STAR-ESDM: High-resolution Station- and Grid-based Climate Projections

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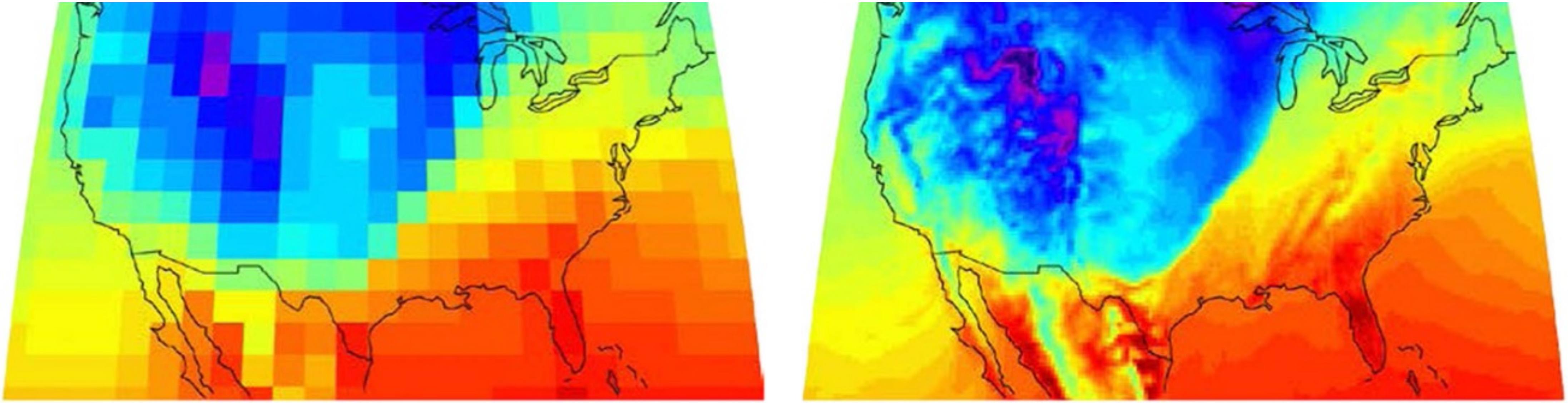
The need for high-resolution climate information

- Climate projections from global climate models (GCMs) are typically too coarse to resolve changes at the scale required by most impact assessments.
- Many climate impact assessments require high-resolution climate projections that are tailored to the location of the asset, either at a single point (weather station) or on a fine grid.



STAR: Seasonal Trends and Analysis of Residuals

A new software package based on signal decomposition algorithms that allows users to rapidly and easily …

- Decompose temporal changes in observed or model data into long-term trend, seasonal climatology, and daily anomalies
- Determine which aspects of the temporal signals are changing for any time series (station or grid-based)
- Bias-correct each component separately as part of an empirical-statistical downscaling model

Unpacking the STAR-ESDM process

ONE. Disaggregate the observed and GCM signal into 4 separate components

1. Long-term trend → **How mean temperature is going to change**
2. Static climatology
3. Dynamic climatology → **How the seasons are going to change**
4. High-frequency anomalies → **How the daily variability is going to change**

TWO. Build appropriate mappings between observations and historical GCM simulations for each of the 4 components

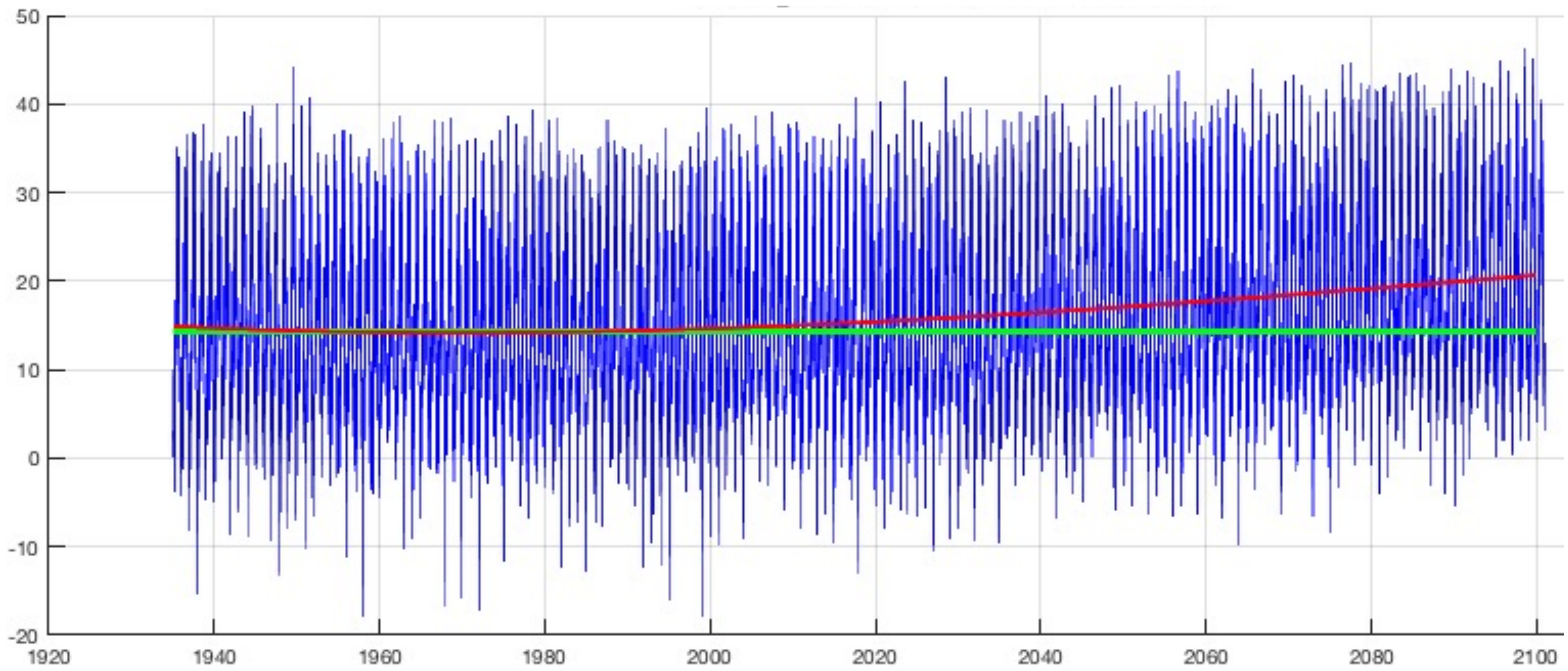
THREE. Bias-correct future projections using these mappings

FOUR. Recombine bias-corrected components to construct a consistent estimate of future time series

COMPONENT ONE: Long-term trend

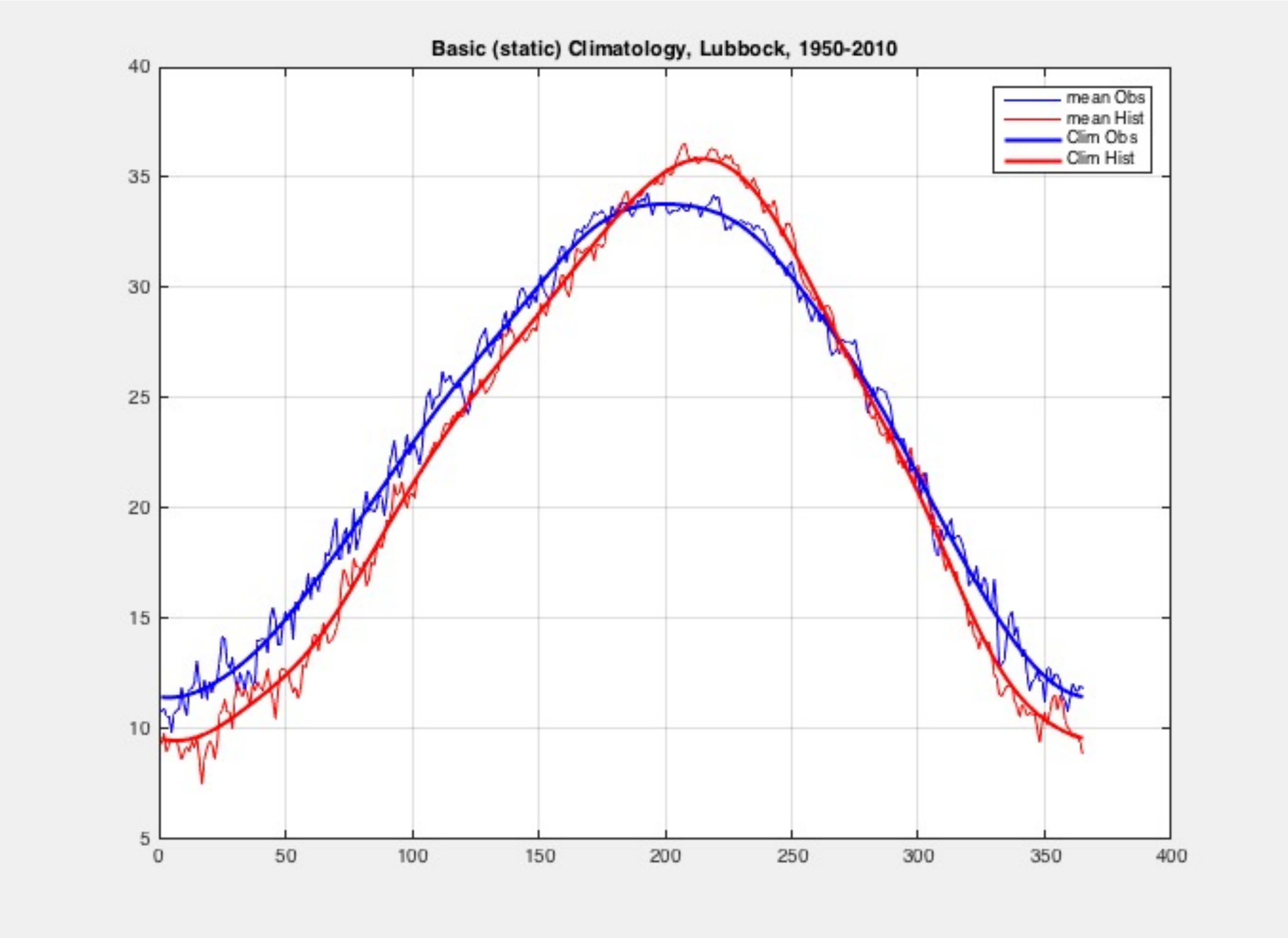
The best fit to a long-term trend to the GCM simulations through 2100 is identified (linear or 3rd order) and removed from the GCM simulations. We assume the GCM long-term trend is correct.

Weather Station: Mount Rainier, Washington State



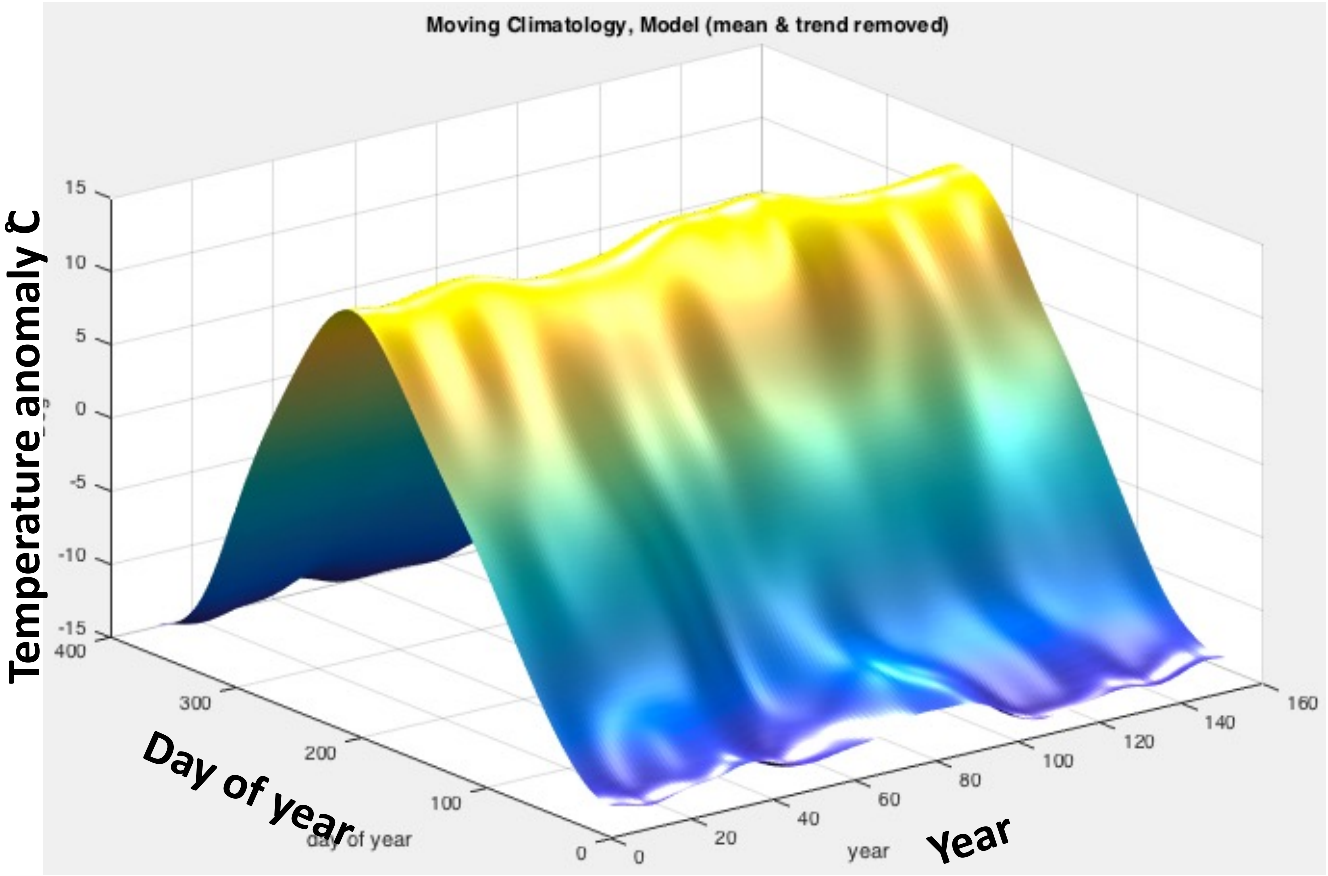
COMPONENT TWO: Static Climatology

- This is the mean annual cycle over the historical period
- It's smoothed using a low-pass frequency filter in the Fourier domain to remove noise (conventional smoothing filters such as rolling means underestimate peaks and overestimate valleys)
- Difference between observed and GCM static climatology is used to adjust the GCM's dynamic climatology to match the observations for the historical period



COMPONENT THREE: Dynamic Climatology

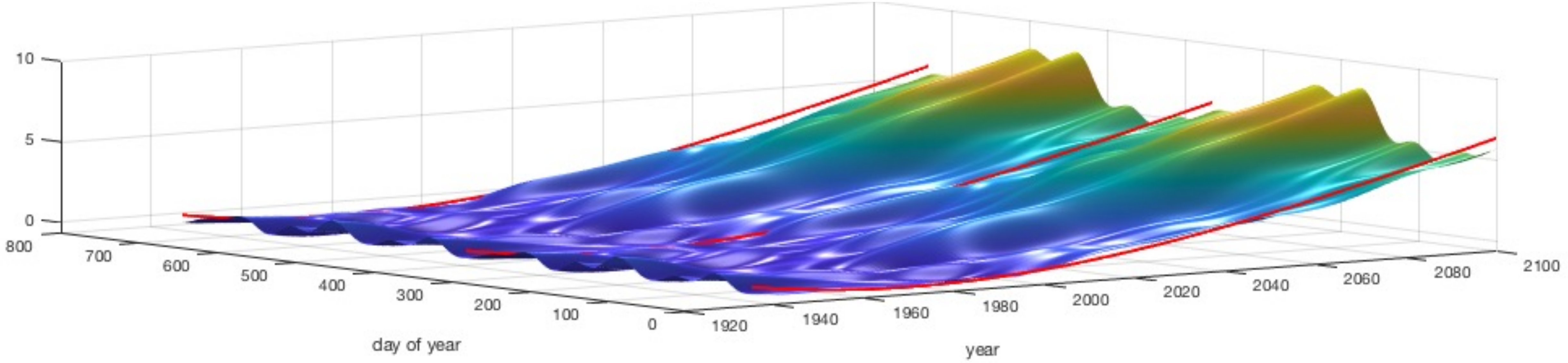
- This is the mean annual cycle that varies by year
- It's smoothed along the year axis to create a climatology surface
- Result is a moving climatology that removes the day-to-day and year-to-year variation
- Captures the change in the shape of the climatology over time



COMPONENT THREE: Dynamic Climatology

- Difference between the GCM future and historical climatology is calculated and applied to the observations for an estimate of the historical and future bias-corrected climatology
- This example shows that spring and fall temperatures increase faster than the long-term trend (red line), broadening the warm season

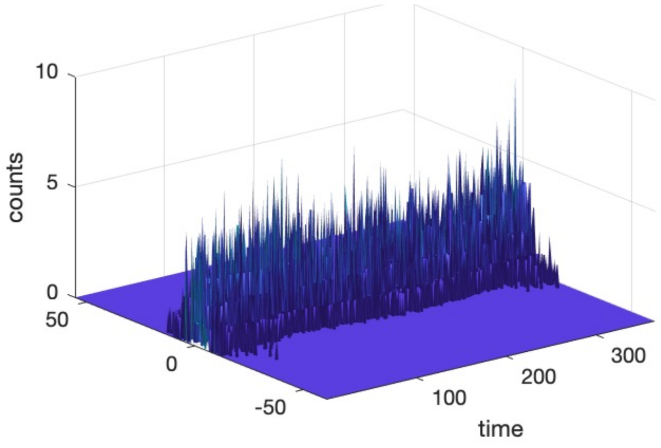
Change from historical climatology



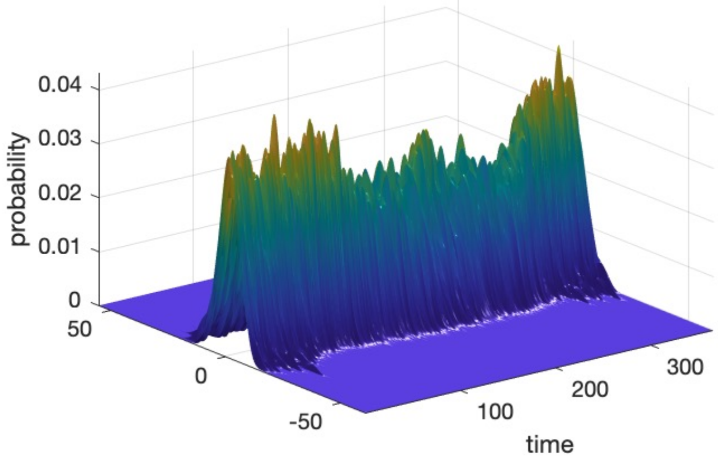
COMPONENT FOUR: High-frequency daily anomalies

- This is the day-to-day weather, which is very important as it affects the intensity and frequency of extremes
- Assume observations' distribution of short-term variability is more accurate than GCM's
- We modify observed variability by simulated changes in the shape of the GCM distribution of daily anomalies, smoothed using kernel density estimation

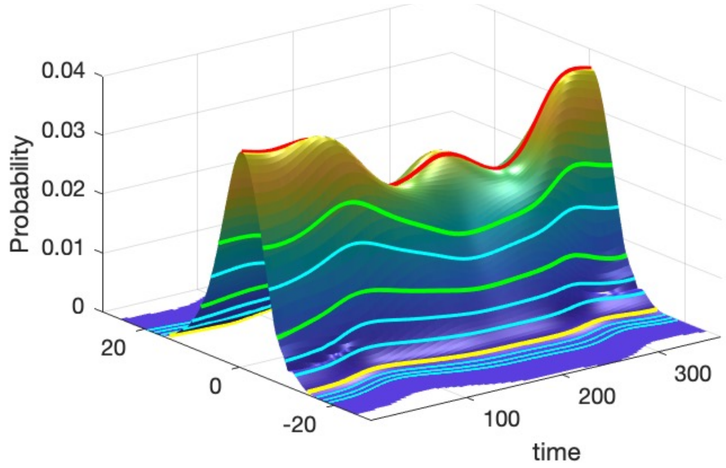
Raw histogram



KDE surface



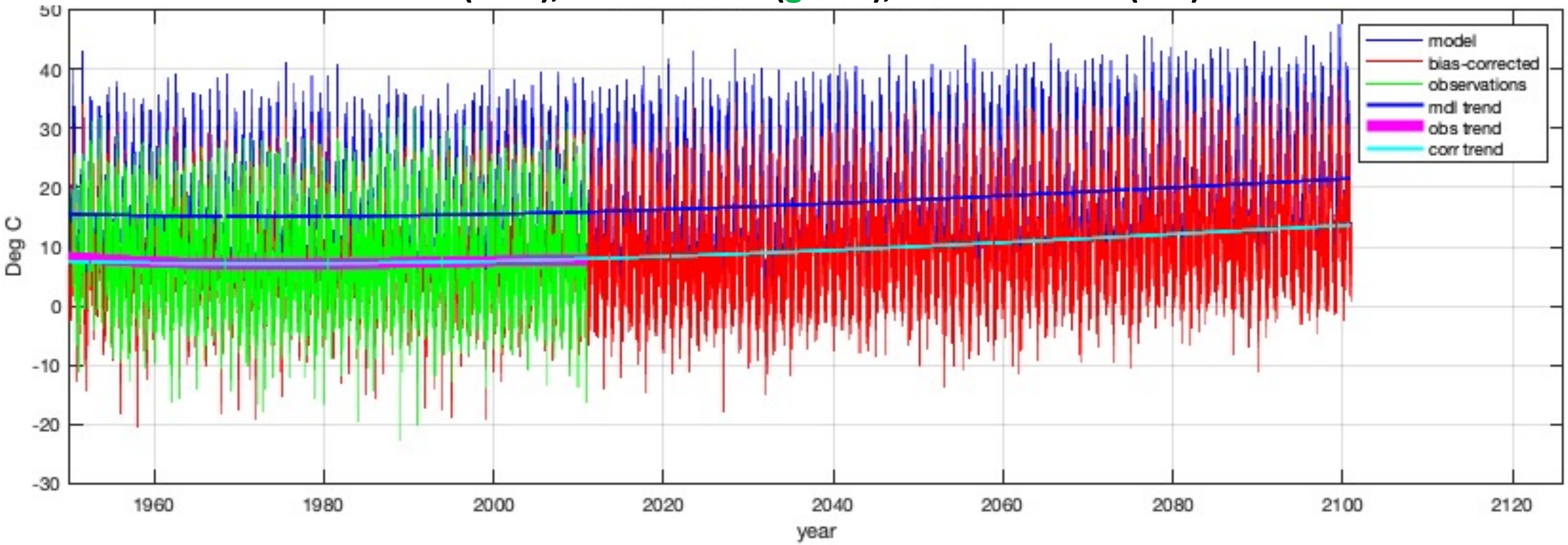
Smoothed KDE surface



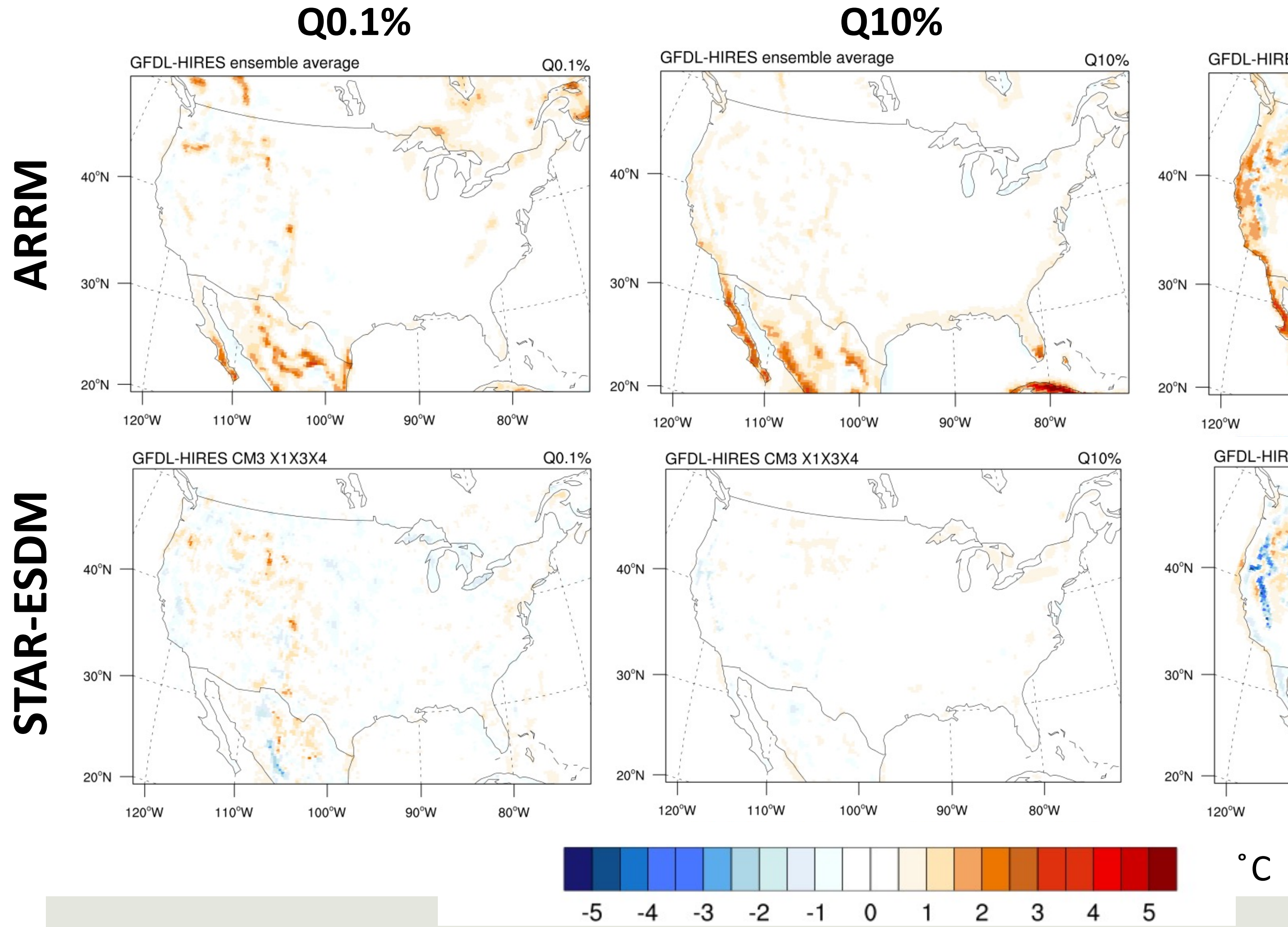
Finally, we put it all back together

Add the mapped anomalies for the daily weather and the annual static and dynamic climatology to the long-term signal to create a single time series for a given station or grid location

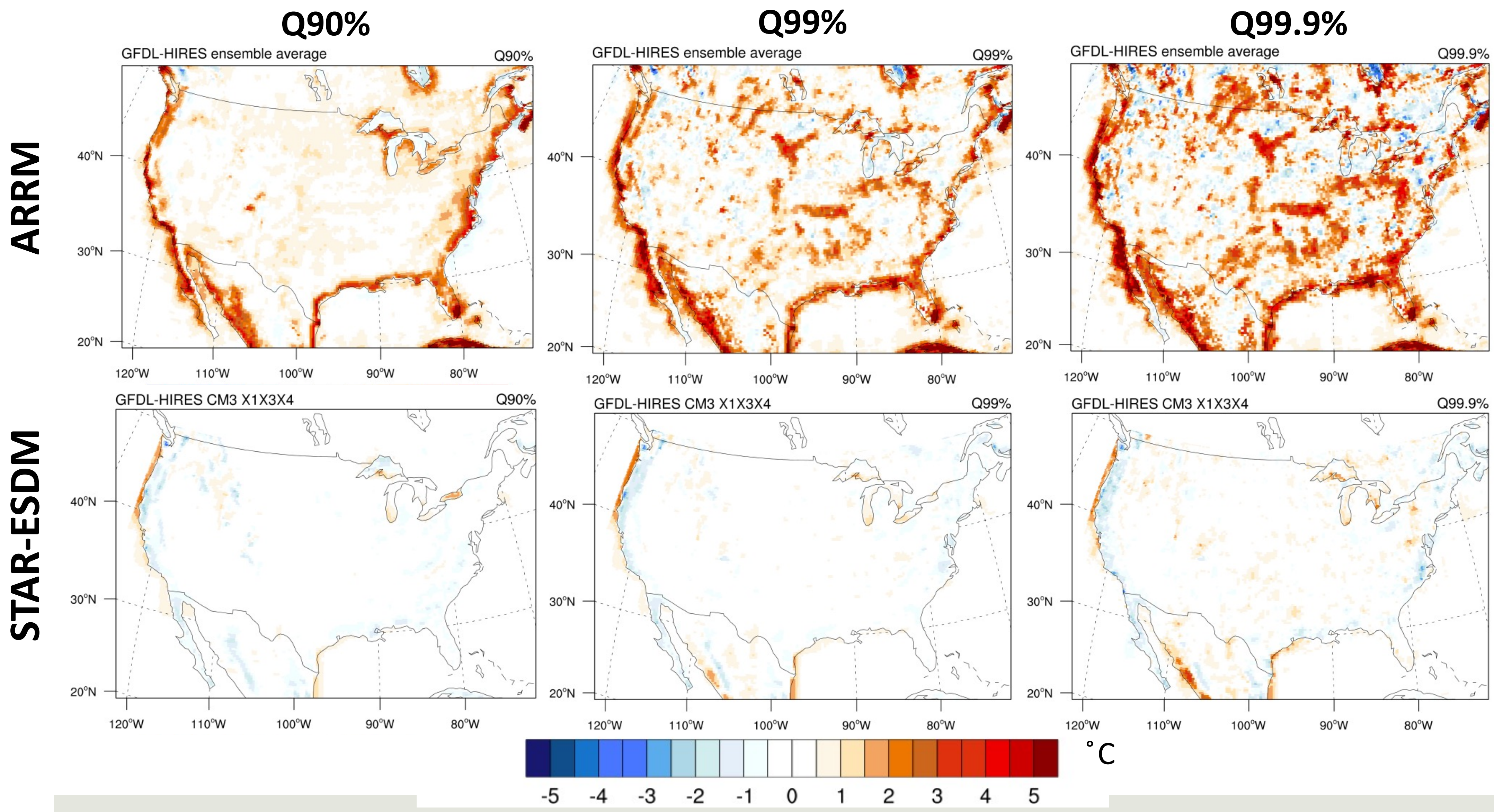
Final product for Mt. Rainier, WA
GCM (blue), observations (green), bias-corrected (red)



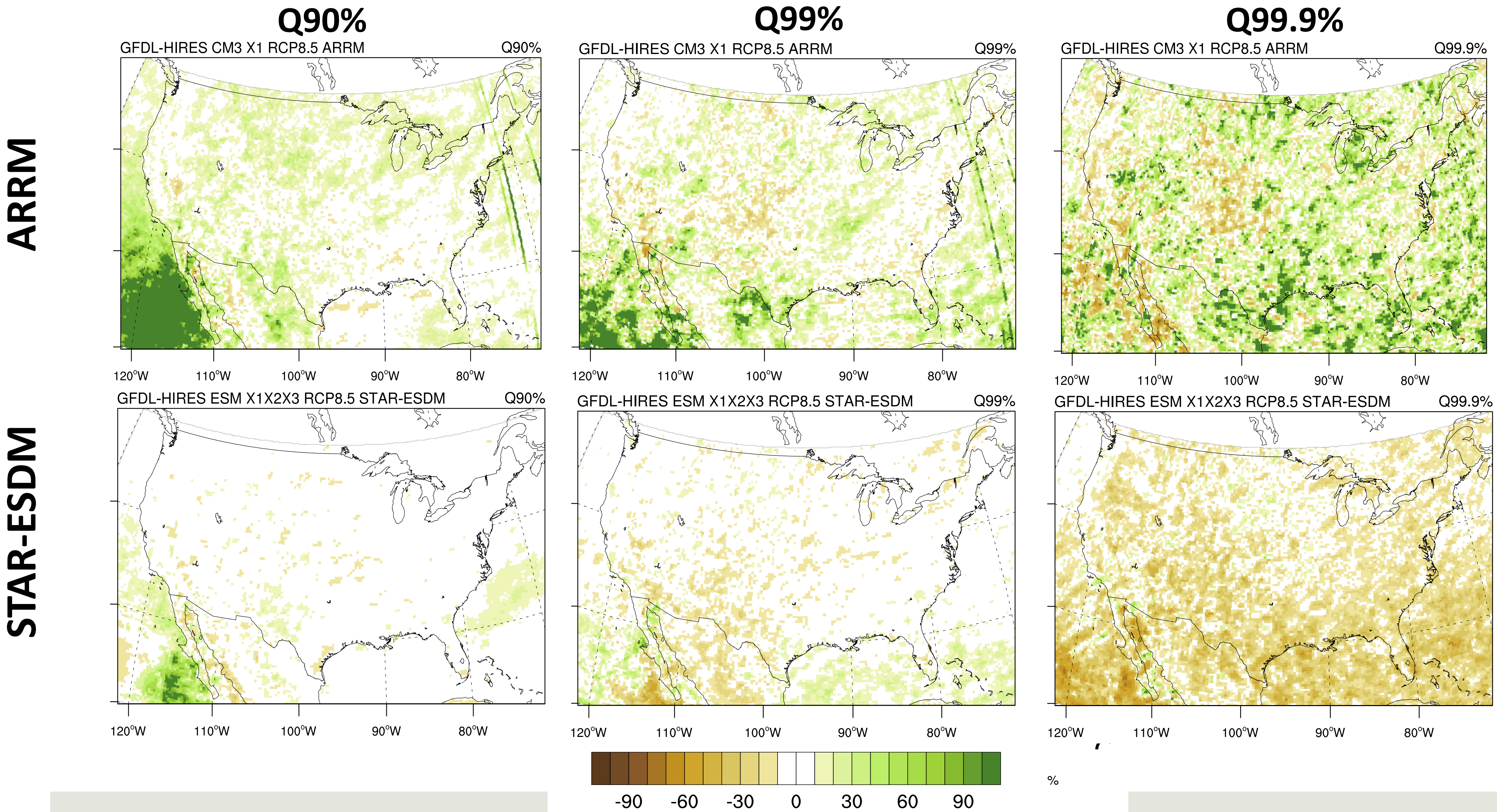
STAR-ESDM: 2086-2095 Perfect Model Maximum Temperature Bias



STAR-ESDM: 2086-2095 Perfect Model Maximum Temperature Bias



STAR-ESDM: 2086-2095 Perfect Model Precipitation Bias



What, When, Where?

Will be available at ESRI.com for free in **summer of 2021** for daily minimum and maximum temperature and daily precipitation for 22+ CMIP5 GCMs, RCP4.5 and RCP8.5 scenarios and CMIP6 models to follow.

- Long-term weather stations across North and Central America
- Livneh gridded 1/16th degree across the CONUS
- NCLIMGRID gridded 5km across the CONUS
- NRCAN gridded 1/12th degree across lower Canada
- Global Sheffield gridded ¼ degree global
- Other datasets as available and appropriate (global stations, re-analysis, etc.)
- RCM simulations

Thank you!

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