ABoVE/ASCENDS: Atmospheric Backscattering Coefficient Profiles from CO2 Sounder, 2017

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Dataset Version: 1

Summary

This dataset provides atmospheric backscattering coefficient profiles collected during Active Sensing of CO2 Emissions over Nights, Days, and Seasons (ASCENDS) deployments from 2017-07-20 to 2017-08-08 over Alaska, U.S., and the Yukon and Northwest Territories of Canada. These profiles were measured by the CO2 Sounder Lidar instrument carried on a DC-8 aircraft. The airborne CO2 Sounder is a pulsed, multi-wavelength Integrated Path Differential Absorption lidar that estimates column-averaged dry-air CO2 mixing ratio (XCO2) in the nadir path from the aircraft to the scattering surface. In addition to XCO2, the lidar receiver recorded the time-resolved atmospheric backscatter signal strength as the laser pulses propagated through the atmosphere. Raw lidar data were converted to the atmospheric backscatter cross-section product and the two-way atmosphere transmission, also known as attenuated backscatter profiles. These ASCENDS flights were coordinated with the 2017 Arctic-Boreal Vulnerability Experiment (ABoVE) campaign and are provided in ICARTT format.

There are 16 data files in ICARTT format (*.ict) included in this dataset. Also included are Matlab scripts used in the data processing of the atmospheric backscatter profiles measured by the CO2 laser sounder during the 2017 ABoVE Airborne Campaign.

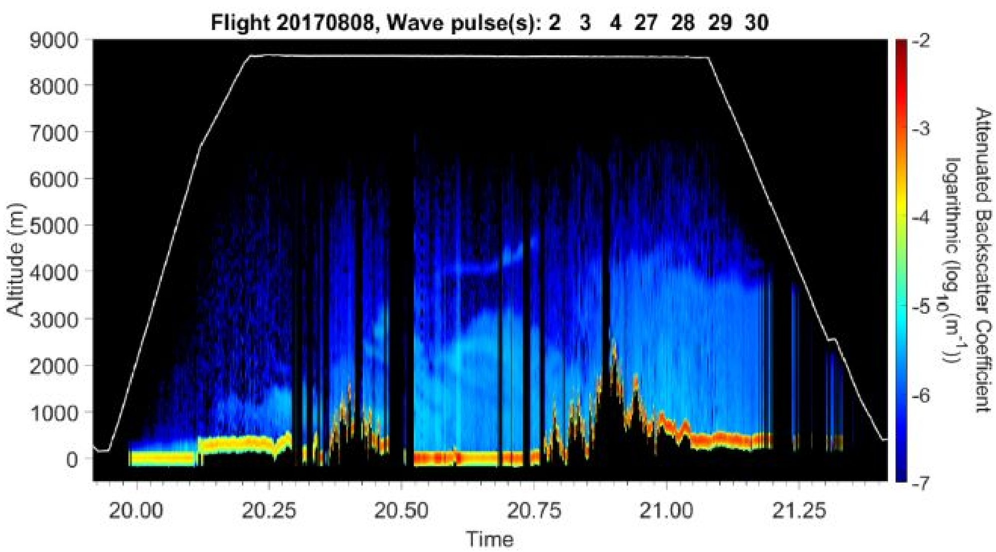

Figure 1. A map showing the ground tracks for the airborne campaign, with a table summarizing each flight. The colors in the table match those shown in the ground tracks.

Citation

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

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1. Dataset Overview

This dataset provides atmospheric backscattering coefficient profiles collected during Active Sensing of CO2 Emissions over Nights, Days, and Seasons (ASCENDS) deployments from 2017-07-20 to 2017-08-08 over Alaska, U.S., and the Yukon and Northwest Territories of Canada. These profiles were measured by the CO2 Sounder Lidar instrument carried on a DC-8 aircraft. The airborne CO2 Sounder is a pulsed, multi-wavelength Integrated Path Differential Absorption lidar that estimates column-averaged dry-air CO_2 mixing ratio (XCO2) in the nadir path from the aircraft to the scattering surface. In addition to XCO2, the lidar receiver recorded the time-resolved atmospheric backscatter signal strength as the laser pulses propagated through the atmosphere. Raw lidar data were converted to the atmospheric backscatter cross-section product and the two-way atmosphere transmission, also known as attenuated backscatter profiles. These ASCENDS flights were coordinated with the 2017 Arctic-Boreal Vulnerability Experiment (ABoVE) campaign.

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

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

- Provides XCO2 measurements from the CO_2 Sounder instrument used to collect backscatter data.

Related Publications

Sun, X., P.T. Kolbeck, J.B. Abshire, S.R. Kawa, and J. Mao. 2022. Attenuated atmospheric backscatter profiles measured by the CO 2 Sounder lidar in the 2017 ASCENDS/ABoVE airborne campaign. Earth System Science Data, 14(8), pp.3821-3833. https://doi.org/10.5194/essd-14-3821-2022

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 (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

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 1-second averaging interval covers a distance of ~87 m. Profiles cover a vertical range from the surface up to 6 km altitude at 15 m vertical resolution.

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 1-second intervals.

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

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Alaska and Canada	-165.210	-103.340	71.210	54.120

Data File Information

There are 16 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-CO2SOUNDER-BSCATPROF_DC8_***YYYYMMDD***_R***X***.ict and Ascends-Hskping_DC8_***YYYYMMDD***_R***X***.ict, where

- *YYYYMMDD* is the date of flight in YYYY = year, MM = month, DD = day, and
- *X* is the revision number for the file.

Table 1. File names and descriptions.

File Name	Description
ASCENDS-CO2SOUNDER-BSCATPROF_DC8_*YYYYMMDD*_R*X*.ict	Backscatter profiles are in files named. These ICARTT files have a multi-dimensional format (FFI=2310).
Ascends-Hskping_DC8_*YYYYMMDD*_R*X*.ict	Meteorological and navigation information for the DC-8 platform. These ICARTT files have a single-dimensional, time-series format (FFI=1101).

Data File Details

The *no_data* value is -9999 for all files.

Table 2. Variable names and descriptions in files named ASCENDS-CO2SOUNDER-BSCATPROF_DC8_ *YYYYMMDD*_R*X*.ict. These files are multi-dimensional ICARTT files. *AttenuatedBackscatterCoefficient* is the primary variable, and the remaining variables are auxiliary variables.

Variable	Units	Description
AttenuatedBackscatterCoefficient	m^{-1}	Lidar BackScattering Profile (a vector of altitude-specific observations, n=*Num_Altitudes* and varies between sample locations)
Num_Altitudes	1	Number of altitude-specific observations of *AttenuatedBackscatterCoefficient*
Geo_Alt_Begin	m	Geometric altitude at which data begin
Alt_Increment	m	Altitude increment between observations
Std_Dev_Noise	m^{-3}	Standard deviation of the noise floor
Aircraft_Latitude	degrees_north	Latitude
Aircraft_Longitude	degrees_east	Longitude
Aircraft_Altitude	m	Height above mean sea level from CO_2 Sounder GPS
Lidar_Off_nadir_Angle	degrees	Angle between lidar beam and nadir
Obs_Flag		Eight-digit observation flag (0 or 1): Flag 1, 1 = the gain was not 1 Flag 2, 1 = missing location data for that second, and location was interpolated from the Ascends-Hskping_DC8_*YYYYMMDD*_R0.ict file Flag 3, 1 = aircraft's roll exceeded 5 degrees Flag 4, 1 = raw data was anomalous (saturation, excessive DC offset, etc.) Flags 5 through 8, unused

Table 3. 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	Latitude
Longitude	degrees	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 sensor
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

Variable	Units	Description
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

Also included are Matlab scripts as **ABoVE_ASCENDS_Backscatter-SoftwareCodes.zip** used in the data processing of the atmospheric backscatter profiles measured by the CO2 laser sounder during the 2017 ABoVE Airborne Campaign. The readme file **ScriptDescription_Co2LidarAtmBackScatProfiles.pdf** within the **ABoVE_ASCENDS_Backscatter-SoftwareCodes.zip** provides a description of all the software codes.

3. Application and Derivation

Backscatter profiles reveal the altitude of the planetary boundary layer and the most relevant altitudes for XCO2 measurements. These data provide additional information about the height-resolved backscatter in the same atmospheric columns where the XCO2 (Abshire et al., 2022) was measured during these 2017 flights.

4. Quality Assessment

Backscattter observations were collected at 10 Hz and then averaged to 1 Hz. 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 sensors during the flight's spiral-down maneuvers (Abshire et al., 2018).

5. Data Acquisition, Materials, and Methods

Atmospheric backscattering coefficient profiles were collected during Active Sensing of CO2 Emissions over Nights, Days, and Seasons (ASCENDS) deployments from 2017-07-20 to 2017-08-08 over Alaska, U.S., and the Yukon and Northwest Territories of Canada. The data were collected in order to capture the spatial and temporal dynamics of the northern high latitude carbon cycle as part of NASA's Arctic-Boreal Vulnerability Experiment (ABoVE) program.

The flights were designed to assess the accuracy of airborne lidar measurements of column-averaged dry-air CO_2 mixing ratio (XCO2) and to extend lidar measurements to the ABoVE study area in the Arctic. Eight flights were conducted with XCO2 measurements from the lidar along with in-situ CO_2 measurements made at the aircraft. Forty-seven spiral-down maneuvers were 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.

These backscatter profiles were measured by the CO_2 Sounder Lidar instrument carried on a NASA DC-8 aircraft. The airborne CO_2 Sounder is a pulsed, multi-wavelength Integrated Path Differential Absorption (IPDA) lidar that 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 (Abshire et al., 2018). In addition, the lidar receiver recorded the time-resolved atmospheric backscatter signal strength as the laser pulses propagated through the atmosphere.

The ASCENDS team processed the data by screening out outliers, correcting for all known instrument artifacts, and converting the raw lidar data to the atmospheric backscatter cross-section product and the two-way atmosphere transmission, also known as attenuated backscatter profiles (Kolbeck and Sun, 2020). These data provide additional information about the height-resolved backscatter in the same atmospheric columns where the XCO2 was measured. The XCO2 observations are available in an associated dataset (Abshire et al., 2022). See Abshire et al. (2018) and Allan et al. (2018) for more information about this research.

6. Data Access

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

ABoVE/ASCENDS: Atmospheric Backscattering Coefficient Profiles from CO2 Sounder, 2017

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
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7. References

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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