Intersection of Earth System and Integrated Assessment Models: Application to Model Evaluation and Decadal Predictability/Prediction

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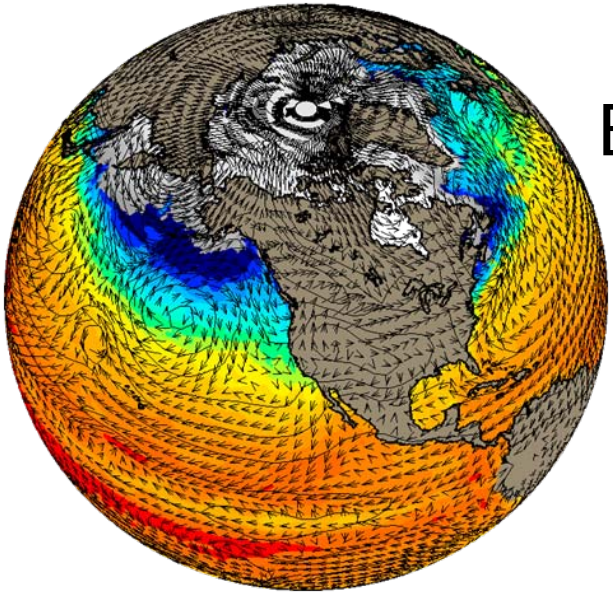
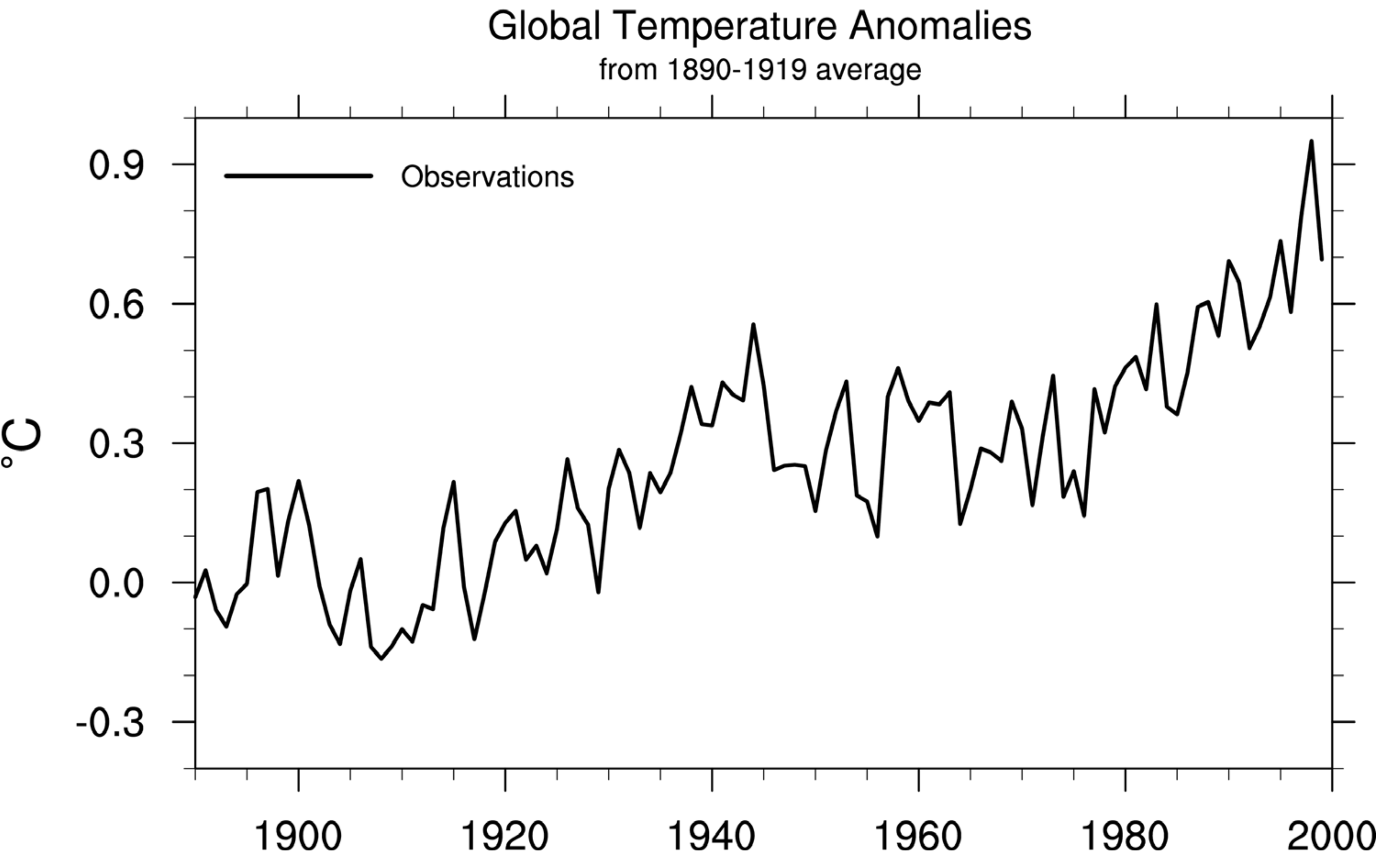
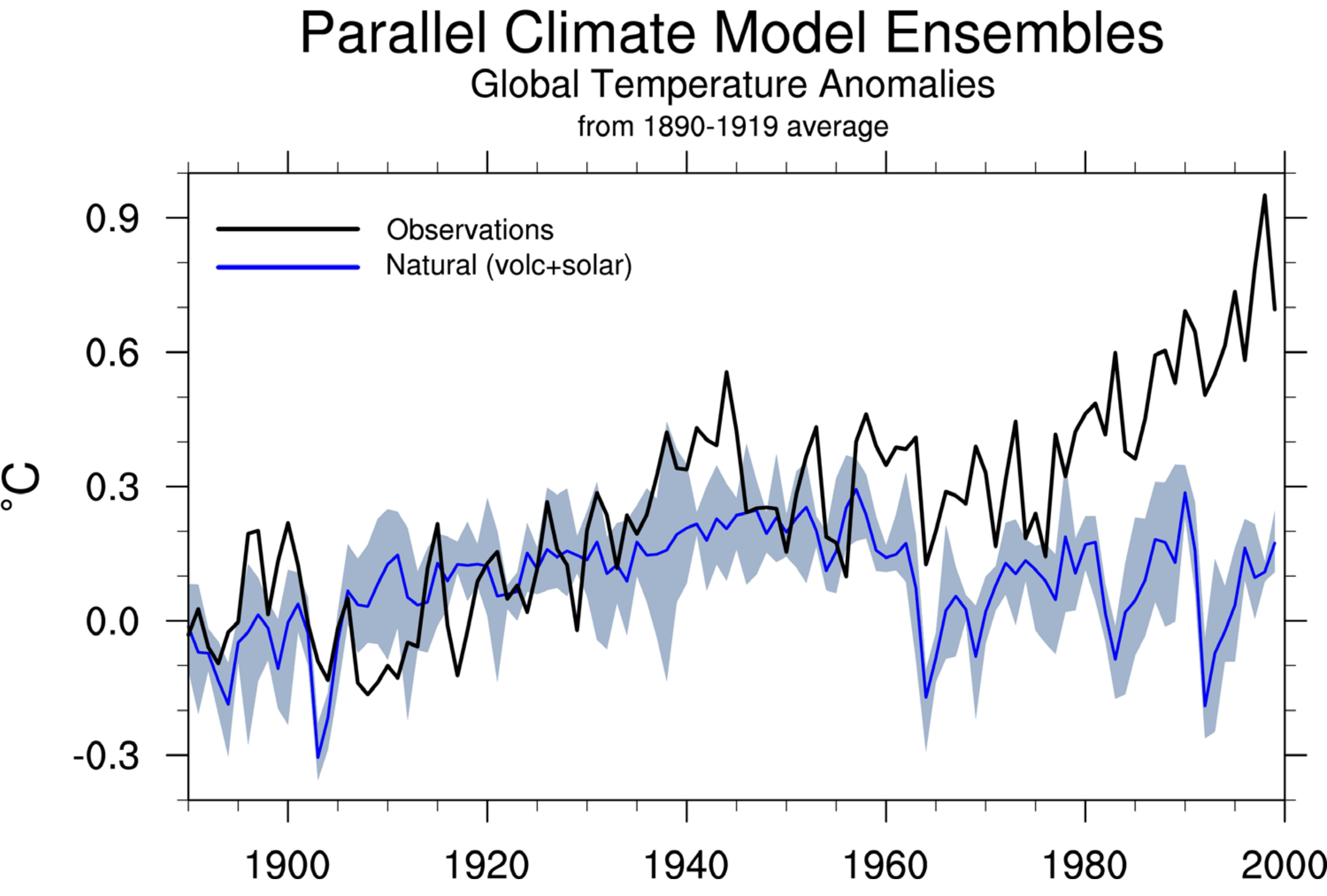


Why do model evaluation?

Credibility of climate model projections depends in part on how well the models can simulate what we have already observed

A model should be able to respond credibly to observed external forcings (e.g. volcanic eruptions, solar variability, increasing GHGs) and also simulate internally-generated observed climate phenomena (e.g. El Niño, heat waves, etc.)

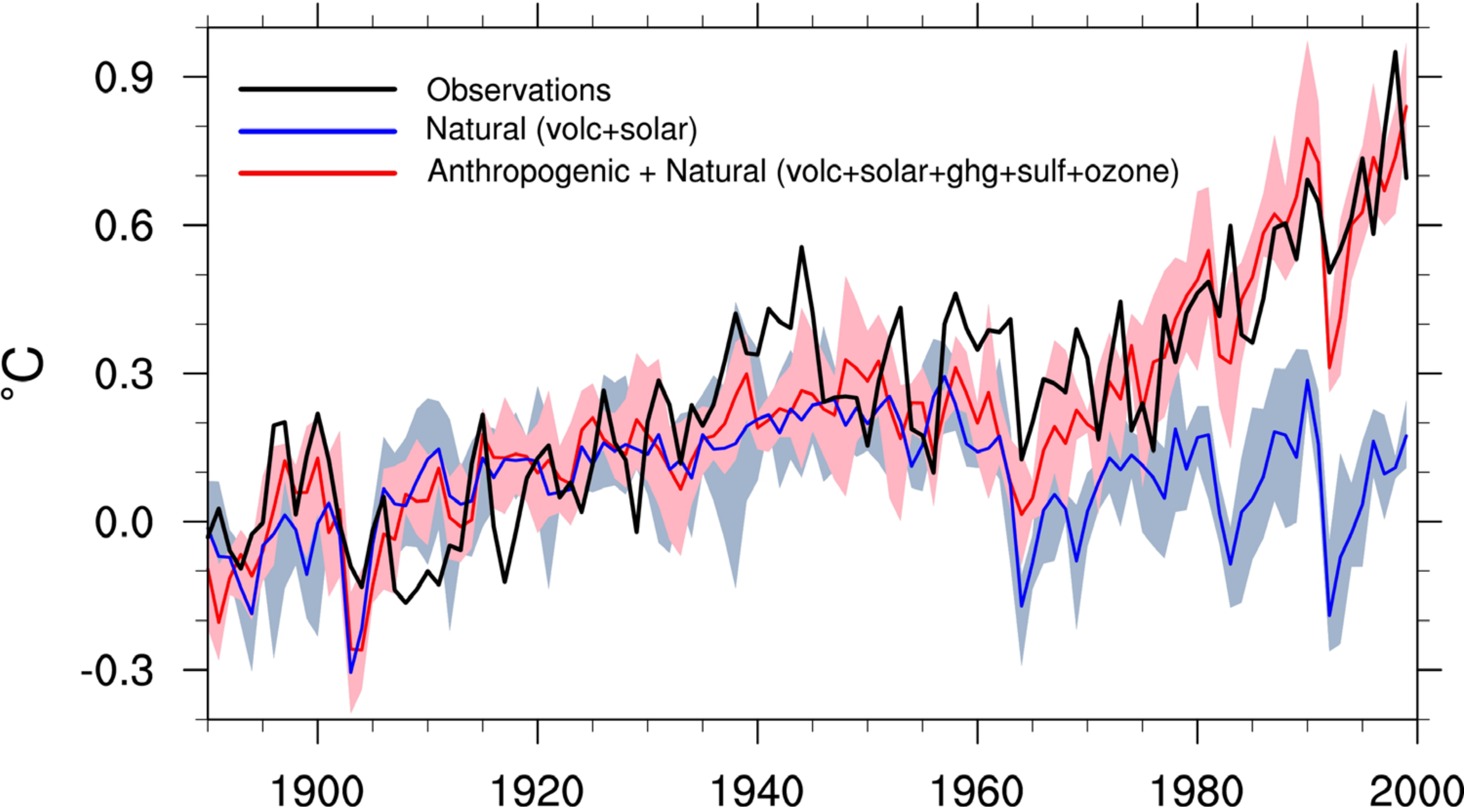

Global Temperature Anomalies
from 1890-1919 average
Observations
°C
0.9
0.6
0.3
0.0
-0.3
1900
1920
1940
1960
1980
2000


Parallel Climate Model Ensembles
Global Temperature Anomalies
from 1890-1919 average
Observations
Natural (volc+solar)
°C
0.9
0.6
0.3
0.0
-0.3
1900
1920
1940
1960
1980
2000

Parallel Climate Model Ensembles

Global Temperature Anomalies

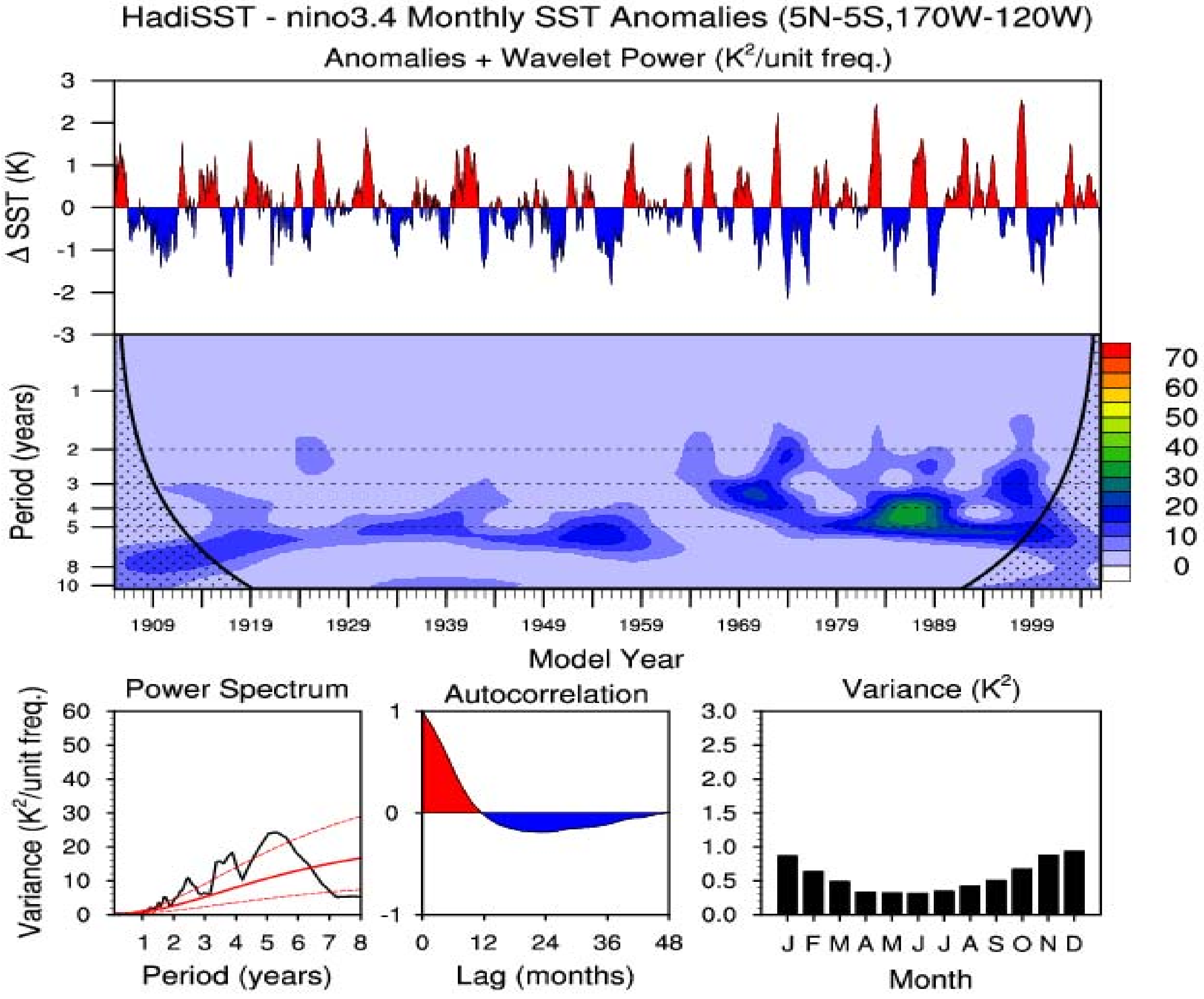
from 1890-1919 average



HadISST

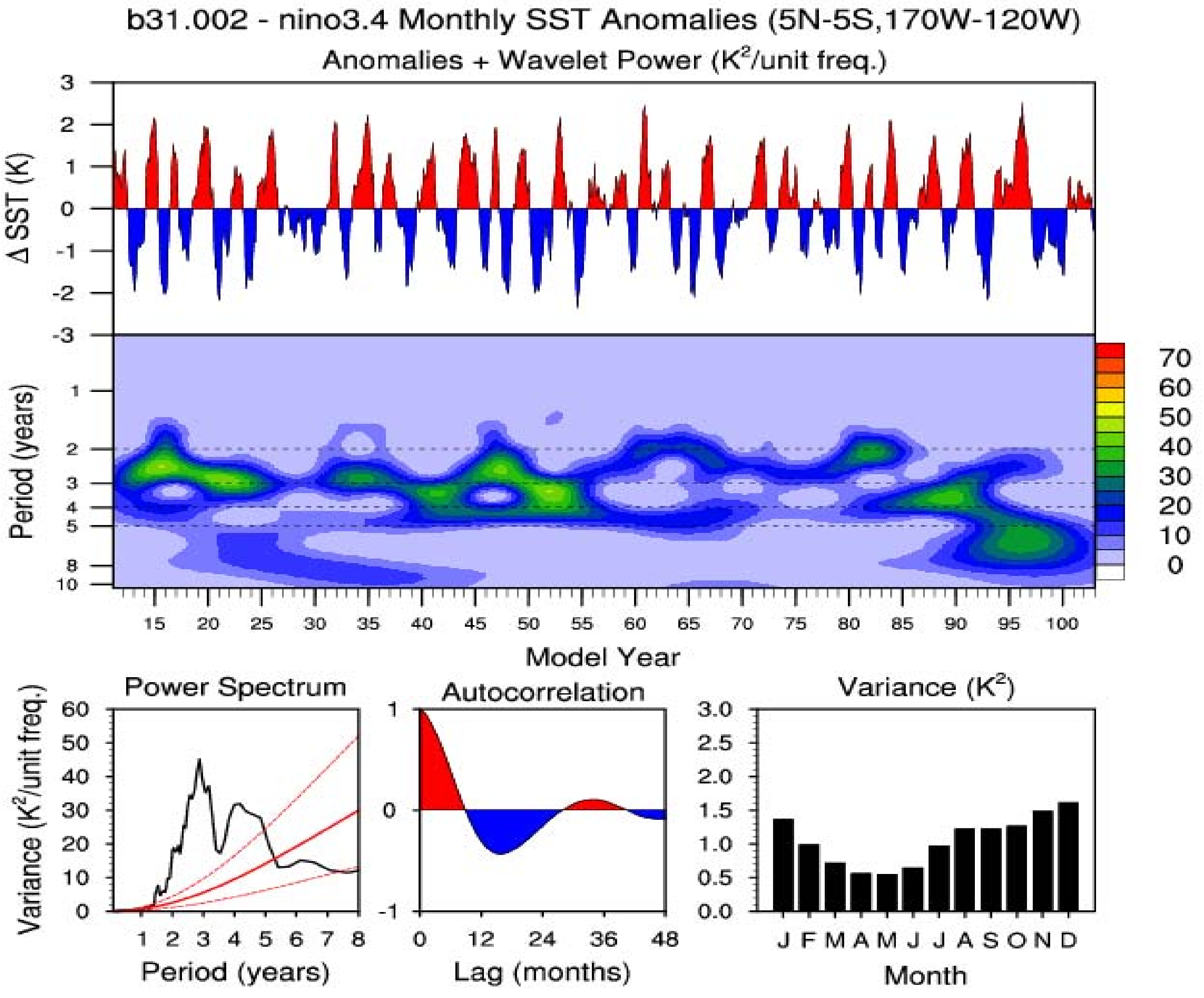
Obs

(100 yrs)



Neale and Richter mods

CCSM3.5



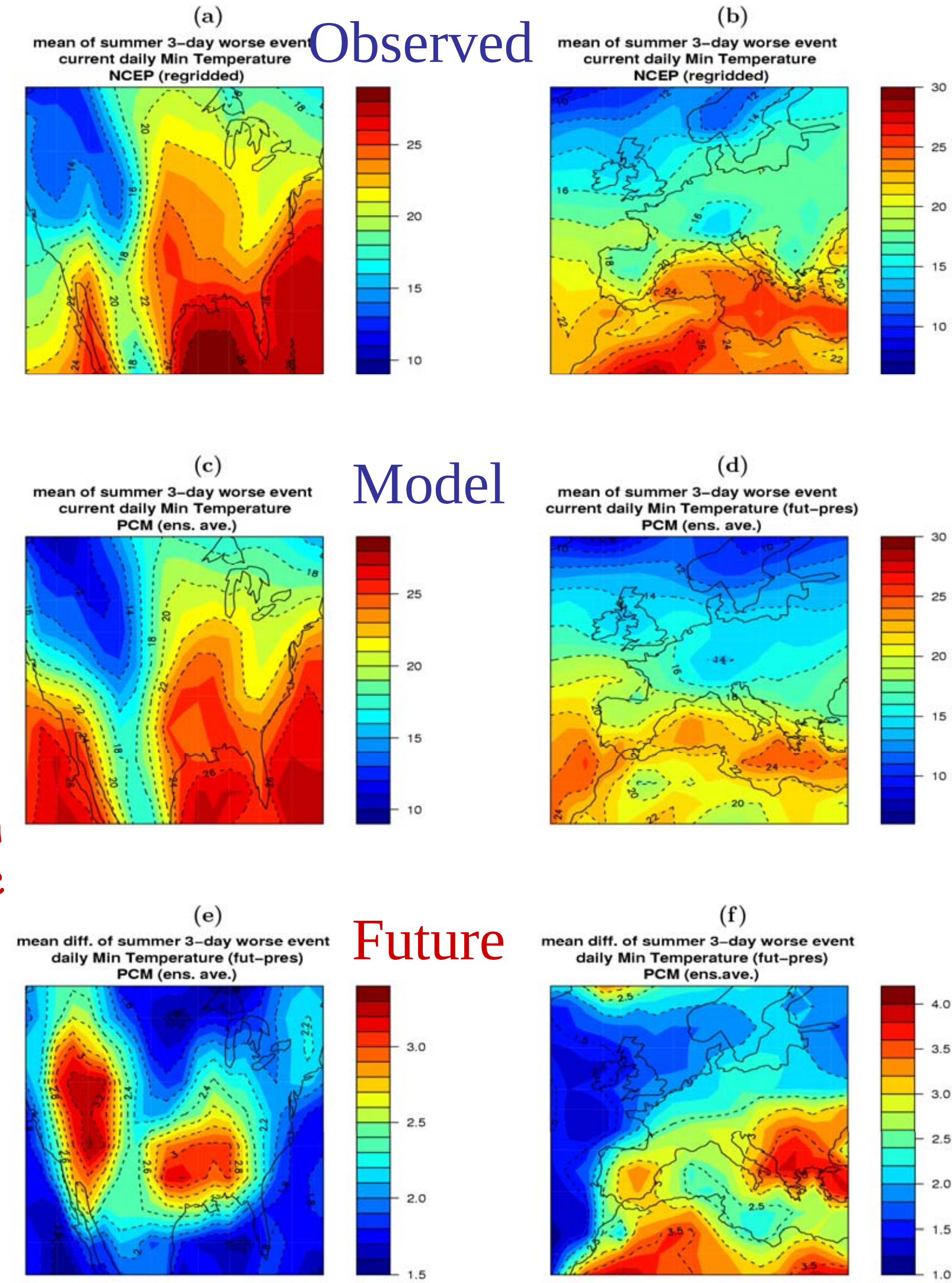
Climate models can be used to provide information on changes in extreme events such as heat waves

Heat wave severity defined as the mean annual 3-day warmest nighttime minima event

Model compares favorably with present-day heat wave severity

In a future warmer climate, heat waves become more severe in southern and western North America, and in the western European and Mediterranean region

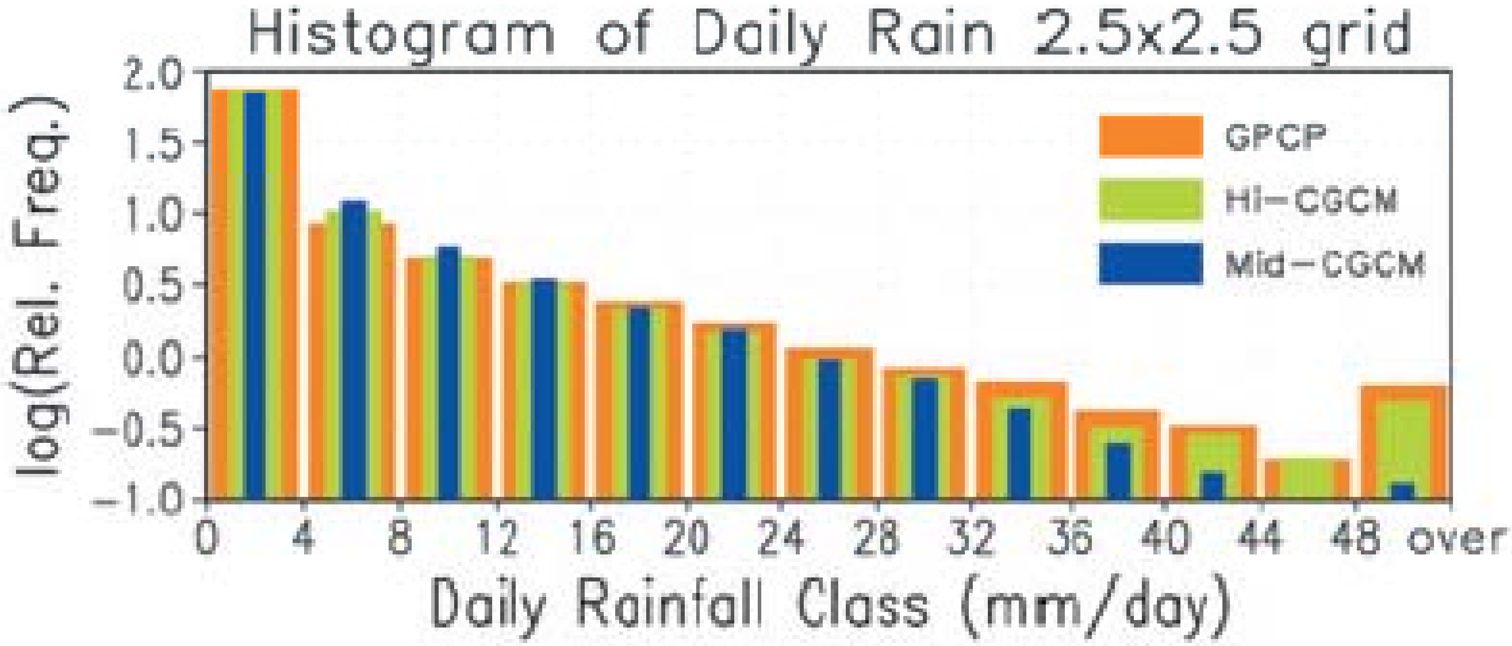
(Meehl, G.A., and C. Tebaldi, 2004: More intense, more frequent and longer lasting heat waves in the 21st century. *Science*, **305**, 994--997.)



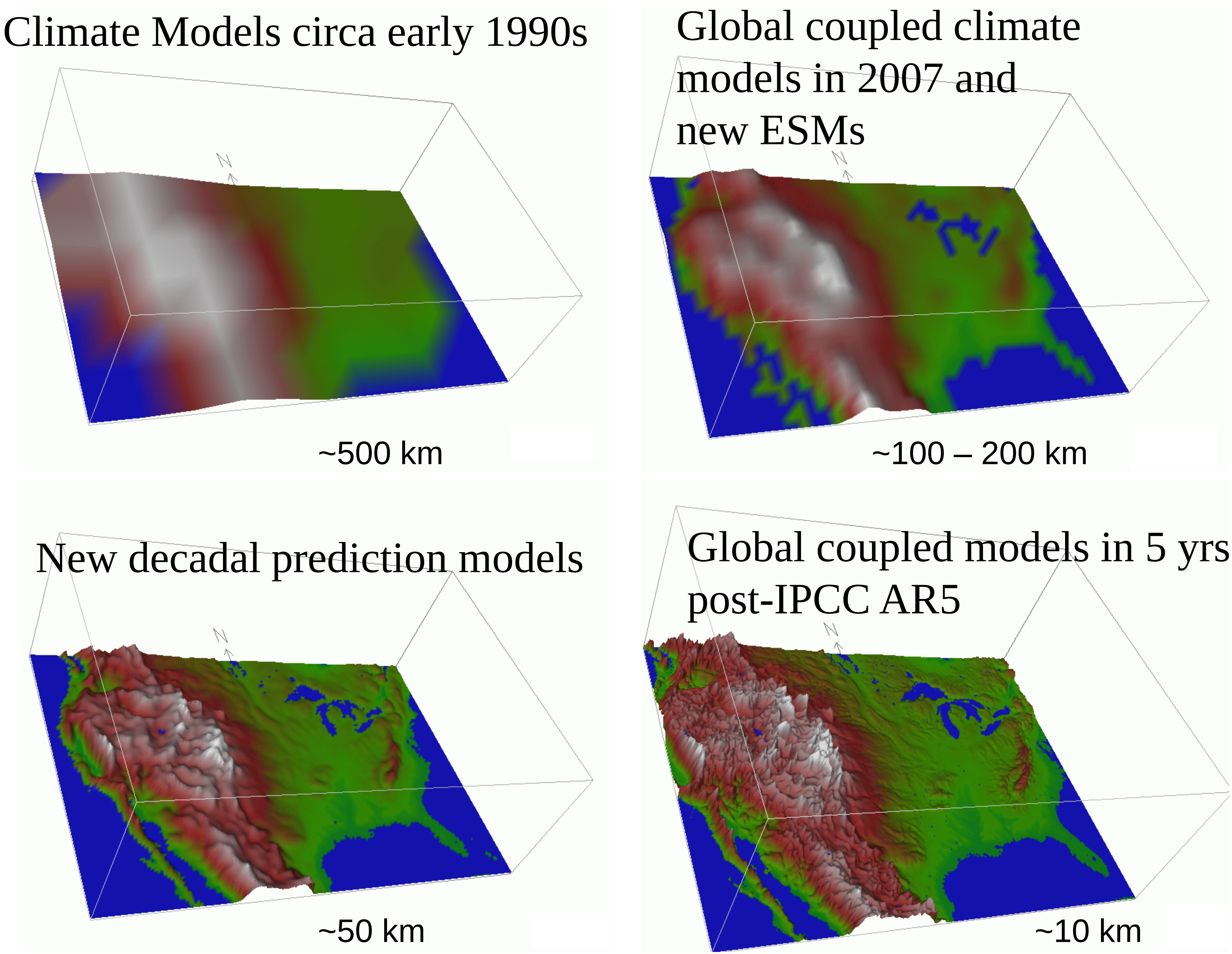
Need higher resolution to simulate extreme precipitation events

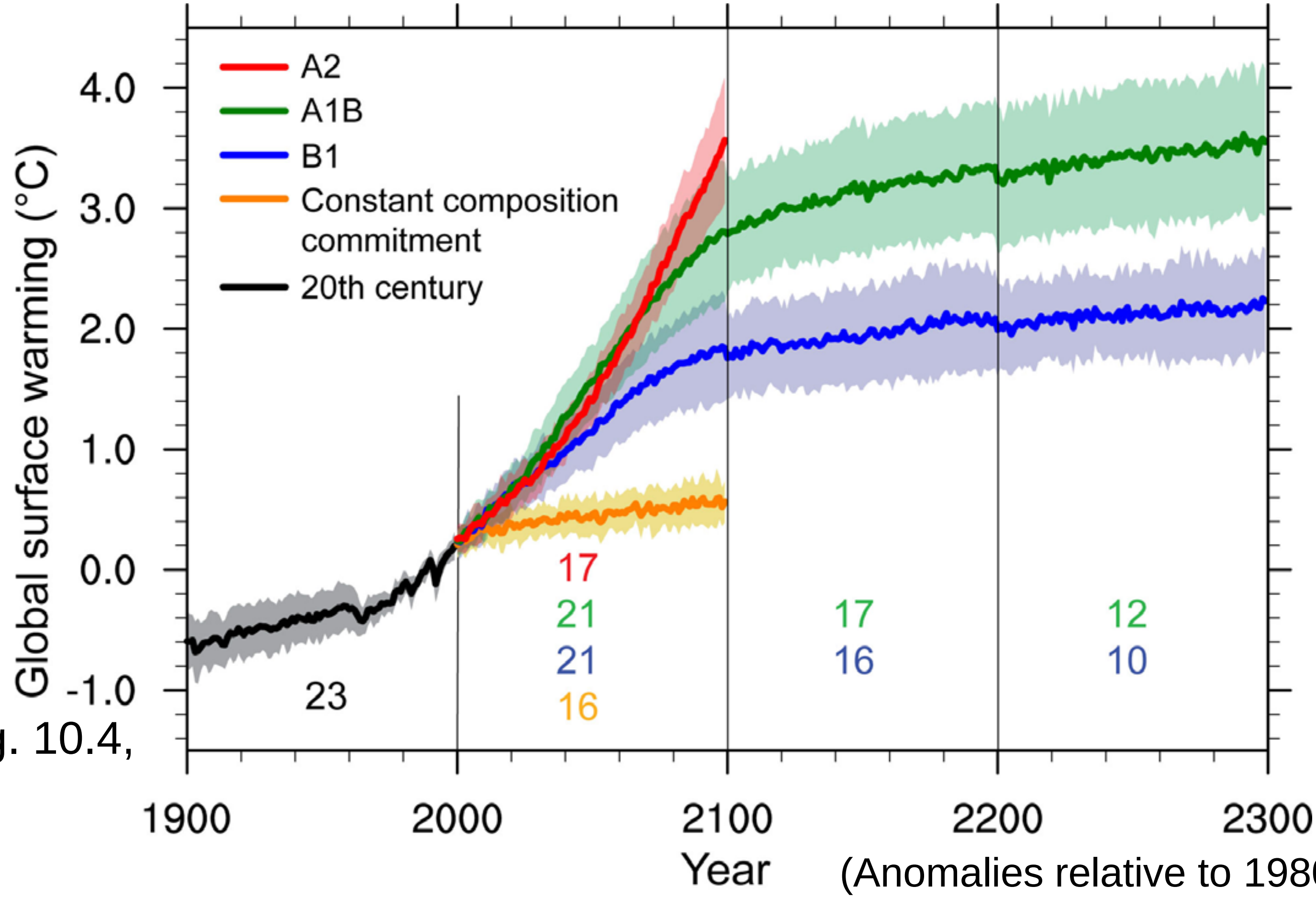
Hi-CGCM = T106 (~100 km)

Mid-CGDM = T42 (~240 km)



(Kimoto et al., 2005)


Climate Models circa early 1990s
~500 km
Global coupled climate models in 2007 and new ESMs
~100 – 200 km
New decadal prediction models
~50 km
Global coupled models in 5 yrs post-IPCC AR5
~10 km



Ch. 10, Fig. 10.4, TS-32

(Anomalies relative to 1980-99)

Committed warming averages 0.1°C per decade for the first two decades of the 21st century; across all scenarios, the average warming is 0.2°C per decade for that time period (recent observed trend **0.2°C** per decade) a new paradigm for post-IPCC AR4 climate change modeling:

Decadal prediction (out to about 2030, adaptation)

better regional predictions of weather and climate extremes with **higher resolution AOGCMs** (~50 km, initialized)

Longer term projections (out to 2100 and beyond, mitigation/adaptation)

earth system models with intermediate resolution (~150 km) and new mitigation scenarios to address processes and **feedbacks**, e.g. carbon cycle

Decadal Prediction Experimental Design

Part of an international climate change modeling activity coordinated by WCRP (WGCM/WGSIP) and IGBP (AIMES)

Results from an Aspen Global Change Institute session on decadal prediction:

"Climate Prediction to 2030: Is it possible, what are the scientific issues, and how would those predictions be used?"

June 23-28, 2008

(co-chairs: Gerald Meehl, Ron Stouffer, Lisa Goddard, and James Murphy)

Basic model runs:

1.1 10 year integrations with initial dates towards the end of 1960, 1965, 1970, 1975, 1980, 1985, 1990, 1995 and 2000 and 2005

- Ensemble size of 3, optionally to be increased to O(10)
- Ocean initial conditions should be in some way representative of the observed anomalies or full fields for the start date
- Land, sea-ice and atmosphere initial conditions left to the discretion of each group
- Model run time: 300 years (optionally, an additional 700 years)

1.2 Extend integrations with initial dates near the end of 1960, 1980 and 2005 to 30 yrs.

- Each start date to use a 3 member ensemble, optionally to be increased to O(10)
- Ocean initial conditions represent the observed anomalies or full fields.
- Model run time: 180 years (optionally, an additional 420 years)

Use an ESM for the "climate" part of an IAM (an "ESIAM")

Evaluate the ESIAM for decadal predictability hindcasts, and use ESIAM for decadal prediction (to 2030)

Initial state for ESIAM would consist of "observed" climate state for the initial year, and the economic system in existence for the initial year

Concept of internal processes and external forcings would apply to all parts of the ESIAM

For climate system, external forcings are unanticipated events that occur during the hindcast period (volcanic eruptions, changes in GHGs and aerosols, etc.); internal processes are climate phenomena internally generated by coupled interactions between model components that can feed back on the climate system and interact with or be influenced by the external forcings

For integrated assessment, external forcings are unanticipated events that occur during the hindcast period (collapse of the Soviet Union, Arab oil embargo, etc.); internal processes are phenomena internally generated by coupled interactions between model components that can interact with or be influenced by the external forcings

Summary

Use an ESM for the "climate" part of an IAM (an "ESIAM")

Evaluate ESIAMs to build credibility and to learn about model processes

A possible framework for evaluation could be decadal hindcasts

Use ESIAMs for decadal predictions (to ~2030) of time-evolving global/regional/local economic/energy/demographic/ecosystem/climate changes to which human societies will have to adapt and to inform policy