ATom: Back Trajectories and Influences of Air Parcels Along Flight Track, 2016-2018

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Dataset Version: 1

Summary

This dataset contains back trajectories, boundary layer influences, and convective influences of air parcels along NASA DC-8 aircraft's flight tracks during the ATom 1-4 campaigns that occurred from 2016-2018. Back trajectories were interpolated using National Centers for Environmental Prediction (NCEP) Global Forecast System (GFS) and Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA2) meteorology. Back trajectory analysis determines the origin of air masses by modeling the path of an air parcel backward in time. It can be used to better understand the sources of atmospheric compounds. Boundary layer Influences were determined based on 30 Day Back Trajectories. The atmospheric boundary layer is the lowest part of the troposphere that is directly influenced by earth's surface. The boundary layer influences wind patterns and thus the dispersal of pollutants and other atmospheric compounds of interest. Convective influences were based on 10 Day Back Trajectories and NASA Langley cloud products. Convective influences model the effects of convection on the movement of water vapor through the atmosphere, which influences cloud behavior.

This dataset includes 192 data files, 144 in NetCDF (*.nc) format and 48 in ICARRT (*.ict) format.

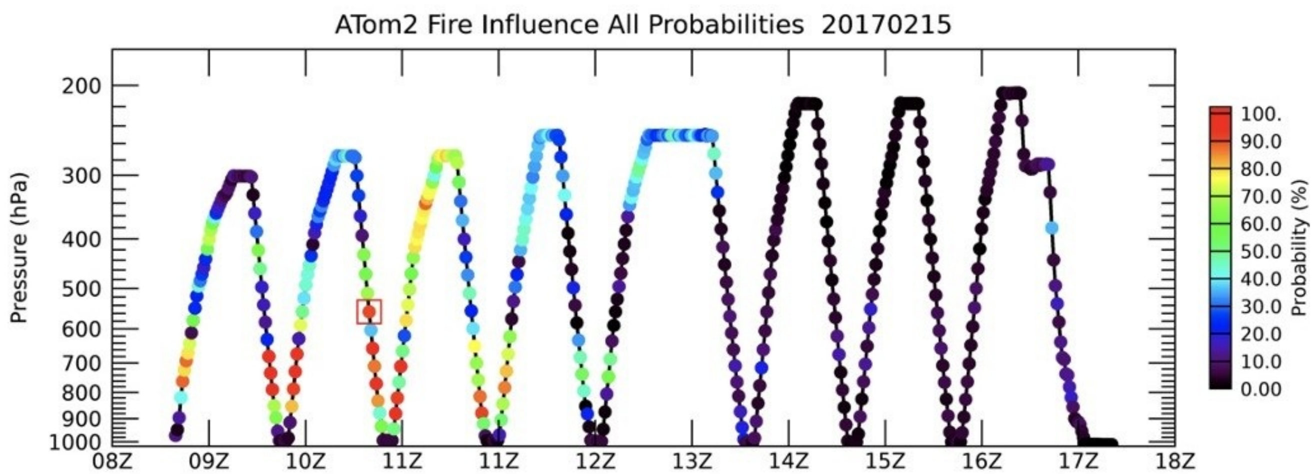

Figure 1. Fire influences for air parcels on the ATom-2 research flight that occurred on 2017-02-15.

Citation

Ray, E.A. 2021. ATom: Back Trajectories and Influences of Air Parcels Along Flight Track, 2016-2018. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1889

Table of Contents

1. Dataset Overview

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Project: Atmospheric Tomography Mission (ATom)

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 Data:

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 for Influences ICARTT files and 0.3 degrees north x 0.3 degrees east x 20 hPa cubes for BackTraj, BdyInfluence, and ConvectInfluence NetCDF files (See Table 2 for descriptions of file types)

Temporal Coverage: Periodic flights occurred during each campaign

Table 1. Flight campaign schedule

Campaign	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: 60 seconds

Data File Information

This dataset includes 192 data files, 144 in NetCDF (*.nc) format and 48 in ICARRT (*.ict) format. Data files conform to the ICARTT File Format Standards V1.1.and NetCDF CONVENTIONS.

File names are structured as ***FileType**_DC8_YYYYMMDD_R#*.ict, where ***FileType*** is the data file type (see Table 2), **YYYYMMDD** is the start date (in UTC time) of the flight, and **R#** is the file version or revision number.

Table 2. Data File Types

Data File Type	File Format	Description
BackTraj	NetCDF	Back trajectories were interpolated from NCEP and MERRA outputs.
BdyInfluence	NetCDF	Boundary layer Influences were determined based on 30 Day Back Trajectories.
ConvectInfluence	NetCDF	Convective influences were based on 10 Day Back Trajectories and NASA Langley cloud products
Influences	ICARTT	Convective and boundary influences derived from back trajectories derived from trajectories run with NCEP GFS and NASA Langley cloud products. These variables were taken directly from the NetCDF files.

Table 3. Data dictionary for *Influecnes_DC8_YYYYMMDD_R#*.ict files

Variable	Units	Description
Start_UTC	Seconds	Start time in seconds since 0000 UTC
Stop_UTC	Seconds	Stop time in seconds since 0000 UTC
Julian_Day	Days	Julian day
Lat	Degrees	Latitude in decimal degrees

	north	
Lon	Degrees east	Longitude in decimal degrees
Pres	hPa	Pressure
Prob_ConvInf	Percent	Probability of convective influence based on the coincidence of the cluster of back trajectories with satellite derived clouds products, RH threshold of 50% and NCEP GFS cloud water. Trajectories were run with NCEP GFS input winds.
Prob_ConvInf_Land	Percent	Probability of convective influence over land based on the coincidence of the cluster of back trajectories with satellite derived clouds products, RH threshold of 50% and NCEP GFS cloud water.
ConvInf_CldTop	Km	Cloud top height of most recent convective influence.
Days_Since_ConvInf	Days	Average days since all convective influence in each trajectory cluster.
Days_Since_Most_Recent_ConvInf	Days	Most recent days since convective influence in each trajectory cluster.
Prob_BdyInf	Percent	Average probability of boundary layer influence for all trajectory times.
Days_Since_BdyInf_Most_Recent	Days	Average time since most recent boundary layer influence in each trajectory cluster.
Days_Since_BdyInf_All	Days	Average time since all boundary layer influence in each trajectory cluster.
Prob_Land_BdyInf	Percent	Average probability of boundary layer influence over land for all trajectory times.
Days_Since_Land_BdyInf_Most_Recent	Days	Average time since most recent boundary layer influence over land in each trajectory cluster.
Prob_SeaIceInf	Percent	Average probability of sea ice boundary layer influence.
Prob_StratInf	Percent	Average probability of stratospheric influence.
Days_Since_StratInf_Most_Recent	Days	Average time since most recent stratospheric influence in each trajectory cluster.
Days_Since_StratInf_All	Days	Average time since all stratospheric influence in each trajectory cluster.
Prob_FireInf	Percent	Average probabilities of trajectory coincidence with MODIS and GFED fire locations. Fire plume heights were estimated from fire radiative power.
Days_Since_FireInf_Most_Recent	Days	Average time since most recent fire influence in each trajectory cluster.
Days_Since_FireInf_All	Days	Average time since all fire influence in each trajectory cluster.
Sunlight_Exposure	Hours	Total sunlight exposure over the trajectories.

Companion Files

Data dictionaries for NetCDF files are included as *.csv companion files. This dataset includes three companion files in *.csv format.

Table 4. Data dictionary companion files

Data File Type	Data Dictionary File Name
BackTraj	BackTraj_data_dictionary.csv
BdyInfluence	BdyInfluence_data_dictionary.csv
ConvectInfluence	ConvectInfluence_data_dictionary.csv

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 (ODS)? 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

Quality flags are provided within the data files for some of the parameters.

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 CCMs. ATom also differentiates between hypotheses for the formation and growth of aerosols over the remote oceans.

Back Trajectories

Back trajectory analysis determines the origin of air masses by modeling the path of an air parcel backward in time. It can be used to better understand the sources of atmospheric compounds. Back trajectories were interpolated from National Centers for Environmental Prediction (NCEP) Global Forecast System (GFS) and Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) meteorology. A cluster of 245 trajectories was initialized in a cube centered at each one minute interval along the ATom flight tracks and run backwards with the Traj3D trajectory model (Bowman, 1993; Bowman and Carrie, 2002). NCEP GFS is a global numerical weather prediction system containing a global computer model and variational analysis. Additional information can be found on the NCEP GFS description page. MERRA-2 models atmospheric characteristics utilizing long-term global reanalysis to assimilate space-based observations of aerosols and represent their interactions with other physical processes in the climate system. Additional information can be found on NASA’s MERRA-2 page.

Boundary Influences

The atmospheric boundary layer is the lowest part of the troposphere that is directly influenced by earth's surface. The boundary layer influences wind patterns and thus the dispersal of pollutants and other atmospheric compounds of interest. Boundary layer Influences were determined based on 30 Day Back Trajectories.

Convective Influences

Convective influences model the effects of convection on the movement of water vapor through the atmosphere, which influences cloud behavior. Convective influences were based on 10 Day Back Trajectories and NASA Langley cloud products.

6. Data Access

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

ATom: Back Trajectories and Influences of Air Parcels Along Flight Track, 2016-2018

Contact for Data Center Access Information:

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

7. References

Bowman, K. P., 1993. Large-scale isentropic mixing properties of the Antarctic polar vortex from analyzed winds. Journal of Geophysical Research 98:23013–23027. https://doi.org/10.1029/93JD02599.

Bowman, K. P., and G. R. Carrie. 2002. The mean-meridional transport circulation of the troposphere in an idealized GCM. Journal of the Atmospheric Sciences 59:1502–1514. https://doi.org/10.1175/1520-0469(2002)059<1502:TMMTCO>2.0.CO;2.