

The climate has always changed -
so why are we concerned now?

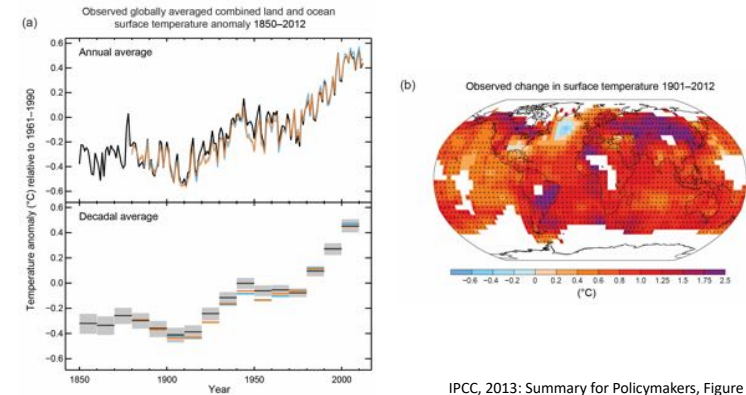
Prof Katrin Meissner

Climate Change
Research Centre

climate extremes
ARC centre of excellence

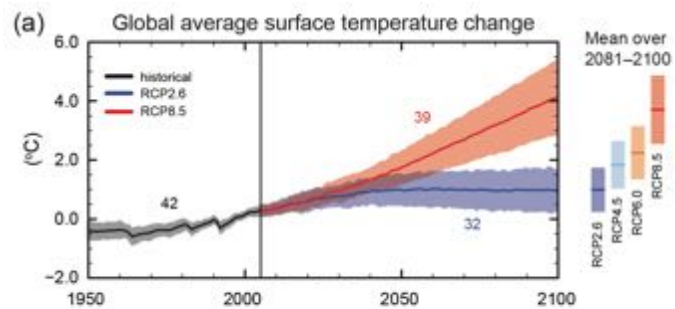


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IPCC, 2013: Summary for Policymakers, Figure SPM.1

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IPCC, 2013: Summary for Policymakers, Figure SPM.7

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The Paris agreement (Article 2)



United Nations



Framework Convention on
Climate Change



CCC/C/CP.2015/L.9/Rev.1

Distr.: Limited
12 December 2015

Article 2

1. This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by:
 - (a) Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;
 - (b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production;
 - (c) Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

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Prof Hubertus Fischer (Universität Bern, Switzerland)
Prof Alan Mix (Oregon State University, USA)

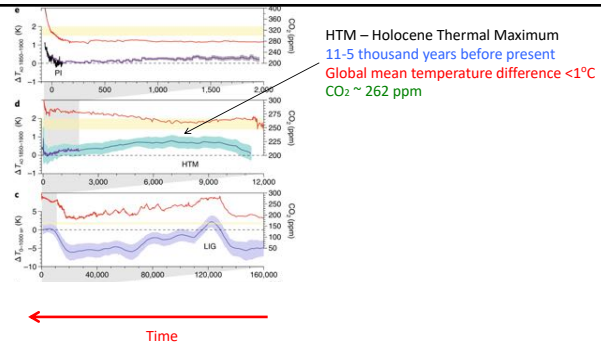
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Future Earth, Past Global Changes
PAGES
Warmer Worlds Workshop
Bern, April 2017



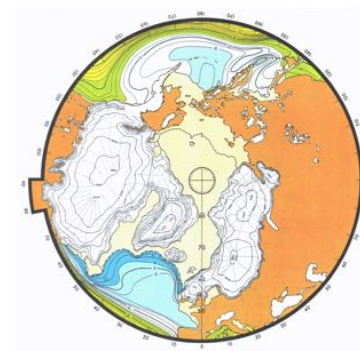
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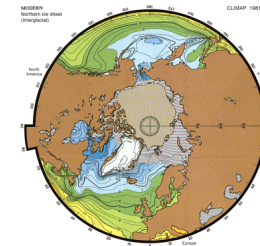
Fischer et al., 2018, *Nature Geoscience*

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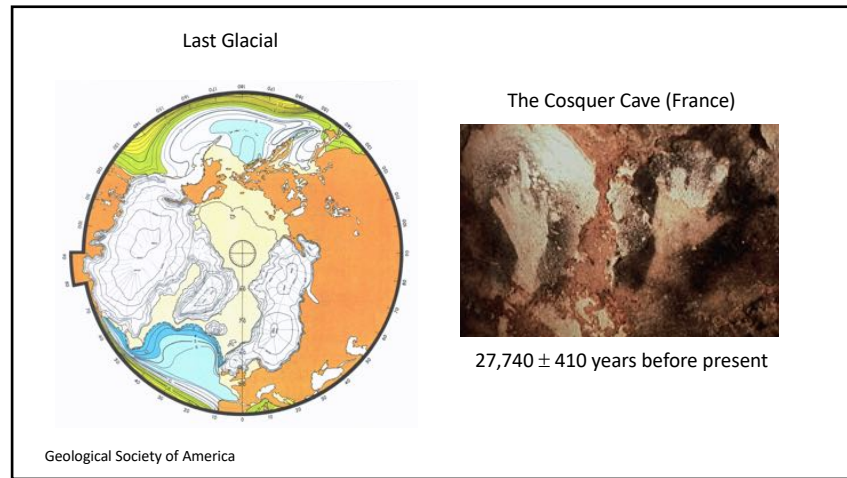
Last Glacial



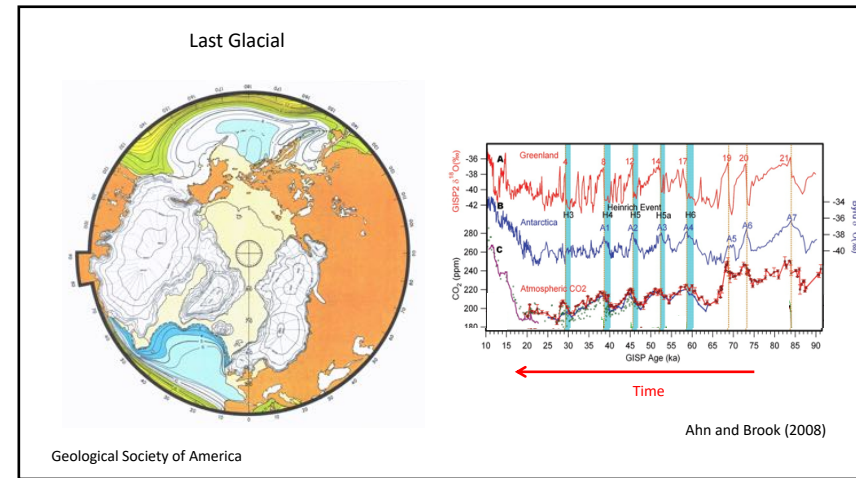
Geological Society of America



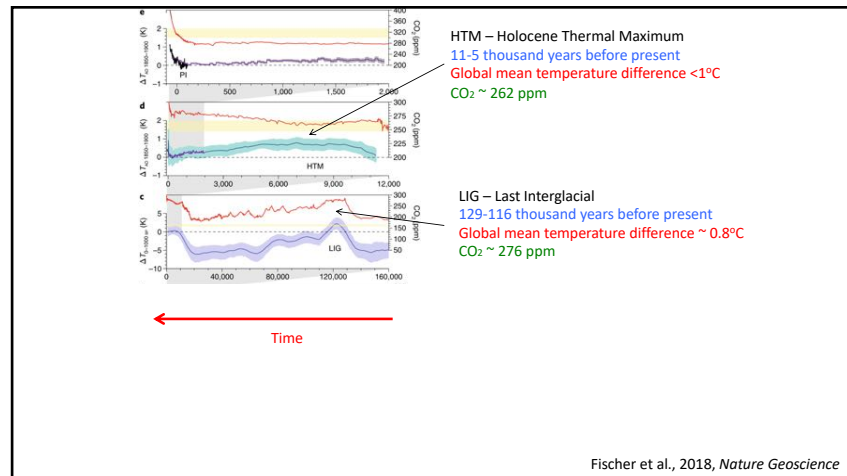
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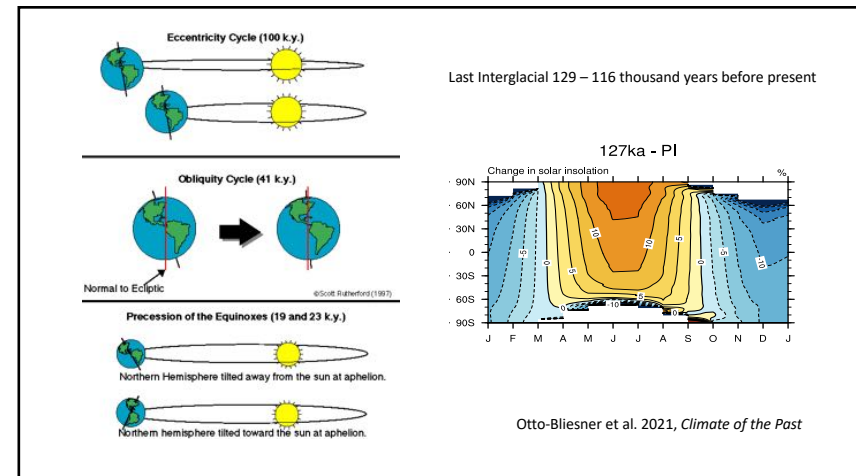
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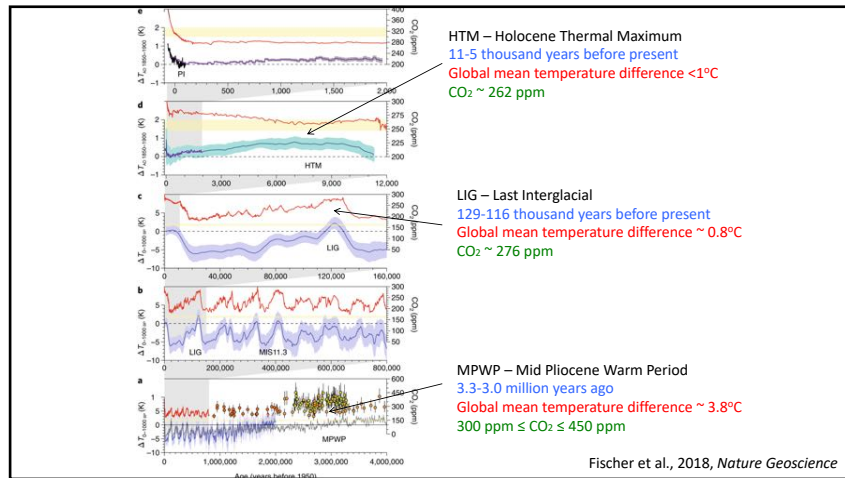
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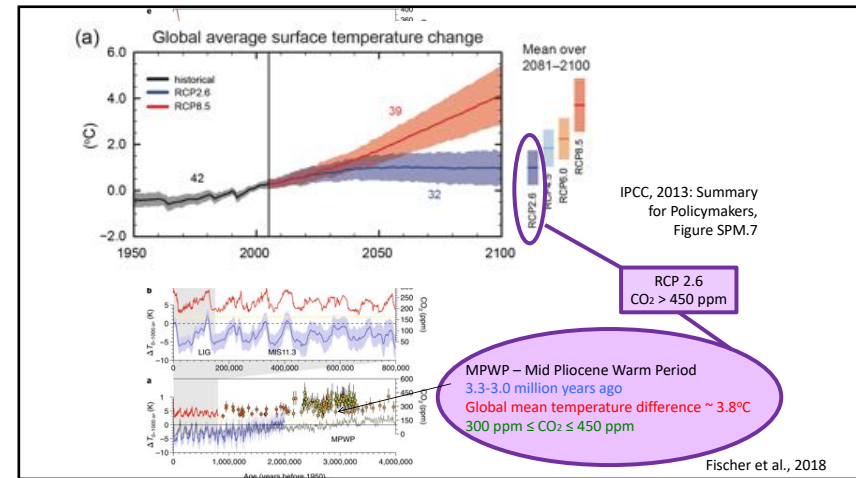
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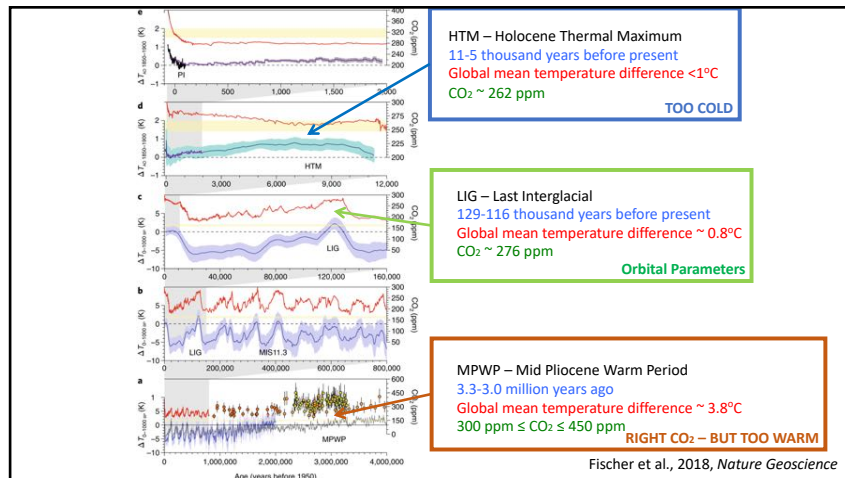
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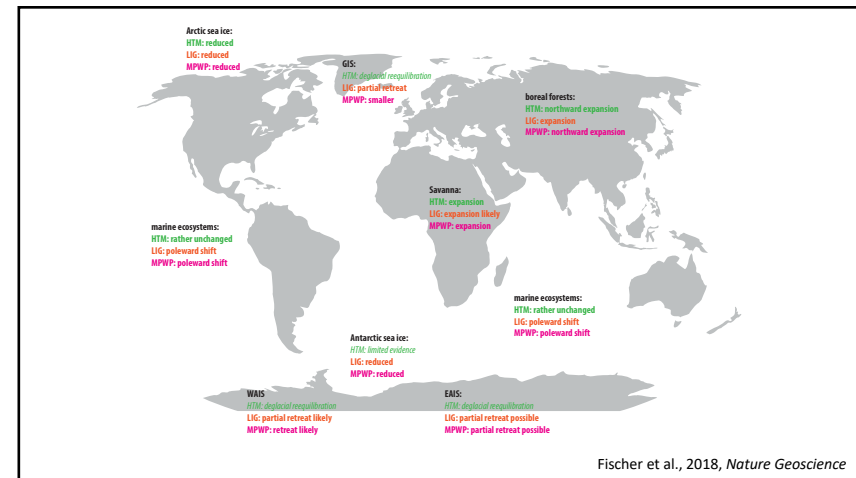
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Main Findings

Strong polar amplification

High latitudes warm more than the rest of the planet

Sea level rise and ice sheets

Last Interglacial - higher sea levels by 6-9 m

Mid Pliocene Warm Period - higher sea levels by at least 6 m (likely much higher)

Terrestrial and aquatic ecosystem

Spatial reorganization. For example: green Sahara, tundra-forest boundaries shift

Peat/permafrost/marine hydrates

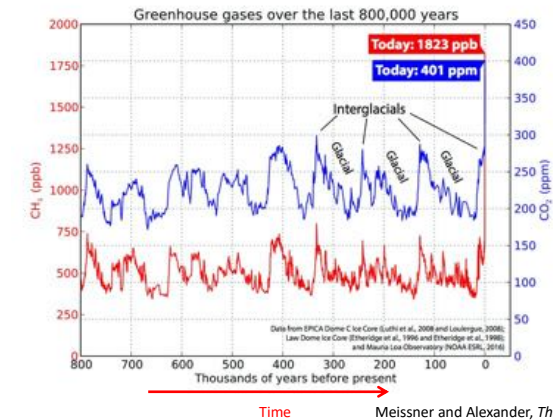
Runaway greenhouse gas feedback risk small...

... if we stay at rates and magnitudes characteristic of last interglacials...

Fischer et al., 2018, *Nature Geoscience*



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Time

Meissner and Alexander, *The Conversation*, 2016

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It's a question of time scales....



NASA/NOAA GOES Project



GETTY/RYERSONCLARK



AUSTRALIAN CURRICULUM LESSONS

MPWP – Mid Pliocene Warm Period

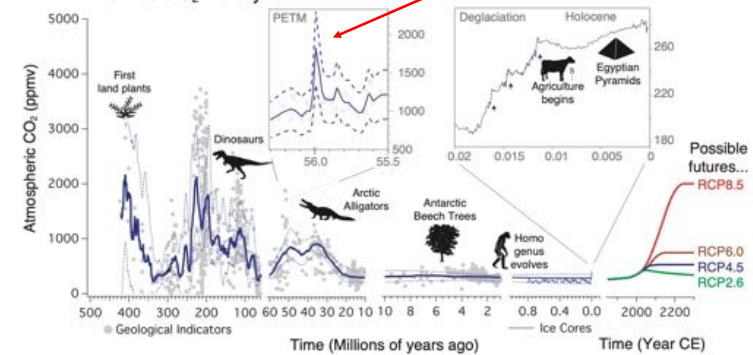
3.3-3.0 million years ago

Global mean temperature difference ~ 3.8°C

300 ppm ≤ CO₂ ≤ 450 ppm

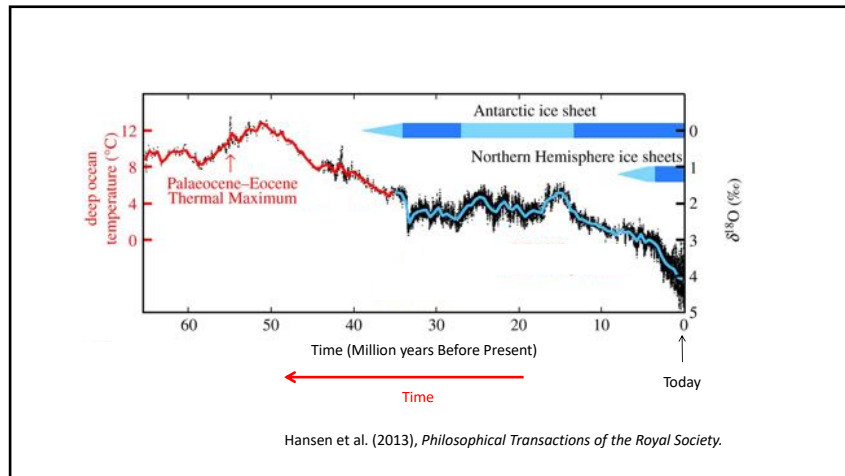
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Earth's CO₂ history



Meissner et al., 2021, *Environmental Research Letters*

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Paleocene-Eocene Thermal Maximum (PETM)



- ~ 55 Million years ago
- ~ 4-5°C sea surface temperature increase
- worldwide decrease in $^{13}\text{C}/^{12}\text{C}$

Massive release of carbon into the atmosphere

Mass extinction on sea floor

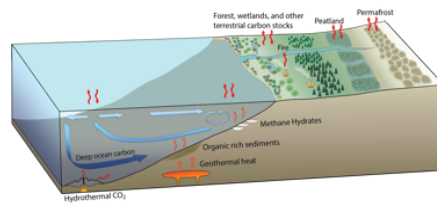
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Paleocene-Eocene Thermal Maximum (PETM)

Questions:

- How much carbon was released?
- Where did it come from?

Methane hydrates?
Permafrost?
Volcanism?



Meissner et al., 2021, *Environmental Research Letters*

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Paleocene-Eocene Thermal Maximum (PETM)

Questions:

- How much carbon was released? ➤ Climate sensitivity
- Where did it come from? ➤ Which carbon reservoirs we should watch closely?
- How fast was it released? ➤ Resilience of ecosystems

Clues:

- $\delta^{13}\text{C}$ excursion
- Magnitude of warming
- Ocean acidification

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Paleocene-Eocene Thermal Maximum (PETM)

Questions:

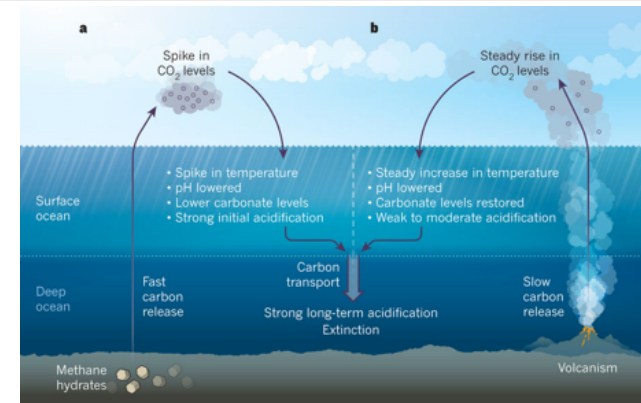
- How much carbon was released? ➤ Between 7,000 and 12,000 Pg C
- Where did it come from? ➤ Likely a combination
- How fast was it released? ➤ Slower than 0.6 Pg C/year

Is this a good analog to present day?

- Background climate was much warmer, topography was different
- Rates of change: less than one tenth of current rates

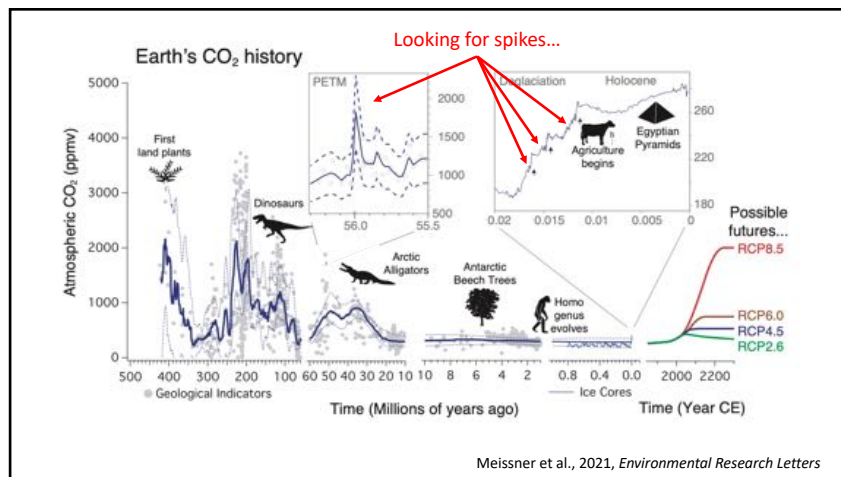


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Meissner and Bralower (2017), *Nature*, 548.

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Meissner et al., 2021, *Environmental Research Letters*

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Rates of change

Paleocene Eocene Thermal Maximum

- Rates of change in CO₂: less than one tenth of current rates

Deglaciation versus 1987-2016:

- CO₂ ~ 2 (19) ppm/decade
- CH₄ ~ 20 (57) ppb/decade
- N₂O ~ 1 (8) ppb/decade



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Some Take Home Messages

- Mid Pliocene Warm Period closest period with higher CO₂ (CO₂ ~ RCP 2.6, but much warmer ~ 3.8°C)
- Even if we stay within the 1.5-2°C guardrail, significant impacts are to be expected
 - Spatial reorganization of ecosystems on land and in the ocean
 - Substantial long-term melting of Greenland and Antarctica, and associated sea level rise
- Runaway greenhouse gas feedbacks not likely if we stay within the guardrail
- Current rates of change are at least 10 times faster than at any other time in the past 65 Million years
- There is no good analog to current climate change in our climate archives



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What are we concerned about?

- Climate extremes



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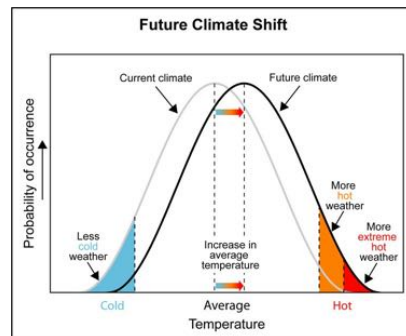
Climate Extremes

Compound events

Tropical storms

Droughts

Fire



Heat waves

Marine heat waves

Extreme rainfall

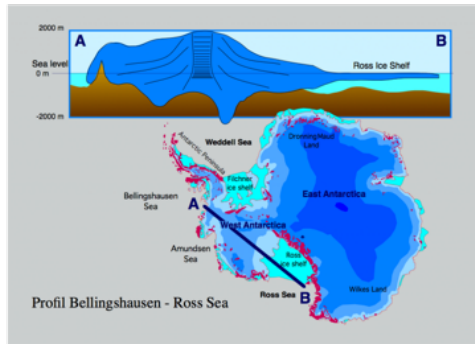


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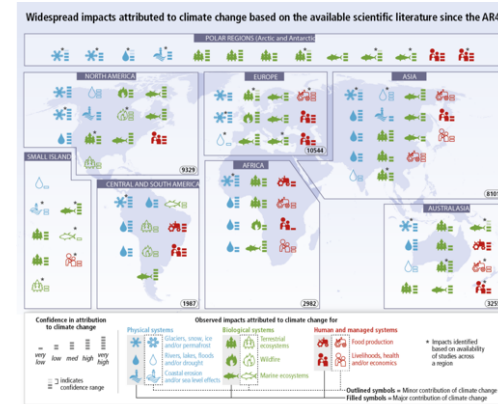
What are we concerned about?

- Climate extremes
- Positive feedbacks within the climate system
- Ocean acidification, ocean deoxygenation
- Thresholds in the climate system

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By Hannes Grobe, Alfred Wegener Institute for
Polar and Marine Research, Bremerhaven,
Germany



IPCC, 2013: Summary for Policymakers, Figure SPM.4

Thank you

Prof Katrin Meissner

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