The role of climate modelling in the study of the last 2000 years

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Context: The climate of the last 2000 years

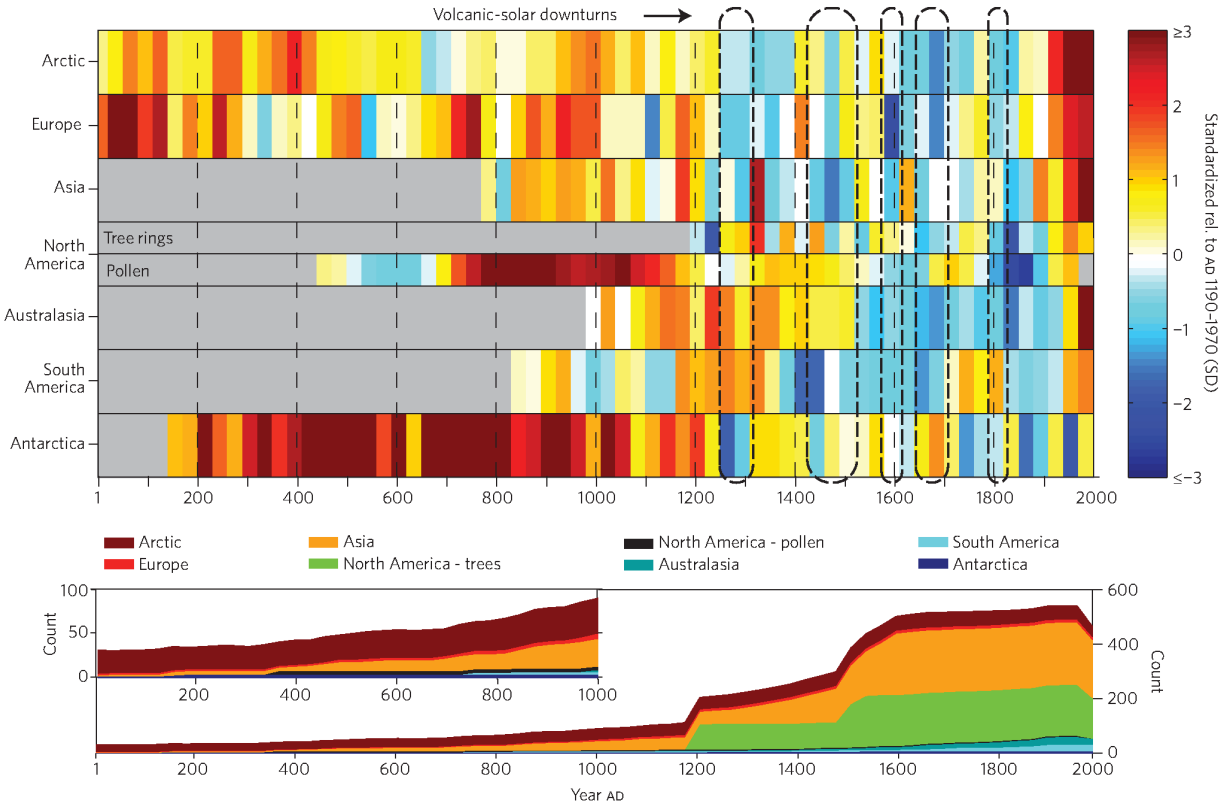
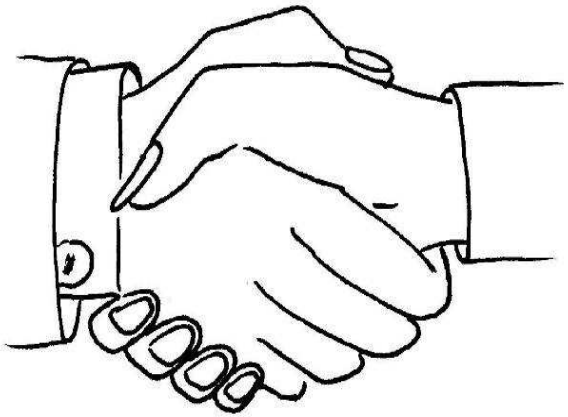


Figure 2 | Continental-scale temperature reconstructions. 30-year-mean temperatures for the seven PAGES 2k Network regions, standardized to have the same mean (0) and standard deviation (1) over the period of overlap among records (AD 1190–1970). North America includes a shorter tree-ring-based and a longer pollen-based reconstruction. Dashed outlines enclose intervals of pronounced volcanic and solar negative forcing since AD 850 (see Methods). The lower panel shows the running count of number of individual proxy records by region. Data are listed in Supplementary Database S2.

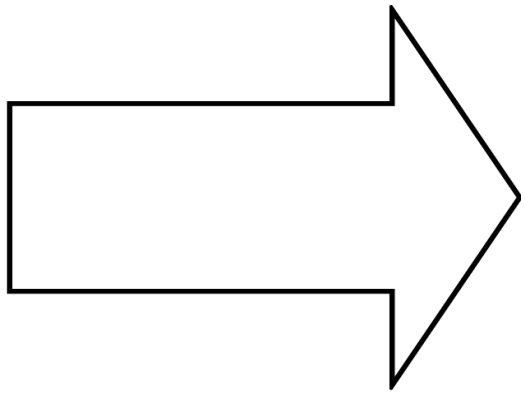
PAGES 2k Consortium (2013)

The "handshake" question



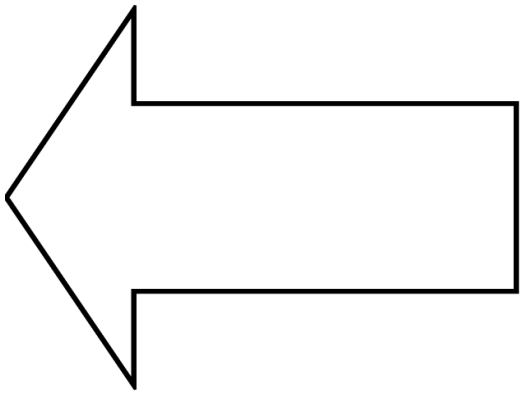
How do we integrate data from natural archives with climate models in a way that extracts the maximum possible information about the dynamics of the climate system?

The inverse approach



- Translate proxy variables into physical climate variables.
- Achieved by calibrating proxy variables against local or remote climatic variables, typically using observational data.
- Involves the necessary but usually implicit assumption of stationarity.
- Proxies can integrate multiple environmental variables, so information is lost when only reconstructing a single variable.

The forward approach



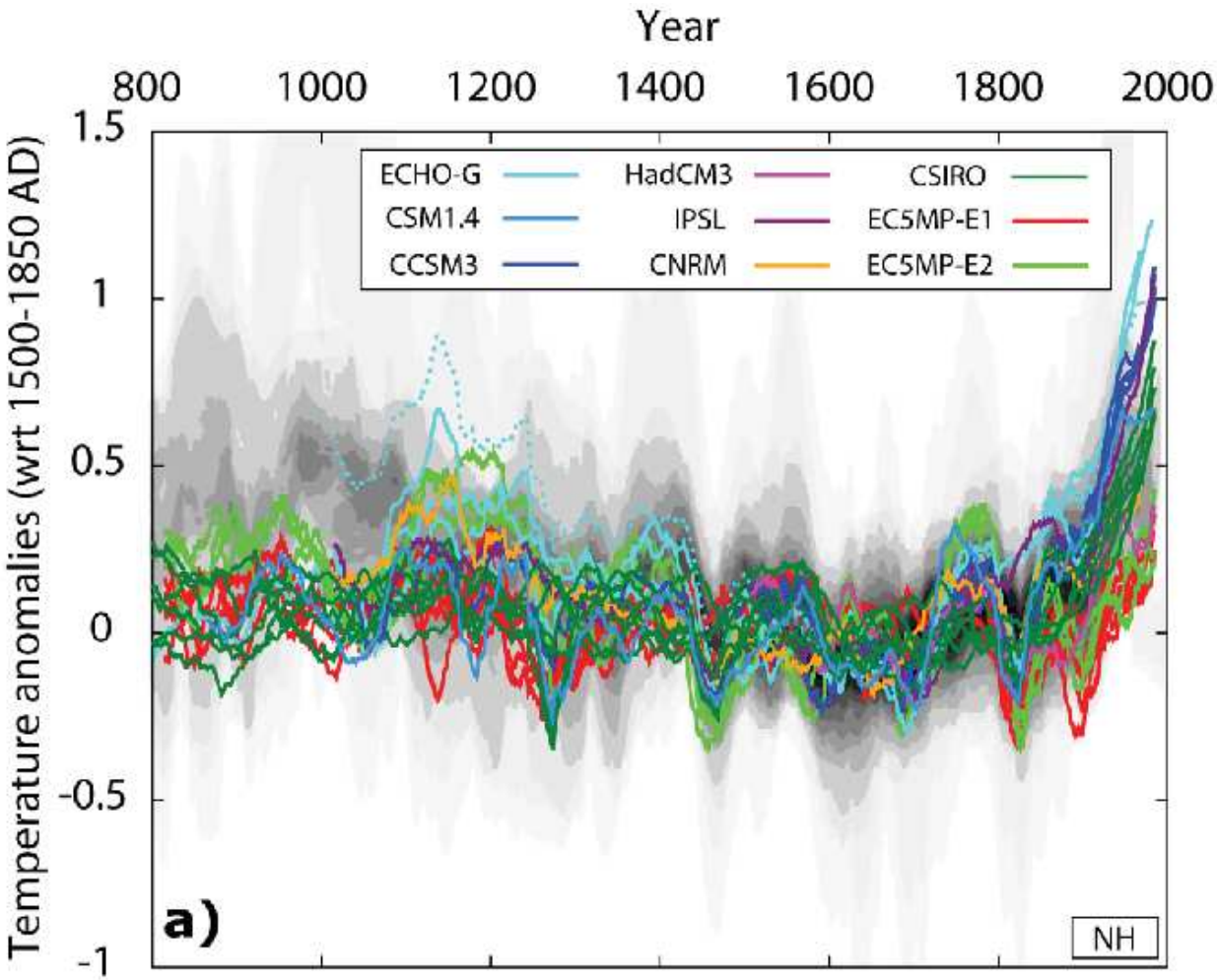
- Translate model variables into proxy variables.
- Achieved by using physical and biological principles to simulate the evolution of proxy variables within a modelling framework.
- Capable of avoiding the assumption of stationarity.
- Can account for the fact that proxies integrate multiple variables.
- Require a complete description of all the relevant processes.

The role of climate modelling

Through the comparison of model simulations with proxy data and climate reconstructions spanning the last 2000 years, we can...

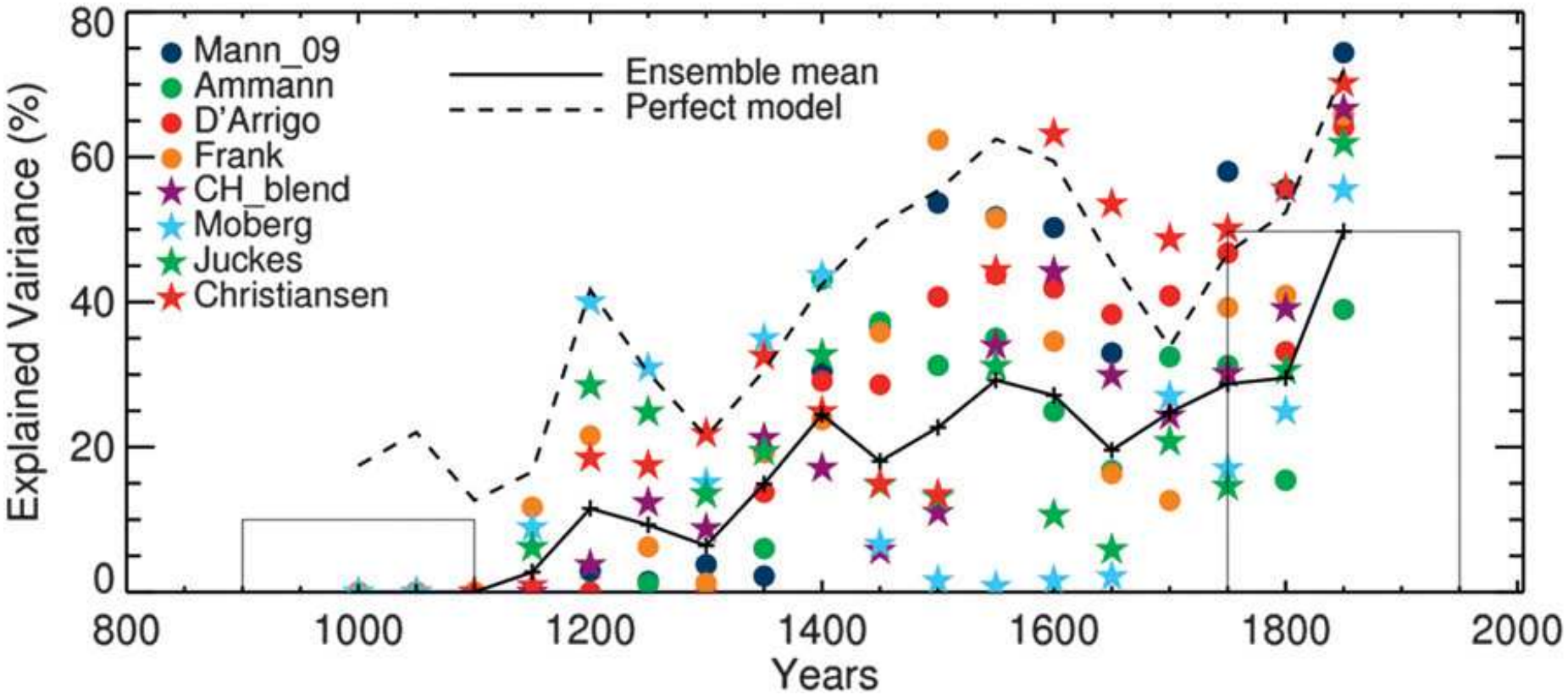
- study the relative roles of forced versus internal variability within the climate system
- determine the characteristics of natural internal climate variability
- derive estimates of the transient climate sensitivity
- test dynamical hypotheses
- evaluate the models that are used to project future climate change

Forced versus internal variability



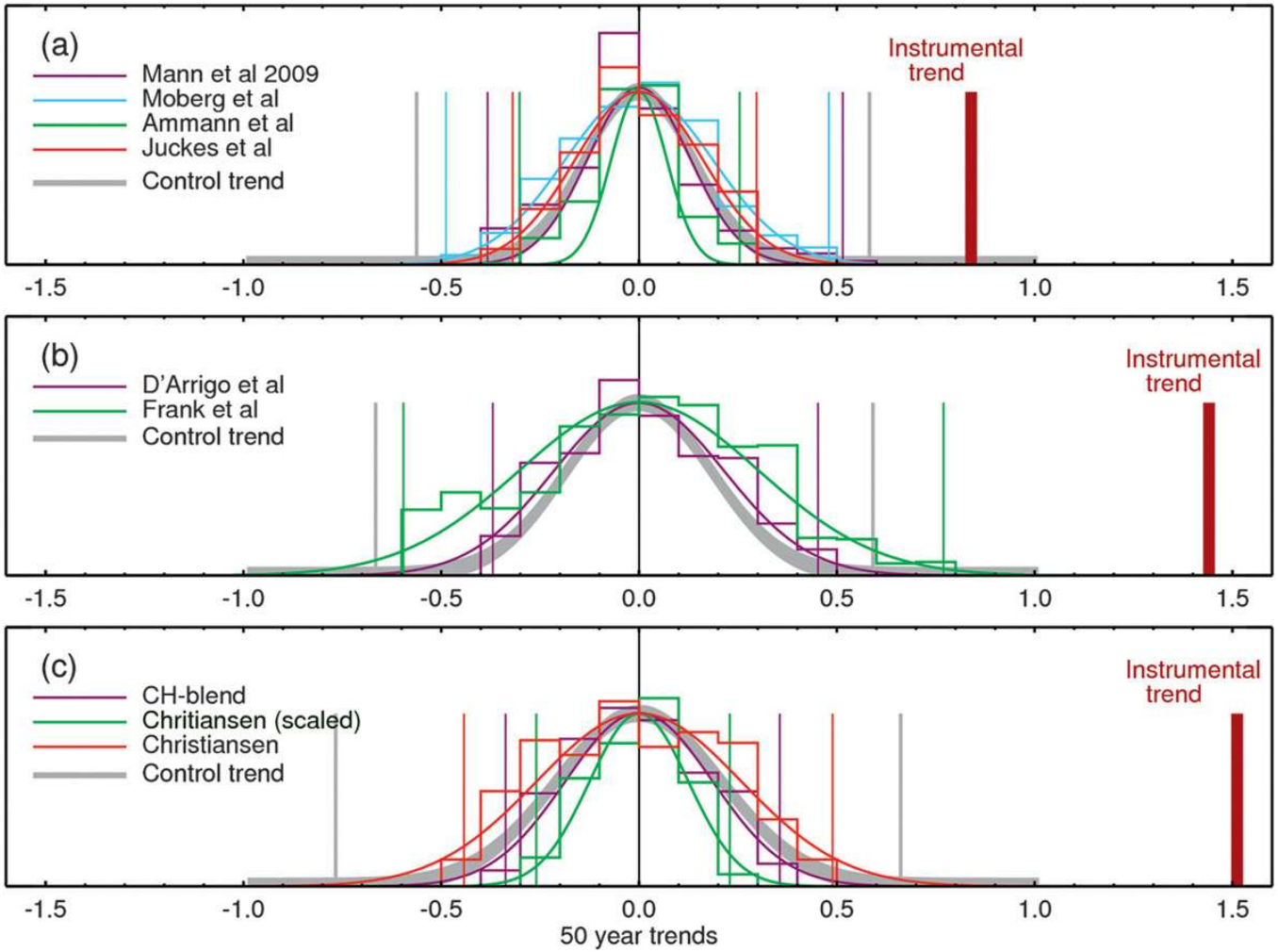
Fernández-Donado et al. (2013)

Forced versus internal variability



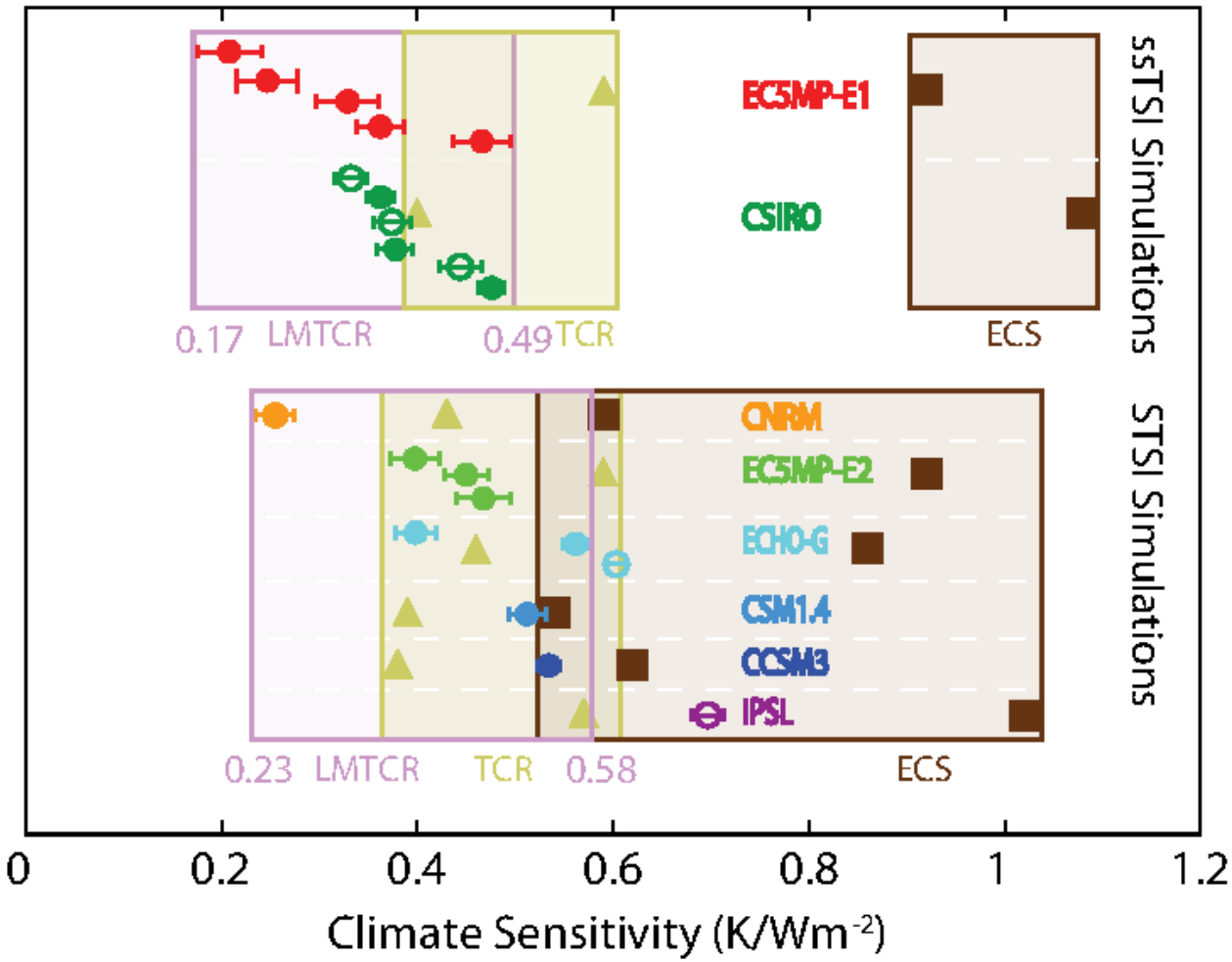
Schurer et al. (2013)

Characteristics of natural internal climate variability



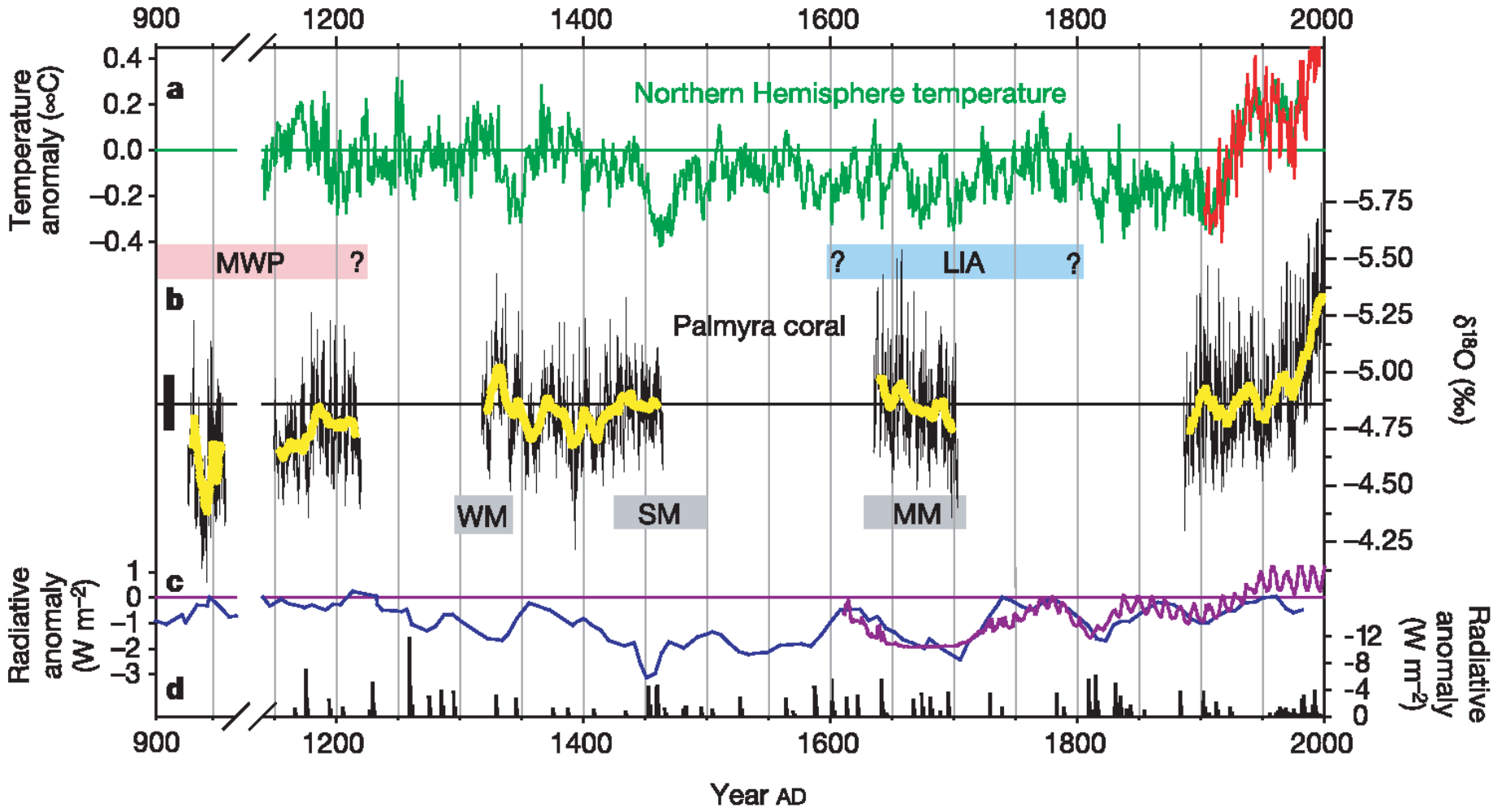
Schurer et al. (2013)

Estimates of the transient climate sensitivity



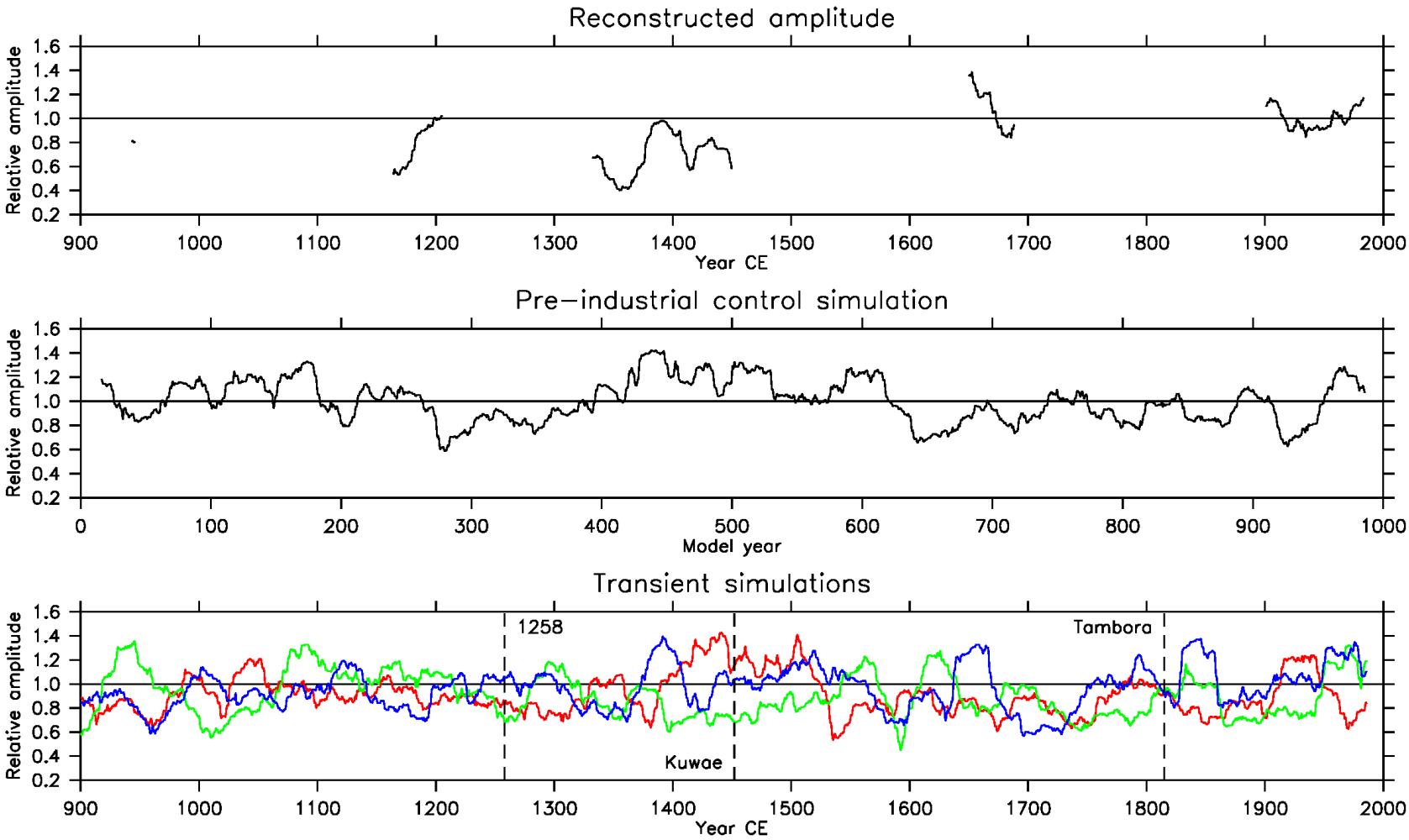
Fernández-Donado et al. (2013)

Test dynamical hypotheses: ENSO



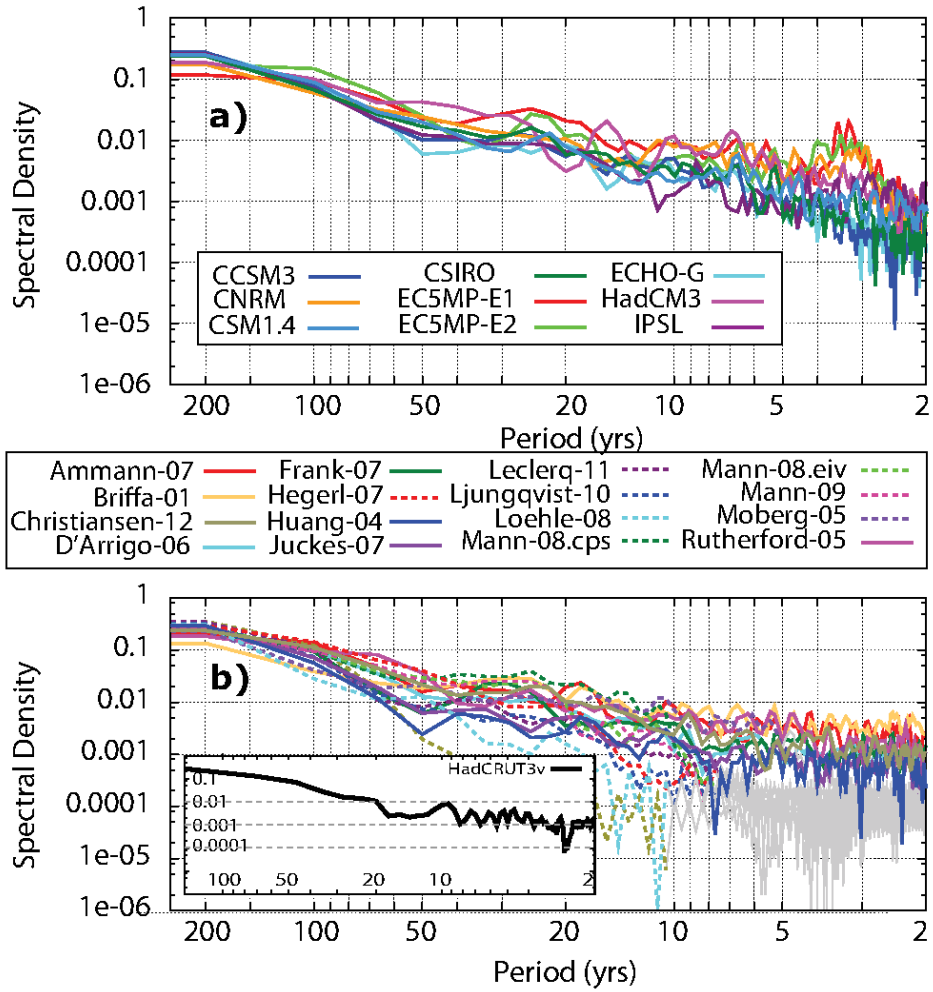
Cobb et al. (2003)

Test dynamical hypotheses: ENSO



Phipps et al. (2013)

Evaluate the models used to project future climate change



Fernández-Donado et al. (2013)

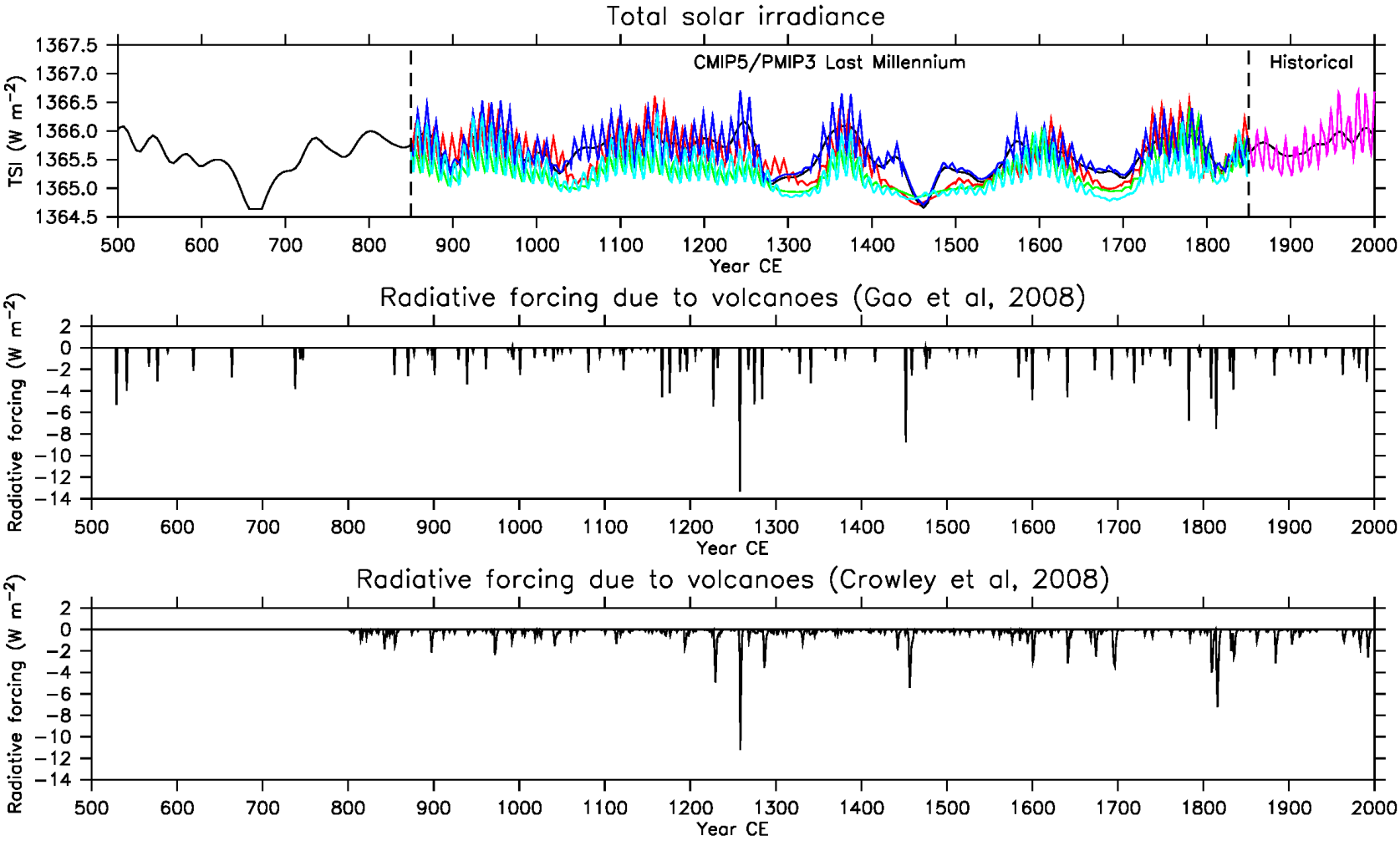
Current limitations

Current limitations on our ability to learn everything that we can from the climate of the last 2000 years include...

- uncertainties in our knowledge of past external forcings, particularly the sun and volcanoes
- uncertainties inherent in climate reconstructions
- deficiencies in model physics

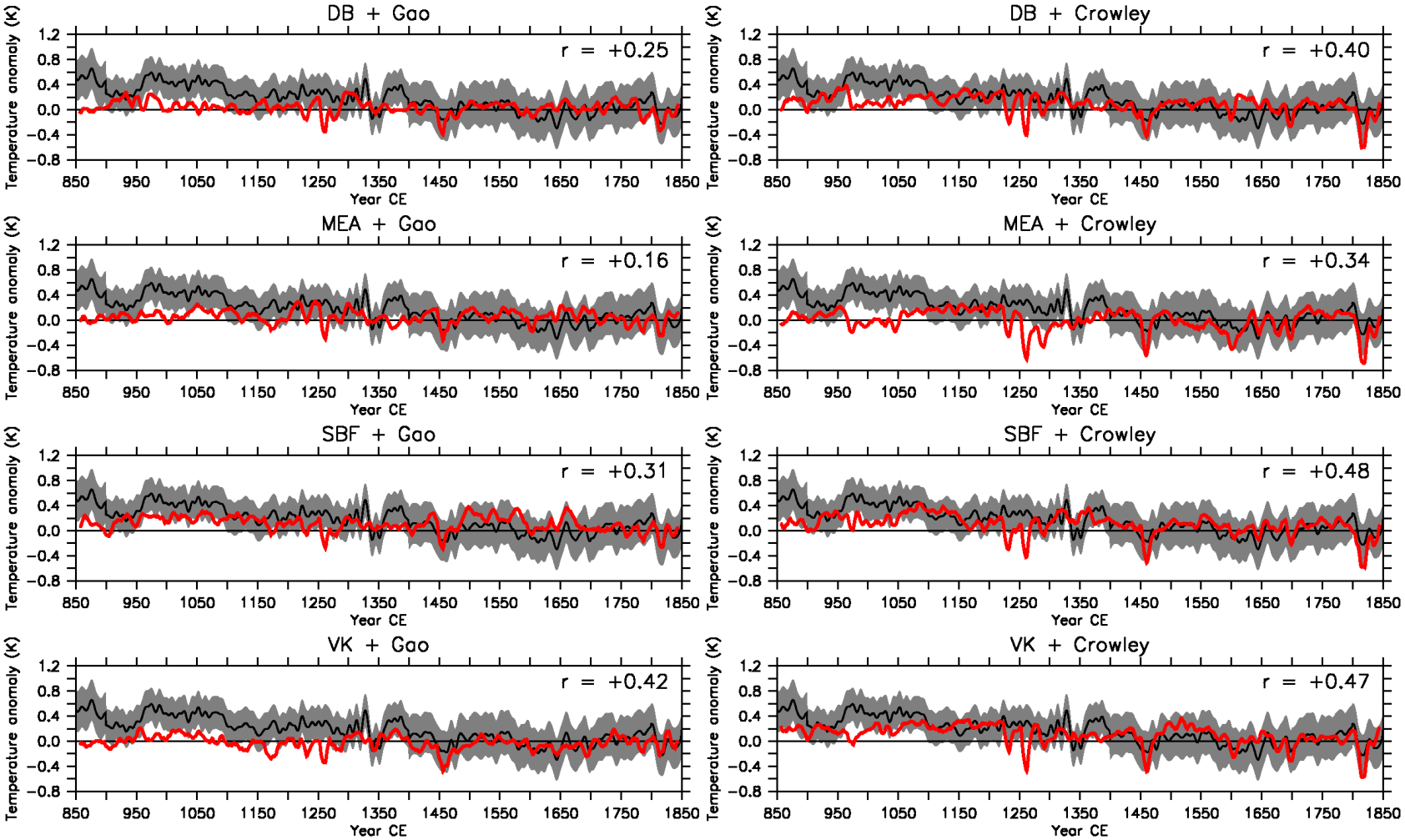
Internal climate variability can also hamper efforts to compare model simulations with reconstructions.

Uncertainty in external forcings: the sun and volcanoes



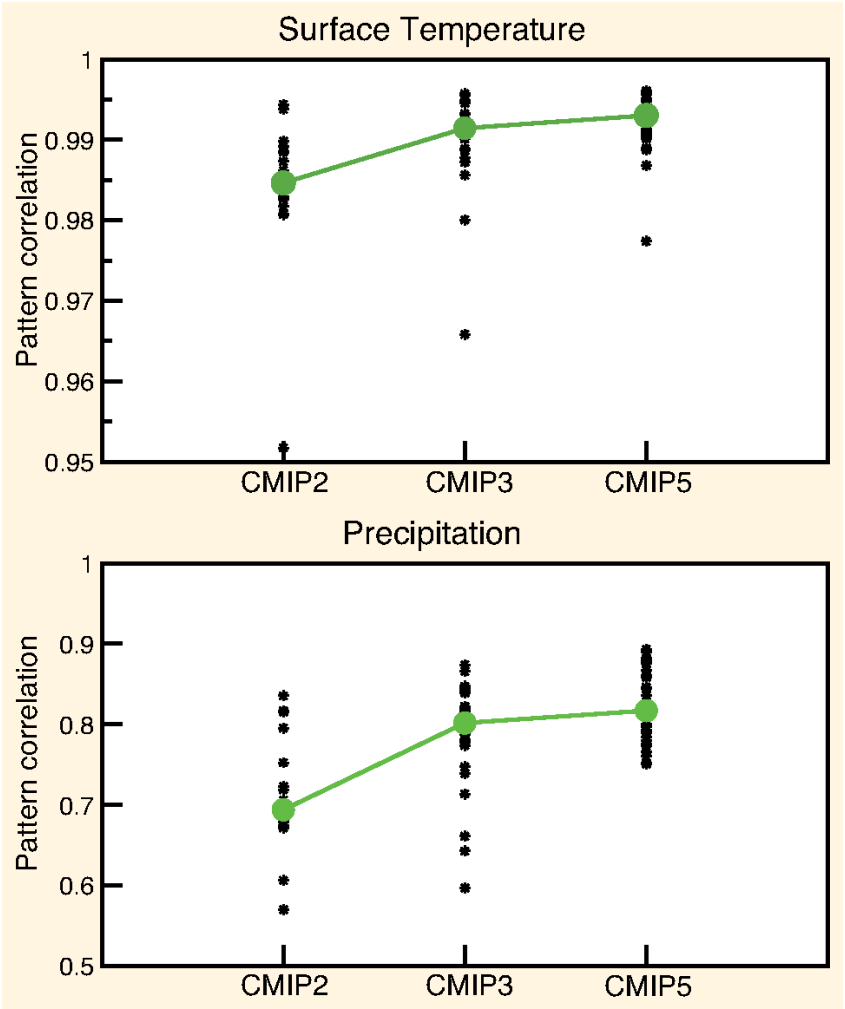
Phipps (in prep.)

Uncertainty in external forcings: the sun and volcanoes



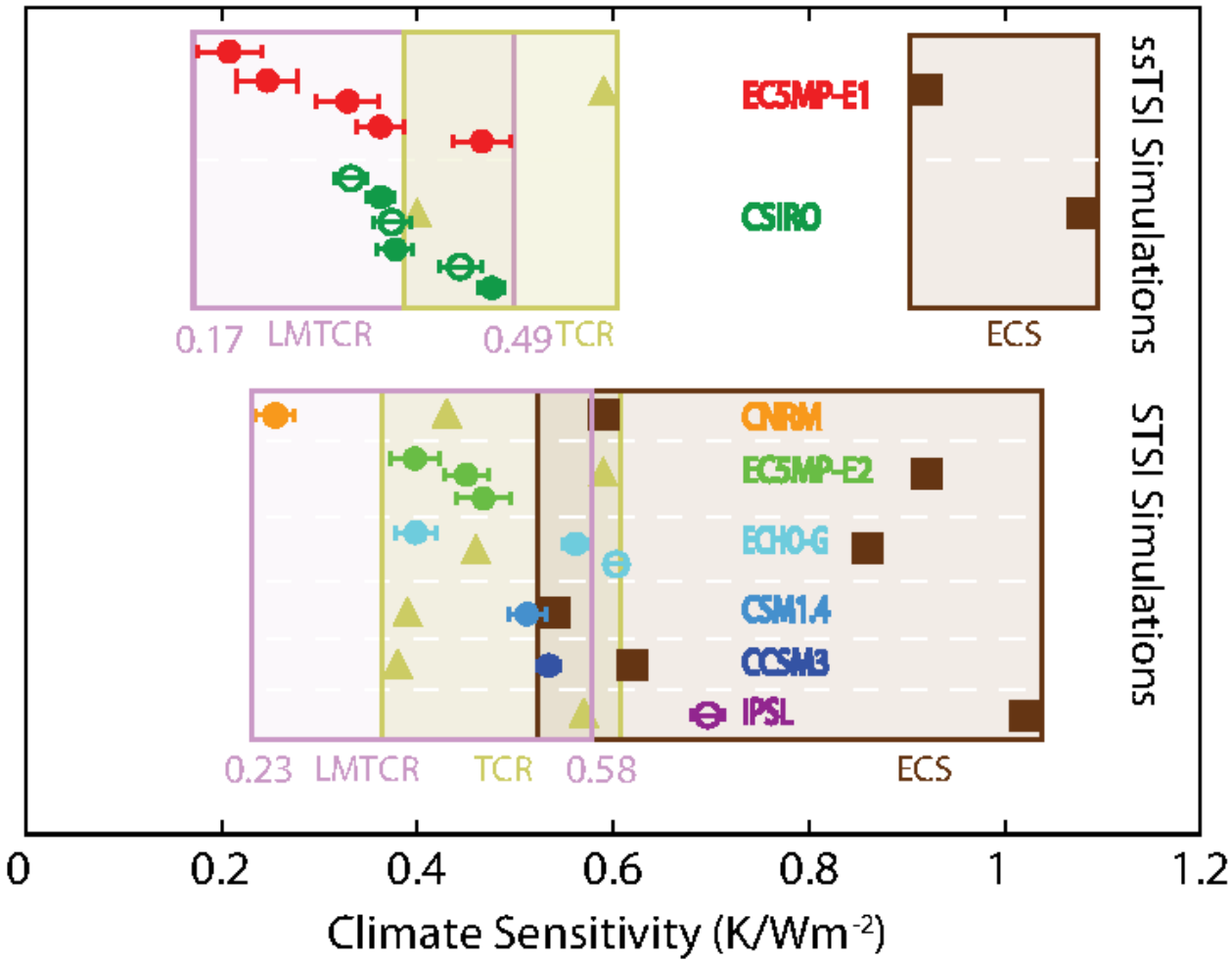
Phipps (in prep.)

Deficiencies in model physics



IPCC Fifth Assessment Report

Internal climate variability



Fernández-Donado et al. (2013)

Future challenges

If we want to learn everything that we can from the climate of the last 2000 years, then future challenges are to...

- develop better reconstructions of past climatic forcings
- use climate modelling to test the assumptions that underlie techniques for climate reconstruction
- continue the development of techniques that allow for more complete integration of climate modelling with proxy data, particularly forward modelling and data assimilation

References

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