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[DAAC Home](#) > [Get Data](#) > [NASA Projects](#) > [Arctic-Boreal Vulnerability Experiment \(ABOVE\)](#) > [User guide](#)

Methane Fluxes from Shorelines and Differing Surfaces, Big Trail Lake, Alaska, 2019

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Summary

This dataset provides methane fluxes from hot-spot and non-hot spot differing surfaces at Big Trail Lake (BTL) in the Goldstream Valley near Fairbanks, AK, USA. Measurements were taken at a remotely-sensed methane hotspot on the shoreline of a pond, adjacent to BTL with a Los Gatos Ultra-Portable Greenhouse Gas Analyzer (UGGA), and from various non-hotspot surfaces representative of the broader thermokarst lake ecosystem with bucket chambers. All data were collected between 2019-07-04 and 2019-12-04 during the daytime hours of 09:35-17:32 local time. A ground-based CH₄ enhancement survey was performed on 2019-07-06 between 13:25-17:15 Alaska Daylight Time (AKDT), approximately two hours following an AVIRIS-NG overflight and hotspot detection at the Eastside Pond. Methane flux is reported in units of both mmol CH₄ m⁻² hr⁻¹ and mg CH₄ m⁻² d⁻¹. Flux errors are quantified for each

Methane flux at hotspots was monitored using chambers constructed from plastic five-gallon (18.9-liter) buckets with bottoms removed and resealable air-tight lids were installed at hotspot flux monitoring locations. Non-hotspot fluxes were measured using permanent aluminum chamber-collars installed to 3–5 cm depth at long-term flux monitoring locations both near the hotspot and other locations of BTL. A large transparent chamber was used at all non-hotspot locations and was designed to enclose vegetation up to ~1.5 m in height. The data represent non-ebullitive (diffusive + potential plant-mediated) flux.

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



Figure 1. Chambers used to measure diffusive CH₄ fluxes. a) Large chamber resting on the pre-installed aluminum collar, sealed on edges with pipe insulation. b) Five-gallon (18.9-liter) bucket with an open bottom and air-tight screw lid to measure hotspot flux locations.

Citation

Elder, C., N. Hasson, P. Hanke, S. Wright, K.W. Anthony, and C.E. Miller. 2021. Methane Fluxes from Shorelines and Differing Surfaces, Big Trail Lake, Alaska, 2019. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/1870>

Table of Contents

1. [Dataset Overview](#)
2. [Data Characteristics](#)
3. [Application and Derivation](#)
4. [Quality Assessment](#)
5. [Data Acquisition, Materials, and Methods](#)
6. [Data Access](#)
7. [References](#)

1. Dataset Overview

This dataset provides methane fluxes from hot-spot and non-hot spot differing surfaces at Big Trail Lake (BTL) in the Goldstream Valley near Fairbanks, AK, USA. Measurements were taken at a remotely-sensed methane hotspot on the shoreline of a pond, adjacent to BTL with a Los Gatos Ultra-Portable Greenhouse Gas Analyzer (UGGA), and from various non-hotspot surfaces representative of the broader thermokarst lake ecosystem with bucket chambers. All data were collected between 2019-07-04 and 2019-12-04 during the daytime hours of 09:35–17:32 local time. A ground-based CH₄ enhancement survey was performed on 2019-07-06 between 13:25–17:15 Alaska Daylight Time (AKDT), approximately two hours following an AVIRIS-NG overflight and hotspot detection at the Eastside Pond. Methane flux is reported in units of both mmol CH₄ m⁻² hr⁻¹ and mg CH₄ m⁻² d⁻¹. Flux errors are quantified for each.

Methane flux at hotspots was monitored using chambers constructed from plastic five-gallon (18.9-liter) buckets with bottoms removed and resealable air-tight lids were installed at hotspot flux monitoring locations. Non-hotspot fluxes were measured using permanent aluminum chamber-collars installed to 3–5 cm depth at long-term flux monitoring locations both near the hotspot and other locations of BTL. A large transparent chamber was used at all non-hotspot locations and was designed to enclose vegetation up to ~1.5 m in height. The data represent non-ebullitive (diffusive + potential plant-mediated) flux.

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

Elder, C.D., D.R. Thompson, A.K. Thorpe, H.A. Chandanpurkar, P.J. Hanke, N. Hasson, S.R. James, B.J. Minsley, N.J. Pastick, D. Olefeldt, K.M. Walter Anthony, and C.E. Miller. 2021. Characterizing methane emission hotspots from thawing permafrost. *Global Biogeochemical Cycles*, 35, e2020GB006922. <https://doi.org/10.1029/2020GB006922>

Related Dataset

Elder, C., P. Hanke, K.W. Anthony, D.R. Thompson, C.E. Miller, and A.K. Thorpe. 2020. ABOVE: Methane Flux across Two Thermokarst Lake Ecosystems, Interior Alaska, 2018. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/1778>

Acknowledgments

This work was funded by NASA's Terrestrial Ecology Program via the Arctic Boreal Vulnerability Experiment (ABOVE) (grant 18-TE18- 0051).

2. Data Characteristics

Spatial Coverage: Big Trail Lake, Gold Stream Valley, interior Alaska

ABOVE Reference Locations

Domain: Core ABOVE

ABOVE grid tile (5 m): Ch040v032

Spatial Resolution: Chamber measurements have footprints <1 m² and could be considered point data that cover a roughly 15 ha study area

Temporal Resolution: Fluxes were collected at various time points and were replicated within 2–3 weeks

Temporal Coverage: 2019-07-04 to 2019-12-14

Study Area: Latitude and longitude are given in decimal degrees.

Site	Northernmost Latitude	Southernmost Latitude	Easternmost Longitude	Westernmost Longitude
Big Trail Lake, Goldstream Valley, interior Alaska	64.92051	64.918594	-147.81868	-147.82454

Data File Information

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

Data File Details

Methane flux is the primary variable in units of both mmol CH₄ m⁻² hr⁻¹ and mg CH₄ m⁻² d⁻¹. Flux errors are quantified for each.

Table 1. Variable names and descriptions.

Variable	Units	Description
plot_id		Plot IDs in which measurements were made using smaller bucket chambers start with either "Hotspot_..." or "HotspotBucket_", " or "c36.1_..." (different teams used slightly different nomenclature). Plot IDs in which measurements were made with a larger transparent chamber, are designated as "Collar", designed to enclose vegetation up to ~1.5 m in height. Plot IDs with "rep" in the name are measurements that were immediately replicated in time from the same "transect ID" location.
transect_id		Identification of measurement stations. Measurements that have the same "transect_ID" represent replicated measurements taken at different times at the same location.
latitude	decimal degrees	Latitude of measurement station
longitude	decimal degrees	Longitude of measurement station
date	YYYY-MM-DD	Date of measurement

time	HH:MM:SS	Time of measurement in HH:MM:SS in local time (Alaska Time)
mmol_ch4	mmol CH ₄ m ⁻² hr ⁻¹	Methane flux reported in mmol CH ₄ m ⁻² hr ⁻¹
flux_error	mmol CH ₄ m ⁻² hr ⁻¹	Flux error for methane reported in mmol CH ₄ m ⁻² hr ⁻¹
mg_ch4	mg CH ₄ m ⁻² d ⁻¹	Methane flux reported in mg CH ₄ m ⁻² d ⁻¹
flux_error_mg	mg CH ₄ m ⁻² d ⁻¹	Flux error for methane reported in mg CH ₄ m ⁻² d ⁻¹
wet_dry		A qualitative assessment of soil saturation. "wet" is typically defined as fully saturated where "dry" may indicate anything less than fully saturated
surface_1		Qualitative assessment of the most prominent surface type within the chamber footprint. All measurements made in the CH ₄ -enhanced area identified by AVIRIS-NG have "surface_1" classified as "hotspot." The general classification of "wet sediment" mostly describes water-saturated mud and lake sediments in the wet shorelines of Big Trail Lake and surrounding wetlands
surface_2		Qualitative assessment of the next 2 nd most prominent surface
surface_3		Qualitative assessment of the 3 rd most prominent surface. If a third surface type was not present (< roughly 10% of measurement footprint) "nan" was used

3. Application and Derivation

The hotspot flux data can be used to quantify typical emissions from AVIRIS-NG-detected CH₄ hotspots. CH₄ fluxes from other various surfaces are useful for upscaling CH₄ emissions across boreal landscapes.

4. Quality Assessment

Uncertainty in the individual flux calculations was determined by propagating our best estimate of chamber volume error and the square root of the residuals to the linear fit of raw data through the ideal gas law calculation. Any flux solutions that required smoothing maintained the error associated with the linear fit through the original 1 Hz resolution data.

5. Data Acquisition, Materials, and Methods

The study site was the Big Trail Lake (BTL), in the Goldstream Creek valley, near Fairbanks. A ground-based CH₄ enhancement survey was performed on July 6, 2019, between 13:25–17:15 Alaska Daylight Time (AKDT), approximately two hours following an AVIRIS-NG overflight and hotspot detection at the Eastside Pond. During the ground-based enhancement survey, atmospheric CH₄ concentrations were measured on foot at 1 Hz with a Los Gatos Ultra-Portable Greenhouse Gas Analyzer (UGGA) (ABB INC., 85 Quebec City, CA). Measurements were made at approximately 0.5 m AGL while walking along a ~10 cm s⁻¹ snaking transect starting in the southwest and working northeast of the hotspot region. The inlet to the UGGA was fitted to the lid of a 18.9 L bucket with the bottom removed to minimize interference from non-local sources and held at arm's length in front of the surveyor. Wooden planks, which were placed at least one hour before measurement, were used as footpaths in sensitive environments to minimize disturbance.

While these enhancement survey data are not part of this dataset, they were important in determining the hotspot vs. non-hotspot locations for the monitoring data included herein.

Methane Flux Monitoring at Hotspots

Hotspot flux monitoring measurements at the Eastside Pond CH₄ hotspot were implemented in July 2019 to further validate airborne detections. Hotspot monitoring chambers, constructed from plastic 18.9 L buckets with bottoms removed and resealable air-tight lids (Gamma Seal Lid, Encore Plastics, Sandusky, OH, USA) (Fig. 1), were installed at hotspot flux monitoring locations.

All diffusive fluxes, including non-hotspot measurements (described below), were calculated from the ideal gas law using chamber volume, temperature, atmospheric pressure measured via a LI-COR LI7700 (LI-COR Inc., Lincoln, Nebraska, USA) operating in the middle of the study area. The slope of linear CH₄ concentration change ($R^2 > 0.985$ correlation to linear least-squares fit) for a minimum of 45 seconds (45 observations) and a maximum of 210 seconds ($45 < n < 210$) was used to determine the mass change within the chambers. Chamber observation periods were ≤5 minutes and observations within the first 3.5 minutes of chamber placement were prioritized. Any observations with non-linear concentration change (R^2 of linear fit < 0.985), no linear sections ≥45 seconds, or with stepwise concentration increases (interpreted as ebullition) were omitted to ensure that the reported measurements represent purely diffusive fluxes. These strict protocols eliminated any disturbance caused by placing the chamber, which we assumed would manifest as a non-linear CH₄ concentration change.

Bucket chambers were installed such that 2–5 cm of the open bottom was submerged in saturated sediments to create a hermetic seal. These hotspot monitoring positions (n=12) were equally spaced 3–4 m apart on sparsely vegetated or bare, saturated surfaces along the southeastern shoreline of the Eastside Pond where the water table was nearest to the surface, or where we expected the highest diffusive fluxes. Buckets were left in place, sans lid, for at least 24 hours before fluxes were measured and remained in place until removal just before seasonal freeze up. During all flux measurements, lids fitted with 0.635 cm diameter plastic valves were gently screwed into the top of each bucket, creating an air-tight closed chamber to recirculate air through the UGGA. Lids were removed after each measurement.

All hotspot fluxes reported here were measured on 5 days in between 2019-07-07 and 2019-09-17, and on 2019-12-14, resulting in 66 total observations from the Eastside Pond hotspot region. Hotspot fluxes were not measured at night; therefore, the daytime measurements were assumed to capture the diurnal variability of CH₄ hotspot emissions. All fluxes were measured between the hours of 09:35 to 17:32 local time. Plant-mediated CH₄ emission potentially contributed to total observed flux in cases where buckets included sparse emergent vegetation and flux was linear. A singular bucket was placed on the snow surface at the hotspot location to observe fluxes on 2019-12-14. The chamber volume was corrected for snow density inside the chamber for this measurement.

Methane Flux Monitoring at Non-Hotspot Locations

Non-hotspot CH₄ fluxes were monitored from various surfaces at BTL via repeat chamber-flux measurements along five shore-to-forest transects since summer 2018 (Elder et al., 2020). Fluxes were also measured starting in July 2019, except that instead of placing chambers directly on the surface,

permanent aluminum chamber-collars were installed to 3–5 cm depth at long-term flux monitoring locations both near the hotspot and other locations of BTL. Aluminum collars were in place for a minimum of one week before flux measurements were made. A removable flotation system constructed of pipe insulation was attached to the chamber for measurements over open water. A larger transparent chamber was used at all non-hotspot locations and was designed to enclose vegetation up to ~1.5 m in height. Therefore, like the hotspot monitoring, these observations also included potential plant-mediated fluxes when vegetation was present in the chamber and fluxes were linear. Thus, fluxes reported herein should be considered as inclusive of linear plant-mediated emission and exclusive of ebullitive emissions. Since ebullition was not determined from any of our chamber observations, our flux estimates are conservative with respect to total flux.

Refer to Elder et al. (2021) for details.

6. Data Access

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

[Methane Fluxes from Shorelines and Differing Surfaces, Big Trail Lake, Alaska, 2019](#)

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
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7. References

Elder, C.D., D.R. Thompson, A.K. Thorpe, H.A. Chandanpurkar, P.J. Hanke, N. Hasson, S.R. James, B.J. Minsley, N.J. Pastick, D. Olefeldt, K.M. Walter Anthony, and C.E. Miller. 2021. Characterizing methane emission hotspots from thawing permafrost. *Global Biogeochemical Cycles*, 35, e2020GB006922. <https://doi.org/10.1029/2020GB006922>

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Policy
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Partners

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Science Themes
NASA Projects
All Datasets

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Data Scope and
Acceptance
Data Authorship Policy
Data Publication Timeline
Detailed Submission
Guidelines

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