ABoVE/ASCENDS: Active Sensing of CO2, CH4, and Water Vapor, Alaska and Canada, 2017

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Documentation Revision Date: 2022-05-04

Dataset Version: 1

Summary

This dataset provides in situ airborne measurements of atmospheric 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 2017-07-20 to 2017-08-08. Measurements were taken onboard a DC-8 aircraft during this Active Sensing of CO2 Emissions over Nights, Days and Seasons (ASCENDS) airborne deployment over portions of the Arctic-Boreal Vulnerability Experiment (ABoVE) domain. CO2 and CH4 were measured with NASA's Atmospheric Vertical Observations of CO2 in the Earth's Troposphere (AVOCET) instrument. Water vapor and relative humidity were measured with Diode Laser Hydrometer. Measurements of column-averaged dry-air mixing ratio CO2 measurements (XCO2) were taken with the CO2 Sounder Lidar instrument. The airborne CO2 Sounder is a pulsed, multi-wavelength Integrated Path Differential Absorption lidar. It estimates XCO2 in the nadir path from the aircraft to the scattering surface by measuring the shape of the 1572.33 nm CO2 absorption line. The data were collected in order to capture the spatial and temporal dynamics of the northern high latitude carbon cycle as part of ABoVE and are provided in ICARTT file format.

There are 40 data files in ICARTT format (*.ict) included in this dataset

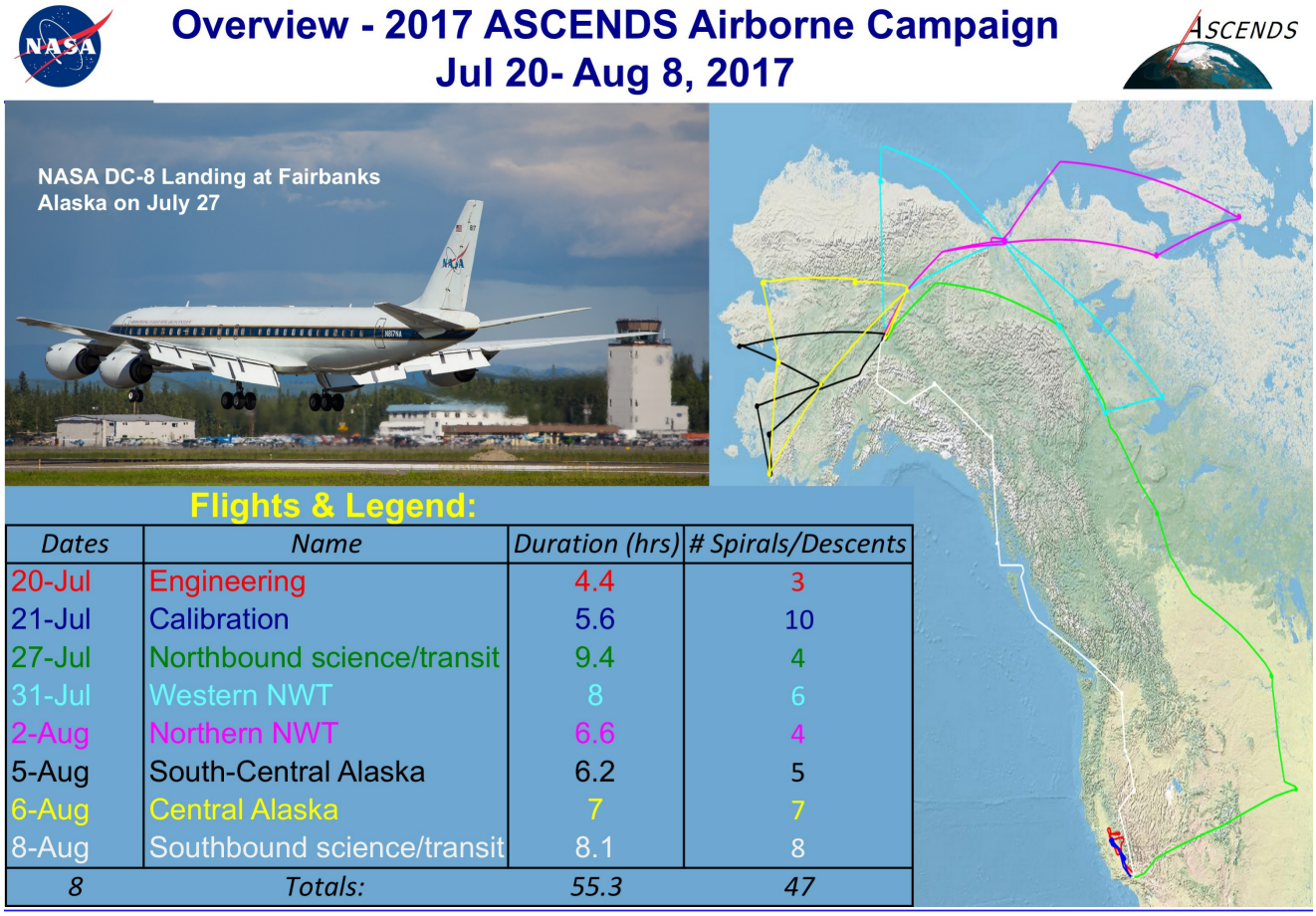

Figure 1. A map showing the ground tracks for the airborne campaign, with a table summarizing each flight. The colors in the table match those shown in the ground tracks.

Citation

Abshire, J.B., J. Mao, H. Riris, S.R. Kawa, and X. Sun. 2022. ABoVE/ASCENDS: Active Sensing of CO2, CH4, and Water Vapor, Alaska and Canada, 2017. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2050

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1. Dataset Overview

This dataset provides in situ airborne measurements of atmospheric carbon dioxide (CO_2), methane (CH_4), 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 2017-07-20 to 2017-08-08. Measurements were taken on board a DC-8 aircraft during this Active Sensing of CO_2 Emissions over Nights, Days, and Seasons (ASCENDS) airborne deployment over portions of the Arctic-Boreal Vulnerability Experiment (ABoVE) domain. CO_2 and CH_4 were measured with NASA's Atmospheric Vertical Observations of CO2 in the Earth's Troposphere (AVOCET) instrument. Water vapor and relative humidity were measured with Diode Laser Hydrometer. Measurements of column-averaged dry-air mixing ratio CO_2 measurements (XCO2) were taken with the CO_2 Sounder Lidar instrument. The airborne CO_2 Sounder is a pulsed, multi-wavelength Integrated Path Differential Absorption lidar. It estimates XCO2 in the nadir path from the aircraft to the scattering surface by measuring the shape of the 1572.33 nm CO_2 absorption line. The data were collected 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 Dataset

Sun, X., P.T. Kolbeck, J.B. Abshire, S.R. Kawa, and J. Mao. 2022. ABoVE/ASCENDS: Atmospheric Backscattering Coefficient Profiles from CO2 Sounder, 2017. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2051

- Provides backscatter profiles from associated measurements of XCO2.

Related Publications

Abshire, J. B., A.K. Ramanathan, H. Riris, G.R. Allan, X. Sun, W.E. Hasselbrack, J. Mao, S. Wu, J. Chen, K. Numata, S.R. Kawa, M.Y.M. Yang, and J. DiGangi. 2018. Airborne measurements of CO_2 column concentrations made with a pulsed IPDA lidar using multiple-wavelength-locked laser and HgCdTe APD detector. Atmospheric Measurement Techniques (AMT) 11:2001-2025. https://doi.org/10.5194/amt-11-2001-2018

Allan, G.R., J.B. Abshire, H. Riris, J. Mao, W.E. Hasselbrack, K. Numata, J. Chen, R. Kawa, M. Rodriguez, and M. Stephen. 2018. Lidar measurements of CO_2 column concentrations in the Arctic region of North America from the ASCENDS 2017 airborne campaign. SPIE Proceedings volume 10779, Lidar Remote Sensing for Environmental Monitoring XVI, 1077906 (24 October 2018). https://doi.org/10.1117/12.2325908

Sun, X., J.B. Abshire, A. Ramanathan, S.R. Kawa, and J. Mao. 2021. Retrieval algorithm for the column CO_2 mixing ratio from pulsed multi-wavelength lidar measurements. Atmospheric Measurement Techniques 14:3909–3922. https://doi.org/10.5194/amt-14-3909-2021

2. Data Characteristics

Spatial Coverage: Alaska, U.S.; Yukon Territory and Northwest Territories, Canada

ABoVE Reference Locations

Domain: Core and extended

State/Territory: Alaska; Yukon; Northwest Territories

Grid cells: Ah000v000, Ah000v001, Ah001v000, Ah001v001, Ah001v002, Ah002v001, Ah002v002

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

Temporal Coverage: 2017-07-20 to 2017-08-08 with 8 single-day flights during the period.

Temporal Resolution: Measurement data have been averaged at 10-second intervals.

Study Areas: Latitude and longitude are given in decimal degrees.

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Alaska and Canada	-165.6848	-98.0895	71.2752	34.5893

Data File Information

There are 40 data files in ICARTT format (*.ict) included in this dataset, and the files conform to the ICARTT File Format Standards V1.1. The files are

named ASCENDS-***AAAA*-*BBB***_DC8_***YYYYMMDD***_R***C***.ict, where

- *AAAA* is "AVOCET", "CO2SOUNDER", "DLH", or "Hskping",
- *BBB is* "CO2", "CH4", or "XCO2",
- *YYYYMMDD* is the date of flight in YYYY = year, MM = month, DD = day, and
- *C* is the revision number for the file.

Table 1. File names and descriptions.

File Name	Descriptions
ASCENDS-AVOCET-CH4_DC8_*YYYYMMDD*_RC.ict	Measurements of methane (CH_4) from the Atmospheric Vertical Observations of CO_2 in the Earth's Troposphere (AVOCET) instrument.
ASCENDS-AVOCET-CO2_DC8_*YYYYMMDD*_RC.ict	Measurements of carbon dioxide (CO_2) from AVOCET.
ASCENDS-CO2SOUNDER-XCO2_DC8_*YYYYMMDD*_RC.ict	Measurements of column-averaged dry-air mixing ratios (XCO2) from the CO_2 Sounder Lidar instrument.
ASCENDS-DLH_DC8_*YYYYMMDD*_RC.ict	Measurements of water vapor and humidity from the Diode Laser Hydrometer instrument.
Ascends-Hskping_DC8_*YYYYMMDD*_RC.ict	Meteorological and navigation measurements from the DC-8 platform.

Data File Details

The *no_data* value is -9999 for all files, except the file ASCENDS-DLH_DC8_ *YYYYMMDD*_R0.ict which has a *no_data* value of -999.9.

Table 2. Variable names and descriptions in files named ASCENDS-AVOCET-CH4_DC8_ *YYYYMMDD*_R0.ict and ASCENDS-AVOCET-CO2_DC8_*YYYYMMDD*_R0.ict.

Variable	Units	Description
Start_UTC	s	Start UTC time of day in seconds
Stop_UTC	s	Stop UTC time of day in seconds
Mid_UTC	s	Mean UTC time of day in seconds
CH4_ppmv	ppmv	Methane dry mixing ratio
CO2_ppmv	ppmv	Carbon dioxide dry mixing ratio

Table 3. Variable names and descriptions in files named ASCENDS-CO2SOUNDER-XCO2_DC8_ *YYYYMMDD*_R0.ict.

Variable	Units	Description
Start_UTC	s	Seconds from midnight UTC on flight date
XCO2_Sounder	ppm	Column-averaged dry-air mixing ratio of CO_2 (XCO2)
Sigma_XCO2_Sounder	ppm	Standard deviation for XCO_2 average
Lidar_Surface_Latitude	degrees_north	Surface latitude
Lidar_Surface_Longitude	degrees_east	Surface longitude
Lidar_Range	m	Distance to reflective surface
Lidar_Off_nadir_Angle	degrees	Angle from lidar beam to aircraft nadir
Lidar_Surface_Elevation	m	Mean seal level of reflective surface
Aircraft_Latitude	degrees_north	Aircraft latitude
Aircraft_Longitude	degrees_east	Aircraft longitude
Aircraft_Altitude	m	GPS height above mean sea level
Aircraft_Pitch_Angle	degrees	Aircraft pitch
Aircraft_Roll_Angle	degrees	Aircraft roll

Table 4. Variable names and descriptions in files named ASCENDS-DLH_DC8_ *YYYYMMDD*_R0.ict.

Variable	Units	Description
Time_UTC	s	Seconds since midnight UTC on flight date
H2O_ppmv	ppmv	Water vapor mixing ratio
RHi_pct	percent	Relative humidity with respect to ice
RHw_pct	percent	Relative humidity with respect to liquid

Table 5. Variable names and descriptions in files named Ascends-Hskping_DC8_ *YYYYMMDD*_R0.ict.

Variable	Units	Description
Start_UTC	s	Seconds since midnight UTC on flight date
Day_Of_Year	d	Day of year, beginning January 1
Latitude	degrees_north	Latitude
Longitude	degrees_east	Longitude
MSL_GPS_Altitude	m	Sensor height above mean sea level
HAE_GPS_Altitude	m	Sensor height above WGS84 ellipsoid
Pressure_Altitude	ft	Aircraft altitude from air pressure
Radar_Altitude	ft	Aircraft altitude from radar
Ground_Speed	$m\ s^{-1}$	Aircraft ground speed
True_Air_Speed	kts	Air speed in knots
Indicated_Air_Speed	kts	Air speed in knots
Mach_Number	mach	Air speed in mach number
Vertical_Speed	$m\ s^{-1}$	Vertical speed
True_Heading	degrees	Aircraft heading, 0-360 degrees, clockwise from +y
Track_Angle	degrees	Aircraft track, 0-360 degrees, clockwise from +y
Drift_Angle	degrees	Aircraft drift, +/-180 degrees, clockwise from +y
Pitch_Angle	degrees	Aircraft pitch, +/-180 degrees, up+
Roll_Angle	degrees	Aircraft roll, +/-180 degrees, right+
Static_Air_Temp	degrees Celsius	Air temperature
Potential_Temp	degrees Kelvin	Air temperature
Dew_Point	degrees Celsius	Dew point temperature
Total_Air_Temp	degrees Celsius	Air temperature
IR_Surf_Temp	degrees Celsius	Surface temperature
Static_Pressure	mb	Air pressure
Cabin_Pressure	mb	Air pressure
Wind_Speed	$m\ s^{-1}$	Wind speed, limited to where *Roll_Angle* <= 5 degrees
Wind_Direction	degrees	Wind direction, 0-360 degrees, clockwise from +y
Solar_Zenith_Angle	degrees	Solar zenith angle
Aircraft_Sun_Elevation	degrees	Aircraft sun elevation angle
Sun_Azimuth	degrees	Sun azimuth angle
Aircraft_Sun_Azimuth	degrees	Aircraft-sun azimuth angle
Mixing_Ratio	$g\ kg^{-1}$	Atmospheric mixing ratio
Part_Press_Water_Vapor	mb	Partial pressure of water vapor
Sat_Vapor_Press_H2O	mb	Saturated vapor pressure over liquid water
Sat_Vapor_Press_Ice	mb	Saturated vapor pressure over ice
Relative_Humidity	percent	Relative humidity with respect to water

3. Application and Derivation

These data contribute to our understanding and predictive capabilities for modeling the land-atmospheric exchange of CO_2 and CH_4 in the ABoVE study region.

4. Quality Assessment

The CO_2 Sounder instrument was calibrated during an engineering flight under known atmospheric conditions and with the vertical profile of CO_2 mixing ratios measured by in situ AVOCET sensor during the flight's spiral-down maneuvers (Abshire et al., 2018).

During this deployment, the CO_2 Sounder lidar results show better than 1 ppm agreement between most lidar and in situ measurements during flights, both north-south and east-west gradients in XCO2, and local features in XCO2, including one caused by wildfires.

The standard deviations for each 10-second average XCO2 value are included in the files named ASCENDS-DLH_DC8_ *YYYYMMDD*_R0.ict.

5. Data Acquisition, Materials, and Methods

Data were collected during eight flights over the ABoVE region during the period 2017-07-20 to 2017-08-08. In situ concentrations of atmospheric carbon dioxide and methane were measured with an infrared absorption spectrometer on NASA's Atmospheric Vertical Observations of CO_2 in the Earth's Troposphere (AVOCET) instrument. Water vapor and relative humidity were measured with Diode Laser Hydrometer.

Column-averaged dry-air CO_2 mixing ratio (XCO2) measurements were taken with the CO $_2$ Sounder Lidar instrument (Abshire et al., 2017). This airborne lidar employs an integrated path differential absorption (IPDA) lidar technique to measure the range and pulse energy to ground or to cloud tops at 30 fixed-wavelength samples. It estimates the XCO2 in the nadir path from the aircraft to the scattering surface by measuring the shape of the 1572.33 nm CO_2 absorption line. For each 1-second integration, the retrieval algorithm (Sun et al., 2021) solves for scattering surface elevation and XCO2 by using radiative transfer calculations, the aircraft altitude, range to the surface, and atmospheric conditions. This lidar has been successfully used in several airborne campaigns. Over desert surfaces, XCO2 measurements with a 1-second integration time have standard deviations of <1 ppm. Observations were averaged to a 10-second interval and are reported with the standard deviation of the average.

The flights included 47 spiral-down maneuvers conducted in locations over California, the Northwest Territories Canada, the Arctic Ocean, and Alaska, along with the transit flights from California to Alaska and return. Each spiral maneuver allowed comparing the XCO2 retrievals from the lidar against those computed from CO_2 measured at the aircraft. In addition to the XCO2 measurement, the lidar receiver also recorded the time-resolved atmospheric backscatter signal strength continuously as the laser pulses propagate through the atmosphere. Backscatter measurements are available in an associated dataset (Sun et al., 2022).

This deployment allowed a new opportunity to assess airborne lidar measurements of XCO2 made in a diverse set of conditions, including those in the Arctic. See Abshire et al. (2018) and Allan et al. (2018) for more information about this research.

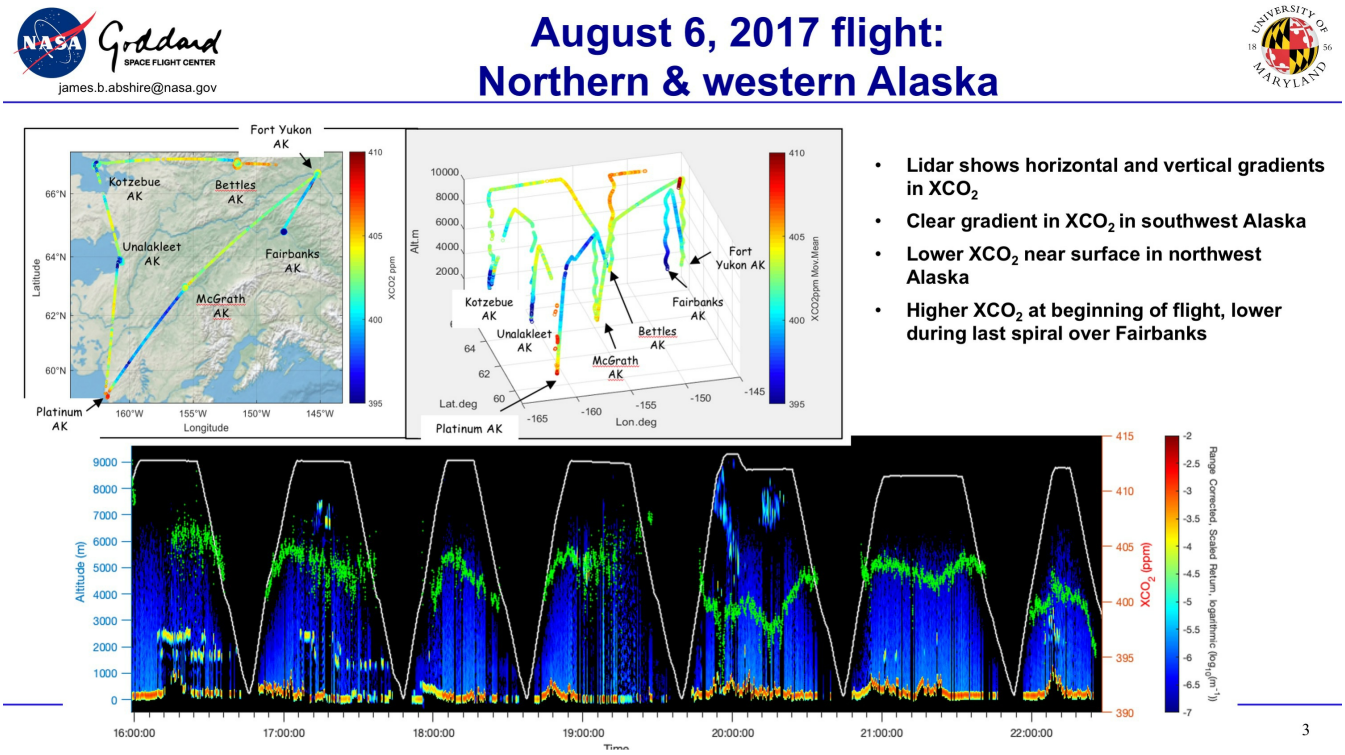

Figure 2. Column-averaged dry-air mixing ratio carbon dioxide (XCO2) concentrations measured by the airborne CO2 Sounder instrument on 06 August 2017 during a flight over Alaska.

6. Data Access

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

ABoVE/ASCENDS: Active Sensing of CO2, CH4, and Water Vapor, Alaska and Canada, 2017

Contact for Data Center Access Information:

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

7. References

Abshire, J. B., A.K. Ramanathan, H. Riris, G.R. Allan, X. Sun, W.E. Hasselbrack, J. Mao, S. Wu, J. Chen, K. Numata, S.R. Kawa, M.Y.M. Yang, and J. DiGangi. 2018. Airborne measurements of CO2 column concentrations made with a pulsed IPDA lidar using multiple-wavelength-locked laser and HgCdTe APD detector. Atmospheric Measurement Techniques 11:2001-2025. https://doi.org/10.5194/amt-11-2001-2018

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Remote Sensing for Environmental Monitoring XVI, 1077906 (24 October 2018). https://doi.org/10.1117/12.2325908

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