Global Modeling and Assimilation Office

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File Specification for GEOS-5 FP
(Forward Processing)

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(Forward Processing)

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Approved by:

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REVISION HISTORY

Version	Revision Date	Extent of Changes
1.0	06/11/2013	Baseline

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1. Introduction

The GEOS-5 FP Atmospheric Data Assimilation System (GEOS-5 ADAS) uses an analysis developed jointly with NOAA's National Centers for Environmental Prediction (NCEP), which allows the Global Modeling and Assimilation Office (GMAO) to take advantage of the developments at NCEP and the Joint Center for Satellite Data Assimilation (JCSDA). The GEOS-5 AGCM uses the finite-volume dynamics (Lin, 2004) integrated with various physics packages (e.g, Bacmeister et al., 2006), under the Earth System Modeling Framework (ESMF) including the Catchment Land Surface Model (CLSM) (e.g., Koster et al., 2000). The GSI analysis is a three-dimensional variational (3DVar) analysis applied in grid-point space to facilitate the implementation of anisotropic, inhomogeneous covariances (e.g., Wu et al., 2002; Derber et al., 2003). The GSI implementation for GEOS-5 FP incorporates a set of recursive filters that produce approximately Gaussian smoothing kernels and isotropic correlation functions.

The GEOS-5 ADAS is documented in Rienecker et al. (2008). More recent updates to the model are presented in Molod et al. (2011). The GEOS-5 system actively assimilates roughly 2×10^6 observations for each analysis, including about 7.5×10^5 AIRS radiance data. The input stream is roughly twice this volume, but because of the large volume, the data are thinned commensurate with the analysis grid to reduce the computational burden. Data are also rejected from the analysis through quality control procedures designed to detect, for example, the presence of cloud.

To minimize the spurious periodic perturbations of the analysis, GEOS-5 FP uses the Incremental Analysis Update (IAU) technique developed by Bloom et al. (1996). More details of this procedure are given in Appendix A.

The assimilation is performed at a horizontal resolution of 0.3125-degree longitude by 0.25-degree latitude and at 72 levels, extending to 0.01 hPa. All products are generated at the native resolution of the horizontal grid. The majority of data products are time-averaged, but four instantaneous products are also available. Hourly data intervals are used for two-dimensional products, while 3-hourly intervals are used for three-dimensional products. These may be on the model's native 72-layer vertical grid or at 42 pressure surfaces extending to 0.1 hPa.

This document describes the gridded output files produced by the GMAO near real-time operational FP, using the most recent version of the GEOS-5 assimilation system. Additional details about variables listed in this file specification can be found in a separate document, the GEOS-5 File Specification Variable Definition Glossary.

Documentation about the current access methods for products described in this document can be found on the GMAO products page: http://gmao.gsfc.nasa.gov/products/.

2. Format and File Organization

GEOS-5 FP 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-5 files is to use the netCDF library, but the HDF-5 library can also be used directly.

Each GEOS-5 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.

All products are compressed with a GRIB-like method that is invisible to the user. This method degrades the precision of the data, but every effort has been made to ensure that differences between the product and the original, uncompressed data are not scientifically meaningful. Once the precision has been degraded, the files are written using the standard gzip deflation available in NetCDF-4.

2.1 Dimensions

GMAO 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., latitude, while the *positive* attribute defines whether a vertical coordinate increases or decreases from the surface to the top of the atmosphere. Some 3D 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.

Table 2.1-1. Dimension Variables Contained in GMAO NetCDF-4 Files

Name	**Description**	**Type**	***units* attribute**	***positive* attribute (3D only)**
lon	longitude	double	degrees_east	n/a
Lat	latitude	double	degrees_north	n/a
lev (3D only)	pressure or layer index	double	hPa or layer	Down
time	minutes since reference date & time	int	Minutes	n/a
TAITIME*	Number of seconds since 1993-01-01 00 UTC, including leap	double	n/a	n/a

*- The "TAITIME" variable is included to maintain continuity with earlier GMAO products that used this ECS convention for time. Metadata attributes identify the contents, but a CF-compliant units attribute is NOT included. For CF-compliant time, use "time".

2.2 Variables

GMAO 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*, *_FillValue*, 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
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	Experiment identification.
History	character	Processing history.
Institution	character	“NASA Global Modeling and Assimilation Office”
Source	character	CVS tag of this release. CVS tags are used internally by the GMAO to designate versions of the system.
References	character	GMAO website address
Comment	character	Standard filename of this granule.

3. Instantaneous vs Time-averaged Products

Each file collection listed in Section 6 contains either instantaneous or time-averaged products, but not both.

Most instantaneous collections contain fields written every 3 hours, at *synoptic times* (00 UTC, 06 UTC, 12 UTC, and 18 UTC) and at *mid-synoptic times* (03 UTC, 09 UTC, 15 UTC, and 21 UTC).

Time-averaged collections contain either hourly or three-hourly means, but not mixtures of the two. Each time-averaged collection consists of a continuous sequence of data averaged over the indicated interval and time-stamped with the central time of the interval. For hourly data, these times are 00:30 UTC, 01:30 UTC, 02:30 UTC, etc. Only products consisting exclusively of two-dimensional (horizontal) fields are produced hourly. Three-hourly time-averaged files contain averages over time intervals centered and time stamped at 01:30 UTC, 04:30 UTC, 07:30 UTC, and so on.

Each hourly and three-hourly collection is a series of files, one timestep per file, with the date and time as part of the filename.

4. Grid Structure

4.1 Horizontal Structure

Fields are produced on the model's native horizontal grid, with a resolution of 5/16 degree longitude by 1/4 degree latitude.

The GEOS-5 FP-IT global horizontal grid consists of **IMn=1152** points in the longitudinal direction and **JMn=721** points in the latitudinal direction. The horizontal native grid origin, associated with variables indexed (i=1, j=1) represents a grid point located at (180°W, 90°S). Latitude and longitude of grid points as a function of their indices (i, j) can be determined by:

$$\lambda_i = -180 + (\Delta\lambda)_n (i-1), \quad i = 1, \text{IMn}$$

$$\varphi_j = -90 + (\Delta\varphi)_n (j-1), \quad j = 1, \text{JMn}$$

Where $(\Delta\lambda)_n$=5/16° and $(\Delta\varphi)_n$ = 1/4°. For example, (i = 577, j = 361) corresponds to a grid point at ($\lambda = 0$, $\varphi = 0$).

4.2 Vertical Structure

Gridded products use four different vertical configurations: horizontal-only (can be vertical averages, single level, or surface values), pressure-level, model-level, or model-edge. Horizontal-only data for a given variable appear as 3-dimensional fields (x, y, time), while pressure-level, model-level, or model-edge data appear as 4-dimensional fields (x, y, z, time). In all cases the time dimension spans multiple files, as each file (granule) contains only one time. Pressure-level data is output on the **LMp=42** pressure levels shown in Appendix B. The model layers used for GEOS-5 FP products are on a terrain-following hybrid sigma-p coordinate. Model-level data is output on the **LM=72** layers shown in the second 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. In the GEOS-4 *eta* files, one could compute the pressure on the edges by using the "ak" and "bk" values and the surface pressure. In GEOS-5, the full 3-dimensional pressure variables are explicitly provided through ($DELP_{\mathbf{ijl}}$) and PTOP. Even though the model-level fields are on a hybrid sigma-p coordinate and their vertical location could be obtained from the "ak-bk" relationship, this may change in future GMAO systems. We thus recommend that users rely on the reported 3D pressure distribution, and not use ones computed from the "ak" and "bk".

Note that the indexing for the GEOS-5 FP 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.

5. File Naming Conventions

Each GEOS-5 FP product file will have a complete file name identified in the metadata attribute *comment*. EOSDIS also requires abbreviated naming indices for each Earth Science Data Type (ESDT). Each GEOS-5 FP file collection has a unique ESDT index. The ESDT index convention is described in section 5.2.

5.1 File Names

The standard generic complete name for the assimilated GEOS-5 FP products will appear as follows:

GEOS.config.mode.collection.timestamp.file_ver.nc4

A brief description of the node fields appear below:

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

config:
GEOS-5 runs in multiple operational configurations, targeted at different user communities. This document is specific to a single configuration, fp.

fp – Operational forward-processing assimilation tailored for mission customers and other real-time users, nominally 12 hours behind real-time using a DAS version that is updated more frequently to include the latest advancements. The current horizontal resolution is 5/16 x 1/4 degree.

mode:
GEOS-5 runs both assimilation and forecast jobs for operational forward-processing

asm - Assimilation. Uses a combination of atmospheric data analysis and model forecasting to generate a time-series of global atmospheric quantities.

fcst – Forecast. After atmospheric data assimilation has completed for a given synoptic time, typically at 00z and 12z, a model forecast is used to generate a time-series of forecast products some number of days into the future. Five or ten days is typical.

collection:
All GEOS-5 FP 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 *freq_dims_group_HV*, where the four attributes are:

freq: time-independent (**const**), instantaneous (**inst***F***),** or time-average (**tavg***F*), where *F* indicates the frequency or averaging interval and can be any of the following:

1 = Hourly
3 = 3-Hourly

dims: **2d** for collections with only 2-dimensional fields or **3d** for collections with a mix of 2- and 3-dimensional fields.

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 and time associated with the data in the file. It has the form *yyyymmdd_hhmm* for assimilation files and *yyyymmdd_hh+yyyymmdd_hhmm* for forecast files.

yyyy - year string (e.g. , "2002")
mm - month string (e.g.., "09" for September)
dd - day of the month string
hh – hour (UTC)
mm - minute

The forecast files have two date nodes separated by a '+'. The first date/time node represents the assimilation cycle that initialized the forecast. The second date/time node represents the valid time for the forecasted data within the file. A forecast time-series will contain numerous files with the same initial node while the second node progresses through the time-span of the forecast (typically 5 or 10 days). For example, the following timestamp would represent a 30-hour GCM forecast from an initialization time of 2013-02-01 at 00z: 20130201_00+20130202_0600.

file_ver:
This denotes the file version in the form V##. Under normal conditions ## will be 01. In the event of a processing error that requires a re-processing, this number will be incremented to identify the new version of this file.

nc4:
All files are in NetCDF-4 format, thus the suffix ".nc4".

EXAMPLES
GEOS.fp.asm.tavg1_2d_slv_Nx.20131015_0430.V01.nc4

- fp: forward-processing

- asm: assimilation
- tavg1_2d_slv_Nx: time-averaged 1-hourly data, 2-dimensional, single-level parameters on the native resolution grid.
- 20131015_0430: valid time is 04:30 GMT, which represents the center point of a 1-hour time-averaging period from 04:00 GMT to 05:00 GMT.

GEOS.fp.fcst.inst3_3d_asm_Np.20131001_12+20131005_1500.V01.nc4

- fp – forward processing
- fcst – forecast product
- inst3_3d_asm_Np: instantaneous 3-hourly data, 3-dimensional, assimilation parameters on the native resolution grid.
- 20131001_12+20131005_1500: Forecast initialized at 2013-10-01 12 GMT. The valid time for the data in this file is 2013-10-05 15 GMT. This file represents a 99-hour forecast.

5.2 Earth Science Data Types (ESDT) Name

As required by the EOSDIS system, all GEOS-5 FP products are identified by a relatively short ESDT name. While GEOS-5 FP products are not currently distributed from the GES DISC, we have retained the ESDT designations for assimilation products. This name, also known as the ShortName, is a short handle for users to access and order data products. It takes the form:
DFPTFHVGGG
where

T: Time Description:
I = Instantaneous
T = Time-averaged
C = Time-independent

F: Frequency
0 = Time-independent
1 = Hourly
3 = 3-Hourly

H: Horizontal Resolution
N = Native

V: Vertical Location
X = Two-dimensional
P = Pressure
V = model layer center
E = model layer edge

GGG: Group

ASM = assimilated state variables (from the IAU corrector, see Appendix A)
TDT **=** tendencies of temperature
UDT **=** tendencies of eastward and northward wind components
QDT **=** tendencies of specific humidity
ODT **=** tendencies of ozone
LND = land surface variables
FLX **=** surface turbulent fluxes and related quantities
MST = moist processes
CLD = cloud-related quantities
RAD **=** radiation
TRB **=** turbulence
SLV = single level
INT = vertical integrals
CHM **=** chemistry forcing
AER = aerosol diagnostics
ADG = aerosol diagnostics (extended)
LSF = large-scale flux
OCN = ocean
LFO = land-surface forcing
NAV = navigation

6. Summary of GEOS-5 FP file collections

The GEOS-5 FP product is organized into the collections listed below. These are described in detail in the next sections. All data is on the model's native horizontal grid, which is a regular latitude-longitude grid with a spacing of 1/4° in latitude and 5/16° in longitude. Horizontal arrays (1152,721) are ordered by longitude first, with the first point at the Dateline and the South Pole, with the inner index increasing eastward. All 3d collections, except the **inst3_3d_asm_Np**, are on the model's native, hybrid sigma-p vertical grid. See Appendix B for the nominal edge pressures at the top of each layer for a surface pressure of 1000 hPa. Data in the **inst3_3d_asm_Np** are interpolated to the 42 pressure levels defined in Appendix B.

Note that the sizes given are the cumulative sizes for all individual granules that comprise one day of assimilation for each collection. If a collection is produced in forecast mode, the size for the forecast will be the daily number multiplied by the number of days in the forecast, typically 5 or 10. Also note that the list of collections here is not comprehensive. GMAO may produce other special-use collections that are not documented here, but are distributed via the NCCS data portal. This is especially true of forecasts, for which certain collections may be added to support specific mission requirements.

Table 6-1 - List of standard assimilation collections. Collections with F in the 2nd column are also produced in forecast mode.

Name		Description	Approx. Daily Size (MB)
const_2d_asm_Nx		Constant fields	
inst3_3d_asm_Nv	F	Basic assimilated fields from IAU corrector	6,200
inst3_3d_asm_Np	F	Basic assimilated fields from IAU corrector	3,400
inst3_2d_asm_Nx		Miscellaneous 2D assimilated fields from IAU corrector	200
tavg3_3d_asm_Nv	F	Basic assimilated fields from IAU corrector	5,800
tavg3_3d_cld_Nv		Upper-air cloud related diagnostics	2,200
tavg3_3d_mst_Nv		Upper-air diagnostics from moist processes	840
tavg3_3d_mst_Ne		Upper-air diagnostics from moist processes at layer edges	760
tavg3_3d_trb_Ne		Upper-air diagnostics from turbulence at layer edges	4,600
tavg3_3d_rad_Nv		Upper-air diagnostics from radiation	2,300
tavg3_3d_tdt_Nv		Upper-air temperature tendencies by process	5,700
tavg3_3d_udt_Nv		Upper-air wind tendencies by process	6,000
tavg3_3d_qdt_Nv		Upper-air humidity tendencies by process	3,600
tavg3_3d_odt_Nv		Upper-air ozone tendencies by process	2,700
tavg3_3d_lsf_Nv		Upper-air large-scale flux	1,600
tavg3_3d_lsf_Ne		Upper-air large-scale flux at layer edges	1,100
tavg1_2d_slv_Nx	F	Single-level atmospheric state variables	1,200
tavg1_2d_flx_Nx	F	Surface fluxes and related quantities	1,100

tavg1_2d_rad_Nx	F	Surface and TOA radiative fluxes	640
tavg1_2d_lnd_Nx	F	Land related surface quantities	780
tavg1_2d_lfo_Nx	F	2D time-averaged land surface forcings	240
inst1_2d_lfo_Nx	F	2D instantaneous land surface forcings	240
tavg1_2d_ocn_Nx		Ocean related surface quantities	340
tavg3_2d_aer_Nx		2D time-averaged aerosol diagnostics	480
tavg3_2d_adg_Nx		2D time-averaged aerosol diagnostics (extended)	690
tavg3_2d_chm_Nx		2D time-averaged chemistry diagnostics	50
inst3_3d_aer_Nv		3D instantaneous aerosol diagnostics	12,000
inst3_3d_chm_Nv		3D instantaneous chemistry diagnostics	1,500
tavg3_3d_nav_Ne		3D time-averaged navigation files (layer edges)	430
tavg3_3d_nav_Nv		3D time-averaged navigation files	430

Estimated total 67.1 GB

Time-independent Variables

These are prescribed 2-dimensional fields that do not vary during the analysis. This collection is available as **GEOS.fp.asm.const_2d_asm_Nx.00000000_0000.V01.nc4**.

const_2d_asm_Nx

ECS short name:	DFPC0NXASM
ECS long name:	FP 2d constants
Characteristics:	time invariant
Dimensions:	longitude: 1152, latitude: 721

Variable Name	**Description**	**Units**
PHIS	Surface geopotential	$m^2\ s^{-2}$
SGH	Standard deviation of topography for gravity wave drag	m
FRLAKE	Fraction of lake type in grid box	1
FRLAND	Fraction of land type in grid box	1
FRLANDICE	Fraction of land ice type in grid box	1
FROCEAN	Fraction of ocean in grid box	1
AREA	Area of grid box	m^2

Time-dependent State Variables and Diagnostics

These histories are produced from the GCM during the last pass of the forward model during the analysis cycle. For the 3D-Var scheme currently used in FP, they are from the “corrector” segment of the IAU cycle.

inst3_3d_asm_Nv

ECS short name:	DFPI3NVASM
ECS long name:	FP 3d assimilated state on native levels
Characteristics:	Instantaneous, model layers (center)
Dimensions:	longitude: 1152, latitude: 721, native levels: 72
Times:	00:00, 03:00, 06:00, 09:00, 12:00, 15:00, 18:00, 21:00 UTC

Variable Name	Description	Units
SLP	Sea-level pressure	Pa
PS	Surface pressure	Pa
PHIS	Surface Geopotential	$m^2 s^{-2}$
DELP	Layer pressure thickness	Pa
PL	Layer pressure	Pa
H	Geopotential height	m
O3	Ozone mixing ratio	$kg\ kg^{-1}$
QV	Specific humidity	$kg\ kg^{-1}$
QL	Cloud liquid water mixing ratio	$kg\ kg^{-1}$
QI	Cloud ice mixing ratio	$kg\ kg^{-1}$
RH	Relative humidity	1
T	Air temperature	K
U	Eastward wind component	$m\ s^{-1}$
V	Northward wind component	$m\ s^{-1}$
EPV	Ertel potential vorticity	$K\ m^2\ kg^{-1} s^{-1}$
OMEGA	Vertical pressure velocity	$Pa\ s^{-1}$
CLOUD	Cloud fraction	1

inst3_3d_asm_Np

ECS short name:	DFPI3NPASM
ECS long name:	FP 3d assimilated state on pressure levels
Characteristics:	Instantaneous, on pressure levels
Dimensions:	longitude: 1152, latitude: 721, native levels: 42
Times:	00:00, 03:00, 06:00, 09:00, 12:00, 15:00, 18:00, 21:00 UTC

Variable Name	Description	Units
SLP	Sea-level pressure	Pa
PS	Surface pressure	Pa
PHIS	Surface Geopotential	$m^2 s^{-2}$
H	Geopotential height	m
O3	Ozone mixing ratio	$kg\ kg^{-1}$
QV	Specific humidity	$kg\ kg^{-1}$
QL	Cloud liquid water mixing ratio	$kg\ kg^{-1}$
QI	Cloud ice mixing ratio	$kg\ kg^{-1}$
RH	Relative humidity	1
T	Air temperature	K
U	Eastward wind component	$m\ s^{-1}$
V	Northward wind component	$m\ s^{-1}$
EPV	Ertel potential vorticity	$K\ m^2 kg^{-1} s^{-1}$
OMEGA	Vertical pressure velocity	$Pa\ s^{-1}$

inst3_2d_asm_Nx

ECS short name:	DFPI3NXASM
ECS long name:	FP 2d assimilated state
Characteristics:	Instantaneous, single-level
Dimensions:	longitude: 1152, latitude: 721
Times:	00:00, 03:00, 06:00, 09:00, 12:00, 15:00, 18:00, 21:00 UTC

Variable Name	Description	Units
SLP	Sea-level pressure	Pa
PS	Surface pressure	Pa
U10M	Eastward wind at 10 m above displacement height	$m\ s^{-1}$
U2M	Eastward wind at 2 m above the displacement height	$m\ s^{-1}$
U50M	Eastward wind at 50 m above surface	$m\ s^{-1}$
V10M	Northward wind at 10 m above the displacement height	$m\ s^{-1}$
V2M	Northward wind at 2 m above the displacement height	$m\ s^{-1}$
V50M	Northward wind at 50 m above surface	$m\ s^{-1}$
T10M	Temperature at 10 m above the displacement height	K
T2M	Temperature at 2 m above the displacement height	K
QV10M	Specific humidity at 10 m above the displacement hght	$kg\ kg^{-1}$
QV2M	Specific humidity at 2 m above the displacement height	$kg\ kg^{-1}$
TS	Surface skin temperature	K
DISPH	Displacement height	m
TROPPV	PV based tropopause pressure	Pa
TROPPT	T based tropopause pressure	Pa
TROPPB	Blended tropopause pressure	Pa
TROPT	Tropopause temperature	K
TROPQ	Tropopause specific humidity	$kg\ kg^{-1}$
TQV	Total column water vapor	$kg\ m^{-2}$
TQL	Total column cloud liquid water	$kg\ m^{-2}$
TQI	Total column cloud ice	$kg\ m^{-2}$
TOX	Total column odd oxygen	$kg\ m^{-2}$

TO3	Total column ozone	Dobson

tavg3_3d_asm_Nv

ECS short name:	DFPT3NVASM
ECS long name:	FP 3d assimilated state on native levels
Characteristics:	Time-averaged, model layers (center)
Dimensions:	longitude: 1152, latitude: 721
Times:	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

Variable Name	**Description**	**Units**
SLP	Sea-level pressure	Pa
PS	Surface pressure	Pa
PHIS	Surface Geopotential	$m^2 s^{-2}$
DELP	Layer pressure thickness	Pa
T	Air temperature	K
QV	Specific humidity	$kg\ kg^{-1}$
QL	Cloud liquid water mixing ratio	$kg\ kg^{-1}$
QI	Cloud ice mixing ratio	$kg\ kg^{-1}$
U	Eastward component of wind	$m\ s^{-1}$
V	Northward component of wind	$m\ s^{-1}$
OMEGA	Vertical pressure velocity	$Pa\ s^{-1}$
H	Geopotential height	m
RH	Relative humidity	1
O3	Ozone mixing ratio	$kg\ kg^{-1}$
EPV	Ertel potential vorticity	$K\ m^2\ kg^{-1} s^{-1}$

tavg3_3d_cld_Nv

ECS short name:	DFPT3NVCLD
ECS long name:	FP 3d cloud diagnostics
Characteristics:	Time averaged, model layers (center)
Dimensions:	longitude: 1152, latitude: 721, levels: 72
Times:	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

Variable Name	Description	Units
PS	Surface pressure	Pa
DELP	Layer pressure thickness	Pa
DTRAIN	Detraining mass flux	kg m^{-2} s^{-1}
RH	Relative humidity	1
QLLS	Cloud liquid water mixing ratio – large-scale	kg kg^{-1}
QILS	Cloud ice mixing ratio – large-scale	kg kg^{-1}
QLAN	Cloud liquid water mixing ratio – anvils	kg kg^{-1}
QIAN	Cloud ice mixing ratio – anvils	kg kg^{-1}
QCCU	Cloud condensate mixing ratio – convective updraft	kg kg^{-1}
CFLS	3-D Cloud fraction – large scale	1
CFAN	3-D Cloud fraction – anvils	1
CFCU	3-D Cloud fraction – convective	1
TAUCLW	3-D Cloud optical thickness of water clouds	1
TAUCLI	3-D Cloud optical thickness of ice clouds	1

tavg3_3d_mst_Nv

ECS short name:	DFPT3NVMST
ECS long name:	FP 3d moist processes diagnostics
Characteristics:	Time averaged, model layers (center)
Dimensions:	longitude: 1152, latitude: 721, levels: 72
Times:	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

Variable Name	**Description**	**Units**
PS	Surface pressure	Pa
DELP	Layer pressure thickness	Pa
DQRCU	Precipitation production rate – convective	$kg\ kg^{-1}\ s^{-1}$
DQRLSAN	Precipitation production rate - large-scale+anvil	$kg\ kg^{-1}\ s^{-1}$
REEVAPCN	Evaporation of precipitating convective condensate	$kg\ kg^{-1}\ s^{-1}$
REEVAPLSAN	Evaporation of precipitating LS & anvil condensate	$kg\ kg^{-1}\ s^{-1}$

tavg3_3d_mst_Ne

ECS short name:	DFPT3NEMST
ECS long name:	FP 3d moist processes diagnostics at edges
Characteristics:	Time averaged, model layers (edge)
Dimensions:	longitude: 1152, latitude: 721, levels: 73
Times:	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

Variable Name	**Description**	**Units**
PLE	Air pressure	Pa
CMFMC	Upward moist convective mass flux	kg m^{-2} s^{-1}
PFLCU	Downward flux of liquid precipitation – convective	kg m^{-2} s^{-1}
PFICU	Downward flux of ice precipitation – convective	kg m^{-2} s^{-1}
PFLLSAN	Downward flux of liquid precipitation - large-scale+anvil	kg m^{-2} s^{-1}
PFILSAN	Downward flux of ice precipitation - large-scale+anvil	kg m^{-2} s^{-1}

tavg3_3d_rad_Nv

ECS short name:	DFPT3NVRAD
ECS long name:	FP 3d radiation diagnostics
Characteristics:	Time averaged, model layers (center)
Dimensions:	longitude: 1152, latitude: 721, levels: 72
Times:	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

Variable Name	**Description**	**Units**
PS	Surface pressure	Pa
DELP	Layer pressure thickness	Pa
CLOUD	Cloud fraction	1
DTDTLWR	T tendency from terrestrial radiation	$K\ s^{-1}$
DTDTLWRCLR	T tendency from terrestrial radiation (clear sky)	$K\ s^{-1}$
DTDTSWR	T tendency from solar radiation	$K\ s^{-1}$
DTDTSWRCLR	T tendency from solar radiation (clear sky)	$K\ s^{-1}$

tavg3_3d_trb_Ne

ECS short name:	DFPT3NETRB
ECS long name:	FP 3d turbulence diagnostics
Characteristics:	Time averaged, model layers (edge)
Dimensions:	longitude: 1152, latitude: 721, levels: 73
Times:	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

Variable Name	**Description**	**Units**
PLE	Air pressure	Pa
KM	Momentum diffusivity	$m^2 s^{-1}$
KMLS	Momentum diffusivity from Louis	$m^2 s^{-1}$
KMLK	Momentum diffusivity from Lock	$m^2 s^{-1}$
KH	Heat (scalar) diffusivity	$m^2 s^{-1}$
KHLS	Heat (scalar) diffusivity from Louis	$m^2 s^{-1}$
KHLK	Heat (scalar) diffusivity from Lock	$m^2 s^{-1}$
KHRAD	Heat (scalar) diffusivity Lock radiative contribution	$m^2 s^{-1}$
KHSFC	Heat (scalar) diffusivity Lock surface contribution	$m^2 s^{-1}$
RI	Richardson Number	Nondimensional

tavg3_3d_tdt_Nv

ECS short name:	DFPT3NVTDT
ECS long name:	FP 3d temperature tendencies
Characteristics:	Time averaged, model layers (center)
Dimensions:	longitude: 1152, latitude: 721, levels: 72
Times:	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

Variable Name	**Description**	**Units**
PS	Surface pressure	Pa
DELP	Layer pressure thickness	Pa
DTDTRAD	Temperature tendency from radiation	$K\ s^{-1}$
DTDTMST	Temperature tendency from moist physics	$K\ s^{-1}$
DTDTTRB	Temperature tendency from turbulence	$K\ s^{-1}$
DTDTFRI	Temperature tendency from frictional heating	$K\ s^{-1}$
DTDTGWD	Temperature tendency from gravity wave drag	$K\ s^{-1}$
DTDTTOT	Temperature tendency from physics	$K\ s^{-1}$
DTDTDYN	Temperature tendency from dynamics	$K\ s^{-1}$
DTDTANA	Temperature tendency from analysis	$K\ s^{-1}$
DTDTFRIC	Temperature tendency from moist proc. friction	$K\ s^{-1}$

tavg3_3d_udt_Nv

ECS short name:	DFPT3NVUDT
ECS long name:	FP 3d wind tendencies
Characteristics:	Time averaged, model layers (center)
Dimensions:	longitude: 1152, latitude: 721, levels: 72
Times:	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

Variable Name	**Description**	**Units**
PS	Surface pressure	Pa
DELP	Layer pressure thickness	Pa
DUDTMST	U-wind tendency from moist physics	$m\ s^{-2}$
DUDTTRB	U-wind tendency from turbulence	$m\ s^{-2}$
DUDTGWD	U-wind tend from gravity wave drag	$m\ s^{-2}$
DUDTDYN	U-wind tendency from dynamics	$m\ s^{-2}$
DUDTANA	U-wind tendency from analysis	$m\ s^{-2}$
DVDTMST	V-wind tendency from moist physics	$m\ s^{-2}$
DVDTTRB	V-wind tendency from turbulence	$m\ s^{-2}$
DVDTGWD	V-wind tend from gravity wave drag	$m\ s^{-2}$
DVDTDYN	V-wind tendency from dynamics	$m\ s^{-2}$
DVDTANA	V-wind tendency from analysis	$m\ s^{-2}$

tavg3_3d_qdt_Nv

ECS short name:	DFPT3NVQDT
ECS long name:	FP 3d moisture tendencies
Characteristics:	Time averaged, model layers (center)
Dimensions:	longitude: 1152, latitude: 721, levels: 72
Times:	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

Variable Name	Description	Units
PS	Surface pressure	Pa
DELP	Layer pressure thickness	Pa
DQVDTMST	Water vapor tendency from moist physics	$kg\ kg^{-1}\ s^{-1}$
DQVDTTRB	Water vapor tendency from turbulence	$kg\ kg^{-1}\ s^{-1}$
DQVDTCHM	Water vapor tendency from chemistry	$kg\ kg^{-1}\ s^{-1}$
DQVDTDYN	Water vapor tendency from dynamics	$kg\ kg^{-1}\ s^{-1}$
DQVDTANA	Water vapor tendency from analysis	$kg\ kg^{-1}\ s^{-1}$
DQIDTMST	Ice tendency from moist physics	$kg\ kg^{-1}\ s^{-1}$
DQIDTTRB	Ice tendency from turbulence	$kg\ kg^{-1}\ s^{-1}$
DQIDTDYN	Ice tendency from dynamics	$kg\ kg^{-1}\ s^{-1}$
DQLDTMST	Liquid water tendency from moist physics	$kg\ kg^{-1}\ s^{-1}$
DQLDTTRB	Liquid tendency from turbulence	$kg\ kg^{-1}\ s^{-1}$
DQLDTDYN	Liquid tendency from dynamics	$kg\ kg^{-1}\ s^{-1}$

tavg3_3d_odt_Nv

ECS short name:	DFPT3NVODT
ECS long name:	FP 3d ozone tendencies
Characteristics:	Time averaged, model layers (center)
Dimensions:	longitude: 1152, latitude: 721, levels: 72
Times:	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

Variable Name	Description	Units
PS	Surface pressure	Pa
DELP	Layer pressure thickness	Pa
DOXDTMST	Ozone tendency from moist physics	$kg\ kg^{-1}\ s^{-1}$
DOXDTTRB	Ozone tendency from turbulence	$kg\ kg^{-1}\ s^{-1}$
DOXDTCHM	Ozone tendency from chemistry	$mol\ mol^{-1}\ s^{-1}$
DOXDTDYN	Ozone tendency from dynamics	$kg\ kg^{-1}\ s^{-1}$
DOXDTANA	Ozone tendency from analysis	$1e\text{-}6\ s^{-1}$

tavg3_3d_lsf_Nv

ECS short name:	DFPT3NVLSF
ECS long name:	FP 3d large-scale flux
Characteristics:	Time averaged, model layers (center)
Dimensions:	longitude: 1152, latitude: 721, levels: 72
Times:	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

Variable Name	**Description**	**Units**
PS	Surface pressure	Pa
DELP	Layer pressure thickness	Pa
MFXC	Pressure-weighted eastward wind	Pa m^2 s^{-1}
MFYC	Pressure-weighted northward wind	Pa m^2 s^{-1}

tavg3_3d_lsf_Ne

ECS short name:	DFPT3NELSF
ECS long name:	FP 3d large-scale flux at edges
Characteristics:	Time averaged, model layers (edge)
Dimensions:	longitude: 1152, latitude: 721, levels: 73
Times:	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

Variable Name	**Description**	**Units**
PLE	Air pressure	Pa
MFZ	Vertical mass flux	kg m^2 s^{-1}

tavg1_2d_slv_Nx

ECS short name:	DFPT1NXSLV
ECS long name:	FP 2d single level diagnostics
Characteristics:	Time averaged, single level
Dimensions:	longitude: 1152, latitude: 721
Times:	0:30, 1:30, 2:30, 3:30, 4:30, …, 23:30 UTC

Variable Name	Description	Units
SLP	Sea level pressure	Pa
PS	Surface pressure	Pa
U850	Eastward wind at 850 hPa	$m\ s^{-1}$
U500	Eastward wind at 500 hPa	$m\ s^{-1}$
U250	Eastward wind at 250 hPa	$m\ s^{-1}$
V850	Northward wind at 850 hPa	$m\ s^{-1}$
V500	Northward wind at 500 hPa	$m\ s^{-1}$
V250	Northward wind at 250 hPa	$m\ s^{-1}$
T850	Temperature at 850 hPa	K
T500	Temperature at 500 hPa	K
T250	Temperature at 250 hPa	K
Q850	Specific humidity at 850 hPa	$kg\ kg^{-1}$
Q500	Specific humidity at 500 hPa	$kg\ kg^{-1}$
Q250	Specific humidity at 250 hPa	$kg\ kg^{-1}$
H1000	Height at 1000 hPa	m
H850	Height at 850 hPa	m
H500	Height at 500 hPa	m
H250	Height at 250 hPa	m
OMEGA500	Vertical pressure velocity at 500 hPa	$Pa\ s^{-1}$
U10M	Eastward wind at 10 m above displacement height	$m\ s^{-1}$
U2M	Eastward wind at 2 m above the displacement height	$m\ s^{-1}$
U50M	Eastward wind at 50 m above surface	$m\ s^{-1}$
V10M	Northward wind at 10 m above the displacement height	$m\ s^{-1}$
V2M	Northward wind at 2 m above the displacement height	$m\ s^{-1}$
V50M	Northward wind at 50 m above surface	$m\ s^{-1}$
T10M	Temperature at 10 m above the displacement height	K

T2M	Temperature at 2 m above the displacement height	K
QV10M	Specific humidity at 10 m above the displacement hght	kg kg^{-1}
QV2M	Specific humidity at 2 m above the displacement height	kg kg^{-1}
TS	Surface skin temperature	K
DISPH	Displacement height	m
TROPPV	PV based tropopause pressure	Pa
TROPPT	T based tropopause pressure	Pa
TROPPB	Blended tropopause pressure	Pa
TROPT	Tropopause temperature	K
TROPQ	Tropopause specific humidity	kg kg^{-1}
CLDPRS	Cloud-top pressure	Pa
CLDTMP	Cloud-top temperature	K
TQV	Total column water vapor	kg m^{-2}
TQL	Total column cloud liquid water	kg m^{-2}
TQI	Total column cloud ice	kg m^{-2}
TOX	Total column odd oxygen	kg m^{-2}
TO3	Total column ozone	Dobson
PBLTOP	Pressure at PBL top	Pa

tavg1_2d_flx_Nx

ECS short name:	DFPT1NXFLX
ECS long name:	FP 2d surface flux diagnostics
Characteristics:	Time averaged, single level
Dimensions:	longitude: 1152, latitude: 721
Times:	0:30, 1:30, 2:30, 3:30, 4:30, …, 23:30 UTC

Variable Name	Description	Units
EFLUX	Latent heat flux (positive upward)	$W\ m^{-2}$
EVAP	Surface evaporation	$kg\ m^{-2}\ s^{-1}$
HFLUX	Sensible heat flux (positive upward)	$W\ m^{-2}$
TAUX	Eastward surface wind stress	$N\ m^{-2}$
TAUY	Northward surface wind stress	$N\ m^{-2}$
TAUGWX	Eastward gravity wave surface stress	$N\ m^{-2}$
TAUGWY	Northward gravity wave surface stress	$N\ m^{-2}$
PBLH	Planetary boundary layer height	m
DISPH	Displacement height	m
BSTAR	Surface buoyancy scale	$m\ s^{-2}$
USTAR	Surface velocity scale	$m\ s^{-1}$
TSTAR	Surface temperature scale	K
QSTAR	Surface humidity scale	$kg\ kg^{-1}$
RISFC	Surface Richardson number	1
Z0H	Roughness length, sensible heat	m
Z0M	Roughness length, momentum	m
HLML	Height of center of lowest model layer	m
TLML	Temperature of lowest model layer	K
QLML	Specific humidity of lowest model layer	$kg\ kg^{-1}$
ULML	Eastward wind of lowest model layer	$m\ s^{-1}$
VLML	Northward wind of lowest model layer	$m\ s^{-1}$
RHOA	Surface air density	$kg\ m^{-3}$
SPEED	Effective surface wind speed	$m\ s^{-1}$
CDH	Surface exchange coefficient for heat	$kg\ m^{-2}\ s^{-1}$
CDQ	Surface exchange coefficient for moisture	$kg\ m^{-2}\ s^{-1}$
CDM	Surface exchange coefficient for momentum	$kg\ m^{-2}\ s^{-1}$

CN	Surface neutral drag coefficient	1
TSH	Effective turbulence skin temperature	K
QSH	Effective turbulence skin humidity	kg kg^{-1}
FRSEAICE	Fraction of sea-ice	1
PRECANV	Surface precipitation flux from anvils	kg m^{-2} s^{-1}
PRECCON	Surface precipitation flux from convection	kg m^{-2} s^{-1}
PRECLSC	Surface precipitation flux from large-scale	kg m^{-2} s^{-1}
PRECSNO	Surface snowfall flux	kg m^{-2} s^{-1}
PRECTOT	Total surface precipitation flux	kg m^{-2} s^{-1}
PGENTOT	Total generation of precipitation	kg m^{-2} s^{-1}
PREVTOT	Total re-evaporation of precipitation	kg m^{-2} s^{-1}
FRCLS	Fractional area of large-scale precipitation	fraction
FRCAN	Fractional area of anvil precipitation	fraction
FRCCN	Fractional area of convective precipitation	fraction
NIRDF	Surface downward NIR diffuse flux	W m^{-2}
NIRDR	Surface downward NIR beam flux	W m^{-2}

tavg1_2d_rad_Nx

ECS short name:	DFPT1NXRAD
ECS long name:	FP 2d radiation diagnostics
Characteristics:	Time averaged, single level
Dimensions:	longitude: 1152, latitude: 721
Times:	0:30, 1:30, 2:30, 3:30, 4:30, …, 23:30 UTC

Variable Name	Description	Units
EMIS	Surface emissivity	1
TS	Surface skin temperature	K
ALBEDO	Surface albedo	1
ALBNIRDF	Diffuse beam NIR surface albedo	1
ALBNIRDR	Direct beam NIR surface albedo	1
ALBVISDF	Diffuse beam VIS-UV surface albedo	1
ALBVISDR	Direct beam VIS-UV surface albedo	1
LWGEM	Emitted longwave at the surface	$W\ m^{-2}$
LWGAB	Absorbed longwave at the surface	$W\ m^{-2}$
LWGABCLR	Absorbed longwave at the surface with no clouds	$W\ m^{-2}$
LWGABCLRCLN	Absorbed longwave at the surface with no clouds or aerosol	$W\ m^{-2}$
LWGNT	Net downward longwave flux at the surface	$W\ m^{-2}$
LWGNTCLR	Net downward longwave flux at the surface for cloud-free sky	$W\ m^{-2}$
LWGNTCLRCLN	Net downward longwave flux at the surface for clear sky	$W\ m^{-2}$
LWTUP	Upward longwave flux at top of atmosphere (TOA)	$W\ m^{-2}$
LWTUPCLR	Upward longwave flux at TOA assuming clear sky	$W\ m^{-2}$
LWTUPCLRCLN	Upward longwave flux at TOA assuming clear clean sky	$W\ m^{-2}$
SWTDN	TOA incident shortwave flux	$W\ m^{-2}$
SWGDN	Surface incident shortwave flux	$W\ m^{-2}$
SWGDNCLR	Surface incident shortwave flux assuming clear sky	$W\ m^{-2}$
SWGNT	Surface net downward shortwave flux	$W\ m^{-2}$
SWGNTCLR	Surface net downward shortwave flux assuming clear sky	$W\ m^{-2}$
SWGNTCLN	Surface net downward shortwave flux assuming clean sky	$W\ m^{-2}$
SWGNTCLRCLN	Surface net downward shortwave flux assuming clear clean sky	$W\ m^{-2}$
SWTNT	TOA net downward shortwave flux	$W\ m^{-2}$

SWTNTCLR	TOA net downward shortwave flux assuming clear sky	W m^{-2}
SWTNTCLN	TOA net downward shortwave flux assuming clean sky	W m^{-2}
SWTNTCLRCLN	TOA net downward shortwave flux assuming clear clean sky	W m^{-2}
TAUHGH	Optical thickness of high clouds	1
TAULOW	Optical thickness of low clouds	1
TAUMID	Optical thickness of mid-level clouds	1
TAUTOT	Optical thickness of all clouds	1
CLDHGH	High-level (above 400 hPa) cloud fraction	1
CLDLOW	Low-level (1000-700 hPa) cloud fraction	1
CLDMID	Mid-level (700-400 hPa) cloud fraction	1
CLDTOT	Total cloud fraction	1

tavg1_2d_lnd_Nx

ECS short name:	DFPT1NXLND
ECS long name:	FP 2d land surface diagnostics
Characteristics:	Time averaged, single level
Dimensions:	longitude: 1152, latitude: 721
Times:	0:30, 1:30, 2:30, 3:30, 4:30, …, 23:30 UTC

Variable Name	Description	Units
GRN	Vegetation greenness fraction	1
LAI	Leaf area index	1
GWETPROF	Total profile soil wetness	Fraction
GWETROOT	Root zone soil wetness	1
GWETTOP	Top soil layer wetness	1
PRMC	Total profile soil moisture content	$m^3\ m^{-3}$
RZMC	Root zone soil moisture content	$m^3\ m^{-3}$
SFMC	Top soil layer soil moisture content	$m^3\ m^{-3}$
TSURF	Mean land surface temperature (incl. snow)	K
TPSNOW	Top snow layer temperature	K
TUNST	Surface temperature of unsaturated zone	K
TSAT	Surface temperature of saturated zone	K
TWLT	Surface temperature of wilted zone	K
TSOIL1	Soil temperature in layer 1	K
TSOIL2	Soil temperature in layer 2	K
TSOIL3	Soil temperature in layer 3	K
TSOIL4	Soil temperature in layer 4	K
TSOIL5	Soil temperature in layer 5	K
TSOIL6	Soil temperature in layer 6	K
PRECSNO	Surface snowfall	$kg\ m^{-2}\ s^{-1}$
PRECTOT	Total surface precipitation	$kg\ m^{-2}\ s^{-1}$
SNOMAS	Snow mass	$kg\ m^{-2}$
SNODP	Snow depth	m
EVPSOIL	Bare soil evaporation	$W\ m^{-2}$
EVPTRNS	Latent heat flux due to transpiration	$W\ m^{-2}$
EVPINTR	Interception loss	$W\ m^{-2}$
EVPSBLN	Sublimation	$W\ m^{-2}$

RUNOFF	Overland runoff	kg m^{-2} s^{-1}
BASEFLOW	Baseflow	kg m^{-2} s^{-1}
SMLAND	Snowmelt	kg m^{-2} s^{-1}
QINFIL	Soil water infiltration rate	kg m^{-2} s^{-1}
FRUNST	Fractional unsaturated area	1
FRSAT	Fractional saturated area	1
FRSNO	Fractional snow-covered area	1
FRWLT	Fractional wilting area	1
PARDF	Surface downward PAR diffuse flux	W m^{-2}
PARDR	Surface downward PAR beam flux	W m^{-2}
SHLAND	Sensible heat flux from land	W m^{-2}
LHLAND	Latent heat flux from land	W m^{-2}
EVLAND	Evaporation from land	kg m^{-2} s^{-1}
LWLAND	Net downward longwave flux over land	W m^{-2}
SWLAND	Net downward shortwave flux over land	W m^{-2}
GHLAND	Downward heat flux at base of top soil layer	W m^{-2}
TWLAND	Total water store in land reservoirs	kg m^{-2}
TELAND	Energy store in all land reservoirs	J m^{-2}
WCHANGE	Total land water change per unit time	kg m^{-2} s^{-1}
ECHANGE	Total land energy change per unit time	W m^{-2}
SPLAND	Spurious land energy source	W m^{-2}
SPWATR	Spurious land water source	kg m^{-2} s^{-1}
SPSNOW	Spurious snow source	W m^{-2}

tavg1_2d_lfo_Nx

ECS short name:	DFPT1NXLFO
ECS long name:	FP 2d land surface forcings
Characteristics:	Time averaged, single level
Dimensions:	longitude: 1152, latitude: 721
Times:	0:30, 1:30, 2:30, 3:30, 4:30, …, 23:30 UTC

Variable Name	Description	Units
SWGDN	Surface incident shortwave flux	$W\ m^{-2}$
SWLAND	Net downward shortwave flux over land	$W\ m^{-2}$
LWGAB	Surface absorbed longwave	$W\ m^{-2}$
PRECCU	Liquid precipitation from convection at the surface	$kg\ m^{-2}\ s^{-1}$
PRECLS	Liquid precipitation from large scale processes at the surface	$kg\ m^{-2}\ s^{-1}$
PRECSNO	Frozen precipitation at the surface	$kg\ m^{-2}\ s^{-1}$
PARDF	Surface downward PAR diffuse flux	$W\ m^{-2}$
PARDR	Surface downward PAR beam flux	$W\ m^{-2}$

inst1_2d_lfo_Nx

ECS short name:	DFPI1NXLFO
ECS long name:	FP 2d assimilated state
Characteristics:	Instantaneous, single-level
Dimensions:	longitude: 1152, latitude: 721
Times:	00:00, 01:00, 02:00, 03:00, 14:00, …, 23:00 UTC

Variable Name	**Description**	**Units**
PS	Surface pressure	Pa
HLML	Height of center of lowest model layer	m
TLML	Temperature of lowest model layer	K
QLML	Specific humidity of lowest model layer	$kg\ kg^{-1}$
SPEEDLML	Surface wind speed	$m\ s^{-1}$

tavg1_2d_ocn_Nx

ECS short name:	DFPT1NXOCN
ECS long name:	FP 2d ocean related variables
Characteristics:	Time averaged, single level
Dimensions:	longitude: 1152, latitude: 721
Times:	0:30, 1:30, 2:30, 3:30, 4:30, …, 23:30 UTC

Variable Name	Description	Units
U10M	Eastward wind at 10 m above displacement height	$m\ s^{-1}$
V10M	Northward wind at 10 m above the displacement height	$m\ s^{-1}$
T10M	Temperature at 10 m above the displacement height	K
QV10M	Specific humidity at 10 m above the displacement height	$kg\ kg^{-1}$
HFLUXWTR	Open water upward sensible heat flux	$W\ m^{-2}$
HFLUXICE	Sea ice upward sensible heat flux	$W\ m^{-2}$
EFLUXWTR	Open water latent heat (energy) flux	$W\ m^{-2}$
EFLUXICE	Sea ice latent heat (energy) flux	$W\ m^{-2}$
LWGNTWTR	Open water net downward longwave flux	$W\ m^{-2}$
LWGNTICE	Sea ice net downward longwave flux	$W\ m^{-2}$
SWGNTWTR	Open water net downward shortwave flux	$W\ m^{-2}$
SWGNTICE	Sea ice net downward shortwave flux	$W\ m^{-2}$
PRECSNOOCN	Snowfall over ocean	$kg\ m^{-2}\ s^{-1}$
RAINOCN	Rainfall over ocean	$kg\ m^{-2}\ s^{-1}$
TAUXWTR	Eastward component of surface stress over open water	$N\ m^{-2}$
TAUYWTR	Northward component of surface stress over open water	$N\ m^{-2}$
TAUXICE	Eastward component of surface stress over sea ice	$N\ m^{-2}$
TAUYICE	Northward component of surface stress over sea ice	$N\ m^{-2}$
FRSEAICE	Fraction of ocean covered by sea ice	1

tavg3_2d_aer_Nx

ECS short name:	DFPT3NXAER
ECS long name:	FP 2d aerosol diagnostics
Characteristics:	Time averaged, single level
Dimensions:	longitude: 1152, latitude: 721
Times:	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

Variable Name	Description	Units
BCSMASS	Black Carbon Surface Mass Concentration	kg m^{-3}
BCCMASS	Black Carbon Column Mass Amount	kg m^{-2}
BCEXTTAU	Black Carbon Extinction AOT [550 nm]	1
BCSCATAU	Black Carbon Scattering AOT [550 nm]	1
BCANGSTR	Black Carbon Angstrom parameter [470-870 nm]	1
BCFLUXU	Black Carbon column u-wind mass flux	kg m^{-1} s^{-1}
BCFLUXV	Black Carbon column v-wind mass flux	kg m^{-1} s^{-1}
DUSMASS	Dust Surface Mass Concentration	kg m^{-3}
DUCMASS	Dust Column Mass Density	kg m^{-2}
DUEXTTAU	Dust Extinction AOT [550 nm]	1
DUSCATAU	Dust Scattering AOT [550 nm]	1
DUANGSTR	Dust Angstrom parameter [470-870 nm]	1
DUSMASS25	Dust Surface Mass Concentration - PM 2.5	kg m^{-3}
DUCMASS25	Dust Column Mass Density - PM 2.5	kg m^{-2}
DUEXTT25	Dust Extinction AOT [550 nm] - PM 2.5	1
DUSCAT25	Dust Scattering AOT [550 nm] - PM 2.5	1
DUFLUXU	Dust column u-wind mass flux	kg m^{-1} s^{-1}
DUFLUXV	Dust column v-wind mass flux	kg m^{-1} s^{-1}
SSSMASS	Sea Salt Surface Mass Concentration	kg m^{-3}
SSCMASS	Sea Salt Column Mass Density	kg m^{-2}
SSEXTTAU	Sea Salt Extinction AOT [550 nm]	1
SSSCATAU	Sea Salt Scattering AOT [550 nm]	1
SSANGSTR	Sea Salt Angstrom parameter [470-870 nm]	1
SSSMASS25	Sea Salt Surface Mass Concentration - PM 2.5	kg m^{-3}
SSCMASS25	Sea Salt Column Mass Density - PM 2.5	kg m^{-2}
SSEXTT25	Sea Salt Extinction AOT [550 nm] - PM 2.5	1

SSSCAT25	Sea Salt Scattering AOT [550 nm] - PM 2.5	1
SSFLUXU	Sea Salt column u-wind mass flux	kg m^{-1} s^{-1}
SSFLUXV	Sea Salt column v-wind mass flux	kg m^{-1} s^{-1}
SO2SMASS	SO2 Surface Mass Concentration	kg m^{-3}
SO2CMASS	SO2 Column Mass Density	kg m^{-2}
SO4SMASS	SO4 Surface Mass Concentration	kg m^{-3}
SO4CMASS	SO4 Column Mass Density	kg m^{-2}
DMSSMASS	DMS Surface Mass Concentration	kg m^{-3}
DMSCMASS	DMS Column Mass Density	kg m^{-2}
SUEXTTAU	SO4 Extinction AOT [550 nm]	1
SUSCATAU	SO4 Scattering AOT [550 nm]	1
SUANGSTR	SO4 Angstrom parameter [470-870 nm]	1
SUFLUXU	SO4 column u-wind mass flux	kg m^{-1} s^{-1}
SUFLUXV	SO4 column v-wind mass flux	kg m^{-1} s^{-1}
OCSMASS	Organic Carbon Surface Mass Concentration	kg m^{-3}
OCCMASS	Organic Carbon Column Mass Density	kg m^{-2}
OCEXTTAU	Organic Carbon Extinction AOT [550 nm]	1
OCSCATAU	Organic Carbon Scattering AOT [550 nm]	1
OCANGSTR	Organic Carbon Angstrom parameter [470-870 nm]	1
OCFLUXU	Organic Carbon column u-wind mass flux	kg m^{-1} s^{-1}
OCFLUXV	Organic Carbon column v-wind mass flux	kg m^{-1} s^{-1}
TOTEXTTAU	Total Aerosol Extinction AOT [550 nm]	1
TOTSCATAU	Total Aerosol Scattering AOT [550 nm]	1
TOTANGSTR	Total Aerosol Angstrom parameter [470-870 nm]	1

tavg3_2d_adg_Nx

ECS short name:	DFPT3NXADG
ECS long name:	FP 2d aerosol diagnostics (extended)
Characteristics:	Time averaged, single level
Dimensions:	longitude: 1152, latitude: 721
Times:	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

This collection is intended to be less rigid than the tavg3_2d_aer_Nx collection. Additional variables may be added and existing variables may be dropped as the aerosol assimilation code evolves. Users can expect the tavg3_2d_aer_Nx to remain static from release to release while tavg3_2d_adg_Nx may change.

The current contents of the tavg3_2d_adg_Nx product can be viewed via the GMAO opendap server, currently located at the following URL:
http://opendap.nccs.nasa.gov:9090/dods/GEOS-5/fpit/0.5_deg/assim/tavg3_2d_adg_Nx.info

tavg3_2d_chm_Nx

ECS short name:	DFPT3NXCHM
ECS long name:	FP 2d chemistry diagnostics
Characteristics:	Time averaged, single level
Dimensions:	longitude: 1152, latitude: 721
Times :	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

Variable Name	Description	Units
LWI	Land-Water-Ice Mask (0=land,1=water,2=ice)	1
CO2EM	CO2 Emission	kg m^{-2} s^{-1}
CO2CL	CO2 Column Load	kg m^{-2}
CO2SC	CO2 Surface Concentration	1e-6
COEM	CO Emission	kg m^{-2} s^{-1}
COPD	CO Chemical Production	kg m^{-2} s^{-1}
COLS	CO Chemical Loss	kg m^{-2} s^{-1}
COSC	CO Surface Concentration	1e-9
COCL	CO Column Burden	kg m^{-2}

inst3_3d_aer_Nv

ECS short name:	DFPI3NVAER
ECS long name:	FP 3d aerosol diagnostics
Characteristics:	Instantaneous, model layers (center)
Dimensions:	longitude: 1152, latitude: 721, levels 72
Times:	0:00, 3:00, 6:00, 9:00, 12:00, 15:00, 18:00, 21:00 UTC

Variable Name	Description	Units
PS	Surface pressure	Pa
DELP	Layer pressure thickness	Pa
LWI	Land-Water-Ice Mask (land=0,water=1,ice=2)	1
RH	Relative Humidity	1
AIRDENS	Air Density	kg m^{-3}
DU001	Dust mixing ratio in bin 1	kg kg^{-1}
DU002	Dust mixing ratio in bin 2	kg kg^{-1}
DU003	Dust mixing ratio in bin 3	kg kg^{-1}
DU004	Dust mixing ratio in bin 4	kg kg^{-1}
DU005	Dust mixing ratio in bin 5	kg kg^{-1}
SS001	Sea Salt mixing ratio in bin 1	kg kg^{-1}
SS002	Sea Salt mixing ratio in bin 2	kg kg^{-1}
SS003	Sea Salt mixing ratio in bin 3	kg kg^{-1}
SS004	Sea Salt mixing ratio in bin 4	kg kg^{-1}
SS005	Sea Salt mixing ratio in bin 5	kg kg^{-1}
DMS	DMS mixing ratio	kg kg^{-1}
SO4	SO_4 mixing ratio	kg kg^{-1}
SO2	SO_2 mixing ratio	kg kg^{-1}
MSA	MSA mixing ratio	kg kg^{-1}
BCPHOBIC	Hydrophobic black carbon mixing ratio	kg kg^{-1}
BCPHILIC	Hydrophilic black carbon mixing ratio	kg kg^{-1}
OCPHOBIC	Hydrophobic organic carbon mixing ratio	kg kg^{-1}
OCPHILIC	Hydrophilic organic carbon mixing ratio	kg kg^{-1}

inst3_3d_chm_Nv

ECS short name:	DFPI3NVCHM
ECS long name:	FP 3d chemistry diagnostics
Characteristics:	Instantaneous, model layers (center)
Dimensions:	longitude: 1152, latitude: 721**,** levels 72
Times:	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

Variable Name	**Description**	**Units**
PS	Surface pressure	Pa
DELP	Layer pressure thickness	Pa
AIRDENS	Air Density	kg m^{-3}
CO	Carbon monoxide mixing ratio	mol mol^{-1}
CO2	Carbon dioxide mixing ratio	mol mol^{-1}

tavg3_3d_nav_Nv

ECS short name:	DFPT3NVNAV
ECS long name:	FP 3d navigation data
Characteristics:	Time averaged, model layers (center)
Dimensions:	longitude: 1152, latitude: 721, levels 72
Times:	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

Variable	Description	Units
H	Geopotential height	m
PL	Layer pressure	Pa

tavg3_3d_nav_Ne

ECS short name:	DFPT3NENAV
ECS long name:	FP 3d navigation data at edges
Characteristics:	Time averaged, model layers (edge)
Dimensions:	longitude: 1152, latitude: 721, levels 73
Times:	1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 UTC

Variable Name	Description	Units
ZLE	Geopotential height at edges	m
PLE	Pressure at edges	Pa

7. 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.

7.1 GES DISC Metadata

The following metadata values will be included for each data granule (file):

Name	**Description**
ShortName	Short identifier for each product. Also known as ESDT. (See section 5.2)
VersionID	System version. Example: “5.11.0”
LocalVersionID	Processing version. Usually “V01”.
LocalGranuleID	Filename (See section 5.1)
Format	The data format of the product files. (NetCDF-4)
RangeBeginningDate	Start date of data in the file (YYYY-MM-DD)
RangBeginningTime	Start time of data in the file (hh:mm:ssZ)
RangeEndingDate	End date of data in the file (YYYY-MM-DD)
RangeEndingTime	End time of data in the file (hh:mm:ssZ)
NorthBoundingCoordinate	Northern extent of data grid.
WestBoundingCoordinate	Western extent of data grid.

Name	**Description**
SouthBoundingCoordinate	Southern extent of data grid.
EastBoundingCoordinate	Eastern extent of data grid.

These metadata values will be stored as global file attributes.

7.2 CF Metadata

When visualization tools such as GrADS, that are CF aware, are used to read GEOS-5 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: The IAU procedure

The implementation of the Incremental Analysis Update (IAU, Bloom et al., 1996) used for GEOS-5 is summarized in Figure A.1. Every six hours, at the synoptic times, an analysis is performed using backgrounds at that time, three hours earlier, and three hours later, and assimilating observations during the six-hour period spanned by the three backgrounds. The analysis increments (i.e., the difference between the analysis and the corresponding synoptic background) are then divided by a time scale (currently 6 hours) to produce an "analysis tendency." The model is then "backed-up", restarting it from its state three hours before the analysis time, and run for six hours, adding in the time-invariant "analysis tendency" in addition to its normal physics tendencies. At that point a restart is created that will be used next time the model is backed-up, and the first background for the next analysis cycle is saved. We refer to this first 6-hour run as the "corrector" segment of the IAU. The run is then continued without an analysis tendency for another six hours, saving the other two backgrounds needed by the next analysis---one at the next synoptic time and another at the end of the six hours. We refer to this 6-hour run as the "predictor" segment of the IAU. The entire cycle is then repeated for subsequent synoptic times. Note that during each of the four daily analysis cycles the model is run for 12 hours---a 6-hour "corrector" followed by a 6-hour "predictor."

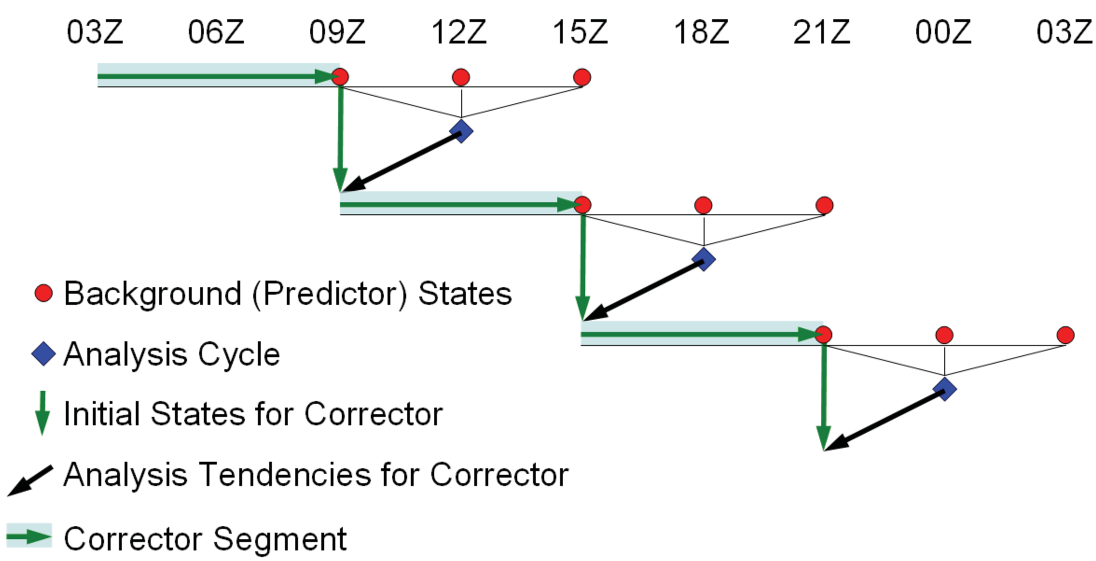


Figure A.1

Except for the analyses themselves, all products from GEOS-5 are produced by the model during the corrector run segment. The sequence of corrector segments (follow the green line in the figure) is a continuous model run, with the extra forcing term from the analysis tendencies. The analysis tendencies do change abruptly every six hours, but state variables are continuous (within the model's time step) solutions of the equations of motion, albeit with the extra forcing term.

Appendix B: Vertical Structure

Pressure-level data will be output on the following 42 pressure levels:

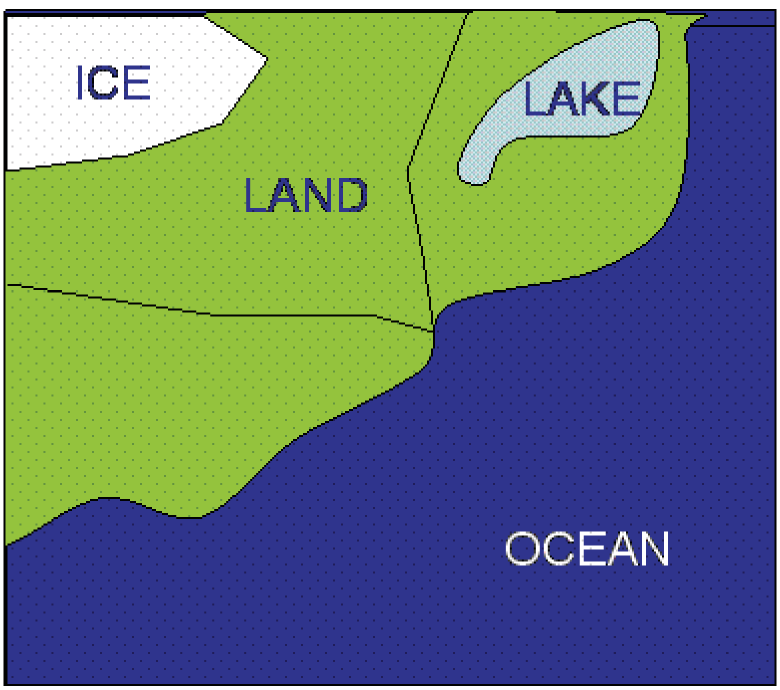
Level	P(hPa)	Level	P(hPa	Level	P(hPa	Level	P(hPa	Level	P(hPa)	Level	P(hPa)
1	1000	8	825	15	600	22	250	29	30	36	2
2	975	9	800	16	550	23	200	30	20	37	1
3	950	10	775	17	500	24	150	31	10	38	0.7
4	925	11	750	18	450	25	100	32	7	39	0.5
5	900	12	725	19	400	26	70	33	5	40	0.4
6	875	13	700	20	350	27	50	34	4	41	0.3
7	850	14	650	21	300	28	40	35	3	42	0.1

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 C: Surface Representation

In GEOS-5 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