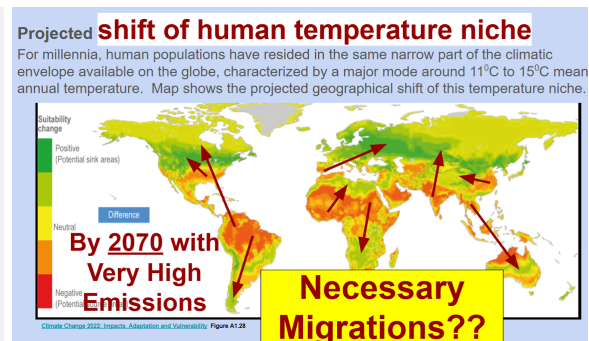
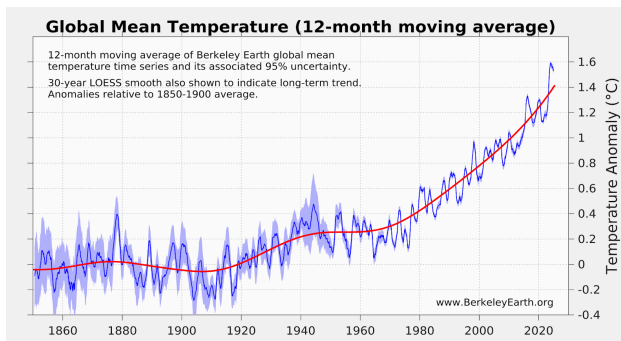




Climate Science and Likely Futures - in Graphics A Global Perspective

Rev.0.6 OCTOBER 22, 2025; Revisions will be posted at:

Latest Revision: Climate Science and Likely Futures - in Graphics A Global Perspective

Mac Lankford

Introduction

After years of climate science study, experimentation, hosting a Climate Science Study Group, and producing Climate Nuggets videos, I have been attempting to stimulate action by U.S. Members of Congress. This Study is an attempt to move the conversation forward - not by my work, but by scientists at the heart of the matter, though I have added a few notes of my own, which will be obvious.

This compilation of the science is intended for two purposes:

1. To provide Members of Congress with the background and language that can help them **lead** their constituents forward to supporting strong and critical climate action, and
2. To provide voters the background and language to demand action from their elected officials. In fact, voters are strongly encouraged to copy graphics, resource references, or a link to this entire study (see above in the title block) in letters to their MoCs, social media posts, Letters to Editors, and even billboards pressing for action by specific MoCs. I have become convinced that MoCs often are generally aware that we have a real problem, but believe their constituents are not pushing for action. **To be most effective, the specific MoC should be named in all communications and copied in social media posts.** That will ensure that their offices are aware of the demand for action.

The Findings of this Study

This particular Study came out of my trying to sort out the point of thousands of pages of Reports and scientific papers. I had become convinced that we are cascading toward a rough future. But where was the political will across the world to work together on solutions? What in the world would get the attention of **Governments** at the level needed? Progress in some regions is encouraging, but a global-level coordination will be required to have the necessary impact.

I finally saw an answer deep in the latest (2023) massive report from the Intergovernmental Panel on Climate Change (IPCC). There were hints throughout the volumes, but it was in an appendix (IPCC: Climate Change 2022: Impacts, Adaptation and Vulnerability Figure A1.28) that I saw the likely shifts of regions of human habitability. My conclusion from this, and a myriad of other sources is that:

Global Societal Disruption is very possible by 2050-2070.

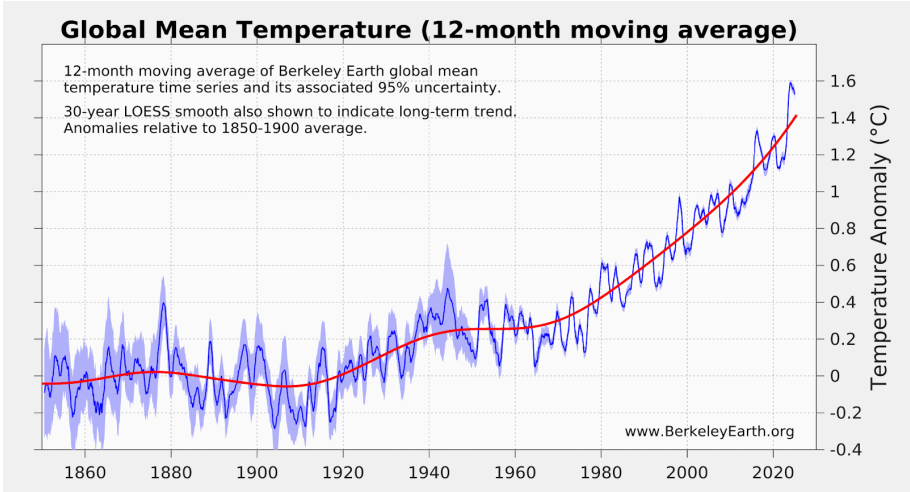
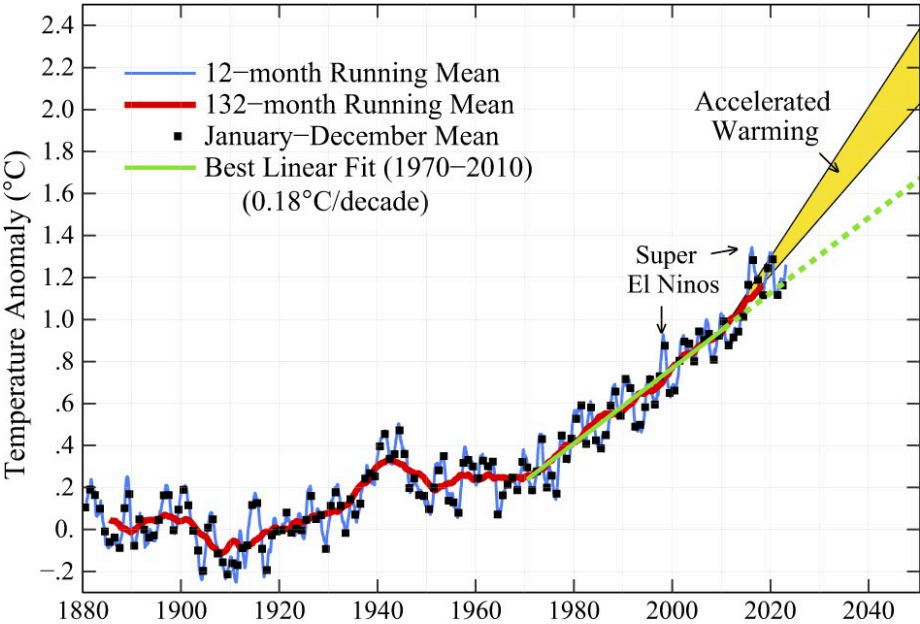
The basis for this alarming conclusion is simple: warming is increasing and accelerating; species extinctions, crop disruptions, and heat/humidity impacts will ruin the ability for at least 1/3 of the global population to stay in their current locations. Massive migrations will become inevitable, and are already starting.

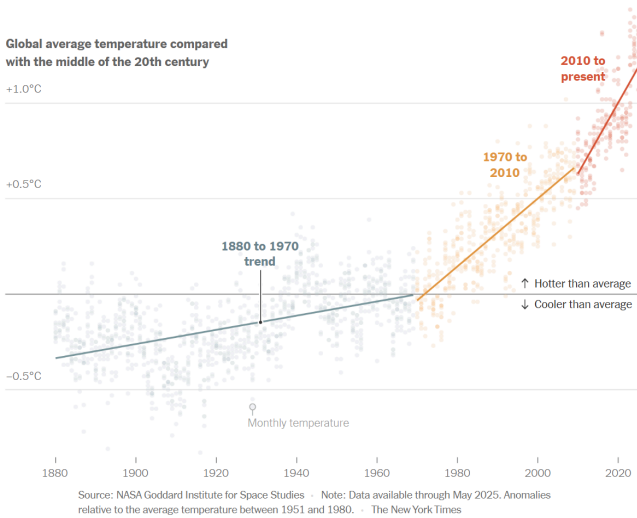
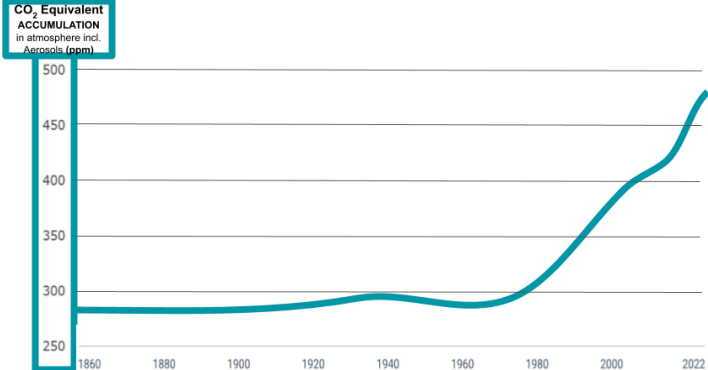
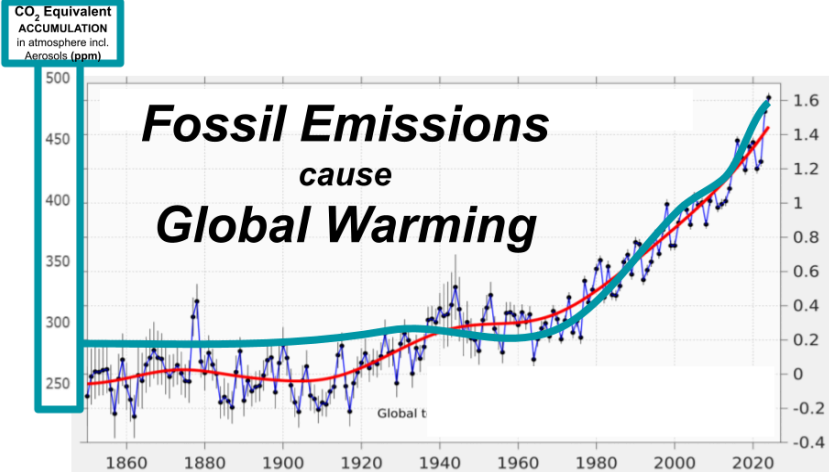
While there are extremely important regional and local impacts to be understood, this current Study tackles only the global picture. The reader is encouraged to explore the References provided as hot links - and to discover other resources as well.

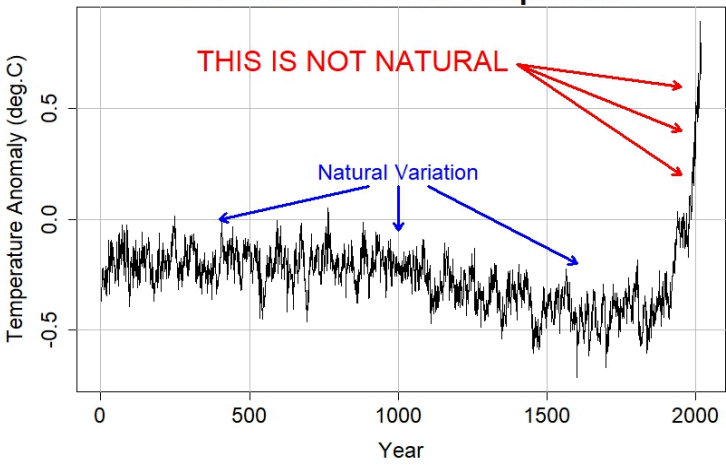
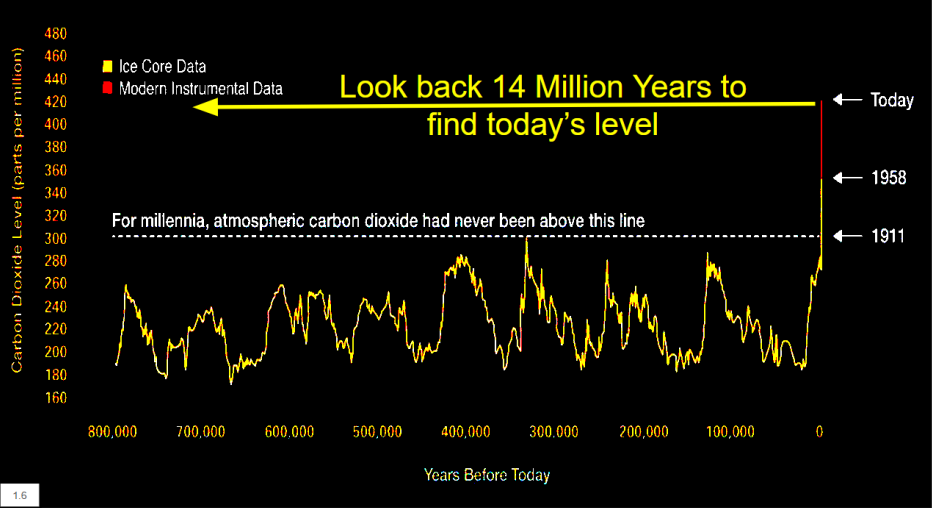
The Graphics below are organized, and hot-linked, to these findings:

1. **TODAY:** [We are already being dangerously impacted](#)
2. **CONFIDENCE IN SCIENCE: [Predictions are credible](#)**
3. **TIMING: [Benchmark temperature increases will be coming FAST](#)**
4. **IMPACTS: [will greatly amplify with more and more heating](#)**
5. **OUR DIRECTION: [Global Societal Disruption is very possible by 2050-2070](#)**
6. **ACTIONS: [How can we change our trajectory to reduce the impacts?](#)**

I encourage you to spend time with the graphics and what they imply. They are the product of tens of thousands of researchers doing their best to sort out the realities of the science and our situation. Finally, I can be contacted at: maclankford.climate@gmail.com.

The Message	The SCIENCE	References
1. We are already in a dangerous situation - serious impacts are obvious now		
1.1 The Planet is Dramatically Heating	Global Mean Temperature (12-month moving average) 12-month moving average of Berkeley Earth global mean temperature time series and its associated 95% uncertainty. 30-year LOESS smooth also shown to indicate long-term trend. Anomalies relative to 1850-1900 average. 	June 2025 Temperature Update - Berkeley Earth
1.2 The temperature increase is accelerating		Global warming in the pipeline Oxford Open Climate Change RealClimate: Much ado about acceleration  NEW RESE... https://assets-eu.researchsquare.com/files/rs-6079807/v1_covered_209e5182-d9a5-4305-a4e0-70204151d2b3.pdf (not yet peer reviewed)

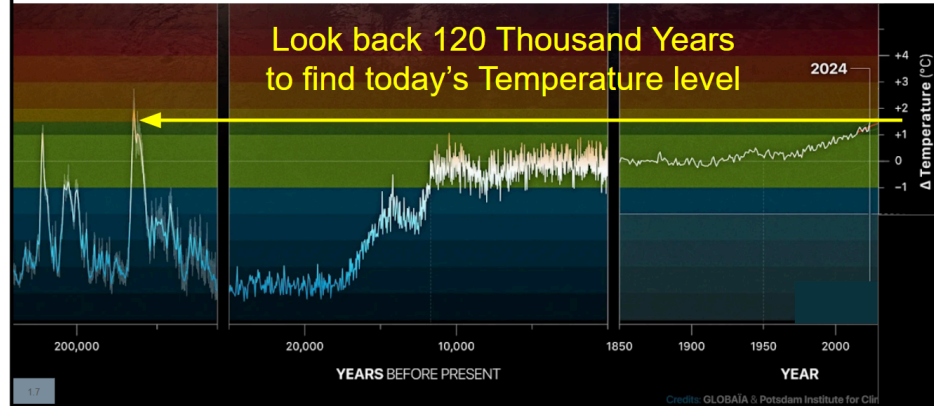
1.2.1		The World Is Warming Up. And It's Happening Faster.
1.3 Greenhouse gases in the Atmosphere have dramatically increased	 Greenhouse gases are primarily from burning fossil fuels. Atmospheric levels will continue to increase as long as emissions continue - even if emissions are decreased - because it takes centuries for the existing concentrations to naturally diminish.	Greenhouse gas emissions - Our World in Data After more than a decade of little change, U.S. electricity consumption is rising again - U.S. Energy Information Administration (EIA) Atmospheric greenhouse gas concentrations European Environment Agency's home page
1.4 Global Warming is a direct result of human-produced greenhouse gases		Greenhouse gas emissions - Our World in Data Atmospheric greenhouse gas concentrations European Environment Agency's home page Intergovernmental Panel of Climate Change: Figure AR6 WG2

1.5 This Warming is NOT “Natural”	2020 Years of Global Temperature 	This is NOT natural Open Mind Florida Climate Center Climate Change
1.6 CO₂ levels now are higher than the last 14 million years.	CO₂ Levels are the highest in 14 Million Years The last time we had this much CO₂ in the atmosphere, global temperatures were 5-10 degrees Fahrenheit higher and the sea level was approximately 75 to 120 feet higher than today. 	NOAA Climate.gov: Climate change: atmospheric carbon dioxide Evidence - NASA Science A New 66 Million-Year History of Carbon Dioxide Offers Little Comfort for Today Toward a Cenozoic history of atmospheric CO₂ Science Evidence - NASA Science

1.7

The Planet is now hotter than it has been for 120,000 years, and can be expected to go much higher

With CO₂ Levels the highest in 14 Million Years, the Planet's Temperature is also Rising - and Rising Fast!



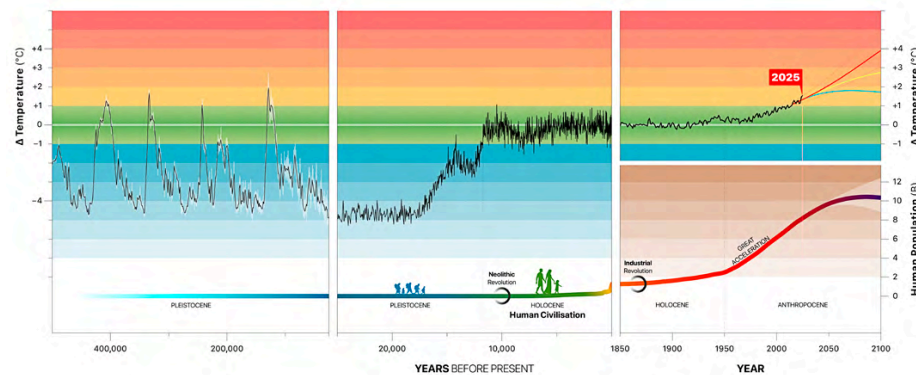
[Orbital and Millennial Antarctic Climate Variability over the Past 800,000 Years | Science](#)

[Planetary Health Check — Globaia](#)

[Analysis: Is it actually hotter now than any time in the last 100,000 years? | PBS News](#)

[World Of Change](#)

1.7.1



[Planetary Health Check 2025](#)

1.7.2

The Great Acceleration

Socio-Economic Trends Since 1750

Earth System Trends Since 1750

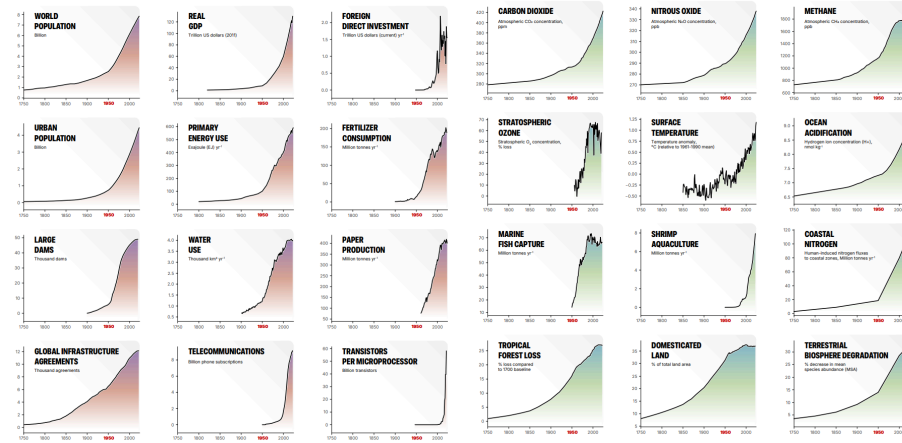


FIGURE 6 - The Great Acceleration - Recent dramatic trends in the Earth system. This updated figure extends the original "Great Acceleration" analysis by Steffen et al. (2015) with new data up to 2024, incorporating new datasets and, in some cases, revised or additional indicators for a list of data sources, see [Supplementary Materials](#). The left-hand side shows the exponential growth in socio-economic drivers such as population, GDP, and energy use. The right-hand side illustrates corresponding Earth system responses, including atmospheric CO₂ levels, global temperature, ocean acidification, and biodiversity decline. These coupled trends, which accelerated markedly after 1950, signify the onset of the Anthropocene and highlight the intensifying

pressure humans place on planetary systems. Updating these trajectories reinforces the urgency of remaining within the Planetary Boundaries to safeguard Earth's resilience. Although a few indicators (such as marine fish capture, domesticated land, and stratospheric ozone depletion) show signs of flattening or recovery, most trends continue to rise steeply, underscoring the intensifying human pressure on planetary systems. These coupled trajectories define the post-1950 onset of the Anthropocene and reinforce the urgency of respecting the Planetary Boundaries to protect Earth's resilience.

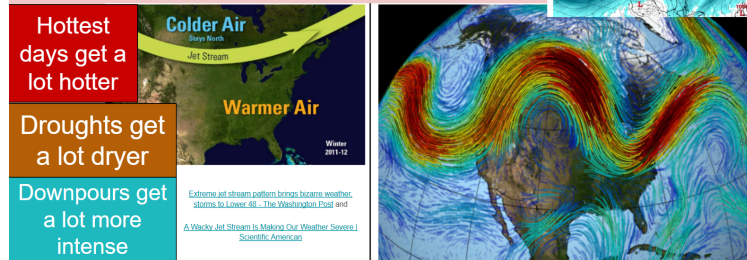
[Planetary Health Check 2025](#)

1.8

Increasingly Erratic and Intensifying Weather has already started

• Globally - Increasingly Erratic and Intensifying Weather has already started

With Warming, the poles warm faster than the equator, weakening the POLAR VORTEX allowing large kinks to develop in the jet stream bringing radically changing weather.

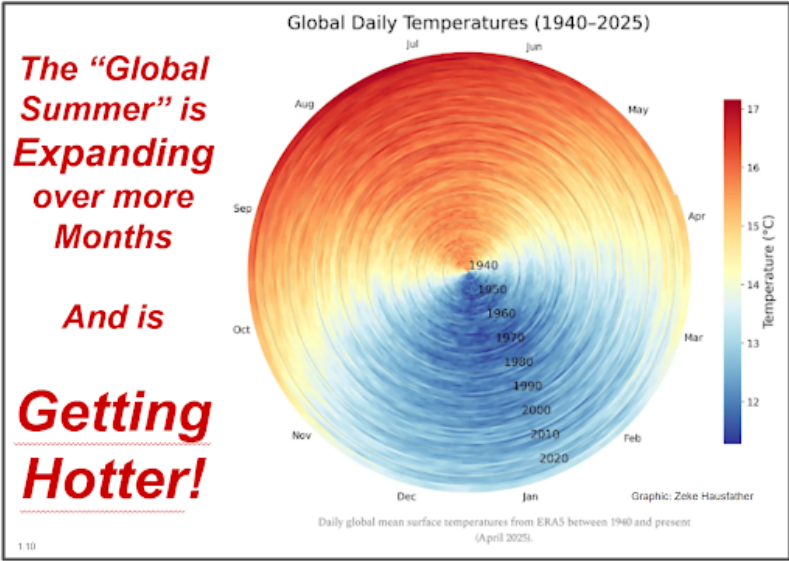
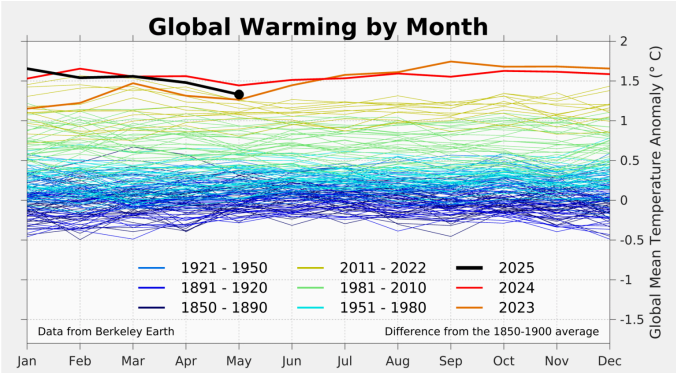


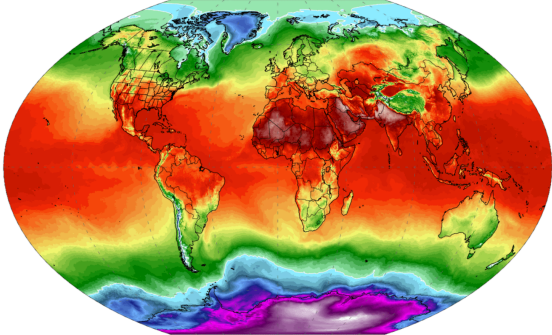
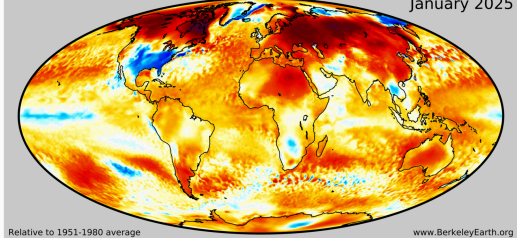
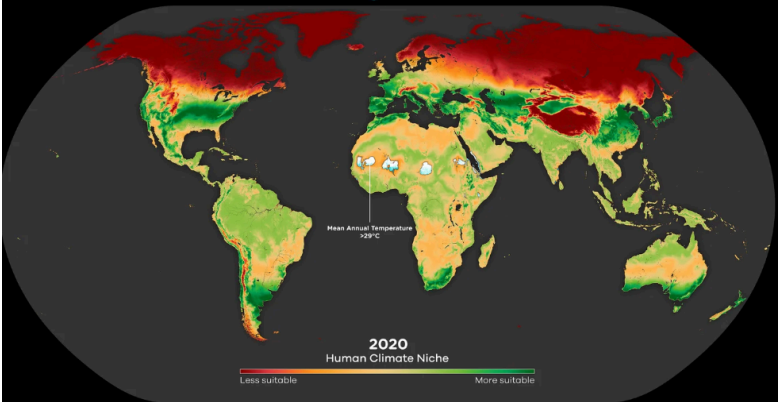
More powerful tropical storms, tornadoes, and thunderstorms, and thus more extreme floods, are driven by high sea surface temperature and a warmer atmosphere that holds more water vapor. Higher global temperature also increases the intensity of heat waves and – at the times and places of dry weather – high temperature increases drought intensity, including “flash droughts” that develop rapidly, even in regions with adequate average rainfall.

[A Wacky Jet Stream Is Making Our Weather Severe | Scientific American](#)

[Extreme jet stream pattern brings bizarre weather, storms to Lower 48 - The Washington Post](#)

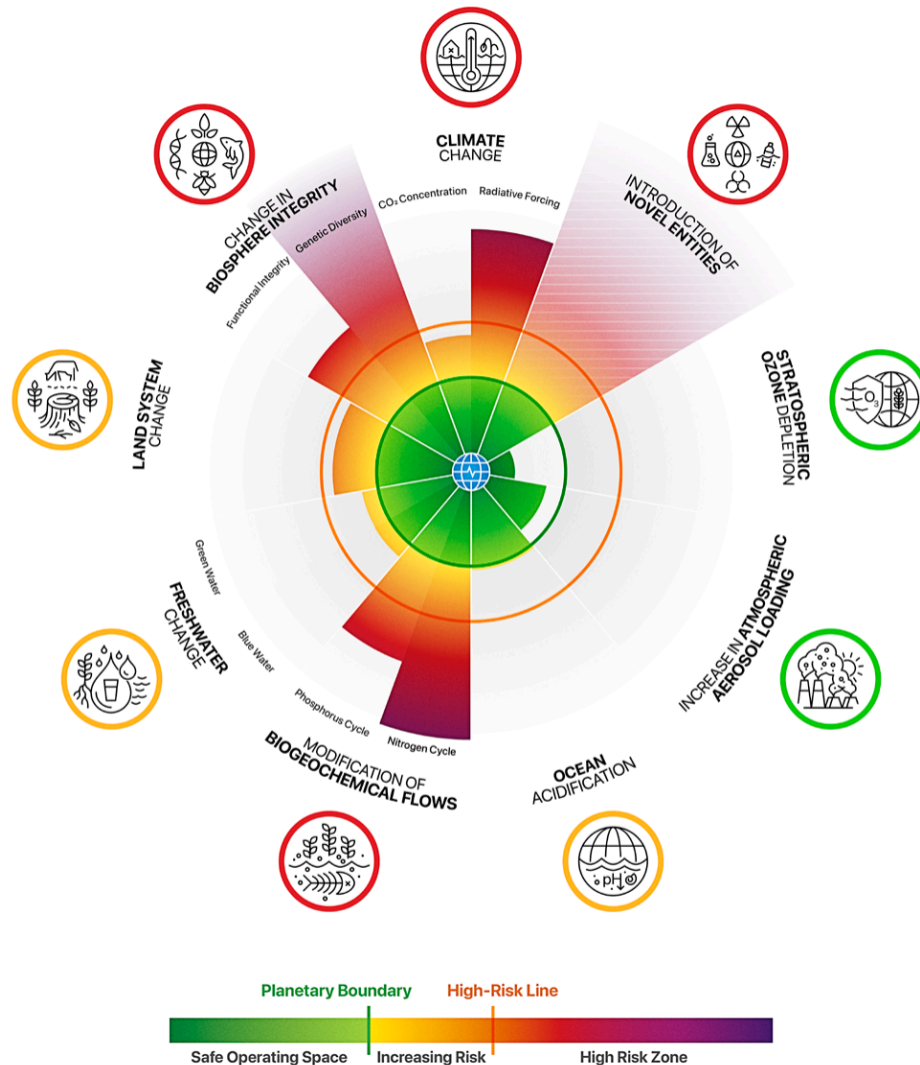
<https://acp.copernicus.org/articles/16/3761/2016/acp-16-3761-2016.html>

1.9 Rising Sea Levels and Extreme Sea Level Events have Already Started	● Rising Sea Levels and Extreme Sea Level Events have Already Started We are currently close to the “Very High” trajectory shown below.  3+ Feet Possible this century without Tipping Points By 2050, 1 billion people exposed Extreme sea level events (100-year return period) will occur 20-30 times more frequent Sea level rise greater than 15m cannot be ruled out with very high emissions Feet 50 Observed 2050 2100 2150 2300 Climate Change 2023 Synthesis Report p.40	Intergovernmental Panel of Climate Change: Climate Change 2023 Synthesis Report p.46 US Fifth National Climate Assessment
1.10 Globally, warmer temperatures have expanded to cover more of the year	The “Global Summer” is Expanding over more Months And is Getting Hotter!  Global Daily Temperatures (1940-2025) 1940 1950 1960 1970 1980 1990 2000 2010 2020 2025 Temperature (°C) 17 16 15 14 13 12 Graphic: Zeke Hausfather Daily global mean surface temperatures from ERA5 between 1940 and present (April 2025). 1.10	Zeke Hausfather https://substack.com/home/post/p-162499826 World of Change: Global Temperatures
1.11 Global temperatures have moved into a new, unprecedented regime	Global Warming by Month  Global Mean Temperature Anomaly (°C) 2 1.5 1 0.5 0 -0.5 -1 -1.5 Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec 1921 - 1950 1891 - 1920 1850 - 1890 2011 - 2022 1981 - 2010 1951 - 1980 2025 2024 2023 Data from Berkeley Earth Difference from the 1850-1900 average	https://berkeleyearth.org/may-2025-temperature-update/

1.12 The equatorial regions are heating fast.	GFS 2m Temperature (°C) 1-day Avg Fri, Jun 13, 2025 ClimateReanalyzer.org Climate Change Institute University of Miami  -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 Species that can, like many fish and whales, are migrating towards the poles	Blue whales go quiet off California after marine heat wave Audible changes in marine trophic ecology: Baleen whale song tracks foraging conditions in the eastern North Pacific PLOS One Today's Weather Maps
1.13 The polar regions are heating even faster, with respect to their average	January 2025  Relative to 1951-1980 average www.BerkeleyEarth.org -10 -5 -2 -1 -0.5 0 0.5 1 2 5 10 Temperature Anomaly (°C) Because of loss of ice and its reflectivity, the north polar region absorbs a greater amount of sunlight in the summer, making its winter much warmer than ever - which also increases ice cap and ice sheet melting	January 2025 Temperature Update - Berkeley Earth
1.14 Already, 600 million people are suffering in regions outside of the human climate niche (white areas), vs. 12 million in the 1960-1990 period	The “human climate niche” refers to the range of temperatures where humans have traditionally lived. GLOBE.A.I.A.  Mean Annual Temperature >24°C 2020 Human Climate Niche Less suitable More suitable Future of the human climate niche, Chi Xu, Timothy A. Kohler, Timothy M. Lenton, Jens Christian Svenning, Martin Scheffer Proceedings of the National Academy of Sciences, May 2020, 2019 10114, DOI: 10.1073/pnas.1910141117	Quantifying the human cost of global warming Nature Sustainability Human Climate Niches — GLOBE.A.I.A.

1.15

Climate Change itself is only one symptom of destructive societal habits. Seven out of the nine Planetary Boundary (PB) processes have gone into the High Risk Zone



This is a clear departure from the conditions in which humans and the biosphere have thrived for the past 10,000 years or so. This breach indicates significant environmental stress and the potential for irreversible changes.

[Planetary Health Check 2025](#)

[Planetary Boundaries Science \(PBScience\) Lab](#)

<https://globalia.org/p/hc>

[planetaryhealthcheck2024_report.pdf](#)

1.15.1

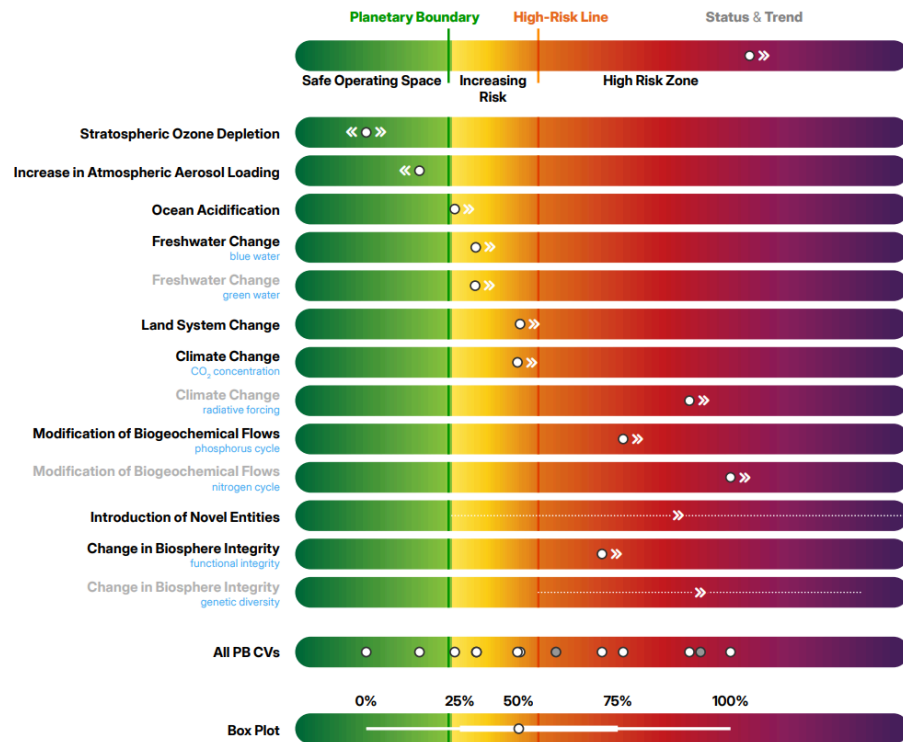


FIGURE ES 1 - Planetary Health at a glance. Just as a blood test provides insights into a human body's health and identifies areas of concern, this Planetary Health Check evaluates the 13 measured control variables across the 9 Planetary Boundary (PB) processes to report on Earth's stability, resilience, and life-support functions – the overall health of our planet. The 2025 assessment shows that seven of the nine PBs have been breached: **Climate Change**, **Change in Biosphere Integrity**, **Land System Change**, **Freshwater Change**, **Modification of Biogeochemical Flows**, **Introduction of Novel Entities**, and **Ocean Acidification**. All of these show increasing trends, suggesting further deterioration in the near future. Two PB processes remain within the Safe Operating Space: **Increase in Atmospheric Aerosol Loading** (improving global trend) and **Stratospheric Ozone Depletion** (currently stable). The Planetary Health Check Symbol (Fig. ES 2) summarizes all of these findings, showing the Planet's overall health at a glance.

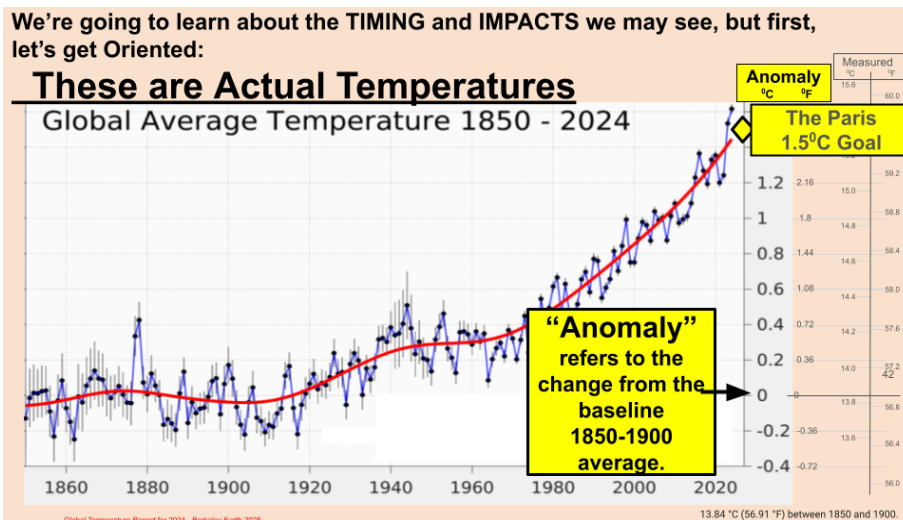
[Planetary Health Check 2025](https://www.planetaryhealthcheck.org/wp-content/uploads/PlanetaryHealthCheck2025_ExecutiveSummary.pdf)

https://www.planetaryhealthcheck.org/wp-content/uploads/PlanetaryHealthCheck2025_ExecutiveSummary.pdf

1.16

It is likely that we will pass the 1.5°C goal set forth in the Paris agreement before 2030

(We have passed it for one year; it will take multiple years above 1.5 °C to confirm this as a climate change of this magnitude)



[Human-Induced and Observed Global Warming, and Trajectory: Insights, Data, Charts: ClimateChangeTraacker.org](https://climatechange.traacker.org/)

[Copernicus: 2024 is the first year to exceed 1.5°C above pre-industrial level.](https://climatechange.traacker.org/)

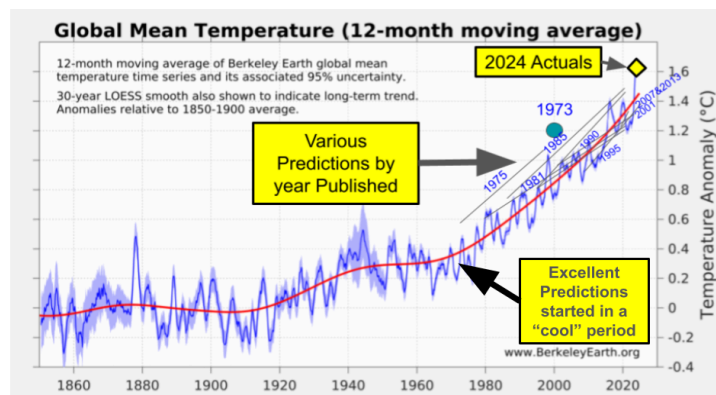
2. Fundamental Climate Science has been well established for many decades, making predictions credible

Projections into the Future are now far more complex and use differing strategies and scenarios, and increasing understanding of uncertainties through research. This results in ranges and uncertainties - but the underlying messages are the same.

2.1

Fundamental climate science has been well understood for many decades.

Predictions about global temperatures have been **amazingly accurate since 1973** - even before clear signs of warming had been observed.



<https://berkeleyearth.org/august-2025-temperature-update/>

Analysis: How well have climate models projected global warming? - Carbon Brief 2017

5 forecasts early climate models got right – the evidence is all around you

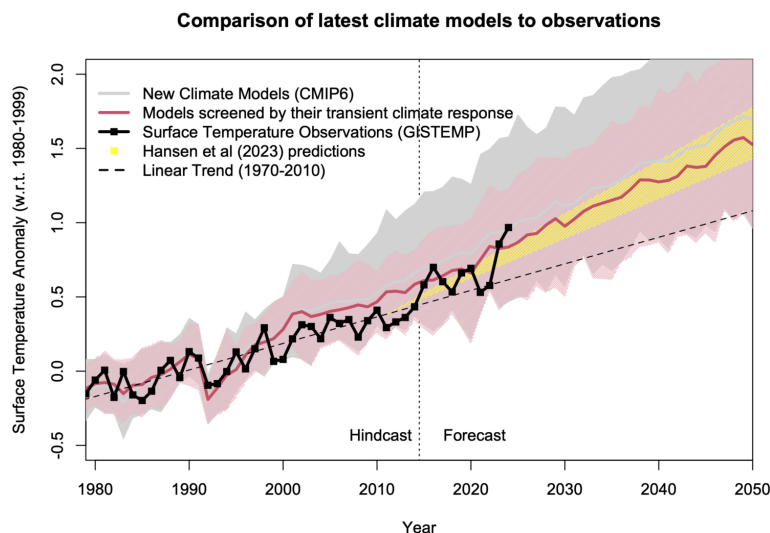
IPCC global surface warming projections have been accurate

2.1.1		https://berkeleyearth.org/august-2025-temperature-update/ Analysis: How well have climate models projected global warming? - Carbon Brief 2017 5 forecasts early climate models got right – the evidence is all around you IPCC global surface warming projections have been accurate Assessing ExxonMobil's global warming projections Science Exxon scientists predicted global warming with 'shocking skill and accuracy,' Harvard researchers say
2.2 More complex modern models deliver a wider range of possibilities. This is NOT a flaw, but is science in action.	Subtle effects of particles (aerosols) and their influence on reflective clouds as well as the complex flows of currents at various depths in the ocean are examples of the efforts to include highly complex features into the models. The most crucial areas of ongoing research are how and how quickly the planet might change, adjust to, and warm with higher levels of greenhouse gases and net incoming solar energy.	Evolution of climate models used in IPCC assessment reports showing how...

3. On our current trajectory, benchmark temperature increases (1.5, 2.0, 3.0 °C, etc. above pre-industrial) will be coming FAST

3.1

Extension of the observed acceleration of warming in recent decades is consistent with model predictions.

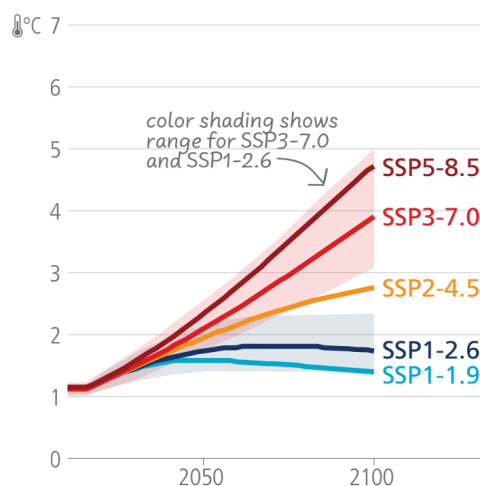


[RealClimate: Much ado about acceleration](#)

[Global warming in the pipeline | Oxford Open Climate Change](#)

3.2

In its latest report in 2023, the IPCC assessed the likely timing of temperature increases for various scenarios.

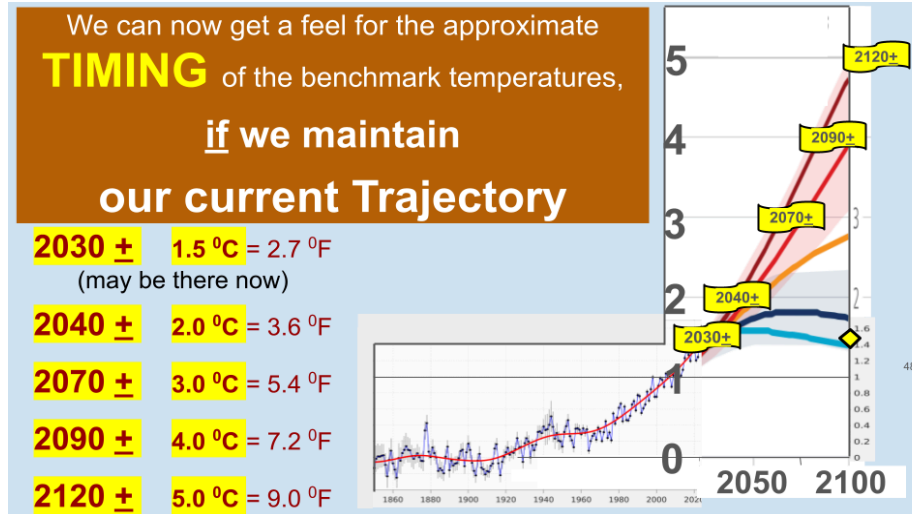


This depiction shows the pink-shaded range for case SSP3-7.0, which was not the worst case considered. Many hope that the SSP2-4.5 case might be achieved, with its upper range closer to 3-4 °C by 2100, but there is much evidence that, with human behaviors and evidence from prehistoric climates, it is more reasonable to expect higher temperatures.

[IPCC Climate Change 2023 Synthesis Report p65](#)

3.3 We are already trending above IPCC 2020 projections, which may be consistent with observations of accelerating warming.	So what kind of PREDICTIONS are <u>now</u> being made? Without going into detail, the Intergovernmental Panel on Climate Change (IPCC) coordinates and synthesizes research worldwide. A wide range of cases are analyzed, with major differences in structures and in assumptions. These 2020 projections are dominated by fossil fuels burned and GHGs emitted into the atmosphere. CMIP6: the next generation of climate models explained - Carbon Brief These “Shared Socio-economic Pathways” (SSPs) bracket how temperatures may be impacted this century. We averaged over 1.5°C last year. color shading shows range for SSP3-7.0 and SSP1-2.6 2024 Actuals are above predictions from 2020 SSP5-8.5 SSP3-7.0 SSP2-4.5 SSP1-2.6 SSP1-1.9 2050 2100	IPCC Climate Change 2023 Synthesis Report p65 Explainer: How ‘Shared Socioeconomic Pathways’ explore future climate change - Carbon Brief CMIP6: the next generation of climate models explained - Carbon Brief Copernicus: 2024 is the first year to exceed 1.5°C above pre-industrial level.
3.4 Our current trajectory implies we must act as if major temperature increases will come quickly	Let's put these two charts together Possible Futures ACTUAL TEMPS TO DATE Our Current Trajectory could be at the high end of cases researched Putting this IPCC projection range together with the Actual temperature record and the accelerating warming we are experiencing and projecting in models, we can get a handle on WHEN various temperature increases may happen.	IPCC Climate Change 2023 Synthesis Report p65 RealClimate: Much ado about acceleration

3.5
Given our
current
behaviors (as
opposed to
policies - see
3.7, below) and
how the planet
is responding,
we could hit
2.0°C by around
2040 and 3.0 °C
by as early as
2070

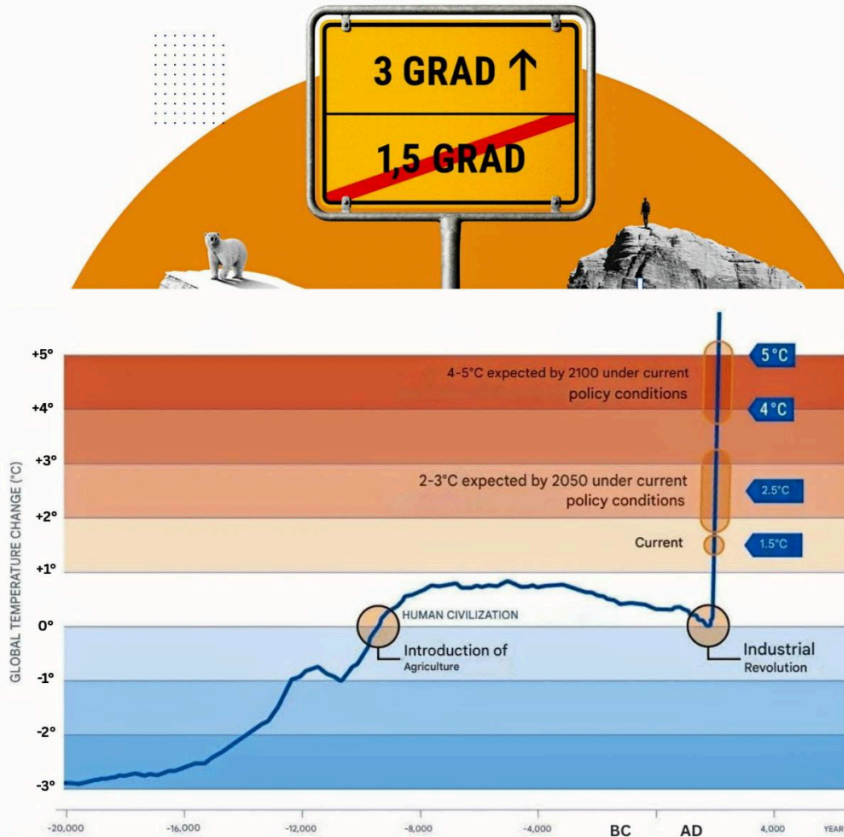


[IPCC Climate
Change 2023
Synthesis Report
p65](#)

[RealClimate: Much
ado about
acceleration](#)

3.5.1

Global warming is accelerating - A call for decisive action



© DPG / Gehlen 2025

The temperate climate of the last 10 millennia has created the conditions for the development of human civilizations. The current generation of young people must be aware of the fact that they may witness the end of these temperate environmental conditions with all their consequences.

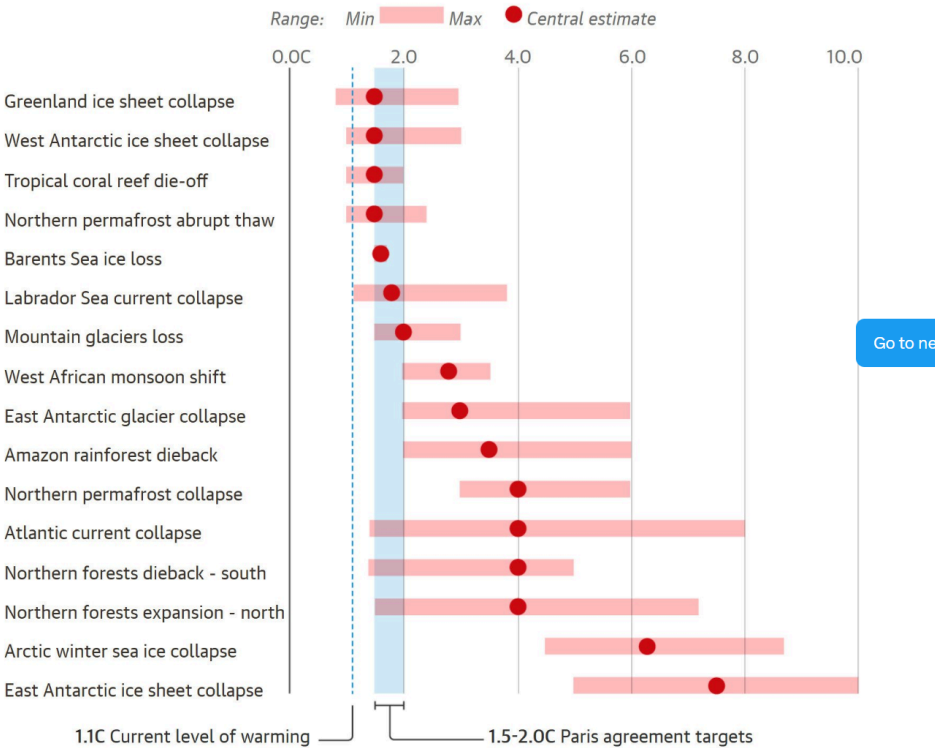


https://www.dpg-physik.de/veroeffentlichungen/publikationen/stellungnahmen-der-dpg/klima-energie/klimaaufruf?set_language=en

<https://x.com/LeonSimons8/status/1971223899040842152>

The risk of climate tipping points is rising rapidly as the world heats up

Estimated range of global heating needed to pass tipping point temperature

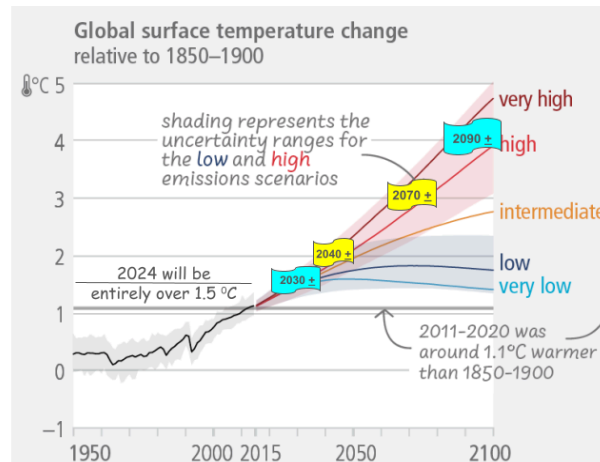


Guardian graphic. Source: Armstrong McKay et al, Science, 2022. Note: Current global heating temperature rise 1.1C Paris agreement targets 1.5-2.0C

Rating	Financial impact	Non-financial impact			
	GDP losses	Human mortality	Climate	Nature	Societal
Extreme	≥50%	≥50% > 4 billion deaths	3°C or more by 2050. Multiple climate tipping points triggered, tipping cascade.	Breakdown of several critical ecosystem services and Earth systems. High level of extinction of higher order life on Earth.	Significant socio-political fragmentation worldwide and/or state failure with rapid, enduring, and significant loss of capital and systems identity. Frequent large scale mortality events.
Catastrophic	≥25%	≥25% >2 billion deaths	2°C or more by 2050. High number of climate tipping points triggered, partial tipping cascade.	Breakdown of some critical ecosystem services and Earth systems. Major extinction events in multiple geographies. Ocean circulation severely impacted.	Severe socio-political fragmentation in many regions, low lying regions lost. Heat and water stress drive involuntary mass migration of billions. Catastrophic mortality events from disease, malnutrition, thirst and conflict.

3.6

Here's a closer look at the same information. Again, these timing projections are based on actual emission rates and the observed responses of the planet.



[IPCC CLIMATE CHANGE 2023](#)
p17

[CMIP6: the next generation of climate models explained - Carbon Brief](#)

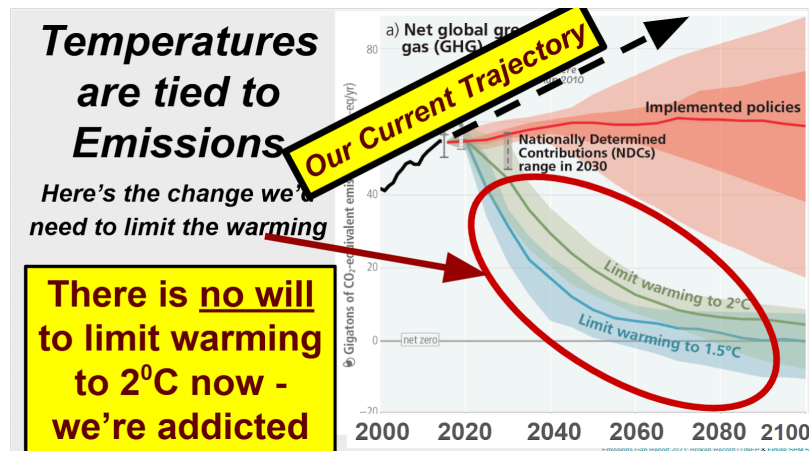
[CO₂ and Greenhouse Gas Emissions - Our World in Data](#)

[New report has terrific news for the climate](#)

3.7

Limiting warming to 2 °C would require cutting global emissions in half within 15 years.

This WILL NOT happen without a massive shift in political will. Even stated policies are not anywhere near enough.



[Emissions Gap Report 2023: Broken Record | UNEP & Figure SPM.5](#)

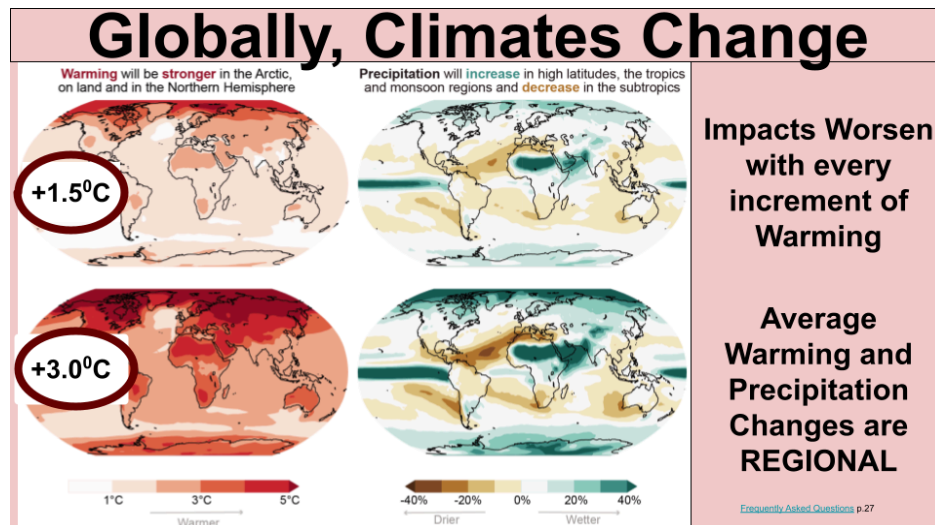
[IPCC CLIMATE CHANGE 2023](#)
p22

[IPCC: Climate Change 2023 Synthesis Report](#)
p59

4. Impacts on Climates will greatly amplify with more and more heating

4.1

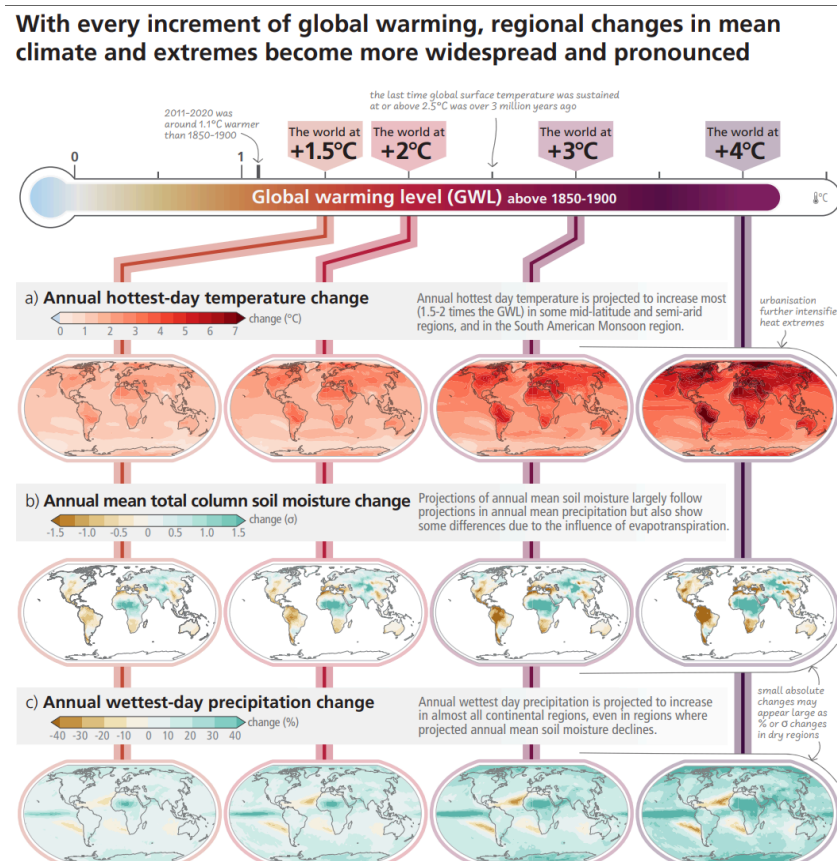
Climate changes are highly regional in nature and worsen with every increment of warming.



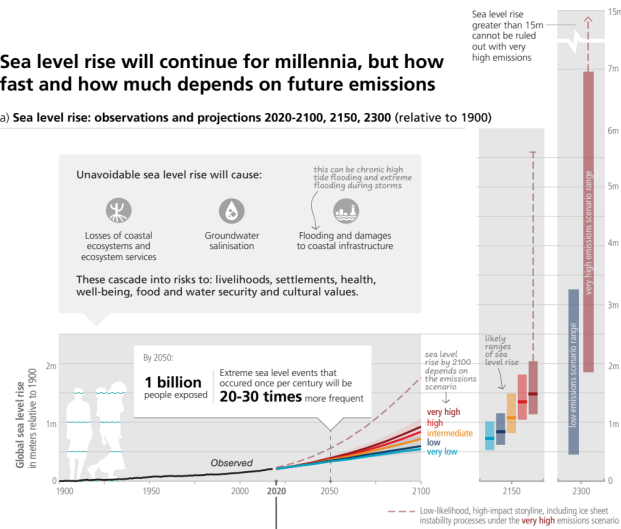
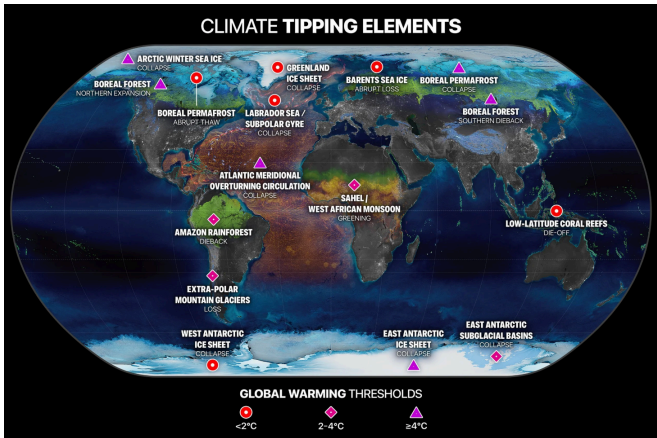
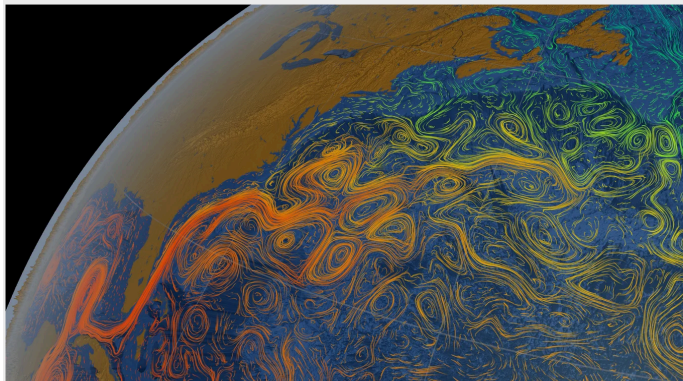
Intergovernmental Panel on Climate Change: [Frequently Asked Questions](#) p.27

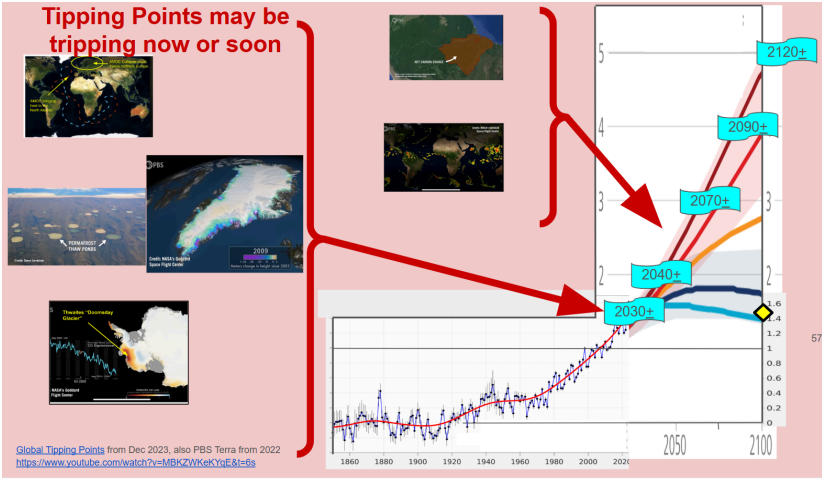
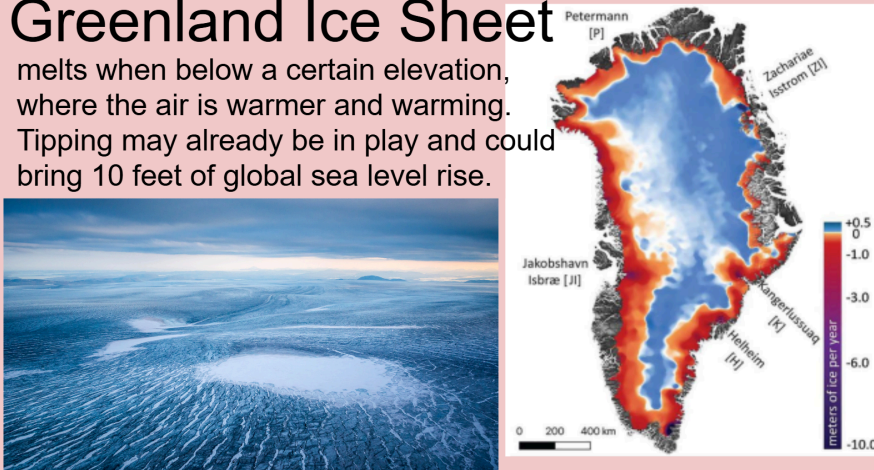
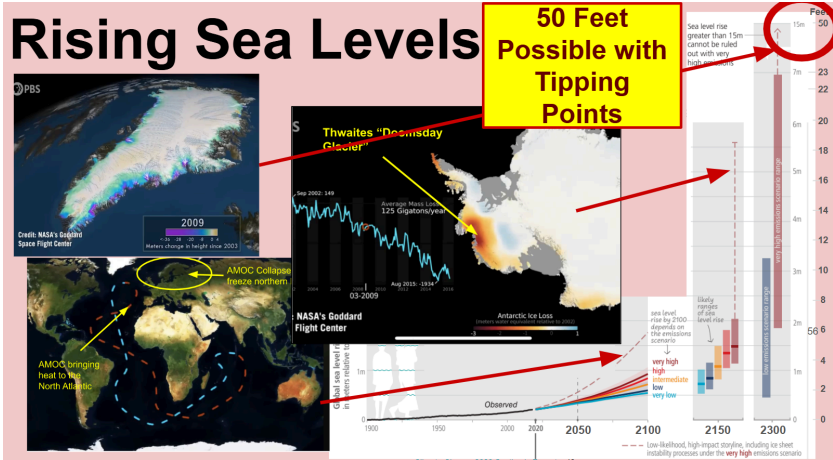
4.2

Weather extremes will also strongly worsen



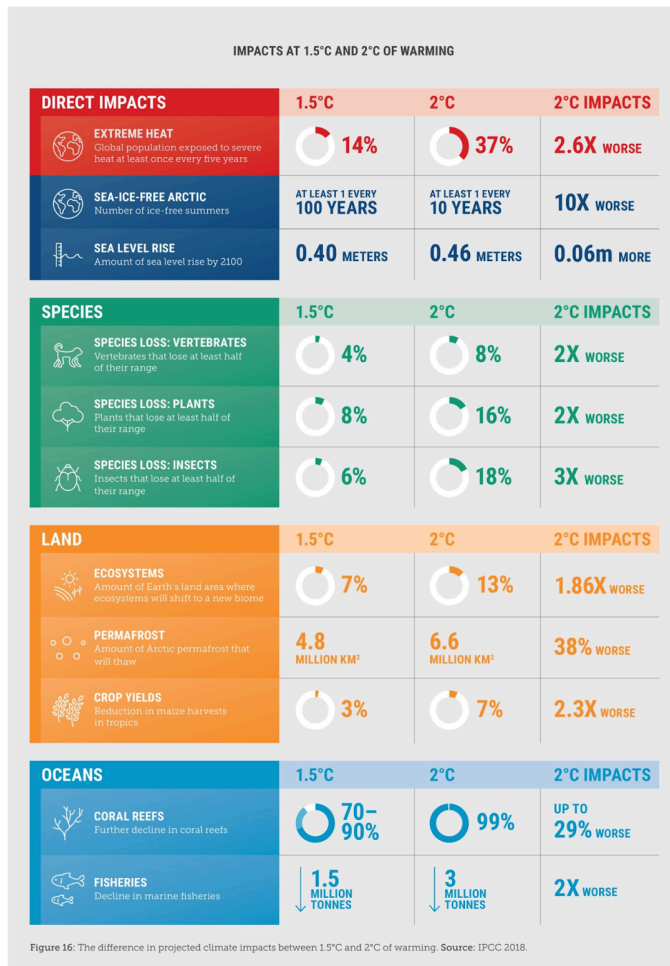
IPCC Climate Change 2023 Synthesis Report p70

4.3 Sea level rise will be more or less depending on emissions. Some estimates, based on pre-historic global data, point toward even higher (over 10') rise this century	Sea level rise will continue for millennia, but how fast and how much depends on future emissions a) Sea level rise: observations and projections 2020-2100, 2150, 2300 (relative to 1900)  Unavoidable sea level rise will cause: - Losses of coastal ecosystems and ecosystem services - Groundwater salinisation - Flooding and damages to coastal infrastructure These cascade into risks to: livelihoods, settlements, health, well-being, food and water security and cultural values. By 2050: 1 billion people exposed Extreme sea level events that occurred once per century will be 20-30 times more frequent Sea level rise greater than 15m cannot be ruled out with very high emissions Global sea level rise in meters relative to 1900 Observed By 2050 By 2100 By 2150 By 2300 Very low Low Intermediate High Very high Low emissions scenario range High emissions scenario range likely ranges of sea level rise depends on the emissions scenario Low likelihood, high-impact storyline, including ice sheet instability processes under the very high emissions scenario	IPCC ClimateChange 2023 Synthesis Report p80 ACP - Ice melt, sea level rise and superstorms: evidence from paleoclimate data, climate modeling, and modern observations that 2 °C global warming could be dangerous
4.4 Exceeding 1.5°C global warming could trigger multiple and compounding climate tipping points... ..and we're already there	CLIMATE TIPPING ELEMENTS  GLOBAL WARMING THRESHOLDS <2°C 2-4°C ≥4°C CLIMATE TIPPING ELEMENTS - ARCTIC WINTER SEA ICE COLLAPSE - BOREAL FOREST NORTHERN EXPANSION - BOREAL PERMAFROST THAW - LABRADOR SEA / SUBPOLAR OYCE COLLAPSE - ATLANTIC MERIDIONAL OVERTURNING CIRCULATION COLLAPSE - SAHEL / WEST AFRICAN MONSOON WEAKENING - AMAZON RAINFOREST DIEBACK - EXTRA-POLAR MOUNTAIN GLACIERS LOSS - WEST ANTARCTIC ICE SHEET COLLAPSE - EAST ANTARCTIC ICE SHEET COLLAPSE - EAST ANTARCTIC SUBGLACIAL BASINS COLLAPSE - LOW-LATITUDE CORAL REEFS DEATH - BAIKAL SEA ICE WEAKENING - BOREAL PERMAFROST COLLAPSE - BOREAL FOREST SOUTHERN DIEBACK - GREENLAND ICE SHEET COLLAPSE	Planetary Tipping Systems — Globalia Exceeding 1.5°C global warming could trigger multiple climate tipping points Science Exceeding 1.5°C global warming could trigger multiple climate tipping points – paper explainer New Research Led by James Hansen Documents Global Warming Acceleration - Inside Climate News Global Warming Has Accelerated: Are the United Nations and the Public Well-Informed?
4.5 Even a 2 °C temperature rise could be disastrous if it disrupts the Atlantic Meridional Overturning Circulation (AMOC)	 Part of a NASA visualization of the Gulf Stream, showing surface temperatures and flow patterns. New research suggests the AMOC could collapse sooner than expected. NASA/Goddard Space Flight Center Scientific Visualization Studio	ACP - Ice melt, sea level rise and superstorms: evidence from paleoclimate data, climate modeling, and modern observations that 2 °C global warming could be dangerous AMOC: Atlantic current collapse 'closer than we think' - Oceanographic Is A Mega Ocean Current About to Shut Down? Scientific American Warning of a forthcoming collapse of the Atlantic meridional overturning circulation Nature Communications

4.6 Other tipping points appear to be near. These could dramatically amplify the climate changes due to direct warming of the planet.	 Global Tipping Points from Dec 2023, also PBS Terra from 2022 https://www.youtube.com/watch?v=1BKCZWkKYoE&list=PL	Global Tipping Points from Dec 2023, also PBS Terra from 2022 Scientists issue warning on 'unstoppable' phenomenon that could have global impact: 'Catastrophic consequences' Earth Nears Irreversible Climate Tipping Points Weather.com High probability of triggering climate tipping points under current policies modestly amplified by Amazon dieback and permafrost thaw
4.7 Tipping Points occur when the change becomes irreversible on human timescales.	Greenland Ice Sheet melts when below a certain elevation, where the air is warmer and warming. Tipping may already be in play and could bring 10 feet of global sea level rise. 	IPCC Frequently Asked Questions p.27 Global Tipping Points from Dec 2023, also PBS Terra from 2022 ▶ What Will Ea... ▶ Earth is Rapi...
4.8 With Tipping Points which may already be in play, we could get 10 feet of sea level rise this century.	Rising Sea Levels 50 Feet Possible with Tipping Points 	Intergovernmental Panel on Climate Change: Climate Change 2023 Synthesis Report p.46 ▶ Earth is Rapi...

4.9

Impacts at 2deg C



[Interactive: The impacts of climate change at 1.5C, 2C and beyond | Carbon Brief](#)

[What Happens When We Cross the 2°C Temperature Limit? - Climate Adaptation Platform.](#)

[1.5 or 2 degrees Celsius of additional global warming: Does it make a difference?](#)

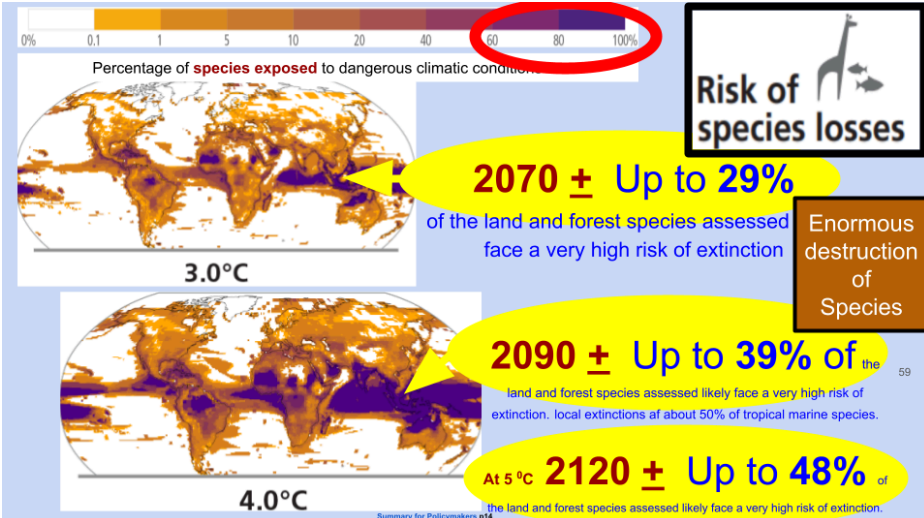
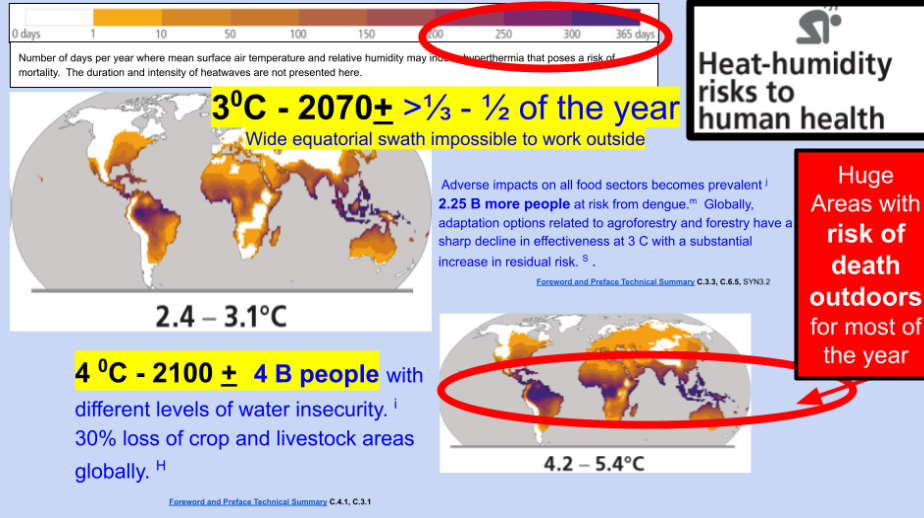
[Impacts at 1.5 and 2 degrees of warming | Climate Council](#)

4.10

Impacts at 3 deg C

[Comparing climate impacts at 1.5°C, 2°C, 3°C and 4°C.](#)

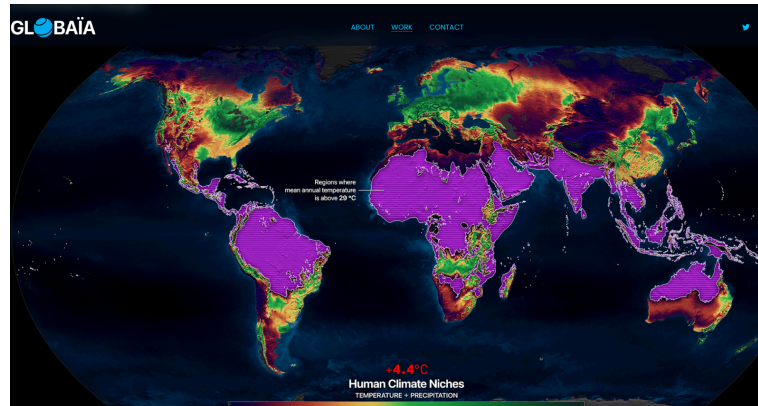
5. Global Societal Disruption is very possible by 2050-2070

5.1 Species loss will dramatically increase with global warming this century, particularly in the hottest equatorial regions.	Future climate change is projected to increase the severity of impacts across natural and human systems and will increase differences across regions.  2070 ± Up to 29% of the land and forest species assessed face a very high risk of extinction 2090 ± Up to 39% of the land and forest species assessed likely face a very high risk of extinction. local extinctions at about 50% of tropical marine species. At 5 °C 2120 ± Up to 48% of the land and forest species assessed likely face a very high risk of extinction. Species loss was evaluated for 30,652 species of birds, mammals, reptiles, amphibians, marine fish, benthic marine invertebrates, krill, cephalopods, corals, and seagrasses.	IPCC Climate Change 2023 Synthesis Report p73 Summary for Policymakers p14 Foreword and Preface Technical Summary SYN3.1.2
5.2 Humans will fare no better - note that the heat/humidity impacts are dire, particularly in the equatorial regions.	The darker colors depict regions with uninhabitable temperatures most of the year  3°C - 2070± >1/3 - 1/2 of the year Wide equatorial swath impossible to work outside 4 °C - 2100 ± 4 B people with different levels of water insecurity. ⁱ 30% loss of crop and livestock areas globally. ^H 4.2 – 5.4°C Huge Areas with risk of death outdoors for most of the year	IPCC Climate Change 2023 Synthesis Report p73 IPCC Foreword and Preface Technical Summary C.4.1, C.3.1 IPCC Foreword and Preface Technical Summary C.3.3, C.6.5, SYN3.2

5.3 Food production, of course, is impacted in the same way.	c) Food production impacts c1) Maize yield⁴ Changes (%) in yield c2) Fisheries yield⁵ Changes (%) in maximum catch potential 1.6 – 2.4°C 3.3 – 4.8°C 3.9 – 6.0°C 0.9 – 2.0°C 3.4 – 5.2°C ⁴Projected regional impacts reflect biophysical responses to changing temperature, precipitation, solar radiation, humidity, wind, and CO₂ enhancement of growth and water retention in currently cultivated areas. Models assume that irrigated areas are not water-limited. Models do not represent pests, diseases, future agro-technological changes and some extreme climate responses. ⁵Projected regional impacts reflect fisheries and marine ecosystem responses to ocean physical and biogeochemical conditions such as temperature, oxygen level and net primary production. Models do not represent changes in fishing activities and some extreme climatic conditions. Projected changes in the Arctic regions have low confidence due to uncertainties associated with modelling multiple interacting drivers and ecosystem responses. Areas with little or no production, or not assessed Areas with model disagreement	IPCC Climate Change 2023 Synthesis Report p 73
5.4 By around 2070, 3.5 BILLION of today's human population could be outside of the “human climate zone”, if they haven't already migrated.	2070 Human Climate Niche Future of the human climate niche, Chi Xu, Timothy A. Kohler, Timothy M. Lenton, Jens-Christian Svenning, Morten Scheffler Proceedings of the National Academy of Sciences, May 2020, 2019 10114; DOI: 10.1073/pnas.1910141117 The white depicts regions outside of the “human climate zone”; blue shading on the white is proportional to population density in those regions. Note that heavily populated India, Southeast Asia, and Malaysia, etc. are included.	Quantifying the human cost of global warming Nature Sustainability Human Climate Niches — Globaia Future of the human climate niche PNAS
5.4.1		

5.5

By 2100, or around 4.4°C increase, the human climate zone will have changed enormously.



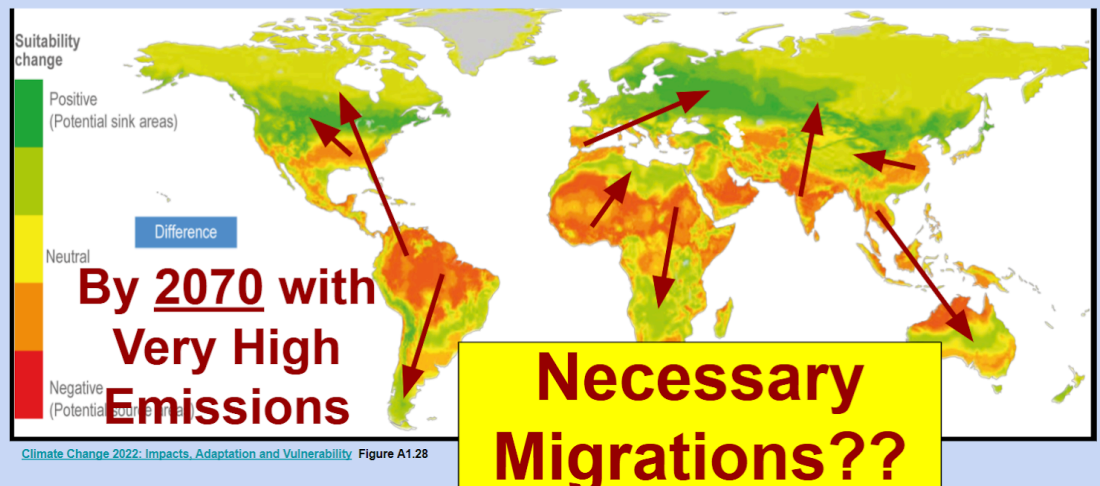
[Human Climate Niches — Globalia](#)

5.6

Global Societal Disruption is likely by 2050-2070, if we stay on our current course!

Projected **shift of human temperature niche**

For millennia, human populations have resided in the same narrow part of the climatic envelope available on the globe, characterized by a major mode around 11°C to 15°C mean annual temperature. Map shows the projected geographical shift of this temperature niche.



IPCC: [Climate Change 2022: Impacts, Adaptation and Vulnerability](#) Figure A1.28

5.6.1

So unless we change course, we're looking at a rapid warming over the 21st century. Most climate scientists agree that a 2°C warming is the 'danger limit'. Figure 5 shows temperature rise for a given CO₂ level. The dark grey area indicates the climate sensitivity likely range of 2 to 4.5°C.

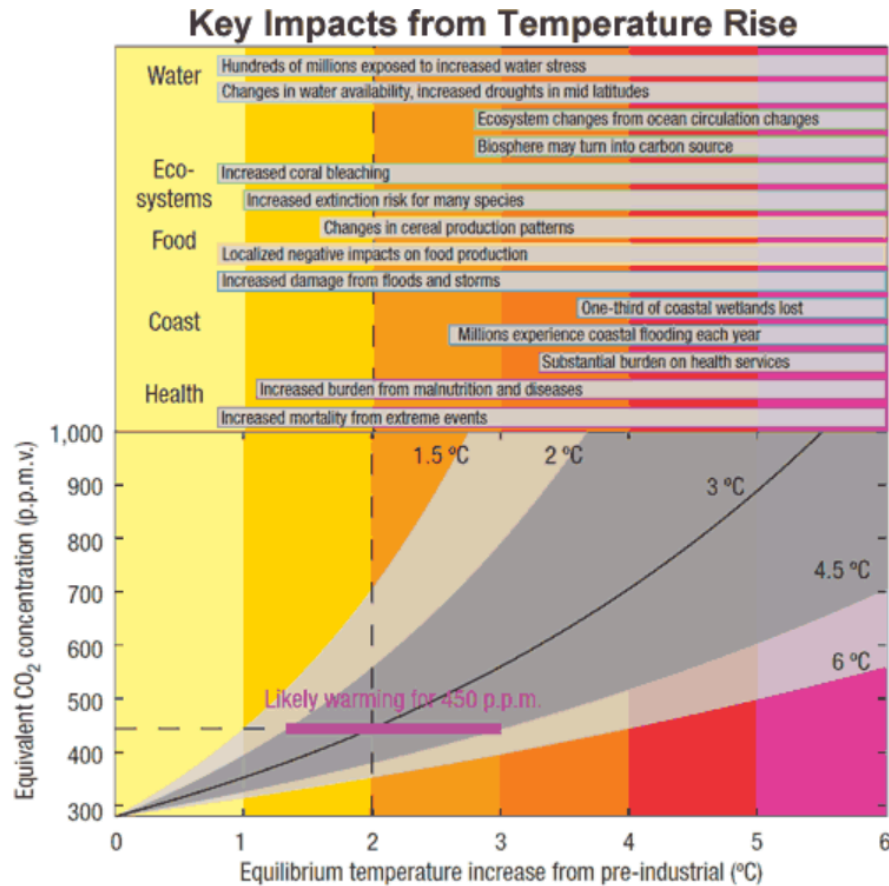


Figure 6: Relation between atmospheric CO₂ concentration and key impacts associated with equilibrium global temperature increase. The most likely warming is indicated for climate sensitivity 3°C (black solid). The likely range (dark grey) is for the climate sensitivity range 2 to 4.5°C. Selected key impacts (some delayed) for several sectors and different temperatures are indicated in the top part of the figure (Knutti and Hegerl 2008)

<https://skepticalscience.com/climate-sensitivity-advanced.htm>

5.7

This is where we may well be headed, given the scientific projections of warming timing and impacts, with our current behaviors.

My Conclusions concerning **IMPACTS**

- At our current trajectory, by **2040 - 2070** we must expect **dramatic extinctions** and **uninhabitable regions**
- **Global-scale migrations** (people and species) could not be prevented

65

6. What Actions could reduce the impacts to below 3°C?

6.1

**STOPPING
EMISSIONS is
NECESSARY,
even with other
strategies**

Build Political Will

End emissions

Take carbon out of the air

Solar radiation modification

Local Adaptation
