The science and progress

We need to talk about Climate
Part 2

What have scientists observed about changes to the global climate?

The WMO State of the Global Climate 2023 report[2], showed that the year 2023:

- had record greenhouse gas levels (Carbon dioxide levels are now higher (419.3 ppm) than any time in the past 800,000 years - even as far back as 4 million years[3])
- was the hottest year in recent history[1], 1.45°C above pre-industry levels (Fig 1 and Fig 2) and higher since the last ice age and the Holocene when humans evolved. (This temperature is very close to the lower limit of 1.5°C, set by the Paris Agreement on Climate Change in 2015.)
- broke records for ocean heat, marine heatwaves, sea level rise, Antarctic sea ice losses, and glacier retreat)

[1] Recently released data shows that **2024 was even hotter than 2023,** NOAA 2025.

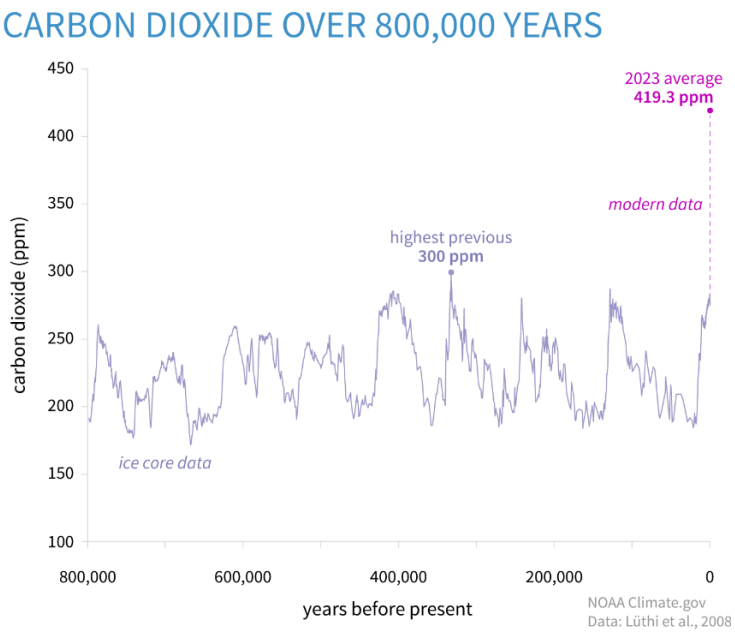

Figure 1. Carbon dioxide in the atmosphere for the past 800,000 years (Source: NOAA climate.gov Data: Luthi et al 2008)

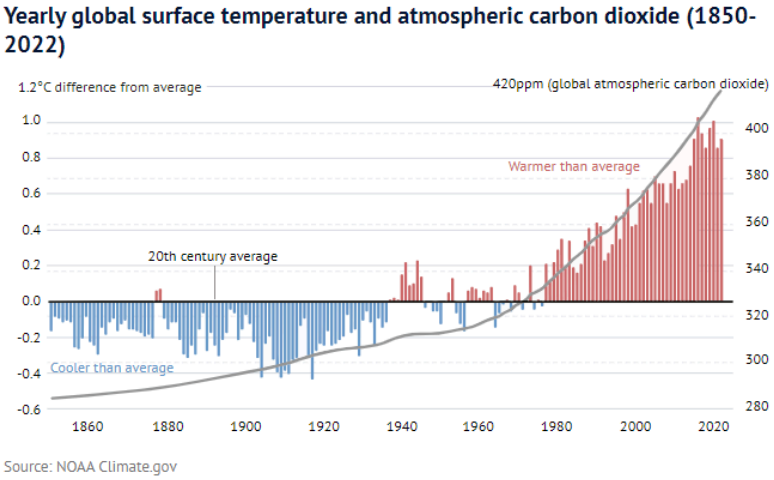

Figure 2. Yearly global air surface temperature and atmospheric carbon dioxide (Source: NOAA Climate.gov)

Note that the 2023 surface air temperature anomaly was 1.45°C, the hottest year in recent history[2].

How do scientists measure past temperatures and levels of carbon dioxide?

Modern day scientists use infrared probes or mercury filled thermometers to measure temperatures. To study past climates, scientists need to use other geological measures, such as:

- Tree rings – the wider the ring, the warmer the temperature for that year (100s to 1000s of years)
- Ice cores - from examining the small bubbles locked away in the layers of ice in ice cores extracted from ice sheets and glaciers, scientists can measure the levels of carbon dioxide, oxygen and nitrogen gases present in past atmospheres. From these measurements, scientists can estimate the temperatures of these past atmospheres from laboratory experiments to measure how these gases retain heat in today's atmospheres[4]. (100s to 1000s of years)
- Naturally occurring isotopes – a common measure is the ratio of the two oxygen isotopes, oxygen-16 and oxygen-18, found in fossils of marine organisms such as corals, clams, and small single celled organisms called Foraminifera (100,000s to millions of years)

What are fossil fuels and how were they formed?

Fossil fuels are formed from the breakdown of fossilised remains of ancient animals and plants that have been buried under layers of rock and subjected to heat and pressure. Over millions of years, plankton decomposes into natural gas and oil, and plants form coal which can be extracted from the earth and used as fuels. Fossil fuels are basically hydrocarbons. When these fuels are burned, as in coal-fired generators or in petrol or diesel vehicles, carbon dioxide gas and water vapour are emitted, adding huge amounts of these greenhouse gases to those naturally occurring in the atmosphere.

How do greenhouse gases cause global warming?

Energy from the Sun reaches the Earth mainly as visible light, which is absorbed by the ground, cities, lakes and oceans. Some of this absorbed energy is reradiated as infrared radiation, at a longer wavelength. Certain gases in the atmosphere, such Nitrogen and Oxygen which are very abundant in the atmosphere, do not absorb these wavelengths of infrared radiation and it passes through unheeded back into space. Other gases, the so called "greenhouse gases ", such as carbon dioxide and methane do absorb these wavelengths and reradiate some back to Earth and some out into space (Figure 3). Fecht 2021

Human activities (such as burning fossil fuels, farming livestock, clearing natural vegetation) and have increased the amount of greenhouse gases in the atmosphere, leading to more reradiated infrared energy from the Earth being absorbed, and heating of the atmosphere and the Earth's surface.

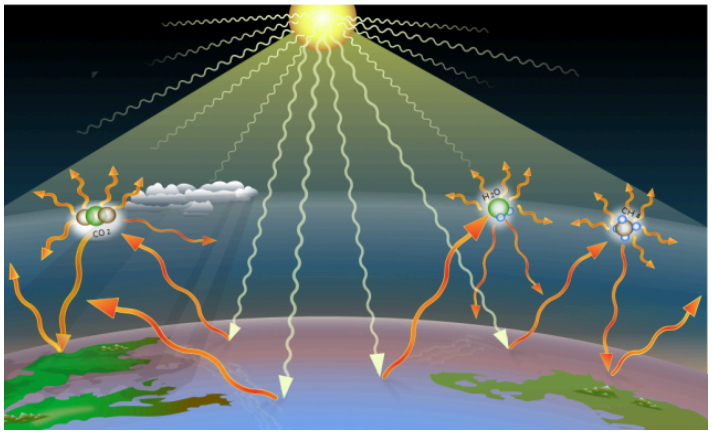

Figure 3. Absorption of infrared radiation from greenhouse gases in the atmosphere. Credit: A loose necktie on Wikimedia Commons

Are we already seeing the impacts of climate change?

The answer is YES. We are already seeing an increase in the frequency and intensity of extreme weather events, such as: heatwaves, tropical cyclones, droughts, extreme rainfall and flooding, and wildfires - causing huge economic losses and misery to millions of people. These events are disproportionally affecting poor and vulnerable people[2]. Increasing ocean temperatures has led to bleaching events in coral reefs, such as the Australian Great Barrier Reef, impacting on reef ecosystems, and the associated tourism industry.

These changes are already impacting food security, water security, agricultural productivity, extreme heat events. They have also lead to an increase in climate-related food borne and water borne diseases, and vector borne diseases; increased mental health challenges and trauma from extreme events; and increased the adverse impacts on infrastructure, human health, livelihoods and cultures[5].

About a quarter of the extra CO_2 in the atmosphere is being absorbed by the oceans, changing the PH of marine waters, a process called acidification. According to The State of the Global Climate 2023, "Ocean acidification affects organisms and ecosystem services, including food security, by reducing biodiversity, degrading habitats and endangering fisheries and aquaculture[2].

Depending on how quickly steps are taken to mitigate (reduce) the emissions of greenhouse gases, we can expect to see the above impacts continue, and likely become even more severe over coming decades[5]. Watch this video to learn the current state of climate crisis and the tipping points of climate change (e.g. thawing of the permafrost) Ted Talk Johan Rockstrom and Tipping Points Climate Council.

What are climate tipping points?

Climate tipping points can be defined as: “the point at which a slow, reversible change becomes irreversible, often with dramatic consequences” An example of a tipping point is the melting of the vast permafrost (frozen tundra across northern Canada, Alaska and Siberia), which will release vast quantities of methane, a potent greenhouse gas, increasing the rate of global warming. Another example is the melting of the Arctic and Antarctic icesheets, which will not only increase sea level rises, but also reduce the reflection of sunlight off the icesheets (albedo effect), increasing the sunlight absorbed by the oceans. Scientists do not know when these tipping points may be triggered. Bill McGuire 2023

What is being done to deal with a rapidly changing climate?

Action to transition to a low GHG economy is taking place at many levels of society:

- **Globally**
    - International research and conventions, such as the United Nations Conference of Parties (COP), where business and government leaders and other interested parties, gather to discuss global initiatives. In 2024, COP 29 was held in Baku, Azerbaijan with the purpose:
      to engage and enhance ambition and enable action to reduce emissions, adapt to climate change, and address loss and damage, to implement and transform key climate related decisions into concrete actions and credible plans to tackle climate change COP 29
    - The State of the Global Climate 2023 report showed promising progress resulting from existing efforts: climate adaptation financing is increasing, and renewable energy projects are booming worldwide. The report pointed out that the cost of climate inaction will be higher than the cost of taking climate action.
- **Countries**
    - 103 countries have communicated net zero targets (in law, policy documents, political pledges). These countries emit 80.7% of global GHG emissions. net-zero-tracker
    - Many countries are now ramping up the rollout of renewable projects, as for example Clean Energy Australia 2023, US energy transition 2023, UK renewables 2023
- **Business**
    - Many businesses have developed climate action policies and plans. Check out 168 companies who are leading the net zero transition - climate action100+
- **State and local / municipal governments**

    - Many governments have developed climate action policies and plans. As an example, by 2023, 31% of Australian local governments have committed to ambitious climate targets 100% renewables
- **Philanthropic and community groups**
    - The Rockefeller Foundation provides an example of a major philanthropic group setting policies and plans to meet the Paris Agreement to limit global warming to 1.5°C. The Foundation has set a target of net-zero GHG emissions for its endowments by 2050. It plans to divest its endowments of fossil fuel investments, and commits to spending $1 billion over five years on climate transition projects.
    - The ESRAG Explainer, What is Rotary doing about climate change?, describes the work of a global voluntary organisation to address climate change. Link
- **Education - universities and schools**
    - Universities provide opportunities for climate change education, research and inter-university networking and collaboration. 45 universities have already joined the International Universities Climate Alliance.
    - Many schools are already taking action for climate through their operations and curriculum through government-run programs, such as Australia's ResourceSmart Schools (schools in this program have avoided over 110,000 t GHGs since 2008).
- **Homes**
    - Home and vehicle owners are reducing GHG emissions and saving money through electrification, more energy efficient homes, rooftop solar, using public transport, and electric vehicles.

References

1. Bureau of Meteorology, & CSIRO. State of the climate 2024. https://www.csiro.au/en/research/environmental-impacts/climate-change/state-of-the-climate
2. World Meteorological Organization. (2024). State of the Global Climate 2023. https://library.wmo.int/viewer/68835/download?file=1347_Global-statement-2023_en.pdf&type=pdf&navigator=1
3. Nelima, V. (2021). 10 most important things to know about Climate Change [in pictures]. Retrieved from https://climatematters.substack.com/p/10-things-about-climate-change
4. Keating-Bitonti, C., & Chang, L. (2018). Here's How Scientists Reconstruct Earth's Past Climates. Retrieved from https://www.smithsonianmag.com/blogs/national-museum-of-natural-history/2018/03/23/heres-how-scientists-reconstruct-earths-past-climates/
5. IPCC. (2023). Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_FullVolume.pdf

Other topics in the ESRAG Explainer Series

- Climate: What were they thinking?
- We need to talk about Climate Part 1. The basics
- What is Rotary doing about climate change?
- Climate change and Rotary's Areas of Focus