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

README Document for North American Land Data Assimilation System Phase 2 Datasets (NLDAS-2.0 in netCDF format)

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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

Prepared By:

Hualan Rui

Name
GES DISC
GSFC Code 610.2

David Mocko

Name
Hydrological Sciences Laboratory (HSL)
GSFC Code 617

July 9, 2020
Date

Reviewed By:

Reviewer Name
GES DISC
GSFC Code 613.2

Date

Goddard Space Flight Center
Greenbelt, Maryland

Revision History

Revision Date	***Changes***	***Author***
2020/07/09	Initial version for NLDAS-2.0 netCDF format: updated based on the README for NLDAS-2 in GRIB format	Hualan Rui
2021/09/22	Added what's new and updated the variable tables	Hualan Rui

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1.0 Data Organization

This REAMDE document is for Phase 2 of North American Land Data Assimilation System (NLDAS-2) data archived in netCDF format at NASA GES DISC. Hereafter this data collection in netCDF format is referred as NLDAS-2.0.

This document provides basic information on the precipitation, land-surface states (e.g., soil moisture and surface temperature), and fluxes (e.g., radiation and latent and sensible heat fluxes) of the NLDAS-2.0.

NLDAS (Mitchell et al., 2004; Xia et al., 2012) integrates a large quantity of observation-based and model reanalysis data to drive offline (not coupled to the atmosphere) land-surface models (LSMs), and executes at 1/8th-degree grid spacing over central North America, enabled by the Land Information System (LIS) (Kumar et al., 2006; Peters-Lidard et al., 2007). NLDAS forcing drives four land-surface models: NASA's Mosaic, NOAA's Noah, the NWS Office of Hydrological Development's (OHD) SAC, and Princeton's implementation of VIC. More information is available at NASA's Land Data Assimilation Systems (LDAS) and Land Information System (LIS) websites, as well as NCEP/EMC's NLDAS and drought websites. NLDAS drought monitoring products support the National Integrated Drought Information System (NIDIS).

NLDAS-2 is a collaboration project among several groups: NCEP's Environmental Modeling Center (EMC), NASA's Goddard Space Flight Center (GSFC), Princeton University, the NWS Office of Hydrological Development (OHD), the University of Washington, and NCEP's Climate Prediction Center (CPC). NLDAS is a core project with support from NOAA's Modeling, Analysis, Predictions, and Projections (MAPP) Program. The NASA/GSFC group led the development of the algorithm to generate the forcing data and produced this data for the retrospective period (January 1979 - December 2007), as well as generated the retrospective Mosaic model simulation. The University of Washington and Princeton University developed the VIC model, and the Princeton group generated the retrospective period VIC model simulation. NCEP/EMC, in collaboration with the University of Washington, made improvements to the Noah model. NCEP/EMC also generated retrospective period model simulations for Noah and OHD's SAC model. The NLDAS-2.0 forcing data and Mosaic, Noah, and VIC model output are accessible through GES DISC HTTPS access, OPeNDAP, GrADS Data Server (GDS), and Giovanni services. Currently, NLDAS-2 SAC model data are only available from NCEP/EMC's NLDAS website.

1.1 Dataset Description

The temporal resolutions for the NLDAS-2.0 data are hourly and monthly. The NLDAS-2.0 primary and secondary forcing data files and Mosaic, Noah, and VIC LSM output files are briefly described here. Descriptions of the output files from the SAC LSM will be added when the

dataset is made available at the GES DISC. Table 1 lists some basic characteristics of the NLDAS-2.0 data.

Table 1. Basic characteristics of the NLDAS-2.0 data.

Contents	Forcing data, land-surface model output
Latitude extent	25° to 53°
Longitude extent	-125° to -67°
Spatial resolution	1/8th degree
Temporal resolution	Hourly and monthly
Temporal coverage	1 January 1979 to present
Dimension	464 (lon) x 224 (lat)
Grid box center points	Lower left: -124.9375, 25.0625 Upper right: -67.0625, 52.9375
Land surface models	Mosaic, Noah, and VIC
File format	**netCDF**

1.2 Digital Object Identifier (DOI) and Citation

A Digital Object Identifier or 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 lists the DOIs for the NLDAS-2.0 datasets.

Table 2. DOIs for NLDAS-2.0 Data Datasets

Dataset Name	**DOI**
NLDAS_FORA0125_H.2.0	10.5067/THUF4J1RLSYG
NLDAS_FORA0125_M.2.0	10.5067/2DPKB5B5N14O
NLDAS_FORA0125_MC.2.0	10.5067/37FBOUKUWCOV
NLDAS_FORB0125_H.2.0	10.5067/96S0R3LFOBTU
NLDAS_FORB0125_M.2.0	10.5067/7EF175EAK5NA
NLDAS_FORB0125_MC.2.0	10.5067/9QBO4LB8AMBF
NLDAS_MOS0125_H.2.0	10.5067/TS58ZCJZIWT5
NLDAS_MOS0125_M.2.0	10.5067/YQ1P3OP48R8M
NLDAS_MOS0125_MC.2.0	10.5067/GXN4C7MNIY4C
NLDAS_NOAH0125_H.2.0	10.5067/T4OW83T8EXDO
NLDAS_NOAH0125_M.2.0	10.5067/WB224IA3PVOJ

NLDAS_NOAH0125_MC.2.0	10.5067/QLW535AYJ498
NLDAS_VIC0125_H.2.0	10.5067/45T7K120BJ2S
NLDAS_VIC0125_M.2.0	10.5067/NL7JTZYO2RVK
NLDAS_VIC0125_MC.2.0	10.5067/VSF4LKP6AC4H

Each of the DOIs in Table 2 is linked to the corresponding dataset page, and the Data Citation for the dataset is located on the page. If you use these data in your research or applications, please include the corresponding citations in your publication(s). The following is a citation example for NLDAS_NOAH0125_H.2.0:

Xia, Y., et al., NCEP/EMC (2012), NLDAS Noah Land Surface Model L4 Hourly 0.125 x 0.125 degree V2.0, Edited by David Mocko, NASA/GSFC/HSL, Greenbelt, Maryland, USA, Goddard Earth Sciences Data and Information Services Center (GES DISC), Accessed: [**Data Access Date**], 10.5067/T4OW83T8EXDO

1.3 Data Disclaimer

Please check the GES DISC web site periodically for the latest NLDAS-2.0 data. The NLDAS-2.0 data are available at the GES DISC in "near real-time," with about a latency about 4-days. Please consider signing up for the LDAS mailing list to receive updates and revisions of the datasets.

1.3.1 Acknowledgement

Please refer to Mitchell et al. (2004) for more information about the NLDAS project. Details about the NLDAS-2 configuration and datasets can be found in Xia et al. (2012). Along with the dataset DOI(s), NASA requests that you include the following acknowledgment in papers published using these data:

"*The data used in this study were acquired as part of the mission of NASA's Earth Science Division and archived and distributed by the Goddard Earth Sciences (GES) Data and Information Services Center (DISC).*"

We would appreciate receiving a copy of your publication, which can be forwarded to the following address:

GES DISC Help Desk
Code 610.2
NASA/Goddard Space Flight Center
Greenbelt, MD 20771

Phone: 301-614-5224
Fax: 301-614-5268
Email: gsfc-dl-help-disc@mail.nasa.gov

1.3.2 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-dl-help-disc@mail.nasa.gov
301-614-5224 (voice)
301-614-5268 (fax)

For general science questions and comments, please contact:

David M. Mocko
Hydrological Sciences Laboratory, Code 617
NASA Goddard Space Flight Center
Greenbelt, Maryland 20771
Email: David.Mocko@nasa.gov
301-614-6222 (voice)
301-614-6246 (fax)

1.4 What's New for NLDAS-2.0 netCDF Collection?

1.4.1 Data Format

This NLDAS-2.0 collection is archived and distributed in netCDF format by NASA GES DISC.

1.4.2 Data Content

The NLDAS-2.0 netCDF files were converted from the corresponding GRIB files with no change to the data, except reversed the sign of the following variables in the Mosaic output.

Short name in netCDF file	PID:Short name in GRIB file	Long_name
ECanop	200:EVCW	Canopy water evaporation
TVeg	210:TRANS	Transpiration
ESoil	199:EVBS	Direct evaporation from bare soil
SubSnow	198:SBSNO	Sublimation (evaporation from snow)

In the Mosaic GRIB files, these four fluxes were incorrectly defined as positive in the *downward* direction. The positive direction of the flux components (ESoil, ECanop, SubSnow, TVeg) is reversed in the netCDF files, to be consistent with the traditional ALMA standard and the same variables in the NOAH and VIC collections.

There is an exception to this exception. The SubSnow variable did have a change in sign before/after 01Z 09 Mar 2008 in the GRIB files. Therefore, for this variable in particular:

Before/on 00Z 09 March 2008: SubSnow (netCDF file) = -SubSnow (GRIB-1 file)
On/after 01Z 09 March 2008: SubSnow (netCDF file) = SubSnow (GRIB-1 file)

To summarize, the sign of these four flux components (ESoil, ECanop, SubSnow, TVeg) in netCDF files is now consistent between the MOS, NOAH, and VIC collections, both before/on/after 01Z 09 March 2008.

For more information on these variables (the evaporation components), please see the NLDAS FAQ (search for "Q. Can you explain the components of the evaporation in the NLDAS-2 model output?").

Starting from 01Z 09 March 2008, the canopy conductance variable in NLDAS-2 Mosaic GRIB files was not properly defined, so the output is not correct. The same issue is there for this variable in netCDF as well. For more information on the variable, please see the NLDAS FAQ (search for "Q. Why is the canopy conductance undefined/wrong in NLDAS-2 Mosaic output?").

1.4.3 Variable Names

The variables in the netCDF files are named following the ALMA conventions as much as possible, https://www.lmd.jussieu.fr/~polcher/ALMA/convention_output_3.html. However, some variables are not in the ALMA list or they have names that are generally similar. For example, "SoilT" is short for "SoilTemp" and "SoilM" is for "SoilMoist". But some variables are completely not in ALMA (such as RSmin, SMAvail, etc.).

The variables in the netCDF files are reordered basically based on the list on the ALMA page, but some of the similar variables are listed next to each other (such as most of the snow variables).

1.4.4 Streamflow Data

A new variable, streamflow, has been added to the Mosaic (MOS), Noah, and VIC LSM datasets. The streamflow is the routed runoff from the LSMs and represents the major river flows on the NLDAS grid.

The streamflow field in the MOS, NOAH, and VIC datasets does not contain valid values over all NLDAS LSM grid points. The streamflow mask in the NLDAS router [Lohmann et al. 2004] was

provided by the National Weather Service over the extent of 12 River Forecast Centers (see the Figure 3 in [Lohmann et al. 2004]). Outside of this mask, the streamflow values are undefined.

1.4.5 Climatology Datasets

The NLDAS-2.0 climatology datasets (in netCDF) are the 40-year (1980 – 2019) monthly climatology (were 30-year climatology in GRIB format before).

1.4.6 Daily Datasets

Upcoming …

1.4.7 Monthly Anomaly Datasets

Upcoming …

2.0 Data Organization

2.1 File Naming Convention

2.1.1 Hourly Datasets

NLDAS-2.0 hourly data files are named in accordance with following convention:

NLDAS_FORA0125_H.A<YYYYMMDD>.<HH>00.020.nc
NLDAS_FORB0125_H.A<YYYYMMDD>.<HH>00.020.nc
NLDAS_MOS0125_H.A<YYYYMMDD>.<HH>00.020.nc
NLDAS_NOAH0125_H.A<YYYYMMDD>.<HH>00.020.nc
NLDAS_VIC0125_H.A<YYYYMMDD>.<HH>00.020.nc

"FORA," "FORB," "MOS," "NOAH", and "VIC" denote primary forcing dataset "File A," secondary forcing dataset "File B," Mosaic model, Noah model, and VIC model, respectively.
"0125" is an indication for 1/8th degree grid spacing.
"H" is an indication for hourly.
"<YYYYMMDD>" is a date format for year, month, and day.
"<HH>" is GMT hour of the day.
"020" indicates the data version 2.0 for NLDAS Phase 2.
"nc" indicates the file is in netCDF format.

2.1.2 Monthly Datasets

NLDAS-2.0 monthly data files are named similarly as follows:

NLDAS_FORA0125_M.A<YYYYMM>.020.nc
NLDAS_FORB0125_M.A<YYYYMM>.020.nc
NLDAS_MOS0125_M.A<YYYYMM>.020.nc
NLDAS_NOAH0125_M.A<YYYYMM>.020.nc
NLDAS_VIC0125_M.A<YYYYMM>.020.nc

"M" is an indication for monthly.
"<YYYYMM>" is a date format for year and month.

2.1.3 Monthly Climatology Datasets

NLDAS-2.0 monthly climatology data files are named as follows:

NLDAS_FORA0125_MC.ACLIM<MM>.020.nc

NLDAS_FORB0125_MC.ACLIM<MM>.020.nc
NLDAS_MOS0125_MC.ACLIM<MM>.020.nc
NLDAS_NOAH0125_MC.ACLIM<MM>.020.nc
NLDAS_VIC0125_MC.ACLIM<MM>.020.nc

"MC" is an indication for monthly climatology.
"CLIM<MM>" is a date format for month.

2.2 File Format and Structure

The NLDAS-2.0 LSM data are in netCDF (http://www.unidata.ucar.edu/software/netcdf/docs/), which facilitates the creation, access, and sharing of array-oriented data in a form that is self-describing and portable. Each netCDF file contains geolocation information (latitude and longitude of grid box centers), and a series of land surface variables(forcing or model output).

3.0 Data Contents

The NLDAS-2.0 collection contains hourly, monthly, and monthly climatology (1980 – 2019) datasets from primary forcing, secondary forcing, Mosaic, Noah, and VIC LSMs.

3.1 Forcing Data

The NLDAS-2.0 hourly and monthly land surface forcing fields are grouped into two sets of files, "File A" and "File B". "File A" (denoted as "FORA") is the primary (default) forcing file and contains eleven fields. "File B" (denoted as "FORB") is the secondary (optional) forcing file and contains ten fields.

The non-precipitation land-surface forcing fields for NLDAS-2 are derived from the analysis fields of the NCEP North American Regional Reanalysis (NARR). NARR analysis fields are 32-km spatial resolution and 3-hourly temporal frequency. Those NARR fields that are utilized to generate NLDAS-2 forcing fields are spatially interpolated to the finer resolution of the NLDAS 1/8th-degree grid and then temporally disaggregated to the NLDAS hourly frequency. Additionally, the fields of surface pressure, surface downward longwave radiation, near-surface air temperature, and near-surface specific humidity are adjusted vertically to account for the vertical difference between the NARR and NLDAS fields of terrain height. This vertical adjustment applies the traditional vertical lapse rate of 6.5 K/km for air temperature. The details of the spatial interpolation, temporal disaggregation, and vertical adjustment are those employed in NLDAS-1, as presented by Cosgrove et al. (2003).

3.1.1 Primary Forcing Data

The group "File A" (denoted as "FORA") contains the primary (default) forcing files.

The surface downward shortwave radiation field in "File A" is a bias-corrected field wherein a bias-correction algorithm was applied to the NARR surface downward shortwave radiation. This bias correction utilizes five years (1996-2000) of the hourly 1/8th-degree GOES-based surface downward shortwave radiation fields derived by Pinker et al. (2003). The potential evaporation field in "File A" is that computed in NARR using the modified Penman scheme of Mahrt and Ek (1984).

The precipitation field in "File A" is not the NARR precipitation forcing, but is rather (over CONUS) a product of a temporal disaggregation of a gauge-only CPC analysis of daily precipitation, performed directly on the NLDAS grid and including an orographic adjustment based on the widely-applied PRISM climatology. The precipitation is temporally disaggregated into hourly fields by deriving hourly disaggregation weights from either WSR-88D Doppler radar-based precipitation estimates, 8-km CMORPH hourly precipitation analyses, or NARR-simulated precipitation (based on availability, in order). The latter fields from radar, CMORPH, and NARR are used only to derive disaggregation weights and do not change the daily total precipitation. For details on the precipitation data used over Mexico and Canada (as well as a further explanation of the data over CONUS), please see the NLDAS-2 forcing webpage. The field in "File A" that gives the fraction of total precipitation that is convective is an estimate derived from the following two NARR precipitation fields (which are provided in "File B"): NARR total precipitation and NARR convective precipitation (the latter is less than or equal to the NARR total precipitation and can be zero). The Convective Available Potential Energy (CAPE) is the final variable in the "File A" dataset, also interpolated from NARR.

Table 3 lists the variables in the NLDAS-2.0 **primary forcing hourly, monthly, and monthly climatology "File A"** files, along with short name, long name, unit, and time definition (point, mean, or sum for instantaneous, hourly-backward-averaged, or hourly backward-accumulated respectively).

Table 3. Variables in the NLDAS-2.0 primary forcing hourly, monthly, and climatology files

Short Name	**Long Name**	**Unit**	**Hourly***	**Monthly***
Tair	2-meter above ground Temperature	K	point	mean
Qair	2-meter above ground Specific humidity	kg kg-1	point	mean
PSurf**	Surface pressure	Pa	point	mean
Wind_E	10-meter above ground Zonal wind speed	m s-1	point	mean
Wind_N	10-meter above ground Meridional wind speed	m s-1	point	mean
LWdown	Longwave radiation flux downwards	W m-2	point	mean
CRainf	Convective precipitation	kg m-2	sum	sum
CAPE	Convective Available Potential Energy	J kg-1	point	mean
PotEvap	Potential evaporation	kg m-2	sum	sum

Rainf	Total precipitation	kg m-2	sum	sum
SWdown	Shortwave radiation flux downwards	W m-2	point	mean

* The columns “Hourly” and “Monthly” provide time definition for each variable (see Table 8 for details).
** indicates a field to which the aforementioned vertical adjustment is applied.

The NLDAS-2.0 **primary forcing monthly “File A”** files are generated from NLDAS-2.0 primary forcing hourly “File A” files, as monthly accumulation for total precipitation, convective precipitation, and potential evaporation, and monthly average for other variables. The convective precipitation monthly total is the hourly convective fraction multiplied by the hourly precipitation (both from the NLDAS-2.0 "File A" files), and then summed over all hours of the month. Monthly period of each month is from 00Z at the start of the month to 23:59Z at the end of the month. The one exception to this is the first month (Jan. 1979) that starts from 00Z 02 Jan 1979, except for the monthly accumulated precipitation, convective precipitation, and potential evaporation that start from 12Z 01 Jan 1979. Table 3 shows a list of variables included in the NLDAS-2.0 monthly forcing “File A” files.

The NLDAS-2.0 **primary forcing monthly climatology** data are the 40-year average (1980 – 2019) of the primary forcing monthly data and contain the same eleven variables as listed in the Table 3.

More information can be found from the NLDAS-2.0 Model Data Description/Information page at:
https://ldas.gsfc.nasa.gov/nldas/v2/models.

3.1.2 Secondary Forcing Data

NLDAS-2 provides the secondary forcing “File B” files, in which the surface temperature, humidity, and wind fields are represented not at 2-meters and 10-meters above the height of the NLDAS terrain, but rather at the same height above the NLDAS terrain as the height above the NARR terrain of the lowest prognostic level of the NARR assimilation system (namely, the same height above the model terrain as the lowest prognostic level of the mesoscale Eta model, which is the assimilating model in NARR). The height is denoted as a NARR hybrid level and varies spatially.

The surface downward surface radiation field in “File B” is taken directly from NARR, without any bias correction. The precipitation and convective precipitation fields in “File B” are also taken directly from NARR, and are used to calculate the convective fraction provided in “File A”. The aerodynamic conductance in “File B” is also taken from NARR.

Table 4 lists the variables included in the NLDAS-2.0 **secondary forcing hourly, monthly, and climatology “File B”** files, along with short name, long name, unit, and time definition.

Table 4. Variables in the NLDAS-2.0 secondary forcing hourly, monthly, and climatology data files

Short Name	Long Name	Unit	Hourly*	Monthly*
SWdown	Shortwave radiation flux downwards (surface)	W m-2	point	mean
Rainf	Total precipitation	kg m-2	sum	sum
CRainf**	Convective precipitation	kg m-2	sum	sum
ACond	Aerodynamic conductance	m s-1	point	mean
Tair	NARR hybrid level Temperature	K	point	mean
Qair	NARR hybrid level Specific humidity	kg kg-1	point	mean
PSurf	NARR hybrid level Surface pressure	Pa	point	mean
Wind_E	NARR hybrid level Zonal wind speed	m s-1	point	mean
Wind_N	NARR hybrid level Meridional wind speed	m s-1	point	mean
PhiS	NARR hybrid level Geopotential height	gpm	point	mean

* The columns "Hourly" and "Monthly" provide time definition for each variable (see Table 8 for details).
** In the hourly primary forcing dataset, "CRain_frac" is the short_name, "Fraction of total precipitation that is convective" is the long_name, and [fraction] is the unit.

The NLDAS-2.0 **secondary forcing monthly data** are generated from the NLDAS-2.0 hourly secondary forcing data, as monthly accumulation for precipitation and convective precipitation and monthly average for the other variables. The monthly period of each month is from 00Z at start of the month to 23:59Z at end of the month. The one exception to this is the first month (Jan. 1979) that starts from 00Z 02 Jan 1979, except for the monthly accumulated precipitation and convective precipitation that both start from 12Z 01 Jan 1979. Table 4 shows a list of variables included in the NLDAS-2.0 monthly forcing "File B" files.

The NLDAS-2.0 **secondary forcing monthly climatology data** are the 40-year (1980 – 2019) average of the monthly data and contain the ten variables same as listed in the Table 4.

More information can be found from the NLDAS-2 Model Data Description/Information page at: https://ldas.gsfc.nasa.gov/nldas/v2/models.

3.2 Land Surface Model (LSM) Output Data

3.2.1 Mosaic Model Data

The **Mosaic hourly dataset** contains a series of land surface variables simulated from the Mosaic land-surface model (LSM) for NLDAS-2.0. Mosaic was developed by Koster and Suarez (1994, 1996) to account for subgrid vegetation variability with a tile approach. Each vegetation tile carries its own energy and water balance and soil moisture and temperature. Each tile has three soil layers, with the first two in the root zone. In NLDAS, Mosaic is configured to support a maximum of 10 tiles per grid cell with a 5% cutoff that ignores vegetation classes covering less than 5% of the cell. Additionally, in NLDAS, all tiles of Mosaic in a grid cell have a predominant

soil type and three soil layers with fixed thickness values of 10, 30, and 160 cm (hence constant rooting depth of 40 cm and constant total column depth of 200 cm). The Mosaic LSM, forced by the hourly NLDAS-2.0 forcing "File A" data, contains thirty-seven variables (see Table 5).

Table 5. Variables in NLDAS-2.0 Mosaic LSM hourly, monthly, and monthly climatology data files

Short Name	**Long Name**	**Unit**	**Hourly***	**Monthly***
SWdown	Shortwave radiation flux downwards (surface)	W m-2	mean	mean
LWdown	Longwave radiation flux downwards (surface)	W m-2	mean	mean
SWnet	Net shortwave radiation flux (surface)	W m-2	mean	mean
LWnet	Net longwave radiation flux (surface)	W m-2	mean	mean
Qle	Latent heat flux	W m-2	mean	mean
Qh	Sensible heat flux	W m-2	mean	mean
Qg	Ground heat flux	W m-2	mean	mean
Qf	Snow phase-change heat flux	W m-2	mean	mean
Snowf	Frozen precipitation (snowfall)	kg m-2	sum	sum
Rainf	Liquid precipitation (rainfall)	kg m-2	sum	sum
Evap	Total evapotranspiration	kg m-2	sum	sum
Qs	Surface runoff (non-infiltrating)	kg m-2	sum	sum
Qsb	Subsurface runoff (baseflow)	kg m-2	sum	sum
Qsm	Snowmelt	kg m-2	sum	sum
AvgSurfT	Average surface skin temperature	K	point	mean
Albedo	Surface albedo	%	point	mean
SWE	Snow Water Equivalent	kg m-2	point	mean
SnowDepth	Snow depth	fraction	point	mean
SnowFrac	Snow cover	m	point	mean
SoilT	Soil temperature	K	point	mean
SoilM_0_10cm	Soil moisture content (0-10cm)	kg m-2	point	mean
SoilM_10_40cm	Soil moisture content (10-40cm)	kg m-2	point	mean
SoilM_40_200cm	Soil moisture content (40-200cm)	kg m-2	point	mean
SoilM_0_40cm	Soil moisture content (0-40cm)	kg m-2	point	mean
SoilM_0_100cm	Soil moisture content (0-100cm)	kg m-2	point	mean
SoilM_0_200cm	Soil moisture content (0-200cm)	%	point	mean
SMAvail_0_40cm	Soil moisture availability (0-40cm)	%	point	mean
SMAvail_0_200cm	Soil moisture availability (0-200cm)	kg m-2	mean	mean
ECanop	Canopy water evaporation	W m-2	mean	mean
TVeg	Transpiration	W m-2	mean	mean
ESoil	Direct evaporation from bare soil	W m-2	mean	mean
SubSnow	Sublimation (evaporation from snow)	W m-2	mean	mean
CanopInt	Plant canopy surface water	kg m-2	point	mean
ACond	Aerodynamic conductance	m s-1	point	mean
CCond	Canopy conductance	m s-1	point	mean
LAI	Leaf Area Index	unitless	point	mean
GVEG	Green vegetation	fraction	point	mean

Streamflow	Streamflow	m^3 sec-1	mean	mean

*The columns “Hourly” and “Monthly” provide time definition for each variable (see Table 8 for details).

The NLDAS-2.0 **Mosaic monthly data** are generated from the NLDAS-2.0 Mosaic hourly data, as monthly accumulation for rainfall, snowfall, subsurface runoff, surface runoff, total evapotranspiration, and snow melt, and monthly average for the other variables. Monthly period of each month is from 00Z at start of the month to 23:59Z at end of the month, except the first month (Jan. 1979) that starts from 00Z 02 Jan 1979. The monthly dataset also contains the same set of variables listed in the Table 5, except that the time is defined differently (see Table 8).

The NLDAS-2.0 **Mosaic monthly climatology data** are the 40-year (1980 – 2019) average of the monthly data from Mosaic model and contain the same set of variables listed in Table 5.

More information can be found from the NLDAS-2 Model Data Description/Information page at: https://ldas.gsfc.nasa.gov/nldas/v2/models.

3.2.2 Noah Model Data

The NLDAS-2.0 **Noah hourly dataset** contains a series of land surface variables simulated from the Noah land-surface model (LSM) for NLDAS-2.0. The Noah model was developed as the land component of the NOAA NCEP mesoscale Eta model [Betts et al. (1997); Chen et al. (1997); EK the land component in the evolving Weather Research and Forecasting (WRF) regional atmospheric model, the NOAA NCEP coupled Climate Forecast System (CFS), and the Global Forecast System (GFS). The model simulates the soil freeze-thaw process and its impact on soil heating/cooling and transpiration, following Koren et al. (1999). The model has four soil layers with spatially invariant thicknesses of 10, 30, 60, and 100 cm. The first three layers form the root zone in non-forested regions, with the fourth layer included in forested regions. The Noah LSM was forced by the hourly NLDAS-2.0 forcing "File A" files and contains fifty-two fields (see Table 6).

Table 6. Variables in Noah LSM hourly, monthly, and monthly climatology data files

Short Name	**Long Name**	**Unit**	**Hourly***	**Monthly***
SWdown	Shortwave radiation flux downwards (surface)	W m-2	mean	mean
LWdown	Longwave radiation flux downwards (surface)	W m-2	mean	mean
SWnet	Net shortwave radiation flux (surface)	W m-2	mean	mean
LWnet	Net longwave radiation flux (surface)	W m-2	mean	mean
Qle	Latent heat flux	W m-2	mean	mean
Qh	Sensible heat flux	W m-2	mean	mean
Qg	Ground heat flux	W m-2	mean	mean
Qf	Snow phase-change heat flux	W m-2	mean	mean

Snowf	Frozen precipitation (snowfall)	kg m-2	sum	sum
Rainf	Liquid precipitation (rainfall)	kg m-2	sum	sum
Evap	Total evapotranspiration	kg m-2	sum	sum
Qs	Surface runoff (non-infiltrating)	kg m-2	sum	sum
Qsb	Subsurface runoff (baseflow)	kg m-2	sum	sum
Qsm	Snowmelt	kg m-2	sum	sum
AvgSurfT	Average surface skin temperature	K	point	mean
Albedo	Surface albedo	%	point	mean
SWE	Snow Water Equivalent	kg m-2	point	mean
SnowDepth	Snow depth	m	point	mean
SnowFrac	Snow cover	fraction	point	mean
SoilT_0_10cm	Soil temperature (0-10cm)	K	point	mean
SoilT_10_40cm	Soil temperature (10-40cm)	K	point	mean
SoilT_40_100cm	Soil temperature (40-100cm)	K	point	mean
SoilT_100_200cm	Soil temperature (100-200cm)	K	point	mean
SoilM_0_10cm	Soil moisture content (0-10cm)	kg m-2	point	mean
SoilM_10_40cm	Soil moisture content (10-40cm)	kg m-2	point	mean
SoilM_40_100cm	Soil moisture content (40-100cm)	kg m-2	point	mean
SoilM_100_200cm	Soil moisture content (100-200cm)	kg m-2	point	mean
SoilM_0_100cm	Soil moisture content (0-100cm)	kg m-2	point	mean
SoilM_0_200cm	Soil moisture content (0-200cm)	kg m-2	point	mean
RootMoist	Root zone soil moisture	kg m-2	point	mean
SMLiq_0_10cm	Liquid soil moisture content (0-10cm)	kg m-2	point	mean
SMLiq_10_40cm	Liquid soil moisture content (10-40cm)	kg m-2	point	mean
SMLiq_40_100cm	Liquid soil moisture content (40-100cm)	kg m-2	point	mean
SMLiq_100_200cm	Liquid soil moisture content (100-200cm)	kg m-2	point	mean
SMAvail_0_100cm	Soil moisture availability (0-100cm)	%	point	mean
SMAvail_0_200cm	Soil moisture availability (0-200cm)	%	point	mean
PotEvap	Potential evapotranspiration	W m-2	mean	mean
ECanop	Canopy water evaporation	W m-2	mean	mean
TVeg	Transpiration	W m-2	mean	mean
ESoil	Direct evaporation from bare soil	W m-2	mean	mean
SubSnow	Sublimation (evaporation from snow)	W m-2	mean	mean
CanopInt	Plant canopy surface water	kg m-2	mean	mean
ACond	Aerodynamic conductance	m s-1	point	mean
CCond	Canopy conductance	m s-1	point	mean
RCS	Solar parameter in canopy conductance	fraction	point	mean
RCT	Temperature parameter in canopy conductance	fraction	point	mean
RCQ	Humidity parameter in canopy conductance	fraction	point	mean
RCSOL	Soil moisture parameter in canopy conductance	fraction	point	mean
RSmin	Minimal stomatal resistance	s m-1	point	mean
RSMacr	Relative soil moist. availability control factor	unitless	point	mean
LAI	Leaf Area Index	fraction	point	mean

GVEG	Green vegetation	0-1	point	mean
Streamflow	Streamflow	m^3 sec-1	mean	

*The columns "Hourly" and "Monthly" provide time definition for each variable (see Table 8 for details).

The NLDAS-2.0 **Noah monthly data** are generated from the NLDAS-2.0 Noah hourly data, as monthly accumulation for rainfall, snowfall, subsurface runoff, surface runoff, total evapotranspiration, and snow melt, and monthly average for the other variables. Monthly period of each month is from 00Z at start of the month to 23:59Z at end of the month, except the first month (Jan. 1979) that starts from 00Z 02 Jan 1979. Also, because the first month (Jan. 1979) does not have valid data exactly on 00Z 02 Jan 1979, this one hour is not included in the average for the instantaneous variables for this month only. The monthly dataset also contains the same set of parameters listed in the Table 6, except that the time is defined differently (see Table 8).

The NLDAS-2.0 **Noah monthly climatology data** are the 40-year (1980 – 2019) average of the monthly data from Noah LSM and contain the same set of variables listed in the Table 6.

More information can be found from the NLDAS-2 Model Data Description/Information page at: https://ldas.gsfc.nasa.gov/nldas/v2/models.

3.2.3 VIC Model Data

The NLDAS-2.0 **VIC hourly dataset** contains a series of land surface parameters simulated from the VIC land-surface model (LSM) for NLDAS-2.0. The VIC model was developed at the University of Washington and Princeton University as a macroscale, semi-distributed, grid-based, hydrologic model [Liang et al., 1994; Wood et al., 1997]. The full water and energy balance models of VIC were used for NLDAS-2.0. VIC uses three soil layers, with thicknesses that vary spatially. The root zone depends on the vegetation type and its root distribution, and can span all three soil layers. The VIC model includes a two-layer energy balance snow model [Cherkauer et al., 2003]. The version of the VIC model used for NLDAS-2.0 data available at the NASA GES DISC is VIC-4.0.3 and this version of the VIC model is the same as used in Sheffield et al. (2003). The VIC LSM is forced by the hourly NLDAS-2.0 forcing "File A" files and contains forty-three fields (see Table 7).

Table 7. Variables in the NLDAS-2.0 VIC LSM hourly, monthly, and monthly climatology data files

Short Name	**Long Name**	**Unit**	**Hourly***	**Monthly***
SWdown	Shortwave radiation flux downwards (surface)	W m-2	mean	mean
LWdown	Longwave radiation flux downwards (surface)	W m-2	mean	mean
SWnet	Net shortwave radiation flux (surface)	W m-2	mean	mean
LWnet	Net longwave radiation flux (surface)	W m-2	mean	mean

Qle	Latent heat flux	W m-2	mean	mean
Qh	Sensible heat flux	W m-2	mean	mean
Qg	Ground heat flux	W m-2	mean	mean
Qf	Snow phase-change heat flux	W m-2	mean	mean
Snowf	Frozen precipitation (snowfall)	kg m-2	sum	sum
Rainf	Liquid precipitation (rainfall)	kg m-2	sum	sum
Evap	Total evapotranspiration	kg m-2	sum	sum
Qs	Surface runoff (non-infiltrating)	kg m-2	sum	sum
Qsb	Subsurface runoff (baseflow)	kg m-2	sum	sum
Qsm	Snowmelt	kg m-2	sum	sum
SnowT	Snow temperature	K	point	mean
AvgSurfT	Average surface skin temperature	K	point	mean
RadT	Surface radiative temperature	K	point	mean
Albedo	Surface albedo	%	point	mean
SWE	Snow Water Equivalent	kg m-2	point	mean
SnowDepth	Snow depth	m	point	mean
SnowFrac	Snow cover	fraction	point	mean
SAlbedo_max	Maximum snow albedo	%	point	mean
SoilT_layer1	Soil temperature VIC layer 1	K	point	mean
SoilT_layer2	Soil temperature VIC layer 2	K	point	mean
SoilT_layer3	Soil temperature VIC layer 3	K	point	mean
SoilM_layer1	Soil moisture content VIC layer 1	kg m-2	point	mean
SoilM_layer2	Soil moisture content VIC layer 2	kg m-2	point	mean
SoilM_layer3	Soil moisture content VIC layer 3	kg m-2	point	mean
SoilM_0_100cm	Soil moisture content (0-100cm)	kg m-2	point	mean
SoilM_total	Soil moisture content VIC total column depth	kg m-2	point	mean
RootMoist	Root zone soil moisture	kg m-2	point	mean
SMLiq_layer1	Liquid soil moisture content VIC layer 1	kg m-2	point	mean
SMLiq_layer2	Liquid soil moisture content VIC layer 2	kg m-2	point	mean
SMLiq_layer3	Liquid soil moisture content VIC layer 3	kg m-2	point	mean
SMAvail_0_100cm	Soil moisture availability (0-100cm)	%	point	mean
SMAvail_total	Soil moisture availability VIC total column depth	%	point	mean
ECanop	Canopy water evaporation	W m-2	mean	mean
TVeg	Transpiration	W m-2	mean	mean
ESoil	Direct evaporation from bare soil	W m-2	mean	mean
SubSnow	Sublimation (evaporation from snow)	W m-2	mean	mean
CanopInt	Plant canopy surface water	kg m-2	point	mean
ACond	Aerodynamic conductance	m s-1	point	mean
LAI	Leaf Area Index	unitless	point	mean
Streamflow	Streamflow	m^3 sec-1	mean	mean

*The columns “Hourly” and “Monthly” provide time definition for each variable (see Table 8 for details).

The NLDAS-2.0 **VIC monthly data** are generated from the NLDAS-2.0 hourly VIC model data, as monthly accumulation for rainfall, snowfall, subsurface runoff, surface runoff, total evapotranspiration, and snow melt, and monthly average for the other variables. The monthly period of each month is from 00Z at start of the month to 23:59Z at end of the month, except the first month (Jan. 1979) that starts from 00Z 02 Jan 1979. Also, because the first month (Jan. 1979) does not have valid data exactly on 00Z 02 Jan 1979, this one hour is not included in the average for the instantaneous variables for this month only. The monthly dataset also contains the same set of parameters listed in the Table 7, except that the time is defined differently (see Table 7).

The NLDAS-2.0 **VIC monthly climatology data** are the 40-year (1980 – 2019) average of the monthly data and contain the same set of variables listed in the Table 7.

More information can be found from the NLDAS-2 Model Data Description/Information page at: https://ldas.gsfc.nasa.gov/nldas/v2/models.

Table 8. Time definitions of the NLDAS-2.0 variables

Dataset	**"Point", "Mean", and "Sum" defined by netCDF metadata "cell_methods"**
Hourly	**Cell_methods = "Point"** for the "Instantaneous" variables that contain the data values "at exactly 00 minute of each hour".
	Cell_methods = "Mean" for the "hourly-backward-averaged" variables that contain the data values averaged over the previous hour of the time listed in the file. For example, for the 03Z files, the data values are the average over the time from 02Z to 03Z.
	Cell_methods = "Sum" for the "hourly-backward-accumulated" variables that contain the data values accumulated over the previous hour of the time listed in the file. For example, for the 03Z files, the data values are the accumulation over the time from 02Z to 03Z.
Monthly	**Cell_methods = "Sum"** for the "monthly-accumulated" variables that contain the data values accumulated over the month. Monthly period of each month is from 00Z at start of the month to 23:59Z at end of the month, except the first month (Jan. 1979) that starts from 00Z 02 Jan 1979.
	Cell_methods = "Mean" for the "monthly-averaged" variables that contain the data values averaged over the month. Monthly period of each month is from 00Z at start of the month to 23:59Z at end of the month, except the first month (Jan. 1979) that starts from 00Z 02 Jan 1979.
Monthly Climatology	**Cell_methods = "time: sum within months time: mean over years"** for the monthly climatology variables that contain the data values accumulated over the month of each year, then average over years (1980 – 2019).
	Cell_methods = "time: mean within months time: mean over years" for the monthly climatology variables that contain the data values averaged over the month of each year, then averaged over years (1980 – 2019).

4.0 Options for Reading the Data

The following are a few of the many command line and visualization tools available for reading netCDF format data, such as the NLDAS-2.0 Datasets. For more comprehensive lists of tools, please see the following:

https://www.unidata.ucar.edu/software/netcdf/docs/

https://www.hdfgroup.org/products/hdf5_tools/

Most of the following tools (e.g., GrADS, NCO, CDO, NCL, IDL) can subset variables or subset data within specified temporal and/or spatial ranges. These tools can also calculate statistics like mean, standard deviation, maximum, minimum, etc.

4.1 Command Line Utilities

4.1.1 ncdump (free)

The ncdump tool (http://www.unidata.ucar.edu/downloads/netcdf/) generates the CDL (Common Data Language) text (ASCII) representation of a netCDF or compatible file and writes to standard output. The tool can also be used as a simple browser for netCDF files, to display the dimension names and lengths; variable names, types, and shapes; attribute names and values; and, optionally, the values of data for all variables or selected variables. A common use of ncdump is with the –h option, with which only the header information is displayed. The ncdump tool comes with the netCDF library as distributed by Unidata.

4.1.2 h5dump (free)

The h5dump tool (https://support.hdfgroup.org/HDF5/doc/RM/Tools.html#Tools-Dump) enables users to examine the contents of an HDF5 file and dump those contents to an ASCII file or, optionally, as XML or binary outputs. It can display the contents of the entire HDF5 file or selected objects, which can be groups, datasets, a subset of a dataset, links, attributes, or datatypes. Please note h5dump may not work with older netCDF formats. The h5dump tool is included with the HDF5 distribution from The HDF Group.

4.1.3 NCO (free)

The netCDF Operator (NCO) (http://nco.sourceforge.net/) toolkit manipulates and analyzes data stored in netCDF-accessible formats, including DAP, HDF4, and HDF5.

4.1.4 CDO (free)

CDO (Climate Data Operators) (https://code.zmaw.de/projects/cdo) is a collection of command line operators to manipulate and analyze Climate and Numerical Weather Prediction (NWP) model Data.

4.2 Visualization Tools

4.2.1 Ncview (free)

Ncview is a quick and easy way to visualize the contents of netCDF files.

http://meteora.ucsd.edu/~pierce/ncview_home_page.html

4.2.2 ncBrowse (free)

ncBrowse is a Java application that provides flexible, interactive graphical displays of data and attributes from a wide range of netCDF data file conventions.

http://www.epic.noaa.gov/java/ncBrowse/

4.2.3 Panoply (free)

Panoply is a Java application, developed by the NASA Goddard Institute for Space Studies (GISS), that plots geo-referenced and other arrays from netCDF, HDF, GRIB, and other data types. Among other capabilities, Panoply enables one to slice and plot geo-referenced latitude-longitude, latitude-vertical, longitude-vertical, time-latitude, or time-vertical arrays from larger multidimensional variables; combine two geo-referenced arrays in one plot by differencing, summing, or averaging; plot maps using various map projections; and access remote catalogs to retrieve data files.

http://www.giss.nasa.gov/tools/panoply/

The How-To's of NASA GES DISC provides a recipe for How to View Remote Data in OPeNDAP with Panoply

4.2.4 HDFview (free)

HDFView is a Java-based visual tool created by The HDF Group for browsing and editing HDF4 and HDF5 files. It allows users to view all objects in an HDF file hierarchy, which is represented as a tree structure, and create, add, delete, and modify object contents and attributes.

https://www.hdfgroup.org/products/java/hdfview/

4.2.5 IDL netCDF tools (commercial)

Users familiar with the IDL programming language (http://www.exelisvis.com/ProductsServices/IDL.aspx) can use the netCDF functions available with the IDL software package to read and visualize the data.

4.2.6 GrADS netCDF tools (free)

Users familiar with the GrADS programming language (http://iges.org/grads/) can use the netCDF functions available with the GrADS software package to read and visualize the data.

4.2.7 NCL (free)

The NCAR Command Language (NCL) (http://www.ncl.ucar.edu/) is a free interpreted language designed specifically for scientific data processing and visualization.

5.0 Data Services

The NASA GES DISC maintains archives of the NLDAS-2.0 datasets and many other Hydrology datasets. The archived data can be accessed via HTTPS network transfer. NLDAS can be accessed via the GES DISC Unified User Interface at https://disc.gsfc.nasa.gov/uui/datasets?keywords=NLDAS

5.1 HTTPS Access

The NLDAS data can be downloaded directly via the GES DISC HTTPS server: https://hydro1.gesdisc.eosdis.nasa.gov/data/NLDAS/.

5.2 EOSDIS Earthdata Search System

The EarthData Search Client (EDSC) can be used to find and retrieve datsets across multiple data centers: https://search.earthdata.nasa.gov/search?q=NLDAS&ok=NLDAS

5.3 OPeNDAP

The NLDAS data can be accessed via OPeNDAP for variable and spatial subsetting: https://hydro1.gesdisc.eosdis.nasa.gov/opendap/hyrax/NLDAS/.

5.4 GrADS Data Server (GDS)

The NLDAS datasets are provided to the GrADS Data Server (GDS) users via https://hydro1.gesdisc.eosdis.nasa.gov/dods/. The GDS is a stable, secure data server that provides subsetting and analysis services. The GDS supports any operation that can be expressed in a single GrADS expression, including basic math functions, averages, smoothing, differencing, correlation, and regression.

5.5 Giovanni

The GES-DISC Interactive Online Visualization ANd aNalysis Interface (Giovanni) is a Web-based application developed by the NASA GES DISC that provides a simple and intuitive way to visualize, analyze, and access vast amounts of Earth science remote sensing data without having to download the data:
https://giovanni.gsfc.nasa.gov/giovanni/#dataKeyword=NLDAS
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.

6.0 More Information

6.1 Data Volume

Model	Resolution	Hourly		Monthly	
		Files/day	Vol/Year	Files/year	Vol/Year
Primary forcing	0.125° × 0.125°	24	~ 17 GB	12	22 MB
Secondary forcing	0.125° × 0.125°	24	~ 16 GB	12	22 MB
Mosaic	0.125° × 0.125°	24	~ 58 GB	12	66 MB
Noah	0.125° × 0.125°	24	~ 72 GB	12	84 MB
VIC	0.125° × 0.125°	24	~ 58 GB	12	70 MB

The monthly climatology datasets have total 60 files with total volume about 280 MB.

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Acronyms

The following acronyms and abbreviations are used in this document.

APE	Convective Available Potential Energy
CMORPH	CPC precipitation MORPHing technique
CPC	NCEP's Climate Prediction Center
CPPA	Climate Prediction Program for the Americas
EMC	NCEP's Environmental Modeling Center
GDS	GrADS Data Server
GES DISC	Goddard Earth Sciences Data and Information Services Center
Giovanni	GES-DISC Interactive On-line Visualization and Analysis Infrastructure
GrADS	Grid Analysis and Display System
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 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
SVAT	*Soil Vegetation* Atmosphere Transfer model
VIC	Variable Infiltration Capacity macroscale model
WSR-88D	Weather Service Radar-Doppler

Appendix

Work in progress