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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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11/16/2017	Add more information regarding accumulation	Carlee Loeser
12/20/2017	Add information for Catchment model data	Hiroko Beaudoing
02/02/2018	Add data interpretation for TWS	Hiroko Beaudoing
02/06/2018	Review and revise	Bailing Li
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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

Table of 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 four land surface models (LSMs): Noah, Catchment (CLSM), the Community Land Model (CLM), 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 Models

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. 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, while the AVHRR-based parameters were used in GLDAS-1 and previous GLDAS-2 products (prior to October 2012). The land mask was modified to accommodate the river routing scheme included in the simulations in the November 2019-December 2020 reprocessing update.

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: one forced with combined forcing data including the GPCP version 1.3 (main production stream), and one without this forcing data (the early production stream). Since the GPCP version 1.3 data have a 3-4 month latency, the GLDAS-2.1 data products are first created without it, and are designated as Early Products (EPs), with about 1.5 month latency. Once the GPCP version 1.3 data become available, the GLDAS-2.1 data products are processed in the main production stream and are removed from the Early Products archive.

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). GRACE data have a latency of 2-6 months; thus, the simulation extends through the present without DA in recent months and the GLDAS-2.2 data are reprocessed and replaced as the GRACE data become available. 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: one with GRACE data assimilation outputs (main production stream), and one without GRACE data (the early production stream). Since the GRACE data have a 2-6 month latency, the GLDAS-2.2 data products are first created without it, and are designated as Early Products (EPs), with about 1.5 month latency. Once the GRACE data become available, the GLDAS-2.2 data products are processed in the main production stream and are removed from the Early Products 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 Early Product V2.1 (GLDAS_CLSM10_M_EP_2.1)	10.5067/1LQF1ORIE8OW
	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 GRACE-DA1 V2.2 (GLDAS_CLSM025_DA1_D_2.2)	10.5067/TXBMLX370XX8
	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 updated Princeton Forcing V2.2 Data, an upgraded version of Noah model (V3.6), and upgraded Land Information System (LIS) software. The reprocessed GLDAS-2 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). The land surface characteristics (i.e., land cover, soil texture) over some grid cells were modified due to the routing. Details of the changes and the new land surface parameter datasets are available at https://ldas.gsfc.nasa.gov/gldas/. 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. During this time, an additional production stream was added for GLDAS-2.1. Since the GPCP version 1.3 data have a 3-4 month latency, the GLDAS-2.1 data products are first created without it, and are now designated as Early Products (EPs), with about 1.5 month latency. Once the GPCP version 1.3 data become available, the GLDAS-2.1 data products are processed in the main production stream and are removed from the Early Products archive.

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 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 will end and all products will be decommissioned 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.

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, we used the GPCP 1-degree Daily dataset (Huffman et al., 2001) and an updated disaggregation routine (making use of GDAS precipitation fields) to prepare 3-hourly GPCP fields. GLDAS-2.1 products obtained before January and February 2020 used the GPCP 1DD v1.2 data for January 2000 through October 2015, and the GDAS was used from November 2015 onward, in order to run GLDAS-2.1 up to present. In the reprocessed GLDAS-2.1 data, a new version 1.3 of the GPCP daily data is used, in which extends through present with 3-4 months latency. GDAS precipitation data fill the gap between the last available GPCP data to present; therefore, GLDAS-2.1 will be reprocessed and replaced for the recent months as the GPCP data updates each month.

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.

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. Due to unreliable Greenland forcing data and the lack of a glacier/ice sheet model, snow water equivalent accumulates indefinitely in Greenland and a few other Arctic points. Therefore, it is highly recommended that Greenland and other points with abnormally large snow water equivalent values be masked out when performing global analyses.
2. 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.
3. Total runoff is the sum of subsurface runoff "Qsb_tavg" and surface runoff "Qs_tavg".
4. 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.

5. 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.
6. 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.
7. 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.
8. 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.
9. 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.
10. 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

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-help-disc@lists.nasa.gov
Phone: 301-614-5224
Fax: 301-614-5268

5.1 HTTPS

Access the online archive via HTTPS for direct download 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 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

The sample image below is generated by NASA Giovanni.

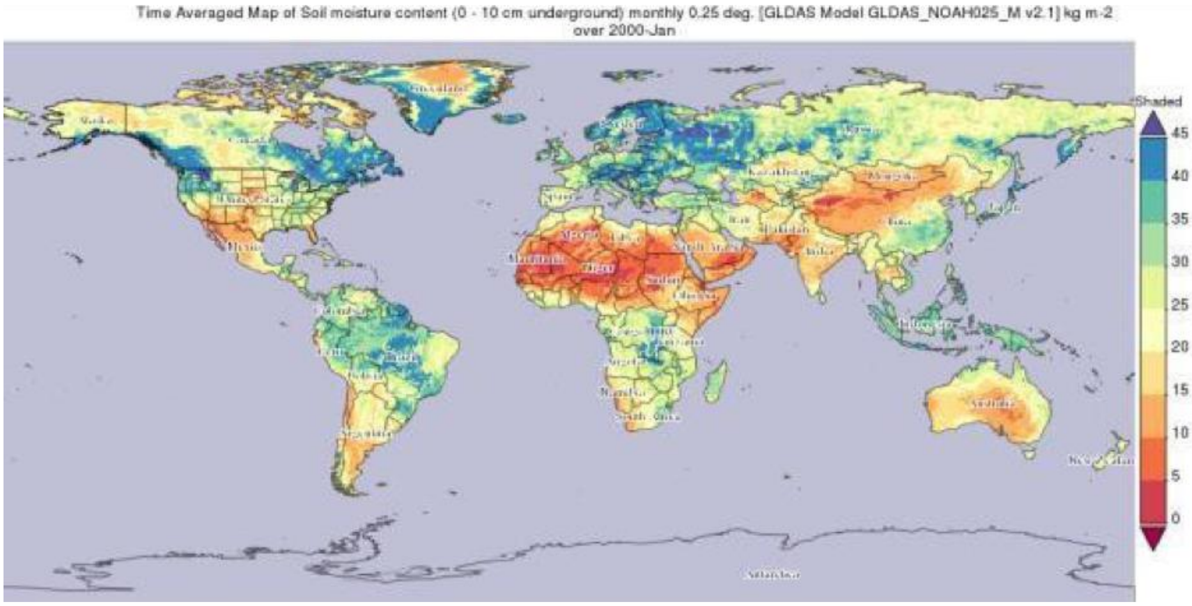

Figure 1. Soil moisture content (0-10 cm underground) map for January 2000, from GLDAS-2.1 Noah Land Surface Model L4 monthly 0.25 x 0.25 degree data.

6.0 More Information

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

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 ->
```