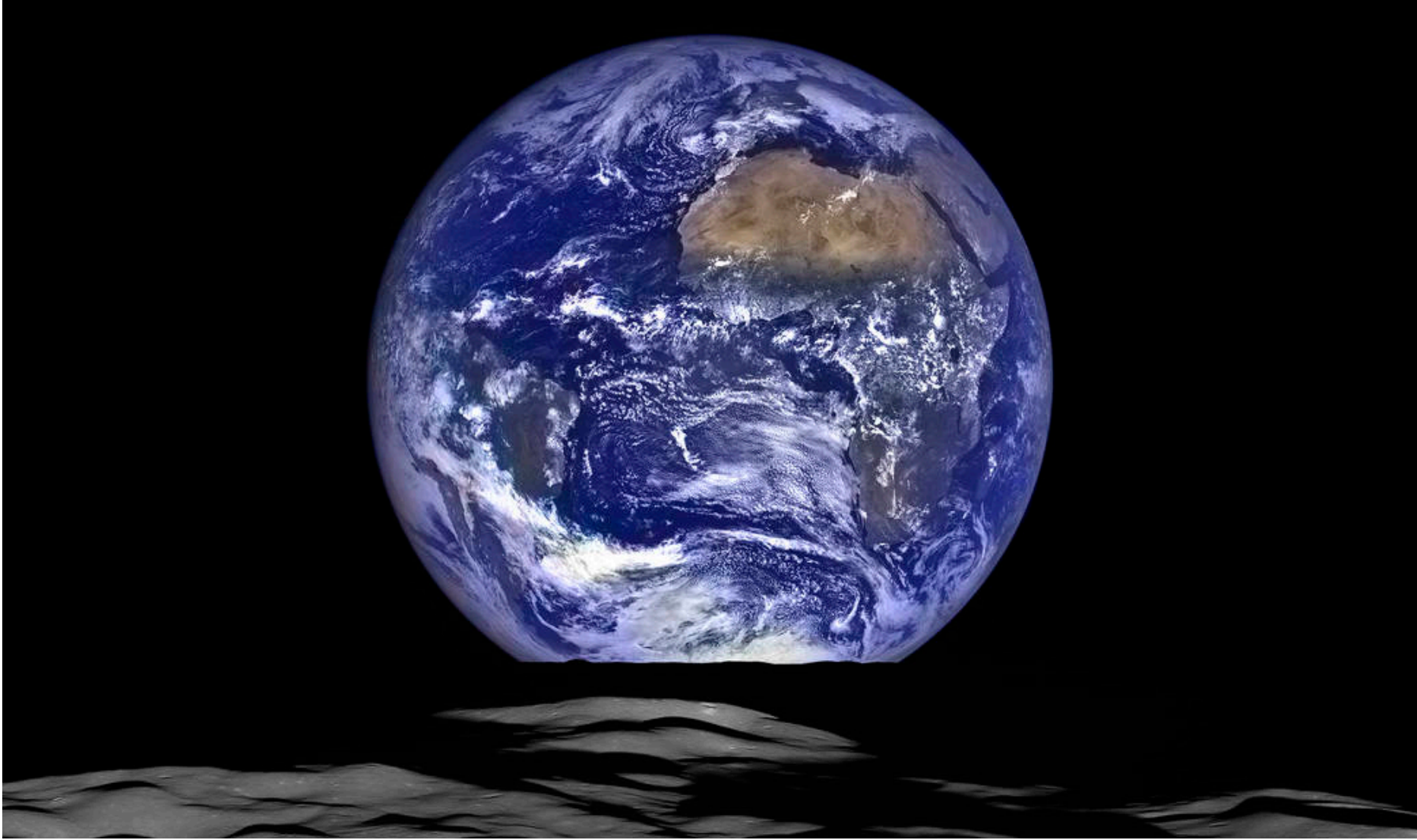


Assessing the Climate Threat

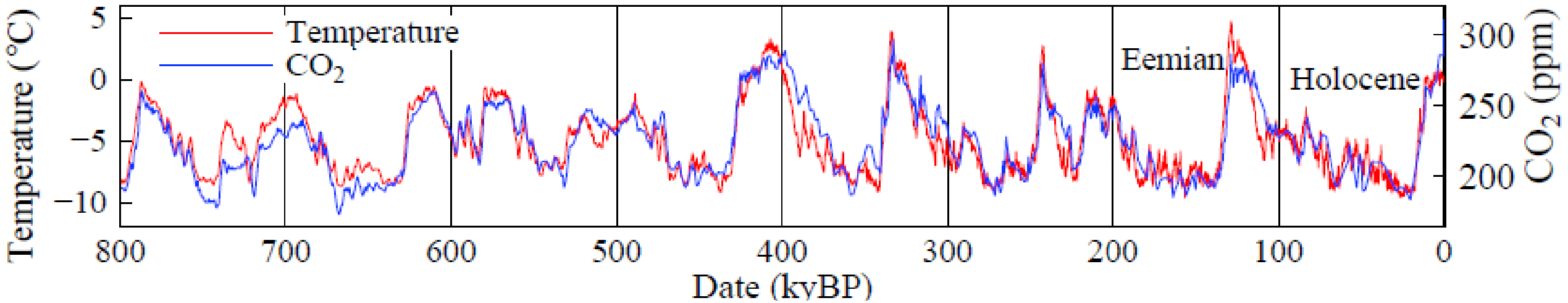
James Hansen

18 October 2023

**CERES Team Meeting
GISS, New York City**



We live on a planet with a climate characterized by delayed response and amplifying feedbacks.



Antarctic Dome C temperature for past 800 ky from Jouzel *et al.* relative to mean of the last 10 ky and Dome C CO₂ amount from Luthi *et al.* (kyBP = kiloyears before present).

Jouzel J, Masson-Delmotte V, Cattani O *et al.* [Orbital and millennial Antarctic climate variability over the past 800,000 years](#). *Science* 2007;**317**:793-6

Luthi D, Le Floch M, Bereiter B *et al.* [High-resolution carbon dioxide concentration record 650,000-800,000 years before present](#). *Nature* 2008;**453**:379-82

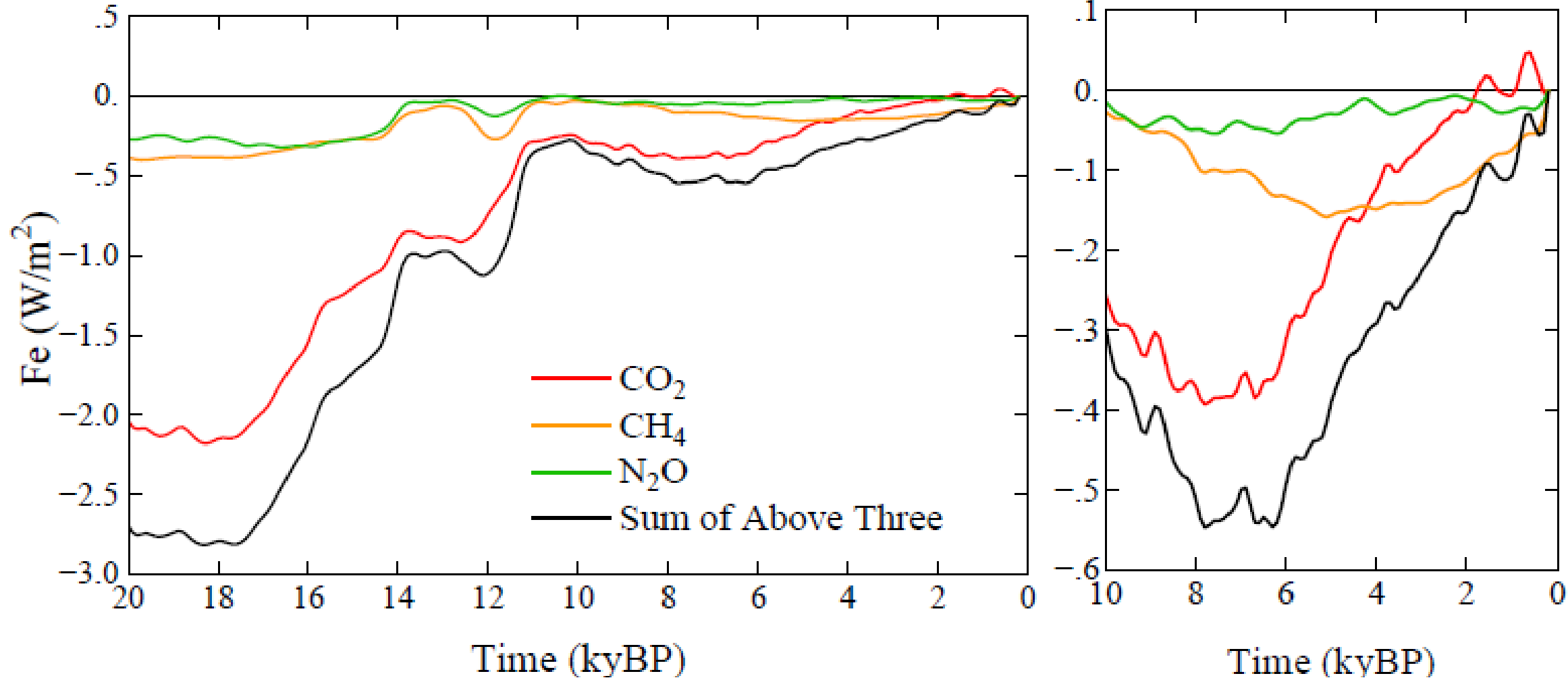
Polar ice cores have long provided precise knowledge of global paleo CO₂ variations.

Recent independent studies of Tierney *et al.* and Seltzer *et al.* provide accurate evaluation of Last Glacial Maximum (LGM) temperature.

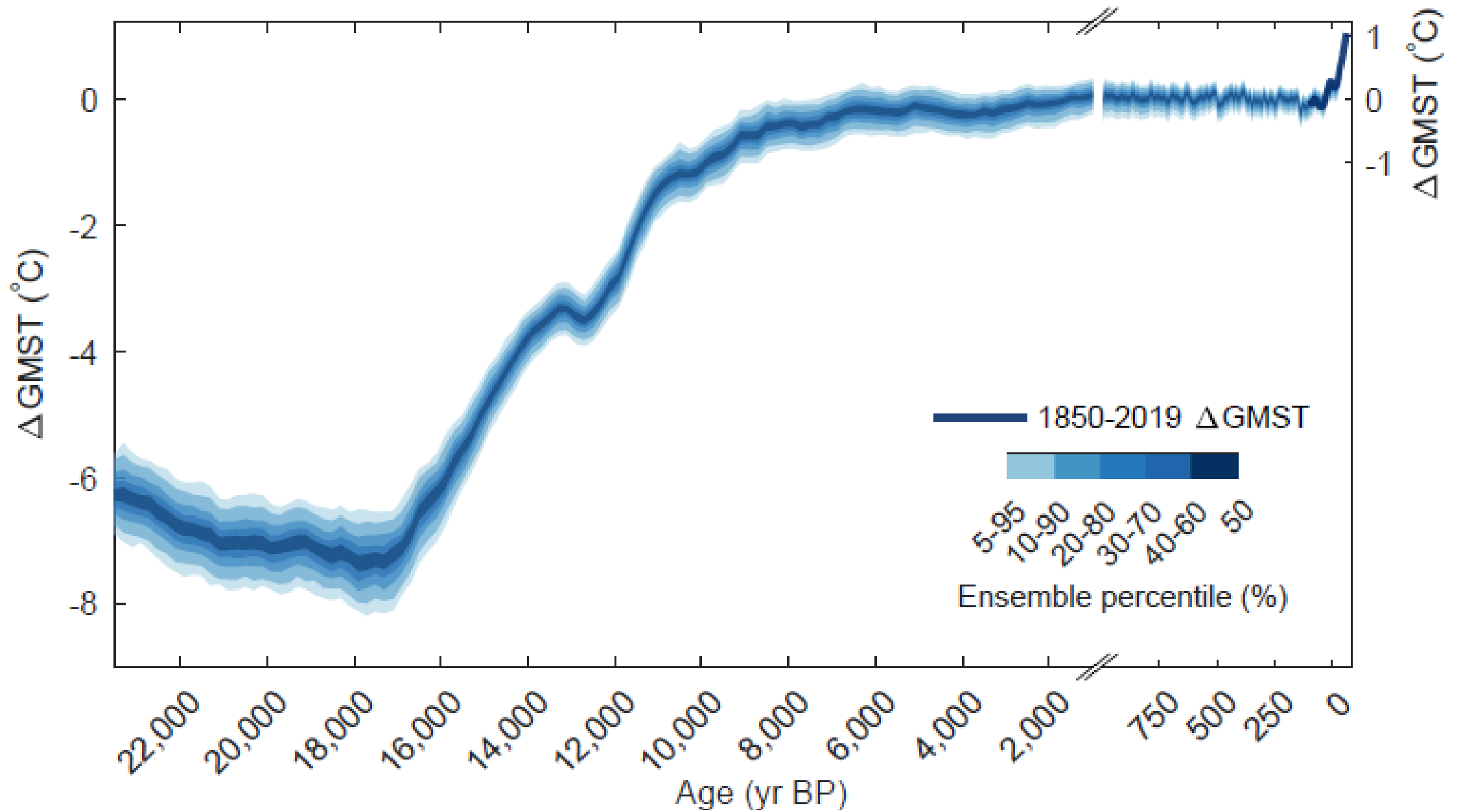
- 1. Peak LGM (21-18 kyBP) cooling = $7.0 \pm 1^\circ\text{C}$ (2σ , 95% confidence)**
- 2. LGM surface albedo forcing = $3.5 \pm 1.0 \text{ W/m}^2$ (2σ)**
- 3. LGM Greenhouse gas forcing = $2.25 \pm 0.225 \text{ W/m}^2$ (2σ)**

$$\text{Climate Sensitivity} = 7.0 / (3.5 + 2.25) = 1.2 \pm 0.3^\circ\text{C per W/m}^2 \text{ (} 2\sigma \text{)}$$
$$= 4.8 \pm 1.2^\circ\text{C for } 2\times\text{CO}_2 \text{ (} 2\sigma \text{)}$$

Excludes IPCC best estimate (3°C for $2\times\text{CO}_2$) at 3σ (99.7% confidence)

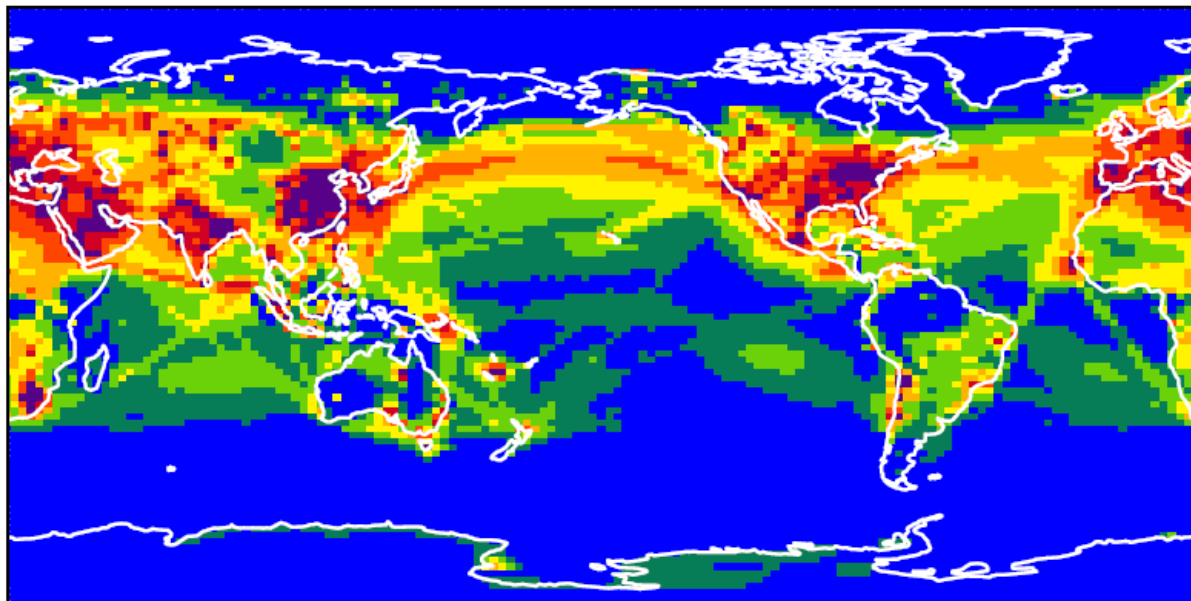


GHG climate forcing in past 20 ky with vertical scale expanded for the past 10 ky on the right.

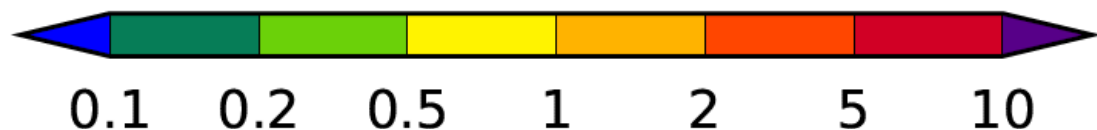


Global mean surface temperature change over the past 24 ky, from Fig. 2 of Osman et al. (2021).

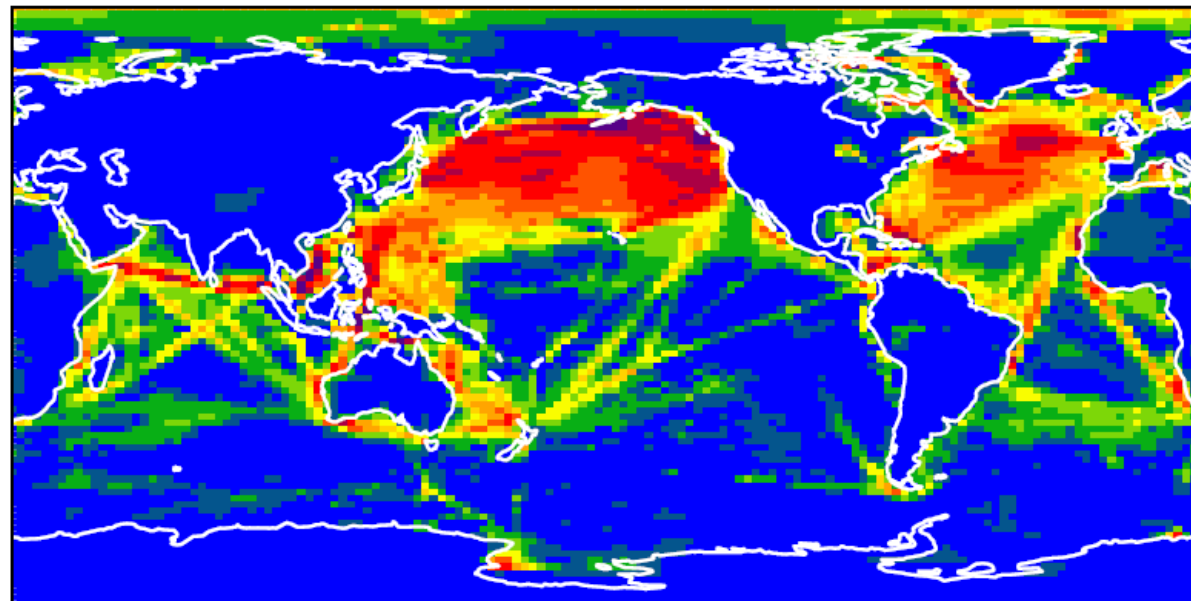
(a) Total sulfate



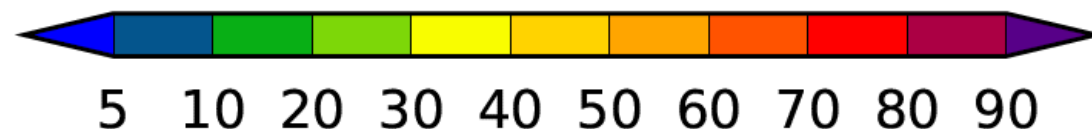
(p.p.t.v.)



(b) Percent of total sulfate from shipping

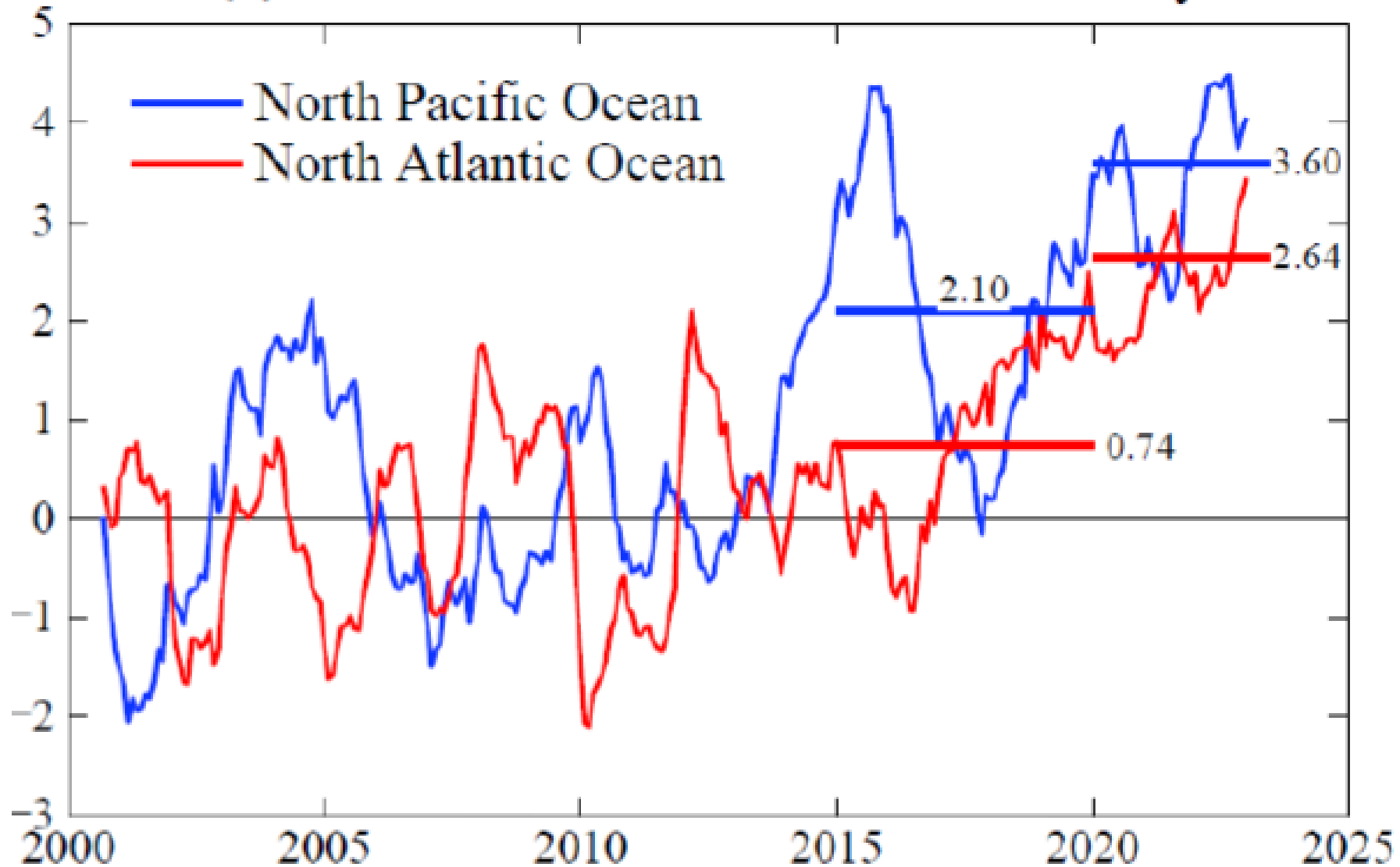


(%)



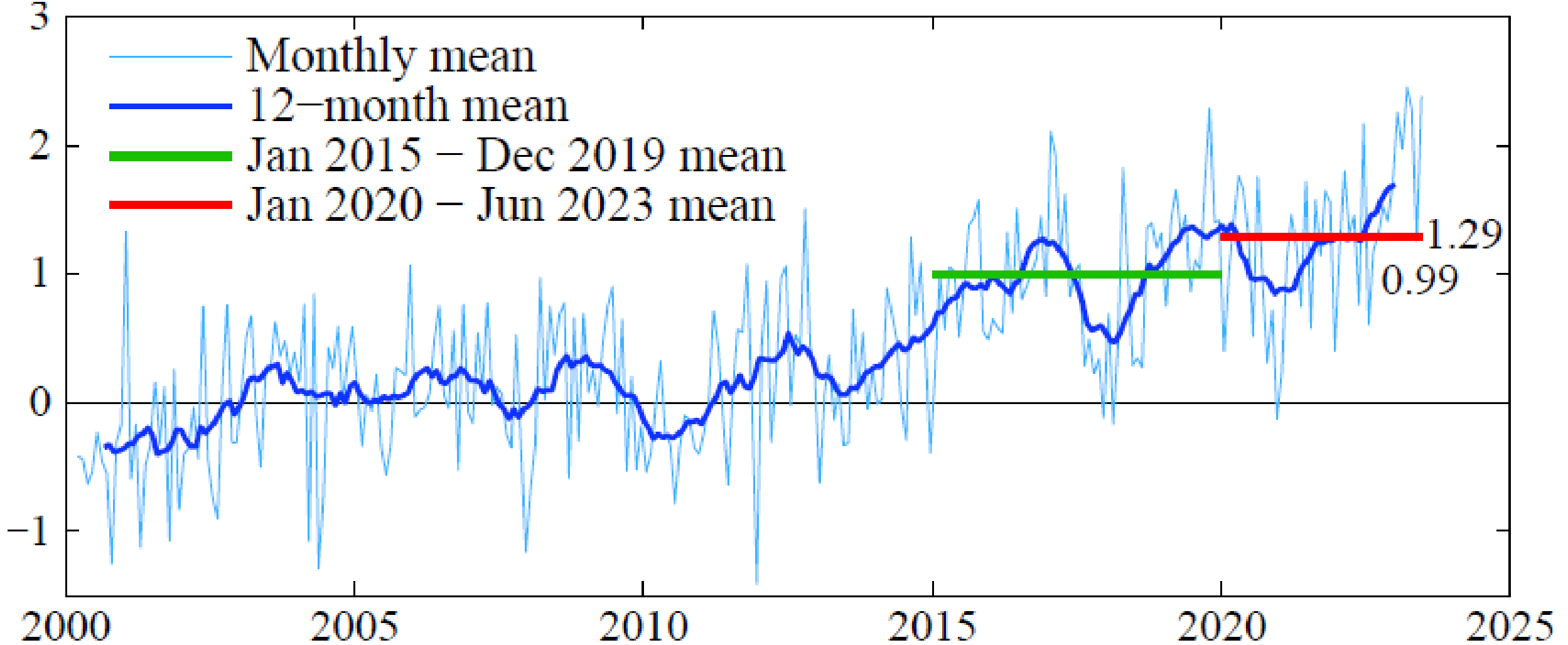
Total sulfate (parts per trillion by volume) and percentage of total sulfate provided by shipping in simulations of Jin et al. prior to IMO regulations on sulfur content of fuels.

(b) Absorbed Solar Radiation Anomaly



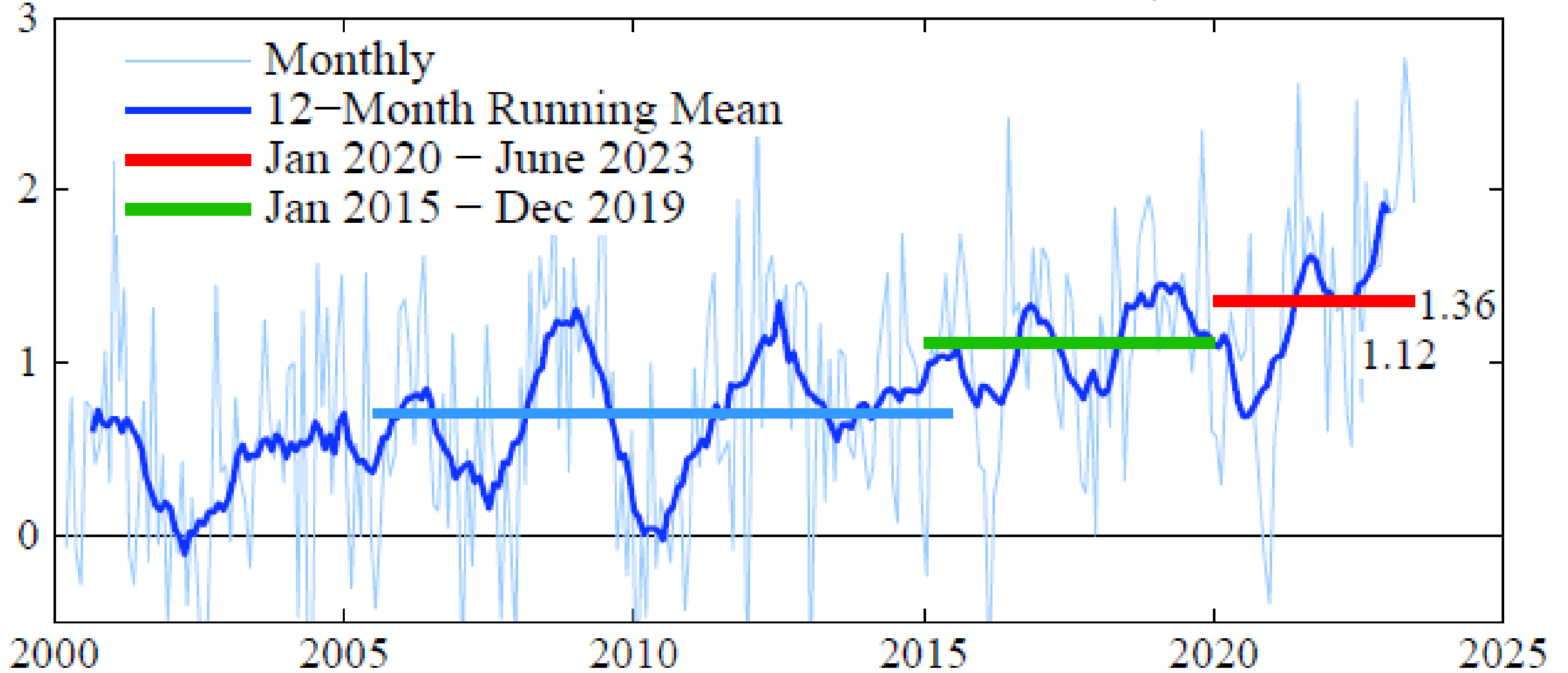
North Atlantic is (20-60°N, 0-60°W) and North Pacific is (20-60°N, 120-220°W).

Data source: http://ceres.larc.nasa.gov/order_data.php



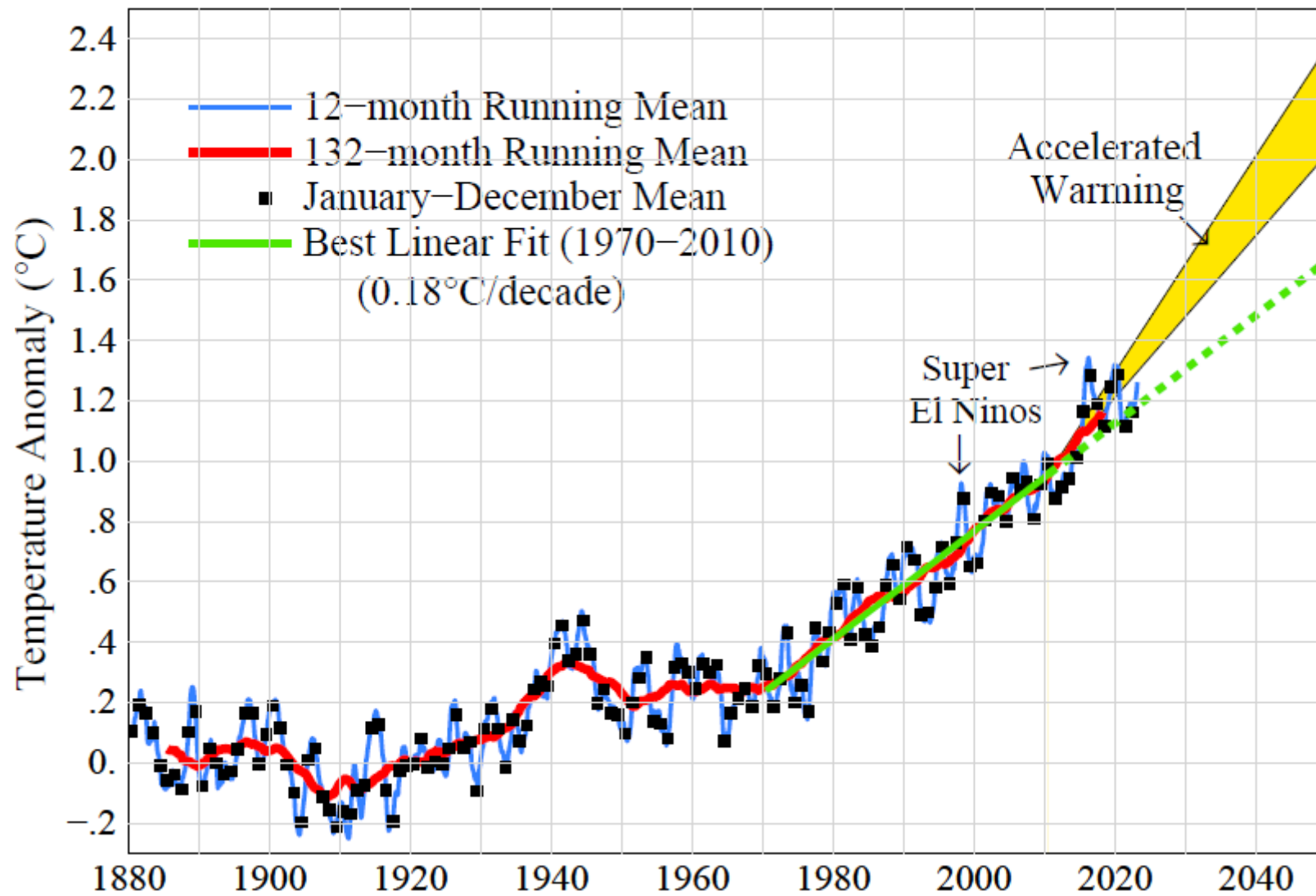
Global absorbed solar radiation (W/m^2) relative to mean of the first 120 months of CERES data

Earth's Energy Imbalance (W/m^2)



12-month running-mean of Earth's energy imbalance based on CERES satellite data for EEI change normalized to $0.71 \text{ W}/\text{m}^2$ mean for July 2005 - June 2015 from in situ data.

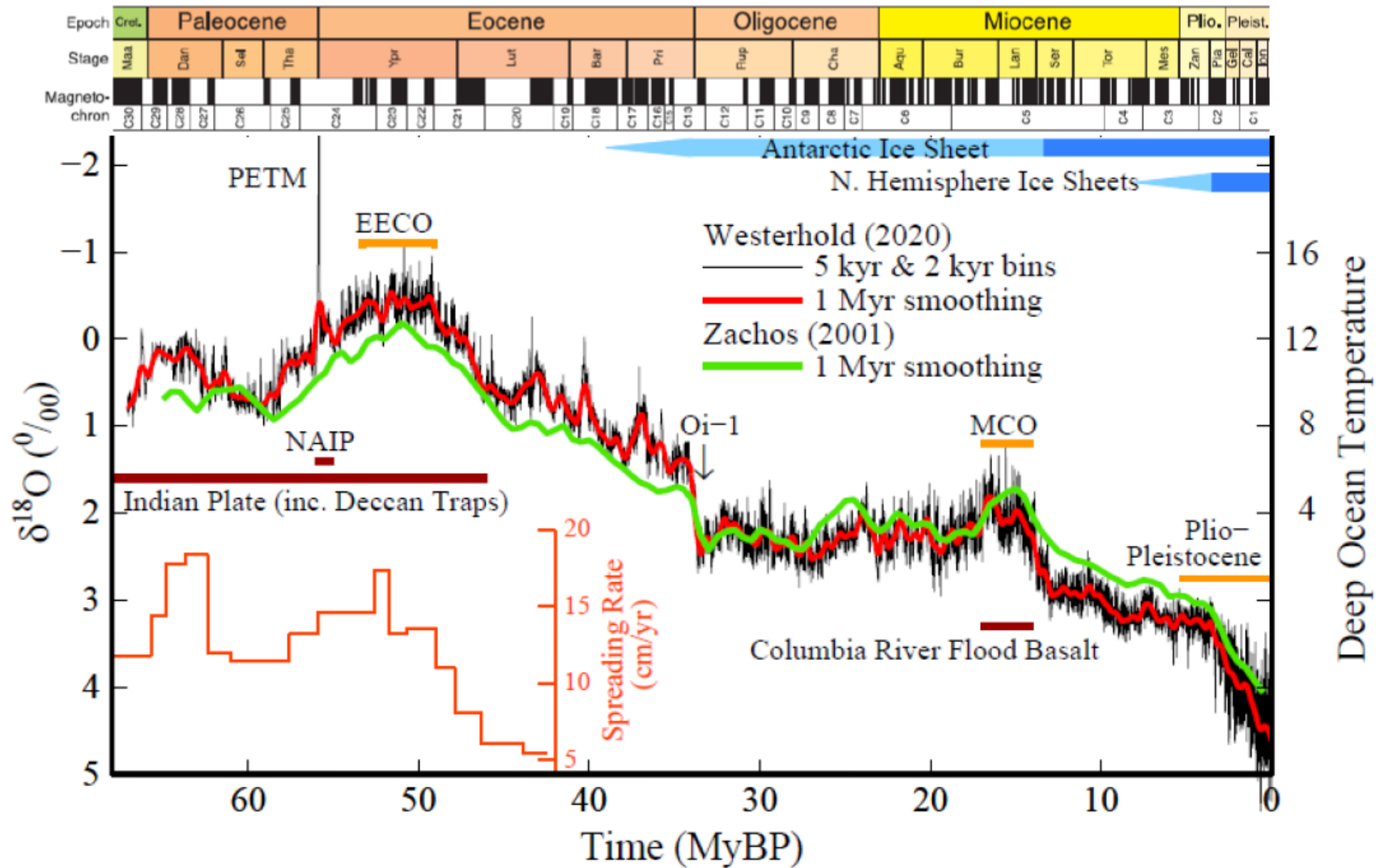




Global temperature relative to 1880-1920. Edges of the predicted post-2010 accelerated warming rate (see text) are 0.36 and 0.27°C per decade.



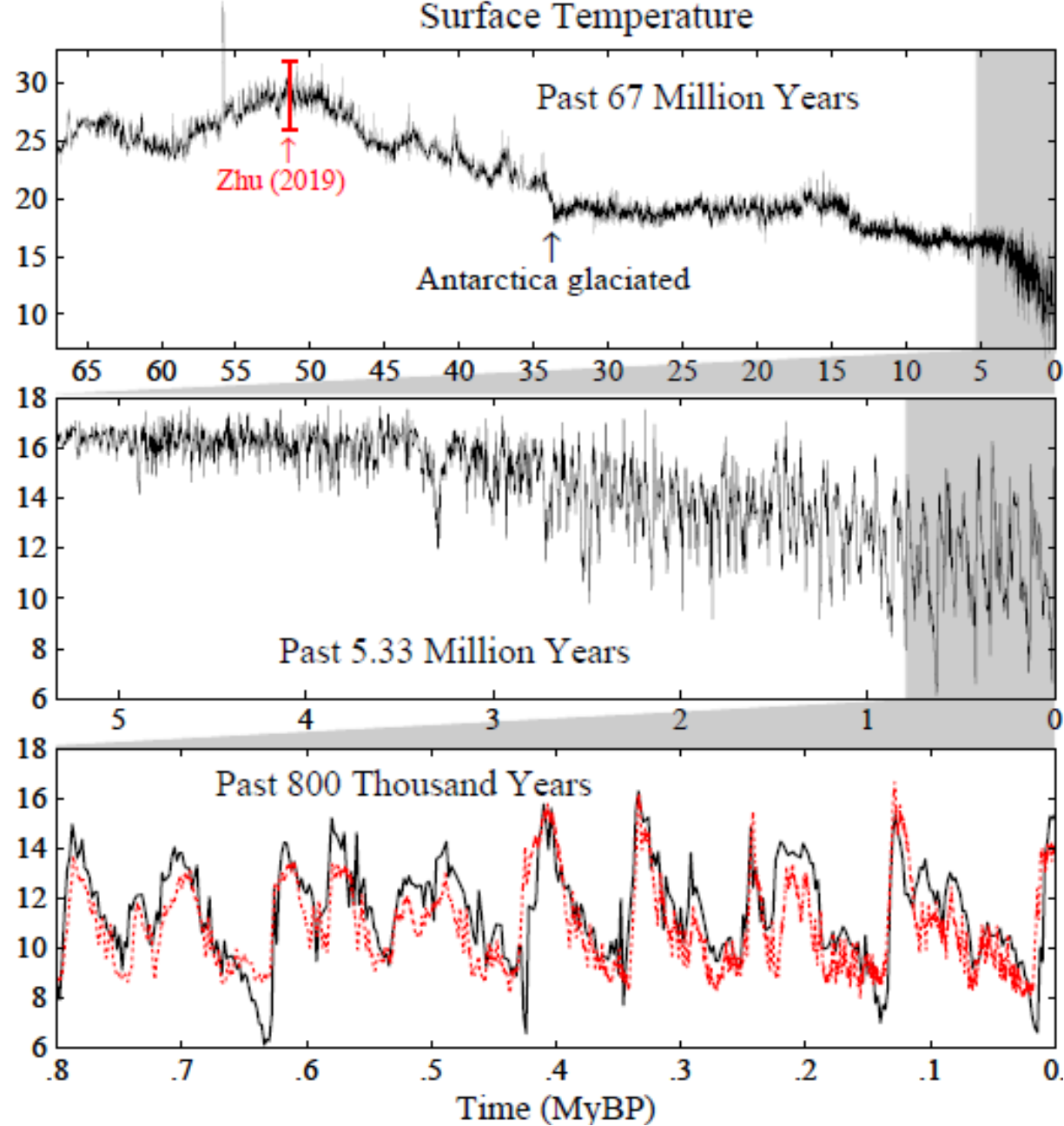
Continental configuration 56 MyBP. Continental shelves (light blue) were underwater as little water was locked in ice. The Indian plate was moving north at about 15 cm per year. A sea floor rift opened in North Atlantic at 56 MyBP as Greenland pulled away from Europe.



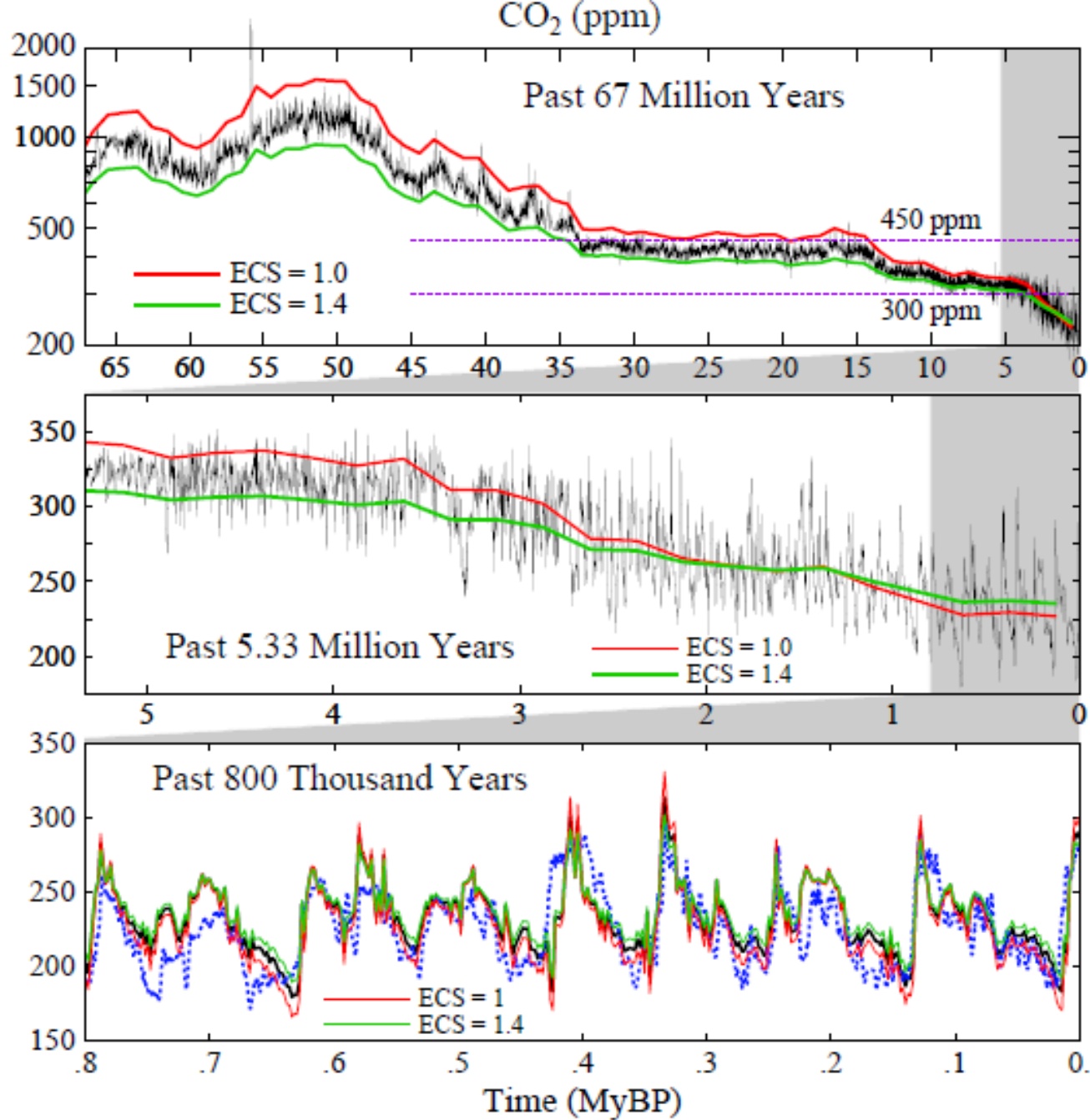
Global deep ocean $\delta^{18}\text{O}$. Black line: high resolution Westerhold *et al.* (2020) data.

Lower left: velocity of Indian tectonic plate.

EECO = Early Eocene Climatic Optimum; Oi-1 = transition to glaciated Antarctica

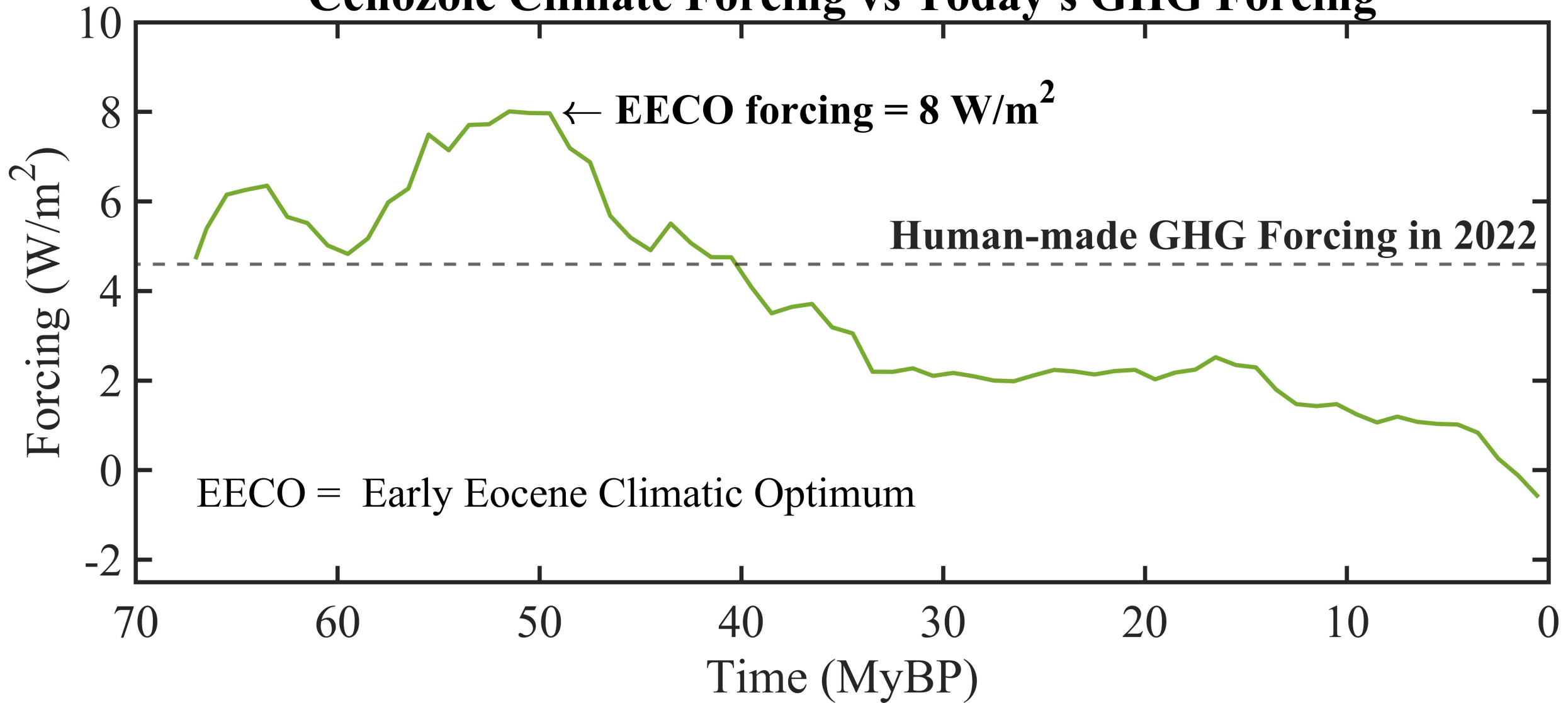


Cenozoic surface temperature estimated from deep ocean oxygen isotope data of Westerhold *et al.* Red data is $0.6 \times$ Antarctic Dome C temperature.



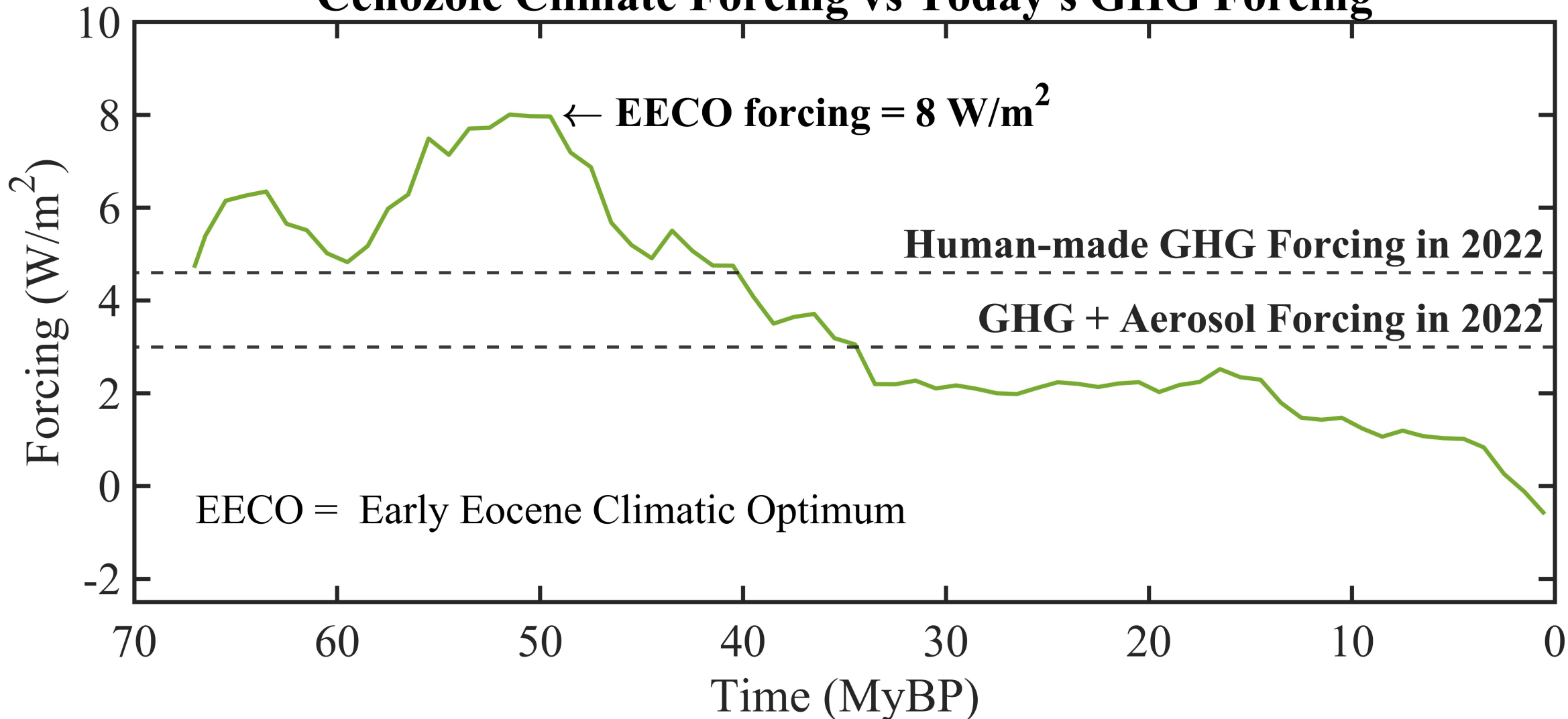
Implied CO₂ history for ECS = 1.2°C per W/m² (black); red & green for ECS = 1.0 and 1.4°C per W/m² are 1 My smoothed

Cenozoic Climate Forcing vs Today's GHG Forcing

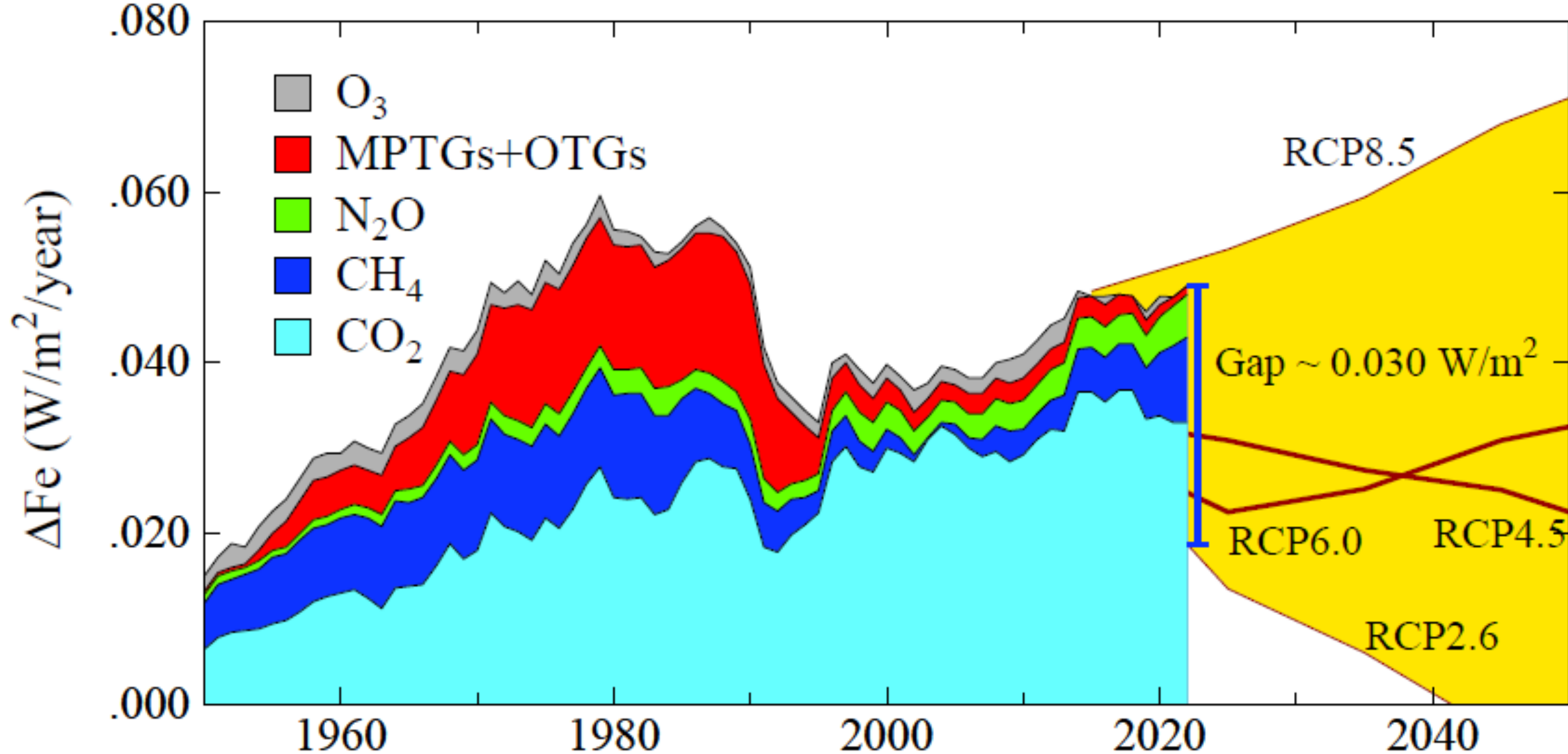


Forcing required to yield Cenozoic temperature for today's solar irradiance, compared with human-made GHG forcing in 2022.

Cenozoic Climate Forcing vs Today's GHG Forcing



Forcing required to yield Cenozoic temperature for today's solar irradiance, compared with human-made GHG forcing in 2022.



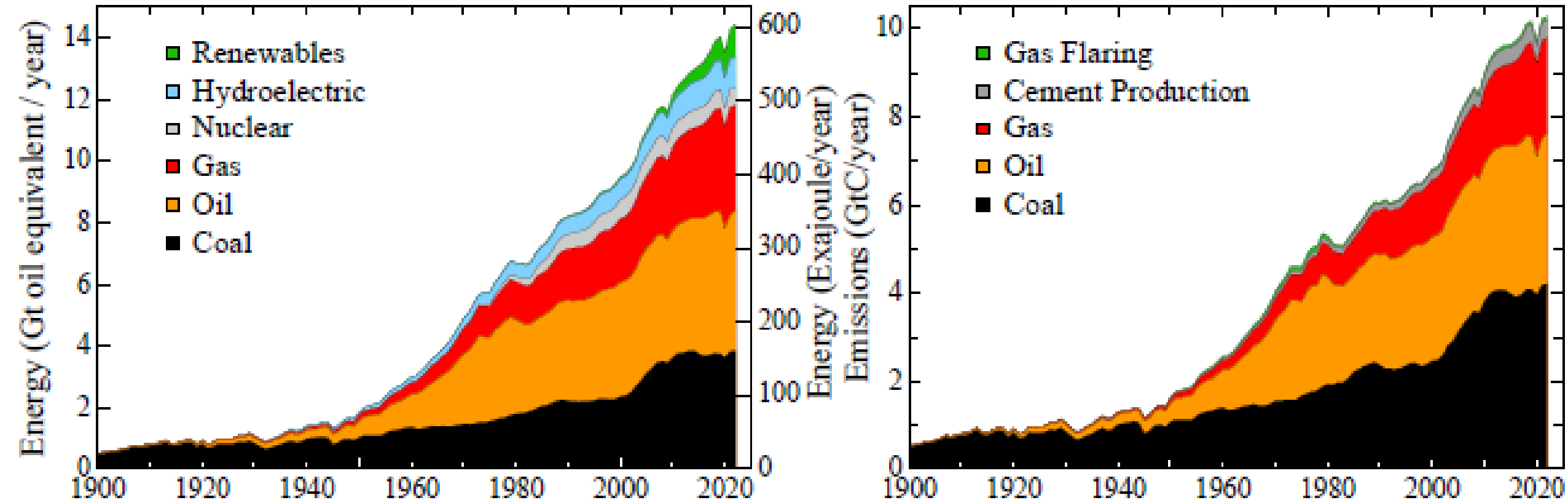
Annual growth of climate forcing by GHGs.

MPTG and OTG are Montreal Protocol and Other Trace Gases.

RCP2.6 scenario is designed to keep global warming < 2C.

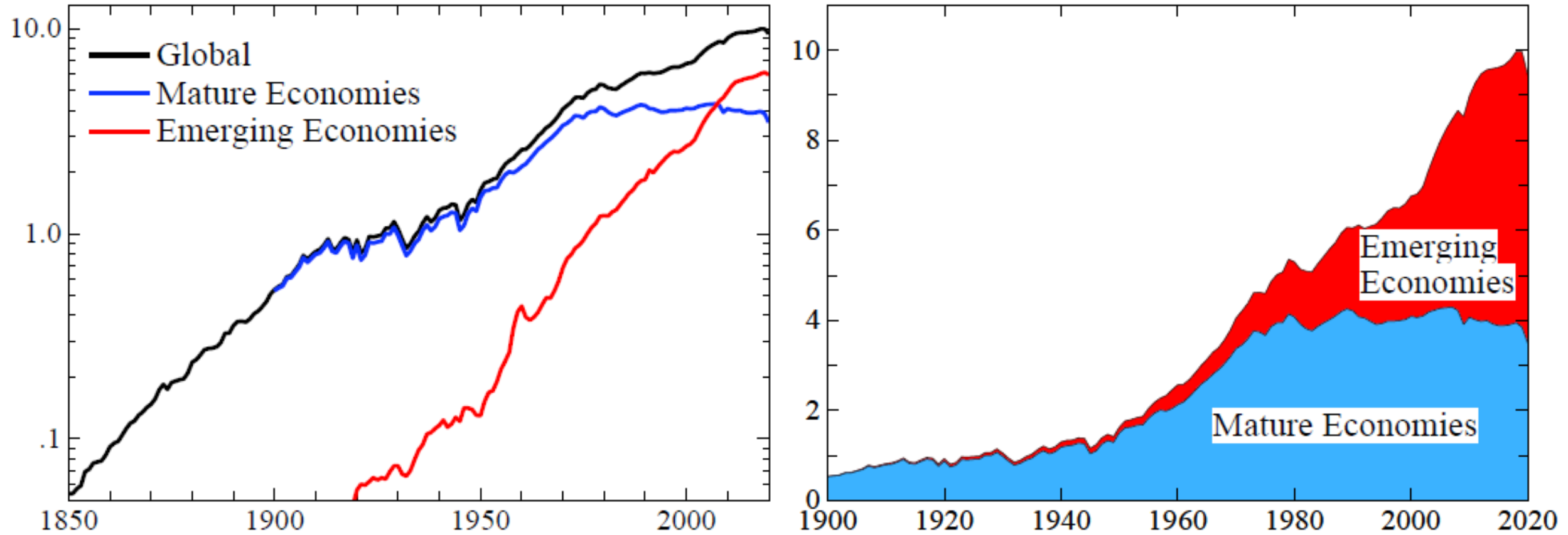
(a) Global Energy Consumption

(b) Global CO₂ Emissions



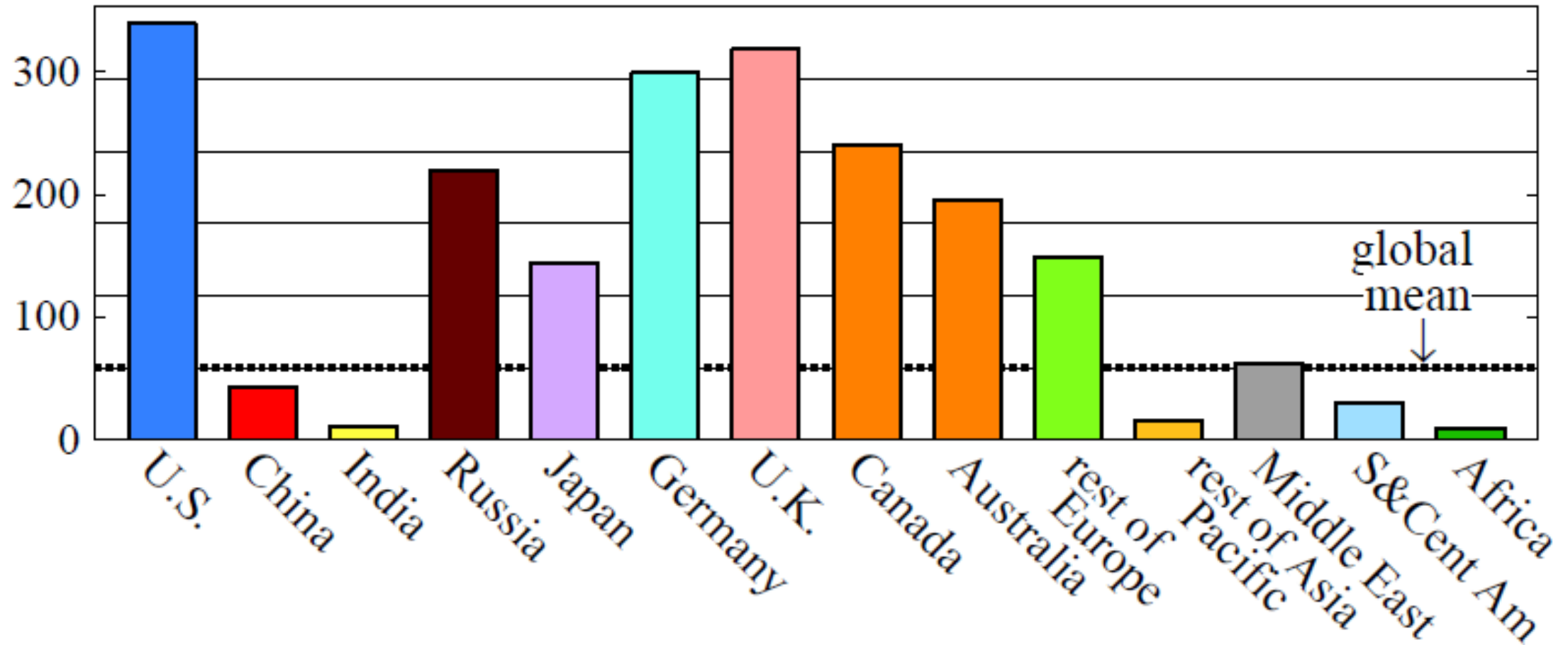
Global energy consumption and CO₂ emissions (Hefner *at al.* and *Energy Institute*)

Global Emissions (GtC/Year)

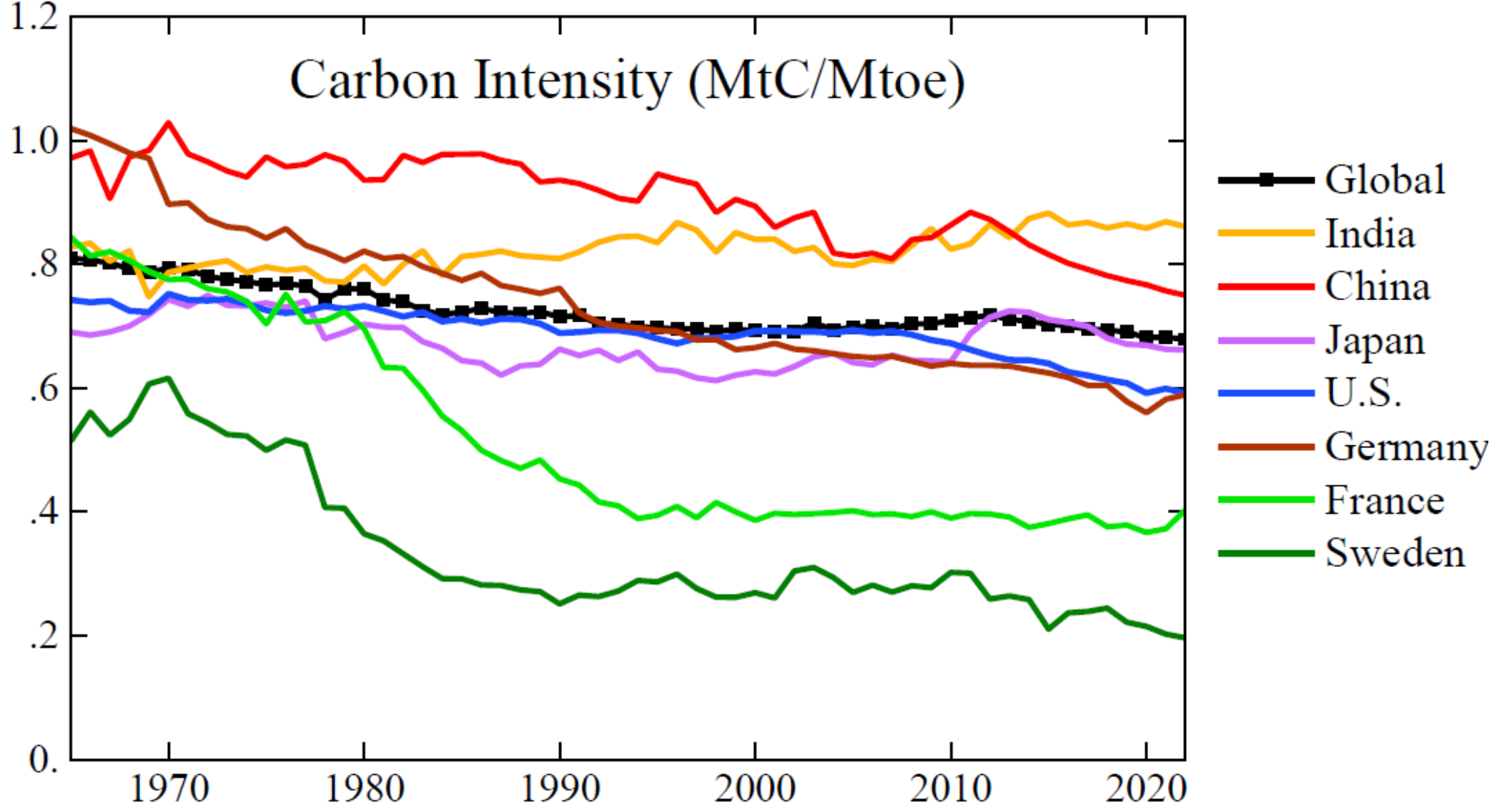


Fossil fuel CO₂ emissions from mature and emerging economies. China is counted in emerging economies.

1751–2020 Cumulative Emissions (tons C/person)



Cumulative per capita national fossil fuel emissions



Carbon intensity (carbon emissions per unit energy use) of several nations and the world. Mtoe = megatons of oil equivalent

Fundamental Required Actions

1. Rising Price (Fee) on Carbon

- All Funds to Public (combating wealth disparities)
- Border Duties (to make carbon fee near-global)

2. East-West Cooperation

- Present focus on military hegemony increases inflation
- Cooperate to make modern nuclear cheaper than gas

3. Actions to Restore Cooler Climate

- 1.5°C limit long dead; 2°C is on deathbed
- Initiate Preparations to Restore Energy Balance

Equal Rights and Opportunity: The Platform

- 1. No funding from special interests**
Individual donations only, max = \$100?/year
- 2. Party control of who/whether to run**
Avoid being spoiler if ranked voting not available
- 3. Advocate ranked voting**
Begin pushing for this immediately
- 4. Carbon fee & 100% dividend**
Eventually supplemented by energy fee
- 5. Renew civilian control over war-making**
Congress should uphold its Constitutional duty