Confronting CLM with land-surface observations

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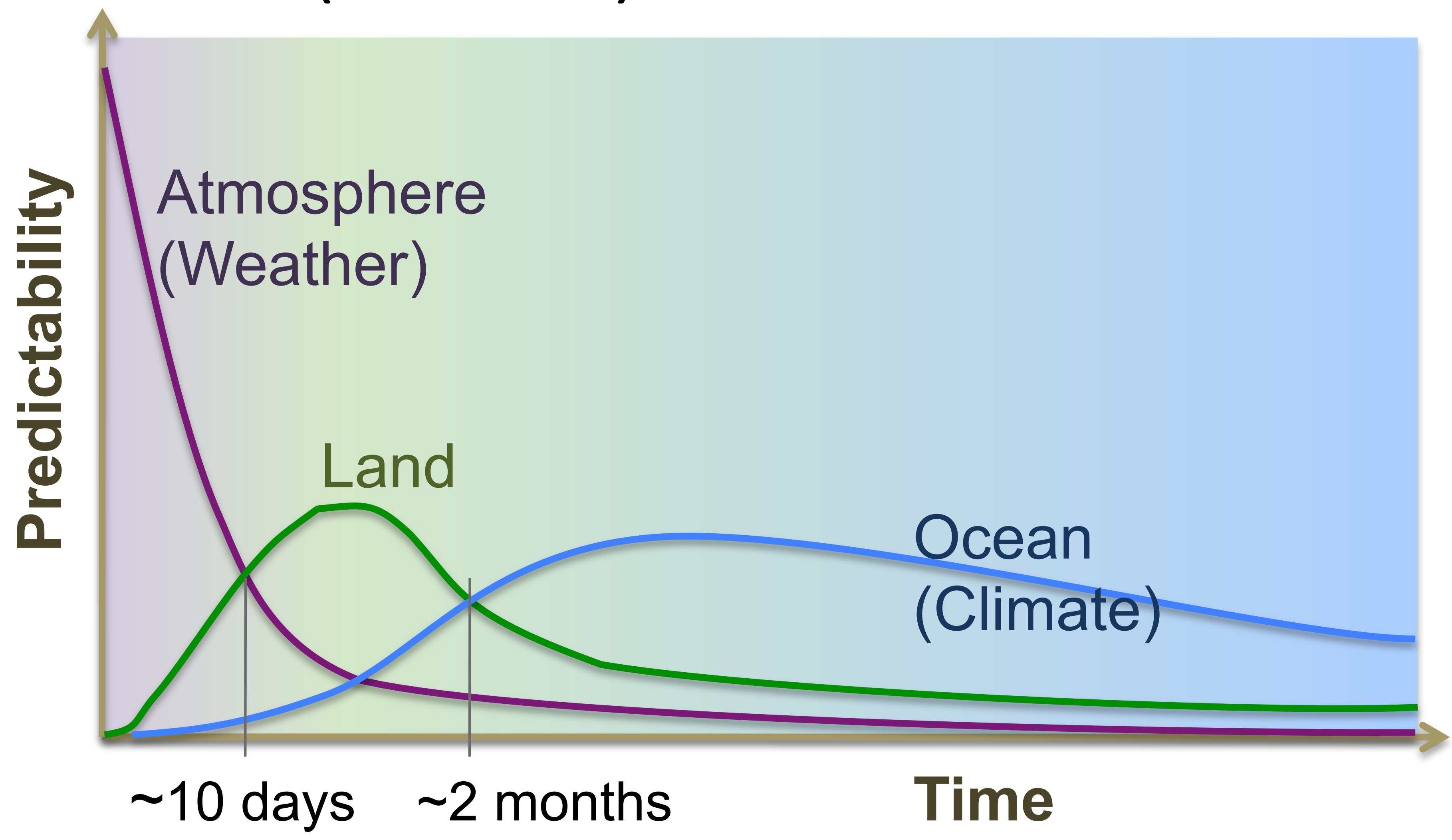
Predictability and Prediction

Land states (namely soil moisture*) can provide predictability in the window from deterministic (weather) to climate (seasonal+) time scales.

- To have an effect, there must exist:
  1. Sensitivity of fluxes to land states, and atmosphere to fluxes
  2. Sufficient variability
  3. Memory of initial land states



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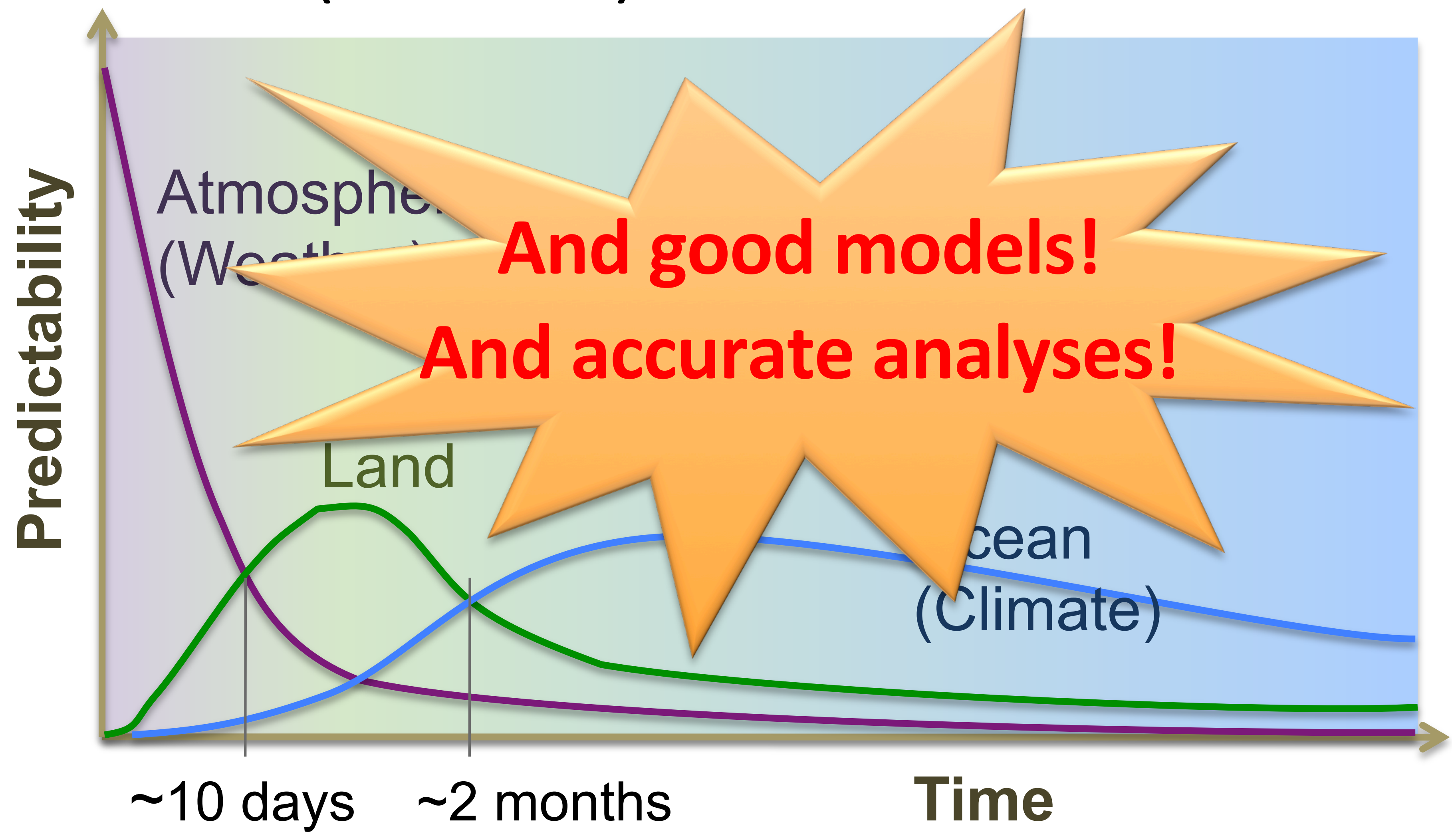

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CONUS Soil Moisture Data

*International Soil Moisture Network**

	Stations	Years	Instruments	Notes
ARM	29	22	Heat Dissipation	Regional (Oklahoma & Kansas)
AWDN	50	13	Dielectric	Regional (Nebraska)
COSMOS	101	7	Cosmic Ray Neutron	Does not measure a set depth
FLUXNET	2	14	Dielectric	Most AMERIFLUX sites not available from ISMN
PBO-H2O	108	8	GPS Reflection	Only 7 locations, multiple instruments at each
SCAN	211	19	Dielectric	Agricultural locations
SNOTEL	415	19	Dielectric	Western US, mostly high altitude locations
SOILSCAPE	135	20	Dielectric	Mostly western US
USCRN	114	15	Dielectric	
USDA-ARS	4	8	Dielectric	

* http://ismn.geo.tuwien.ac.at/ ** Also *North American Soil Moisture Data Bank* – results not quite ready

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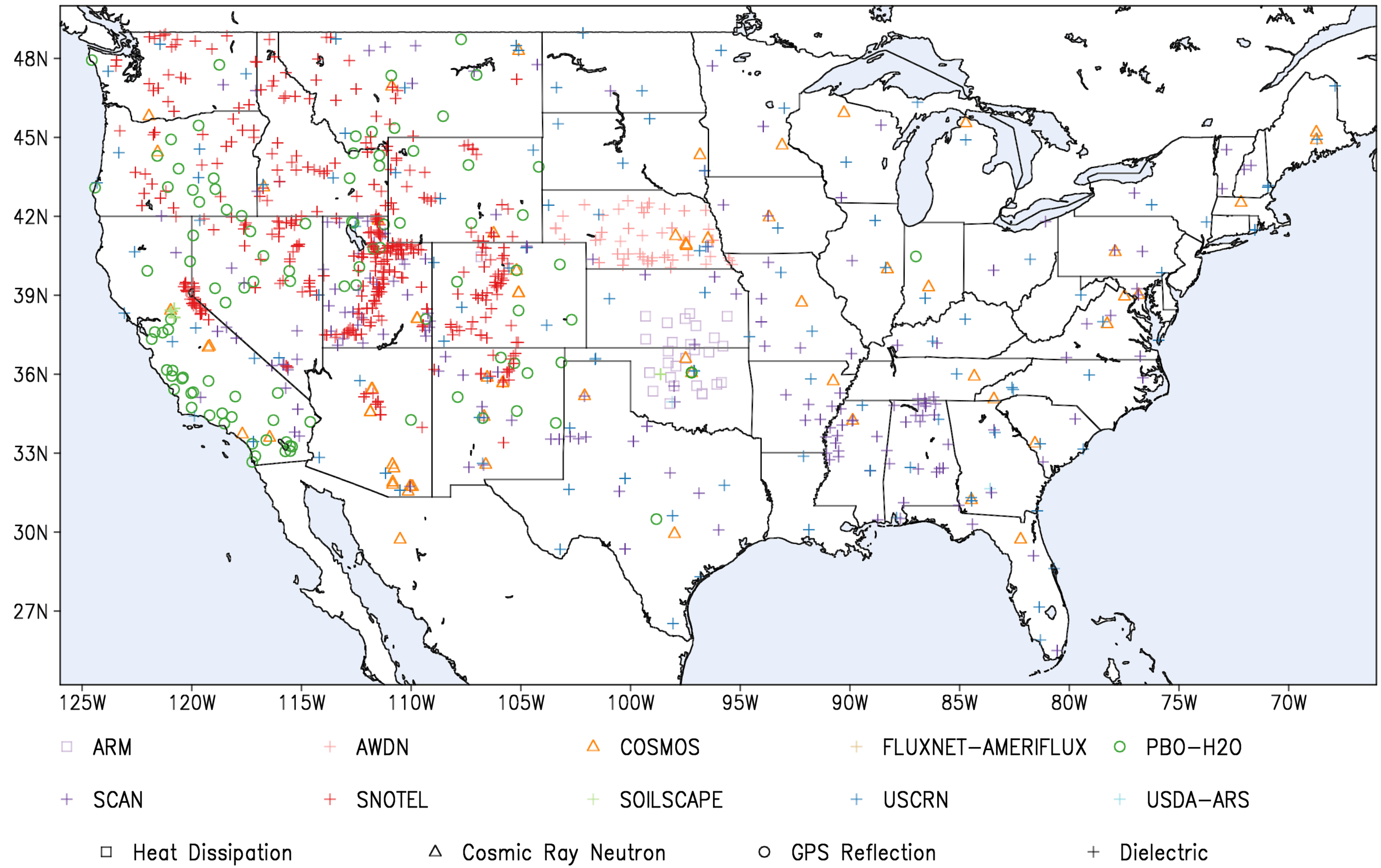
Distribution of ISMN data over CONUS



Global Models Used

~30 years for each, covering ~1980s-2000s

	"Offline" Land model simulations	Free-running GCMs (unconstrained)	Atmospheric Reanalyses (constrained by DA)
NCEP/ EMC	Global LDAS *All gridded observational forcing* Noah2.7 land model 1°x1°	CFS Seasonal Forecasts *initialized from CFSR* Noah2.7 land model (T126) 0.94°x0.95°	Coupled Forecast System Reanalysis CFSv2 AGCM Noah2.7 land model (T384) 0.31°x0.37°
NASA/ GSFC/ GMAO	MERRA-Land *MERRA + GPCP forcing* Catchment land model 0.67°x0.5°	GEOS5 "AMIP" Simulation *run in MERRA-2 mode* Catchment land model 0.67°x0.5°	MERRA GEOS5 AGCM Catchment land model 0.67°x0.5°
ECMWF	Earth2Observe *WFDEI gridded forcing* HTESSEL land model 0.5°x0.5°	Athena Project *IFS "AMIP" Annual Forecasts* HTESSEL land model (T1279) 0.14°x0.14°	ERA-Interim Reanalysis IFS AGCM HTESSEL land model 0.75°x0.75°
NCAR	Global offline *Qian et al. forcing* CLM4.0-SP land model 1.25°x0.9°	CCSM4 Seasonal Forecasts *initialized from CMIP Branch run* CLM4.0-CN land model 1.25°x0.9°	--none--

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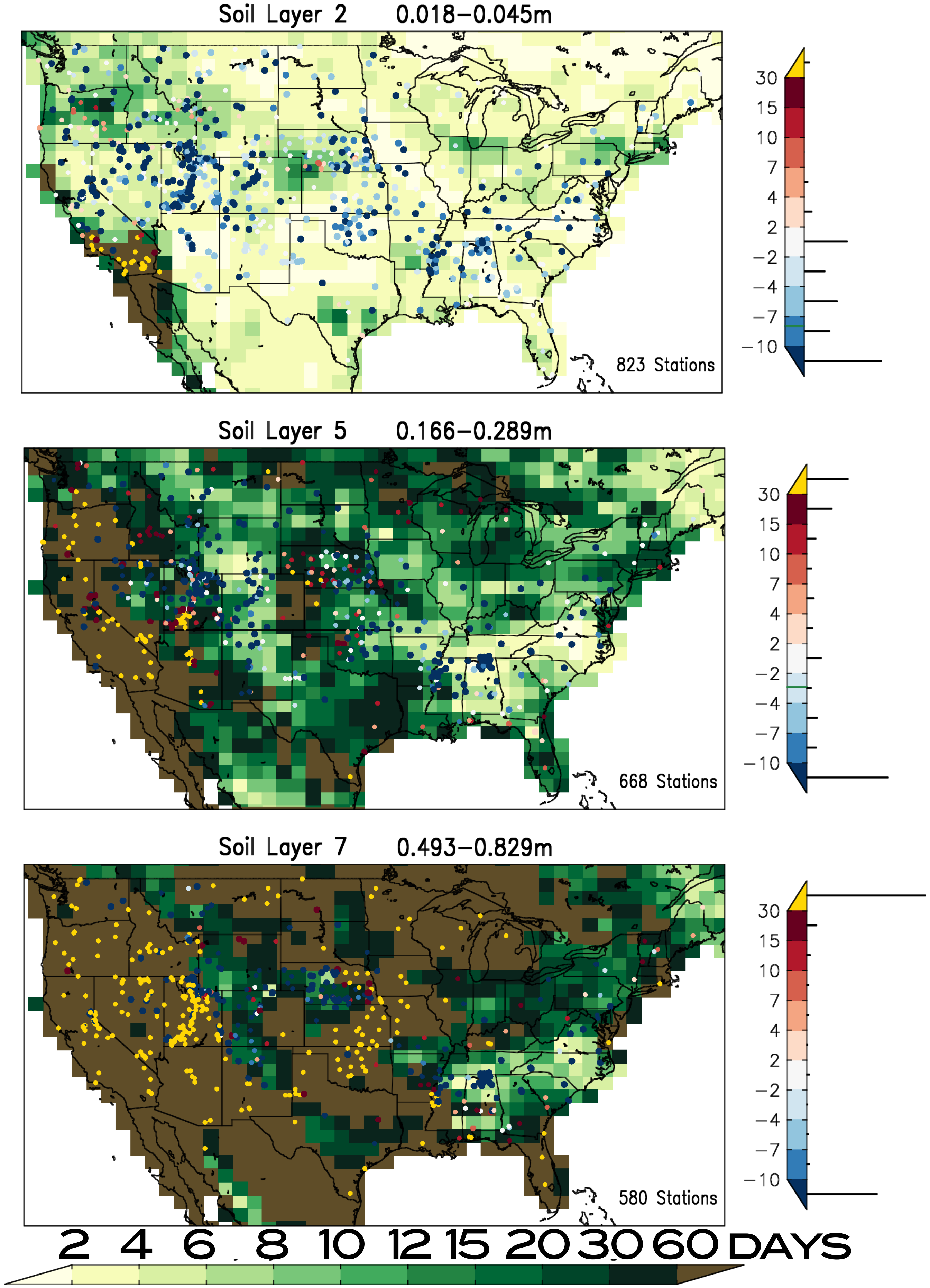
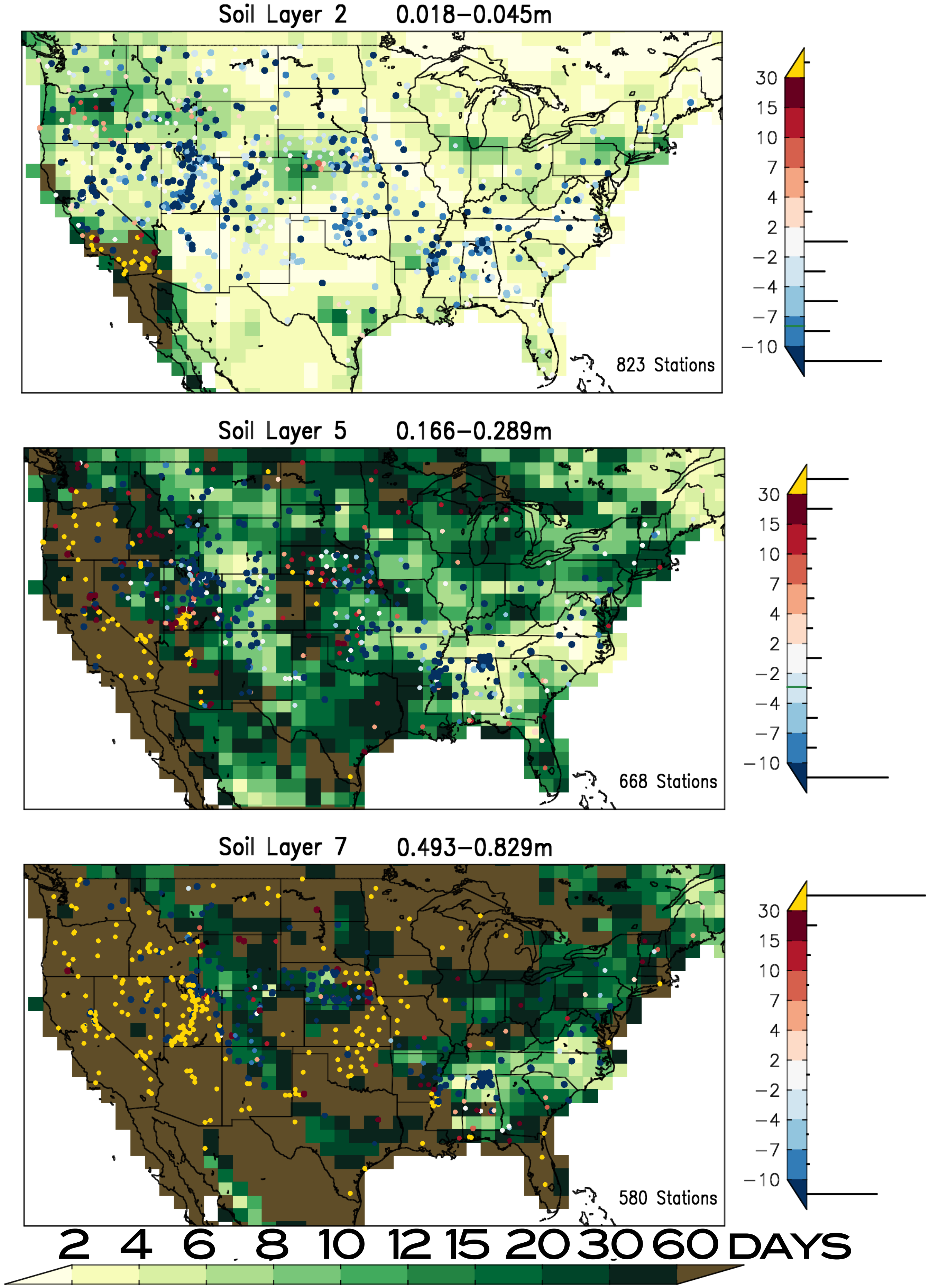
All results for JJA only



CLM4+CCSM4: τ

- **Dots** = bias at each station
- **Bars** next to colors = distribution of biases



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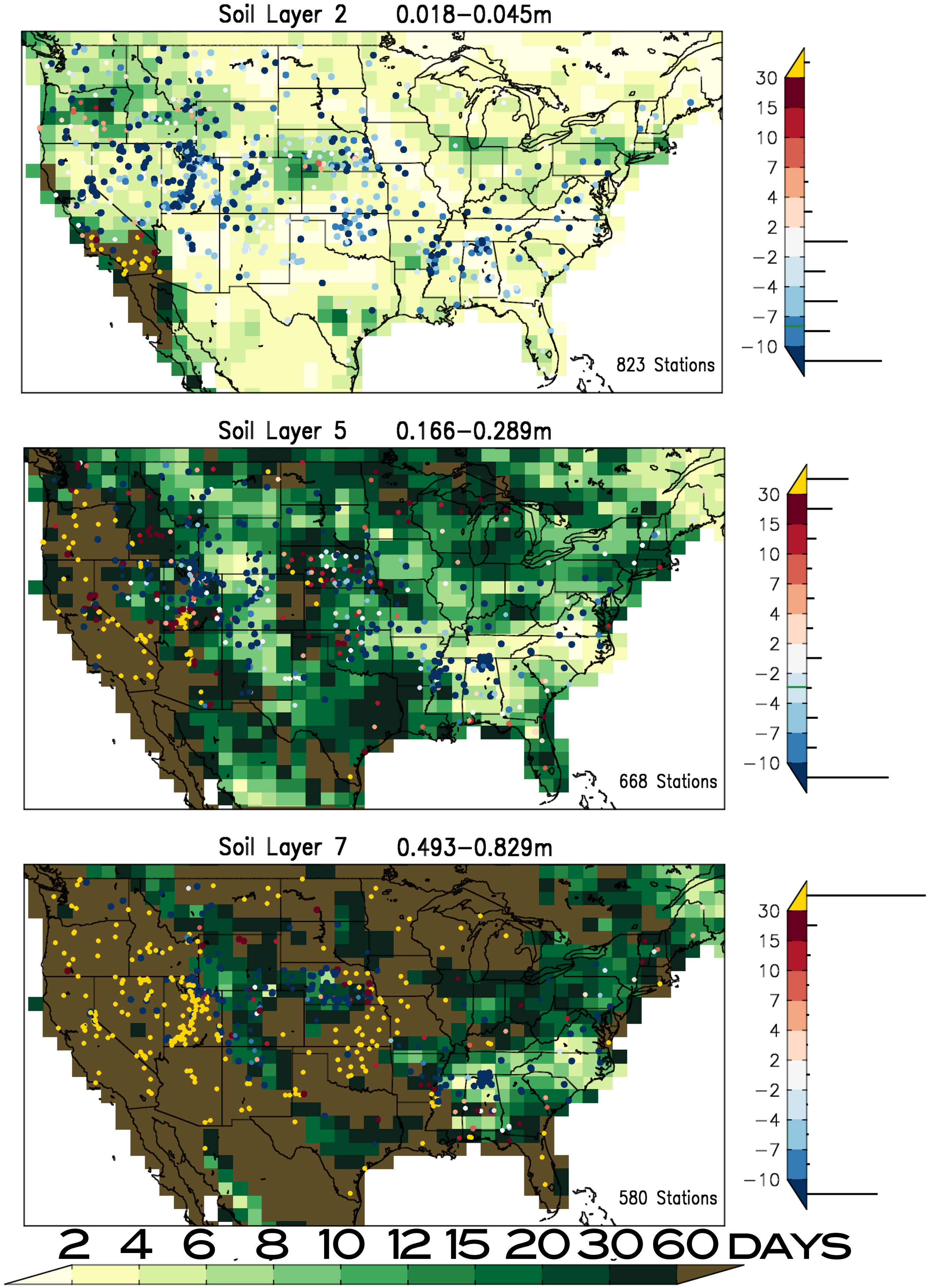

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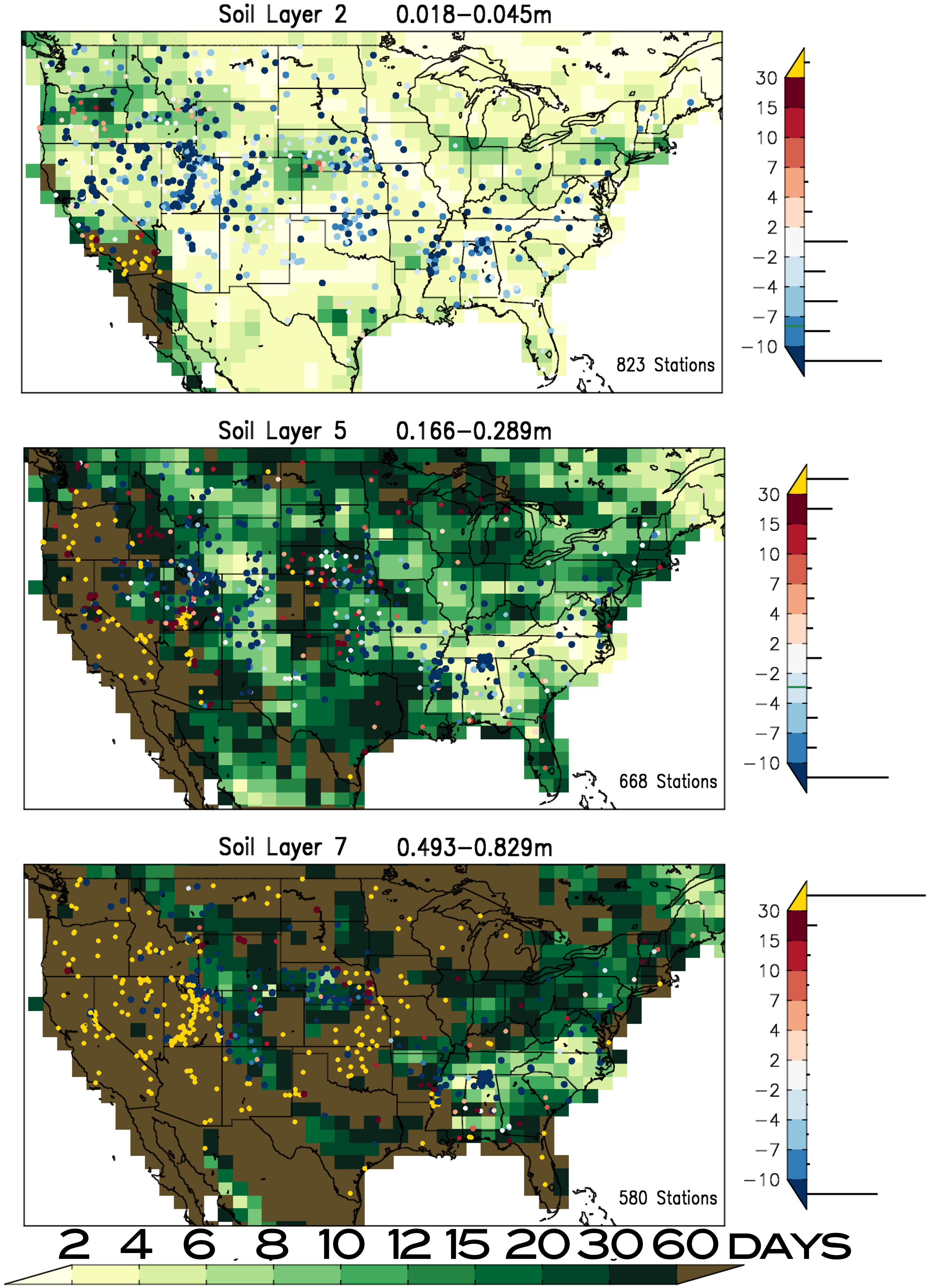

CLM4+CCSM4: τ

- Dots = bias at each station
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- Too little persistence of soil moisture anomalies in surface layers.
- Switches over to too much persistence at deep layers.
- In between, average bias not bad, but **distribution is poor**.

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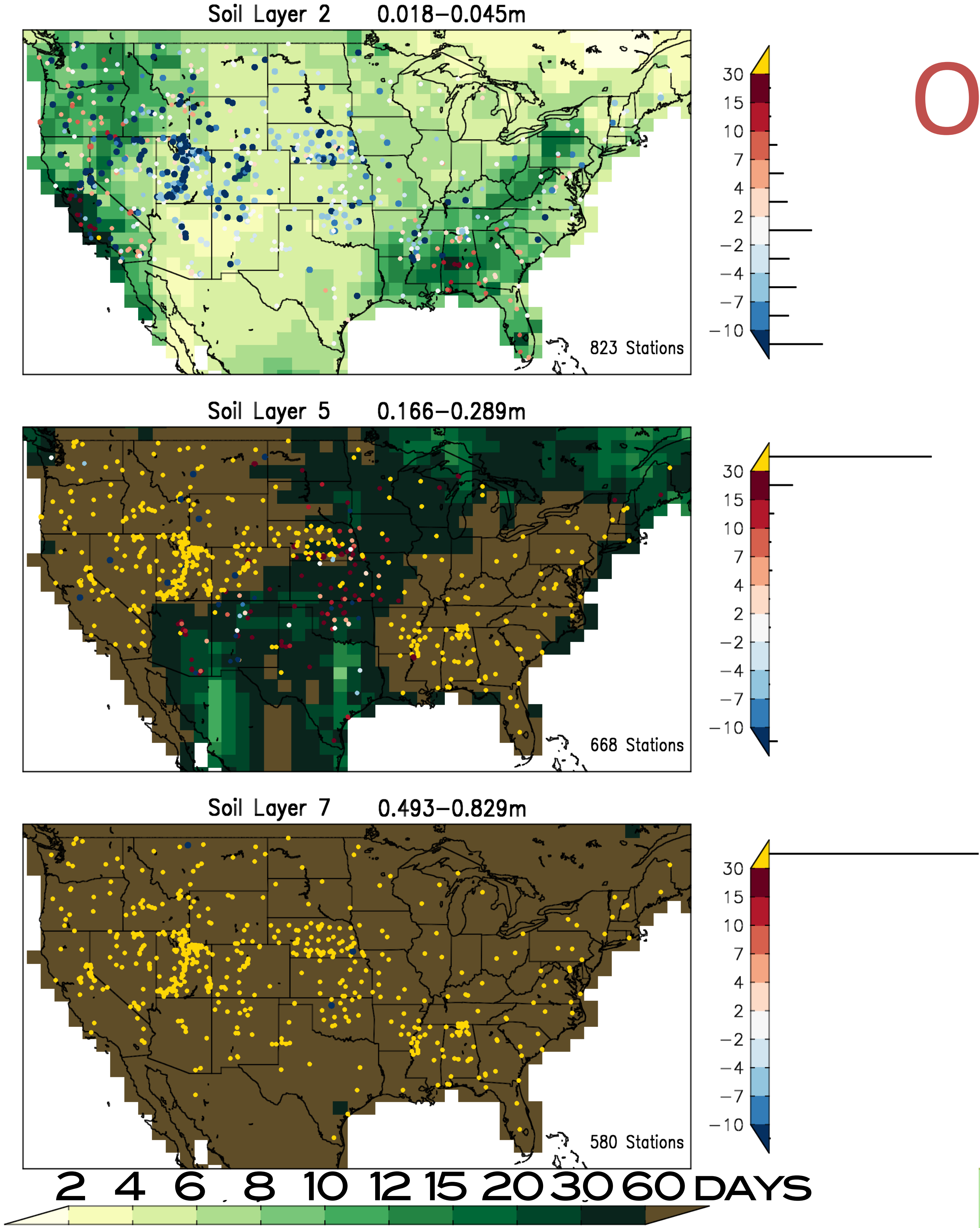
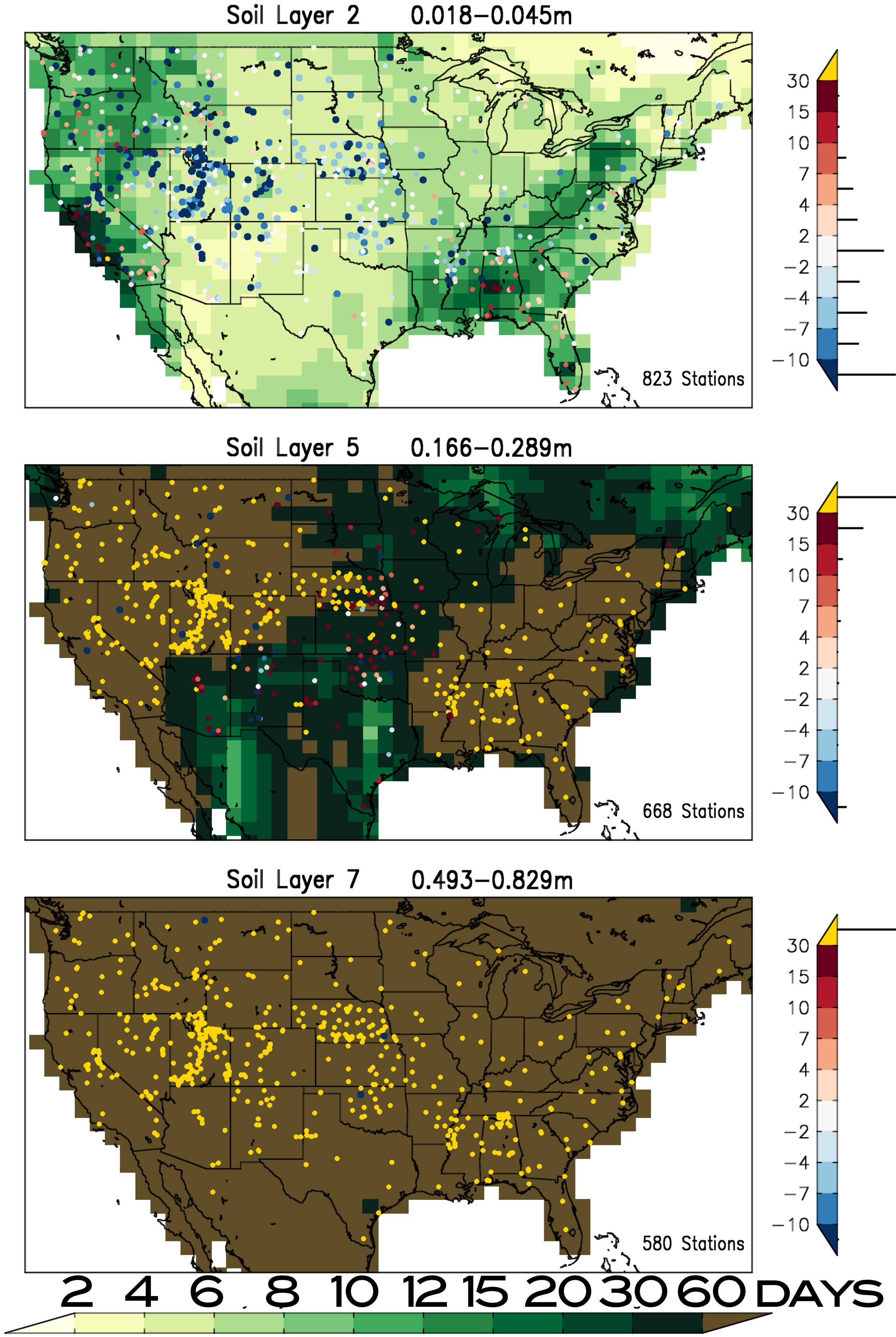
Offline CLM4: τ



- **Excessive persistence is even more prevalent**, sets in at shallower depths.



Offline CLM4: τ

- Excessive persistence is even more prevalent, sets in at shallower depths.
- **Scale differences** (point measurements vs grid boxes) and **random measurement error** do contribute to these biases – we are working to understand how much they impact results.

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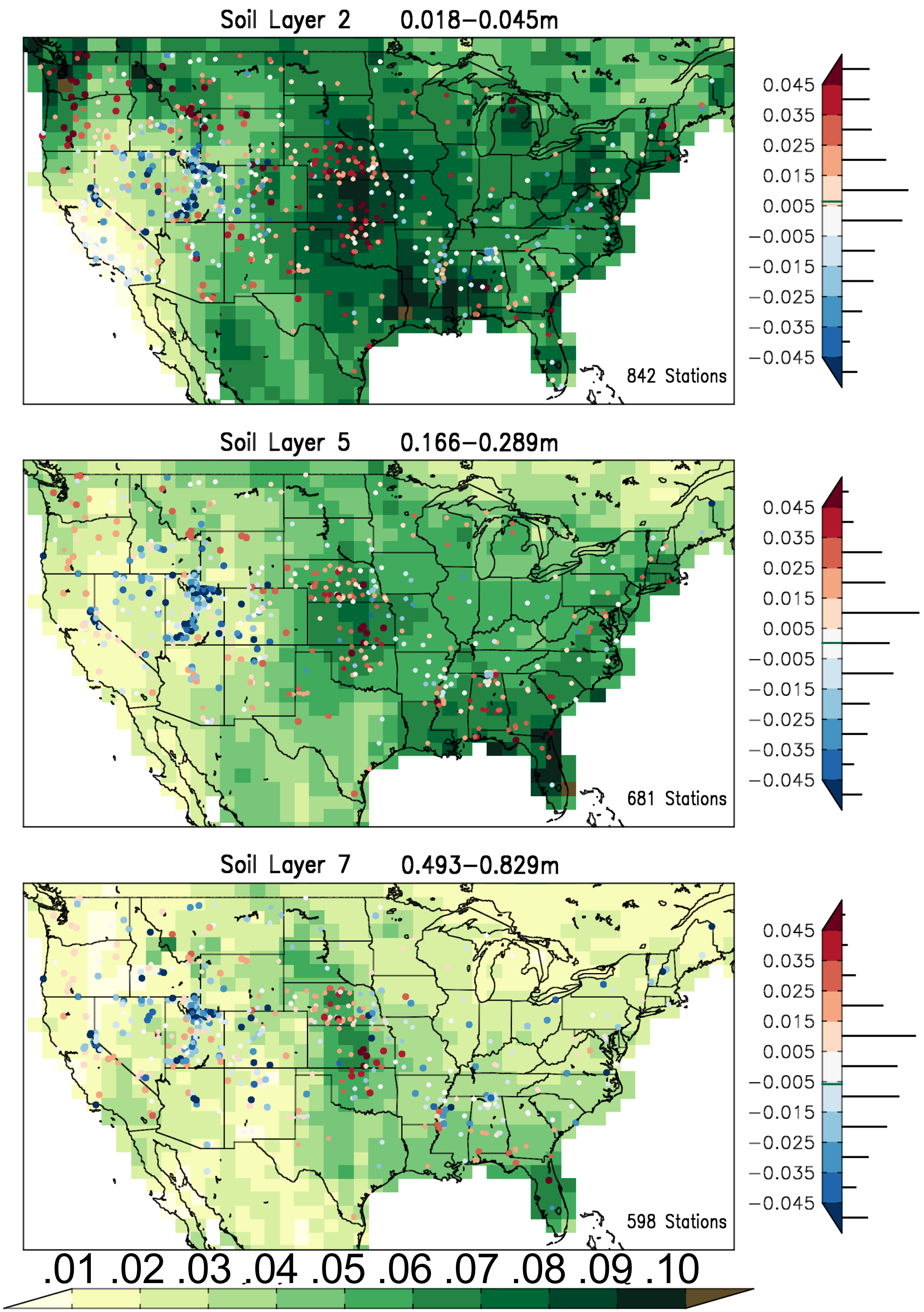

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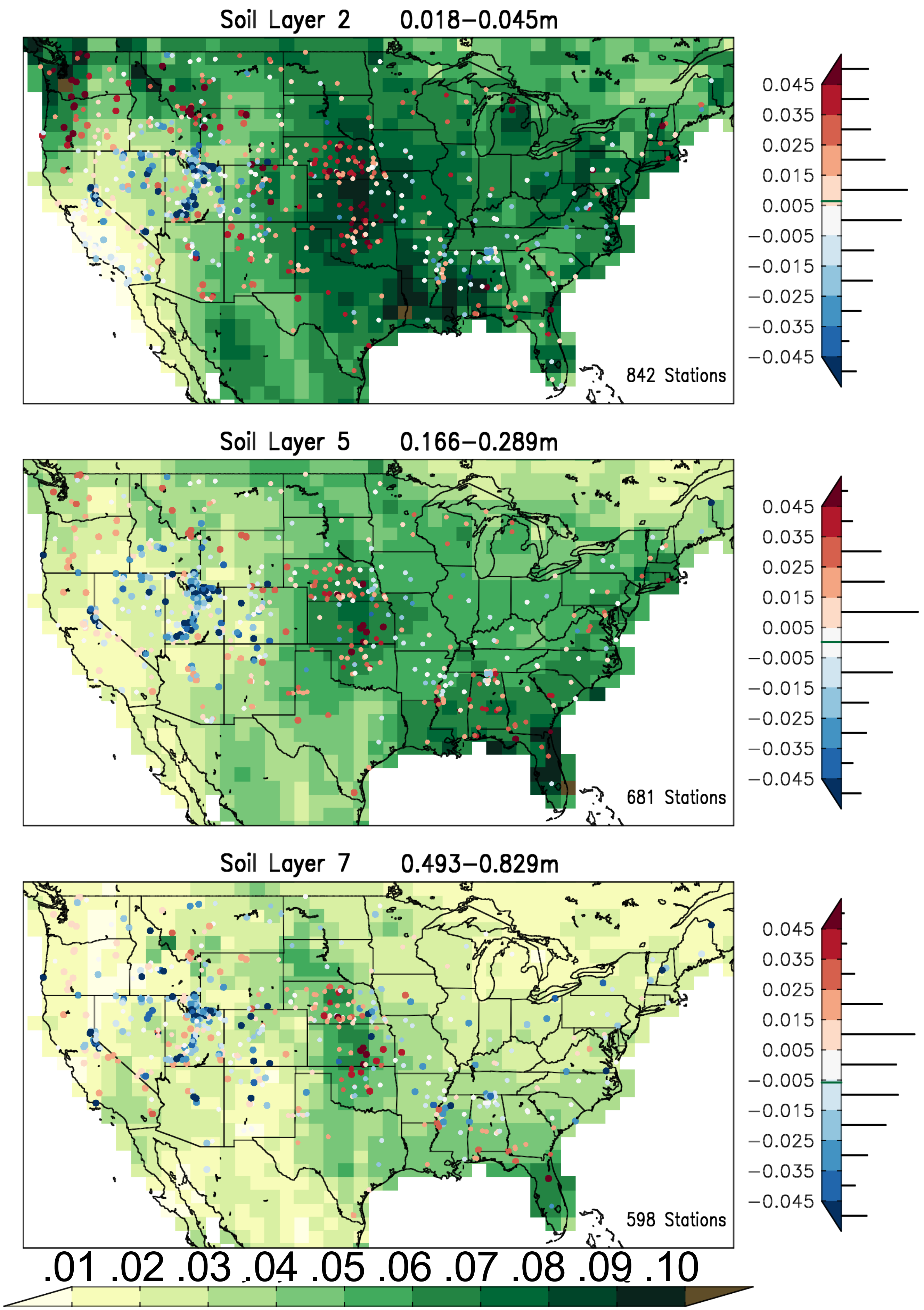
  - Maximum over central Great Plains appears to be too strong



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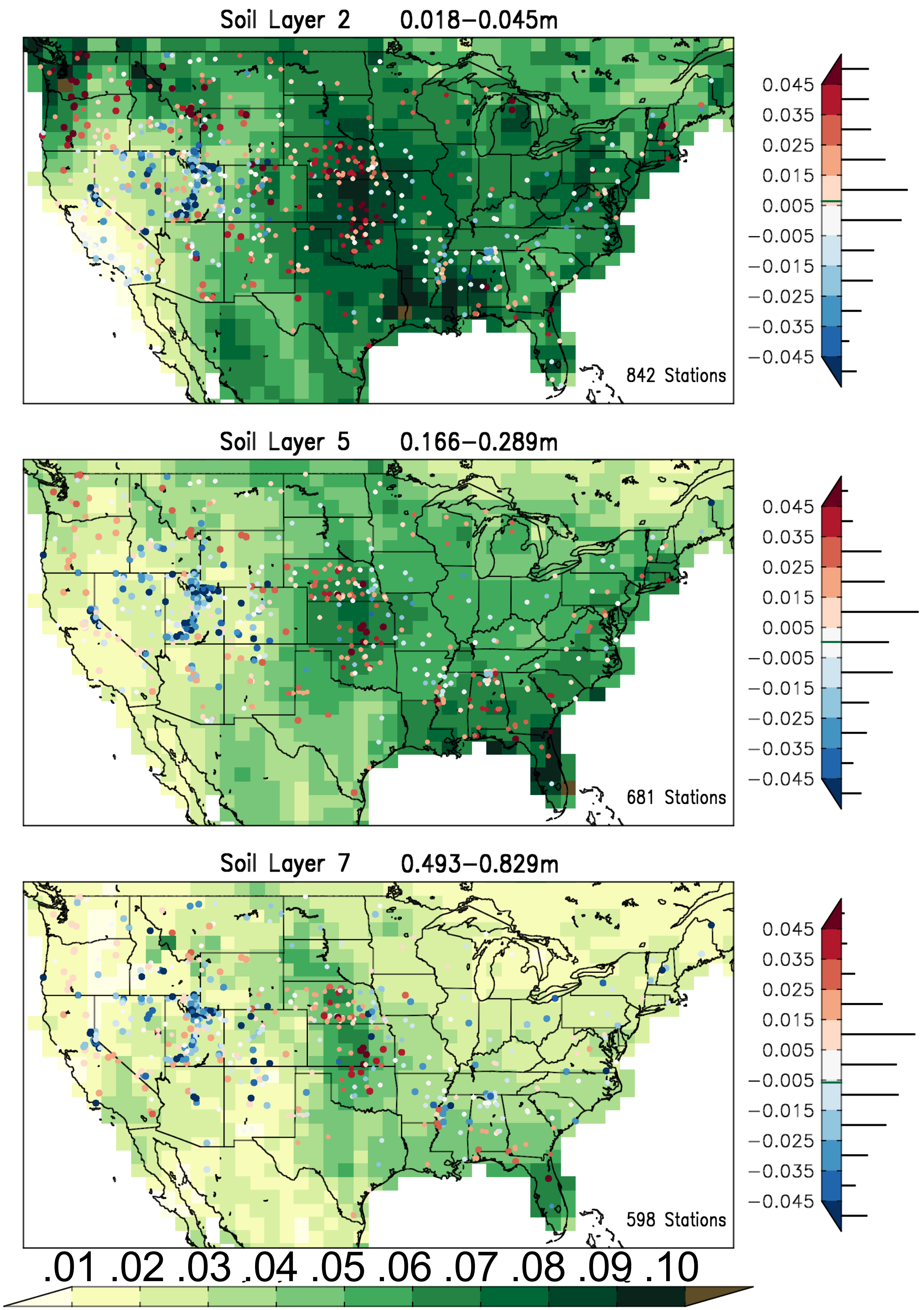

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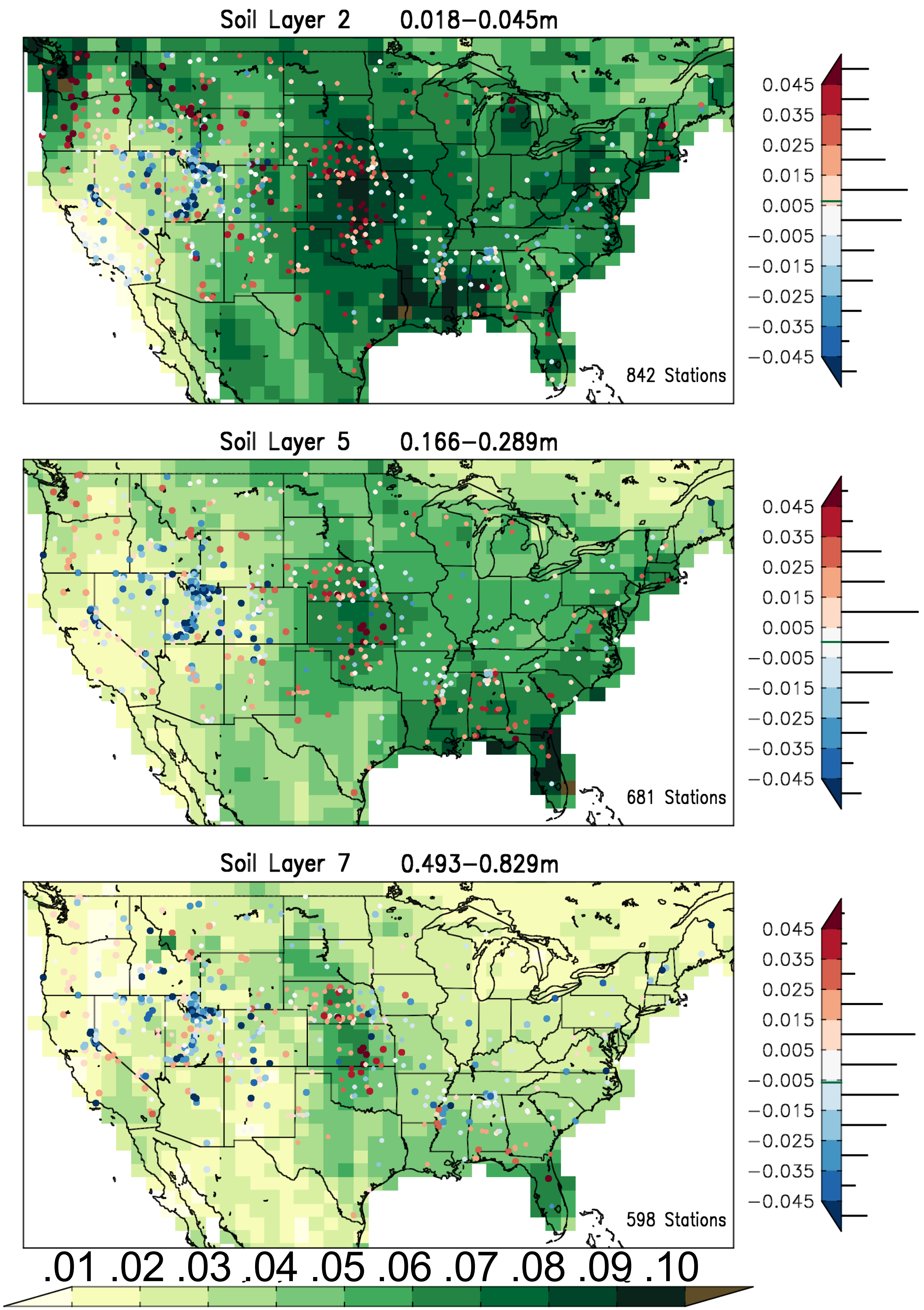

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- Some issues in spatial variability –
  - Maximum over central Great Plains appears to be too strong
  - Too little variability over inter-mountain West (mostly SNOTEL sites – could be an altitude bias on top of other biases)
  - No doubt that local soil properties are not matching coarse CLM data set.

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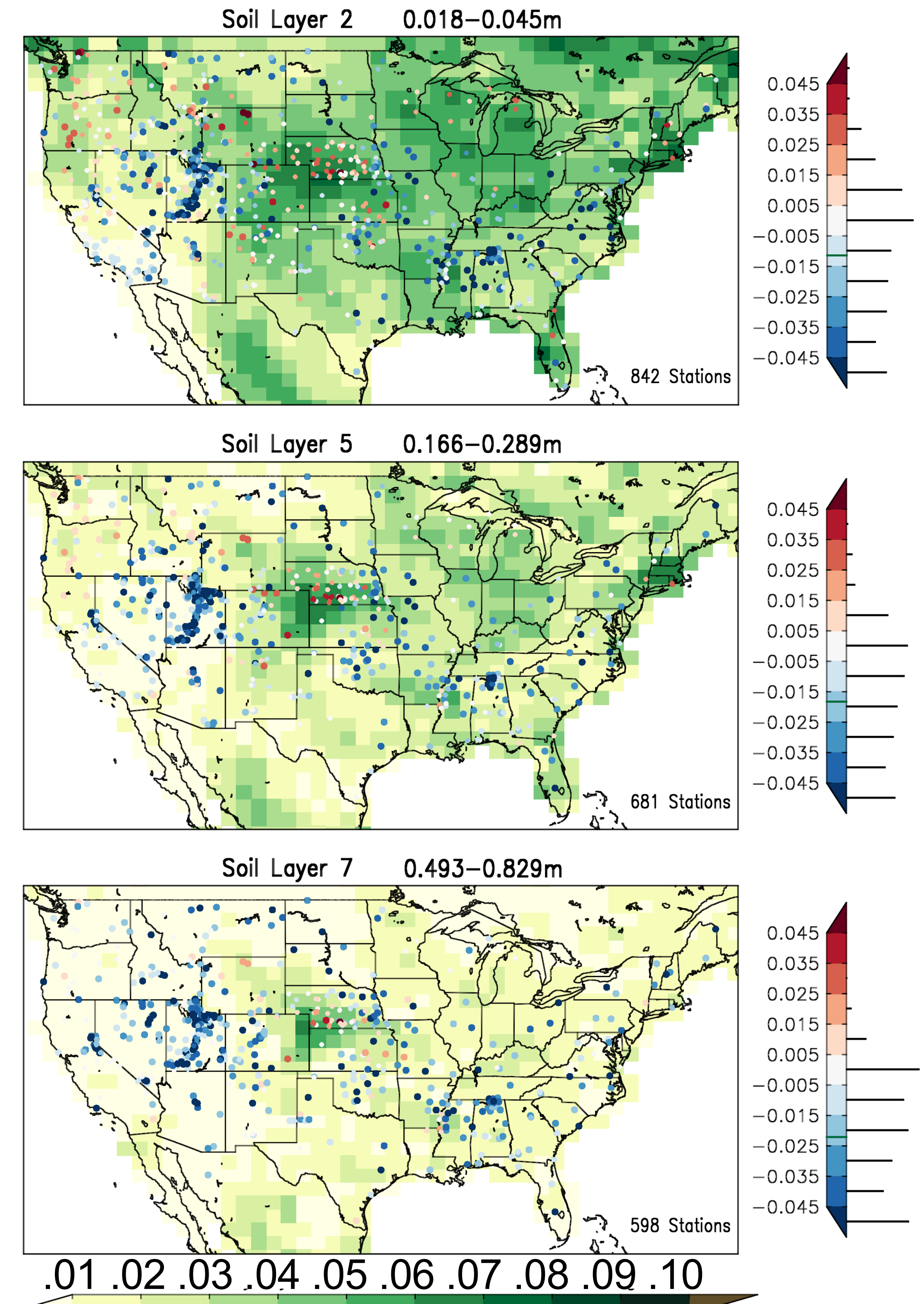

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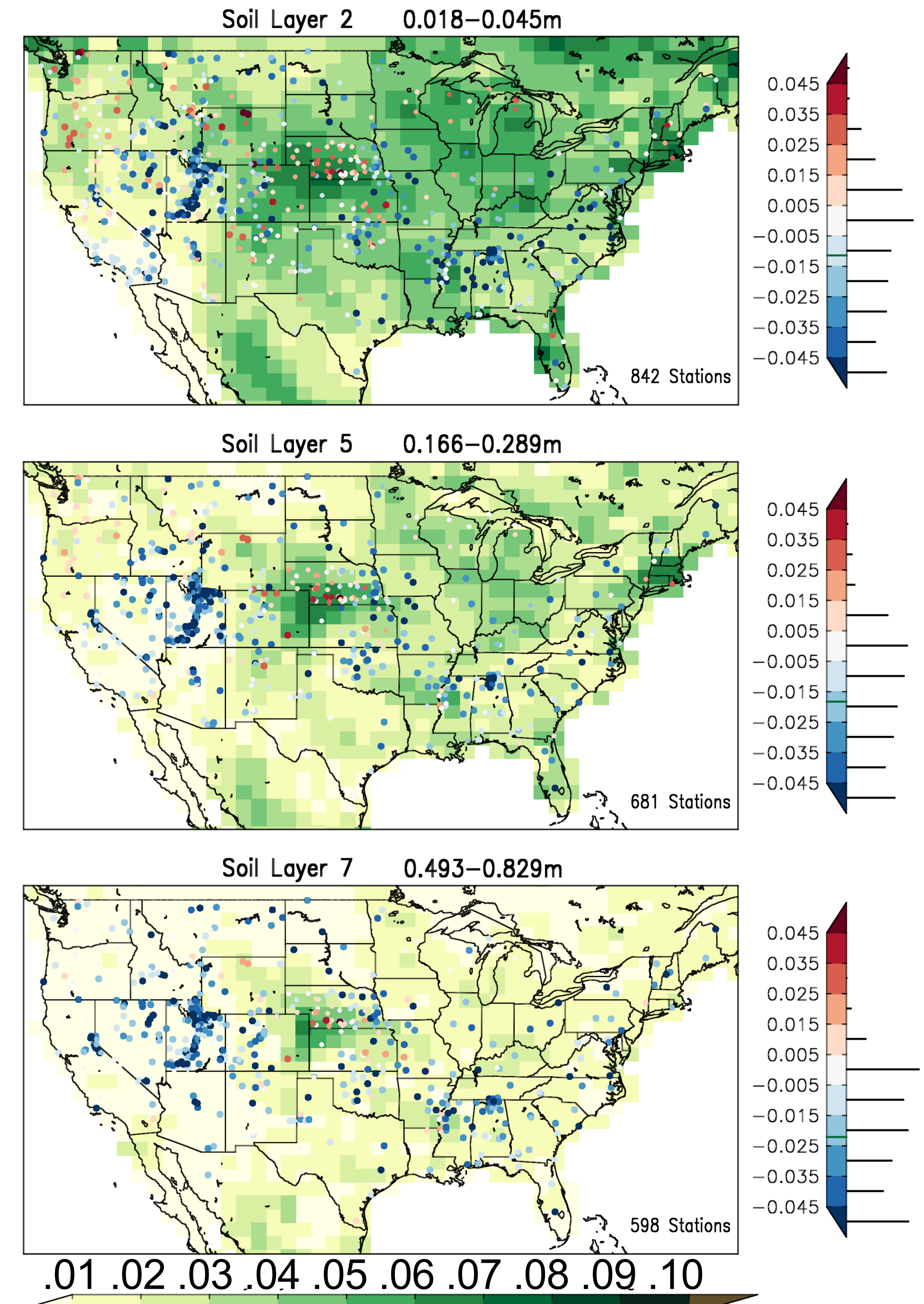

CLM4+CCSM4: σ

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- **Why?**

Conclusions

- Enough observational data becoming available to begin confronting our weather and climate models regarding their coupled land-atmosphere behavior.
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  - Spatial scale differences – point measurements vs. model grid box
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  - Spatial scale differences – point measurements vs. model grid box
  - Instrument error increases σ, decreases τ; while model data are "perfect" in the statistical sampling sense. Must account for this too!
- We may ultimately be able to attribute some biases
  - Soil parameter errors
  - GCM meteorological biases (esp. precipitation and radiation)
  - Poor LSM parameterizations (e.g., suggested by PLUMBR)

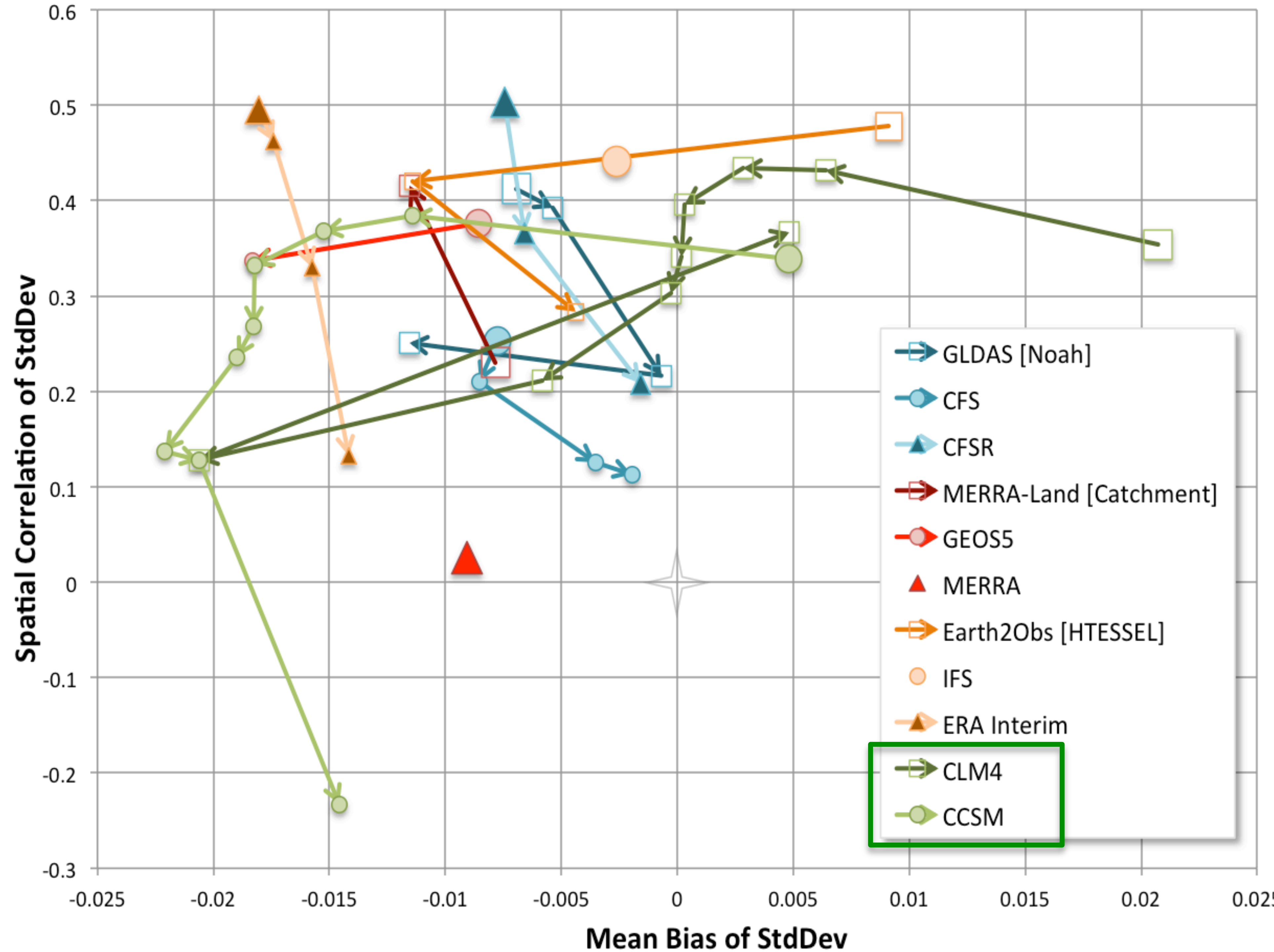
In Process:

- Added many more networks for CONUS from NASMDB http://soilmoisture.tamu.edu/ – approaching 2000 stations.
- We are looking at the **scaling** and **measurement error** issues.
- To examine **coupled** sensitivity, need co-located fluxes, surface met (FLUXNET, ARM); would love atmospheric soundings as well.
  - Full LaThuile FLUXNET data set will be examined over US and global
  - Collaboration with J. Santanello (NASA/GSFC) for access to ARM data
- Recent community workshops on coupled L-A issues:

http://www.iges.org/lsm/
http://inside.mines.edu/~thogue/nsf-hydro-atmo-workshop/

Models σ vs. Station Observations

- Have not accounted for scale differences (working on it).



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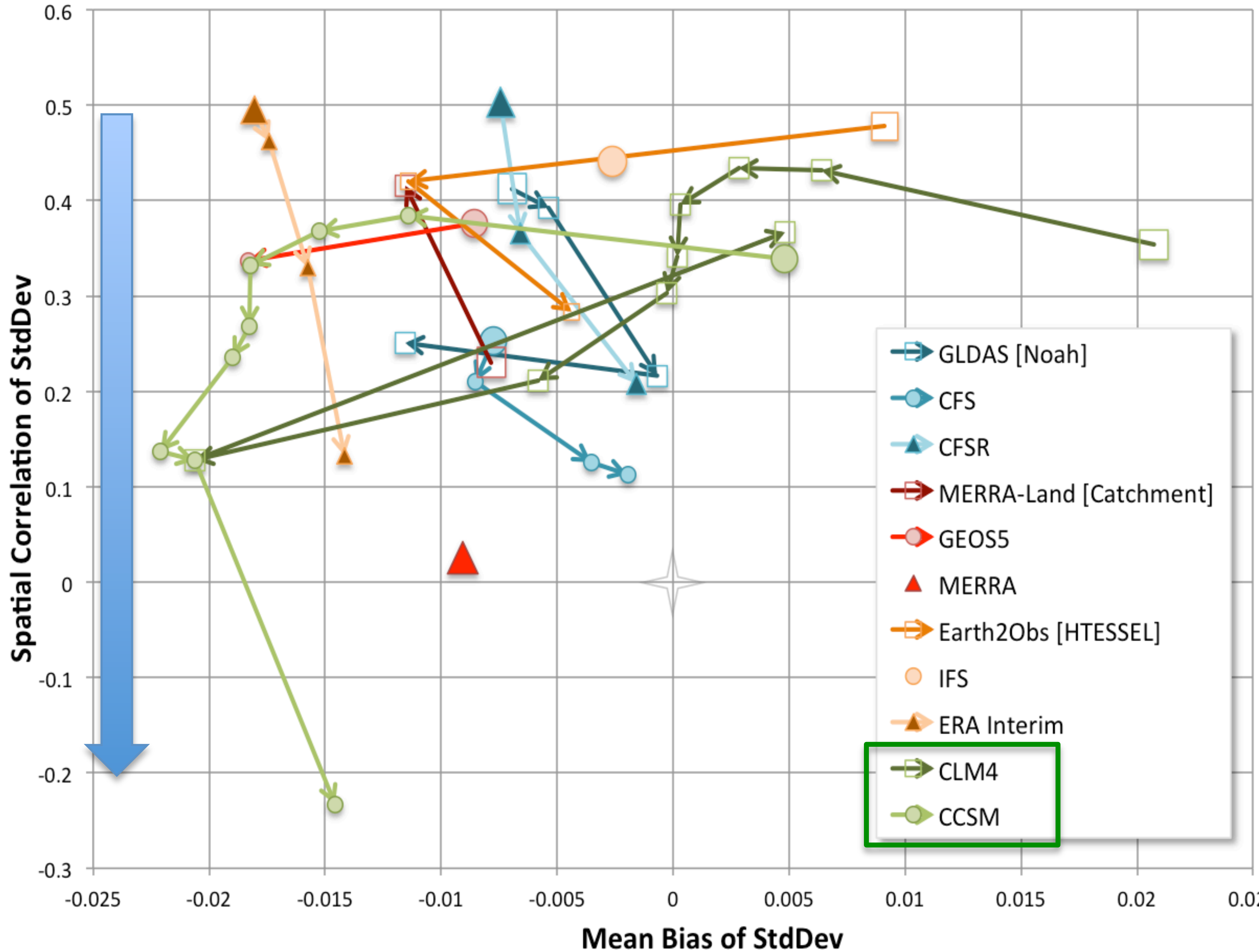

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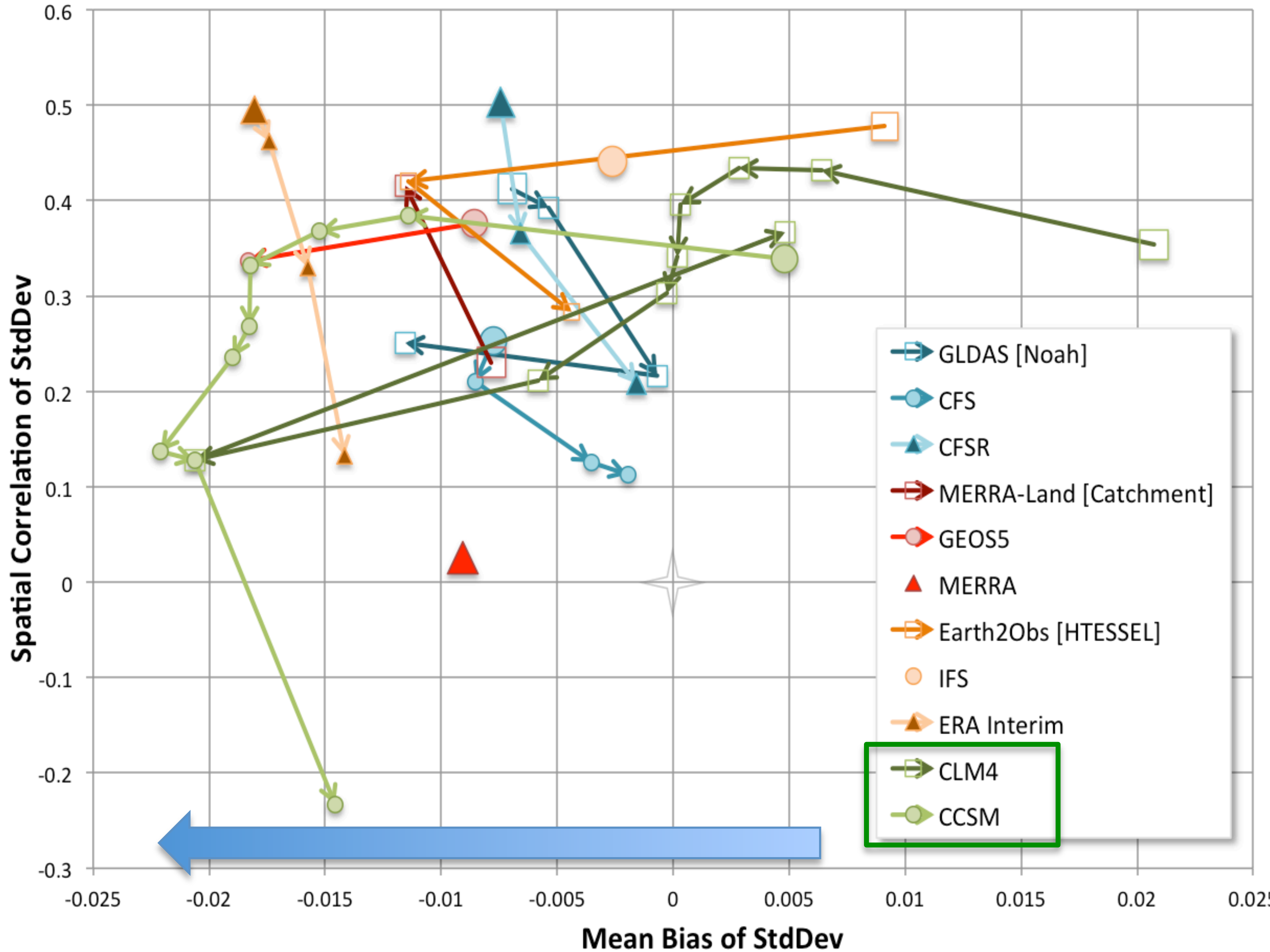
- **Biases generally negative**, more so at depth – in part a scaling issue.



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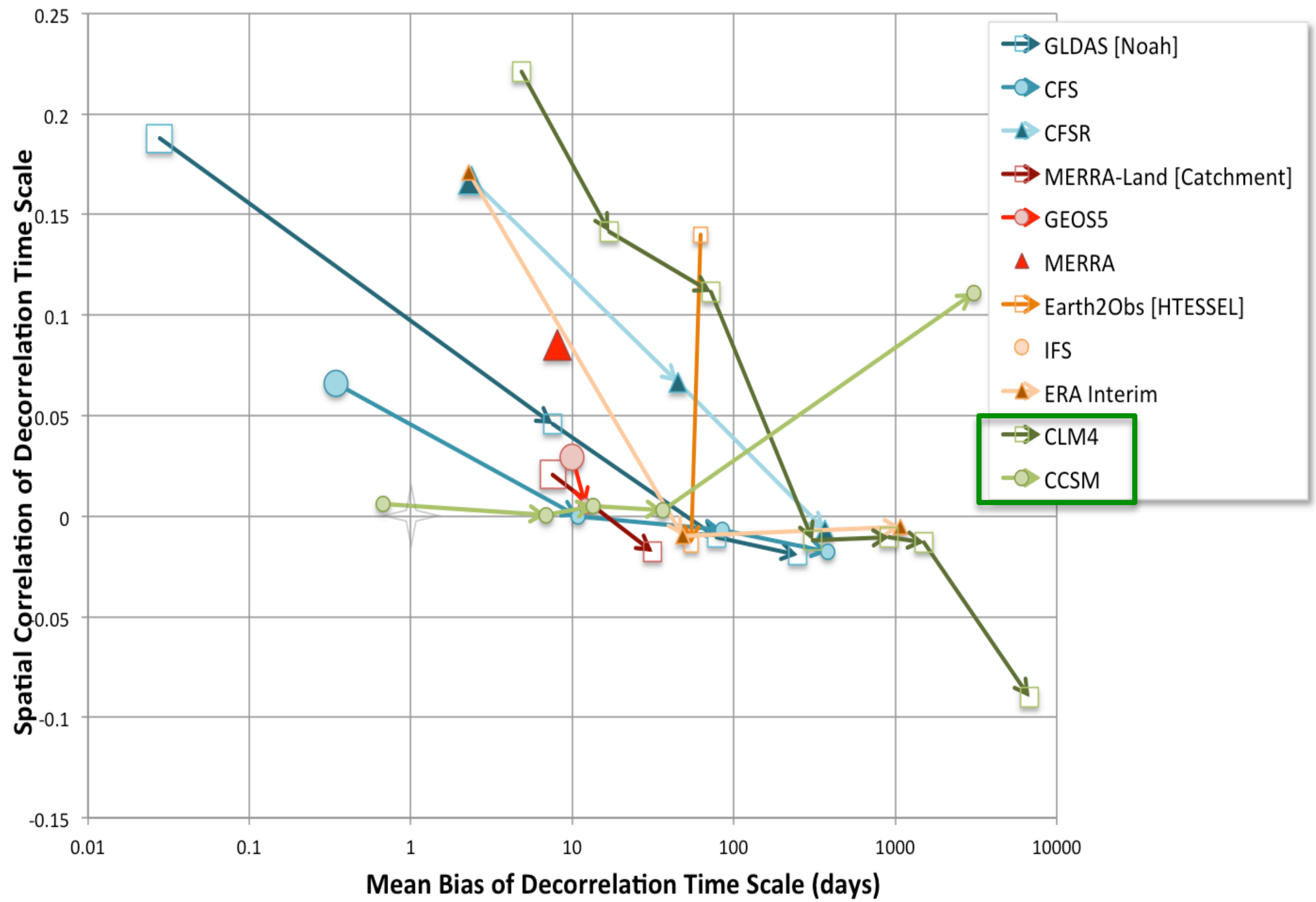

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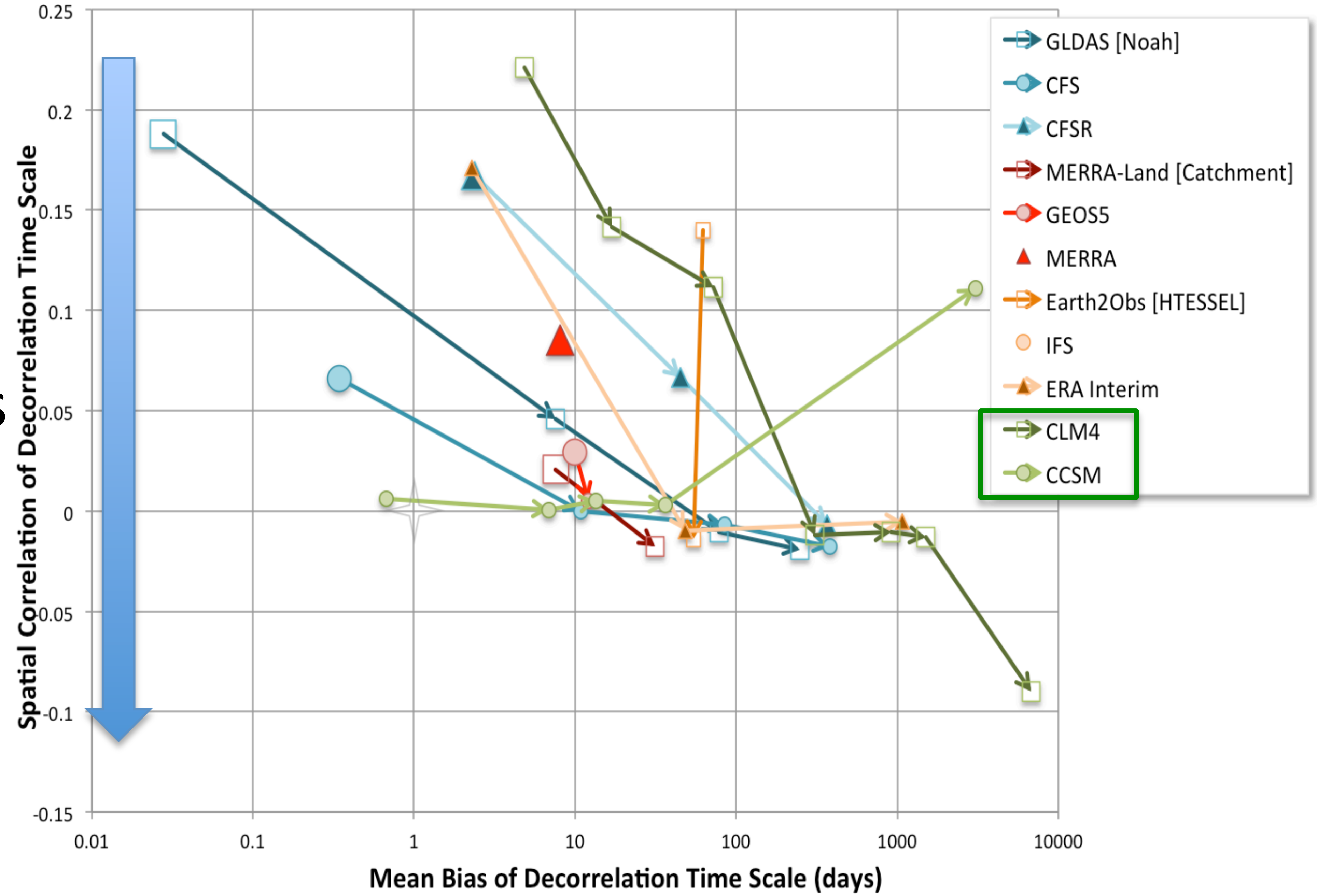

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- Model biases not bad at surface (controlled by precip), **much too long at depth**.