ABoVE: Soil Moisture and Active Layer Thickness in Alaska and NWT, Canada, 2008-2020

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Documentation Revision Date: 2021-10-27

Dataset Version: 1

Summary

This dataset provides soil thaw depth and moisture (STDM) measurements and dielectric properties measured by different research teams at sites in Alaska, U.S., and the Northwest Territories, Canada. There are multiple observations per site and 352,719 total observations. The dataset includes 206,000 observations of active layer thickness measured by mechanical probing (6.0%) or ground penetrating radar (GPR) (94.0%). Approximately 16,000 volumetric water content measurements were collected using GPR (22.1%), Hydrosense I and II probes (75.3%), and DualEM (2.6%). Metadata includes the location, time, geospatial coordinates, technique, measurement teams. Measurements were typically collected in August and September near the end of the thaw season and cover the period 2008-06-22 to 2020-08-15.

This dataset, referred to as Field Measurements of Soil Moisture and Active layer Thickness (SMALT) in the related publication Clayton et al. (2021), consists of thousands of measurements of thaw depth and soil moisture collected at study sites in or near Barrow, Seward Peninsula, the North Slope, Fairbanks, Coldfoot, the Yukon-Kuskokwin (YK) Delta, the Delta Junction of Alaska, US, and the Northwest Territories of Canada. SMALT includes 206,000 observations of ALT measured using either mechanical probing (6.0%) or ground penetrating radar (GPR) (94.0%). Approximately 16,000 volumetric water content (VWC) measurements were collected by GPR (22.1%), Hydrosense I and II probes (75.3%), and DualEM (2.6%)

There is one data file in comma-separated values (*.csv) format included in this dataset.

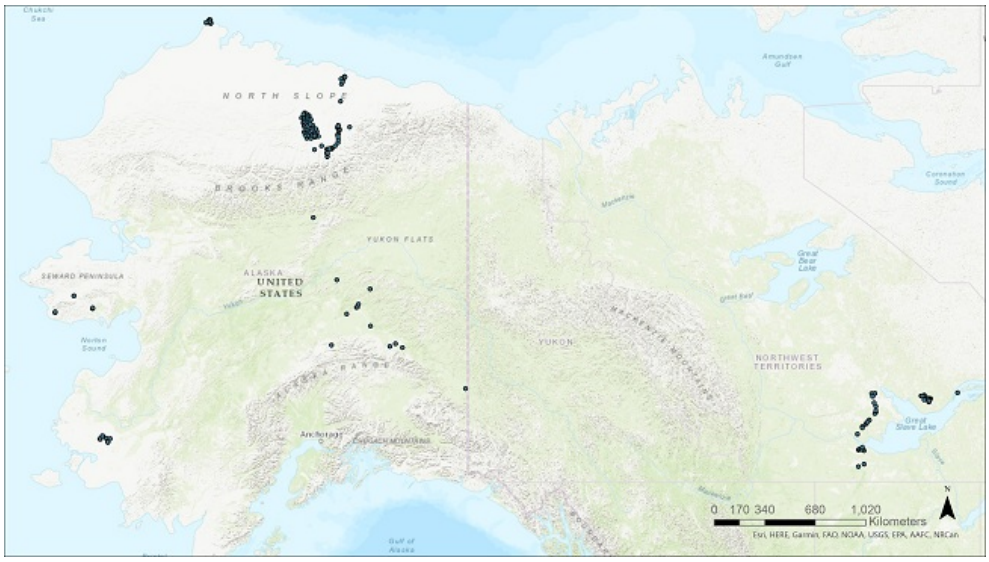

Figure 1. Map indicating the location of the study sites.

Citation

Schaefer, K., L.K. Clayton, M.J. Battaglia, L.L. Bourgeau-Chavez, R.H. Chen, A.C. Chen, J. Chen, K. Bakian-Dogaheh, T.A. Douglas, S.E. Grelick, G. Iwahana, E. Jafarov, L. Liu, S. Ludwig, R.J. Michaelides, M. Moghaddam, S. Natali, S.K. Panda, A.D. Parsekian, A.V. Rocha, S.R. Schaefer, T.D. Sullivan, A. Tabatabaeenejad, K. Wang, C.J. Wilson, H.A. Zebker, T. Zhang, and Y. Zhao. 2021. ABoVE: Soil Moisture and Active Layer Thickness in Alaska and NWT, Canada, 2008-2020. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1903

Table of Contents

1. Dataset Overview

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Project: Arctic-Boreal Vulnerability Experiment

The Arctic-Boreal Vulnerability Experiment (ABoVE) is a NASA Terrestrial Ecology Program field campaign being conducted in Alaska and western Canada, for 8 to 10 years, starting in 2015. Research for ABoVE links field-based, process-level studies with geospatial data products derived from airborne and satellite sensors, providing a foundation for improving the analysis, and modeling capabilities needed to understand and predict ecosystem responses to, and societal implications of, climate change in the Arctic and Boreal regions.

Related Publication

Clayton, L.K., K. Schaefer, M.J. Battaglia, L. Bourgeau-Chavez, J. Chen, R.H. Chen, A. Chen, K. Bakian-Dogaheh, S. Grelik, E. Jafarov, L. Liu, R.J. Michaelides, M. Moghaddam, A.D. Parsekian, A.V. Rocha, S.R. Schaefer, T. Sullivan, A. Tabatabaeenejad, K. Wang, C.J. Wilson, H.A. Zebker, T. Zhang, and Y. Zhao. 2021. Active layer thickness as a function of soil water content. Environmental Research Letters 16:055028. https://doi.org/10.1088/1748-9326/abfa4c

Acknowledgments

This work was funded by the NASA Terrestrial Ecology Program (grants NNX10AR63G, NNX06AE65G, NNX13AM25G, NNX17AC59A, NNX17AC57A, NNX15AT83A) and the Terrestrial Hydrology Program (grants 80NSSC18K0983, 80NSSC19M0107, 80NSSC18K1410).

2. Data Characteristics

Spatial Coverage: Alaska, U.S., and the Northwest Territories, Canada

> **ABoVE Reference Locations**
>
> Domain: Core
>
> State/Territory: Alaska and Canada
>
> Grid Cells: All sites are located in ABoVE grid tiles Ah000v000, Ah001v000, Ah001v001, Ah002v001, Ah002v002, and the following 5 m "C" grid tiles: Ch013v021, Ch013v022, Ch014v021, Ch014v022, Ch022v010, Ch024v011, Ch024v013, Ch036v033, Ch039v032, Ch040v029, Ch040v032, Ch040v035, Ch040v037, Ch040v038, Ch042v032, Ch043v024, Ch043v045, Ch047v020, Ch048v017, Ch048v018, Ch048v019, Ch048v020, Ch048v021, Ch049v007, Ch049v017, Ch049v018, Ch049v019, Ch049v020, Ch049v021, Ch050v007, Ch050v020, Ch051v020, Ch052v018, Ch053v017, Ch053v018, Ch075v071, Ch075v072, Ch076v069, Ch076v070, Ch076v071, Ch076v072, Ch077v068, Ch078v067, Ch078v068, Ch079v065, Ch079v066, Ch079v067, Ch083v067, Ch084v067, Ch084v068, Ch087v067

Spatial Resolution: Point measurements

Temporal Coverage: 2008-06-22 to 2020-08-15

Temporal Resolution: Minute

Site Boundaries: Latitude and longitude are given in decimal degrees.

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Alaska and NWT	-165.97342	-111.3675	71.323614	60.45244

Data file information

There is one data file in comma-separated values (*.csv) format included in this dataset. The file is named ABoVE_Soil_ThawDepth_Moisture_Validation.csv and provides soil active layer thickness (ALT), volumetric water content (VWC), and dielectric properties measured by different research teams at burned and unburned sites in Alaska and the NWT. There are multiple observations per site and 352,719 total observations.

Data File Details

Missing values are provided as -999 in the data file.

Table 1. Variable names and descriptions in ABoVE_Soil_ThawDepth_Moisture_Validation.csv.

Variable	Units	Description
site_name		Site where measurements were collected
plot		Plot at site where measurements were collected
point		Point number within a survey
survey_technique		Survey technique used by research team
team_name		Research team name
organization		Research team organization
observer		Name of observer associated with the study plots/measurements
observer_email		Observer email

latitude	Decimal degrees (N)	Latitude (N) of the measurement site
longitude	Decimal degrees (E)	Longitude (E) of the measurement site
PDOP	Decimal degrees	Position Dilution of Precision; accuracy of the GPS measurement
date	YYYY-MM-DD	Date of collection
time	HH:MM:SS	Time of collection; 24-hour clock
ALT_instrument		Instrument used to measure Active layer thickness (ALT): probe or GPR
ALT	cm	Active layer thickness (ALT); thaw depth at time of measurement
ALT_err	cm	ALT measurement error
VWC_instrument		Instrument used to measure volumetric water content (VWC): Hydrosense I, Hydrosense II, DualEM, or ground penetrating radar (GPR)
depth_top	cm	Depth to the top of the VWC measurement
depth_bottom	cm	Depth to the bottom of the VWC measurement
attenuation		Attenuation of HydroSense measurement
dielectric_permittivity		Soil dielectric permittivity
period	microseconds	Period of HydroSense measurement
VWC	percent	Volumetric water content
VWC_err	percent	VWC measurement error
corrected	flag	Errors corrected from version 1 to 2: 0=no, 1=yes

3. Application and Derivation

These data could be useful to climate modeling studies.

4. Quality Assessment

Uncertainty was estimated for all parameters when possible. The uncertainty in mechanical ALT measurement is 3 cm. The uncertainty in ground penetrating radar (GPR) active layer thickness (ALT) and volumetric water content (VWC) measurements were based on the standard deviation in measured wave velocity. The uncertainty was estimated in all calculations using Gaussian error propagation.

5. Data Acquisition, Materials, and Methods

Site Description

This soil thaw depth and moisture (STDM) dataset (referred to as Field Measurements of Soil Moisture and Active layer Thickness (SMALT) in Clayton et al. (2021)) consists of thousands of measurements of thaw depth and soil moisture collected at study sites in or near Barrow, Seward Peninsula, the North Slope, Fairbanks, Coldfoot, the Yukon-Kuskokwin (YK) Delta, the Delta Junction of Alaska, and the Northwest Territories (NWT) of Canada. The Utqiagvik (Barrow) sites lie on the Arctic coastal plain, which consists of drained thermokarst lakes and open tundra covered with grass, moss, and lichen. The North Slope sites cover hilly areas of glacial debris covered with tussocks and moss. The Fairbanks sites all lie in the boreal forest zone, typically in open meadows of tussocks and moss surrounded by wooded areas of black spruce and shrubs. The Coldfoot site is just south of the Brooks Range and similar in vegetation and surface characteristics to the Fairbanks site. The Delta Junction sites also occur in the boreal forest zone, but all lie in landscapes dominated by the dynamics of the Tanana River. The YK Delta consists of raised peat plateaus covered by grass, moss, and lichen separated by sunken thermokarst gulleys, wetlands, and lakes. The Seward Peninsula sites lie in narrow valleys covered in sedge grass, moss, and lichen surrounded by mountains.

The sites were grouped into regions (Fig. 1) for statistical analysis and are not described in this document. Some sites were affected by prior fires, but burn status and fire history are not included in this dataset. Refer to Clayton et al. (2021) for details.

Data Collection

The dataset includes 206,000 observations of ALT measured using either mechanical probing (6.0%) or GPR (94.0%). The teams typically made their measurements in August and September, near the end of the thaw season. It was assumed that thaw depth measured in August and September represented an acceptable approximation of ALT.

Mechanical probing entails pressing a graduated T-shaped rod into the ground until it hits the permafrost table. The mechanical probe measures the thaw depth with an uncertainty of 3 cm (Schaefer et al., 2015; Chen et al., 2016). For GPR measurements, the transmitting antenna emits a pulse at a center frequency of 500 MHz that travels downwards through the active layer and reflects off the permafrost table (Schaefer et al., 2015; Chen et al., 2016; Jafarov et al., 2017). The receiver measures the two-way travel time (TWTT) as the time from the transmitter to the permafrost table and back. The teams pulled the GPR antenna along the ground to acquire multi-kilometer transects with a pulse frequency of ~3 Hz, which results in a typical average spacing of ~0.3 m. Because of rough surface topography due mainly to tussocks, not every pulse resulted in a useable reflection, so the STDM dataset includes ~140,000 GPR records with neither ALT nor VWC. Every few minutes, the teams measured thaw depth with a mechanical probe as calibration points to convert the TWTT into wave velocity. The calibration points give an average wave velocity for a site or region to convert all the TWTT to thaw depths. The standard deviation of wave velocity at each site represents the uncertainty in thaw depth, with a typical thaw depth uncertainty of ~20% (Chen et al., 2016).

The dataset includes 16,000 VWC measurements collected by GPR (22.1%), Hydrosense I and II probes (75.3%), and DualEM (2.6%). For the GPR measurements of VWC, thaw depth was divided by the TWTT to get a wave speed as a measure of soil dielectric permittivity. All VWC measurements represent an average value over the depth reached by the instrument used (Bourgeau-Chavez et al., 2010). The Hydrosense measurements represent the average VWC of the surface soil to a depth of either 6, 12, or 20 cm, depending on the probe length used, referred to as surface VWC. The VWC measurements from GPR and DualEM represent the average water content over the entire active layer, referred to as the bulk VWC.

Refer to Clayton et al. (2021) for additional information.

6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

ABoVE: Soil Moisture and Active Layer Thickness in Alaska and NWT, Canada, 2008-2020

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
- Telephone: +1 (865) 241-3952

7. References

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