Opportunities and Limitations of High-Resolution Climate Data to Inform Adaptation and Development

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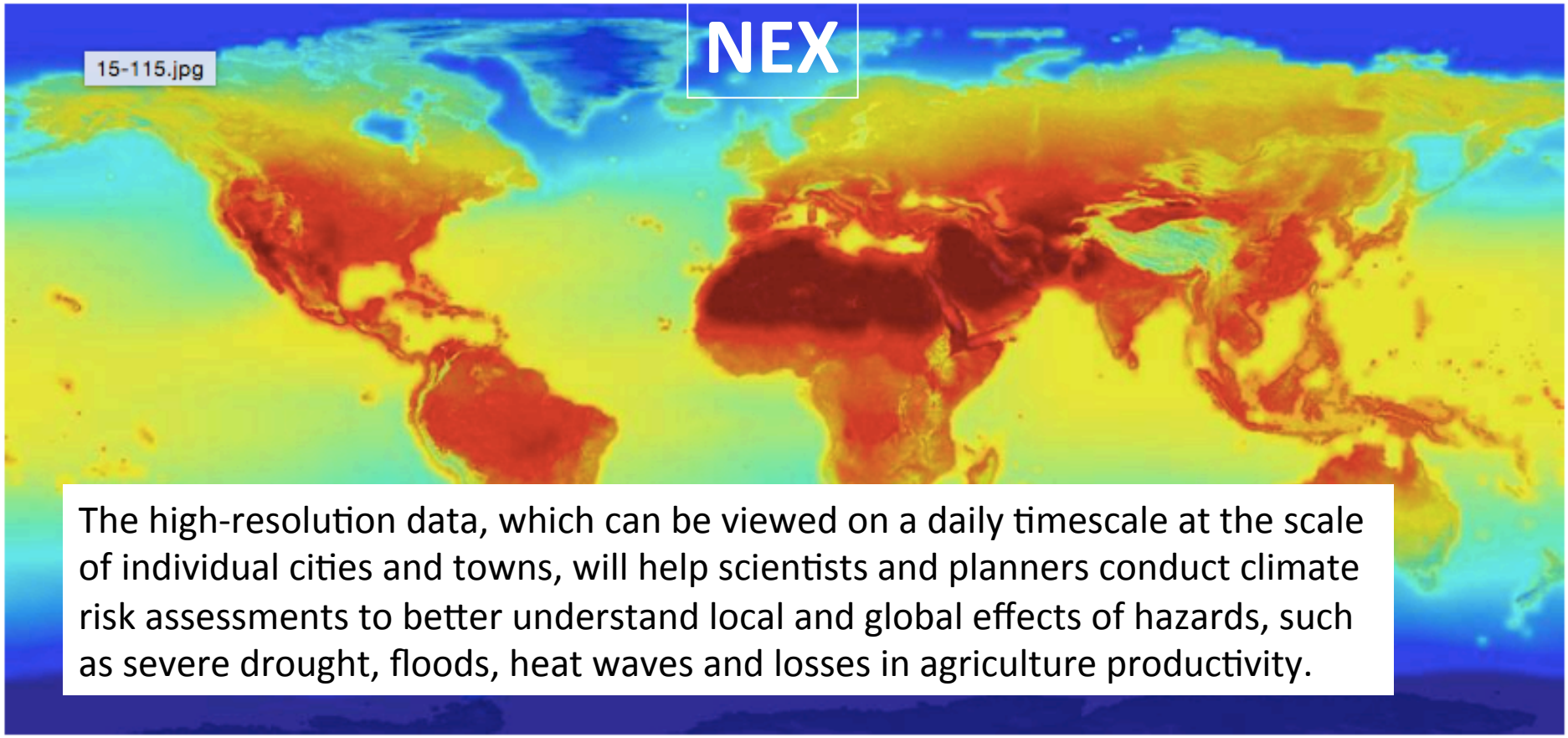
NASA Releases Detailed Global Climate Change Projections

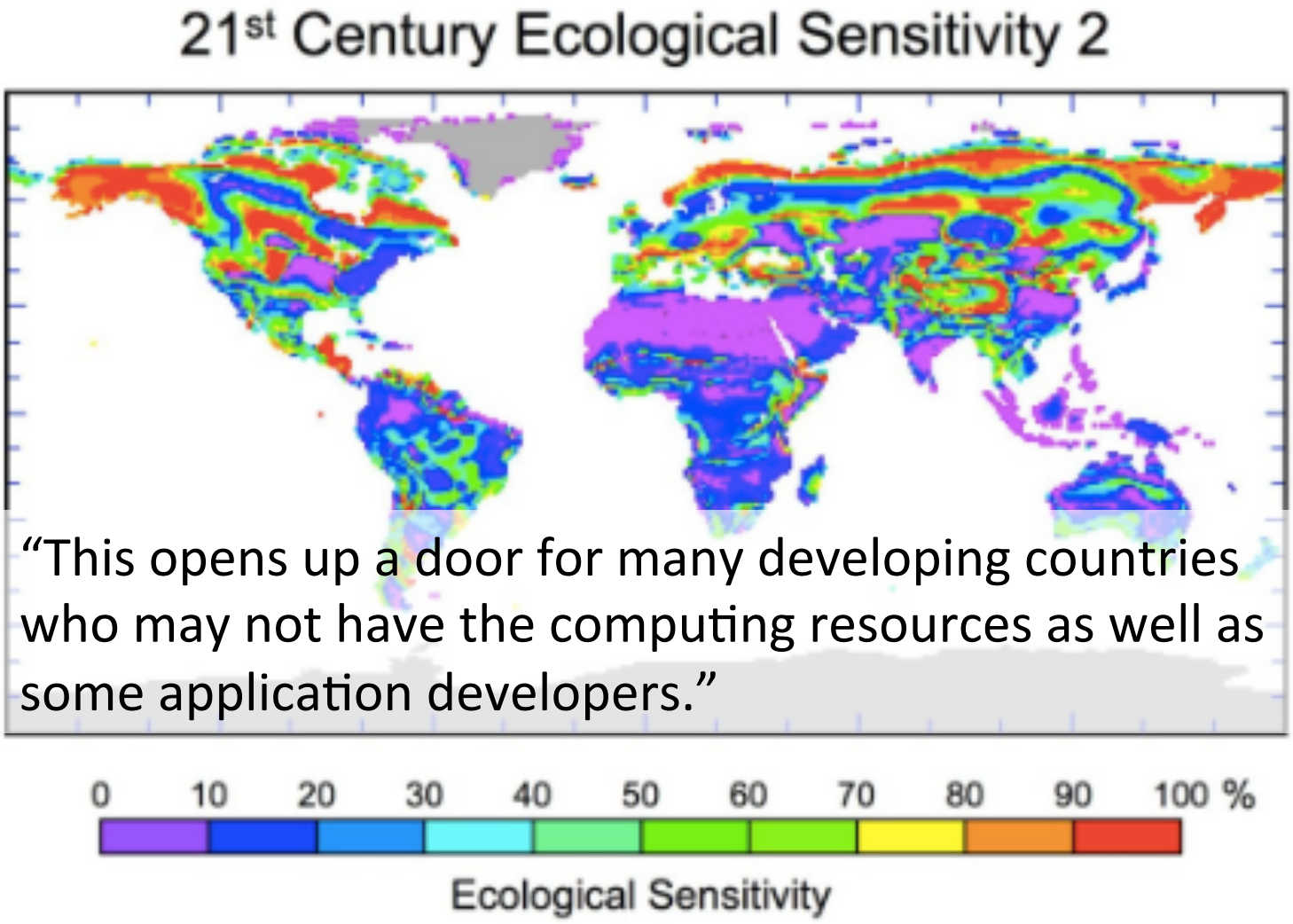


The high-resolution data, which can be viewed on a daily timescale at the scale of individual cities and towns, will help scientists and planners conduct climate risk assessments to better understand local and global effects of hazards, such as severe drought, floods, heat waves and losses in agriculture productivity.

The new NASA global data set combines historical measurements with data from climate simulations using the best available computer models to provide forecasts of how global temperature (shown here) and precipitation might change up to 2100 under different greenhouse gas emissions scenarios.

Credits: NASA

… based on NEX data



"This opens up a door for many developing countries who may not have the computing resources as well as some application developers."

Assumptions

1. The most important climate information needed for adaptation and development is climate change projections

2. The main limitation to the use of climate models is the scale mismatch.

Main Questions
in the minds of practitioners

1. How will things change?
   - The future "average climate" we need to adapt to
   - Extremes → Shocks to the system
2. How will *my* system perform through some future period?
3. Is the climate data easy to get and easy to use?
4. Is the climate information easy to interpret?

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4. Is the climate information easy to interpret?

Main Questions

in the minds of practitioners

0. **How well have these tools worked in the past?**
1. How will things change?
2. How will *my* system perform through some future period?
3. Is the climate data easy to get and easy to use?
4. Is the climate information easy to interpret?

Statistical Downscaling:
BCSD ("Bias Corrected Statistical Disaggregation")

Bias Correction

1. Put high-resolution observational data on coarse model grid

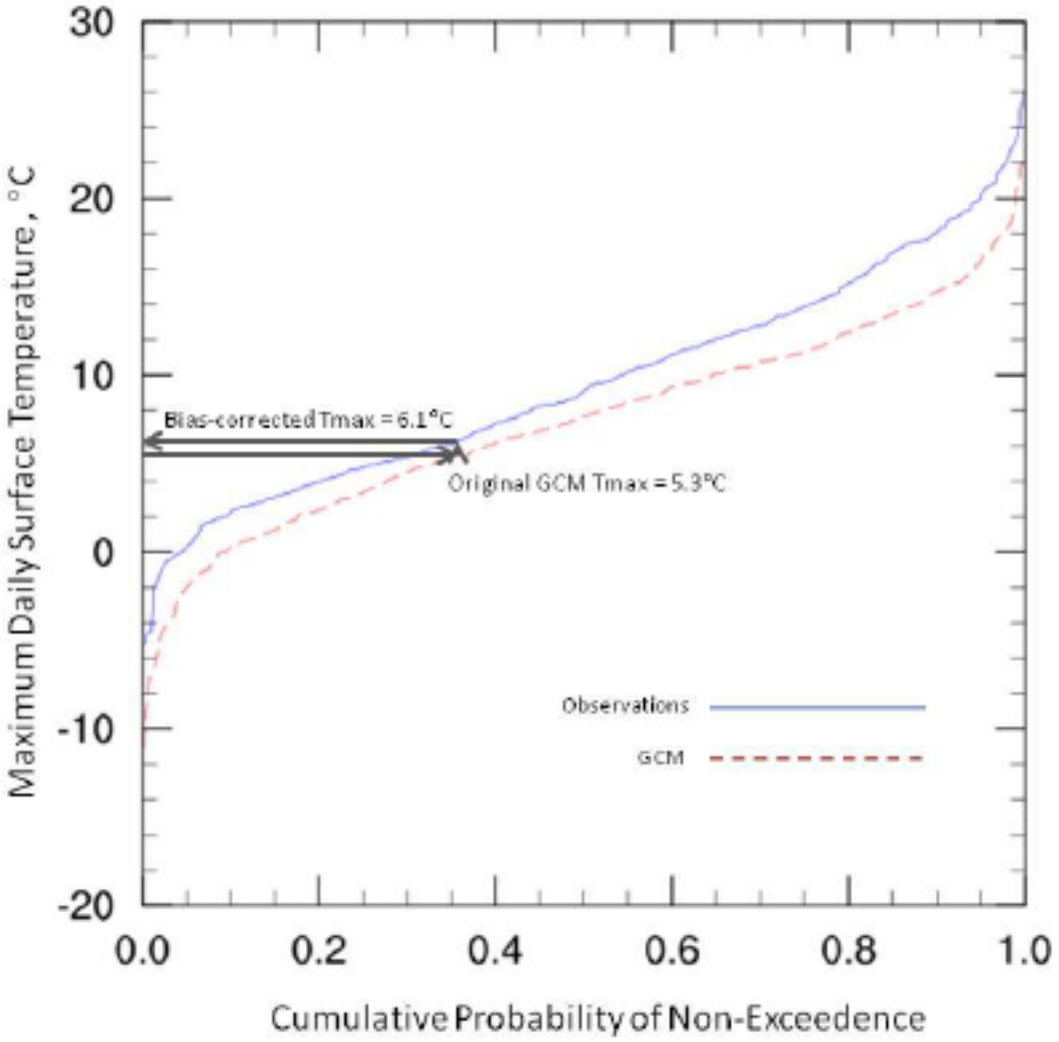
2. Sort time series of both observed and model data, from smallest to largest. Create cumulative distribution.

3. For future GCM temperature, remove the "trend" = 9-yr running mean climate

4. Bias-correct: replace quantitative values of future model timeseries with observed values by quantile-matching the future GCM values with the two distributions.

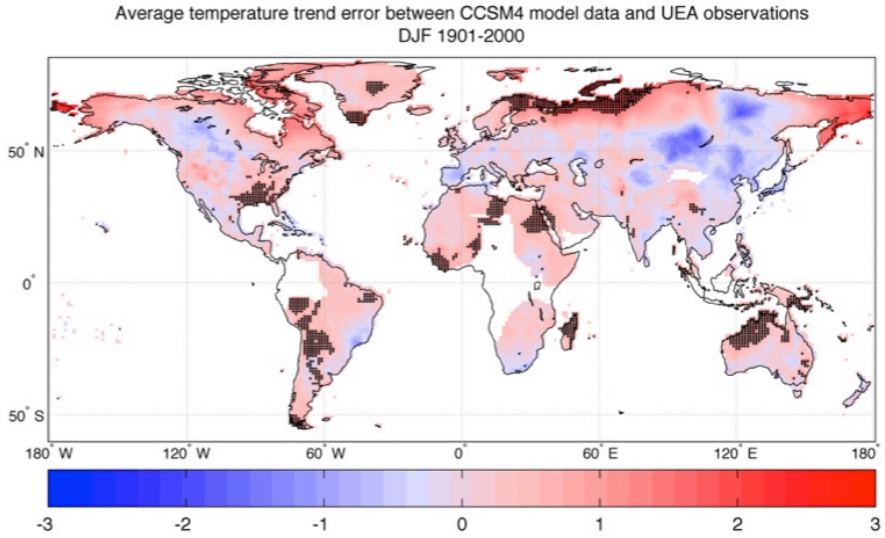
5. Add the "trend" back to the corrected future temperature.

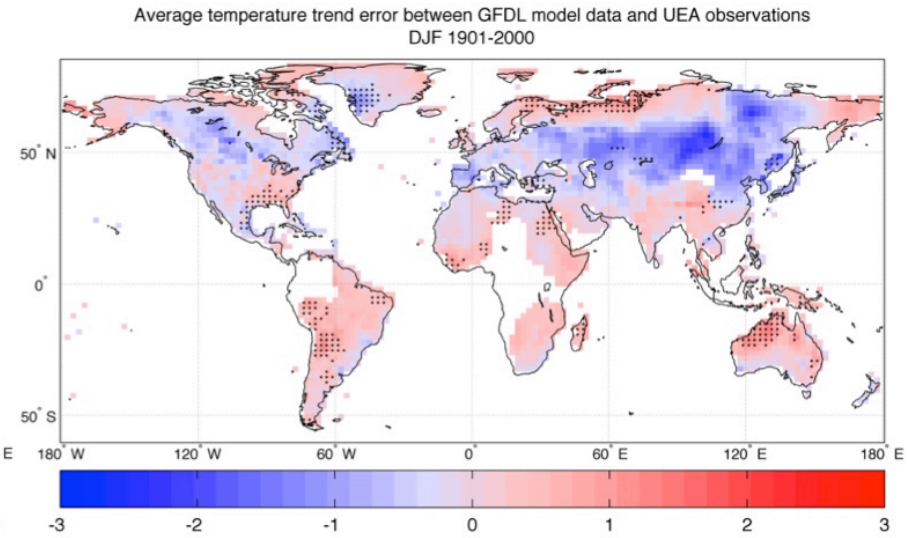
Example of quantile-mapping

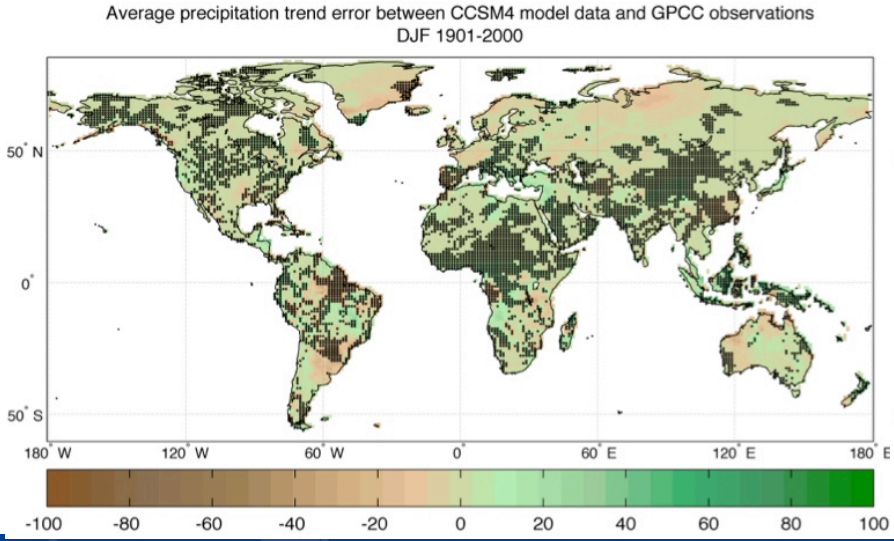


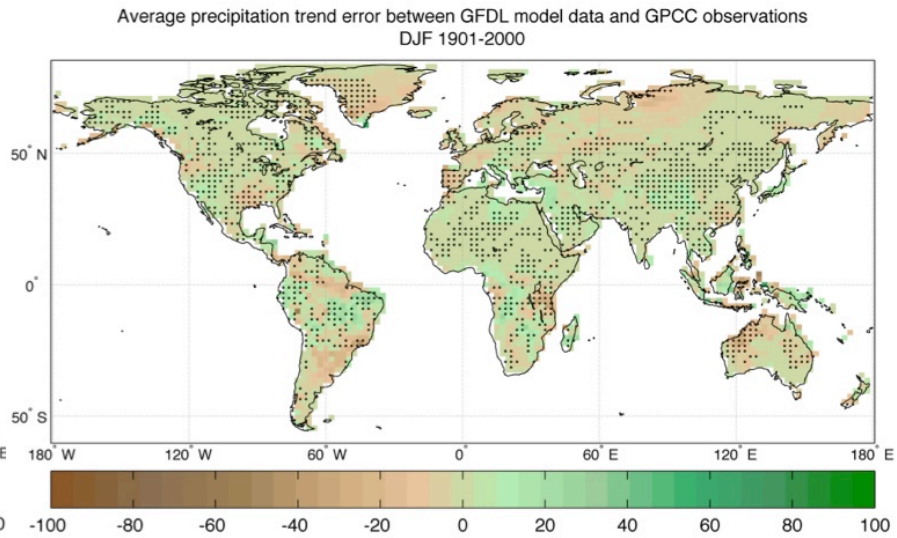
Problem: Models are not perfect

Trend errors from 2 climate models

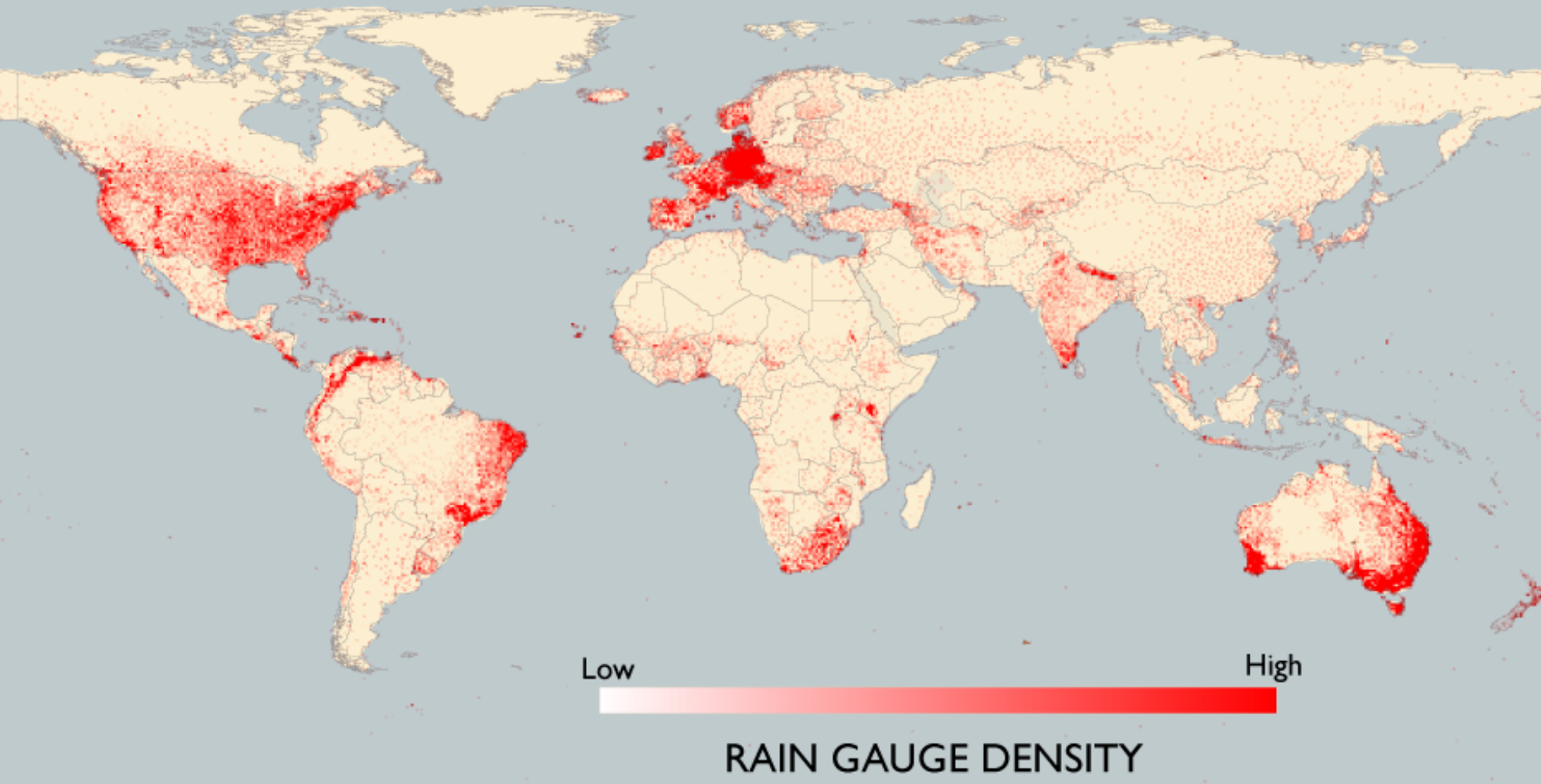








Problem: Observations are limited

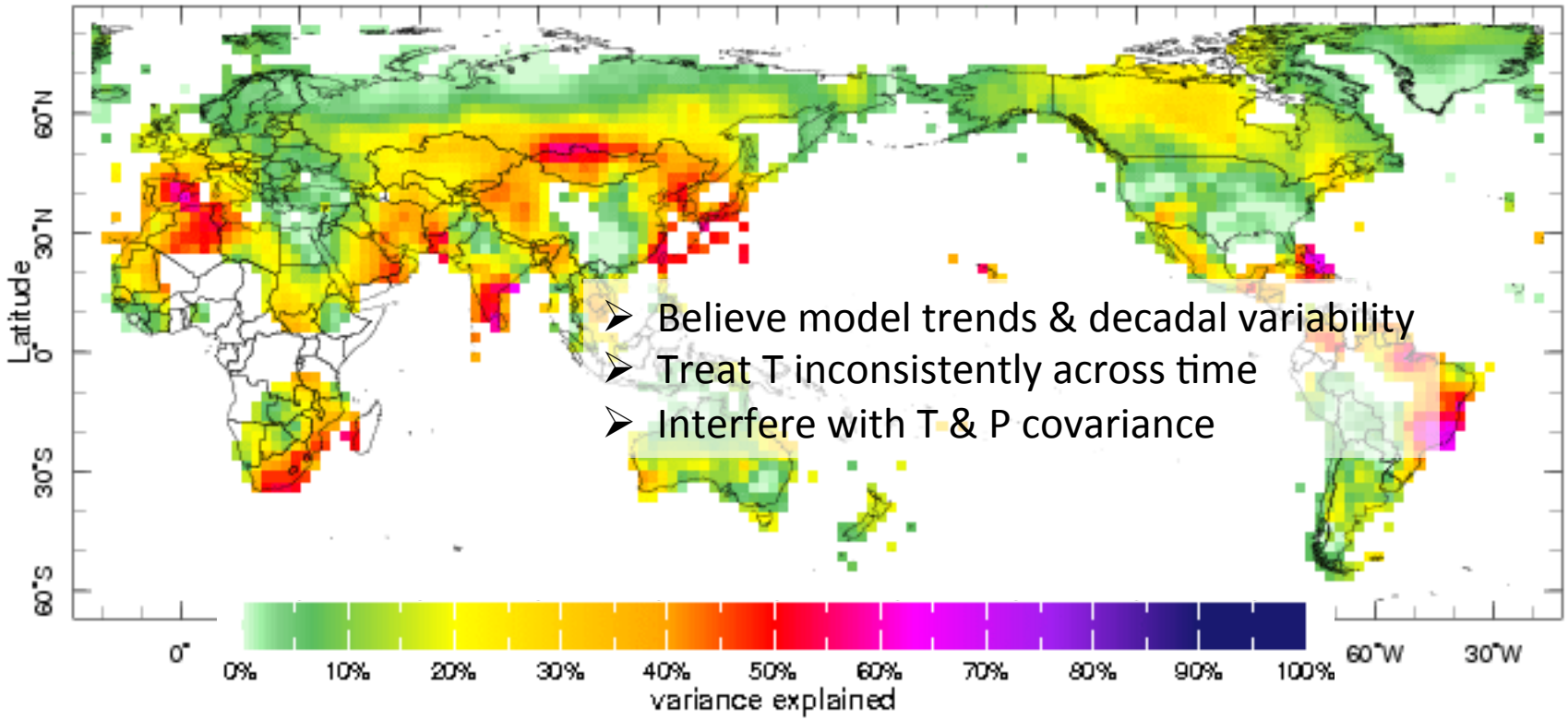


Problem: BCSD Methodology is questionable

Historical T data (obs and models) NOT detrended for 20th century.
Future model T data IS detrended (9-yr running avg), which is added back after correction.

Temperature Trends: Percent of total variance

20th Century Gridded Observations -- Annual Means



- Believe model trends & decadal variability
- Treat T inconsistently across time
- Interfere with T & P covariance

Verification is CRITICAL

1. Climatology?

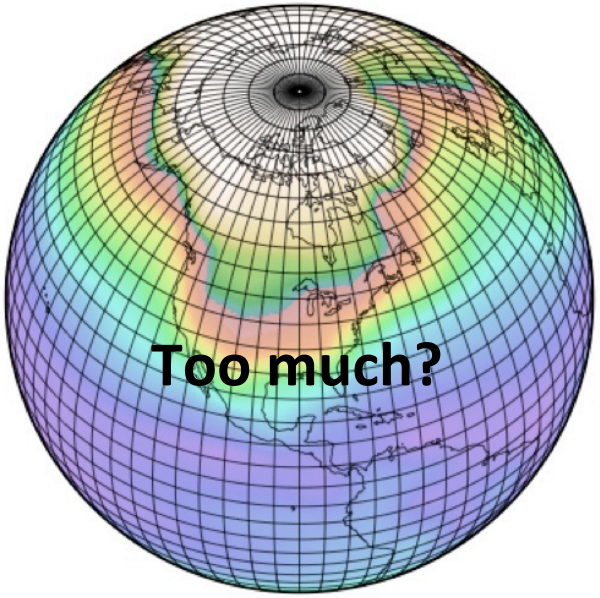
   - Tells you little to nothing about the ability to predict the future

2. Response to forcing?

   - Yes, PLEASE!

3. Processes?

   - Are you getting a reasonable response for the right reason?



Thank You

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Take Away Message

1 – Verification is critical.
What is important to get right, for YOU?

2- Many high-resolution datasets offered to the adaptation and development communities seem to focus more on provision of answers and access, than understanding response and risk

3- Expert communities must work together to better account for the opportunities and limitations in each of our data and models.

Problem: BCSD Methodology is questionable

Historical T data (obs and models) NOT detrended for 20th century.
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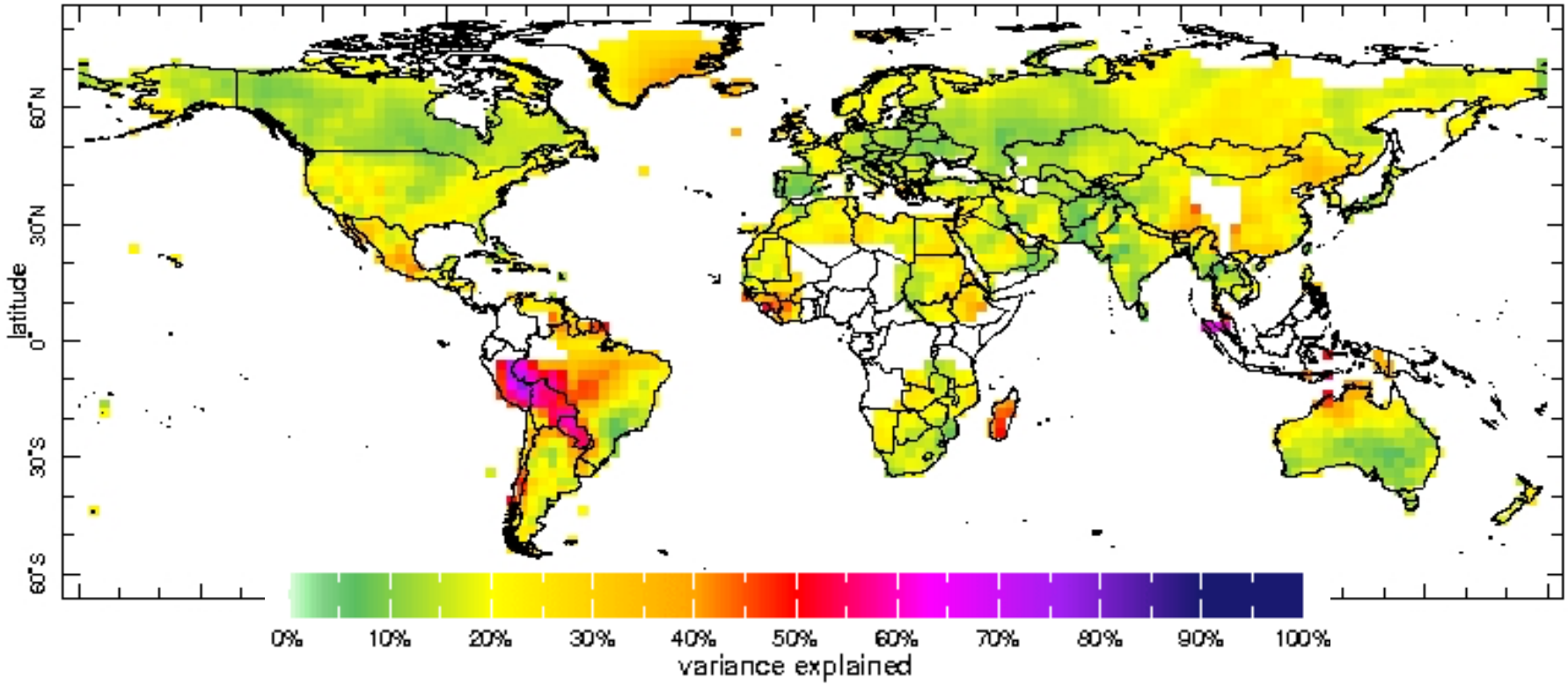
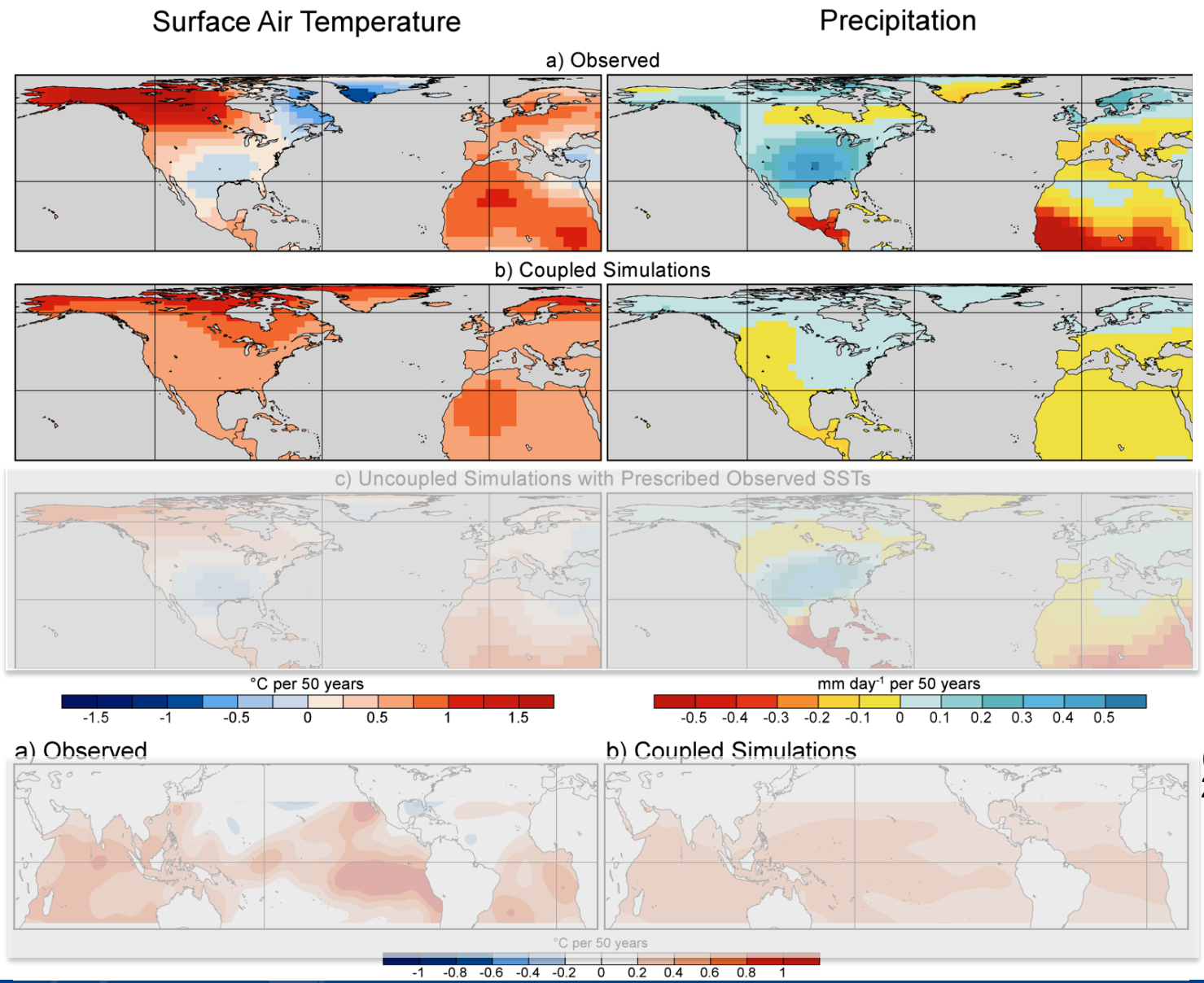
Temperature Decadal Variability: Percent of total variance

20th Century Gridded Observations -- Annual Means



Models may not get correct pattern of trend

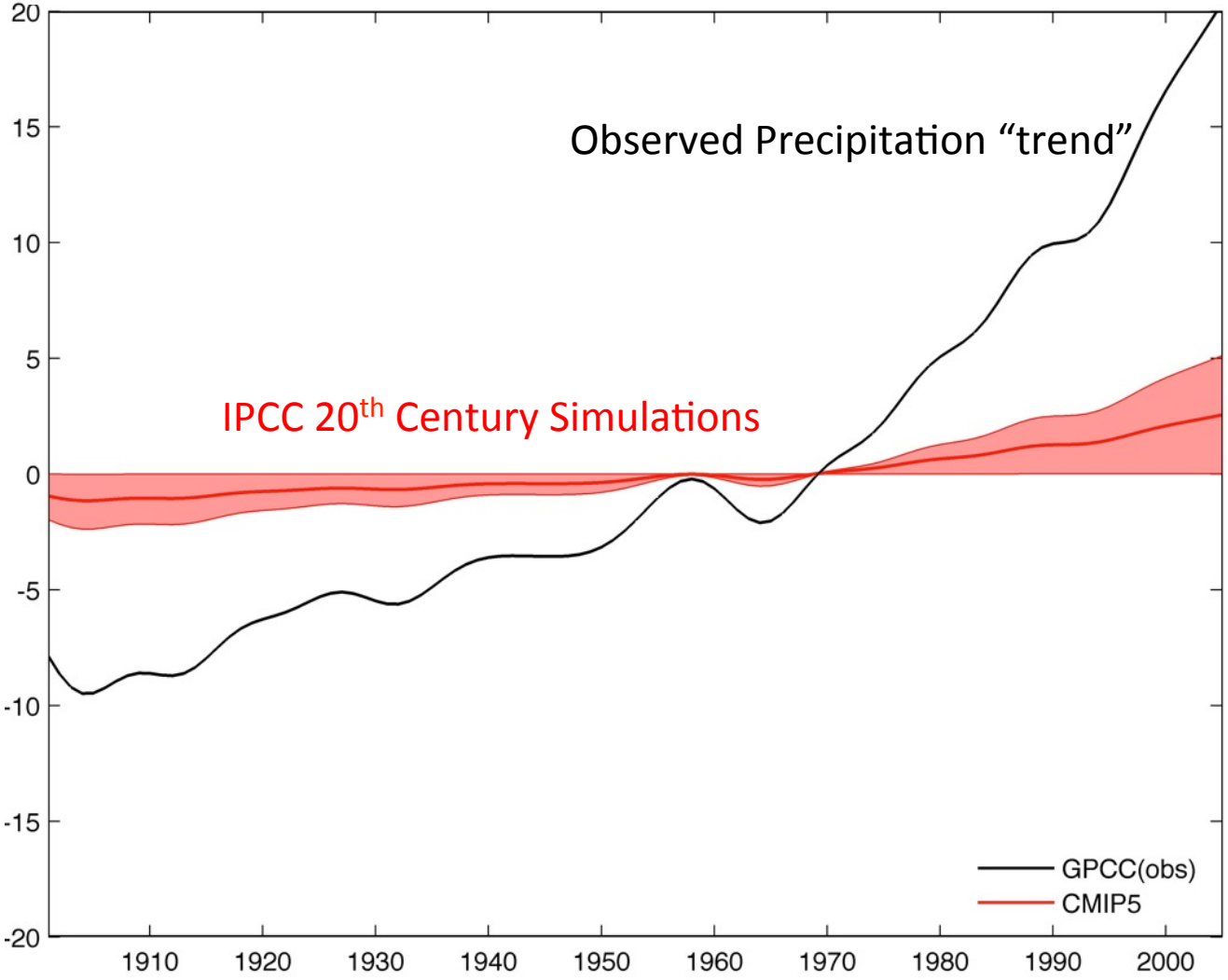


20th Century: Observed **patterns of T & P trends** agree better with models that have more realistic **patterns of SST trends**.

(Shin and Sardeshmukh, 2010, *Climate Dynamics)*

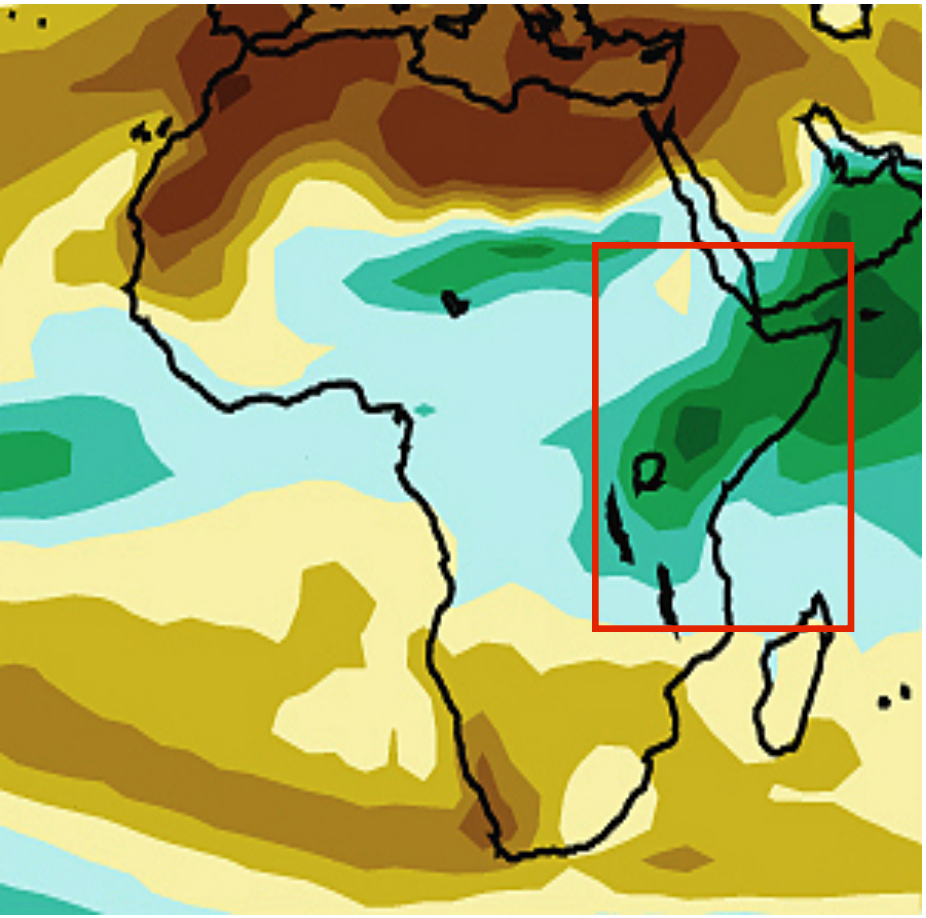
Models may not get correct magnitude of trend

Precipitation Changes over SE South America (Sep-Feb 1901-2005)

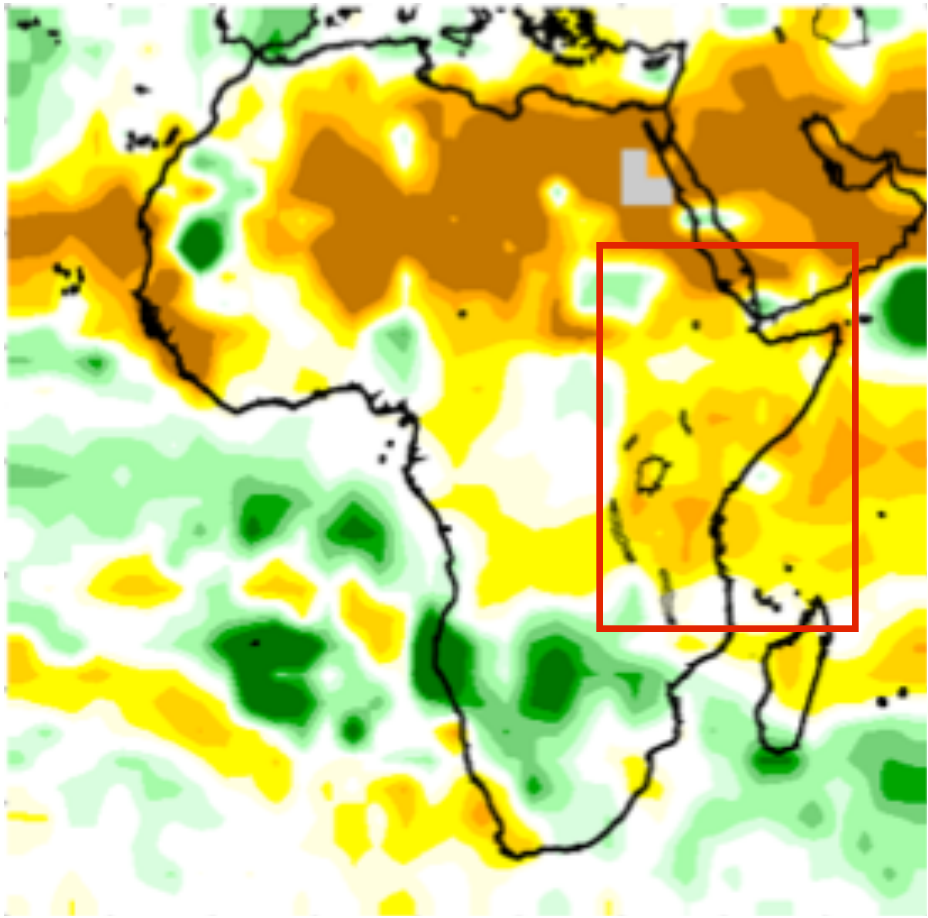


Decadal-scale variability is important

Climate Change Projections
(end of 21st century)



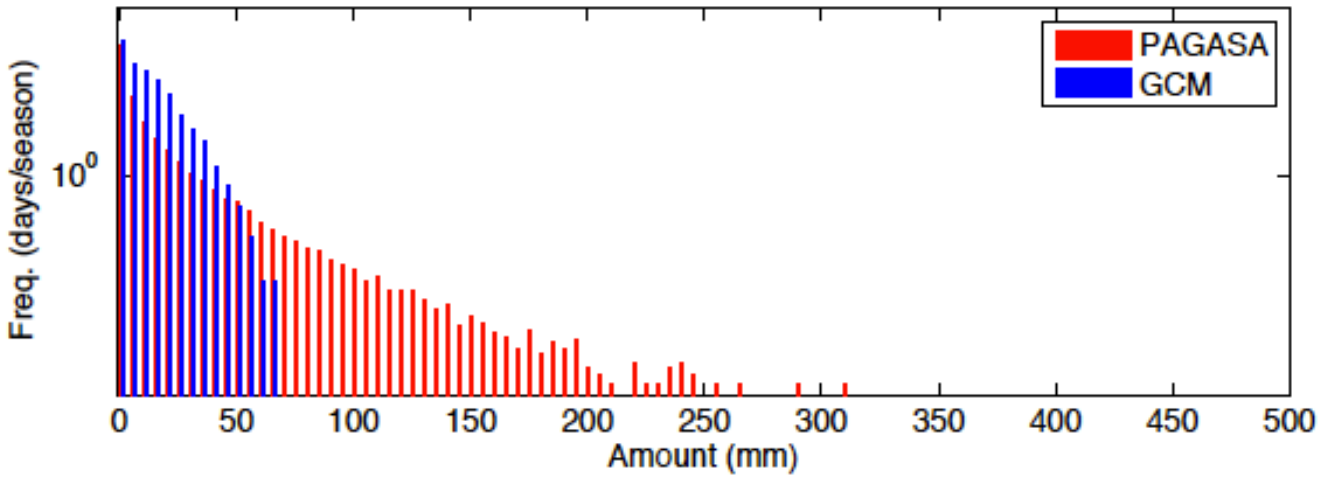
Observations
(last 15 years)



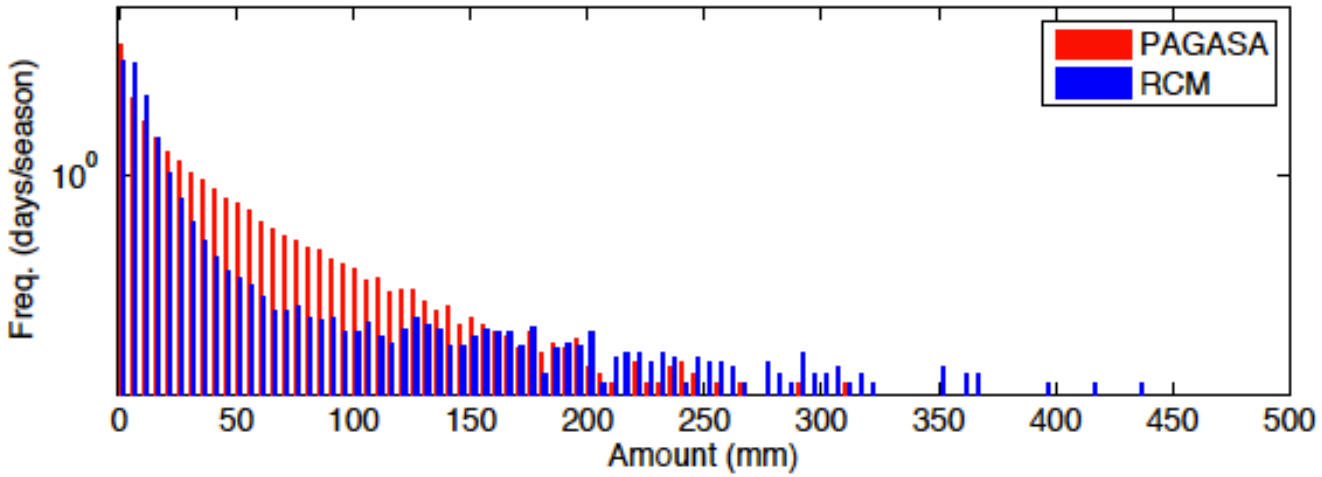
Dynamical Downscaling ??

Precipitation Biases -- Models don't capture extremes

(a) GCM vs. PAGASA (Philippines Met Svc Stations)



(b) RCM vs. PAGASA (Philippines Met Svc Stations)



(Robertson et al. 2012)

Main Questions
in the minds of practitioners

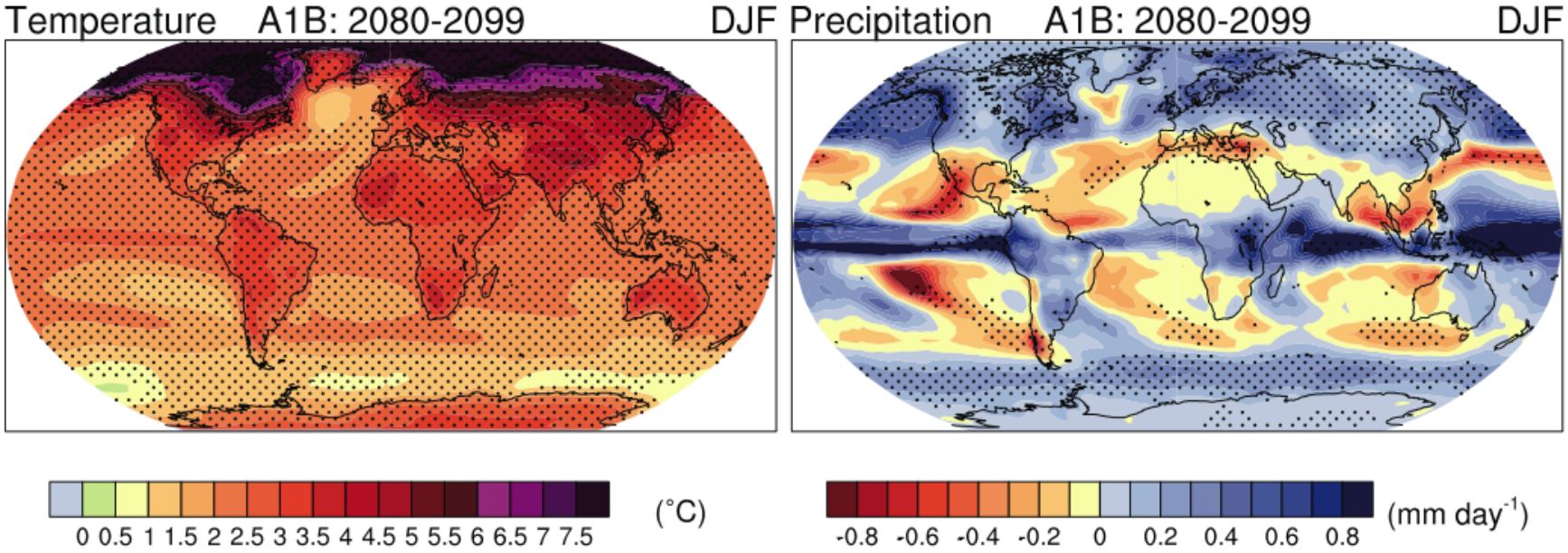
1. How will things change?

What is the form of the ANSWERS??

What is the form of the climate change answer?

Sign? Relative magnitude?

Multi-Model Mean Changes: (2080-2099)-(1980-1999)



IPCC AR4, WG1, Figure 10.9

What is the form of the climate change answer?

Quantitative risk? Possible scenarios?

Multi-Model Changes: (2080-2099)-(1980-1999)

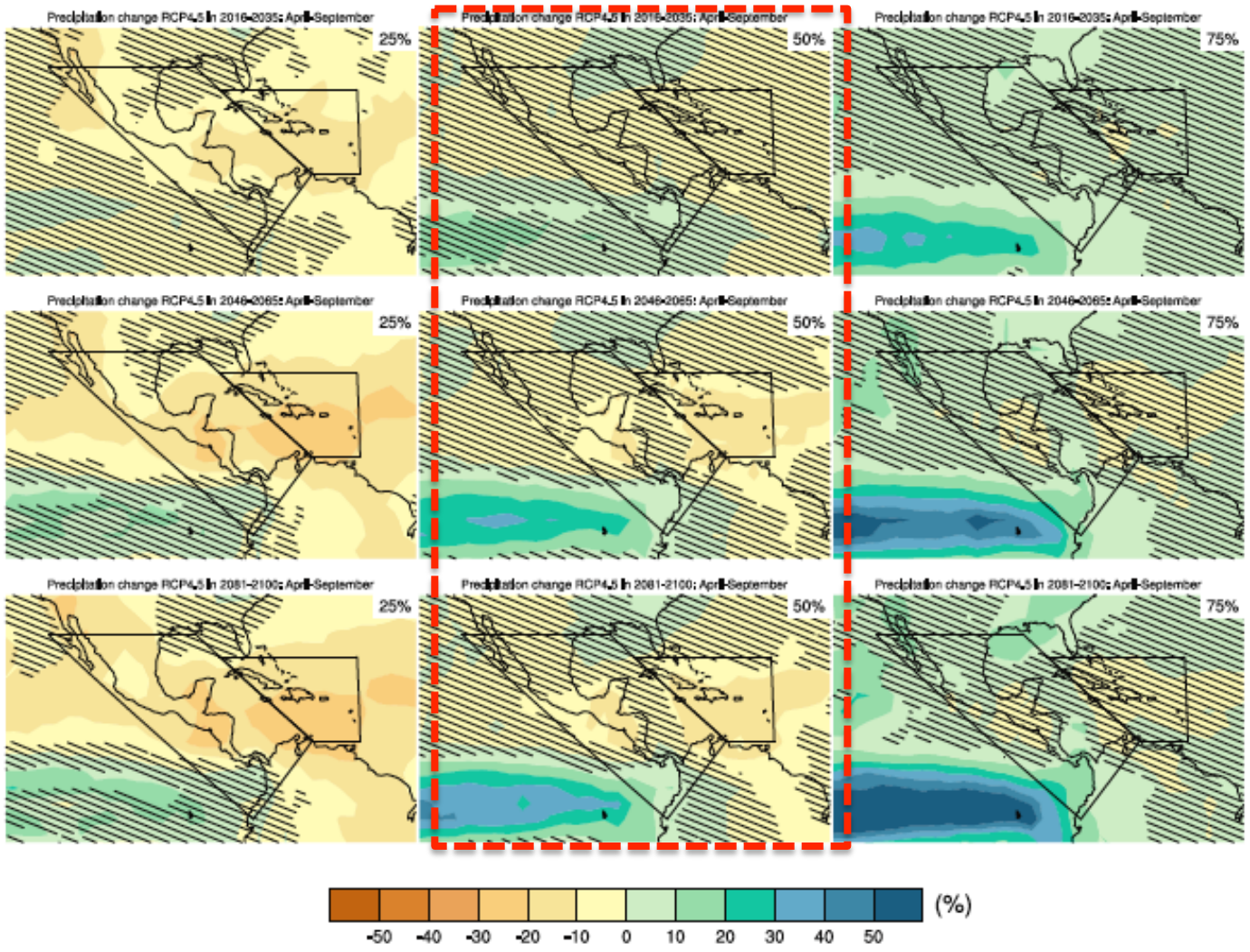
IPCC - AR5

RCP4.5

2016-2035

2046-2065

2081-2100



Questionable Situations

1) What if the model trend is opposite to the observed trend?
2) What if the trend is ok but the persistence is off (or the covariation between P & T)?
3) What if the trend is ok but the CDF changes over time, perhaps due to synoptic-scale regime changes?

Questionable Situations (cont.)

4) What if the GCM spatial modes are misplaced (i.e. downwind of mountains because the GCM doesn't have mountains)?

5) What if the GCM seasonality is wrong (e.g. GCM dry season falls in the observed wet season)

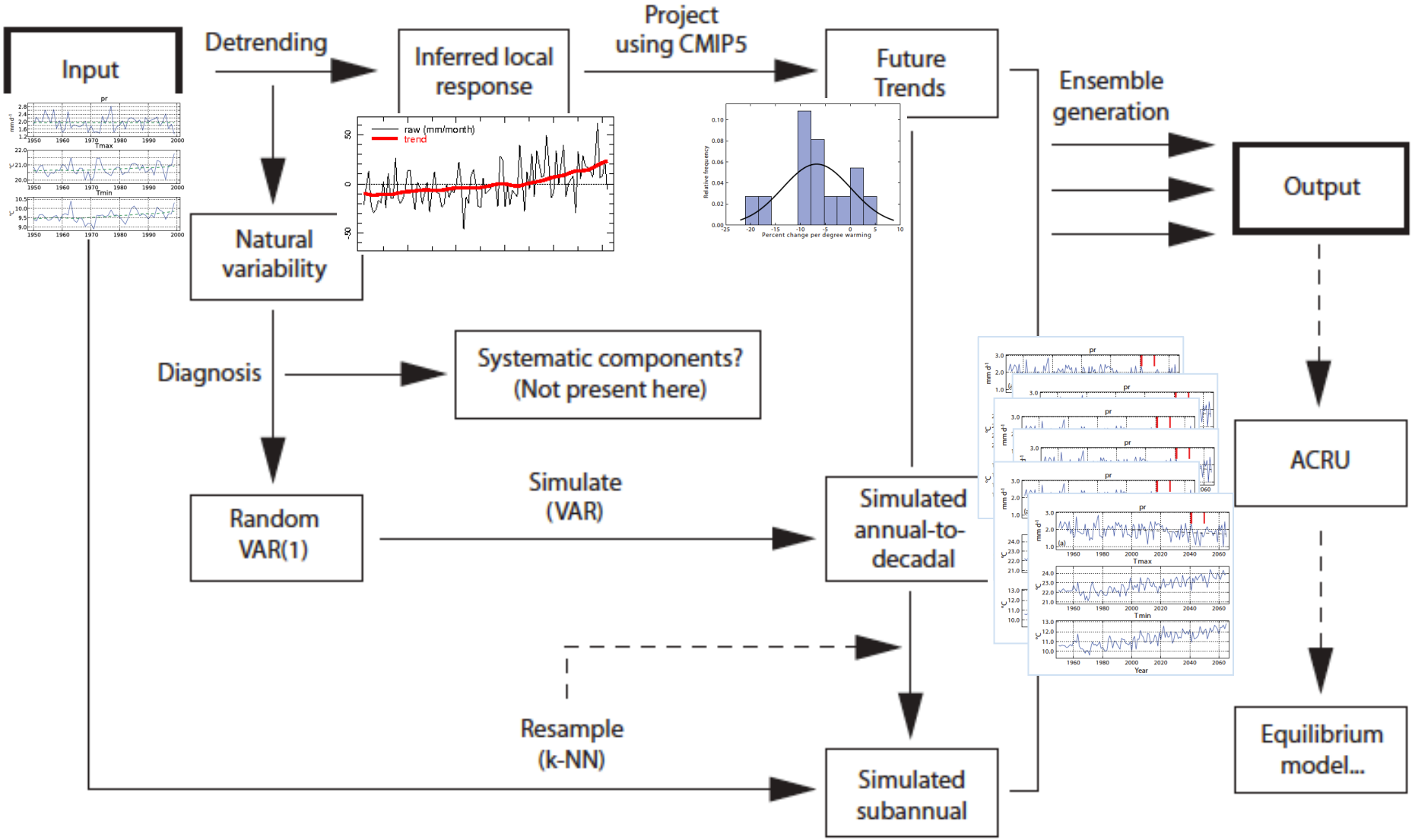
6) Is there any reason to have faith in the high frequency extremes produced by BCSD (i.e. daily or 3-day precip)?

INTERANNUAL-to-DECADAL VARIABILITY

Capturing characteristics/ quantifying risk

STOCHASTIC SIMULATIONS: *2 Ensemble Members*

(Greene, et al. 2012)



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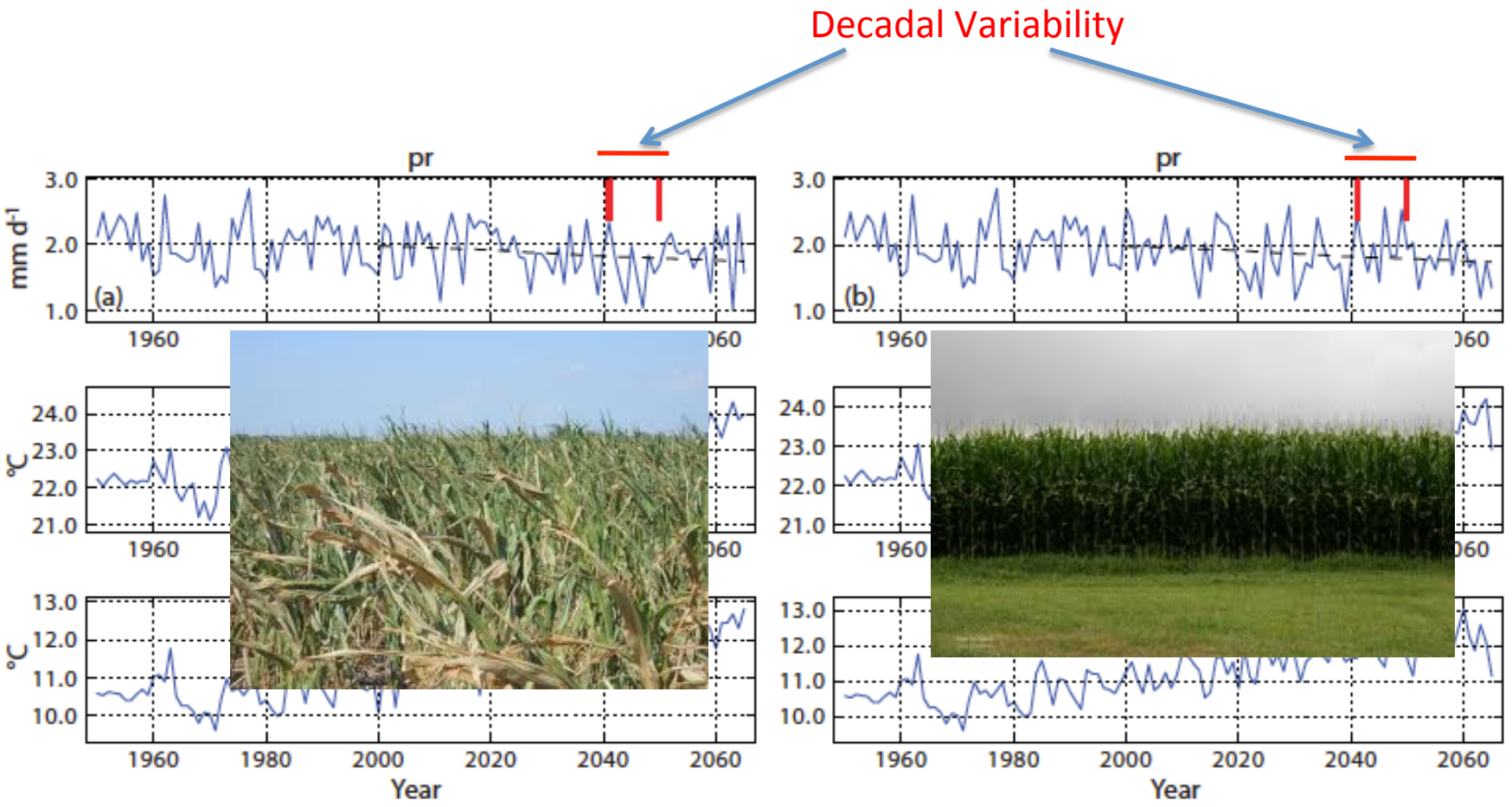

Lag-1 Auto-correlation coefficients

Source	Precipitation	Tmax	Tmin
Observations	0.003	0.166	0.293
Simulation	-0.010	0.175	0.299

Cross-correlation statistics

Observations

	Precip	Tmax	Tmin
Precip	1.000		
Tmax	-0.499	1.000	
Tmin	-0.066	0.732	1.000

Simulations

	Precip	Tmax	Tmin
Precip	1.000		
Tmax	-0.445	1.000	
Tmin	0.068	0.733	1.000

(Greene, et al. 2012, Water Resources Res.)

Methodology for 'Near Term Climate Change' Information

Using Models & Observations

1 – Climate Change:

Examine how well models to capture past trends.

Can one recalibrate patterns of trends & reduce errors?

2 – Decadal Variability:

In absence of prediction skill use "climatology"

e.g. stochastic simulation of current climate

3 – Seasonal-to-Interannual (and weather):

Will that change?

What is the form of the climate change answer?

Multi-Model Mean Changes: (2080-2099)-(1980-1999)

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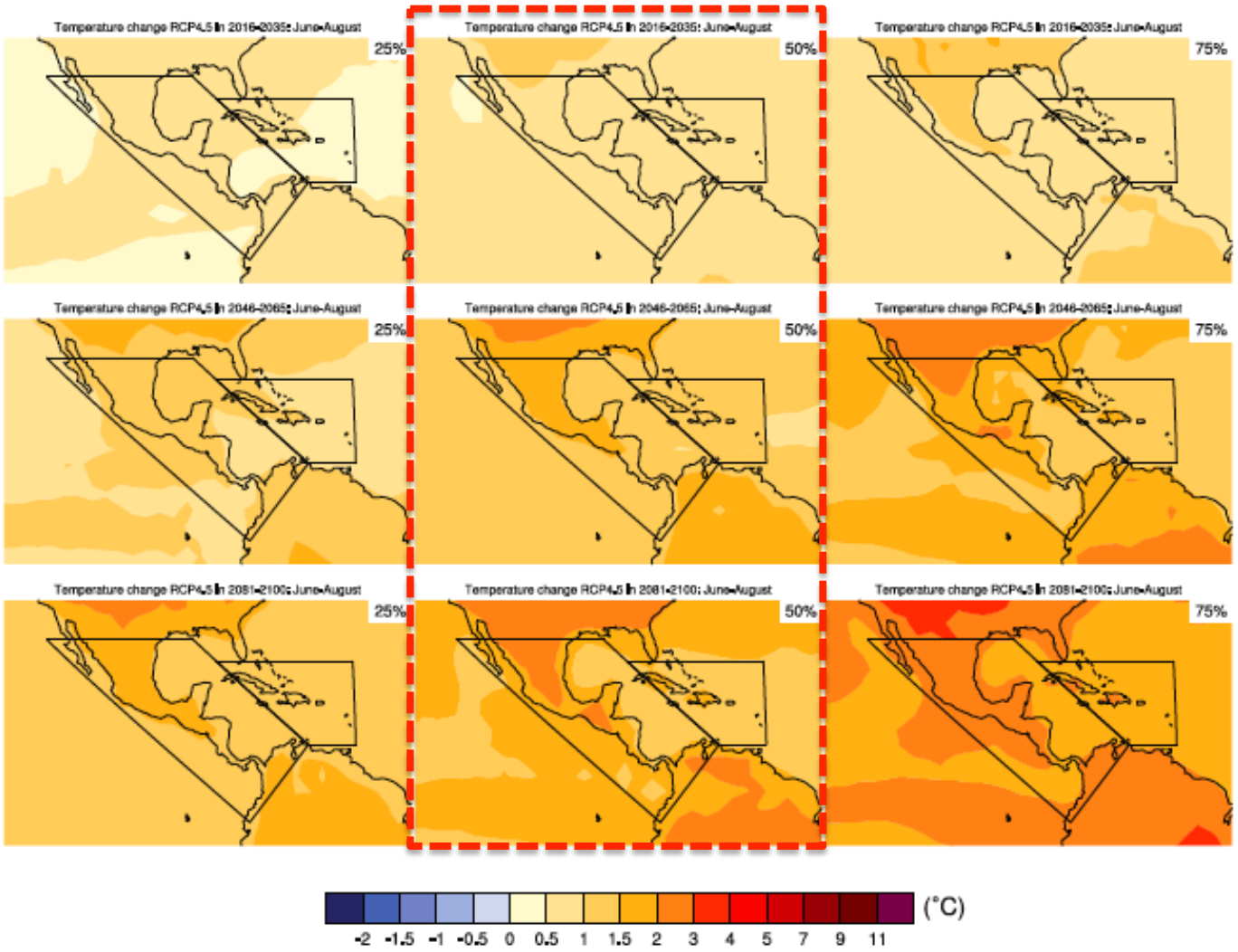

BCSD Methodology

"Bias Corrected Statistical Disaggregation"

Spatial Disaggregation

5. Calculate the additive anomaly for T and multiplicative anomaly for P for the bias-corrected future GCM climate, compared to the GCM historical climate.

6. Linearly interpolate coarse-resolution future climate model **anomalies** to the centers of high-resolution observational data grid

7. Calculate the high-resolution observed mean climatology for the historical period

8. Apply the bias-corrected, interpolated anomaly field (from #5) to the observed fine-resolution mean climatology (adding for T and multiplying for P).

Temporal Disaggregation (if bias-correcting monthly data)

9. Sample month-long daily weather sequences from observational history for a particular month from a year with appropriate regime (i.e. cold/warm/wet/dry, or just wet/dry), similar to k-nn approach.

OPPORTUNITY:

Connect future climate information with climate-impacted sectors and vulnerable communities to facilitate better decisions and a more resilient world.

LIMITATION:

High-resolution data used without thought for its quality, and what important information needs it does not address.