Quality and Possible Contribution of Multi-Model NLDAS-2 Products to Coordinated National Soil Moisture Network

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NLDAS Land Surface Models: NCEP/Noah, NASA/Mosaic, NWC/SAC, and Princeton/Washington/VIC

- **NLDAS Product**s:

  water fluxes – precipitation, runoff, routed streamflow, snowmelt, sublimation, ET;

  energy fluxes – downward/upward shortwave and longwave radiation, net radiation, sensible heat flux, latent heat flux, ground heat flux;

  state variables – soil temperature, soil moisture (liquid, frozen, total), skin temperature, SWE, snow cover and fraction.

- **Product evaluation/validation**
  Using in situ observations, remote sensing data, and reanalysis data to compressively evaluate almost all NLDAS products for different spatial and temporal scales. For more details, please see NASA NLDAS website:

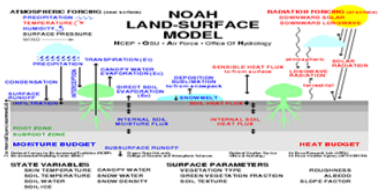
http://ldas.gsfc.nasa.gov/nldas/NLDAS2valid.php
http://ldas.gsfc.nasa.gov/nldas/NLDASpublications.php

- NLDAS is a multi-model land modeling and data assimilation system…
- …run in uncoupled mode driven by atmospheric forcing (using surface meteorology data sets)…
- …with *"long-term"* retrospective and near real-time output of land-surface water and energy budgets.

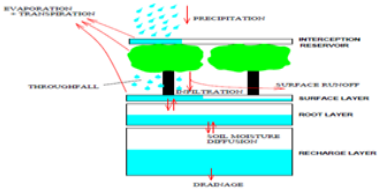
NLDAS Configuration: Land models

- Uncoupled ("offline") simulations.
- Input: atmospheric forcing.
- Output: water/energy budgets (surface fluxes, land states)

Atmospheric Community

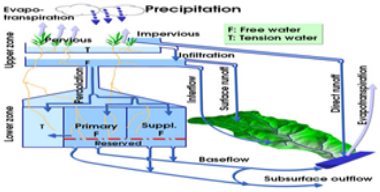


Noah
NCEP operational land model

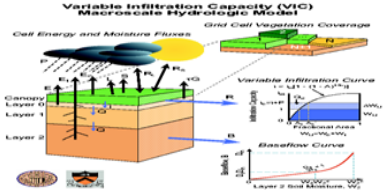


Mosaic
NASA GSFC

Hydrology Community



SAC
NWS operational hydrological model



VIC
Princeton & U. Washington

NLDAS Soil Moisture and Temperature

- **NLDAS Reliability:** NCEP operational product with a 4-day lag
  Resolution: spatial – 0.125 degree (~12-14 km), temporal –hourly (daily, monthly, yearly)
- **Vertical Soil Depth**: 0-10 cm (5cm at mid-soil layer), 10-40 cm (25 cm), 40-100 cm (70 cm), 100-200 cm (150cm). SAC and VIC use their post-processes to convert simulated soil moisture to Noah soil layers. Only Noah and VIC has four layers soil temperature.
- **Covering Period**: 02 January 1979 - present

Near Future NLDAS Update

Achieve Actual Real-time by Closing the 4-day lag (~ 1-2 years)

Upgrade Land Surface Models: Noah-2.8 → Noah-3.6; Mosaic → Catchment Model; SAC → SAC-HT-ET; VIC-4.0.3 → VIC-4.1.2; Possibly add Noah-MP to NLDAS system. All models will include soil temperature output (~2-4 years)

Achieve Actual Data Assimilation by using remotely sensed soil moisture, snowpack and GRACE TWS data (~2-4 years)

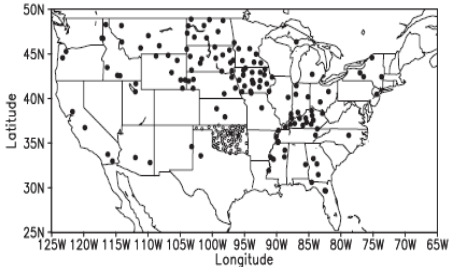
For more details about NLDAS system, please see NLDAS overview poster from Xia et al. and NLDAS Science Testbed poster from Mocko et al. Please also follow NLDAS-DA talk from Kumar et al.

NLDAS Noah Soil Temperature Validation

J. Appl. Meteorol. Climatol.,52, 455-471 , 2013

Validation of Noah-Simulated Soil Temperature in the North American Land Data Assimilation System Phase 2

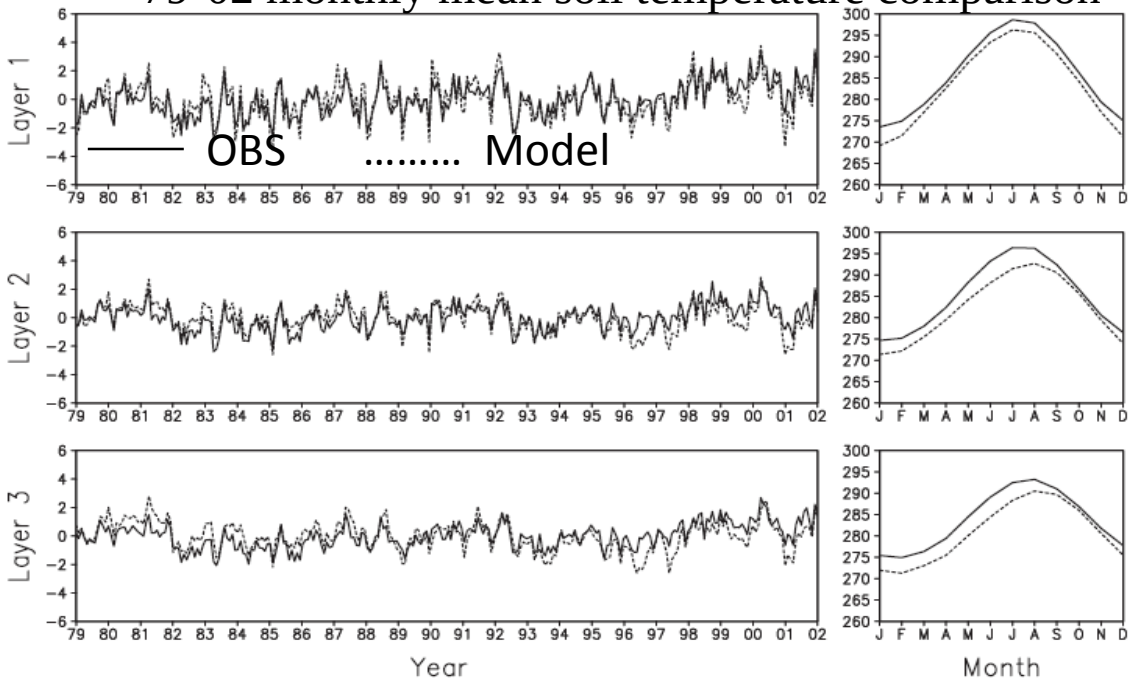
YOULONG XIA,*,+ MICHAEL EK,+ JUSTIN SHEFFIELD,# BEN LIVNEH,@ MAOYI HUANG,& HELIN WEI,*,+ SONG FENG,** LIFENG LUO,++ JESSE MENG,*,+ AND ERIC WOOD#

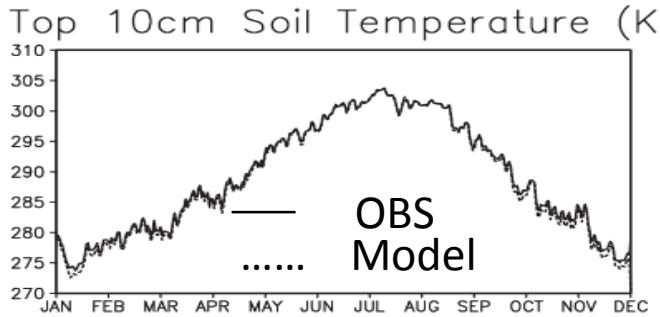


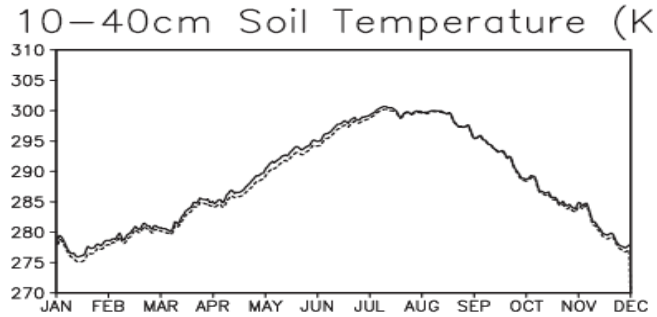
137 US cooperative station and 72 Oklahoma Mesonet stations

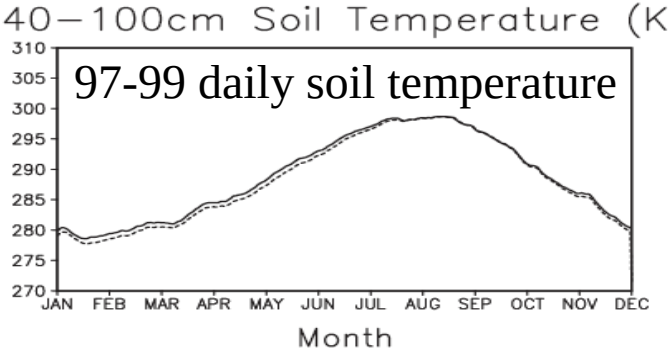
Errors < 3°C for most cases

79-02 monthly mean soil temperature comparison







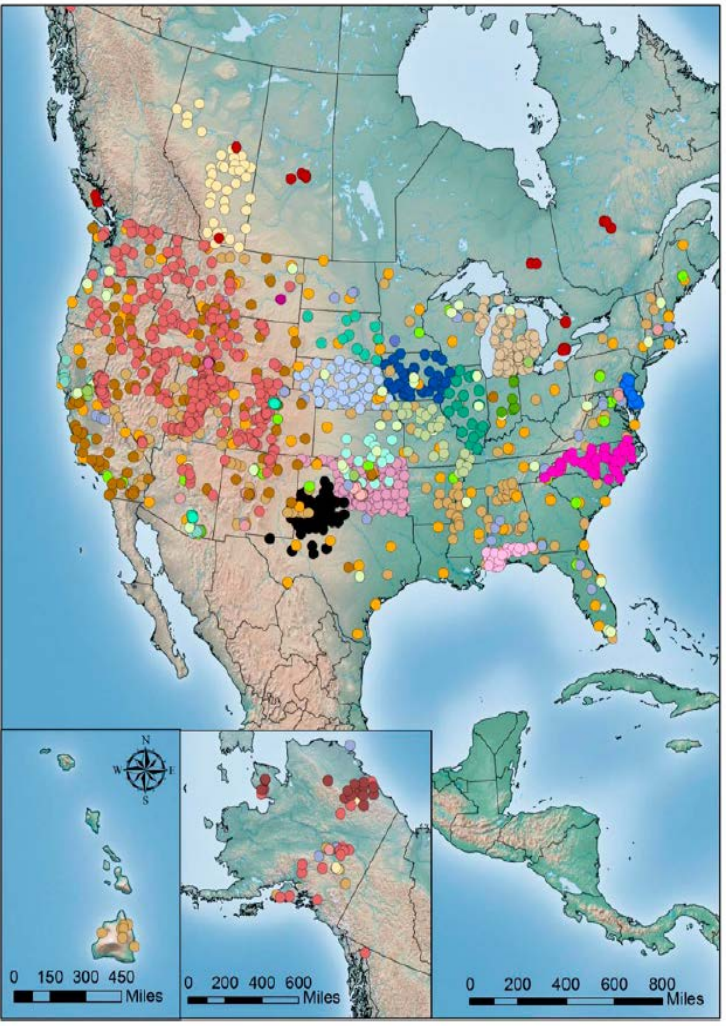


NLDAS soil temperature helps control NASMD data

J. Appl. Meteorol. Climatol., 54, 1267-1282, 2015

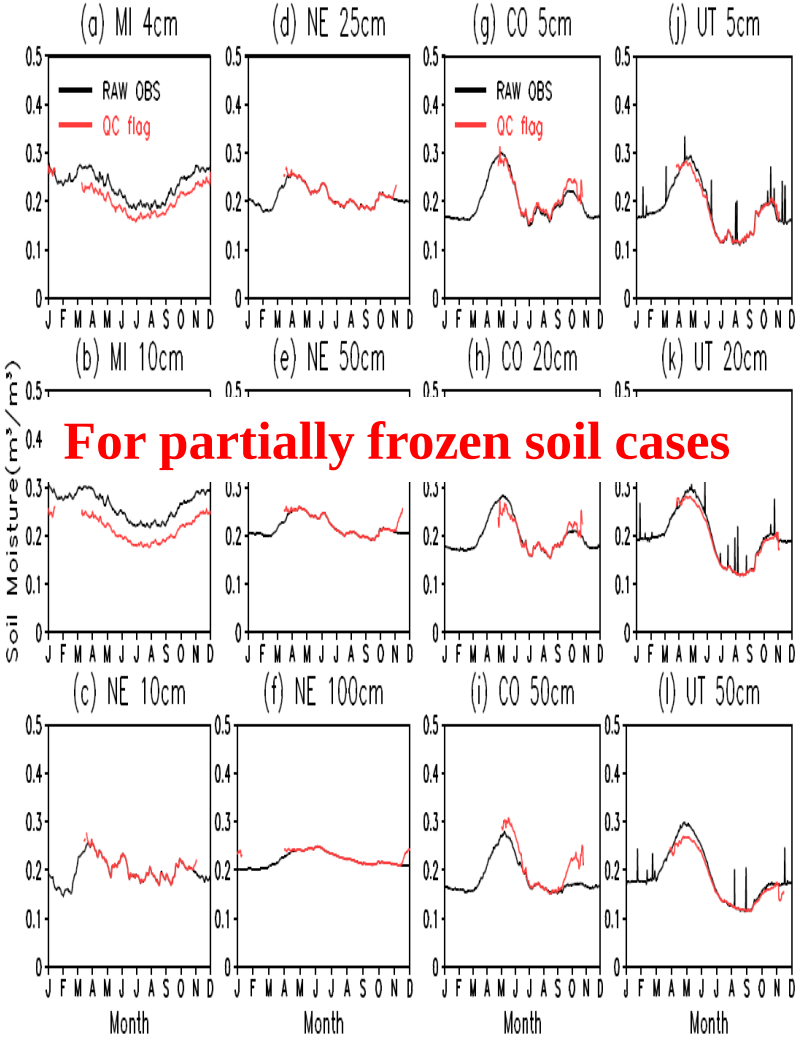
Automated Quality Control of In Situ Soil Moisture from the North American Soil Moisture Database Using NLDAS-2 Products

YOULONG XIA, TRENT W. FORD, YIHUA WU, STEVEN M. QUIRING, AND MICHAEL B. EK



Networks

- Agricultural Research Service
- Alberta Agriculture and Rural Development
- AmeriFlux
- Atmospheric Radiation Measurement
- Automated Weather Data Network
- CHILI
- Central Plains Experimental Range
- Climate Reference Network
- Cosmic Ray Soil Moisture Observing Station
- Critical Zone Observatory
- Delaware Environmental Observing System
- ECONET
- Fluxnet Canada
- GPS Soil Moisture
- ISGMN
- Illinois Climate Network
- Iowa Historical Soil Moisture
- Livestock and Range Research Laboratory
- Long Term Ecological Research Network
- Michigan Automated Weather Network
- Missouri AgEBB
- NOAA HMT
- National Ecological Observatory Network
- Oklahoma Mesonet
- SNOTEL
- Soil Climate Analysis Network
- Soilscape
- South Dakota Automated Weather Network
- Southwest Research and Outreach Center
- TW Daniels Experimental Forest
- Water and Environmental Research Center
- West Texas Mesonet



For partially frozen soil cases

NLDAS soil moisture evaluation in Soil and Climate Analysis Network (SCAN)

Journal of Hydrology 512 (2014) 107–125

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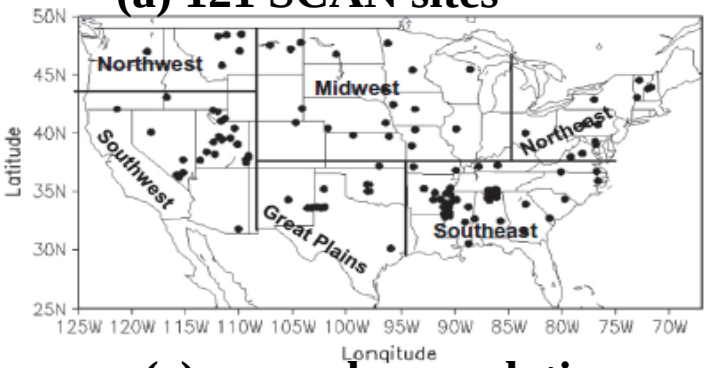
journal homepage: www.elsevier.com/locate/jhydrol

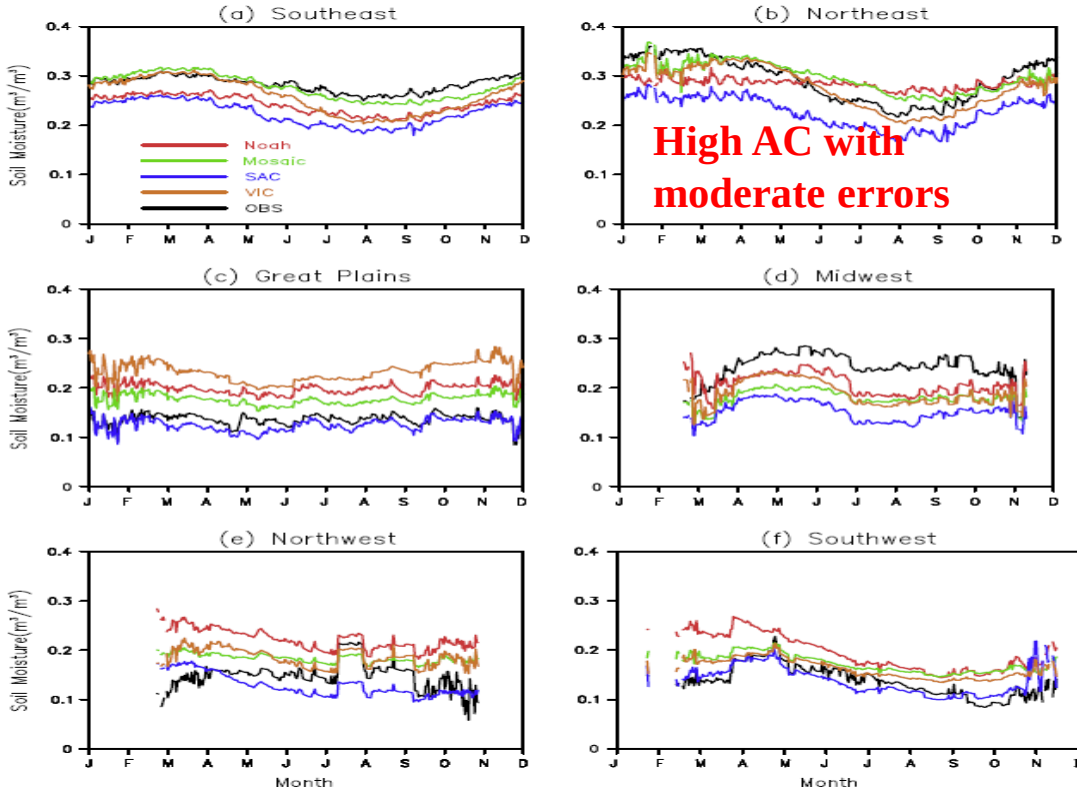
Evaluation of multi-model simulated soil moisture in NLDAS-2

Youlong Xia [a,b,*], Justin Sheffield [c], Michael B. Ek [a], Jiarui Dong [a,b], Nathaniel Chaney [c], Helin Wei [a,b], Jesse Meng [a,b], Eric F. Wood [c]

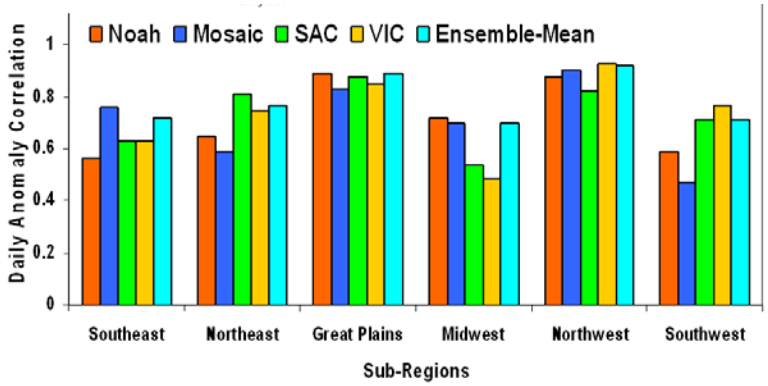
(a) 121 SCAN sites



(b) 8-year (2002-2009) mean daily top 1m soil moisture



(c) anomaly correlation

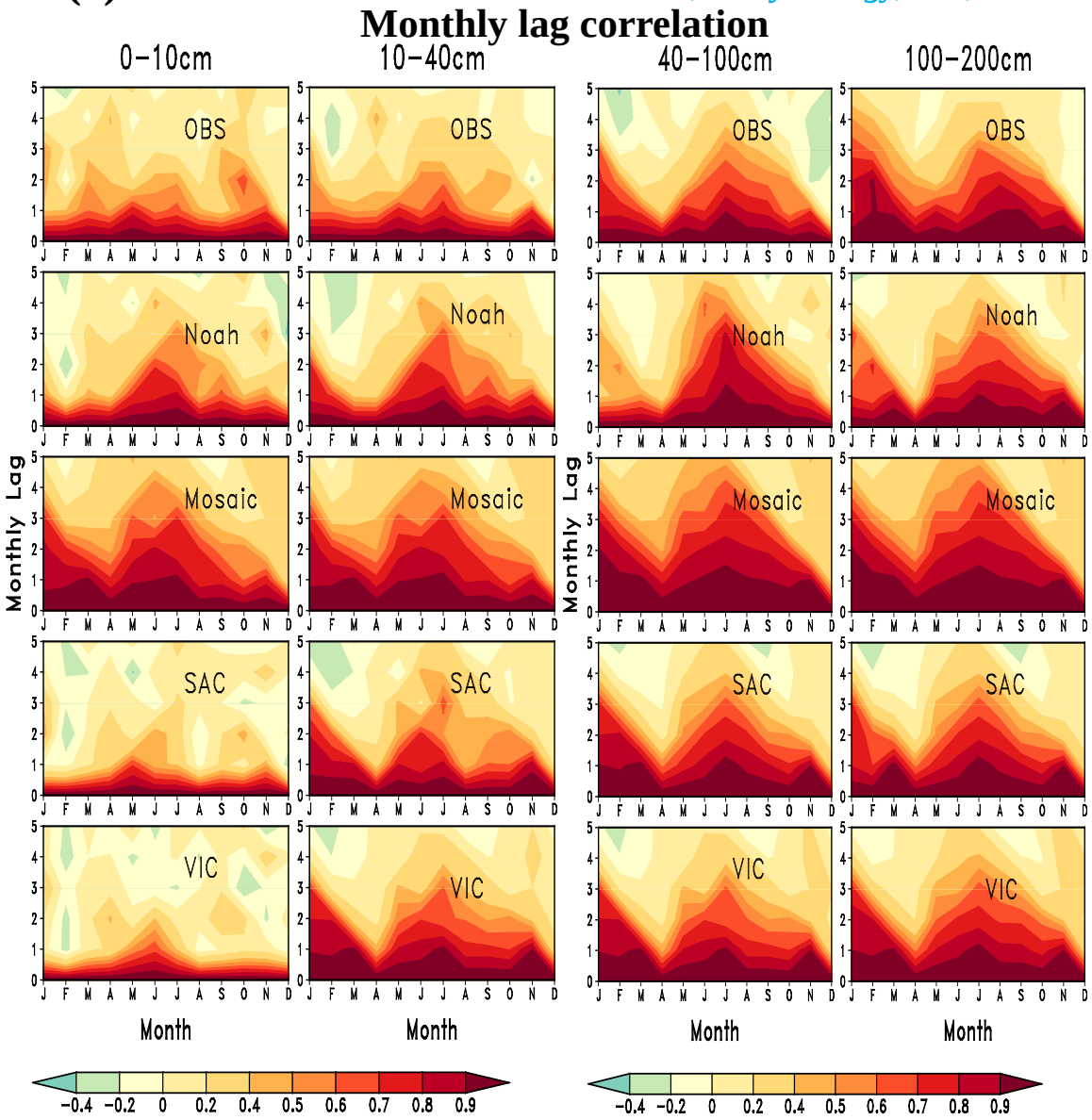


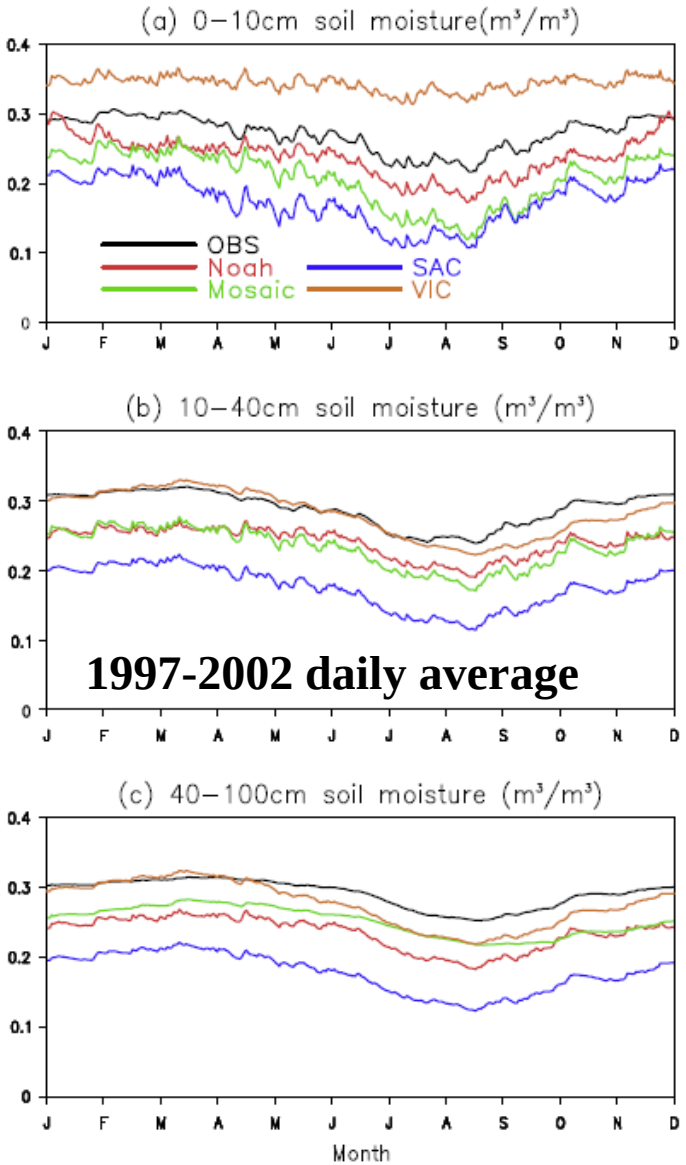
NLDAS soil moisture evaluation in Illinois and Oklahoma Mesonet

(a) Illinois

Xia et al., J. Hydrology, 512, 107-125, 2014

(b) Oklahoma



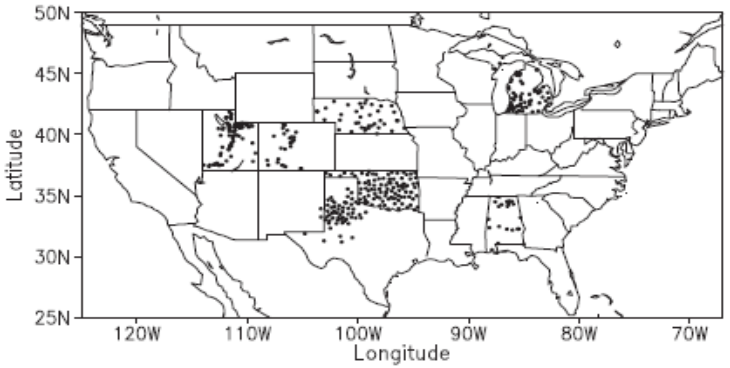


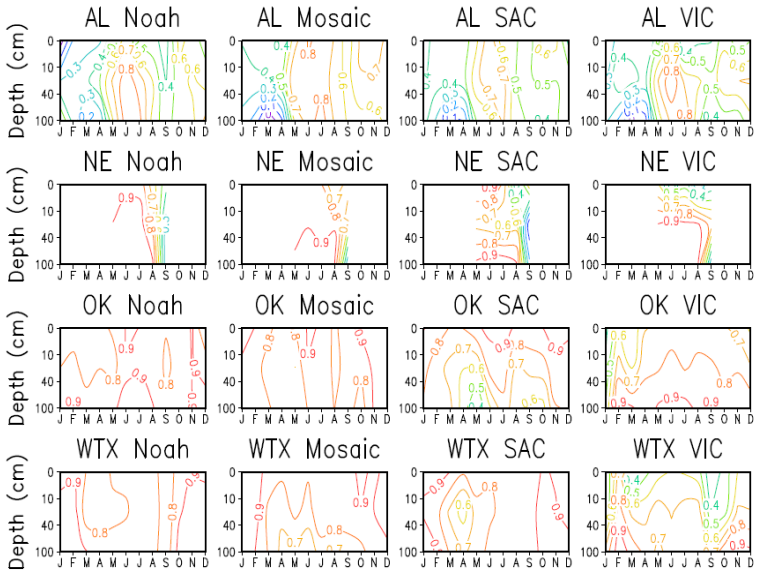
NLDAS soil moisture evaluation in North American Soil Moisture Database (NASMD)

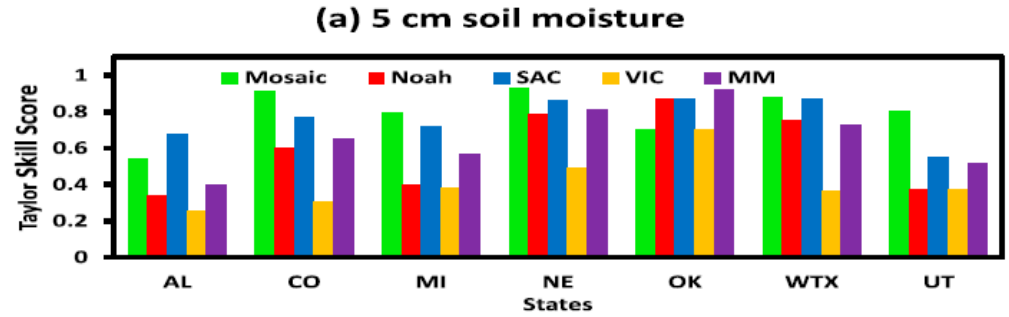
J. Hydrometeor., 16, 1962-1980, 2015

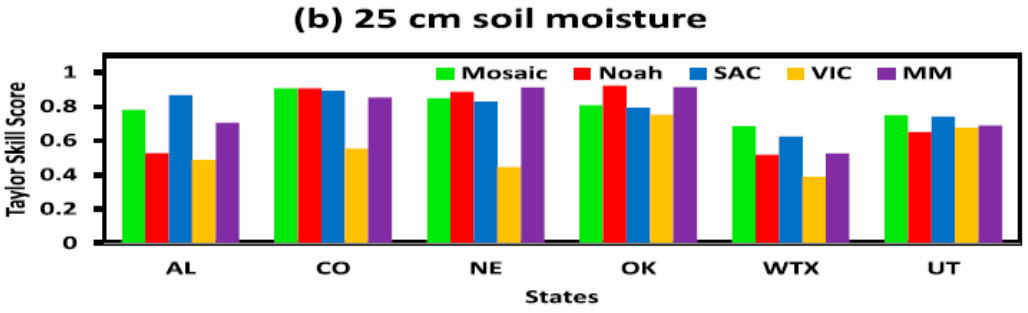
Comparison of NLDAS-2 Simulated and NASMD Observed Daily Soil Moisture. Part I: Comparison and Analysis

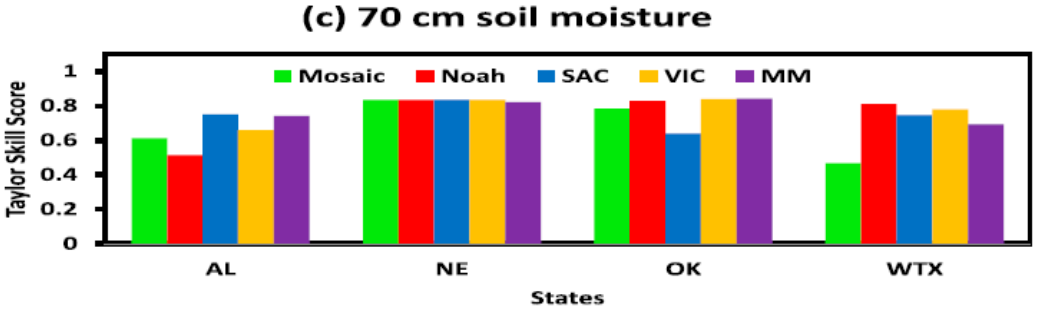
YOULONG XIA, MICHAEL B. EK, YIHUA WU, TRENT W. FORD, AND STEVEN M. QUIRING







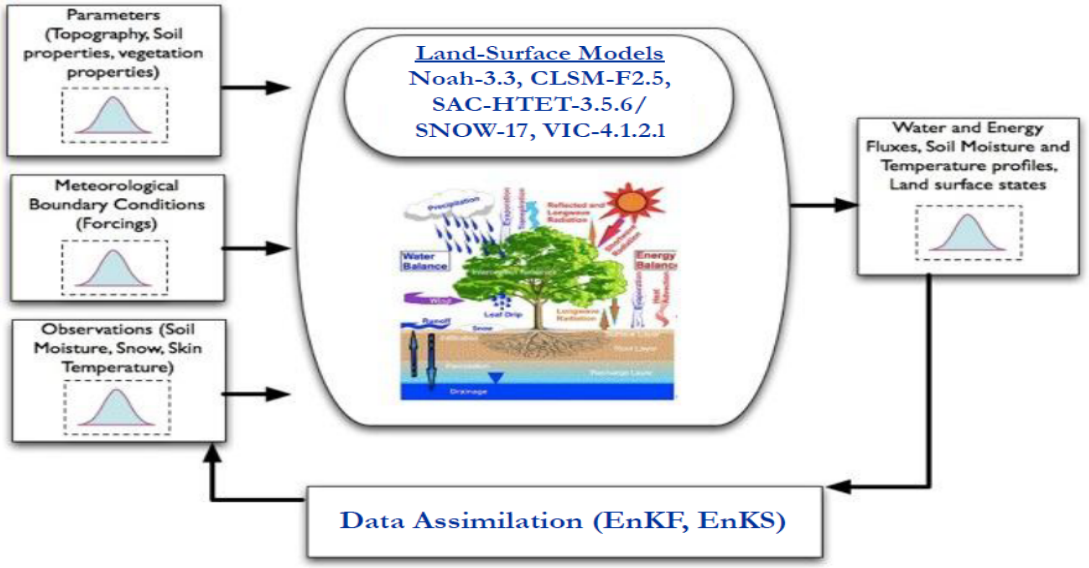




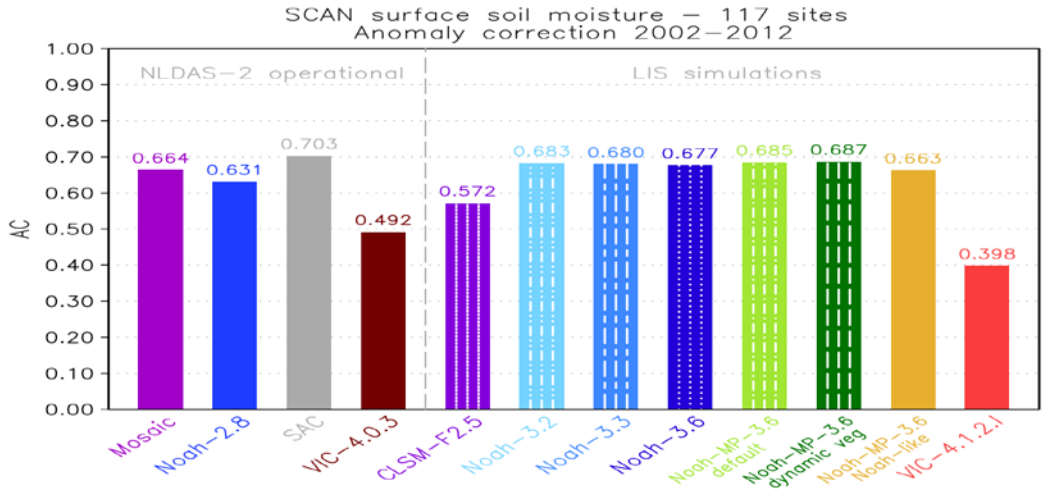
Improvement of NLDAS soil moisture via (1) upgrading model physics and (2) adding actual assimilation process

1979-present NLDAS-2 Forcing and Parameters

Data assimilation of: soil moisture, snow depth/area, terrestrial water storage (TWS), and irrigation intensity

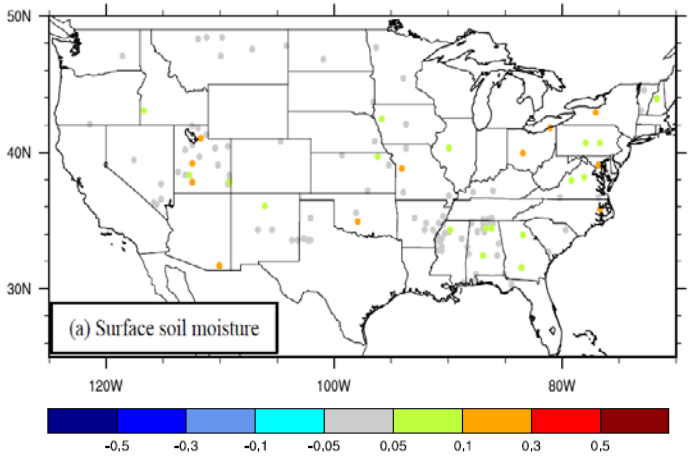


Kumar et al., 2016, J. Hydrometeor. (in press)



5 cm soil moisture evaluation

CLSM-F2.5 with GRACE DA



Warm color - significant improvement

Future work plan

- To close 4-day lag to achieve actual real-time NLDAS system to meet the public requirements
- To transition LIS-based NLDAS system developed at NASA to NCEP to move toward operational implementation (R2O)
- To establish NLDAS science and evaluation testbed to help R2O task via O2R experiments
- To extend NLDAS to North America and 1/8th degree to 3~4 km
- To unify NLDAS with GLDAS to form unified LDAS system at NCEP
- To improve surface forcing, to upgrade soil and vegetation parameter datasets, to add irrigation, vegetation dynamics, groundwater dynamics, lake model , ecosystem processes, biochemistry, carbon and nitrogen dynamics etc.