



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

README Document for NASA GLDAS Version 2 Data Products

Last Revised August 6, 2019

Goddard Earth Sciences Data and Information Services Center (GES DISC)
<http://disc.gsfc.nasa.gov>
NASA Goddard Space Flight Center
Code 610.2
Greenbelt, MD 20771 USA

README for NASA GLDAS Version 2 Data

Prepared By:

Hualan Rui

GES DISC
GSFC Code 610.2

Hiroko Beaudoin

Hydrological Sciences Laboratory (HSL)
GSFC Code 617

August 6, 2019

Date

Reviewed By:

Carlee Loeser

GES DISC
GSFC Code 610.2

August 6, 2019

Date

**Goddard Space Flight Center
Greenbelt, Maryland**

Revision History

Revision Date	Changes	Author
05/19/2010	Initial version based on information from Hiroko Beadoing.	Hualan Rui
06/17/2010	Review and revise	Hiroko Beadoing
11/21/2011	Update GES DISC Helpdesk email address	Hualan Rui
10/16/2012	Add information for GLDAS-2.0	Hiroko Beadoing
11/01/2012	Add information for GLDAS-2.0	Hualan Rui
11/15/2013	Add information for GLDAS-2.0 0.25° product	Hiroko Beadoing
11/18/2014	Update Table 3 for additional fields	Hualan Rui
05/12/2015	Add Table 2: DOIs for GLDAS-2 products	Hualan Rui
06/16/2015	Add information for GLDAS-2.0 products	Hualan Rui
07/03/2015	Review and revise	Hiroko Beadoing
07/22/2016	Add information for GLDAS-2.1 Noah 1.0 ° products	Hiroko Beadoing
08/01/2016	Add GLDAS-1 and GLDAS-2.1 differences	Hiroko Beadoing
11/11/2016	Add information for GLDAS-2.1 Noah 0.25 ° products	Hualan Rui
02/08/2017	Convert to comply with the newer README template	Hualan Rui
07/18/2017	Update URLs to comply with GES DISC new Web site	Hualan Rui
11/16/2017	Add more information regarding accumulation variables	Carlee Loeser
12/20/2017	Add information for Catchment model data	Hiroko Beadoing
02/02/2018	Add data interpretation for TWS	Hiroko Beadoing
02/06/2018	Review and revise	Bailing Li
03/29/2018	Add DOI for Catchment model data product	Hualan Rui
04/05/2019	Update Data Interpolation for TWS and GWS	Hualan Rui
08/06/2019	Update References and add snow density note	Carlee Loeser

Table of Contents

1.0 Introduction	5
1.1 Dataset Basic characteristics	5
1.2 Digital Object Identifier (DOI) and Citation	6
1.3 Contact Information	7
1.4 What's New?	8
1.4.1 What are the differences between GLDAS-1 and GLDAS-2?	8
1.4.2 What is new about the reprocessed GLDAS-2.0?	9
1.4.3 What are the differences between GLDAS-1 and GLDAS-2.1?	9
2.0 Data Organization	10
2.1 File Naming Convention	10
2.2 File Format and Structure	10
3.0 Data Contents	11
3.1 Noah Model Data	11
3.2 Catchment Model Data	12
3.3 Data Interpretation	13
4.0 Options for Reading the Data	15
4.1 Utilities	15
4.2 Panoply	15
4.3 GrADS	15
5.0 Data Services	18
5.1 NASA Earthdata Login System	18
5.2 Data services	19
5.2.1 HTTP	19
5.2.2 EarthData Search	19
5.2.3 OPeNDAP	19
5.2.4 GrADS Data Server (GDS)	19
5.2.5 Giovanni	19
6.0 More Information	20
7.0 Acknowledgements	20
References	21
Acronyms	22

1.0 Introduction

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

The goal of the NASA Global Land Data Assimilation System (GLDAS) is to ingest satellite- and ground- based observational data products, using advanced land surface modeling and data assimilation techniques, in order to generate optimal fields of land surface states and fluxes (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, 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 data products of Version 2 of the Global Land Data Assimilation System (hereafter, GLDAS-2).

1.1 Dataset Basic characteristics

NASA GLDAS-2 has two components: one forced entirely with the Princeton meteorological forcing data (hereafter, GLDAS-2.0), and the other forced with a combination of model and observation based forcing datasets (hereafter, GLDAS-2.1). GLDAS-2.0 currently extends from 1948 through 2014 and will be extended to recent years as the dataset becomes available. GLDAS-2.1 extends from 2000 to present with about 1.5 month latency and will be updated monthly. Other LSMs simulation outputs will be added to GLDAS-2.1 as they become available. GLDAS-2.1 is a replacement for GLDAS-1 product stream. Daily Catchment LSM outputs at 0.25-degree resolution are added to the GLDAS-2.0 suite (Li et al, 2017), and reprocessing of GLDAS-2.0 with the latest Princeton meteorological dataset, version 2.2 through 2014 is undergoing for the Noah LSM as of late 2017.

The temporal resolution 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 data related alert message at [GES DISC Alerts](#).

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

Contents	Outputs from NOAH and Catchment 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, and monthly

README for NASA GLDAS Version 2 Data

Temporal coverage	GLDAS-2.0: 03Z Jan 1, 1948 – 21Z Dec 31, 2014
	GLDAS-2.1: 03Z Jan 1, 2000 – present, with 1.5 month latency
Dimension	360 (lon) x 150 (lat) for the 1.0° x 1.0° data products 1440 (lon) x 600 (lat) for the 0.25° x 0.25° data products
Origin (1 st grid center)	(179.5W, 59.5S) for the 1.0° x 1.0° data products (179.875W, 59.875S) for the 0.25° x 0.25° data products
Land Surface Models	NOAH 3.3, Catchment-F2.5

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 data set from Princeton University (Sheffield et al., 2006). Each simulation uses the common GLDAS data sets for land water mask (MOD44W: Carroll et al., 2009) and elevation (GTOPO30) along with the model default land cover and soils datasets. Noah model uses the Modified IGBP MODIS 20-category vegetation classification and the soil texture based on the Hybrid STATSGO/FAO) datasets. Catchment model uses the Mosaic land cover classification and soils, topographic, and other model-specific parameters were derived in a consistent manner as in the NASA/GMAO's GEOS-5 climate modeling system. The MODIS based land surface parameters are used in the current GLDAS-2.0 and GLDAS-2.1 products while the AVHRR base parameters were used in GLDAS-1 and previous GLDAS-2 products (prior to October 2012).

The GLDAS-2.1 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) precipitation fields (Adler et al., 2003), and the Air Force Weather Agency's AGRicultural METeorological modeling system (AGRMET) radiation fields which became available for March 1, 2001 onwards.

1.2 Digital Object Identifier (DOI) and Citation

Users of GLDAS data products should cite, in research papers, the data used, along with their Digital Object Identifiers (DOIs) (Table 2). 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. DOIs for NASA GLDAS-2 Data Products

Product Short Name	Product Description	DOI
GLDAS_NOAH025_3H_2.0	GLDAS Noah Land Surface Model L4 3 hourly 0.25 x 0.25 degree, V2.0	10.5067/3420HQM9AK6Q
GLDAS_NOAH025_M_2.0	GLDAS Noah Land Surface Model L4 monthly 0.25 x 0.25 degree, V2.0	10.5067/9SQ1B3ZXP2C5

README for NASA GLDAS Version 2 Data

GLDAS_NOAH10_3H_2.0	GLDAS Noah Land Surface Model L4 3 hourly 1.0 x 1.0 degree, V2.0	10.5067/LOJGCNVBNRAX
GLDAS_NOAH10_M_2.0	GLDAS Noah Land Surface Model L4 monthly 1.0 x 1.0 degree, V2.0	10.5067/QN80TO7ZHFJZ
GLDAS_NOAH025_3H_2.1	GLDAS Noah Land Surface Model L4 3 hourly 0.25 x 0.25 degree, V2.1	10.5067/E7TYRXPJKWOQ
GLDAS_NOAH025_M_2.1	GLDAS Noah Land Surface Model L4 monthly 0.25 x 0.25 degree,	10.5067/SXAVCZFAQLNO
GLDAS_NOAH10_3H_2.1	GLDAS Noah Land Surface Model L4 3 hourly 1.0 x 1.0 degree, V2.1	10.5067/IIG8FHR17DA9
GLDAS_NOAH10_M_2.1	GLDAS Noah Land Surface Model L4 monthly 1.0 x 1.0 degree, V2.1	10.5067/LWTYSMP3VM5Z
GLDAS_CLSM025_D_2.0	GLDAS Catchment Land Surface Model L4 daily 0.25 x 0.25 degree,	10.5067/LYHA9088MFWQ

Each of DOIs in Table 2 is linked to its corresponding data product page. On the page, the tab “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). The following is an example citation (for GLDAS_NOAH025_3H_2.1):

Beaudoin, Hiroko 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](https://doi.org/10.5067/E7TYRXPJKWOQ)

Primary Reference:

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.

1.3 Contact Information

For information about or assistance in using any GES DISC data, please contact the GES DISC Help Desk at:

GES DISC
Code 610.2
NASA Goddard Space Flight Center
Greenbelt, Maryland 20771
Email: gsfc-help-disc@lists.nasa.gov 301-614-5224
(voice)
301-614-5268 (fax)

For general science questions and comments, please contact:

README for NASA GLDAS Version 2 Data

Matthew Rodell, Ph.D.
Hydrological Sciences Laboratory, Code 617
NASA Goddard Space Flight Center
Greenbelt, MD 20771
Email: Matthew.Rodell@nasa.gov
Phone: 301-286-9143

Or

Hiroko Kato Beaudoin, M.S.
Earth System Science Interdisciplinary Center
University of Maryland, College Park
Hydrological Sciences Laboratory, Code 617
NASA Goddard Space Flight Center Greenbelt,
MD 20771
Email: Hiroko.Kato-1@nasa.gov Phone:
301-286-9143

Or

Bailing Li, Ph.D.
Earth System Science Interdisciplinary Center
University of Maryland, College Park
Hydrological Sciences Laboratory, Code 617
NASA Goddard Space Flight Center Greenbelt,
MD 20771
Email: bailing.li-1@nasa.gov

1.4 What's New?

1.4.1 What are the differences between GLDAS-1 and GLDAS-2?

GLDAS-1 forcing data sources were switched several times, over the record from 1979 to present, which introduced unnatural trends and resulted in highly uncertain forcing fields in 1995-1997. More information about the GLDAS-1 forcing data is available at <https://ldas.gsfc.nasa.gov/gldas/GLDASforcing.php>.

GLDAS-2 has two components, GLDAS-2.0 and GLDAS-2.1. The main objective for GLDAS-2.0 is to create more climatologically consistent data sets, using the “[Global Meteorological Forcing Dataset](#)” from Princeton University, currently extending from 1948 - 2010. GLDAS-2.1 is analogous to GLDAS-1 product stream, with upgraded models forced by [a combination of GDAS, disaggregated GPCP, and AGRMET radiation data sets](#).

Other enhancements made in GLDAS-2 include model version upgrade, switching to MODIS-based land surface parameter data sets, and initialization of soil moisture over desert. In the Noah model, the bottom layer temperature was also updated. More details regarding the land surface parameter data changes are available at <https://ldas.gsfc.nasa.gov/gldas/>.

1.4.2 What is new about the reprocessed GLDAS-2.0?

The GLDAS-2.0 data have been reprocessed with updated Princeton Forcing V2.2 Data and upgraded Land Information System (LIS) software. The reprocessed GLDAS-2.0 data are archived in NetCDF-4 format. Additional model output fields are included (see Table 3). Streamlining the output format resulted in changing some of the units from the GLDAS2.0 data prior to July 2015. The land surface characteristics (i.e. land cover, soil texture) over some grid cells were modified due to a bug fix. Details of the changes and the new land surface parameter datasets are available at <https://ldas.gsfc.nasa.gov/gldas/>.

1.4.3 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 flux displayed sharp, unnatural gradient lines in the Northern Hemisphere in 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 are 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 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 use the GPCP 1-degree Daily (1DD) v1.2 dataset (Huffman et al., 2001) and an updated disaggregation routine (making use of GDAS precipitation fields) to prepare 3-hourly GPCP fields. However, the GPCP 1DD data is not updated regularly and currently ends in October, 2015. Consequently, at the time of writing the GDAS was used for November, 2015 onwards in order to run GLDAS-2.1 up to present. Once the GPCP data is updated, GLDAS-2.1 will be reprocessed for the recent months.

2.0 Data Organization

The GLDAS-2.0 and GLDAS-2.1 consist of 3-hourly, daily, and monthly data products at 0.25° x 0.25° and 1.0° x 1.0° resolutions.

2.1 File Naming Convention

NASA GLDAS-2 data are named in accordance with the following convention:

GLDAS_<Model><Grid spacing>_<Temporal spacing>_A<Date>.<Product version>.nc4

Attribute	Description
<Model>	"NOAH" for the Noah Model
	"CLSM" for the Catchment Model
	"CLM" for the Common Land Model
	"VIC" for the Variable Infiltration Capacity Model
<Grid spacing>	"025" for 1/4th degree
	"10" for 1.0 degree
<Temporal spacing>	"3H" for 3-hourly datasets
	"D" for daily datasets
	"M" for monthly datasets
<Date> *	<YYYYMMDD>.<HHHH> for 3-hourly
	<YYYYMMDD> for daily datasets
	<YYYYMM> for monthly datasets
<Product version>	"020" for GLDAS-2.0
	"021" for GLDAS-2.1

* (4-digit year; 2-digit month; 2-digit day of month; 4-digit GMT hour of day)

For examples, file name for monthly 1.0 degree GLDAS-2.0 Noah data for January 1948 is "GLDAS_NOAH10_M_A194801.020.nc4" and file name for 3-hourly 0.25 degree GLDAS-2.1 Noah data at 03:00Z on 1 January 2000 is "GLDAS_NOAH025_3H.A20000101.0300.021.nc4." File name for daily 0.25 degree GLDAS-2.0 Catchment data on 1 January, 1948 is "GLDAS_CLSM025_D.A19480101.0000.020.nc4".

2.2 File Format and Structure

The 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, <https://www.unidata.ucar.edu/software/netcdf/docs/>.

3.0 Data Contents

3.1 Noah Model Data

Both 3-hourly and monthly data products from GLDAS-2 Noah model contain thirty-six parameters, as listed in Table 3.1. Brief description about Noah Model is available at <https://disc.gsfc.nasa.gov/information/documents/5a70903bca6d24bac24118eb/gldas-lsm-description#Noah>.

Table 3.1 Parameters in the GLDAS-2 Noah model data

Short Name	Description	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	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 per 3-hour
Qsb_acc	Baseflow-groundwater runoff	kg m ⁻² per 3-hour
Qsm_acc	Snow melt	kg m ⁻² per 3-hour
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	kg m ⁻²
SoilMoi10_40cm_inst	Soil moisture	kg m ⁻²
SoilMoi40_100cm_inst	Soil moisture	kg m ⁻²
SoilMoi100_200cm_inst	Soil moisture	kg m ⁻²
SoilTMP0_10cm_inst	Soil temperature	K
SoilTMP10_40cm_inst	Soil temperature	K
SoilTMP40_100cm_inst	Soil temperature	K
SoilTMP100_200cm_inst	Soil temperature	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

README for NASA GLDAS Version 2 Data

Rainf_f_tavg	Total precipitation rate	kg m ⁻² s ⁻¹
Tair_f_inst	Temperature	K
Qair_f_inst	Specific humidity	kg/kg
Psurf_f_inst	Pressure	Pa
SWdown_f_tavg	Downward short-wave radiation	W m ⁻²
LWdown_f_tavg	Downward long-wave radiation	W m ⁻²

The short names with extension “_tavg” are past 3-hr averaged variables. The short names with extension “_acc” are past 3-hr accumulated variables. The short names with extension “_inst” are instantaneous variables. The short names with “_f” are forcing variables.

3.2 Catchment Model Data

Daily product from GLDAS-2 Catchment model contains thirty-three parameters, as listed in Table 3.2. Brief description about Catchment Model is available at <https://disc.gsfc.nasa.gov/information/documents/5a70903bca6d24bac24118eb/gldas-lsm-description#CLSM>.

Table 3.2 Parameters in the GLDAS-2 Catchment model data

Short Name	Description	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	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

README for NASA GLDAS Version 2 Data

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
Psurf_f_tavg	Pressure	Pa
SWdown_f_tavg	Downward short-wave radiation	W m ⁻²
LWdown_f_tavg	Downward long-wave radiation	W m ⁻²

The short names with extension “_tavg” are 24-hr averaged variables.

The short names with “_f” are forcing variables.

3.3 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 and surface runoff.
4. The Catchment land surface model (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: $GWS = TWS - \text{Rootzone_SoilMoisture} - \text{Snow_Water_Equivalent} - \text{Canopy_interception}$. For computing Noah TWS, it 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/m²/s. So 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 that 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:

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

README for NASA GLDAS Version 2 Data

For accumulated variables such as Qs_acc , 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:

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

This would be irrelevant, and the above formulas should not be used, if the field of interest were an instantaneous state.

7. Heights of forcing fields depend on the data sets used to drive the simulation. Presently, all the GLDAS data sets use the 2 m temperature and specific humidity and the 10 m wind for the entire time span.
8. The number of vertical levels for Soil Temperature and Soil Moisture is model specific. NOAH has total of 4 layers thickness: 0-10, 10-40, 40- 100, and 100-200 cm. CLSM does not have explicit vertical levels, instead soil moisture is represented in Surface (0-2cm), Root Zone (0-100cm), and Profile (varies grid-by-grid) reservoirs. They are inclusive-- Profile includes Surface and Root Zone and Root Zone includes Surface.
9. The mean fields in monthly data (e.g. evapotranspiration, see Table 3) contain straight average over 3z on the 1st day of month to 0z on the 1st day of next month. Similarly, the accumulated fields (e.g. runoff) contain straight average of 3 -hour accumulation from 3z on the 1st to 0z on the first day of next month. The instantaneous fields are averaged over 0z on the 1st day of month to 21z on the last day of month.
10. Snow density computed using the snow water equivalent and snow depth included in the current GLDAS CLSM product is not valid. Snow depth was not accounted for the grid fraction of snow cover at the time the simulation was done. Reprocessing the simulation is under consideration.

4.0 Options for Reading the Data

4.1 Utilities

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

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 sets.

The [HowTo](#) of NASA 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 file 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 [variable_name]”, etc. can be used to query file information, read and display the data. 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
```

README for NASA GLDAS Version 2 Data

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 Sensible heat net flux

qg_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

soilmoi40_100cm 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->

README for NASA GLDAS Version 2 Data

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 1.0x1.0 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_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 Sensible heat net flux
  qg_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
soilmoi40_100cm 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->

5.0 Data Services

5.1 NASA Earthdata Login System

Access to GES DISC data requires all users to be registered with the NASA Earthdata Login system (as of August 1st, 2016). Data continue to be free of charge and accessible via HTTP. Access to data via FTP will no longer be available (as of October 3, 2016). Detailed instructions on how to register and receive authorization to access GES DISC data are provided at <https://disc.sci.gsfc.nasa.gov/data-access>.

GES DISC users who deploy scripting methods to list and download data in bulk via anonymous FTP are advised to review the [How to Download Data Files from HTTP Service with wget](#) recipe that provides examples of GNU wget commands for listing and downloading data via HTTP.

README for NASA GLDAS Version 2 Data

If you need assistance or wish to report a problem:

Email: gsfc-help-disc@lists.nasa.gov

Voice: 301-614-5224

Fax: 301-614-5268

Address:

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

5.2 Data services

[The NASA GLDAS data collections page](#) provides a list of GLDAS data products and each data product is linked to the corresponding data product landing page that provides product summary, data citation, documentation, and data access.

5.2.1 HTTPS

Access the online archive data via HTTPS: <https://hydro1.gesdisc.eosdis.nasa.gov/data/GLDAS>

5.2.2 EarthData Search

Use the Earthdata Search Client (EDSC) to find and retrieve data sets across multiple data enters: <https://search.earthdata.nasa.gov/search?q=GLDAS>

5.2.3 OPeNDAP

Access the data via the OPeNDAP protocol for parameter and spatial subsetting: <https://hydro1.gesdisc.eosdis.nasa.gov/opendap/GLDAS/>

5.2.4 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/>

5.2.5 Giovanni

The GES-DISC Interactive Online Visualization ANd aNalysis Interface (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](#).

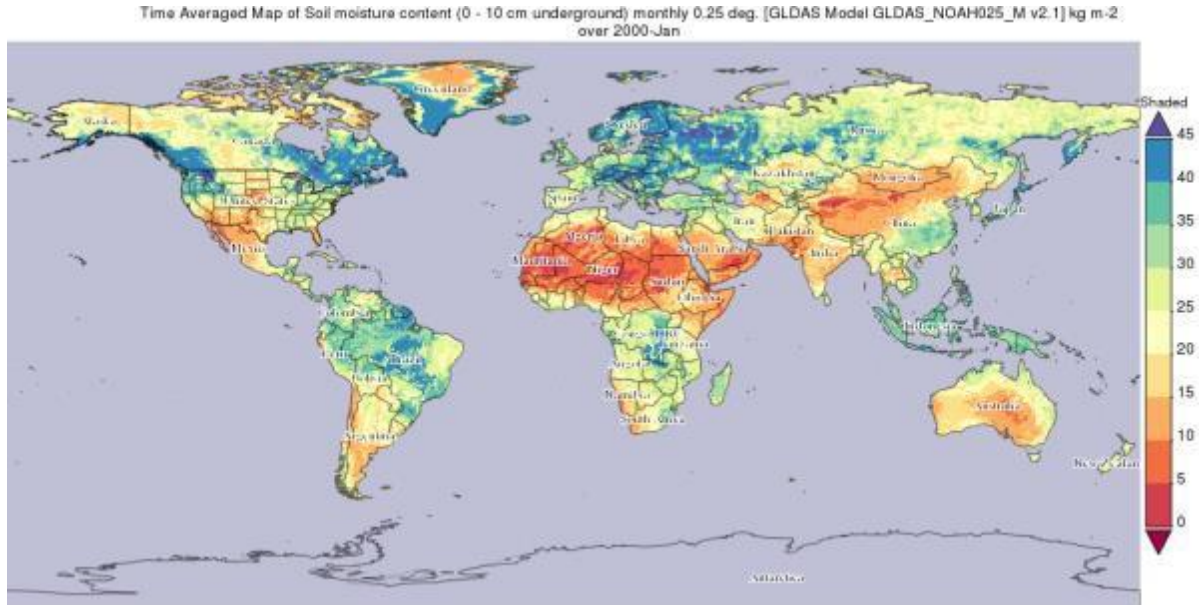


Figure 1. Soil moisture (0 – 10 cm) map for January 2000, from GLDAS-2.1 Noah 0.25 x 0.25 degree monthly data.

6.0 More Information

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

7.0 Acknowledgements

The GLDAS data are produced by NASA GSFC Hydrological Sciences Laboratory (HSL).

Please refer to Rodell et al. (2004) for more information about the GLDAS project.

References

- 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.
- Adler, R.F., G.J. Huffman, A. Chang, R. Ferraro, P. Xie, J. Janowiak, B. Rudolf, U. Schneider, S. Curtis, D. Bolvin, A. Gruber, J. Susskind, P. Arkin, E. Nelkin 2003: The Version 2 Global Precipitation Climatology Project (GPCP) Monthly Precipitation Analysis (1979-Present). *J. Hydrometeor.*, 4,1147-1167.
- Carroll, ML, Townshend, JR, DiMiceli, CM, Noojipady, P, Sohlberg, RA (2009). A new global raster water mask at 250 m resolution. *International Journal of Digital Earth*, 2(4), 291-308.
- Derber, J. C., D. F. Parrish, and S. J. Lord, 1991: The new global operational analysis system at the National Meteorological Center. *Weather Forecasting*, 6, 538-547.
- Friedl, M.A., Sulla-Menashe, D., Tan, B., Schneider, A., Ramankutty, N., Sibley, A., & Huang, X. (2010). MODIS Collection 5 global land cover: Algorithm refinements and characterization of new datasets. *Remote Sensing of Environment*, 114, 168-182.
- Li, B., Rodell, M., Sheffield, J., Wood, E., and Sutanudjaja, E. (2019). Long-term, non-anthropogenic groundwater storage changes simulated by three global-scale hydrological models, *Scientific Reports*, 9, 10746(2019).
- Reynolds C.A., T. J. Jackson, and W.J. Rawls. (1999). Estimating Available Water Content by Linking the FAO Soil Map of the World with Global Soil Profile Databases and Pedo-transfer Functions. *Proceedings of the AGU 1999 Spring Conference*, Boston, MA. May 31-June 4, 1999.
- Sheffield, J., G. Goteti, and E. F. Wood, 2006: Development of a 50-yr high-resolution global dataset of meteorological forcings for land surface modeling, *J. Climate*, 19 (13), 3088-3111

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	CPC 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
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
Mirador	Fast interface for searching Earth science data at NASA GES DISC
NARR	North American Regional Reanalysis
NASA	National Aeronautics and Space Administration
NCEP	National Centers for Environmental Prediction
netCDF	network Common Data Form
NIDIS	National Drought Integrated Information System
NLDAS	North America 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