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

README Document for Famine Early Warning Systems Network (FEWS NET) Land Data Assimilation System (FLDAS) Products

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Revision History

Revision Date	***Changes***	***Author***
08/05/2015	Initial version based on information from Amy McNally.	Hualan Rui
09/28/2015	Add information for VIC model	Hualan Rui
12/09/2015	Update the Table 2 and Table 3	Hualan Rui
04/12/2016	Add new data products from simulation “C”	Hualan Rui
08/09/2016	Remove data products from simulation “B”	Hualan Rui
10/12/2016	Add daily FLDAS products	Hualan Rui
11/21/2016	Review and revise	Amy McNally
12/09/2016	Add DOIs for daily products	Hualan Rui
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04/28/2017	Add new variable for Noah simulation “C”	Carlee Loeser
08/02/2017	Update URLs to comply with new GES DISC website	Carlee Loeser
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08/08/2018	Remove note about concatenation with GrADS and CDO – known issues resolved	Carlee Loeser
10/15/2018	Add new global products	Carlee Loeser
10/18/2018	Review and revise	Amy McNally
11/12/2018	Add volume information for global products	Carlee Loeser
05/13/2019	Add water body mask and update file volumes	Carlee Loeser
07/10/2019	Corrected variable long names for Rainf_f_tavg	Carlee Loeser

Table of Contents

1.0 Introduction

This document provides the basic information for using the Famine Early Warning Systems Network (FEWS NET) Land Data Assimilation System (FLDAS) products.

The Famine Early Warning Systems Network (FEWS NET) Land Data Assimilation System (FLDAS) is a custom instance of the NASA Land Information System (LIS; http://lis.gsfc.nasa.gov) that has been adapted to work with domains, data streams, and monitoring and forecast requirements associated with food security assessment in data-sparse, developing country settings. Adopting LIS allows FEWS NET to leverage existing land surface models and generate ensembles of soil moisture, ET, and other variables based on multiple meteorological inputs or land surface models. The goal of the FLDAS project is to achieve more effective use of limited available hydroclimatic observations and is designed to be adopted for routine use for FEWS NET decision support.

The FLDAS includes a crop water balance model used operationally by FEWS NET (GeoWRSI: Verdin and Klaver, 2002; Senay and Verdin, 2003), Africa-specific daily rainfall from NOAA Climate Prediction Center (RFE2; Xie and Arkin, 1997), and CHIRPS, a quasi-global rainfall dataset designed for seasonal drought monitoring and trend analysis (Funk et al., 2014). Additional features include a temporal desegregation scheme so that daily rainfall inputs can be used in both energy and water balance calculations, an irrigation module, and global irrigation and crop maps. State-of-the-practice land data assimilation methods are available in LIS, and will be explored in an associated forecasting project.

1.1 Dataset Description

FLDAS data are produced from Noah and VIC Land Surface Models (LSMs), each with two simulation runs (two different sets of forcing data). Each simulation runs over three different African regions, but one simulation also runs globally. Simulation run “A” refers to the simulation run forced by the combination of NCEP's Global Data Assimilation System (GDAS) data and NOAA CPC Africa Rainfall Estimation Algorithm v2 (RFE2) data. Simulation run “C” refers to the simulation run forced by the combination of the new version of Modern-Era Retrospective analysis for Research and Applications version 2 (MERRA-2) data and Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS).

The regional “C” runs use Noah version 3.3 and CHIRPS-6hourly rainfall from UCSB (ftp://ftp.chg.ucsb.edu/pub/org/chg/products/CHIRPS-2.0/africa_6-hourly/). The global “C” runs use Noah version 3.6.1 and CHIRPS-6hourly rainfall that has been downscaled using the NASA Land Data Toolkit (LDT; 10.5194/gmd-11-3605-2018). There was an update to the soil parameter table which is particularly notable for sandy soils.

Each simulation run “A” was initialized on January 1, 2001 using soil moisture and other state fields from the respective FLDAS model climatology for that day of the year. Each simulation run “C” was initialized on January 1, 1982 using soil moisture and other state fields from the respective FLDAS model climatology for that day of the year.

In the global FLDAS data sets, a water body mask needs to be applied to set the data values over inland water to null. The values in the data sets do not represent the fluxes over open water. The MOD44W MODIS Water Mask is the standard land/sea mask for FLDAS, and is available for download at https://ldas.gsfc.nasa.gov/index.php/fldas/vegetation-class.

1.2 Data Disclaimer

Please periodically check the GES DISC web site and GES DISC Hydrology Page for the latest FLDAS data. The FLDAS_A daily data are updated no later than 3pm each day, for the previous days LSM outputs. FLDAS_A and C monthly data is updated no later than the 5th of the month for their respective latencies. For example, on Nov 5th FLDAS_A will be updated through October 31, and FLDAS_C will be updated through September 30.

1.2.1 Acknowledgment

Please refer to McNally et al. (2017) for more information about the FLDAS project.
McNally, A. *et al.* A land data assimilation system for sub-Saharan Africa food and water security applications. *Sci. Data* 4:170012 doi: 10.1038/sdata.2017.12 (2017)

NASA requests including 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:

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1.2.2 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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1.2.3 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 1 lists DOIs for FLDAS data products.

Table 1. DOIs for FLDAS Version 001 Data Products

Product Name	**DOI**
FLDAS_NOAH01_A_EA_D.001	10.5067/VXRGZFAYSUT2
FLDAS_NOAH01_A_EA_M.001	10.5067/J36A1H1TWN1T
FLDAS_NOAH01_A_SA_D.001	10.5067/BJGBWP3V3B2C
FLDAS_NOAH01_A_SA_M.001	10.5067/AR7NJ3IYBVM7
FLDAS_NOAH01_A_WA_D.001	10.5067/XH9S0WJHMTMH
FLDAS_NOAH01_A_WA_M.001	10.5067/CQ7NJRGZV7T9
FLDAS_NOAH01_C_EA_M.001	10.5067/XLNQ30KMZVHX
FLDAS_NOAH01_C_EA_MA.001	10.5067/VDJUB2H7TR0T
FLDAS_NOAH01_C_EA_MC.001	10.5067/DNT2RIPPUI6B
FLDAS_NOAH01_C_GL_M.001	10.5067/5NHC22T9375G
FLDAS_NOAH01_C_GL_MA.001	10.5067/GNKZZBAYDF4W

FLDAS_NOAH01_C_GL_MC.001	10.5067/9JBLK69HNL3V
FLDAS_NOAH01_C_SA_M.001	10.5067/8LPWNKCBUDA6
FLDAS_NOAH01_C_SA_MA.001	10.5067/4A6JIEEB1KUI
FLDAS_NOAH01_C_SA_MC.001	10.5067/2E785UZDLKAD
FLDAS_NOAH01_C_WA_M.001	10.5067/XR8B8Y58OVV9
FLDAS_NOAH01_C_WA_MA.001	10.5067/J7O0YW0WPR9H
FLDAS_NOAH01_C_WA_MC.001	10.5067/ME2MVU3K32AF
FLDAS_VIC025_A_EA_D.001	10.5067/RZSOLTPV7XR0
FLDAS_VIC025_A_EA_M.001	10.5067/BIF2EPDNHD4V
FLDAS_VIC025_A_SA_D.001	10.5067/MJMKSFIXSVFG
FLDAS_VIC025_A_SA_M.001	10.5067/RS9NFRACQ33N
FLDAS_VIC025_A_WA_D.001	10.5067/SVHPIU7HXEML
FLDAS_VIC025_A_WA_M.001	10.5067/FRUFXGQHNYQB
FLDAS_VIC025_C_EA_M.001	10.5067/OMUF7M783R89
FLDAS_VIC025_C_SA_M.001	10.5067/8YWIDP9CZ2KS
FLDAS_VIC025_C_WA_M.001	10.5067/7E2VFYF8BYGY

Each of the DOIs in Table 1 is linked to the corresponding data product page, and the Data Citation for the data product is located on the page. If you use these data in your research or applications, please include a reference in your publication(s) similar to the following example:

Amy McNally, NASA/GSFC/HSL (2016), *FLDAS Noah Land Surface Model L4 monthly 0.1 x 0.1 degree for Southern Africa (MERRA-2 and CHIRPS) V001*, Greenbelt, MD, USA, Goddard Earth Sciences Data and Information Services Center (GES DISC), Accessed [**Data Access Date]**, 10.5067/8LPWNKCBUDA6

1.3 What are the differences between FLDAS Global data and GLDAS data?

The FEWS NET LDAS is optimized for FEWS NET agricultural drought monitoring applications in Africa, Central America, and Central Asia. By using CHIRPS rainfall and MERRA-2 meteorological inputs, the FLDAS produces hydrologic estimates from 1982-present, at 10 km resolution, and ~1 month latency, that are consistent with other FEWS NET products that are forced with CHIRPS and MERRA-2. The FLDAS also shares many features with GLDAS: both use NASA LIS 7 as the underlying software framework, as well as FAO soils parameters, and provide

similar input and output variables. The main differences are the meteorological inputs (CHIRPS+MERRA2), the spatial resolution (10 km), and the LSM model version (Noah361).

2.0 Data Organization

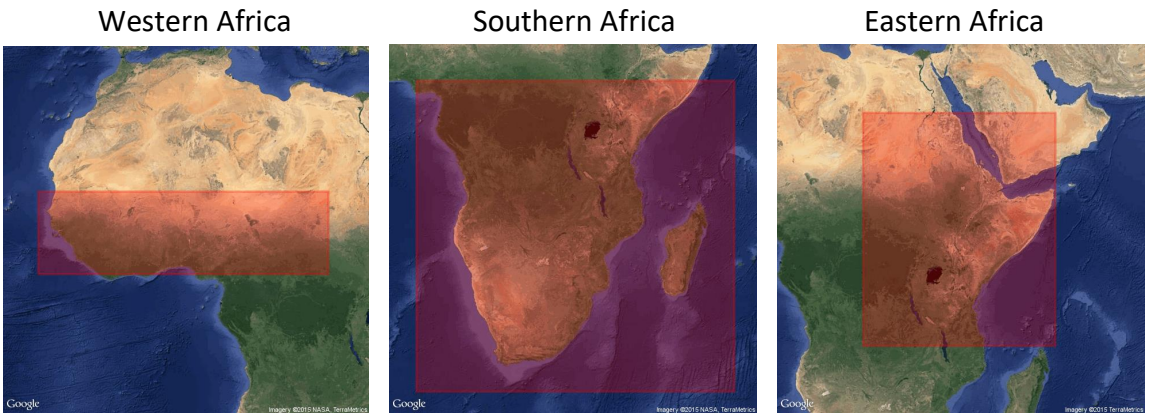
The currently released FLDAS data are version 001 daily, monthly, monthly climatology, and monthly anomaly data. Temporal coverage is January 2001 to present for the simulation "A" runs and January 1982 to present for the simulation "C" runs. Spatial resolution is 0.1 x 0.1 degree for FLDAS Noah model data and 0.25 x 0.25 degree for FLDAS VIC model data. The spatial resolutions and coverages are summarized in Table 2.

2.1 Spatial Resolution and Coverage

Table 2. FLDAS Spatial Resolution and Coverage

LSM	Region	Spatial Coverage	Spatial Resolution	Dimension lat x lon
Noah	Eastern Africa (EA)	11.8 S ~ 23.0 N, 22.0 E ~ 51.4 E	0.1° x 0.1°	348 x 294
Noah	Southern Africa (SA)	37.9 S ~ 6.4 N, 6.0 E ~ 54.6 E	0.1° x 0.1°	443 x 486
Noah	Western Africa (WA)	5.3 N ~ 17.7 N, 18.7 W ~ 25.9 E	0.1° x 0.1°	124 x 446
Noah	Global (GL)	60.0 S ~ 90.0 N, 180.0 W ~ 180.0 E	0.1° x 0.1°	1500 x 3600
VIC	Eastern Africa (EA)	12.0 S ~ 23.25 N, 21.75 E ~ 51.25 E	0.25° x 0.25°	141 x 118
VIC	Southern Africa (SA)	34.75 S ~ 6.75 N, 5.75 E ~ 51.25 E	0.25° x 0.25°	166 x 182
VIC	Western Africa (WA)	5.0N ~ 18.0N, 17.25W ~ 25.75E	0.25° x 0.25°	52 x 172

Figure 1. FLDAS spatial coverage for 0.1° x 0.1° Noah LSM regional data products



2.2 File Naming Convention

FLDAS data are grouped and named based on LSM, spatial resolution, forcing data, spatial coverage, and temporal resolution (Table 3). Each group is referred to as a data product and named in accordance with the following convention:
FLDAS_<Model><Grid spacing>_<Forcing type>_<Region>_<Temporal spacing>

Attribute	Description
<Model>	“NOAH” for the Noah Model
	“VIC” for the Variable Infiltration Capacity Model
<Grid spacing>	“025” for 0.25 degree
	“01” for 0.1 degree
<Forcing Type>	"A" for forced with GDAS and RFE2 data
	"C" for forced MERRA-2 and CHIRPS data
<Region>	"EA" for Eastern Africa
	"WA" for Western Africa
	"SA" for Southern Africa
	“GL” for Global
<Temporal spacing>	“D” for daily data
	“M” for monthly data
	“MA” for monthly anomaly data
	“MC” for monthly climatology data

For example, FLDAS_NOAH01_C_EA_M is the product name for the FLDAS monthly data from the Noah LSM forced by MERRA-2 and CHIRPS, at 0.1 x 0.1 degree resolution for Eastern Africa.

FLDAS data files are named in accordance with the following convention:
Daily and monthly: <Product ID>.A<Date>.<Product version>.nc
Monthly anomaly: <Product ID>.ANOM<Date>.<Product version>.nc
Monthly climatology: <Product ID>.CLIM<Date>.<Product version>.nc

Attribute	Description
<Product ID>	Data Product Short Name (see Table 3)
<Date> *	<YYYYMMDD> for daily data products
	<YYYYMM> for monthly, monthly anomaly, and monthly climatology data products
<Product version>	“001” for Version 1

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

For example, “FLDAS_NOAH01_C_EA_M.A198201.001.nc” is the filename for version 1 of the FLDAS monthly data from the Noah LSM forced by MERRA-2 and CHIRPS data, at 0.1 x 0.1 degree resolution for January 1982 for Eastern Africa.

“FLDAS_NOAH01_C_GL_MA.ANOM201204.001.nc” is the filename for version 1 of the FLDAS monthly anomaly global data from the Noah LSM forced by MERRA-2 and CHIRPS data, at 0.1 x 0.1 degree resolution for April 2012.

2.3 File Format and Structure

The FLDAS data are archived in NetCDF format. NetCDF 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 [see more].

3.0 Data Contents

3.1 Data Products

Based on the data product naming convention listed in Section 2.2, the FLDAS data products that are currently available at the GES DISC are named in Table 3. There are 27 FLDAS data products total.

Table 3. FLDAS Data Products

	Model	Forcing Data	Region	Product Short Name
Monthly	**Noah**	GDAS and RFE2 Referred as "A"	Eastern Africa (EA)	FLDAS_NOAH01_A_EA_M
			Southern Africa (SA)	FLDAS_NOAH01_A_SA_M
			Western Africa (WA)	FLDAS_NOAH01_A_WA_M
		MERRA-2 and CHIRPS Referred as "C"	Eastern Africa (EA)	FLDAS_NOAH01_C_EA_M
			Southern Africa (SA)	FLDAS_NOAH01_C_SA_M
			Western Africa (WA)	FLDAS_NOAH01_C_WA_M
			Global (GL)	FLDAS_NOAH01_C_GL_M
	VIC	GDAS and RFE2 Referred as "A"	Eastern Africa (EA)	FLDAS_VIC025_A_EA_M
			Southern Africa (SA)	FLDAS_VIC025_A_SA_M
			Western Africa (WA)	FLDAS_VIC025_A_WA_M
		MERRA-2 and CHIRPS Referred as "C"	Eastern Africa (EA)	FLDAS_VIC025_C_EA_M
			Southern Africa (SA)	FLDAS_VIC025_C_SA_M
			Western Africa (WA)	FLDAS_VIC025_C_WA_M
Daily	**Noah**	GDAS and RFE2 Referred as “A”	Eastern Africa (EA)	FLDAS_NOAH01_A_EA_D
			Southern Africa (SA)	FLDAS_NOAH01_A_SA_D
			Western Africa (WA)	FLDAS_NOAH01_A_WA_D
	VIC	GDAS and RFE2 Referred as “A”	Eastern Africa (EA)	FLDAS_VIC025_A_EA_D
			Southern Africa (SA)	FLDAS_VIC025_A_SA_D
			Western Africa (WA)	FLDAS_VIC025_A_WA_D

Monthly Anomaly	**Noah**	MERRA-2 and CHIRPS Referred as "C"	Eastern Africa (EA)	FLDAS_NOAH01_C_EA_MA
			Southern Africa (SA)	FLDAS_NOAH01_C_SA_MA
			Western Africa (WA)	FLDAS_NOAH01_C_WA_MA
			Global (GL)	FLDAS_NOAH01_C_GL_MA
Monthly Climatology	**Noah**	MERRA-2 and CHIRPS Referred as "C"	Eastern Africa (EA)	FLDAS_NOAH01_C_EA_MC
			Southern Africa (SA)	FLDAS_NOAH01_C_SA_MC
			Western Africa (WA)	FLDAS_NOAH01_C_WA_MC
			Global (GL)	FLDAS_NOAH01_C_GL_MC

3.2 Data Parameters

3.2.1 FLDAS Noah Model Data

The FLDAS Noah model has two simulation runs ("A" and "C") for Eastern Africa, Southern Africa, and Western Africa, and one simulation run ("C") for global land data. The Noah simulation "A" was initialized on January 1, 2001, forced by soil moisture and other state fields from GDAS and RFE2. The Noah simulation "C" was initialized on January 1, 1982, forced by soil moisture and other state fields from MERRA-2 and CHIRPS.

3.2.1.1 FLDAS Noah Regional Model Data: Daily and Monthly

The FLDAS Noah model daily and monthly data products for the regional datasets (EA, SA, WA) from simulation "A" contain 25 fields, and those from simulation "C" contain 26 fields, as listed in Table 4a.

Table 4a. Parameters from FLDAS Noah daily and monthly data for the regional datasets.

Short Name	**Description**	**Unit**
Evap_tavg	Evapotranspiration	kg m-2 s-1
LWdown_f_tavg	Downward longwave radiation flux	W m-2
Lwnet_tavg	Net longwave radiation flux	W m-2
Psurf_f_tavg	Surface pressure	Pa
Qair_f_tavg	Specific humidity	kg kg-1
Qg_tavg	Soil heat flux	W m-2
Qh_tavg	Sensible heat net flux	W m-2
Qle_tavg	Latent heat net flux	W m-2
Qs_tavg	Storm surface runoff	kg m-2 s-1
Qsb_tavg	Baseflow-groundwater runoff	kg m-2 s-1
RadT_tavg	Surface radiative temperature	K

Rainf_f_tavg	Rainfall flux	kg m-2 s-1
SM01_Percentile	Soil moisture percentiles	%
SMRZ_Percentile*	Root zone soil moisture percentiles	%
SoilMoi00_10cm_tavg	Soil moisture (0 - 10 cm underground)	m^3 m-3
SoilMoi10_40cm_tavg	Soil moisture (10 - 40 cm underground)	m^3 m-3
SoilMoi100_200cm_tavg	Soil moisture (100 - 200 cm underground)	m^3 m-3
SoilMoi40_100cm_tavg	Soil moisture (40 - 100 cm underground)	m^3 m-3
SoilTemp00_10cm_tavg	Soil temperature (0 - 10 cm underground)	K
SoilTemp10_40cm_tavg	Soil temperature (10 - 40 cm underground)	K
SoilTemp100_200cm_tavg	Soil temperature (100 - 200 cm underground)	K
SoilTemp40_100cm_tavg	Soil temperature (40 - 100 cm underground)	K
SWdown_f_tavg	Surface downward shortwave radiation	W m-2
Swnet_tavg	Net shortwave radiation flux	W m-2
Tair_f_tavg	Near surface air temperature	K
Wind_f_tavg	Near surface wind speed	m s-1

The short names with extension "_tavg" are past 3-hr averaged variables.
The short names with "_f" are forcing variables.
SM01_Percentile represents the soil moisture percentiles for 0-10 cm underground, and SMRZ_Percentile represents the soil moisture percentiles for 0-200 cm underground.
*SMRZ_Percentile is only available in three datasets: FLDAS_NOAH01_C_EA_M, FLDAS_NOAH01_C_SA_M, and FLDAS_NOAH01_C_WA_M.

3.2.1.2 FLDAS Noah Global Model Data: Monthly

The FLDAS Noah model daily and monthly data for the global dataset from simulation "C" contains 28 fields, as listed in Table 4b.

Table 4b. Parameters from FLDAS Noah monthly data for the global dataset.

Short Name	**Description**	**Unit**
Evap_tavg	Evapotranspiration	kg m-2 s-1
LWdown_f_tavg	Downward longwave radiation flux	W m-2
Lwnet_tavg	Net longwave radiation flux	W m-2
Psurf_f_tavg	Surface pressure	Pa
Qair_f_tavg	Specific humidity	kg kg-1
Qg_tavg	Soil heat flux	W m-2
Qh_tavg	Sensible heat net flux	W m-2
Qle_tavg	Latent heat net flux	W m-2
Qs_tavg	Storm surface runoff	kg m-2 s-1
Qsb_tavg	Baseflow-groundwater runoff	kg m-2 s-1

RadT_tavg	Surface radiative temperature	K
Rainf_f_tavg	Rainfall flux	kg m-2 s-1
SnowCover_inst	Snow cover	fraction
SnowDepth_inst	Snow depth	m
Snowf_tavg	Snowfall rate	kg m-2 s-1
SoilMoi00_10cm_tavg	Soil moisture (0 - 10 cm underground)	m^3 m-3
SoilMoi10_40cm_tavg	Soil moisture (10 - 40 cm underground)	m^3 m-3
SoilMoi100_200cm_tavg	Soil moisture (100 - 200 cm underground)	m^3 m-3
SoilMoi40_100cm_tavg	Soil moisture (40 - 100 cm underground)	m^3 m-3
SoilTemp00_10cm_tavg	Soil temperature (0 - 10 cm underground)	K
SoilTemp10_40cm_tavg	Soil temperature (10 - 40 cm underground)	K
SoilTemp100_200cm_tavg	Soil temperature (100 - 200 cm underground)	K
SoilTemp40_100cm_tavg	Soil temperature (40 - 100 cm underground)	K
SWdown_f_tavg	Surface downward shortwave radiation	W m-2
SWE_inst	Snow water equivalent	kg m-2
Swnet_tavg	Net shortwave radiation flux	W m-2
Tair_f_tavg	Near surface air temperature	K
Wind_f_tavg	Near surface wind speed	m s-1

3.2.1.3 FLDAS Noah Regional and Global Model Data: Monthly Anomaly and Monthly Climatology

The FLDAS Noah model data for monthly anomaly and monthly climatology products are derived from the Noah monthly data for the simulation "C" run. The monthly climatology data are generated from the Noah monthly data, as a 35-year (1982-2016) monthly average. The monthly anomaly data are generated by taking the difference between the monthly data and monthly climatology data for the given region. This difference represents how the given month compares to the 35-year climatology. The FLDAS Noah model monthly anomaly and monthly climatology data contain eight fields, as listed in Table 4c.

Table 4c. Parameters from FLDAS Noah model data for monthly anomaly and monthly climatology datasets.

Short Name	**Description**	**Unit**
Evap_tavg	Evapotranspiration	kg m-2 s-1
Qtotal_tavg	Total runoff (surface + subsurface)	kg m-2 s-1
Rainf_f_tavg	Rainfall flux	kg m-2 s-1
SoilMoi00_10cm_tavg	Soil moisture (0 – 10 cm underground)	m^3 m-3
SoilMoi10_40cm_tavg	Soil moisture (10 – 40 cm underground)	m^3 m-3
SoilMoi100_200cm_tavg	Soil moisture (100 – 200 cm underground)	m^3 m-3

SoilMoi40_100cm_tavg	Soil moisture (40 – 100 cm underground)	m^3 m-3
Tair_f_tavg	Near surface air temperature	K

3.2.2 FLDAS VIC Model Data

The FLDAS VIC model has three simulation runs ("A" and "C") for Eastern Africa, Southern Africa, and Western Africa. The VIC simulation "A" was initialized on January 1, 2001, forced by soil moisture and other state fields from GDAS and RFE2. The VIC simulation "C" was initialized on January 1, 1982, forced by soil moisture and other state fields from MERRA-2 and CHIRPS. The FLDAS VIC model data contain twenty-three fields, as listed in Table 4d.

Table 4d. Parameters from FLDAS VIC model datasets.

Short Name	**Description**	**Unit**
Evap_tavg	Evapotranspiration	kg m-2 s-1
LWdown_f_tavg	Downward longwave radiation flux	W m-2
Lwnet_tavg	Net longwave radiation flux	W m-2
Psurf_f_tavg	Surface pressure	Pa
Qair_f_tavg	Specific humidity	kg kg-1
Qg_tavg	Soil heat flux	W m-2
Qh_tavg	Sensible heat net flux	W m-2
Qle_tavg	Latent heat net flux	W m-2
Qs_tavg	Storm surface runoff	kg m-2 s-1
Qsb_tavg	Baseflow-groundwater runoff	kg m-2 s-1
RadT_tavg	Surface radiative temperature	K
Rainf_f_tavg	Rainfall flux	kg m-2 s-1
SM01_Percentile	Soil moisture percentiles	%
SoilMoi00_10cm_tavg	Soil moisture (0 - 10 cm underground)	m^3 m-3
SoilMoi10_160cm_tavg	Soil moisture (10 - 160 cm underground)	m^3 m-3
SoilMoi160_190cm_tavg	Soil moisture (160 - 190 cm underground)	m^3 m-3
SoilTemp00_10cm_tavg	Soil temperature (0 - 10 cm underground)	K
SoilTemp10_160cm_tavg	Soil temperature (10 - 160 cm underground)	K
SoilTemp160_190cm_tavg	Soil temperature (160 - 190 cm underground)	K
SWdown_f_tavg	Surface downward shortwave radiation	W m-2
Swnet_tavg	Net shortwave radiation flux	W m-2
Tair_f_tavg	Near surface air temperature	K
Wind_f_tavg	Near surface wind speed	m s-1

The short names with extension "_tavg" are past 3-hr averaged variables.
The short names with "_f" are forcing variables.

Soil moisture percentiles are an indicator of growing season conditions in the context of historical observations. More information about the soil moisture percentiles can be found at http://lis.gsfc.nasa.gov/sites/default/files/LIS/docs/SoilMoisturePercentile.pdf.

4.0 Options for Reading the Data

4.1 Utilities

The FLDAS data are archived in self-describing and machine-independent netCDF format. The Unidata page, http://www.unidata.ucar.edu/software/netcdf/software.html, 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 datasets.

The How-To section of NASA GES DISC provides a recipe for Quick View Data 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/.

Each individual FLDAS NetCDF file can be opened by GrADS sdfopen directly without a data descriptor file (aka 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 sdfopen a FLDAS NetCDF file and query for the dimensions and variables of the file.

```
hrui@hydro1:~/FLDAS_1.0$ grads

              Welcome to the OpenGrADS Bundle Distribution
              -------------------------------------------

For additional information enter "grads -h".

Starting "/opt/grads-
2.1.a2.oga.1/Linux/Versions/2.1.a2.oga.1/x86_64/grads    " ...
```

```
Grid Analysis and Display System (GrADS) Version 2.1.a2.oga.1
Copyright (c) 1988-2013 by the Institute for Global Environment and
Society (IGES)
GrADS comes with ABSOLUTELY NO WARRANTY
See file COPYRIGHT for more information

Config: v2.1.a2.oga.1 little-endian readline grib2 netcdf hdf4-sds
hdf5 opendap-grids,stn athena geotiff shapefile cairo
Issue 'q config' command for more detailed configuration information
Loading User Defined Extensions table </opt/grads-
2.1.a2.oga.1/Linux/Versions/2.1.a2.oga.1/x86_64/gex/udxt> ... ok.
Landscape mode? ('n' for portrait):
GX Package Initialization: Size = 11 8.5
ga-> sdfopen FLDAS_NOAH01_C_SA_M.A198201.001.nc
Scanning self-describing file:  FLDAS_NOAH01_C_SA_M.A198102.001.nc
SDF file FLDAS_NOAH01_C_SA_M.A198201.001.nc is open as file 1
LON set to 6.05 54.55
LAT set to -37.85 6.35
LEV set to 0 0
Time values set: 1982:1:1:0 1982:1:1:0
E set to 1 1
ga-> q file
File 1 : LVT land surface analysis output
  Descriptor: FLDAS_NOAH01_C_SA_M.A198201.001.nc
  Binary: FLDAS_NOAH01_C_SA_M.A198201.001.nc
  Type = Gridded
  Xsize = 486  Ysize = 443  Zsize = 1  Tsize = 1  Esize = 1
  Number of Variables = 26
     evap_tavg  0  t,y,x  total evapotranspiration
     lwdown_f_inst  0  t,y,x  surface downward longwave radiation
     lwnet_tavg  0  t,y,x  net downward longwave radiation
     psurf_f_inst  0  t,y,x  surface pressure
     qair_f_inst  0  t,y,x  specific humidity
     qg_tavg  0  t,y,x  soil heat flux
     qh_tavg  0  t,y,x  sensible heat flux
     qle_tavg  0  t,y,x  latent heat flux
     qs_tavg  0  t,y,x  surface runoff
     qsb_tavg  0  t,y,x  subsurface runoff amount
     radt_tavg  0  t,y,x  surface radiative temperature
     rainf_f_tavg  0  t,y,x  rainfall flux
     sm01_percentile  0  t,y,x  soil moisture percentiles
     swdown_f_tavg  0  t,y,x  surface downward shortwave radiation
     soilmoi00_10cm_  0  t,y,x  soil moisture content
     soilmoi10_40cm_  0  t,y,x  soil moisture content
     soilmoi40_100cm 0  t,y,x  soil moisture content
     soilmoi100_200c  0  t,y,x  soil moisture content
     soiltemp00_10cm  0  t,y,x  soil temperature
     soiltemp10_40cm  0  t,y,x  soil temperature
     soiltemp40_100c  0  t,y,x  soil temperature
     soiltemp100_200  0  t,y,x  soil temperature
     swnet_tavg  0  t,y,x  net downward shortwave radiation
     tair_f_avg  0  t,y,x  air temperature
     wind_f_avg  0  t,y,x  wind speed
     smrz_percentile  0  t,y,x  root zone soil moisture percentiles
ga->
```

With a GrADS descriptor file, by using GrADS command xdfopen, multiple FLDAS 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 monthly 0.1 x 0.1 degree Noah model data product FLDAS_NOAH01_C_SA_M.001.

FLDAS_NOAH01_M.001.xdf, a sample data descriptor file

```
DSET FLDAS_NOAH01_C_SA_M.A%y4%m2.001.nc
OPTIONS template
TDEF time   411  LINEAR       Jan1982  1mo
*** variable name may not appear completely (max 15 characters)
```

An example for using xdfopen to open **FLDAS_NOAH01_C_SA_M.001.XDF**

```
ga-> xdfopen FLDAS_NOAH01_C_SA_M.001.XDF
Scanning Descriptor File:  FLDAS_NOAH01_C_SA_M.001.XDF
SDF file /var/tmp/hrui/FLDAS/FLDAS_NOAH01_C_SA_M.A%y4%m2.001.nc is
open as file 1
LON set to 6.05 54.55
LAT set to -37.85 6.35
LEV set to 0 0
Time values set: 1982:1:1:0 1982:1:1:0
E set to 1 1
ga-> q file
File 1 : LIS land surface model output
  Descriptor: FLDAS_NOAH01_C_SA_M.001.XDF
  Binary: /var/tmp/hrui/FLDAS/FLDAS_NOAH01_C_SA_M.A%y4%m2.001.nc
  Type = Gridded
  Xsize = 486  Ysize = 443  Zsize = 1  Tsize = 411  Esize = 1
  Number of Variables = 26
     evap_tavg  0  t,y,x  total evapotranspiration
     lwdown_f_tavg  0  t,y,x  surface downward longwave radiation
     lwnet_tavg  0  t,y,x  net downward longwave radiation
     psurf_f_tavg  0  t,y,x  surface pressure
     qair_f_tavg  0  t,y,x  specific humidity
     qg_tavg  0  t,y,x  soil heat flux
     qh_tavg  0  t,y,x  sensible heat flux
     qle_tavg  0  t,y,x  latent heat flux
     qs_tavg  0  t,y,x  surface runoff
     qsb_tavg  0  t,y,x  subsurface runoff amount
     radt_tavg  0  t,y,x  surface radiative temperature
     rainf_f_tavg  0  t,y,x  rainfall flux
     sm01_percentile  0  t,y,x  soil moisture percentiles
     swdown_f_tavg  0  t,y,x  surface downward shortwave radiation
     soilmoi00_10cm_  0  t,y,x  soil moisture content
     soilmoi10_40cm_  0  t,y,x  soil moisture content
     soilmoi40_100cm  0  t,y,x  soil moisture content
     soilmoi100_200c  0  t,y,x  soil moisture content
     soiltemp00_10cm  0  t,y,x  soil temperature
     soiltemp10_40cm  0  t,y,x  soil temperature
     soiltemp40_100c  0  t,y,x  soil temperature
     soiltemp100_200  0  t,y,x  soil temperature
     swnet_tavg  0  t,y,x  net downward shortwave radiation
     tair_f_tavg  0  t,y,x  air temperature
     wind_f_tavg  0  t,y,x  wind speed
     smrz_percentile  0  t,y,x  root zone soil moisture percentiles
ga->
```

5.0 Data Services

The NASA GES DISC maintains archives of all FLDAS data products and many other Hydrology data sets. The archived data can be accessed via HTTPS network transfer. FLDAS data can be accessed via the GES DISC Unified User Interface (UUI) at https://disc.gsfc.nasa.gov/datasets?keywords=FLDAS.

5.1 HTTPS Access

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

5.2 EOSDIS Earthdata Search System

The EarthData Search can be used to find and retrieve datasets across multiple data centers: https://search.earthdata.nasa.gov/search?q=FLDAS&ok=FLDAS.

5.3 OPeNDAP Access

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

5.4 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=FLDAS.

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

6.0 More Information

6.1 Data Volume

Model	Resolution	Spatial Coverage	File Size / Volume per year			
			Daily Data	Monthly Data	Monthly Anomaly Data	Monthly Climatology Data
Noah	0.1° × 0.1°	Eastern Africa	9.9 MB/ 3.5 GB	10 MB/ 120 MB	7.2 MB/ 86.4 MB	3.2 MB/ 38.4 MB
		Southern Africa	21 MB/ 7.5 GB	22 MB/ 264 MB	11 MB/ 132 MB	6.6 MB/ 79.2 MB
		Western Africa	5.5 MB/ 1.97 GB	5.7 MB/ 68.4 MB	5.8 MB/ 69.6 MB	1.8 MB/ 21.6 MB
		Global	-	1.2 GB/ 14.4 GB	169 MB/ 1.98 GB	169 MB/ 1.98 GB
VIC	0.25° × 0.25°	Eastern Africa	1.6 MB/ 585 MB	1.6 MB/ 19.2 MB	-	-
		Southern Africa	2.8 MB/ 1.0 GB	2.8 MB/ 33.6 MB	-	-
		Western Africa	1.0 MB/ 366 MB	1.0 MB/ 12 MB	-	-

The table will be updated as data volume information for other models become available.

7.0 Acknowledgements

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References

McNally, A. et al. A land data assimilation system for sub-Saharan Africa food and water security applications. *Sci. Data* 4:170012 doi: 10.1038/sdata.2017.12 (2017)

Appendices

The following acronyms and abbreviations are used in this document.

CHIRPS	Climate Hazards Group InfraRed Precipitation with Station data
FLDAS	Famine Early Warning Systems Network (FEWS NET) Land Data Assimilation System
GDAS	Global Data Assimilation System
GDS	GrADS Data Server
GES DISC	Goddard Earth Sciences Data and Information Services Center
Giovanni	GES-DISC Interactive Online 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
MERRA	Modern Era Retrospective-analysis for Research and Applications
MERRA-2	MERRA Version 2
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NetCDF	network Common Data Form
NIDIS	National Integrated Drought Information System
Noah	National Centers for Environmental Prediction/Oregon State University/ Air Force/Hydrologic Research Lab (Noah)
VIC	Variable Infiltration Capacity macroscale model