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Uncertainties in the North American Land Data Assimilation Systems

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ABSTRACT

The National Centers for Environmental Prediction's (NCEP) Environmental Modeling Center (EMC) and the University of Washington (UW) run parallel drought monitoring systems based on the North American Land Data Assimilation System (NLDAS). Both systems use a suite of land surface models, one of which is the Variable Infiltration Capacity (VIC) model. We performed an assessment of differences in drought characteristics estimated using both systems for the period 1979-2006. For soil moisture (SM) percentiles and runoff indices, differences are small among different models in the same system. However, the ensemble mean differences between the two systems are large over the western United States - in some cases exceeding 20% for SM and runoff percentile differences. These differences are most apparent after 2002. We found that precipitation forcing differences are the source of the SM and runoff differences - while temperature forcing differences are also large after 2002, their contribution to SM and runoff differences are much smaller than for precipitation.

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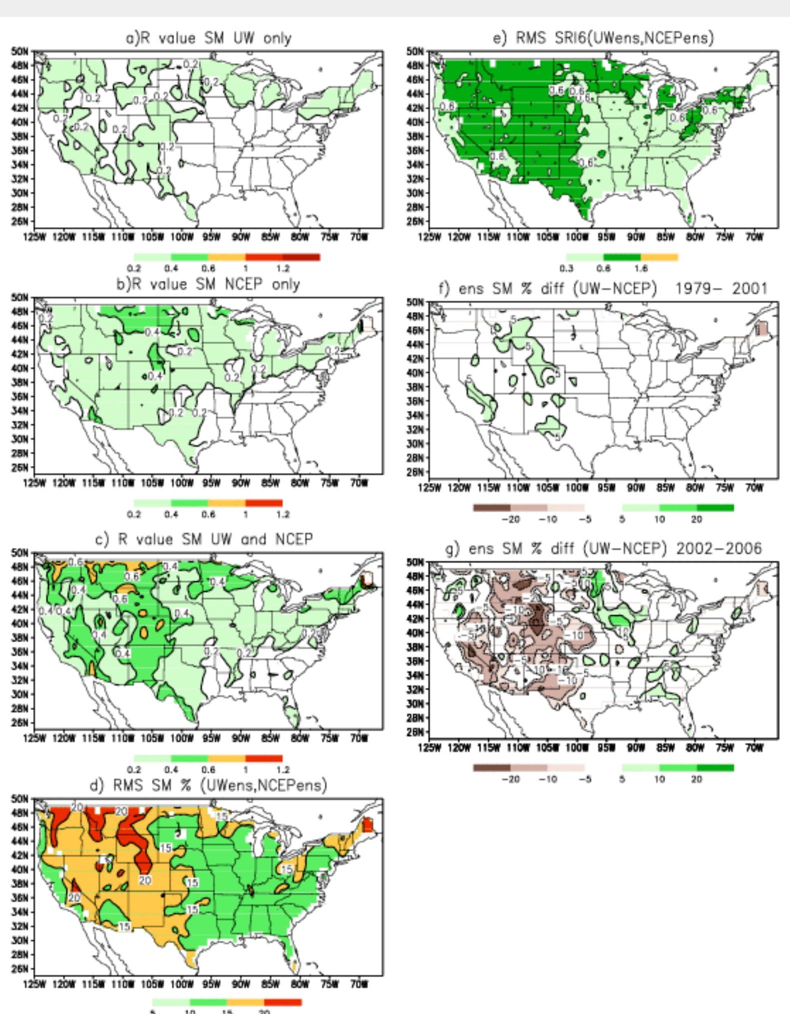
BACKGROUND

- The National Centers for Environmental Prediction (NCEP) (http://www.emc.ncep.noaa.gov/mmb/nldas/drought/) and the University of Washington (UW) (http://www.hydro.washington.edu/forecast/monitor/) run parallel drought monitoring systems over the continental U.S. based on the North American Land Data Assimilation System (NLDAS).
- Both systems use a suite of land surface models (LSMs).
- Both systems are used by USDM authors and the National Integrated Drought Information System (NIDIS) community to classify droughts.
- The ensemble mean differences between the two systems are large over the western United States – in some cases exceeding 20% for Soil Moisture Percentile (SMP) and Standardized Runoff Index-6 (SRI-6) differences, which is too large for drought classification purposes.

Objective:

To assess the sources of these differences (uncertainties) in drought indices derived from the two systems

UNCERTAINTIES IN NCEP AND UW SYSTEMS



- The differences among multiple models In the same system are small (Fig. 1 (a) and (b))
- The differences among soil moisture percentile (SMP) and SRI-6 of both systems are particularly large over the western U.S. and during 2002-2006 (Fig. 1 (c), (d), (e) (f) and (g))
- The NCEP system started to use real-time forcings in 2002 and UW system went real-time in 2005.

Figure 1: (a) R values (the ratio of the variance of the inter-model spread and the interannual variance of the ensemble means) for soil moisture percentile (SMP) between members of the UW system. Contour interval is 0.2; (b) same as (a), but for the NCEP system; (c) same as (a), but for all eight members of the UW and NCEP systems combined; (d) Root Mean Square (RMS) difference of the ensemble mean of SMP between the UW and NCEP systems. Contour interval is 5%; (e) same as (d) but for SRI-6. Contour interval is 0.3; (f) difference of the ensemble mean of SMP between the UW and NCEP systems (UW-NCEP) averaged over the historical period (1979-2001). Contour interval is 5%. Zero contours are omitted; and (g) same as (f), but for the real-time period (2002-2006).

EXPERIMENTAL SETUP

Model used: Variable Infiltration Capacity (VIC) model.
Spatial resolution: ½ degree
Spatial domain: Contiguous United States
Period of analysis: 1979-2008.

- We first conducted control experiments for both systems and then a set of experiments to estimate the impact of differences in Precipitation, Temperature (both Tmax and Tmin) and radiation and sp. humidity forcings on the differences in SMP and SRI-6 values (Table 1).

P forcings: Precipitation
F forcings: Tmax, Tmin and Wind speed
LW: Longwave raditaion
SW: Shortwave radiation

Table 1: List of experiments

Control experiments				
Exp (F_{UW},P_{UW})	UW Initial state	UW P forcings	UW F forcings	
Exp (F_{NCEP},P_{NCE})	UW Initial state	NCEP P forcings	NCEP F forcings	
1: Impact of differences in precipitation forcings				
Exp (F_{UW},P_{NCEP})	UW Initial state	NCEP P forcings	UW F forcings	
Exp (F_{NCEP},P_{UW})	UW Initial state	UW P forcings	NCEP F forcings	
2: Impact of differences in temperature forcings				
Exp (F_{NCEP},P_{UW})	UW Initial state	UW P forcings	NCEP F forcings	
Exp (F_{UW},P_{NCEP})	UW Initial state	NCEP P forcings	UW F forcings	
3: Impact of differences in radiation and humidity forcings forcings				
Exp (Rad_{UW})	UW Initial state	UW P forcings	UW F forcings	LW, SW and Sp. humidity estimated internally
Exp (Rad_{NCEP})	UW Initial state	UW P forcings	UW F forcings	NCEP LW, SW and Sp. Humidity provided externally

RESULTS

1: Impact of differences in precipitation forcings

RMS SMP　RMS SRI-6

Exp (F_{UW},P_{NCEP}) – Exp (F_{UW},P_{UW})

Exp (F_{NCEP},P_{UW}) – Exp (F_{NCEP},P_{NCEP})

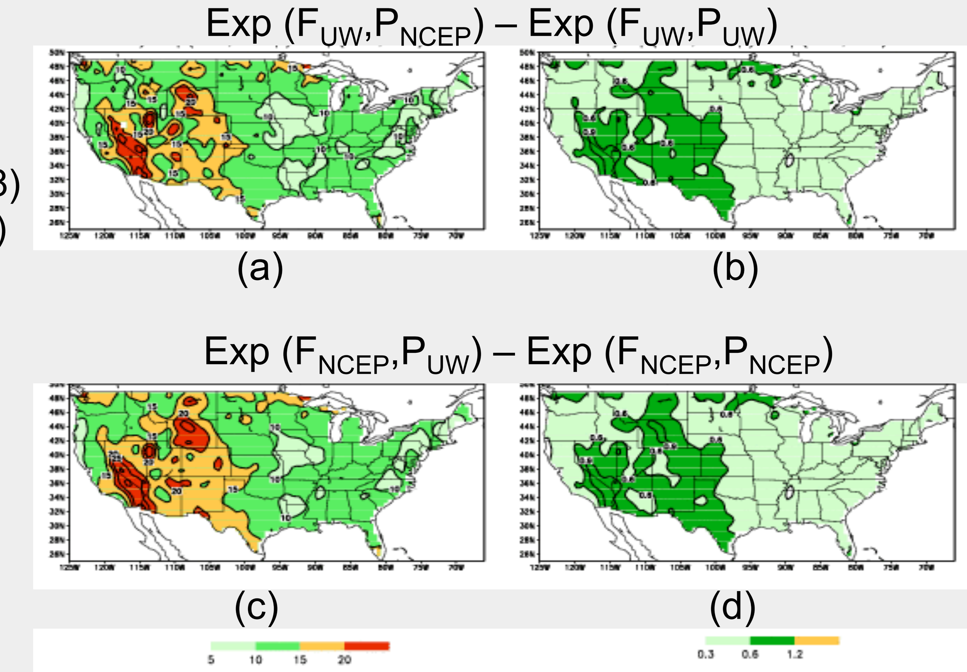


Figure 2: Root Mean Square (RMS) difference in (a) SMP and (b) SRI-6 for the period (1979-2008) between Exp(F_{UW}, P_{NCEP}) and Exp(F_{UW}, P_{UW}). Contour interval is given by the color bar; (c) and (d) same as (a) and (b) respectively but showing the differences between Exp(F_{UW}, P_{NCEP}) and Exp(F_{UW}, P_{UW})

2: Impact of differences in temperature forcings

RMS SMP　RMS SRI-6

Exp (F_{UW},P_{UW}) – Exp (F_{NCEP},P_{UW})

Exp (F_{UW},P_{NCEP}) – Exp (F_{NCEP},P_{NCEP})

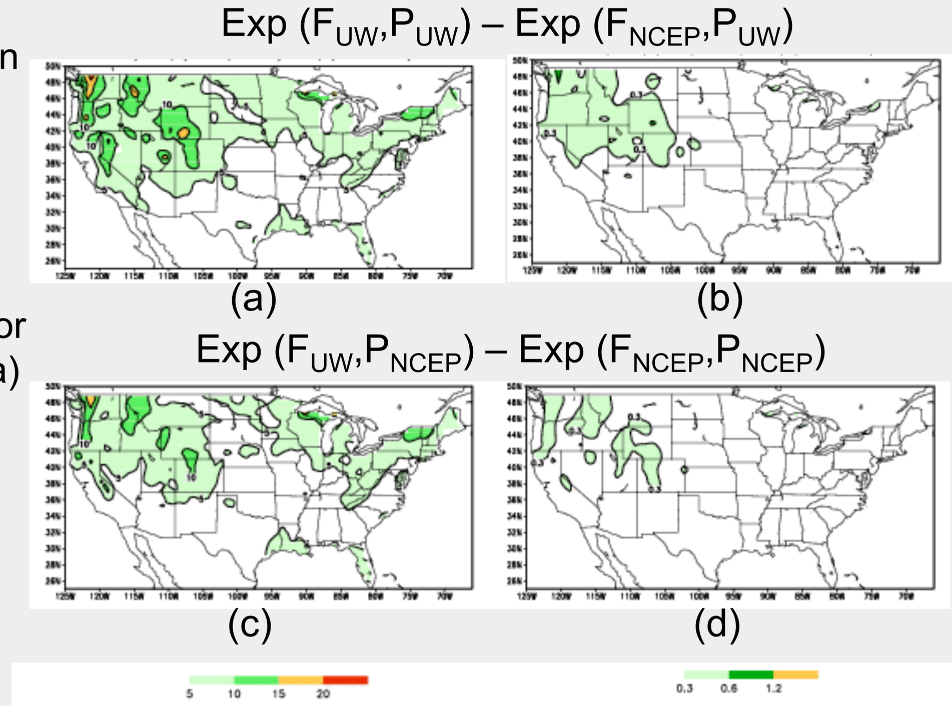


Figure 3: RMS difference in (a) SMP and (b) SRI-6 for the experimental period (1979-2008) between Exp(F_{UW}, P_{UW}) and Exp(F_{NCEP}, P_{UW}). Contour interval is given by the color bar; (c) and (d) same as (a) and (b) respectively but showing the differences between Exp(F_{UW}, P_{NCEP}) and Exp(F_{NCEP}, P_{NCEP})

RESULTS (cont.)

3: Impact of differences in radiation and humidity forcings

RMS SMP　RMS SRI-6

Exp (Rad_{UW}) – Exp (Rad_{NCEP})

Figure 4: RMS difference in (a) SMP and (b) SRI-6 between Exp (Rad_{UW}) and Exp (Rad_{NCEP})
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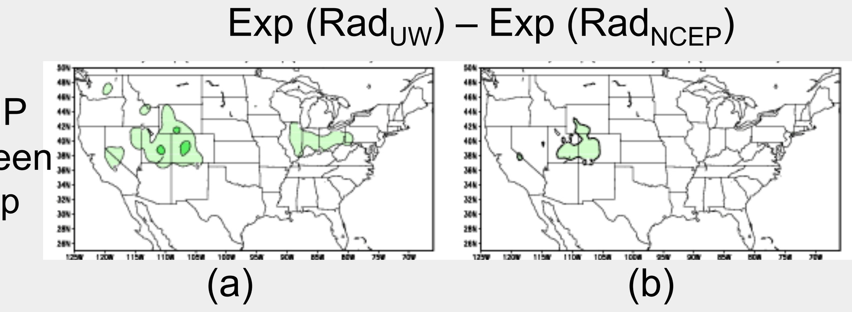

CONCLUSIONS AND DISCUSSION

- Based on the experiments conducted we conclude that differences in precipitation forcings are the main source of uncertainties in the UW and NCEP systems.
- The uncertainties are particularly large post 2001 due to decrease in the number of stations reporting valid data in real-time especially in the NCEP system.

For example as shown in the figure below the number of precipitation gauges reporting data used by NCEP decreased substantially post 2001. This pattern is observed to a lesser extent among UW index stations post 2004.

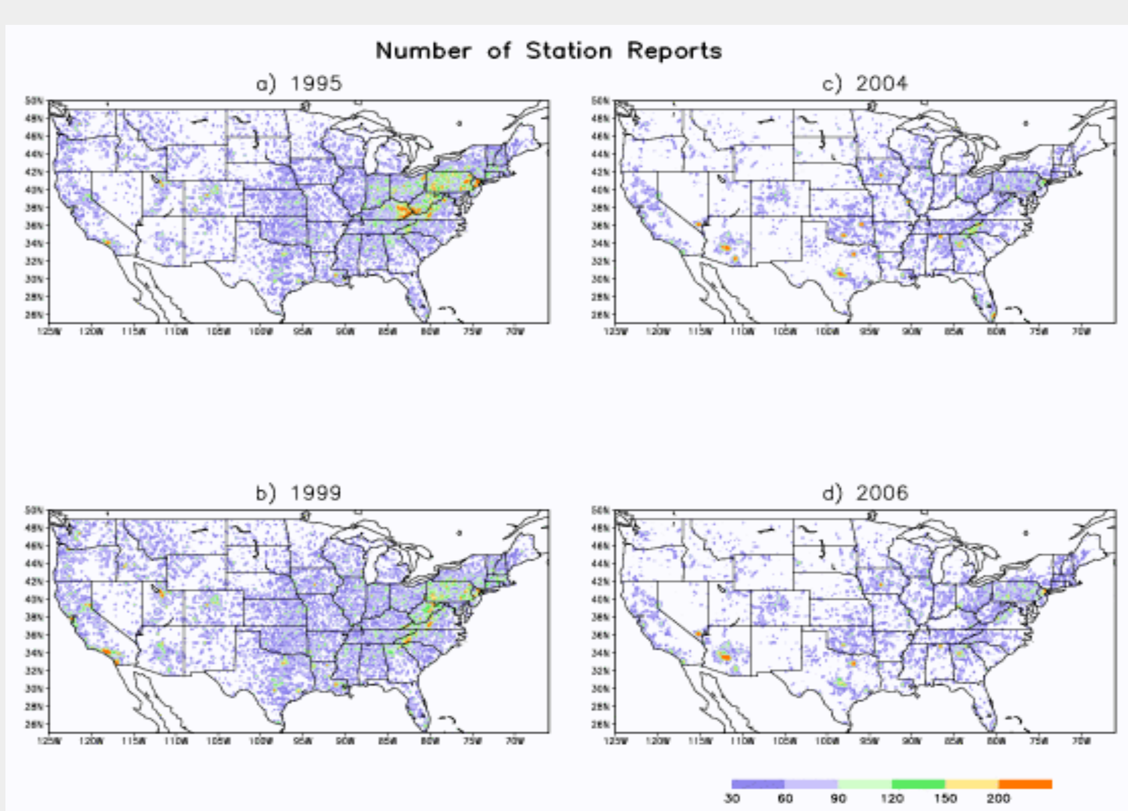

Figure 5: Number of precipitation gauge reports per grid box per month for the NCEP system averaged for Years (a) 1995, (b) 1999, (c) 2004, and (d) 2006. Colors indicate the range of report numbers.

REFERENCE

Mo, K. C., L. Chen, S. Shukla, T. Bohn, and D. P. Lettenmaier. 2011. Uncertainties in north american land data assimilation systems over the contiguous United States. *J. Hydrometeor.* (Submitted)

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