ATom: Flight Dynamics and Environmental Parameters of the NASA DC-8 Aircraft

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Documentation Revision Date: 2021-10-28

Dataset Version: 1

Summary

This dataset contains flight dynamics and environmental parameters (often referred to as housekeeping) specific to the DC-8 aircraft as collected from an assortment of instruments across all four ATom campaigns flown from 2016 through 2018. Measurements include aircraft position, altitude, speed, wind parameters, air temperature, and atmospheric and cabin pressure. These data can be used to understand the interior and exterior conditions and positioning of the DC-8 aircraft at 1-second resolution.

There are 48 data files in ICARTT (*.ict) format included in this dataset

Figure 1. Photo of NASA's DC-8 flying laboratory.

Citation

Yang, M.M., and J.R. Bennett. 2021. ATom: Flight Dynamics and Environmental Parameters of the NASA DC-8 Aircraft. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1909

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1. Dataset Overview

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Project: Atmospheric Tomography Mission

The Atmospheric Tomography Mission (ATom) was a NASA Earth Venture Suborbital-2 mission. It studied the impact of human-produced air pollution on greenhouse gases and on chemically reactive gases in the atmosphere. ATom deployed an extensive gas and aerosol payload on the NASA DC-8 aircraft for systematic, global-scale sampling of the atmosphere, profiling continuously from 0.2 to 12 km altitude. Flights occurred in each of four seasons over a 4-year period.

Related Datasets

Wofsy, S.C., S. Afshar, H.M. Allen, E.C. Apel, E.C. Asher, B. Barletta, J. Bent, H. Bian, B.C. Biggs, D.R. Blake, N. Blake, I. Bourgeois, C.A. Brock, W.H. Brune, J.W. Budney, T.P. Bui, A. Butler, P. Campuzano-Jost, C.S. Chang, M. Chin, R. Commane, G. Correa, J.D. Crounse, P. D. Cullis, B.C. Daube, D.A. Day, J.M. Dean-Day, J.E. Dibb, J.P. DiGangi, G.S. Diskin, M. Dollner, J.W. Elkins, F. Erdesz, A.M. Fiore, C.M. Flynn, K.D. 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, 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.A. 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.L. Wagner, A. Watt, R. Weber, B.B. Weinzierl, P.O. Wennberg, C.J. Williamson, J.C. Wilson, G.M. Wolfe, C.T. Woods, L.H. Zeng, and N. Vieznor. 2021. ATom: Merged Atmospheric Chemistry, Trace Gases, and Aerosols, Version 2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1925.

- Data from all ATom instruments and all four flight campaigns, including aircraft location and navigation data, merged to several different time bases

Wofsy, S.C., and ATom Science Team. 2018. ATom: Aircraft Flight Track and Navigational Data. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1613

- Flightpath (location and altitude) data for each of the four campaigns provided in KML and CSV format.

2. Data Characteristics

Spatial Coverage: Global. Flights circumnavigate the globe, primarily over the oceans

Spatial Resolution: Point measurements

Temporal Coverage: Periodic flights occurred during each campaign

Deployment	Date Range
ATom-1	July 29 - August 23, 2016
ATom-2	January 26 - February 21, 2017
ATom-3	September 28 - October 28, 2017
ATom-4	April 24 - May 21, 2018

Temporal Resolution: 1 second

Data File Information

There are 48 data files in ICARTT (*.ict) format included in this dataset that contain flight dynamics and environmental parameters. Data files conform to the ICARTT File Format Standards V1.1. The files are named Hskping _DC8_YYYYMMDD_R#.ict, where YYYYMMDD is the start date (in UTC time) of the flight and
R# is the file version or revision number.

Data File Details

Missing data are represented by -9999.

Table 1. Instruments used for data collection and their associated variables.

Instrument Name	Variables Measured
LN251 EGI	Positional parameters, altitude parameters, ground_speed, and vertical_speed
LN251 EGI, Aircraft Data System-85	Wind_Speed and Wind_Direction
APN-232	Radar_Altitude
Rosemount 102	Total_Air_Temperature, used to derive Static_Air_Temperature and Potential_Temperature
KT-19.85	IR_Surface_Temp
MKS Baratron 220D	Cabin_Pressure
Edgetech hygrometer	Dew_Point, used to derive associated water vapor parameters
Aircraft Data System-85	Pressure_Altitude, Indicated_Air_Speed, True_Air_Speed, Mach_Number, Static_Pressure

Table 2. Variables and descriptions for the 46 data files named Hskping _DC8_YYYYMMDD_R#.ict.

Name	Units	Description
Start_UTC	Seconds	Seconds from 0000 UTC
Day_Of_Year	Numeric	Day beginning January 1
Latitude	Decimal degrees	Degrees North
Longitude	Decimal degrees	Degrees East
MSL_GPS_Altitude	Meters	Height above mean sea level
HAE_GPS_Altitude	Meters	Height above ellipsoid WGS84
Pressure_Altitude	Feet	Height above a standard datum plane
Radar_Altitude	Feet	Height above ground
Ground_Speed	Meters/second	Aircraft speed relative to ground
True_Air_Speed	Knots	Aircraft speed relative to air
Indicated_Air_Speed	Knots	Aircraft speed relative to air as indicated on instrument panel
Mach_Number	Mach	Air speed: speed of sound ratio

Vertical_Speed	Meters/second	Rate of ascent/decent
True_Heading	Degrees	Aircraft orientation relative to due north, 0-360, clockwise from North
Track_Angle	Degrees	Projection of the aircraft path onto the earth's surface, 0-360, clockwise from North
Drift_Angle	Degrees	Angle difference between True_Heading and Track_Angle. +/-180, clockwise from North
Pitch_Angle	Degrees	Angle between aircraft longitudinal axis and the horizon, +/-180, up+
Roll_Angle	Degrees	Angle measurement where aircraft lateral axis is horizontal, +/-180, rt+
Static_Air_Temp	Celsius	Temperature of undisturbed air. Reduction from Total_Air_Temp
Potential_Temp	Kelvin	Potential temperature, derived from Static_Air_Temp and Static_Pressure
Dew_Point	Celsius	Temperature where dew/ice may begin to form
Total_Air_Temp	Celsius	Temperature within aircraft boundary layer (including dynamic effects)
IR_Surf_Temp	Celsius	Aircraft infrared surface temperature
Static_Pressure	Millibar	Pressure of aircraft static pressure system
Cabin_Pressure	Millibar	Pressure inside cabin
Wind_Speed	Meters/second	Derived horizontal wind speed
Wind_Direction	Degrees	Derived wind direction
Solar_Zenith_Angle	Degrees	Angle between the sun and the vertical direction
Aircraft_Sun_Elevation	Degrees	Elevation (altitude, in angle) of the sun with respect to the aircraft.
Sun_Azimuth	Degrees	Angle between the sun and solar noon
Aircraft_Sun_Azimuth	Degrees	Sun azimuth angle with respect to the aircraft.
Mixing_Ratio	Gram/kilogram	Mixing ratio of water in the air
Part_Press_Water_Vapor	Millibar	Partial pressure of water vapor
Sat_Vapor_Press_H2O	Millibar	Pressure where water will begin to condense
Sat_Vapor_Press_Ice	Millibar	Pressure where ice will begin to deposit
Relative_Humidity	Percent	Humidity with respect to water

3. Application and Derivation

ATom builds the scientific foundation for mitigation of short-lived climate forcers, in particular methane (CH_4), tropospheric ozone (O_3), and Black Carbon aerosols (BC).

ATom Science Questions

Tier 1

- What are chemical processes that control the short-lived climate forcing agents CH_4, O_3, and BC in the atmosphere? How is the chemical reactivity of the atmosphere on a global scale affected by anthropogenic emissions? How can we improve chemistry-climate modeling of these processes?

Tier 2

- Over large, remote regions, what are the distributions of BC and other aerosols important as short-lived climate forcers? What are the sources of new particles? How rapidly do aerosols grow to CCN-active sizes? How well are these processes represented in models?
- What type of variability and spatial gradients occur over remote ocean regions for greenhouse gases (GHGs) and ozone depleting substances (ODSs)? How do the variations among air parcels help identify anthropogenic influences on photochemical reactivity, validate satellite data for these gases, and refine knowledge of sources and sinks?

Significance

ATom delivers unique data and analysis to address the Science Mission Directorate objectives of acquiring “datasets that identify and characterize important phenomena in the changing Earth system” and “measurements that address weaknesses in current Earth system models leading to improvement in modeling capabilities.” ATom will provide unprecedented challenges to the CCMs used as policy tools for climate change assessments, with comprehensive data on atmospheric chemical reactivity at global scales, and will work closely with modeling teams to translate ATom data to better, more reliable CCMs. ATom provides extraordinary validation data for remote sensing.

4. Quality Assessment

Table 3. Uncertainties of variables according to instrument manufacturer's specifications.

Name	Uncertainty
Start_UTC	Low order milliseconds
Latitude	5 meters spherical error probable
Longitude	5 meters spherical error probable
MSL_GPS_Altitude	N/A
HAE_GPS_Altitude	5 meters spherical error probable
Pressure_Altitude	20 feet, increasing to 138 feet with altitude

Radar_Altitude	2 feet, +- 2% at altitude
Ground_Speed	0.015 m/s
True_Air_Speed	4 kts
Indicated_Air_Speed	5 kts at TAS 50 kts; 2 kts at TAS 100 kts; 2.8 kts at TAS 300 kts
Mach_Number	0.01 mach
Vertical_Speed	Greater of 0.152 m/s or 5%
True_Heading	0.02 degree
Track_Angle	0.02 degree
Drift_Angle	0.02 degree
Pitch_Angle	0.02 degree
Roll_Angle	0.02 degree
Static_Air_Temp	0.5 degree C
Dew_Point	0.2 degree C
Total_Air_Temp	0.3 degree C
IR_Surf_Temp	0.5 degree C + 0.7%*(target-housing)
Static_Pressure	2.5 hPa
Cabin_Pressure	0.15%
Wind_Speed	1 m/s during straight and level flight legs
Wind_Direction	0.5 degree
Relative_Humidity	2 – 5 %

5. Data Acquisition, Materials, and Methods

Project Overview

ATom makes global-scale measurements of the chemistry of the atmosphere using the NASA DC-8 aircraft. Flights span the Pacific and Atlantic Oceans, nearly pole-to-pole, in continuous profiling mode, covering remote regions that receive long-range inputs of pollution from expanding industrial economies. The payload has proven instruments for in situ measurements of reactive and long-lived gases, diagnostic chemical tracers, and aerosol size, number, and composition, plus spectrally resolved solar radiation and meteorological parameters.

Combining distributions of aerosols and reactive gases with long-lived GHGs and ODSs enables disentangling of the processes that regulate atmospheric chemistry: emissions, transport, cloud processes, and chemical transformations. ATom analyzes measurements using customized modeling tools to derive daily averaged chemical rates for key atmospheric processes and to critically evaluate Chemistry-Climate Models (CCMs). ATom also differentiates between hypotheses for the formation and growth of aerosols over the remote oceans.

Flight Dynamics & Environmental Parameters

This dataset contains measurements from multiple instruments on the DC-8 aircraft. Additional information about instrumentation built into DC-8 can be found in the Experimenter's Handbook on the ESPO DC-8 Description page.

6. Data Access

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

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Contact for Data Center Access Information:

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7. References