ABoVE: Atmospheric Profiles of CO, CO2 and CH4 Concentrations from Arctic-CAP, 2017

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Documentation Revision Date: 2019-05-01

Dataset Version: 1

Summary

This dataset provides in situ airborne measurements of atmospheric carbon monoxide (CO), carbon dioxide (CO2), methane (CH4), and water vapor concentrations, plus air temperature, pressure, relative humidity, and wind speed values over Alaska and the Yukon and Northwest Territories of Canada during the Arctic Carbon Aircraft Profile (Arctic-CAP) monthly sampling campaigns from April-November 2017. Observations have been averaged to a 10-second interval and are reported with the number of samples (N) and standard deviation. During each of the six monthly campaigns, flights over the Arctic-Boreal Vulnerability Experiment (ABoVE) domain included 25 vertical profiles, from the surface up to 6 km altitude, at locations selected to complement regular long-term vertical profiles, remote sensing data, and ground-based flux tower measurements.

The data were collected for the Arctic-CAP project to capture the spatial and temporal dynamics of the northern high latitude carbon cycle as part of ABoVE.

There is one data file in NetCDF (.nc) format with this dataset.

Figure 1. Arctic-CAP flight lines (orange) sample Arctic and boreal regions of Alaska and the Yukon and the Northwest Territories of Canada. Monthly campaigns extended from April through November, capturing the carbon dynamics of the 2017 growing season. Pins mark the locations of the 25 vertical profiles acquired during each monthly campaign. Source: Scientific Aviation, 2019.

Citation

Sweeney, C., and K. McKain. 2019. ABoVE: Atmospheric Profiles of CO, CO2 and CH4 Concentrations from Arctic-CAP, 2017. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1658

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1. Dataset Overview

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The data were collected in order to capture the spatial and temporal dynamics of the northern high latitude carbon cycle as part of ABoVE.

Project: Arctic-Boreal Vulnerability Experiment

The Arctic-Boreal Vulnerability Experiment (ABoVE) is a NASA Terrestrial Ecology Program field campaign based 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 and societal implications.

Related Data Set:

Oechel, W., and A. Kalhori. 2018. ABoVE: CO2 and CH4 Fluxes and Meteorology at Flux Tower Sites, Alaska, 2015-2017. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1562

Wofsy, S.C., et al. 2018. ATom: Merged Atmospheric Chemistry, Trace Gases, and Aerosols. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1581

Acknowledgement:

This research received funding from the NASA Terrestrial Ecology Program, grant number NNX17AC61A.

2. Data Characteristics

Spatial Coverage: Alaska and Canada

ABoVE Reference Locations:

Domain: Core and extended

State/territory: Alaska and Yukon and Northwest Territories of Canada

Grid cells: Ah000v000, Ah000v001, Ah001v001, Ah002v001

Spatial Resolution: Point locations. At aircraft speed of 170 knots (87.5 m/s), one 10-s averaging interval covers a distance of ~875 m. Profiles cover a vertical range from the surface up to 6 km altitude.

Temporal Coverage: 2017-04-26 to 2017-11-05

Temporal Resolution: Data were collected in approximately monthly campaigns with 7-8 flight days for each campaign. Measurement data have been averaged to 10-second intervals.

Study Areas (All latitude and longitude given in decimal degrees)

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Alaska and Canada	-166.04539	-104.1124	71.287399	40.0387

Data File Information

There is one data file in NetCDF (.nc) format with this dataset.

For each variable, there are 107,400 observations (10-sec averages) collected during 55 individual flights over the period 2017-04-26 to 2017-11-05.

Table 1. Summary table listing each of the 55 unique flights with their respective campaigns and beginning and ending locations. The Flight_ID format is the date (YYYYMMDD) on which the flight began. Note that the starting and ending locations don't necessarily indicate the full flight path for that day.

Campaign	Flight ID	lat_start	lon_start	Start_loc	lat_end	lon_end	End_loc
Transit flight	20170426	40.0391	-105.2322	Colorado	62.4684	-114.4433	Yellowknife
April-May	20170427	62.4702	-114.4493	Yellowknife	62.469	-114.4441	Yellowknife
	20170428	62.4707	-114.4517	Yellowknife	68.3039	-133.4776	Inuvik
	20170429	68.3033	-133.5016	Inuvik	64.8053	-147.8663	Fairbanks
	20170430	64.805	-147.8816	Fairbanks	64.5093	-165.3624	Nome
	20170501	64.5078	-165.4506	Nome	64.8219	-147.8505	Fairbanks

	20170503	64.8044	-147.8827	Fairbanks	60.7129	-135.0704	Whitehorse
	20170504	60.7172	-135.0731	Whitehorse	62.4704	-114.4502	Yellowknife
June	20170606	62.4657	-114.4295	Yellowknife	68.3039	-133.4776	Inuvik
	20170607	68.3033	-133.5	Inuvik	64.806	-147.8651	Fairbanks
	20170608	64.8032	-147.8849	Fairbanks	64.5114	-165.443	Nome
	20170609	64.5083	-165.4497	Nome	64.8051	-147.8667	Fairbanks
	20170613	64.8131	-147.8667	Fairbanks	64.8064	-147.8643	Fairbanks
	20170614	64.8135	-147.866	Fairbanks	60.5655	-151.2556	Anchorage
	20170618	59.6415	-151.4882	Anchorage	60.7152	-135.0678	Whitehorse
	20170619	60.7121	-135.0692	Whitehorse	62.4681	-114.4402	Yellowknife
July	20170709	62.4708	-114.4522	Yellowknife	62.4697	-114.4434	Yellowknife
	20170710	62.4704	-114.4504	Yellowknife	68.3035	-133.4927	Inuvik
	20170712	68.3033	-133.4994	Inuvik	64.8215	-147.8513	Fairbanks
	20170713	64.8035	-147.8843	Fairbanks	64.5127	-165.4405	Nome
	20170714	64.508	-165.4503	Nome	64.8096	-147.8584	Fairbanks
	20170717	64.8135	-147.866	Fairbanks	64.811	-147.8705	Fairbanks
	20170718	64.8266	-147.8419	Fairbanks	64.8205	-147.8531	Fairbanks
	20170719	64.2617	-146.0123	Fairbanks	60.7157	-135.0721	Whitehorse
	20170721	60.7175	-135.0734	Whitehorse	62.4701	-114.4435	Yellowknife
August	20170817	56.6532	-111.2097	Fort McMurray	68.3038	-133.4824	Inuvik
	20170818	68.3034	-133.4991	Inuvik	64.8203	-147.8535	Fairbanks
	20170821	64.8134	-147.8662	Fairbanks	64.8082	-147.8609	Fairbanks
	20170823	64.826	-147.8429	Fairbanks	64.5106	-165.444	Nome
	20170824	64.7501	-164.3066	Quartz Creek	65.4121	-164.6727	Quartz Creek
	20170826	64.5178	-165.43	Nome	64.5125	-165.441	Nome
	20170827	64.5085	-165.4491	Nome	64.8219	-147.8504	Fairbanks
	20170828	64.8121	-147.8686	Fairbanks	60.7146	-135.0712	Whitehorse
	20170829	60.7179	-135.0737	Whitehorse	62.4699	-114.4435	Yellowknife
	20170830	62.4702	-114.4493	Yellowknife	62.4691	-114.4448	Yellowknife
September	20170908	62.4656	-114.4292	Yellowknife	60.7135	-135.0665	Whitehorse
	20170910	60.7186	-135.0742	Whitehorse	60.9571	-137.4537	Whitehorse
	20170913	60.7178	-135.0737	Whitehorse	64.8206	-147.8529	Fairbanks
	20170915	64.8128	-147.8672	Fairbanks	70.1957	-148.4543	Deadhorse
	20170917	64.8137	-147.8656	Fairbanks	64.5112	-165.4482	Nome
	20170918	64.5094	-165.4366	Nome	64.8093	-147.859	Fairbanks
	20170921	64.8131	-147.8667	Fairbanks	64.8091	-147.8593	Fairbanks
	20170924	64.8134	-147.8661	Fairbanks	64.8112	-147.8702	Fairbanks
	20170927	64.8124	-147.868	Fairbanks	62.4685	-114.4421	Yellowknife
	20170928	62.471	-114.4527	Yellowknife	55.1845	-118.8811	Grand Prairie
October-November	20171018	56.6532	-111.2067	Fort McMurray	62.4604	-114.442	Yellowknife
	20171021	62.4658	-114.4297	Yellowknife	68.3036	-133.4895	Inuvik
	20171022	68.3042	-133.4667	Inuvik	64.8215	-147.8512	Fairbanks
	20171023	64.8126	-147.8676	Fairbanks	64.8077	-147.8766	Fairbanks

	20171025	64.8039	-147.8836	Fairbanks	64.8091	-147.874	Fairbanks
	20171031	64.8036	-147.8842	Fairbanks	64.8082	-147.8757	Fairbanks
	20171101	64.8264	-147.8423	Fairbanks	64.8099	-147.8726	Fairbanks
	20171102	64.8041	-147.8832	Fairbanks	60.7151	-135.0716	Whitehorse
	20171104	60.7029	-135.0622	Whitehorse	55.1845	-118.8797	Grand Prairie
Transit flight	20171105	55.1845	-118.874	Grand Prairie	40.209	-104.9237	Colorado

Data Dictionary

File name: **ABoVE_2017_insitu_10sec.nc**

Table 2. Variables in the data file

Variable	Units/format	Description
altitude	m.a.s.l.	Sample altitude (GPS altitude) in meters above sea level
flight_id	YYYYMMDD	A unique number identifying each flight. The format is the date in YYYYMMDD on which the flight began. See Table 1.
CH4	nmol per mol	Mole fraction of methane in dry air. Average of all measurements made in the time interval. Mole fraction reported in units of nanomole per mol (1e-9 mol per mol of dry air); equivalent to ppb (parts per billion). Fill value: -9999
CH4_nvalue		Number of individual measurements used to compute reported value. Fill value: -9
CH4_stdv	nmol per mol	Standard deviation of all measurements made in the time interval. A value of 0 occurs when nvalue is equal to 1. The mole fraction reported in units of nanomole per mol (1e-9 mol per mol of dry air). Fill value: -9999
CH4_unc	nmol per mol	Estimated uncertainty of the reported value. May be a single average uncertainty value for the whole dataset. The mole fraction reported in units of nanomole per mol (1e-9 mol per mol of dry air). Fill value: -9999
CO2	umol per mol	Mole fraction of carbon dioxide in dry air; average of all measurements made in the time interval. Mole fraction reported in units of micromole per mole (1e-6 mol per mol of dry air); equivalent to ppm (parts per million). Fill value: -9999
CO2_nvalue		Number of individual measurements used to compute reported value. Fill value: -9
CO2_stdv	umol per mol	Standard deviation of all measurements made in the time interval. A value of 0 occurs when nvalue is equal to 1. The mole fraction reported in units of micromole per mole (1e-6 mol per mol of dry air); equivalent to ppm (parts per million). Fill value: -9999
CO2_unc	umol per mol	Estimated uncertainty of the reported value. May be a single average uncertainty value for the whole dataset. The mole fraction reported in units of micromole per mole (1e-6 mol per mol of dry air); equivalent to ppm (parts per million).Fill value: -9999
CO	nmol per mol	Mole fraction of carbon monoxide in dry air; average of all measurements made in the time interval. Mole fraction reported in units of nanomole per mol (1e-9 mol per mol of dry air); equivalent to ppb (parts per billion).
CO_nvalue		Number of individual measurements used to compute reported value. Fill value: -9
CO_stdv	nmol per mol	Standard deviation of all measurements made in the time interval. A value of 0 occurs when nvalue is equal to 1. The mole fraction reported in units of nanomole per mol (1e-9 mol per mol of dry air). Fill value: -9999
CO_unc	nmol per mol	Estimated uncertainty of the reported value. May be a single average uncertainty value for the whole dataset. The mole fraction reported in units of nanomole per mol (1e-9 mol per mol of dry air). Fill value: -9999
H2O	%	Water vapor; Average of all measurements made in the time interval. Fill value: -9999
H20_nvalue		Number of individual measurements used to compute reported value. Fill value: -9
H20_stdv	%	Standard deviation of all measurements made in the time interval. A value of 0 occurs when nvalue is equal to 1. Fill value: -9999
H2O_unc	%	Estimated uncertainty of the reported value. May be a single average uncertainty value for the whole dataset
latitude	Decimal degrees	Latitude at which air sample was collected
longitude	Decimal degrees	Longitude at which air sample was collected
T	Degrees K	Air temperature from the Vaisala instrument; average of all measurements made in the time interval. Not calibrated
T_nvalue		Number of individual measurements used to compute reported value. Fill value: -9
		Standard deviation of all measurements made in the time interval. A value of 0 occurs when

T_stdv	Degrees K	nvalue is equal to 1
T_unc	Degrees K	Estimated uncertainty of the reported value. May be a single average uncertainty value for the whole dataset. Fill value: -9999
P	Pa	Air pressure; average of all measurements made in the time interval. Not calibrated. Measuring instrument: Picarro G2401
P_nvalue	Pa	Number of individual measurements used to compute reported value. Fill value: -9
P_stdv	Pa	Standard deviation of all measurements made in the time interval. A value of 0 occurs when nvalue is equal to 1. Fill value: -9999
P_unc	Pa	Estimated uncertainty of the reported value. May be a single average uncertainty value for the whole dataset. Fill value: -9999
profile_id		A unique integer greater than 0 for each profile on each flight number; a value of 0 means that those data are not part of a profile
RH	%	Relative humidity; average of all measurements made in the time interval. Not calibrated
RH_nvalue	%	Number of individual measurements used to compute reported value. Fill value: -9
RH_stdv	%	Standard deviation of all measurements made in the time interval. A value of 0 occurs when nvalue is equal to 1. Fill value: -9999
RH_unc	%	Estimated uncertainty of the reported value. May be a single average uncertainty value for the whole dataset. Fill value: -9999
time	seconds since 1970-01-01T00:00:00Z	Number of seconds since January 1, 1970 in UTC. Time-averaged values are reported at the beginning of the averaging interval
time_components	YMDHMS	Calendar time components as integers. Times and dates are UTC. Time-averaged values are reported at the beginning of the averaging interval. Provided in the order: year, month, day, hour, minute, second
time_decimal		Decimal year in UTC. Time-averaged values are reported at the beginning of the averaging interval
u	m/s	Eastward wind (Aspen instrument); Average of all measurements made in the time interval. Aircraft calibrated. Fill value: -9999
u_nvalue	m/s	Number of individual measurements used to compute reported value. Fill value: -9
u_stdv	m/s	Standard deviation of all measurements made in the time interval. A value of 0 occurs when nvalue is equal to 1. Fill value: -9999
u_unc	m/s	Estimated uncertainty of the reported value. May be a single average uncertainty value for the whole dataset. Fill value: -9999
v	m/s	Northward wind (Aspen instrument); Average of all measurements made in the time interval. Aircraft calibrated. Fill value: -9999
v_nvalue	m/s	Number of individual measurements used to compute reported value. Fill value: -9
v_stdv	m/s	Standard deviation of all measurements made in the time interval. A value of 0 occurs when nvalue is equal to 1. Fill value: -9999
v_unc	m/s	Estimated uncertainty of the reported value. May be a single average uncertainty value for the whole dataset. Fill value: -9999

User Note: The variable "**profile_id**" identifies the observations that are part of a vertical profile during a flight. A unique integer greater than 0 identifies each profile on each flight (**flight_id**). A value of 0 means that those data are not part of a vertical profile.

3. Application and Derivation

Large changes in surface air temperature, sea ice cover and permafrost in the Arctic Boreal Ecosystems (ABE) are likely to have significant impact on the critical ecosystem services and the human societies that are dependent on the ABE. In order to predict the outcome of continued change to the climate system in the ABE, it is necessary to understand the vulnerabilities of the underlying ABE ecosystems by understanding what processes drive both spatial variability and interannual variability.

These data contribute to our understanding and predictive capabilities for modeling the land-atmospheric exchange of CO2 and CH4 to better understand the feedbacks that these greenhouse gases will have on the ABE.

4. Quality Assessment

The number of samples (N) and standard deviation for each 10-second average value are included in the data file. Measurement uncertainties are also included for each variable -- may be a single average uncertainty value for the whole dataset.

5. Data Acquisition, Materials, and Methods

The Arctic Carbon Aircraft Profile (Arctic-CAP) project was designed to measure vertical profiles of atmospheric CO2, CH4, and CO concentrations to capture the spatial and temporal dynamics of the northern high latitude carbon cycle as part of the Arctic-Boreal Vulnerability Experiment (ABoVE) (Miller et al., 2019).

The sampling strategy involved acquiring vertical profiles of CO2, CH4, and CO concentrations from the surface to 6 km altitude around the ABoVE domain each month. The profiles were acquired from locations selected to complement regular long-term vertical profiles, remote sensing data, and ground-based flux tower measurements. These data spatially link the regular vertical profiles obtained at Poker Flats, AK and East Trout Lake, SK as part of the ESRL/GMD Aircraft Program (https://www.esrl.noaa.gov/gmd/ccgg/aircraft/). These measurements were complemented by additional vertical profiles that were acquired at altitudes up to 14 km by the NASA DC-8 in August (Active Sensing of CO2 Emissions over Nights, Days, & Seasons [ASCENDS], https://www-air.larc.nasa.gov/missions/ascends/index.html) and October (Atmospheric Tomography Mission [AToM], Wofsy et al. (2018)).

Six campaigns were flown from April to early November in 2017 with instrumentation aboard a Mooney Ovation 3 M20R (N617DH, Scientific Aviation). Airborne in situ measurements included CO2, CO, CH4, water vapor, RH, temperature and wind.

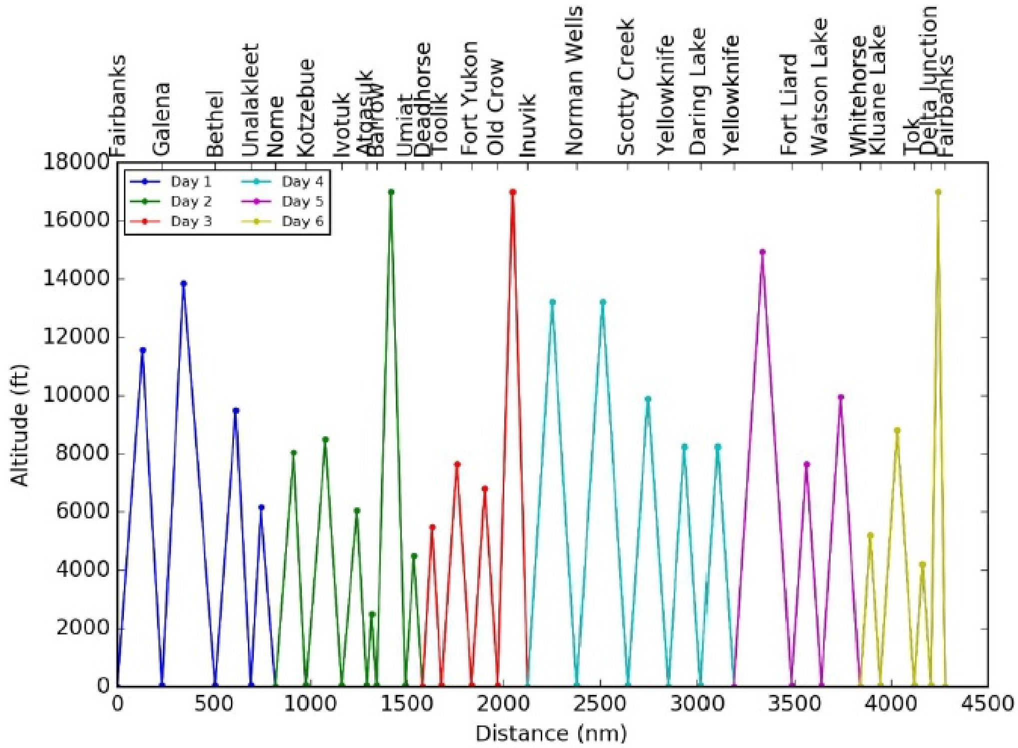

Figure 2. For each campaign, vertical profiles were flown at each of the ~25 locations listed across the top of this figure. These locations are shown on Figure 1. Nominally, the campaign would require 6 flying days to complete all of the profiles.

The profiles were acquired from locations selected to complement regular long-term vertical profiles, remote sensing data, and ground-based flux tower measurements.

The measurements are described in Table 2. Instruments utilized are provided in Table 3.

Table 3. Airborne in situ instruments

Instrument	Measurement frequency	Measurement
Picarro G2401	2.4 seconds	CH4, CO, CO2, and water vapor (H20), Air pressure (P)
Vaisala	1 Hz	Relative humidity (RH), air temperature (T)
Aspen	1 Hz	Eastward wind (u) and northward wind (v) speeds

6. Data Access

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

ABoVE: Atmospheric Profiles of CO, CO2 and CH4 Concentrations from Arctic-CAP, 2017

Contact for Data Center Access Information:

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

7. References

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K. Froyd, D.W. Gesler, S.R. Hall, T.F. Hanisco, R.A. Hannun, A.J. Hills, E.J. Hintsa, A. Hoffman, R.S. Hornbrook, L.G. Huey, S. Hughes, J.L. Jimenez, B.J. Johnson, J.M. Katich, R.F. Keeling, M.J. Kim, A. Kupc, L.R. Lait, J.-F. Lamarque, J. Liu, K. McKain, R.J. Mclaughlin, S. Meinardi, D.O. Miller, S.A. Montzka, F.L. Moore, E.J. Morgan, D.M. Murphy, L.T. Murray, B.A. Nault, J.A. Neuman, P.A. Newman, J.M. Nicely, X. Pan, W. Paplawsky, J. Peischl, M.J. Prather, D.J. Price, E. Ray, J.M. Reeves, M. Richardson, A.W. Rollins, K.H. Rosenlof, T.B. Ryerson, E. Scheuer, G.P. Schill, J.C. Schroder, J.P. Schwarz, J.M. St.Clair, S.D. Steenrod, B.B. Stephens, S.A. Strode, C. Sweeney, D. Tanner, A.P. Teng, A.B. Thames, C.R. Thompson, K. Ullmann, P.R. Veres, N. Vieznor, N.L. Wagner, A. Watt, R. Weber, B. Weinzierl, P. Wennberg, C.J. Williamson, J.C. Wilson, G.M. Wolfe, C.T. Woods, and L.H. Zeng. 2018. ATom: Merged Atmospheric Chemistry, Trace Gases, and Aerosols. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1581