ESM/IAM/IAV coupling
Snowmass 2016

Pattern Scaling and Climate Statistics

Pattern Scaling and Statistical Climate

Motivation

To supplement (substitute?) ESM output by relatively low cost projections of climate outcomes for

- for arbitrary forcing scenarios
- for a more complete representation of model/internal variability uncertainties

for use in impact or integrated assessment models.

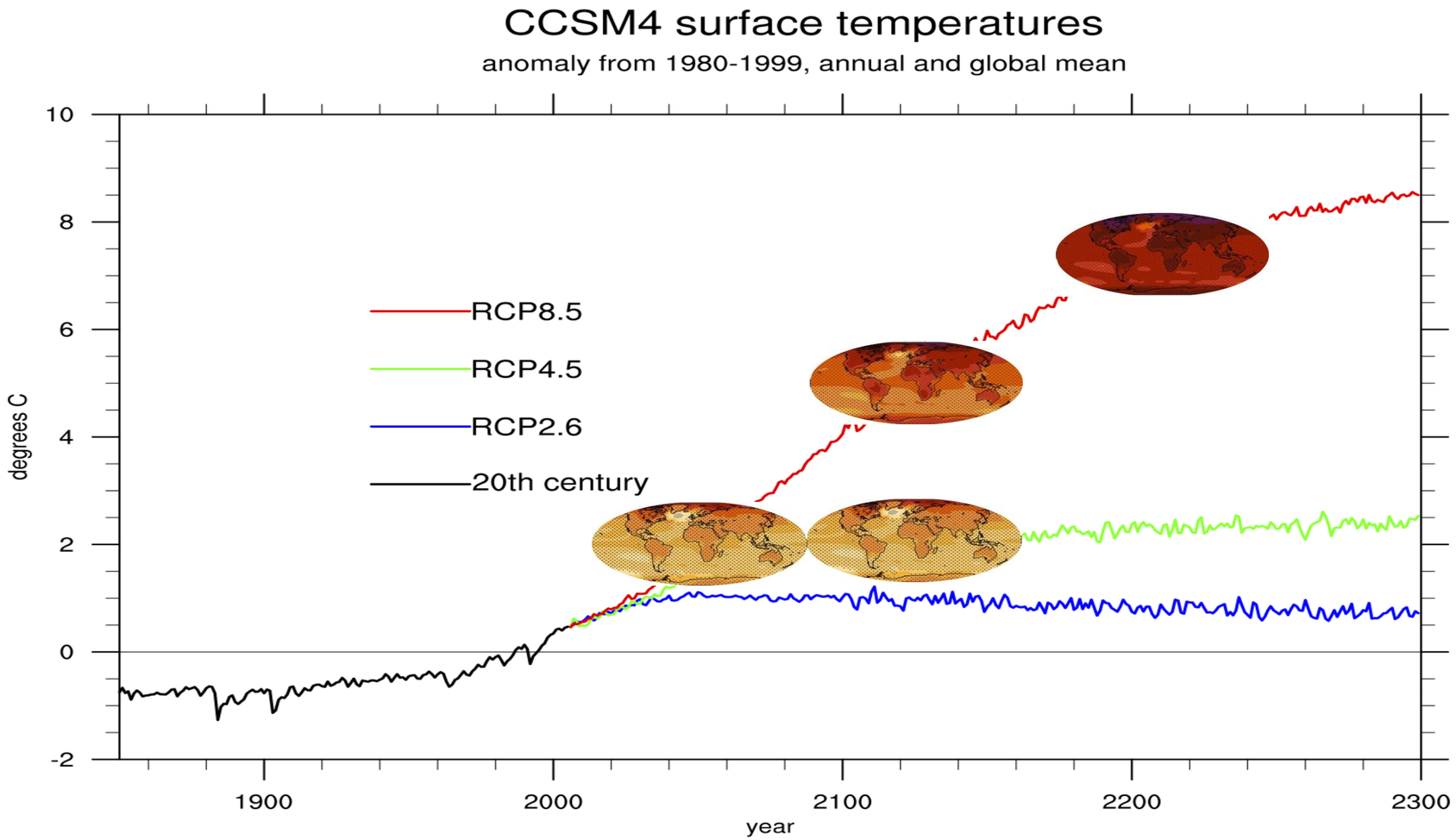
Statistical Emulators

In their simplest form (Simple Pattern Scaling) they can approximate seasonal/annual means of temperature and (less accurately) precipitation. They can therefore provide a cheap and accessible library of outcomes (snapshots) for *arbitrary* forcing scenarios, based on available model simulations.

Everything else is more problematic. Everything else being

- Other variables/Extreme indices
- Other model parametrizations
- Characterization of internal variability/of high frequency variables
- Simulation of joint variables
- Simulation of temporally and spatialy coherent climate outcomes

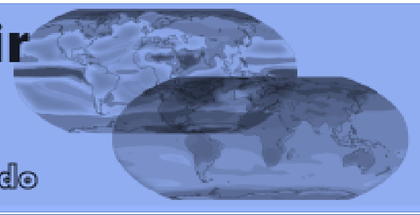
Pattern Scaling in a picture



Current Understanding and Practices

Pattern Scaling, Climate Model Emulators and their Application to the New Scenario Process

April 23-25, 2014 NCAR Boulder Colorado



Goals:

Assess the current state of climate model emulator science

Assess to what extent current approaches can meet the needs of integrated assessment and impact modelers for climate change information

Identify and prioritize research directions so that these statistical methods can better meet the needs of applied research in the future.

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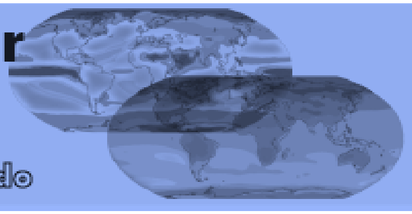
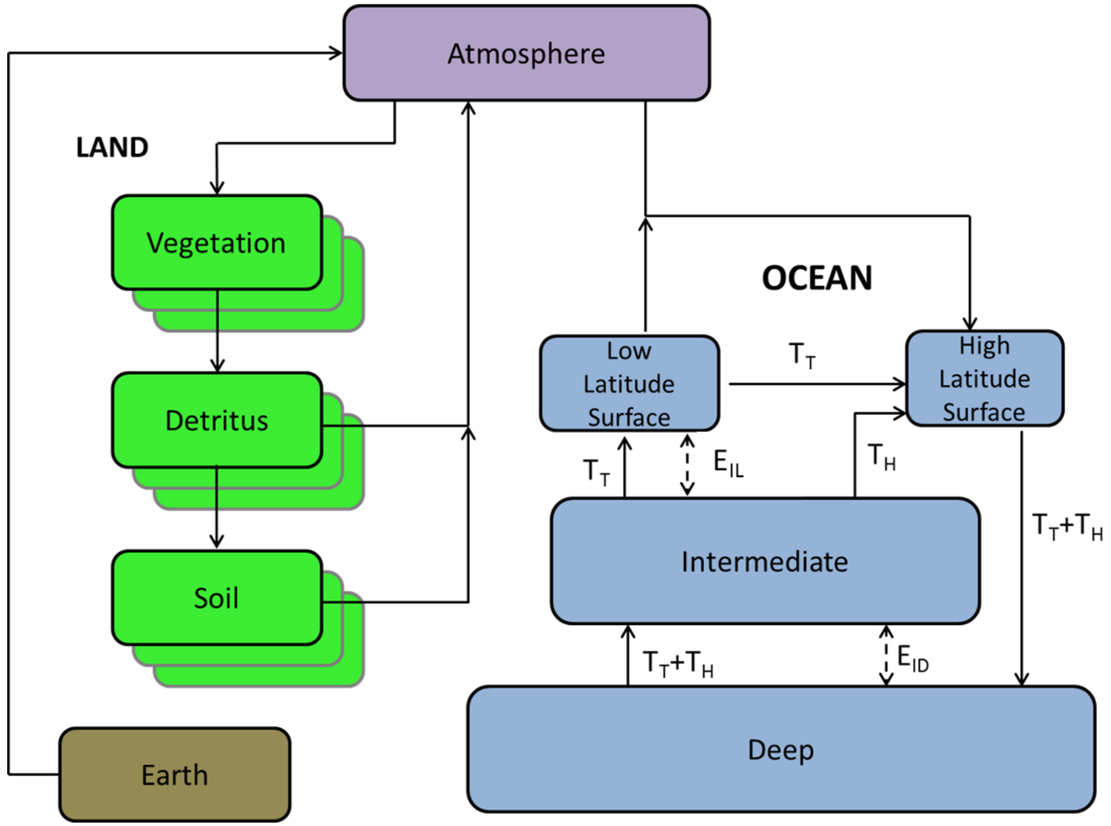


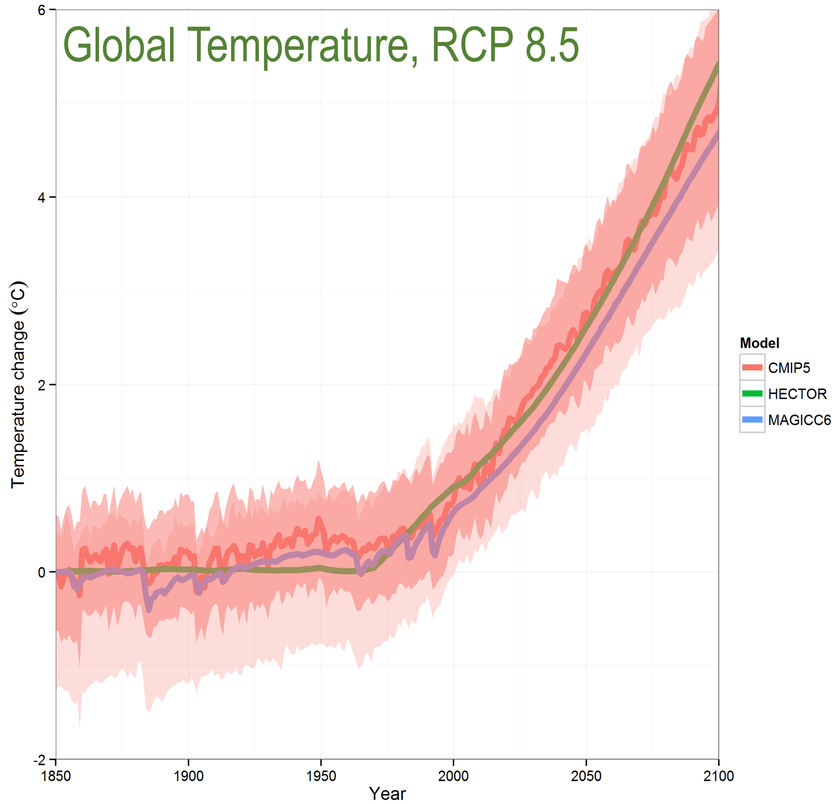
Findings:

It is widely used, but has not been systematically tested.
No “off-the-shelf” product is available to satisfy users’ needs
Sophisticated statistical approaches and use of simple or intermediate complexity models have been proved effective and methods can be harnessed and further developed.

Some examples of approaches currently in use or development

Hector: Reduced Form Climate-Carbon Cycle Model





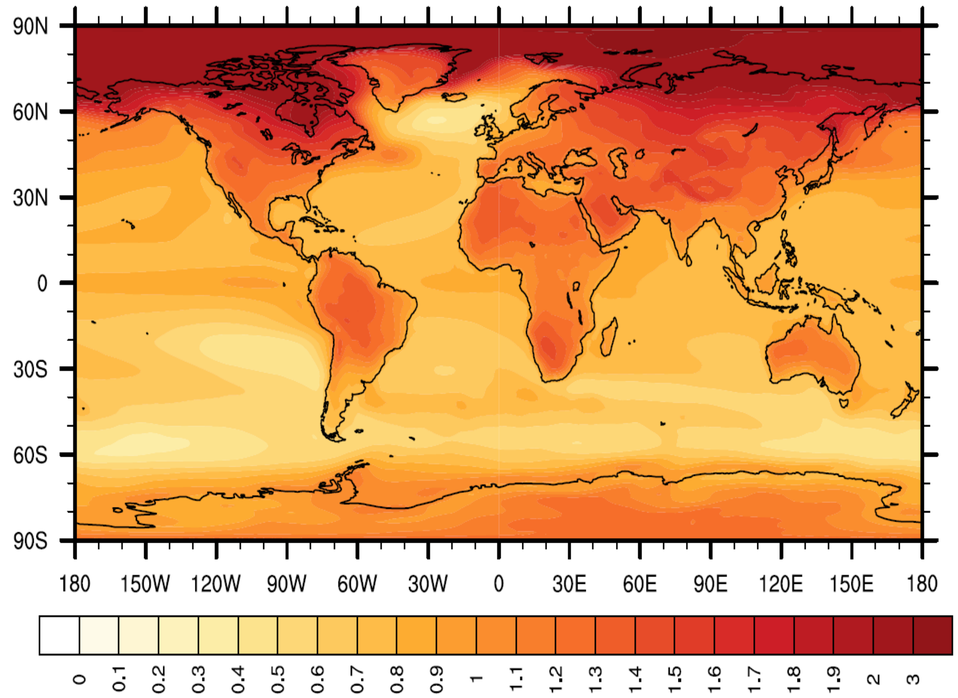
Hartin et al., (2015), A simple object-oriented and open-source model for scientific and policy analyses of the global climate system – Hector v1.0, Geoscientific Model Development

Slide courtesy of C. Hartin, JGCRI

Ongoing Regional Climate Emulation Research

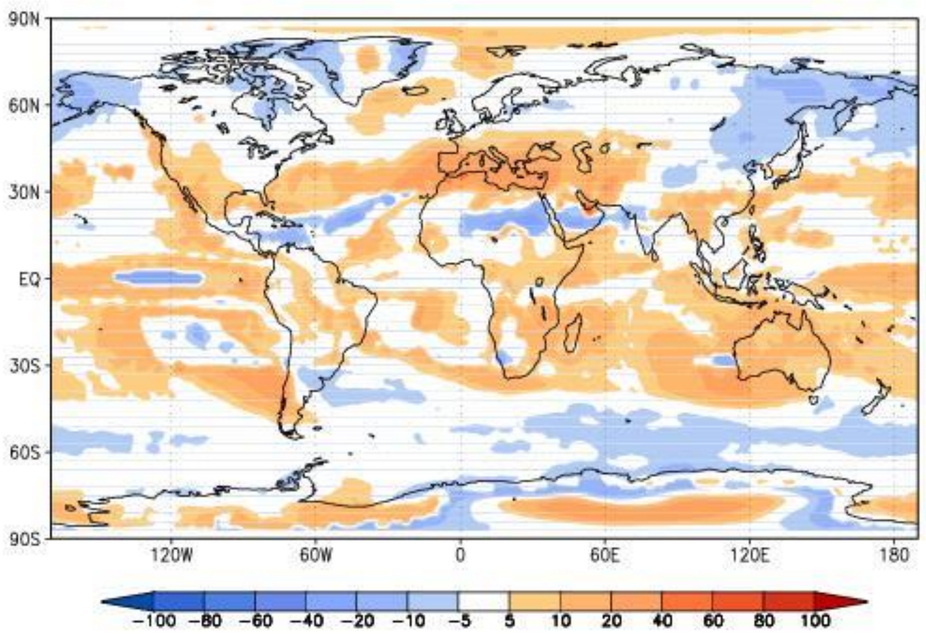
(1) Pattern Scaling – Temperature and Precipitation

Lynch et al., 2016 – submitted JGR - Atm



- Relational pattern between GMT and local temperature
- Least squares regression – local temperature scales with global temperature

Kravitz et al., 2016 – in preparation



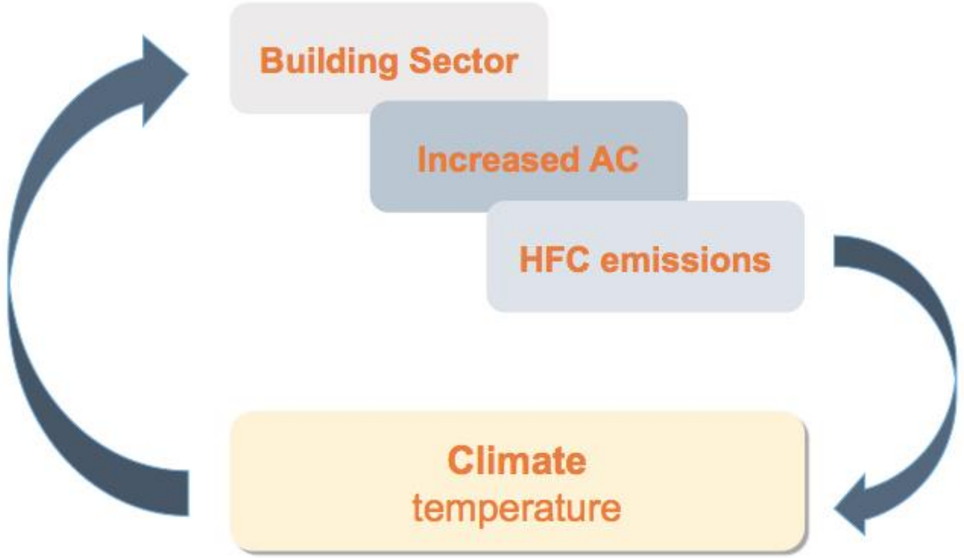
- Relational pattern between GMT and local precipitation
- % difference between the model mean and reconstructed precipitation

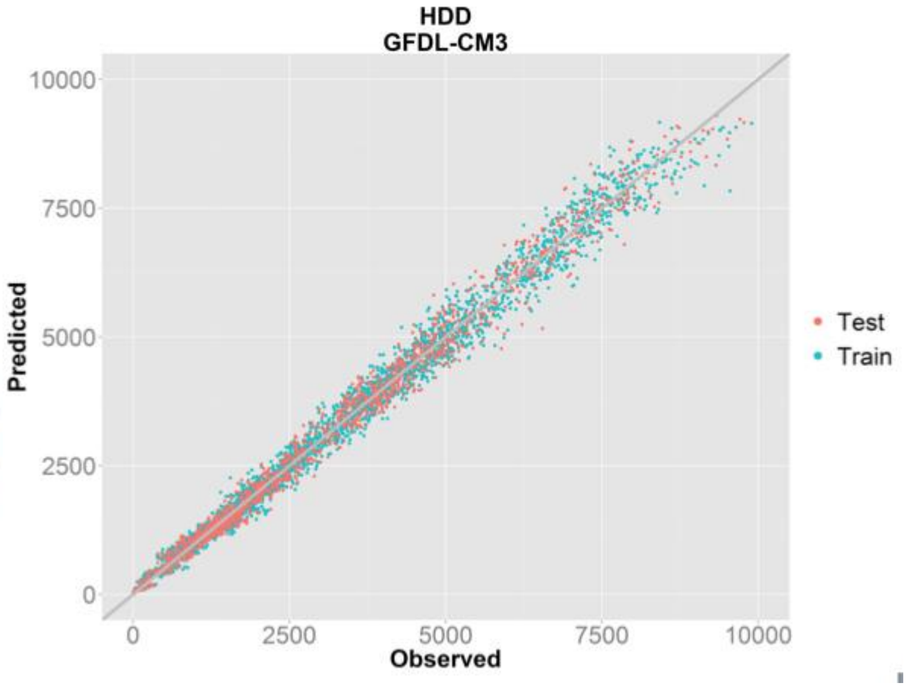
Slide courtesy of C. Hartin, JGCRI

Ongoing Regional Climate Emulation Research

(2) Heating and Cooling Degree Days

Developed a statistical relationship between Global Mean Temperature and HDD/CDD at the country level

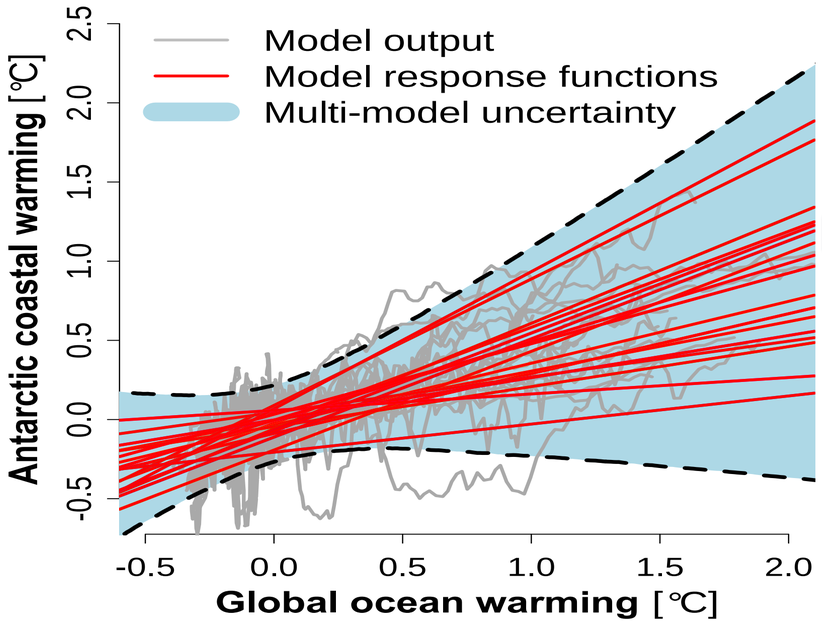


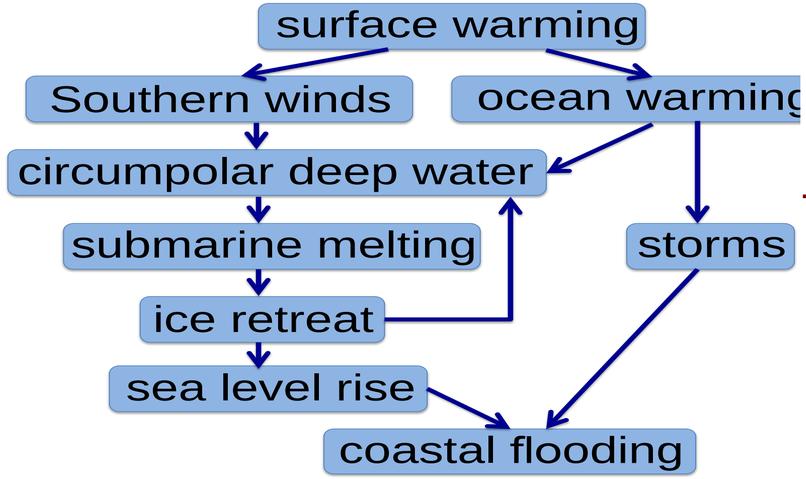


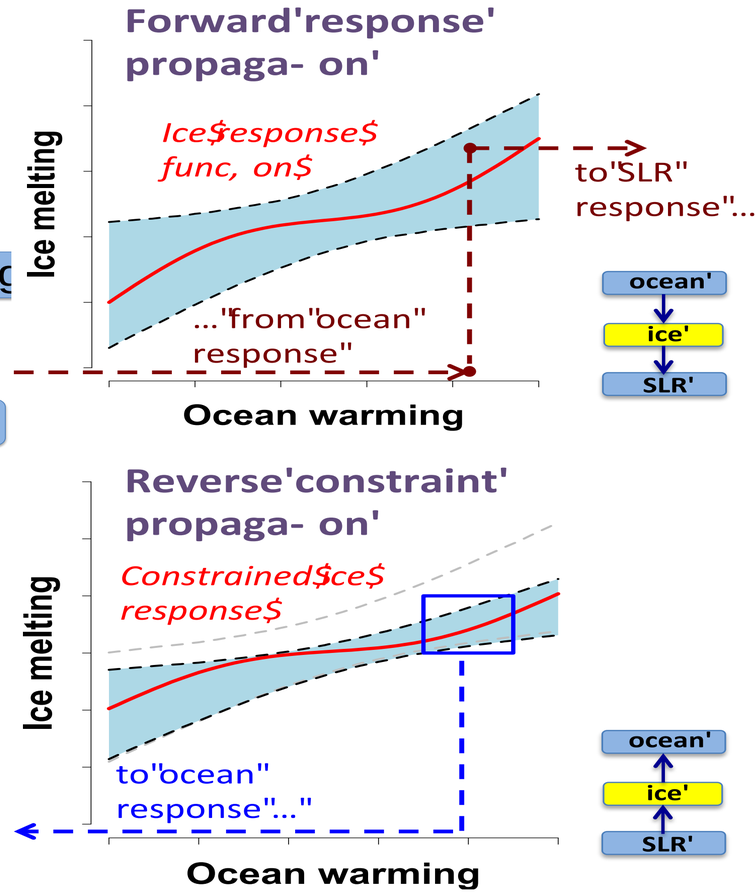
Slide courtesy of C. Hartin, JGCRI

Modular Uncertainty Decomposition

Status quo: try to emulate complex output of numerical model
Alternative: decompose output into network of statistical relationships (linked emulators)

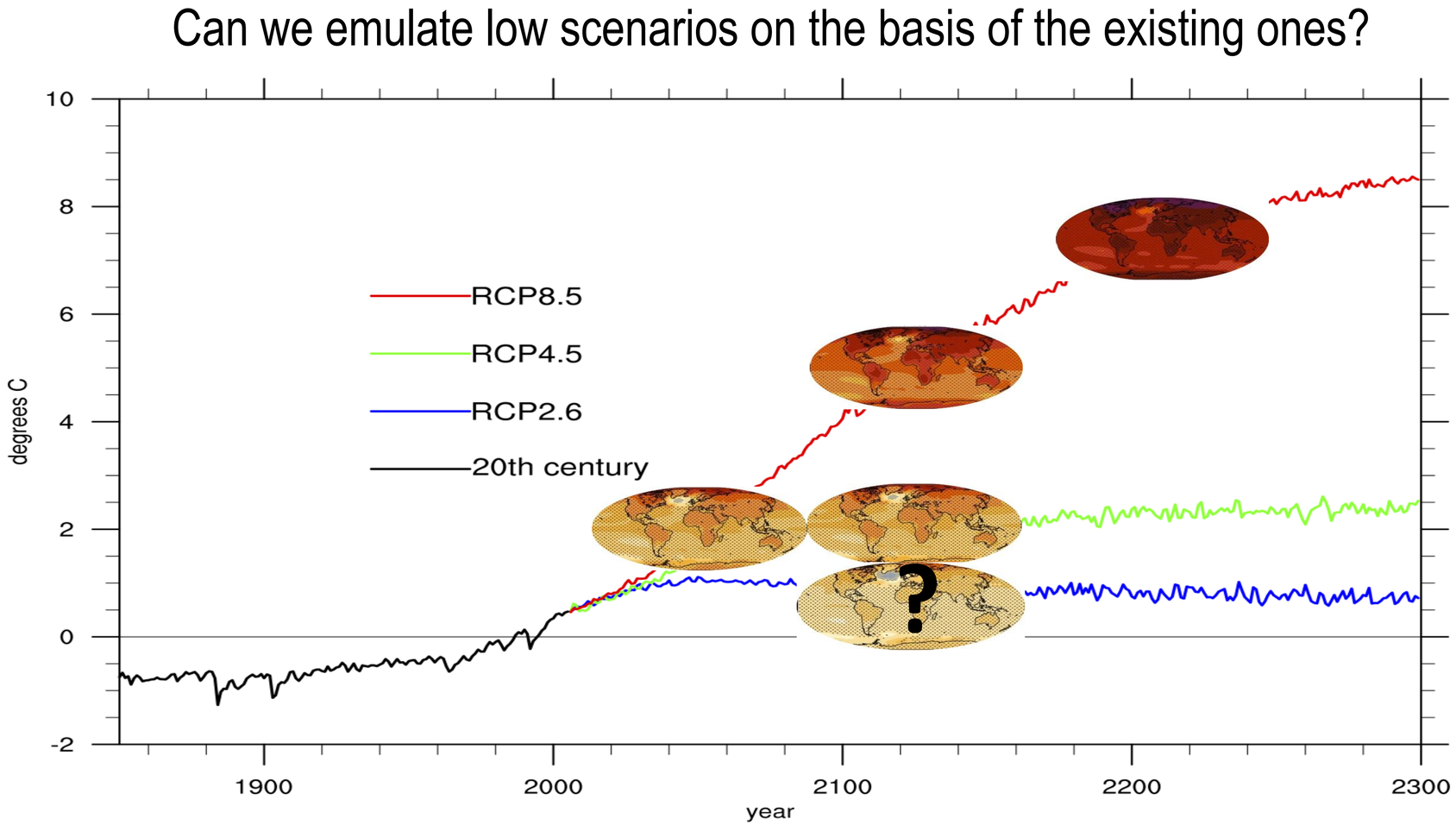






Slide courtesy of N. Urban and collaborators, LANL

A pressing issue if you are concerned about low scenario impacts



Not just about low scenarios

What about overshoots? What about stabilized scenarios?

What about regionally and temporally varying forcings, like aerosols and land use?

To Do List
(beyond seasonal means of T & P)

- Hyper-parameterization to characterize the CMIP family of GCMs;
- Joint Temperature/Precipitation/Other variables? Which ones? Seasonally-consistent modeling
- Downscaling to daily time resolution
- Emulators for variability/extremes
- Modeling of regional effects from aerosols/land use
- Modeling for scenarios other than steadily increasing GHGs

Final Thought

The value of a concerted effort, given interests, needs, activities seems obvious

Not a product focused-effort: emulators , like models, should be built differently depending on the purpose addressed, no size fits all. Most-effective is the development of tailored emulation.

Rather, a community of practice, a research network, a space to compare notes, learn from others' efforts, borrow possibly.