ABoVE: Soil Moisture and Active Layer Thickness in Alaska, USA and Canada, 2005-2022

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Documentation Revision Date: 2025-06-10

Dataset Version: 1

Summary

This dataset provides soil thaw depth and moisture 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 528,703 total observations. The dataset includes 223,230 observations of active layer thickness measured by mechanical probing (9.8%) or ground penetrating radar (GPR) (90.2%). Approximately 179,154 volumetric water content (VWC) measurements were collected using GPR (2.0%), HydroSense I and II probes (8.8%), in situ loggers (89.2%), and DualEM (<1.0%). Metadata includes the location, time, geospatial coordinates, sampling technique, measurement teams, and field team contact information. Measurements were typically collected in August and September near the end of the thaw season and cover the period from 2005 to 2022. This dataset, referred to as field measurements of Soil Moisture and Active layer Thickness (SMALT) (Schaefer et al., 2021), was developed for work in Clayton et al. (2021). It has been expanded in Version 2 to comprise a comprehensive dataset of NASA Arctic-Boreal Vulnerability Experiment (ABoVE) field campaign measurements of soil moisture and active layer thickness, including logger data of relevance to Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) acquisitions. The data are provided in comma separated values (CSV) format.

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

Figure 1. Map indicating the location of the data locations and their relationship to UAVSAR flight data swaths (Miller et al., 2024). Map created in ArcGIS Pro (Redlands, CA).

Citation

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Table of Contents

1. Dataset Overview

This dataset provides soil thaw depth and moisture 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 528,703 total observations. The dataset includes 223,230 observations of active layer thickness measured by mechanical probing (9.8%) or ground penetrating radar (GPR) (90.2%). Approximately 179,154 volumetric water content (VWC) measurements were collected using GPR (2.0%), HydroSense I and II probes (8.8%), in situ loggers (89.2%), and DualEM (<1.0%). Metadata includes the location, time, geospatial coordinates, sampling technique, measurement teams, and field team contact information. Measurements were typically collected in August and September near the end of the thaw season and cover the period from 2005 to 2022.

This dataset, referred to as field measurements of Soil Moisture and Active layer Thickness (SMALT) (Schaefer et al., 2021), was developed for work in Clayton et al. (2021) where it is referred to as field measurements of Soil Moisture and Active layer Thickness (SMALT) (Schaefer et al., 2021). It has been expanded in Version 2 to comprise a comprehensive dataset of NASA Arctic-Boreal Vulnerability Experiment (ABoVE) field campaign measurements of soil moisture and active layer thickness, including logger data of relevance to Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) acquisitions. This updated dataset includes 175,000 new observations from *in situ* loggers (83.8%) and manual probing (16.2%). A majority of field probed measurements were collected in coordination with UAVSAR L- and P-band flights for the purpose of assessing SAR inferences of soil moisture and active layer thickness (Miller et al., 2024). This dataset contains measurements collected at study sites in or near Barrow, Seward Peninsula, the North Slope, Fairbanks, Coldfoot, Noatak River, the Yukon-Kuskokwim (YK) Delta in southwestern Alaska, near Delta Junction, Alaska, US, and the Mackenzie River Delta and near Great Slave Lake in the Northwest Territories in Canada. A significant portion of these data observations were coincident in space and time with NASA ABoVE airborne campaign UAVSAR flights.

Project: ABoVE

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

Related Datasets

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

- The SMALT Version 1 dataset originally developed for work in Clayton et al. (2021).

Bourgeau-Chavez, L.L. 2024. ABoVE: Soil Moisture and ALT Field Collection Protocols and Probe Calibration. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2373

- This dataset provides updated field collection protocols and calibration information.

Acknowledgments

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2. Data Characteristics

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

ABoVE Reference Locations:
Domain: Core
State/Territory: Alaska. U.S., and Northwest Territories (NWT), 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: 2005-01-10 to 2022-09-28

Temporal Resolution: Minute or one-time sampling

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

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Alaska and NWT	-165.9737	-111.3675	71.3236	58.2077

Data File Information

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

ABoVE_Soil_ThawDepth_Moisture_Validation_V2.csv 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 529,423 total observations.

Data File Details

Missing numeric values are provided as -9999; missing text values are provided as NA.

Table 1. Variable names and descriptions in **ABoVE_Soil_ThawDepth_Moisture_Validation_V2.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	degrees north	Latitude (N) of the measurement site in decimal degrees
longitude	degrees east	Longitude (E) of the measurement site in decimal degrees
PDOP	degrees	Position Dilution of Precision; accuracy of the GPS measurement in decimal degrees
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: "probe" or "GPR" (ground penetrating radar)
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 GPR
depth_top	cm	Depth to the top of the VWC measurement
depth_bottom	cm	Depth to the bottom of the VWC measurement
attenuation	1	Attenuation factor of HydroSense measurement
dielectric_permittivity		Soil dielectric permittivity
period	µs	Period of HydroSense measurement in microseconds
VWC	percent	Volumetric water content
VWC_err	percent	VWC measurement error
V2Update	flag	0=not changed from Version 1,1=new in Version 2

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 GPR, ALT, and VWC measurements were based on the standard deviation in measured wave velocity. The uncertainty was estimated in all calculations using Gaussian error propagation. Some teams adjusted soil moisture measurements using petrophysical calibration curves generated using either local soil samples or the general curves provided by Bourgeau-Chavez (2024).

5. Data Acquisition, Materials, and Methods

Site Description

This dataset consists of hundreds 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, Noatak River, the Yukon-Kuskokwim (YK) Delta in southwestern Alaska, near Delta Junction, Alaska, US, and the Mackenzie River Delta and near Great Slave Lake in the Northwest Territories in 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 Mackenzie River Delta is a low lying area of lake-dotted coastal plains. The Great Slave Lake sites are within the northern boreal forest zone. 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 223,230 observations of ALT measured by mechanical probing (9.8%) or ground penetrating radar (GPR) (90.2%). 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. Field data were collected by ABoVE field campaign teams according to a standardized protocol (Bourgeau-Chavez, 2024; https://doi.org/10.3334/ORNLDAAC/2373)

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 usable reflection; therefore, this 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 179,154 VWC measurements collected using GPR (2.0%), HydroSense I and II probes (8.8%), *in-situ* loggers (89.2%), and DualEM (<1.0%). For 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.

Additional information is available in Bourgeau-Chavez (2024) and Clayton et al. (2021).

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, USA and Canada, 2005-2022

Contact for Data Center Access Information:

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7. References

Bourgeau-Chavez, L.L. 2024. ABoVE: Soil Moisture and ALT Field Collection Protocols and Probe Calibration. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2373

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8. Dataset Revisions

Version Number	Publication Date	Description
2	2025-06-05	Additional data were added to the dataset. The data were collected according to an updated ABoVE field collections protocol https://doi.org/10.3334/ORNLDAAC/2373
1	2021-10-29	Version 1 of this dataset https://doi.org/10.3334/ORNLDAAC/1903