The Problem of Climate Change

Assignments

Brightspace discussion question:

“What year are you in and what do you want to do after graduation?”

Due this Friday by 5pm.

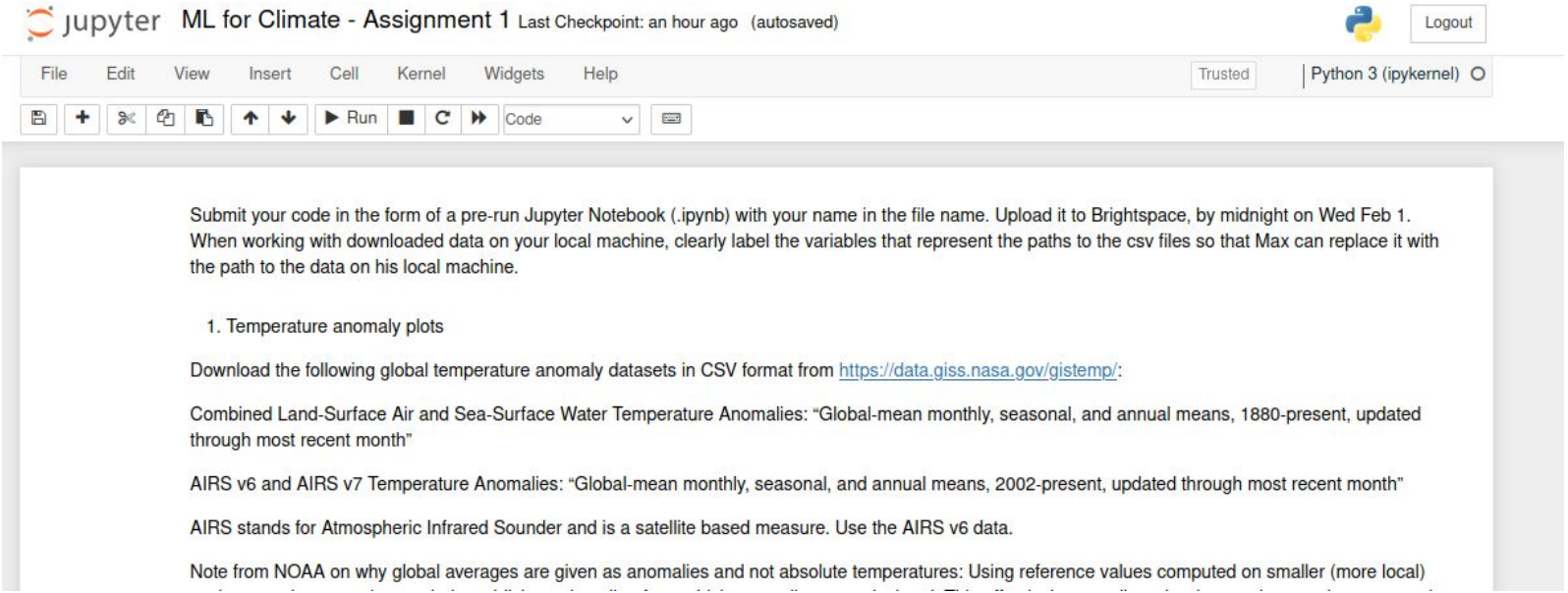
First programming assignment:

Climate data visualization

Due Fri Feb 3 by midnight.

First programming assignment

Find and turn in on Brightspace



Climate change in the news

AP NEWS

U.S. News | World News | Politics | Sports | Entertainment | Business | Technology | Health | Science | Oddities | Lifestyle | Photography | Videos

Trending News | Mass shootings | Russia-Ukraine war | Oscar nominations | NFL Playoffs

Uganda begins oil drilling, hopes for production by 2025

yesterday

KAMPALA, Uganda (AP) — Oil drilling has begun in a Chinese-operated field in Uganda and the East African country expects to start production by 2025, an official said Tuesday.

The spokesman for Uganda's ministry of energy and mineral development, Solomon Muyita, said the beginning of drilling at the Kingfisher oil field in the Kikuube district was "a significant stride" toward achieving commercial oil production.

The project has been strongly criticized on environmental grounds.

The China National Offshore Oil Corporation, CNOOC, operates the field. Uganda is estimated to have recoverable oil reserves of at least 1.4 billion barrels.

Muyita also said construction is starting this year on the 897-mile (1,443-kilometer) East Africa Crude Oil Pipeline, planned by TotalEnergies and CNOOC, between Uganda and the Indian Ocean port of Tanga in Tanzania. Authorities have described it as the world's longest heated oil pipeline.

The pipeline should be completed by 2025 as well, Muyita said.

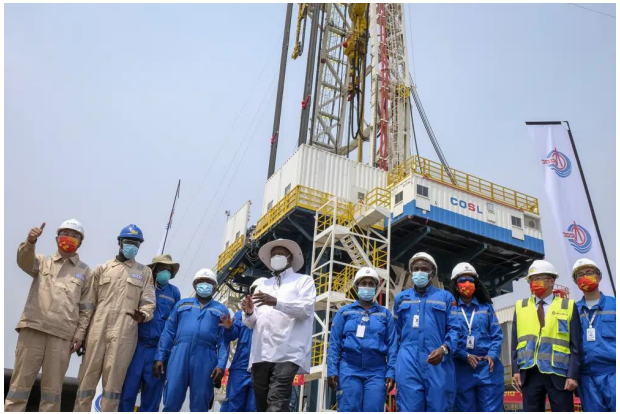
Climate activists have raised concerns about the effects of the pipeline on local communities and the environment.

Uganda's president last year was angered by a resolution by the European Union's Parliament urging the international community to exert "maximum pressure" on Ugandan and Tanzanian authorities, as well as the project promoters and stakeholders, "to protect the environment and to put an end to the extractive activities in protected and sensitive ecosystems, including the shores of Lake Albert."

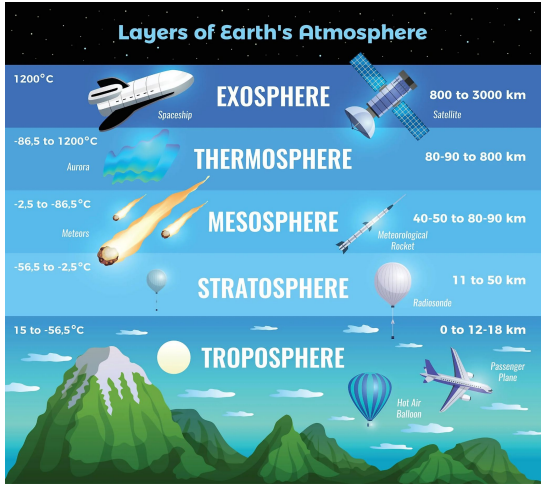
The EU parliament had warned that the pipeline project placed 100,000 people "at imminent risk of displacement ... without proper guarantees of adequate compensation."

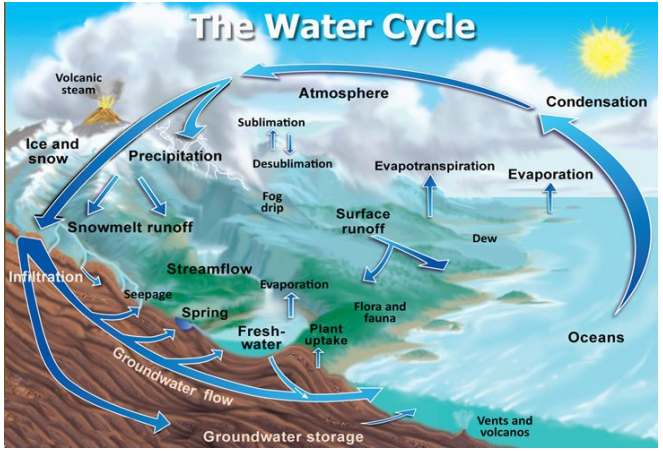
Ugandan authorities see the pipeline as key to economic development and assert that oil wealth can lift millions out of poverty.

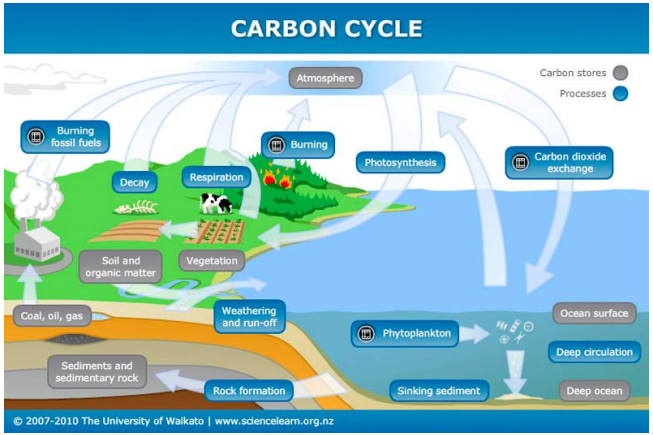
Uganda's National Environmental Management Authority has sought to ease environmental concerns. And Muyita asserted that thousands of families displaced by the project have been compensated.

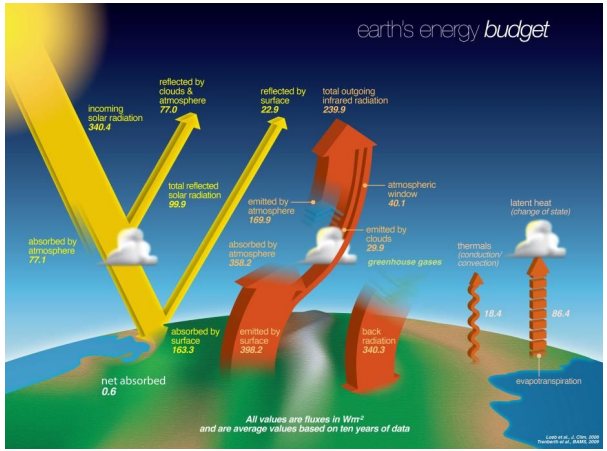


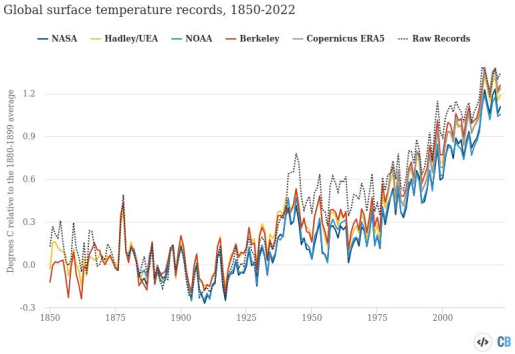
Recap of last lecture



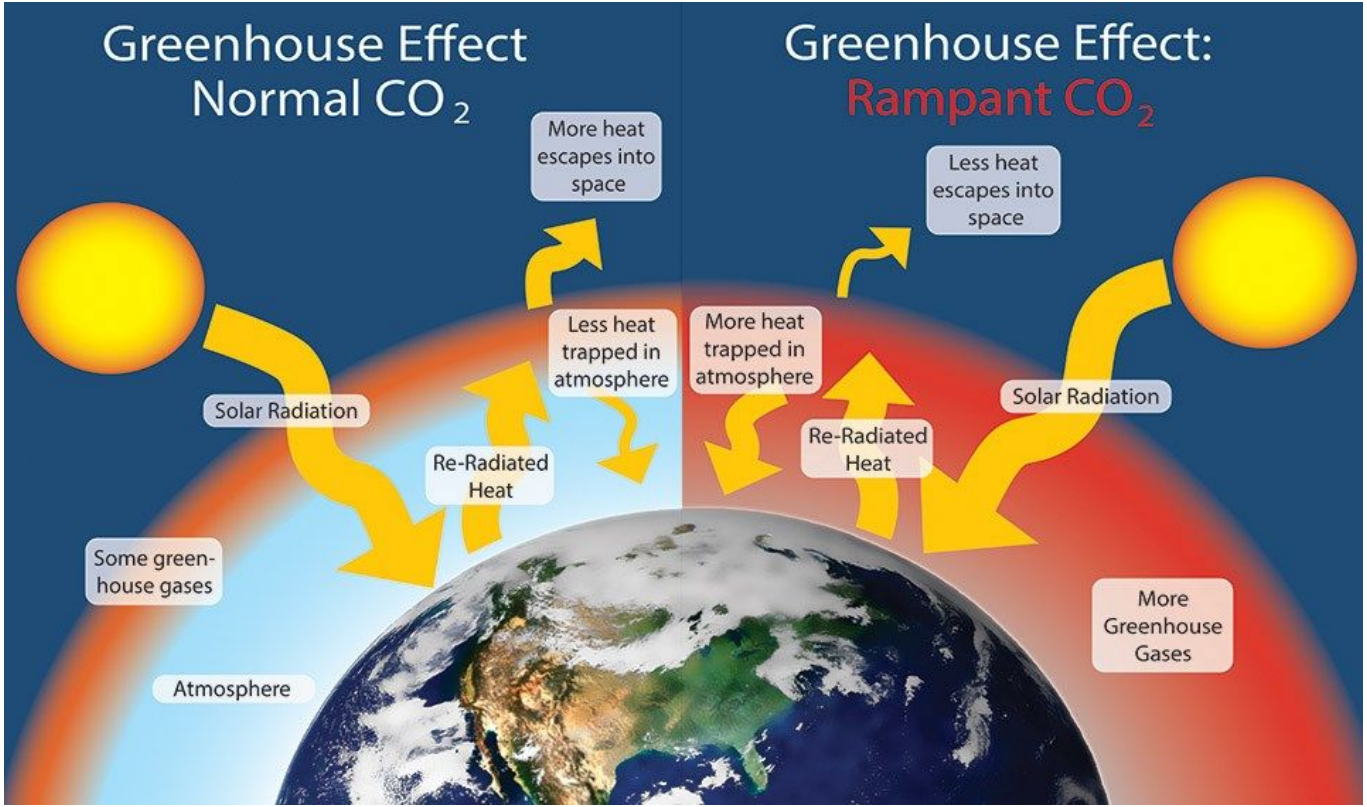






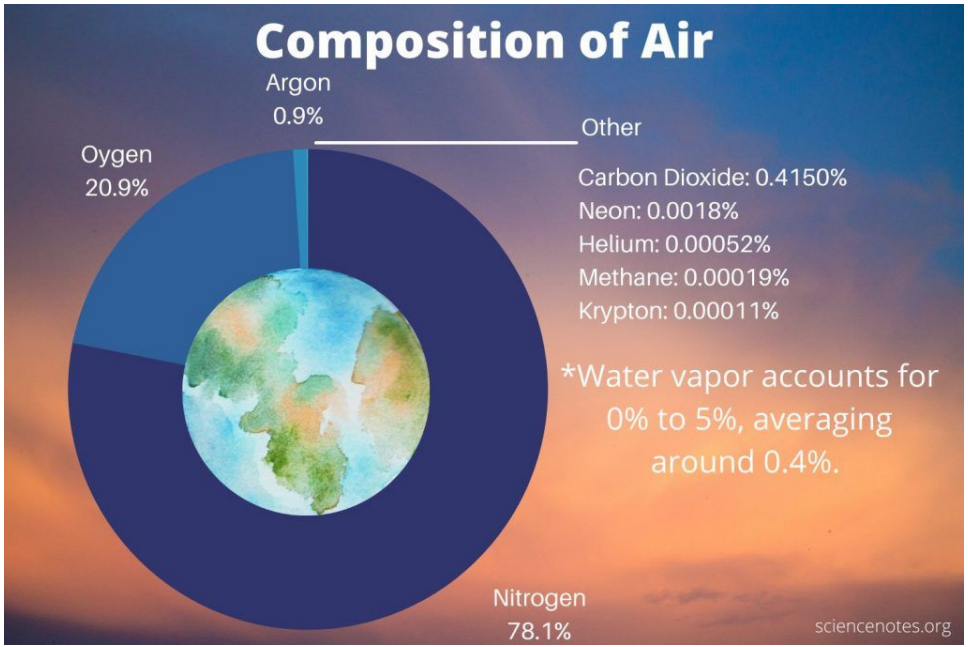


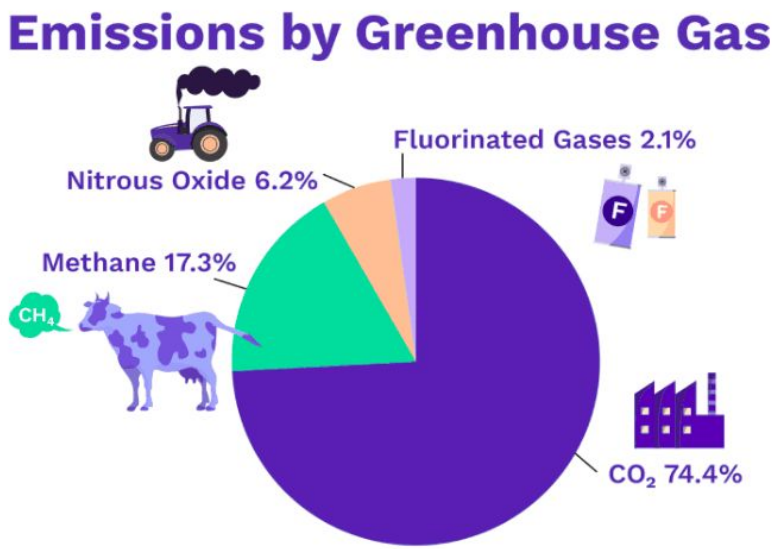
Greenhouse effect



nps.org

What are greenhouse gases?





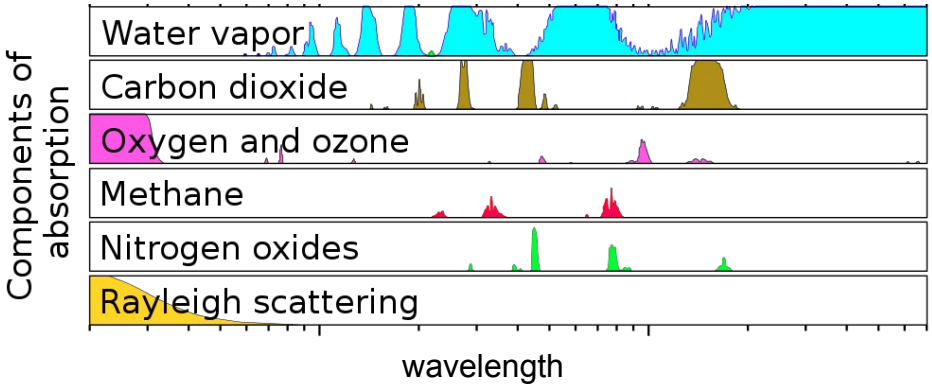
Source: World Resource Institute- [World Greenhouse Gas Emissions: 2016].

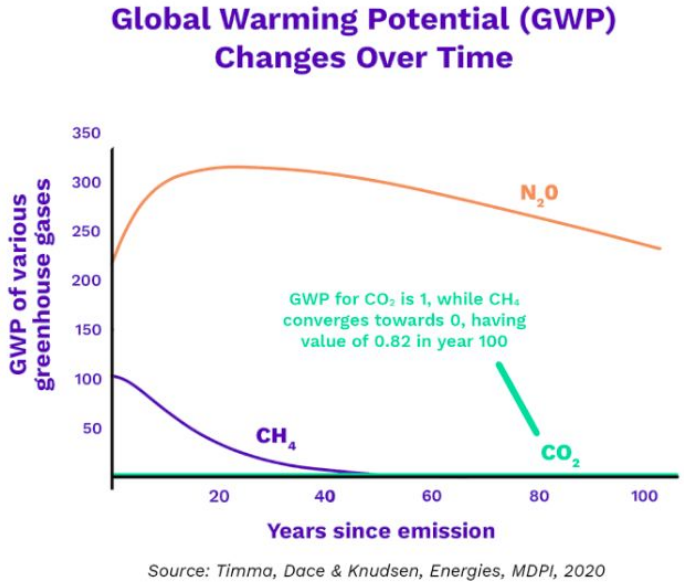
Non-water vapor greenhouse gases make up a tiny (>1%) fraction of the atmosphere

Not all greenhouse gases work the same way

The GWP measures the relative warming impact of one tonne of a greenhouse gas compared to one tonne of CO_2 over a given period of time. Different gases have different effects on warming

Chemical structure determines the absorption properties of gases

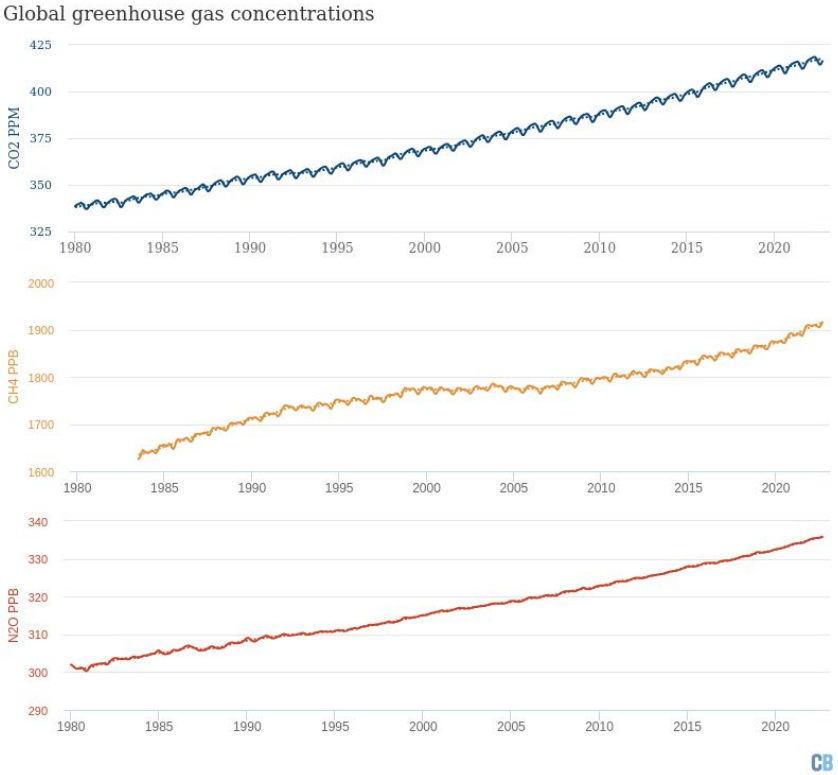


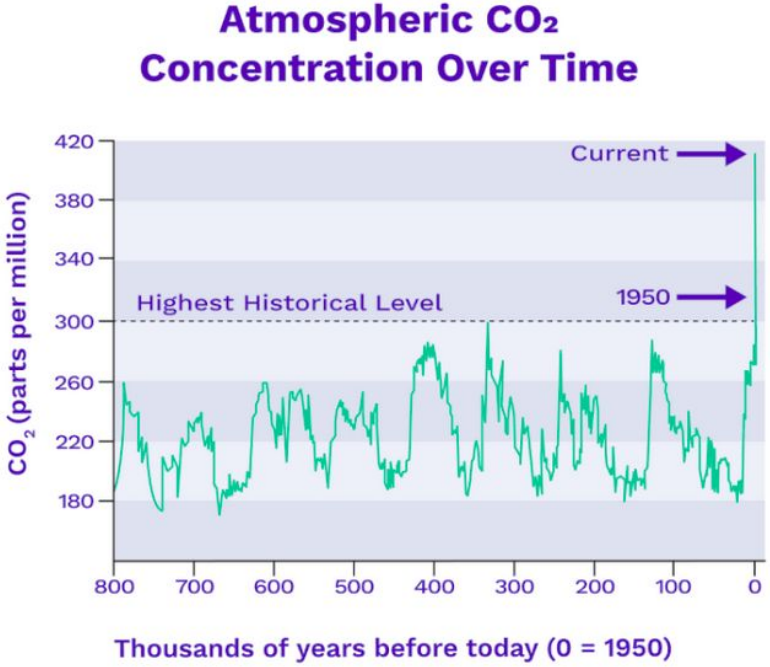


*water vapor has a timescale of only 9 days

climatescience.org

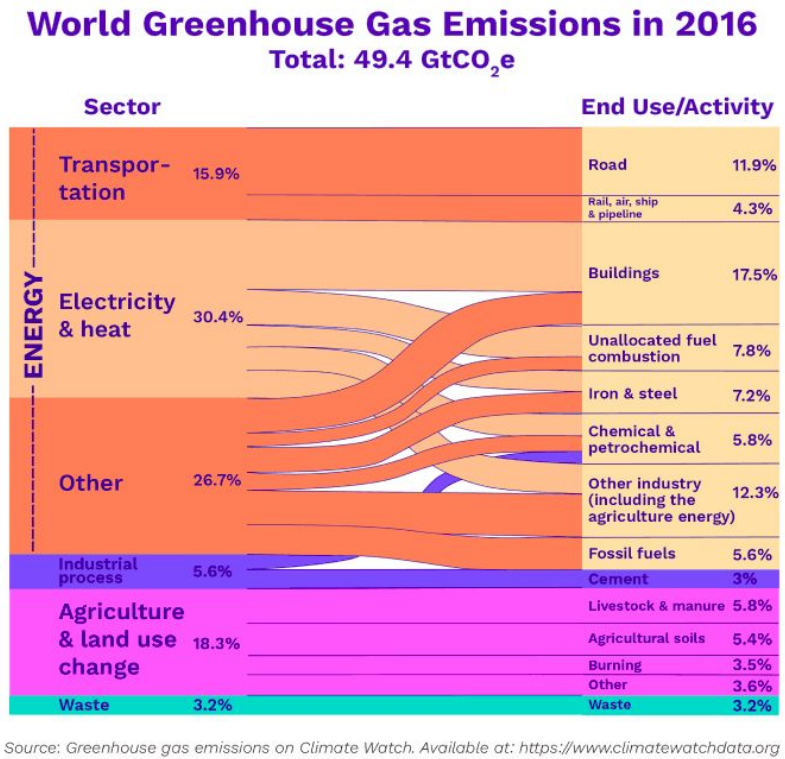
Humans are rapidly increasing the amount of greenhouse gases in the atmosphere





Source: NASACO2, https //climate.nasa.gov/vital-signs/carbon-dioxide

Which activities contribute to GHG emissions?



Source: Greenhouse gas emissions on Climate Watch. Available at: https://www.climatewatchdata.org

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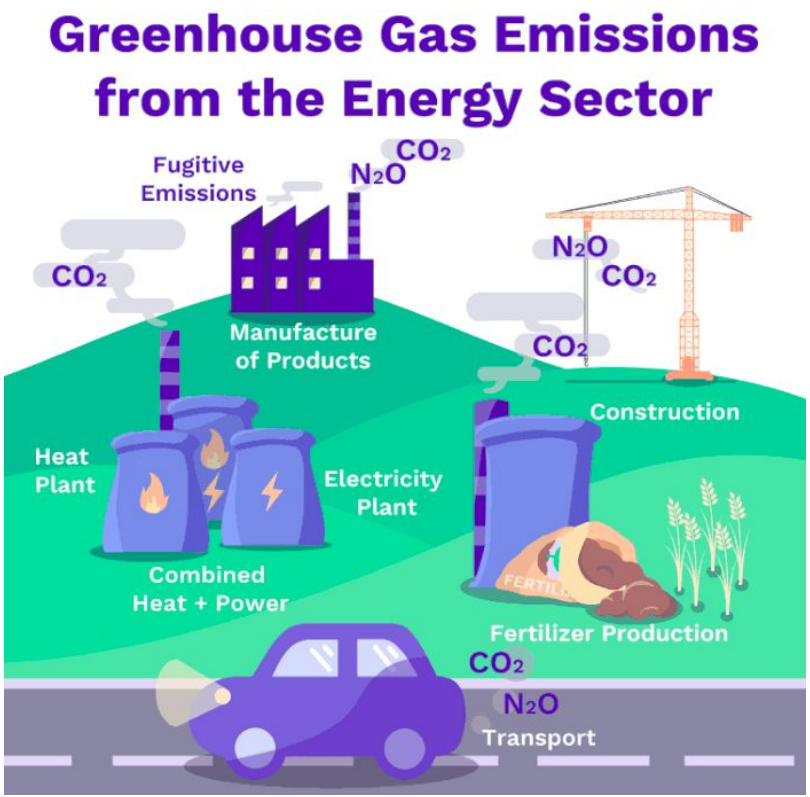

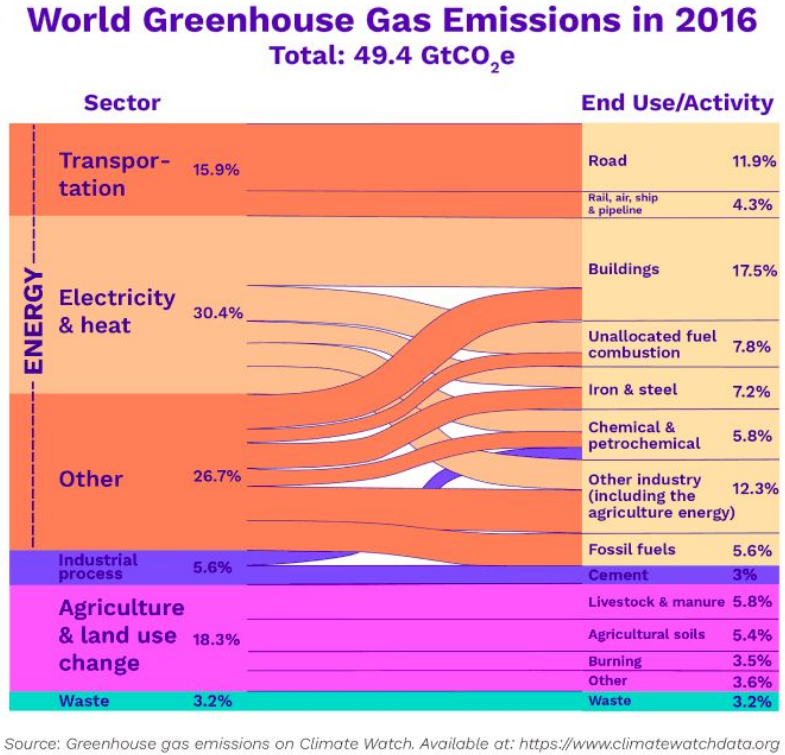

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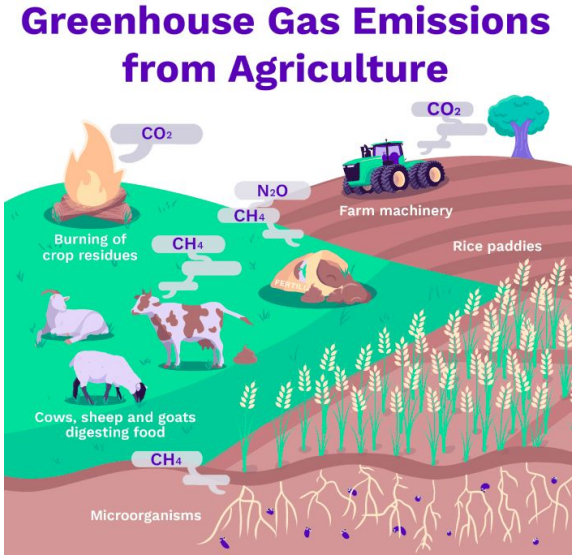
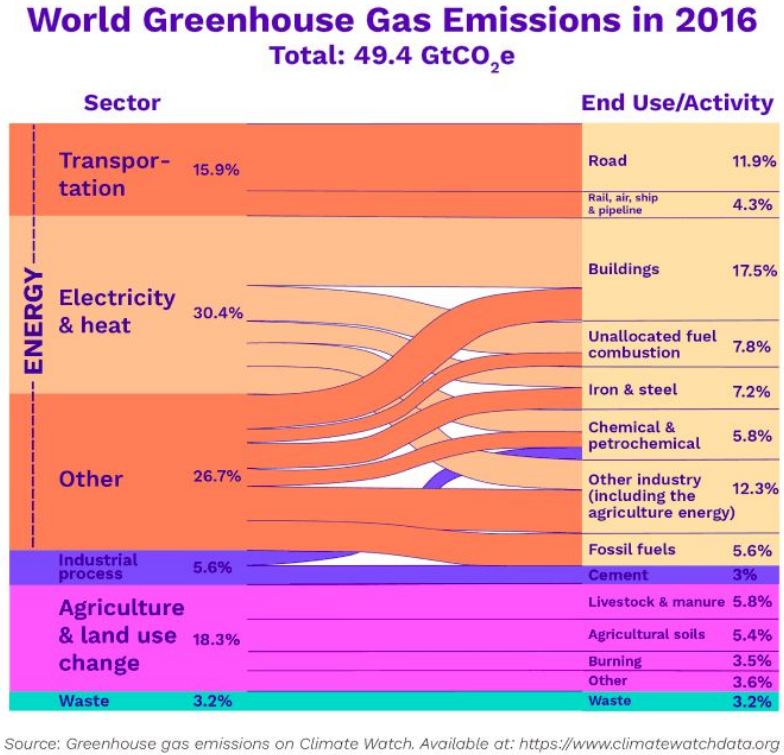


Flooding of rice fields encourages bacteria that decomposes organic matter, leading to up to **12% of global methane emissions**



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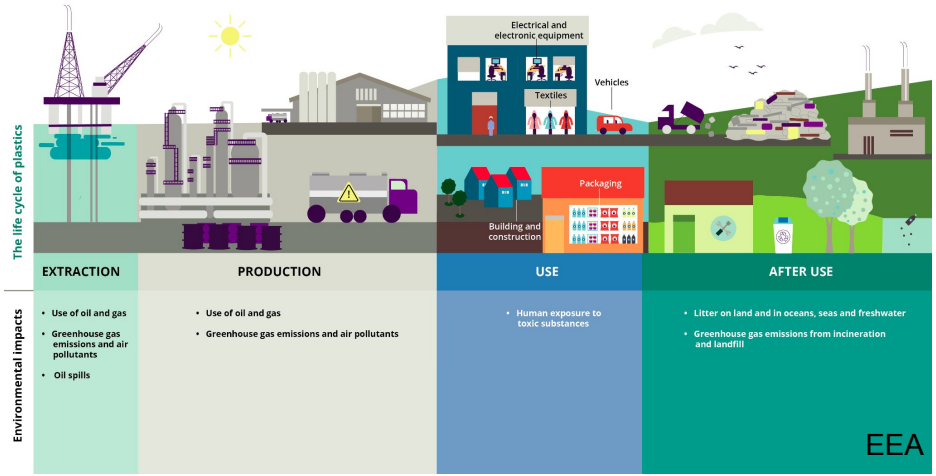
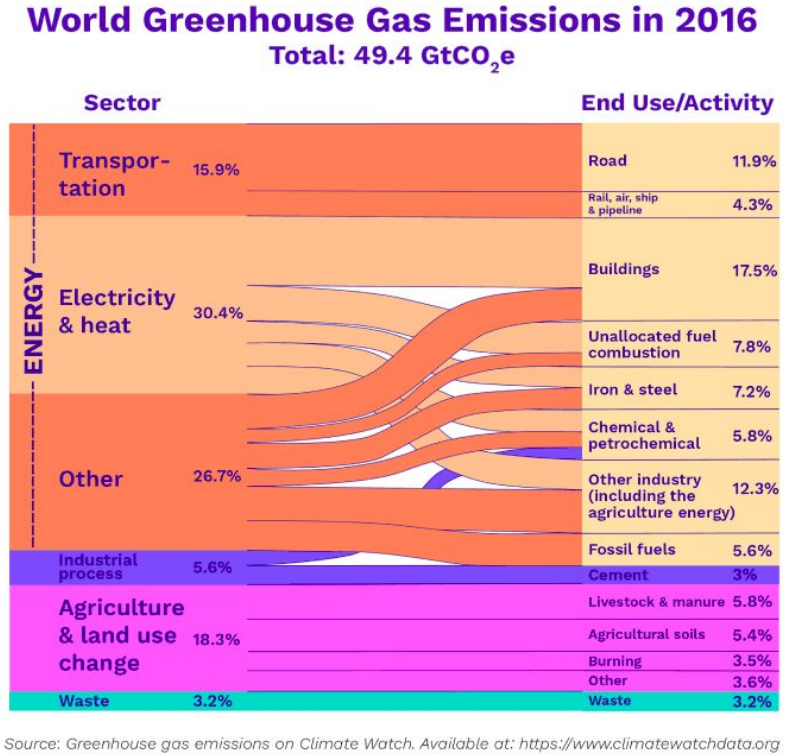




Source: Greenhouse gas emissions on Climate Watch. Available at: https://www.climatewatchdata.org

Industrial processes includes emissions from producing cement, chemicals, and various other materials (like plastics, rubber and human-made fabric).This is one of the fastest growing sources of greenhouse emissions and has grown by 203% since 1990.

Which activities contribute to GHG emissions?

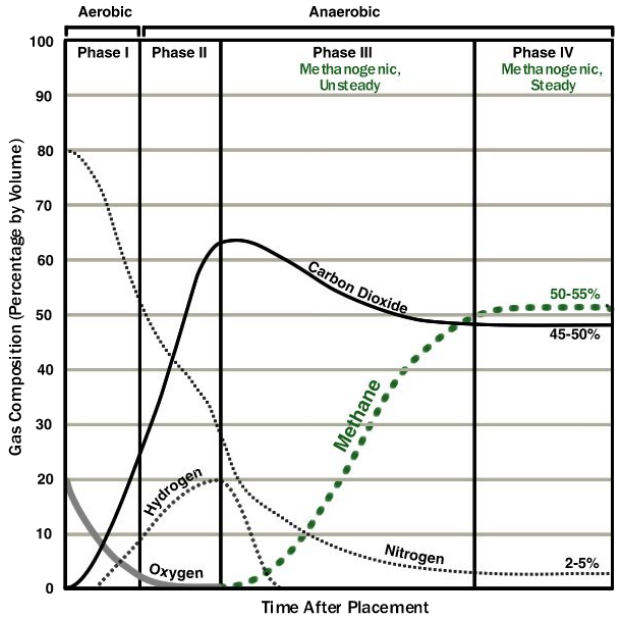
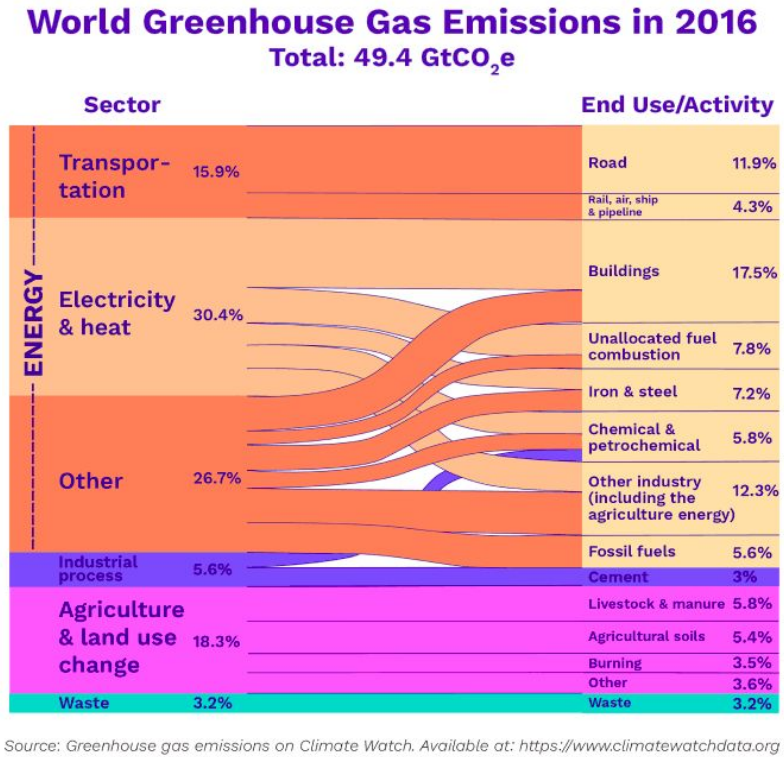


Figure adapted from ATSDR 2008. Chapter 2: Landfill Gas Basics.

Decomposing waste releases a variety of greenhouse gases. Sorting wastewater and treating human sewage also contributes.



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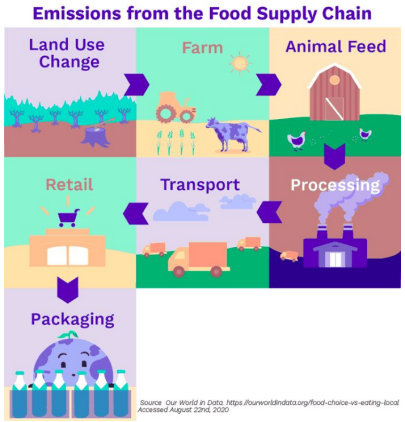
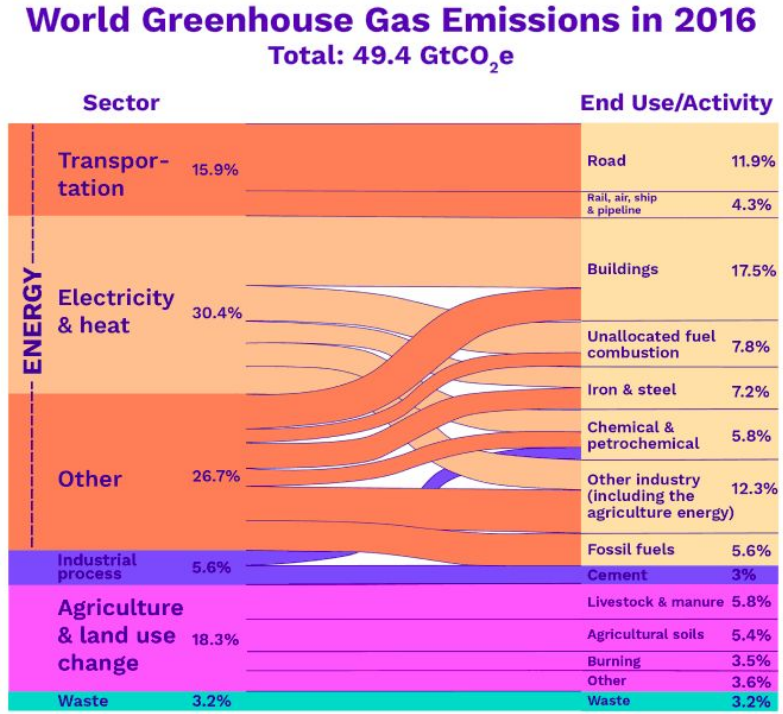


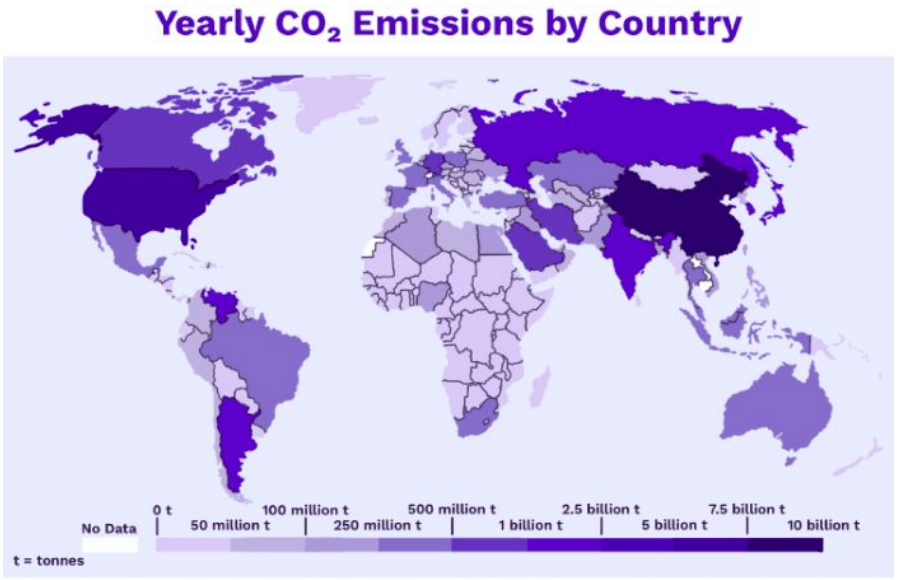
Source: European Parliament.
https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/633143/EPRS_BRI(2019)633143_EN.pdf
Accessed 20 October 2020.



Source: Greenhouse gas emissions on Climate Watch. Available at: https://www.climatewatchdata.org

Calculating GHGs in terms of end product can be more effective for encouraging individual change.

Where are GHGs coming from?



Source: OWID - [CO2 and Greenhouse Gas Emissions] Accessed on [05/08/20]

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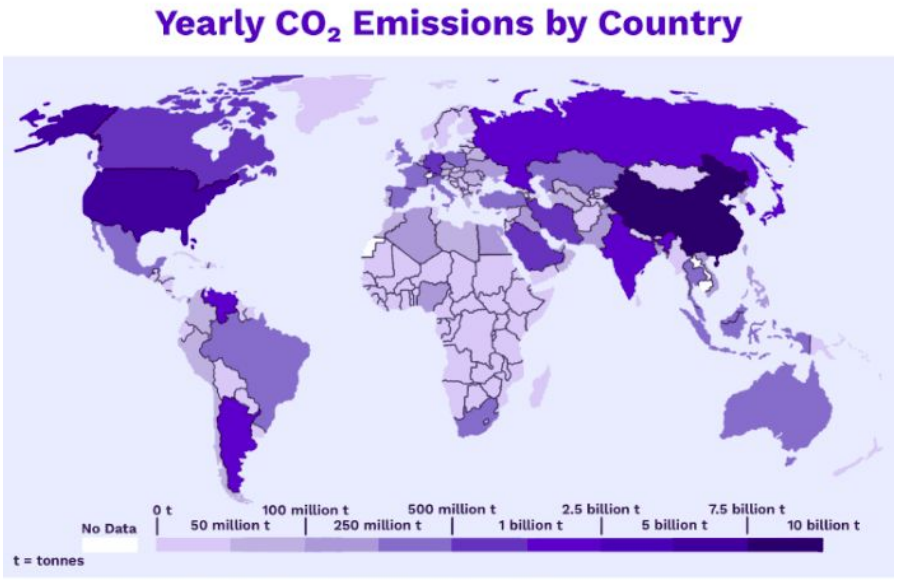

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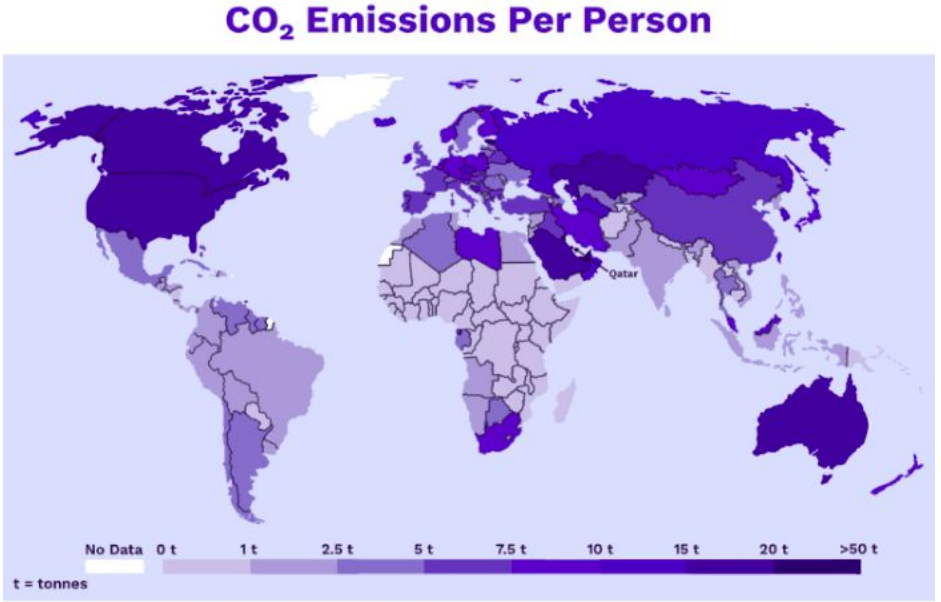

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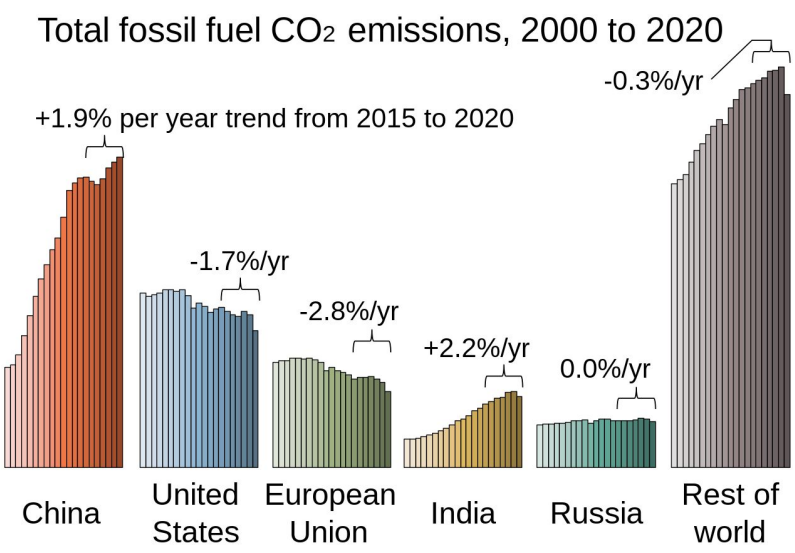
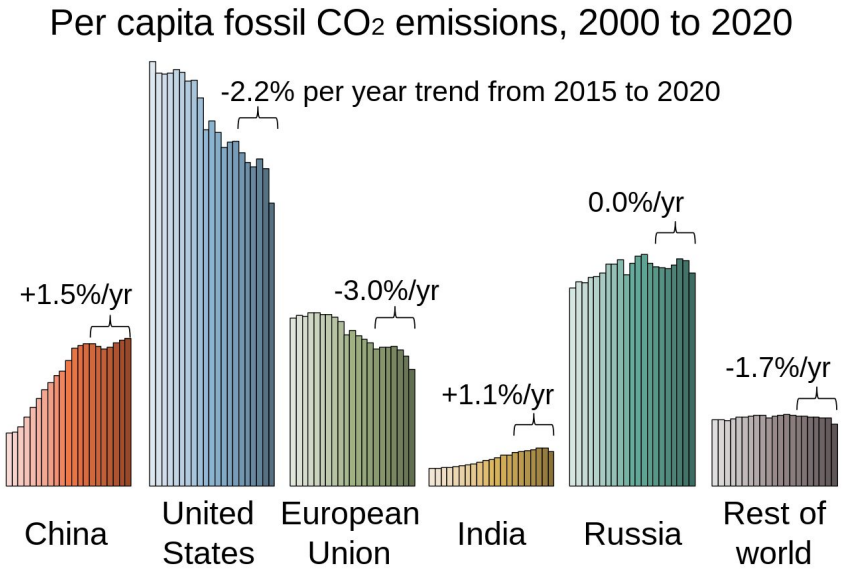
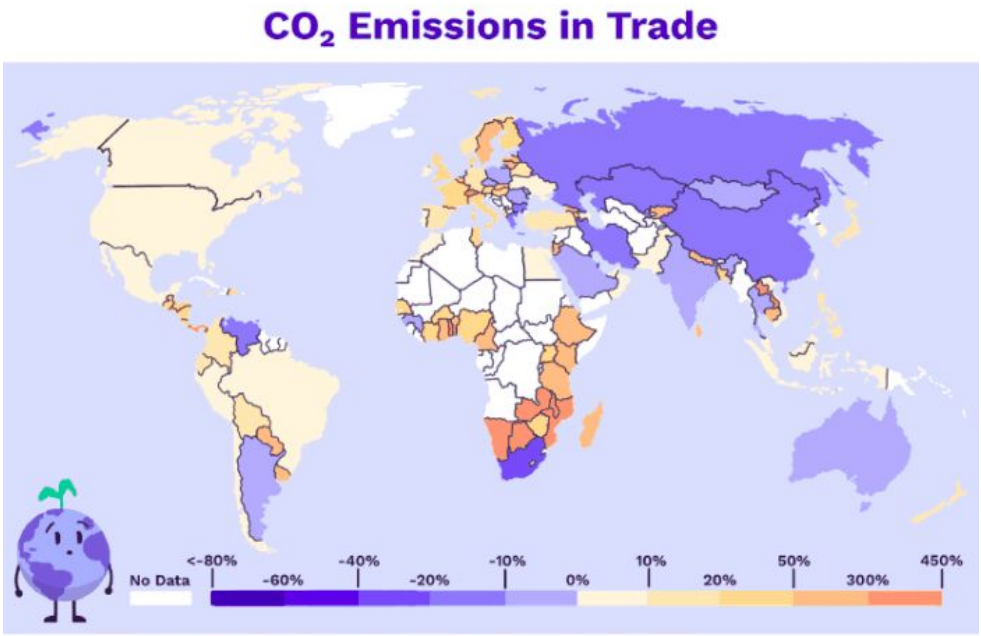




global carbon product

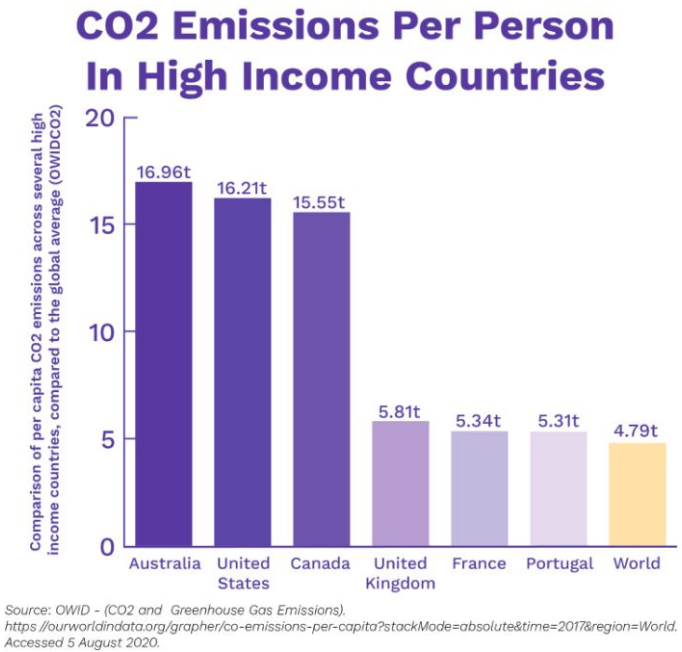
Where are GHGs coming from?

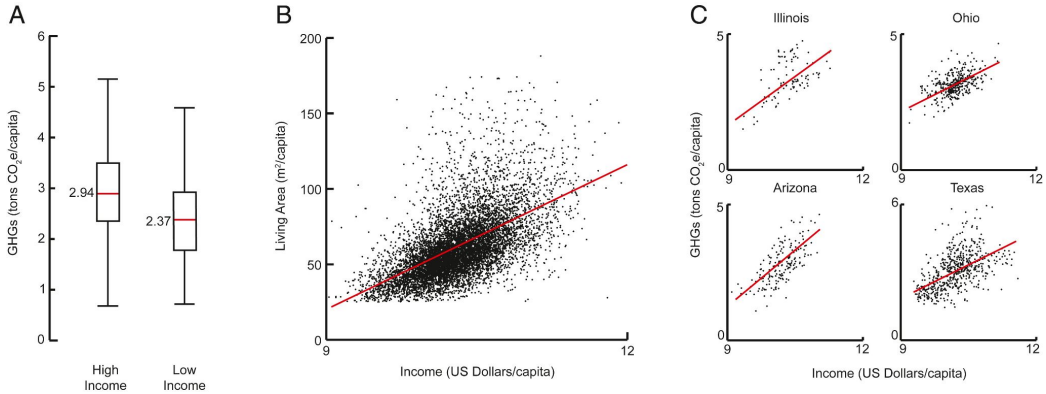


Source: OWID - [CO2 and Greenhouse Gas Emissions]. Accessed on [05/08/20]

Countries shown in blue are net exporters of emissions; more CO_2 is released in the production of goods that are then exported than in the products that are imported.

Where are GHGs coming from?





Goldstein et al, 2020

ENVIRONMENT

Investments of 125 billionaires have the same carbon footprint as France, study finds

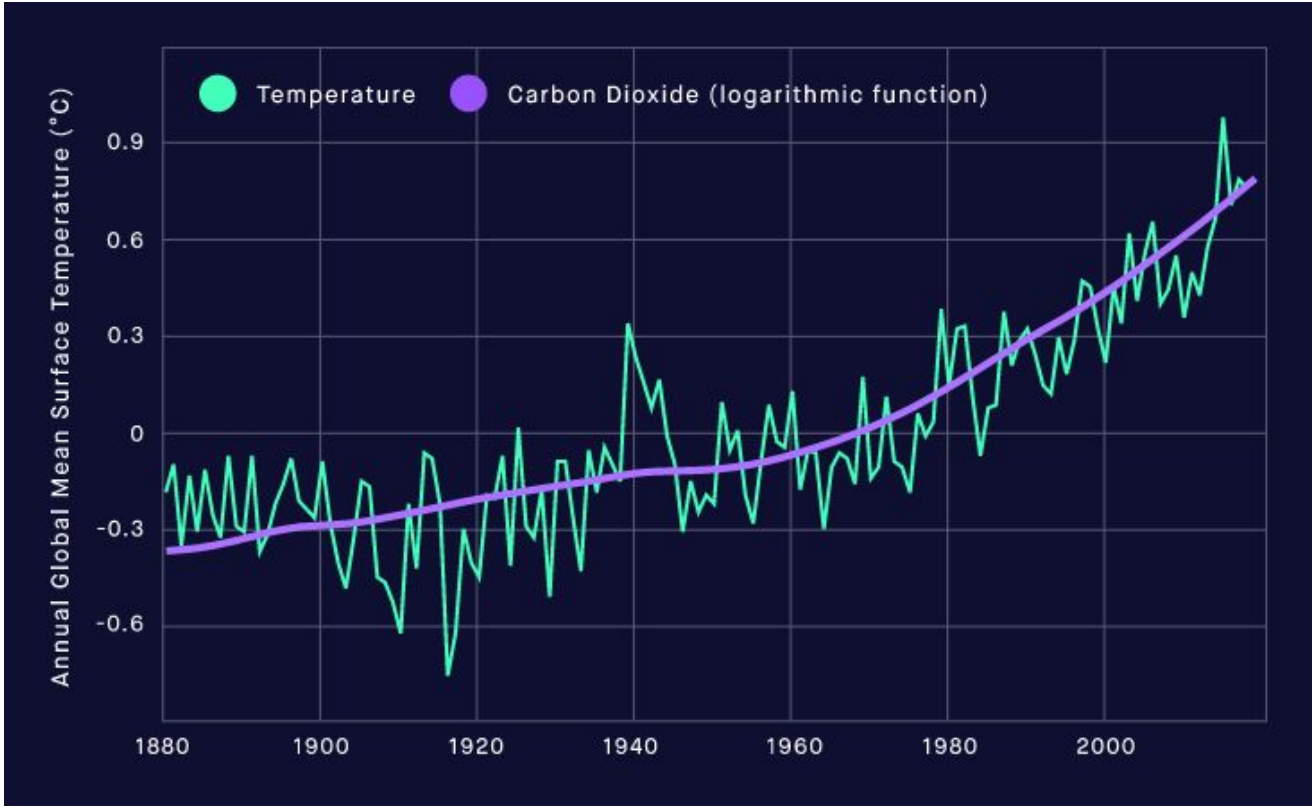
November 9, 2022 · 5:25 AM ET

AYANA ARCHIE

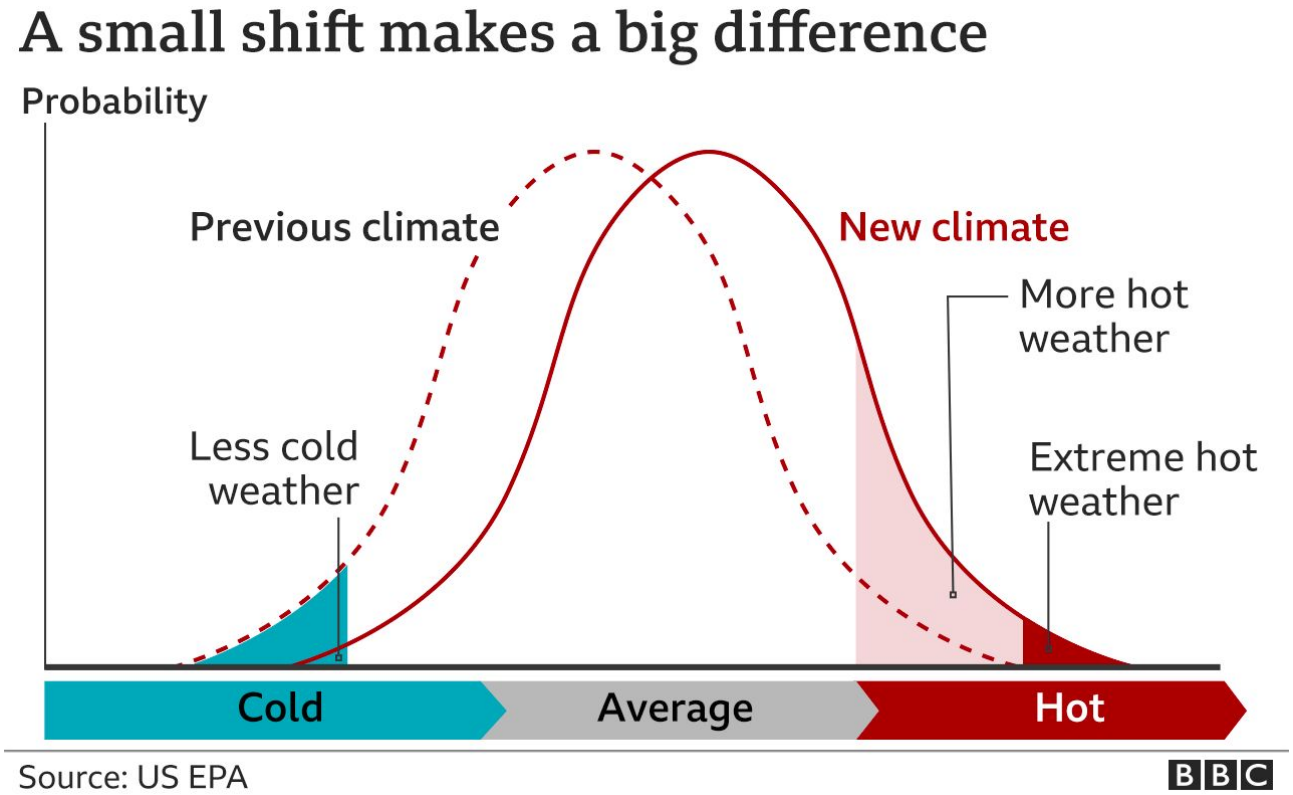
There is an association between income and per capita and emissions, on a local and global scale.

MIT climate primer

Human-caused climate change has already occured



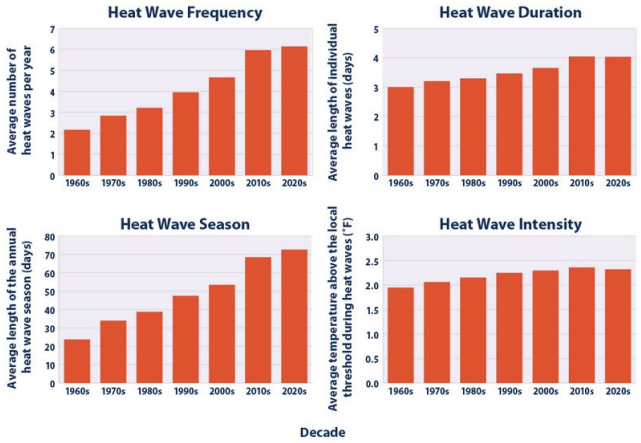
Climate change increases extreme events



EPA

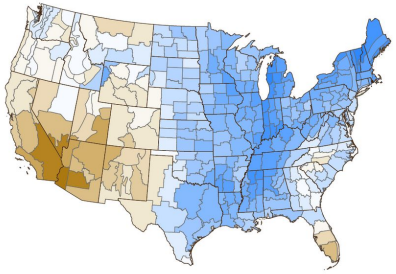
Climate change has already increased extreme events

Figure 1. Heat Wave Characteristics in the United States by Decade, 1961–2021



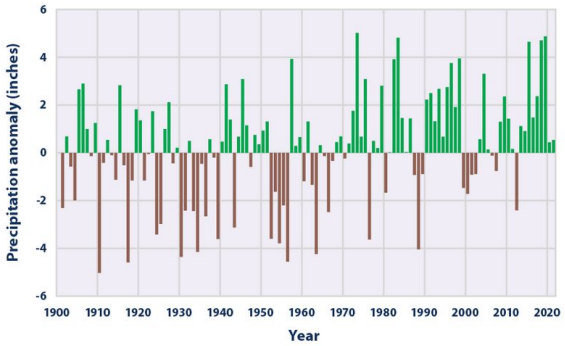
This indicator measures drought conditions of U.S. lands.

Figure 3. Average Change in Drought (Five-Year SPEI) in the Contiguous 48 States, 1900–2020



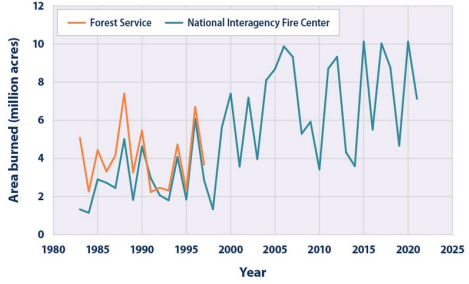
This indicator describes trends in average precipitation for the United States and the world.

Figure 1. Precipitation in the Contiguous 48 States, 1901–2021



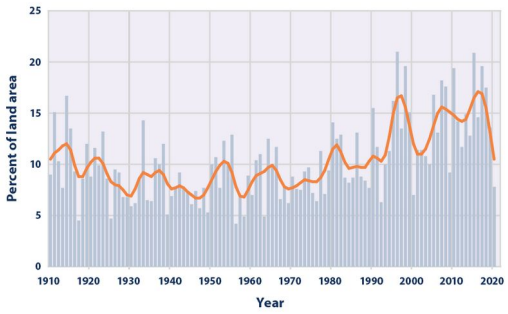
This indicator tracks the frequency, extent, and severity of wildfires in the United States.

Figure 2. Wildfire Extent in the United States, 1983–2021



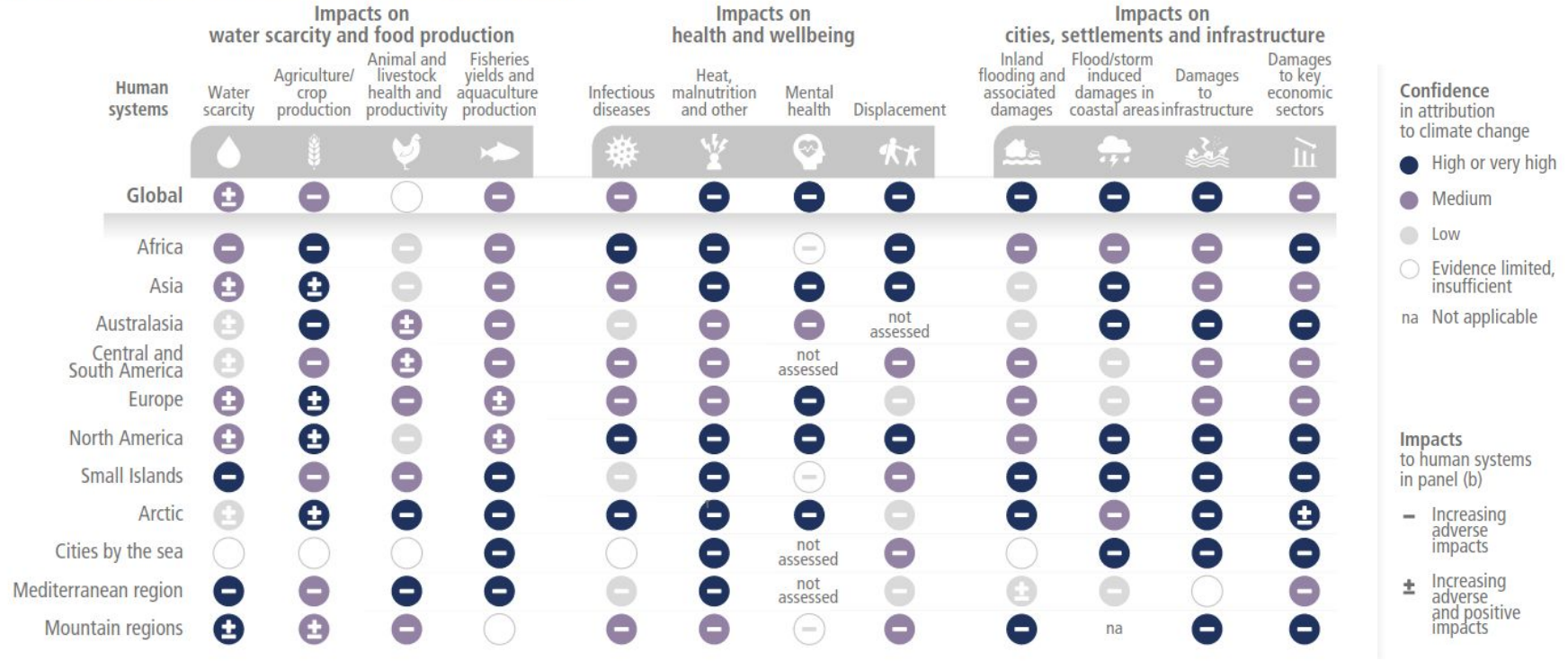
This indicator tracks the frequency of heavy precipitation events in the United States.

Figure 1. Extreme One-Day Precipitation Events in the Contiguous 48 States, 1910–2020



Climate change has already impacted human systems

(b) Observed impacts of climate change on human systems



What’s in store for the future?

Paris Agreement

- International treaty on climate change adopted in 2015
- Aims are to keep the rise in mean global temperature to well below 2 °C above pre-industrial levels (preferably to 1.5 °C), to increase the ability to adapt to climate change, and to encourage finance flows to support emissions reductions.
- Different scenarios have been devised to understand how to achieve these goals.

Shared Socio-Economic Pathways (SSPs)

- 5 narrative scenarios, representing different approaches and resulting challenges
- SSPs include social, economic, and governmental forces and challenges
- Provide a framework for making predictions of possible futures

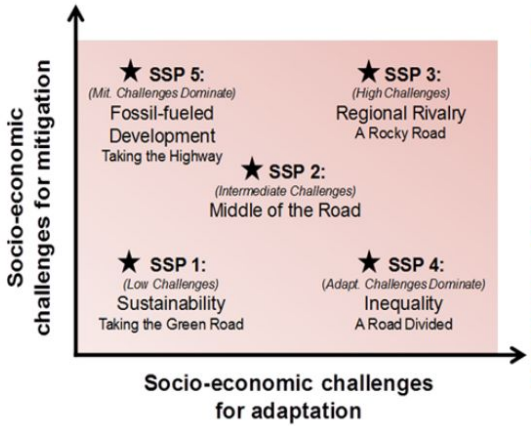


Fig. 1 Overview of SSPs
(Narratives in O'Neill et al., 2016, Glob Env Change, online first)

SSP1: low challenges for mitigation (resource efficiency) and adaptation (rapid development)
SSP3: high challenges for mitigation (regionalized energy / land policies) and adaptation (slow development)
SSP4: low challenges for mitigation (global high tech economy), high for adapt. (regional low tech economies)
SSP5: high challenges for mitigation (resource / fossil fuel intensive) and low for adapt. (rapid development)

The Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change.

Reports

The IPCC prepares comprehensive Assessment Reports about the state of scientific, technical and socio-economic knowledge on climate change, its impacts and future risks, and options for reducing the rate at which climate change is taking place. It also produces Special Reports on topics agreed to by its member governments, as well as Methodology Reports that provide guidelines for the preparation of greenhouse gas inventories. The IPCC is working on the Sixth Assessment Report which consists of three Working Group contributions and a Synthesis Report. The Working Group I contribution was finalized in August 2021, the Working Group II contribution in February 2022 and the Working Group III contribution in April 2022.

Working Group 1
The Physical Science Basis

This report focuses on how and why the world's climate has changed in the past, and how it is projected to change in the future.

Working Group 2
Impacts, Adaptation, and Vulnerability

This report focuses on how climate change affects people, our built systems, and the natural world. It also addresses how we can adapt and become more resilient to climate change.

Working Group 3
Mitigation of Climate Change

This report focuses on the actions we can take to reduce future climate change and prevent it from becoming too extreme.

Scenarios considered in recent IPCC reports

SSP1-1.9 for the 1.5°C Paris Agreement goal

SSP1-2.6 for sustainable pathways

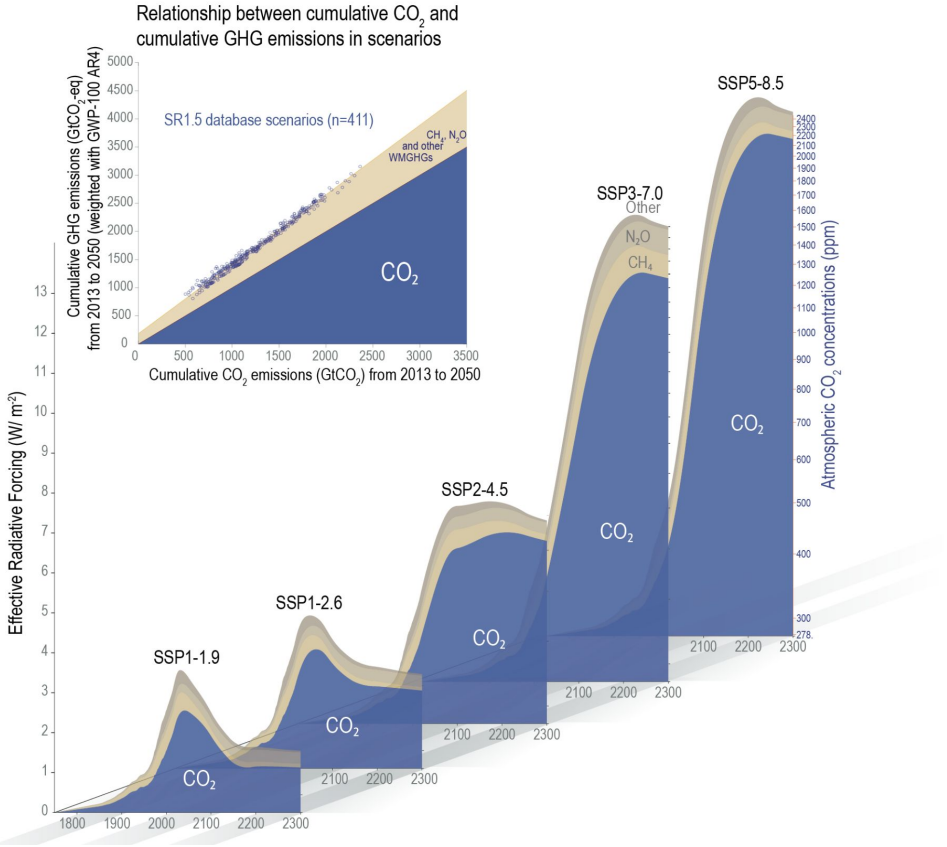
SSP2-4.5 for middle-of-the-road

SSP3-7.0 for regional rivalry

SSP5-8.5 for fossil fuel-rich development.

(Labels indicate SSP type and amount of radiative forcing)

Possible futures



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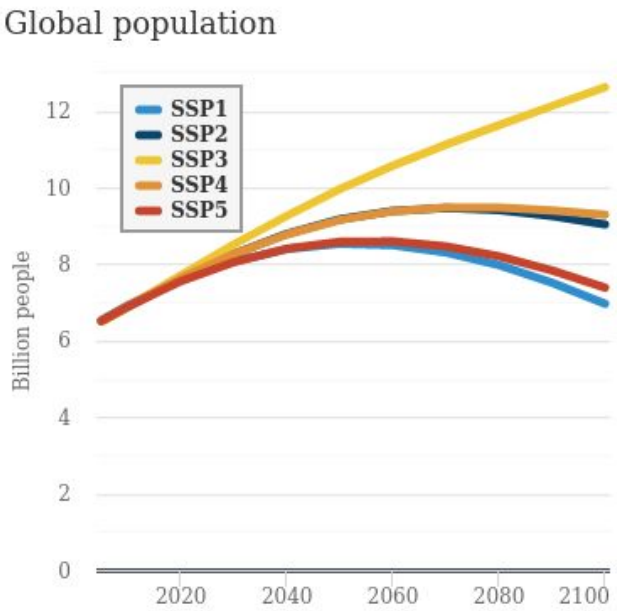
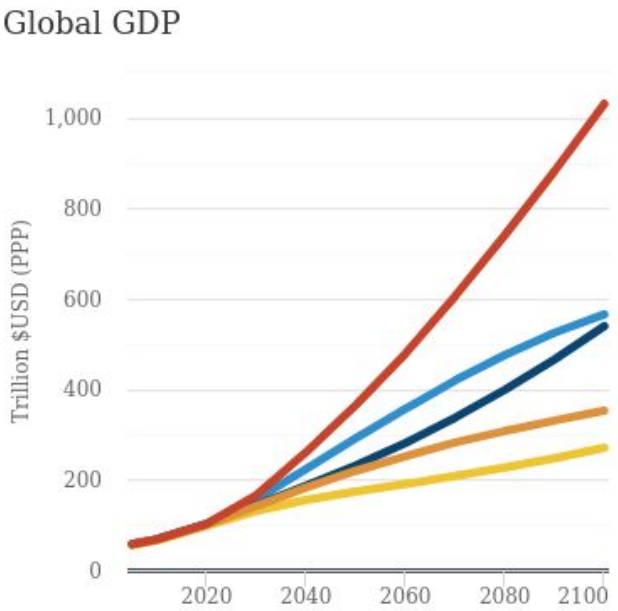
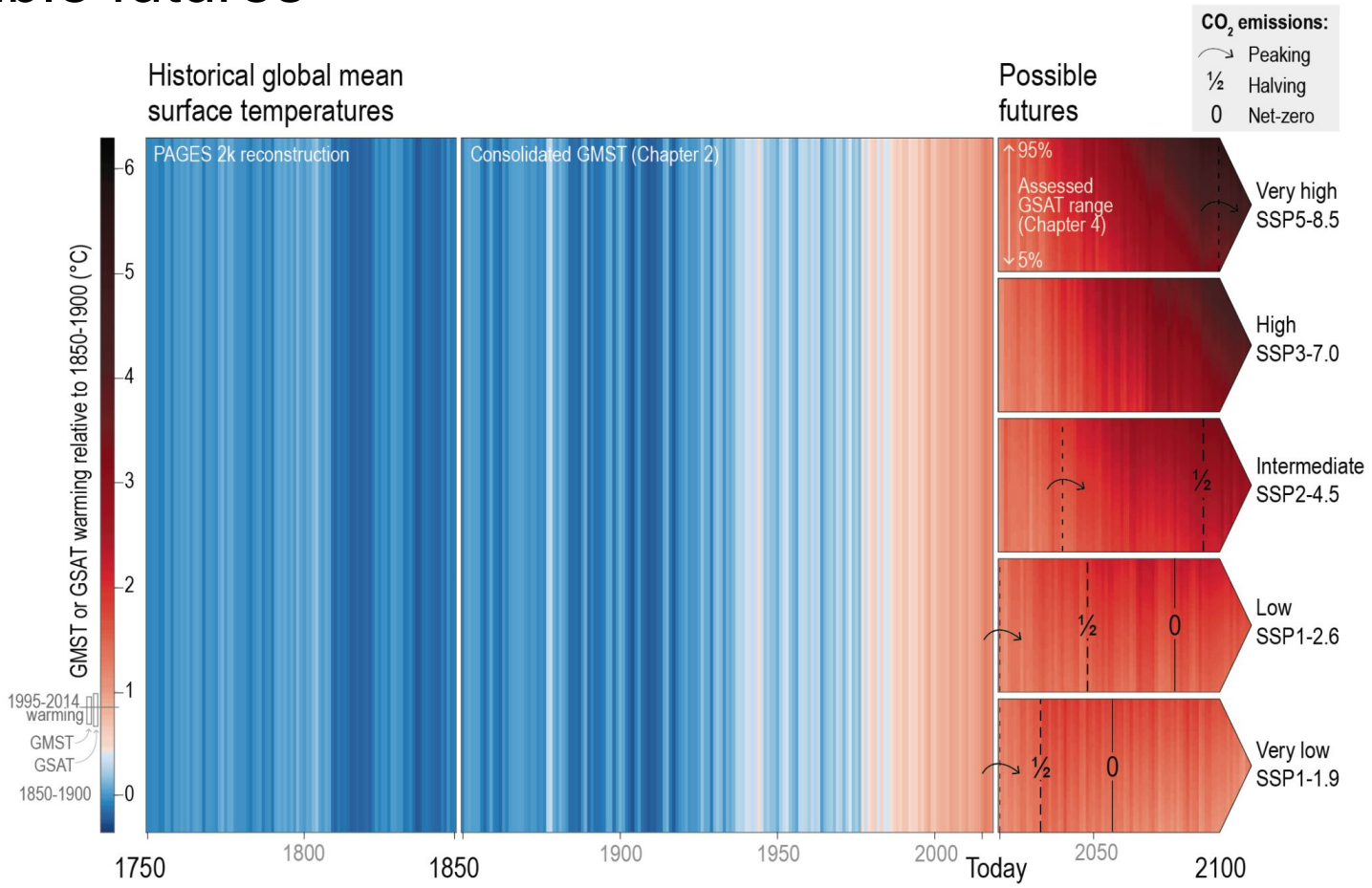
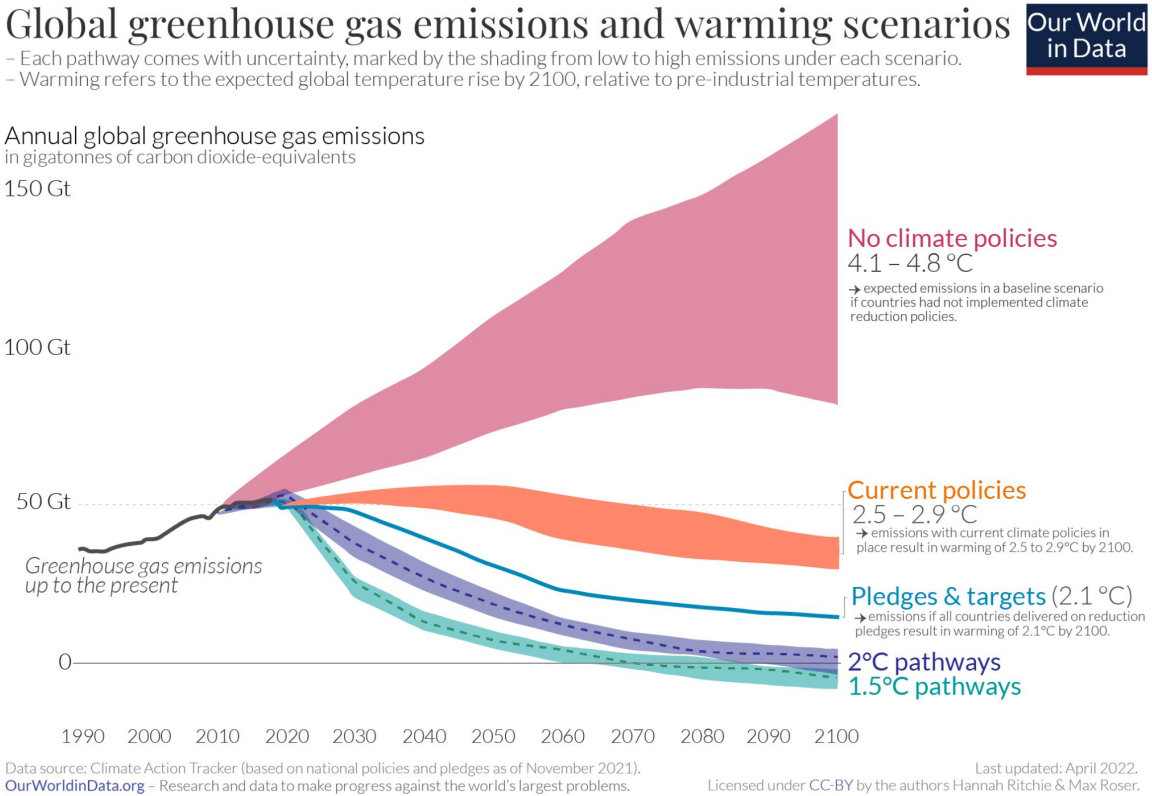




Possible futures

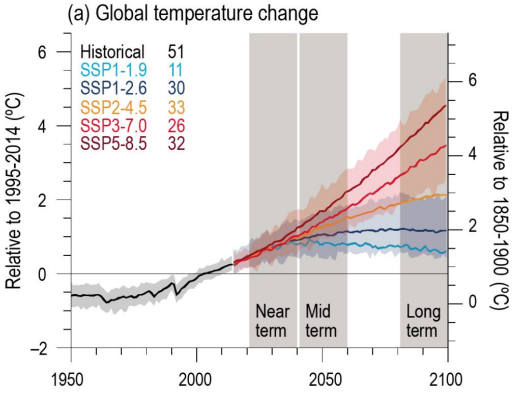


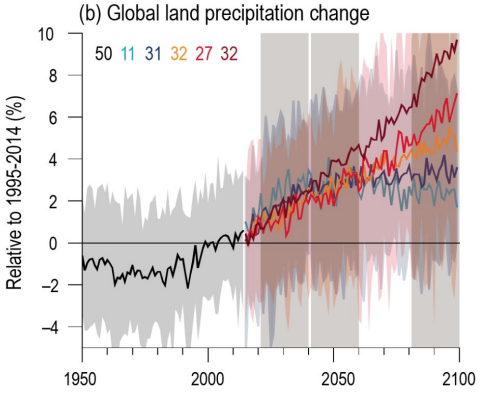
Possible futures

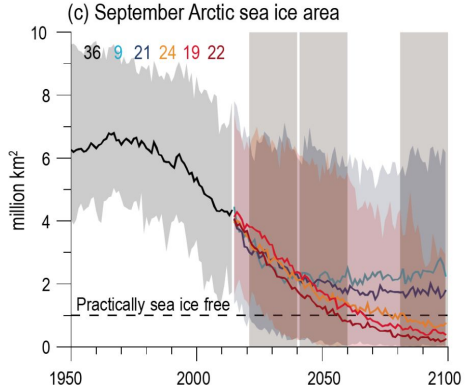


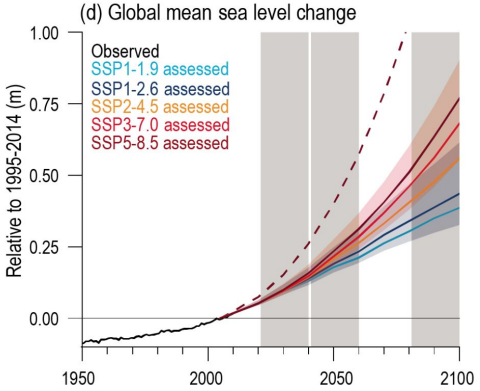
Discussions of temperature increases are usually in degrees celsius relative to pre-industrial averages. We are currently at +1.1C

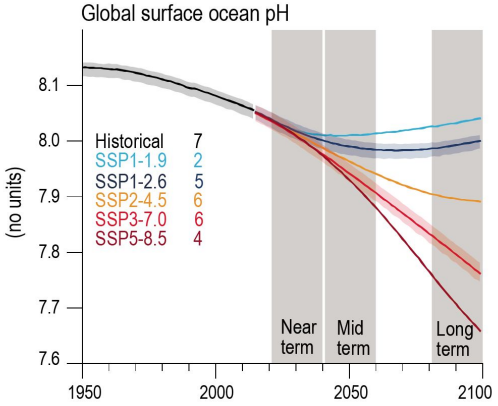
Possible futures



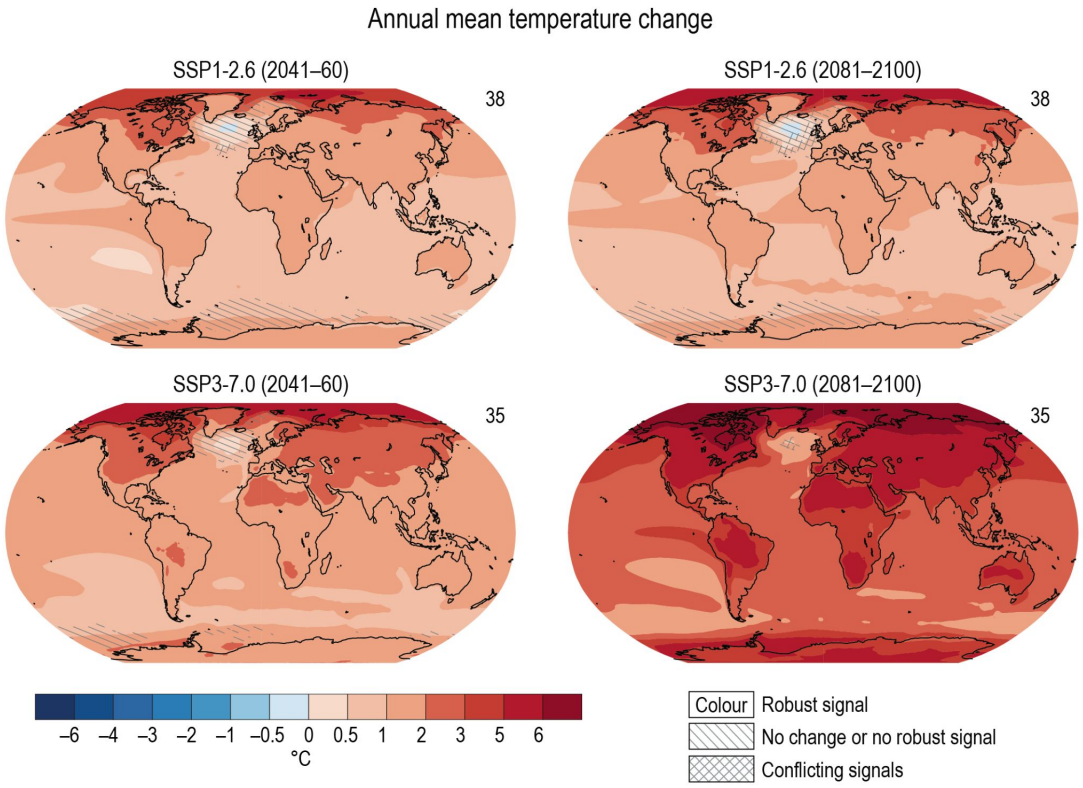








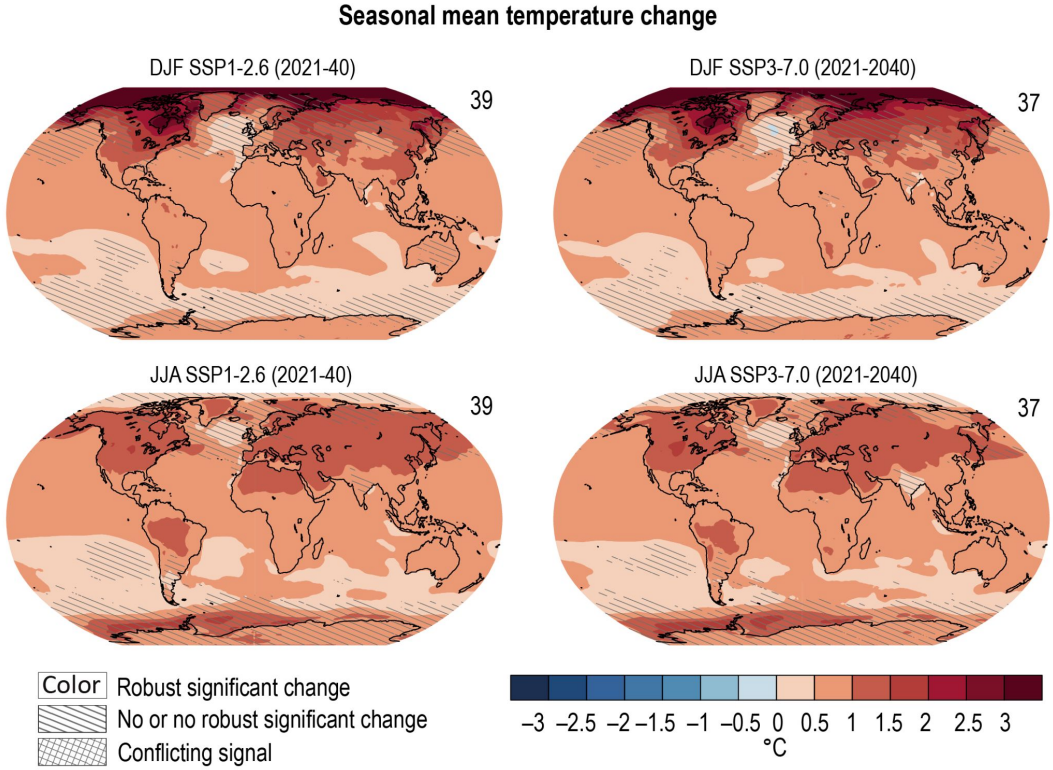
Possible futures



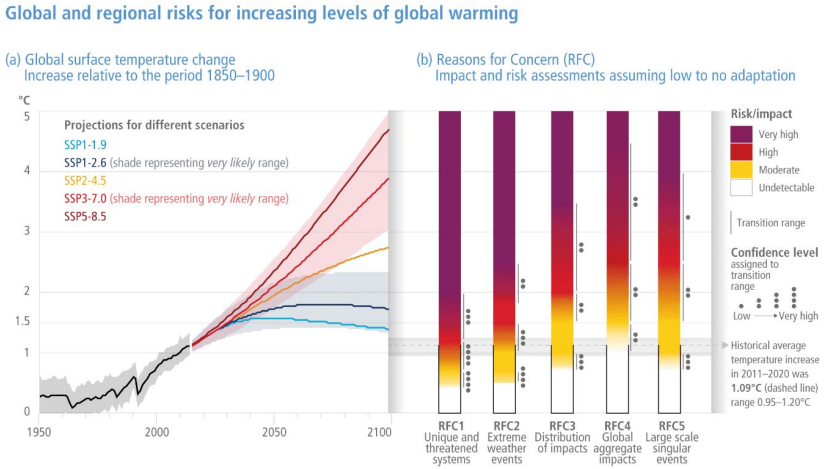
Possible futures

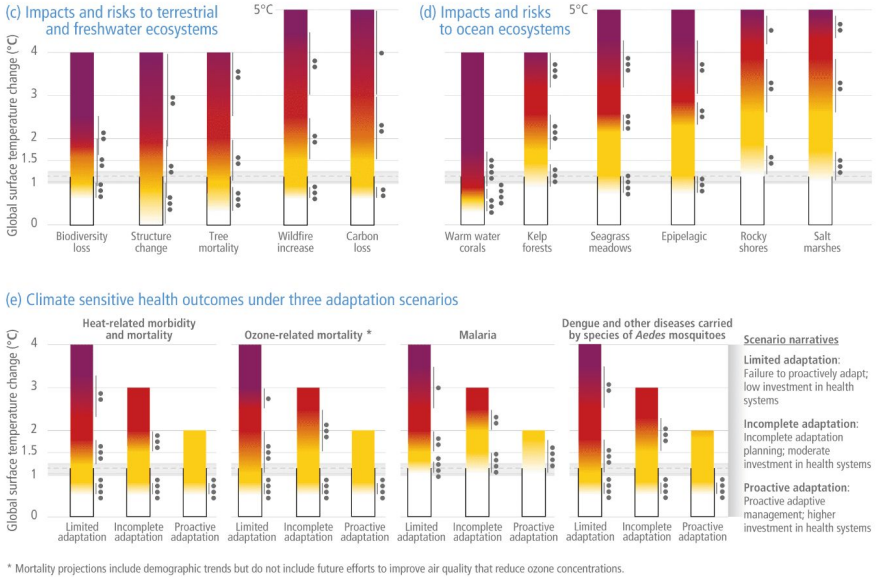
Winter:

Summer:



Possible futures





How 2 degree warming will play out in different locations

1:33-5:50

Tipping points

"*Tipping points occur when change in part of the climate system becomes self-perpetuating beyond a warming threshold as a result of asymmetry in the relevant feedbacks, leading to substantial and widespread Earth system impacts*"
Mckay et al. 2022, Science

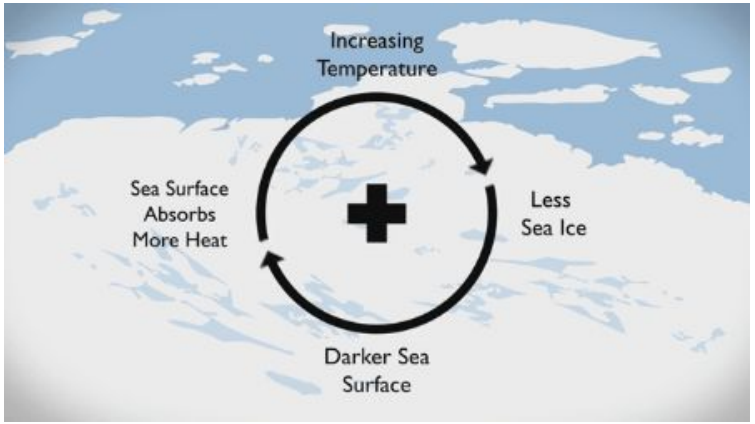
Positive feedback loops in how earth systems function cause tipping points.

Reducing emissions after a tipping point has been passed may not restore the original conditions. That is, these systems are not reversible.

Tipping points

Ice sheet collapse:

- .8-3 degrees heating
- Can cause up to 10m sea level rise
- Albedo feedback loop



Tipping points

Permafrost melt:

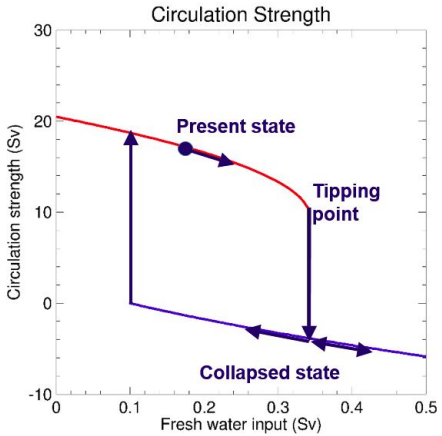
- 1-2.3 degrees heating
- GHG release feedback loop
- Collapse at 3-6 degrees

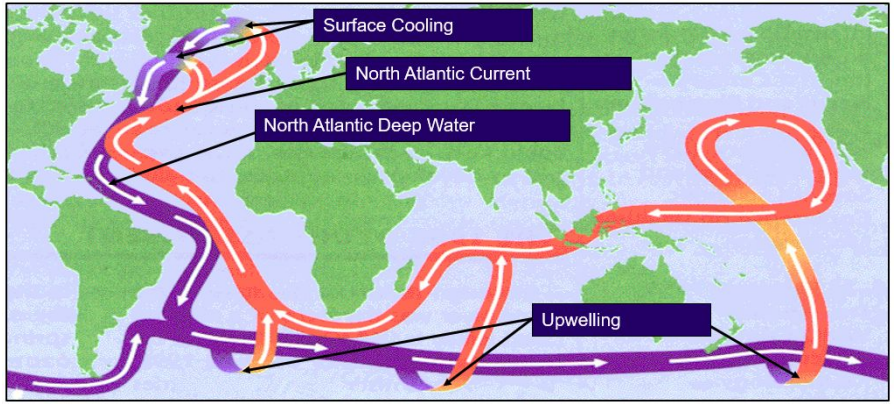
NASA

Tipping points

Ocean circulation slowing:

- Depends on temperature and salinity
- Would cause cooling in the North Atlantic but warming in the south
- Complete shutdown could come by 2300





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Tipping points

Deforestation:

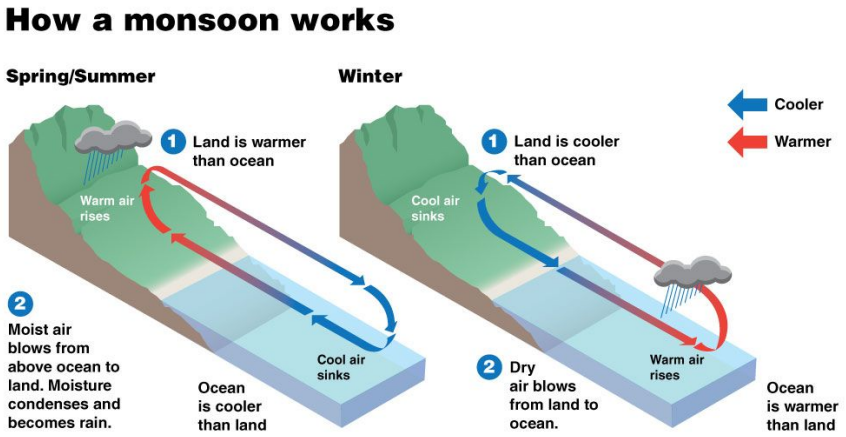
- Releases carbon into the atmosphere from trees and soil
- Increased warming and decreased rainfall intensifies wildfires and other threats to forests
- Amazon could transition into savannah (at around 3.5 degrees)

Getty

Tipping points

Monsoon shifts:

- West African Monsoon could expand northwards or collapse
- Indian Monsoon could strengthen or weaken



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What do we need to do?

Recommendations from IPCC reports

More laws, activism, and policy:

Following current climate pledges to 2030 would make it “impossible” to limit warming to 1.5C with “no or limited overshoot” – and “strongly increas[e] the challenge” for 2C. (most likely path under current policy leads to 2.5-3C by 2100)

Although at least 90% of global GHG emissions are covered by climate targets, only 53% are covered by “direct” climate laws.

Accelerated climate action is “critical” to achieving sustainable development.

Carbon Brief

Recommendations from IPCC reports

No more fossil fuels:

All scenarios limiting warming to 2C or below include “greatly reduced” fossil fuel use, with unabated coal being “completely” phased out by 2050.

The world can emit just 460 gigatonnes more of carbon dioxide, measured from the start of 2020, if we want at least a 50 percent chance of staying below 1.5 degrees. In recent years, the world has emitted about 36.4 gigatonnes annually. **If we continue at that pace, we will blow our entire carbon budget in about a decade.**

Carbon Brief

Recommendations from IPCC reports

Carbon dioxide removal technology is needed:

“The deployment of carbon dioxide removal (CDR) to counterbalance hard-to-abate residual emissions is unavoidable if net-zero CO2 or GHG emissions are to be achieved.”

Carbon Brief

Recommendations from IPCC reports

In real terms:

“[The report is a] file of shame, cataloguing the empty pledges that put us firmly on track towards an unlivable world”.

“Climate activists are sometimes depicted as dangerous radicals. But the truly dangerous radicals are the countries that are increasing the production of fossil fuels…[The report] sets out viable, financially sound options [for cutting emissions] in every sector that can keep the possibility of limiting warming to 1.5C alive.”

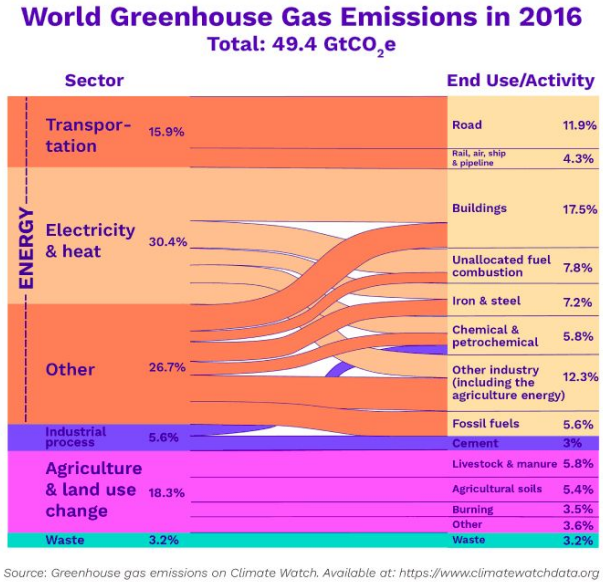
-UN secretary-general António Guterres

Furthermore, the global economic benefit of limiting warming to 2C is reported to exceed the cost of mitigation in most of the assessed literature.

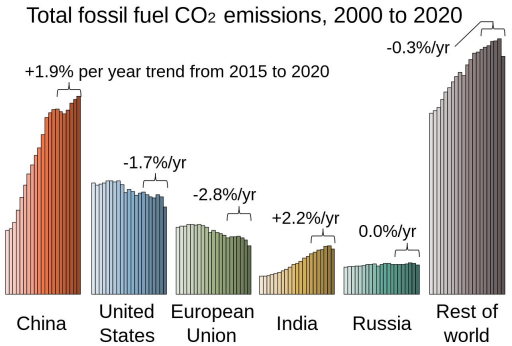
Carbon Brief


Vox

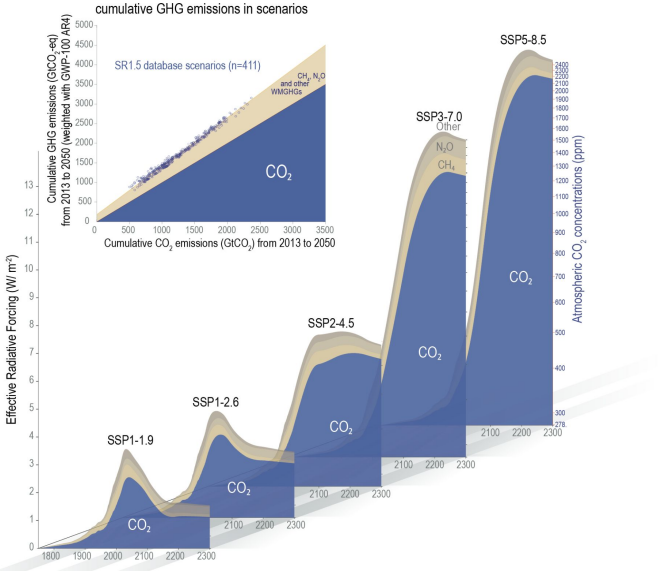
Summary



Source: Greenhouse gas emissions on Climate Watch. Available at: https://www.climatewatchdata.org



The Intergovernmental Panel on Climate Change



We need to rapidly stop releasing GHGs.