ATom: Global Modeling Initiative (GMI) Chemical Transport Model (CTM) Output

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Documentation Revision Date: 2022-01-03

Dataset Version: 1

Summary

This dataset contains Global Modeling Initiative (GMI) Chemical Transport Model (CTM) outputs from the four Atom campaigns. GMI simulations of the ATom flight periods have a horizontal resolution of 1.0 x 1.25 degrees, with output every 15 minutes. The ICARTT files are generated by spatially and temporally interpolating the output to the ATom flight track. Vertical interpolation is linear in log-pressure. The netCDF files provide three-dimensional (3D) GMI simulation output for the region surrounding the flight track every 15 minutes at the original model resolution. GMI is a 3-D CTM that includes full chemistry for both the troposphere and stratosphere. GMI simulates the concentrations of many of the species measured during ATom.

There are 48 data files in ICARTT (*.ict) format and 48 data files in netCDF format (*.nc) included in this dataset.

Figure 1. NASA's DC-8 flying laboratory. All four ATom campaigns were conducted with DC-8.

Citation

Strode, S.A., S.D. Steenrod, J.M. Nicely, J. Liu, M.R. Damon, and S.E. Strahan. 2021. ATom: Global Modeling Initiative (GMI) Chemical Transport Model (CTM) Output. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1897

Table of Contents

1. Dataset Overview

This dataset contains Global Modeling Initiative (GMI) Chemical Transport Model (CTM) outputs from the four Atom campaigns. GMI simulations of the ATom flight periods have a horizontal resolution of 1.0 x 1.25 degrees, with output every 15 minutes. The ICARTT files are generated by spatially and temporally interpolating the output to the ATom flight track. Vertical interpolation is linear in log-pressure. The netCDF files provide three-dimensional (3D) GMI simulation output for the region surrounding the flight track every 15 minutes at the original model resolution. GMI investigations support the development and integration of a state-of-the-art modular 3D CTM that includes full chemistry for both the troposphere and stratosphere. The GMI model is involved in the assessment of the impacts of atmospheric composition change due to anthropogenic emissions of gases and aerosols, such as those from aircraft, biomass burning, fossil fuel combustion, and production of ozone-depleting substances. GMI studies investigate changes in stratospheric ozone and the roles of long-range transport and changing emissions on air quality.

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 Publications

Hall, S.R., K. Ullmann, M.J. Prather, C.M. Flynn, L.T. Murray, A.M. Fiore, G. Correa, S.A. Strode, S.D. Steenrod, J.-F. Lamarque, J. Guth, B. Josse, J. Flemming, V. Huijnen, N.L. Abraham, and A.T. Archibald. 2018. Cloud impacts on photochemistry: building a climatology of photolysis rates from the Atmospheric Tomography mission. Atmospheric Chemistry and Physics 18:16809–16828. https://doi.org/10.5194/acp-18-16809-2018

Prather, M.J., C.M. Flynn, X. Zhu, S.D. Steenrod, S.A. Strode, A.M. Fiore, G. Correa, L.T. Murray, and J.-F. Lamarque. 2018. How well can global chemistry models calculate the reactivity of short-lived greenhouse gases in the remote troposphere, knowing the chemical composition. Atmospheric Measurement Techniques 11:2653–2668. https://doi.org/10.5194/amt-11-2653-2018

Prather, M.J., X. Zhu, C.M. Flynn, S.A. Strode, J.M. Rodriguez, S.D. Steenrod, J. Liu, J.-F. Lamarque, A.M. Fiore, L.W. Horowitz, J. Mao, L.T. Murray, D.T. Shindell, and S.C. Wofsy. 2017. Global atmospheric chemistry – which air matters. Atmospheric Chemistry and Physics 17:9081–9102. https://doi.org/10.5194/acp-17-9081-2017

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 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: 10 seconds

Data File Information

There are 48 data files in ICARTT (*.ict) format and 48 data files in netCDF format (*.nc) included in this dataset that contain GMI model outputs along the flight track. Data files conform to the ICARTT File Format Standards V1.1. The files are named GMI _DC8_YYYYMMDD_R#.ext, where YYYYMMDD is the start date (in UTC time) of the flight, R# is the file version or revision number, and ext is the file extension.

Data File Details

Missing data are represented by -99999.

Table 1. Variables and descriptions for files named GMI _DC8_YYYYMMDD_R#.ict.

Name	Units	Description
UTC_Start	Seconds	Start time of observation in seconds from 0000 UTC
UTC_Stop	Seconds	Stop time of observation in seconds from 0000 UTC
Lat	Decimal degrees	Latitude
Lon	Decimal degrees	Longitude
StaticPressure_GMI	hPa,	Pressure
TroposphereIndicator_GMI	0 or 1	Presence (1) or absence (0) of current location being inside troposphere
StaticTemperature_GMI	Kelvin	Temperature
CH2O_GMI	Parts per billion by volume	Formaldehyde abundance
CH4_GMI	Parts per billion by volume	Methane abundance
CO_GMI	Parts per billion by volume	Carbon monoxide abundance
H2_GMI	Parts per billion by volume	Hydrogen abundance
CHOOH_GMI	Parts per billion by volume	Methyl hydroperoxide abundance
HNO3_GMI	Parts per billion by volume	Nitric acid abundance
HNO4_GMI	Parts per billion by volume	Pernitric acid abundance
H2O_GMI	Parts per billion by volume	Water abundance
HO2_GMI	Parts per billion by volume	Perhydroxyl radical abundance
H2O2_GMI	Parts per billion by volume	Hydrogen peroxide abundance

CH3OH_GMI	Parts per billion by volume	Methanol abundance
CH3OOH_GMI	Parts per billion by volume	Methyl hydroperoxide abundance
N2O_GMI	Parts per billion by volume	Nitrous oxide abundance
NO_GMI	Parts per billion by volume	Nitric oxide abundance
NO2_GMI	Parts per billion by volume	Nitrogen dioxide abundance
N2O5_GMI	Parts per billion by volume	Dinitrogen Pentoxide abundance
O3_GMI	Parts per billion by volume	Ozone abundance
OH_GMI	Parts per billion by volume	Hydroxyl radical abundance
CH3Br_GMI	Parts per billion by volume	Methyl bromide abundance
CH3Cl_GMI	Parts per billion by volume	Methyl chloride abundance
CFC11_GMI	Parts per billion by volume	CFC11 abundance
CFC12_GMI	Parts per billion by volume	Freon 12 abundance
CFC113_GMI	Parts per billion by volume	CFC113 (C2Cl3F3) abundance
CFC114_GMI	Parts per billion by volume	CFC114 (C2Cl2F4) abundance
CFC115_GMI	Parts per billion by volume	CFC115 (C2ClF5) abundance
HCFC22_GMI	Parts per billion by volume	HCFC22 (CClF2H) abundance
HCFC141b_GMI	Parts per billion by volume	HCFC141b (C2Cl2FH3) abundance
HCFC142b_GMI	Parts per billion by volume	HCFC142b (C2ClF2H3) abundance
H1202_GMI	Parts per billion by volume	Halon 1202 abundance
H1211_GMI	Parts per billion by volume	Halon 1211 abundance
H1301_GMI	Parts per billion by volume	Halon 1301 abundance
H2402_GMI	Parts per billion by volume	Halon 2402
CH3CHO_GMI	Parts per billion by volume	Acetaldehyde abundance
C4-C5Alkanes_GMI	Parts per billion by volume	C4-C5Alkanes abundance
Ethane_GMI	Parts per billion by volume	Ethane abundance
Propane_GMI	Parts per billion by volume	Propane abundance
Ethanol_GMI	Parts per billion by volume	Ethanol abundance
C2H5OOH_GMI	Parts per billion by volume	Ethylhydroperoxide abundance
Isoprene_GMI	Parts per billion by volume	Isoprene abundance
MAC_GMI	Parts per billion by volume	Methacrolein (C4H6O) abundance
CH3CO3_GMI	Parts per billion by volume	Peroxyacetyl radical (C2H3O3) abundance
MEK_GMI	Parts per billion by volume	Methyl ethyl ketone (C4H8O) abundance
MVK_GMI	Parts per billion by volume	Methyl vinyl ketone (C4H6O) abundance
PAN_GMI	Parts per billion by volume	Peroxyacetyl nitrate (C2H3NO5) abundance
MPAN_GMI	Parts per billion by volume	Peroxymethacryloyl nitrate (C4H5O5N) abundance
PPN_GMI	Parts per billion by volume	Peroxypropionyl nitrate (C3H5O5N) abundance
Propene_GMI	Parts per billion by volume	Propene abundance
C4andC5Alkylnitrates_GMI	Parts per billion by volume	C4 and C5 Alkynitrates abundance
C3toCnAldehydes_GMI	Parts per billion by volume	>C2 aldehydes (C3H6O) abundance
Acetone_GMI	Parts per billion by volume	Acetone abundance

Table 2. Variables and descriptions for files named GMI _DC8_YYYYMMDD_R#.nc.

Name	Units	Description
Acetone_GMI	Volume mixing ratio	Acetone abundance
ai_GMI	Unitless	Hybrid pressure edge term
AirMass_GMI	Kg	Mass
am_GMI	Unitless	Hybrid pressure term
bi_GMI	Unitless	Hybrid sigma edge term
bm_GMI	Unitless	Hybrid sigma term
C2H5OOH_GMI	Volume mixing ratio	Ethylhydroperoxide abundance
C3toCnAldehydes_GMI	Volume mixing ratio	>C2 aldehydes (C3H6O) abundance

C4andC5Alkylnitrates_GMI	Volume mixing ratio	C4 and C5 Alkynitrates abundance
C4-C5Alkanes_GMI	Volume mixing ratio	C4-C5Alkanes abundance
CFC11_GMI	Volume mixing ratio	CFC11 abundance
CFC113_GMI	Volume mixing ratio	CFC113 (C2Cl3F3) abundance
CFC114_GMI	Volume mixing ratio	CFC114 (C2Cl2F4) abundance
CFC115_GMI	Volume mixing ratio	CFC115 (C2ClF5) abundance
CFC12_GMI	Volume mixing ratio	Freon 12 abundance
CH2O_GMI	Volume mixing ratio	Formaldehyde abundance
CH3Br_GMI	Volume mixing ratio	Methyl bromide abundance
CH3CHO_GMI	Volume mixing ratio	Acetaldehyde abundance
CH3Cl_GMI	Volume mixing ratio	Methyl chloride abundance
CH3CO3_GMI	Volume mixing ratio	Peroxyacetyl radical (C2H3O3) abundance
CH3OH_GMI	Volume mixing ratio	Methanol abundance
CH3OOH_GMI	Volume mixing ratio	Methyl hydroperoxide abundance
CH4_GMI	Volume mixing ratio	Methane abundance
CHOOH_GMI	Volume mixing ratio	Methyl hydroperoxide abundance
CO_GMI	Volume mixing ratio	Carbon monoxide abundance
Ethane_GMI	Volume mixing ratio	Ethane abundance
Ethanol_GMI	Volume mixing ratio	Ethanol abundance
GridBoxArea_GMI	Meters^2	Grid box area
GridBoxHeight_GMI	Meters	Grid box height
H1202_GMI	Volume mixing ratio	Halon 1202 abundance
H1211_GMI	Volume mixing ratio	Halon 1211 abundance
H1301_GMI	Volume mixing ratio	Halon 1301 abundance
H2_GMI	Volume mixing ratio	Hydrogen abundance
H2402_GMI	Volume mixing ratio	Halon 2402
H2O_GMI	Volume mixing ratio	Water abundance
H2O2_GMI	Volume mixing ratio	Hydrogen peroxide abundance
HCFC141b_GMI	Volume mixing ratio	HCFC141b (C2Cl2FH3) abundance
HCFC142b_GMI	Volume mixing ratio	HCFC142b (C2ClF2H3) abundance
HCFC22_GMI	Volume mixing ratio	HCFC22 (CClF2H) abundance
HNO3_GMI	Volume mixing ratio	Nitric acid abundance
HNO4_GMI	Volume mixing ratio	Pernitric acid abundance
HO2_GMI	Volume mixing ratio	Perhydroxyl radical abundance
Isoprene_GMI	Volume mixing ratio	Isoprene abundance
latitude	Decimal degrees	Latitude
longitude	Decimal degrees	Longitude
MAC_GMI	Volume mixing ratio	Methacrolein (C4H6O) abundance
MEK_GMI	Volume mixing ratio	Methyl ethyl ketone (C4H8O) abundance
model_levels	Numeric	Model level number
MPAN_GMI	Volume mixing ratio	Peroxymethacryloyl nitrate (C4H5O5N) abundance
MVK_GMI	Volume mixing ratio	Methyl vinyl ketone (C4H6O) abundance
N2O_GMI	Volume mixing ratio	Nitrous oxide abundance
N2O5_GMI	Volume mixing ratio	Dinitrogen Pentoxide abundance
NO_GMI	Volume mixing ratio	Nitric oxide abundance
NO2_GMI	Volume mixing ratio	Nitrogen dioxide abundance
O3_GMI	Volume mixing ratio	Ozone abundance
OH_GMI	Volume mixing ratio	Hydroxyl radical abundance
PAN_GMI	Volume mixing ratio	Peroxyacetyl nitrate (C2H3NO5) abundance
PPN_GMI	Volume mixing ratio	Peroxypropionyl nitrate (C3H5O5N) abundance

PressureTop_GMI	hPa	Pressure top
Propane_GMI	Volume mixing ratio	Propane abundance
Propene_GMI	Volume mixing ratio	Propene abundance
StaticPressure_GMI	hPa	Pressure
StaticTemperature_GMI	Kelvin	Temperature
SurfacePressure_GMI	mb	Surface Pressure
time	Seconds	Seconds since 0000 UTC
TropopausePressure	mb	Tropopause Pressure
TroposphereIndicator_GMI	0 or 1	Presence (1) or absence (0) of current location being inside troposphere

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

Uncertainty information is not provided.

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.

Global Modeling Initiative Chemical Transport Model

The Global Modeling Initiative (GMI) Chemical Transport Model (CTM) is part of the NASA Modeling Analysis and Prediction (MAP) program. The GMI CTM is used to assess the impacts of atmospheric circulation and composition change due to anthropogenic emissions, such as those from aircraft, biomass burning, fossil fuel combustion, and use of ozone-depleting substances (ODS). GMI studies investigate changes in stratospheric ozone and the roles of long-range transport and changing emissions on air quality.

GMI CTM simulations use a combined stratospheric-tropospheric chemical mechanism that has been adopted by the GEOS models. Updates to the GMI mechanism are first evaluated in the GMI CTM prior to adoption by GEOS. The GMI mechanism simulates the chemical interactions of NOx, HOx, VOCs, aerosols, and ozone. It includes 149 chemical species and approximately 400 reactions.

Additional information on the history, applications and publications related to GMI can be found on NASA’s GMI page.

6. Data Access

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

ATom: Global Modeling Initiative (GMI) Chemical Transport Model (CTM) Output

Contact for Data Center Access Information:

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

7. References

Hall, S.R., K. Ullmann, M.J. Prather, C.M. Flynn, L.T. Murray, A.M. Fiore, G. Correa, S.A. Strode, S.D. Steenrod, J.-F. Lamarque, J. Guth, B. Josse, J. Flemming, V. Huijnen, N.L. Abraham, and A.T. Archibald. 2018. Cloud impacts on photochemistry: building a climatology of photolysis rates from the Atmospheric Tomography mission. Atmospheric Chemistry and Physics 18:16809–16828. https://doi.org/10.5194/acp-18-16809-2018

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