ATom: In Situ Atmospheric Water Vapor from the Diode Laser Hygrometer, Version 2

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Documentation Revision Date: 2022-01-03

Dataset Version: 2

Summary

This dataset provides the concentrations of water measured by the Diode Laser Hygrometer (DLH) flown on the NASA DC-8 during the ATom 1-4 campaigns from 2016 - 2018. The DLH measures the water vapor in the atmosphere by wavelength modulated differential absorption spectroscopy of an isolated rovibrational line. The measurements include water vapor mixing ratio in parts-per-million-by-volume (ppmv) and relative humidity in percent. Relative humidity, both with respect to liquid water and with respect to ice, are quantities derived from measurements of water vapor mixing ratio as well as ambient temperature and pressure.

The DLH is an open path airborne tunable diode laser-based instrument which operates in the near-infrared spectral region at a wavelength of approximately 1.4 micrometers. The DLH laser is modulated at approximately 2 kHz and operates in a 'line-locked' mode; the signal is demodulated at twice the modulation frequency (2F detection) to provide good sensitivity and rapid time response. The returned laser power (DC) is also measured. The DLH laser is characterized in the laboratory in order to understand its dynamic tuning behavior. From the characterization data and a multiparameter spectral model, a set of coefficients is developed, and these coefficients are used to convert the measured 2F/DC ratio, along with local ambient temperature and pressure (which are measured by separate instruments aboard the aircraft), to water vapor mixing ratio. Data are reported both at 1/sec and 20/sec data rates. Timing is synchronized to an internal GPS receiver which should provide better than 1 ms registration.

This Version 2 of this dataset. In Version 2, there are two updated files from 2016-08-12 (DLH-H2O-20Hz_DC8_20160812_R2.ict and DLH-H2O_DC8_20160812_R3.ict). No other files have changed. For addition details see Section 8. Dataset Revisions.

This dataset includes 96 files in comma-delimited text (ICARTT) format, with two files per flight.

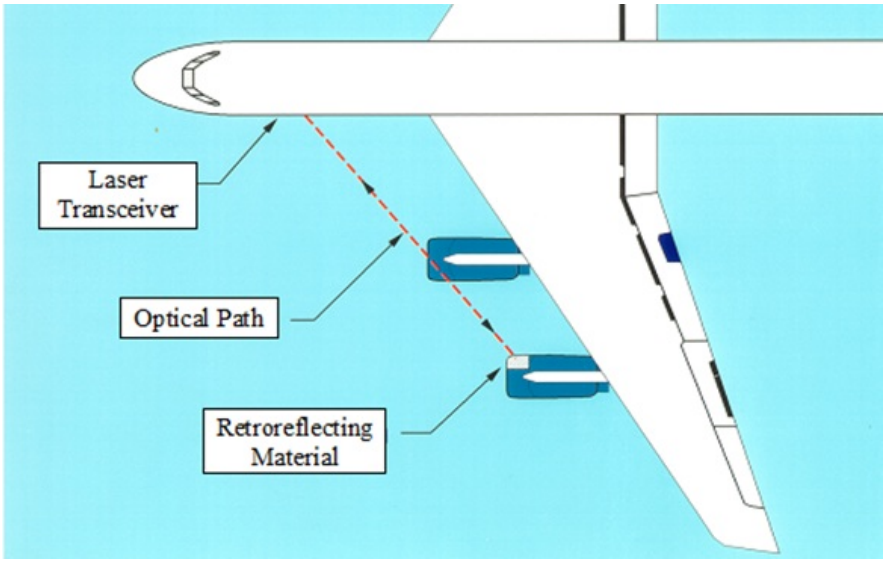

Figure 1. Location of external path DLH on DC-8 (typical port-side installation).

Citation

Diskin, G.S., and J.P. DiGangi. 2021. ATom: In Situ Atmospheric Water Vapor from the Diode Laser Hygrometer, Version 2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1937

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 a 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

- Flightpath (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 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: 1 second

Data File Information

There are 96 data files in ICARTT (*.ict) format included in this dataset. Data files conform to the ICARTT File Format Standards V1.1.

The files are named DLH-H2O_DC8_**YYYYMMDD_R#**.ict or DLH-H2O-20Hz DC8_**YYYYMMDD_R#**.ict, where **YYYYMMDD** is the start date (in UTC time) of the flight and **R#** is the file version or revision number.

DLH-H2O files contain water vapor mixing ratio and relative humidity at 1 Hz temporal resolution.
DLH-H2O-20Hz files contain water vapor mixing ratio at 20 Hz temporal resolution.

Table 2. Variable names and descriptions for *DLH-H2O files*

Name	Units	Description
Time_UTC	seconds	seconds since 000UTC
H2O_DLH	ppmv	water vapor mixing ratio in parts per million by volume
RHi_DLH	percent	relative humidity with respect to ice
RHw_DLH	percent	relative humidity with respect to liquid

Table 3. Variable names and descriptions for *DLH-H2O-20Hz* files.

Name	Units	Description
Time_UTC	seconds	seconds since 0000 UTC
H2O_DLH	ppmv	water vapor mixing ratio in parts per million by volume

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 the 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

Uncertainty for H2O(v) is 5% and for relativity humidity it is 10%.

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.

Diode Laser Hygrometer (DLH)

The DLH has been successfully flown during many previous field campaigns on several aircraft, most recently ACTIVATE (Falcon); FIREX-AQ, ATom, KORUS-AQ, and SEAC4RS (DC-8); POSIDON (WB-57); CARAFE (Sherpa); CAMP2Ex and DISCOVER-AQ (P-3); and ATTREX (Global Hawk).

This sensor measures water vapor (H2O(v)) via absorption by one of three strong, isolated spectral lines near 1.4 µm and is comprised of a compact laser transceiver and a sheet of high grade retroflecting road sign material to form the optical path. Optical sampling geometry is aircraft-dependent, as each DLH instrument is custom-built to conform to aircraft geometric constraints. Using differential absorption detection techniques, H2O(v) is sensed along the external path negating any potential wall or inlet effects inherent in extractive sampling techniques. A laser power normalization scheme enables the sensor to accurately measure water vapor even when flying through clouds. An algorithm calculates H2O(v) concentration based on the differential absorption signal magnitude, ambient pressure, and temperature, and spectroscopic parameters found in the literature and/or measured in the laboratory. Preliminary water vapor mixing ratio and derived relative humidity are provided in real-time to investigators. Additional information can be found in Diskin, et al. (2002), and Podolske, et al. (2003).

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

Diskin, G.S., J.R. Podolske, G.W. Sachse, and T.A. Slate. 2002. Open-path airborne tunable diode laser hygrometer. In *Diode lasers and applications in atmospheric sensing.* 4817:196-204. International Society for Optics and Photonics. https://doi.org/10.1117/12.453736.

Podolske, James R., Sachse, Glen W., and Diskin, Glenn S. 2003. Calibration and data retrieval algorithms for the NASA Langley/Ames Diode Laser Hygrometer for the NASA Transport and Chemical Evolution Over the Pacific (TRACE-P) mission. Journal of Geophysical Research, Volume 108, Issue D20, https://doi.org/10.1029/2002JD003156 .

8. Dataset Revisions

Version	Release Date	Description

2.0	2021-12-20	Released two updated files from 2016-08-12: DLH-H2O-20Hz_DC8_20160812_R2.ict and DLH-H2O_DC8_20160812_R3.ict. No other files were changed.
1.0	2019-06-21	Initial release of data. Now superseded and available only upon request.