North American Land Data Assimilation System (NLDAS) Data: 30 Years of Hourly Gridded Precipitation, Surface Meteorology and Fluxes, Soil Moisture, Runoff, and Snow Cover Available at the NASA Goddard GES DISC

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The NLDAS Project and NLDAS-2 Forcing Data and Model Output

NLDAS Description and Forcing Data Generation

NLDAS Phase 2 is a collaborative project among several groups: National Centers for Environmental Prediction's (NCEP) Environmental Modeling Center (EMC), NASA's Goddard Space Flight Center (GSFC), Princeton University, the National Weather Service's (NWS) Office of Hydrologic Development (OHD), the University of Washington, and NCEP's Climate Prediction Center (CPC). NLDAS is a core project with support from NOAA's Climate Prediction Program for the Americas (CPPA). The NASA/GSFC group led the development of the algorithm to generate the forcing data for Phase 2 and produced this data for the retrospective period (January 1979 - December 2007); this group also generated the retrospective Mosaic model simulation using the Land Information System (LIS), an award-winning software framework for high-performance land-surface modeling and data assimilation developed within the Hydrological Sciences Branch at NASA/GSFC. The University of Washington and Princeton University developed the Variable Infiltration Capacity (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 model simulations for Noah and OHD's Sacramento (SAC) model. Since January 2008, NCEP/EMC has taken the lead to produce NLDAS forcing data and simulate all four models in near real-time (with a four-day lag). NCEP/EMC updates the NLDAS website (with output from all 4 models; http://www.emc.ncep.noaa.gov/mmb/nldas/) and drought monitor products to support the National Integrated Drought Information System (NIDIS).

The main NLDAS Phase 2 product is an hourly 30-year (January 1979 to present, in near real-time with a four day lag) 1/8th-degree surface meteorology and hydrology dataset over the contiguous United States, southern Canada, and northern Mexico. The non-precipitation land-surface forcing fields for NLDAS-2 are derived from the analysis fields of the NCEP North American Regional Reanalysis (NARR). These fields are 32-km spatial resolution and 3-hourly temporal frequency, and are spatially interpolated to the NLDAS grid and then temporally disaggregated to hourly temporal resolution. The NCEP/CPC daily gauge precipitation is interpolated with John Schaake's PRISM (Parameter-elevation Regressions on Independent Slopes Model) algorithm to the NLDAS grid. Daily gauge precipitation is then temporally disaggregated into hourly using Stage II radar precipitation estimates. If the radar is not available, the CMORPH (CPC MORPHing technique) precipitation analysis, CPC HPD (Hourly Precipitation Data), or NARR precipitation are used. The NARR downward shortwave (SW) radiation also was bias corrected using retrieved GOES (Geostationary Operational Environmental Satellite) data. The NLDAS-2 forcing is used to drive four land-surface models (LSMs) – NCEP/Noah, NASA/Mosaic, Princeton/VIC, and OHD/SAC – to output water/energy fluxes and model state variables. The forcing and all four models' outputs are staged on NCEP/EMC public ftp servers via their NLDAS website. At the same time, NASA GES DISC distributes NLDAS forcing and Mosaic model output (see box on right for more information).

Forcing	Coverage	Temporal Resolution	Spatial Resolution	Notes
NARR Model	1979-2003	3 Hourly	32km	
R-CDAS Model	2003-Present	3 Hourly	32km	Realtime version of NARR
GOES Radiation	1996-2000	Hourly	1/8th degree	Used to bias correct NARR
CPC PRISM Gauge	1979-Present	Daily	1/8th degree	Used over CONUS, Mexico
CPC Gauge	1979-Present	Hourly	2 X 2.5 degree	Used over CONUS
CMORPH Precip	2002-Present	1/2 Hourly	8km	Used over CONUS, Mexico
Stage II Precip	1996-Present	Hourly	4km	Used over CONUS

Table 1: Overview of data sets used in NARR-based NLDAS drought monitor.

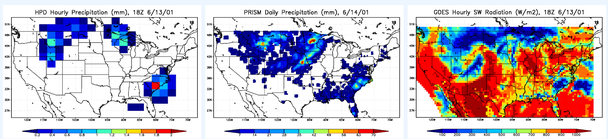


Figure 1: Samples of base datasets which make up the NLDAS Phase 2 forcing. (Left, clockwise from top left): NARR 2-m temperature (K), 10-m wind speed (m/s), simulated precipitation (mm), and shortwave radiation at the surface (W/m^2); and (Above, left to right): CPC HPD hourly precipitation (mm), CPC PRISM daily precipitation, and GOES shortwave radiation (W/m^2).

NLDAS Model Output and Drought Monitoring

Figure 2 (right) depicts the entire drought monitoring system, including the data within the NLDAS forcing used to drive the model simulations. Precipitation observations are combined with surface data from the NARR reanalysis (a blend of a regional atmospheric model and observational data). The NARR surface SW is also bias-corrected using GOES observations. The NLDAS forcing separately drives four LSMs (NCEP/Noah, NASA/Mosaic, Princeton/VIC, OHD/SAC) to produce model output; an ensemble-mean is also produced. Some of the available NLDAS variables include:

- Surface meteorology (2-m temperature/moisture, 10-m wind, surface pressure)
- Precipitation (total and convective-only)
- Shortwave and longwave fluxes (downward and net) at the surface
- Sensible and latent heat fluxes (including potential evaporation)
- Soil moisture (at multiple levels), runoff, and snow cover/depth
- Surface and soil temperatures

These variables are used in various combinations in a post-processor to generate different drought indices. The three main types of droughts to be investigated are:

- Meteorological (primarily from precipitation deficit)
- Hydrological (primarily from streamflow/runoff deficit)
- Agricultural (primarily from soil moisture deficit)

A list of drought indices, their types, the required forcing and/or LSM variables, and comparison data is shown in Table 2. The different drought indices and output from the separate LSMs will be evaluated against historical and current drought observations.

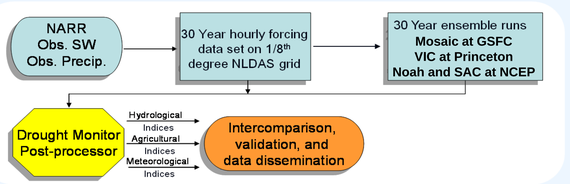


Figure 2: Overview of NLDAS drought monitoring system. NLDAS forcing separately drives the LSMs, from which an ensemble is generated. Drought indices are produced using the LSM outputs as well as NLDAS forcing.

	Drought Index	Drought Type	Required NARR/NLDAS Monitor Data	Comparison Data
Standard Indices	Wtd/UnWtd PDSI	Meteorological	Forcing	NCDC PDSI
	SPI	Meteorological	Forcing	U. Nebraska SPI
	PHDI	Hydrological	Forcing	NCDC PHDI
	TWD	Hydrological	Streamflow Output	USGS Streamflow
	Palmer Z	Agricultural	Forcing	NCDC Palmer Z
	VIC Percentile	Agricultural	LSM Soil Moisture Output	U. Washington
Experimental LDAS Indices	LDAS PDSI	Meteorological	LSM Output and Forcing	NCDC PDSI
	LDAS PHDI	Hydrological	LSM Output and Forcing	NCDC PHDI
	LDAS Palmer Z	Agricultural	LSM Output and Forcing	NCDC Palmer Z
	CLM3 VHI	Agricultural	CLM3 LAI/NDVI Output	NOAA VHI

Self calibrating (duration and climate characteristic parameters)

Table 2: Overview of drought indices planned to be output by drought monitor.

NLDAS Data Access and Drought Monitor Output

NLDAS Data Access at the NASA GES DISC

(http://disc.gsfc.nasa.gov/hydrology)

The hourly NLDAS data can be accessed via the National Aeronautics and Space Administration (NASA)'s Goddard Earth Sciences Data and Information Services Center (GES DISC)'s Hydrology Data and Information Services Center (HDISC) (Figure 3, right). Users can access the data by searching and downloading via anonymous ftp or Mirador (Figure 4, below left). Mirador, a fast interface for searching Earth science data at NASA GES DISC, uses keywords and time span to find and download data quickly in a batch mode. Figures 4 and 5 (below left) illustrate the Mirador search interface and results, respectively.

The NLDAS products are also made available to GrADS Data Server (GDS) users (Figure 6, below). The GDS is a stable, secure data server that provides sub-setting and analysis services across the internet. The GDS provides subsets of any NLDAS data set, in ASCII comma-delimited format and/or binary format. Figure 7 (below, right) shows an example of the layer 1 soil moisture content in ASCII format. More advanced tools will be provided in later releases, such as spatial and parameter sub-setting, data format transformation, and an online visualization and analysis tool (Giovanni).

HDISC Data Holdings

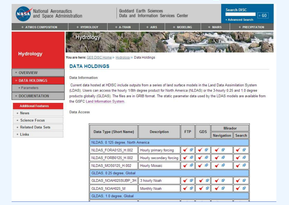


Figure 3: HDISC Data Holdings webpage.

Mirador Search Interface

Figure 4: Mirador webpage.

Mirador Search Results

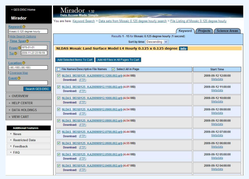


Figure 5: Sample Mirador results.

GES DISC GDS for NLDAS Dataset (http://hydro1.sci.gsfc.nasa.gov/dods/)

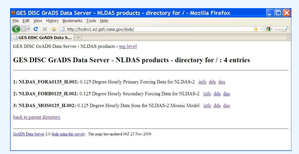


Figure 6: NLDAS GrADS Data Server (GDS).

Soil Moisture Content Through GDS

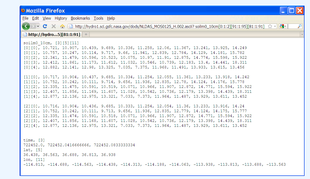


Figure 7: Sample NLDAS data via GDS.

Real-time NLDAS Drought Monitor

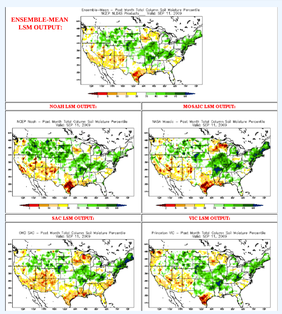
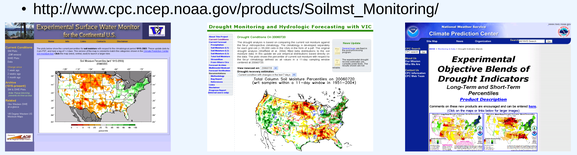


Figure 8 (left): NLDAS real-time drought monitor. (*NOAA/NCEP has taken over main hosting duties from NASA/GSFC*).

- Climatological mean soil wetness values were computed for each day of the year (1979 discarded due to spin-up)
- Anomalies are computed by comparing the near real-time data (past day/week/month) to the same time of the year in the mean climatology
- Percentiles are computed by ranking the current soil wetness values (past day/week/month) against values from +/-5 surrounding days over the previous years
- 4 different LSMs are provided to study their individual strengths/weaknesses

NLDAS drought monitor modeled after existing websites (**Figure 9**, below, L to R):

- http://www.hydro.washington.edu/forecast/monitor/
- http://hydrology.princeton.edu/forecast/
- http://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/



Sample NLDAS Drought Monitor Output

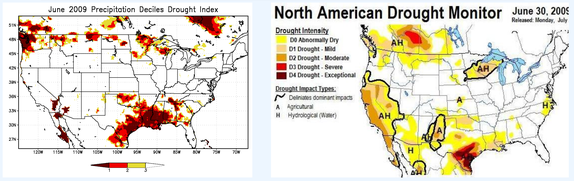


Figure 10 (above): (L) Precipitation deciles drought index from the NLDAS forcing and the (R) North American Drought monitor product for June 2009. This index "misses" the CA/NV agricultural/hydrological drought, as this index only considers meteorological drought, so a different drought index may need to be used instead.

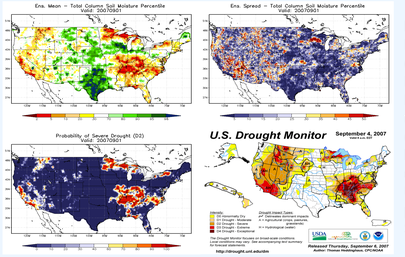


Figure 11 (left): Upper: Ensemble (L) mean and (R) spread from Noah, Mosaic, and SAC LSMs; Lower: (L) Probability that severe drought (level D2) is occurring based on the ensemble drought monitor; (R) U.S. Drought Monitor product for early September 2007.

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