Recent updates on the NLDAS Science Testbed

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The **North American Land Data Assimilation System (NLDAS)** is a collaborative project between NOAA/NCEP, NASA/GSFC, Princeton Univ., Univ. of Washington, and NOAA/OHD, and is supported by the NOAA Climate Program Office's Modeling Analysis, Predictions, and Projections (MAPP) Program.

Acknowledgements: Grey Nearing, Augusto Getirana, Jim Geiger, Bailing Li, Ken Mitchell, John Schaake, and numerous members of both the NLDAS and LIS teams over the last 15+ years

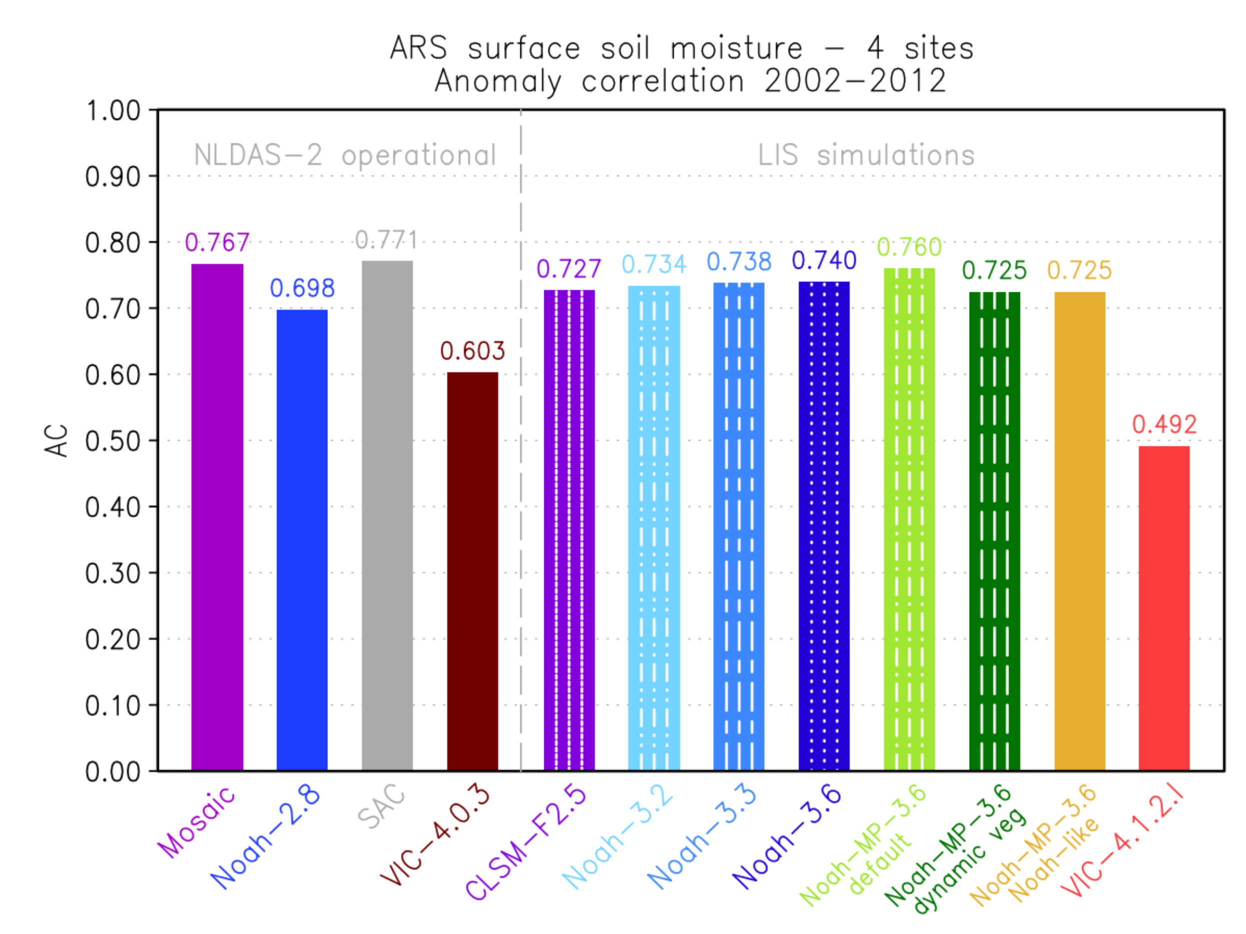
1 – NASA/GSFC; 2 – SAIC; 3 – Univ. MD; 4 – NOAA/NCEP/EMC; 5 – IMSG

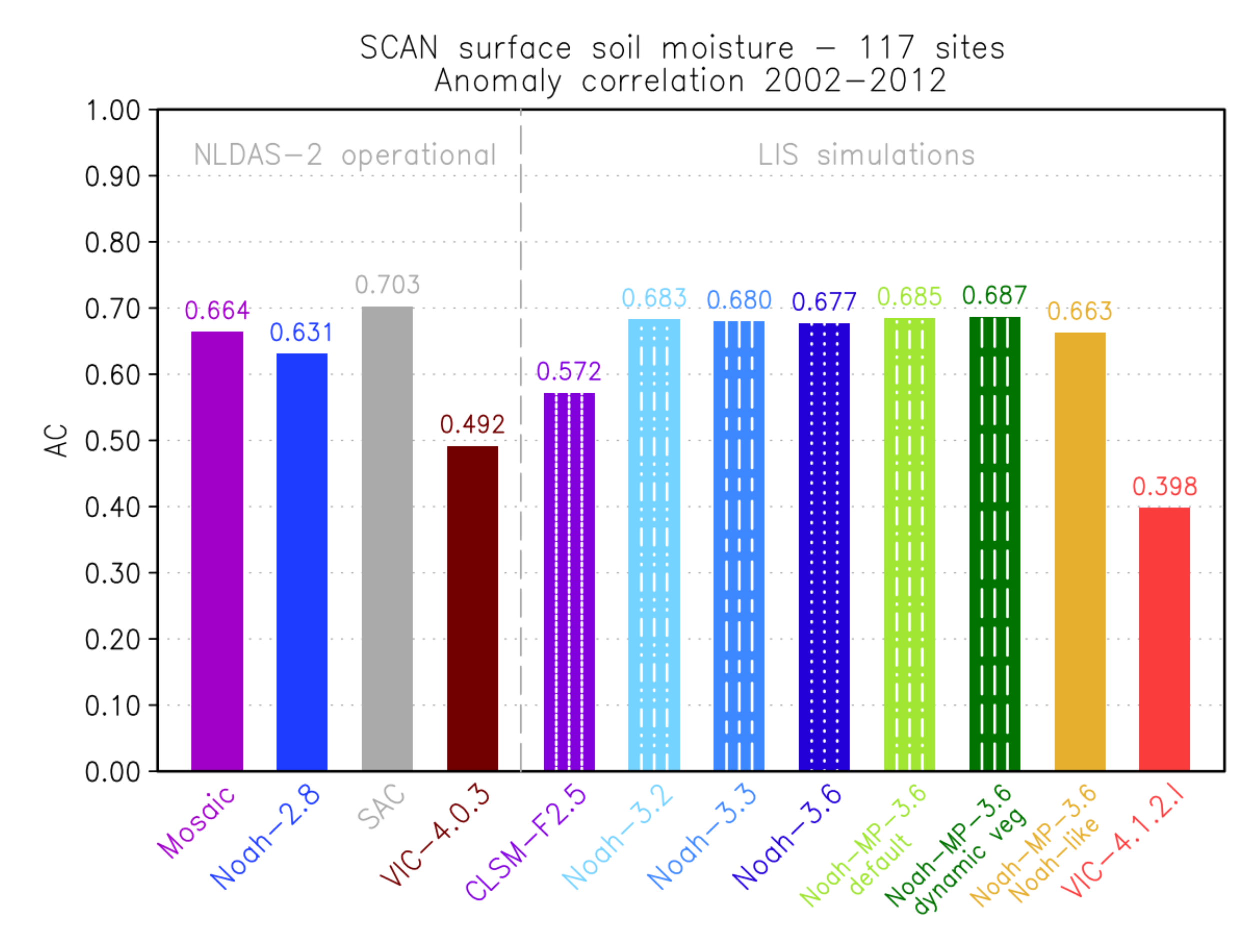
NLDAS Science Testbed

The LIS group has developed an NLDAS Science Testbed, designed to test LSMs, parameters, and data assimilation within the **Land Information System (LIS)** using the NLDAS configuration. These simulations are also being evaluated against the four operational LSMs running in NLDAS Phase 2.

- Spin-Up: 70 years (1979 to 2014 twice) – and then running 1979 to 2015
- Evaluation period: (2002-2012; 11 years with the most evaluation data)
- Output:
    - Monthly water/vegetation states during the two spin-up periods
    - Daily output during the third simulation of all relevant energy/water terms
- Evaluation: Using the **Land Verification Toolkit (LVT)** to evaluate soil moisture, snow, ET/fluxes, surface radiation, runoff, streamflow, groundwater, etc.

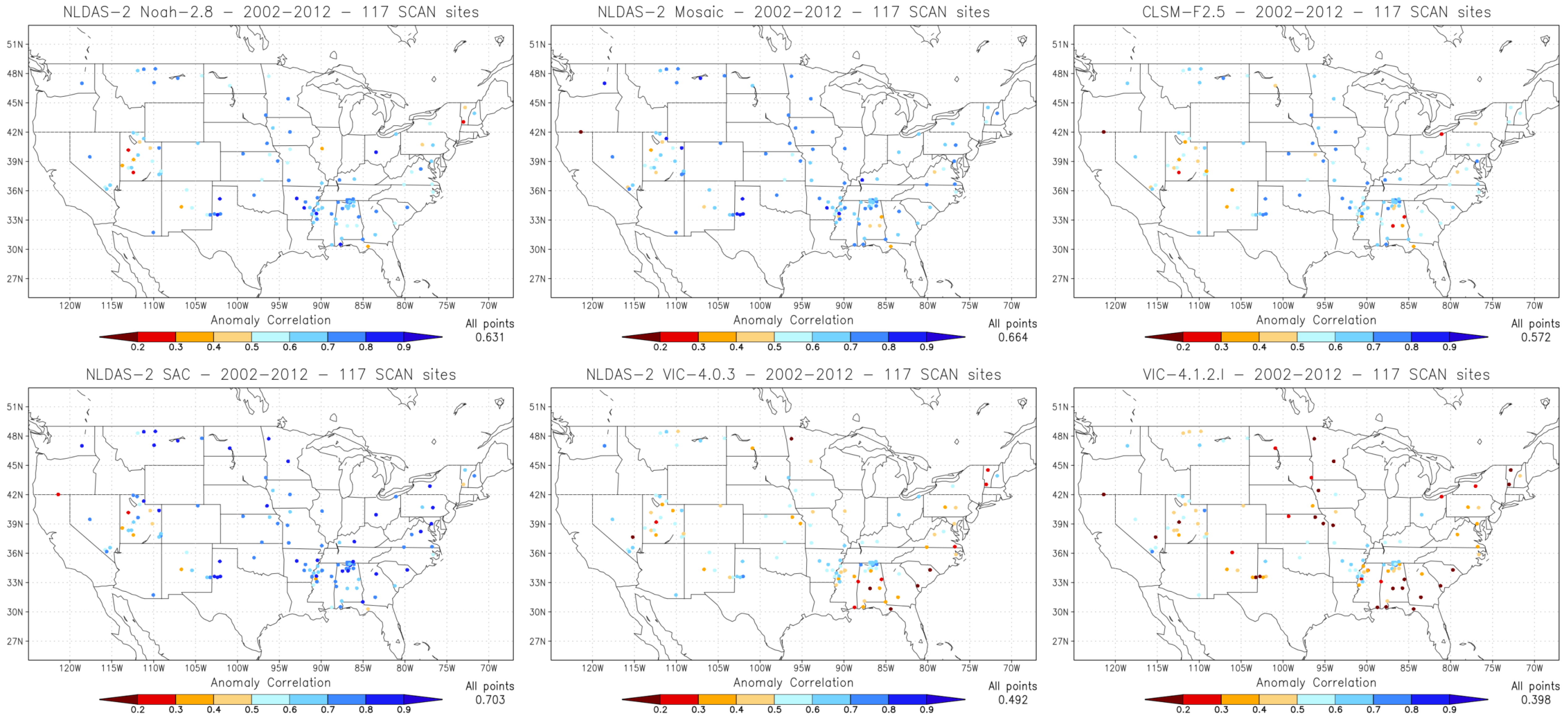
Soil Moisture – anomaly correlations



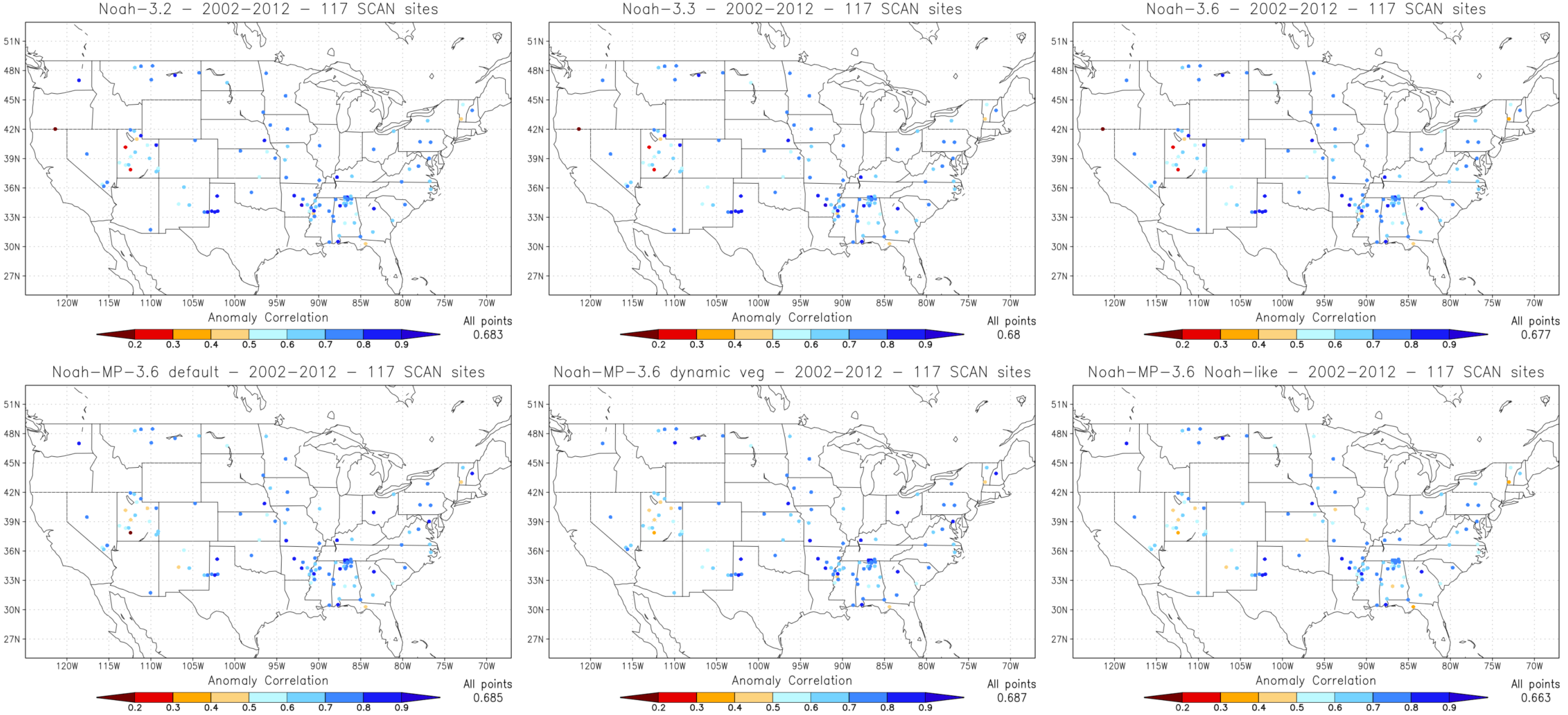


SM evaluations show: 1) CLSM-F2.5 does not do as well as Mosaic; 2) Noah-3.x versions are improved over Noah-2.8; 3) Noah-MP slightly better than Noah-3.x; 4) Noah-MP dynamic veg. does about as well as default Noah-MP; and 5) VIC-4.1.2.l does not do as well as VIC-4.0.3.

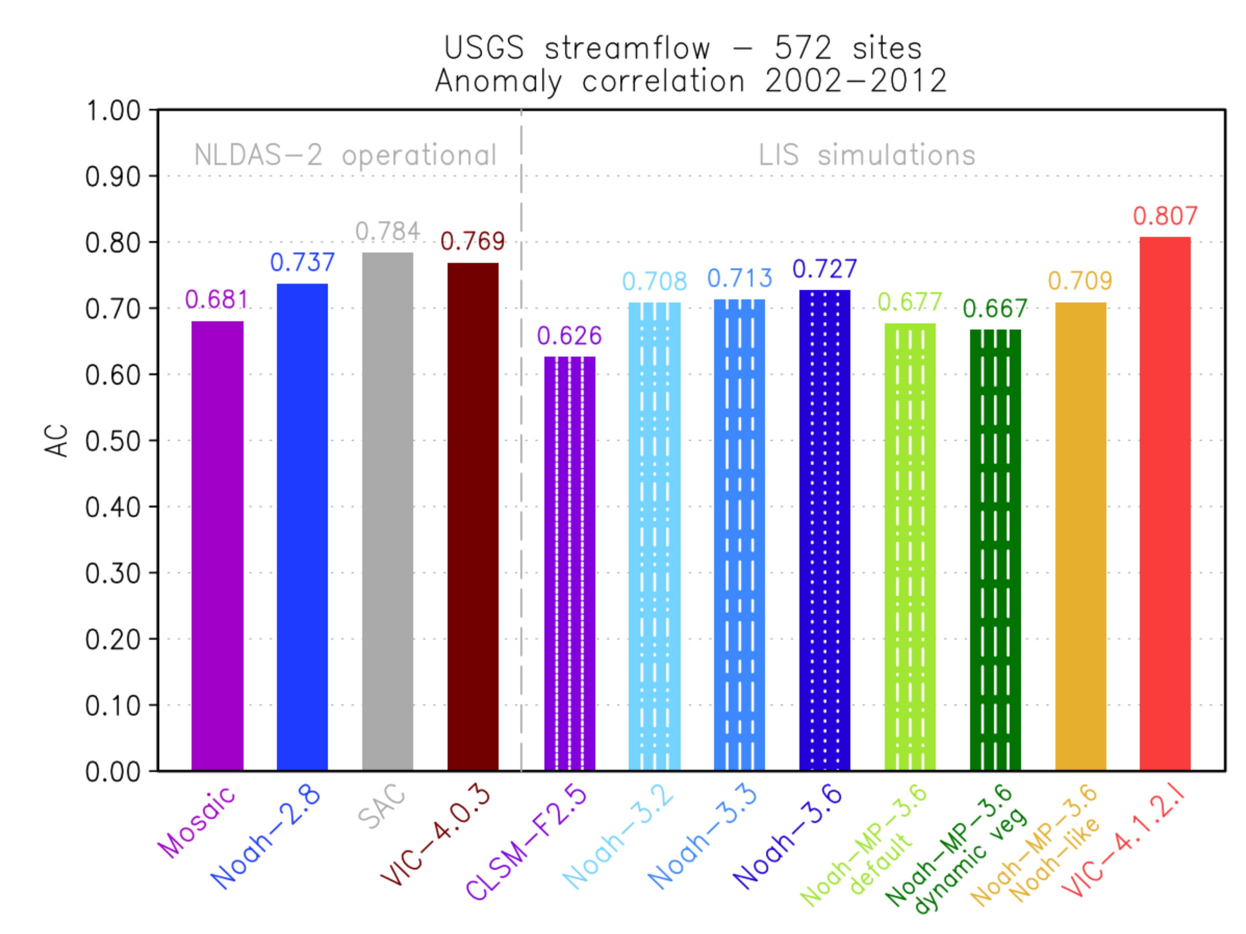
Soil Moisture – anomaly correlations

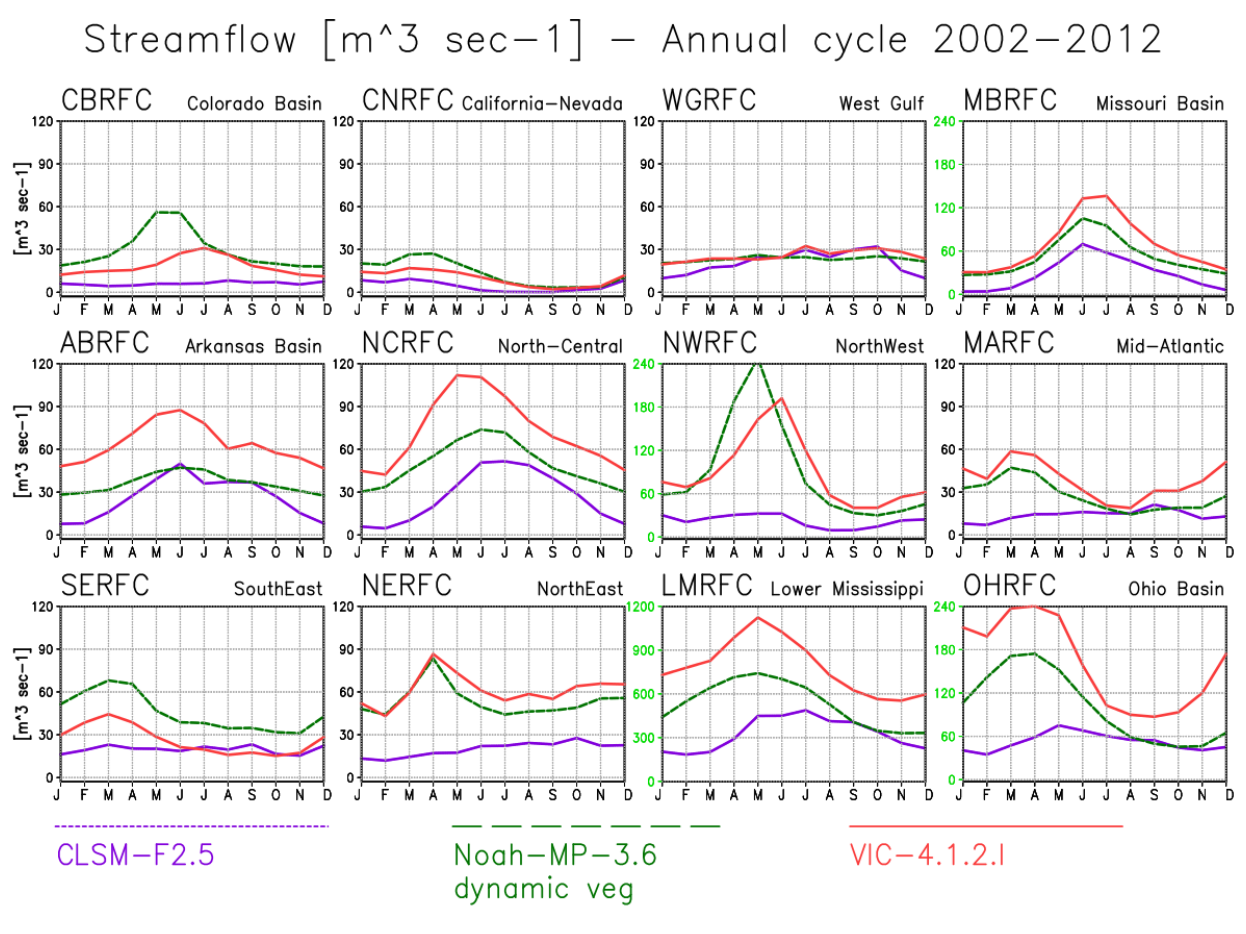


Soil Moisture – anomaly correlations



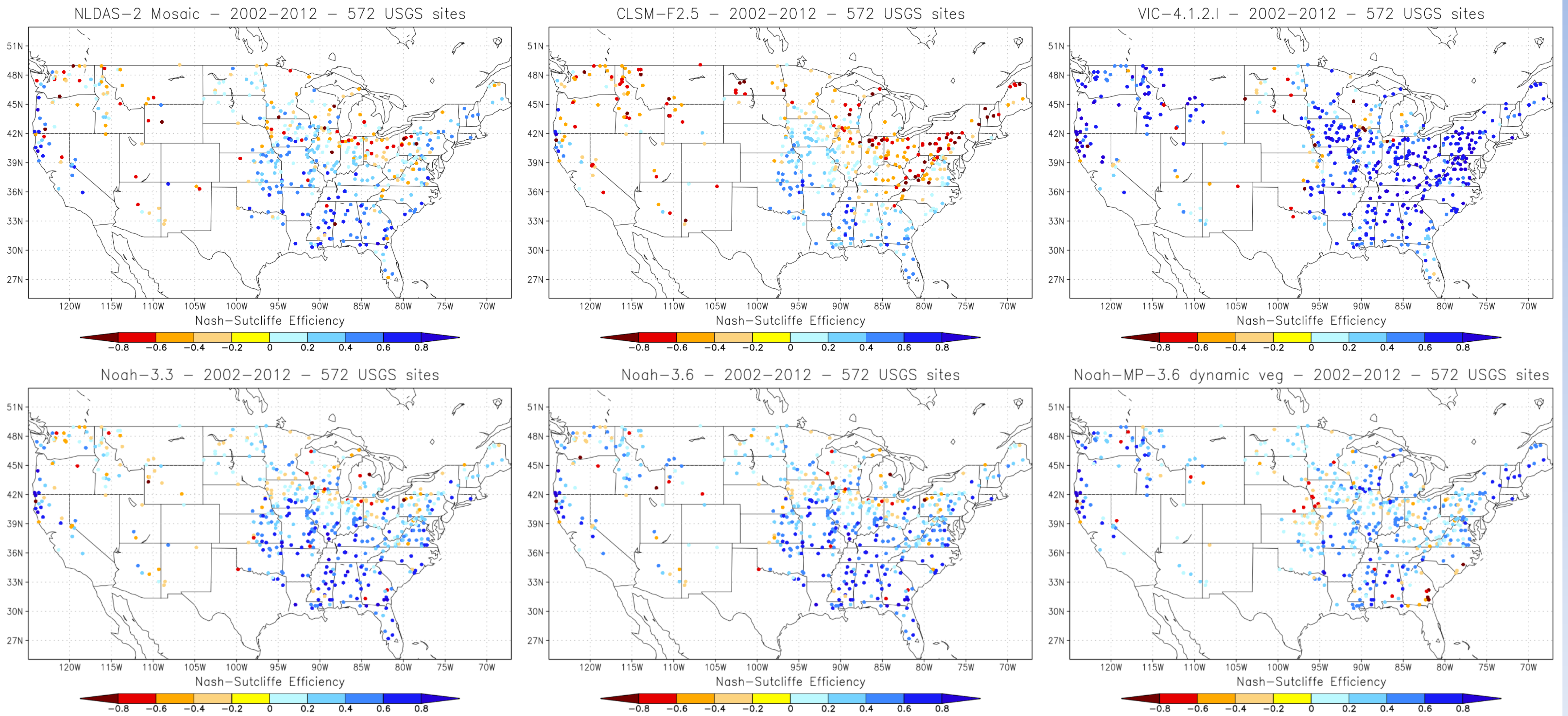
Streamflow – AC and monthly cycle



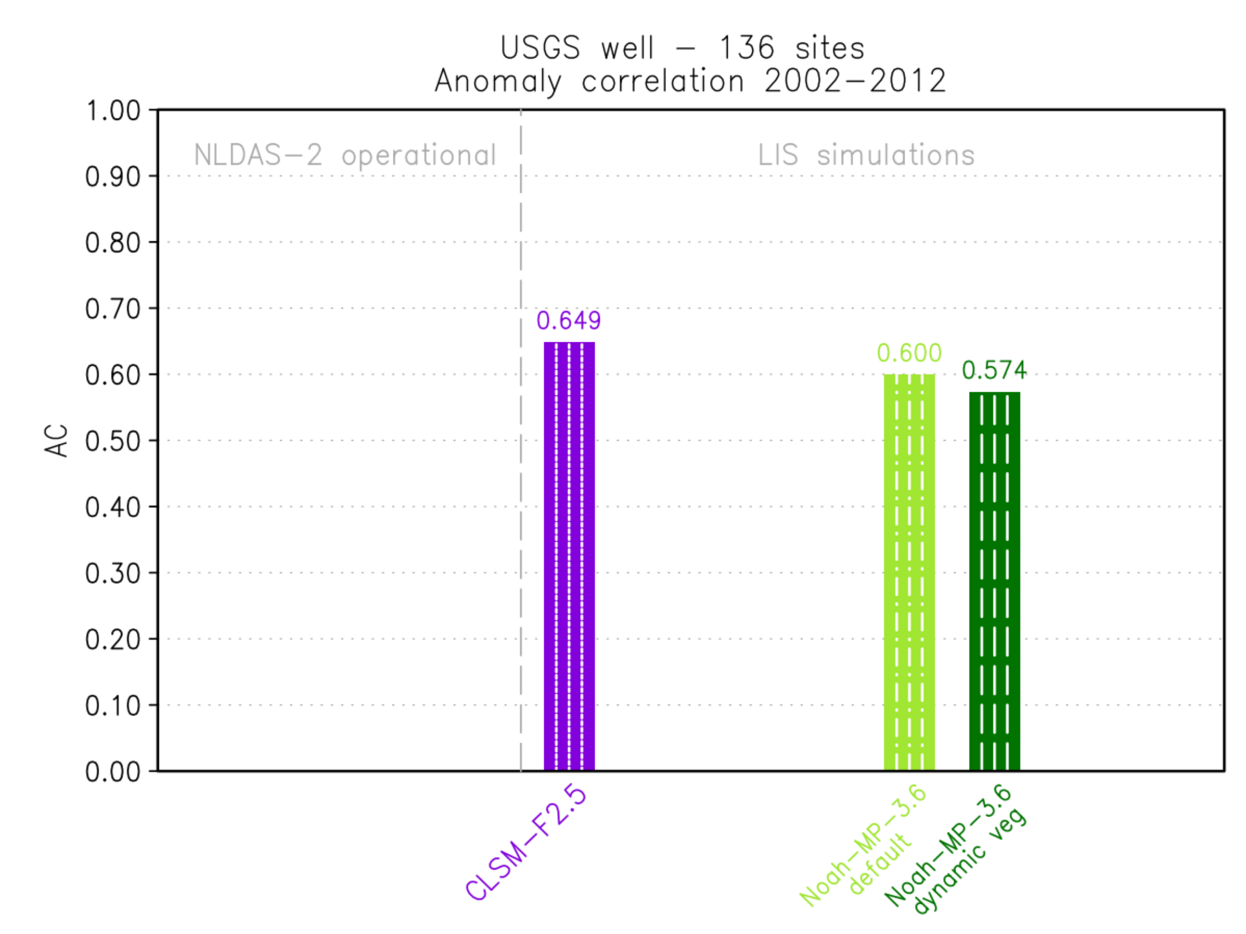


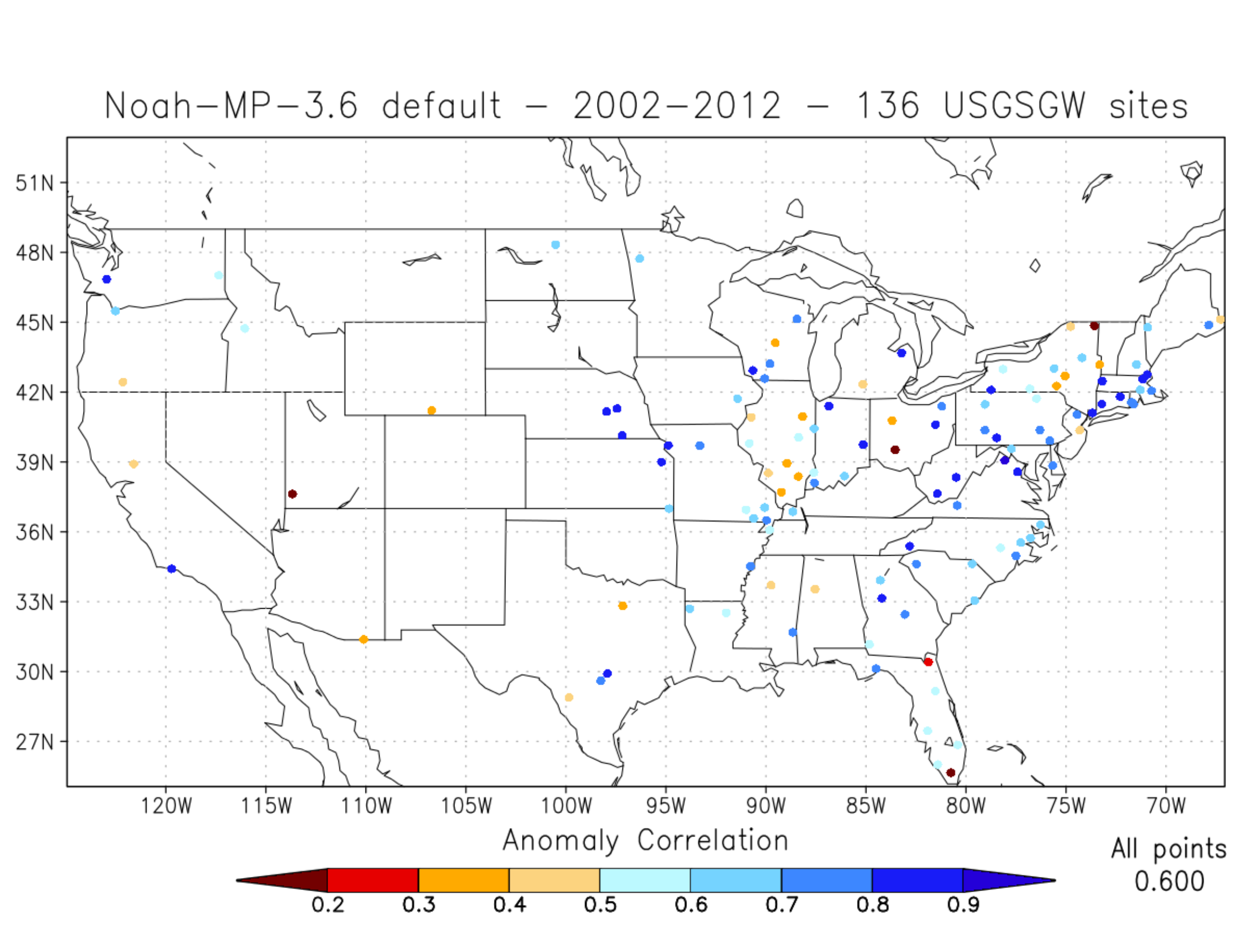
Streamflow evaluations show: 1) CLSM-F2.5 does not do as well as Mosaic, and has low values for streamflow; 2) Noah-3.x performs similarly to Noah-2.8; 3) Noah-MP is slightly worse than Noah-3.x; and 4) VIC-4.1.2.l has higher streamflow and is improved over VIC-4.0.3.

Streamflow – NSE



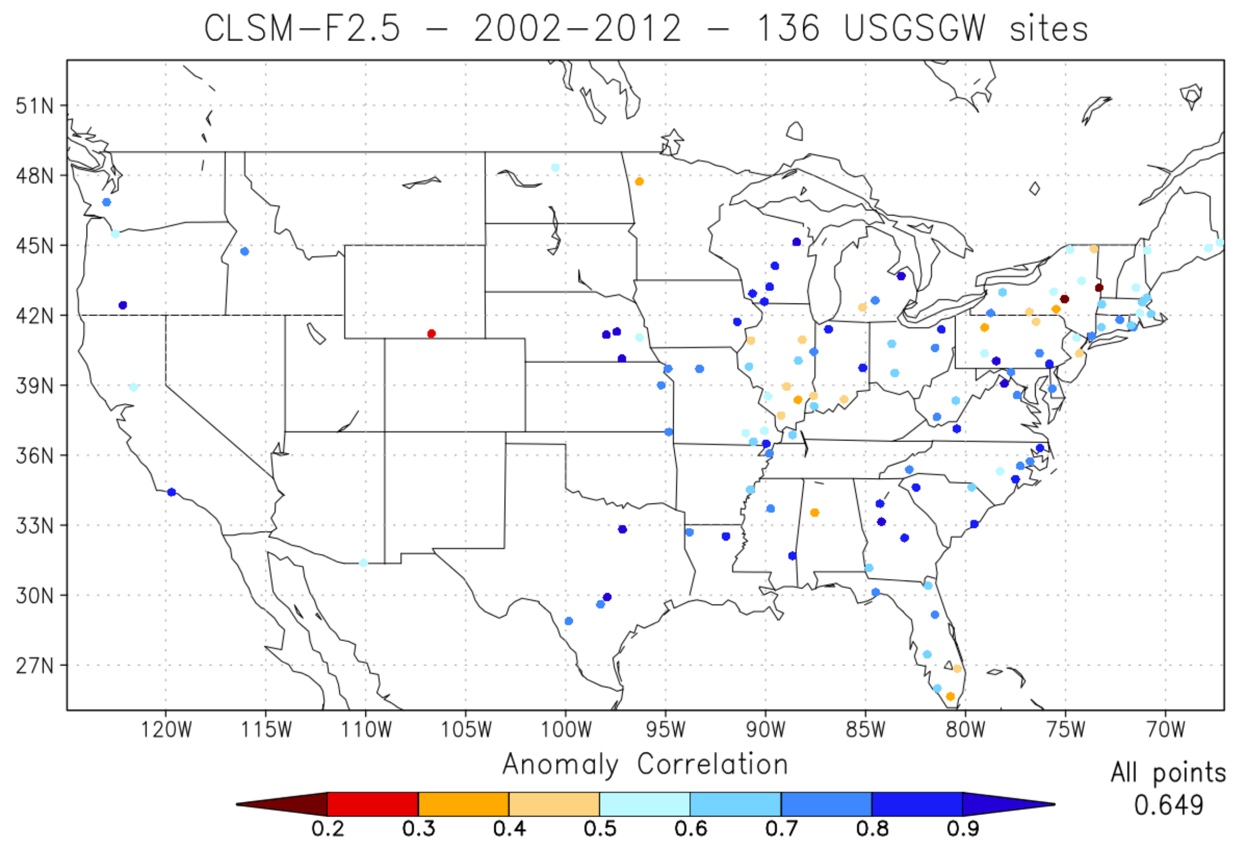
Groundwater – Anomaly correlations

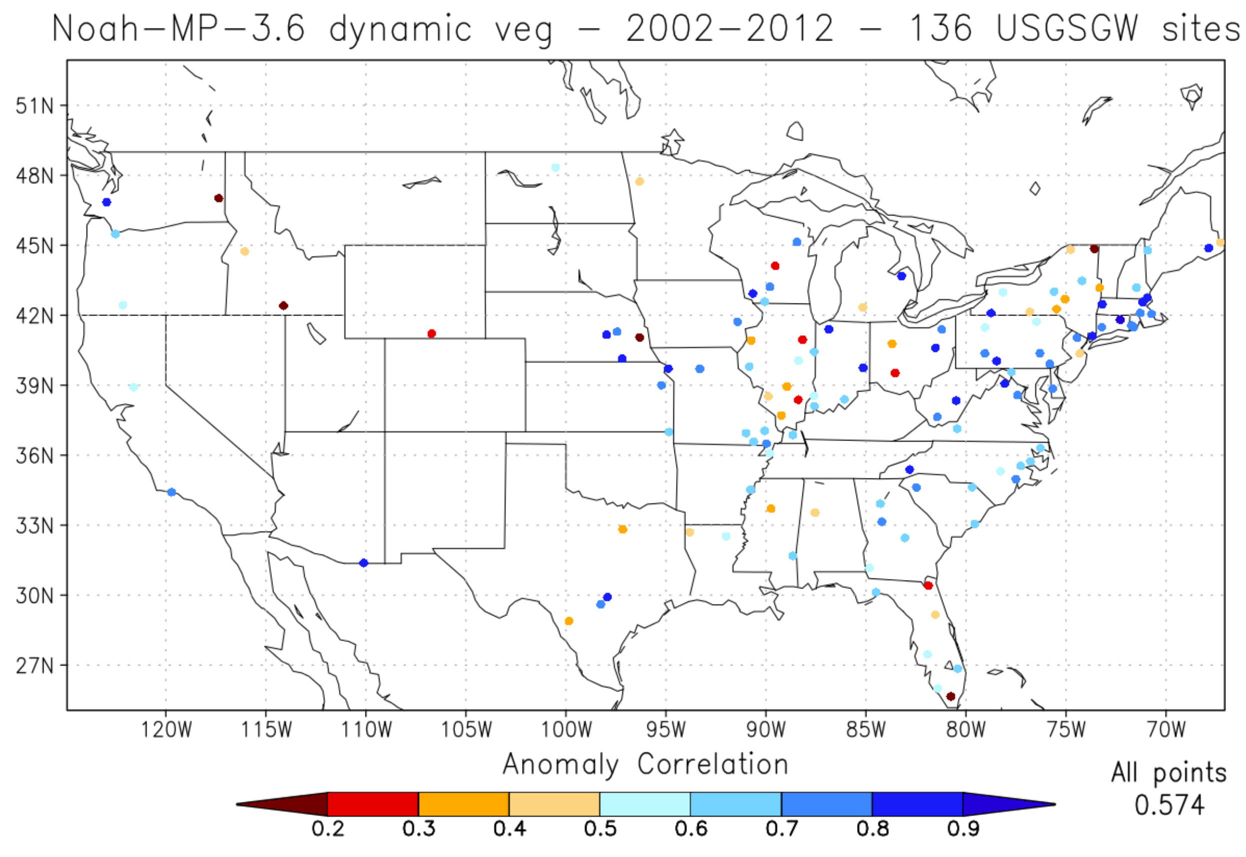




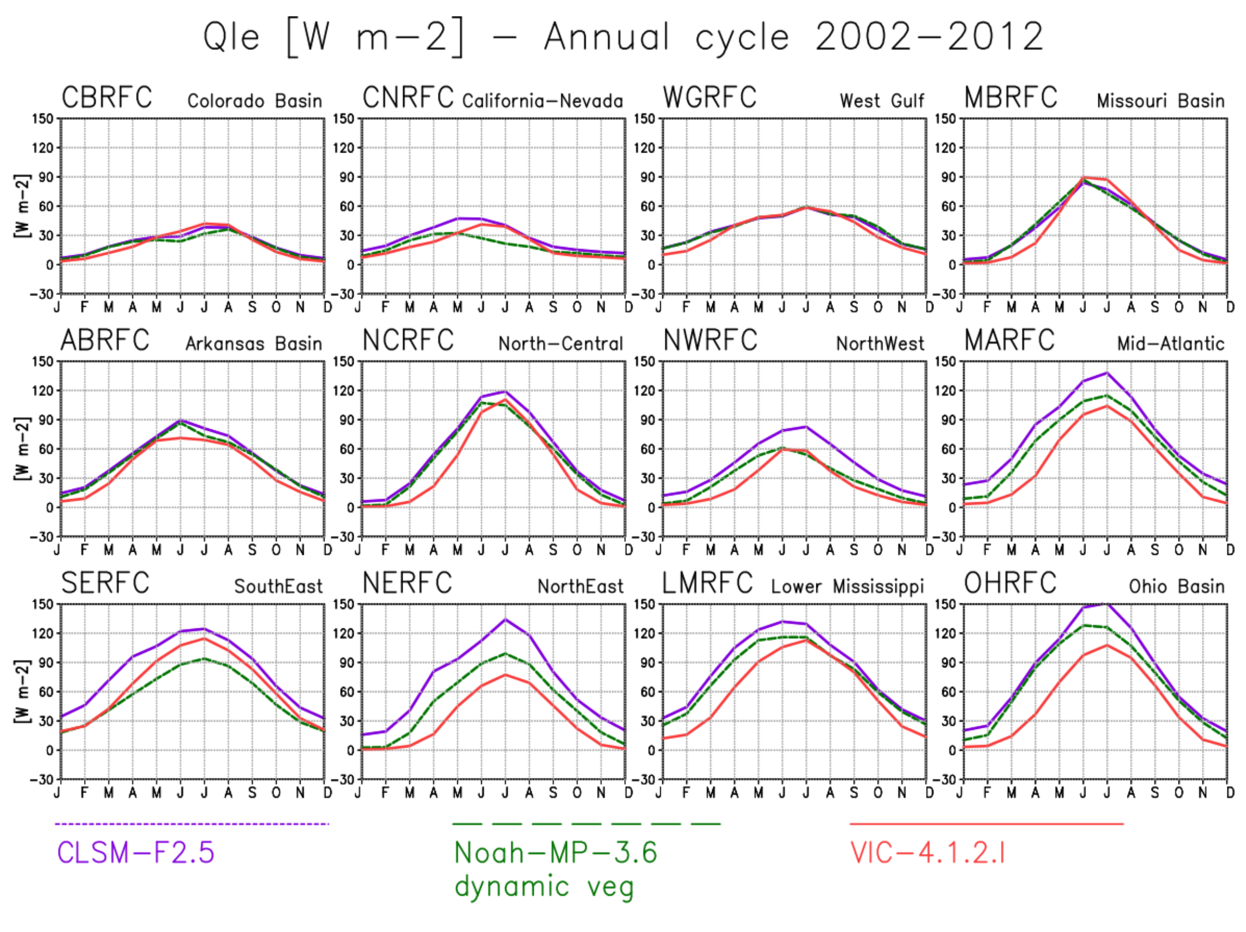
Groundwater evaluations show: 1) CLSM-F2.5 does better than Noah-MP; and 2) Noah-MP dynamic vegetation does slightly worse than default Noah-MP.

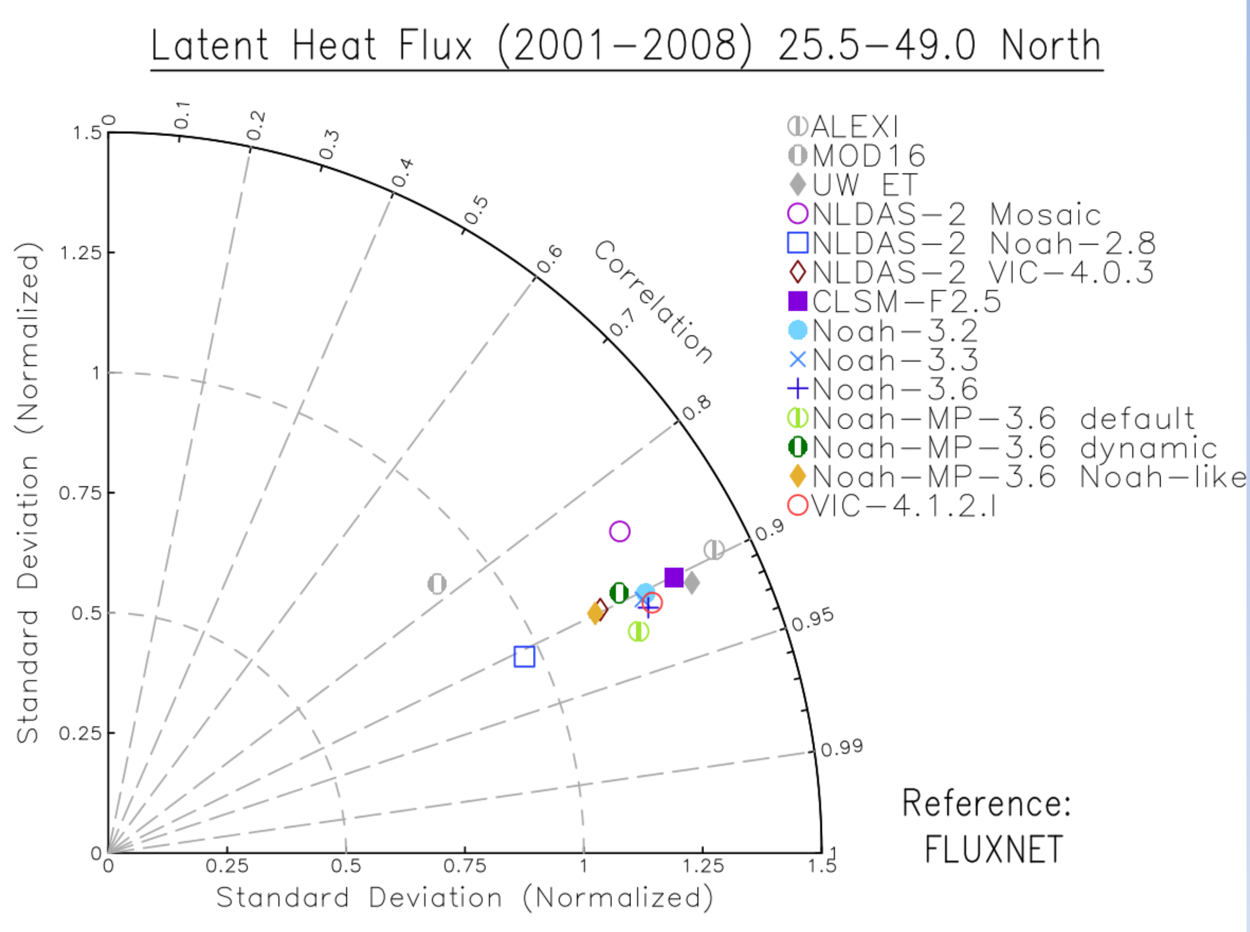
Groundwater – Anomaly correlations





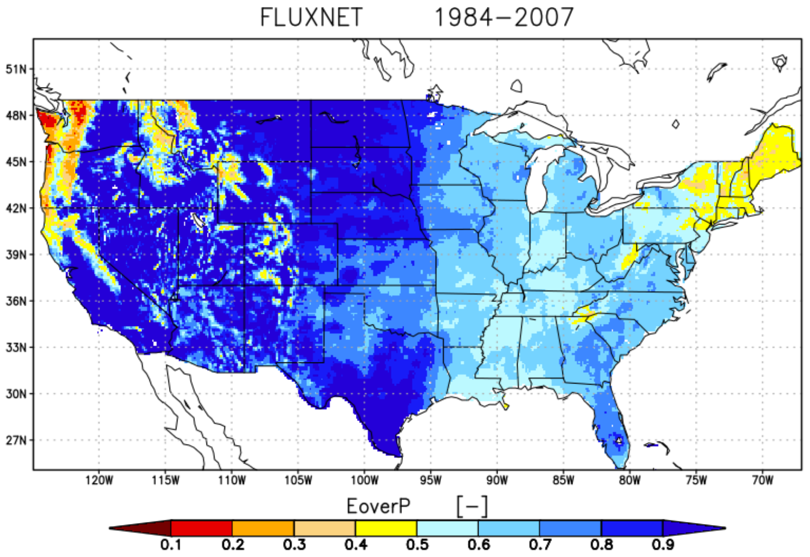
Fluxes

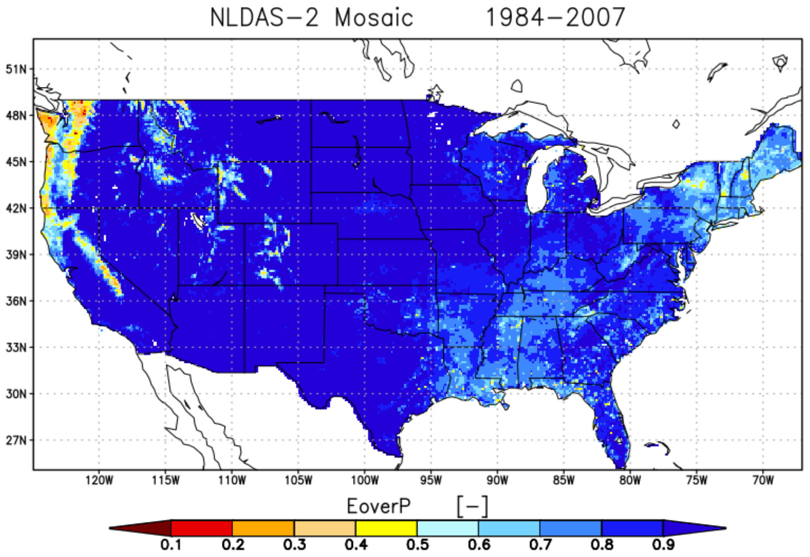


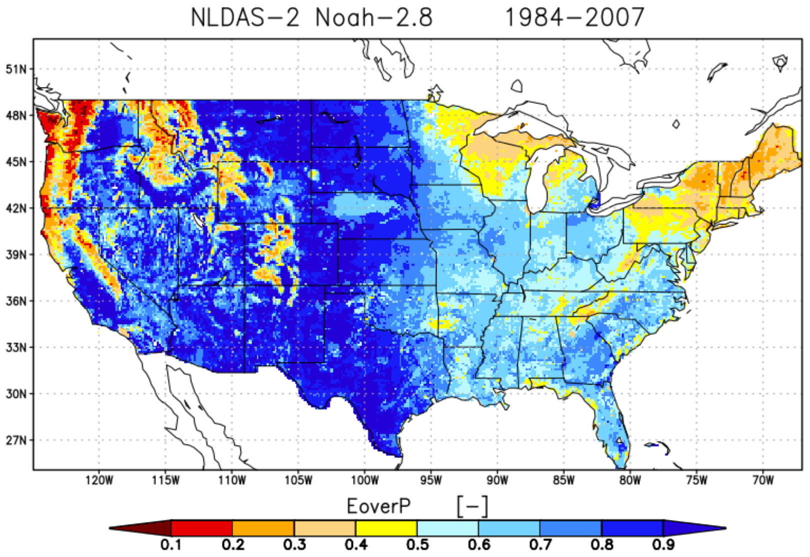


Latent heat flux evaluations show: 1) CLSM-F2.5 has high latent heat and VIC-4.1.2.l has low latent heat; 2) Noah-3.x has higher latent heat than Noah-2.8, with Noah-MP in the middle; and 3) other reference datasets (ALEXI, MOD16, UW ET) don’t compare better to FLUXNET than LSMs

Evaporation over Precipitation



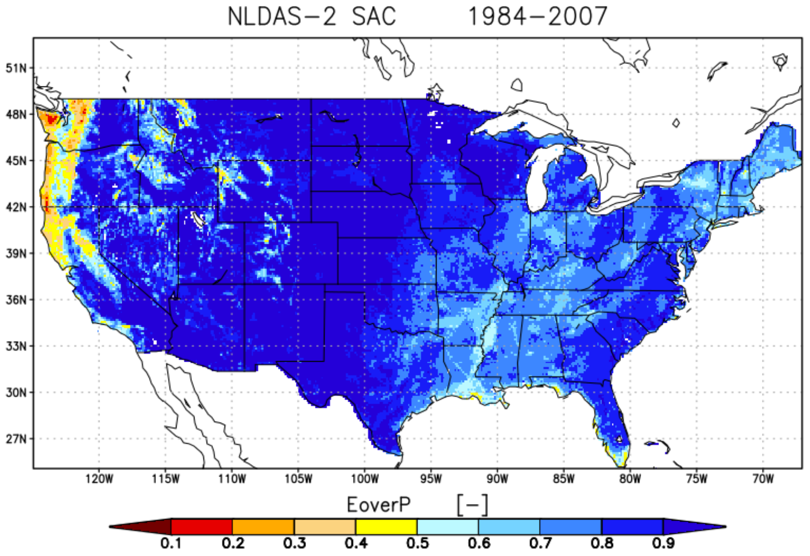


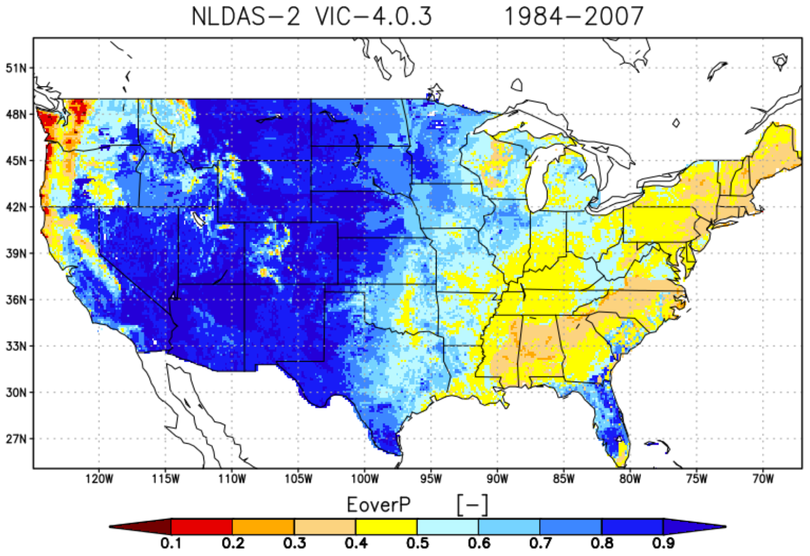


FLUXNET = reference ET product

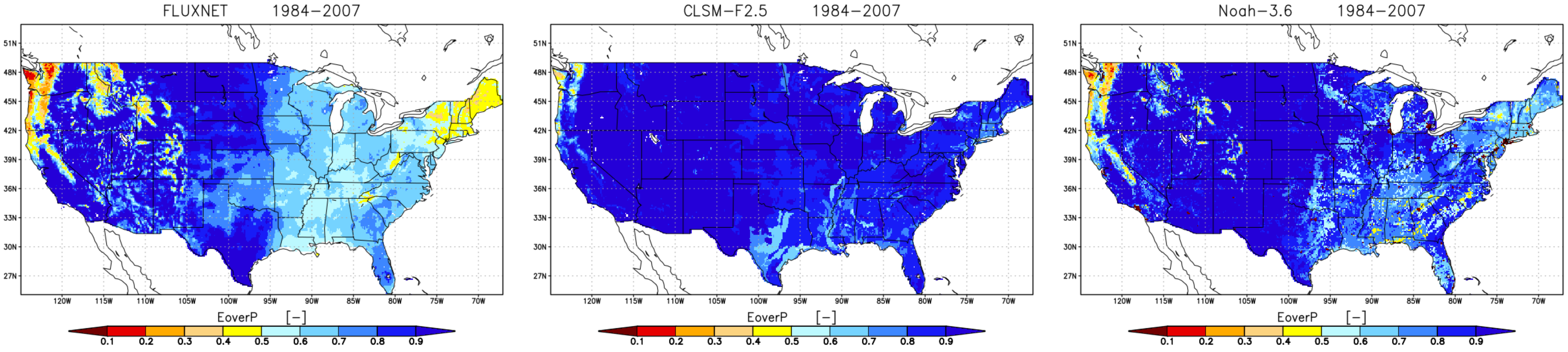
NLDAS-2 operational LSMs

Mosaic and SAC have high ET
Noah-2.8 has lower ET
VIC-4.0.3 has low ET esp. in the SE





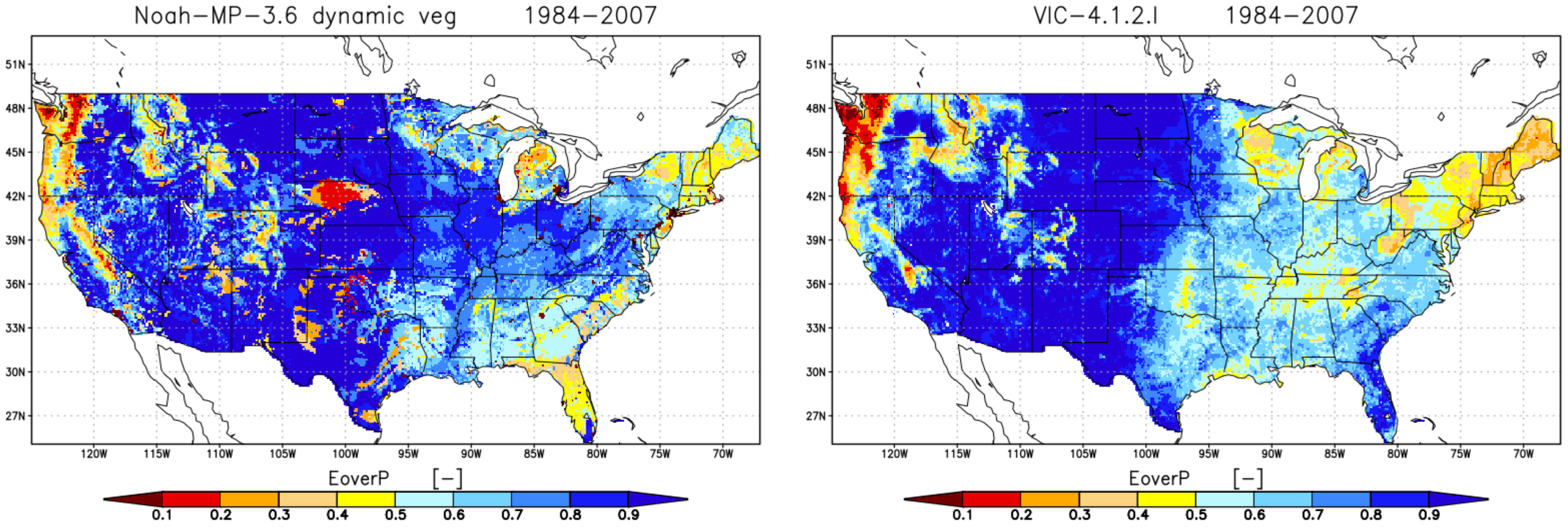
Evaporation over Precipitation



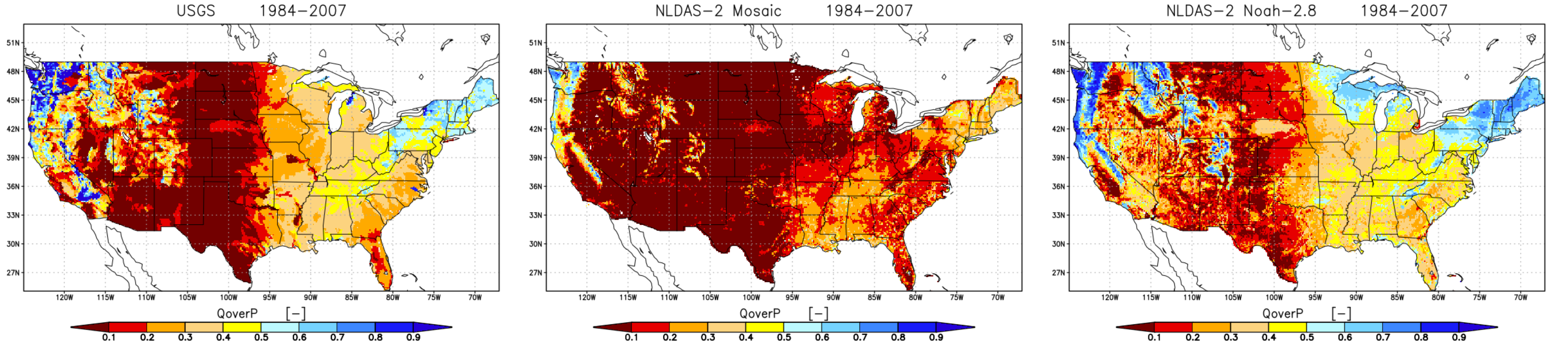
FLUXNET = reference ET product

NLDAS Science Testbed LSMs

CLSM-F2.5 has higher ET than Mosaic
Noah-3.6 has higher ET vs. Noah-2.8



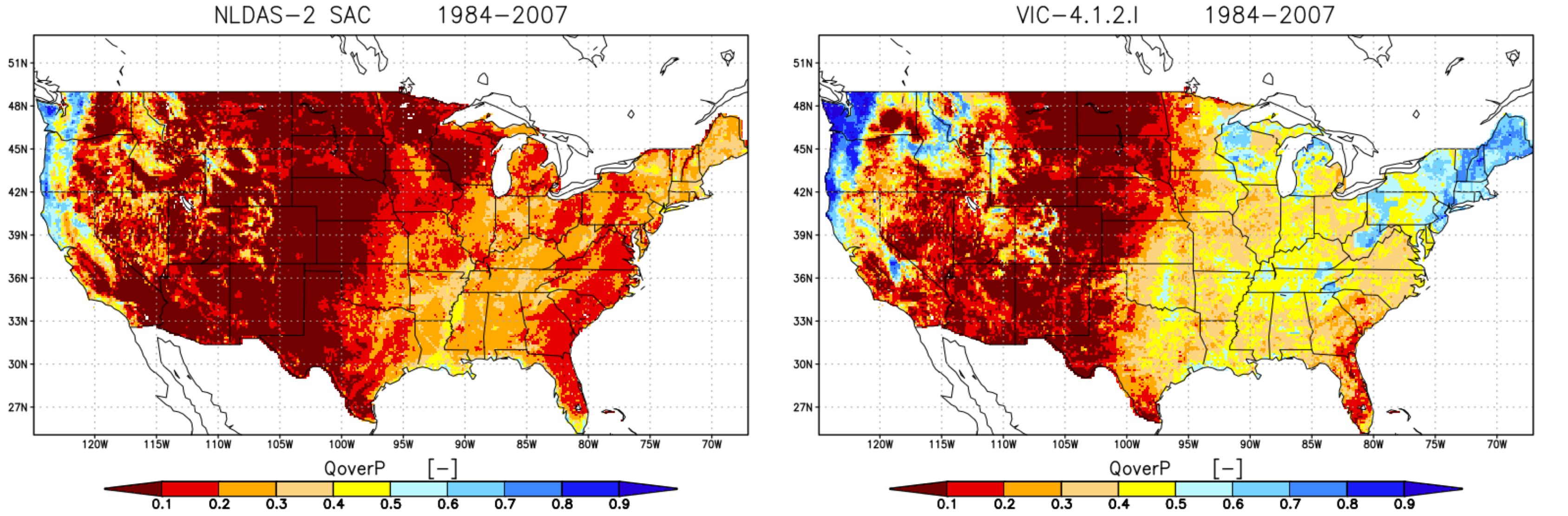
Runoff over Precipitation



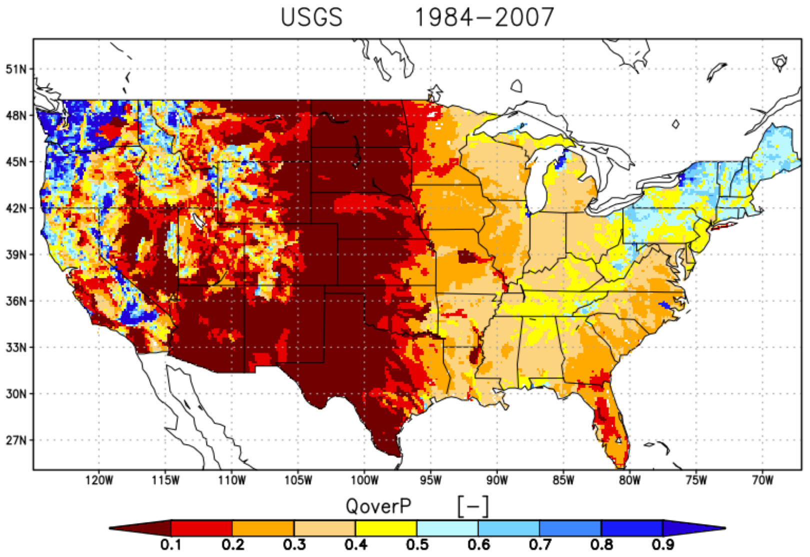
USGS = reference Q product

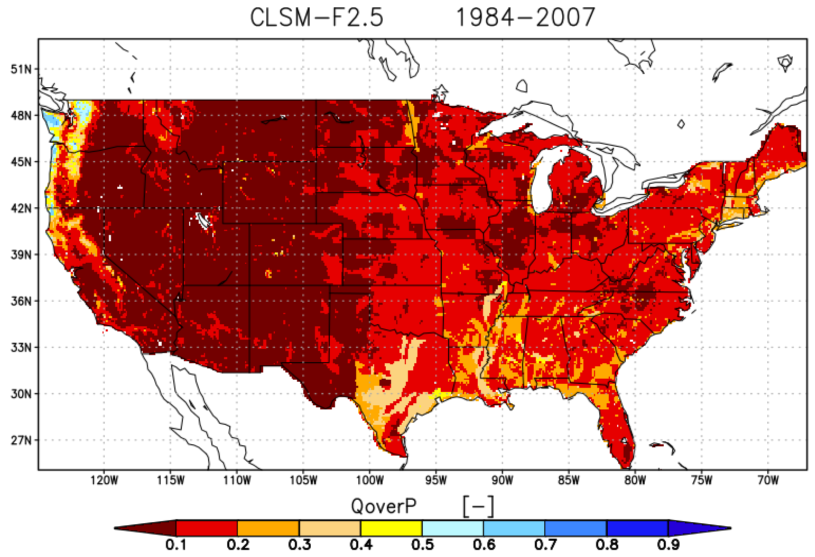
NLDAS-2 operational LSMs

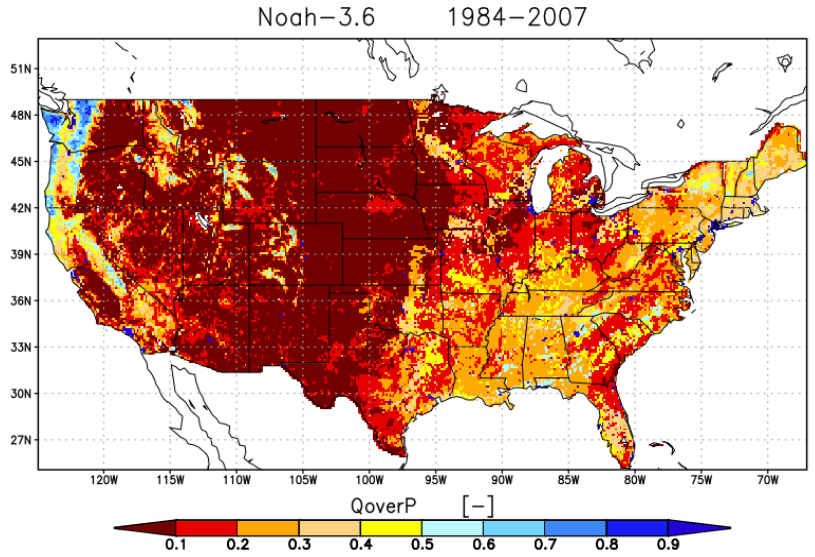
Mosaic and SAC have lower Q
Noah-2.8 and VIC-4.0.3 compare well to USGS



Runoff over Precipitation



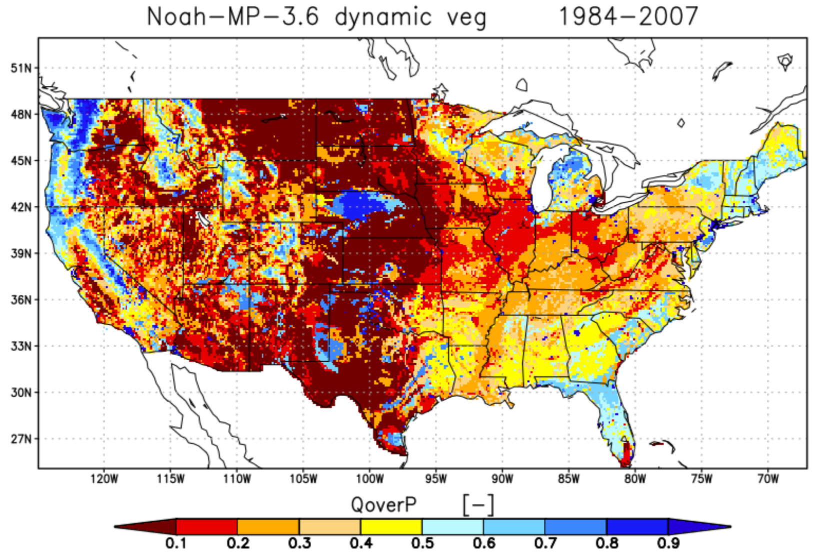


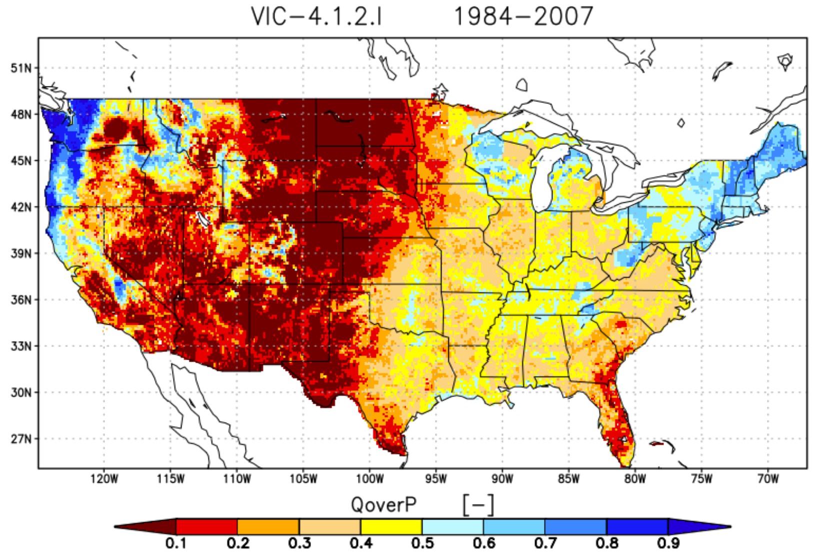


USGS = reference Q product

NLDAS Science Testbed LSMs

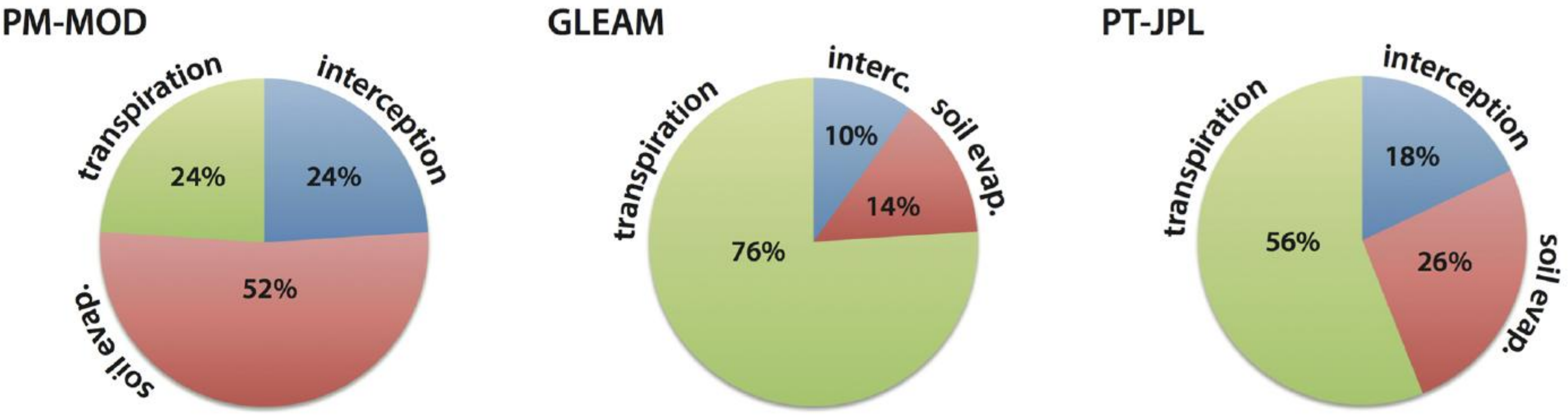
CLSM-F2.5 again has low Q
Noah-MP-3.6 does well (although notably not very well in the Sandhills or in FL)





The WACMOS-ET project – Part 2: Evaluation of global terrestrial evaporation data sets

D. G. Miralles[1,2], C. Jiménez[3], M. Jung[4], D. Michel[5], A. Ershadi[6], M. F. McCabe[6], M. Hirschi[5], B. Martens[2], A. J. Dolman[1], J. B. Fisher[7], Q. Mu[8], S. I. Seneviratne[5], E. F. Wood[9], and D. Fernández-Prieto[10]



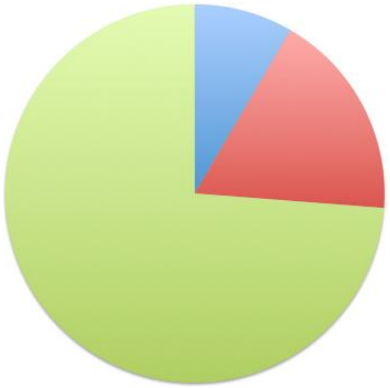
Three different models partitioned the ET _very_ differently.
These are GLOBAL percentages of total ET (2005-2007).

Miralles et al., 2016, Hydrol. Earth. Syst. Sci.

http://www.hydrol-earth-syst-sci.net/20/823/2016/

NLDAS-2 LSMs (1980-2013)

GLEAM v3.0a



Interception

Soil evap.

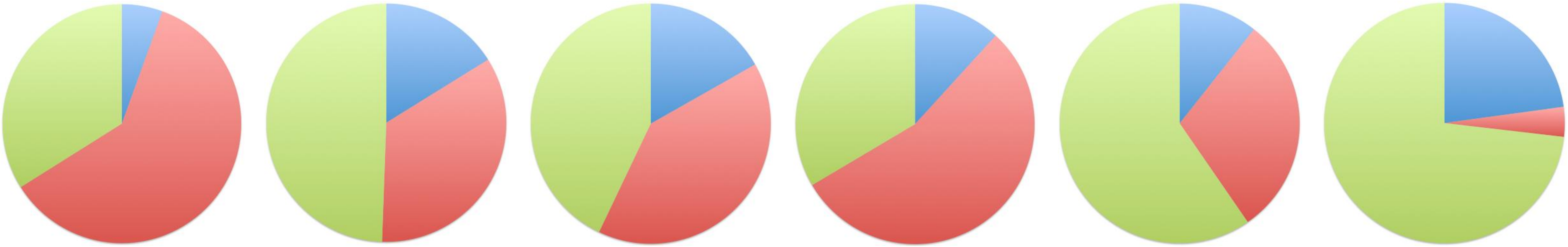
Transpiration

Reference/ LSM	Qle [W/m²]
GLEAM v3.0a	37.2 [*]
FLUXNET	37.7 [**]
N2 Mosaic	46.7
N2 Noah-2.8	33.5
N2 VIC-4.0.3	31.9
CLSM-F2.5	45.2
Noah-3.6	44.4
MP WRF default	38.7
MP dynamic veg	37.4
MP Noah-like	38.1
VIC-4.1.2.l	33.8

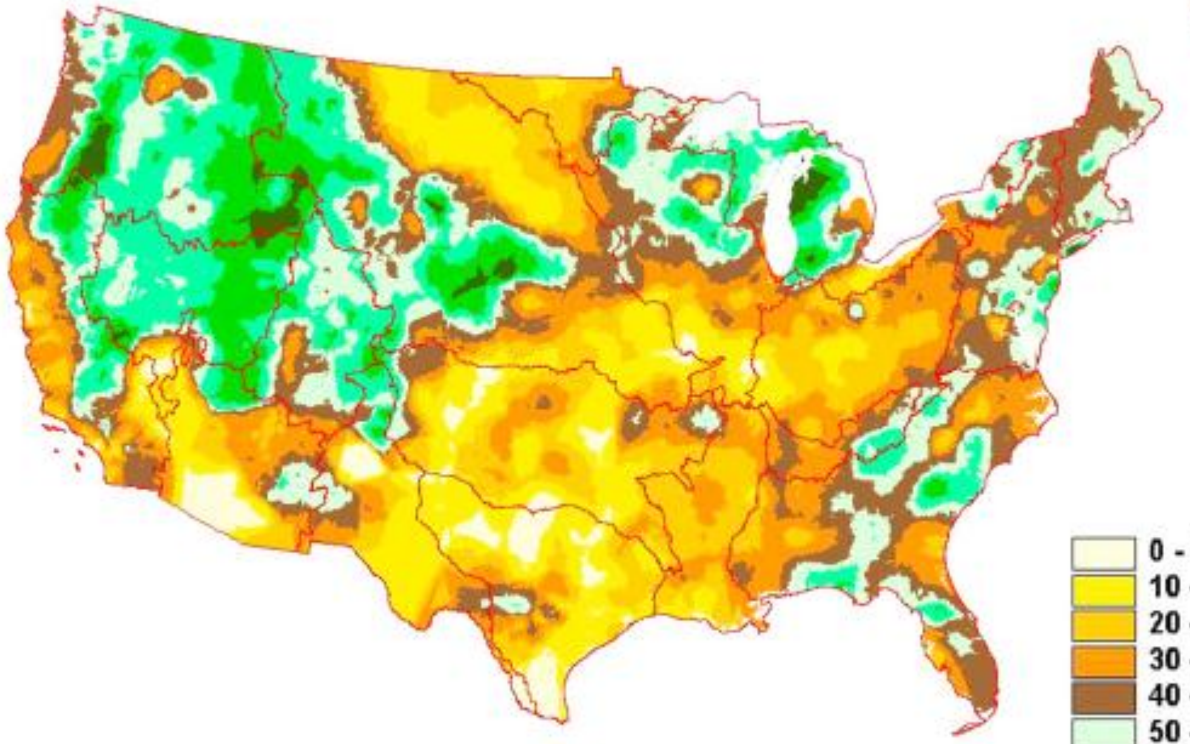
Pie charts and values in the table are area-averaged over the NLDAS domain 1980-2013

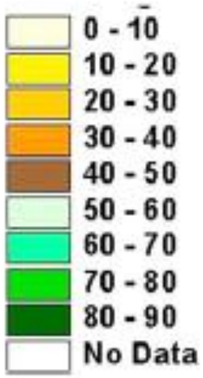
[*] - converted from [mm day^{-1}]
[**] - 1984-2007 climatology

NLDAS Science Testbed



Santhi et al., 2008, J. Hydrology





BFI calculated using:

USGS Base Flow index (Wolock, 2003)

Figure 1 USGS grid map of the base flow index (in %) for the conterminous United States developed from USGS BFI method.

BFI is defined as the baseflow divided by the total runoff.

In the LSMs using the ALMA convention:

BFI = Qsb / (Qs + Qsb)

doi:10.1016/j.jhydrol.2007.12.018

http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_013190.pdf

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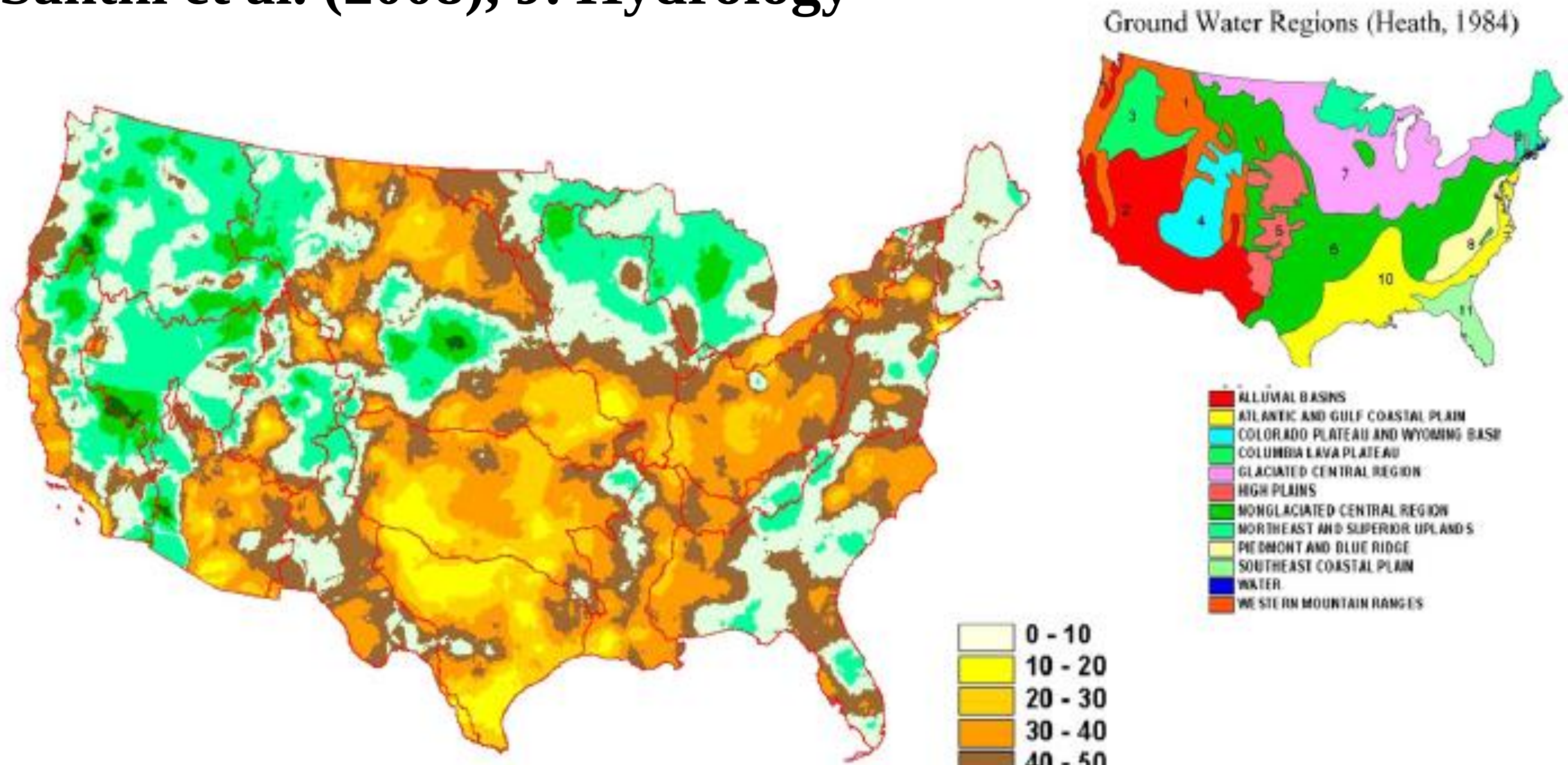
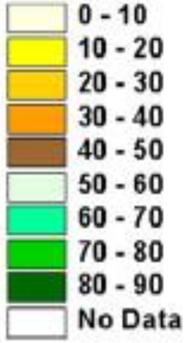
Santhi et al. (2008), J. Hydrology





BFI calculated using:
digital filter method (Santhi et al., 2008)

Figure 2 Grid map of the base flow index (in %) for the conterminous United States developed from digital filter method.

doi:10.1016/j.jhydrol.2007.12.018

http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_013190.pdf

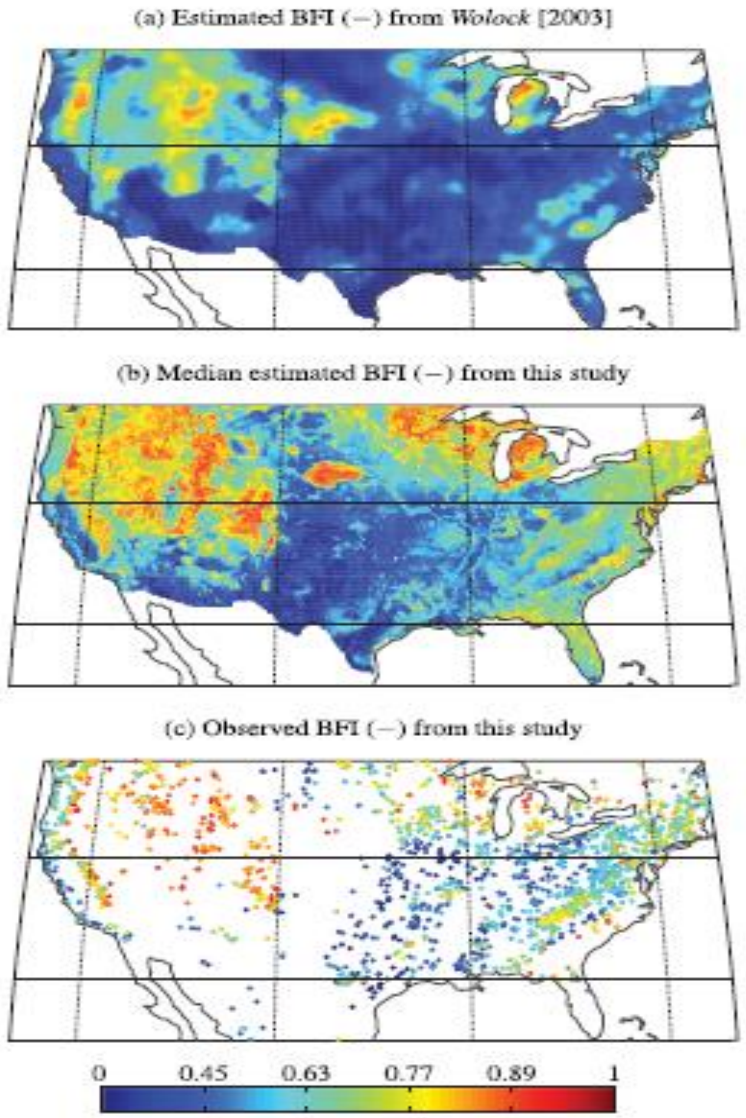


Figure 13. Map of the conterminous USA showing (a) estimated BFI from *Wolock* [2003], (b) median estimated BFI from this study, and (c) observed BFI. In (b) only values for the conterminous USA are shown. The BFI values in (a) were computed using a different method than the BFI values in (b) and (c). The maps have limits 25–48°N and 125–70°W and grid lines at every 10° latitude and 15° longitude.

Beck et al., 2013, WRR

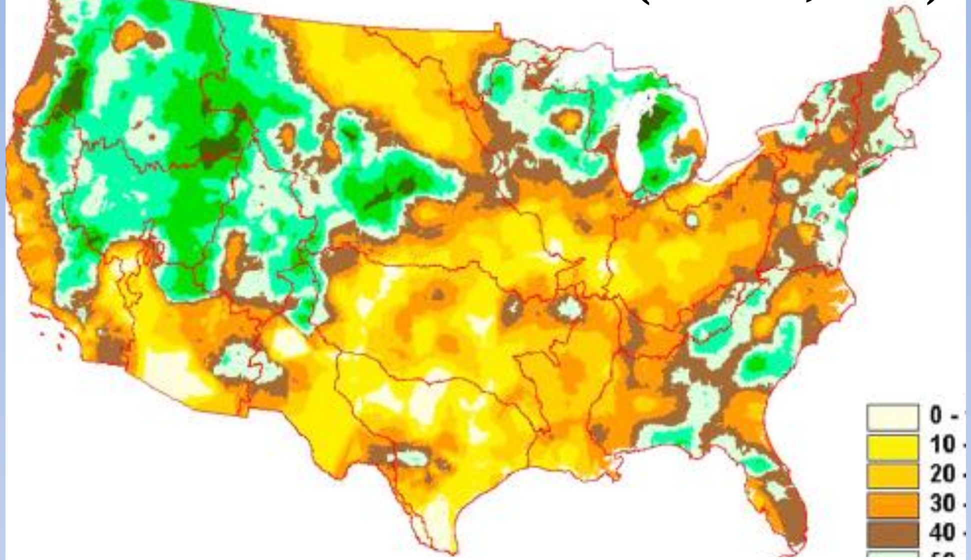
doi:10.1002/2013WR013918, 2013
http://onlinelibrary.wiley.com/doi/10.1002/2013WR013918/abstract

The different methodologies and the observed BFI values all generally show the same features:

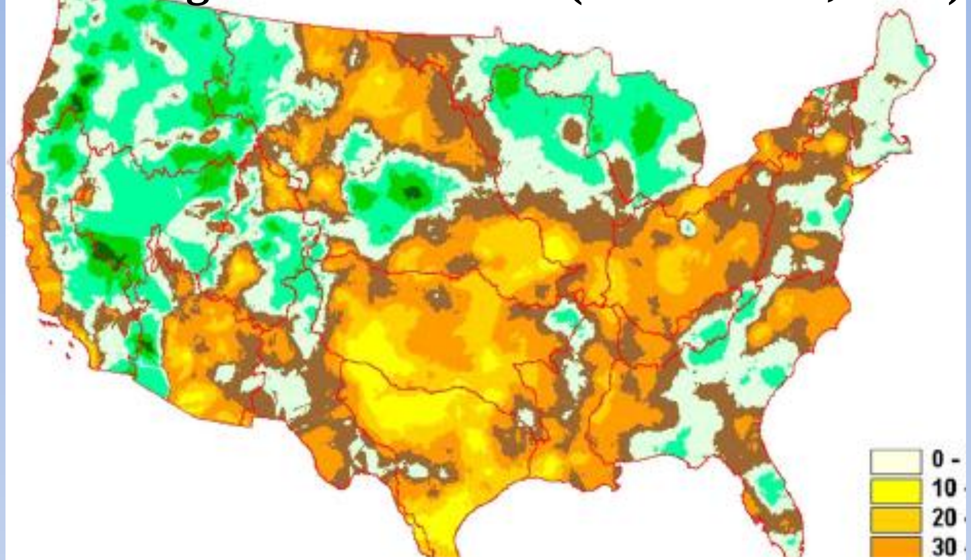
1) Higher BFI in the western U.S. high terrain
2) Lower BFI in the central U.S.
3) Pocket regions of higher BFI on the east side of the Appalachians and in the Northeast
4) High BFI around the western Great Lakes
5) High BFI in the Sandhills region (Nebraska)

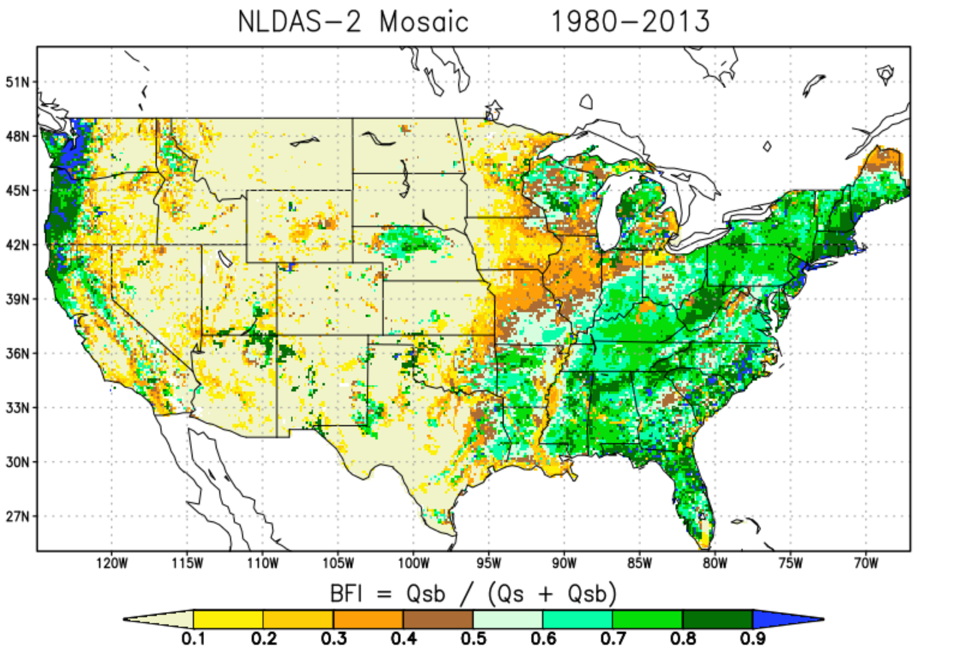
$$BFI = Qsb / (Qs + Qsb)$$

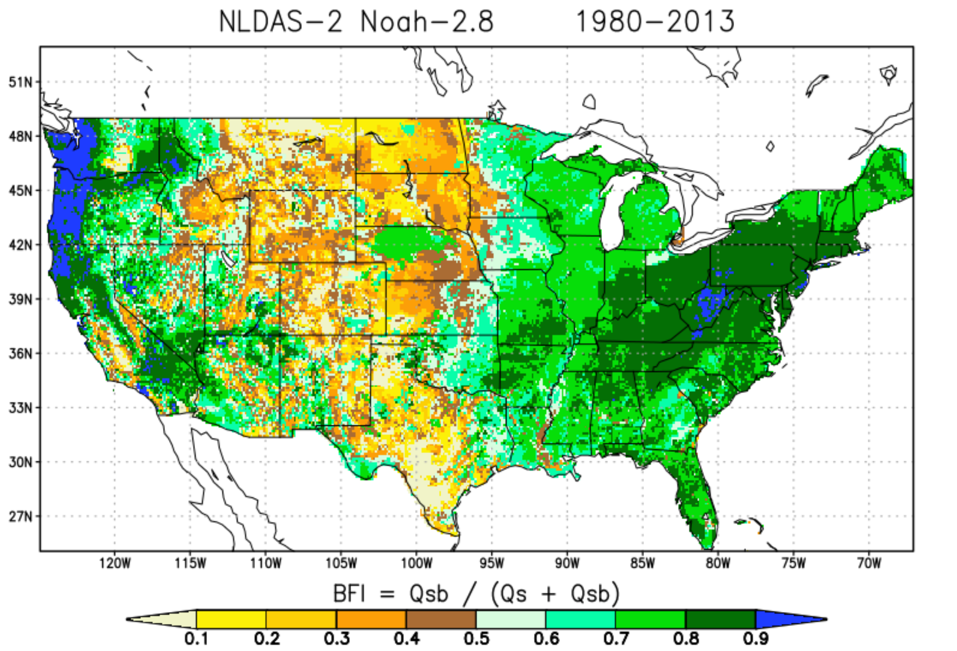
USGS Base Flow index (Wolock, 2003)



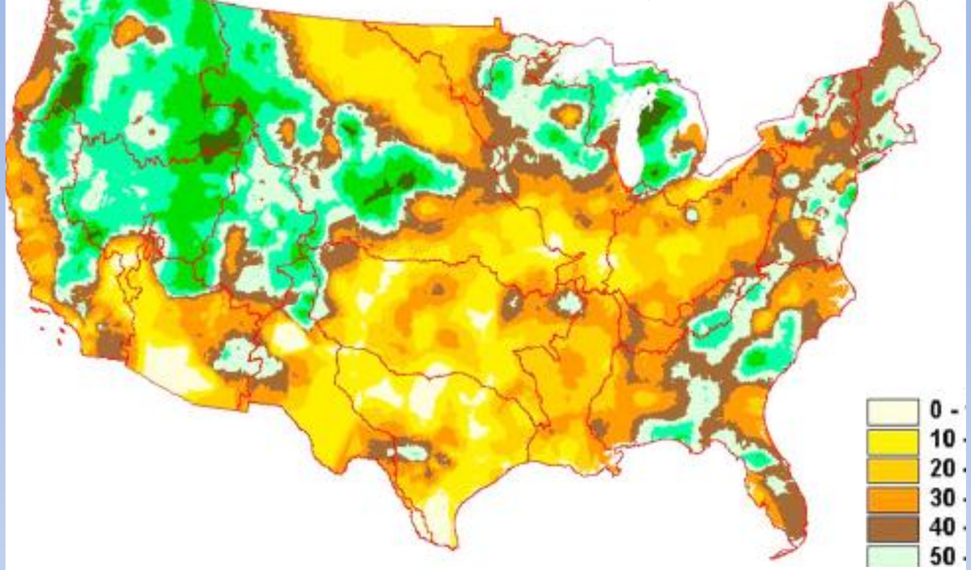
Digital filter method (Santhi et al., 2008)



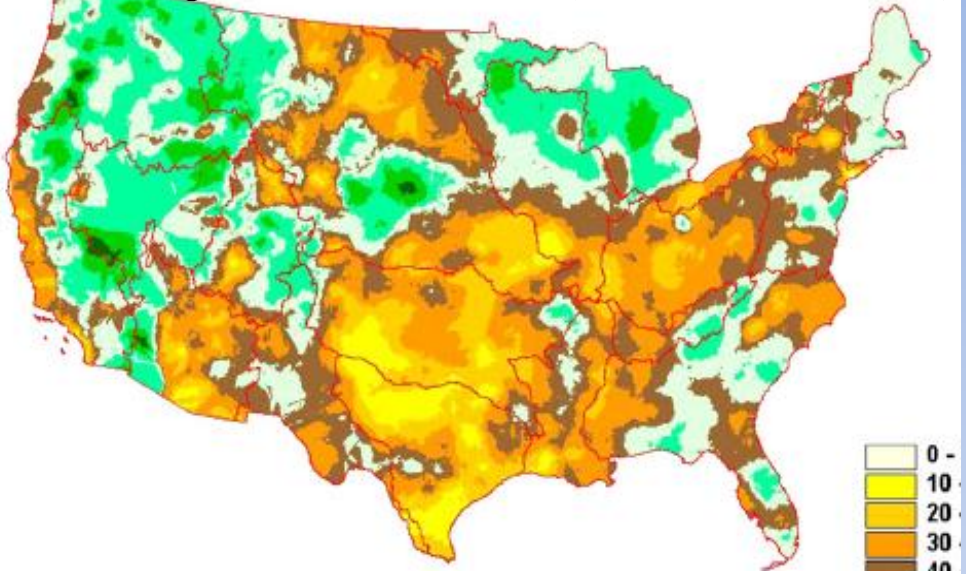


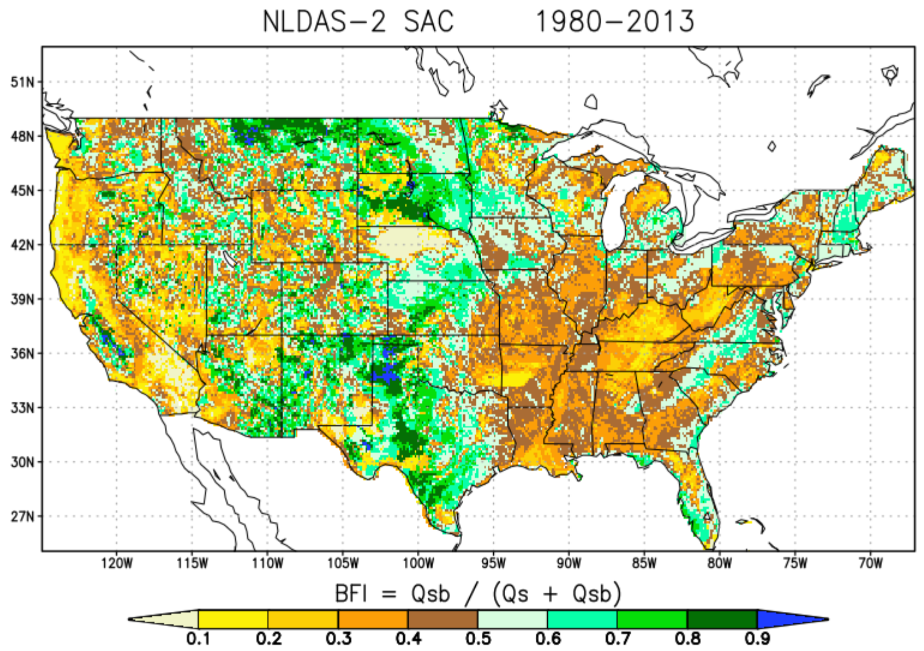


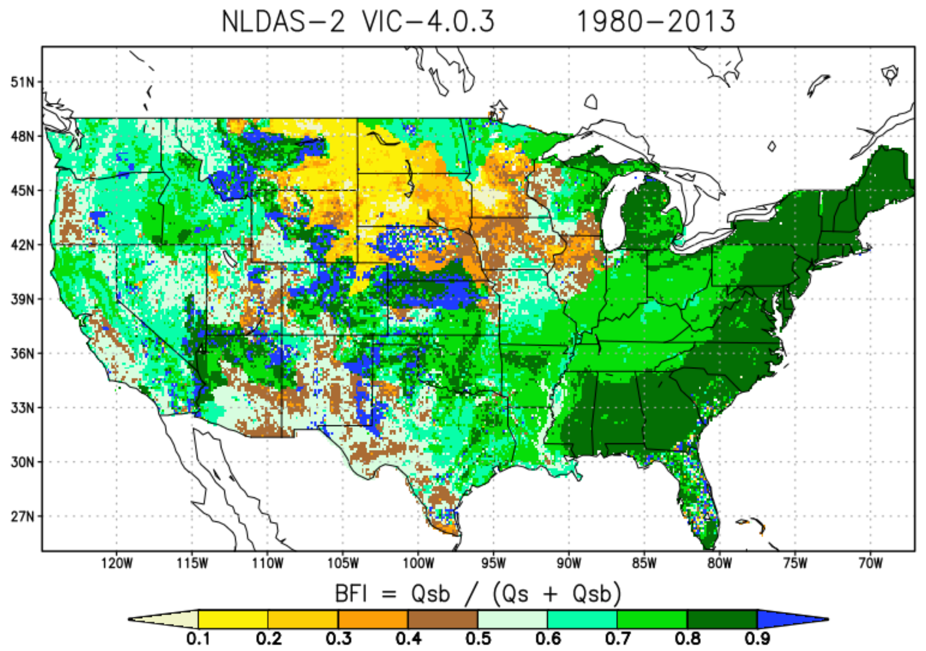
USGS Base Flow index (Wolock, 2003)



Digital filter method (Santhi et al., 2008)







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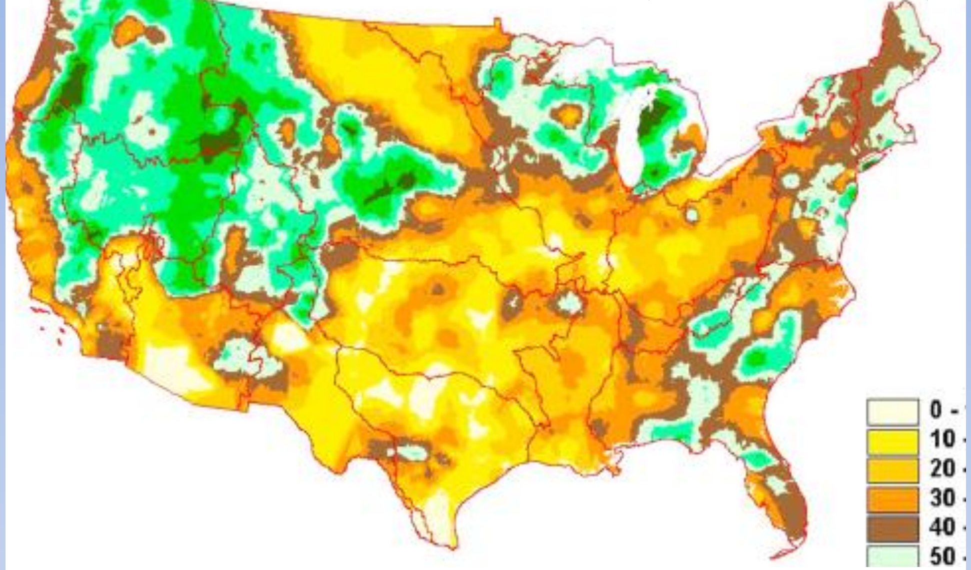

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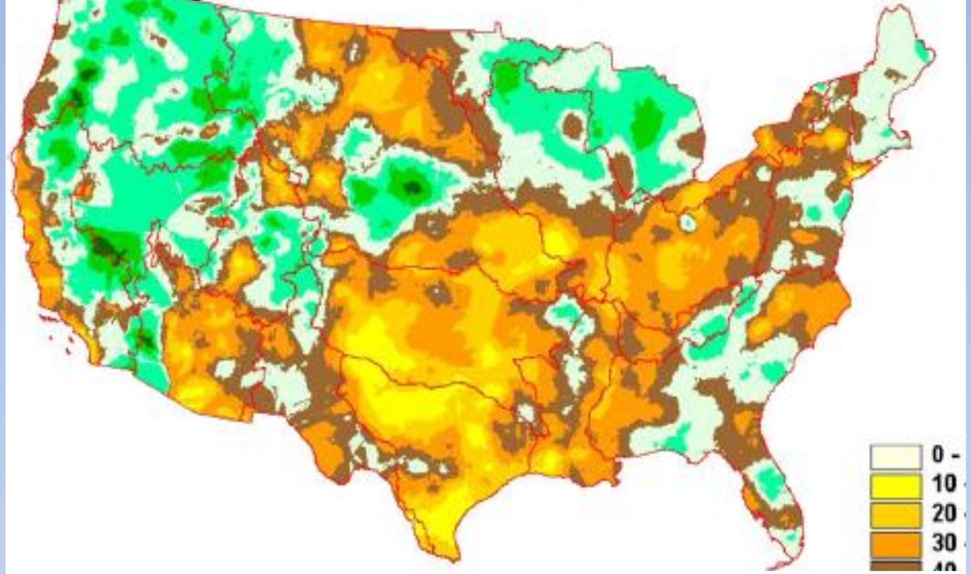

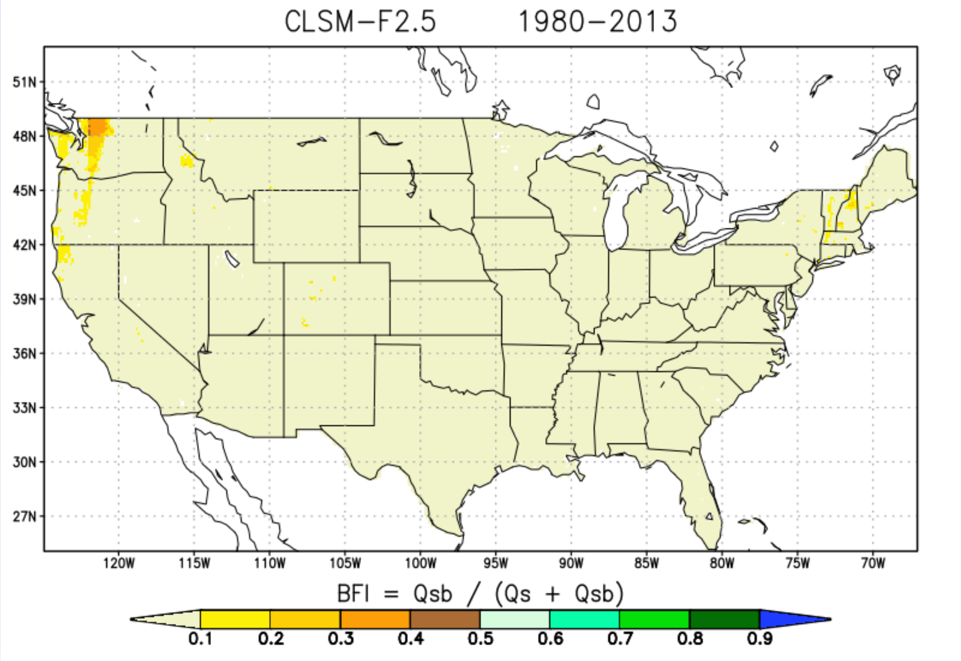

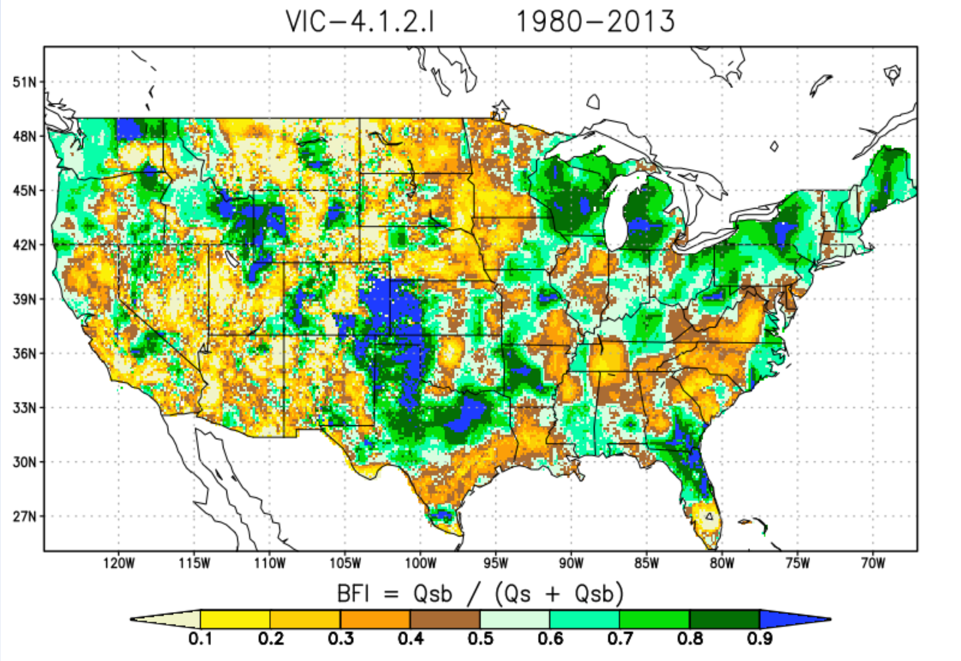

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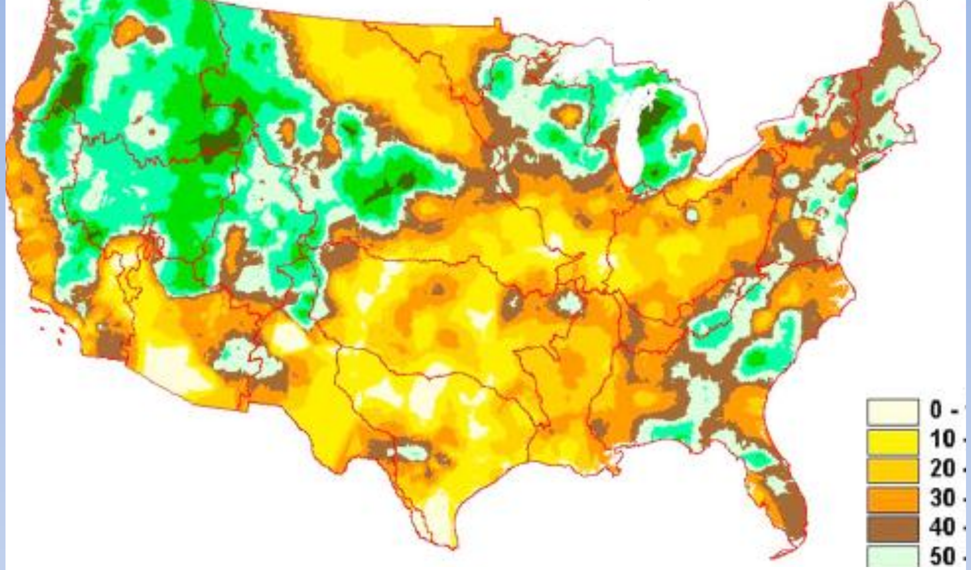

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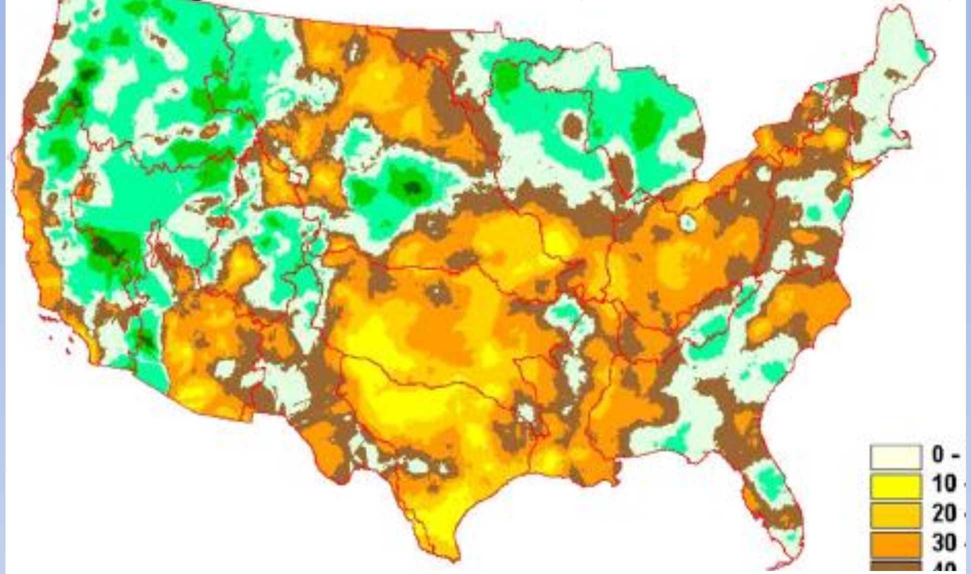
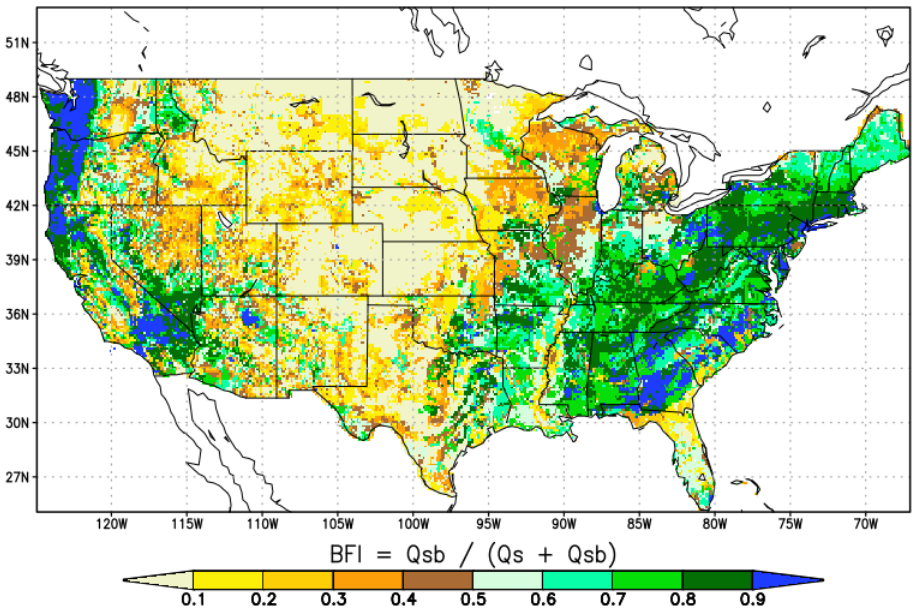
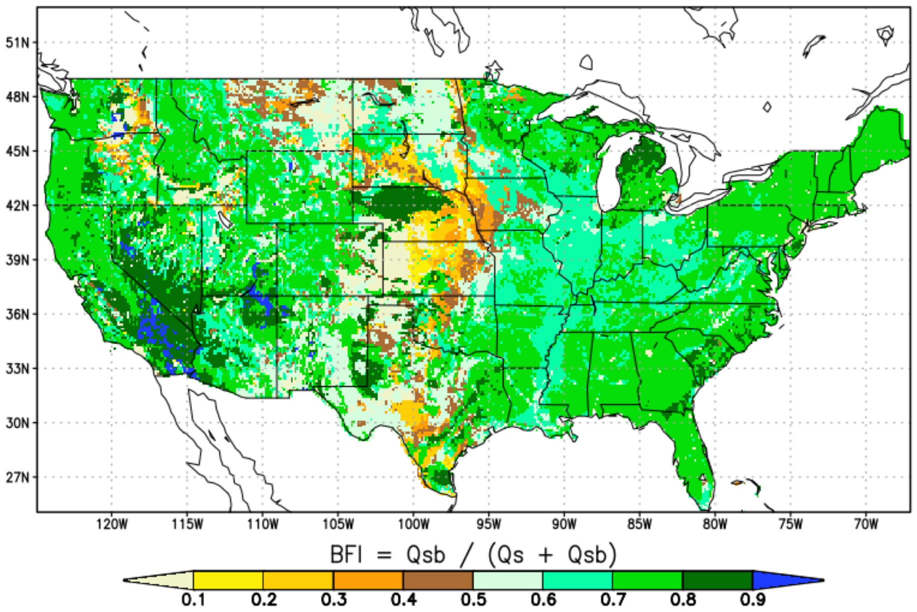


Noah–3.6 1980–2013



Noah–MP–3.6 dynamic veg 1980–2013



Other areas of development

- CLM-4.5 LSM has been integrated into the LIS software and will be evaluated in the NLDAS environment
- RUC LSM is also in LIS and is being evaluated for NLDAS
- Adding new evaluations to the Testbed (updated North American Soil Moisture Database, GLEAM ET and soil moisture, etc.)
- Evaluating the NLDAS router against the HyMAP router
- Testing Noah-MP various options (vegetation, canopy stomatal resistance, runoff/groundwater, surface layer drag coeff., etc.)
- Looking to improve performance of CLSM-F2.5 or later version

http://ldas.gsfc.nasa.gov/nldas/

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