Uncertainties of regional climate projections

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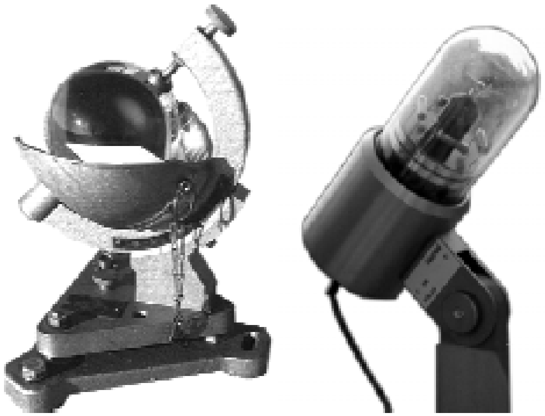
Sources of the errors and uncertainties of downscaled climate simulations

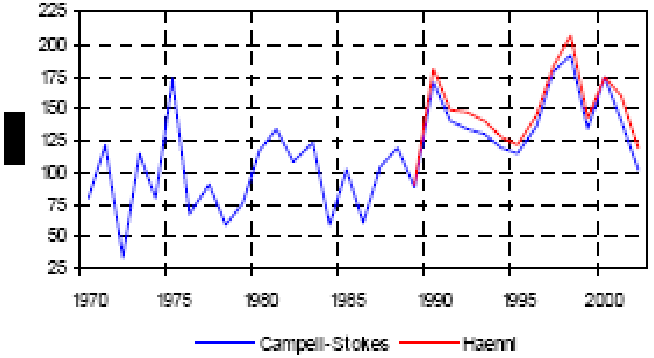
- ***an imperfect model formulation,***
  - ***errors of the driving GCM,***
  - ***errors inherent in the downscaling approach,***
  - ***errors in observations themselves,***
- ***uncertain future concentrations of GHGs,***
- ***internally generated climate variability.***

Uncertainty begins with the observations:

- *How accurate are the instruments used for measurements?*
- *How the measurement device sensitivity influences the quality of measurements ?*
- *How unstable and affected by biases is the observing system over time?*
- *How intermittent are observations in space and time?*
- *How representative are those observations of the true ambient climate at that point in space and time?*

The influence of sensitivity of measuring device on measured variables





What about the unhomogeneity of observations?

- *Changes in environment aound the station*
- *Changes in measurement procedures*
- *Changes in instruments*
- *Changes in observers*
- *Changes in density of measurement net*

Then the data have to be assimilated in models:

- *How strong is the impact of processing steps to move from raw observational data to a gridded Climate Data Record (CDR)?*
- *Which method should be selected for doing it?*
- *How it influences the resulting simulations?*

An example of station density used for gridding

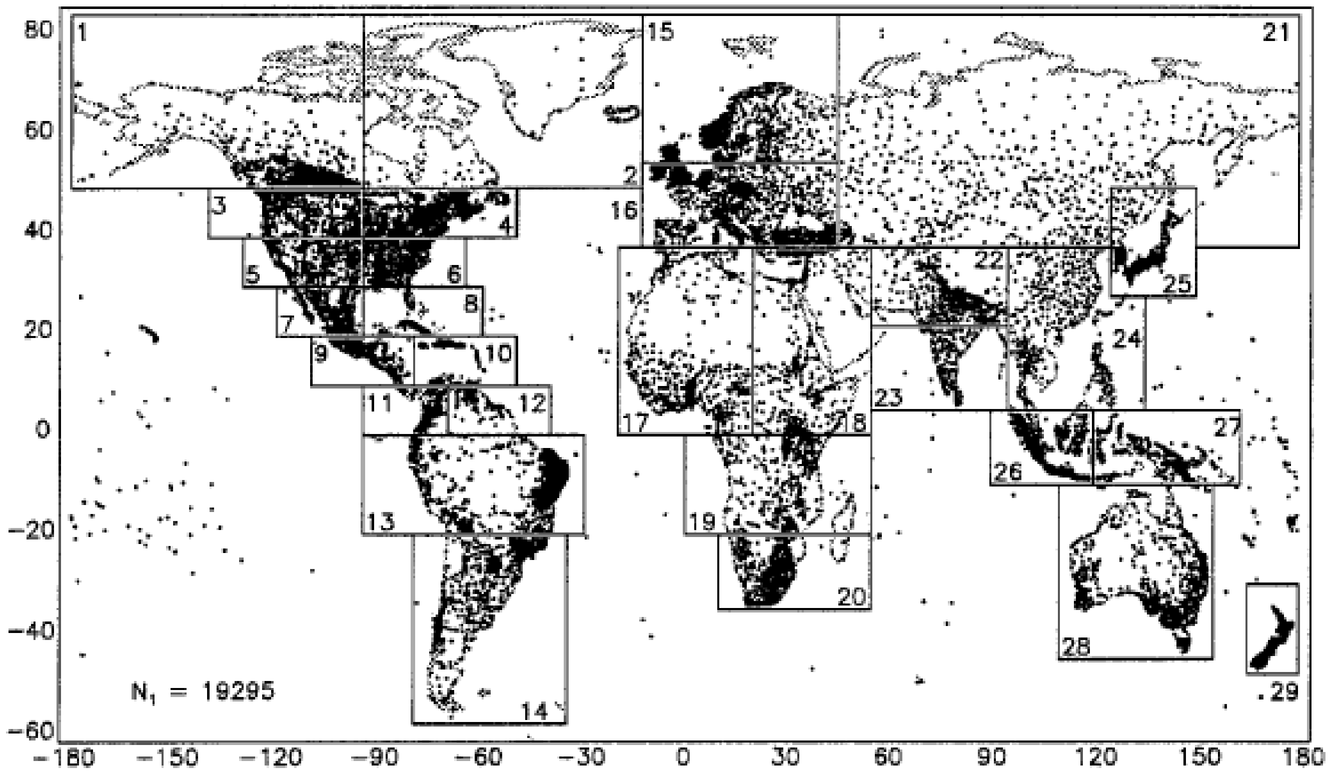
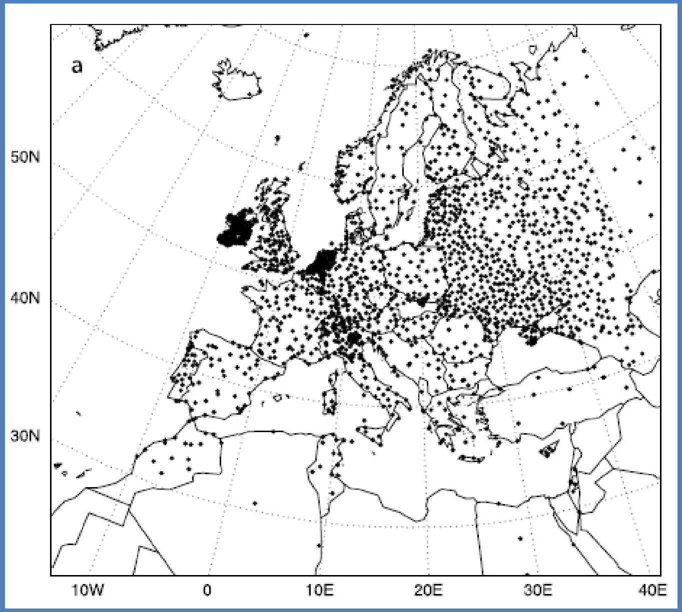


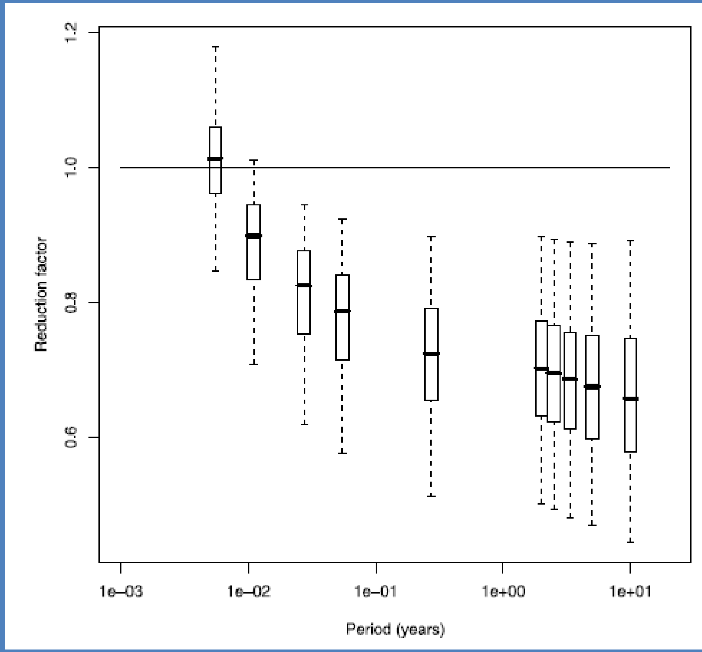
FIG. 1. Location of stations with precipitation normals. Geographic tiles used in the interpolation are shown and *N* signifies the total number of stations used. Note that (i) for all variables, oceanic stations were used during the interpolation of a global "background" tile and (ii) tile numbers and sizes differ between variables.

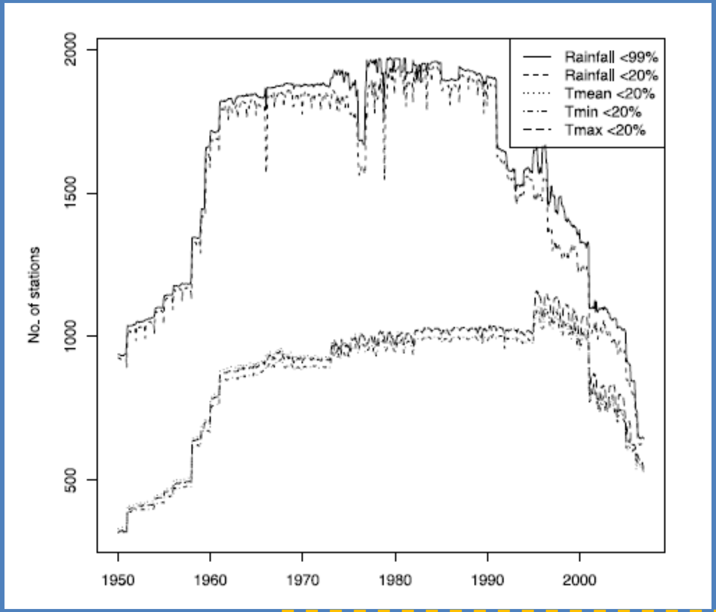
New, 1999



The complete gridding region (land-only), showing the station network for precipitation

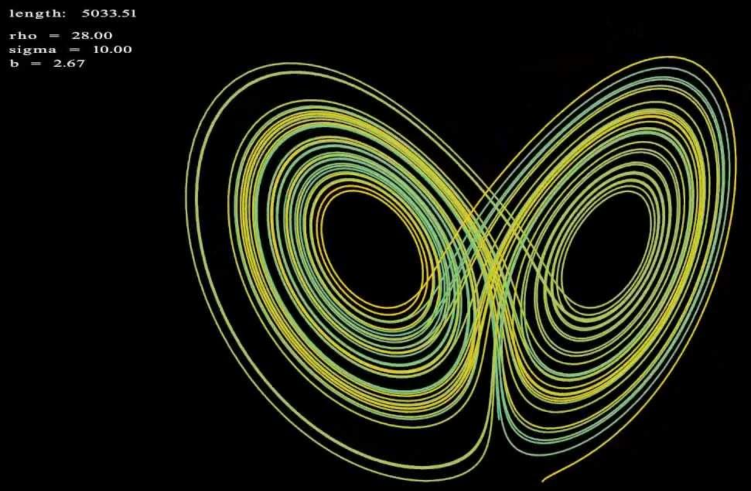
Haylock et al., 2008





The number of stations with less than 99% and 20% missing observations for each month.

Areal reduction factor for daily quantiles of precipitation from the median (50% quantile) up to the 10-year return level.



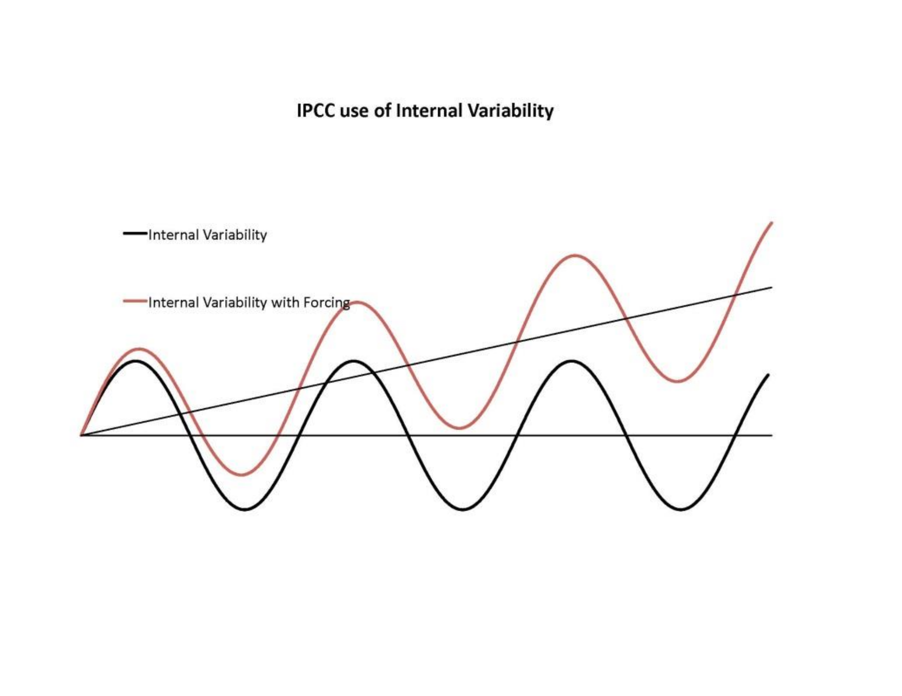
In chaos theory, the **butterfly effect** is the sensitive dependence on initial conditions in which a small change in one state of a deterministic nonlinear system can result in large differences in a later state. The name of the effect, coined by Edward Lorenz, is derived from the metaphorical example of the details of a hurricane (exact time of formation, exact path taken) being influenced by minor perturbations such as the flapping of the wings of a distant butterfly several weeks earlier. Lorenz discovered the effect when he observed that runs of his weather model with initial condition data that was rounded in a seemingly inconsequential manner would fail to reproduce the results of runs with the unrounded initial condition data. A very small change in initial conditions had created a significantly different outcome.

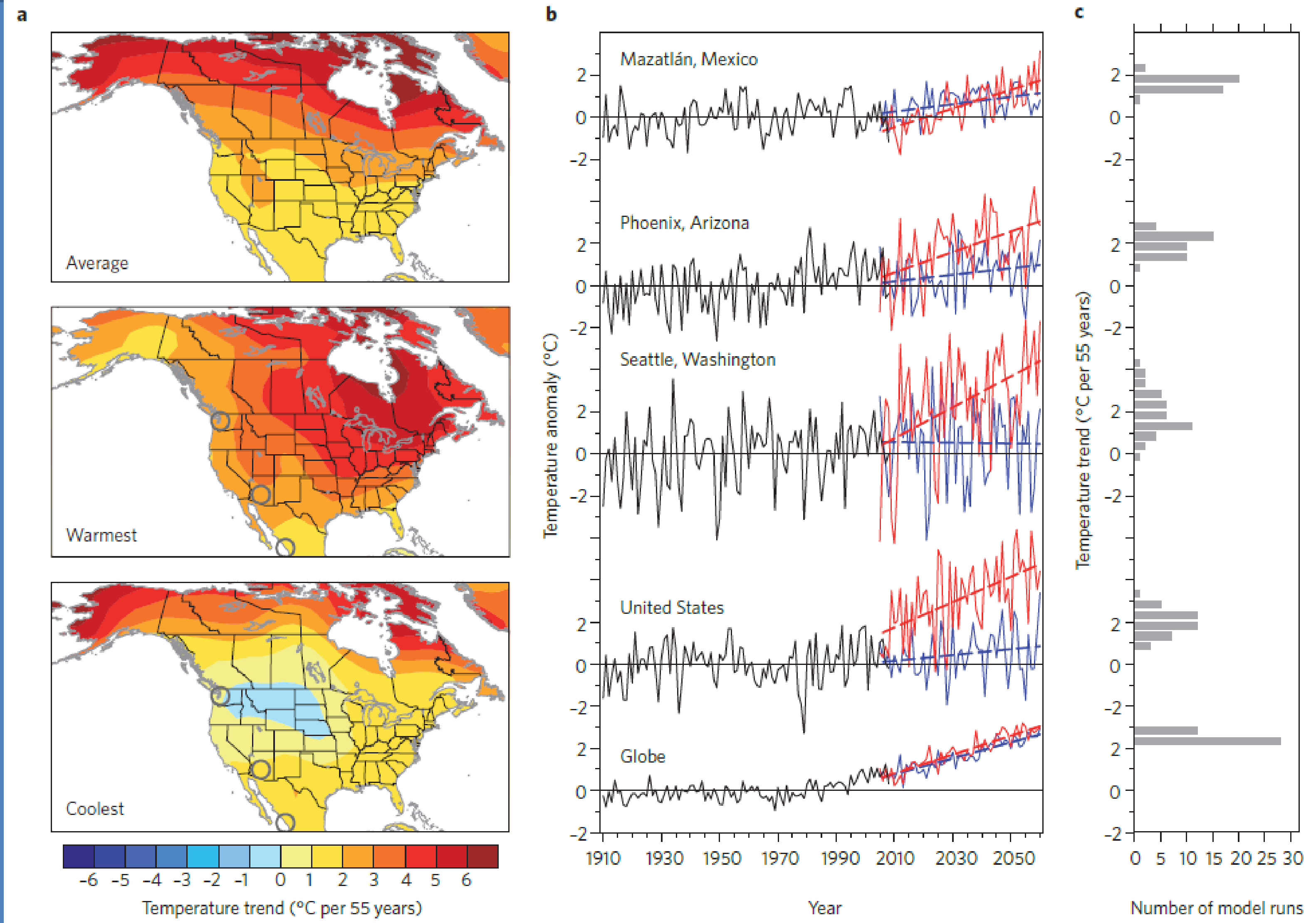
What is internal variability?

Variability due to natural internal processes within the climate system.

Known examples:

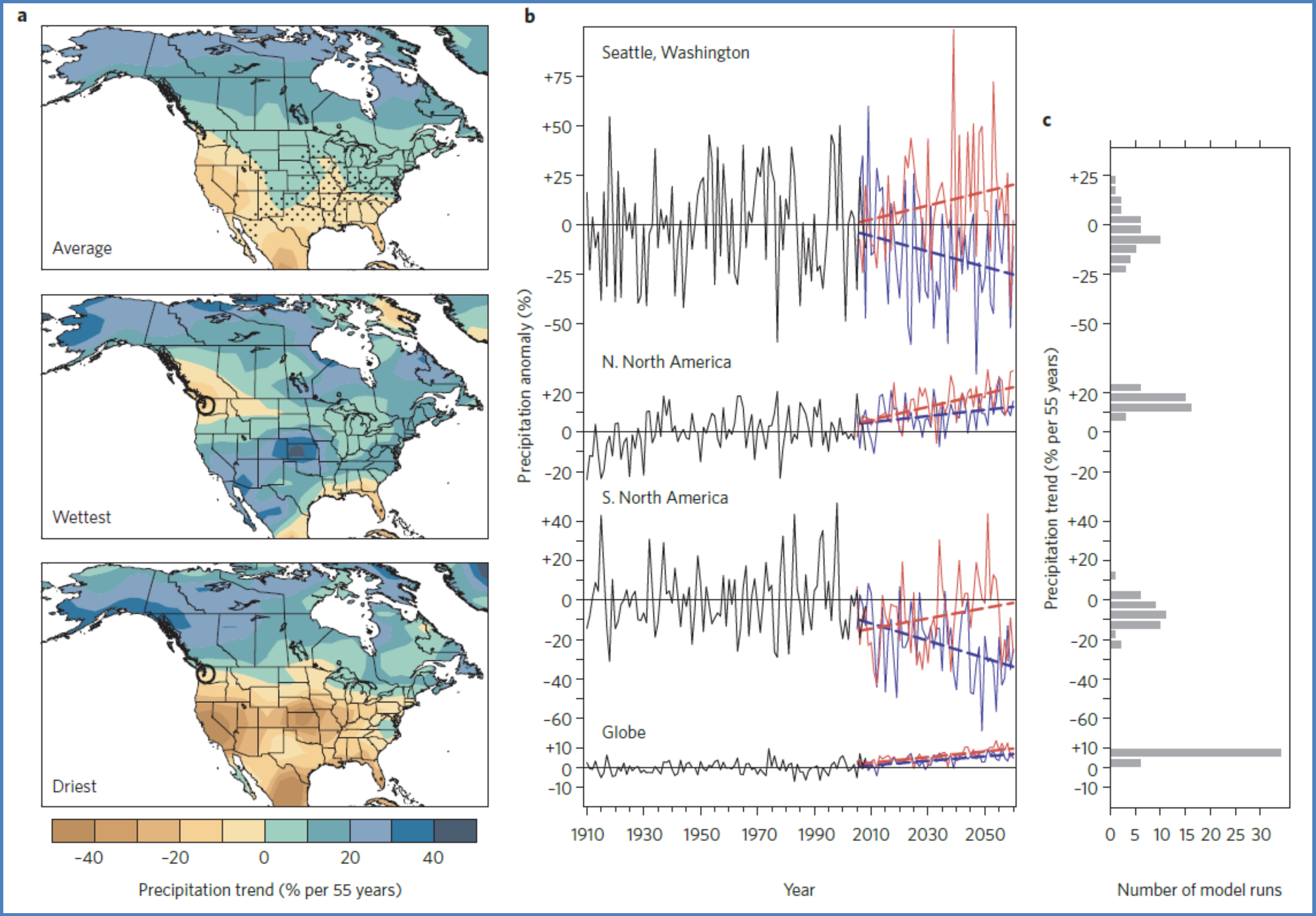
- *ENSO,*
- *AMO,*
- *PDO,*
- *Thermohaline Circulation*





Deser et al., 2012, Nature Climate Change

Range of future climate outcomes. **a**, (DJF) temperature trends during 2005–2060; **b**, DJF temperature anomaly time series for selected places. Black - observed anomalies from 1910 to 2008; red and blue - model projections for 2005–2060 from the realizations with the largest and smallest future trends, respectively, with the best-fit linear trends. **c**, Distribution of projected DJF temperature trends (2005–2060) across the 40 ensemble members at the locations shown in panel



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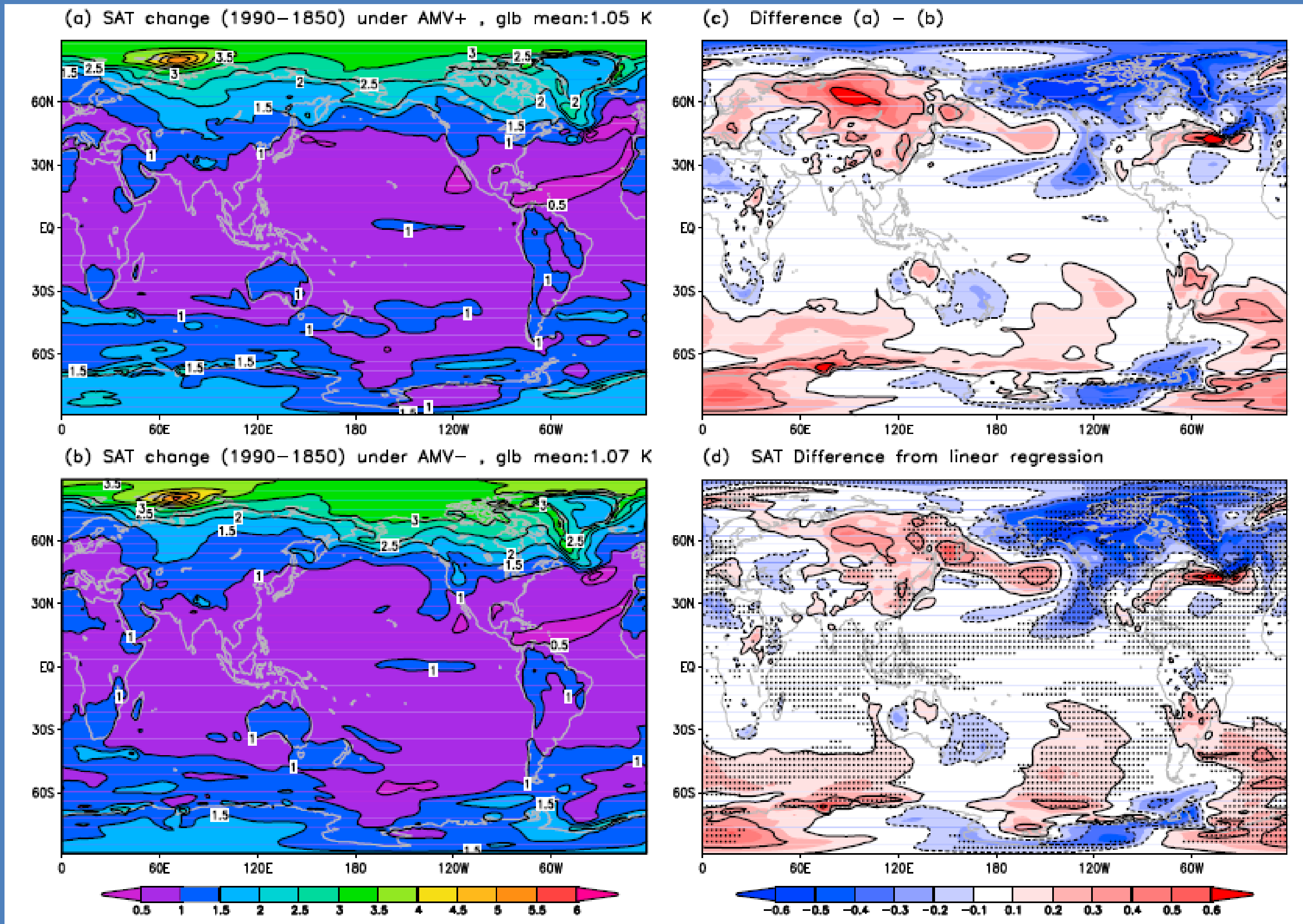

Lu et al., 2014 GRL