Modeling chaos:

The math behind climate predictions

UNIVERSITÄT GREIFSWALD
Wissen lockt. Seit 1456

Anna Burns
M.Sc. Landscape Ecology and Nature Conservation
anna.burns@stud.uni-greifswald.de

Frida Böwing
M.Sc. Biodiversity and Ecology
frida.boewing@stud.uni-greifswald.de

The models that drive IPCC reports

DECK:
Diagnostic, Evaluation and Characterization of Klima
A set of common experiments to establish continuity across sub-models

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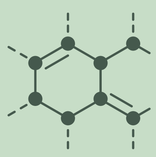
Common standards, coordination, infrastructure and documentation

CMIP6

MIPs:
Model Intercomparison Project
21 sub-models that are evaluated to answer key scientific questions about global climate

Together, 21 models run 190 experiments - totaling 40000 simulation hours!


Atmosphere

Carbon cycle


Geoengineering


Monsoons


Predictions


Forcings


Land-use


Scenarios

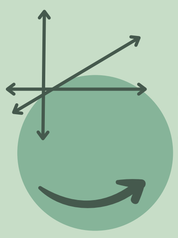

Clouds


Impacts


Paleoclimate


Oceans + ice

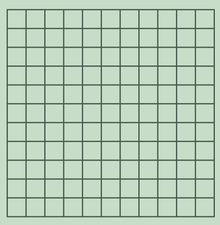
Why is modeling climate so difficult?



The challenge: three-dimensional fluid dynamics on a rotating sphere!

Partial differential equations » **Systems of linear equations** » **Reduce complexity (parameters)**

The problem of scale



50 x 50 grid resolution

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Inverting a 2500 x 2500 matrix!

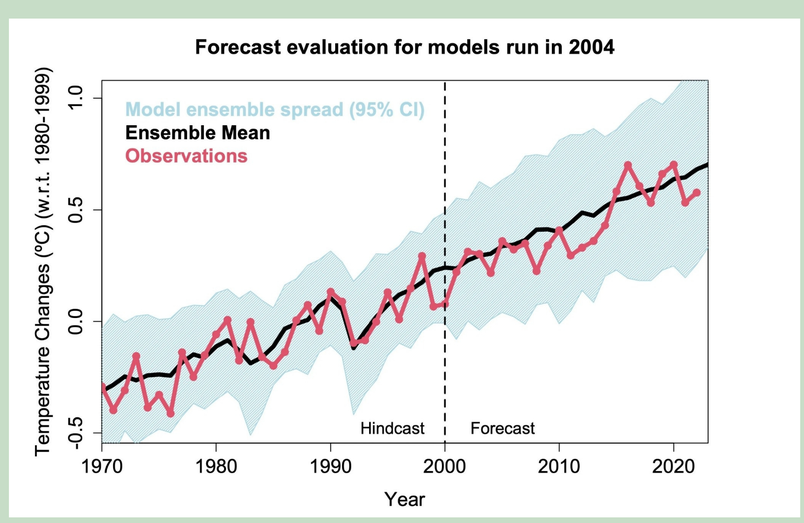
Climate systems are complex, bifurcated, unstable, non-linear, high-dimensional, and CHAOTIC!

Current climate models have been very effective at recreating past climate trends.

However, such modeling is complex and contains inherent uncertainties due to the nature of the systems involved.

The key to using climate models as a tool to combat climate change is to communicate them effectively.

Are the predictions actually working?



Trends in 20 year average surface temperatures predicted by models (4th AR IPCC, 2007) largely align with actual temperatures observed in the Surface Temperature Index (GISTEMP) [8]

Climate predictions: Only understandable by scientists?

studies show that people have trouble understanding:

- **climate as a process not an object**
- **multiple feedback loops and extended time delays in climate forcing**
- **relationships between stock & flow in phenomena of accumulation**

Disclosing uncertainties in studies increases trust in science

Ways to communicate uncertainties

average

- **easily understandable**
- **might be perceived as if no uncertainties occur**

range

- **shows uncertainties**
- **interpretations focus mostly on worst and best outcomes**

multi-values

- **most accurate and transparent**
- **can be too complex and detailed information for some viewers**

References:

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[3] Mihailovic DT, Mimic G, Arsenic I. *Climate predictions: The chaos and complexity in climate models*. Advances in Meteorology 2014.
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[5] Fujimi T, Watanabe M & Tatano H. *Public trust, perceived accuracy, perceived likelihood, and concern on multi-model climate projections communicated with different formats*. Mitig Adapt Strateg Glob Change 2021, 26:20.
[6] Sterman J, Booth Sweeney L. *Cloudy skies: assessing public understanding of global warming*. Syst Dyn Rev 2002, 18:207–240.
[7] Howe LC, MacInnis B, Krosnick JA et al. *Acknowledging uncertainty impacts public acceptance of climate scientists' predictions*. Nat. Clim. Chang. 2019, 9:863–867.
[8] https://climate.nasa.gov/news/2943/study-confirms-climate-models-are-getting-future-warming-projections-right/ . Accessed: 12.07.2023.

For more information