ATom: Aerosol Extinction and Absorption Measurements from SOAP Instrument, 2018

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Documentation Revision Date: 2021-12-20

Dataset Version: 1

Summary

This dataset contains one-second aerosol extinction and absorption measurements from the Spectrometers for Optical Aerosol Properties (SOAP) instrument aboard the NASA DC-8 aircraft during the ATom-4 campaign that occurred in 2018. SOAP is a compact, low maintenance instrument that measures aerosol extinction and absorption at 532 nm. Aerosol extinction is measured by cavity ringdown spectroscopy and aerosol absorption by photoacoustic spectroscopy. Extinction is measured with sufficient precision and accuracy for the remote atmosphere. The absorption measurements are valid only in strongly absorbing cases, such as in dilute plumes from wildfire smoke. The absorption and extinction of visible light by aerosol particles is a major component of the earth's radiation budget, strongly affecting climate. Highly absorbing particles directly heat the atmosphere, while particles that scatter light tend to cool the atmosphere. Extinction is the sum of absorption and scattering; in most cases scattering represents >90% of extinction, with absorption making up the remainder. These aerosol-radiation interactions also alter air temperature and the rates of photochemical reactions.

There are 13 data files in ICARTT (*.ict) format included in this dataset.

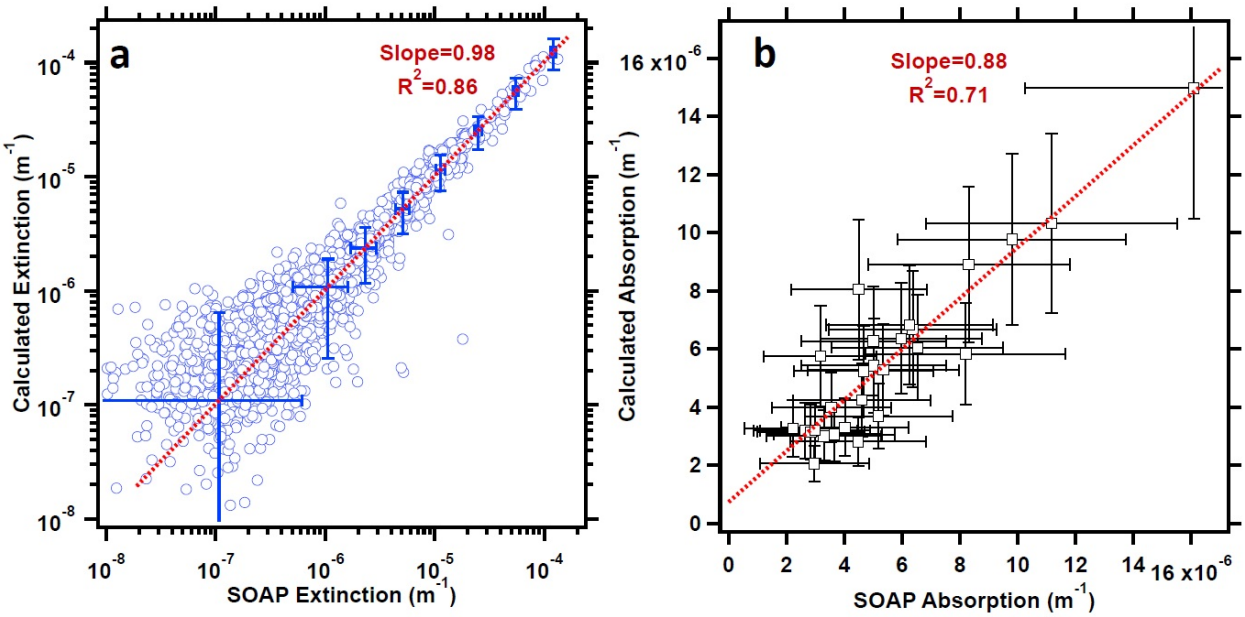

Figure 1. (a) Aerosol extinction calculated using Mie theory from composition-resolved size distributions plotted as a function of measured extinction from the SOAP cavity ring-down spectrometer during the ATom-4 campaign, showing representative error bars. (b) Calculated aerosol absorption and measured absorption from the SOAP photoacoustic spectrometer for cases when absorption >2 *10-6 m-1 (2x the detection limit).

Citation

Wagner, N.L., C.A. Brock, C.J. Williamson, A. Kupc, K.D. Froyd, and D.M. Murphy. 2021. ATom: Aerosol Extinction and Absorption Measurements from SOAP Instrument, 2018. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1898

Table of Contents

1. Dataset Overview

This dataset contains one-second aerosol extinction and absorption measurements from the Spectrometers for Optical Aerosol Properties (SOAP) instrument aboard the NASA DC-8 aircraft during the ATom-4 campaign that occurred in 2018. SOAP is a compact, low-maintenance instrument that measures aerosol extinction and absorption at 532 nm. Aerosol extinction is measured by cavity ringdown spectroscopy and aerosol absorption by photoacoustic spectroscopy. Extinction is measured with sufficient precision and accuracy for the remote atmosphere. The absorption measurements are valid only in strongly absorbing cases, such as in dilute plumes from wildfire smoke. The absorption and extinction of visible light by aerosol particles is a major component of the earth's radiation budget, strongly affecting climate. Highly absorbing particles directly heat the atmosphere, while particles that scatter light tend to cool the atmosphere. Extinction is the sum of absorption and scattering; in most cases, scattering represents >90% of extinction, with absorption making up the remainder. These aerosol-radiation interactions also alter air temperature and the rates of photochemical reactions.

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, 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

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

2. Data Characteristics

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

Spatial Resolution: Point measurements

Temporal Coverage: Periodic flights occurred during the ATom-4 campaign

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: 1 second

Data File Information

There are 13 data files in ICARTT (*.ict) format included in this dataset that provide aerosol extinction and absorption measurements from the SOAP instrument for the ATom-4 Campaign. Data files conform to the ICARTT File Format Standards V1.1.

Files are named SOAP_DC8_**YYYYMMDD**_R#.ict (e.g., SOAP_DC8_20180517_R1.ict), where

YYYYMMDD = year, month and day, and
R# = revision number of the data.

Data File Details

Missing data are indicated by -9999.

Table 2. Variables in the data files SOAP_DC8_YYYYMMDD_R#.ict.

Variable	Units	Description
UTC_Start	Seconds	Start time in seconds since 0000 UTC
Extinction_SOAP	Mm-1	Extinction coefficient (inverse Mm) at dry (<20 % RH) conditions at 532 nm wavelength due to aerosol particles with aerodynamic diameters <2 micrometers, reported at standard temperature and pressure (1013 hPa, 273.15 K).
Absorption_SOAP	Mm-1	Absorption_SOAP: Absorption coefficient (inverse Mm) at dry (<20 % RH) conditions at 532 nm wavelength due to aerosol particles with aerodynamic diameters <2 µm, reported at standard temperature and pressure (1013 hPa, 273.15 K).

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 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 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 for SOAP instrument

Variable	Uncertainty
Extinction_SOAP	One-sigma uncertainty is 5% + 0.5 Mm-1.
Absorption_SOAP	One-sigma uncertainty is 30% + 1 Mm-1. Due to spectrometer sensitivity, users are encouraged to interpret only those data that exceed the two-sigma threshold (2 Mm-1). See Data Acquisition, Materials, and Methods section for additional details.

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 greenhouse gases (GHG) and ozone-depleting substances (ODS) 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.

Spectrometers for Optical Aerosol Properties

Spectrometers for Optical Aerosol Properties (SOAP) is a compact, low-maintenance instrument that measures aerosol extinction and absorption at 532 nm. Extinction measurement is by cavity ringdown spectroscopy (CRDS) and absorption by photoacoustic spectroscopy (PAS). A thorough description of these techniques is provided in Langridge et al. (2011) and Lack et al. (2011); the SOAP instrument uses the same designs described in these references but operates at a single wavelength. Measurements by the SOAP during ATom were made downstream a Nafion dryer that reduced RH to <20%, followed by an impactor with an aerodynamic cut-point of 2 µm at STP. Calibrations of the PAS were made in-flight using generated ozone that passed through both the CRDS and the PAS; the CRDS measurement, which is based on first principles and laboratory calibrations, provided the absorption value for the PAS calibration. The PAS sensitivity (1 Mm-1) is not sufficient to provide a signal in most of the ATom datasets. Users are encouraged to interpret only those data that exceed the two-sigma threshold (2 Mm-1). For additional information, see the NOAA SOAP 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

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