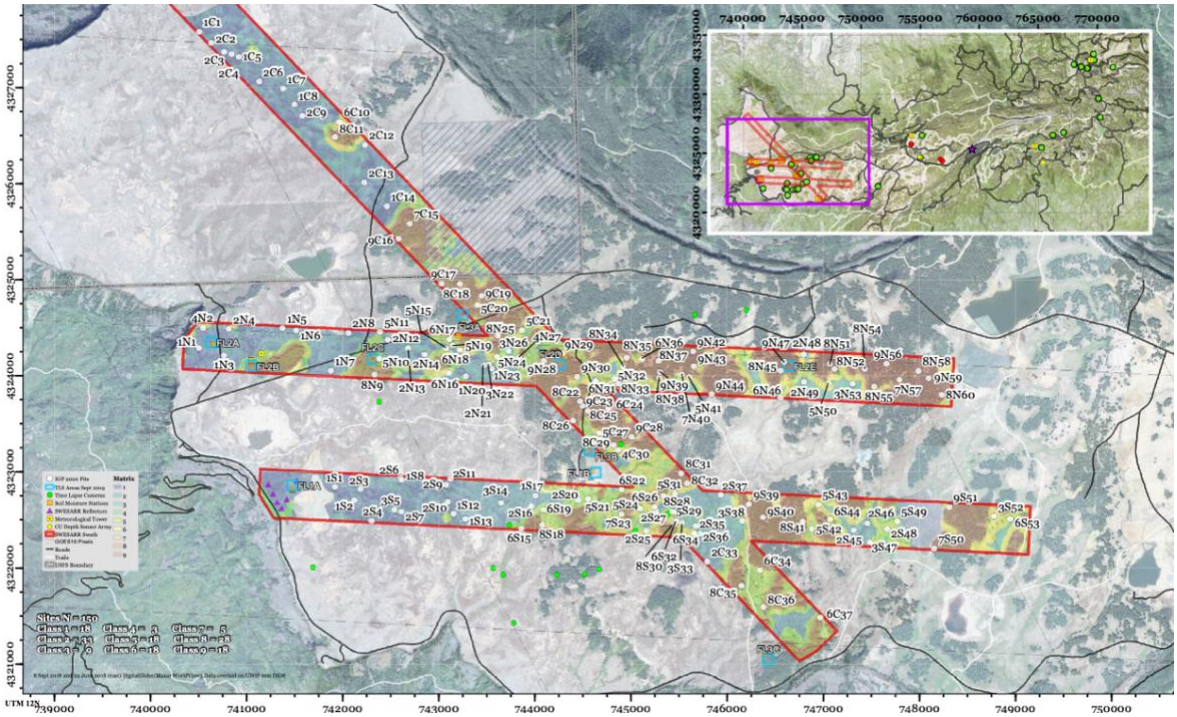

Figure 1. Location of the North (upper horizontal line), South (lower horizontal line), and Cross (diagonal line) flight lines and the location of the 150 Grand Mesa IOP snow pits.

2.2 Acquisition

Observations were made at three frequencies (10.65, 18.7 and 36.5 GHz; referring to X-, K- and Ka-bands, respectively), with horizontal polarization and a nominal 45-degree look angle.

2.3 Processing

Data post-processing steps convert the raw count measurements to calibrated radiometric observations expressed in Kelvin. The key processing steps, for each flight, aim to:

- Filter out radar contaminations.
- Separate and average counts by look type (i.e., internal calibration looks vs. antenna looks).
- Use internal calibration looks to estimate gain and offset downstream of internal calibration sources.
- Apply downstream gain and offset to the antenna look counts to derive an internal brightness temperature.
- Process pre- and post-flight calibrations (including sky calibration, ingesting concurrent data from a commercial upward-looking radiometer and from nearby radiosondes).
- Use pre- and post-flight calibrations to estimate gain and offset upstream of internal calibration sources.
- Apply all gains and offsets to antenna counts to derive a higher-level brightness temperature.
- Process noise injection calibration and black body calibrations conducted pre-, post- and in-flight.
- Utilize these calibrations to refine upstream gain and offset
- Apply refined gain and offset to the internal brightness temperature to derive the calibrated SWESARR brightness temperature available in this product
- Find aircraft position and altitude, and positioner roll, for each TB timestamp
- Calculate beam center position at the surface
- Calculate field of view position
- Combine all end-user relevant information to generate this data product.

2.4 Quality, Errors, and Limitations

The SWESARR radiometer absolute calibrations of TB can only be done pre- and post-flight by viewing the sky, and a microwave absorber foam. For in-flight calibration, the pre- and post-flight absolute calibrations are linearly interpolated. An estimate of a TB error incurred by this interpolation has been calculated for each frequency and each flight (Table 4).

Table 4. Interpolation based TB error bound

Date	Flight	TB error bound (K)		
		X band	K band	Ka band
11 Feb 2020	7	2	2.8	0.3
12 Feb 2020	8	1.5	0.9	1.6
12 Feb 2020	9	0.4	0.9	1

Other sources of absolute error are not quantified, due to lack of information with which to quantify them. However, it is noted that it may be possible to estimate a bound on absolute accuracy from in-flight observations of microwave absorbing foam. These observations were made about 1 minute after each flight line, for a duration of 1 minute. The physical temperature of the foam can be roughly approximated from concurrent records of the cabin air temperature. It should also be possible to estimate a bound for data precision by using measurements of the ocean which were taken on 6 February 2020 (a test flight following instrument integration in California).

The geolocation for both the SWESARR radar and radiometer products were impacted by the uncertainty stemming from the loss of the time server before February 2020 flights. This timing uncertainty resulted in spatial along-track offsets of 100-300 m. This brightness temperature product has been manually corrected to minimize this offset. With a new footprint recorded every 8-10 m along track, the spatial uncertainty is estimated to 1-3 footprints (i.e., up to about 30 m) after the manual correction.

Wintertime data taken on and before 2020-02-10 (flight 6) have larger errors, because these data were acquired as procedural issues in the calibration and flight operations were worked out (e.g., to keep aircraft cabin temperature stable from pre-flight calibration through post-flight calibration). These data are thus not distributed in this data set version but might be distributed in a future version of this data set.

2.5 Instrumentation

This data set was collected by the microwave radiometer part of the SWESARR (Snow Water Equivalent Synthetic Aperture Radar and Radiometer) instrument.

3 SOFTWARE AND TOOLS

The .csv files can be accessed using software that reads ASCII text.

4 VERSION HISTORY

Table 5. Version History Summary

Version	Release Date	Description of Changes
1	15 June 2021	Initial release

5 RELATED DATA SETS

SnowEx at NSIDC | Data Sets

SnowEx20 Airborne SWESARR Backscatter Intensity (not yet published)

6 RELATED WEBSITES

SnowEx at NSIDC | Overview

SnowEx at NASA

NASA SnowEx 2020 Experimental Plan

7 CONTACTS AND ACKNOWLEDGMENTS

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NASA Goddard Space Flight Center

8 DOCUMENT INFORMATION

8.1 Publication Date

15 June 2021

8.2 Date Last Updated

15 June 2021