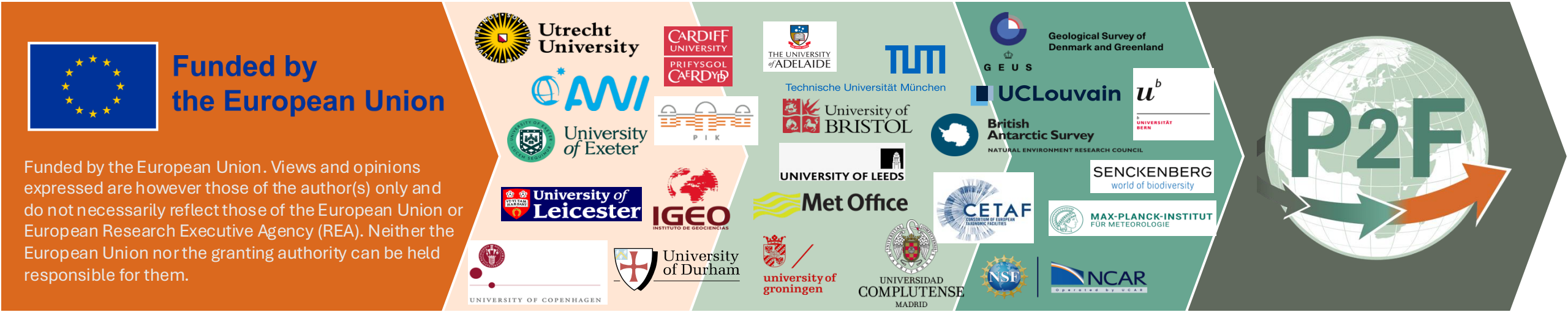
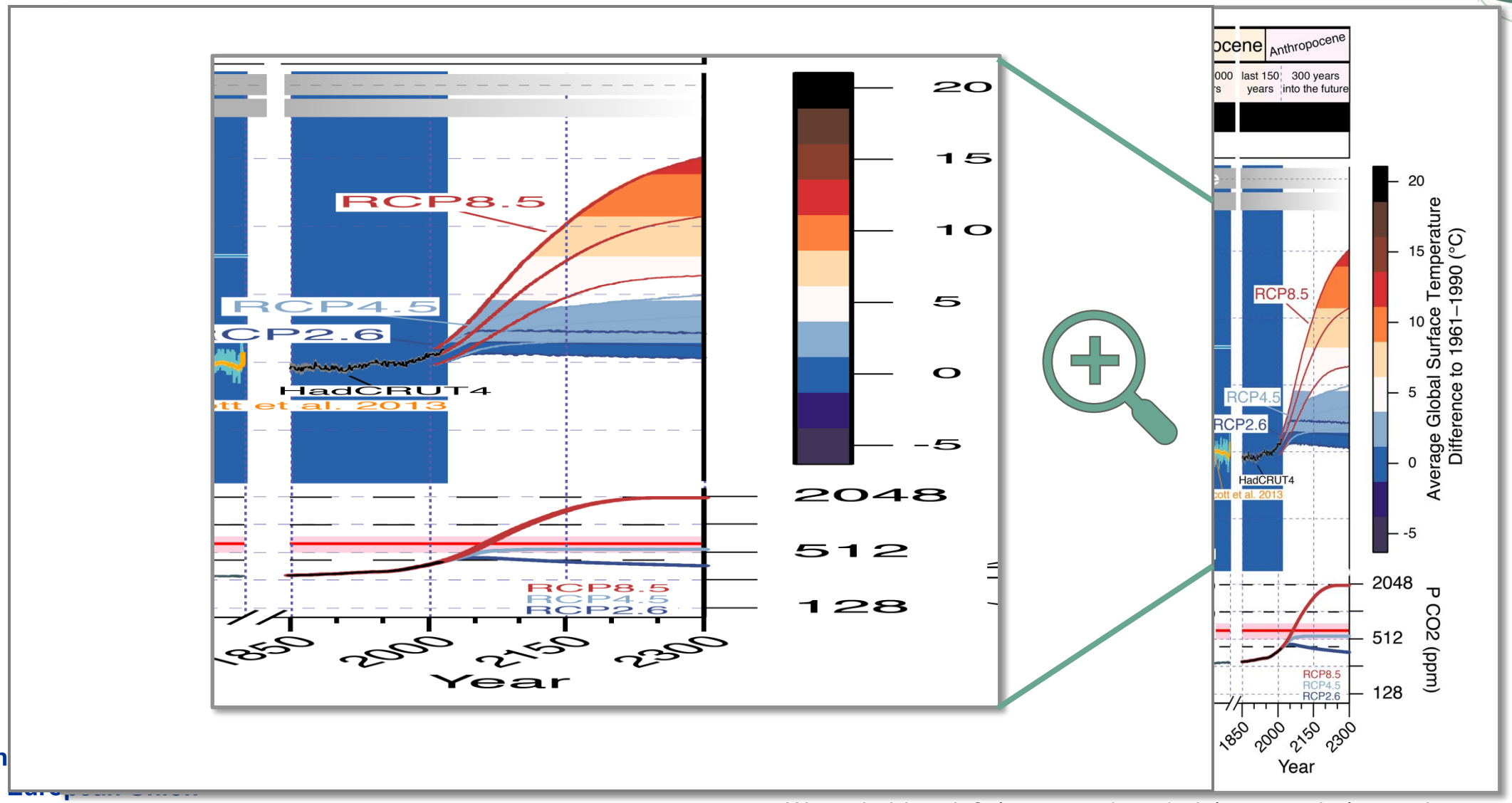
Past to future: Towards fully paleo-informed future climate projections

Anna von der Heydt

Grant Agreement Number: 101184070



Heading towards a climate state not been observed by (human-made) measurements before



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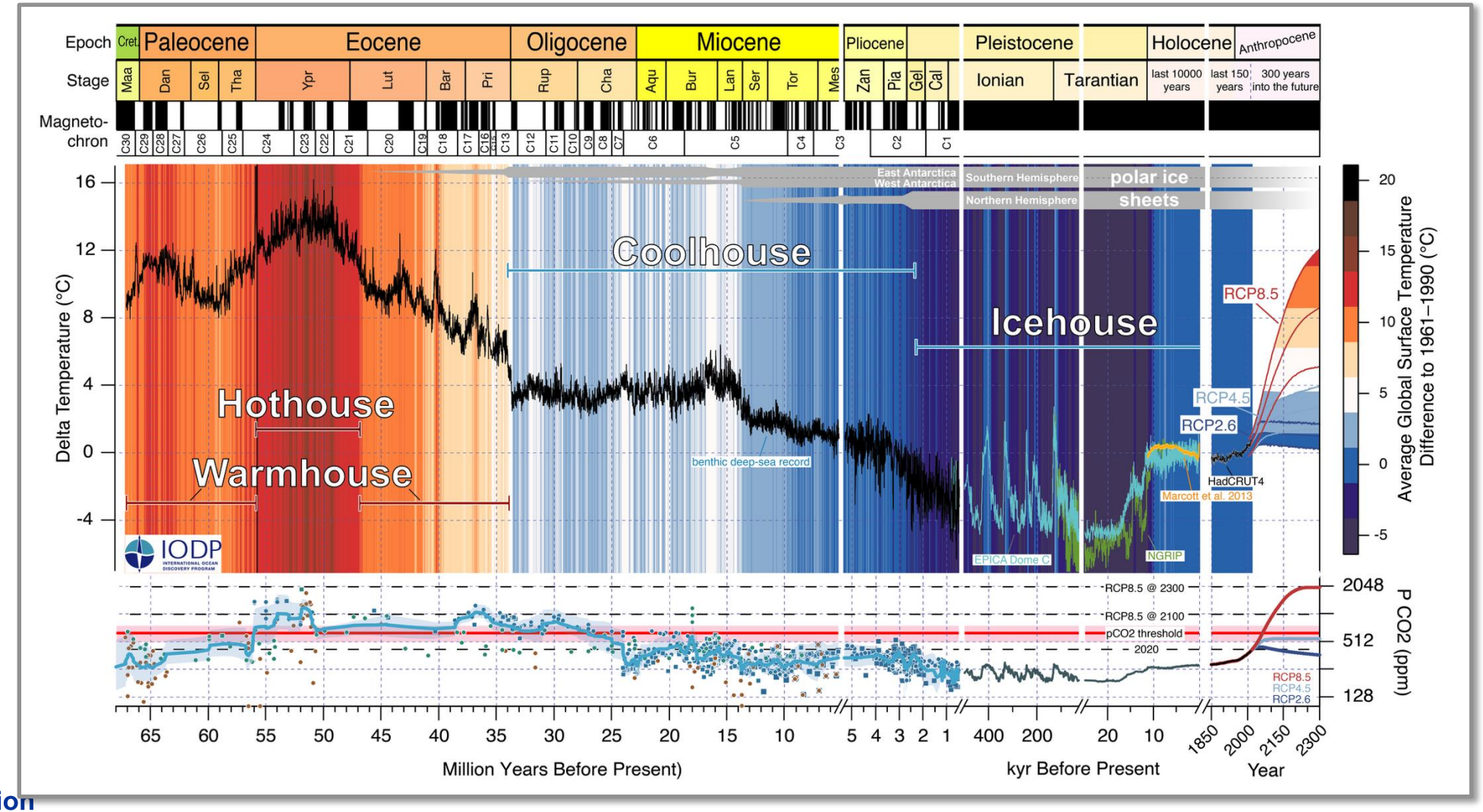
Westerhold et al. Science **369** (2020), doi:10.1126/science.aba6853

Challenge: transform knowledge on past processes into future projections for the Earth system



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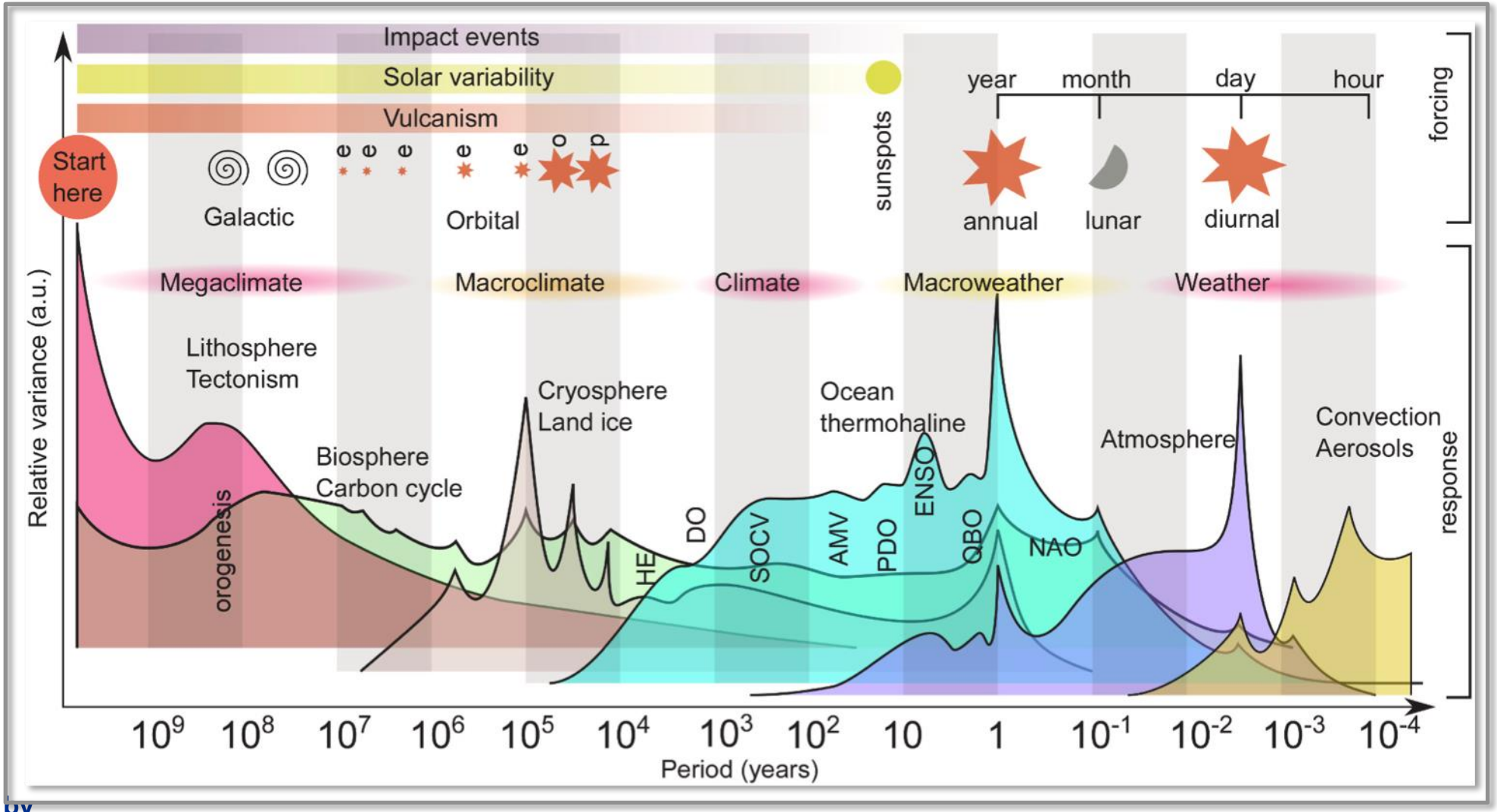
Westerhold et al. Science **369** (2020), doi:10.1126/science.aba6853

The climate variability spectrum



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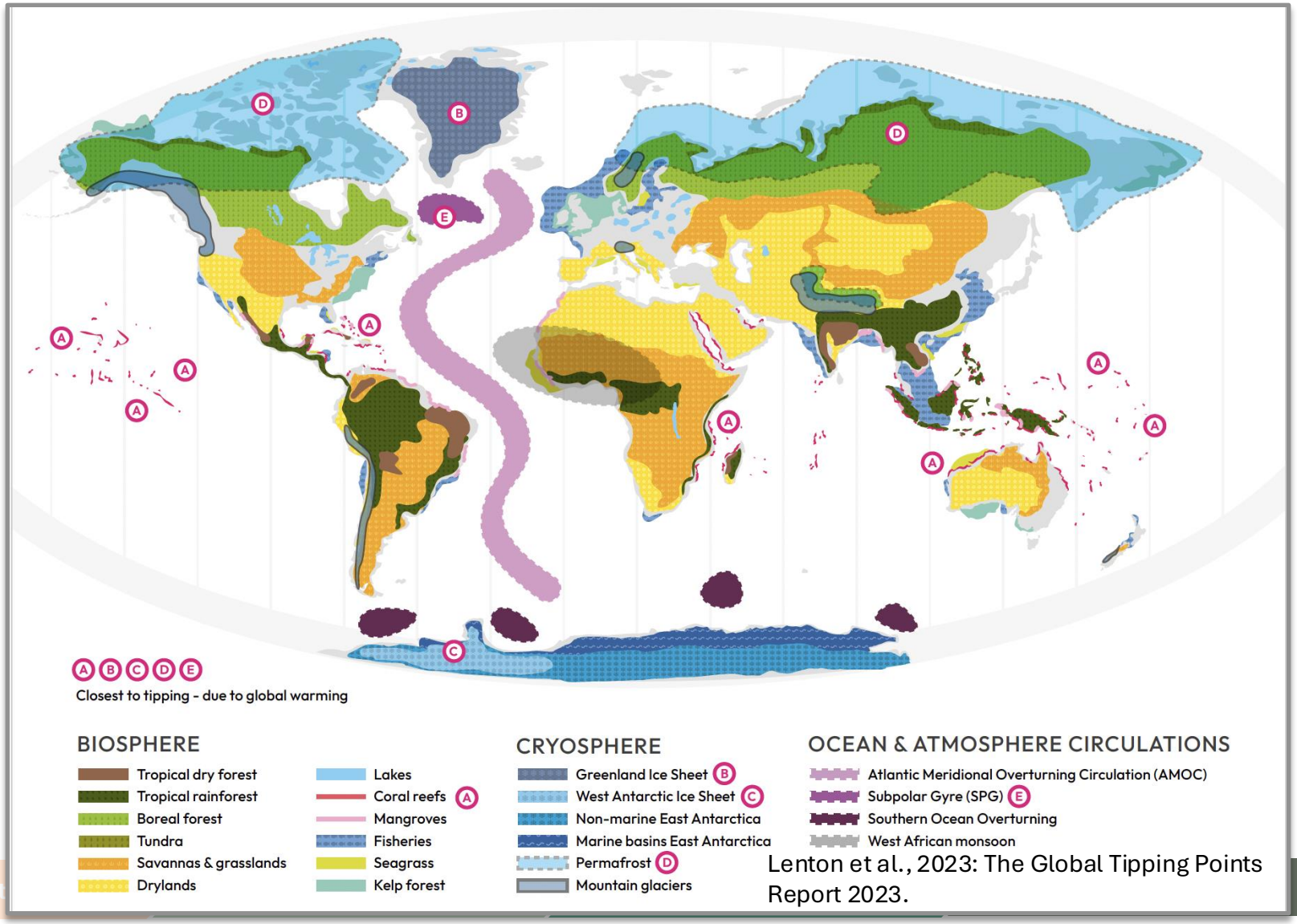
von der Heydt et al. Global and Planetary Change (2021), doi: 10.1016/j.gloplacha.2020.103399

Challenge: transform knowledge on past processes into future projections for the Earth system

Tipping points in the climate system

- Relevant for societies: regional scale
- Extreme events, variability
- Abrupt changes
- Cascading impacts or tipping



Lenton et al., 2023: The Global Tipping Points Report 2023.

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Solution part 1: Evaluate and improve Earth System Models through paleoclimate constraints

- Model development of CMIP-class comprehensive Earth System models (cESMs)
- Snapshot simulations and model-data comparison with cESMs
- “Grand Challenge” of tuning cESMs to paleo-time slices

- Development and improvement of fast Earth System models (fESMs)
- Constrain long-term climate change, variability, and interactions between climate components with fESMs

Future simulations with improved paleo-informed ESMs (fast and comprehensive)

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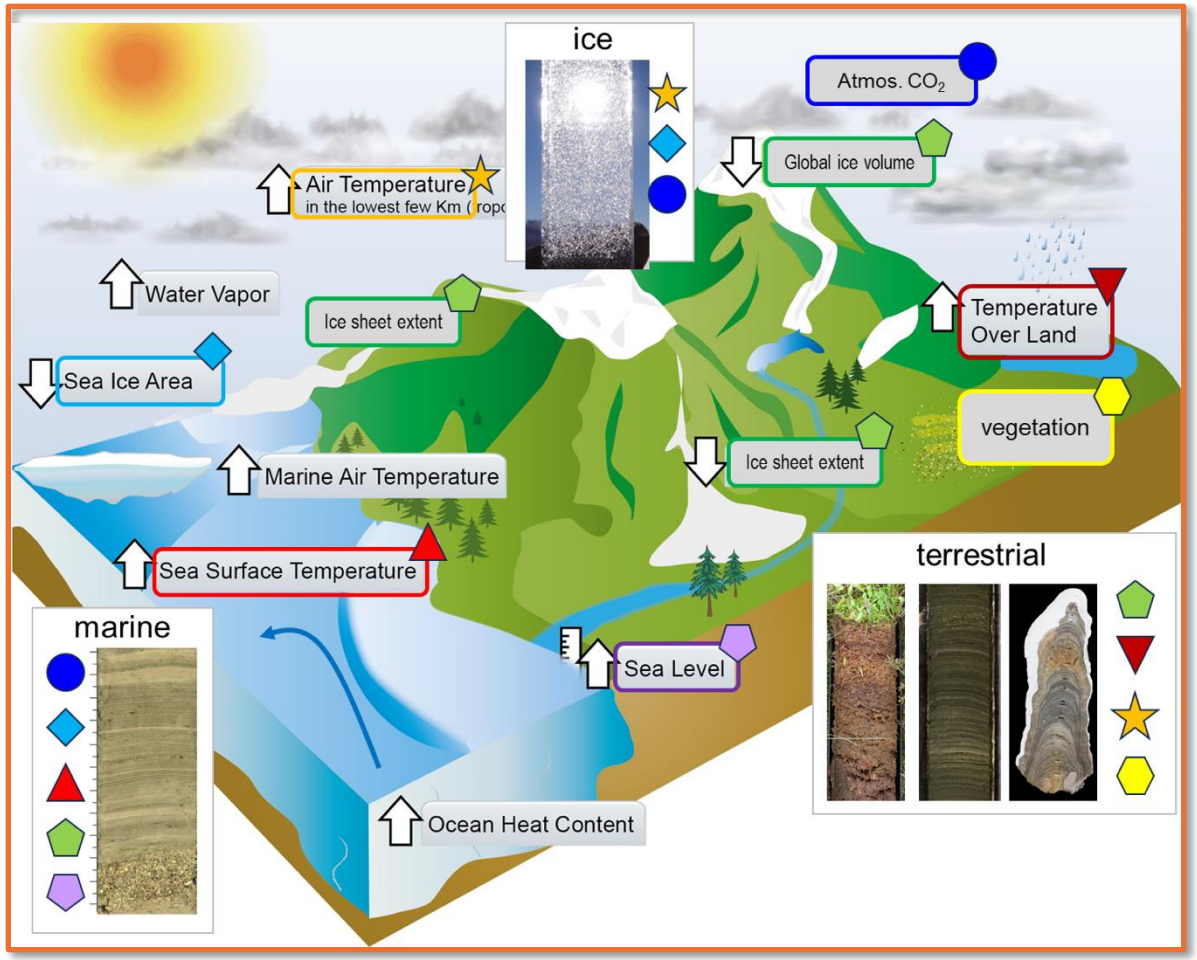
Solution part 2: Integrate and re-evaluate paleoclimate data and add key paleo-proxy reconstructions to key sites and time intervals

- Ice core, terrestrial and marine records
- Extend instrumental time series into both colder and warmer-than-modern climate states
  - Late Pleistocene (~low CO_2 climate)
  - Pliocene (~high CO_2 climate)
- Deep sea temperature and global sea level reconstructions
- Defining the states and variability of
  - the carbon cycle,
  - the terrestrial cryosphere,
  - sea ice,
  - the surface ocean,
  - the terrestrial biosphere.



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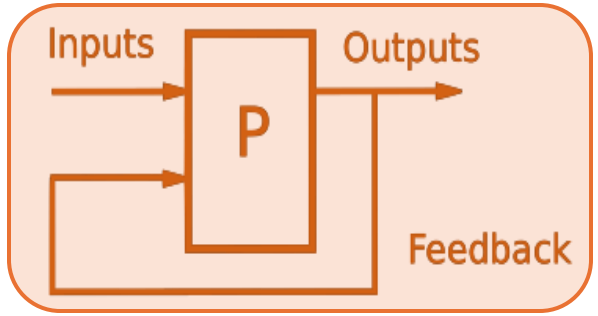
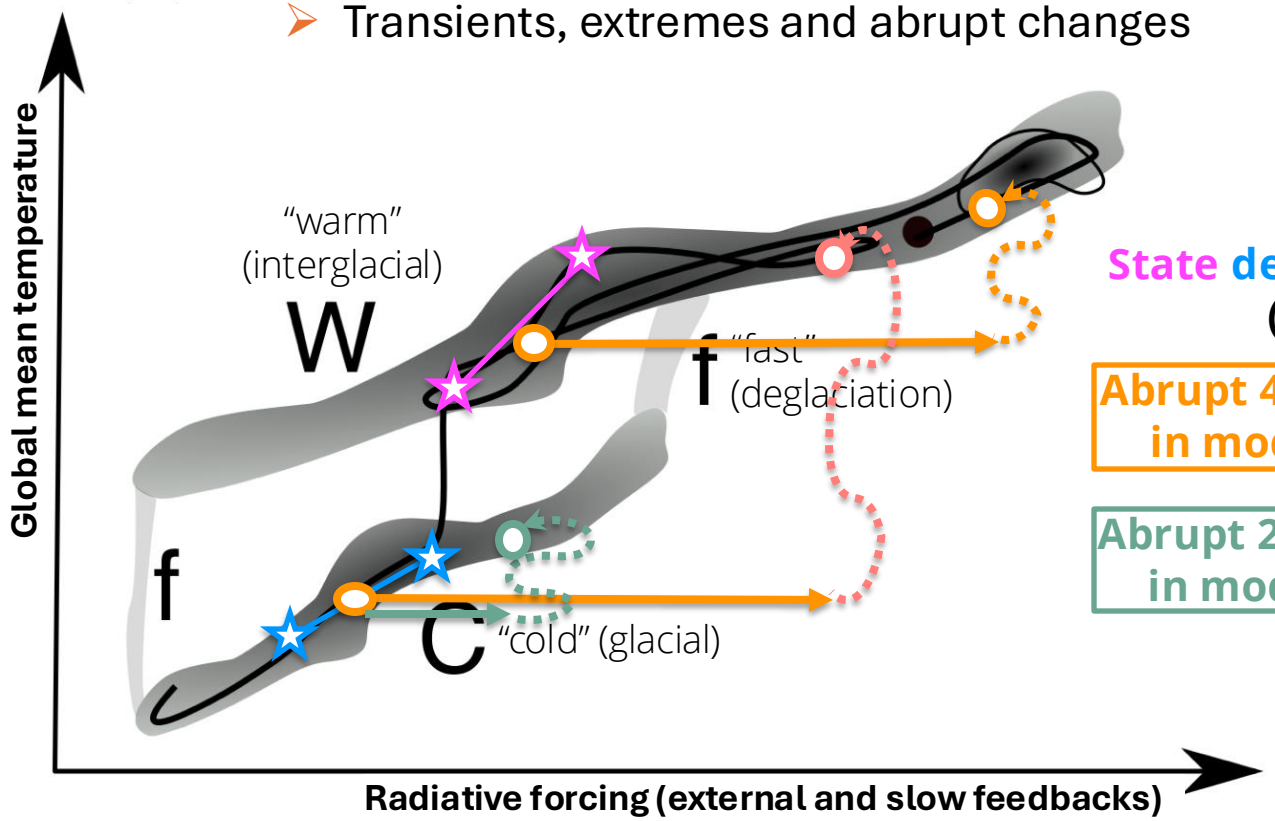
Solution part 3: Improve methods - response theory, patterns of natural variability and tipping behaviour

develop new tools for analysis of model output or data, model validation and tuning, & testable methods that underpin faster and more accurate climate projections.

- Climate response, feedbacks and environmental limits
- Spatial patterns, long-term variability and process interaction
- Transients, extremes and abrupt changes





State dependence of feedbacks (non-constant λ)

Abrupt 4xCO_2 in model

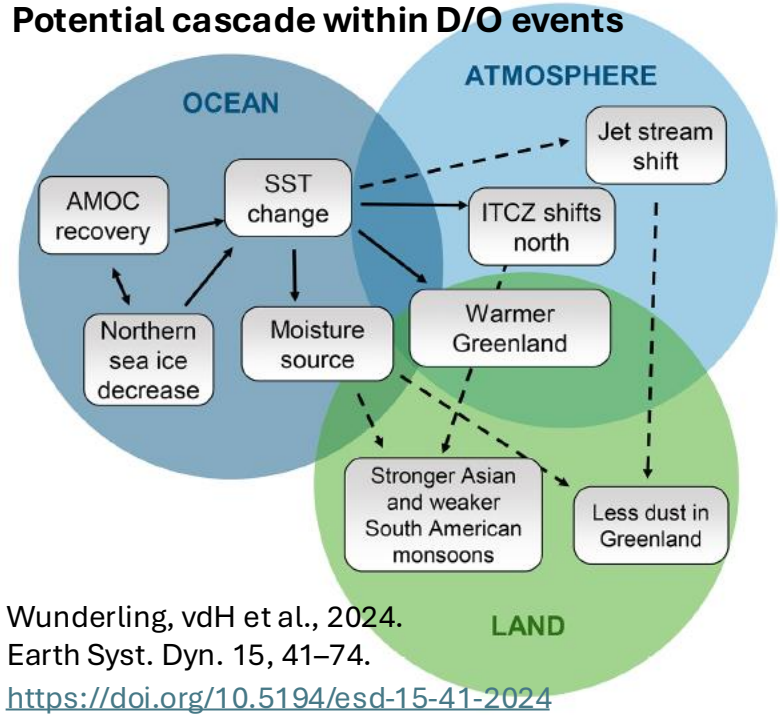
Abrupt 2xCO_2 in model

von der Heydt & Ashwin, Dyn. Stat. Clim. Syst. 1 (2016)
DOI: 10.1093/climsys/dzx001

Solution part 4: Learn about both likely and possible regional impacts and local effects of large-scale climate on ecosystems, carbon cycle and societies

- Bias correction and downscaling of ESM simulations to a scale of a few kilometres for impact analysis
- Impact of climate trends, variability and abrupt changes on the terrestrial biosphere
- Cascading impacts of abrupt warming events and extremes on carbon cycle and ecosystems (B/A onset, Holocene)
- Climate impact on past societies

Potential cascade within D/O events



Wunderling, vdH et al., 2024. Earth Syst. Dyn. 15, 41–74. https://doi.org/10.5194/esd-15-41-2024

Archaeological data and modelling

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PAST TO FUTURE: TOWARDS FULLY PALEO-INFORMED FUTURE CLIMATE PROJECTIONS

Fact Sheet

Project description

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Paleoenvironmental data to improve climate change predictions

Project Information

P2F

Grant agreement ID: 101184070

DOI

10.3030/101184070

Grant Agreement Number: 101184070

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