The Alpha Jet Atmospheric eXperiment

Data Product User Guide

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Introduction

The Alpha Jet Atmospheric eXperiment (AJAX) was a long-term partnership between NASA's Ames Research Center and H211, L.L.C. Beginning in 2011, AJAX facilitated routine in-situ measurements over multiple seasons collecting data over California, Nevada, and the coastal Pacific. All data files available in the AJAX collections are in the ICARTT (.ict) file format, which can be easily opened in basic text editors such as Notepad, Microsoft Excel, or can be opened similarly to a Comma-Separated Values (.CSV) file in many programming languages. This user guide aims to allow users, both new and experienced, to better understand the AJAX campaign and its data, promote data access, and make the data more accessible to a wider audience.

Disclaimer: Please follow any stipulations on use provided by instrument Principal Investigators in the data files prior to data use.

Citation

NASA Data Use Guidance

DOI Citation Formatter

Campaign Level DOI

https://doi.org/10.5067/ASDC/SUBORBITAL/AJAX/DATA001

Data Use Policy

Consultation with the PI is strongly encouraged when using data collected by the Alpha Jet Atmospheric eXperiment (AJAX) project. Please take careful note of all supporting information contained in the header of each file. If AJAX data is essential to your study, an offer of co−authorship may be appropriate. Please include the following in all manuscripts and presentations which include AJAX data:

The NASA AJAX project recognizes support from Ames Research Center Director's funds, the NASA Postdoctoral Program, the NASA OCO-2 Science Team, the NASA Atmospheric Composition Campaign Data Analysis and Modeling (20-ACCDAM20-0083) program, and the California Air Resources Board (Contract No. 17RD004), as well as by the Atmospheric Composition Program through the NASA ISFM. The partnership and support of H211, LLC is gratefully acknowledged.

Campaign Overview

AJAX facilitated routine in-situ measurements over California, Nevada, and the coastal Pacific in support of satellite validation. The standard payload complement included rigorously calibrated ozone (O_3), formaldehyde (HCHO), carbon dioxide (CO_2), and methane (CH_4) mixing ratios, as well as meteorological data including 3D winds. Multiple vertical profiles (to ~8.5 km) could be accomplished in each 2-hour flight. AJAX collected trace gas data on a regular basis in all seasons for nearly a decade, helping to assess satellite sensors' health and calibration over significant portions of their lifetimes, and complementing surface and tower-based observations collected elsewhere in the region.

AJAX supported NASA's Orbiting Carbon Observatory (OCO-2/3) and Japan's GOSAT and GOSAT-2, and collaborated with many other research organizations including NOAA, CARB, USFS, and the EPA. AJAX flew 229 science flights, investigating topics as varied as stratospheric-to-tropospheric transport, forest fire plumes, atmospheric river events, long-range transport of pollution from Asia to the western US, urban outflow, and emissions from gas leaks, oil fields, and dairies.

An additional 15 flights were performed by Scientific Aviation using a different aircraft (Mooney M20M) in late 2018 and 2019. The payload was largely similar, but the greenhouse gas files also include uncalibrated carbon monoxide (CO) observations and no formaldehyde measurements. These flights are referred to as the SNAAX (Scientific Aviation NASA Ames Airborne eXperiment) supplement to the AJAX project, and the support of our partners is greatly appreciated.

Known OCO-2 Coincidences

One of the primary goals of the AJAX project was to provide in situ validation data for satellite column observations. AJAX collected 58 vertical profiles at Railroad Valley, Nevada, a location used for satellite vicarious calibration and validation. Most of these profiles were coincident with GOSAT overpasses, and 13 were executed after the launch of OCO-2. Additionally, 8 profiles were executed at NASA's Armstrong (formerly Dryden) Flight Research Center, six of which coincide with observations from a Total Carbon Column Observing Network (TCCON) instrument. To simplify identification of the flights which contained vertical profiles under the Orbiting Carbon Observatory-2 satellite, a list is given in the table below.

Flight	Location	Date	OCO-2	GOSAT
144	RRV	2014-10-02	yes	yes
148	TCCON	2014-11-06	yes	yes
158	CentralValley	2015-05-19	yes	no
160	TCCON	2015-06-02	yes	yes
162	RRV	2015-06-29	yes	yes
163	RRV	2015-07-01	yes	yes
186	CentralValley	2016-04-26	yes	no
188	Offshore	2016-05-12	(glint)	
189	THD	2016-05-19	yes (glint)	no
193	RRV	2016-07-01	yes	yes
205	RRV	2017-01-27	yes	no
215	RRV	2017-12-06	yes	yes
223	RRV	2018-04-13	yes	yes
230	Offshore	2018-10-25	yes (glint)	
232	THD	2018-12-21	(glint)	no
242	Offshore	2019-07-08	yes (glint)	

Flight Objectives

AJAX had several flight objectives, and often more than one objective was met during an individual flight. The relevant objectives are indicated in each file and are a searchable field in the Flight Catalog described below. The following table describes the objectives and their abbreviations:

Objective	Description
CABOTS	In support of CARB's California Baseline Ozone Transport Study (Summer 2016)
CentralValley	Boundary layer measurements in California's Central Valley
DAQ	Focused on boundary layer over Central CA during DISCOVER-AQ campaign (Jan-Feb 2013)
Fire	Sampling influenced by one or more fires, usually wildfires
O&G	Sampling over known oil and/or gas infrastructure
Offshore	Sampling off the California coast, does not include vertical profile
On/Off	At least one vertical profile over land and at least one offshore (>5 km)
Profile	Spiral vertical profile from ~8 km to surface
RRV	Vertical profile over Railroad Valley, NV (elev. ~1.4 km), usually coordinated with GOSAT
SanBernardino WestMojave	Boundary layer measurements in the San Bernardino Mountains and/or west Mojave Desert regions
SFBayArea	Boundary layer measurements in the San Francisco Bay Area
TCCON	Vertical profile over TCCON instrument at NASA's Armstrong Flight Research Center
THD	Vertical profile near Trinidad Head observatory, usually coordinated with NOAA ozonesonde
UrbanOutflow	Boundary layer measurements around Sacramento, CA
VPocean	Vertical profile over ocean, with top altitude $\geq$ ~5 km

Information for Data Users

Latitude is in deg N, and longitude in deg E (with degrees W indicated as negative). In the Greenhouse Gas data files, water vapor mixing ratio is reported as parts per hundred by volume. Uncertainty estimates are provided in the file headers. In the MMS data files, be aware of the row of conversion factors in the header which need to be applied to the values provided. AJAX MMS Data files report GPS altitude, not altitude above mean sea level, so some negative altitudes are reported near the surface. SNAAX altitude is reported as meters above mean sea level. Time stamps are all in UTC (not GPS) time.

Data Products

ICARTT file naming conventions dictate the naming of AJAX data files. As discussed in the "File Naming Convention" sub-section below, this organizational scheme depends on a data product identifier (dataID) and a measurement platform (locationID, in this case ALPHA). One data file contains the data collected from one instrument during one flight.

Per the NASA Airborne Data Management Group (ADMG), a data product is "a logically meaningful group of data with the same basic characteristics (instrument source or class of source, processing level, resolution, etc.) but may have multiple variables." Data products are commonly referred to as collections and represent items that are listed on Earthdata Search and are typically assigned data product DOIs when they are publicly released.

There are four data products within the AJAX collection, one for each instrument in the payload, as shown in the table below. Each data product contains is what is referred to in this user guide as "granules", or individual data files that can be accessed and downloaded. Granules, or data files, contain the data collected by a single instrument during a particular flight.

Data ID	AJAX-CH2O	AJAX-CO2CH4	AJAX-MMS	AJAX-O3
DOI	10.5067/ASDC/AJAX_CH2O	10.5067/ASDC/AJAX_CO2_CH4	10.5067/ASDC/AJAX_MMS	10.5067/ASDC/AJAX_O3
Date	12 Dec 2015 – 6 June 2018	11 June 2011 – 6 June 2018	20 June 2013 – 6 June 2018	1 Feb 2011 – 6 June 2018
Key Variables	Formaldehyde (CH_2O)	Carbon dioxide (CO_2), Methane (CH_4), Water Vapor (H_2O)	U, V, and W Wind Speeds, Potential Temperature, GPS Position	Ozone (O_3)
File Format	ICARTT	ICARTT	ICARTT	ICARTT
Instrument	COFFEE (COmpact Formaldehyde FluorescencE Experiment)	Picarro CRDS (model 2301-m, S/N:634-CFDDS2120)	Meteorological Measurement System (MMS)	2B Technologies, model 205, S/N: 734
Sampling Frequency	1 Hz	0.33 Hz	1 Hz	0.1 Hz
Principal Investigator	Thomas Hanisco	Laura Iraci	Paul Bui	Emma Yates
Institution	NASA Goddard Space Flight Center	NASA Ames Research Center	NASA Ames Research Center	NASA Ames Research Center
Data on Earthdata Search	EARTHDATA	EARTHDATA	EARTHDATA	EARTHDATA

When using Earthdata Search to look up granules, it is important to note a few "wildcards" on the website. When looking up granules in specific collections, these wildcards are meant to let Earthdata Search know what exactly the user is looking for. The two wildcards are the asterisk (*) and the question mark (?). An asterisk would be used to search exact characters. For example, typing "*20230623*" into the search bar would return granules that have "20230623" in their name. The question mark is used to match exactly one character in a search. For example, to search for a granule in all days of a month or every revision of a granule, replace a character with a "?". For example, to search for a granule in the year 2018, use the string "*2018????*". This would have Earthdata Search pull up granules within the year 2018 with all available months and days.

In addition to the release of the entire data set, a Compendium focusing on emissions sampled by AJAX in and around 12 wildfires and 1 prescribed fire event in California between 2013 and 2017 has been assembled and is available at DOI: 10.5067/ASDC/AJAX/wildfire. This Compendium has been described in a publication in the journal *Earth and Space Science* as part of the American Geophysical Union's Fire in the Earth System Special Collection and is linked

here and in the Resources section below. Additionally, a peer-reviewed manuscript describing the entire AJAX dataset was published in 2023 and is also linked in the Resources section below.

File Naming Convention

The AJAX data files adopt ICARTT naming conventions:

DataID_LocationID_YYYYMMDD_R#_Description.extension

where:

DataID: a data product identifier, e.g., a short description of measured parameter/species, instrument, or model. The dataID for AJAX data products are prefixed by "AJAX", e.g., AJAX-CH2O, AJAX-O3

LocationID: An identifier of measurement/sampling platform, e.g., "ALPHA"

YYYYMMDD: UTC sampling date when the flight took off

R#: Revision number. The revision number will be R0, R1, R2, for the publication quality data. Note: archived files cannot be overwritten, only replaced by files with subsequent revisions. Letter revisions, such RA, RB, etc. indicate data that is preliminary and not suitable for use in publications or scientific analyses.

Description: Optional additional description of the file if necessary. For example:

"L1" or L2" are the equivalent of "Launch 1" or "Launch 2"

"V1" or "V2" are the equivalent of "Volume 1" or "Volume 2"

Extension: "ict" for ICARTT files, "nc" for netCDF, and "h5" for HDF 5 files, etc.

Data on the Sub-Orbital Order Tool (SOOT):

Here is where to find the AJAX data on SOOT, an ASDC tool designed to promote suborbital data discovery, research, and analysis:

Data Processing Workflow

To provide quality-controlled trace gas data, standardized processing was applied, as described in Yates et al., 2023 (https://doi.org/10.5194/essd-15-2375-2023) and St. Clair et al., 2017 (https://doi.org/10.5194/amt-10-4833-2017). Briefly, for ozone data:

- removal of data points outside of a predefined operational limit: if the reported flow rate through the sample cell fell below 1 L min−1 , those data points were removed from the dataset;
- removal of outliers in the data due to instrument instability: if $1O_3(O_3(i) - O_3(i + 1))$ is greater than the 1σ standard deviation of the entire O_3 data set, those data points ($O_3(i)$ and $O_3(i + 1)$) were removed;
- calibration based on the linearity and zero-offset factors calculated from the closest calibration to the flight (typically ±1 d);
- averaging of O_3 data from 2 s resolution to report at 10 s resolution, improving precision and the overall quality of the finalized dataset.

AJAX CO_2 and CH_4 measurements were subjected to the following quality control procedures to generate the finalized GHG dataset:

- removal of instrument lag time (5 s), calculated given the length of the inlet tubing and measured flow rate;
- removal of outliers in the data due to in-flight instability of the optical cavity pressure: data points where the cavity pressure deviated by more than 0.2 % were removed;
- removal of data points outside of operational temperature limits: data points were removed when the cavity temperature was > 45.15 $^{\circ}$C or < 44.95 $^{\circ}$C;
- water vapor corrections: AJAX applies the water vapor corrections described by Chen et al. (2010) using simultaneous water observations;
- application of calibration based on the closest calibration to the flight (typically ±1 d);
- averaging of GHG data from 3 Hz resolution to report at 3 s resolution, improving precision and the overall quality of the reported, finalized dataset.

Calibration procedures for the AJAX Meteorological Measurement System (MMS) are described in Yates et al. 2023, and SNAAX meteorological files are compiled from multiple data streams provided by the vendor, including the Aspen airplane primary flight information system, Hemisphere precision GPS system, and a Vaisala HMP60 probe.

FlightCatalog

The ASDC and AJAX science team collaborated on a Searchable Flight Catalog, which is accessible from the AJAX project landing page. The flight catalog includes flight dates, flight numbers, indications as to which measurements were taken on each flight date, and the flight objectives, and links to analysis documents when available.

Acknowledgments

The ASDC gratefully acknowledges members of the AJAX science team for their feedback provided on this user guide and for their contributions during the revision process.

Resources

AJAX Landing Page on Earthdata

AJAX Project Website

AJAX on Earthdata Search

AJAX on the Sub-Orbital Order Tool (SOOT)

Earthdata Forum

AJAX Data in Action StoryMap

ICARTT Documentation

References

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Acronym List

Short Name:	Long Name:
AJAX	Alpha Jet Atmospheric eXperiment
ARC	Ames Research Center
ASDC	Atmospheric Science Data Center
CARB	California Air Resources Board
COFFEE	COmpact Formaldehyde FluorescencE Experiment
CRDS	Cavity Ring-Down Spectroscopy
EPA	United States Environmental Protection Agency
GOSAT/GOSAT-2	Greenhouse gases Observing SATellite (2)
GPS	Global Positioning System
ICARTT	International Consortium for Atmospheric Research on Transport and Transportation
MMS	Meteorological Measurement System
NOAA	National Oceanic and Atmospheric Administration
OCO-2/3	Orbiting Carbon Observatory
PI	Principal Investigator
USFS	United States Department of Agriculture Forest Services