CARVE: Fire-Related Aerosol and Soil Elemental and Isotopic Composition, Alaska, 2013

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Summary

This data set provides measurements of the isotopic composition of black carbon and organic carbon aerosols collected at two locations in interior Alaska during the summer of 2013, as part of NASA's Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE). The delta14C end member of fire aerosol was derived and linked to soil elemental and isotopic composition in Alaskan boreal forests. Soil and aerosol measurements were used to estimate average depth of burn in Alaska during the summer of 2013.

This data set includes five data files in comma-separated values (*.csv) format.

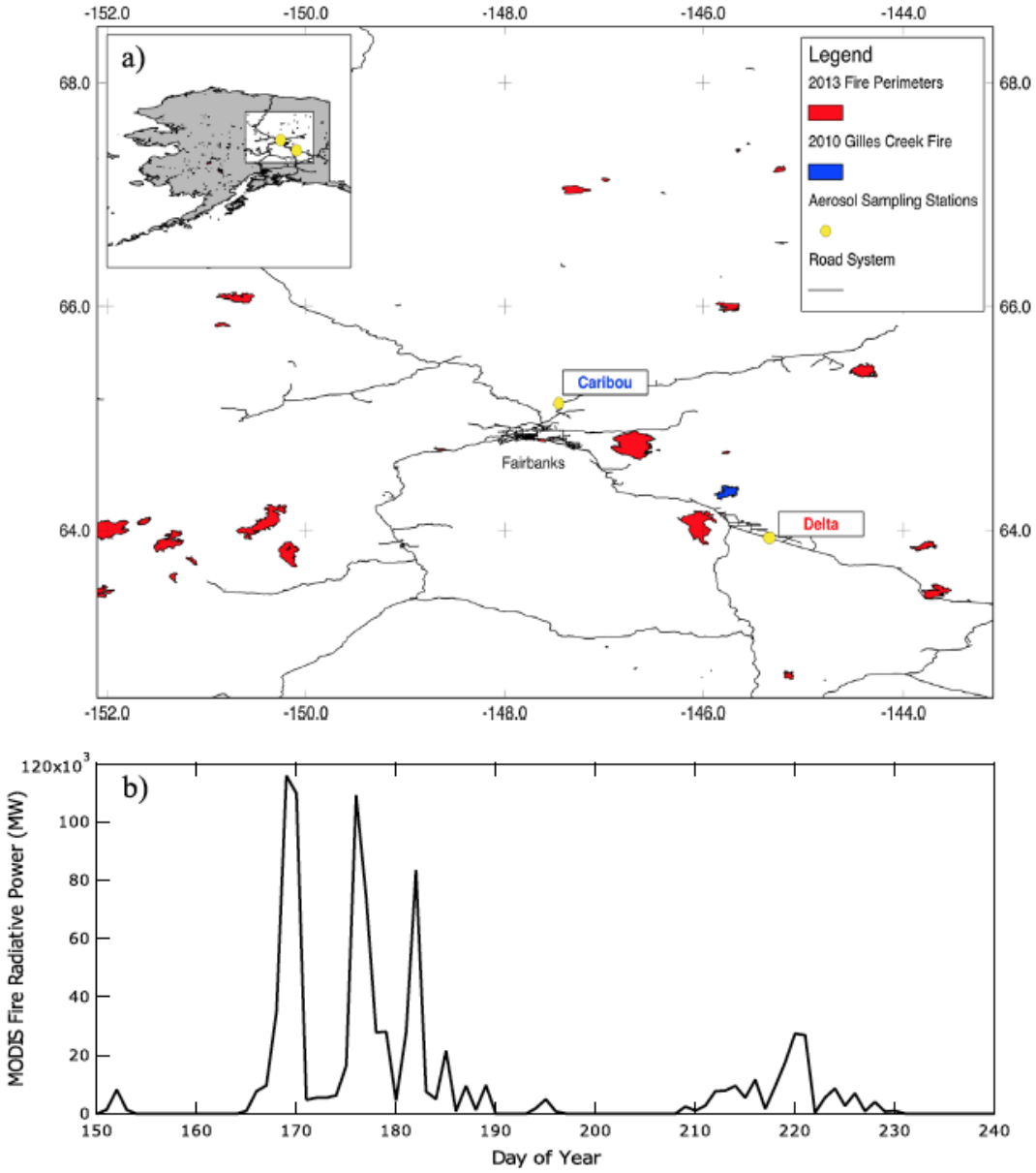

Figure 1: (a) Map of the aerosol sampling stations in Alaska, (b) daily sum of fire radiative power from MODIS active fires in 2013 Alaska (Mouteva et al 2015).

Citation

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Table of Contents

1. Data Set Overview

This data set provides results of aerosol sampling for black carbon, organic carbon, total carbon, and nitrogen and their isotopic composition from boreal fire emissions in Alaska in summer 2013. The delta14C end member of fire aerosol was derived and linked to soil elemental and isotopic composition. Soil and aerosol measurements were used to estimate average depth of burn in Alaska during the summer of 2013. These data were collected as part of NASA's Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE).

Project: Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE)

CARVE is collecting detailed measurements of important greenhouse gases on local to regional scales in the Alaskan Arctic and demonstrating new remote sensing and improved modeling capabilities to quantify Arctic carbon fluxes and carbon cycle-climate processes. Ultimately, CARVE will provide an integrated set of data that will provide unprecedented experimental insights into Arctic carbon cycling.

Related Publication:

Mouteva, G. O., et al. (2015), Black carbon aerosol dynamics and isotopic composition in Alaska linked with boreal fire emissions and depth of burn in organic soils, Global Biogeochem. Cycles, 29, http://dx.doi.org/10.1002/2015GB005247

Related Data Sets:

Veraverbeke, S., B.M. Rogers, and J.T. Randerson. 2015. CARVE: Alaskan Fire Emissions Database (AKFED), 2001-2013. ORNL DAAC, Oak Ridge, Tennessee, USA. http://dx.doi.org/10.3334/ORNLDAAC/1282

2. Data Characteristics

Spatial Coverage: Interior Alaska, USA

Spatial Resolution: Point locations

Temporal Coverage: 20130627 to 20130810

Temporal Resolution: Variable

Study Area: (Latitude and longitude given in decimal degrees)

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Interior Alaska, US	-168	-140	70.5	61.5

Table 1. Data files

File Name	Description
aerosol_C_N_composition.csv	Carbon and nitrogen composition and isotopic data from summer 2013 aerosol sampling
fire_derived_14C_endmember.csv	Isotopic analysis of total carbon in aerosols
BC_modeled_emissions.csv	Black carbon emissions modeled by combining the Alaska Fire Emissions Database with the coupled WRF-STILT model of Henderson et al (2015)
soil_core_C_N_composition.csv	Carbon and nitrogen composition and isotopic data from soil cores taken by Rogers et al. (2014)
soil_depth_integrated_C_N_composition.csv	Depth-integrated soil core composition and carbon loss due to fires

Table 2. Data fields in *aerosol_C_N_composition.csv*. Missing data are coded as -999.

Field name	Units	Description
Sampling begin	yyyymmdd	Date aerosol sampling began

date		
Sampling end date	yyyymmdd	Date aerosol sampling ended
Station		Aerosol sampling location
Sample description		Description of fire conditions during sample collection
Day of year	Day	Sampling period in day of year 2013
BC	Micrograms per cubic meter of air	Black carbon aerosols
BC_14C	Per mil	BC radiocarbon measurement raw data
BC_14C_fire	Per mil	BC radiocarbon measurement after background subtraction via isotope mass balance
TC	Micrograms per cubic meter of air	Total carbon aerosol
TC_14C	Per mil	TC radiocarbon measurement raw data
TC_14C_fire	Per mil	TC radiocarbon measurement after background subtraction via isotope mass balance
OC	Micrograms per cubic meter of air	Organic carbon aerosol
OC_14C	Per mil	OC radiocarbon measurement raw data
OC_14C_fire	Per mil	OC radiocarbon measurement after background subtraction via isotope mass balance
delta13C	Per mil	Stable carbon isotope
Nitrogen	Micrograms per cubic meter of air	Nitrogen content
delta15N	Per mil	Nitrogen stable isotope raw data
delta15N_fire	Per mil	Nitrogen stable isotope measurement after background subtraction via isotope mass balance. Background measurements are listed as ‘bkg’.
Carbon:Nitrogen	n/a	Total carbon to nitrogen ratio raw data

C:N_fire	n/a	Total carbon to nitrogen ratio after separately subtracting carbon background and nitrogen background and calculating new background corrected ratio. Background measurements are listed as 'bkg'.

Table 3. Data fields in *fire_derived_14C_endmember.csv.* Missing data are coded to -999.

Field name	Units	Description
Method and Station	n/a	Method of background subtraction and sampling station.
BC_14C_fire	Per mil	Fire-derived 14C of BC. Average of all fire samples at corresponding station and for applied method
BC_fire_Stdev	Per mil	Standard deviation of all fire 14C BC samples at corresponding station and for applied method
TC_14C_fire	Per mil	Fire-derived 14C of TC. Average of all fire samples at corresponding station and for applied method
TC_fire_Stdev	Per mil	Standard deviation of all fire 14C TC samples at corresponding station and for applied method
OC_14C_fire	Per mil	Fire-derived 14C of OC. Average of all fire samples at corresponding station and for applied method
OC_fire_Stdev	Per mil	Standard deviation of all fire 14C OC samples at corresponding station and for applied method

*Note: The last row in *fire_derived_14C_endmember.csv* contains values averaged over both stations and both methods.

Table 4. Data fields in *BC_modeled_emissions.csv.* Missing data are coded to -999.

Field name	Units	Description
Day of Year	Fractional day	Fractional Julian day of 2013 at a 6-h time step
BC Caribou	Micrograms per cubic meter of air	Modeled BC concentrations at Caribou sampling station
BC Delta	Micrograms per cubic meter of air	Modeled BC concentrations at Delta sampling station

Table 5. Data fields in *soil_core_C_N_composition.csv.* Missing data are coded to -999.

Field name	Units	Description

Identifier	n/a	Soil core collection location identifier from Rogers et al., 2014
Core	n/a	Soil core description. A-F denotes different cores within each collection area from Rogers et al., 2014.
Soil_Horizon	n/a	Soil horizon description: LD - top live layer; F - fibric; M - mesic & humic; H - mineral soil with possibly some humic
Upper_depth	cm below surface	Upper depth of soil layer
Lower_depth	cm below surface	Lower depth of soil layer
Weight	g	Weight of soil horizon samples
Volume	cm3	Volume of soil horizon sample
Bulk_Density	g/cm3	Bulk density of soil horizon sample
pct_C	%	Percent carbon content of soil horizon sample
pct_N	%	Percent nitrogen content of soil horizon sample
C/N	n/a	Carbon to nitrogen ratio of soil horizon sample
mgC/g soil	mg/g	Calculated soil horizon carbon content per soil mass
mgN/g soil	mg/g	Calculated soil horizon nitrogen content per soil mass
mgC/cm3 soil	mg/cm3	Calculated soil horizon carbon content per soil volume
mgN/cm3 soil	mg/cm3	Calculated soil horizon nitrogen content per soil volume
d15N	Per mil	Nitrogen stable isotope content of soil horizon
13C	Per mil	Carbon stable isotope content of soil horizon, measured via gas bench
14C	Per mil	Radiocarbon content of soil horizon, measured by AMS
14C_err	Per mil	Radiocarbon measurement uncertainty, measured by AMS

Table 6. Data fields in *soil_depth_integrated_C_N_composition.csv.* Missing data are coded to -999.

Field name	Units	Description
Depth	cm	Soil depth, measured from top of soil. We used 0.5 cm intervals to integrate cumulative elemental and isotopic composition at depth. For depths >29 cm, values were calculated by assuming a linear relationship within the last few layers and propagating it to depth.
14C	Per mil	Cumulative radiocarbon content of soil integrated with depth
13C	Per mil	Cumulative stable carbon isotopic content of soil integrated with depth
15N	Per mil	Cumulative stable nitrogen isotopic content of soil integrated with depth
C_loss	Kg C/ m2	Carbon loss per m2 integrated with depth

*Note: At the bottom of the table, average values are provided for all black spruce land cover types (average of data from cores COO2, COO5, and COO6). A weighted average contribution from black spruce and white spruce/mixed aspen land cover types is also provided for each soil horizon. The weighting was 0.7 black spruce + 0.3 white spruce.

Companion files:

One companion file: PWRF-STILT_BC_Model.pdf is provided. This file describes the integration of the AKFED and WFR-STILT models to produce black carbon estimates from Alaskan fires.

3. Application and Derivation

Black carbon (BC) aerosol emitted by boreal fires has the potential to accelerate losses of snow and ice in many areas of the Arctic, yet the importance of this source relative to fossil fuel BC emissions from lower latitudes remains uncertain. These measurements of fire-emitted BC and aerosol composition constrain the end-member of boreal forest fire contributions to aerosol deposition in the Arctic and may ultimately reduce uncertainties related to the impact of a changing boreal fire regime on the climate system.

4. Quality Assessment

Measurement uncertainty and standard deviation in the observations are reported in the data files.

5. Data Acquisition, Materials, and Methods

Aerosol Samples

Aerosol samples were collected at two locations in interior Alaska during the summer of 2013 (27 June to 10 August). One site was located at Caribou Poker Creek Long-Term Ecological Research Station (“Caribou”; 65.13°N, 147.45°W) and the other at Delta Junction Agricultural and Forestry Experimental Site (“Delta”; 63.97°N, 145.40°W).

High-volume total suspended particulate samplers (HIVOL-AMCLD, Thermo Environmental Instruments, Franklin, MA, USA) with PM2.5 impactor plates (TE-230-QZ, Tisch Environmental, Cleves, OH, USA) were used. Black carbon content of each PM2.5 aerosol sample was isolated from the organic carbon fraction and the 14C content was measured via accelerator mass spectrometry (AMS). Aerosol samples were also analyzed for their total carbon and nitrogen (N) content and stable isotope ratios.

Soil Cores

To help relate carbonaceous aerosol measurements to soil emissions, a set of four soil cores were collected in August of 2012 in unburned (control) areas near the Gilles Creek fire perimeter (COO2: 64.33°N, 145.88°W; COO4: 64.31°N, 145.94°W; COO5: 64.32°N, 145.89°W; COO6: 64.36°N, 145.58°W), described by Rogers et al. (2014), were analyzed. The four soil cores representing control sites of typical land cover types outside the Gilles Creek 2010 fire. The cores were separated into three soil horizons and analyzed for their total carbon and nitrogen elemental composition, stable isotopes delta13C and delta15N, and delta14C. All of the measurements represent a vertical average for each soil horizon.

Depth integration was calculated for each soil core for every 1 cm depth interval. Depth-integrated measurements of delta14C, delta13C, carbon loss per m2, and delta15N were calculated as weighted average contribution of black spruce (70%) and mixed white spruce aspen (30%) forest of all soil cores. We used a linear regression in the mesic layer to extend the estimates deeper in the soil for the purpose of comparing with the aerosol measurements.

Modeled Black Carbon

Black carbon emissions from fires were modeled by combining the Alaska Fire Emissions Database (AKFED) model [Veraverbeke et al., 2015; available online here: http://dx.doi.org/10.3334/ORNLDAAC/1282] with the coupled Weather Research and Forecasting-Stochastic Time- Inverted Lagrangian Transport (WRF-STILT) model [Henderson et al., 2015]. Carbon emissions from AKFED were converted with an emission factor of 0.5 g BC per 1 kg biomass, based on Akagi et al. [2011], and integrated with the WRF-STILT model to estimate BC concentrations from fires at the Caribou and Delta aerosol sampling stations. See companion file **PWRF-STILT_BC_Model.pdf** for more details.

For more information on methodology, see Mouteva et al (2015).

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:

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7. References

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