SnowEx23 Soil Moisture Sensor Measurements, Version 1 Technical Reference

1 INTRODUCTION

1.1 Data Set Overview

This dataset contains soil sensor measurements collected as part of the SnowEx Alaska 2023 field campaign. Time series measurements occurred at two locations within the Bonanza Creek Experimental Forest (BCEF), Alaska, from sensors inserted into the soil and into a tree. Variables measured include soil volumetric water content, soil and tree temperature, soil electrical conductivity, and tree apparent dielectric permittivity. Soil measurements were obtained using a Campbell Scientific CS650 water content reflectometer, and tree-mounted measurements were obtained using a METER Group TEROS 12 sensor.

1.2 File Information

1.2.1 Format

The data are available in two comma-separated values (.csv) files

1.2.2 File Contents

The data files each contain 11 or 13 columns, as described in Table 1.

Table 1. File Header Description

Column Title	Description	Unit
State	State in the United States	N/A
Date	Date of measurements MM/DD/YYYY	N/A
Time	Time of measurement hh:mm	N/A
RN	Record number	N/A
Soil VWC	Soil volumetric water content	m^3/m^3
Soil Temp	Soil temperature	°C
Soil EC	Soil electrical conductivity	dS/m
A_Tree Dielectric	Sensor A tree apparent dielectric permittivity	m^3/m^3
A_Tree Temp	Sensor A tree temperature	°C
B_Tree Dielectric	Sensor B tree apparent dielectric permittivity	m^3/m^3
B_Tree Temp	Sensor B tree temperature	°C

Column Title	Description	Unit
C_Tree Dielectric*	Sensor C tree apparent dielectric permittivity	m^3/m^3
C_Tree Temp*	Sensor C tree temperature	°C

*Only available for BCEF2

1.2.3 Naming Convention

The granules containing the primary data files are named according to the following convention:

`SNEX23_Tree_SM_BCEF[N]_[YYYYMMDD-YYYYMMDD]_v01.csv`,

where `SNEX23_Tree_SM` is the data set short name, `BCEF[N]`is the site identifier, and `YYYYMMDD-YYYYMMDD` is the date range of data collection.

1.3 Spatial Information

1.3.1 Coverage

Northernmost Latitude: 64.706417° N

Southernmost Latitude: 64.702361° N

Easternmost Longitude: 148.294333° W

Westernmost Longitude: 148.307722° W

1.3.2 Geolocation

This data set conforms to the WGS 84 coordinate reference system / UTM zone 6N (EPSG 32606).

1.4 Temporal Information

1.4.1 Coverage

BCEF1: 25 October 2021 to 30 May 2023

BCEF2: 25 October 2021 to 06 October 2023

1.4.2 Resolution

Hourly

2 DATA ACQUISITION AND PROCESSING

2.1 Background

This data set presents two categories of time series measurements: 1) soil moisture, soil temperature, and soil electrical conductivity time series measurements collected using a Campbell Scientific CS650 water content reflectometer, and 2) tree apparent dielectric permittivity and tree temperature time series measurements collected using a TEROS 12 sensor from METER Group. Sensors were deployed at two locations within the Bonanza Creek Experimental Forest (BCEF), which is part of the University of Alaska Fairbanks Long Term Ecological Research (LTER) Program. The location and elevation for each site is listed in Table 2. The BCEF1 site (Fig. 1a) is located on a bluff in the southern portion of the BCEF. The BCEF1 site is located within a mixed forest habitat consisting of birch, cottonwood, and white spruce trees. The BCEF2 site (Fig. 1b) is located below the bluff and south of BCEF1. The BCEF2 site is located within a wetland's habitat consisting of black spruce and tamarack trees. Access to both sites is possible by vehicle from May to October and by snow machine from November to April.

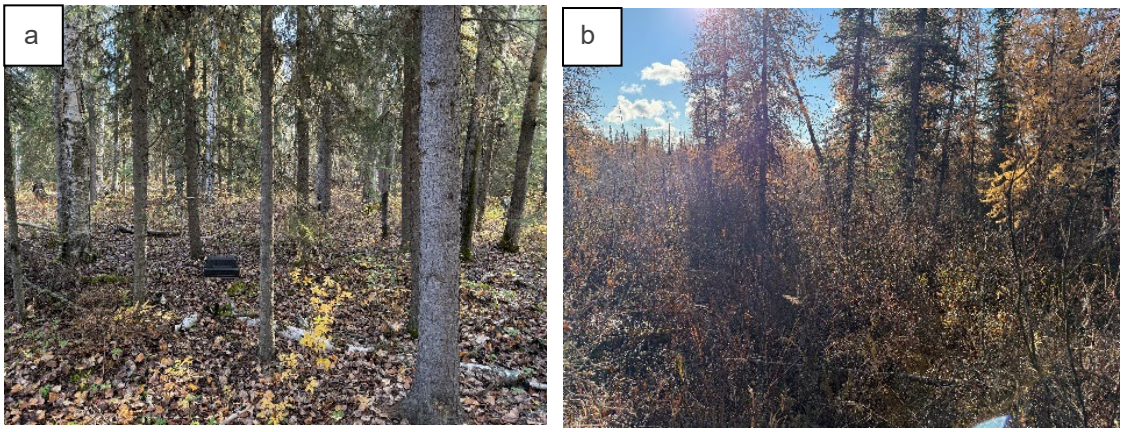

Figure 1. Pictures representing the habitat of the BCEF1 site (a) and the BCEF2 site (b).

Table 2. Site Locations and Elevation

Site Name	Latitude	Longitude	Elevation (m)
BCEF1	64.706417° N	148.307722° W	192
BCEF2	64.702361° N	148.294333° W	133

2.2 Acquisition

At BCEF1, the METER Group TEROS 12 sensors were placed into white spruce trees approximately one meter above the ground surface (Fig. 2a). At BCEF2, the METER Group TEROS 12 sensors were placed into black spruce trees approximately one meter above the ground

surface (Fig. 2c). The maximum snow depth at both sites was less than one meter. The Campbell Scientific CS650 sensors were installed so that the probes of the sensor protruded approximately 10 cm below the ground surface (Fig. 2b). A summary of the sensors installed at each site and the corresponding data collection periods are provided in Table 3.

Figure 2. Pictures of TEROS 12 sensors installed into white spruce trees at BCEF1 (a), the CS650 sensor installed at BCEF1 (b), and the TEROS 12 sensors installed into black spruce trees at BCEF2 (c). White arrows are pointing to the location of the sensors.

Table 3. List of Sensors and Data Collection Periods

Site	Instrument	Sensor	Time Period
BCEF1	Campbell Scientific CS650	Soil	25 October 2021 – 17 November 2022; 23 January 2023 – 30 May 2023
BCEF1	METER Group TEROS 12	A_Tree	25 October 2021 – 17 November 2022; 23 January 2023 – 01 March 2023
BCEF1	METER Group TEROS 12	B_Tree	23 January 2023 – 30 May 2023
BCEF2	Campbell Scientific CS650	Soil	25 October 2021 – 06 October 2023
BCEF2	METER Group TEROS 12	A_Tree	25 October 2021 – 06 October 2023
BCEF2	METER Group TEROS 12	B_Tree	17 November 2022 – 06 October 2023
BCEF2	METER Group TEROS 12	C_Tree	17 November 2022 – 06 October 2023

2.3 Processing

The raw data was recorded using a Campbell Scientific CR206X data logger, downloaded, and QA/QC for missing or erroneous measurements. Data was then exported to a single .csv file.

2.4 Quality, Errors, and Limitations

The METER Group TEROS 12 sensors have a resolution of: VWC=0.001 $m^{3/}m^3$, temperature=0.1°C, EC=0.001 dS/m, and dielectric measurement frequency=70 MHz as reported in the user manual. The Campbell Scientific CS650 user manual only reported a temperature resolution of 0.001°C. The TEROS 12 sensor was originally designed and factory-calibrated for use

in soil rather than trees. Their application in trees likely introduced systematic bias and increased measurement uncertainty.

Field data collection at the Upper Bonanza Creek site was subject to several challenges that affected both data continuity and measurement quality. During the monitoring period, cable damage caused by wildlife resulted in a short circuit of a Campbell Scientific CR206X data logger, disrupting data collection with some of the sensors. In addition, subfreezing temperatures adversely impacted sensor performance, occasionally rendering instruments nonfunctional. Data was downloaded manually during site visits depending on accessibility.