

Uncertainty in regional climate projections

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<http://globalchange.mit.edu/>

Motivation

There are large uncertainties in future regional climate projections:

- Emissions forecasting
- Climate system response
- Natural variability
- Model structural uncertainty
- ...

These uncertainties limit projections of future climate change impacts.

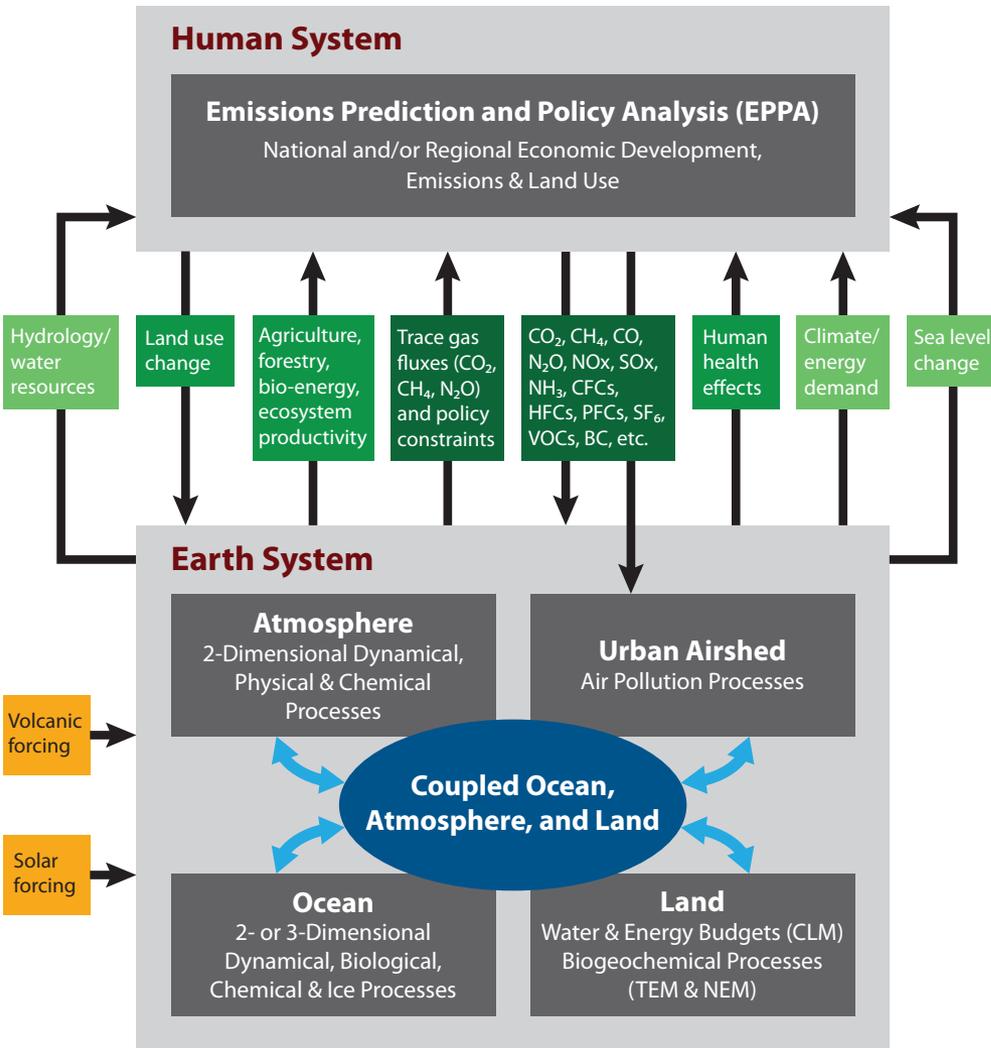
Our aim is to investigate the contribution of these sources of uncertainty in future climate projections over several regions of interest.

The MIT Integrated Global System Model

The IGSM is an integrated assessment model that couples an earth system model of intermediate complexity to a human activity model.

Major advantages of the IGSM:

- Flexibility to change the climate system response
 - climate sensitivity
 - strength of aerosol forcing
 - ocean heat uptake rate
- Flexibility to test different climate policies
- High computational efficiency, allowing large ensemble simulations



- Exchanges represented in standard runs of the system
- Exchanges utilized in targeted studies
- Implementation of feedbacks is under development

Regional climate modeling framework

The IGSM has a 2D zonal-mean atmosphere, so we use a two-pronged approach to obtain regional changes:

- Dynamical downscaling:

The IGSM-CAM, which links the IGSM to the NCAR Community Atmosphere Model (CAM).

New modules in CAM to allow climate parameters to be changed to match those of the IGSM. The climate sensitivity of CAM is changed through cloud radiative adjustment method.

- Statistical downscaling:

A pattern scaling method that extends the IGSM 2D zonal-mean atmosphere using patterns from observations and from IPCC AR4 climate models.

Description of simulations

30 IGSM-CAM simulations:

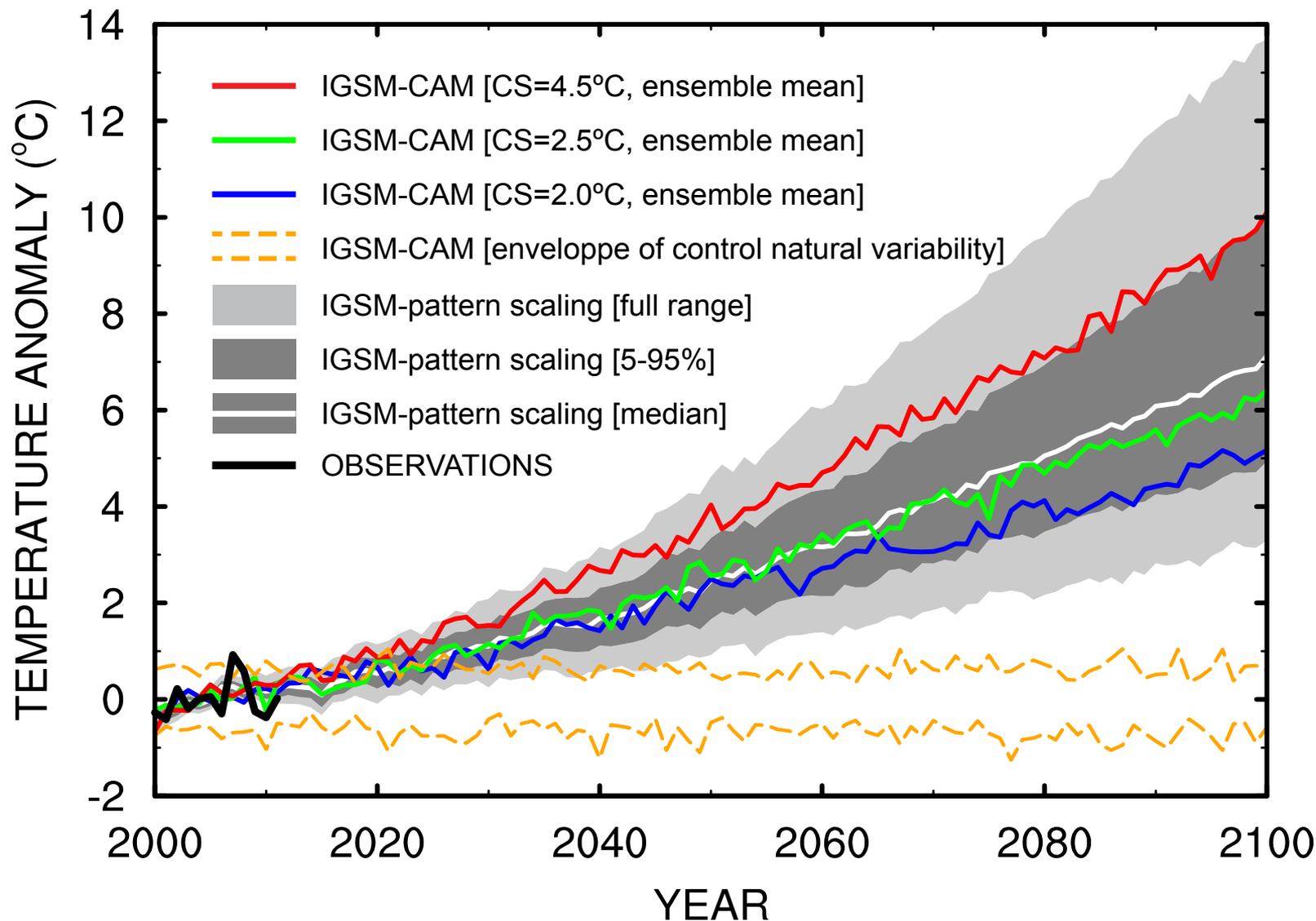
- 2 emissions scenarios:
 - Unconstrained Emissions scenario (UCE), similar to RCP8.5
 - Level 2 stabilization (L2S), similar to RCP4.5
- 3 climate sensitivities:
 - 2.0, 2.5 and 4.5°C
 - associated net aerosol forcing chosen to best reproduce 20th century
- 5 different representations of natural variability
(incl. initial conditions and ocean wind stress)

13,600 IGSM-pattern scaling simulations:

- 2 emissions scenarios (UCE and L2S)
- 400-member ensemble of IGSM, with Latin Hypercube sampling of climate parameters (climate sensitivity, net aerosol forcing, ocean heat uptake rate) based on their PDFs
- 17 IPCC AR4 GCM patterns

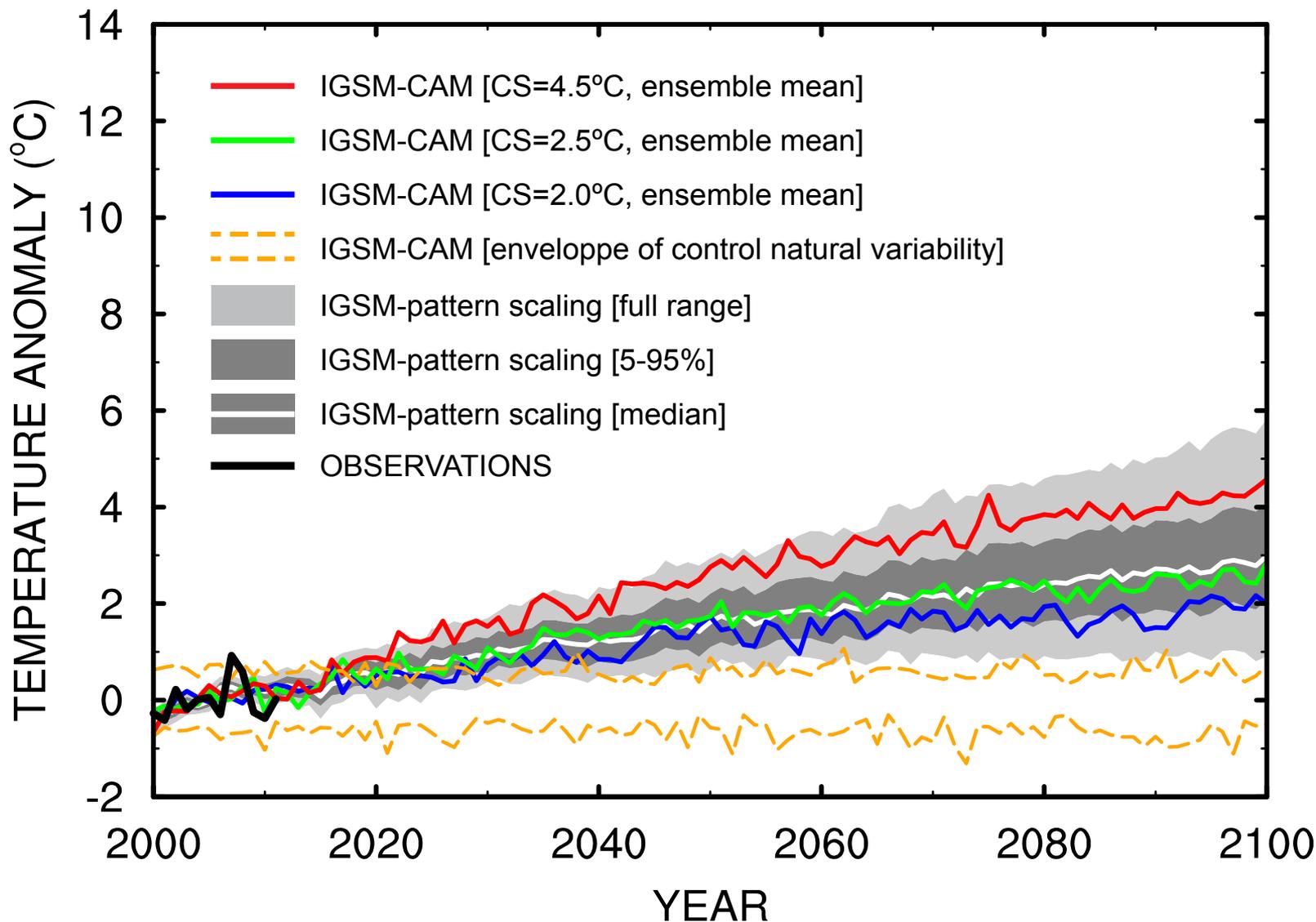
Northern Eurasia temperature change time series

a) ΔT under UCE



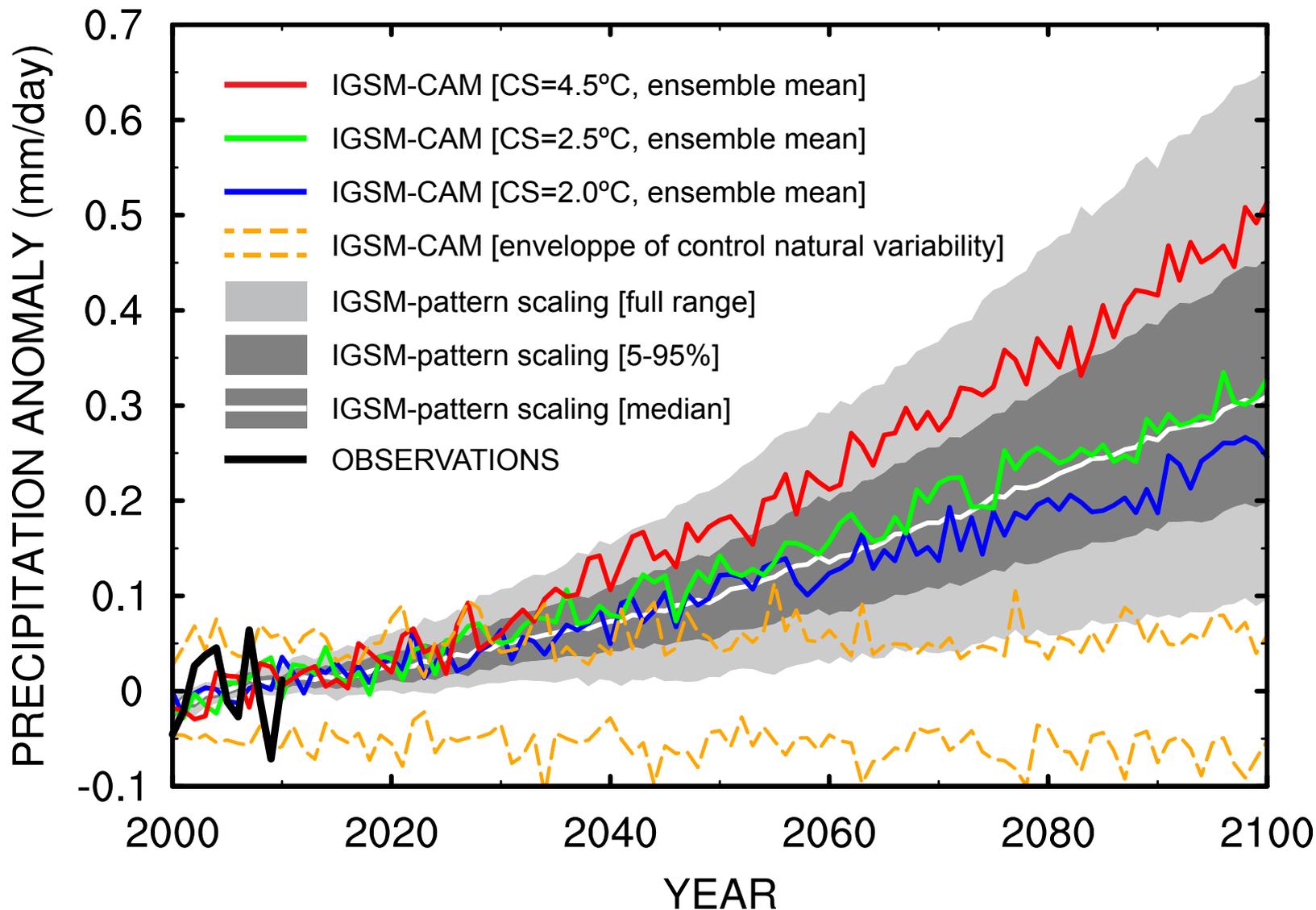
Northern Eurasia temperature change time series

b) ΔT under L2S



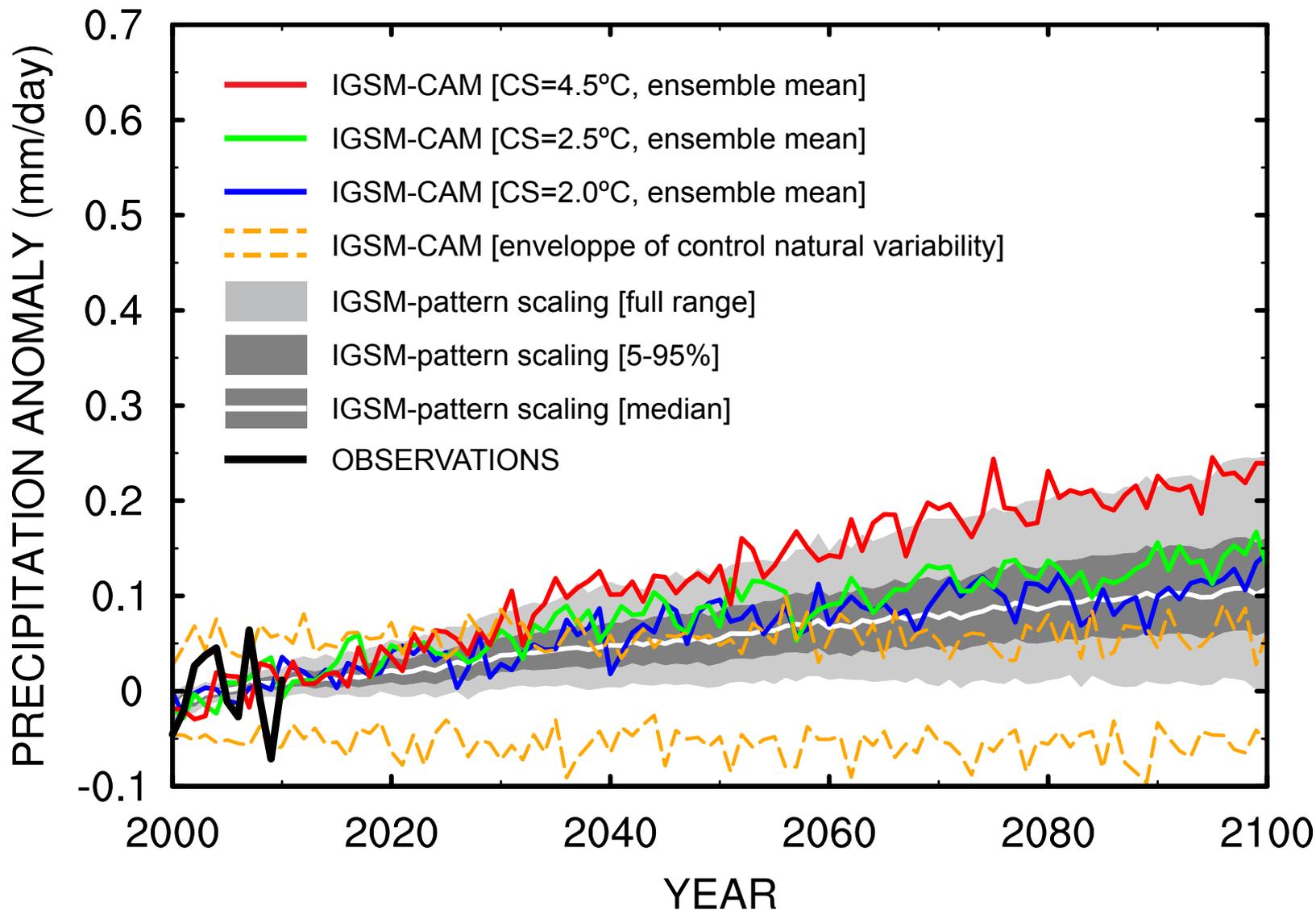
Northern Eurasia precipitation change time series

c) ΔP under UCE



Northern Eurasia precipitation change time series

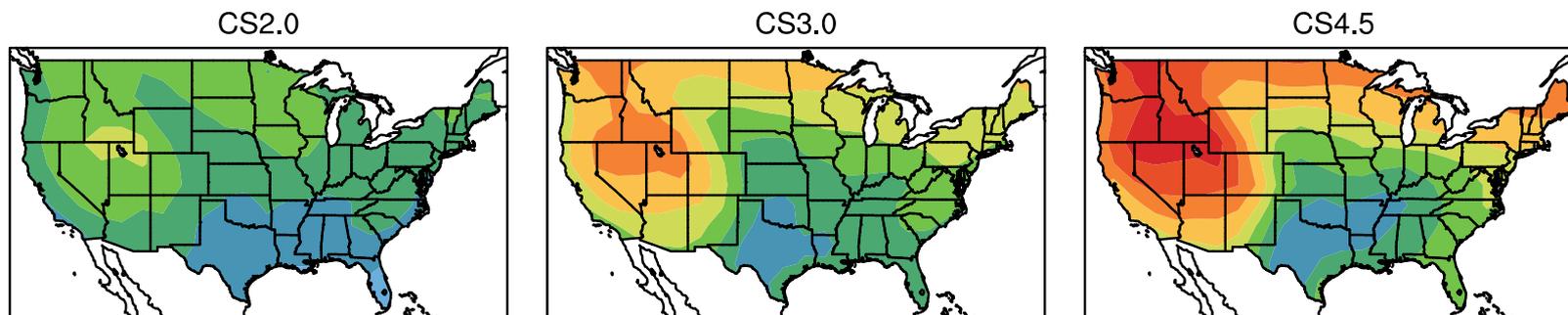
d) ΔP under L2S



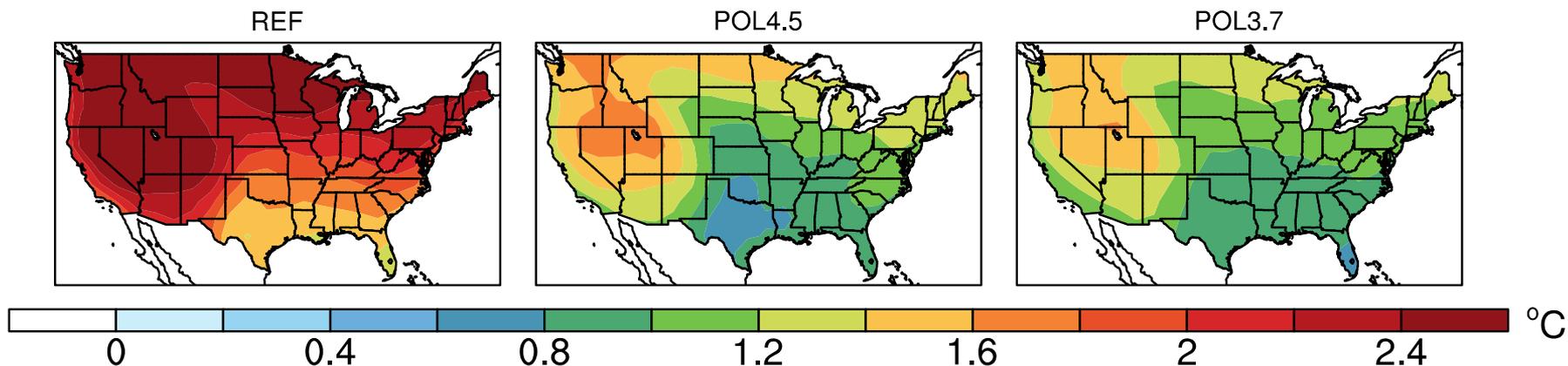
Impact of choice of policy and climate response

2041-2060 mean minus 1991-2010 mean

a) IGSM-CAM ENSEMBLE MEAN FOR POL4.5 WITH DIFFERENT CLIMATE SENSITIVITIES



b) IGSM-CAM ENSEMBLE MEAN FOR CS3.0 WITH DIFFERENT POLICIES

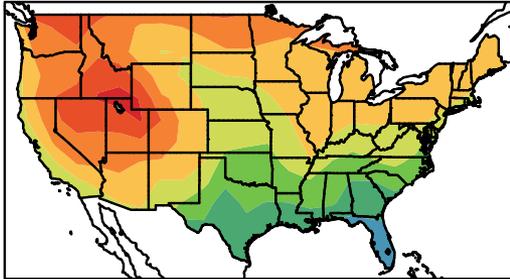


Impact of natural variability and choice of model

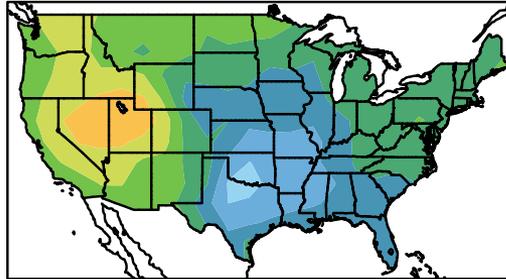
2041-2060 mean minus 1991-2010 mean

a) IGSM-CAM FOR CS3.0_POL4.5 WITH DIFFERENT INITIAL CONDITIONS

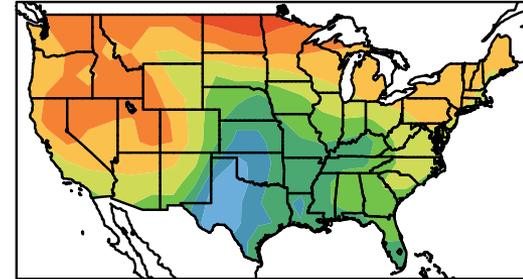
INITIAL CONDITION 1



INITIAL CONDITION 3

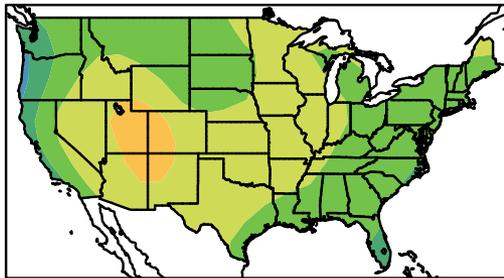


INITIAL CONDITION 5

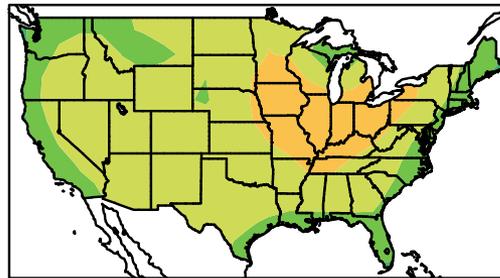


b) IGSM-PATTERN SCALING FOR C3.0_POL4.5 WITH DIFFERENT MODELS

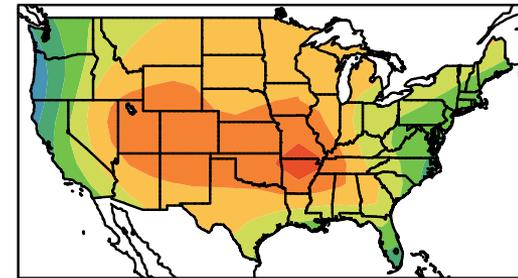
NCAR_CC3M3.0



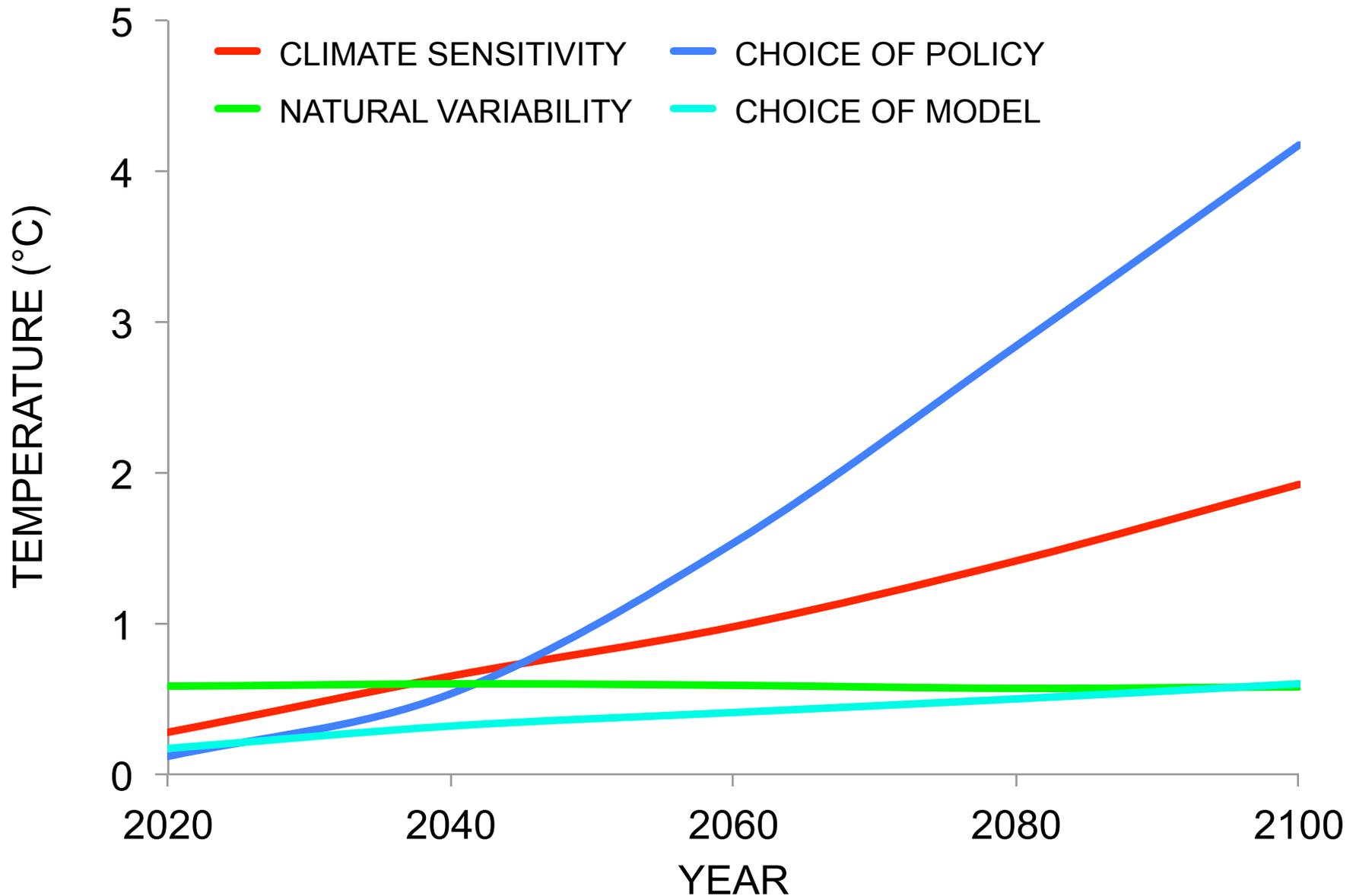
BCCR_BCM2.0



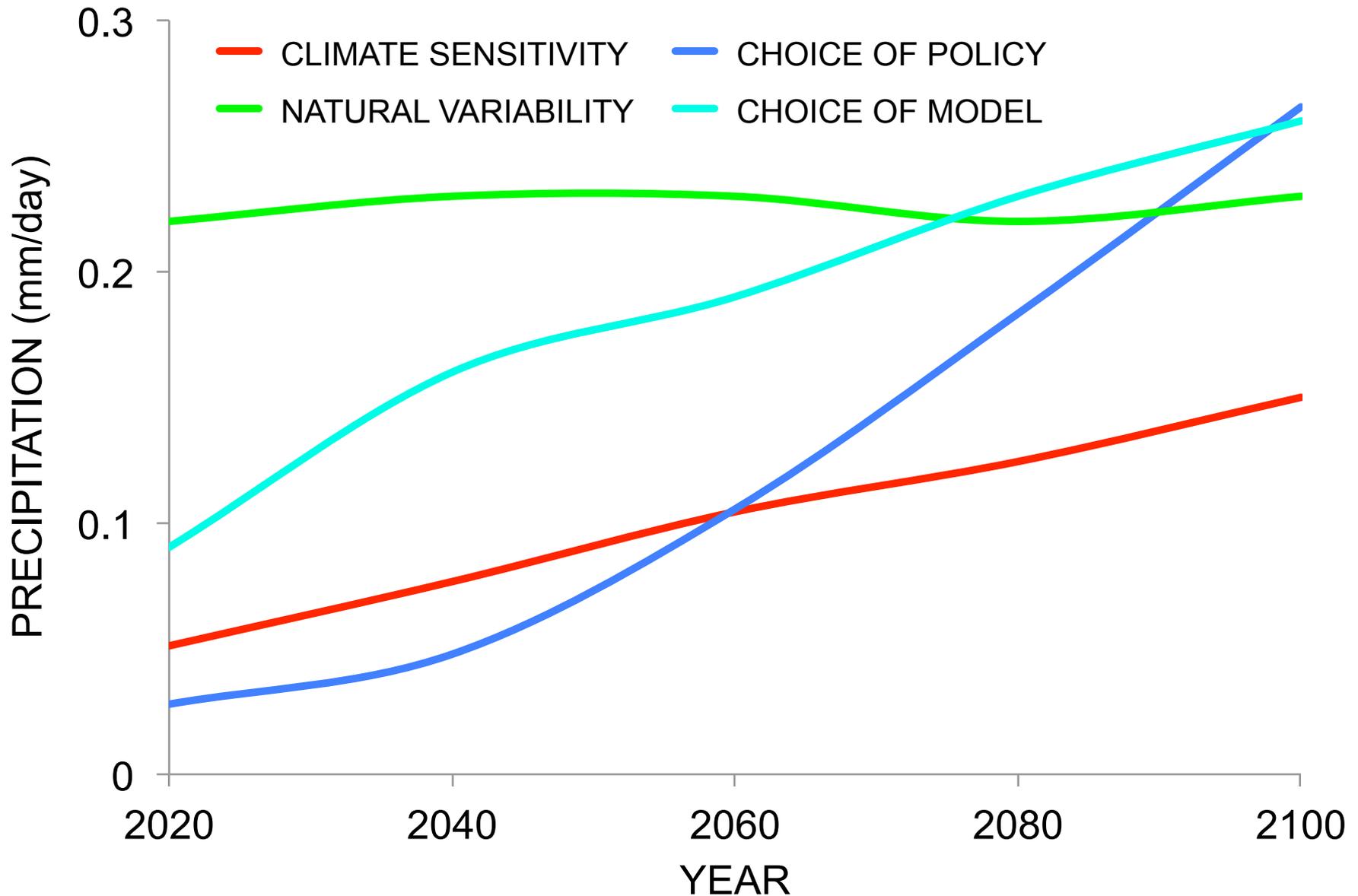
MIROC3.2_MEDRES



Impact of sources of uncertainty



Impact of sources of uncertainty



Conclusions

Each source of uncertainty considered contributes substantially to the projected range of temperature and precipitation changes.

Wide range of temperature and precipitation changes over the contiguous US or Northern Eurasia, even using one single climate model.

⇒ need to sample the global climate system response and natural variability within each model.

What does this mean for climate impacts?

Economic valuation of the impacts and risks of climate change should take into account the large uncertainty in regional climate projections.

Relying on a small ensemble of climate simulations would likely underestimate climate impacts.

Future work

Investigate the contribution each source of uncertainty by

- Region (within the US, for different continents...)
- Season

Extending the size of the ensemble for natural variability, choice of policy and global climate system response (ocean heat uptake rate)

Investigating the contribution each source of uncertainty on extreme events