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

README Document for NASA GLDAS Version 2 Data Products

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Revision History

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02/27/2020	Add new GLDAS-2.1 and GLDAS-2.2 products	Carlee Loeser
04/06/2020	Add description for root zone	Hualan Rui
09/10/2020	Add GLDAS-2.0 new 1.0-degree products from CLSM and VIC Land Surface Models	Hualan Rui
09/16/2020	Review and revise	Carlee Loeser
11/16/2020	Add information for the post-processing to mask out data over inland water in October 2020	Hualan Rui
11/17/2020	Review and revise	Carlee Loeser
02/26/2021	Update the email address of GES DISC Help Desk	Hualan Rui
06/18/2021	Clarify the data latencies and make the related information consistent across the document.	Hualan Rui

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10/11/2022	Add "Quality Issues" section and review	Hiroko Beaudoing
10/13/2022	Updated GES DISC code to 619	Stephanie Stettz

Contents

1.0 Introduction

This document provides the basic information for using NASA GLDAS Version 2 products.

The goal of the NASA Global Land Data Assimilation System (GLDAS) is to generate optimal fields of land surface states and fluxes, by ingesting satellite- and ground-based observational data products, using advanced land surface modeling and data assimilation techniques (Rodell et al., 2004). GLDAS drives multiple, offline (not coupled to the atmosphere) land surface models, integrates a huge quantity of observation-based data, and executes globally at high resolutions (2.5° to 1 km), enabled by the Land Information System (LIS) (Kumar et al., 2006). Currently, GLDAS drives three land surface models (LSMs): Noah, Catchment (CLSM), and the Variable Infiltration Capacity (VIC). More information is available at the Land Data Assimilation Systems (LDAS) and Land Information System (LIS) websites.

This document specifically describes the reprocessed data products of Version 2 of the Global Land Data Assimilation System (hereafter, GLDAS-2).

1.1 Basic Characteristics of GLDAS-2

NASA GLDAS-2 has three components: GLDAS-2.0, GLDAS-2.1, and GLDAS-2.2. GLDAS-2.0 is forced entirely with the Princeton meteorological forcing input data and provides a temporally consistent time series from 1948 through 2014. GLDAS-2.1 is forced with a combination of model and observation data from 2000 to present. GLDAS-2.2 product suites use data assimilation (DA), whereas the GLDAS-2.0 and GLDAS-2.1 products are "open-loop" (i.e., no data assimilation). Choice of forcing data, as well as DA observation source, variable, and scheme vary for different GLDAS-2.2 products. Currently, the GLDAS-2.2 products include data assimilation from the Gravity Recovery and Climate Experiment (GRACE) from 2003 to present.

The temporal resolutions for the GLDAS-2 products are 3-hourly and daily. The monthly products are generated through temporal averaging of the 3-hourly products. Table 1 lists some basic characteristics of the GLDAS-2 data. Please check up on the newest hydrology-related alert messages at GES DISC Alerts.

Table 1. Basic characteristics of the NASA GLDAS-2 data.

Contents	Outputs from Land Surface Models
Format	NetCDF
Latitude Extent	-60° to 90°
Longitude Extent	-180° to 180°
Spatial Resolution	1.0°, 0.25°
Temporal Resolution	3-hourly, daily, monthly
Temporal Coverage	GLDAS-2.0: 03Z January 1, 1948 – 21Z December 31, 2014

	GLDAS-2.1: 03Z January 1, 2000 – Present
	GLDAS-2.2: February 1, 2003 – Present
Dimensions	360 (lon) x 150 (lat) for the 1.0° x 1.0° data
	1440 (lon) x 600 (lat) for the 0.25° x 0.25° data
Origins (1st grid center)	(179.5 W, 59.5 S) for the 1.0° x 1.0° data
	(179.875 W, 59.875 S) for the 0.25° x 0.25° data
Land Surface Models	Noah-3.6, CLSM-F2.5, VIC-4.1.2

1.2 Specifications of GLDAS-2

1.2.1 Land Surface Characteristics

The Noah model uses the Modified IGBP MODIS 20-category vegetation classification and the soil texture based on the Hybrid STATSGO/FAO datasets. The Catchment model uses the Mosaic land cover classification, together with soils, topographic, and other model-specific parameters that were derived in a manner consistent with that of the NASA/GMAO's GEOS-5 climate modeling system. Alternatively, the Daily Catchment model simulations uses the UMD land cover classification, with the rest of parameters from the GEOS-5 system. The VIC model uses the UMD land cover classification, and the parameters are derived from the 0.5-degree Global VIC dataset (Nijssen et al., 2014).

1.2.2 GLDAS-2.0

The GLDAS-2.0 model simulations were initialized on simulation date January 1, 1948, using soil moisture and other state fields from the LSM climatology for that day of the year. The simulations were forced by the global meteorological forcing dataset from Princeton University (Sheffield et al., 2006). Each simulation uses the common GLDAS datasets for land water mask (MOD44W: Carroll et al., 2009) and elevation (GTOPO30), along with the model default land cover and soils datasets. The MODIS-based land surface parameters are used in the current GLDAS-2.0 and GLDAS-2.1 products, except for the Daily Catchment simulation's land cover data based on AVHRR.

1.2.3 GLDAS-2.1

The GLDAS-2.1 model simulation started on January 1, 2000 using the conditions from the GLDAS-2.0 simulation. This simulation was forced with National Oceanic and Atmospheric Administration (NOAA)/Global Data Assimilation System (GDAS) atmospheric analysis fields (Derber et al., 1991), the disaggregated Global Precipitation Climatology Project (GPCP) V1.3 Daily Analysis precipitation fields (Adler et al., 2003; Huffman et al., 2001), and the Air Force Weather Agency's AGRicultural METeorological modeling system (AGRMET) radiation fields. The simulation was only

used with GDAS and GPCP from January 2000 to February 2001, followed by the addition of AGRMET from March 1, 2001 onwards.

GLDAS-2.1 data products are available in two production streams, the Main Production (MP) stream at a latency about 3-4 months and the Early Production (EP) stream at a latency about 1.5 months. Since the GPCP v1.3 data have a latency about 3-4 months, the early production stream first generates new data files without the GPCP forcing, designated as the early products. Once the GPCP v1.3 data become available, the main production stream generates new data files with the GPCP forcing, designated as the main products, and then the corresponding data files will be removed from the early products archive. As a result, the main products have a long archive from January 2000 to present, with a latency about 3-4 months and the early products have a short rolling archive about 2-3 months, with a latency about 1.5 months.

1.2.4 GLDAS-2.2

The GLDAS-2.2 Daily Catchment model simulation started on February 1, 2003 using the conditions from the GLDAS-2.0 Daily Catchment model simulation. This simulation was forced with the meteorological analysis fields from the operational European Centre for Medium-Range Weather Forecasts (ECMWF) Integrated Forecasting System (https://www.ecmwf.int/en/publications/ifs-documentation). The total terrestrial water anomaly observation from Gravity Recovery and Climate Experiment (GRACE) was assimilated (Li et al., 2019). The GRACE RL06 and GRACE Follow-On data were provided by the Center for Space Research at the University of Texas (Save et al., 2012; Save et al., 2016). The Daily Catchment model simulations use the UMD land cover scheme from AVHRR land cover map. Due to the data agreement with the ECMWF that prohibits dissemination of the IFS product, this GLDAS-2.2 Daily product does not include the meteorological fields.

GLDAS-2.2 data products are available in two production streams, the main production stream with GRACE data assimilation and the early production stream without GRACE data assimilation. Since the GRACE data have a latency about 2-6 months, the early product stream first generates the new data files without GRACE data assimilation, designated as the early product, with a latency about 1.5 months. Once the GRACE data become available, the main production stream generates the new data files with the GRACE data assimilation, designated as the main product, with a latency about 2-6 months, and then the corresponding data files are removed from the Early Product archive.

1.3. Digital Object Identifier (DOI) and Citations

Users of GLDAS data products should cite the data in their research papers with the Digital Object Identifiers (DOIs). A DOI is a unique alphanumeric string used to identify

a digital object and provide a permanent link online. DOIs are often used in online publications in citations. Table 2 provides the DOIs for each GLDAS-2 data product.

Table 2. DOIs for NASA GLDAS-2 Data Products

	Data Product Name	**DOI**
GLDAS-2.0	GLDAS Catchment Land Surface Model L4 daily 0.25 x 0.25 degree V2.0 (GLDAS_CLSM025_D_2.0)	10.5067/LYHA9088MFWQ
	GLDAS Catchment Land Surface Model L4 3 hourly 1.0 x 1.0 degree V2.0 (GLDAS_CLSM10_3H_2.0)	10.5067/T3BX5Y6QK5FO
	GLDAS Catchment Land Surface Model L4 monthly 1.0 x 1.0 degree V2.0 (GLDAS_CLSM10_M_2.0)	10.5067/SGSL3LNKGJWW
	GLDAS Noah Land Surface Model L4 3 hourly 0.25 x 0.25 degree V2.0 (GLDAS_NOAH025_3H_2.0)	10.5067/342OHQM9AK6Q
	GLDAS Noah Land Surface Model L4 monthly 0.25 x 0.25 degree V2.0 (GLDAS_NOAH025_M_2.0)	10.5067/9SQ1B3ZXP2C5
	GLDAS Noah Land Surface Model L4 3 hourly 1.0 x 1.0 degree V2.0 (GLDAS_NOAH10_3H_2.0)	10.5067/L0JGCNVBNRAX
	GLDAS Noah Land Surface Model L4 monthly 1.0 x 1.0 degree V2.0 (GLDAS_NOAH10_M_2.0)	10.5067/QN80TO7ZHFJZ
	GLDAS VIC Land Surface Model L4 3 hourly 1.0 x 1.0 degree V2.0 (GLDAS_VIC10_3H_2.0)	10.5067/B6OMXPRI022J
	GLDAS VIC Land Surface Model L4 monthly 1.0 x 1.0 degree V2.0 (GLDAS_VIC10_M_2.0)	10.5067/ZRIHVF29X43C
GLDAS-2.1	GLDAS Catchment Land Surface Model L4 3 hourly 1.0 x 1.0 degree V2.1 (GLDAS_CLSM10_3H_2.1)	10.5067/VCO8OCV72XO0
	GLDAS Catchment Land Surface Model L4 3 hourly 1.0 x 1.0 degree Early Product V2.1 (GLDAS_CLSM10_3H_EP_2.1)	10.5067/W024WFHJXZ0E
	GLDAS Catchment Land Surface Model L4 monthly 1.0 x 1.0 degree V2.1 (GLDAS_CLSM10_M_2.1)	10.5067/FOUXNLXFAZNY
	GLDAS Catchment Land Surface Model L4 monthly 1.0 x 1.0 degree	10.5067/1LQF1ORIE8OW

	Early Product V2.1 (GLDAS_CLSM10_M_EP_2.1)	
	GLDAS Noah Land Surface Model L4 3 hourly 0.25 x 0.25 degree V2.1 (GLDAS_NOAH025_3H_2.1)	10.5067/E7TYRXPJKWOQ
	GLDAS Noah Land Surface Model L4 3 hourly 0.25 x 0.25 degree Early Product V2.1 (GLDAS_NOAH025_3H_EP_2.1)	10.5067/G90R32A924YM
	GLDAS Noah Land Surface Model L4 monthly 0.25 x 0.25 degree V2.1 (GLDAS_NOAH025_M_2.1)	10.5067/SXAVCZFAQLNO
	GLDAS Noah Land Surface Model L4 monthly 0.25 x 0.25 degree Early Product V2.1 (GLDAS_NOAH025_M_EP_2.1)	10.5067/5OVHMFF2IAV3
	GLDAS Noah Land Surface Model L4 3 hourly 1.0 x 1.0 degree V2.1 (GLDAS_NOAH10_3H_2.1)	10.5067/IIG8FHR17DA9
	GLDAS Noah Land Surface Model L4 3 hourly 1.0 x 1.0 degree Early Product V2.1 (GLDAS_NOAH10_3H_EP_2.1)	10.5067/7FK9SEEE6VP3
	GLDAS Noah Land Surface Model L4 monthly 1.0 x 1.0 degree V2.1 (GLDAS_NOAH10_M_2.1)	10.5067/LWTYSMP3VM5Z
	GLDAS Noah Land Surface Model L4 monthly 1.0 x 1.0 degree Early Product V2.1 (GLDAS_NOAH10_M_EP_2.1)	10.5067/MCM8JKVDO3W3
	GLDAS VIC Land Surface Model L4 3 hourly 1.0 x 1.0 degree V2.1 (GLDAS_VIC10_3H_2.1)	10.5067/ZOG6BCSE26HV
	GLDAS VIC Land Surface Model L4 3 hourly 1.0 x 1.0 degree Early Product V2.1 (GLDAS_VIC10_3H_EP_2.1)	10.5067/KMPD4R2A549N
	GLDAS VIC Land Surface Model L4 monthly 1.0 x 1.0 degree V2.1 (GLDAS_VIC10_M_2.1)	10.5067/VWTH7S6218SG
	GLDAS VIC Land Surface Model L4 monthly 1.0 x 1.0 degree Early Product V2.1 (GLDAS_VIC10_M_EP_2.1)	10.5067/472GKYTU73QR
GLDAS-2.2	GLDAS Catchment Land Surface Model L4 daily 0.25 x 0.25 degree	10.5067/TXBMLX370XX8

	GRACE-DA1 V2.2 (GLDAS_CLSM025_DA1_D_2.2)	
	GLDAS Catchment Land Surface Model L4 daily 0.25 x 0.25 degree GRACE-DA1 Early Product V2.2 (GLDAS_CLSM025_DA1_D_EP_2.2)	10.5067/IIU5JWU2AGRP

Each of the DOIs in Table 2 is linked to its corresponding dataset landing page. On the page, the tab labeled "Data Citation" provides the recommended citation for that product. If you use a GLDAS data product(s) in your research or applications, please include the corresponding reference(s) in your publication(s).

For example, the following is the citation for GLDAS_NOAH025_3H_2.1:
Beaudoing, H. and M. Rodell, NASA/GSFC/HSL (2016), GLDAS Noah Land Surface Model L4 3 hourly 0.25 x 0.25 degree V2.1, Greenbelt, Maryland, USA, Goddard Earth Sciences Data and Information Services Center (GES DISC), Accessed: [*Data Access Date*], 10.5067/E7TYRXPJKWOQ

Please also cite the primary reference for GLDAS-2:
Rodell, M., P.R. Houser, U. Jambor, J. Gottschalck, K. Mitchell, C.-J. Meng, K. Arsenault, A. Cosgrove, J. Radakovich, M. Bosilovich, J. K. Entin, J. P. Walker, D. Lohmann, and D. Toll, 2004. The Global Land Data Assimilation System, *Bull. Amer. Meteor. Soc.*, 85(3): 381-394, 10.1 I75/BAMS-85-3-38I.

1.4 Contact Information

For information about or assistance in using any GES DISC data, please contact the GES DISC Help Desk at:
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1.5 What's New?

1.5.1 What is new about the reprocessed GLDAS-2.0 and GLDAS-2.1?

In November and December 2019, the GLDAS-2.0 Noah products were reprocessed with the updated Princeton Forcing V2.2 Data, the upgraded version of Noah model (V3.6), and the upgraded Land Information System (LIS) software. The GLDAS-2.0 data were extended through December 2014 during this time.

In January and February 2020, the GLDAS-2.1 Noah products were also reprocessed with these same upgrades of Noah model and LIS. GLDAS-2.1 production was transitioned to two production streams, the Main Production (MP) stream at a latency about 3-4 months and the Early Production (EP) stream at a latency about 1.5 months. More information about the GLDAS-2.1 data latencies are available in the section "1.2.3 GLDAS-2.1".

The reprocessed GLDAS-2.0 and GLDAS-2.1 data are archived in NetCDF-4 format. Additional model outputs are included and described for each model (see Tables 3.1, 3.2, 3.3, and 3.4).

A river routing scheme has been included in these GLDAS-2.0 and GLDAS-2.1 Noah model simulations, which required modifying the land mask to accommodate routing outputs over inland water. As a result, some grid boxes over inland water had non-missing values. However, the values were not valid since the model considered these grid boxes as over land, as opposed to open water. Therefore, all the 3-hourly and monthly GLDAS-2.0 and GLDAS-2.1 were post-processed in October 2020 to mask out the invalid data over inland water. The post-processing corrected this issue and masked out all model output variables over inland water, leaving the meteorological forcing variables unchanged. If you downloaded the data of the affected variables before November 1, 2020, please download them again. The land water mask for GLDAS is available for download through the LDAS project website:
https://ldas.gsfc.nasa.gov/gldas/vegetation-class-mask.

1.5.2 What are the newest datasets for GLDAS-2?

In March 2018, Daily Catchment LSM outputs at 0.25-degree resolution were added to the GLDAS-2.0 suite (Li et al., 2019).

In February 2020, GLDAS-2.1 VIC and CLSM LSMs simulation outputs were publicly released. GLDAS-2.1 extends from 2000 to present with about 1.5-month latency (for the early products) and is updated monthly.

In February 2020, the GLDAS-2.2 daily data products with GRACE data assimilation (known as DA1) were publicly released. GLDAS-2.2 extends from February 1, 2003 to present.

In March 2020, the GLDAS-1 forward stream ended and all products were removed from GES DISC in June 2020. **GLDAS-2.1 will serve as the replacement for GLDAS-1**.

In September 2020, GLDAS-2.0 VIC and CLSM LSMs simulation outputs at 1.0 degree resolution were publicly released in 3-hourly and monthly data sets.

In October 2020, all the 3-hourly and monthly GLDAS-2.0 and GLDAS-2.1 data products were post-processed to mask out the data of model output variables over inland water, but leaving the meteorological forcing variables unchanged.

1.5.3 What are the differences between GLDAS-1 and GLDAS-2.1?

The main objective of GLDAS-2.1 is to provide up-to-date global land surface model outputs, using observation-based forcing, while preserving consistency of the long-term climatology (i.e., GLDAS-2.0) to the extent possible. Two major issues were found in the GLDAS-1 forcing fields. First, the AGRMET shortwave downward radiation flux displayed sharp, unnatural gradient lines in the Northern Hemisphere during certain years. Second, there was a dramatic change in precipitation in certain locations starting in 2009. Furthermore, comparisons of GLDAS-1 radiation and precipitation fields revealed that GLDAS-1 had high bias relative to the well-validated Surface Radiation Budget (SRB) dataset (Stackhouse et al., 2011), and GLDAS-1 precipitation (i.e., CMAP) had low bias relative to the Global Precipitation Climatology Project (GPCP) dataset. Similar biases were observed compared to GLDAS-2.0 (i.e., Princeton forcing), whose radiation fields were bias corrected to the SRB dataset and precipitation fields were disaggregated using the GPCP and Tropical Rainfall Measuring Mission (TRMM) datasets.

GLDAS-2.1 addressed these issues as follows. The AGRMET radiation flux fields were bias-corrected using the period of overlap between AGRMET and SRB (2002-2007) to

compute monthly, gridded scale factors that are applied for the overlapping period of AGRMET data. Similarly, GDAS radiation fields were bias-corrected to SRB for the period of 2000-2001/02. Because AGRMET displayed high bias compared to SRB, the fluxes for 2008 onwards are adjusted by applying another set of gridded scale factors that are computed from the annual mean climatology of 2002-2007, thus avoiding a discontinuity in the GLDAS-2.1 data. The bias-corrected AGRMET forcing data should be consistent with the climatology of SRB; however, due to the short overlapping period, the scaling approach is unable to correct an apparent shift (of unknown origin) in the AGRMET climatology after 2011. For the precipitation fields, the GPCP 1-degree Daily dataset (Huffman et al., 2001) and an updated disaggregation routine (making use of GDAS precipitation fields) were used to prepare 3-hourly GPCP fields. More information about the GLDAS-2.1 data latencies are available in the section "1.2.3 GLDAS-2.1".

1.5.4 What is GLDAS-2.2?

GLDAS-2.2 explores the data assimilation capabilities in the LIS (Kumar et al., 2016; Kumar et al., 2019). The Catchment land surface model provides the model design that is suitable for assimilating the GRACE TWS (Terrestrial water storage) anomaly observation as shown in past studies. The GLDAS-2.2 Daily Catchment product is the outcome of the study by Li et al., 2019.

1.6 Quality Issues

Users should be aware that combining the GLDAS-2.0, 2.1, and 2.2 datasets into a single time series may result in temporal discontinuities due to biases between the meteorological datasets used to force the models, and because data assimilation (GLDAS 2.2) exerts changes in the modeled states, which also affect the fluxes. Further, it is possible that a meteorological forcing dataset contains its own discontinuities due to changes in the atmospheric analyses and in situ data from which it was constructed.

Due to the lack of a glacier/ice sheet model in any of the GLDAS LSMs, snow water equivalent accumulates indefinitely in Greenland, certain other Arctic locations, and permanently frozen regions in the Himalayas. Therefore, users are advised to mask out Greenland and other grid cells with abnormally large snow water equivalent values when performing analyses.

There are many factors that influence the accuracy of GLDAS estimates. These include (1) uncertainty in the meteorological forcing data, which tends to be larger at high latitudes, high altitudes, and in regions with sparse observational networks, (2) simplified representations of complex physical processes in the models, and (3) errors in the land surface parameters that describe vegetation and land cover, soil properties, and elevation, and (4) inadequate calibration of model parameters.

2.0 Data Organization

GLDAS-2.0 consists of 3-hourly, daily, and monthly products at 0.25° x 0.25° and 1.0° x 1.0° spatial resolutions. GLDAS-2.1 consists of 3-hourly and monthly products at 0.25° x 0.25° and 1.0° x 1.0° spatial resolutions. GLDAS-2.2 consists of one daily product at a 0.25° x 0.25° spatial resolution.

2.1 File Naming Convention

NASA GLDAS-2.0 and GLDAS-2.1 data files are named in accordance with the following convention:
GLDAS_<Model><SpatialResolution>_<TemporalResolution>.A<Date><ProductVersion>.nc4

Attribute	Description
<Model>	"CLSM" for the Catchment Model
	"NOAH" for the Noah Model
	"VIC" for the Variable Infiltration Capacity Model
<SpatialResolution>	"025" for 0.25 degree
	"010" for 1.0 degree
<TemporalResolution>	"3H" for 3-hourly
	"D" for daily
	"M" for monthly
<Date>*	<YYYYMMDD>.<HHHH> for 3-hourly
	<YYYYMMDD> for daily
	<YYYYMM> for monthly
<ProductVersion>	"020" for GLDAS-2.0
	"021" for GLDAS-2.1
	"022" for GLDAS-2.2

*Date represented as 4-digit year, 2-digit month, 2-digit day of month, 4-digit GMT hour and minute of day.

NASA GLDAS-2.1 Early Product data files are named in accordance with the following convention:
GLDAS_<Model><SpatialResolution>_<TemporalResolution>_EP.A<Date><ProductVersion>.nc4
…where all attributes are the same as above, but with the added EP designation.

NASA GLDAS-2.2 data files are named in accordance with the following convention:
GLDAS_<Model><SpatialResolution>_<DataAssimilationReference>_<TemporalResolution>_A<Date>.<ProductVersion>.nc4

…where all attributes are the same as above, but with the added DataAssimilationReference designation.

Examples:
The file name for the monthly 1.0 degree GLDAS-2.0 Noah data for January 1948 is:
GLDAS_NOAH10_M_A194801.020.nc4

The file name for the 3-hourly 0.25 degree GLDAS-2.1 Noah data at 03:00Z on January 1, 2000 is:
GLDAS_NOAH025_3H.A20000101.0300.021.nc4

The file name for the daily 0.25 degree GLDAS-2.0 Catchment data on January 1, 1948 is:
GLDAS_CLSM025_D.A19480101.020.nc4

The file name for the daily 0.25 degree GLDAS-2.2 Catchment with GRACE-DA1 on February 1, 2003 is:
GLDAS_CLSM025_DA1_D.A20030201.022.nc4

2.2 File Format and Structure

All GLDAS-2 data files are in NetCDF format, which is a set of software libraries and self-describing, machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data. More information can be found here: https://www.unidata.ucar.edu/software/netcdf/docs/.

3.0 Data Contents

GLDAS-2 includes nine data products from GLDAS-2.0, eight (main) data products from GLDAS-2.1, and one (main) data products from GLDAS-2.2, as summarized by the Table 3.0. The GLDAS-2.1 and GLDAS-2.2 Early Products include the same parameters as in the main products.

Table 3.0 GLDAS-2 data products and parameters

Component	Model	Temporal Resolution	Spatial Resolution	Number of parameters
GLDAS-2.0 (Jan 1948 – Dec 2014)	CLSM-F2.5	Daily	0.25° x 0.25°	33, see Table 3.1
		3-hourly	1.0° x 1.0°	38, see Table 3.2
		Monthly		
	Noah-3.6	3-hourly	0.25° x 0.25°	36, see Table 3.3

		Monthly		
		3-hourly	1.0° x 1.0°	
		Monthly		
	VIC-4.1.2	3-hourly	1.0° x 1.0°	34, see Table 3.4
		Monthly		
GLDAS-2.1 (Jan 2000 – present)	CLSM-F2.5	3-hourly	1.0° x 1.0°	38, see Table 3.2
		Monthly		
	Noah-3.6	3-hourly	0.25° x 0.25°	36, see Table 3.3
		Monthly		
		3-hourly	1.0° x 1.0°	
		Monthly		
	VIC-4.1.2	3-hourly	1.0° x 1.0°	34, see Table 3.4
		Monthly		
GLDAS-2.2 (Feb 2003 – present)	CLSM-F2.5	Daily	0.25° x 0.25°	24, see Table 3.1

The GLDAS-2.0 includes nine data products from Catchment, Noah, and VIC LSMs.
- The Catchment daily data product contains 33 parameters (Table 3.1).
- The Catchment 3-hourly and monthly data products contain 38 parameters each (Table 3.2).
- The Noah 3-hourly and monthly data products contain 36 parameters each (Table 3.3).
- The VIC 3-hourly and monthly data products contain 34 parameters each (Table 3.4).

GLDAS-2.1 includes eight main products and eight early production products from Noah-LSM, and two main products and two early production products from Catchment-LSM and VIC-LSM, respectively.
- The Catchment 3-hourly and monthly 1.0-degree data products contain 38 parameters each (Table 3.2).
- The Noah model 3-hourly and monthly 0.25-degree and 1.0-degree data products contain 36 parameters each (Table 3.3).
- The VIC 3-hourly and monthly 1.0-degree data products contain 34 parameters each (Table 3.4).

GLDAS-2.2 currently includes a main product and an early product from Catchment-LSM. The daily 0.25-degree product contains 24 parameters (Table 3.1), with the forcing variables, including Rainf_tavg and Snowf_tavg, excluded.

3.1 Catchment-LSM Parameters: Daily Products

Table 3.1 below lists the parameters in the GLDAS-2.0 and GLDAS-2.2 0.25 degree daily products from the Catchment-LSM:
- GLDAS_CLSM025_D_2.0
- GLDAS_CLSM025_DA1_D_2.2
- GLDAS_CLSM025_DA1_D_EP_2.2

Table 3.1 Parameters in the GLDAS-2.0 and GLDAS-2.2 0.25-degree daily data products from Catchment-LSM

Short Name	Long Name	Unit
Swnet_tavg	Net short wave radiation flux	W m-2
Lwnet_tavg	Net long-wave radiation flux	W m-2
Qle_tavg	Latent heat net flux	W m-2
Qh_tavg	Sensible heat net flux	W m-2
Qg_tavg	Ground heat flux	W m-2
Snowf_tavg*	Snow precipitation rate	kg m-2 s-1
Rainf_tavg*	Rain precipitation rate	kg m-2 s-1
Evap_tavg	Evapotranspiration	kg m-2 s-1
Qs_tavg	Storm surface runoff	kg m-2 s-1
Qsb_tavg	Baseflow-groundwater runoff	kg m-2 s-1
Qsm_tavg	Snow melt	kg m-2 s-1
SnowT_tavg	Snow surface temperature	K
AvgSurfT_tavg	Average surface skin temperature	K
SWE_tavg	Snow depth water equivalent	kg m-2
SnowDepth_tavg	Snow depth	m
SoilMoist_S_tavg	Surface soil moisture	kg m-2
SoilMoist_RZ_tavg	Root zone soil moisture	kg m-2
SoilMoist_P_tavg	Profile soil moisture	kg m-2
ECanop_tavg	Canopy water evaporation	kg m-2 s-1
TVeg_tavg	Transpiration	kg m-2 s-1
ESoil_tavg	Direct evaporation from bare soil	kg m-2 s-1
CanopInt_tavg	Plant canopy surface water	kg m-2
EvapSnow_tavg	Snow evaporation	kg m-2 s-1
ACond_tavg	Aerodynamic conductance	m s-1
TWS_tavg	Terrestrial water storage	mm
GWS_tavg	Ground water storage	mm
Wind_f_tavg*	Wind speed	m s-1
Rainf_f_tavg*	Total precipitation rate	kg m-2 s-1
Tair_f_tavg*	Temperature	K
Qair_f_tavg*	Specific humidity	kg kg-1
Psurf_f_tavg*	Surface pressure	Pa
SWdown_f_tavg*	Downward short-wave radiation flux	W m-2

| LWdown_f_tavg* | Downward long-wave radiation flux | W m-2 |

The short names with extension "_tavg" are 24-hr averaged variables.
The short names with "_f" are forcing variables.
*All these forcing and forcing related variables are excluded in GLDAS-2.2 Catchment-LSM, due to the data agreement with ECMWF.

3.2 Catchment-LSM Parameters: 3-hourly and Monthly Products

Table 3.2 below lists the parameters in the GLDAS-2.0 and GLDAS-2.1 1.0 degree 3-hourly and monthly products from the Catchment-LSM:
- GLDAS_CLSM10_3H_2.0
- GLDAS_CLSM10_M_2.0
- GLDAS_CLSM10_3H_2.1
- GLDAS_CLSM10_3H_EP_2.1
- GLDAS_CLSM10_M_2.1
- GLDAS_CLSM10_M_EP_2.1

Table 3.2 Parameters in the GLDAS-2.0 and GLDAS-2.1 3-hourly and monthly 1.0-degree data products from Catchment-LSM

Short Name	Long Name	Unit
Swnet_tavg	Net short wave radiation flux	W m-2
Lwnet_tavg	Net long-wave radiation flux	W m-2
Qle_tavg	Latent heat net flux	W m-2
Qh_tavg	Sensible heat net flux	W m-2
Qg_tavg	Ground heat flux	W m-2
Snowf_tavg	Snow precipitation rate	kg m-2 s-1
Rainf_tavg	Rain precipitation rate	kg m-2 s-1
Evap_tavg	Evapotranspiration	kg m-2 s-1
Qs_acc	Storm surface runoff	kg m-2
Qsb_acc	Baseflow-groundwater runoff	kg m-2
Qsm_acc	Snow melt	kg m-2
SnowT_tavg	Snow surface temperature	K
AvgSurfT_inst	Average surface skin temperature	K
Albedo_inst	Albedo	%
SWE_inst	Snow depth water equivalent	kg m-2
SnowDepth_inst	Snow depth	m
SoilMoist_S_inst	Surface soil moisture	kg m-2
SoilMoist_RZ_inst	Root zone soil moisture	kg m-2
SoilMoist_P_inst	Profile soil moisture	kg m-2
SoilTMP0_10cm_inst	Soil temperature (0-10 cm)	K
SoilTMP10_29cm_inst	Soil temperature (10-29 cm)	K
SoilTMP29_68cm_inst	Soil temperature (29-68 cm)	K

SoilTMP68_144cm_inst	Soil temperature (68-144 cm)	K
SoilTMP144_295cm_inst	Soil temperature (144-295)	K
SoilTMP295_1295cm_inst	Soil temperature (295-1295 cm)	K
ECanop_tavg	Canopy water evaporation	W m-2
TVeg_tavg	Transpiration	W m-2
ESoil_tavg	Direct evaporation from bare soil	W m-2
CanopInt_inst	Plant canopy surface water	kg m-2
ACond_tavg	Aerodynamic conductance	m s-1
TWS_inst	Terrestrial water storage	mm
Wind_f_inst	Wind speed	m s-1
Rainf_f_tavg	Total precipitation rate	kg m-2 s-1
Tair_f_inst	Air temperature	K
Qair_f_inst	Specific humidity	kg kg-1
Psurf_f_inst	Surface pressure	Pa
SWdown_f_tavg	Downward short-wave radiation flux	W m-2
LWdown_f_tavg	Downward long-wave radiation flux	W m-2

The short names with extension "_tavg" are backward 3-hour averaged variables.
The short names with extension "_acc" are backward 3-hour accumulated variables.
The short names with extension "_inst" are instantaneous variables.
The short names with "_f" are forcing variables.

3.3 Noah-LSM Parameters

Table 3.3 below lists the parameters in the GLDAS-2.0 and GLDAS-2.1 0.25 and 1.0 degree, 3-hourly and monthly products from the Noah-LSM:

- GLDAS_NOAH025_3H_2.0
- GLDAS_NOAH025_M_2.0
- GLDAS_NOAH10_3H_2.0
- GLDAS_NOAH10_M_2.0
- GLDAS_NOAH025_3H_2.1
- GLDAS_NOAH025_3H_EP_2.1
- GLDAS_NOAH025_M_2.1
- GLDAS_NOAH025_M_EP_2.1
- GLDAS_NOAH10_3H_2.1
- GLDAS_NOAH10_3H_EP_2.1
- GLDAS_NOAH10_M_2.1
- GLDAS_NOAH10_M_EP_2.1

Table 3.3 Parameters in the GLDAS-2.0 and GLDAS-2.1 3-hourly and monthly 0.25-degree and 1.0-degree data products from Noah-LSM

Short Name	Long Name	Unit
Swnet_tavg	Net short wave radiation flux	W m-2
Lwnet_tavg	Net long-wave radiation flux	W m-2

Qle_tavg	Latent heat net flux	W m-2
Qh_tavg	Sensible heat net flux	W m-2
Qg_tavg	Ground heat flux	W m-2
Snowf_tavg	Snow precipitation rate	kg m-2 s-1
Rainf_tavg	Rain precipitation rate	kg m-2 s-1
Evap_tavg	Evapotranspiration	kg m-2 s-1
Qs_acc	Storm surface runoff	kg m-2
Qsb_acc	Baseflow-groundwater runoff	kg m-2
Qsm_acc	Snow melt	kg m-2
AvgSurfT_inst	Average surface skin temperature	K
Albedo_inst	Albedo	%
SWE_inst	Snow depth water equivalent	kg m-2
SnowDepth_inst	Snow depth	m
SoilMoi0_10cm_inst	Soil moisture (0-10 cm)	kg m-2
SoilMoi10_40cm_inst	Soil moisture (10-40 cm)	kg m-2
SoilMoi40_100cm_inst	Soil moisture (40-100 cm)	kg m-2
SoilMoi100_200cm_inst	Soil moisture (100-200 cm)	kg m-2
SoilTMP0_10cm_inst	Soil temperature (0-10 cm)	K
SoilTMP10_40cm_inst	Soil temperature (10-40 cm)	K
SoilTMP40_100cm_inst	Soil temperature (40-100 cm)	K
SoilTMP100_200cm_inst	Soil temperature (100-200 cm)	K
PotEvap_tavg	Potential evaporation rate	W m-2
ECanop_tavg	Canopy water evaporation	W m-2
Tveg_tavg	Transpiration	W m-2
ESoil_tavg	Direct evaporation from bare soil	W m-2
RootMoist_inst	Root zone soil moisture	kg m-2
CanopInt_inst	Plant canopy surface water	kg m-2
Wind_f_inst	Wind speed	m s-1
Rainf_f_tavg	Total precipitation rate	kg m-2 s-1
Tair_f_inst	Air temperature	K
Qair_f_inst	Specific humidity	kg kg-1
Psurf_f_inst	Surface pressure	Pa
SWdown_f_tavg	Downward short-wave radiation flux	W m-2
LWdown_f_tavg	Downward long-wave radiation flux	W m-2

The short names with extension "_tavg" are backward 3-hour averaged variables.
The short names with extension "_acc" are backward 3-hour accumulated variables.
The short names with extension "_inst" are instantaneous variables.
The short names with "_f" are forcing variables.

3.4 VIC-LSM Parameters

Table 3.4 below lists the parameters in the GLDAS-2.0 and GLDAS-2.1 1.0 degree 3-hourly and monthly products from the VIC-LSM:

- GLDAS_VIC10_3H_2.0
- GLDAS_VIC10_M_2.0
- GLDAS_VIC10_3H_2.1
- GLDAS_VIC10_3H_EP_2.1
- GLDAS_VIC10_M_2.1
- GLDAS_VIC10_M_EP_2.1

Table 3.4 Parameters in the GLDAS-2.0 and GLDAS-2.1 3-hourly and monthly 1.0-degree data products from VIC-LSM

Short Name	Long Name	Unit
Swnet_tavg	Net short wave radiation flux	W m-2
Lwnet_tavg	Net long-wave radiation flux	W m-2
Qle_tavg	Latent heat net flux	W m-2
Qh_tavg	Sensible heat net flux	W m-2
Qg_tavg	Ground heat flux	W m-2
Snowf_tavg	Snow precipitation rate	kg m-2 s-1
Rainf_tavg	Rain precipitation rate	kg m-2 s-1
Evap_tavg	Evapotranspiration	kg m-2 s-1
Qs_acc	Storm surface runoff	kg m-2
Qsb_acc	Baseflow-groundwater runoff	kg m-2
Qsm_acc	Snow melt	kg m-2
AvgSurfT_inst	Average surface skin temperature	K
Albedo_inst	Albedo	%
SWE_inst	Snow depth water equivalent	kg m-2
SnowDepth_inst	Snow depth	m
SoilMoi0_30cm_inst	Soil moisture (0-30 cm)	kg m-2
SoilMoi_depth2_inst	Soil moisture (VIC soil layer 2)	kg m-2
SoilMoi_depth3_inst	Soil moisture (VIC soil layer 3)	kg m-2
SoilTMP0_30cm_inst	Soil temperature (0-30 cm)	K
SoilTMP_depth2_inst	Soil temperature (VIC soil layer 2)	K
SoilTMP_depth3_inst	Soil temperature (VIC soil layer 3)	K
ECanop_tavg	Canopy water evaporation	W m-2
TVeg_tavg	Transpiration	W m-2
ESoil_tavg	Direct evaporation from bare soil	W m-2
RootMoist_inst	Root zone soil moisture	kg m-2
CanopInt_inst	Plant canopy surface water	kg m-2
ACond_tavg	Aerodynamic conductance	m s-1
Wind_f_inst	Wind speed	m s-1
Rainf_f_tavg	Total precipitation rate	kg m-2 s-1
Tair_f_inst	Air temperature	K
Qair_f_inst	Specific humidity	kg kg-1
Psurf_f_inst	Surface pressure	Pa
SWdown_f_tavg	Downward short-wave radiation flux	W m-2

LWdown_f_tavg	Downward long-wave radiation flux	W m-2

The short names with extension "_tavg" are backward 3-hour averaged variables.
The short names with extension "_acc" are backward 3-hour accumulated variables.
The short names with extension "_inst" are instantaneous variables.
The short names with "_f" are forcing variables.

3.5 Data Interpretation

1. Total precipitation rate is the sum of rain and snow precipitation rates. The forcing variable "Rainf_f_tavg" is the total precipitation rate, whereas "Rainf_tavg" and "Snowf_tavg" are the liquid precipitation rate and frozen precipitation rate, respectively.
2. Total runoff is the sum of subsurface runoff "Qsb_tavg" and surface runoff "Qs_tavg".
3. The number of vertical levels for soil moisture (SoilMoi) and soil temperature (SoilTMP) is model specific. Please follow the list below for the correct depths of the soil layers.
   - Noah (4 layers): 0-10, 10-40, 40-100, 100-200 cm
   - VIC (3 layers): 0-10 cm surface, variable depth for the second and bottom layers. The map of depths are available to download from: https://ldas.gsfc.nasa.gov/gldas/specifications.
   - CLSM does not have explicit vertical levels for soil moisture. Instead, soil moisture is represented in Surface (0-2 cm), Root Zone (0-100 cm), and Profile (varies grid-by-grid) reservoirs. They are inclusive: Profile includes Surface and Root Zone, and Root Zone includes Surface.
   - CLSM has six layers for soil temperature: 0-10, 10-29, 29-68, 68-144, 144-295, and 295-1295 cm.
   - CLSM has a uniform depth of 100 cm for the root zone depth, while Noah and VIC determine root depth depending on the vegetation types. If the vegetation type is grass, the root zone is sum of the top three layers and root zone soil moisture is a sum of layer1+layer2+layer3, but if the vegetation is forest, the root zone is the total depth of all layers (i.e. sum of all four layers). In the GLDAS simulations, "vegetation tiling" is applied to try to represent sub-grid heterogeneity by using vegetation tiles, since the simulations are fairly coarse resolutions. A grid may contain more than one vegetation tile and in that case the output value is weighted average of vegetation tiles. It is difficult to trace back the root zone depth, therefore, the variable "root zone soil moisture" is provided in addition to individual layer soil moisture for the case of VIC and Noah.
4. CLSM does simulate shallow groundwater, so Terrestrial Water Storage (TWS) in CLSM is the sum of soil water, snow water equivalent, canopy water, and groundwater. Ground Water Storage (GWS) in CLSM is already included in TWS. Ground Water Storage (GWS) in CLSM was computed using formula:
   GWS = TWS - RootZoneSoilMoisture - SnowWaterEquivalent - CanopyInterception.
   Noah TWS is the sum of soil moisture in all layers, accumulated snow, and plant canopy surface water.

5. Use temporal averaging, not accumulation, to upscale the data to different temporal resolutions. For example, rainfall and snowfall are provided as rates, i.e., $kg/m^2/s$. The correct method of upscaling is averaging, which does not change the units.
6. Monthly average files contain straight averages of 3-hourly data, so each monthly average has units PER 3 HOURS. For example, total evapotranspiration (Evap_tavg) for April 1979 is the average 3-hour mean rate of evapotranspiration over all 3-hour intervals in April 1979. It is NOT the accumulated evapotranspiration in April 1979. To compute the latter, use this formula:

    Evap_tavg (April)$\{kg/m^2\}$ =
    Evap_tavg (April)$\{kg/m^2/sec\}$ * 10800{sec/3hr} * 8{3hr/day} * 30{days}

    For accumulated variables such as Qs_acc, the monthly mean surface runoff is the average 3-hour accumulation over all 3-hour intervals in April 1979. To compute monthly accumulation, use this formula:

    Qs_acc (April)$\{kg/m^2\}$ = Qs_acc (April)$\{kg/m^2/3hr\}$ * 8{3hr/day} * 30{days}

    This would be irrelevant, and the above formula should not be used, if the field of interest is an instantaneous state.
7. Heights of forcing fields depend on the datasets used to drive the simulation. Presently, all the GLDAS datasets use the 2-meter temperature and specific humidity and the 10-meter wind for the entire time span.
8. The mean fields in monthly data (e.g., evapotranspiration, see Table 3.1) contain straight average of 3-hour accumulation from 0300z on the 1st to 0000z on the first day of the next month. The instantaneous fields are averaged over 0000z on the 1st day of the month to 2100z on the last day of the month.
9. Snow density computed using the snow water equivalent and snow depth included in the current GLDAS-2.0 Daily CLSM product is not valid, because snow depth had not accounted for the grid fraction of snow cover at the time the simulation was done. This problem doesn't apply to the 3-hourly and monthly GLDAS-2.1 and GLDAS-2.2 products.

4.0 Options for Reading the Data

4.1 Utilities

NASA GLDAS-2 data are archived in self-describing and machine-independent NetCDF format. This Unidata page provides a list of software for manipulating or displaying NetCDF data: https://www.unidata.ucar.edu/software/netcdf/software.html.

4.2 Panoply

Panoply (https://www.giss.nasa.gov/tools/panoply/) is a cross-platform application that plots geo-referenced and other arrays from NetCDF, HDF, GRIB, and other data formats. The HowTo page from the GES DISC provides a recipe for How to View Remote Data in OPeNDAP with Panoply.

4.3 GrADS

The Grid Analysis and Display System (GrADS) is an interactive desktop tool for easy access, manipulation, and visualization of earth science data. GrADS supports several data formats, such as binary, NetCDF, HDF, and GRIB. The documentation and software for GrADS can be found at http://cola.gmu.edu/grads/grads.php.

Each individual GLDAS-2 NetCDF can be opened by the GrADS utility sdfopen directly without a data descriptor file (i.e., a ctl file). After calling sdfopen, GrADS commands, such as "q file", "d [VariableName]", etc. can be used to query file information, and read and display the data. An example showing how to use sdfopen to read a GLDAS-2 NetCDF file and query for its dimensions and variables is in Appendix A.

5.0 Data Services

The NASA GES DISC maintains archives of the GLDAS datasets and many other Hydrology datasets. GLDAS can be accessed via the GES DISC website at: https://disc.gsfc.nasa.gov/datasets?keywords=GLDAS

As of August 1, 2016, access to GES DISC data requires all users to be registered with the NASA Earthdata Login. Data continue to be free of charge and accessible via HTTPS. As of October 3, 2016, access to data via FTP is no longer available. Detailed instructions on how to register and receive authorization to access all GES DISC data are provided at https://disc.gsfc.nasa.gov/data-access.

GES DISC users who deploy scripting methods to list and download data in bulk are advised to review the instructions from the link above that provide examples of GNU wget commands for listing and downloading data via HTTPS.

If you need assistance or wish to report a problem, please contact us:
 Goddard Earth Sciences Data and Information Services Center, Code 610.2
 NASA Goddard Space Flight Center
 Greenbelt, MD 20771
 Email: gsfc-dl-help-disc@mail.nasa.gov
 Phone: 301-614-5224
 Fax: 301-614-5268

5.1 HTTPS Access

Access the online archive via HTTPS for direct download of entire files: https://hydro1.gesdisc.eosdis.nasa.gov/data/GLDAS/.

5.2 Earthdata Search

Use the Earthdata Search interface to find and retrieve datasets from the GES DISC and other NASA data centers: https://search.earthdata.nasa.gov/search?q=GLDAS.

5.3 GES DISC Subsetter/Regridder

Access the GES DISC Regridder and Subsetter tool through the GLDAS search results page or any GLDAS dataset landing page by selecting the Subset/Get Data link. This tool allows for spatial, temporal, and variable subsetting, as well as re-gridding the data to various other grids through several interpolation methods.

5.4 OPeNDAP

Access the data via the OPeNDAP protocol for parameter and spatial subsetting, with several output formats: https://hydro1.gesdisc.eosdis.nasa.gov/opendap/GLDAS/.

5.5 GrADS Data Server (GDS)

The GrADS Data Server (GDS) is another form of OPeNDAP that provides subsetting and some analysis services across the internet: https://hydro1.gesdisc.eosdis.nasa.gov/dods/.

5.6 THREDDS (TDS)

The THREDDS Data Server for this mission provides data access to aggregated datasets through OPeNDAP, WCS, WMS, and various others. The datasets are aggregated to one file, where the spatial extent and variables can be subsetted and retrieved.

There are published How-To articles to walk users through accessing aggregated data through TDS:
How to Obtain a Time Series at a Single Point using TDS
How to Obtain a Spatially Subsetted Time Series using TDS

5.7 Giovanni

The GES-DISC Interactive Online Visualization And aNalysis Infrastructure (Giovanni) is a web-based tool that allows users to interactively visualize and analyze data: https://giovanni.gsfc.nasa.gov/giovanni/#dataKeyword=GLDAS

Users simply select one or more parameters, spatial and temporal ranges, and the visualization function, and then click on "Plot Data" button to get a result. Several visualization and analysis functions are available in the current instance, including time averaged maps, correlation maps, and area-averaged time series.
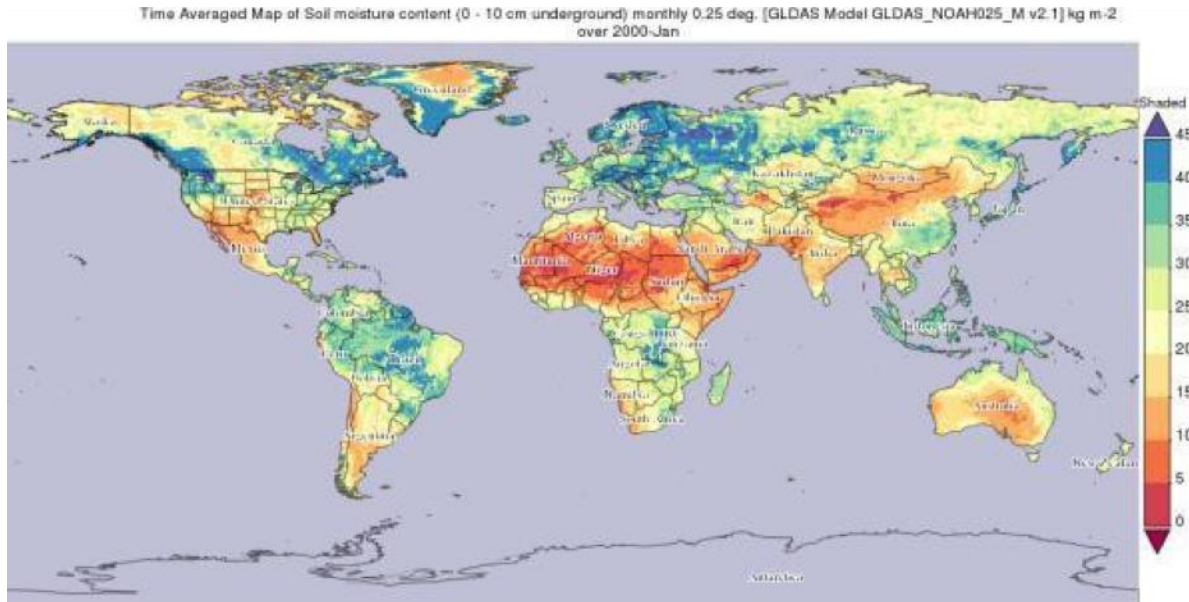The sample image below is generated by NASA Giovanni.

Figure 1. Soil moisture content (0-10 cm underground) map for January 2000, from GLDAS-2.1 Noah Land Surface Model L4 monthly 0.25 x 0.25 degree data.

6.0 More Information

Land Data Assimilation System (LDAS) Project: https://ldas.gsfc.nasa.gov/

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7.0 Acknowledgements

The GLDAS data are produced by the NASA GSFC Hydrological Sciences Laboratory (HSL). Please refer to Rodell et al. (2004) for more information about the GLDAS project.

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Acronyms

The following acronyms and abbreviations are used in this document.

AGRMET   AGRicultural METeorological Modeling System

CAPE	Convective Available Potential Energy
CMAP	CPC Merged Analysis of Precipitation
CMORPH	CPCF precipitation MORPHing technique
CPC	NCEP's Climate Prediction Center
CPPA	Climate Prediction Program for the Americas
EMC	NCEP's Environmental Modeling Center
GDAS	Global Data Assimilation System
GDS	GrADS Data Server
GES DISC	Goddard Earth Sciences Data and Information Services Center
Giovanni	GES-DISC Interactive On-line Visualization and Analysis Infrastructure
GLDAS	Global Land Data Assimilation System
GRACE	Gravity Recovery and Climate Experiment
GrADS	Grid Analysis and Display System
GPCP	Global Precipitation Climatology Project
GRIB	GRIdded Binary
HDF	Hierarchical Data Format
HDISC	Hydrology Data and Information Services Center
LDAS	Land Data Assimilation System
LIS	Land Information System
LSM	Land Surface Model
NARR	North American Regional Reanalysis
NASA	National Aeronautics and Space Administration
NCEP	National Centers for Environmental Prediction
NetCDF	Network Common Data Form
NIDIS	National Integrated Drought Information System
NLDAS	North American Land Data Assimilation System
NOAA	National Oceanic and Atmospheric Administration
OHD	NOAA's Office of Hydrologic Development
PRISM	Parameter-elevation Regressions on Independent Slopes Model
SAC	Sacramento model
SRB	Surface Radiation Budget
SVAT	Soil Vegetation Atmosphere Transfer model
VIC	Variable Infiltration Capacity macroscale model

Appendix A

Below is an example showing how to use sdfopen to read a GLDAS-2 NetCDF file and query for its dimensions and variables.

```
ga -> xdfopen GLDAS_NOAH10_M.2.0.xdf
Scanning Descriptor File: GLDAS_NOAH10_M.2.0.xdf
SDF file
/ftp/data/s4pa/GLDAS_GLDAS_NOAH10_M.2.0/%y4/GLDAS_NOAH10_M.A%y4%m2.
020.nc4
is open as file 1
LON set to 0 360
LAT set to -59.5 89.5
LEV set to 0 0
Time Values set: 1948:1:1:0 1948:1:1:0
E set to 1
1 ga -> q file
File 1: GLDAS2.0 LIS land surface model output monthly mean
  Descriptor: GLDAS_NOAH10_M.2.0.XDF
  Binary: GLDAS_NOAH10_M.2.0/%y4/GLDAS_NOAH10_M.A%y4%m2.020.nc4
  Type = Gridded
  Xsize = 360 Ysize = 150 Zsize = 1 Tsize = 780 Esize = 1
  Number of Variables = 36
      swnet_tavg 0 t,y,x Net short wave radiation flux
      lwnet_tavg 0 t,y,x Net long-wave radiation flux
      qle_tavg 0 t,y,x Latent heat net flux
      qh_tavg 0 t,y,x Heat flux
      snowf_tavg 0 t,y,x Snow precipitation rate
      rainf_tavg 0 t,y,x Rain precipitation rate
      evap_tavg 0 t,y,x Evapotranspiration
      qs_acc 0 t,y,x Storm surface runoff
      qsb_acc 0 t,y,x Baseflow-groundwater runoff
      qsm_acc 0 t,y,x Snow melt
      avgsurft_inst 0 t,y,x Average Surface Skin temperature
      albedo_inst 0 t,y,x Albedo
      swe_inst 0 t,y,x Snow depth water equivalent
      snowdepth_inst 0 t,y,x Snow depth
      soilmoi0_10cm_i 0 t,y,x Soil moisture
```

```
            soilmoi10_40cm_ 0 t,y,x Soil moisture
            soilmoi100_200c 0 t,y,x Soil moisture
            soiltmp0_10cm_i 0 t,y,x Soil temperature
            soiltmp10_40cm_ 0 t,y,x Soil temperature
            soiltmp40_100cm 0 t,y,x Soil temperature
            soiltmp100_200c 0 t,y,x Soil temperature
            potevap_tavg 0 t,y,x Potential evaporation rate
            ecanop_tavg 0 t,y,x Canopy water evaporation
            tveg_tavg 0 t,y,x Transpiration
            esoil_tavg 0 t,y,x Direct Evaporation from Bare Soil
            rootmoist_inst 0 t,y,x Root zone soil moisture
            canopint_inst 0 t,y,x Plant canopy surface water
            wind_f_inst 0 t,y,x Wind speed
            rainf_f_tavg 0 t,y,x Total precipitation rate
            tair_f_inst 0 t,y,x Temperature
            qair_f_inst 0 t,y,x Specific humidity
            psurf_f_inst 0 t,y,x Pressure
            swdown_f_tavg 0 t,y,x Downward short-wave radiation flux
            lwdown_f_tavg 0 t,y,x Downward long-wave radiation flux
ga ->
```

With a GrADS descriptor file, by using GrADS command xdfopen, multiple GLDAS-2 NetCDF files can be opened. Therefore, time aggregation-related visualization and data analysis can be done by GrADS. Below is a GrADS sample descriptor file for 3-hourly 1.0 x 1.0 degree Noah data product, GLDAS_NOAH10_3H.2.0.

```
GLDAS_NOAH10_M.2.0.xdf, a sample data descriptor file
DSET ./GLDAS_NOAH10_M.2.0/%y4/GLDAS_NOAH10_M.A%y4%m2.020.nc4
OPTIONS template
TDEF time 780 LINEAR jan1948 1mo
***variable name may not appear completely (max 15 characters)
```

An example for using xdfopen to open GLDAS_NOAH10_3H.2.0.xdf:

```
ga -> xdfopen GLDAS_NOAH10M.2.0.xdf
Scanning Descriptor File: GLDAS_NOAH10_M.2.0.xdf
SDF file
/ftp/data/s4pa/GLDAS/GLDAS_NOAH10_M.2.0/%y4/GLDAS_NOAH10_M.A%y4%m2.0
20.nc4
is open as file 1
LON set to 0 360
LAT set to -59.5 89.5
LEV set to 0 0
Time values set: 1948:1:1:0 1948:1:1:0
E set to 1 1
```

ga -> q file
File 1: GLDAS2.0 LIS land surface model output monthly mean
  Descriptor: GLDAS_NOAH10_M.2.0.XDF
  Binary: GLDAS_NOAH10_M.2.0/%y4/GLDAS_NOAH10_M.A%y4%m2.020.nc4
  Type = Gridded
  Xsize = 360 Ysize = 150 Zsize = 1 Tsize = 780 Esize = 1
  Number of Variables = 36
     swnet_tavg 0 t,y,x Net short wave radiation flux
     lwnet_tavg 0 t,y,x Net long-wave radiation flux
     qle_tavg 0 t,y,x Latent heat net flux
     qh_tavg 0 t,y,x Heat flux
     snowf_tavg 0 t,y,x Snow precipitation rate
     rainf_tavg 0 t,y,x Rain precipitation rate
     evap_tavg 0 t,y,x Evapotranspiration
     qs_acc 0 t,y,x Storm surface runoff
     qsb_acc 0 t,y,x Baseflow-groundwater runoff
     qsm_acc 0 t,y,x Snow melt
     avgsurft_inst 0 t,y,x Average Surface Skin temperature
     albedo_inst 0 t,y,x Albedo
     swe_inst 0 t,y,x Snow depth water equivalent
     snowdepth_inst 0 t,y,x Snow depth
     soilmoi0_10cm_i 0 t,y,x Soil moisture
     soilmoi10_40cm_ 0 t,y,x Soil moisture
     soilmoi100_200c 0 t,y,x Soil moisture
     soiltmp0_10cm_i 0 t,y,x Soil temperature
     soiltmp10_40cm_ 0 t,y,x Soil temperature
     soiltmp40_100cm 0 t,y,x Soil temperature
     soiltmp100_200c 0 t,y,x Soil temperature
     potevap_tavg 0 t,y,x Potential evaporation rate
     ecanop_tavg 0 t,y,x Canopy water evaporation
     tveg_tavg 0 t,y,x Transpiration
     esoil_tavg 0 t,y,x Direct Evaporation from Bare Soil
     rootmoist_inst 0 t,y,x Root zone soil moisture
     canopint_inst 0 t,y,x Plant canopy surface water
     wind_f_inst 0 t,y,x Wind speed
     rainf_f_tavg 0 t,y,x Total precipitation rate
     tair_f_inst 0 t,y,x Temperature
     qair_f_inst 0 t,y,x Specific humidity
     psurf_f_inst 0 t,y,x Pressure
     swdown_f_tavg 0 t,y,x Downward short-wave radiation flux
     lwdown_f_tavg 0 t,y,x Downward long-wave radiation flux
ga ->