# Global Modeling and Assimilation Office

*GMAO Office Note No. 15 (Version 1.0)*

# File Specification for M2AMIP Products

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

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# File Specification for M2AMIP Products

Document maintained by Allison Collow (GMAO, USRA)

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Approved by:

____________________________________

Steven Pawson Date

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

**REVISION HISTORY**

| Version Number | Revision Date | Extent of Changes |
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| 1.0 | 04/02/2018 | Baseline |

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# 1. Introduction

The Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) is an atmospheric reanalysis computed with the Goddard Earth Observing System, Version 5.12.4 (GEOS) data assimilation system (Gelaro et al., 2017). To supplement the reanalysis, the GEOS General Circulation Model (GCM) used in MERRA-2 has been used to generate a 10-member ensemble of simulations, configured following the convention of the Atmospheric Model Intercomparison Project (AMIP; Gates et al., 1992). Each ensemble member was initialized using meteorological fields from a different date in November 1979. The AMIP simulations used the sea-surface temperature (SST) and sea-ice boundary conditions that were used in MERRA-2 (Bosilovich et al., 2016). This 10-member ensemble of AMIP simulations, denoted M2AMIP, is available for download in a group of self-describing files, which are documented in this office note.

All data collections are provided on the same horizontal grid as MERRA-2. This grid has 576 points in the longitudinal direction and 361 points in the latitudinal direction, corresponding to a resolution of 0.625° x 0.5°. Although data collections are available at this grid, all fields are computed on a cubed-sphere grid with an approximate resolution of 50 km x 50 km and are then spatially interpolated to the latitude-longitude grid. There are no changes in the vertical grids used: variables are provided on either the native vertical grid of 72 model layers, or interpolated to 42 standard pressure levels. Unlike MERRA, no data collections are available at the vertical layer edges. More details on the grid are provided in Section 4.

MERRA-2 introduced observation-based precipitation forcing for the land surface parameterization and the corresponding variable *PRECTOTCORR* in the MERRA-2 FLX and LFO collections (see Section 6; Reichle et al., 2017). While this variable is still available for M2AMIP, there was no observation-based forcing, making the value identical to the model derived precipitation, *PRECTOT*. Similarly, without data assimilation, the values for the analysis increments, D*DTANA, in the tendency and vertically integrated file collections are zero.

The M2AMIP data are available for download online through the NASA Center for Climate Simulation (NCCS) DataPortal (https://portal.nccs.nasa.gov/datashare/gmao_m2amip/). Data are arranged in subdirectories based on ensemble member, followed by year and month. Control files that are compatible with the Grid Analysis and Display System (GrADS) are available in the ctl_daily and ctl_monthly directories for the hourly, three hourly, and monthly mean data. Control files for the monthly mean diurnal cycle can be found in the ctl_diurnal subdirectory within the directory for each individual ensemble member.

2. Format and File Organization

M2AMIP data files are provided in netCDF-4 format, rather than the HDF-5/HDF-EOS format used for MERRA. Since netCDF-4 files are actually HDF-5 files that are structured in a special way, netCDF-4 files can also be read by HDF-5 tools. The data files adhere to the netCDF "classic" data model, which will allow source code used to read older netCDF formats to still work when compiled with the netCDF-4 and HDF-5 libraries. The data products will adhere to the older COARDS metadata conventions and many of the CF metadata conventions, although the files are not fully CF-compliant. The conventions for identifying dimension information are followed, which should allow M2AMIP files to be used by many tools that are CF-compliant.

Due to the size of the M2AMIP archive, most product collections are 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, non-degraded data are not scientifically meaningful. Once the precision has been degraded, the files are written using the standard (internal) Lempel-Ziv deflation available in netCDF-4.

M2AMIP is run on a cube-sphere grid, but these native data are not distributed. Rather, in post-processing the data, it has been interpolated to the regulate latitude-longitude grid discussed in this document. The interpolation includes two options, a conservative remapping (simply a binning routine) and a non-conservative bilinear interpolation. Most variable collections were transformed using the bilinear interpolation. The conservatively remapped file collections are the vertical integrals and aerosol diagnostics, specifically:

tavgM_2d_int_Nx
tavgM_2d_aer_Nx

In some collections, there are duplicate or component variables. For example, net surface longwave radiation is in the time averaged vertical integral collection, while the components are in the 2-D radiation collection. Computing the net surface longwave radiation from the tavgM_2d_rad_Nx files will not precisely equal the net longwave radiation in tavgM_2d_int_Nx, because of the difference in remapping. As a rule of thumb, only the data that have been conservatively remapped will balance to the highest precision.

## *2.1 Dimensions*

Every M2AMIP collection will contain variables that define the dimensions of longitude, latitude, and time. Product collections that contain three-dimensional data will also have a vertical dimension that defines either pressure levels or the index associated with the model level (see section 4.2). Dimension variables 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.

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

| **Name** | **Description** | **Type** | ***units* attribute** |
|---|---|---|---|

| | | | |
|---|---|---|---|
| lon | Longitude | double | degrees_east |
| lat | Latitude | double | degrees_north |
| lev | pressure or layer index | double | hPa or layer |
| time | minutes since first time in file | int | minutes |

## *2.2 Variables*

Variables are stored as HDF-5 dataset objects, which are analogous to the HDF-4 SDS arrays used for MERRA. M2AMIP uses the "classic" netCDF data model and does not use and of the extensions supported by netCDF-4 and the underlying HDF-5 format. This allows applications written to read netCDF files to easily read variables without having to modify code. Variable names are listed in Section 6 along with the number and sizes of dimensions. One can quickly list the variables in the file by using common utilities such as *ncdump,* which is distributed with the netCDF-4 library. With the '-h' flag, this utility will display all information about the file and its contents, including metdata associated with each variable. The variable name is analogous to the *short name* in the M2AMIP HDF-EOS files. A short description of the variable is provided in the *long_name* and *standard_name* metadata parameters.

Each variable has 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.

Table 2.2-1 Metadata attributes associated with each SDS.

| **Name** | **Type** | **Description** |
|---|---|---|
| _FillValue | 32-bit float | Floating-point value used to identify missing data. Normally set to 1e15. Required by CF. |
| missing_value | 32-bit float | Same as _FillValue. Required for COARDS backwards compatibility. |
| valid_range | 32-bit float, 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. In MERRA files these are set to -/+ _FillValue. |
| long_name | String | A brief description of the variable contents taken from the *Description* column of the tables in Appendix D. |
| standard_name | Char 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, but is not strictly CF-compliant. (Eaton et al., 2011; NOAA, 2015). |

| Name | Type | Description |
|---|---|---|
| units | Char String | The units of the variable. Must be a string that can be recognized by UNIDATA's Udunits package. |
| scale_factor | 32-bit float | If variable is packed as 16-bit integers, this is the scale_factor for expanding to floating-point. Currently data are not packed, thus value is 1.0. |
| add_offset | 32-bit float | If variable is packed as 16-bit integers, this is the offset for expanding to floating-point. Currently, data are not packed, thus value is 0.0. |

### *2.3 Global Attributes*

In addition to HDF-5 dataset variables and dimension scales, global metadata is also stored in GMAO netCDF-4 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 M2AMIP files is shown in Table 2.3-1. All global metadata parameters are of type character

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

| Name | Description |
|---|---|
| History | Production/creation date of this file. |
| Comment | Internal/original GMAO filename (for provenance). |
| Filename | Filename of this granule. |
| Conventions | Identification of the file convention used, currently "CF-1.0" |
| Institution | "NASA Global Modeling and Assimilation Office" |
| References | "http://gmao.gsfc.nasa.gov" |
| Format | "NetCDF-4/HDF-5" |
| SpatialCoverage | Global |
| VersionID | The GEOS version used for M2AMIP, "5.12.4". |
| Temporal Range | The beginning and ending dates of M2AMIP. The ending date is assumed but may change. |

| **Name** | **Description** |
|---|---|
| identifier_product_doi_authority | “http://dx.doi.org” |
| Shortname | Product short name used by G-DISC |
| RangeBeginningDate | Date corresponding to the first timestep in this file. |
| RangeBeginningTime | Time corresponding to the first timestep in this file. |
| RangeEndingDate | Date corresponding to the last timestep in this file. |
| RangeEndingTime | Time corresponding to the last timestep in this file. |
| GranuleID | Filename for this product. |
| ProductionDateTime | Production date & time of this granule. |
| LongName | Description of product type. |
| Title | Description of product type. |
| SouthernmostLatitude | “-90.0” |
| NorthernmostLatitue | “90.0” |
| WesternmostLatitude | “-180.0” |
| EasternmostLatitude | “179.375” |
| LatitudeResolution | “0.5” |
| LongitudeResolution | “0.625” |
| DataResolution | Horizontal and vertical resolution of granule. |
| identifier_product_doi | Unique Digital Object Identifier |
| Source | CVS tag associated with GEOS version. |
| Contact | “http://gmao.gsfc.nasa.gov” |

# 3. Instantaneous vs Time-averaged Products

Each file collection listed in Section 6 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 *mid-synoptic times* (03 GMT, 09 GMT, 15 GMT, and 21 GMT). 1-hourly instantaneous diagnostics of some states fields and other weather diagnostics are also provided. Monthly means of instantaneous diagnostics have also been computed.

Time-averaged collections contain hourly, three-hourly, monthly, or monthly diurnal 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. Due to the large amount of disk storage required for the ten ensemble members, sub-monthly files are only available for ensemble member 02. Monthly files represent averages for the calendar months, accounting for leap years. For monthly means, each file contains a single month.

In M2AMIP, a collection is included for certain daily statistics computed from the model time step integration. Daily maximum and minimum temperatures are saved from the time step in which they occur and saved as a daily value, alongside the daily mean temperature (all at 2m above the surface) and daily precipitation.

Each hourly or three-hourly collection, whether instantaneous or time-averaged, consist of a set of daily files, with the date as part of the filename. For collections of monthly or seasonal means each month or season is in a separate file, and file names also include a date in the file name. Monthly means also include certain quadratic information (such as the variance and covariance of certain variables).

# 4. Grid Structure

## *4.1 Horizontal Structure*

In M2AMIP, all fields will be produced on the same 5/8 longitude by ½ latitude grid. The GEOS M2AMIP ***native grid*** is a cubed sphere. The gridded output is on a global horizontal grid, consisting of **IMn=576** points in the longitudinal direction and **JMn=361** 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 ( $\varphi$) and longitude ( $\lambda$) 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 $(\Delta\lambda)_n$=5/8$^{\circ}$ and $(\Delta\varphi)_n$ = 1/2$^{\circ}$. For example, ($i$ = 289, $j$ = 181) 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 with one time in each file. Pressure-level data is output on the **LMp=42** pressure levels shown in Table 4.1. The GEOS model layers used for M2AMIP products are on a terrain-following hybrid sigma-p coordinate. Model-level data will be output on the **LM=72** layers shown in the second table of Table 4.2. 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**. As with MERRA and MERRA-2, 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, the full 3-dimensional pressure variables are explicitly provided through ($DELP_{\mathbf{ijl}}$) and PTOP. For the M2AMIP products documented here, all model-level fields are on a hybrid-sigma coordinate, and their vertical location could be obtained from the "ak-bk" relationship as well. But 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 vertical coordinate system in the vertical 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. In early versions of certain post processing routines, such as the GES DISC Subsetter, may alter meta data and the direction of the vertical grid. While this has likely been addressed in the M2AMIP interface to the data, it is prudent to verify the meta data of downloaded or post processed data.

Table 4.1 Pressure-level data is 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 4.2 Products on the native vertical grid are 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 |

# 5. File Naming Conventions

The filename of each GEOS product will be stored in the metadata parameter GranuleID. Each product also has a 9-character "Shortname" which is specified in the metadata and is often called an Earth Science Data Type (ESDT). In M2AMIP each file collection has a unique ESDT index. The ESDT index convention is described in section 5.2.

## *5.1 File Names*

The standard full name for the assimilated GEOS M2AMIP products will consist of three dot-delimited nodes:

***runid. collection.timestamp***

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

***runid***

All M2AMIP *Mainstream* ensemble members runs will be identified by **m2amip**EE , where the numeric qualifier EE denotes the ensemble member, or "_ens" for the ensemble mean.

***collection*:**

All M2AMIP 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*)**,** statistics (**stat***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
**M** = Monthly mean
**D** = Daily Value (mean or other statistic, only used for **stat**)
**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. As of M2AMIP, the only **D** is **stat**, and vice versa. This was added to incorporate daily statistics to the MERRA-2 output collections.

*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**: Native (5/8 x ½) horizontal resolution

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

**m2amip02.tavgM_3d_tdt_Np.200209.nc4**

This is an example of a M2AMIP filename from the second ensemble member ("m2amip02"). The data are monthly time-averages ("tavgM"), three-dimensional ("3d"), temperature tendency products ("tdt"), at native horizontal resolution and interpolated to pressure levels ("Np"). The file contains 8 the monthly average for September 2002 and is in "nc4" format.

## *5.2 Earth Science Data Types (ESDT) Name*

To accommodate EOSDIS toolkit requirements, all M2AMIP 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 M2AMIP the ESDT will be used to identify the *Mainstream collections* and consists of a compressed version of the collection name of the form:

**M***TFHVGGG*

where

*T*: Time Description:

**I** = Instantaneous
**T =** Time-averaged
**C** = Time-independent
**S** = Statistics

*F*: Frequency

**1** = Hourly
**3** = 3-Hourly
**M** = Monthly mean
**D =** Daily statistics
**U** = Monthly-Diurnal mean
**0 =** Not Applicable

*H*: Horizontal Resolution

**N** = Native

*V*: Vertical Location

**X** = Two-dimensional
**P** = Pressure
**V =** model layer center

*GGG*: Group

**ASM** = assimilated state variables
**INT** = vertical integrals
**LFO** = land surface forcing output
**SLV** = single level
**CSP** = COSP satellite simulator
**FLX =** surface turbulent fluxes and related quantities
**LND** = land surface variables
**OCN** = ocean
**RAD =** radiation
**AER** = aerosol mixing ratio
**TDT =** tendencies of temperature
**UDT =** tendencies of eastward and northward wind components
**QDT =** tendencies of specific humidity
**ODT =** tendencies of ozone
**GLC** = Land Ice Surface
**MST** = moist processes
**CLD** = clouds
**TRB** = turbulence

# 6: M2AMIP data collections

This section lists the variables in each data collection. More details on the variable definitions may be found in the GEOS Variable Definition Glossary, available on the GMAO web page at https://gmao.gsfc.nasa.gov/products/documents/GEOS-5_Filespec_Glossary.pdf. In the tables, variable names refer to HDF names, which are uppercase.

## *Constants*

### const_2d_asm_Nx (M2C0NXASM): Constant Model Parameters

**Frequency:** *constant from 03:00 UTC (time-invariant)*

**Spatial Grid:** *2D, single-level, full horizontal resolution*

**Dimensions:** *longitude=576, latitude=361, time=1*

**Granule Size:** *~1.2 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| AREA | tyx | grid cell area | |
| FRLAKE | tyx | fraction of lake* | 1 |
| FRLAND | tyx | fraction of land | 1 |
| FRLANDICE | tyx | fraction of land ice | 1 |
| FROCEAN | tyx | fraction of ocean | 1 |
| PHIS | tyx | surface geopotential height | $m^2 s^{-2}$ |
| SGH | tyx | isotropic stdv of GWD topography | m |

## *Instantaneous Two-Dimensional Collections*

### instM_2d_asm_Nx (M2I1NXASM): Single-Level Diagnostics

**Frequency:** *Monthly from 00:00 UTC (instantaneous)*

**Spatial Grid:** *2D, single-level, full horizontal resolution*

**Dimensions:** *longitude=576, latitude=361, time=1*

**Granule Size:** *~32 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| DISPH | tyx | zero plane displacement height | m |
| PS | tyx | surface pressure | Pa |
| QV10M | tyx | 10-meter specific humidity | kg $kg^{-1}$ |
| QV2M | tyx | 2-meter specific humidity | kg $kg^{-1}$ |
| SLP | tyx | sea level pressure | Pa |
| T10M | tyx | 10-meter air temperature | K |
| T2M | tyx | 2-meter air temperature | K |
| TO3 | tyx | total column ozone | Dobsons |
| TOX | tyx | total column odd oxygen | kg $m^{-2}$ |
| TQI | tyx | total precipitable ice water | kg $m^{-2}$ |
| TQL | tyx | total precipitable liquid water | kg $m^{-2}$ |
| TQV | tyx | total precipitable water vapor | kg $m^{-2}$ |
| TROPPB | tyx | tropopause pressure based on blended estimate | Pa |
| TROPPT | tyx | tropopause pressure based on thermal estimate | Pa |
| TROPPV | tyx | tropopause pressure based on EPV estimate | Pa |
| TROPQ | tyx | tropopause specific humidity using blended TROPP estimate | kg $kg^{-1}$ |
| TROPT | tyx | tropopause temperature using blended TROPP estimate | K |
| TS | tyx | surface skin temperature | K |
| U10M | tyx | 10-meter eastward wind | m $s^{-1}$ |
| U2M | tyx | 2-meter eastward wind | m $s^{-1}$ |
| U50M | tyx | eastward wind at 50 meters | m $s^{-1}$ |
| V10M | tyx | 10-meter northward wind | m $s^{-1}$ |
| V2M | tyx | 2-meter northward wind | m $s^{-1}$ |
| V50M | tyx | northward wind at 50 meters | m $s^{-1}$ |

### instM_2d_int_Nx (M2I1NXINT): Vertically Integrated Diagnostics

**Frequency:** *Monthly from 00:00 UTC (instantaneous)*
**Spatial Grid:** *2D, single-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, time=1*
**Granule Size:** *~11 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| CPT | tyx | vertically integrated enthalpy | J $m^{-2}$ |
| KE | tyx | vertically integrated kinetic energy | J $m^{-2}$ |
| MASS | tyx | atmospheric mass | kg $m^{-2}$ |
| THV | tyx | vertically integrated virtual potential temperature | K |
| TOX | tyx | total column odd oxygen | kg $m^{-2}$ |
| TQI | tyx | total precipitable ice water | kg $m^{-2}$ |
| TQL | tyx | total precipitable liquid water | kg $m^{-2}$ |
| TQV | tyx | total precipitable water vapor | kg $m^{-2}$ |

### instM_2d_lfo_Nx (M2I1NXLFO): Land Surface Forcings

**Frequency:** *Monthly from 00:00 UTC (instantaneous)*
**Spatial Grid:** *2D, single-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, time=1*
**Granule Size:** *~6.8 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| HLML | tyx | surface layer height | m |
| PS | tyx | surface pressure | Pa |
| QLML | tyx | surface specific humidity | 1 |
| SPEEDLML | tyx | surface wind speed | m $s^{-1}$ |
| TLML | tyx | surface air temperature | K |

## *Instantaneous Three-Dimensional Collections*

### instM_3d_asm_Np (M2I3NPASM): Assimilated Meteorological Fields

**Frequency:** *Monthly from 00:00 UTC (instantaneous)*
**Spatial Grid:** *3D, pressure-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, level=42, time=8*
**Granule Size:** *~1.3 GB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| EPV | tzyx | ertels potential vorticity | $K\ m^2\ kg^{-1}\ s^{-1}$ |
| H | tzyx | edge heights | m |
| O3 | tzyx | ozone mass mixing ratio | $kg\ kg^{-1}$ |
| OMEGA | tzyx | vertical pressure velocity | $Pa\ s^{-1}$ |
| PHIS | tyx | surface geopotential height | $m^2\ s^{-2}$ |
| PS | tyx | surface pressure | Pa |
| QI | tzyx | mass fraction of cloud ice water | $kg\ kg^{-1}$ |
| QL | tzyx | mass fraction of cloud liquid water | $kg\ kg^{-1}$ |
| QV | tzyx | specific humidity | $kg\ kg^{-1}$ |
| RH | tzyx | relative humidity after moist | 1 |
| SLP | tyx | sea level pressure | Pa |
| T | tzyx | air temperature | K |
| U | tzyx | eastward wind | $m\ s^{-1}$ |
| V | tzyx | northward wind | $m\ s^{-1}$ |

### instM_3d_asm_Nv (M2I3NVASM): Assimilated Meteorological Fields

**Frequency:** *Monthly from 00:00 UTC (instantaneous)*
**Spatial Grid:** *3D, model-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, level=72, time=8*
**Granule Size:** *~2.2 GB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| EPV | tzyx | ertels potential vorticity | K $m^2$ $kg^{-1}$ $s^{-1}$ |
| H | tzyx | mid layer heights | m |
| O3 | tzyx | ozone mass mixing ratio | kg $kg^{-1}$ |
| OMEGA | tzyx | vertical pressure velocity | Pa $s^{-1}$ |
| PHIS | tyx | surface geopotential height | $m^2$ $s^{-2}$ |
| PS | tyx | surface pressure | Pa |
| QI | tzyx | mass fraction of cloud ice water | kg $kg^{-1}$ |
| QL | tzyx | mass fraction of cloud liquid water | kg $kg^{-1}$ |
| QV | tzyx | specific humidity | kg $kg^{-1}$ |
| RH | tzyx | relative humidity after moist | 1 |
| SLP | tyx | sea level pressure | Pa |
| T | tzyx | air temperature | K |
| U | tzyx | eastward wind | m $s^{-1}$ |
| V | tzyx | northward wind | m $s^{-1}$ |

## *Time Averaged Two-Dimensional Collections*

### statM_2d_slv_Nx (M2SDNXSLV): Single-Level Diagnostics

**Frequency:** *daily from 00:30 UTC (aggregated statistics)*
**Spatial Grid:** *2D, single-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, time=1*
**Granule Size:** *~6.3 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| HOURNORAIN | tyx | time-during an hour with no precipitation | s |
| T2MMAX | tyx | 2-meter air temperature | K |
| T2MMEAN | tyx | 2-meter air temperature | K |

| | | | |
|---|---|---|---|
| T2MMIN | tyx | 2-meter air temperature | K |
| TPRECMEAN | tyx | total precipitation | kg m$^{-2}$ s$^{-1}$ |

### tavgM_2d_csp_Nx (M2T1NXCSP): COSP Satellite Simulator

**Frequency:** *Monthly from 00:30 UTC (time-averaged)*
**Spatial Grid:** *2D, single-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, time=1*
**Granule Size:** *~19 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| ISCCPALB | tyx | isccp cloud albedo | 1 |
| ISCCPCLDFRC | tyx | isccp total  cloud area fraction | 1 |
| MDSCLDFRCH2O | tyx | modis cloud fraction water mean | 1 |
| MDSCLDFRCHI | tyx | modis cloud fraction high mean | 1 |
| MDSCLDFRCICE | tyx | modis cloud fraction ice mean | 1 |
| MDSCLDFRCLO | tyx | modis cloud fraction low mean | 1 |
| MDSCLDFRCMID | tyx | modis cloud fraction mid mean | 1 |
| MDSCLDFRCTTL | tyx | modis cloud fraction total mean | 1 |
| MDSCLDSZH20 | tyx | modis cloud particle size water mean | m |
| MDSCLDSZICE | tyx | modis cloud particle size ice mean | m |
| MDSCLDTOPPS | tyx | modis cloud top pressure total mean | Pa |
| MDSH2OPATH | tyx | modis liquid water path mean | Kg m$^{-2}$ |
| MDSICEPATH | tyx | modis ice water path mean | Kg m$^{-2}$ |
| MDSOPTHCKH2O | tyx | modis optical thickness water mean | 1 |
| MDSOPTHCKH2OLG | tyx | modis optical thickness water logmean | 1 |
| MDSOPTHCKICE | tyx | modis optical thickness ice mean | 1 |
| MDSOPTHCKICELG | tyx | modis optical thickness ice logmean | 1 |
| MDSOPTHCKTTL | tyx | modis optical thickness total mean | 1 |

| | | | |
|---|---|---|---|
| MDSOPTHCKTTLLG | tyx | modis optical thickness total logmean | 1 |

**tavgM_2d_flx_Nx (M2T1NXFLX): Surface Flux Diagnostics**

**Frequency:** *Monthly from 00:30 UTC (time-averaged)*
**Spatial Grid:** *2D, single-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, time=1*
**Granule Size:** *~61 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| BSTAR | tyx | surface bouyancy scale | $m\ s^{-2}$ |
| CDH | tyx | surface exchange coefficient for heat | $kg\ m^{-2}\ s^{-1}$ |
| CDM | tyx | surface exchange coefficient for momentum | $kg\ m^{-2}\ s^{-1}$ |
| CDQ | tyx | surface exchange coefficient for moisture | $kg\ m^{-2}\ s^{-1}$ |
| CN | tyx | surface neutral drag coefficient | 1 |
| DISPH | tyx | zero plane displacement height | m |
| EFLUX | tyx | total latent energy flux | $W\ m^{-2}$ |
| EVAP | tyx | evaporation from turbulence | $kg\ m^{-2}\ s^{-1}$ |
| FRCAN | tyx | areal fraction of anvil showers | 1 |
| FRCCN | tyx | areal fraction of convective showers | 1 |
| FRCLS | tyx | areal fraction of nonanvil large scale showers | 1 |
| FRSEAICE | tyx | ice covered fraction of tile | 1 |
| GHTSKIN | tyx | Ground heating for skin temp | $W\ m^{-2}$ |
| HFLUX | tyx | sensible heat flux from turbulence | $W\ m^{-2}$ |
| HLML | tyx | surface layer height | m |
| NIRDF | tyx | surface downwelling nearinfrared diffuse flux | $W\ m^{-2}$ |
| NIRDR | tyx | surface downwelling nearinfrared beam flux | $W\ m^{-2}$ |
| PBLH | tyx | planetary boundary layer height | m |
| PGENTOT | tyx | Total column production of precipitation | $kg\ m^{-2}\ s^{-1}$ |

| | | | |
|---|---|---|---|
| PRECANV | tyx | anvil precipitation | kg $m^{-2}$ $s^{-1}$ |
| PRECCON | tyx | convective precipitation | kg $m^{-2}$ $s^{-1}$ |
| PRECLSC | tyx | nonanvil large scale precipitation | kg $m^{-2}$ $s^{-1}$ |
| PRECSNO | tyx | snowfall | kg $m^{-2}$ $s^{-1}$ |
| PRECTOT | tyx | total precipitation | kg $m^{-2}$ $s^{-1}$ |
| PRECTOTCORR | tyx | total precipitation | kg $m^{-2}$ $s^{-1}$ |
| PREVTOT | tyx | Total column re-evap/subl of precipitation | kg $m^{-2}$ $s^{-1}$ |
| QLML | tyx | surface specific humidity | 1 |
| QSH | tyx | effective surface specific humidity | kg $kg^{-1}$ |
| QSTAR | tyx | surface moisture scale | kg $kg^{-1}$ |
| RHOA | tyx | air density at surface | kg $m^{-3}$ |
| RISFC | tyx | surface bulk richardson number | 1 |
| SPEED | tyx | surface wind speed | m $s^{-1}$ |
| SPEEDMAX | tyx | surface wind speed | m $s^{-1}$ |
| TAUGWX | tyx | surface eastward gravity wave stress | N $m^{-2}$ |
| TAUGWY | tyx | surface northward gravity wave stress | N $m^{-2}$ |
| TAUX | tyx | eastward surface stress | N $m^{-2}$ |
| TAUY | tyx | northward surface stress | N $m^{-2}$ |
| TCZPBL | tyx | transcom planetary boundary layer height | m |
| TLML | tyx | surface air temperature | K |
| TSH | tyx | effective surface skin temperature | K |
| TSTAR | tyx | surface temperature scale | K |
| ULML | tyx | surface eastward wind | m $s^{-1}$ |
| USTAR | tyx | surface velocity scale | m $s^{-1}$ |
| VLML | tyx | surface northward wind | m $s^{-1}$ |
| Z0H | tyx | surface roughness for heat | m |
| Z0M | tyx | surface roughness | m |

**tavgM_2d_int_Nx (M2T1NXINT): Vertically Integrated Diagnostics**

**Frequency:** *Monthly from 00:30 UTC (time-averaged)*
**Spatial Grid:** *2D, single-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, time=1*
**Granule Size:** *~110 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| AUTCNVRN | tyx | autoconversion loss of cloud water | kg $m^{-2}$ $s^{-1}$ |
| BKGERR | tyx | vertically integrated kinetic energy residual for BKG energy conservation | W $m^{-2}$ |
| COLCNVRN | tyx | accretion loss of cloud water to rain | kg $m^{-2}$ $s^{-1}$ |
| COLCNVSN | tyx | accretion loss of cloud water to snow | kg $m^{-2}$ $s^{-1}$ |
| CUCNVCI | tyx | convective source of cloud ice | kg $m^{-2}$ $s^{-1}$ |
| CUCNVCL | tyx | convective source of cloud water | kg $m^{-2}$ $s^{-1}$ |
| CUCNVRN | tyx | convective production of rain water | kg $m^{-2}$ $s^{-1}$ |
| DHDT_ANA | tyx | total potential energy tendency due to analysis | W $m^{-2}$ |
| DHDT_BKG | tyx | vertically integrated potential energy tendency due to gravity wave background | W $m^{-2}$ |
| DHDT_CUF | tyx | vertically integrated potential energy tendency due to cumulus friction | W $m^{-2}$ |
| DHDT_DYN | tyx | vertically integrated potential energy tendency due to dynamics | W $m^{-2}$ |
| DHDT_FRI | tyx | vertically integrated potential energy tendency due to friction | W $m^{-2}$ |
| DHDT_GWD | tyx | vertically integrated potential energy tendency across gwd | W $m^{-2}$ |
| DHDT_MST | tyx | vertically integrated potential energy tendency across moist | W $m^{-2}$ |
| DHDT_ORO | tyx | vertically integrated potential energy tendency due to orographic gravity waves | W $m^{-2}$ |
| DHDT_PHY | tyx | total potential energy tendency due to physics | W $m^{-2}$ |

| | | | |
|---|---|---|---|
| DHDT_RAD | tyx | vertically integrated potential energy tendency across radiation | W $m^{-2}$ |
| DHDT_RAY | tyx | vertically integrated potential energy tendency due to Rayleigh friction | W $m^{-2}$ |
| DHDT_RES | tyx | vertically integrated cpt tendency residual | W $m^{-2}$ |
| DHDT_TRB | tyx | vertically integrated potential energy tendency across turbulence | W $m^{-2}$ |
| DKDT_ANA | tyx | total kinetic energy tendency due to analysis | W $m^{-2}$ |
| DKDT_BKG | tyx | vertically integrated kinetic energy dissipation due to gravity wave background | W $m^{-2}$ |
| DKDT_DYN | tyx | vertically integrated kinetic energy tendency due to dynamics | W $m^{-2}$ |
| DKDT_GWD | tyx | vertically integrated kinetic energy tendency across gwd | W $m^{-2}$ |
| DKDT_GWDRES | tyx | vertically integrated kinetic energy residual for total energy conservation | W $m^{-2}$ |
| DKDT_INT | tyx | vertically integrated kinetic energy dissipation due to diffusion | W $m^{-2}$ |
| DKDT_MST | tyx | vertically integrated kinetic energy tendency across moist | W $m^{-2}$ |
| DKDT_ORO | tyx | vertically integrated kinetic energy dissipation due to orographic gravity waves | W $m^{-2}$ |
| DKDT_PHY | tyx | vertically integrated kinetic energy tendency due to physics | W $m^{-2}$ |
| DKDT_PHYPHY | tyx | vertically integrated kinetic energy tendency across physics | W $m^{-2}$ |
| DKDT_RAY | tyx | vertically integrated kinetic energy dissipation due to Rayleigh friction | W $m^{-2}$ |
| DKDT_SRF | tyx | vertically integrated kinetic energy dissipation due to surface friction | W $m^{-2}$ |
| DKDT_TOP | tyx | vertically integrated kinetic energy dissipation due to topographic friction | W $m^{-2}$ |
| DKDT_TRB | tyx | vertically integrated kinetic energy tendency across turbulence | W $m^{-2}$ |

| | | | |
|---|---|---|---|
| DMDT_ANA | tyx | vertically integrated mass tendency due to analysis | kg $m^{-2}$ $s^{-1}$ |
| DMDT_DYN | tyx | vertically integrated mass tendency due to dynamics | kg $m^{-2}$ $s^{-1}$ |
| DMDT_PHY | tyx | vertically integrated mass tendency due to physics | kg $m^{-2}$ $s^{-1}$ |
| DOXDT_ANA | tyx | vertically integrated ozone tendency due to analysis | kg $m^{-2}$ $s^{-1}$ |
| DOXDT_CHM | tyx | vertically integrated odd oxygen tendency due to chemistry | kg $m^{-2}$ $s^{-1}$ |
| DOXDT_DYN | tyx | vertically integrated ozone tendency due to dynamics | kg $m^{-2}$ $s^{-1}$ |
| DOXDT_FIL | tyx | vertically integrated ox adjustment from filling | kg $m^{-2}$ $s^{-1}$ |
| DOXDT_PHY | tyx | vertically integrated odd oxygen tendency due to physics | kg $m^{-2}$ $s^{-1}$ |
| DPDT_ANA | tyx | mountain work tendency due to analysis | W $m^{-2}$ |
| DPDT_DYN | tyx | mountain work tendency due to dynamics | W $m^{-2}$ |
| DPDT_PHY | tyx | mountain work tendency due to physics | W $m^{-2}$ |
| DQIDT_ANA | tyx | vertically integrated ice water tendency due to analysis | kg $m^{-2}$ $s^{-1}$ |
| DQIDT_DYN | tyx | vertically integrated ice water tendency due to dynamics | kg $m^{-2}$ $s^{-1}$ |
| DQIDT_FIL | tyx | vertically integrated qi adjustment from filling | kg $m^{-2}$ $s^{-1}$ |
| DQIDT_MST | tyx | vertically integrated ice tendency due to moist processes | kg $m^{-2}$ $s^{-1}$ |
| DQIDT_PHY | tyx | vertically integrated ice tendency due to physics | kg $m^{-2}$ $s^{-1}$ |
| DQLDT_ANA | tyx | vertically integrated liquid water tendency due to analysis | kg $m^{-2}$ $s^{-1}$ |
| DQLDT_DYN | tyx | vertically integrated liquid water tendency due to dynamics | kg $m^{-2}$ $s^{-1}$ |
| DQLDT_FIL | tyx | vertically integrated ql adjustment from filling | kg $m^{-2}$ $s^{-1}$ |
| DQLDT_MST | tyx | vertically integrated liquid water tendency due to moist processes | kg $m^{-2}$ $s^{-1}$ |
| DQLDT_PHY | tyx | vertically integrated liquid water tendency due to physics | kg $m^{-2}$ $s^{-1}$ |

| | | | |
|---|---|---|---|
| DQVDT_ANA | tyx | vertically integrated water vapor tendency due to analysis | kg $m^{-2}$ $s^{-1}$ |
| DQVDT_CHM | tyx | vertically integrated water vapor tendency due to chemistry | kg $m^{-2}$ $s^{-1}$ |
| DQVDT_DYN | tyx | vertically integrated water vapor tendency due to dynamics | kg $m^{-2}$ $s^{-1}$ |
| DQVDT_FIL | tyx | vertically integrated qv adjustment from filling | kg $m^{-2}$ $s^{-1}$ |
| DQVDT_MST | tyx | vertically integrated water vapor tendency due to moist processes | kg $m^{-2}$ $s^{-1}$ |
| DQVDT_PHY | tyx | vertically integrated water vapor tendency due to physics | kg $m^{-2}$ $s^{-1}$ |
| DQVDT_TRB | tyx | vertically integrated water vapor tendency due to turbulence | kg $m^{-2}$ $s^{-1}$ |
| DTHDT_ANA | tyx | vertically integrated THV tendency due to analysis | K kg $m^{-2}$ $s^{-1}$ |
| DTHDT_DYN | tyx | vertically integrated THV tendency due to dynamics | K kg $m^{-2}$ $s^{-1}$ |
| DTHDT_PHY | tyx | vertically integrated THV tendency due to physics | K kg $m^{-2}$ $s^{-1}$ |
| EVAP | tyx | evaporation from turbulence | kg $m^{-2}$ $s^{-1}$ |
| EVPCL | tyx | evaporation loss of cloud water | kg $m^{-2}$ $s^{-1}$ |
| EVPRN | tyx | evaporation loss of precip water | kg $m^{-2}$ $s^{-1}$ |
| FRZCL | tyx | net freezing of cloud condensate | kg $m^{-2}$ $s^{-1}$ |
| FRZRN | tyx | net freezing of precip condensate | kg $m^{-2}$ $s^{-1}$ |
| HFLUX | tyx | sensible heat flux from turbulence | W $m^{-2}$ |
| LSCNVCI | tyx | statistical source of cloud ice | kg $m^{-2}$ $s^{-1}$ |
| LSCNVCL | tyx | statistical source of cloud water | kg $m^{-2}$ $s^{-1}$ |
| LSCNVRN | tyx | spurious rain from RH cleanup | kg $m^{-2}$ $s^{-1}$ |
| LWGNET | tyx | surface net downward longwave flux | W $m^{-2}$ |
| LWTNET | tyx | upwelling longwave flux at toa | W $m^{-2}$ |
| PRECCU | tyx | convective rainfall | kg $m^{-2}$ $s^{-1}$ |
| PRECLS | tyx | large scale rainfall | kg $m^{-2}$ $s^{-1}$ |
| PRECSN | tyx | snowfall | kg $m^{-2}$ $s^{-1}$ |

| | | | |
|---|---|---|---|
| QTFILL | tyx | vertically integrated total water adjustment from filling | kg $m^{-2}$ $s^{-1}$ |
| SDMCI | tyx | sedimentation loss of cloud ice | kg $m^{-2}$ $s^{-1}$ |
| SUBCI | tyx | sumblimation loss of cloud ice | kg $m^{-2}$ $s^{-1}$ |
| SUBSN | tyx | sumblimation loss of precip ice | kg $m^{-2}$ $s^{-1}$ |
| SWNETSRF | tyx | surface net downward shortwave flux | W $m^{-2}$ |
| SWNETTOA | tyx | toa net downward shortwave flux | W $m^{-2}$ |
| UFLXCPT | tyx | eastward flux of atmospheric enthalpy | J $m^{-1}$ $s^{-1}$ |
| UFLXKE | tyx | eastward flux of atmospheric kinetic energy | J $m^{-1}$ $s^{-1}$ |
| UFLXPHI | tyx | eastward flux of atmospheric potential energy | J $m^{-1}$ $s^{-1}$ |
| UFLXQI | tyx | eastward flux of atmospheric ice | kg $m^{-1}$ $s^{-1}$ |
| UFLXQL | tyx | eastward flux of atmospheric liquid water | kg $m^{-1}$ $s^{-1}$ |
| UFLXQV | tyx | eastward flux of atmospheric water vapor | kg $m^{-1}$ $s^{-1}$ |
| VFLXCPT | tyx | northward flux of atmospheric enthalpy | J $m^{-1}$ $s^{-1}$ |
| VFLXKE | tyx | northward flux of atmospheric kinetic energy | J $m^{-1}$ $s^{-1}$ |
| VFLXPHI | tyx | northward flux of atmospheric potential energy | J $m^{-1}$ $s^{-1}$ |
| VFLXQI | tyx | northward flux of atmospheric ice | kg $m^{-1}$ $s^{-1}$ |
| VFLXQL | tyx | northward flux of atmospheric liquid water | kg $m^{-1}$ $s^{-1}$ |
| VFLXQV | tyx | northward flux of atmospheric water vapor | kg $m^{-1}$ $s^{-1}$ |

### tavgM_2d_lfo_Nx (M2T1NXLFO): Land Surface Forcings

**Frequency:** *Monthly from 00:30 UTC (time-averaged)*
**Spatial Grid:** *2D, single-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, time=1*
**Granule Size:** *~7.5 MB*

| ***Name*** | ***Dim*** | ***Description*** | ***Units*** |
|---|---|---|---|
| LWGAB | tyx | surface absorbed longwave radiation | W $m^{-2}$ |

| | | | |
|---|---|---|---|
| PARDF | tyx | surface downwelling par diffuse flux | W $m^{-2}$ |
| PARDR | tyx | surface downwelling par beam flux | W $m^{-2}$ |
| PRECCUCORR | tyx | liquid water convective precipitation | kg $m^{-2}$ $s^{-1}$ |
| PRECLSCORR | tyx | liquid water large scale precipitation | kg $m^{-2}$ $s^{-1}$ |
| PRECSNOCORR | tyx | snowfall | kg $m^{-2}$ $s^{-1}$ |
| SWGDN | tyx | Incident shortwave land | W $m^{-2}$ |
| SWLAND | tyx | Net shortwave land | W $m^{-2}$ |

### tavgM_2d_lnd_Nx (M2T1NXLND): Land Surface Diagnostics

**Frequency:** *Monthly from 00:30 UTC (time-averaged)*
**Spatial Grid:** *2D, single-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, time=1*
**Granule Size:** *~19 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| BASEFLOW | tyx | baseflow flux | kg $m^{-2}$ $s^{-1}$ |
| ECHANGE | tyx | rate of change of total land energy | W $m^{-2}$ |
| EVLAND | tyx | Evaporation land | kg $m^{-2}$ $s^{-1}$ |
| EVPINTR | tyx | interception loss energy flux | W $m^{-2}$ |
| EVPSBLN | tyx | snow ice evaporation energy flux | W $m^{-2}$ |
| EVPSOIL | tyx | baresoil evap energy flux | W $m^{-2}$ |
| EVPTRNS | tyx | transpiration energy flux | W $m^{-2}$ |
| FRSAT | tyx | fractional area of saturated zone | 1 |
| FRSNO | tyx | fractional area of land snowcover | 1 |
| FRUNST | tyx | fractional area of unsaturated zone | 1 |
| FRWLT | tyx | fractional area of wilting zone | 1 |
| GHLAND | tyx | Ground heating land | W $m^{-2}$ |

| | | | |
|---|---|---|---|
| GRN | tyx | greeness fraction | 1 |
| GWETPROF | tyx | ave prof soil moisture | 1 |
| GWETROOT | tyx | root zone soil wetness | 1 |
| GWETTOP | tyx | surface soil wetness | 1 |
| LAI | tyx | leaf area index | 1 |
| LHLAND | tyx | Latent heat flux land | W $m^{-2}$ |
| LWLAND | tyx | Net longwave land | W $m^{-2}$ |
| PARDFLAND | tyx | surface downwelling par diffuse flux | W $m^{-2}$ |
| PARDRLAND | tyx | surface downwelling par beam flux | W $m^{-2}$ |
| PRECSNOLAND | tyx | snowfall land | kg $m^{-2}$ $s^{-1}$ |
| PRECTOTLAND | tyx | Total precipitation land | kg $m^{-2}$ $s^{-1}$ |
| PRMC | tyx | water profile | m-3 m-3 |
| QINFIL | tyx | Soil water infiltration rate | kg $m^{-2}$ $s^{-1}$ |
| RUNOFF | tyx | overland runoff including throughflow | kg $m^{-2}$ $s^{-1}$ |
| RZMC | tyx | water root zone | $m^{-3}$ $m^{-3}$ |
| SFMC | tyx | water surface layer | $m^{-3}$ $m^{-3}$ |
| SHLAND | tyx | Sensible heat flux land | W $m^{-2}$ |
| SMLAND | tyx | Snowmelt flux land | kg $m^{-2}$ $s^{-1}$ |
| SNODP | tyx | snow depth | m |
| SNOMAS | tyx | Total snow storage land | kg $m^{-2}$ |
| SPLAND | tyx | rate of spurious land energy source | W $m^{-2}$ |
| SPSNOW | tyx | rate of spurious snow energy | W $m^{-2}$ |
| SPWATR | tyx | rate of spurious land water source | kg $m^{-2}$ $s^{-1}$ |
| SWLAND | tyx | Net shortwave land | W $m^{-2}$ |
| TELAND | tyx | Total energy storage land | J $m^{-2}$ |
| TPSNOW | tyx | surface temperature of snow | K |
| TSAT | tyx | surface temperature of saturated zone | K |

| | | | |
|---|---|---|---|
| TSOIL1 | tyx | soil temperatures layer 1 | K |
| TSOIL2 | tyx | soil temperatures layer 2 | K |
| TSOIL3 | tyx | soil temperatures layer 3 | K |
| TSOIL4 | tyx | soil temperatures layer 4 | K |
| TSOIL5 | tyx | soil temperatures layer 5 | K |
| TSOIL6 | tyx | soil temperatures layer 6 | K |
| TSURF | tyx | surface temperature of land incl snow | K |
| TUNST | tyx | surface temperature of unsaturated zone | K |
| TWLAND | tyx | Avail water storage land | kg $m^{-2}$ |
| TWLT | tyx | surface temperature of wilted zone | K |
| WCHANGE | tyx | rate of change of total land water | kg $m^{-2}$ $s^{-1}$ |

### tavgM_2d_ocn_Nx (M2T1NXOCN): Ocean Surface Diagnostics

**Frequency:** *Monthly from 00:30 UTC (time-averaged)*
**Spatial Grid:** *2D, single-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, time=1*
**Granule Size:** *~17 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| EFLUXICE | tyx | sea ice latent energy flux | W $m^{-2}$ |
| EFLUXWTR | tyx | open water latent energy flux | W $m^{-2}$ |
| FRSEAICE | tyx | ice covered fraction of tile | 1 |
| HFLUXICE | tyx | sea ice upward sensible heat flux | W $m^{-2}$ |
| HFLUXWTR | tyx | open water upward sensible heat flux | W $m^{-2}$ |
| LWGNTICE | tyx | sea ice net downward longwave flux | W $m^{-2}$ |
| LWGNTWTR | tyx | open water net downward longwave flux | W $m^{-2}$ |
| PRECSNOOCN | tyx | ocean snowfall | kg $m^{-2}$ $s^{-1}$ |
| QV10M | tyx | 10-meter specific humidity | kg $kg^{-1}$ |

| | | | |
|---|---|---|---|
| RAINOCN | tyx | ocean rainfall | kg $m^{-2}$ $s^{-1}$ |
| SWGNTICE | tyx | sea ice net downward shortwave flux | W $m^{-2}$ |
| SWGNTWTR | tyx | open water net downward shortwave flux | W $m^{-2}$ |
| T10M | tyx | 10-meter air temperature | K |
| TAUXICE | tyx | eastward stress over ice | N $m^{-2}$ |
| TAUXWTR | tyx | eastward stress over water | N $m^{-2}$ |
| TAUYICE | tyx | northward stress over ice | N $m^{-2}$ |
| TAUYWTR | tyx | northward stress over water | N $m^{-2}$ |
| TSKINICE | tyx | sea ice skin temperature | K |
| TSKINWTR | tyx | open water skin temperature | K |
| U10M | tyx | 10-meter eastward wind | m $s^{-1}$ |
| V10M | tyx | 10-meter northward wind | m $s^{-1}$ |

### tavgM_2d_rad_Nx (M2T1NXRAD): Radiation Diagnostics

**Frequency:** *Monthly from 00:30 UTC (time-averaged)*
**Spatial Grid:** *2D, single-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, time=1*
**Granule Size:** *~45 MB*

| ***Name*** | ***Dim*** | ***Description*** | ***Units*** |
|---|---|---|---|
| ALBEDO | tyx | surface albedo | 1 |
| ALBNIRDF | tyx | surface albedo for near infrared diffuse | 1 |
| ALBNIRDR | tyx | surface albedo for near infrared beam | 1 |
| ALBVISDF | tyx | surface albedo for visible diffuse | 1 |
| ALBVISDR | tyx | surface albedo for visible beam | 1 |
| CLDHGH | tyx | cloud area fraction for high clouds | 1 |
| CLDLOW | tyx | cloud area fraction for low clouds | 1 |
| CLDMID | tyx | cloud area fraction for middle clouds | 1 |

| | | | |
|---|---|---|---|
| CLDTOT | tyx | total cloud area fraction | 1 |
| EMIS | tyx | surface emissivity | 1 |
| LWGAB | tyx | surface absorbed longwave radiation | W $m^{-2}$ |
| LWGABCLR | tyx | surface absorbed longwave radiation assuming clear sky | W $m^{-2}$ |
| LWGABCLRCLN | tyx | surface absorbed longwave radiation assuming clear sky and no aerosol | W $m^{-2}$ |
| LWGEM | tyx | longwave flux emitted from surface | W $m^{-2}$ |
| LWGNT | tyx | surface net downward longwave flux | W $m^{-2}$ |
| LWGNTCLR | tyx | surface net downward longwave flux assuming clear sky | W $m^{-2}$ |
| LWGNTCLRCLN | tyx | surface net downward longwave flux assuming clear sky and no aerosol | W $m^{-2}$ |
| LWTUP | tyx | upwelling longwave flux at toa | W $m^{-2}$ |
| LWTUPCLR | tyx | upwelling longwave flux at toa assuming clear sky | W $m^{-2}$ |
| LWTUPCLRCLN | tyx | upwelling longwave flux at toa assuming clear sky and no aerosol | W $m^{-2}$ |
| SWGDN | tyx | surface incoming shortwave flux | W $m^{-2}$ |
| SWGDNCLR | tyx | surface incoming shortwave flux assuming clear sky | W $m^{-2}$ |
| SWGNT | tyx | surface net downward shortwave flux | W $m^{-2}$ |
| SWGNTCLN | tyx | surface net downward shortwave flux assuming no aerosol | W $m^{-2}$ |
| SWGNTCLR | tyx | surface net downward shortwave flux assuming clear sky | W $m^{-2}$ |
| SWGNTCLRCLN | tyx | surface net downward shortwave flux assuming clear sky and no aerosol | W $m^{-2}$ |
| SWTDN | tyx | toa incoming shortwave flux | W $m^{-2}$ |
| SWTNT | tyx | toa net downward shortwave flux | W $m^{-2}$ |
| SWTNTCLN | tyx | toa net downward shortwave flux assuming no aerosol | W $m^{-2}$ |
| SWTNTCLR | tyx | toa net downward shortwave flux assuming clear sky | W $m^{-2}$ |

| | | | |
|---|---|---|---|
| SWTNTCLRCLN | tyx | toa net downward shortwave flux assuming clear sky and no aerosol | W $m^{-2}$ |
| TAUHGH | tyx | in cloud optical thickness of high clouds(EXPORT) | 1 |
| TAULOW | tyx | in cloud optical thickness of low clouds | 1 |
| TAUMID | tyx | in cloud optical thickness of middle clouds | 1 |
| TAUTOT | tyx | in cloud optical thickness of all clouds | 1 |
| TS | tyx | surface skin temperature | K |

### tavgM_2d_slv_Nx (M2T1NXSLV): Single-Level Diagnostics

**Frequency:** *Monthly from 00:30 UTC (time-averaged)*
**Spatial Grid:** *2D, single-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, time=1*
**Granule Size:** *~63 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| CLDPRS | tyx | cloud top pressure | Pa |
| CLDTMP | tyx | cloud top temperature | K |
| DISPH | tyx | zero plane displacement height | m |
| H1000 | tyx | height at 1000 mb | m |
| H250 | tyx | height at 250 hPa | m |
| H500 | tyx | height at 500 hPa | m |
| H850 | tyx | height at 850 hPa | m |
| OMEGA500 | tyx | omega at 500 hPa | Pa $s^{-1}$ |
| PBLTOP | tyx | pbltop pressure | Pa |
| PS | tyx | surface pressure | Pa |
| Q250 | tyx | specific humidity at 250 hPa | kg $kg^{-1}$ |
| Q500 | tyx | specific humidity at 500 hPa | kg $kg^{-1}$ |
| Q850 | tyx | specific humidity at 850 hPa | kg $kg^{-1}$ |

| | | | |
|---|---|---|---|
| QV10M | tyx | 10-meter specific humidity | kg $kg^{-1}$ |
| QV2M | tyx | 2-meter specific humidity | kg $kg^{-1}$ |
| SLP | tyx | sea level pressure | Pa |
| T10M | tyx | 10-meter air temperature | K |
| T250 | tyx | air temperature at 250 hPa | K |
| T2M | tyx | 2-meter air temperature | K |
| T2MDEW | tyx | dew point temperature at 2 m | K |
| T2MWET | tyx | wet bulb temperature at 2 m | K |
| T500 | tyx | air temperature at 500 hPa | K |
| T850 | tyx | air temperature at 850 hPa | K |
| TO3 | tyx | total column ozone | Dobsons |
| TOX | tyx | total column odd oxygen | kg $m^{-2}$ |
| TQI | tyx | total precipitable ice water | kg $m^{-2}$ |
| TQL | tyx | total precipitable liquid water | kg $m^{-2}$ |
| TQV | tyx | total precipitable water vapor | kg $m^{-2}$ |
| TROPPB | tyx | tropopause pressure based on blended estimate | Pa |
| TROPPT | tyx | tropopause pressure based on thermal estimate | Pa |
| TROPPV | tyx | tropopause pressure based on EPV estimate | Pa |
| TROPQ | tyx | tropopause specific humidity using blended TROPP estimate | kg $kg^{-1}$ |
| TROPT | tyx | tropopause temperature using blended TROPP estimate | K |
| TS | tyx | surface skin temperature | K |
| U10M | tyx | 10-meter eastward wind | m $s^{-1}$ |
| U250 | tyx | eastward wind at 250 hPa | m $s^{-1}$ |
| U2M | tyx | 2-meter eastward wind | m $s^{-1}$ |
| U500 | tyx | eastward wind at 500 hPa | m $s^{-1}$ |
| U50M | tyx | eastward wind at 50 meters | m $s^{-1}$ |
| U850 | tyx | eastward wind at 850 hPa | m $s^{-1}$ |

| | | | |
|---|---|---|---|
| V10M | tyx | 10-meter northward wind | m $s^{-1}$ |
| V250 | tyx | northward wind at 250 hPa | m $s^{-1}$ |
| V2M | tyx | 2-meter northward wind | m $s^{-1}$ |
| V500 | tyx | northward wind at 500 hPa | m $s^{-1}$ |
| V50M | tyx | northward wind at 50 meters | m $s^{-1}$ |
| V850 | tyx | northward wind at 850 hPa | m $s^{-1}$ |
| ZLCL | tyx | lifting condensation level | m |

**tavgM_2d_aer_Nx (M2T3NXAER): Aerosol Diagnostics**

**Frequency:** *Monthly from 01:30 UTC (time-averaged)*
**Spatial Grid:** *2D, single-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, time=1*
**Granule Size:** *~183 MB*

| ***Name*** | ***Dim*** | ***Description*** | ***Units*** |
|---|---|---|---|
| BCANGSTR | tyx | Black Carbon Angstrom parameter [470-870 nm] | 1 |
| BCCMASS | tyx | Black Carbon Column Mass Density | kg $m^{-2}$ |
| BCDP001 | tyx | Black Carbon Dry Deposition Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| BCDP002 | tyx | Black Carbon Dry Deposition Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| BCEM001 | tyx | Black Carbon Emission Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| BCEM002 | tyx | Black Carbon Emission Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| BCEMAN | tyx | Black Carbon Anthropogenic Emissions | kg $m^{-2}$ $s^{-1}$ |
| BCEMBB | tyx | Black Carbon Biomass Burning Emissions | kg $m^{-2}$ $s^{-1}$ |
| BCEMBF | tyx | Black Carbon Biofuel Emissions | kg $m^{-2}$ $s^{-1}$ |
| BCEXTTAU | tyx | Black Carbon Extinction AOT (550 nm) | 1 |
| BCFLUXU | tyx | Black Carbon column u-wind mass flux | kg $m^{-1}$ $s^{-1}$ |
| BCFLUXV | tyx | Black Carbon column v-wind mass flux | kg $m^{-1}$ $s^{-1}$ |
| BCHYPHIL | tyx | Black Carbon Hydrophobic to Hydrophilic | kg $m^{-2}$ $s^{-1}$ |

| | | | |
|---|---|---|---|
| BCSCATAU | tyx | Black Carbon Scattering AOT (550 nm) | 1 |
| BCSMASS | tyx | Black Carbon Surface Mass Concentration | kg $m^{-3}$ |
| BCSV001 | tyx | Black Carbon Convective Scavenging Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| BCSV002 | tyx | Black Carbon Convective Scavenging Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| BCWT001 | tyx | Black Carbon Wet Deposition Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| BCWT002 | tyx | Black Carbon Wet Deposition Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| DMSCMASS | tyx | DMS Column Mass Density | kg $m^{-2}$ |
| DMSSMASS | tyx | DMS Surface Mass Concentration | kg $m^{-3}$ |
| DUAERIDX | tyx | Dust TOMS UV Aerosol Index | 1 |
| DUANGSTR | tyx | Dust Angstrom parameter [470-870 nm] | 1 |
| DUCMASS | tyx | Dust Column Mass Density | kg $m^{-2}$ |
| DUCMASS25 | tyx | Dust Column Mass Density - PM 2.5 | kg $m^{-2}$ |
| DUDP001 | tyx | Dust Dry Deposition Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| DUDP002 | tyx | Dust Dry Deposition Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| DUDP003 | tyx | Dust Dry Deposition Bin 003 | kg $m^{-2}$ $s^{-1}$ |
| DUDP004 | tyx | Dust Dry Deposition Bin 004 | kg $m^{-2}$ $s^{-1}$ |
| DUDP005 | tyx | Dust Dry Deposition Bin 005 | kg $m^{-2}$ $s^{-1}$ |
| DUEM001 | tyx | Dust Emission Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| DUEM002 | tyx | Dust Emission Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| DUEM003 | tyx | Dust Emission Bin 003 | kg $m^{-2}$ $s^{-1}$ |
| DUEM004 | tyx | Dust Emission Bin 004 | kg $m^{-2}$ $s^{-1}$ |
| DUEM005 | tyx | Dust Emission Bin 005 | kg $m^{-2}$ $s^{-1}$ |
| DUEXTT25 | tyx | Dust Extinction AOT [550 nm] - PM 2.5 | 1 |
| DUEXTTAU | tyx | Dust Extinction AOT [550 nm] | 1 |
| DUEXTTFM | tyx | Dust Extinction AOT [550 nm] - PM 1.0 um | 1 |
| DUFLUXU | tyx | Dust column u-wind mass flux | kg $m^{-1}$ $s^{-1}$ |
| DUFLUXV | tyx | Dust column v-wind mass flux | kg $m^{-1}$ $s^{-1}$ |
| DUSCAT25 | tyx | Dust Scattering AOT [550 nm] - PM 2.5 | 1 |

| | | | |
|---|---|---|---|
| DUSCATAU | tyx | Dust Scattering AOT [550 nm] | 1 |
| DUSCATFM | tyx | Dust Scattering AOT [550 nm] - PM 1.0 um | 1 |
| DUSD001 | tyx | Dust Sedimentation Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| DUSD002 | tyx | Dust Sedimentation Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| DUSD003 | tyx | Dust Sedimentation Bin 003 | kg $m^{-2}$ $s^{-1}$ |
| DUSD004 | tyx | Dust Sedimentation Bin 004 | kg $m^{-2}$ $s^{-1}$ |
| DUSD005 | tyx | Dust Sedimentation Bin 005 | kg $m^{-2}$ $s^{-1}$ |
| DUSMASS | tyx | Dust Surface Mass Concentration | kg $m^{-3}$ |
| DUSMASS25 | tyx | Dust Surface Mass Concentration - PM 2.5 | kg $m^{-3}$ |
| DUSV001 | tyx | Dust Convective Scavenging Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| DUSV002 | tyx | Dust Convective Scavenging Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| DUSV003 | tyx | Dust Convective Scavenging Bin 003 | kg $m^{-2}$ $s^{-1}$ |
| DUSV004 | tyx | Dust Convective Scavenging Bin 004 | kg $m^{-2}$ $s^{-1}$ |
| DUSV005 | tyx | Dust Convective Scavenging Bin 005 | kg $m^{-2}$ $s^{-1}$ |
| DUWT001 | tyx | Dust Wet Deposition Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| DUWT002 | tyx | Dust Wet Deposition Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| DUWT003 | tyx | Dust Wet Deposition Bin 003 | kg $m^{-2}$ $s^{-1}$ |
| DUWT004 | tyx | Dust Wet Deposition Bin 004 | kg $m^{-2}$ $s^{-1}$ |
| DUWT005 | tyx | Dust Wet Deposition Bin 005 | kg $m^{-2}$ $s^{-1}$ |
| LWI | tyx | Land (1) / Water (0) / Ice (2) Flag | 1 |
| OCANGSTR | tyx | Organic Carbon Angstrom parameter [470-870 nm] | 1 |
| OCCMASS | tyx | Organic Carbon Column Mass Density | kg $m^{-2}$ |
| OCDP001 | tyx | Organic Carbon Dry Deposition Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| OCDP002 | tyx | Organic Carbon Dry Deposition Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| OCEM001 | tyx | Organic Carbon Emission Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| OCEM002 | tyx | Organic Carbon Emission Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| OCEMAN | tyx | Organic Carbon Anthropogenic Emissions | kg $m^{-2}$ $s^{-1}$ |
| OCEMBB | tyx | Organic Carbon Biomass Burning Emissions | kg $m^{-2}$ $s^{-1}$ |

| | | | |
|---|---|---|---|
| OCEMBF | tyx | Organic Carbon Biofuel Emissions | kg $m^{-2}$ $s^{-1}$ |
| OCEMBG | tyx | Organic Carbon Biogenic Emissions | kg $m^{-2}$ $s^{-1}$ |
| OCEXTTAU | tyx | Organic Carbon Extinction AOT [550 nm] | 1 |
| OCFLUXU | tyx | Organic Carbon column u-wind mass flux | kg m-1 s-1 |
| OCFLUXV | tyx | Organic Carbon column v-wind mass flux | kg m-1 s-1 |
| OCHYPHIL | tyx | Organic Carbon Hydrophobic to Hydrophilic | kg $m^{-2}$ $s^{-1}$ |
| OCSCATAU | tyx | Organic Carbon Scattering AOT [550 nm] | 1 |
| OCSMASS | tyx | Organic Carbon Surface Mass Concentration | kg $m^{-3}$ |
| OCSV001 | tyx | Organic Carbon Convective Scavenging Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| OCSV002 | tyx | Organic Carbon Convective Scavenging Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| OCWT001 | tyx | Organic Carbon Wet Deposition Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| OCWT002 | tyx | Organic Carbon Wet Deposition Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| SO2CMASS | tyx | SO2 Column Mass Density | kg $m^{-2}$ |
| SO2EMAN | tyx | SO2 Anthropogenic Emissions | kg $m^{-2}$ $s^{-1}$ |
| SO2EMBB | tyx | SO2 Biomass Burning Emissions | kg $m^{-2}$ $s^{-1}$ |
| SO2EMVE | tyx | SO2 Volcanic (explosive) Emissions | kg $m^{-2}$ $s^{-1}$ |
| SO2EMVN | tyx | SO2 Volcanic (non-explosive) Emissions | kg $m^{-2}$ $s^{-1}$ |
| SO2SMASS | tyx | SO2 Surface Mass Concentration | kg $m^{-3}$ |
| SO4CMASS | tyx | SO4 Column Mass Density | kg $m^{-2}$ |
| SO4EMAN | tyx | SO4 Anthropogenic Emissions | kg $m^{-2}$ $s^{-1}$ |
| SO4SMASS | tyx | SO4 Surface Mass Concentration | kg m-3 |
| SSAERIDX | tyx | Sea Salt TOMS UV Aerosol Index | 1 |
| SSANGSTR | tyx | Sea Salt Angstrom parameter [470-870 nm] | 1 |
| SSCMASS | tyx | Sea Salt Column Mass Density | kg $m^{-2}$ |
| SSCMASS25 | tyx | Sea Salt Column Mass Density - PM 2.5 | kg $m^{-2}$ |
| SSDP001 | tyx | Sea Salt Dry Deposition Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| SSDP002 | tyx | Sea Salt Dry Deposition Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| SSDP003 | tyx | Sea Salt Dry Deposition Bin 003 | kg $m^{-2}$ $s^{-1}$ |

| | | | |
|---|---|---|---|
| SSDP004 | tyx | Sea Salt Dry Deposition Bin 004 | kg $m^{-2}$ $s^{-1}$ |
| SSDP005 | tyx | Sea Salt Dry Deposition Bin 005 | kg $m^{-2}$ $s^{-1}$ |
| SSEM001 | tyx | Sea Salt Emission Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| SSEM002 | tyx | Sea Salt Emission Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| SSEM003 | tyx | Sea Salt Emission Bin 003 | kg $m^{-2}$ $s^{-1}$ |
| SSEM004 | tyx | Sea Salt Emission Bin 004 | kg $m^{-2}$ $s^{-1}$ |
| SSEM005 | tyx | Sea Salt Emission Bin 005 | kg $m^{-2}$ $s^{-1}$ |
| SSEXTT25 | tyx | Sea Salt Extinction AOT [550 nm] - PM 2.5 | 1 |
| SSEXTTAU | tyx | Sea Salt Extinction AOT [550 nm] | 1 |
| SSEXTTFM | tyx | Sea Salt Extinction AOT [550 nm] - PM 1.0 um | 1 |
| SSFLUXU | tyx | Sea Salt column u-wind mass flux | kg $m^{-1}$ $s^{-1}$ |
| SSFLUXV | tyx | Sea Salt column v-wind mass flux | kg $m^{-1}$ $s^{-1}$ |
| SSSCAT25 | tyx | Sea Salt Scattering AOT [550 nm] - PM 2.5 | 1 |
| SSSCATAU | tyx | Sea Salt Scattering AOT [550 nm] | 1 |
| SSSCATFM | tyx | Sea Salt Scattering AOT [550 nm] - PM 1.0 um | 1 |
| SSSD001 | tyx | Sea Salt Sedimentation Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| SSSD002 | tyx | Sea Salt Sedimentation Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| SSSD003 | tyx | Sea Salt Sedimentation Bin 003 | kg $m^{-2}$ $s^{-1}$ |
| SSSD004 | tyx | Sea Salt Sedimentation Bin 004 | kg $m^{-2}$ $s^{-1}$ |
| SSSD005 | tyx | Sea Salt Sedimentation Bin 005 | kg $m^{-2}$ $s^{-1}$ |
| SSSMASS | tyx | Sea Salt Surface Mass Concentration | kg $m^{-3}$ |
| SSSMASS25 | tyx | Sea Salt Surface Mass Concentration - PM 2.5 | kg $m^{-3}$ |
| SSSV001 | tyx | Sea Salt Convective Scavenging Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| SSSV002 | tyx | Sea Salt Convective Scavenging Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| SSSV003 | tyx | Sea Salt Convective Scavenging Bin 003 | kg $m^{-2}$ $s^{-1}$ |
| SSSV004 | tyx | Sea Salt Convective Scavenging Bin 004 | kg $m^{-2}$ $s^{-1}$ |
| SSSV005 | tyx | Sea Salt Convective Scavenging Bin 005 | kg $m^{-2}$ $s^{-1}$ |
| SSWT001 | tyx | Sea Salt Wet Deposition Bin 001 | kg $m^{-2}$ $s^{-1}$ |

| | | | |
|---|---|---|---|
| SSWT002 | tyx | Sea Salt Wet Deposition Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| SSWT003 | tyx | Sea Salt Wet Deposition Bin 003 | kg $m^{-2}$ $s^{-1}$ |
| SSWT004 | tyx | Sea Salt Wet Deposition Bin 004 | kg $m^{-2}$ $s^{-1}$ |
| SSWT005 | tyx | Sea Salt Wet Deposition Bin 005 | kg $m^{-2}$ $s^{-1}$ |
| SUANGSTR | tyx | SO4 Angstrom parameter [470-870 nm] | 1 |
| SUDP001 | tyx | Sulfate Dry Deposition Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| SUDP002 | tyx | Sulfate Dry Deposition Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| SUDP003 | tyx | Sulfate Dry Deposition Bin 003 | kg $m^{-2}$ $s^{-1}$ |
| SUDP004 | tyx | Sulfate Dry Deposition Bin 004 | kg $m^{-2}$ $s^{-1}$ |
| SUEM001 | tyx | Sulfate Emission Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| SUEM002 | tyx | Sulfate Emission Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| SUEM003 | tyx | Sulfate Emission Bin 003 | kg $m^{-2}$ $s^{-1}$ |
| SUEM004 | tyx | Sulfate Emission Bin 004 | kg $m^{-2}$ $s^{-1}$ |
| SUEXTTAU | tyx | SO4 Extinction AOT [550 nm] | 1 |
| SUFLUXU | tyx | SO4 column u-wind mass flux | kg $m^{-1}$ $s^{-1}$ |
| SUFLUXV | tyx | SO4 column v-wind mass flux | kg $m^{-1}$ $s^{-1}$ |
| SUPMSA | tyx | MSA Prod from DMS Oxidation [column] | kg $m^{-2}$ $s^{-1}$ |
| SUPSO2 | tyx | SO2 Prod from DMS Oxidation [column] | kg $m^{-2}$ $s^{-1}$ |
| SUPSO4AQ | tyx | SO4 Prod from Aqueous SO2 Oxidation [column] | kg $m^{-2}$ $s^{-1}$ |
| SUPSO4G | tyx | SO4 Prod from Gaseous SO2 Oxidation [column] | kg $m^{-2}$ $s^{-1}$ |
| SUPSO4WT | tyx | SO4 Prod from Aqueous SO2 Oxidation (wet dep) [column] | kg $m^{-2}$ $s^{-1}$ |
| SUSCATAU | tyx | SO4 Scattering AOT [550 nm] | 1 |
| SUSV001 | tyx | Sulfate Convective Scavenging Bin 001 | kg $m^{-2}$ $s^{-1}$ |
| SUSV002 | tyx | Sulfate Convective Scavenging Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| SUSV003 | tyx | Sulfate Convective Scavenging Bin 003 | kg $m^{-2}$ $s^{-1}$ |
| SUSV004 | tyx | Sulfate Convective Scavenging Bin 004 | kg $m^{-2}$ $s^{-1}$ |
| SUWT001 | tyx | Sulfate Wet Deposition Bin 001 | kg $m^{-2}$ $s^{-1}$ |

| | | | |
|---|---|---|---|
| SUWT002 | tyx | Sulfate Wet Deposition Bin 002 | kg $m^{-2}$ $s^{-1}$ |
| SUWT003 | tyx | Sulfate Wet Deposition Bin 003 | kg $m^{-2}$ $s^{-1}$ |
| SUWT004 | tyx | Sulfate Wet Deposition Bin 004 | kg $m^{-2}$ $s^{-1}$ |
| TOTANGSTR | tyx | Total Aerosol Angstrom parameter [470-870 nm] | 1 |
| TOTEXTTAU | tyx | Total Aerosol Extinction AOT [550 nm] | 1 |
| TOTSCATAU | tyx | Total Aerosol Scattering AOT [550 nm] | 1 |

### tavgM_2d_glc_Nx (M2T3NXGLC): Land Ice Surface Diagnostics

**Frequency:** *Monthly from 01:30 UTC (time-averaged)*
**Spatial Grid:** *2D, single-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, time=8*
**Granule Size:** *~1.2 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| ASNOW_GL | tyx | fractional area of glaciated surface snowcover | 1 |
| RUNOFF | tyx | runoff flux | kg $m^{-2}$ $s^{-1}$ |
| SNICEALB | tyx | aggregated snow ice broadband albedo | 1 |
| SNOMAS_GL | tyx | snow mass over glaciated surface | kg $m^{-2}$ |
| SNOWDP_GL | tyx | snow depth over glaciated surface | m |
| WESNEXT | tyx | total snow mass residual due to densification | kg $m^{-2}$ $s^{-1}$ |
| WESNSC | tyx | top snow layer mass change due to sub con | kg $m^{-2}$ $s^{-1}$ |

### tavgM_3d_cld_Np (M2T3NPCLD): Cloud Diagnostics

**Frequency:** *Monthly from 01:30 UTC (time-averaged)*
**Spatial Grid:** *3D, pressure-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, level=42, time=8*
**Granule Size:** *~290 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| CFCU | tzyx | updraft areal fraction | 1 |
| CLOUD | tzyx | cloud fraction for radiation | 1 |
| DTRAIN | tzyx | detraining mass flux | kg $m^{-2}$ $s^{-1}$ |
| INCLOUDQI | tzyx | in cloud cloud ice for radiation | kg $kg^{-1}$ |
| INCLOUDQL | tzyx | in cloud cloud liquid for radiation | kg $kg^{-1}$ |
| QI | tzyx | mass fraction of cloud ice water | kg $kg^{-1}$ |
| QL | tzyx | mass fraction of cloud liquid water | kg $kg^{-1}$ |
| RH | tzyx | relative humidity after moist | 1 |
| TAUCLI | tzyx | in cloud optical thickness for ice clouds | 1 |
| TAUCLW | tzyx | in cloud optical thickness for liquid clouds | 1 |

### tavgM_3d_mst_Np (M2T3NPMST): Moist Processes Diagnostics

**Frequency:** *Monthly from 01:30 UTC (time-averaged)*
**Spatial Grid:** *3D, pressure-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, level=42, time=8*
**Granule Size:** *~191 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| CMFMC | tzyx | cumulative mass flux | kg $m^{-2}$ $s^{-1}$ |
| DQRCU | tzyx | convective rainwater source | kg $kg^{-1}$ $s^{-1}$ |
| DQRLSAN | tzyx | large scale rainwater source | kg $kg^{-1}$ $s^{-1}$ |
| PFICU | tzyx | 3D flux of ice convective precipitation | kg $m^{-2}$ $s^{-1}$ |
| PFILSAN | tzyx | 3D flux of ice nonconvective precipitation | kg $m^{-2}$ $s^{-1}$ |
| PFLCU | tzyx | 3D flux of liquid convective precipitation | kg $m^{-2}$ $s^{-1}$ |
| PFLLSAN | tzyx | 3D flux of liquid nonconvective precipitation | kg $m^{-2}$ $s^{-1}$ |
| REEVAPCN | tzyx | evap subl of convective precipitation | kg $kg^{-1}$ $s^{-1}$ |
| REEVAPLSAN | tzyx | evap subl of non convective precipitation | kg $kg^{-1}$ $s^{-1}$ |

## tavgM_3d_odt_Np (M2T3NPODT): Ozone Tendencies

**Frequency:** *Monthly from 01:30 UTC (time-averaged)*
**Spatial Grid:** *3D, pressure-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, level=42, time=8*
**Granule Size:** *~174 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| DOXDTANA | tzyx | total ozone analysis tendency | mol $mol^{-1}$ $s^{-1}$ |
| DOXDTCHM | tzyx | tendency of odd oxygen mixing ratio due to chemistry | mol $mol^{-1}$ $s^{-1}$ |
| DOXDTDYN | tzyx | tendency of ozone due to dynamics | kg $kg^{-1}$ $s^{-1}$ |
| DOXDTMST | tzyx | tendency of odd oxygen due to moist processes | kg $kg^{-1}$ $s^{-1}$ |
| DOXDTTRB | tzyx | tendency of odd oxygen due to turbulence | kg $kg^{-1}$ $s^{-1}$ |

## tavgM_3d_qdt_Np (M2T3NPQDT): Moist Tendencies

**Frequency:** *Monthly from 01:30 UTC (time-averaged)*
**Spatial Grid:** *3D, pressure-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, level=42, time=8*
**Granule Size:** *~335 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| DQIDTDYN | tzyx | tendency of ice water due to dynamics | kg $kg^{-1}$ $s^{-1}$ |
| DQIDTMST | tzyx | total ice water tendency due to moist | kg $kg^{-1}$ $s^{-1}$ |
| DQIDTTRB | tzyx | tendency of frozen condensate due to turbulence | kg $kg^{-1}$ $s^{-1}$ |
| DQLDTDYN | tzyx | tendency of liquid water due to dynamics | kg $kg^{-1}$ $s^{-1}$ |
| DQLDTMST | tzyx | total liq water tendency due to moist | kg $kg^{-1}$ $s^{-1}$ |
| DQLDTTRB | tzyx | tendency of liquid condensate due to turbulence | kg $kg^{-1}$ $s^{-1}$ |
| DQVDTANA | tzyx | total specific humidity analysis tendency | kg $kg^{-1}$ $s^{-1}$ |

| | | | |
|---|---|---|---|
| DQVDTCHM | tzyx | tendency of water vapor mixing ratio due to chemistry | kg $kg^{-1}$ $s^{-1}$ |
| DQVDTDYN | tzyx | tendency of specific humidity due to dynamics | kg $kg^{-1}$ $s^{-1}$ |
| DQVDTMST | tzyx | specific humidity tendency due to moist | kg $kg^{-1}$ $s^{-1}$ |
| DQVDTTRB | tzyx | tendency of specific humidity due to turbulence | kg $kg^{-1}$ $s^{-1}$ |

### tavgM_3d_rad_Np (M2T3NPRAD): Radiation Diagnostics

**Frequency:** *Monthly from 01:30 UTC (time-averaged)*
**Spatial Grid:** *3D, pressure-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, level=42, time=8*
**Granule Size:** *~236 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| CLOUD | tzyx | cloud fraction for radiation | 1 |
| DTDTLWR | tzyx | air temperature tendency due to longwave | K $s^{-1}$ |
| DTDTLWRCLR | tzyx | air temperature tendency due to longwave for clear skies | K $s^{-1}$ |
| DTDTSWR | tzyx | air temperature tendency due to shortwave | K $s^{-1}$ |
| DTDTSWRCLR | tzyx | air temperature tendency due to shortwave for clear skies | K $s^{-1}$ |

### tavgM_3d_tdt_Np (M2T3NPTDT): Temperature Tendencies

**Frequency:** *Monthly from 01:30 UTC (time-averaged)*
**Spatial Grid:** *3D, pressure-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, level=42, time=8*
**Granule Size:** *~371 MB*

| *Name* | *Dim* | *Description* | *Units* |
|---|---|---|---|
| DTDTANA | tzyx | total temperature analysis tendency | K $s^{-1}$ |
| DTDTDYN | tzyx | tendency of air temperature due to dynamics | K $s^{-1}$ |
| DTDTFRI | tzyx | tendency of air temperature due to friction | K $s^{-1}$ |

| | | | |
|---|---|---|---|
| DTDTGWD | tzyx | air temperature tendency due to GWD | K $s^{-1}$ |
| DTDTMST | tzyx | tendency of air temperature due to moist processes | K $s^{-1}$ |
| DTDTRAD | tzyx | tendency of air temperature due to radiation | K $s^{-1}$ |
| DTDTTOT | tzyx | tendency of air temperature due to physics | K $s^{-1}$ |
| DTDTTRB | tzyx | tendency of air temperature due to turbulence | K $s^{-1}$ |

### tavgM_3d_trb_Np (M2T3NPTRB): Turbulence Diagnostics

**Frequency:** *Monthly from 01:30 UTC (time-averaged)*
**Spatial Grid:** *3D, pressure-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, level=42, time=8*
**Granule Size:** *~353 MB*

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

### tavgM_3d_udt_Np (M2T3NPUDT): Wind Tendencies

**Frequency:** *Monthly from 01:30 UTC (time-averaged)*
**Spatial Grid:** *3D, pressure-level, full horizontal resolution*
**Dimensions:** *longitude=576, latitude=361, level=42, time=8*
**Granule Size:** *~387 MB*

| ***Name*** | ***Dim*** | ***Description*** | ***Units*** |
|---|---|---|---|
| DUDTANA | tzyx | total eastward wind analysis tendency | m $s^{-2}$ |
| DUDTDYN | tzyx | tendency of eastward wind due to dynamics | m $s^{-2}$ |
| DUDTGWD | tzyx | tendency of eastward wind due to GWD | m $s^{-2}$ |
| DUDTMST | tzyx | zonal wind tendency due to moist | m $s^{-2}$ |
| DUDTTRB | tzyx | tendency of eastward wind due to turbulence | m $s^{-2}$ |
| DVDTANA | tzyx | total northward wind analysis tendency | m $s^{-2}$ |
| DVDTDYN | tzyx | tendency of northward wind due to dynamics | m $s^{-2}$ |
| DVDTGWD | tzyx | tendency of northward wind due to GWD | m $s^{-2}$ |
| DVDTMST | tzyx | meridional wind tendency due to moist | m $s^{-2}$ |
| DVDTTRB | tzyx | tendency of northward wind due to turbulence | m $s^{-2}$ |

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# Web Resources

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

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

GEOS-5 Variable Definition Glossary:
https://gmao.gsfc.nasa.gov/products/documents/GEOS-5_Filespec_Glossary.pdf