Spectral Reflectance and Ancillary Data, Tundra Transect, North Slope, AK, 2000-2022

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Documentation Revision Date: 2023-11-17

Dataset Version: 1

Summary

This dataset provides visible-near infrared spectral reflectance, descriptions of vegetation cover, surface temperature, the total fraction of absorbed photosynthetically active radiation (fAPAR, 2001 only), permafrost active layer depth, elevation, and soil temperature at 5 cm depth. Measurements were made at every meter along a 100-m transect aligned mainly in an east-west direction, located approximately 300 m southeast of the National Oceanic and Atmospheric Administration (NOAA) Global Monitoring Laboratory (GML) baseline observatory near Utqiagvik, Alaska. Reflectance measurements were collected at nearly weekly intervals through the growing seasons of 2000 to 2002 to describe characteristics of green-up, peak growth, and senescence. Reflectance measurements were also collected once near peak growth in 2022. Ancillary measurements were collected at intervals through the 2001 and 2002 growing seasons.

This dataset includes 10 data files in comma-separated values (.csv) and one file in .zip format holding plot photos.

Figure 1. Photograph of field plot on August 8, 2001, located 73 m from western end of transect. Source: 010811METER73.JPG.

Citation

Huemmrich, K.F., and J.A. Gamon. 2023. Spectral Reflectance and Ancillary Data, Tundra Transect, North Slope, AK, 2000-2022. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2232

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1. Dataset Overview

Measurements were made along a 100-m transect aligned mainly in an east-west direction, located approximately 300 m southeast of the NOAA GML baseline observatory near Utqiagvik, Alaska. Reflectance measurements were collected at nearly weekly intervals through the growing seasons of 2000 to 2002 to describe characteristics of green-up, peak growth, and senescence. Reflectance measurements were also collected once near peak growth in 2022. Ancillary measurements were collected at intervals through the 2001 and 2002 growing seasons.

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 dataset

Huemmrich, K.F., and J.A. Gamon. 2022. Tundra Plant Reflectance, CO2 Exchange, PAM Fluorometry, and Pigments, AK, 2001-2002. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1960

- Measurements of plots of tundra vegetation collected in conjunction with the transect measurements.

Acknowledgement

This study was funded under the NASA ABoVE program (grant NNX17AC58A).

2. Data Characteristics

Study Area: 100-m transect aligned mainly in an east-west direction located approximately 300 m southeast of the NOAA GML baseline observatory near Utqiagvik, AK (BRW)

ABoVE Reference Locations

Domain: Core ABoVE

State/Territory: Alaska

Grid cells: Ah001v000, Bh008v001, Ch050v007

Spatial Resolution: Point measurements along a transect

Temporal Coverage: 2000-06-30 to 2022-08-08

Temporal Resolution: Measurements made during the growing season

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

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
transect near Utqiagvik, AK	-156.604369	-156.601561	71.322071	71.321974

Data file information

This dataset includes 10 data files in comma-separated values (.csv) format and one file in .zip format with plot photos.

Missing numeric data are -9999 in all files. Missing text data are "NA" in all files. In *Tram_Transect_SoilTemp.csv*, -8888 indicates ice.

Table 1. File names and descriptions.

File name	Description
Tram_Transect_Reflectance_YYYY.csv	Four spectral reflectance files interpolated to 1-nm intervals where YYYY = 2000, 2001, 2002, or 2022
Tram_Transect_Elevation.csv	Ground elevation data relative to meter one (western end) of the transect (assigned a value of one meter elevation)
Tram_Transect_SurfTemp.csv	Surface temperature data measured using Everest IR thermometer
Tram_Transect_SoilTemp.csv	Soil temperature data at 5-cm depth
Tram_Transect_ThawDepth.csv	Thaw depth data (active layer depth) measured in 2001 and 2002 mainly during June, July, and August approximately every three days
Tram_Transect_fAPAR.csv	The fraction of photosynthetically active radiation (fAPAR) absorbed by the standing vegetation, measured with a mini light bar
Tram_Transect_VegetationCover.csv	Estimated percent cover of vegetation and standing water

Plot_Photos.zip-contains files named YYMMDDMeterXX.jpeg	Photos of every meter along the transect where the first set of digits are the date (YYMMDD) and XX is the location of the photo in meters from the western end of the transect. All photos were taken of areas on the south side of the transect where reflectance measurements were collected

Variables in the .csv files

Table 2. Variables in the four reflectance files: Tram_Transect_Reflectance_2000.csv, Tram_Transect_Reflectance_2001.csv, Tram_Transect_Reflectance_2002.csv, and Tram_Transect_Reflectance_2022.csv

Variable	Units	Description
date	YYYY-MM-DD	Date
time_adt	hh:mm:ss	Start time of measurements in Alaska Daylight Time (UTC - 8 h)
location	m	Position along the transect starting from the western end of the transect
rfl_400 - rfl_1000	1	Spectral reflectance interpolated to 1-nm intervals; the numbers in the column names refer to the wavelengths in nm
notes	-	Comments on the measurements

Table 3. Variables in the file Tram_Transect_Elevation.csv

Variable	Units	Description
date	YYYY-MM-DD	Date
location	m	Position along the transect starting from the western end of the transect
relative_elevation	cm	Elevation of ground surface relative to meter one of the transect

Table 4. Variables in the file Tram_Transect_SurfTemp.csv

Variable	Units/format	Description
location	m	Position along the transect starting from the western end of the transect
surface_temp_YYYYMMDD	degrees C	Date surface temperature was measured using Everest IR thermometer

Table 5. Variables in the file Tram_Transect_SoilTemp.csv. Note: -8888 indicates ice.

Variable	Units/format	Description
location	m	Position along the transect starting from the western end of the transect
soil_temp_5cm_YYYYMMDD	degrees C	Date of soil temperature measurements made at 5-cm depth

Table 6. Variables in the file Tram_Transect_ThawDepth.csv

Variable	Units/format	Description
location	m	Position along the transect starting from the western end of the transect
thaw_depth_YYYYMMDD	cm	Thaw depth (active layer depth) measured in 2001 and 2002 mainly during June, July, and August approximately every three days. There are eight measurements only in 2001: one on June 16, two in July, and five in August. Measurements for 2002 begin June 9 and end September 1. Measurements were made using a metal rod graduated in centimeter intervals

Table 7. Variables in the file Tram_Transect_fAPAR.csv. Notes on the vegetation color are included for certain dates.

Variable	Units/format	Description
location	m	Position along the transect starting from the western end of the transect
total_fAPAR_YYYYMMDD	1	Total fraction of absorbed photosynthetically active radiation (fAPAR) where YYYYMMDD is one of 20010616, 20010627, 20010706, 20010711, 20010721, and 20010725
notes_total_fAPAR_YYYYMMDD	-	Notes for the dates 20010627, 20010721, and 20010725

Table 8. Variables in the file Tram_Transect_VegetationCover.csv

Variable	Units	Description
date	YYYY-MM-DD	Date
location	m	Position along the transect starting from the western end of the transect
green_cover	percent	Percent cover of green plants
graminoid_cover	percent	Percent cover of graminoids
other_vascular_plant_cover	percent	Percent cover of other vascular plants (i.e., nongraminoids)

total_vascular_plant_cover	percent	Percent cover of all vascular plants
moss_cover	percent	Percent cover of mosses
lichen_cover	percent	Percent cover of lichens
bare_ground_cover	percent	Percent cover of bare ground
standing_dead_vegetation_cover	percent	Percent cover of standing dead plants
standing_water_cover	percent	Percent cover of standing water
moss_fraction_tiny_carpet_moss	percent	Percent of moss cover that are tiny carpet mosses
moss_fraction_carpet_moss	percent	Percent of moss cover that are carpet mosses
moss_fraction_Polytrichum	percent	Percent of moss cover that are *Polytrichum* spp.
moss_fraction_dark_brown_moss	percent	Percent of moss cover that are dark brown mosses
moss_fraction_brown_curly_moss	percent	Percent of moss cover that are brown curly mosses
moss_fraction_sphagnum_moss	percent	Percent of moss cover that are *Sphagnum* spp.
moss_fraction_gold_brown_moss	percent	Percent of moss cover that are gold-brown mosses
moss_fraction_fuzzy_gold_brown_moss	percent	Percent of moss cover that are fuzzy gold-brown mosses
lichen_fraction_D_arctica	percent	Percent of lichen cover that are *Dactylina arctica*
lichen_fraction_C_cucullatta	percent	Percent of lichen cover that are *Cetraria cucullata*
lichen_fraction_C_nivalis	percent	Percent of lichen cover that are *Cetraria nivalis*
lichen_fraction_Cetraria	percent	Percent of lichen cover that are *Cetraria spp.*
lichen_fraction_T_subuliformis	percent	Percent of lichen cover that are *Thamnolia subuliformis*
lichen_fraction_S_globosus	percent	Percent of lichen cover that are *Sphaerophorus globosus*
lichen_fraction_A_nigricans	percent	Percent of lichen cover that are *Alectoria nigricans*
lichen_fraction_C_uncialis	percent	Percent of lichen cover that are *Cladonia uncialis*
lichen_fraction_Cladonia_finger	percent	Percent of lichen cover that are *Cladonia spp.* With finger growth form
lichen_fraction_Cladonia_cups	percent	Percent of lichen cover that are *Cladonia spp.* With cup growth form
lichen_fraction_Cladonia_red_brown	percent	Percent of lichen cover that are *Cladonia spp.* That are red-brown
lichen_fraction_O_frigida	percent	Percent of lichen cover that are *Ochrolechia frigida*
lichen_fraction_yellow_stick	percent	Percent of lichen cover that are yellow stick lichens
lichen_fraction_Pertusaria	percent	Percent of lichen cover that are *Pertusaria spp.*
graminoid_fraction_E_angustifolium	percent	Percent of graminoid cover that are *Eriophorum angustifolium*
graminoid_fraction_E_vaginatum	percent	Percent of graminoid cover that are *Eriophorum vaginatum*
graminoid_fraction_E_russeolum	percent	Percent of graminoid cover that are *Eriophorum russeolum*
graminoid_fraction_L_arctica	percent	Percent of graminoid cover that are *Luzula arctica*
graminoid_fraction_L_confusa	percent	Percent of graminoid cover that are *Luzula confusa*
graminoid_fraction_P_arctica	percent	Percent of graminoid cover that are *Poa arctica*
graminoid_fraction_D_fisheri	percent	Percent of graminoid cover that are *Duptonia fisheri*
graminoid_fraction_A_latifolia	percent	Percent of graminoid cover that are *Arctagrostis latifolia*
graminoid_fraction_C_aquatilis	percent	Percent of graminoid cover that are *Carex aquatilis*
other_vascular_plant_fraction_R_nivalis	percent	Percent of other vascular plant cover that are *Ranunculus nivalis*
other_vascular_plant_fraction_S_rotundifolia	percent	Percent of other vascular plant cover that are *Salix rotundifolia*
other_vascular_plant_fraction_P_frigidus	percent	Percent of other vascular plant cover that are *Petasites frigidus*
other_vascular_plant_fraction_P_hyparctica	percent	Percent of other vascular plant cover that are *Potentilla hyparctica*
other_vascular_plant_fraction_C_officinalis	percent	Percent of other vascular plant cover that are *Cochlearia officinalis*
other_vascular_plant_fraction_S_hieracifolia	percent	Percent of other vascular plant cover that are *Saxifraga hieracifolia*
other_vascular_plant_fraction_V_vitis-idaea	percent	Percent of other vascular plant cover that are *Vaccinium vitis-idaea*
other_vascular_plant_fraction_P_macounii	percent	Percent of other vascular plant cover that are *Papaver macounii*
other_vascular_plant_fraction_S_atropupureus	percent	Percent of other vascular plant cover that are *Senecio atropupureus*

other_vascular_plant_fraction_S_cernua	percent	Percent of other vascular plant cover that are *Saxifraga cernua*
notes		Includes estimation of percent of plants that have turned red in the post-peak period

3. Application and Derivation

The objective of this study was to examine spatial and seasonal variations in spectral reflectance as it varies across the tundra landscape and how it is related to vegetation and environmental characteristics.

4. Quality Assessment

The Unispec instrument has a spectral resolution of approximately 3 nm, and the processed reflectance spectra were interpolated to 1-nm bands. The reflectance curve often has spikes over wavelengths between 759 and 766 nm, most likely due to the effect of the atmospheric O_2 absorption band in that spectral region. These spikes have not been removed from this dataset.

Thaw depth can be underestimated due to the rod hitting a rock instead of the permafrost.

Coverage of bare ground and standing dead plants was estimated.

5. Data Acquisition, Materials, and Methods

Site Description

The 100-m transect (endpoint latitude-longitude coordinates: 71.321974° N, -156.604369° E and 71.322071° N, -156.601561° E) aligned mainly in an east-west direction was located approximately 300 m southeast of the NOAA GML baseline observatory near Utqiagvik, AK (BRW) in a landscape of wet sedge wetland tundra patterned ground with high centered polygons producing microtopographic variations between troughs and the higher polygon centers.

Measurement Frequency

Reflectance measurements were collected at nearly weekly intervals through the growing seasons of 2000 to 2002 to describe characteristics of green-up, peak growth, and senescence. Reflectance measurements were also collected once near peak growth in 2022. Ancillary measurements were collected at intervals through the 2001 and 2002 growing seasons.

Measurement Methods

Spectral Reflectance

Visible-near infrared spectral reflectance measurements were collected at 1-m intervals along the 100-m transect using a dual channel spectroradiometer (Unispec DC, PP Systems, Amesbury MA, USA). This spectrometer has two fiber-optic cables, one with a diffuser head viewing upward and the other pointing vertically downward to view the ground. Each measurement simultaneously collects both reflected radiance and incident irradiance. By collecting incident and reflected radiance at the same time data from this dual-detector spectrometer were able to account for changing light conditions.

Measurements were collected of a white reference standard (Spectralon, LabSphere, North Sutton, New Hampshire, USA) to produce a cross-calibration between the measured incident and reflected radiance used to calculate reflectance.

When the dual-detector spectrometer was not available, reflectance was sampled by a single-detector spectrometer (UniSpec SC, PP Systems, Amesbury MA), and reflectance calculated by dividing the surface radiance against the radiance of the same reference panel.

The Unispec instrument has a spectral resolution of approximately 3 nm, and the processed reflectance spectra were interpolated to 1-nm bands. The reflectance curve often has spikes over wavelengths between 759 and 766 nm, most likely due to the effect of the atmospheric O_2 absorption band in that spectral region. These spikes have not been removed from this dataset.

Spectrometer measurements viewed the area to the south of the transect with a nadir view. In 2000 and 2001, a track was constructed along the transect with the track positioned less than a meter above the ground. In these years, reflectance data were collected from a tram cart that ran along the tracks and carried the spectrometer with the fiber optics suspended in a vertical (nadir) position over the targets resulting in an approximately 0.8-m diameter field of view. The track was marked at meter intervals for accurate spatial location of repeat measurements. The tram tracks were not installed for the 2002 and 2022 measurements. For these measurements, a 100-m tape measure was extended along the transect to locate points and the spectrometer measurements were collected by a person carrying the spectrometer (Gamon et al., 2013).

Surface Temperature

In 2001 and 2002, surface temperatures were measured using a handheld Everest Infrared Thermometer (Everest Interscience Inc., Chino Hills, CA). One measurement was collected at every meter along the transect.

Thaw Depth

In 2001 and 2002, thaw depth (or active layer depth) was measured using a metal rod graduated in centimeter intervals. The rod was inserted into the ground until stopped by a frozen layer of soil and the depth was read off the rod and recorded in a notebook. Thaw depth can be underestimated due to the rod hitting a rock instead of the permafrost.

Soil Temperatures

Only collected in 2002, soil temperatures were measured at 5-cm depth using a temperature probe. The temperatures were recorded to the nearest °C.

fAPAR

fAPAR was only collected in 2001. To determine total fAPAR, a series of photosynthetically active radiation (PAR) measurements were made using a custom-made “light bar” consisting of a linear array of GaAsP sensors (G1118 Hamamatsu Corp., Bridgewater, N.J) mounted within an aluminum U-bar under a white plastic diffuser. The size of this light bar (1 cm wide × 1 cm deep × 10 cm long) was specifically chosen to fit under the low tundra vegetation canopy. A datalogger (LI-1000, LI-COR, Lincoln, NE, USA) was used to read the PAR values from the light bar sensor array. The light bar was held horizontally above the canopy approximately 30 cm above the ground with the sensors looking downward to measure the reflected PAR (Qr), then flipped over to measure incident PAR (Qin). Due to the low stature of the canopy, and the dark understory surface (typically covered by moss or a thin layer of standing water), it was difficult to obtain a measurable value of the PAR reflected from the ground under the canopy (Qrb), and this value was found to be

negligible so set to zero in the calculation of fAPAR. The PAR transmitted through the canopy (Qt) was measured by placing the light bar at ground level under the vascular plant canopy. Three repetitions of Qt were made at each meter along the transect and averaged. fAPAR was then calculated as:

fAPAR = (Qin – Qr – Qt)/Qin

The fAPAR measurements were collected under cloudy (diffuse light) conditions.

Microtopography

The microtopography along the transect was measured on June 23, 2001. The distance from the tram track to the ground was measured at every meter using a tape measure along with the angle of horizontal of the track using a digital level. The ground elevation relative to meter 1 (western end) of the transect (assigned a value of 1 meter elevation) was calculated as the measured distance from the track to the ground adjusted by the cumulative variation of the track elevation derived from the angle measurements.

Vegetation Cover Descriptions

Three times in 2001 vegetation cover was described for every meter along the transect. An early season (pre-peak) cover description was made June 28-30, peak season cover on August 6-11, and a late season (post-peak) cover September 2-4, 2001. Sampling was done by laying a one meter by one meter quadrat every meter along the transect. The percentage cover was estimated in that square meter. The primary aim of these measurements was to describe the coverage of different plant functional types (PFT). The functional type groups were: lichen, moss, and vascular plants, which was divided up into graminoids and other vascular plants. In addition, coverage of bare ground and standing dead plants was estimated. For the peak and post-peak cover of standing water was also explicitly described, for pre-peak observations standing water cover was qualitatively given in the comments. In the post-peak data, a specific estimation of the coverage of plants that had changed color (%red) was included in notes. Total cover can be greater than 100% due to the three dimensional structure of the plant canopies.

The PFT coverage was further broken down by species fractions of each PFT cover. Species identification, particularly for lichens and mosses, was difficult so many of the species' descriptions are simply physical descriptions of the plants.

6. Data Access

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

Spectral Reflectance and Ancillary Data, Tundra Transect, North Slope, AK, 2000-2022

Contact for Data Center Access Information:

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

7. References

Gamon, J.A., K.F. Huemmrich, R.S. Stone, and C.E. Tweedie. 2013. Spatial and temporal variation in primary productivity (NDVI) of coastal Alaskan tundra: Decreased vegetation growth following earlier snowmelt. *Remote sensing of environment*, *129*, 144-153. https://doi.org/10.1016/j.rse.2012.10.030

Huemmrich, K.F., and J.A. Gamon. 2022. Tundra Plant Reflectance, CO2 Exchange, PAM Fluorometry, and Pigments, AK, 2001-2002. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1960