NLDAS EMC CCB meeting, April 03, 2014

North American Land Data Assimilation System (NLDAS)
Version 1.0.0 -- a New Implementation

Michael B. Ek, Youlong Xia and Yuqiu Zhu
NLDAS: Partners

- **NLDAS, Data Sets, Land Model Development:**
  - M. Ek, Y. Xia, J. Dong, J. Meng (NCEP/EMC)
  - J. Sheffield, E. Wood et al (Princeton U.)
  - D. Mocko, C. Peters-Lidard (NASA/GSFC)
  - V. Koren, B. Cosgrove (NWS/OHD)
  - D. Lettenmaier et al (U. Washington)
  - L. Luo (U. Michigan, formerly Princeton)
  - Z-L Yang et al (UT-Austin); F. Chen et al (NCAR); X. Zeng et al (U. Ariz.)

- **NLDAS Maintenance and Operational Transition:**
  - Y. Xia (NCEP/EMC)

- **NLDAS Products Application:**
  - K. Mo, L.-C. Chen (NCEP/CPC)
  - E. Luebhusen, U.S.D.M. Author Group (USDA)
NLDAS V1.0.0 SET UP
North American Land Data Assimilation System (NLDAS)

- Multi-land-modeling & land data assimilation system.
- Uncoupled land model runs driven by atmospheric forcing using surface meteorology data sets.
- Long-term retrospective and near real-time runs.
- Land model output of water and energy budgets.
- 30-year land model runs provide climatology.
- Anomalies used for drought monitoring.
- Multi-institute collaboration (NCEP, OHD, NASA, Princeton, Univ. Wash.).
Land Surface Observation, Modeling and Data Assimilation

Overview of the North American Land Data Assimilation System (NLDAS)

Part 4: Application

Overview of the North American Land Data Assimilation System (NLDAS)

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Youlong Xia, Brian A. Cosgrove, Michael B. Ek, Justin Sheffield, Lifeng Luo, Eric F. Wood, Kingtse Ma, and NLDAS team (2013)

doi: 10.1142/9789814472616_0011
NLDAS: Land Models

Noah
NCEP operational land model

Mosaic
NASA GSFC

Hydrology Community

SAC
NWS operational hydrological model

VIC
Princeton & U. Washington
Vegetation Type  
(1-deg, UMD)

Soil Type  
(1-deg, Zobler)

Max.-Snow Albedo  
(1-deg, Robinson)

Green Vegetation Fraction  
(monthly, 1/8-deg, NESDIS/AVHRR)

Snow-Free Albedo  
(seasonal, 1-deg, Matthews)

• Fixed climatologies, or near real-time obs, some quantities to be assimilated (e.g. soil moist., snow).
NLDAS: Atmospheric Forcing

- Common atmospheric forcing from Regional Climate Data Assimilation System (real time extension of North American Regional Reanalysis), except precip.
- CPC gauge-based observed precipitation, temporally disaggregated using radar/satellite data (stage IV, CMORPH).
NLDAS: Simulations

- 30-year retrospective land model runs, Oct 1979 – Sep 2008 (after 15-year spin-up) to provide land model climatologies.

- Quasi-operational near real-time, Sep 2008–present; hourly, 0.125-deg, CONUS domain.

- Land model output: surface fluxes (latent, sensible & soil heat fluxes, & net radiation), soil states (soil moisture, temperature & ice), runoff/streamflow.

- Depict conditions as anomalies and percentiles.
NLDAS V1.0.0 Products: Evaluation and Validation
NLDAS: Evaluation and Validation

- Energy flux validation from tower: net radiation, sensible, latent & ground heat fluxes.
- Water budget: evaporation, total runoff/streamflow.
- State variables: soil moisture, soil temperature, skin temperature, snow water equivalent, snow cover.

Xia et al., JGR, 2012
Xia et al., J. Hydrol., 2014a
NLDAS: Evaluation (continue)

Soil Temperature Comparison: NLDAS vs US Soil T (Xia et al., JAMC, 2013)

Land Skin Temperature in ARM/CART

(a) Noah–OBS

Ground Heat Flux in ARM/CART

(a) Noah–OBS (W/m²)

Difference between Noah simulated and observed LH at ARM/CART (We et al., Hydrological Processes, 2012)

(a) Monthly Mean Latent Heat Flux (W/m²) CASE CNTR–OBS

(b) Monthly Mean Latent Heat Flux (W/m²) CASE RTDS–OBS
To Evaluate NLDAS v1.0 ET Products Using Tower Observations
Xia, Hobbins, Mu, and Ek, Hydrological Processes (in revision)

Variability Validation

The data are grouped based on vegetation types (Mo et al., 2010). Daily value with 3 months are polled for several years. The correlation may be overestimated in spring and fall due to seasonal cycle (ET sharply increases in spring and sharply decreases in fall).
NLDAS v1.0.0 Products: 
Users and Applications
NLDAS: Users

- US Drought Monitor (www.droughtmonitor.unl.edu)
- Other government, academic, private users.
Geotiffs of NLDAS are imported directly into the US Drought Monitor (USDM) editing process via GIS.
NLDAS GIS data are an integral part of the USDM process, both operationally and also as part of a weekly ppt sent to the USDM Listserv.

NLDAS website: http://www.emc.ncep.noaa.gov/mmb/nldas
NLDAS GIS data are also used in conjunction with USDA crop-area shapefiles for crop-weather assessment. Here, recent dryness depicted in the Corn Belt.
NLDAS shows a variety of adverse conditions afflicting cotton, from Texas’ Drought to excessive wetness in the mid-Atlantic.
NLDAS data indicate dire planting prospects for winter wheat on the southern Plains.
Overview:

What is WestWide Drought Tracker?

The western United States consists of complex terrain where local precipitation and temperature can vary dramatically across short distances, which in turn impact local drought conditions. The goal of WestWide Drought Tracker (WWDT) is to provide easy access to fine-scale drought monitoring and climate products that can be utilized by a variety of users. The climate data sets, drought indices, and maps that are found on WWDT use monthly data which are updated with new values at the beginning of each month.

For days 1-10 of each month the NLDAS-2 data are used to provide an initial view of the spatial patterns before the PRISM data are available. The 1/8th degree (approximately 12 km) NLDAS-2 temperature and precipitation data are bilinearly interpolated to the PRISM grid and bias corrected by accounting for monthly differences in climatology of NLDAS and PRISM over a common time period from 1979-2011 (Abatzoglou, 2011). The PRISM data is then assimilated back into the WWDT once it is made available (after day 10 of each month).

What products are available on WWDT?

- Drought Indices
  - Palmer Drought Severity Index (PDSI)
  - Self-Calibrated Palmer Drought Severity Index (sc-PDSI)
  - Palmer Z-Index
  - Standardized Precipitation Index (SPI)
  - Standardized Precipitation Evapotranspiration Index (SPEI)

- Climate Data
All data sets can be made available to interested researchers upon request. Please contact amir.a@uci.edu

Explore the available data using the Global Integrated Drought Monitoring and Prediction System (GIDMaPS)

Global Multivariate Standardized Drought Index, MSDI, (1990-present)

This data set include monthly Multivariate Standardized Drought Index (MSDI) obtained using the NASA Modern Era Retrospective-Analysis for Research and Applications (MERRA) soil moisture and precipitation data. MSDI combines both precipitation and soil moisture and provides a composite model for drought analysis. The data set is available at different time scales (e.g., 1-month, 6-month). Spatial resolution: 1/2 degrees latitude x 2/3 degrees longitude.

NLDAS-Based Multivariate Standardized Drought Index, MSDI, (1980-present)

This data set include monthly Multivariate Standardized Drought Index (MSDI) obtained using the NASA North American Land Data Assimilation System (NLDAS) soil moisture and precipitation data. MSDI combines both precipitation and soil moisture and provides a composite model for drought analysis. The data set is available at different time scales (e.g., 1-month, 6-month). Spatial resolution: 1/8th-degree grid.

Global Standardized Soil Moisture Index, SSI, (1980-present)

This data set include monthly Standardized Soil Moisture Index (SSI) obtained using the NASA Modern Era Retrospective-Analysis for Research and Applications (MERRA) soil moisture data. The data set can be used to study global agricultural droughts, hydrology and ecosystem impact studies. The data set is available at different time scales (e.g., 1-month, 6-month). Spatial resolution: 1/2 degrees latitude x 2/3 degrees longitude.
NCAR/UCAR

NLDAS: NORTH AMERICAN LAND DATA ASSIMILATION SYSTEM: MONTHLY CLIMATOLOGIES

The North American Land Data Assimilation System (NLDAS) monthly climatology data sets are broadly used by various user communities in modeling, research, and applications, such as drought and flood monitoring, watershed and water quality management.

Centers for Disease Control and Prevention

North America Land Data Assimilation System (NLDAS) Daily

1. Organize table layout:

Select Measures (Check box to include in results. Must select at least one.)

- Daily Max Air Temperature (F):
  - Avg Temperature
  - # of Observations
  - Range

- Daily Min Air Temperature (F):
  - Avg Temperature
  - # of Observations
  - Range

- Daily Max Heat Index (F):
  - Avg Heat Index
  - # of Observations
  - Range

- Title
To develop an objective framework to blend multiple drought indices to support operational drought monitoring task.
Near real-time weekly 4-model ensemble total soil moisture percentile, 5 Jan – 14 Sept 2011 (D0 yellow/moderate – D4 red/extreme)
USDM-based optimally blended NLDAS Drought Index, Jan 2011 – Aug 2012 (D0 yellow/moderate – D4 red/extreme)
Century California Drought Monitoring

Improvement and Termination of Drought
Ensemble mean daily streamflow anomaly (m³/s)
Hurricane Irene and Tropical Storm Lee
20 August – 17 September 2011
NLDAS: Flood Monitoring

Ensemble mean daily streamflow anomaly (m$^3$/s) Superstorm Sandy
29 October – 04 November 2012
NLDAS Flood Monitoring
Ensemble mean daily streamflow anomaly (m³/s)
Colorado Front Range Flooding
September 2013
NLDAS: Web Site Information

NASA/GSFC NLDAS Website

USGS Geo Data Portal

This page is a catalog of the datasets that have been tested to work well for access with the Geo Data Portal. Select one of the buttons below to see a list of these datasets. At its core, the Geo Data Portal is an advanced Open Geospatial Consortium Web Processing Service that can be used in a wide variety of applications against any web-accessible standards-compliant dataset. If you'd like to see all the datasets that are compatible with one of the processing types the Geo Data Portal can perform, select one of those buttons below.

For more information about the Geo Data Portal, please visit the Geo Data Portal Documentation Home.

Datasets

- All
- Climate
- Landscape

Processing

- Areal Statistics
- Data Subsets

Select Dataset

0.125 Degree Hourly Primary Forcing Data for NLDAS-2

North American Land Data Assimilation System Phase 2

0.125 Degree Hourly Primary Forcing Data for NLDAS-2

The goal of the North American Land Data Assimilation System (NLDAS) is to construct quality-controlled, and spatially and temporally consistent, land-surface model (LSM) datasets from the best available observations and model output to support modeling activities. Specifically, this system is intended to reduce the errors in the stores of soil moisture and energy which are often present in numerical weather prediction models, and which degrade the accuracy of forecasts. NLDAS is currently running in near real-time on a 1/8th-degree grid over central North America, retrospective NLDAS datasets and simulations also extend back to January 1979. NLDAS constructs a forcing dataset from gauge-based observed precipitation data (temporally disaggregated using Stage II radar data), bias-correcting shortwave radiation, and surface meteorology reanalyses to drive several different LSMs to produce model outputs of surface fluxes, soil moisture, and snow cover. For more information visit: http://ldas.gsfc.nasa.gov/ldas
NLDAS v1.0.0
Operational Implementation
NLDAS V1.0.0 release note

Computing resource information:
This model system runs only once per day (12Z).
Total runtime is about 50-60 minutes.
All the jobs will be running in serial mode, and the whole system will use at most 3 processors during the runtime period.
Total disk usage is about 700 mb per day.

Dissemination info:
The forcing (only the grib2 format), model output data and the river streamflow data (all in grib2 format) will need to be sent out to the public.

Primary Users:
NIDIS
US Drought Monitor
NCEP Climate Prediction Center
Other external users such as Princeton University, University of Washington, NWS/OHD, NASA/GSFC. COLA, The Climate Corporation.

Archive to HPSS:
All of the output data (including the restart files) will need to be archived to HPSS.
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Standard layer (2-m air T and q, 10-m wind u, v)
Noah model run check
cmp_grib1_grib2.sh
/land/noscrub/Youlong.Xia/tempest/Noah/20140318/2014031823.NOAH.grb
/meso/noscrub/Yuqiu.Zhu/com/nldas/dev/nldas.20140318/noah.t12z.grbf23

Noah tempest run
Gyre operational NLDAS run

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## Mosaic run check

**cmp_grib1_grib2.sh**

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/meso/noscrub/Yuqiu.Zhu/com/nldas/dev/nldas.20140318/mosaic.t12z.grbf23

**Mosaic model tempest run**

**Mosaic model gyre operational run**

**Correlation and RMSE analysis for Mosaic model output**

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SAC model run check

cmp_grib1_grib2.sh
/land/noscrub/Youlong.Xia/tempest/SAC/20140318/2014031823.SAC.grb
/meso/noscrub/Yuqiu.Zhu/com/nldas/dev/nldas.20140318/sac.t12z.grbf23

SAC model tempest run

SAC model gyre operational run

Correlation and RMSE Analysis
1:0:ARAIN:rpn_corr=1:rpn_rms=3.49182e-07
2:26723:TSNOW:rpn_corr=1:rpn_rms=6.01532e-07
3:58851:EVP:rpn_corr=0.99999:rpn_rms=0.000423051
4:165955:PEVAP:rpn_corr=0.999995:rpn_rms=0.329297
5:273688:SSRUN:rpn_corr=1:rpn_rms=2.09334e-05
6:322020:BGRUN:rpn_corr=1:rpn_rms=1.80222e-06
7:402589:SOILM:rpn_corr=1:rpn_rms=0.00182474
8:544600:SOILM:rpn_corr=1:rpn_rms=0.000868685
9:589296:SOILM:rpn_corr=1:rpn_rms=0.00105583
10:743782:SOILM:rpn_corr=1:rpn_rms=0.00023138
11:809975:SOILM:rpn_corr=1:rpn_rms=0.00043525
12:931007:SOILM:rpn_corr=1:rpn_rms=0.00232602
13:1087446:SOILM:rpn_corr=1:rpn_rms=0.00259044
14:1245232:SNOM:rpn_corr=1:rpn_rms=6.06631e-05
15:1278811:WEASD:rpn_corr=1:rpn_rms=2.19175e-06
16:1339718:SNOD:rpn_corr=1:rpn_rms=1.49913e-06
**VIC model run check**

cmp_grib1_grib2.sh
/land/noscrub/Youlong.Xia/tempest/VIC/20140318/2014031823.VIC.grb
/meso/noscrub/Yuqiu.Zhu/com/nldas/dev/nldas.20140318/vic.t12z.grbf23

**VIC model tempest run**

**VIC model gyre operational run**

**Correlation and RMSE Analysis for VIC output**

```
1:0:NSWRS:rpn_corr=1:rpn_rms=0.0676232
3:213807:LHTFL:rpn_corr=0.999956:rpn_rms=0.295993
5:434643:GFLUX:rpn_corr=0.999998:rpn_rms=0.0518071
7:586807:DSWRF:rpn_corr=1:rpn_rms=0.00178282
9:788045:TSNOW:rpn_corr=1:rpn_rms=0.000269208
11:846946:EVP:rpn_corr=0.99987:rpn_rms=2.80676e-06
15:1114033:SNOT:rpn_corr=0.999389:rpn_rms=0.181234
17:1262322:RADT:rpn_corr=0.99991:rpn_rms=0.0493852
19:1484947:WEASD:rpn_corr=1:rpn_rms=0.00269208
21:1646068:TSOIL:rpn_corr=0.99997:rpn_rms=0.023467
23:1855529:TSOIL:rpn_corr=1:rpn_rms=0.000189012
25:2187489:SOILM:rpn_corr=1:rpn_rms=0.00279199
27:2642231:SOILM:rpn_corr=1:rpn_rms=0.00335408
29:3043792:SOILM:rpn_corr=1:rpn_rms=0.00295705
31:3459537:lSOIL:rpn_corr=1:rpn_rms=0.00174501
33:3894769:MSTAV:rpn_corr=1:rpn_rms=0.000543052
35:4229253:EVCW:rpn_corr=0.989605:rpn_rms=0.00167994
37:4264087:EVBS:rpn_corr=1:rpn_rms=0
39:4294602:ACOND:rpn_corr=1:rpn_rms=6.52771e-09
41:4500496:SNOD:rpn_corr=1:rpn_rms=0.000119043
43:4622262:SalBD:rpn_corr=0.999998:rpn_rms=0.0698244

2:111540:NLWRS:rpn_corr=0.999994:rpn_rms=0.205884
4:319533:SHTFL:rpn_corr=0.999995:rpn_rms=0.301886
6:529635:SNOHF:rpn_corr=0.999978:rpn_rms=0.121072
8:690270:DLWRF:rpn_corr=0.999969:rpn_rms=0.291681
10:819997:ARAIN:rpn_corr=1:rpn_rms=3.49119e-07
12:957357:SSRUN:rpn_corr=0.999991:rpn_rms=0.0452243
14:1081440:SNOM:rpn_corr=0.999961:rpn_rms=0.034728
16:1153991:AVSFT:rpn_corr=0.999961:rpn_rms=0.034728
20:1590969:CNWAT:rpn_corr=0.998339:rpn_rms=0.000643589
22:1752645:TSOIL:rpn_corr=1:rpn_rms=0.00652019
24:1957305:SOILM:rpn_corr=1:rpn_rms=0.00279405
26:2418926:SOILM:rpn_corr=1:rpn_rms=0.0027351
30:3268500:LSOIL:rpn_corr=1:rpn_rms=0.000643589
32:3459537:lSOIL:rpn_corr=1:rpn_rms=0.000643589
34:4060787:MSTAV:rpn_corr=1:rpn_rms=0.00542267
36:4243898:TRANS:rpn_corr=0.999977:rpn_rms=0.000356705
38:4277928:SBSNO:rpn_corr=0.999609:rpn_rms=0.000595401
40:4376107:LAI:rpn_corr=1:rpn_rms=1.00863e-07
42:4583288:SNOWC:rpn_corr=0.999999:rpn_rms=0.0452108
```
Strategy for checking NCO 30-day test run:

(1) Yuqiu Zhu will run her NLDAS on production machine and compared her run with NCO run.

(2) Youlong Xia will compared tempest run and NCO run using two simple methods:

(2a) run common script to check as shown above.
(2b) randomly make difference plot to check for some specific variables.
**NLDAS: Future**

*Post-operational implementation of NLDAS drought monitoring over CONUS*

- Run NLDAS under NASA Land Information System (parallel environment, latest land model versions, land data assimilation and validation tools).
- NLDAS seasonal hydrological prediction using VIC land model with CFS/other seasonal climate forcing.
- Improve atmospheric and observational precipitation forcing; data sets (e.g. land use, soils, greenness).
- Improve land model physics (e.g. Noah land model).
- Land data assimilation of e.g. snow, soil moisture.
- Higher res/downscaling, enhance land model spinup.
- Extend NLDAS domain (entire North America, eventually global); initial land cond. for NAM, GFS.