

ABoVE: Seasonal Dissolved Gases and Isotopes in Arctic Alaska Rivers

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Summary

This dataset provides dissolved carbon dioxide (CO₂) and methane (CH₄) concentrations alongside their stable and radiocarbon isotopic compositions within the Arctic Sagavanirktok and Kuparuk River watersheds located on the North Slope of Alaska. The data were collected during the spring, fall, and summer seasons in 2022. In field separation of the bulk gaseous components (N₂, CO₂, and CH₄) from the liquid phase was achieved using a degassing membrane contactor. Laboratory isotopic analyses were conducted at the W. M. Keck Carbon Cycle Accelerator Mass Spectrometer facility at UC Irvine. This collection aims to provide insights into the seasonal dynamics of greenhouse gas emissions in these critical Arctic environments, thereby contributing valuable information for climate change research and monitoring programs. The data are provided in comma separated values (CSV) format.

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

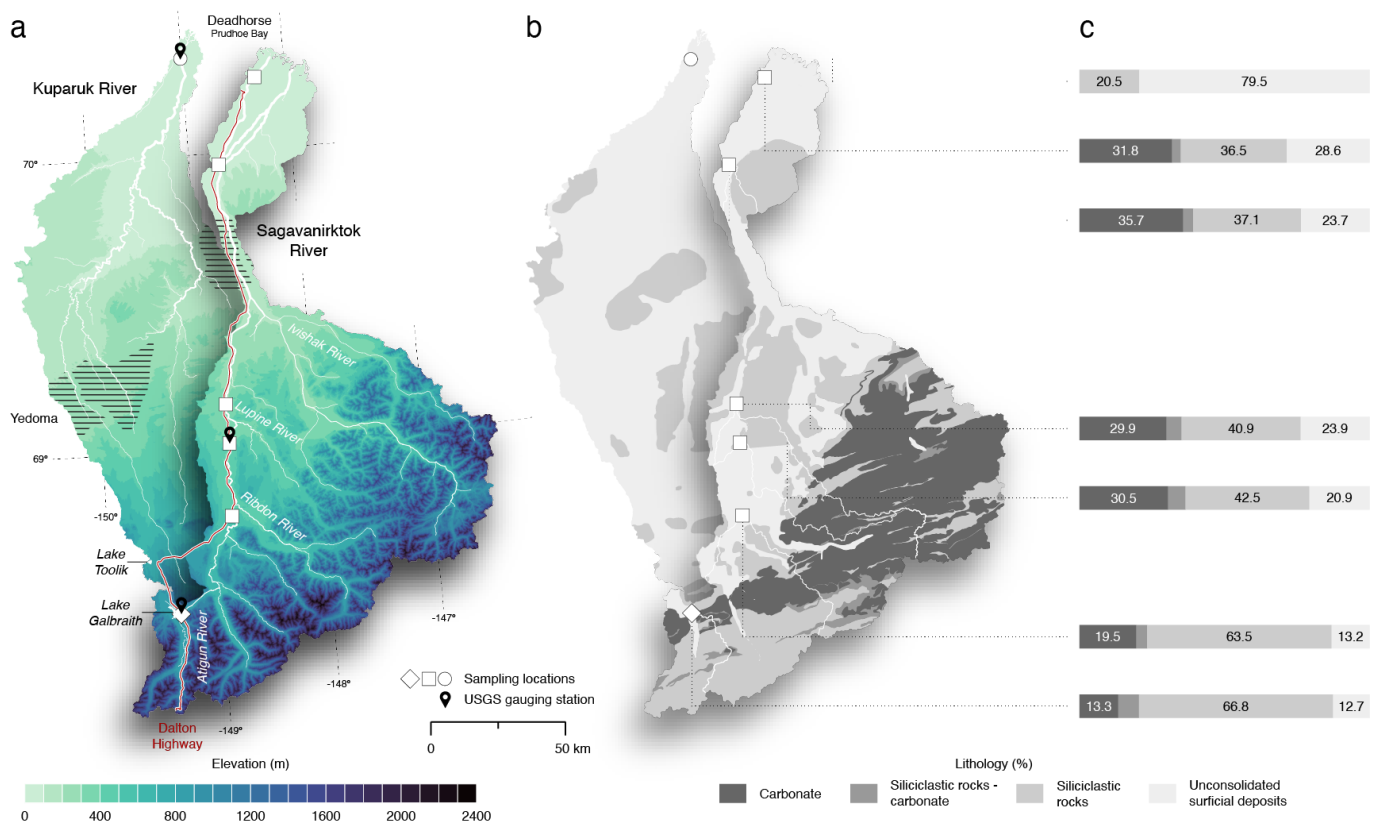


Figure 1. Topographical and lithological overview of the Sagavanirktok and Kuparuk River Basins: This figure illustrates (a) elevation, (b) underlying lithology based on Wilson et al. (2015) and (c) lithology percentages per sub-watershed. Sampling locations are marked as follows: a diamond for Atigun River, squares for Sagavanirktok River, and a circle for Kuparuk River.

Citation

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1. Dataset Overview

This dataset provides dissolved carbon dioxide (CO₂) and methane (CH₄) concentrations alongside their stable and radiocarbon isotopic compositions within the Arctic Sagavanirktok and Kuparuk River watersheds located on the North Slope of Alaska. The data were collected during the spring, fall, and summer seasons in 2022. In field separation of the bulk gaseous components (N₂, CO₂, and CH₄) from the liquid phase was achieved using a degassing membrane contactor. Laboratory isotopic analyses were conducted at the W. M. Keck Carbon Cycle Accelerator Mass Spectrometer facility at UC Irvine. This collection aims to provide insights into the seasonal dynamics of greenhouse gas emissions in these critical Arctic environments, thereby contributing valuable information for climate change research and monitoring programs. The data are provided in comma separated values (CSV) format.

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

Schwab, M.S., C.D. Elder, X. Xu, C.I. Czimczik, and C.E. Miller. 2024. Isotopic Seasonality of Fluvial-Derived Greenhouse Gases Imply Active Layer Deepening. In review in *Environmental Research Letters*.

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2. Data Characteristics

Spatial Coverage: Sagavanirktok and Kuparuk Rivers, North Slope Borough, Alaska, USA.

ABoVE Reference Locations

Domain: Core
State/Territory: Alaska
Grid Cells: Ah001v000, Bh008v002, Bh008v003, Ch048v021, Ch049v021, Ch050v020, Ch052v018, Ch053v016, Ch053v017

Spatial Resolution: Point samples

Temporal Coverage: Spring: 2022-06-05 to 2022-06-09; Summer: 2022-07-15 to 2022-07-19; Fall: 2022-08-30 to 2022-09-04

Temporal Resolution: Samples were collected over the course of a week during spring and replicated for summer and fall.

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

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Alaska	-149.3744	-148.3033	70.3307	68.4519

Data File Information

There is one file with this dataset: **Dissolved_GreenhouseGases_Sagavanirktok_Kuparuk_Rivers.csv**.

Table 1. Variables in the data file

Variable	Units/Format	Description
id	-	Unique identifier for each discrete measurement
location	-	Name of the nearest location to the measurement site
river	-	River name corresponding to water collection site
latitude	degrees north	Latitude coordinate of the sampling site, expressed in decimal degrees
longitude	degrees east	Longitude coordinate of the sampling site, expressed in decimal degrees
date	YYYY-MM-DD	Date of sample collection
season	-	Season corresponding to the time of sample collection
discharge	m ³ s ⁻¹	Discharge measured at the USGS gauging station 15905100, 15908000, and 15896000 in cubic meters per second
co2	μmol L ⁻¹	Dissolved CO ₂ concentration, expressed in micromoles per liter

co2_f14c	1	Fraction modern of dissolved CO ₂ (CO ₂ -F ¹⁴ C)
co2_f14c_sd	1	Standard deviation corresponding to the fraction modern of dissolved CO ₂
co2_d13c	‰	Stable carbon isotopic composition of dissolved CO ₂ (CO ₂ -d ¹³ C) in per mille (‰)
co2_d13c_sd	‰	Standard deviation corresponding to the stable isotopic composition of dissolved CO ₂ in per mille (‰)
ch4	μmol L ⁻¹	Dissolved CH ₄ concentration, expressed in micromoles per liter (μmol L ⁻¹)
ch4_f14c	1	Fraction modern of dissolved CH ₄ (CH ₄ -F ¹⁴ C)
ch4_f14c_sd	1	Standard deviation corresponding to the fraction modern of dissolved CH ₄
ch4_d13c	‰	Stable carbon isotopic composition of dissolved CH ₄ (CH ₄ -d ¹³ C) in per mille (‰)
ch4_d13c_sd	‰	Standard deviation corresponding to the stable isotopic composition of dissolved CH ₄ in per mille (‰)

3. Application and Derivation

This study represents the first collection of dissolved CO₂ and CH₄ stable (δ¹³C) and radiocarbon (¹⁴C) isotopic data from two Arctic river systems during the ice-free period. By examining temporal and geomorphological gradients, patterns and pinpoint source contributions of these greenhouse gases can be discerned to enhance understanding of Arctic fluvial biogeochemistry.

4. Quality Assessment

The measurement uncertainties and quality controls for δ¹³C and F¹⁴C data in the provided study were addressed using high-precision instruments and robust calibration methods. For F¹⁴C, uncertainties were mitigated through corrections for process blank contamination based on the methods detailed by Elder (2018) and Elder et al. (2018). The ¹⁴C content was measured using an accelerator mass spectrometer, with procedural blanks included to account for any background contamination. For δ¹³C, the data quality was ensured by using isotope-ratio mass spectrometry calibrated against known laboratory standards of CH₄ and CO₂. This calibration helps in maintaining the accuracy and consistency of δ¹³C measurements across different samples. The procedures used effectively minimize biases and enhance the reliability of the carbon isotope data reported.

5. Data Acquisition, Materials, and Methods

Sample Collection

Dissolved CO₂ and CH₄ were sampled from six locations along the Sagavanirktok River, spanning a geomorphological gradient, and from a single site in the Kuparuk River delta. These collections occurred shortly after ice breakup (5-9 June), during summer (15-19 July), and in fall (30 August to 3 September) of 2022. A Liqui-Cel membrane contactor was used (Membrana, 3M Company) to extract the dissolved gases as described in Elder et al. (2018, 2019). River water was drawn through tubing connected to a peristaltic pump from the riverbank, maintaining an average flow rate of 1.3 L min⁻¹ for durations ranging from 90 to 180 min. The setup included a filtration system with two stainless steel mesh filters (178 μm (T-29595-39) and 40 μm (T-2959-35), Cole-Parmer) and two polypropylene sediment depth filters (20 μm SD-25-0520 Flow-Pro and 5 μm SD-25-0505 Hydronix, FreshWatersystems) to remove suspended particulates. The separation of the bulk gaseous components (N₂, CO₂, and CH₄) from the liquid phase was achieved using a degassing membrane contactor. These gases were then captured in a pre-evacuated, pre-weighed 2 L stainless steel canister equipped with a stainless-steel bellows sealed valve (SS-4BG, Swagelok). To mitigate the risk of cross-contamination, all filters were replaced, and the system was flushed with river water for 30 min before each sampling session.

Laboratory Analyses

All isotopic analyses were conducted at the W. M. Keck Carbon Cycle Accelerator Mass Spectrometer facility at UC Irvine. Canisters were weighed to quantify the mass of accumulated dissolved gases before connecting them to a flow-through vacuum extraction line designed for the sequential separation and purification of CO₂ and CH₄ (Pack et al., 2015). Upon introducing the sample gas into the vacuum line, CO₂ was cryogenically isolated from CH₄, carbon monoxide (CO), and non-condensable gases (e.g., N₂) using a liquid nitrogen trap. CO was converted into CO₂ at 290°C with cupric oxide and captured in another liquid nitrogen trap. Similarly, CH₄ was oxidized to CO₂ in a 975°C furnace in the presence of cupric oxide. CH₄-derived CO₂ and sample CO₂ were further purified on the vacuum line, quantified manometrically, and chemically reduced into graphite using the sealed-tube zinc-reduction method (Xu et al., 2007). Isotopic standards were extracted using the same methods to evaluate the procedural contamination of the sampling methods/extraction line system.

The ¹⁴C content of the graphitized samples was measured with a 0.5 MV 1.5SDH-2 accelerator mass spectrometer (AMS, National Electrostatics Corporation) alongside procedural blanks and analytical standards (Beverly et al., 2010). To compensate for process blank contamination, all samples were corrected following the methods described in Elder (2018) and Elder et al. (2018) and reported as fraction modern, F¹⁴C (Reimer et al., 2004). For samples > 0.2 mg C, an aliquot was analyzed for δ¹³C using isotope-ratio mass spectrometry (IRMS) (GasBench II coupled to a Finnigan Delta

Plus IRMS (Thermo Scientific)). Stable isotope samples were calibrated against gaseous CH₄ and CO₂ laboratory standards and reported in δ¹³C notation relative to Vienna Pee Dee Belemnite (VPDB).

The CO₂ and CH₄ concentrations were computed from the extracted yields and corrected to reflect a 90% efficiency of the vacuum line extraction (Elder 2018). Subsequently, these concentrations were refined by applying the efficiencies of the Liqui-Cel extraction for CO₂ and CH₄, which were empirically determined based on the average flow rate (x) as follows:

$$\text{CO}_2 \text{ efficiency} = -0.4 * \ln(x) + 4 \quad (1)$$

$$\text{CH}_4 \text{ efficiency} = -0.49 * x^2 + 1.1 * x + 0.4. \quad (2)$$

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