A primer on global-scale coupled climate models
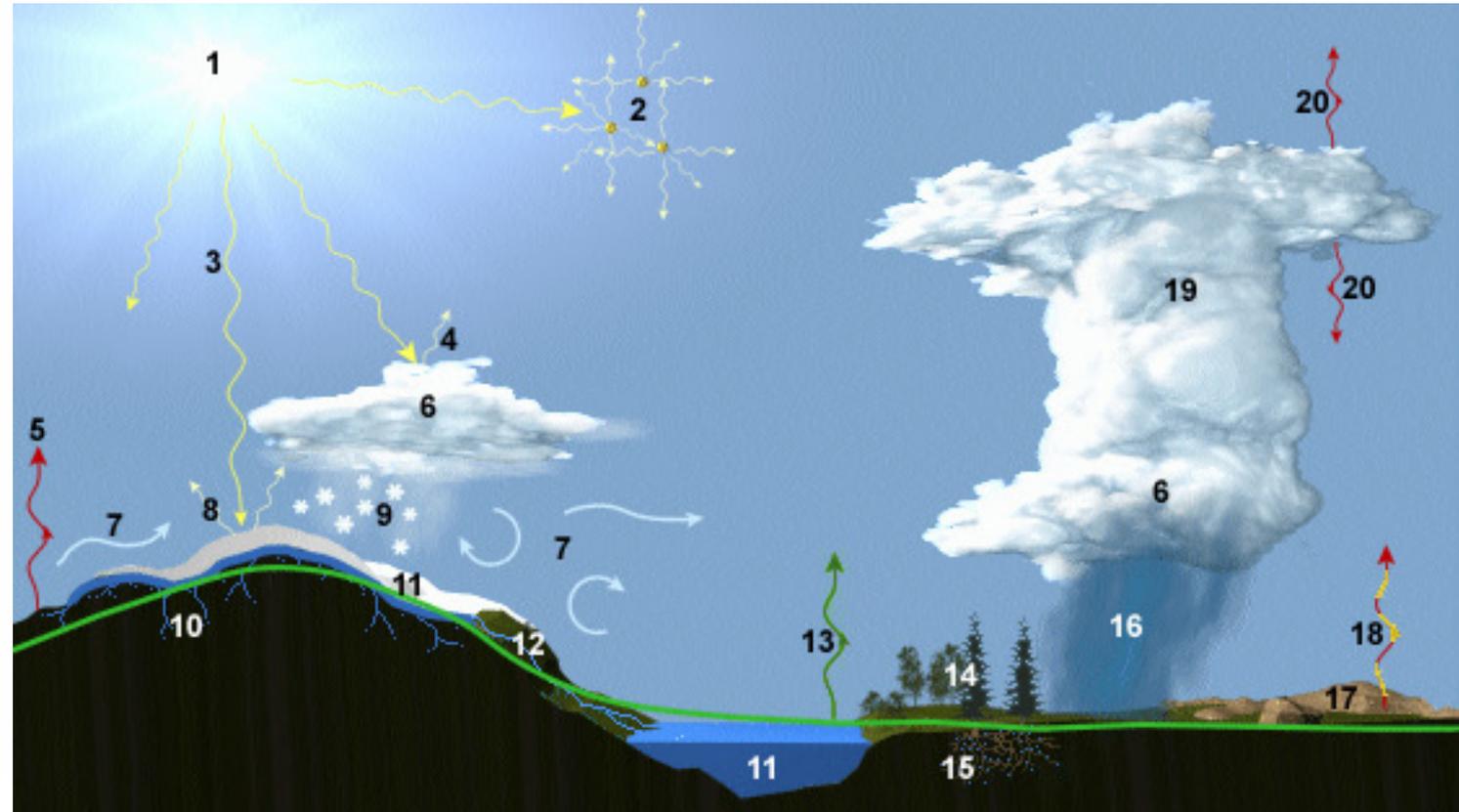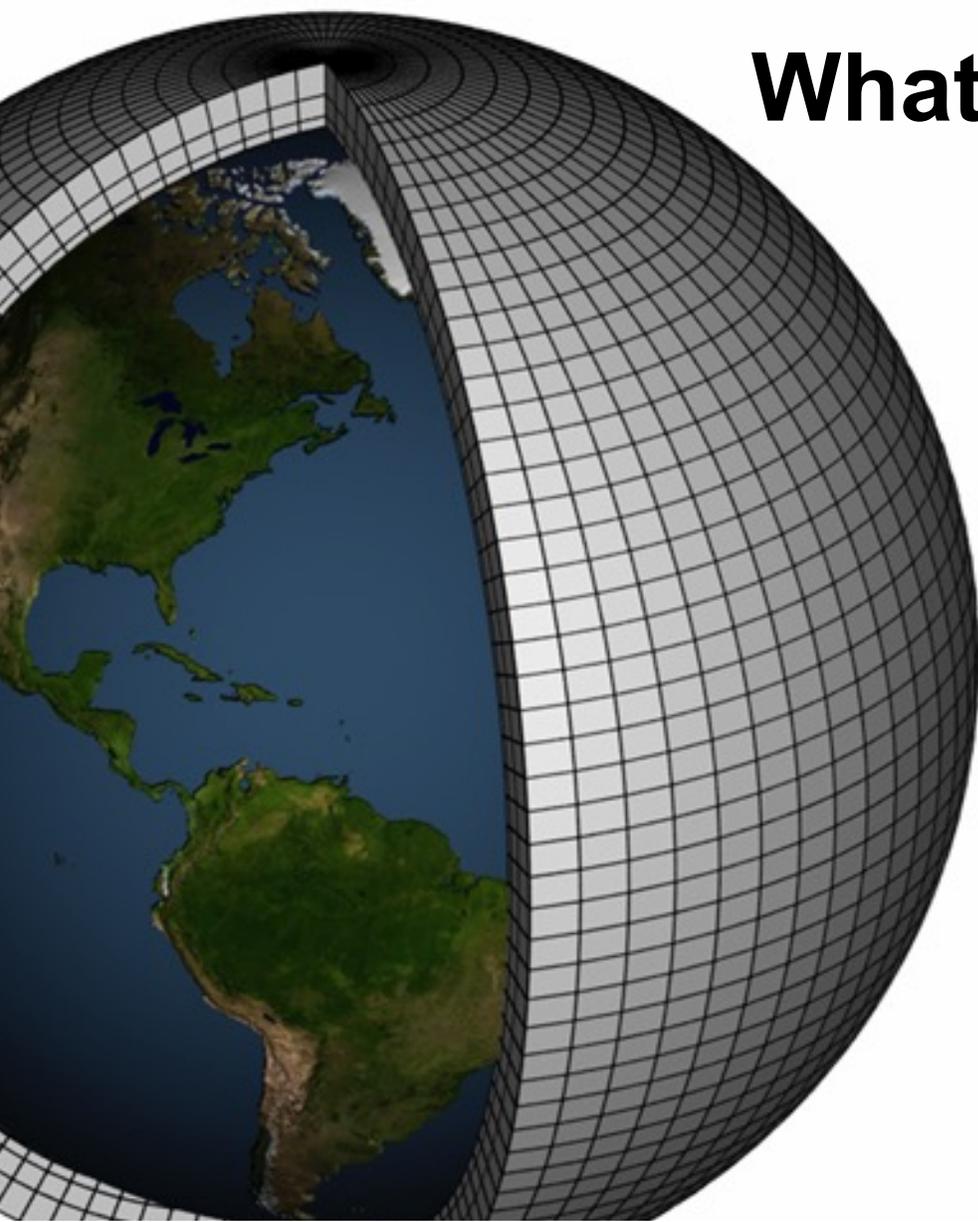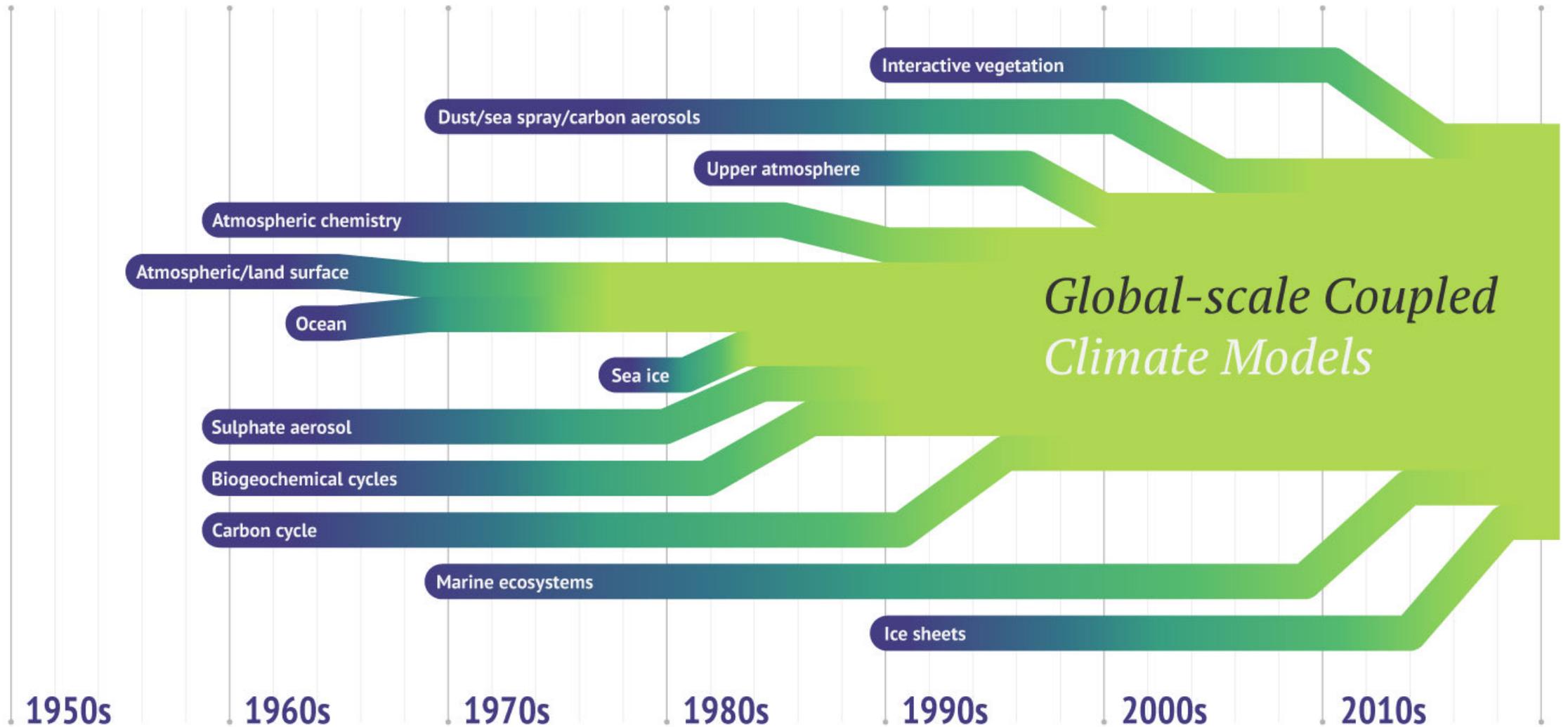
## Stanford-EPRI Educational Webcast Series

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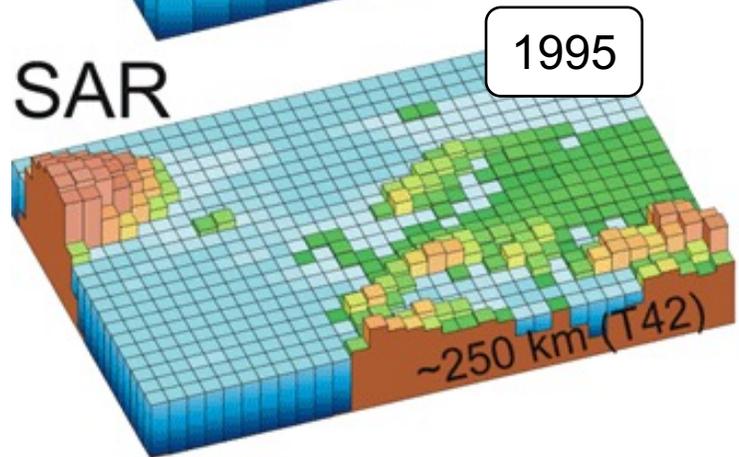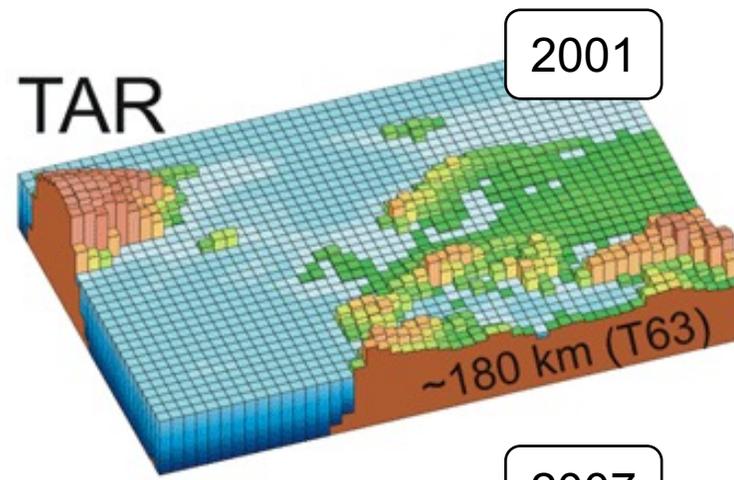
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What are climate models?
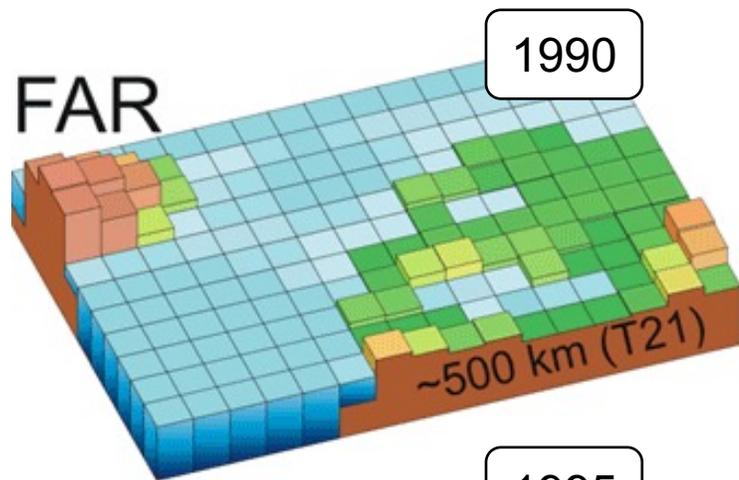
Mathematical representations of the dynamical, physical, chemical and biological processes that drive weather and climate on Earth.

Evolution of climate models: components

Evolution of climate models: resolution

FAR — 1990 — ~500 km (T21)

SAR — 1995 — ~250 km (T42)

TAR — 2001 — ~180 km (T63)

AR4 — 2007 — ~110 km (T106)
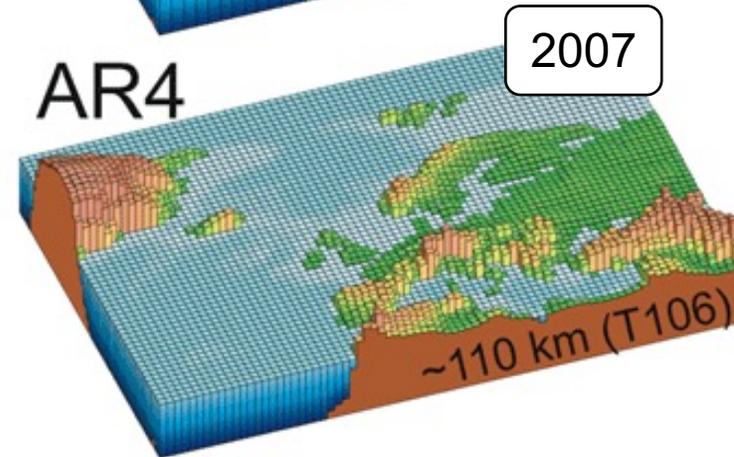
AR5 still ~ 110km

AR6 still ~ 110km
HighResMIP ~ 28km

# Climate modeling teams around the world

Coupled Model Intercomparison Projects (CMIPs)

The **Coupled Model Intercomparison Projects (CMIPs)** coordinate efforts to run climate models through various scenarios and experiments to examine biases, identify responses to forcing, and provide future projections.
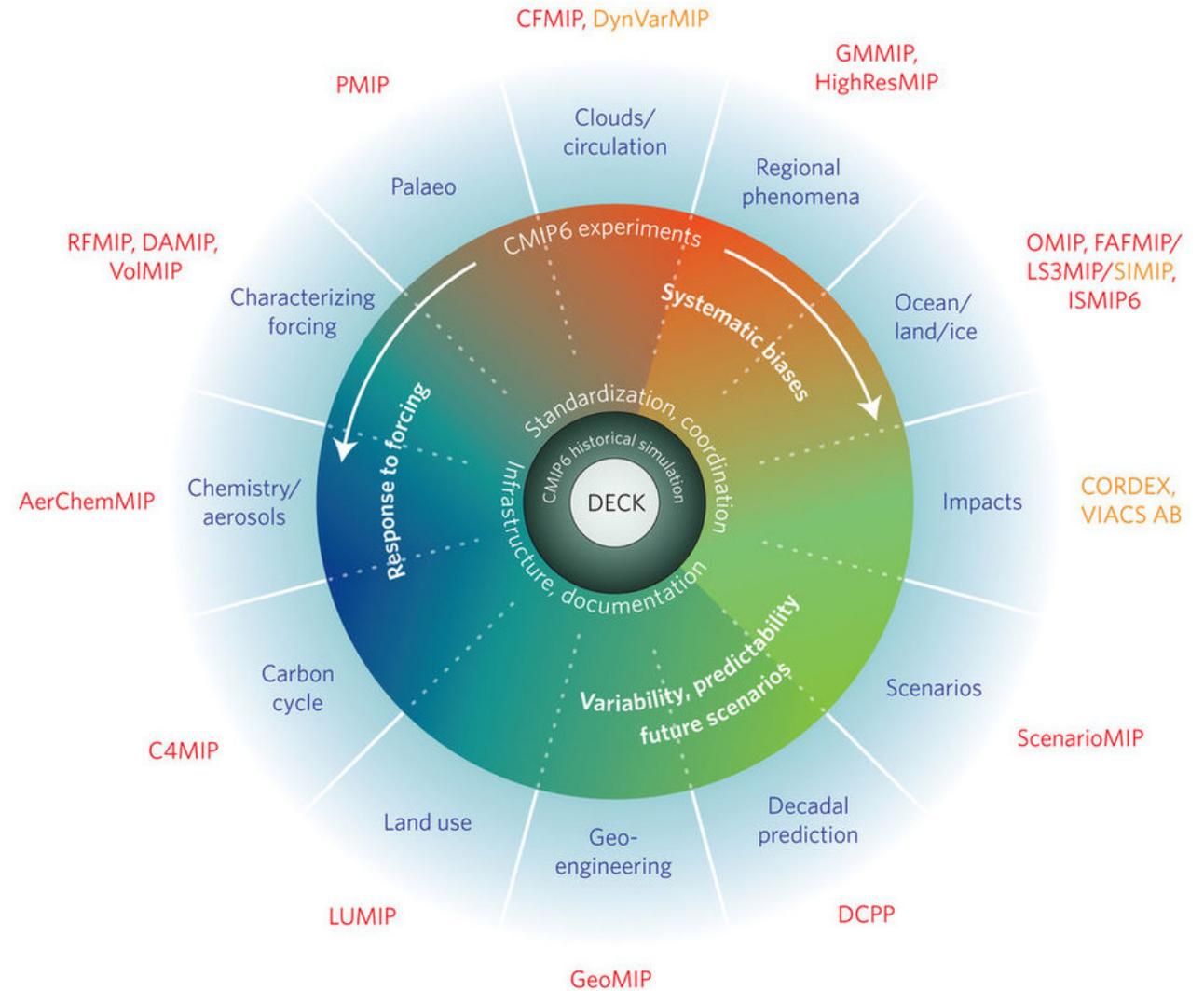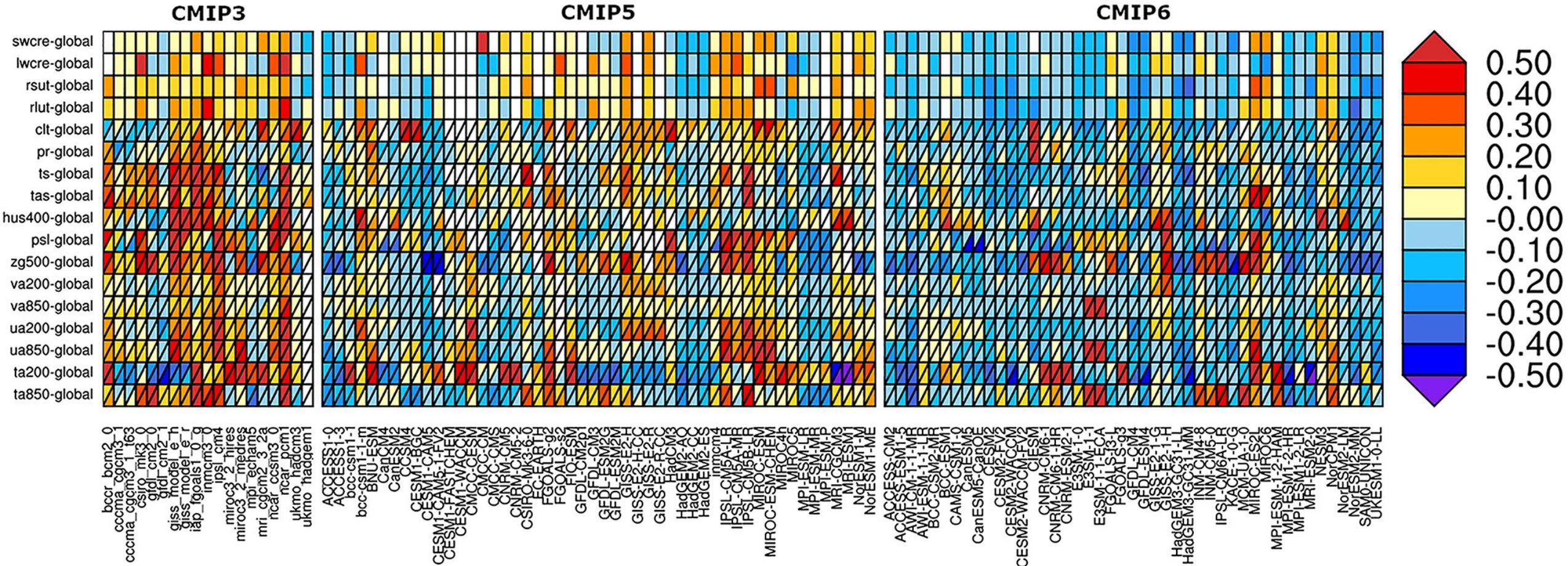
Why do we need multiple models?

In general, the **multi-model mean** is a significantly more skillful approximation to the real climate than any individual model result.
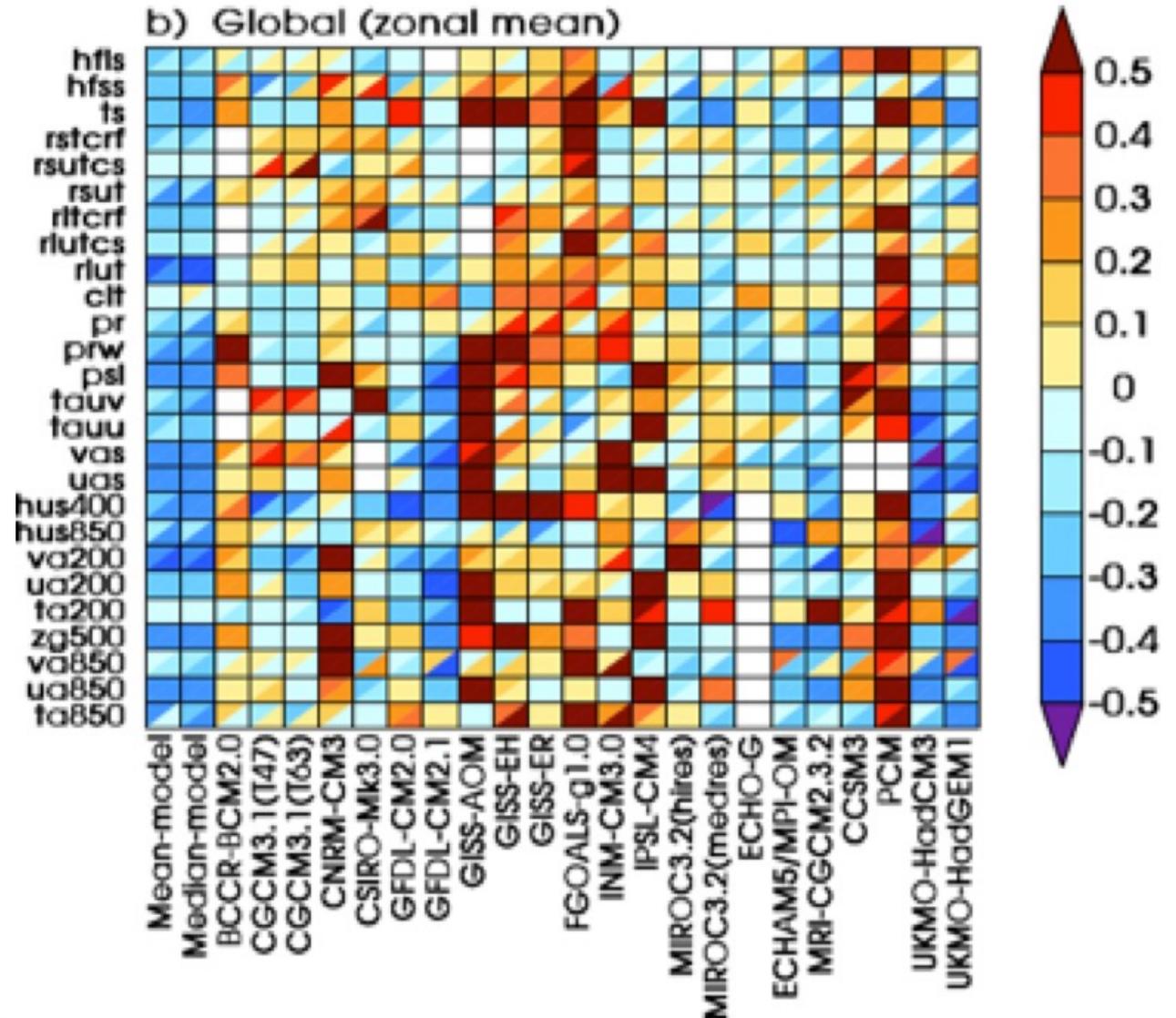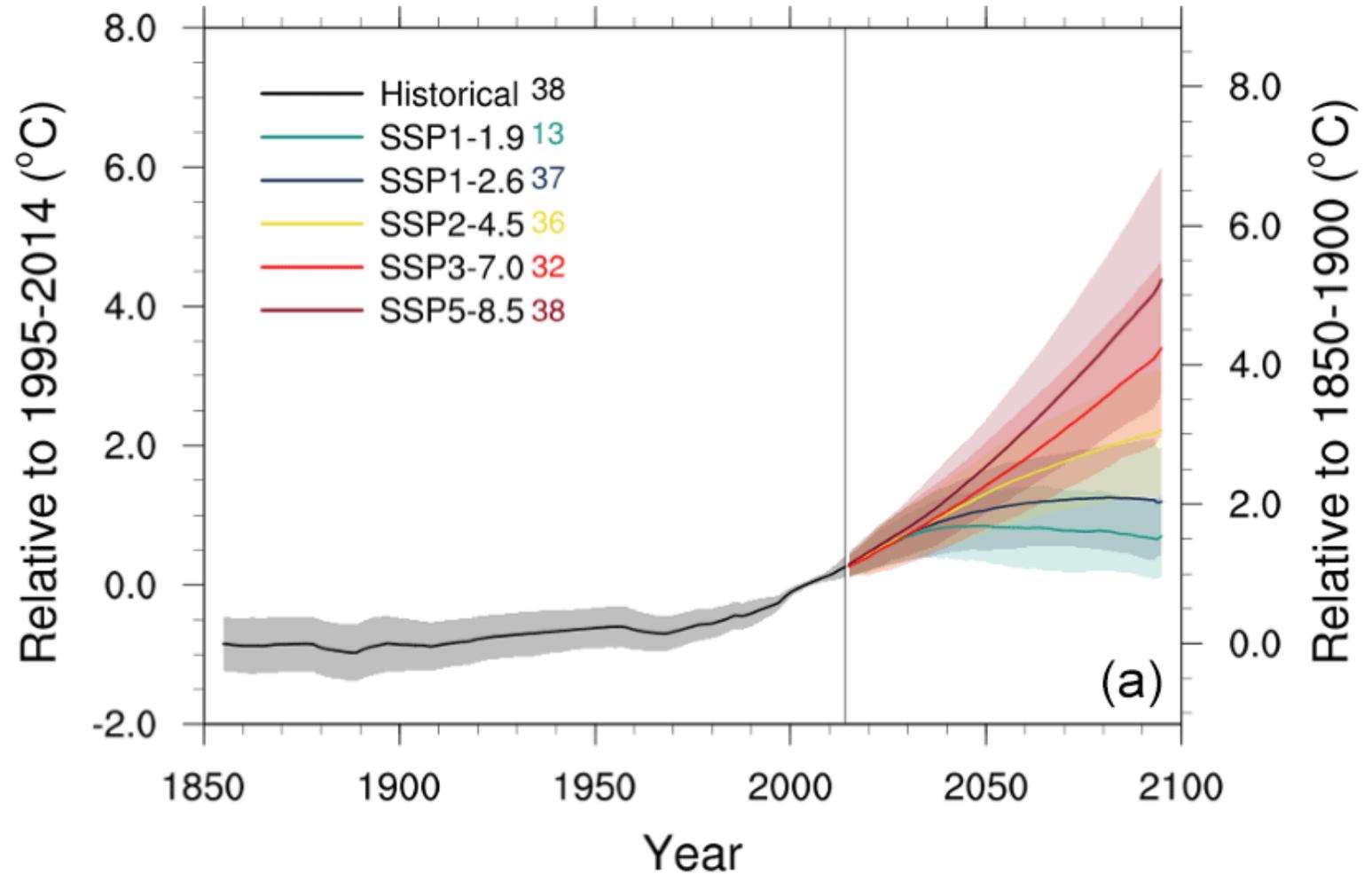
Climate models are getting better

Bock et al. (2020)

Why do we need multiple models?

Global mean temperature projections under different scenarios and different climate models reveal large uncertainties.
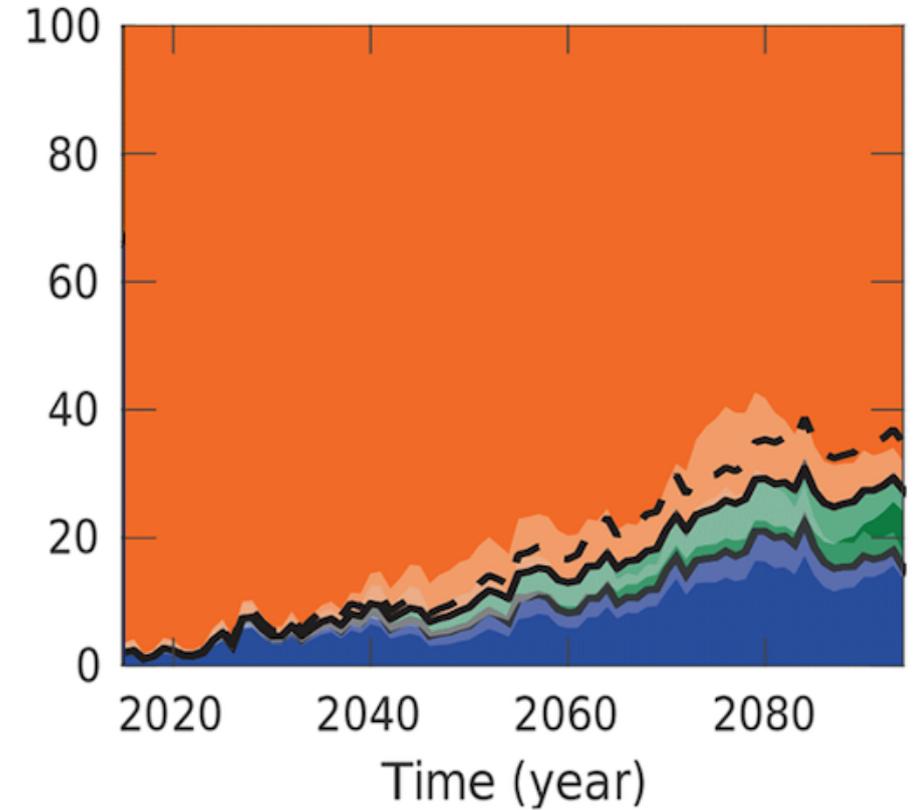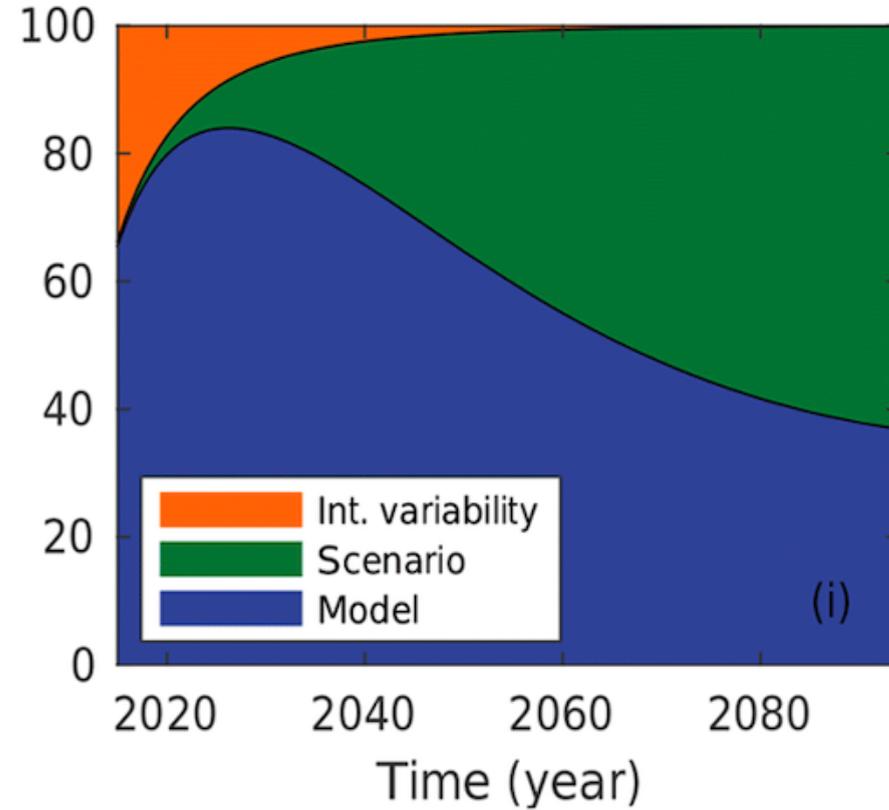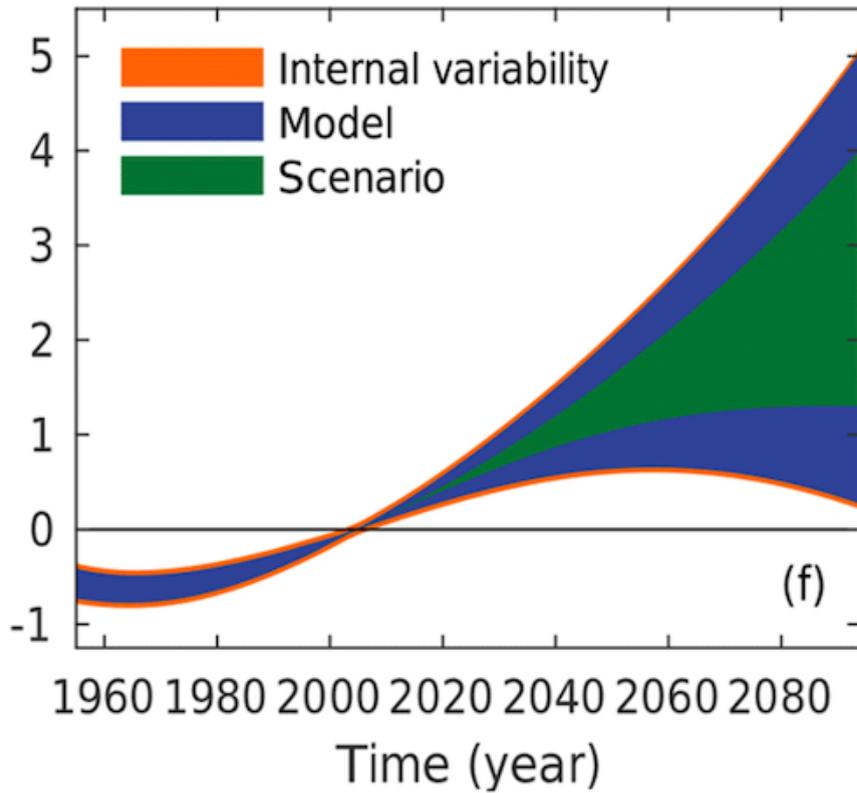
Tebaldi et al. (2020)

Uncertainty in global, regional, and local projections
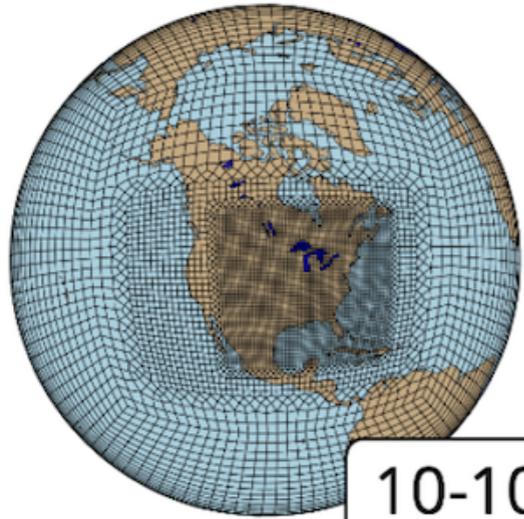

Global mean temperature · Seattle Winter precipitation

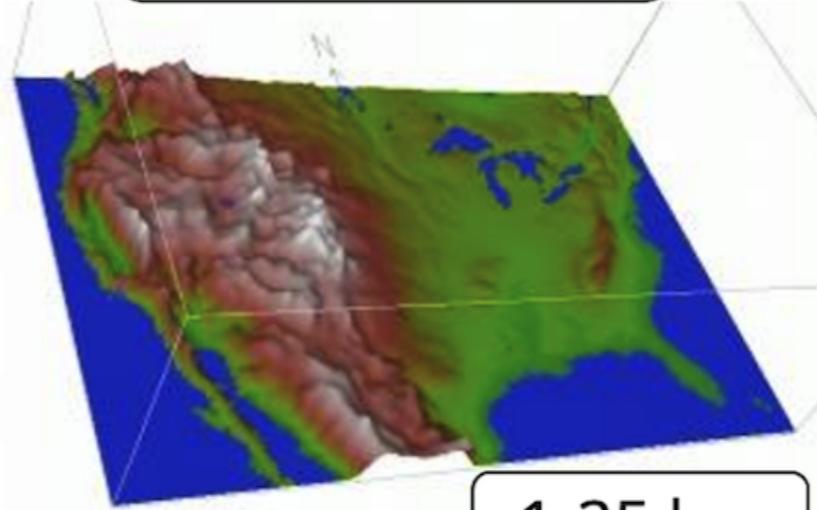Lehner et al. (2020)

Reaching regional scales

Variable resolution

10-100 km

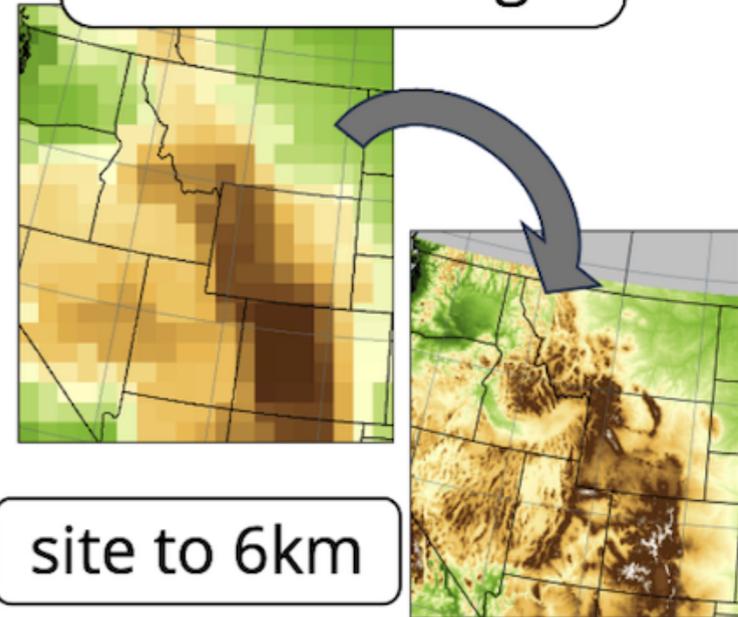Climate model with different resolutions across the globe

Regional climate models

1-25 km

Boundary conditions must be specified by a global model or reanalysis data

Statistical downscaling

site to 6km

Linking large scale to local scale using historical data and statistical methods

High-resolution ensembles

Changes in winter precipitation by end of century from statistically downscaled CMIP6 ensemble simulations for 9 climate models under the SSP5-8.5 scenario (~6km resolution).

Seattle annual temperature

Lafferty and Sriver (2023)
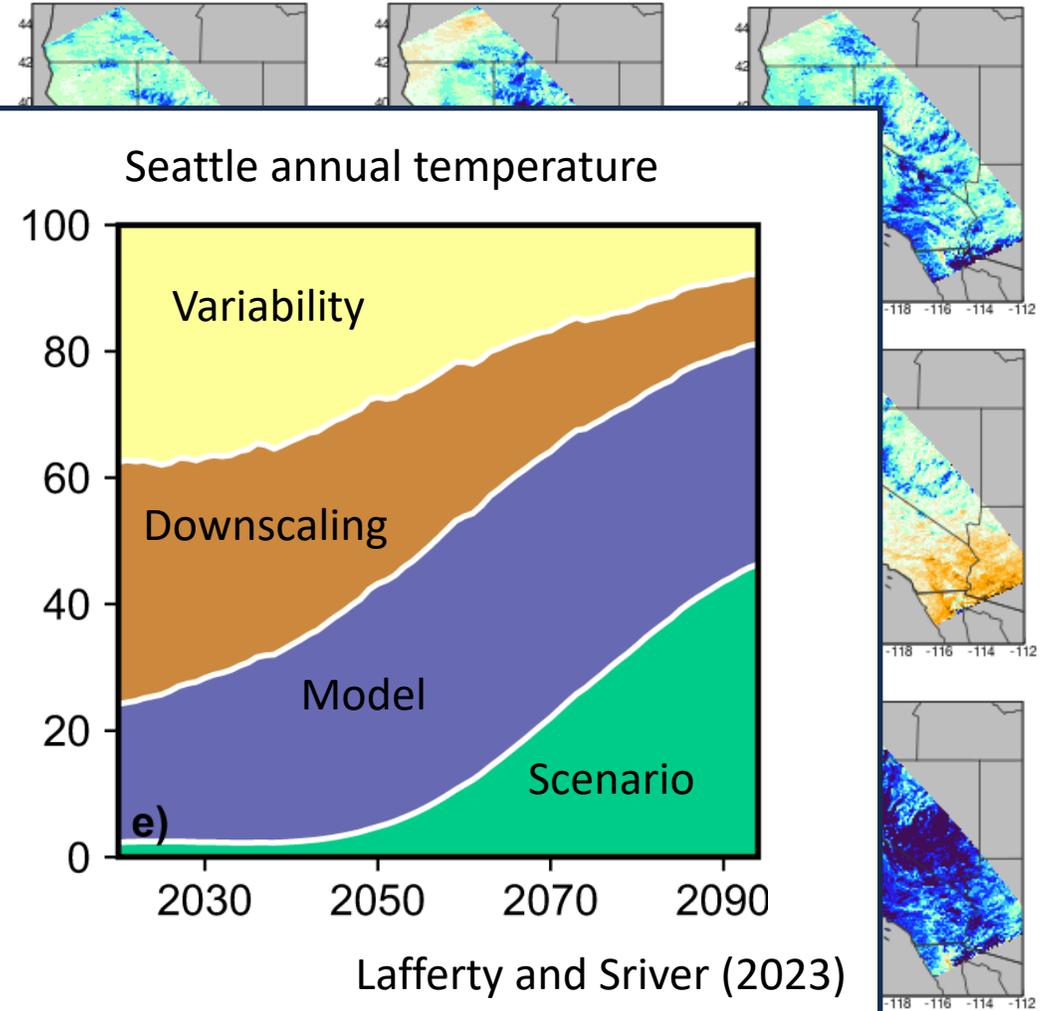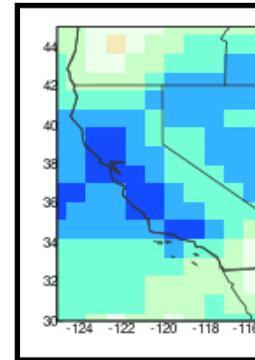
% Source: LOCA2

Some take aways

- Global-scale climate models allow us to **test our understanding** of the dynamical, physical, chemical and biological climate system against observations.

- Global-scale climate models are our primary tool for **making projections** on the future climate of Earth.

- Major ongoing efforts to improve climate projections include:
    - Increasing model resolution to (better) represent fine-scale weather events
    - Incorporating human systems, i.e. water resource management
    - Improved characterization of uncertainty in global to local climate projections
    - Developing credible high-resolution data products to quantify climate impacts