EGU General Assembly 2025 – 29.04.2025

The Adaptive Emission Reduction Approach
Model Intercomparison Project

Sharing is encouraged

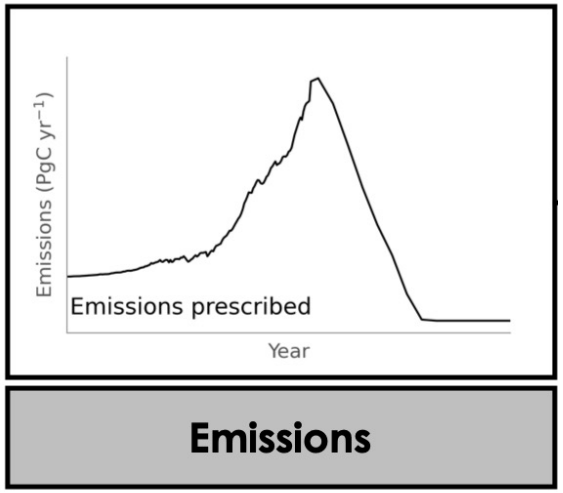
UNIVERSITÄT BERN
OESCHGER CENTRE CLIMATE CHANGE RESEARCH

Silvy et al. 2024, ESD

TCRE, emission pathways and remaining budgets compatible with 1.5 and 2°C global warming stabilization

Yona Silvy, Thomas L. Frölicher, Jens Terhaar, Fortunat Joos, Friedrich A. Burger, Fabrice Lacroix, Myles Allen, Raffaele Bernardello, Laurent Bopp, Victor Brovkin, Jonathan R. Buzan, Patricia Cadule, Martin Dix, John Dunne, Pierre Friedlingstein, Goran Georgievski, Tomohiro Hajima, Stuart Jenkins, Michio Kawamiya, Nancy Y. Kiang, Vladimir Lapin, Donghyun Lee, Paul Lerner, Nadine Mengis, Estela A. Monteiro, David Paynter, Glen P. Peters, Anastasia Romanou, Jörg Schwinger, Sarah Sparrow, Eric Stofferahn, Jerry Tjiputra, Etienne Tourigny, and Tilo Ziehn

A need for emission-driven simulations to stabilize global mean temperature



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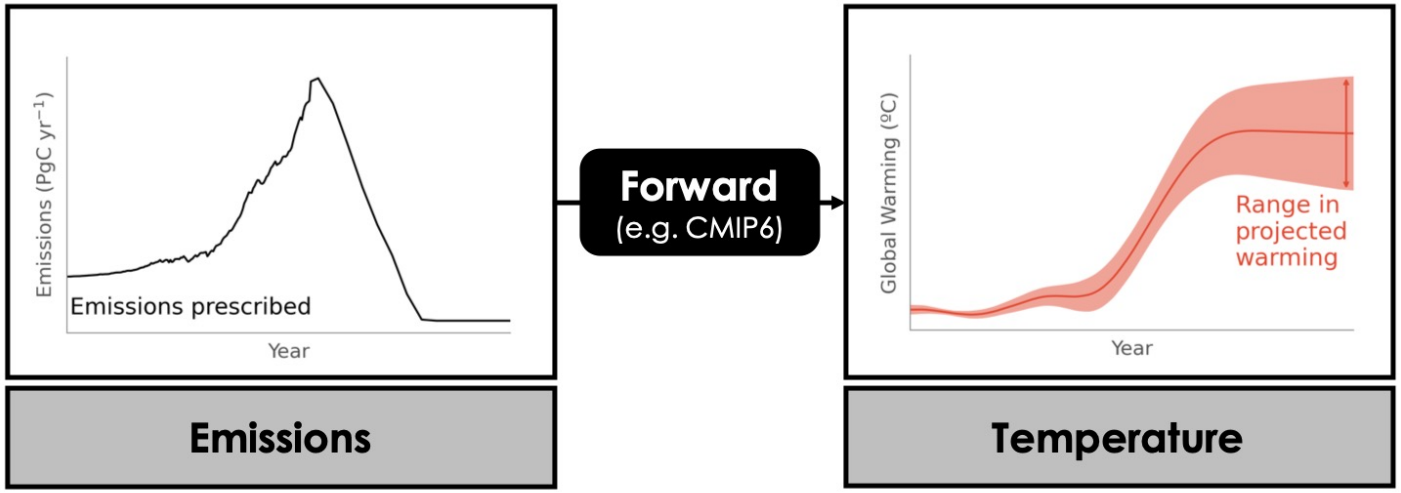

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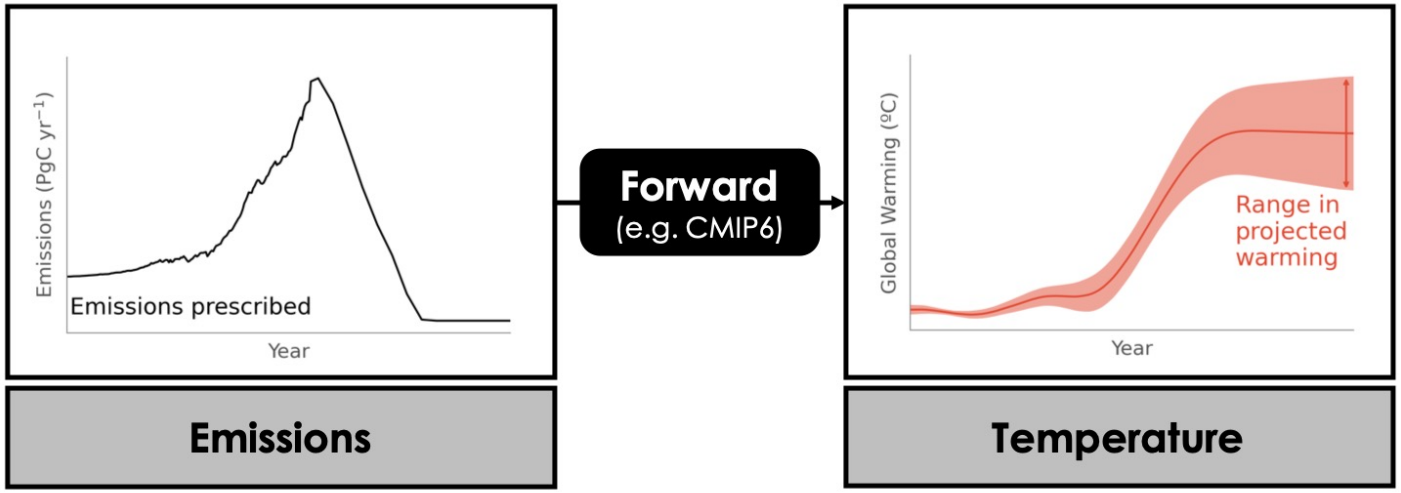

- Emission pathways compatible with specific warming levels?

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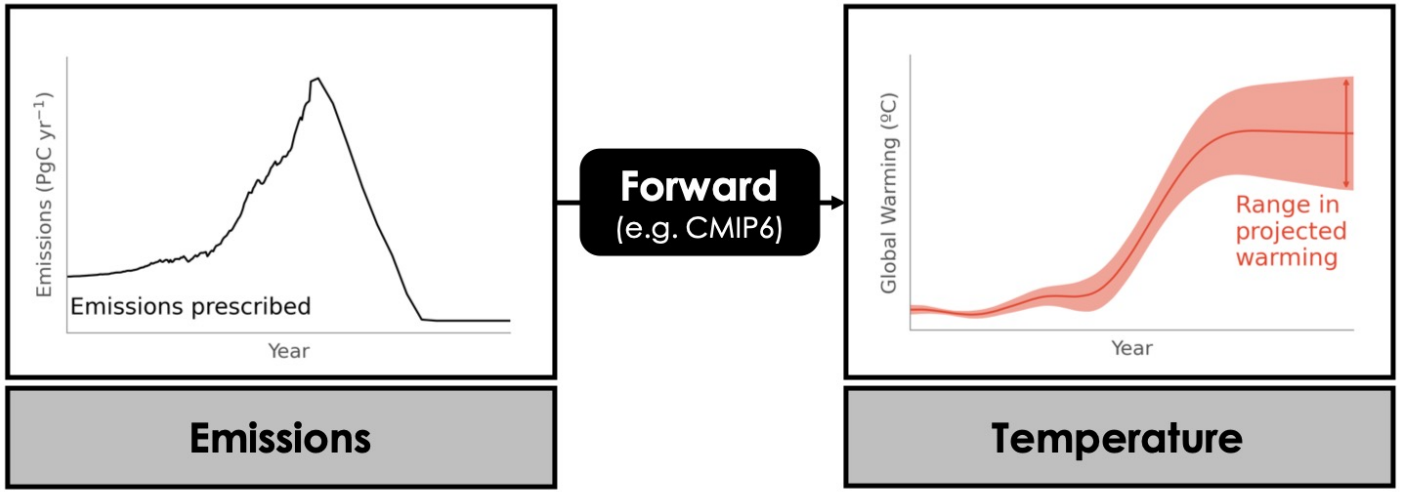

- Emission pathways compatible with specific warming levels?
- Impacts per GWL evaluated at different time slices during transient warming

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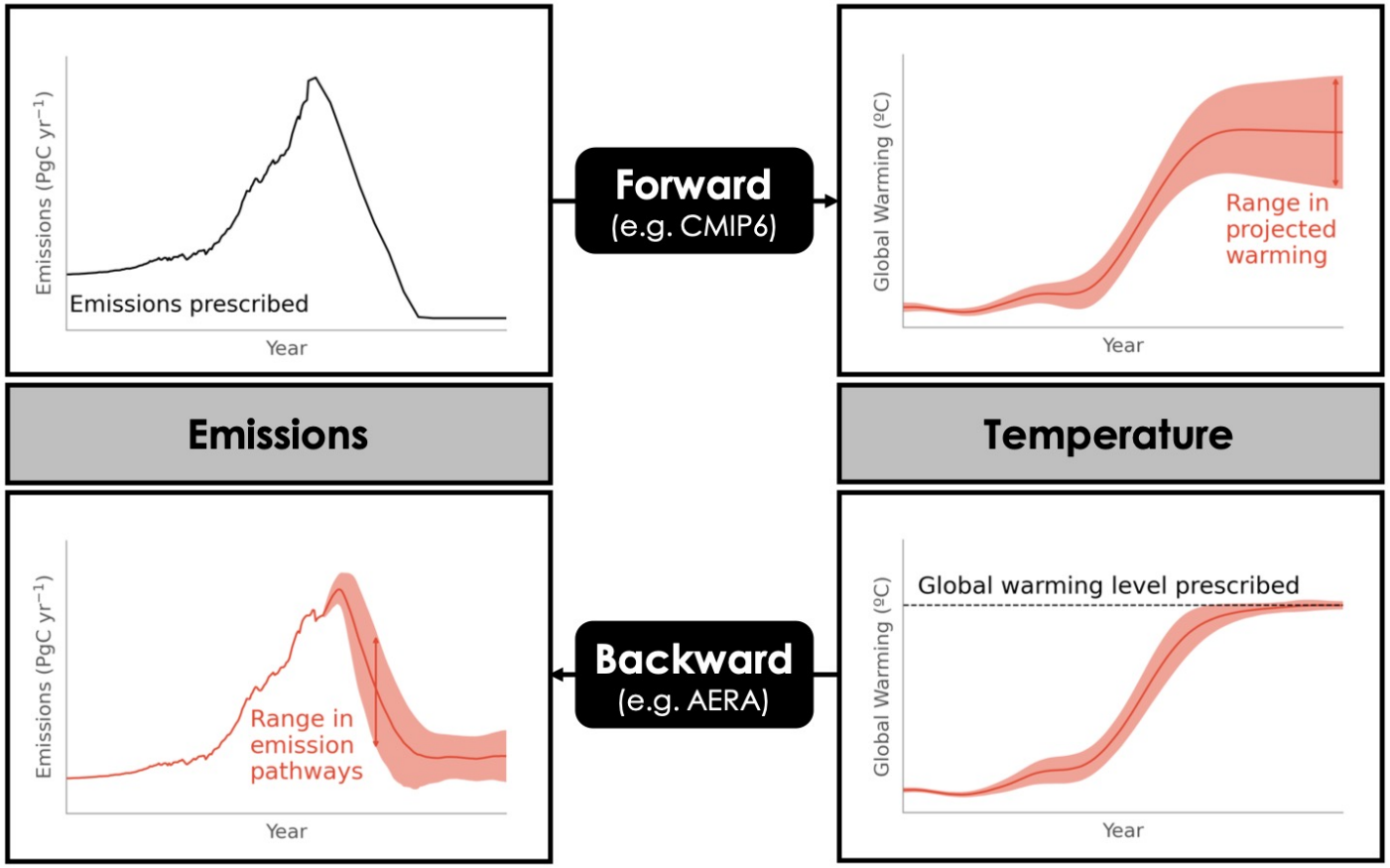
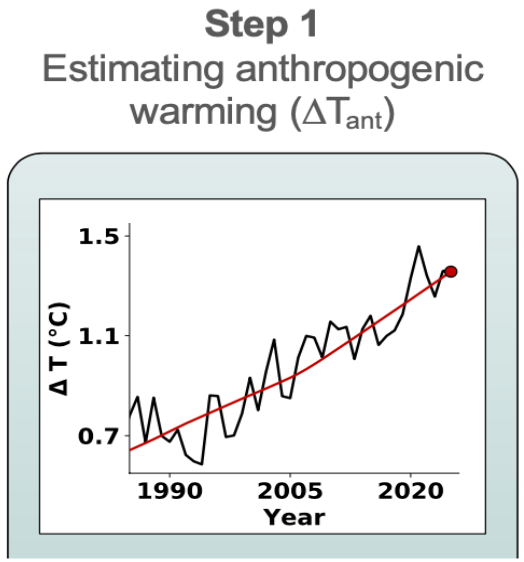


The Adaptive Emission Reduction Approach

AERA developed by Terhaar et al. (2022)



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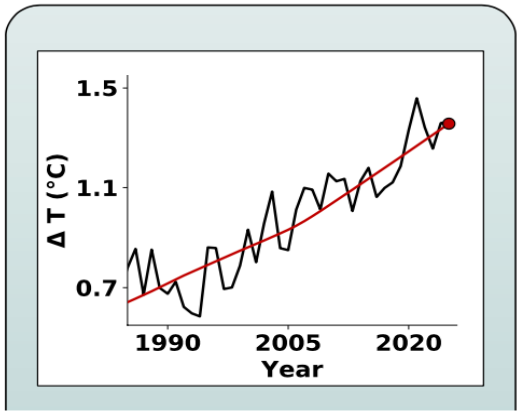
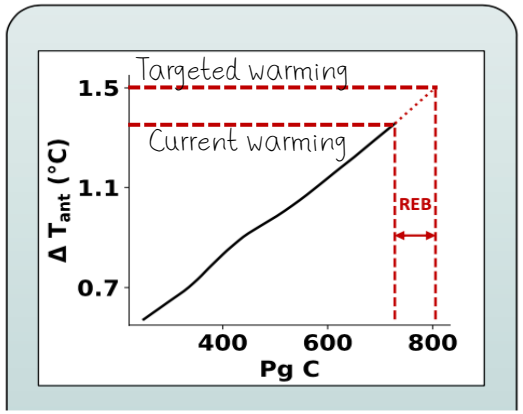
Estimating anthropogenic warming (ΔT_{ant})



Step 2
Estimating the remaining CO_2-fe budget (REB)



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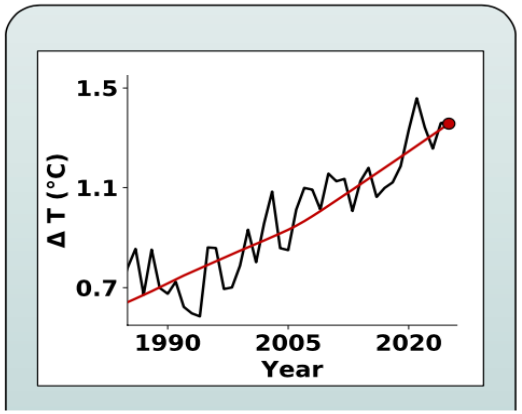

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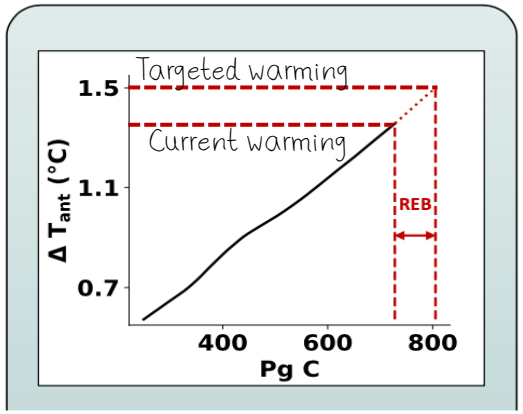
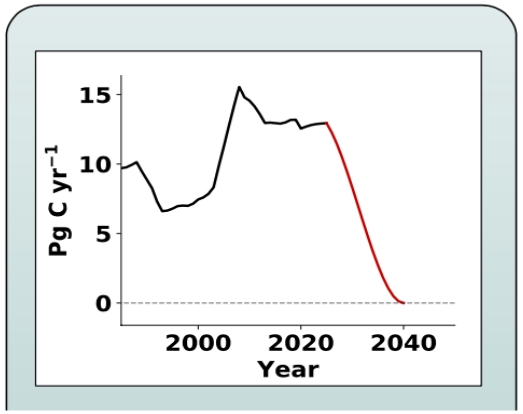


Step 3
Allocating emissions for the next five years and beyond



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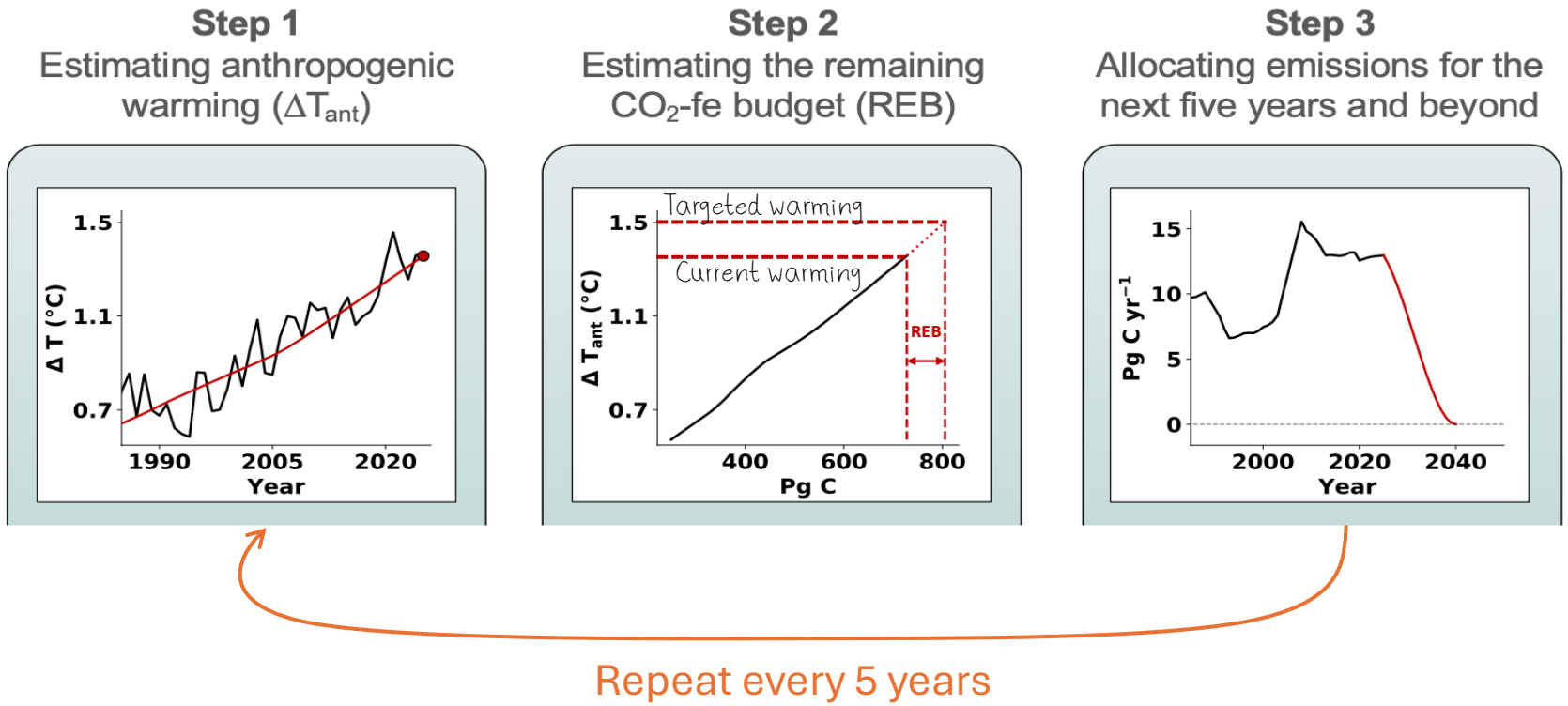

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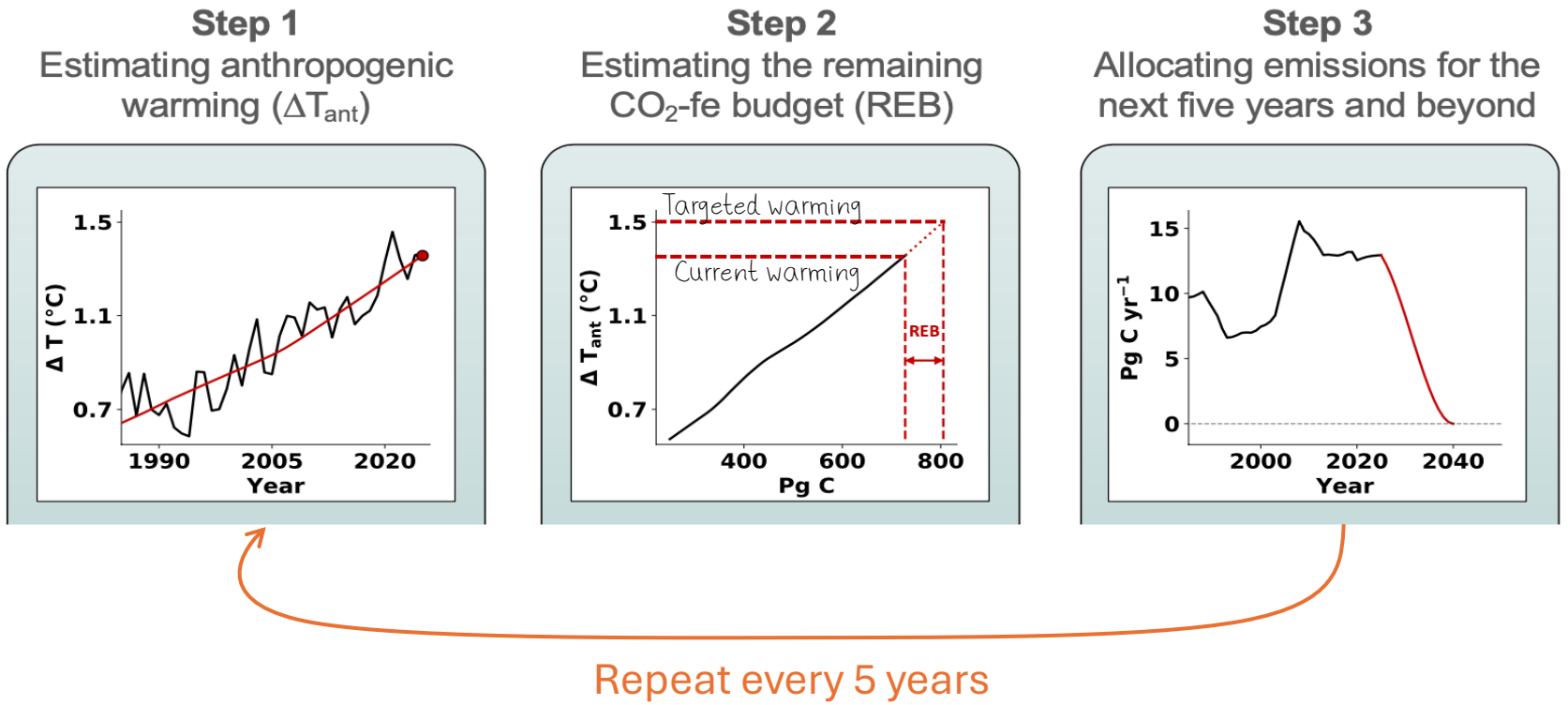
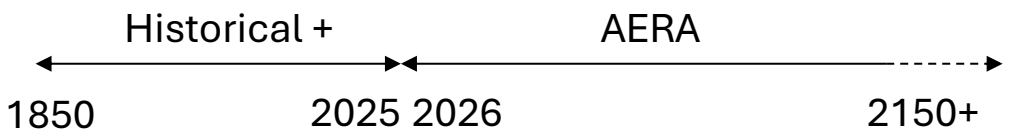


- Adapting emissions successively like a feedback loop until the warming level is reached, and temperature stabilizes

AERA-MIP

Simulation protocol

- Branched from extended emission-driven historical simulations until 2025
- From 2026, fossil fuel CO_2 emissions calculated by the AERA python code
- non-CO_2 agents follow ssp1-2.6
- 1.5ºC and 2ºC relative temperature targets (remaining warming based on observations to remove simulated historical warming biases)



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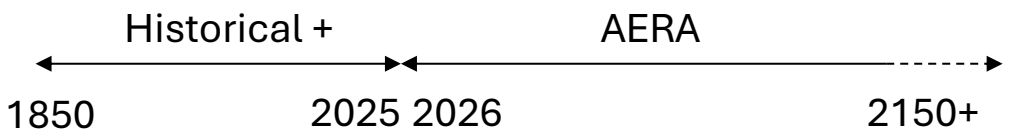
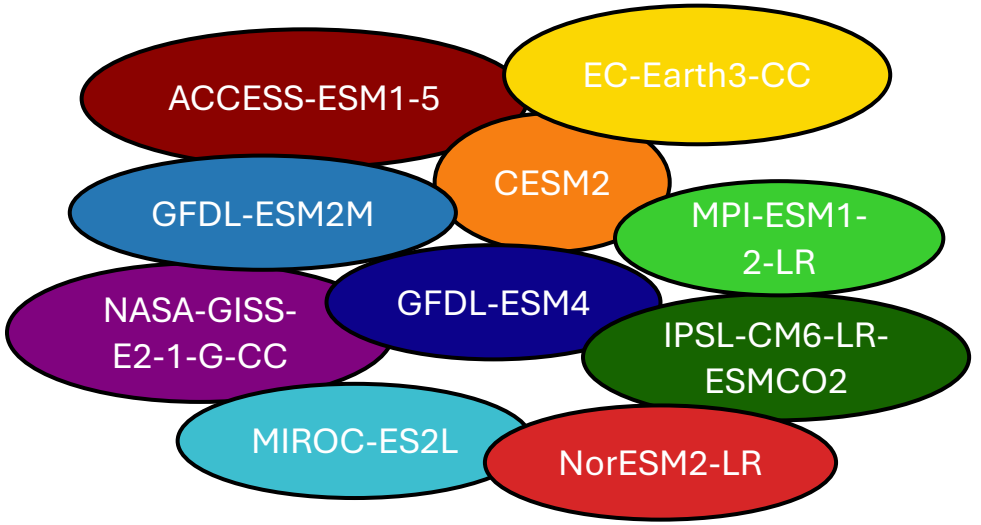
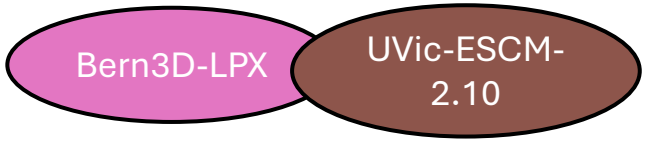


13 Earth System Models



10 fully-coupled ESMs

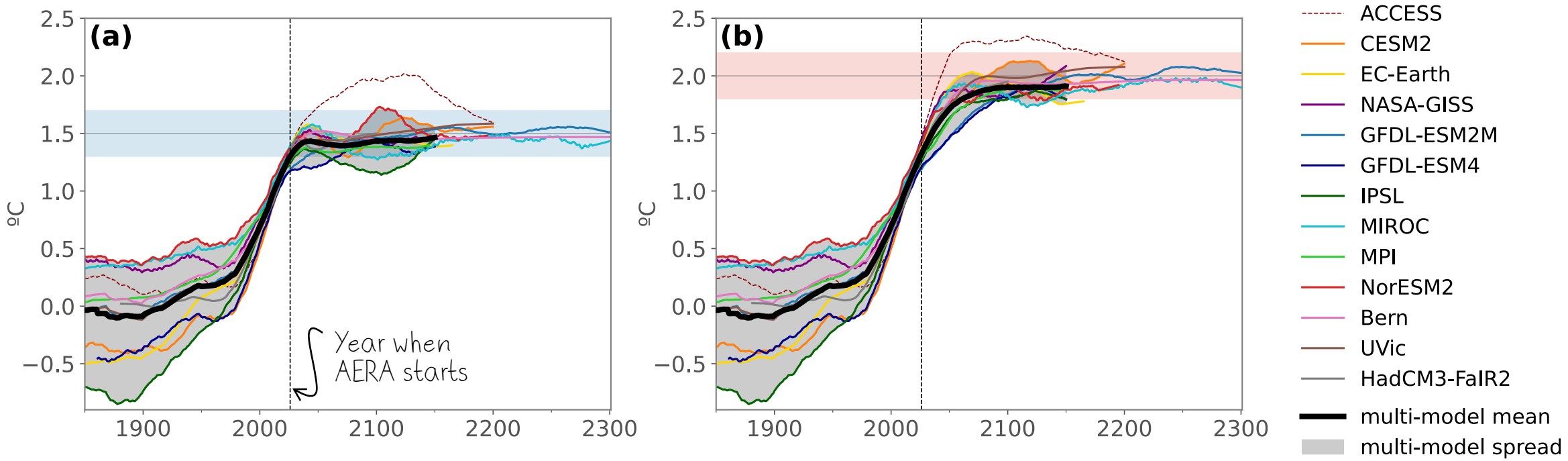


2 EMICs

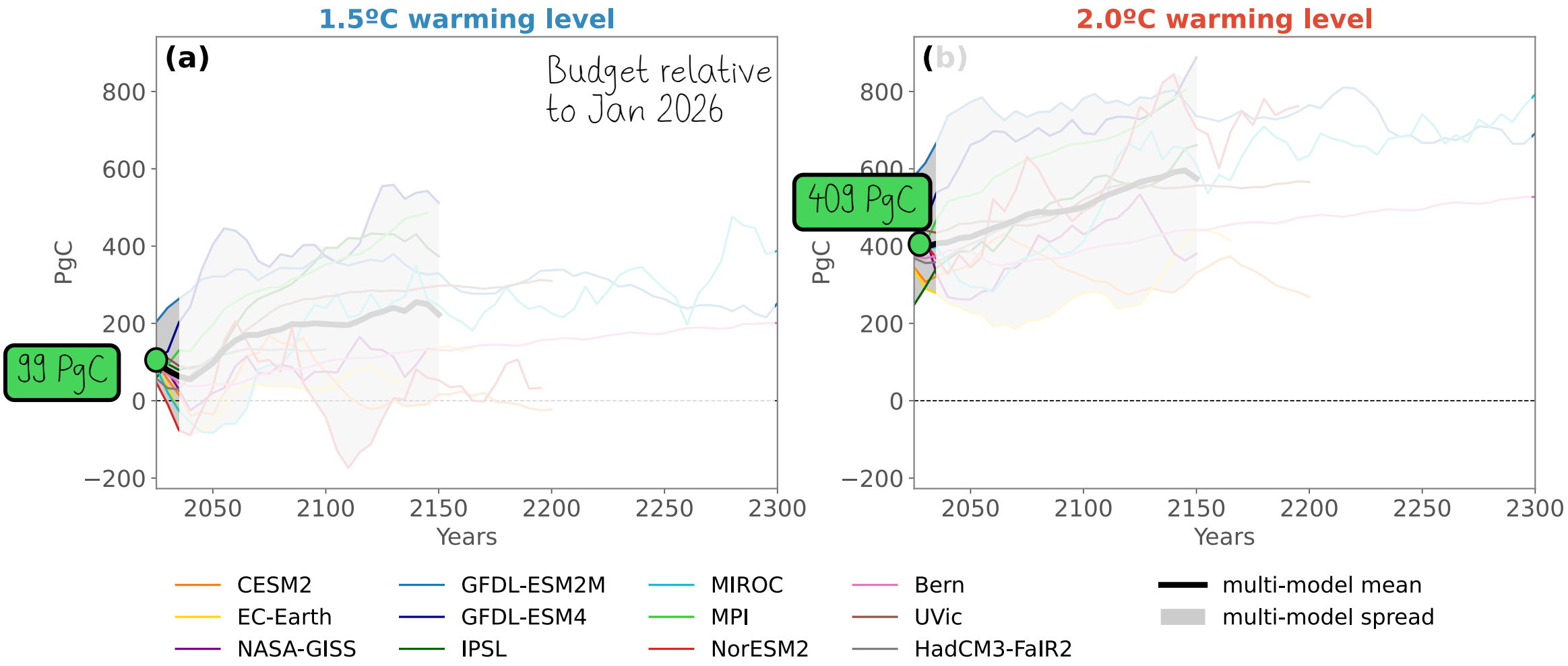
1 AOGCM coupled to an emulator

Models converge and stabilize at 1.5ºC and 2ºC

1.5ºC warming level **2.0ºC warming level**



The remaining emission budget increases...



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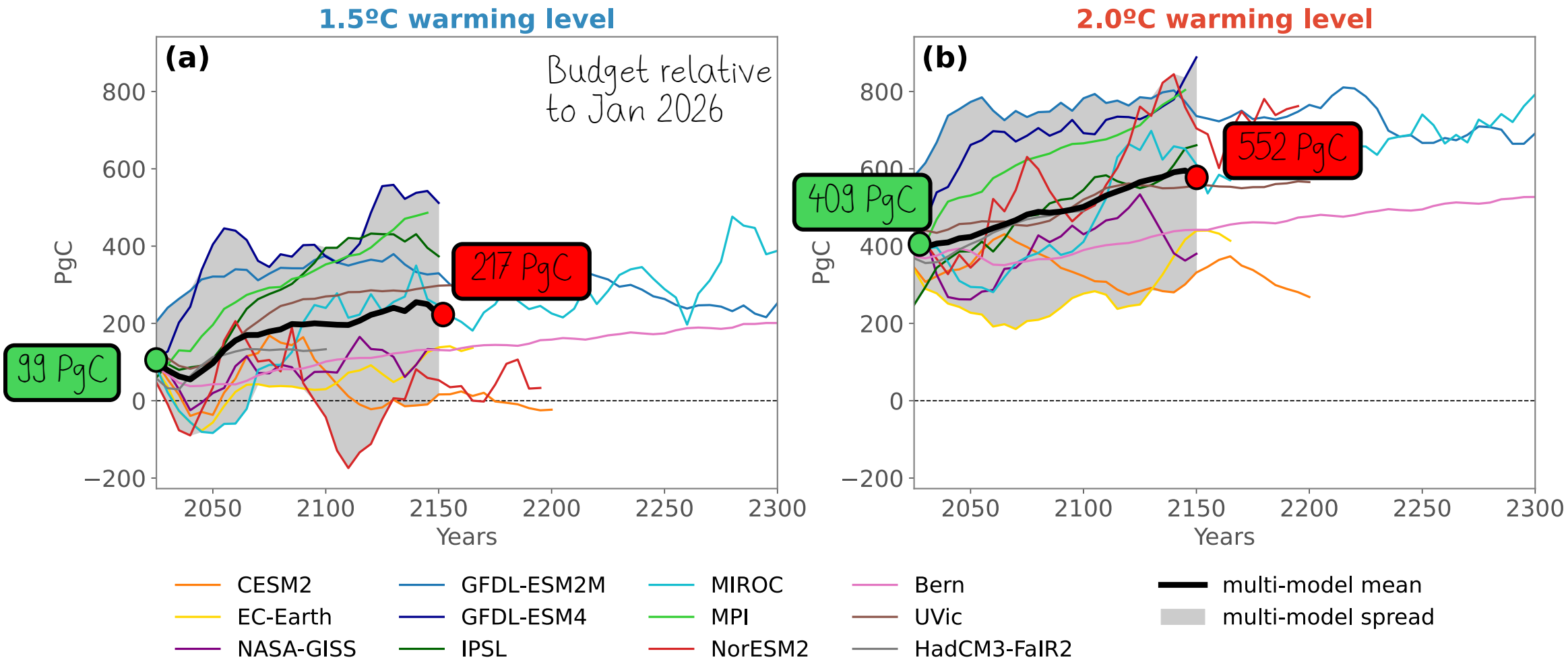
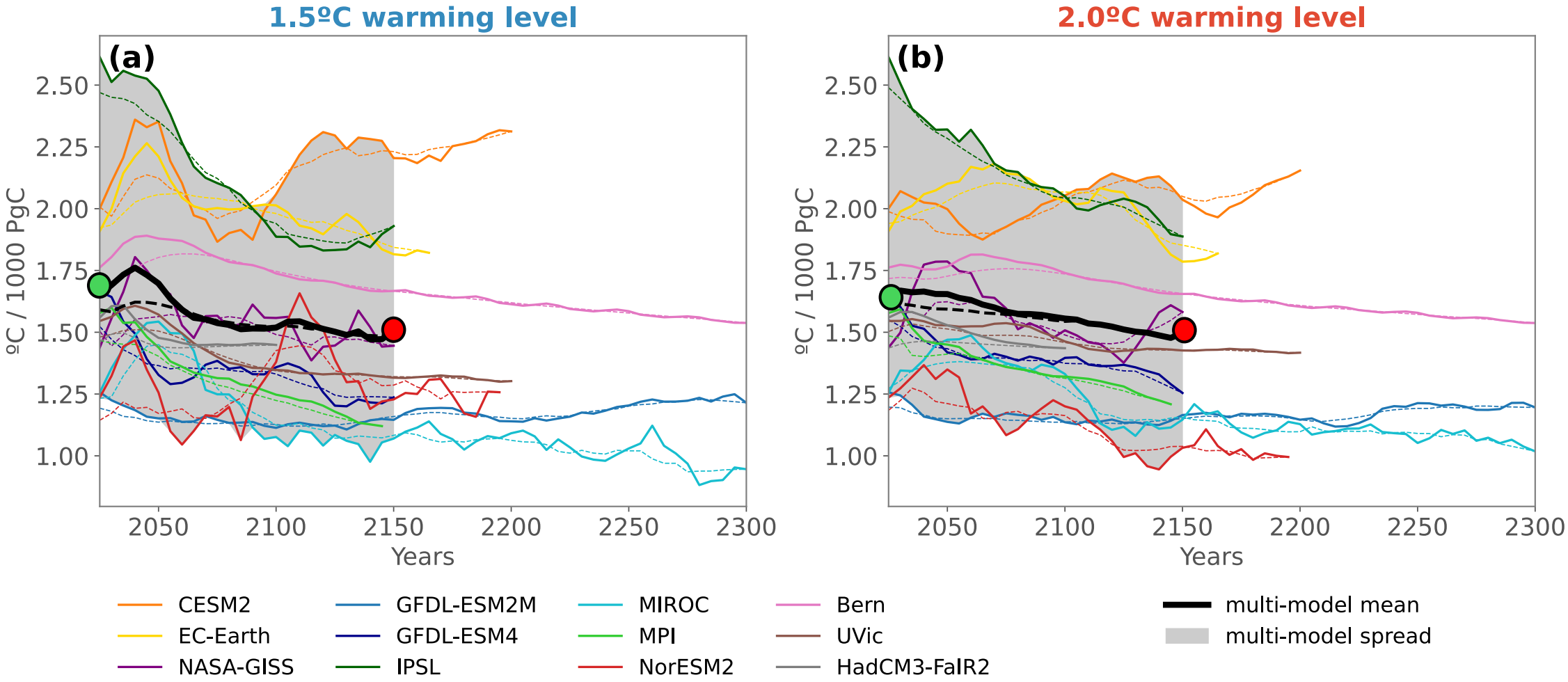


...because TCRE decreases



The emission budget from 2020 to 2150 is larger than the AR6 RCB estimate

	Warming level	Total CO_2-fe $E_{FOS} + E_{LUC} + E_{non\text{-}CO_2\text{-}fe}$	FF+LUC CO_2 $E_{FOS} + E_{LUC}$	FF CO_2 E_{FOS}	LUC CO_2 E_{LUC}	non-CO_2 $E_{non\text{-}CO_2\text{-}fe}$
This study	1.5 °C	900 (450 to 1800)	800 (250 to 1800)	700 (250 to 1450)	150 (50 to 300)	10 (-10 to 20)
IPCC AR6 WGI	1.5 °C		500 (300 to 900)			220-440
Forster et al. (2024)	1.5 °C		400 (200 to 750)			
This study	2.0 °C	2150 (1600 to 2900)	2250 (1350 to 2900)	2050 (1350 to 2600)	150 (50 to 300)	10 (-10 to 20)
IPCC AR6 WGI	2.0 °C		1350 (900 to 2350)			220-440
Forster et al. (2024)	2.0 °C		1300 (900 to 2200)			

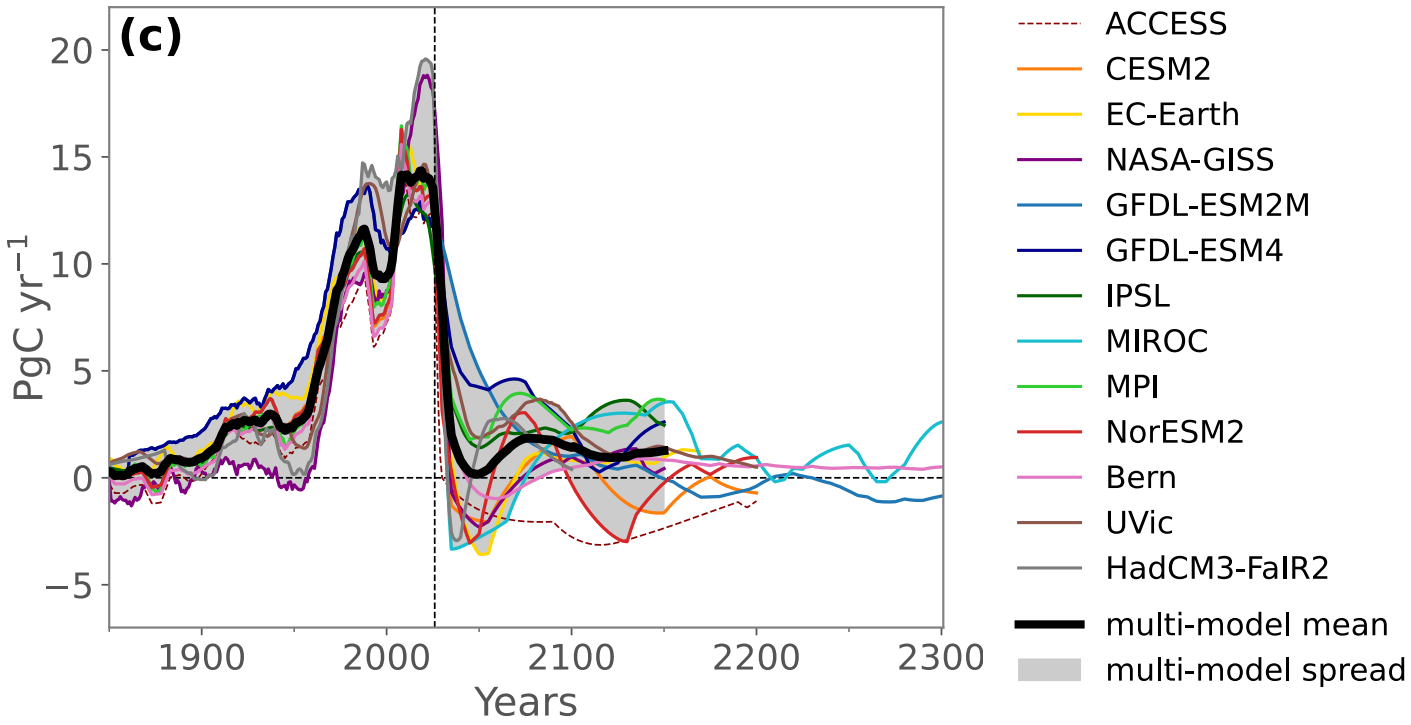
1.5 ºC warming level

2 ºC warming level

in $GtCO_2$

Compatible CO_2-fe emission pathways

1.5ºC warming level



- -98% between 2025 and 2050
- Stabilization at 1 PgC yr^{-1} beyond 2100

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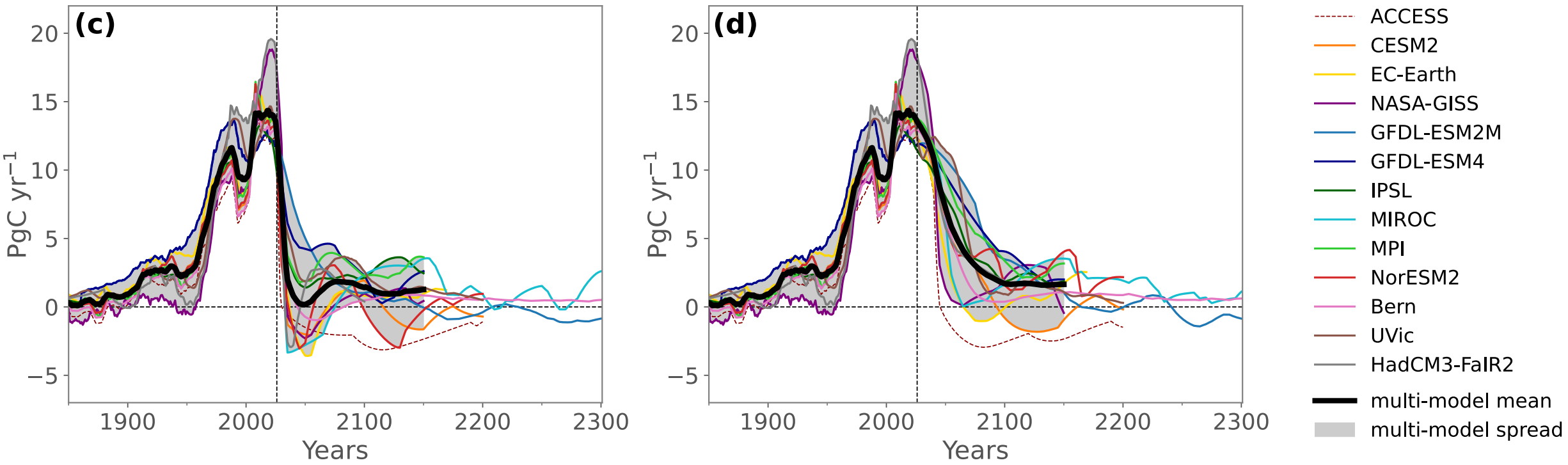

- -98% between 2025 and 2050
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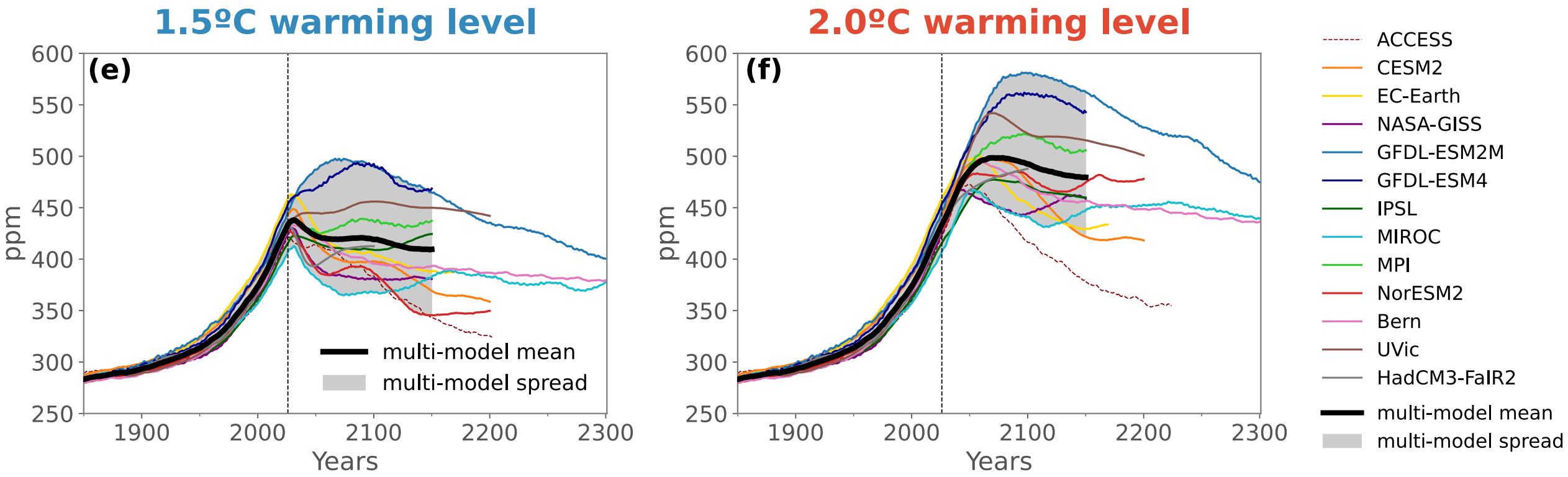
- -47% between 2025 and 2050
- Stabilization at 1.7 PgC yr^{-1} beyond 2100

Atmospheric CO_2 peaks and declines



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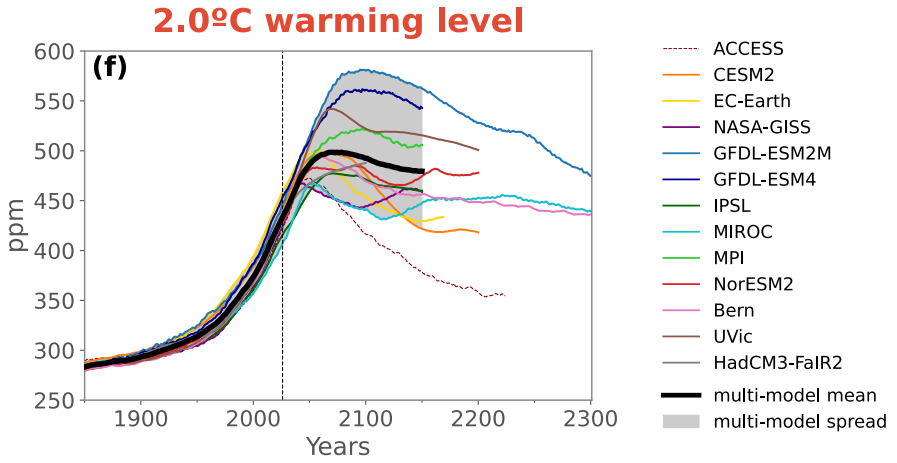

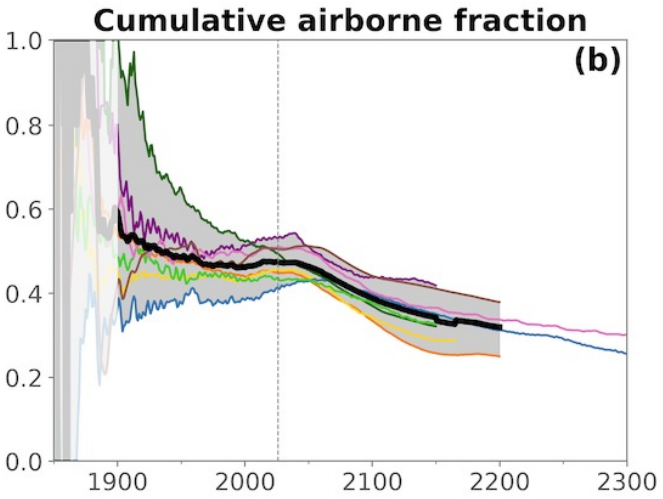

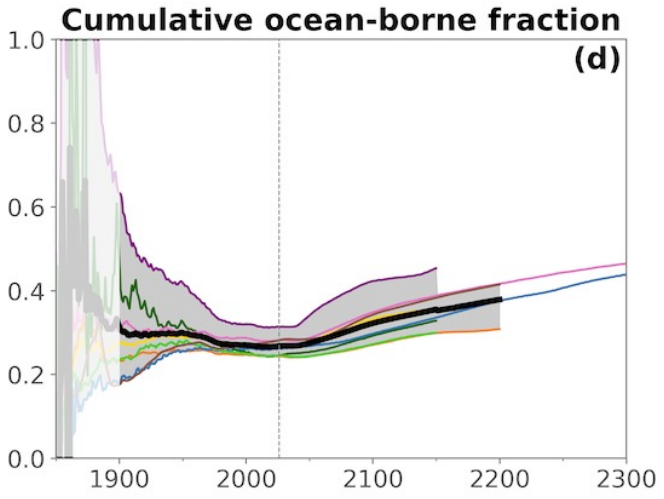

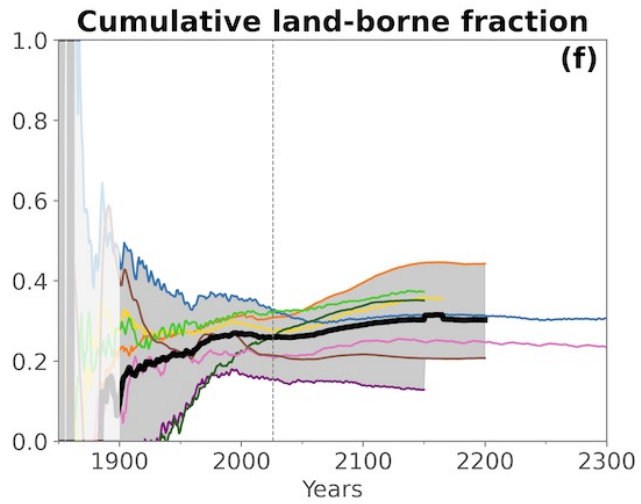

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Key messages

Silvy et al. 2024

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- AERA-MIP simulations are directly comparable in terms of impacts under equal warming.

Silvy et al. 2024

Poster at X4.37 on Thursday afternoon on the ocean heat and carbon response in long stabilization simulations

EGU25-8581

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✉ Get in touch: yona.silvy@unibe.ch
Also now in the IPCC AR7 WGI Technical Support Unit