Evaluation of Long-term and High-resolution NLDAS Products and Their Application to Operational Drought Monitoring and Prediction

Youlong Xia¹, Michael B. Ek¹, Justin Sheffield², Eric Wood², Brian Cosgrove³, Kingtse Mo⁴, David Mocko⁵, Ben Livneh⁶, and Eric Luebehusen⁷

¹ Environmental Modeling Center, NCEP/NOAA, Camp Springs, MD
² Department of Civil and Environmental Engineering, Princeton U, NJ
³ Office of Hydrologic Development, NWS/NOAA, Silver Spring, MD
⁴ Climate Prediction Center, NCEP/NOAA, Camp Springs, MD
⁵ Hydrological Sciences Branch, GSFC/NASA, Greenbelt, MD
⁶ Department of Civil and Environmental Engineering, U Washington, Seattle, WA
⁷ USDA, World Agricultural Outlook Board, Washington DC

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This work is associated with three workshop objectives:

(1) Agricultural and hydrological drought products for regional applications

(2) Close collaboration with NASA and the other NLDAS partners including assessment and application of NLDAS products to operational drought monitoring and prediction

(3) Use of NASA GES DISC system to effectively distribute NLDAS products to users
Drought Monitoring and Prediction

Agricultural drought, hydrologic drought, meteorological drought, etc.

Indices from precipitation, air temperature, soil moisture, total runoff/streamflow, evaporation, etc.

Evaluation of Soil Moisture and Streamflow

How Reliable?
Evaluation of Simulated Soil Moisture

(Xia et al., JHM, 2011, in preparation)

Focus on top 1 m and 2 m soil moisture used in NLDAS monitor and operations

Three Soil Moisture Data Sets:
- Illinois state – 17 sites, monthly, 1985-2004
- Oklahoma Mesonet – 72 sites, hourly, 1997-2002
- USDA/SCAN – 121 sites, daily, 2002-2009

Soil Climate Analysis Network (SCAN)

Six regions are divided
Monthly anomaly correlation for top 2 m

NLDAS: Noah = 0.82, Mosaic = 0.63, SAC = 0.78, VIC = 0.76

Other NCEP Products from Noah model: GR2 = 0.47, NARR = 0.67, CFSR = 0.61
High anomaly correlation means quite robust NLDAS soil moisture product.

Top 1 m soil moisture anomaly correlation

- Daily
- Monthly

1997-2002 averaged soil moisture comparison

OBS, Noah, Mosaic, SAC, VIC have the smallest error, the other three models, in particular SAC, underestimate observed soil moisture, and however, all models capture daily and seasonal variation of observed soil moisture well.
Spatial averaged daily top 1m soil moisture anomaly correlation over continental United States

U.S. Soil Climate Analysis Network (SCAN), 1 January 2002 - 31 December 2009
SCAN (Continue)

8-year averaged top 1 m volumetric soil moisture comparison

(a) Southeast

(b) Northeast

(c) Great Plains

(d) Midwest

(e) Northwest

(f) Southwest

Noah: low E, High R, wet soil wetness, will be fixed soon

Irrigation, farming, ground water capillary effect?

Large available water holding capacity?
1. All models capture variability of daily and monthly soil moisture well

2. Overall performance of four-model ensemble mean is more robust

3. Models indeed display biases to simulate observed soil moisture, and need to be further investigated

4. NLDAS top 1m and 2m soil moisture products can be used to agricultural drought monitoring and prediction. More in situ soil moisture observations are needed for further evaluation
Evaluation of Simulated Streamflow

(Xia et al., JGR, 2011, submitted)

USGS Streamflow – daily, 961 small – medium size basins and 8 large basins, 1979-2007

Mean annual relative bias SIM-OBS/OBS, (OCT 1979 – SEP 2007) different model version and the same forcing

Negative bias reduced

Positive bias reduced

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Monthly Anomaly Correlation
Small Basins

(1) Ensemble-mean has higher simulation skill than individual model
(2) SAC and VIC (hydrological community), perform better than Noah and Mosaic (land model community)
Cumulative Distribution Function (CDF) for different time scales

SAC and VIC are more skillful than Noah and Mosaic

Ensemble-mean performs the best
Anomaly Correlation
Large Basins

Monthly anomaly of simulated and observed streamflow

- Columbia
- Missouri
- Ohio
- Arkansas
- Mississippi
- Potomac
- Colorado
- Alabama

Gray – OBS, Black – MM, red – Noah, green – Mosaic, blue – SAC, orange - VIC

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Evaluation of Simulated Streamflow Summary

1. Ensemble-mean has the highest skill when compared with individual model, and hydrological models (SAC, VIC) have higher skills than land surface models (Noah, Mosaic).

2. Anomaly correlation is high in the east of U.S. and western coast, and it is low in interior dry states. This conclusion is true for both small and large basins except heavily regulated Colorado basin.

3. NLDAS total runoff/streamflow can be used for hydrological drought monitoring and prediction for different time scales varying from day to year.

4. Bias between simulated and observed streamflow needs to be reduced in future by the collaboration with our NLDAS partners.
Application to Drought Monitor and Prediction

NLDAS Products

NLDAS Drought Monitor and Prediction

USMD Author Group

CPC Monthly Drought Briefing

CPC Seasonal Drought Outlook

Public and Private Sectors

Regional Climate Centers

Others?

Daily Cron Job

Model Outputs and Plots

Graphics

Graphics

Graphics
Summary and Future Work

NLDAS is in quasi-operational mode now and will be transitioned to NCEP operations.

Further NLDAS products evaluation/validation, e.g., ET using MODIS Product, Arm/Cart, AmeriFlux

Extend current NLDAS to run under the NASA Land Information System (LIS) & to assimilate land-data, e.g. snow, soil moisture, etc.

Improve land-surface models (physics) through collaboration with NLDAS and other partners.

Continue to provide support for NCEP Climate Prediction Center and National Integrated Drought Information System.
Further Validation Underway
Both in situ and remote sensing data

Energy flux validation from tower: net radiation, sensible heat, latent heat, ground heat

Water flux: evaporation, total runoff/streamflow

State variables: soil moisture, soil temperature, skin temperature, snow water equivalent, snow cover

NLDAS Validation: Fluxnet data sets
Monthly diurnal average surface latent and sensible heat flux: Chestnut Ridge, TN, 2008

One of Ameriflux stations

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Thanks for your attention!

Welcome to use NLDAS products

NOAA NLDAS Website
http://www.emc.ncep.noaa.gov/mmb/nldas/

NASA NLDAS Website
http://ldas.gsfc.nasa.gov/nldas/

Comments and Suggestions to:
NLDAS: Youlong.Xia@noaa.gov, Michael.Ek@noaa.gov

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