File Specification for GEOS-DAS Gridded Output
Version 5.2

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http://dao.gsfc.nasa.gov

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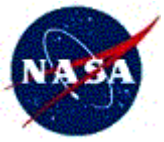
Version 5.2
To support EOS with GEOS-4.x



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May 23, 2002

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REVISION HISTORY

Version Number	Revision Date	Pages Affected/Extent of Changes	Approval Authority
Version 1.0 (original - no electronic copy)	April 8, 1997	All	Not Approved
Version 3.0 (DAO-1001.30)	November 4, 1997	- Added 5 authors - Reorganized the document - Replaced Sections 3, 5, 6, and Appendix B	Not Approved
Version 3.1 (DAO-1001.31)	January 5, 1998	- Added Figure 1 - Revised size estimate for single level mis and lsm in Sections 6.1 and 6.2 - Made various changes to the list of variables in the assimilated time averaged files in Section 6.3	Rob Lucchesi 1/26/99 (Closed CR 131)
Version 3.2 (DAO-1001.32)	March 4, 1999	- Changed "GEOS-3" to "GEOS-AM1" throughout the document - Updated scope and launch date in Section 1 - Provided more detailed description of file format including Dimensions, Variables, and Attributes in Section 2 - Modified the horizontal resolution and clarified the description of the grids in Section 4 - Included version ID in the filename convention described in Section 5.1 - The file sizes were updated in Section 6 to reflect the new horizontal resolution - Improved the description of packing and included directions for unpacking in Section 8 - Two sample programs were added in Section 9 to demonstrate using the HDF library and the HDF-EOS library for reading the data files - Updated the description of First Look Analysis and added a description of Late Look Analysis in Appendix A - Added references for the data format	CCB 3/16/99

Version Number	Revision Date	Pages Affected/Extent of Changes	Approval Authority
Version 4.0 (DAO-1001.4)	May 19, 1999	- Title changed to "File Specification for GEOS-DAS Gridded Output" - Changed details of internal products in Section 1 - Added a figure and description of the horizontal grid structure, removed references to sigma levels in the vertical grid description, and indicated differences in the grids of the CHM products in Section 4 - Indicated that forecast and analysis products will not be archived for distribution by ECS and removed filenaming information for sigma and forecast products in Section 5 - Various changes made to Section 6: - split product table into one table for first look and one for late look - removed sigma products and sigma sizes and definitions - added ESDTs - adjusted the horizontal resolution of CHM products - removed forecast products - added a discussion of the different horizontal and vertical grid structures of the CHM products - Updated the description of First Look Analysis in Appendix A - Added a new table of pressure levels for CHM products and removed the table of sigma levels in Appendix C - Added references for the data format - Levels 36 and 42 in Appendix C tables were changed from 0.1 to 0.2 because in 3D pressure products, 0.2 hPa is now the highest level, changed from 0.1 hPa in earlier documentation	CCB 5/19/99
Version 4.1 (DAO-1001v4.1)	August 18, 1999	- Slight adjustment of variable content for tavg_cld_p, tavg3d_tmp_p, and tavg3d_tmp_p products.	CCB 8/18/99
Version 4.2	January 21, 2000	- Re-write Section 3 to clarify description of time-averaged products. - Changed AM-1 to Terra throughout document. - Added approval dates to revision history for Version 4.0 and Version 4.1.	CCB 1/21/00
Version 4.3	September 20, 2001	- In Table 6.1, adjusted the sizes of three products to match the detailed descriptions in Section 6.2: DFLAXENG changes from 66.7 to 58.4 DLLAPCLD changes from 150.1 to 112.6 DLLAPTMP changes from 337.8 to 412.9	CCB 5/17/00
Version 5.0 *DRAFT* in support of GEOS-4.x.	November 07, 2001	-The horizontal resolution of output products has been changed to 288x181. The prior value was 360x181. This change is reflected in Sections 4 and 6. -The grid origin has been changed from (-180.0W,-90.0S) to (0.0W,-90.0S). This change is documented in Section 4. -Adjustments were made to Section 3 to describe the different time-averaging characteristics of the GEOS-4.x system output variables. In particular, 6-hourly time averages now have a different averaging period. This will result in different range begin and end times for 3D pressure products. -In section 6, variables that were unavailable from the GEOS-4.x system were removed from DAS product descriptions. Variables that were previously produced by GEOS-3.x but are no longer available are indicated with a strike-through. Similarly, the old file size calculations are indicated with strike-throughs. -Appendix A was cleaned up to better describe the assimilation modes that are used in the operational arena. -Figures specific to GEOS-3.x were removed.	DDB 10/31/01

Version Number	Revision Date	Pages Affected/Extent of Changes	Approval Authority
Version 5.0 in support of GEOS-4.x	March 20, 2002	-Time-averaging definitions were changed. All time-averages will be timestamped with the center of the averaging period. The range time for each time-averaged product will be 00GMT to 00 GMT. This is different from GEOS-3, where products had range times from 21 GMT to 21 GMT. Users will have adjust indices used to read time in order to get data valid for the same time period. -Z0 replaced by Z0H and Z0M in tavg2d_str_x. -GWET in tsyn2d_mis_x was replaced by GWETROOT and GWETTOP in tavg2d_eng_x. -Variable name TGROUND changed to TSKIN in tsyn2d_mis_x and tavg2d_eng_x. -OMEGA moved from tsyn3d_mis_p to tavg3d_mom_p. -Added PRECL to tavg2d_eng_x. PREACC = PRECL + PRECON. -Moved PARDR and PARDF from tavg2d_lsm_x to tavg2d_eng_x. -Removed from tsyn2d_mis_x: ALBEDO, VAVEU, VAVEV, VAVET, TPW, GWET, SNOW -Removed from tsyn3d_mis_p: TKE, OMEGA. -Removed from tavg2d_eng_x: QICE, CT, VAVEQIAU, VAVEQFIL, VAVETIAU. -Removed from tavg2d_str_x: GWDUT, GWDVT, CU, Z0, PIAU. -Removed from tavg2d_lsm_x: SNOWFALL, GREEN, DLWDTC, PARDR, PARDF. -Removed from tavg2d_cld_x: TAULOW, TAUMID, TAUHI, CLDTMP, CLDPRS. -Removed from tavg3d_cld_p: CLDRAS. -Removed from tavg3d_mom_p: RFU, RFV, UIAU, VIAU, DUDT, DVDT. -Removed from tavg3d_mst_p: DQLS, QIAU, QFILL, DQDT. -Removed from tavg3d_tmp_p: TURBT, MOISTT, RADLW, RADSW, GWDT -Added TROPQ, UFLUX, VFLUX, and HFLUX to tsyn2d_mis_x; -PBL replaced by PBLH.	CCB 3/22/02
Version 5.1	April 25,2002	The longitude range of the grid was changed from (0 -> 360) to (-180 -> 180). This is consistent with the GEOS-3 products and with ECS conventions.	DDB 04/25/2002
Version 5.2	May 23, 2002	-The filename examples in section 5 were updated to reflect the new range times of time-averaged products. -Appendix D was added highlighting the differences between GEOS-3 and GEOS-4 products.	CCB off-line 5/23/2002

Table of Contents

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1. Introduction

This document describes the gridded output files from the version of the Goddard EOS Data Assimilation System (GEOS-4), which will support level-4 product generation. The intended audience is EOS instrument teams and other users of GEOS-4 products who need to write software to read DAO products. The gridded data described in this document will be produced by the GEOS-4 Data Assimilation System (DAS) beginning in 2002 and delivered to the Goddard Distributed Active Archive Center (DAAC), part of the EOSDIS Core System (ECS). Two production suites will run daily, the first-look assimilation and the late-look assimilation (see Appendix A for definitions). To conserve space, a limited set of products will be generated by the first-look assimilation while the full set will be generated by the late-look assimilation. The product descriptions in Section 6 will identify which products are generated by each run. Information on the status of DAO product generation can be found at http://dao.gsfc.nasa.gov/Operations/.

2. Format and File Organization

GEOS- 4 files are in HDF-EOS format, which is an extension of the Hierarchical Data Format (HDF), Version 4 developed at the National Center for Supercomputing Applications (NCSA). Each GEOS- 4 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 lon/lat grid and some files will contain 3-D variables on the same lon/lat grid but with an additional vertical dimension. All files will have a time dimension with the number of times dependent on the file type (see Section 6). GEOS- 4 products always contain one complete day of data.

The variables are created using the **GDdeffield** function from the HDF-EOS GD API which implements them as HDF Scientific Data Set (SDS) arrays so 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 insure that a wide variety of graphical display tools can interpret the dimension scales. In particular, there is a set of dimension scales that adhere to the COARDS conventions (see References).

ECS metadata and other information will be stored as global attributes.

2.1 Dimensions

DAO 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 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 as suggested in the ECS technical paper "Writing HDF-EOS Grid Products for Optimum Subsetting Services."

Table 2.1-1. Dimension Variables Contained in DAO HDF-EOS Files

Name	Description	Type	*units* attribute
XDim:EOSGRID	longitude values	float32	degrees_east
YDim:EOSGRID	latitude values	float32	degrees_north
Height:EOSGRID (3D only)	pressure levels	float32	millibar
TIME:EOSGRID	minutes since first time in file	float32	minutes since YYYY-MM-DD HH:MM:SS
XDim	longitude values	float64	N/A
YDim	latitude values	float64	N/A
Height (3D only)	pressure levels	float64	N/A
Time	seconds since 1/1/93	float64	N/A

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

2.2 Variables

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 short name of the variable and the dimensions. You can quickly list the variables in the file by using common utilities such as *ncdump* or *hdp* . The latter utility is distributed from NCSA with the HDF library. A sample scan of one DAO HDF-EOS file is shown below:

```
unix% hdp dumpsds -h
DAS.flk.asm.tsyn3d_mis_p.GEOS400.1999052800.1999052818.V01 | grep Variable

Variable Name = UWND
Variable Name = VWND
Variable Name = HGHT
Variable Name = TMPU
Variable Name = SPHU
Variable Name = RH
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
```

In Section 8 we will present sample code for reading one or more data fields from this file. The short names for all variables in all DAO data products are listed in the File Collections chapter, Section 6.

Each variable will have metadata attributes defined that may be useful. Many of these attributes are required by the COARDS conventions while others are for internal DAO use. A listing of required attributes follows:

- FillValue (Type = 32-bit floating point or 16-bit signed integer)
  Any missing data will be filled with this value. This attribute is generated automatically by the HDF-EOS library. It will be of the same data type as the variable, thus could be 16-bit integer if the variable is packed.
- long_name (Type = 8-bit signed char)
  Long name or description for this variable.
- units (Type = 8-bit signed char)
  The units of the geophysical variable (ud-units compliant).
- scale_factor (Type = 32-bit floating point)
  If this variable is packed into 16-bit integers, this value would be multiplied to each data value to obtain the floating point number.
- add_offset (Type = 32-bit floating point)
  For a packed variable, add this number after multiplying by the scale_factor.
- missing_value (Type = 32-bit floating point or 16-bit signed integer)
  For an unpacked variable, this is a floating-point representation of the fill value. For a packed variable, this is an integer representation of the fill value.
- fmissing_value (Type = 32-bit floating point)
  Always a floating-point representation of the fill value.
- vmin (Type = 32-bit floating point)
  For internal DAO use.
- vmax (Type = 32-bit floating point)
  For internal DAO use.

Since we are not planning to pack the products intended for use by EOS instrument teams, attributes that support packing can be ignored. There may be other attributes that are meant for internal DAO use that can also be ignored.

2.3 Global Attributes

In addition to SDS arrays containing variables and dimension scales, there is additional metadata stored in DAO HDF-EOS files. Some of this metadata is required by the COARDS conventions, some is present due to ECS requirements, and some may exist as a convenience to internal DAO users. A summary of global attributes that will exist in all DAO files follows:

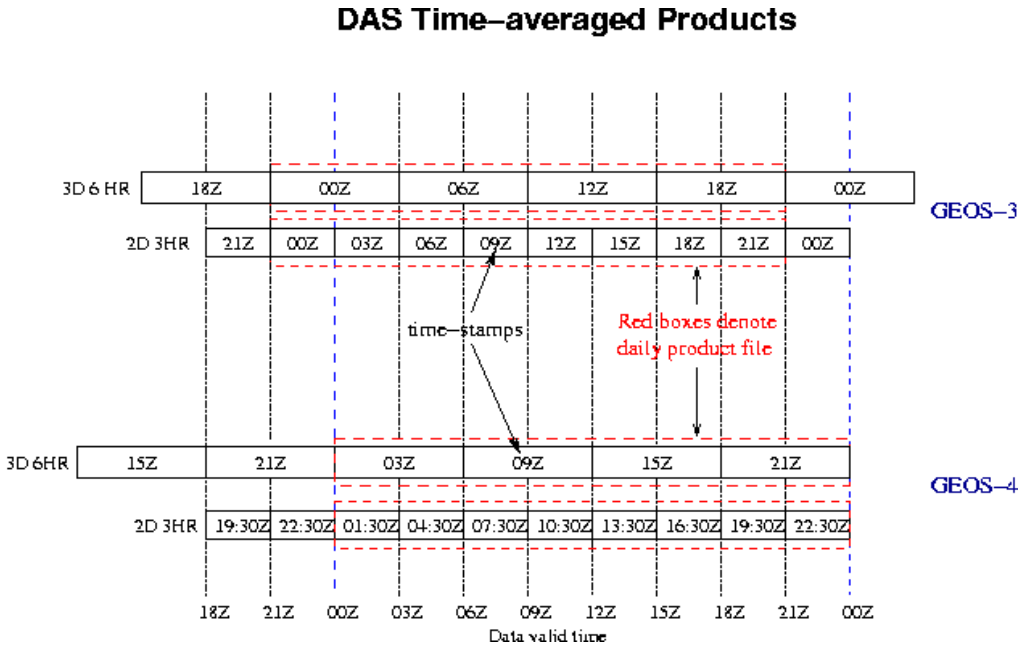
- HDFEOSVersion - Version of the HDF-EOS library used to create this file.
- StructMetadata.0 - This is the GridStructure metadata that is created by the HDF-EOS library.
- CoreMetadata.0 - The ECS inventory metadata.
- ArchivedMetadata.0 - The ECS archive metadata.
- Title - GEOS-DAS Version number and CVS tag.

- Conventions - Should always be set to "COARDS".
- Source - NASA Data Assimilation Office, GEOS-DAS Version.
- Contact - Where to send questions.
- History - Version of DAS output library.

3. Synoptic vs Time-averaged Products

GEOS-4 gridded output files are identified as either synoptic or time-averaged products. Synoptic products are defined in Section 6.2 while time-averaged products are defined in Section 6.3. Additional synoptic products associated with the ozone assimilation are defined in Section 6.4. All synoptic products contain fields which are snapshots of a specific time. The synoptic products defined in Section 6.2 are generated directly from the atmospheric data analysis, which is performed every six hours at the four *synoptic times* (00 GMT, 06 GMT, 12 GMT, and 18 GMT). The "tsyn3d_mis_p" product has a time frequency of 6 hours, with data for each synoptic time. The "tsyn2d_mis_x" synoptic product has a time-frequency of 3 hours. The values for 03 GMT, 09 GMT, 15 GMT, and 21 GMT are time-interpolated from the synoptic times. This is done to make the product consistent with GEOS-3 products.

Time-averaged products are averaged over a 3-hour period for single level files or a 6-hour period for pressure level files. Single level products contain 8 times, with time-stamps of 01:30, 04:30, 07:30, 10:30, 01:30, 16:30, 19:30, and 22:30 GMT. Each time-stamp represents the center of a three-hour average, i.e., the first time in each file (time stamped with 01:30 GMT) represents the average between 00 GMT and 03 GMT. Time-averaged pressure level products contain 4 times with time-stamps of 03, 09, 15, and 21 GMT. Each time-stamp represents the center of a 6-hour average, i.e., the first time in the file (time-stamped with 03 GMT) represents an average between 00 GMT and 06 GMT. The valid range time of a daily file is 00 GMT to 00 GMT for both 3-hour and 6-hour average products. Note that the time-averaging of GEOS-4 products is different than with the preceding GEOS-3 system (see diagram).



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4. Grid Structure

Most GEOS-4 gridded output will be on a 1.25 x 1.0 degree global longitude-latitude horizontal grid (288,181). Products from the DAO ozone assimilation (D4FAXCHM, D4FAPCHM, D4LAXCHM, D4LAPCHM) will be on a 2.5 x 2.0 degree longitude-latitude horizontal grid (144,91). The horizontal grid origin is the lower-left point and represents the geolocation (-180.0 W, -90.0 S). Latitude or longitude as a function of the index can be determined by:

lon = -180 + (x-1) * dx
lat = -90 + (y-1) * dy

where dx = 1.25, dy = 1.0 except in the case of ozone products where dx = 2.5, dy = 2.0. The gridpoints represent the center of a box, i.e., the value at (lon=5,lat=0) represents a box bounded by the points (lon=4.375,lat=-0.5), (lon=5.625,lat=0.5), (lon=5.625,lat=0.5), and (lon=4.375,lat=-0.5). Scalar values are the volume mean within the box.

The vertical structure of gridded products will have 2 different configurations: single-level (can be vertical averages) or pressure levels. Single level data for a given variable appear as 3-dimensional fields (x,y,time) while pressure level data appear as 4-dimensional fields (x,y,z,time). Pressure level data will be output on 36 pressure levels (hPa), except for D4FAPCHM and D4LAPCHM which will have 42 pressure levels (see Appendix C). The appropriate grid structure will be specified both in the filename and the metadata.

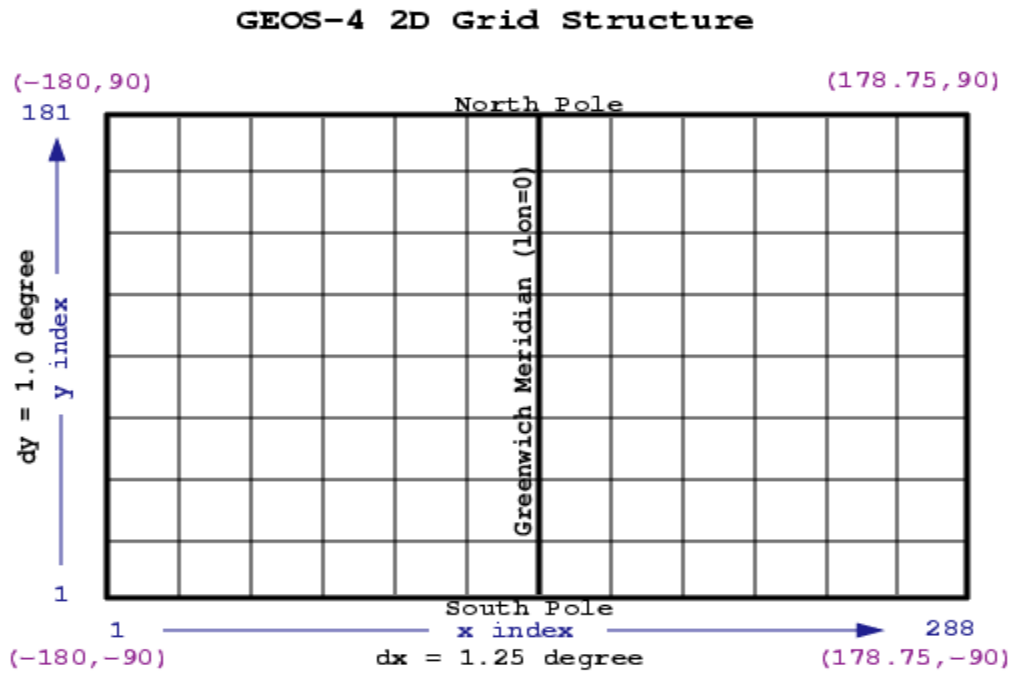

Figure 4-1: 1.25 x 1.0 degree horizontal grid.
The origin is at lower-left corner (-180W,-90S).
lon = -180 + (x-1) * dx
lat = -90 + (y-1) * dy

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5. File Naming Convention

Each GEOS-4 product will have a complete file name identified in the EOSDIS metadata as "LocalGranuleID". EOSDIS also requires abbreviated naming indices (8-character limit) for each Earth Science Data Type (ESDT). The ESDT indices convention is described in section 5.2.

5.1 File Name

The standard generic complete name for the assimilated GEOS- 4 configuration products will appear as follows:
DAS.config.mode.filetype.expid.yyyymmddhh.yyyymmddhh.version

A brief description of the node fields appear below:

DAS:
Identifies output as a Data Assimilation System product.

config:
GEOS-4 will run in two different configurations. Appendix A describes these configurations. These are the strings that can appear in the config field.

flk - First Look
llk - Late Look

mode:
GEOS-4 can run in different modes of operation, but the only mode used to support EOS instrument teams is "asm".

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

filetype:
The major filetypes are subdivided into file collections. Collections contain several fields with common characteristics. These collections are necessary to keep file sizes reasonable. Each filetype will contain the following information:

type/dimension_group_level

type/dimension:

There exist four possible type/dimension conventions for the DAS data products:

tsyn2d - 2-dimensional instantaneous fields at synoptic times (no time averaging).
tsyn3d - 3-dimensional instantaneous fields at synoptic times (no time averaging).
tavg2d - 2-dimensional 3-hour time averaged fields, time-stamped at the center of the averaging period. For example, 04:30z output would be a 3z-6z time average).

tavg3d - 3-dimensional 6-hour time averaged fields, time-stamped at the center of the averaging period. For example, 3z output would be a 0z-6z time average.

group (for files which contain 2-dimensional fields):

str: stress related fields
eng: energy related fields
cld: cloud related fields
lsm: land surface model related fields
chm: chemical related fields (e.g. ozone)
mis: mixture of prognostic and diagnostic fields

group (for files which contain 3-dimensional fields):

mis: mixture of prognostic and diagnostic fields
mom: momentum profile fields
tmp: temperature profile fields
mst: moisture profile fields
cld: cloud profile related fields
trp: transport profile fields (e.g. eddy diffusivity)
chm: chemical profile fields

level: There are two possible level types for the DAS data:

x: single level data (surface, column integrated, single level)
p: pressure level data (see Appendix C for pressure levels)

expid:
Experiment Identification. The GEOS-4 DAS data sets will be labeled:

GEOS4##

where ## is a two-digit number. When GEOS-4 is initialized in operations, the experiment identification will be GEOS401. When a reprocessing or reanalysis experiment is run over previously processed data periods we will increment the ## sequentially. Note that products produced by GEOS-3 had an experiment identification of AM101. These First-look and Late-look products were generated between January 1, 2000 and the operations date of GEOS-4 (expected to be sometime in 2002). As updated versions of the GEOS software are implemented in operations, this will be captured in the metadata parameter "Title" as well as on the DAO operations status web page (http://dao.gsfc.nasa.gov/Operations/).

yyyymmddhh.yyyymmddhh:
This group defines the beginning date and synoptic time as well as the ending date and synoptic time.

yyyy - year string (e.g. "2002")
mm - month string (e.g. "09" for September)
dd - day of the month string (e.g. "10" for the tenth day of the month)
hh - time (synoptic hour, e.g. "18" for 18:00 Greenwich Mean Time)

version:
This group defines the file version and takes the form V##. Under normal conditions ## will be 01. In the event of a processing error that requires a re-processing, this number will be incremented to identify the new version of this file. The file version will also be represented in the EOSDIS metadata as "LocalVersionID".

EXAMPLE:

DAS.flk.asm.tavg3d_mom_p.GEOS401.2002091500.2002091600.V01

This is an example of a DAS filename. It is a first look assimilation product. The data are 6-hour time averaged output on pressure levels (3 dimensions). The filetype consists of momentum fields. The valid range time for the file is Sep 15 at 00 GMT through Sep 16 at 00 GMT. There are 4 times, each representing a 6-hour average. The first average is from 00 GMT to 06 GMT. The last average is from 18 GMT to 00 GMT. See the discussion on time-averaged data in section 3 for more information.

5.2 Earth Science Data Types (ESDT) Name

To accommodate EOSDIS toolkit requirements, GEOS-4 complete filenames are associated to shorter or abbreviated indices in the ESDTs. EOSDIS requires a short (8 character) name for each ESDT. Below is the abbreviated naming convention for the GEOS-4 gridded ESDTs. The standard ESDT naming convention for the GEOS-4 gridded output will have the form:

DSPMVCCC

D: DAS identifier. Always **D**.

S: Major system number. For GEOS-4, **4.**

P: Product

F = First Look
L = Late Look

M: Mode

A = Assimilation
F = Forecast (currently not used)

V: Vertical Coordinate:

X = Single-Level
P = Pressure

CCC: Filetype

MIS = misc
ENG = energy
LSM = land surface model
STR = stress
CHM = chemical
CLD = cloud
MOM = momentum
MST = moisture
TMP = temperature
TRP = transport fields

Example:

Abbreviated Name: D4FAPMOM

Complete Name: DAS.flk.asm.tavg3d_mom_p.GEOS401.2002091500.2001091600.V01

6. File Collections

The contents of the Data Assimilation System file collections are described in sections 6.2, 6.3 and 6.4 while the sizes of each file are discussed in Section 6.1.

6.1 File Sizes

With the exception of chemistry (chm) products, GEOS-4 HDF files contain 1 day of data on a 1.25 degree x 1 degree lon-lat grid using 32-bit floating-point storage. Chm products are stored on a 2.5 degree by 2.0 degree lon-lat grid. See Appendix C for details about vertical levels. File sizes are approximate as metadata can cause slight variations in file size.

First-Look Filetype Group	Single Level (MB/day) (288,181,1) 8X/day	Pressure Levels (MB/day) (288,181,36) 4X/day
mis	31.7 (D4FAXMIS)	180.2 (D4FAPMIS)
eng	51.7 (D4FAXENG)	N/A
str	21.7 (D4FAXSTR)	N/A
chm	0.4 (D4FAXCHM) *	8.8 (D4FAPCHM) **
cld	15.0 (D4FAXCLD)	Not produced
lsm	11.7 (D4FAXLSM)	N/A
mom	N/A	Not produced
mst	N/A	Not produced
tmp	N/A	Not produced
trp	N/A	Not produced
Totals	132.2	189.0

Late-Look Filetype Group	Single Level (MB/day) (288,181,1) 8X/day	Pressure Levels (MB/day) (288,181,36) 4X/day
mis	31.7 (D4LAXMIS)	180.2 (D4LAPMIS)
eng	51.7 (D4LAXENG)	N/A
str	21.7 (D4LAXSTR)	N/A
chm	0.4 (D4LAXCHM) *	8.8 (D4LAPCHM) **
cld	15.0 (D4LAXCLD)	90.1 (D4LAPCLD)
lsm	11.7 (D4LAXLSM)	N/A
mom	N/A	150.2 (D4LAPMOM)
mst	N/A	60.1 (D4LAPMST)
tmp	N/A	150.2 (D4LAPTMP)
trp	N/A	120.1 (D4LAPTRP)
Total	132.2	759.7

* = (144, 91, 1) ** = (144, 91, 42)

6.2 Assimilated Synoptic Files

Below are the variables that are output into each syn file. These are instantaneous fields (no time averaging). The approximate size of each file below is determined by the following:

A x B x C x D x E x F = bytes/day

where:

A: X-Dimension
B: Y-Dimension
C: Vertical dimension
D: Number of fields in file
E: Number of times in file
F: Number of bytes per floating point number

The method for calculating sizes is the same in 6.2, 6.3, and 6.4.

NOTE: All HDF variable names are UPPERCASE.

- **tsyn2d_mis_x** (8 times per day)

  First-look ECS short name: D4FAXMIS
  First-look ECS long name: DAS First-look 2d state (miscellaneous), instantaneous
  Late-look ECS short name: D4LAXMIS
  Late-look ECS long name: DAS Late-look 2d state (miscellaneous), instantaneous
  Size: 288 x 181 x 1 x 19 x 8 x 4 = 31.7 MB/day

Variable Name	Description	Units
PHIS	Surface geopotential	$(m/s)^2$
PS	Surface pressure	hPa
SLP	Sea level pressure	hPa
SURFTYPE	Surface types	0=water, 1=land, 2=ice
TSKIN	Skin temperature	K
T2M	Temperature at 2 m above surface	K
T10M	Temperature at 10 m above surface	K
Q2M	Specific humidity at 2 m above surface	g/kg
Q10M	Specific humidity at 10 m above surface	g/kg
U2M	Zonal wind at 10 m above surface	m/s
V2M	Meridional wind at 2 m above surface	m/s
U10M	Zonal wind at 10 m above surface	m/s
V10M	Meridional wind at 10 m above surface	m/s
UFLUX	Zonal wind surface stress	N/m^2
VFLUX	Meridional wind surface stress	N/m^2
HFLUX	Sensible heat flux (pos. upward)	W/m^2
TROPP	Tropopause pressure	hPa
TROPT	Tropopause temperature	K
TROPQ	Tropopause specific humidity	g/kg

- **tsyn3d_mis_p** (4 times per day)

  First-look ECS short name: D4FAPMIS
  First-look ECS long name: DAS First-look 3d state (miscellaneous), instantaneous on pressure coordinates
  Late-look ECS short name: D4LAPMIS

Late-look ECS long name: DAS Late-look 3d state (miscellaneous), instantaneous on pressure coordinates
Size: 288 x 181 x 36 x 6 x 4 x 4 = 180.2 MB/day

Variable Name	Description	Units
UWND	Zonal wind	m/s
VWND	Meridional wind	m/s
HGHT	Geopotential height (virtual)	m
TMPU	Temperature	K
SPHU	Specific humidity	g/kg
RH	Relative humidity	percent

6.3 Assimilated Time Averaged Files

Below are the variables which are output in each "tavg" file. These are time averaged fields. Single-level, or 2-dimensional data will be output every 3 hours while 3-dimensional data will be output every 6 hours.

- **tavg2d_eng_x** (8 times per day)
  First-look ECS short name: D4FAXENG
  First-look ECS long name: DAS First-look 2d energy, averaged
  Late-look ECS short name: D4LAXENG
  Late-look ECS long name: DAS Late-look 2d energy, averaged
  Size: 288 x 181 x 1 x 31 x 8 x 4 = 51.7 MB/day

Variable Name	Description	Units
PREACC	Total precipitation rate	mm/day
PRECL	Large-scale precipitation rate	mm/day
PRECON	Convective precipitation rate	mm/day
TPW	Total precipitable water	g/cm^2
EVAP	Surface evaporation	mm/day
GWETROOT	Root zone soil wetness	fraction
GWETTOP	Top soil layer wetness	fraction
HFLUX	Sensible heat flux (positive upward)	W/m^2
TSKIN	Skin temperature	K
T2M	Temperature interpolated to 2 meters	K
T10M	Temperature interpolated to 10 meters	K
Q2M	Specific humidity interpolated to 2 meters	g/kg
Q10M	Specific humidity interpolated to 10 meters	g/kg
RADLWG	Net upward longwave flux at the ground	W/m^2
RADSWG	Net downward shortwave flux at the ground	W/m^2
PARDF	Diffuse-beam photosynthetically active radiation	W/m^2
PARDR	Direct-beam photosynthetically active radiation	W/m^2
LWGCLR	Clear sky net longwave flux at the ground	W/m^2
SWGCLR	Clear sky net downward shortwave radiation at the ground	W/m^2
ALBEDO	Surface albedo	fraction
ALBVISDR	Direct beam VIS surface albedo	fraction
ALBVISDF	Diffuse beam VIS surface albedo	fraction
ALBNIRDR	Direct beam NIR surface albedo	fraction
ALBNIRDF	Diffuse beam NIR surface albedo	fraction
VAVEU	Vertically averaged zonal wind	m/s
VAVEV	Vertically averaged meridional wind	m/s
VAVET	Vertically averaged temperature	K
VAVEUQ	Vertically averaged UWND*SPHU	m-g/s-kg
VAVEVQ	Vertically averaged VWND*SPHU	m-g/s-kg
VAVEUT	Vertically averaged UWND*TMPU	m-K/s
VAVEVT	Vertically averaged VWND*TMPU	m-K/s

- **tavg2d_str_x** (8 times per day)
  First-look ESDT: D4FAXSTR
  First-look ECS long name: DAS First-look 2d stress, averaged
  Late-look ECS short name: D4LAXSTR
  Late-look ECS long name: DAS Late-look 2d stress, averaged
  Size: 288 x 181 x 1 x 13 x 8 x 4 = 21.7 MB/day

Variable Name	Description	Units
PS	Time averaged surface pressure	hPa
UFLUX	Zonal wind surface stress	N/m^2
VFLUX	Meridional wind surface stress	N/m^2
GWDUS	Zonal wind gravity wave surface stress	N/m^2
GWDVS	Meridional wind gravity wave surface stress	N/m^2
USTAR	Friction velocity	m/s
Z0H	Roughness length , sensible heat	m
Z0M	Roughness length , momentum	m
PBLH	Planetary boundary layer height	m
U2M	Zonal wind interpolated to 2 meters	m/s
V2M	Meridional wind interpolated to 2 meters	m/s
U10M	Zonal wind interpolated to 10 meters	m/s
V10M	Meridional wind interpolated to 10 meters	m/s

- **tavg2d_lsm_x** (8 times per day)
  First-look ESDT: D4FAXLSM
  First-look ECS long name: DAS First-look 2d Land Surface Model (LSM), averaged
  Late-look ECS short name: D4LAXLSM
  Late-look ECS long name: DAS Late-look 2d Land Surface Model (LSM), averaged
  Size: 288 x 181 x 1 x 7 x 8 x 4 = 11.7 MB/day

Variable Name	Description	Units
RAINCON	Convective rainfall (liquid precipitate)	mm/day
RAINLSP	Large-scale rainfall (liquid precipitate)	mm/day
LWGDOWN	Downward longwave radiation at the ground	W/m^2
LWGUP	Upward longwave radiation at the ground	W/m^2
LAI	Leaf area index	percent
DTG	Total change in ground temperature	K/s
SNOW	Snow depth	mm (water equivalent)

- **tavg2d_cld_x** (8 times per day)
  First-look ESDT: D4FAXCLD
  First-look ECS long name: DAS First-look 2d cloud, averaged
  Late-look ECS short name: D4LAXCLD
  Late-look ECS long name: DAS Late-look 2d cloud, averaged
  Size: 288 x 181 x 1 x 9 x 8 x 4 = 15.0 MB/day

Variable Name	Description	Units
OLR	Outgoing longwave radiation	W/m^2
OLRCLR	Clear sky outgoing longwave radiation	W/m^2
RADSWT	Incident shortwave radiation at top of atmosphere	W/m^2
OSR	Outgoing shortwave radiation	W/m^2
OSRCLR	Clear sky outgoing shortwave radiation	W/m^2
CLDFRC	Total cloud fraction	fraction
CLDLOW	Low-level (1000-700 hPa) cloud fraction	fraction
CLDMID	Mid-level (700-400 hPa) cloud fraction	fraction
CLDHI	High-level (above 400 mb) cloud fraction	fraction

- **tavg3d_cld_p** (4 times per day)
  Late-look ECS short name: D4LAPCLD
  Late-look ECS long name: DAS Late-look 3d cloud, averaged on pressure coordinates
  Size: 288 x 181 x 36 x 3 x 4 x 4 = 90.1 MB/day

Variable Name	Description	Units
TAUCLI	Cloud optical depth, ice	non-dimensional
TAUCLW	Cloud optical depth, water	non-dimensional
CLDTOT	3-D total cloud fraction	fraction

- **tavg3d_mom_p** (4 times per day)
  Late-look ECS short name: D4LAPMOM
  Late-look ECS long name: DAS Late-look 3d momentum, averaged on pressure coordinates
  Size: 288 x 181 x 36 x 5 x 4 x 4 = 150.2 MB/day

Variable Name	Description	Units
TURBU	Zonal wind tendency due to turbulence	m/s/day
TURBV	Meridional wind tendency due to turbulence	m/s/day
GWDU	Zonal wind tendency due to gravity wave drag	m/s/day
GWDV	Meridional wind tendency due to gravity wave drag	m/s/day
OMEGA	Vertical velocity	Pa/s

- **tavg3d_mst_p** (4 times per day)
  Late-look ECS short name: D4LAPMST
  Late-look ECS long name: DAS Late-look 3d moisture, averaged on pressure coordinates
  Size: 288 x 181 x 36 x 2 x 4 x 4 = 60.1 MB/day

Variable Name	Description	Units
TURBQ	Specific humidity tendency due to turbulence	g/kg/day
MOISTQ	Specific humidity tendency due to moist processes	g/kg/day

- **tavg3d_tmp_p** (4 times per day)
  Late-look ECS short name: D4LAPTMP
  Late-look ECS long name: DAS Late-look 3d temperature, averaged on pressure coordinates
  Size: 288 x 181 x 36 x 5 x 4 x 4 = 150.2 MB/day

Variable Name	Description	Units
TURBT	Temperature tendency due to turbulence	K/day
MOISTT	Temperature tendency due to moist processes	K/day
RADLW	Temperature tendency due to longwave radiation	K/day
RADSW	Temperature tendency due to shortwave radiation	K/day
GWDT	Temperature tendency due to gravity wave drag	K/day

- **tavg3d_trp_p** (nominally 4 times per day)
  Late-look ECS short name: D4LAPTRP
  Late-look ECS long name: DAS Late-look 3d transport, averaged on pressure coordinates
  Size: 288 x 181 x 36 x 4 x 4 x 4 = 120.1 MB/day

Variable Name	Description	Units
KH	Eddy diffusivity coefficient for scalars	m^2/s
KM	Eddy diffusivity coefficient for momentum	m^2/s
CLDMAS	Cloud mass flux	$kg/m^2/s$
DTRAIN	Detrainment cloud mass flux	$kg/m^2/s$

6.4 Assimilated Chemistry Files

The following variables are generated by the DAO Ozone Assimilation System. These are instantaneous fields (no time averaging). These products are produced from an offline (OL) ozone assimilation (reference TBD), which uses the wind data from the DAS as input. The ozone assimilation operates at a coarser resolution than the DAS, thus these products have horizontal resolution of 2.5 x 2 degrees. In addition, the vertical structure of the 3-D ozone products is different than other 3-D DAS products. See Appendix C for details.

The ozone mixing ratio fields in the tavg3d_chm_p product at the following levels: 1000, 975, 950, 925, 900, and 875 hPa are provided at the request of users. The ozone values provided at these levels are identical to the values at 850 hPa. Ozone data are assimilated between 850 and 0.2 hPa. No geophysical significance should be attributed to the 1000, 975, 950, 915, 900, and the 875 hPa levels.

- **tsyn2d_chm_x** (8 times per day)
  First-look ECS short name: D4FAXCHM
  First-look ECS long name: DAS First-look 2d chemistry, instantaneous
  Late-look ECS short name: D4LAXCHM
  Late-look ECS long name: DAS Late-look 2d chemistry, instantaneous
  Size: 144 x 91 x 1 x 1 x 8 x 4 = 0.4 MB/day

Variable Name	Description	Units
OZONE	Total ozone	DU

- **tsyn3d_chm_p** (4 times per day)
  First-look ECS short name: D4FAPCHM
  First-look ECS long name: DAS First-look 3d chemistry, instantaneous on pressure coordinates
  Late-look ECS short name: D4LAPCHM
  Late-look ECS long name: DAS Late-look 3d chemistry, instantaneous on pressure coordinates
  Size: 144 x 91 x 42 x 1 x 4 x 4 = 8.8 MB/day

Variable Name	Description	Units
OZONE	Ozone mixing ratio	ppmv

7. Metadata

GEOS-4 gridded output files will be associated with two types of metadata. Depending on the utility you use to access the file, one set of metadata will be read and the other ignored.

7.1 EOSDIS Metadata

If you are using the EOSDIS toolkit you will only use the EOSDIS metadata. EOSDIS identifies two major types of metadata, collection and granule.

Collection metadata are stored in a separate index file. This file is like a library card catalog. Each ESDT has a "card" that contains its unique collection attributes. Appendix B describes the ESDT collection metadata.

Granule metadata is the "table of contents" information stored on the data file itself. The EOSDIS granule metadata include:

- file name (local granule ID)
- grid structure
- number of times per day fields are stored in this file
- number of vertical levels for each variable in this file
- names of variables in this file
- variable format (32-bit floating point, 16-bit integer, etc.)
- variable storage dimensions

  2-d fields will have 3 storage dimensions, time, latitude and longitude

  3-d fields will have 4 storage dimensions, time, latitude, longitude and vertical levels
- "missing" value for each variable
- unpacking scale factor for each packed variable (see section 8)
- unpacking off-set value for each packed variable (see section 8)

7.2 COARDS Metadata

If you use GRADS or FERRET to view GEOS-4 gridded data sets you will only use the COARDS metadata. These metadata will comply with the COARDS convention and include the following information:

- space-time grid information (dimension variables)
- variable long names (descriptions)
- variable units

- "missing" value for each variable
- unpacking scale factor for each packed variable (see section 8)
- unpacking off-set value for each packed variable (see section 8)

8. Sample Software

Presented here is software that illustrates using the standard HDF library or the ECS HDF-EOS library to read GEOS-4 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 DAO web page:

http://dao.gsfc.nasa.gov/Operations/

```
/************************************************************************/
/* This program demonstrates how to read a field from a DAO 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 */
/* rlucchesi@dao.gsfc.nasa.gov */
/* 2/12/1999 */
/************************************************************************/

#include "hdf.h"
#include "mfhdf.h"
#include <stdio.h>

#define XDIM 288
#define YDIM 181
#define ZDIM 36

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[ZDIM][YDIM][XDIM];
float32 avg, sum;
int32 i,j,k;
int32 file_id, gd_id;

if (argc != 3) {
printf("Usage: avg <filename> <field> \n");
exit (-1);
```

```
}

fname = argv[1];
vname = argv[2];

/* Open the file (read-only) */

file_id = GDopen (fname, DFACC_RDONLY);
if (file_id < 0) {
printf ("Could not open %s\n",fname);
exit(-1);
}

/* Attach to the EOS grid contained within the file. */
/* The DAO uses the generic name "EOSGRID" for the grid in all products. */

gd_id = GDattach (file_id,"EOSGRID");
if (gd_id < 0) {
printf ("Could not open %s\n",fname);
exit(-1);
}

/* 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;

/*
```

In this program, we read the entire field. By manipulating the start and edges arrays, it is possible to read a subset of the entire array. For example, to read a 3D section defined by x=100,224; y=50,149; z=15,16 you would set the start and edges arrays to the following:

```
start[0] = 0; time start location
start[1] = 15; z-dim start location
start[2] = 50; y-dim start location
start[3] = 100; x-dim start location

edges[0] = 1; time length
edges[1] = 2; z-dim length
edges[2] = 100; y-dim length
edges[3] = 125; x-dim length

*/

/* 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<XDIM; i++)
for (j=0; j<YDIM; j++)
for (k=0; k<ZDIM; k++)
sum += data_array[k][j][i];

avg = sum/(XDIM*YDIM*ZDIM);

printf ("Average of %s in 3 dimensions is=%f\n",vname,avg);

/* Close file. */

status = GDdetach (gd_id);
status = GDclose (file_id);

}
```

```
/*************************************************************************/
/* This program demonstrates how to read a field from a DAO 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 */
/* rlucchesi@dao.gsfc.nasa.gov */
/* 2/12/1999 */
/*************************************************************************/

#include "hdf.h"
#include "mfhdf.h"
#include <stdio.h>

#define XDIM 288
#define YDIM 181
#define ZDIM 36

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[ZDIM][YDIM][XDIM];
float32 avg, sum;
int32 i,j,k;

if (argc != 3) {
printf("Usage: avg <filename> <field> \n");
exit (-1);
}

fname = argv[1];
vname = argv[2];

/* Open the file (read-only) */

sd_id = SDstart (fname, DFACC_RDONLY);
if (sd_id < 0) {
printf ("Could not open %s\n",fname);
exit(-1);
}
```

```
/* Find the index and ID of the SDS for the given variable name. */

sds_index = SDnametoindex (sd_id, vname);
if (sds_index < 0) {
printf ("Could not find %s\n",vname);
exit(-1);
}

sds_id = SDselect (sd_id,sds_index);

/* 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;

/*
In this program, we read the entire field. By manipulating the start
and edges arrays, it is possible to read a subset of the entire array.
For example, to read a 3D section defined by x=100,224; y=50,149;
z=15,16 you would set the start and edges arrays to the following:

start[0] = 0; time start location
start[1] = 15; z-dim start location
start[2] = 50; y-dim start location
start[3] = 100; x-dim start location

edges[0] = 1; time length
edges[1] = 2; z-dim length
edges[2] = 100; y-dim length
edges[3] = 125; x-dim length

*/
```

```
/* 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<XDIM; i++)
for (j=0; j<YDIM; j++)
for (k=0; k<ZDIM; k++)
sum += data_array[k][j][i];

avg = sum/(XDIM*YDIM*ZDIM);


printf ("Average of %s in 3 dimensions is=%f\n",vname,avg);

/* Close file. */

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

}
```

Appendix A. Types of Assimilation Configurations

First Look Assimilation. Atmospheric observations from satellites, balloons, aircraft, ships, and other sources are grouped into six-hour data windows and processed by the atmospheric analysis four times each day. The first look analysis will run 6 to 10 hours after the 4 analysis times (0Z, 6Z, 12Z, 18Z). It will run using whatever conventional and satellite observations are available at the data cut-off time. Even though first-look will run as 4 distinct segments, the DAO will only distribute products that contain one complete day. Products produced from this and any other *assimilation* are a combination of output from the statistical analysis system and a short GCM forecast.

Late Look Assimilation. The software configuration is identical to the first look assimilation but, due to a delay of at least two weeks, a more complete set of input observations can be used. Unlike the first look analysis, the late look analysis will process one day at a time. The late look assimilation produces a greater volume of output products, since computational performance is not as critical.

Forecast/Simulation. This is a GCM forecast, with no insertion of atmospheric data via the analysis. The only outside data that enters the system are the boundary conditions, i.e., sea surface temperature and sea-ice concentration. Five-day forecasts are typically generated to support NASA field campaigns and to assess assimilation and forecast skill. Multi-year simulations are produced to investigate the climatology of the GCM. DAO forecast products are not distributed to ECS and file formats are not discussed in this document.

Reprocessing. The DAO will reprocess specified time periods since EOS-Terra launch using a recent version of the GEOS DAS software to support instrument team reprocessing requirements. A reprocessing run will use the Late Look assimilation file groupings and will use a version of GEOS DAS that is held constant through the reprocessing period. It is expected that new ECS ESDTs will be generated for each reprocessing run.

Reanalysis. The DAO will occasionally run reanalysis experiments. Reanalysis is the same as reprocessing except the time period is often much longer and not necessarily part of the EOS period. Reanalysis experiments are often run using baseline versions of the GEOS DAS system to support a wide variety of research activities internal and external to the DAO. Unique ESDTs will be generated for any reanalysis data distributed through ECS.

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Appendix B. Collection Metadata

GEOS-4 collection metadata will contain the following. To view the ESDTs associated with DAO products, which include collection metadata, see the DAO Operations web page: http://dao.gsfc.nasa.gov/Operations.

ECS Collection
- Revision Date
- Suggested Usage

Single Type Collection
- Collection State
- Maintenance and Update Frequency

Spatial
- Spatial Coverage Type

Bounding Rectangle
- West Bounding Coordinate
- North Bounding Coordinate
- East Bounding Coordinate
- South Bounding Coordinate

Altitude System Definition (for 3d files only)
- Altitude Datum Name
- Altitude Distance Units
- Altitude Encoding Method
- Altitude Resolution Class
- Altitude Resolution

Depth System Definition (land surface files only)
- Depth Datum Name
- Depth Distance Units
- Depth Encoding Method
- Depth Resolution Class
- Depth Resolution

Geographic Coordinate System
- Latitude Resolution
- Longitude Resolution
- Geographic Coordinate Units

Temporal
- Time Type
- Date Type
- Temporal Range Type

Precision of Seconds
Ends at Present Flag

Range Date Time
Range Beginning Date
Range Beginning Time
Range Ending Date
Range Ending Time

Contact Person
Role
Hours of Service
Contact Job Position
Contact First Name
Contact Middle Name
Contact Last Name

Contact Person Address
Street address
City
State/Province
Postal Code
Country

Telephone
Telephone Container
Telephone Number
Telephone Number Type

Email
Electronic Mail Address

Contact Organization
Role
Hours of Service
Contact Instruction
Contact Organization Name

Contact Organization Address
Street Address
City
State/Province
Postal Code
Country

Organization Telephone Number
Telephone Number
Telephone Number Type

Organizational Email
Electronic Mail Address

Discipline Topic Parameters
ECS Discipline Keyword
ECS Topic Keyword
ECS Term Keyword
ECS Variable Keyword
ECS Parameter Keyword

Temporal Keyword Class
Temporal Keyword

Spatial Keyword Class
Spatial Keyword

Processing Level
Processing Level Description
Processing Level ID

Analysis Source
Analysis Short Name
Analysis Long Name
Analysis Technique
Analysis Type

CSDT Description
Primary CSDT

Additional Attributes
Additional Attribute Data Type
Additional Attribute Description
Additional Attribute Name

Physical Parameter Details
Parameter Units of Measure
Parameter Range
Parameter Value Accuracy
Parameter Value Accuracy Explanation
Parameter Measurement Resolution

Storage Medium Class (filled in by DAAC)
Storage Medium

Appendix C. Vertical Grid Structure

Pressure level data will be output on the following 36 pressure levels for all 3-D products except chemistry:

Level	Pressure (hPa)	Level	Pressure (hPa)	Level	Pressure (hPa)
1	1000	13	600	25	50
2	975	14	550	26	40
3	950	15	500	27	30
4	925	16	450	28	20
5	900	17	400	29	10
6	875	18	350	30	7
7	850	19	300	31	5
8	825	20	250	32	3
9	800	21	200	33	2
10	750	22	150	34	1
11	700	23	100	35	0.4
12	650	24	70	36	0.2

Due to the scientific characteristics of the ozone assimilation, 3-D chemistry products (D4FAPCHM, D4LAPCHM) will have a different set of pressure levels:

Level	Pressure (hPa)	Level	Pressure (hPa)	Level	Pressure (hPa)
1	1000	15	500	29	50
2	975	16	450	30	40
3	950	17	400	31	30
4	925	18	350	32	25
5	900	19	300	33	20
6	875	20	250	34	15
7	850	21	200	35	10
8	825	22	170	36	7
9	800	23	150	37	5
10	750	24	130	38	3
11	700	25	115	39	2
12	650	26	100	40	1
13	600	27	85	41	0.4
14	550	28	70	42	0.2

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Appendix D. Summary of differences between GEOS-3 and GEOS-4

In this section we summarize the differences between the GEOS-3 and GEOS-4 products. We will not discuss the scientific characteristics of the systems, but only the differences in format and content of the products. GEOS-3 products are generated using the GEOS-3 Data Assimilation System until 2002, after which products from the GEOS-4 Data Assimilation System will be produced. See the Data Assimilation Office Operations web page, listed in the References section, for exact transition dates. The same 21 products are produced from both systems, 8 from First-look and 13 from Late-look. The format of all products is the HDF-4 version of HDF-EOS. Details of the differences follow.

- The horizontal resolution is different. The GEOS-3 resolution is 360x181. The GEOS-4 resolution is 288x181.

- The averaging periods of time-averaged products has been changed. Averages are now between synoptic times rather than spanning them. For example, the first average in a 3D 6-hourly file from GEOS-4 is the period from 00 GMT to 06 GMT. The first average in a corresponding GEOS-3 file would be 21 GMT to 03 GMT. This has changed the effective range times of the GEOS-4 time-averaged products. See section 3 of this document for more information.

- Some variables were discontinued.

    - tsyn2d_mis_x: ALBEDO, VAVEU, VAVEV, VAVET, TPW, GWET, SNOW

    - tsyn3d_mis_p: TKE, OMEGA

    - tavg2d_eng_x: QICE, CT, VAVEQIAU, VAVEQFIL, VAVETIAU

    - tavg2d_str_x: GWDUT, GWDVT, CU, PIAU

    - tavg2d_lsm_x: SNOWFALL, GREEN, DLWDTC

    - tavg2d_cld_x: TAULOW, TAUMID, TAUHI, CLDTMP, CLDPRS

    - tavg3d_cld_p: CLDRAS

    - tavg3d_mom_p: RFU, RFV, UIAU, VIAU, DUDT, DVDT

    - tavg3d_mst_p: DQLS, QIAU, QFILL, DQDT

    - tavg3d_tmp_p: TURBT, MOISTT, DTLS, RADLW, RADSW, RFT, GWDT, TIAU, DTDT, LWCLR, SWCLR

- Some variables were added or modified.
    - tsyn2d_mis_x: TGROUND was renamed TSKIN; added TROPQ; GWET moved to tavg2d_eng_x
    - tsyn3d_mis_p: OMEGA moved to tavg3d_mom_p
    - tavg2d_eng_x: added PRECL, VAVEU, VAVEV, VAVET; GWETTOP and GWETROOT added (replaced GWET from tsyn2d_mis_x); TGROUND was renamed TSKIN
    - tavg2d_str_x: Z0 was split into Z0H and Z0M; PBL changed to PBLH (units changed from hPa to m)
    - tavg3d_cld_p: TAUCLD was split into TAUCLI and TAUCLW
    - tavg3d_mom_p: OMEGA was added (moved from tsyn3d_mis_p)
- Due to these changes, there are differences in the daily file sizes.
- The filename convention was changed slightly. *AM1* was changed to *GEOS4*. The hour in the filename is different for time-averaged products due to the difference of time ranges mentioned above. See section 5 for more details about the file naming convention.
- New ESDTs were defined for GEOS-4. The names are listed in section 6 of this document. For First-look the ESDT names now start with *D4F* and for Late-look *D4L*. For GEOS-3 the names started with *DFL* and *DLL*.
- The data contained in the tsyn2d_mis_x product is 3-hourly, however the source data from GOES-4 is 6-hourly. The interim times are computed by time interpolating between synoptic times. This is done to provide consistency with the corresponding GEOS-3 product. See section 3 for more information.

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