ATom: Measurements from Airborne Tropospheric Hydrogen Oxides Sensor (ATHOS), V2

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Documentation Revision Date: 2021-10-28

Dataset Version: 2

Summary

This dataset provides the mixing ratios of hydrogen oxides measured by the Airborne Tropospheric Hydrogen Oxides Sensor (ATHOS) during the ATom 1-4 campaigns. ATHOS uses laser-induced fluorescence (LIF) to measure hydroxide (OH) and hydroperoxyl (HO2) simultaneously. The measurements include OH and HO2 mixing ratios and the OH interference determined by chemical removal of OH. The reactivity of OH is measured by the OH Reactivity (OHR) instrument using the discharge flow method and is integrated into the ATHOS electronics. These data provide insights into the oxidative state of the global atmosphere. These data are useful for testing the oxidation chemistry in models and other analytical methods being developed to deduce the atmosphere's oxidative state.

This is Version 2 of this dataset. All previously released data were updated to the latest available versions. For details, see Section 8. Dataset Revisions.

There are 138 data files in ICARTT (*.ict) format included in this dataset.

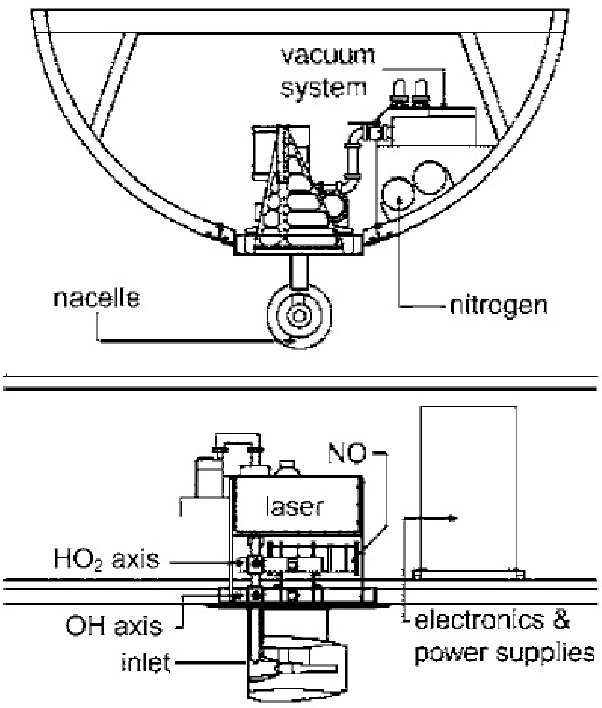

Figure 1. A schematic of ATHOS looking from in front of the electronics rack (top) and from the DC-8 aircraft's port side (bottom).

Citation

Brune, W.H., D.O. Miller, and A.B. Thames. 2021. ATom: Measurements from Airborne Tropospheric Hydrogen Oxides Sensor (ATHOS), V2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1930

Table of Contents

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 Publications

Brune, W.H., D.O. Miller, A.B. Thames, H.M. Allen, E.C. Apel, D.R. Blake, T.P. Bui, R. Commane, J.D. Crounse, B.C. Daube, G.S. Diskin, J.P. DiGangi, J.W. Elkins, S.R. Hall, T.F. Hanisco, R.A. Hannun, E.J. Hintsa, R.S. Hornbrook, M.J. Kim, K. McKain, F.L. Moore, J.A. Neuman, J.M. Nicely, J. Peischl, T.B. Ryerson, J.M. St. Clair, C. Sweeney, A.P. Teng, C. Thompson, K. Ullmann, P.R. Veres, P.O. Wennberg, and G.M. Wolfe. 2020. Exploring oxidation in the remote free troposphere: insights from Atmospheric Tomography (ATom). Journal of Geophysical Research: Atmospheres 125. https://doi.org/10.1029/2019JD031685

Thames, A.B., W.H. Brune, D.O. Miller, H.M. Allen, E.C. Apel, D.R. Blake, T.P. Bui, R. Commane, J.D. Crounse, B.C. Daube, G.S. Diskin, J.P. DiGangi, J.W. Elkins, S.R. Hall, T.F. Hanisco, R.A. Hannun, E. Hintsa, R.S. Hornbrook, M.J. Kim, K. McKain, F.L. Moore, J.M. Nicely, J. Peischl, T.B. Ryerson, J.M. St. Clair, C. Sweeney, A. Teng, C.R. Thompson, K. Ullmann, P.O. Wennberg, and G.M. Wolfe. 2020. Missing OH reactivity in the global marine boundary layer. Atmospheric Chemistry and Physics 20:4013–4029. https://doi.org/10.5194/acp-20-4013-2020

Related Datasets

Brune, W.H., D.O. Miller, and A.B. Thames. 2019. ATom: L2 Measurements from Airborne Tropospheric Hydrogen Oxides Sensor (ATHOS). ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1709

- Version 1 of the current dataset. Now superseded and available only upon request.

Wofsy, S.C., S. Afshar, H.M. Allen, E.C. Apel, E.C. Asher, B. Barletta, et al. 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: HOx: 30 seconds, OHI:150 seconds, OHR: 60 seconds

Data File Information

There are 138 data files in ICARTT (*.ict) format included in this dataset that contain ATHOS measurements of OH and HO_2. Data files conform to the ICARTT File Format Standards V1.1. The files are named ATHOS-MEA_DC8_YYYYMMDD_R#.ict, where

MEA is the three-letter abbreviation for the measurement (HOx = mixing ratios, OHI = OH Interference, or OHR = OH Reactivity)
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. Variables and descriptions for the 46 data files named ATHOS-HOx_DC8_YYYYMMDD_R#.ict.

Variable Name	Units	Description
Start_UTC	Seconds	Start time in seconds since 0000 UTC

Stop_UTC	Seconds	Stop time in seconds since 0000 UTC
Mid_UTC	Seconds	Middle time in seconds since 0000 UTC
OH_ATHOS	pptv	OH mixing ratio in parts per trillion by volume
HO2_ATHOS	pptv	HO_2 mixing ratio in parts per trillion by volume

Table 2. Variables and descriptions for 46 data files named ATHOS-OHI_DC8_YYYYMMDD_R#.ict.

Variable Name	Units	Description
Start_UTC	Seconds	Start time in seconds since 0000 UTC
Stop_UTC	Seconds	Stop time in seconds since 0000 UTC
Mid_UTC	Seconds	Middle time in seconds since 0000 UTC
OHInterference_ATHOS	pptv	OH interference in parts per trillion by volume

Table 3. Variables and descriptions for 46 data files named ATHOS-OHR_DC8_YYYYMMDD_R#.ict

Variable Name	Units	Description
Start_UTC	Seconds	Start time in seconds since 0000 UTC
Stop_UTC	Seconds	Stop time in seconds since 0000 UTC
Mid_UTC	Seconds	Middle time in seconds since 0000 UTC
T_OHR	Kelvin	Temperature inside OHR instrument
P_OHR	kPa	Pressure inside OHR instrument
OHReactivity_OHR	Hz	OH reactivity in Hz

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 5. Uncertainties for ATHOS variables.

File Type	Variable Name	Uncertainty
ATHOS-HOx	OH_ATHOS and HO2_ATHOS	HOx absolute accuracy ±35%, 2 sigma confidence
ATHOS-OHI	OHInterference_ATHOS	OHI absolute accuracy ±35%, 2 sigma confidence
ATHOS-OHR	OHReactivity_OHR	OHR measurement uncertainty ±5% at 2 sigma confidence, with 0.8 s^{-1} at 2 sigma confidence in the zero uncertainty.

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.

Airborne Tropospheric Hydrogen Oxides Sensor

Airborne Tropospheric Hydrogen Oxides Sensor (ATHOS) uses laser-induced fluorescence (LIF) to measure OH and HO_2 simultaneously. OH is both excited and detected near 308 nm. HO2 is reacted with reagent NO to form OH and is then detected with LIF. The laser is turned on and off the OH wavelength to determine the fluorescence and background signals. ATHOS can detect OH and HO_2 in clear air and in all but the densest clouds from Earth's surface to the lower stratosphere. The ambient air is slowed from the aircraft speed of 240 m/s to 8-40 m/s in an aerodynamic nacelle. It is then pulled by a vacuum pump through a small inlet, up a sampling tube, and into two low-pressure detection cells - the first for OH and the second for HO_2. Detection occurs in each cell at the intersection of the airflow, the laser beam, and the detector field of view. Added to ATHOS is a second method for separating the OH signal from the background: a special inlet was attached just in front of the pinhole inlet and an OH scavenger was periodically added to remove OH. The removed signal is due to OH and the remaining signal is due to background and any OH interference. Integrated into the ATHOS electronics is the OH Reactivity (OHR) instrument. It measures the OH reactivity, which is the inverse of the OH lifetime. This instrument uses the discharge flow method, in which OH is added to the ambient flow at different distances from an OH detection system and the OH decay is measured as the distance between the OH source and the OH detection is increased. Additional information can be found on the ESPO ATHOS Instrument 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:

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

7. References

Brune, W.H., D.O. Miller, A.B. Thames, H.M. Allen, E.C. Apel, D.R. Blake, T.P. Bui, R. Commane, J.D. Crounse, B.C. Daube, G.S. Diskin, J.P. DiGangi, J.W. Elkins, S.R. Hall, T.F. Hanisco, R.A. Hannun, E.J. Hintsa, R.S. Hornbrook, M.J. Kim, K. McKain, F.L. Moore, J.A. Neuman, J.M. Nicely, J. Peischl, T.B. Ryerson, J.M. St. Clair, C. Sweeney, A.P. Teng, C. Thompson, K. Ullmann, P.R. Veres, P.O. Wennberg, and G.M. Wolfe. 2020. Exploring oxidation in the remote free troposphere: insights from Atmospheric Tomography (ATom). Journal of Geophysical Research: Atmospheres 125. https://doi.org/10.1029/2019JD031685

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8. Dataset Revisions

Version	Release Date	Description
2.0	2021-10-30	All previously-released data were updated to the latest available versions. New versions contain improved calibration methods and, as a result, different data values from the previous version.
1.0	2019-07-18	Initial release of data.