CARVE: L2 Merged Atmospheric CO2, CO, O3 and CH4 Concentrations, Alaska, 2012-2015

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Documentation Revision Date: 2016-07-28

Data Set Version: V1

Summary

This data set provides atmospheric carbon dioxide (CO2), methane (CH4), carbon monoxide (CO), ozone (O3), and water vapor (H2O) concentrations from airborne campaigns over the Alaskan and Canadian arctic for the Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE). These data are merged and gap-filled outputs from two different cavity ring-down spectrometers (CRDS; Picarro Inc.) flown aboard the CARVE aircraft and are presented at 5-second intervals throughout each flight. Aircraft latitude, longitude, and altitude are also provided. Flight campaigns took place from 2012 to 2015 between the months of March and November to enable investigation of both seasonal and inter-annual variability in atmospheric gas content. The measurements included in this data set are crucial for understanding changes in Arctic carbon cycling and the potential threats posed by thawing of Arctic permafrost.

These measurements are one part of an innovative multi-instrument remote sensing payload flown for the CARVE campaign.

There are 3 data files in comma-separated values (*.csv) format, one for each campaign year, with this data set. Please note that 2015 year data has not been released yet.

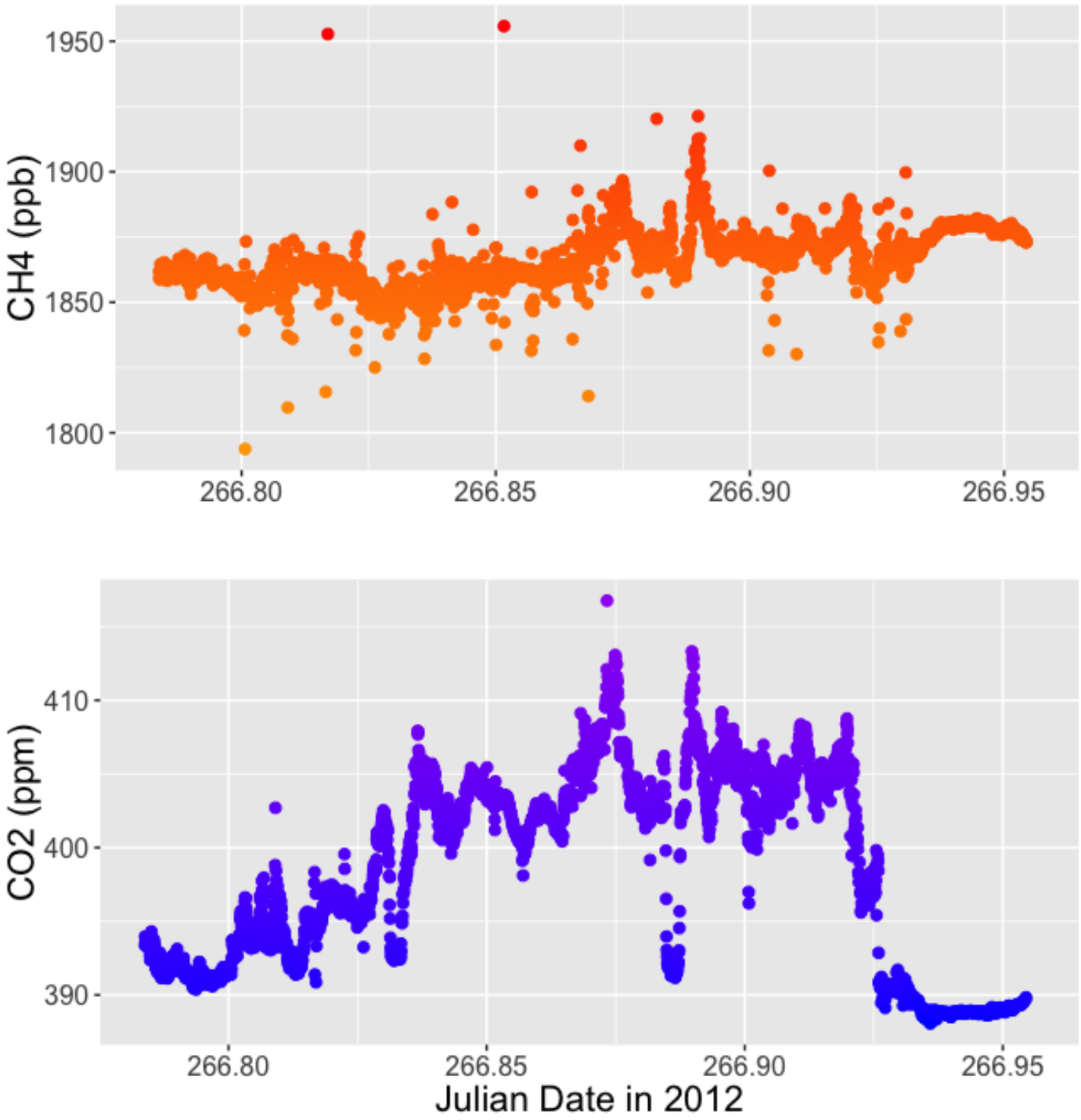

Figure 1. Airborne methane and CO2 concentrations during a CARVE flight over the Yukon Flats area, Alaska on 23 September, 2012.

Citation

Budney, J.W., R.Y-W. Chang, R. Commane, B.C. Daube, A. Dayalu, S.J. Dinardo, E.W. Gottlieb, A. Karion, J.O.W. Lindaas, C.E. Miller, J.B. Miller, S. Miller, M. Pender, J.V. Pittman, J. Samra, C. Sweeney, S.C. Wofsy, and B. Xiang. 2016. CARVE: L2 Merged Atmospheric CO2, CO, O3 and CH4 Concentrations, Alaska, 2012-2015. ORNL DAAC, Oak Ridge, Tennessee, USA. http://dx.doi.org/10.3334/ORNLDAAC/1402

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1. Data Set Overview

Project: Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE)

The Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) is a NASA Earth Ventures (EV-1) investigation designed to quantify correlations between atmospheric and surface state variables for Alaskan terrestrial ecosystems through intensive seasonal aircraft campaigns, ground-based observations, and analysis sustained over a 5-year mission. CARVE collected detailed measurements of greenhouse gases on local to regional scales in the Alaskan Arctic and demonstrated new remote sensing and improved modeling capabilities to quantify Arctic carbon fluxes and carbon cycle-climate processes. CARVE science fills a critical gap in Earth science knowledge and satisfies high priority objectives across NASA's Carbon Cycle and Ecosystems, Atmospheric Composition, and Climate Variability & Change focus areas as well as the Air Quality and Ecosystems elements of the Applied Sciences program. CARVE data also complements and enhances the science return from current NASA and non-NASA sensors.

Related Data:

Airborne CARVE greenhouse gas concentrations from both the NOAA and Harvard Picarro CRDS instruments are also available as separate data sets:

CARVE: L2 Atmospheric CO2, CO and CH4 Concentrations, Harvard CRDS, Alaska, 2012-2014

CARVE: L2 Atmospheric CO2, CO and CH4 Concentrations, NOAA CRDS, Alaska, 2012-2015

A full list of CARVE data products is available at: https://carve.ornl.gov/dataproducts.html

2. Data Characteristics

Spatial Coverage: CARVE flights over the Alaskan and Canadian Arctic

Spatial Resolution: Point measurements

Temporal Coverage: Periodic flights occurred during the growing seasons (approx. March – November) of 2012 through 2015.

Temporal Resolution: All measurements were aggregated to 5-second intervals for distribution with this data set.

Study Area (coordinates in decimal degrees)

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Alaska and Canadian Arctic	-168.11	-131.75	71.56	60.21

Data File Information

There are 3 data files in *.csv format with this data set. Each file provides measurements of dry mole fractions of atmospheric gasses acquired during a campaign year.

Table 1. CARVE file naming convention. Example file name: carve_AtmosISGA_L2_Merge_2012_20160722.csv

Name element	Example value	Units
Project name	*carve*	
Instrument	*AtmosISGA*	
Processing level	*L2*	
Investigator group	*Merge*	*merged product*
Campaign year	*2012*	*year*

Processing date	*20160722*	*yyyymmdd*

Data variables

Each file contains 31 variables described in Table 2. All measurements were aggregated from the original temporal resolution to 5 second intervals for this merged product. Fill value or missing data were set to -999.9 for all variables. All dates and times are recorded in UTC time.

Table 2. Data variables in each .csv file.

Variable	Units	Description
SOY		Seconds of year from midnight on Jan 1
JD		Fractional Julian Day of year
UTC		Seconds since the start of day (midnight)
YYYYMMDD	YYYYMMDD	Date (UTC time)
Lat	decimal degrees	Decimal degrees North reported by aircraft
Long	decimal degrees	Decimal degrees East reported by aircraft
GPS_Alt	meters	Aircraft altitude
CO2.X	ppm	Merged CO2 product
CH4.X	ppb	Merged CH4 product
CO.X	ppb	Merged CO product
H2O.X	percent	Merged H2O product
O3.X	ppb	Merged O3 product
NOAA.CO2.ppm	ppm	CO2 data from NOAA Picarro instrument
NOAA.CH4.ppb	ppb	CH4 data from NOAA Picarro instrument
NOAA.CO.ppb	ppb	CO data from NOAA Picarro instrument
NOAA.CO2.QC		NOAA CO2 quality flag. 0 = Valid data, 1 = Data out of calibration range, 2 = Cavity anomaly, 3 = System leak or calibration problem, Do not use.
		NOAA CH4 quality flag. 0 = Valid data, 1 =

NOAA.CH4.QC		Data out of calibration range, 2 = Cavity anomaly, 3 = System leak or calibration problem, Do not use.
NOAA.CO.QC		NOAA CO quality flag. 0 = Valid data, 1 = Data out of calibration range, 2 = Cavity anomaly, 3 = System leak or calibration problem, Do not use.
HU.CO2	ppm	CO2 data from Harvard Picarro instrument
HU.CH4	ppb	CH4 data from Harvard Picarro instrument
HU.CO	ppb	CO data from Harvard Picarro instrument
CO2.HU.flag		Harvard CO2 quality flag. 0 = Valid data, 1 = Data out of calibration range, 2 = Cavity anomaly, 3 = System leak or calibration problem, Do not use.
CH4.HU.flag		Harvard CH4 quality flag. 0 = Valid data, 1 = Data out of calibration range, 2 = Cavity anomaly, 3 = System leak or calibration problem, Do not use.
CO.HU.flag		Harvard CO quality flag. 0 = Valid data, 1 = Data out of calibration range, 2 = Cavity anomaly, 3 = System leak or calibration problem, Do not use.
O3.ppb	ppb	JPL O3 data from DADS file
H2O.pct	percent	Water vapor percentage from NOAA Picarro instrument
H2O.QC		NOAA H20 quality flag. 0 = Valid data, 1 = Data out of calibration range, 2 = Cavity anomaly, 3 = System leak or calibration problem, Do not use.
H2O.corr	percent	H2O data corrected for pressure
Tcorr	degrees C	Processed air temperature
Pcorr	mbar	Processed air pressure
AmbientPress.mb	mbar	Raw ambient air pressure

3. Application and Derivation

These data files contain high-frequency atmospheric CO_2, CH_4, CO, H_2O, and O_3 content observations for CARVE flights during March– November of 2012 to 2015. The CARVE project was designed to collect detailed measurements of important greenhouse gases on local to regional scales in the Alaskan arctic and

demonstrate new remote sensing and improved modeling capabilities to quantify Arctic carbon fluxes and carbon cycle-climate processes. The CARVE data provide insights into Arctic carbon cycling that may be useful in numerous applications.

4. Quality Assessment

Continuous measurements from the CRDS instruments (Picarro, Inc.) were calibrated against on-board standard gas samples once every 30 minutes by an automated system. Quality control flags for each gas measurement are included in the data file.

5. Data Acquisition, Materials, and Methods

CARVE Flights

These data represent one part of the data collected by the Carbon in Arctic Reservoirs Vulnerability Experiment (Miller et al, 2012). A C-23 Sherpa aircraft made frequent flights out of Fairbanks, Alaska between March and November over multiple years, observing the spring thaw, summer draw-down, and fall refreeze of the Arctic growing season. Flights concentrate observations on three study domains: the North Slope, the interior, and the Yukon River valley. North Slope flights cover regions of tundra and continuous permafrost and were anchored by flux towers in Barrow, Atqasuk, and Ivotuk. Flights to Prudhoe Bay characterize the CO2 and CH4 emissions from oil and natural gas processing plants. Flights over interior Alaska sample discontinuous permafrost, boreal forests, and wetlands. A complete list of CARVE flights can be found at: https://carve.ornl.gov/flights.html. Flight paths and atmospheric gas concentrations for CARVE surveys can be visualized through the CARVE Flight Data Visualization Tool (http://carve.ornl.gov/visualize).

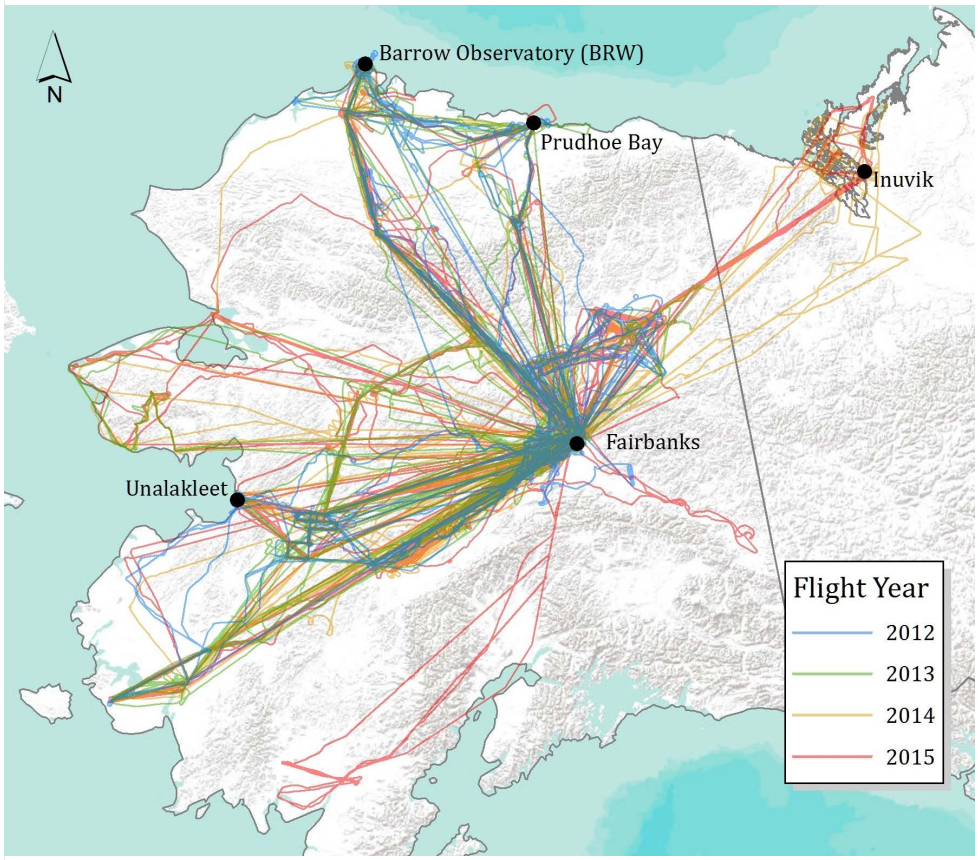

Figure 2. CARVE flights during 2012-2015 delivered measurements over continuous and discontinuous permafrost regimes.

The CARVE aircraft carried a remote sensing and atmospheric sampling payload consisting of the following instruments: a passive/active L-band system (PALS), a Fourier transform spectrometer (FTS), and an in situ gas analyzer suite (ISGAS) with a gas analyzer and flask sampling system (see https://carve.ornl.gov/documentation.html). All instruments were controlled by a master computer system (Data Acquisition and Distribution System, DADS). DADS also recorded GPS data (Lat, Lon, altitude), aircraft pitch, roll, and yaw, as well as basic meteorological data from onboard instruments.

In situ gas analyzer

This data set includes in situ measurements merged from two cavity ring-down spectroscopy (CRDS) instruments (Picarro Inc.). The two instruments are named according to the investigator teams at NOAA and Harvard University. Note that the Harvard CRDS was not used in 2015. CRDS is a technique for measuring quantities of gaseous substances based on the rate of light intensity decay following laser illumination of a highly-reflective containment cavity. A CRDS system measures the time constant of decay to 1/*e* of its initial intensity, its *ring-down time*, in order to calculate the concentration of the absorbing gas mixture within the cavity.

Merged Data

- The merged CO2 and CH4 data were constructed by aggregating the raw data into 5 second intervals, calculating the median difference between the Harvard values (e.g. HU.CO2) and the NOAA values (e.g. NOAA.CO2.ppm) and gap-filling the HU data with the NOAA data (plus offset).

- The merged CO data were created from 5 second averaged values from the Harvard university Picarro instrument.
- H20 data was recorded only by the NOAA Picarro instrument.
- The O3 data came directly from the onboard computer system (Data Acquisition and Distribution System, DADS). DADS also recorded GPS data (Lat, Lon, altitude), aircraft pitch, roll, and yaw, as well as basic meteorological data from onboard instruments.

Gas concentration data from both the NOAA and Harvard Picarro CRDS instruments are also available in NetCDF file format:

CARVE: L2 Atmospheric CO2, CO and CH4 Concentrations, Harvard CRDS, Alaska, 2012-2014

CARVE: L2 Atmospheric CO2, CO and CH4 Concentrations, NOAA CRDS, Alaska, 2012-2015

6. Data Access

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

CARVE: L2 Merged Atmospheric CO2, CO, O3 and CH4 Concentrations, Alaska, 2012-2015

Contact for Data Center Access Information:

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

7. References

Miller, C.E., Dinardo, S.J. et al. (2012). CARVE: The Carbon in Arctic Reservoirs Vulnerability Experiment., *2012 IEEE Aerospace Conference*. doi: 10.1109/AERO.2012.6187026