ABoVE: Year-Round Soil CO2 Efflux in Alaskan Ecosystems, Version 2

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Documentation Revision Date: 2020-02-14

Dataset Version: 2

Summary

This dataset provides soil-surface carbon dioxide (CO2) efflux derived from measurements of soil respiration with forced diffusion (FD) chambers. Soil Respiration Stations (SRS) were installed at 11 boreal and tundra sites along a broad S-N transect starting from near Fairbanks in interior Alaska and extending to Atqasuk in northern Alaska. Each SRS measures soil respiration and ambient atmospheric CO2 concentrations with a forced diffusion (FD) chamber to derive soil CO2 flux. The SRS also measures soil CO2 concentrations and temperatures using instrumented chambers buried at 5, 10, and 15 cm depths in the soil profile. At the highest measurement frequency, data is collected hourly, and during the lowest winter frequency, every 48 hours. The data include flux values and running median filtered values from the two or three FD chambers at each site. Soil CO2 and temperature profile data (beginning June 2017) were collected beginning 2016-08-18 through 2018-09-12. As of this publication, sampling is continuing and new data will be added as available.

The soil respiration forced diffusion (FD) chambers are fully automated, low-powered systems that measured soil surface CO2 efflux and ambient atmospheric CO2 concentrations using an eosGP CO2 gas analyzer and pumping system. Flux was calculated using the two CO2 values and a chamber-specific precalibrated constant. Two or three FD chambers were deployed at each site.

This dataset includes 11 data files in Comma Separated Value (*.csv) format.

Figure 1. a) A Soil Respiration Station (SRS) deployed at a boreal forest site in central Alaska; b) the SRS data logger; c) a Forced Diffusion Chamber (FD chamber) installed at a site.

Citation

Minions, C., S. Natali, J.D. Watts, S. Ludwig, and D. Risk. 2019. ABoVE: Year-Round Soil CO2 Efflux in Alaskan Ecosystems, Version 2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1762

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1. Dataset Overview

This dataset provides soil-surface carbon dioxide (CO2) efflux derived from measurements of soil respiration with forced diffusion (FD) chambers. Soil Respiration Stations (SRS) were installed at 11 boreal and tundra sites along a broad S-N transect starting from near Fairbanks in interior Alaska and extending to Atqasuk in northern Alaska. Each SRS measures soil respiration and ambient atmospheric CO2 concentrations with a forced diffusion (FD) chamber to derive soil CO2 flux. The SRS also measures soil CO2 concentrations and temperatures using instrumented chambers buried at 5, 10, and 15 cm depths in the soil profile. At the highest measurement frequency, data is collected hourly, and during the lowest winter frequency, every 48 hours. The data include flux values and running median filtered values from the two or three FD chambers at each site. Soil CO2 and temperature profile data (beginning June 2017) were collected beginning 2016-08-18 through 2018-09-12. As of this publication, sampling is continuing and new data will be added as available.

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Project: Arctic-Boreal Vulnerability Experiment

The Arctic-Boreal Vulnerability Experiment (ABoVE) is a NASA Terrestrial Ecology Program field campaign conducted in Alaska and western Canada between 2016 and 2021. 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

Minions, C., S. Natali, S. Ludwig, and J. Watts. 2018. ABoVE: Year-round Soil CO2 Efflux in Alaskan Ecosystems. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1620

User Note: Minions et al. (2018) is Version 1 of the Year-round Soil CO2 Efflux data. The data from these previously reported sites and time periods have undergone more rigorous processing and are provided in this Version 2 dataset (Minions et al., 2020). Version 2 replaces and supersedes the Version 1 data and includes additional measurement sites.

Acknowledgments

This work was funded by NASA ABoVE grant NNX15AT81A.

2. Data Characteristics

Spatial Coverage: Alaska, USA

> **ABoVE Reference Locations**
>
> Domain: Core ABoVE
>
> State/Territory: Alaska
>
> Grid Cells: Ah01av0 Bh7bv5 Ch042cv32, Ah01av0 Bh6bv4 Ch40cv29, Ah01av0 Bh6bv5 Ch37cv34, Ah01av0 Bh8bv3 Ch48cv21, Ah01av0 Bh6bv5 Ch39cv32

Spatial Resolution: multiple points

Temporal Coverage: 2016-08-18 to 2018-09-12

Temporal Resolution: hourly

Study Area: (all latitudes and longitudes given in decimal degrees)

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
full extent	-157.41	-146.55833	70.47	63.880123

Data File Information

There are 11 data files in Comma Separated Value (*.csv) format. The naming convention of the files is Alaska_**X**_CO2_flux.csv, where **X** designates the site code as shown in Table 3.

Table 1. File names and descriptions.

File Name	Description
Alaska_AKB_CO2_flux.csv	CO2 flux, soil CO2 and temperature data, Anaktuvuk *burned* site
Alaska_AKU_CO2_flux.csv	CO2 flux, soil CO2 and temperature data, Anaktuvuk *unburned* site
Alaska_ATQ_CO2_flux.csv	CO2 flux, soil CO2 and temperature data, Atqasuk site
Alaska_BNZ_CO2_flux.csv	CO2 flux, soil CO2 and temperature data, Bonanza Creek site

Alaska_EML_CO2_flux.csv	CO2 flux, soil CO2 and temperature data, Eight Mile Lake site
Alaska_HCB_CO2_flux.csv	CO2 flux, soil CO2 and temperature data, Hess Creek *burned* site
Alaska_HCU_CO2_flux.csv	CO2 flux, soil CO2 and temperature data, Hess Creek *unburned* site
Alaska_IMH_CO2_flux.csv	CO2 flux at the I-MINUS *high* site
Alaska_IML_CO2_flux.csv	CO2 flux at the I-MINUS *low* site
Alaska_NCB_NEW_CO2_flux.csv	CO2 flux, soil CO2 and temperature data, Nome Creek *burned* site
Alaska_NCU_OLD_CO2_flux.csv	CO2 flux at the Nome Creek *unburned* site

Data File Details

- Missing values are represented by -9999.
- Note that soil CO2 and temperature profile data were measured only after June 2017. In files with no data after June 2017 (e.g., Alaska_NCU_OLD_CO2_flux.csv) the variable columns are provided for consistency, but all values are missing (-9999). For data files beginning in August 2016 and continuing (e.g., Alaska_BNZ_CO2_flux.csv) to the present, these variables are missing until June 2017.
- Due to some technical issues, some sites are missing data for some of the listed variables.
- See Table 4 for the data availability at each site and known data gaps.

Table 2. Variables names and descriptions.

Variable	Units	Description
date	YYYY-MM-DD	Date of measurement
data_time	YYYY-MM-DD HH:MM:SS	Date and time of measurement
FD#_flux	µmol CO2 m-2 s-1	Soil CO2 flux values calculated for FD chambers. There are two or three chambers per site (e.g., FD28, FD17, FD29)
FD#_flux_median	µmol CO2 m-2 s-1	Soil CO2 flux value after running median filter. There are two or three chambers per site (e.g., FD28, FD17, FD29)
soil_CO2_5cm	ppm	Soil CO2 concentration at 5 cm depth
soil_CO2_15cm	ppm	Soil CO2 concentration at 15 cm depth
soil_CO2_25cm	ppm	Soil CO2 concentration at 25 cm depth
soil_temp_5cm	C	Soil temperature at 5 cm depth
soil_temp_15cm	C	Soil temperature at 15 cm depth
soil_temp_25cm	C	Soil temperature at 25 cm depth
ATM_TEMP	C	Approximate atmospheric temperature (between 5-30 cm above soil surface depending on site)

3. Application and Derivation

Measurements of soil CO2 efflux provide critical information on soil carbon balance. The soil respiration station FD chamber provides a stable field technique for measuring soil CO2 efflux in remote areas such as Alaska. The method currently uses 10 times less power than a comparable autochamber, with the potential for further gains. It is also inherently reliable because there are no moving parts.

4. Quality Assessment

All raw CO2 concentration measurements that were below the instrument's limit of detection (LOD) were discarded before fluxes were calculated. A LOD for CO2 measured from the FD chambers was also determined and applied.

5. Data Acquisition, Materials, and Methods

Study Area

Eleven boreal and tundra sites were selected for year-round soil flux measurements along a broad S-N transect from near Fairbanks in interior Alaska to Atqasuk in northern Alaska.

Table 3. Site details.

Site	Code	Latitude	Longitude	Description
Anaktuvuk burned site	AKB	68.990797	-150.2702	Located near the Anaktuvuk river north of Toolik field station within the severely burned area of the 2007 Anaktuvuk river fire. The vegetation is characterized by moss and tussock tundra. The SRS was deployed in late June of 2017.
Anaktuvuk unburned site	AKU	68.929906	-150.2798	Located in an undisturbed area near the Anaktuvuk river north of Toolik field station. The vegetation at the site is characterized by moss and tussock tundra. The SRS was deployed in late June of 2017.
Atqasuk site	ATQ	70.47	-157.41	Located near the city of Atqasuk, and the vegetation at the site is characterized by sedge and tussock tundra. The SRS was deployed in late July of 2017.
Bonanza				Located near the Bonanza Creek LTER Site, within a boreal black spruce stand. The

Creek site	BNZ	64.695999	-148.325677	SRS was deployed in August of 2016.
Eight Mile Lake site	EML	63.880123	-149.256008	Located off of the Stampede Trail in Healy. The area is characterized by moist tundra and sedge/shrub vegetation. The SRS was deployed in August of 2016.
Hess Creek burned site	HCB	65.568762	-148.92344	Located off of the Dalton Highway between mile 11 and 12, within a burned boreal black spruce forest (1995). The SRS was deployed in August of 2016.
Hess Creek unburned site	HCU	65.567389	-148.925157	Located off of the Dalton Highway between mile 11 and 12, within an unburned boreal black spruce forest. The SRS was deployed in August of 2016.
I-MINUS high site	IMH	68.557159	-149.532908	Located approximately 1 km off of the Dalton Highway, a few miles south of Toolik Field Station. The station is located on top of a hillside and is characterized by tussock tundra. The SRS was deployed in August of 2016 and removed in late June of 2017.
I-MINUS low site	IML	68.5593	-149.51605	Located approximately 1 km off of the Dalton Highway, a few miles south of Toolik Field Station. The station is in a lowland, wet sedge fen area (Riparian). The SRS was deployed in August of 2016 and removed in late June of 2017.
Nome Creek burned site	NCB_NEW	65.28603	-146.55833	Located less than a 1 km off of the Steese Highway near mile 63. The station is in a burned area (2004), and the vegetation is characterized by willow/herbaceous scrub. The SRS was deployed in early September of 2017.
Nome Creek unburned site	NCU_OLD	65.285561	-146.560019	Located within the White Mountain Recreation Area, on a south-facing slope characterized by willow/herbaceous scrub vegetation. The SRS was deployed in August of 2016 and removed in late June of 2017.

Flux Measurements and Calculations

The soil respiration station (SRS) is a fully automated, low-powered system that measures soil surface CO2 flux from three forced diffusion (FD) chambers (Figure 1). The FD chambers function in a similar capacity to dynamic chambers, but instead of employing moving parts, the FD chambers use passive membranes to regulate the flow of gas allowing for instrumentation to be powered off between measurement intervals, thereby achieving very low power consumption and high reliability (Risk et al., 2011). Two measurements are recorded from each FD chamber; one for atmospheric (Atm) [CO2] and one for soil [CO2] using an eosGP CO2 gas analyzer (Eosense Inc.), and pump system. The units for soil CO2 and atm CO2 are in ppm. Using these two values, and a chamber-specific, pre-calibrated constant, G, flux can be determined with the equation:

Flux = G (SoilCO2 - AtmCO2)

The units for flux are in µmol CO2 m-2 s-1. At the highest measurement frequency, data are collected hourly, and at the lowest frequency once per day. The measurement frequency is reduced during the winter months to conserve power.

Soil CO2 and Temperature Measurements

The SRS also records the concentration of CO2 throughout the soil profile at depths of 5, 15 and 25 cm using soil-depth chambers. Each of the chambers is equipped with a thermocouple wire. Measurements for profile [CO2] are taken at the same frequency as the flux data.

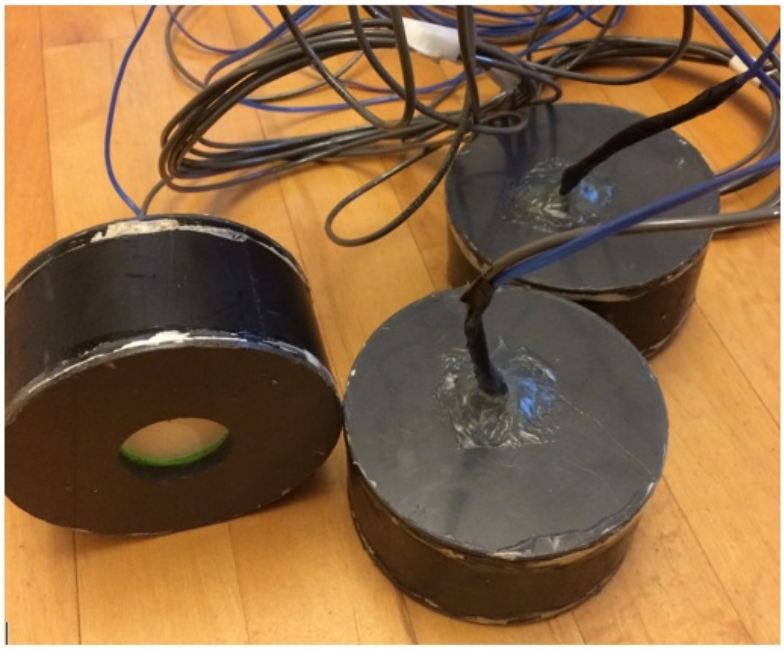

Figure 2. Soil-Depth chambers used to measure the concentration of CO2 and temperature within the soil profile at depths of 5, 15 and 25 cm.

SRS Data Processing

Data from the soil respiration stations are recorded on a set measurement frequency using either a CR800 series or CR1000 series datalogger (Campbell Scientific, Logan, Utah, USA). All of the SRS data were processed using Rstudio. The data were initially processed by applying a function that “cleans up” the raw data file.

- The first step in this clean-up process removes any data recorded at an insufficient battery voltage level (Battery voltage < 12

volts). At voltage levels below this defined threshold, the system does not have sufficient power to function properly.
- Any soil or atmospheric CO2 concentration measurements from the FD chambers that are below 200 ppm were filtered out.
- To remove any unnatural spikes and noise within the dataset, a moving average based on a set window size was used to compare a measurement to those before and after. If the data point in question was greater than the moving average by 200 ppm or more the measurement was replaced with NA.

Once the CO2 concentration data were 'cleaned-up', the flux for each FD chamber was calculated. The flux data were then filtered again, using a moving average based on a set window size, similar to what was done for the CO2 concentration data. If the average of the window plus two standard deviations were less than the flux value in question, the data point was replaced with NA. Figures of the data were generated for before and after the initial processing for comparison to make sure no viable data were removed. The second part of the data processing involves assessing, and removing any spikes that may remain, and any periods where there may have been an equipment malfunction that wasn't caught during the first round of processing. Lastly, a running median was calculated for the flux data using the previous 5 measurements to reduce noise within the dataset.

Table 4. Data availability at each Site.

- Sites marked with * are no longer collecting data.
- Some stations were deployed in 2016, and others in 2017. Some stations were removed in 2017. Compare to Table 3.
- There may be a few sporadic measurements within the defined gap period.

Site	Data Start Date (mm/dd/yy)	Data End Date (mm/dd/yy)	Large Data Gaps (mm/dd/yy)
Anaktuvuk Burned	06/23/17	2009-02-18	10/05/17 to 02/20/18, 03/08/18 to 07/11/18
Anaktuvuk Unburned	06/23/17	2009-02-18	11/26/17 to 02/10/18, 02/21/18 to 03/23/18, 04/20/18 to 07/11/18
Atqasuk	07/28/17	07/30/18	12/26/17 to 02/04/18, 02/18/18 to 05/12/18, 06/02/18 to 06/27/18
Bonanza Creek	08/29/16	2004-08-18	09/12/16 to 10/02/16, 10/28/16 to 02/14/17, 02/25/17 to 03/11/17, 01/20/18 to 03/09/18
Eight Mile Lake	08/18/16	2009-12-18	11/25/16 to 01/06/17, 12/31/17 to 07/04/18
Hess Creek Burned	08/30/16	2009-04-18	11/04/16 to 03/03/17, 01/12/18 to 03/17/18
Hess Creek Unburned	08/28/16	2009-04-18	10/17/16 to 02/26/17,12/23/17 to 03/21/18
I-MINUS High*	08/21/16	11/16/16	NA
I-MINUS Low*	08/19/16	2006-12-17	11/14/16 to 01/31/17, 03/09/17 to 04/09/17
Nome Creek Burned NEW	2011-01-17	08/25/18	01/04/18 to 02/05/18, 02/13/18 to 03/07/18, 07/05/18 to 07/19/18
Nome Creek Unburned OLD*	08/28/16	06/13/17	11/13/16 to 02/14/17

6. Data Access

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

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Contact for Data Center Access Information:

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

7. References

Risk, D., Nickerson, N., Creelman, C., McArthur, G., Owens, J., 2011. Forced Diffusion soil flux: A new technique for continuous monitoring of soil gas efflux. Agricultural and Forest Meteorology 151, 1622-1631. https://doi.org/10.1016/j.agrformet.2011.06.020

8. Dataset Revisions

Product Version	Release Date	Revision Notes
2	Feb 15, 2020	ORNL DAAC released Version 2 which replaces and supersedes the Version 1 data and includes additional measurement sites.
1	Dec 31, 2018	ORNL DAAC released Minions et al. (2018), Version 1 of the Year-round Soil CO2 Efflux data

User Note: Minions et al. (2018), https://doi.org/10.3334/ORNLDAAC/1620, is Version 1 of the Year-round Soil CO2 Efflux data. The data from these previously reported sites and time periods have undergone more rigorous processing and are provided in this Version 2 dataset (Minions et al., 2020). Version 2 replaces and supersedes the Version 1 data and includes additional measurement sites.