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ATom: Observed and GEOS-5 Simulated CO Concentrations with Tagged Tracers for ATom-1

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Data Set Version: 1

Summary

This dataset contains carbon monoxide (CO) observations at 10-second intervals from flights during the ATom-1 campaign in 2016 and simulated CO concentrations from the Goddard Earth Observing System version 5 (GEOS-5) model for the corresponding locations along the ATom flight tracks. The Atmospheric Tomography Mission (ATom) is a NASA Earth Venture Suborbital-2 mission studying the impact of human-produced air pollution on greenhouse gases and on chemically reactive gases in the atmosphere. The airborne observations were collected using the Quantum Cascade Laser System (QCLS) instrument, a high-frequency laser spectroscopy instrument for in situ atmospheric gas sampling. This dataset provides a direct comparison of observational and simulated CO that will be used to inform future atmospheric modeling experiments. The dataset also contains simulated tagged-CO tracer concentrations, which represent the contribution of specific regional sources to the total simulated CO. This dataset contributes to one of the ATom mission objectives to create an observation-based chemical climatology of important atmospheric constituents and their reactivity in the remote troposphere.

This dataset includes 11 files in comma-delimited text (*.csv) format and 11 files in NetCDF (*.nc) format.

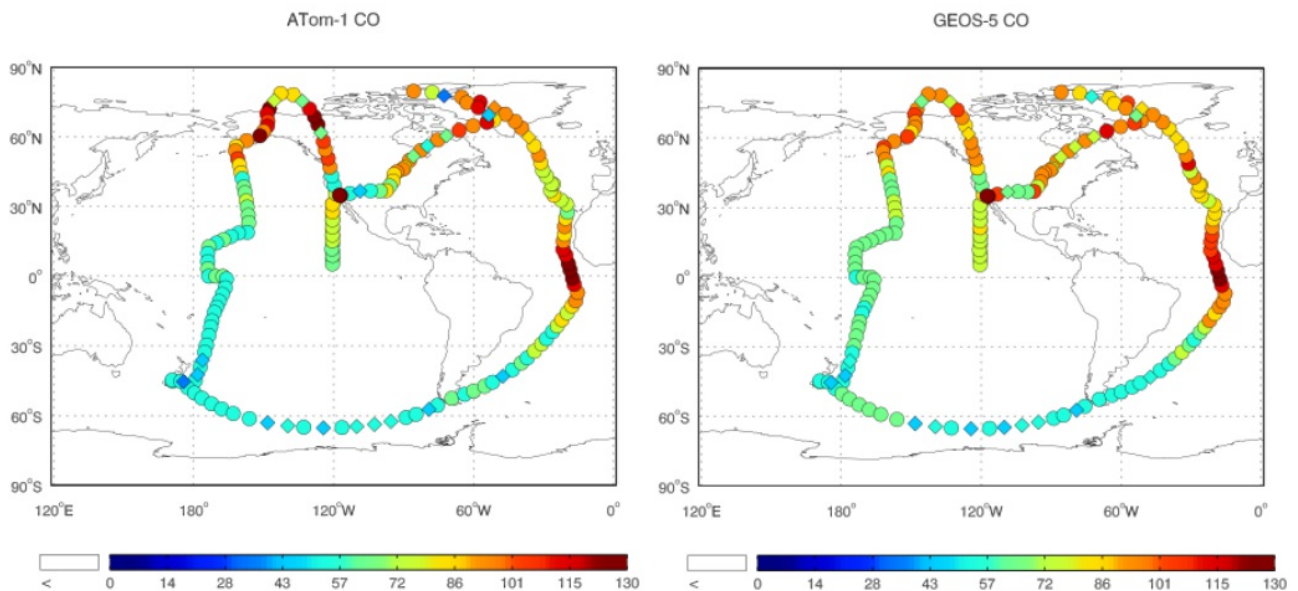


Figure 1. CO (ppb) from the QCLS observations (left) and GEOS-5 analysis (right) for the ATom-1 circuit including all 11 research flight segments. The GEOS-5 CO is taken from the analysis closest to the mid-point of the flight time and interpolated to the flight track following the longitude, latitude and pressure given in 10-second merged observations. For visualization in this figure, both model forecast and ATom measurements are averaged into a sample rate of one per 360-second. Data in the troposphere are plotted in a circle; data in the stratosphere are plotted in a diamond (from Strode et al. 2018).

Citation

Strode, S.A., J. Liu, L. Lait, R. Commane, B.C. Daube, S.C. Wofsy, A. Conaty, P. Newman, and M.J. Prather. 2018. ATom: Observed and GEOS-5 Simulated CO Concentrations with Tagged Tracers for ATom-1. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/1604>

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1. Data Set Overview

Project: [Atmospheric Tomography Mission \(ATom\)](#)

The Atmospheric Tomography Mission (ATom) is a NASA Earth Venture Suborbital-2 mission. It will study the impact of human-produced air pollution on greenhouse gases and on chemically reactive gases in the atmosphere. 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 will occur in each of 4 seasons over a 4-year period.

Related Publication:

Strode, S. A., Liu, J., Lait, L., Commane, R., Daube, B., Wofsy, S., Conaty, A., Newman, P., and Prather, M. Forecasting Carbon Monoxide on a Global Scale for the ATom-1 Aircraft Mission: Insights from Airborne and Satellite Observations and Modeling. *Atmos. Chem. Phys. Discuss.* <https://doi.org/10.5194/acp-2018-150>, in review, 2018.

Related Data Set:

Wofsy, S.C., E. Apel, D.R. Blake, C.A. Brock, W.H. Brune, T.P. Bui, B.C. Daube, J.E. Dibb, G.S. Diskin, J.W. Elkins, K. Froyd, S.R. Hall, T.F. Hanisco, L.G. Huey, J.L. Jimenez, K. McKain, S.A. Montzka, T.B. Ryerson, J.P. Schwarz, B.B. Stephens, B. Weinzierl, and P. Wennberg. 2018. ATom: Merged Atmospheric Chemistry, Trace Gases, and Aerosols. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/1581>

Acknowledgement: This work was supported by NASA (Grant Number NNH16ZDA001N-MAP).

2. Data Characteristics

Spatial Coverage: ATom-1 flights over the Atlantic and Pacific Oceans

Spatial Resolution: Point measurements along ATom1 flight paths

Temporal Coverage: 2016-07-29 - 2016-08-23

Temporal Resolution: 10-seconds

Study Area (These coordinates are the approximate locations of the study sites and may not match the extent of the data files. All latitude and longitude are given in decimal degrees.)

Site	Northern Extent	Southern Extent	Western Extent	Eastern Extent
ATom 1 flights	80.0086	-65.3316	179.983	-179.999

Data File Information

There are a total of 22 files in this dataset: one comma-delimited text file (*.csv) and one geo-trajectory NetCDF (*.nc) per flight for 11 ATom flights during July and August 2016. Each pair of files contains carbon monoxide (CO) concentrations measured by the QCLS instrument during one ATom flight as well as a simulated CO concentration from the Goddard Earth Observing System version 5 (GEOS-5) forward processing system and accompanying tracers from biomass burning and non-burning sources by region.

The files are named as follows:

GEOS_and_QCLS_CO_ATom1_<YYYYMMDD>.<ext>

where <YYYYMMDD> indicates the date of the ATom flight and the file extensions is either *.csv or *.nc

Example filename: *GEOS_and_QCLS_CO_ATom1_20160729.nc*

Data Dictionary

Missing values are coded as -99999. There are regular occurrences of missing values in the QCLS instrument measurement data due to calibration procedures as noted in Section 5.

Table 1. Names, units, and descriptions for variables included in the files. Variable names vary slightly between formats.

Variable Name (NetCDF)	Variable Name (CSV)	Units	Description
time	time	s	seconds since flight datetime UTC (YYYY-MM-DD 00:00:00)
time_bnds	*	s	time bounds for sample measurement (10-second window)
latitude	Lat	decimal degrees	latitude
longitude	Lon	decimal degrees	longitude

Variable Name (NetCDF)	Variable Name (CSV)	Units	Description
pressure		hectopascals	air pressure -- Pressure was used as the vertical coordinate instead of altitude since pressure was used to identify the vertical level of the model that corresponded to the observation point on flight track.
CO_QCLS	QCLS_CO	ppb	CO mixing ratio from the QCLS instrument in ppb. The data are reported on the NOAA/WMO CO_X2014A calibration scale using standards CB10182 and CB11484.
CO_GEOS	GEOS_CO	ppb	simulated CO mixing ratio from the GEOS forward processing system in ppb
CO_biomass_burning_africa	CO_bbAfrica	ppb	GEOS tracer for CO from African biomass burning in ppb
CO_biomass_burning_eurasia	CO_bbEuras	ppb	GEOS tracer for CO from Eurasian biomass burning in ppb
CO_biomass_burning_global	CO_bbGlobal	ppb	GEOS tracer for CO from Global biomass burning in ppb
CO_biomass_burning_na	CO_bbNAM	ppb	GEOS tracer for CO from North American biomass burning in ppb
CO_biomass_burning_sa	CO_bbSAM	ppb	GEOS tracer for CO from South American biomass burning in ppb
CO_nonburning_sources_asia	CO_nbAsia	ppb	GEOS tracer for CO from Asian non-burning sources
CO_nonburning_sources_europe	CO_nbEuro	ppb	GEOS tracer for CO from European non-burning sources
CO_nonburning_sources_global	CO_nbGlobal	ppb	GEOS tracer for CO from Global non-burning sources
CO_nonburning_sources_na	CO_nbNam	ppb	GEOS tracer for CO from North American non-burning sources

Notes:

- *time_bnds* variable is included only in the NetCDF files.
- Non-burning sources include fossil fuels, biofuels, biogenic emissions, and methane oxidation.
- The relationship between (pressure) altitude and the horizontal coordinates of the ATom data is not unique to this dataset. Data points correspond to those in the ATom 10-second merged product. See related dataset.
- GEOS tracers: CO source contributions are the calculated contribution of different CO sources to the total simulated CO using the GEOS-5 tagged CO tracers sampled along the ATom flight tracks. This analysis provides a picture of the dominant sources affecting the constituent concentrations observed during ATom-1 for different regions of the atmosphere.

3. Application and Derivation

These data were used to assess the coherence of the simulated CO concentrations from GEOS-5 to CO concentrations observed during the ATom-1 flights. Tagged tracers were also used to find that non-biomass burning sources were the dominant contributors of CO along the ATom transects except over the tropical Atlantic, where African biomass burning makes a large contribution to the CO concentration.

4. Quality Assessment

No quality assessment or estimates of uncertainty are provided with this dataset.

5. Data Acquisition, Materials, and Methods

ATom-1 Flights

ATom-1 flew transects through the Pacific, Southern, Atlantic, and Arctic Oceans with the NASA DC-8 aircraft in July and August 2016. Each of the 11 flights included sampling from the boundary layer to the top of the aircraft range (around 39,000 ft; 12,000 m).

Quantum Cascade Laser System

The Harvard Quantum Cascade Laser System (QCLS) instrument package contains two separate optical assemblies and calibration systems, DUAL and CO2, and a common data system and power supply.

The Harvard QCL DUAL instrument simultaneously measures CO, CH₄, and N₂O concentrations in situ using two thermoelectrically cooled pulsed-quantum cascade lasers (QCL) light sources, a multiple pass absorption cell, and two liquid nitrogen-cooled solid state detectors. The sample gas is dried and measured for trace gas concentrations by measuring absorption from their infrared transition lines at 4.59 microns for CO and 7.87 microns for CH₄ and N₂O. In-flight calibrations are performed by replacing the air sample with reference gas every 10 minutes, with a low-span and a high-span gas every 20 minutes. The Harvard QCL CO₂ instrument measures CO₂ concentrations in situ using a similar apparatus.

This dataset includes CO measurements from the Harvard QCL DUAL instrument.

GEOS-5 Forward Processing System

Simulated CO concentrations were generated by the GEOS-5 Forward Processing (FP) system. The FP stream from the Global Modeling and Assimilation Office (GMAO) generates GEOS-5 forecast products as well as assimilation products using the most current system approved for near-real-time production. The GEOS-5 model (Molod et al. 2015) is a global general circulation model with 72 vertical levels reaching from the surface to 1 Pa.

The GEOS-5 FP system (Lucchesi, 2017) simulates the transport of CO as well as tagged CO tracers from specific regions and sources, which helps track the transport of pollution outflow. Tagged tracers are available for biomass burning (BB) globally as well as biomass burning from Eurasia, North America, Africa, and Central and South America; and for non-BB sources globally and from Europe, Asia, and North America. Non-BB sources include fossil fuels, biofuels, CO from oxidation of biogenic VOCs, and CO from methane oxidation, as described in Ott et al. (2010).

The GEOS-5 model is engaged during the ATom mission to provide chemical forecasts for each flight that include the major chemical species and, for CO, tagged tracers for different sources. The chemical forecasts are used together with meteorological forecast for day-to-day flight planning. This dataset was produced through an assessment of the performance of the GEO-5 forecasts by comparing the simulated CO to the QCLS observations. See Strode et al. (2018) for a full explanation of data sources and methods.

6. Data Access

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

[ATom: Observed and GEOS-5 Simulated CO Concentrations with Tagged Tracers for ATom-1](#)

Contact for Data Center Access Information:

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

7. References

Lucchesi, R, File Specification for GEOS-5 FP. GMAO Office Note No. 4 (Version 1.1), 61pp, 2017, available from http://gmao.gsfc.nasa.gov/pubs/office_notes.

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Ott, L., Duncan, B., Pawson, S., Colarco, P., Chin, M., Randles, C., Diehl, T., and Nielsen, E. 2010. Influence of the 2006 Indonesian biomass burning aerosols on tropical dynamics studied with the GEOS-5 AGCM, *Journal of Geophysical Research-Atmospheres*, 115, <https://dx.doi.org/10.1029/2009jd013181>.

Strode, S. A., Liu, J., Lait, L., Commane, R., Daube, B., Wofsy, S., Conaty, A., Newman, P., and Prather, M.: Forecasting Carbon Monoxide on a Global Scale for the ATom-1 Aircraft Mission: Insights from Airborne and Satellite Observations and Modeling. *Atmos. Chem. Phys. Discuss.* <https://doi.org/10.5194/acp-2018-150>, in review, 2018.



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