Application of NARR-Based NLDAS Ensemble Simulations to Continental-Scale Drought Monitoring

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New NARR-Based NLDAS Drought Monitor

Project Overview

Government estimates indicate that droughts cause billions of dollars of damage to agricultural interests each year. More effective identification of droughts would directly benefit decision makers, and would allow for the more efficient allocation of resources that might mitigate the event. Land data assimilation systems, with their high quality representations of soil moisture, present an ideal platform for drought monitoring, and offer many advantages over traditional modeling systems. The recently released North American Regional Reanalysis (NARR) covers the NLDAS domain and provides all fields necessary to force the NLDAS for 27 years. This presents an ideal opportunity to combine NARR and NLDAS resources into an effective real-time drought monitor.

Toward this end, our project seeks to validate and explore the NARR's suitability as a base for drought monitoring applications—both in terms of data set length and accuracy. Along the same lines, the project will examine the impact of the use of different (longer) LDAS model climatologies on drought monitoring, and will explore the advantages of ensemble simulations versus single model simulations in drought monitoring activities.

Continuing the collaborative aspects of the NLDAS project, work will proceed alongside ongoing, complementary NLDAS-partner drought monitoring efforts at NOAA NCEP/NESDIS, Princeton University, and the University of Washington.

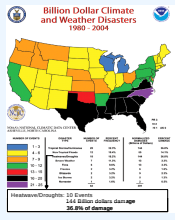


Figure 1. Economic costs of droughts.

Project Goals

- Construct and validate 1/8th degree forcing dataset based on NARR and observed precipitation and radiation
- Investigate optimal NLDAS forcing methodology using Noah and CLM3 LSMs
- Using optimal forcing methodology, execute two separate 1/8th degree 27 year-long multi-model ensemble runs using Noah, CLM3, Mosaic, HySSiB, and Catchment LSMs; one set forced with NARR-only data, and one set forced with NARR and observed data
- Intercompare LSM output and validate against observations
- Construct and execute drought monitor processing system using LSM output and meteorological forcing data
- Analyze drought monitor output to determine effect of model selection and NARR climatology length on drought characterization, and to determine performance versus existing drought monitoring systems
- Transition system to real-time operations, disseminate data for use in NLDAS and other projects

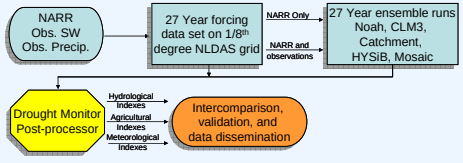


Figure 2. Overview of proposed NLDAS/NARR drought monitoring system. NARR and observed data sets are processed into 1/8th degree files which are used to force the ensemble LSM system. Drought indices are then produced based on LSM output and forcing data.

NARR-Based Drought Monitor Approach

Drought Index Overview:

- Drought monitor will compute several drought indices from NLDAS LSM output, NARR fields, and forcing data
- To aid in verification both standard and new NLDAS-based drought indices will be computed

	Drought Index	Drought Type	Required NARR/NLDAS Monitor Data	Comparison Data
Standard Indices	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	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

Table 1. Overview of drought indices that will be output by proposed drought monitor.

Index-based focus questions:

- How does the characterization of drought vary by LSM?
- What impact does use of the ensemble mean and ensemble spread have on drought detection?
- How do drought indexes produced by the ensemble LSMs and NARR land surface fields compare?
- Can a NARR/NLDAS system produce new drought indices which capture the same droughts detected by established measures such as PSDI and US Drought Monitor?
- How does NARR climatology-length affect drought characterization?

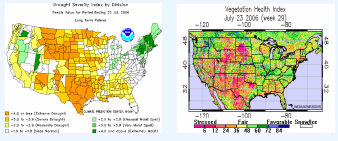


Figure 3. Example of Palmer Drought Severity and Vegetation Health Indices that will be used as comparison data for NARR-based monitor.

Forcing Data Used For Drought Monitor

- Compatible with current NLDAS systems (interpolated to hourly, 1/8th degree resolution) from 1979-Present
- Model base and observation overlay following NLDAS protocol

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	
GOES Radiation	2000-Present	Hourly	1/2 degree	Used in NLDAS
CPC Gauge	1979-Present	Daily	1/8th degree	PRISM, IDS Weighting
CPC Gauge	1979-Present	Hourly	2 X 2.5 degree	

Table 2. Overview of data sets used in NARR-based NLDAS drought monitor

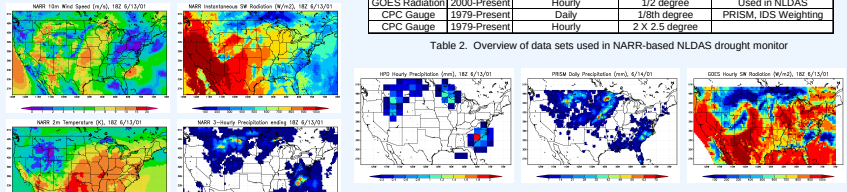


Figure 4. Sample of base datasets which will make up the NLDAS drought monitor forcing data set. Left: NARR precipitation (mm), 2m temperature (K), 10m wind speed (m/s), SW radiation (W/m²). Above: CPC HPD hourly precipitation (mm), CPC PRISM precipitation, GOES SW radiation (W/m²)

Prototype Real-time NLDAS Drought Monitor

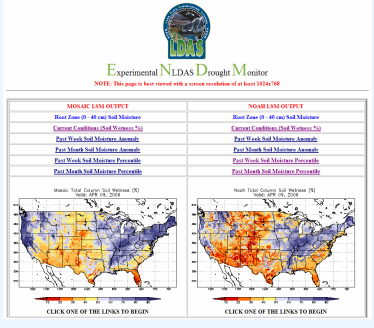
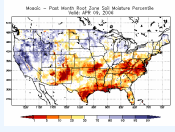


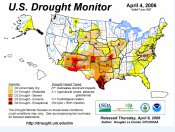
Figure 5. Prototype NLDAS drought monitor with Mosaic and Noah LSMs

- Prototype for NARR-based NLDAS drought monitor
- Mean root zone and total column soil wetness values were computed for each day of the year from the 1997-2005 NLDAS Mosaic and Noah output (1996 discarded due to spin-up) and stored in mean daily climatology files
- Anomalies are computed by comparing the near real-time data (past week/month) to the same time of the year in the mean climatology files
- 365 daily data distributions were also developed from the historic data using an 11-day data window (11 daily mean values)
- Percentiles are extracted by comparing (# greater/less than) the current soil wetness values (past week/month) against the daily data distributions

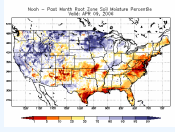
NLDAS – Mosaic LSM Output



NDMC – Weekly Drought Monitor



NLDAS – Noah LSM Output



CPC - Leaky Bucket Model

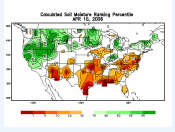


Figure 6. Comparison of NLDAS (Mosaic- and Noah-based), U.S. Drought Monitor, and CPC drought monitor fields at the start of April, 2006.

- Prototype NLDAS drought monitor modeled after existing websites:
  - http://www.hydro.washington.edu/forecast/monitor/index.shtml
  - http://hydrology.princeton.edu/forecast/
  - http://www.cpc.ncep.noaa.gov/soilmst/

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