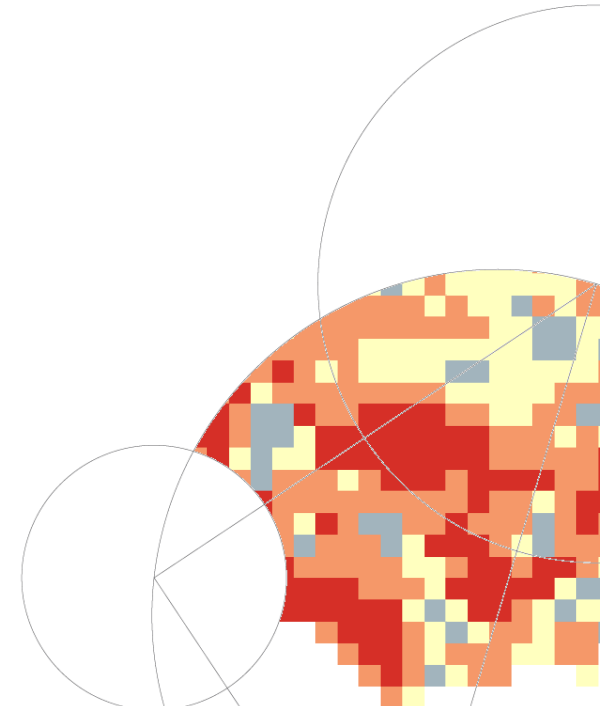




Evaluation of spatial patterns in hydrological modeling

Spatial validation of NLDAS models against seasonal LST patterns using innovative performance metrics.

Julian Koch



Content

Introduction

- The importance of spatial patterns
- The need for pattern metrics

NLDAS Work

- LST dataset for large scale seasonal validation
- Two innovative spatial performance metrics
 - EOF analysis
 - Connectivity analysis
- Highlight LST coupling to WB



Journal of Geophysical Research: Atmospheres

RESEARCH ARTICLE

10.1002/2015JD024482

Key Points:

- Comprehensive spatial validation of three land surface models over the contiguous United States
- Incorporating a 30 year remote sensing dataset of monthly land surface temperature maps
- Application of two innovative performance metrics to assess the simulated spatial pattern

Spatial validation of large-scale land surface models against monthly land surface temperature patterns using innovative performance metrics

Julian Koch^{1,2,3}, Amanda Siemann³, Simon Stisen², and Justin Sheffield³

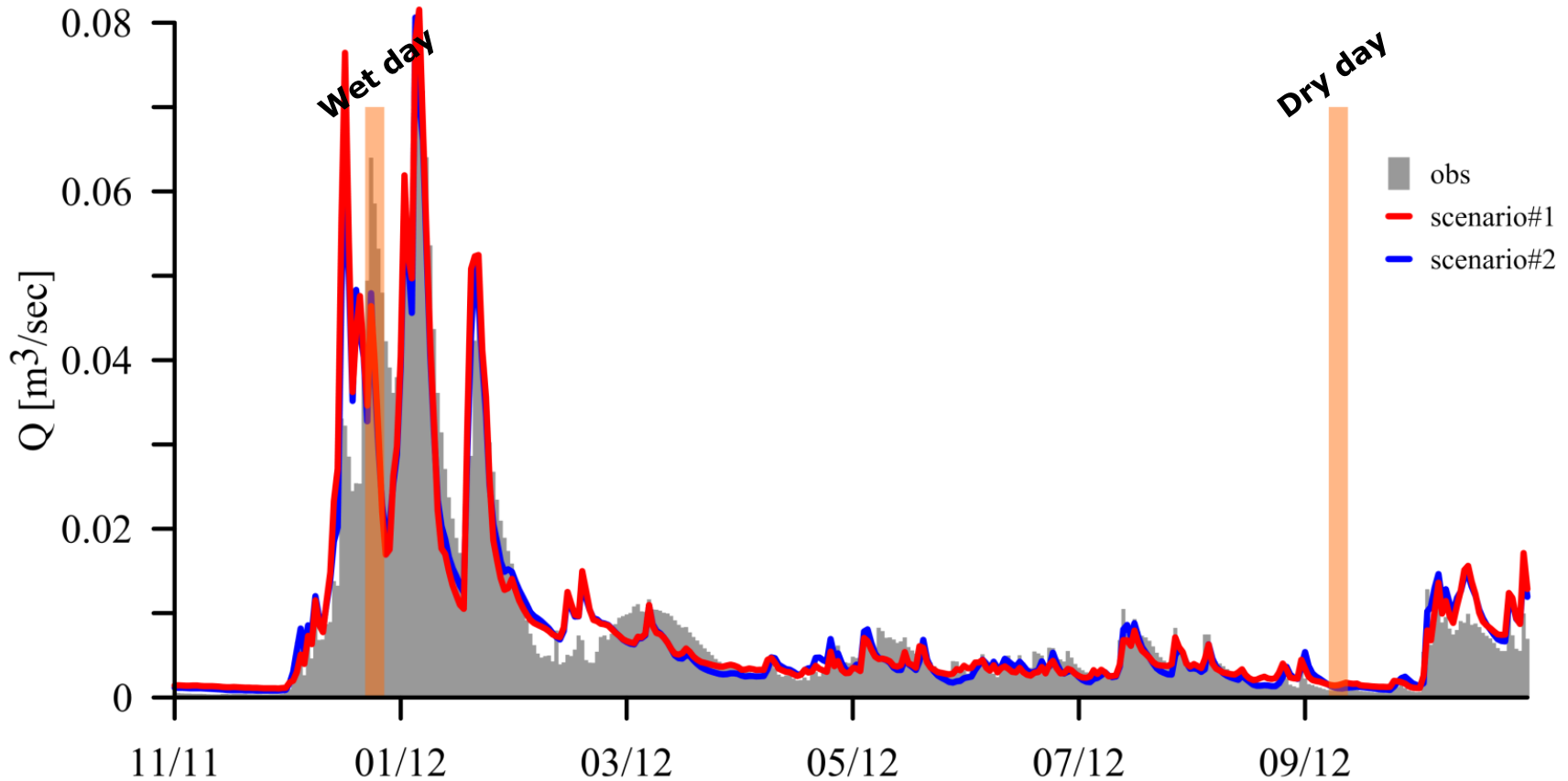
¹Department of Geosciences and Natural Resources Management, University of Copenhagen, Copenhagen, Denmark,

²Department of Hydrology, Geological Survey of Denmark and Greenland, Copenhagen, Denmark, ³Department of Environmental and Civil Engineering, Princeton University, Princeton, New Jersey, USA



Introduction

The importance of spatial patterns



Koch, J. et al. "Inter-comparison of three distributed hydrological models with respect to seasonal variability of soil moisture patterns at a small forested catchment." *Journal of hydrology* 533 (2016): 234-249.



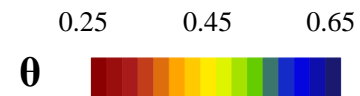
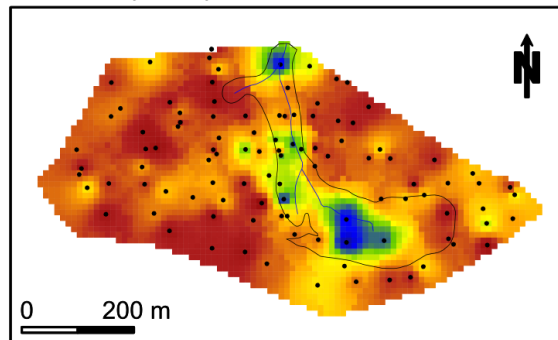
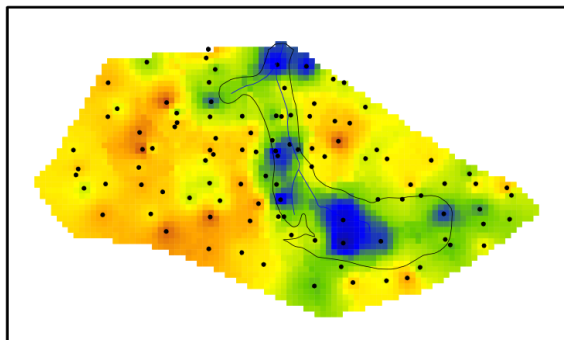
Introduction

The importance of spatial patterns

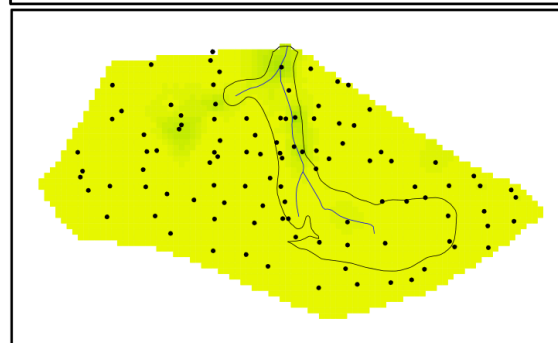
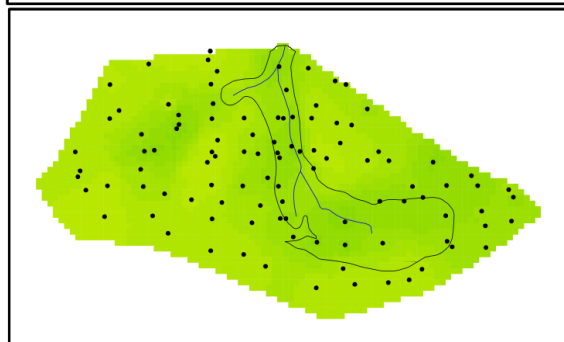
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dry day: 25-12-2011

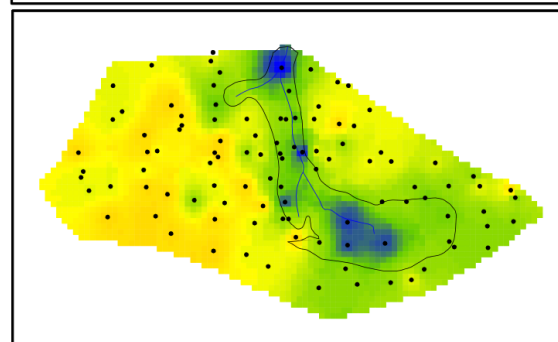
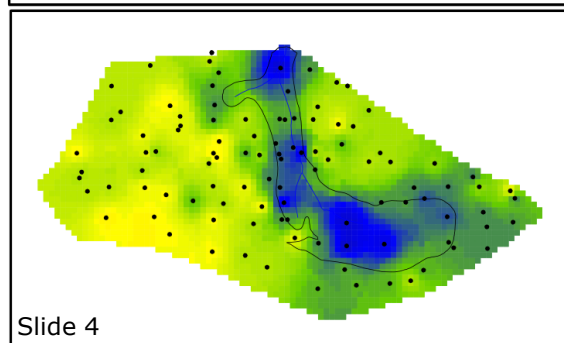
Observed



Scenario#1



Scenario#2



Slide 4

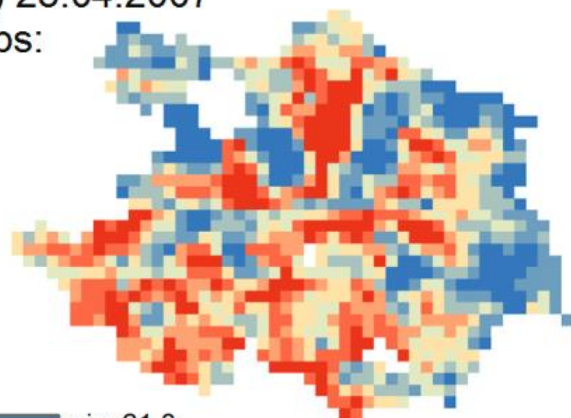


Introduction

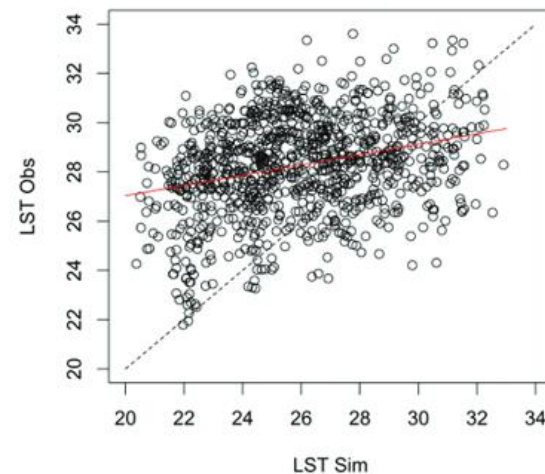
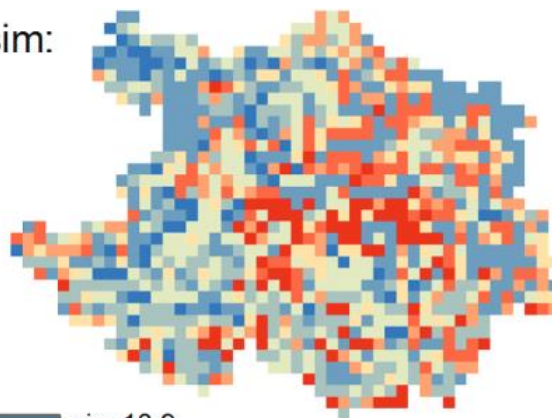
The need for pattern metrics

a) 28.04.2007

obs:

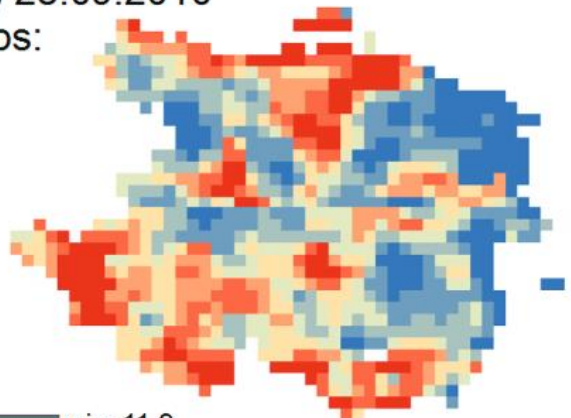


sim:

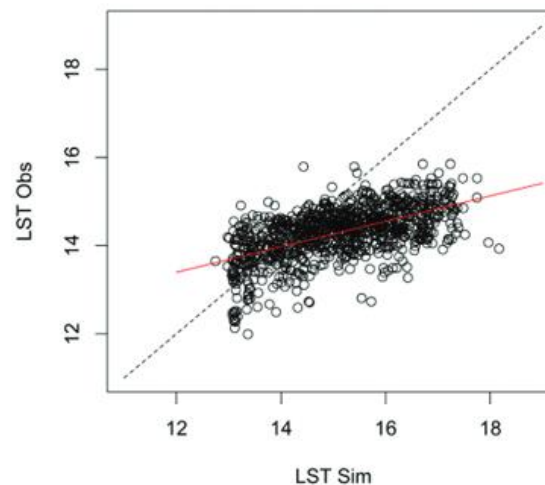
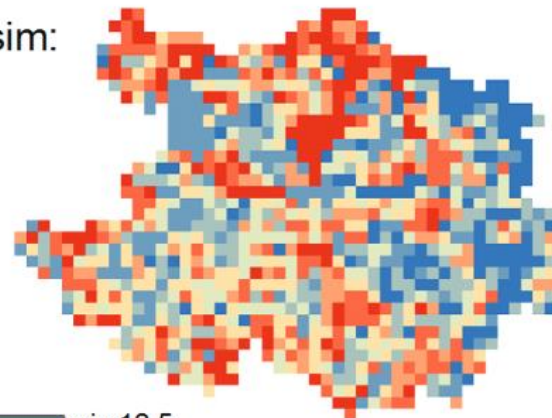


b) 28.09.2010

obs:



sim:



Introduction

Important Notes

- Discharge validation can yield right results for the wrong reasons – not sensitive to spatial patterns
- Pattern comparison challenging – What metric to use?
- What validation data/variable to use?
- LST is an important hydrological state with coupling to WB and EB



Spatial validation of NLDAS-2

- 3 LSMs: Mosaic, Noah, VIC
- SVAT – atmosphere coupling
- Water balance, Energy balance → **LST**
- Many validation studies



LDAS Land Data Assimilation Systems

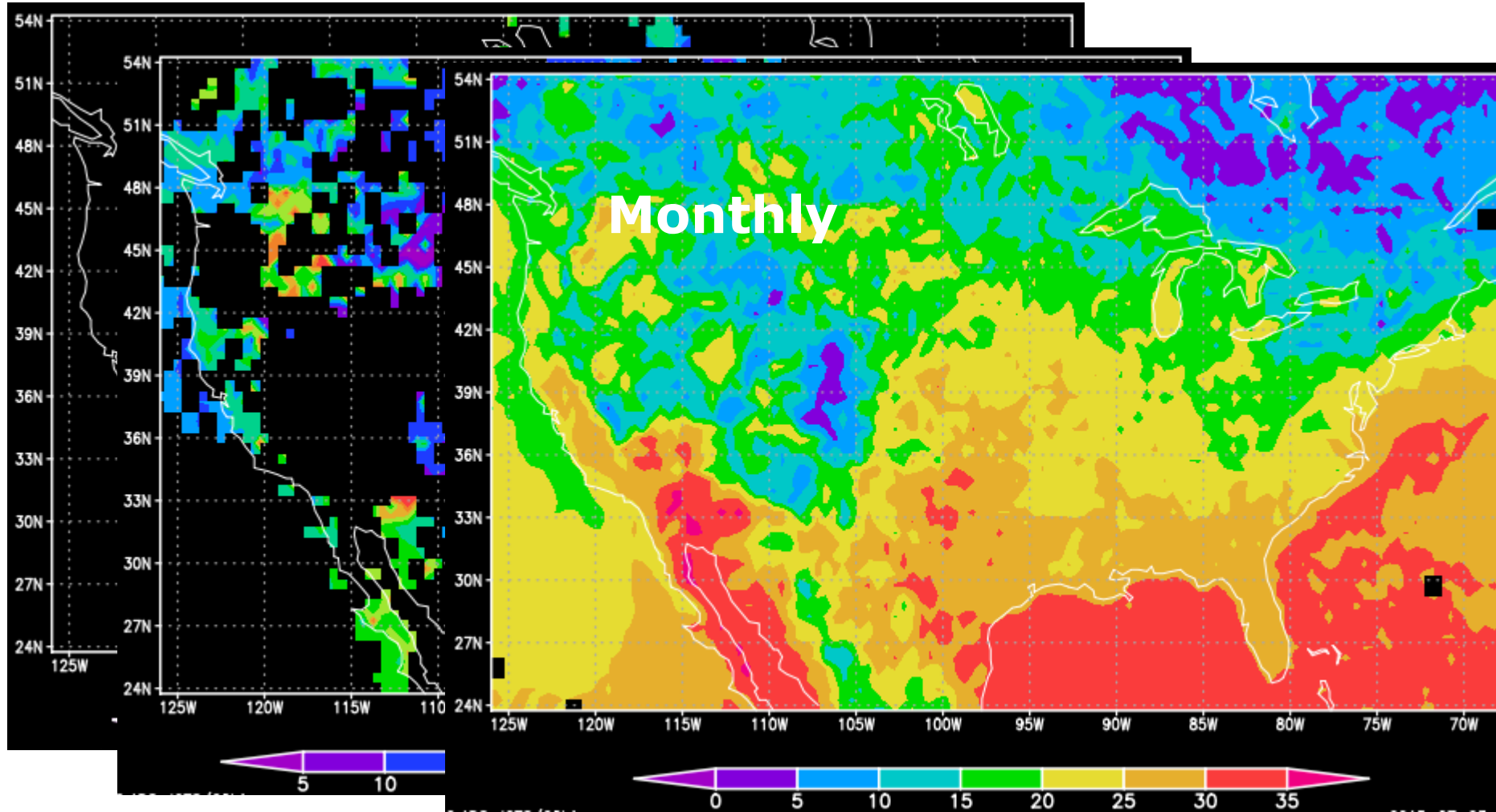


HIRS LST Data

- High resolution Infrared Radiation Sounder
- NOAA polar orbiting satellites
- Hourly data at 0.5 deg resolution
- ~2 overpasses a day per location
- Long record 1979 – 2009
- → **Long term seasonal spatial validation**



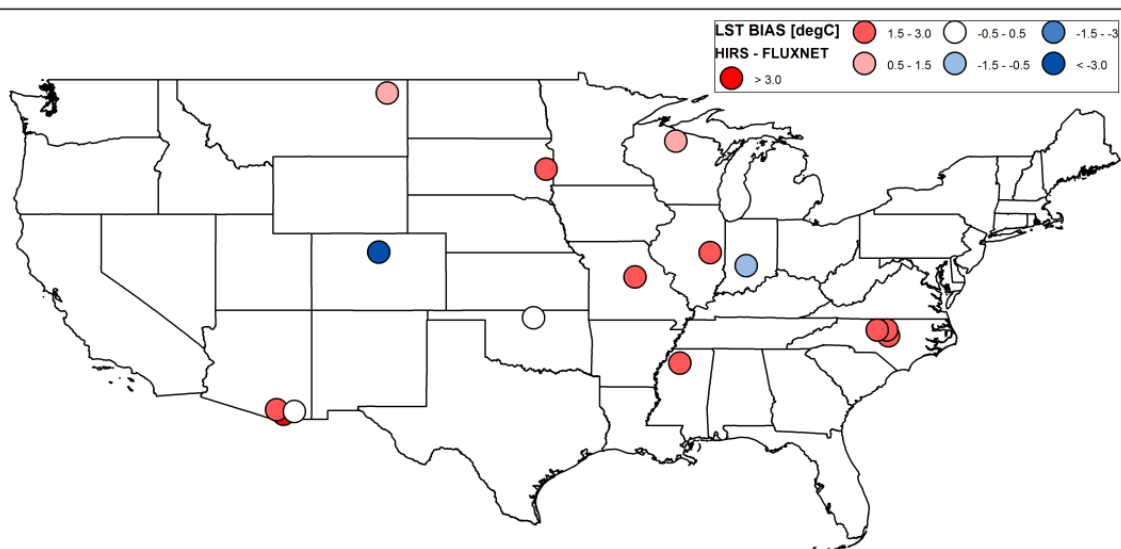
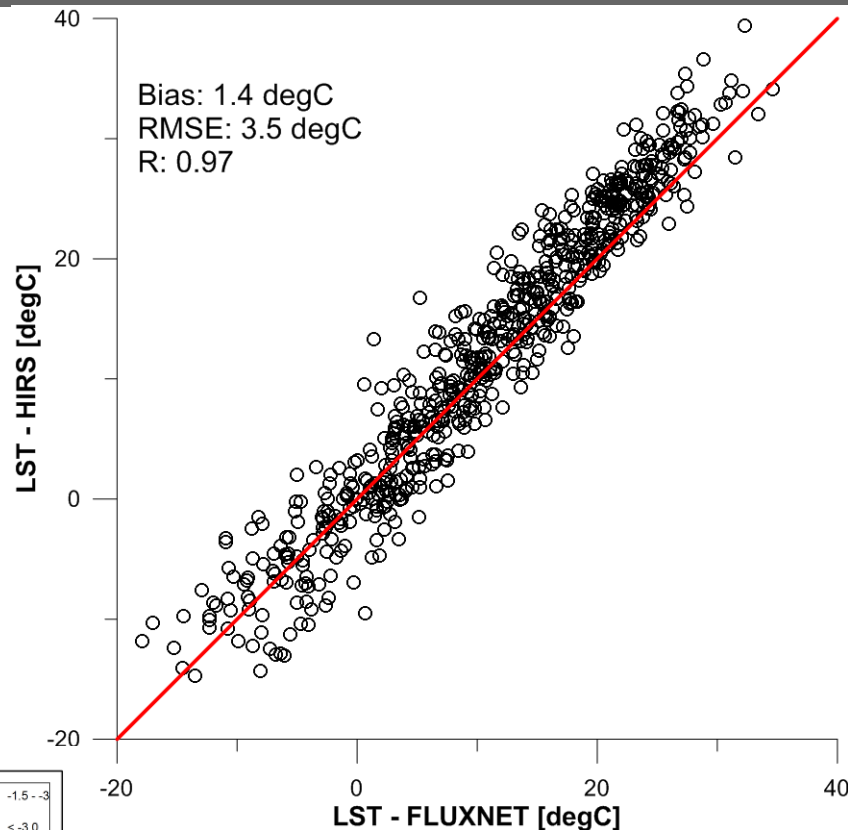
HIRS LST Data



HIRS LST Data

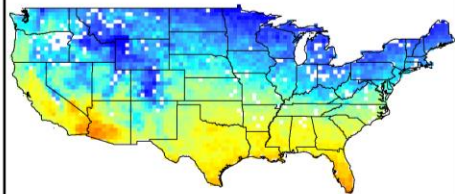
Comparison against FluxNET Sites

- Derived from monthly longwave up
- 15 stations – temp. correlation >0.95
- Spat. Correlation – 0.84 avg

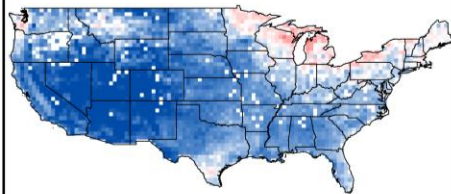


LST Validation: Error Maps

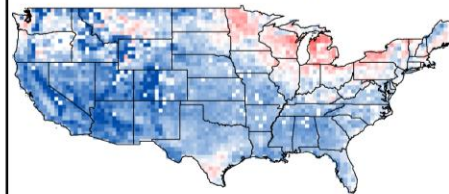
March 2004



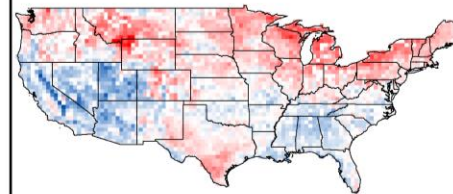
Mosaic - OBS



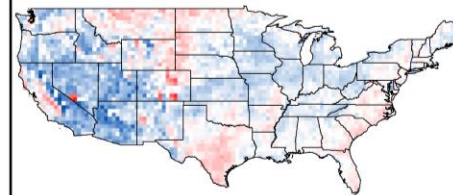
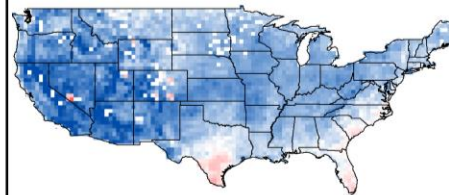
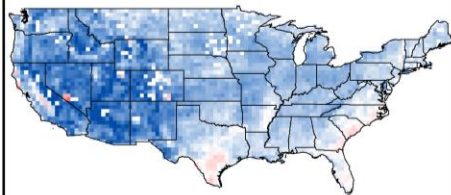
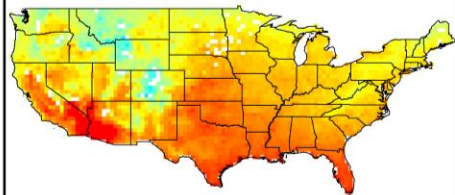
Noah - OBS



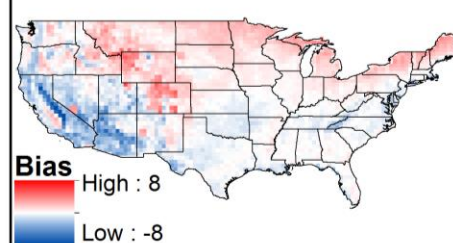
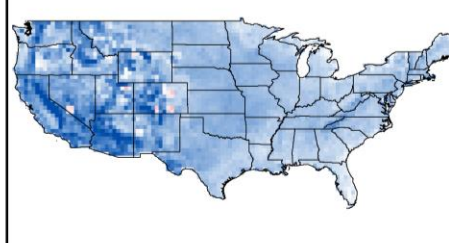
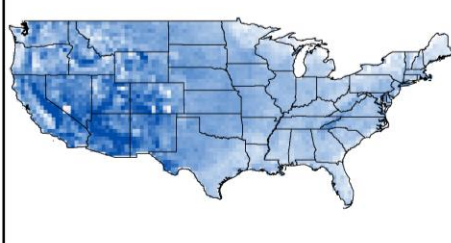
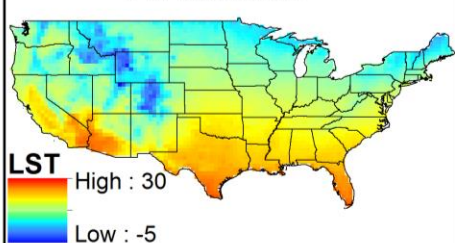
VIC- OBS



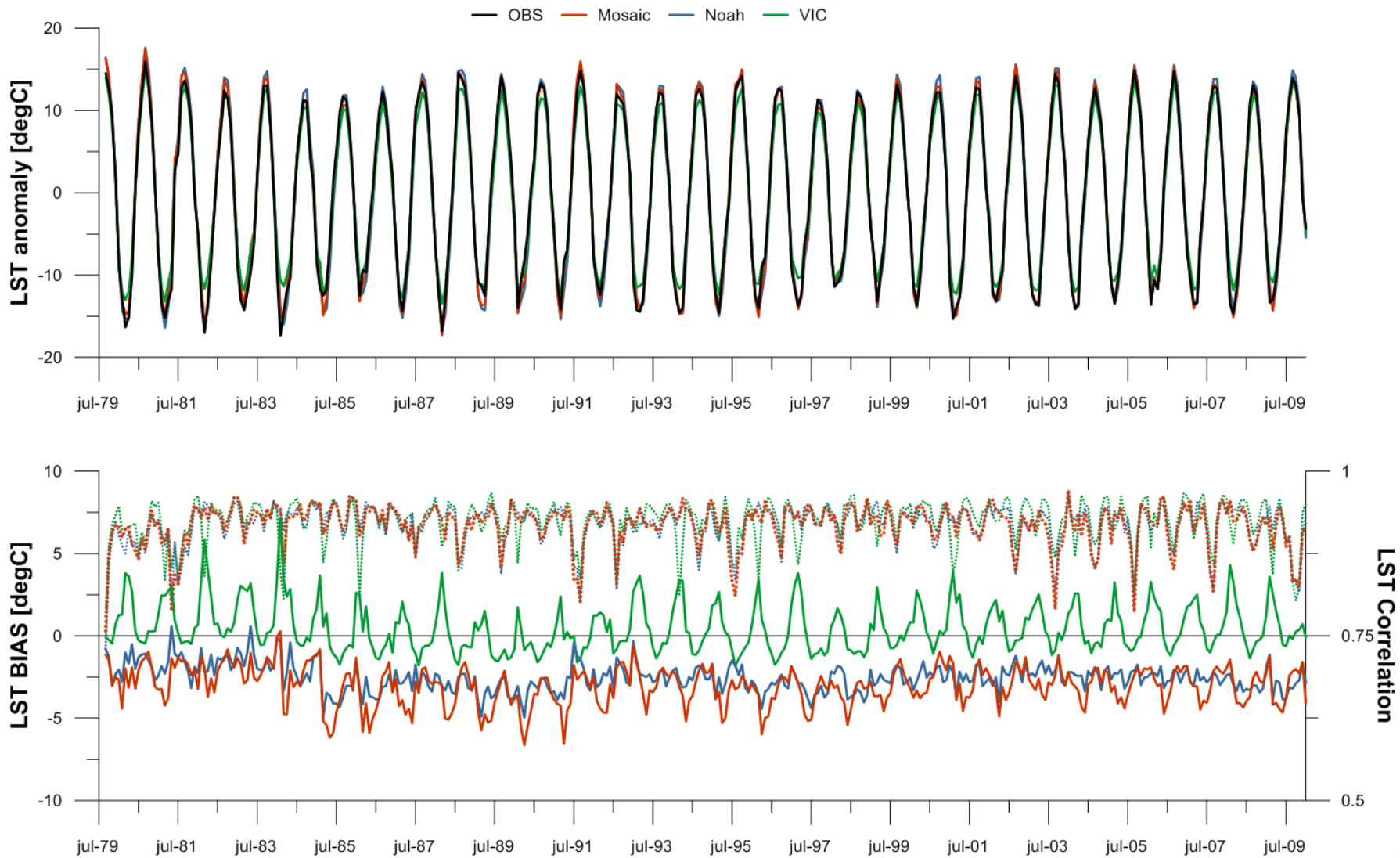
August 2004



All months

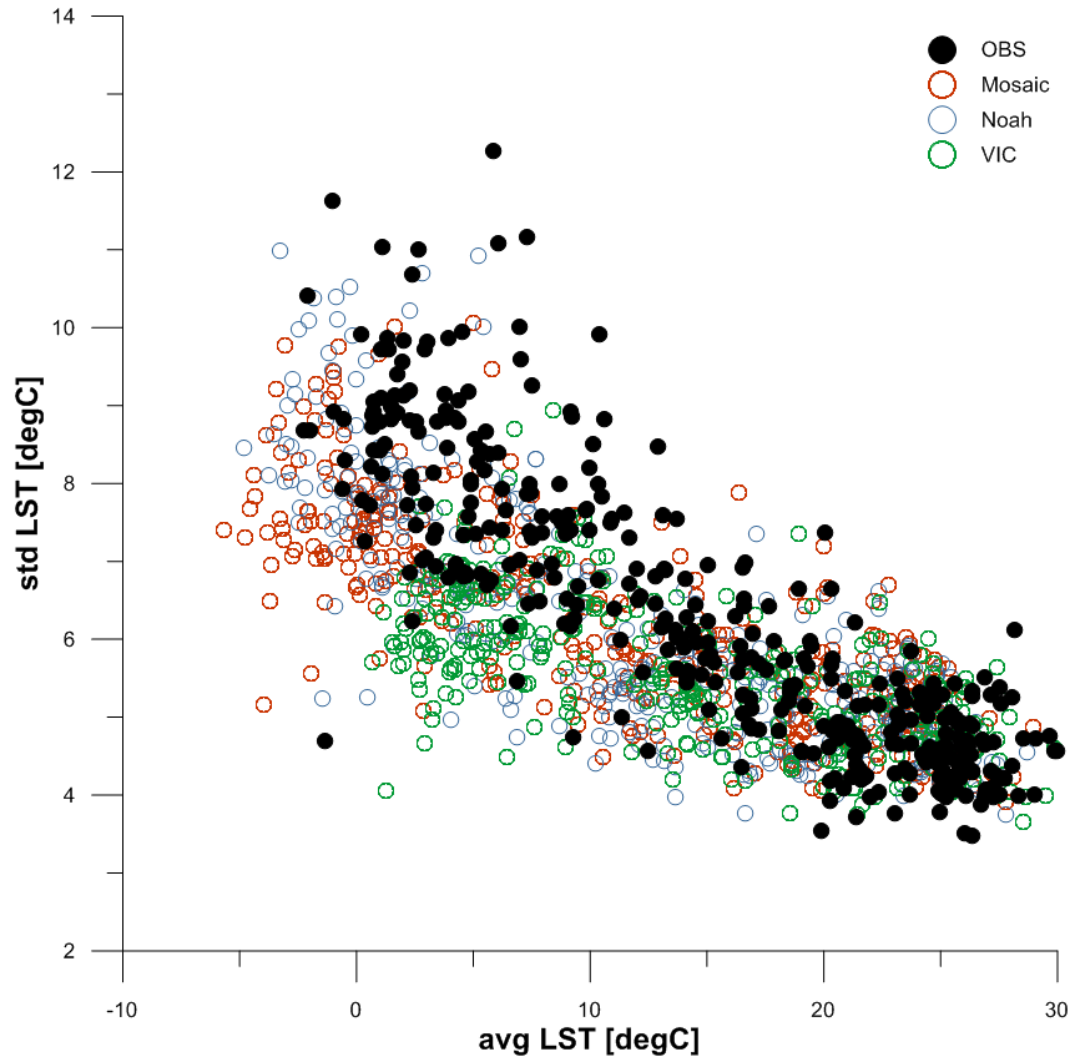


LST Validation: Annual Cycle

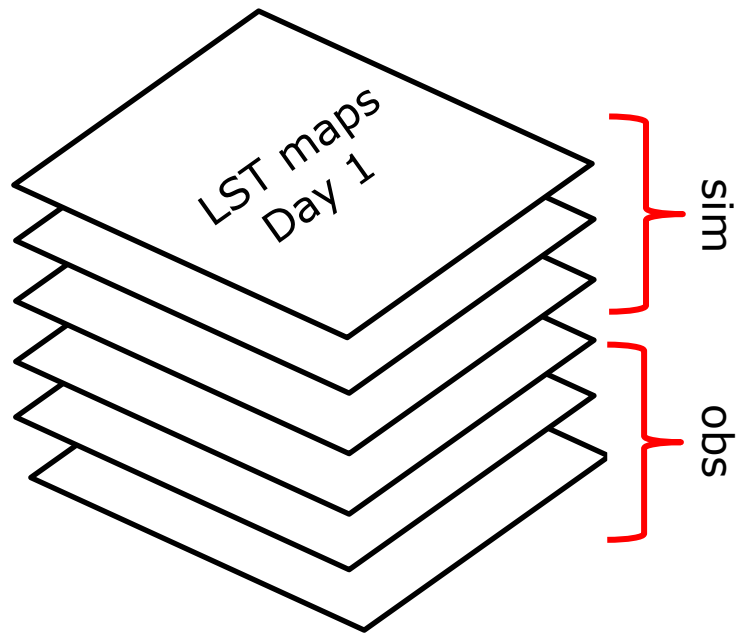


LST Spatial Validation

- Spatio-temporal Analysis



Empirical Orthogonal Functions - Analysis

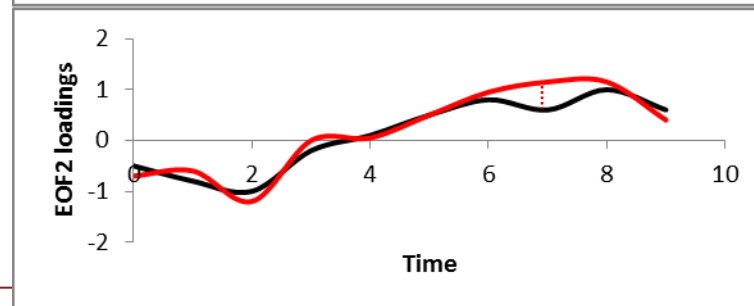
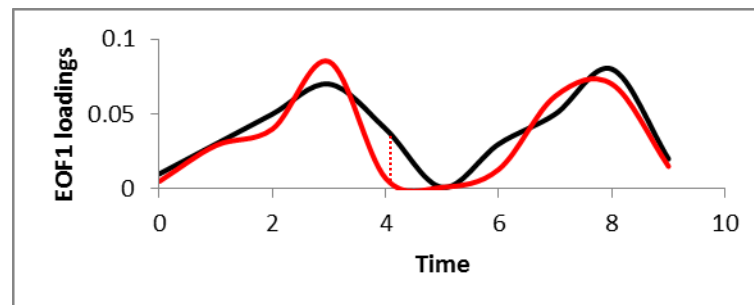
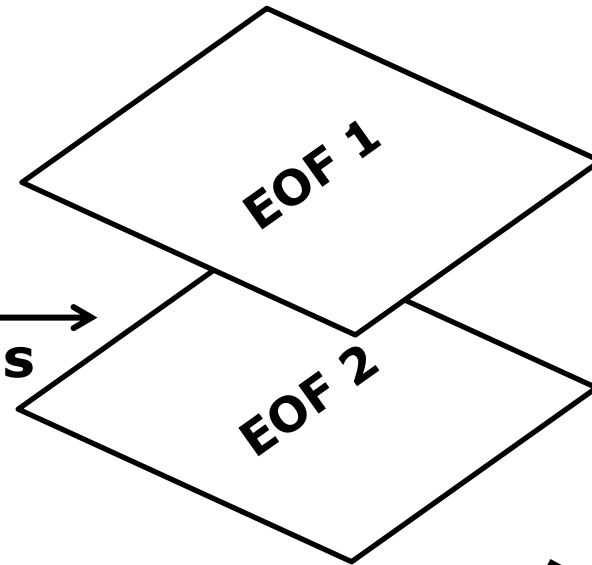


	Day_1	...	Day_n
Cell_1	Lst_11		
⋮			
Cell_n			Lst_nn

Skill score = weighted sum of the differences in loadings

Slide 14

**EOF
Analysis**

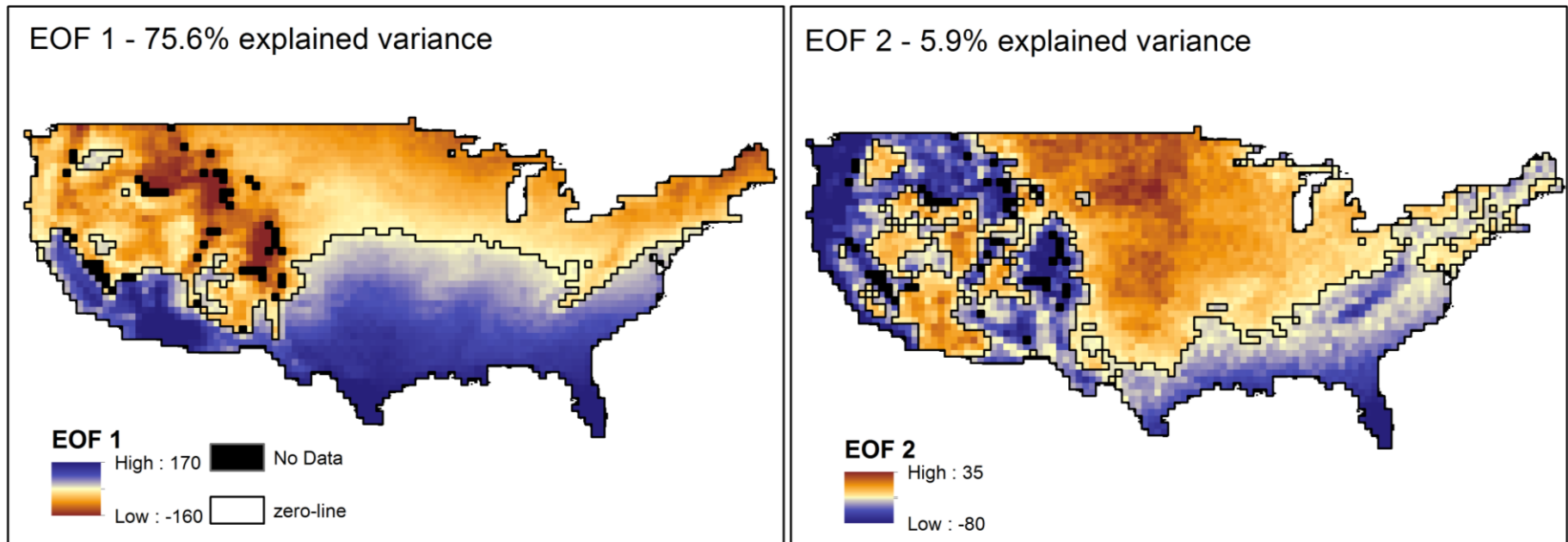


EOF-loadings



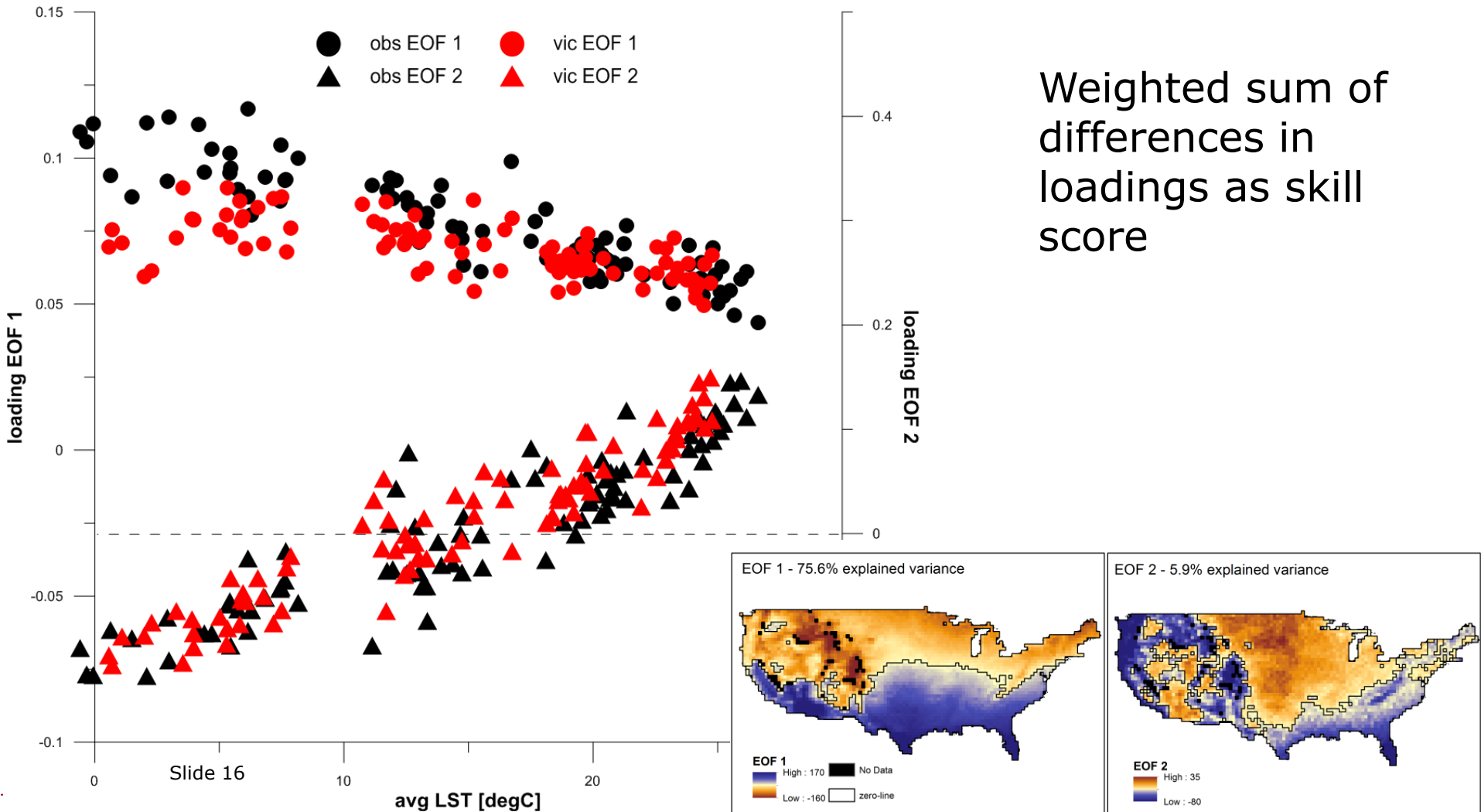
LST Spatial Validation - EOF

- EOF-Analysis – High coverage (>**90%**) months only
→ **91** months



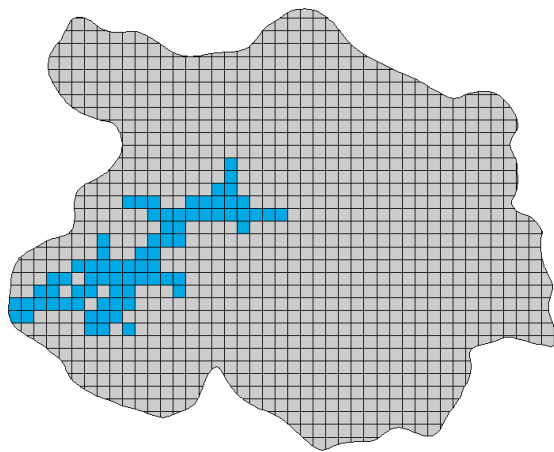
LST Spatial Validation - EOF

EOF-Analysis: loadings of 90 months

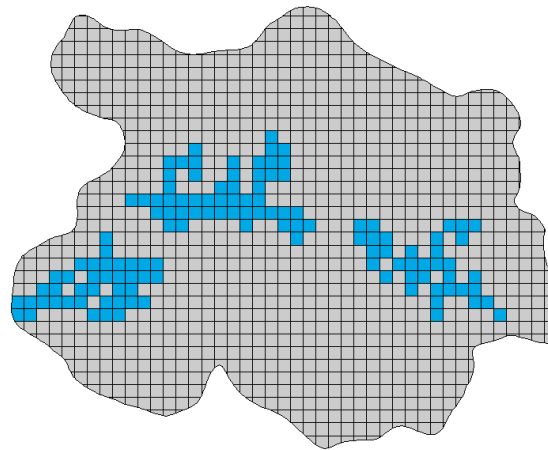


LST Spatial Validation - Connectivity

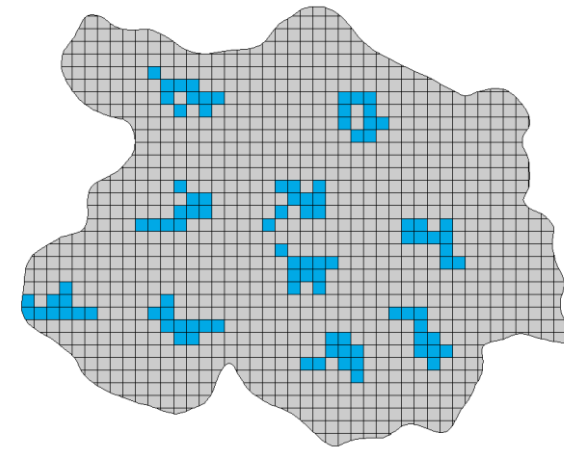
- Percolation Theory: **Probability of connection**



1
1



1
0.33



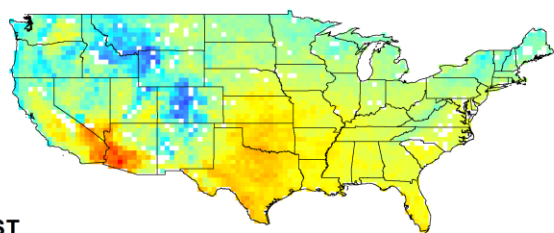
1
0.1

Renard, P., & Allard, D. (2013). Connectivity metrics for subsurface flow and transport. *Advances in Water Resources*, 51, 168-196.

LST Spatial Validation - Connectivity

August 1993

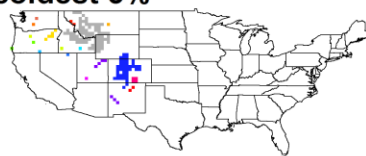
LST - OBS



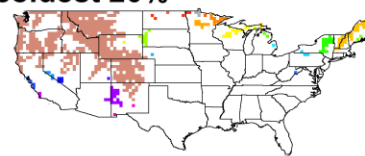
LST

High : 41
Low : 5

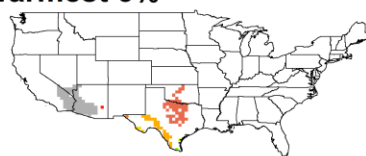
coldest 5%



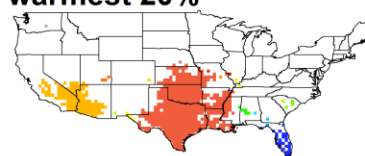
coldest 20%



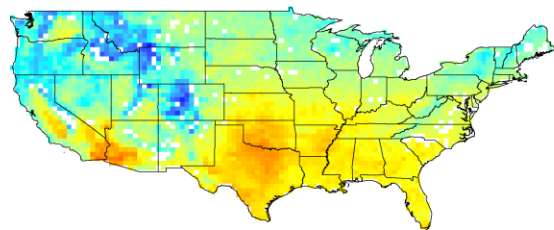
warmest 5%



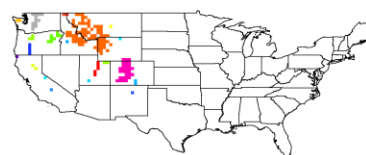
warmest 20%



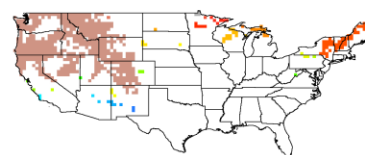
LST - VIC



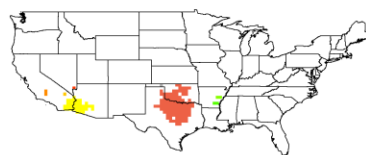
coldest 5%



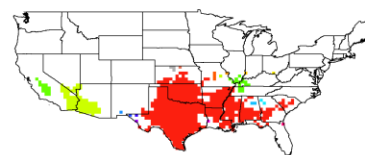
coldest 20%



warmest 5%



warmest 20%



Each percentile
as threshold



Binary map

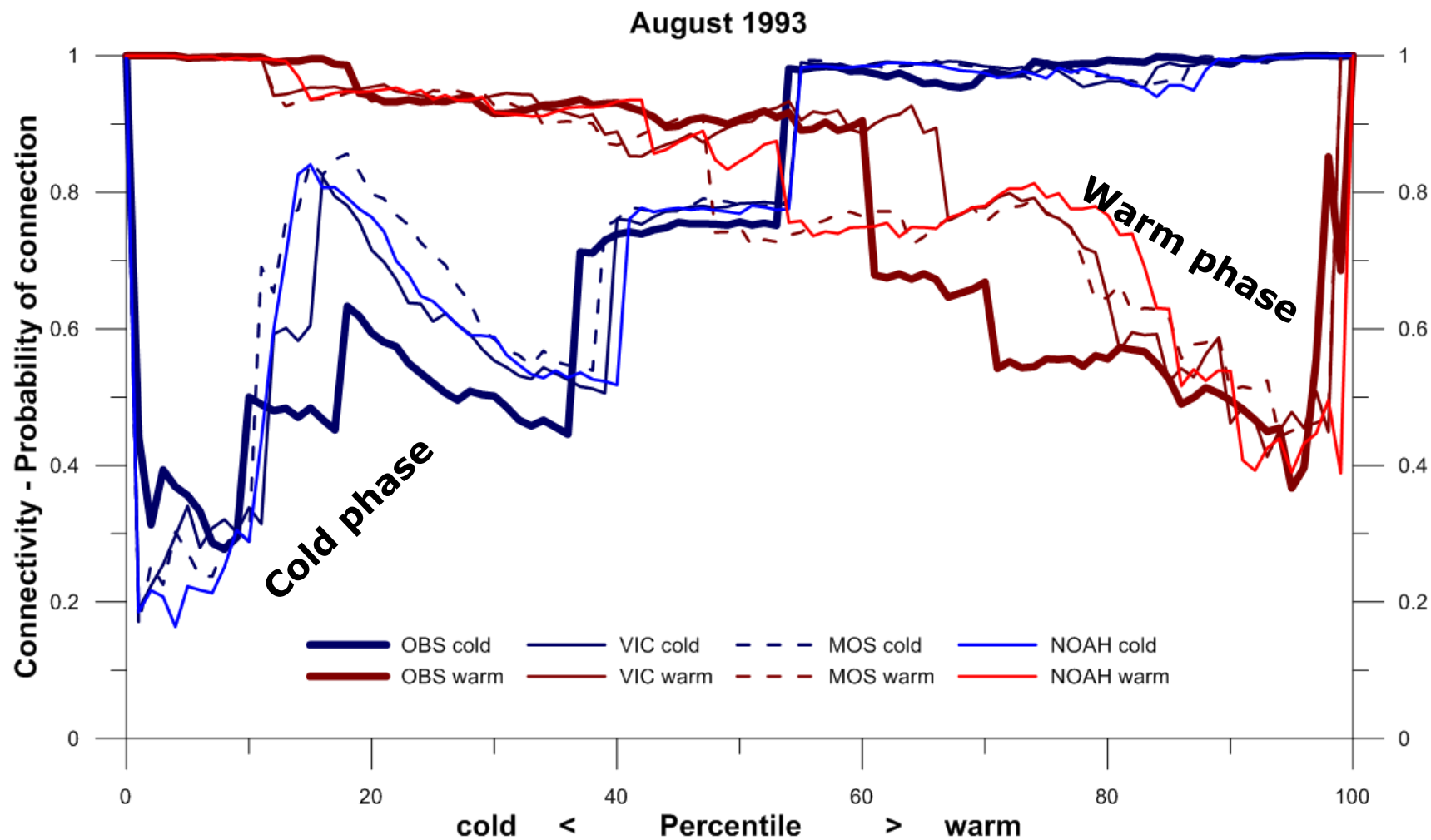


Cluster Analysis



Probability of
connection

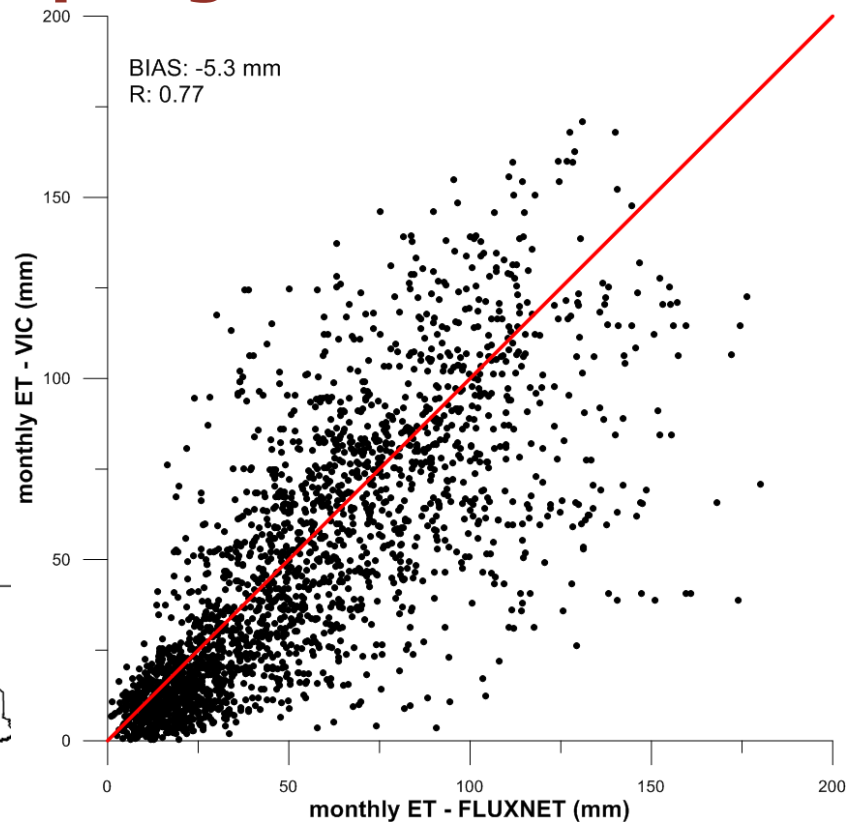
LST Spatial Validation - Connectivity



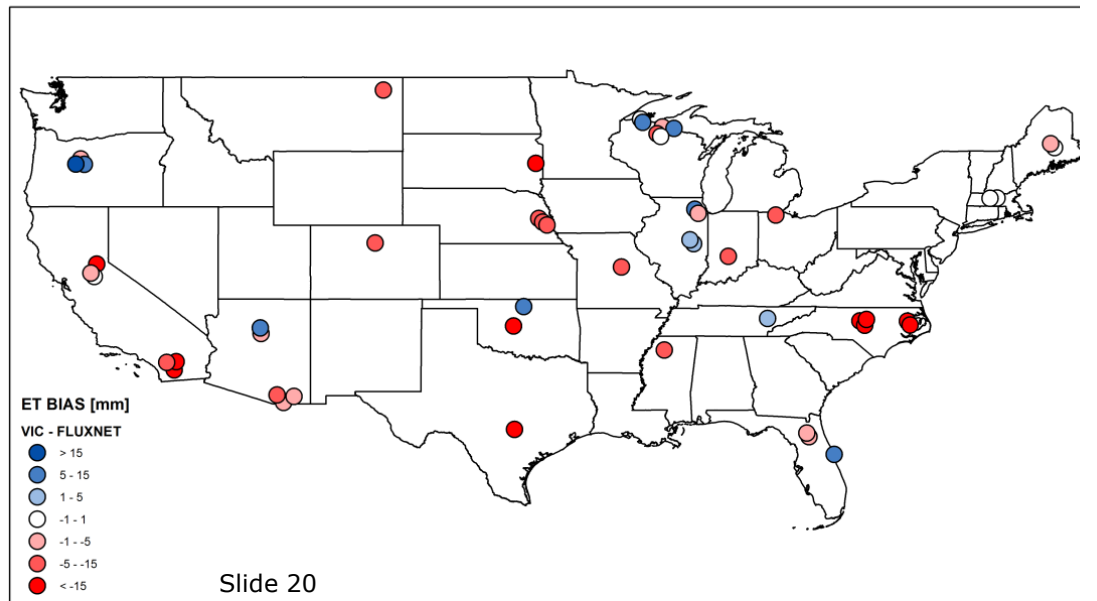
LST – Water Balance Coupling

Comparison of ET against FluxNET Sites

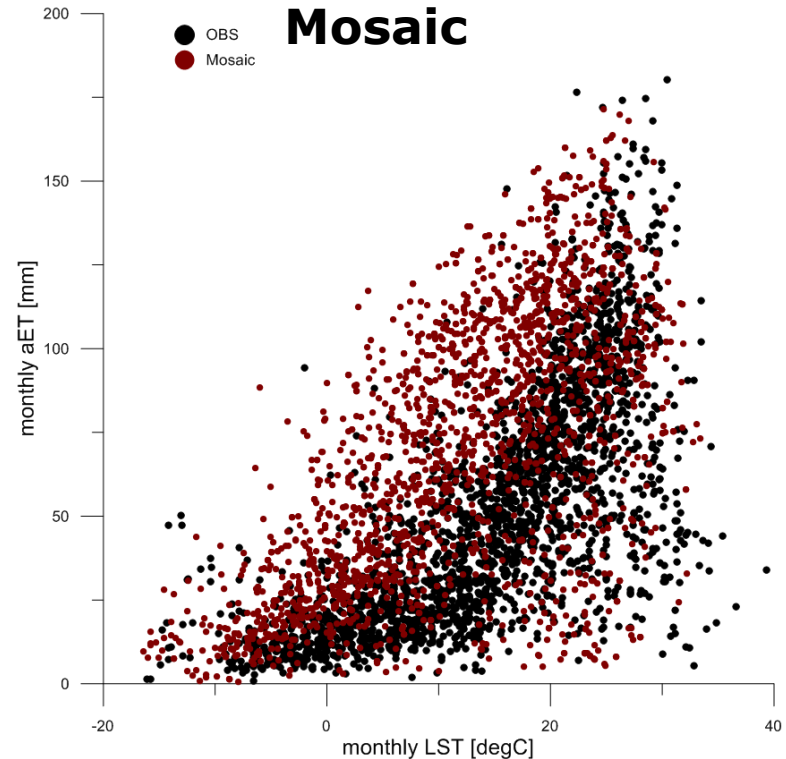
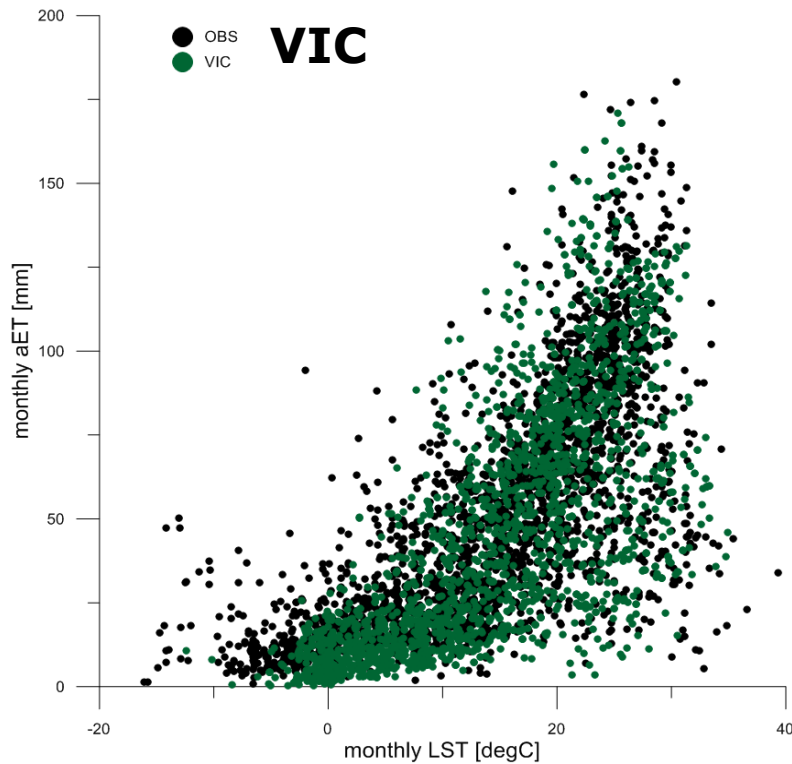
- Latent Heat and air Temperature
- Monthly Values
- 51 stations – Correlation > 0.6



**Correlation between
dLST and dET?**



LST – Water Balance Coupling

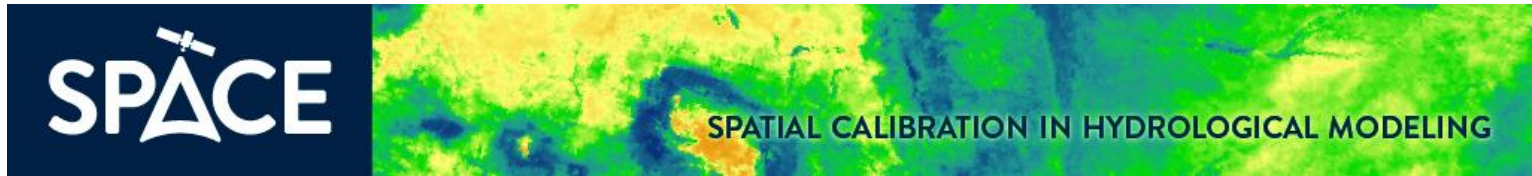


- LST – ET coupling reveals water/energy – limited areas
- VIC has the correct coupling at high Temp but too low ET at low Temp (warm bias)
- Mosaic overpredicts ET → Cooling

Conclusions

- LSMs have different LST **biases** (temporal and spatial)
- **EOF**: Decomposes the spatio-temporal variability of two datasets to quantify spatial performance
- **Connectivity**: The spatial structure is quantified through cluster analysis at threshold percentiles
- Metrics to be tested in spatial pattern oriented **model calibration**
- LST errors can partly be linked to **WB errors**





SPATIAL CALIBRATION IN HYDROLOGICAL MODELING

space.geus.dk

Thank you for your attention!

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The logo for the Journal of Geophysical Research: Atmospheres (JGR), featuring the letters 'JGR' in white on a purple curved background.

Journal of Geophysical Research: Atmospheres
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