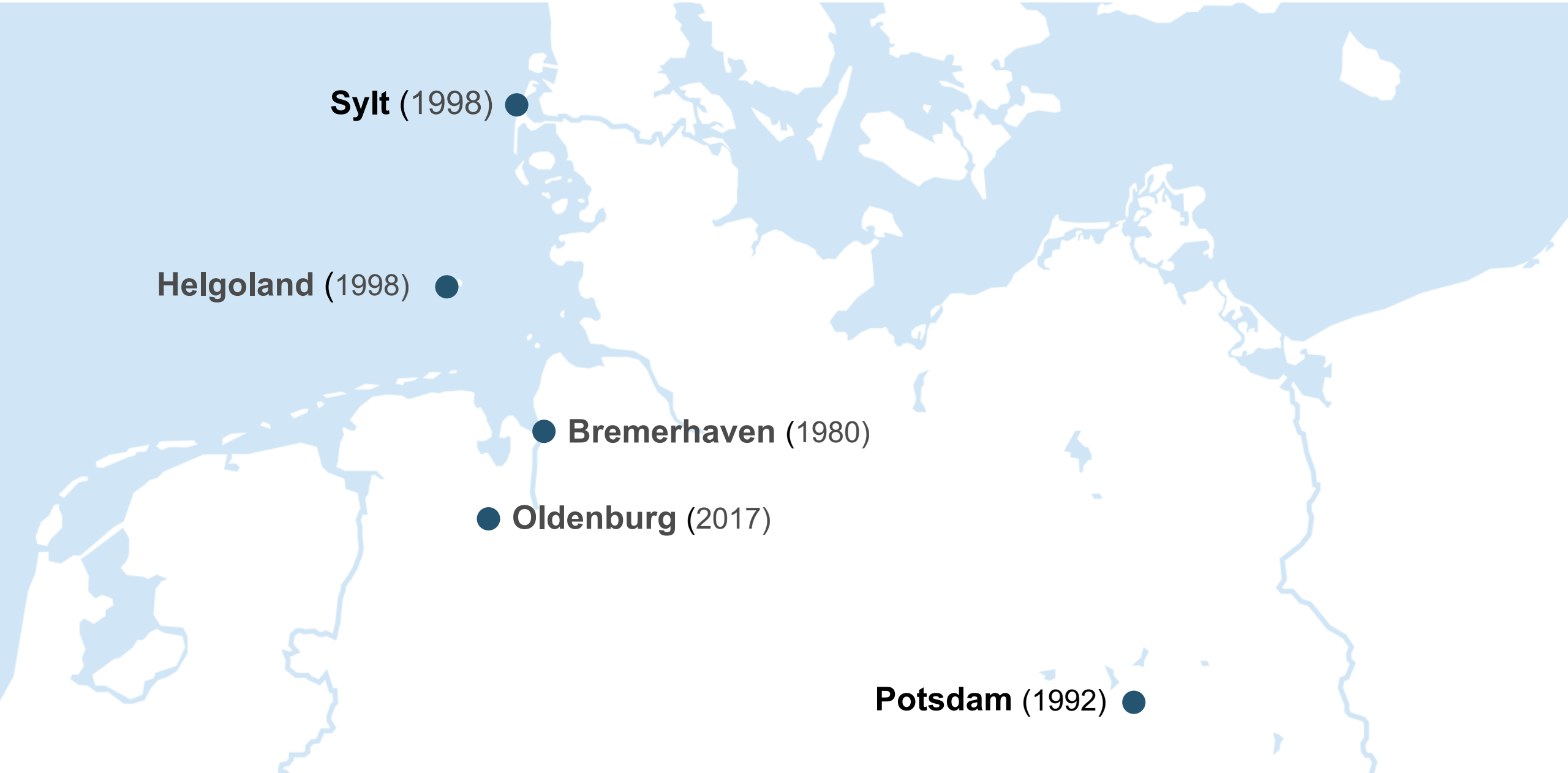
Gerrit Lohmann

AWI in Germany



Bremerhaven ≈ 1000 Persons

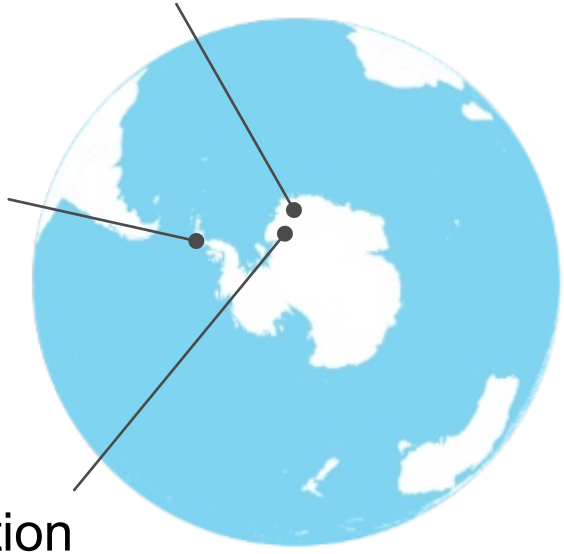
Research Infrastructure

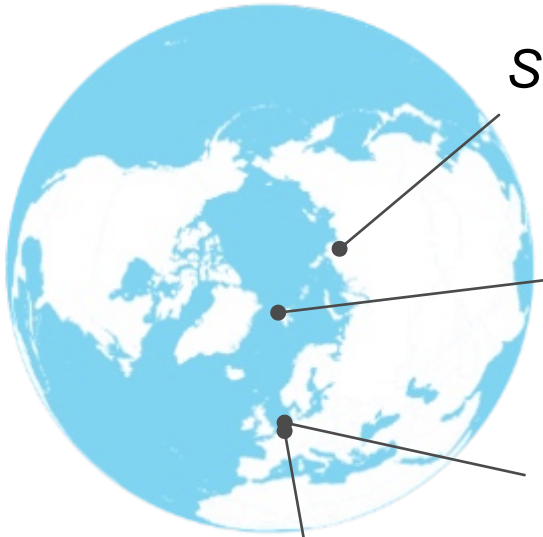
Polar 5 | Polar 6

Neumayer-Station III

Dallmann-Labor

Kohnen-Station





Samoylov-Station

AWIPEV

Küstenstationen
Helgoland und Sylt

Alfred-Wegener-Institut

FS Polarstern

FS Mya II

Aade

FK Uthörn

FS Heincke

FS Polarstern

Built:	1982
Harbor:	Bremerhaven
Areas:	Arctic & Antarctic Ocean
Length:	118 Meter
Crew:	42 Persons
Science:	55 Persons

Folke Mehrtens/AWI

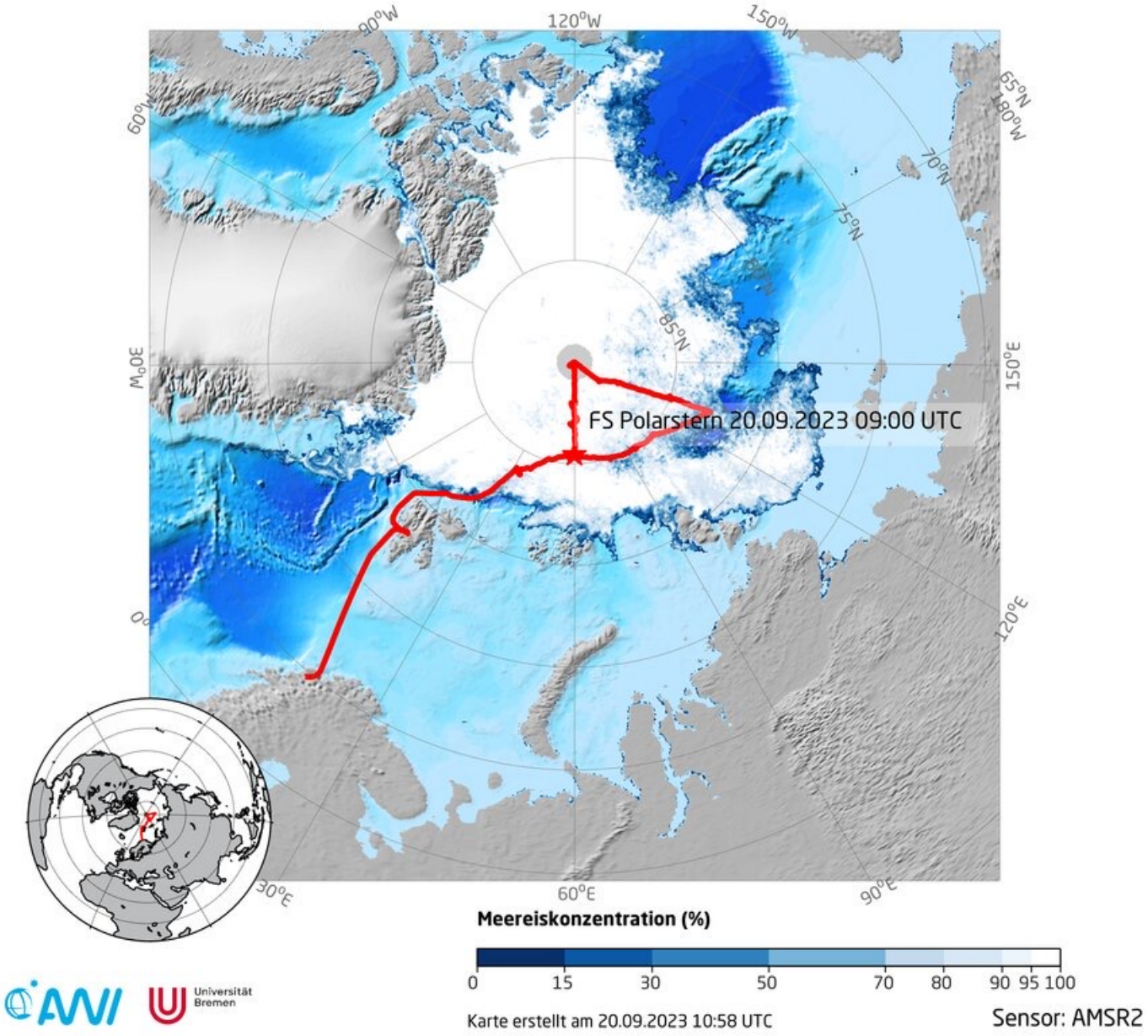
Icebreaker Polarstern

https://mosaic-expedition.org

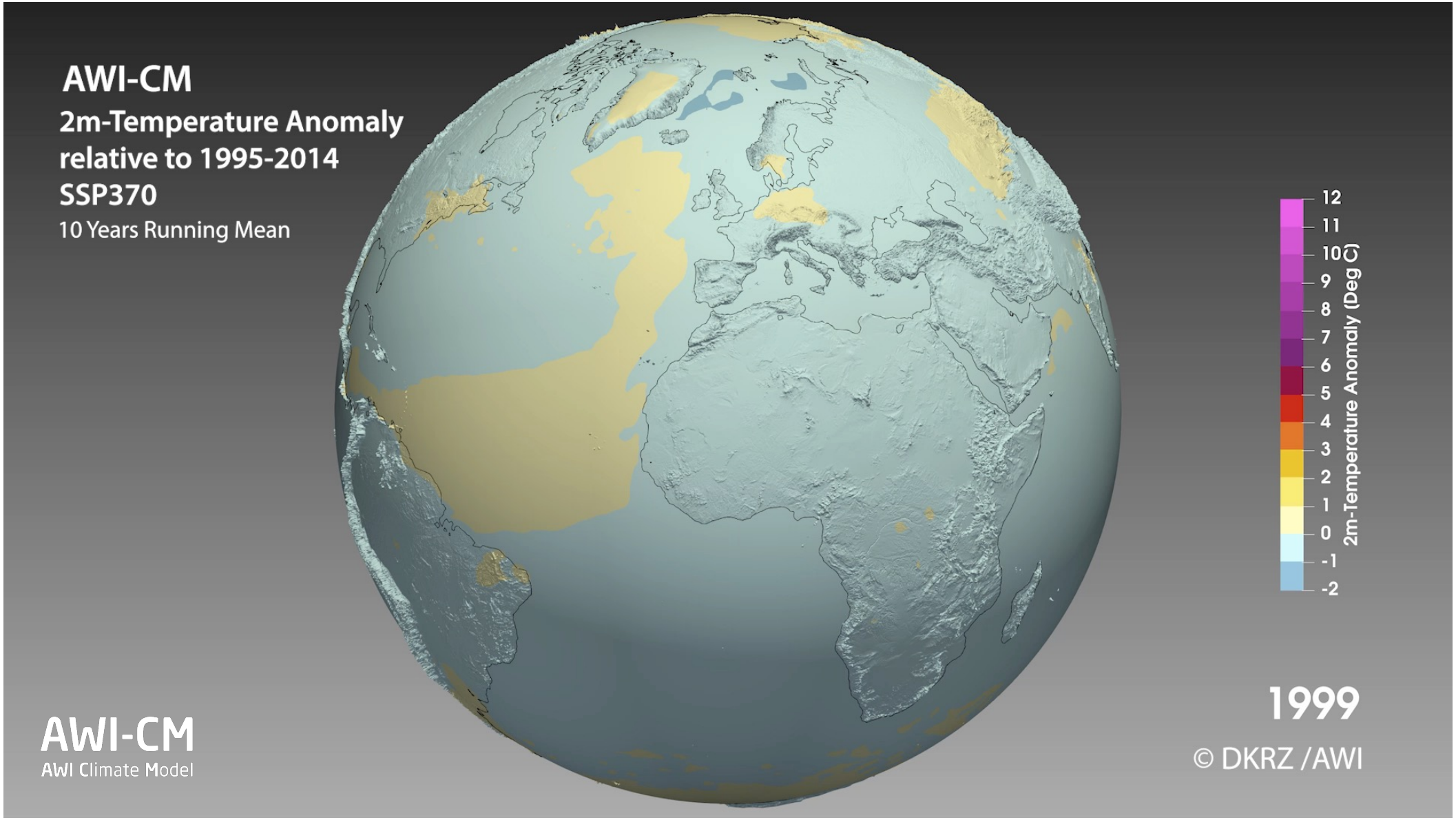
Expedition - MOSAiC

600 Researchers from 20 Nations

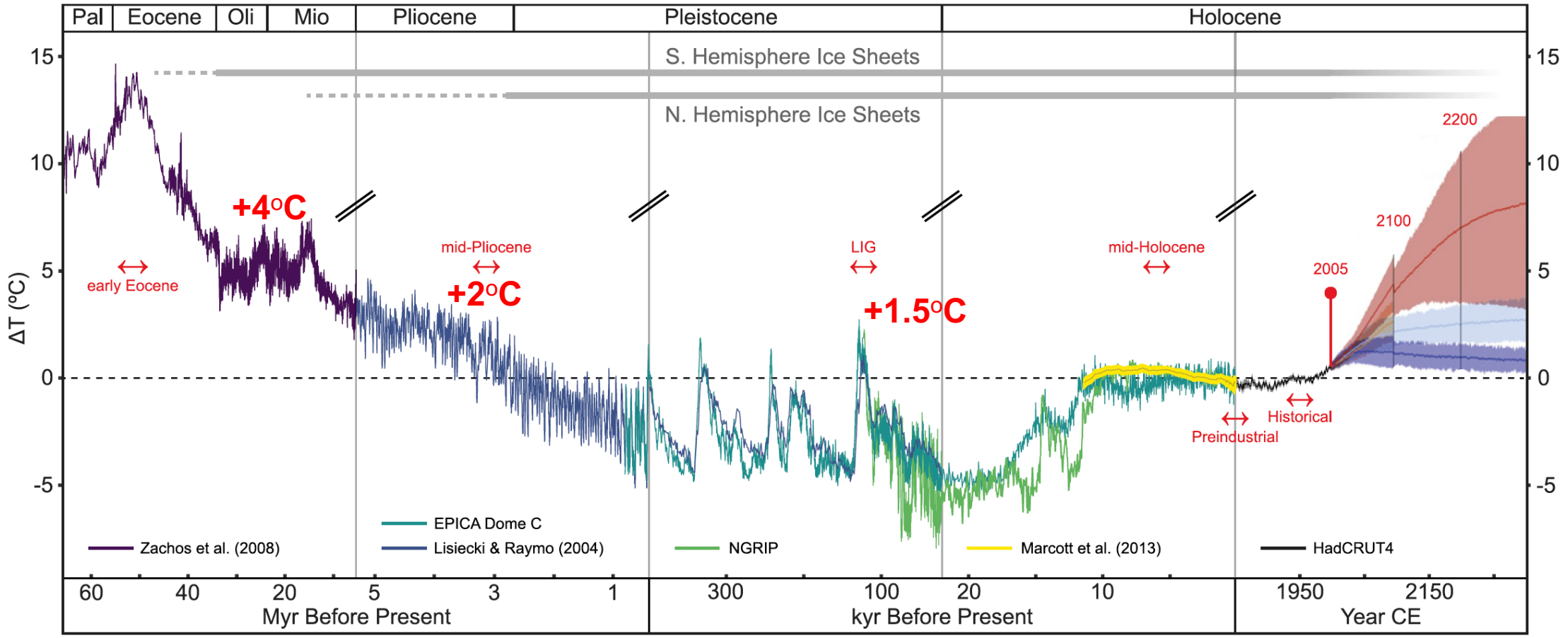
Where is Polarstern ?



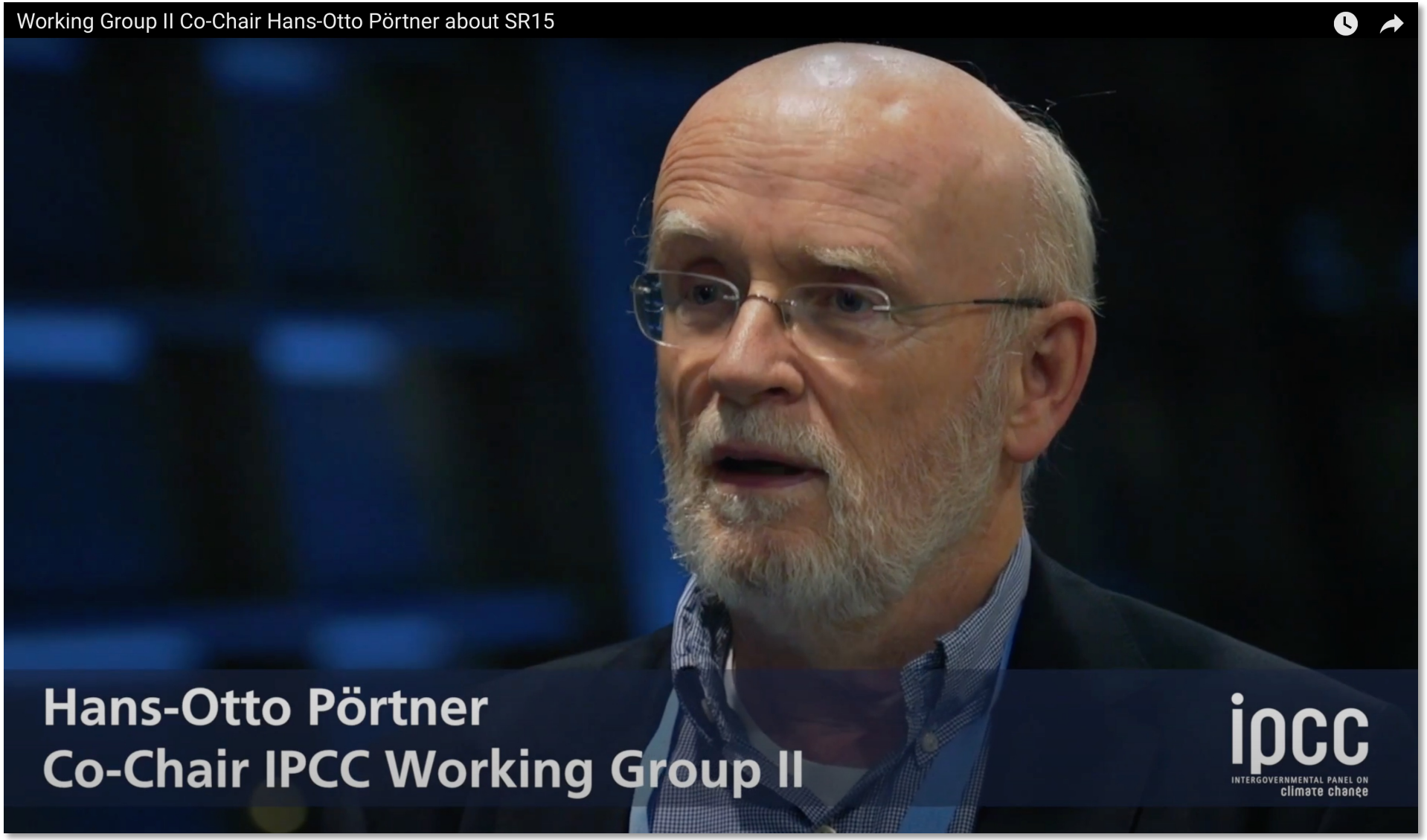
Modelling


AWI-CM
2m-Temperature Anomaly
relative to 1995-2014
SSP370
10 Years Running Mean
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
2m-Temperature Anomaly (Deg C)
1999
© DKRZ /AWI
AWI-CM
AWI Climate Model

Lessons from the Past



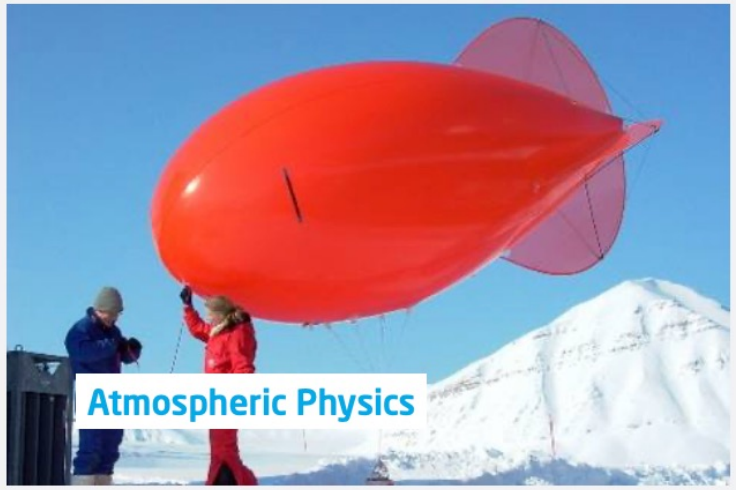
Communication with Society

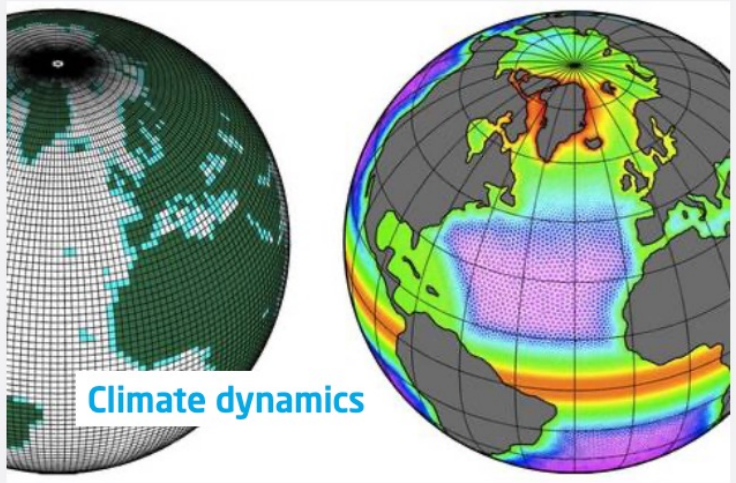


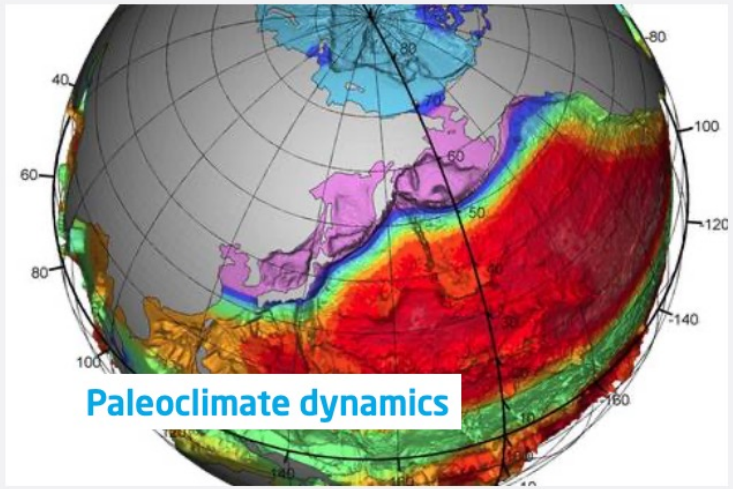
„Endurance“

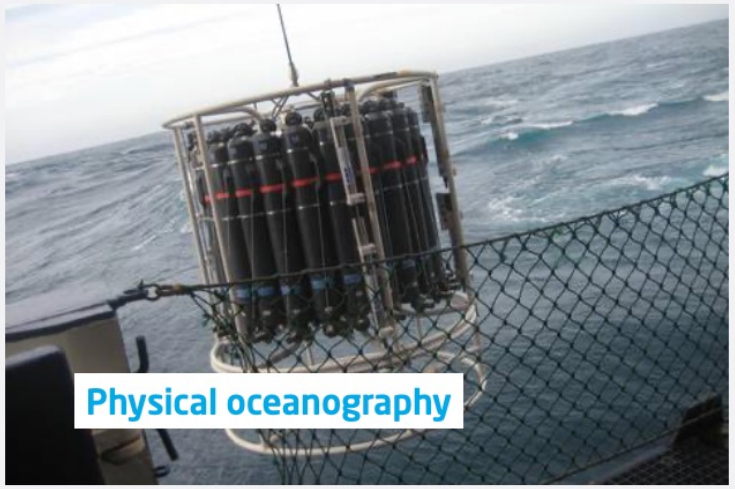
Außerordentlich hohe internationale Reichweite auch für das AWI: Anfang Februar brach ein internationales Expeditionsteam in die Antarktis auf, um das 1915 im Weddellmeer gesunkene Schiff von Sir Ernest Shackleton – die Endurance – zu finden. Drei Wochen nach dem Start konnte das Team das bisher verschollene Wrack orten. Mit an Bord waren mehrere Forschende des Alfred-Wegener-Instituts.

Climate Sciences

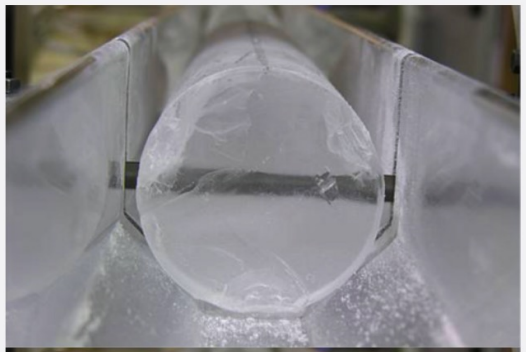


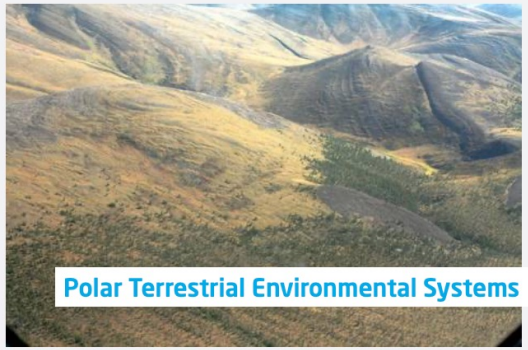


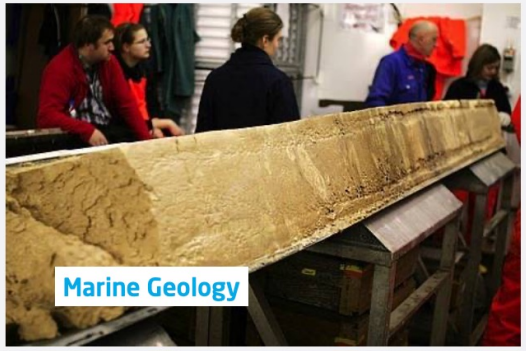




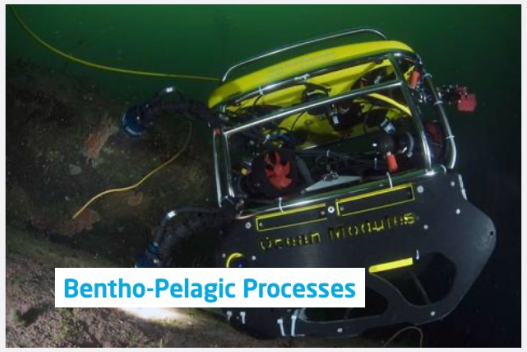
Geosciences

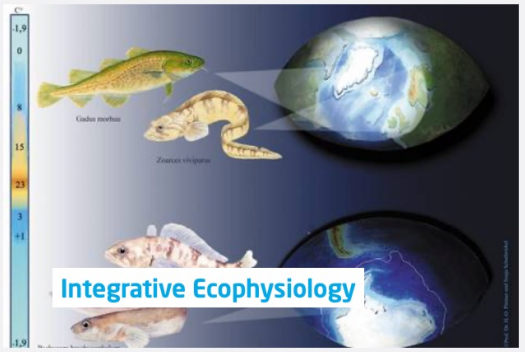


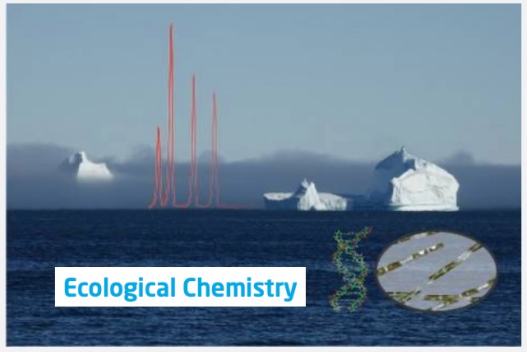


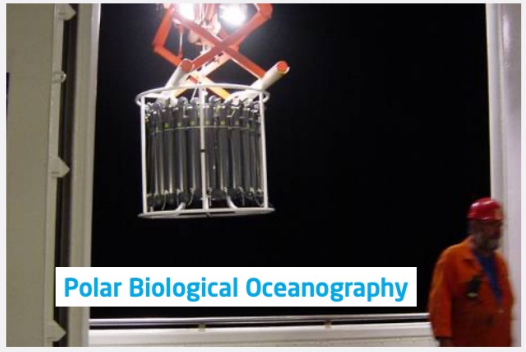


Biosciences



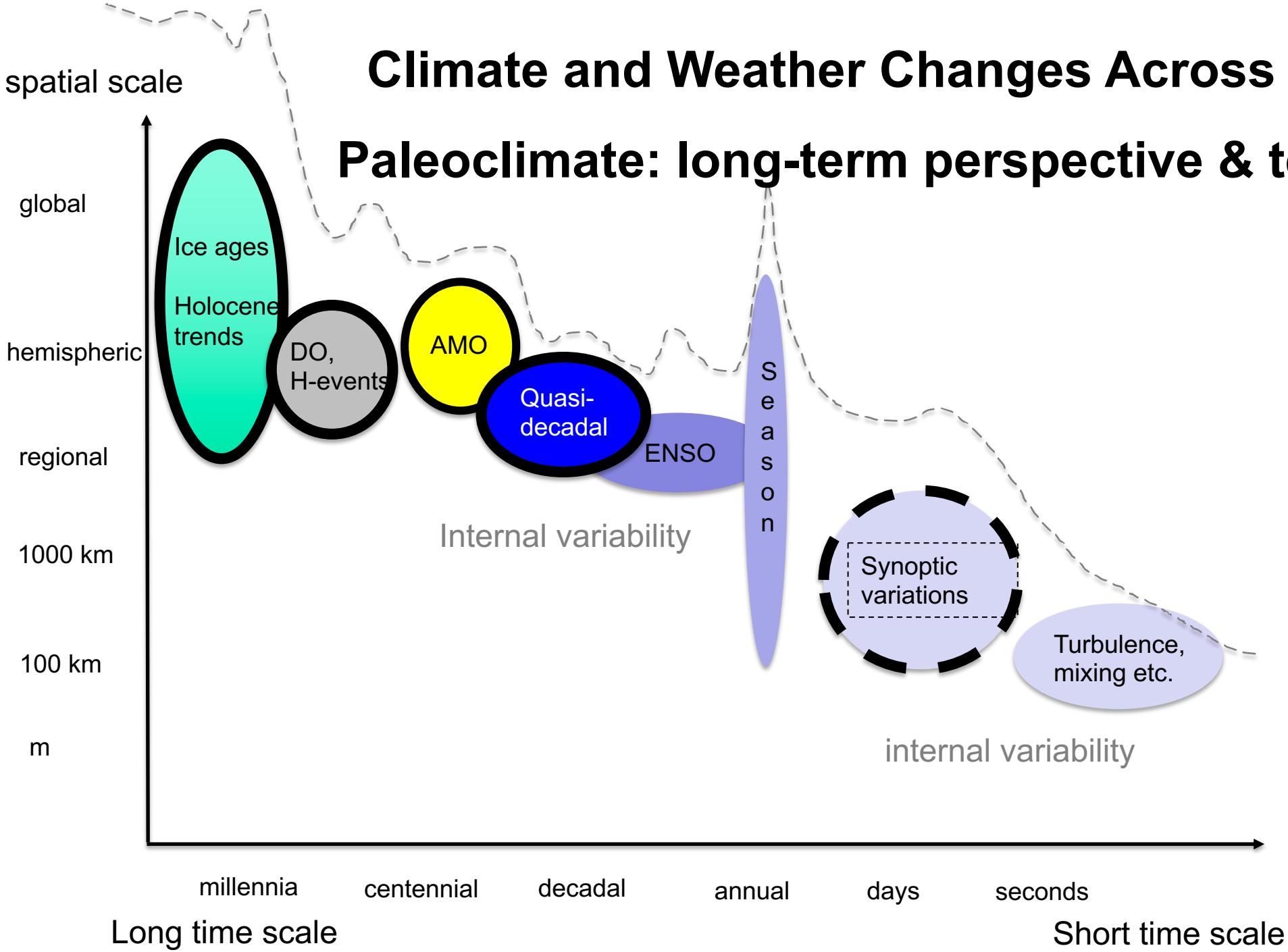






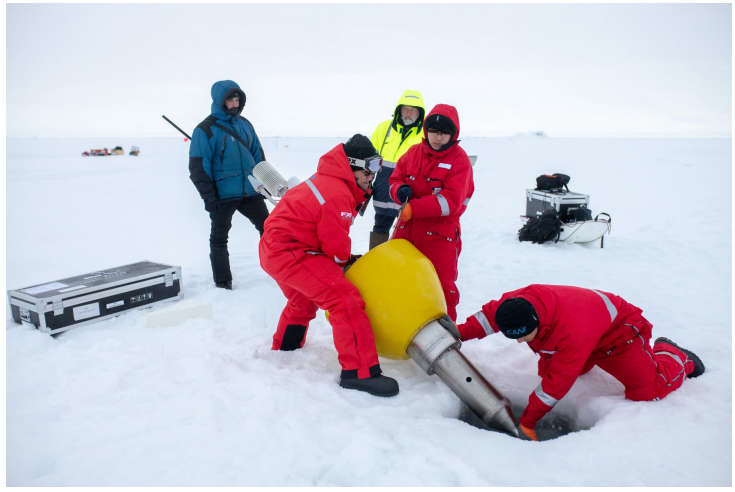
Climate and Weather Changes Across Time Scales

Paleoclimate: long-term perspective & test of models



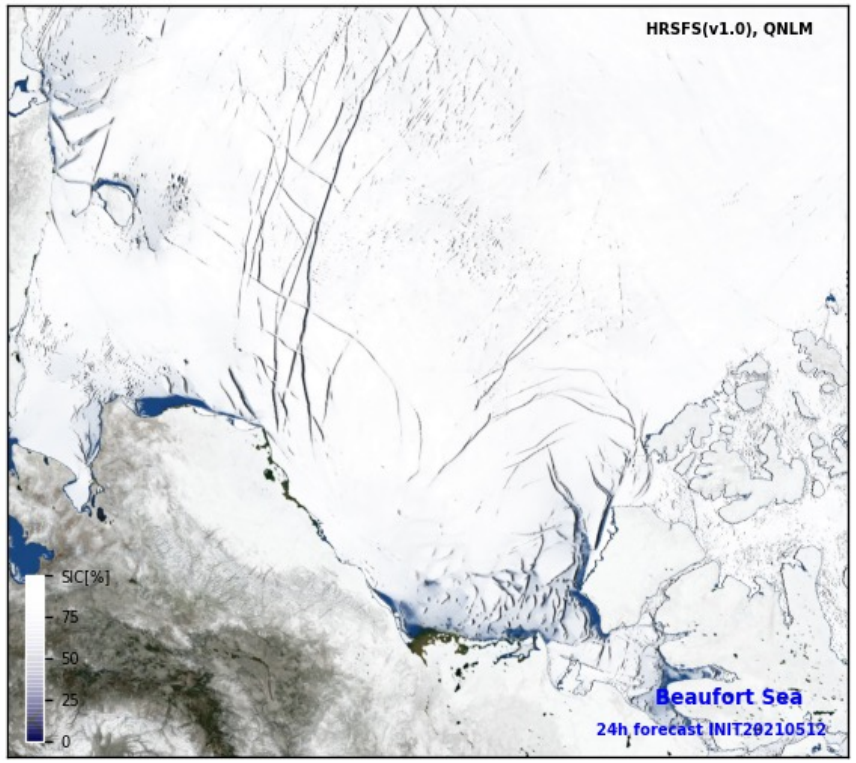
Scientists are collaborating

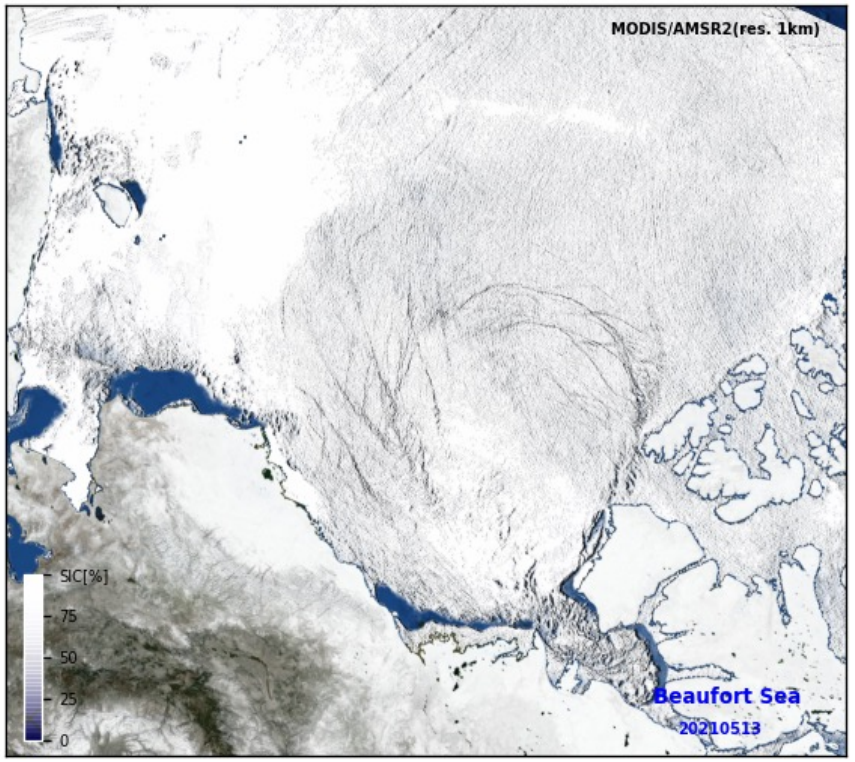
MOSAiC



Scientists are collaborating, will be improved

Jointly develop the high-resolution Arctic model

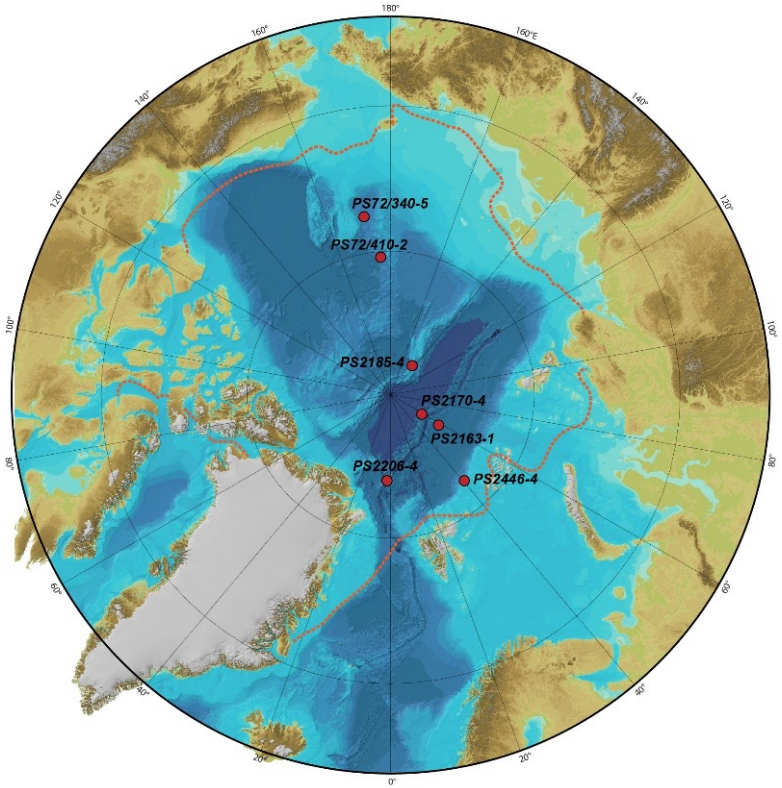


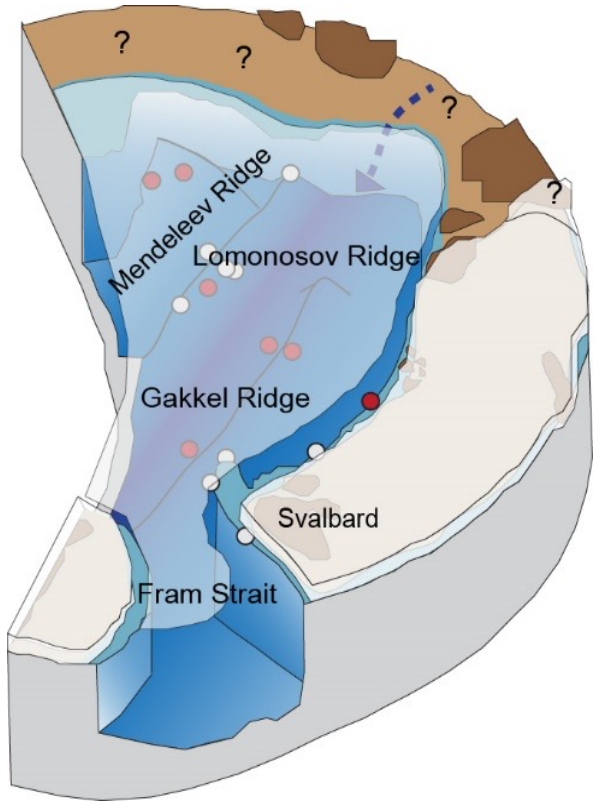


Scientists are collaborating

- **Sediment cores**

Provide the direct evidence about the seasonal sea ice cover in the Arctic during the LGM.



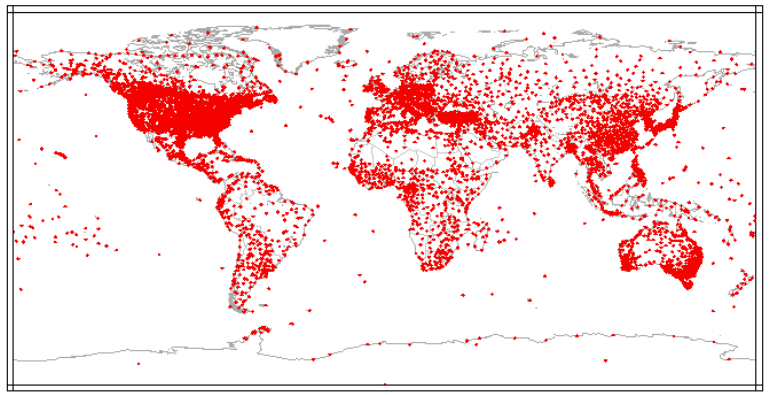


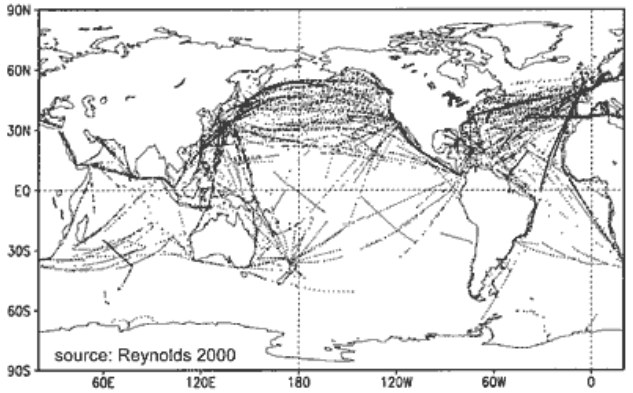
North Atlantic Warm Water

How do we **know** what's happening?

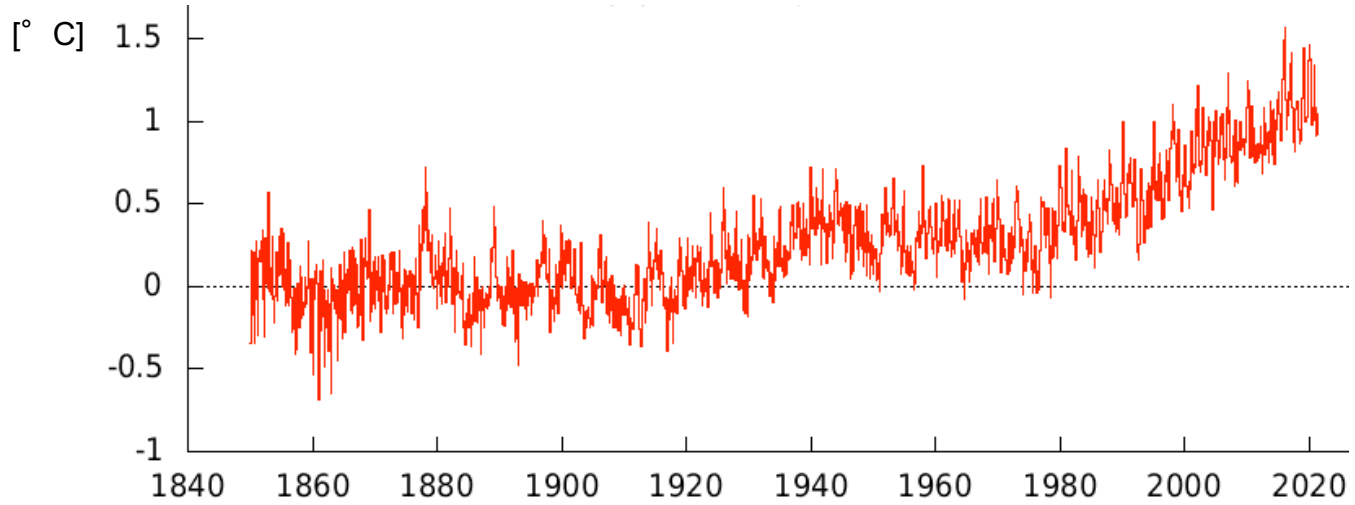
Measuring temperature, pressure, precipitation

Observational sites





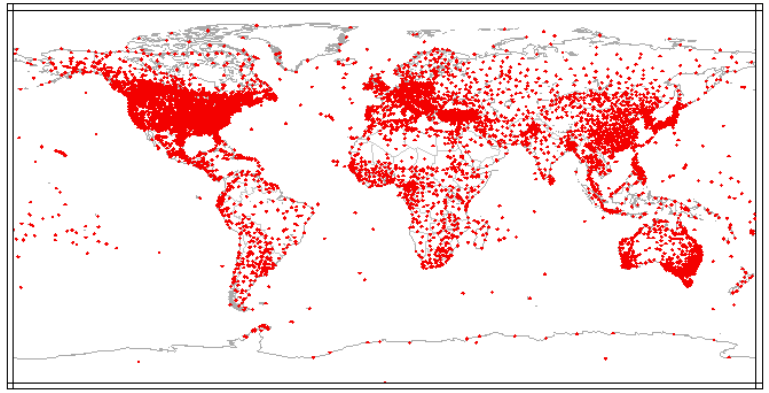
Shipping routes

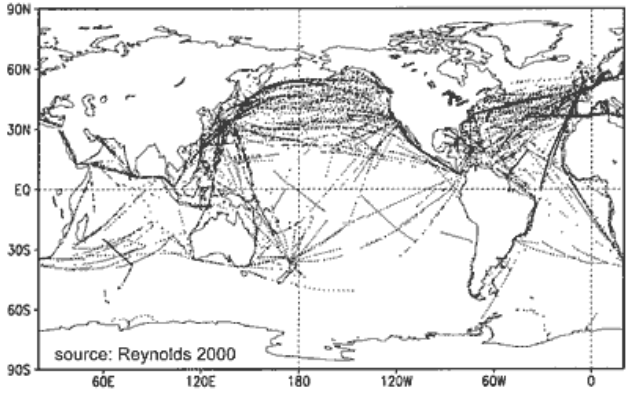


How do we **know** what's happening?

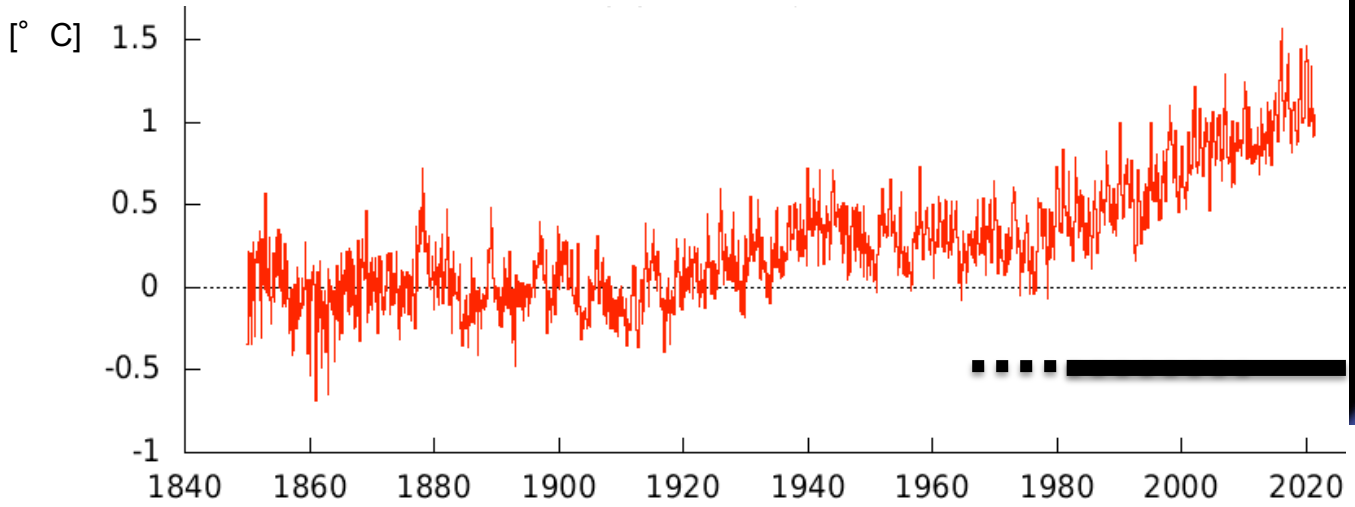
Measuring temperature, pressure, precipitation

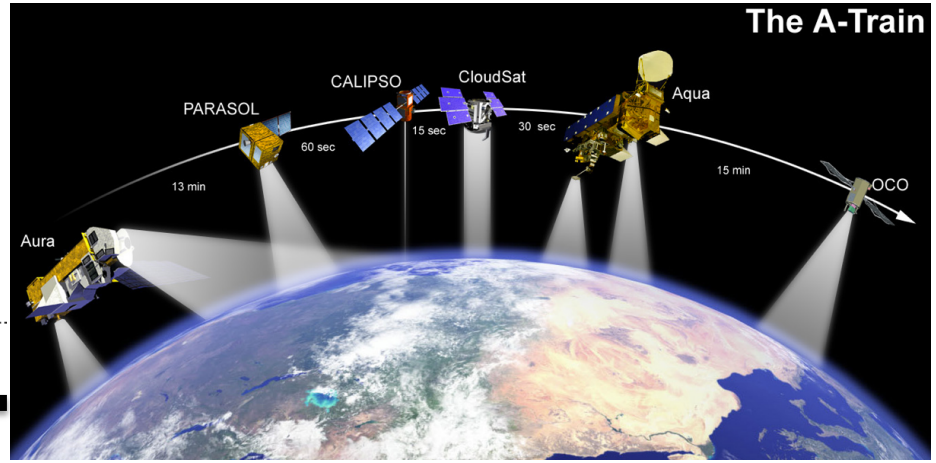
Observational sites





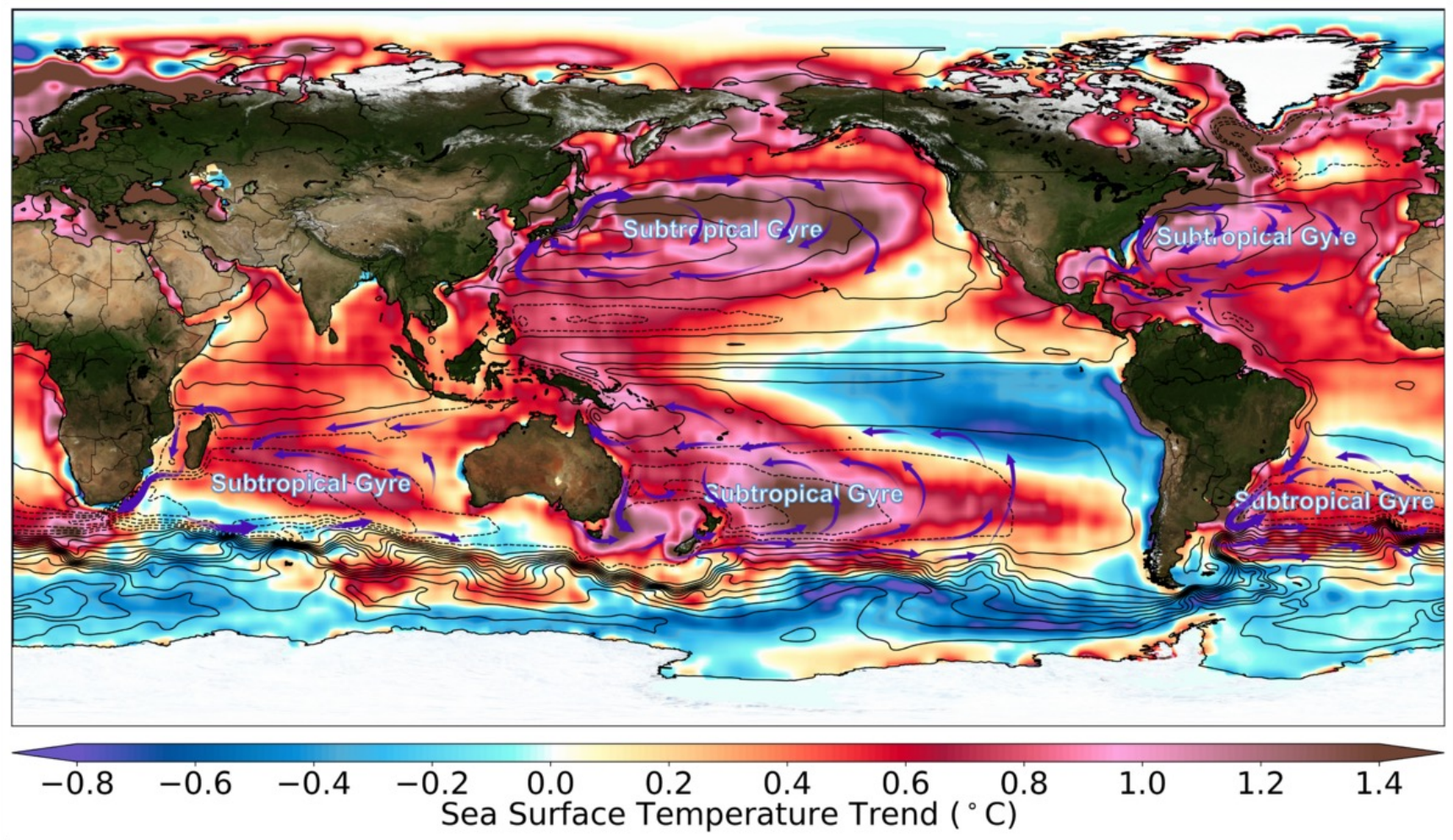
Shipping routes





Earth observing Satellites

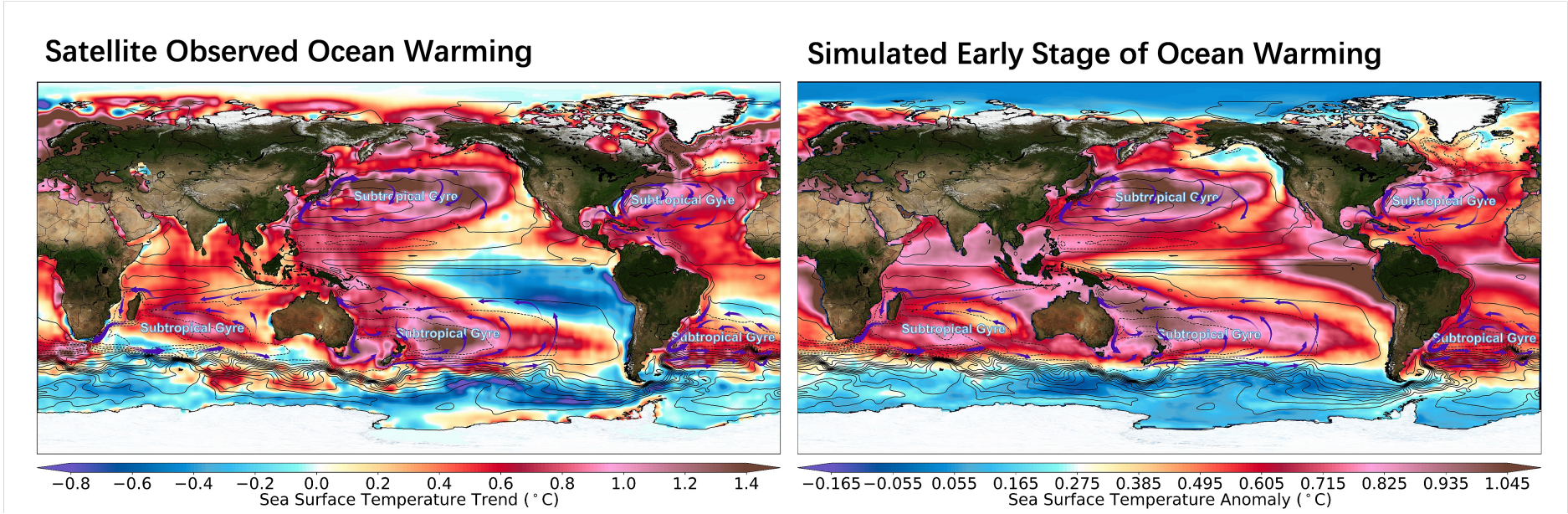
Temperature trend of the last 40 years



Information based on satellites

Hu Yang, G. Lohmann, … & J. Müller, 2023: The emergent pattern of infant stage ocean warming in satellite measurements. Communications Earth & Environment

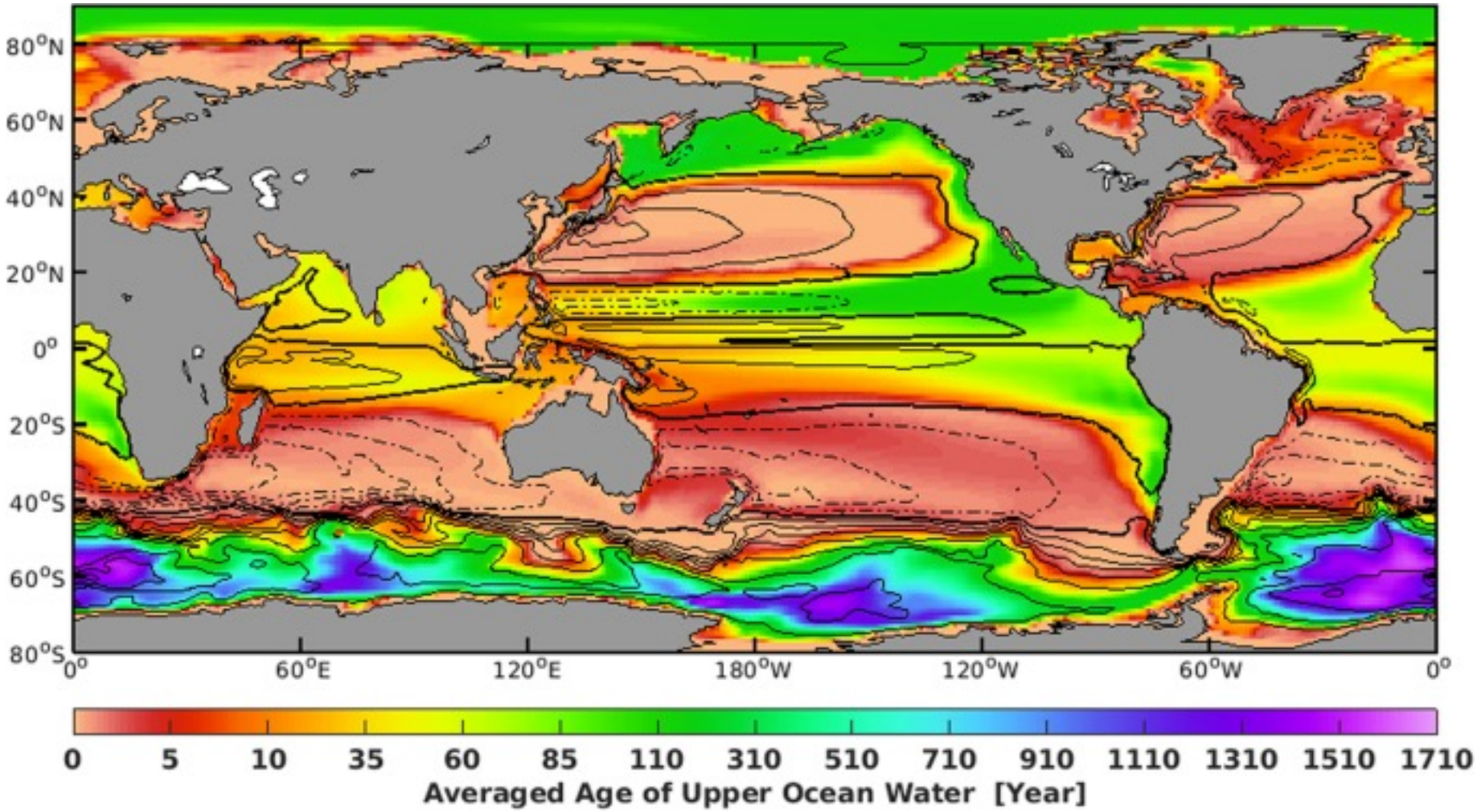
Satellite-observed strong subtropical ocean warming as an early signature of global warming



AWI-ESM:
initial shock

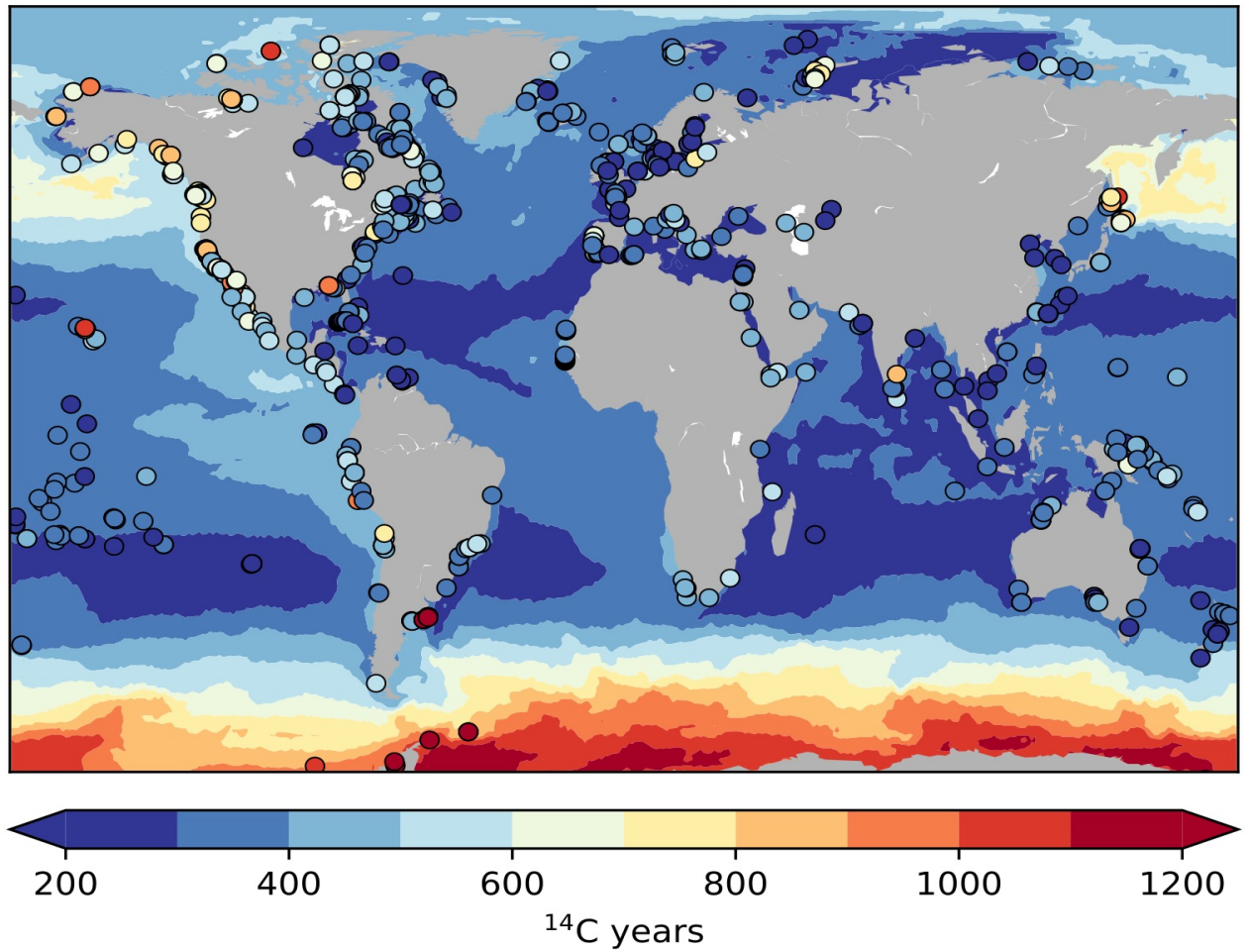
observed warming pattern is likely a short-term transient response to the increased CO_2 forcing, which only emerges during the early stage of anthropogenic warming.

Simulated averaged age of the upper 300-m ocean water column



Yang et al. 2023

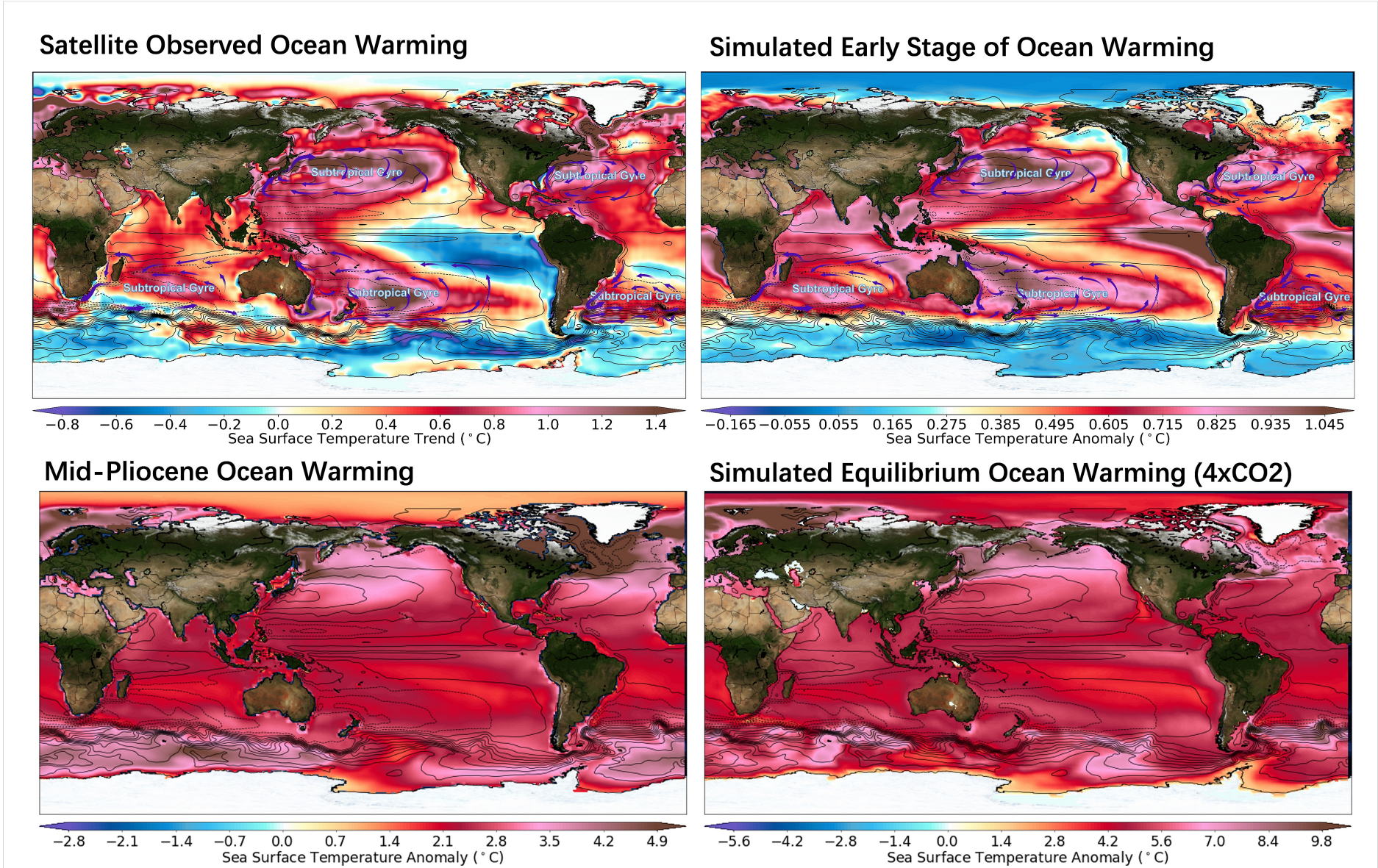
Radiocarbon Tracer (with the same model)



Radiocarbon age in the late Holocene.
simulation results using a ^{14}C-equipped multiresolution ocean model
historical values collected at the ^{14}CHRONO Marine Reservoir Database

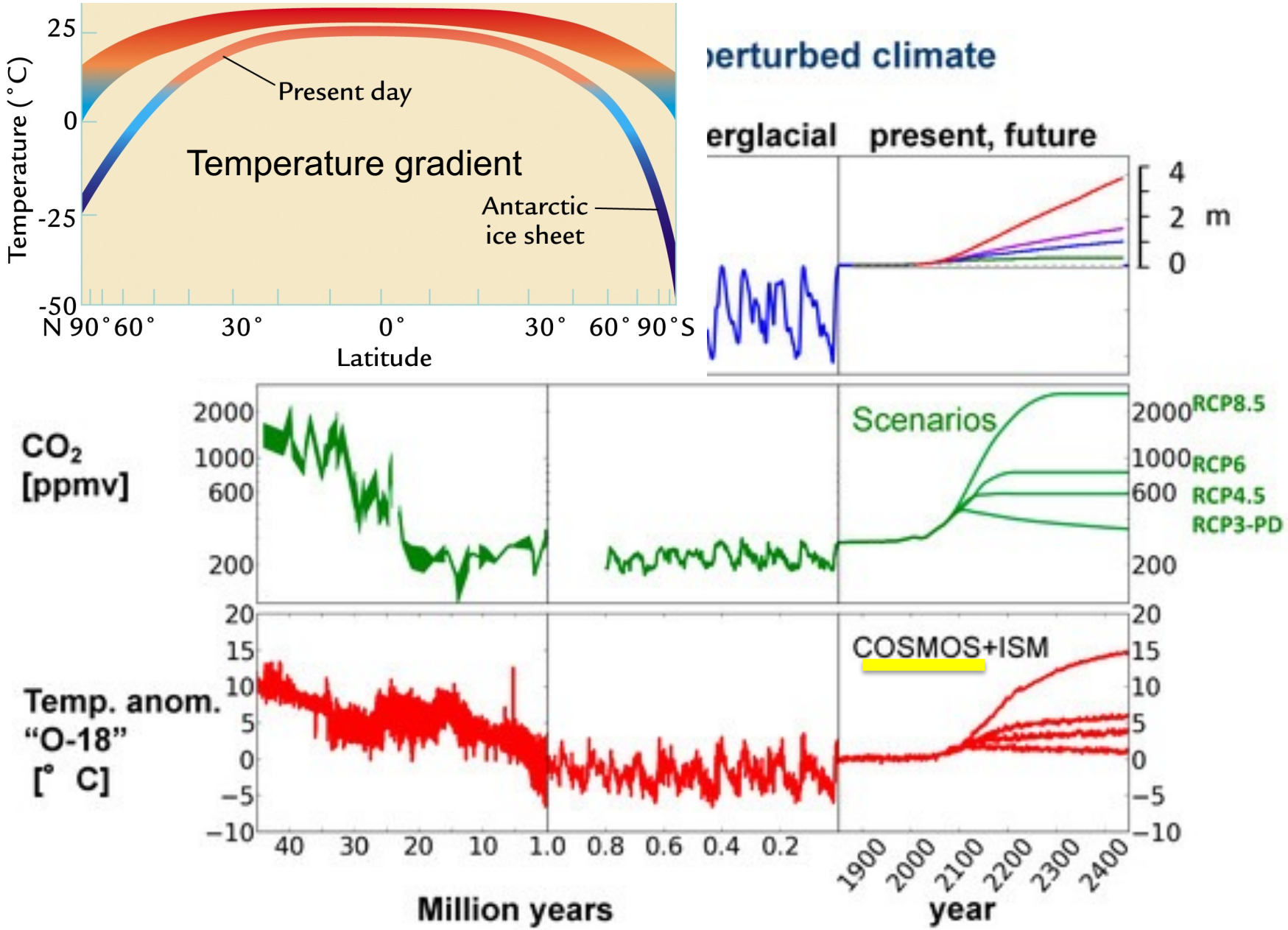
Lohmann et al., 2020

Satellite-observed strong subtropical ocean warming as an early signature of global warming



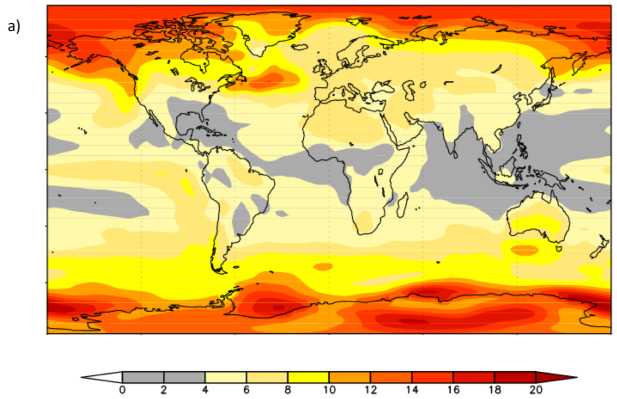
Early stage

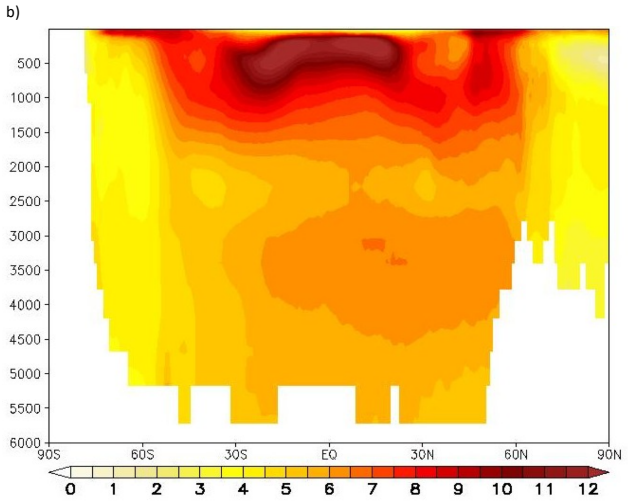
equiliibrated stage



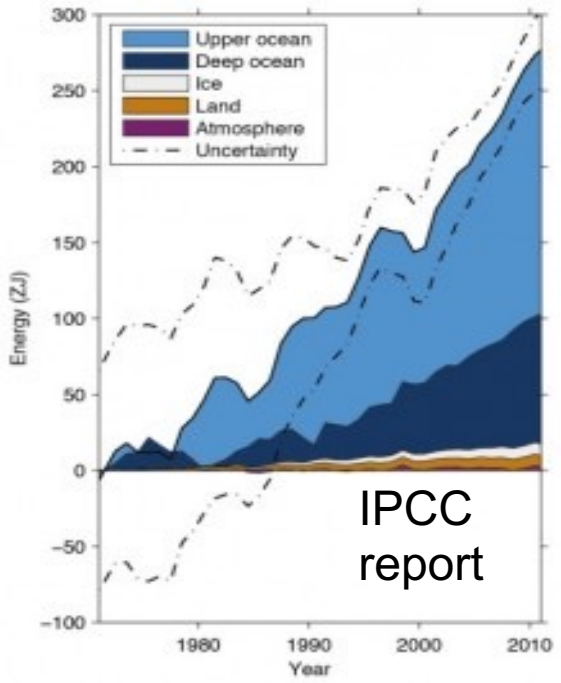
Lohmann et al., 2020b

Effective heat capacity/heat uptake





$$C_p^o \partial_t T = \partial_z \left(k^o \partial_z T \right)$$



Increased k leads to high latitude warming

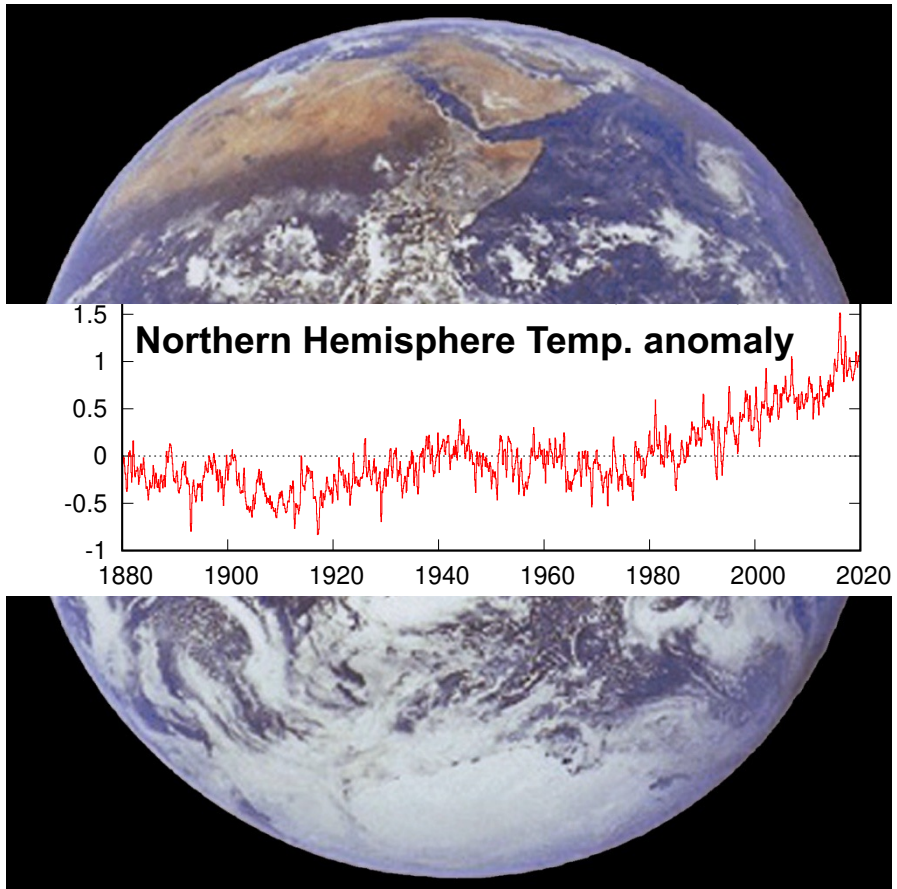
& pronounced warming at the thermocline.

k depends on

turbulence, waves breaking, internal waves, tides, ocean bottom floor, …

Lohmann, 2020

Challenges of Climate Science as interdisciplinary and international Research Project: A personal perspective

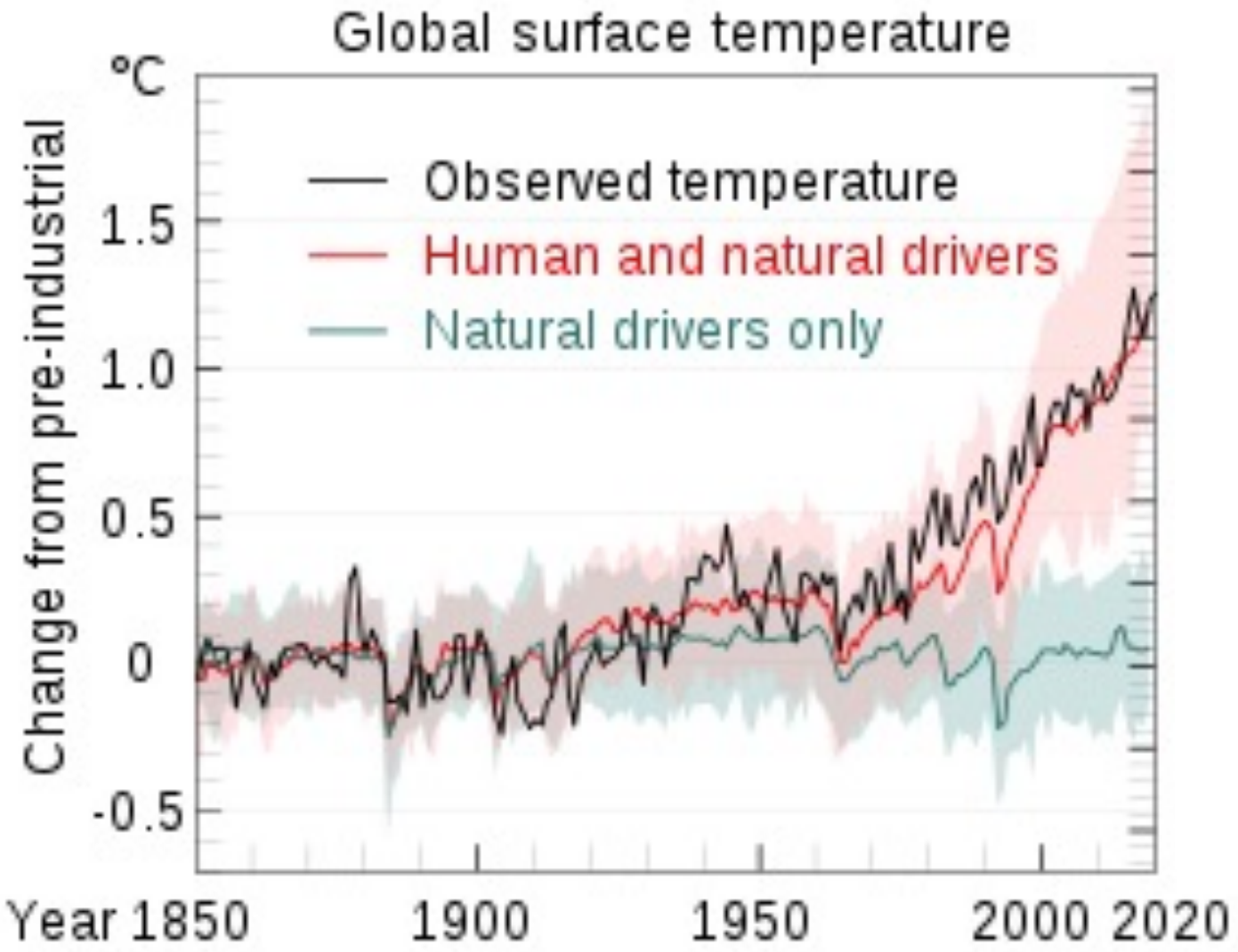


Gerrit Lohmann. @320 ppm

Uni Bremen & AWI

Wuhan, 2024, Oct 9
China University of Geosciences

Attribution of climate change: identify mechanisms



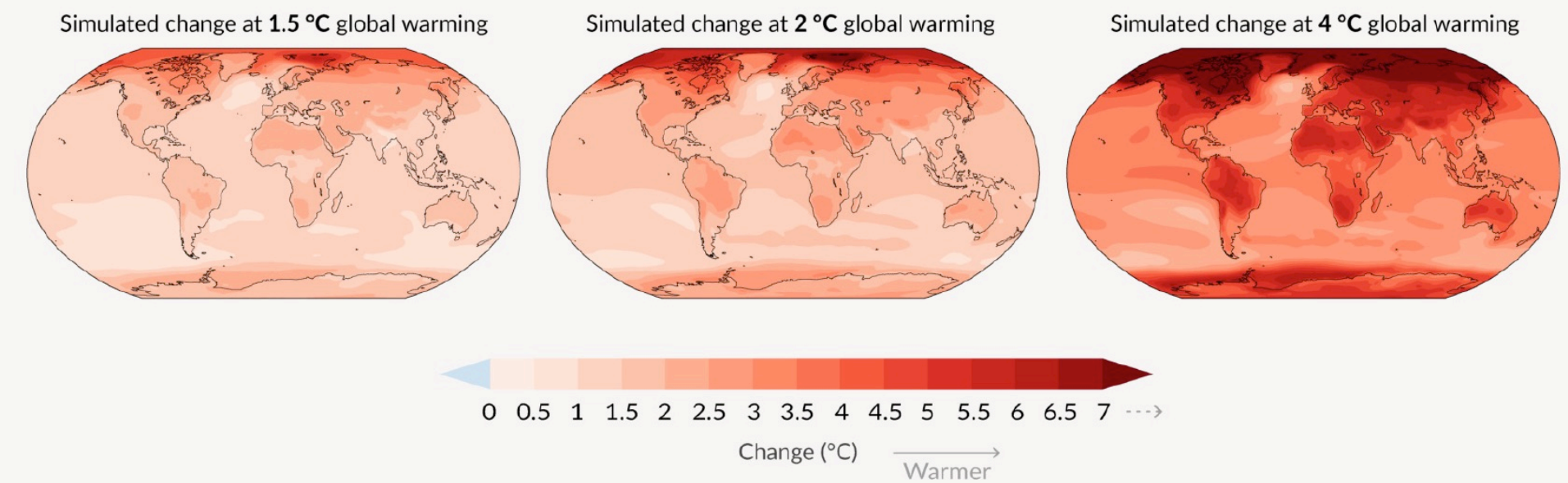
Climate projections

Temperature

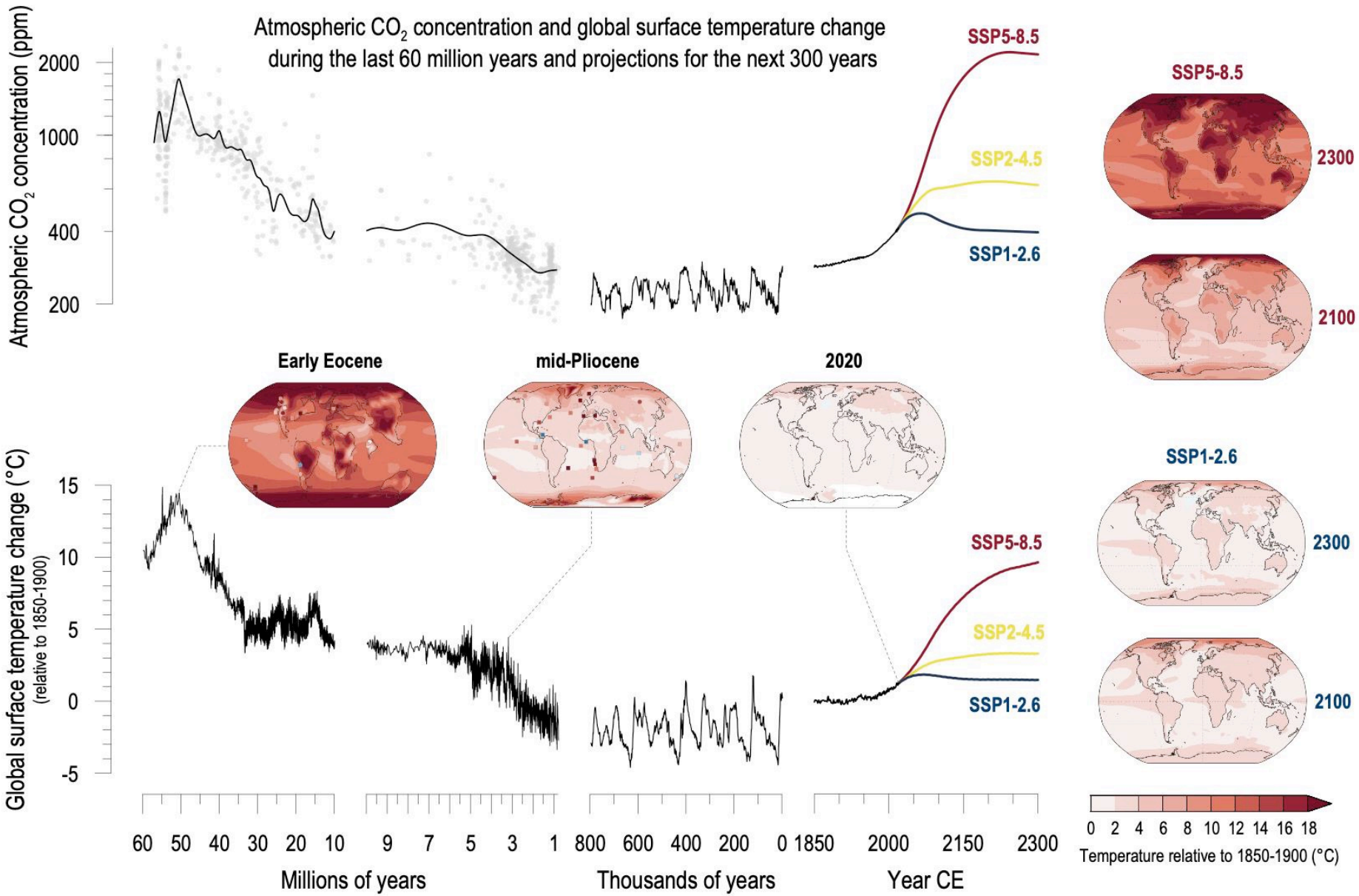
+1,5° C

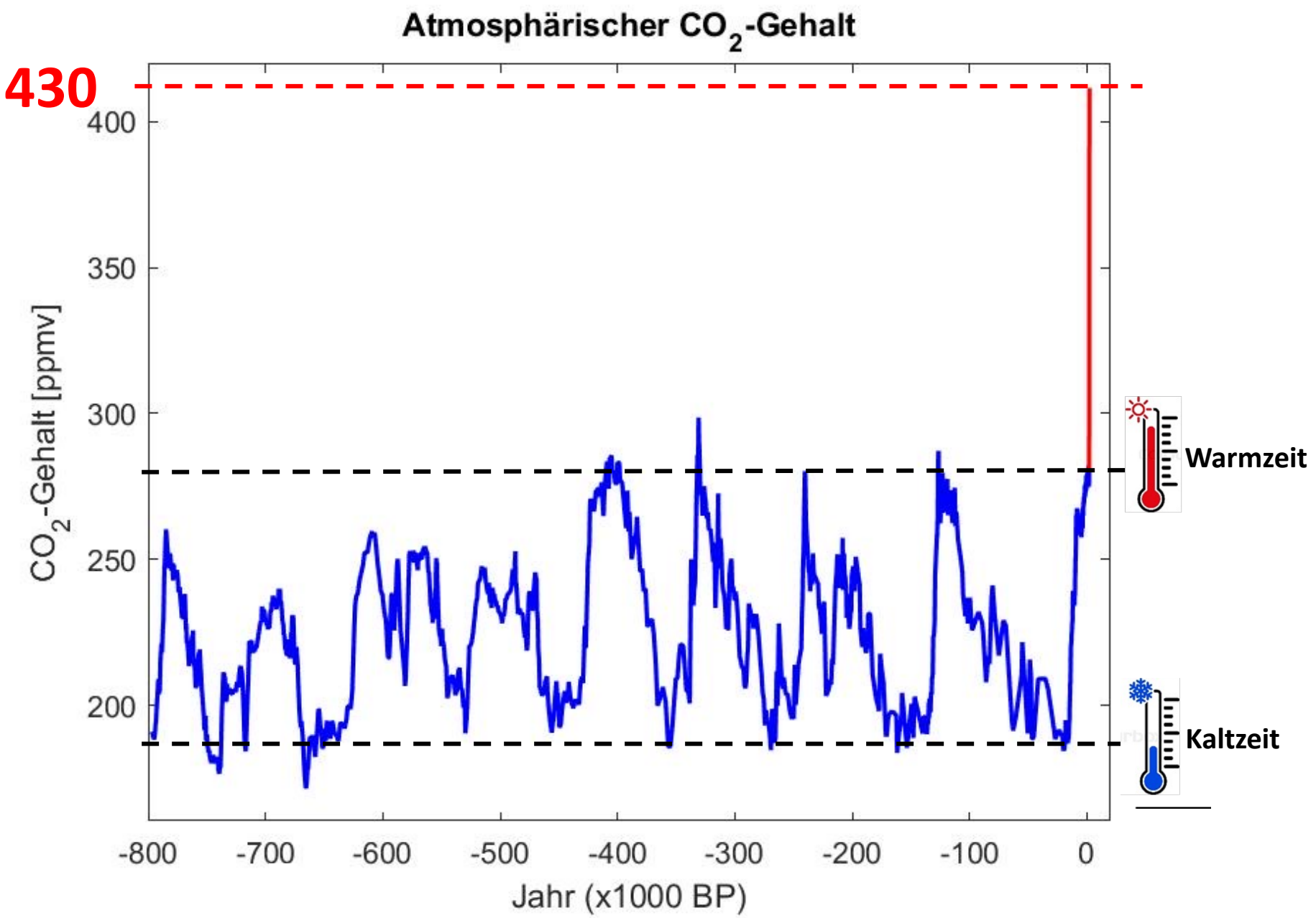
+2,0° C

+4,0° C



IPCC, AR6 (2021)

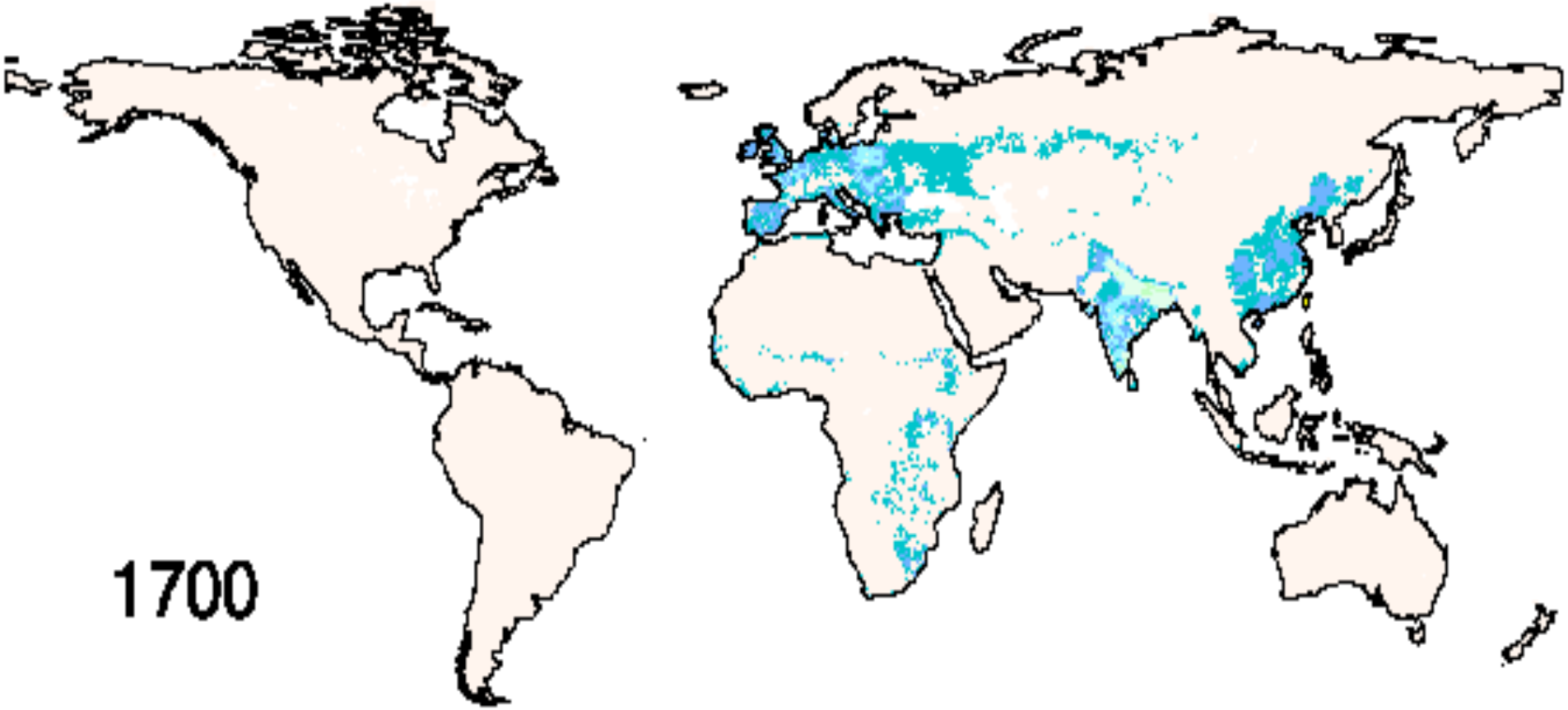

Atmospheric CO_2 concentration and global surface temperature change during the last 60 million years and projections for the next 300 years
Atmospheric CO_2 concentration (ppm)
2000
1000
400
200
SSP5-8.5
SSP2-4.5
SSP1-2.6
SSP5-8.5
2300
2100
Early Eocene
mid-Pliocene
2020
Global surface temperature change (°C)
(relative to 1850-1900)
15
10
5
0
-5
SSP1-2.6
2300
2100
SSP5-8.5
SSP2-4.5
SSP1-2.6
60 50 40 30 20 10 9 7 5 3 1 800 600 400 200 0 1850 2000 2150 2300
Millions of years
Thousands of years
Year CE
0 2 4 6 8 10 12 14 16 18
Temperature relative to 1850-1900 (°C)

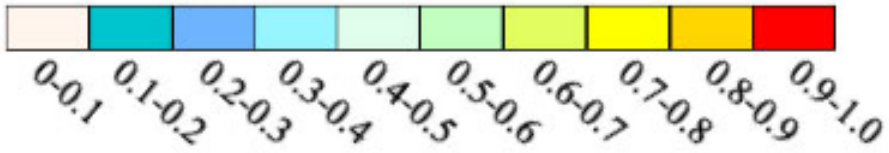

Atmosphärischer CO_2-Gehalt
430
400
350
300
250
200
CO_2-Gehalt [ppmv]
-800
-700
-600
-500
-400
-300
-200
-100
0
Jahr (x1000 BP)
Warmzeit
Kaltzeit

The Challenge: Food Security

Global Crop Cover Change
1700 to 1992

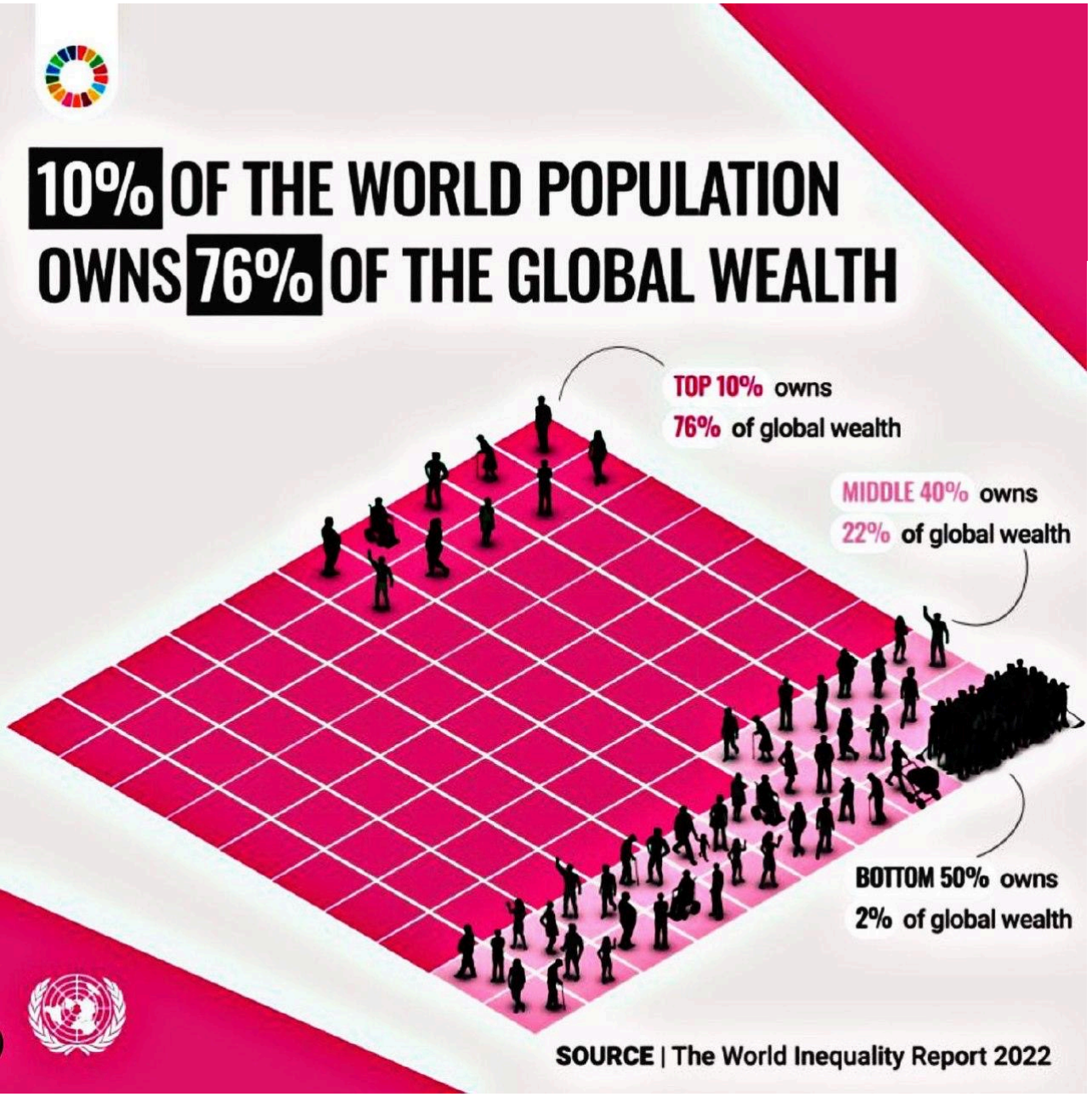
Center for
Sustainability and
the Global Environment
Institute for Environmental Studies
University of Wisconsin-Madison



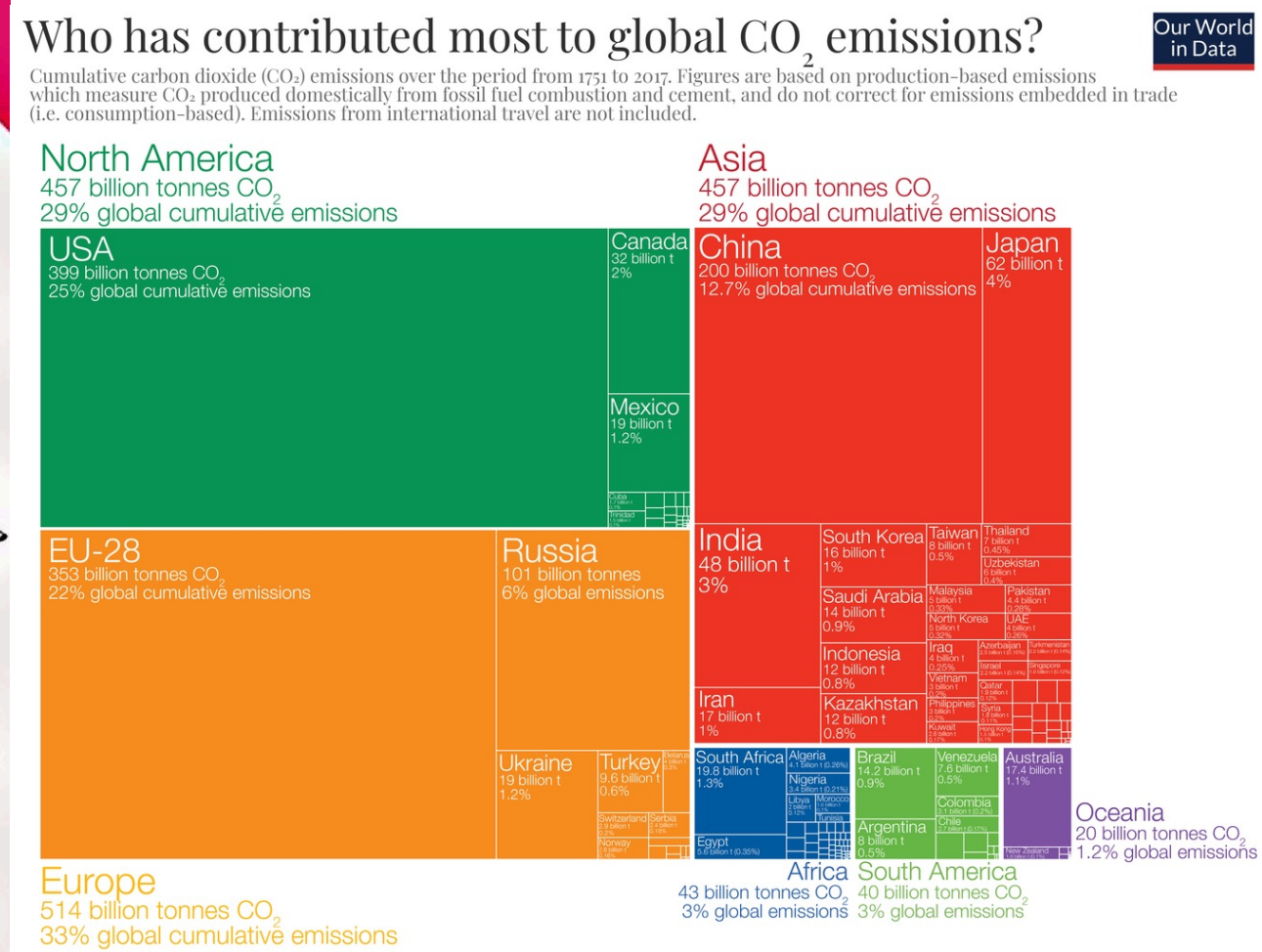


Fraction of Grid Cell in Croplands

BIOME 300
PAGES
LUCC

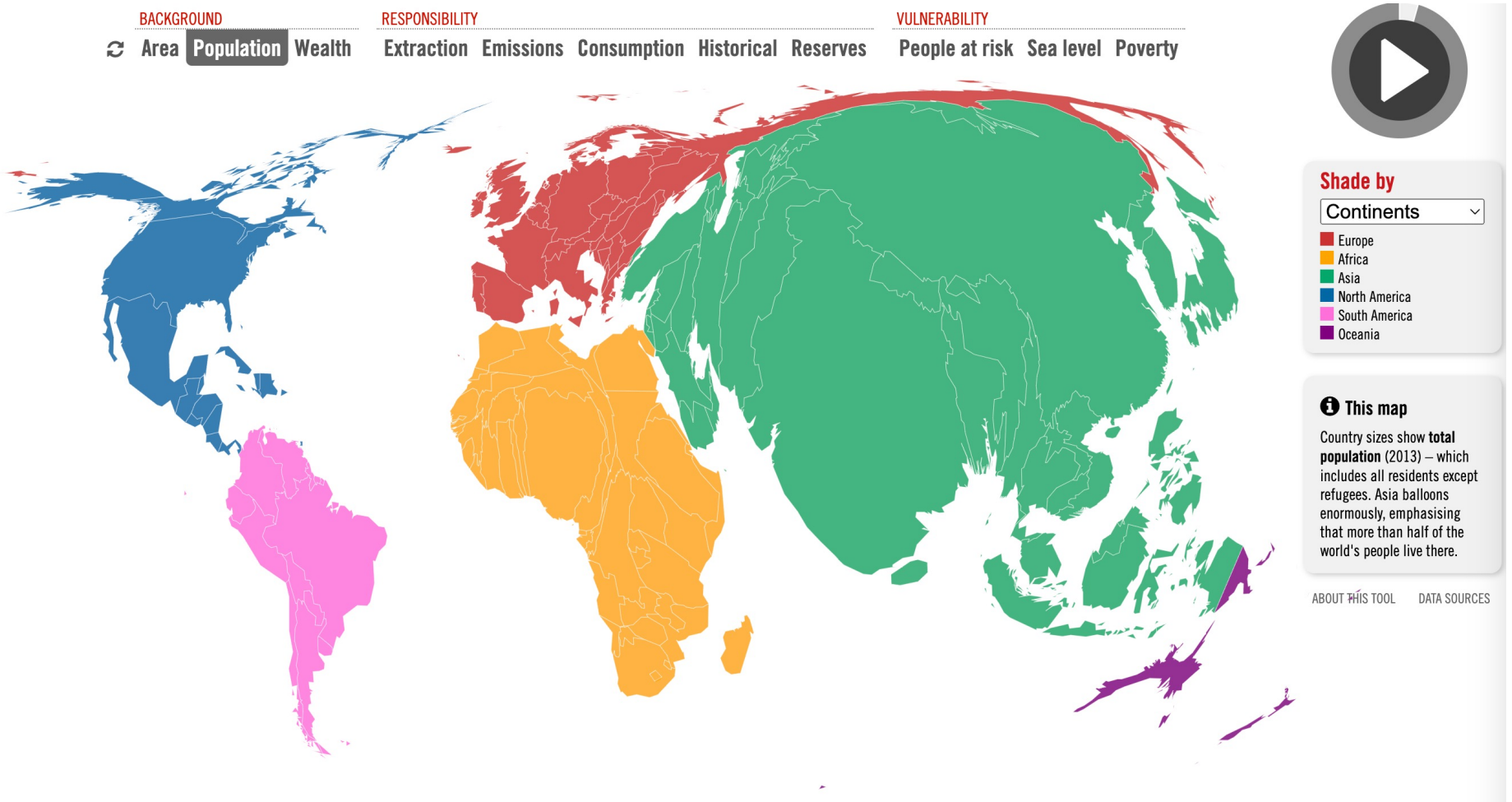


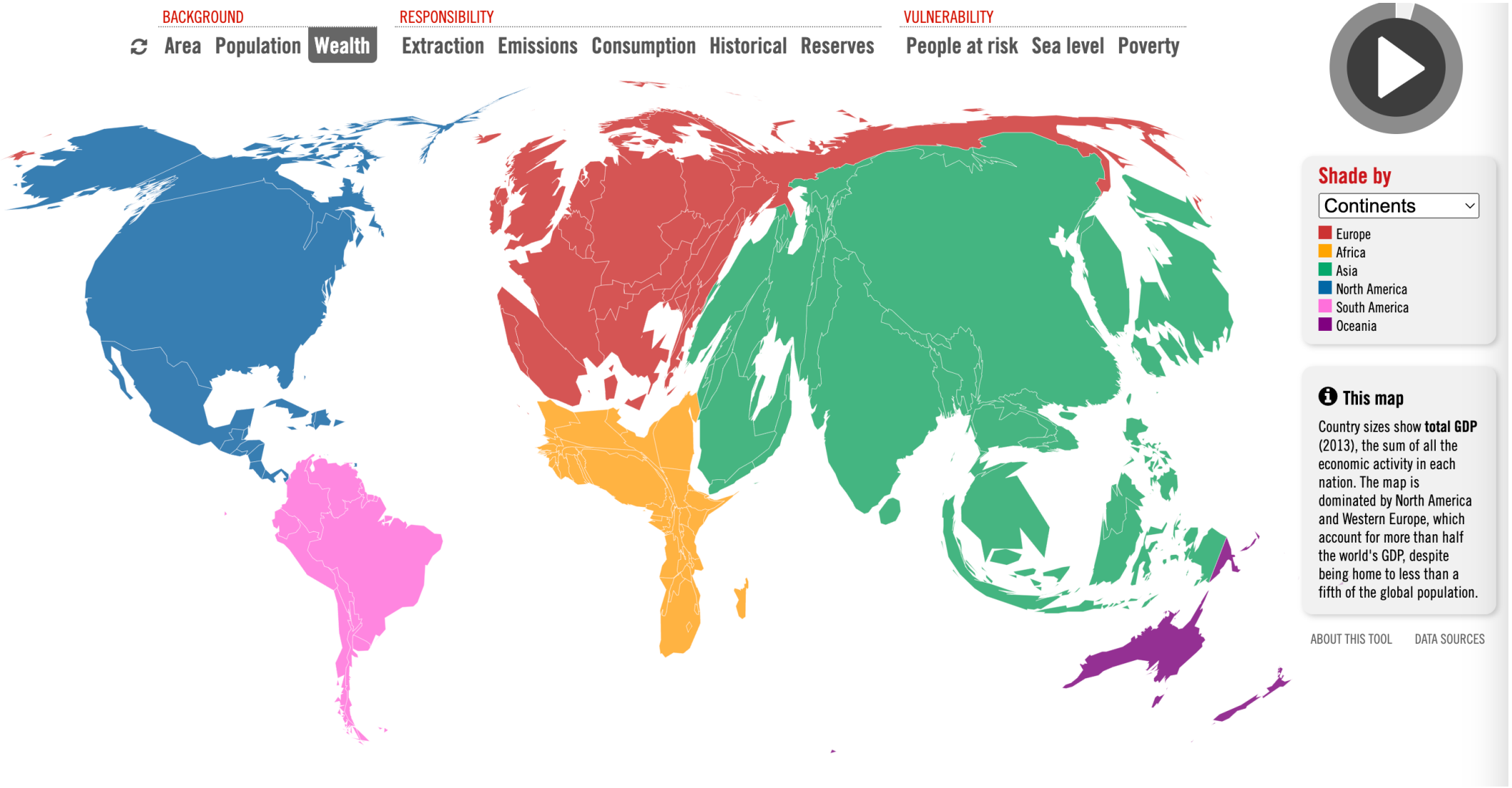
UN, Department of Global Communications | August 2023



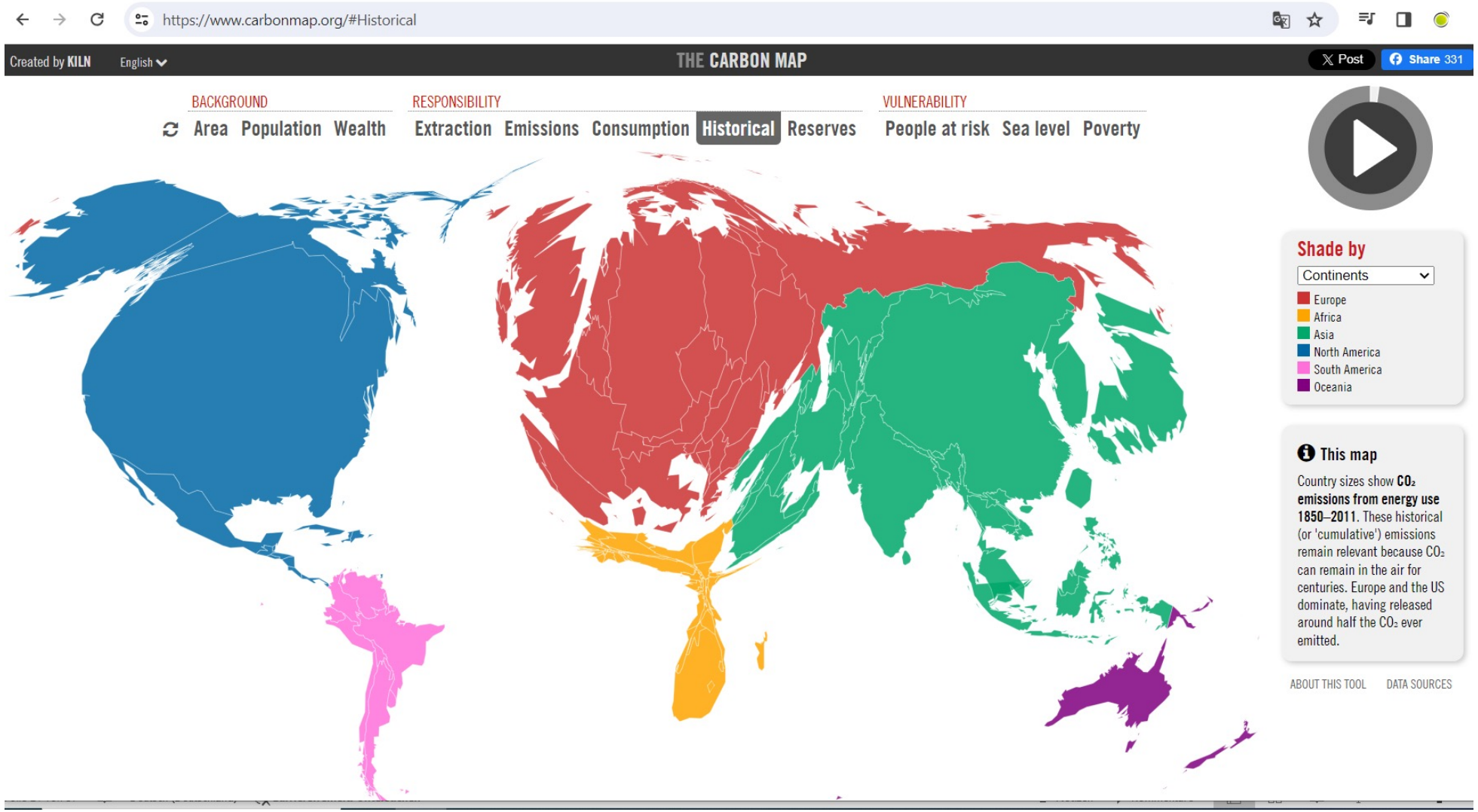
Figures for the 28 countries in the European Union have been grouped as the 'EU-28' since international targets and negotiations are typically set as a collaborative target between EU countries. Values may not sum to 100% due to rounding.

Data source: Calculated by Our World in Data based on data from the Global Carbon Project (GCP) and Carbon Dioxide Analysis Center (CDIAC).
This is a visualization from OurWorldinData.org, where you find data and research on how the world is changing.


BACKGROUND
Area
Population
Wealth
RESPONSIBILITY
Extraction
Emissions
Consumption
Historical
Reserves
VULNERABILITY
People at risk
Sea level
Poverty
Shade by
Continents
Europe
Africa
Asia
North America
South America
Oceania
This map
Country sizes show total population (2013) – which includes all residents except refugees. Asia balloons enormously, emphasising that more than half of the world's people live there.
ABOUT THIS TOOL
DATA SOURCES

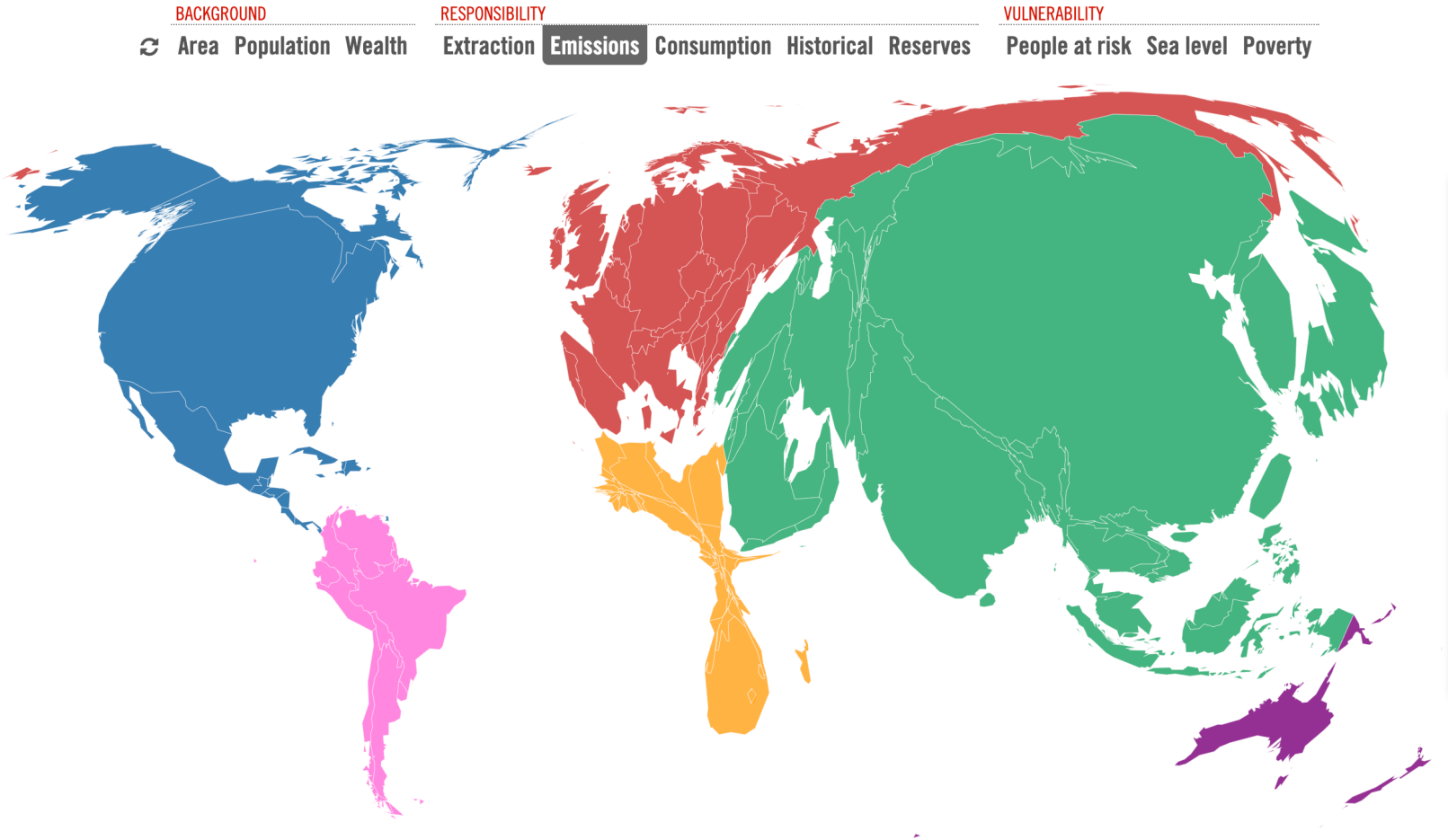


Country sizes show **total GDP** (2013), the sum of all the economic activity in each nation.

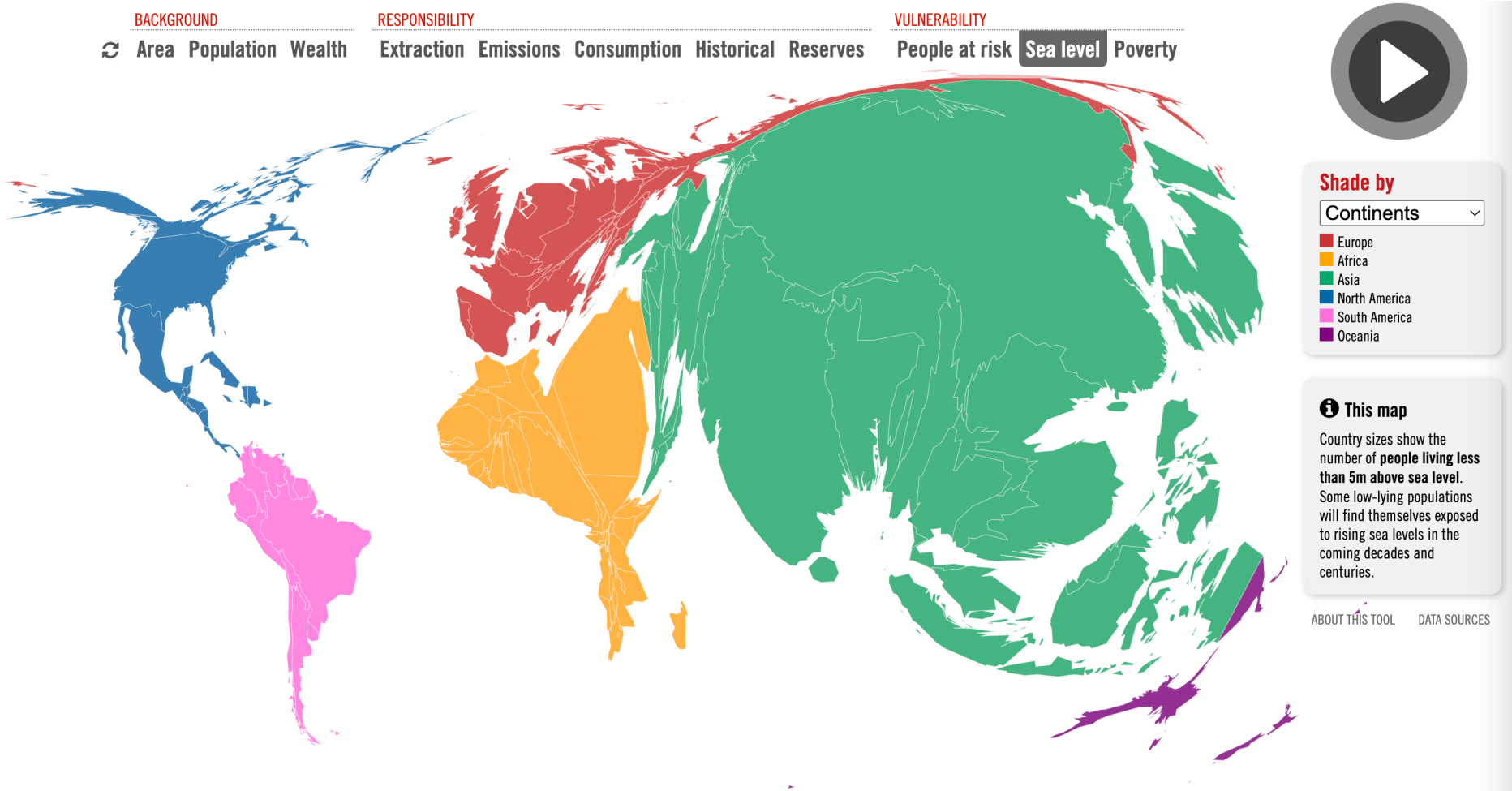


Country sizes show **CO_2 emissions from energy use 1850–2011**. These historical (or 'cumulative') emissions remain relevant because CO_2 can remain in the air for centuries. Europe and the US dominate, having released around half the CO_2 ever emitted.

carbonmap.org



Countries are sized to show their annual **CO_2 emissions from fossil fuel use** and cement production (2013). This is the conventional way to view national emissions, but it ignores imports and exports of fossil fuels (the Extraction map) and goods and services (the Consumption map).



Country sizes show the number of **people living less than 5m above sea level**. Some low-lying populations will find themselves exposed to rising sea levels in the coming decades and centuries.

Where is the CO_2 ?

Sources = **Sinks**

34.8 $GtCO_2$/yr

89%

11%

4.1 $GtCO_2$/yr

18.6 $GtCO_2$/yr

48%

29%

11.2 $GtCO_2$/yr

26%

10.2 $GtCO_2$/yr

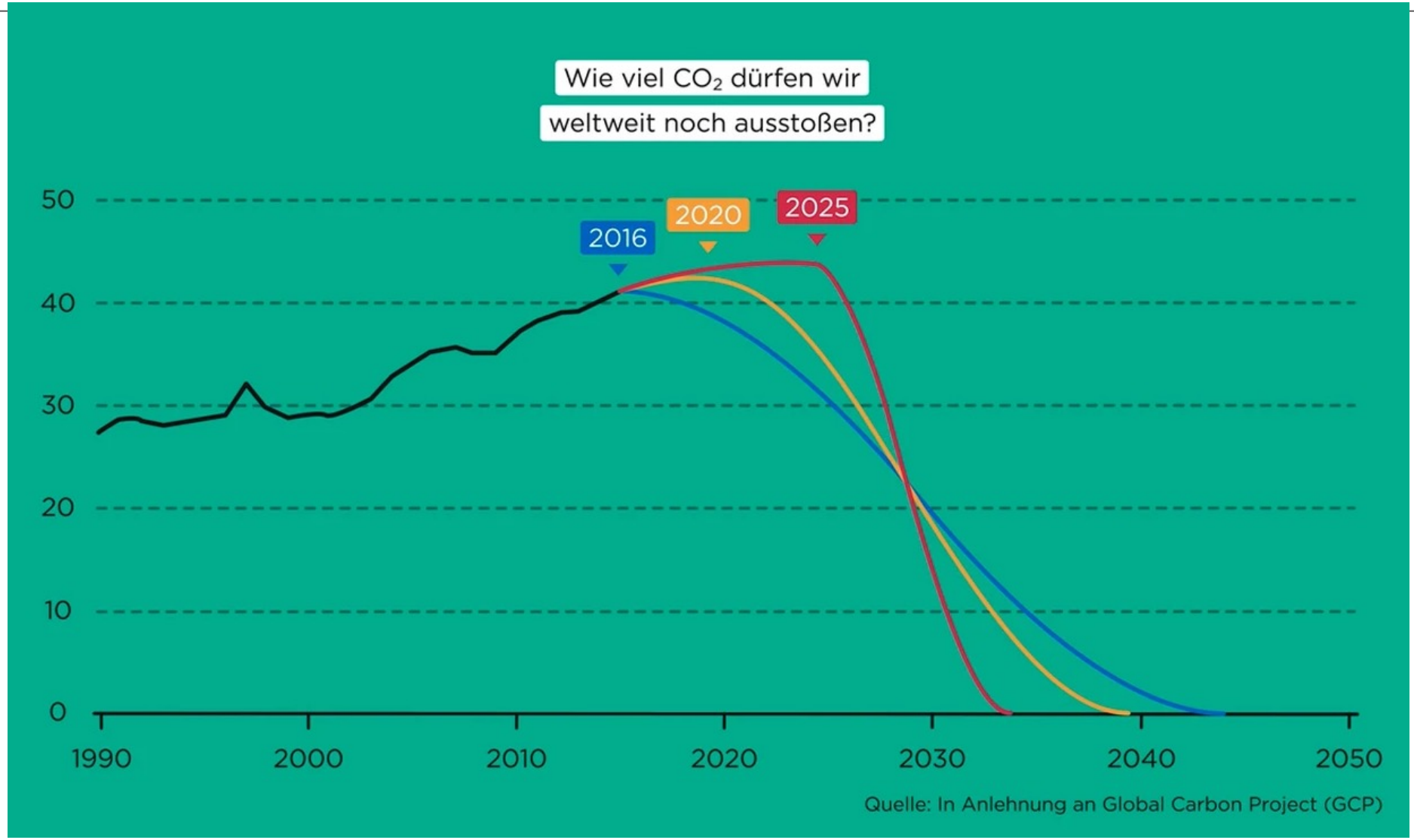
Budget Imbalance:
(the difference between estimated sources & sinks)

3%

-1.0 $GtCO_2$/yr

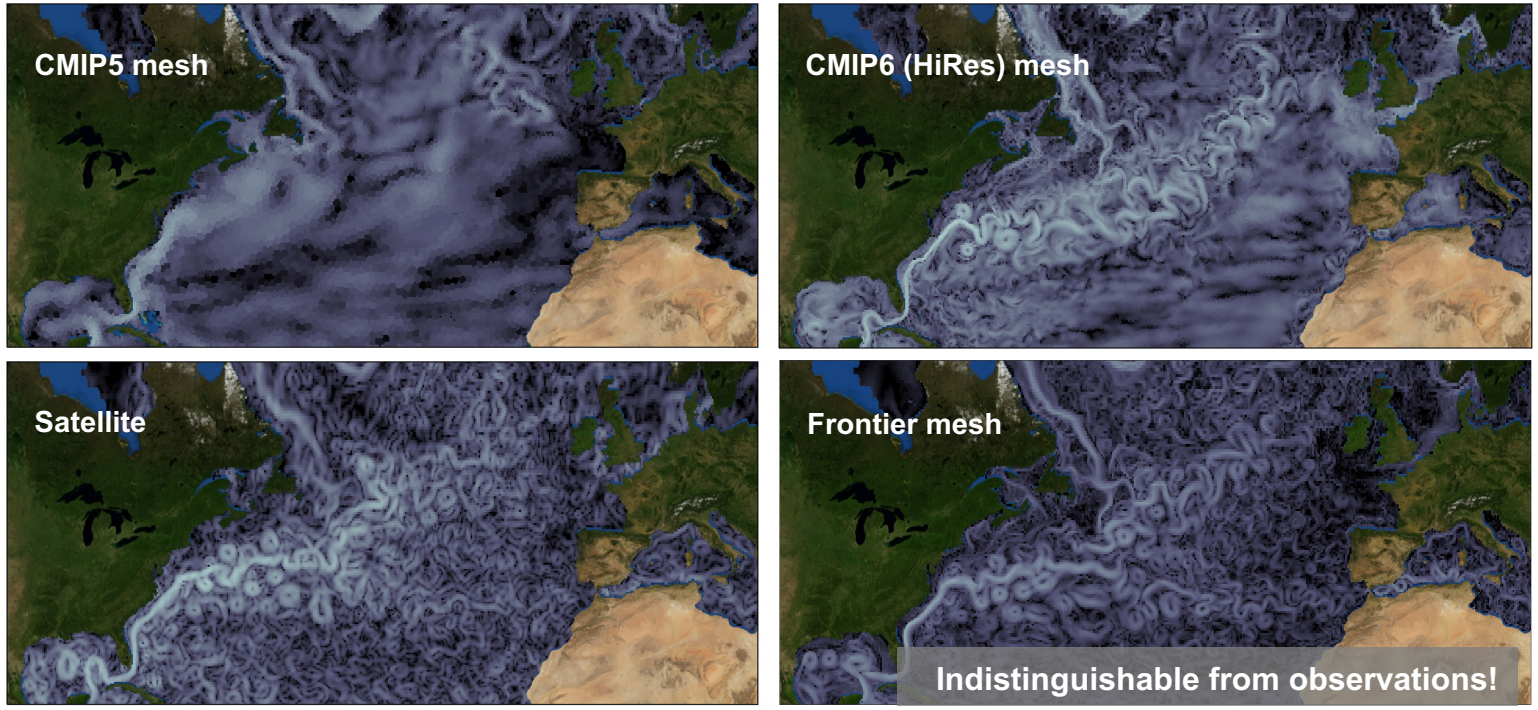
(Data: 2011-2020)

GLOBAL CARBON PROJECT

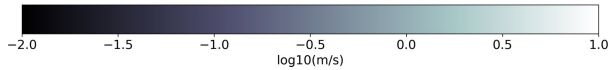


How realistic are models ?

Ocean velocity



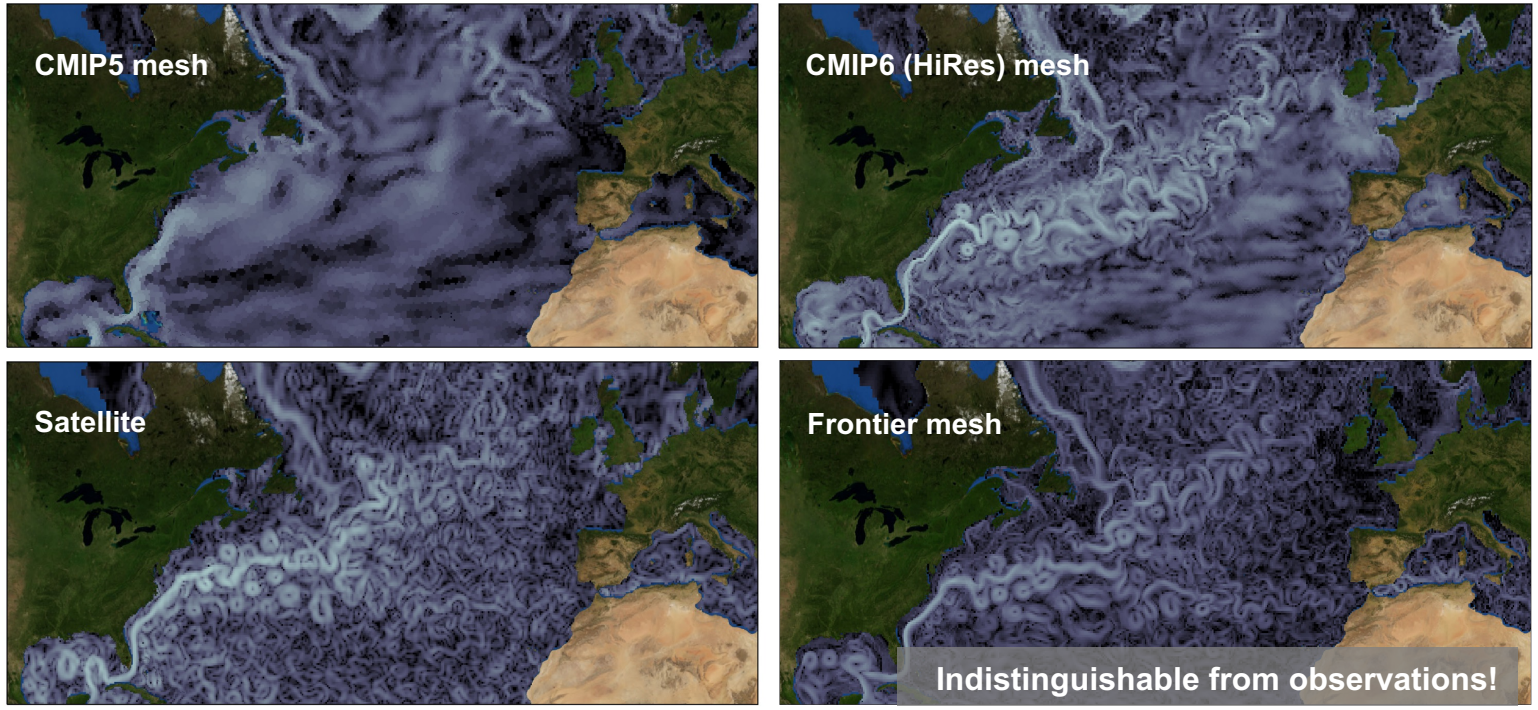
Displayed on a common 1/4° mesh



Thanks to T. Jung

How realistic are models ?

Ocean velocity



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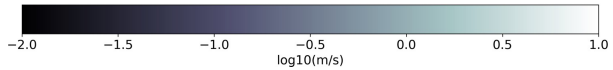
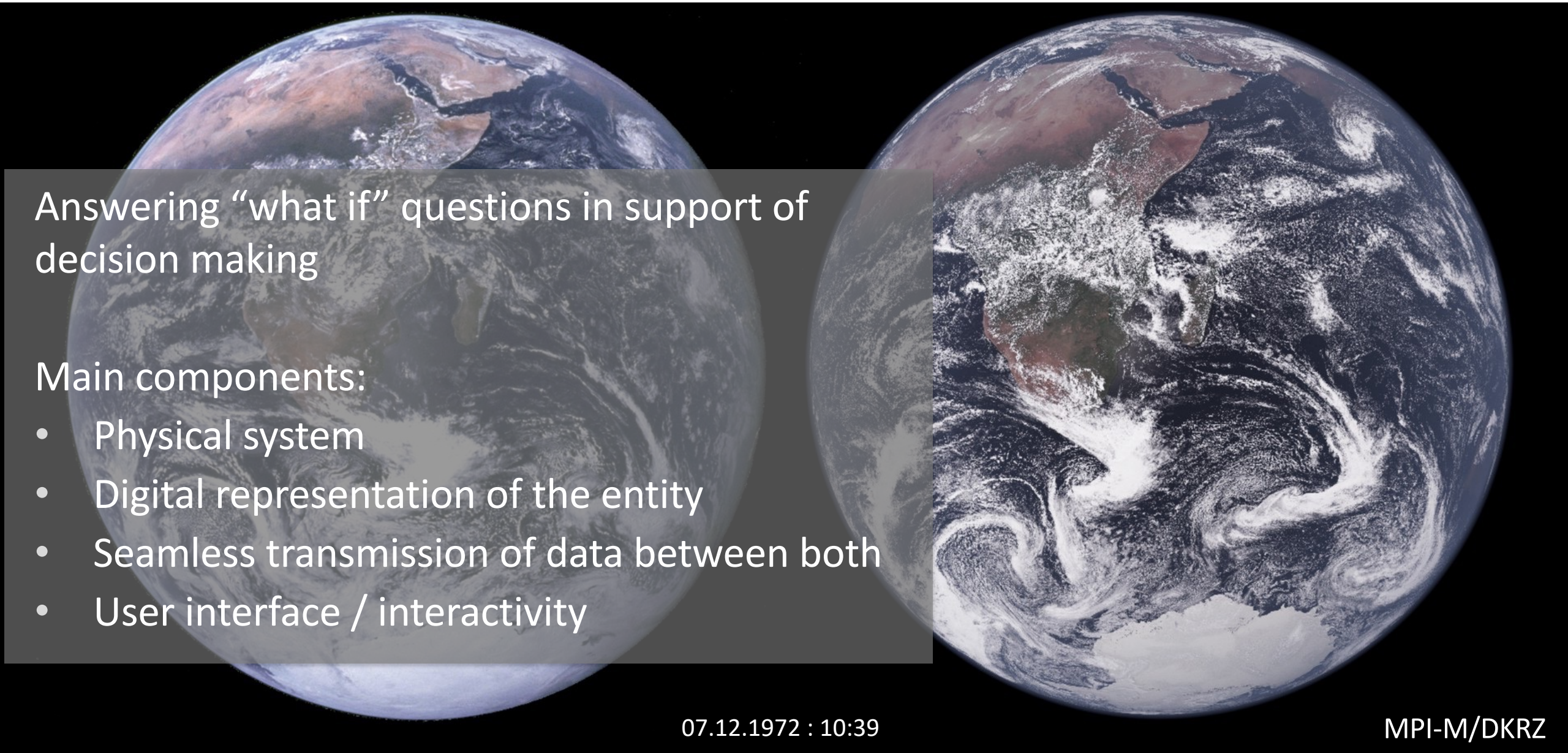


➔ **Large uncertainties in regional changes**

➔ **Limitations for extreme events**

As an outlook … Digital Twins



Answering “what if” questions in support of decision making

Main components:

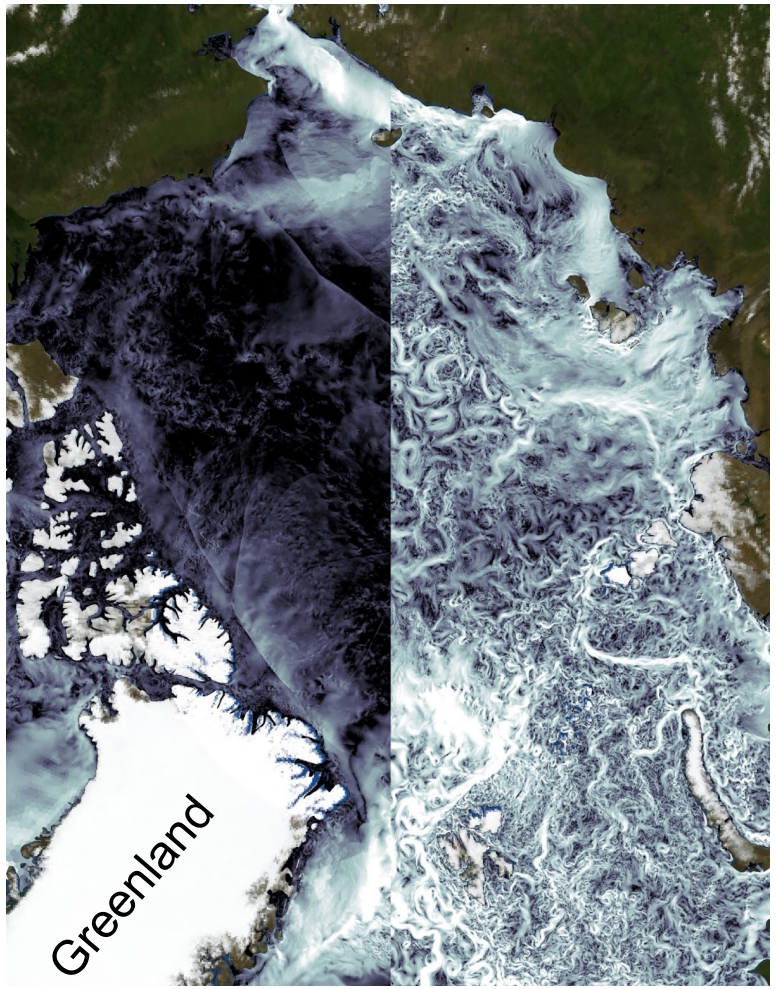
- Physical system
- Digital representation of the entity
- Seamless transmission of data between both
- User interface / interactivity

07.12.1972 : 10:39

MPI-M/DKRZ

Climate model simulations: Look into a 4° C warmer world

Present day +4° C warmer world



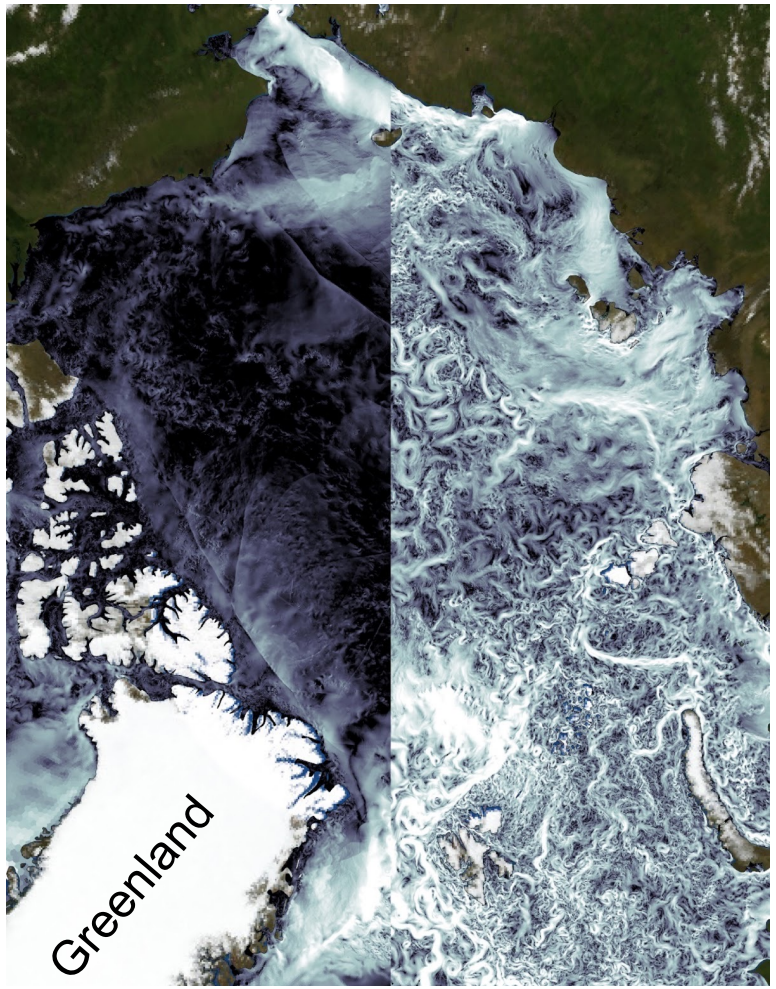
Snapshots of ocean currents and eddy activity

Li et al. (2024)

HELMHOLTZ

Climate model simulations: Look into a 4° C warmer world

Present day +4° C warmer world



Snapshots of ocean currents and eddy activity

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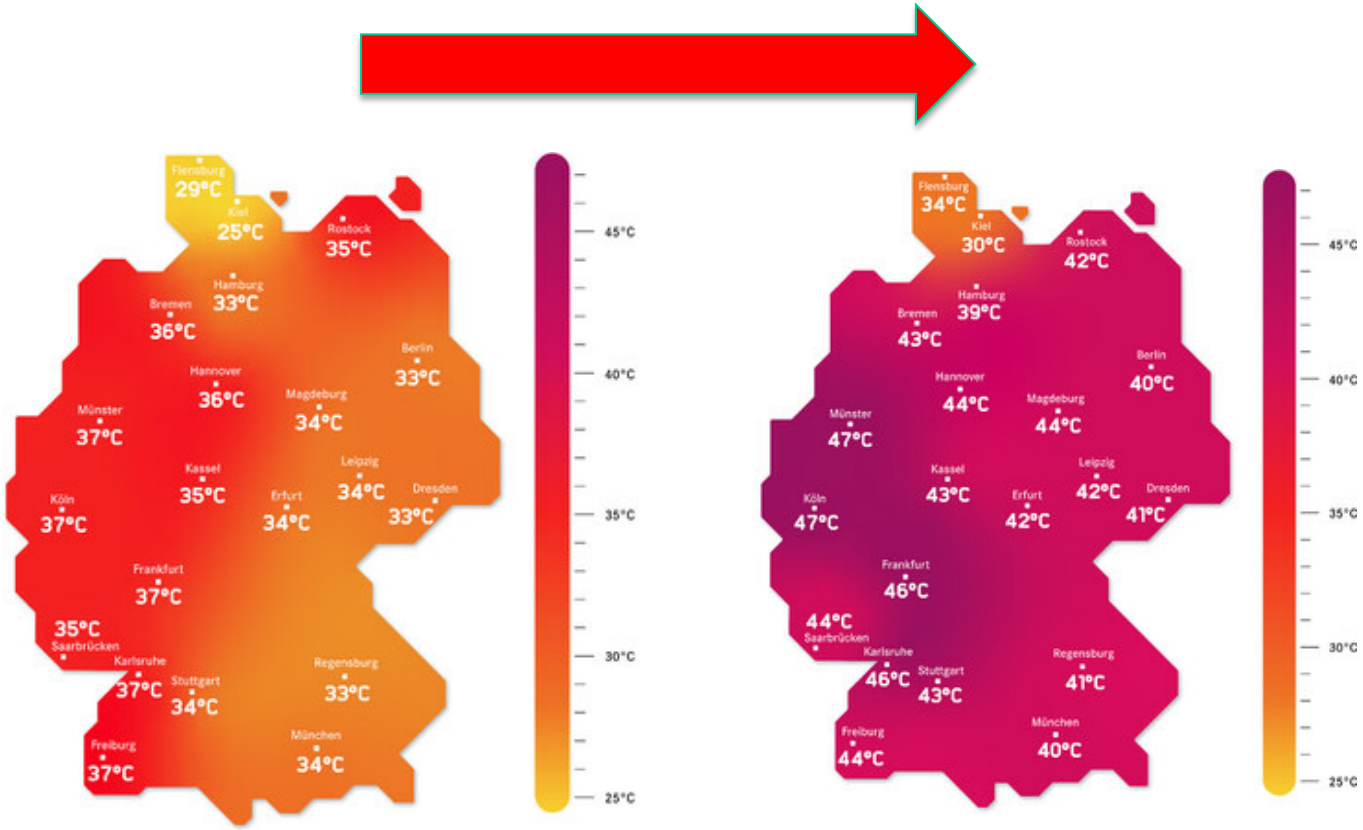


Evolution of the amplitude of heat extremes in Germany

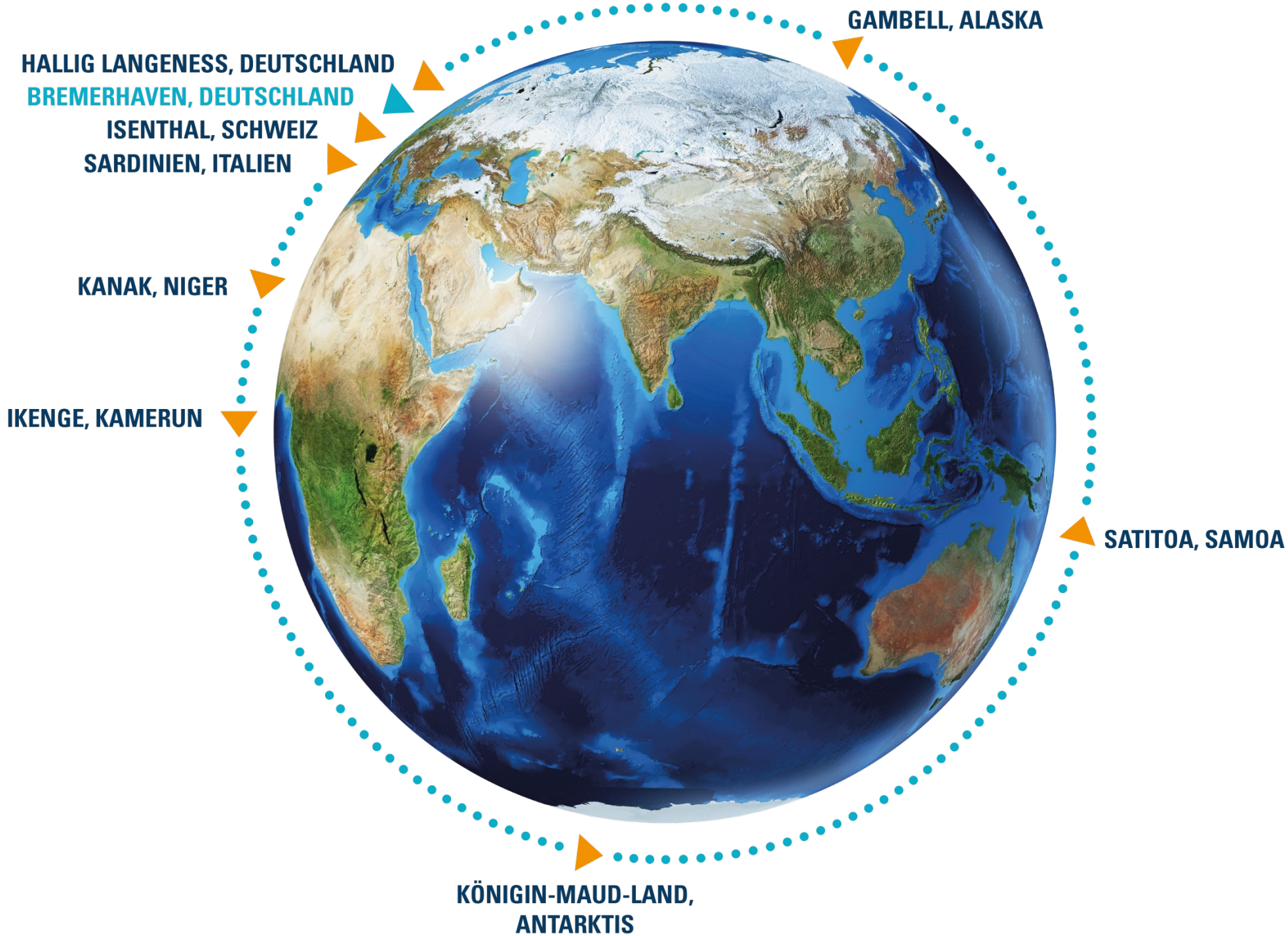
Strong heterogeneity due to atmospheric circulation

INNOPOOL Project Gössling et al., 2024

Klimahaus Bremerhaven

Es geht um die Welt

KLIMAHAUS®
BREMERHAVEN


GAMBELL, ALASKA
HALLIG LANGENESS, DEUTSCHLAND
BREMERHAVEN, DEUTSCHLAND
ISENTHAL, SCHWEIZ
SARDINIEN, ITALIEN
KANAK, NIGER
IKENGE, KAMERUN
SATITOA, SAMOA
KÖNIGIN-MAUD-LAND,
ANTARKTIS


Journey


WORLD FUTURE LAB
Gestalte deine Zukunft


perspectives

Traces of rainforests in West Antarctica

90 million-year-old forest soil provides unexpected evidence for exceptionally warm climate near the South Pole in the Cretaceous

Klages et al. 2021, Nature. doi: 10.1038/s41586-020-2148-5

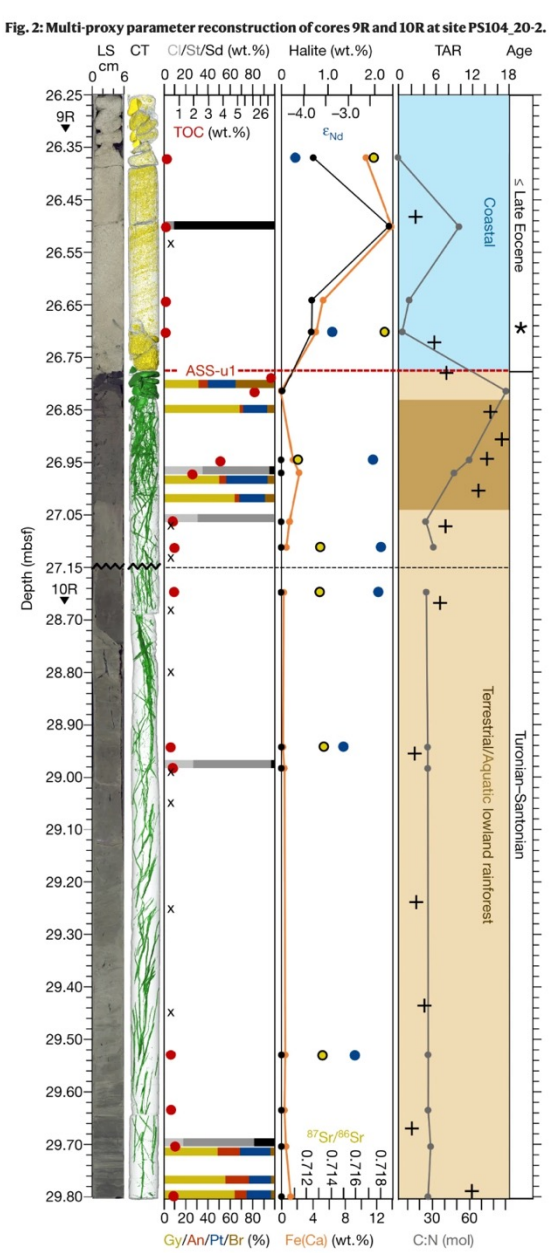


Fig. 2: Multi-proxy parameter reconstruction of cores 9R and 10R at site PS104_20-2. The MARUM-MeBo70 seafloor drill rig drilled 30.7 m into the seafloor and recovered 5.91 m of core length. The lower ~3 m consists of a fossil root-bearing mudstone with an ~5-cm-thick layer of brecciated lignite on top (from ~26.77 mbsf downwards), both of Turonian–Santonian age. A Late Eocene or younger quartzitic gravelly sandstone overlies the lignite. The upper lignite boundary defines the impedance contrast between the

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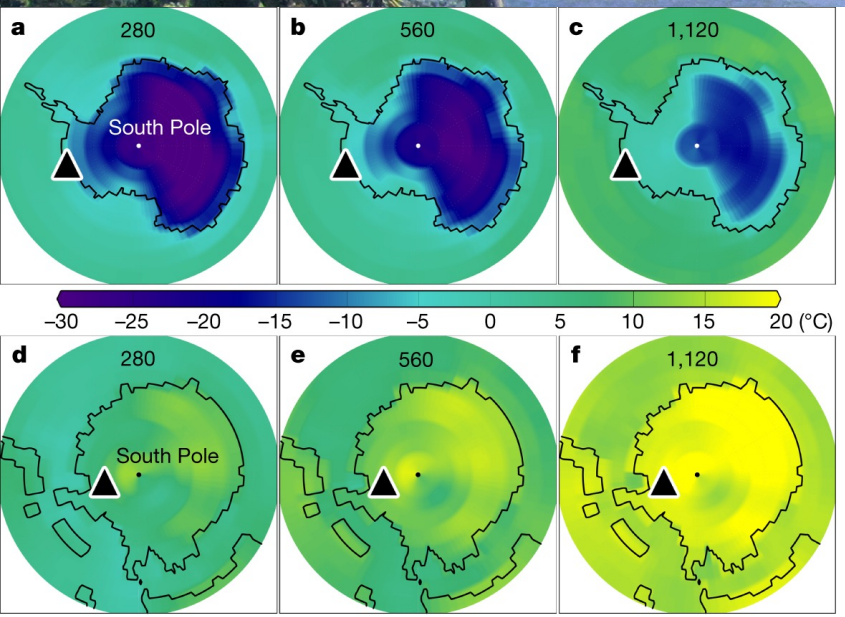

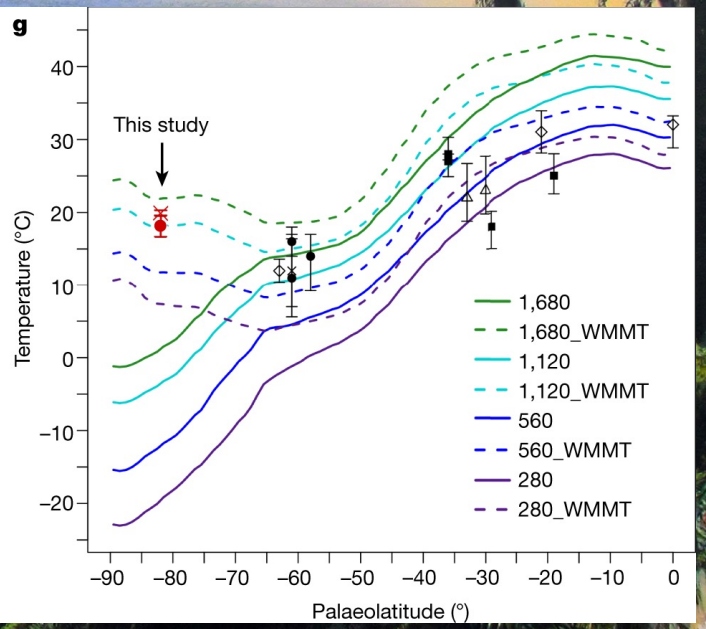

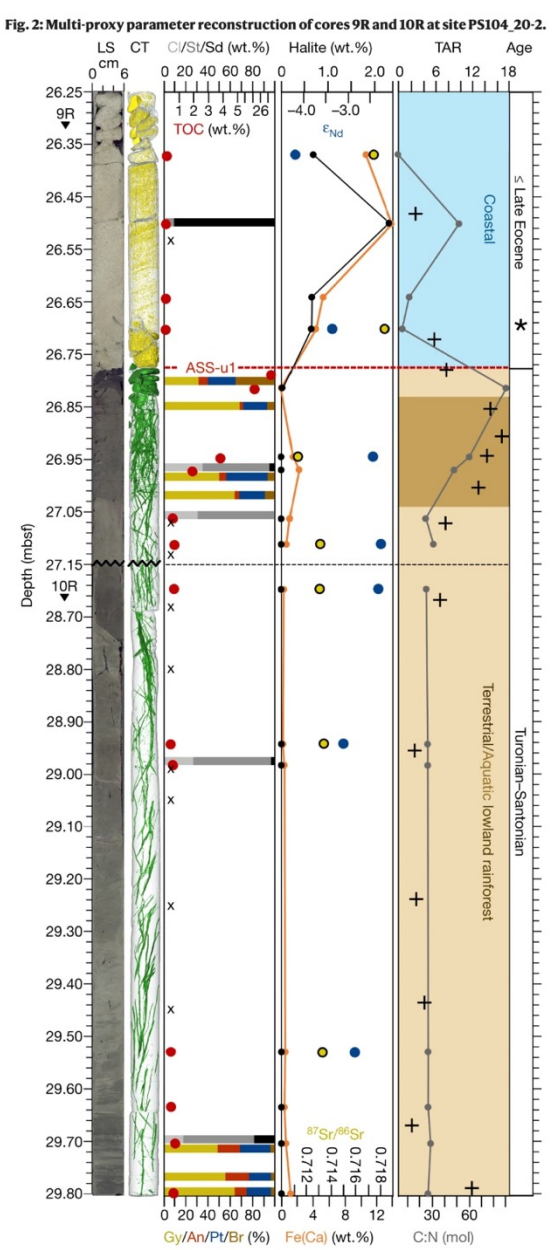

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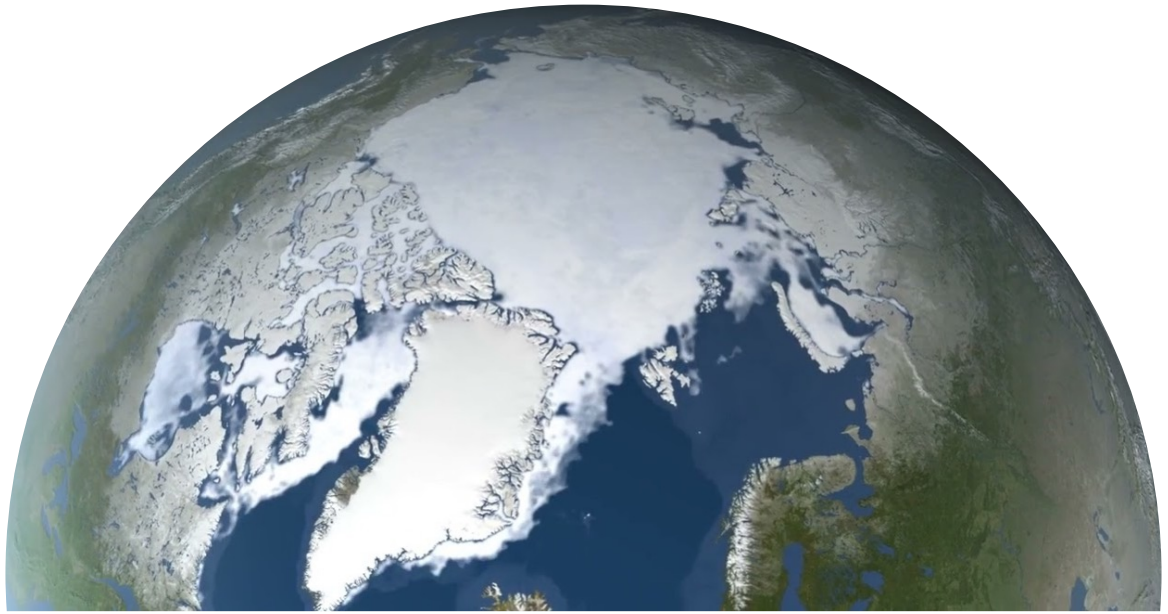
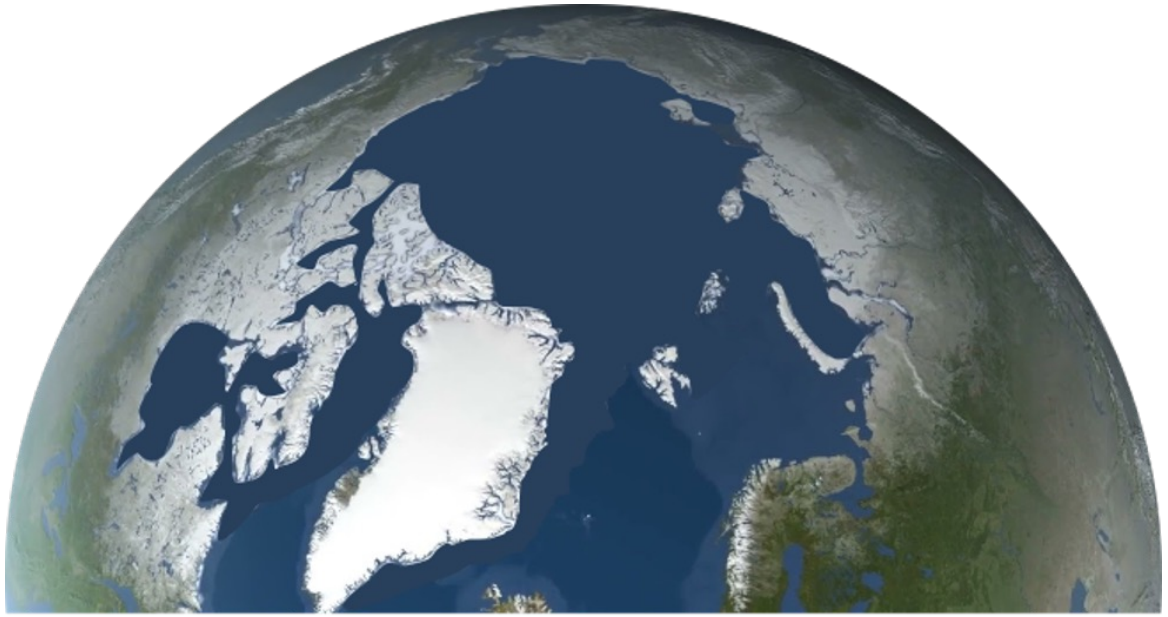
Klages et al. 2021, Nature. doi: 10.1038/s41586-020-2148-5

Into the Blue

TODAY



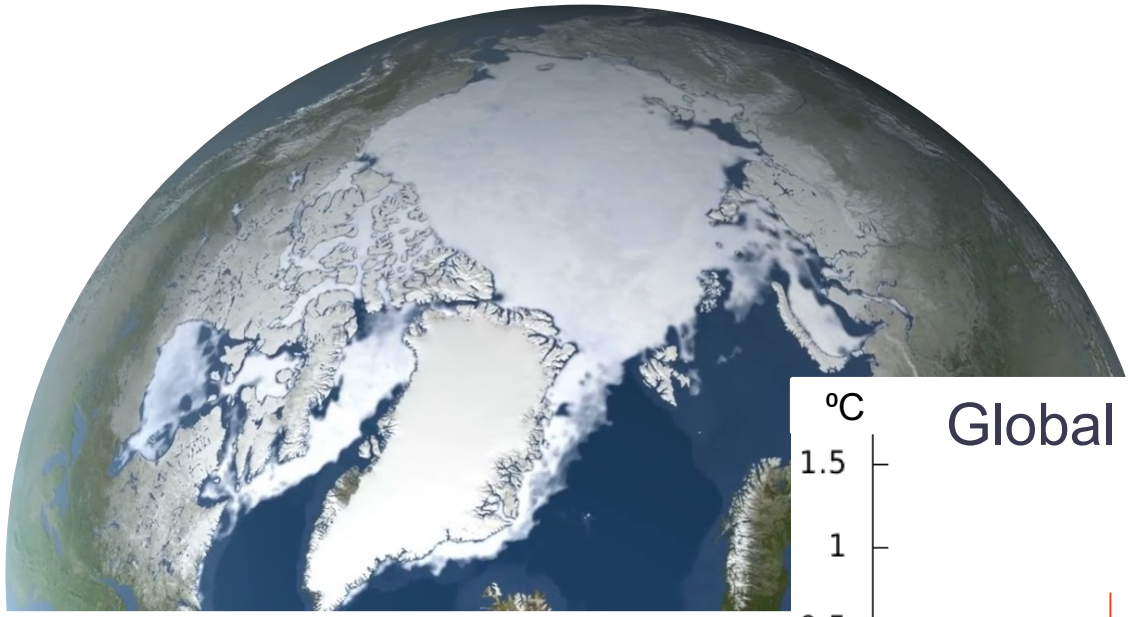
OUR FUTURE

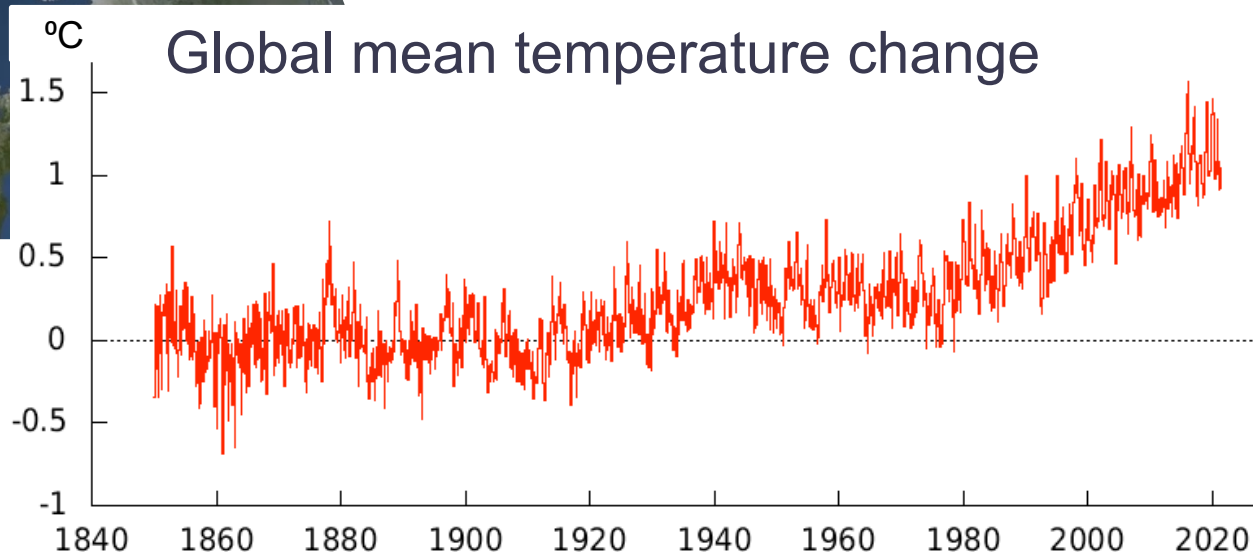


What will happen with our Arctic in a warmer world?

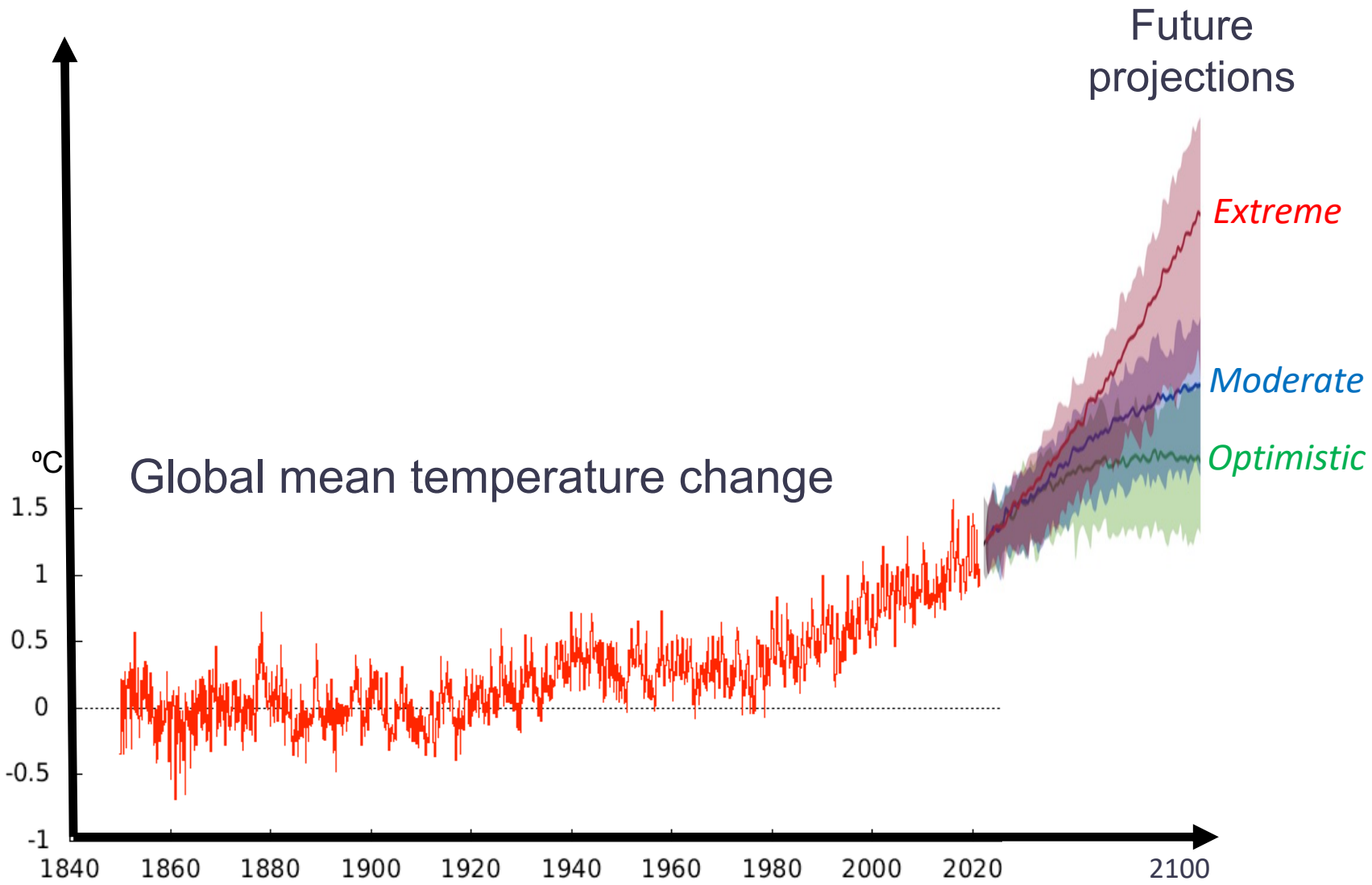
Why We Must Look Into The Past

TODAY





Why We Must Look Into The Past



Why We Must Look Into The Past

Miocene

~17 million years

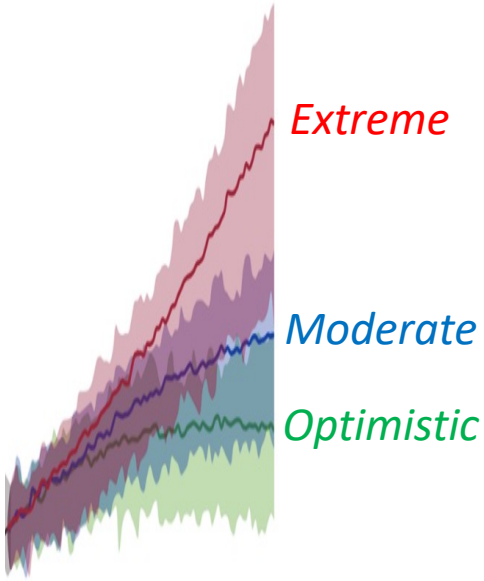
Pliocene

~3 million years

Interglacial

~130 000 years

Future projections



The Arctic Challenge

Lack of key Arctic archives

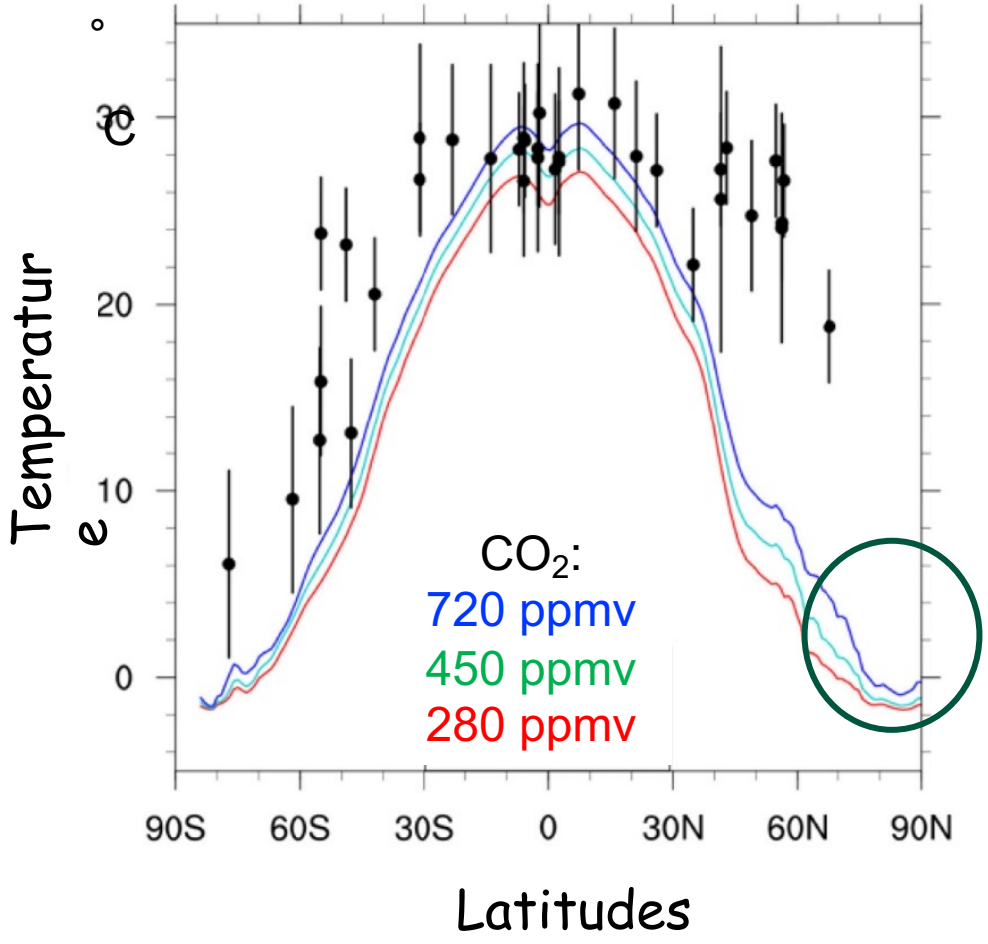
IODP ACEX Expedition, 2004

The Arctic Challenge

Lack of key Arctic archives

IODP ACEX Expedition, 2004

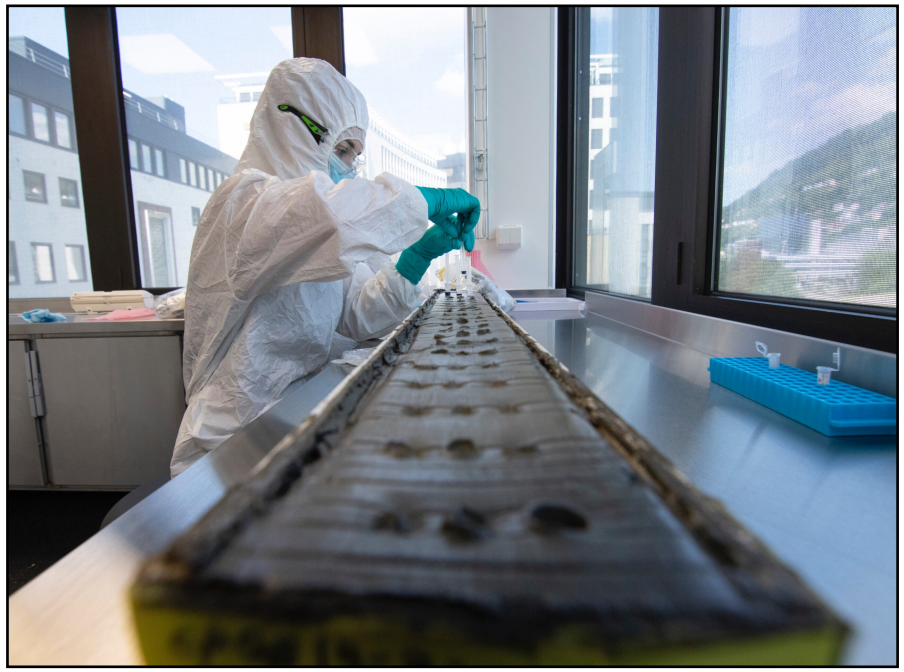
Lack of model skill

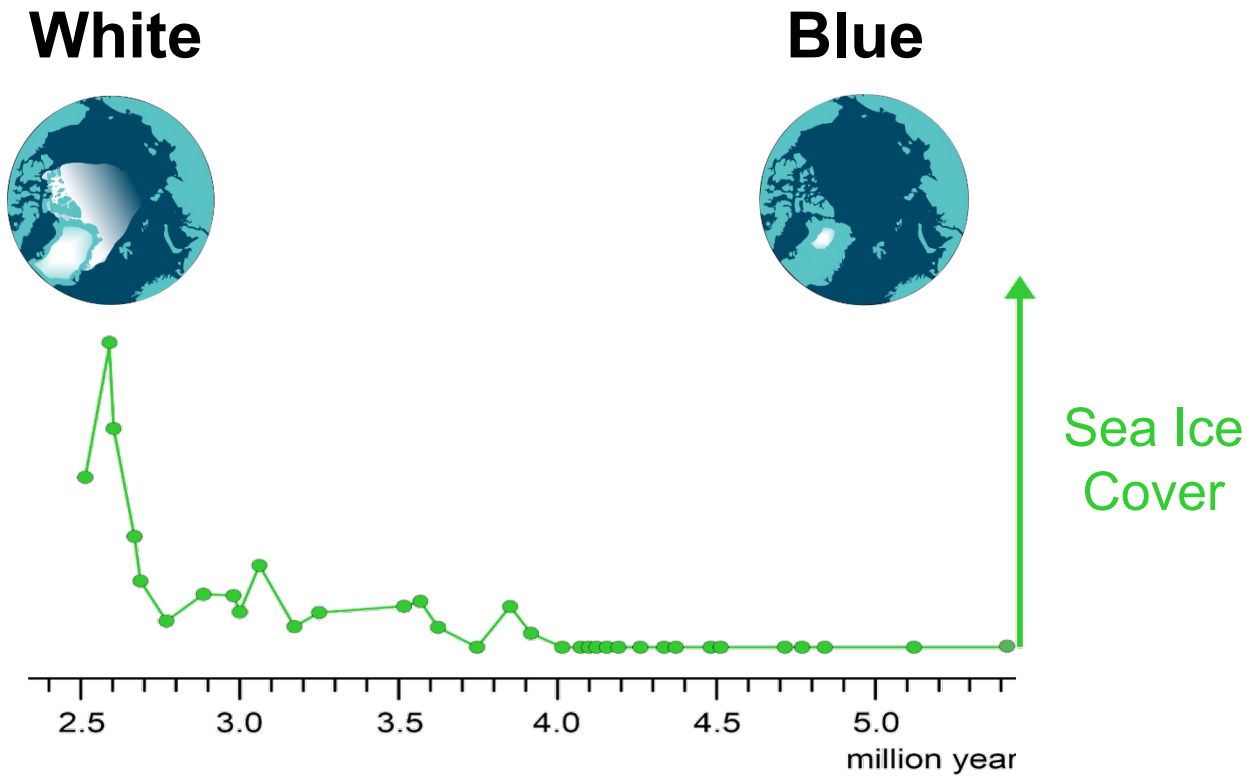


Hossain et al., 2023

Quantifying

Integration of novel and classical methods





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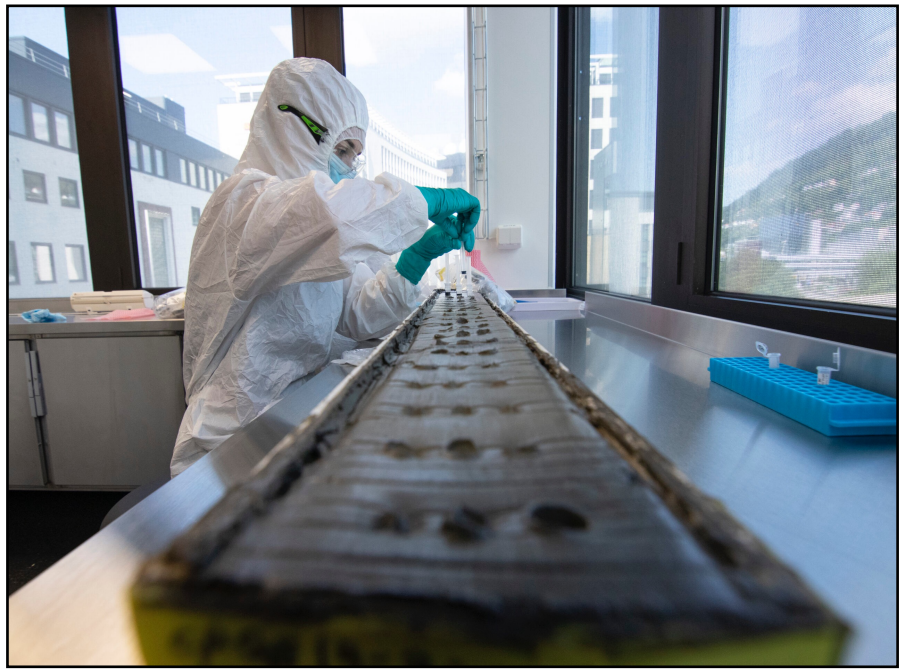
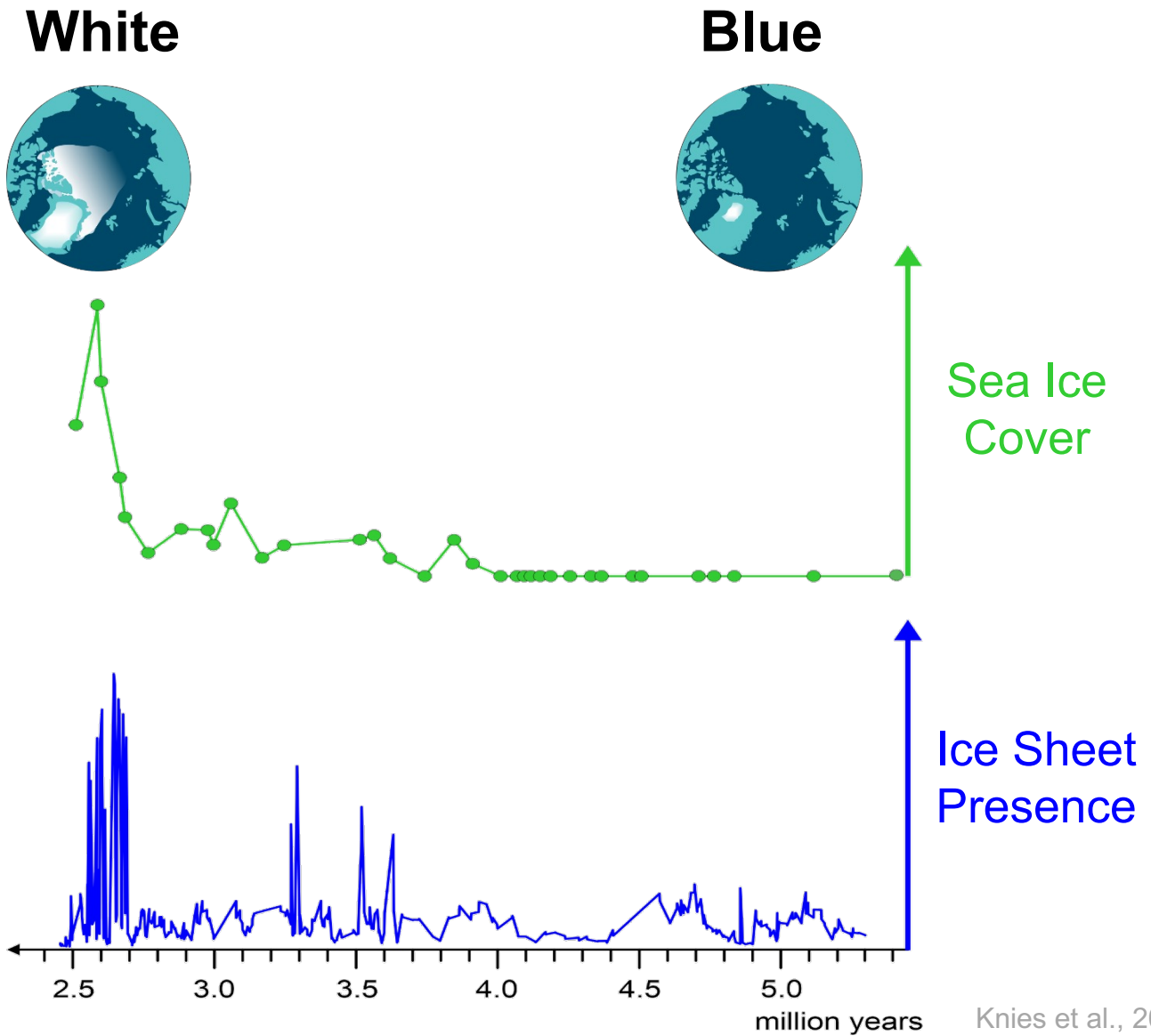
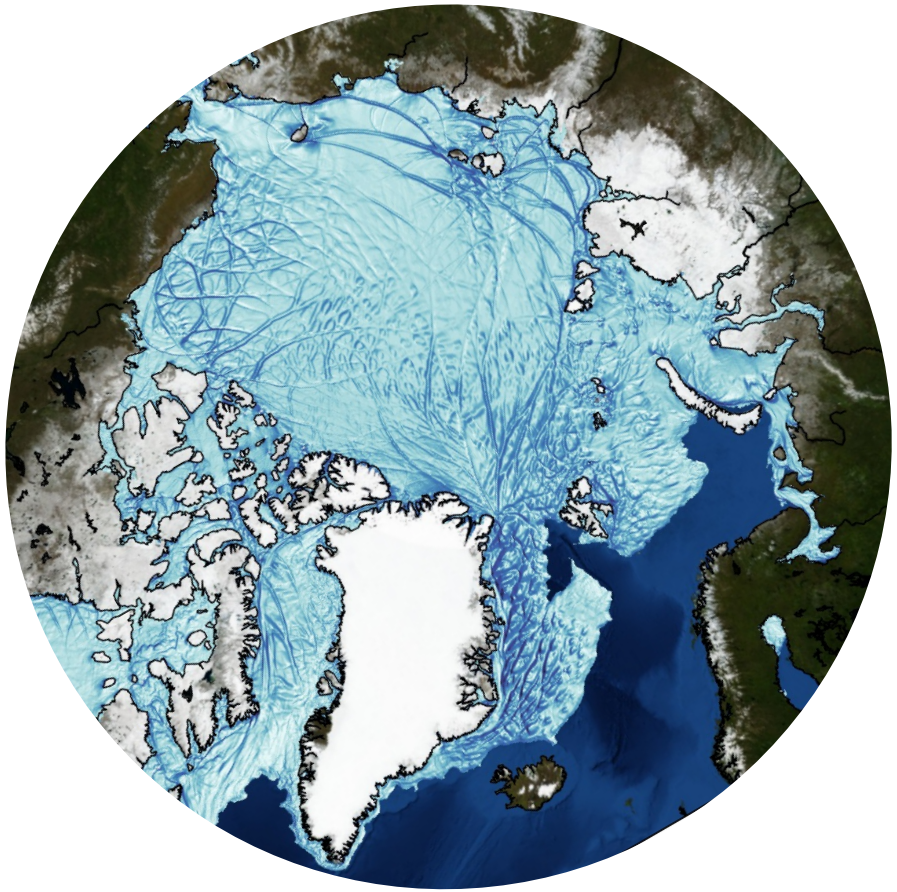




Knies et al., 2014

Understanding

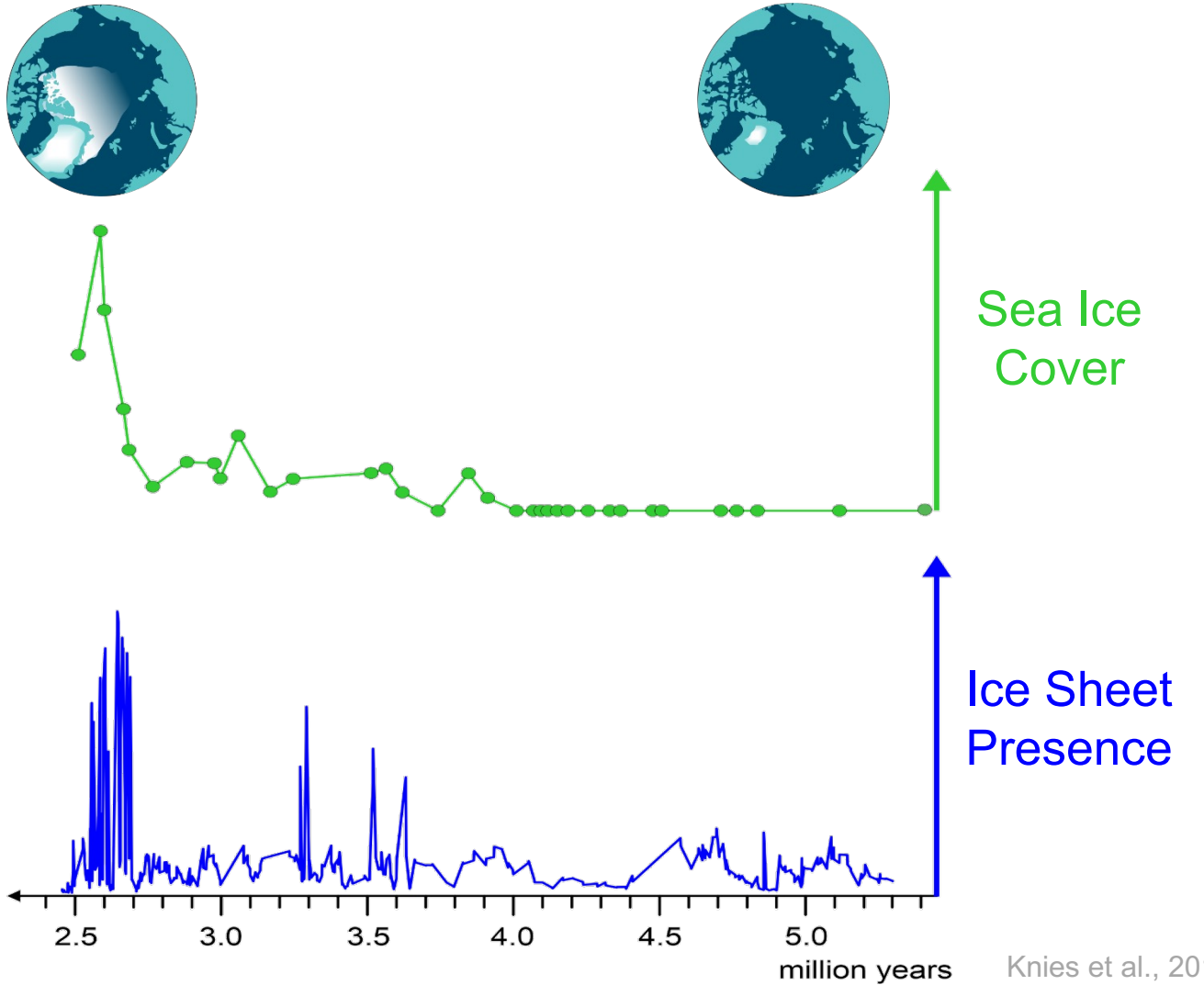
High-resolution, efficient model



Sein et al., 2017

White

Blue



Knies et al., 2014

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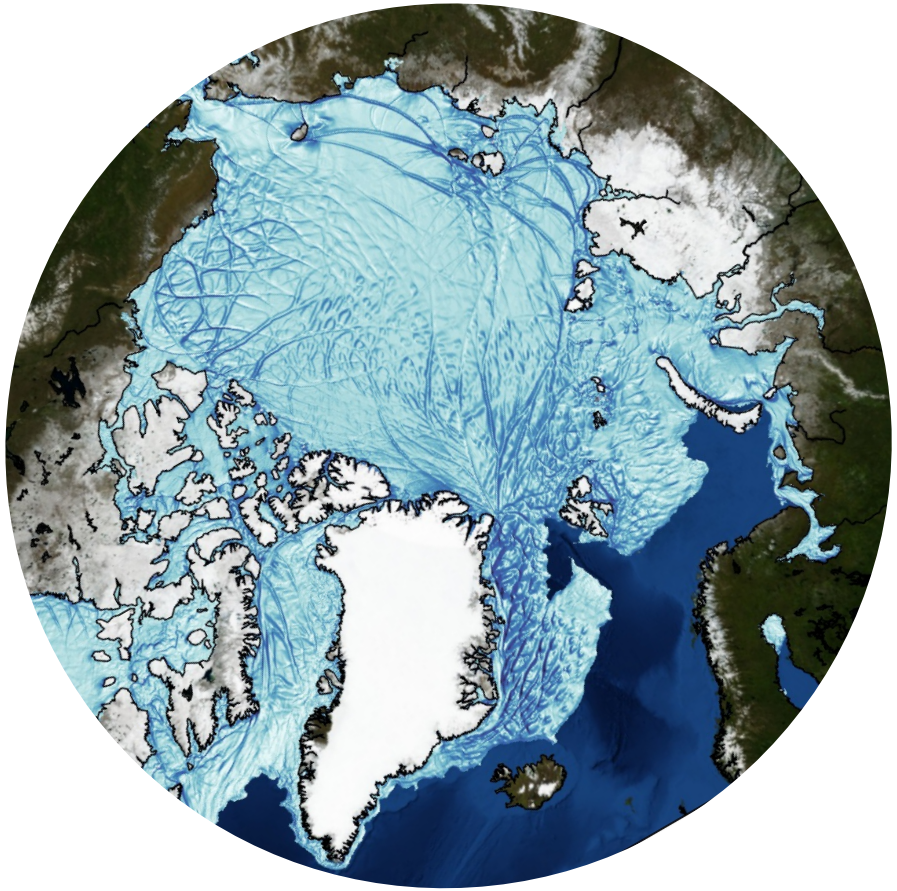
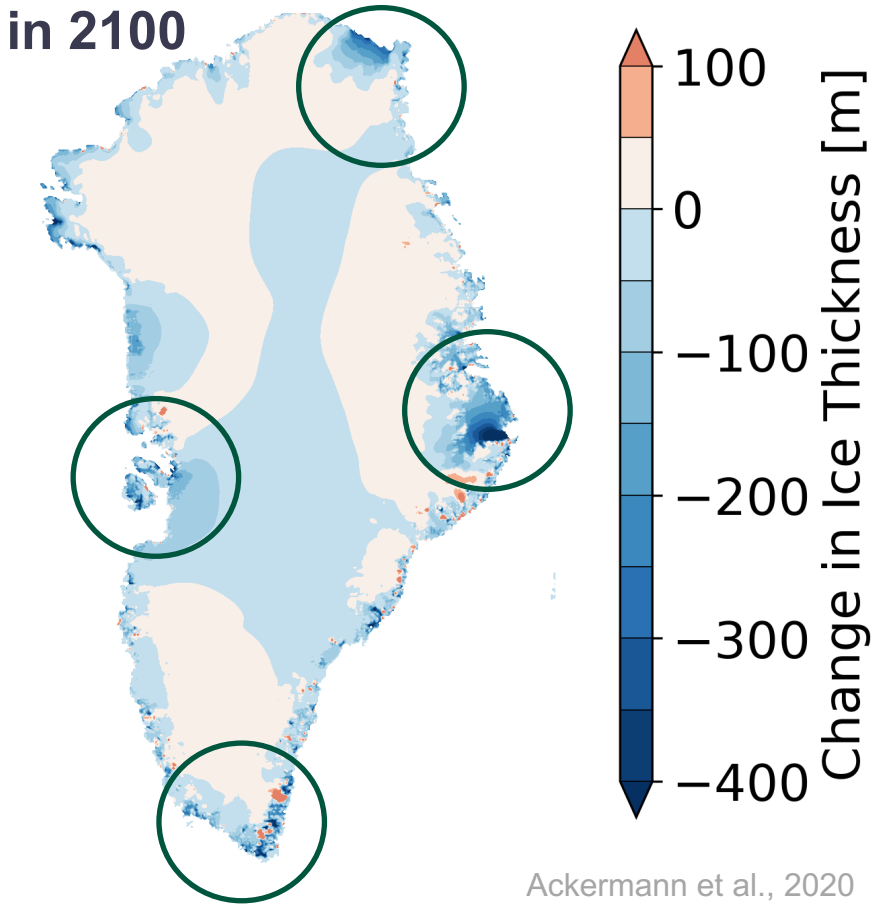


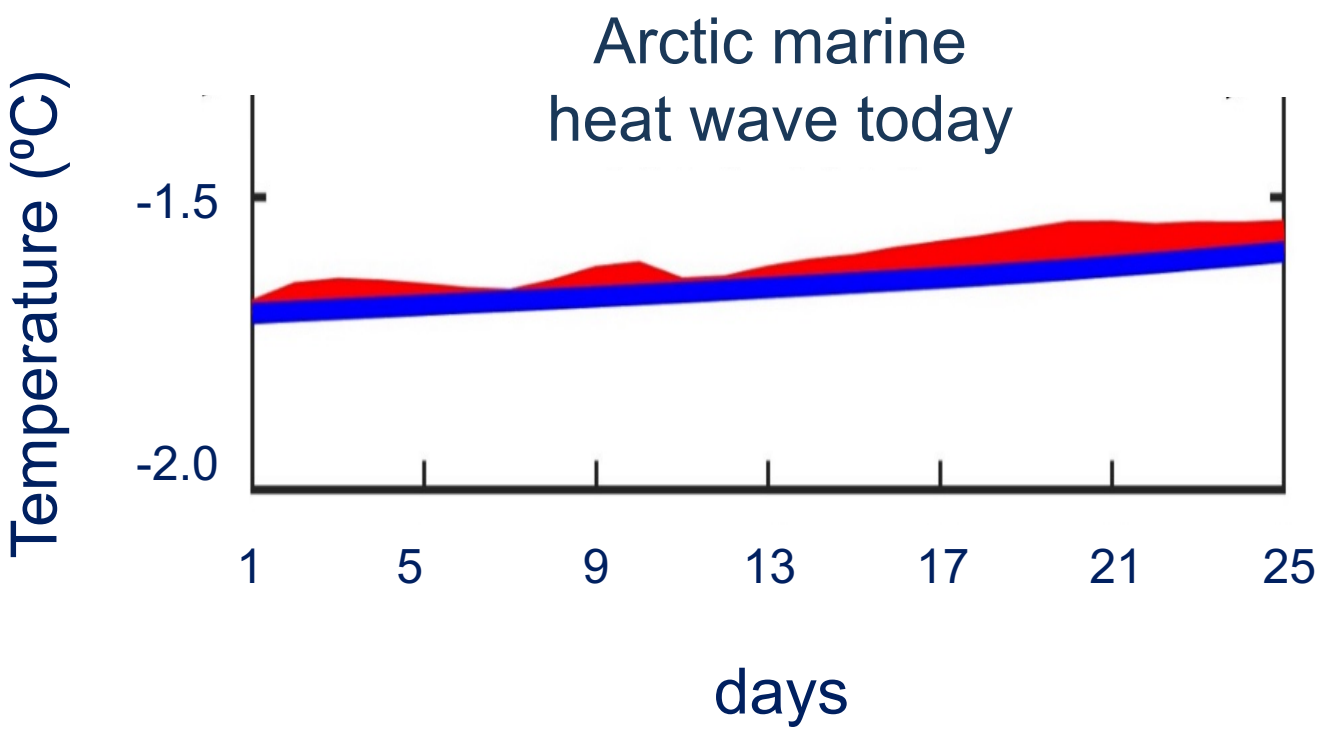
Sein et al., 2017

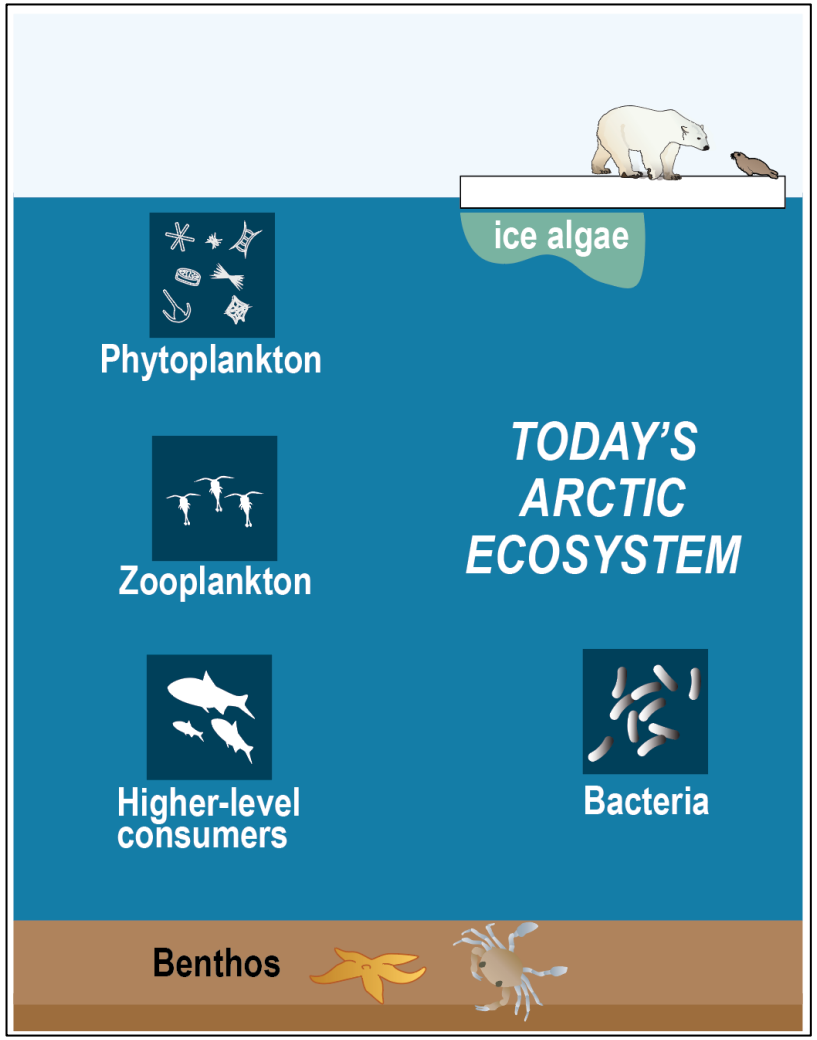
Changing ice sheets in the model



Ackermann et al., 2020

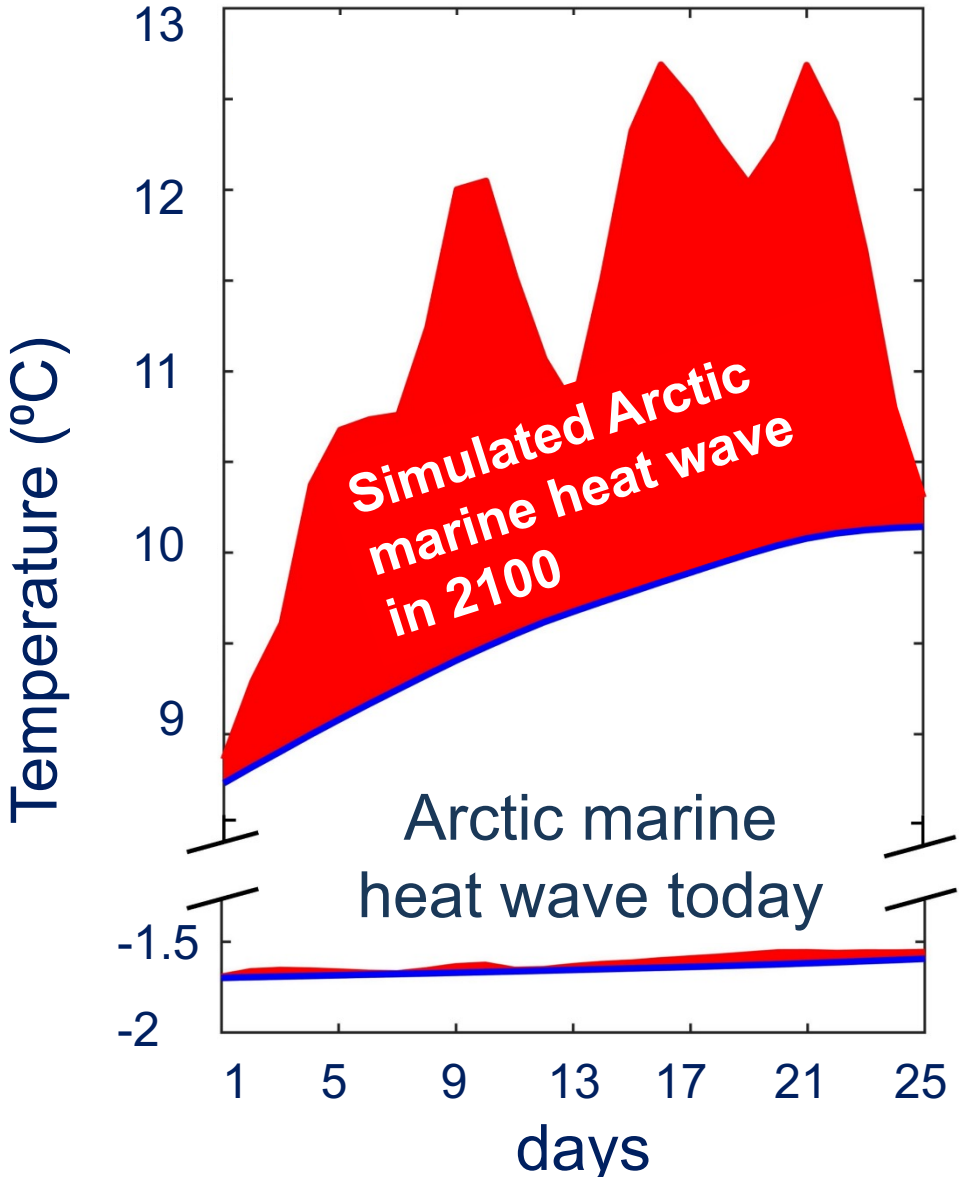
Impacts





Gou, Lohmann et al.

Impacts


Temperature (°C)
13
12
11
10
9
-1.5
-2
Simulated Arctic marine heat wave in 2100
Arctic marine heat wave today
1
5
9
13
17
21
25
days

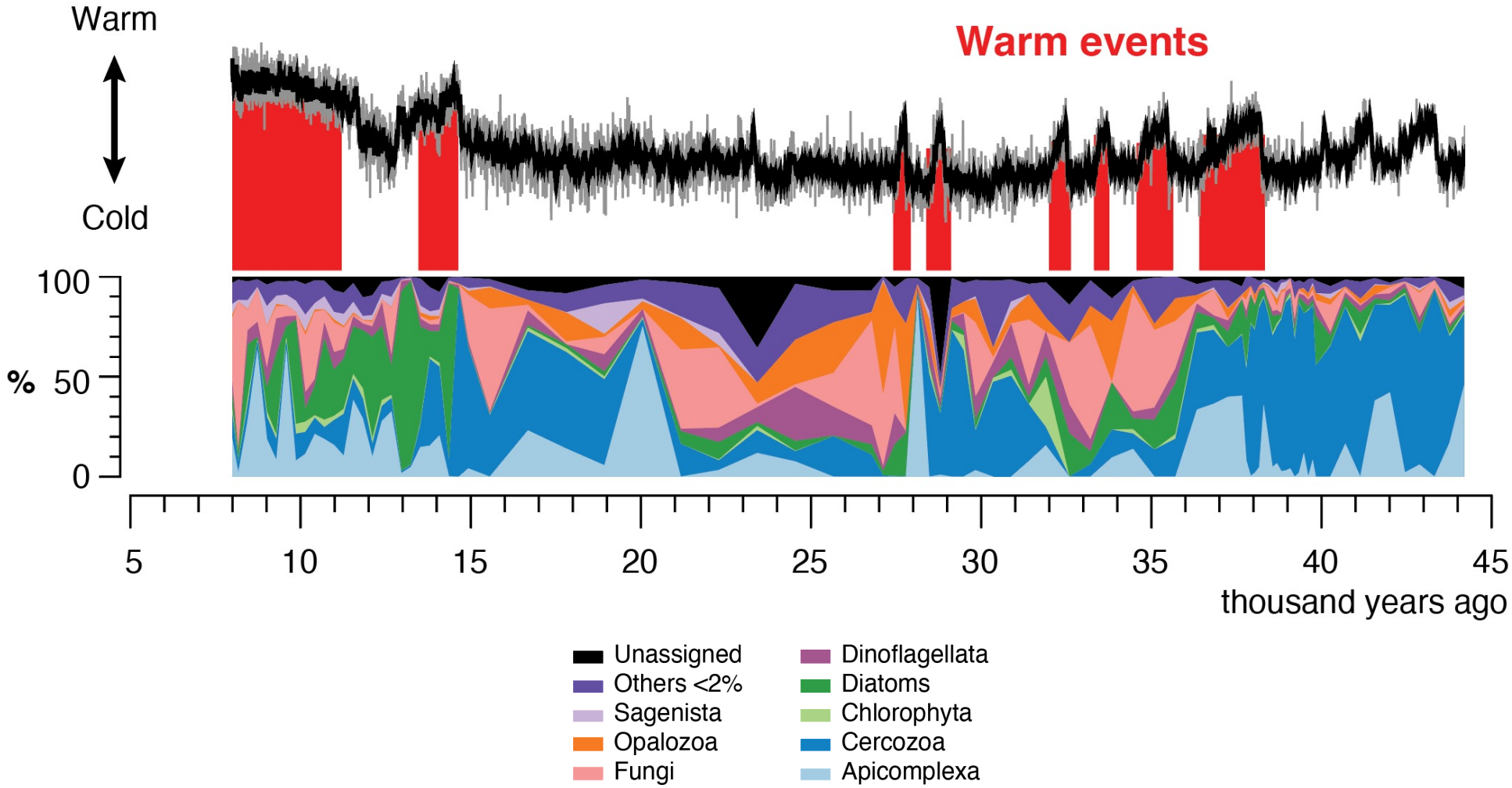

Phytoplankton
Zooplankton
Higher-level consumers
Bacteria
BLUE ARCTIC ECOSYSTEM
Benthos

Impacts

Biodiversity shifts during climate warming

Climate

Biodiversity



Vegetation Dynamics

A greener and cooler Sinai can bring more moisture to the Sinai region influencing the larger weather systems in the Mediterranean realm.

We envision a holistic, multidimensional, symbiotic approach for ecological regeneration in the Sinai. There is much to study and to do. We have identified five main steps for development:

STEP 1

Restore The Lagoon

STEP 2

Restore The Wetlands

STEP 3

Reuse Marine Sediments

STEP 4

Regreen The Desert

STEP 5

Restore The Watershed

https://www.greenthesinai.com/how

Paleo-evidence for an enhancement rainfall from Mediterranean sources,

a regional monsoon-type circulation induced by increased land-sea temperature contrast

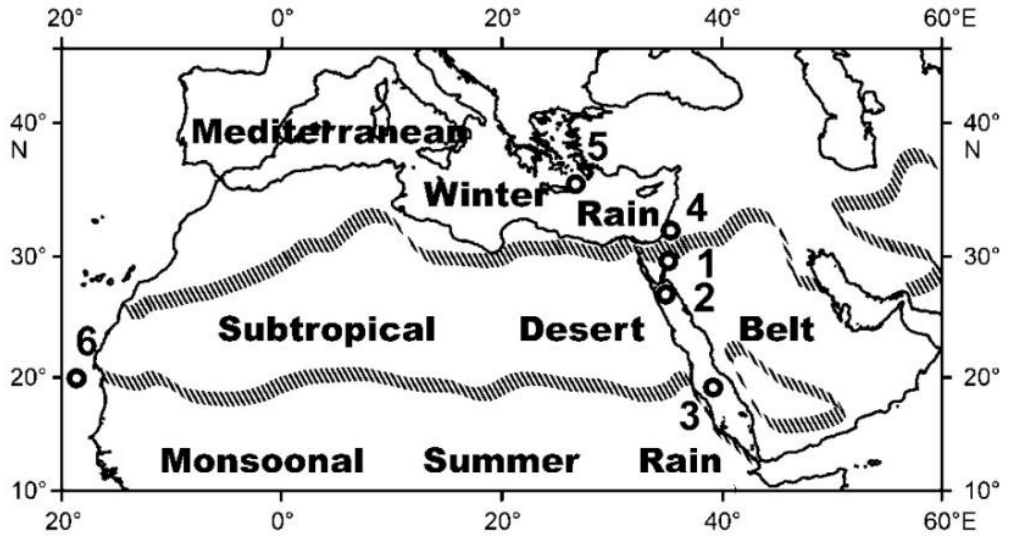


Fig. 1. Map with location of sites discussed in the text: 1, core GeoB 5804-4 (this study); 2, core GeoB 5844-2 (this study); 3, core KL 11 (*16*); 4, Soreq Cave (*18*); 5, core LC21 (*29*); 6, ODP Site 658C (*6*). The map also includes a schematic representation of modern rainfall regimes showing the 100 mm/year isohyets as limits of winter and summer rainfall regimes [after (*25*)].

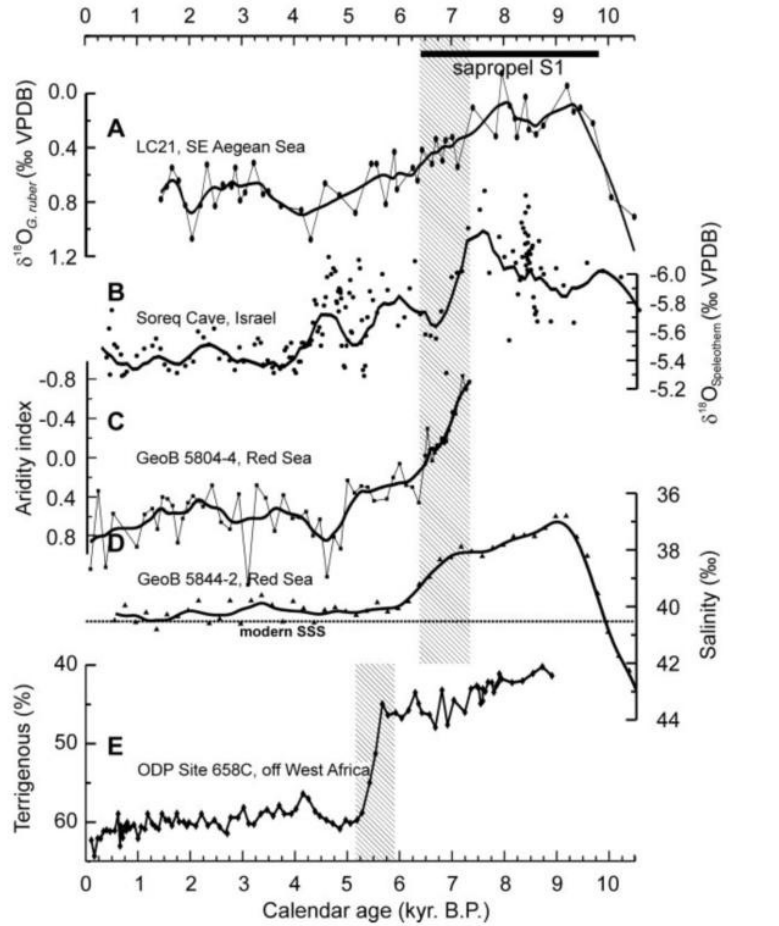


Fig. 3. Timing of the early- to mid-Holocene humid interval in the northern Red Sea compared with proxy records from the eastern Mediterranean, southern Oman, and West Africa. (**A**) $\delta^{18}O$ record of *G. ruber* (white) of the southeast Aegean Sea core LC21 (*29*), marking the enhanced freshwater flux to the eastern Mediterranean Sea. Black bar indicates the extent of anoxic sedimentation in LC21, representing sapropel S1. (**B**) $\delta^{18}O$ speleothem record, Soreq Cave, as a proxy for regional rainfall in Israel (*18*). (**C**) Aridity index from the northern Gulf of Aqaba core GeoB 5804-4 (this study). (**D**) Paleosalinity record from the northern Red Sea core GeoB 5844-2 (this study). (**E**) Eolian sedimentation, ODP Site 658C, off West Africa as a proxy for aridity in subtropical North Africa (*6*). Original data in (A) to (D) have been smoothed by simple moving averaging (bold lines). Vertical bars emphasize the major humid to arid transition in the various records.

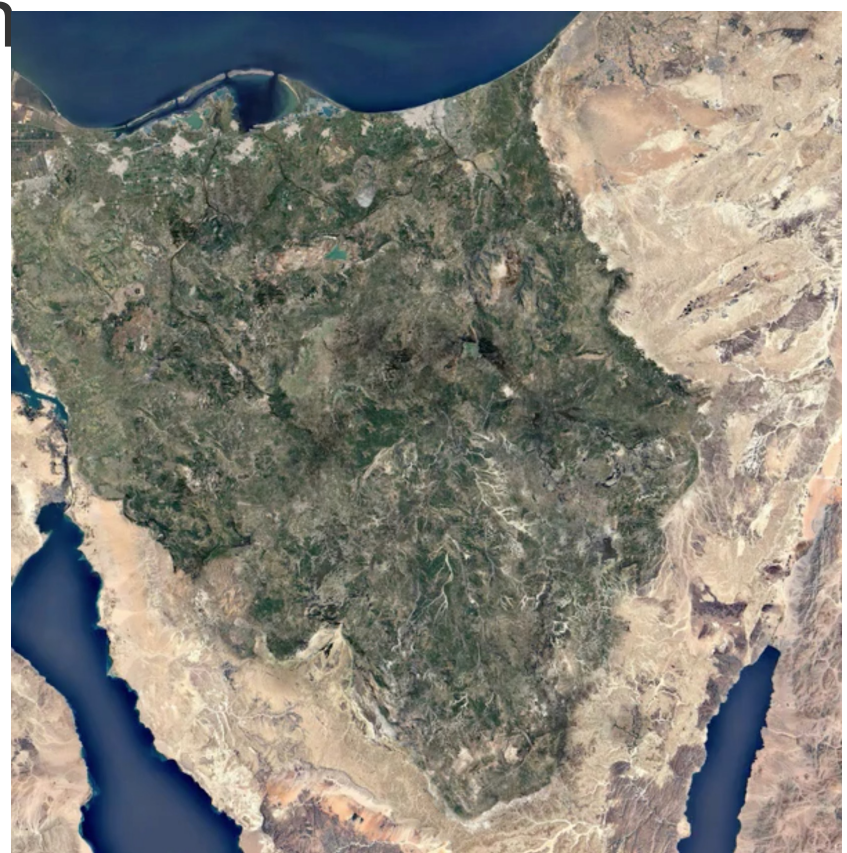
Arz, Lamy et al., 2003

The Loess plateau in northern China

Within 20 years, the deserts of the Loess plateau became green valleys and productive farmland

greening of the Sinai: A climatological, technological **and political challenge**

Idea: A greener and cooler Sinai can bring more moisture to the Sinai region influencing the larger weather systems in the Mediterranean realm



Political dimension and chances for the Sinai

The Sinai would be made greener

Development of Greater Gaza into a prosporous region

New habor town and international airport in Greater Gaza

Palestinian refugies can enter Greater Gaza area

Military: under Egyptian and Jordanian control (de-militarized)

West Jerusalem: Israel

East Jerusalem: Palestinian

Old town of Jerusalem: International control, free access to the religious places

Tunnel/ connection between the West Bank and Greater Gaza

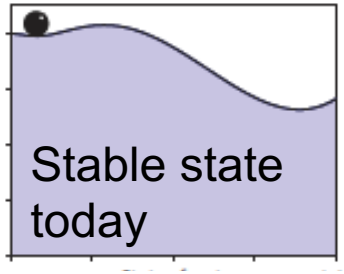
Selected Israelian settlements in the West Bank can remain under Israelian control (TBD)

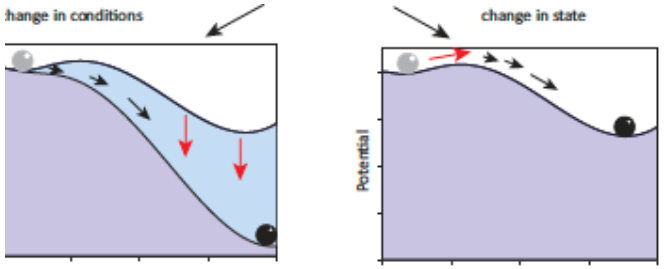
Palestina_Sinai

This plan would solve: refugies, space and perspective for Palestina, Jerusalem, safety for Israel, climate lab, energy

Tipping Points: Science and Communication

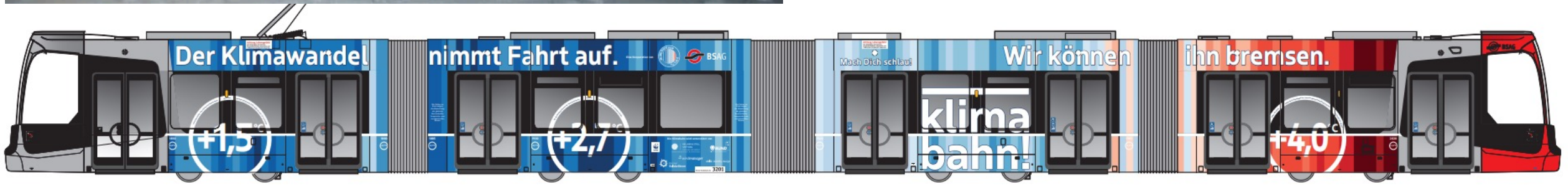
Science





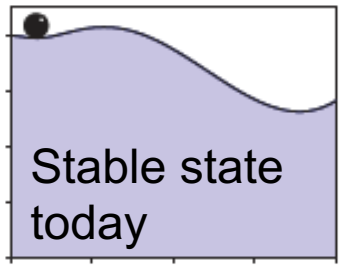
van Nes et al., 2016

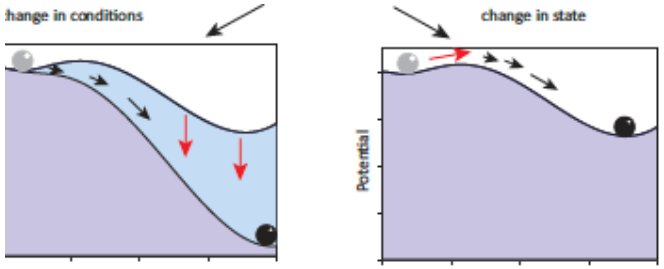

#Scientists4Future
We deliver the facts. It's time to act!


Der Klimawandel
(+1,5°C)
nimmt Fahrt auf.
(+2,7°C)
BSAG
Mach Dich schlau!
Wir können
klima
bahn!
ihn bremsen.
+4,0°C

Tipping Points: Science and Communication

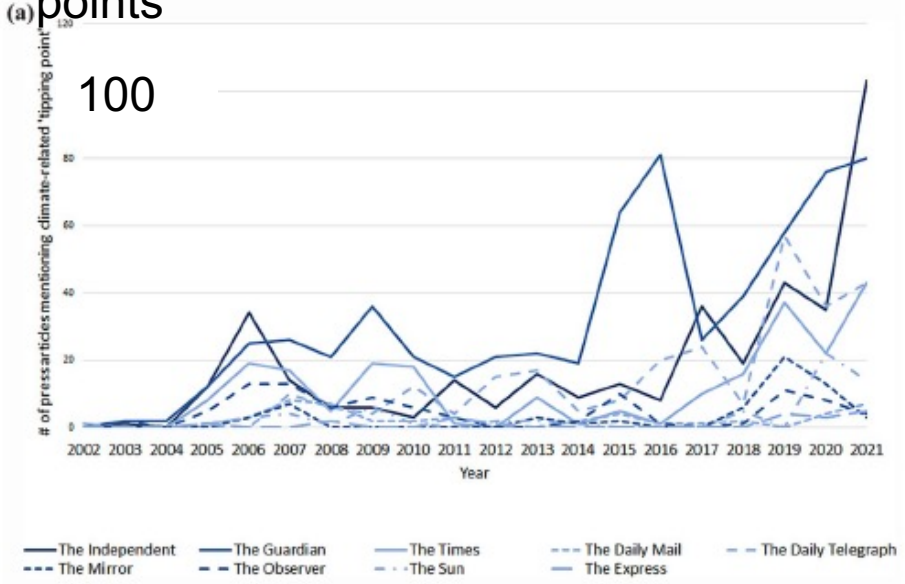
Science → Communication → **Society**





van Nes et al., 2016

press articles mentioning tipping points



Belamy, 2023

welt.de, 2023

Tipping Points: Science and Communication

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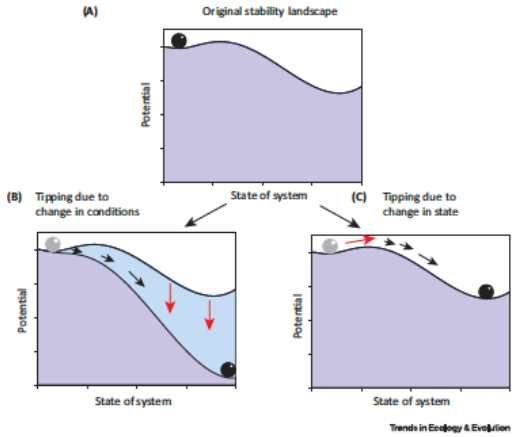
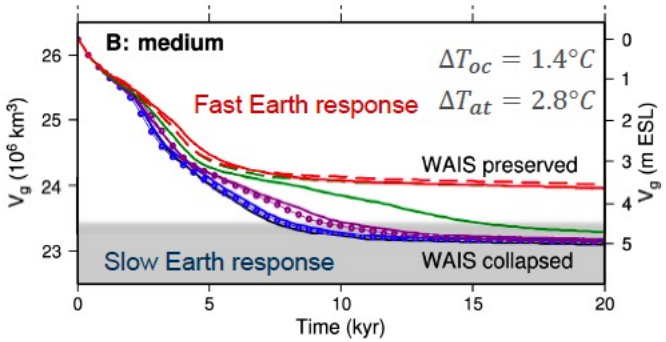
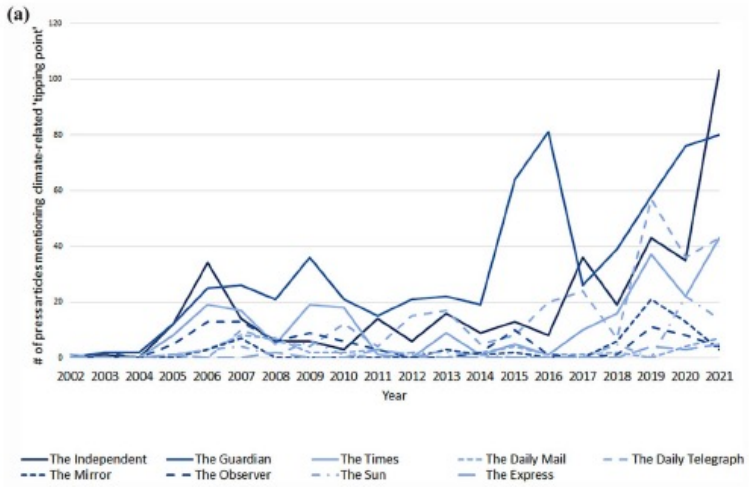


From: van Nes et al., 2016



From: Ingo Sasgen



From: Belamy, 2023

From: welt.de, June 2023

Goal: Strategies to develop a sound approach to Tipping Points in Science and Communication

Problems with this Concept

-Not all climate problems have something to do with tipping points

-Deterministic view

-Often probabilities are important

-Not yet well understood

AWI Students' day

- **When:** **Monday, 30th of June 2025**, 10:00 bis 16:00 Uhr
- **Where:** **Alfred-Wegener-Institut,** Klußmannstraße 3 (white building), 27570 Bremerhaven, room 0048 ground floor
-
- Introduction with coffee & tea
- Lecture given by Gerrit Lohmann and Torsten Kanzow
- Lunch around 12:00 hrs
- Visit at the Geo lab at 13:15 hrs
- Back at seminar room at 14:00 hrs, introduction of Master theses
- Afterwards time to visit the building
- 16:00 hrs end of programme

14:00 Uhr:	Christian Haas
14:20 Uhr:	Astrid Bracher
14:40 Uhr:	Thomas Jung
15:00 Uhr:	Gerrit Lohmann
15:20 Uhr:	Torsten Kanzow

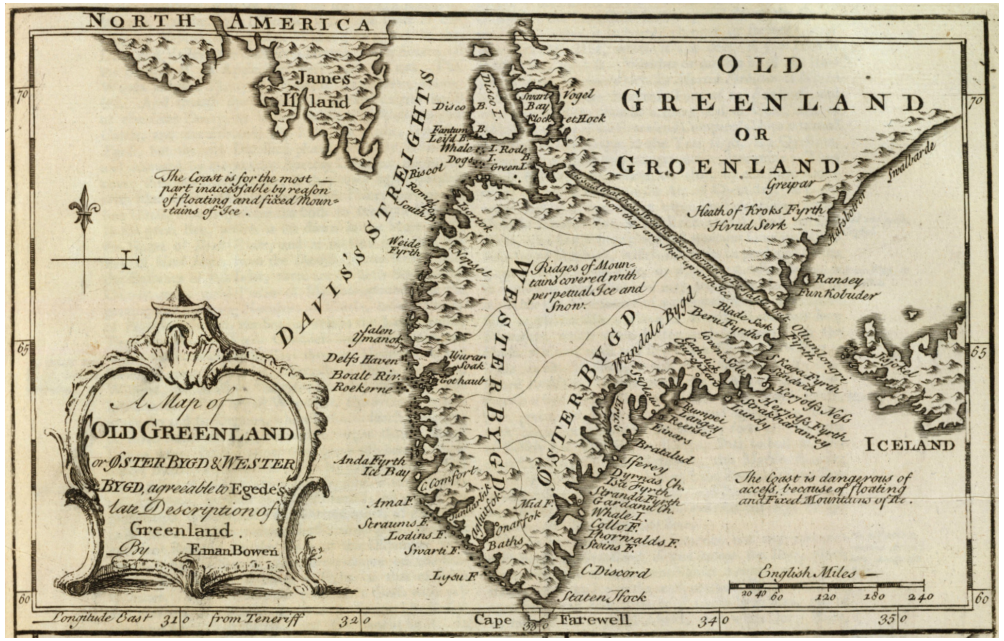
Greenland from the Medieval Period to Today

Using Reanalysis Data to reconstruct the Surface Mass Balance of the Greenland Ice Sheet since 1400.

Models can reconstruct the weather of the past.

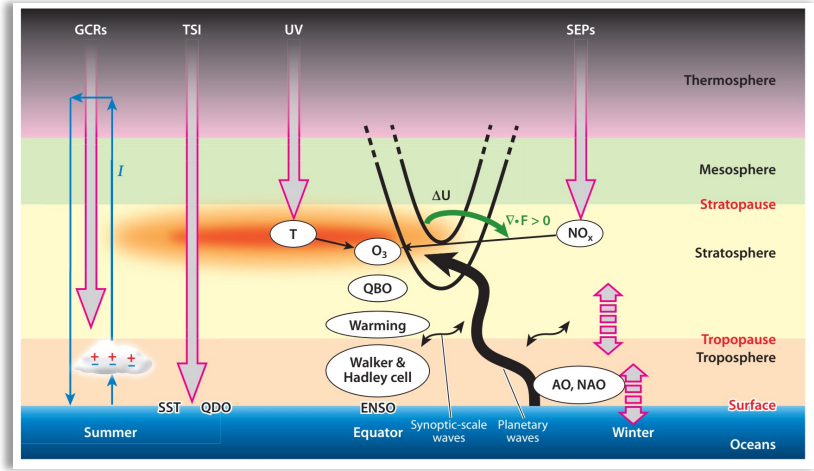
Here we want to use these reconstructions to study changes in the Greenland ice sheet.

- How did the little ice age influence surface melt? How frequent were extreme melt events before the industrial period?
- Can we relate past melt events to evidence from ice cores or other archives?
- Did natural climate variability cause substantial variation in ice mass?

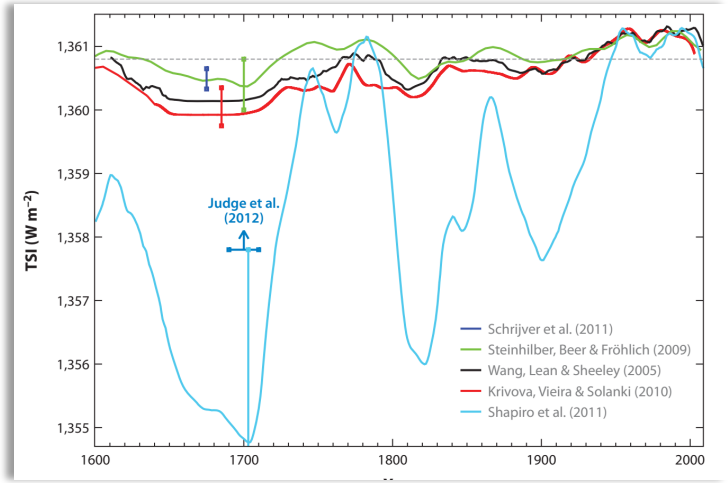


Contact:
uta.krebs-kanzow@awi.de

How Centennial Solar Variability Drives Climate: Bottom-Up vs. Top-Down



Solar forcing since the 17th century



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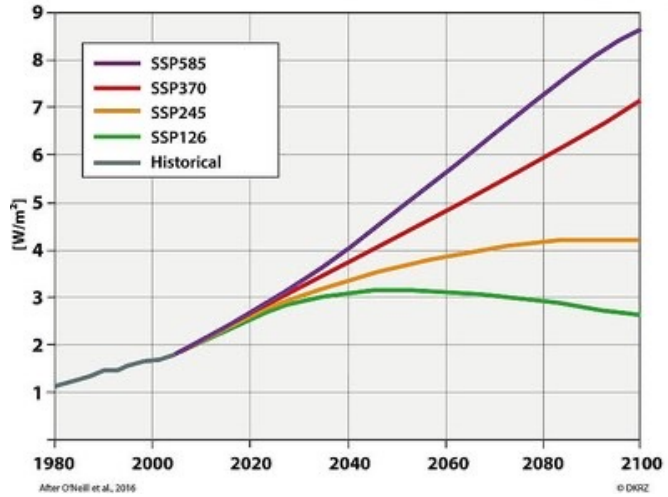
Projected anthropogenic forcing



Solar Forcing & Earth's Climate System

- Solar forcing influences climate via two main pathways:
  - **Bottom-up effects**
    - Driven by **Total Solar Irradiance (TSI)**
    - **Affect** sea surface temperatures and cloud feedbacks
  - **Top-down effects**
    - Driven by **Solar Spectral Irradiance (SSI)**
    - **Involve** UV, ozone, and polar vortex dynamics
    - **Act** from the middle atmosphere to the surface

Bottom-up vs. Top-down Contributions

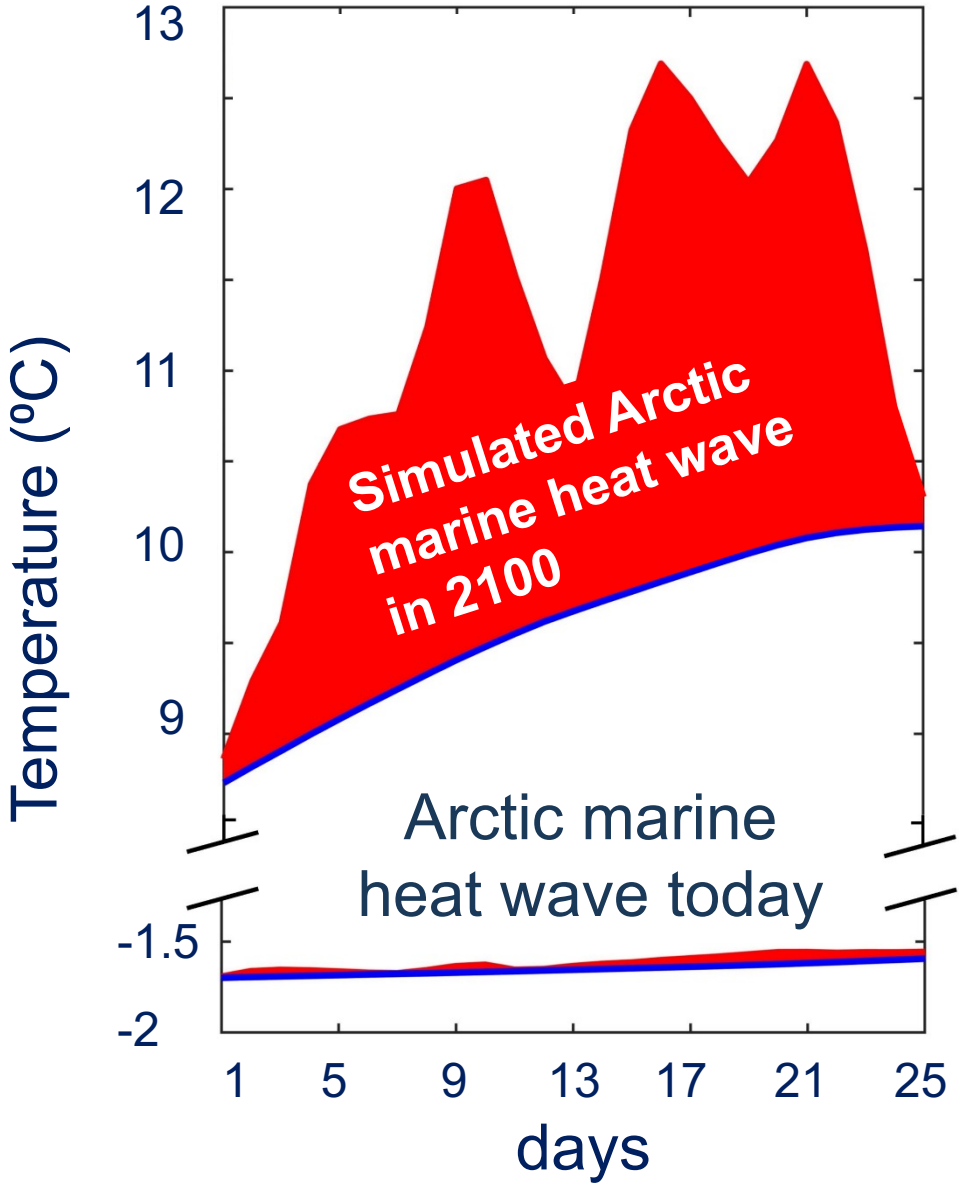
- **Bottom-up processes** are generally **well represented** in most climate models
- **Top-down effects** are often **neglected** due to:
  - Need for **high-resolution radiation schemes**
  - Requirement for **interactive ozone chemistry**

Master's Project Scope

- The candidate will perform **guided experiments** using the **ECHAM/MESSy chemistry-climate model**
- Simulations are designed to **separately assess** the contributions of:
  - **Top-down effects** (e.g. UV–ozone–dynamics coupling)
  - **Bottom-up effects** (e.g. ocean–surface–cloud feedbacks)
- **Aim:** to understand how each pathway **contributed to the climate system in past climate stages** – and to evaluate whether these mechanisms **remain relevant in a future high-CO_2 (hothouse) climate state**
- The candidate will also **connect with leading experts** in the field – within the framework of the **InnoPool project SOLVe**

Tobias.Spiegl@awi.de

Impact of warmth and heat waves

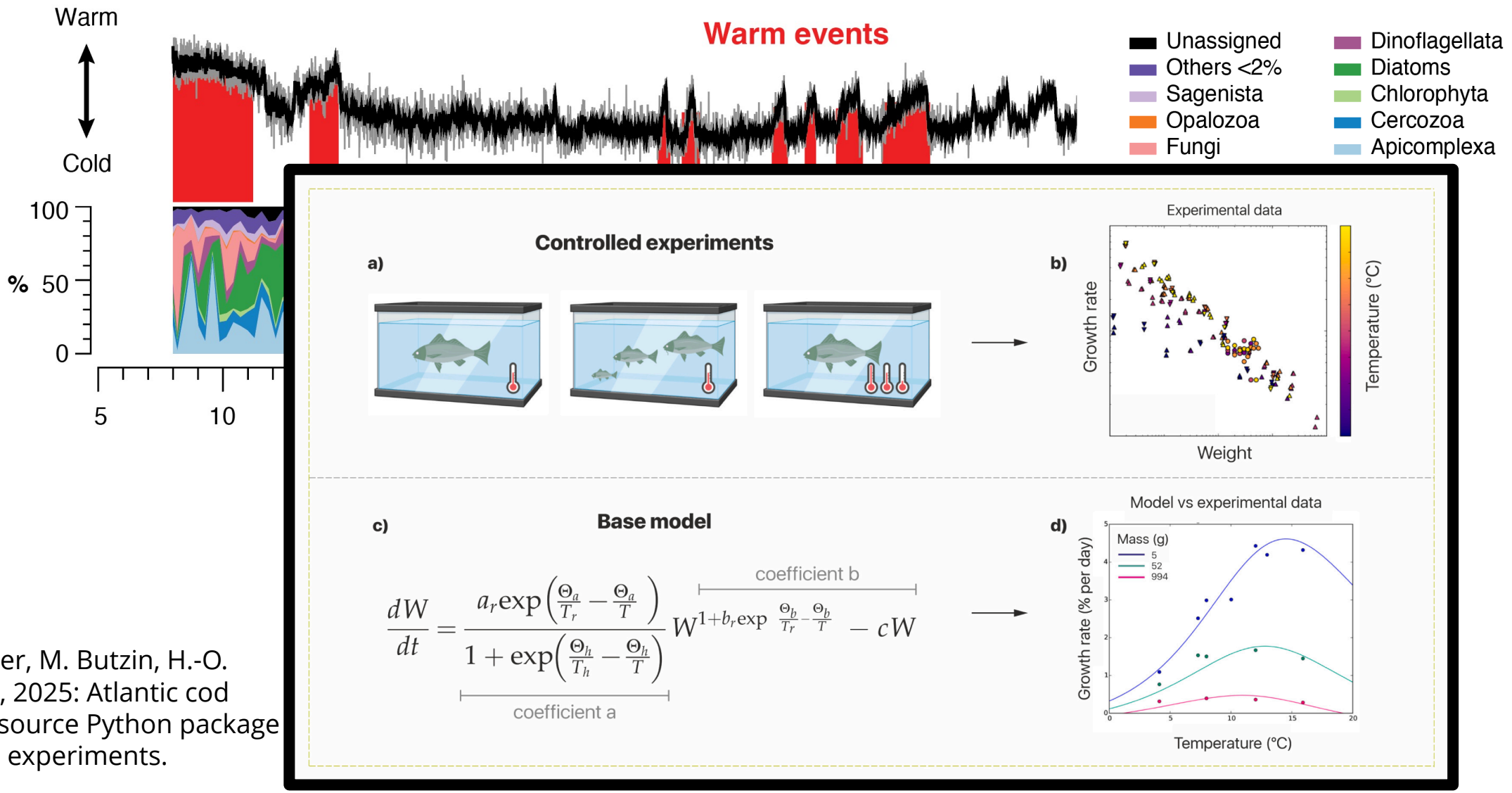


Gou, … Lohmann, 2025. Nat Climate Change

Biodiversity shifts during climate warming

Climate

Biodiversity



Sokolova, N., A. Rohner, M. Butzin, H.-O. Pörtner, G. Lohmann, 2025: Atlantic cod growth model: open source Python package for numerical growth experiments. SoftwareX, 30, 102113, doi:10.1016/jsoftx.2025.1022113

… and biogeochemistry models

1. With sea ice retreating, the **Arctic Ocean** would have **strengthened convection** in high-resolution simulations. Together with colleagues from the Nansen Center in Norway, we would like to understand the occurring mechanism and **impacts on the overturning circulation**.

2. **Machine learning** is a powerful tool of making weather forecast. Its unique advantage in learning the graphics and the new development in combining physics make it appealing for **sea ice forecast**.

3. Sea ice is treated as a **continuum** in climate models. This means that the **eddy-floe interactions** can not be properly represented, and could lead to a problematic sea ice projection. We could improve the **sea ice modelling** in climate models by considering its **discrete nature**.

4. From our discussion: AWI is dedicated to advanced climate and biogeochemistry modelling. We could explore **the effects of extremes and eddies on biogeochemistry** in changing climates by **combining the ultra-high-resolution climate models and sophisticated biogeochemistry models**.

Dr. Ruijian Gou, email: ruijian.gou@awi.de