Briefing to the GLASS Panel: LoCo-Relevant Research

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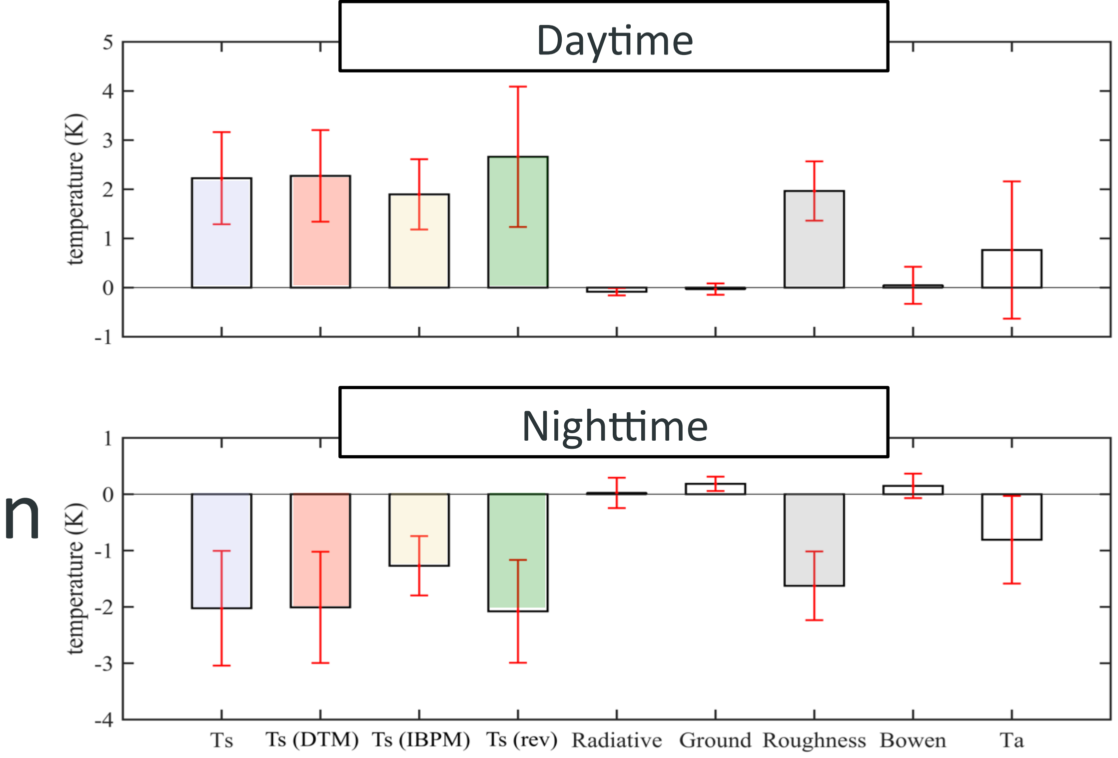
LULCC – LoCo Principles

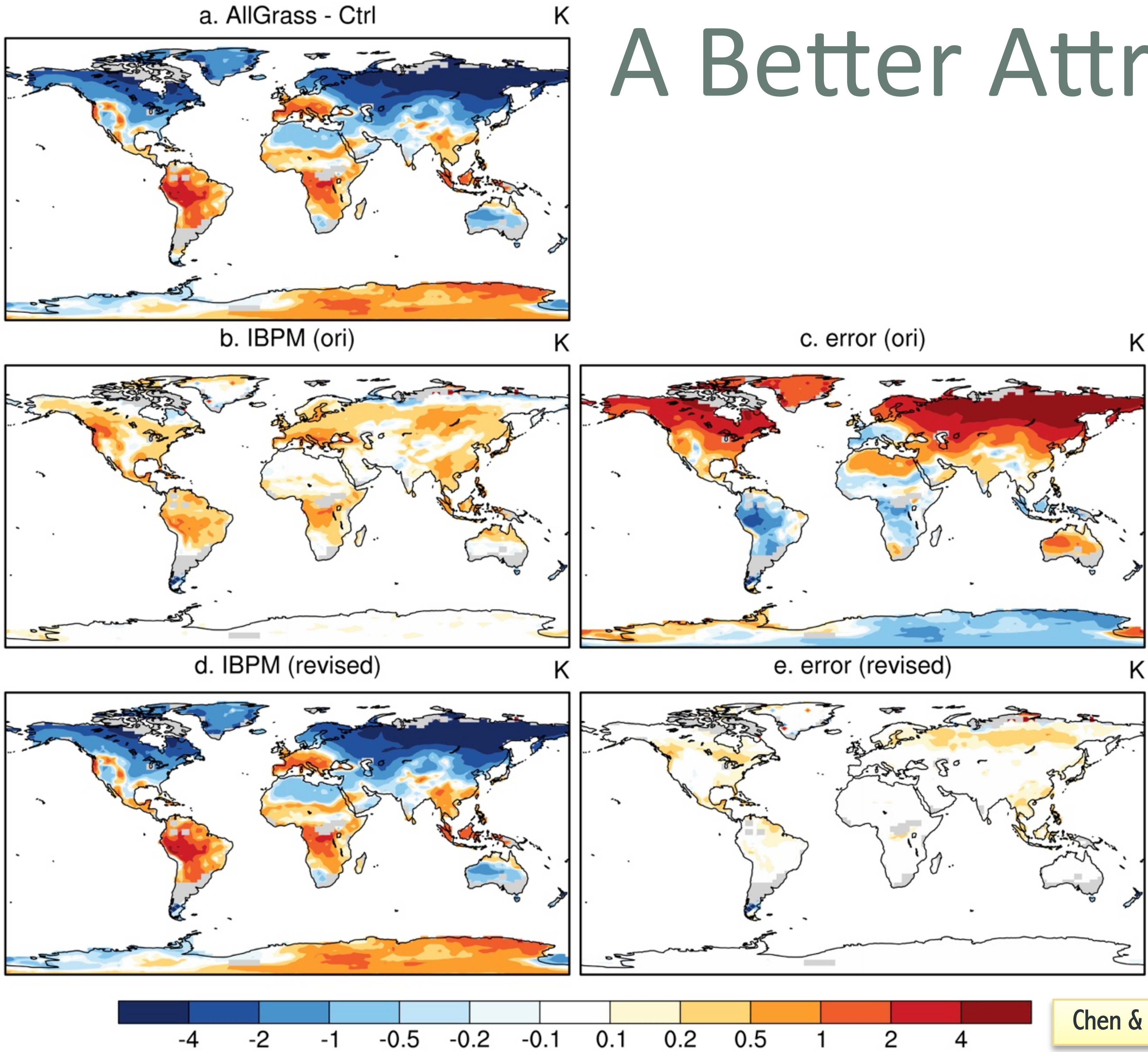
- Lee et al. (2011) proposed a measure of LULCC impact on T_S based on changes in albedo, Bowen ratio and aerodynamic resistance among areas with different vegetation; assumes atmosphere is unchanged.
- Luyssaert et al. (2014) applied a similar decom-position based on surface energy balance.
- Chen and Dirmeyer (2016) account for atmospheric variations, apply to 8 paired FLUXNET sites and extend to climate model applications where atmospheric feedbacks are unavoidable.



Temperature changes at paired FLUXNET sites (forest vs. crop/grass): Observed, Lee method, Luyssaert method, Chen method. Chen's decomposition shows change in surface roughness is the main factor, followed by air temperature feedbacks (white).

Lee et al. 2011: *Nature*, 10.1038/nature10588
Luyssaertet al. 2014:*Nature Clim. Change*, 10.1038/nclimate2196
Chen & Dirmeyer 2016: *Env. Res. Lett.*, 10.1088/1748-9326/11/3/034002

A Better Attribution Method



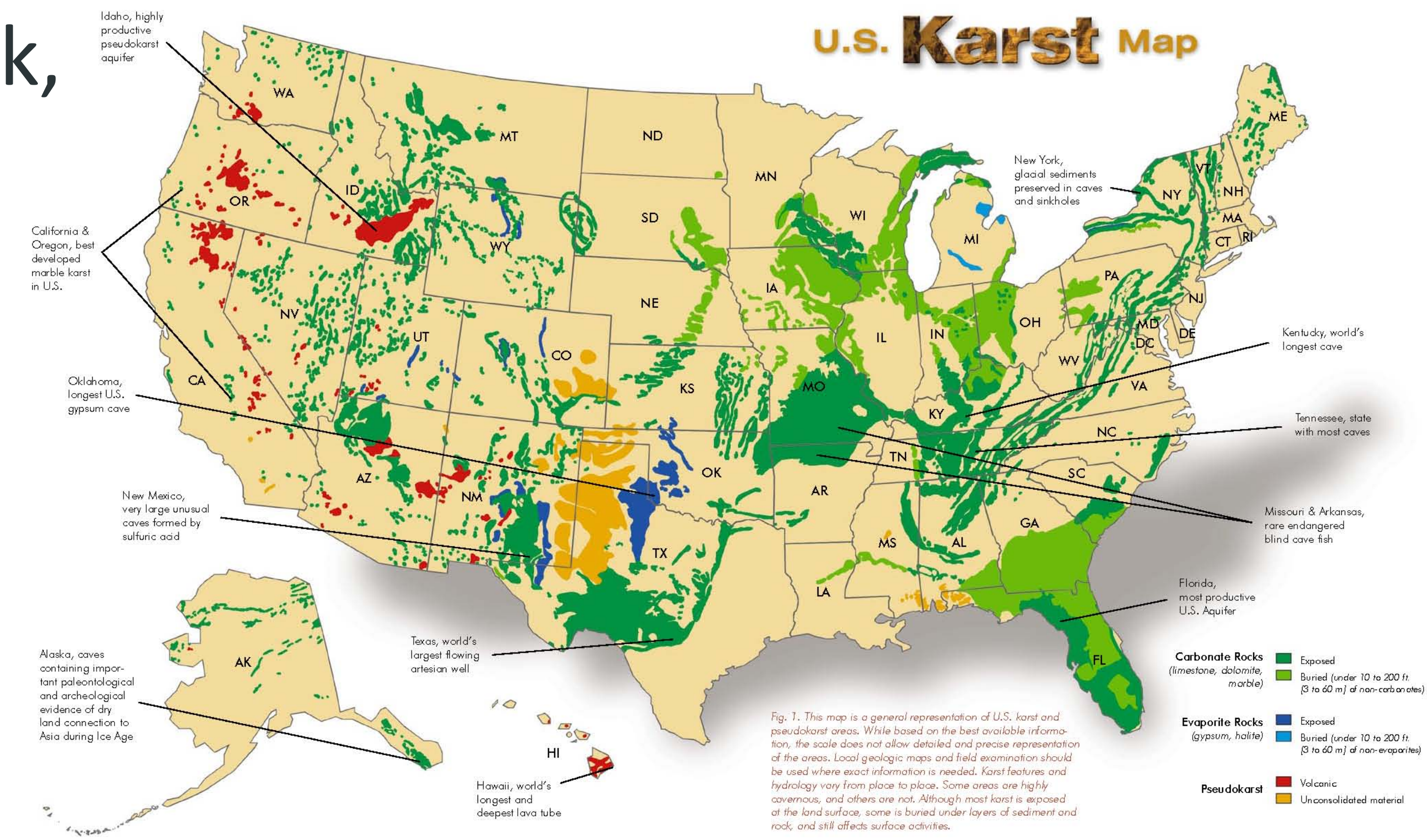
(a) JJA ΔT_S where all forests changed to grass in CLM4.5+ CAM5.3; (b) ΔT_S based on Lee method; (c) error of Lee method; (d) ΔT_S based on Chen's revision of Lee method; (e) error of revised approach.

With FLUXNET2015 we have >20 paired sites, more opportunities including exploring coupling metrics and how they change with LULCC.

Chen & Dirmeyer 2016: *Env. Res. Lett.*, 10.1088/1748-9326/11/3/034002

Geology and LoCo

- LSMs treat baseflow only as a function of average terrain slope, and if coupled to a groundwater scheme, depth of water table.
- In reality, underlying geology has a large effect on drainage, and thus soil moisture, surface fluxes, and potentially L-A coupling.
- Karst (fractured or porous bedrock, e.g, limestone formations) allows freer drainage compared to most igneous and quartz substrates.
- Is the impact of subsurface karst formations detectable at the surface?



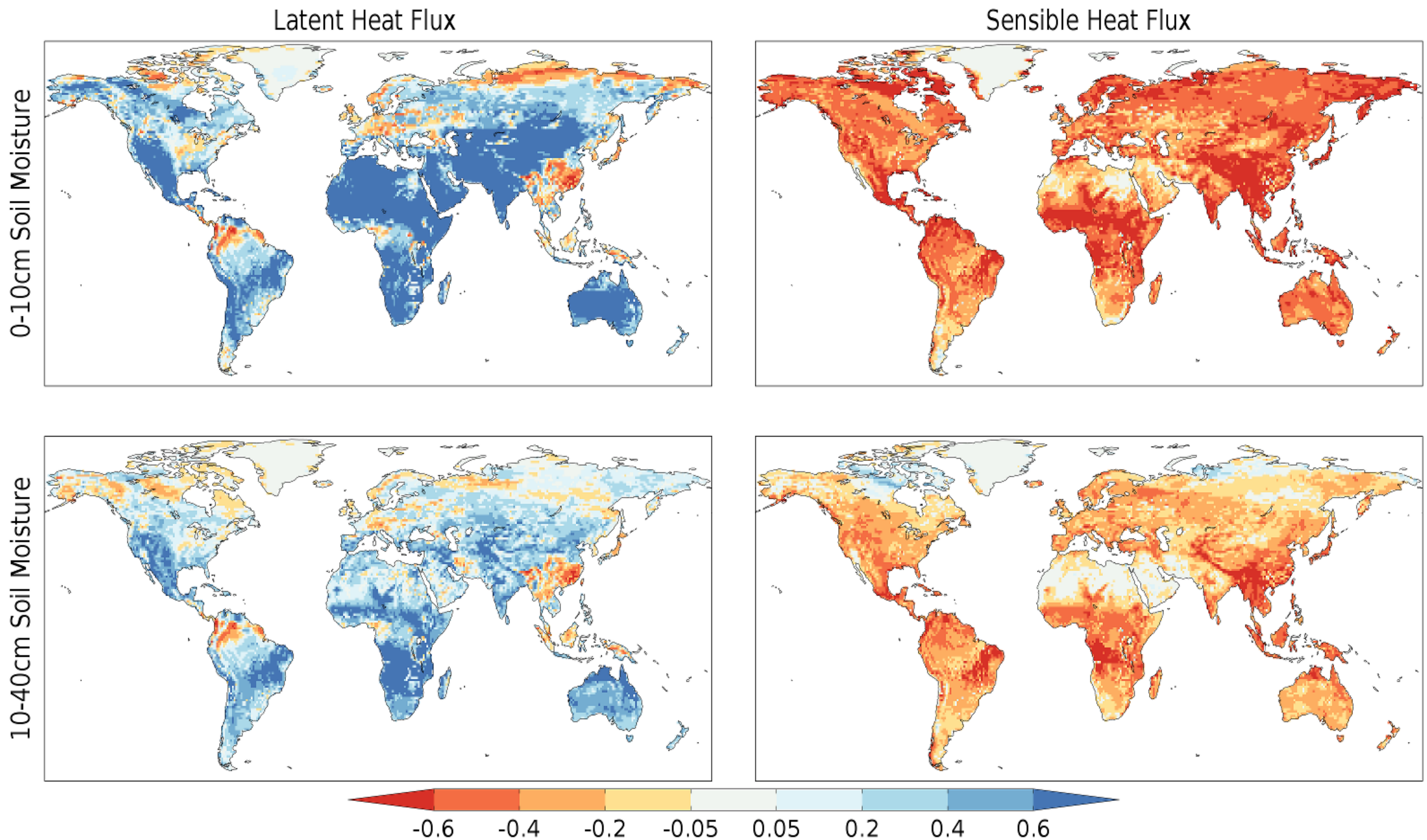
Coupling on Weather Time Scales

- We have seen how the "terrestrial coupling indices" that correlate daily surface flux variability with soil moisture indicate the pattern and strength of L-A feedbacks.
- Our conventional wisdom is that this feedback operates on subseasonal-seasonal time scales – on "weather" time scales (hours to a few days) the atmosphere is "deterministic", i.e. dependent on initial atmospheric state of weather forecasts.
- Using the NWS/NCEP operational global forecast model (Noah, GFS), we challenge this notion.

Dirmeyer & Halder, 2016: *Wea. Fcst.*, doi: 10.1175/WAF-D-16-0049.1

Coupling as We Typically Define It

"Conventional" coupling – correlations across days 3-7 of all 28 forecast ensemble members for years 1982-2009 (784 simulations) initialized on 1 June.



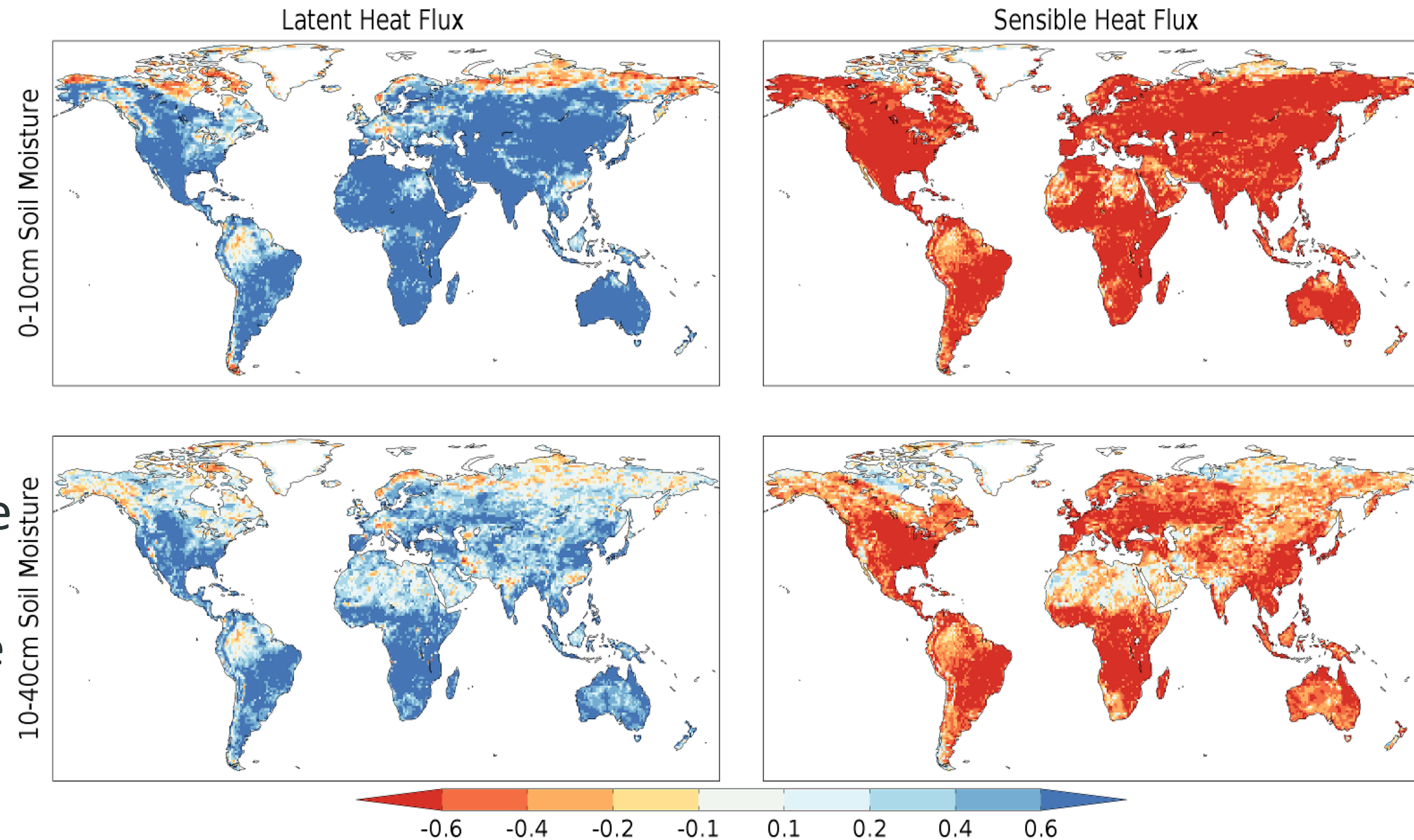
* Magnitudes greater than 0.05 are significant at the 95% confidence level.

Dirmeyer & Halder, 2016: *Wea. Fcst.*, doi: 10.1175/WAF-D-16-0049.1

Coupling on Weather Time Scales

Correlations between differences in 1 June initial soil moisture between ensemble members with identical 1 June initial atmospheric and oceanic states and the corresponding differences in day one surface heat fluxes.

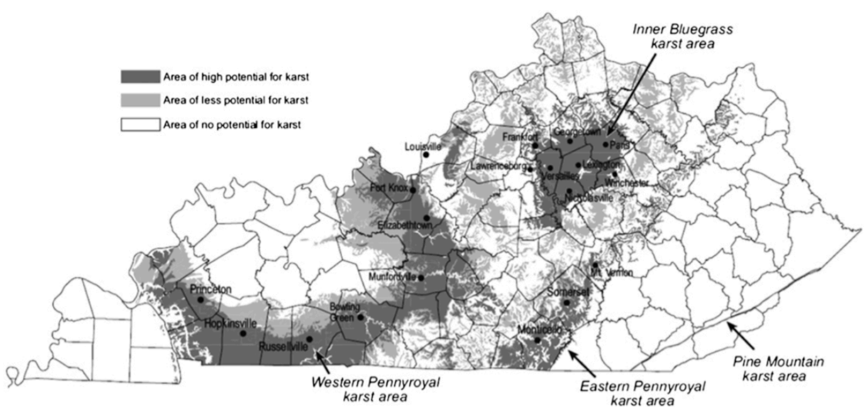
* Magnitudes greater than 0.10 are significant at the 95% confidence level.

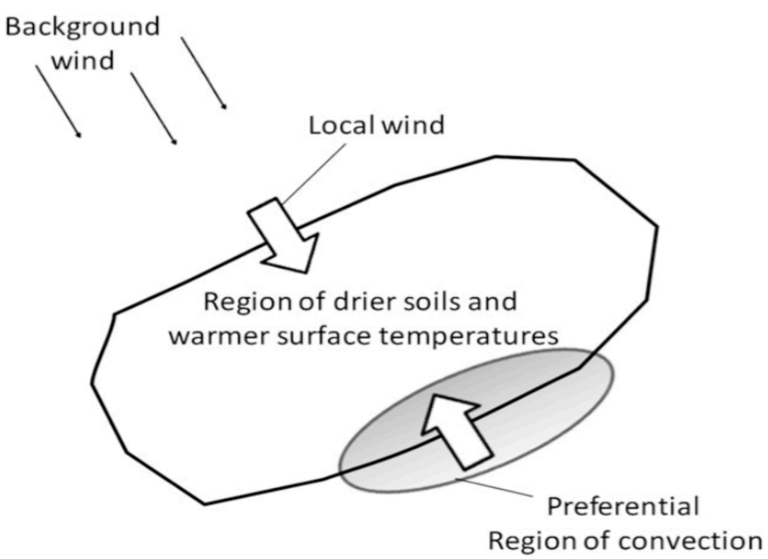


Dirmeyer & Halder, 2016: *Wea. Fcst.*, doi: 10.1175/WAF-D-16-0049.1

Karst and Water Cycle

- Based on isotopic evidence, Good et al. (2015) suggest that >20% of infiltration quickly drains from soil, disconnecting from the surface water cycle (right).





- Observational and modeling studies (e.g., Leeper et al. 2011) have suggested non-frontal precipitation may be altered when moving over karst (left), similar to C. Taylor's mechanism over the Sahel, implicating PBL property and circulation changes.

Good et al., 2015: *Science*, 10.1126/science.aaa5931.
Leeper et al. 2011: *J. Hydrometeor.*, 10.1175/2011JHM1260.1

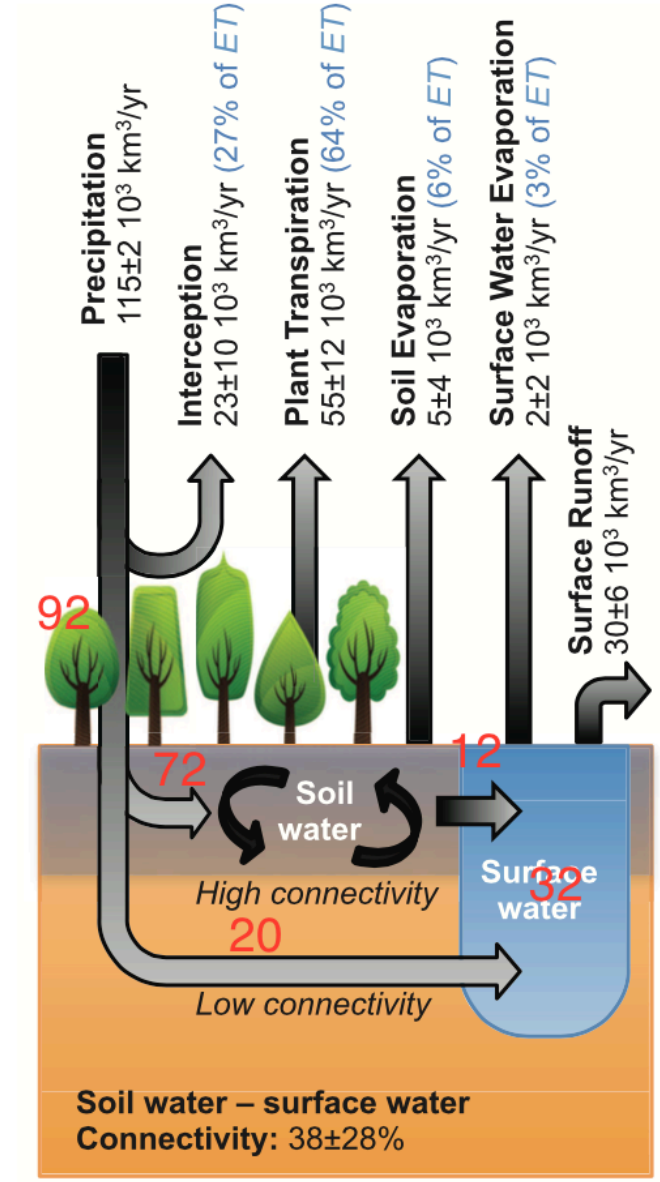


Fig. 3. Partitioned continental hydrologic fluxes. Terrestrial precipitation (annual mean ± 1 SD) not intercepted by vegetation mixes into soils or flows into surface waters. Soil water is withdrawn by plant roots via transpiration, subjected to evaporation, and leaks into the surface water. Of the flux entering the surface waters, our results suggest that 38% is derived from the soils, with the remainder being consistent with precipitation routed directly via preferential flow paths. Surface water that does not evaporate returns to the ocean as runoff.

Soil Moisture Memory

- In preliminary work, we are finding soil moisture memory (lagged auto-correlation) from SCAN stations over karst (green) generally decays faster than stations not over karst (red) for stations in/around northern Alabama, where karst formations are common.
- Done: offline Noah sensitivity study.
- To do: extend observational investigation across U.S., coupled L-A model sensitivity studies, new parameterization.

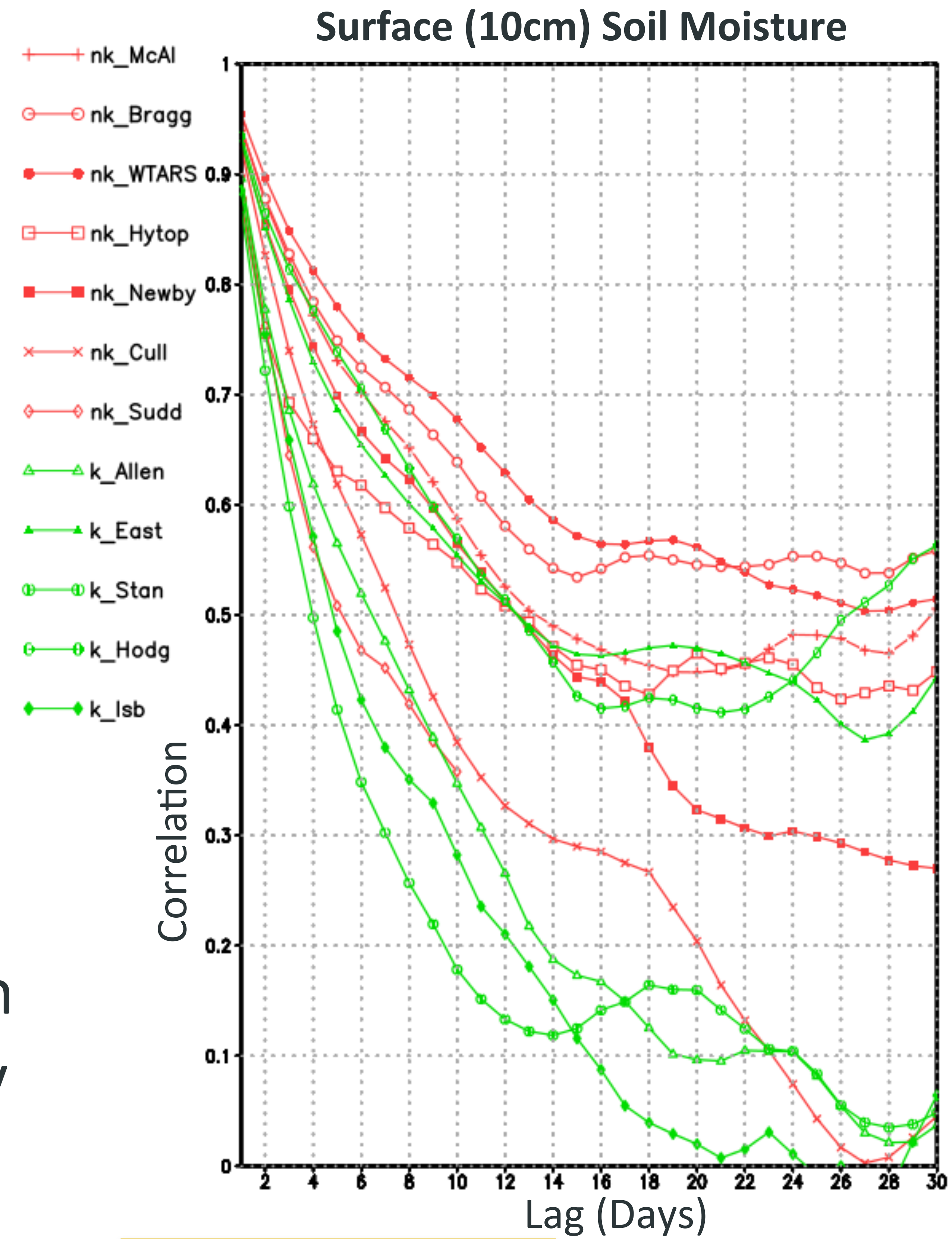


Figure: H. Norton-Sobczynski

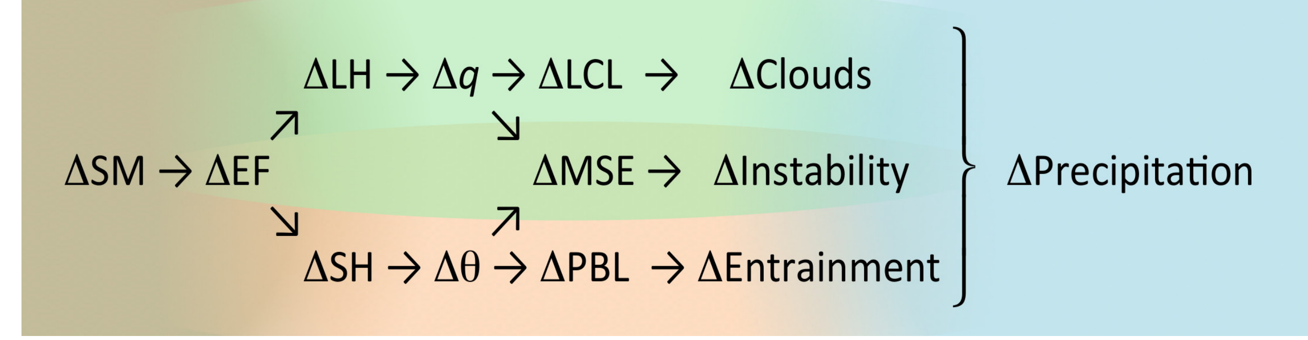
NASA-MAPP LoCo Proposal

"Global Indices of Land-Atmosphere Coupling from Models and Remote Sensing" – *Dirmeyer, Santanello, Ferguson*

- Use satellite remote sensing data to evaluate coupled L-A processes and the fidelity of their representation in ESMs by: producing global estimates of the patterns and seasonality of key L-A coupling indices; assessing their accuracy with in situ observations; and confronting a variety of ESMs with these new data sets.

Variable	Satellite product	Period	Resolution		Reference
Precipitation	GPCP v2.2	1996-2015	2.5°	d	Huffman et al. (2009)
	TRMM TMPA	1998-pres	0.25°	3h	Huffman et al. (2007)
	CMORPH	2002-pres	0.25°	3h, d	Joyce et al. (2004)
	GSMaP Reanalysis	2000-2014	0.1°	1h	Kubota et al. (2007)
Soil moisture	ESA CCI	1978-2014	0.25°	d	Parinussa et al. (2015)
	MEaSUREs LSMEM	2002-2011	0.25°	d	Wood et al. (2009)
	LPRM	1978-2011	0.25°	d	Owe et al. (2008)
	SMAP	2015-pres	36 km	d	O'Neill et al. (2015)
Terrestrial water storage	Tellus RL05.1	2002-pres	1°	m	Landerer and Swenson (2012)
Evapotranspiration	GLEAM	2003-2014	0.25°	d	Miralles et al. (2011)
	MEaSUREs	1984-2007	0.5°	3h	Vinukollu et al. (2011)
	MOD16	2000-2010	1 km	8d	Mu et al. (2011)
	ALEXI	2003-2013	10 km	1h	Anderson et al., (2007)
	MW-ALEXI	2003-2013	0.25°	15min	Holmes et al. (2015)
Atm. temp. profile	AIRS	2002-pres	13 km	d	Susskind et al. (2014)
Atm. spec. hum. prof.	AIRS	2002-pres	13 km	d	Susskind et al. (2014)
	MEaSUREs NVAP	1988-2009	1°	d	Vonder Haar et al. (2012)
4-comp. sfc. radiation	MEaSUREs SRB	1983-2009	0.5°	3h	Ma and Pinker (2012)
	CERES SYN	2000-2015	1°	3h	Wielicki et al. (1996)
Land sfc. (skin) temp.	PU HIRS	1979-2009	0.5°	1h	Coccia et al. (2015)
	LPRM	1978-2011	0.25°	d	Holmes et al. (2009)
Leaf area index	GIMMS LAI3g	1982-2011	8 km	16d	Zhu et al. (2013)
	MOD15	2000-pres	1 km	16d	Yang et al. (2006)
NDVI	GIMMS NDVI3g	1981-2011	8 km	16d	Tucker et al. (2005)
	MCD13	2000-pres	1 km	16d	Spruce et al. (2015)
Vegetation optical depth	LPRM	1978-2011	0.25°	d	Liu et al. (2011)
Vapor pressure deficit	AIRS V6 L2	2002-pres	13 km	d	Susskind et al. (2014)
Snow cover extent	MEaSUREs	1999-2012	0.25°	d	Robinson et al. (2014)
Cloud fraction	CERES SYN	2000-2015	1°	3h	Wielicki et al. (1996)

NASA-MAPP LoCo Proposal



"Global Indices of Land-Atmosphere Coupling from Models and Remote Sensing" – *Dirmeyer, Santanello, Ferguson*

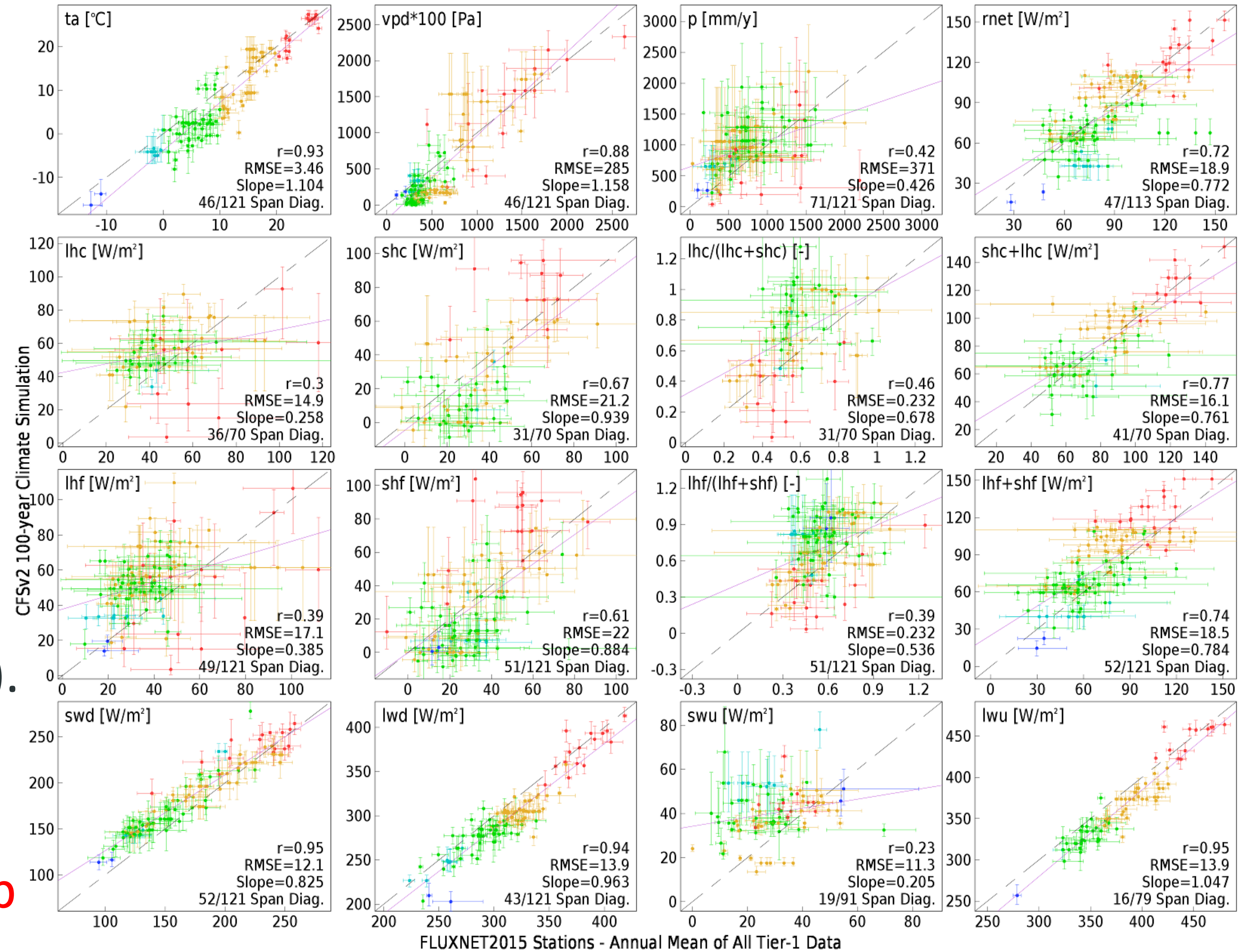
Questions:

- Which metrics of L-A coupling are most amenable to the application of satellite data?
  - Can disparate remote sensing data sets from different platforms be effectively combined to estimate L-A coupling metrics?
  - How do these satellite-based metrics compare to ground-based estimates (e.g., FLUXNET, ARM-SGP, or state-level mesonets)?
- How do ESM representations of L-A coupling compare to remote sensing estimates across spatial (regional, continental and global) and temporal (diurnal, seasonal, interannual) scales?
- How well do current metrics represent the scope and variability of coupled L-A processes, what is their mutual information content and how complimentary are they?

FLUXNET2015

- Beginning to "confront" models with the new FLUXNET2015 data set.
- Here, CFSv2 100y climate simulation compared to FLUXNET sites in corresponding grid box (bars span interannual variability of yearly means).
- Biggest problems – precipitation (GCM's fault) and its descendants, SW up (albedo – Noah BC's fault).

CFSv2 vs. FLUXNET2015 – color=~~T~~$_{2m}$



http://fluxnet.fluxdata.org/data/fluxnet2015-dataset/