ATom: CO2, CH4, and CO Measurements from Picarro, 2016-2018

Get Data

Documentation Revision Date: 2021-10-28

Dataset Version: 1

Summary

This dataset contains atmospheric measurements of CO2, CH4, and CO mixing ratios made with a Picarro G2401 spectrometer during the four ATom campaigns. Picarro G2401 uses Wavelength-Scanned Cavity Ring Down Spectroscopy (WS-CRDS), a time-based measurement utilizing a near-infrared laser to measure a spectral signature of the molecule. For the ATom mission, the Picarro instrument was modified in the laboratory to operate across the full pressure altitude range of flight campaigns. The instrument was also modified to have a shorter measurement interval.

There are 55 data files in ICARTT (*.ict) format included in this dataset.

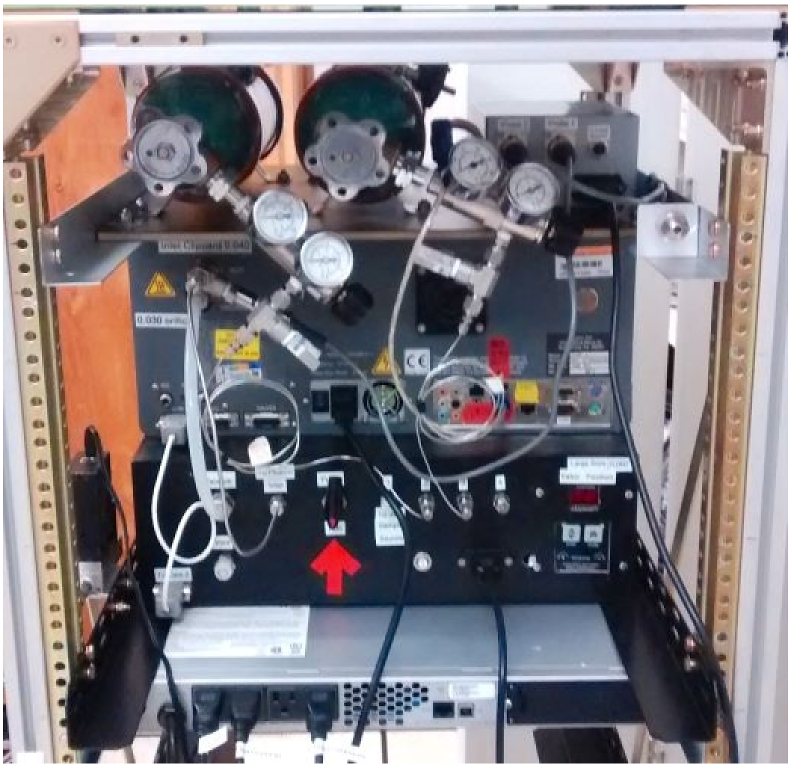

Figure 1. The forward-facing side of the NOAA Picarro G2401 instrument used on the four ATom campaigns.

Citation

McKain, K., and C. Sweeney. 2021. ATom: CO2, CH4, and CO Measurements from Picarro, 2016-2018. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1732

Table of Contents

1. Dataset Overview

This dataset contains atmospheric measurements of CO_2, CH_4, and CO mixing ratios made with a Picarro G2401 spectrometer during the four ATom campaigns. Picarro G2401 uses Wavelength-Scanned Cavity Ring Down Spectroscopy (WS-CRDS), a time-based measurement utilizing a near-infrared laser to measure a spectral signature of the molecule. For the ATom mission, the Picarro instrument was modified in the laboratory to operate across the full pressure altitude range of flight campaigns. The instrument was also modified to have a shorter measurement interval.

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, J. Bent, H. Bian, B.C. Biggs, D.R. Blake, N. Blake, I. Bourgeois, C.A. Brock, W.H. Brune, J.W. Budney, T.P. Bui, A. Butler, P. Campuzano-Jost, C.S. Chang, M. Chin, R. Commane, G. Correa, J.D. Crounse, P. D. Cullis, B.C. Daube, D.A. Day, J.M. Dean-Day, J.E. Dibb, J.P. DiGangi, G.S. Diskin, M. Dollner, J.W. Elkins, F. Erdesz, A.M. Fiore, C.M. Flynn, K.D. Froyd, D.W. Gesler, S.R. Hall, T.F. Hanisco, R.A. Hannun, A.J. Hills, E.J. Hintsa, A. Hoffman, R.S. Hornbrook, L.G. Huey, S. Hughes, J.L. Jimenez, B.J. Johnson, J.M. Katich, R.F. Keeling, M.J. Kim, A. Kupc, L.R. Lait, K. McKain, R.J. Mclaughlin, S. Meinardi, D.O. Miller, S.A. Montzka, F.L. Moore, E.J. Morgan, D.M. Murphy, L.T. Murray, B.A. Nault, J.A. Neuman, P.A. Newman, J.M. Nicely, X. Pan, W. Paplawsky, J. Peischl, M.J. Prather, D.J. Price, E.A. Ray, J.M. Reeves, M. Richardson, A.W. Rollins, K.H. Rosenlof, T.B. Ryerson, E. Scheuer, G.P. Schill, J.C. Schroder, J.P. Schwarz, J.M. St.Clair, S.D. Steenrod, B.B. Stephens, S.A. Strode, C. Sweeney, D. Tanner, A.P. Teng, A.B. Thames, C.R. Thompson, K. Ullmann, P.R. Veres, N.L. Wagner, A. Watt, R. Weber, B.B. Weinzierl, P.O. Wennberg, C.J. Williamson, J.C. Wilson, G.M. Wolfe, C.T. Woods, L.H. Zeng, and N. Vieznor. 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: 1 second

Data File Information

There are 55 data files in ICARTT (*.ict) format included in this dataset that contain Picarro measurements of CO_2, CH_4, and CO. Data files conform to the ICARTT File Format Standards V1.1. The files are named CO2-CH4-CO_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. The dataset contains the companion file NOAA-Picarro_ATom1234_readme.pdf that contains specific details and specifications on the Picarro instrument and data analysis specific to this dataset.

Data File Details

Missing data are represented by -99999.

Table 1. Variables and descriptions for files named CO2-CH4-CO_DC8_YYYYMMDD_R#.ict.

Name	Units	Description
UTC_Start	seconds	Seconds since 0000 UTC
CO2_NOAA	ppm	Carbon dioxide dry-air mixing ratio
CH4_NOAA	ppb	Methane dry-air mixing ratio
CO_NOAA	ppb	Carbon monoxide dry-air mixing ratio

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 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

The following information is summarized from the companion file NOAA-Picarro_ATom1234_readme.pdf.

Two 2 L high-pressure reference cylinders with the following concentration ranges were flown with the Picarro system: 388–405 ppm CO_2 on ATom-1 and 2, 393–411 ppm CO2 on ATom-3, 399–414 ppm CO_2 on ATom-4, 1818–1918 ppb CH_4 on ATom-1 and 2, 1851–1920 ppb CH_4 on ATom-3, 1864–1951 ppb CH_4 on ATom-4, 128–135 ppb CO on ATom-1 and 2, 121–129 ppb CO on ATom-3, 130–132 ppb CO on ATom-3 and 4. Each of the cylinders was measured immediately before and after each flight, and during flight for 3 minutes every other hour on ATom-1 and 2 and for 1.5-minutes every 1.5 hours on ATom-3 and 4. These in-situ calibration measurements were used to apply a single offset correction to the measurements for each flight.

Average total analytical uncertainty was approximated and summarized as independent components for CO_2 in ppm, CH_4 in ppb, CO in ppb shown in Table 3.

Table 3. Uncertainties for each compound.

Compound	Uncertainty
CO_2	0.08 ppm
CH_4	0.7 ppb
CO (1 second)	8.9 ppb
CO (10 seconds)	3.6 ppb

5. Data Acquisition, Materials, and Methods

Data Collection & Processing

The following information is summarized from the companion file NOAA-Picarro_ATom1234_readme.pdf.

On ATom-1, the instrument was located on a rack shared with the PANTHER instrument with an inlet mounted on window #10 on the port side of the NASA DC8. On ATom-2 through ATom-4, the instrument was located on a rack shared with the DLH instrument with an inlet mounted on window #5 on the port side of the aircraft. Sample air was collected via a pump located downstream of the analyzer. Mass flow through the analyzer was constant, but volume flow varied with temperature and pressure. Measurement times were corrected for a lag time in the sample line of 5–15 seconds for ATom-1, 2–10 seconds for ATom-2, and 2–8 seconds for ATom-3 and 4, using ambient pressure and temperature measurements from the DC8, and then bin-averaged into 1-second intervals.

Dry mole fractions were computed using analyzer-specific empirical corrections, derived from laboratory tests performed before and after each campaign. Lab tests were performed to characterize the dependence of reported measurements to small excursions in cell pressure away from its set point of 80 torr induced by changes in sample pressure at the analyzer inlet due to rapid changes in altitude.

Dry-air mixing ratios are reported in parts per million for CO_2 and parts per billion for CH_4 and CO on the following WMO scales: CO2-X2007, CH4-X2004A, CO-X2014A.

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.

Picarro G2401

The Picarro G2401m is a commercial instrument that measures CO_2, CH_4, CO, and H_2O. The analyzer is based on Wavelength-Scanned Cavity Ring Down Spectroscopy (WS-CRDS), a time-based measurement utilizing a near-infrared laser to measure a spectral signature of the molecule. Gas is circulated in an optical measurement cavity with an effective path length of up to 20 km. A patented, high-precision wavelength monitor makes certain that only the spectral feature of interest is being monitored, greatly reducing the analyzer’s sensitivity to interfering gas species, and enabling ultra-trace gas concentration measurements even if there are other gases present. As a result, the analyzer maintains high linearity, precision, and accuracy over changing environmental conditions with minimal calibration required. Additional information can be found in the companion file NOAA-Picarro_ATom1234_readme.pdf and the ESPO Picarro Instrument page.

6. Data Access

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

ATom: CO2, CH4, and CO Measurements from Picarro, 2016-2018

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov

- Telephone: +1 (865) 241-3952

7. References