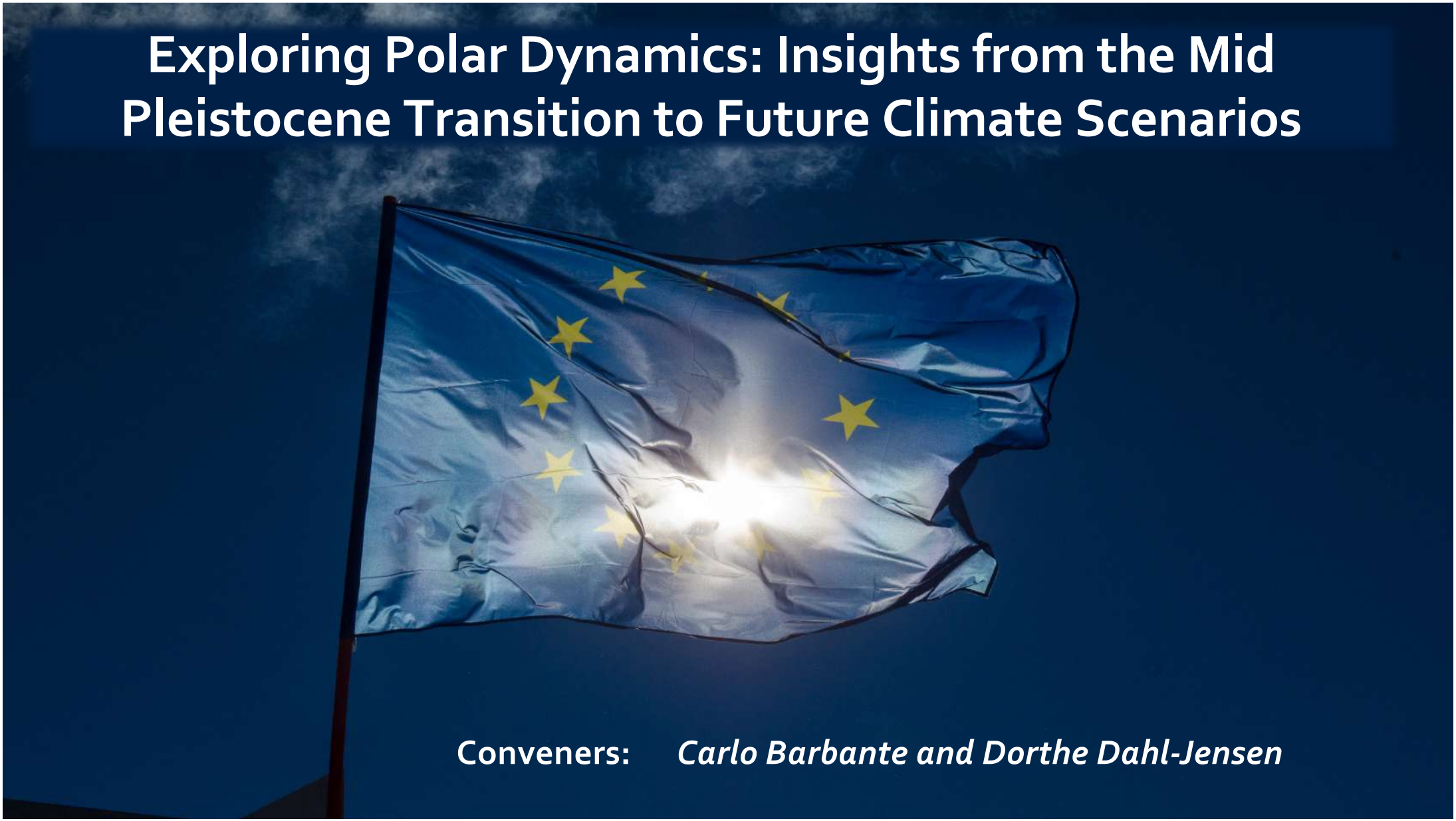
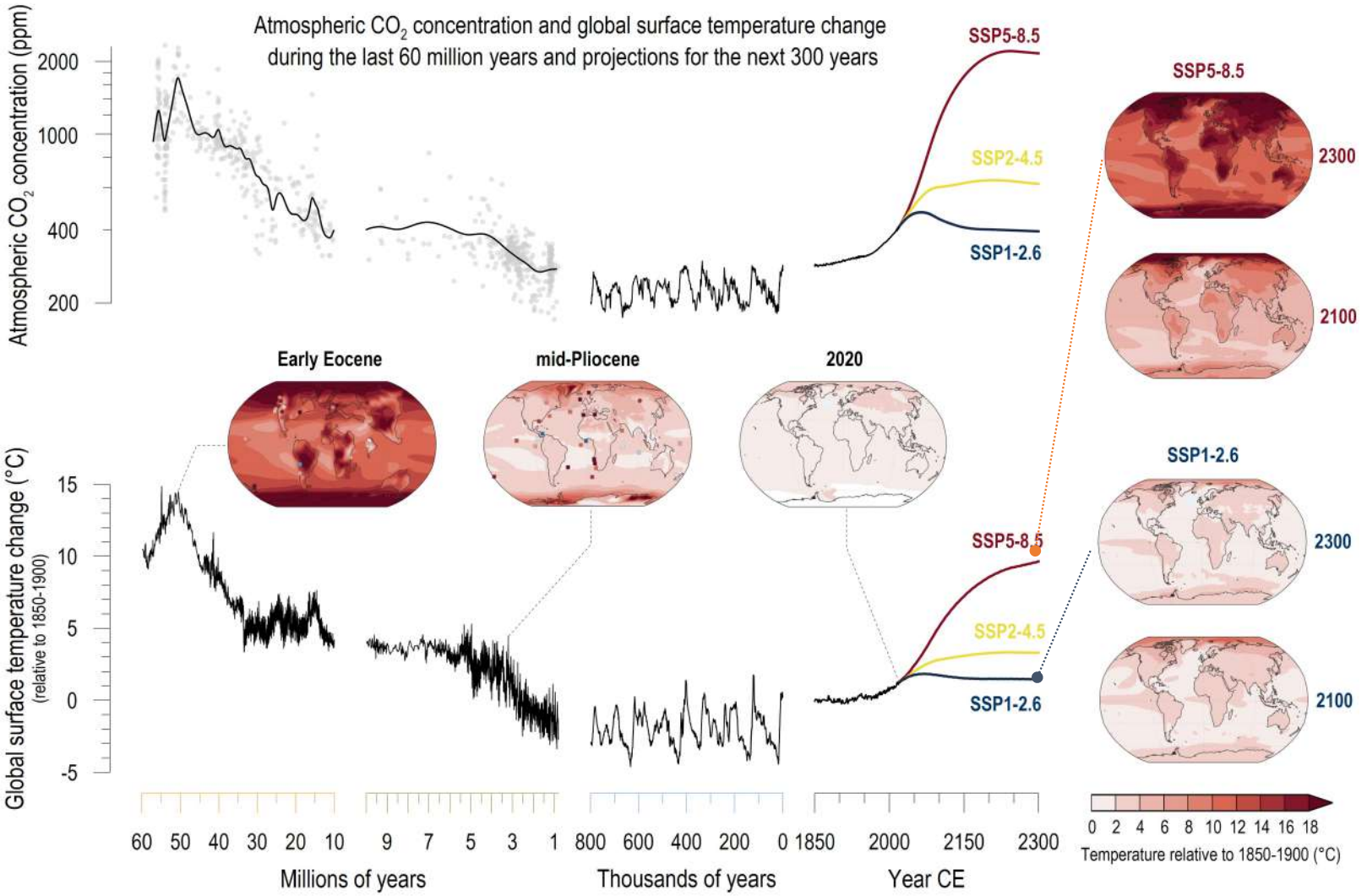
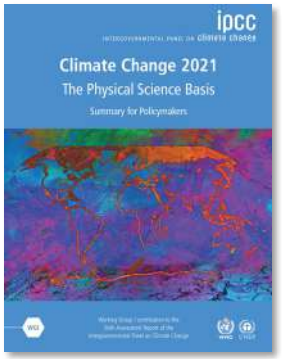
Exploring Polar Dynamics: Insights from the Mid Pleistocene Transition to Future Climate Scenarios



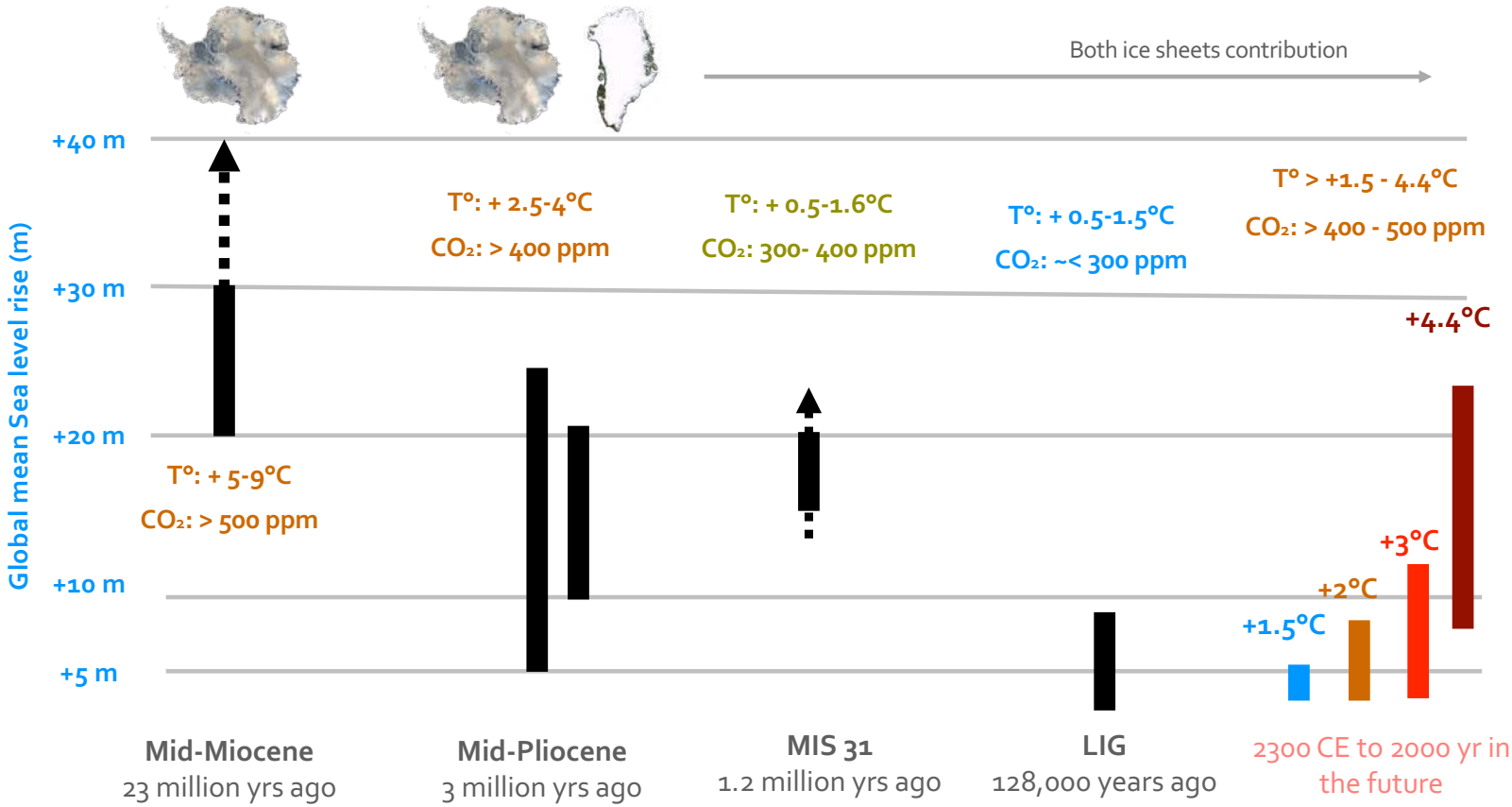
Conveners: *Carlo Barbante and Dorthe Dahl-Jensen*





IPCC 2021, WGI Fig. TS.1

Paleo data show: this is no science fiction !



After Colleoni et al. (2022)

Main objectives of the session

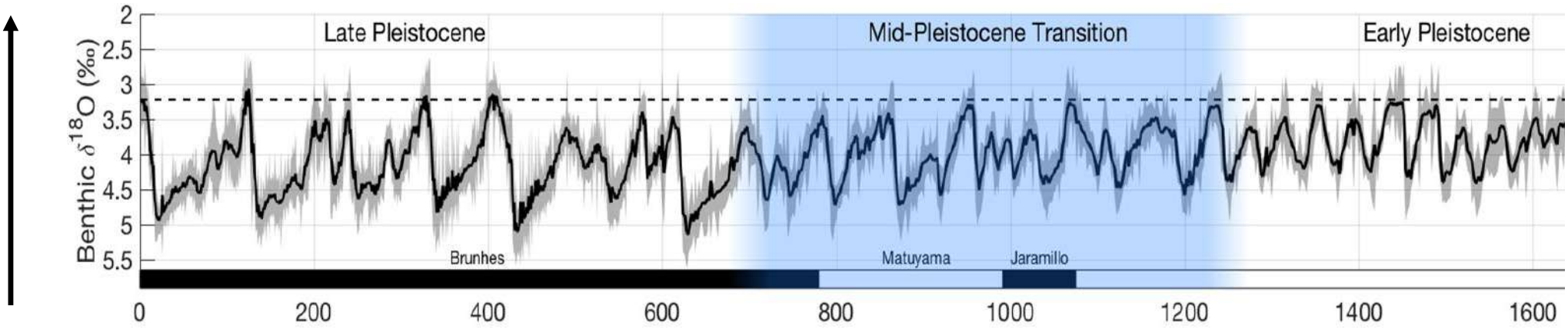
- Investigation of the intricate dynamics shaping the polar regions, from the enigmatic transitions of the past to the pressing challenges of the future
- Analysis of the Mid Pleistocene Transition, the evolution of the polar ice sheets, and the complex interplay of carbon dioxide and biogeochemical cycles in polar environments
- Understanding the mechanisms driving this transition, providing invaluable insights into the sensitivity of Earth's climate system to external forcings and internal feedbacks
- Improving our observational capacity of the past, enhancing the basic understanding of the drivers and processes governing those changes, and translating knowledge into solutions for society

The MPT in Proxy Archives

Warmer,
less ice

«100 ka world»

«40 ka world»



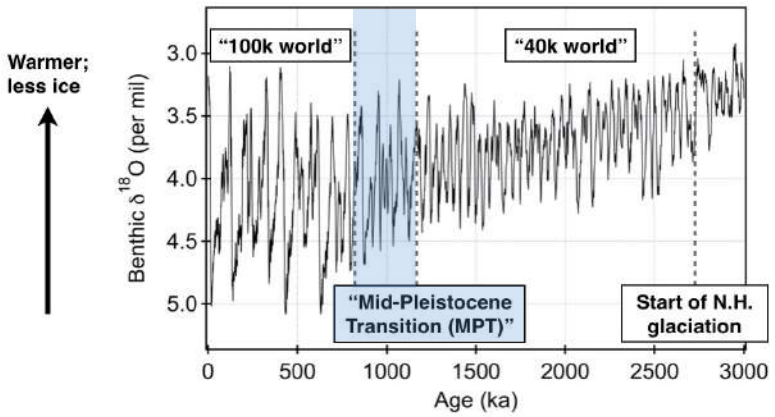
Time (kyr ago)

Climate evolution over the past 1.6 Ma recorded in the oxygen isotope compositions of benthic foraminifera shells [data from Lisiecki and Raymo, 2005]

Berends et al. (2021)

The Mid Pleistocene Transition (MPT)

MPT is a fundamental change in the behaviour of glacial cycles during the Quaternary glaciations. The transition happened approximately 1.25 – 0.7 million years ago. **Before the MPT**, the glacial cycles were dominated by a 41,000-year periodicity with low-amplitude, thin ice sheets and a linear relationship to the Milankovitch forcing from axial tilt.



After the MPT there have been strongly asymmetric cycles with long-duration cooling of the climate and build-up of thick ice sheets, followed by a fast change from extreme glacial conditions to a warm interglacial. The cycle lengths have varied, with an average length of approximately 100,000 years.

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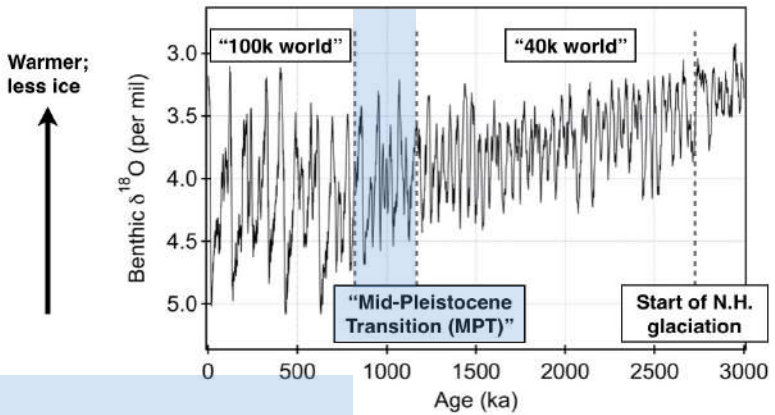
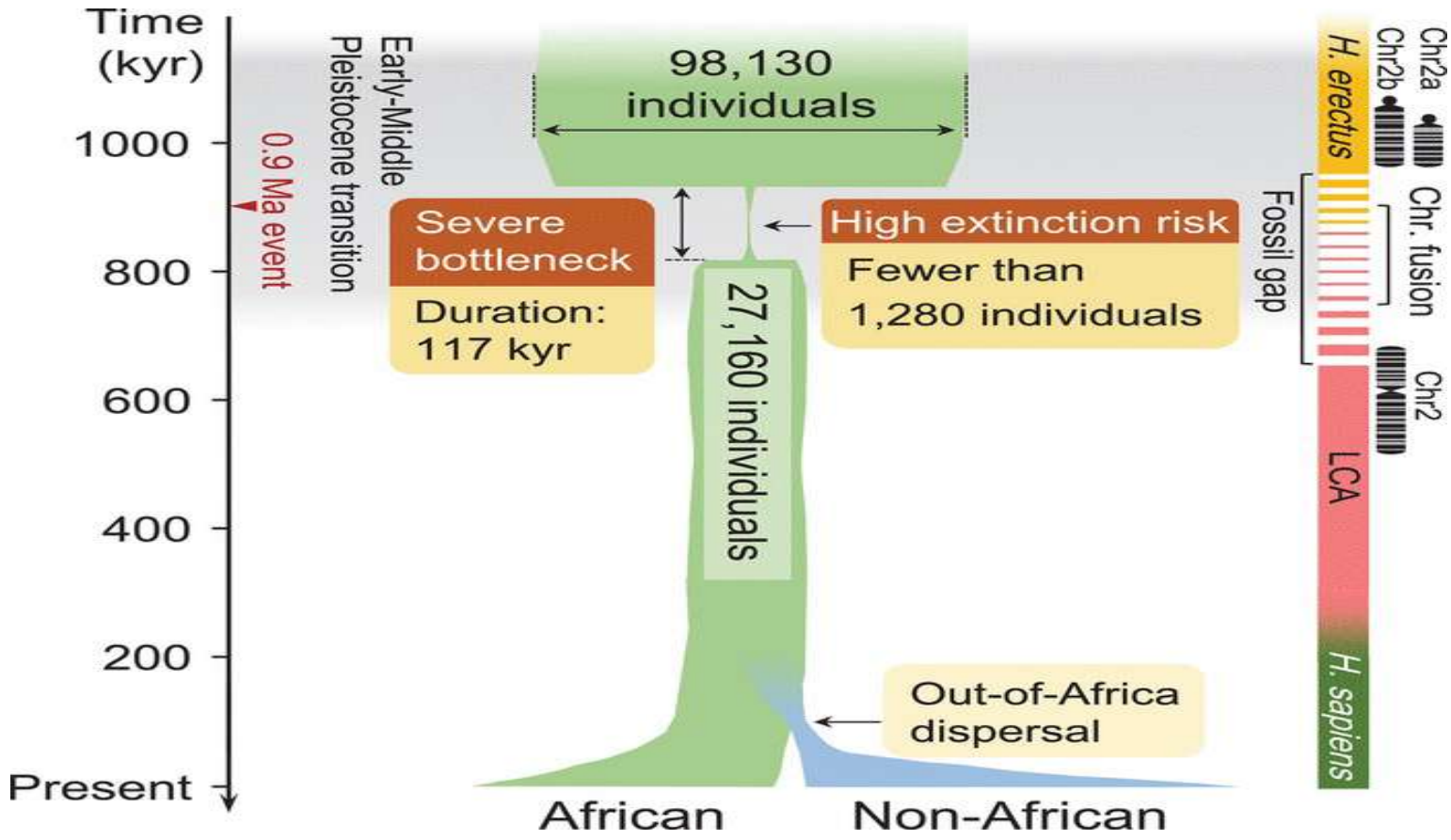


These findings gave rise to two main questions:

1. How can ~100 kyr glacial cycles occur in a world forced by insolation changes with only a very small 100 kyr term and much larger term for 20 and 40 kyr terms?

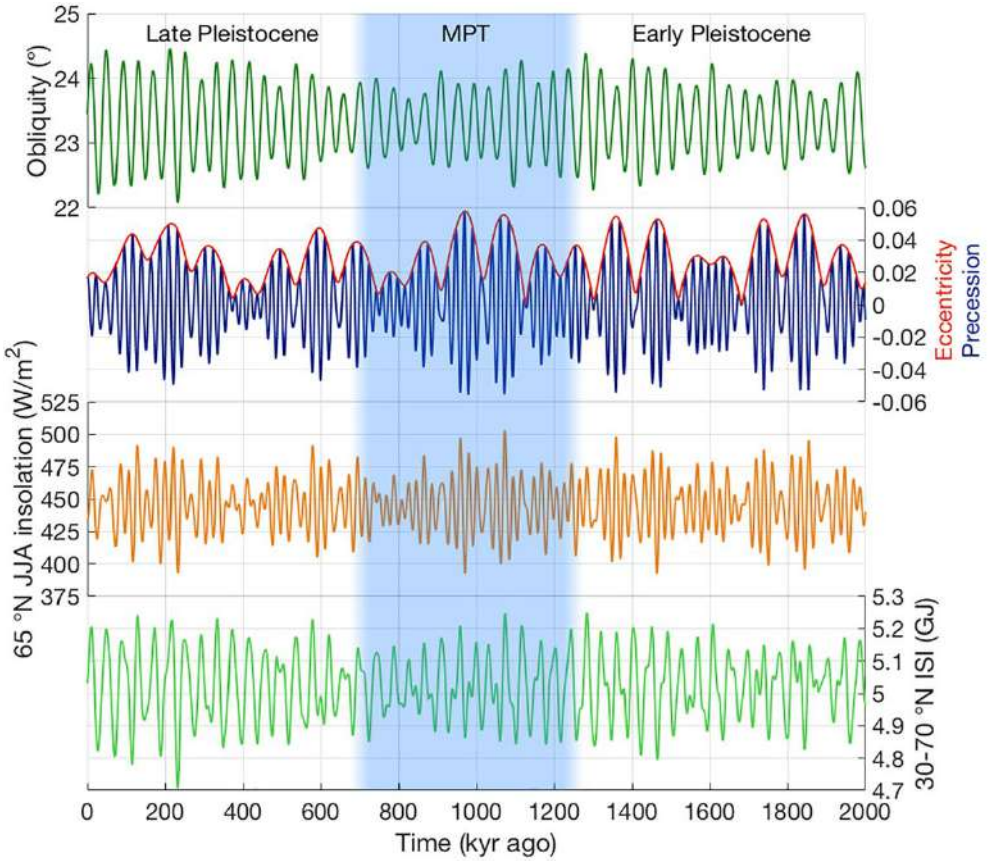
2. Why did these ~100 kyr cycles only appear after the MPT despite no obvious change in solar forcing around that time?

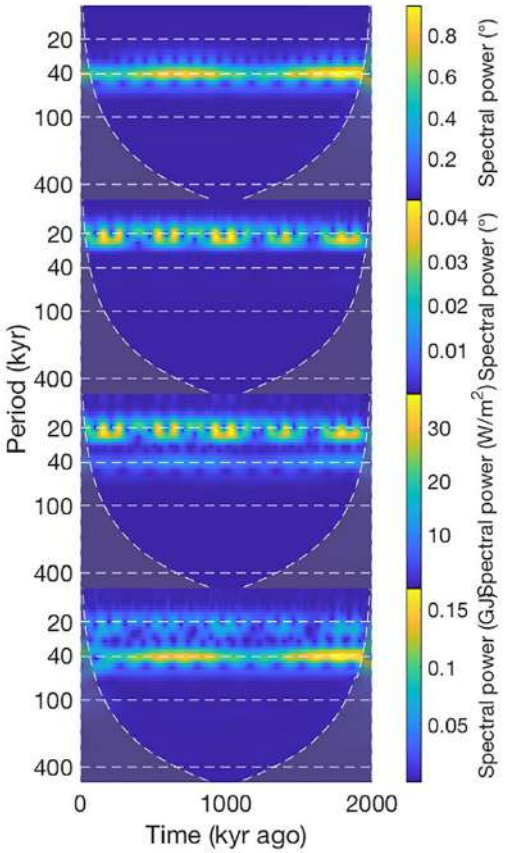
Did our ancestors nearly die out during the PMT?



Hu et al. (2023)

MPT – Orbital Forcing ?





Berends et al. (2021)

Three ways in which ice cores have changed our perception of the climate

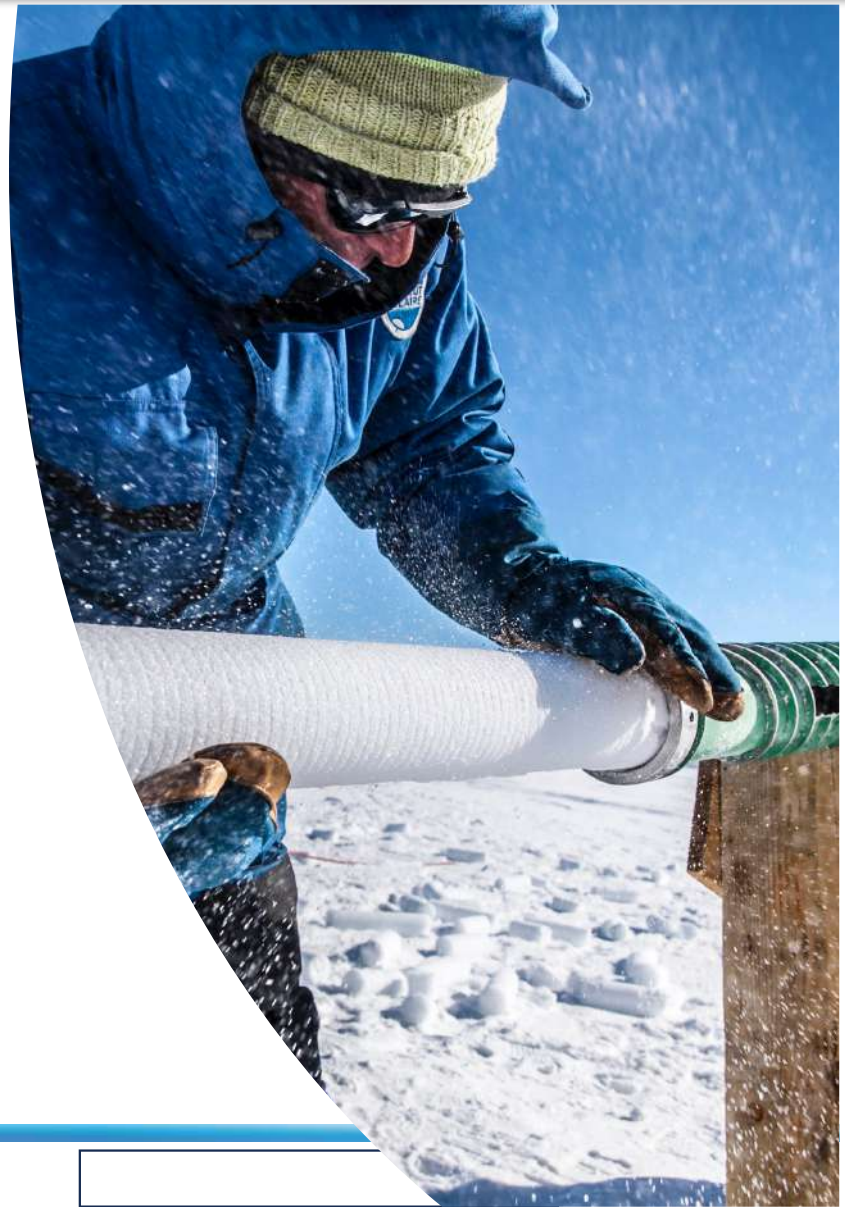
1. Quantification of climate forcings (orbital, greenhouse gases, volcanic, and solar)
2. Direct observation of climate-carbon cycle links
3. Existence, dynamics and role of millennial scale changes (e.g. D/O events)

Underlying Science

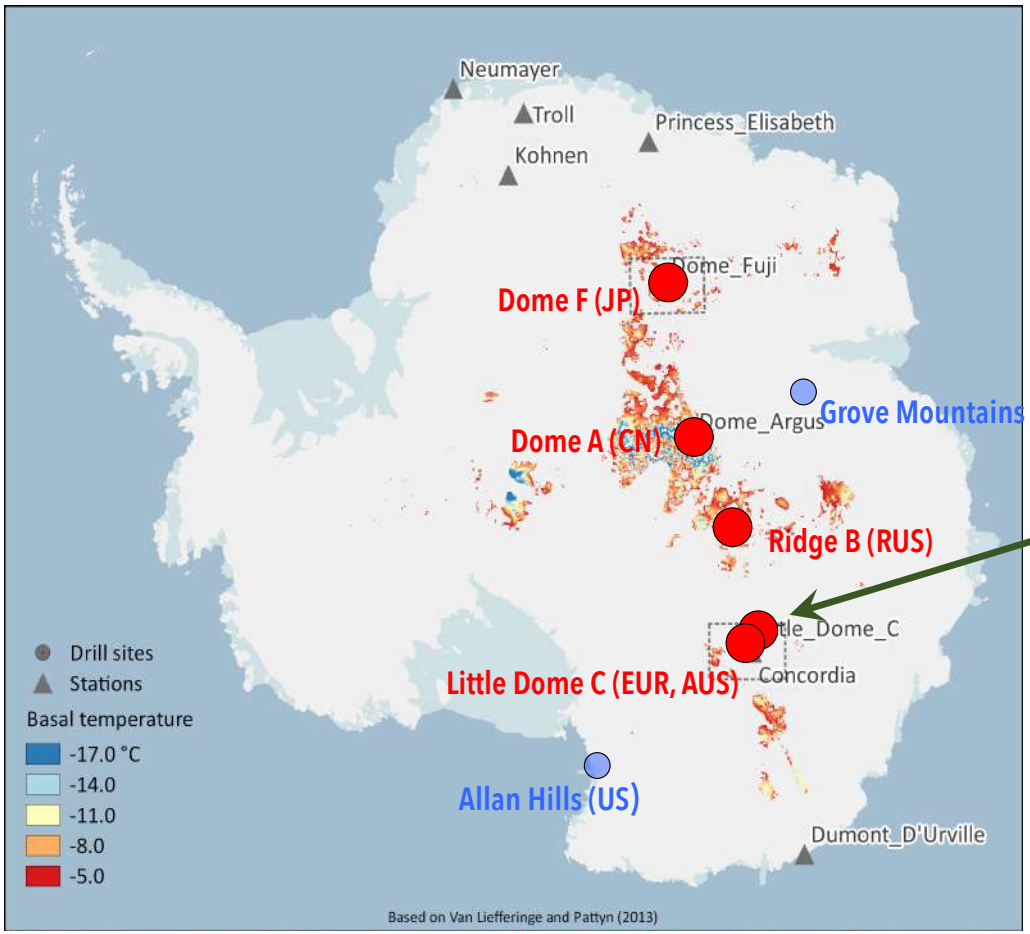
- Unless we understand the transition from 40 kyr cycles to 100 kyr cycles, we don't really understand today's climate

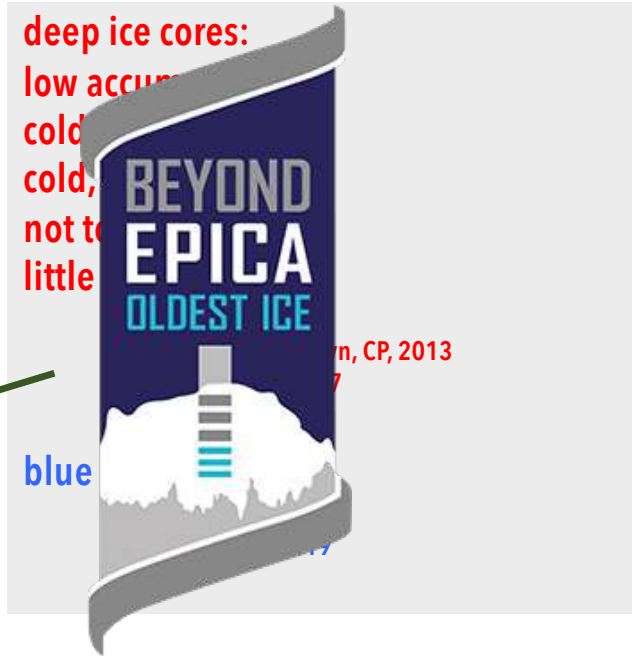
- Why did we have the Mid-Pleistocene Transition (MPT) around 900 kyr ago?

- Why do we now live in a 100 kyr world?



Where to find such old stratified ice ?





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Talk 1 "**Global and regional temperature change over the past 4.5 million years + implications**"
Peter Koehler, *Alfred Wegener Institute*, Germany

Talk 2 "**Characterising the Antarctic Ice Sheet through time and space**"
Olaf Eisen, *Alfred Wegener Institute*, Germany

Talk 3 "**The role of the Antarctic ice sheet in the regional to global climate system**"
Laura De Santis, *National Institute of Ocenography and Apllied Geophysics*, Italy

Future perspectives – Formulate recommendations for a Polar Science Agenda

Thank you for your attention