Global Modeling and Assimilation Office

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File Specification for GEOS Products Sampled Along Aircraft Trajectories

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Global Modeling and Assimilation Office
Earth Sciences Division
NASA Goddard Space Flight Center
Greenbelt, Maryland 20771

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File Specification for GEOS Products Sampled Along Aircraft Trajectories

Document maintained by Allison Collow (GMAO, USRA)

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Approved by:

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Steven Pawson Date

Head, Global Modeling and Assimilation Office
Code 610.1, NASA GSFC

REVISION HISTORY

Version	Revision Date	Extent of Changes
1.0	06/11/2020	Baseline

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1. Introduction

This document describes the Goddard Earth Observing System (GEOS) trajectory sampled data products that are intended to be complementary to the data collected during NASA airborne field campaigns. Fields included in these data products originate from global analyses using the GEOS Atmospheric Data Assimilation System (ADAS). GEOS data analyses are constrained through the assimilation of roughly 2 x 10^6 observation for each analysis time step. Additional details about the GEOS ADAS and the underlying numerical model can be found in Rienecker et al. (2008) and Molod et al. (2011), while details on the forward processing version of GEOS can be found in Lucchesi (2018). However, the data assimilation and model physics used to produce the GEOS analysis that is sampled along a flight trajectory can vary and therefore the model version is noted in the source attribute of each GEOS trajectory sampled data file.

The GEOS trajectory sampler uses the navigational data collected during aircraft flights to sample global GEOS products for the matching data point in time and space. This means the trajectory sampled files are 1-dimensional in time for 2-dimensional GEOS fields, and 2-dimensional in time and height for 3-dimensional GEOS fields. It is important to note the temporal and spatial resolutions of the GEOS global analyses used as input differ from the trajectory sampled data. While the trajectory sampled data is available at a temporal resolution of 60 seconds and the location matches latitude and longitude of the aircraft at the given time, this data is sampled from a global analysis with a spatial resolution of 0.3125-degree longitude by 0.25-degree latitude and a temporal resolution of one hour for 2-dimensional fields and three hours for 3-dimensional fields.

Data files described in this document can be found on the NASA Center for Climate Simulation (NCCS) data portal at https://portal.nccs.nasa.gov/datashare/iesa/campaigns/. Additional details about variables listed in this file specification can be found in a separate document, the GEOS File Specification Variable Definition Glossary.

2. Format and File Organization

GEOS files are generated with the Network Common Data Form (NetCDF-4) library, which uses Hierarchical Data Format Version 5 (HDF-5) as the underlying format. NetCDF-4 is an open-source product of UCAR/Unidata (https://www.unidata.ucar.edu/software/netcdf/) and HDF-5 is developed by the HDF Group (http://www.hdfgroup.org/). One convenient method of reading GEOS files is to use the netCDF library, but the HDF-5 library can also be used directly.

Each GEOS file contains a collection of geophysical quantities that we will refer to as “fields” or “variables” as well as a set of coordinate variables that contain information about the grid coordinates. While the coordinate variables are COARDS and CF compliant, the metadata associated with the data variables may not strictly meet all CF requirements.

2.1 Dimensions and Navigational Data

GEOS trajectory sampled NetCDF-4 files contain dimension variables that can be identified and interpreted by the *units* and *positive* metadata attributes, as defined in the CF metadata conventions. The *units* attribute uses standard terminology to define specific coordinate variables, e.g., time, while the *positive* attribute defines whether a vertical coordinate increases or decreases from the surface to the top of the atmosphere. 2D products are defined on model layers rather than pressure coordinates and the units attribute is set to **layer.** This is allowed under the CF conventions to be backward compatible with the older COARDS conventions.

Variables are written to the time dimension, sampled along the latitude and longitude trajectories of the aircraft flights completed during NASA field campaigns. Note that the length of the time dimension in each file will vary, dependent of the length of a flight. A fake latitude and longitude are included within the files to allow for compatibility with GrADS.

Table 2.1-1. Dimension and Navigation Variables Contained in GEOS Trajectory Sampled NetCDF-4 Files

Name	**Description**	**Type**	***units* attribute**	***positive* attribute (3D only)**
time	seconds since reference date & time	int	Seconds	n/a
isotime	Time in ISO Format	char	n/a	n/a
lev (3D only)	Vertical Level	float	layer	Down
x	Fake Longitude for GrADS Compatibility	float	n/a	n/a
y	Fake Longitude for GrADS Compatibility	float	n/a	n/a
trjLon	Longitude	float	degrees_east	n/a
trjLat	Latitude	float	degrees_north	n/a

2.2 Variables

NetCDF-4 files are written using the NetCDF classic model. Arrays of scientific data are stored as variables of type **float** that contain various attributes such as *units*, *long_name*, *standard_name*, *missing_value*, and others. Please note that we do not guarantee that the value in the *standard_name* attribute will conform to the CF metadata conventions. You can quickly list the variables as well as the complete structure of the file by using common utilities such as *ncdump* or *h5dump*. The utilities are distributed with the NetCDF and HDF distributions.

Table 2.2-1 Metadata attributes associated with each variable.

Name	**Type**	**Description**
_FillValue	float	Floating-point value used to identify missing data. Will normally be set to 1e15. Required by CF.
missing_value	float	Same as _FillValue. Included for backward compatibility.
valid_range	float32, array(2)	This attribute defines the valid range of the variable. The first element is the smallest valid value and the second element is the largest valid value. Required by CF, but this attribute is not
long_name	String	An ad hoc description of the variable as required by COARDS. It approximates the standard names as defined in an early version of CF conventions. (See References). The *Description* column from the tables of Section 6 is based on this name.
standard_name	String	Same as long_name.
Units	String	The units of the variable. Must be a string that can be recognized by UNIDATA's Udunits package.
scale_factor	float32	If variable is packed as 16-bit integers, this is the scale_factor for expanding to floating-point. Currently we do not plan to pack data, thus value will be 1.0

Name	Type	Description
add_offset	float32	If variable is packed as 16-bit integers, this is the offset for expanding to floating-point. Currently, we do not plan to pack data, thus value will be 0.0.

2.3 Global Attributes

In addition to scientific variables and dimension scales, global metadata is also stored in GMAO NetCDF-4 files. These metadata attributes are largely defined by the CF/COARDS conventions.

Table 2.3-1 Global metadata attributes associated with each variable.

Name	Type	Description
Conventions	character	Identification of the file convention used, currently "CF"
Title	character	"GEOS-5 Trajectory Sampler"
History	character	Processing history.
Institution	character	"NASA Global Modeling and Assimilation Office"
Source	character	Version of GEOS used to produce the global analysis
References	character	"n/a"
trjFile	character	Input file for the trajectory sampler containing navigational data for the sampled flight.

3. Vertical Structure

Gridded products use three different vertical configurations: horizontal-only (can be vertical averages, single level, or surface values), model-level, or model-edge. Horizontal-only data for a given variable appear as 1-dimensional fields (time), while model-level or model-edge data appear as 2-dimensional fields (z, time). The model layers used for GEOS products are on a terrain-following hybrid sigma-p coordinate. Model-level data is output on the **LM=72** layers shown in table of Appendix B. The model-edge products contain fields with **LMe = LM + 1** levels representing the layer edges. The pressure at the model top is a fixed constant, **PTOP=0.01 hPa**. Pressures at model edges should be computed by summing the DELP starting at PTOP. A representative pressure for the layer can then be obtained from these. The vertical column pressure variables are explicitly provided through ($DELP_{\mathbf{ijl}}$) and PTOP, even though the model-level fields are on a hybrid sigma-p.

Note that the indexing for the GEOS vertical coordinate system is top to bottom, i.e., layer 1 is the top layer of the atmosphere, while layer LM is adjacent to the earth's surface. The same is true for edge variables, with level 1 being the top of the model's atmosphere (PTOP), and level LM+1 being the surface.

4. File Naming Conventions

Each GEOS trajectory sampled product file will have a complete file name in the format described below.

4.1 File Names

The standard generic complete name for the assimilated GEOS FP products will appear as follows:

fieldcampaign-GEOS-*collection-aircraft*_Model_*date*_R*fileversion*.nc

A brief description of the node fields appears below:

fieldcampaign:
Identifies which field campaign the model was sampled for.

GEOS:
Identifies output as a data assimilation system product produced by GEOS.

collection:
All GEOS data are organized into file *collections* that contain fields with common characteristics. These collections are used to make the data more accessible for specific purposes. Fields may appear in more than one collection. Collection names are of the form *group_HV*, where the two attributes are:

group: A three-letter mnemonic for the type of fields in the collection. It is a lowercase version of the group designation used in the ESDT name, as listed in the next section.

HV: Horizontal and Vertical grid.

H can be:

N: Nominal horizontal resolution on lat/lon grid. See config above.

V can be:

x: horizontal-only data (surface, single level, etc.); *dims* must be **2D**
p: pressure-level data (see Appendix B for levels); *dims* must be **3D**
v: model layer centers (see Appendix B); *dims* must be **3D**
e: model layer edges (see Appendix B); *dims* must be **3D**

timestamp:
This node defines the date associated with the data in the file. It has the form *yyyymmdd*.

yyyy - year string (e.g. , "2019")
mm - month string (e.g.., "09" for September)
dd - day of the month string

fileversion:
This denotes the file version in the form R#. The source attribute within each file will contain the model version used to produce that particular version of the sampled file.

nc:
All files are in NetCDF format, thus the suffix ".nc".

EXAMPLE
CAMP2Ex-GEOS-slv-Nx-P3B_Model_20191005_R0.nc

- CAMP2Ex: The Cloud, Aerosol and Monsoon Processes Philippines Experiment
- slv-Nx: single-level parameters on the native resolution grid.
- P3B: P3 Aircraft
- 20191005: valid date is 05 October 2019.
- R0: first version of the data file

5. Summary of GEOS trajectory sampled file collections

The GEOS trajectory sampled product is organized into the collections listed below. These are described in detail in the next sections. All data is at a temporal resolution of one minute, with data corresponding to the latitude and longitude of the aircraft at that time. All 2d collections are on the model's native, hybrid sigma-p vertical grid, or on the model layer edges. See Appendix A for the nominal edge pressures at the top of each layer for a surface pressure of 1000 hPa.

Table 5-1 - List of file collections.

Name	Description
asm_Nx	Miscellaneous 1D assimilated fields from IAU corrector
slv_Nx	Single-level atmospheric state variables
flx_Nx	Surface fluxes and related quantities
rad_Nx	Surface and TOA radiative fluxes
lnd_Nx	Land related surface quantities
lfo_Nx	1D land surface forcings
ocn_Nx	Ocean related surface quantities
aer_Nx	1D aerosol diagnostics
adg_Nx	1D aerosol diagnostics (extended)
chm_Nx	1D chemistry diagnostics
asm_Nv	Basic assimilated fields from IAU corrector
aer_Nv	2D aerosol diagnostics
chm_Nv	2D chemistry diagnostics
cld_Nv	Upper-air cloud related diagnostics
ext355_Nv	2d aerosol extinction at 355 nm
ext532_Nv	2d aerosol extinction at 532 nm
ext1064_Nv	2d aerosol extinction at 1064 nm
mst_Nv	Upper-air diagnostics from moist processes
rad_Nv	Upper-air diagnostics from radiation
tdt_Nv	Upper-air temperature tendencies by process
qdt_Nv	Upper-air humidity tendencies by process
udt_Nv	Upper-air wind tendencies by process
nav_Nv	2D navigation files
mst_Ne	Upper-air diagnostics from moist processes at layer edges
trb_Ne	Upper-air diagnostics from turbulence at layer edges
nav_Ne	2D navigation files (layer edges)

1D State Variables and Diagnostics

adg_Nx: 1d extended aerosol diagnostics

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight*

Name	***Dim***	***Description***	***Units***
BCDP001	t	Black Carbon Dry Deposition Bin 001	kg m^{-2} s^{-1}
BCDP002	t	Black Carbon Dry Deposition Bin 002	kg m^{-2} s^{-1}
BCEM001	t	Black Carbon Emission Bin 001	kg m^{-2} s^{-1}
BCEM002	t	Black Carbon Emission Bin 002	kg m^{-2} s^{-1}
BCEMAN	t	Black Carbon Anthropogenic Emissions	kg m^{-2} s^{-1}
BCEMBB	t	Black Carbon Biomass Burning Emissions	kg m^{-2} s^{-1}
BCEMBF	t	Black Carbon Biofuel Emissions	kg m^{-2} s^{-1}
BCHYPHIL	t	Black Carbon Hydrophobic to Hydrophilic	kg m^{-2} s^{-1}
BCSV	t	black carbon tendency due to conv scav	kg m^{-2} s^{-1}
BCWT001	t	Black Carbon Wet Deposition Bin 001	kg m^{-2} s^{-1}
BCWT002	t	Black Carbon Wet Deposition Bin 002	kg m^{-2} s^{-1}
DUAERIDX	t	Dust TOMS UV Aerosol Index	1
DUDP001	t	Dust Dry Deposition Bin 001	kg m^{-2} s^{-1}
DUDP002	t	Dust Dry Deposition Bin 002	kg m^{-2} s^{-1}
DUDP003	t	Dust Dry Deposition Bin 003	kg m^{-2} s^{-1}
DUDP004	t	Dust Dry Deposition Bin 004	kg m^{-2} s^{-1}
DUDP005	t	Dust Dry Deposition Bin 005	kg m^{-2} s^{-1}
DUEM001	t	Dust Emission Bin 001	kg m^{-2} s^{-1}
DUEM002	t	Dust Emission Bin 002	kg m^{-2} s^{-1}
DUEM003	t	Dust Emission Bin 003	kg m^{-2} s^{-1}
DUEM004	t	Dust Emission Bin 004	kg m^{-2} s^{-1}
DUEM005	t	Dust Emission Bin 005	kg m^{-2} s^{-1}
DUEXTTFM	t	Dust Extinction AOT [550 nm] - PM 1.0 um	1
DUSCATFM	t	Dust Scattering AOT [550 nm] - PM 1.0 um	1
DUSD001	t	Dust Sedimentation Bin 001	kg m^{-2} s^{-1}
DUSD002	t	Dust Sedimentation Bin 002	kg m^{-2} s^{-1}
DUSD003	t	Dust Sedimentation Bin 003	kg m^{-2} s^{-1}
DUSD004	t	Dust Sedimentation Bin 004	kg m^{-2} s^{-1}
DUSD005	t	Dust Sedimentation Bin 005	kg m^{-2} s^{-1}
DUSV	t	dust tendency due to conv scav	kg m^{-2} s^{-1}
DUWT001	t	Dust Wet Deposition Bin 001	kg m^{-2} s^{-1}
DUWT002	t	Dust Wet Deposition Bin 002	kg m^{-2} s^{-1}
DUWT003	t	Dust Wet Deposition Bin 003	kg m^{-2} s^{-1}
DUWT004	t	Dust Wet Deposition Bin 004	kg m^{-2} s^{-1}
DUWT005	t	Dust Wet Deposition Bin 005	kg m^{-2} s^{-1}
NH3DP	t	Ammonia Dry Deposition	kg m^{-2} s^{-1}
NH3EM	t	Ammonia Emission	kg m^{-2} s^{-1}

NH3SV	t	Ammonia Convective Scavenging	kg m^{-2} s^{-1}
NH3WT	t	Ammonia Wet Deposition	kg m^{-2} s^{-1}
NH4DP	t	Ammonium Dry Deposition	kg m^{-2} s^{-1}
NH4SD	t	Ammonium Settling	kg m^{-2} s^{-1}
NH4SV	t	Ammonium Convective Scavenging	kg m^{-2} s^{-1}
NH4WT	t	Ammonium Wet Deposition	kg m^{-2} s^{-1}
NIDP001	t	Nitrate Dry Deposition Bin 001	kg m^{-2} s^{-1}
NIDP002	t	Nitrate Dry Deposition Bin 002	kg m^{-2} s^{-1}
NIDP003	t	Nitrate Dry Deposition Bin 003	kg m^{-2} s^{-1}
NIHT001	t	Nitrate Production from Het Chem Bin 001	kg m^{-2} s^{-1}
NIHT002	t	Nitrate Production from Het Chem Bin 002	kg m^{-2} s^{-1}
NIHT003	t	Nitrate Production from Het Chem Bin 003	kg m^{-2} s^{-1}
NIPNH3AQ	t	Ammonia Change from Aqueous Chemistry	kg m^{-2} s^{-1}
NIPNH4AQ	t	Ammonium Production from Aqueous Chemistry	kg m^{-2} s^{-1}
NIPNO3AQ	t	Nitrate Production from Aqueous Chemistry	kg m^{-2} s^{-1}
NISD001	t	Nitrate Sedimentation Bin 001	kg m^{-2} s^{-1}
NISD002	t	Nitrate Sedimentation Bin 002	kg m^{-2} s^{-1}
NISD003	t	Nitrate Sedimentation Bin 003	kg m^{-2} s^{-1}
NISV001	t	Nitrate Convective Scavenging Bin 001	kg m^{-2} s^{-1}
NISV002	t	Nitrate Convective Scavenging Bin 002	kg m^{-2} s^{-1}
NISV003	t	Nitrate Convective Scavenging Bin 003	kg m^{-2} s^{-1}
NIWT001	t	Nitrate Wet Deposition Bin 001	kg m^{-2} s^{-1}
NIWT002	t	Nitrate Wet Deposition Bin 002	kg m^{-2} s^{-1}
NIWT003	t	Nitrate Wet Deposition Bin 003	kg m^{-2} s^{-1}
OCDP001	t	Organic Carbon Dry Deposition Bin 001	kg m^{-2} s^{-1}
OCDP002	t	Organic Carbon Dry Deposition Bin 002	kg m^{-2} s^{-1}
OCEM001	t	Organic Carbon Emission Bin 001	kg m^{-2} s^{-1}
OCEM002	t	Organic Carbon Emission Bin 002	kg m^{-2} s^{-1}
OCEMAN	t	Organic Carbon Anthropogenic Emissions	kg m^{-2} s^{-1}
OCEMBB	t	Organic Carbon Biomass Burning Emissions	kg m^{-2} s^{-1}
OCEMBF	t	Organic Carbon Biofuel Emissions	kg m^{-2} s^{-1}
OCEMBG	t	Organic Carbon Biogenic Emissions	kg m^{-2} s^{-1}
OCHYPHIL	t	Organic Carbon Hydrophobic to Hydrophilic	kg m^{-2} s^{-1}
OCSV	t	organic carbon tendency due to conv scav	kg m^{-2} s^{-1}
OCWT001	t	Organic Carbon Wet Deposition Bin 001	kg m^{-2} s^{-1}
OCWT002	t	Organic Carbon Wet Deposition Bin 002	kg m^{-2} s^{-1}
SO2EMAN	t	SO2 Anthropogenic Emissions	kg m^{-2} s^{-1}
SO2EMBB	t	SO2 Biomass Burning Emissions	kg m^{-2} s^{-1}
SO2EMVE	t	SO2 Volcanic (explosive) Emissions	kg m^{-2} s^{-1}
SO2EMVN	t	SO2 Volcanic (non-explosive) Emissions	kg m^{-2} s^{-1}
SO4EMAN	t	SO4 Anthropogenic Emissions	kg m^{-2} s^{-1}
SSAERIDX	t	Sea Salt TOMS UV Aerosol Index	1
SSDP001	t	Sea Salt Dry Deposition Bin 001	kg m^{-2} s^{-1}
SSDP002	t	Sea Salt Dry Deposition Bin 002	kg m^{-2} s^{-1}
SSDP003	t	Sea Salt Dry Deposition Bin 003	kg m^{-2} s^{-1}
SSDP004	t	Sea Salt Dry Deposition Bin 004	kg m^{-2} s^{-1}

SSDP005	t	Sea Salt Dry Deposition Bin 005	kg m^{-2} s^{-1}
SSEM001	t	Sea Salt Emission Bin 001	kg m^{-2} s^{-1}
SSEM002	t	Sea Salt Emission Bin 002	kg m^{-2} s^{-1}
SSEM003	t	Sea Salt Emission Bin 003	kg m^{-2} s^{-1}
SSEM004	t	Sea Salt Emission Bin 004	kg m^{-2} s^{-1}
SSEM005	t	Sea Salt Emission Bin 005	kg m^{-2} s^{-1}
SSEXTTFM	t	Sea Salt Extinction AOT [550 nm] - PM 1.0 um	1
SSSCATFM	t	Sea Salt Scattering AOT [550 nm] - PM 1.0 um	1
SSSD001	t	Sea Salt Sedimentation Bin 001	kg m^{-2} s^{-1}
SSSD002	t	Sea Salt Sedimentation Bin 002	kg m^{-2} s^{-1}
SSSD003	t	Sea Salt Sedimentation Bin 003	kg m^{-2} s^{-1}
SSSD004	t	Sea Salt Sedimentation Bin 004	kg m^{-2} s^{-1}
SSSD005	t	Sea Salt Sedimentation Bin 005	kg m^{-2} s^{-1}
SSSV	t	sea salt tendency due to conv scav	kg m^{-2} s^{-1}
SSWT001	t	Sea Salt Wet Deposition Bin 001	kg m^{-2} s^{-1}
SSWT002	t	Sea Salt Wet Deposition Bin 002	kg m^{-2} s^{-1}
SSWT003	t	Sea Salt Wet Deposition Bin 003	kg m^{-2} s^{-1}
SSWT004	t	Sea Salt Wet Deposition Bin 004	kg m^{-2} s^{-1}
SSWT005	t	Sea Salt Wet Deposition Bin 005	kg m^{-2} s^{-1}
SUDP001	t	Sulfate Dry Deposition Bin 001	kg m^{-2} s^{-1}
SUDP002	t	Sulfate Dry Deposition Bin 002	kg m^{-2} s^{-1}
SUDP003	t	Sulfate Dry Deposition Bin 003	kg m^{-2} s^{-1}
SUDP004	t	Sulfate Dry Deposition Bin 004	kg m^{-2} s^{-1}
SUEM001	t	Sulfate Emission Bin 001	kg m^{-2} s^{-1}
SUEM002	t	Sulfate Emission Bin 002	kg m^{-2} s^{-1}
SUEM003	t	Sulfate Emission Bin 003	kg m^{-2} s^{-1}
SUEM004	t	Sulfate Emission Bin 004	kg m^{-2} s^{-1}
SUPMSA	t	MSA Prod from DMS Oxidation [column]	kg m^{-2} s^{-1}
SUPSO2	t	SO2 Prod from DMS Oxidation [column]	kg m^{-2} s^{-1}
SUPSO4AQ	t	SO4 Prod from Aqueous SO2 Oxidation [column]	kg m^{-2} s^{-1}
SUPSO4G	t	SO4 Prod from Gaseous SO2 Oxidation [column]	kg m^{-2} s^{-1}
SUPSO4WT	t	SO4 Prod from Aqueous SO2 Oxidation (wet dep) [column]	kg m^{-2} s^{-1}
SUSV	t	sulfate tendency due to conv scav	kg m^{-2} s^{-1}
SUWT001	t	Sulfate Wet Deposition Bin 001	kg m^{-2} s^{-1}
SUWT002	t	Sulfate Wet Deposition Bin 002	kg m^{-2} s^{-1}
SUWT003	t	Sulfate Wet Deposition Bin 003	kg m^{-2} s^{-1}
SUWT004	t	Sulfate Wet Deposition Bin 004	kg m^{-2} s^{-1}

aer_Nx: 1d primary aerosol diagnostics

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight*

Name	*Dim*	*Description*	*Units*

BCANGSTR	t	Black Carbon Angstrom parameter [470-870 nm]	1
BCCMASS	t	Black Carbon Column Mass Density	kg m^{-2}
BCEXTTAU	t	Black Carbon Extinction AOT [550 nm]	1
BCFLUXU	t	Black Carbon column u-wind mass flux	kg m^{-1} s^{-1}
BCFLUXV	t	Black Carbon column v-wind mass flux	kg m^{-1} s^{-1}
BCSCATAU	t	Black Carbon Scattering AOT [550 nm]	1
BCSMASS	t	Black Carbon Surface Mass Concentration	kg m-3
DMSCMASS	t	DMS Column Mass Density	kg m^{-2}
DMSSMASS	t	DMS Surface Mass Concentration	kg m-3
DUANGSTR	t	Dust Angstrom parameter [470-870 nm]	1
DUCMASS	t	Dust Column Mass Density	kg m^{-2}
DUCMASS25	t	Dust Column Mass Density - PM 2.5	kg m^{-2}
DUEXTT25	t	Dust Extinction AOT [550 nm] - PM 2.5	1
DUEXTTAU	t	Dust Extinction AOT [550 nm]	1
DUFLUXU	t	Dust column u-wind mass flux	kg m^{-1} s^{-1}
DUFLUXV	t	Dust column v-wind mass flux	kg m^{-1} s^{-1}
DUSCAT25	t	Dust Scattering AOT [550 nm] - PM 2.5	1
DUSCATAU	t	Dust Scattering AOT [550 nm]	1
DUSMASS	t	Dust Surface Mass Concentration	kg m-3
DUSMASS25	t	Dust Surface Mass Concentration - PM 2.5	kg m-3
HNO3CMASS	t	Nitric Acid Column Mass Density	kg m-3
HNO3SMASS	t	Nitric Acid Surface Mass Concentration	kg m-3
NH3CMASS	t	Ammonia Column Mass Density	kg m-3
NH3SMASS	t	Ammonia Surface Mass Concentration	kg m-3
NH4CMASS	t	Ammonium Column Mass Density	kg m-3
NH4SMASS	t	Ammonium Surface Mass Concentration	kg m-3
NIANGSTR	t	Nitrate Angstrom parameter [470-870 nm]	1
NICMASS	t	Nitrate Column Mass Density	kg m^{-2}
NICMASS25	t	Nitrate Column Mass Density [PM2.5]	kg m^{-2}
NIEXTTAU	t	Nitrate Extinction AOT [550 nm]	1
NIEXTTFM	t	Nitrate Extinction AOT [550 nm] - PM 1.0 um	1
NIFLUXU	t	Nitrate column u-wind mass flux	kg m^{-1} s^{-1}
NIFLUXV	t	Nitrate column v-wind mass flux	kg m^{-1} s^{-1}
NISCATAU	t	Nitrate Scattering AOT [550 nm]	1
NISCATFM	t	Nitrate Scattering AOT [550 nm] - PM 1.0 um	1
NISMASS	t	Nitrate Surface Mass Concentration	kg m-3
NISMASS25	t	Nitrate Surface Mass Concentration [PM2.5]	kg m-3
OCANGSTR	t	Organic Carbon Angstrom parameter [470-870 nm]	1
OCCMASS	t	Organic Carbon Column Mass Density	kg m^{-2}
OCEXTTAU	t	Organic Carbon Extinction AOT [550 nm]	1
OCFLUXU	t	Organic Carbon column u-wind mass flux	kg m^{-1} s^{-1}
OCFLUXV	t	Organic Carbon column v-wind mass flux	kg m^{-1} s^{-1}
OCSCATAU	t	Organic Carbon Scattering AOT [550 nm]	1
OCSMASS	t	Organic Carbon Surface Mass Concentration	kg m-3
SO2CMASS	t	SO2 Column Mass Density	kg m^{-2}

SO2SMASS	t	SO2 Surface Mass Concentration	kg m-3
SO4CMASS	t	SO4 Column Mass Density	kg m^{-2}
SO4SMASS	t	SO4 Surface Mass Concentration	kg m-3
SSANGSTR	t	Sea Salt Angstrom parameter [470-870 nm]	1
SSCMASS	t	Sea Salt Column Mass Density	kg m^{-2}
SSCMASS25	t	Sea Salt Column Mass Density - PM 2.5	kg m^{-2}
SSEXTT25	t	Sea Salt Extinction AOT [550 nm] - PM 2.5	1
SSEXTTAU	t	Sea Salt Extinction AOT [550 nm]	1
SSFLUXU	t	Sea Salt column u-wind mass flux	kg m^{-1} s^{-1}
SSFLUXV	t	Sea Salt column v-wind mass flux	kg m^{-1} s^{-1}
SSSCAT25	t	Sea Salt Scattering AOT [550 nm] - PM 2.5	1
SSSCATAU	t	Sea Salt Scattering AOT [550 nm]	1
SSSMASS	t	Sea Salt Surface Mass Concentration	kg m-3
SSSMASS25	t	Sea Salt Surface Mass Concentration - PM 2.5	kg m-3
SUANGSTR	t	SO4 Angstrom parameter [470-870 nm]	1
SUEXTTAU	t	SO4 Extinction AOT [550 nm]	1
SUFLUXU	t	SO4 column u-wind mass flux	kg m^{-1} s^{-1}
SUFLUXV	t	SO4 column v-wind mass flux	kg m^{-1} s^{-1}
SUSCATAU	t	SO4 Scattering AOT [550 nm]	1
TOTANGSTR	t	Total Aerosol Angstrom parameter [470-870 nm]	1
TOTEXTTAU	t	Total Aerosol Extinction AOT [550 nm]	1
TOTSCATAU	t	Total Aerosol Scattering AOT [550 nm]	1

asm_Nx: 1d assimilated state

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight*

Name	*Dim*	*Description*	*Units*
DISPH	t	zero plane displacement height	m
HOURNORAIN	t	time-during an hour with no precipitation	s
PS	t	surface pressure	Pa
QV10M	t	10-meter specific humidity	kg kg^{-1}
QV2M	t	2-meter specific humidity	kg kg^{-1}
SLP	t	sea level pressure	Pa
T10M	t	10-meter air temperature	K
T2M	t	2-meter air temperature	K
T2MMAX	t	2-meter air temperature	K
T2MMIN	t	2-meter air temperature	K
TO3	t	total column ozone	Dobsons
TOX	t	total column odd oxygen	kg m^{-2}
TPRECMAX	t	total precipitation	kg m^{-2} s^{-1}
TQI	t	total precipitable ice water	kg m^{-2}
TQL	t	total precipitable liquid water	kg m^{-2}

TQV	t	total precipitable water vapor	kg m^{-2}
TROPPB	t	tropopause pressure based on blended estimate	Pa
TROPPT	t	tropopause pressure based on thermal estimate	Pa
TROPPV	t	tropopause pressure based on EPV estimate	Pa
TROPQ	t	tropopause specific humidity using blended TROPP estimate	kg kg^{-1}
TROPT	t	tropopause temperature using blended TROPP estimate	K
TS	t	surface skin temperature	K
U10M	t	10-meter eastward wind	m s^{-1}
U2M	t	2-meter eastward wind	m s^{-1}
U50M	t	50-meter eastward wind	m s^{-1}
V10M	t	10-meter northward wind	m s^{-1}
V2M	t	2-meter northward wind	m s^{-1}
V50M	t	50-meter northward wind	m s^{-1}

chm_Nx: 1d chemistry diagnostics

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight*

Name	*Dim*	*Description*	*Units*
CO2CL	t	CO2 Bulk Mixing Ratio (Column Mass/ps) Bin 001	1
CO2EM	t	CO2 Emission Bin 001	kg m^{-2} s^{-1}
CO2SC	t	CO2 Surface Concentration Bin 001	1e-6
COCL	t	CO Column Burden	kg m^{-2}
COEM	t	CO Emission	kg m^{-2} s^{-1}
COLS	t	CO Chemical Loss	kg m^{-2} s^{-1}
COPD	t	CO Chemical Production	kg m^{-2} s^{-1}
COSC	t	CO Surface Concentration in ppbv	1e-9
LWI	t	land(1) water(0) ice(2) flag	1

flx_Nx: 1d surface flux diagnostics

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight*

Name	*Dim*	*Description*	*Units*
BSTAR	t	surface buoyancy scale	m s^{-2}
CDH	t	surface exchange coefficient for heat	kg m^{-2} s^{-1}
CDM	t	surface exchange coefficient for momentum	kg m^{-2} s^{-1}
CDQ	t	surface exchange coefficient for moisture	kg m^{-2} s^{-1}
CN	t	surface neutral drag coefficient	1
DISPH	t	zero plane displacement height	m

EFLUX	t	total latent energy flux	W m^{-2}
EVAP	t	evaporation from turbulence	kg m^{-2} s^{-1}
FRCAN	t	areal fraction of anvil showers	1
FRCCN	t	areal fraction of convective showers	1
FRCLS	t	areal fraction of nonanvil large scale showers	1
FRSEAICE	t	ice covered fraction of tile	1
HFLUX	t	sensible heat flux from turbulence	W m^{-2}
HLML	t	surface layer height	m
NIRDF	t	surface downwelling nearinfrared diffuse flux	W m^{-2}
NIRDR	t	surface downwelling nearinfrared beam flux	W m^{-2}
PBLH	t	planetary boundary layer height	m
PGENTOT	t	Total column production of precipitation	kg m^{-2} s^{-1}
PRECANV	t	anvil precipitation	kg m^{-2} s^{-1}
PRECCON	t	convective precipitation	kg m^{-2} s^{-1}
PRECLSC	t	nonanvil large scale precipitation	kg m^{-2} s^{-1}
PRECSNO	t	snowfall	kg m^{-2} s^{-1}
PRECTOT	t	total precipitation	kg m^{-2} s^{-1}
PREVTOT	t	Total column re-evap/subl of precipitation	kg m^{-2} s^{-1}
QLML	t	surface specific humidity	1
QSH	t	effective surface specific humidity	kg kg^{-1}
QSTAR	t	surface moisture scale	kg kg^{-1}
RHOA	t	air density at surface	kg m-3
RISFC	t	surface bulk richardson number	1
SPEED	t	surface ventilation velocity	m s^{-1}
TAUGWX	t	surface eastward gravity wave stress	N m^{-2}
TAUGWY	t	surface northward gravity wave stress	N m^{-2}
TAUX	t	eastward surface stress	N m^{-2}
TAUY	t	northward surface stress	N m^{-2}
TLML	t	surface air temperature	K
TSH	t	effective surface skin temperature	K
TSTAR	t	surface temperature scale	K
ULML	t	surface eastward wind	m s^{-1}
USTAR	t	surface velocity scale	m s^{-1}
VLML	t	surface northward wind	m s^{-1}
Z0H	t	surface roughness for heat	m
Z0M	t	surface roughness	m

lfo_Nx: 2d instantaneous land surface forcing

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight*

Name	*Dim*	*Description*	*Units*
LWGAB	t	surface absorbed longwave radiation	W m^{-2}
PARDF	t	surface downwelling par diffuse flux	W m^{-2}

PARDR	t	surface downwelling par beam flux	W m^{-2}
PRECCU	t	liquid water convective precipitation	kg m^{-2} s^{-1}
PRECLS	t	liquid water large scale precipitation	kg m^{-2} s^{-1}
PRECSNO	t	snowfall	kg m^{-2} s^{-1}
SWGDN	t	surface incoming shortwave flux	W m^{-2}
SWLAND	t	Net shortwave land	W m^{-2}

lnd_Nx: 2d time-averaged land surface diagnostics

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight*

Name	*Dim*	*Description*	*Units*
BASEFLOW	t	baseflow flux	kg m^{-2} s^{-1}
ECHANGE	t	rate of change of total land energy	W m^{-2}
EVLAND	t	Evaporation land	kg m^{-2} s^{-1}
EVPINTR	t	interception loss energy flux	W m^{-2}
EVPSBLN	t	snow ice evaporation energy flux	W m^{-2}
EVPSOIL	t	baresoil evap energy flux	W m^{-2}
EVPTRNS	t	transpiration energy flux	W m^{-2}
FRSAT	t	fractional area of saturated zone	1
FRSNO	t	fractional area of land snowcover	1
FRUNST	t	fractional area of unsaturated zone	1
FRWLT	t	fractional area of wilting zone	1
GHLAND	t	Ground heating land	W m^{-2}
GRN	t	greenness fraction	1
GWETPROF	t	ave prof soil moisture	1
GWETROOT	t	root zone soil wetness	1
GWETTOP	t	surface soil wetness	1
LAI	t	leaf area index	1
LHLAND	t	Latent heat flux land	W m^{-2}
LWLAND	t	Net longwave land	W m^{-2}
PARDF	t	surface downwelling par diffuse flux	W m^{-2}
PARDR	t	surface downwelling par beam flux	W m^{-2}
PRECSNO	t	snowfall	kg m^{-2} s^{-1}
PRECTOT	t	total precipitation	kg m^{-2} s^{-1}
PRMC	t	water profile	m+3 m-3
QINFIL	t	Soil water infiltration rate	kg m^{-2} s^{-1}
RUNOFF	t	overland runoff including throughflow	kg m^{-2} s^{-1}
RZMC	t	water root zone	m+3 m-3
SFMC	t	water surface layer	m+3 m-3
SHLAND	t	Sensible heat flux land	W m^{-2}
SMLAND	t	Snowmelt flux land	kg m^{-2} s^{-1}
SNODP	t	snow depth	m
SNOMAS	t	Total snow storage land	kg m^{-2}

SPLAND	t	rate of spurious land energy source	W m^{-2}
SPSNOW	t	rate of spurious snow energy	W m^{-2}
SPWATR	t	rate of spurious land water source	kg m^{-2} s^{-1}
SWLAND	t	Net shortwave land	W m^{-2}
TELAND	t	Total energy storage land	J m^{-2}
TPSNOW	t	surface temperature of snow	K
TSAT	t	surface temperature of saturated zone	K
TSOIL1	t	soil temperatures layer 1	K
TSOIL2	t	soil temperatures layer 2	K
TSOIL3	t	soil temperatures layer 3	K
TSOIL4	t	soil temperatures layer 4	K
TSOIL5	t	soil temperatures layer 5	K
TSOIL6	t	soil temperatures layer 6	K
TSURF	t	surface temperature of land incl snow	K
TUNST	t	surface temperature of unsaturated zone	K
TWLAND	t	Avail water storage land	kg m^{-2}
TWLT	t	surface temperature of wilted zone	K
WCHANGE	t	rate of change of total land water	kg m^{-2} s^{-1}

ocn_Nx: 2d time-averaged ocean related variables

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight*

Name	***Dim***	***Description***	***Units***
BCOOL	t	buoyancy generation in cool layer	m^2 s-3
COSZ	t	cosine of the solar zenith angle	1
DCOOL	t	depth of cool layer	m
DELTS	t	change of surface skin temperature	K
DTSDT_ANA	t	total skin temperature tendency	K s^{-1}
DWARM	t	depth at base of warm layer	m
EFLUXICE	t	sea ice latent energy flux	W m^{-2}
EFLUXWTR	t	open water latent energy flux	W m^{-2}
EVAPOUT	t	evaporation	kg m^{-2} s^{-1}
FRLAKE	t	fraction of lake	1
FRLAND	t	fraction of land	1
FRLANDICE	t	fraction of land ice	1
FROCEAN	t	fraction of ocean	1
FRSEAICE	t	ice covered fraction of tile	1
HFLUXICE	t	sea ice upward sensible heat flux	W m^{-2}
HFLUXWTR	t	open water upward sensible heat flux	W m^{-2}
LANGM	t	Langmuir number	1
LCOOL	t	Saunders parameter	1
LWGNTICE	t	sea ice net downward longwave flux	W m^{-2}
LWGNTWTR	t	open water net downward longwave flux	W m^{-2}

PHIW	t	Similarity function in warm layer	1
PRECSNOOCN	t	ocean snowfall	kg m^{-2} s^{-1}
QCOOL	t	net cooling in cool layer	W m^{-2}
QV10M	t	10-meter specific humidity	kg kg^{-1}
QWARM	t	net heating in warm layer	W m^{-2}
RAINOCN	t	ocean rainfall	kg m^{-2} s^{-1}
SWCOOL	t	solar heating in cool layer	W m^{-2}
SWGNTICE	t	sea ice net downward shortwave flux	W m^{-2}
SWGNTWTR	t	open water net downward shortwave flux	W m^{-2}
SWWARM	t	solar heating in warm layer	W m^{-2}
T10M	t	10-meter air temperature	K
TAUTW	t	relaxation time of TW to TS FOUND	s
TAUXICE	t	eastward stress over ice	N m^{-2}
TAUXWTR	t	eastward stress over water	N m^{-2}
TAUYICE	t	northward stress over ice	N m^{-2}
TAUYWTR	t	northward stress over water	N m^{-2}
TBAR	t	mean temperature of interface layer	K
TDEL	t	temperature at base of cool layer	K
TDROP	t	temperature drop across cool layer	K
TSKINICE	t	sea ice skin temperature	K
TSKINWTR	t	open water skin temperature	K
TS_FOUND	t	foundation temperature for interface layer	K
U10M	t	10-meter eastward wind	m s^{-1}
USTARW	t	ustar over water layer	m s^{-1}
V10M	t	10-meter northward wind	m s^{-1}
ZETA_W	t	Stability parameter in Warm Layer	1

rad_Nx: 2d time-averaged radiation diagnostics

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight*

Name	*Dim*	*Description*	*Units*
ALBEDO	t	surface albedo	1
ALBNIRDF	t	surface albedo for near infrared diffuse	1
ALBNIRDR	t	surface albedo for near infrared beam	1
ALBVISDF	t	surface albedo for visible diffuse	1
ALBVISDR	t	surface albedo for visible beam	1
CLDHGH	t	cloud area fraction for high clouds	1
CLDLOW	t	cloud area fraction for low clouds	1
CLDMID	t	cloud area fraction for middle clouds	1
CLDTOT	t	total cloud area fraction	1
EMIS	t	surface emissivity	1
LWGAB	t	surface absorbed longwave radiation	W m^{-2}

LWGABCLR	t	surface absorbed longwave radiation assuming clear sky	W m^{-2}
LWGABCLRCLN	t	surface absorbed longwave radiation assuming clear sky and no aerosol	W m^{-2}
LWGEM	t	longwave flux emitted from surface	W m^{-2}
LWGNT	t	surface net downward longwave flux	W m^{-2}
LWGNTCLR	t	surface net downward longwave flux assuming clear sky	W m^{-2}
LWGNTCLRCLN	t	surface net downward longwave flux assuming clear sky and no aerosol	W m^{-2}
LWTUP	t	upwelling longwave flux at toa	W m^{-2}
LWTUPCLR	t	upwelling longwave flux at toa assuming clear sky	W m^{-2}
LWTUPCLRCLN	t	upwelling longwave flux at toa assuming clear sky and no aerosol	W m^{-2}
SWGDN	t	surface incoming shortwave flux	W m^{-2}
SWGDNCLR	t	surface incoming shortwave flux assuming clear sky	W m^{-2}
SWGNT	t	surface net downward shortwave flux	W m^{-2}
SWGNTCLN	t	surface net downward shortwave flux assuming no aerosol	W m^{-2}
SWGNTCLR	t	surface net downward shortwave flux assuming clear sky	W m^{-2}
SWGNTCLRCLN	t	surface net downward shortwave flux assuming clear sky and no aerosol	W m^{-2}
SWTDN	t	toa incoming shortwave flux	W m^{-2}
SWTNT	t	toa net downward shortwave flux	W m^{-2}
SWTNTCLN	t	toa net downward shortwave flux assuming no aerosol	W m^{-2}
SWTNTCLR	t	toa net downward shortwave flux assuming clear sky	W m^{-2}
SWTNTCLRCLN	t	toa net downward shortwave flux assuming clear sky and no aerosol	W m^{-2}
TAUHGH	t	in cloud optical thickness of high clouds(EXPORT)	1
TAULOW	t	in cloud optical thickness of low clouds	1
TAUMID	t	in cloud optical thickness of middle clouds	1
TAUTOT	t	in cloud optical thickness of all clouds	1
TS	t	surface skin temperature	K

slv_Nx: 2d time-averaged single level diagnostics

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight*

Name	***Dim***	***Description***	***Units***
CLDPRS	t	cloud top pressure	Pa
CLDTMP	t	cloud top temperature	K
DISPH	t	zero plane displacement height	m
H1000	t	height at 1000 mb	m
H250	t	height at 250 hPa	m
H500	t	height at 500 hPa	m
H850	t	height at 850 hPa	m
OMEGA500	t	omega at 500 hPa	Pa s^{-1}
PBLTOP	t	pbltop pressure	Pa
PS	t	surface pressure	Pa
Q250	t	specific humidity at 250 hPa	kg kg^{-1}
Q500	t	specific humidity at 500 hPa	kg kg^{-1}
Q850	t	specific humidity at 850 hPa	kg kg^{-1}
QV10M	t	10-meter specific humidity	kg kg^{-1}
QV2M	t	2-meter specific humidity	kg kg^{-1}
SLP	t	sea level pressure	Pa
T10M	t	10-meter air temperature	K
T250	t	air temperature at 250 hPa	K
T2M	t	2-meter air temperature	K
T500	t	air temperature at 500 hPa	K
T850	t	air temperature at 850 hPa	K
TO3	t	total column ozone	Dobsons
TOX	t	total column odd oxygen	kg m^{-2}
TQI	t	total precipitable ice water	kg m^{-2}
TQL	t	total precipitable liquid water	kg m^{-2}
TQV	t	total precipitable water vapor	kg m^{-2}
TROPPB	t	tropopause pressure based on blended estimate	Pa
TROPPT	t	tropopause pressure based on thermal estimate	Pa
TROPPV	t	tropopause pressure based on EPV estimate	Pa
TROPQ	t	tropopause specific humidity using blended TROPP estimate	kg kg^{-1}
TROPT	t	tropopause temperature using blended TROPP estimate	K
TS	t	surface skin temperature	K
U10M	t	10-meter eastward wind	m s^{-1}
U250	t	eastward wind at 250 hPa	m s^{-1}
U2M	t	2-meter eastward wind	m s^{-1}
U500	t	eastward wind at 500 hPa	m s^{-1}
U50M	t	eastward wind at 50 meters	m s^{-1}
U850	t	eastward wind at 850 hPa	m s^{-1}
V10M	t	10-meter northward wind	m s^{-1}
V250	t	northward wind at 250 hPa	m s^{-1}
V2M	t	2-meter northward wind	m s^{-1}
V500	t	northward wind at 500 hPa	m s^{-1}
V50M	t	northward wind at 50 meters	m s^{-1}

V850	t	northward wind at 850 hPa	m s^{-1}

2D State Variables and Diagnostics on Model Levels

aer_Nv: 3d aerosol diagnostics

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight; level=72*

Name	*Dim*	*Description*	*Units*
AIRDENS	tz	moist air density	kg m-3
BCPHILIC	tz	Hydrophilic Black Carbon	kg kg^{-1}
BCPHOBIC	tz	Hydrophobic Black Carbon	kg kg^{-1}
DELP	tz	pressure thickness	Pa
DMS	tz	Dimethylsulphide	kg kg^{-1}
DU001	tz	Dust Mixing Ratio (bin 001)	kg kg^{-1}
DU002	tz	Dust Mixing Ratio (bin 002)	kg kg^{-1}
DU003	tz	Dust Mixing Ratio (bin 003)	kg kg^{-1}
DU004	tz	Dust Mixing Ratio (bin 004)	kg kg^{-1}
DU005	tz	Dust Mixing Ratio (bin 005)	kg kg^{-1}
LWI	t	land(1) water(0) ice(2) flag	1
MSA	tz	Methanesulphonic acid	kg kg^{-1}
NH3	tz	Ammonia (NH3, gas phase)	kg kg^{-1}
NH4A	tz	Ammonium ion (NH4+, aerosol phase)	kg kg^{-1}
NO3AN1	tz	Nitrate size bin 001	kg kg^{-1}
NO3AN2	tz	Nitrate size bin 002	kg kg^{-1}
NO3AN3	tz	Nitrate size bin 003	kg kg^{-1}
OCPHILIC	tz	Hydrophilic Organic Carbon (Particulate Matter)	kg kg^{-1}
OCPHOBIC	tz	Hydrophobic Organic Carbon (Particulate Matter)	kg kg^{-1}
PS	t	surface pressure	Pa
RH	tz	relative humidity after moist	1
SO2	tz	Sulphur dioxide	kg kg^{-1}
SO4	tz	Sulphate aerosol	kg kg^{-1}
SS001	tz	Sea Salt Mixing Ratio (bin 001)	kg kg^{-1}
SS002	tz	Sea Salt Mixing Ratio (bin 002)	kg kg^{-1}
SS003	tz	Sea Salt Mixing Ratio (bin 003)	kg kg^{-1}
SS004	tz	Sea Salt Mixing Ratio (bin 004)	kg kg^{-1}
SS005	tz	Sea Salt Mixing Ratio (bin 005)	kg kg^{-1}

asm_Nv: 2d assimilated state on native levels

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight; level=72*

Name	*Dim*	*Description*	*Units*
CLOUD	tz	cloud fraction for radiation	1
DELP	tz	pressure thickness	Pa
EPV	tz	ertels potential vorticity	$K\ m^2\ kg^{-1}\ s^{-1}$
H	tz	mid layer heights	m
O3	tz	ozone mass mixing ratio	$kg\ kg^{-1}$
OMEGA	tz	vertical pressure velocity	$Pa\ s^{-1}$
PHIS	t	surface geopotential height	$m^2\ s^{-2}$
PL	tz	mid level pressure	Pa
PS	t	surface pressure	Pa
QI	tz	mass fraction of cloud ice water	$kg\ kg^{-1}$
QL	tz	mass fraction of cloud liquid water	$kg\ kg^{-1}$
QR	tz	mass fraction of falling rain	$kg\ kg^{-1}$
QS	tz	mass fraction of falling snow	$kg\ kg^{-1}$
QV	tz	specific humidity	$kg\ kg^{-1}$
RH	tz	relative humidity after moist	1
SLP	t	sea level pressure	Pa
T	tz	air temperature	K
U	tz	eastward wind	$m\ s^{-1}$
V	tz	northward wind	$m\ s^{-1}$

chm_Nv: 2d chemistry diagnostics

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight; level=72*

Name	*Dim*	*Description*	*Units*
AIRDENS	tz	moist air density	kg m-3
CO	tz	Carbon Monoxide (All Sources)	$mol\ mol^{-1}$
CO2	tz	Carbon Dioxide (All Sources)	$mol\ mol^{-1}$
DELP	tz	pressure thickness	Pa
PS	t	surface pressure	Pa

cld_Nv: 2d cloud diagnostics

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight; level=72*

Name	*Dim*	*Description*	*Units*
CFAN	tz	convective cloud area fraction	1
CFCU	tz	updraft areal fraction	1

CFLS	tz	large scale cloud area fraction	1
DELP	tz	pressure thickness	Pa
DTRAIN	tz	detraining mass flux	kg m^{-2} s^{-1}
PS	t	surface pressure	Pa
QCCU	tz	grid mean convective condensate	kg kg^{-1}
QIAN	tz	mass fraction of convective cloud ice water	kg kg^{-1}
QILS	tz	mass fraction of large scale cloud ice water	kg kg^{-1}
QLAN	tz	mass fraction of convective cloud liquid water	kg kg^{-1}
QLLS	tz	mass fraction of large scale cloud liquid water	kg kg^{-1}
RH	tz	relative humidity after moist	1
TAUCLI	tz	in cloud optical thickness for ice clouds	1
TAUCLW	tz	in cloud optical thickness for liquid clouds	1

ext***_Nv: 2d aerosol extinction at 355, 532, and 1064 nm

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight; level=72*

Name	***Dim***	***Description***	***Units***
aback_sfc	tz	attenuated aerosol backscatter for a lidar at the surface	sr^{-1}
aback_toa	tz	attenuated aerosol backscatter for a lidar at the top of the atmosphere	sr^{-1}
backscat	tz	backscatter	km^{-1} sr^{-1}
depol	tz	depolarization ratio	1
ext	tz	extinction	km^{-1}
ext2back	tz	extinction to backscatter ratio	sr
g	tz	asymmetry parameter	1
scatext	tz	scattering extinction	km^{-1}
ssa	tz	single scattering albedo	1
tau	tz	optical depth	1

mst_Nv: 2d moist processes diagnostics

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight; level=72*

Name	***Dim***	***Description***	***Units***
DELP	tz	pressure thickness	Pa
DQRCU	tz	convective rainwater source	kg kg^{-1} s^{-1}
DQRLSAN	tz	large scale rainwater source	kg kg^{-1} s^{-1}
PS	t	surface pressure	Pa
REEVAPCN	tz	evap subl of convective precipitation	kg kg^{-1} s^{-1}
REEVAPLSAN	tz	evap subl of non convective precipitation	kg kg^{-1} s^{-1}

nav_Nv: 2d vertical coordinate navigation

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight; level=72*

Name	*Dim*	*Description*	*Units*
H	tz	mid layer heights	m
PL	tz	mid level pressure	Pa

qdt_Nv: 2d moisture tendencies

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight; level=72*

Name	*Dim*	*Description*	*Units*
DELP	tz	pressure thickness	Pa
DQIDTDYN	tz	tendency of ice water due to dynamics	$kg\ kg^{-1}\ s^{-1}$
DQIDTMST	tz	total ice water tendency due to moist	$kg\ kg^{-1}\ s^{-1}$
DQIDTTRB	tz	tendency of frozen condensate due to turbulence	$kg\ kg^{-1}\ s^{-1}$
DQLDTDYN	tz	tendency of liquid water due to dynamics	$kg\ kg^{-1}\ s^{-1}$
DQLDTMST	tz	total liq water tendency due to moist	$kg\ kg^{-1}\ s^{-1}$
DQLDTTRB	tz	tendency of liquid condensate due to turbulence	$kg\ kg^{-1}\ s^{-1}$
DQVDTANA	tz	total specific humidity vapor analysis tendency	$kg\ kg^{-1}\ s^{-1}$
DQVDTCHM	tz	tendency of water vapor mixing ratio due to chemistry	$kg\ kg^{-1}\ s^{-1}$
DQVDTDYN	tz	tendency of specific humidity due to dynamics	$kg\ kg^{-1}\ s^{-1}$
DQVDTMST	tz	specific humidity tendency due to moist	$kg\ kg^{-1}\ s^{-1}$
DQVDTTRB	tz	tendency of specific humidity due to turbulence	$kg\ kg^{-1}\ s^{-1}$
PS	t	surface pressure	Pa

rad_Nv: 2d radiation diagnostics

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight; level=72*

Name	*Dim*	*Description*	*Units*
CLOUD	tz	cloud fraction for radiation	1
DELP	tz	pressure thickness	Pa
DTDTLWR	tz	air temperature tendency due to longwave	$K\ s^{-1}$
DTDTLWRCLR	tz	air temperature tendency due to longwave for clear skies	$K\ s^{-1}$

DTDTSWR	tz	air temperature tendency due to shortwave	K s^{-1}
DTDTSWRCLR	tz	air temperature tendency due to shortwave for clear skies	K s^{-1}
PS	t	surface pressure	Pa

tdt_Nv: 2d temperature tendencies

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight; level=72*

Name	*Dim*	*Description*	*Units*
DELP	tz	pressure thickness	Pa
DTDTANA	tz	total temperature analysis tendency	K s^{-1}
DTDTDYN	tz	tendency of air temperature due to dynamics	K s^{-1}
DTDTFRI	tz	tendency of air temperature due to friction	K s^{-1}
DTDTFRIC	tz	tendency of air temperature due to moist processes friction	K s^{-1}
DTDTGWD	tz	air temperature tendency due to GWD	K s^{-1}
DTDTMST	tz	tendency of air temperature due to moist processes	K s^{-1}
DTDTRAD	tz	tendency of air temperature due to radiation	K s^{-1}
DTDTTOT	tz	tendency of air temperature due to physics	K s^{-1}
DTDTTRB	tz	tendency of air temperature due to turbulence	K s^{-1}
PS	t	surface pressure	Pa

udt_Nv: 2d wind tendencies

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight; level=72*

Name	*Dim*	*Description*	*Units*
DELP	tz	pressure thickness	Pa
DUDTANA	tz	total eastward wind analysis tendency	m s^{-2}
DUDTDYN	tz	tendency of eastward wind due to dynamics	m s^{-2}
DUDTGWD	tz	tendency of eastward wind due to GWD	m s^{-2}
DUDTMST	tz	zonal wind tendency due to moist	m s^{-2}
DUDTTRB	tz	tendency of eastward wind due to turbulence	m s^{-2}
DVDTANA	tz	total northward wind analysis tendency	m s^{-2}
DVDTDYN	tz	tendency of northward wind due to dynamics	m s^{-2}
DVDTGWD	tz	tendency of northward wind due to GWD	m s^{-2}
DVDTMST	tz	meridional wind tendency due to moist	m s^{-2}
DVDTTRB	tz	tendency of northward wind due to turbulence	m s^{-2}
OMEGA	tz	vertical pressure velocity	Pa s^{-1}
PS	t	surface pressure	Pa
U	tz	eastward wind	m s^{-1}
V	tz	northward wind	m s^{-1}

mst_Ne: 2d moist processes diagnostics at edges

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight; level=73*

Name	Dim	Description	Units
CMFMC	tz	cumulative mass flux	kg m^{-2} s^{-1}
PFICU	tz	3D flux of ice convective precipitation	kg m^{-2} s^{-1}
PFILSAN	tz	3D flux of ice nonconvective precipitation	kg m^{-2} s^{-1}
PFLCU	tz	3D flux of liquid convective precipitation	kg m^{-2} s^{-1}
PFLLSAN	tz	3D flux of liquid nonconvective precipitation	kg m^{-2} s^{-1}
PLE	tz	edge pressure	Pa

nav_Ne: 2d vertical coordinate navigation at edges

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight; level=73*

Name	Dim	Description	Units
PLE	tz	edge pressure	Pa
ZLE	tz	edge heights	m

trb_Ne: 2d turbulence diagnostics at edges

Frequency: *60 seconds from onset of flight*
Dimensions: *time=dependent on length of flight; level=73*

Name	Dim	Description	Units
KH	tz	total scalar diffusivity	m^2 s^{-1}
KHLK	tz	entrainment heat diffusivity from Lock	m^2 s^{-1}
KHLS	tz	scalar diffusivity from Louis	m^2 s^{-1}
KHRAD	tz	radiation driven scalar diffusivity from Lock scheme	m^2 s^{-1}
KHSFC	tz	surface driven scalar diffusivity from Lock scheme	m^2 s^{-1}
KM	tz	total momentum diffusivity	m^2 s^{-1}
KMLK	tz	entrainment momentum diffusivity from Lock	m^2 s^{-1}
KMLS	tz	momentum diffusivity from Louis	m^2 s^{-1}
PLE	tz	edge pressure	Pa
RI	tz	Richardson number from Louis	1

6. Metadata

In addition to the metadata discussed in section 2, we have included additional metadata recommended by the GES DISC.   In former versions of GMAO data products, this information as bundled into EOSDIS Metadata.   As discussed earlier, metadata related to the CF conventions is also present. In addition to what is documented here, additional metadata may be present.

6.1 CF Metadata

When visualization tools such as GrADS, that are CF aware, are used to read GEOS gridded data sets, the application will use the CF metadata embedded in the data products. These metadata include the following information:

- Space-time grid information (dimension variables)
- Variable names and descriptions
- Variable units
- "Missing" value for each variable

Grid information and units comply with the CF conventions.   Most variables, but not all, will conform to CF conventions for identification by having a valid “standard_name” attribute defined.

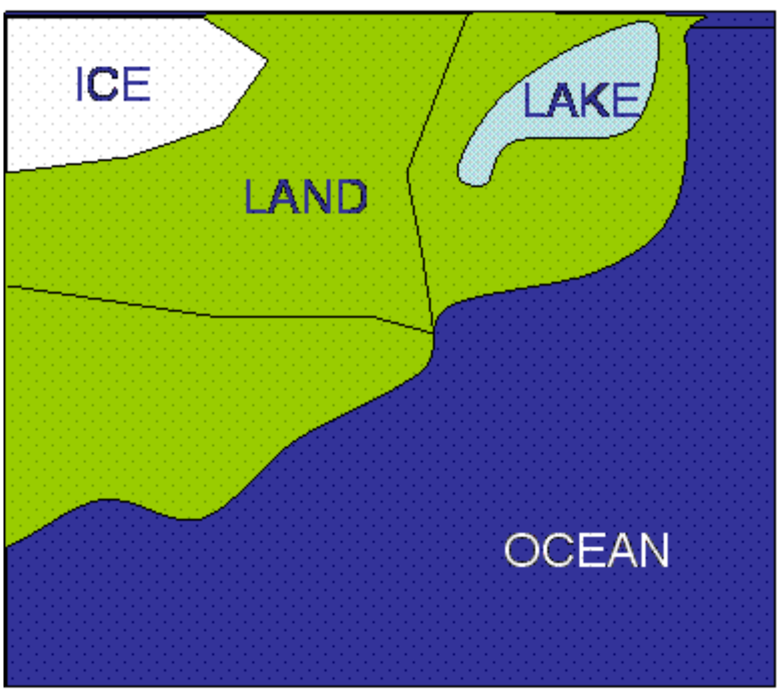
Appendix A: Vertical Structure

Products on the native vertical grid will be output on the following levels. Pressures are nominal for a 1000 hPa surface pressure and refer to the top edge of the layer. Note that the bottom layer has a nominal thickness of 15 hPa.

Lev	P(hPa)	Lev	P(hPa)	Lev	P(hPa)	Lev	P(hPa)	Lev	P(hPa)	Lev	P(hPa)
1	0.0100	13	0.6168	25	9.2929	37	78.5123	49	450.000	61	820.000
2	0.0200	14	0.7951	26	11.2769	38	92.3657	50	487.500	62	835.000
3	0.0327	15	1.0194	27	13.6434	39	108.663	51	525.000	63	850.000
4	0.0476	16	1.3005	28	16.4571	40	127.837	52	562.500	64	865.000
5	0.0660	17	1.6508	29	19.7916	41	150.393	53	600.000	65	880.000
6	0.0893	18	2.0850	30	23.7304	42	176.930	54	637.500	66	895.000
7	0.1197	19	2.6202	31	28.3678	43	208.152	55	675.000	67	910.000
8	0.1595	20	3.2764	32	33.8100	44	244.875	56	700.000	68	925.000
9	0.2113	21	4.0766	33	40.1754	45	288.083	57	725.000	69	940.000
10	0.2785	22	5.0468	34	47.6439	46	337.500	58	750.000	70	955.000
11	0.3650	23	6.2168	35	56.3879	47	375.000	59	775.000	71	970.000
12	0.4758	24	7.6198	36	66.6034	48	412.500	60	800.000	72	985.000

Appendix B: Surface Representation

In GEOS the surface below each atmospheric column consists of a set of tiles that represent various surface types. Tiles can be of four different types: Ocean, Land, Ice, Lake, as illustrated in the figure. In each grid box a single Ice tile represents those areas covered by permanent ice. Similarly a single Lake tile represents continental areas covered permanently by water. Other continental areas (non Lake or Ice) can be further subdivided into tiles that represent parts of the grid box in different hydrological catchments, defined according to the Pfafstetter (1989) system. Each of these is, in turn, divided into subtiles (not shown in figure) that represent the wilted, unsaturated, saturated, and snow-covered fractions of the tile. These fractions vary with time and are predicted by the model based on the hydrological state of the catchment and its fine-scale topographic statistics. Details of the land model, including the partitioning into subtiles, can be found in Koster et al. (2000). The Ocean tile can be divided into two subtiles that represent the ice-covered and ice-free parts of the ocean part of the atmospheric grid box. The fractional cover of these subtiles also varies with time.



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Web Resources

GMAO web site: http://gmao.gsfc.nasa.gov/

GMAO Products page: http://gmao.gsfc.nasa.gov/products/

NetCDF information: http://www.unidata.ucar.edu/software/netcdf/

CF Standard Description: http://cf-pcmdi.llnl.gov/

The HDF Group: http://www.hdfgroup.org /

Acronyms

ADAS	atmospheric data assimilation system
AOT	aerosol optical thickness
CF	Climate and Forecast metadata convention
CLSM	Catchment Land Surface Model
COARDS	Cooperative Ocean/Atmosphere Research Data Service metadata convention
DMS	dimethylsulphide
ECS	EOS Core System
EOS	Earth Observing System
ESDT	Earth Science Data Type
ESMF	Earth System Modeling Framework
FP	Forward-processing
GES DISC	Goddard Earth Sciences Data and Information Services Center
GMAO	Global Modeling and Assimilation Office
GRIB	GRIdded Binary
GSI	Gridpoint Statistical Interpolation
HDF	Hierarchical Data Format
IAU	Incremental Analysis Update
JCSDA	Joint Center for Satellite Data Assimilation
MSA	methane sulphonic acid
NCEP	National Center for Environmental Prediction
NetCDF	Network Common Data Form
PAR	photosynthetically active radiation
TOA	top of atmosphere
TOMS	Total Ozone Mapping Spectrometer
UTC	Universal Time, Coordinated