ATom: L2 In Situ Measurements from NOAA Nitrogen Oxides and Ozone (NOyO3) Instrument

Get Data

Documentation Revision Date: 2019-09-05

Dataset Version: 1

Summary

This dataset provides in situ concentrations of nitric oxide (NO), nitrogen dioxide (NO2), total reactive nitrogen oxides (NOy), and ozone (O3) measured by the NOAA Nitrogen Oxides and Ozone (NOyO3) 4-channel chemiluminescence (CL) instrument during airborne campaigns conducted by NASA's Atmospheric Tomography (ATom) mission. NOyO3 provides fast-response, specific, high precision, and calibrated measurements of nitrogen oxides and ozone at a spatial resolution of better than 100 m. ATom deploys 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 4 seasons from 2016 to 2018. Flights originate from the Armstrong Flight Research Center in Palmdale, California, fly north to the western Arctic, south to the South Pacific, east to the Atlantic, north to Greenland, and return to California across central North America. ATom establishes a single, contiguous, global-scale dataset. This comprehensive dataset will be used to improve the representation of chemically reactive gases and short-lived climate forcers in global models of atmospheric chemistry and climate.

The NOyO3 4-channel chemiluminescence instrument detects species based on the gas-phase CL reaction of NO with O3 at low pressure, resulting in photoemission from electronically excited NO2.

This dataset includes 192 files in comma-delimited text (ICARTT) format, with four data files per flight.

Figure 1. The NOAA NOyO3 4-channel chemiluminescence (CL) instrument.

Citation

Ryerson, T.B., C.R. Thompson, J. Peischl, and I. Bourgeois. 2019. ATom: L2 In Situ Measurements from NOAA Nitrogen Oxides and Ozone (NOyO3) Instrument. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1734

Table of Contents

1. Dataset Overview

This dataset provides in situ concentrations of nitric oxide (NO), nitrogen dioxide (NO2), total reactive nitrogen oxides (NOy), and ozone (O3) measured by the NOAA Nitrogen Oxides and Ozone (NOyO3) 4-channel chemiluminescence (CL) instrument during airborne campaigns conducted by NASA's Atmospheric Tomography (ATom) mission. NOyO3 provides fast-response, specific, high precision, and calibrated measurements of nitrogen oxides and ozone at a spatial resolution of better than 100 m. ATom deploys 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 4 seasons from 2016 to 2018. Flights originate from the Armstrong Flight Research Center in Palmdale, California, fly north to the western Arctic, south to the South Pacific, east to the Atlantic, north to Greenland, and return to California across central North America. ATom establishes a single, contiguous, global-scale dataset. This comprehensive dataset will be used to improve the representation of chemically reactive gases and short-lived climate forcers in global models of atmospheric chemistry and climate.

The NOyO3 4-channel chemiluminescence instrument detects species based on the gas-phase CL reaction of NO with O3 at low pressure, resulting in photoemission from electronically excited NO2.

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:

ATom: Merged Atmospheric Chemistry, Trace Gases, and Aerosols. Data from all ATom instruments and all four flight campaigns, including aircraft location and navigation data, merged to several different time bases: https://doi.org/10.3334/ORNLDAAC/1581

ATom Flight Track and Navigational Data. Flight path (location and altitude) data for each of the four campaigns provided in KML and csv format: https://doi.org/10.3334/ORNLDAAC/1613

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

Table 1. Flight campaign schedule

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

This dataset includes 192 files in comma-delimited text (ICARTT) format, with four files (one for each measurement type) per flight date for all four ATom flight campaigns. Data files conform to the ICARTT File Format Standards V1.1.

File names are structured as NOyO3-**MEA**_DC8_**YYYYMMDD**_**R#**.ict, where **MEA** is the two- or three-letter abbreviation for the measurement type: NO = nitric oxide, NO2 = nitrogen dioxide, NOy = reactive nitrogen, O3 = ozone; **YYYYMMDD** is the start date (in UTC time) of the flight, and **R#** is the file version or revision number.

Data Variables

Missing data are indicated by -9999.000.

Table 2. Variables in the nitric oxide data files *NOyO3-NO_DC8_YYYYMMDD_R#.ict.*

Name	Units	Description
UTC_start	seconds	seconds since UTC midnight on day of takeoff
NO_CL	ppbv	nitric oxide in air mixing ratio in parts-per-billion-by-volume
NO_CL_2sigma	ppbv	2-sigma uncertainty of 1Hz data

Table 3. Variables in the nitrogen dioxide data files *NOyO3-NO2_DC8_YYYYMMDD_R#.ict.*

Name	Units	Description
UTC_start	seconds	seconds since UTC midnight on day of takeoff
NO2_CL	ppbv	nitrogen dioxide in air mixing ratio in parts-per-billion-by-volume
NO2_CL_2sigma	ppbv	2-sigma uncertainty of 1Hz data

Table 4. Variables in the reactive nitrogen data files *NOyO3-NOy_DC8_YYYYMMDD_R#.ict.*

Name	Units	Description
UTC_start	seconds	seconds since UTC midnight on day of takeoff
NOy_CL	ppbv	reactive nitrogen in air mixing ratio in parts-per-billion-by-volume

NOy_CL_2sigma	ppbv	2-sigma uncertainty of 1Hz data

Table 5. Variables in the ozone data files *NOyO3-O3_DC8_YYYYMMDD_R#.ict.*

Name	Units	Description
UTC_start	seconds	seconds since UTC midnight on day of takeoff
O3_CL	ppbv	ozone in air mixing ratio in parts-per-billion-by-volume
O3_CL_2sigma	ppbv	2-sigma uncertainty of 1Hz data

3. Application and Derivation

ATom builds the scientific foundation for mitigation of short-lived climate forcers, in particular methane (CH4), tropospheric ozone (O3), and Black Carbon aerosols (BC).

ATom Science Questions

Tier 1

- What are chemical processes that control the short-lived climate forcing agents CH4, O3, 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

Measurement uncertainty is provided by the columns **MEA**_CL_2sigma in each data file, where **MEA** is the two- or three-letter abbreviation for the measurement: NO = nitric oxide, NO2 = nitrogen dioxide, NOy = reactive nitrogen, or O3 = ozone.

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.

NOAA Nitrogen Oxides and Ozone

Instrument	Full Name	Contact Person	Type	Measurements	Data Variables
$NOyO_3$	NOAA Nitrogen Oxides and Ozone	Thomas B. Ryerson	Chemiluminescence	nitrogen oxides, ozone	NO, NO2, NOy, O3

The NOAA NOyO3 4-channel chemiluminescence (CL) instrument provides in-situ measurements of nitric oxide (NO), nitrogen dioxide (NO2), total reactive nitrogen oxides (NOy), and ozone (O3). Different versions of this instrument have flown on the NASA DC-8 and NOAA WP-3D research aircraft on field projects since 1995. Detection is based on the gas-phase CL reaction of NO with O3 at low pressure, resulting in photoemission from electronically excited NO2. Photons are detected and quantified using pulse counting techniques, providing ~5 to 10 part-per-trillion by volume (pptv) precision at 1 Hz data rates. One detector of the integrated 4-channel instrument is used to measure ambient NO directly, a second detector is equipped with a UV-LED converter to photodissociate ambient NO2 to NO, and a third detector is equipped with a heated gold catalyst to reduce ambient NOy species to NO. Reagent ozone is added to these sample streams to drive the CL reactions with NO. Ambient O3 is detected in the fourth channel by adding reagent NO. More information is provided in Ryerson et al. (2000).

6. Data Access

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

ATom: L2 In Situ Measurements from NOAA Nitrogen Oxides and Ozone (NOyO3) Instrument

Contact for Data Center Access Information:

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

7. References

Ryerson, T. B., et al. (2000), An efficient photolysis system for fast-response NO2 measurements, J. Geophys. Res., 105, 26447-26461. https://doi.org/10.1029/2000JD900389