How realistic are the spatial patterns simulated from field-scale resolving land surface models?

Nathaniel Chaney, Laura Torres Rojas,
Jiaxuan Cai, and Noemi Vergopolan

Duke UNIVERSITY

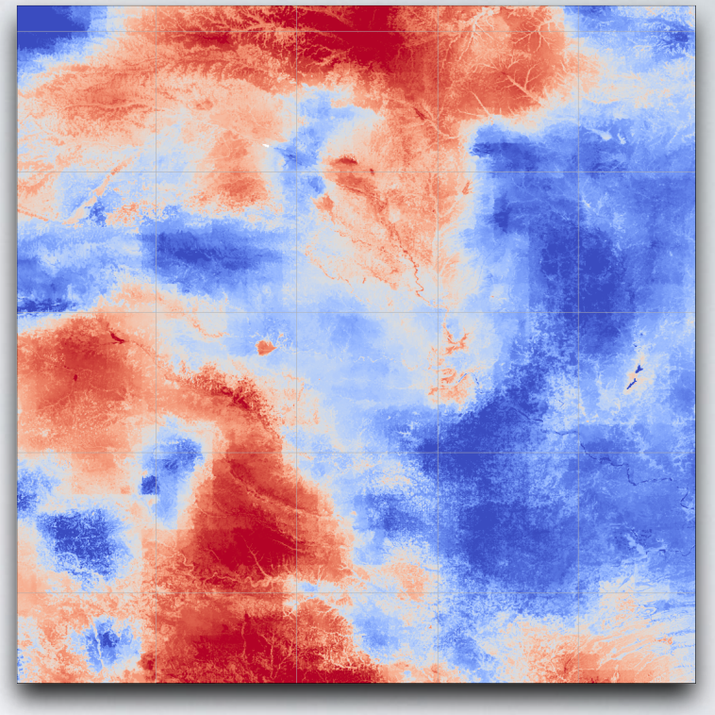
PRINCETON UNIVERSITY

Motivation

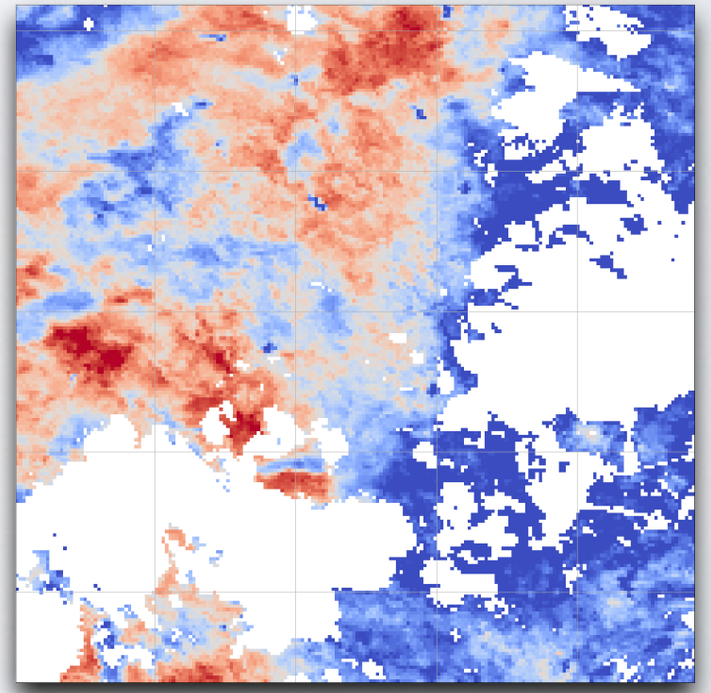
- Land models aim to model the multi-scale spatial heterogeneity of water and energy cycles
- Approaches: Fully distributed (e.g., hyper-resolution), semi-distributed (e.g., tile schemes)…
- Need to evaluate how well these models capture heterogeneity.
  - Land surface temperature (LST) is a good candidate due to available observations and its important role in LSMs

Objective: Evaluate the modeled spatial fields of land surface temperature using satellite remote sensing

Model

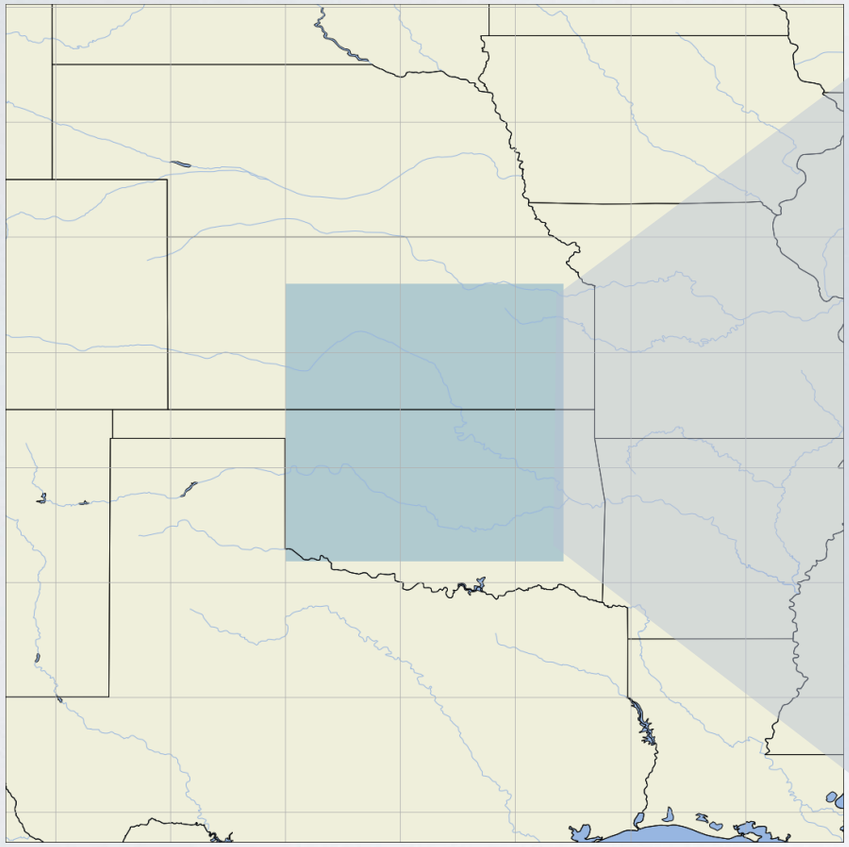


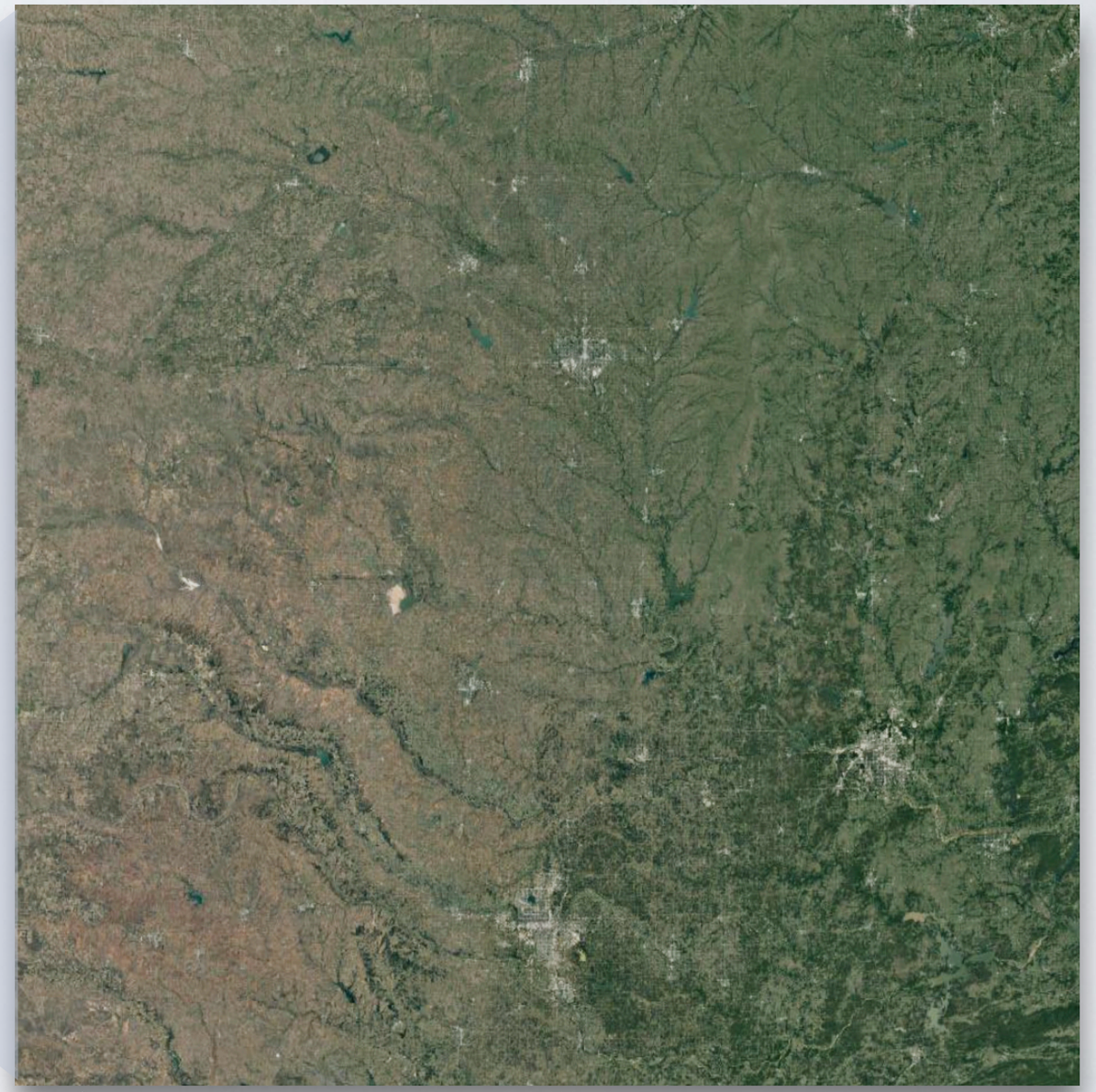
Vs.



Observation

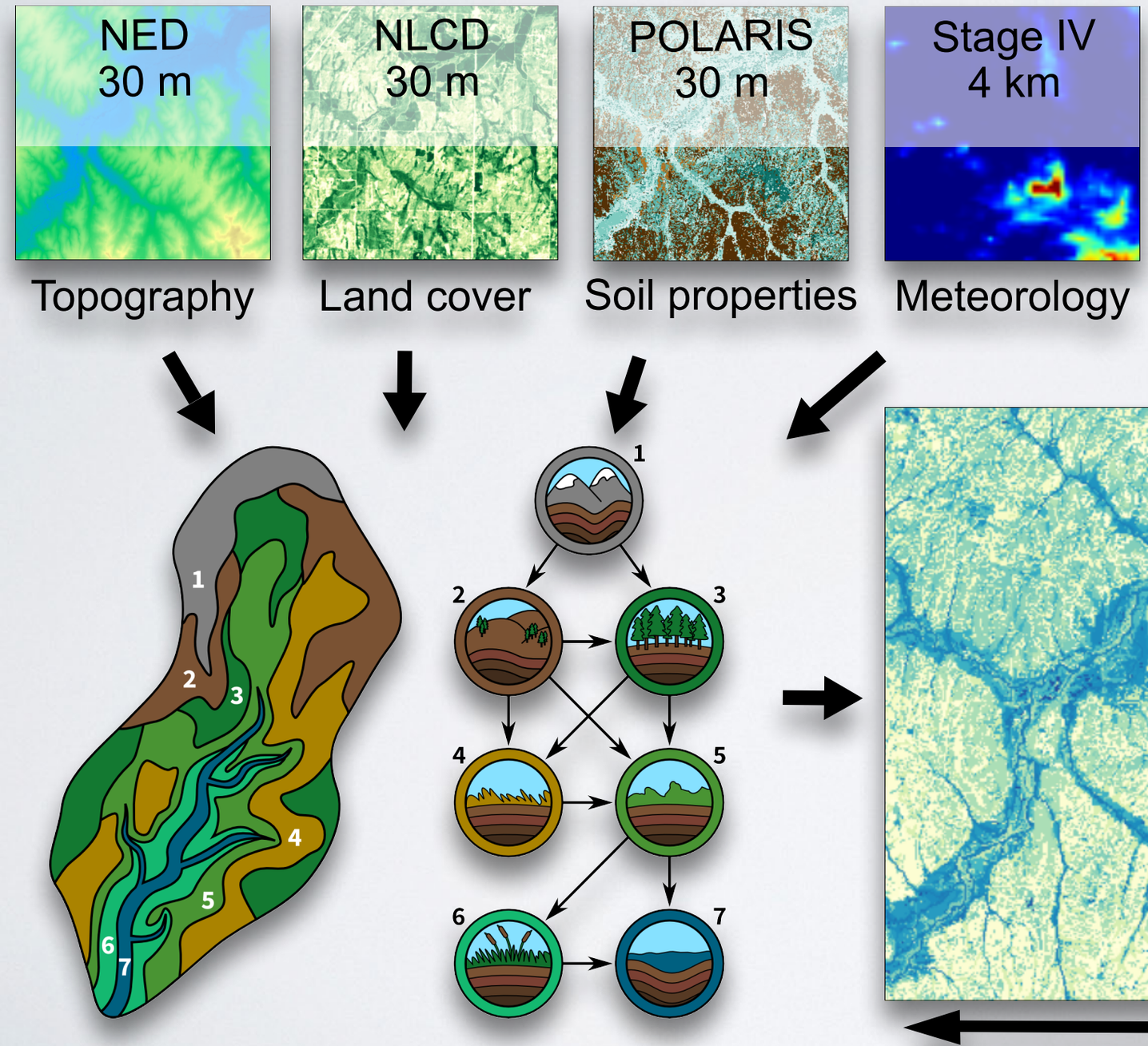
Study area: 500 km domain centered at the Southern Great Plains site in Oklahoma





500 km

HydroBlocks



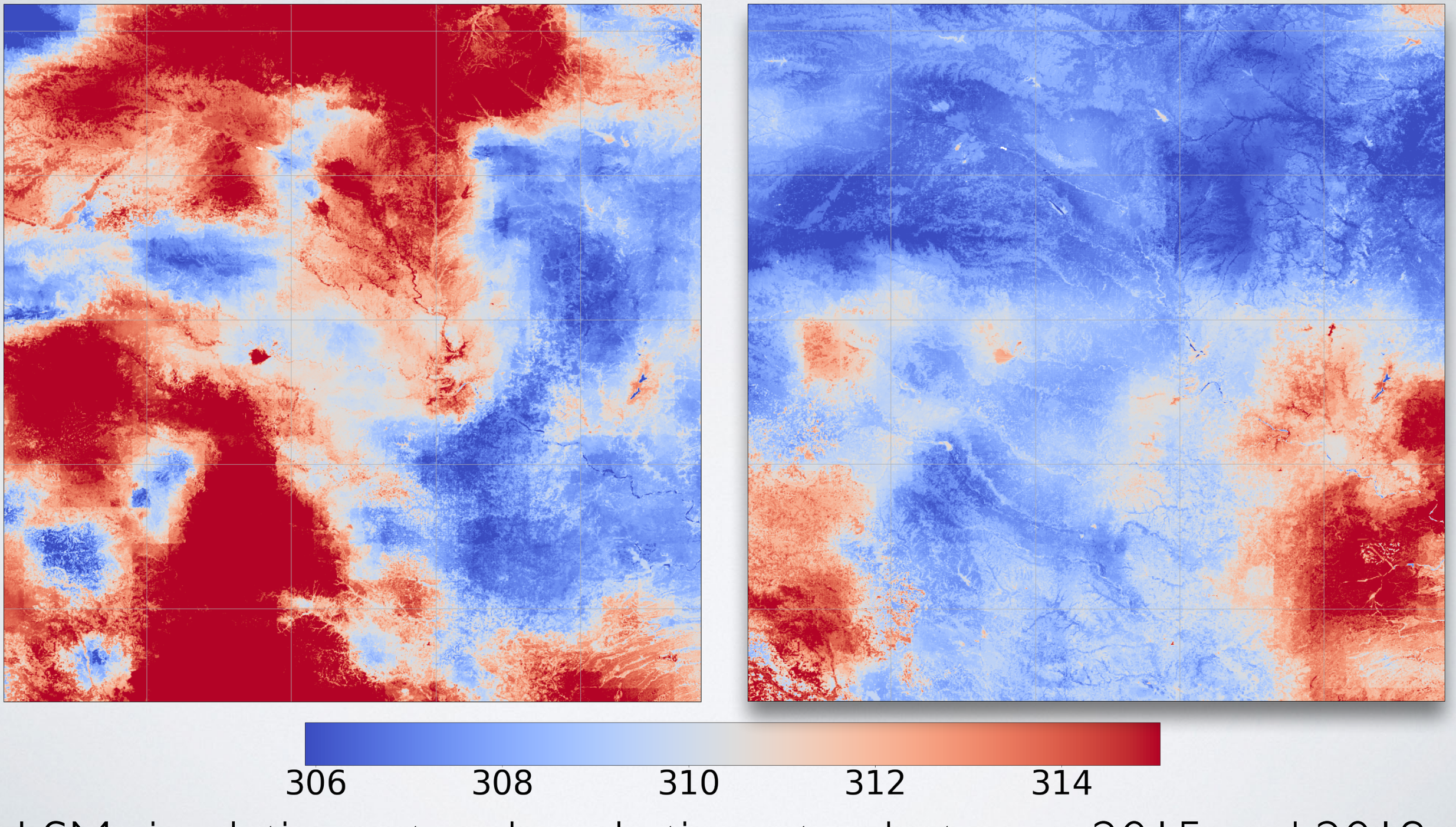
Field-scale resolving land surface model

Chaney et al., 2016, 2018, 2021

Study domain (500 x 500 km^2): Simulated LST

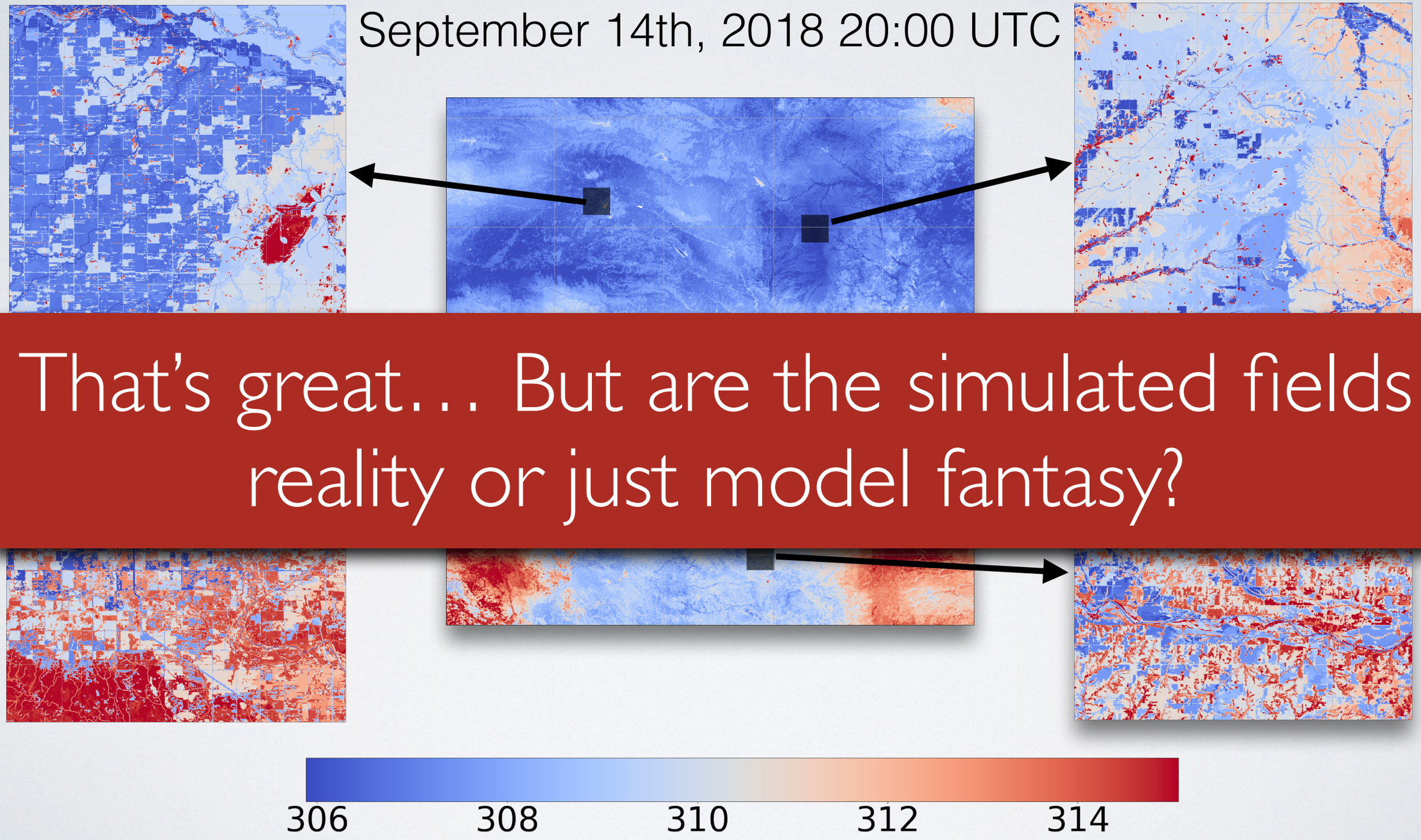
June 14th, 2018 17:00 UTC

September 14th, 2018 20:00 UTC



LSM simulations at an hourly time step between 2015 and 2019

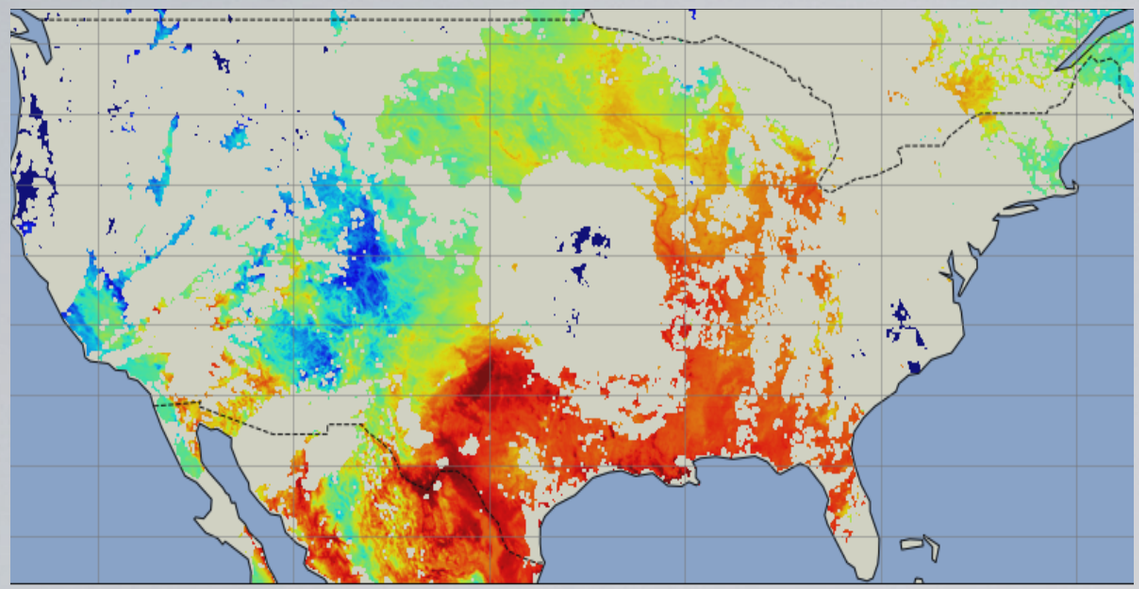
Study domain: LSM simulated LST



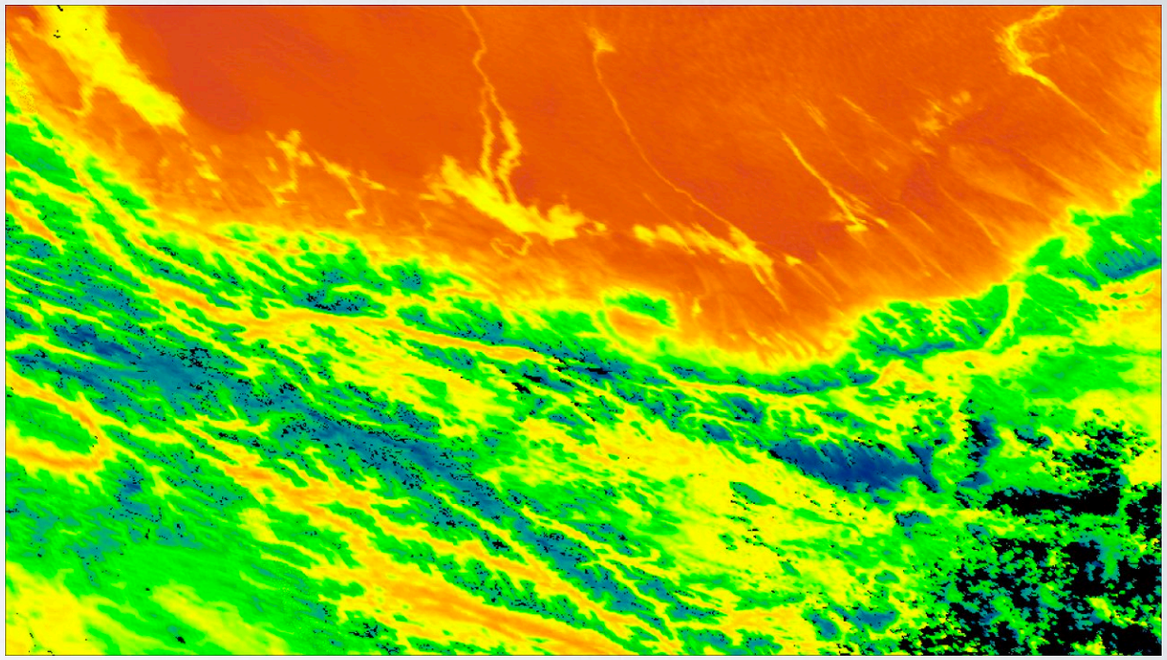
That's great… But are the simulated fields reality or just model fantasy?

Satellite remote sensing of LST

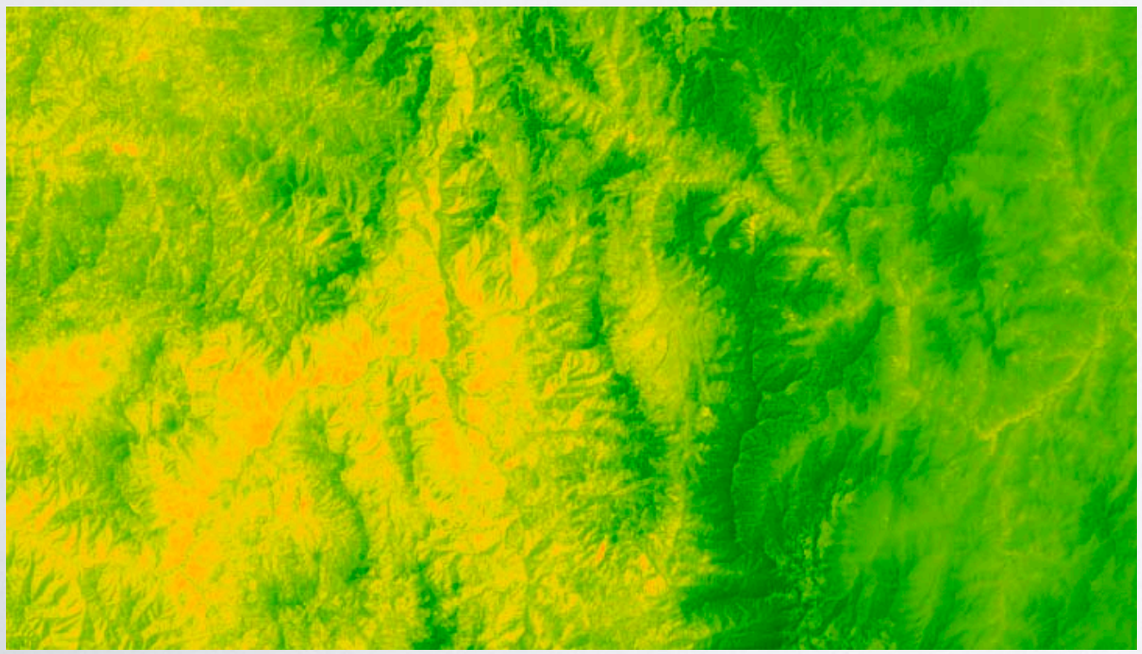
GOES 16/17(~2 km, hourly)



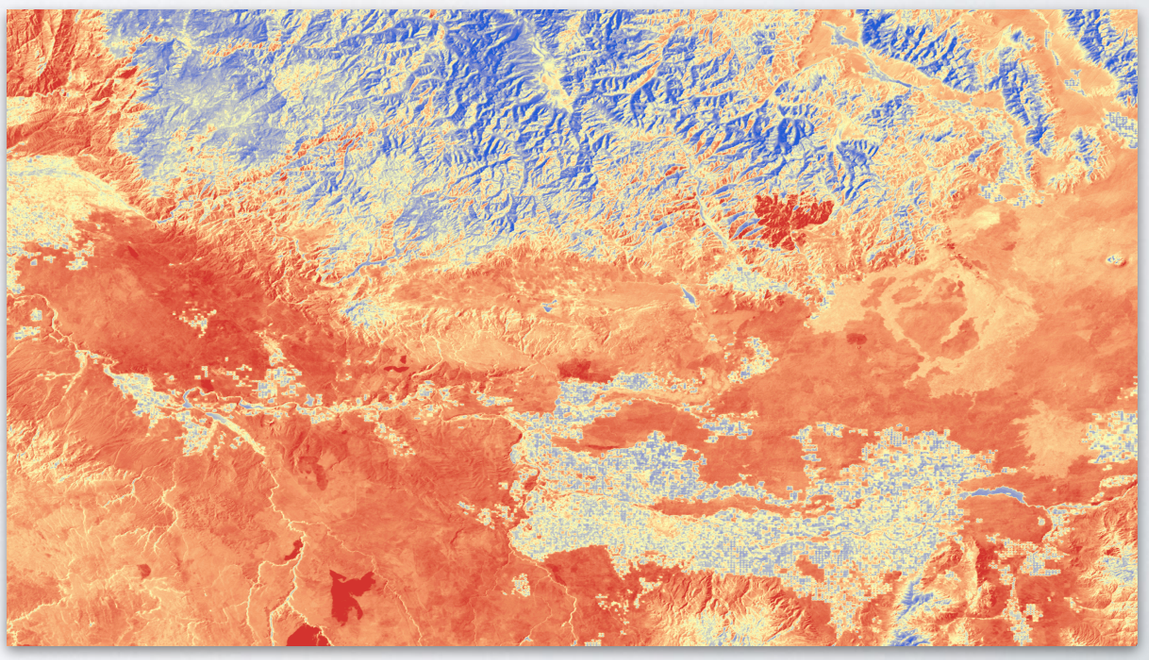
MODIS (~1 km, daily)



Landsat 8/9 (~100 m, 8 days)

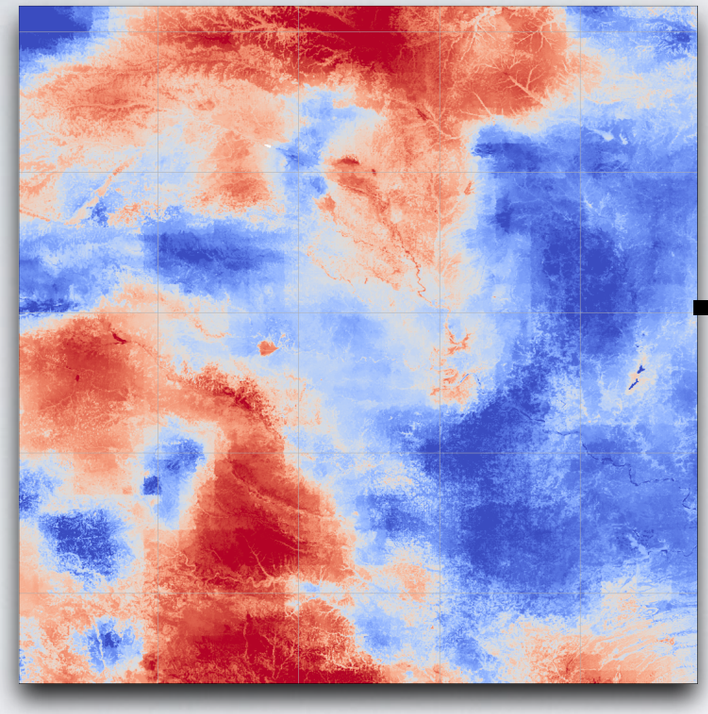


ECOSTRESS (~70 m, ~4 days)

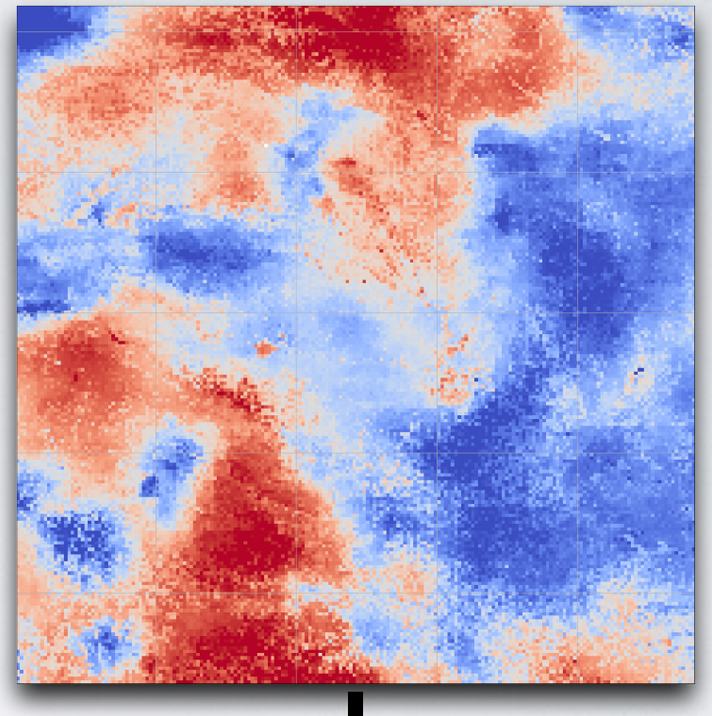


June 14th, 2018 17:00 UTC

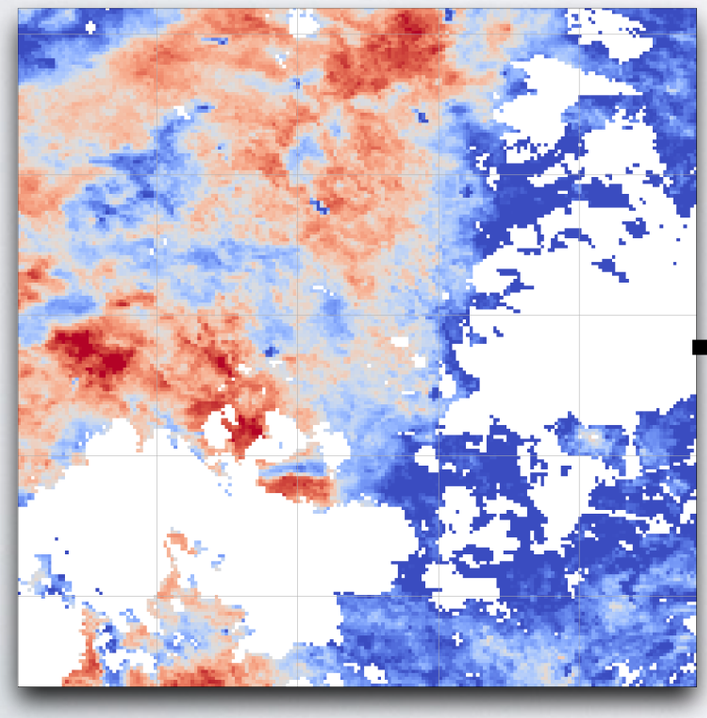
HydroBlocks



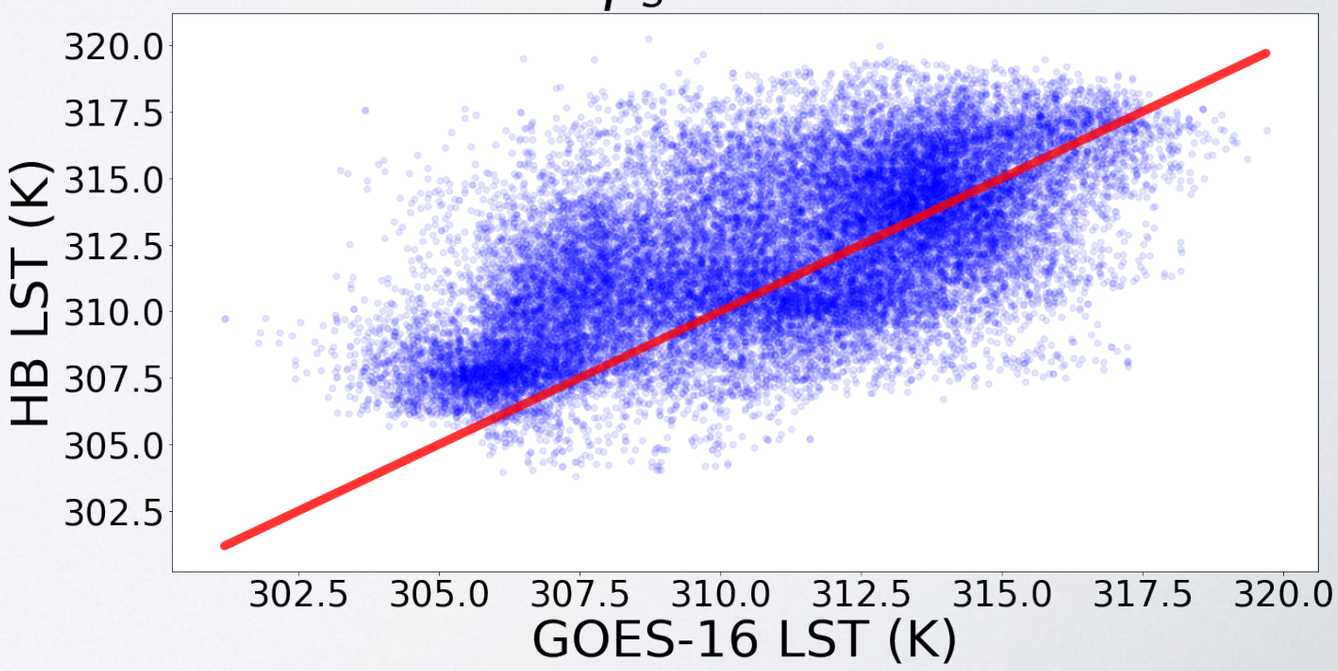
Upscaled
to ~2 km



GOES16

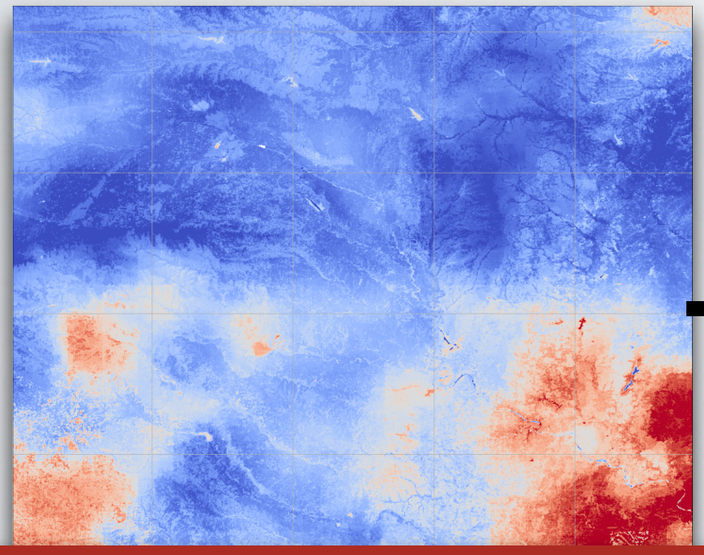


$\rho_s = 0.62$

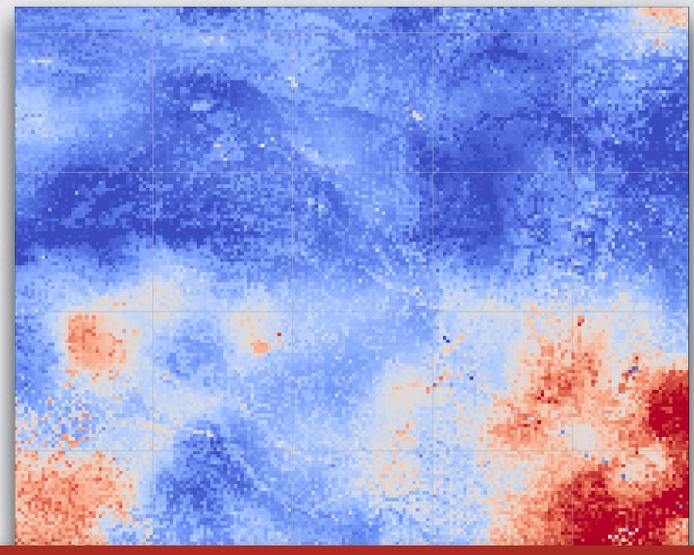


September 14th, 2018 20:00 UTC

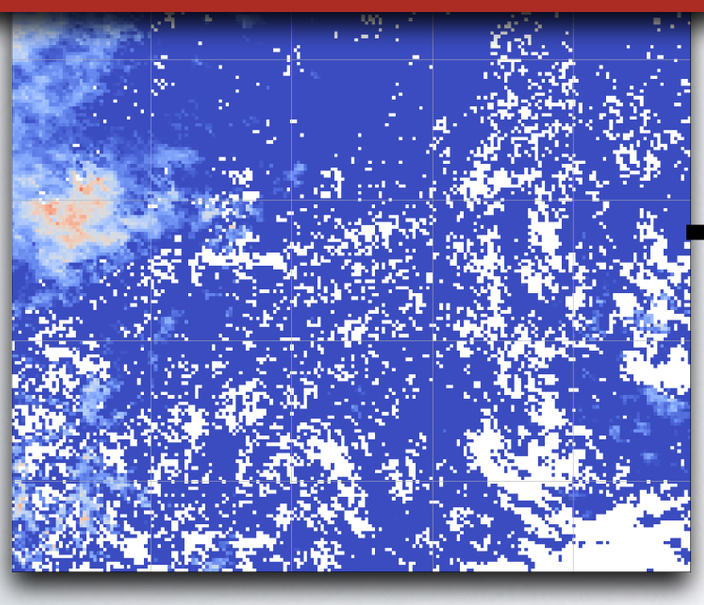
HydroBlocks

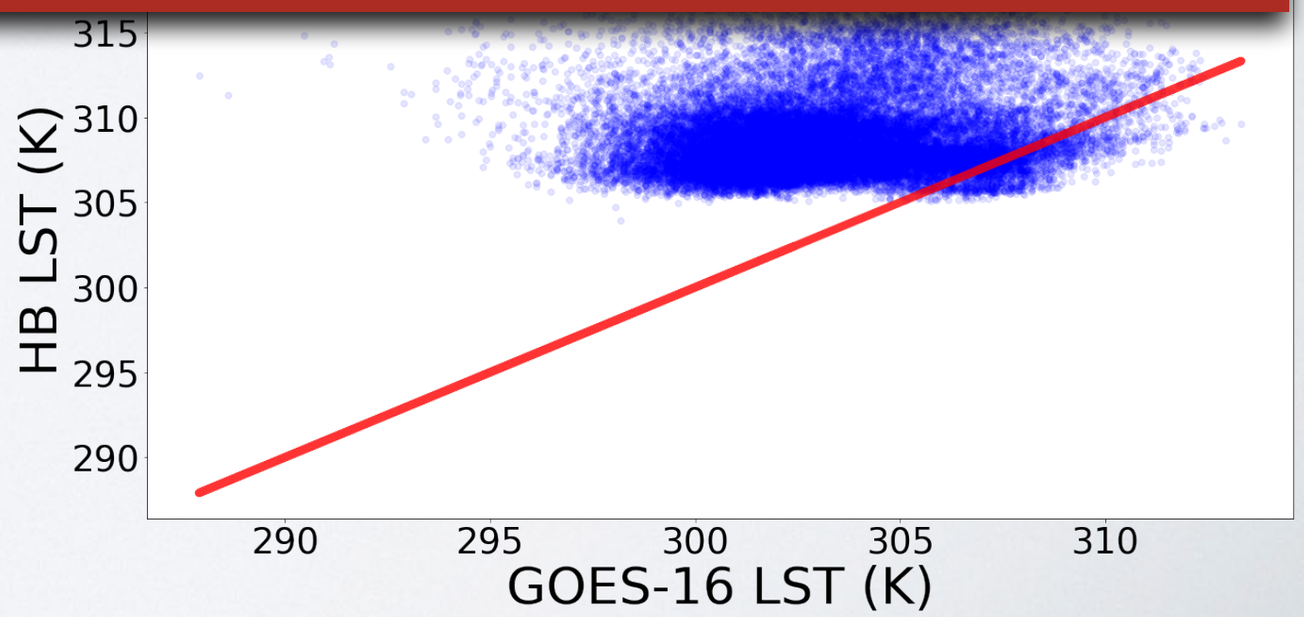


Upscaled
to ~2 km



More rigorous way to evaluate the simulated LST spatial fields?



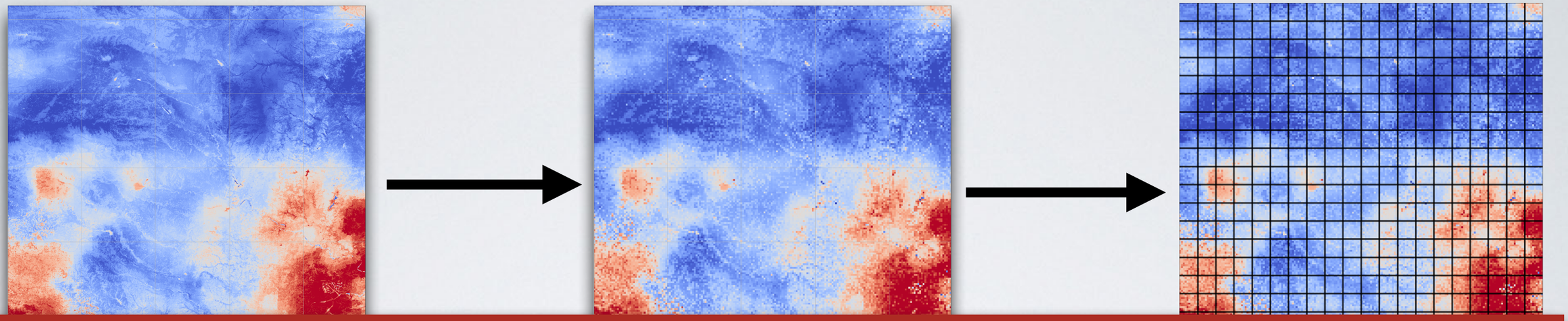


Derive ~25 km spatial statistics

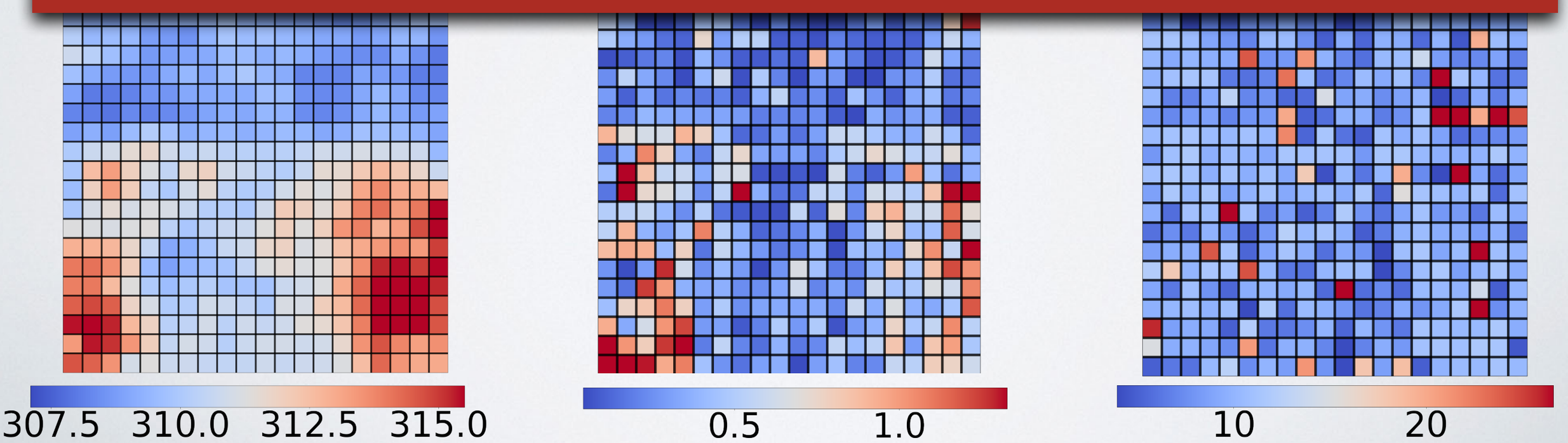
Simulated LST

Upscale to ~2 km

~25 km grid



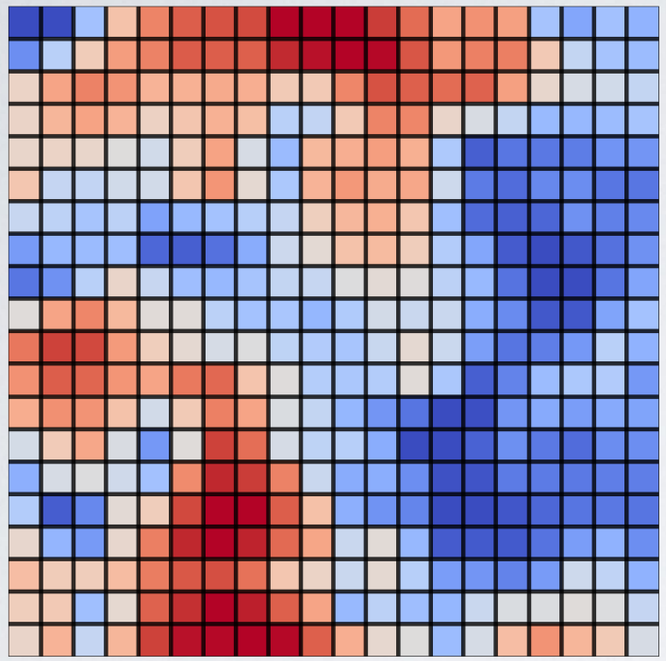
Produce summary spatial statistics maps over entire 2018 at each hour

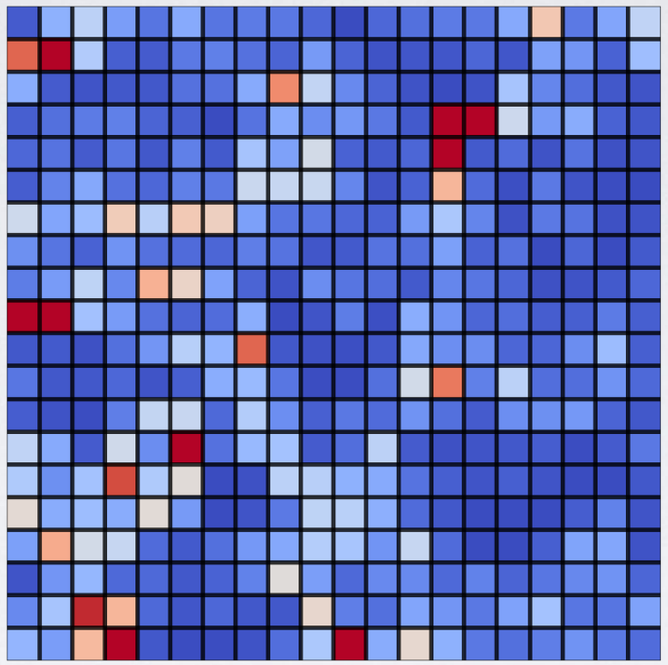


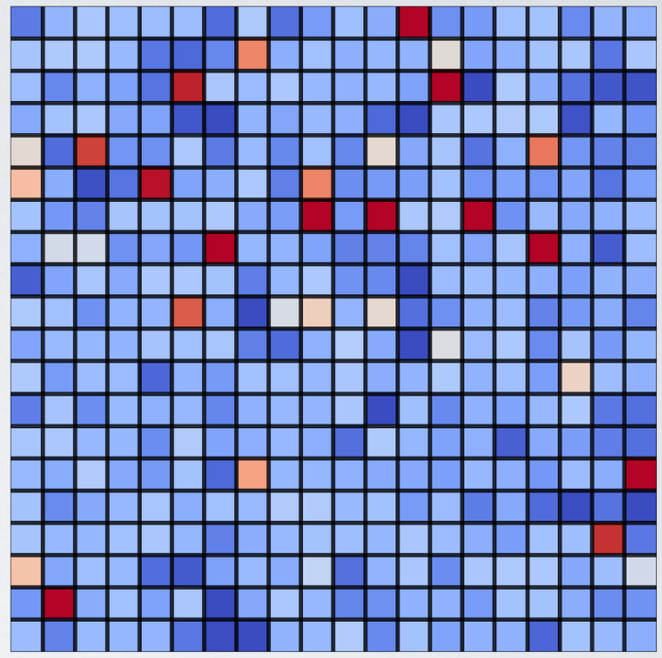
June 14th, 2018 17:00 UTC

Spatial mean (K) | Spatial variance (K^2) | Correlation length (Km)

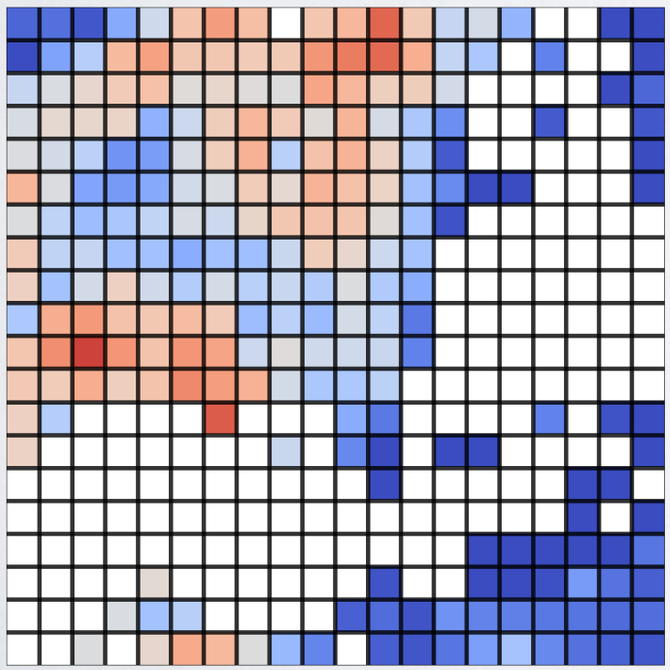
Simulated



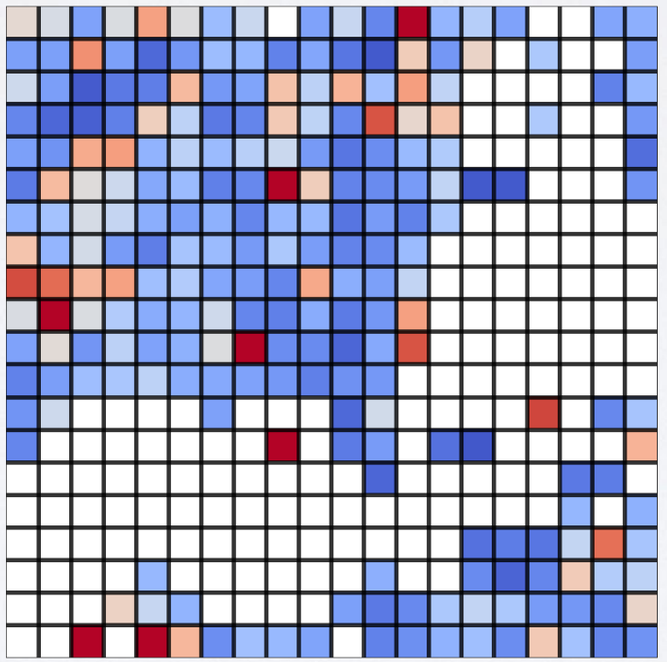




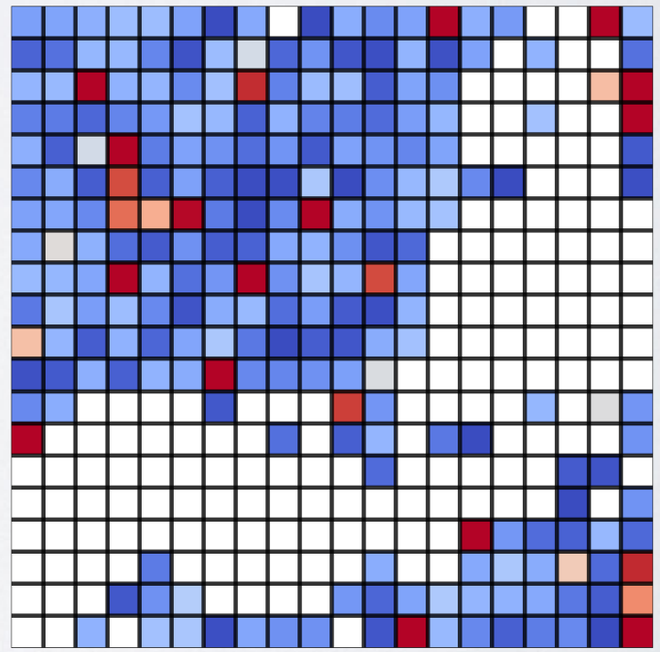
Observed



310 315



2 4

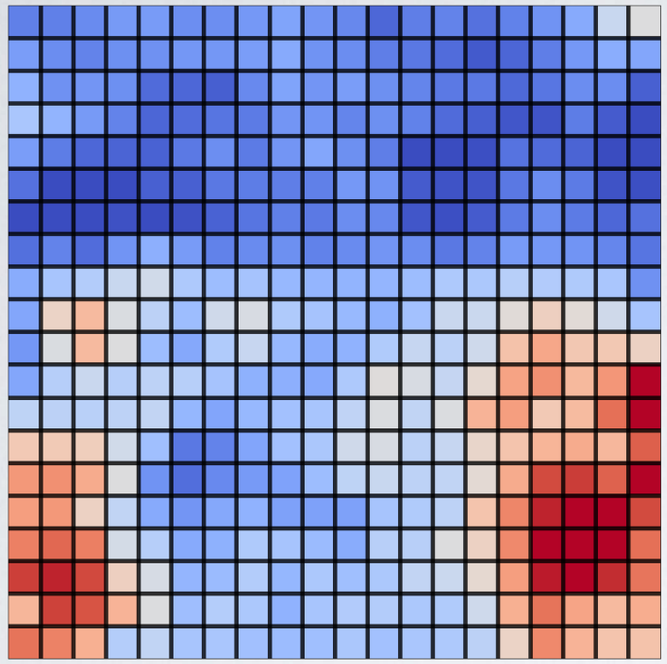


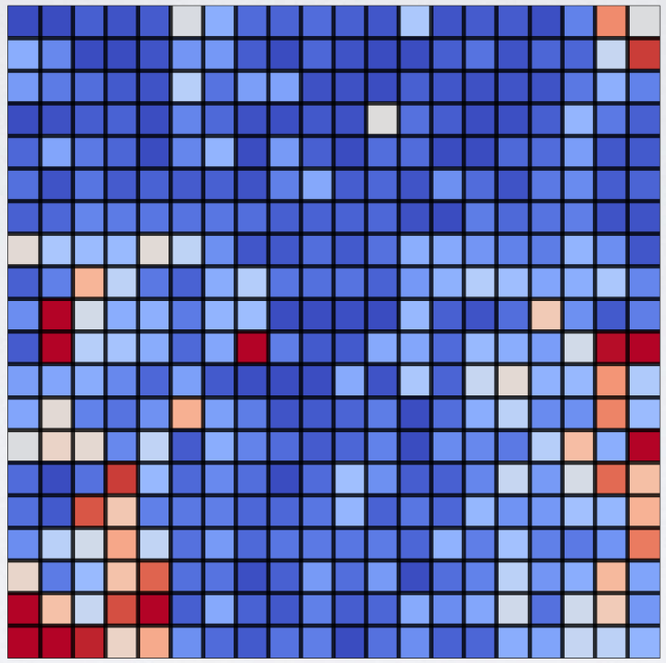
10 15 20

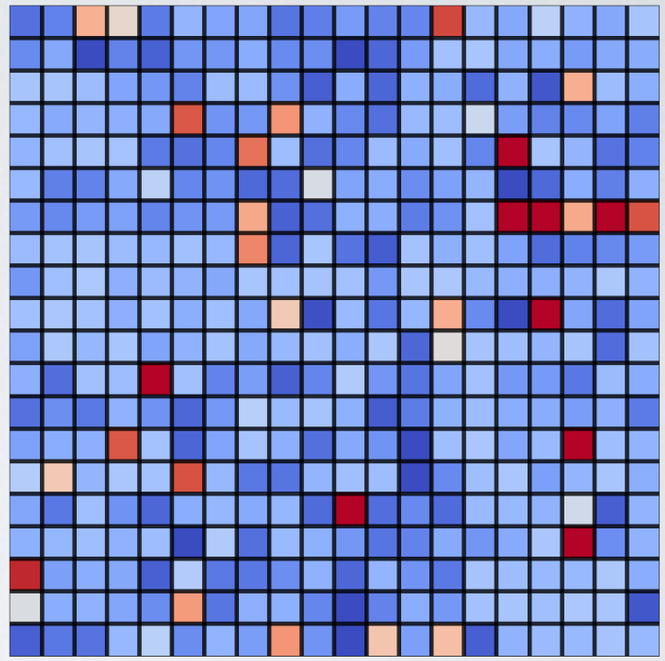
September 14th, 2018 20:00 UTC

Spatial mean (K) | Spatial variance (K^2) | Correlation length (Km)

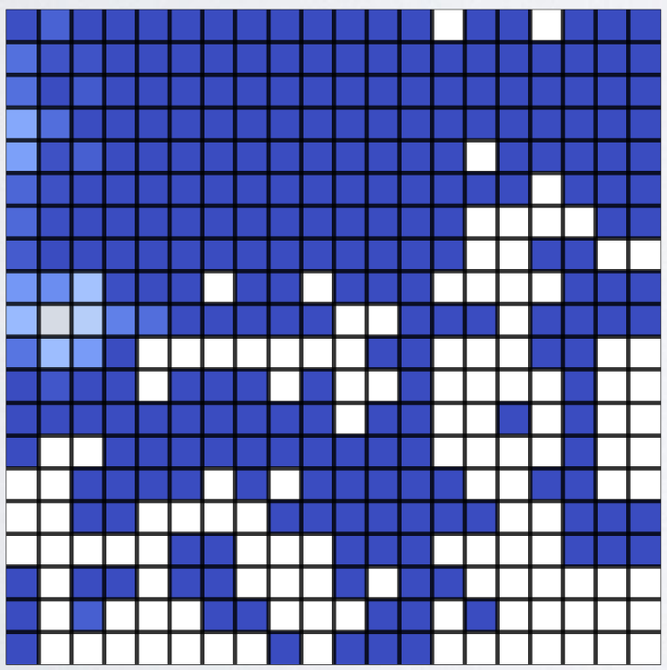
Simulated

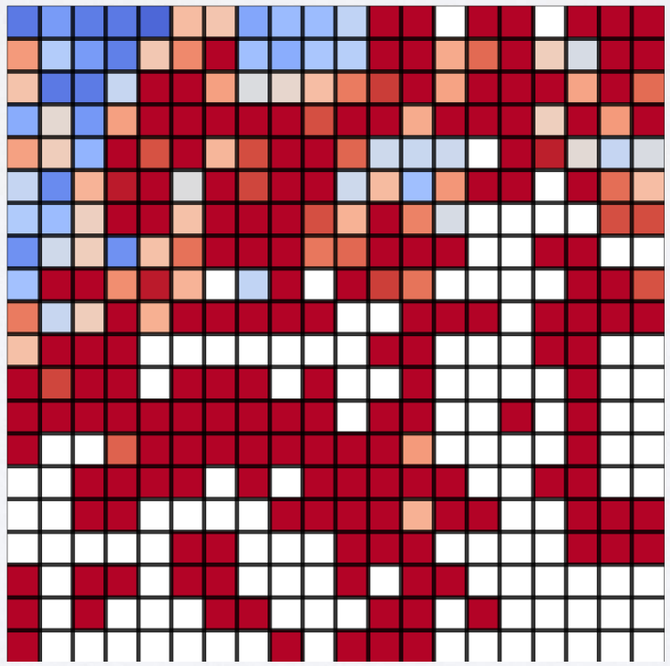


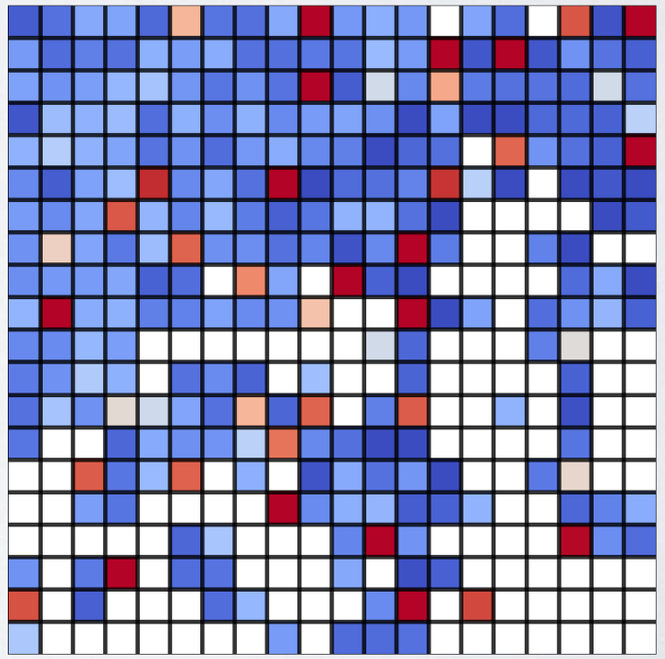




Observed







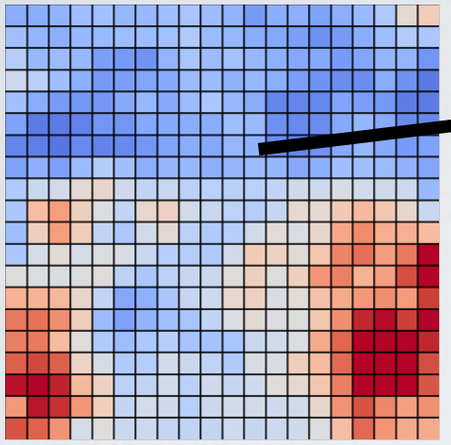
307.5 310.0 312.5 315.0

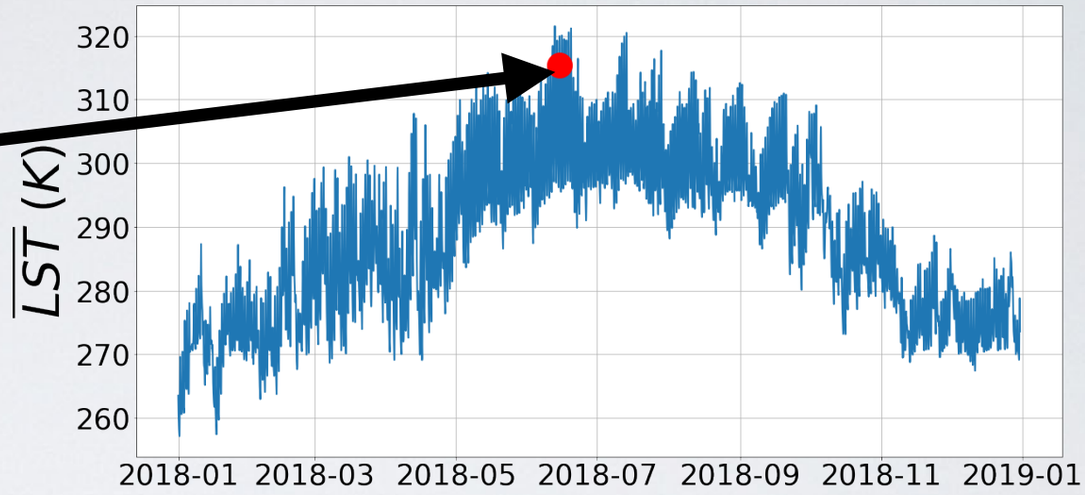
0.5 1.0

10 20

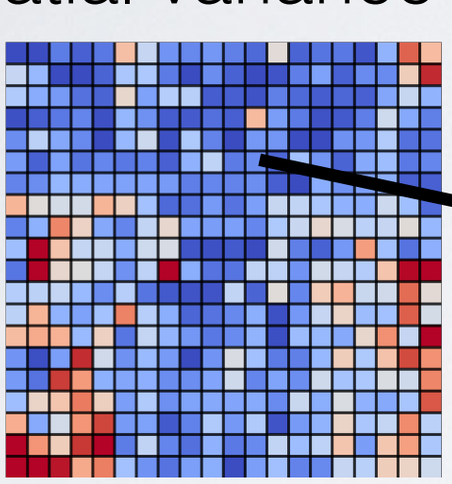
Temporal series of spatial statistics

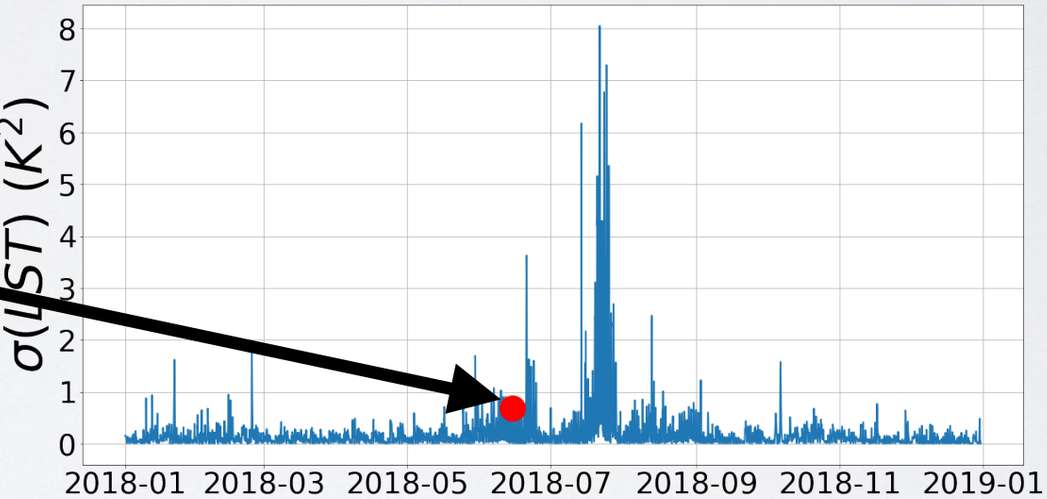
Spatial mean (K)



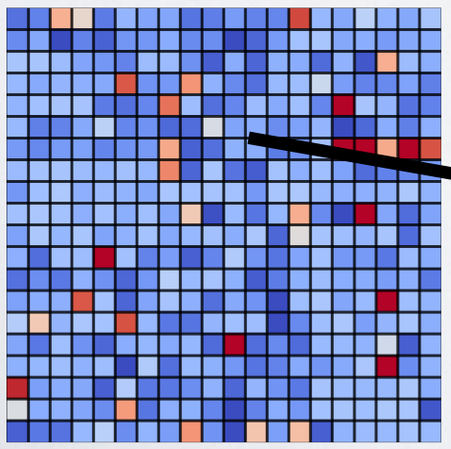


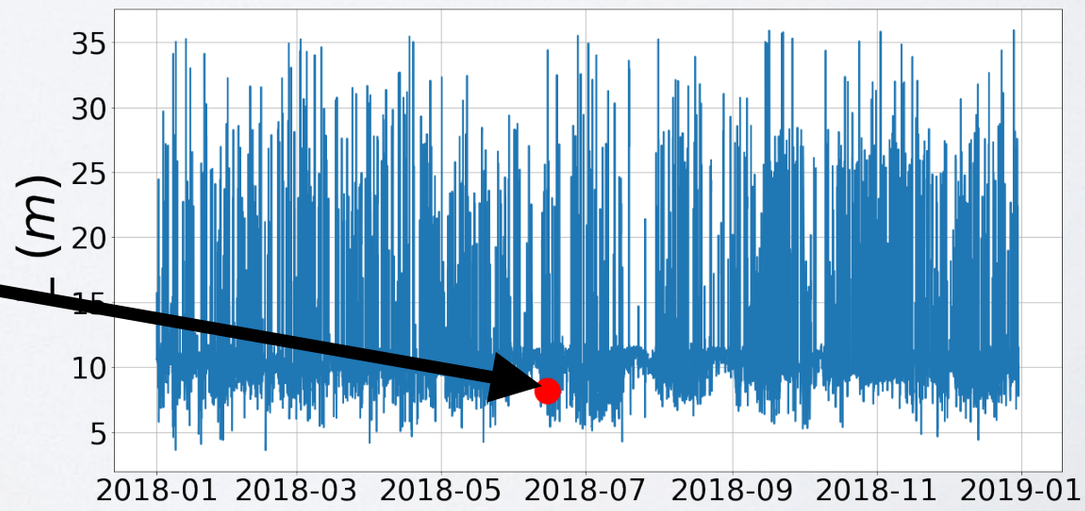
Spatial variance (K^2)





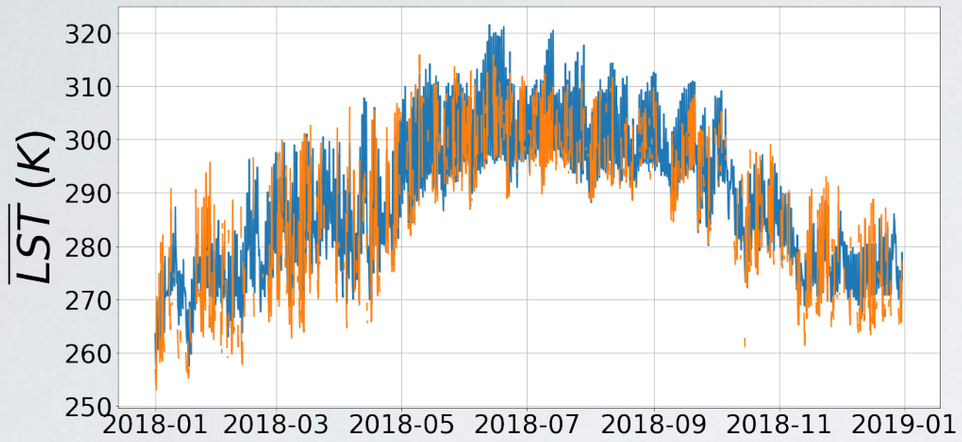
Correlation length (Km)

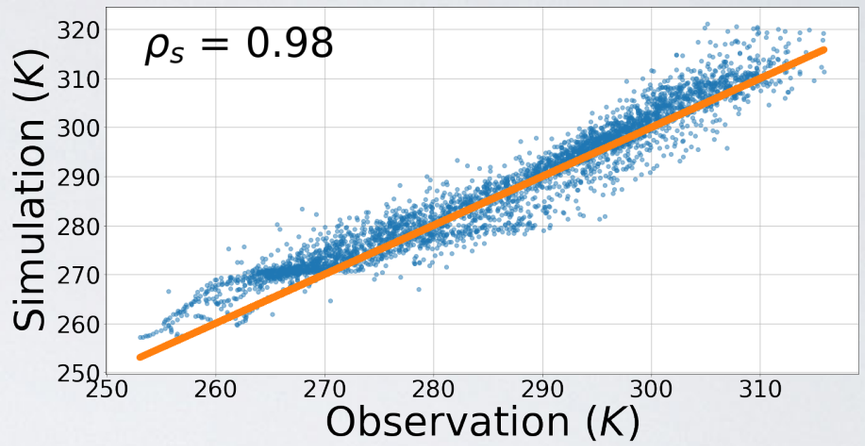




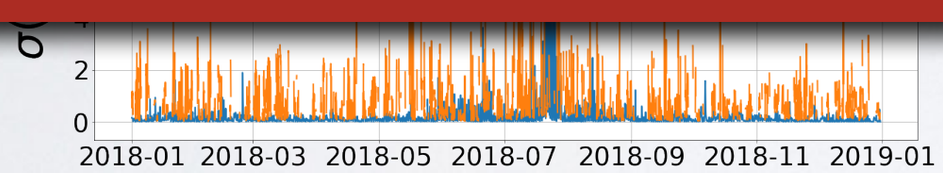
Example pixel: Simulated vs. Observations

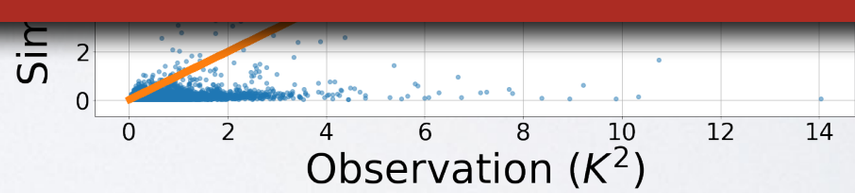
Spatial mean



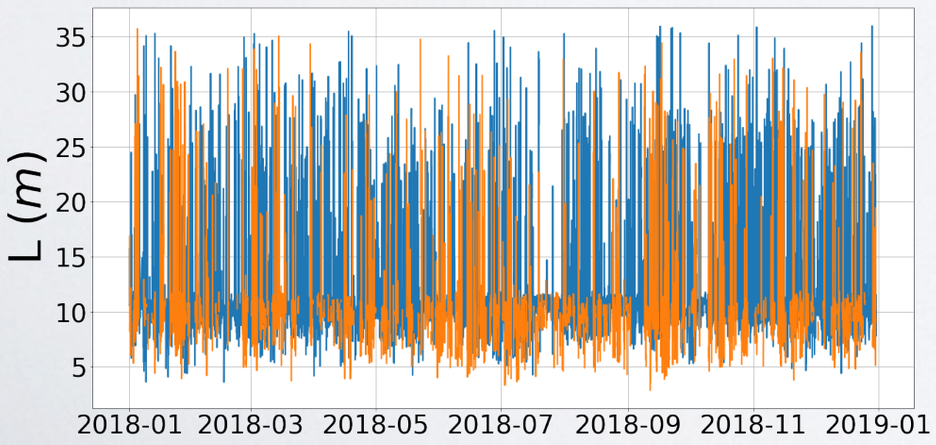


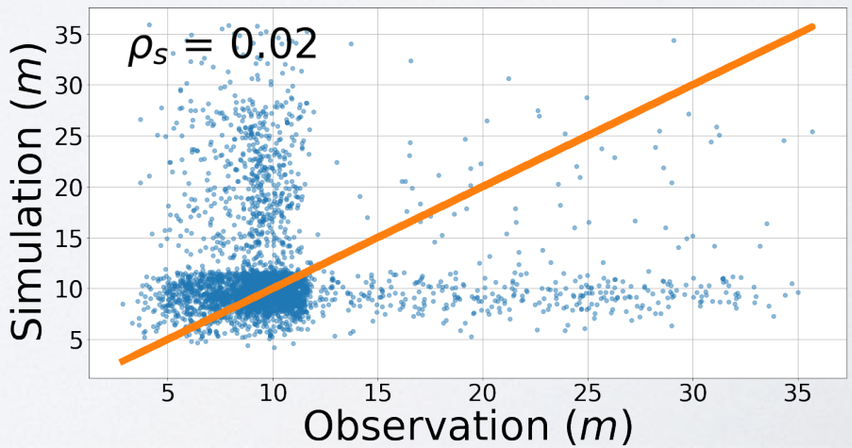
Let's compute the spearman correlations for each ~25 km pixel





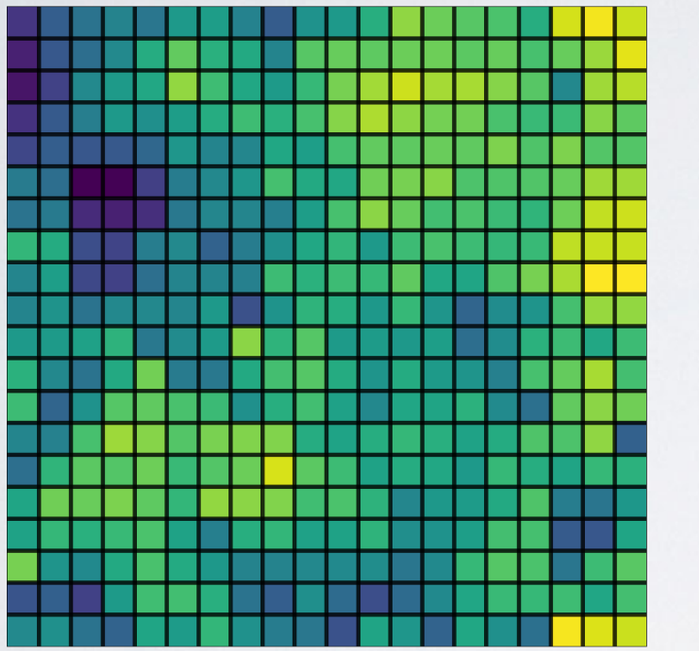
Correlation length





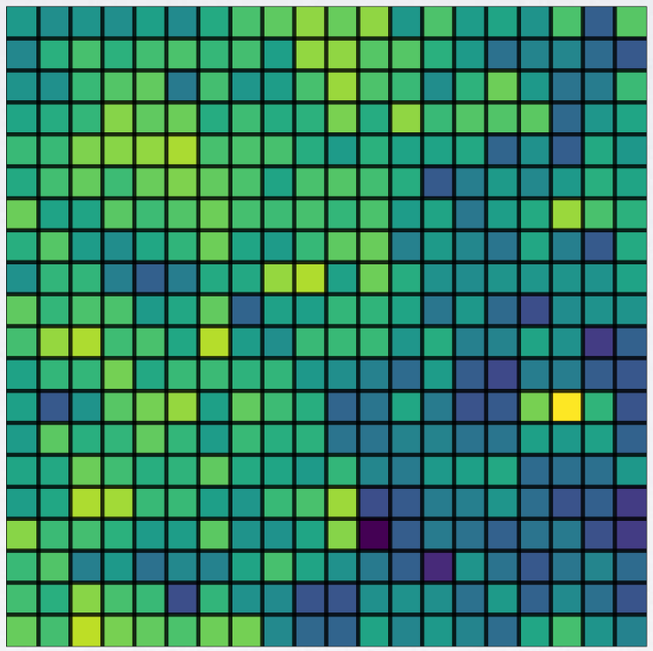
Spearman correlation of spatial statistics time series

Spatial mean



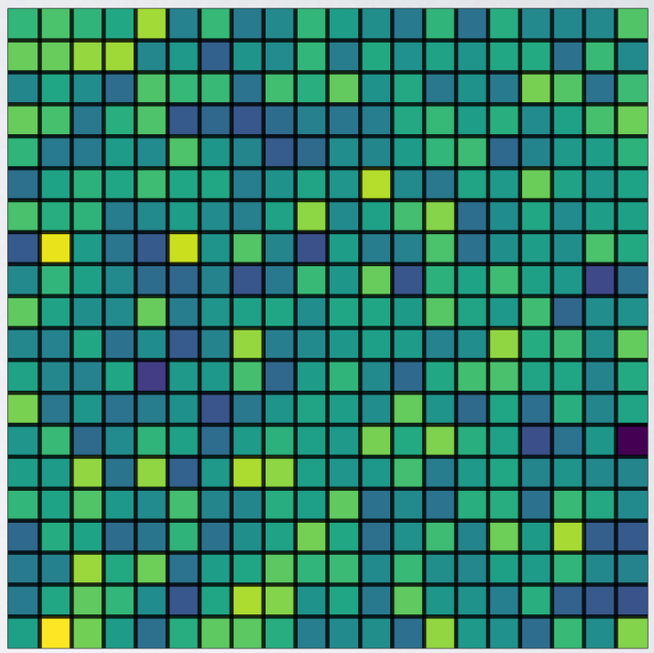
0.970 0.975 0.980

Spatial variance



0.0 0.2 0.4

Correlation length



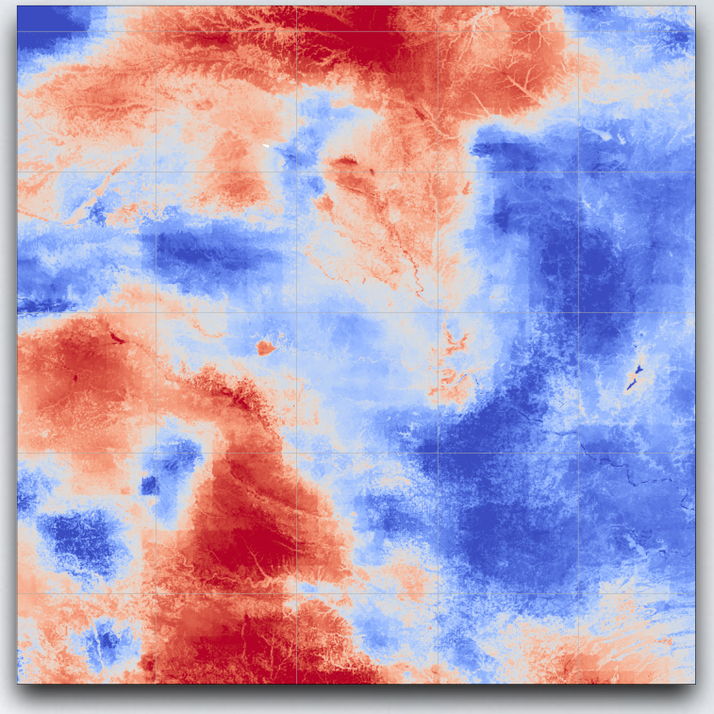
−0.1 0.0 0.1

😀 🤷 😢

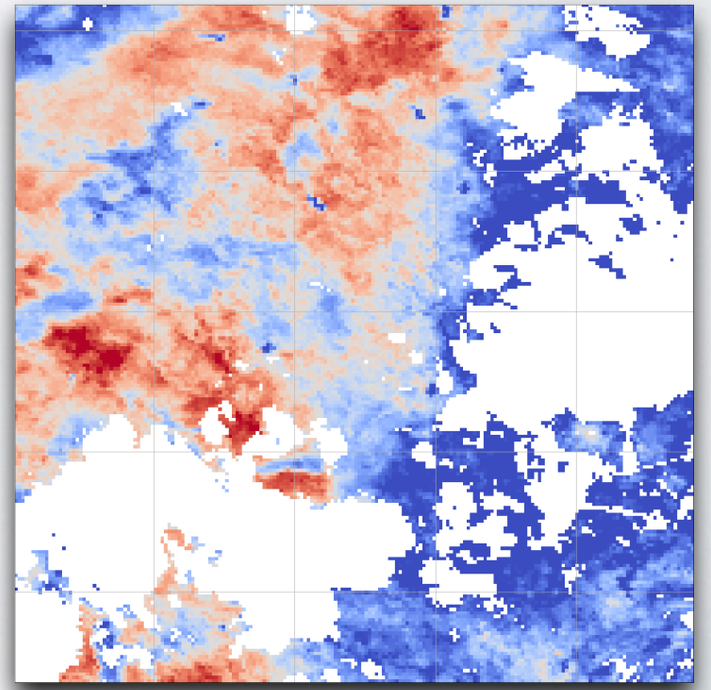
Summary and Future Directions

- The modeled multi-scale LST spatial fields are generally quite poor even with ~fully distributed 30 meter simulations (*"hyper-resolution"*).
- Plans to expand analysis to entire Contiguous United States (CONUS).
- Use Landsat 8/9 and Ecostress to start to evaluate the finer spatial scales.
- Need to be careful how we take remotely sensed LST as "truth". However, is is generally still better than model simulations when compared to in-situ observations.
- It's time to be much more rigorous about the evaluation of the simulated high resolution spatial fields (e.g. LST).

Model



Vs.



Observation