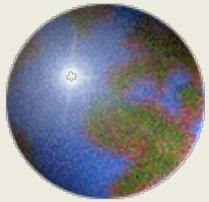


Non-linear and Non-robust Long-term Climate Responses

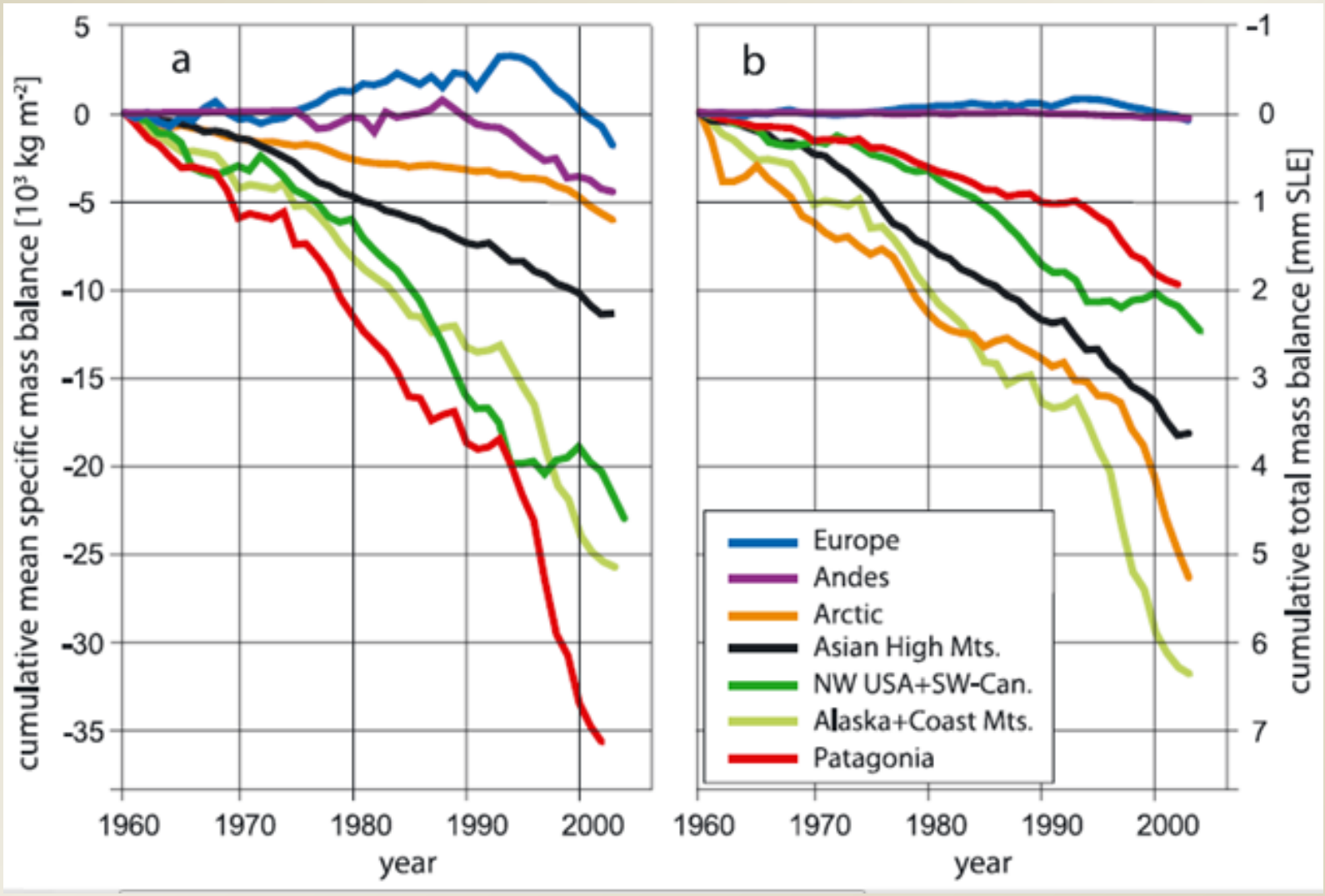
Introduction

- Many climate parameters—such as global and regional temperatures—show a quasi-linear response to changes in radiative forcing associated with increasing greenhouse gas concentrations
- Other parameters—such as water availability, heat indices and extreme event occurrences—may behave in more complex ways
  - "Tipping-point" behavior (i.e. increased sensitivity to forcing)
  - "Turning-point" behavior (i.e. reduced or even reversed sensitivity to forcing)
- Further, inconsistency between forecasts, introduced through natural climate variability or initial-state dependence, poses further limits to climate predictability

Highlights

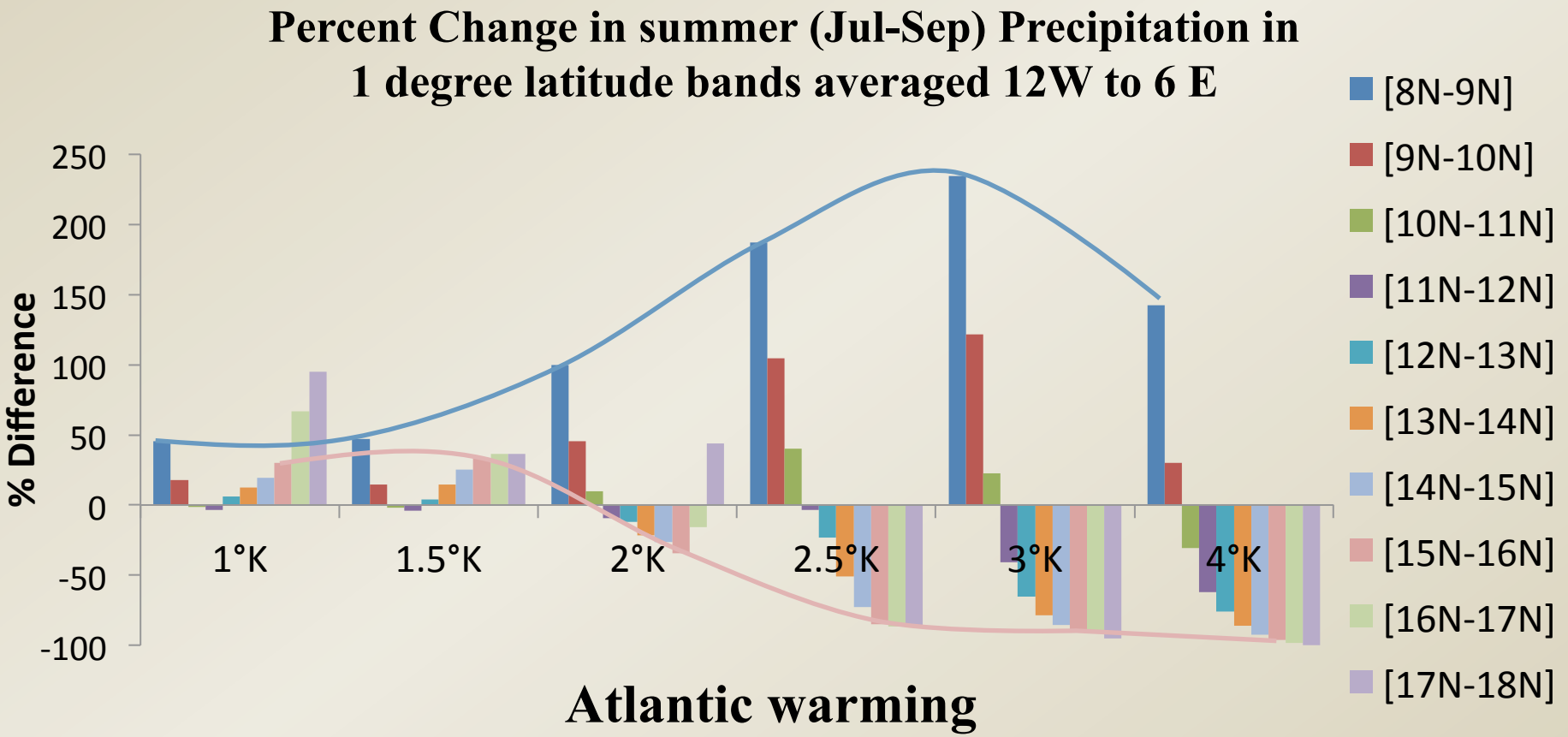
- These slides emphasize the need to identify and analyze regions with the propensity for highly non-linear and/or non-robust long-term climate evolutions
- Many times we (as scientists) get excited about results that are robust
- From a risk management perspective, however, priority should be on the identification and assessment of "*the effect of uncertainty on objectives*"
- Emphasis is on providing a more refined projection of the climate system in response to human-induced forcing such that risk can be managed
  - The transition towards the end-of-century climate states that captures both short-term and long-term impacts
  - The uncertainties that accompany this transition

Historical Glacier Mass Balance



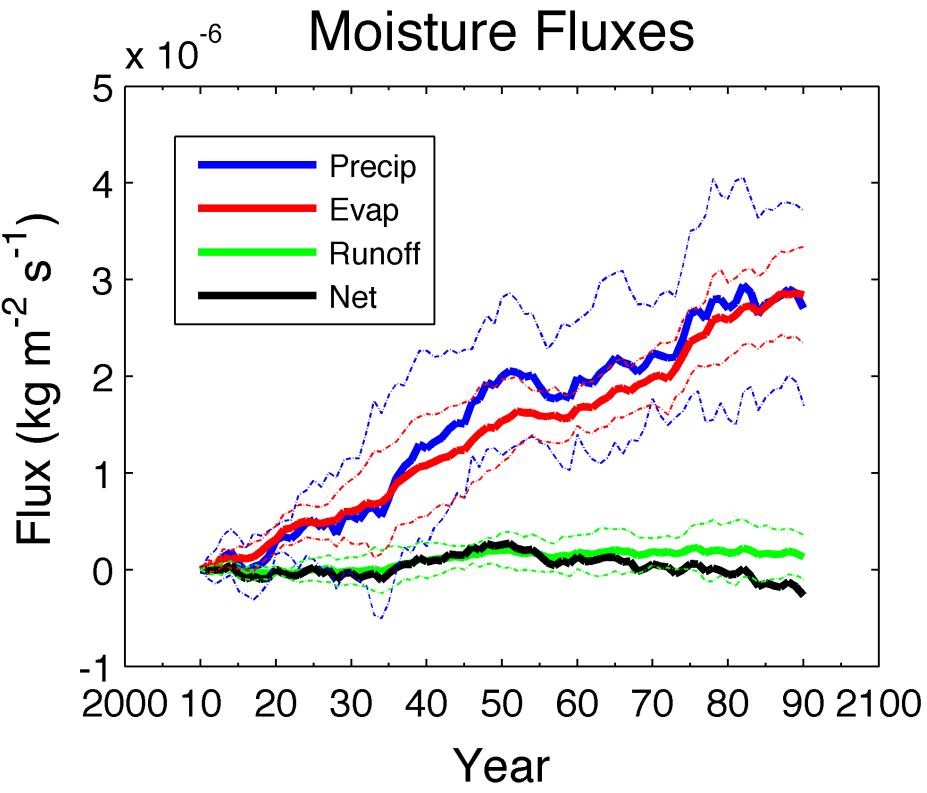
Kaser et al., GRL, 2006

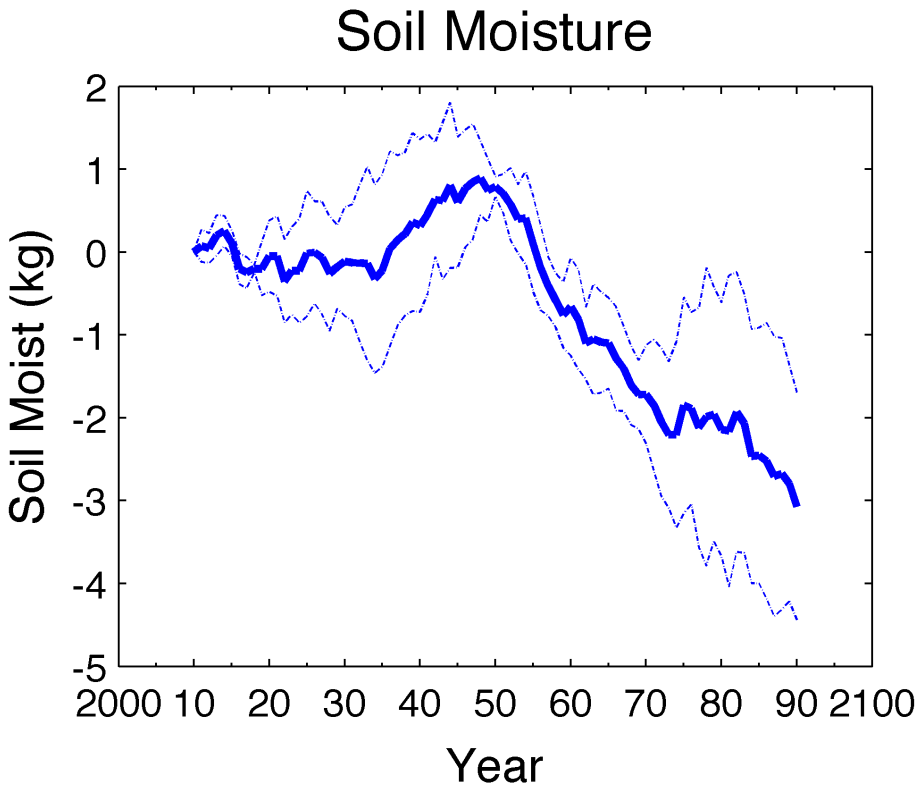
Climate Change Precipitation: Sahel



Cook et al., GRL, 2012

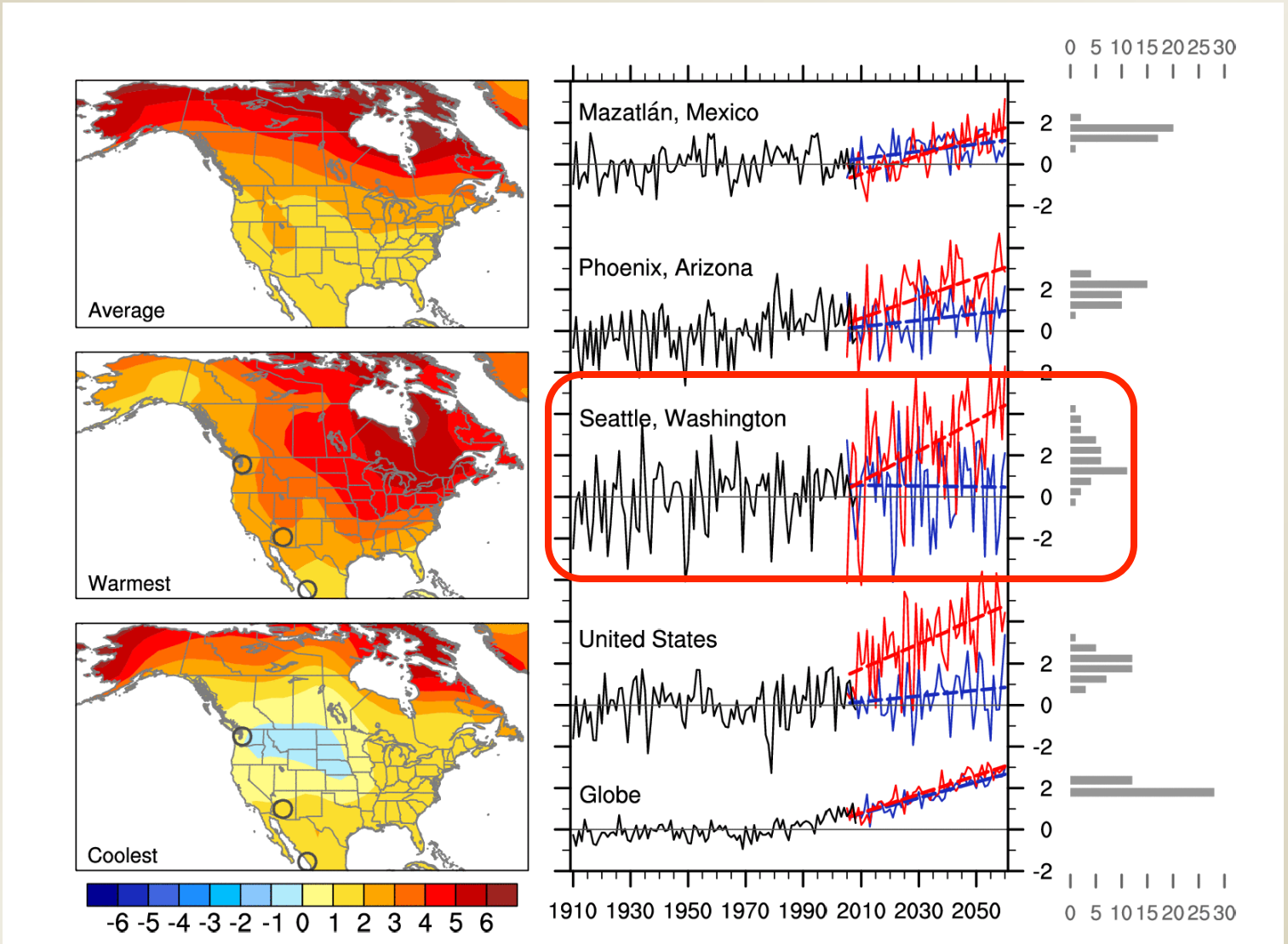
Climate Change Soil Moisture: Eastern US





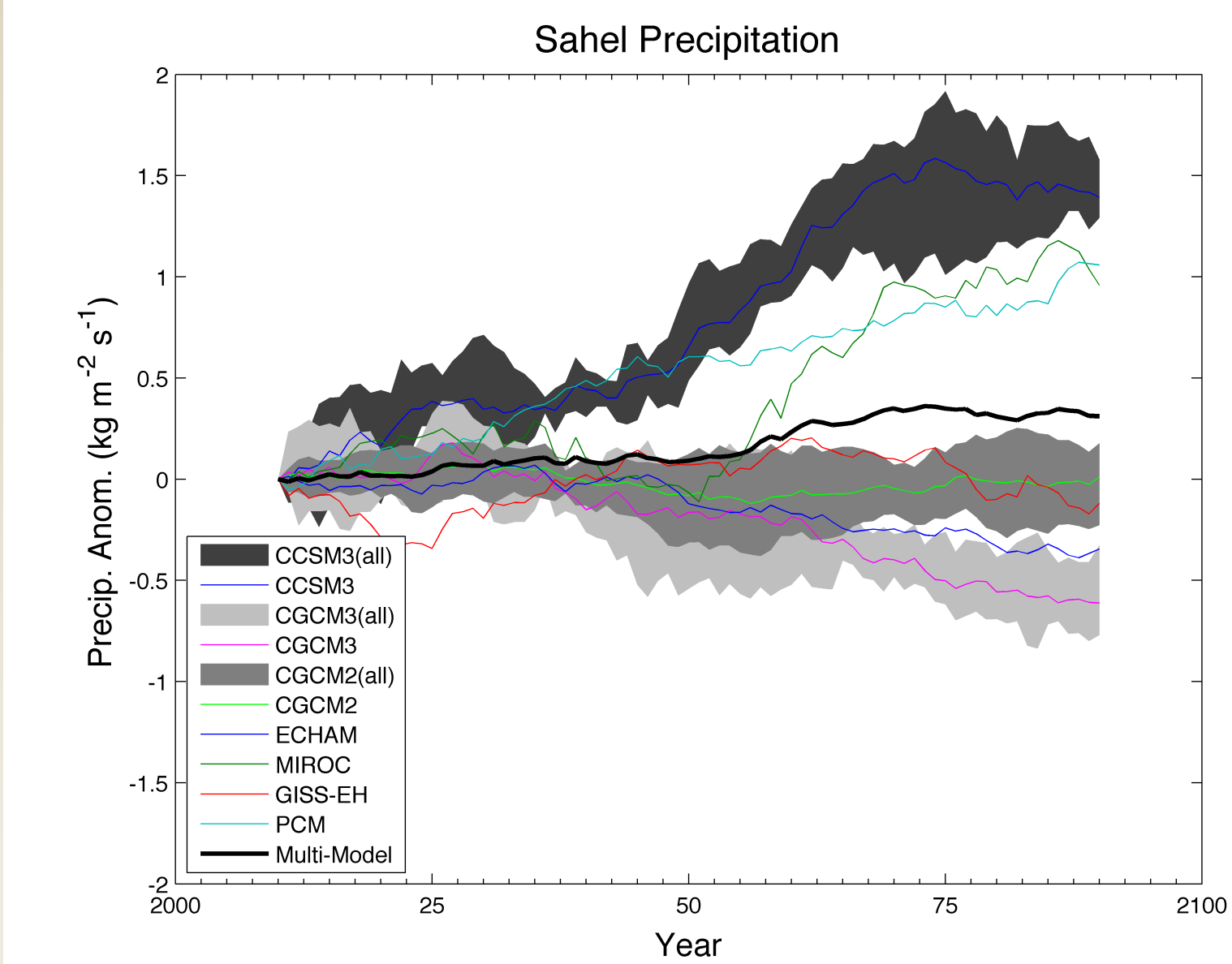
Anderson et al., Earth Interactions, 2009

Climate Change Temperature: N.America

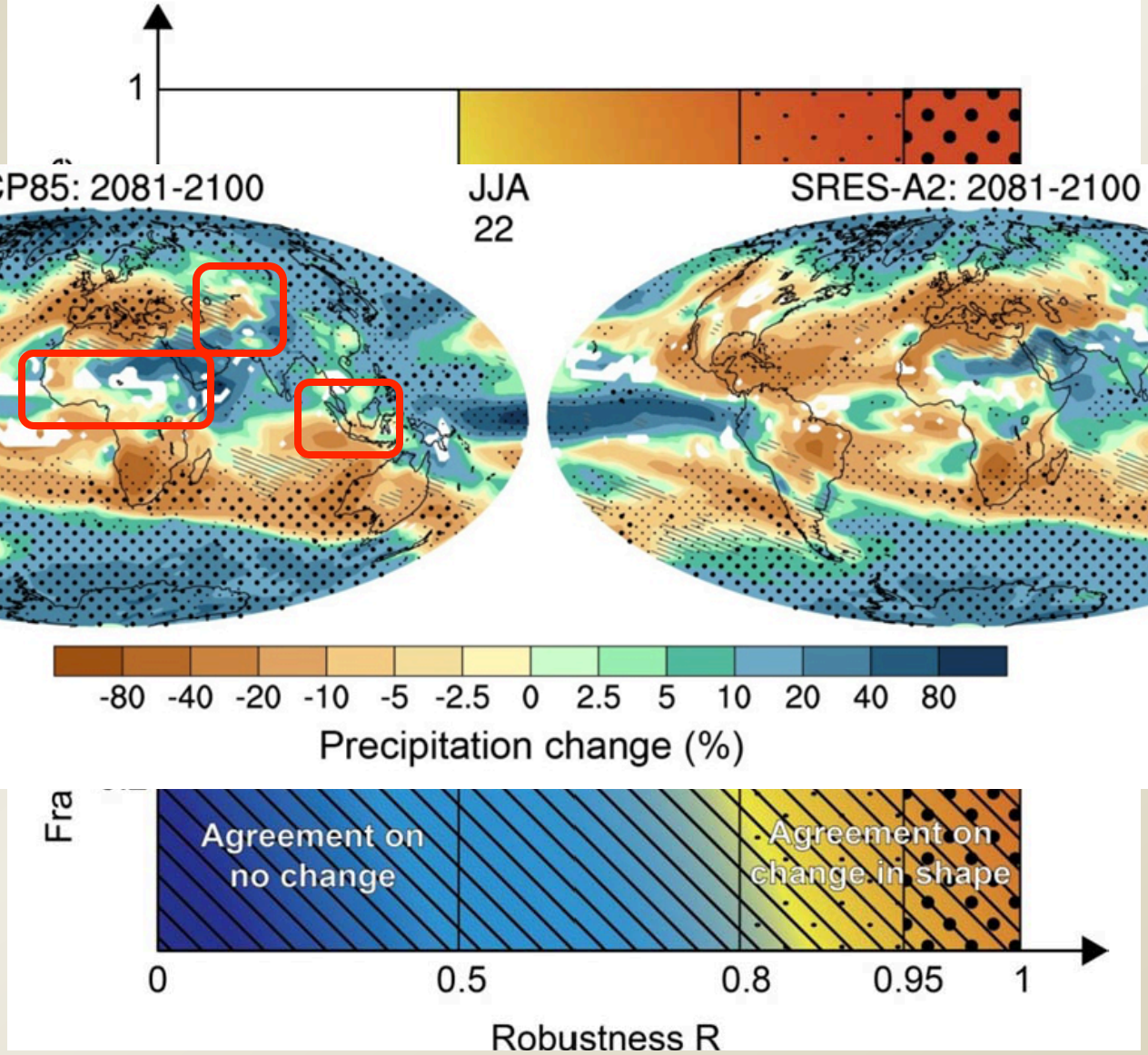


Deser et al., Nature – Clim. Change, 2012

Climate Change Precipitation: Sahel



Robustness of Climate Change



Knutti et al., Nature – Clim. Change, 2012

Highlights

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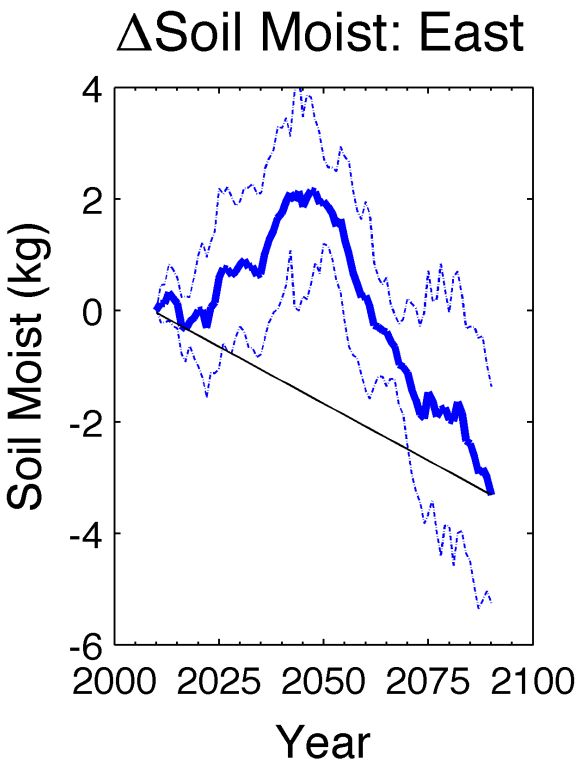
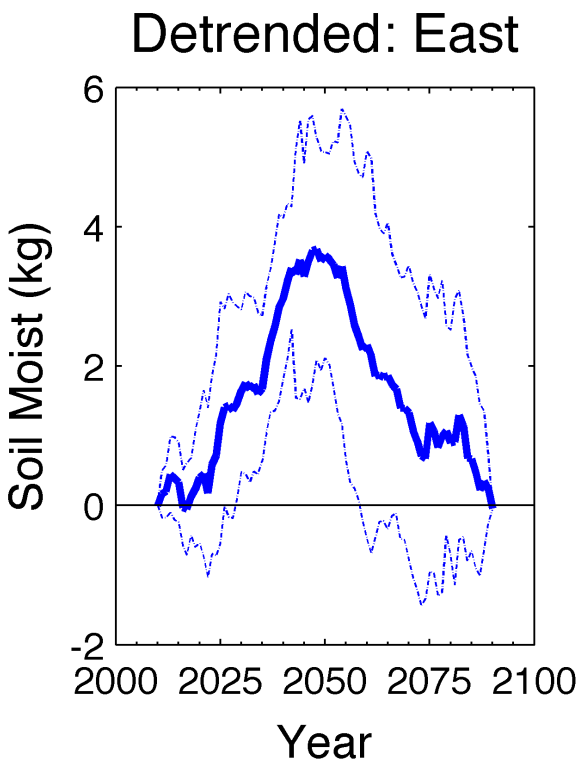
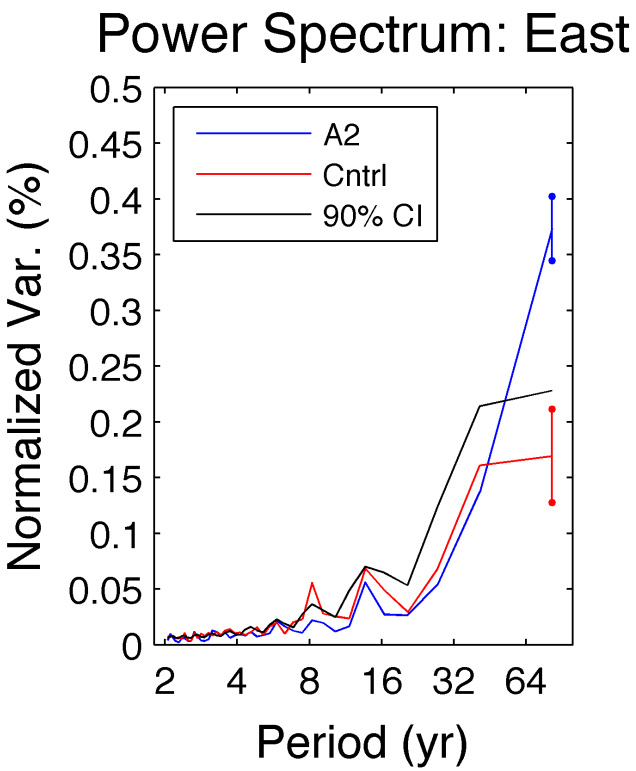
Climate Change Soil Moisture: Eastern US

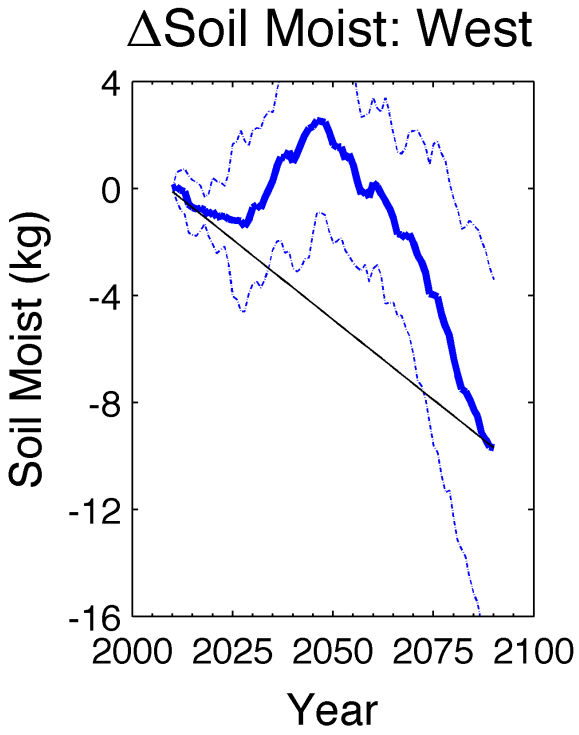


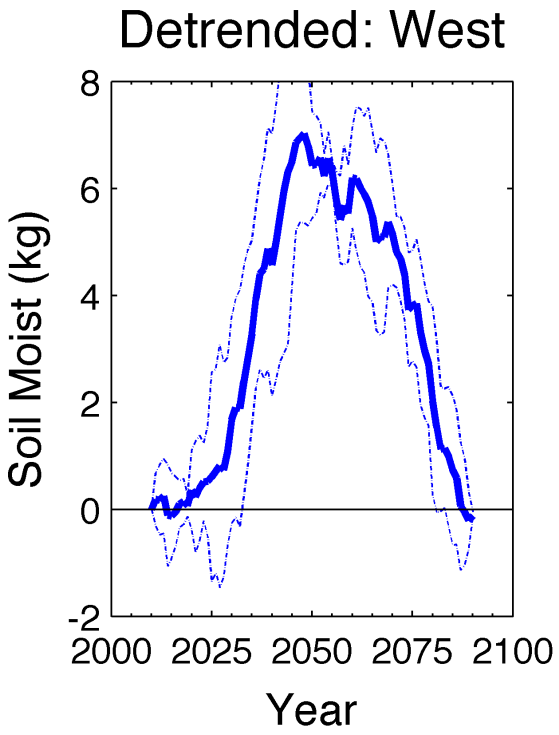


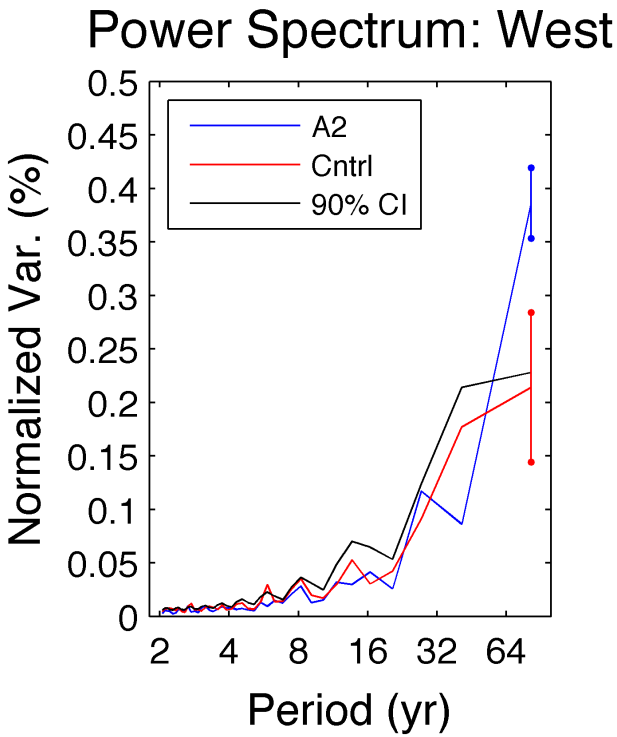


B. Anderson et al., Earth Interactions, 2009

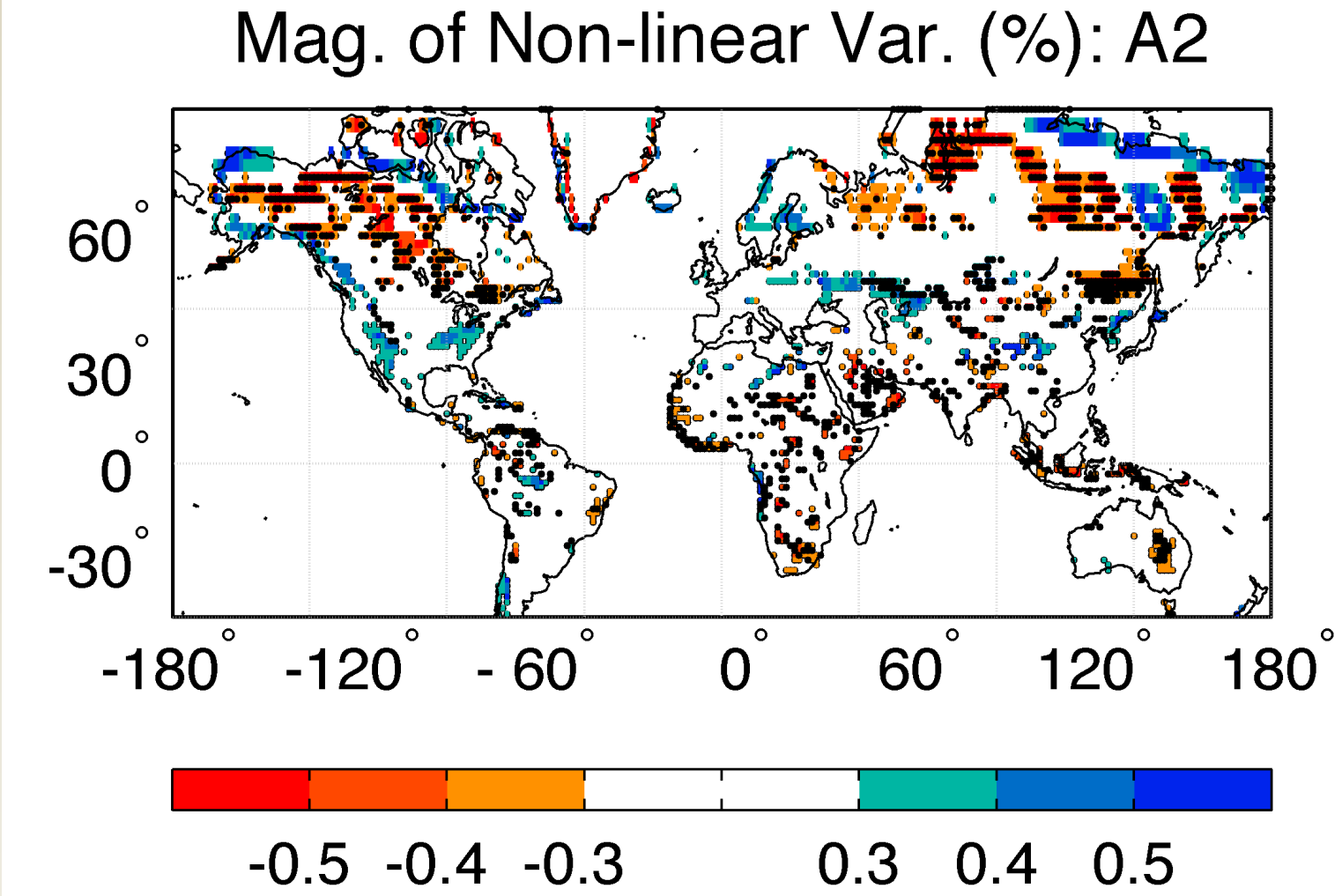
Regional Non-linear Behavior

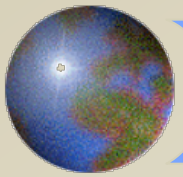






Non-linear Behavior Across Globe

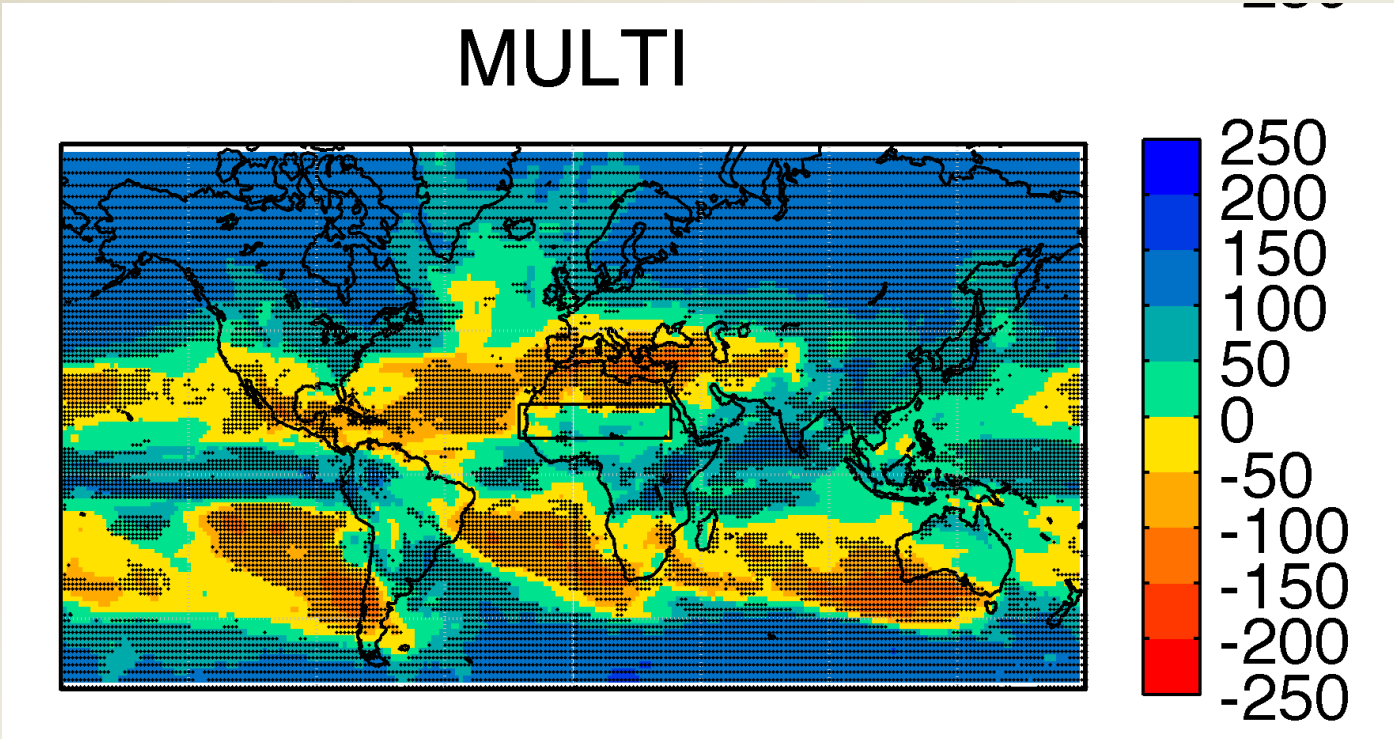




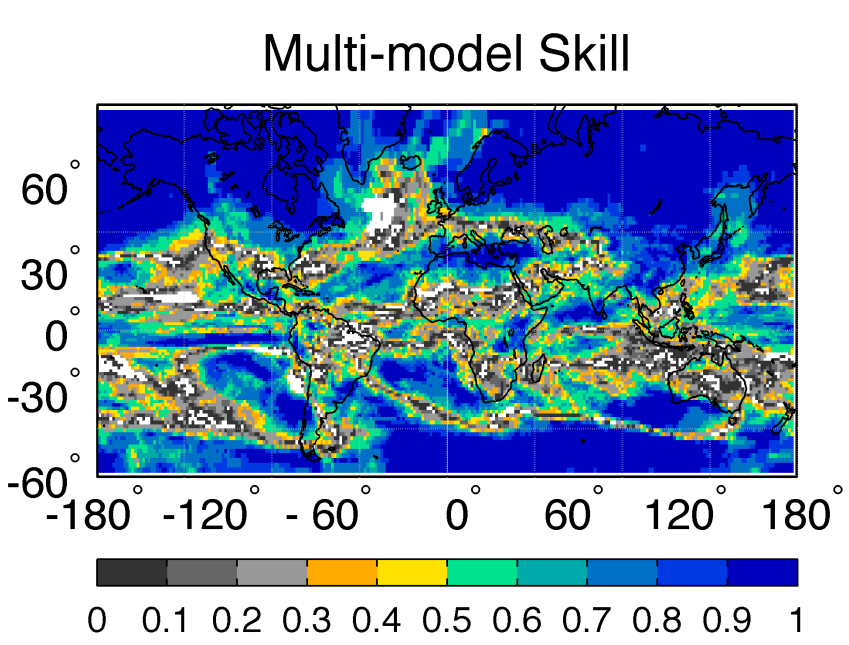
Introduction

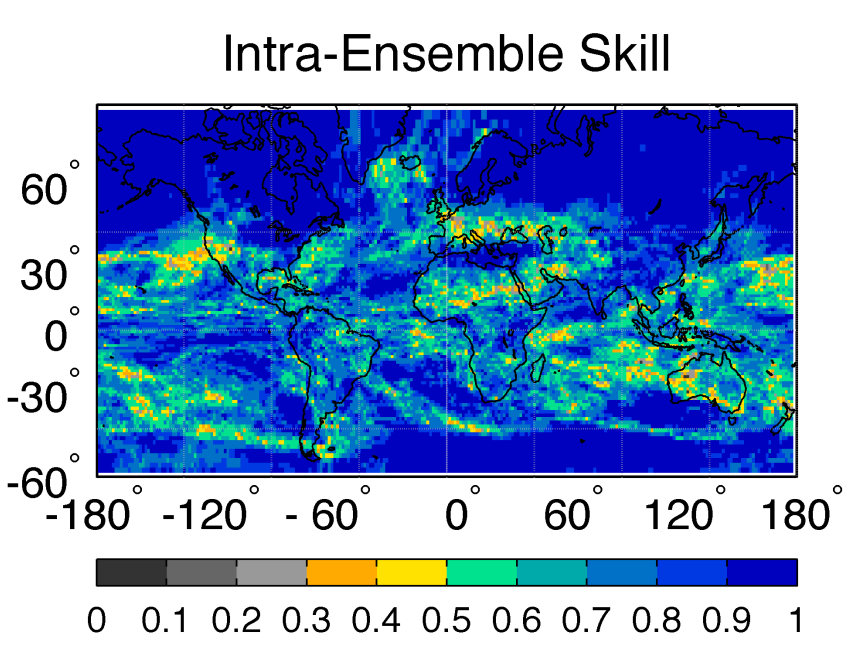
- Generally, in climate forecasting the use of ensembles of model predictions (via ensemble means) or ensembles of model predictions from multiple models (via multi-model ensemble means) provides better forecast skill than any one individual forecast
- However, at regional levels and for certain parameters such as precipitation, there is little inter-model consistency, even in the sign of the projected climate changes
- Given the quasi-linear evolution of certain parameters, we want to determine whether the short-term behavior of even a single realization of the climate system may provide information about the future, long-term behavior of its own evolution

Climate Change Projections: A1B Scenario

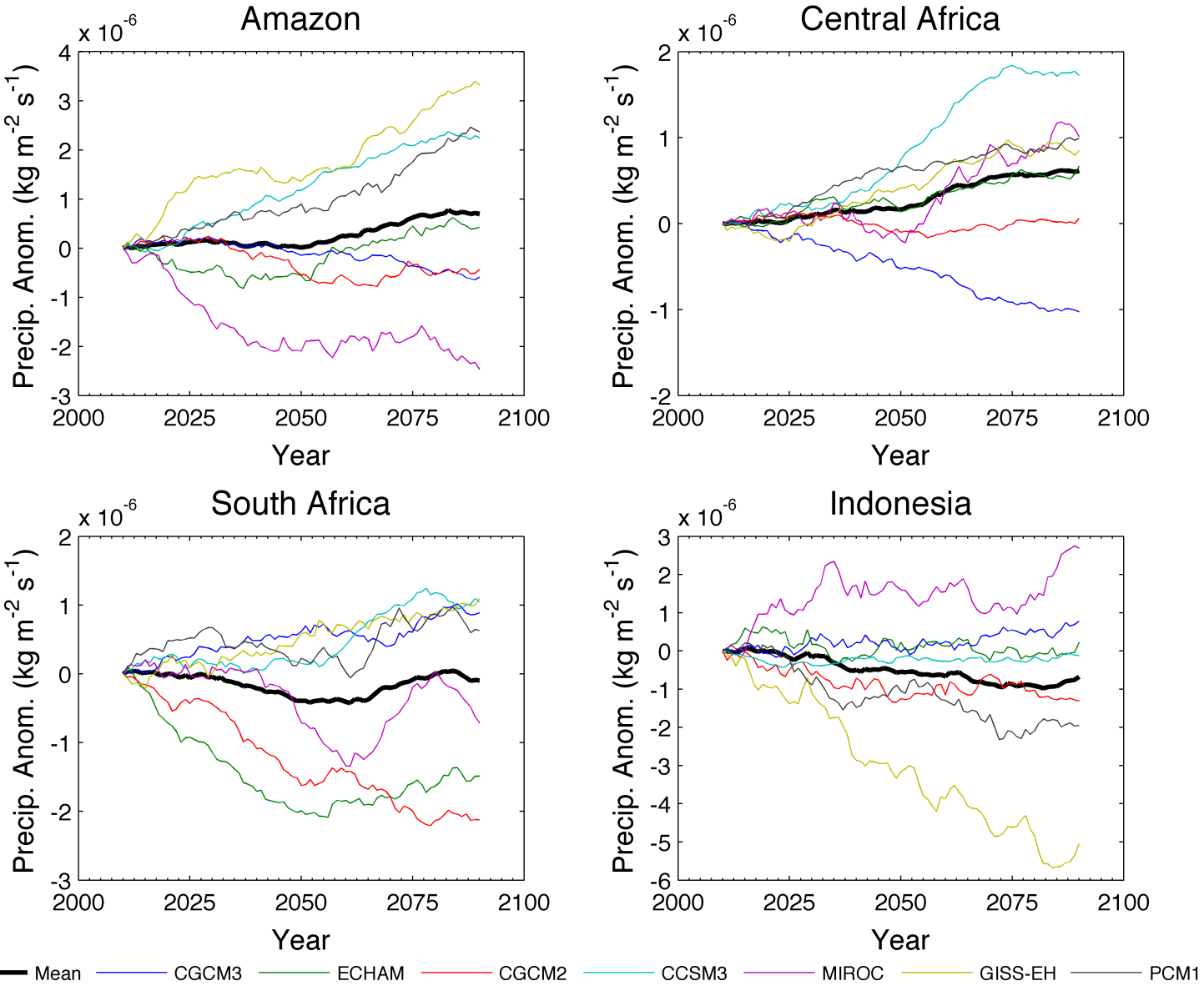


Regional Skill for Individual Simulations

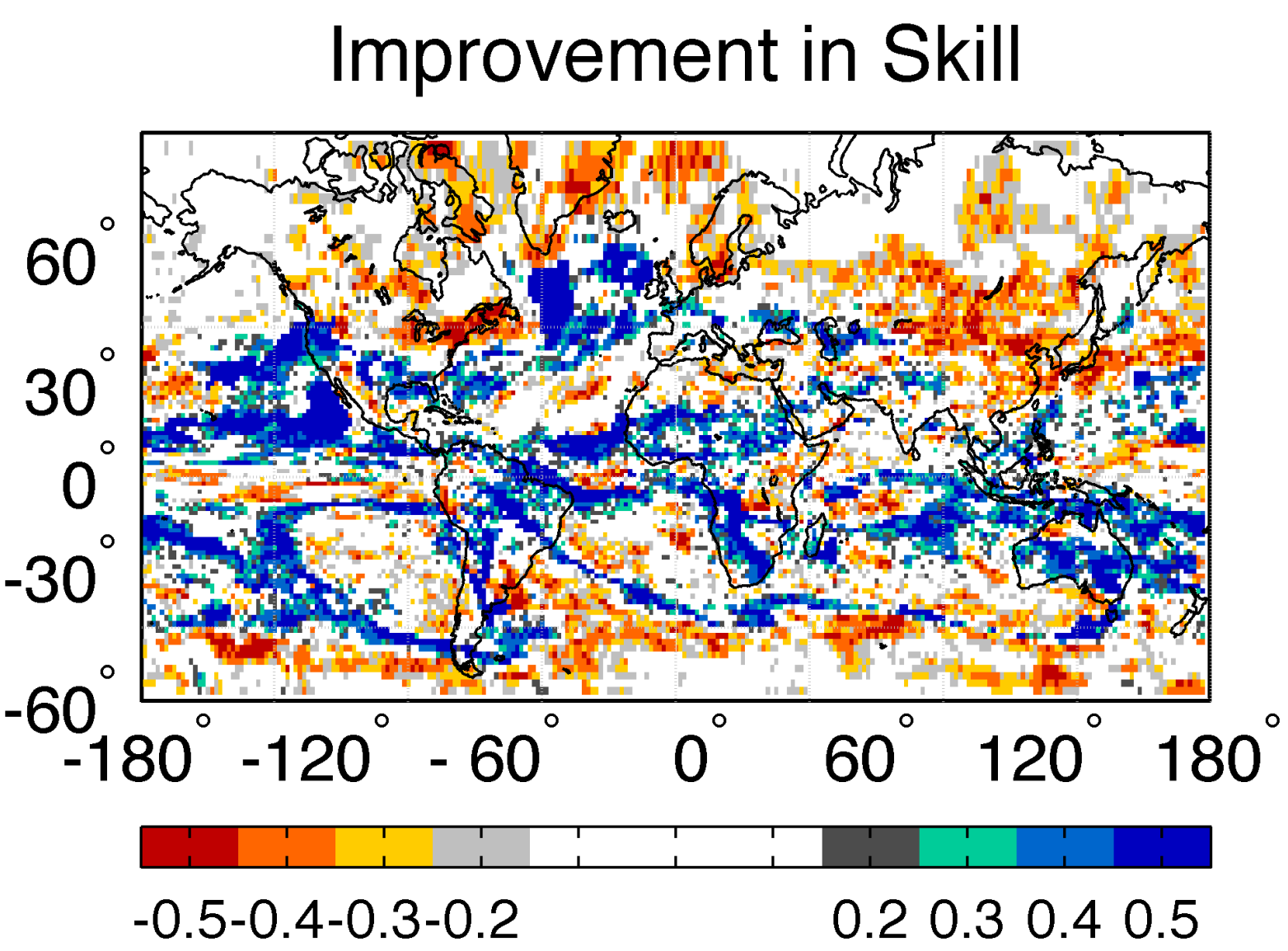




Improvement in Skill for Individual Simulations



Skill of Individual Simulations



Highlights

- In many regions, the large spread of individual model realizations, each of which is considered an equally-plausible evolution of the actual climate system, precludes the use of multi-model ensemble means to make predictions of the response of the climate system to anthropogenic forcing
- However, given a priori knowledge of the underlying (model) climate system, the skill of the projections is markedly improved, indicating that the evolution of the system is constrained by the internal dynamics of the model itself
- In addition, short term trends of individual model realizations also provide improved skill in predicting their own state by the end of the simulation period
- These results suggest that the historical evolution of the climate system inherently contains information about its own future evolution that can be used to augment model-based climate change projections.