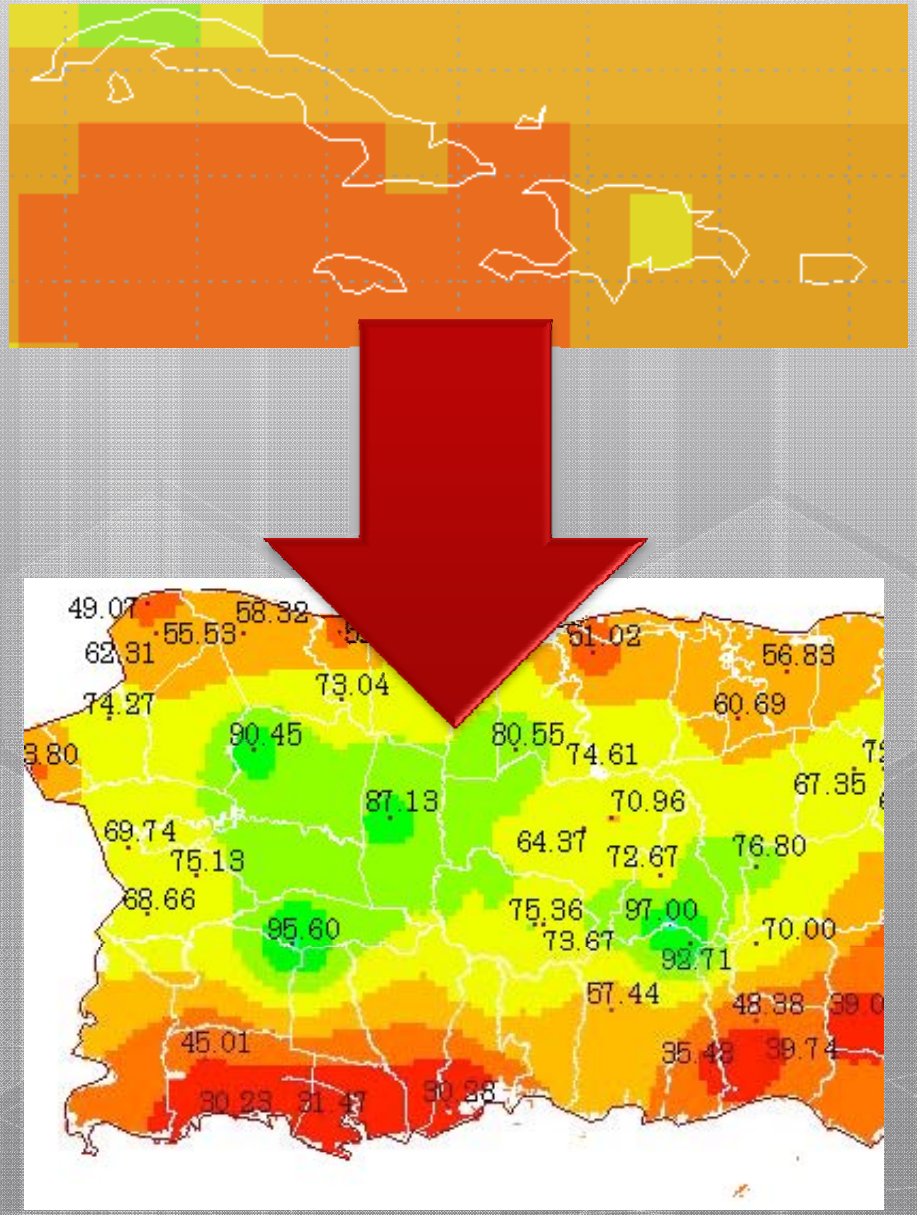
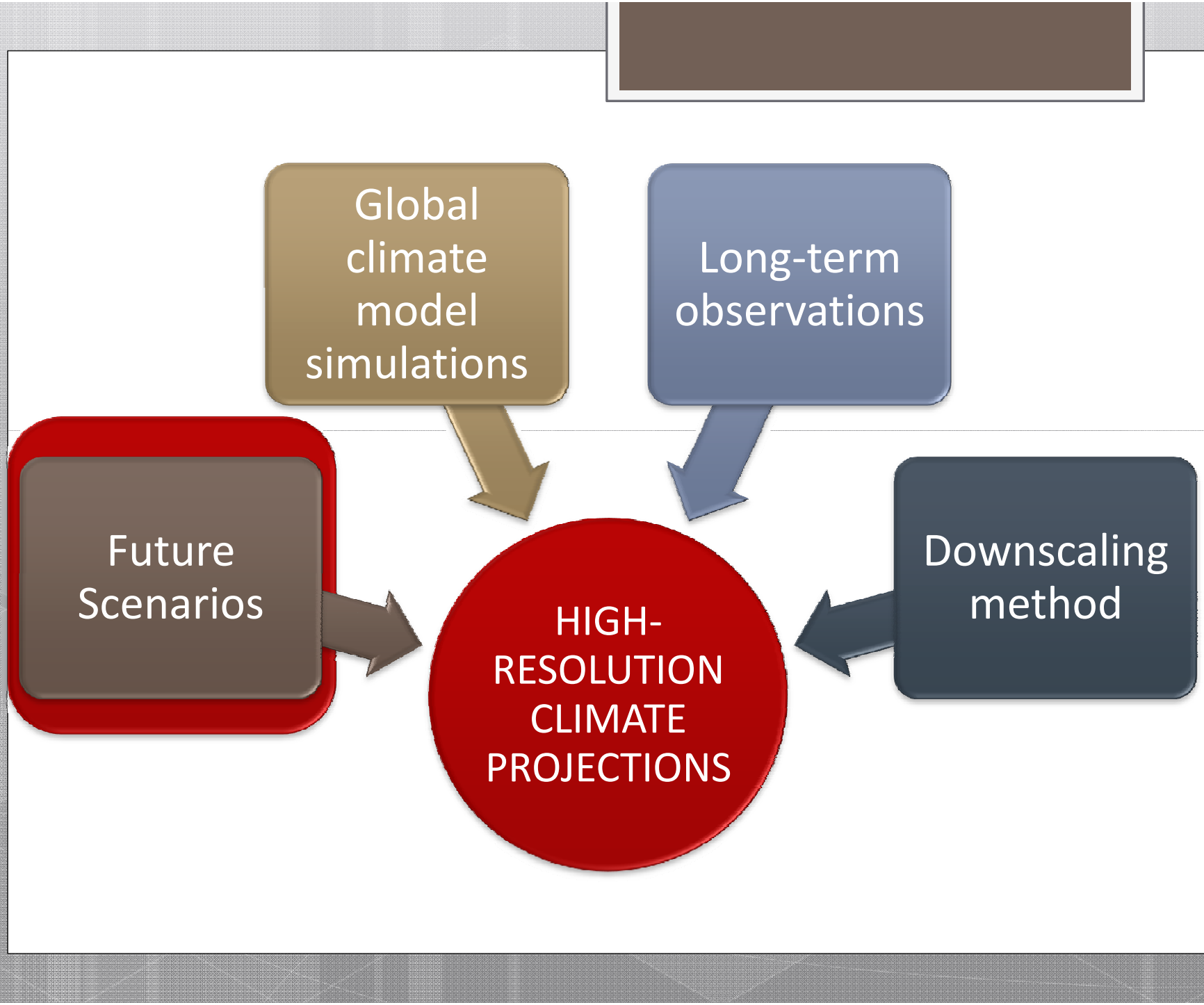


Generating High-Resolution Climate Projections for Puerto Rico and the Caribbean

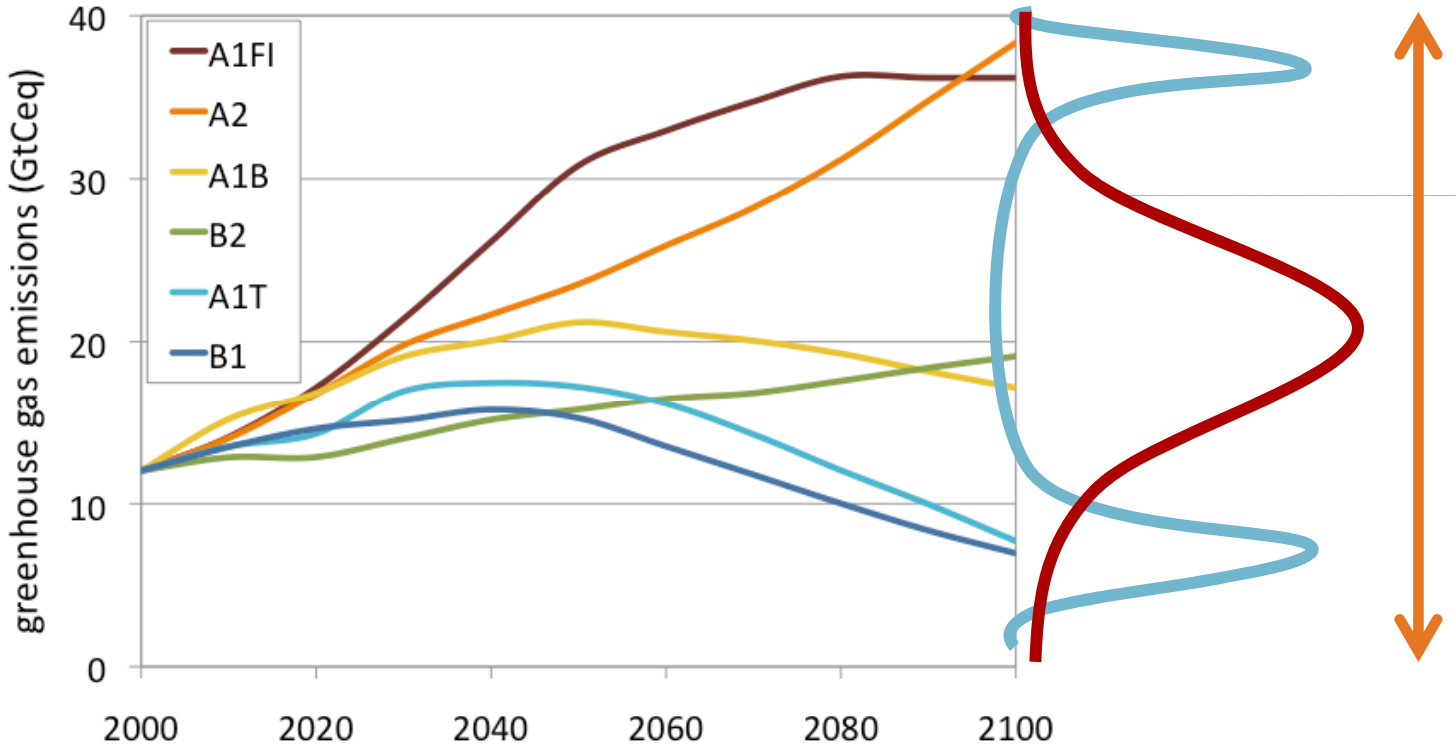
KATHARINE HAYHOE
TEXAS TECH UNIVERSITY


Global climate model simulations
Long-term observations
Future Scenarios
HIGH-RESOLUTION CLIMATE PROJECTIONS
Downscaling method

FUTURE SCENARIOS

How to choose?

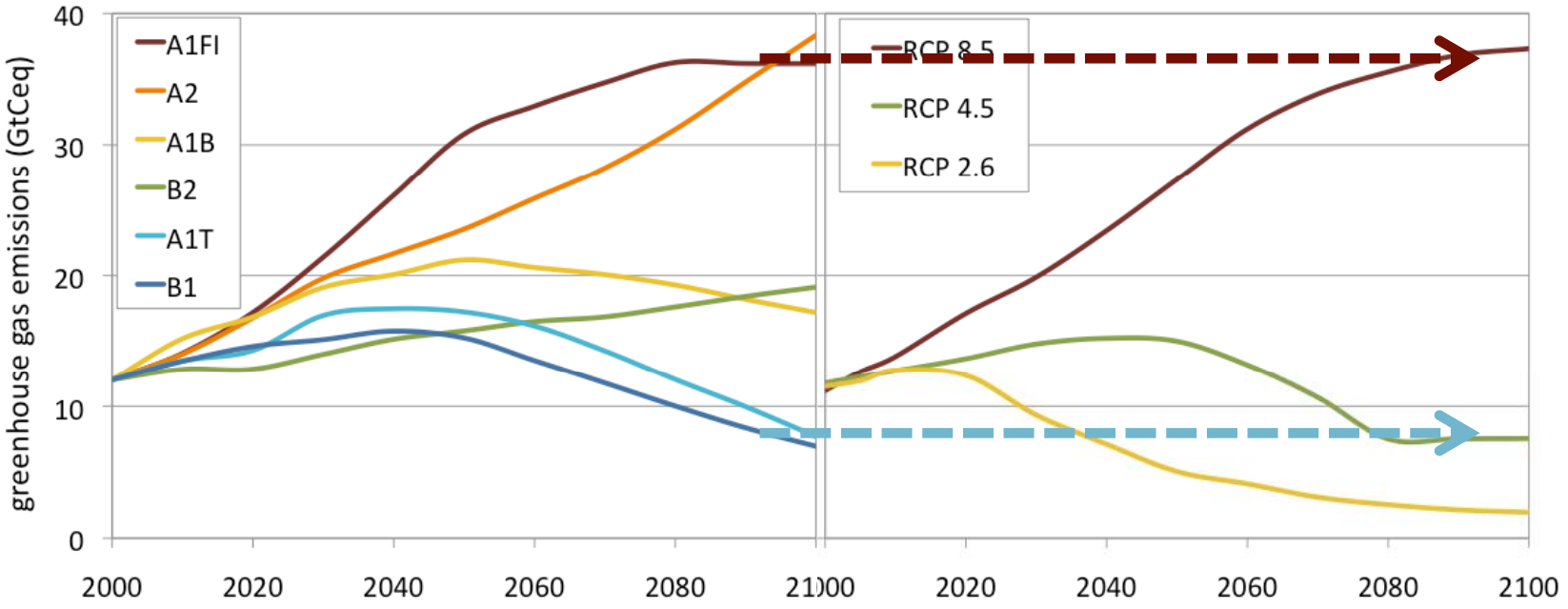
Can we assume a probability distribution?



Special Report on Emission Scenarios (SRES) - IPCC 2000

FUTURE SCENARIOS

Transitioning from SRES to RCP

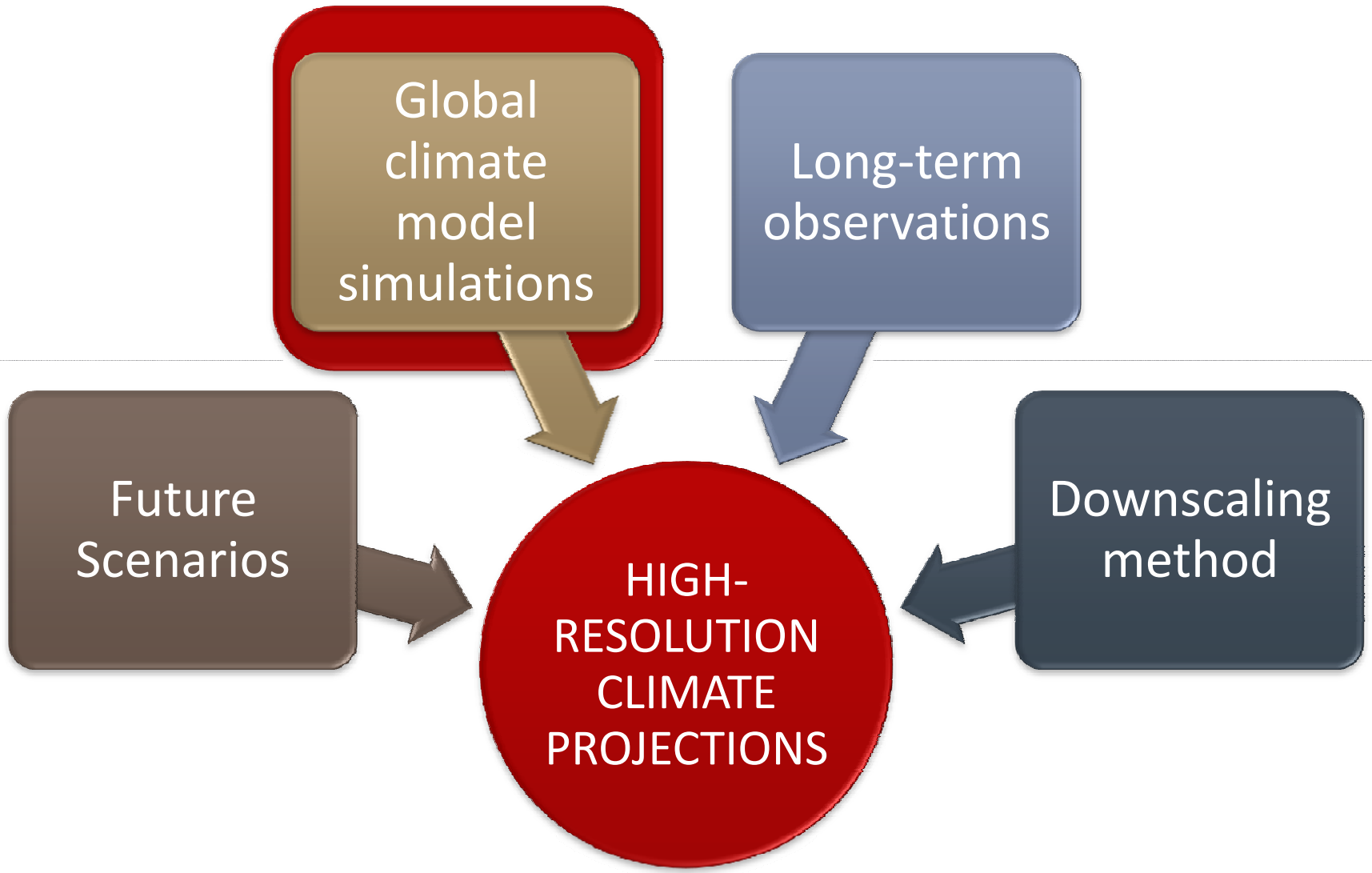


Special Report on Emission Scenarios (SRES)
IPCC 2000

Representative Concentration Pathways (RCPs)
IPCC 2009

Human Uncertainty

- The most important source of uncertainty in temperature projections beyond 60-70 yrs
- Use multiple scenarios covering a range from high to low (SRES A1fi/B1 or RCP 8.5/2.8)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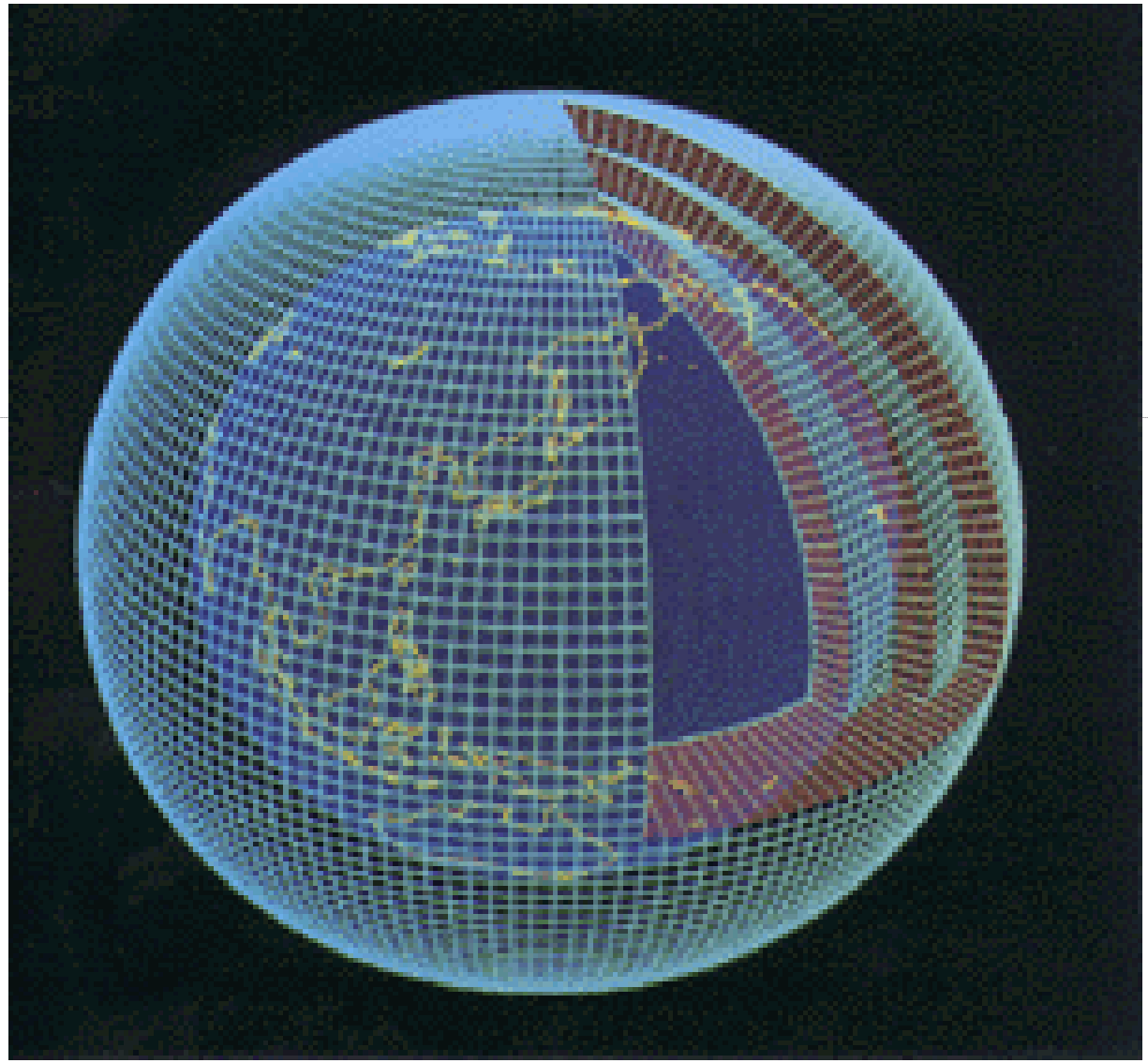
GCM =

Global Climate Model

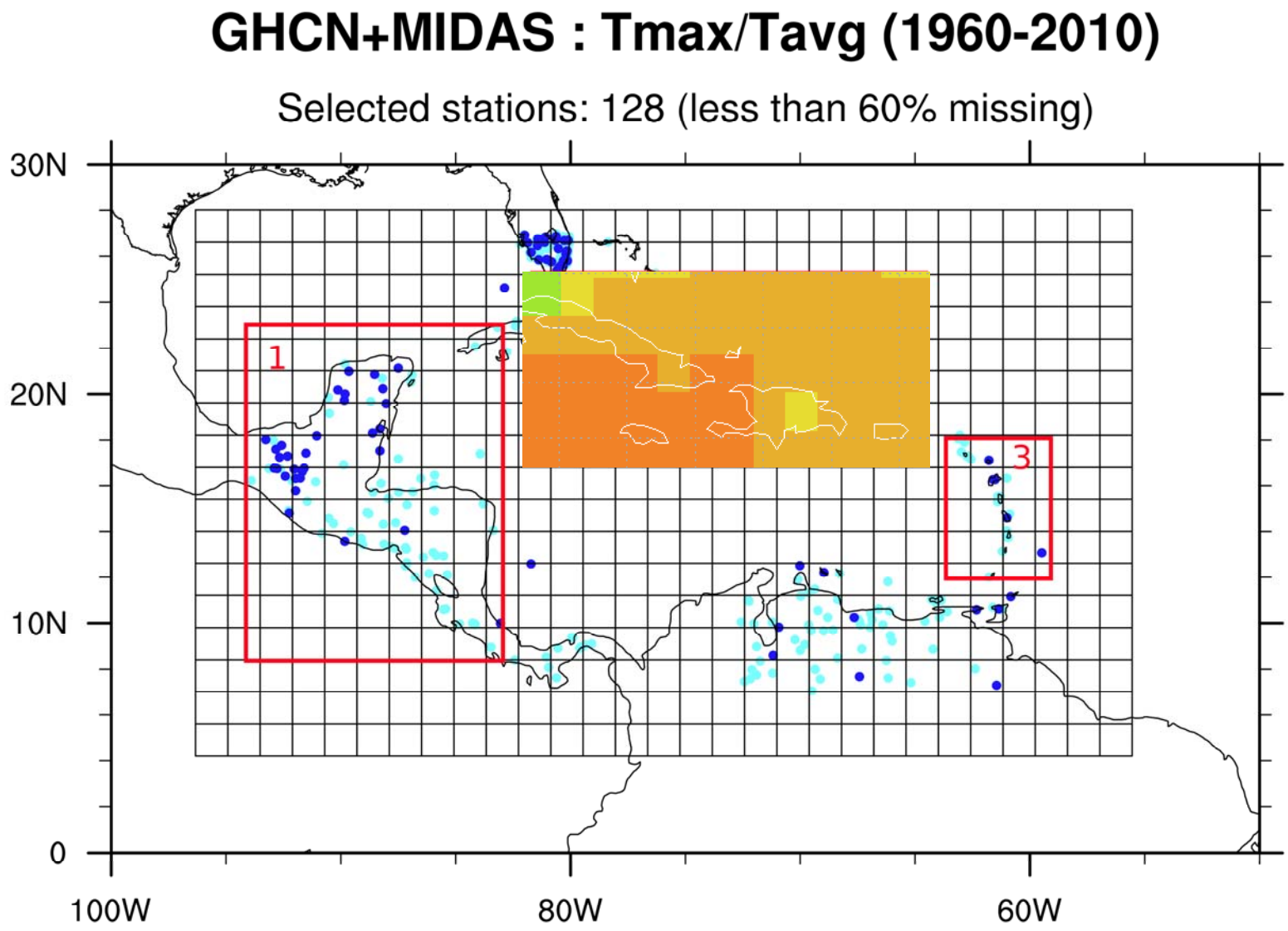
or

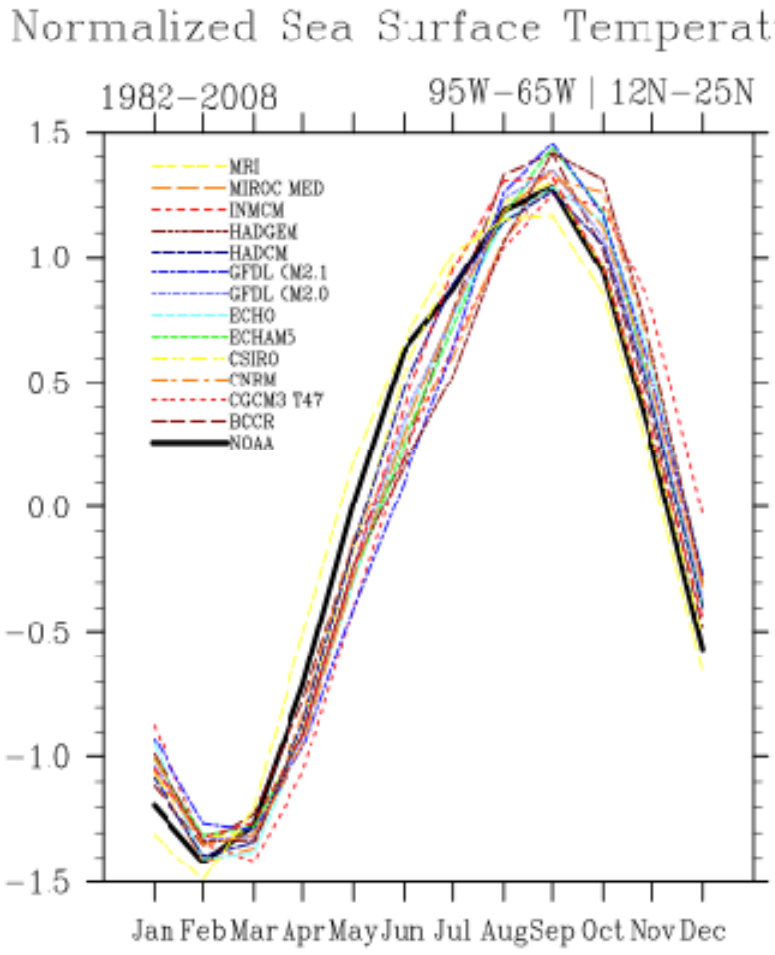
General Circulation Model

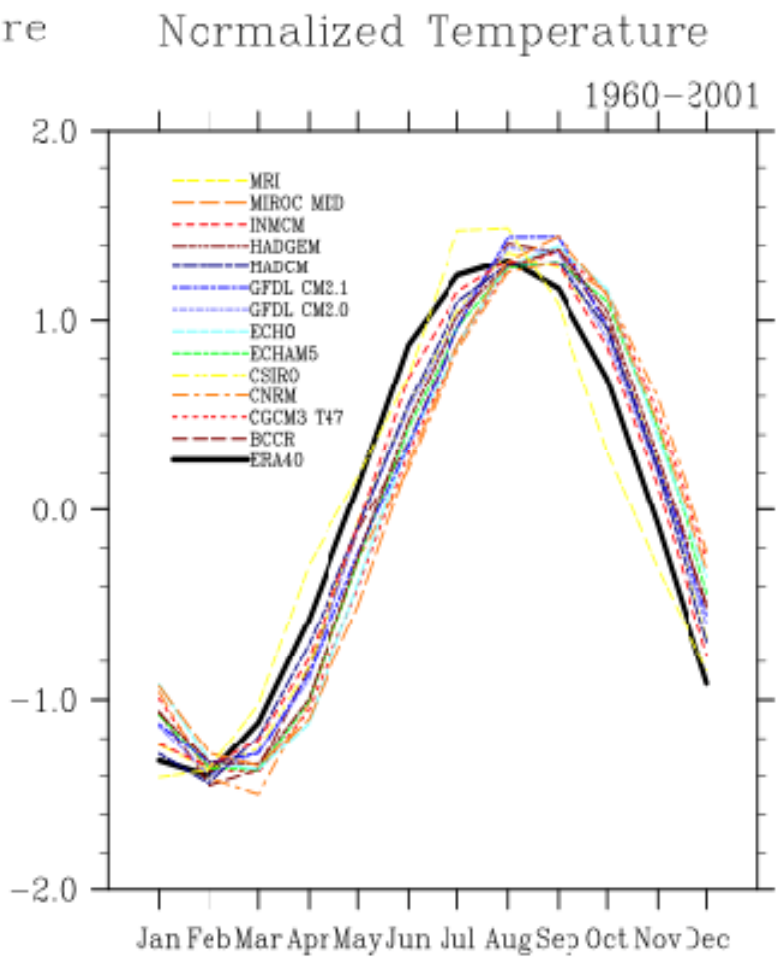


Evaluating climate models

NO MODEL IS PERFECT
BUT MANY
CAN BE USEFUL


GHCN+MIDAS : Tmax/Tavg (1960-2010)
Selected stations: 128 (less than 60% missing)
30N
20N
10N
0
100W
80W
60W
1
3



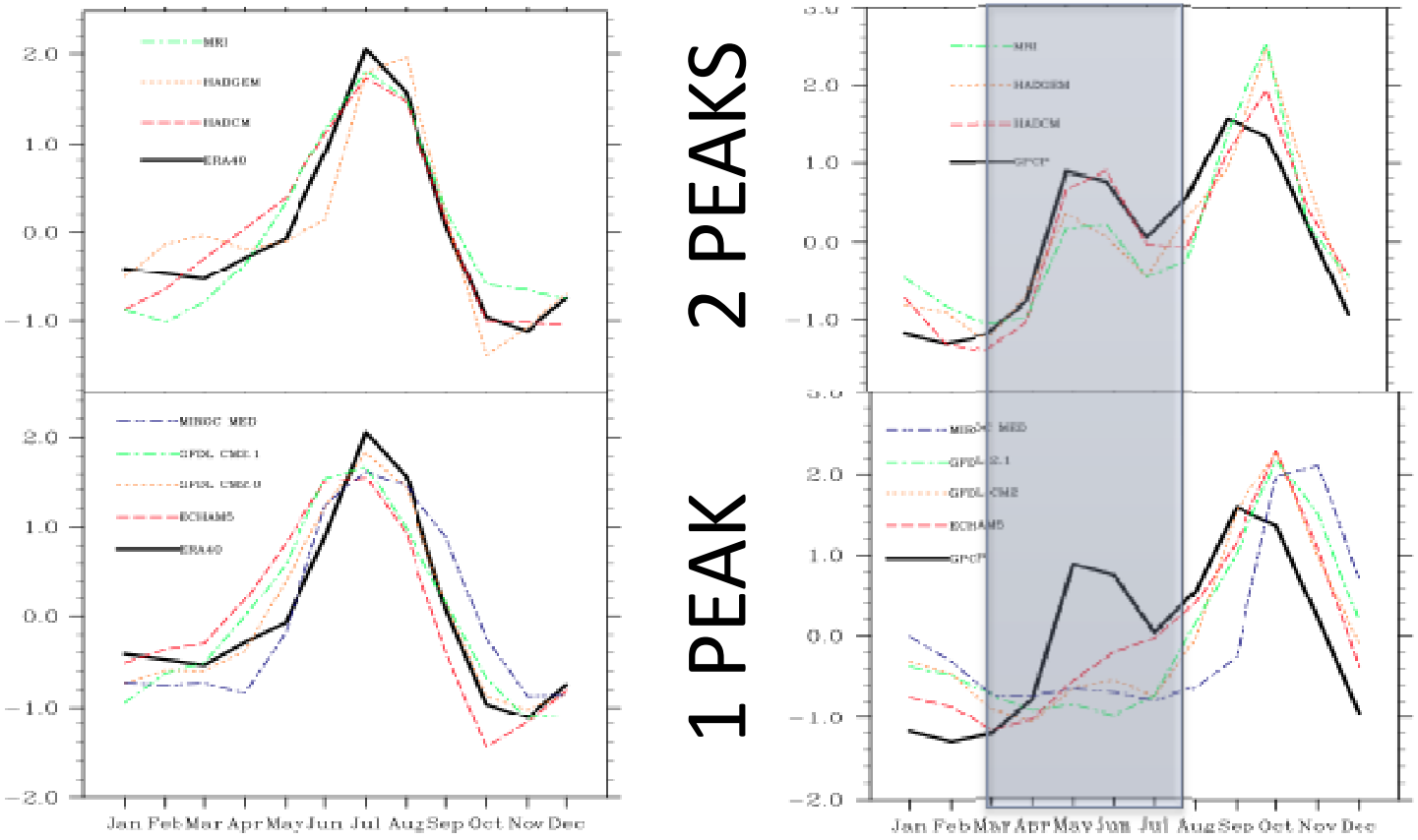


Land temperature & SST are related

Most GCMs have a 1m lag in both

925mb heights

rainfall

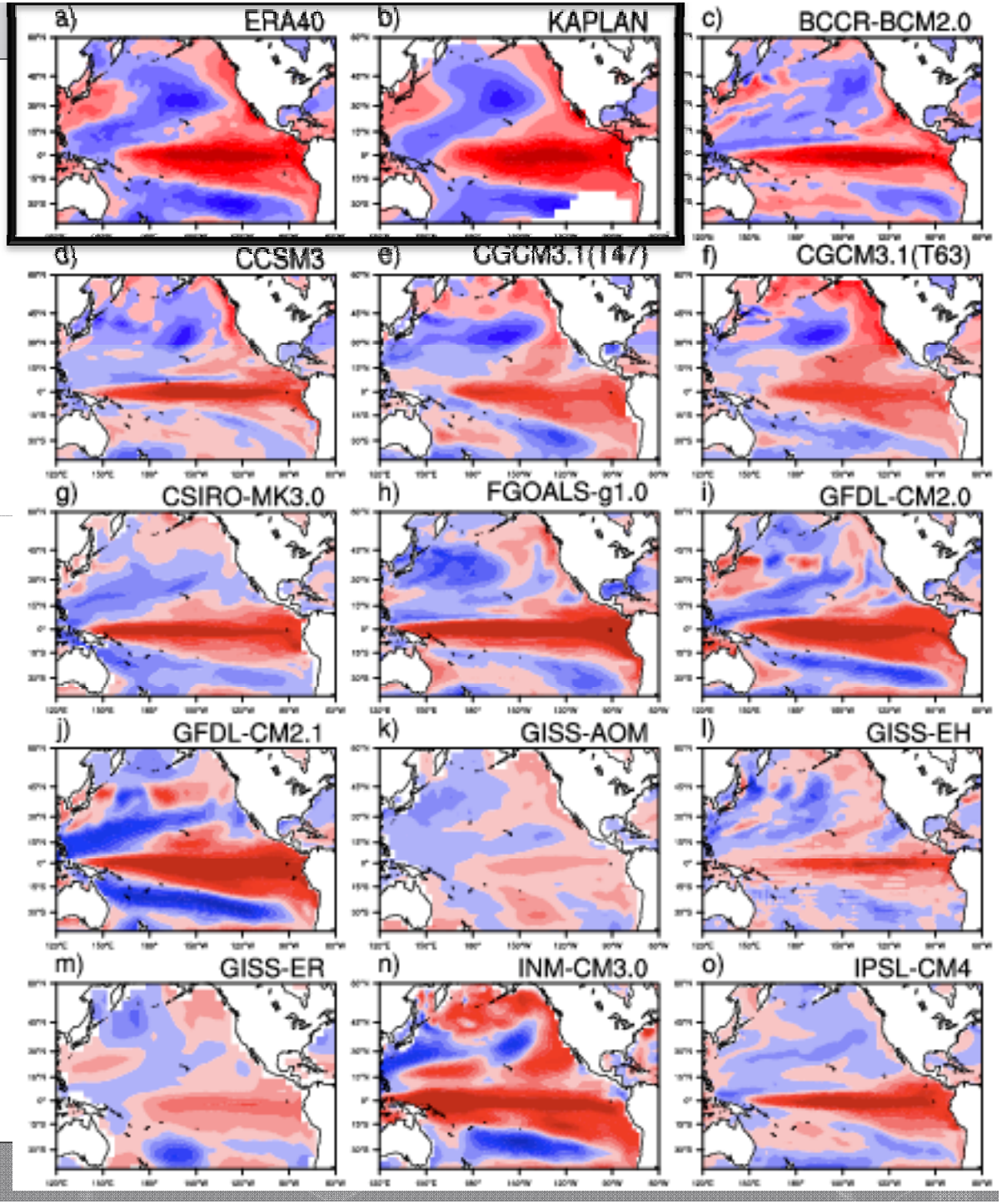


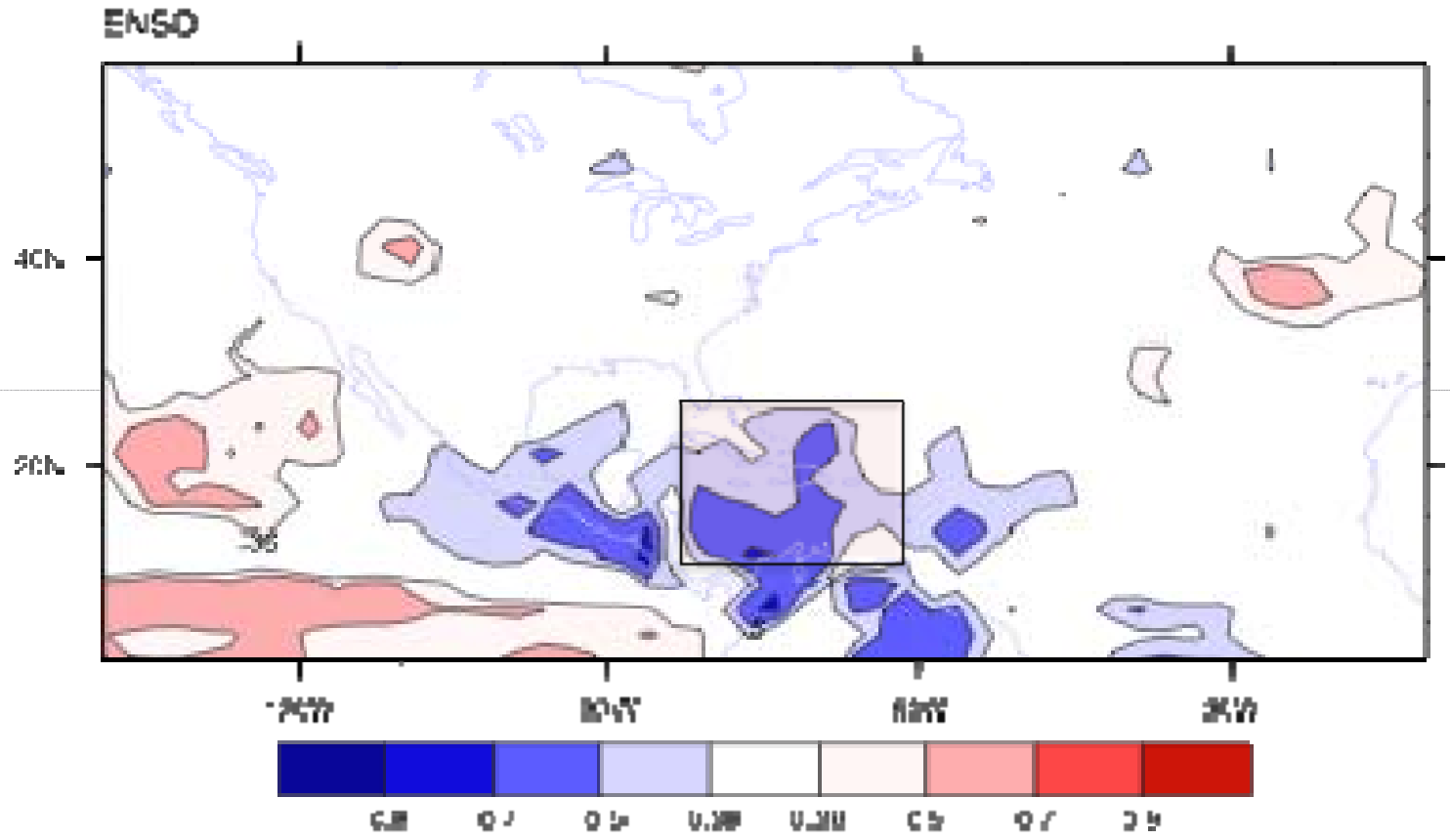
GCMs that capture double rainfall peak also better at near-surface pressure fields

WHAT ABOUT ENSO?

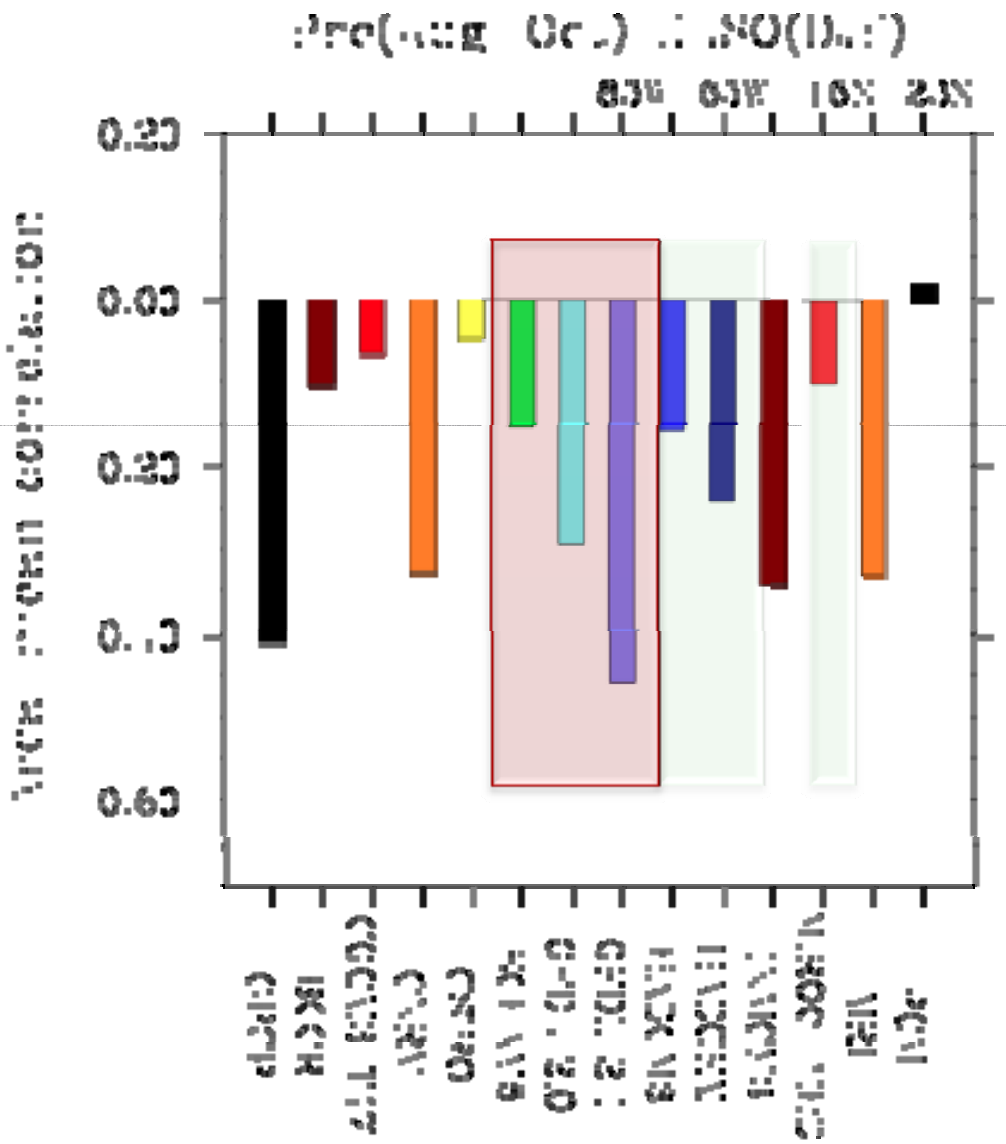
- **All models capture a recognizable ENSO pattern**
- Most models too strong, warm tongue extends too far west

Stoner, Hayhoe 2009





In the observations, there is a strong negative correlation between ENSO & Aug-Oct rain

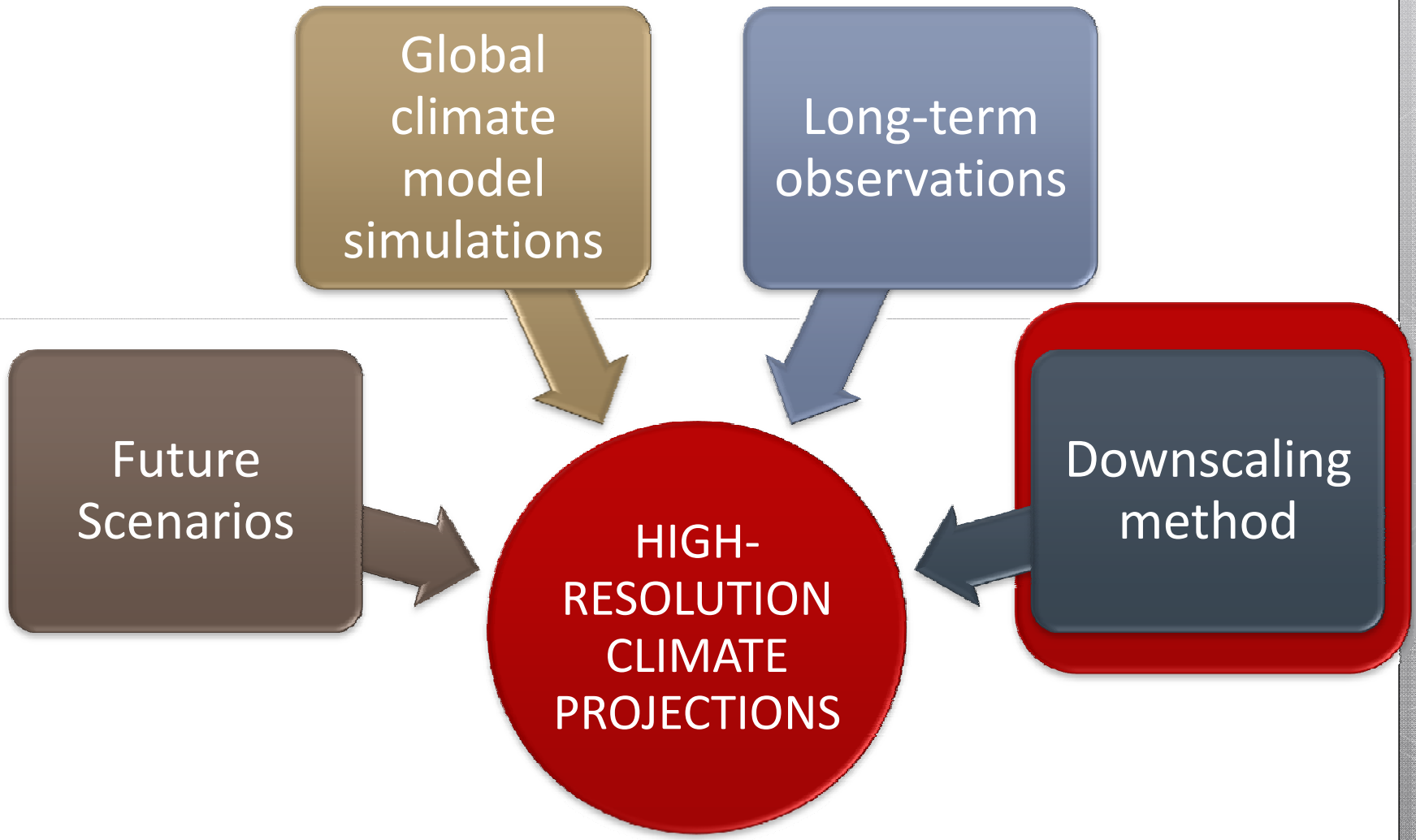


CORRELATION BETWEEN ENSO AND AUG-OCT PRECIP

Nearly every GCM gets the sign right.

Scientific Uncertainty

- Most important source of uncertainty in projections for next 40-60 yrs in temperature and 40-100 years in rainfall
- Use simulations from many, many climate models to cover an adequate range of climate sensitivity and model uncertainty
- Only **eliminate** climate models if they do not reproduce large-scale circulation features essential to the research question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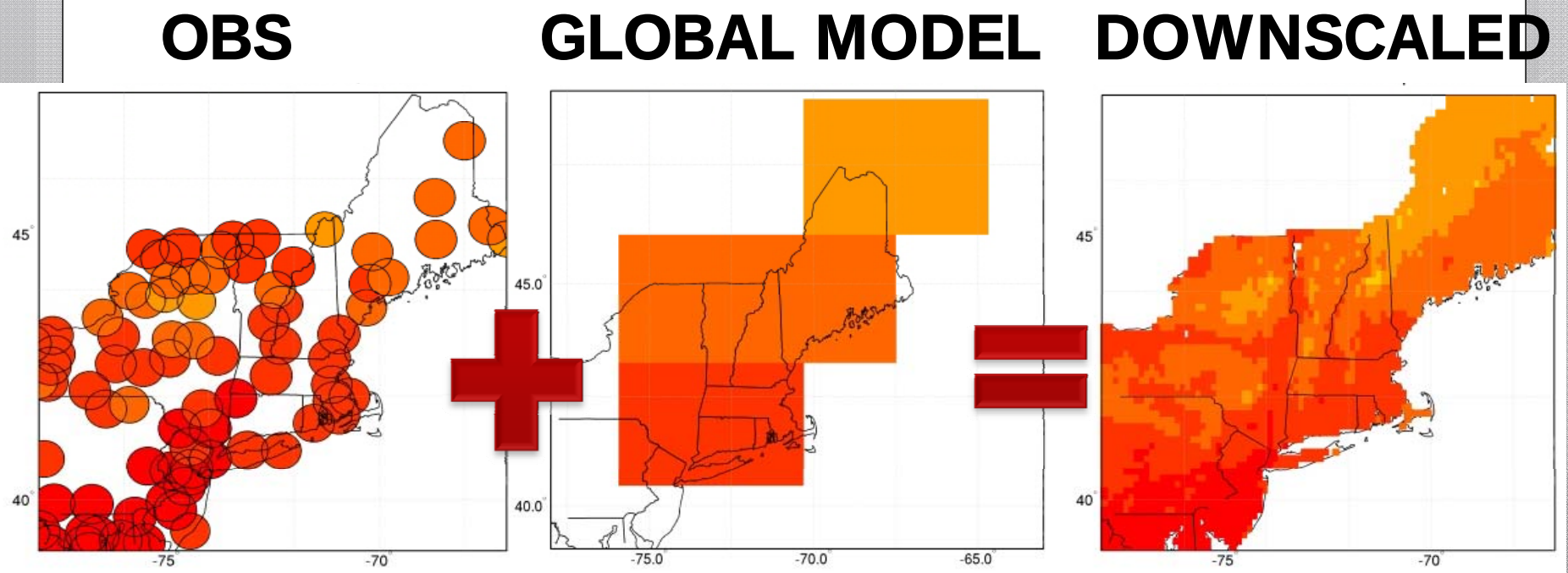
DOWNSCALING

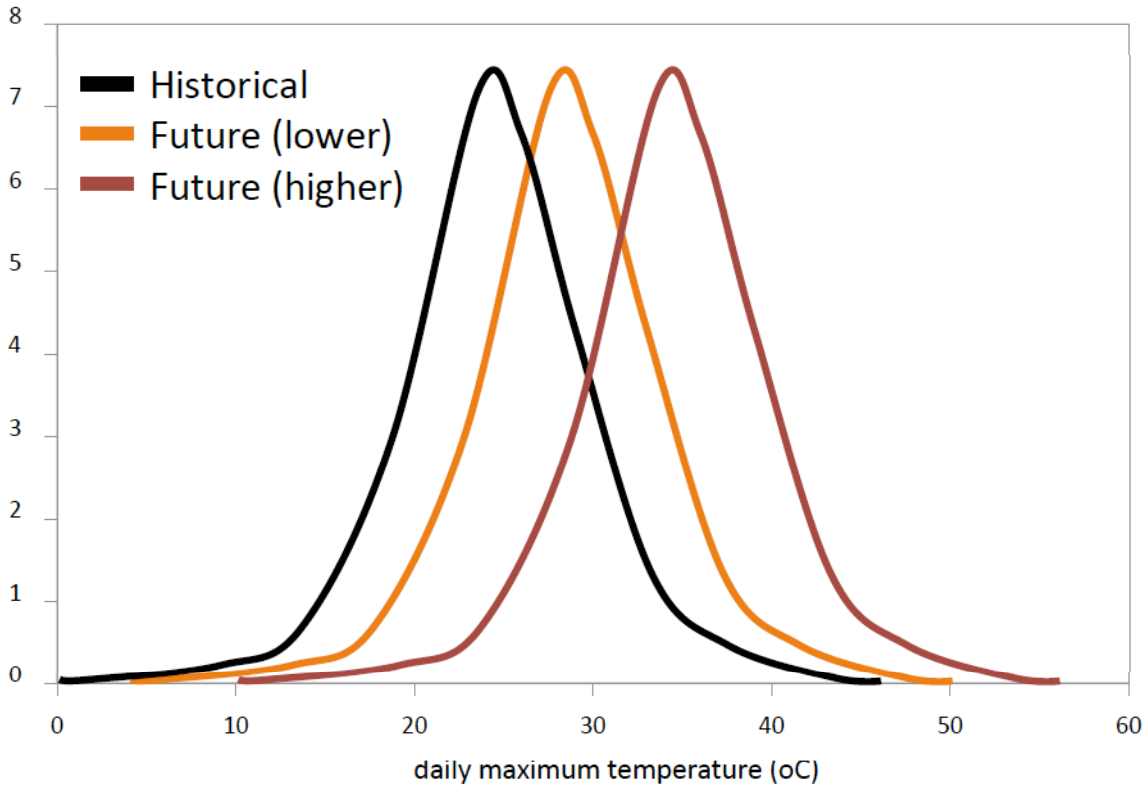


Simulating sub-gridscale variables from coarser-resolution fields

Based on assumption that variables at finer resolution than the spatial or temporal scale of the input are reproducible function of large-scale features resolvable by GCMs

Source: Hayhoe et al. 2009. MITI

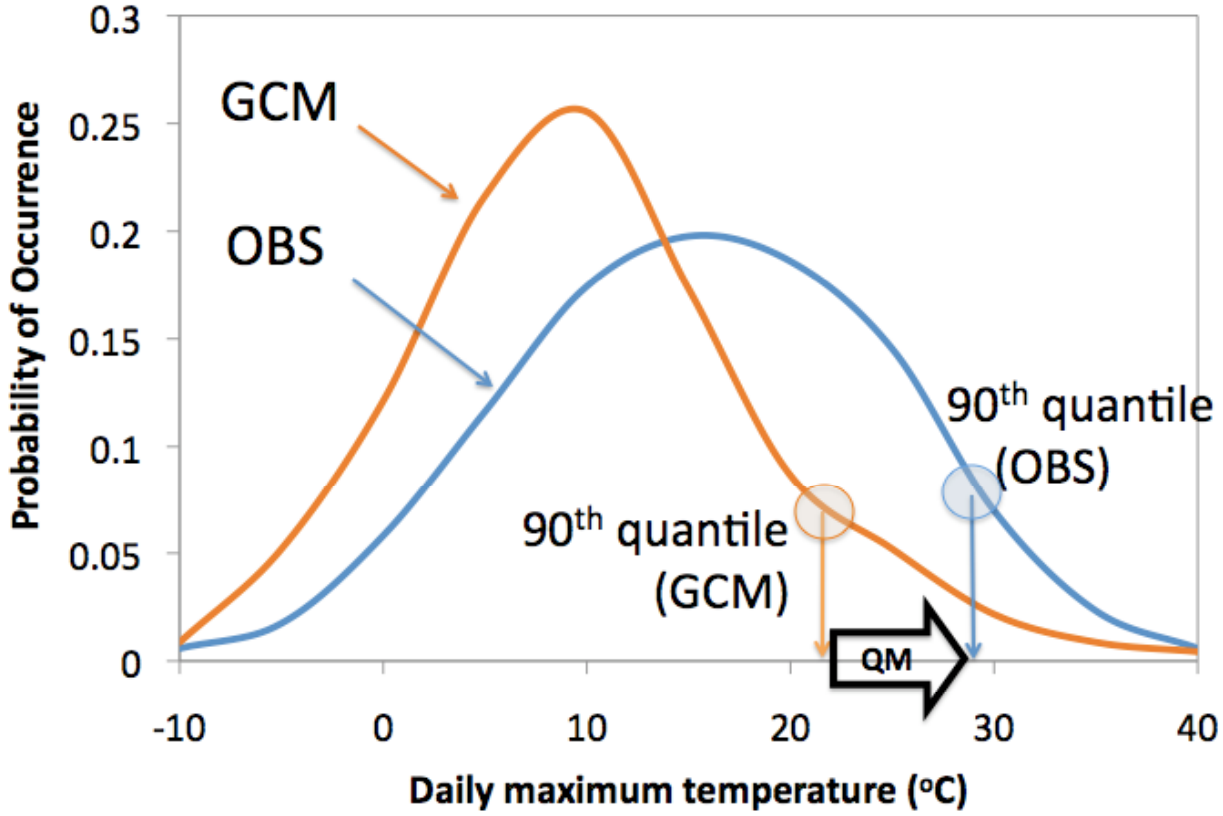
Simple: “delta” downscaling



- Most commonly used method
- Can be applied to any pair of simulated and observed variables
- Good choice for impacts affected primarily by **seasonal** or **annual mean** temperatures

TEMPERATURE

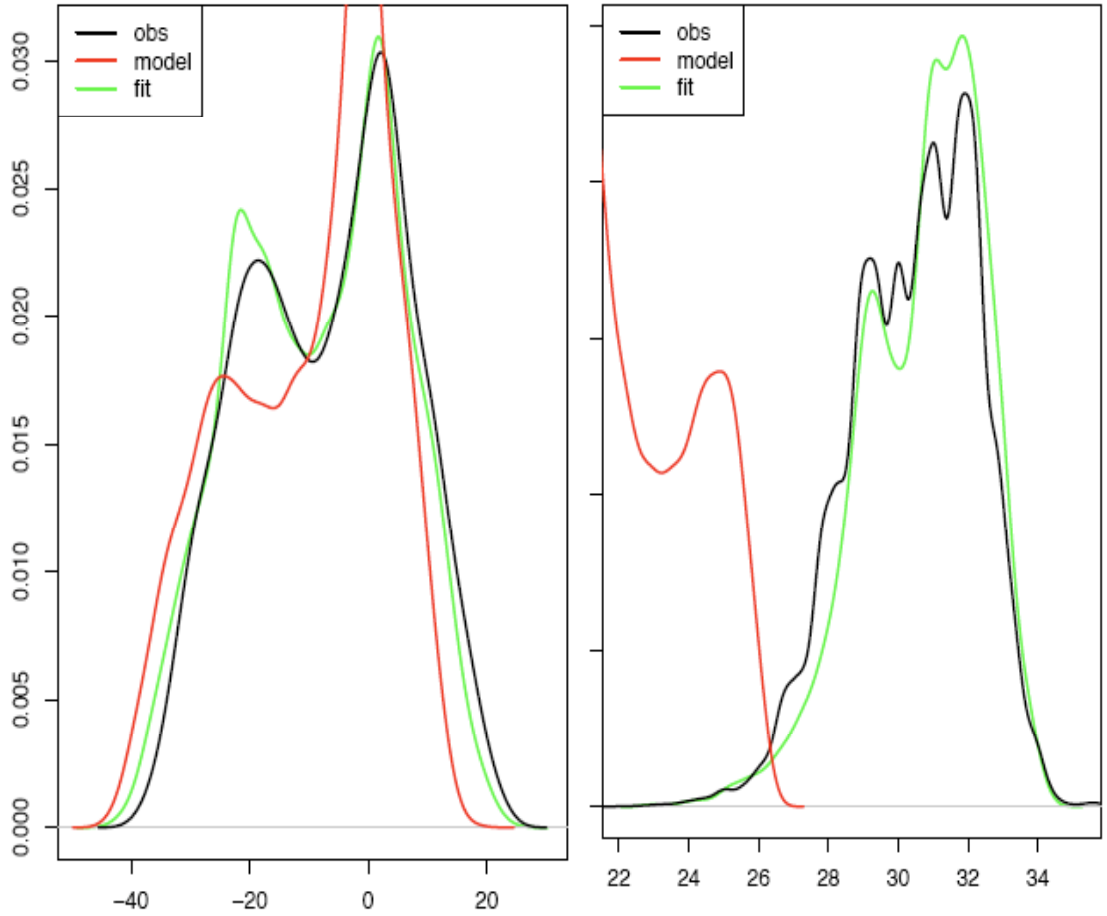
Intermediate: monthly quantile mapping



- Most commonly used method in hydrological applications in US
- Good choice for impacts that depend on variability over **timescales of weeks to months**

Used in the BCSD approach (developed by Wood, Maurer et al.)

Advanced: Asynchronous Regional Regression Model



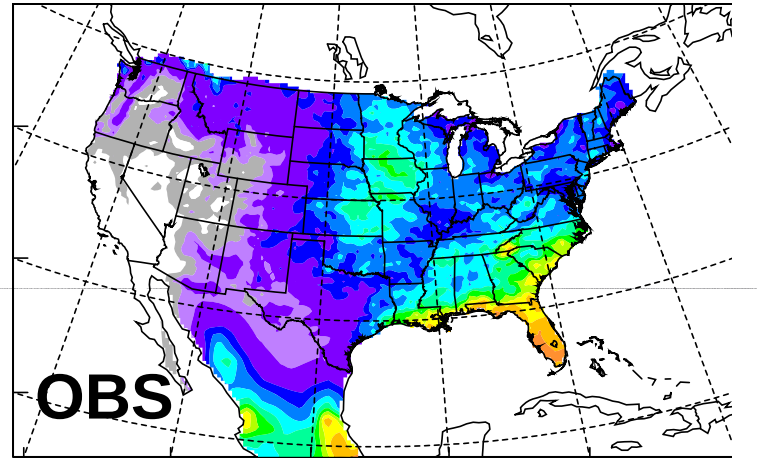
Corrects entire daily distribution, by month

First operational implementation in upcoming USGS national database

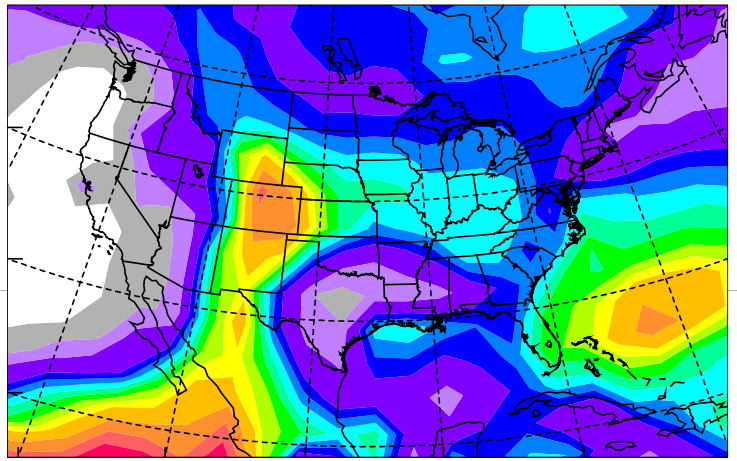
Good choice for impacts that depend on variability over timescales of **days to weeks**

Regional climate models

OBS Rainfall (mm/day) 1991-1995 JJA

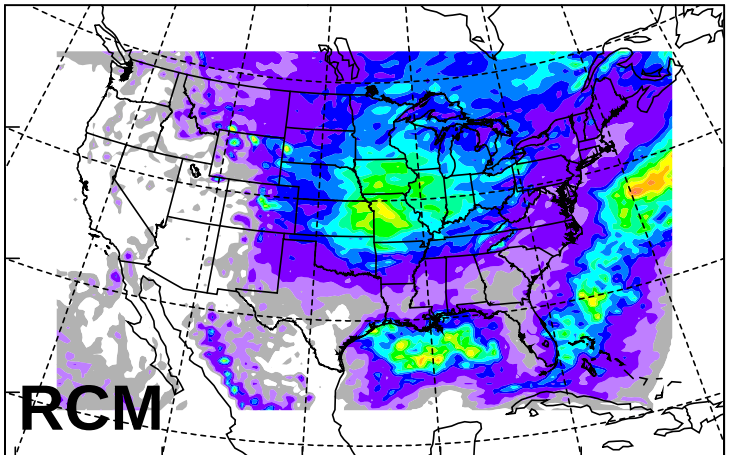


PCM Rainfall (mm/day) 1991-1995 JJA



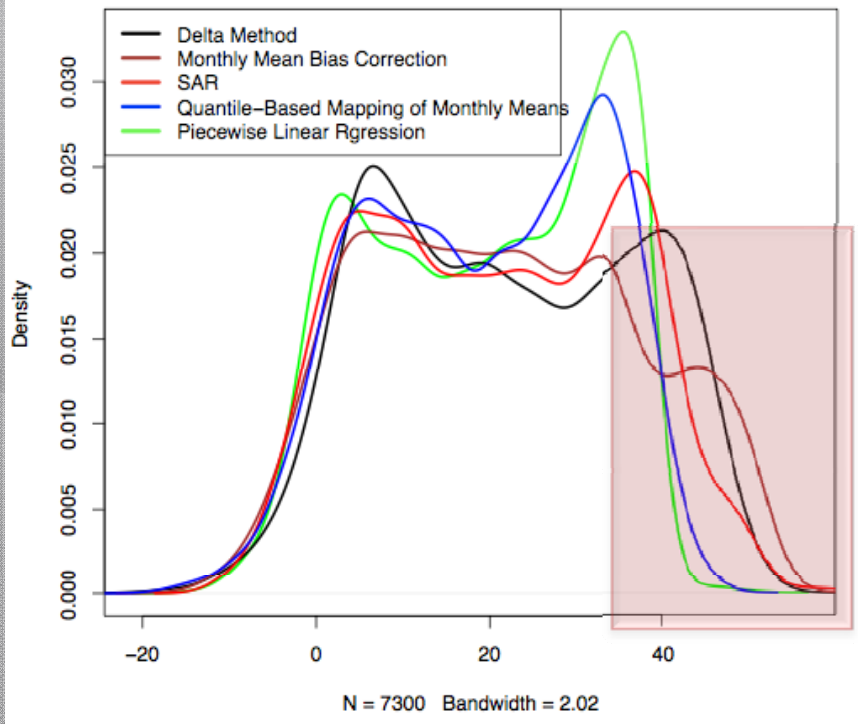
120W 110W 100W 90W 80W

RCM (PCM) Rainfall (mm/day) 1991-1995 JJA

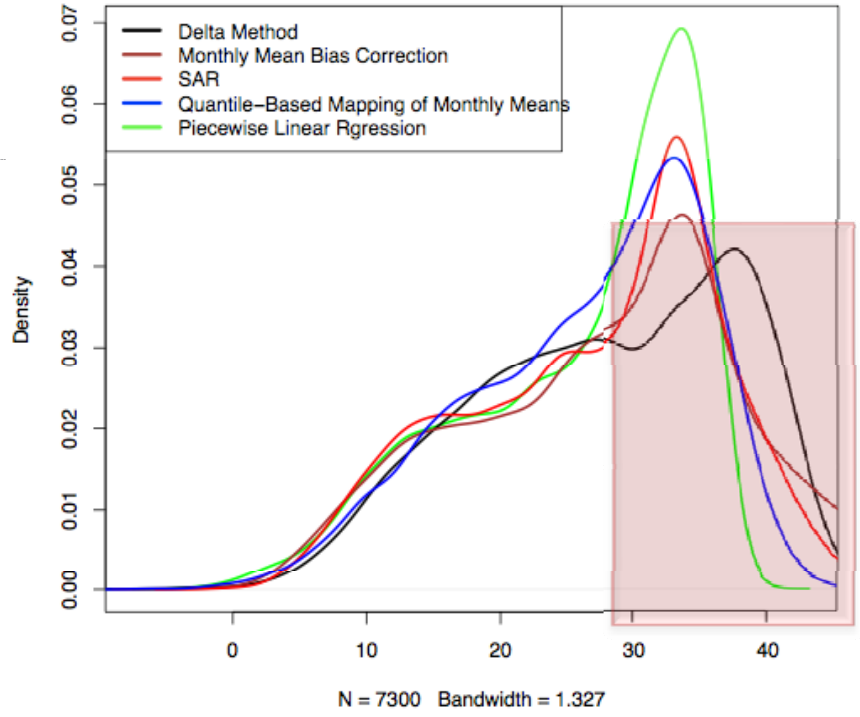


Future projections can be very sensitive to downscaling method

Chicago

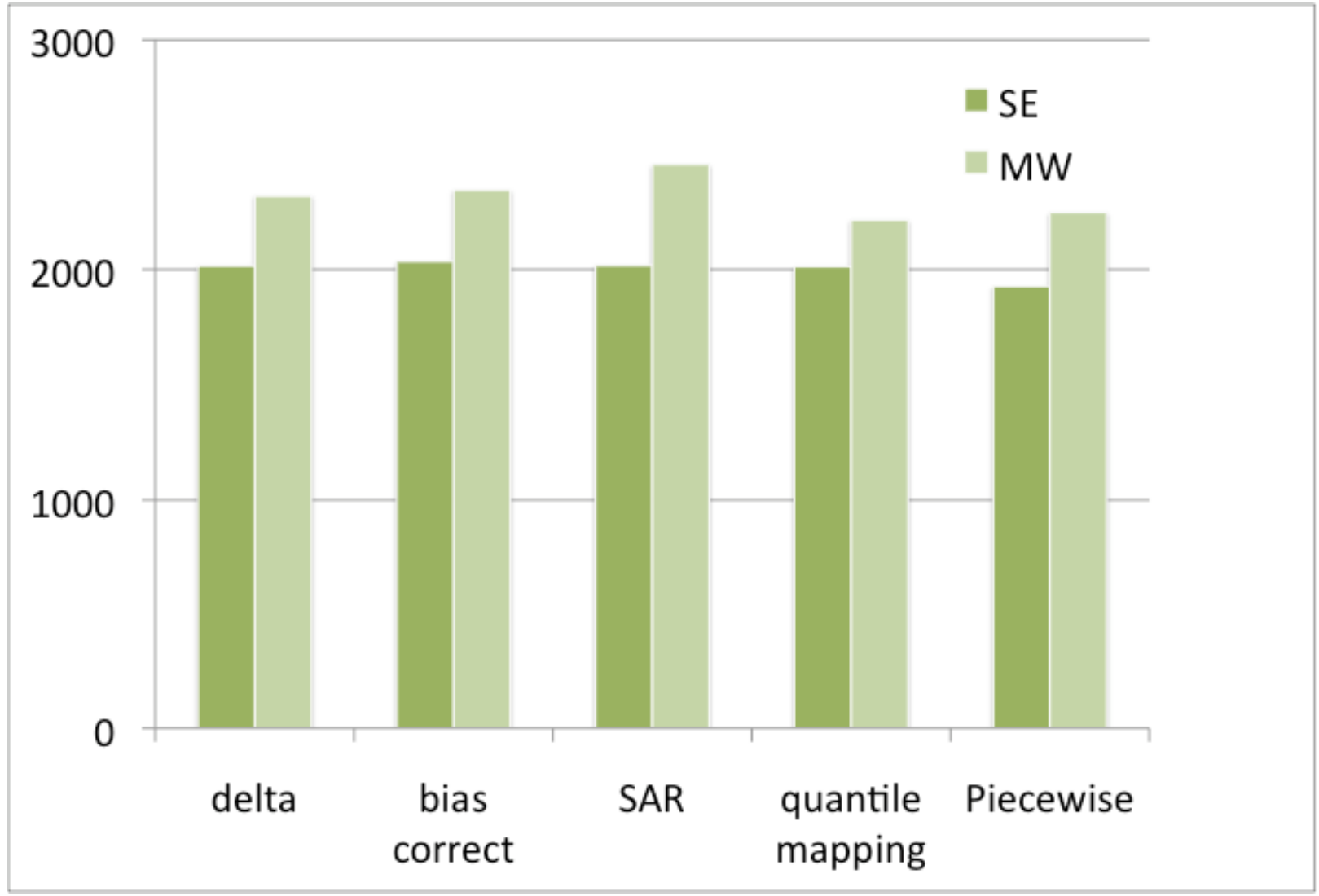


Atlanta



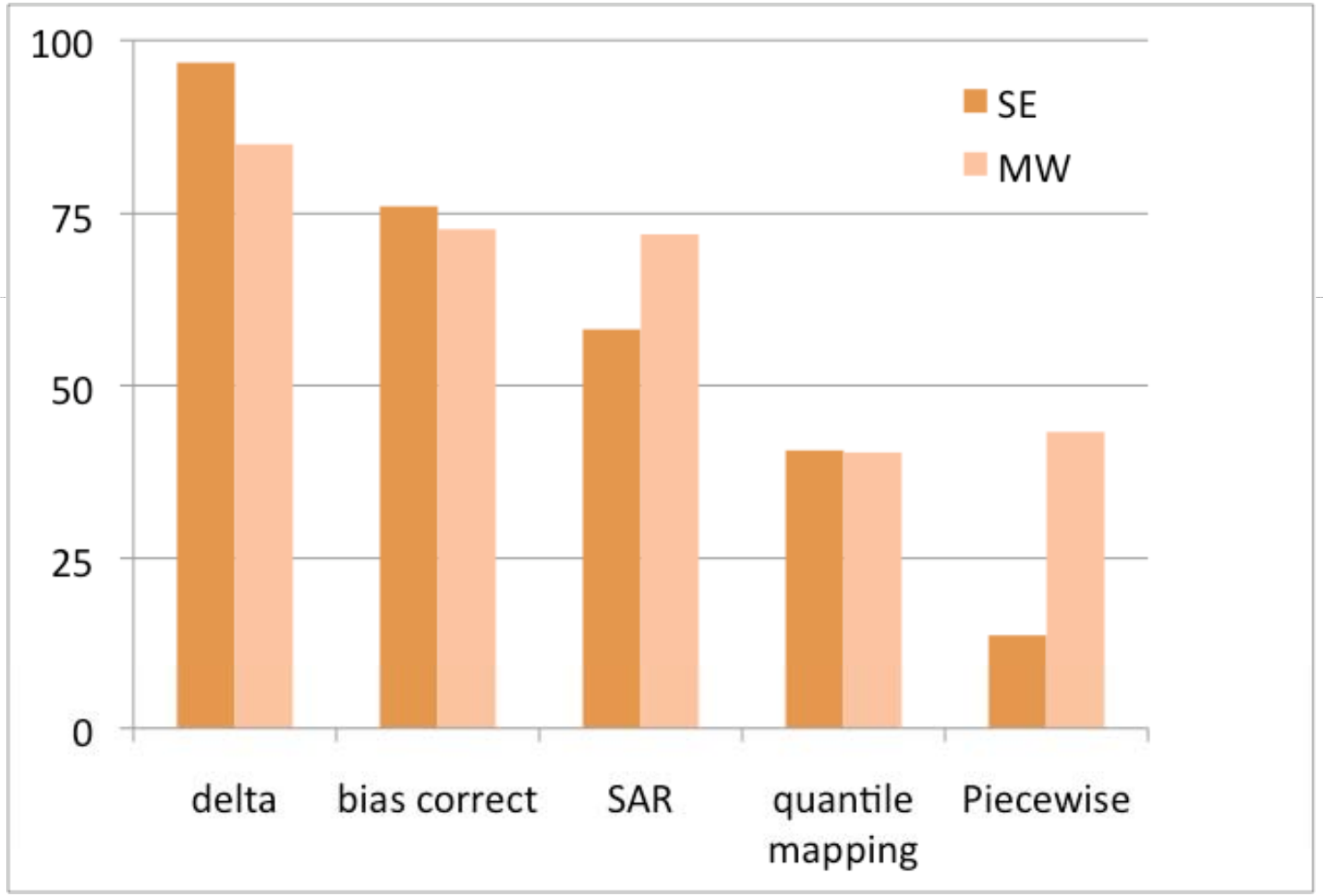
daily maximum temperature 2080-2099

Future accumulated degree-days



Source: K. Hayhoe. In preparation.

Future days over 95ºF



Source: K. Hayhoe. In preparation.

DOWNSCALING

- Simple methods are (surprisingly) reliable for simulating climatological means
- More complex methods are needed to simulate changes in thresholds and extremes
- No method – not even a regional model – is guaranteed to successfully correct for global model biases in multi-day events

COMING SOON

REPORT: a summary on climate model performance over the Caribbean

DATA: Downscaled projections for individual weather stations (using downscaling method #3 that resolves changes in daily values)

BOOK: Climate Projections for Impact Assessments: A Practical User's Guide (USFWS book)

Why are future projections uncertain?

1. On-going natural variations in climate are chaotic, making it difficult to predict conditions over time scales shorter than a decade
2. We don't know exactly how sensitive the climate system is to these emissions
3. Our ability to simulate the climate system is limited and incomplete, particularly at the local to regional scale
4. We don't know what future emissions from human activities will be
5. Each location and region responds to global change in a different way

THE BOTTOM LINE

1. There are many sources of uncertainty in future projections. Which one is more important depends on the question you are asking!

2. There is no perfect climate model but most aren't bad. Understanding their limitations is key to using them appropriately.

3. Any downscaling is better than none. Downscaling method should be selected based on whether it resolves your temporal scale of interest (yearly, seasonal, or daily).

THE END

www.katharinehayhoe.com