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ACT-America: L1 Meteorological and Aircraft Navigational Data

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Dataset Version: 1.1

Summary

This dataset provides aircraft navigational parameters and related meteorological data (often referred to as "housekeeping" data) in support of the research activities for the two aircrafts that flew for the NASA Atmospheric Carbon and Transport-America (ACT-America) project. ACT-America's mission spans five years and includes five 6-week intensive field campaigns covering all 4 seasons and 3 regions of the central and eastern United States. Two instrumented aircraft platforms, the NASA Langley Beechcraft B200 King Air and the NASA Goddard Space Flight Center's C-130H Hercules, were used to collect high-quality in situ measurements across a variety of continental surfaces and atmospheric conditions. During these flights, aircraft positional, meteorological, and environmental data are recorded by a variety of instruments. For this dataset, measurements include, but are not limited to: latitude, longitude, altitude, ground speed, air temperature, and wind speed and direction. These data are incorporated into related ACT-America flight-instrumented datasets to provide geotrajjectory file information for position, attitude, and altitude awareness of instrumented sampling.

ACT-America's objectives are to study the transport and fluxes of atmospheric CO₂ and CH₄. At times they flew directly under Orbiting Carbon Observatory-2 (OCO-2) overpasses to evaluate the ability of OCO-2 to observe high-resolution atmospheric CO₂ variations.

This dataset provides results from all five campaigns (i.e. the Summer 2016, Winter and Fall 2017, Spring 2018, and Summer 2019) of the ACT-America project and contains 289 ICARTT files and 289 netCDF files, one file of each type per flight.



Figure 1. The ACT-America team on the tarmac with the B-200 King Air and C-130 Hercules NASA aircraft in Shreveport, Louisiana.

Citation

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Table of Contents

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

1. Dataset Overview

This dataset provides aircraft navigational parameters and related meteorological data (often referred to as "housekeeping" data) in support of the research activities for the two aircrafts that flew for the NASA Atmospheric Carbon and Transport-America (ACT-America) project. ACT-America's mission spans five years and includes five 6-week intensive field campaigns covering all 4 seasons and 3 regions of the central and eastern United States. Two instrumented aircraft platforms, the NASA Langley Beechcraft B200 King Air and the NASA Goddard Space Flight Center's C-130H Hercules, were used to collect high-quality in situ measurements across a variety of continental surfaces and atmospheric conditions. During these flights, aircraft positional, meteorological, and environmental data are recorded by a variety of instruments. For this dataset, measurements include, but are not limited to: latitude, longitude, altitude, ground speed, air temperature, and wind speed and direction. These data are incorporated into related ACT-America flight-instrumented datasets to provide geotrajjectory file information for position, attitude, and altitude awareness of instrumented sampling.

Project: [Atmospheric Carbon and Transport \(ACT-America\)](#)

The ACT-America, or Atmospheric Carbon and Transport - America, project is a NASA Earth Venture Suborbital-2 mission to study the transport and fluxes of atmospheric carbon dioxide and methane across three regions in the eastern United States. Each flight campaign measures how weather systems transport these greenhouse gases. Ground-based measurements of greenhouse gases were also-collected. Better estimates of greenhouse gas sources and sinks are needed for climate management and for prediction of future climate.

Dataset Visualization: [Visualize ACT-America Data](#)

2. Data Characteristics

Spatial Coverage: Flights over eastern and central United States

Spatial Resolution: Point measurements

Temporal Coverage: Periodic flights occurred during each intensive campaign.

Campaign	Beginning and ending dates
Summer 2016	2016-05-27 to 2016-08-29
Winter 2017	2017-01-21 to 2017-03-10
Fall 2017	2017-09-22 to 2017-11-13
Spring 2018	2018-03-28 to 2018-05-20
Summer 2019	2019-06-07 to 2019-07-27

Temporal Resolution: 1 second

Study Area: (coordinates in decimal degrees)

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Eastern and Central United States	-106.494	-71.9109	49.1083	28.562

Data File Information

There are 289 data files in netCDF (*.nc) version 4 format following Climate and Forecast (CF) conventions 1.6. NetCDF files are structured as GeoTrajectory files, where the observations for a flight segment are connected along a one-dimensional track in space, with time increasing monotonically along the track. These files contain data from the respective aircraft's flight parameters and related environmental data.

There are 289 data files in the ICARTT file format (*.ict). ICARTT files have detailed header information and follow the standards established and summarized in the ICARTT File Format Standards V1.1. <https://www-air.larc.nasa.gov/missions/etc/IcarttDataFormat.htm>. The ICARTT files contain the same flight data as the NetCDF files. The flight data are available from the ACT-America P3-B Data System (PDS; for B-200 flights) and Housekeeping data (for C-130 flights). Files are organized by data system and aircraft (B-200 and C-130).

Naming conventions are the same for both file formats. Files are organized by instrument and aircraft for the flight(s) on a given date.

ACT-America file naming convention

File names are standardized by:

where:

project = ACTAMERICA

data system = either 'Hskping' or 'PDS'

aircraft = either 'c130' or 'B200'

YYYYMMDD = flight date (UTC)

R# = revision number of data. A higher number indicates a more recent revision.

L# = optional launch number. Some flights had more than one sortie or launch.

ext = file extension. either '.nc' for NetCDF or '.ict' for ICARTT

Companion Files

Additional information on the aircraft platforms deployed by ACT-America is provided in the accompanying files: **Platform_B200.pdf**, **Platform_C130.pdf**, and **ACTAMERICA_Hskping_Experimenter_Handbook_Jan2011v2.pdf**.

Data Dictionary:

Variable name	Description	Units
Flight Information		
Aircraft_Sun_Azimuth	aircraft sun azimuth	degree
Aircraft_Sun_Elevation	aircraft sun elevation	degree
Cabin_Pressure	cabin pressure	mb
Day_of_Year	day of year starting Jan 1 UTC	d
Dew_Point	dew point	Celcius
Drift_Angle	drift angle	degree
Flight_ID	flight identification (aircraft and flight date)	NA
GPS_Altitude	global positioning system altitude	meters
Ground_Speed	ground speed	meters per second
Indicated_Air_Speed	indicated air speed	meters per second
Latitude	latitude	degree north
Longitude	longitude	degree east
Mach_Number	mach number	mach
**ManeuverFlag	data flag for sampling based on aircraft maneuver	NA
Mixing_Ratio	H2O mixing ratio	g per kg
Part_Press_Water_Vapor	H2O vapor pressure	mb
Pitch_Angle	pitch angle	degree
Potential_Temp	potential temperature	Kelvin
Pressure_Altitude	pressure altitude	ft
Relative_Humidity	relative humidity	percent
Roll_Angle	roll angle	degree
Sat_Vapor_Press_H2O	H2O sat vapor pressure of water	mb
Sat_Vapor_Press_Ice	H2O sat vapor pressure of ice	mb
Solar_Zenith_Angle	Solar zenith angle	degree
Start_UTC	start UTC time of day	seconds
Static_Air_Temp	static air temperature	Celcius
Static_Pressure	static pressure	mb
Sun_Azimuth	sun azimuth	degree
*time	time	seconds since 2016-01-01 00:00:00.0 UTC
Total_Air_Temp	total air temperature	Celcius
Track_Angle	track angle	degree
True_Air_Speed	true air speed	kts
True_Heading	true heading	degree
Vertical_Speed	vertical speed	m per minute

Wind_Direction	wind direction	degree
Wind_Speed	wind speed	m per second
Elevation		
Altitude_AGL_m	Aircraft altitude above ground level	m
Ground_Elevation_m	Ground elevation a.m.s.l.	m
Out of Range or Missing		
ulod_flag	Data greater than the upper limit of detection	-7777
llod_flag	Data less than the lower limit of detection	-8888
Missing data, nodata, or _FillValue		-9999

* "Flight_ID" and "time" provided only in netCDF files.

** Only available in C-130 aircraft files. ManeuverFlag definition: 0 = on ground; 1 = take off; 2 = in-line ascent; 3 = in-line descent; 4 = spiral up; 5 = spiral down; 6 = constant altitude legs; 7 = landing.

3. Application and Derivation

ACT-America, or Atmospheric Carbon and Transport - America, conducted five airborne campaigns across three regions in the eastern United States to study the transport of atmospheric carbon. The eastern half of the United States is a region that includes a highly productive biosphere, vigorous agricultural activity, extensive gas and oil extraction and consumption, dynamic, seasonally varying weather patterns and the most extensive carbon cycle and meteorological observing networks on Earth, serves as an ideal setting for the mission.

Each 6-week campaign accurately and precisely quantifies anomalies in atmospheric carbon, also known as Carbon Flux. Accurate carbon flux data is necessary to address all terrestrial carbon cycle science questions. ACT-America addresses the three primary sources of uncertainty in atmospheric inversions — transport error, prior flux uncertainty and limited data density.

ACT-America advances society's ability to predict and manage future climate change by enabling policy-relevant quantification of the carbon cycle. Sources and sinks of atmospheric carbon dioxide (CO₂) and methane (CH₄) are poorly known at regional to continental scales. ACT-America enables and demonstrates a new generation of atmospheric inversion systems for quantifying CO₂ and CH₄ sources and sinks.

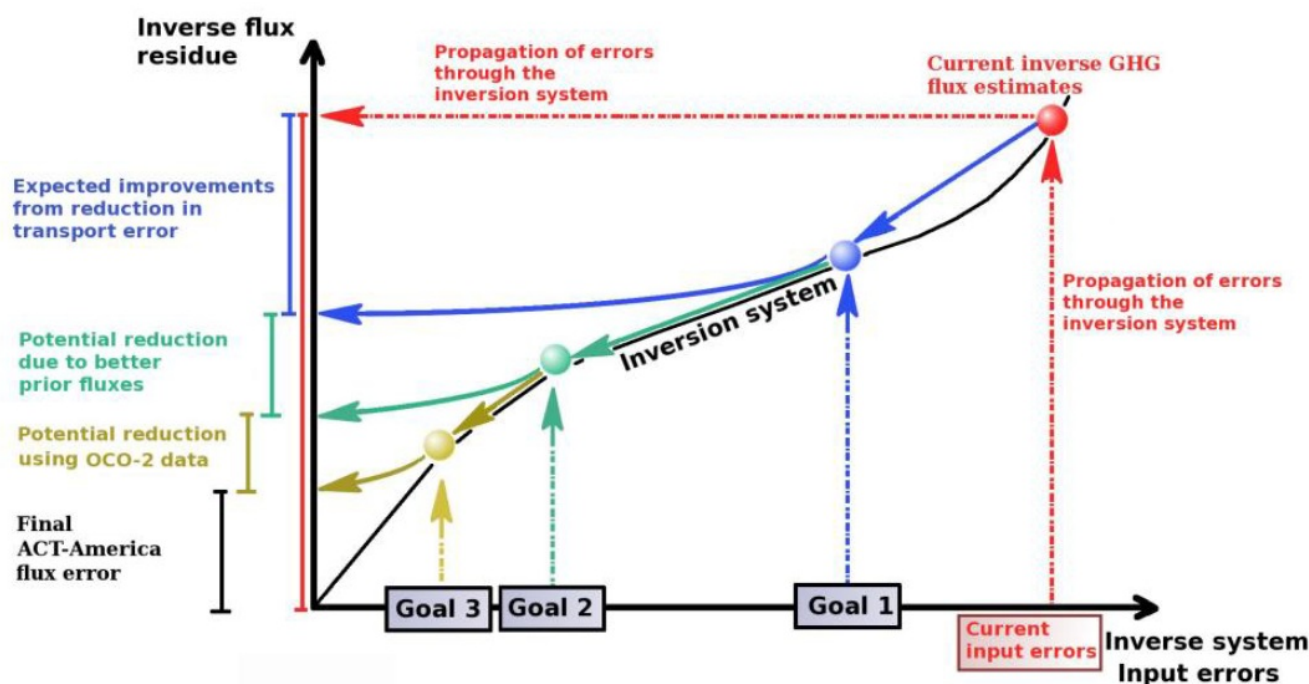


Figure 2. A schematic showing ACT-America project goals.

ACT-America Goals:

1. To quantify and reduce atmospheric transport uncertainties.
2. To improve regional-scale, seasonal prior estimate of CO₂ and CH₄ fluxes.
3. To evaluate the sensitivity of Orbiting Carbon Observatory (OCO-2) column measurements to regional variability in tropospheric CO₂.

ACT-America achieves these goals by deploying airborne and ground-based platforms to obtain data that can be combined with data from existing measurement networks and integrated with an ensemble of atmospheric inversion systems. Aircrafts instrumented with remote and in situ sensors observe how mid-latitude weather systems interact with CO₂ and CH₄ sources and sinks to create atmospheric CO₂/CH₄ distributions. A model ensemble consisting of a mesoscale atmospheric transport model with multiple physics and resolution options nested within global inversion models and surface CO₂/CH₄ flux ensembles is used to predict atmospheric CO₂ and CH₄ distributions.

Beyond the conclusion of the mission, application of the knowledge gained from this mission will improve diagnoses of the carbon cycle across the globe for decades.

4. Quality Assessment

Within the data, nodata and out-of-range values are provided in the dataset as described. The table below lists the uncertainties

associated with the corresponding instruments.

Variable name	C-130 System	B-200 System
Latitude/Longitude/GPS_Altitude	5 meters spherical error probability *	5 meters spherical error probability *
Ground Speed	0.01 m/s *	0.05 m/s *
True_Heading	0.015 deg *	0.07 deg *
Pitch_Angle, Roll_Angle	0.01 deg *	0.01 deg *
Dew_Point	0.2 deg C *	0.5 - 1.0 C (Dynamic Cond,)
Total_Air_Temp	1.5 deg C *	+/- 0.6 C (Dynamic Cond.)
Cabin_Pressure	0.25% FS *	NA

* Uncertainties quoted on instrument spec sheet

5. Data Acquisition, Materials, and Methods

ACT-America Overview

The eastern half of the United States, a region that includes a highly productive biosphere, vigorous agricultural activity, extensive gas and oil extraction, dynamic, seasonally varying weather patterns and the most extensive carbon cycle and meteorological observing networks on Earth, serves as an ideal setting for the mission. Flights concentrated observations on three study domains: Northeast, South-central, and Midwest.

ACT-America deployed the NASA C-130 and B-200 aircraft to measure atmospheric CO₂ and CH₄ in the atmospheric boundary layer (ABL) and free troposphere (FT). The mission conducted a total of 121 science flights, more than 1140 hours of observations, dedicated in a roughly 3:3:1 ratio among fair weather, stormy weather, and OCO-2 underpass flight patterns.

For fair and stormy weather flights, the C-130 flew at 3-8 km above ground, collecting in situ measurements in the lower FT, remotely sensed, column-averaged CO₂ measurements focused on the ABL, and occasional in situ vertical profiles. The B-200 primarily sampled the ABL. For OCO-2 underflights, the C-130 flew at 8 km above ground with the B-200 flying in the ABL, both along the OCO-2 flight track. The existing in situ tower CO₂/CH₄ observing network were enhanced with five additional tower sites.

The mission delivered 2-3 times more high-quality lower tropospheric CO₂ and CH₄ observations than any previous airborne campaign.

Flight Plans

Data from the fair-weather flights are intended to quantify regional CO₂ and CH₄ fluxes, and to evaluate fair weather atmospheric C transport processes. The flight pattern is designed to provide extensive sampling of the ABL and lower FT in source/sink regions, meeting the requirements for the fair weather investigation. The C-130 aircraft flew a U-shape pattern with flight legs perpendicular to the wind, sampling FT and ABL properties downwind of the sources and sinks of C. The C-130 flew at roughly two times the midday ABL depth, (~3-4 km above ground level (AGL)) with periodic descents and ascents (5 to 10 times in a 6-8-hr flight) to sample the ABL. Although clear sky conditions were targeted, the C-130 conducted more profiling if low-altitude clouds interfered with the remote sensors. The B-200 aircraft partook in two flights per day and sampled a subset of the C-130 flight path focusing on long transects in the ABL with periodic ascents to the FT. The two aircraft operated over the same time period, but precise coordination was not required.

Data from stormy-weather flights are used in combination with the data from fair-weather flights to evaluate the transport of C in the mid-latitudes. The flight plans include flight legs parallel to and crossing frontal boundaries at two or more altitudes, and crossing the frontal zone at two or more locations, meeting the requirements for the stormy weather investigation.

The pattern for the OCO-2 inter-comparison flights was designed to obtain data to evaluate the degree to which OCO-2 column CO₂ measurements capture true spatial variability in column CO₂ content over the continents. Two OCO-2 under flights were planned to be conducted during each campaign and would be selected to cover varying surface reflectance, topography, and aerosol and cloud cover, all possible sources of bias in the OCO-2 measurements. The C-130 flights would be 1000 km in length and flown at 8 km (28 kft) altitude to maximize the fraction of the atmospheric column sampled by the MFL. The B-200 aircraft would sample a shorter (~360 km) leg in the ABL, often the largest source of variability in column CO₂. The B-200 flight would be centered with the C-130 and both aircraft would be vertically stacked during the OCO-2 overpass.

Airborne Instruments

For this dataset, the table below lists the names and model number of the instruments used to collect the flight parameters and environmental data, where applicable. For detailed information on the instrumentation, see the information in the **ACTAMERICA_Hskping_Experimenter_Handbook_Jan2011v2.pdf** contained in the companion files in this dataset.

Variable	C-130 Data System	B-200 Data System
Latitude	Honeywell H-764	Applanix Model 510 V5
Longitude	Honeywell H-764	Applanix Model 510 V5
GPS_Altitude	Honeywell H-764	Applanix Model 510 V5
Pressure_Altitude	derived	Derived (Honeywell PPT2)
Ground_Speed	Honeywell H-764	Applanix Model 510 V5
True_Air_Speed	derived	Derived
Indicated_Air_Speed	derived	NA
Mach_Number	Collins ADC_86A (Calculated from Pitot-Static system)	Honeywell PPT2 (Calculated from Pitot-Static system)
Vertical_Speed	Collins ADC_86A	NA
True_Heading	Honeywell H-764	Hemisphere DGPS - VS131
Track_Angle	Honeywell H-764	Applanix Model 510 V5

Drift_Angle	Honeywell H-764	NA
Pitch_Angle	Honeywell H-764	Applanix Model 510 V5
Roll_Angle	Honeywell H-764	Applanix Model 510 V5
Static_Air_Temp	Derived from Total_Air_Temp & Mach_Number	Derived from Total_Air_Temp & Mach_Number
Potential_Temp	Derived from Static_Air_Temp and Static_Pressure	Derived from Static_Air_Temp and Static_Pressure
Dew_Point	Edgetech Vigilant 137, 3-stage TEC	Edgetech Vigilant 137, 3-stage TEC
Total_Air_Temp	Rosemount 102 deiced	Rosemount 102 deiced
Static_Pressure	Honeywell PPT2	Honeywell PPT2
Cabin_Pressure	Measurement Specialties EPRB-2-XU63-30P-/Z1	NA
Wind_Speed	Derived from EGI	Derived Using Applanix & DGPS Heading
Wind_Direction	Derived from EGI	Derived Using Applanix & DGPS Heading
Solar_Zenith_Angle	derived	NA
Aircraft_Sun_Elevation	derived	NA
Sun_Azimuth	derived	NA
Aircraft_Sun_Azimuth	derived	NA
Mixing_Ratio	derived	Derived
Part_Press_Water_Vapor	derived	Derived
Sat_Vapor_Press_H2O	derived	Derived
Sat_Vapor_Press_Ice	derived	Derived
Relative_Humidity	derived	Derived

6. Data Access

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

[ACT-America: L1 Meteorological and Aircraft Navigational Data](#)

Contact for Data Center Access Information:

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

7. References

ICARTT files have detailed header information and follow the standards established and summarized in the ICARTT File Format Standards V1.1. <https://www-air.larc.nasa.gov/missions/etc/icarttDataFormat.htm>

8. Dataset Revisions

Version 1.1 (released 2020-06-10) updated all data from Summer 2016 and Winter 2017 campaigns and data from the Fall 2017, Spring 2018 and Summer 2019 campaign were added to this dataset.

Version 1.0 (released 2018-04-17) provided data from Summer 2016 and Winter 2017 campaigns.



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Home

About Us

Mission
Data Use and Citation Policy
User Working Group
Partners

Get Data

Science Themes
NASA Projects
All Datasets

Submit Data

Submit Data Form
Data Scope and Acceptance
Data Authorship Policy
Data Publication Timeline
Detailed Submission
Guidelines

Tools

MODIS
THREDDS
SDAT
Daymet
CARVE Data Viewer
Soil Moisture Visualizer
Land - Water Checker

Resources

Learning
Data Management
News

Contact Us