ATom: Light-Absorbing Metallic Aerosols, Single Particle Soot Photometer, 2016-2018

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Documentation Revision Date: 2021-06-28

Dataset Version: 1

Summary

This dataset provides mass mixing ratios and number density of light-absorbing metallic aerosols (LAM) in the size range 180-1290 nm obtained with the NOAA Single Particle Soot Photometer (SP2) during the four deployments of the NASA Atmospheric Tomography (ATom) airborne mission from 2016-2018. The NOAA SP2 detects light absorbing aerosols, such as black carbon (BC), via laser-induced incandescence to provide real-time in situ quantification of refractory aerosol mass and number density. The percent of LAM aerosols attributed to anthropogenic iron oxides (FeOx) by mass is also provided.

The ATom mission deployed an extensive gas and aerosol payload on the NASA DC-8 aircraft for a systematic, global-scale sampling of the atmosphere, profiling continuously from 0.2 to 12 km altitude. Flights occurred in each of four seasons from 2016 to 2018.

There are 46 data files in ICARTT (*.ict) format.

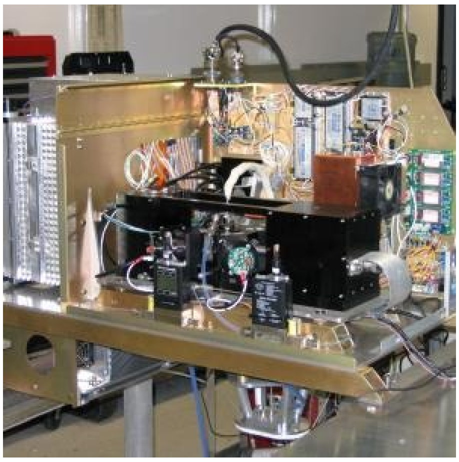

Figure 1. The NOAA Single Particle Soot Photometer (SP2) instrument.

Citation

Lamb, K., J.P. Schwarz, and J.M. Katich. 2021. ATom: Light-Absorbing Metallic Aerosols, Single Particle Soot Photometer, 2016-2018. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1828

Table of Contents

1. Dataset Overview

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The ATom mission deployed an extensive gas and aerosol payload on the NASA DC-8 aircraft for a systematic, global-scale sampling of the atmosphere, profiling continuously from 0.2 to 12 km altitude. Flights occurred in each of four seasons from 2016 to 2018.

Project: Atmospheric Tomography Mission

The Atmospheric Tomography Mission (ATom) was a NASA Earth Venture Suborbital-2 mission to study 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 a systematic, global-scale sampling of the atmosphere, profiling continuously from 0.2 to 12 km altitude. Around-the-world flights were conducted in each of four seasons between 2016 and 2018.

Related Publication

Lamb, K.D., H. Matsui, J.M. Katich, A.E. Perring, J.R. Spackman, B. Weinzierl, M. Dollner, and J.P. Schwarz. 2021. Global-scale constraints on light-absorbing anthropogenic iron oxide aerosols. npj Climate and Atmospheric Science 4. https://doi.org/10.1038/s41612-021-00171-0

Related Datasets

Katich, J.M., J.P. Schwarz, K. Froyd, B. Weinzierl, M. Dollner, T.P. Bui, C.S. Chang, and J.M. Dean-Day. 2018. ATom: Black Carbon Mass Mixing Ratios from ATom-1 Flights. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1618

- The data products provided were obtained with the same instrument.

Schwarz, J.P., and J.M. Katich. 2019. ATom: L2 In Situ Measurements from Single Particle Soot Photometer (SP2). ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1672

- The data products provided were obtained with the same instrument.

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

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

Acknowledgments

This work was supported by the ATom NASA-Department of Commerce Interagency Agreement (grant NNH15AB12I).

2. Data Characteristics

Spatial Coverage: ATom flights with near-global coverage

Spatial Resolution: ~250 m, along DC 8 flight trajectory

Temporal Coverage: 2016-07-29 to 2018-05-21

Temporal Resolution: 1 second

Deployment	Number of Flights	Date Range
ATom-1	11	July 29 - August 23, 2016
ATom-2	10	January 26 - February 21, 2017
ATom-3	12	September 28 - October 28, 2017
ATom-4	13	April 24 - May 21, 2018

Data File Information

There are 46 data files in ICARTT (*.ict) format. Data files conform to the ICARTT File Format Standards V1.1. The file naming convention is ATOM-SP2-LAM-MMR_DC8_**YYYYMMDD_R#**.ict, where **YYYYMMDD** is the date of the flight and **R#** is the revision number.

Table 1. File names and descriptions.

File Names	Description
ATOM-SP2-LAM-MMR_DC8_YYYYMMDD_R#.ict	Observations of light-absorbing metallic aerosols (LAM) associated with anthropogenic combustion sources obtained with the NOAA Single-Particle Soot Photometer (SP2)

Data File Details

Missing values are represented by -9999.99.

R1 revisions include final 1-second data and fixed error in Mie Scattering calculation.

No spatial coordinates are provided in the data files. Merge with Wofsy et al. (2018; https://doi.org/10.3334/ORNLDAAC/1613) by date and time (i.e., the UTC variable) for Aircraft Flight Track and Navigational Data.

Table 2. Variable names and descriptions.

Variable Name	Units	Description
UTC	seconds since midnight	Bin start time
LAM_mass_180to1290nm	ng LAM/std. m^3	LAM mass mixing ratio. Standard m^3 at 1013 mb pressure and 273 K temperature.
LAM_num_180to1290nm	(std. $cm^3)^{-1}$	Number density of observed LAM aerosols. Number/(std. $cm^3)^{-1}$. Standard cm^3 at 1013 mb pressure and 273 K temperature.
percent_anthrofeox	percent	Anthropogenic-like FeOx by mass

3. Application and Derivation

ATom built 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 occurs 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 delivered 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 provided unprecedented challenges to the CCMs used as policy tools for climate change assessments, with comprehensive data on atmospheric chemical reactivity at global scales, and worked closely with modeling teams to translate ATom data to better, more reliable CCMs. ATom provided extraordinary validation data for remote sensing.

4. Quality Assessment

At least 25 percent systematic uncertainty from flow and mass calibration, and aspiration efficiency.

In-cloud, spurious, and calibration data have been removed. Artifact-like LAM were removed.

5. Data Acquisition, Materials, and Methods

Project Overview

ATom made global-scale measurements of the chemistry of the atmosphere using the NASA DC-8 aircraft. Flights spanned 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 had 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 enabled disentangling of the processes that regulate atmospheric chemistry: emissions, transport, cloud processes, and chemical transformations. ATom analyzed 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 differentiated between hypotheses for the formation and growth of aerosols over the remote oceans.

Measurements

The NOAA Single-Particle Soot Photometer (SP2) detected light-absorbing metallic aerosols (LAM) in the size range 180–1290 nm volume-equivalent diameter for 5.17 g/cc density. Mass calibrations were based on the Fe3O4 incandescent to mass relationship (Yoshida et al., 2016). Percent anthopogenic-like by mass determined as discussed in Lamb et al. (2021). In-cloud, spurious, and calibration data were removed.

The NOAA SP2 was calibrated with PSL’s before each research flight to calibrate laser power. rBC mass was calibrated using a differential mobility diameter (DMA) several times during each campaign. During ATom-3 and ATom-4, measurements of Fe_2O_3 and Fe_3O_4 laboratory calibration materials preceding research flights provided further verification of the color-temperature ratio regime for FeO_x. Additional details of SP2 sampling and calibrations during ATom were discussed in detail in Katich et al. (2018). During the ATom airborne campaigns, the SP2 sampling rate was 4 cc/s. Periods identified as ice and liquid phase clouds were flagged based on the observations from the CAPS cloud probes Spanu et al. (2020). Additional cloudy periods were identified by plume length and flagged manually. These criteria removed approximately 14% of flight data points. Transmission efficiency of aerosols sampled on the aircraft from the inlet was >50% for 1.2 μm particles sampled at altitudes below 200 hPa. ATom-2 had a higher gain setting for the broadband PMT, which meant that only particles with LAM <1150 nm were quantified during this campaign.

SP2 Instrument

The SP2 is a laser-induced incandescence instrument primarily used for measuring the BC mass content of individual particles. It is able to provide this data product independently of the total particle morphology and mixing state, and thus delivers detailed information not only about BC loadings but also size distributions, even in exceptionally clean air. The instrument can also provide the optical size of individual particles containing BC, and identify the presence of coatings associated with the BC fraction (i.e., identify the BC’s mixing state). Since its introduction in 2003, the SP2 has been substantially improved, and now can be considered a highly competent instrument for assessing BC loadings and mixing state in situ. More information can be found in Huang et al. (2011) and Schwarz et al. (2006; 2010).

6. Data Access

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

ATom: Light-Absorbing Metallic Aerosols, Single Particle Soot Photometer, 2016-2018

Contact for Data Center Access Information:

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

7. References

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