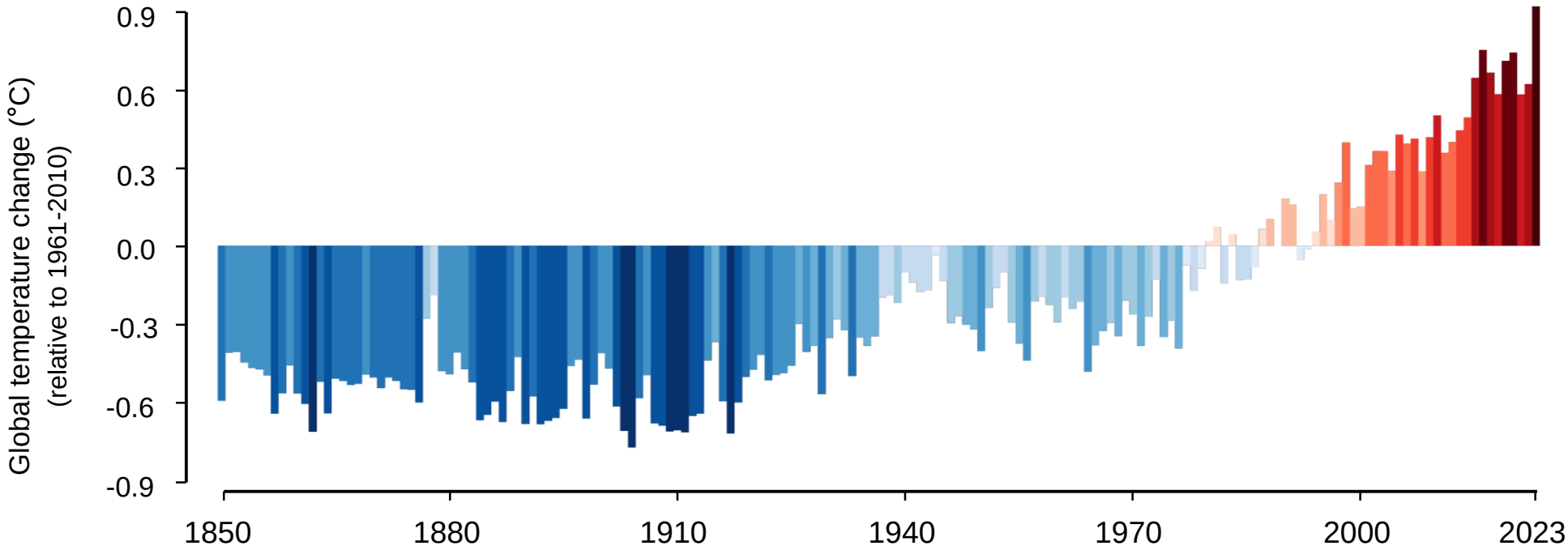
Reliability of species distribution model projections

From past to future climate changes

Victor Van der Meersch & Isabelle Chuine

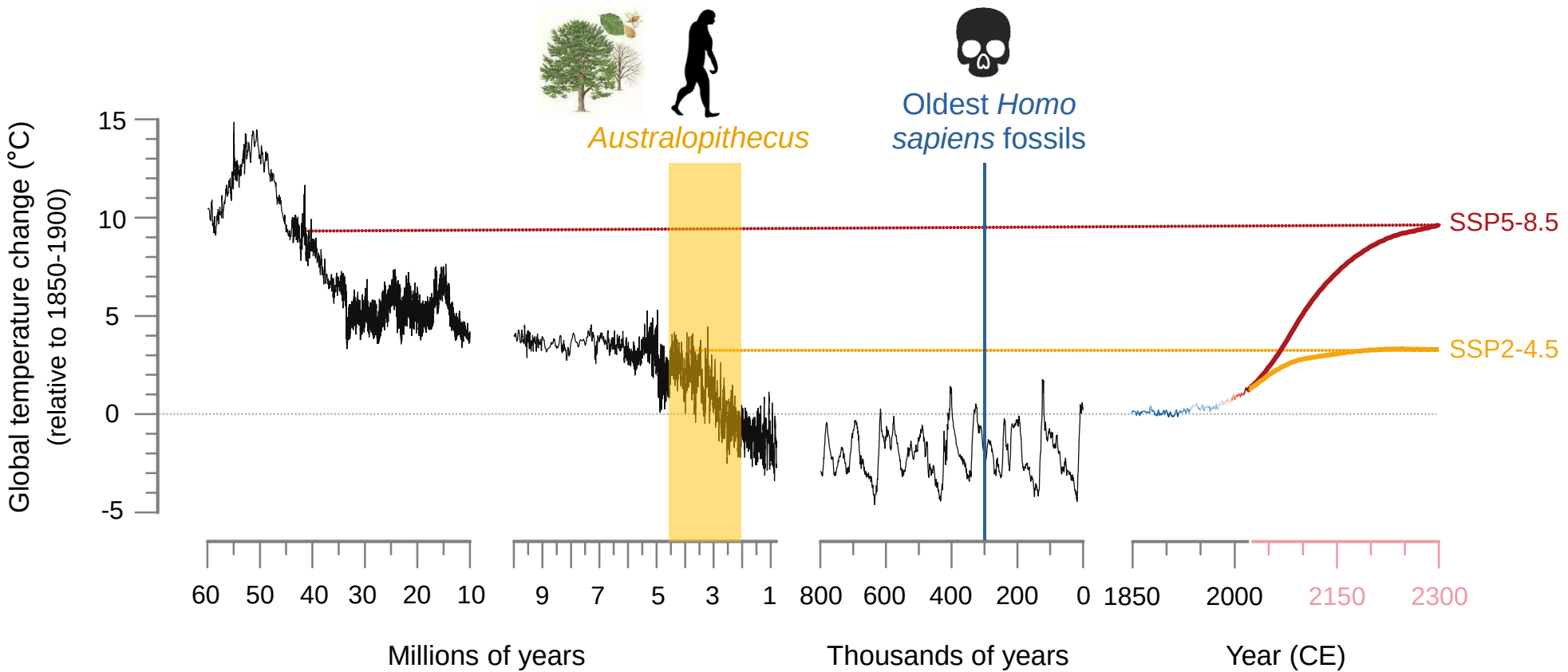
FOREM, Montpellier 1-3 avril 2025

The need for reliable model projections



Ed Hawkins, UK Met Office (2023)

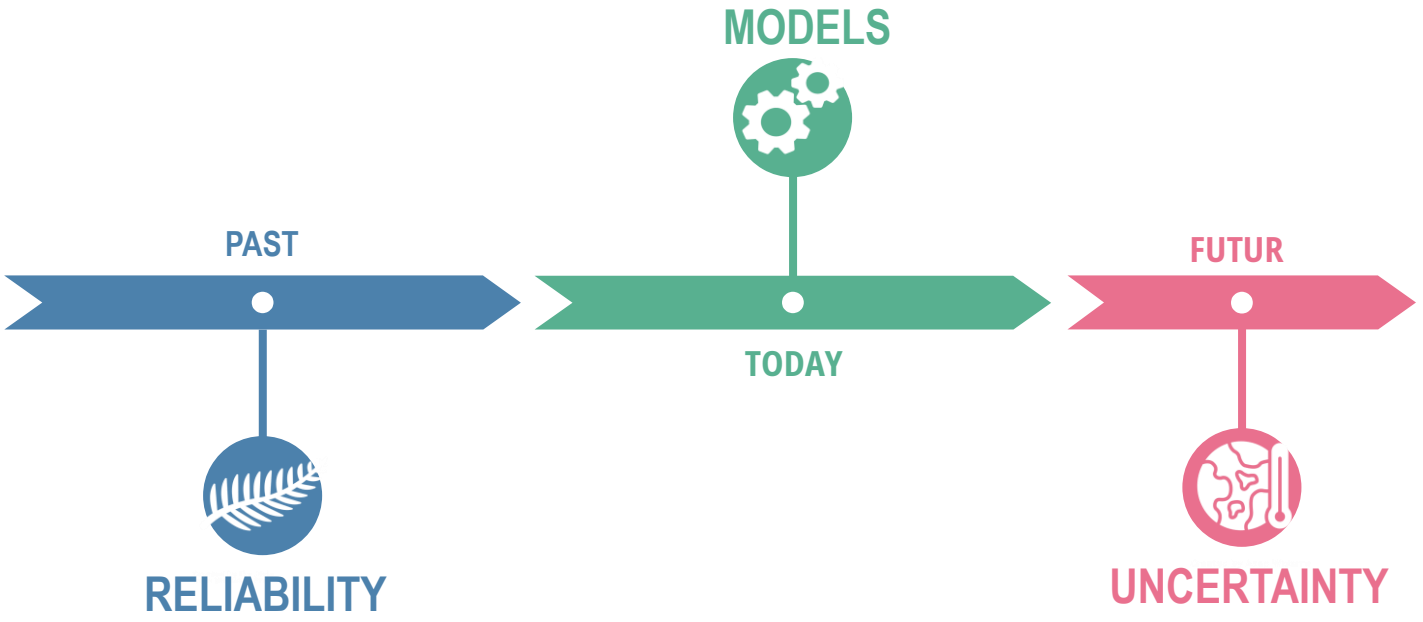
The need for reliable model projections



IPCC (2021)

The need for reliable model projections

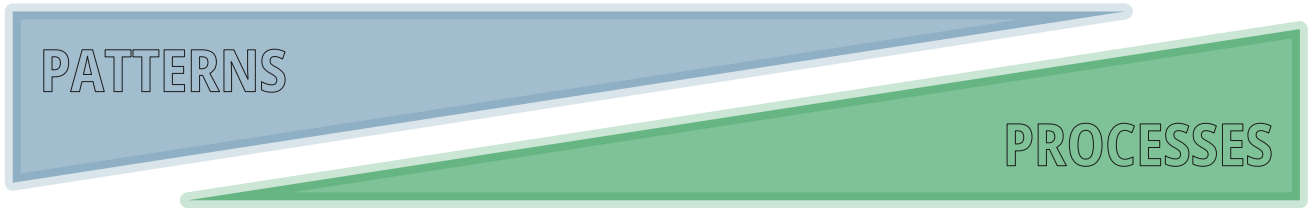
Can we build models that will provide
reliable projections to inform decision-making under the
deep uncertainty of climate change ?



Model characteristics

Correlative models

Process-explicit models



Dormann et al. (2012)

Model characteristics

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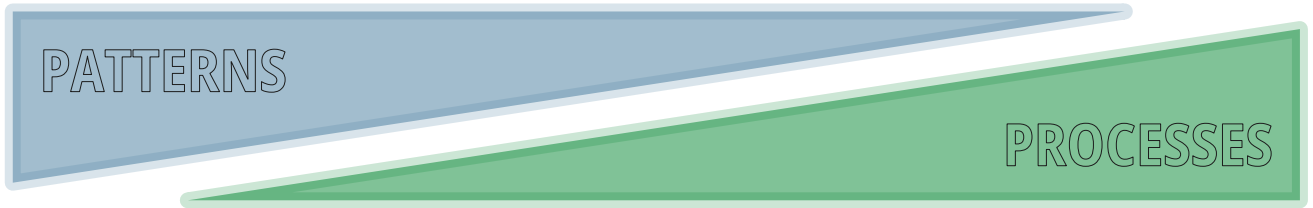

- implicit representation of processes

- explicit representation of processes

Dormann et al. (2012)

Model characteristics

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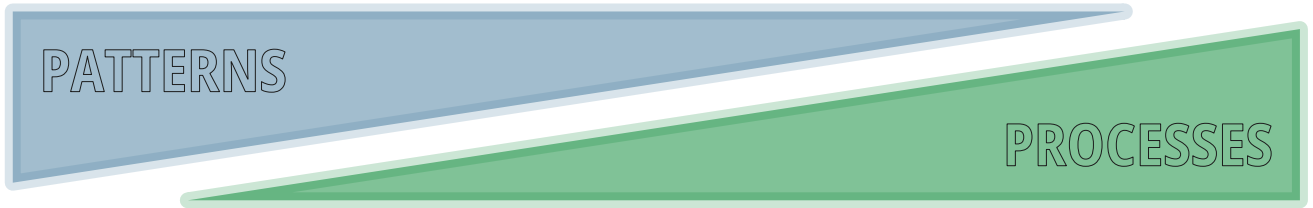
Process-explicit models



- implicit representation of processes
- calibrated with current distribution data

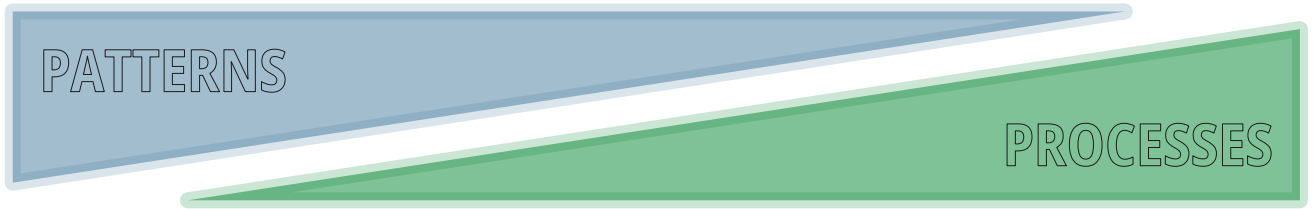
- explicit representation of processes
- calibrated with process-related data

Dormann et al. (2012)

Which factors contribute to model robustness?

Correlative models

Process-explicit models



▸ implicit representation of processes

▸ calibrated with current distribution data

Hypothesis

?

Calibration

▸ explicit representation of processes

▸ calibrated with process-related data

Which factors contribute to model robustness?

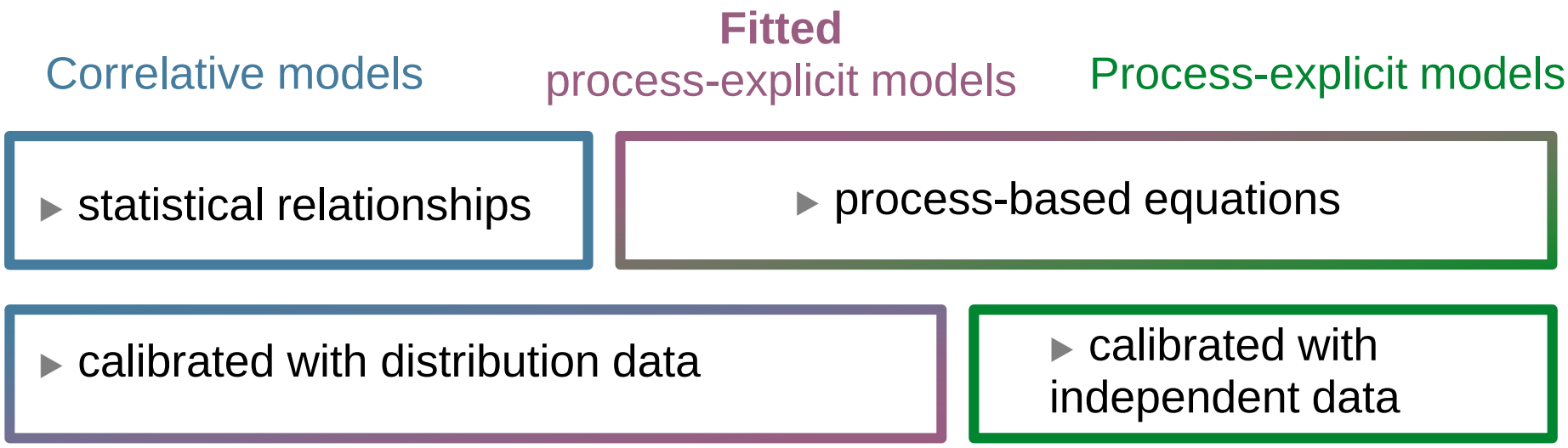
▸ implicit representation of processes

▸ explicit representation of processes

▸ calibrated with current distribution data

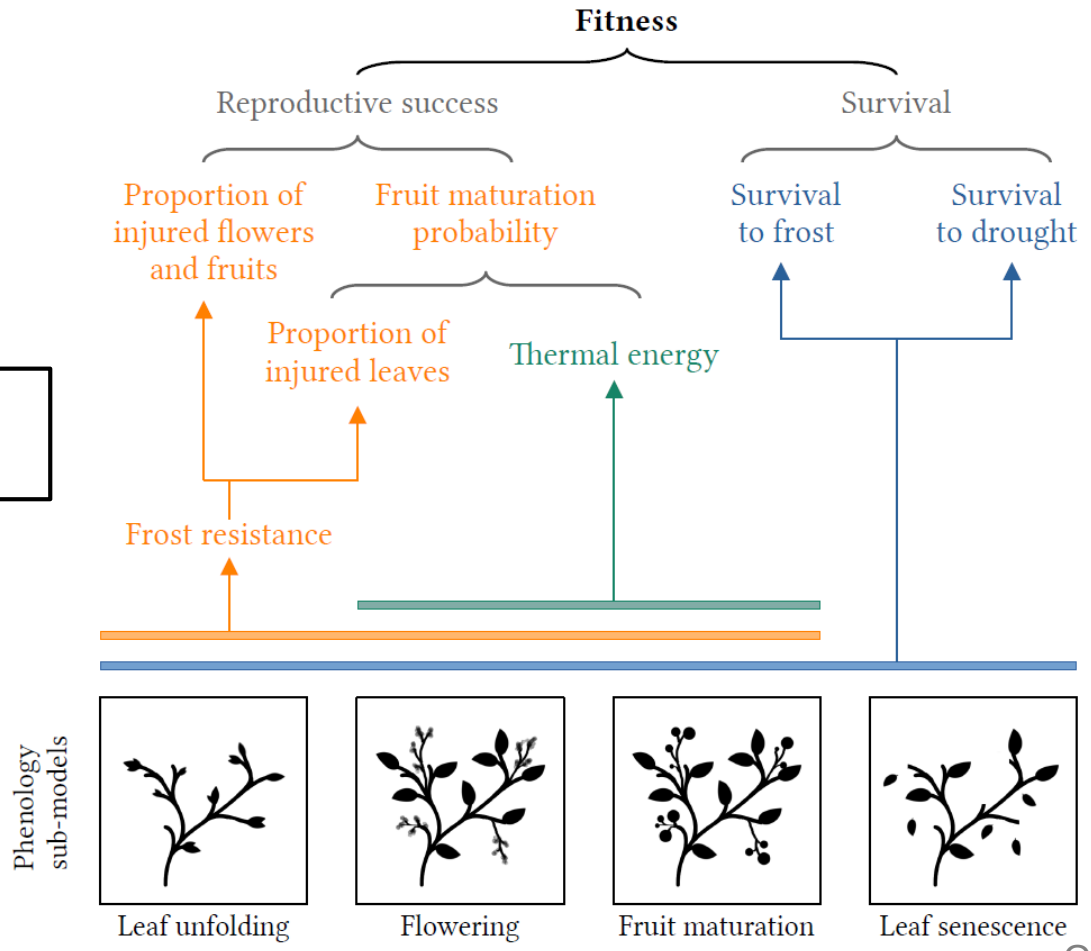
▸ calibrated with process-related data

Capturing a large spectrum of models



CAPSIS models used

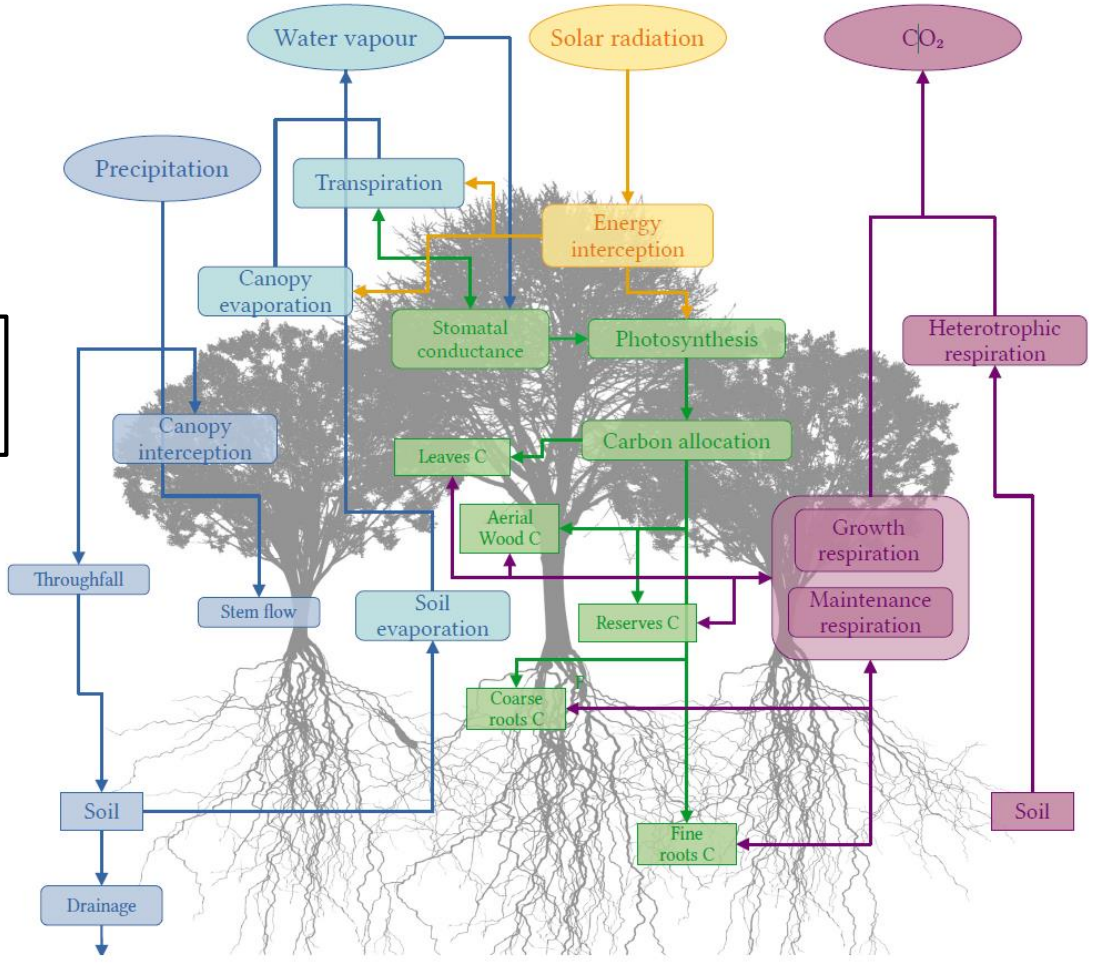
PHENOFIT4 model



Chuine and Beaubien (2001)

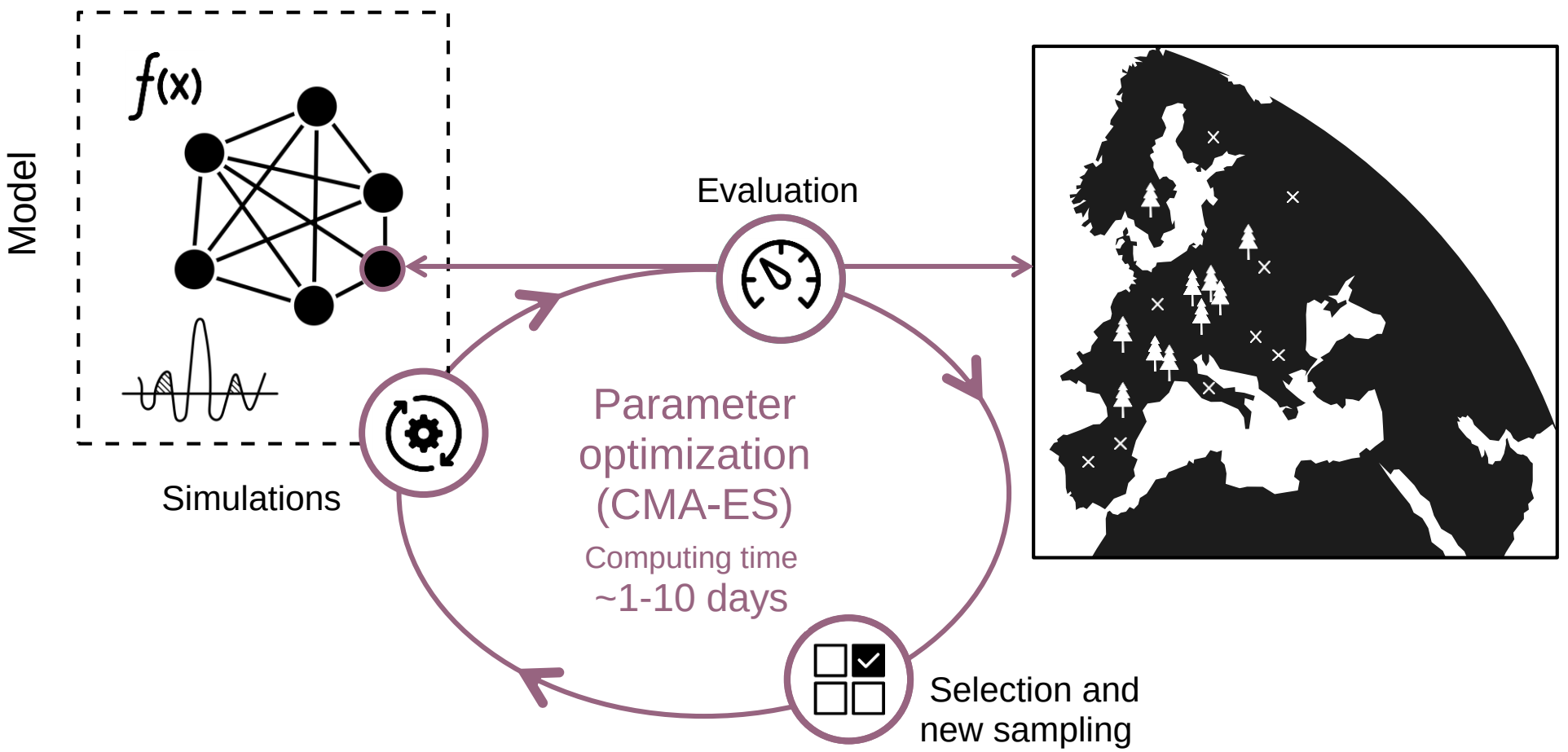
CAPSIS models used

CASTANEA model

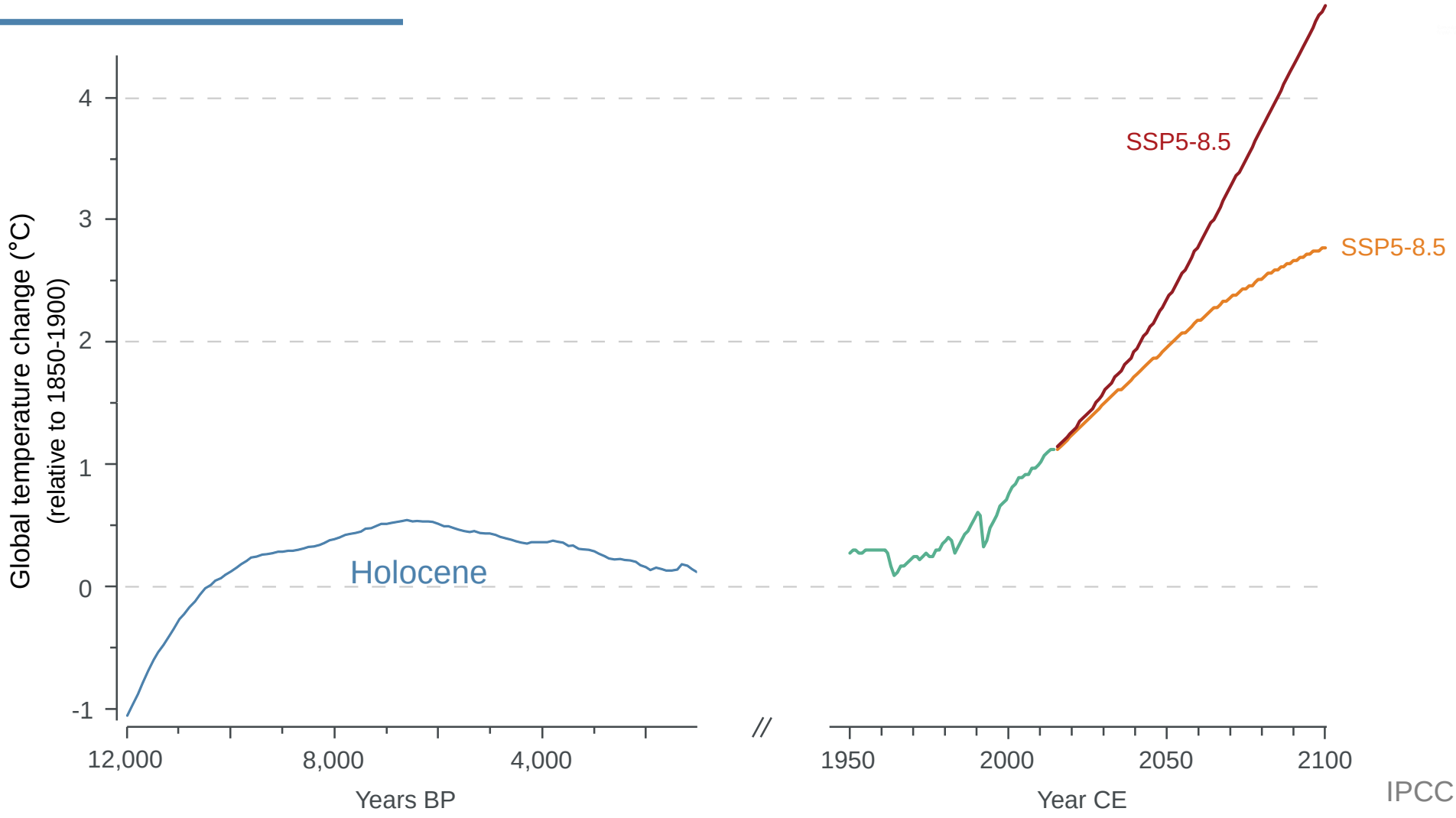


Dufrêne et al. (2005)

Inverse calibration of process-explicit models



Evaluation of models using paleorecords



IPCC (2021)

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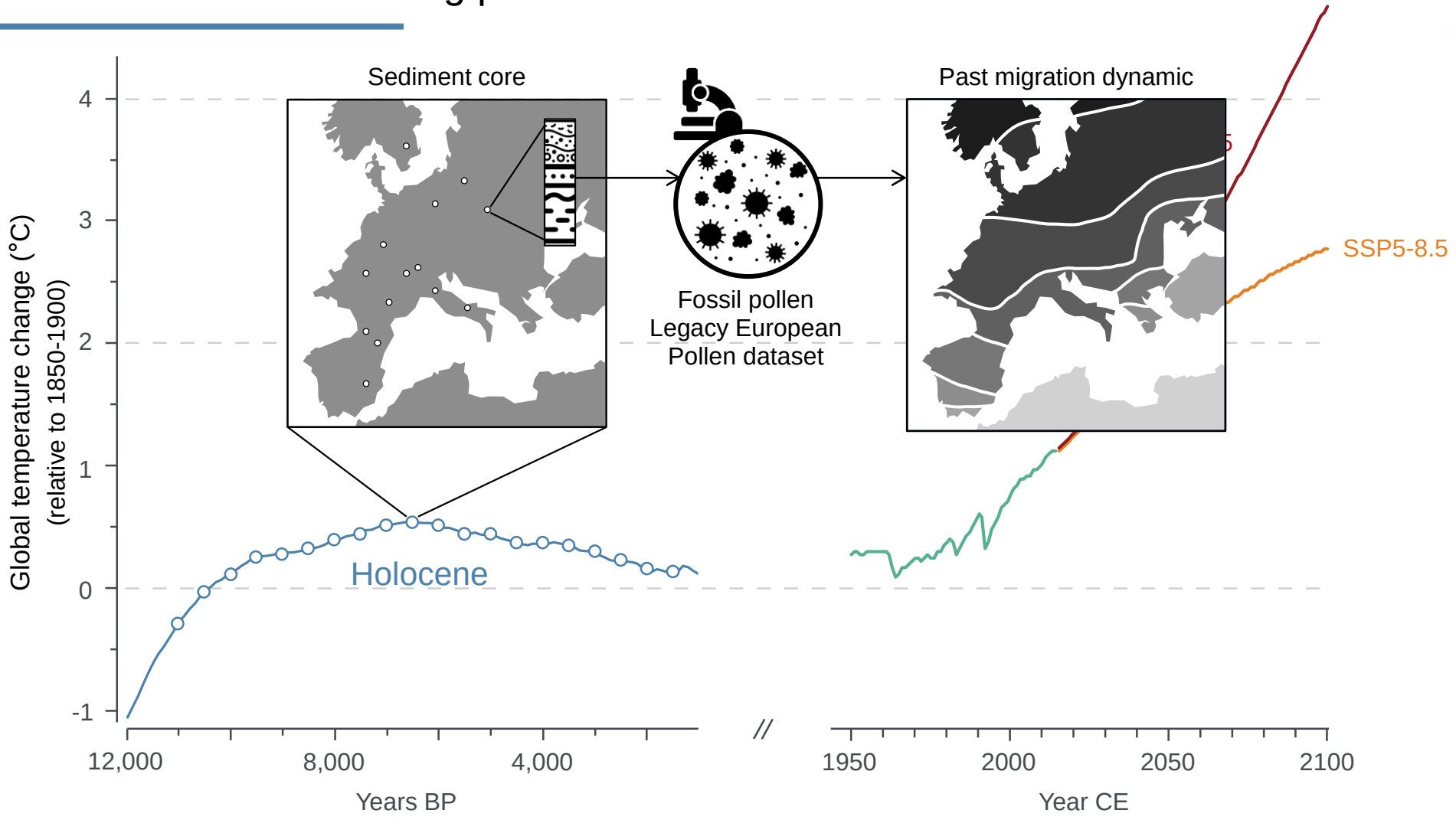

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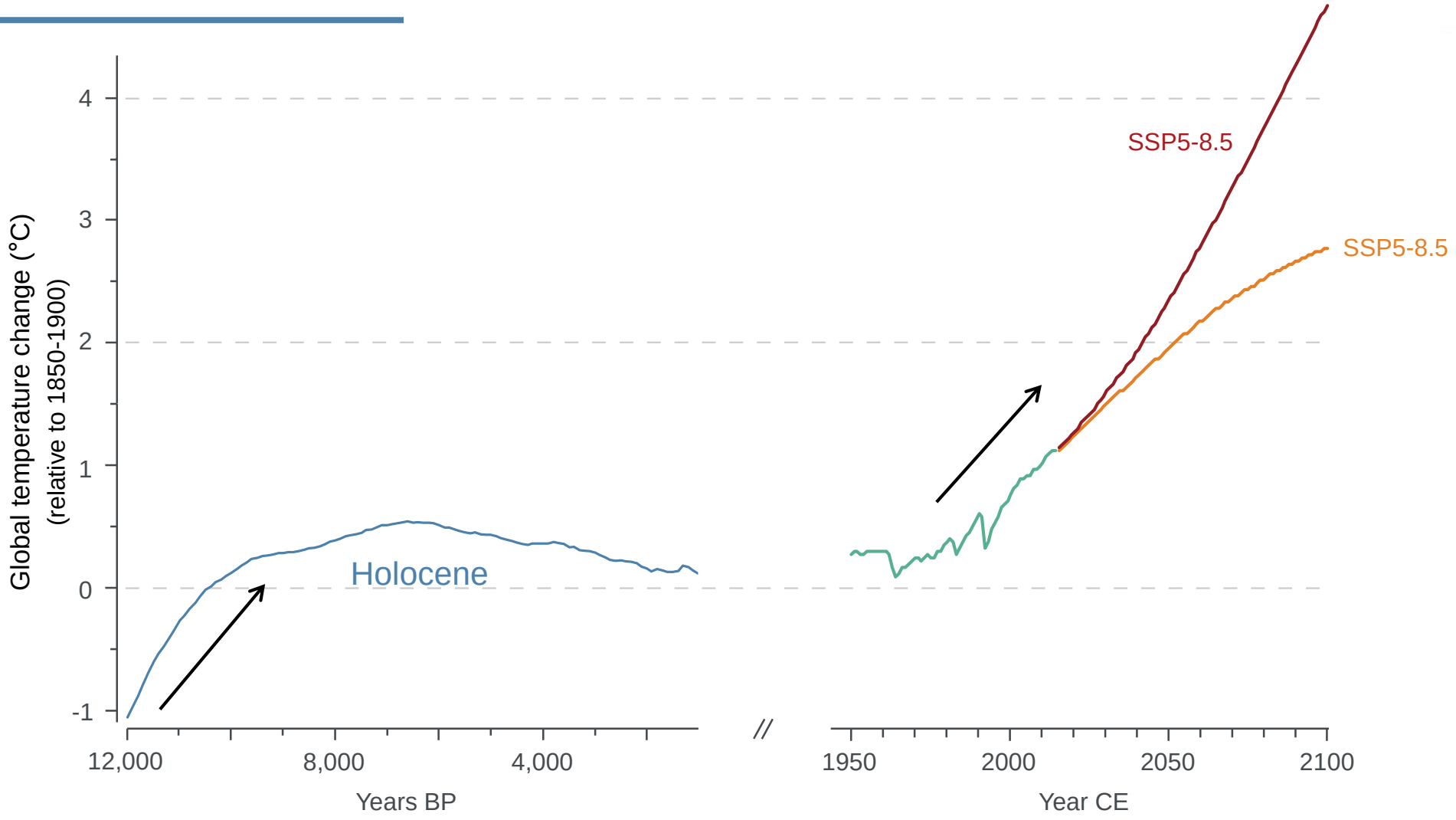

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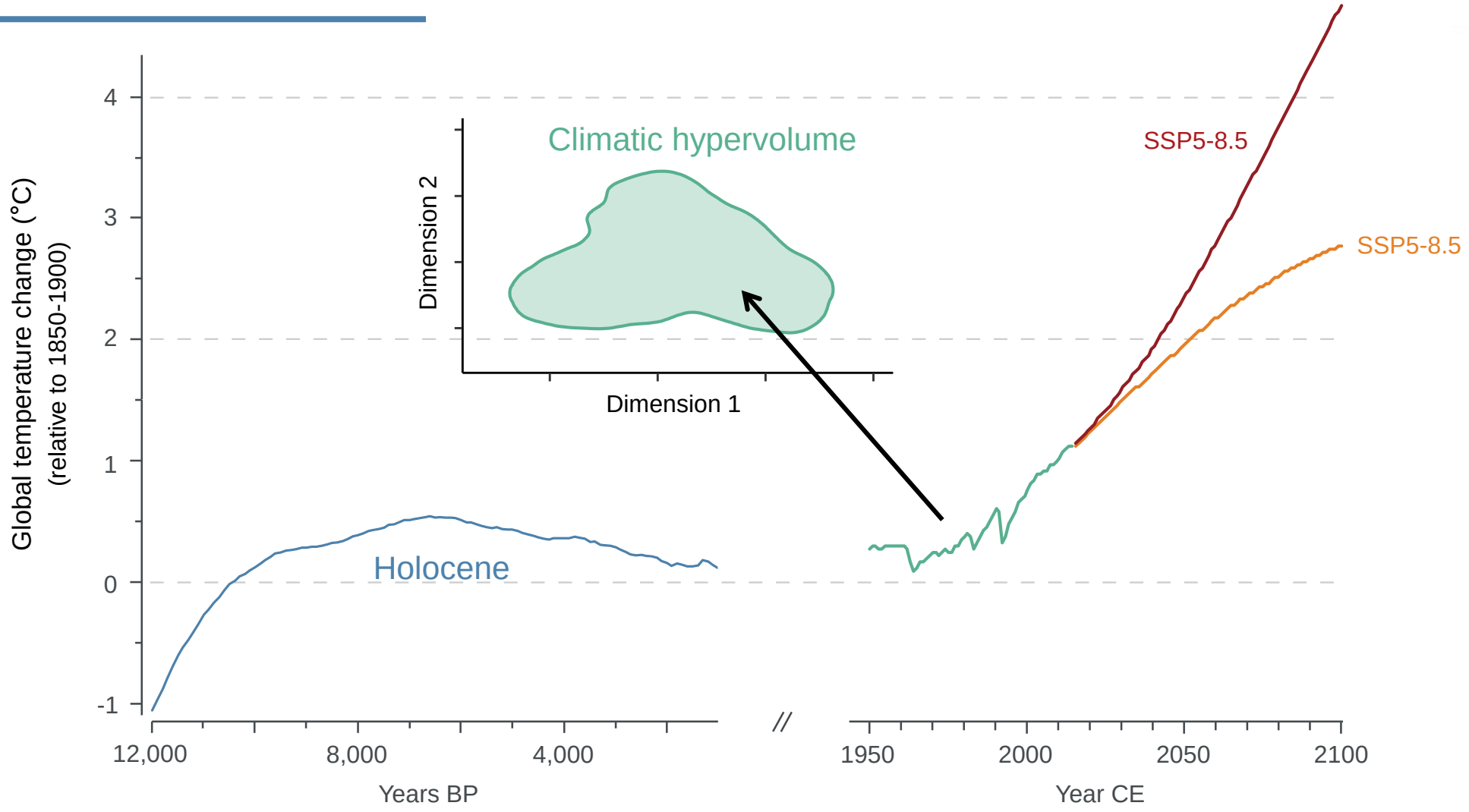
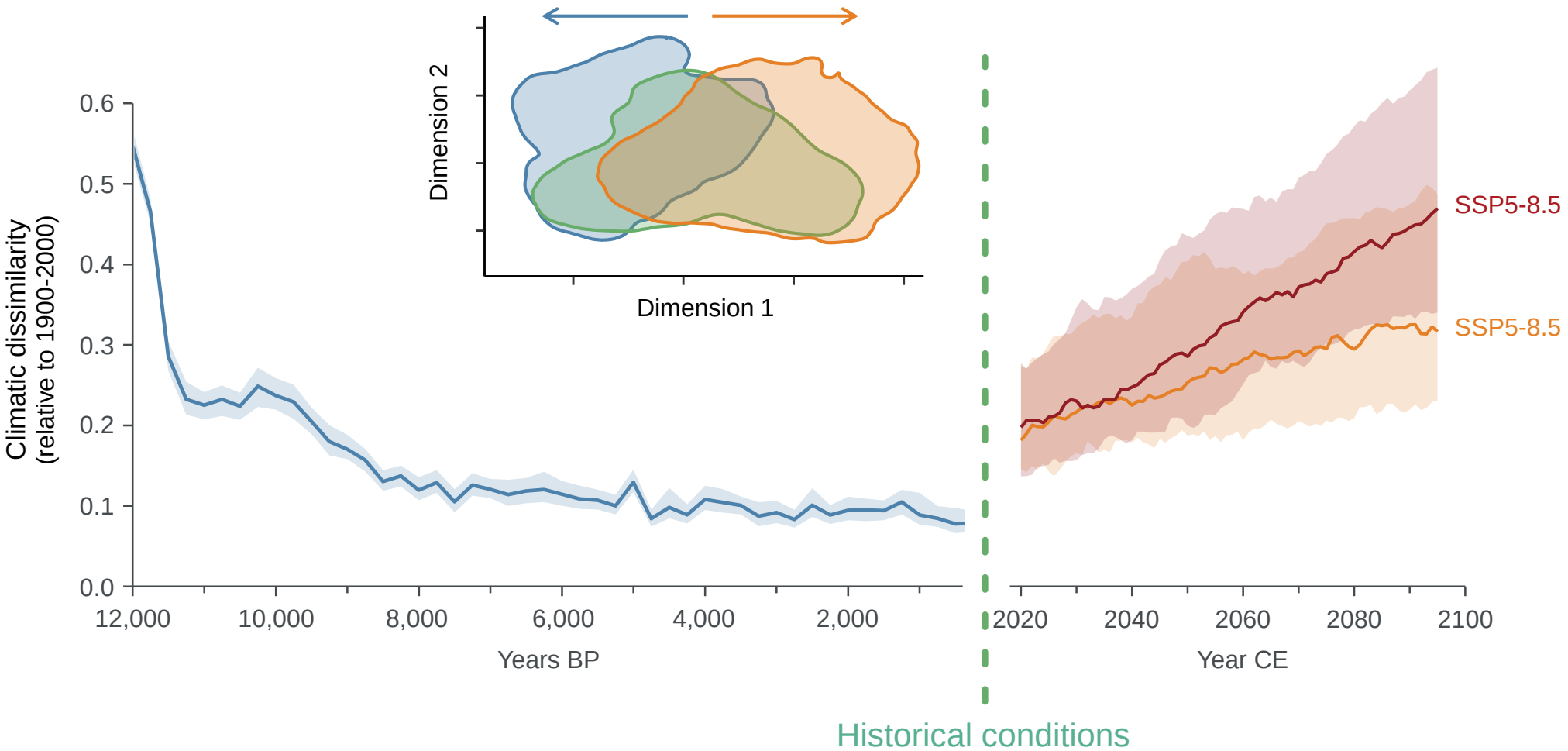
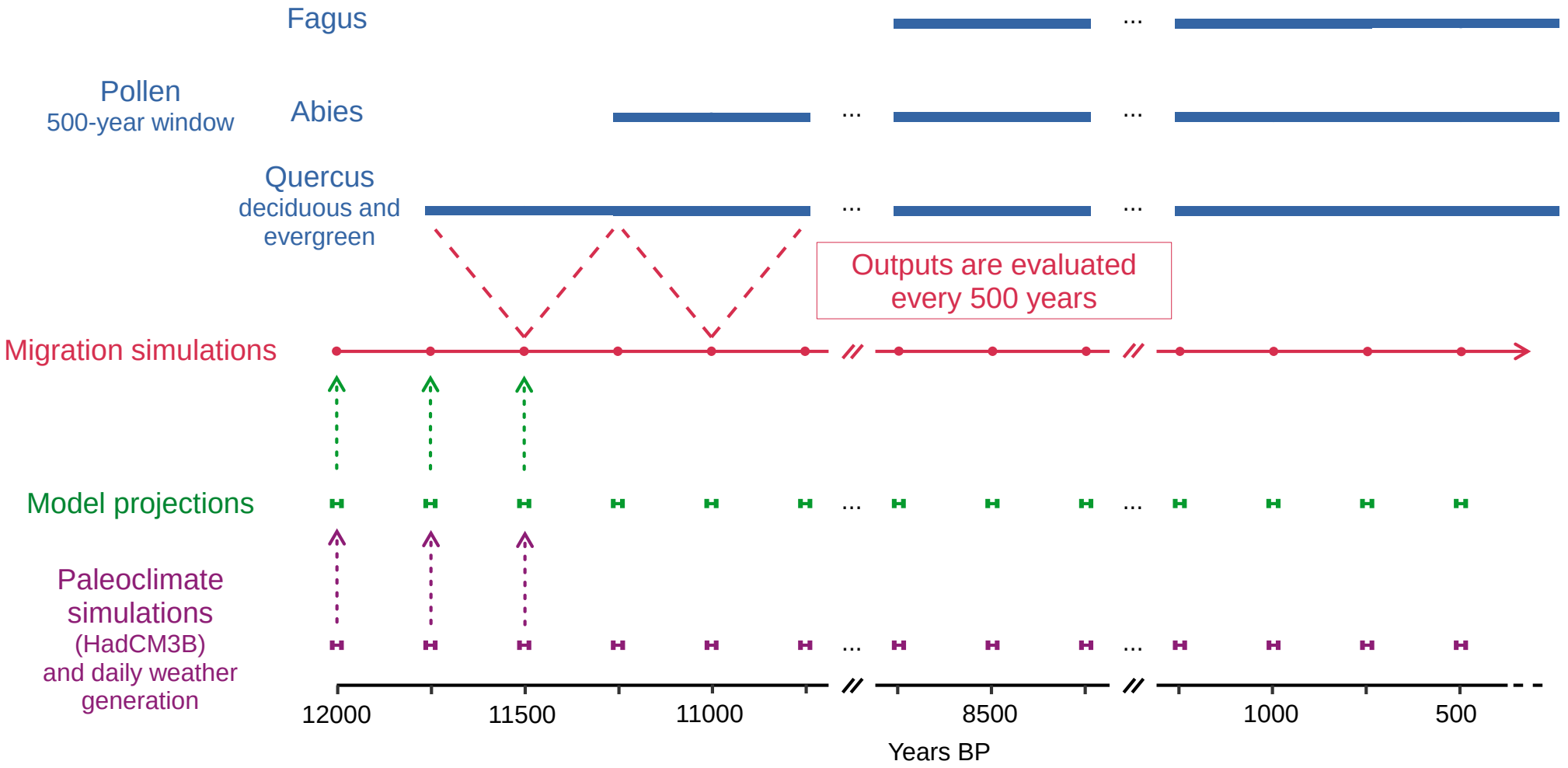


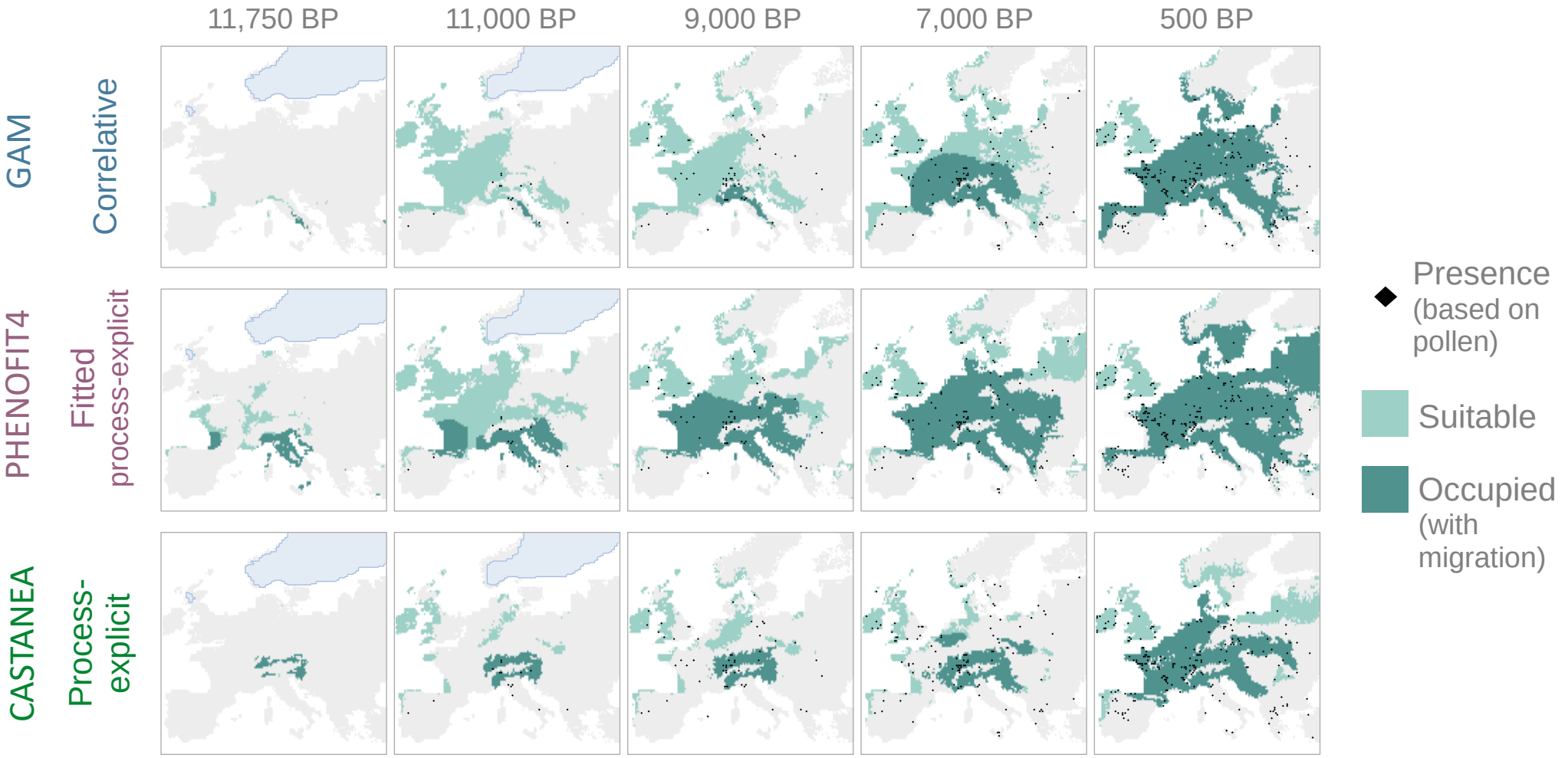
Evaluation of models in dissimilar climates



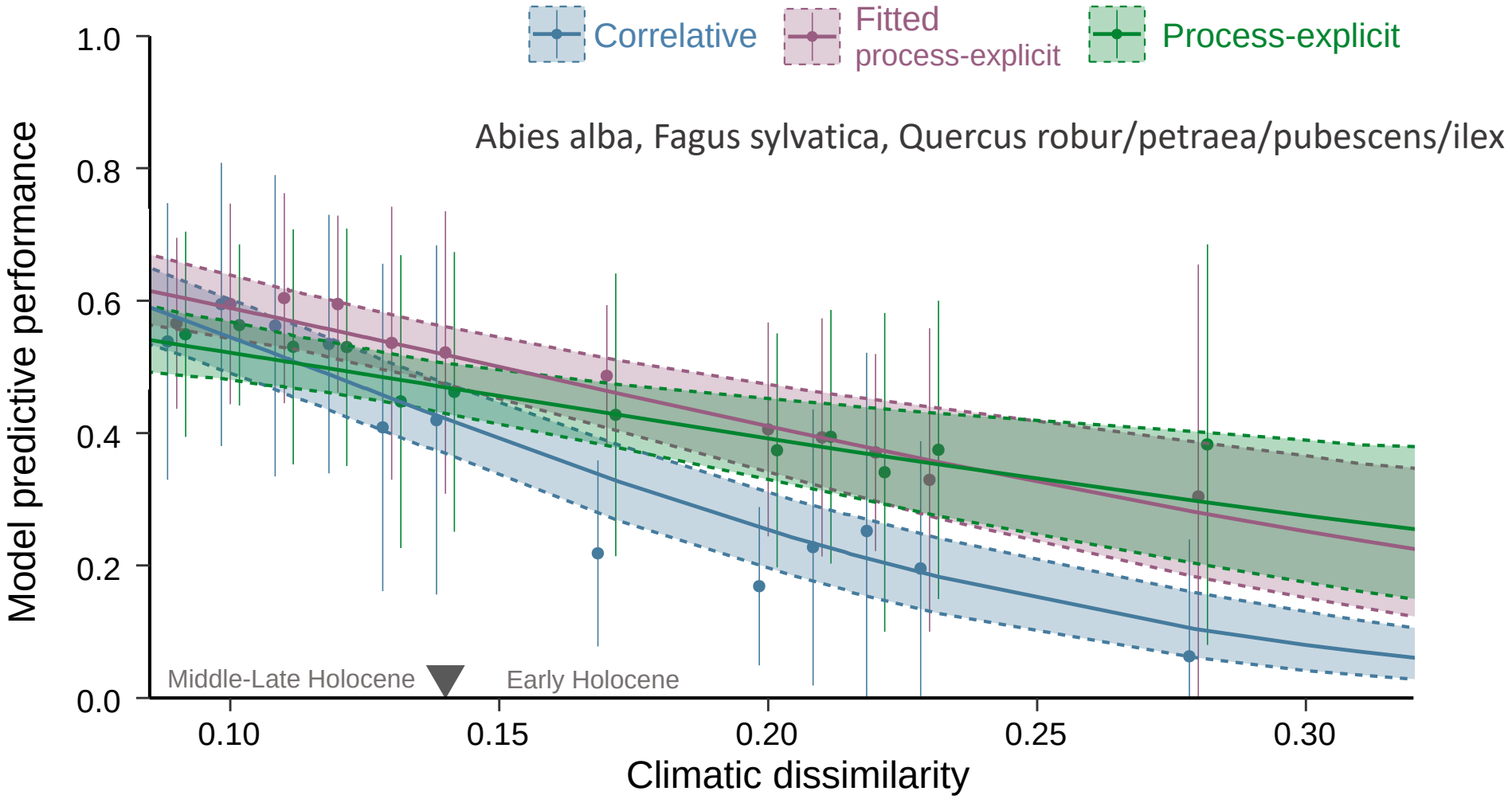
Model evaluation framework



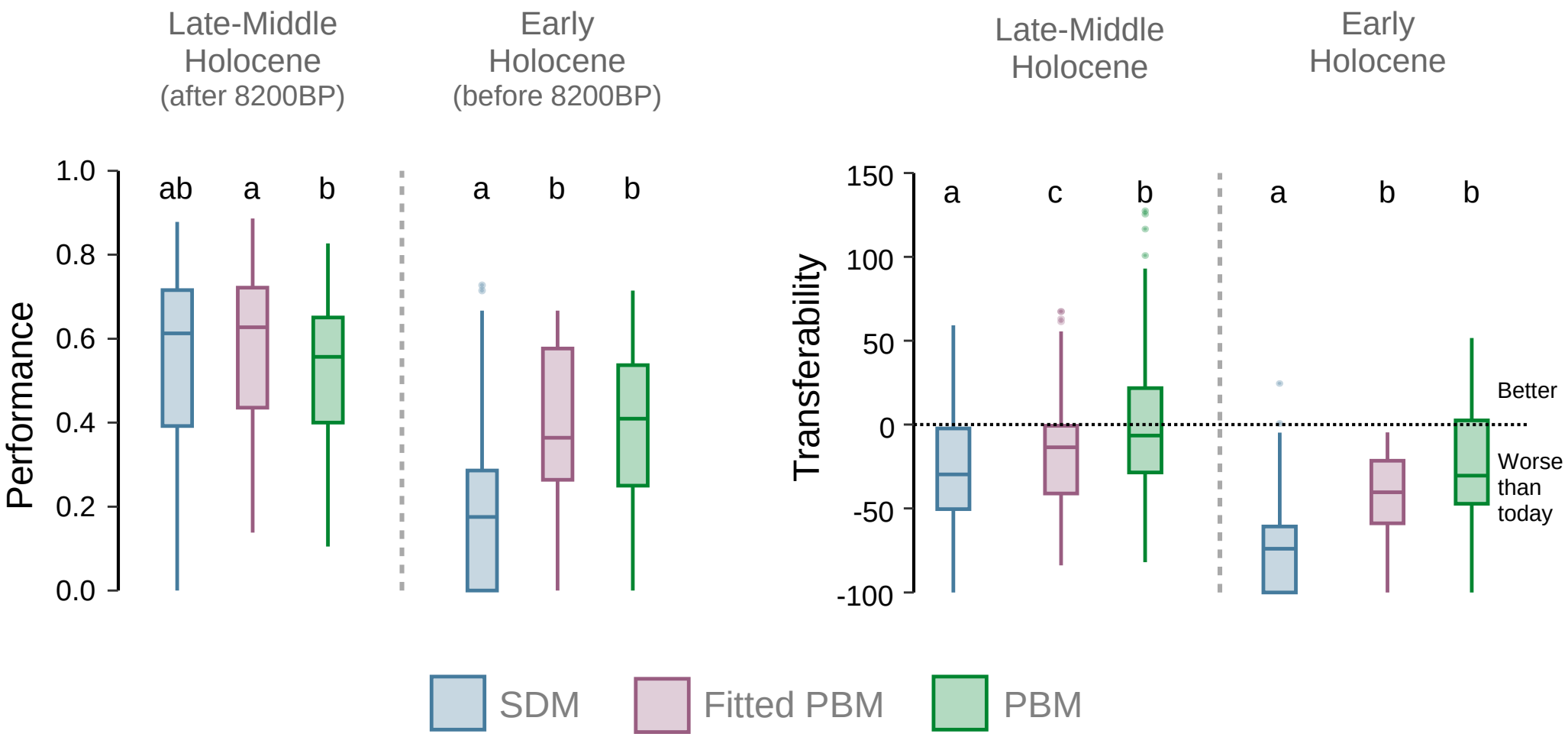
Example of deciduous *Quercus* paleosimulations



Decrease of model performance in the past



The higher transferability of process-explicit models



Mechanisms, not calibration method, convey model robustness

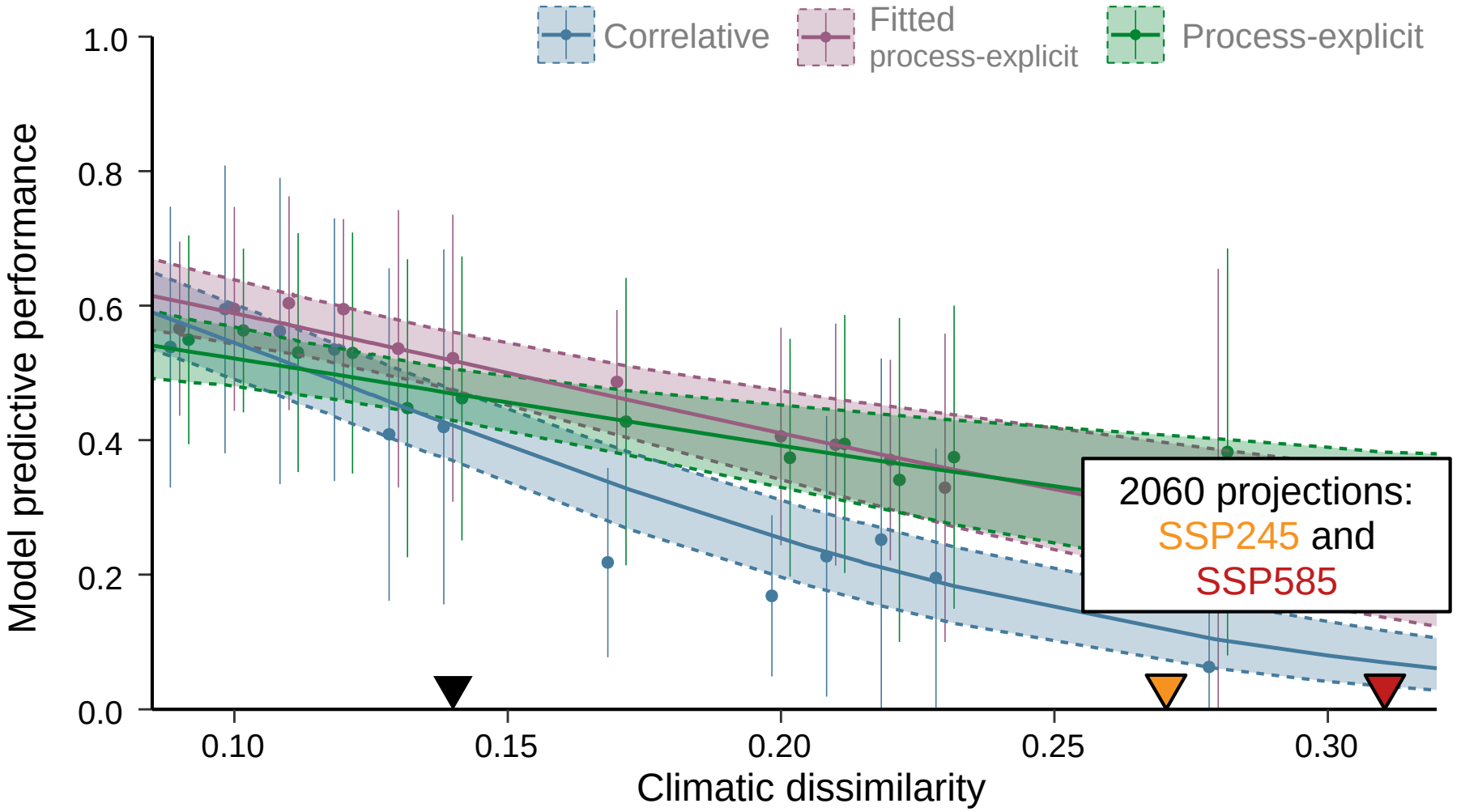
- Process-explicit models less affected by the increase in climatic dissimilarity
- Fitted process-explicit models similar to classical process-explicit models

Biological mechanisms embedded into process-explicit models

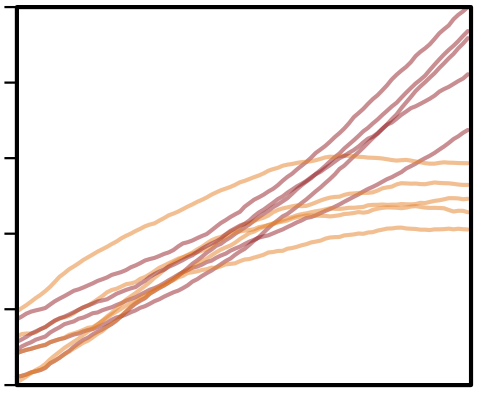
=

a real advantage over the empirical relationships used in correlative models

A new avenue to increase model projection reliability in the future



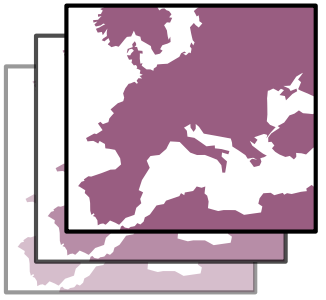
Sources of projection uncertainties



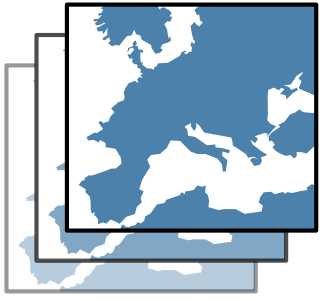
Climate projections

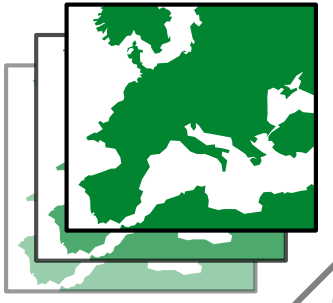
GCMs

SSPs



Models

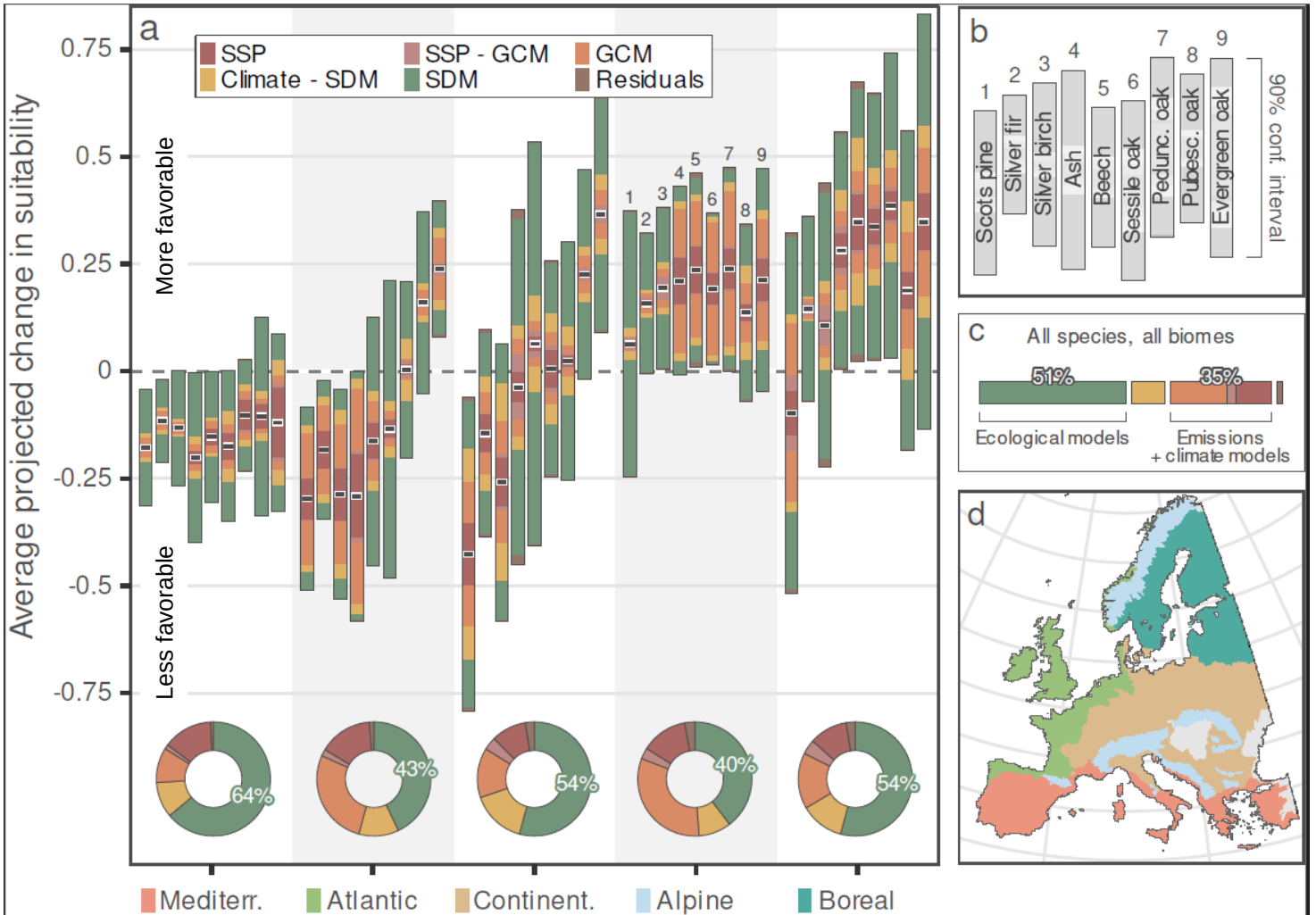




Species

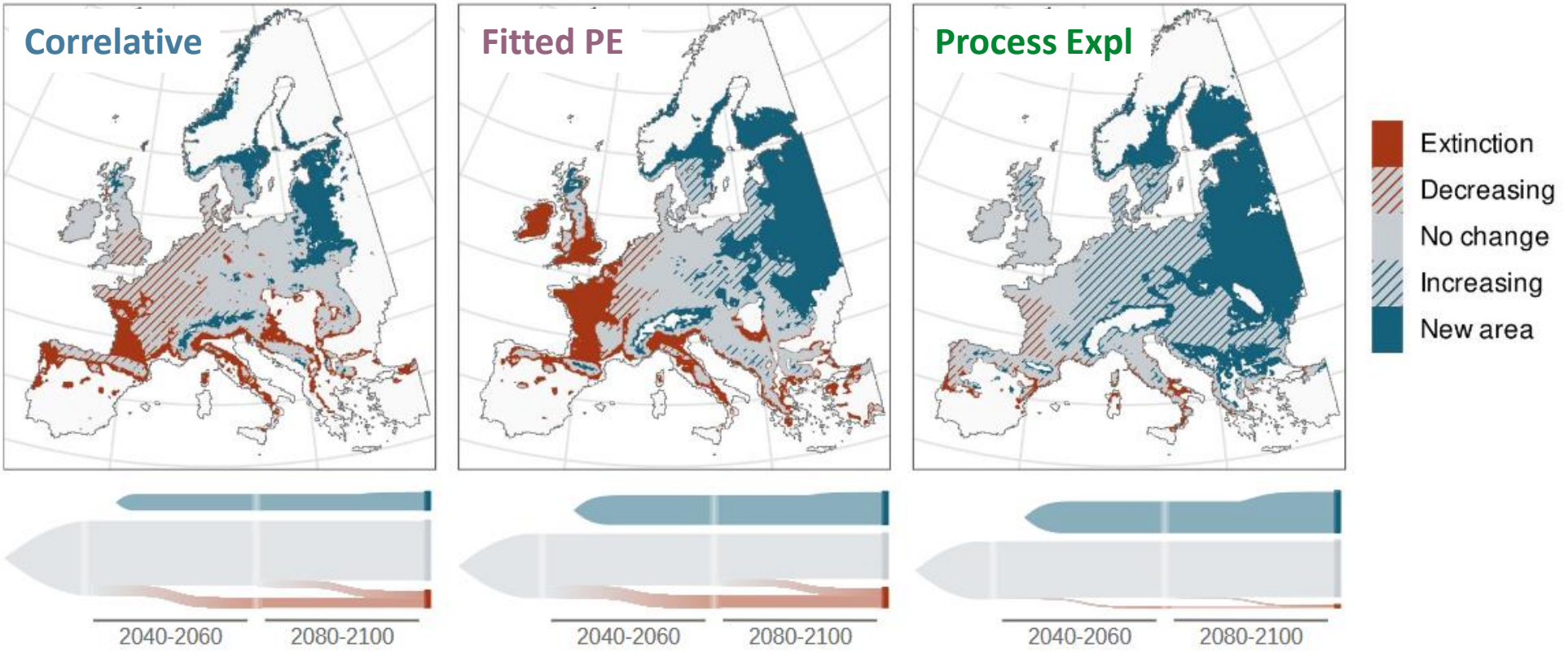
ANOVA-based
variance decomposition

Modeling approaches are the main source of uncertainty

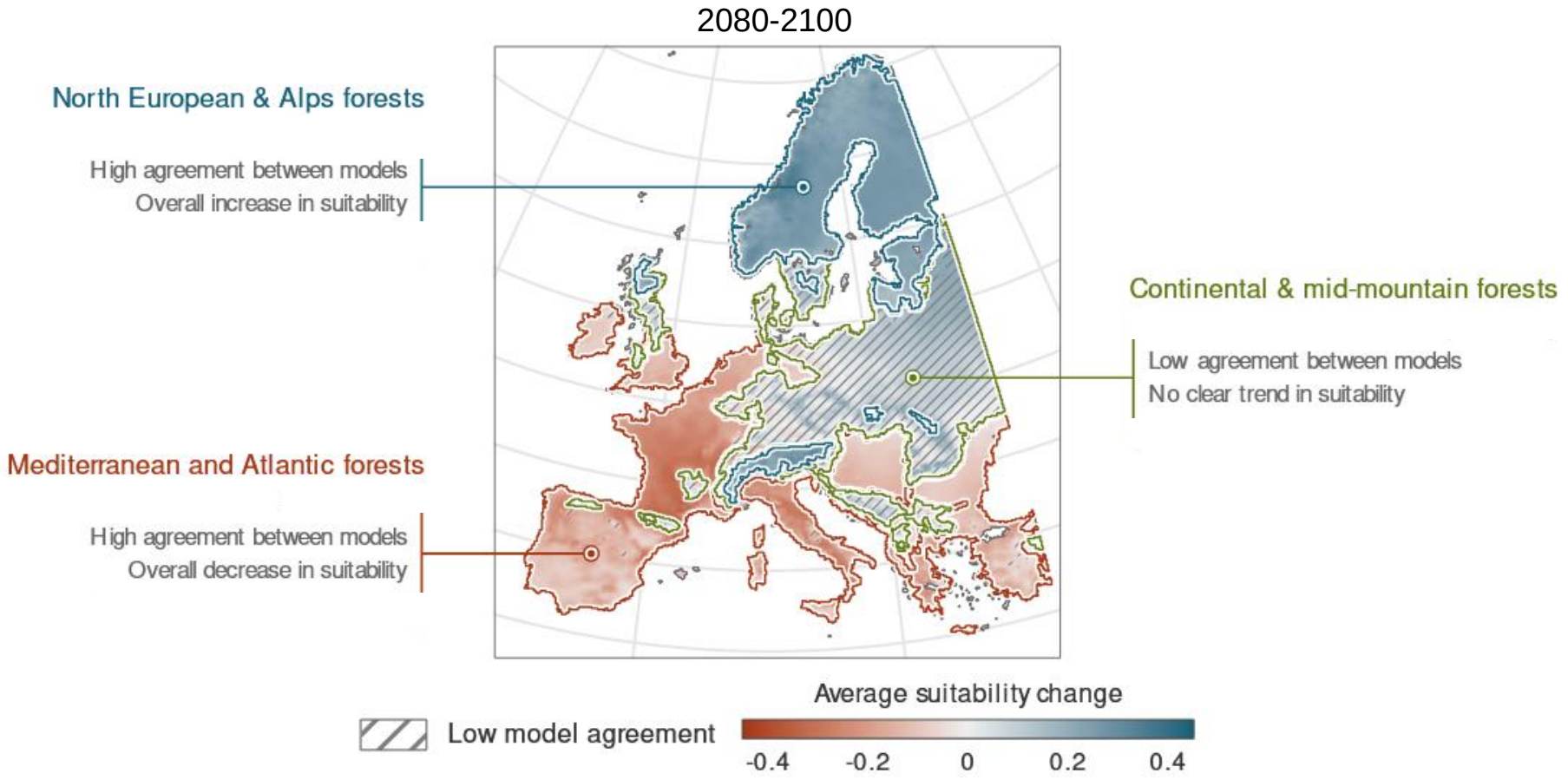


Modeling approaches are the main source of uncertainty

Uncertainty in beech distribution change



Which levers of action to address future climate risks?



Thank you for your attention!

Thanks to

- Hendrik Davi
- Florent Mouillot
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Van der Meersch V., E. Armstrong, F. Mouillot, A. Duputié, H. Davi, F. Saltré & I. Chuine (2025) Ecology Letters 28(2) e70080 https://doi.org/10.1111/ele.70080