Dendrometer, Soil, and Weather Observations, Arctic Tree Line, AK and NWT, 2016-2019

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Documentation Revision Date: 2023-08-23

Dataset Version: 1

Summary

This dataset provides in situ measurements of radial tree growth of selected white spruce (Picea glauca) and black spruce (Picea mariana) trees, as well as simultaneous in situ measurements of environmental variables (air temperature, air pressure, relative humidity, soil temperature, volumetric water content, and solar irradiance) at two Arctic treeline sites: one in the Brooks Range of Alaska (AK), USA, and the other near Inuvik, Northwest Territories (NWT), Canada. In AK, 36 trees were monitored from June 7, 2016 to September 13, 2019, and in NWT, 24 trees were monitored from July 5, 2017 to July 25, 2019 with a sampling interval of 5- or 20-minutes for radial tree growth and 5-minutes for all environmental variables. The dendrometer data included in this dataset are only those gathered from 2016-2017. Dendrometer data from 2018-2019 are available from a related dataset. The data were collected to better understand the influence of environmental variables on radial tree growth dynamics. The data are provided in comma-separated values (CSV) format.

There are eight data files in comma-separated values (*.csv) format with this dataset. Seven files provide the variables measured, and one file provides the locations of measured trees.

Figure 1. Locations of plots (red squares) for Arctic treeline dendrometer and weather observations in Alaska, USA, and Northwest Territories, Canada.

Citation

Jensen, J., N. Boelman, J. Eitel, L. Vierling, A.J. Maguire, and K. Griffin. 2023. Dendrometer, Soil, and Weather Observations, Arctic Tree Line, AK and NWT, 2016-2019. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2185

Table of Contents

1. Dataset Overview

This dataset provides in situ measurements of radial tree growth of selected white spruce (Picea glauca) and black spruce (Picea mariana) trees, as well as simultaneous in situ measurements of environmental variables (air temperature, air pressure, relative humidity, soil temperature, volumetric water content, and solar irradiance) at two Arctic treeline sites: one in the Brooks Range of Alaska (AK), USA, and the other near Inuvik, Northwest Territories (NWT), Canada. In AK, 36 trees were monitored from June 7, 2016 to September 13, 2019, and in NWT, 24 trees were monitored from July 5, 2017 to July 25, 2019 with a sampling interval of 5- or 20-minutes for radial tree growth and 5-minutes for all environmental variables. The dendrometer data here include only those gathered from 2016-2017. For dendrometer data from 2018-2019 please see the related dataset, *Photochemical Reflectance and Tree Growth, Brooks Range, Alaska, 2018-2019* (Eitel et al., 2020). The data were collected to better understand the influence of environmental variables on radial tree growth dynamics. The data are provided in comma-separated values (CSV) format.

At each site, a transect was established from south to north (5.5 km long in AK, 23.8 km long in NWT) where tree density becomes increasingly sparse until eventually transitioning into treeless tundra. Six plots were established along the transects in AK and four plots in NWT. Six trees were selected at each plot using stratified random sampling with a diameter at breast height (DBH) of 10 cm as the stratification variable: all of the selected trees were white spruce (Picea glauca) except for six of the 24 trees in NWT (all located at the same plot), which were black spruce (*Picea mariana*).

Each tree was outfitted with a micrometeorological station and a point dendrometer. The environmental variables monitored included air temperature, soil temperature, relative humidity (RH), pressure, soil volumetric water content (VWC), and solar irradiance. All environmental variables were monitored at 5-minute intervals on a EM50 datalogger (METER Group). The data were collected to better understand the influence of environmental variables on radial tree growth dynamics.

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 Datasets

Maguire, A.J., J. Eitel, L. Vierling, N. Boelman, K. Griffin, J.S. Jennewein, and J.E. Jensen. 2020. ABoVE: Terrestrial Lidar Scanning Forest-Tundra Ecotone, Brooks Range, Alaska, 2016. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1782

Eitel, J., A.J. Maguire, K. Griffin, N. Boelman, J.E. Jensen, S.C. Schmiege, and L. Vierling. 2020. ABoVE: Photochemical Reflectance and Tree Growth, Brooks Range, Alaska, 2018-2019. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1781

- This dataset provides dendrometer data from 2018-2019

Related Publications

Eitel, J.U.H., K. L. Griffin, N.T. Boelman, A.J. Maguire, A.J.H. Meddens, J. Jensen, L.A. Vierling, S.C. Schmiege, and J.S. Jennewein. 2020. Remote sensing tracks daily radial wood growth of evergreen needleleaf trees. Global Change Biology 26:4068-4078. https://doi.org/10.1111/gcb.15112

Eitel, J.U.H., A.J. Maguire, N. Boelman, L.A. Vierling, K.L. Griffin, J. Jensen, T.S. Magney, P.J. Mahoney, A.J.H. Meddens, C. Silva, and O. Sonnentag. 2019. Proximal remote sensing of tree physiology at northern treeline: Do late-season changes in the photochemical reflectance index (PRI) respond to climate or photoperiod? Remote Sensing of Environment, 221:340–350. https://doi.org/10.1016/j.rse.2018.11.022

Jensen, J., N. Boelman, J. Eitel, L. Vierling, A. Maguire, and K. L. Griffin. Heat vs moisture: dissecting the relative influence of temperature, relative humidity, and soil moisture on intra-annual radial stem growth at Arctic treeline. In preparation.

Acknowledgments

This work was supported by NASA ABoVE (grant NNX15AT86A).

2. Data Characteristics

Spatial Coverage: Brooks Range, Alaska (AK), USA Northwest Territories (NWT), Canada

ABoVE Reference Locations

For AK:

Domain: Core ABoVE

State/Territory: Alaska

Grid cells: Ch046v022

For NWT:

Domain: Core ABoVE

State/Territory: Northwest Territories

Grid cells: Ah001v000

Spatial Resolution: Points within plots along two transects (one in AK, one in NWT).

Temporal Coverage: 2016-06-07 to 2019-09-13

Temporal Resolution: Dendrometer data are reported as a 5- or 20-minute averages. Environmental data are reported at 5-minute intervals.

Study Area: Latitude and longitude are given in decimal degrees for the two study areas. Coordinates for the individual sites are provided in the data files.

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Alaska, US	-149.761	-149.716	68.019	67.972
Northwest Territories, Canada	-133.773	-133.531	68.727	68.532

Data File Information

There are eight data files in comma-separated values (*.csv) format. Seven files provide the variables measured, and one file provides the locations of measured trees. Data were quality checked and denoted using the “flag” column in each .csv file. Researchers are encouraged to perform their own quality-assurance using the “flag” column.

Table 1 provides the file names and variables measured in each file. Table 2 describes five variables found in all files.

Table 1. File names and descriptions of variables specific to the file. All files have variables listed in Table 2.

File Names	Variables	Units	Description
Air_Pressure.csv	air_pressure_kPa	kPa	Atmospheric pressure reported at 5-minute intervals.
Air_Temperature.csv	air_temperature_degC	degrees C	Air Temperature reported at 5-minute intervals.
Relative_Humidity.csv	relative_humidity	1	Relative humidity reported at 5-minute intervals.
Soil_Temperature.csv	soil_temperature_degC	degrees C	Soil Temperature reported at 5-minute intervals.
	sensor	-	Sensor deployed, METER Group: "5TM" or "ECT"
Solar_Irradiance.csv	solar_W_per_sqm	W m^{-2}	Solar irradiance reported at 5-minute intervals.
Tree_Trunk_Radius.csv	stem_radius	cm	Stem radius of a tree trunk at dendrometer height (~1.37 m) reported as a 5- or 20-minute average of 1-minute measurements. Intervals were 5-minutes when recorded on an EM50 datalogger, and 20-minutes when recorded on a Campbell datalogger.
	basal_area	cm^2	Basal area of tree stem computed from stem_radius
Volumetric_Water_Content.csv	VWC_m3_per_m3	m^3 m^{-3}	Volumetric water content (VWC). 5-minute reporting interval.
Tree_locations.csv	species	-	Tree species: "P glauca" or "P mariana", where "P" denotes the genus *Picea*.
	longitude	degree east	Longitude of trees and plots in decimal degrees
	latitude	degree north	Latitude of trees and plots in decimal degrees

Table 2. Descriptions of variables in all files (*time* and *flag* are not provided in the file ***Tree_locations.csv***). Missing values are coded as NA.

Column name	Units	Description
site	-	"AK" for Alaska, USA site. "NWT" for Northwest Territories, Canada site.
plot	-	In AK, plots are numbered 1-6. In NWT, plots are numbered 1-4.
tree	-	Identification code of individual trees (n = 36 in AK; n = 24 in NWT). In AK, trees IDs have the form <plot number><A-F>. In NWT, tree id’s range from 200- 206 at plot 2, 207-212 at plot 1, 301-306 at plot 3, and 307 - 312 at plot 4.
time	YYYY-MM-DD hh:mm:ss	Local time of sampling. Time Zone in AK is UTC-8 and NWT is UTC-7.
flag	-	"NA": No flag; data are correct and should not be discarded. "out of range": data are flagged for being out of the reasonable range for the variable. "sensor malfunction": data are flagged due to a sensor malfunction and should be discarded. "sensor set up": data are flagged since sensor was being set up and should be discarded. "sensor take down" : data are flagged since sensor was being taken down and should be discarded.

3. Application and Derivation

This dataset provides simultaneous in-situ measurements of six environmental variables as well as radial tree growth of selected white spruce trees (*Picea glauca* (Moench) Voss) at two Arctic treeline sites. The data were collected to better understand the influence of environmental variables on radial tree growth dynamics.

4. Quality Assessment

All data were manually reviewed and flagged (see 'flag' column) for sensor malfunctions and for outliers lying outside the reasonable range for the variable.

Dendrometer

Although this inexpensive potentiometer has independent linearity of ± 1%, the range of motion on a single tree at field sites over the course of a year was very small (< 2 mm) and the relative response of each unit was considered linear. Each potentiometer was independently calibrated at the time the dendrometer was installed and related to the measured tree diameter at DBH to derive tree stem radial changes from the voltage difference signal.

A test of temperature effects on the complete dendrometer/data logger system was conducted by holding a plunger in a fixed position, depressed by approximately 50% with a thin stainless-steel band attached to the potentiometer body, which demonstrated less than one bit of resolution change (< 0.1 µm) while ambient temperature naturally varied across a range of more than 30° C. (Griffin 2020, unpublished data).

The dendrometers were placed on top of the thin bark (after carefully removing any loose bark with a small rasp, while avoiding damage to the living tissues), which all processes that caused changes in the stem diameter were recorded. These processes included bark swelling and shrinking, cambial activity, changes in phloem, xylogenesis, and stem hydraulics. Of these, only xylogenesis caused an irreversible change in stem diameter and is the focus of this study. However, caution should be taken when assessing shorter-term responses to consider other processes, particularly changes in stem diameter caused by tree hydrology.

5. Data Acquisition, Materials, and Methods

Parts of the following descriptions were excerpted from Jensen et al. (2022, in prep) and Eitel et al. (2020).

Study Area

Field data were collected at two Arctic treeline sites: one on the southern side of the Brooks Range, Alaska, USA, and the other near Inuvik, Northwest Territories, Canada. The Alaska treelines site, hereafter 'AK', was located south of Chandalar Shelf and Atigun Pass on the east side of the Dalton Highway (727 m a.s.l.). The Northwest Territories treeline site, hereafter 'NWT', was located approximately 40 km north of Inuvik along the Inuvik-Tuktoyaktuk Highway (15 m a.s.l.). In AK, trees were monitored from June 7, 2016 to September 13, 2019. In NWT, trees were monitored from July 5, 2017 to July 25, 2019.

At both sites, continuous permafrost underlies the Arctic treeline where tree cover predominantly consists of white spruce (*Picea glauca* (Moench) Voss) with occasional black spruce (*Picea mariana* (Mill.) BSP). The understory is dominated by tundra vegetation such as sedges (e.g., *Eriophorum* spp.), moss and lichen (e.g., *Cladonia rangiferina*), short evergreen shrubs (e.g., *Arctostaphylos uva-ursi*), and low (< 1.5 m) deciduous shrubs (e.g., *Salix* spp., *Betula nana* L., *Alnus* spp.).

In AK, trees grow along the floodplain of the Dietrich River and gently sloping lower elevations (727 m a.s.l.); tundra vegetation dominates upslope at only slightly higher elevations. In NWT, the longer transect exhibits a more diffuse transition between forest and tundra. Trees grow in pockets, like in AK, but over gently rolling hills at lower elevations (15 m a.s.l.), between which often lie pools of water.

Sampling Design

At each site, a transect was established from south to north (5.5 km long in AK, 23.8 km long in NWT) where tree density becomes increasingly sparce until eventually transitioning into treeless tundra. Along the transects, six plots were established in AK and four plots in NWT. Six trees were selected at each plot using stratified random sampling with a diameter at breast height (DBH) of 10 cm as the stratification variable: Three trees between 5-10 cm and three >10 cm DBH were selected at each plot (n = 36 trees in AK, n = 24 trees in NWT). All of the selected trees were white spruce except for 6 of the 24 trees in NWT (all located at the same plot); these 6 trees were black spruce.

Radial Stem Growth of Trees

Near continuous measurements of tree stem radius were made using point dendrometers. The dendrometer is based on a linear motion, spring-loaded potentiometer (LP-10F, Midori USA). A custom-made mounting bracket held the potentiometer in a fixed position relative to the outer bark by inserting a stainless steel 6.35 mm diameter threaded rod, with 20 threads 25.4 mm^{-1}, inserted approximately one cm into the stem. All dendrometers were installed on the north side of the tree (to minimize exposure to direct solar radiation) at a height of 1.37 m from the ground surface after removing any loose outer bark. An excitation voltage was sent to the potentiometer every minute and the corresponding half-bridge return signal was recorded using a data logger (CR300, Campbell Scientific, Logan Utah, USA or EM50, Meter Group Inc, Pullman, WA 99163). Data were recorded as 5- or 20-minute averages depending on the datalogger recording the measurement (EM50 and Campbell, respectively). Each potentiometer was calibrated at the time of installation with stem diameter to derive the stem radius and basal area (BA), so that:

$$R_0 = \frac{D_0}{2}$$
$$R_t = d_t + R_0$$
$$B_t = \pi {R_t}^2$$

where D_0 and R_0 are the DBH and stem radius at the time of installation, respectively; d_t is the linear distance at time t; R_t is the stem radius at time t; and B_t is the basal area at time t.

Importantly, the dendrometer data here include only those gathered from 2016-2017. For dendrometer data from 2018-2019 please see the related dataset, "*Photochemical Reflectance and Tree Growth, Brooks Range, Alaska, 2018-2019"* (Eitel et al., 2020).

Environmental variables

Each tree was outfitted with a micrometeorological station. The environmental variables monitored included air temperature, soil temperature, relative humidity (RH), pressure, soil volumetric water content (VWC), and solar irradiance. At every tree, we monitored air temperature, soil temperature, relative humidity (RH), pressure, and radial stem growth. However, not all environmental variables were monitored at each tree. Solar irradiance was monitored at 24 trees in AK and five trees in NWT. VWC was collected on 18 trees in AK and 15 trees in NWT. All environmental variables were monitored at 5-minute intervals on a EM50 datalogger (METER Group).

Air temperature, pressure, and RH were measured using VP-4 sensors (METER Group) placed approximately 1.5 m above the ground on the south side of each tree, just within the canopy perimeter. Soil temperature and VWC sensors were installed at 10 cm depth on the north side of the tree just inside the canopy perimeter. Soil temperature was measured using one of two sensors: 5TM or ECT sensors (METER Group). VWC was measured using 5TM (METER Group). Solar irradiance was measured using a pyranometer (PYR, METER Group) placed either on the canopy floor or mounted to the trunk at ~1.5 m above ground. Pyranometers were placed at this height on the trunk to continue monitoring solar irradiance in the fall and spring months when snow covered the ground.

Gaps in the dendrometer and environmental data may be present due to exhausted batteries in the datalogger.

6. Data Access

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

Dendrometer, Soil, and Weather Observations, Arctic Tree Line, AK and NWT, 2016-2019

Contact for Data Center Access Information:

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

7. References

Eitel, J.U.H., K.L. Griffin, N.T. Boelman, A.J. Maguire, A.J.H. Meddens, J. Jensen, L.A. Vierling, S.C. Schmiege, and J.S. Jennewein. 2020. Remote sensing tracks daily radial wood growth of evergreen needleleaf trees. Global Change Biology 26:4068-4078. https://doi.org/10.1111/gcb.15112

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