March 2026

Worst-Case : The Evidence

Climate change indicators and IPCC **scenarios**

State of the Climate Emergency Indicators

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(Consensus AI (science research) is used for confirmation of results)

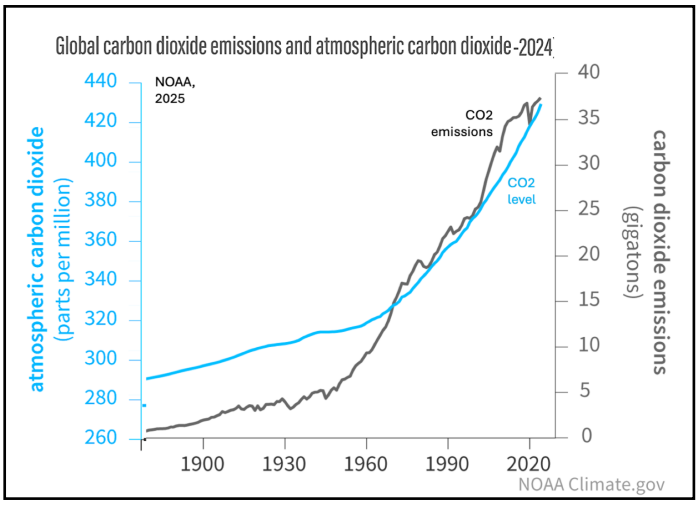
The scientific consensus is that the danger limit is a global warming of 1.5°C, replacing the old 2°C limit. How do today's climate and climate scenarios affect the limits?

Indicators

Used for this exercise

- o Global CO2 emissions
- o Total GHG emissions as CO2 equivalent
- o Feedback emissions
- o Atmospheric CO2 concentration
- o Atmospheric methane concentration
- o Total combined GHG concentration as CO2 equivalent
- o Radiative forcing (heat)
- o Ocean heat
- o Global warming
- o Ocean surface warming (SST)
- o Greenland ice sheet
- o Antarctic ice sheet
- o Sea level rise
- o Earth energy imbalance

Accelerating increase CO2 emissions and atmospheric CO2 1900-2024 (NOAA, 2025)



Global warming drivers

- o Atmopheric CO2 eq.
- o Radiative forcing
- o Earth energy imbalance

Result in brief

All climate change indicators, including all drivers of global warming, are record high and increasing as fast as ever (several faster).

Current scenario estimates based on global CO2 emissions, conclude global climate change is increasing on a mid-range scenario (SSP2-4.5), as Global Carbon Project, 2025

However, there is published evidence that indicators may be on the worst-case scenario (SSP5-8.5), including global heating (radiative forcing) and global warming.

Method

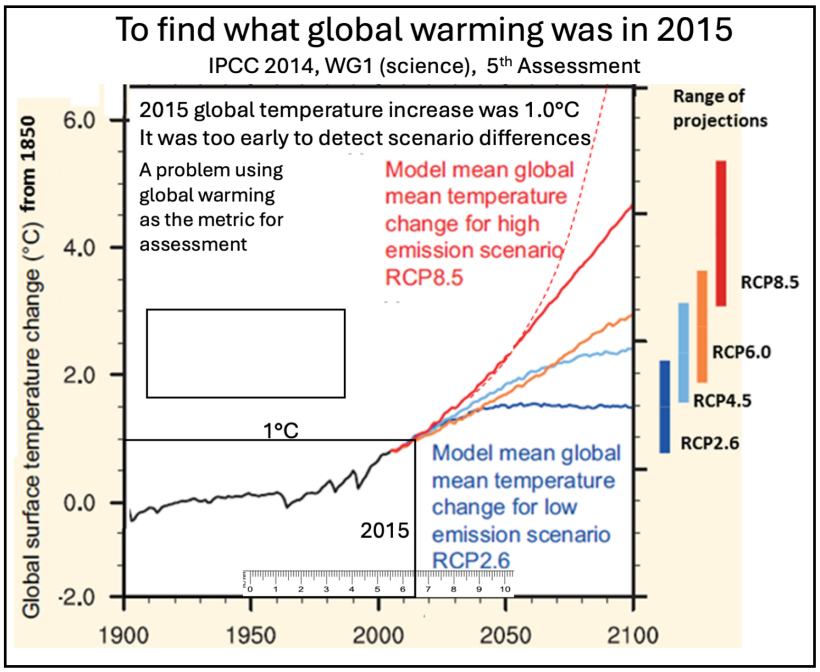
o Current climate indicator values are matched against IPCC scenario median projections
o Changes are taken from preindustrial
o Only IPCC or peer-reviewed published science is used
o A ruler is used for accuracy of values on time series
o Matching is done with a computer object square (empty)- from year to scenario

Results are checked with Consensus AI (science research)

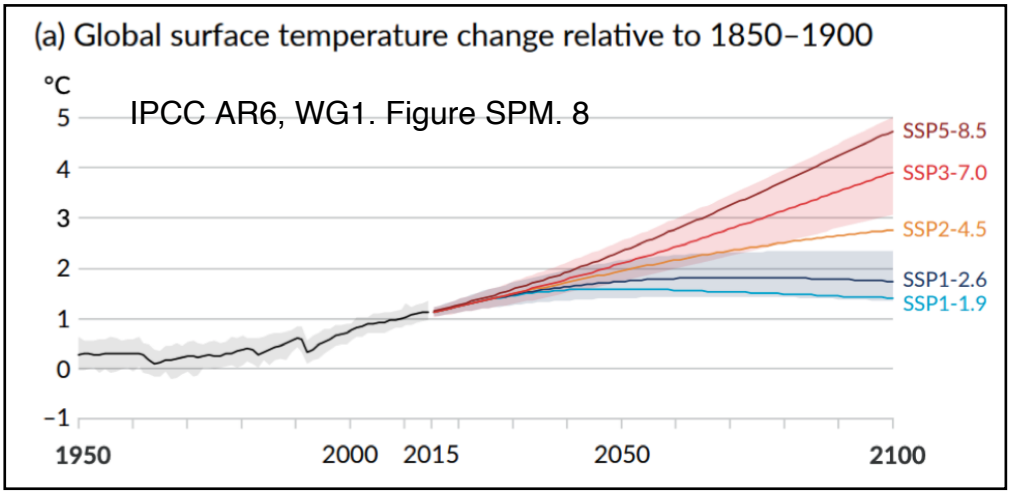
2015 warming was 1.0°C, but was too early for scenarios to seperate

Square for matching

Ruler



By 2025 the scenarios are diverging

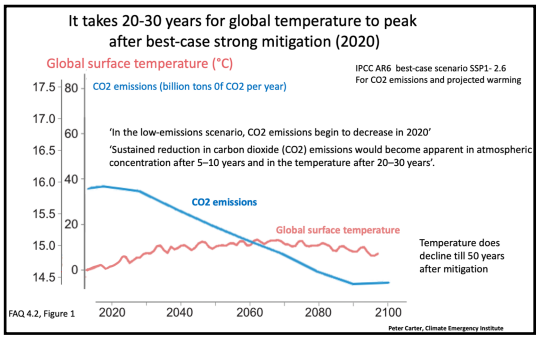


Climate Inertia: committed extra warming to stabilization

Climate system inertia means there will be a delay from mitigation to temperature response, with more incurred warming.

IPCC AR6

My combined graph (best case emissions)



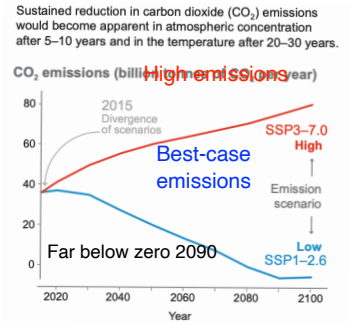
"Sustained (Best-case) reduction in carbon dioxide (CO2) emissions would become apparent in atmospheric concentration after 5–10 years and in the temperature after 20–30 years)" (IPCC AR6). This is a 20-30 year real **commitment**

Global warming today (2026) is 1.44° (WMO)
1.47°C (NASA GISS, Copernicus).

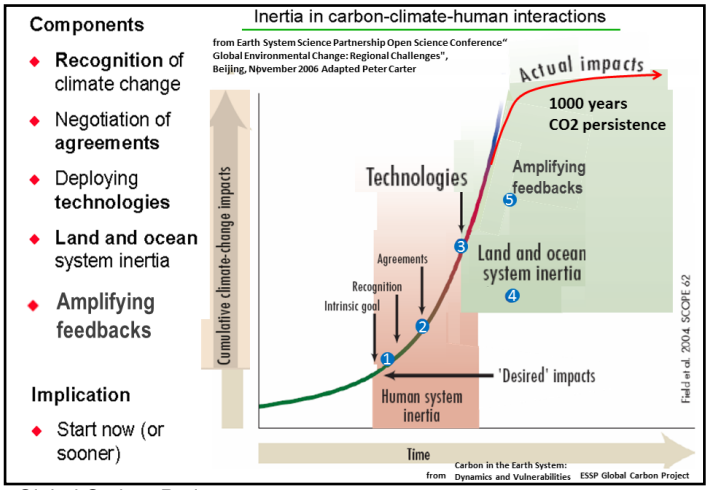
For mitigation today, this incurred warming to stabilization alone makes the 1.5°C limit out of the question and, as there is no action on emissions (but increase) 2°C is now not feasible.

IPCC AR6 best-case scenarios have assumed successful -ve CO2 emissions from 2050-2070. Some CO2 removal is essential and is urgently needed, but capacity at scale would take decades. Assuming successful CDR at scale, starting decades away, is not valid for mitigation.

CO2 emissions

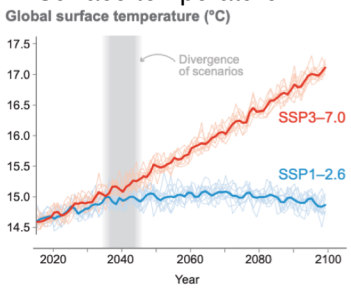


CO2 emissions here decline by 2020.

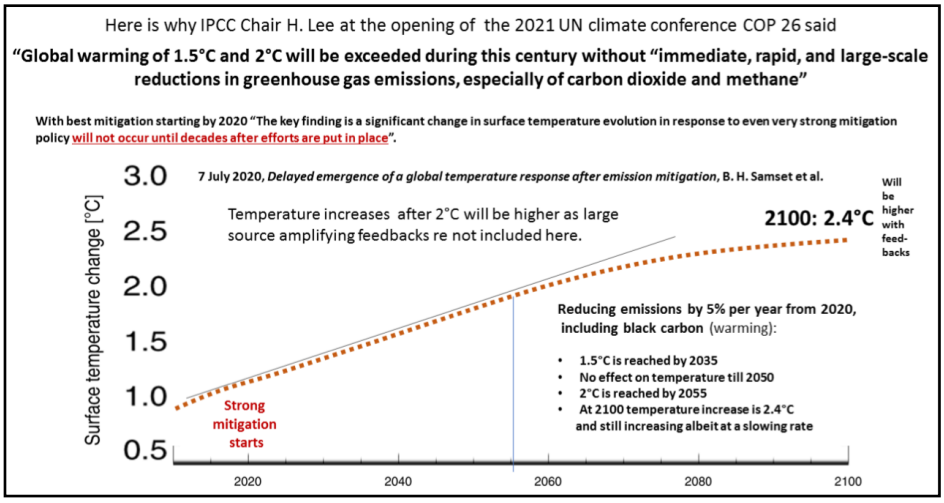


Global Carbon Project, 2006

Surface temperature



IPCC AR6, WG1, FAQ 4.2,



CO2 Emissions

The main emissions driver of global climate change, with main source fossil fuel combustion.

'Land use change' activities, primarily deforestation and agricultural expansion, also biomass burning, is a CO2 source, which is steady at about 10% of global emissions.

CO2 is very long-lasting in the atmosphere (50- 100 years), so more CO2 emissions will increase atmospheric CO2, by accumulation

The Global Carbon Project put 2025 global fossil fuel CO2 emissions at a new record high of 38.1 billion tonnes. It is a 69% increase on 1990. Note that for 2°C and 1.5°C limits IPCC AR6 had global emissions in decline by 2025

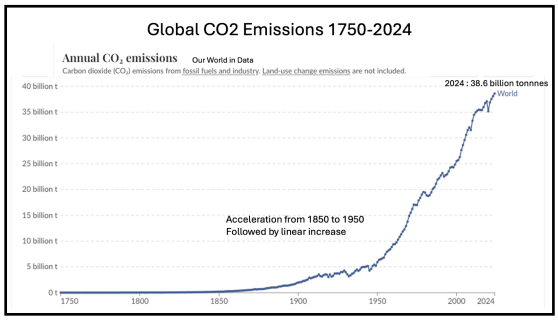
2025 record increasing CO2 emissions are on "mid-range" IPCC scenario SSP2-4.5 (below).

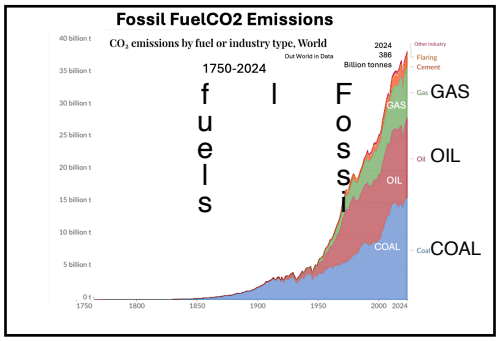
Here emissions decline is delayed to 2040, to reach 2.7°C by 2100.

However, Global CO2 emissions are large underestimates "accounting shortfalls are staggering: scientific estimates of global GHG emissions are at least 30% higher (Greenhouse gas Accounting Gaps, Leehi Yona, 2025).

Such large emissions under-reporting could put CO2 emissions near worst-case scenario.

These records of CO2 emissions from 1750 to 2024 by Our World in Data, puts today's sustained rapid rate of fossil fuel CO2 emissions increase into perspective.

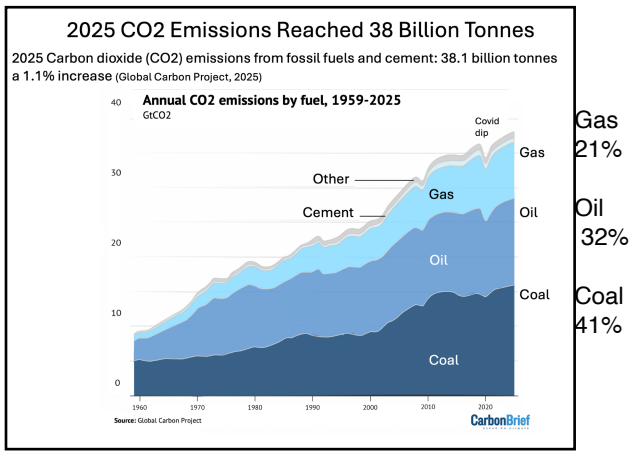




Source: Global Carbon Project, Nov. 2025

Global fossil fuel CO2 emissions 2025 38.1 Gt
1.1% increase on 2024, 69% increase since 1990

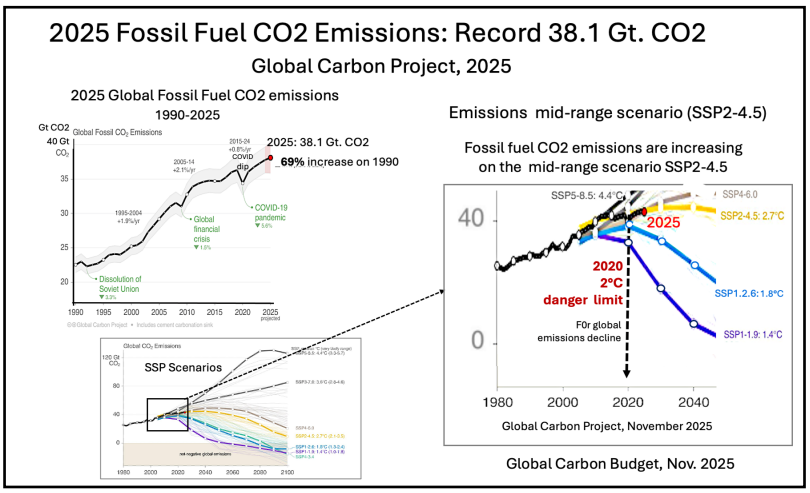
Global emissions are still **increasing** on IPCC mid-range scenario



Gas 21%

Oil 32%

Coal 41%



Under-reporting puts mid-range scenario SSP2-4.5 nearer to worst-case

Earth's Carbon Sinks CO2 source

The land (mainly forests) and ocean carbon sinks absorb 50% of CO2 emissions, 21% by the land (mainly forests) and 29% by the oceans (Global Carbon Project, 13 Nov. 2025)

If the sinks weaken more of CO2 emissions will remain in the atmosphere, driving accelerating climate change faster, making for worst-case or worse climate change effects.

In IPCC AR6 Increasing emissions over time makes carbon sinks become less effective. 'Under scenarios with increasing CO2 emissions, the ocean and land carbon sinks are projected to be less effective at slowing the accumulation of CO2 in the atmosphere'. 'This is projected to result in a higher proportion of emitted CO2 remaining in the atmosphere'.

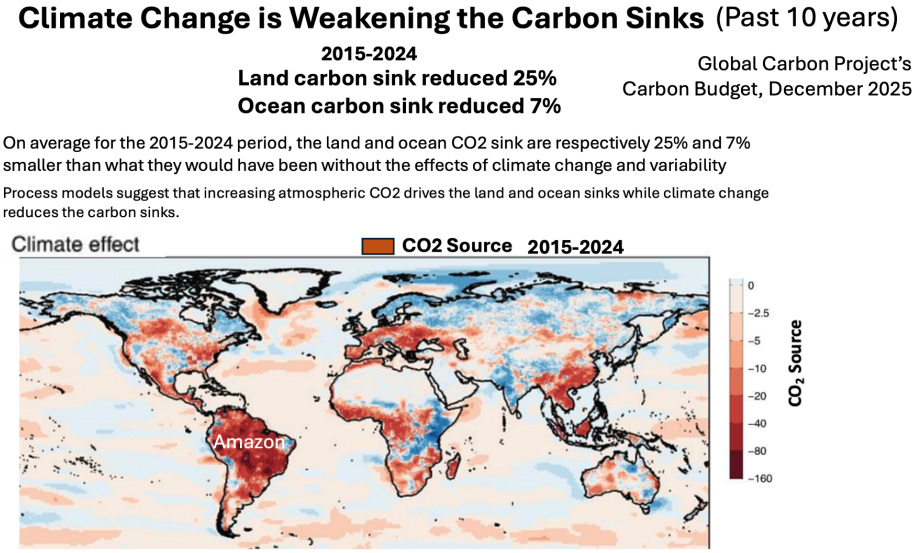
There are signs that both land and ocean carbon sinks are losing efficiency.

30 Oct. 2025, Potsdam Climate Institute, 2025, 10 New Insights in Climate Science finds the planet's natural carbon sinks are reaching critical limits, absorbing fewer emissions than expected as climate change is weakening their capacity.

The 10 New Insights reports, under *Global land carbon sink under strain*, that Weaker land carbon sinks have been identified, not only in tropical ecosystems, but also in high latitude regions, which had been considered more stable carbon sinks.

Also the unprecedented pace of ocean surface warming and the intensification of marine heatwaves are… "weakening the ocean's role as a carbon sink.

For the past four years the Global Carbon Project's annual Global Carbon Budget has published process model carbon exchange results, showing a progressive decline in the efficiency of land and ocean carbon sinks.



More Worst-case and Worse Scenarios

Global Methane Emissions

Methane contribution to global warming is about 30%

Recent studies indicate that methane emissions are increasing at an accelerating rate, aligning with worst-case scenarios for greenhouse gas emissions.

(September 2024, Global Carbon Project's Global Methane Budget)

Worst-case scenario, accelerating increase

The trends of CH4 emissions from human activities are tracking scenarios that assume no/minimal climate change mitigation policies proposed by the IPCC.

The increase in methane emissions is accelerating.

Methane emissions have increased 20% over the past 20 years, higher since 2020 and record in 2023 (Global Carbon Project).

Sources (being increased)

Fossil fuels: natural gas industry and coal mining.

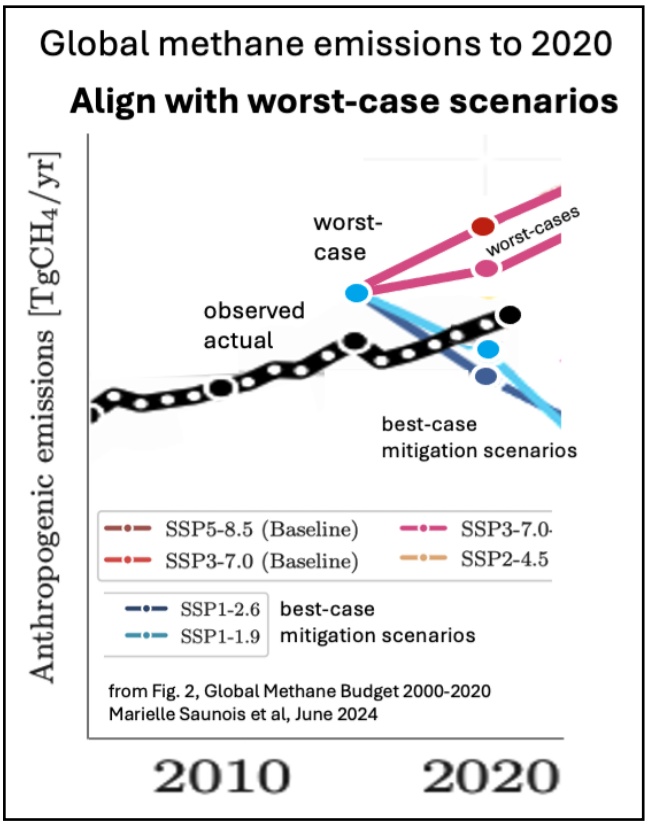
Methane emissions from the natural gas industry (gas is mainly methane) continue to grow. Coal mining emits methane, active and abandoned. Coal production is still increasing (Record high 2024).

Livestock, mainly cattle (exhalation)

Artificial wetland rice cultivation

In addition to anthropogenic, natural emissions, particularly from wetlands, show signs of rising due to warming. Thawing permafrost emits methane.

Global Carbon Project, 2024



IPCC AR6 for mitigation has methane emissions in decline by 2020 and cut 40% by 2030.

Worst-case Scenario

Global Nitrous Oxide Emissions

Global carbon Project, Nitrous Oxide Budget, 2024

Nitrous oxide contribution to global warming is about 10%, which is highly significant.
It has a warming potential 274 times that of CO2 and lasts in the atmosphere 174 years.

Nitrous oxide (N2O) emissions are increasing at an accelerating rate, aligning with worst-case scenarios.

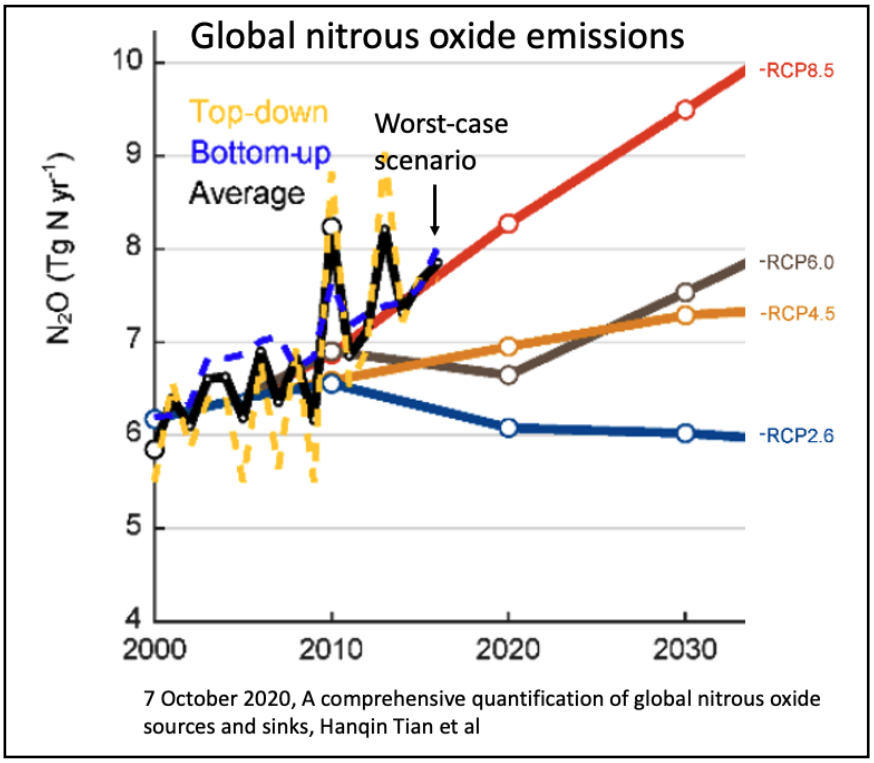
The growth rate is accelerating.

This trend is primarily driven by agricultural use of nitrogen fertilizers, and some emissions from manure management. Power plant coal combustion is a source

The global ocean continues to be a source of N_2O.

Process models show that soil emissions increased substantially due to climate change since the 1980s, constituting a nitrous oxide feedback.

Image from Global Carbon Project, Nitrous Oxide Budget, 12 June 2024



Worst-case Scenario

Greenhouse gas emissions

Global CO2 equivalent emissions, is all long-lived GHGs, including methane.

The increase of atmospheric greenhouse gas emissions drives global heating.
UNEP, Emissions Gap Report, 2024 *Another year of broken records,* global GHG emissions reached **57.7 GtCO2e in 2024**, a large 2.3% increase from 2023' (below).

Estimates of greenhouse gas emissions vary.

Climate Action Tracker (climate expert site) has 2024 GHG emissions at 56.4 Gt CO2 eq.

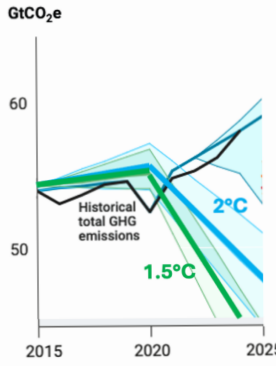
IPCC AR5 provides CO2 eq. RCP scenarios, with worst-case RCP8.5 (not IPCC AR6).

2024 emissions reach the lowest range of the worst-case RCP 8.5, by both estimates.

However, global GHG emissions are large underestimates due to under-reporting "accounting shortfalls are staggering: scientific estimates of global GHG emissions are at least 30% higher than governments account for (Greenhouse gas Accounting Gaps, Leehi)Yona, 2025)

Global greenhouse gas emissions align with worst-case scenarios when compared to climate models and projections. (Consensus AI).

UNEP estimated 2024 global greenhouse gas emissions at 57.7 Gt CO2 equivalent.

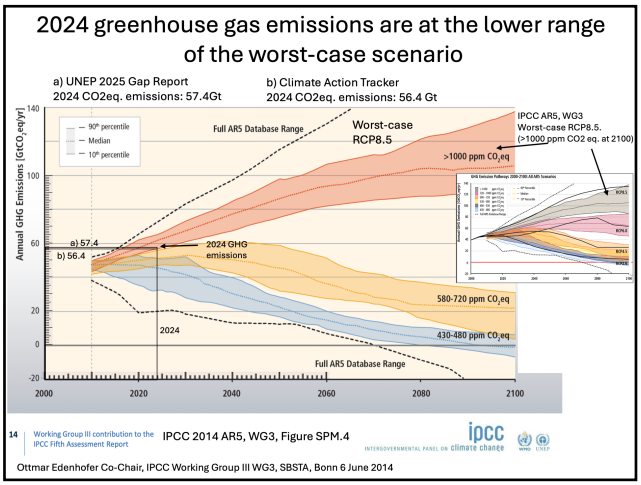


'Another year of broken records – global GHG emissions reached 57.7 GtCO2e in 2024, a 2.3 per cent increase from 2023 levels. The 2.3 per cent increase in total GHG emissions from 2023 levels is high compared with the 2022–2023 increase of 1.6 per cent'.

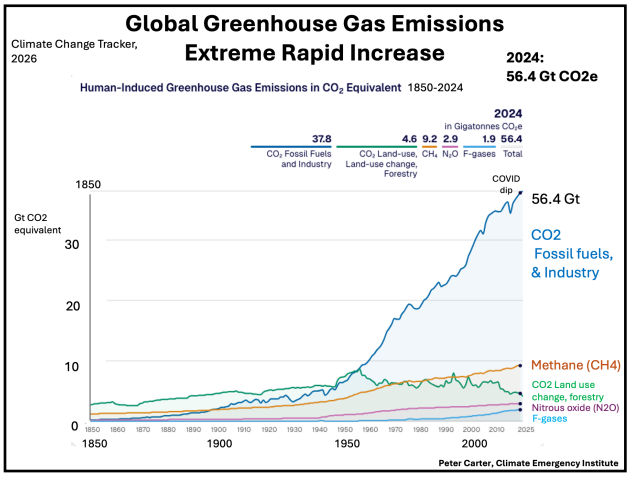
(UNEP 2025 Emissions Gap

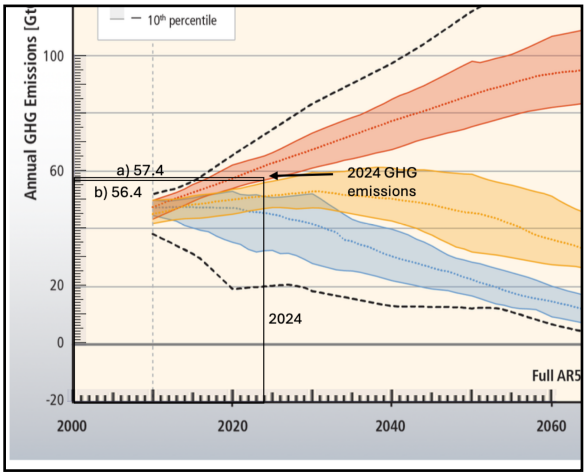
Emissions have increased extremely fast 75% from 1990.

IPCC AR5 Global CO2 eq. emissions



Climate Change Tracker





Worst-case Scenario

Feedback emissions

It has long been known that at some degree, global warming causes feedback emissions from warmed planetary sources, which increase with temperature and time.
Global surface warming at some point causes more global warming.
Feedback sources are many and enormous (image below)
However, they are only partially included in IPCC projections, permafrost is not.
They are called uncertainties, though certain to happen with unmitigated warming.
This inclusion could put emissions on higher scenarios than estimated today.
Arctic changes are taking place much sooner (decades) than projections.
The Arctic is warming four times faster than the global average- up from two times.
Arctic warming releases CO2, methane and nitrous oxide, as GHG feedback emissions.
Melting ice & snow reduces albedo cooling of Earth, which is adding to Arctic warming which increases wetland peat and permafrost thaw, and Greenland ice melt
Future ice free Arctic and snow loss albedo feedback increases global warming.

Greenhouse gas feedback emissions sources (see map)

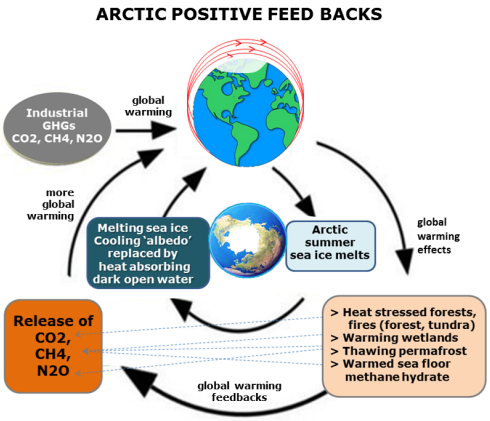
- o large wildfires CO2 (e.g. northern Canada and global)
- o The Amazon rainforest
- o The African rainforest (Congo)
- o Boreal forest
- o Global wetlands- increased methane emissions (subArctic and tropical)
- o Arctic permafrost thaw CO2, methane and nitrous oxide emissions,

Decline of albedo (cooling) feedback

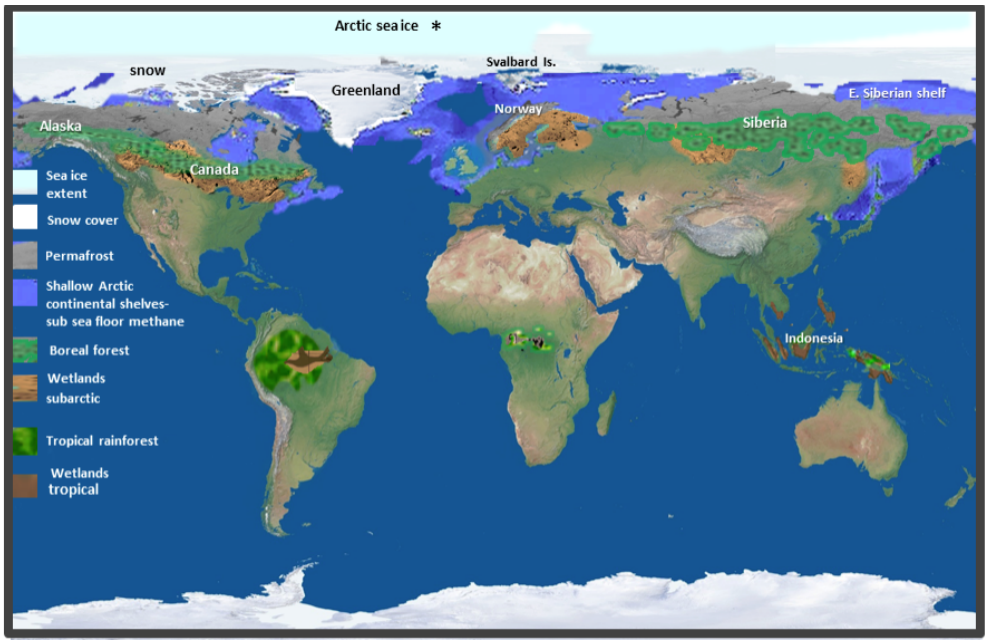
- o Arctic Summer sea ice loss
- o Antarctic sea ice loss,
- o Greenland ice sheet
- o Global glacier melt,

Arctic Most of the largest feedback sources are in the Arctic

ARCTIC FEEDBACK LOOPS are inter-reinforcing
Summer sea ice loss (Arctic amplfication) feedback, links with permafrost, Boreal forest, subarctic wetland peat and Greenland ice sheet.



Many large sources of +ve amplifying feedback to global warming



Feedbacks continued and **Carbon Sinks**

There is evidence that today's estimated climate change mid-range scenario is under-estimated, SSP2-4.5 (2.7°C this century) from carbon feedbacks and sink decline.

IPCC projections incompletely include the large sources of amplifying feedback (permafrost is not included) emissions, nor the long-predicted carbon sink decline- till after 2050.

(IPCC AR6, WG1, SPM "Under under the intermediate GHG emissions scenario that stabilizes atmospheric CO2 concentrations this century (SSP2-4.5), the rates of CO2 taken up by the land and ocean are projected to decrease in the second half of the 21st century".

If near-term amplifying feedbacks and carbon sink weakening were included in IPCC projections, accelerating global climate change would be faster, and so lead to higher scenarios than estimated. There is considerable evidence that these are already occurring.

(*Interplay between climate and carbon cycle feedbacks could substantially enhance future warming, (*C. Kaufhold, 2025) **Under higher scenarios appproximately 50% of additional warming is attributed to positive climate–carbon cycle feedbacks** (amplifying) with comparable contributions from CO2 and CH4C (methane).

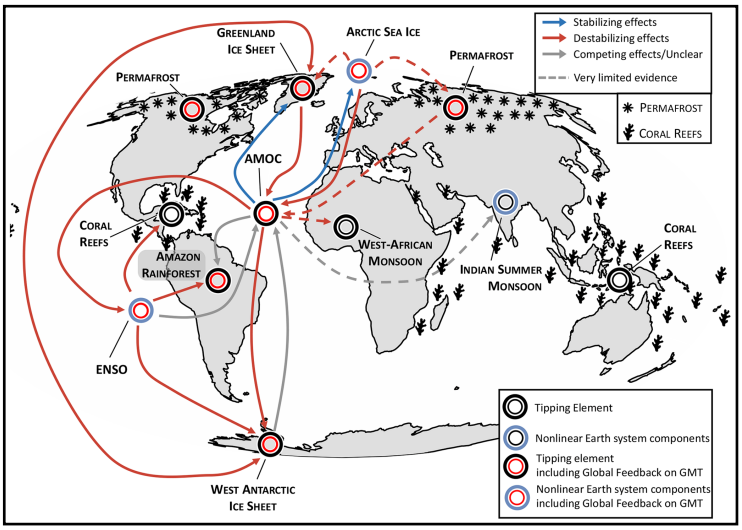
Feedback emissions and carbon sink weakening have been detected.

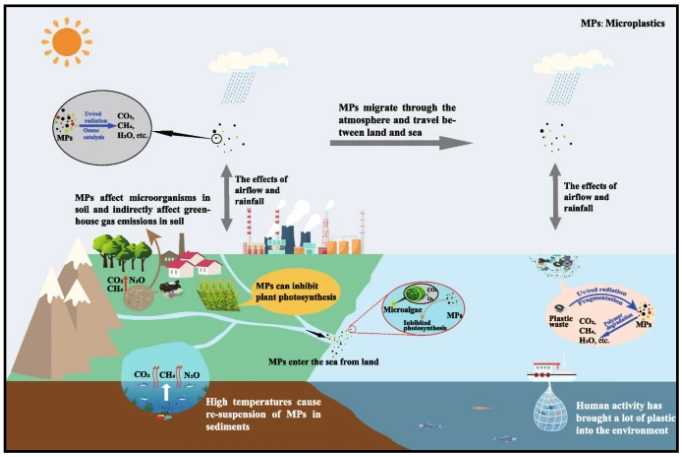
Feedback emissions

Some of these large planetary sources of amplifying feedback are **tipping points**

o Amazon rainforest (CO2)
o Boreal forest (CO2)
o Permafrost thaw (methane, CO2)
o Himalaya-Tibetan Plateau (Third Pole)
o Labrador–Irminger Sea convection system (Arctic)
-weakening of AMOC
oNorth Atlantic meridional overturning circulation
AMOC (CO2 ocean uptake)

Tipping points interact (Wunderling. 2024)
The global carbon cycle disruption potential is enormous.





Mircro -plastics (MP) Micro plastic land and ocean pollution is known and ubiquitous. This has a large potential of reducing land and ocean sinks, by interfering with photosynthesis, the basis of life on land. This is well established by science (Kui Li, 2024). The effect on soil carbon has been demonstrated. MP effect on the carbon cycle is not yet included in global warming projections.

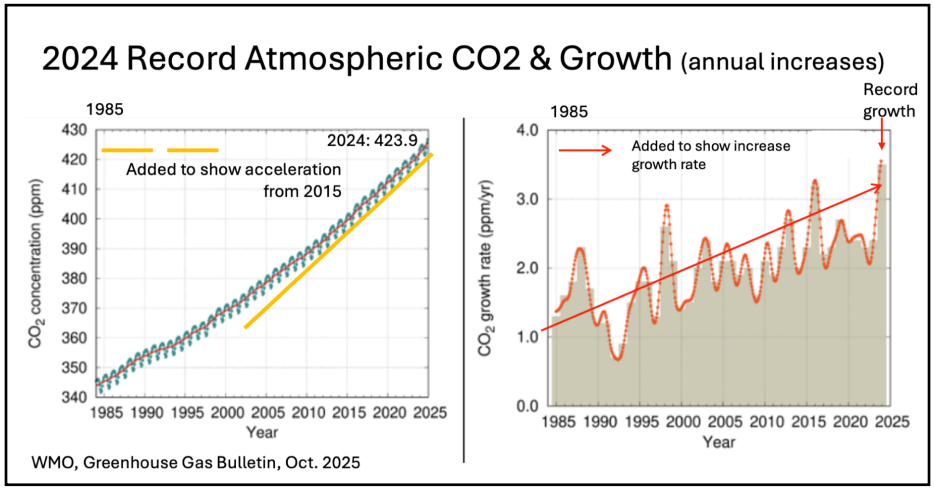
Carbon Sink decline 2015-2014, "the land and ocean CO2 sink are respectively 25% and 7% smaller" with climate change. (Global Carbon Project, 2025)

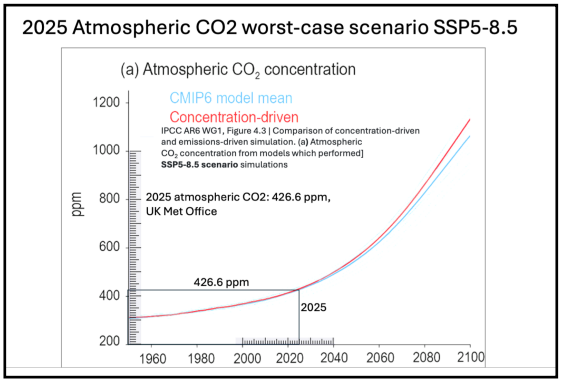
Atmospheric CO2 (main atmospheric GHG driver)

2024 CO2 was a record high (423.9 ppm), and 2024 a record annual increase (3.5 ppm) **(**WMO, Greenhouse Gas Bulletin, October 2025). “Atmospheric CO2 continued to increase in 2024, with no sign of slowing down. From 2023 to 2024, CO2 increased by 3.5 ppm. This was the largest one-year increase on record. (last decade average 2.4 ppm) “This increase was driven by continued fossil CO2 emissions, enhanced fire emissions and reduced terrestrial/ocean sinks in 2024” (WHO, 2025). The increase in atmospheric CO2 concentration has been accelerating since 1990, and right up to the present (see 2025 NOAA below) and at an overall **exponential increase rate.**

Recent reconstructions and satellite datasets (2003–2021) show a persistent upward trend with ~2–3 ppm/yr average growth, consistent with continued near-exponential increase. (Consensus AI)

The acceleration is due to the continued increase in CO2 emissions with its long atmospheric lifetime, making CO2 emissions highly cumulative in the atmosphere. If carbon sinks weaken, as long predicted (IPCC AR6), and recent research suggests, more CO2 is left in the atmosphere.





Atmospheric CO2 concentration is deemed to be on a mid-range scenario, but AI finds it higher ‘it is outpacing midrange scenarios] with a rate closer to **high emissions scenarios’** (Consensus AI). IPCC AR6 projection of worst-case SSP5-8.5 (above right) scenario suggests current atmospheric CO2 is aligning towards worst-case.

Cumulative CO2 emissions are increasing at an accelerating, near-exponential rate, on worst-case scenarios. (Consensus AI)

High Emissions Scenario

Atmospheric methane (CH4)

30% of climate change
Lasts average of 12 years in the atmosphere
86X CO2 over 20 years

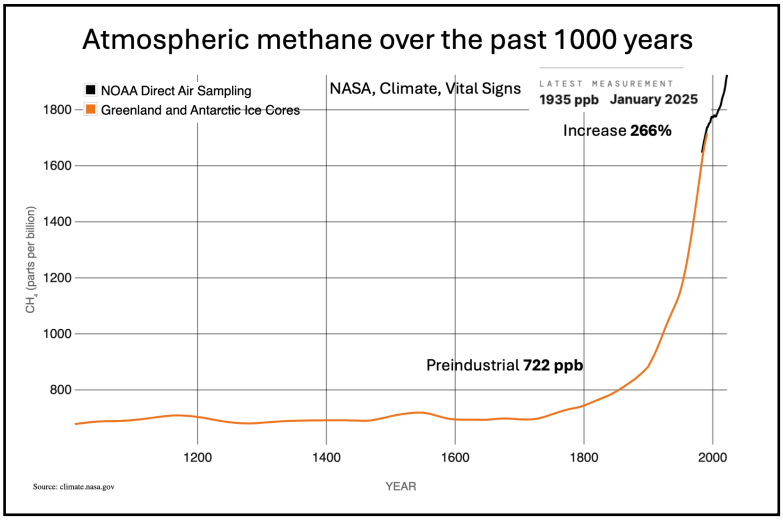
(30% climate change contribution) The increase in atmospheric methane is accelerating. Research indicates that after a period of stagnation in the early 2000s, atmospheric methane levels began to rise again in 2007, with a significant acceleration starting in 2014.

The increase in atmospheric methane is aligning with worst-case scenarios for greenhouse gas emissions. Recent studies indicate that methane concentrations are rising faster than at any time in the past two decades.

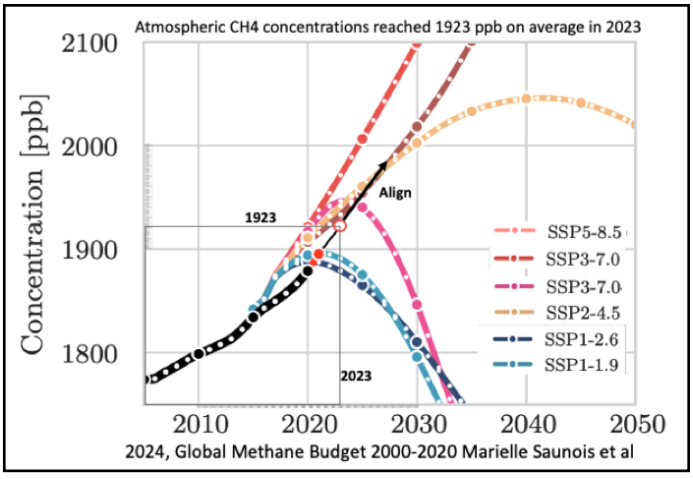
The recent rise in methane is predominantly biogenic, from wetlands (also hydroxyl).

Global Carbon Project
'Atmospheric CH4 concentrations reached 1897 parts per billion (ppb) in 2024, 2.66 times pre-industrial levels. CH4 accumulation in the atmosphere has accelerated in the past decade, with higher growth rates over the past three years (2020-2022) than any previous observed year. The observed atmospheric CH4 concentrations in the past decade follow the trends of the IPCC most pessimistic illustrative future GHG trajectories'. (Global Carbon Project, September 2024)

Atmospheric methane, NASA, 1000 years to to 2025



Global Carbon Project 2024



Worst-case Scenario

Atmospheric nitrous oxide (N2O)

270X CO2
Lasts 120 years

Atmospheric nitrous oxide (N2O) is accelerating. Recent studies indicate that the growth rate of atmospheric N2O has increased significantly over the past decades.

Global N2O emissions have risen substantially, particularly since 2009, at a rate faster than previously estimated by the IPCC. This increase is largely attributed to agricultural practices and the use of nitrogen fertilizers.

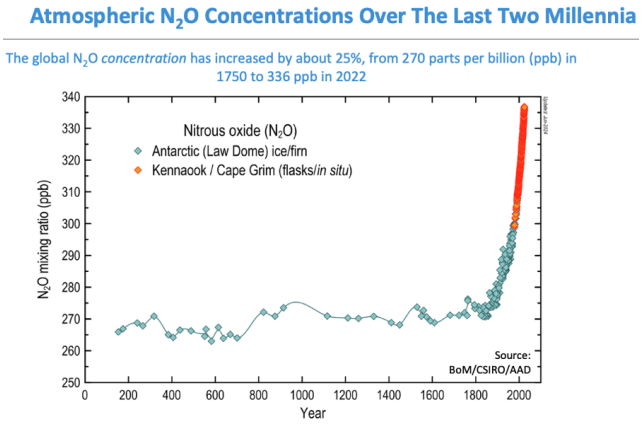
Since the industrial revolution, N2O concentrations have increased by about 20%, with a notable rise in the rate of increase around the 1960s due to the expanded use of the synthetic nitrogen fertilizers.

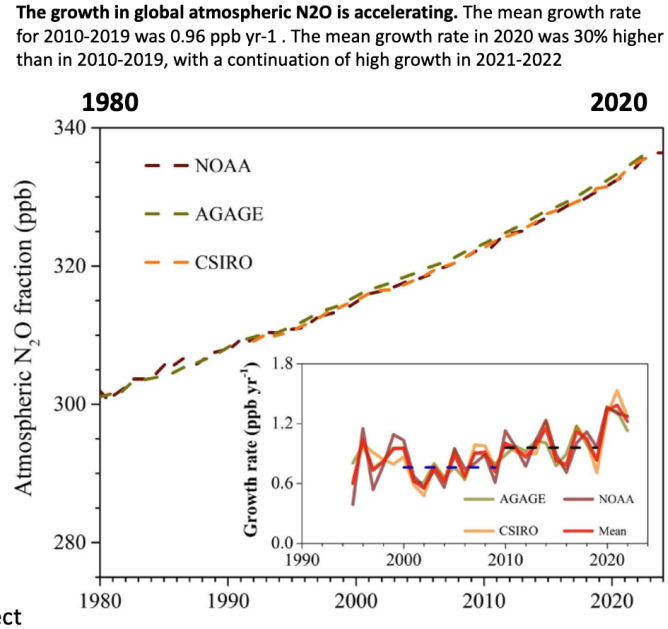
Global Carbon Project
'The observed atmospheric N2O concentrations in the past decade have exceeded the most pessimistic illustrative future GHG trajectories used by the IPCC'.
(Global Carbon Project, nitrous oxide budget, June 2024)

Global Carbon Project, 2024

Atmospheric Concentration and Growth Rate of Nitrous Oxide (N2O)

Atmospheric nitrous oxide over the past 2000 years





Global Carbon Project

Worst-case Scenario

Atmospheric greenhouse gas concentration (CO2 equivalent)

Record high in 2024, at 539 atmospheric CO2 eq. (NOAA)- see below.
The increase is accelerating right up to present and much faster than accelerating CO2.

CO2 equivalent is all the long-lived greenhouse gases (including methane)

Atmospheric CO2eq. is provided annually by NOAA's Greenhouse Gas Index

The single time series source found of atmospheric CO2 eq. emissions with scenarios is EPA, 2017. EPA here puts CO eq. of 539 ppm, far above worst-case RCP 8.5.

It could presently be very high, as it is accelerating faster than atmospheric CO2.
Also atmospheric methane is worst-case, as is nitrous oxide.
In addition, **F-gases** (included in CO2 eq.)include the most potent long-lived GHGs and contribute 13% of warming, They are increasing the fastest of all GHGs at accelerating rates

Atmospheric CO2 eq. aligns with worst-case scenarios.
Current ~539 ppm CO_2-eq. aligns with the upper half of mainstream scenario space and is broadly compatible with high-end baseline paths (SSP3-7.0/SSP5-8.5)' (Consensus AI)

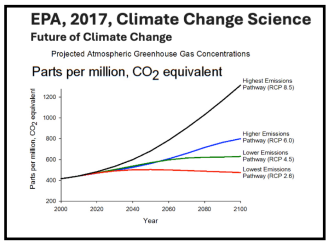
NOAA, Atmospheric GHG Index, 2025

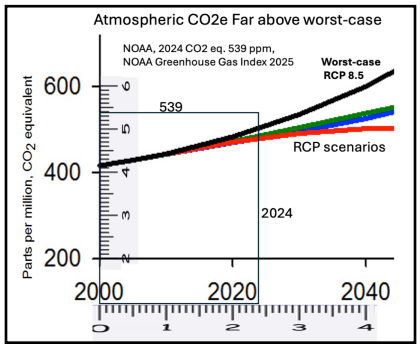
"In terms of CO2 equivalents, the atmosphere in 2024 contained 539 ppm"

2017, EPA, Future Climate Change, for scenarios

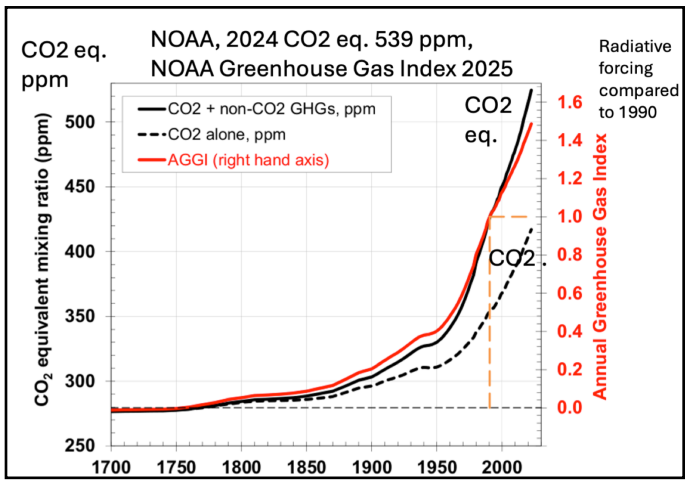
"The top pathway assumes that greenhouse gas emissions will continue to rise throughout the current century. The bottom pathway assumes that emissions reach a peak between 2010 and 2020, declining thereafter".

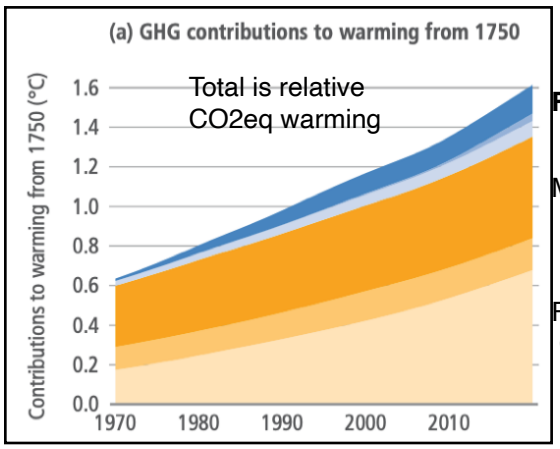
Even if we stabilized concentrations of today's atmosphere (which would require a dramatic reduction in current greenhouse gas emissions), surface air temperatures would continue to warm. This is because the oceans, which store heat,





IPCC AR6 WG3, Fig. 2.4





Worst-case scenario

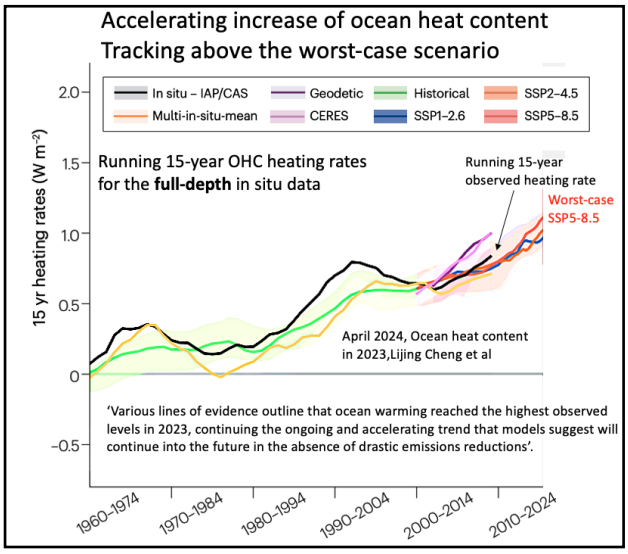
Ocean heat content

Accelerating ocean heat is aligning with the **worst-case, high-emission scenarios**

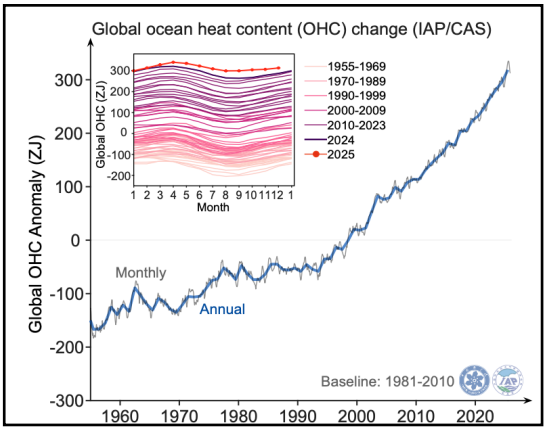
The oceans absorb over 90% of our anthropogenic heat from GHG emissions.
2025 was another record for ocean heat, like every year since 1995. ‘This reinforces marine heat waves and intensifies extreme weather events’ (Ocean heat content sets another record in 2025, Jan. 2026, Yuing Pan, L. Cheng et al
The amount of heat in the oceans has been increasing faster since the 1990s.
The rate of warming in the oceans has quadrupled since 1985.

The 2023 Zhi Li study (below right) documented a strong acceleration in global ocean warming (OHC, heat content) since the 1990s, amounting to a >25% increase in OHC during 2010–2020 relative to 2000–2010, and nearly a twofold increase during 2010–2020 relative to 1990–2000.

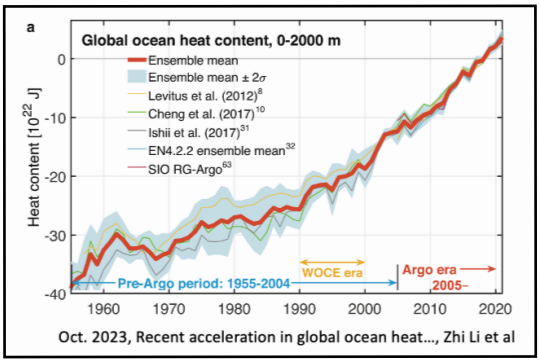
The 2024 Cheng study of 2023 ocean heat (left), showed full ocean depth heat increasing at an accelerating rate, above the worst-case scenario.



‘Ongoing and accelerating trend’
April 2024, Ocean heat content in 2023, Lijing Cheng et al



Pan, Cheng, 2026



28 Oct. 2023, Recent acceleration in global ocean heat accumulation ..., Zhi Li et al

‘Heat stored in deeper layers of the ocean will eventually be released, committing Earth to at least some additional surface warming in the future. (NOAA, 26 June 2025)

Worst-case Scenario

Global Warming (Global average surface temperature increase)

Global warming is accelerating, over the long term and recent short term.

The 2025 Climate indicator update (2024) by Piers Forster (et al) stated ‘human induced warming has been increasing at a rate that is unprecedented in the instrumental record’.

2023 was a record warming, by an unexpected large margin, even with El Nino (warming).
2024 was a new record (1.55°C), even more unexpected, with La Nina (cooling)
2025 made the last 3 year average above 1.5°C (Copernicus, 2025 1.47°C)

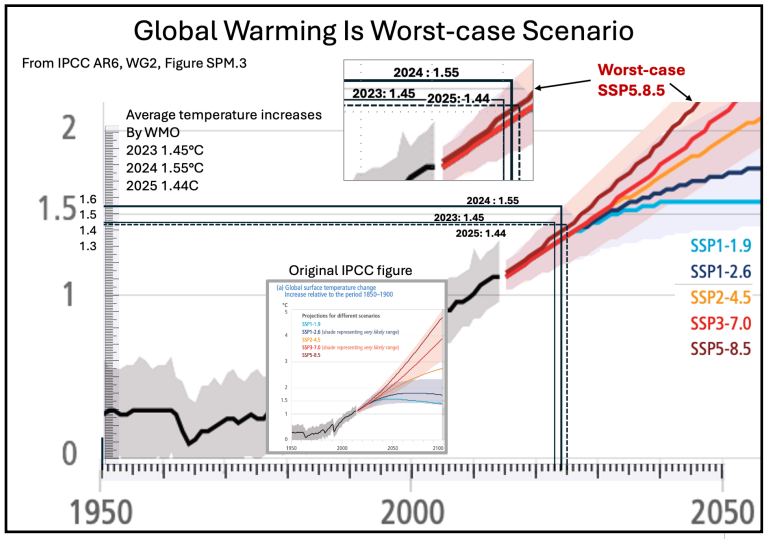
Reasons: Radiative forcing and atmospheric greenhouse gas concentrations increasing faster than ever. Also global emissions record in 2024, melted land ice reduced albedo cooling, and reduced air pollution cooling aerosols (Forster).

The 2024 record of 1.55°C (WMO) is worst-case scenario (using IPCC AR6).
Acceleration of warming to the present makes 1.5°C and higher certain, as does the record high and accelerating warming drivers, like radiative forcing.
James Hansen predicts 2°C in 2030s, not 2050 (J. Hansen, Feb 2026, 2°C in 2030s).

Using IPCC AR6 temperature projections, 2025 keeps global warming on the worst-case scenario (SSP5-8.5), 2023-2026.

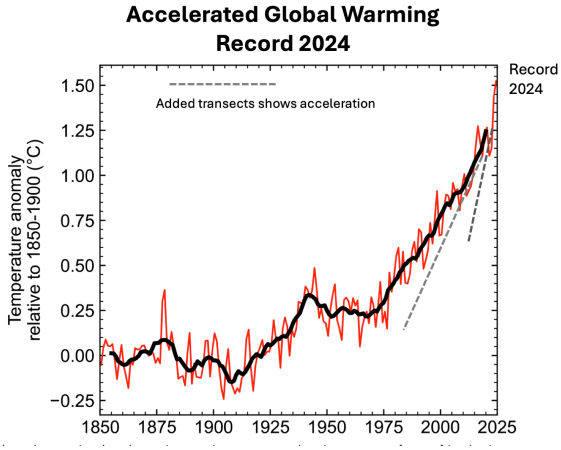
This is supported by D. Carvalho et al, 2023. ‘The observed warming is closer to the upper level of the projected ones, revealing that CMIPs (models) future climate scenarios with higher GHG emissions appear to be the most realistic ones.

Warming average 2023-2025 above 1.5°C
2025 is worst-case scenario.



IPCC AR6, WG2, Figure SPM, 3
Temperature projections

Unprecedented rate of temperature increase
Global warming is accelerating



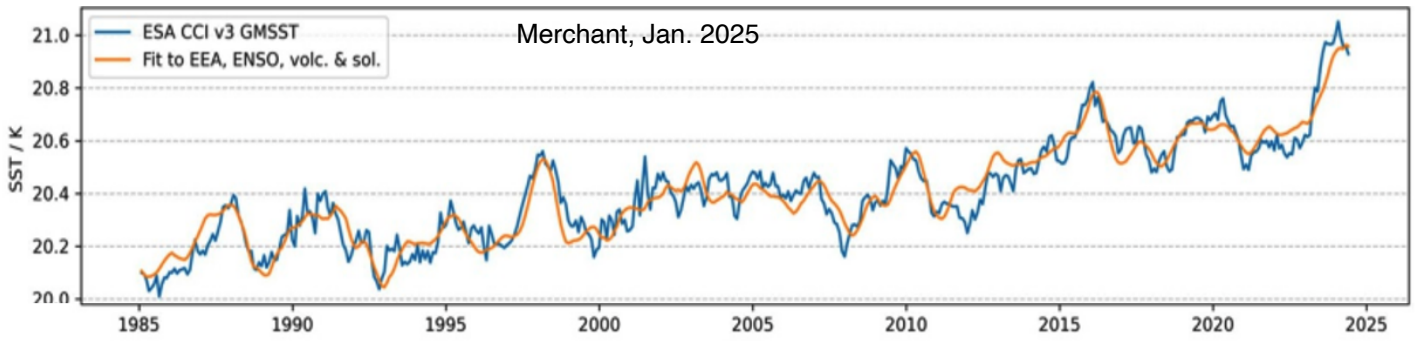
(Indicators of Global Climate Change 2024: annual update… , Piers Forster et al, June 2025)

Worst-case Scenario

Ocean surface warming (Sea surface temperature (SST) increase)

Sea surface temperature (SST) is increasing at an accelerating rate.
Global sea surface warming has more than quadrupled over the past 40 years.
The rate of sea surface temperature warming has risen from 0.06° per decade in the 1980s to 0.27°C per decade today.
(28 Jan. 2025, C. Merchant et al, Quantifying the acceleration of multidecadal global sea surface warming driven by Earth's energy imbalance)

1985 Global mean SST deseasonalized 2025

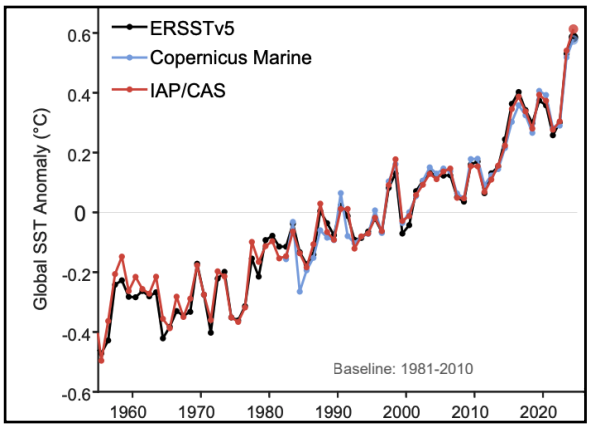


Observed SST increases in recent years are already **matching or exceeding the rates projected for the end of the century under high-emission scenarios** (Consensus).

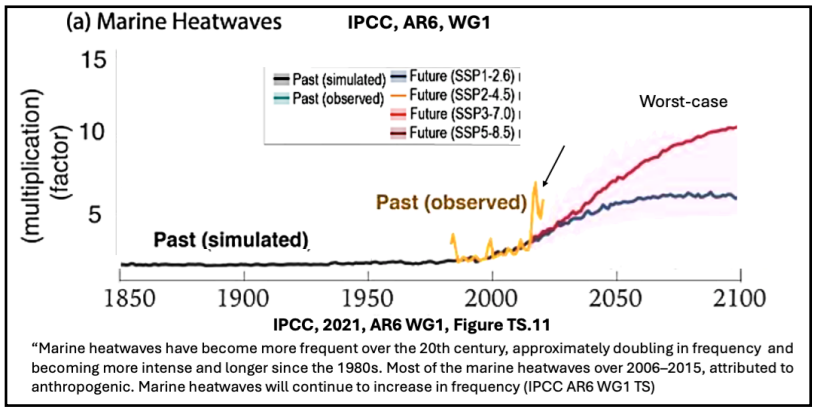
Marine heatwaves are increasing, above the IPCC worst-case scenario (below).

Global annual mean SST changes from three data products (ERSST, Copernicus Marine, and IAP/CAS).

(Record High Temperatures in the Ocean in 2024, Lijing CHENG et al, June 2025)



Marine heatwaves are tracking above the worst-case scenario (IPCC AR6, WG1, Figure TS 11)



Global sea surface temperature (SST) is warming at an unprecedented, accelerated rate, increasing from 0.16°C/decade in the late 1980s to 0.27°C/decade by 2023.
(C. Merchent, 2025)
The record-shattering temperature jump 2023-2024, was far above worst scenarios.

Worst-case Scenario

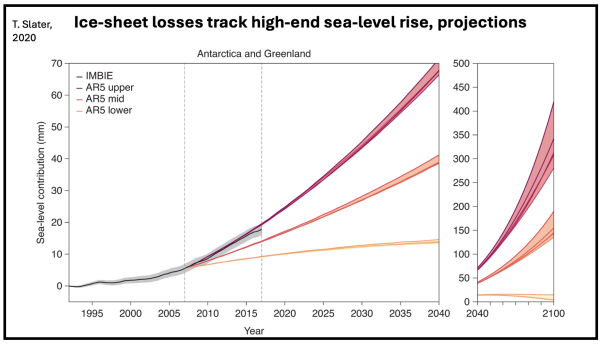
Ice Sheets (both) Greenland and Antarctic

Greenland, Antarctica Melting Six Times Faster Than in the 1990s NASA, 16 March 2025

The two polar regions have lost 6.4 trillion tons of ice in three decades.

'Ice losses from the Greenland and Antarctic ice sheets have accelerated since the 1990s, accounting for a significant increase in the global mean sea level'.
(20 April 2023, Mass balance of the Greenland and Antarctic ice sheets from 1992 to 2020
Inez Otosaka et al)

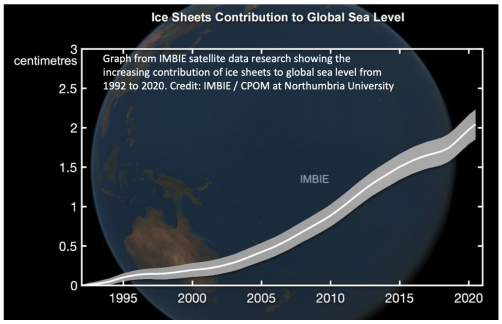
Ice-sheet losses track high-end sea-level rise, projections, Aug. 2020, T. Slater et al



Accelerating trend of ice sheet mass loss as sea level rise (IMBIE) from the melting of Greenland and Antarctic ice sheets

Ice Sheet Mass Balance Inter-comparison Exercise (IMBIE).

Ice sheet loss as ice sheets' contribution to global sea level

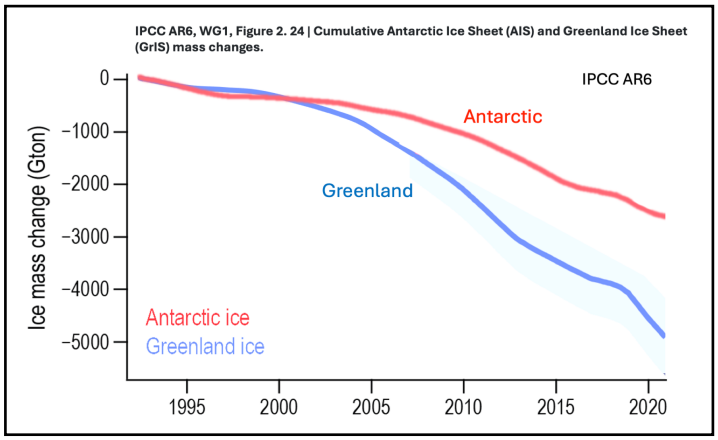


Warming of +1.5 °C is too high for polar ice sheets

(20 May 2025, Warming of +1.5 °C is too high for polar ice sheets, C.R. Stokes et al.
This indicates that sea level rise is sooner and higher than anticipated.

Accelerating mass loss of Greenland & Antarctic ice sheets

IPCC AR6, WG1, Figure 2. 24 Cumulative Antarctic Ice Sheet and Greenland Ice Sheet mass changes.



According to two research papers mass loss of ice sheets is upper range scenarios.
Ice sheet losses track close to the IPCC upper range scenario (Shepherd, 2019)
Ice-sheet losses track high-end sea-level rise projections (Slater et al, 2020)

Upper Range Emissions Scenario

The accelerating melt of ice sheets by the global surface warming is the most dramatically clear indicator of the accelerating and enormous surface heating.

Greenland Ice Sheet

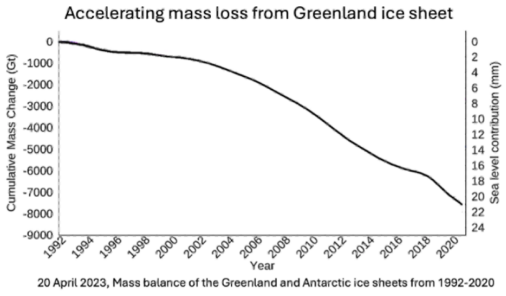
10 Dec. 2019, Mass balance of the Greenland Ice Sheet from 1992 to 2018, by the IMBIE Team, "Cumulative ice losses from Greenland as a whole have been close to the rates predicted by the IPCC for their high-end climate warming scenario".

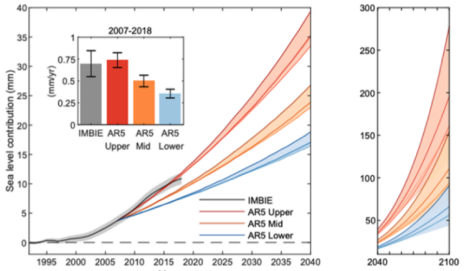
Ice-sheet losses track high-end sea-level rise projections, T.Slater, 2020

Ice losses from the Greenland and Antarctic ice sheets have accelerated since the 1990s, Inez Otosaka et al, 20 April 2023, Mass balance of ice sheets

Mass balance of the Greenland ice sheet from 1992-2018, A Shepherd, Dec. 2019. 'Observed ice-sheet losses are close to the upper range of the IPCC Fifth Assessment Report sea-level predictions'

Greenland ice sheet's accelerated mass loss is matching or exceeding the IPCC Change (IPCC)'s worst-case climate warming

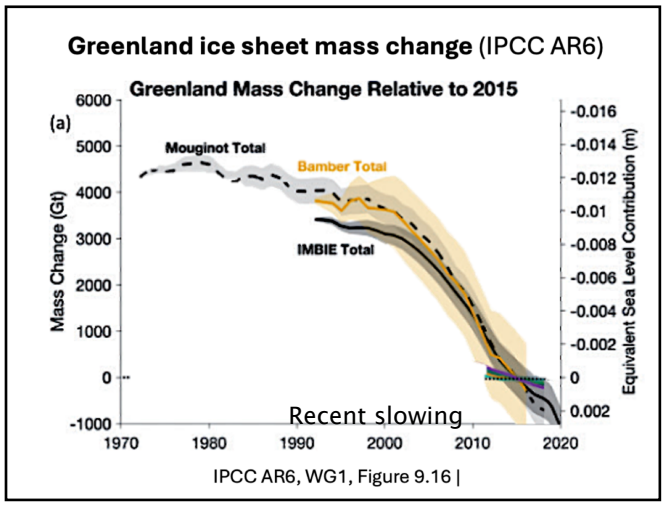




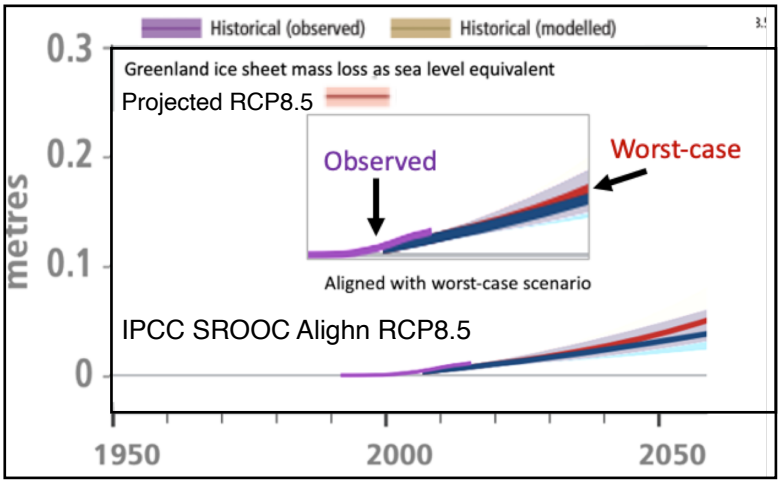
Also a warming of 1.5°C is too high for ice sheets, for ice sheets, i.e. Greenland.

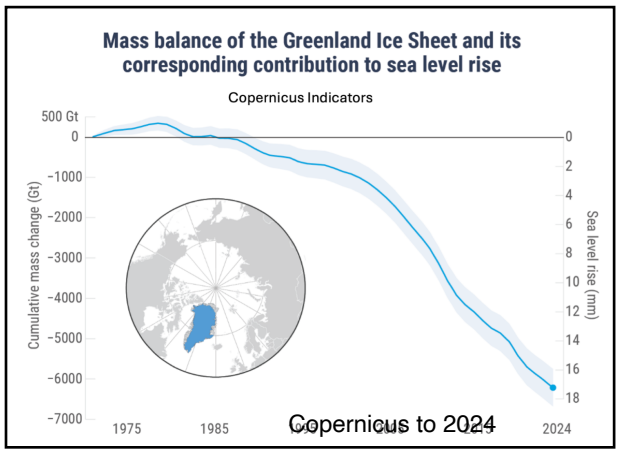
(2025, Stokes, **Warming of +1.5 °C is too high for polar ice sheets)**

IPCC AR6, WG1 Figure 9.16 |
Greenland Ice Sheet cumulative mass change rate- accelerating loss.

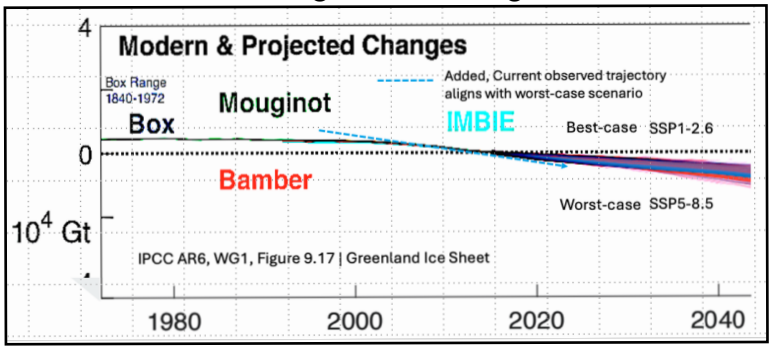


IPCC SROOC, Fig. SPM.1 shows mass loss of the Greenland ice sheet as aligned with worst-case scenario





IPCC AR6, WG1, Figure 9.17 Aligned worst-case



Worst-case

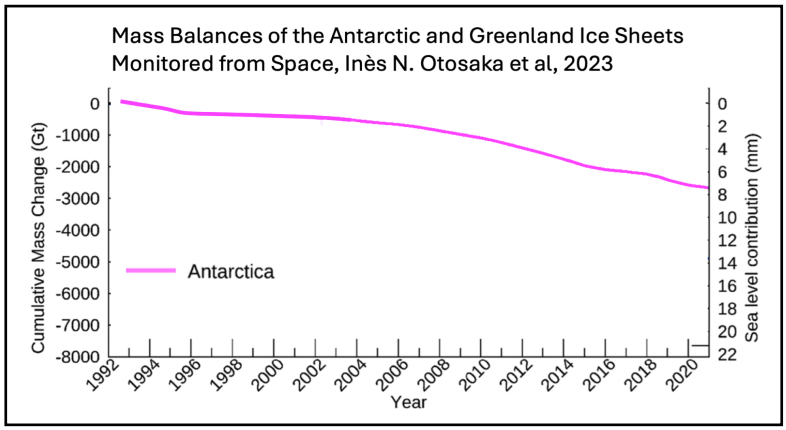
Antarctic ice sheet

Ice losses from the Antarctic ice sheet have accelerated since the 1990s, to 2021
(Mass Balances of the Antarctic and Greenland Ice Sheets Monitored from Space Inès N. Otosaka et al)

Both ice sheets
2020 Ice-sheet losses track high-end sea-level rise projections, T. Slater et al

Antarctic ice sheet mass loss is accelerating

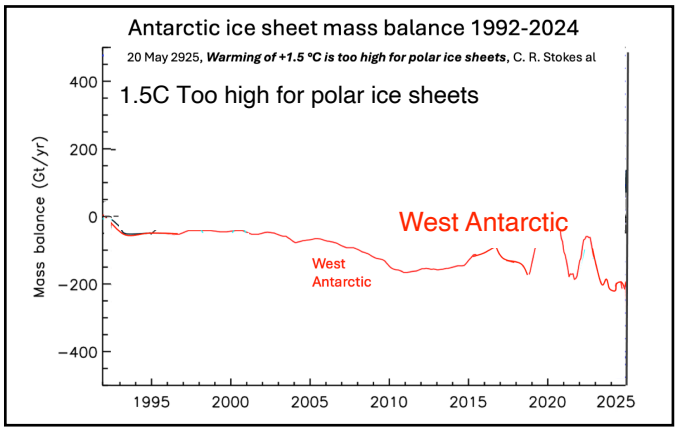
'Ice losses from the Antarctic ice sheet has accelerated during the past few decades'
(20 April 2023, Inez Otosaka et al)



West Antarctic ice sheet destabilized

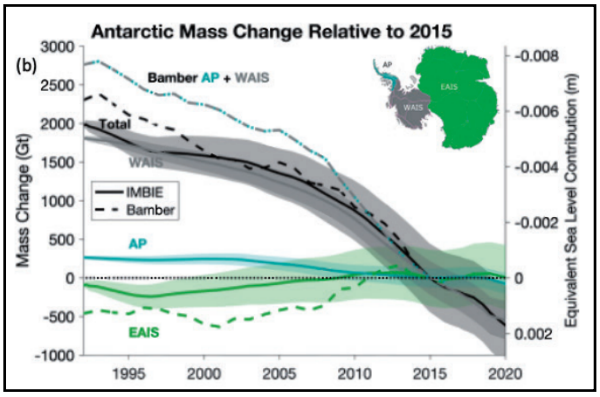
Unavoidable future increase in West Antarctic ice-shelf melting over the twenty-first century,
(K Naughten et al, Oct. 2023).

Emerging evidence of abrupt changes in the Antarctic environment.
(N. Abram Aug. 2025)

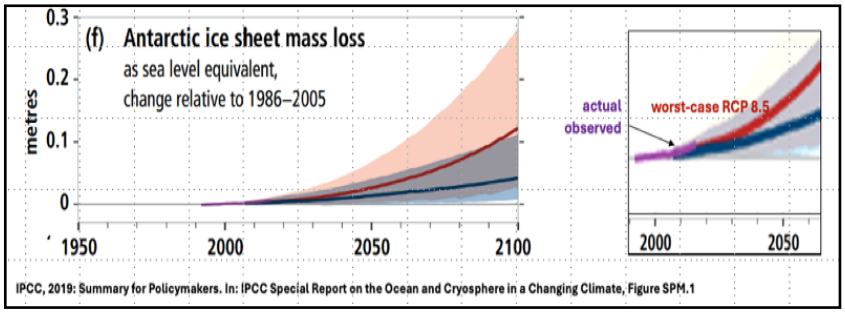


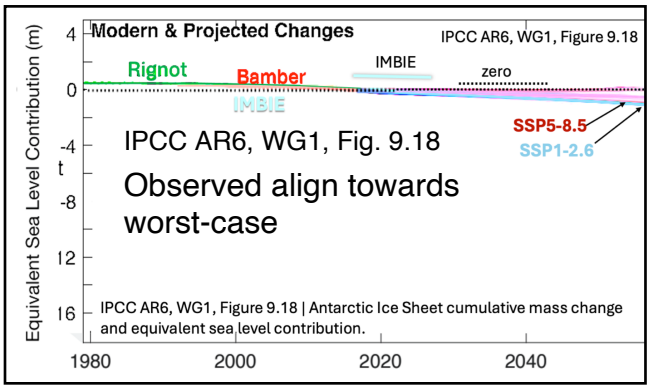
AR6, Acceleration loss West Ant. ice sheet,
& Antarctic Peninsula, E. Antarctic no change

IPCC AR6, WG1, Figure 9.16



The IPCC SROOC Report observation plot on oceans indicates Antarctic ice sheet loss is worst-case scenario.





IPCC AR6, WG1, Fig. 9.18
Observed align towards worst-case

High-end Scenario. (Consensus AI)
Align towards worst-case

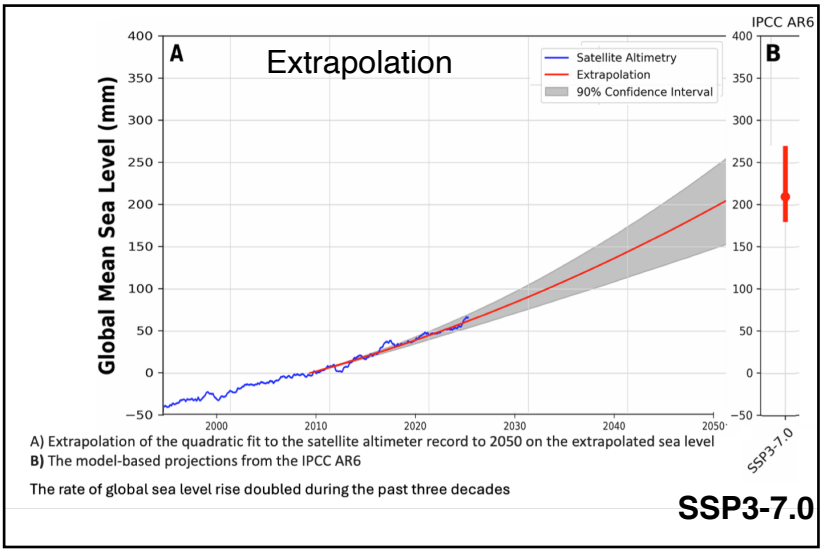
Sea level rise (SLR)

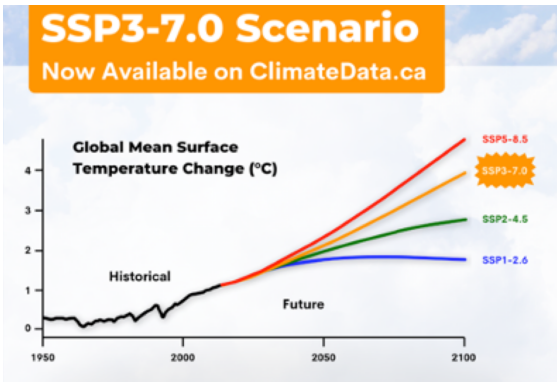
Sea level rise is accelerating
Global sea level is rising due to two factors caused by global warming: the expansion of seawater as it warms and the melting of land-based ice, glaciers and ice sheets.

30% of the global mean sea level rise can be attributed to ocean thermal expansion, the remaining contribution comes from the melting of glaciers and polar ice sheets (Copernicus).

The accelerating rate of global sea level rise doubled during the past three decades.
B. D. Hamlington et al. Oct. 2024

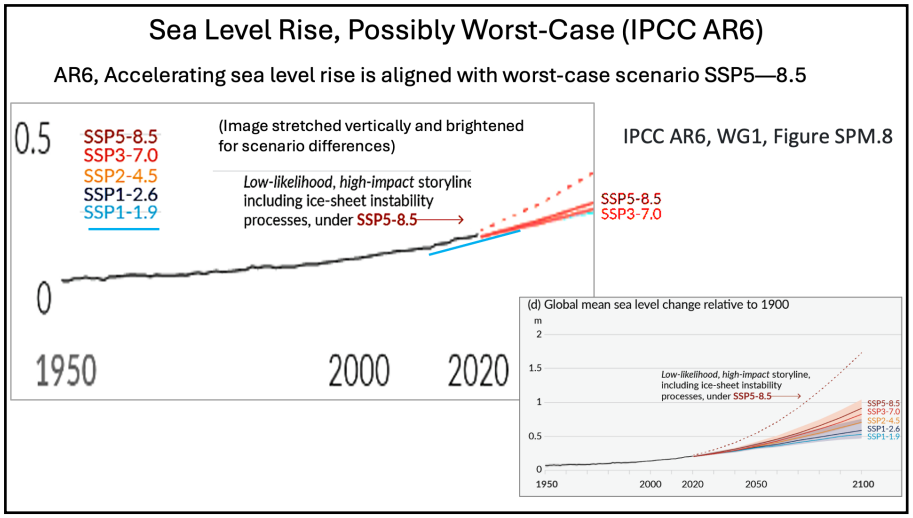
Hamlington's extrapolation puts sea level rise on second highest scenario, SSP3-7.0





This IPCC AR6 figure puts sea level rise accelerating towards the worst-case

No worst-case sea level rise is found. Consensus AI is high end.
Acceleration of SLR makes worst-case likely.
Most SLR is now from Greenland- accelerating losss.
With rapid ice sheet loss and current large scale changes that portend faster melt, worst-case looks inevitable.



High-end- Potentially Worst-case

Radiative Forcing

Radiative forcing is the direct driver of climate change, so its current scenario is crucial.

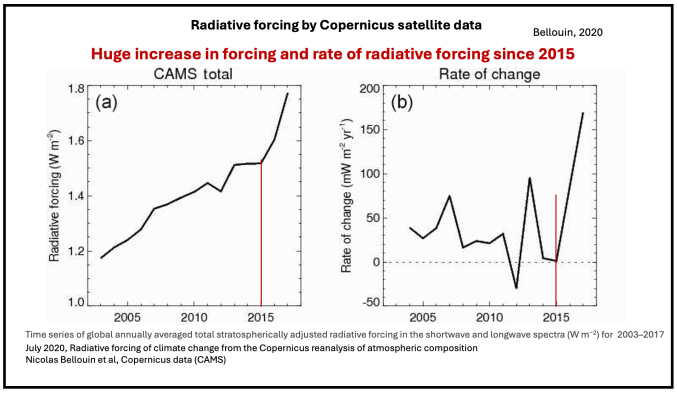
Radiative (heat) forcing is defined by the IPCC, as 'the net change in the downward minus upward radiative flux at the tropopause due to external drivers of climate change, such as greenhouse gases or solar output. It is measured in Watts per square meter (W/ m^{-2}) , where positive values cause warming and negative values cause cooling'.

In short, it tells us the total heat power and the net heat added to the climate system (planet) It is calculated from climate change data.

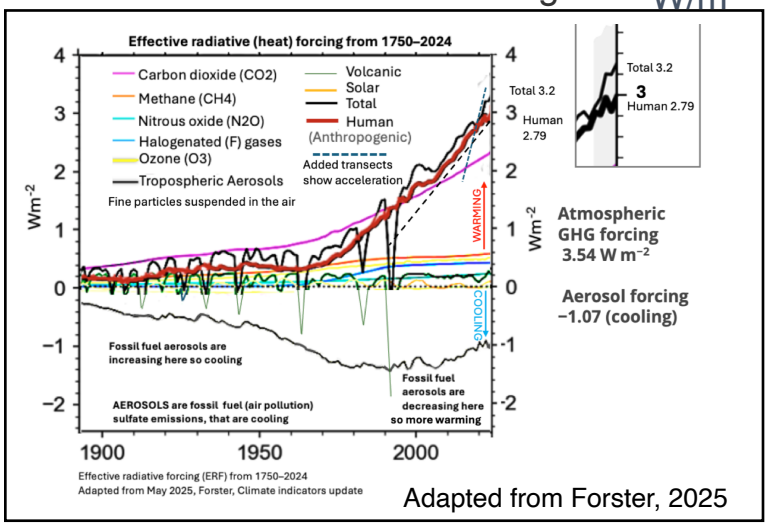
Radiative forcing is accelerating (Meniere, 2023), with 2024 a record high at 3.2 W/m^{-2} (Forster Indicators, 2025)
Since 1990 It has increased 60-70% (Consensus AI). There is a recent (2023-2024) jump.

Aerosols: Fossil fuel combustion air pollution emissions of acid aerosols have a global cooling effect, which has offset warming. Measures to improve air quality have reduced the aerosol emissions which reduced the cooling, with an acceleration of forcing and warming.

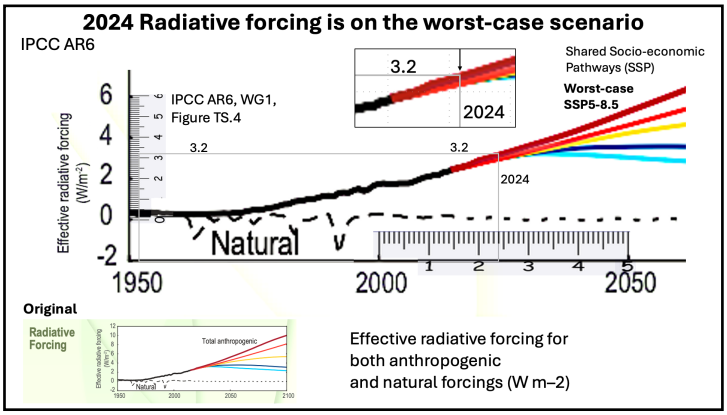
The Image below is research using Copernicus satellite data for radiative forcing, which shows a large, fast increase in forcing from 2015.



2024 record total radiative forcing 3.2 W/m^2



IPCC AR6, WG1, TS.4. **(total radiative forcing)**



IPCC AR6 Accelerated forcing from 1980 to present

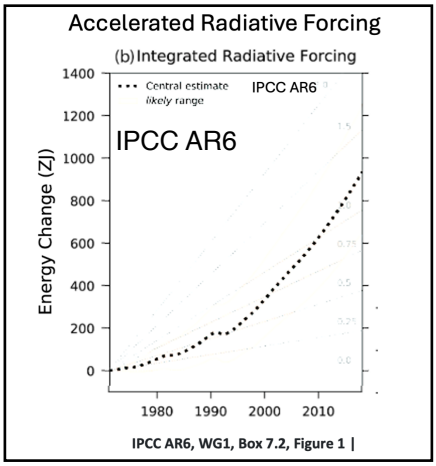


Image from IPCC AR6 shows 2024 radiative forcing of 3.2 on the worst-case SSP5-8.5 scenario, which indicates climate change would be worst-case.

Worst-case Scenario (but not published other than IPCC)

Radiative Forcing (continued)

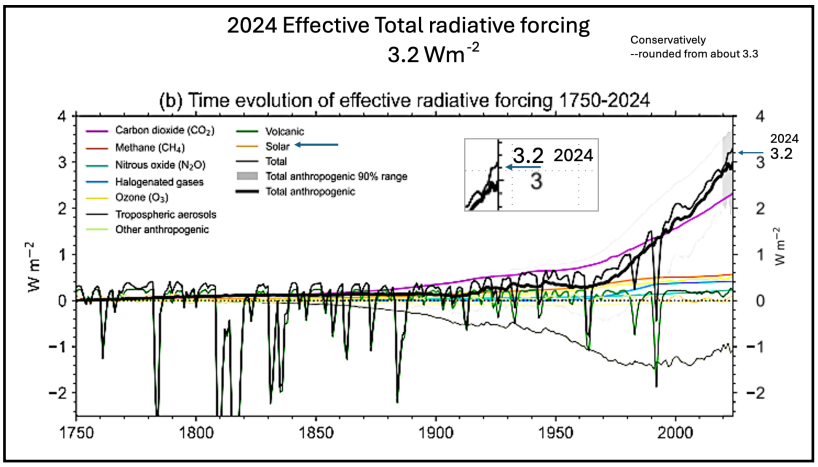
Here, there are two IPCC AR6 forcing projections that show 2024 on worst-case scenario

The image below shows 2024 forcings and contributions, the orginal from Forster 2025 .
The radiative forcing projection shows two totals. Total anthropogenic (human forcing) and the actual total that adds natural forcings to the anthropogenic, which makes it a bit higher.
However, there is no published number for the full total (Consensus checked)

From 2025 Forster (for 2024) anthropogenic forcing is 2.97 Wm-2, and as measured to the full total at 3.2 Wm-2. It looks to be 3.3, which was rounded to a conservative 3.2.

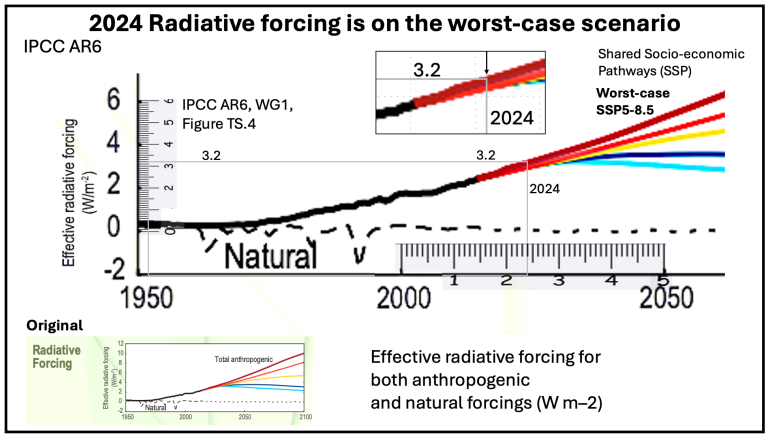
As the heat power added to the planet, the radiative forcing is the single most important indicator
Two below are IPCC, and three papers (below, bottom). They all put 3.2 forcing on worst-case.

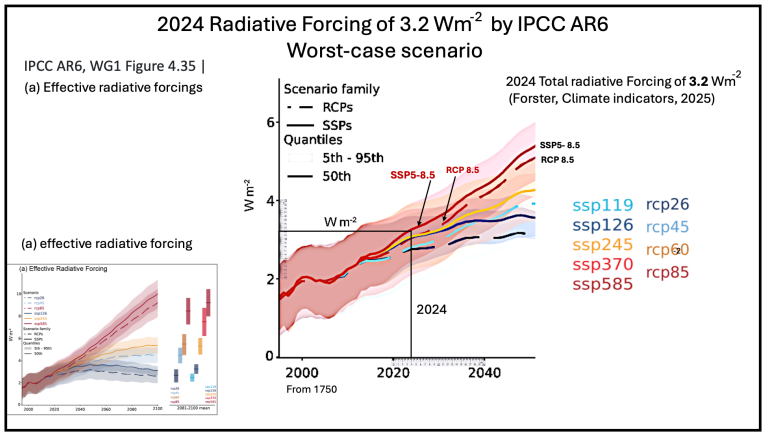
This image shows the full total 2024 forcing, of 3.2 Wm-2. from the original Forster on indicators, 2025.



This clear (medians only) image of forcing derived from an IPCC AR6 Technical Summary image, and matched the 2024 forcing of 3.2. to it.
It is on the worst-case scenario (SSP5-8.5)

This IPCC AR6 image is from IPCC AR6, WG1, Chapter 4.
It shows from 2000, with baseline of 1750.
3.2 is on the worst-case scenario SSP5-8.5 and above the previous (AR5) worst-case scenario RCP8.5.





Three published papers.

Van Vuuren, 2011, A special issue on the RCPs. Forcing of 3.2 above worst-case
K.Rahi (et 23) 2017, The Shared Socioeconomic Pathways … An overview. Forcing of 3.2 above worst-case
E. Krieglera, 2017, Fossil-fueled development (SSP5)… Forcing of 3.2 above worst-case

Note also : Acceleration of radiative forcing, 27 Dec. 2023, Robust acceleration of Earth system heating observed over the past six decades, Audrey Minière e al

Worst-case Scenario (but not published outside of IPCC)

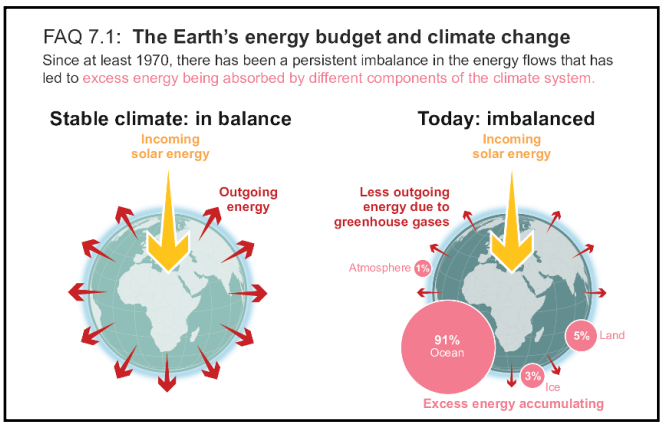
Earth Energy Imbalance

Earth energy imbalance (EEI) is accelerating, and has doubled over the past two decades. It is definitive worst-case scenario evidence

In 2023, the imbalance reached a new record high, twice that of the IPCC estimate.

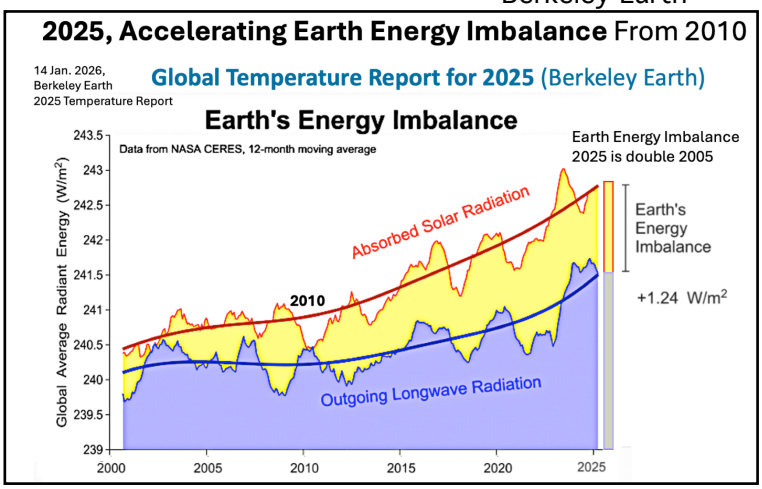
Earth energy imbalance (EEI) has been referred to as the gold standard for measuring climate change. This would be the clincher on worst-case scenario.
EEI is the difference between the amount of solar energy that the Earth receives and the amount of energy it radiates back into space. This imbalance is primarily caused by human greenhouse gas emissions. The imbalance is driving global warming and is an essential indicator of climate change.

There have been successive increases in EEI for each 20-year period since1974.
It has more than doubled from 1975-1994 to 2005-2024
This has been linked to rising concentrations of greenhouse gases and recent reductions in aerosol emissions [fossil fuel air pollution that is cooling]
(June 2025, P. Forster et al, Indicators of Global Climate Change in 2024…)



IPCC 6th Assessment

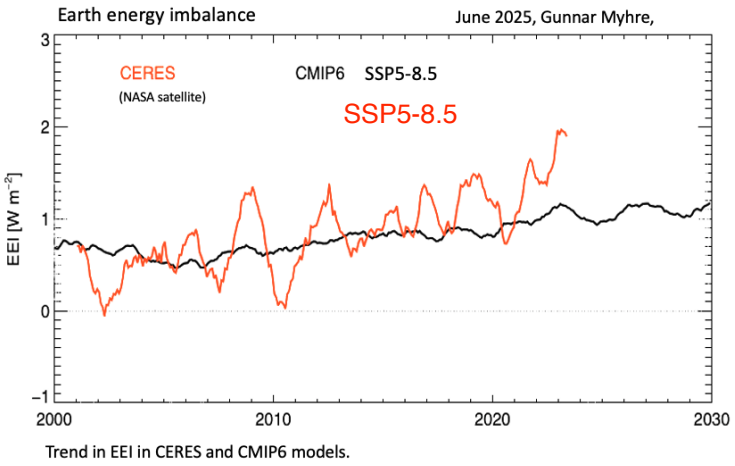
Berkeley Earth



This 2025 research (opposite) shows that Earth energy imbalance as measured by NASA CERES (satellite) is above the worst-case scenario, SSP-8.5.
The Increase is accelerating, with a jump from 2023-2024.

12 June 2025, Observed trend in Earth energy imbalance …, Gunnar Myhre et al.

EEI has and is increasing far faster than model projection, in effect making it on worst-case scenario.



Trend in EEI in CERES and CMIP6 models.

Worst-case Scenario, but not published as such

Earth Energy Imbalance (continued)

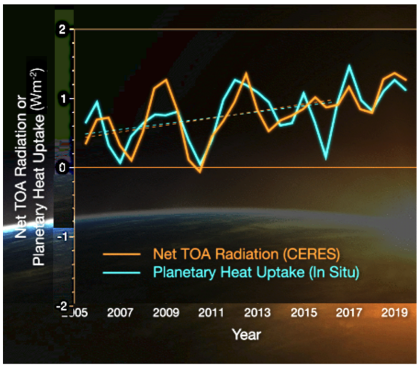
As Earth's energy imbalance (EEI) is the difference between the energy the Earth receives from the sun and the energy it radiates back into space, it is the single most definite indicator of climate change

In 2021 NASA and NOAA announced EEI had increased and had doubled in the 14 year period from 2005 to 2019

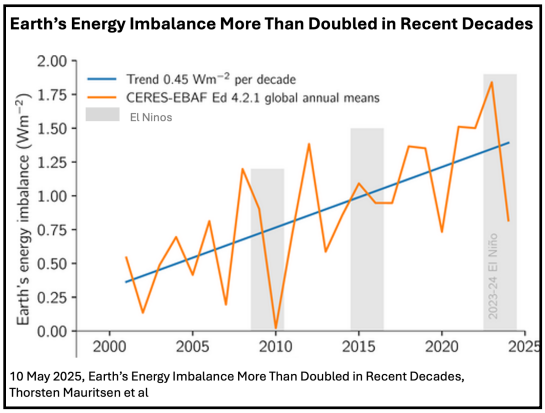
'Shocking finding
15 Jun 2021, Joint NASA, NOAA Study Finds Earth's Energy Imbalance Has Doubled'
(jount NASA NOAA press release)

Researchers have found that Earth's energy imbalance approximately doubled during the 14-year period from 2005 to 2019.
A positive energy imbalance means the Earth system is gaining energy, causing the planet to heat up.

15 June 2021, **Joint NASA, NOAA Study Finds Earth's Energy Imbalance Has Doubled**



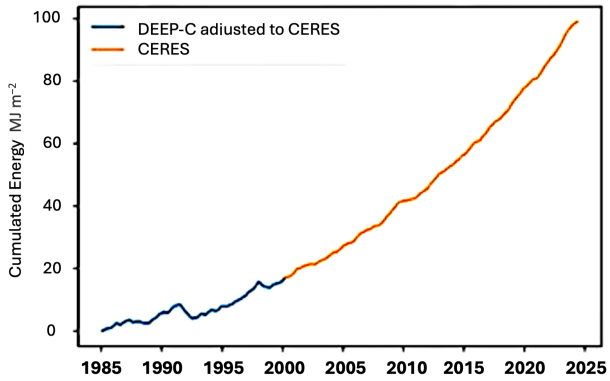
Most recent research was 10 May 2025, *Earth's Energy Imbalance More Than Doubled in Recent Decades,* by T. Mauritsen et al.



10 May 2025, Earth's Energy Imbalance More Than Doubled in Recent Decades, Thorsten Mauritsen et al

This 2025 research showed acceleration of Earth energy imbalance with an adjusted graph for the trend
C.J. Merchent e al, Jan. 2025

Integrated deseasonalized Earth Energy Imbalance (EEI)



28 Jan 2025, Quantifying the acceleration of multidecadal global sea surface warming driven by Earth's energy imbalance, Christopher J Merchant et al

There is no research available to check EEI against scenarios. How ever is so far above the IPCC (double) and climate models, making it on if not above on or above the worst-case.

Worst-case scenario, not published as such

Robust Acceleration of Earth system heating

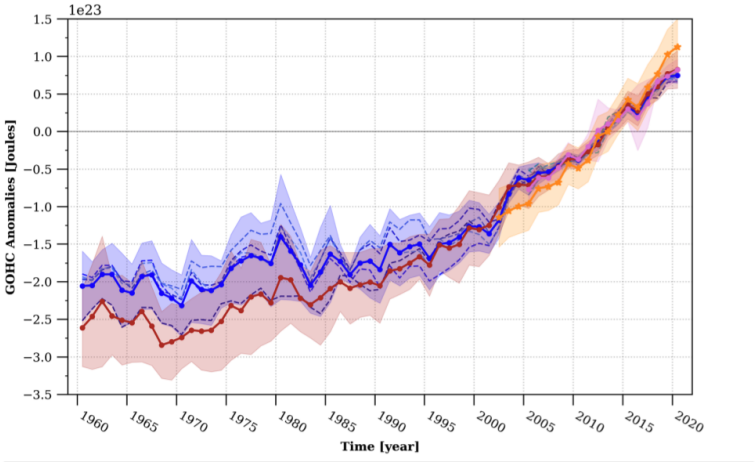
27 Dec. 2023, Robust acceleration of Earth system heating observed over the past six decades, Audrey Minière et al

2023 research finds *'**robust acceleration** of Earth system heating observed over the past six decades'. (*Radiative forcing acceleration)

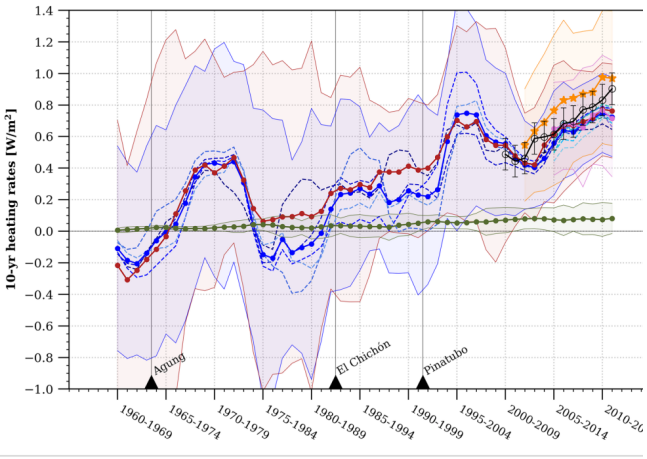
This heating is the global heat accumulation in the climate system, resulting from the current positive Earth's Energy Imbalance (EEI) at the top of the atmosphere.

This research examines the global heat accumulation rate across the entire climate system, including the ocean, atmosphere, cryosphere, and land.

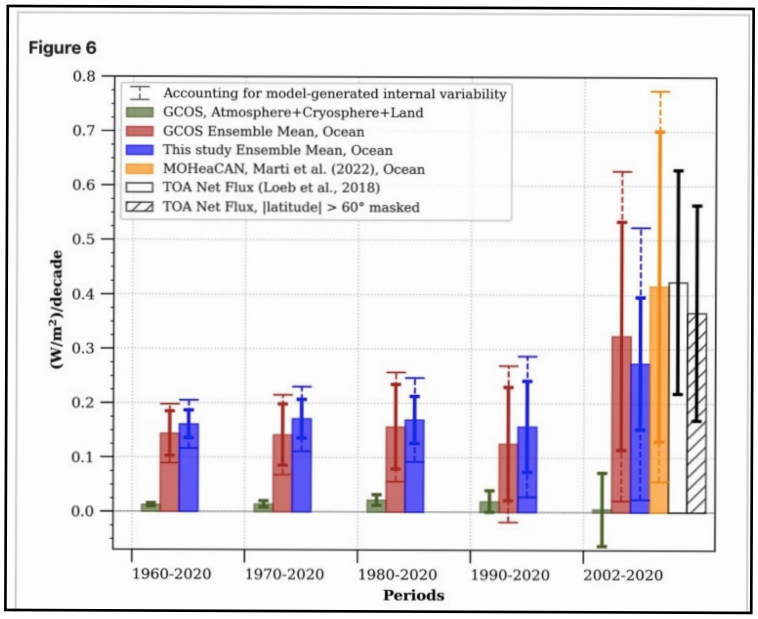
Time evolution of global ocean heat content (GOHC) anomalies.



1960–2020 time evolution of decadal heating rates of the Earth.



Earth system constant heating acceleration.



Evidence of worst-case scenario

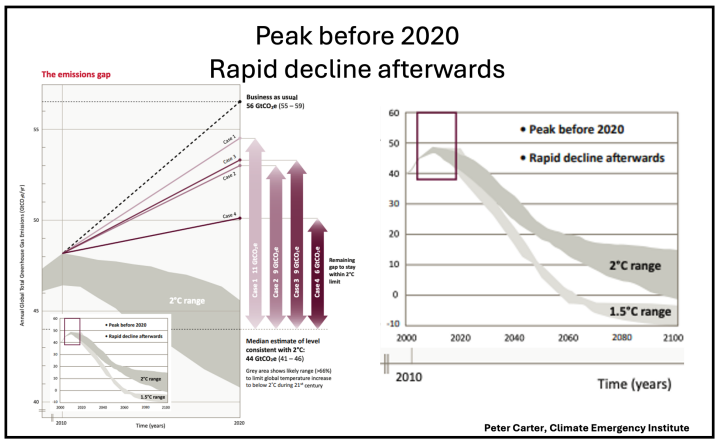
Conclusion

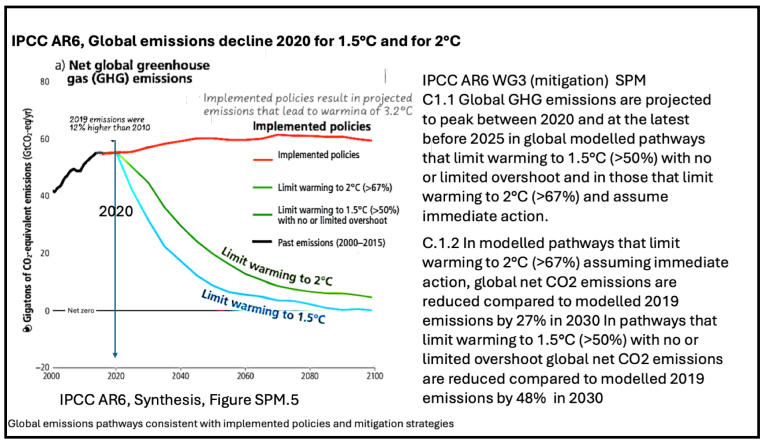
No other such exercise is available for comparison.

The acceleration and worst-case scenario of radiative forcing, using IPCC AR6, would be evidence that climate change is on the worst-case scenario.
Evidence also comes from the accelerating Earth Energy Imbalance (EEI), which has doubled over the past 20 years.

The unprecedented and accelerated rate of global warming is found to be worst-case scenario (2023-2025), using IPCC AR6. These have not been included in projections yet. Projections that don't include large planetary sources of amplifying feedback would underestimate future warming. The same applies if carbon sinks are weakening.

Since 2011 UNEP Gap reports (Gap Report below) and IPCC Assessments have 2020 as the global emissions decline deadline for 2°C (equiibrium). IPCC AR6 mitigation projections (below) have the deadline for 1.5°C and 2°C at 2020. IPCC AR6 mitigation for both 1.5°C and 2°C have global emissions in decline by 2025, which has not otherwise been recommended. This is more than urgent. There can be no further delay in urging immediate action by governments.





The above challenges the idea that the 1.5°C (danger limit) can only be determined by a 20-30 year average, which is a mitigation delay, when for mitigation global emissions decline by 2025 (IPCC AR6), and accelerating drivers would increase warming above 1.5°C. Today's record high accelerating radiative forcing may drive warming above 2°C (J. Hansen 2023.

Recommendation Immediate emegency response

This simple exercise needs to be tested in short order by climate experts, but climate change experts, organizations and national academies are in any case bound, by scientific and ethical integrity, to formally recommend to their governments immediate action to put global emissions into immediate decline (as IPCC AR6), first by the immediate termination of all fossil fuel subsidies and incentives now $7 Trillion/year (as IMF, Aug. 2023, S. Black et al)