Analysis of hydrological spatial and temporal characteristic scales over the Contiguous United States using GOES-16 Land Surface Temperature retrievals

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Abstract

Land surface features such as elevation, soils, land use, and vegetation fluctuate on scales ranging from millimeters to hundreds of kilometers. The state of the land surface and many hydrological processes vary accordingly. Land surface temperature (LST) is a crucial factor determining the interactions between the land surface and the atmosphere (i.e., energy, water, and carbon fluxes). Decades of global satellite remote sensed LST fields are now available, constituting an unprecedented opportunity to understand better the factors influencing hydrological variability from regional to global scales. An important under-researched aspect regarding variability, at least over continental extents, is determining the scales for which hydrological variations are spatially and temporally related. These scales would serve as indicators for the required time and spatial resolution for observational systems. This presentation will address this gap in understanding across scales through a comprehensive analysis of spatial and temporal correlation lengths of LST across the contiguous United States (CONUS). Correlation lengths (CLs) are measures of the stationarity of a property distribution both in space and time. They reveal the scales of variability for fields thus, contributing to estimating the stationarity of the property. Temporal correlation lengths (tCLs) express the property changes in time for a fixed location, providing a measure of the persistence or variability of the time series. On the other hand, spatial correlation lengths (sCLs) depict the spatial patterns of the property over a predefined area by representing the distance for which variations are spatially related. As part of our evaluation, we will analyze derived fields of tCLs and sCLs for the ~2x2 km^2 GOES-16 LST hourly product over CONUS. A 0.25-degree regular grid over CONUS will be defined, and an hourly time step between 2017 and 2021 will be used for the analysis. The obtained CLs will be assessed in terms of the time of the day and season. Additionally, we propose a comparison of well-known spatiotemporal influencing factors of LST such as land cover, surface thermal properties, topography, incoming solar radiation, and meteorological conditions.

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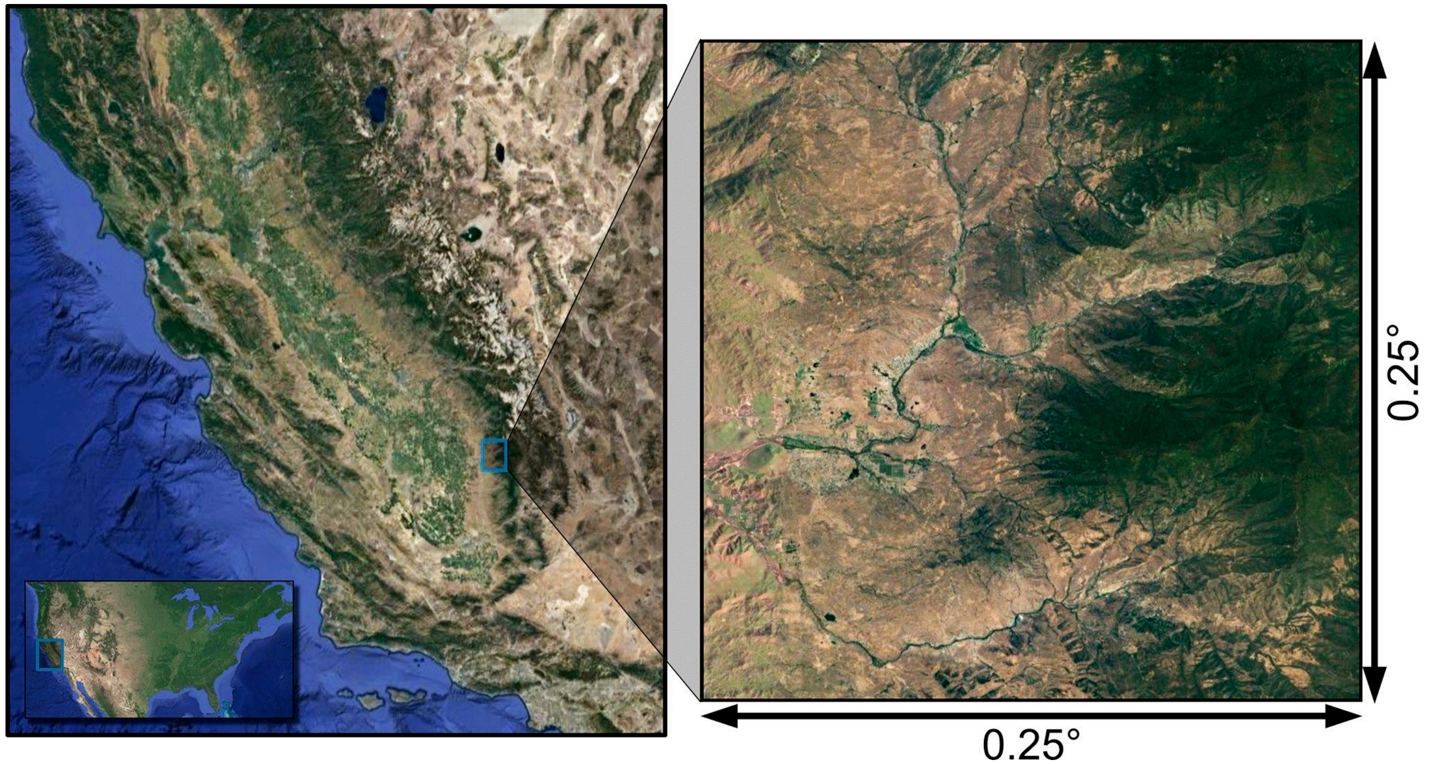
Motivation

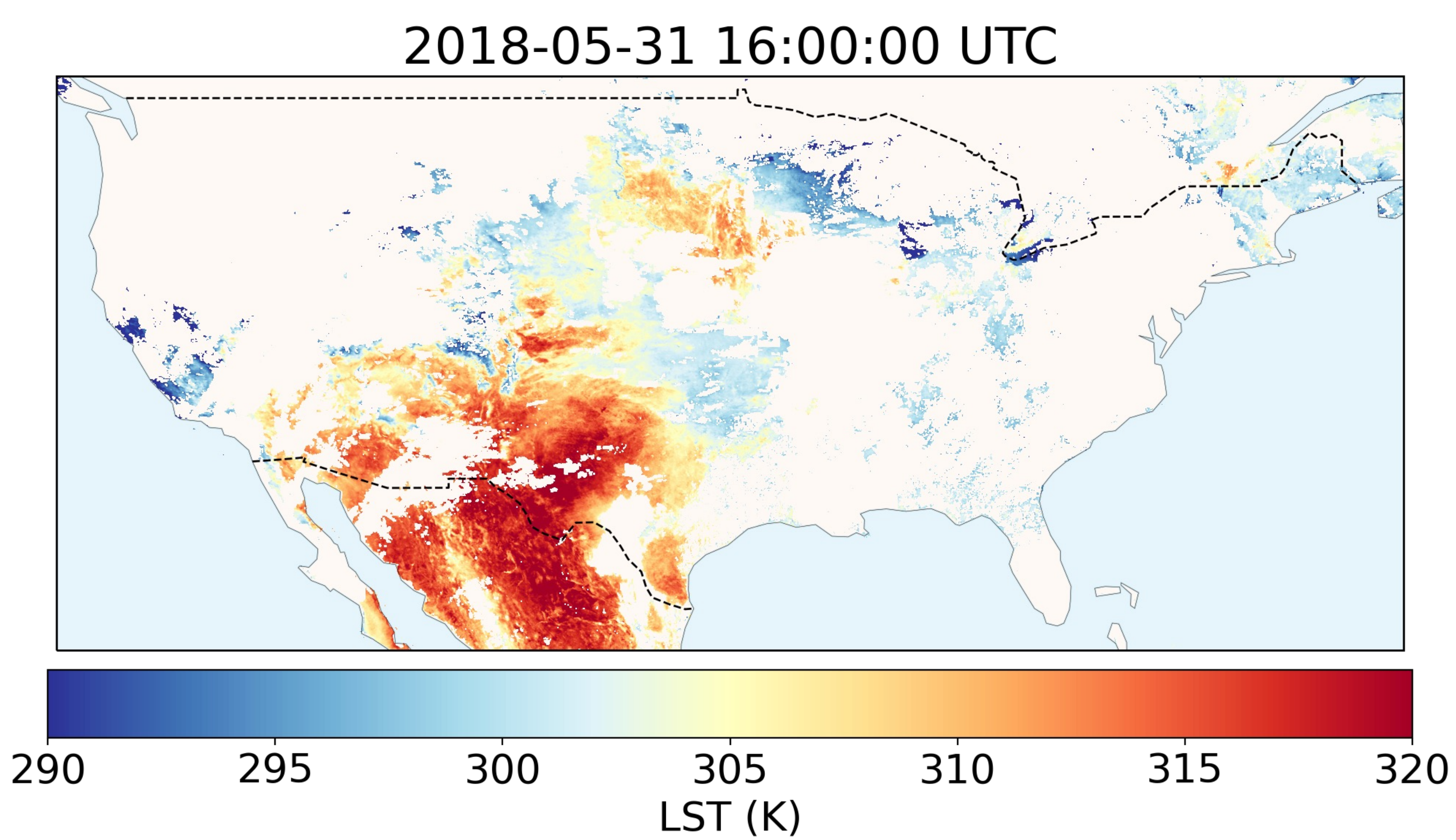
- Land models (LM) aim to model the multi-scale spatial heterogeneity of water and energy cycles: Land-atmospheric coupling.
- Need to evaluate how well models capture heterogeneity using satellite remote sensing.
- Land surface temperature (LST) is a good candidate.



Chaney, 2018

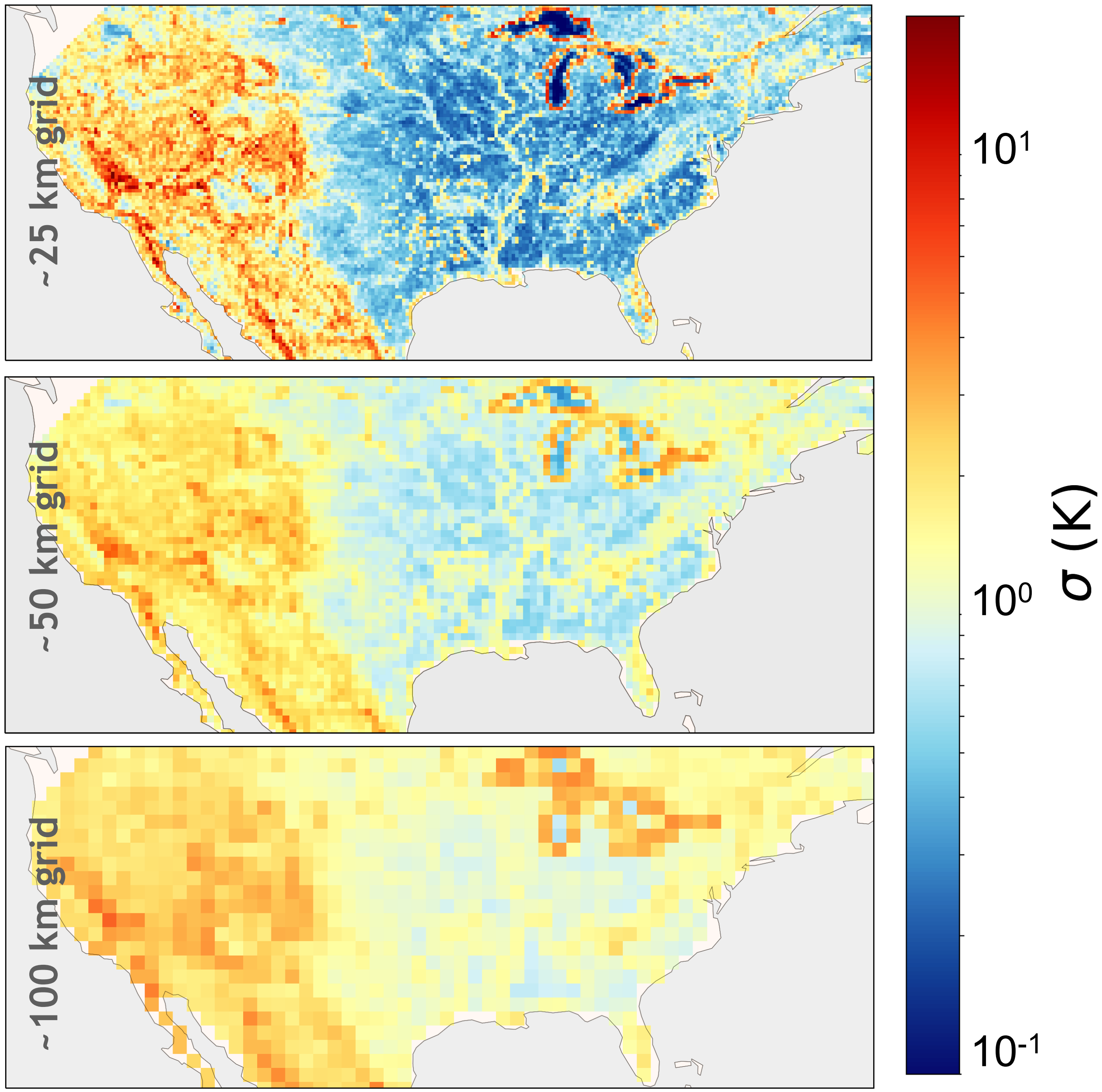
GOES-R

- NOAA's Geostationary Operational Environmental Satellites.
- Spatial coverage: Full disk (FD) and CONUS
- Time coverage: 2017-05 - present
- Resolution:
  - Time: 1 hr
  - Space: ~5km (FD), ~2km (CONUS)

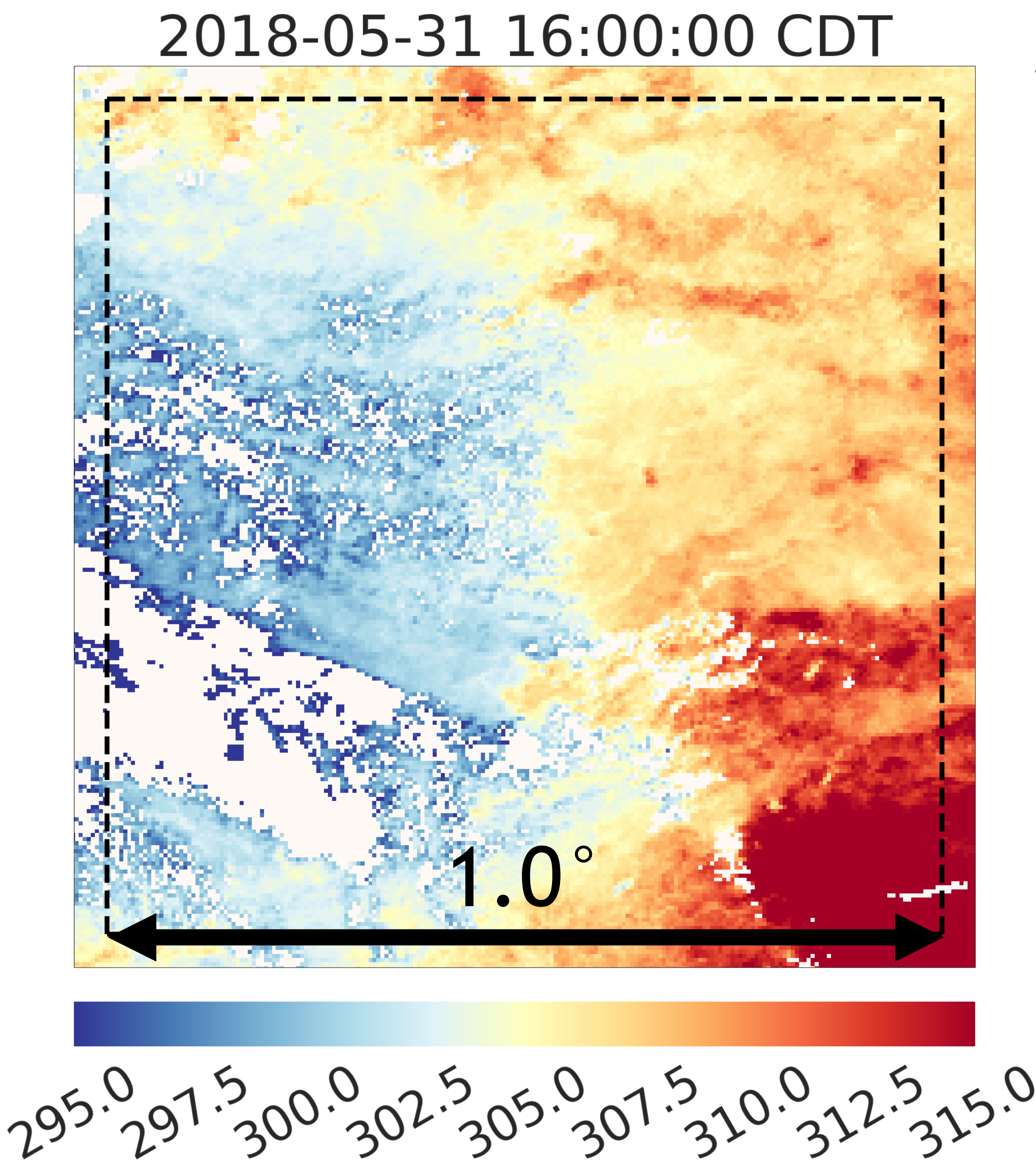


How to make the most of the data?

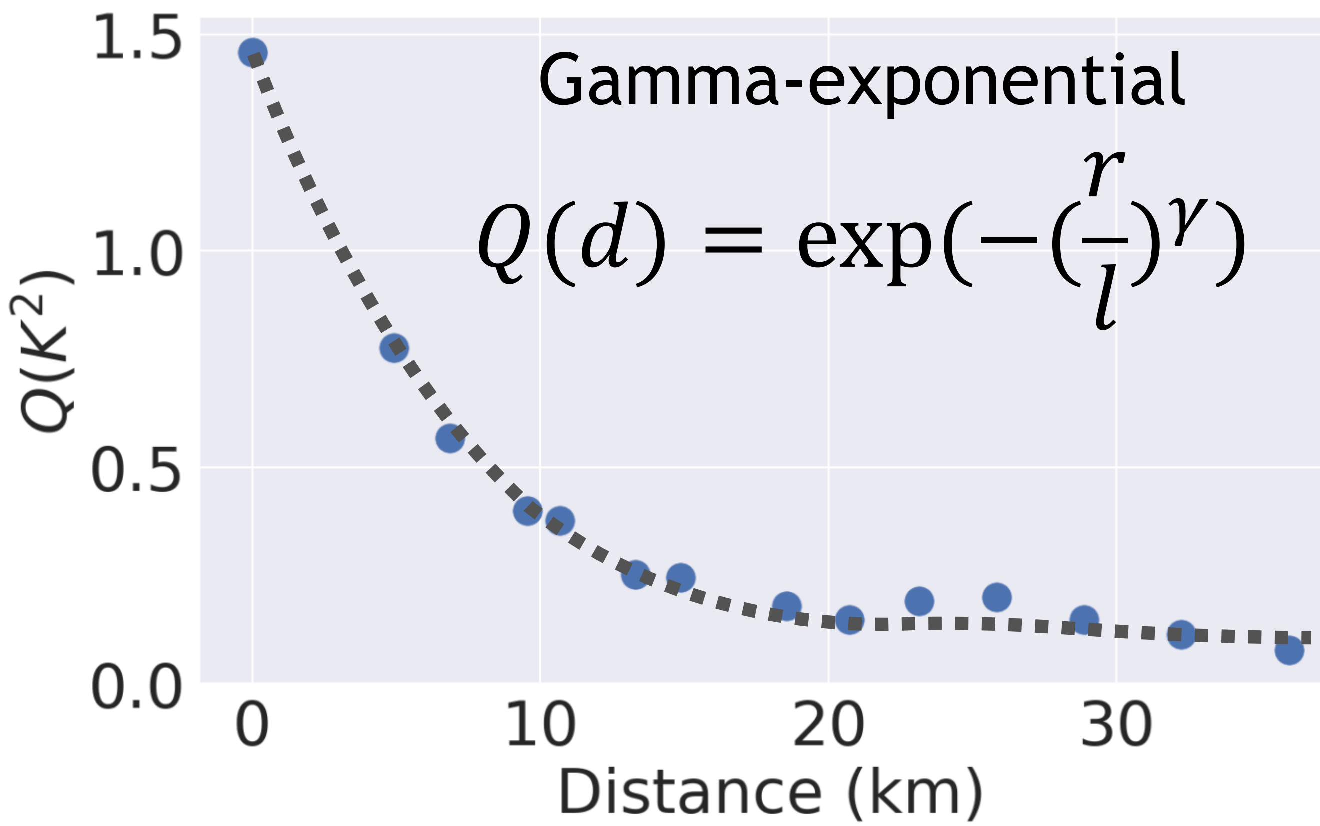
Summary statistics maps



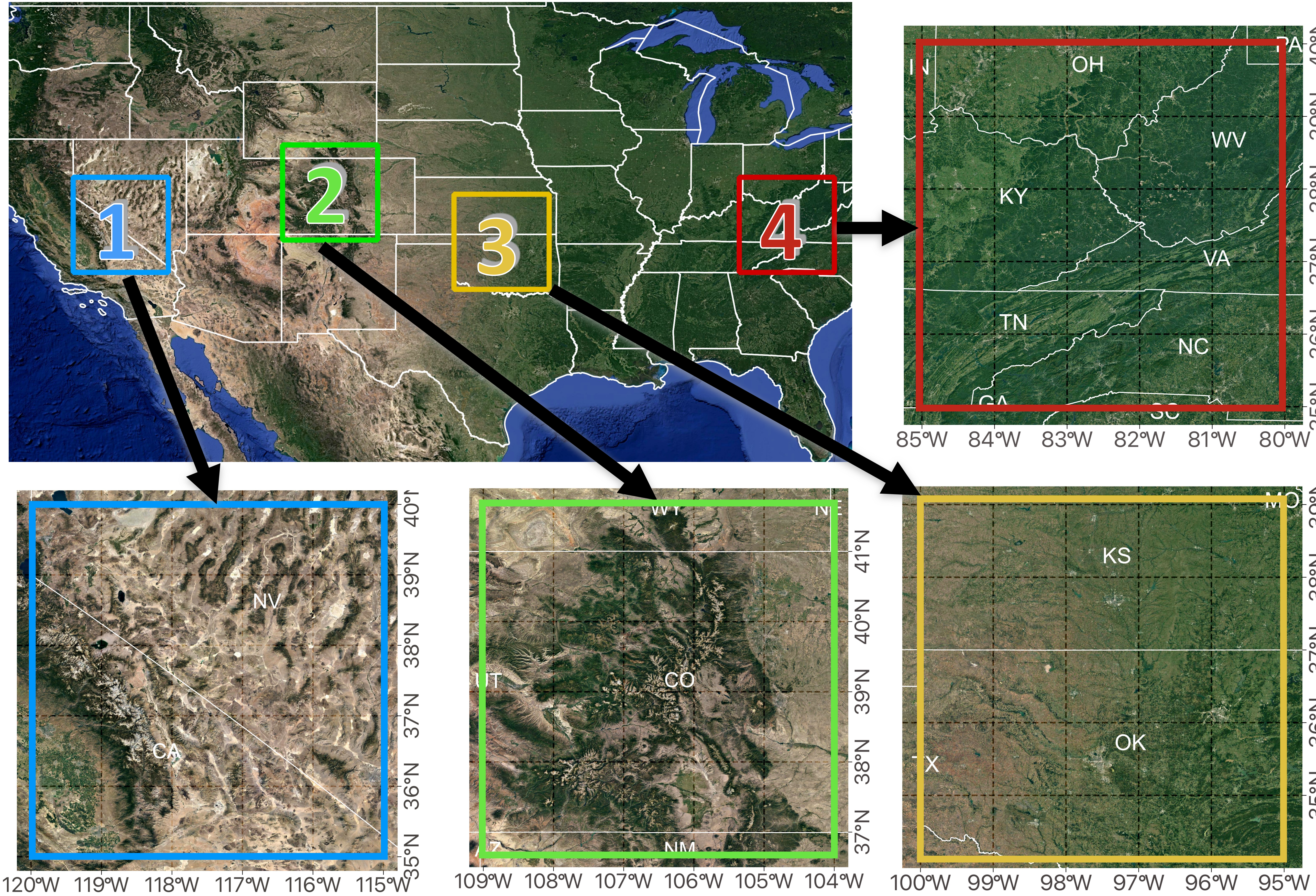
What statistics?



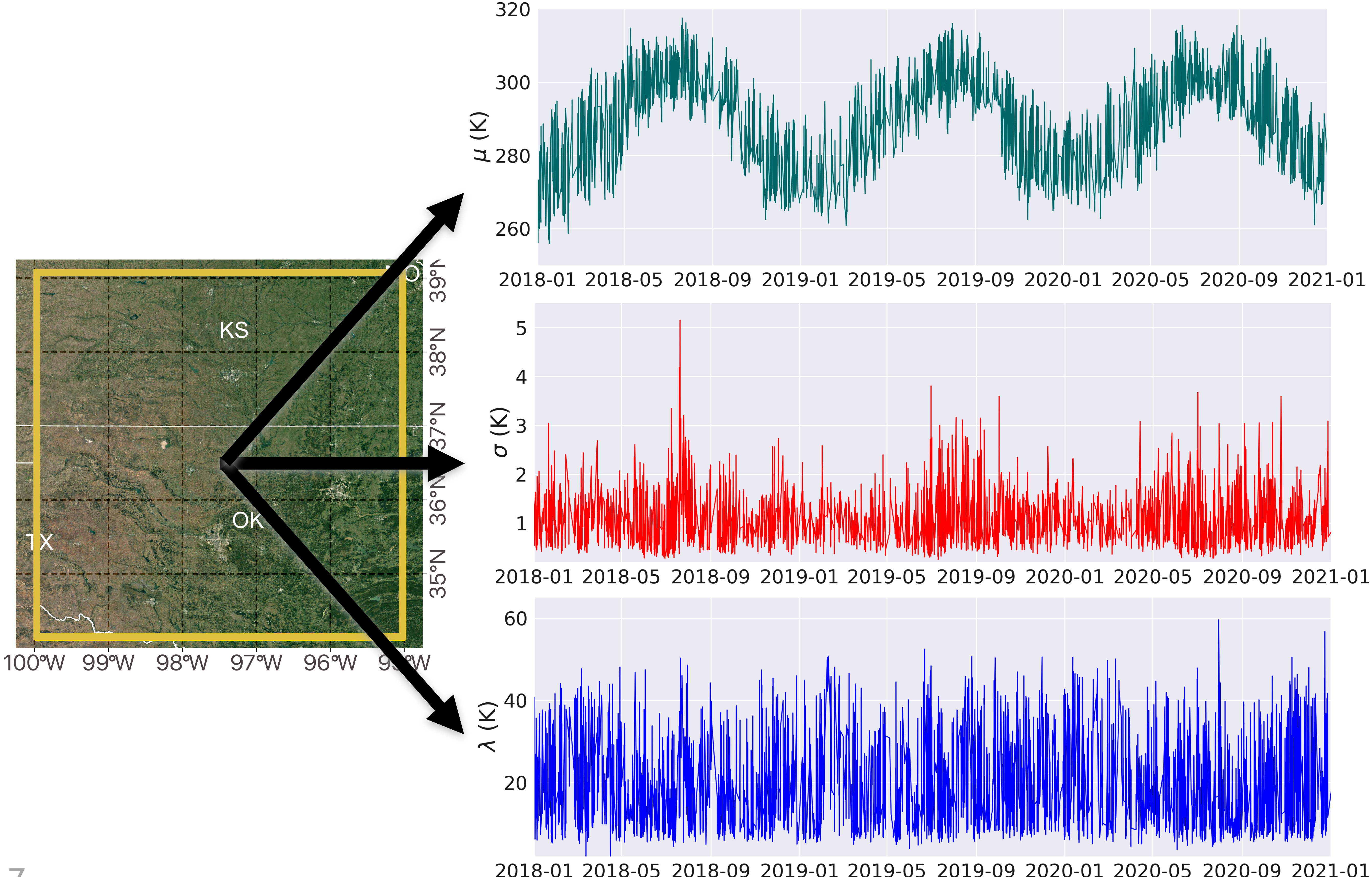
A. Spatial mean.
B. Spatial standard deviation (~range/difference of LST among patches).
C. Spatial correlation length (~size of LST patches).



Study areas: 500km domains

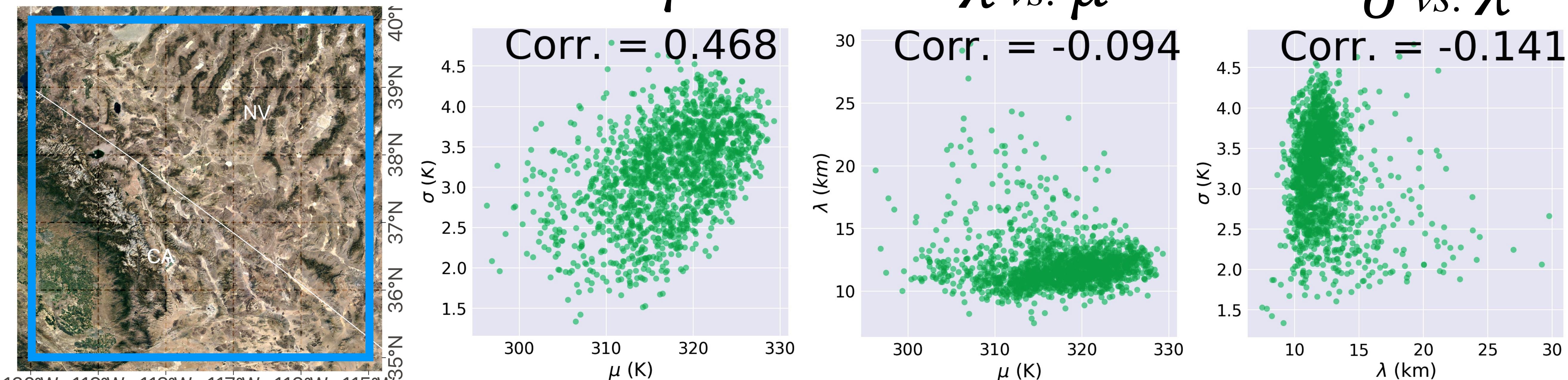


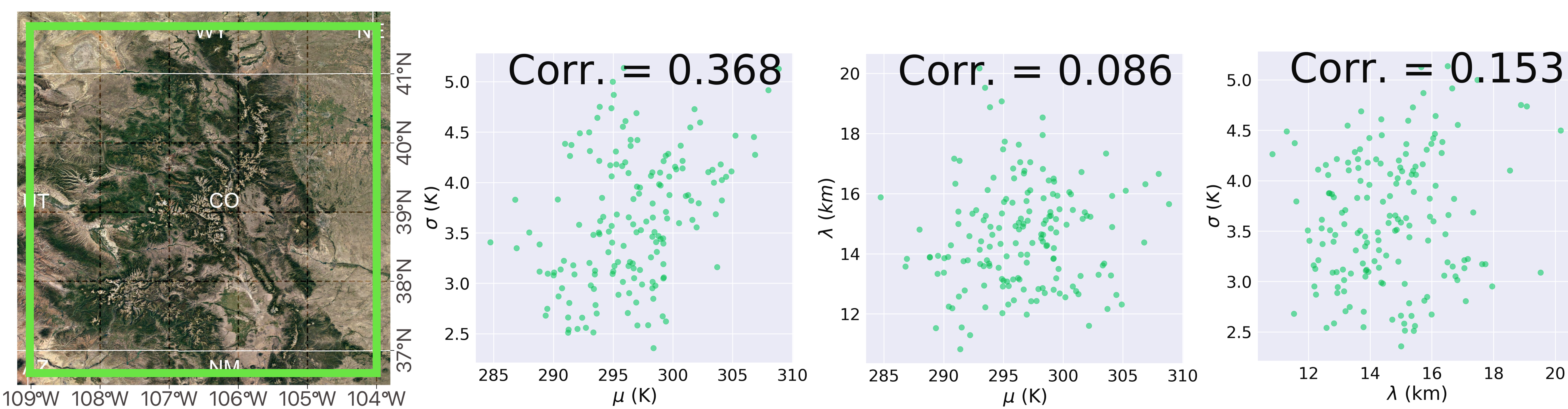
Time series of stats



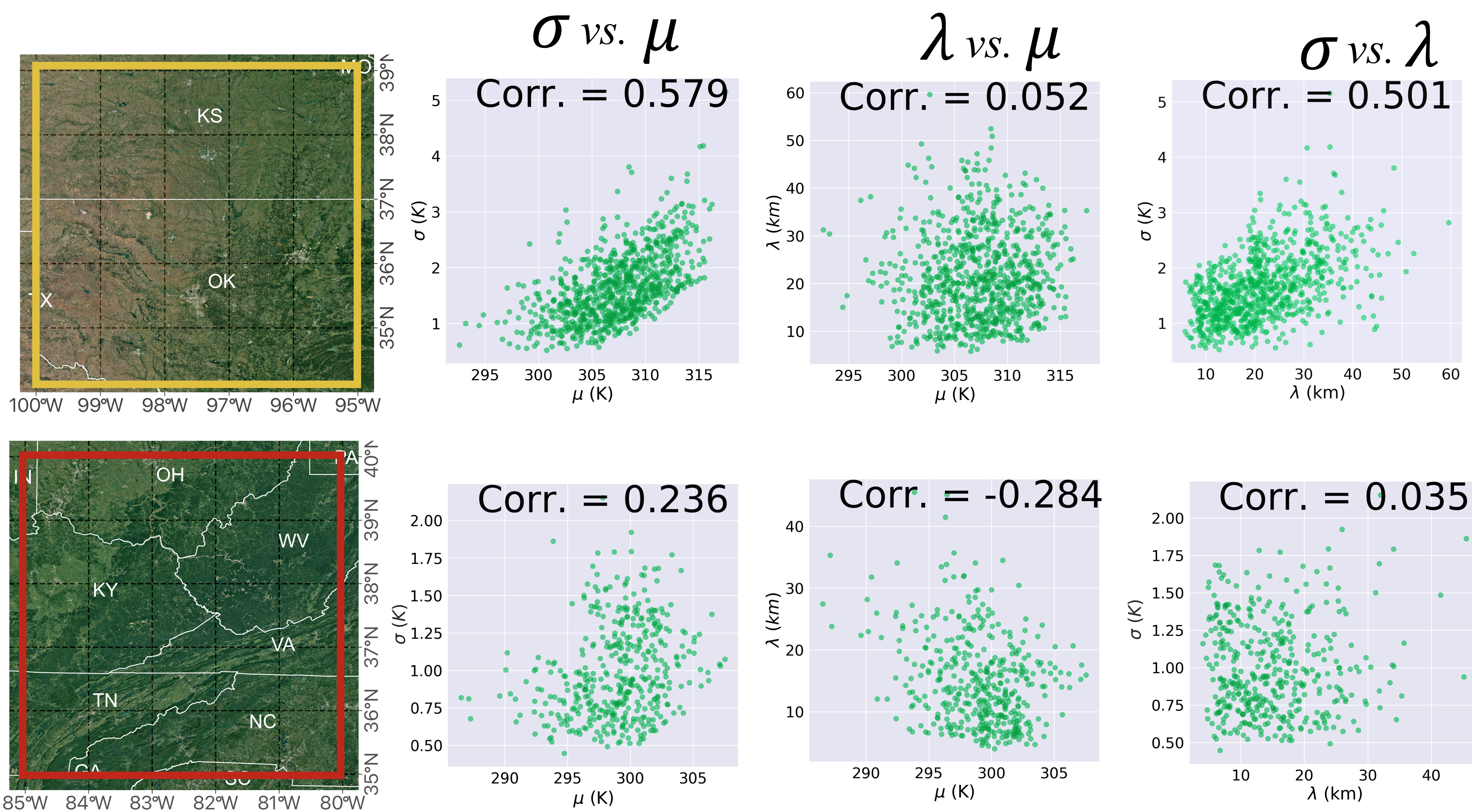
Correlation between stats

σ vs. μ | λ vs. μ | σ vs. λ



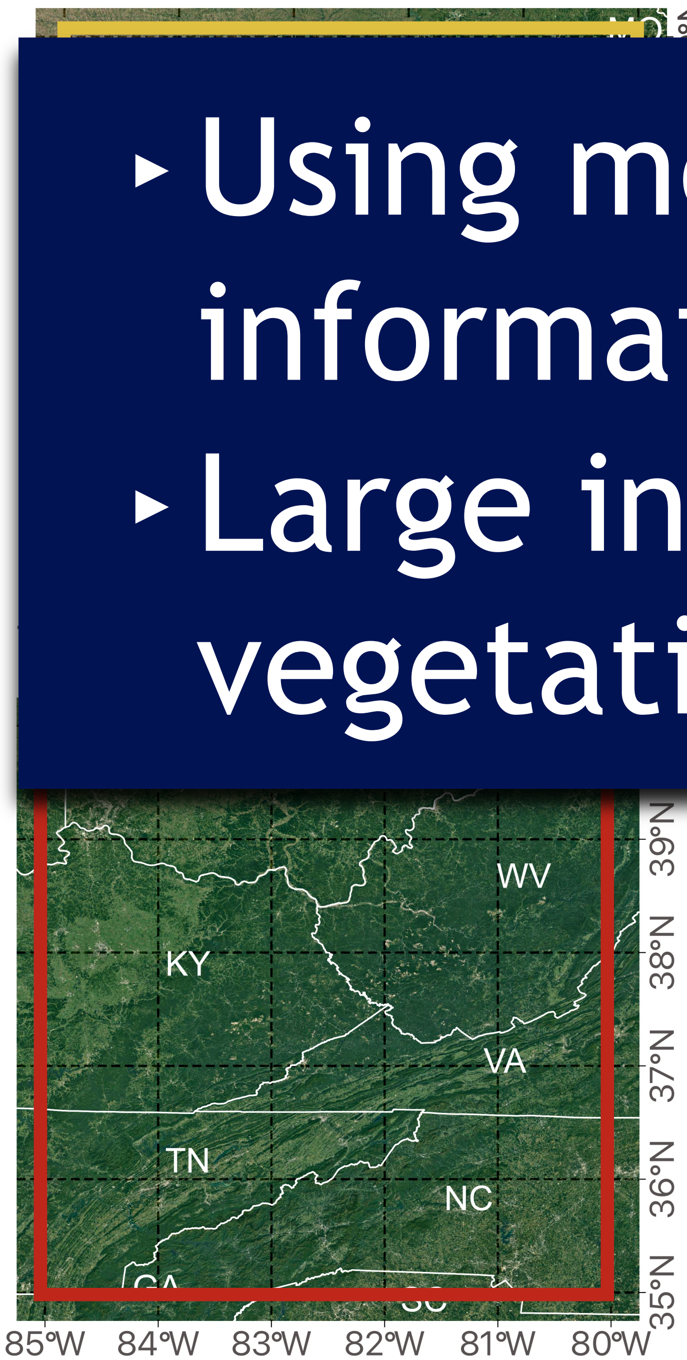


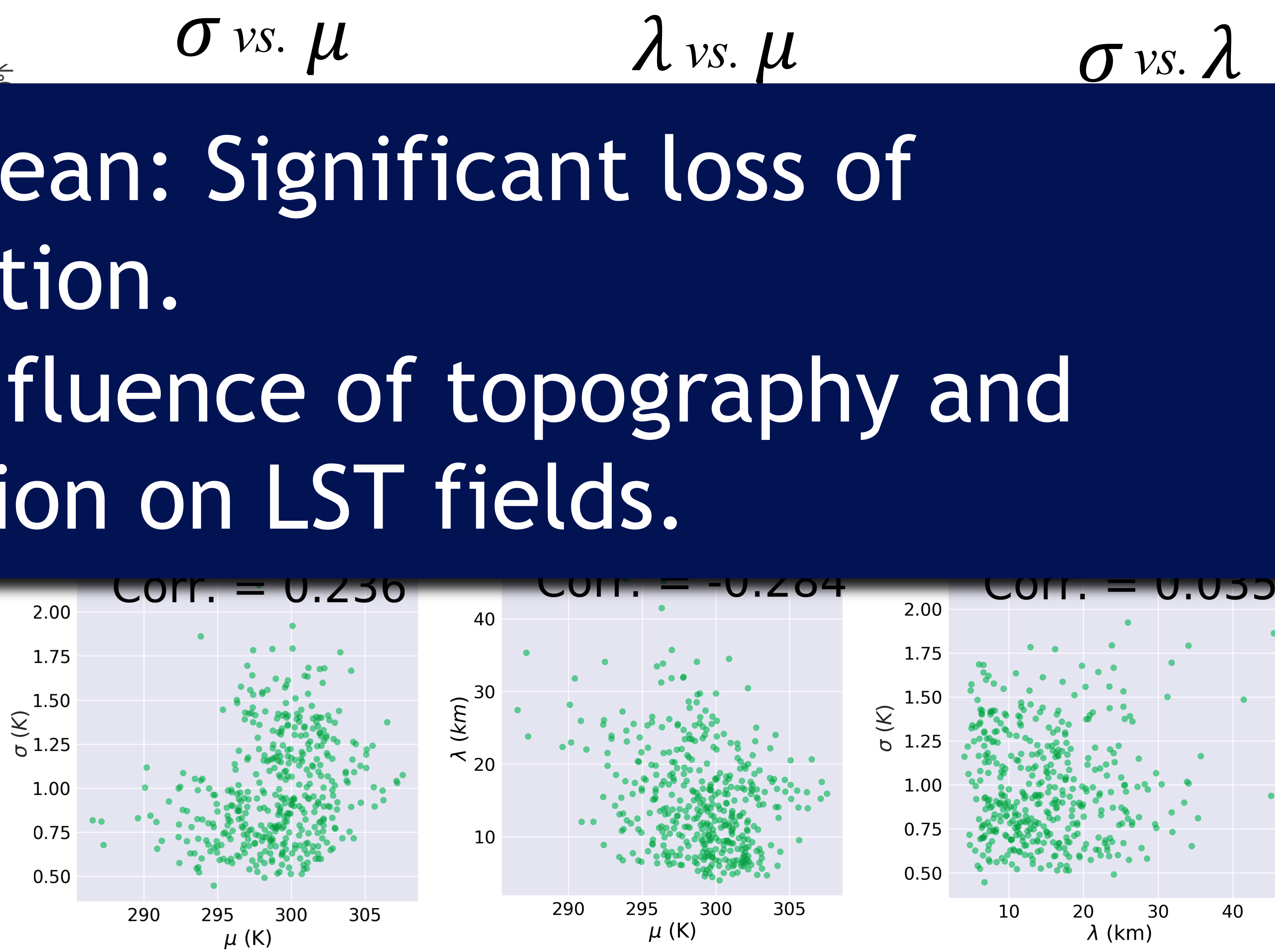
Correlation between stats



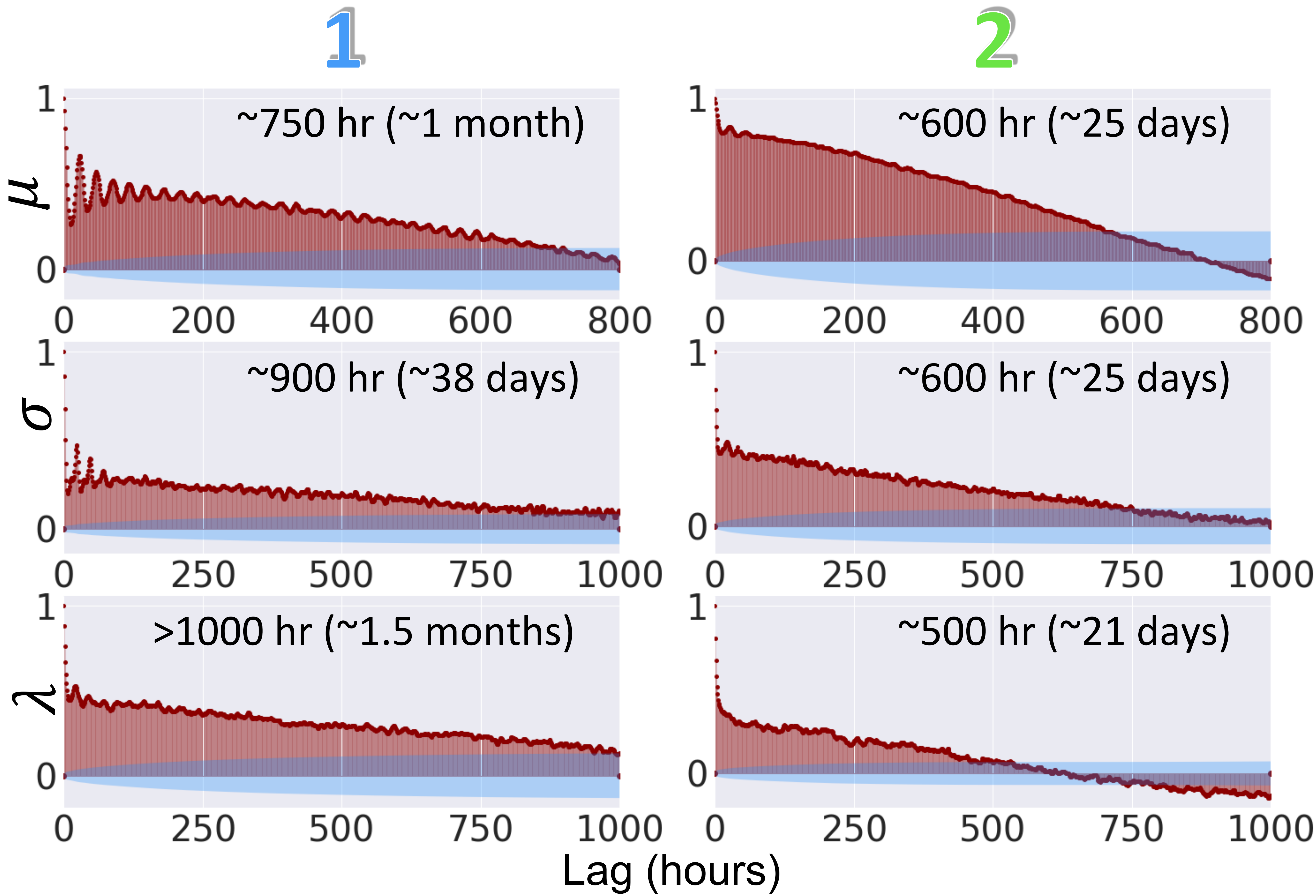
Correlation between stats

- Using mean: Significant loss of information.
- Large influence of topography and vegetation on LST fields.





Autocorrelation: Persistence



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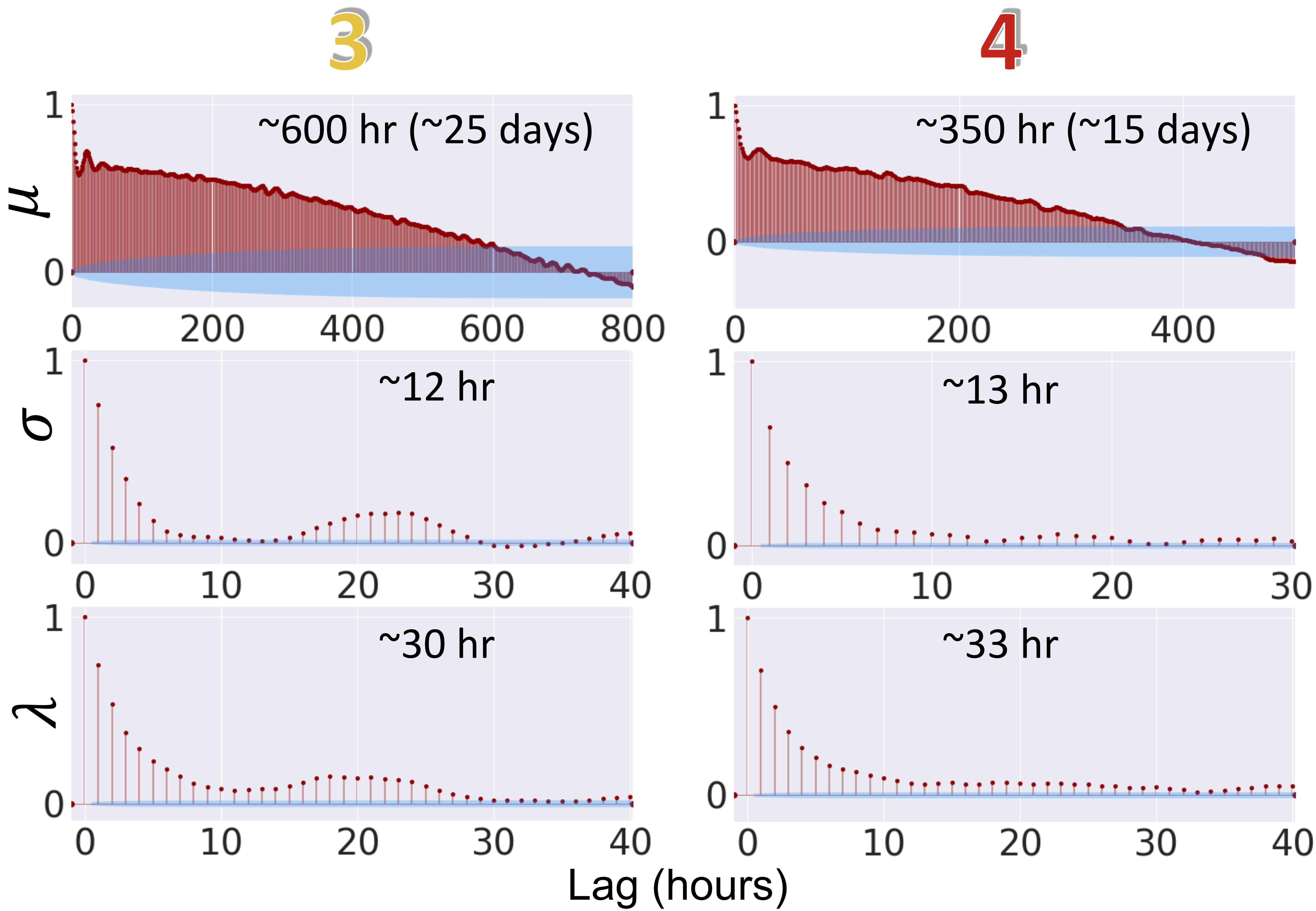
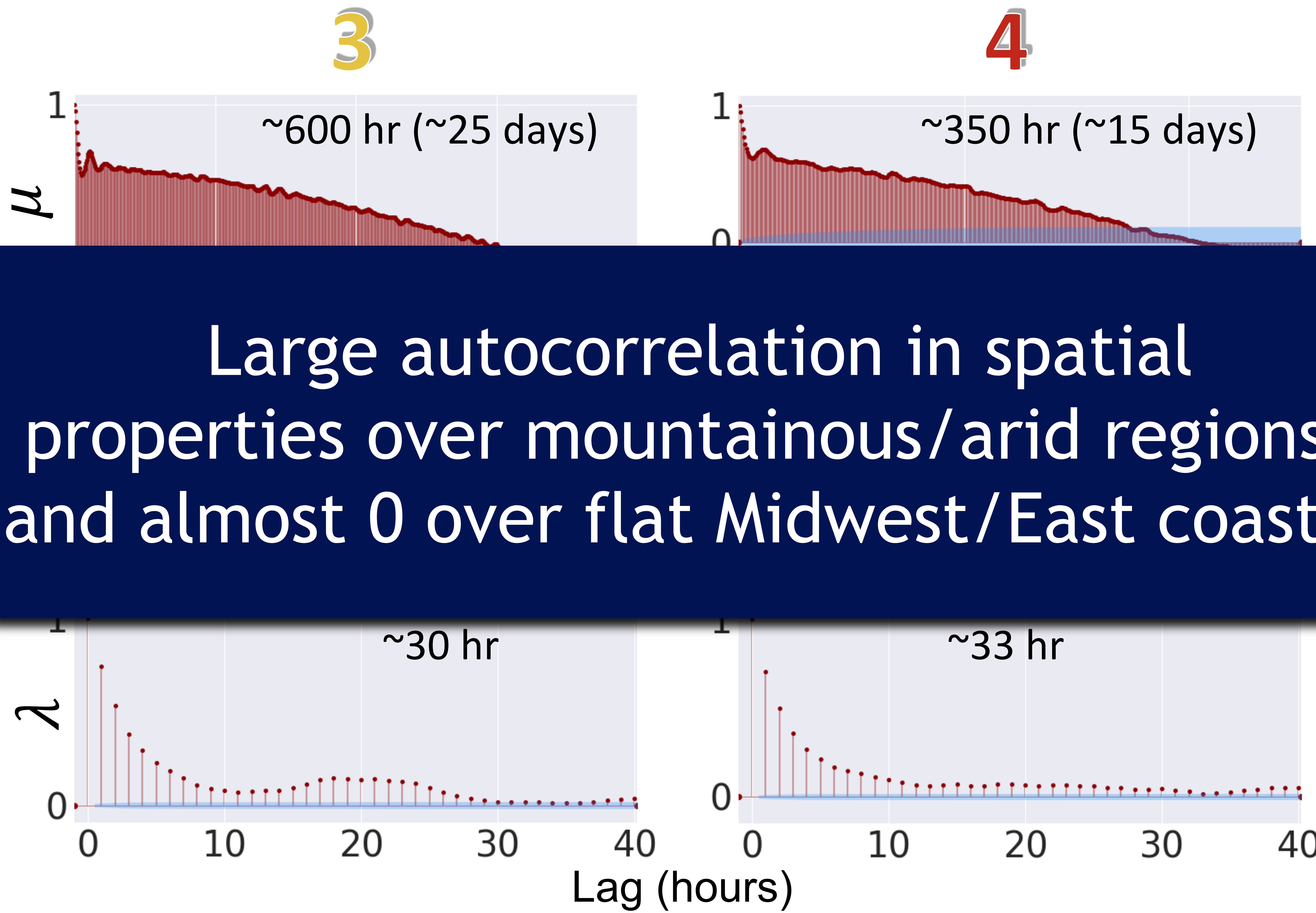


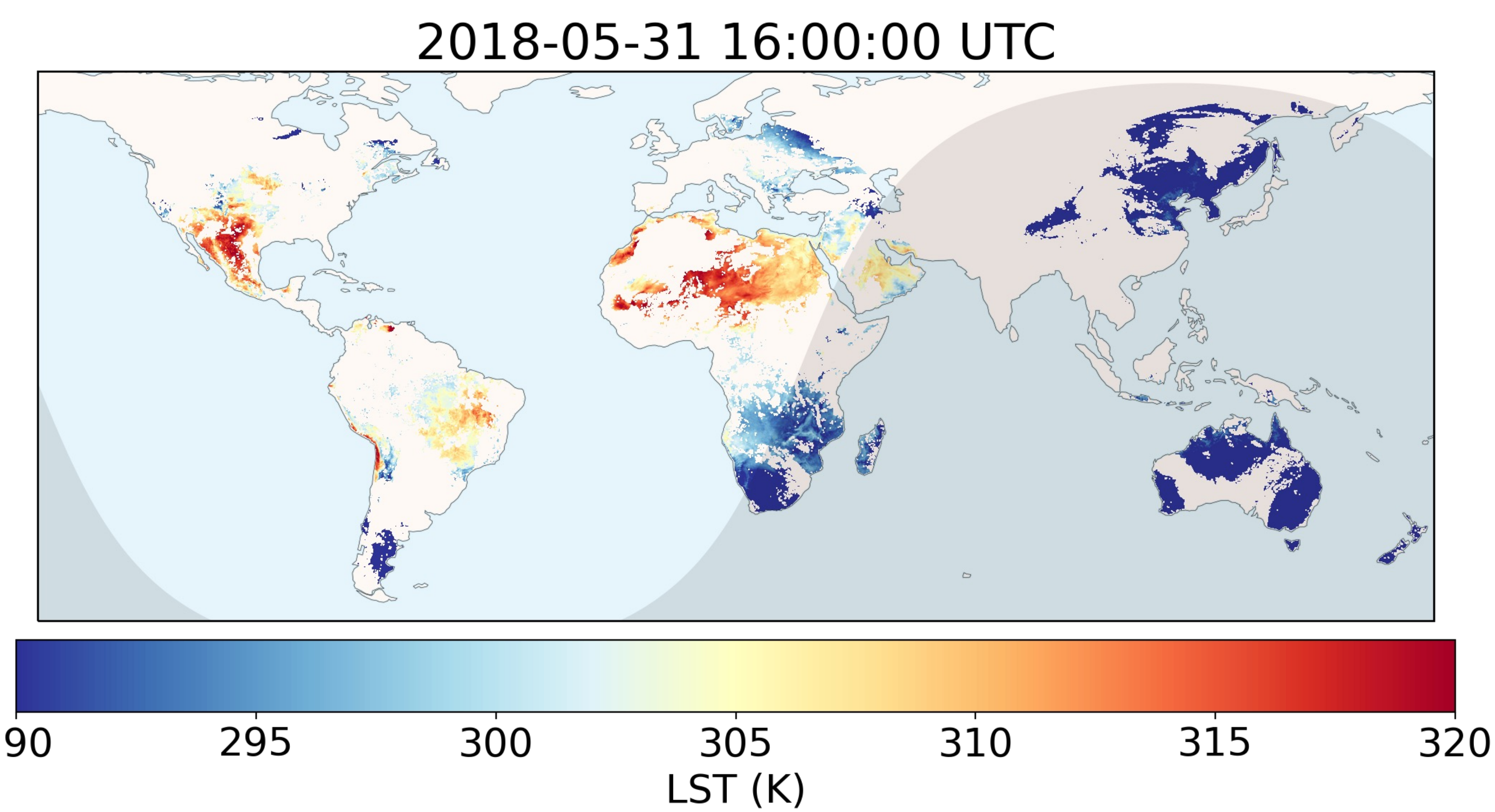
Autocorrelation: Persistence

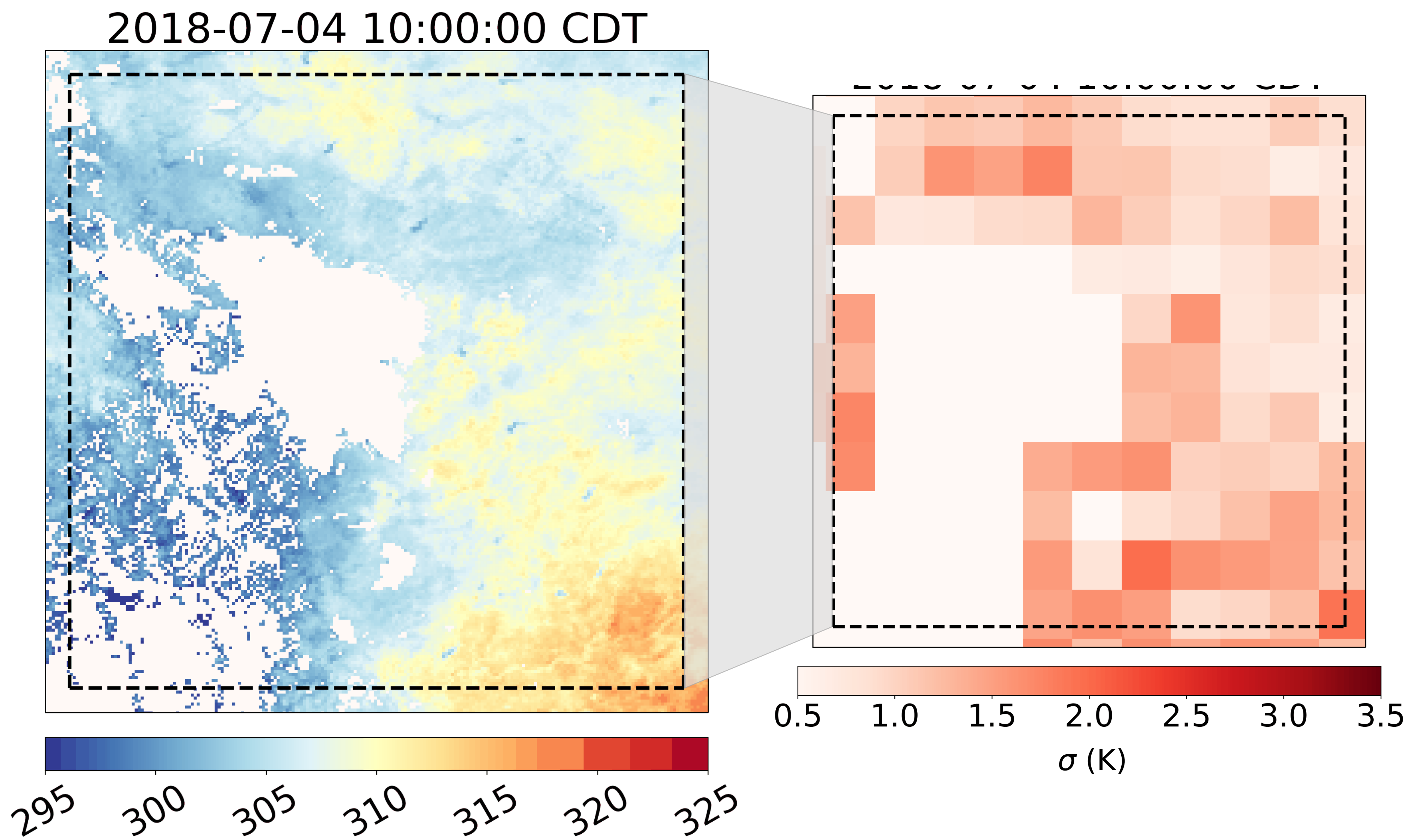


Large autocorrelation in spatial properties over mountainous/arid regions and almost 0 over flat Midwest/East coast.

Conclusions and next Steps

- **We need to be careful about taking remotely sensed data as “truth.”**
- The derived spatial statistics can be used to evaluate the sub-grid representation in LMs.
- Perspectives:
  - Other variables and datasets: LAI (MODIS), reanalysis (2mT, SMC, LH, SH), other LST products.
  - Global analysis (Copernicus LST v2).





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