# Overview of Downscaling

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# PURPOSE OF DOWNSCALING

To produce climate information and projections

that can be used to assess the impacts of climate variability and change

on human and natural systems

whose processes operate at finer spatial and/or temporal scales than a typical global model

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# Global Climate Models (GCMs)

- Why is there the need to downscale Global Climate Model data?
- First, what happens in a GCM?

# Global Climate Models (GCMs)

- The earth's atmosphere is broken into grid boxes
- Typical horizontal dimensions of grid boxes is 100-200 km
- Equations that describe atmospheric processes are solved for each grid box
- Each grid box is characterized by a single value of temperature, precipitation, humidity, and other state variables at each time step

# Global Climate Models (GCMs)

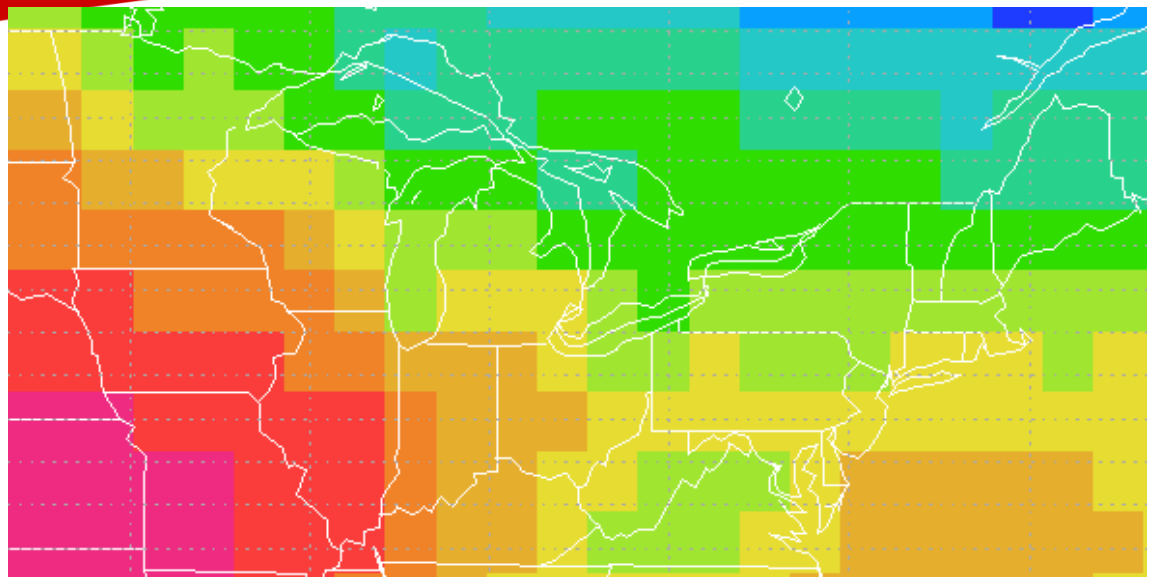
- Surface topography is resolved at the same dimensions (100-200 km): the surface is essentially a set of 100-200 km plateaus
- As a result, details of topographically-induced climate features are not well simulated in mountainous regions
  - Upwind enhancement of precipitation; rain shadows, etc.

# Global Climate Models (GCMs)

- In addition, some important physical processes and meteorological phenomena occur at smaller scales than the typical GCM resolution
- One of these is convective precipitation, which is the dominant form in warm seasons and climates

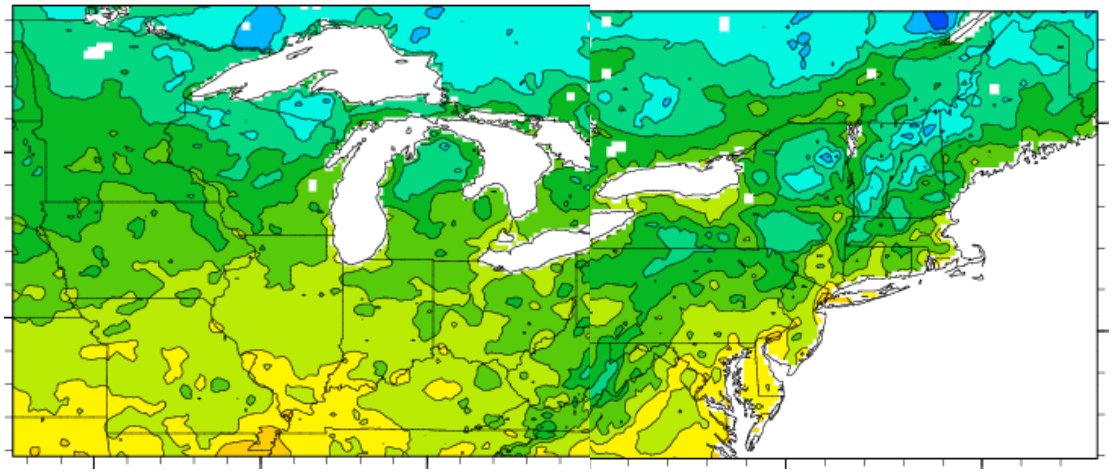
# Examples of GCM simulation data

# FROM GLOBAL TO LOCAL

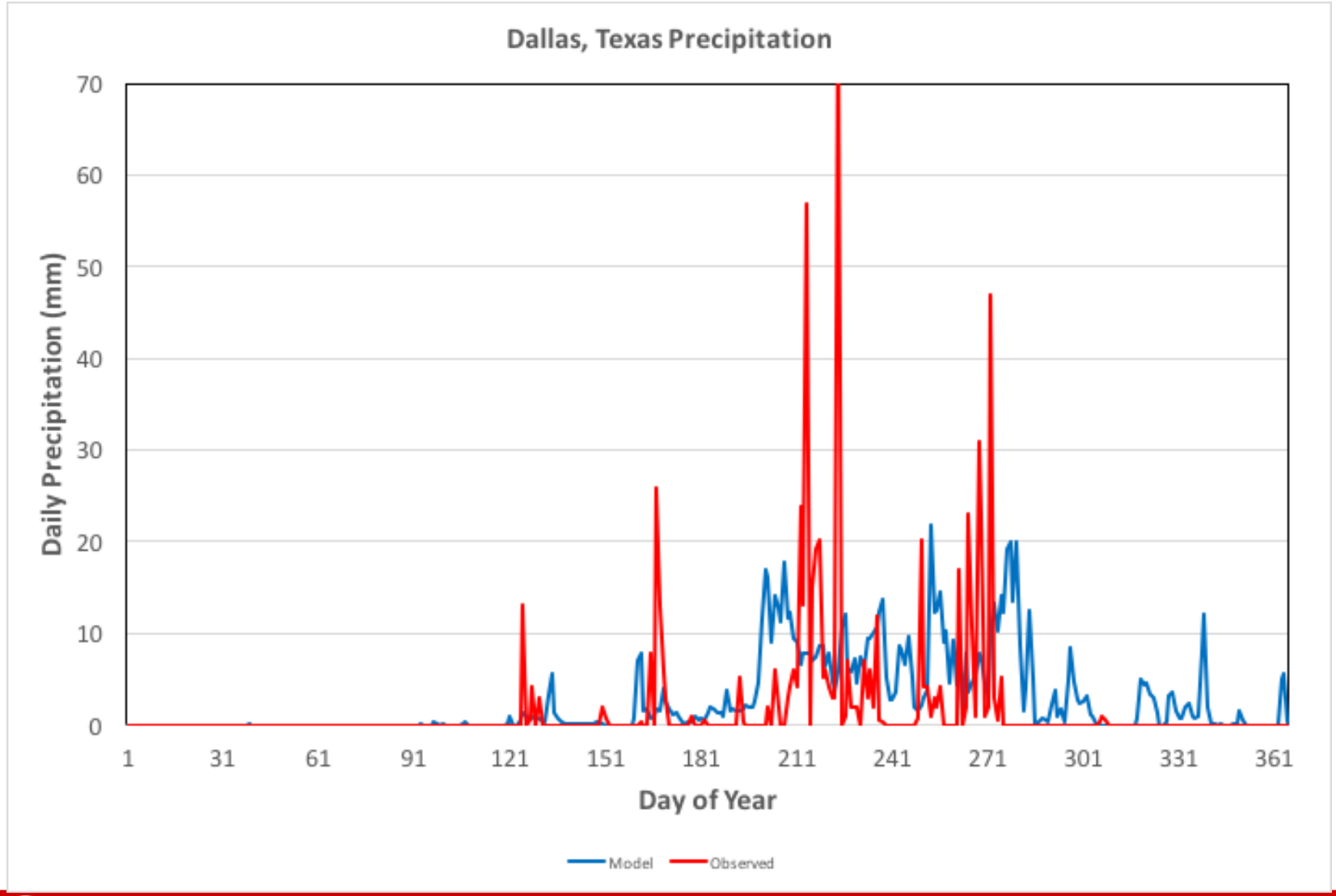


2m TEMPERATURE

GROWING SEASON LENGTH



# Example – Pune



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**EMPIRICAL-STATISTICAL MODELING**

**REGIONAL CLIMATE MODELING**

# Empirical-Statistical Downscaling Techniques

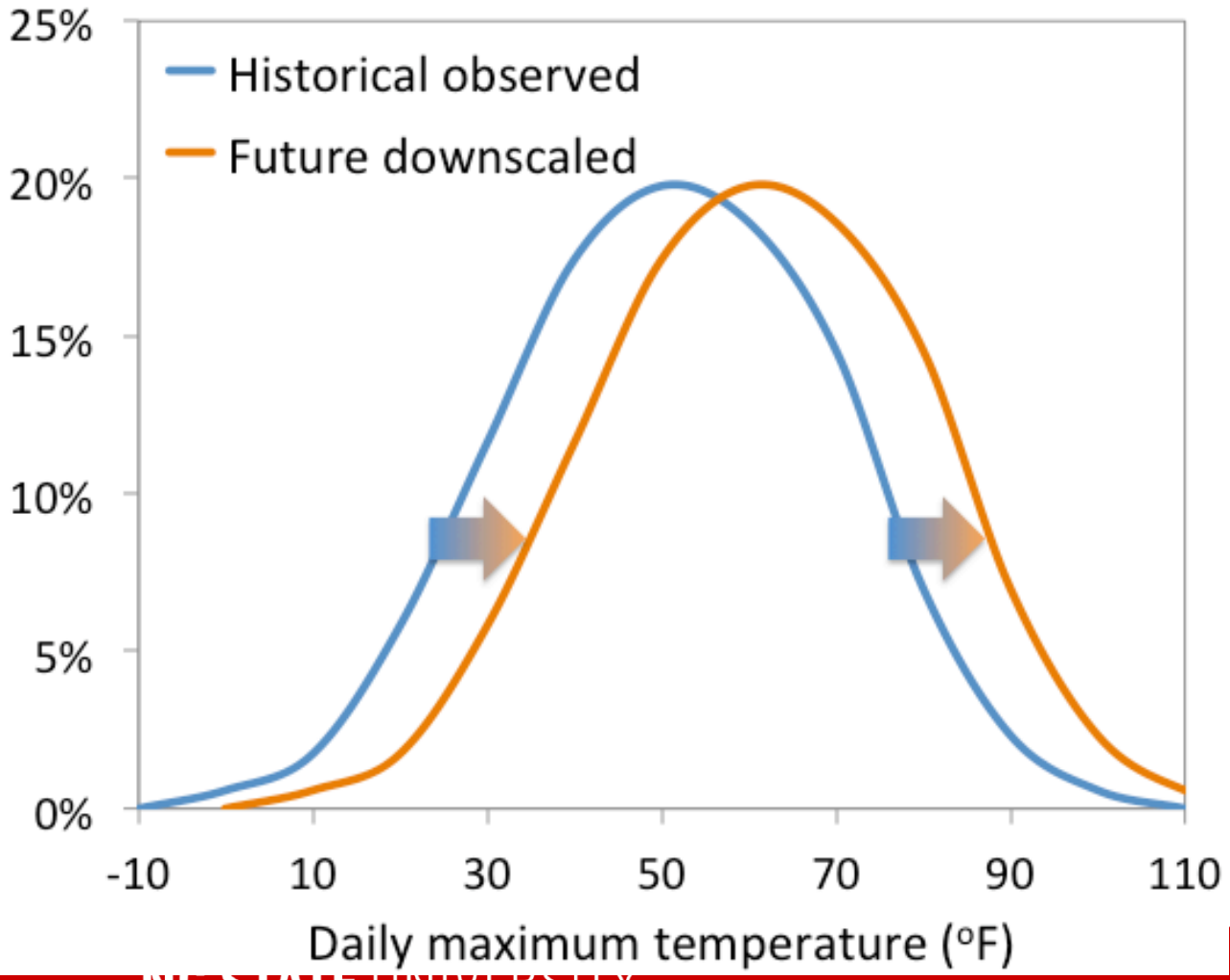
- Use historical observations and model simulation of historical period to “train” a statistical model
- Apply statistical relationships to model simulation of future (this assumes that these relationships remain constant in the future)

# Statistical Downscaling Techniques

- Simple bias correction (”delta” model):
- Variance correction
  - Inflate or deflate magnitude of daily variations

# Delta Change

Calculates average difference between present and future GCM simulations, then adds that difference to the observed time series for the point of interest

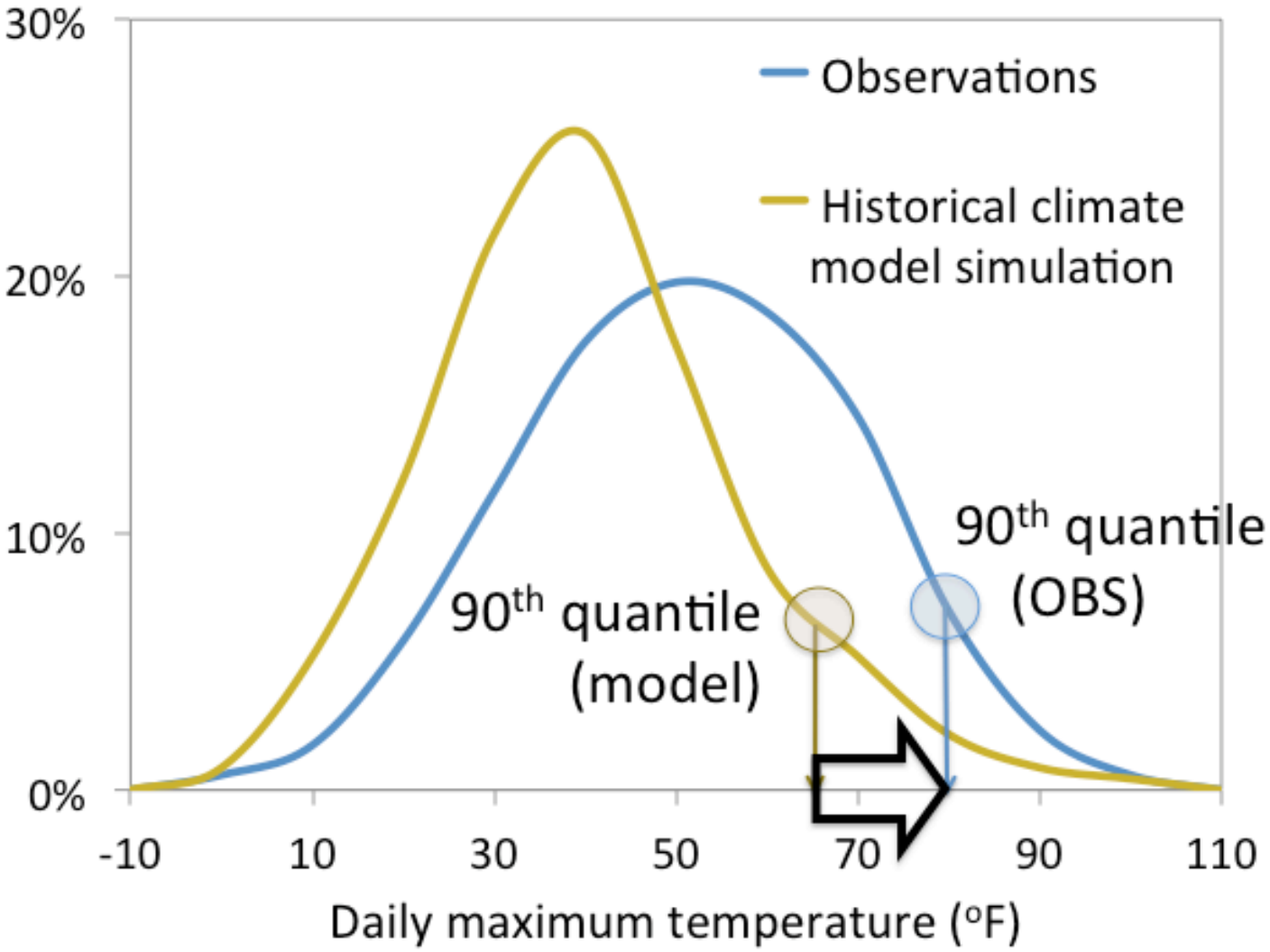


# Statistical Downscaling Techniques

- Quantile mapping – use entire probability density function, the major aim being to ensure that the extreme values are properly represented

# Empirical Quantile Mapping

Projects PDFs for monthly or daily simulated GCM variables onto historical observations



# Statistical Downscaling Advantages

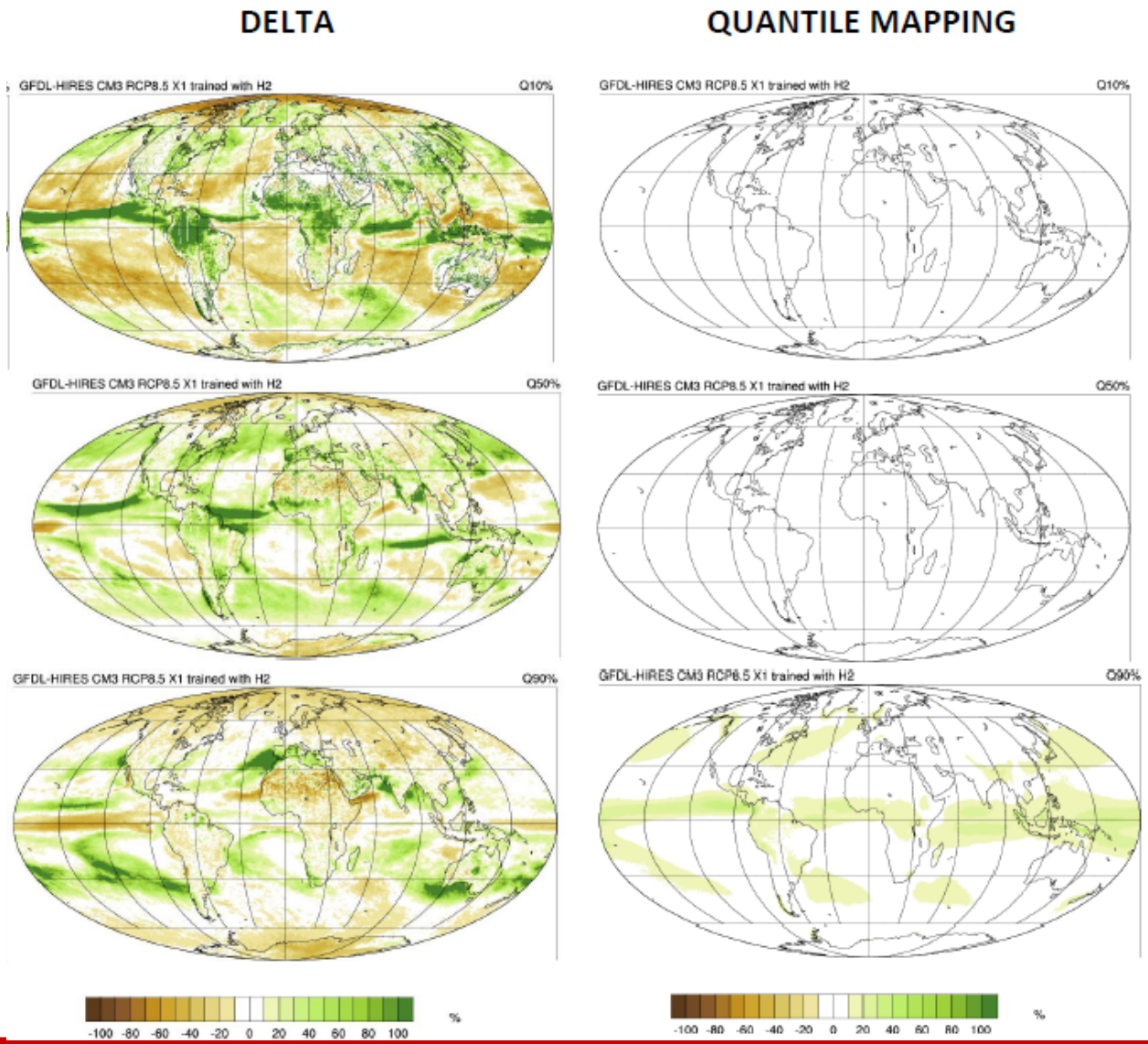
- Computationally inexpensive
- Modern techniques produce good representation of extreme tails

# Daily wet-day precipitation

**10 percentile**

**Median**

**90 percentile**



# Statistical Downscaling Disadvantages

- Need lengthy and accurate observational record (minimum 20-30 years)
- Cannot produce new physics (e.g. can't get a mesoscale convective system if it isn't in the GCM)

# Dynamical Downscaling Techniques

- A high resolution version of a climate model is applied for a limited geographical area
- Because the geographical area is limited in size, higher resolution is possible because computer resources are not being used to simulate the entire globe
- HOWEVER, a global model is required to establish the conditions on the boundary of the domain

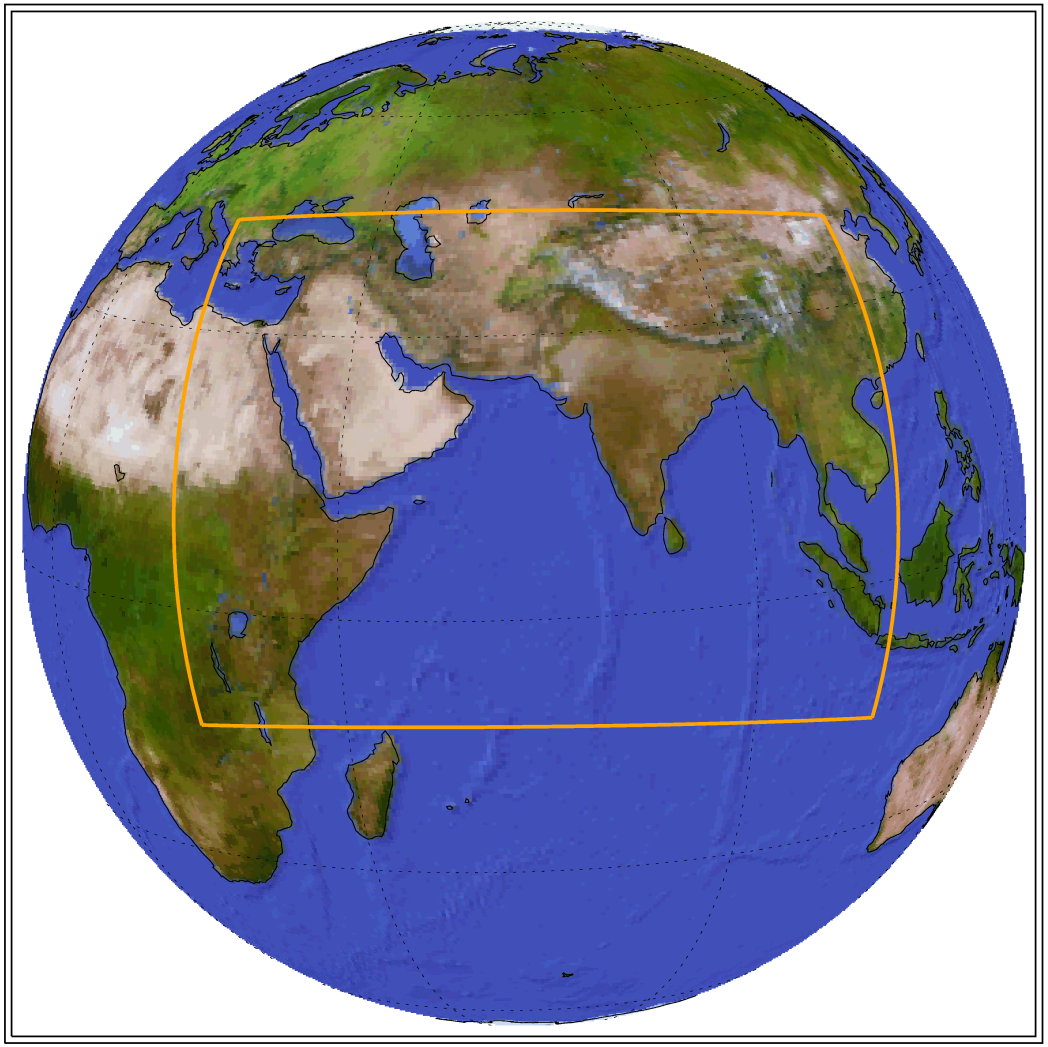
# CORDEX

- CORDEX: Coordinated Regional Climate Downscaling Experiment
- Coordinated by the World Climate Research Programme
- Experiments being conducted/planned over all land areas

# CORDEX South Asia Domain

The domain covers approximately 10% of the global surface.

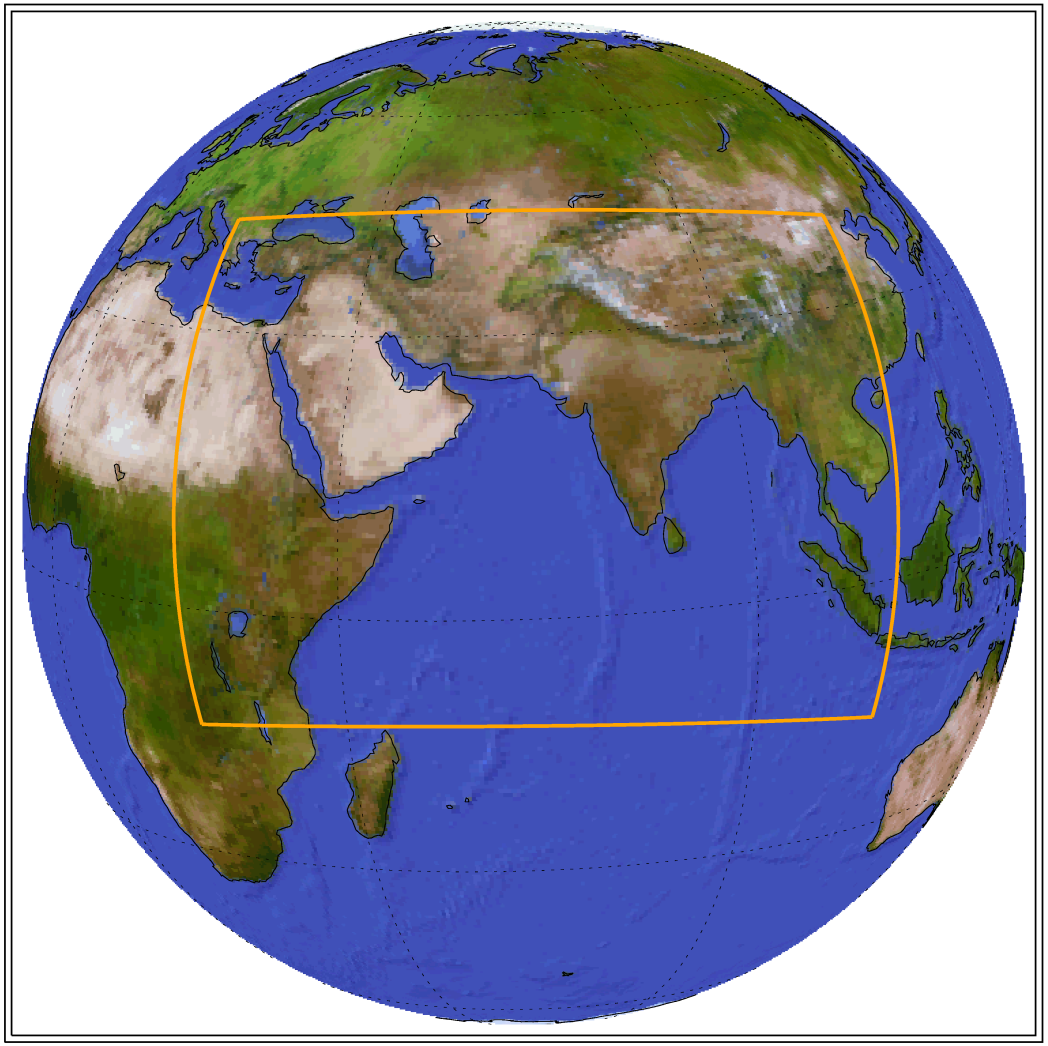
Can use computer resources for higher spatial resolution



# CORDEX South Asia Domain

A global climate model is needed to provide the conditions on the boundary of the regional climate model domain

Specify lateral boundary conditions every 6 hours

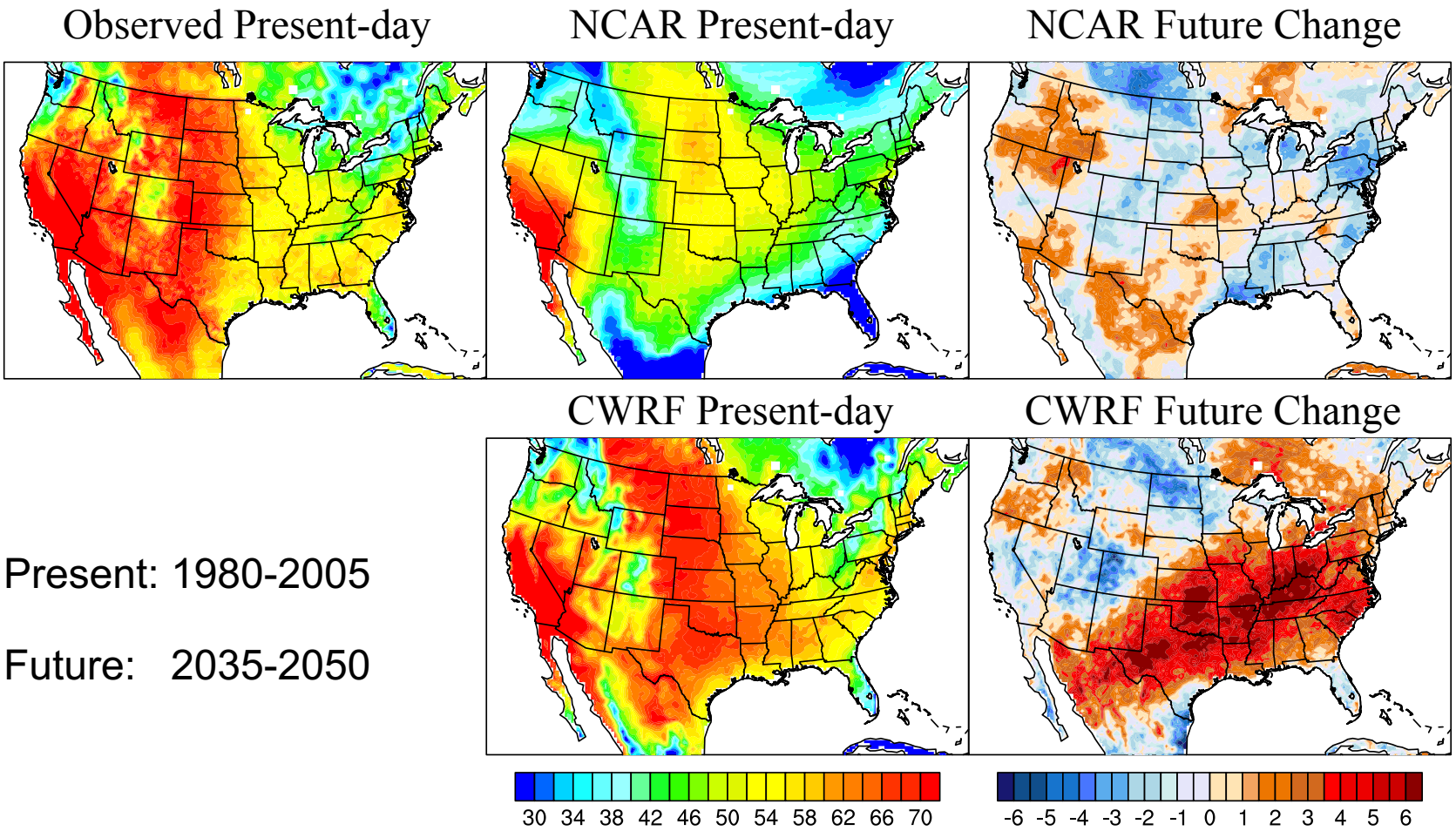


# Dynamical Downscaling Techniques

- One of the CORDEX experiments is a 25 km resolution simulation for 1950-2100

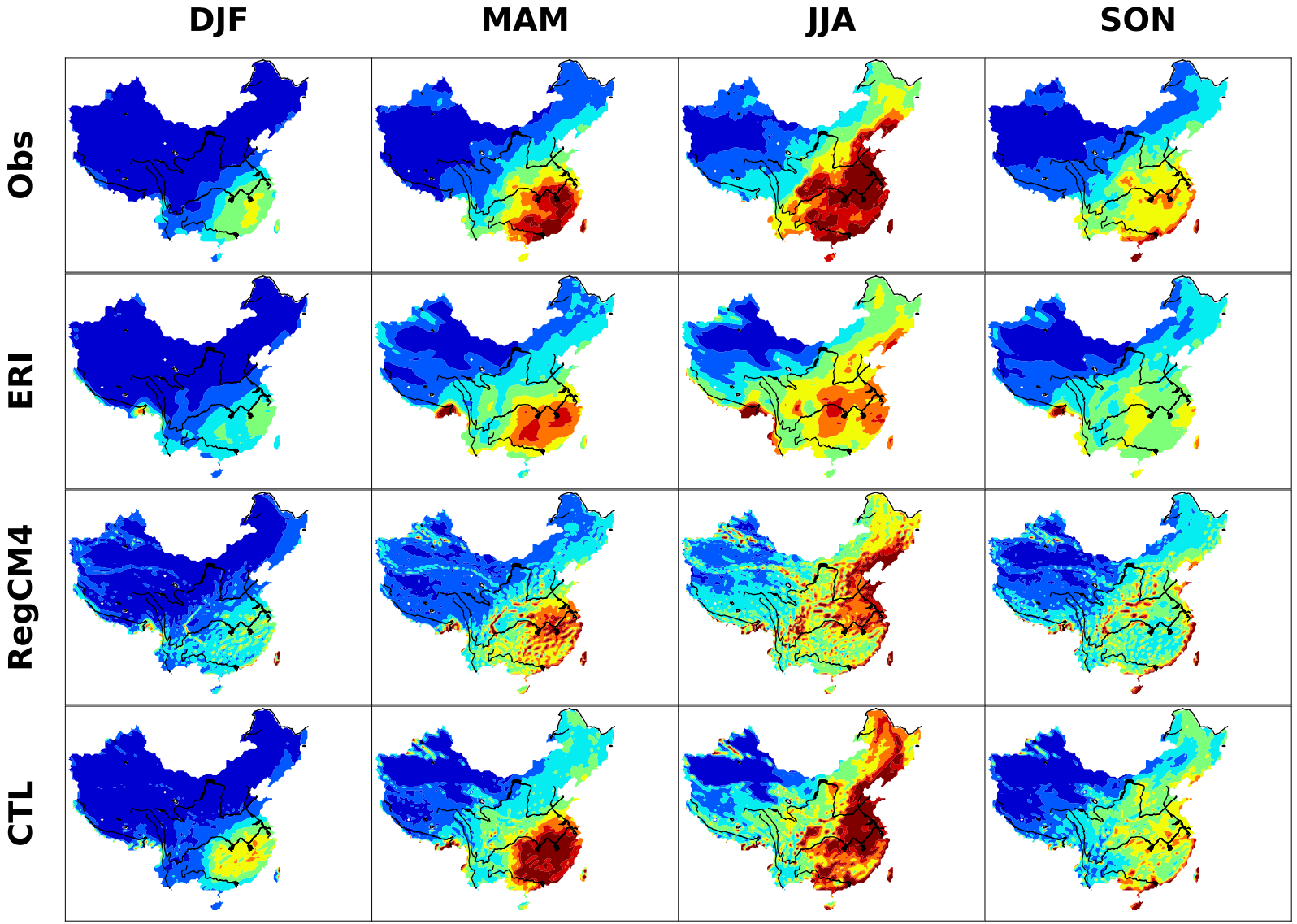
# CWRF Improves NCAR Climate Change Projection

## No of dry days (precipitation < 0.25 mm)




Present: 1980-2005

Future: 2035-2050


DJF
MAM
JJA
SON
Obs
ERI
RegCM4
CTL
PCT95
(mm/day)
0
5
10
15
20
25
30
35

# Dynamical Downscaling Advantages

- The model can create its own weather, for example, for phenomena such as convective systems and tropical cyclones
- Topographically-forced features can be simulated with much better fidelity

# Dynamical Downscaling Disadvantages

- Very computationally intensive
- It is only practically possible to run a few experiments

# Conclusions

- Some type of downscaling is usually required to transform global climate model simulation data into something that can be applied to impacts assessments
- Empirical-statistical downscaling: very inexpensive and can thus employ all available GCMs
- Dynamical downscaling: can produce new physics