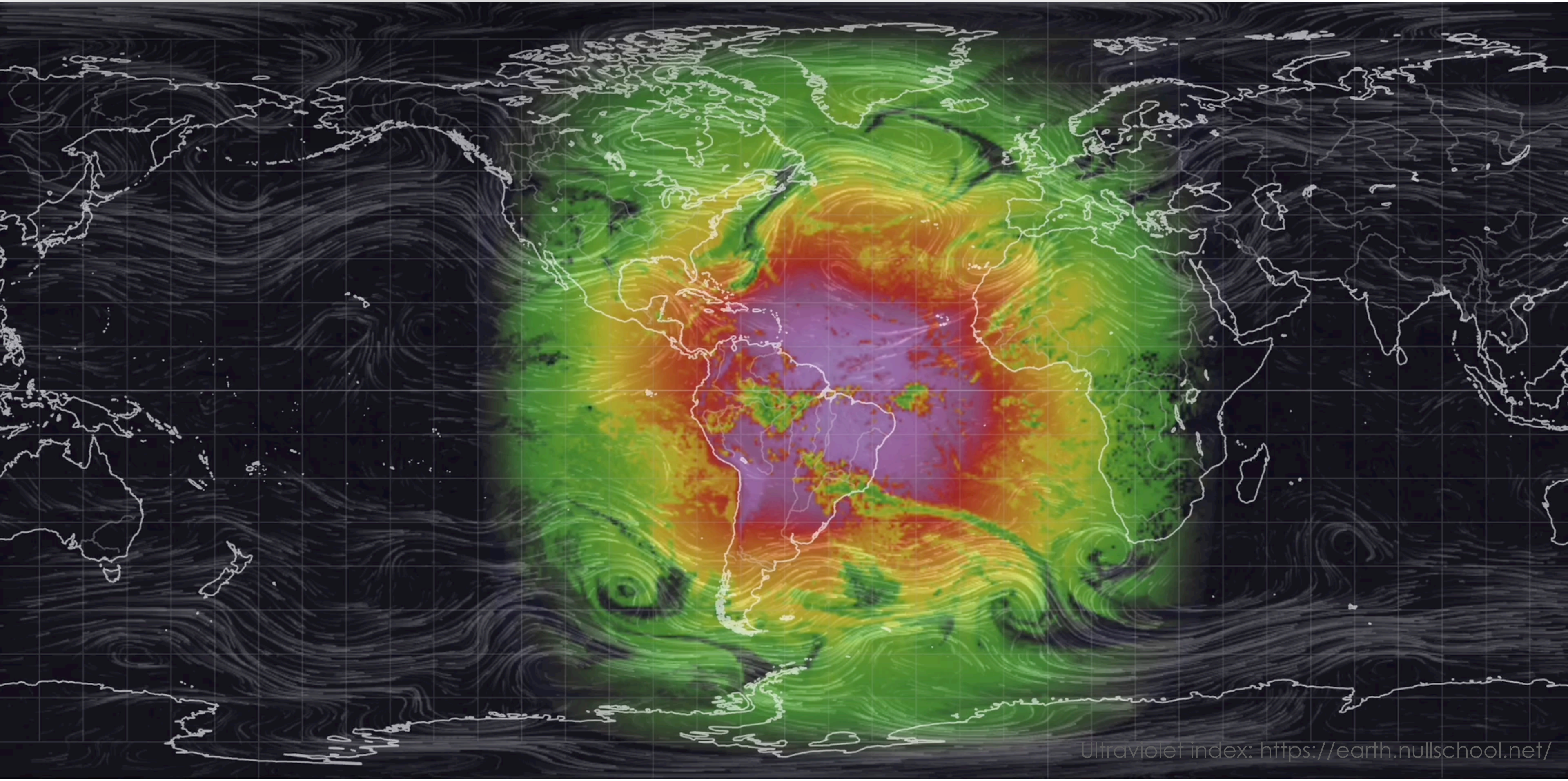
Low Resolution Secrets of High-resolution Statistical Downscaling

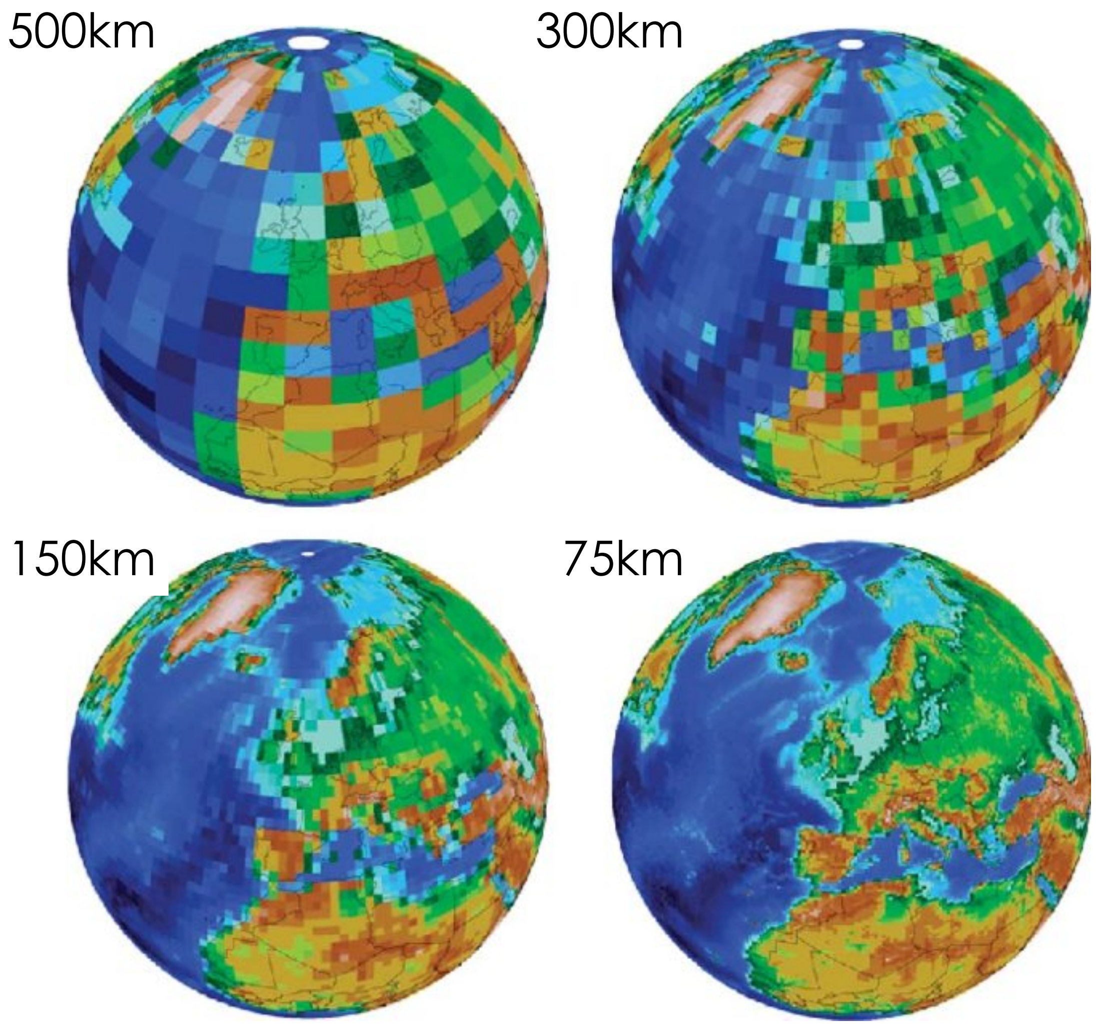


Moet Ashfaq

6th Workshop on Water Resources in Developing Countries: Hydroclimate Modeling, Information Tools and Simulation Techniques

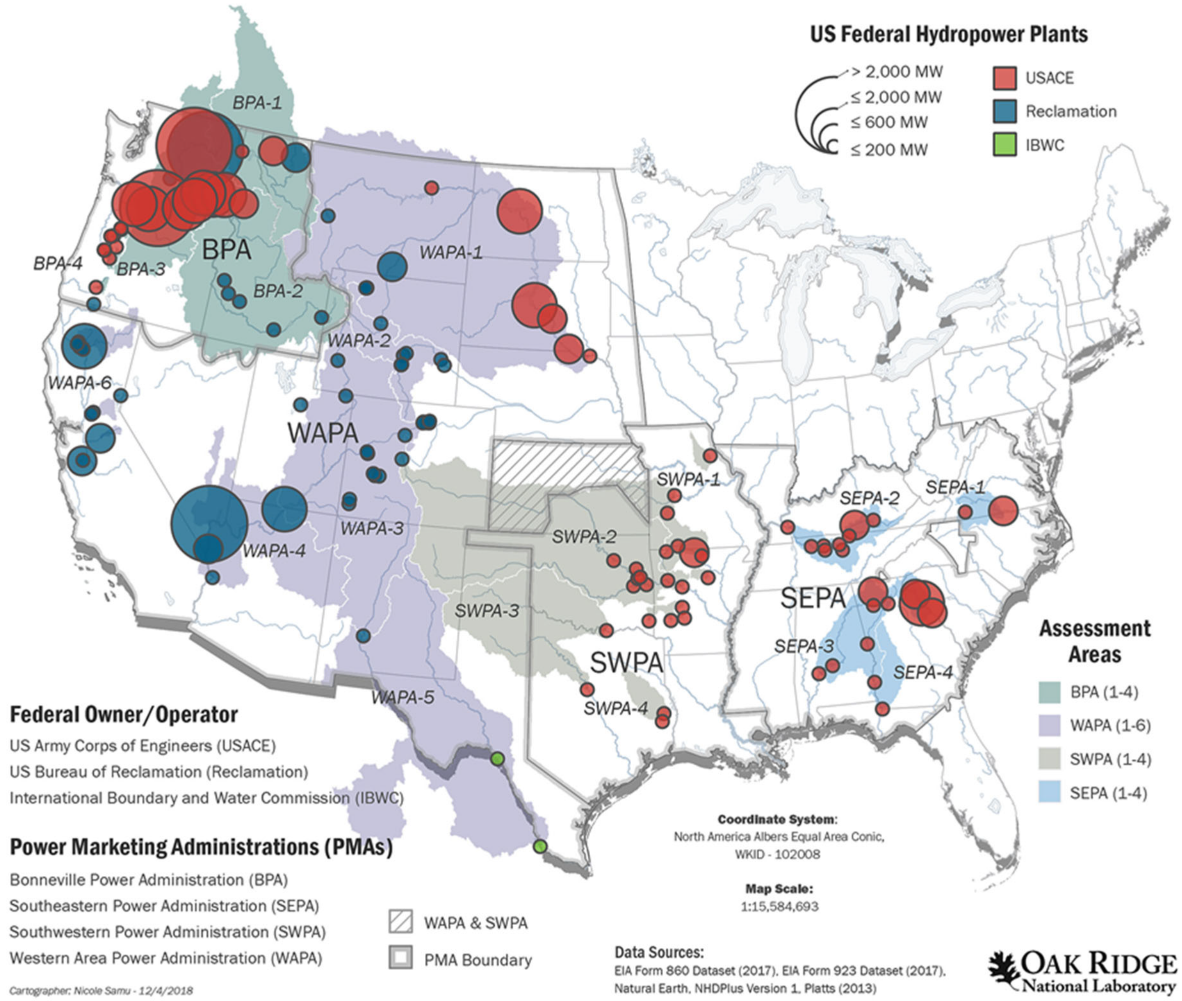
May 20, 2024

Why do we need downscaling?



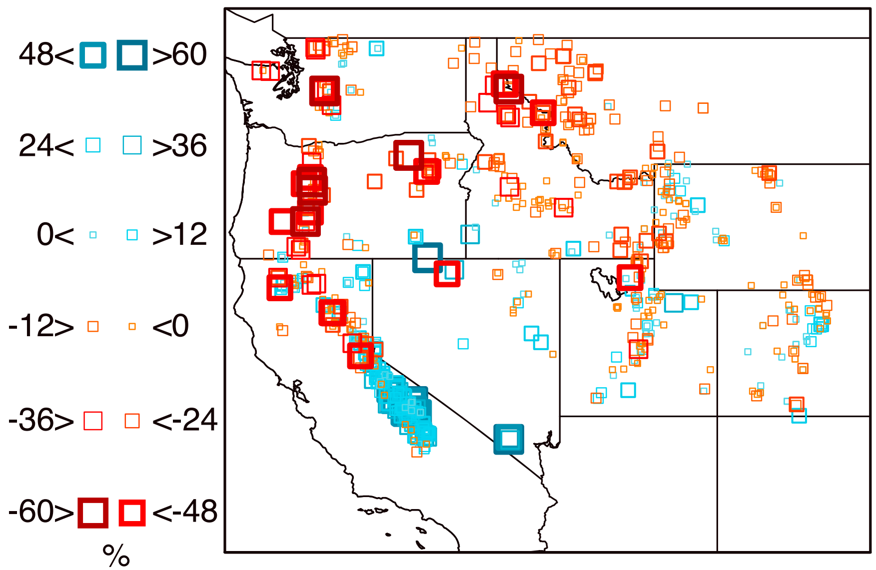
Washington et al., 2008

Downscaling: Regional Climate Change Assessments

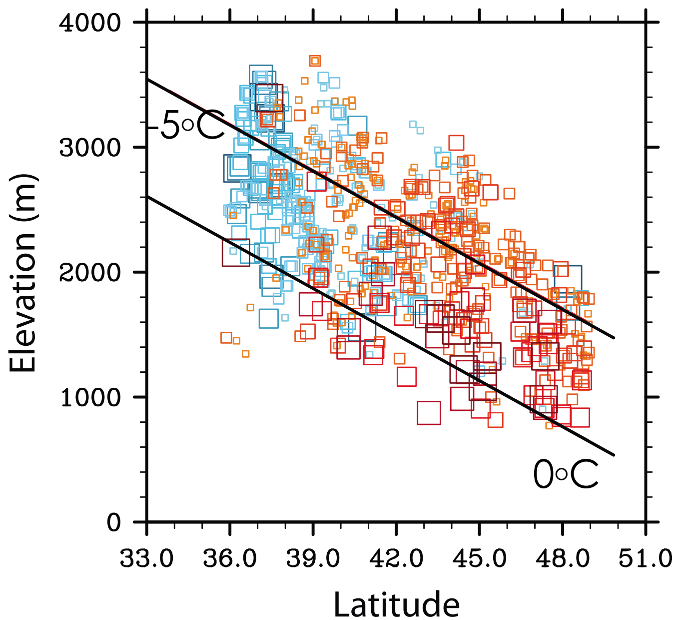


Downscaling: Fine Scale Processes

Trends in Snow Accumulation

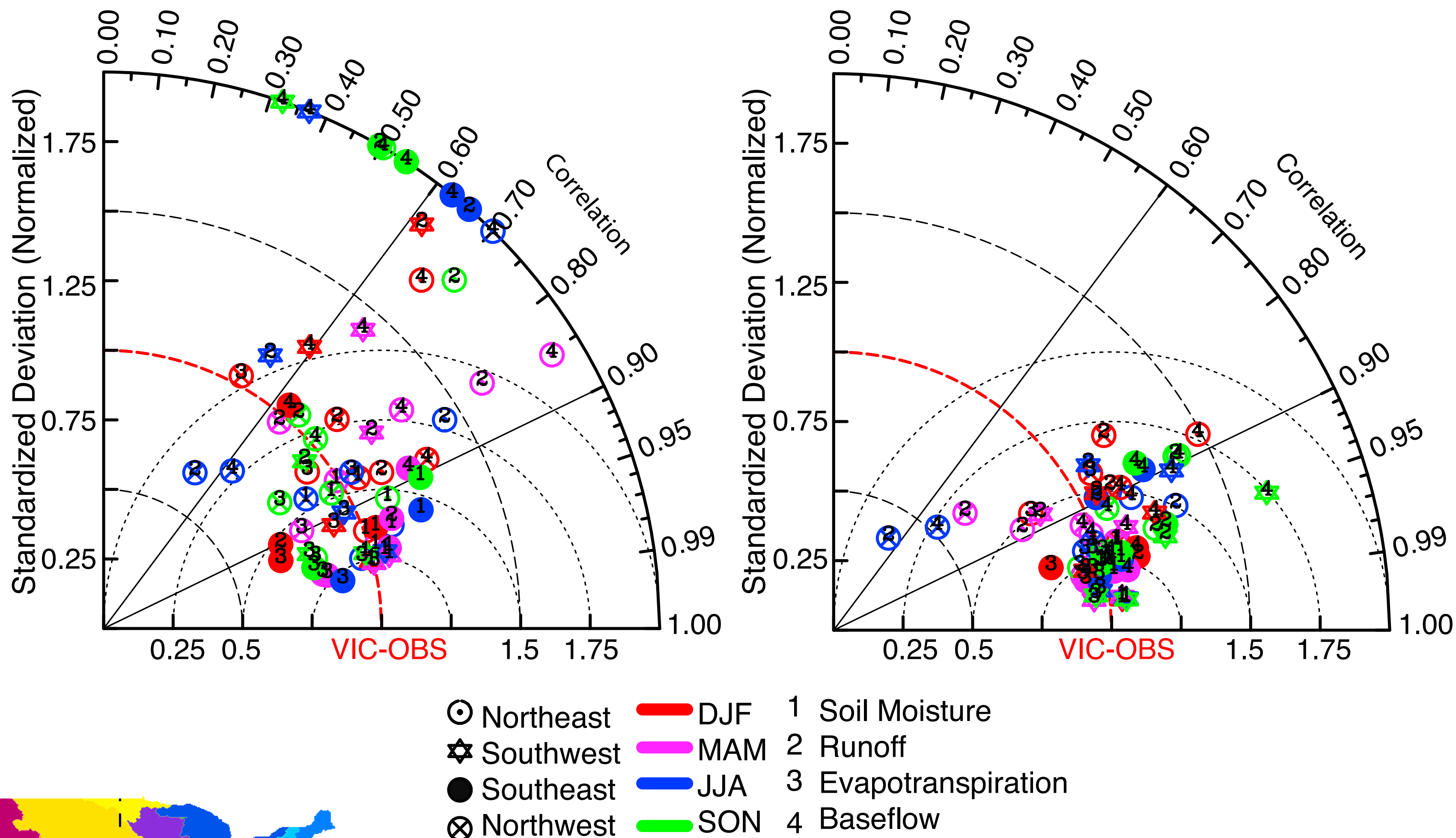


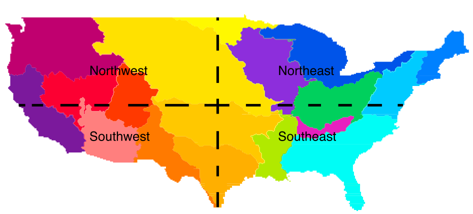
Trends w.r.t Surface Elevation



Ashfaq et al., 2013

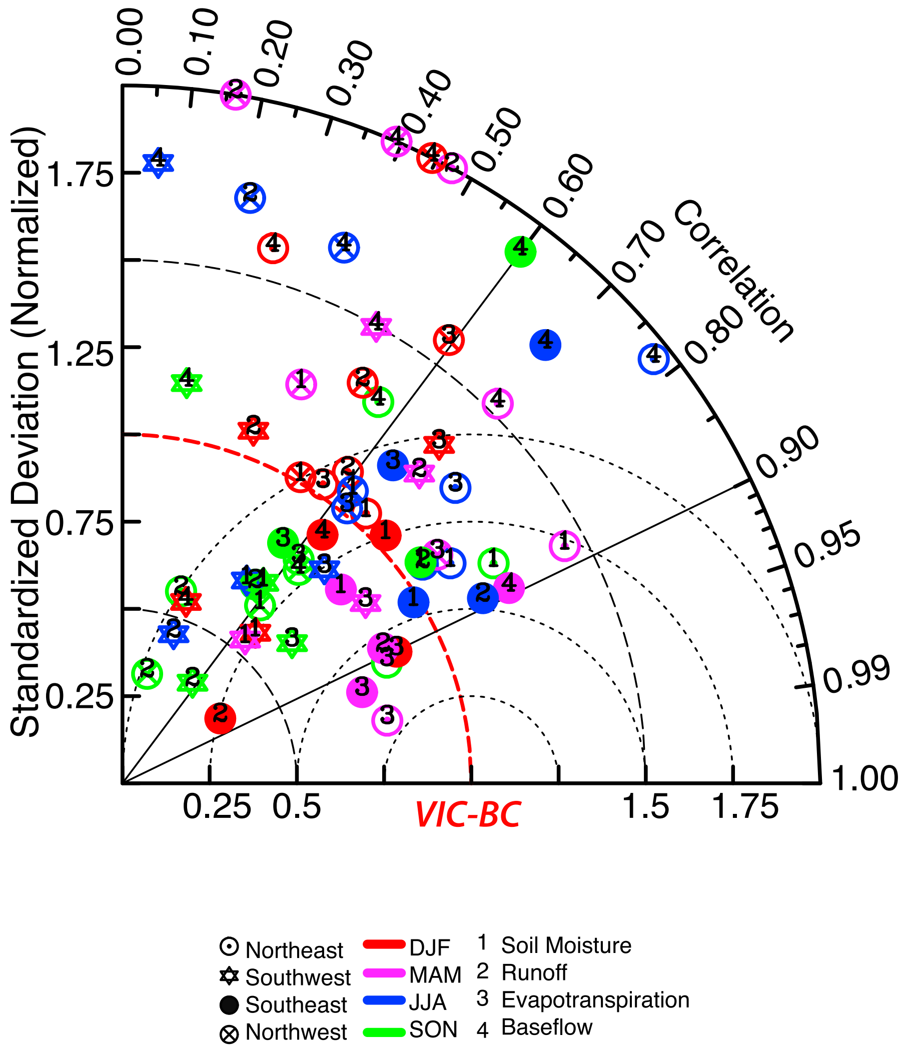
Downscaling: Reduce Biases





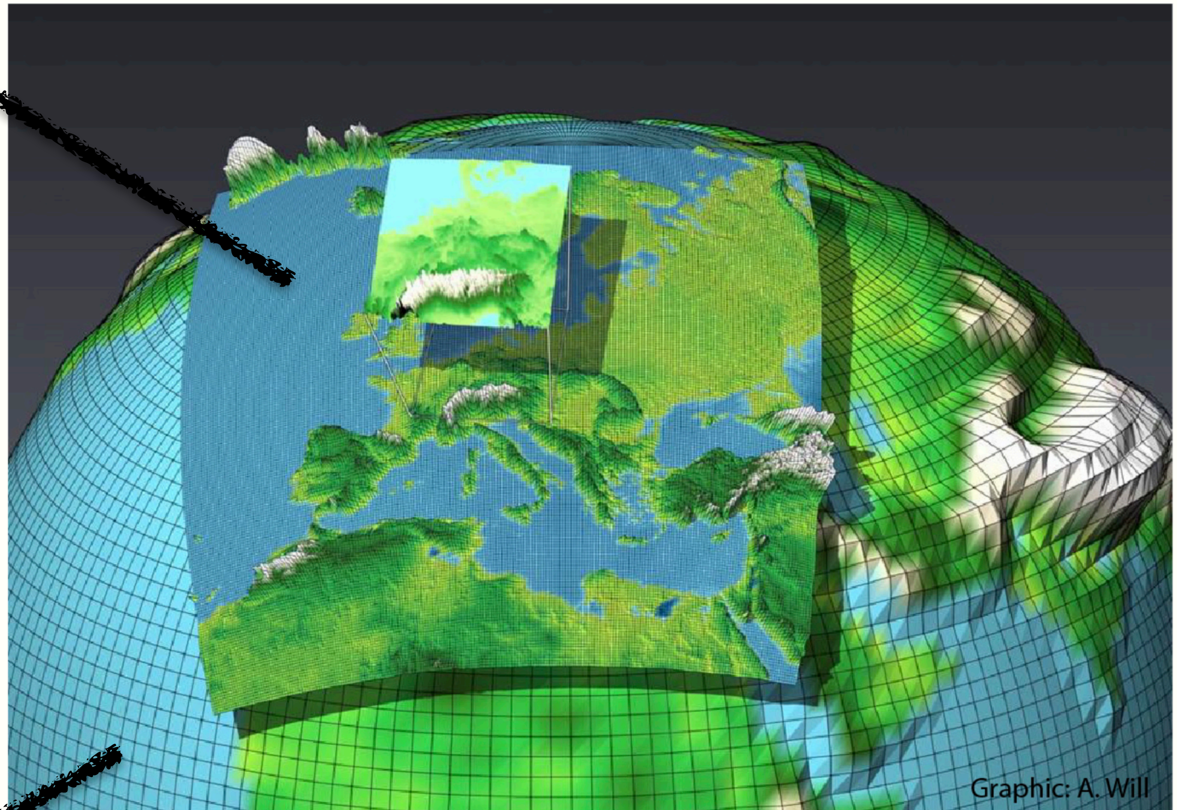
Ashfaq et al., 2010

Downscaling: Reduce Biases



Downscaling Types: Dynamical

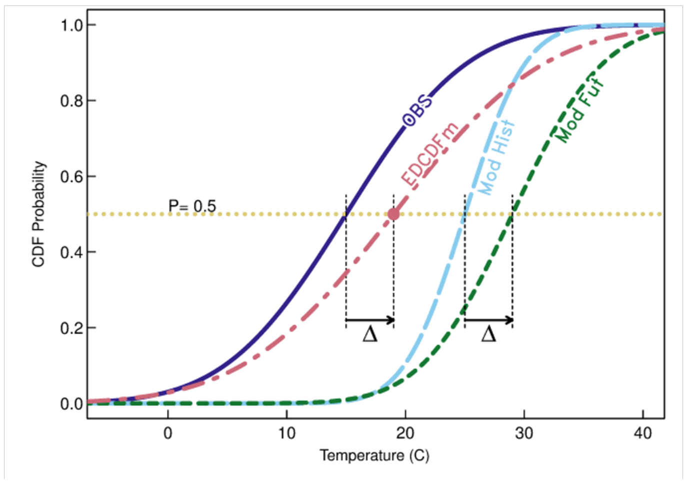
Regional Climate Model



Global Climate Model

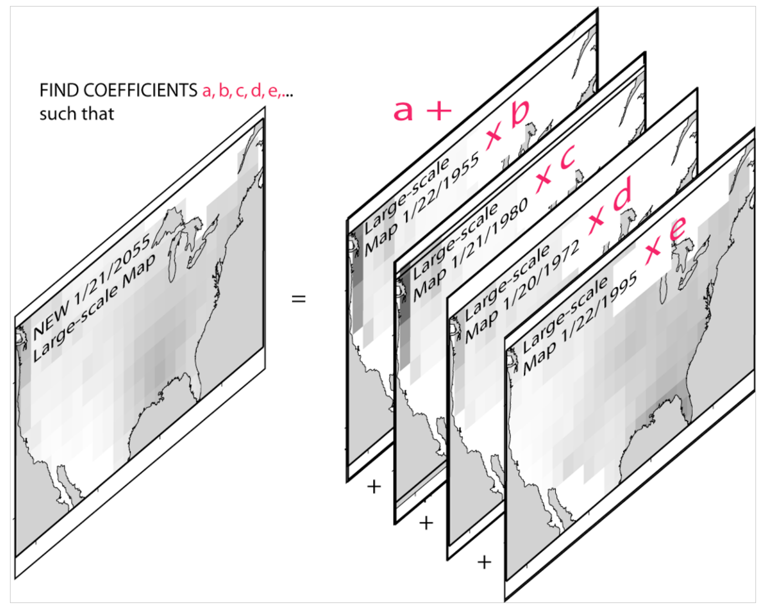
Downscaling Types: Statistical

Quantile Mapping



Li, et al., 2010

Constructed Analogs



Hidalgo, et al., 2008

Statistical downscaled data is typically coarser than the dynamical downscaled data at comparable grid spacing

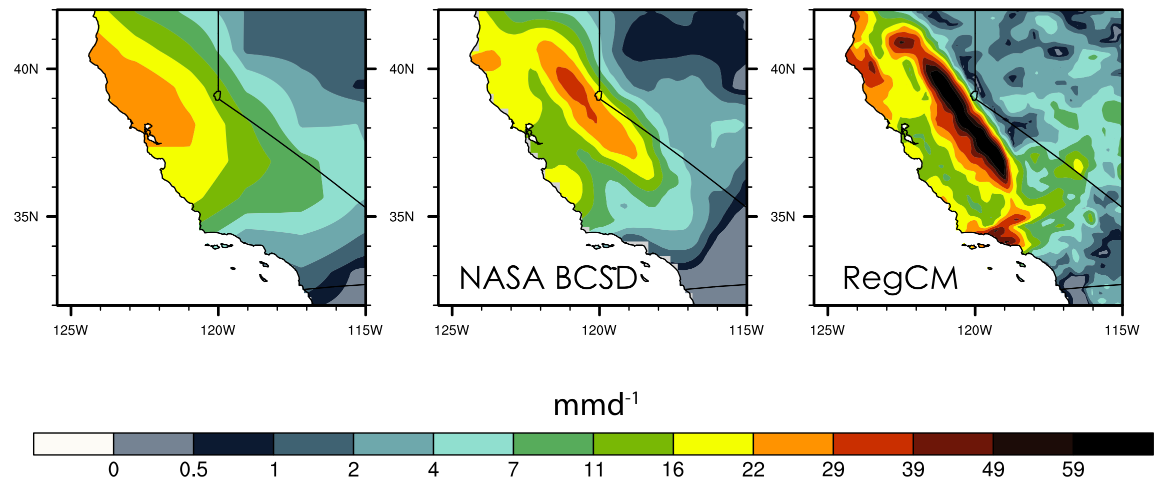
Statistical Downscaling: Coarser than Physical Models

California Topography

GCM (~250km)

Statistical Downscaling (~25km)

Dynamical Downscaling (~25km)

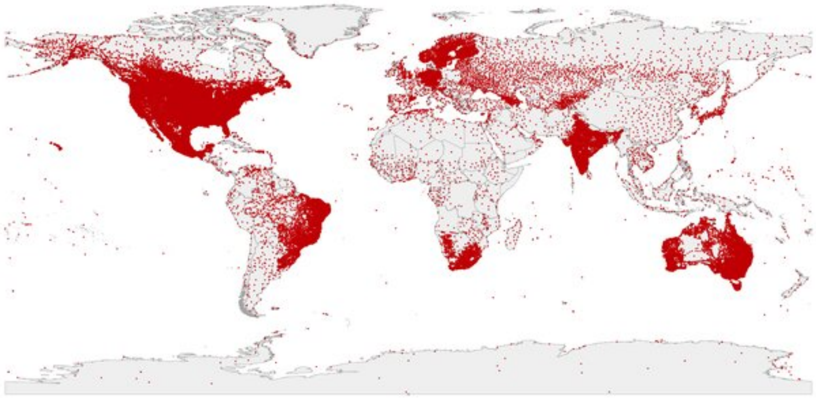


Data used in explanations

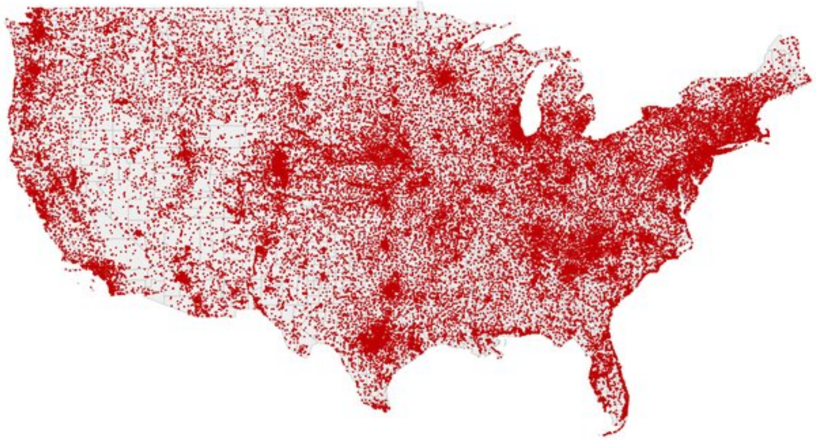
- Four datasets:
  - A GCM (**ACCESS-CM2**) from CMIP6
  - Dynamical Downscaling: An RCM (**RegCM4.5**) forced by that GCM (**25** km)
  - Statistical Downscaling: Two statistically downscaled datasets using that GCM
    - **LOCA** (Localized Constructed Analogs, **6** km)
    - **BCSD** (Bias Correction Statistical Disaggregation, **25** km) - **NASA-NEX-GDDP**

Sparse Ground Observations

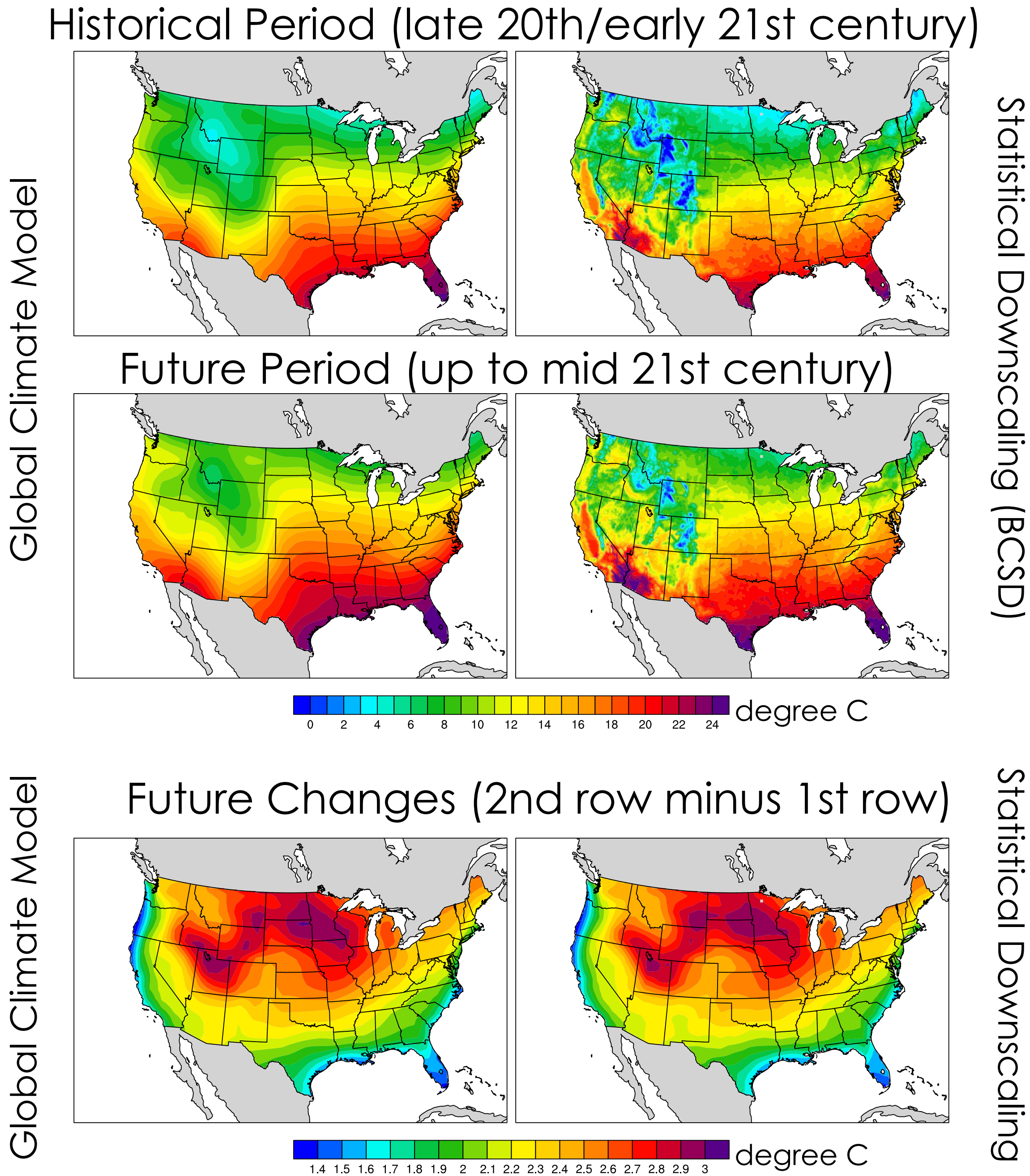
Global Stations Network



Stations across CONUS



Statistical downscaled data does not necessarily mean spatially downscaled climate change signal


Historical Period (late 20th/early 21st century)
Future Period (up to mid 21st century)
Global Climate Model
Statistical Downscaling (BCSD)
0 2 4 6 8 10 12 14 16 18 20 22 24
degree C
Future Changes (2nd row minus 1st row)
Global Climate Model
Statistical Downscaling
1.4 1.5 1.6 1.7 1.8 1.9 2 2.1 2.2 2.3 2.4 2.5 2.6 2.7 2.8 2.9 3
degree C

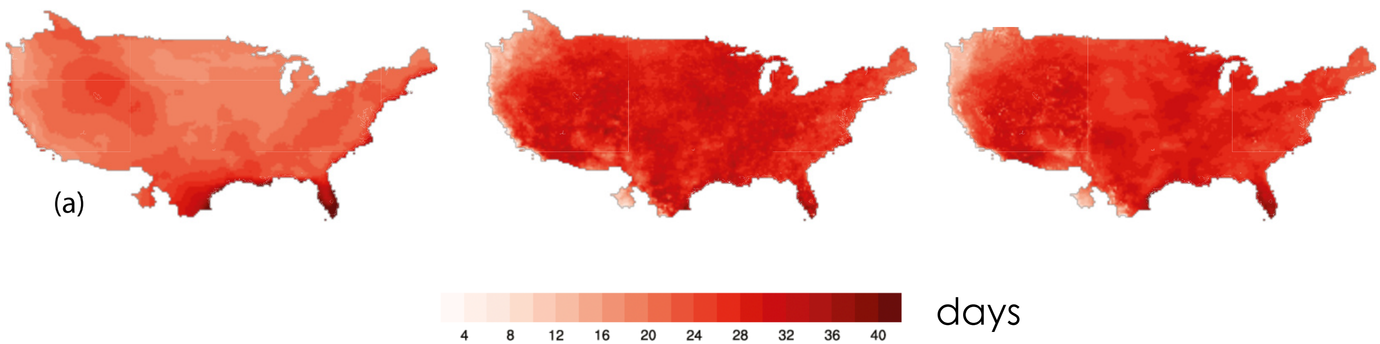
Statistical downscaling is sensitive to the choice of reference observations and can perturb climate change signal, which is not physically explainable.

Changes in Extremes

Statistically Downscaled

GCM | Obs: Livneh | Obs: Daymet

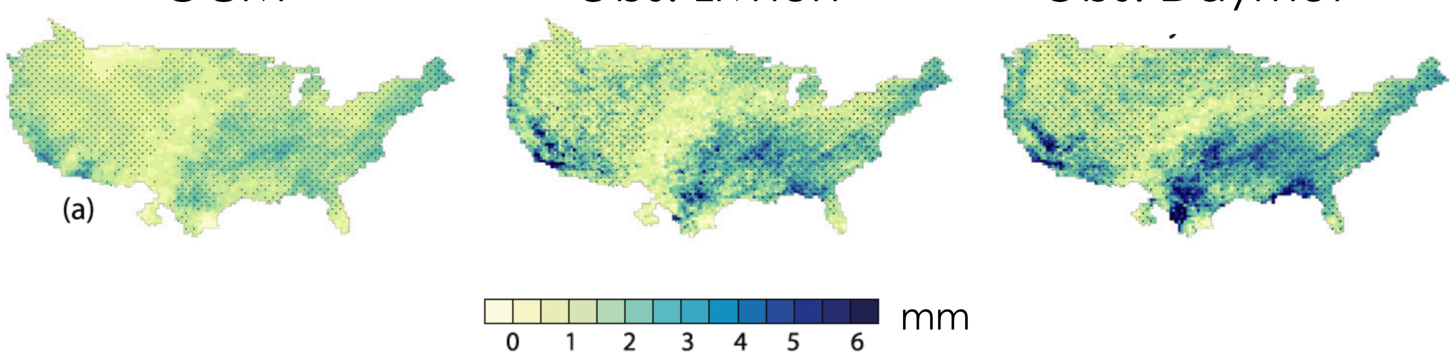
Hot days (days above **T95**)



days

GCM | Obs: Livneh | Obs: Daymet

Magnitude of Extremes (**P95**)



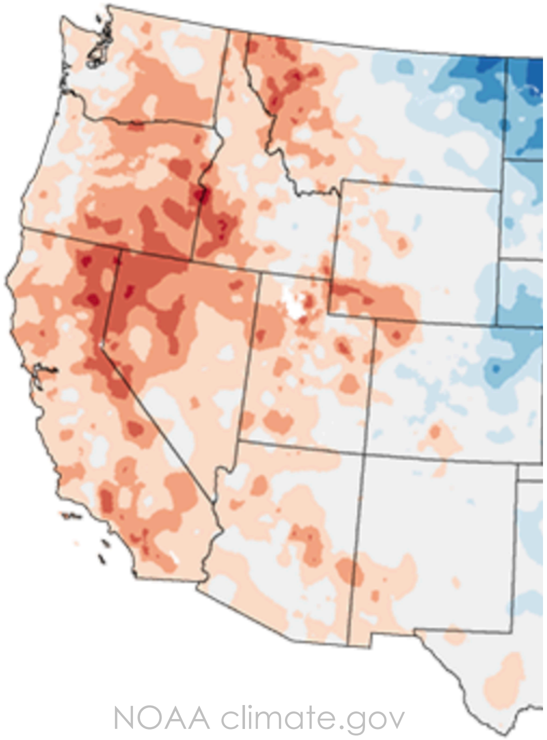
mm

Rastogi et al., 2022

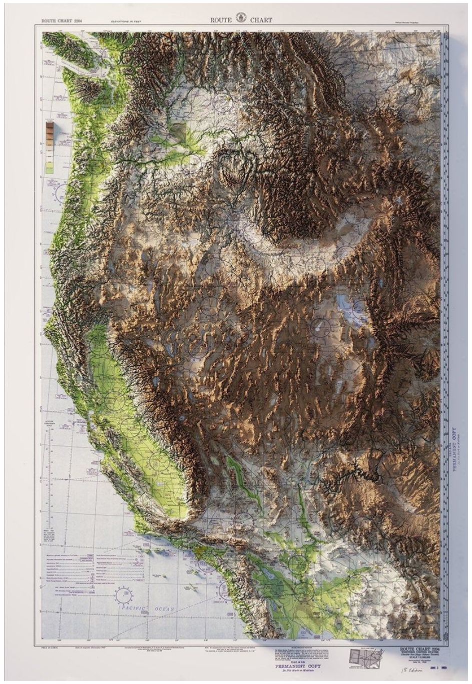
Statistical downscaling cannot correct poor representation of fine-scale feedbacks

Observed Temperature Trends in Western U.S.

1987-2016



Western U.S. Topography



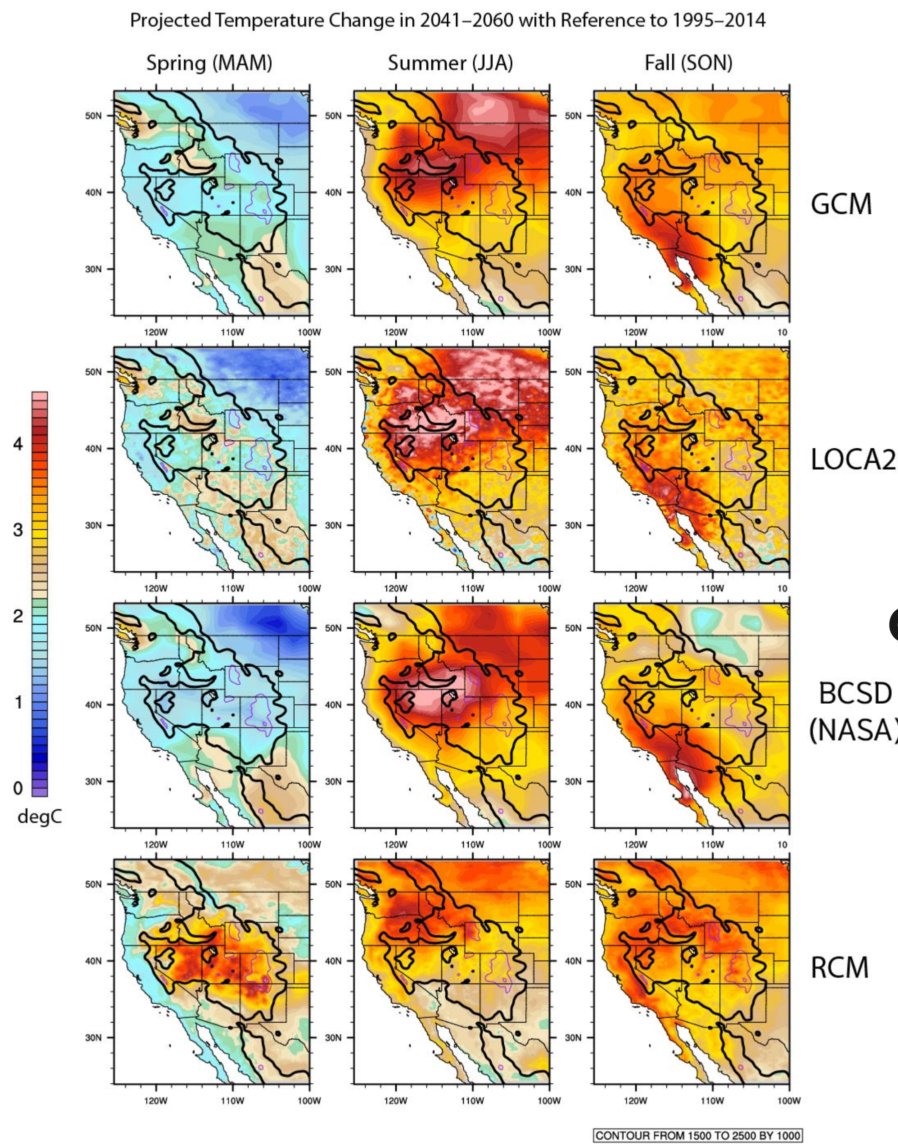
Lack of Elevation Dependent Future Warming

Global Climate Model

Statistical Downscaling (LOCA)

Statistical Downscaling (BCSD)

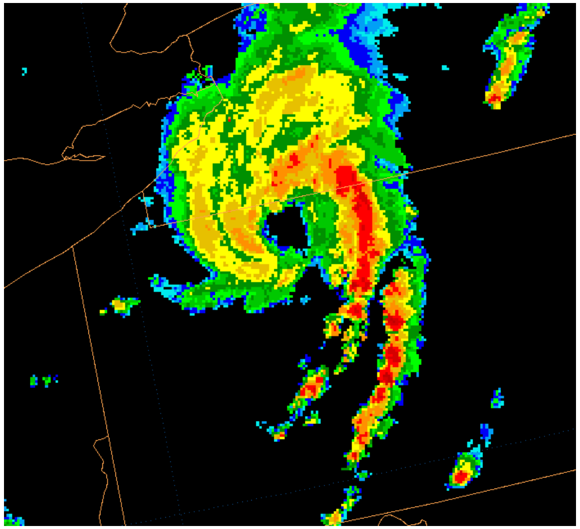
Dynamical Downscaling

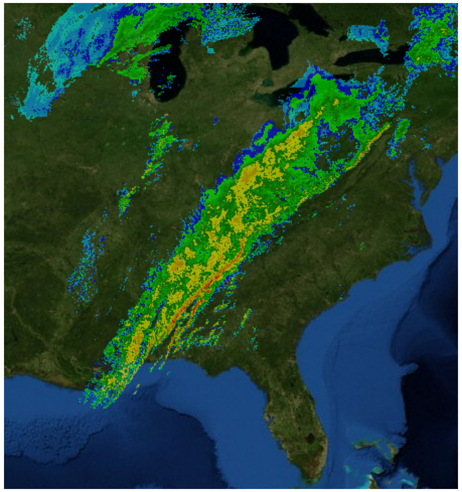


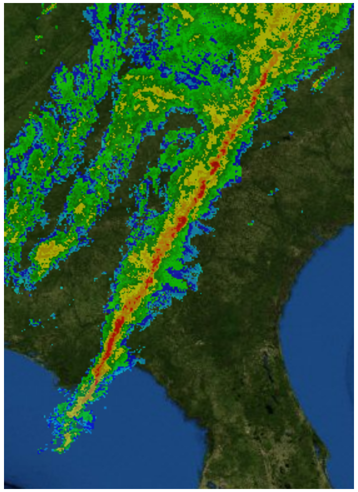
If a GCM has errors in threshold responses, **statistical downscaling will have them too**!

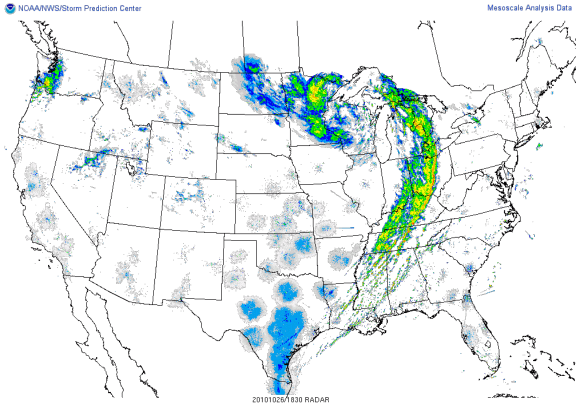
Statistical downscaled cannot correct poor representation of fine-scale precipitation generating physical processes

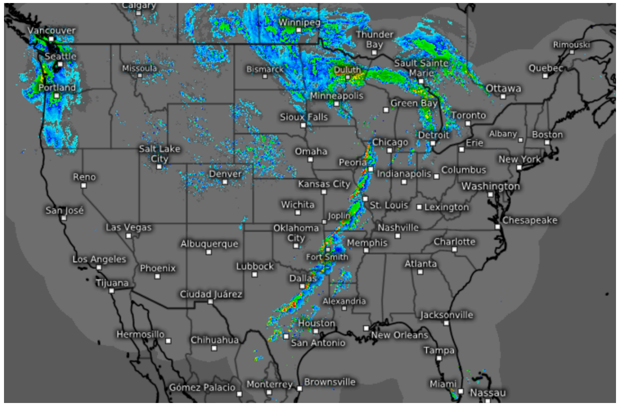
Few Examples of strom-types over the U.S.

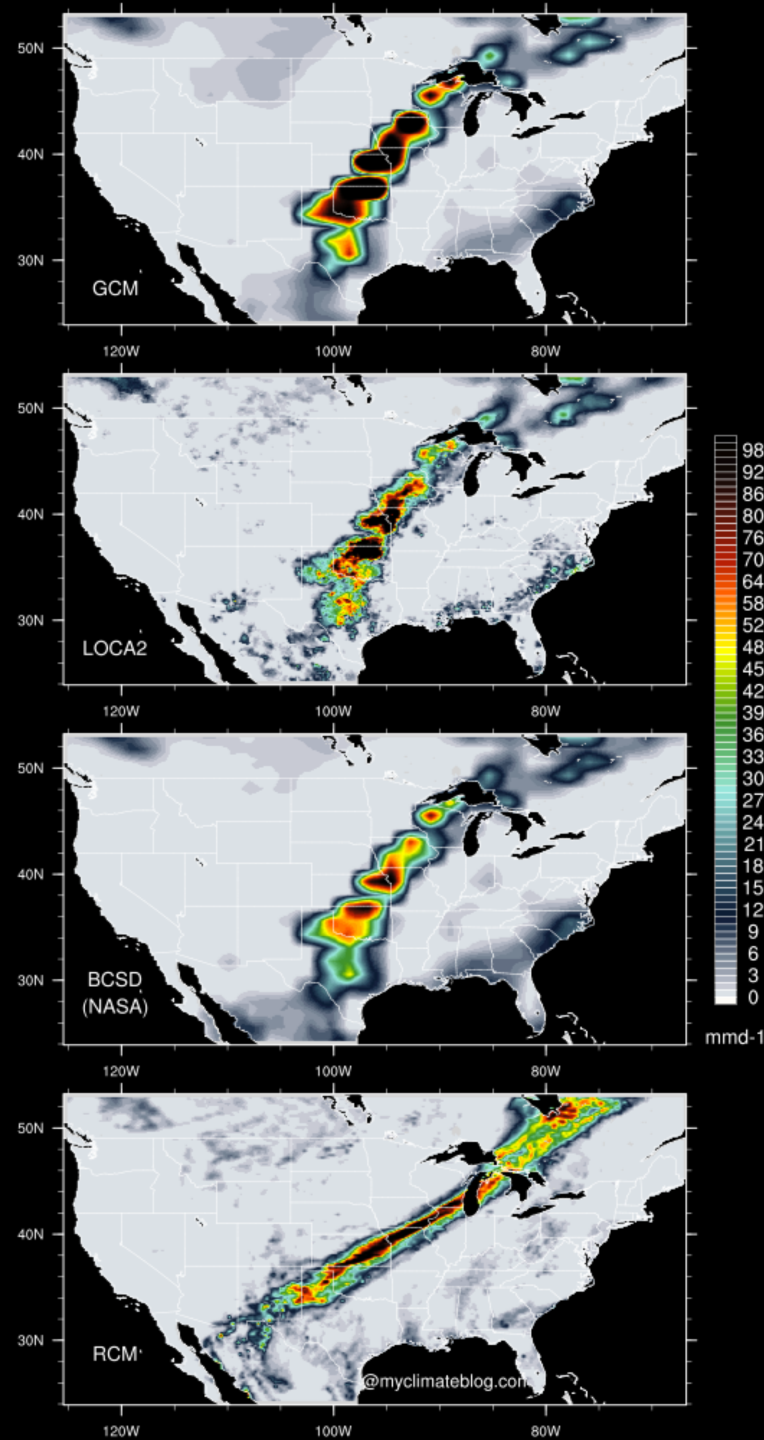











GCM
LOCA2
BCSD
(NASA)
RCM
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100W
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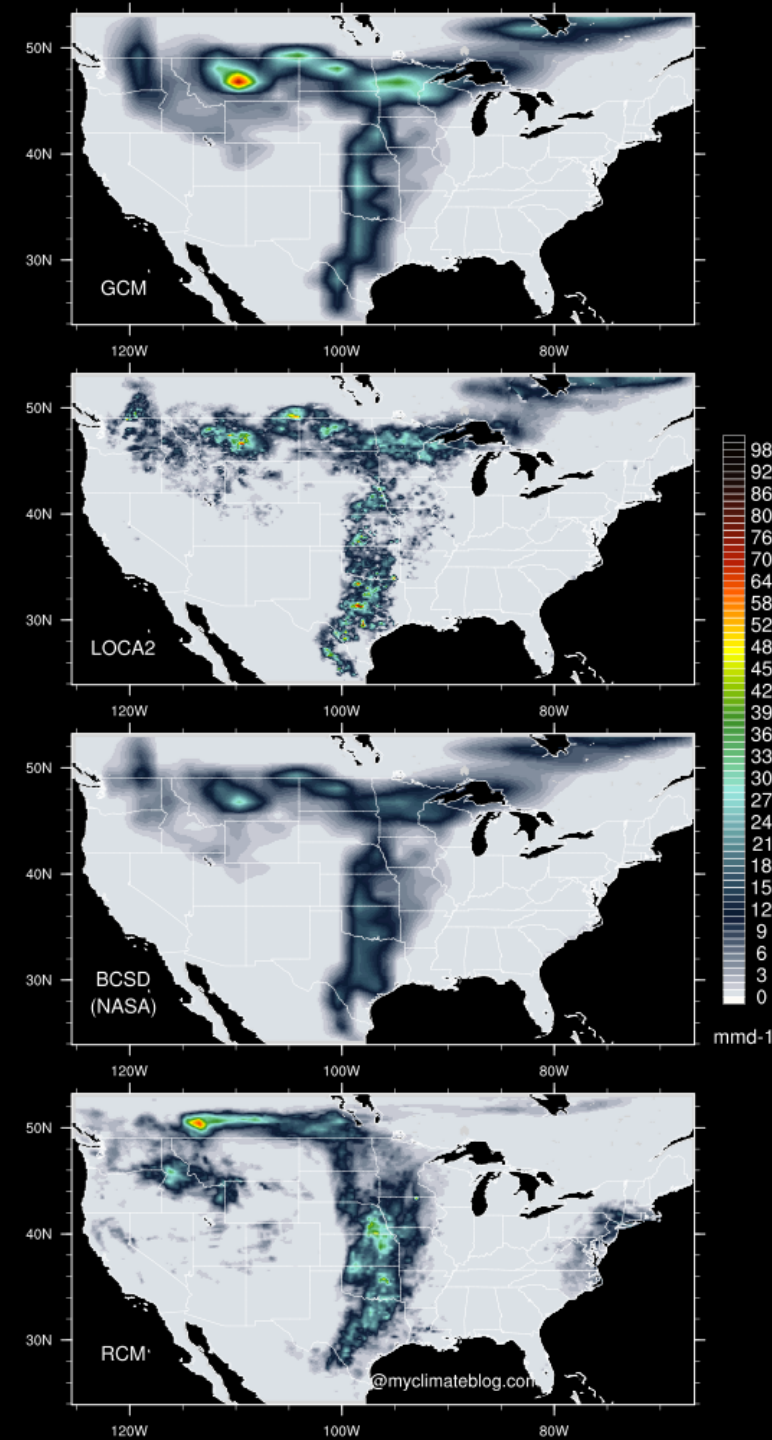
@myclimateblog.com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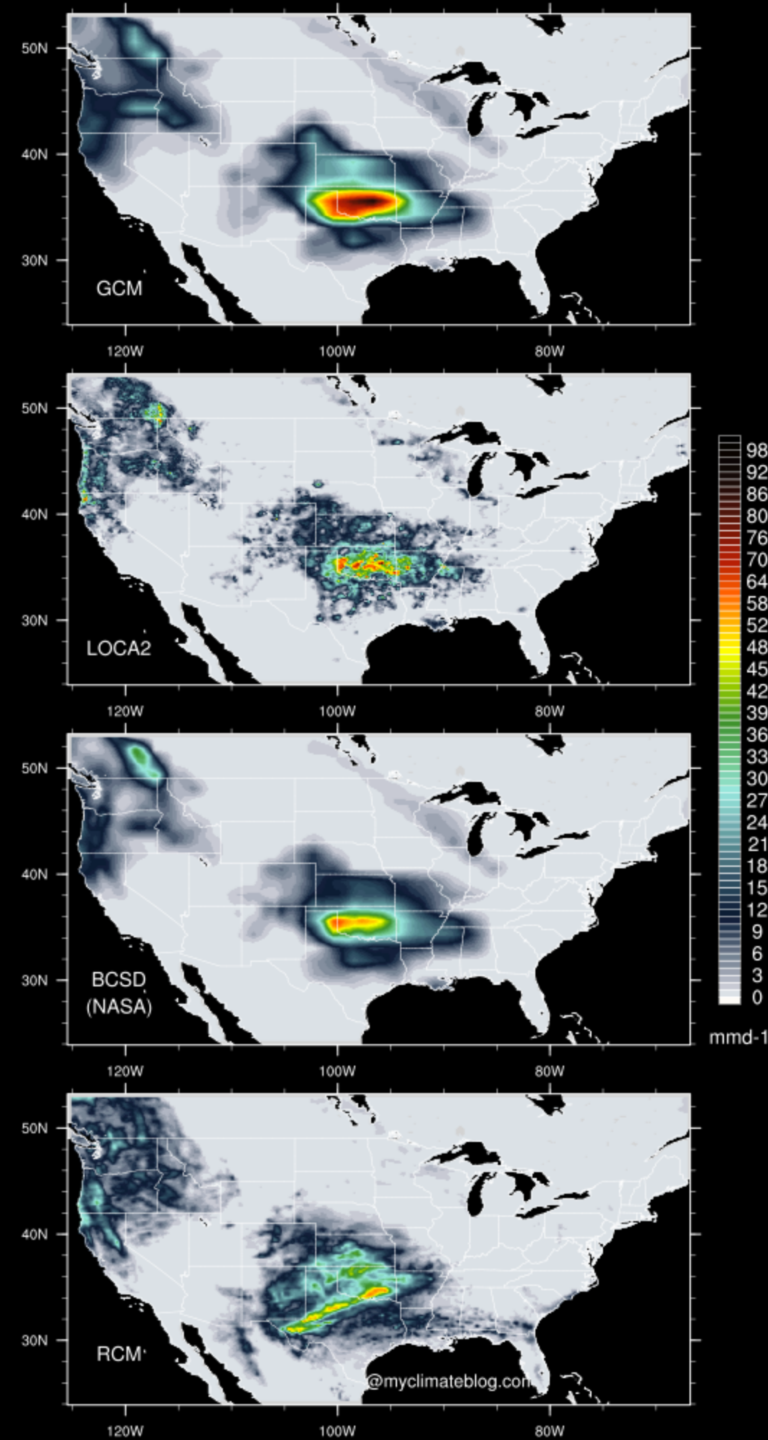
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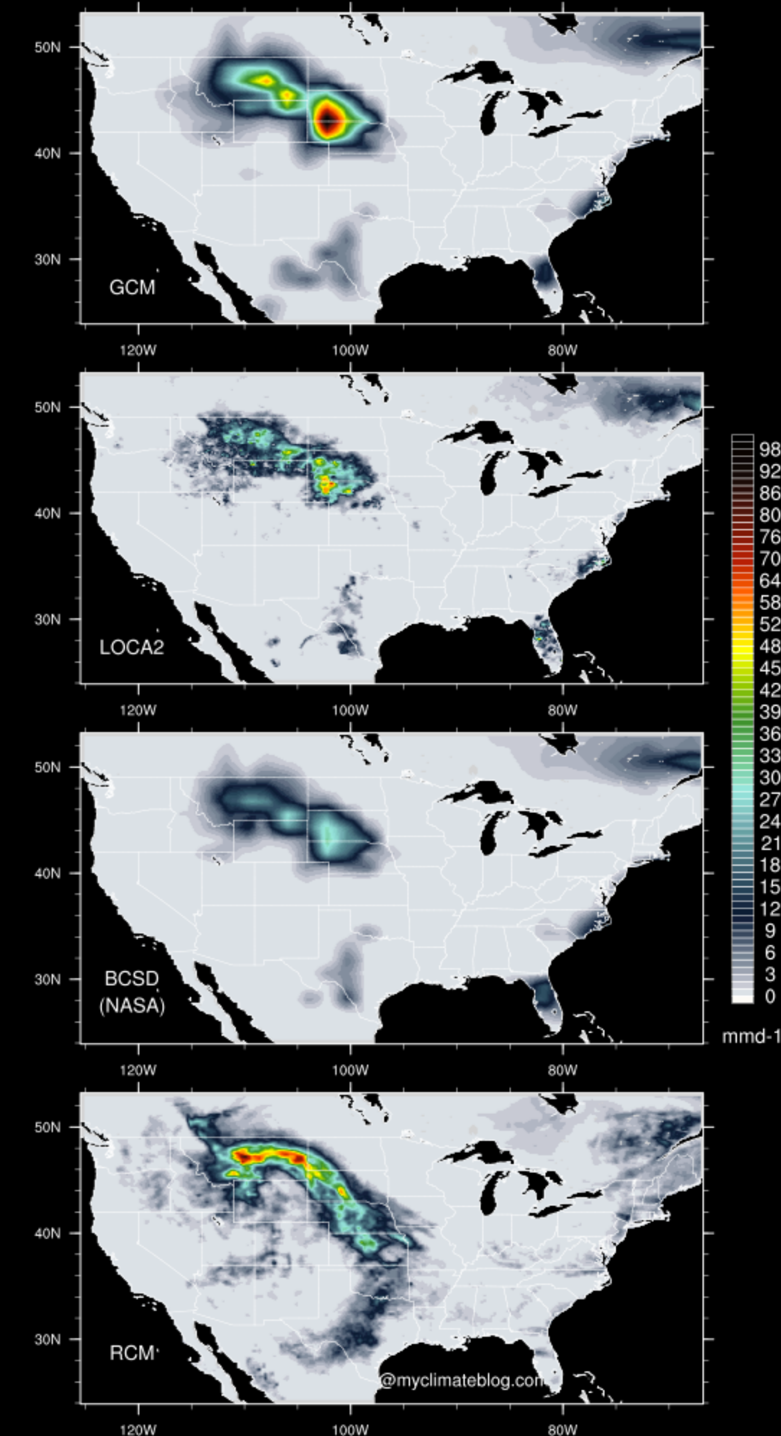

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mmd-1

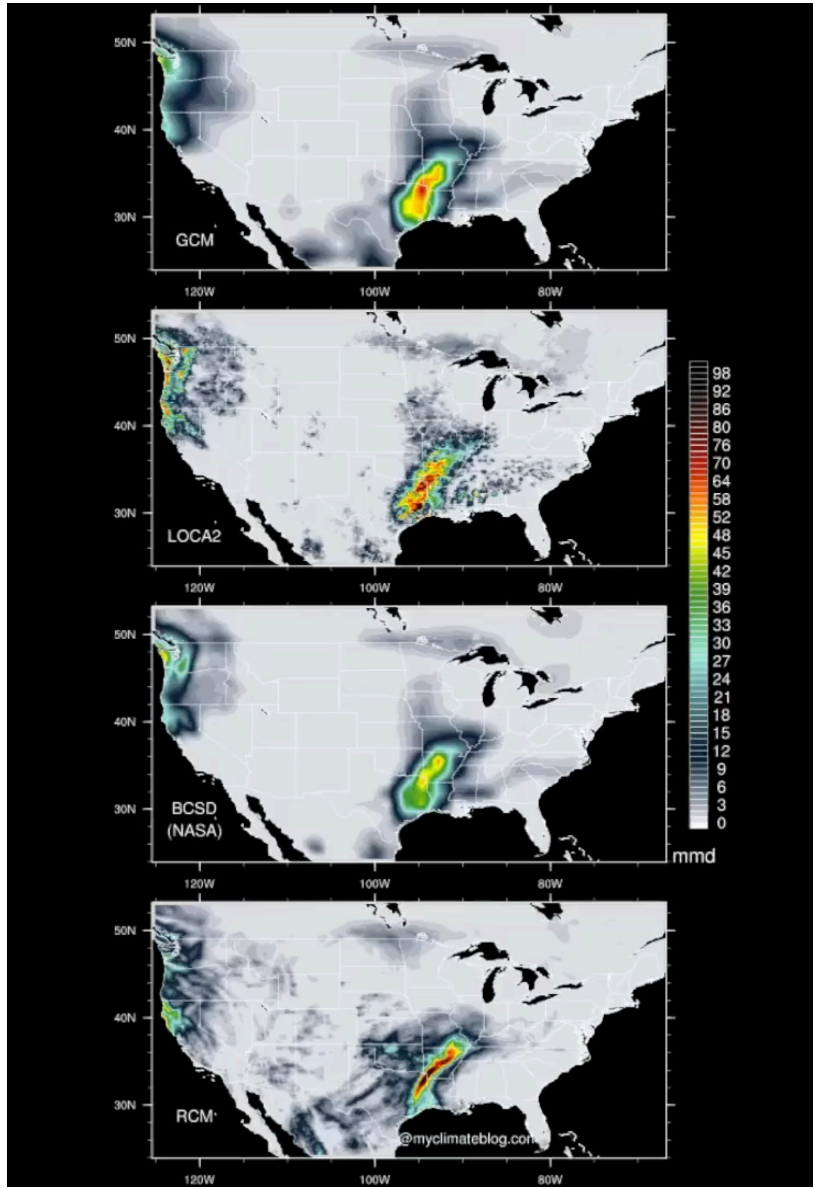
Statistical Downscaling Issues

Global Climate Model

Statistical Downscaling (LOCA)

Statistical Downscaling (BCSD)

Dynamical Downscaling



If a GCM does **not** have squall lines or MCS vortices, **statistical downscaling won't have either**!

This is an animation; download it from the following link: https://tinyurl.com/2ek9dn66ppt26w&dl=0

Summary

- In addition to the assumption of stationarity, statistical downscaling has the following lesser-described issues:

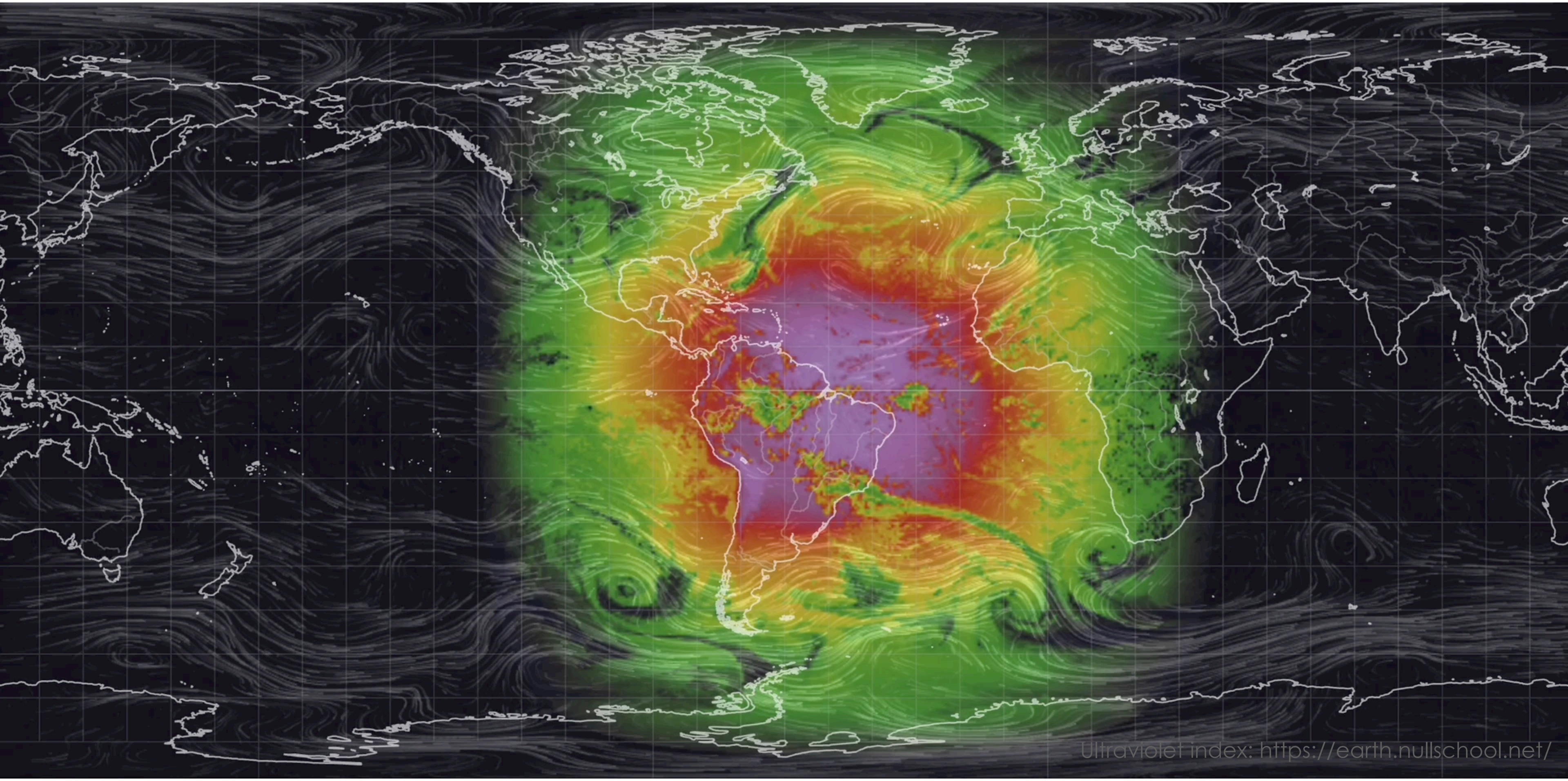
  ➡ Resolved scales are coarser than physical models.

  ➡ Climate change signal is often as coarse as GCMs.

  ➡ Perturbation in GCMs projected climate change has no physical explanation.

  ➡ Cannot correct GCM's errors in fine-scale feedbacks.

  ➡ Cannot improve the physical representation of precipitation-generating processes.



Questions?