An Integrated Terrestrial Water Analysis System for the NCA (NCA-LDAS)

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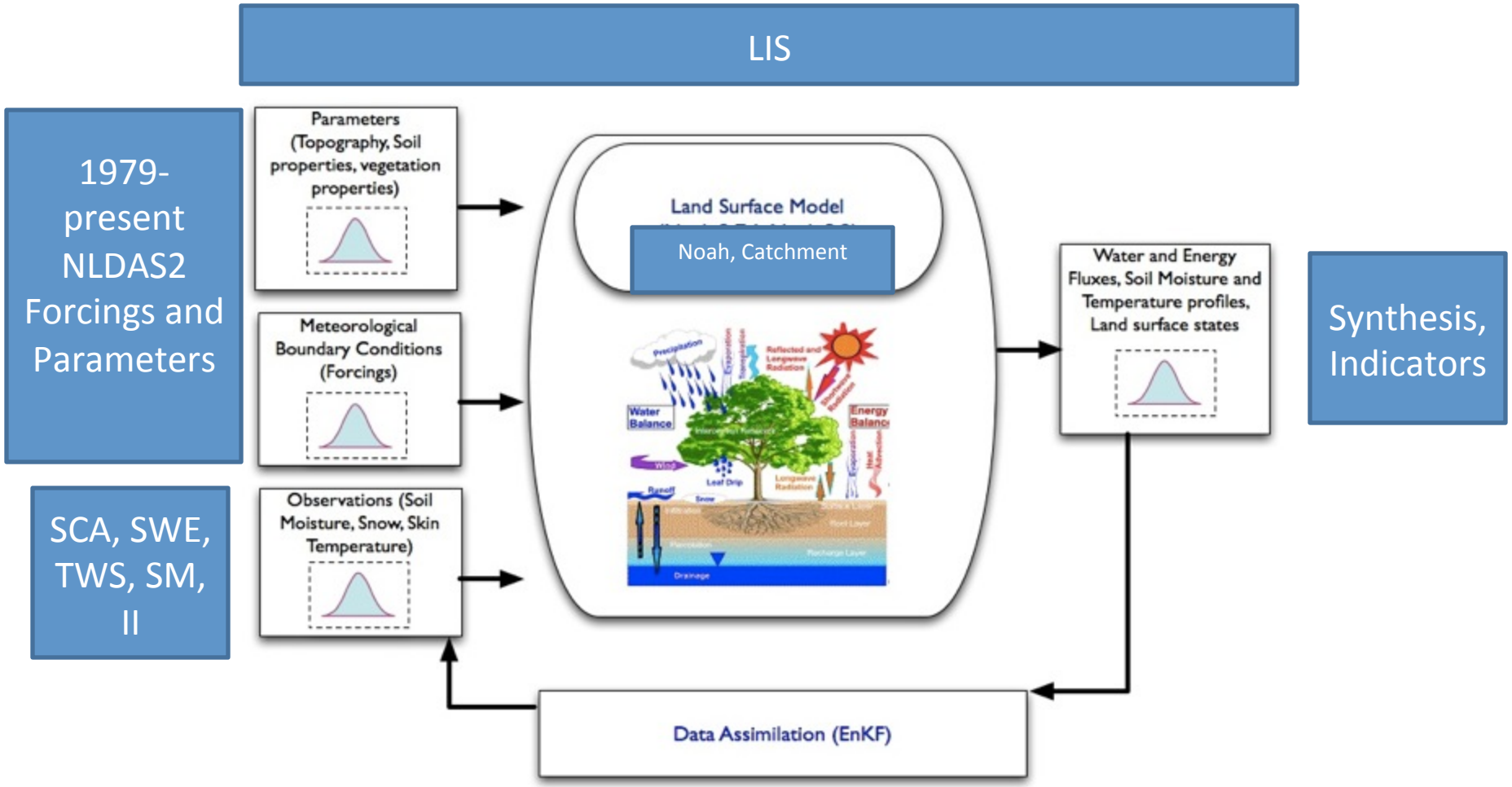
NCA-LDAS Science

The hypothesis to be tested in this project is that *assimilating NASA's satellite soil moisture, SWE, SCA, TWS and irrigation products into an NCA-LDAS will produce improved characterization of the continental scale water budget, which will directly improve the monitoring and prediction of climate-relevant water availability indicators, including droughts and floods*.

Specific science questions to be addressed include:

- How have North American water storages and fluxes evolved in the satellite era?
- How have the relationships among hydrologic fluxes and states changed?
  - Snowpack-streamflow-flood anomalies?
  - Groundwater-soil moisture-evapotranspiration-drought anomalies?
  - Irrigation impacts?
- Which global indicators help us understand North American impacts?
- What are key hydrologic indicators that encapsulate these impacts?

NCA-LDAS Schematic



LDAS (Land Data Assimilation System), SCA (Snow Covered Area), SWE (Snow Water Equivalent), TWS (Terrestrial Water Storage), SM (Soil Moisture), II (Irrigation Intensity)

NCA-LDAS EDRs

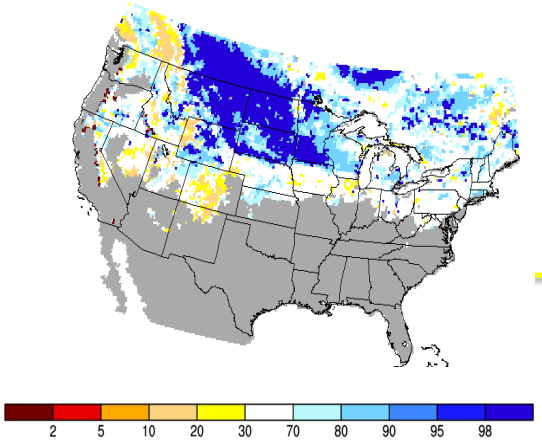
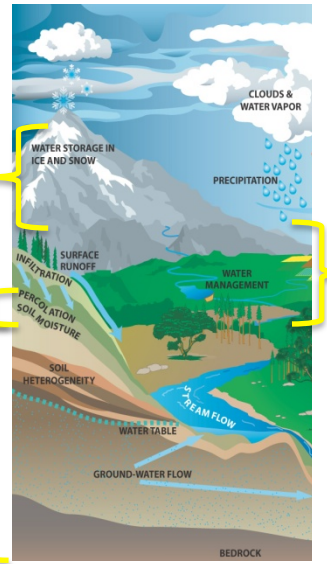


Figure 1: March 2011 Snow Water Equivalent (SWE) Mean Percentile from NASA Aqua/AMSR-E EDR (2003-2011).



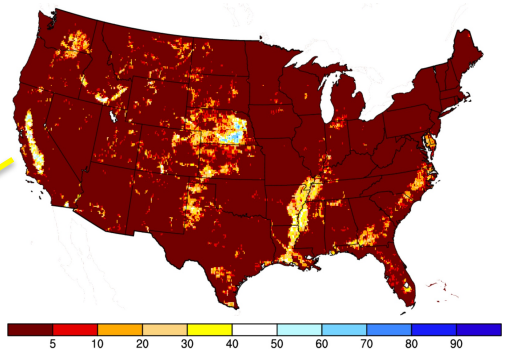


Figure 2: Irrigation Intensity (% Area) from MODIS circa 2001 (Ozdogan and Gutman 2008)

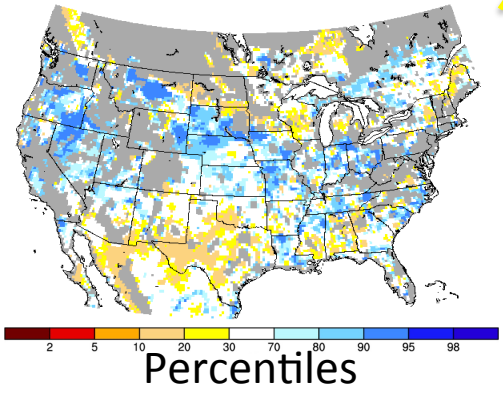


Figure 3: March 2011 Surface Soil Moisture Percentile from LPRM v5 – NASA Aqua/AMSR-E Aqua EDR (2003-2011)

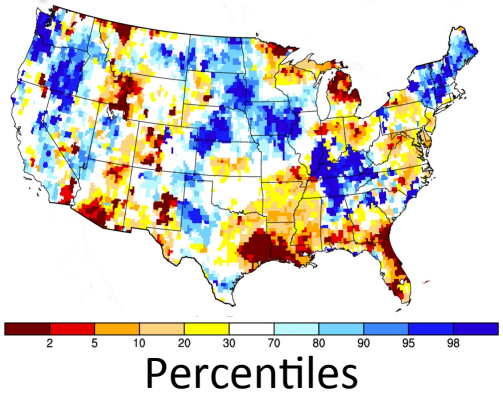
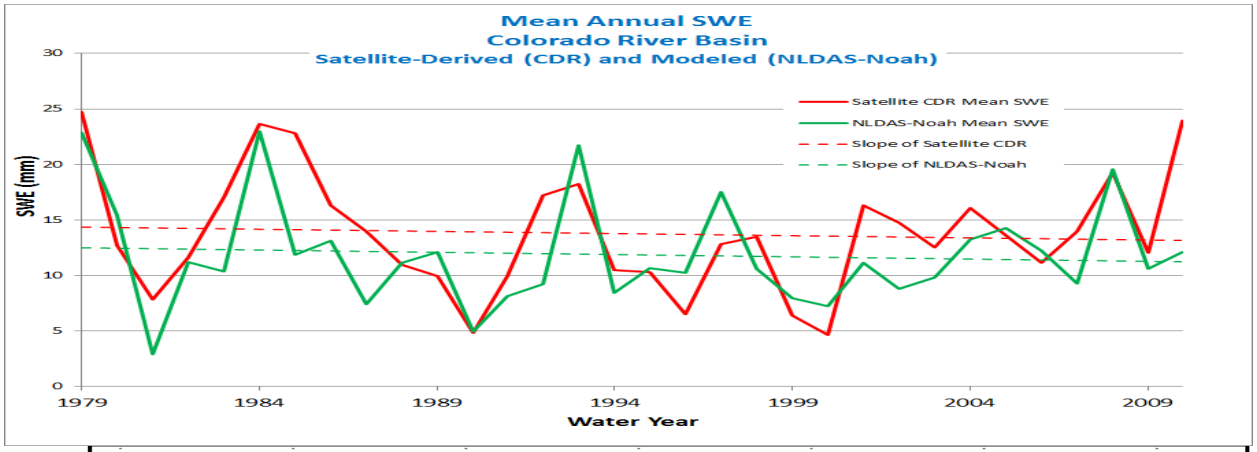
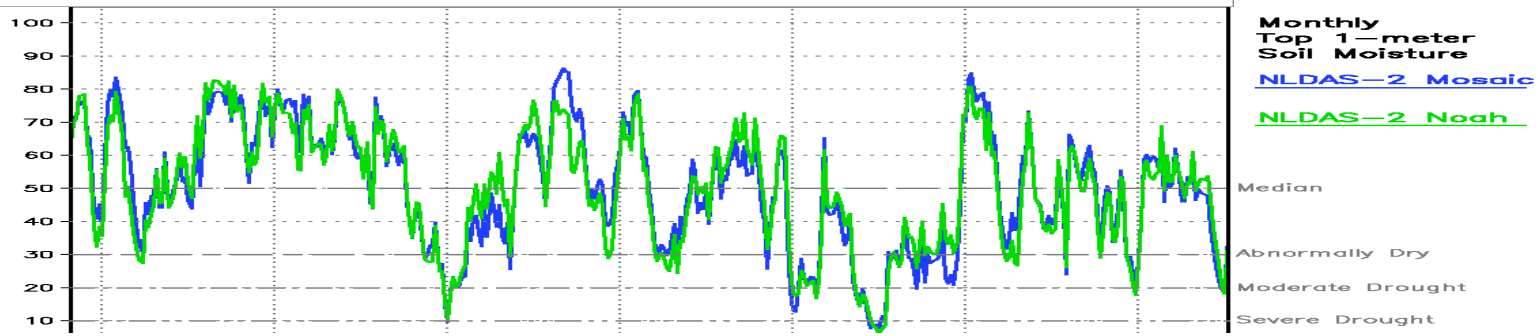
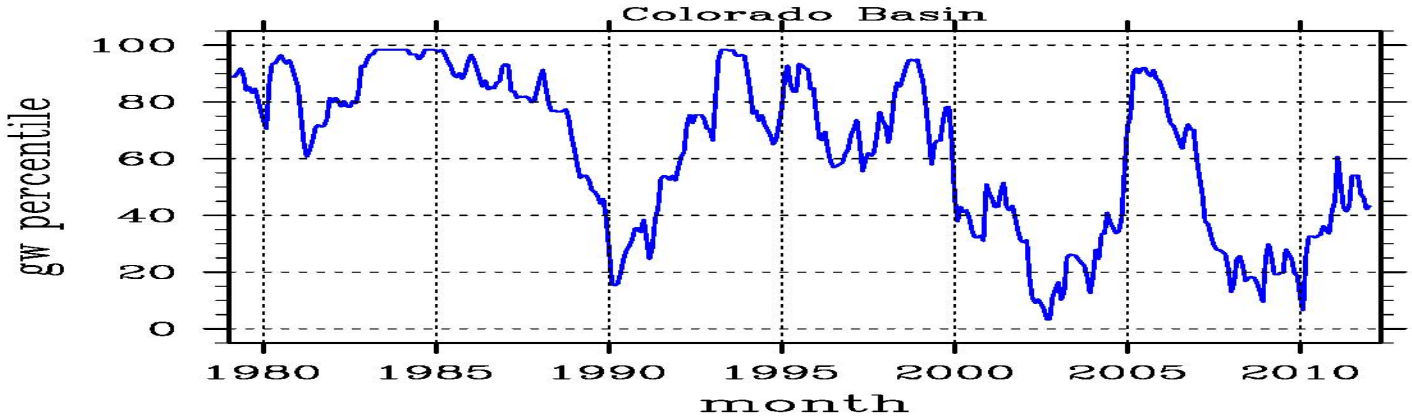


Figure 4: March 2011 GRACE-based Groundwater Percentile from GRACE TWS EDR (2002-present).

Mean Annual SWE, NLDAS-2 Soil Moisture, and GW EDR percentiles for Colorado River Basin



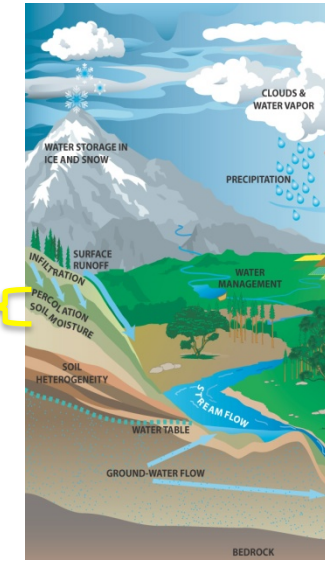




NCA-LDAS Soil Moisture Data Assimilation

Experimental Setup:

- Domain: CONUS, NLDAS
- Resolution: 0.125 deg.
- Period: 1979-01 to 2012-01
- Forcing: NLDASII
- LSM: Noah 3.3



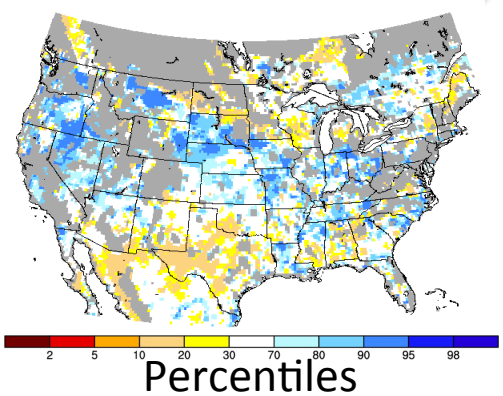


Figure 3: March 2011 Surface Soil Moisture Percentile from LPRM v5 – NASA Aqua/AMSR-E Aqua EDR (2003-2011)

Data Assimilation:

- AMSR-E LPRM (Owe et al., 2008; Peters-Lidard et al., 2011) 2002-2011
- ESA ECV (Liu et al., 2012; Wagner et al., 2012) 1978-2011

- Flags: light and moderate vegetation, precipitation, snow cover, frozen ground, RFI

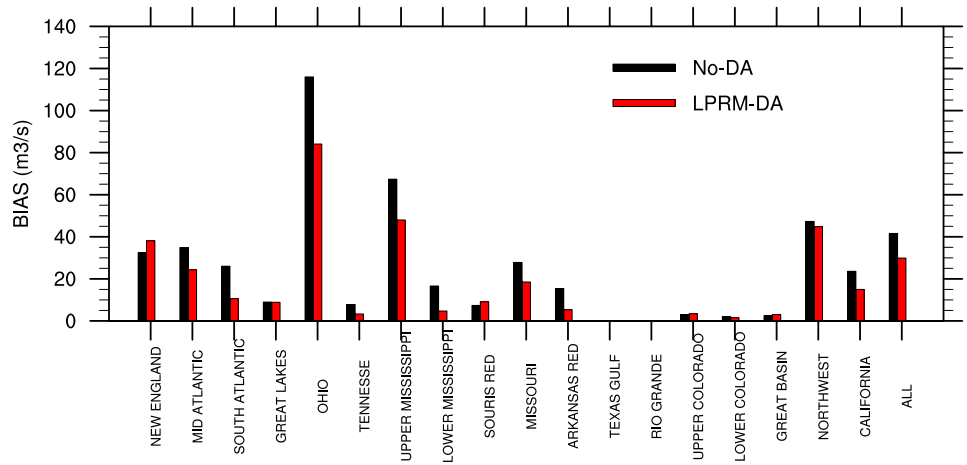
- The observations are scaled to the LSM's climatology using CDF matching

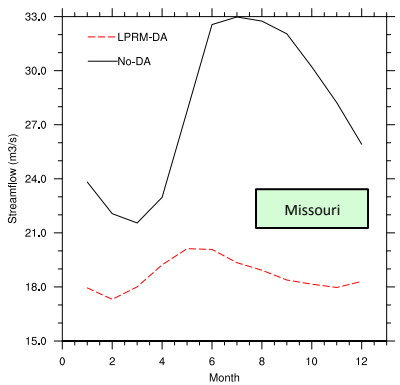
- 12-member ensemble

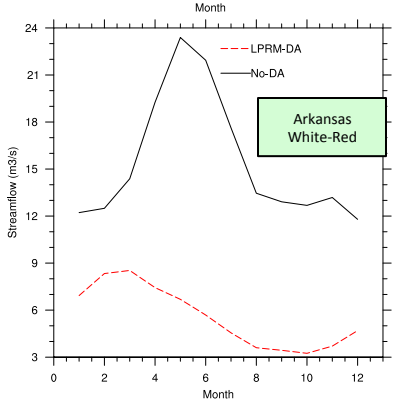
- A spatially distributed observation error standard deviation (between 0.02-0.12 m3/m3)

Soil moisture DA (LPRM): Evaluation of streamflow

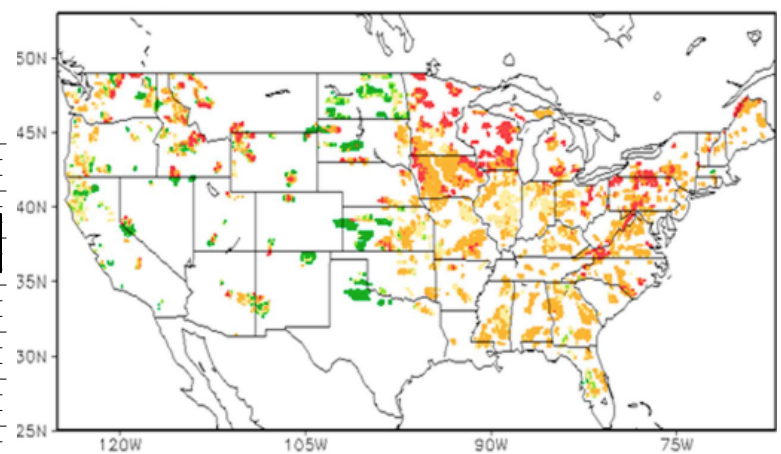
Streamflow (USGS)	Open loop (no DA)	LPRM DA
RMSE (m3/s)	51.0 +/- 4.0	**36.5 +/- 4.0**
Bias (m3/s)	41.6 +/- 4.0	**29.9 +/- 4.0**

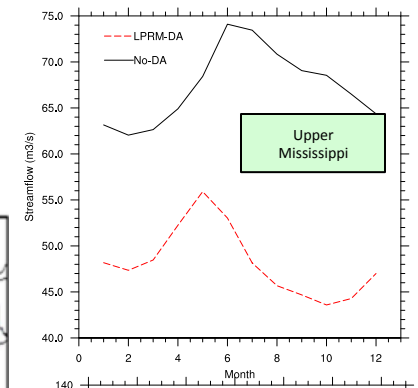


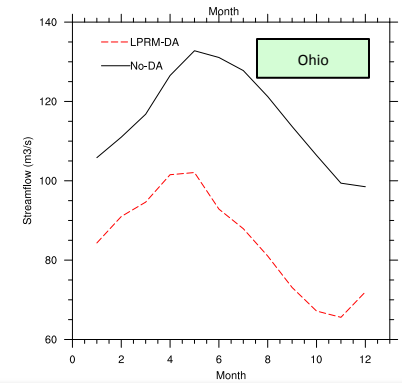




Average seasonal cycle of RMSE

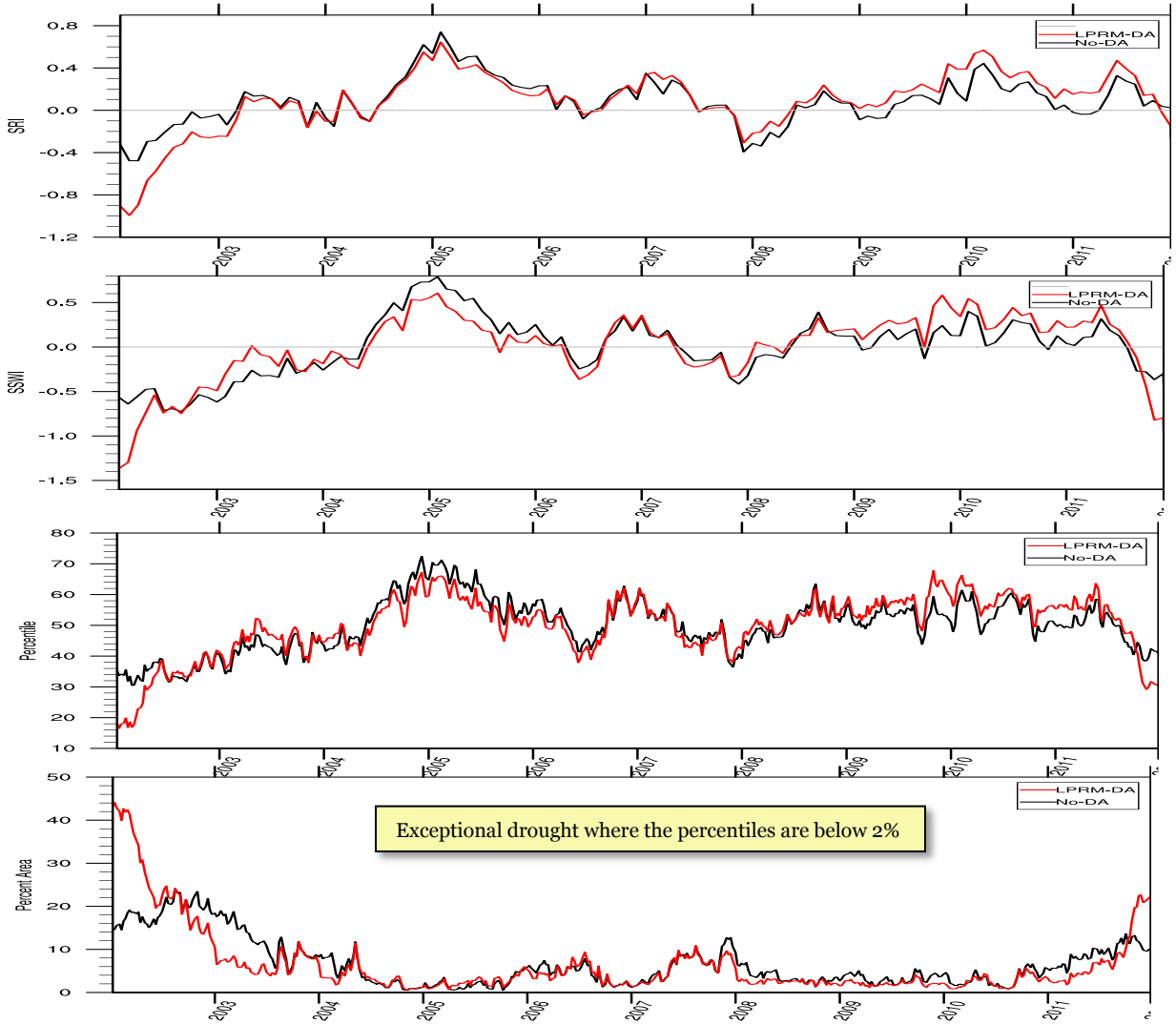






Significant improvements to the streamflow simulations are observed in most basins

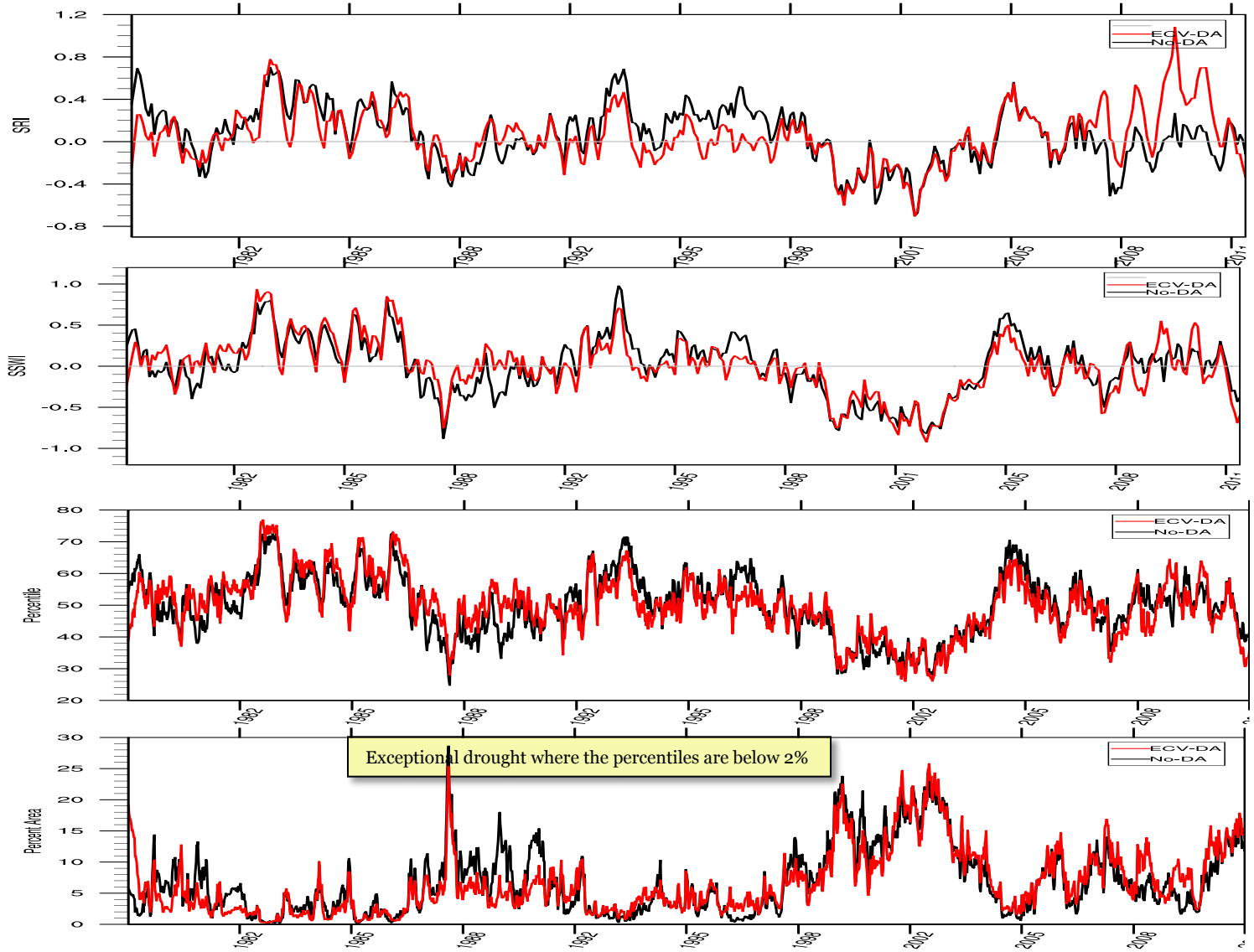
Soil moisture DA (LPRM): Drought indices (NLDAS domain average)



SRI, SSWI, and Soil Moisture Percentiles indicate that DA causes an increased drought in early 2000s and reduced drought 2008-2011. DA also simulates an increased onset of the 2011-2012 drought.

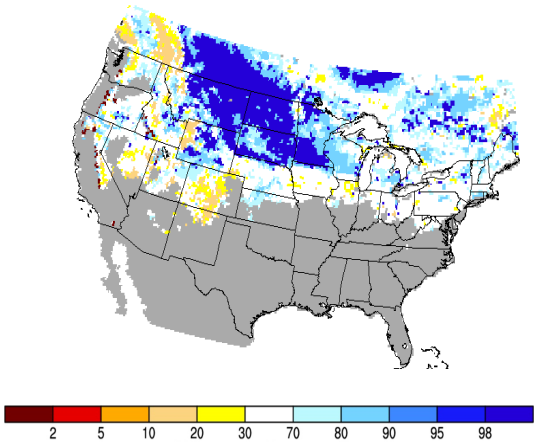
Note: The fitted distributions for SRI/SSWI/Percentiles in this analysis are computed by using 2002-2011 period.

Soil moisture DA (ECV) : Drought indices (NLDAS domain average)



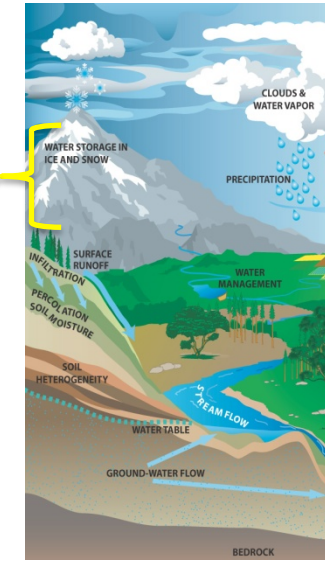
SRI, SSWI, and Soil Moisture Percentiles indicate that DA indicates an increased drought in early 2000s and reduced drought 2008-2011. DA also simulates an increased onset of the 2011-2012 drought.

NCA-LDAS Snow Data Assimilation



Percentiles

Figure 1: March 2011 Snow Water Equivalent (SWE) Mean Percentile from LPRM v5 – NASA Aqua/AMSR-E EDR (2003-2011).

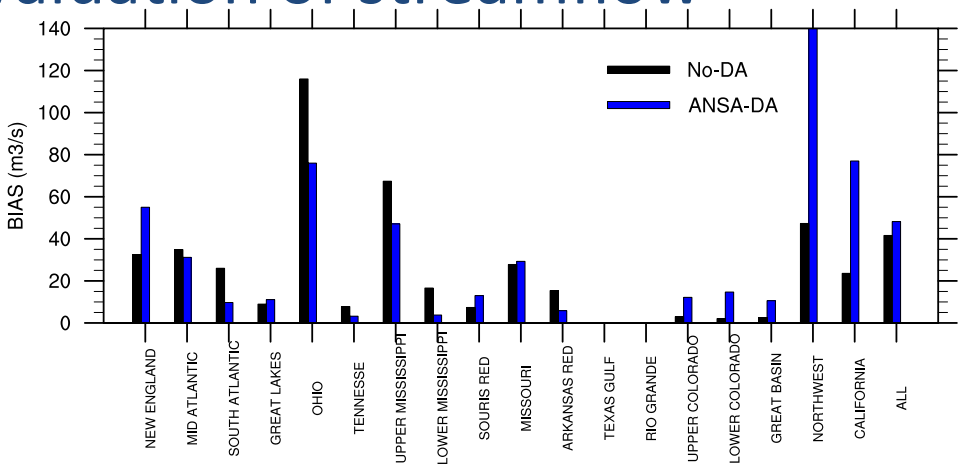


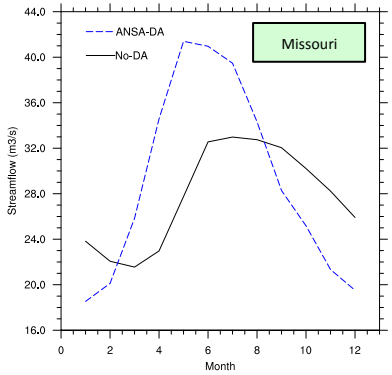
Data Assimilation:

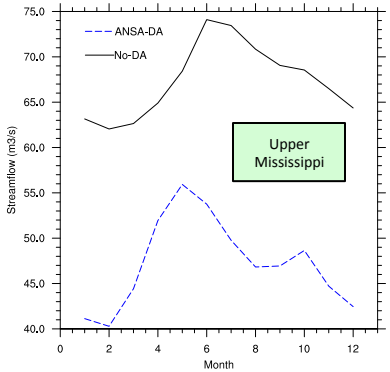
- SMMR (spans 1978-1987), SSM/I (spans 1987-2002) and AMSR-E (spans 2002-2011); SMMR and SSM/I retrievals are based on the Chang et al. (1987) and AMSR-E retrievals are based on the improved retrieval algorithm from Kelly et al. (2009).
- AMSR-E retrievals are further improved by combining the information from MODIS snow cover retrievals – a product known as ANSA (AFWA NASA snow algorithm; Foster et al. 2010).

Snow DA (SWE): Evaluation of streamflow

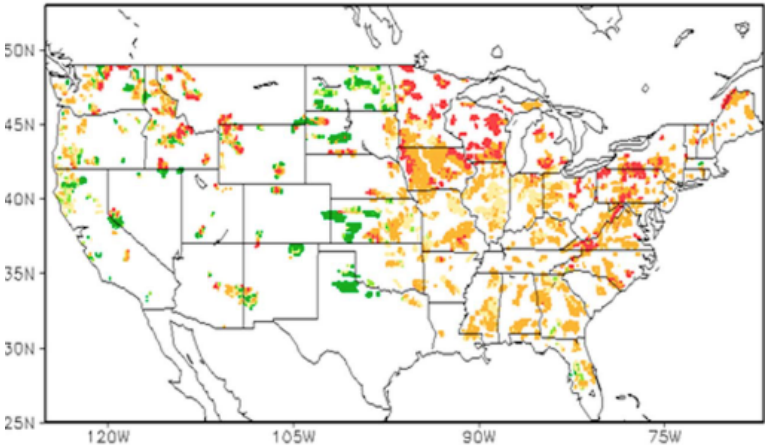
Streamflow (USGS)	Open loop (no DA)	SWE DA
RMSE (m3/s)	**50.8 +/- 4.0**	66.1 +/- 4.0
Bias (m3/s)	**41.2 +/- 4.0**	48.2 +/- 4.0

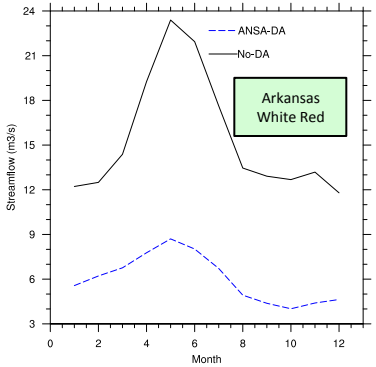


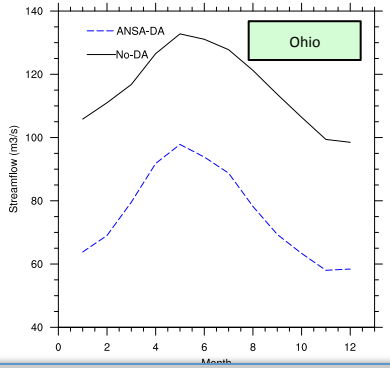




Average seasonal cycle of RMSE

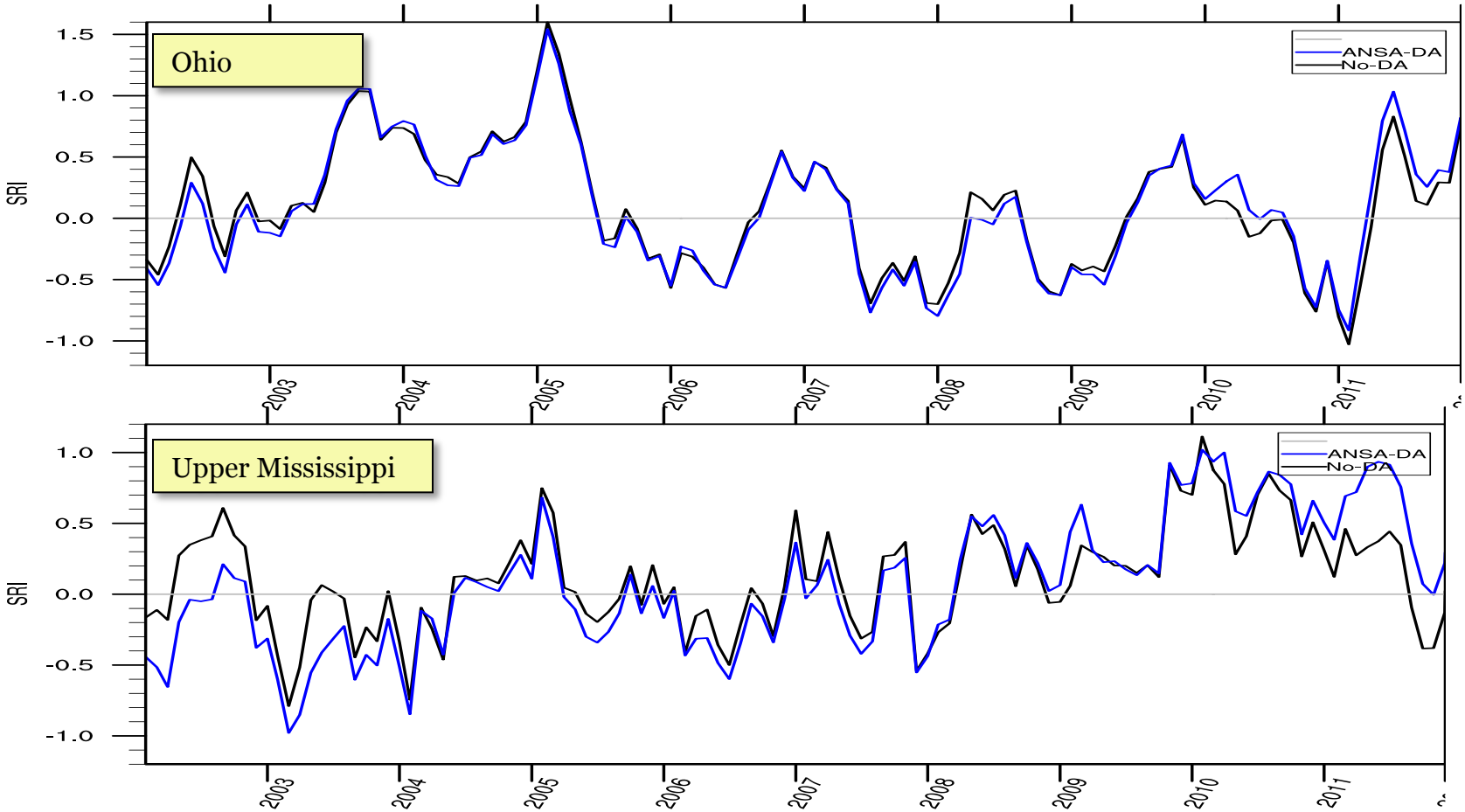






Significant improvements to the streamflow simulations are observed in Ohio, Upper Mississippi, Significant degradations in Northwest and California.

Snow DA (SWE) : Drought indices (basin averages)



Over both basins, DA estimates increased drought in early 2000s and reduced drought 2009-2011.

Note: The fitted distributions for SRI in this analysis are computed by using 2002-2011 period.

Next Steps

Open Loop (no DA)

- Complete open loop run with Catchment Fortuna 2.5

Data Assimilation Tasks

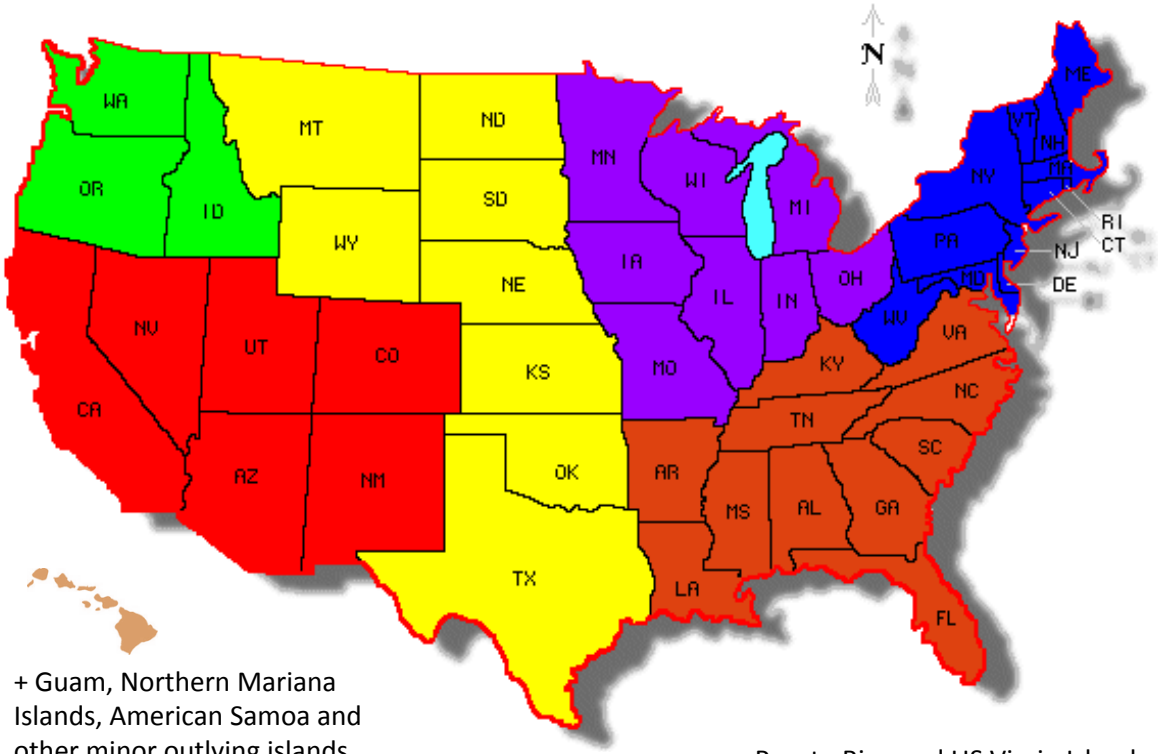
- Finalize station-based bias correction for SWE
- Finalize EnKF assimilation of SCA using depletion curves for Noah and Catchment
- Complete ensemble smoother for GRACE terrestrial water storage
- Complete irrigation module

NCA-LDAS

- Complete Noah assimilation runs with SM, SWE, SCA, and II
- Complete Catchment assimilation runs with SM, SWE, SCA, II and GRACE DA
- Assess indicators and trends

NCA Regions

- Northeast
- Southeast and Caribbean
- Midwest
- Great Plains
- Northwest
- Southwest
- Alaska and Arctic
- Hawaii and Pacific Islands

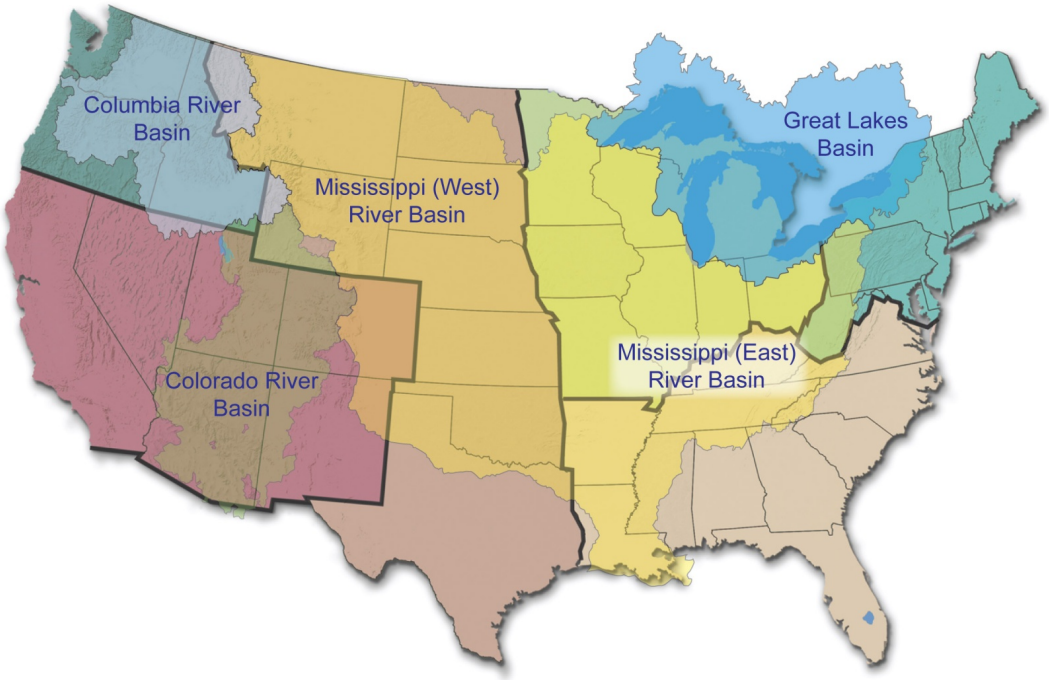


+ Guam, Northern Mariana Islands, American Samoa and other minor outlying islands

+ Puerto Rico and US Virgin Islands

NCA Biogeographical Cross-Cuts

- Oceans and marine resources
- Coastal zone, development, and ecosystems, e.g.,
  - SF Bay Delta
  - Chesapeake Bay
  - Gulf Coast
- Watersheds, e.g.
  - Great Lakes
  - Colorado River
  - Columbia River
  - Mississippi River



References

- Hydrology DISC (HDISC) http://disc.gsfc.nasa.gov/hydrology/
- NASA/GSFC NLDAS website: http://ldas.gsfc.nasa.gov/nldas/
- NASA/GSFC LIS website: http://lis.gsfc.nasa.gov/