

Climate Science:

Reasons to Trust the Science and What it's Predicting

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Let's get a handle on what our Climate situation is likely to be in the coming decades, given the path we are on...

1. **TRUST (OR NOT) THE SCIENCE**
2. **TIMING** - of **TEMPERATURE** increases
3. **IMPACTS** - **CLIMATE** and **SOCIETAL**
4. **Personal Perspectives** - mine and yours...

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1. **TRUST:**

How much should we trust
scientists about Greenhouse
Gases?

As an indicator, let's take a quick look
at a single parameter -
global temperatures.

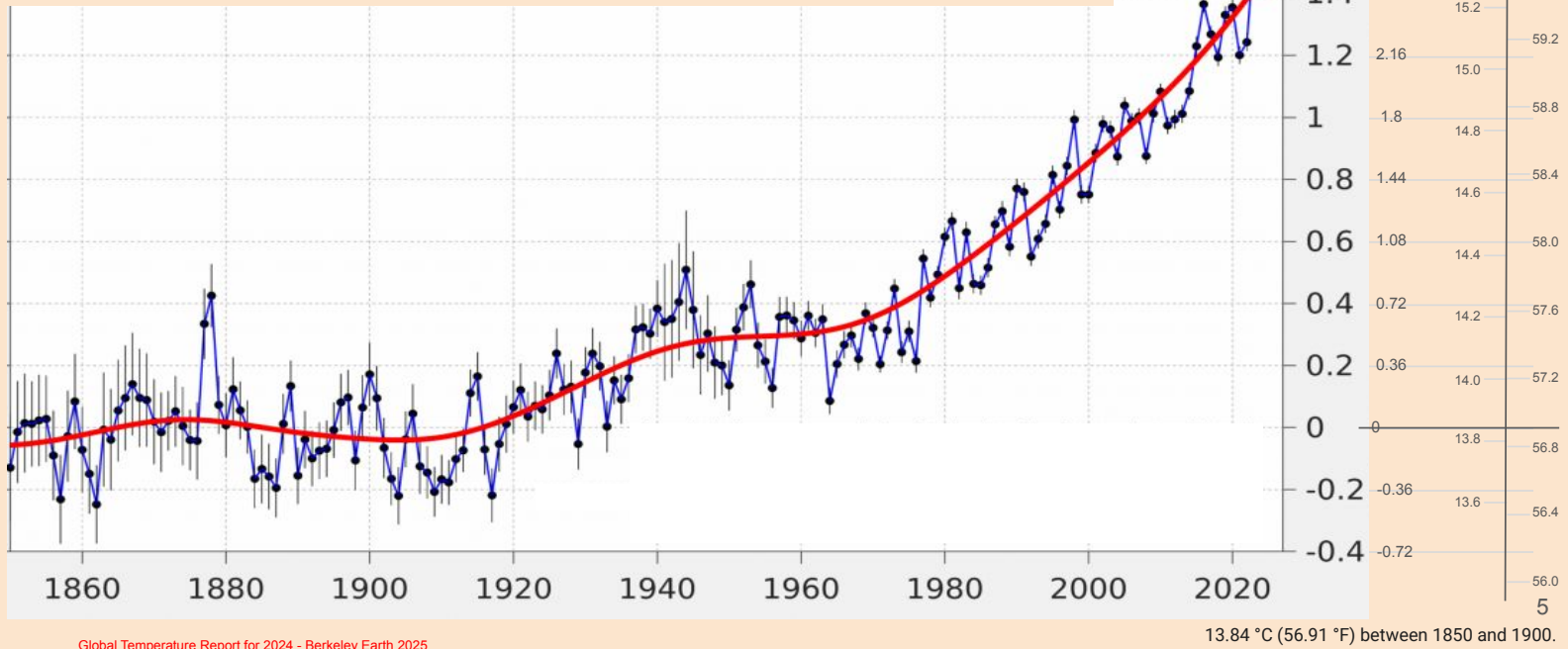
3

To assess how confident we can be with
scientific understanding...

Let's look at the early predictions about the
Warming now unfolding

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Here are the Global Temperatures for the last 174 years. I've added some info on the right to tie the usual Celsius measures into Fahrenheit and to point out the context of the Paris Agreement...

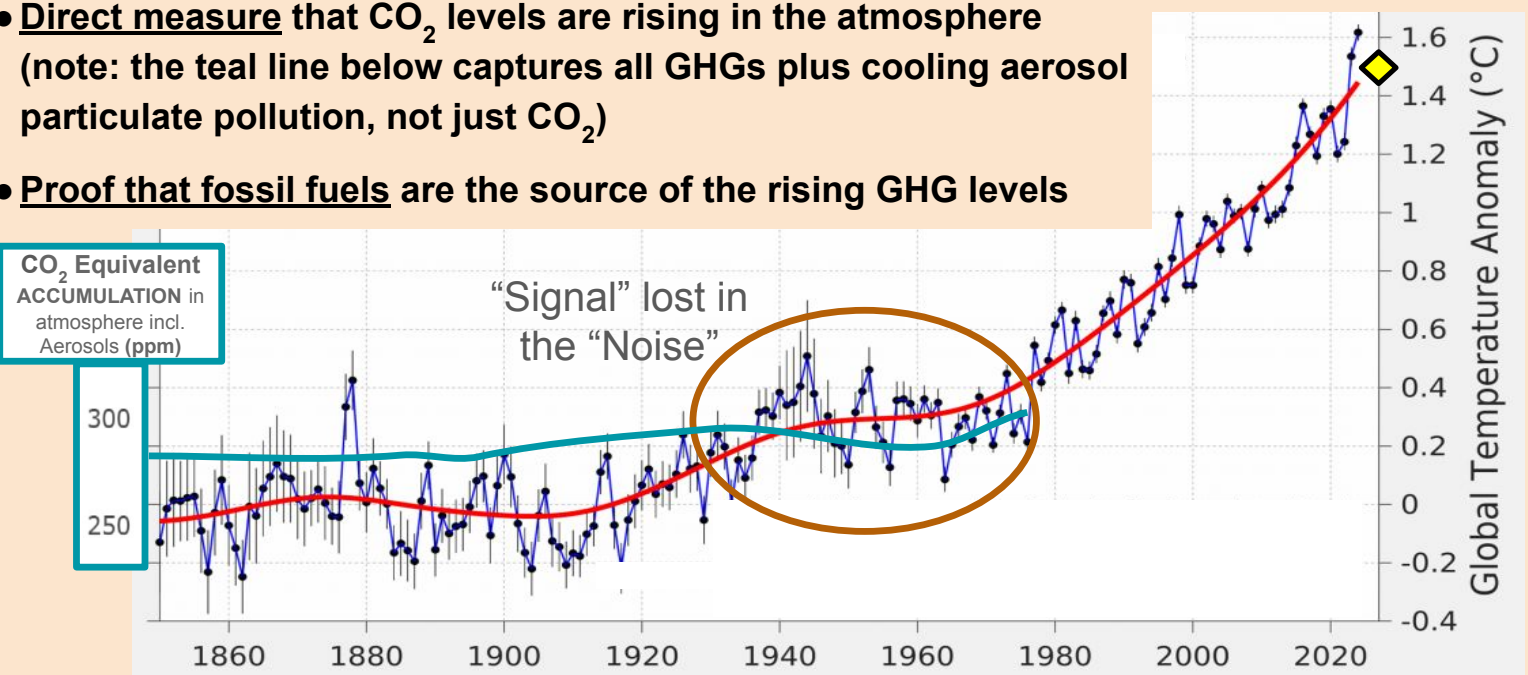


Global Temperature Report for 2024 - Berkeley Earth 2025

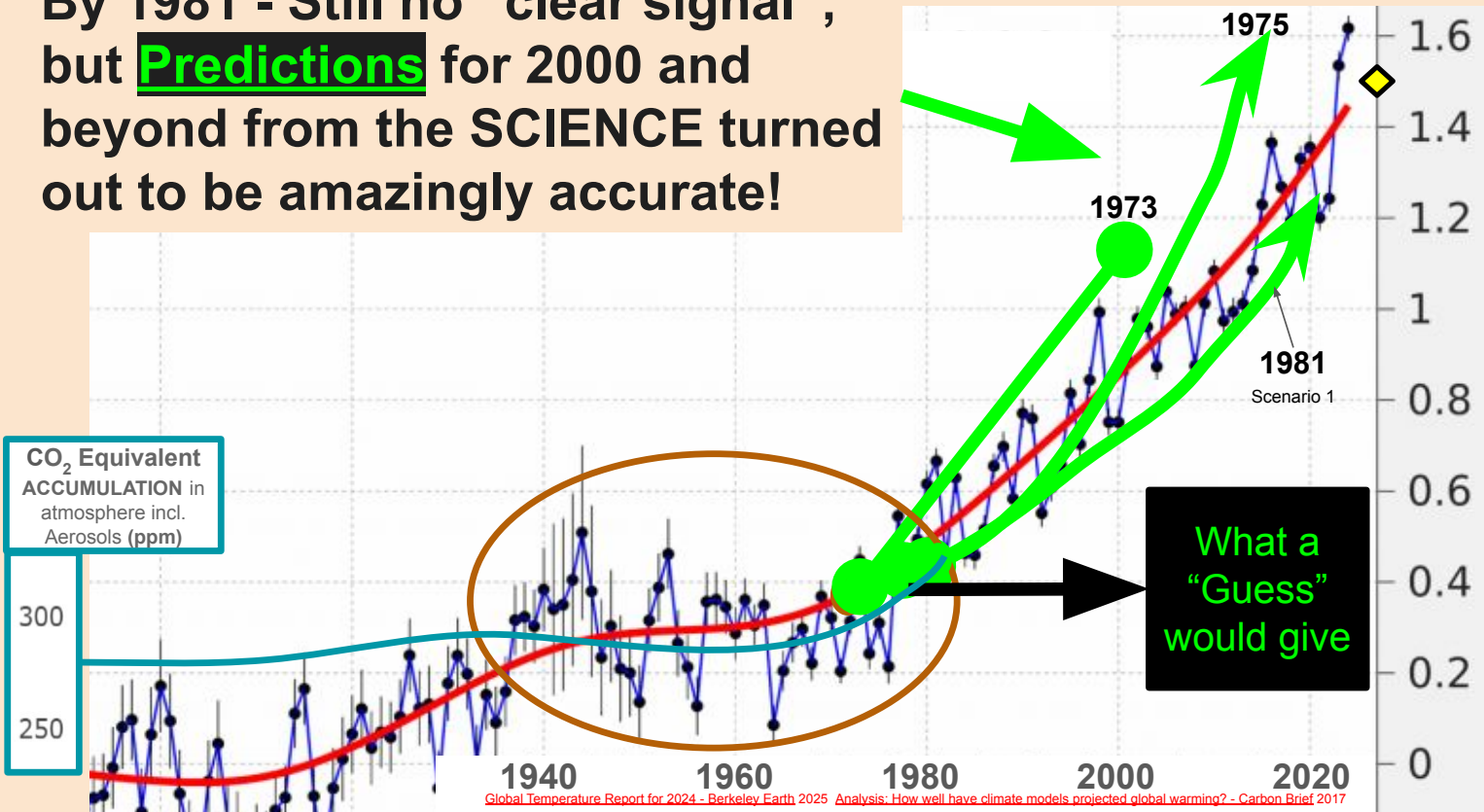
Let's start 70 years ago... By 1958 scientists had in hand:

- Demonstrations that CO₂ and other greenhouse gases (GHGs) can cause warming
- Direct measure that CO₂ levels are rising in the atmosphere (note: the teal line below captures all GHGs plus cooling aerosol particulate pollution, not just CO₂)
- Proof that fossil fuels are the source of the rising GHG levels

By Mid-Century, most climate scientists were expecting future warming from CO₂ and other GHGs even though no “Clear Signal” of Global Warming had emerged from the “Noise”, in part because of the aerosol cooling effects.



By 1981 - Still no “clear signal”,
but **Predictions** for 2000 and
beyond from the SCIENCE turned
out to be amazingly accurate!



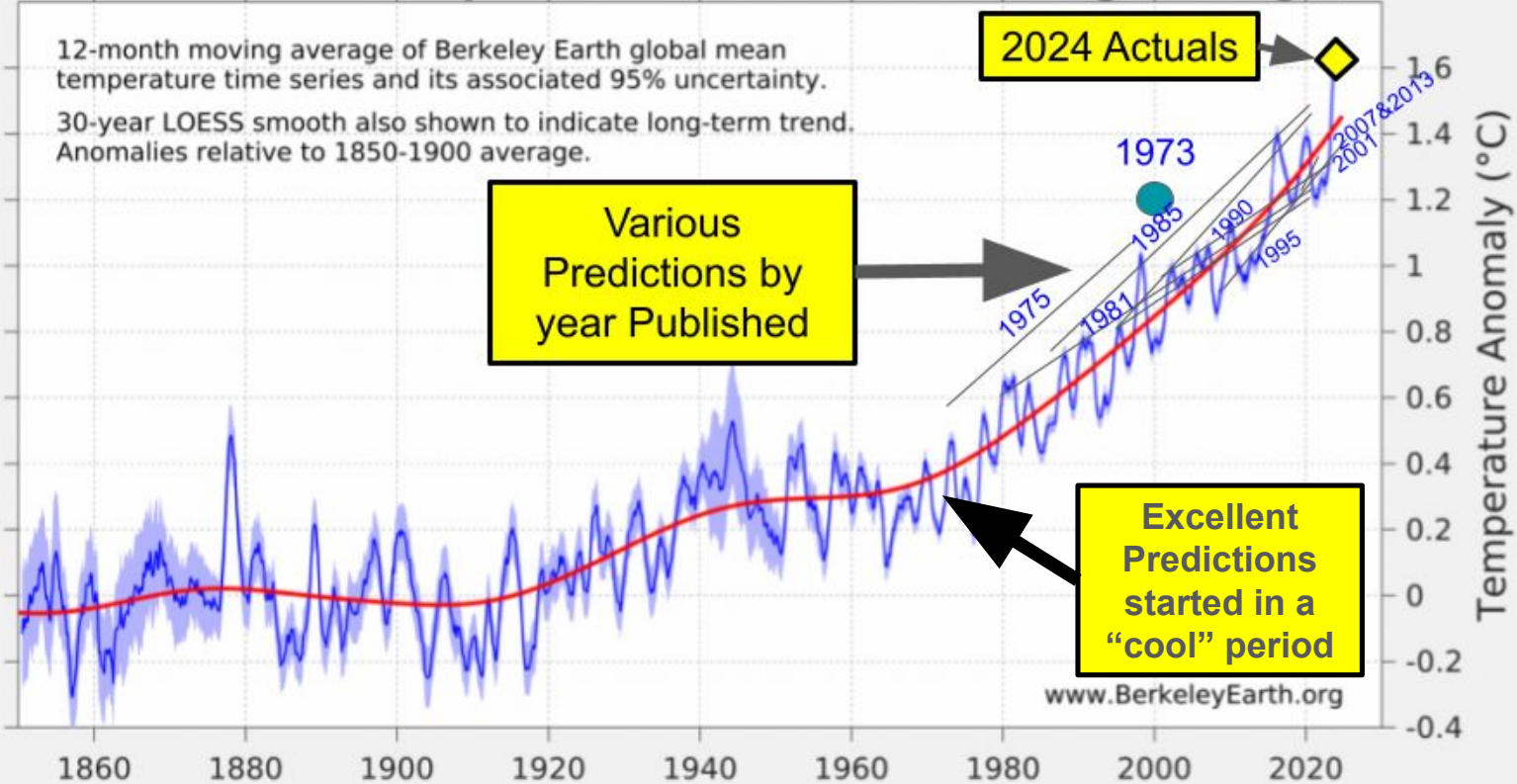
Global Mean Temperature (12-month moving average)

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.

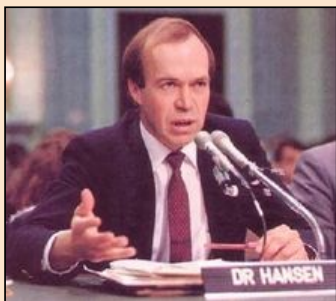
Various Predictions by year Published

2024 Actuals

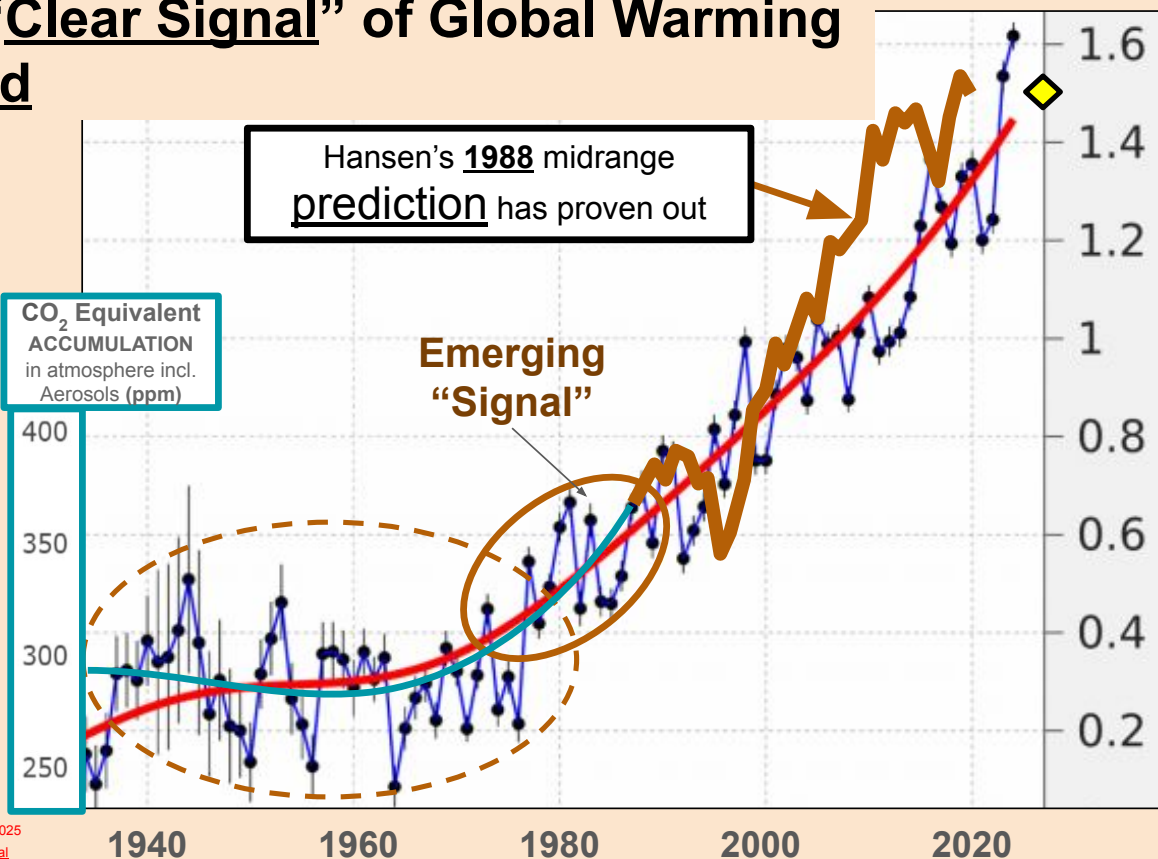
Excellent Predictions started in a "cool" period



1988 - The “Clear Signal” of Global Warming has emerged



In 1988 James Hansen from NASA, testified before Congress, and got the World’s attention

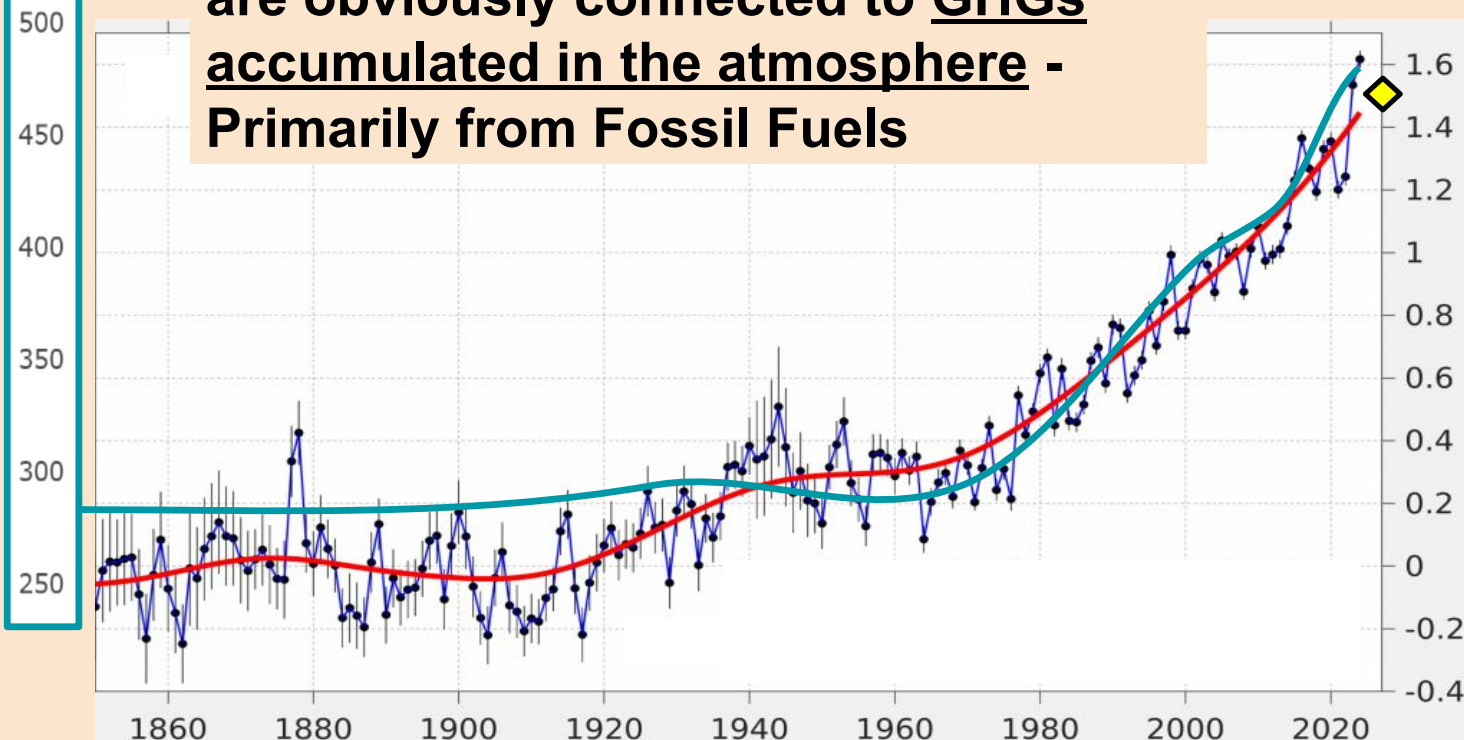


Global Temperature Report for 2024 - Berkeley Earth 2025
Analysis: How well have climate models projected global warming? - Carbon Brief 2017

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CO₂ Equivalent ACCUMULATION in atmosphere incl. Aerosols (ppm)

2025 - As anticipated, temperatures are obviously connected to GHGs accumulated in the atmosphere - Primarily from Fossil Fuels



Global Temperature Report for 2024 - Berkeley Earth 2025

CO₂ and Greenhouse Gas Emissions - Our World in Data
Greenhouse gas emissions include carbon dioxide, methane and nitrous oxide from all sources, including land-use change. They are measured in tonnes of carbon dioxide-equivalents over a 100-year timescale.

Atmospheric greenhouse gas concentrations | European Environment Agency's home page

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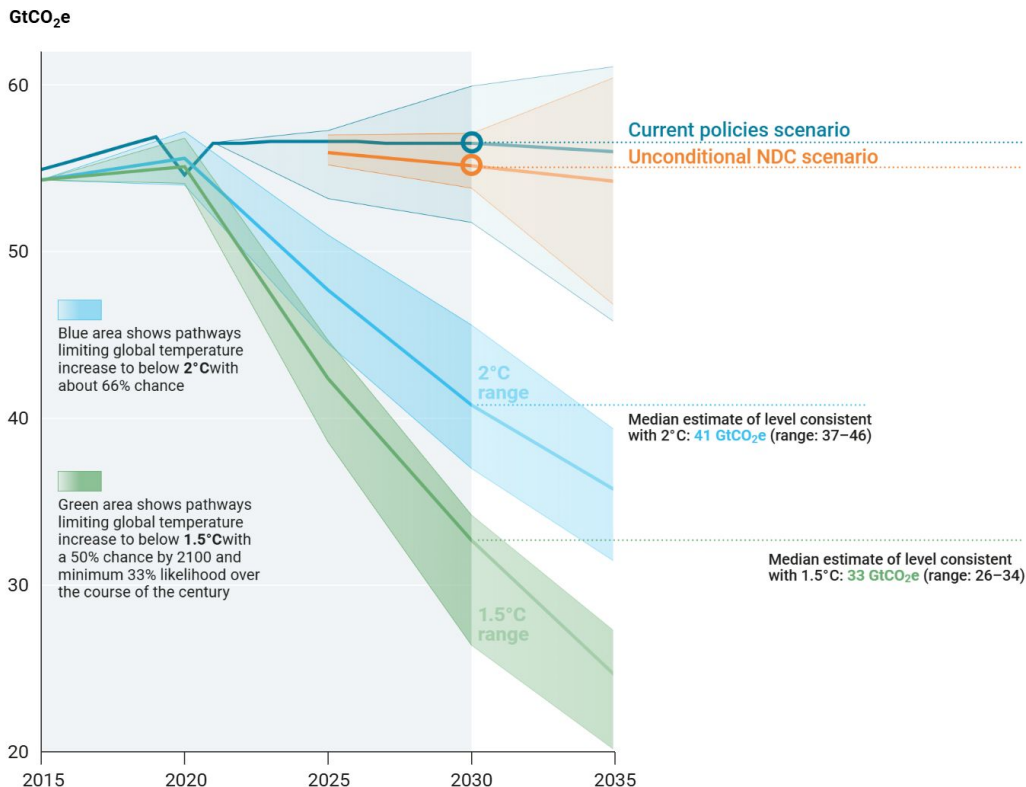
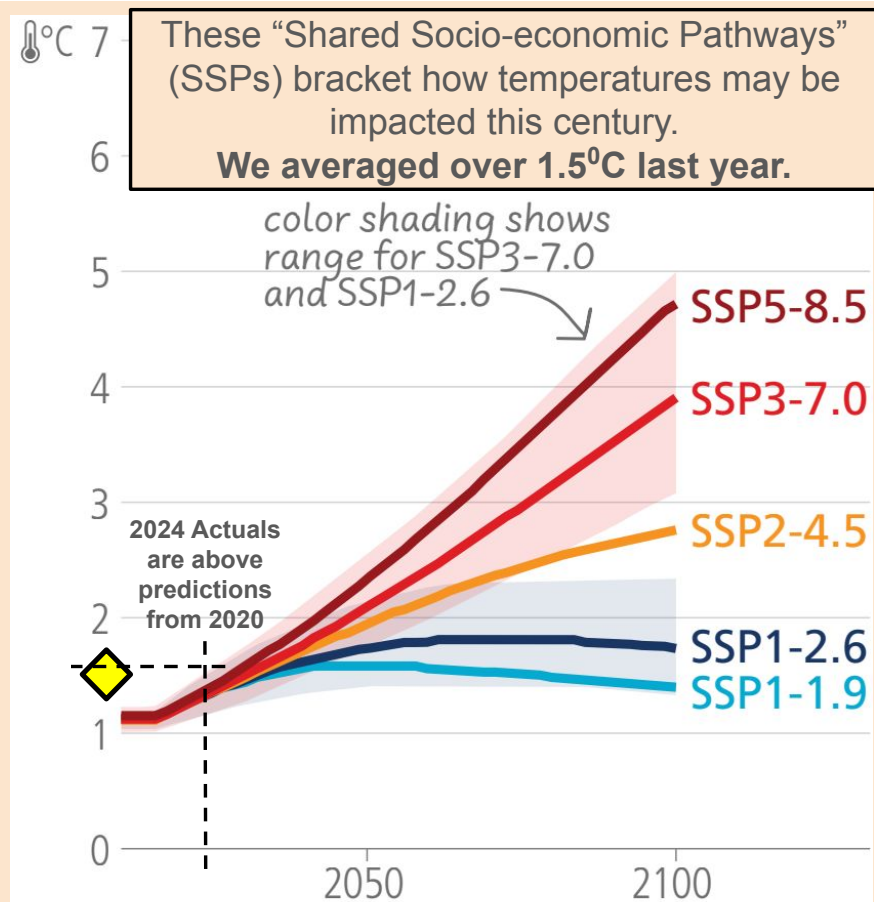
So what kind of PREDICTIONS are now being made?

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.

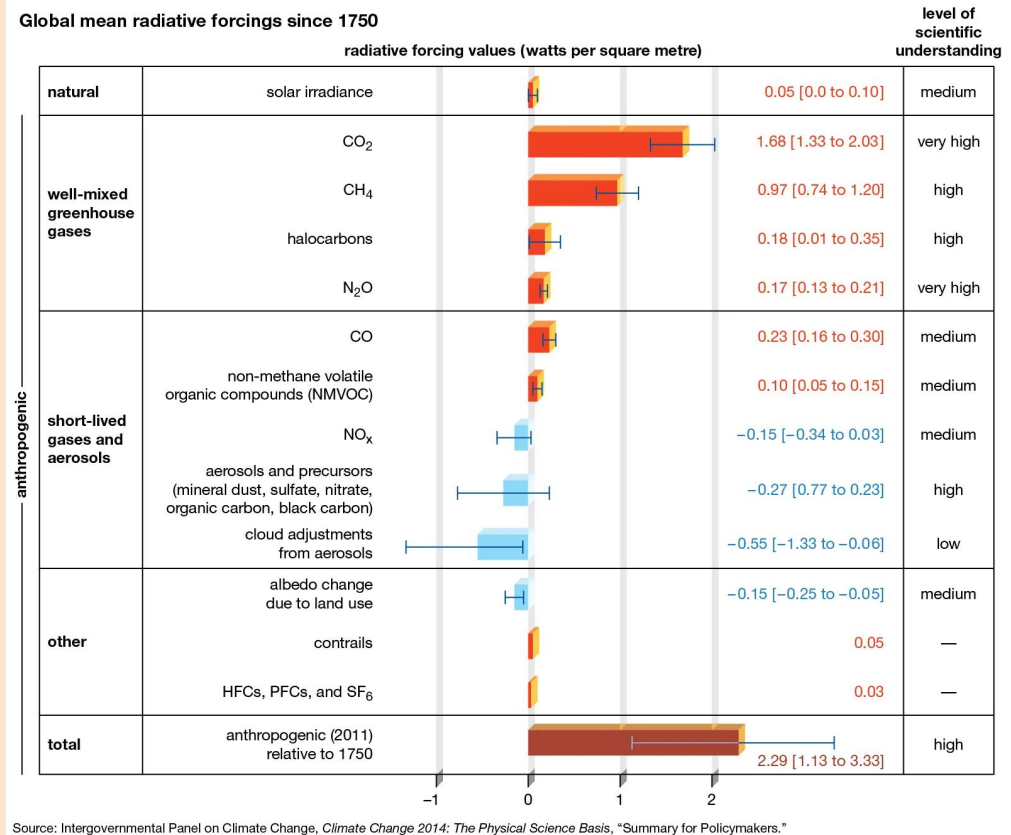
[CMIP6: the next generation of climate models explained - Carbon Brief](#)



[Emissions Gap Report 2023: Broken Record | UNEP - UN Environment Programme](#)

For the Record, a lot of factors add up to the measured temperatures. Here's a few...

- Well-mixed greenhouse gases are well understood and do a lot of heating
- Aerosols (particulate pollution) do a lot of cooling, so heating increases as we clean up the air (!)



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My Conclusions concerning Scientific Integrity and Results

- Scientists deliver reasonable predictions, based on physics.
- Accumulation of Human-caused Greenhouse Gases in the Atmosphere is clearly the main cause of Warming
- Early projections were extremely successful at the global level
- Recent, more complex models can be relied on generally - and keep improving. *"Remember, Science is not about what we know...It's about what we don't know."*
- Tipping Points, energy demand, and technology assumptions add complexity

These are the types of reports we rely on for the details:

The State of Knowledge about Climate Change

WGII

WGIII

Special Report

ipcc

Climate Change 2021 The Physical Science Basis

Climate Change 2022 Impacts, Adaptation and Vulnerability

Climate Change 2022 Mitigation of Climate Change

The Ocean and Cryosphere in a Changing Climate

Climate Change and Land

Global Warming of 1.5 °C

In the Contiguous USA, sea level rose 7 inches from 1970 to present.

Sea Level Annual Cycle Over Time, 1970 - present

Updated: 12/3/2024

This chart shows the change in sea level over time in the Contiguous USA relative to the 1970s average for the month of January. The chart shows up and down throughout the year from things like tides and changes in seasons. There are also higher and lower years due to natural fluctuations in the ocean. In places where sea level is rising, there is an upward shift as the years go by. The change in level over time is caused mostly by human-caused climate change and other local factors. In places where sea level is currently rising, the red line will likely continue to rise higher in the future. The Total Sea Level Rise over the chosen time period is estimated from a quadratic fit to the tide gauge record from 1970 to present.

Total sea level rise: 1970 - Present, 7.0 inches

Key Points

- Global warming is causing sea level to rise almost everywhere.
- There are ups and downs from year-to-year associated with natural fluctuations in the ocean. The thicker line shows where sea level is right now.
- In most locations, sea level will continue to rise and isn't returning to where it was in the past.

Clicking to zoom

Snapshot

Explainer

Transcript

Replay

National Sea Level Explorer

2023 FLORIDA WEATHER AND CLIMATE SUMMARY

Prepared by Emily Powell
Florida Climate Center
February 2024

From top left to right: Damage to Hurricane Beach from Hurricane Idalia (left); FEMA's severely dry pasture in Okeechobee on April 3, 2023 reported by a local observer; eastern Pacific Ocean sea surface temperature anomalies showing strengthening of El Niño (middle); NOAA's time series showing the percentage of the state in drought, from the US Drought Monitor (bottom).

The Florida State University Center for Ocean-Atmospheric Prediction Studies
2020 Levy Ave., Building A, Suite 250, Tallahassee, FL 32306-2741
Dr. Emily Powell, Director (904) 904-4900

2023 FLORIDA WEATHER AND CLIMATE SUMMARY

https://www.ipcc.ch/report/ar6/syr/downloads/press/IPCC_AR6_SYR_SlideDeck.pdf p.3

PLUS: Ongoing Scientific Research Publications

For Reference, these are foundational

- The Intergovernmental Panel on Climate Change (IPCC) provides the best compilation of global research from 1990 to the present
- The U.S. Global Change Research Program publishes further analysis, based on the IPCC reports and local info, since 1990
- The Florida Climate Center provides up-to-date analysis - other States also have agencies

2. TIMING:

What's the projected timing for global temperature increases, on our **current path**?

- Cumulative GHGs in the atmosphere relate to temperatures in a spectrum of IPCC “cases”, and give us a handle on timing

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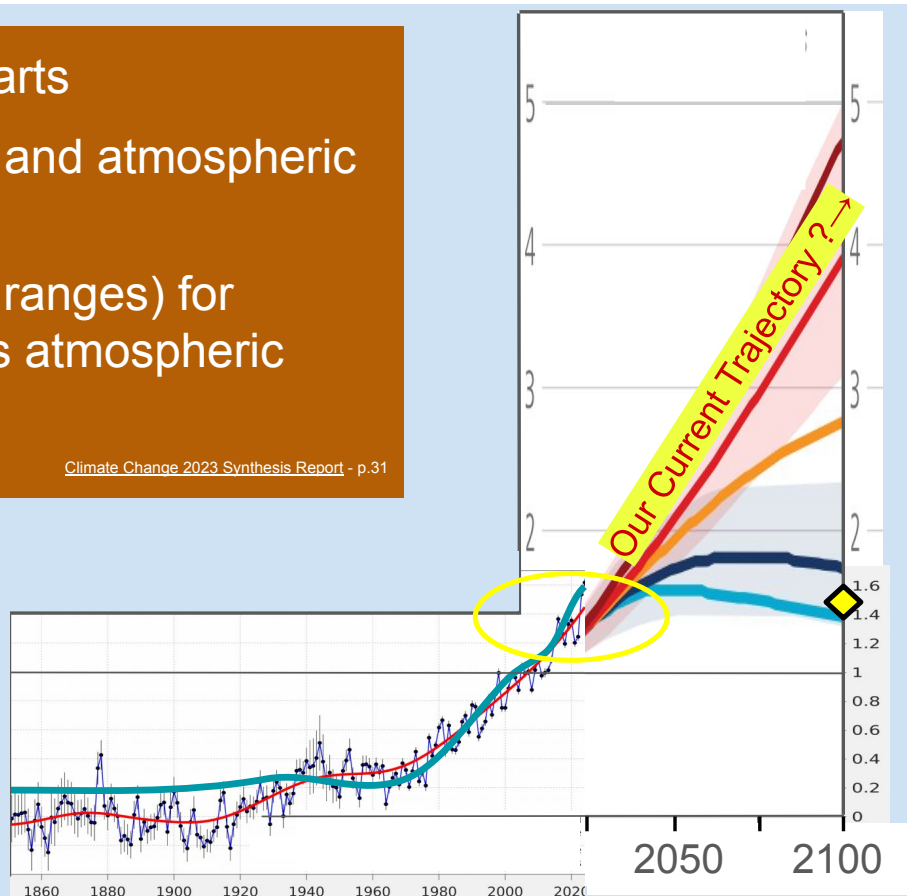
This is a melding of two charts

- ACTUAL temperatures and atmospheric GHG levels, and
- the IPCC timeline (and ranges) for temperatures at various atmospheric concentration cases

Climate Change 2023 Synthesis Report - p.31

Note that:

- Both our global temperatures and the added line showing cumulative GHGs in the atmosphere are relentlessly increasing, and
- We may be heating **even FASTER** than projections



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We can now get a feel for the approximate **TIMING** of the benchmark temperatures,

**if we maintain
our current Trajectory**

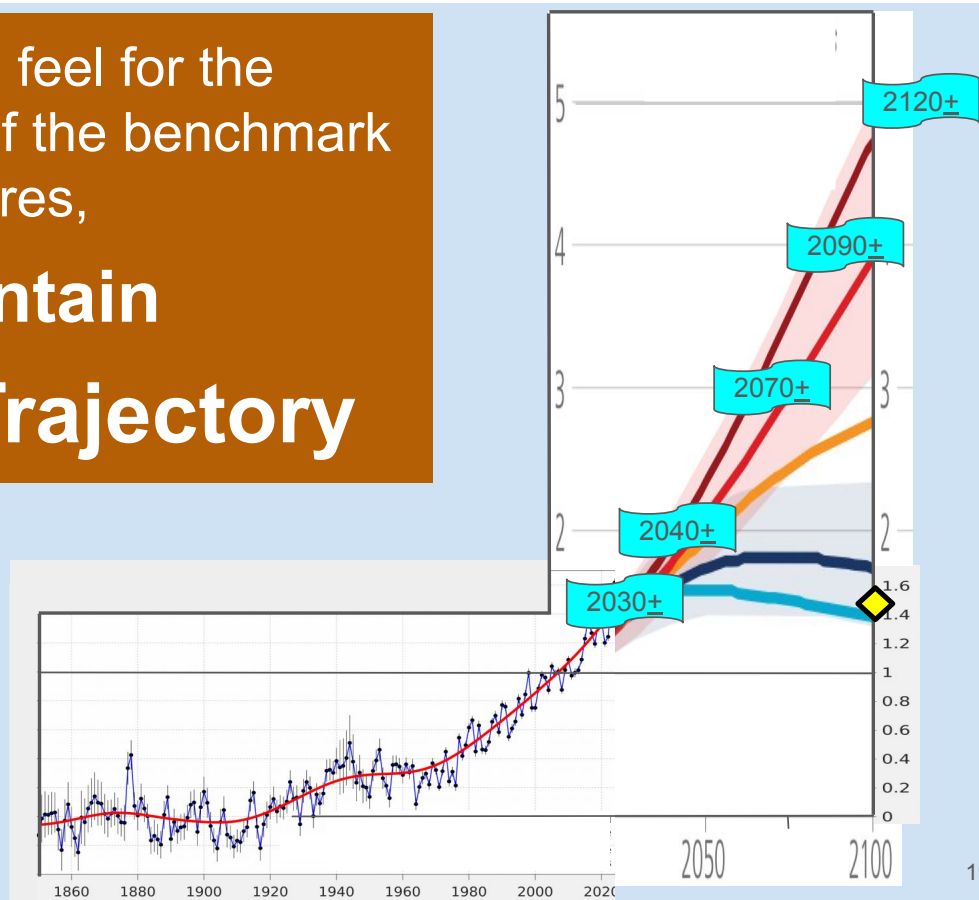
2030 ± 1.5 °C = 2.7 °F
(may be there now)

2040 ± 2.0 °C = 3.6 °F

2070 ± 3.0 °C = 5.4 °F

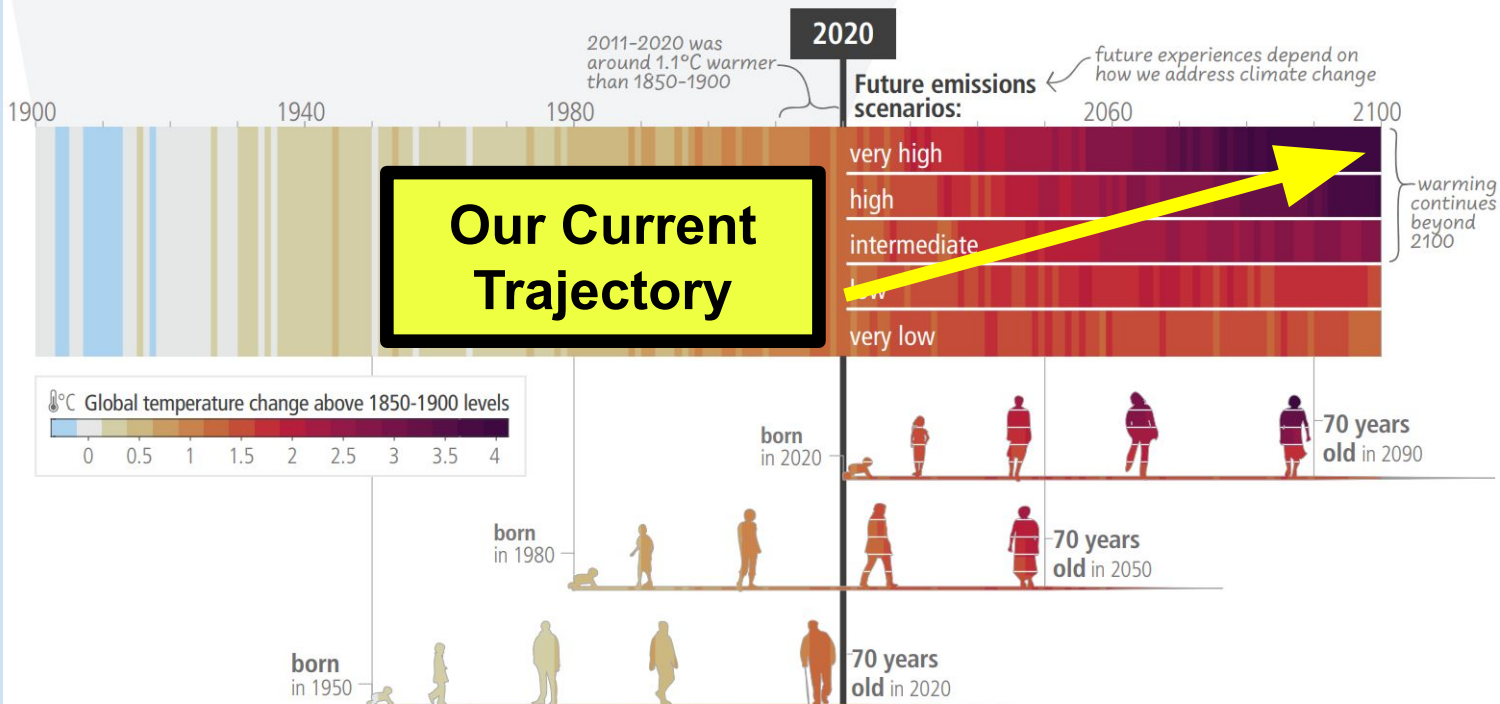
2090 ± 4.0 °C = 7.2 °F

2120 ± 5.0 °C = 9.0 °F



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c) The extent to which current and future generations will experience a hotter and different world depends on choices now and in the near term



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My Conclusions concerning **TIMING** of Temperature Increases, at our current trajectory

- In **this century**, we are likely to experience around **4°C** (7.2°F) global average temperature rise
- This increase would precipitate **IMPACTS** described by the IPCC in their “High” to “Very High” Emissions cases

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3. **IMPACTS:**

What **global impacts** are likely to emerge if we continue to heat up?

And will it take **societal disruption** to stimulate the political will to do something?

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Given our Current Trajectory, let's look first at...

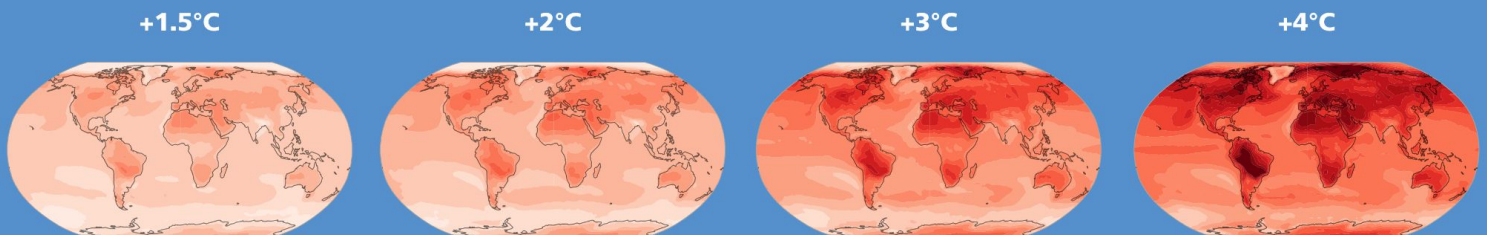
Impacts on Climates and Weather

- 1. Global Climates will change**
- 2. Increasingly Erratic and Intense Weather**
- 3. Rising Sea Levels**
- 4. Tipping Points and Compounded Impacts**

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In General...

Extremes become more widespread and pronounced with every increment of warming



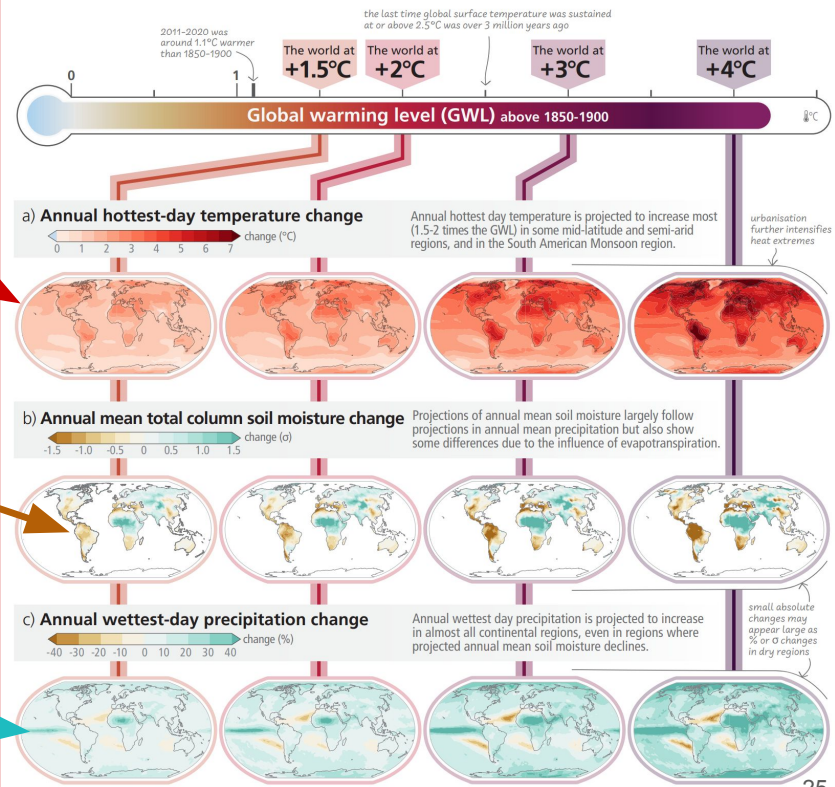
While these are just a very few of the studied changes the planet may see, they paint a severe picture as temperatures rise...(read details in Ref.)

Hottest days get a lot hotter

Droughts get a lot dryer

Downpours get a lot more intense

With every increment of global warming, regional changes in mean climate and extremes become more widespread and pronounced



CLIMATE CHANGE 2023 p.20

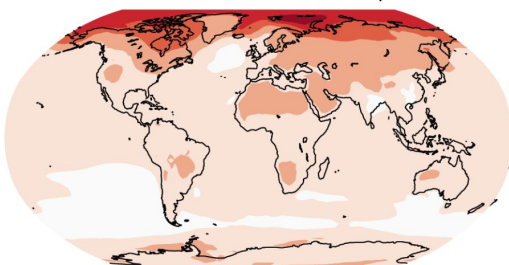
25

FAQ 4.3: Climate change and regional patterns

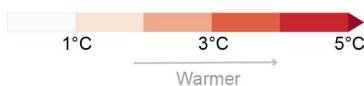
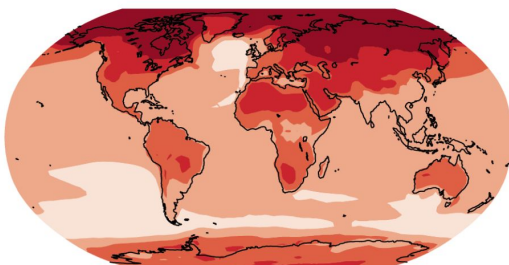
Climate change is not uniform and proportional to the level of global warming.

Warming will be **stronger** in the Arctic, on land and in the Northern Hemisphere

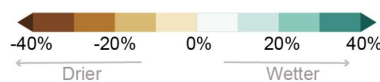
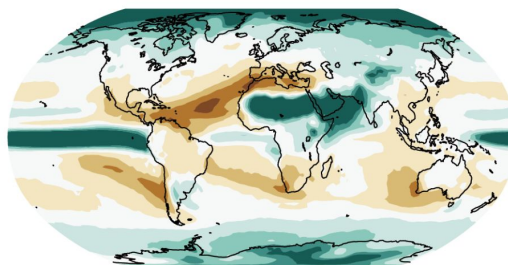
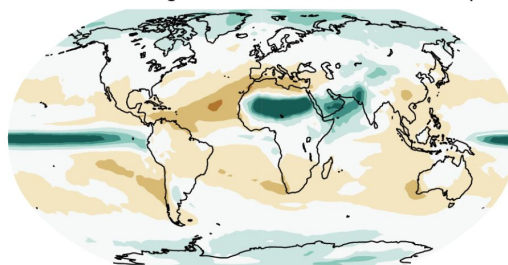
+1.5°C



+3.0°C



Precipitation will **increase** in high latitudes, the tropics and monsoon regions and **decrease** in the subtropics



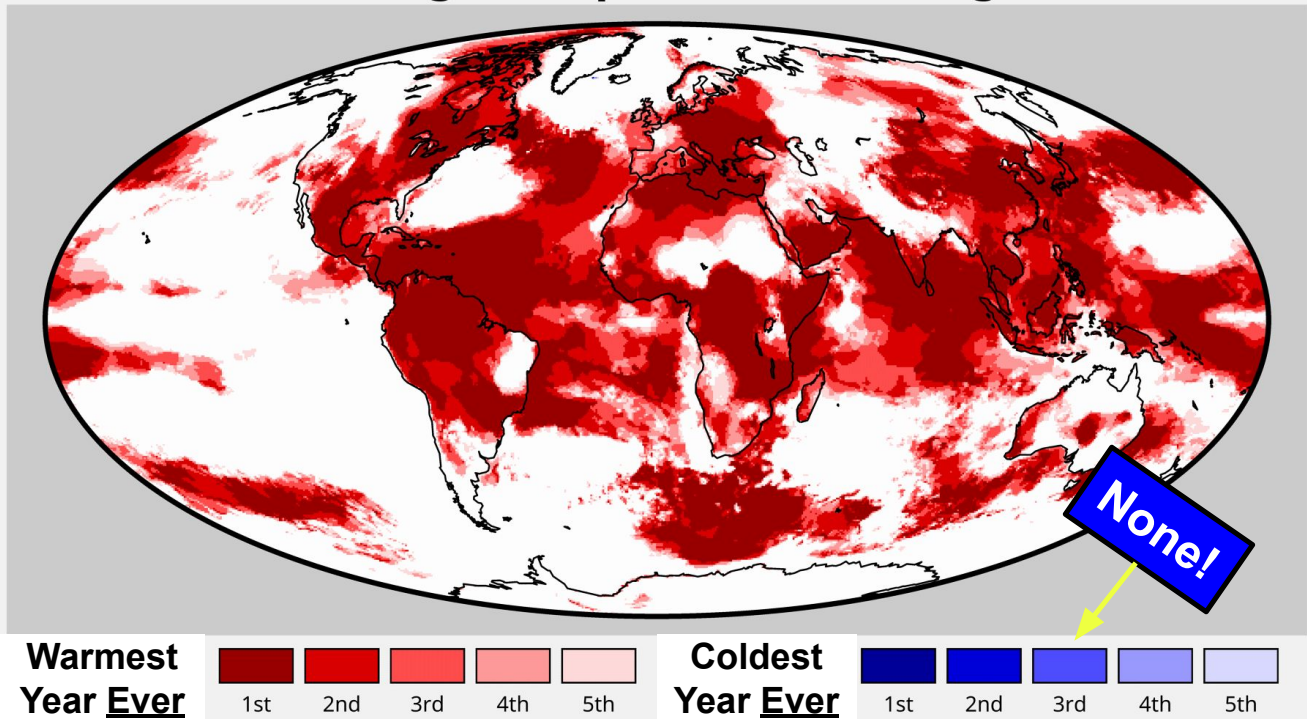
Climate Changes are REGIONAL

Look carefully at average WARMING and PRECIPITATION (not the extreme DAYS on the previous chart).

Predicted changes around the globe are severe (precipitation goes both directions).

Meanwhile, the earth is already getting walloped...

Annual Average Temperature Rankings in 2024

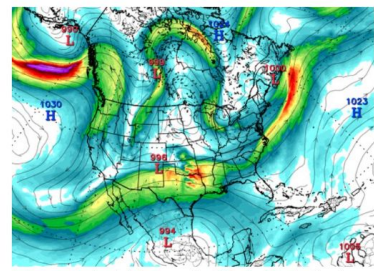


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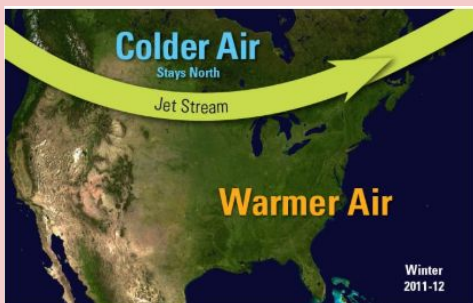
Globally Increasing Erratic Weather has already started

With Warming, the poles warm faster than the equator, weakening the jet stream, allowing large kinks to develop, bringing radically changing weather stimulated by intensification of temperatures and precipitation patterns.

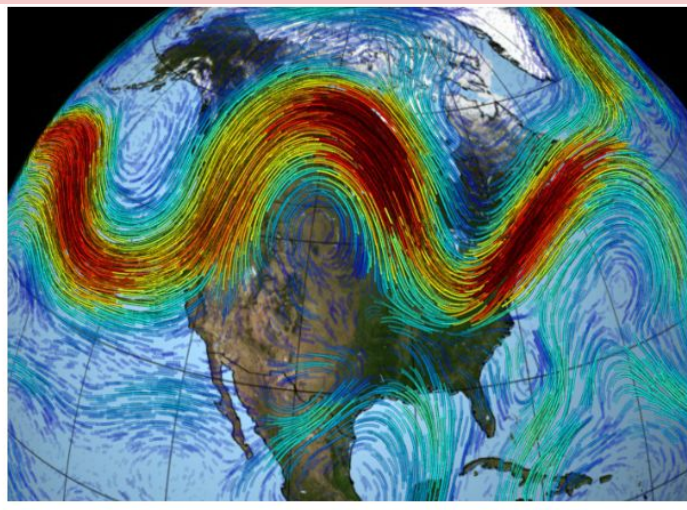
The weird jet stream



The jet stream pattern shown by the American model – valid Thursday night – shows the northern branch of the jet bulging north over central Canadian forming a 'heat dome' while the southern branch zips over the southern United States, energizing storms. (TropicalTidbits.com)



Until recent decades, the jet stream's dominant behavior was gently wavy, but generally stable. With warming, waves in the jet stream are far more commonly dramatic. Patterns can stall for long periods, further intensifying the effects.



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

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

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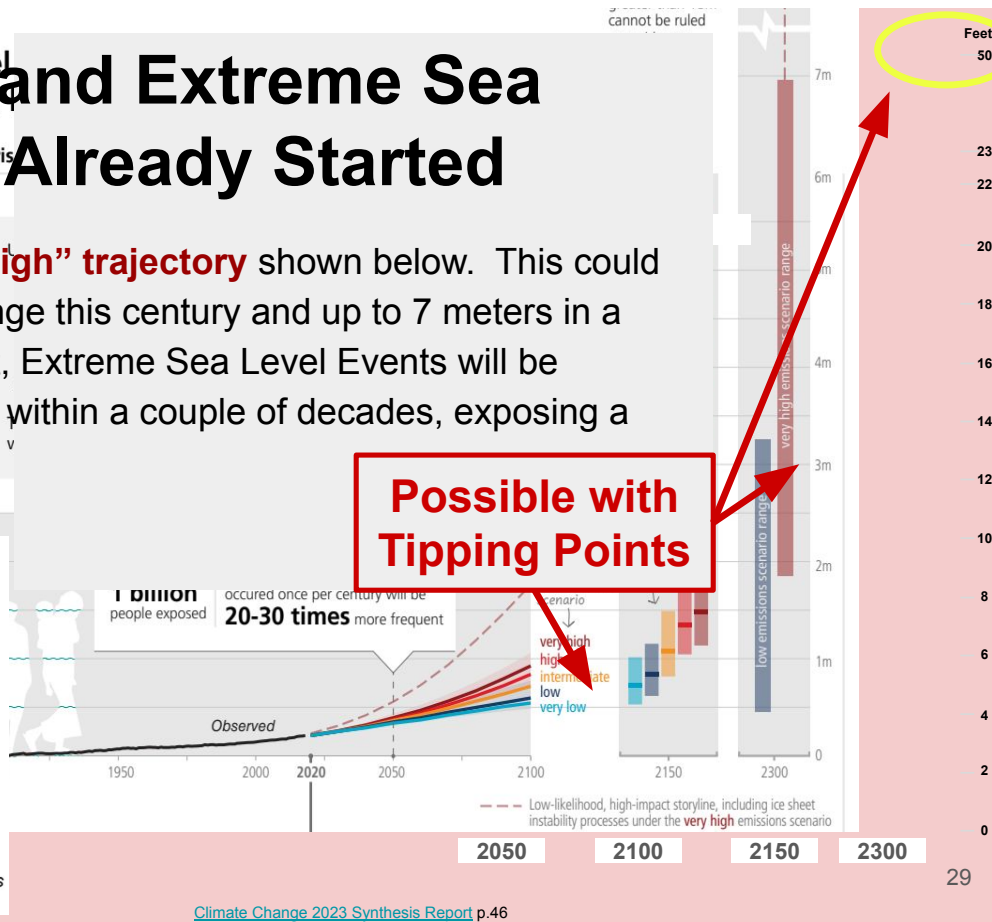
Rising Sea Levels and Extreme Sea Level Events have Already Started

We are currently close to the **“Very High” trajectory** shown below. This could result in a meter of (average) SL change this century and up to 7 meters in a couple of centuries. As a direct result, Extreme Sea Level Events will be occurring much more frequently even within a couple of decades, exposing a billion people by 2050.

Extreme sea level events add on to the simple rise of sea levels. Storm surges from high winds and lower air pressures add to the higher sea level itself. These can cause the most damage.



The extremely low atmospheric pressure below the storm lifts the sea level like a vacuum cleaner. As the storm hits land, the surge can bring sea levels up far above any protections.



Tipping Points are Getting close (or some may already have tripped) and will compound

Risks associated with large-scale singular events or tipping points, such as ice sheet instability or ecosystem loss from tropical forests, transition to a high risk between 1.5 and 2.5 C and to very high risk between 2.5 to 4 C.

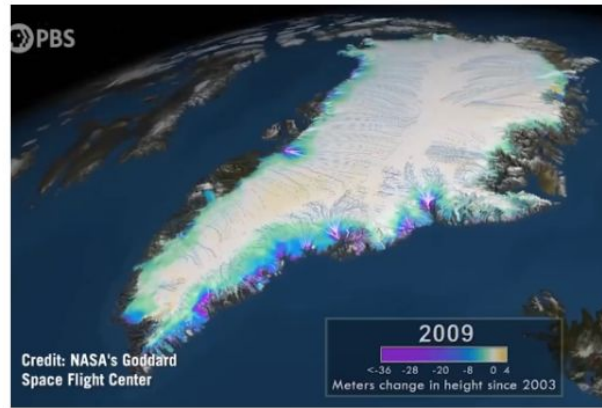
26 Potential Tipping Points have been carefully assessed. Five were flagged as near to tipping, including the **Greenland and West Antarctica Ice Sheets** (irreversibly adding 6 meters of sea level rise over a long period (see Sea Level Rise, above).

A tipping point itself only makes recovery impossible. The full playout of its impacts could take decades to centuries, particularly for melting ice sheets. With respect to the **AMOC** (see below), a shutdown could have very early impacts.

Tipping Point #1 Greenland Ice Sheet - GIS

(Could tip as soon as 1.5 °C)
Possible by 2025 ±

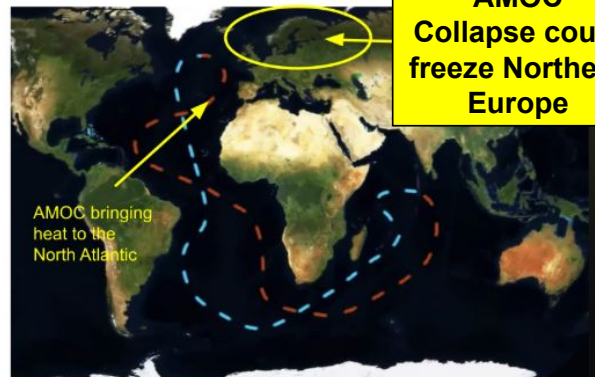
The GIS may well be tipping now. GTP¹¹ estimates 0.8-3.0 C for tipping and 3m Sea Level Rise. Global impacts.



Tipping Point #2 Atlantic Meridional Overturning Circulation - AMOC

(Could tip as soon as 1.1-2 °C)
Possible by 2040 ±

AMOC (responsible for keeping North and Western Europe warm) is measurably slowing. Collapse of this circulation would have disastrous effects in the North and globally.¹² 15% recent slowdown.

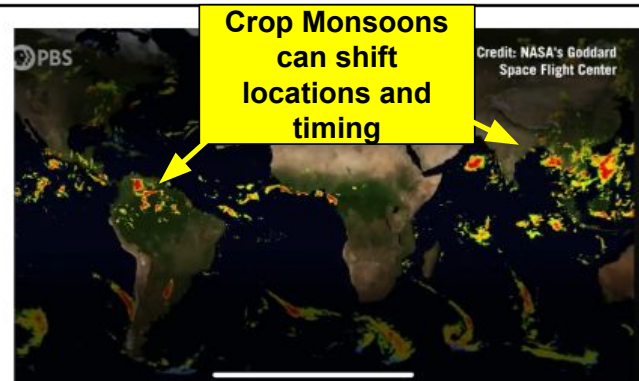


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Tipping Point #3 Global Monsoons

(Could tip as soon as 2-3 °C)
Possible by Midcentury ±

Already experiencing regional disruptions of crop monsoons. Will have major impacts on productivity and human wellbeing.



Tipping Point #4 Amazon Rainforest

(Could tip as soon as 2-3 °C)
Possible by Midcentury ±

Already have lost a large part of the Amazon to drought and clearcut, becoming a carbon source, instead of a carbon sink.

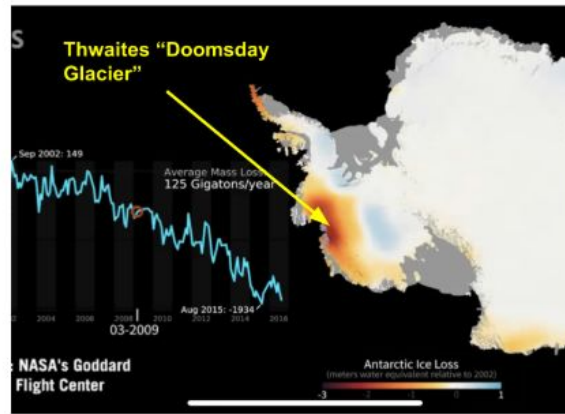


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Tipping Point #5 West Antarctic Ice Sheet - WAIS

(Could tip as soon as 1.5 °C)
Possible by 2040 ±

The Western AIC is being more rapidly undercut than expected. GTP¹¹ estimates between 1.0-3.0 °C and 3m Sea Level Rise. Global impacts.



Tipping Point #6 Permafrost

(Could tip as soon as 1.5 °C)
Possible by 2040 ±

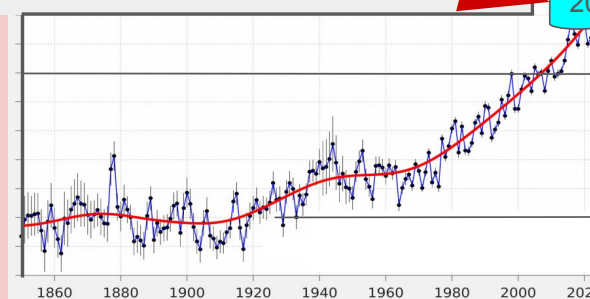
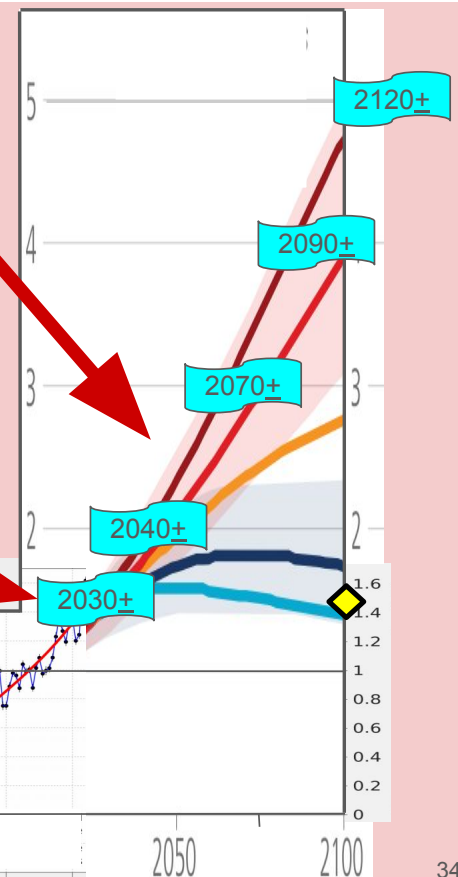
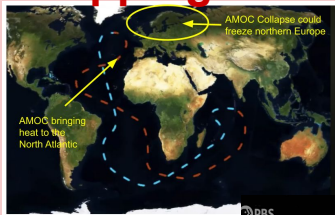
Ecosystem disruptions and large methane emissions. Many signs of deterioration. Could go on multidecadal to century timescales. Global impacts.



Global Tipping Points from Dec 2023, also PBS Terra from 2022 <https://www.youtube.com/watch?v=MBKZWKeYqE&t=6s>

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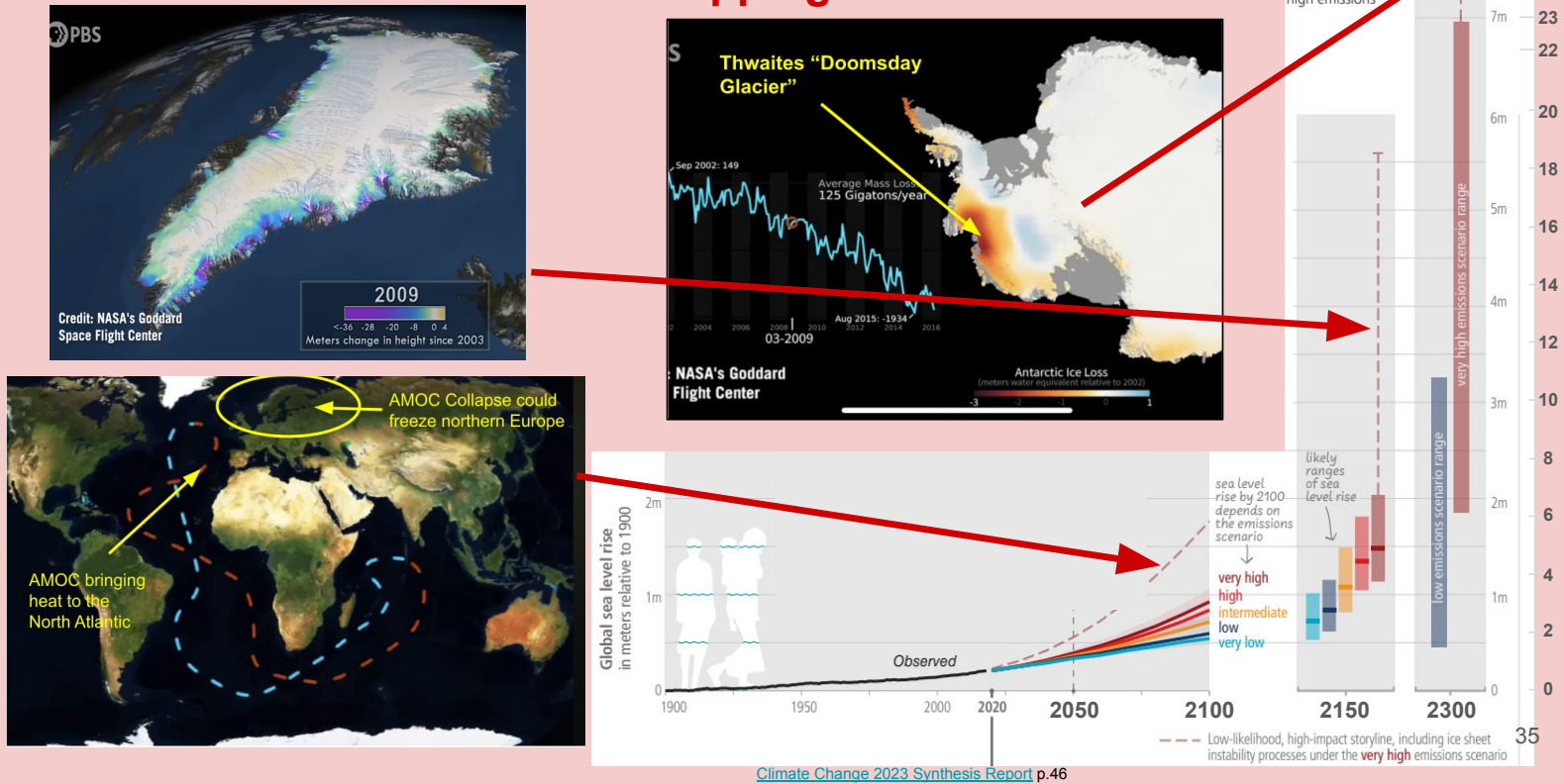
Tipping Points may be tipping now or soon



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Rising Sea Levels

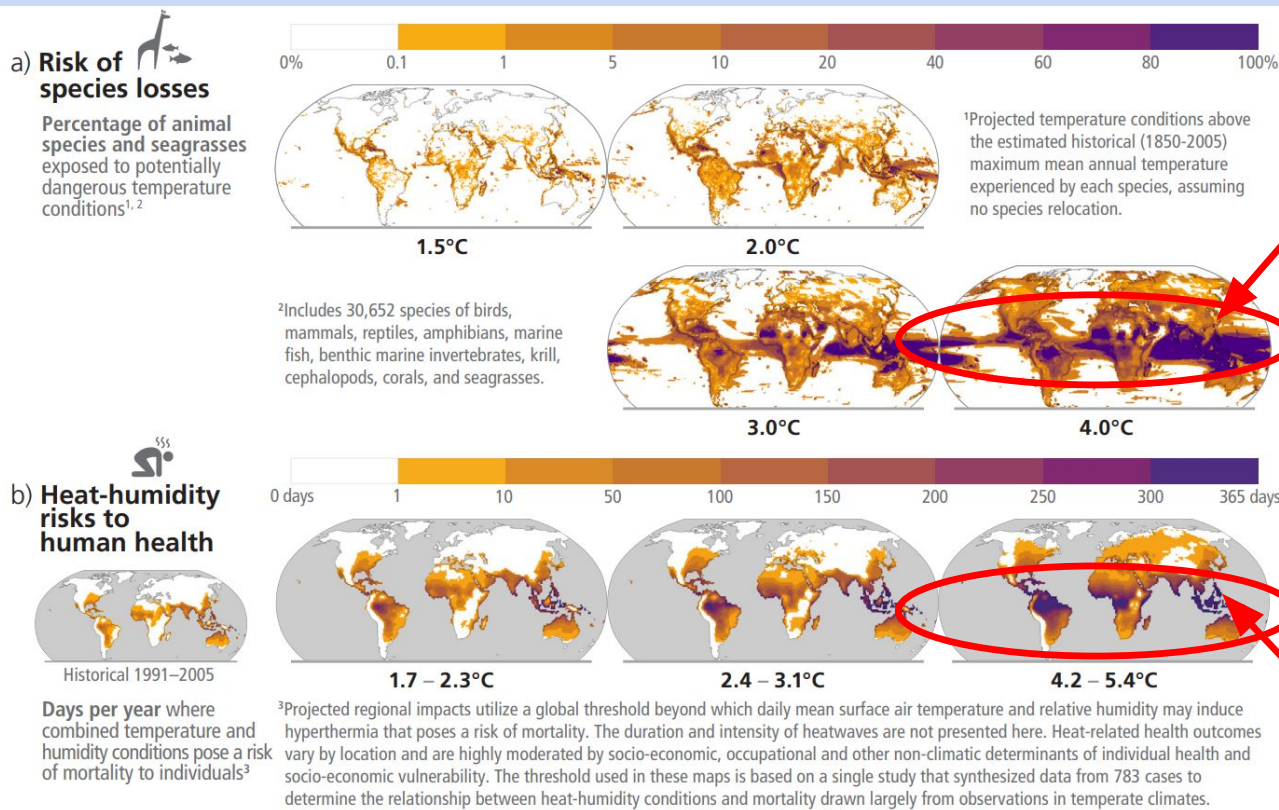
Will result from Tipping Points



And, given our Current Trajectory, there may well be...

IMPACTS on Societies Worldwide

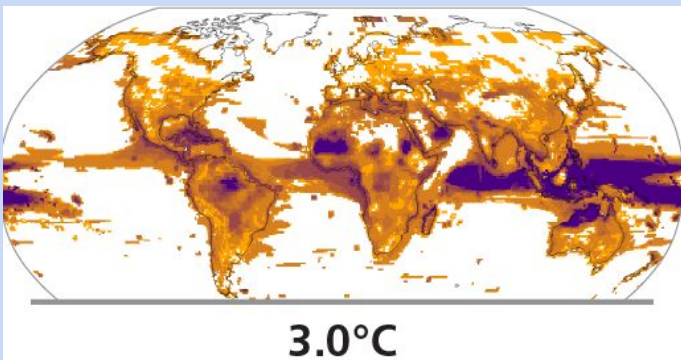
1. Species Extinctions and loss of food supply
2. Major shifts of the human habitability niche by 2070



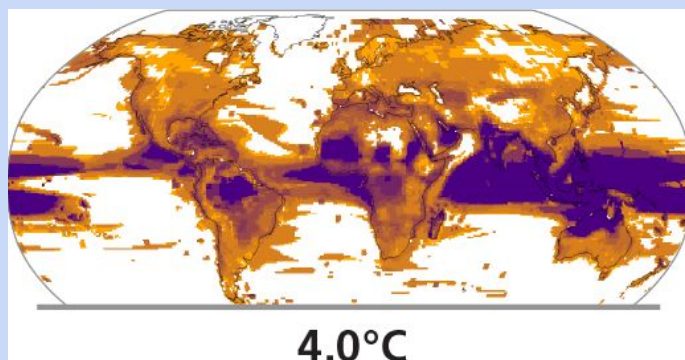
Enormous destruction of Species

Huge Areas with risk of death outdoors for most of the year³⁷

IPCC: [CLIMATE CHANGE 2023](#) p.22

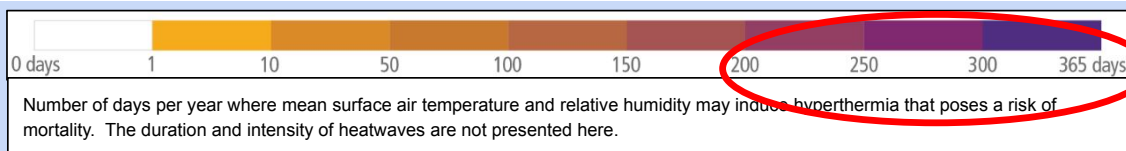


2070 ± Up to **29%** of the land and forest species assessed likely face a very high risk of extinction

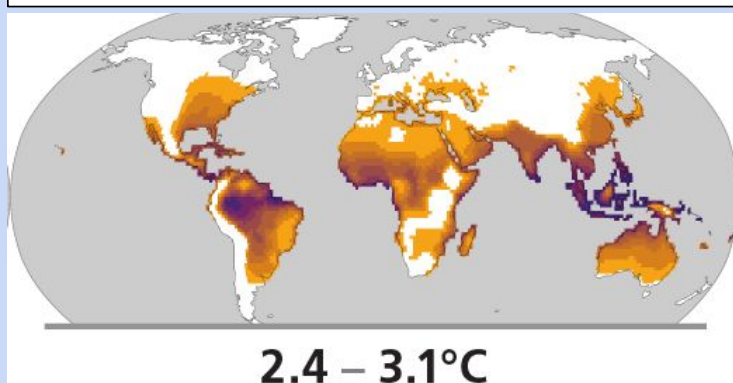


2090 ± Up to **39%** of the land and forest species assessed likely face a very high risk of extinction. local extinctions of about 50% of tropical marine species.

At 5 °C **2120 ±** Up to **48%** of the land and forest species assessed likely face a very high risk of extinction.



Heat-humidity risks to human health



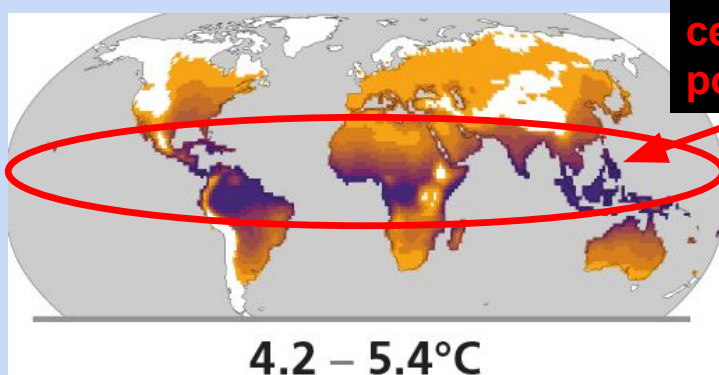
3°C - 2070± Adverse impacts on all food sectors becomes prevalent ^j **2.25 B more people** at risk from dengue. ^m Globally, adaptation options related to agroforestry and forestry have a sharp decline in effectiveness at 3°C with a substantial increase in residual risk. ^s Notice the wide equatorial swath with >1/3 - 1/2 of the year impossible to be outside.

[Foreword and Preface Technical Summary C.3.3, C.6.5, SYN3.2](#)

Hard to live in these regions after a certain point

4°C - 2100 ± **4 B people** with different levels of water insecurity. ⁱ 30% loss of crop and livestock areas globally. ^H

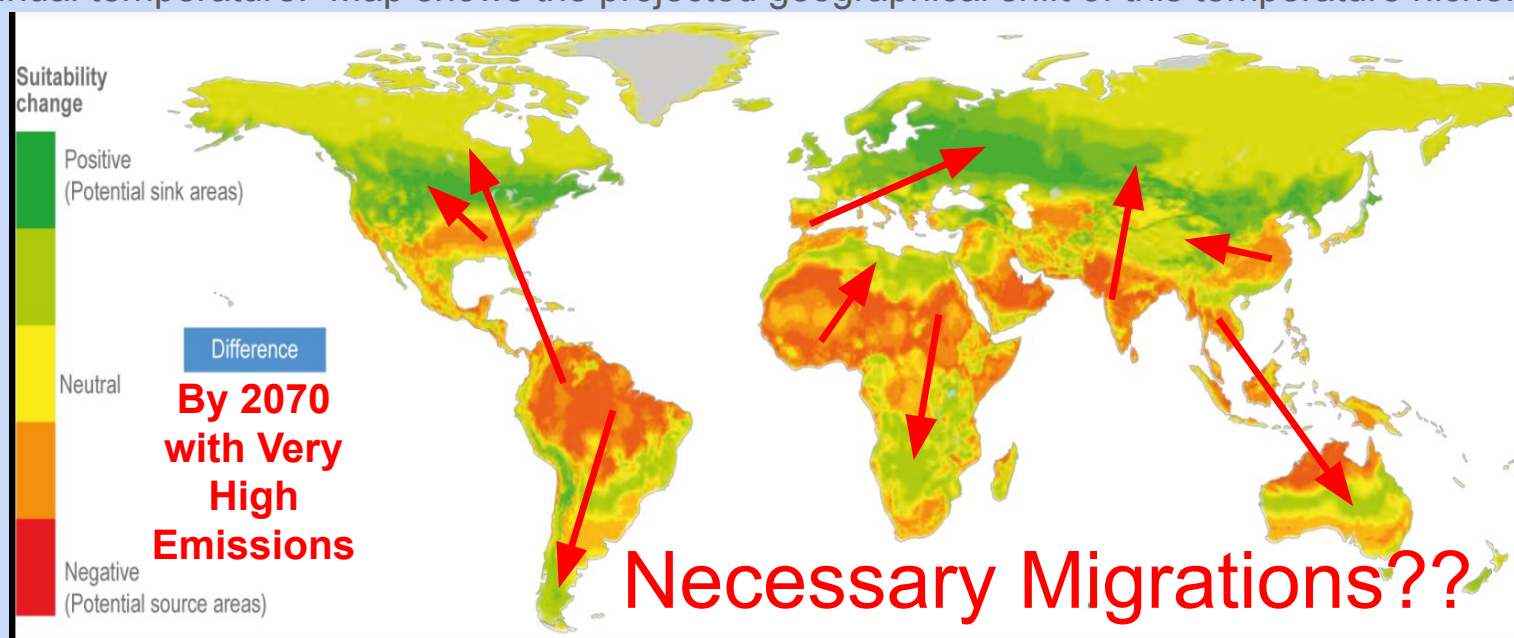
[Foreword and Preface Technical Summary C.4.1, C.3.1](#)



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Projected geographical shift of the 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.



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

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My Conclusions concerning **IMPACTS** of Temperature Increases, at our current trajectory

- By 2040 - 2070 we must expect dramatic extinctions and uninhabitable regions
- Global-scale migrations could not be prevented

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4. **Personal Perspectives:** How can we change our trajectory?

1. Meeting 1.5°C and 2.0°C Goals is impossible
2. Massive Global Migrations will ensue with no change
3. Carbon emissions must be stopped and Atmospheric carbon must be removed

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My Perspectives:

The future built on our current trajectory of burning fossil fuels is too awful to accept.

Every strategy for stopping Temperature Increases **MUST** be pushed **HARD**.

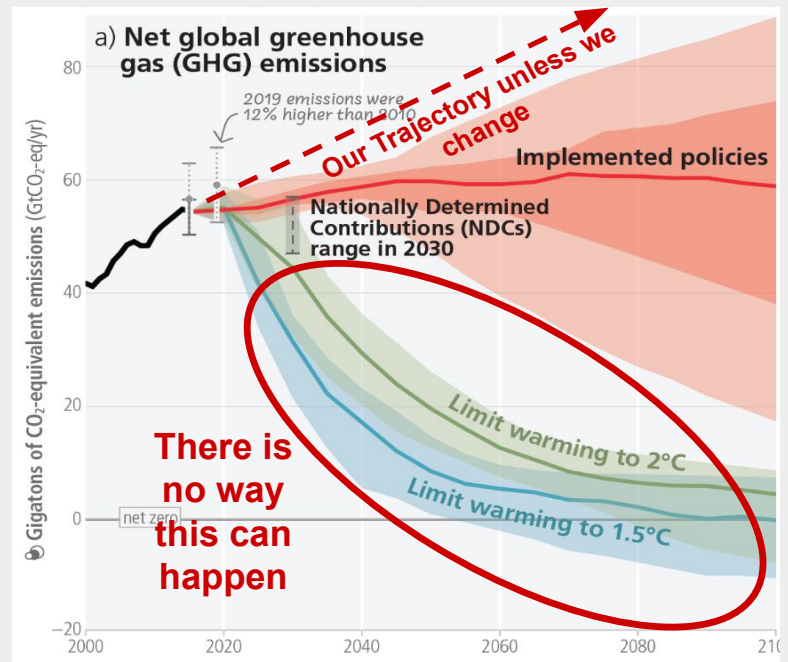
A major disruption of attitudes is required - nowhere to be seen yet.

FUNDAMENTAL:

Carbon Emissions must be stopped and atmospheric carbon removed

REQUIRED:

- National awareness that we have an urgent problem
- Global Cooperation for Drastic and Urgent Emissions Cuts
- Global Coordination of Migrations, which have already started



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

FOR ACCESS TO TODAY'S PRESENTATIONS



You can access all the other references from the Presentation Pages

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