****

**Global Modeling and Assimilation Office**

*GMAO Office Note No. 18 (Version 1.0)*

**File Specification for GEOS Products Sampled Along Aircraft Trajectories**

Release Date: 06/11/2020

**Global Modeling and Assimilation Office**

**Earth Sciences Division**

**NASA Goddard Space Flight Center**

**Greenbelt, Maryland 20771**

This page intentionally left blank.

**File Specification for GEOS Products Sampled Along Aircraft Trajectories**

Document maintained by Allison Collow (GMAO, USRA)

This document should be cited as

Collow, A., Lucchesi, R., and Da Silva, A., 2020: File Specification for GEOS Products Sampled Along Aircraft Trajectories. GMAO Office Note No. 18 (Version 1.0), 36 pp, available from http://gmao.gsfc.nasa.gov/pubs/office\_notes.

Approved by:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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 |

Table of Contents

1. Introduction 1

2. Format and File Organization 1

2.1 Dimensions and Navigational Data 2

2.2 Variables 3

2.3 Global Attributes 4

3. Vertical Structure 5

4. File Naming Conventions 5

4.1 File Names 5

5. Summary of GEOS trajectory sampled file collections 7

1D State Variables and Diagnostics 8

adg\_Nx: 1d extended aerosol diagnostics 8

aer\_Nx: 1d primary aerosol diagnostics 10

asm\_Nx: 1d assimilated state 12

chm\_Nx: 1d chemistry diagnostics 13

flx\_Nx: 1d surface flux diagnostics 13

lfo\_Nx: 2d instantaneous land surface forcing 14

lnd\_Nx: 2d time-averaged land surface diagnostics 15

ocn\_Nx: 2d time-averaged ocean related variables 16

rad\_Nx: 2d time-averaged radiation diagnostics 17

slv\_Nx: 2d time-averaged single level diagnostics 18

2D State Variables and Diagnostics on Model Levels 20

aer\_Nv: 3d aerosol diagnostics 20

asm\_Nv: 2d assimilated state on native levels 20

chm\_Nv: 2d chemistry diagnostics 21

cld\_Nv: 2d cloud diagnostics 21

ext\*\*\*\_Nv: 2d aerosol extinction at 355, 532, and 1064 nm 22

mst\_Nv: 2d moist processes diagnostics 22

nav\_Nv: 2d vertical coordinate navigation 23

qdt\_Nv: 2d moisture tendencies 23

rad\_Nv: 2d radiation diagnostics 23

tdt\_Nv: 2d temperature tendencies 24

udt\_Nv: 2d wind tendencies 24

mst\_Ne: 2d moist processes diagnostics at edges 25

nav\_Ne: 2d vertical coordinate navigation at edges 25

trb\_Ne: 2d turbulence diagnostics at edges 25

6. Metadata 26

6.1 CF Metadata 26

Appendix A: Vertical Structure 27

Appendix B: Surface Representation 28

References 29

Web Resources 30

Acronyms 30

# 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 106 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 loaded with useful data. |
| long\_name | String | An ad hoc description of the variable as required by [COARDS](#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 |
| 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**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 | m2 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 m2 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 | m2 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 | m2 s-1 |
| KHLK | tz | entrainment heat diffusivity from Lock | m2 s-1 |
| KHLS | tz | scalar diffusivity from Louis | m2 s-1 |
| KHRAD | tz | radiation driven scalar diffusivity from Lock scheme | m2 s-1 |
| KHSFC | tz | surface driven scalar diffusivity from Lock scheme | m2 s-1 |
| KM | tz | total momentum diffusivity | m2 s-1 |
| KMLK | tz | entrainment momentum diffusivity from Lock | m2 s-1 |
| KMLS | tz | momentum diffusivity from Louis | m2 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](http://www.iges.org/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.

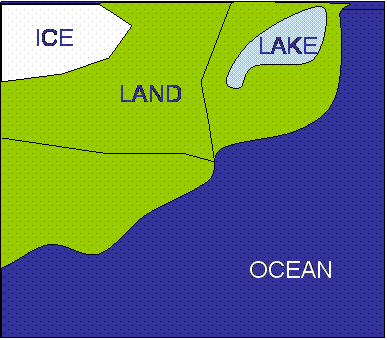
|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Lev | P(hPa) | Lev | P(hPa) | Lev | P(hPa) | Lev | P(hPa) | Lev | P(hPa) | Lev | P(hPa) |
| 1 | 0.0100 | 13 | 0.6168 | 25 | 9.2929 | 37 | 78.5123 | 49 | 450.000 | 61 | 820.000 |
| 2 | 0.0200 | 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.



# References

1. Lucchesi, R., 2018: File Specification for GEOS FP. GMAO Office Note No. 4 (Version 1.2), 61 pp, available from http://gmao.gsfc.nasa.gov/pubs/office\_notes.
2. Molod, A., L. Takacs, M.J. Suarez, J. Bacmeister, I.S. Song, A. Eichmann, Y. Chang, 2011: The GEOS-5 Atmospheric General Circulation Model: Mean Climate and Development from MERRA to Fortuna. *Technical Report Series on Global Modeling and Data Assimilation 104606*, **v28**.
3. Pfafstetter, Otto., 1989. Classification of hydrographic basins: coding methodology, unpublished manuscript, Departamento Nacional de Obras de Saneamento, August 18, 1989, Rio de Janeiro; available from J.P. Verdin, U.S. Geological Survey, EROS Data Center, Sioux Falls, South Dakota 57198 USA. See, for example: Verdin, K.L. and J.P. Verdin, 1999, A topological system for delineation and codification of the Earth's river basins," *Journal of Hydrology*, vol. 218, nos. 1-2, pp. 1-12 or <http://gis.esri.com/library/userconf/proc01/professional/papers/pap1008/p1008.htm>
4. Rienecker, M.M., M.J. Suarez, R. Todling, J. Bacmeister, L. Takacs, H.-C. Liu, W. Gu, M. Sienkiewicz, R.D. Koster, R. Gelaro, I. Stajner, and E. Nielsen, 2008: The GEOS-5 Data Assimilation System - Documentation of Versions 5.0.1, 5.1.0, and 5.2.0. *Technical Report Series on Global Modeling and Data Assimilation 104606*, **v27**.

# 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