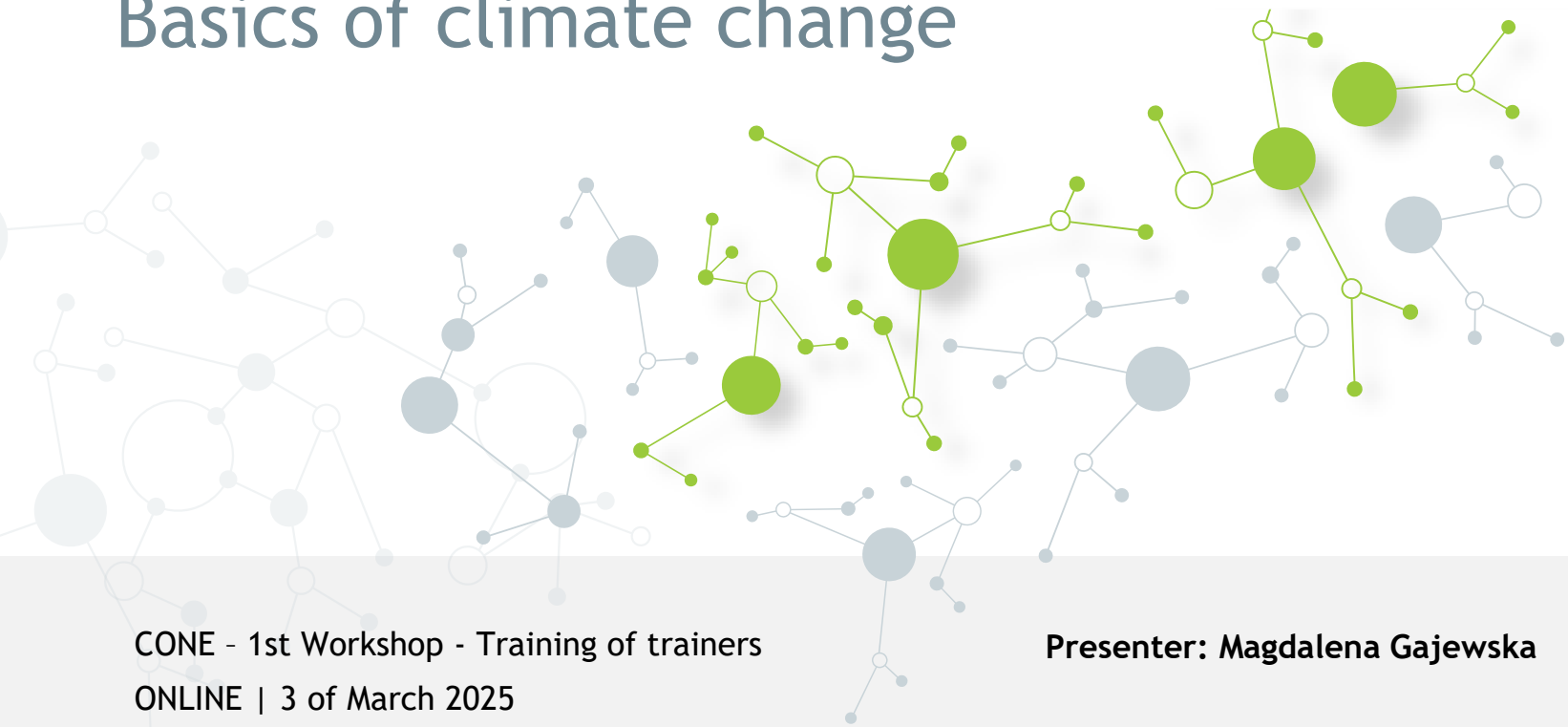
Basics of climate change



CONE – 1st Workshop - Training of trainers

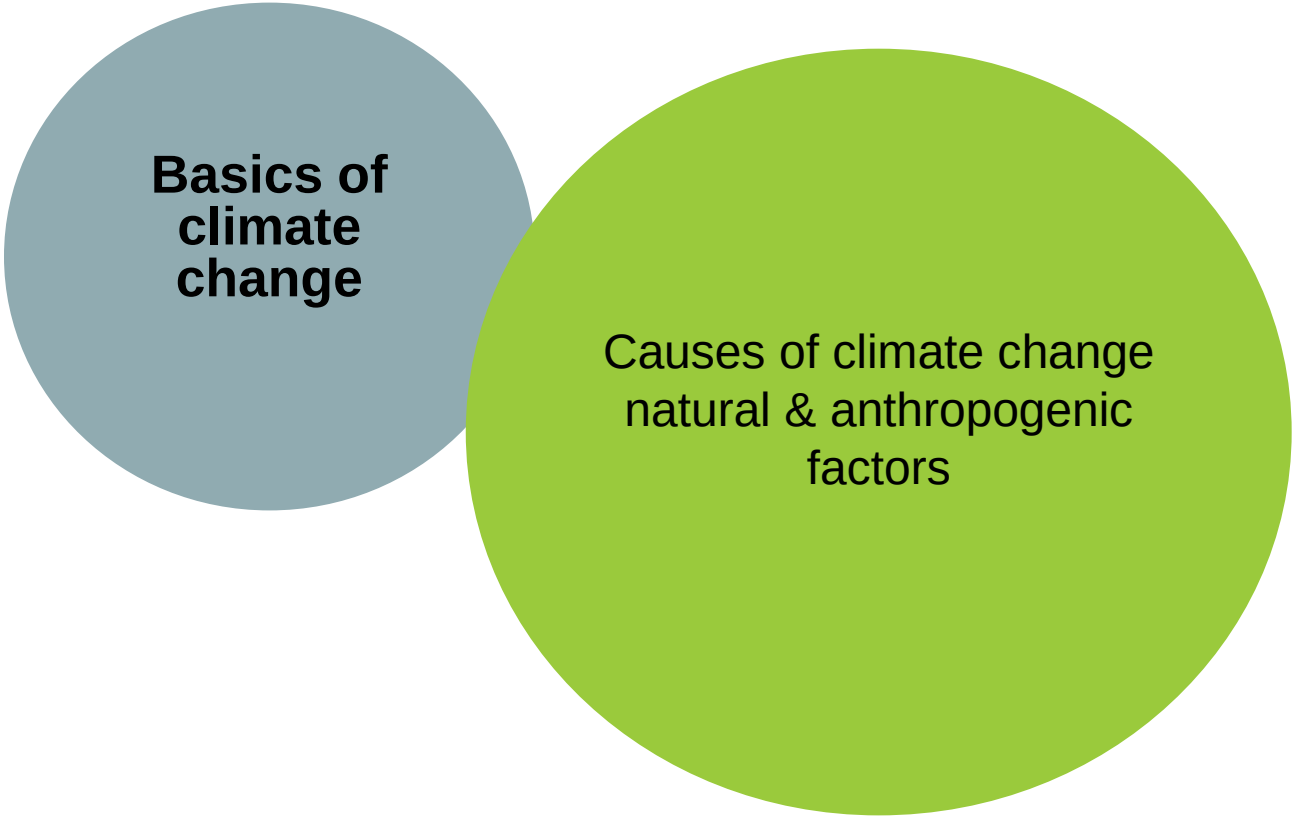
ONLINE | 3 of March 2025

Presenter: Magdalena Gajewska

GDAŃSK UNIVERSITY OF TECHNOLOGY

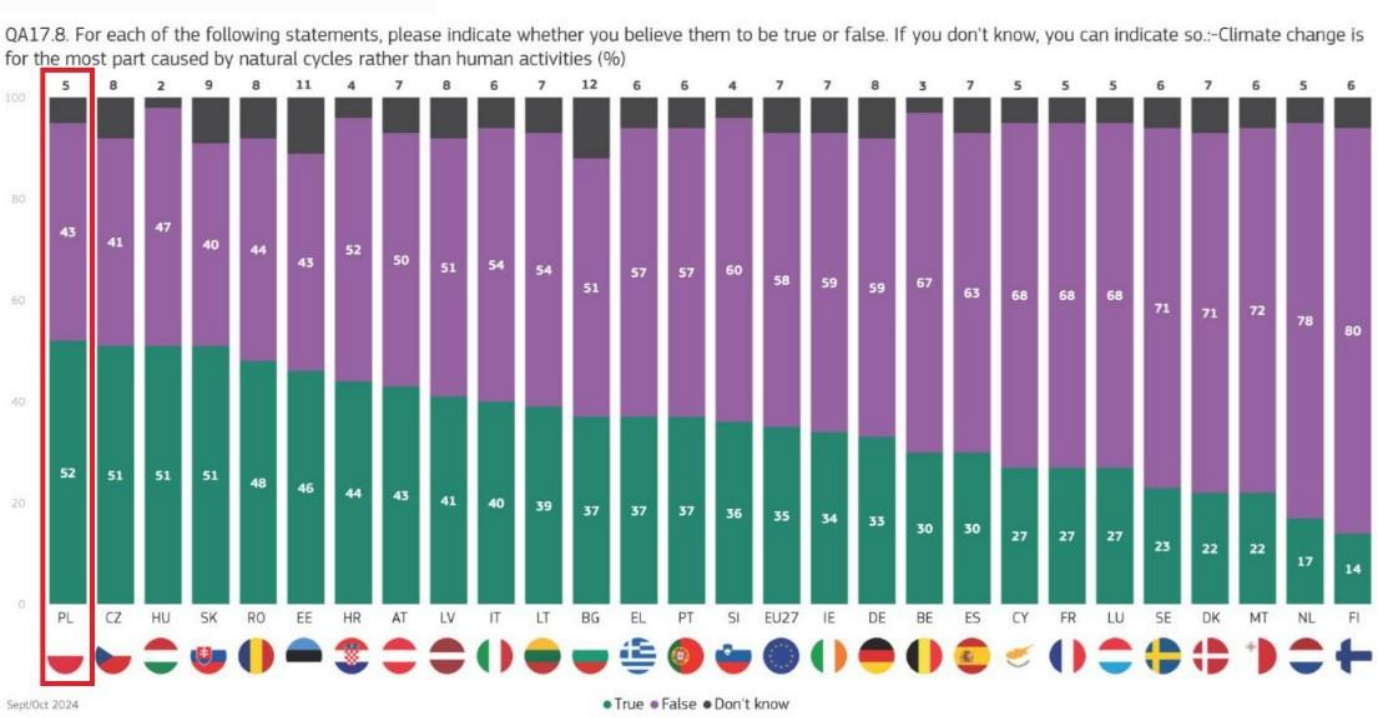
Prof. Magdalena Gajewska

- **Chair of IWA Scientific Group „ Treatment wetlands for water pollution control” 2016-2020**
- **Coordinator of EcoTech Center, Gdańsk University of Technology**
- **GWP – Central and Eastern Europe, Sustainable Sanitation Task Force, since 2021**


Basics of climate change
Causes of climate change natural & anthropogenic factors

Do we still have doubts ?

Really should we ?



Źródło: Eurobarometer. Raport "European citizens' knowledge and attitudes towards science and technology 2024"

Weather vs climate

Weather can be thought of as short-term changes (over hours or days) and climate as long-term changes (over years or even thousands of years).

- **Weather includes factors such as temperature, wind, rain, clouds, atmospheric pressure and humidity.**

These are observed or predicted over smaller regions. Weather is influenced by the global climate system.

- **Climate is defined by long-term weather averages, variations and extremes.**

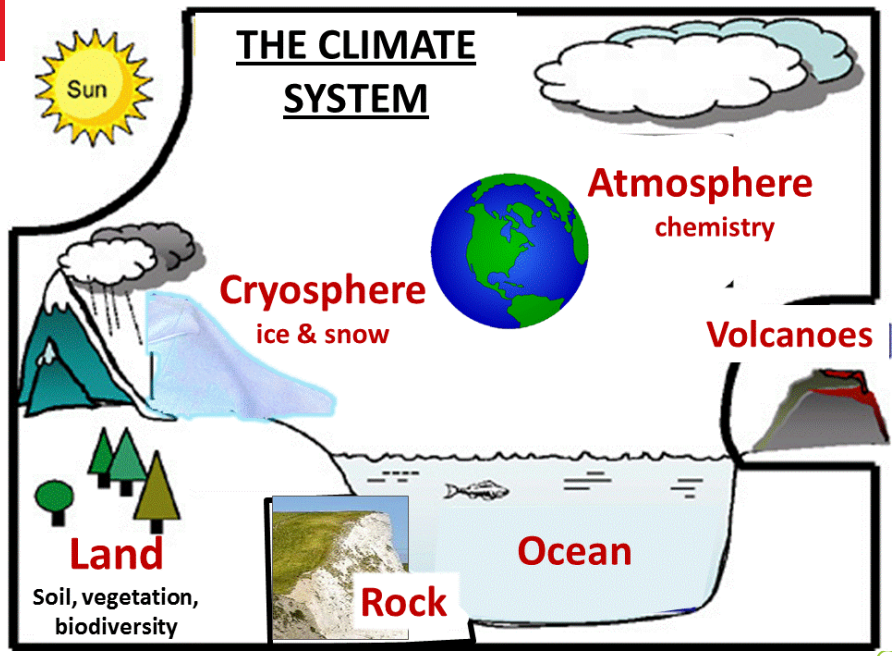
Local climates are influenced by their distance from the equator, elevation, distance from water bodies, vegetation, the presence or absence of mountains, and other geographical features. Climate also varies over time through seasons, years, decades and much longer timescales such as the Ice Ages.

EARTH'S CLIMATE SYSTEM

The global climate system arises from the interaction of 5 systems interacting together

To understand our climate and how it is changing, we first need to understand these 5 systems:

- The atmosphere (the thin layer of gases surrounding the Earth)
- The lithosphere (the land surfaces such as soil and rocks, and human-made surfaces such as roads and buildings)
- The hydrosphere (the Earth's liquid water in oceans, rivers, lakes and underground)
- The cryosphere (the frozen water in ice and snow)
- The biosphere (the living things such as plants and animals including humans).



Does it have an effect?

- **Data by American Science Academy for 2023r :**

Mass number of mammals:

Land – 20 million tone

Water – 40 million tons

People - 390 million tons

Livestock – 630 million tons

- **The term climate change refers to how the Earth's climate changes over time.**

These changes can be caused by long-term natural processes (such as changes in the Earth's orbit)

- **FEEDBACK MECHANISMS** are climate-affecting phenomena occurring within the climate system as a result of **FORCINGS**.

FORCING

FORCINGS refer to external influences on the climate system that originate outside of it.

Examples of climate forcings include:

- **Astronomical factors, such as variations in solar activity or changes in Earth's orbital e.g** **Milankovitch (Orbital) Cycles -** changes in Earth's position relative to the Sun are a strong driver of Earth's ***long-term*** climate, and are responsible for triggering the beginning and end of glaciation periods (Ice Ages) (41 thousand years).
- **Volcanic activity, which can lead to temporary cooling due to aerosol emissions.**
- **Anthropogenic factors, including changes in atmospheric greenhouse gas concentrations or aerosol levels due to the combustion of fossil fuels.**

Once a forcing occurs, it can trigger a cascade of secondary changes within the climate system, further altering the energy balance

TAMBORA, INDONESIA ERUPTION in 1815

The world experienced a volcanic winter, and historians described 1815 as "the year without a summer." The eruption caused climatic anomalies and reduced the temperature on Earth by approximately 3-4 degrees Celsius.

Global grain imports also collapsed.

The Tambora volcano is said to have led to starvation deaths even in France, Spain, Switzerland, Belgium and England.
Social anxiety was growing, initiating, among others, political changes.

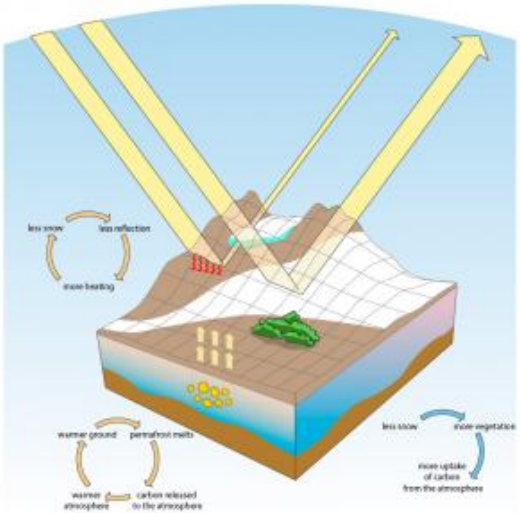
Feedback

- Some of the most evident feedback mechanisms include changes in the intensity of evaporation or the extent of sea ice due to a forced increase or decrease in atmospheric and oceanic temperatures.
- Changes in evaporation rates influence the intensity of the greenhouse effect (as water vapor is a greenhouse gas), while variations in sea ice coverage alter the planetary albedo.

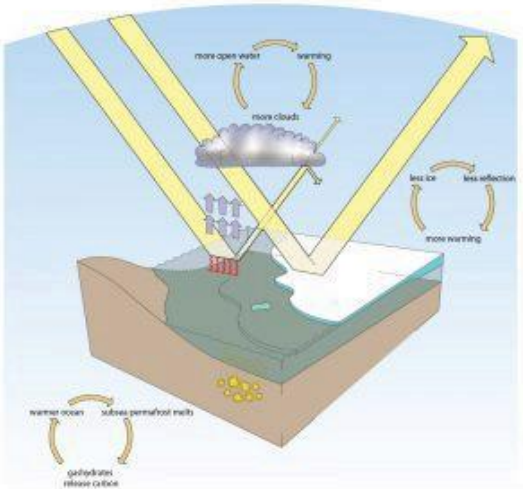
ALBEDO

- **the amount of the light hitting a surface that it reflects back, especially the surface of a planet or other body in space:**
- *Open water is one of the substances with the lowest albedo that we have on Earth.*

The albedo effect on land.



The albedo effect on sea.



The planets of the Solar System have an albedo ranging from 0.142 (Mercury) to 0.67 (Venus).

Earth's albedo is 0.367.

lawn (0.25), human skin (0.05 to 0.6), ocean (0.06) fresh snow (0.8)

Norwegian Polar Institute

NEGATIVE CLIMATE FEEDBACK

- A response within the climate system that counteracts the effects of an initial forcing.

An example of negative feedback is the increase in planetary heat radiation following a rise in temperature—this slows further warming and helps stabilize the system.

DISTINCTION BETWEEN FORCINGS AND FEEDBACKS

- **The same phenomenon can act as either a forcing or a feedback, depending on its origin.**

For example, an increase in atmospheric carbon dioxide (CO_2) levels can be:

1. **A FORCING if it results from human activities, such as fossil fuel combustion (since the carbon in these fuels originates from sedimentary rocks, external to the climate system – SLOW *long - term carbon cycle*).**
2. **A FEEDBACK if it results from processes such as vegetation dieback or oceanic degassing triggered by prior global temperature increases.**

- **TIPPING POINT**

A threshold value of a specific parameter, beyond which the equilibrium state of the climate system shifts irreversibly.

EXAMPLES OF CLIMATE FEEDBACKS AND TIPPING POINTS

- **ARCTIC SEA ICE MELTING: A positive feedback mechanism—rising temperatures reduce ice cover, which lowers albedo, leading to greater solar absorption and further warming. If ice cover decreases beyond a certain threshold, this effect alone could drive the complete melting of remaining ice.**

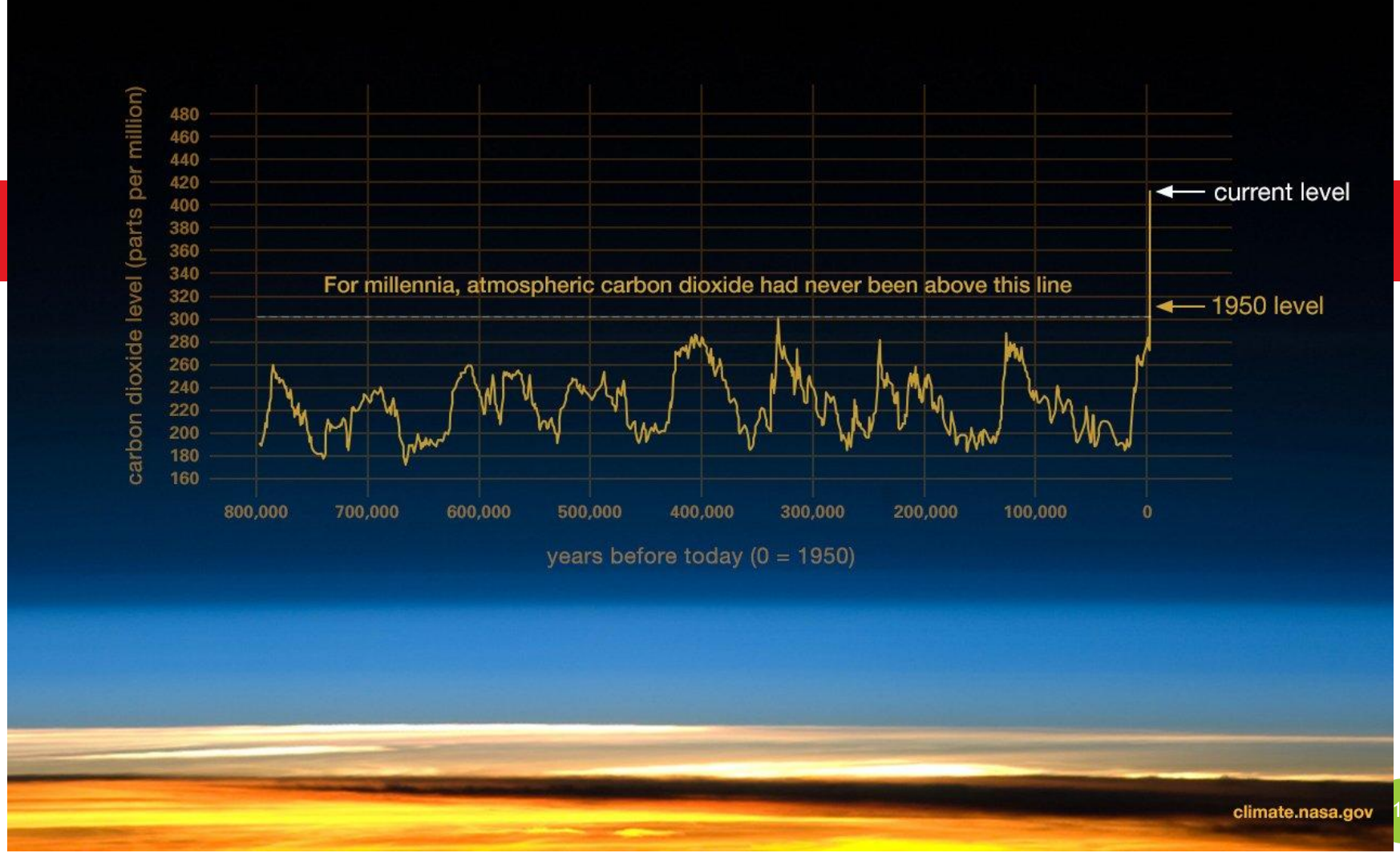
- **PERMAFROST THAWING: Permafrost consists of soil that has remained below freezing for extended periods. Rising temperatures cause it to thaw, leading to the decomposition of previously frozen organic matter and the release of methane (CH_4) and CO_2—both potent greenhouse gases. This intensifies the greenhouse effect, further accelerating warming, creating another positive feedback loop. If a critical volume of permafrost thaws, the resulting greenhouse gas emissions may be sufficient to sustain further warming, making the process self-reinforcing.**

FEEDBECK

- **Climate change impacts on METHANE HYDRATES- (CH4·5.75H2O or 4CH4·23H2O) is a solid clathrate compound in which a large amount of methane is trapped within a crystal structure of water, forming a solid similar to ice**

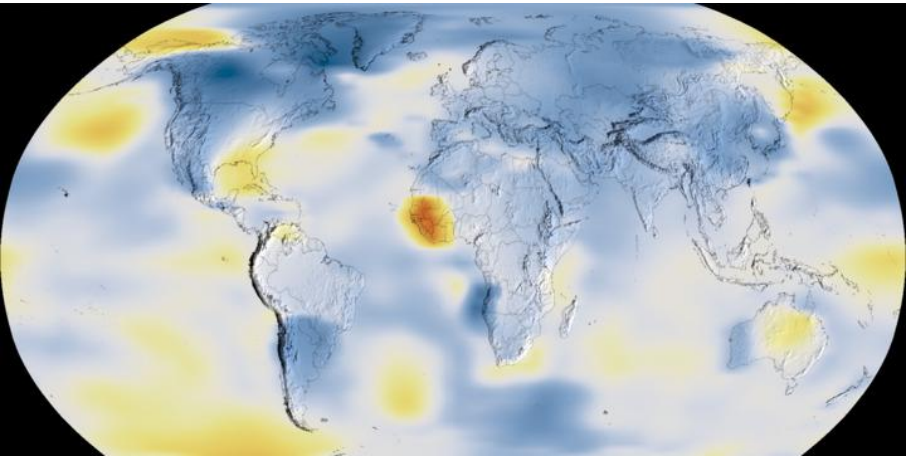
Huge amounts of methane are stored around the world on the sea floor in the form of solid methane hydrates.

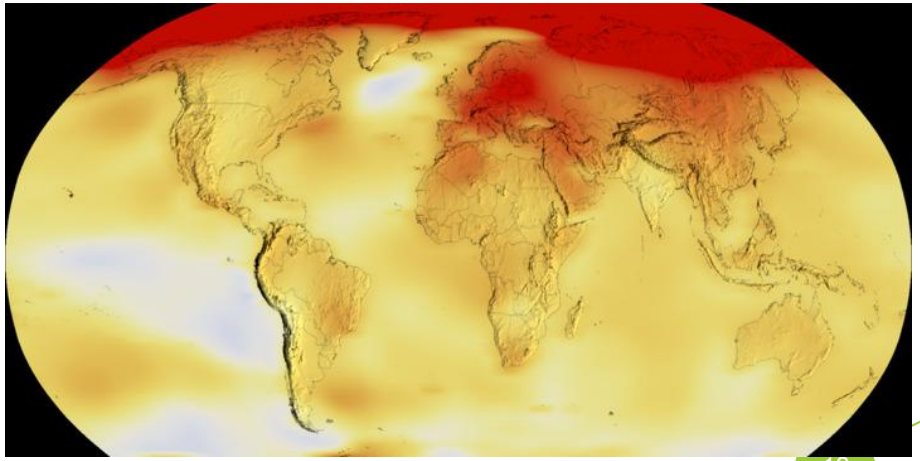
These hydrates represent a large energy reserve for humanity. Climate warming, however, could cause the hydrates to destabilize. The methane, a potent greenhouse gas, would escape unused into the atmosphere and could even accelerate climate change.


carbon dioxide level (parts per million)
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
For millennia, atmospheric carbon dioxide had never been above this line
current level
1950 level
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
years before today (0 = 1950)
climate.nasa.gov

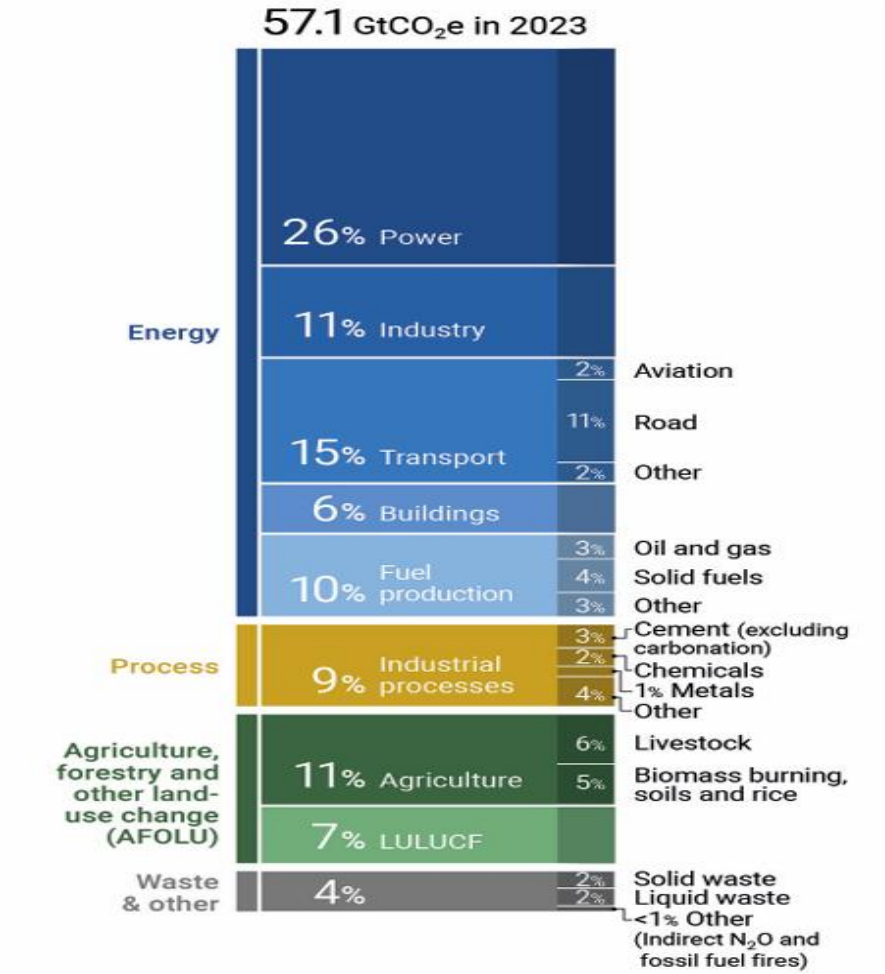
TEMPERATURE

1884 2022





NASA's Scientific Visualization Studio



CO2 emmission by sectors 2023

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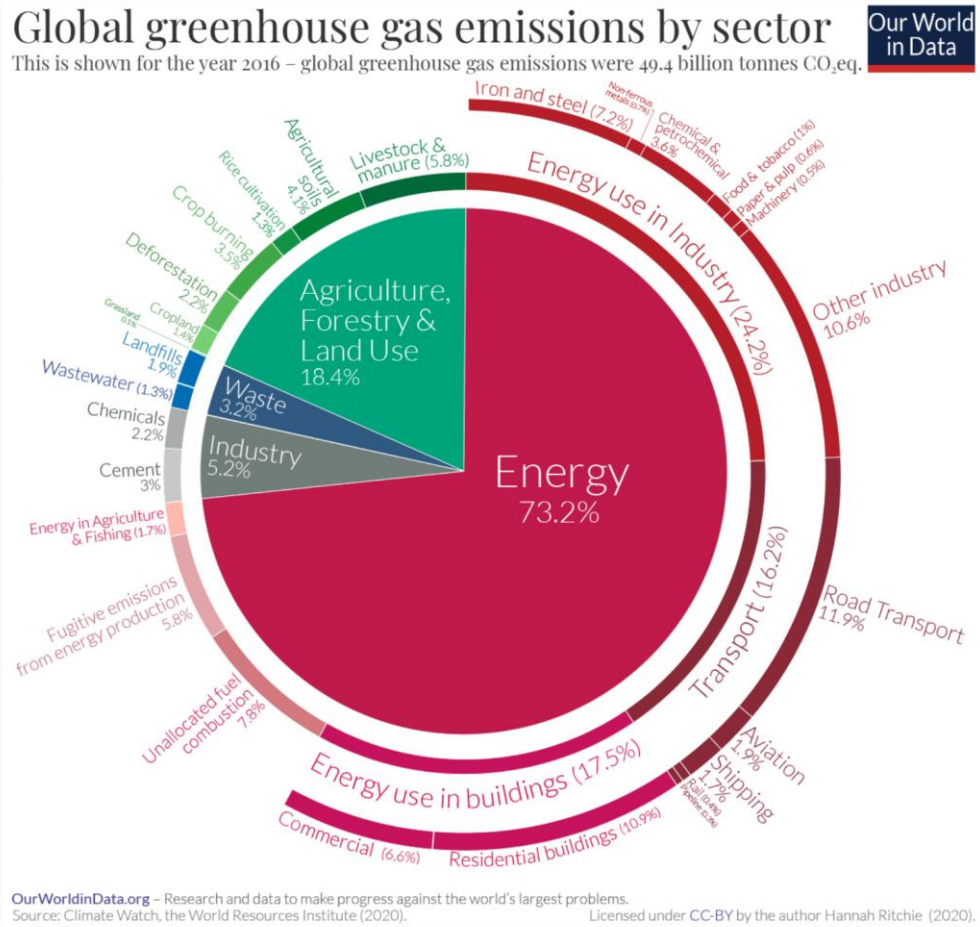
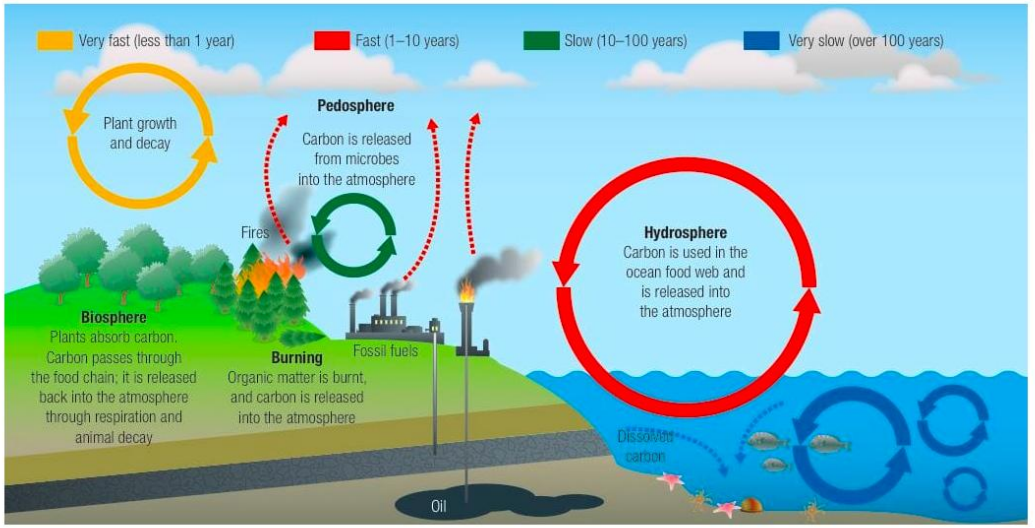
Unnamed area



POLITECHNIKA GDAŃSKA

UCZELNIA BADAWCZA

CARBON CYCLE DYNAMICS

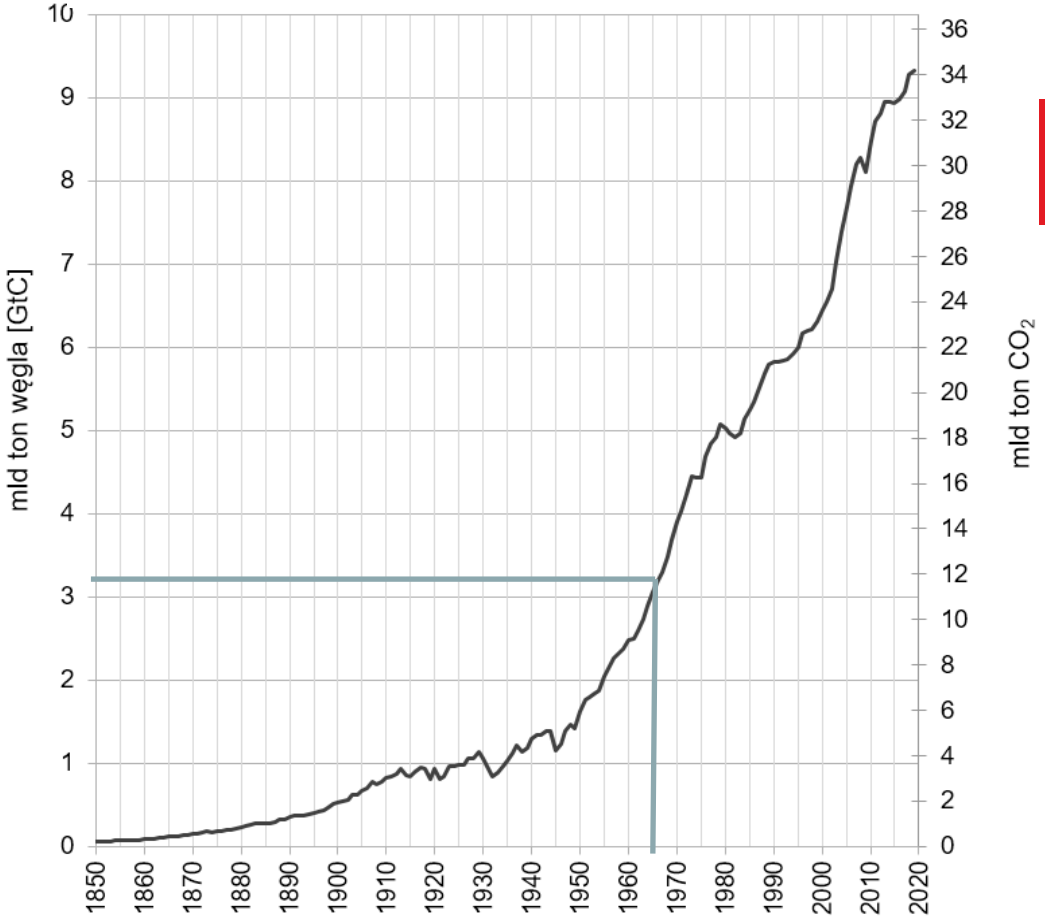


The difference between the slow and fast carbon cycle. Infographic: © Oxford Big Ideas

- **SLOW CARBON CYCLE (Geological Cycle): Involves carbon exchange processes that operate on geological timescales, spanning thousands to hundreds of thousands of years.**
- **FAST CARBON CYCLE: Encompasses carbon exchange processes occurring on shorter timescales, typically over years to decades.**

EMISSION of CO2

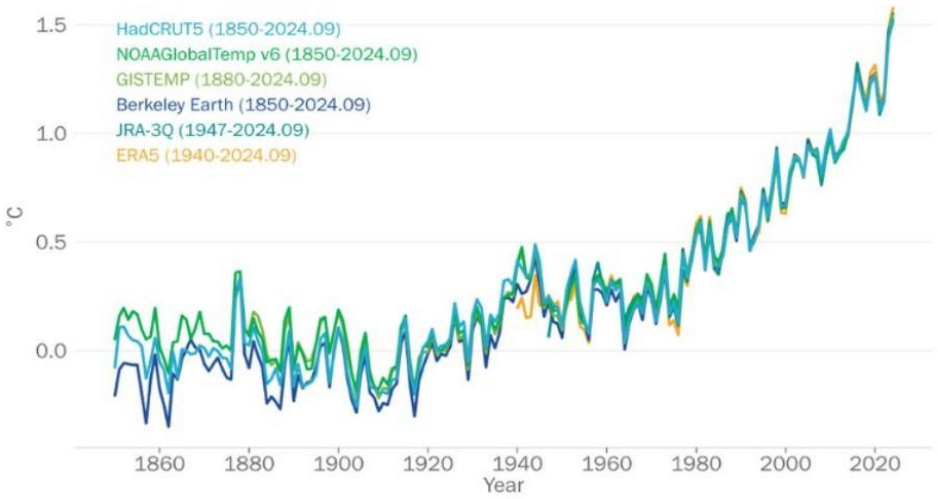
Emission of CO_2 from fossil fuels



Temperature deviations till 2024

Global mean temperature

2024 on track to be the warmest year on record



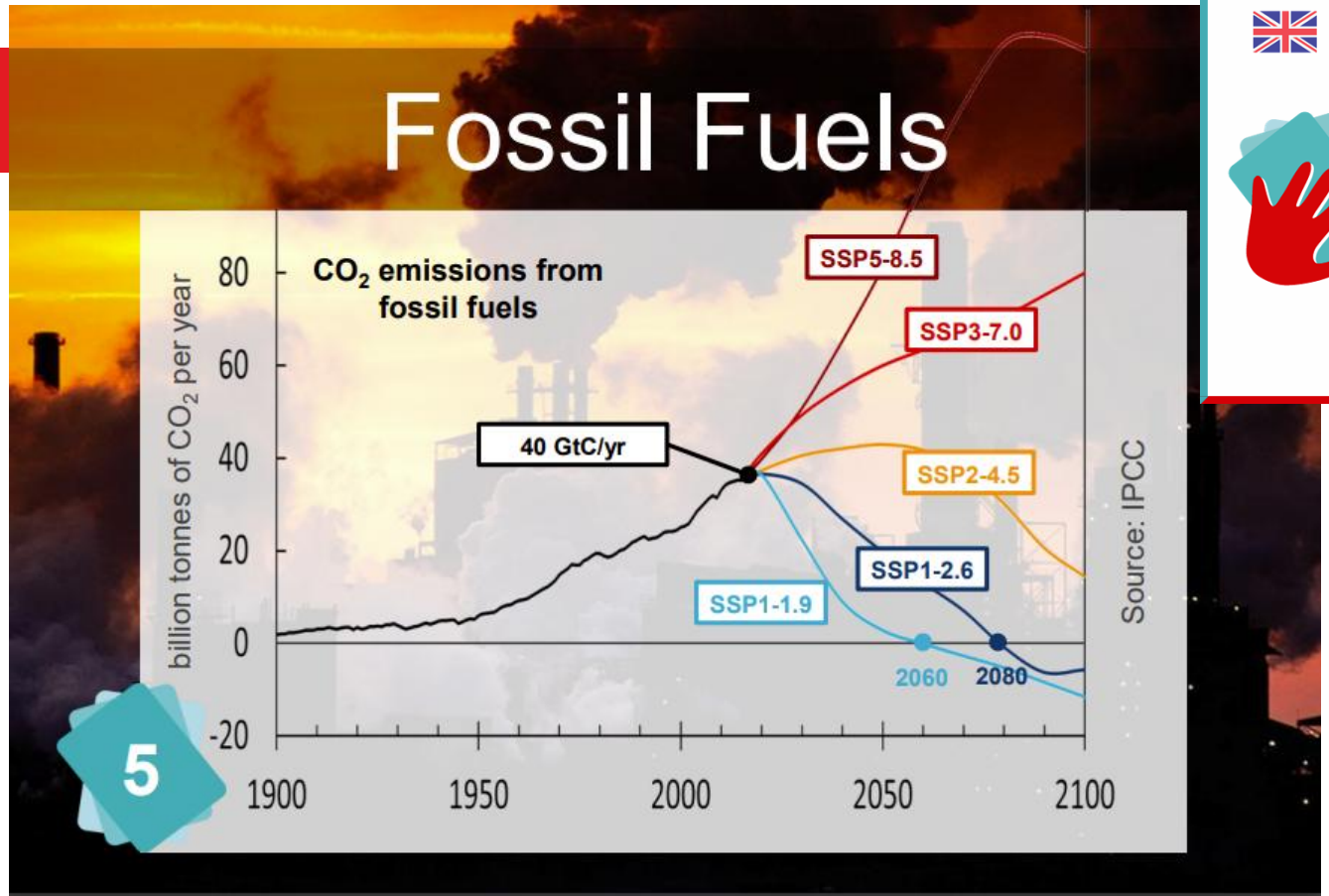
WMO

IPCC = Intergovernmental Panel on Climate Change)

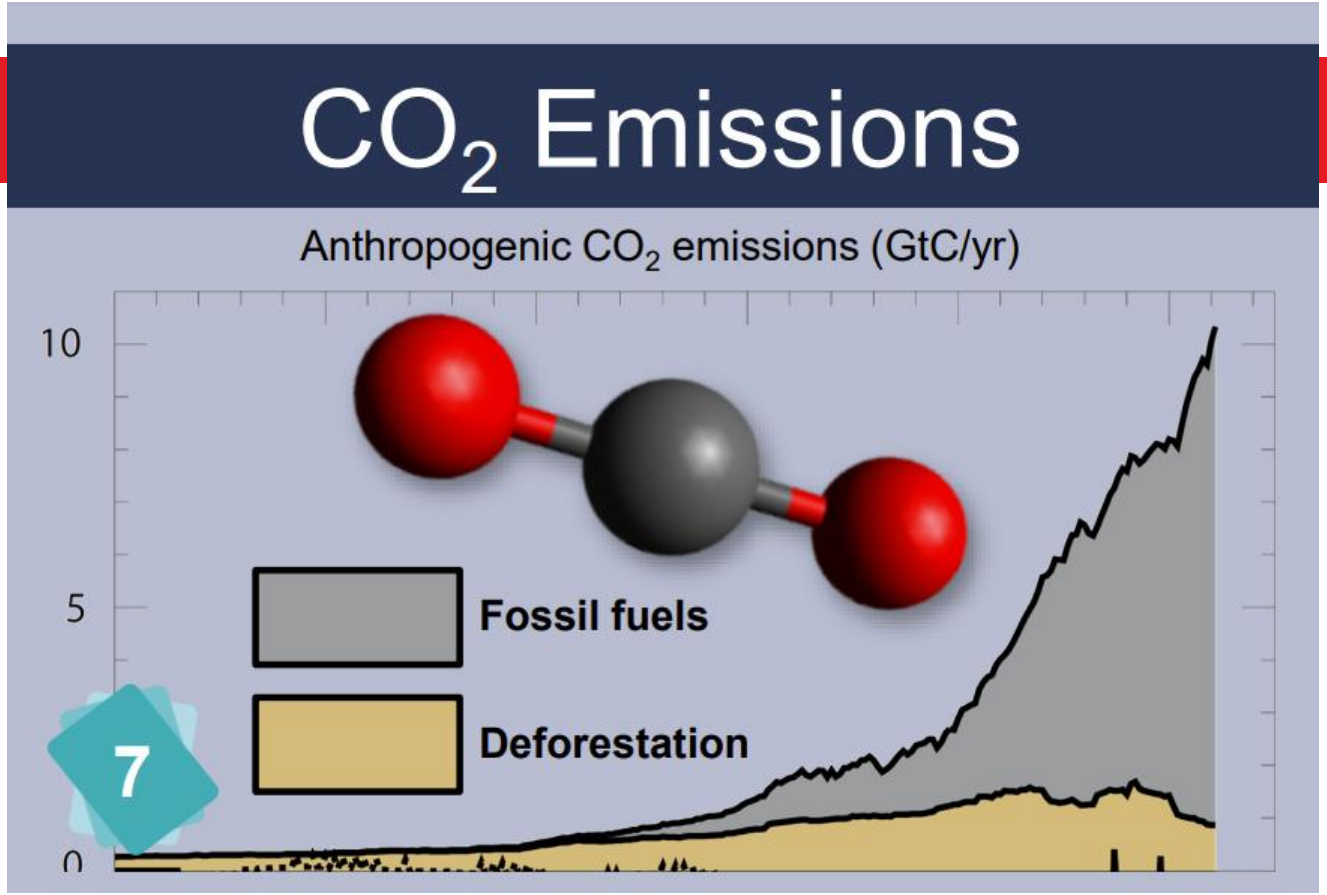
EN-GB Adults

CL!MATE FRESK

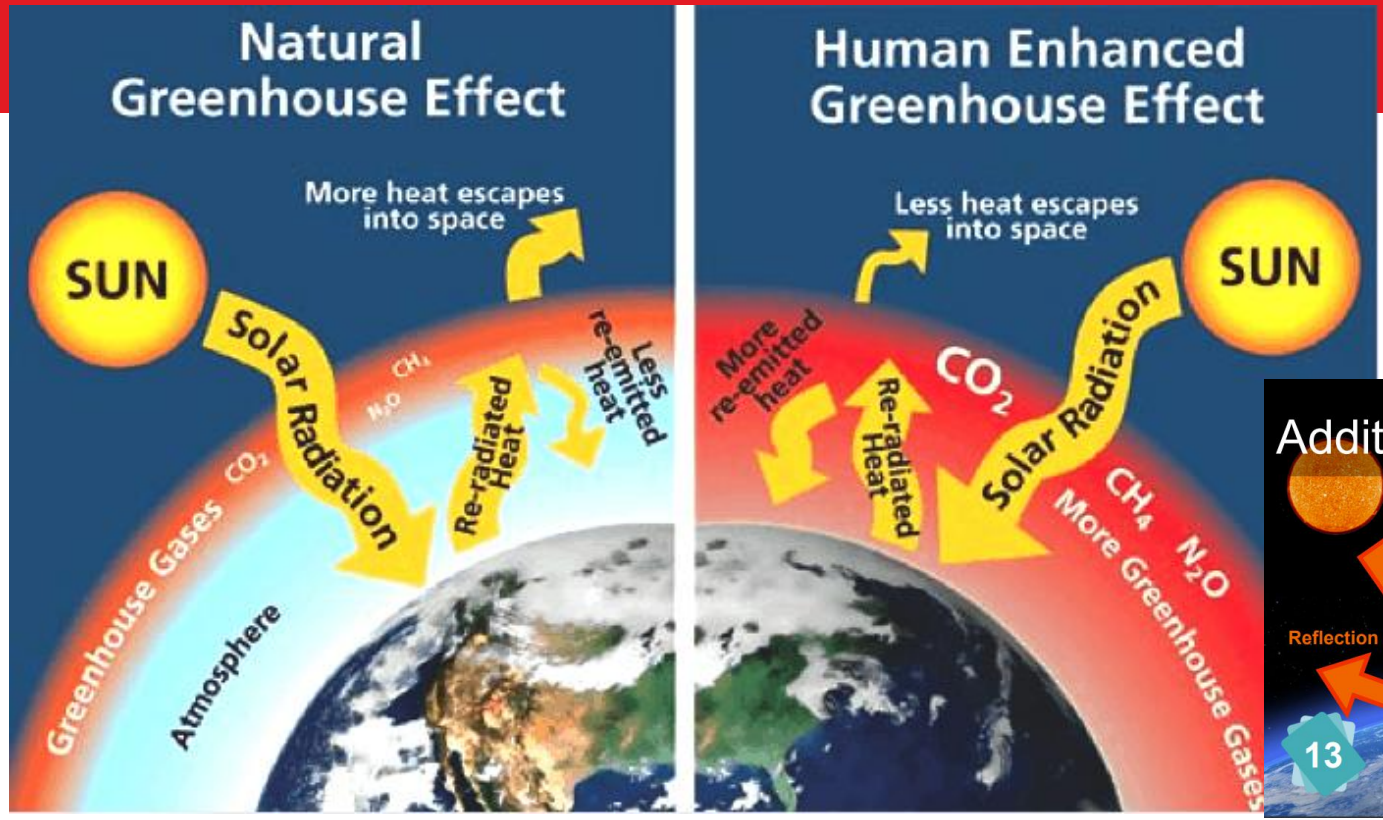
All the cards are in your hands!

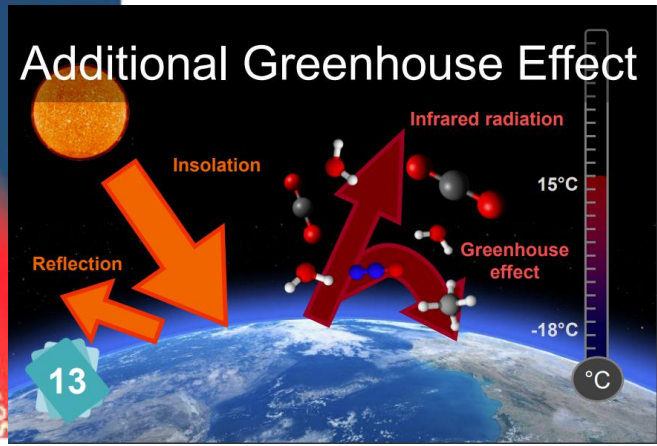


CO_2 Emissions

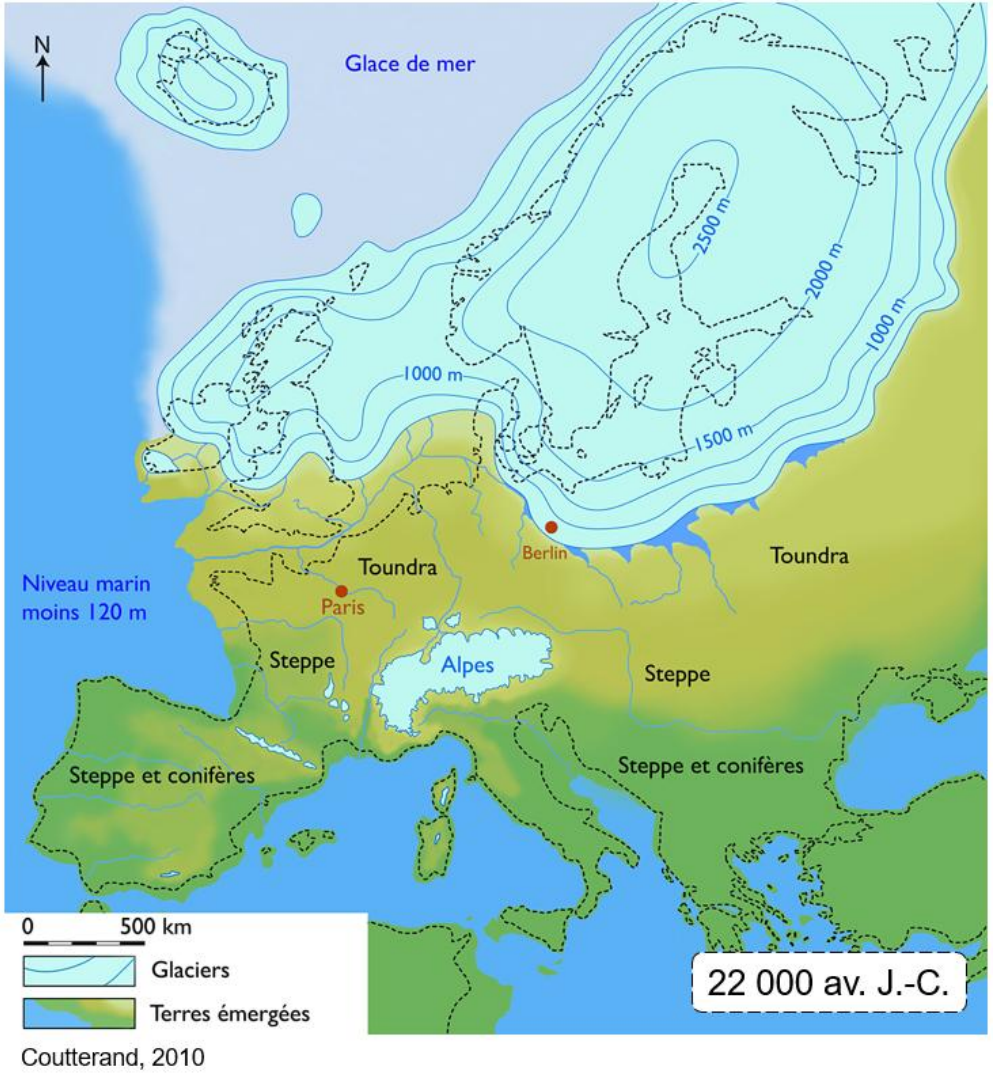


Emission – more CO_2 and the consequence……..



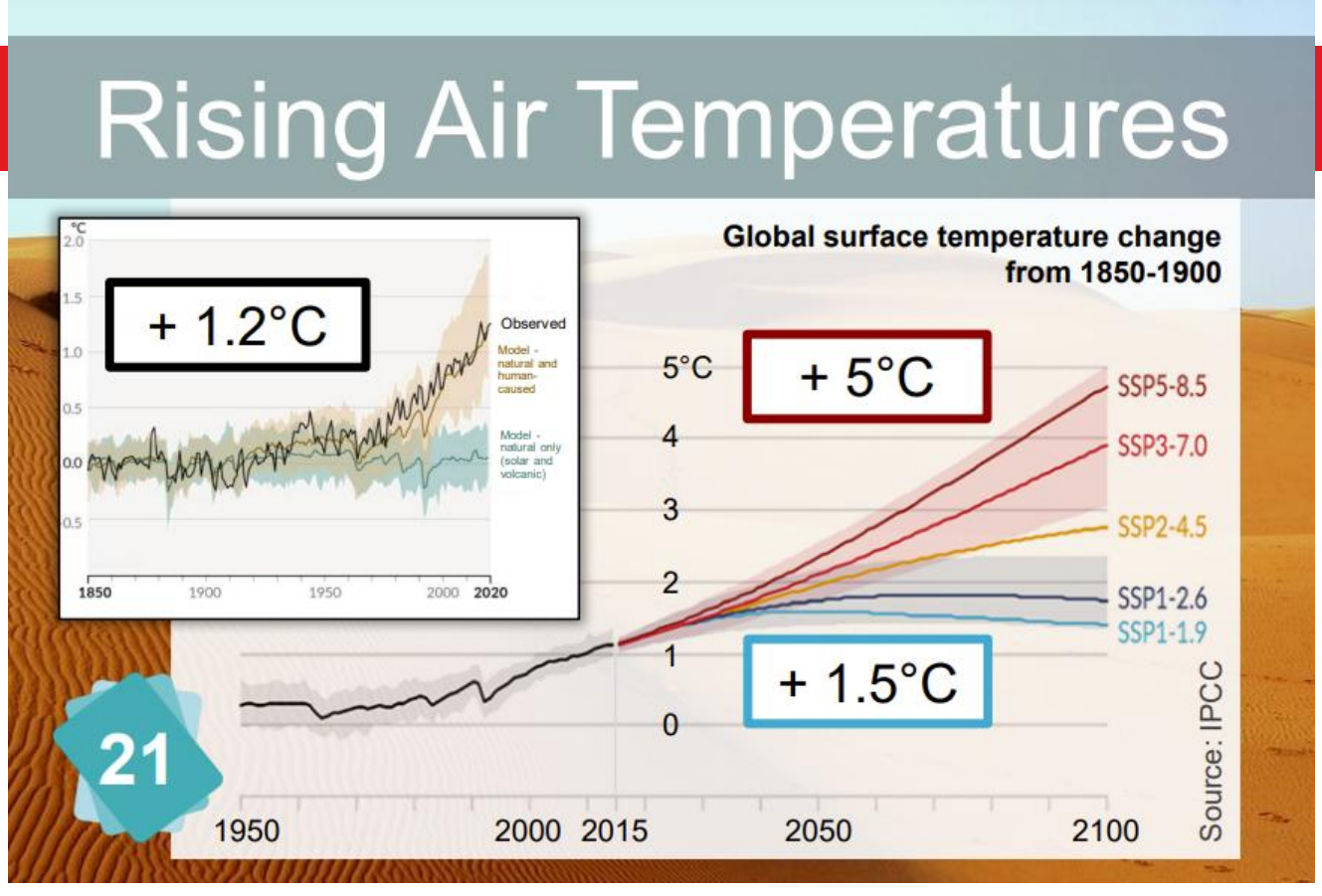


- Only 5˚C less

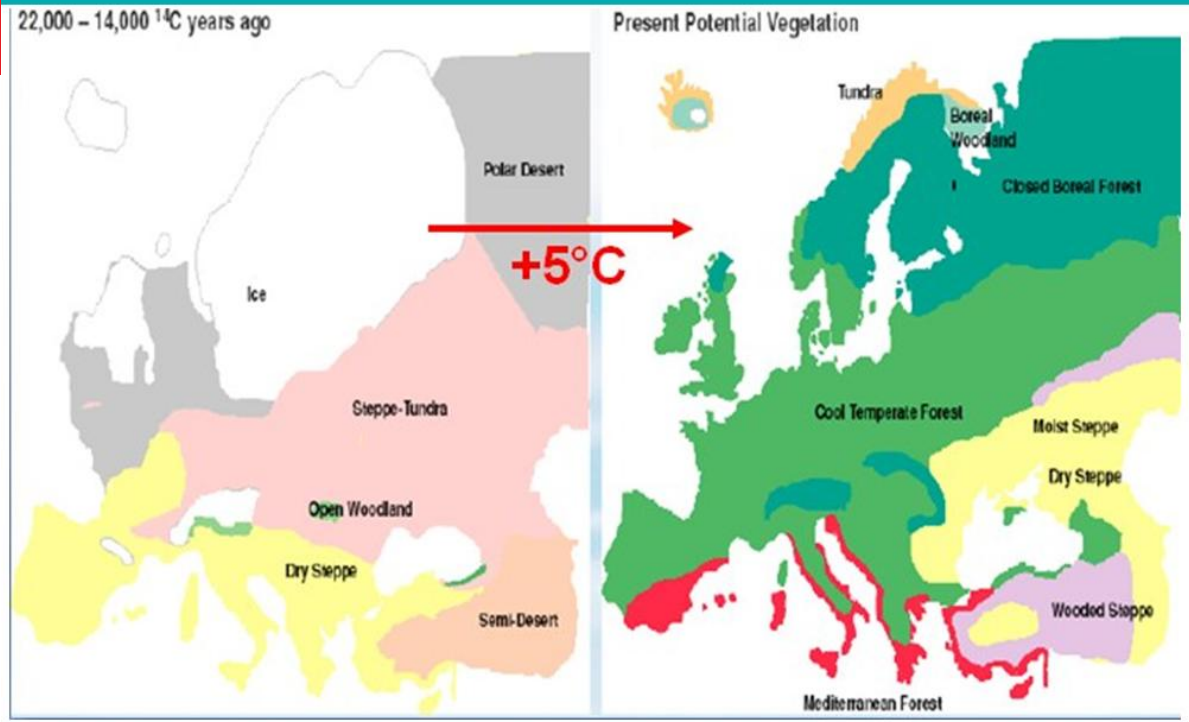


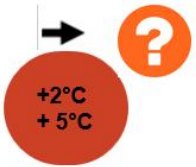
Coutterand, 2010

Rising Air Temperatures



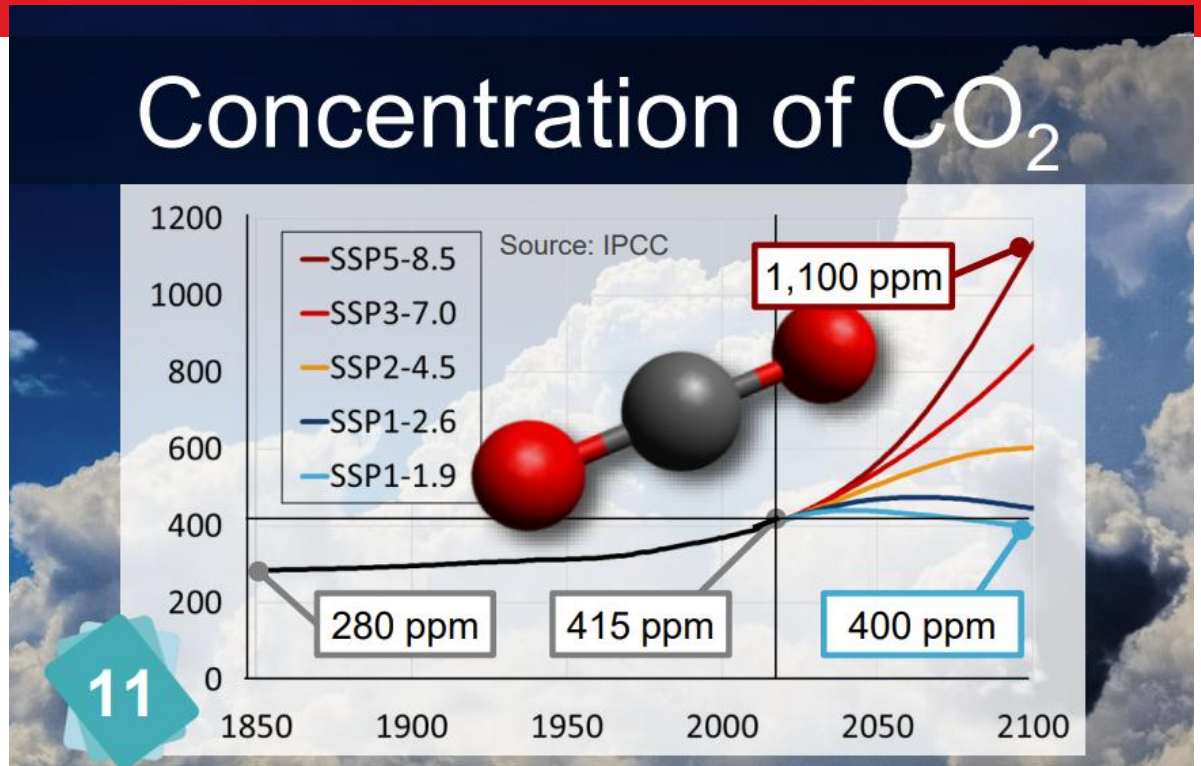
+2°C TO +5°C: IT'S A HUGE CHANGE...



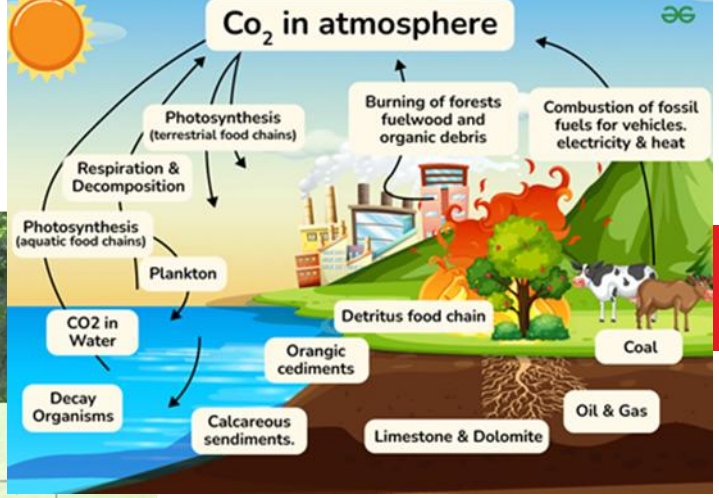


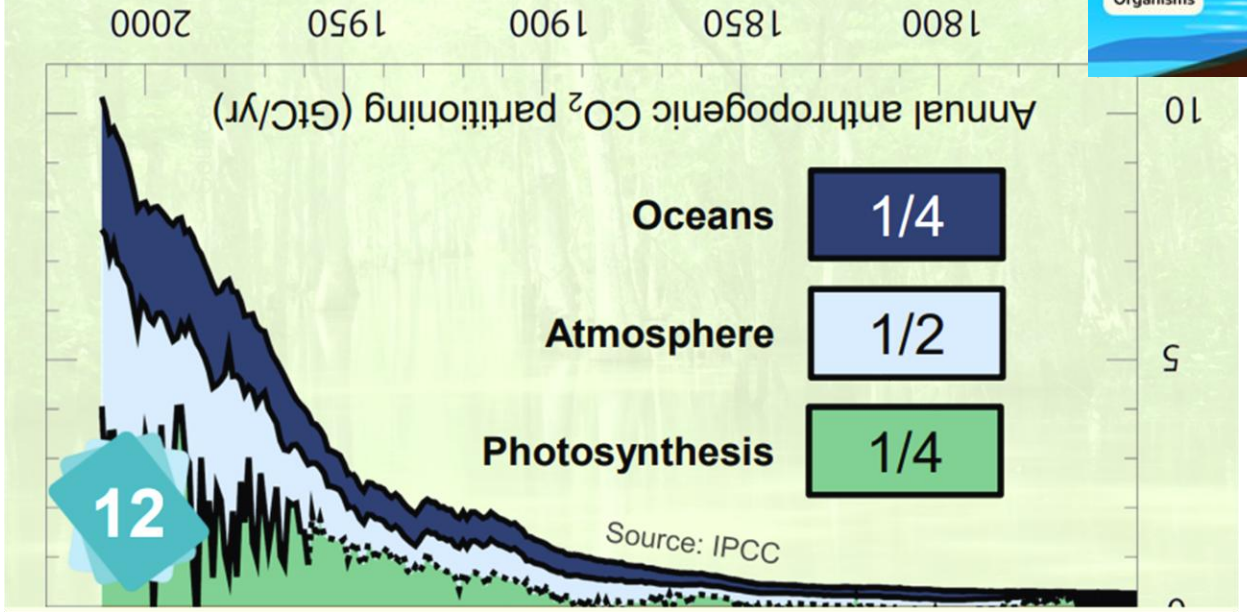
20 000 years ago | Today | 2050

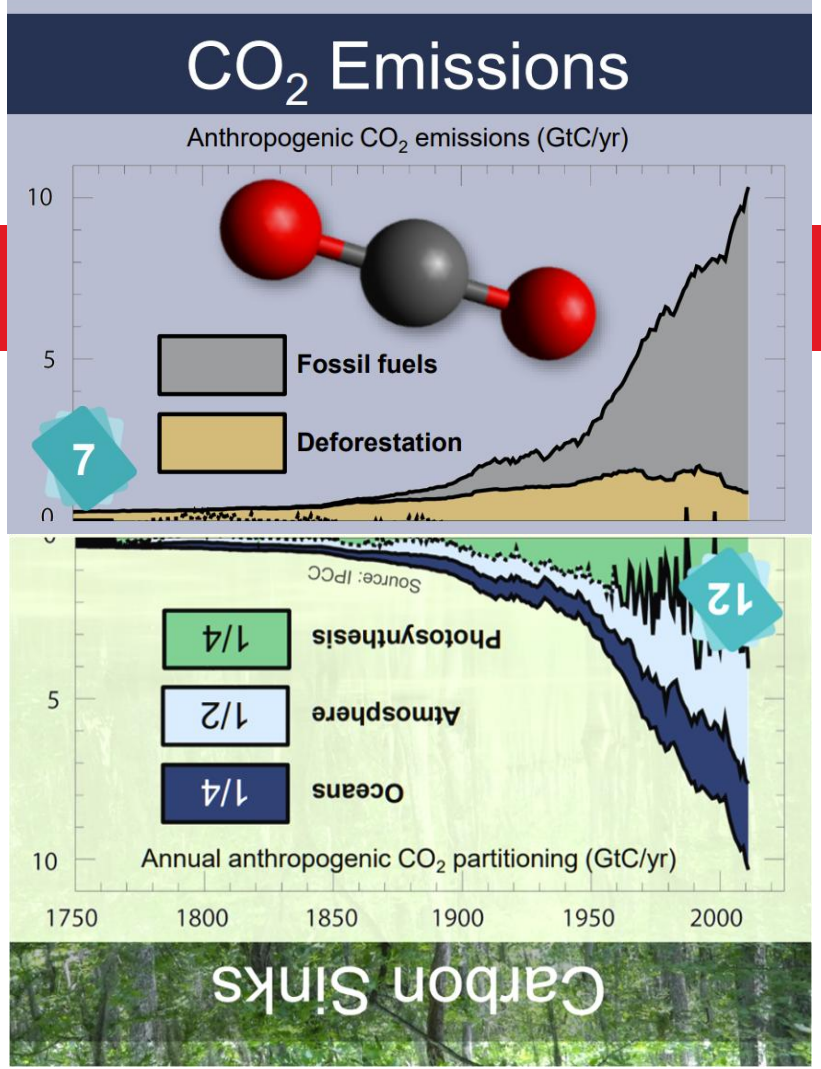
CONSEQUENCES of Anthropogenic activities



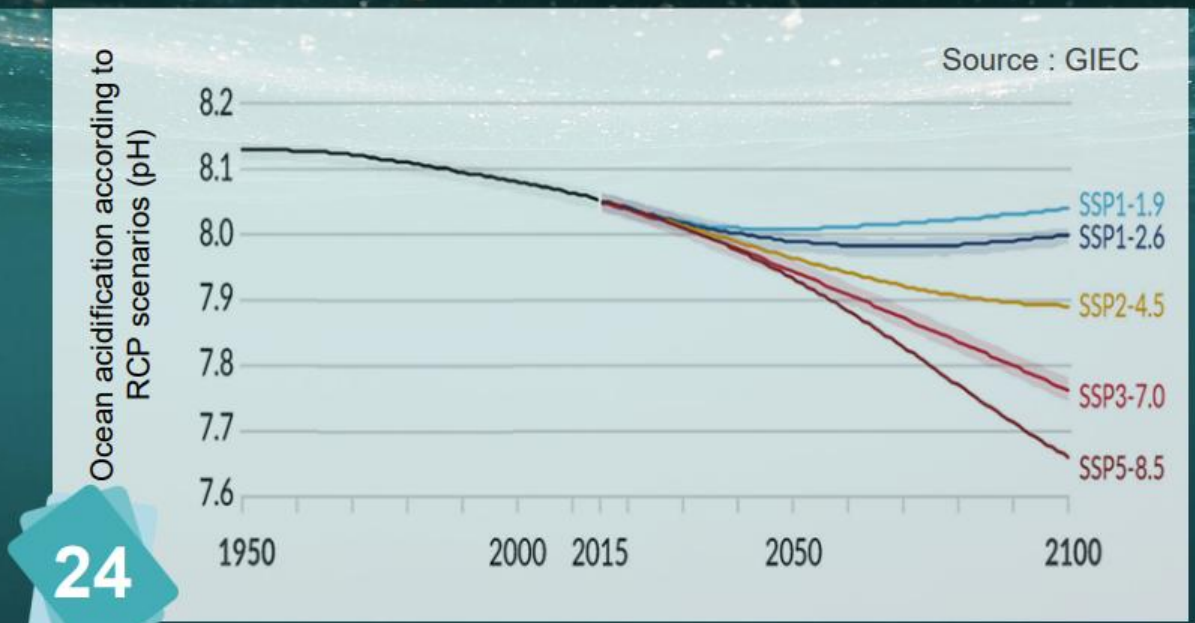
Carbon Sinks



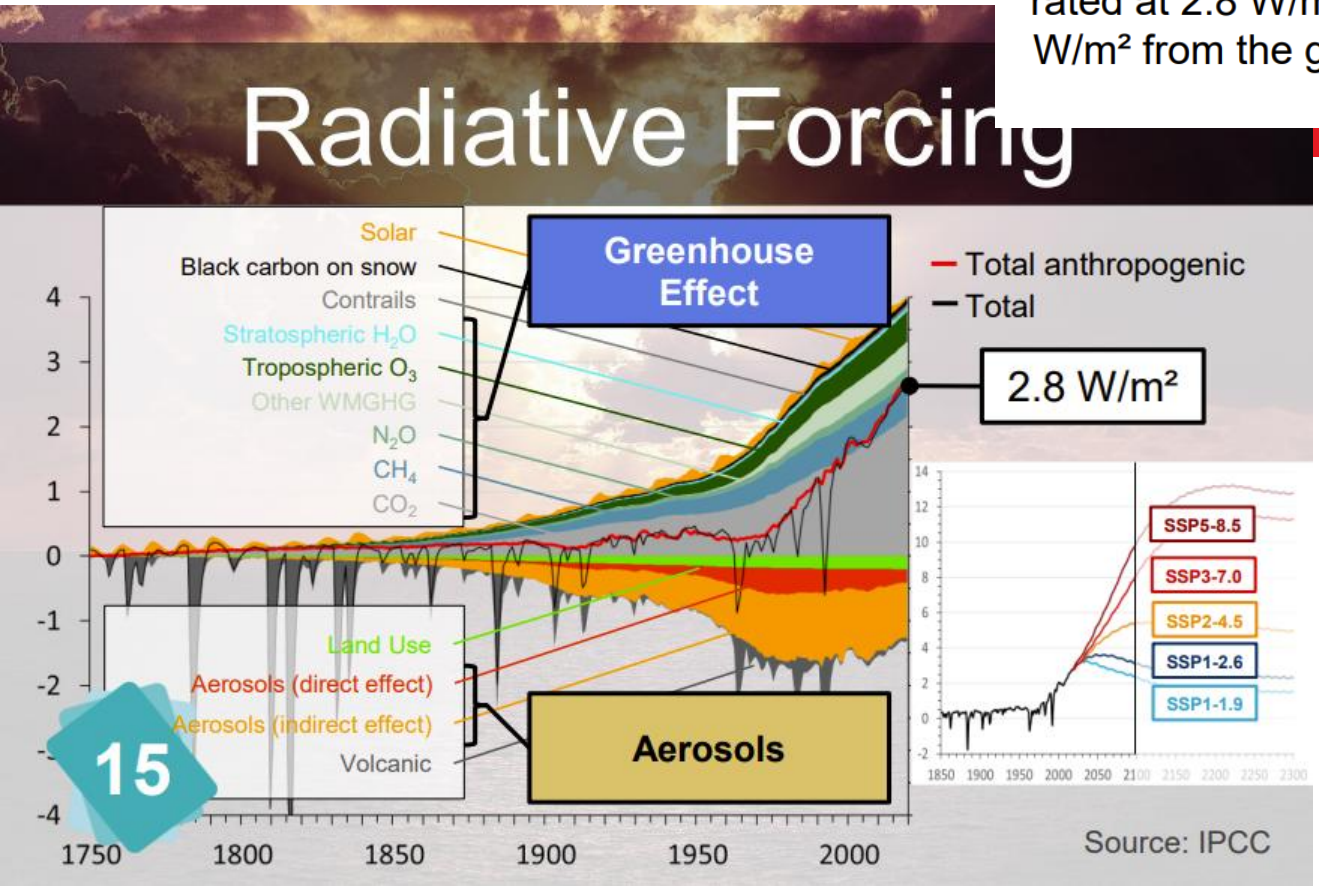



CO_2 Emissions
Anthropogenic CO_2 emissions (GtC/yr)
10
5
0
Fossil fuels
Deforestation
7
Source: IPCC
12
Photosynthesis
1/4
Atmosphere
1/2
Oceans
1/4
5
10
Annual anthropogenic CO_2 partitioning (GtC/yr)
1750
1800
1850
1900
1950
2000
Carbon Sinks

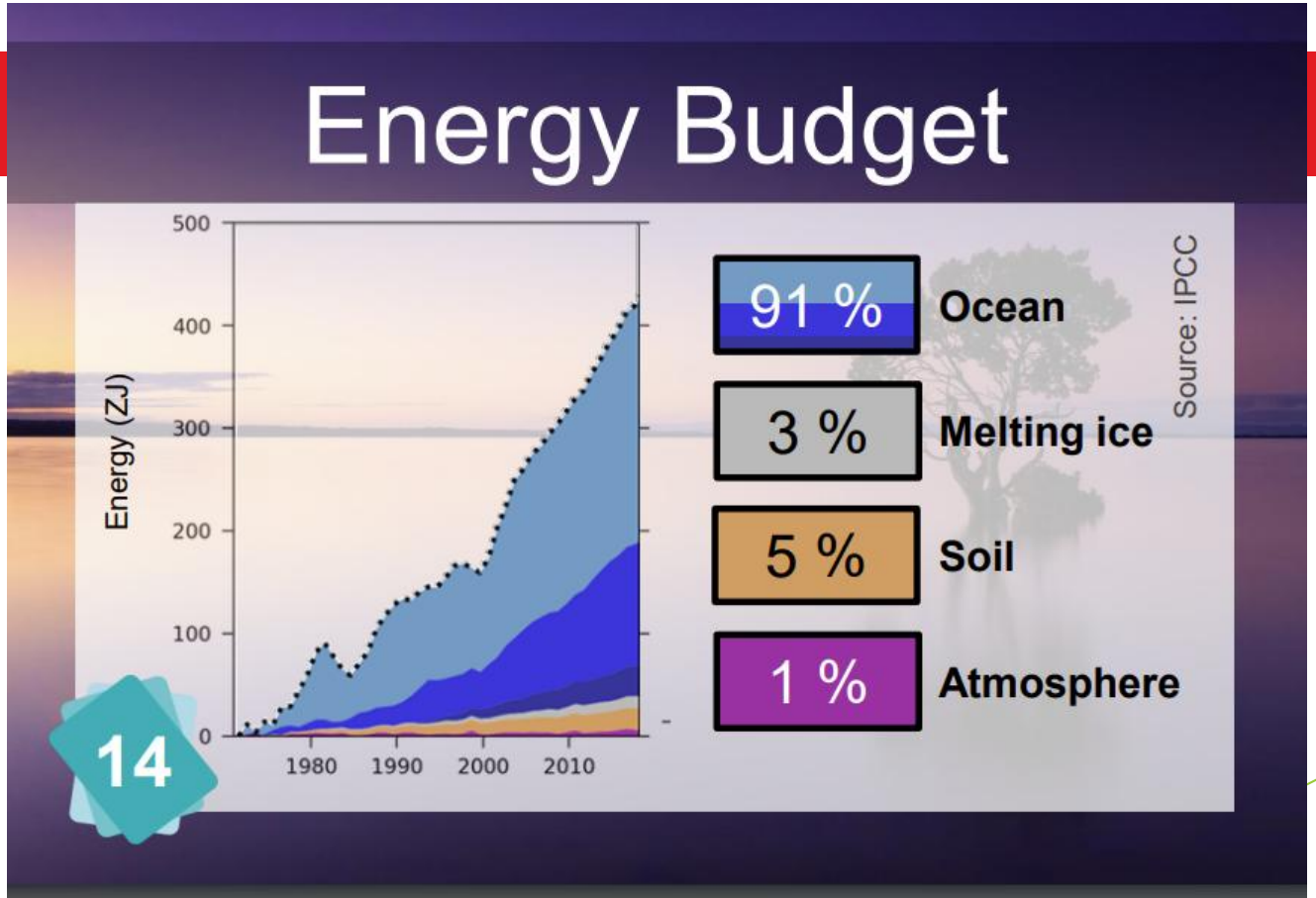
Ocean Acidification



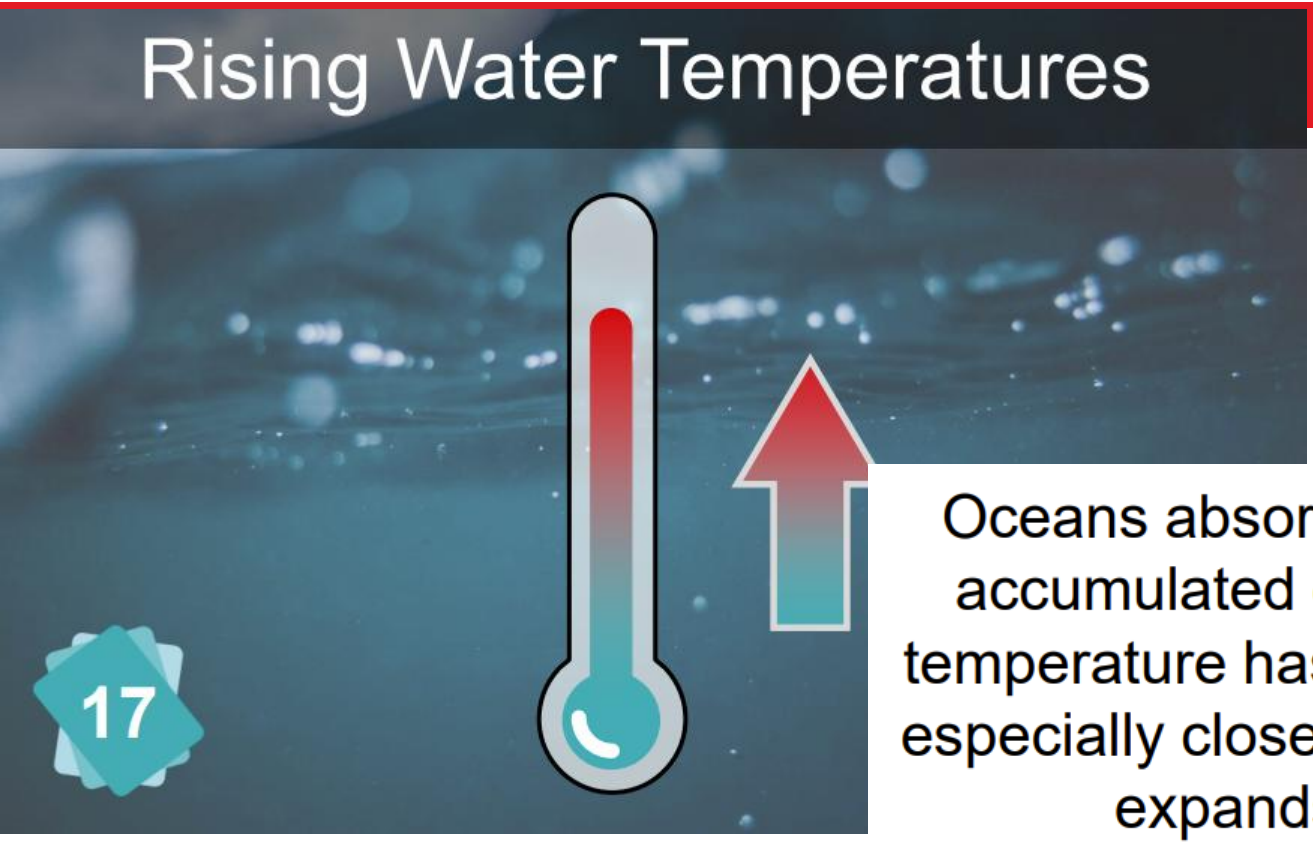
Radiative forcing represents the difference between the energy that reaches the Earth each second and the energy that is released. It is rated at 2.8 W/m² (Watt per square metre), 3.8 W/m² from the greenhouse effect and -1 W/m² from aerosols.



This Energy goes to ……



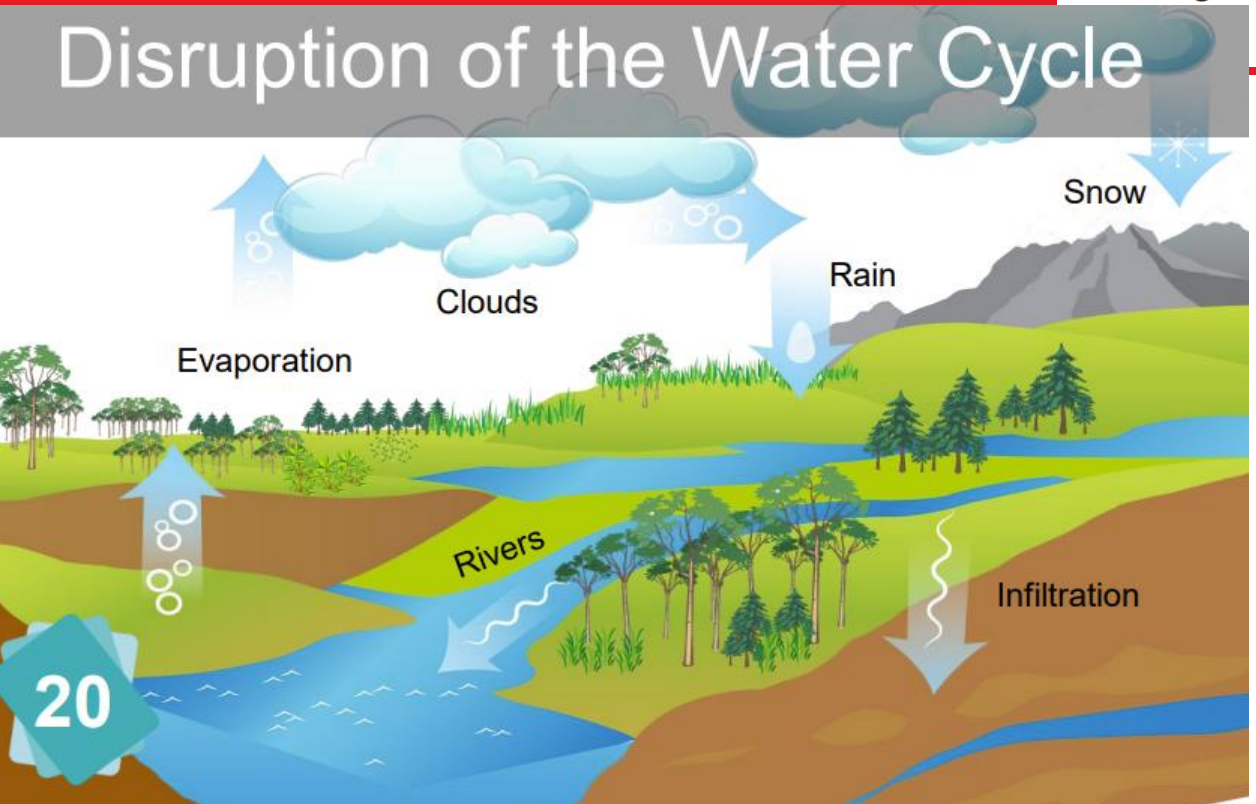
Rising Water Temperatures

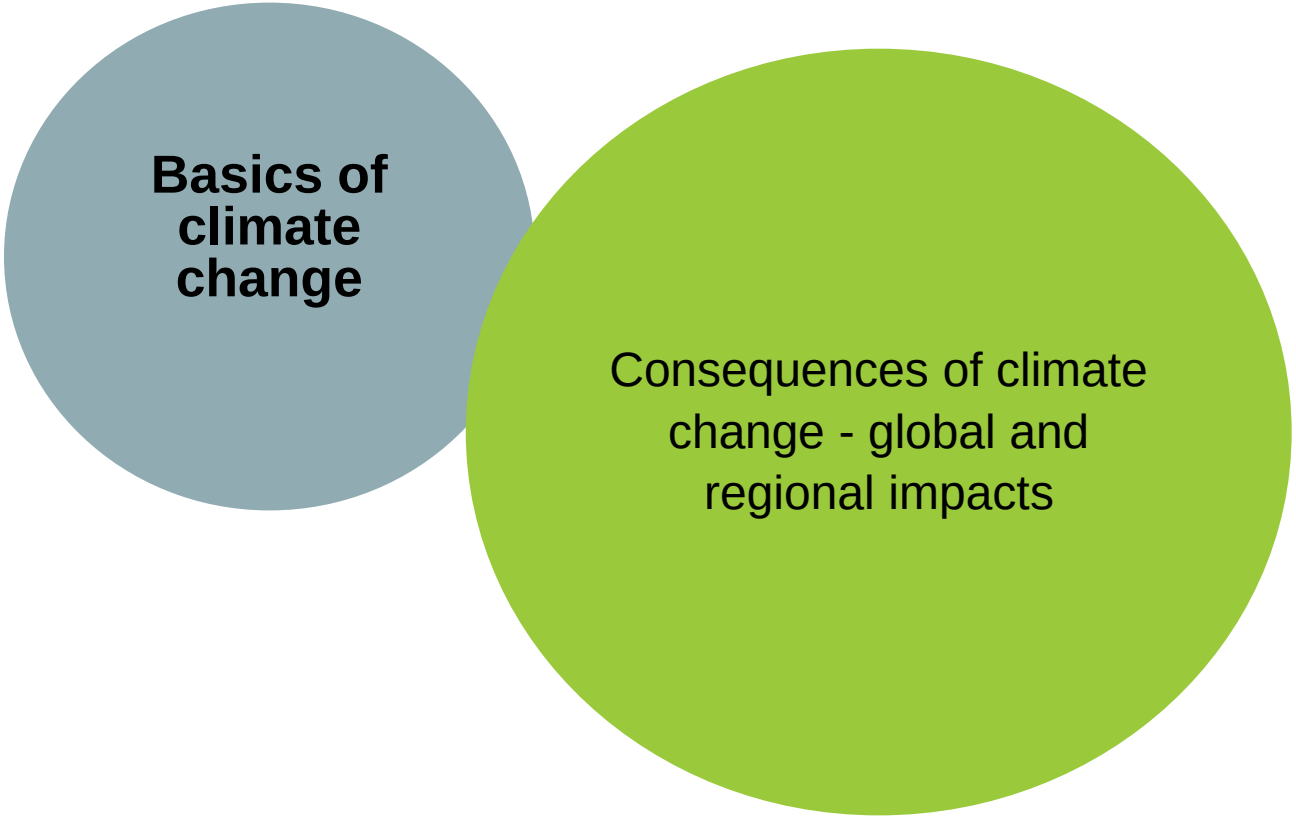


Oceans absorb 91% of the energy accumulated on Earth. The water temperature has therefore increased, especially close to the surface. Water expands as it warms.

Hotter oceans and a hotter atmosphere lead to stronger evaporation, causing rainclouds and rainfall. Hotter land and a hotter atmosphere also lead to stronger evaporation, this time causing the ground to dry out.

Disruption of the Water Cycle




Basics of climate change
Consequences of climate change - global and regional impacts

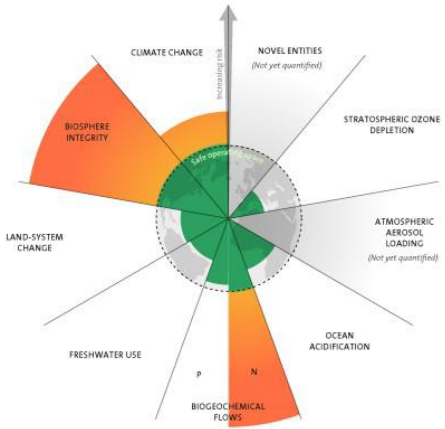
Many direct and indirect consequences of CC

- Terrestial and marine biodiversity,
- River flooding
- Cyclons
- Droughths
- Marine submersions
- Vectors of diseases
- Decline in agricultural yield
- Refugies
- Conflicts for resources

THE FALLACY OF LINEARITY IN CLIMATE CHANGE

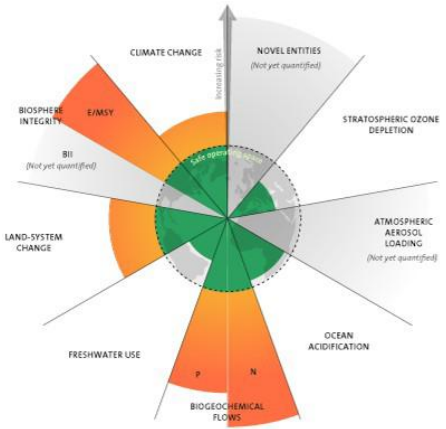
- The relationship between temperature rise and associated phenomena (e.g., ice sheet melting or sea level rise) is not linear.
- Thus, it is incorrect to assume that:
  - Every additional 0.5°C of warming will result in merely proportionally greater impacts.
  - If global warming is halted or reversed, other climate changes (such as ice sheet loss or sea level rise) will automatically revert.
- Many processes have **tipping points**, beyond which they accelerate uncontrollably or become irreversible. This means that if warming progresses too far, we risk losing the ability to stabilize temperature increases and their associated consequences.

2009



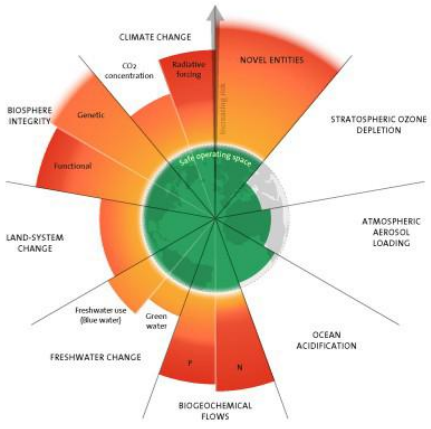
3 boundaries crossed

2015



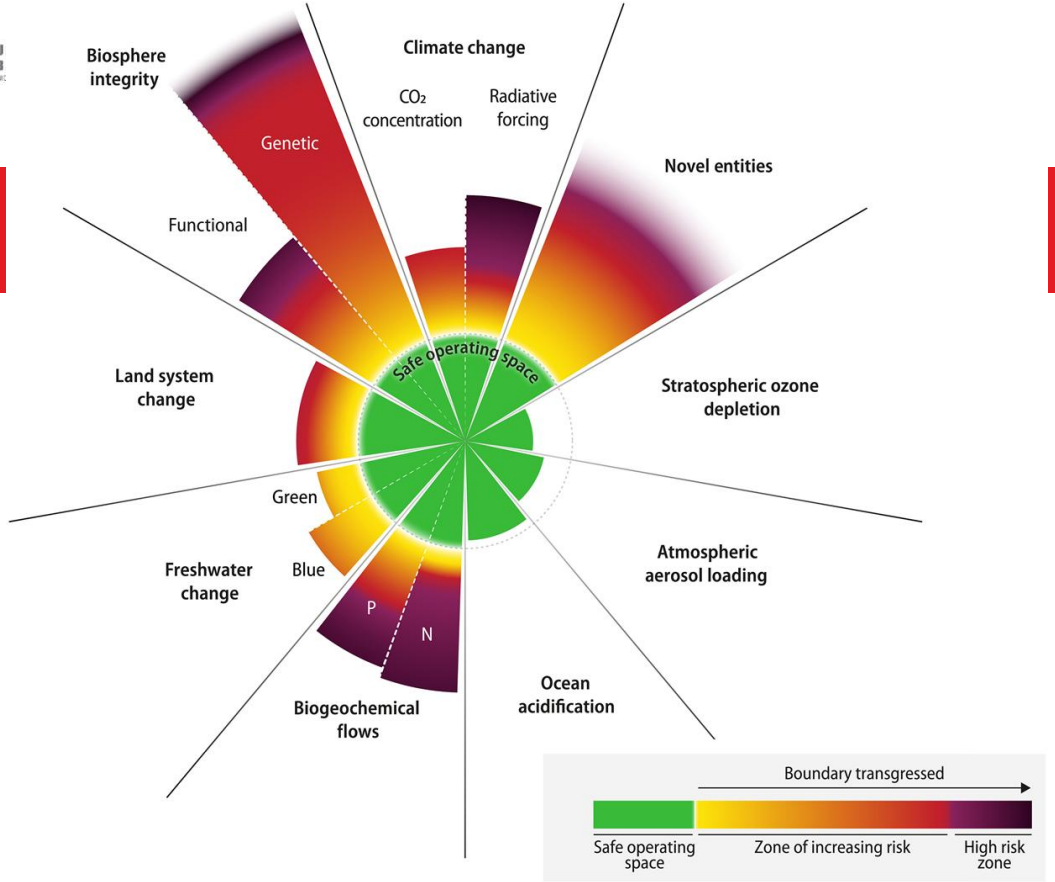
4 boundaries crossed

2023

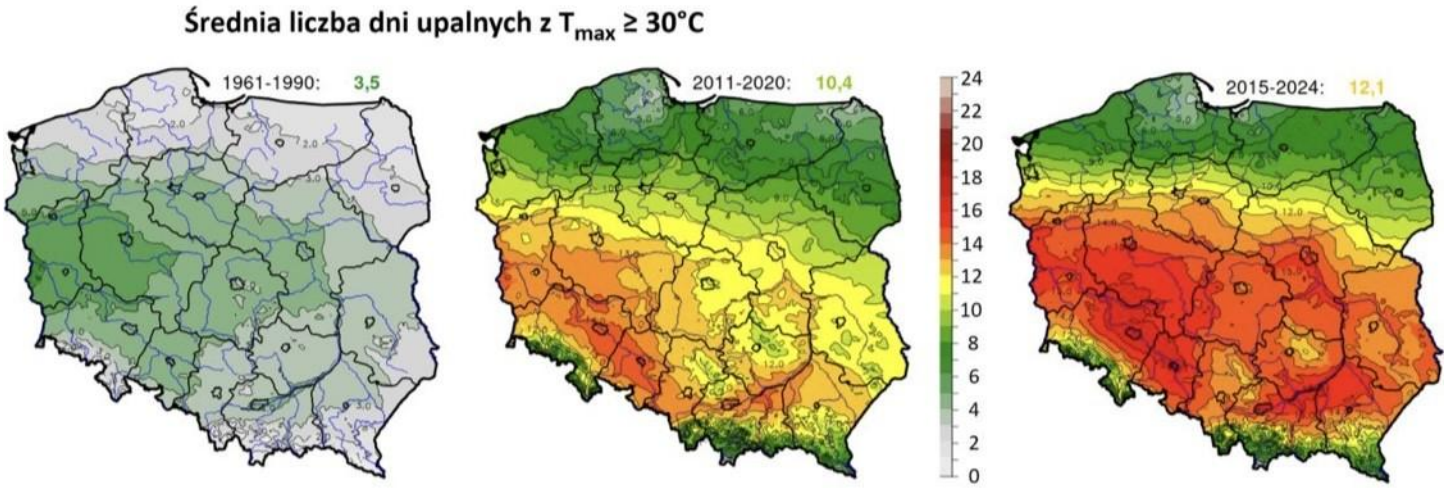


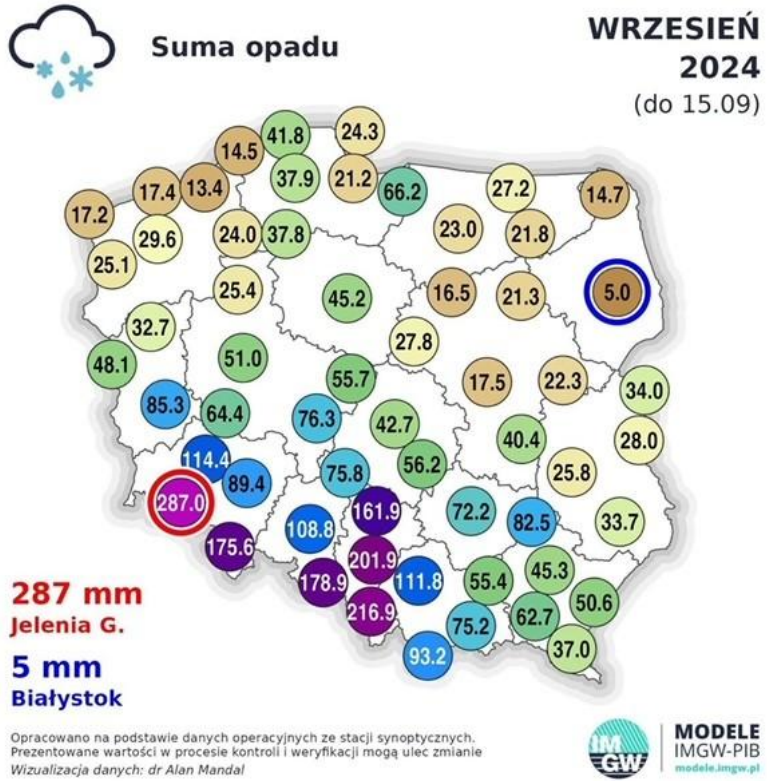
6 boundaries crossed

Richardson, K., Steffen, W., Lucht, W., Bendtsen, J., Cornell, S.E.,Donges, J.F., Drüke, M., Fetzer, I., Bala, G., von Bloh, W., Feulner, G.,Fiedler, S., Gerten, D., Gleeson, T., Hofmann, M., Huiskamp, W.,Kummu, M., Mohan, C., Nogués-Bravo, D., Petri, S., Porkka, M.,Rahmstorf, S., Schaphoff, S., Thonicke, K., Tobian, A., Virkki, V., Weber,L. & Rockström, J. 2023. ***Earth beyond six of nine planetary boundaries****. Science Advances 9, 37.****DOI: 10.1126/sciadv.adh2458***



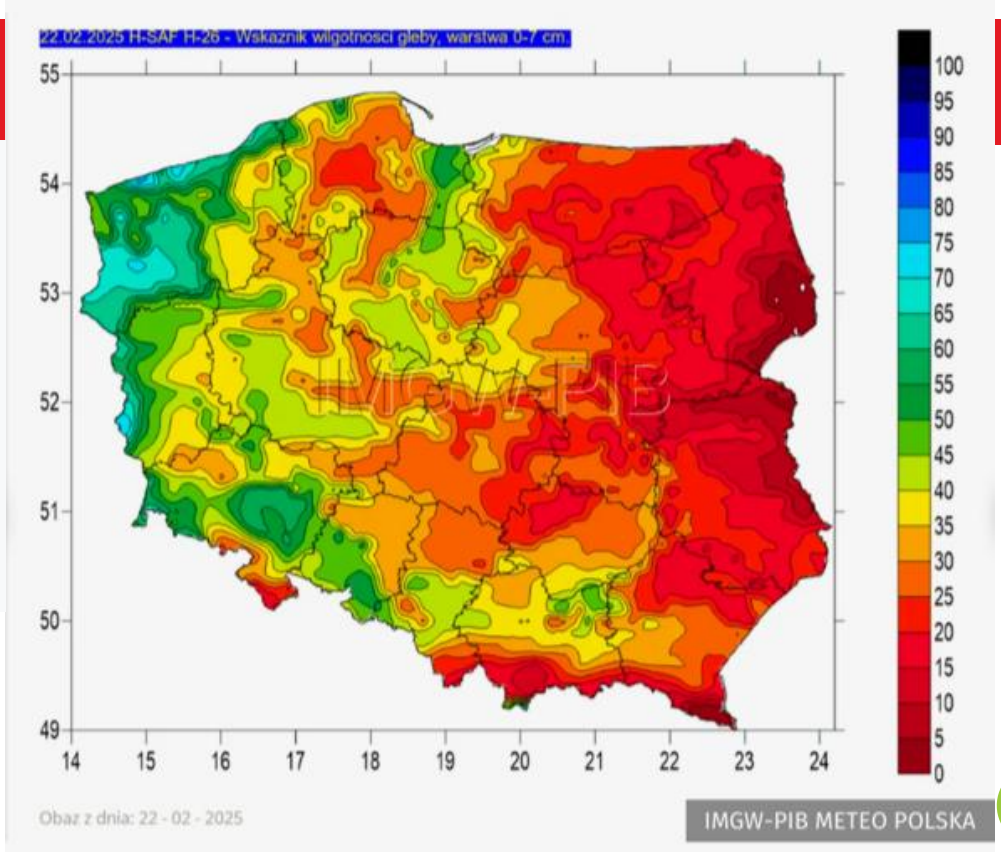
Richardson, K., Steffen, W., Lucht, W., Bendtsen, J., Cornell, S.E.,Donges, J.F., Drüke, M., Fetzer, I., Bala, G., von Bloh, W., Feulner, G.,Fiedler, S., Gerten, D., Gleeson, T., Hofmann, M., Huiskamp, W.,Kummu, M., Mohan, C., Nogués-Bravo, D., Petri, S., Porkka, M.,Rahmstorf, S., Schaphoff, S., Thonicke, K., Tobian, A., Virkki, V., Weber,L. & Rockström, J. 2023. ***Earth beyond six of nine planetary boundaries****. Science Advances 9, 37.****DOI: 10.1126/sciadv.adh2458***


Średnia liczba dni upalnych z T_{max} ≥ 30°C
1961-1990: 3,5
2011-2020: 10,4
2015-2024: 12,1
24
22
20
18
16
14
12
10
8
6
4
2
0

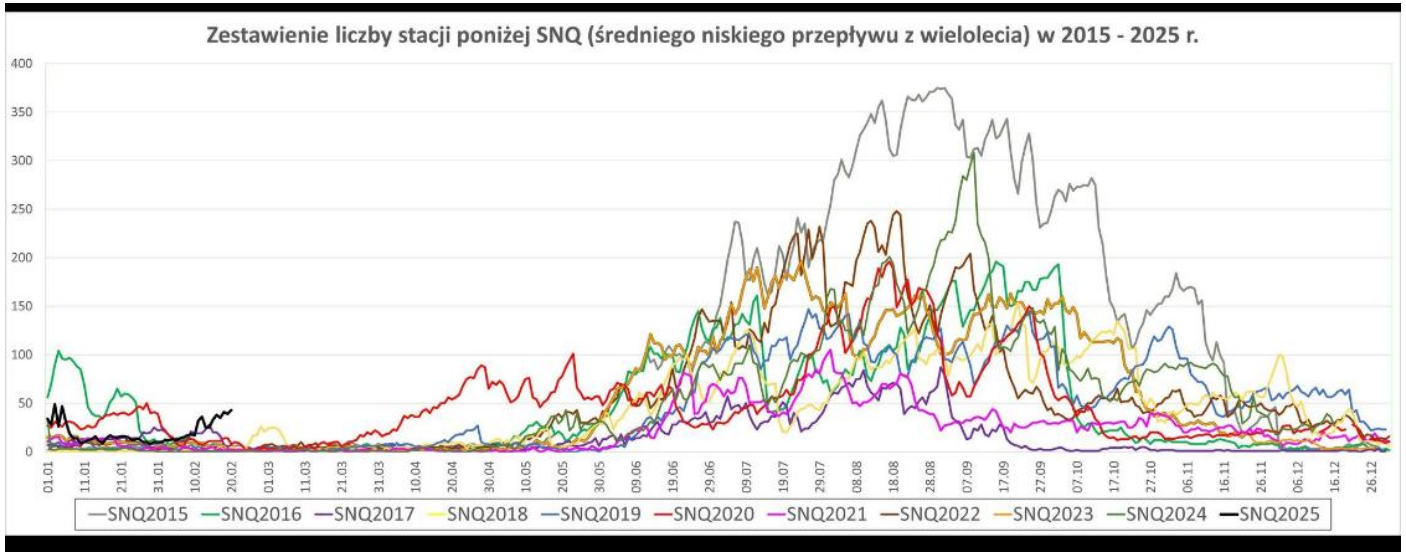

Suma opadu
WRZESIEŃ 2024
(do 15.09)
14.5
41.8
24.3
17.4
13.4
37.9
21.2
66.2
27.2
14.7
17.2
29.6
24.0
37.8
23.0
21.8
25.1
25.4
45.2
16.5
21.3
5.0
32.7
27.8
48.1
51.0
55.7
17.5
22.3
34.0
85.3
64.4
76.3
42.7
40.4
28.0
114.4
89.4
75.8
56.2
25.8
287.0
161.9
72.2
82.5
33.7
108.8
175.6
201.9
178.9
111.8
55.4
45.3
216.9
75.2
62.7
50.6
93.2
37.0
287 mm
Jelenia G.
5 mm
Białystok
Opracowano na podstawie danych operacyjnych ze stacji synoptycznych.
Prezentowane wartości w procesie kontroli i weryfikacji mogą ulec zmianie
Wizualizacja danych: dr Alan Mandal
MODELE
IMGW-PIB
modele.imgw.pl

The consequences, low soil moisture

Groundwater level as of January 31, 2025, 11 voivodeships received an alert from IMWM (Institute of meteorology and water managment) about the state of hydrogeological threat



Number of stations below average low flow in rivers in Poland



FLESH FLOODs phenomena

In June 2001 during 24h up to 130 mm of precipitation

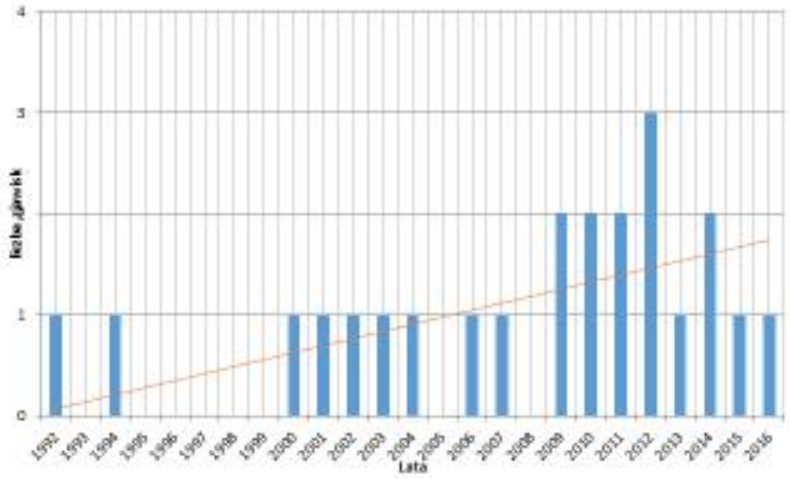
GDAŃSK

14/15 of June 2016 during 14 h was 160 mmm of precipitation which corresponds to a two-month rainfall

FLESH FLOODs phenomena

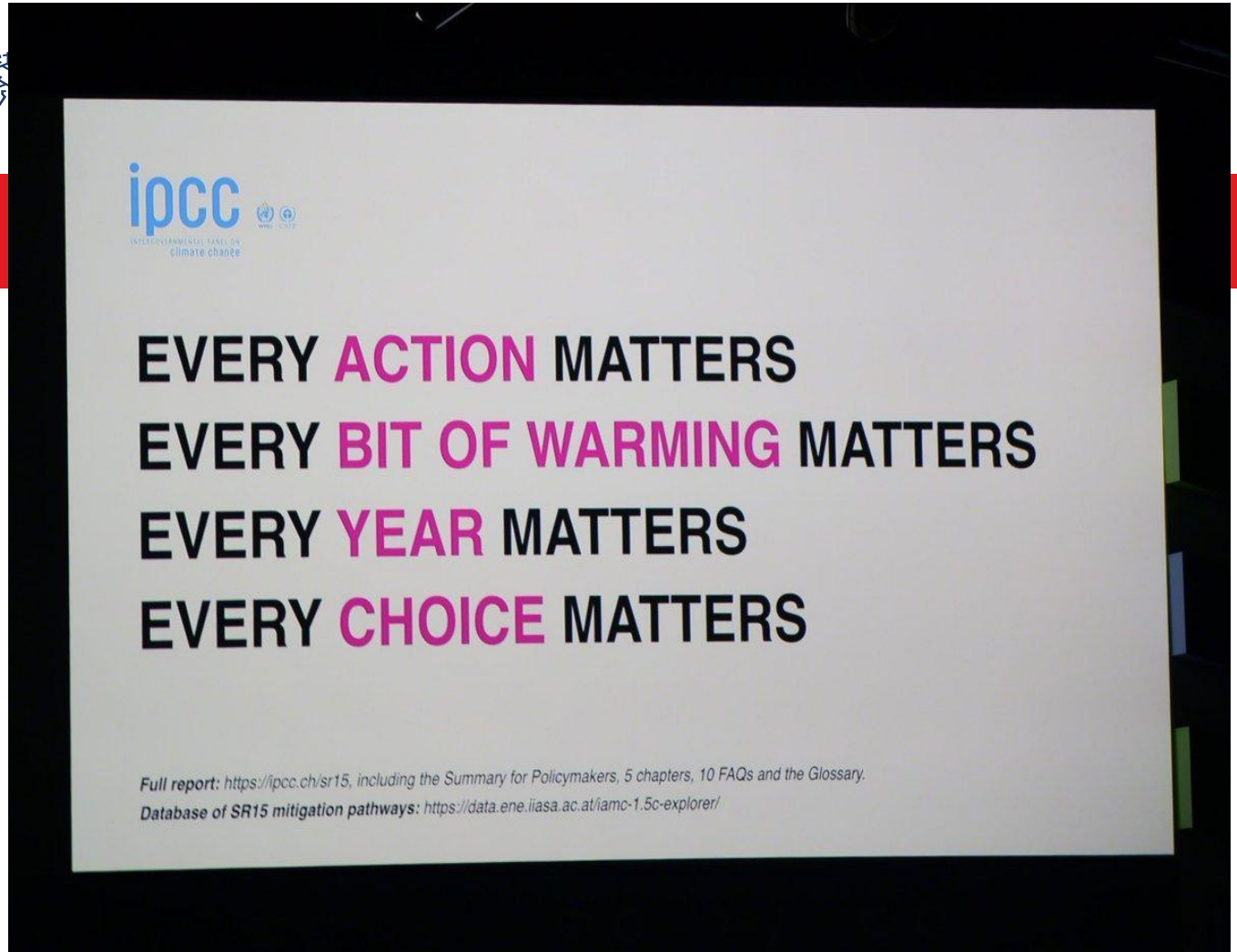
In XXI in Gdańsku:

- 4 events resulting from longer rainfall with sums exceeding daily 100 mm –over 100 years of rain
- flash flood over 100-yerars np. 11 May 2018, 12 June 2018, 1 August 2018



Number of flash flood phenomena in Gdansk

Gdańsk 11.05.2018. st. Twarda

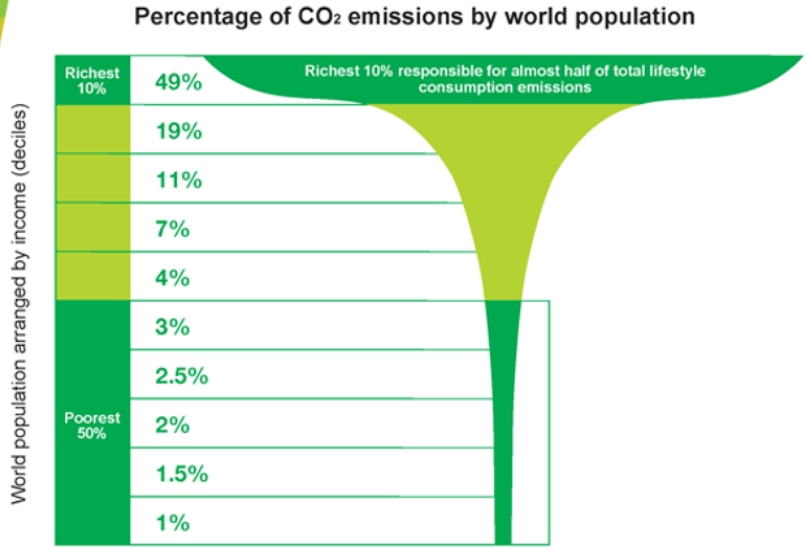

ipcc
INTERGOVERNMENTAL PANEL ON climate change
EVERY ACTION MATTERS
EVERY BIT OF WARMING MATTERS
EVERY YEAR MATTERS
EVERY CHOICE MATTERS
Full report: https://ipcc.ch/sr15, including the Summary for Policymakers, 5 chapters, 10 FAQs and the Glossary.
Database of SR15 mitigation pathways: https://data.ene.iiasa.ac.at/iamc-1.5c-explorer/

MORE FACTS

OXFAM

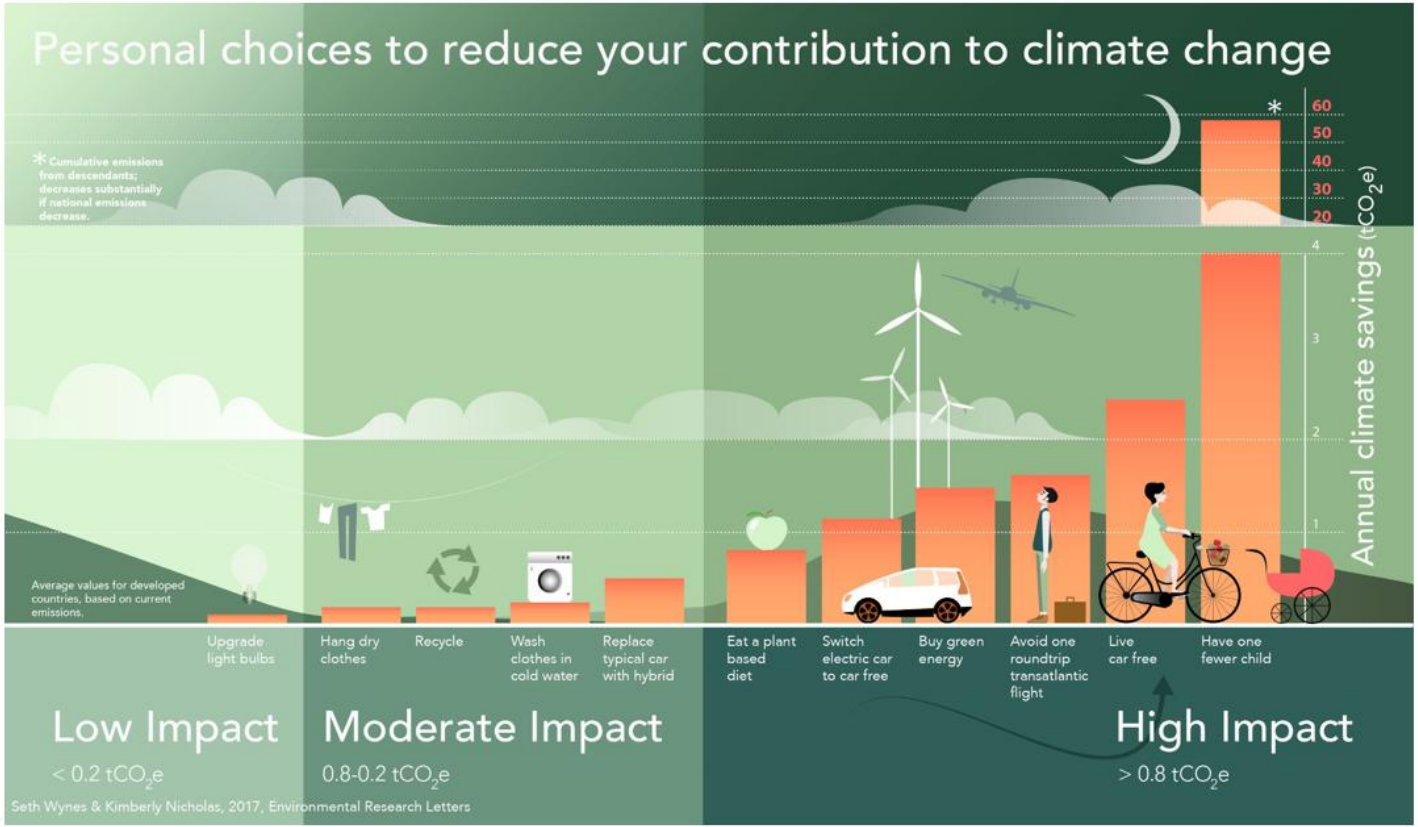
The poorest **50%** is only responsible for around **10%** of total lifestyle consumption emissions.

OXFAM MEDIA BRIEFING: EXTREME CARBON INEQUALITY



Source: Oxfam

INDIVIDUAL ACTIONS

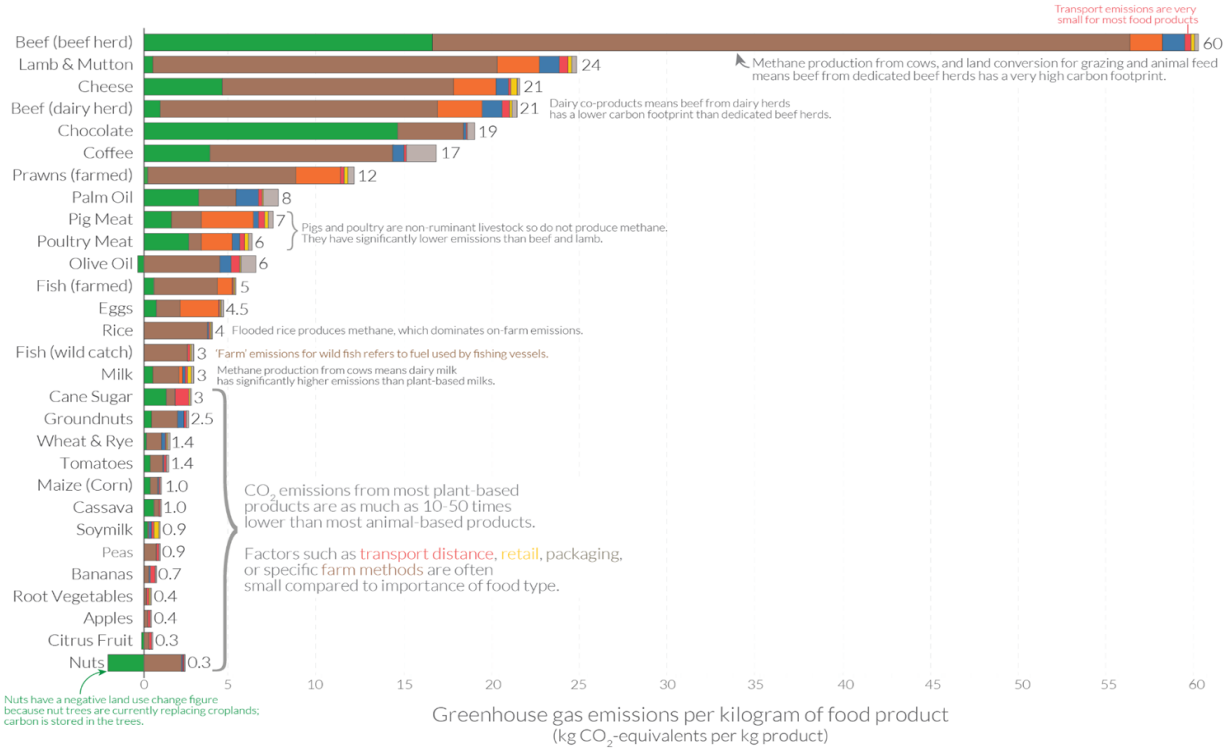


Source: Kim Nicholas

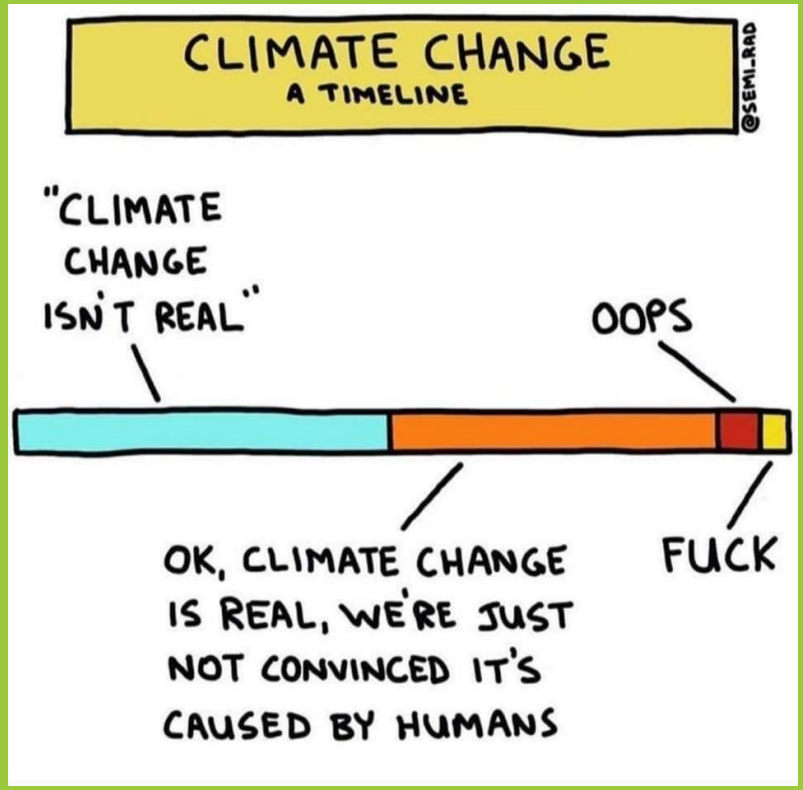
Food: greenhouse gas emissions across the supply chain

Our World in Data

Land Use Change	Farm	Animal Feed	Processing	Transport	Retail	Packaging
Aboveground changes in biomass from deforestation, and belowground changes in soil carbon	Methane emissions from cows, methane from rice, emissions from fertilizers, manure, and farm machinery	On-farm emissions from crop production and its processing into feed for livestock	Emissions from energy use in the process of converting raw agricultural products into final food items	Emissions from energy use in the transport of food items in-country and internationally	Emissions from energy use in refrigeration and other retail processes	Emissions from the production of packaging materials, material transport and end-of-life disposal



Note: Greenhouse gas emissions are given as global average values based on data across 38,700 commercially viable farms in 119 countries.
Data source: Poore and Nemecek (2018). Reducing food's environmental impacts through producers and consumers. *Science*. Images sourced from the Noun Project.
OurWorldinData.org – Research and data to make progress against the world's largest problems.


CLIMATE CHANGE
A TIMELINE
@SEMI_RAD
"CLIMATE CHANGE ISN'T REAL"
OOPS
OK, CLIMATE CHANGE IS REAL, WE'RE JUST NOT CONVINCED IT'S CAUSED BY HUMANS
FUCK

Thank you

Interreg
CENTRAL EUROPE

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