


 **EARTHDATA**


Data Discovery ▾ DAACs ▾ Community ▾ Science Disciplines ▾






ORNL DAAC
DISTRIBUTED ACTIVE ARCHIVE CENTER
FOR BIOGEOCHEMICAL DYNAMICS



 **About Us** **Get Data** **Submit Data** **Data Management** **Tools**

 **Sign in**

[DAAC Home](#) > [Get Data](#) > [Field Campaigns](#) > [CARVE](#) > Data Set Documentation

CARVE: L1 Spectral Radiances from Airborne FTS, Alaska, 2012-2015

Get Data

Documentation Revision Date: 2017-03-01

Data Set Version: V1

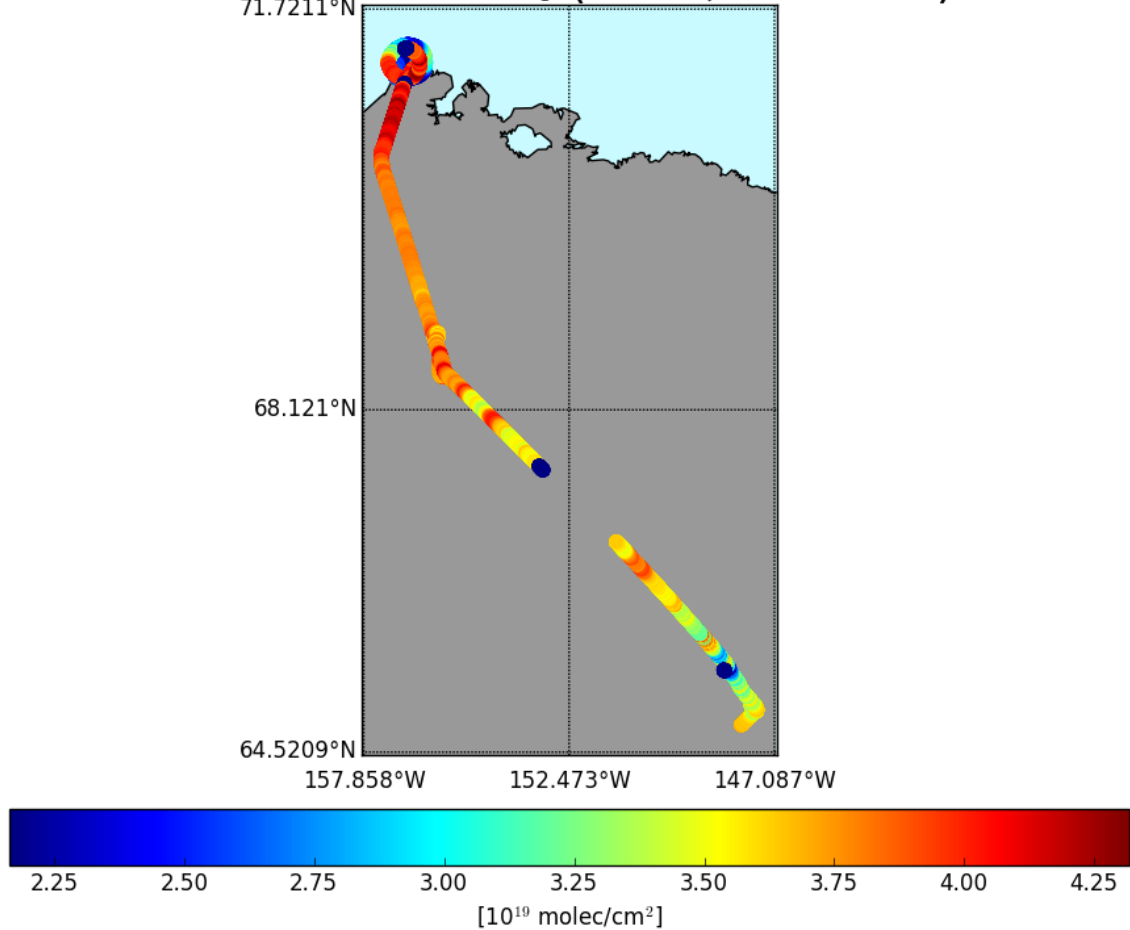
Summary

This data set contains Level 1 spectral radiance data collected using the Fourier Transform Spectrometer (FTS) during airborne campaigns over the Alaskan and Canadian Arctic for the Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE). 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 investigation.

There are 2725 files in NetCDF file format (*.nc) included in this data set.

2012-05-23: Total Column CH₄ (Band 2; 100 CoAdds) <V3.0.0>



JPL © Jet Propulsion Laboratory/
California Institute of Technology

Figure 1. Total column CH₄ retrievals (from Level 2 FTS product) from a CARVE flight on May 23, 2012, flying north from Fairbanks over the North Slope to Barrow.

Citation

Kurosu, T.P., C.E. Miller, S.J. Dinardo, and CARVE Science Team . 2017. CARVE: L1 Spectral Radiances from Airborne FTS, Alaska, 2012-2015. ORNL DAAC, Oak Ridge, Tennessee, USA. <http://dx.doi.org/10.3334/ORNLDAAC/1426>

Table of Contents

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

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:

Level 2 Column Gas measurements from the Fourier Transform Spectrometer aboard CARVE flights are available as a separate data set:

[CARVE: L2 Column Gas and Uncertainty from Airborne FTS, 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: 20120523 - 20151113

Temporal Resolution: 1-second

Study Area (coordinates in decimal degrees)

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Alaska and Canadian Arctic	-168.111	-131.752	71.435	58.8438

Data File Information

There are 2725 files in NetCDF file format (*.nc) included in this data set. Each file contains spectral radiance values collected from the oxygen A (abo2), strong CO₂ (sco2), and weak CO₂ (wco2) bands of the FTS instrument during a portion of a CARVE flight.

Table 1. CARVE file naming convention. Example file name: *carve_FTS_L1_b23_20120511_160419_20150915171127.nc*

Name element	Example value	Units
Project name	<i>carve</i>	
Instrument	<i>FTS</i>	
Processing level	<i>L1</i>	
Build ID	<i>b23</i>	
Flight date	<i>20120511</i>	<i>yyyymmdd</i>
Acquisition time	<i>160419</i>	<i>hhmmss</i>
Processing date and time	<i>20150915171127</i>	<i>yyyymmddhhmmss</i>

Data variables

Each file contains four variable groups: *aviation_housekeeping*, *geolocation*, *measurement_ancillary_info*, and *science_measurement*. The variables contained within each variable group are described in Tables 2 to 5.

Table 2. *aviation_housekeeping* group in the NetCDF files

Data variable	Units	Description
platform_latitude_low_precision	degree_north	platform latitude low precision
platform_longitude_low_precision	degree_east	platform longitude low precision

Table 3. *geolocation* group in the NetCDF files

Data variable	Units	Description
azimuth	degree	azimuth angle
center_lat	degree_north	latitude of footprint center
center_lat_standard_error	degree_north	standard error of latitude of footprint center
center_lon	degree_east	longitude of footprint center
center_lon_standard_error	degree_east	standard error of longitude of footprint center
geolocation_qc	N/A	geolocation calculations status
ground_speed	m s-1	ground speed
heading	degree	heading
height	meters	height
height_bnds	meters	height of footprint vertex
height_standard_error	meters	standard error of height
lat_bnds	degree_north	latitude of footprint vertex
lon_bnds	degree_east	longitude of footprint vertex
measurement_time	seconds	seconds since 1980-01-06 0:0:0
pitch	degree	pitch
platform_geolocation_qc	N/A	platform geolocation status
platform_height	meters	instrument height
platform_height_standard_error	meters	uncertainty of platform height
platform_latitude	degree_north	platform latitude
platform_latitude_standard_error	degree_north	uncertainty of platform latitude
platform_longitude	degree_east	platform longitude
platform_longitude_standard_error	degree_east	uncertainty of platform longitude
roll	degree	roll
solar_azimuth	degree	solar azimuth angle
solar_zenith	degree	solar zenith angle
stokes_coefficients	N/A	stokes polarization coefficients
TAI93	N/A	seconds since 1993-01-01 0:0:0
temperature_time	seconds	seconds since 1980-01-06 0:0:0
time	seconds	seconds since 1980-01-06 0:0:0
zenith	degree	zenith angle

Table 4. *measurement_ancillary_info* group in the NetCDF files

Data variable	Units	Description
beamsplitter_temperature	degrees_celsius	beamsplitter temperature
delta_opd_abo2	cm-1	delta opd abo2
delta_opd_sco2	cm-1	delta opd sco2
delta_opd_wco2	cm-1	delta opd wco2
detector_enclosure_temperature	degrees_celsius	detector enclosure temperature
detector_saturation_abo2	N/A	detector saturation abo2

Feedback

detector_saturation_sco2	N/A	detector saturation sco2
detector_saturation_wco2	N/A	detector saturation wco2
detector_temp_abo2	degrees_celsius	abo2 detector temperature
detector_temp_sco2	degrees_celsius	sco2 detector temperature
detector_temp_wco2	degrees_celsius	wco2 detector temperature
electronic_box_temperature	degrees_celsius	electronic box temperature
instrument_mode *	N/A	instrument mode during data acquisition
interferometer_if_temperature	degrees_celsius	interferometer if temperature
internal_pressure	pascals	internal pressure
laser_temperature	degrees_celsius	laser temperature
maximum_opd_abo2	cm-1	maximum optical path difference abo2
maximum_opd_sco2	cm-1	maximum optical path difference sco2
maximum_opd_wco2	cm-1	maximum optical path difference wco2
minimum_opd_abo2	cm-1	minimum optical path difference abo2
minimum_opd_sco2	cm-1	minimum optical path difference sco2
minimum_opd_wco2	cm-1	minimum optical path difference wco2
number_of_interferogram_points_abo2	N/A	number of interferogram points abo2
number_of_interferogram_points_sco2	N/A	number of interferogram points sco2
number_of_interferogram_points_wco2	N/A	number of interferogram points wco2
outside_air_temperature	kelvins	outside air temperature
phase_correction_abo2	N/A	phase correction abo2
phase_correction_sco2	N/A	phase correction sco2
phase_correction_wco2	N/A	phase correction wco2
phase_residual_abo2	N/A	phase residual abo2
phase_residual_sco2	N/A	phase residual sco2
phase_residual_wco2	N/A	phase residual wco2
preamp_adc_enclosure_temperature	degrees_celsius	preamp adc enclosure temperature
spectral_sampling_abo2	cm-1	spectral sampling abo2
spectral_sampling_sco2	cm-1	spectral sampling sco2
spectral_sampling_wco2	cm-1	spectral sampling wco2
start_wavenumber_abo2	cm-1	start wavenumber abo2
start_wavenumber_sco2	cm-1	start wavenumber sco2
start_wavenumber_wco2	cm-1	start wavenumber wco2
sweep_direction **	N/A	sweep direction
zero_opd_abo2	cm-1	zero optical path difference abo2
zero_opd_sco2	cm-1	zero optical path difference sco2
zero_opd_wco2	cm-1	zero optical path difference wco2

* instrument_mode: 0 --- Off; 1 --- Science; 2 --- Calibration; 3 --- Unknown

** sweep_direction: 0 --- Forward; 1 --- Reverse; 2 --- Both

Table 5. science_measurement group in the NetCDF files

Data variable	Units	Description
spectral_radiance_imaginary_abo2	N/A	upwelling spectral radiance in air abo2 band status

spectral_radiance_imaginary_sco2	N/A	upwelling spectral radiance in air sco2 band status
spectral_radiance_imaginary_wco2	N/A	upwelling spectral radiance in air wco2 band status
spectral_radiance_real_abo2	W cm-2 cm-1 sr-1	upwelling spectral radiance in air abo2 band real part
spectral_radiance_real_sco2	W cm-2 cm-1 sr-1	upwelling spectral radiance in air sco2 band real part
spectral_radiance_real_wco2	W cm-2 cm-1 sr-1	upwelling spectral radiance in air wco2 band real part
spectral_radiance_abo2_qc	W cm-2 cm-1 sr-1	upwelling spectral radiance in air abo2 band imaginary part
spectral_radiance_sco2_qc	W cm-2 cm-1 sr-1	upwelling spectral radiance in air sco2 band imaginary part
spectral_radiance_wco2_qc	W cm-2 cm-1 sr-1	upwelling spectral radiance in air wco2 band imaginary part

3. Application and Derivation

The carbon budget of Arctic ecosystems is not known with confidence because fundamental elements of this complex system are poorly quantified. The CARVE project was designed to collect data 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 carbon cycling that may be useful in numerous applications.

4. Quality Assessment

Each NetCDF file contains a global attribute *master_quality_flag* that provides a summary indication of the data quality level of the whole file. Its values are set to: "Good" --- all low level quality assessments passed; "Bad" --- some or all low level quality assessments failed; "UNK" --- quality is unknown.

In addition, each spectral radiance data product - from abo2 (oxygen A), sco2 (strong CO2), and wco2 (weak CO2) bands - has a quality flag associated with it. This flag consists of an integer number for each reported observation: -1 --- missing; 0 --- valid; 1 --- out of range; 2 --- error.

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. 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 Iqotuk. 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>) and are illustrated in Figure 2.

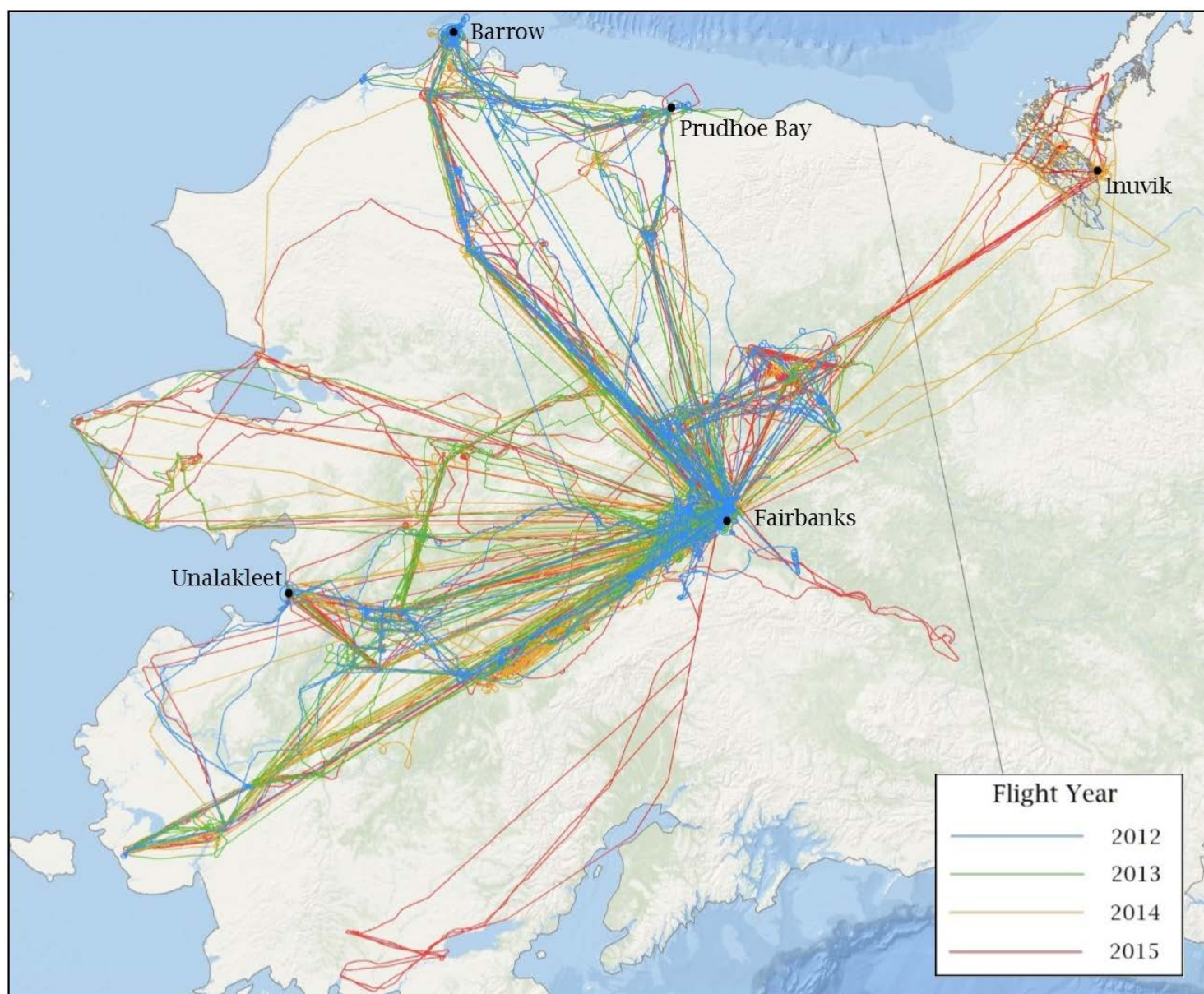


Figure 2. CARVE flights during 2012-2015 delivered measurements over continuous and discontinuous permafrost regimes.

The CARVE aircraft carried a remote sensing and atmospheric sampling payload consisting of the following instruments: a Fourier transform spectrometer (FTS), and an in situ gas analyzer suite (ISGA) with a gas analyzer and PFP sampling system (see <https://carve.ornl.gov/documentation.html>). All instruments were controlled by a master computer system (Data Acquisition and Distribution System, DADS). Data were logged and UTC time stamped at 1 second intervals. DADS also recorded GPS data (Lat, Lon, elevation), aircraft pitch, roll, and yaw, as well as basic meteorological data from onboard instruments.

Fourier Transform Spectrometer

The CARVE Fourier Transform Spectrometer (FTS; Figure 2) consists of three near-IR channels with spectral ranges of $12,920 - 13,180 \text{ cm}^{-1}$ (Band 1), $5,820 - 6,380 \text{ cm}^{-1}$ (Band 2), and $4,200 - 4,322 \text{ cm}^{-1}$ (Band 3). Each band has a spectral resolution of 0.2 cm^{-1} . The instrument can be operated in polarization mode, where each band records the S- and P-polarization components separately, or un-polarized. During 2012, the first year of operations, the FTS observed in polarization mode. In 2013, prompted by the challenging observation conditions in the Alaskan Arctic, the instrument configuration was changed to un-polarized in order to improve signal-to-noise ratios.

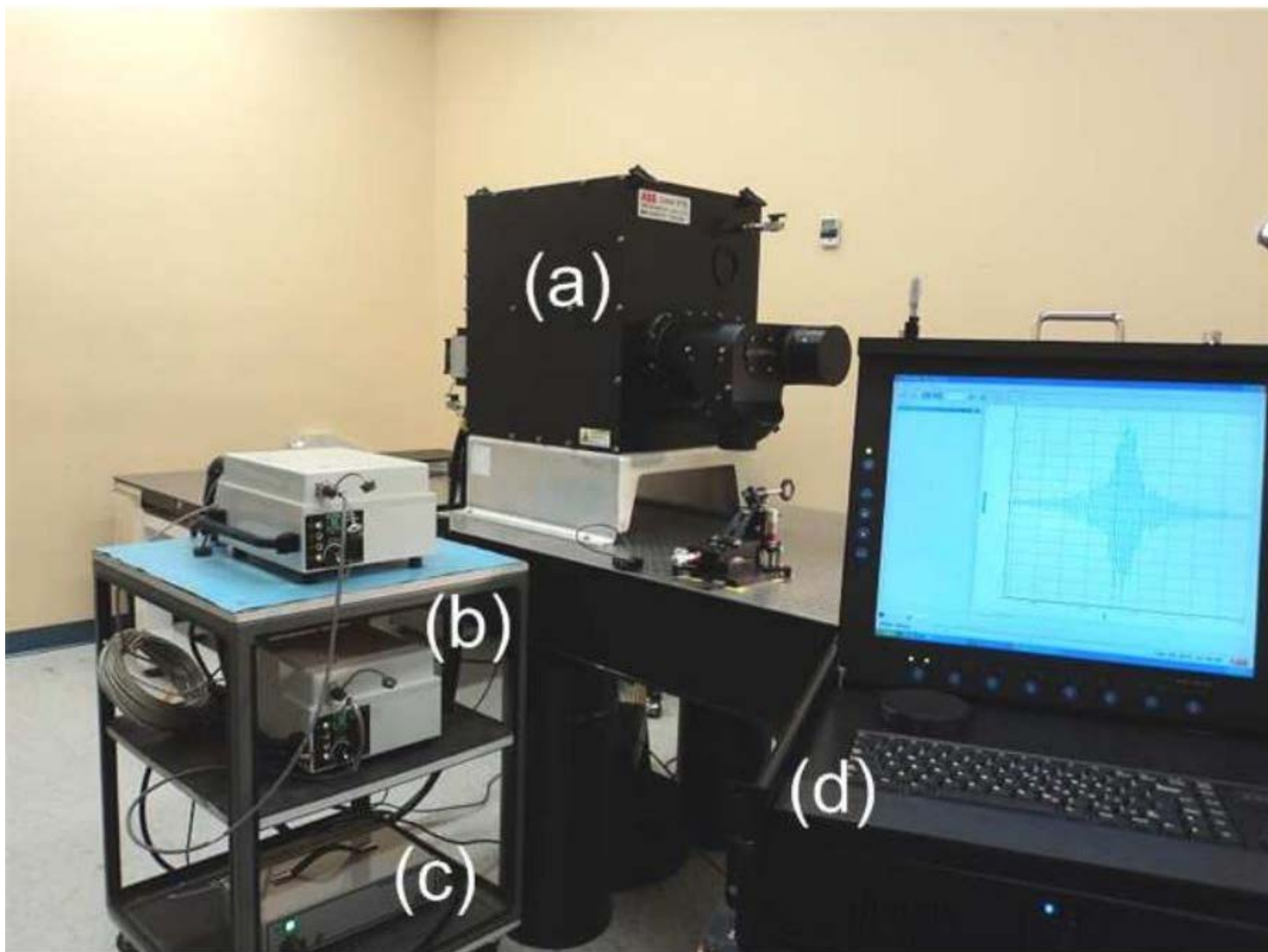


Figure 3. CARVE-FTS system: (a) instrument, (b) control electronic boxes, (c) power supply, and (d) interface control computer. Figure from Dupont et al., 2012.

The CARVE aircraft takes FTS nadir measurements in 1-second intervals along the flight track, corresponding roughly to a displacement of 100 m on the ground. For the retrievals, up to 100 of these 1-second observations are co-added to a single spectrum, corresponding to roughly 10 km along flight track. Pre-retrieval co-adding improves signal-to-noise ratio (SNR) of the observations and provides greatly improved uncertainties in the retrieved column values. Not necessarily all 100 spectra (per FTS band) with the 100-second co-adding interval are being used in the final, co-added spectrum. Rather, the selection is based on whether the specific set of three spectra – one from each of the three FTS bands – improves overall SNRs across the bands. If one or more of the three spectra significantly degrades the over SNR, the whole set is rejected. This ensures that (a) low SNR observations are discarded, and that (b) exactly the same set of 1-second observations is used in the 100-second co-added spectra for each band. The latter is important because dry-air columns are derived from ratios of retrievals performed in different bands, using different sets of 1 second spectra in each band for the same co-added observation would introduce a random source of error.

The CARVE FTS has a 10 degree field of view, which makes across-track coverage dependent on flight altitude.

Level 1 FTS Spectra product

The data from the FTS instrument was converted from Level 0 in raw form into a NetCDF 4 formatted Level 1 data product with the addition of quality control flags. Please contact the PI regarding whether any algorithm is applied in generating this data.

No radiometric calibration was performed for the FTS. Real radiance is uncalibrated atmospheric spectral radiance. Imaginary radiance is for diagnostic purposes only.

6. Data Access

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

CARVE: L1 Spectral Radiances from Airborne FTS, Alaska, 2012-2015

Contact for Data Center Access Information:

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

7. References

Dupont, F., F. Tanguay, M. Li, G. Perron, C.E. Miller, S.J. Dinardo, and T.P. Kurosu (2012). CARVE-FTS Observations of Arctic CO2, CH4, and CO - Overview of the Instrument, *Proc. Of SPIE*, 8532, 853204. <http://dx.doi.org/10.1117/12.979826>

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



Privacy Policy | Feedback | Help



Home	About Us Who We Are Partners User Working Group Biogeochemical Dynamics Data Citation Policy News Workshops	Get Data Complete Data Set List Search for Data Field Campaigns Validation Regional/Global Model Archive	Data Management Plan Manage Archive DAAC Curation Submit Data	Tools Data Search Site Search Search by DOI WebGIS SDAT MODIS Land Subsets THREDDS	Help FAQs	Contact Us
----------------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-------------------------------------	----------------------------