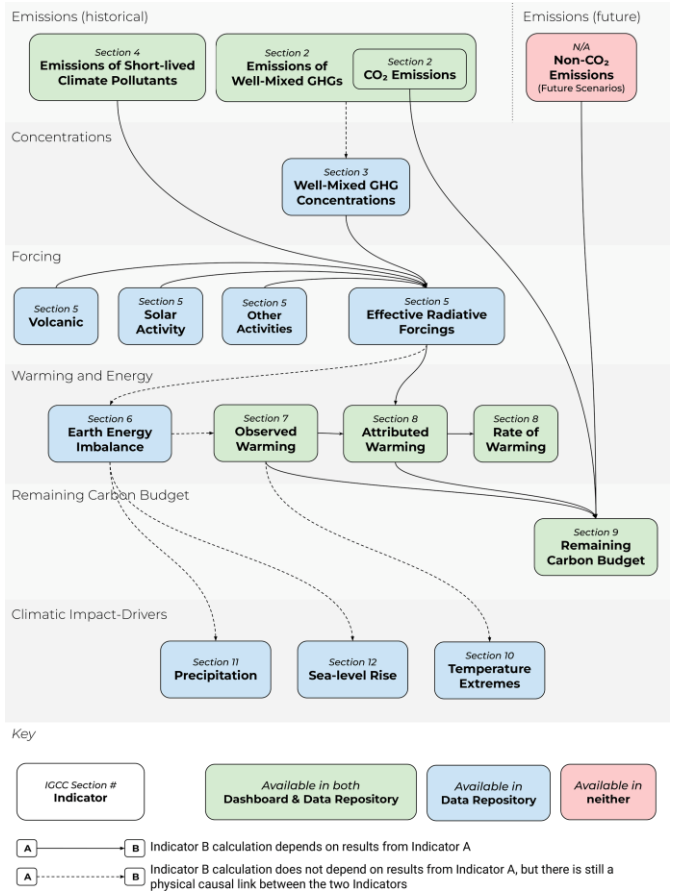
Key indicators of the state of the climate system and human influence



Forster et al, Indicators of Global Climate Change 2024, Earth Syst. Sci. Data, 2025

61 scientists
54 institutions
17 countries

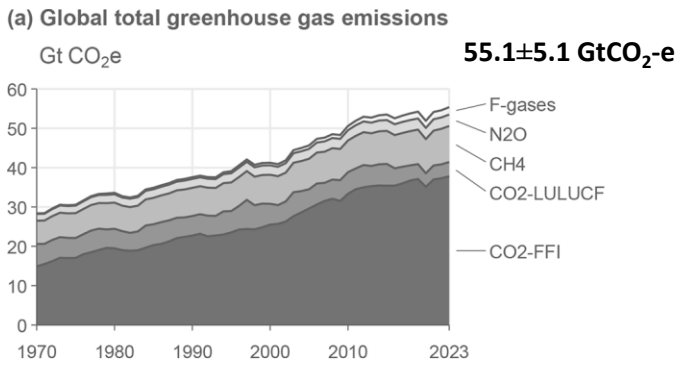
Valérie Masson-Delmotte

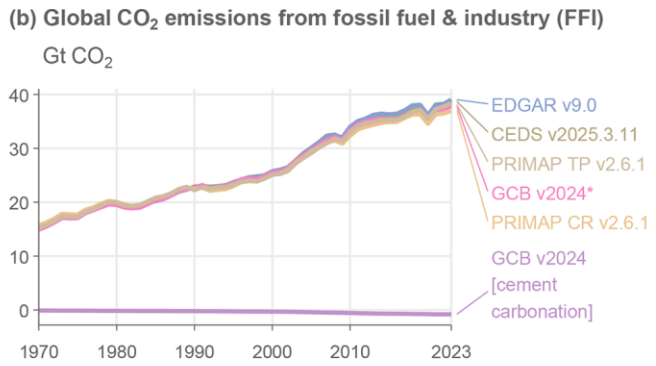
Centre Climat Société, Institut Pierre-Simon Laplace (IPSL)

Laboratoire des Sciences du Climat et de l'Environnement (LSCE, CEA-CNRS-UVSQ), Université Paris Saclay

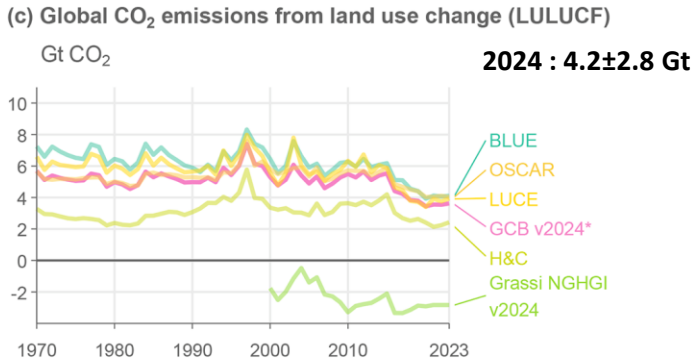
↑ Greenhouse gas emissions resulting from human activities

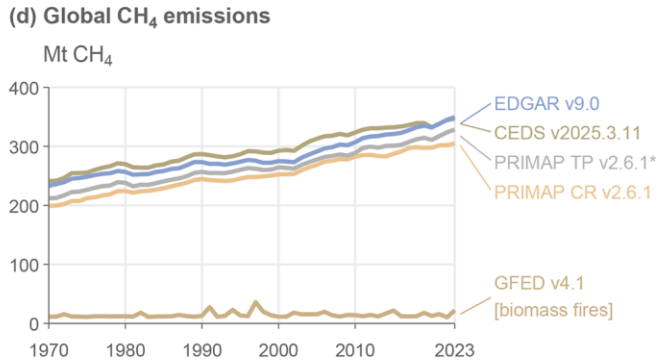
Last decade :
slower rate of increase



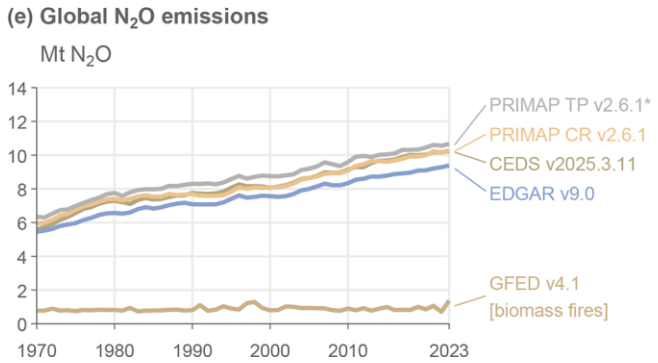


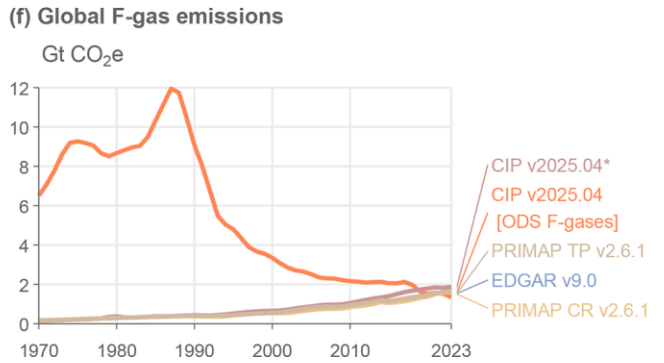
accounts for forest fires driven by deforestation but not fires driven by climate change



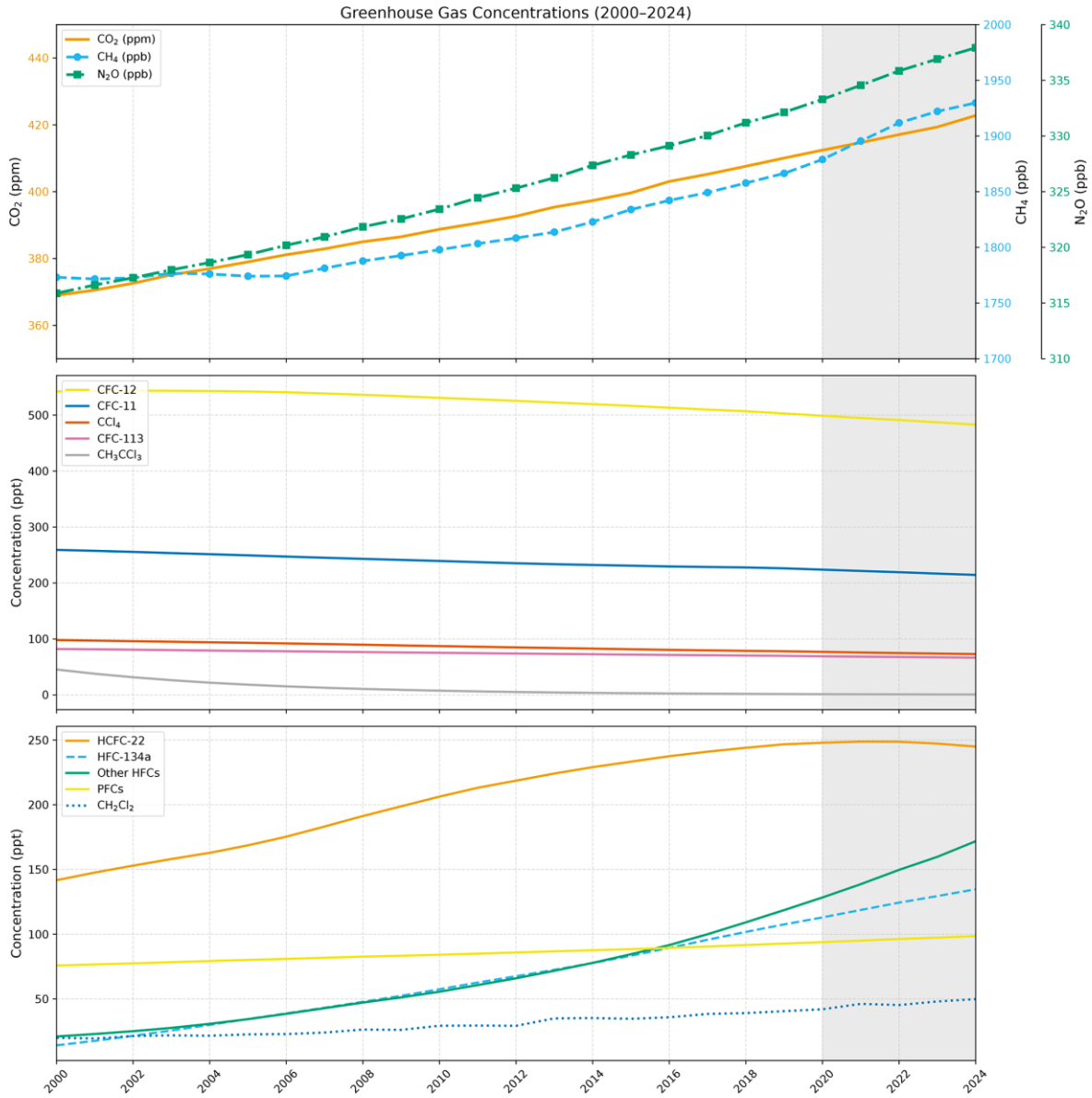


does not account for wetland emissions driven by climate change





↑ Atmospheric greenhouse gas concentrations



Last 5 years : 2019 – 2024

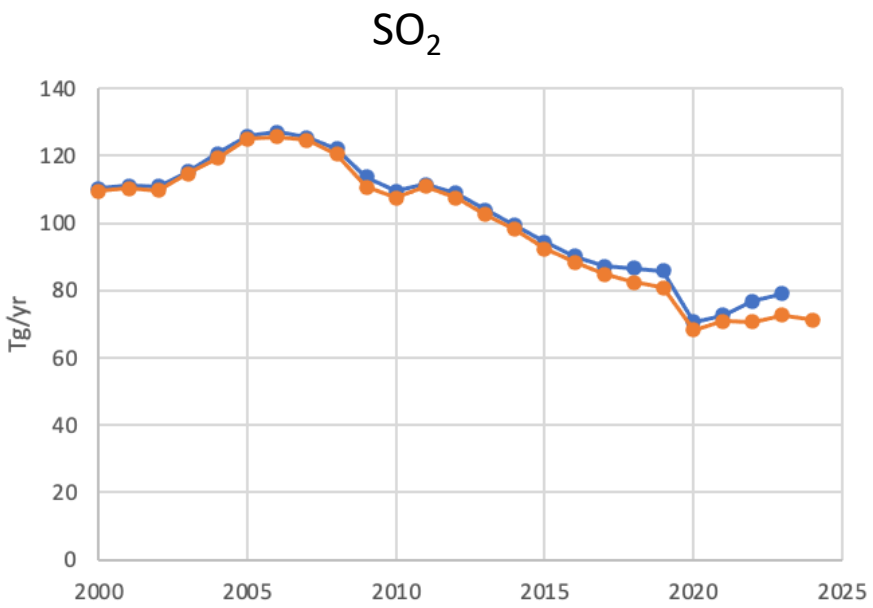
+12.7 ppm CO_2
+ 63.3 ppb CH_4
+ 5.7 ppb N_2O

2023 and 2024 :

El Niño effect
droughts
weak land carbon sink

HFC-134a : + 25% since 2019

↓ Short-lived climate forcers



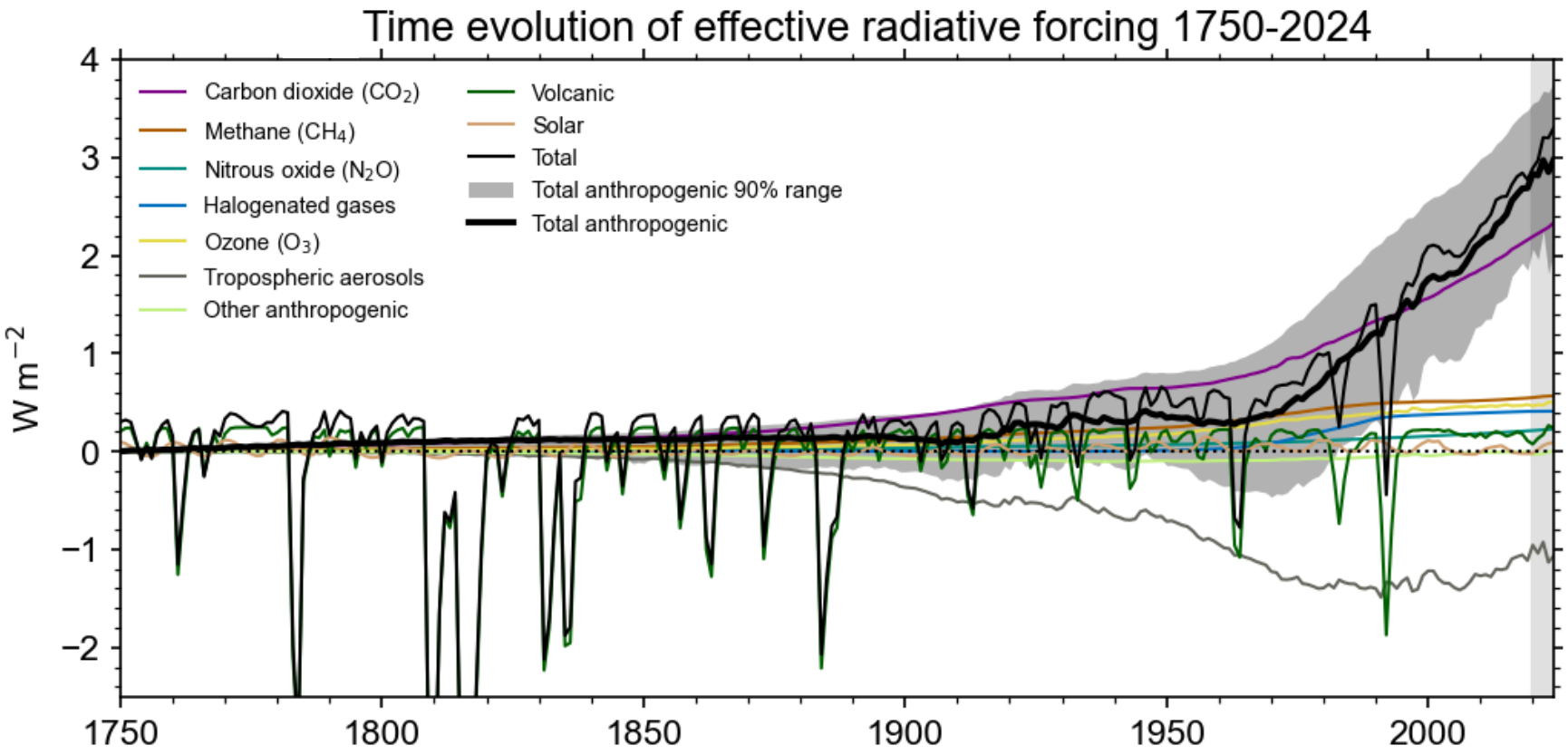
Last 10 years :

SO_2 emission reduction consistent with SSP1 and SSP3 (« strong pollution control »)

Maritime transportation : -8 TgSO2 2019-2020

Variability biomass combustion emissions

↑ Human-caused radiative forcing

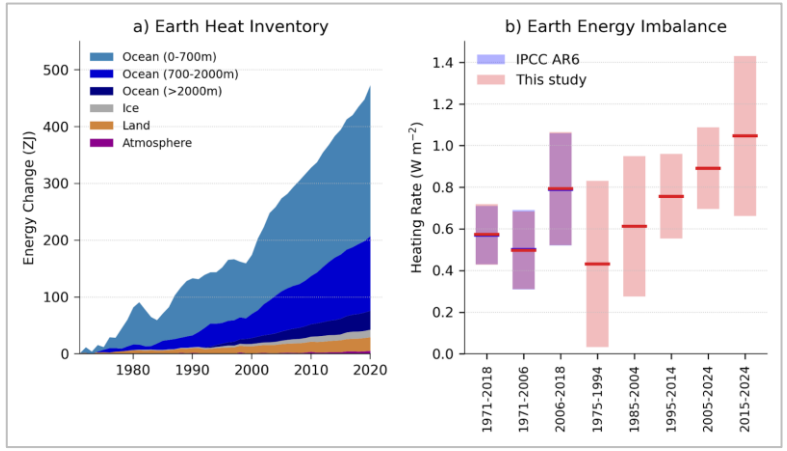


Human activities 1750-2024 :
+ 3.0 [2.0 – 3.8] W/m^2

increases in greenhouse gas concentrations and reductions in aerosol precursors

↑ Heating of the climate system

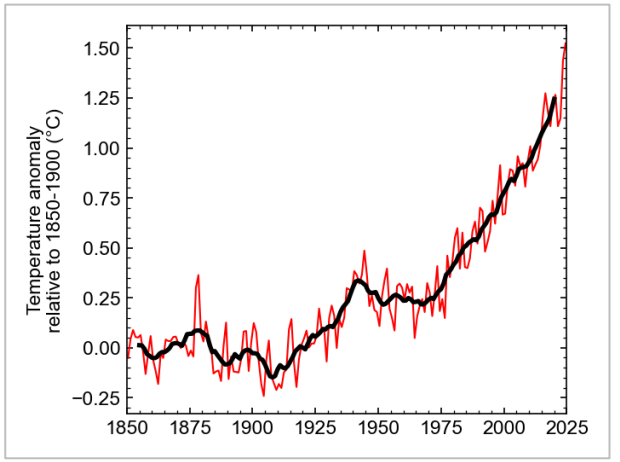
Earth's energy imbalance



2012-2024
+ 1.0 W m^{-2}

+ 25% in 5 years
x 2 since the 1980s

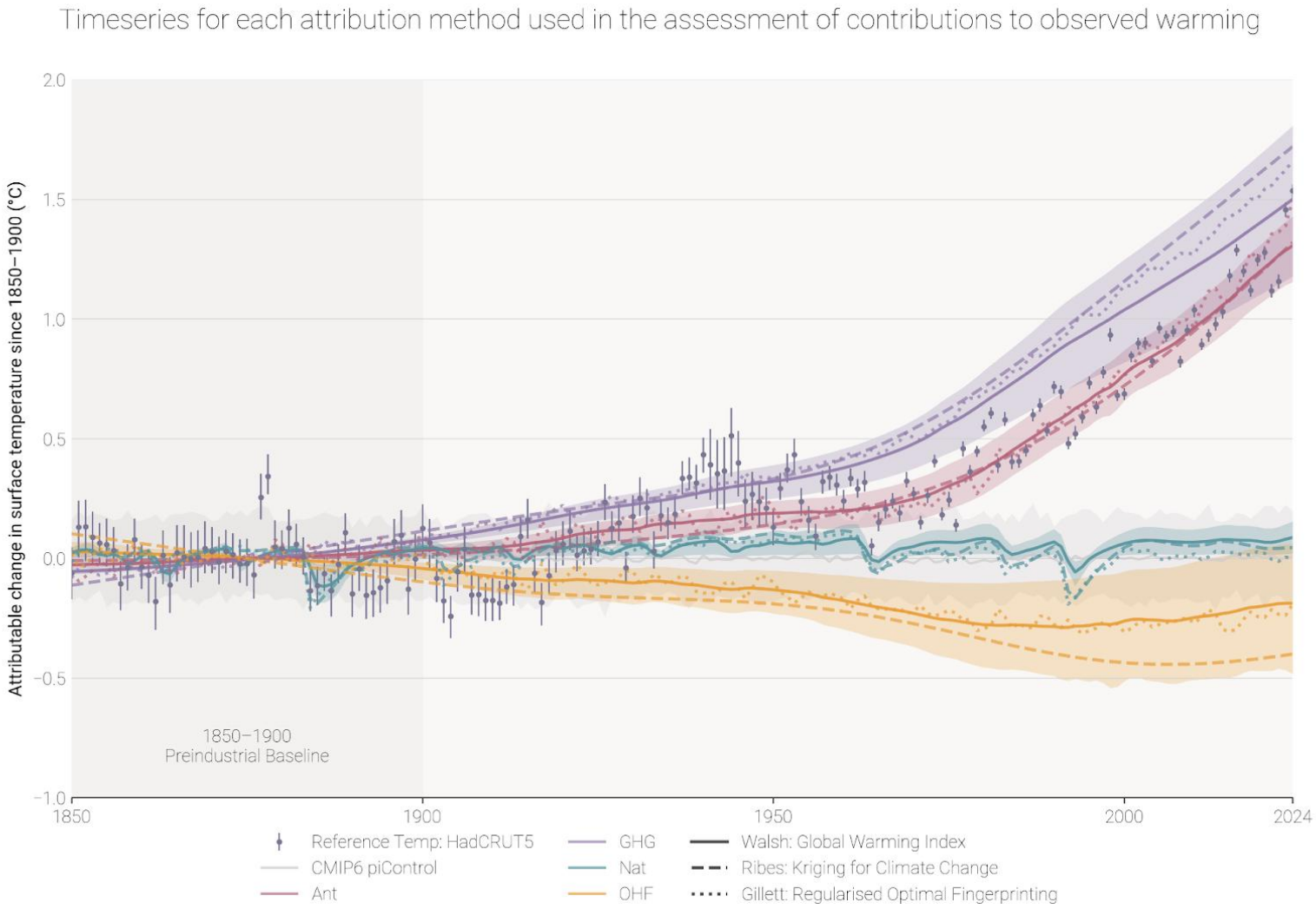
Global surface temperature



2015-2024
Ocean : 1.02 °C [0.81 to 1.13]
Land : 1.79 °C [1.56 to 2.03]

Global : 1.24 °C [1.11 to 1.35]

Attribution



Greenhouse gases from human activities

Human influence

Natural drivers

Other factors from human activities

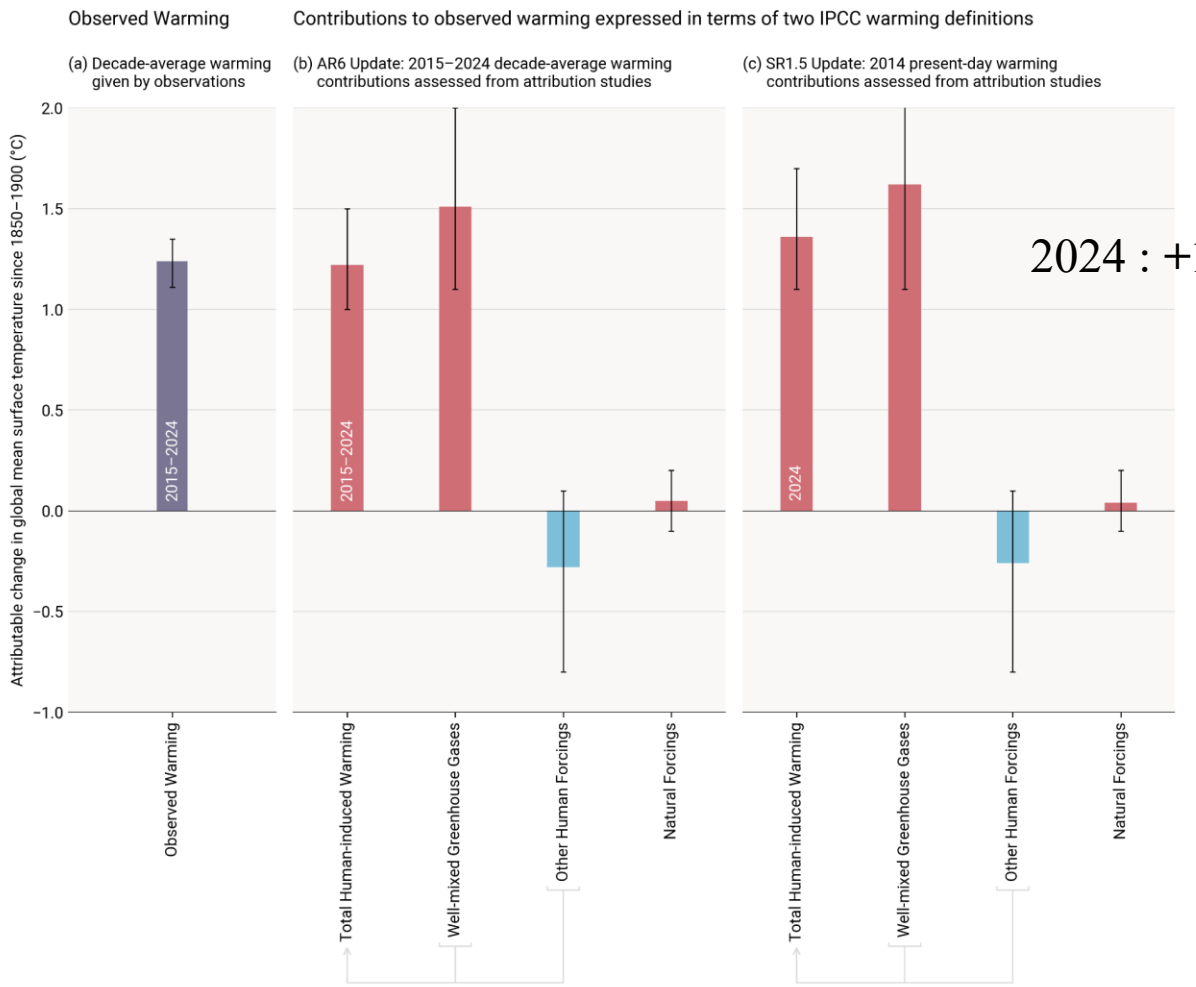
↑ Human-caused warming

Observed :
2015-2024 : + 1.24 [1.1 – 1.35] °C

+ 0.26°C / decade

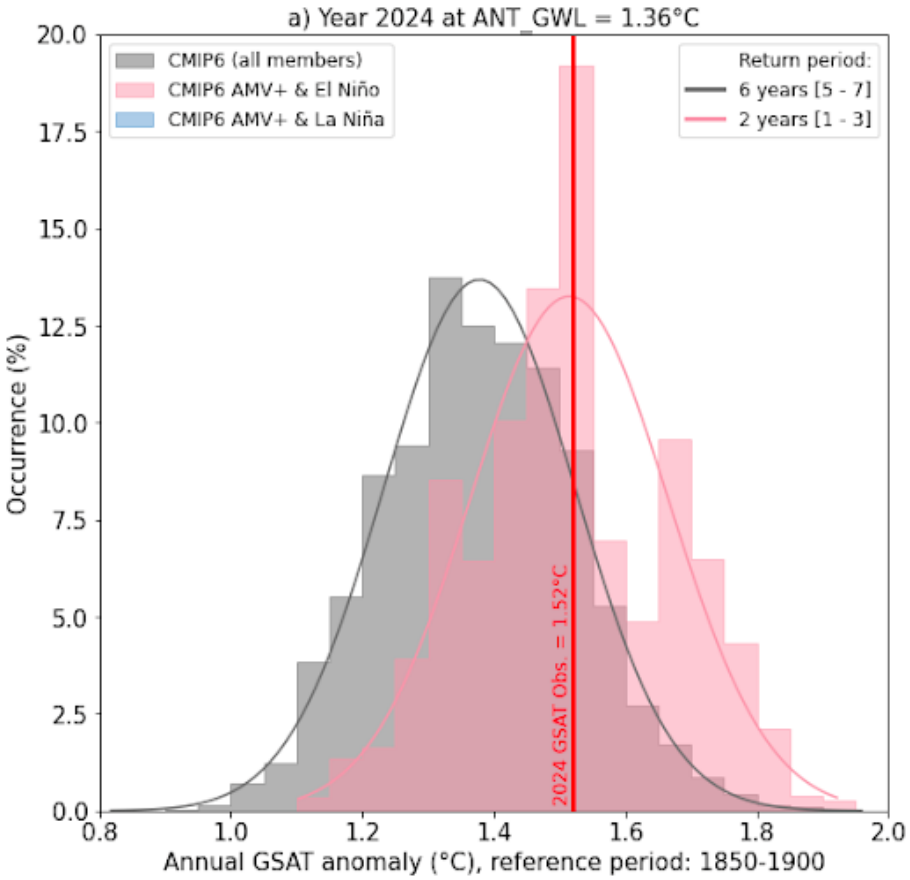
Attributed to human activities :
2015-2024 : + 1.22 [1.0 – 1.5] °C

+ 0.27 [0.2 to 0.4] °C / decade



2024 : **+1.36 [1.1 to 1.7] °C**

Modulation by natural variability



Range of natural variability : ± 0,17°C (obs) to ±0.25°C (CMIP6)

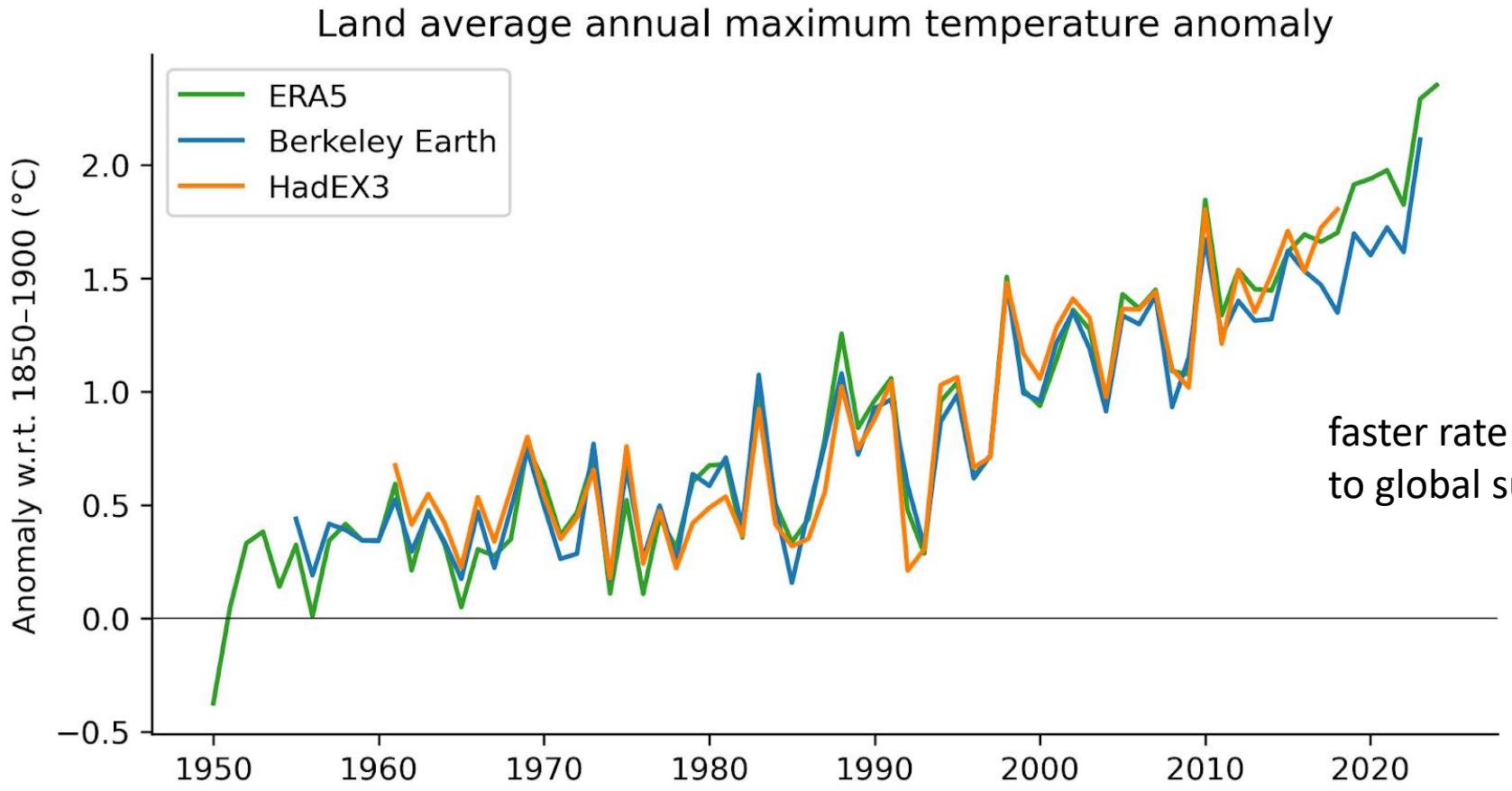
Grey : simulated inter-annual anomalies of global surface temperature (15 CMIP6 models) for a global warming level of 1.36°C

Red : conditional to the positive phases of ENSO and Atlantic multidecadal variability

Probability of reaching 1.52°C in a 1.36°C warmer world in 2024 :

- 1 chance out of 6
- 1 chance out of 2 for combined El Nino and positive Atlantic AMV variability

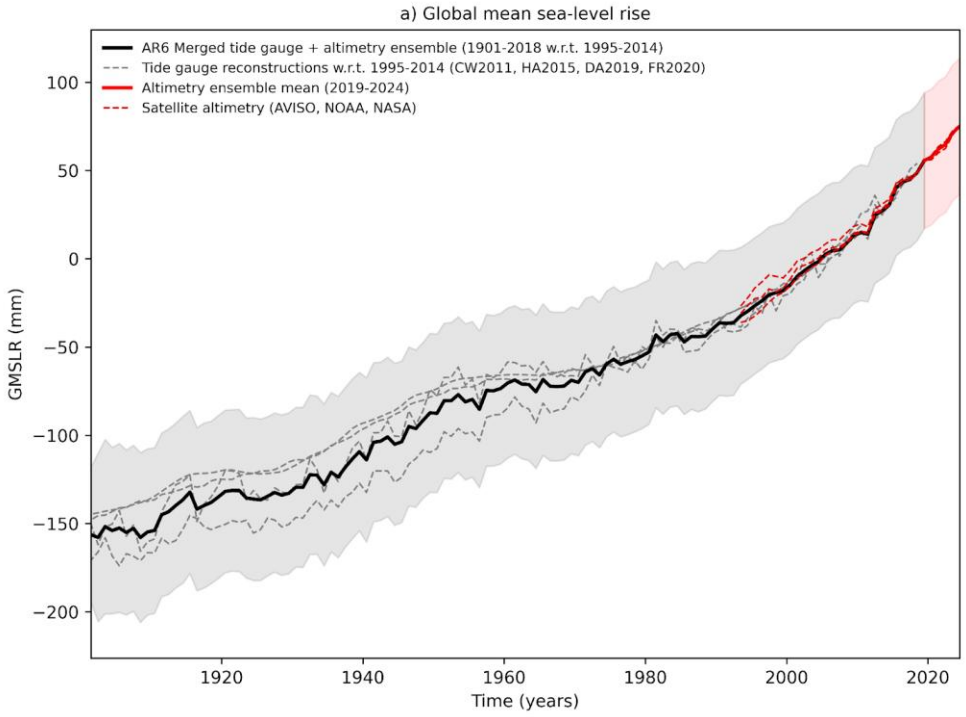
↑ Indicator of extreme events : maximum temperature over land



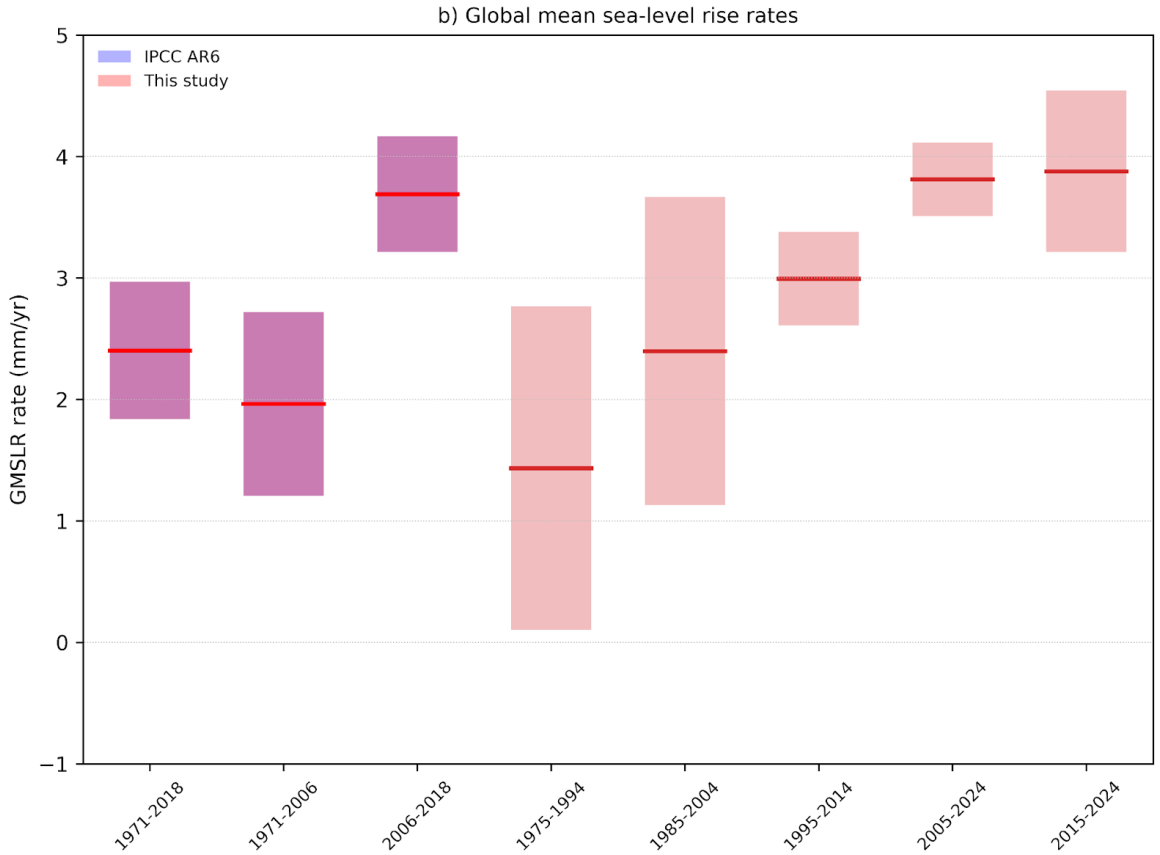
+1.9°C
2015–2024

faster rate of increase compared to global surface temperature

↑ Sea-level rise



Acceleration
2006-2024 : + 4 mm/year
+ 26 mm from 2019 to 2024 (+13%)



Since 1901 : + 227.0 [176.4 to 229.6] mm

Well anticipated by 1995 sea-level projections

Törnqvist et al, Earth's Future, 2025

↓ Remaining carbon budgets

Temperature (°C)	Estimated remaining carbon budgets from the beginning of 2025 ($GtCO_2$)				
Avoidance probability:	17%	33%	50%	67%	83%
1.5	320	200	130	80	30
1.6	620	420	310	240	160
1.7	910	640	490	390	290
2.0	1790	1310	1050	870	690

Summary of changes since the IPCC AR6 2021 report

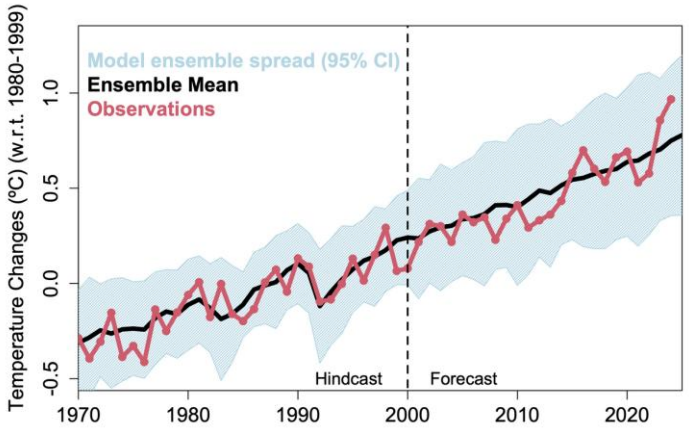
igcc earth 2025

Key Indicators of Global Climate Change:
Since IPCC Sixth Assessment Report

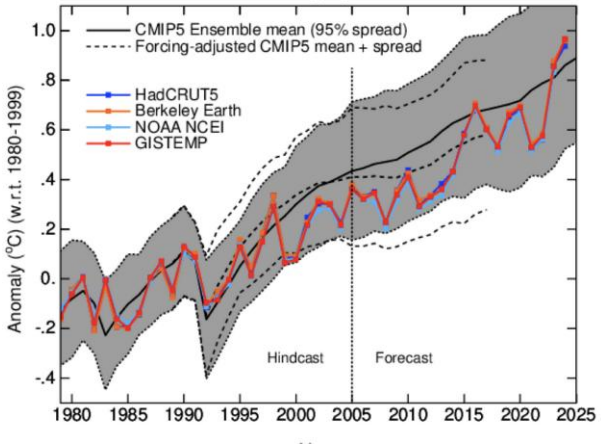
	IPCC 6th assessment	→	2024		Change %
Greenhouse gas **emissions**	52.9	↗	53.6	$GtCO_2$ e/year	+1.3%
CO_2 concentration	410.1	↗	422.8	ppm	+3.1%
CH_4 concentration	1 866.3	↗	1 929.7	ppb	+3.4%
N_2O concentration	332.1	↗	337.9	ppb	+1.7%
Effective **radiative forcing**	2.72	↗	2.97	W/m^2	+9.2%
Earth's energy **imbalance**	0.79	↗	0.99	W/m^2	+25.3%
Global mean surface **temperature change**	1.09°	↗	1.24°	°C	+13.8%
Human-induced **warming** (decade)	1.07°	↗	1.22°	°C	+14.0%
Land average max **temp change**	1.55°	↗	1.9°	°C	+22.6%
Remaining carbon **budget** (∓1.5°C, 50% probability)	500	↘	130	$GtCO_2$	-74.0%
Sea level rise (GMSLR)	201.9	↗	228	mm	+12.9%

Projections compared to observations : global surface temperature

Models run in 2000

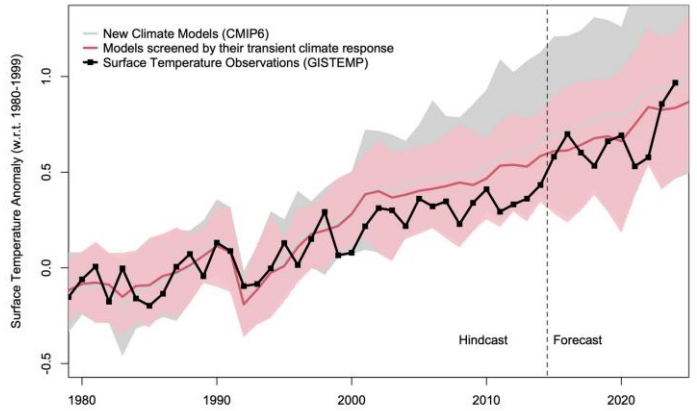


Models run in 2005



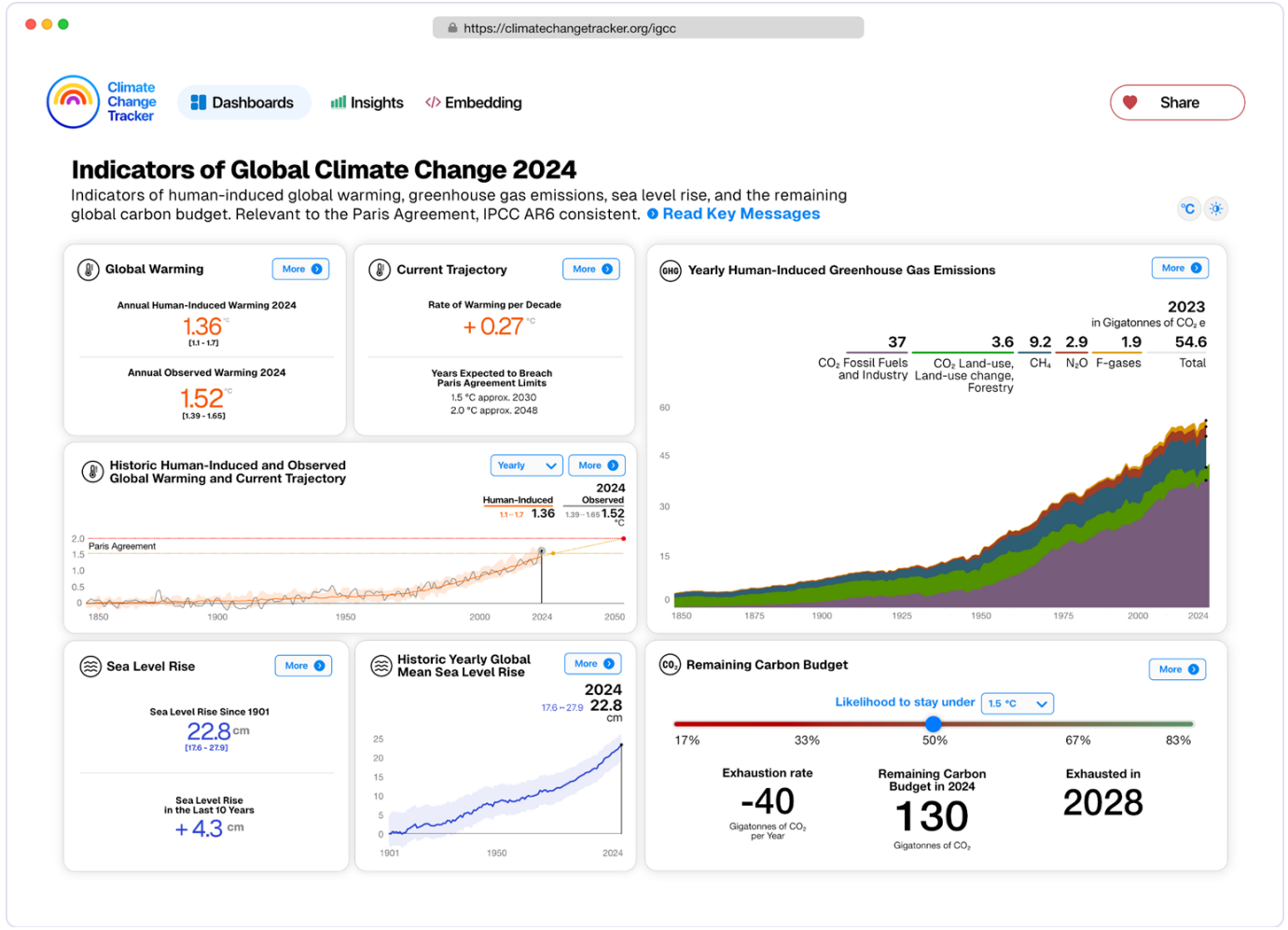
- Forced warming : robust indicator of the state of the climate system
- Towards annual updates of both forced warming and constrained projections

Models run in 2015



https://www.realclimate.org/index.php/climate-model-projections-compared-to-observations/

Data dashboard



https://climatechangetracker.org/igcc