National Aeronautics and Space Administration Goddard Earth Science Data Information and Services Center (GES DISC)

README Document for MERRA Data Products

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Revision History

Revision Date	***Changes***	***Author***
08/09/2010	Created new document to replace the old Readme which was written from an earlier draft file spec	D. Ostrenga
07/26/2011	Updated the definition of SPEED in the flx_Nx product. Additional URLs were added for the new Giovanni instances.	D. Ostrenga
12/05/2011	Added the new Ocean Diagnostics product MAT1NXOCN, adjusted some of the formatting of the document and added the files sizes in tables 1 and 2	D. Ostrenga
04/11/2012	Added the new MERRA-Land Land Diagnostics product MST1NXMLD; minor corrections to 'Description' of 'lnd' variables	D. Ostrenga
03/03/2021	Updated the document and data service links, updated help-desk email, replaced MDISC by GES DISC	S. Shen

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1.0 Introduction

This document provides basic information for using MERRA Gridded Output products.

The Modern Era Retrospective-analysis for Research and Applications (MERRA) is a NASA atmospheric data reanalysis for the satellite era using a major new version of the Goddard Earth Observing System Data Assimilation System Version 5 (GEOS-5). MERRA focuses on historical analyses of the hydrological cycle on a broad range of weather and climate time scales, and places the NASA EOS suite of observations in a climate context.

1.1 Dataset/Mission Instrument Description

Observational input for MERRA is the Goddard Earth Observing System Data Assimilation System Version 5 (GEOS-5). See the *Appendix A* and File ***Specification for MERRA Products*** available at GMAO MERRA for a detailed list of MERRA observational input.

Model Description

MERRA focuses on historical analyses of the hydrological cycle on a broad range of weather and climate time scales and places the NASA EOS suite of observations in a climate context.

Details on the MERRA analysis can be found in ***File Specification for MERRA Products*** available at GMAO MERRA.

Applicable Data Products

Table 1 lists the Table 1. MERRA products available through the Goddard Earth Sciences Data and Information Services Center (GES DISC) to which this document applies.

Short Name	Descriptive Short Name	Long Name
Time-independent Variables - These are prescribed 2-dimensional fields that do not vary during the reanalysis.		
MAC0NXASM	const_2d_asm_Nx	MERRA DAS 2d constants
MSC0NXMLD	Const_2d_mld_Nx	MERRA-Land 2d Land surface constants
Analysis Files - These are the fields resulting from the GSI analyses performed at the four synoptic times. They are produced on the native horizontal grid and on both model levels and pressure levels in the vertical. The data on model levels are the values actually analyzed.		

MAI6NVANA	inst6_3d_ana_Nv	MERRA DAS 3d analyzed state
MAI6NPANA	inst6_3d_ana_Np	MERRA DAS 3d analyzed state on pressure
History Files - These histories are produced from the GCM during the "corrector" segment of the IAU cycle. All collections in this group are at reduced horizontal resolution and 3-D fields are on pressure levels.		
MAI3CPASM	inst3_3d_asm_Cp	MERRA IAU 3d assimilated state on pressure
MAT3CPCLD	tavg3_3d_cld_Cp	MERRA IAU 3d cloud diagnostics
MAT3CPMST	tavg3_3d_mst_Cp	MERRA IAU 3d moist processes diagnostic
MAT3CPRAD	tavg3_3d_rad_Cp	MERRA IAU 3d radiation diagnostics
MAT3CPTRB	tavg3_3d_trb_Cp	MERRA IAU 3d turbulence diagnostics
MAT3CPTDT	tavg3_3d_tdt_Cp	MERRA IAU 3d temperature tendencies
MAT3CPUDT	tavg3_3d_udt_Cp	MERRA IAU 3d eastward wind tendencies
MAT3CPQDT	tavg3_3d_qdt_Cp	MERRA IAU 3d moisture tendencies
MAT3CPODT	tavg3_3d_odt_Cp	MERRA IAU 3d ozone tendencies
MAT1NXSLV	tavg1_2d_slv_Nx	MERRA IAU 2d atmospheric single-level diagnostics
MAT1NXFLX	tavg1_2d_flx_Nx	MERRA IAU 2d surface turbulent flux diagnostics
MAT1NXOCN	tavg1_2d_ocn_Nx	MERRA IAU 2d ocean surface diagnostics
MAT1NXRAD	tavg1_2d_rad_Nx	MERRA IAU 2d surface and TOA radiation fluxes
MAT1NXLND	tavg1_2d_lnd_Nx	MERRA IAU 2d land surface diagnostics
MST1NXMLD	Tavg1_2d_mld_Nx	MERRA-Land 2d land surface diagnostics
MAT1NXINT	tavg1_2d_int_Nx	MERRA IAU 2d Vertical integrals

MAI1NXINT	inst1_2d_int_Nx	MERRA IAU 2d Vertical Integrals
MERRAistry Forcing Files - These histories are intended for forcing off-line MERRAistry/aerosol models with the results of the reanalysis. Like other histories, they are produced from the GCM during the "corrector" segment of the IAU cycle.		
MAC0FXCNS	const_2d_chm_Fx	MERRA Constant at native FV resolution
MAT3FVCHM	tavg3_3d_chm_Fv	MERRA IAU 3d Chem On Layers
MAT3FECHM	tavg3_3d_chm_Fe	MERRA IAU 3d Chem On Layer Edges
MAT3FXCHM	tavg3_2d_chm_Fx	MERRA IAU 2d Chem
MAT3NVCHM	tavg3_3d_chm_Nv	MERRA IAU 3d Chem On Layers
MAT3NECHM	tavg3_3d_chm_Ne	MERRA IAU 3d Chem On Layer Edges
MAI3NECHM	inst3_3d_chm_Ne	MERRA IAU 3d Chem On Layer Edges

Table 1. MERRA products available through the Goddard Earth Sciences Data and Information Services Center (GES DISC).

1.2 Data Interpretation/Citation

If you use MERRA data in publications, please acknowledge the Global Modeling and Assimilation Office (GMAO) and the GES DISC for the dissemination of MERRA. Also, we would appreciate receiving a preprint and/or reprint of publications utilizing the data for inclusion in the GMAO/MERRA bibliography. Relevant publications should be sent to:
Head, Global Modeling and Assimilation Office Code 610.1 NASA/Goddard Space Flight Center
Greenbelt, MD 20771

Scales and Offsets

As of September 2nd, 2008, variables are not packed. If and when variables are packed as 16-bit integers, scales and offsets needed to reconstitute the variable will be listed the metadata of the variable's SDS.

To obtain UnpackingScaleFactor and UnpackingOffset from the SDS metadata:

hdp dumpsds –h –c –n <variable name> <MERRA file>

See Appendix D for a list of variable names appropriate for each dataset.

Geolocation

Geolocation information can be view by dumping the appropriate SDS: XDim (longitude), YDim (latitude), and Height (level).

hdp dumpsds -c -n <XDim|YDim|Height> <MERRA file>

Alternatively, the XDim:EOSGRID, YDim:EOSGRID, and Height:EOSGRID SDSs can be dumped to view geolocation information.

The difference between the two set of geolocation SDSs is that the ‘EOSGRID’ SDSs store data as 32-bit floats and specify units as an attribute; the XDim, YDim, and Height SDSs contain 64-bit floats and do not specify units. Both formats of geolocation are used to conform to both COARDS (EOSGRID) and ECS conventions.

Quality Screening and Interpretation

Information pertinent to quality and interpretation—such as missing data flag (missing_value), valid range (valid_range), quality information (AUTOMATICQUALITYFLAG, AUTOMATICQUALITYFLAGEXPLANATION)—can be found in the metadata section of a variables SDS.

To view this information:

hdp dumpsds –h –c –n <variable name> <MERRA file>

2.0 Data Organization

Hourly, three-hourly, and six hourly collections consists of daily files. For collections of monthly or seasonal means, each month or season is in a separate file.

2.1 File Naming Convention

Each GEOS-5 product file will have a complete file name identified in the EOSDIS metadata as "LocalGranuleID". EOSDIS also requires eight-character abbreviated naming indices for each Earth Science Data Type (ESDT). In MERRA each file collection has a unique ESDT index. The ESDT index convention is described below under **Earth Science Data Types (ESDT) Name**.

File Names

The standard full name for the assimilated GEOS-5 MERRA products will consist of five dot-delimited nodes:

runid.runtype.config.collection.timestamp

The node fields, which vary from file to file, are defined as follows:

runid

All MERRA runs will be identified by **MERRA**SVv , where the numeric qualifiers S and Vv denote the production *Stream* and the *Version* numbers.

MERRA will be run in three production *Streams*, each covering approximately a third of the MERRA period, plus overlaps and spin-up periods. If the stream number is not applicable (the case for ancillary products, such as forecasts), *S* is set to 0, otherwise it is 1, 2, or 3.

The *Version* numbers are non-zero when there is more than one version of the dataset. It is usually zero, denoting the original processing. MERRA will be conducted with a frozen assimilation system, so there should be no updates or patches to the GEOS-5 software. Version changes indicate either that a problem was encountered after product release and a reprocessing was necessary (v), or a period was reprocessed with a modified version of the system for scientific studies (V). For any such reprocessing, we will increment the version number appropriately and this will be documented in the metadata parameter "history." Information on version differences will also be available at the MERRA web site (http://gmao.gsfc.nasa.gov/merra/).

runtype:

The main GEOS-5 MERRA products will be from standard production (**prod**) runs. Products from other runs or run segments may be made available for specialized analyses.

prod - Standard product **ovlp**
- Overlap product
spnp - Spin-up product**swep** – Sweeper/Scout product
rosb - Reduced observing system product **cers** - CERES
observing system product

config:

The GEOS-5 analysis and forecast system can run in different configurations.
assim – Assimilation. Uses a combination of atmospheric data analysis and model forecasting to generate a time-series of global atmospheric quantities.
simul – Simulation. Uses a free-running atmospheric model with some prescribed external forcing, such as sea-surface temperatures. For MERRA-Land indicates simulation with prescribed surface meteorological data. **frcst** – Forecasts. Uses a free-running atmospheric model initialized from an analyzed state.

The main configuration used to support MERRA will be assimilation (**assim**). A long, AMIP-style simulation will also be performed and it will be labeled **simul**.

collection:

All MERRA 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 (**cnst**), 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

6 = 6-Hourly

M = Monthly mean

U = Monthly-Diurnal mean

0 = Not Applicable

A *freq* designation of **M** or **U** can apply to either an **inst** or a **tavg** file depending on whether it is a monthly mean of instantaneous or time-averaged data.

dims: **2d** for collections with only 2-dimensional fields or **3d** for collections with a mix of 2- and 3dimensional 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 below in ***Earth Science Data Types (ESDT) Name***

HV: Horizontal and Vertical grid.

H can be:

N: Native (2/3 x 1/2) horizontal resolution

C: Reduced (1.25 x 1.25) horizontal resolution

F: Reduced FV (1.25 x 1) horizontal resolution *V*

can be:

x: horizontal-only data (surface, single level, etc.) ; *dims* must be **2D**

p: pressure-level data (see Table 5.   Levels for pressure-level data) ; *dims* must be **3D v**:

model layer centers (see Table 6. Levels for model-level data) *dims* must be **3D**

e: model layer edges (see GMAO HDF-EOS files will contain two sets of dimension scale (coordinate) information. One set of dimensions is defined using the **SDsetdimscale** function of the standard HDF SD interface. This set of scales will have an attribute named "units," set to an appropriate string defined by the CF and COARDS conventions that can be used by applications to identify the dimension. The other set of dimension scales is created using the **GDdeffield/GDwritefield** functions.

Name	**Description**	**Type**	***units* attribute**
XDim:EOSGRID	Longitude	float32	degrees_east
YDim:EOSGRID	Latitude	float32	degrees_north

Height:EOSGRID (3D only)	pressure or layer index	float32	hPa or layer
TIME:EOSGRID	minutes since first time in file	float32	minutes
XDim	Longitude, in degrees east	float64	N/A
YDim Height (3D only) Time	Latitude, in degrees north pressure or level indices seconds since 00:00Z on 1 January 1993	float64 float64 float64	N/A N/A N/A

Table 4. Dimension Variables Contained in GMAO HDF-EOS Files.

The 32-bit dimension variables have a "units" attribute that makes them COARDS-compliant, while the 64-bit dimension variables satisfy ECS requirements.

Data Profile *dims* must be **3D**

timestamp:

This node defines the date and time associated with the data in the file. It has the form *yyyymmdd* for either instantaneous or time-averaged daily files, *yyyymm* for monthly-mean files.
yyyy - year string (e.g. , "2002") **mm** - month
string (e.g.., "09" for September) **dd** - day of
the month string (optional)

Example:

MERRA300.prod.assim.tavg3_3d_tdt_Cp.20020915.hdf
This is an example of a MERRA filename from the production segment of the original version of the third (most recent) assimilation stream. The data are time-averaged, three-dimensional, temperature tendency products, at reduced horizontal resolution, interpolated to pressure levels.

The file contains all data for 15 September 2002.

Earth Science Data Types (ESDT) Name

To accommodate EOSDIS toolkit requirements, all MERRA files are associated with a nine character ESDT. The ESDT is a short (and rather cryptic) handle for users to access sets of files. In MERRA the ESDT will be used to identify *collections* and will consist of a compressed version of the collection name of the form:

M*CTFHVGGG* where

C: Configuration

A = Assimilation

F = Forecast

S = Simulation *T*:

Time Description:

I = Instantaneous

T = Time-averaged

C = Time-independent

F: Frequency

1 = Hourly

3 = 3-Hourly

6 = 6-Hourly

M = Monthly mean

U = Monthly-Diurnal mean

0 = Not Applicable

H: Horizontal Resolution

N = Native (see Resolution section)

F = Resolution version of model grid (see Resolution section)

C = Reduced resolution (see Resolution section)

V: Vertical Location

X = Two-dimensional

P = Pressure

V = model layer center

E = model layer edge

GGG: Group

ANA = direct analysis products

ASM = assimilated state variables (See Appendix A of ***File Specification for MERRA Products*** available at GMAO MERRA.)

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 = clouds

RAD = radiation

TRB = turbulence

SLV = single level

INT = vertical integrals

CHM = chemistry forcing

2.2 File Format and Structure

GEOS-5 files are in HDF-EOS format, which is an extension of the Hierarchical Data Format Version 4 (HDF-4), developed at the National Center for Supercomputing Applications http://www.hdfgroup.org/. HDF-EOS provides additional capabilities over HDF-4, but does not prevent the use of the files as standard HDF-4 files.

Each GEOS-5 file will contain a single HDF-EOS grid, which in turn contains a number of geophysical quantities that we will refer to as "fields" or "variables." Some files will contain 2-D variables on a longitude-latitude grid, and some files will contain 3-D variables, or a mixture of 2-D and 3-D variables on the same longitude-latitude grid, but with a vertical dimension applicable to all the 3D variables.

The variables are created using the **GDdeffield** function from the HDF-EOS GD (GriD) API, which stores them as HDF Scientific Data Set (SDS) arrays, so that they can be read with standard HDF routines. In addition to the geophysical variables, the files will have SDS arrays that define dimension scales (or coordinate variables). There will be two distinct scales for each dimension, which will ensure that a wide variety of graphical display tools can interpret the data. In particular, there are dimension scales that adhere to the CF conventions, as well as ones that adhere to the COARDS conventions.

Due to the size of the MERRA archive, all data will be compressed with a GRIB-like method that is invisible to the user. This method does degrade 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 HDF-4.

EOS Core System (ECS) metadata and other information are stored as global attributes.

2.3 Key Science Data Fields

Geophysical Parameters

The GEOS-5 MERRA product is organized into the 28 collections listed in Tables 2 and 3. The 21 collections in Table 2 are the "standard" products intended for most diagnostic work. The seven "chemistry" collections in Table 3 are more specialized products, intended for forcing off-line chemistry transport models (CTMs).

Name	**Description**	**Size Gbytes/day // Tbytes**
const_2d_asm_Nx	Constant fields	
const_2d_mld_Nx	Land constants fields	
inst6_3d_ana_Nv	Analyzed fields on model layers	0.452

inst6_3d_ana_Np	Analyzed fields at pressure levels	0.291
inst3_3d_asm_Cp	Basic assimilated fields from IAU corrector	0.231
tavg3_3d_cld_Cp	Upper-air cloud related diagnostics	0.075
tavg3_3d_mst_Cp	Upper-air diagnostics from moist processes	0.056
tavg3_3d_trb_Cp	Upper-air diagnostics from turbulence	0.147
tavg3_3d_rad_Cp	Upper-air diagnostics from radiation	0.088
tavg3_3d_tdt_Cp	Upper-air temperature tendencies by process	0.191
tavg3_3d_udt_Cp	Upper-air wind tendencies by process	0.244
tavg3_3d_qdt_Cp	Upper-air humidity tendencies by process	0.166
tavg3_3d_odt_Cp	Upper-air ozone tendencies by process	0.083
tavg1_2d_slv_Nx	Single-level atmospheric state variables	0.285
tavg1_2d_flx_Nx	Surface turbulent fluxes and related quantities	0.267
tavg1_2d_ocn_Nx	Ocean quantities	0.189
tavg1_2d_rad_Nx	Surface and TOA radiative fluxes	0.146
tavg1_2d_lnd_Nx	Land related surface quantities	0.017
Tavg1_2d_mld_Nx	Land related surface quantities	0.017
tavg1_2d_int_Nx	Vertical integrals of tendencies	1.500
inst1_2d_int_Nx	Vertical integrals of quantities	0.115

Table 2. List of standard collections.

Name	**Description**	**Size Gbytes/day // Tbytes**
const_2d_chm_Fx	2-D invariants on chemistry grid	0.6
tavg3_3d_chm_Fv	Chemistry related 3-D at model layer centers	0.329

tavg3_3d_chm_Fe	Chemistry related 3-D at model layer edges	0.166
tavg3_2d_chm_Fx	Chemistry related 2-DSingle-level	0.020
tavg3_3d_chm_Nv	Accumulated transport fields at layers	0.915
tavg3_3d_chm_Ne	Accumulated transport fields at edges	0.469
inst3_3d_chm_Ne	Instantaneous fields for off-line transport	0.050

Table 3. List of chemistry collections.

3.0 Data Contents

3.1 Dimensions

GMAO HDF-EOS files will contain two sets of dimension scale (coordinate) information. One set of dimensions is defined using the **SDsetdimscale** function of the standard HDF SD interface. This set of scales will have an attribute named “units,” set to an appropriate string defined by the CF and COARDS conventions that can be used by applications to identify the dimension. The other set of dimension scales is created using the **GDdeffield/GDwritefield** functions.

Name	**Description**	**Type**	***units* attribute**
XDim:EOSGRID	Longitude	float32	degrees_east
YDim:EOSGRID	Latitude	float32	degrees_north
Height:EOSGRID	pressure or layer index	float32	hPa or layer
(3D only)			
TIME:EOSGRID	minutes since first time in file	float32	minutes
XDim	Longitude, in degrees east	float64	N/A
YDim Height (3D only) Time	Latitude, in degrees north pressure or level indices seconds since 00:00Z on 1 January 1993	float64 float64 float64	N/A N/A N/A

Table 4. Dimension Variables Contained in GMAO HDF-EOS Files. 0.469

The 32-bit dimension variables have a "units" attribute that makes them COARDS-compliant, while the 64-bit dimension variables satisfy ECS requirements.

Data Profile

Gridded products will use four different vertical configurations: a, *horizontal-only* (can be vertical averages, single level, or surface values); b, *pressure-level*; c, *model-level*; and d, *model-edge*.

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

Table 5. Levels for pressure-level data.

Model-level data will be output on the **LM=72** layers shown below:

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

Table 6. Levels for model-level data.

The model-edge products contain fields with **LMe = LM + 1** levels representing the layer edges.

For more details on MERRA vertical profiling see ***File Specification for MERRA Products*** available at GMAO MERRA.

Resolution

MERRA field are produced on three different horizontal grids: *a*, the native grid of the Finite-Volume dynamical core (FV), with a resolution of 0.66 degree longitude by 0.5 degree latitude; *b*, a coarse version of the FV grid, with a resolution of 1.25 degree longitude by 1 degree latitude; and *c*, and a uniform coarse grid, with a resolution of 1.25 by 1.25 degrees. A detailed discussion of horizontal resolution for MERRA can be found in GMAO document ***File Specification for MERRA Products.*** A link to this document can be found on the GMAO MERRA page.

Each MERRA file collection described in this document contains either instantaneous or time-averaged products, but not both.
All instantaneous collections contain fields at *synoptic times* (00 GMT, 06 GMT, 12 GMT, and 18 GMT). In addition, three-hourly instantaneous collections also include snapshots at *midsynoptic times* (03 GMT, 09 GMT, 15 GMT, and 21 GMT).

Time-averaged collections may contain either hourly, three-hourly, monthly, or seasonal means, but not mixtures of these. 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, for example, these times are 00:30 GMT, 01:30 GMT, 02:30 GMT, 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 GMT, 04:30 GMT, 07:30 GMT, and so on. Monthly files represent averages for the calendar months, accounting for leap years. For monthly means, each file contains a single month.

Short Name	**Descriptive Name**	**Spatial Resolution** (deg lat x deg lon)	**Temporal Resolution** (hours)

MAC0NXCNS	const_2d_asm_Nx	½ x ⅔	time independent
MSC0NXMLD	Const_2d_mld_Nx	½ x ⅔	time independent
MAI6NVANA	inst6_3d_ana_Nv	½ x ⅔	6 (instantaneous)
MAI6NPANA	inst6_3d_ana_Np	½ x ⅔	6 (instantaneous
MAI3CPASM	inst3_3d_asm_Cp	1.25 x 1.25	3 (instantaneous)
MAT3CPCLD	tavg3_3d_cld_Cp	1.25 x 1.25	3 (time averaged)
MAT3CPMST	tavg3_3d_mst_Cp	1.25 x 1.25	3 (time averaged)
MAT3CPTRB	tavg3_3d_trb_Cp	1.25 x 1.25	3 (time averaged)
MAT3CPRAD	tavg3_3d_rad_Cp	1.25 x 1.25	3 (time averaged)
MAT3CPTDT	tavg3_3d_tdt_Cp	1.25 x 1.25	3 (time averaged)
MAT3CPUDT	tavg3_3d_udt_Cp	1.25 x 1.25	3 (time averaged)
MAT3CPQDT	tavg3_3d_qdt_Cp	1.25 x 1.25	3 (time averaged)
MAT3CPODT	tavg3_3d_odt_Cp	1.25 x 1.25	3 (time averaged)
MAT1NXSLV	tavg1_2d_slv_Nx	½ x ⅔	1 (time averaged)
MAT1NXFLX	tavg1_2d_flx_Nx	½ x ⅔	1 (time averaged)
MAT1NXOCN	tavg1_2d_ocn_Nx	½ x ⅔	1 (time averaged)
MAT1NXRAD	tavg1_2d_rad_Nx	½ x ⅔	1 (time averaged)
MAT1NXLND	tavg1_2d_lnd_Nx	½ x ⅔	1 (time averaged)
MST1NXMLD	tavg1_2d_mld_Nx	½ x ⅔	1 (time averaged)
MAT1NXINT	tavg1_2d_int_Nx	½ x ⅔	1 (time averaged)
MAI1NXINT	inst1_2d_int_Nx	½ x ⅔	1 (instantaneous)
MAC0FXCNS	const_2d_chm_Fx	1.0 x 1.25	time independent
MAT3FVCHM	tavg3_3d_chm_Fv	1.0 x 1.25	3 (time averaged)

MAT3FECHM	tavg3_3d_chm_Fe	1.0 x 1.25	3 (time averaged)
MAT3FXCHM	tavg3_2d_chm_Fx	1.0 x 1.25	3 (time averaged)
MAT3NVCHM	tavg3_3d_chm_Nv	½ x ⅔	3 (time averaged)
MAT3NECHM	tavg3_3d_chm_Ne	½ x ⅔	3 (time averaged)
MAI3NECHM	inst3_3d_chm_Ne	½ x ⅔	3 (instantaneous)

Table 7 Summary of resolution for products available through the Goddard Earth Sciences Data and Information Services Center (GES DISC).

3.2 Global Attributes

In addition to SDS arrays containing variables and dimension scales, global metadata is also stored in GMAO HDF-EOS files. Some metadata are required by the CF/COARDS conventions, some are present to meet ECS requirements and others as a convenience to users of GMAO products. A summary of global attributes present in all MERRA files is shown in Table 2.3-1.

	Type	Description
Conventions	character	Identification of the file convention used, currently “CF-1.0”
title	character	Experiment identification: “MERRA”
history	character	CVS tag of this release. CVS tags are used internally by the GMAO to designate versions of the system.
institution	character	“NASA Global Modeling and Assimilation Office”
source	character	CFIO Version (CFIO is the GMAO’s IO layer)
references	character	GMAO website address
comment	character	As required
HDFEOSVersion	character	Version of the HDF-EOS library used to create this file.
StructMetadata.0	character	This is the GridStructure metadata that is created by the HDFEOS library.

CoreMetadata.0 * ArchivedMetadata.0	character character	The ECS inventory metadata. The ECS archive metadata.

Table 8. Global metadata attributes associated with each SDS.

*The following metadata fields are found in the CoreMetadata.0 attribute:

- LOCALGRANULEID**
- LOCALVERSIONID
- PARAMETERNAME**
- AUTOMATICQUALITYFLAG
- AUTOMATICQUALITYFLAGEXPLANATION
- SHORTNAME (ESDT Name)
- VERTICALSPATIALDOMAINTYPE
- VERTICALSPATIALDOMAINVALUE
- WESTBOUNDINGCOORDINATE
- EASTBOUNDINGCOORDINATE
- NORTHBOUNDINGCOORDINATE
- SOUTHBOUNDINGCOORDINATE
- RANGEBEGINNINGTIME**
- RANGEBEGINNINGDATE**
- RANGEENDINGTIME**
- RANGEENDINGDATE**

The following metadata fields are found on the ArchivedMetadata.0 attribute:

- TimesPerDay
- ParameterFormat
- MissingValue
- UnpackingScaleFactor
- UnpackingOffset

To view the CoreMetadata and the ArchivedMetdata attributes:

hdp dumpsds -c –h <MERRA file name>

Key Metadata Fields

A list of key metadata fields can be found in Table 9. Key Metadata Items. These and other metadata fields can found in the ”CoreMetadata.0” global attribute. Global attributes in a MERRA file can be viewed with *ncdump* software: ncdump –h -c <MERRA file>

Field name	**Description**

RANGEBEGINNINGDATE	The date when coverage began.
RANGEBEGINNINGTIME	The time when coverage began
RANGEENDINGDATE	The date when coverage ended.
RANGEENDINGTIME	The time when the granule coverage ended
LOCALGRANULEID	Unique identifier for the granule
PARAMETERNAME	Name of measured parameter

Table 9. Key Metadata Items.

3.3 Products/Parameters

Variables are stored as SDS arrays, even though they are defined with the HDF-EOS **GDdeffield** function. As a result, one can use the SD interface of the HDF library to read any variable from the file. The only thing one must know is the SDS variable name or *short name* of the variable and the number of dimensions (the rank). You can quickly list the variables in the file by using common utilities such as *ncdump* or *hdp (see* **Error! Reference source not found.** below). Both utilities are distributed from NCSA with the HDF library. *Appendix B* ***Error! Reference source not found.*** presents sample code for reading one or more data fields from this file. The *short names* for all variables in all GMAO data products are listed in Appendix D.

A glossary with a brief description of each variable can be found in File ***Specification for MERRA Products*** available at GMAO MERRA

Each variable will have several useful metadata attributes. Many of these attributes are required by the CF and COARDS conventions, while others are specific for GMAO products. The following table lists required attributes. Other attributes may be included for internal GMAO use and can be ignored.

Name	Type	Description
_FillValue	float32	Floating-point value used to identify missing data. Will normally be set to 1e15. Required by CF.
missing_value	float32	Same as _FillValue. Required for COARDS backwards 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
long_name	String	Ad hoc description of the variable. Required by COARDS.

standard_name	String	Standard description of the variable as defined in CF conventions. (See References).
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. As of September 2008, no data is packed, thus the value will be 1.0 units.
add_offset	float32	If variable is packed as 16-bit integers, this is the offset for expanding to floating-point. As of September 2008, no data is packed, thus value will be 0.0.

Table 10. Metadata attributes associated with each SDS.

Products const_2d_asm_Nx

ECS short name: MAC0NXCNS

ECS long name: MERRA DAS 2d constants,

Characteristics: Constant at native resolution

Dimensions: longitude: 540, latitude: 361

Size/file: 5.5 MBytes

Variable Name	Description	Units
PHIS	Surface geopotential	m2 s-2
SGH	Standard deviation of topography for gravity wave drag	m
FRLAKE	Fraction of lake type in grid box	fraction
FRLAND	Fraction of land type in grid box	fraction
FRLANDICE	Fraction of land ice type in grid box	fraction
FROCEAN	Fraction of ocean in grid box	fraction
AREA	Area of grid box	m2

const_2d_mld_Nx

ECS short name: MSC0NXMLD

ECS long name: MERRA-Land 2d land surface constants,

Characteristics: Constant at native resolution

Dimensions: longitude: 540, latitude: 361

Variable Name	Description	Units
DZSF	Thickness of soil layer associated with SFMC and GWETTOP	m
DZRZ	Thickness of soil layer associated with RZMC and GWETROOT	m
DZPR	Thickness of soil layer associated with PRMC and GWETPROF (“depth-to-bedrock” in the Catchment model)	m
DZTS	Thickness of soil layer associated with TSAT, TUNST, and TWLT	m
DZGT1	Thickness of soil layer associated with TSOIL1	m
DZGT2	Thickness of soil layer associated with TSOIL2	m
DZGT3	Thickness of soil layer associated with TSOIL3	m
DZGT4	Thickness of soil layer associated with TSOIL4	m
DZGT5	Thickness of soil layer associated with TSOIL5	m
DZGT6	Thickness of soil layer associated with TSOIL6	m
WPWET	Soil wilting point (in degree of saturation units)	Fraction
WPMC	Soil wilting point (in volumetric units)	m3 m-3
WPEMW	Soil wilting point (in units of equivalent mass of total profile water)	kg m-2

inst6_3d_ana_Nv

ECS short name: MAI6NVANA
ECS long name: MERRA DAS 3d analyzed state,

Characteristics: Instantaneous, on model levels, at native resolution

Dimensions: longitude: 540, latitude: 361, levels: 72 (see Table 5. Levels for pressure-level data)

Times: 00, 06, 12, 18 GMT

Variable Name	Dims	Description	Units
PS	2D	Surface pressure	Pa
DELP	3D	Layer pressure thickness	Pa
T	3D	Air temperature	K
U	3D	Eastward wind component	m s-1
V	3D	Northward wind component	m s-1
QV	3D	Specific humidity	kg kg-1
O3	3D	Ozone mixing ratio	kg kg-1

inst6_3d_ana_Np

ECS short name: MAI6NPANA

ECS long name: MERRA DAS 3d analyzed state on pressure,

Characteristics: Instantaneous, on pressure levels, at native resolution

Dimensions: longitude: 540, latitude: 361, pressure levels: 42 (Table 5. Levels for pressure-level data)

Times: 00, 06, 12, 18 GMT ; monthly and seasonal also available.

Variable Name	Dims	Description	Units
SLP	2D	Sea-level pressure	Pa
PS	3D	Surface pressure	Pa
H	3D	Geopotential height	m
T	3D	Air temperature	K
U	3D	Eastward wind component	m s-1
V	3D	Northward wind component	m s-1
QV	3D	Specific humidity	kg kg-1
O3	3D	Ozone mixing ratio	kg kg-1

inst3_3d_asm_Cp

ECS short name: MAI3CPASM

ECS long name: MERRA IAU 3d assimilated state on pressure,

Characteristics: Instantaneous, on pressure levels, at reduced resolution

Dimensions: longitude: 288, latitude: 144, pressure levels: 42 (see Table 5. Levels for pressure-level data)

Times: 00, 03, 06, 09, 12, 15, 18, 21 GMT ; monthly and seasonal also available

Variable Name	Dims	Description	Units
SLP	2D	Sea-level pressure	Pa
PS	2D	Surface pressure	Pa
PHIS	2D	Surface Geopotential	m2s-2
H	3D	Geopotential height	m
O3	3D	Ozone mixing ratio	kg kg-1
QV	3D	Specific humidity	kg kg-1
QL	3D	Cloud liquid water mixing ratio	kg kg-1
QI	3D	Cloud ice mixing ratio	kg kg-1
RH	3D	Relative humidity	percent
T	3D	Air temperature	K
U	3D	Eastward wind component	m s-1
V	3D	Northward wind component	m s-1
EPV	3D	Ertel potential vorticity	K m2 kg-1s-1
OMEGA	3D	Vertical pressure velocity	Pa sec-1

tavg3_3d_cld_Cp

ECS short name: MAT3CPCLD

ECS long name: MERRA IAU 3d cloud diagnostics,

Characteristics: Time averaged, on pressure levels, at reduced resolution

Dimensions: longitude: 288, latitude: 144, levels: 42 (see Table 5. Levels for pressure-level data)

Times: 1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 GMT ; monthly and seasonal also available

Variable Name	Dims	Description	Units
RH	3D	Relative humidity	Percent
QLLS	3D	Cloud liquid water mixing ratio – large-scale	kg kg-1
QILS	3D	Cloud ice mixing ratio – large-scale	kg kg-1
QLAN	3D	Cloud liquid water mixing ratio – anvils	kg kg-1
QIAN	3D	Cloud ice mixing ratio – anvils	kg kg-1
QCCU	3D	Cloud condensate mixing ratio – convective updraft	kg kg-1
CFLS	3D	3-D Cloud fraction – large scale	fraction
CFAN	3D	3-D Cloud fraction – anvils	fraction
CFCU	3D	3-D Cloud fraction – convective	fraction

tavg3_3d_mst_Cp

ECS short name: MAT3CPMST

ECS long name: MERRA IAU 3d moist processes diagnostic,

Characteristics: Time averaged, on pressure levels, at reduced resolution

Dimensions: longitude: 288, latitude: 144, levels: 42 (see Table 5. Levels for pressure-level data)

Times: 1:30,4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 GMT ; monthly and seasonal also available

Variable Name	Dims	Description	Units
CMFMC	3D	Upward moist convective mass flux	kg m-2 s-1
DQRCU	3D	Precipitation production rate – convective	kg kg-1 s-1
DQRLSAN	3D	Precipitation production rate - large-scale+anvil	kg kg-1 s-1
PFLCU	3D	Downward flux of liquid precipitation – convective	kg m-2 s-1
PFICU	3D	Downward flux of ice precipitation – convective	kg m-2 s-1
PFLLSAN	3D	Downward flux of liquid precip - large-scale+anvil	kg m-2 s-1
PFILSAN	3D	Downward flux of ice precip - large-scale+anvil	kg m-2 s-1
REEVAPCN	3D	Evaporation of precipitating convective condensate	kg kg-1 s-1
REEVAPLSAN	2D	Evaporation of precipitating LS &anvil condensate	kg kg-1 s-1

tavg3_3d_rad_Cp

ECS short name: MAT3CPRAD

ECS long name: MERRA IAU 3d radiation diagnostics,

Characteristics: Time averaged, on pressure levels, at reduced resolution

Dimensions: longitude: 288, latitude: 144, levels: 42 (see Table 5. Levels for pressure-level data)

Times: 1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 GMT ; monthly and seasonal also available

Variable Name	Dims	Description	Units
CLOUD	3D	3-D Cloud fraction	fraction
DTDTLWR	3D	T tendency from terrestrial radiation	K s-1
DTDTLWRCLR	3D	T tendency from terrestrial radiation (clear sky)	K s-1
DTDTSWR	3D	T tendency from solar radiation	K s-1
DTDTSWRCLR	3D	T tendency from solar radiation (clear sky)	K s-1

tavg3_3d_trb_Cp

ECS short name: MAT3CPTRB

ECS long name: MERRA IAU 3d turbulence diagnostics,

Characteristics: Time averaged, on pressure levels, at reduced resolution

Dimensions: longitude: 288, latitude: 144, levels: 42 (see Table 5. Levels for pressure-level data)

Times: 1:30,4:30,7:30,10:30,13:30,16:30,19:30,22:30 GMT; monthly and seasonal also available

Variable Name	Dims	Description	Units
KM	3D	Momentum diffusivity	m2 s-1
KMLS	3D	Momentum diffusivity from Louis	m2 s-1
KMLK	3D	Momentum diffusivity from Lock	m2 s-1
KH	3D	Heat (scalar) diffusivity	m2 s-1

KHLS	3D	Heat (scalar) diffusivity from Louis	m2 s-1
KHLK	3D	Heat (scalar) diffusivity from Lock	m2 s-1
KHRAD	3D	Heat (scalar) diffusivity Lock radiative contribution	m2 s-1
KHSFC	3D	Heat (scalar) diffusivity Lock surface contribution	m2 s-1
RI	3D	Richardson Number	Nondimensional

tavg3_3d_tdt_Cp

ECS short name: MAT3CPTDT

ECS long name: MERRA IAU 3d temperature tendencies,

Characteristics: Time averaged, on pressure levels, at reduced resolution

Dimensions: longitude: 288, latitude: 144, levels: 42 (see Table 5. Levels for pressure-level data)

Times: 1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 GMT ; monthly and seasonal also available

Variable Name	Dims	Description	Units
DTDTRAD	3D	Temperature tendency from radiation	K s-1
DTDTMST	3D	Temperature tendency from moist physics	K s-1
DTDTTRB	3D	Temperature tendency from turbulence	K s-1
DTDTFRI	3D	Temperature tendency from frictional heating	K s-1
DTDTGWD	3D	Temperature tendency from gravity wave drag	K s-1
DTDTTOT	3D	Temperature tendency from physics	K s-1
DTDTDYN	3D	Temperature tendency from dynamics	K s-1
DTDTANA	3D	Temperature tendency from analysis	K s-1

tavg3_3d_udt_Cp

ECS short name: MAT3CPUDT

ECS long name: MERRA IAU 3d eastward wind tendencies,

Characteristics: Time averaged, on pressure levels, at reduced resolution

Dimensions: longitude: 288, latitude: 144, levels: 42 (see Table 5. Levels for pressure-level data)

Times: 1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 GMT ; monthly and seasonal also available

Variable Name	Dims	Description	Units
DUDTMST	3D	U-wind tendency from moist physics	m s-2
DUDTTRB	3D	U-wind tendency from turbulence	m s-2
DUDTGWD	3D	U-wind tend from gravity wave drag	m s-2
DUDTDYN	3D	U-wind tendency from dynamics	m s-2
DUDTDANA	3D	U-wind tendency from analysis	m s-2
DVDTMST	3D	V-wind tendency from moist physics	m s-2
DVDTTRB	3D	V-wind tendency from turbulence	m s-2
DVDTGWD	3D	V-wind tend from gravity wave drag	m s-2
DVDTDYN	3D	V-wind tendency from dynamics	m s-2
DVDTDANA	3D	V-wind tendency from analysis	m s-2

tavg3_3d_qdt_Cp

ECS short name: MAT3CPQDT

ECS long name: MERRA IAU 3d moisture tendencies,

Characteristics: Time averaged, on pressure levels, at reduced resolution

Dimensions: longitude: 288, latitude: 144, pressure levels: 42 (see Table 5. Levels for pressure-level data

Times: 1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 GMT; monthly and seasonal also available

Variable Name	Dims	Description	Units
DQVDTMST	3D	Water vapor tendency from moist physics	kg kg-1 s-1
DQVDTTRB	3D	Water vapor tendency from turbulence	kg kg-1 s-1
DQVDTCHM	3D	Water vapor tendency from chemistry	kg kg-1 s-1
DQVDTDYN	3D	Water vapor tendency from dynamics	kg kg-1 s-1
DQVDTANA	3D	Water vapor tendency from analysis	kg kg-1 s-1
DQIDTMST	3D	Ice tendency from moist physics	kg kg-1 s-1

DQIDTTRB	3D	Ice tendency from turbulence	kg kg-1 s-1
DQIDTDYN	3D	Ice tendency from dynamics	kg kg-1 s-1
DQLDTMST	3D	Liquid water tendency from moist physics	kg kg-1 s-1
DQLDTTRB	3D	Liquid tendency from turbulence	kg kg-1 s-1
DQLDTDYN	3D	Liquid tendency from dynamics	kg kg-1 s-1

tavg3_3d_odt_Cp

ECS short name: MAT3CPODT

ECS long name: MERRA IAU 3d ozone tendencies,

Characteristics: Time averaged, on pressure levels, at reduced resolution

Dimensions: longitude: 288, latitude: 144, levels: 42 (see Table 5. Levels for pressure-level data)

Times: 1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 GMT ; monthly and seasonal also available

Variable Name	Dims	Description	Units
DOXDTMST	3D	Ozone tendency from moist physics	kg kg-1 s-1
DOXDTTRB	3D	Ozone tendency from turbulence	kg kg-1 s-1
DOXDTCHM	3D	Ozone tendency from chemistry	kg kg-1 s-1
DOXDTDYN	3D	Ozone tendency from dynamics	kg kg-1 s-1
DOXDTANA	3D	Ozone tendency from analysis	kg kg-1 s-1

tavg1_2d_slv_Nx

ECS short name: MAT1NXSLV

ECS long name: MERRA IAU 2d atmospheric single-level diagnostics

Characteristics: Time averaged, single-level, at native resolution

Dimensions: longitude: 540, latitude: 361

Times: 0:30, 1:30, 2:30, 3:30, 4:30, … GMT ; monthly and seasonal also available

Variable Name	Description	Units
SLP	Sea level pressure	Pa
PS	Time averaged 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 1000hPa	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 day-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 height	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	Tropopause pressure	Pa
TROPPT	T based tropopause pressure	Pa
TROPPB	Blended tropopause pressure	Pa
TROPQ	Tropopause specific humidity	kg kg-1

TROPT	Tropopause temperature	K
CLDPRS	Cloud-top pressure	Pa
CLDTMP	Cloud-top temperature	K

tavg1_2d_flx_Nx

ECS short name: MAT1NXFLX

ECS long name: MERRA IAU 2d surface turbulent flux diagnostics

Characteristics: Time averaged, single level, at native resolution

Dimensions: longitude: 540, latitude: 361

Times: 0:30, 1:30, 2:30, 3:30, 4:30, … GMT ; monthly and seasonal also available

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-1
USTAR	Surface velocity scale	m s-1
TSTAR	Surface temperature scale	K
QSTAR	Surface humidity scale	kg kg-1
RI	Surface Richardson number	nondimensional
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 including 3d winds and gustiness	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	nondimensional
TSH	Effective turbulence skin temperature	K
QSH	Effective turbulence skin humidity	kg kg-1
FRSEAICE	Fraction of sea-ice	fraction
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

tavg1_2d_ocn_Nx

ECS short name: MAT1NXOCN

ECS long name: MERRA IAU 2d ocean surface diagnostics

Characteristics: Time averaged, single level, at native resolution

Dimensions: longitude: 540, latitude: 361

Times: 0:30, 1:30, 2:30, 3:30, 4:30, … GMT ; monthly and seasonal also available

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

tavg1_2d_rad_Nx

ECS short name: MAT1NXRAD

ECS long name: MERRA IAU 2d surface and TOA radiation fluxes

Characteristics: Time averaged, single level, at native resolution

Dimensions: longitude: 540, latitude: 361

Times: 0:30, 1:30, 2:30, 3:30, 4:30, … GMT ; monthly and seasonal also available

Variable Name	Description	Units
EMIS	Surface emissivity	fraction
TS	Surface skin temperature	K
ALBEDO	Surface albedo	fraction
ALBNIRDF	Diffuse beam NIR surface albedo	fraction
ALBNIRDR	Direct beam NIR surface albedo	fraction
ALBVISDF	Diffuse beam VIS-UV surface albedo	fraction
ALBVISDR	Direct beam VIS-UV surface albedo	fraction

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

tavg1_2d_lnd_Nx

ECS short name: MAT1NXLND

ECS long name: MERRA IAU 2d land surface diagnostics

Characteristics: Time averaged, single level, at native resolution

Dimensions: longitude: 540, latitude: 361

Times: 0:30, 1:30, 2:30, 3:30, 4:30, … GMT ; monthly and seasonal also available

Variable Name	Description	Units
GRN	Vegetation greenness fraction (LAI-weighted)	Fraction
LAI	Leaf area index	m2 m-2
GWETROOT	Root zone soil wetness	fraction
GWETTOP	Top soil layer wetness	fraction
TPSNOW	Top snow layer temperature	K
TUNST	Surface temperature of unsaturated zone (but nonwilting) zone	K
TSAT	Surface temperature of saturated zone	K
TWLT	Surface temperature of wilted zone	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	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 over land	kg m-2 s-1
FRUNST	Fractional unsaturated (but non-wilting) area	fraction
FRSAT	Fractional saturated area	fraction
FRSNO	Fractional snow-covered area	fraction
FRWLT	Fractional wilting area	fraction
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 into 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	J m-2 s-1
SPLAND	Spurious land energy source	W m-2
SPWATR	Spurious land water source	kg m-2 s-1
SPSNOW	Spurious snow energy source	W m-2

***PAR = Photosynthetically Active Radiation*

tavg1_2d_mld_Nx

ECS short name: MST1NXMLD

ECS long name: MERRA-Land 2d land surface diagnostics

Characteristics: Time averaged, single level, at native resolution

Dimensions: longitude: 540, latitude: 361

Times: 0:30, 1:30, 2:30, 3:30, 4:30, … GMT ; monthly and seasonal also available

Variable Name	Description	Units
GRN	Vegetation greenness fraction (LAI-weighted)	Fraction
LAI	Leaf area index	m2 m-2
GWETPROF*	Total profile soil wetness	Fraction
GWETROOT	Root zone soil wetness	Fraction
GWETTOP	Top soil layer wetness	Fraction
PRMC*	Total profile soil moisture content	m3 m-3
RZMC*	Root zone soil moisture content	m3 m-3
SFMC*	Top soil layer soil moisture content	m3 m-3
TSURF*	Mean land surface temperature (incl. snow)	K
TPSNOW	Top snow layer temperature	K
TUNST	Surface temperature of unsaturated (but nonwilting) zone	K
TSAT	Surface temperature of saturated zone	K
TWLT	Surface temperature of wilting 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	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 over land	kg m-2 s-1
QINFIL*	Soil water infiltration rate	kg m-2 s-1
FRUNST	Fractional unsaturated (but non-wilting) area	Fraction
FRSAT	Fractional saturated area	Fraction
FRSNO	Fractional snow-covered area	Fraction
FRWLT	Fractional wilting area	Fraction
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 into top soil layer	W m-2
TWLAND	Total water stored in land reservoirs	kg m-2
TELAND	Energy stored 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 energy source	W m-2

***PAR = Photosynthetically Active Radiation*

tavg1_2d_int_Nx

ECS short name: MAT1NXINT

ECS long name: MERRA IAU 2d Vertical integrals

Characteristics: Time averaged, single level, at native resolution

Dimensions: longitude: 540, latitude: 361

Times: 0:30, 1:30, 2:30, 3:30, 4:30, … GMT ; monthly and seasonal also available

Variable Name	Description	Units
DMDT_ANA	Vertically integrated atmospheric mass tendency for analysis	kg/m2/s
DMDT_DYN	Vertically integrated atmospheric mass tendency for dynamics	kg/m2/s
DQVDT_DYN	Vertically integrated water tendency for dynamics	Kg/m/s
DQVDT_PHY	Vertically integrated water tendency for physics	Kg/m/s
DQVDT_MST	Vertically integrated water tendency for moist	Kg/m/s
DQVDT_TRB	Vertically integrated water tendency for turbulence	Kg/m/s
DQVDT_CHM	Vertically integrated water tendency for chemistry	Kg/m/s
DQVDT_ANA	Vertically integrated water tendency for analysis	Kg/m/s
DQLDT_DYN	Vertically integrated liquid water tendency for dynamics	Kg/m/s
DQLDT_PHY	Vertically integrated liquid water tendency for physics	Kg/m/s
DQLDT_ANA	Vertically integrated liquid water tendency for analysis	Kg/m/s
DQLDT_MST	Vertically integrated liquid water tendency for moist	Kg/m/s

DQIDT_DYN	Vertically integrated ice water tendency for dynamics	Kg/m/s
DQIDT_PHY	Vertically integrated ice water tendency for physics	Kg/m/s
DQIDT_ANA	Vertically integrated ice water tendency for analysis	Kg/m/s
DQIDT_MST	Vertically integrated ice water tendency for moist	Kg/m/s
DOXDT_DYN	Vertically integrated total ozone tendency for dynamics	Kg/m/s
DOXDT_PHY	Vertically integrated total ozone tendency for physics	Kg/m/s
DOXDT_CHM	Vertically integrated total ozone tendency for chemistry	Kg/m/s
DOXDT_ANA	Vertically integrated total ozone tendency for analysis	Kg/m/s
DKDT_DYN	Vertically integrated kinetic energy tendency for dynamics	W/m2
DKDT_PHY	Vertically integrated kinetic energy tendency for physics	W/m2
DKDT_ANA	Vertically integrated kinetic energy tendency for analysis	W/m2
DKDT_PHYPHY	Kinetic energy tendency as computed in physics	W/m2
DHDT_DYN	Vertically integrated cpT tendency for dynamics	W/m2
DHDT_PHY	Vertically integrated cpT tendency for physics	W/m2
DHDT_ANA	Vertically integrated cpT tendency for analysis	W/m2
DHDT_RES	Residual cpT tendency	W/m2
DPDT_DYN	Potential energy tendency for dynamics	W/m2
DPDT_PHY	Potential energy tendency for physics	W/m2
DPDT_ANA	Potential energy tendency for analysis	W/m2
UFLXCPT	Vertically integrated eastward flux of dry enthalpy	J/m/s
VFLXCPT	Vertically integrated northward flux of dry enthalpy	J/m/s
UFLXPHI	Vertically integrated eastward flux of geopotential	J/m/s

VFLXPHI	Vertically integrated northward flux of geopotential	J/m/s
UFLXKE	Vertically integrated eastward flux of kinetic energy	J/m/s
VFLXKE	Vertically integrated northward flux of kinetic energy	J/m/s
UFLXQV	Vertically integrated eastward flux of specific humidity	Kg/m/s
VFLXQV	Vertically integrated northward flux of specific humidity	Kg/m/s
UFLXQL	Vertically integrated eastward flux of liquid condensate	Kg/m/s
VFLXQL	Vertically integrated northward flux of liquid condensate	Kg/m/s
UFLXQI	Vertically integrated eastward flux of ice condensate	Kg/m/s
VFLXQI	Vertically integrated northward flux of ice condensate	Kg/m/s
CONVCPT	Vertically integrated convergence of dry enthalpy	Kg/m/s
CONVPHI	Vertically integrated convergence of geopotential	Kg/m/s

CONVKE	Vertically integrated convergence of kinetic energy	Kg/m/s
CONVTHV	Vertically integrated convergence of potential temperature	Kg/m/s
TEFIXER	Total energy added by artificial energy fixer	W/m2
DKDT_GEN	Generation of kinetic energy	W/m2
DKDT_PG	Kinetic energy tendency due to pressure gradient force	W/m2
DKDT_REMAP	Kinetic energy tendency due to remapping (spurious)	W/m2
DKDT_INRES	Kinetic energy tendency residual from inertial terms (spurious)	W/m2
DKDT_PGRES	Kinetic energy tendency residual from pressure terms(spurious)	W/m2
DKDT_GWD	Kinetic energy tendency due to gravity wave drag (GWD)	W/m2
DKDT_RAY	Kinetic energy tendency due to Rayleighfriction	W/m2

DKDT_BKG	Kinetic energy tendency due to background GWD	W/m2
DKDT_ORO	Kinetic energy tendency due to orographic GWD	W/m2
DKDT_GWDRES	Kinetic energy residual due to errors in GWD (spurious)	W/m2
BKGERR	Energy residual due to errors in background GWD (spurious)	W/m2
DKDT_TRB	Kinetic energy tendency due to turbulence	W/m2
DKDT_SRF	Kinetic energy tendency due to surface friction	W/m2
DKDT_INT	Kinetic energy tendency due to internal friction	W/m2
DKDT_TOP	Kinetic energy tendency due to topographic lowlevel drag	W/m2
DKDT_MST	Kinetic energy tendency due to moist processes	W/m2
DHDT_REMAP	Virtual enthalpy change due to remapping	W/m2
DHDT_GWD	Virtual enthalpy change due to all gravity wave drag processes	W/m2
DHDT_RAY	Virtual enthalpy change due to Rayleigh friction	W/m2
DHDT_BKG	Virtual enthalpy change due to background gravity wave drag	W/m2
DHDT_ORO	Virtual enthalpy change due to orographic gravity wave drag	W/m2
DHDT_TRB	Virtual enthalpy change due to all turbulent	W/m2
DHDT_MST	Virtual enthalpy change due to all moist processes	W/m2
DHDT_FRI	Virtual enthalpy change due to all friction processes	W/m2
DHDT_RAD	Virtual enthalpy change due to radiation	W/m2
DHDT_CUF	Virtual enthalpy change due to cumulus friction	W/m2

DPDT_REMAP	Potential energy change due to remappin(spurious)	W/m2
QTFILL	Artificial filling of total water	Kg/m2/s
DQVDT_FIL	Artificial filling of water vapor	Kg/m2/s
DQIDT_FIL	Artificial filling of frozen water	Kg/m2/s
DQLDT_FIL	Artificial filling of liquid water	Kg/m2/s
DOXDT_FIL	Artificial filling of odd oxygen	Kg/m2/s
HFLUX	Upward turbulent flux of sensibleheat at the surface	W/m2

EVAP	Upward turbulent flux of water vapor at the surface	Kg/m2/s
PRECCU	Liquid precipitation from convection at the surface	Kg/m2/s
PRECLS	Liquid precipitation from large scale processes at the surface	Kg/m2/s
PRECSN	Frozen precipitation at the surface	Kg/m2/s
DTHDT_ANA	Virtual potential tendency due to analysis	K-kg/m2/s
DTHDT_PHY	Virtual potential tendency due to physics	K-kg/m2/s
DTHDT_DYN	Virtual potential tendency due to dynamics	K-kg/m2/s
DTHDT_REMAP	Virtual potential tendency due to dynamics remapping	K-kg/m2/s
DTHDT_CONSV	Virtual potential tendency due to dynamics conservation	K-kg/m2/s
DTHDT_FIL	Virtual potential tendency due to dynamics water filling	K-kg/m2/s
LWTNET	Net Downward longwave radiation at the top of the atmosphere	W/m2
LWGNET	Net Downward longwave radiation at the surface	W/m2
SWNETTOA	Net Downward shortwave radiation at the top of the atmosphere	W/m2
SWNETSRF	Net Downward shortwave radiation at the surface	W/m2
LSCNVCL	Large-scale conversion of water vapor to cloud liquid	Kg/m2/s
LSCNVCI	Large-scale conversion of water vapor to cloud ice	Kg/m2/s
LSCNVRN	Large-scale conversion of water vapor to liquid precipitation	Kg/m2/s
CUCNVCL	Convective conversion of water vapor to cloud liquid	Kg/m2/s
CUCNVCI	Convective conversion of water vapor to cloud ice	Kg/m2/s
CUCNVRN	Convective conversion of water vapor to liquid precipitation	Kg/m2/s
EVPCL	Evaporation of cloud liquid water	Kg/m2/s
EVPRN	Evaporation of rain liquid water	Kg/m2/s
SUBCI	Sublimation of cloud ice	Kg/m2/s

SUBSN	Sublimation of frozen precipitation	Kg/m2/s
AUTCNVRN	Auto conversion of cloud liquid water to liquid precipitation	Kg/m2/s
SDMCI	Sedimentation of cloud ice	Kg/m2/s
COLCNVRN	Conversion of cloud liquid water to rain through collection	Kg/m2/s
COLCNVSN	Conversion of cloud liquid water to snow through collection	Kg/m2/s
FRZCL	Net freezing of cloud water	Kg/m2/s
FRZRN	Net freezing of rain water	Kg/m2/s

inst1_2d_int_Nx

ECS short name: MAI1NXINT

ECS long name: MERRA IAU 2d Vertical integrals

Characteristics: Instantaneous, single level, at native resolution

Dimensions: longitude: 540, latitude: 361

Times : 0, 1, 2, 3, 4, …,23 GMT monthly and seasonal also available

Variable Name	Description	Units
TQV	Total water vapor	kg m-2
TQI	Total cloud ice water	kg m-2
TQL	Total cloud liquid water	kg m-2
TOX	Total column odd oxygen	kg m-2
MASS	Atmospheric Mass	kg m-2
KE	Kinetic Energy	J m-2
CPT	Dry enthalpy	J m-2
THV	Virtual potential temperature	K

const_2d_chm_Fx

ECS short name: AC0FXCNS

ECS long name: MERRA CHM 2d constants,

Characteristics: Constant at native FV resolution

Dimensions: longitude: 288, latitude: 181

Variable Name	Description	Units
PHIS	Surface geopotential	m2 s-2
SGH	Standard deviation of topography for gravity wave drag	m
FRLAKE	Fraction of lake type in grid box	fraction
FRLAND	Fraction of land type in grid box	fraction
FRLANDICE	Fraction of land ice type in grid box	fraction
FROCEAN	Fraction of ocean in grid box	fraction

tavg3_3d_chm_Fv

ECS short name: MAT3FVCHM

ECS long name: MERRA IAU 3d Chem On Layers

Characteristics: Time averaged, 3D model levels, at reduced FV resolution

Dimensions: longitude: 288, latitude: 181, levels: 72 (see Table 6. Levels for model-level data)

Times: 1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 GMT

Variable Name	Description	Units
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
CFLS	Large-scale cloud fraction	fraction
CFAN	Anvil cloud fraction	fraction
CFCU	Convective cloud fraction	fraction
DQRCON	Precipitation production rate – convective	kg kg-1 s-1
DQRLSC	Precipitation production rate - large-scale	kg kg-1 s-1
DQRANV	Precipitation production rate - anvils	kg kg-1 s-1

DTRAIN	Detrainment cloud mass flux	kg m-2 s-1
TAUCLI	Layer ice cloud optical thickness	nondimensional
TAUCLW	Layer liquid cloud optical thickness	nondimensional

tavg3_3d_chm_Fe

ECS short name: MAT3FECHM

ECS long name: MERRA IAU 3d Chem On Layer Edges

Characteristics: Time averaged, 3D model levels, at reduced FV resolution

Dimensions: longitude: 288, latitude: 181, levels: 73 (see Table 6. Levels for model-level data)

Times: 1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 GMT

Variable Name	Description	Units
MFZ	Upward resolved mass flux	kg m-2 s-1
CMFMC	Upward moist convective mass flux	kg m-2 s-1
PFLLSAN	Liquid large-scale plus anvil precipitation	kg m-2 s-1
PFILSAN	Ice large-scale plus anvil precipitation	kg m-2 s-1
PFLCU	Liquid convective precipitation	kg m-2 s-1
PFICU	Ice convective precipitation	kg m-2 s-1
KH	Total scalar diffusivity	m2 s-1

tavg3_2d_chm_Fx

ECS short name: MAT3FXCHM

ECS long name: MERRA IAU 2d Chem

Characteristics: Time averaged, single-level, at reduced FV resolution

Dimensions: longitude: 288, latitude: 181

Times: 1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 GMT ; monthly and seasonal also available

Variable Name	Description	Units
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
FRCLS	Fractional area of large-scale precipitation	Fraction
FRCAN	Fractional area of anvil precipitation	Fraction
FRCCN	Fractional area of convective precipitation	Fraction
PRECSNO	Surface snowfall flux	kg m-2 s-1
TS	Surface skin temperature	K
QV2M	Specific humidity 2 m above displacement height	kg kg-1
T2M	Temperature 2 m above displacement height	K
U10M	Eastward wind 10 m above displacement height	mM s-1
V10M	Northward wind 10 m above the displacement height	mM s-1
PARDF	Surface downward PAR diffuse flux	W m-2
PARDR	Surface downward PAR beam flux	W m-2
NIRDF	Surface downward NIR diffuse flux	W m-2
NIRDR	Surface downward NIR beam flux	W m-2
LWGNET	Surface net downward longwave flux	W m-2
SWGNET	Net surface downward shortwave flux	W m-2
LWGDWN	Surface downward longwave flux	W m-2
SWGDWN	Surface downward shortwave flux	W m-2
EVAP	Surface evaporation	kg m-2 s-1
HFLUX	Sensible heat flux (positive upward)	W m-2
GWETROOT	Root zone soil wetness	fraction
GWETTOP	Top soil layer wetness	fraction
CLDHGH	High-level (above 400 hPa) cloud fraction	fration
CLDLOW	Low-level (1000-700 hPa) cloud fraction	fraction
CLDMID	Mid-level (700-400 hPa) cloud fraction	fraction
CLDTOT	Total cloud fraction	fraction
PBLH	Planetary boundary layer height above surface	m
PBLTOP	Pressure at PBL top	Pa
PS	Surface pressure	Pa

tavg3_3d_chm_Nv

ECS short name: MAT3NVCHM

ECS long name: MERRA IAU 3d Chem On Layers

Characteristics: Time averaged, 3D model levels, at native resolution

Dimensions: longitude: 540, latitude: 361, model levels: 72 (see Table 6. Levels for model-level data)

Times: 1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 GMT

Variable Name	Description	Units
MFXC	Eastward mass flux on C-Grid	Pa m s-1
MFYC	Northward mass flux on C-Grid	Pa m s-1
UC	Eastward component of wind on C-Grid	m s-1
VC	Northward component of wind on C-Grid	m s-1
DTRAIN	Detrainment cloud mass flux	kg m-2 s-1

tavg3_3d_chm_Ne

ECS short name: MAT3NECHM

ECS long name: MERRA IAU 3d Chem On Layer Edges

Characteristics: Time averaged, 3D model levels, at native resolution

Dimensions: longitude: 540, latitude: 361, model levels: 73 (see Table 6. Levels for model-level data)

Times: 1:30, 4:30, 7:30, 10:30, 13:30, 16:30, 19:30, 22:30 GMT

Variable Name	Description	Units
MFZ	Upward mass flux on C-Grid	kg m-2 s-1
CMFMC	Upward moist convective mass flux	kg m-2 s-1
KH	Total scalar diffusivity	m2 s-1

inst3_3d_chm_Ne

ECS short name: MAI3NECHM

ECS long name: MERRA IAU 3d Chem On Layer Edges

Characteristics: Instantaneous, 3D model levels at native resolution

Dimensions: longitude: 540, latitude: 361, model levels: 73 (see Table 6. Levels for model-level data)

Times: 0, 3, 6, 9, 12, 15, 18, 21 GMT

Variable Name	Description	Units
PLE	Edge pressures	Pa

4.0 Options for Reading the Data

4.1 Command Line Utilities

4.1.1 Grads

The Grid Analysis and Display System (GrADS) is a suite of executable well suited for the visualization of MERRA data. MERRA HDF files are self-describing with respect to the gradshdf executable and the sdsopen command within the executable.

GrADS Example

The following brief example demonstrates how to open a MERRA tavg1_2d_slv_Nx and create an image of cloud top temperatures over the eastern United States.

To open the file for reading type 'gradshdf' at the system prompt and choose the landscape or portrait mode.

To open a file type the file name at the GrADS prompt (ga->):

ga-> sdfopen MERRA300.prod.assim.tavg1_2d_slv_Nx.20001231.hdf

GrADS will respond with:

Scanning self-describing file: /var/tmp/MERRA300.prod.assim.tavg1_2d_slv_Nx.20001231.hdf
SDF file MERRA300.prod.assim.tavg1_2d_slv_Nx.20001231.hdf is open as file 1
LON set to 0 360
LAT set to -90 90
LEV set to 0 0
Time values set: 2000:12:31:0 2000:12:31:0

For a brief description of the file as well as a list of parameters available in the file:

ga-> q file
File 1 : MERRA reanalysis. GEOS-5.2.0
 Descriptor: MERRA300.prod.assim.tavg1_2d_slv_Nx.20001231.hdf
 Binary: MERRA300.prod.assim.tavg1_2d_slv_Nx.20001231.hdf
Type = Gridded
 Xsize = 540 Ysize = 361 Zsize = 1 Tsize = 24
Number of Variables = 38 slp 0 -999 Sea
level pressure
 ps 0 -999 Time averaged surface pressure u850 0 -999 Eastward
wind at 850 hPa u500 0 -999 Eastward wind at 500 hPa u250 0 -999
Eastward wind at 250 hPa v850 0 -999 Northward wind at 850 hPa
v500 0 -999 Northward wind at 500 hPa v250 0 -999 Northward wind
at 250 hPa t850 0 -999 Temperature at 850 hPa t500 0 -999
Temperature at 500 hPa t250 0 -999 Temperature at 250 hPa q850 0
-999 Specific humidity at 850 hPa q500 0 -999 Specific humidity at 500
hPa q250 0 -999 Specific humidity at 250 hPa h850 0 -999 Height at
850 hPa h500 0 -999 Height at 500 hPa h250 0 -999 Height at 250
hPa omega500 0 -999 Vertical pressure velocity at 500 hPa u10m 0 -
999 Eastward wind at 10 m above displacement height u2m 0 -999
Eastward wind at 2 m above the displacement height u50m 0 -999
Eastward wind at 50 m above surface v10m 0 -999 Northward wind at
50 m above the displacement height v2m 0 -999 Northward wind at 2
m above the displacement height v50m 0 -999 Northward wind at 50
m above t10m 0 -999 Temperature at 10 m above the displacement
height t2m 0 -999 Temperature at 2 m above the displacement height
qv10m 0 -999 Specific humidity at 10 m above the displacement height
qv2m 0 -999 Specific humidity at 2 m above the displacement height
tsrad 0 -999 Radiative skin temperature disph 0 -999 Displacement
height tropp 0 -999 Tropopause pressure tropt 0 -999 Tropopause
temperature tropq 0 -999 Tropopause specific humidity

To view an image of the Cloud-top temperature (cldtmp):

ga-> d cldtmp

Contouring: 200 to 300 interval 10

This will create an image of the cloud-top temperatures shown as contours in a separate window.

To create a PNG image of the eastern United States in a file called ‘cldtmpUSeast.png’:

ga-> set lat 30, 45 ga-> set lon
-85, -70 ga-> clear ga->d
cldtmp ga-> printim
cldtmpUSeast.png

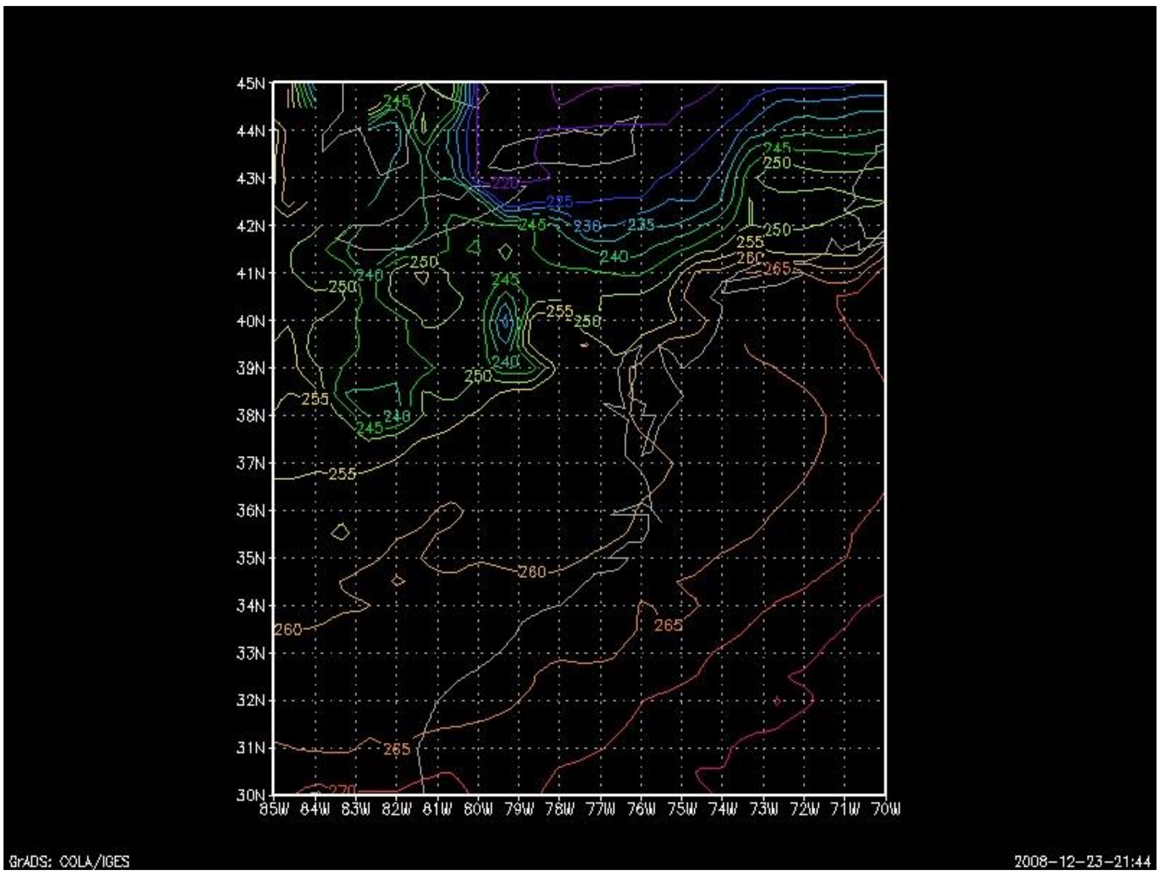

Figure 1 cldtmpUSeast.png

GrADS can do much more than was demonstrated above, including

- Calculating statistical data from variables
- Plotting and overlaying variables
- Comparing datasets
- Regridding data

For more information on Grads visit **http://www.iges.org/grads/** and for more information and to download gradshdf and other grads tools see **http://www.iges.org/grads/downloads.html**.

4.1.2 hdp and ncdump

The HDF Toolkit ships with two binary executables, *hdp* and *ncdump*, that can be used to extract values from any HDF file.

These are also available as standalone executables in the utilities subdirectory for each operating system at:
ftp://ftp.hdfgroup.org/HDF/HDF_Current/bin,
e.g., ftp://ftp.hdfgroup.org/HDF/HDF_Current/bin/linux/utilities.

To dump entire file:

hdp <file name> ncdump
<file name>

To dump an SDS

hdp dumpsds -d -n <SDS name> <MERRA file>

or

ncdump –v <SDS name> <MERRA file>

SDS names are listed in Appendix D and can be obtained from a MERRA file by searching for the string "Variable Name" in the SDS headings, for example:

```
hdp dumpsds -h MERRA300.prod.assim.tavg3_3d_qdt_Cp.20001231.hdf | grep 'Variable Name'
Variable Name = DQVDTMST
Variable Name = DQVDTTRB
Variable Name = DQVDTCHM
Variable Name = DQVDTDYN
Variable Name = DQVDTANA
Variable Name = DQIDTMST
Variable Name = DQIDTTRB
Variable Name = DQIDTDYN
Variable Name = DQLDTMST
Variable Name = DQLDTTRB
Variable Name = DQLDTDYN
Dimension Variable Name = XDim:EOSGRID
Dimension Variable Name = YDim:EOSGRID
```

Dimension Variable Name = Height:EOSGRID
Dimension Variable Name = TIME:EOSGRID
Variable Name = XDim
Variable Name = YDim
Variable Name = Height
Variable Name = Time

4.2 Tools/Programming

The following example illustrates the use of the standard HDF library or the ECS HDF-EOS library to read GEOS-5 products. The program shown below will accept as command line arguments a file name and a field name. It will open the file, read the requested field at the first time, compute an average for this field, and print the result to standard output. There are two versions of this program. The first version uses the HDF-EOS library to read the file. The second version uses the standard HDF library to read the file. Electronic copies of these programs can be obtained from the Operations section of the GMAO web page.

HDF-EOS Example

```
/*****************************************************************************/
/* This program demonstrates how to read a field from a GMAO HDF-EOS */
/* product using the HDF-EOS library. It will take a file name and */
/* field name on the command line, read the first time of the given */
/* field, calculate an average of that time and print the average. */ /*
*/
/* usage: avg <file name> <field name> */
/* */
/* Rob Lucchesi */
/* rob.lucchesi@nasa.gov */
/*****************************************************************************/
#include "hdf.h"
#include "mfhdf.h" #include
<stdio.h> main(int argc,char
*argv[]) { int32 sd_id, sds_id,
status; int32 sds_index; int32
start[4], edges[4], stride[4]; char
*fname, *vname; float32
*data_array; float32 avg, sum;
int32 i; int32 file_id, gd_id; int32
xdim, ydim, zdim, len;
if (argc != 3) {
printf("Usage: avg <filename> <field> \n");
exit (-1);
```

```
}

fname = argv[1]; vname
= argv[2];
/* Open the file (read-only) */ if ( (file_id = GDopen
(fname, DFACC_RDONLY))< 0) { printf ("Could not
open %s\n",fname); exit(-1);
}
/* Attach to the EOS grid contained within the file. */
/* The GMAO uses the generic name "EOSGRID" for the grid in all products. */
if ( (gd_id = GDattach (file_id,"EOSGRID"))< 0) {
printf ("Could not open %s\n",fname); exit(-1);
}
status = GDget(file_id,xdim,ydim,zdim),
/* Set positioning arrays to read the entire field at the first time. */
start[0] = 0; start[1] = 0; start[2] = 0; start[3] = 0; stride[0] = 1;
stride[1] = 1; stride[2] = 1; stride[3] = 1; edges[0] = 1; edges[1] =
zdim; edges[2] = ydim; edges[3] = xdim; len = xdim*ydim*zdim;
data_array = (float32 *)malloc(len); /* Read the data into
data_array */
status = GDreadfield (gd_id, vname, start, stride, edges, data_array); printf
("Read status=%d\n",status);

/* Calculate and print the average */ sum=0.0;
for (i=0; i<len; i++) sum += data_array[i];
avg = sum/(float32)len; printf ("Average of %s in 3
dimensions is=%f\n",vname,avg);
/* Close file. */ status =
GDdetach (gd_id); status =
GDclose (file_id);
}
```

HDF (non EOS) Example

```
/***************************************************************************/
/* This program demonstrates how to read a field from a GMAO HDF-EOS */
/* product using the HDF library (HDF-EOS not required). It will take */
/* a file name and field name on the command line, read the first time */
/* of the given field, calculate an average of that time and print the average. */ /*
*/
/* usage: avg <file name> <field name> */
/* */
/* Rob Lucchesi */
```

```
/* rob.lucchesi@nasa.gov */
/* */
/**************************************************************************/ #include
"hdf.h"
#include "mfhdf.h" #include
<stdio.h> main(int argc,char
*argv[]) { int32 sd_id, sds_id,
status; int32 sds_index; int32
start[4], edges[4], stride[4]; char
*fname, *vname; float32
*data_array; float32 avg, sum;
int32 i, xdim, ydim , zdim, len;
if (argc != 3) { printf("Usage: avg
<filename> <field> \n"); exit (-1);
}
fname = argv[1]; vname
= argv[2];
/* Open the file (read-only) */ if ( (sd_id = SDstart
(fname, DFACC_RDONLY))< 0) { printf ("Could not
open %s\n",fname); exit(-1);
}
/* Find the index and ID of the SDS for the given variable name and get its dimensions. */

if ( (sds_index = SDnametoindex (sd_id, vname)) < 0) {
printf ("Could not find %s\n",vname); exit(-1);
}
sds_id = SDselect (sd_id,sds_index); status
= GDget(file_id,xdim,ydim,zdim),
/* Set positioning arrays to read the entire field at the first time. */
start[0] = 0; start[1] = 0;
start[2] = 0; start[3] = 0; stride[0] =
1; stride[1] = 1; stride[2] = 1;
stride[3] = 1; edges[0] = 1; edges[1]
= zdim; edges[2] = ydim; edges[3] =
xdim; len = xdim*ydim*zdim;
data_array = (float32 *)malloc(len);
/* Read the data into data_array */
status = SDreaddata (sds_id, start, stride, edges, (VOIDP) data_array);
printf ("read status=%d\n",status); /* Calculate and print the average
*/ sum=0.0;
for (i=0; i<len; i++) sum += data_array[i];
avg = sum/(float32)len; printf ("Average of %s in 3
dimensions is=%f\n",vname,avg);
/* Close file. */
```

```
status = SDendaccess (sds_id); status
= SDend (sd_id);
}
```

HDFView

HDFView is a Java based graphical user interface created by the HDF Group which can be used to browse MERRA HDF files. The utility allows users to view all objects in an HDF file hierarchy which is represented as a tree structure.

HDFView software and documentation can be downloaded at HDF Group.

Giovanni

Selected variables have been integrated into on GES DISC online visualization tool https://giovanni.gsfc.nasa.gov/

Search for Platform/Instrument=MERRA Model

5.0 Data Services

You can begin to familiarize yourself with the MERRA data by reading this document and find a data collection that contains your interested variables. Then you may visit the GES DISC Web: http://disc.gsfc.nasa.gov

Browse data by Category => project=> MERRA to see all data collection: (https://disc.gsfc.nasa.gov/datasets?page=1&project=MERRA)

MERRA data is also available through OPeNDAP, GDS, and as data subsets. Links to these services can be found at on the products Data set Landing Pages.

If you need assistance or wish to report a problem, please contact us:

Email: gsfc-dl-help-disc@mail.nasa.gov
Voice: 301-614-5224
Fax: 301-614-5268

Address:

Goddard Earth Sciences Data and Information Services Center
NASA Goddard Space Flight Center
Code 610.2
Greenbelt, MD 20771 USA

6.0 More Information

Bosilovich, Michael, 2008. **NASA's Modern Era Retrospective-analysis for Research and Applications: Integrating Earth Observations**. *Earthzine*. E-Zine Article.
M. Bosilovich, J. Chen, F. R. Robertson and R. F. Adler, 2008. **Evaluation of Global Precipitation in Reanalyses**. *Journal of Applied Meteorology and Climatology*. Journal Article

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Hdp and HDFview were created by the HDF Group.

Ncdump was produced by Unidata

Appendix A: Observational Inputs to MERRA

Data Type	Time Period	Source
Radiosonde	1977 - present	NCEP (Woollen)
Dropsonde	1977 - present	NCEP (Woollen)
Aircraft	1977 - present	NCEP (Woollen)
Pilot Balloon	1977 - present	NCEP (Woollen)
Surface Obs	1977 - present	NCEP (Woollen)
Ship, Buoy	1977 - present	NCEP (Woollen)
Wind Profiler	1992/5/14 - present	UCAR CDAS
PAOB	1978 - present	NCEP CDAS

Table 11. Conventional Observations.

Data Type	Time Period	Source Timeline of TOVS satellite missions
TOVS/tn (TIROS N)	1978/10/30 - 1980/06/01	NCAR/NESDIS
TOVS/na (NOAA 6)	1979/07/02 - 1983/04/17	NCAR
TOVS/nc (NOAA 7)	1981/07/11 - 1986/06/01	NCAR
TOVS/ne (NOAA 8)	1983/04/26 - 1985/01/01	NCAR
TOVS/nf (NOAA 9)	1985/01/01 - 1988/11/01	NCAR
TOVS/ng (NOAA 10)	1986/11/25 - 1991/09/17	NCAR

TOVS/nh (NOAA 11)	1988/09/02 - 1994/12/31	NCAR
TOVS/nd (NOAA 12)	1991/08/18 - 1997/07/14	NCAR
TOVS/nj (NOAA 14)	1995/01/19 - present	NCAR/NESDIS
TOVS/nk (NOAA 15)	1998/07/01 - present	NCAR/NESDIS
TOVS/nl (NOAA 16)	2001/03/02 - present	NCAR/NESDIS
TOVS/nm (NOAA 17)	2003/03/01 - present	NESDIS

Table 12. TOVS Satellite Observations used in full MERRA analysis and Reduced Observing System Baseline.

Data Type	Time Period	Source
SSM/I Radiance	1987 - present	RSS (Wentz V6)
SSM/I rain rate	1987 - present	GPROF
SSM/I winds	1987 - present	RSS (Wentz V6)
TRMM rain rate	1998 - present	NASA GSFC DAAC
AIRS	Oct. 2002 - present	NOAA
SBUV	1978 - present	NASA GSFC code916
Cloud Motion Winds	1977 - present	NCEP (Woollen)
GOES Sounder	Apr 1994 - present	NCEP
QuikScat	July 1999 - present	JPL

ERS-1 and -2	1991/8/5 - 1996/5/21, 1996/3/19 - 2001/1/17	ESA
MODIS Winds	TERRA July 2002 - present, AQUA Sept 2003 - present	NCEP

Table 13. Other Satellite Observations used in full MERRA analysis only.

Data Type	**Time Period**	**Source**
Sea/Ice	1977 - present	Hadley, Reynolds
SST	1977 - present	Hadley, Reynolds

Table 14. Boundary Conditions.