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What comes to your mind when I say "CLIMATE CHANGE"?

II. Climate Change (CC)

Earth System process	Control variable	Threshold avoided or influenced by slow variable	Planetary Boundary (zone of uncertainty)	State of knowledge*
Climate change	Atmospheric CO ₂ concentration, ppm; Energy imbalance at Earth's surface, W m ⁻²	Loss of polar ice sheets. Regional climate disruptions. Loss of glacial freshwater supplies. Weakening of carbon sinks.	Atmospheric CO ₂ concentration: 350 ppm (350–550 ppm) Energy imbalance: +1 W m ⁻² (+1.0–+1.5 W m ⁻²)	1. Ample scientific evidence. 2. Multiple sub-system thresholds. 3. Debate on position of boundary.

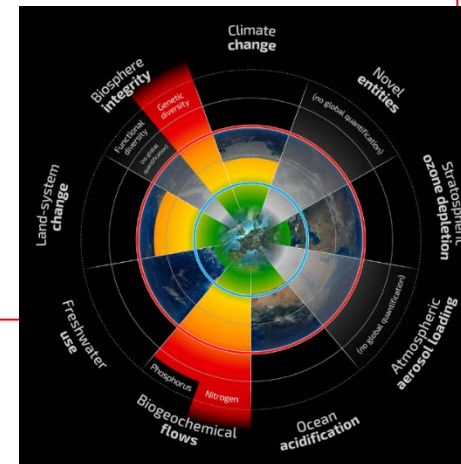
Boundary: Atmospheric CO₂ concentration no higher than 350 ppm

Pre-industrial level: 280 ppm

• **Current level** : January 2022: 418.19 ppm

Mauna Loa January 2021: 415.52 ppm

Diagnosis: Boundary exceeded



History of Climate Change Research

Can you guess the year when the
greenhouse effect was **DISCOVERED**?

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CC - history

1824 – Joseph Fourier - greenhouse effect in the atmosphere

1861 – John Tyndall - water vapour
and other gases are GHG

Tyndall°Centre[®]
for Climate Change Research

1896 – Svante Arrhenius – hypothesis on enhancement of GH
effect due to increase of CO₂ in the atmosphere as a
consequence of fossil fuels combustion

- the prognosis on increase of the temperature by
several °C when GHG concentration doubles is still valid



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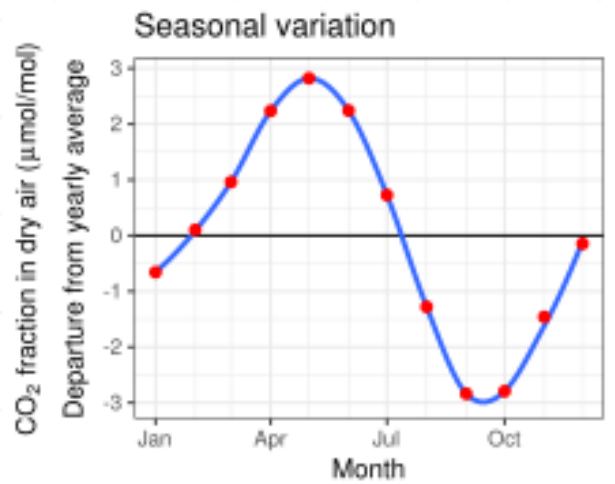
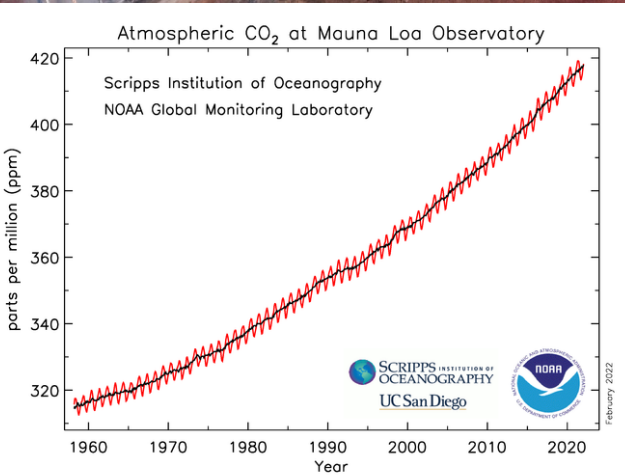
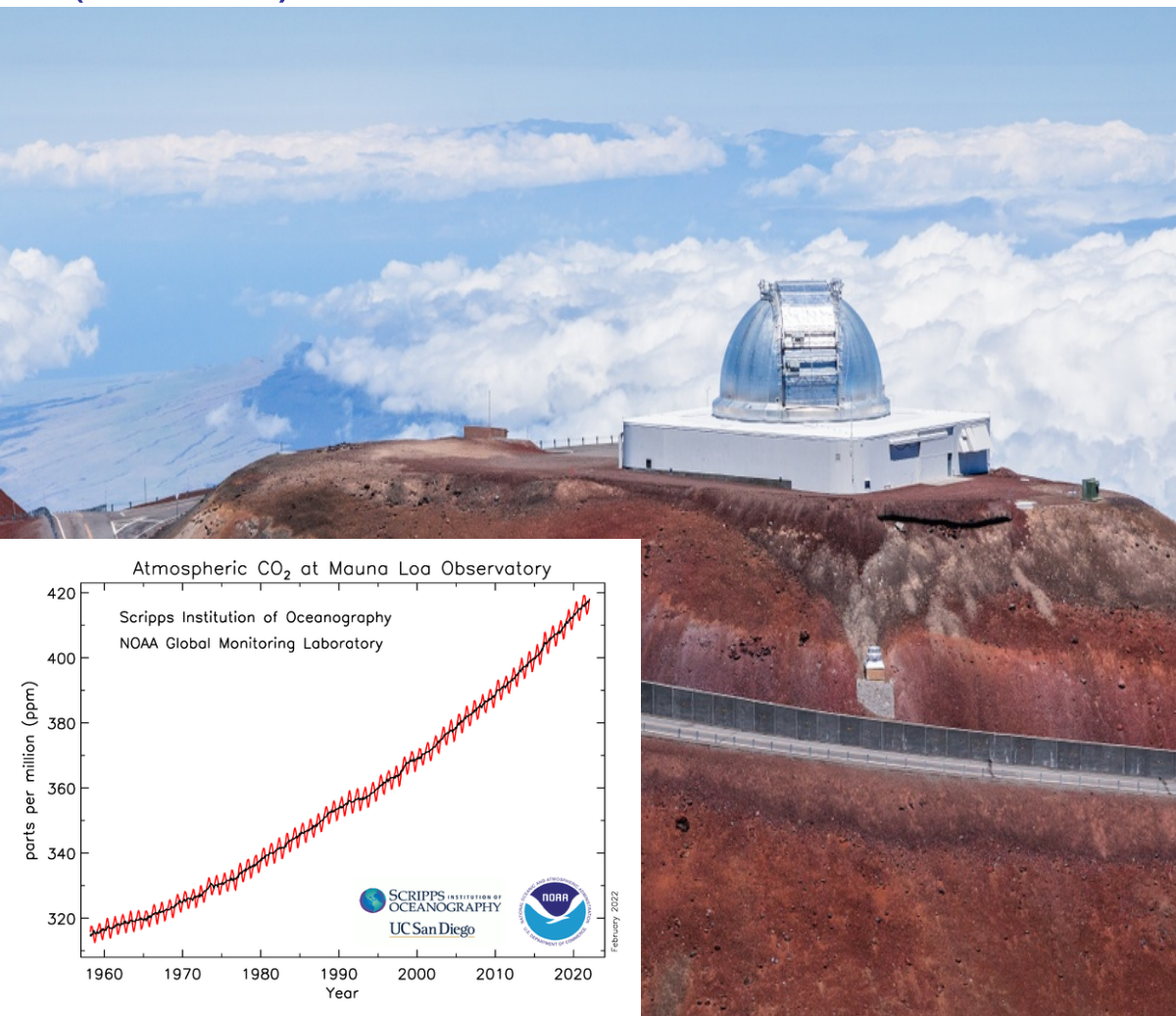
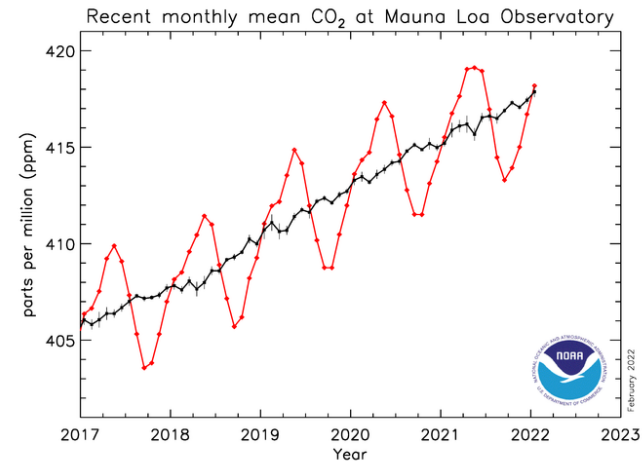
- the prognosis on increase of the temperature by several °C when GHG concentration doubles is still valid



1957 – **oceanographer** Roger Revelle and chemist Hans Suess shown that oceans can not **absorb entire CO₂** produced by people

*"Human beings are now carrying out
a large scale geophysical experiment.,,"*

1950 – Charles David Keeling
 continuous measurements
 taken at the Mauna Loa
Observatory since 1950
 (till now)



What do you think about the seasonal variation of CO₂? What is the reason for increase in summer and decrease in autumn?

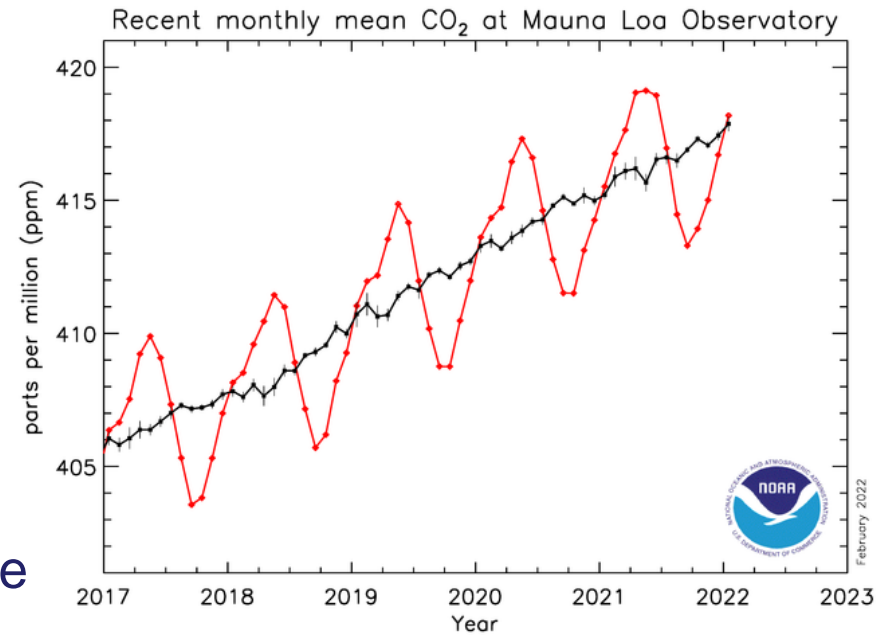
- Increase from October to May

-  +  give off CO₂

- Decrease from May to October

- Just before  start to remove

large amounts of CO₂ from the atmosphere
(northern hemisphere)



CC... and politics

1972 – *UNCHE*, Stockholm.
becomes one of the global priorities

1990 – 1st IPCC report – „temperature increase by 0.3-0.6 °C is caused also by the human activities“

1992 – *Earth summit* – *UN Framework Convention on CC*, Rio de Janeiro

2005 – Kyoto Protocol (1997)

! CHINA – developing country, USA – did not sign !

2013 - 5th IPCC report „Scientists are 95% certain that humans are the "dominant cause" of global warming since the 1950s“

2016 – *Paris Treaty* came into force

2021-2022 - 6th IPCC report

2021 – UNCC Conference, *Glasgow*



Greenhouse Effect and global Climate Change

- Greenhouse effect (GE) – **natural atmospheric effect** essential for life on the Earth
- GE dampens temperature fluctuation between day and night and thus provides favorable conditions for life



🌐 When poll is active, respond at pollev.com/lenkasuchankova345

📱 Text **LENKASUCHANKOVA345** to **+420 736 350 959** once to join

What is the average temperature on Earth?



33 °C

0 °C

15 °C

-2 °C

None of the above

Total Results: 0

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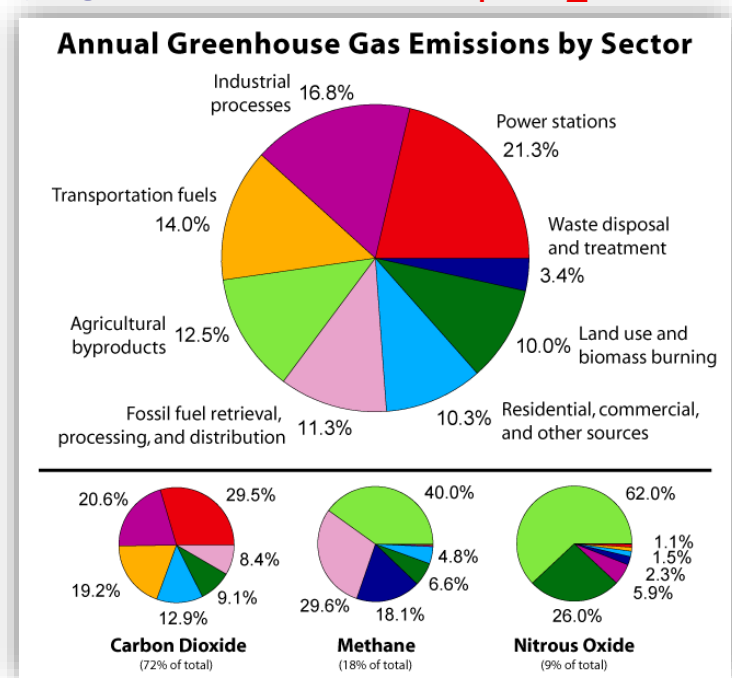
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Greenhouse Gasses (GH) in the atmosphere

- the most important GHG is water vapour - $\text{H}_2\text{O}(\text{g})$ that creates some 2/3 of greenhouse effect
- however $\text{H}_2\text{O}(\text{g})$ concentration in the atmosphere **is not significantly influenced** by human activities
- second most important GHG is CO_2 (~ 20 % GH effect)
- last 13 % of GH effect – mainly gases like CH_4 , N_2O , CFC

	Water	Carbon Dioxide	Methane	Nitrous Oxide
				
Atmospheric Concentration	0.01–4%*	385 ppm	1797 ppb	322 ppb
Rate of Increase	n/a	1.5 ppm/yr	7.0 ppb/yr	0.8 ppb/yr
Atmospheric Lifetime	Very short 1–5 days	Variable 5–200 yr	12 yr	120 yr
Global Warming Potential (GWP)	n/a†	1	21	310

* The amount of water vapor in the air varies according to temperature and density of air (usually ~1–3% of troposphere)
 † Water vapor levels vary strongly according to region, so rates of change and warming potential cannot be assessed

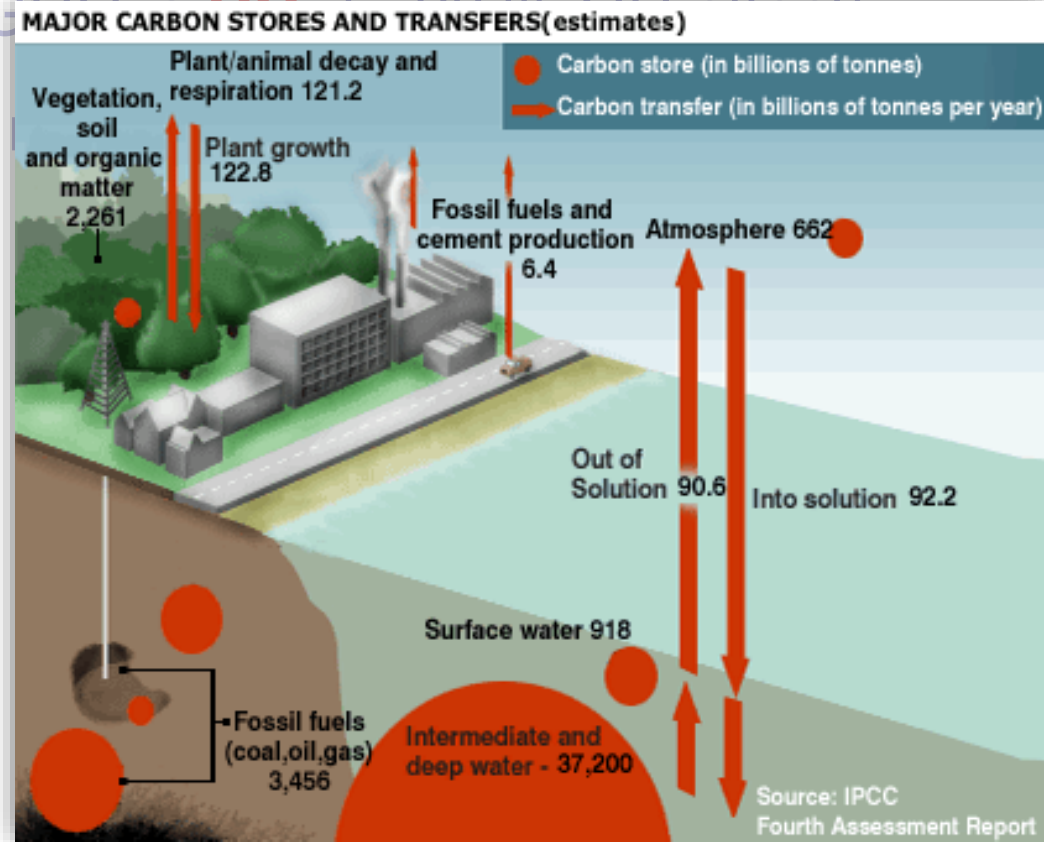


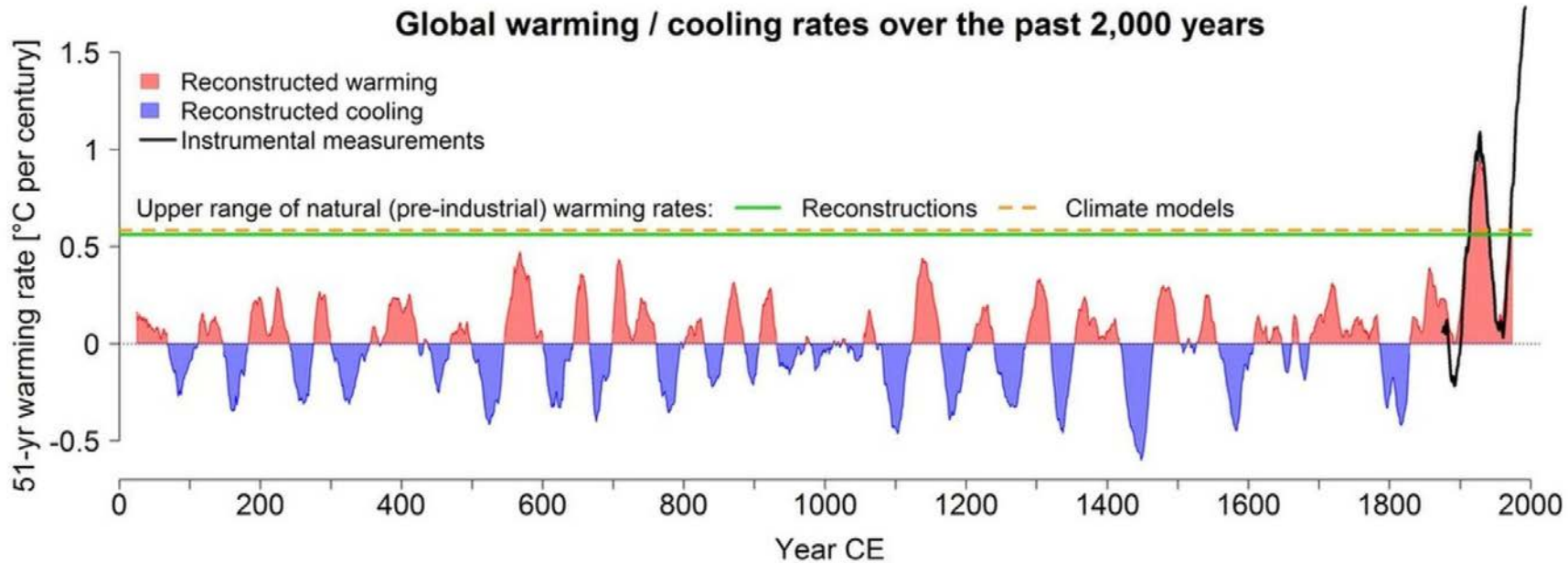
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- however $\text{H}_2\text{O}(\text{g})$ concentration in the atmosphere is not significantly influenced by human activities
- second most important GHG is $\text{CO}_2(\text{g})$ (23%)
- last 13 % of GH effect –

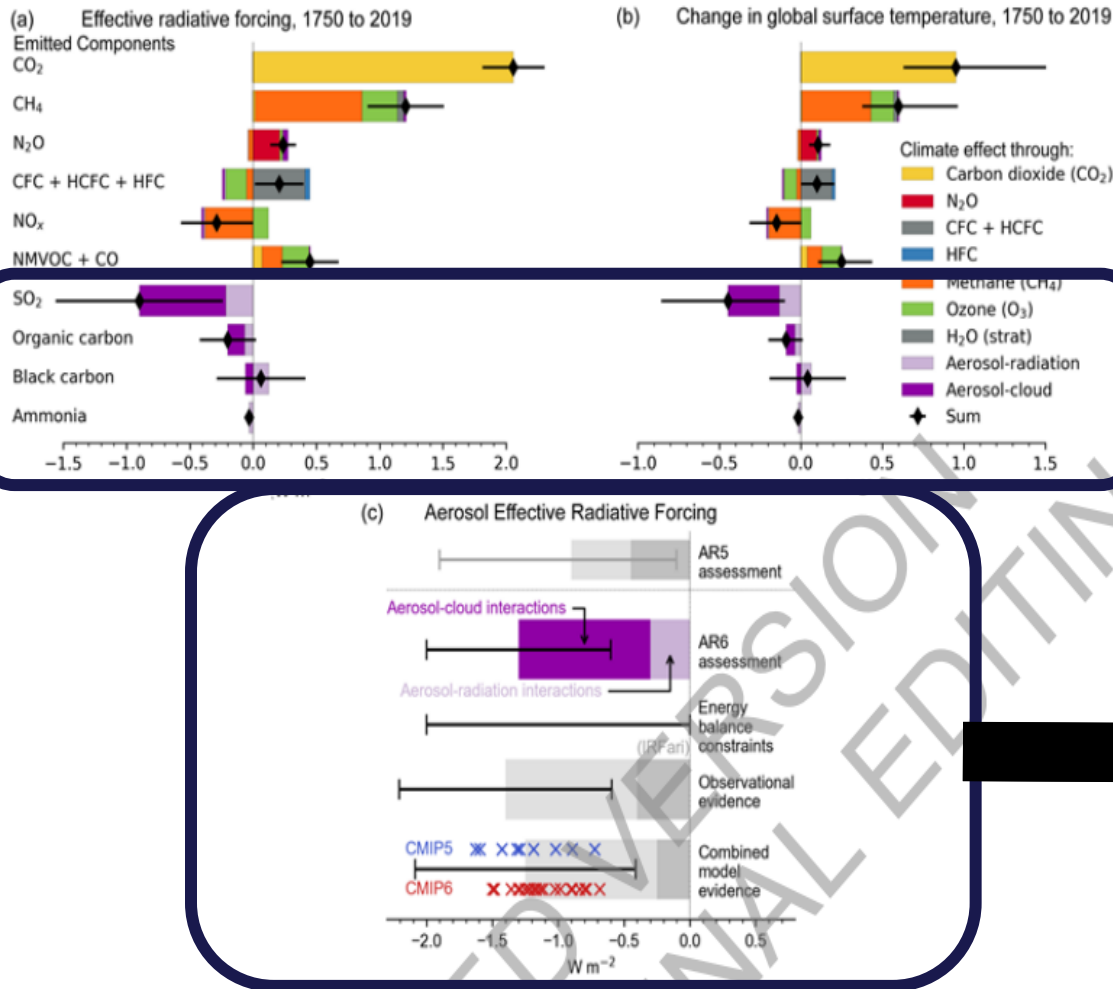
Problem

- increase of CO_2 level in the atmosphere due to the antropogenic action - disruption of the balance between release and absorption of CO_2 in the carbon geochemical cycle





GLACIAL/INTERGLACIAL PERIOD



?

One of the biggest uncertainties in estimation of climate models

?

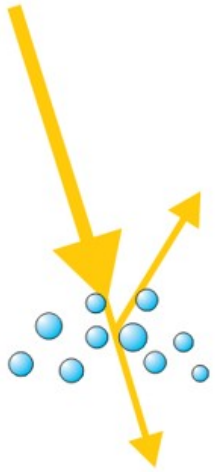
Figure TS.15: Contribution to ERF and b) global surface temperature change from component emissions between 1750 to 2019 based on CMIP6 models and c) net aerosol effective radiative forcing (ERF) from different lines of evidence. *The intent of the figure is to show advances since AR5 in the*

IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.

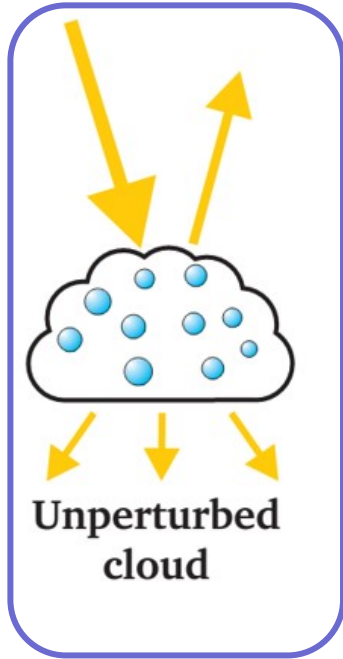
TINY BY SIZE, HUGE BY IMPORTANCE

AEROSOLS

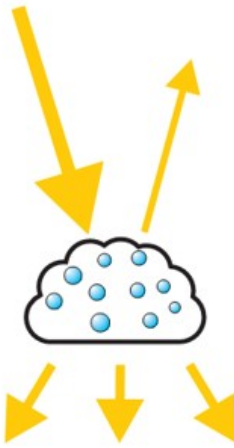
Incoming solar radiation



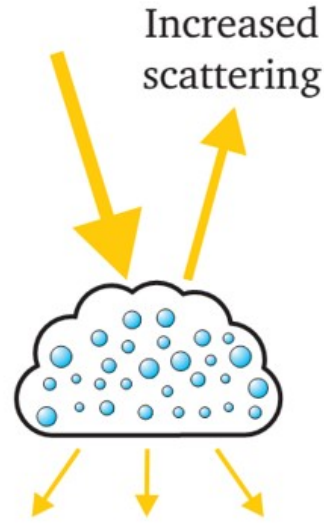
Direct Effect
Scattering/
absorption



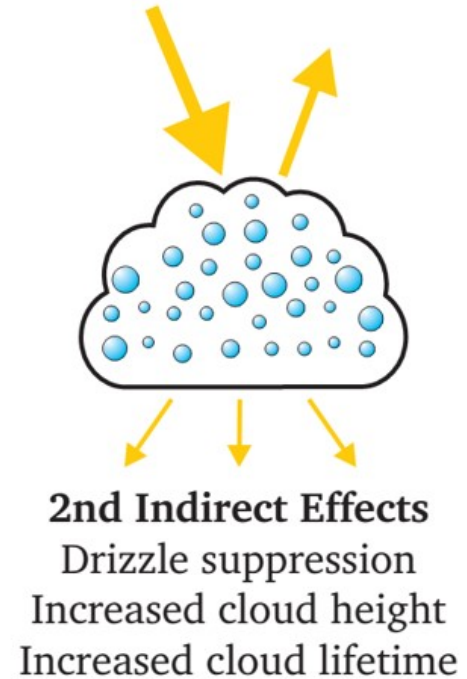
**Unperturbed
cloud**



**Semi-direct
Effect**
Cloud burn-off



**1st Indirect
Effect**
Increased CDNC

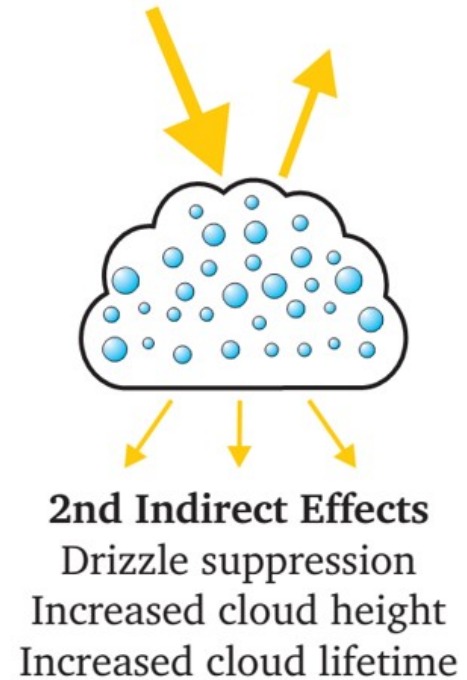
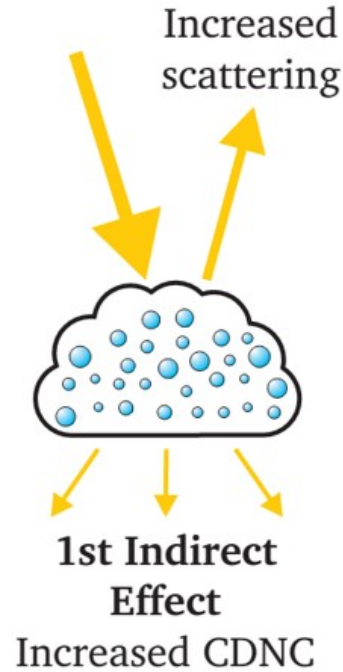
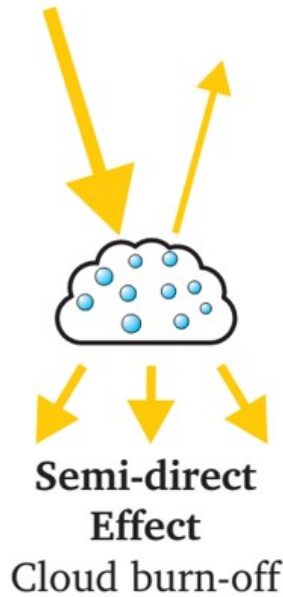
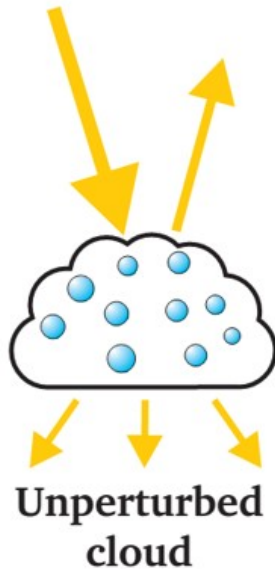
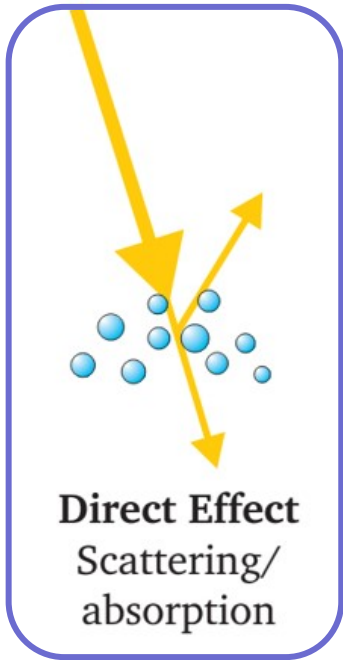


2nd Indirect Effects
Drizzle suppression
Increased cloud height
Increased cloud lifetime

TINY BY SIZE, HUGE BY IMPORTANCE

AEROSOLS

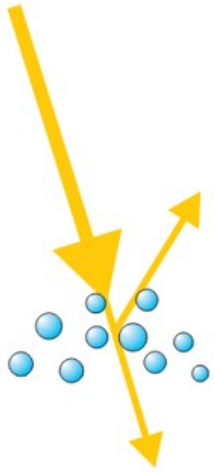
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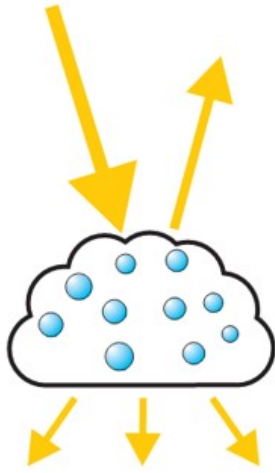
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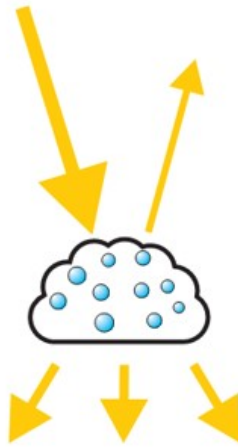
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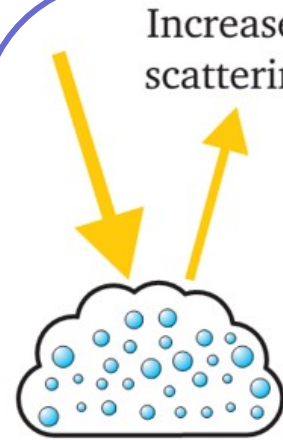
Direct Effect
Scattering/
absorption



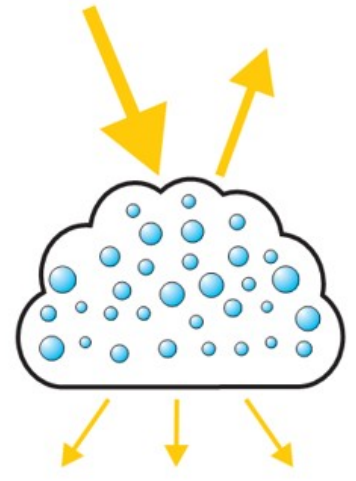
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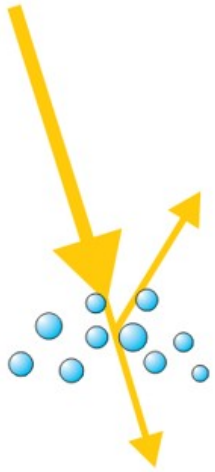
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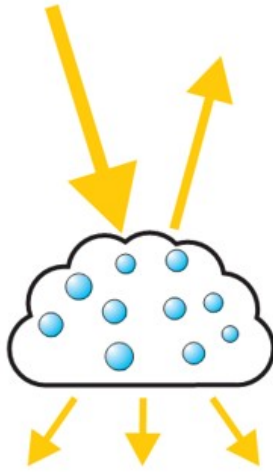
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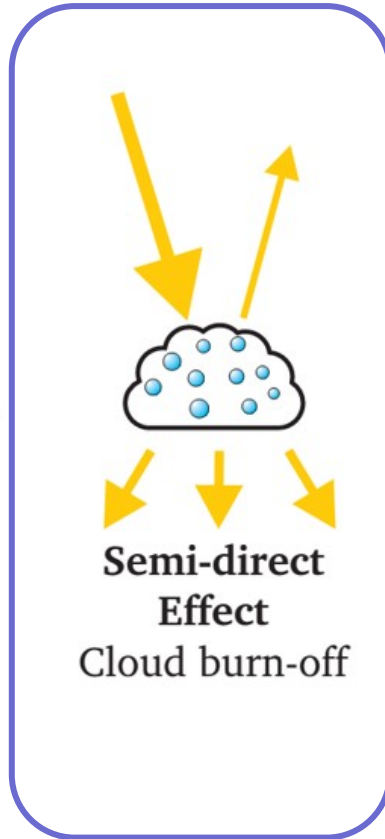
Incoming solar radiation



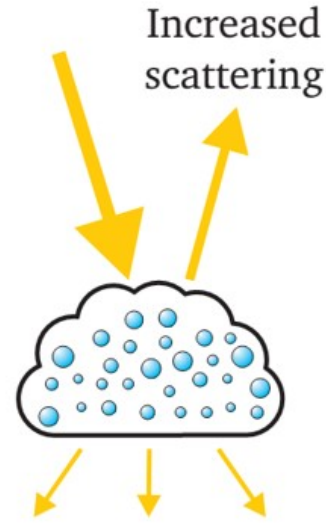
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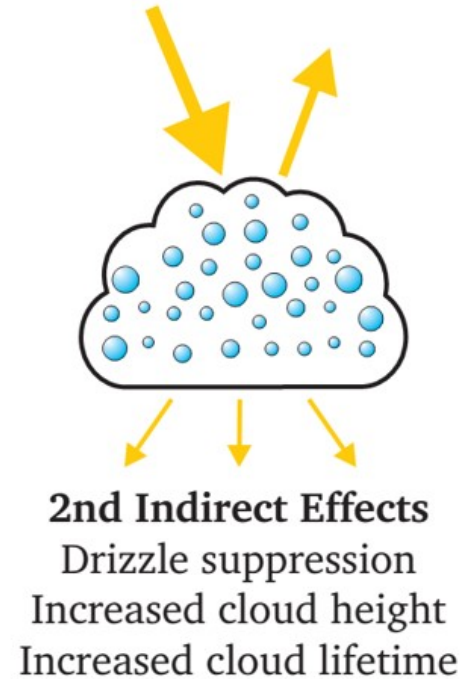
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2nd Indirect Effects
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A world map where the landmasses are outlined in a vibrant orange-brown color. The background is a complex, abstract pattern of colors including deep blues, purples, magentas, and greens, suggesting a global climate or data visualization. The text is overlaid on the left side of the map.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

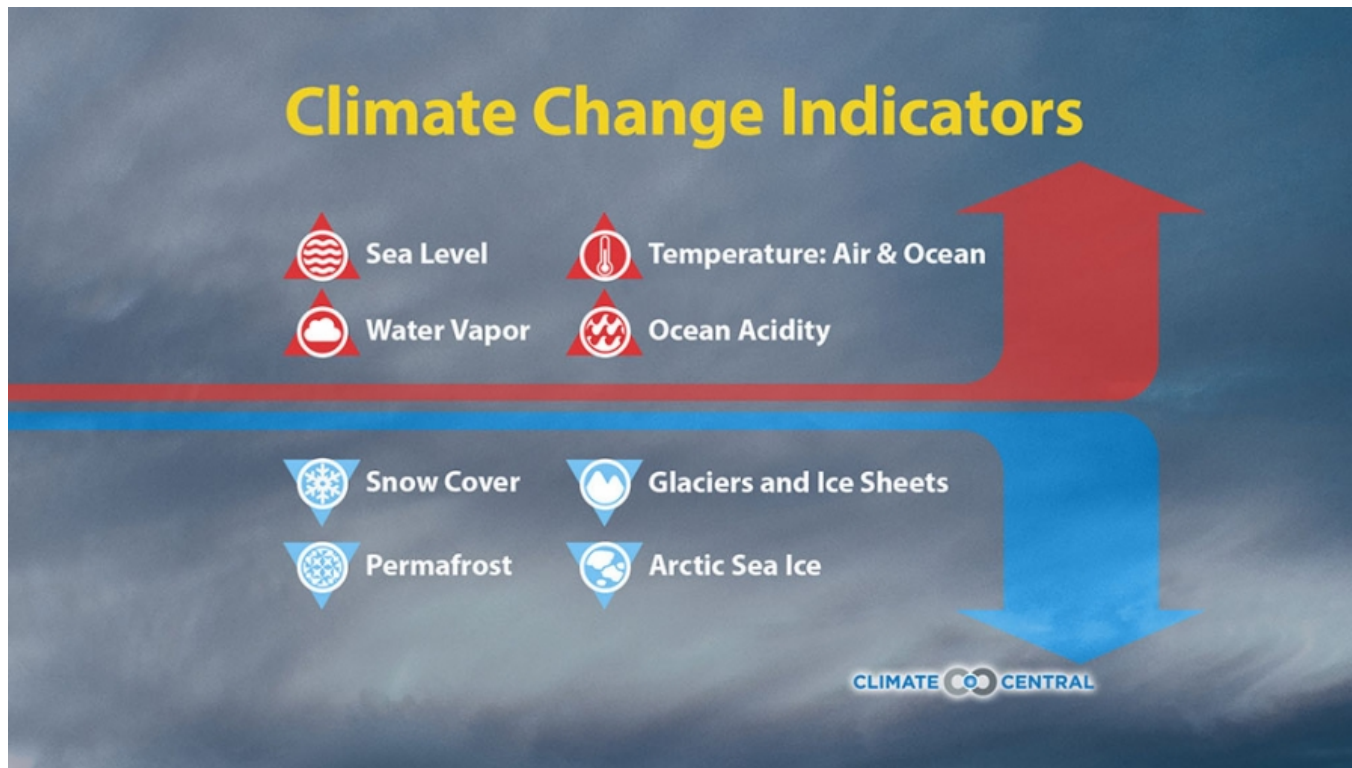
AR6 CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS

July 2021

Changing by the artist Alisa Singer



CC indicators



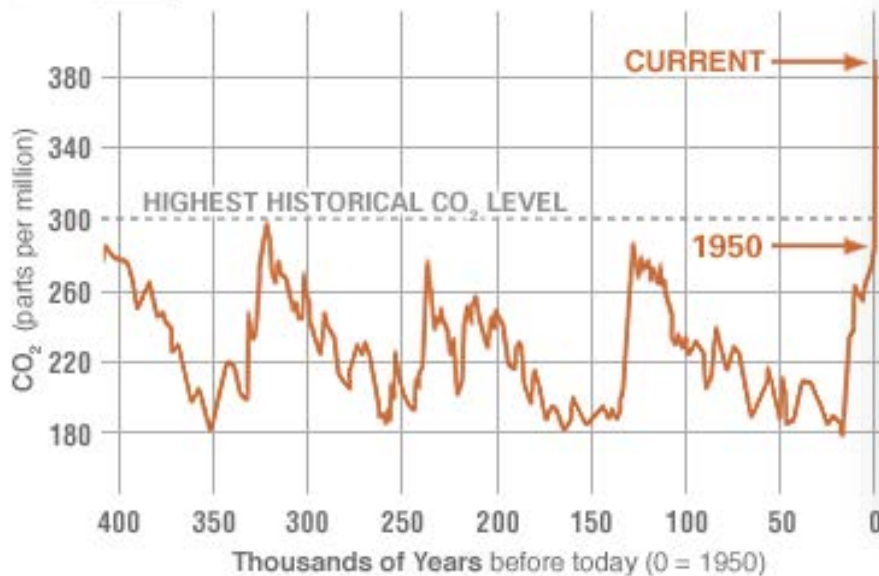
Increase of CO₂ level

- CO₂ level **increased more than >40 % since pre-industrial level**
- level of other greenhouse gases increases as well
- main source of this increase is **fossil fuels combustion + deforestation**

PROXY (INDIRECT) MEASUREMENTS

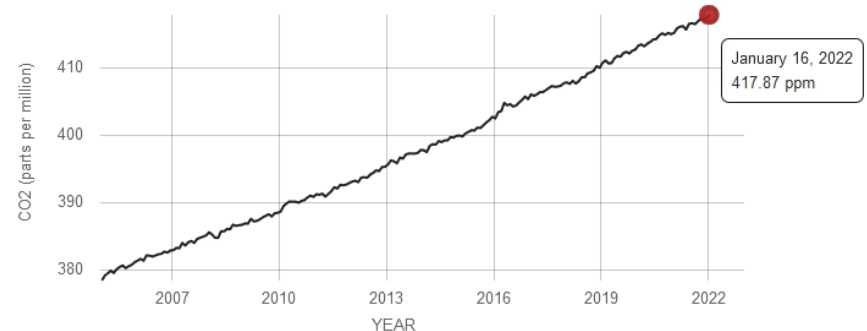
Data source: Reconstruction from ice cores.

Credit: [NOAA](#)



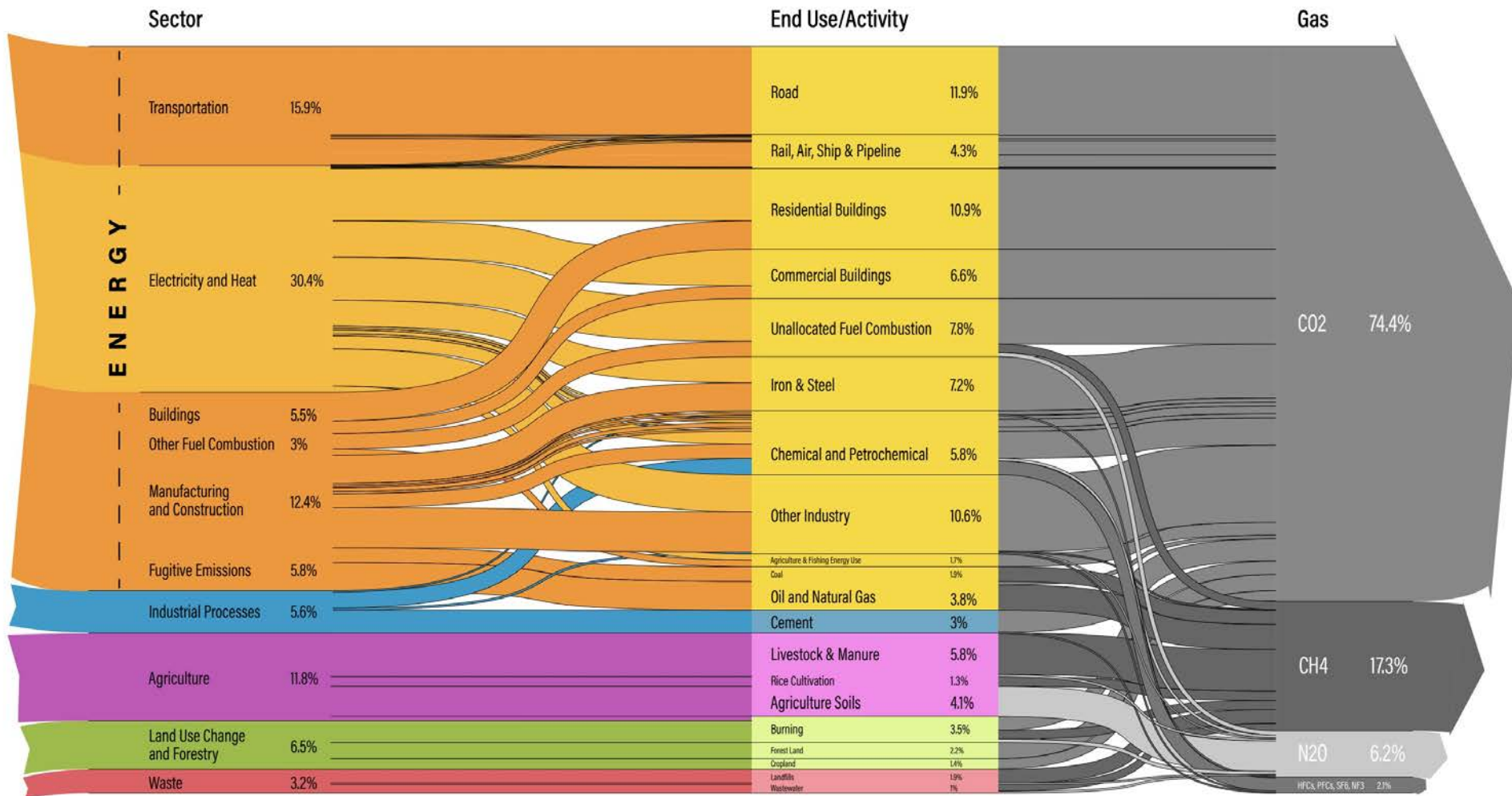
DIRECT MEASUREMENTS: 2005-PRESENT

Data source: Monthly measurements (average seasonal cycle removed). Credit: [NOAA](#)



World Greenhouse Gas Emissions in 2016

Total: 49.4 MtCO₂



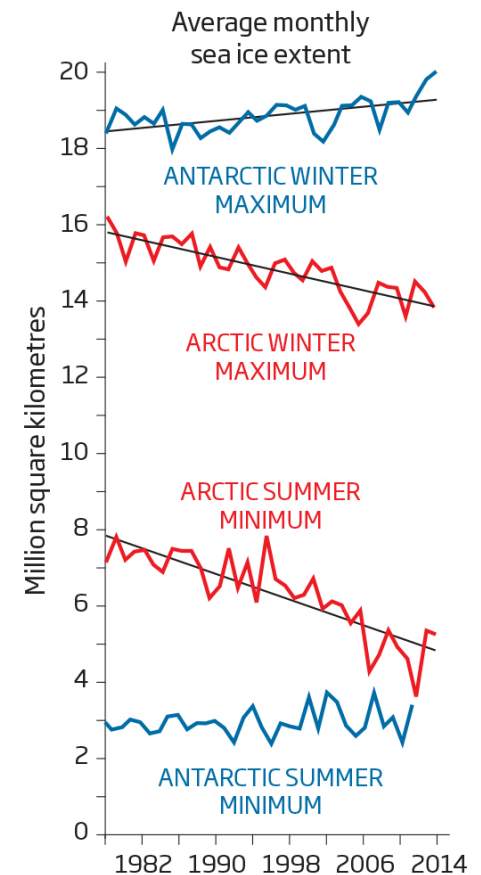
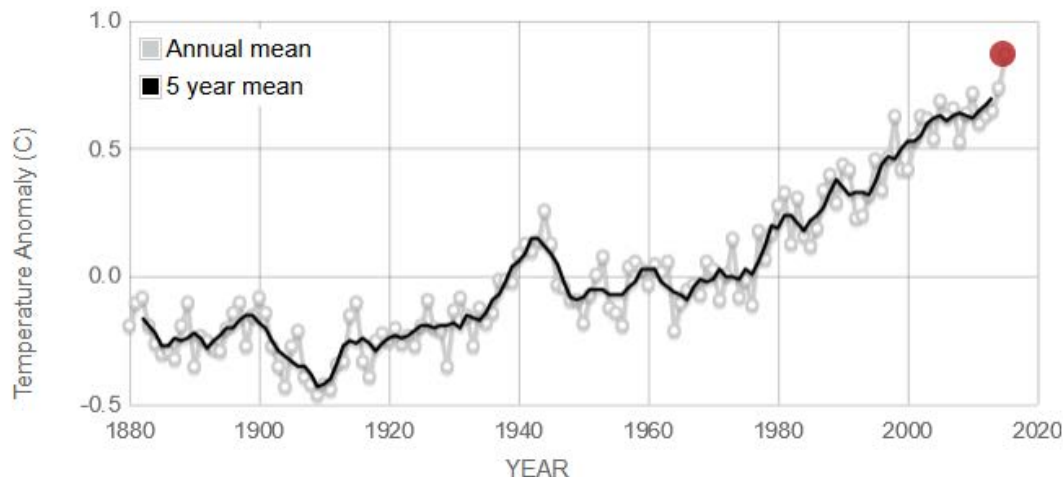
Source: Greenhouse gas emissions on Climate Watch. Available at: <https://www.climatewatchdata.org>

Other indicators (variables) of CC

- changes in temperature (land/ocean)
- changes in ice cover in Arctic ocean
- changes in ice cover in North and South pole
- sea level rise
- humidity rise

GLOBAL LAND-OCEAN TEMPERATURE INDEX

Data source: NASA's Goddard Institute for Space Studies (GISS)
Credit: NASA/GISS



Less ice in the Arctic ocean

- new naval routes from Europe to Asia



Global Agenda Arctic Future of the Environment Geo-economics

The final frontier: how Arctic ice melting is opening up trade opportunities

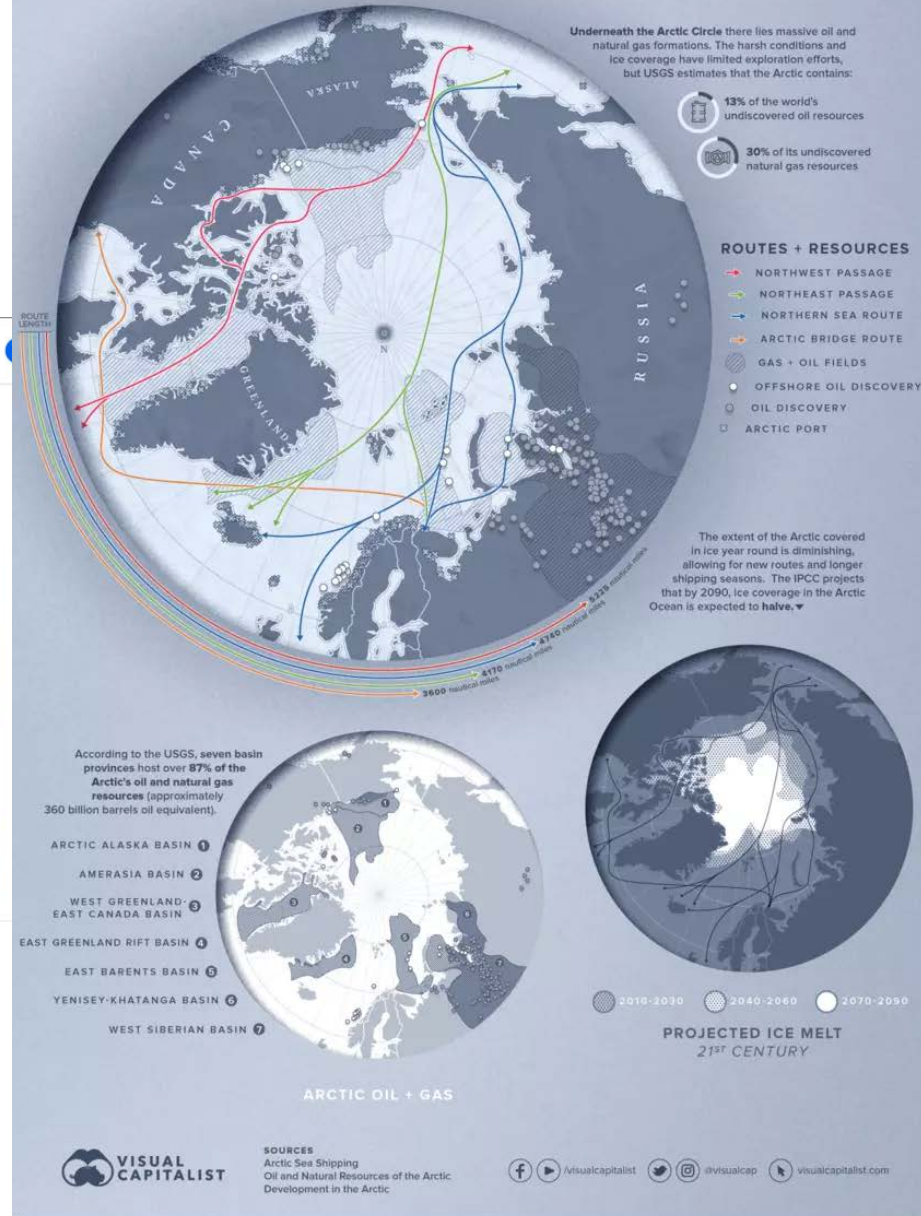


With financial gains to be exploited, will the world have enough restraint to resist damaging this landscape? Image: Unsplash/Valeria Buganova

Breaking the Ice

MAPPING A CHANGING ARCTIC

As the Arctic region becomes more accessible from reduced ice cover, nations with Arctic real estate are looking to develop their remote landscapes. Here are the trade routes and resources attracting their attention.



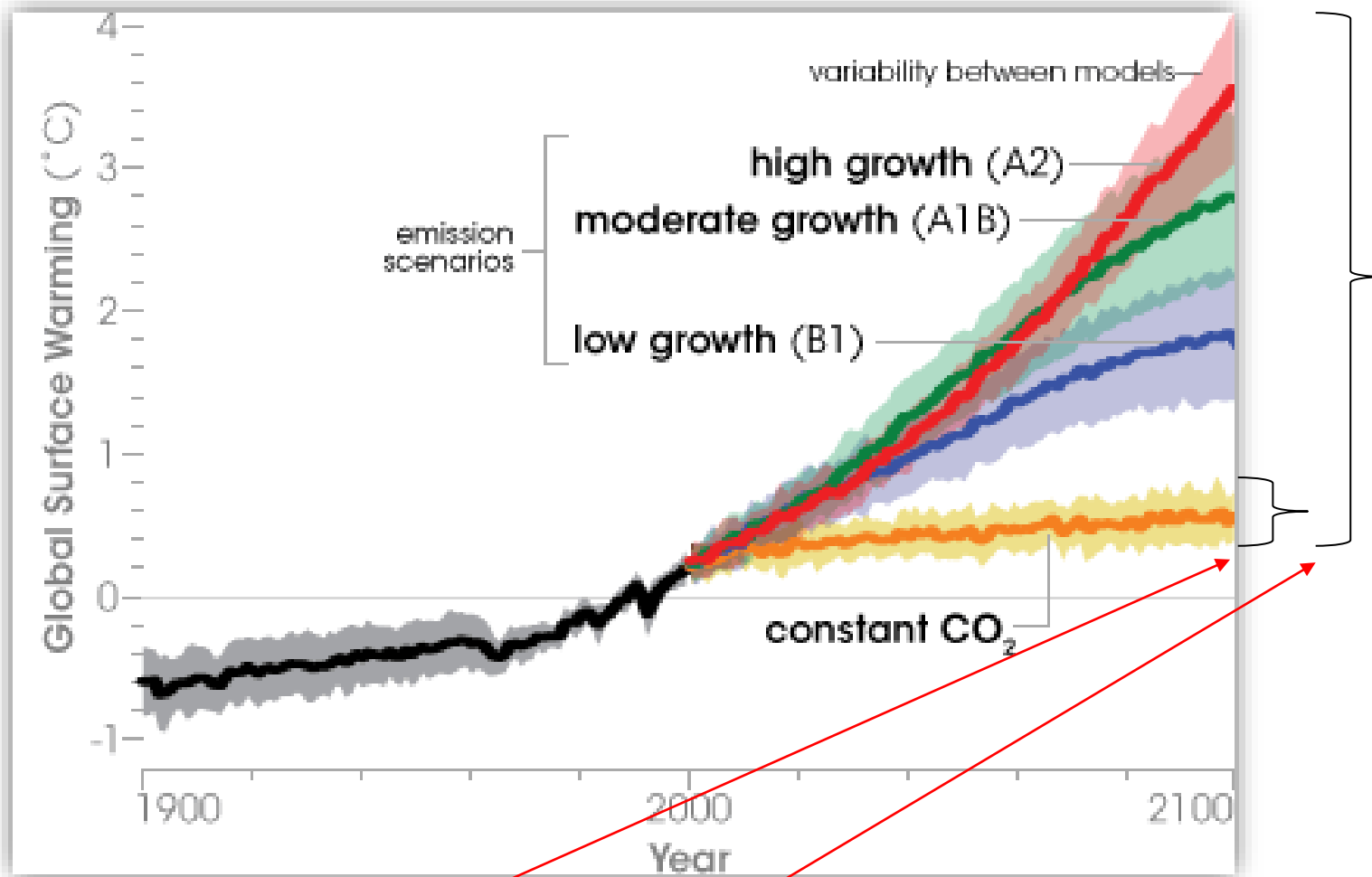
Glacier calving in Arctic ocean



Glacier Watching Day 17

"CHASING ICE" captures largest glacier calving ever filmed - OFFICIAL VIDEO

Temperature rise scenarios to 2100



- scientific vs. political uncertainty

CC consequences

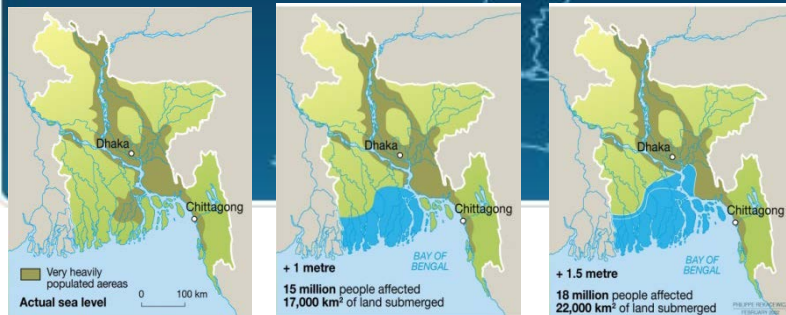


Consequences of CC

- regionally specific
- e.g. increasing vs. decreasing yields in some regions

Likely Scenarios if Climate Change Continues

SELECT CLIMATE IMPACTS



WHAT YOU CAN DO TO HELP

Consequences of CC

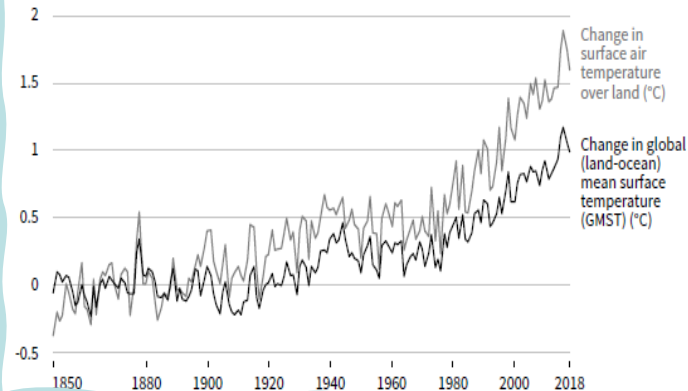
- Heat waves, floods, drought, storm intensity
- **DESERTIFICATION**



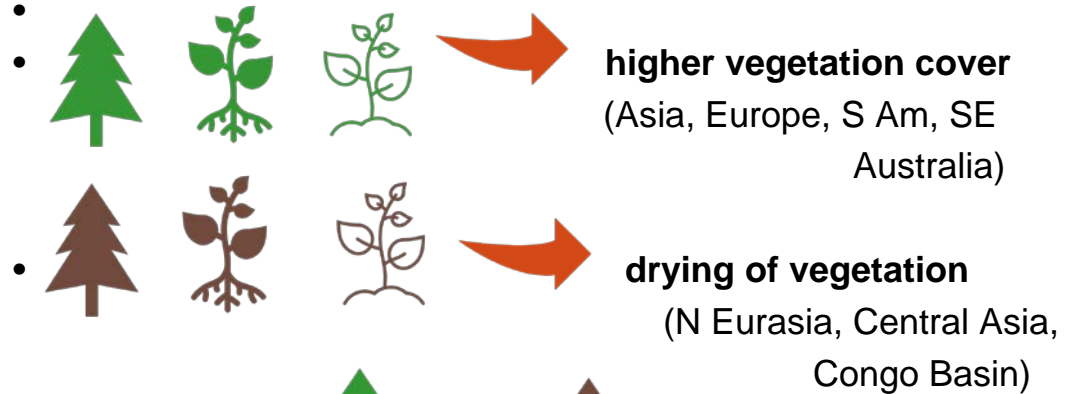
A. Observed temperature change relative to 1850-1900

Since the pre-industrial period (1850-1900) the observed mean land surface air temperature has risen considerably more than the global mean surface (land and ocean) temperature (GMST).

CHANGE in TEMPERATURE rel. to 1850-1900 (°C)

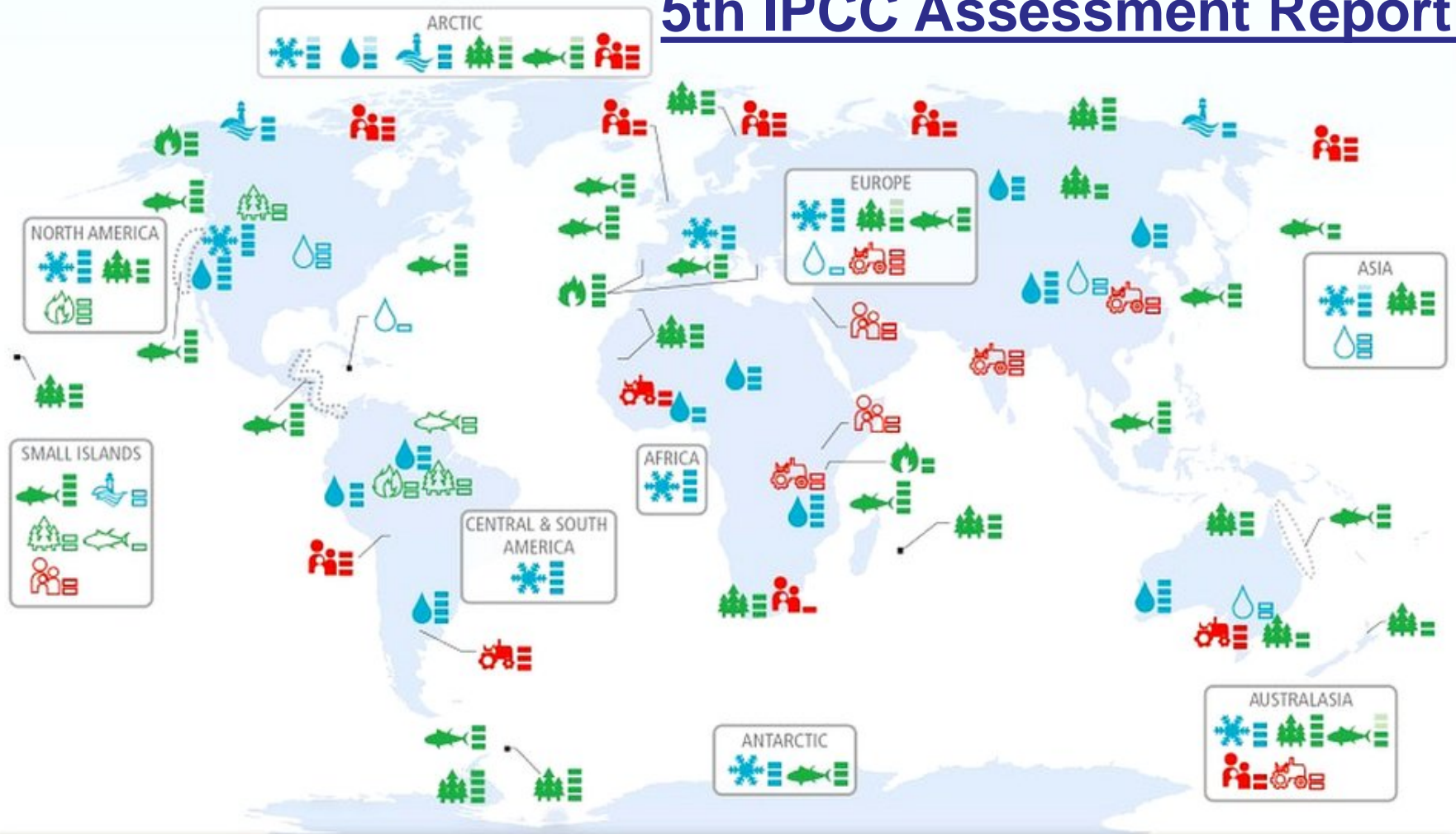


• CHANGES OF BIODIVERSITY

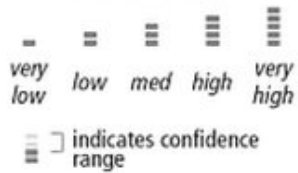


(2019)

5th IPCC Assessment Report



Confidence in attribution to climate change



Observed impacts attributed to climate change for

Physical systems



Biological systems



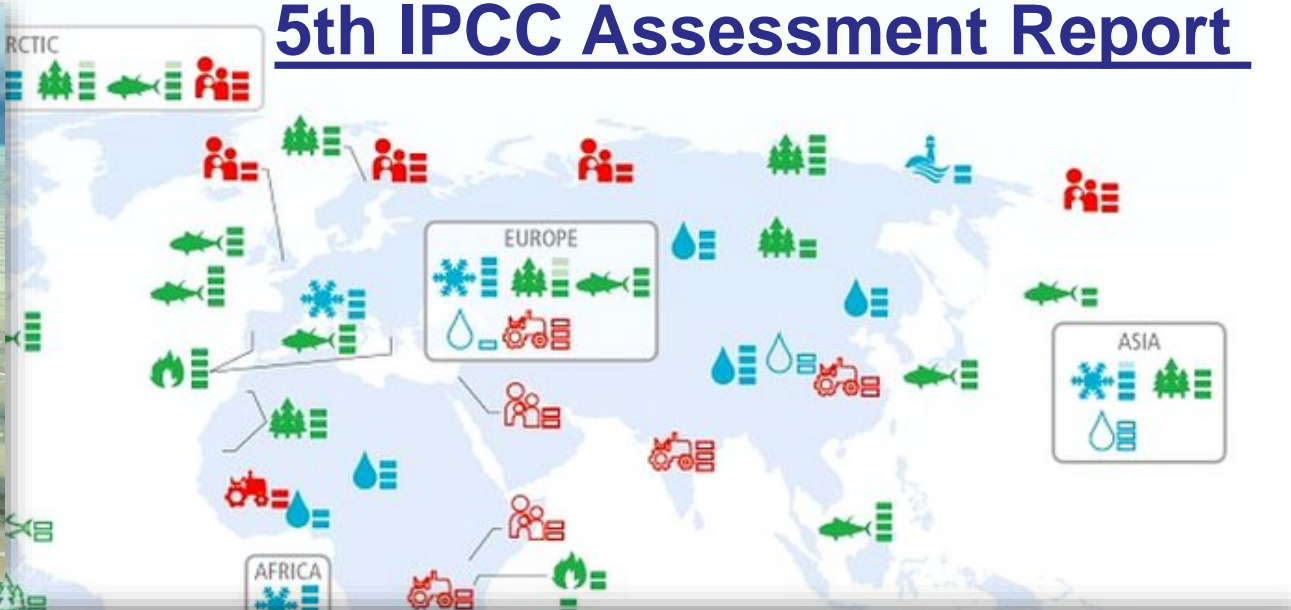
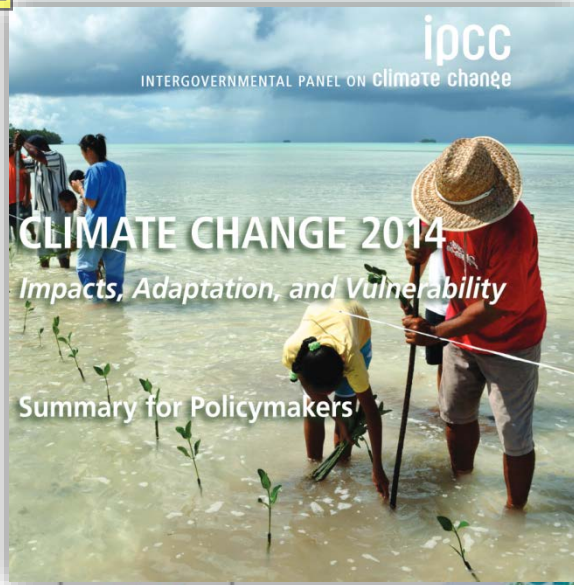
Human and managed systems



▭ Regional-scale impacts

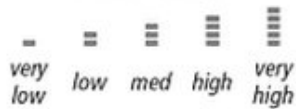
Outlined symbols = Minor contribution of climate change
 Filled symbols = Major contribution of climate change

5th IPCC Assessment Report



Europe	
Snow & Ice, Rivers & Lakes, Floods & Drought	<ul style="list-style-type: none"> Retreat of Alpine, Scandinavian, and Icelandic glaciers (<i>high confidence</i>, major contribution from climate change) Increase in rock slope failures in western Alps (<i>medium confidence</i>, major contribution from climate change) Changed occurrence of extreme river discharges and floods (<i>very low confidence</i>, minor contribution from climate change) <p>[18.3, 23.2-3, Tables 18-5 and 18-6; WGI AR5 4.3]</p>
Terrestrial Ecosystems	<ul style="list-style-type: none"> Earlier greening, leaf emergence, and fruiting in temperate and boreal trees (<i>high confidence</i>, major contribution from climate change) Increased colonization of alien plant species in Europe, beyond a baseline of some invasion (<i>medium confidence</i>, major contribution from climate change) Earlier arrival of migratory birds in Europe since 1970 (<i>medium confidence</i>, major contribution from climate change) Upward shift in tree-line in Europe, beyond changes due to land use (<i>low confidence</i>, major contribution from climate change) Increasing burnt forest areas during recent decades in Portugal and Greece, beyond some increase due to land use (<i>high confidence</i>, major contribution from climate change) <p>[4.3, 18.3, Tables 18-7 and 23-6]</p>
Coastal Erosion & Marine Ecosystems	<ul style="list-style-type: none"> Northward distributional shifts of zooplankton, fishes, seabirds, and benthic invertebrates in northeast Atlantic (<i>high confidence</i>, major contribution from climate change) Northward and depth shift in distribution of many fish species across European seas (<i>medium confidence</i>, major contribution from climate change) Plankton phenology changes in northeast Atlantic (<i>medium confidence</i>, major contribution from climate change) Spread of warm water species into the Mediterranean, beyond changes due to invasive species and human impacts (<i>medium confidence</i>, major contribution from climate change) <p>[6.3, 23.6, 30.5, Tables 6-2 and 18-8, Boxes 6-1 and CC-MB]</p>
Food Production & Livelihoods	<ul style="list-style-type: none"> Shift from cold-related mortality to heat-related mortality in England and Wales, beyond changes due to exposure and health care (<i>low confidence</i>, major contribution from climate change) Impacts on livelihoods of Sámi people in northern Europe, beyond effects of economic and sociopolitical changes (<i>medium confidence</i>, major contribution from climate change) Stagnation of wheat yields in some countries in recent decades, despite improved technology (<i>medium confidence</i>, minor contribution from climate change) Positive yield impacts for some crops mainly in northern Europe, beyond increase due to improved technology (<i>medium confidence</i>, minor contribution from climate change) Spread of bluetongue virus in sheep and of ticks across parts of Europe (<i>medium confidence</i>, minor contribution from climate change) <p>[18.4, 23.4-5, Table 18-9, Figure 7-2]</p>

Confidence in attribution to climate change



indicates confidence range

Physical systems



Marine ecosystems

Outlined symbols = Minor contribution of climate change
Filled symbols = Major contribution of climate change

Main consequences of CC - summary

Present trends caused by CC.

Very likely >90 %, Likely >60 %

Phenomena	Likelihood that trend occurred in late 20th century
Cold days, cold nights and frost less frequent over land areas	Very likely
More frequent hot days and nights	Very likely
Heat waves more frequent over most land areas	Likely
Increased incidence of extreme high sea level *	Likely
Global area affected by drought has increased (since 1970s)	Likely in some regions
Increase in intense tropical cyclone activity in North Atlantic (since 1970)	Likely in some regions

* Excluding tsunamis, which are not due to climate change.

Future trends caused by CC.

Virtually certain >99 %, Very likely >90 %, Likely >60 % .

Phenomena	Likelihood of trend
Contraction of snow cover areas, increased thaw in permafrost regions, decrease in sea ice extent	Virtually certain
Increased frequency of hot extremes, heat waves and heavy precipitation	Very likely to occur
Increase in tropical cyclone intensity	Likely to occur
Precipitation increases in high latitudes	Very likely to occur
Precipitation decreases in subtropical land regions	Very likely to occur
Decreased water resources in many semi-arid areas, including western U.S. and Mediterranean basin	High confidence

- Scientific language is very brief and talking in the words of probability

CC - controversy



The video player shows two men in a split-screen format. On the left is Bjorn Lomborg, wearing glasses and a dark suit over a light blue shirt. On the right is Peter Robinson, wearing a dark t-shirt. The background of the left side shows a living room with a red chair and bookshelves. The background of the right side shows a room with a staircase and various plants.

UNCOMMON KNOWLEDGE WITH PETER ROBINSON

HOOVER INSTITUTION

Keeping Your Cool on the Climate Debate with Bjorn Lomborg

54 588 zhladnutí • 10. 3. 2021

1,1 TIS. 68 ZDIELANIE ULOŽIŤ


„How much do we want to spend on the climate compare to other problems?“

„...more heat will damage crop growth in many warmer climates, but it means better agricultural production in cold countries. And, CO₂ is a fertiliser — commercial greenhouses pump in extra CO₂ to grow bigger tomatoes. So overall, we can expect agriculture to gain from global warming in the short and medium term...“ B. Lomborg




Let's discuss!

Powered by  **Poll Everywhere**



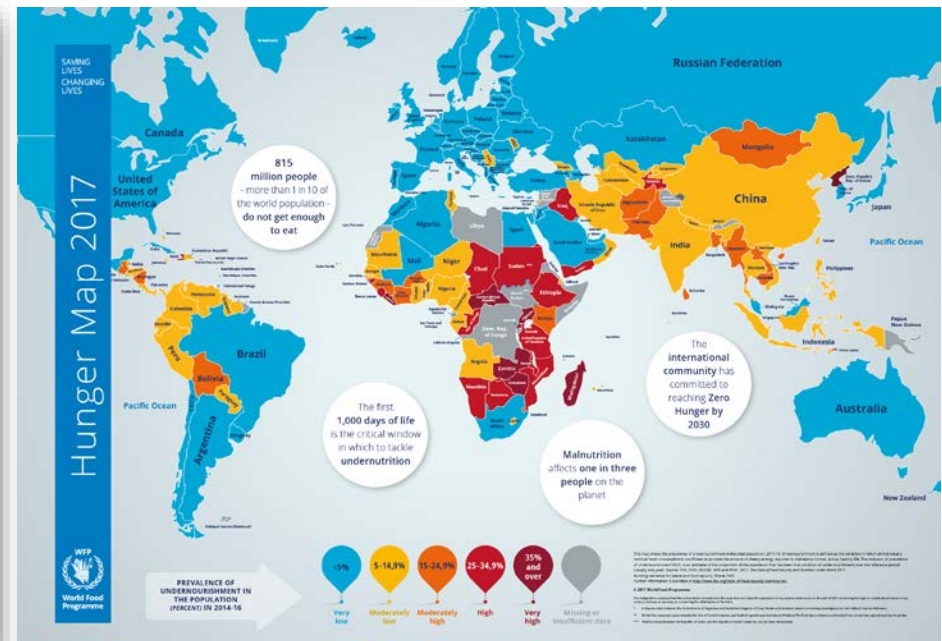
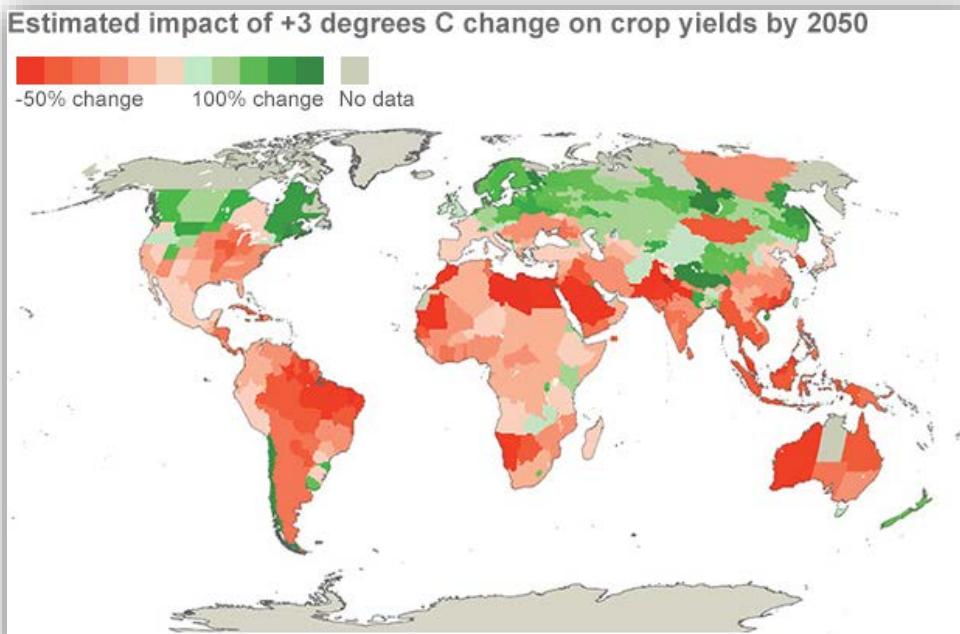
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Moral dimension of CC

„...more heat will damage crop growth in many warmer climates, but it means better agricultural production in cold countries. And, CO₂ is a fertiliser — commercial greenhouses pump in extra CO₂ to grow bigger tomatoes. So overall, we can expect agriculture to gain from global warming in the short and medium term...“ B. Lomborg

– yes, increasing yields, but mainly in countries with the actual overproduction, while the agrarian countries in developing world (with significant hunger) will experience even drop in the production



Climate change: The great civilisation destroyer?

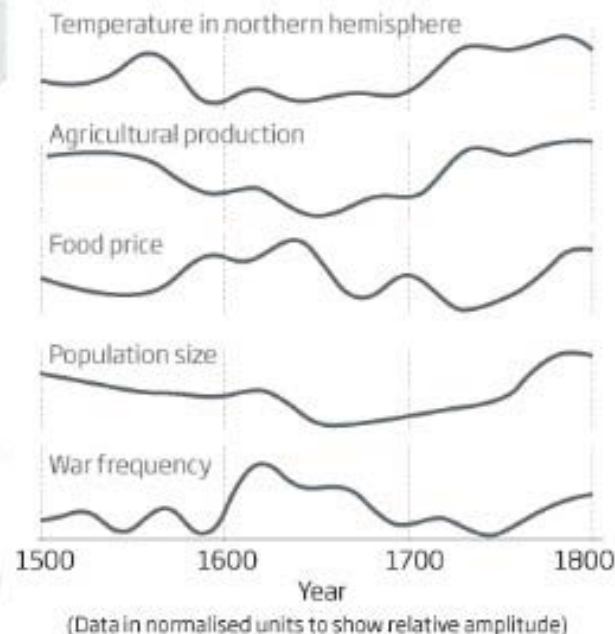
War and unrest, and the collapse of many mighty empires, often followed changes in local climates. Is this more than a coincidence?



More than coincidence?

©NewScientist

The decline and fall of many civilisations coincided with periods of climate change, and there are also correlations between climate change, population size and the frequency of wars, as data from Europe shows (right)



Solutions of CC?

Solutions?

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The Nobel Peace Prize 2007

Intergovernmental Panel on Climate Change , Al Gore

Share this:      67 

The Nobel Peace Prize 2007

IPCC

INTERGOVERNMENTAL
PANEL ON
CLIMATE CHANGE



WMO



UNEP

Intergovernmental
Panel on Climate
Change (IPCC)

Prize share: 1/2



Photo: Ken Opprann

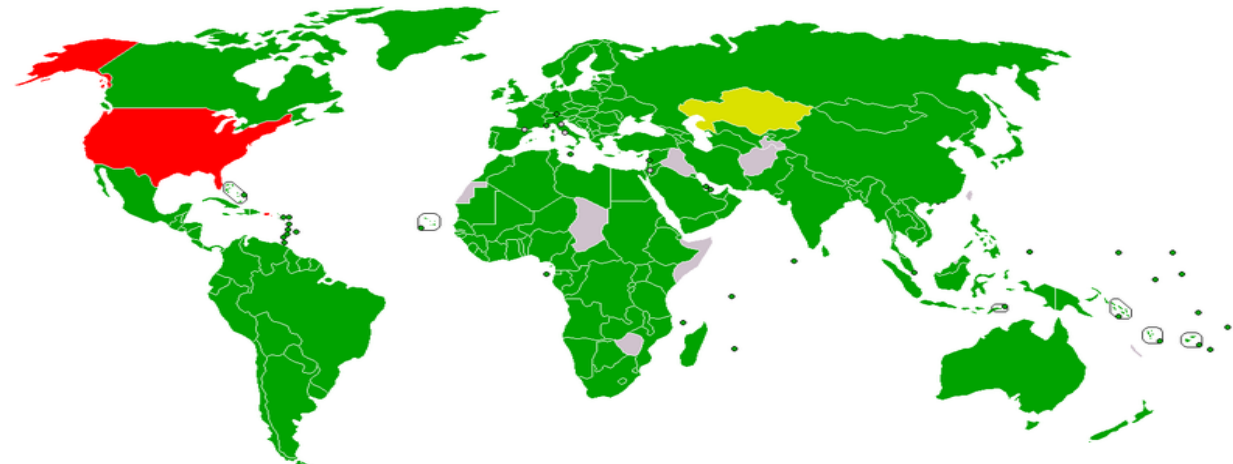
Albert Arnold (Al)
Gore Jr.

Prize share: 1/2

The Nobel Peace Prize 2007 was awarded jointly to Intergovernmental Panel on Climate Change (IPCC) and Albert Arnold (Al) Gore Jr. *"for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change"*

Politics on CC

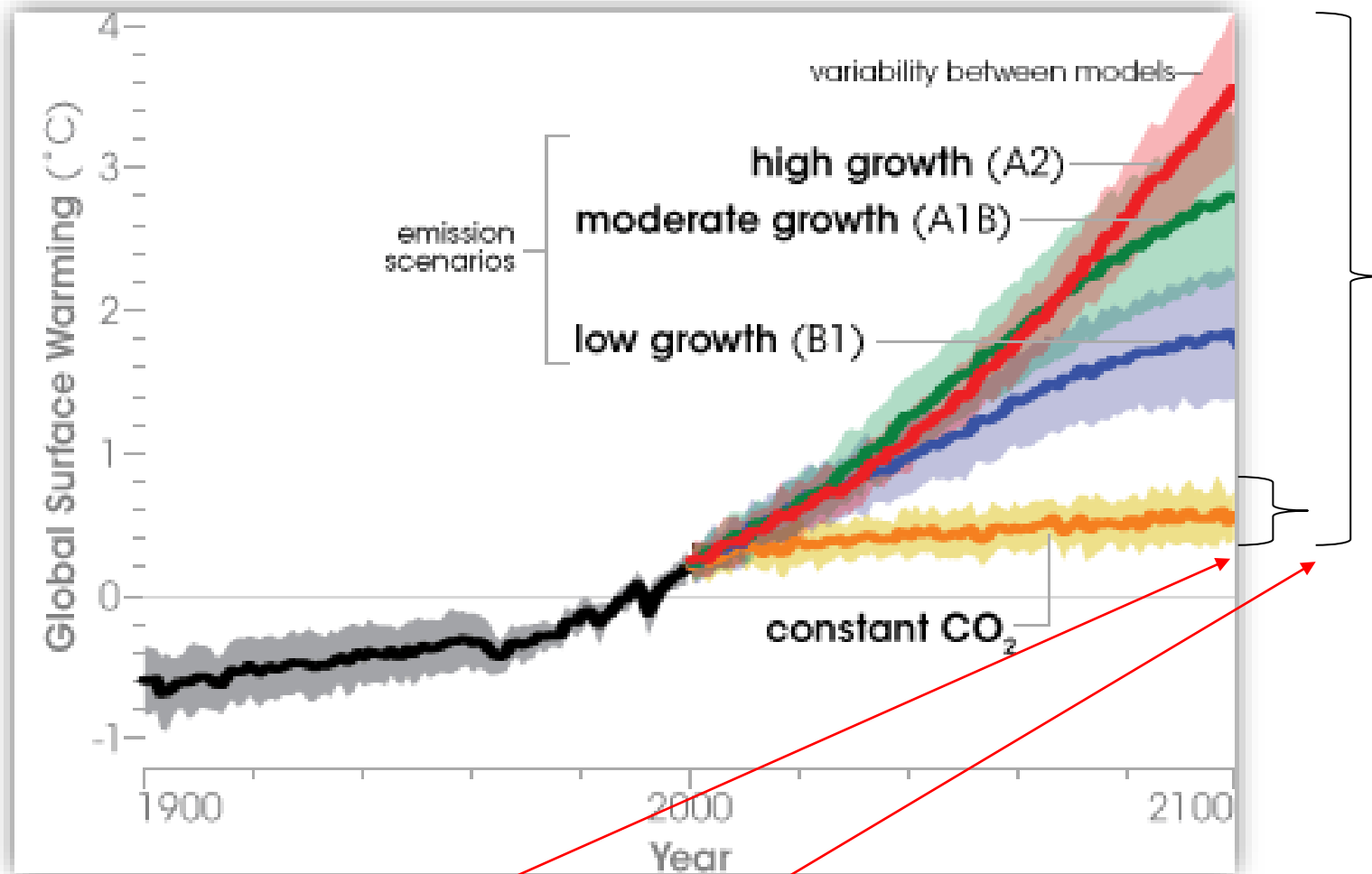
- main aim – decrease the GHG emissions, mainly CO₂
- 1992: UN Framework Convention on Climate Change
- 1997: Kyoto protocol (in force from 2005)
- industrial countries should decrease their GHG emissions until the year 2012 for 5.2 % compared to the year 1990
- different threshold for different countries (e.g. EU 8%)
- however, industrial countries (Annex I countries with Kyoto targets) contributed „only“ with 24 % of global CO₂ emission (2010)



Participation in the Kyoto Protocol

- Signed and ratified
- Signed, ratification pending
- Signed, ratification declined
- [citation needed]
- Non-signatory

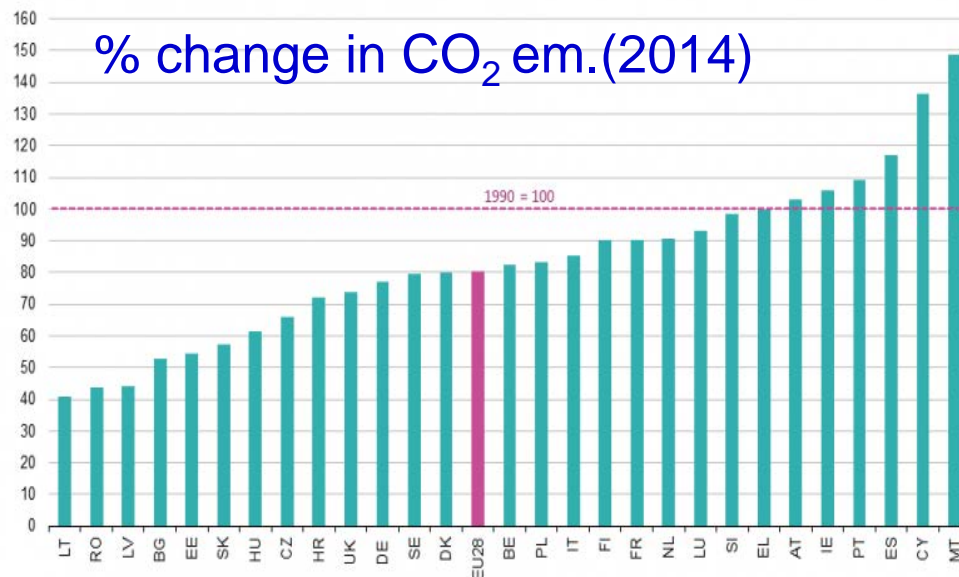
Temperature rise scenarios to 2100



- scientific vs. political uncertainty

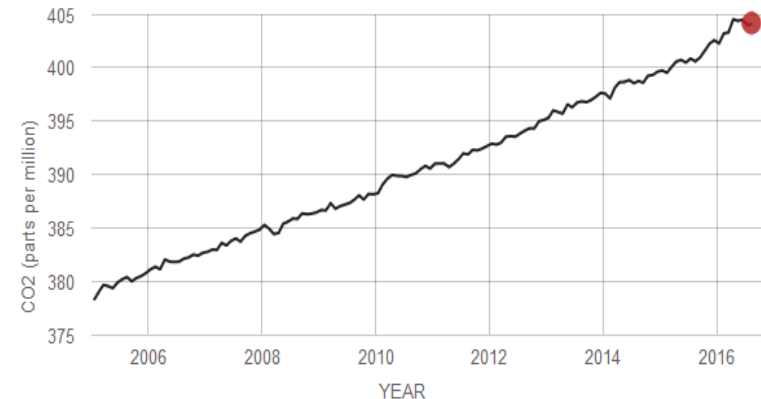
Kyoto protocol – result (2012)

- industrial countries (Annex I countries with Kyoto targets) **reduced their emissions for 24.2 % !** (much more than promised target 5.2 %)
- however, emission in other countries have risen so fast, that global CO₂ emissions increased by 32 % from 1990 to 2010 ☹
- extension of the Kyoto Protocol until 2020
- certain countries (the EU and a few other countries) have committed themselves to further reducing CO₂ emissions.
- EU e.g. by 20-30% compared to 1990
- Average – 18% - generally achieved



DIRECT MEASUREMENTS: 2005-PRESENT

Data source: Monthly measurements (average seasonal cycle removed). Credit: [NOAA](#)



Paris treaty (2015)

- continuation of the prolonged Kyoto protocol (2020)
- aim: Limit the temperature rise not more than 2 °C compared to pre-industrial era, ideally below 1.5 °C
- **came into force April 4th 2016**



How to decrease CO₂ emissions?

- decrease the fossil fuels consumption
 - increase efficiency of the industr. production
 - end the non-effective industr. production
 - save the energy and material
- economic tools to decrease CO₂ - International Emission Trading (IET)
- bio-fuels? Probably not...
- **Geo-engineering?**



Atmos. Chem. Phys. Discuss., 7, 11191–11205, 2007
www.atmos-chem-phys-discuss.net/7/11191/2007/
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N₂O release from agro-biofuel production negates global warming reduction by replacing fossil fuels

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²Scripps Institution of Oceanography, University of California, La Jolla, USA

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Received: 28 June 2007 – Accepted: 19 July 2007 – Published: 1 August 2007

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Geo-engineering – types and opportunities

Transforming Earth

It is now possible to identify the methods and locations where planetary geoengineering will have to take place

T PLANT TREES
 Plant forests and regularly harvest them. Trees are a carbon sink as long as they are growing, and not allowed to rot.
 Location: unused farmland

BE BECCS (Bioenergy with carbon capture and storage)
 Suck out atmospheric CO2 by growing biofuel crops like sugar cane, burn them for energy, capture the resulting CO2, and bury it.
 Location: the tropics, where growth is fastest

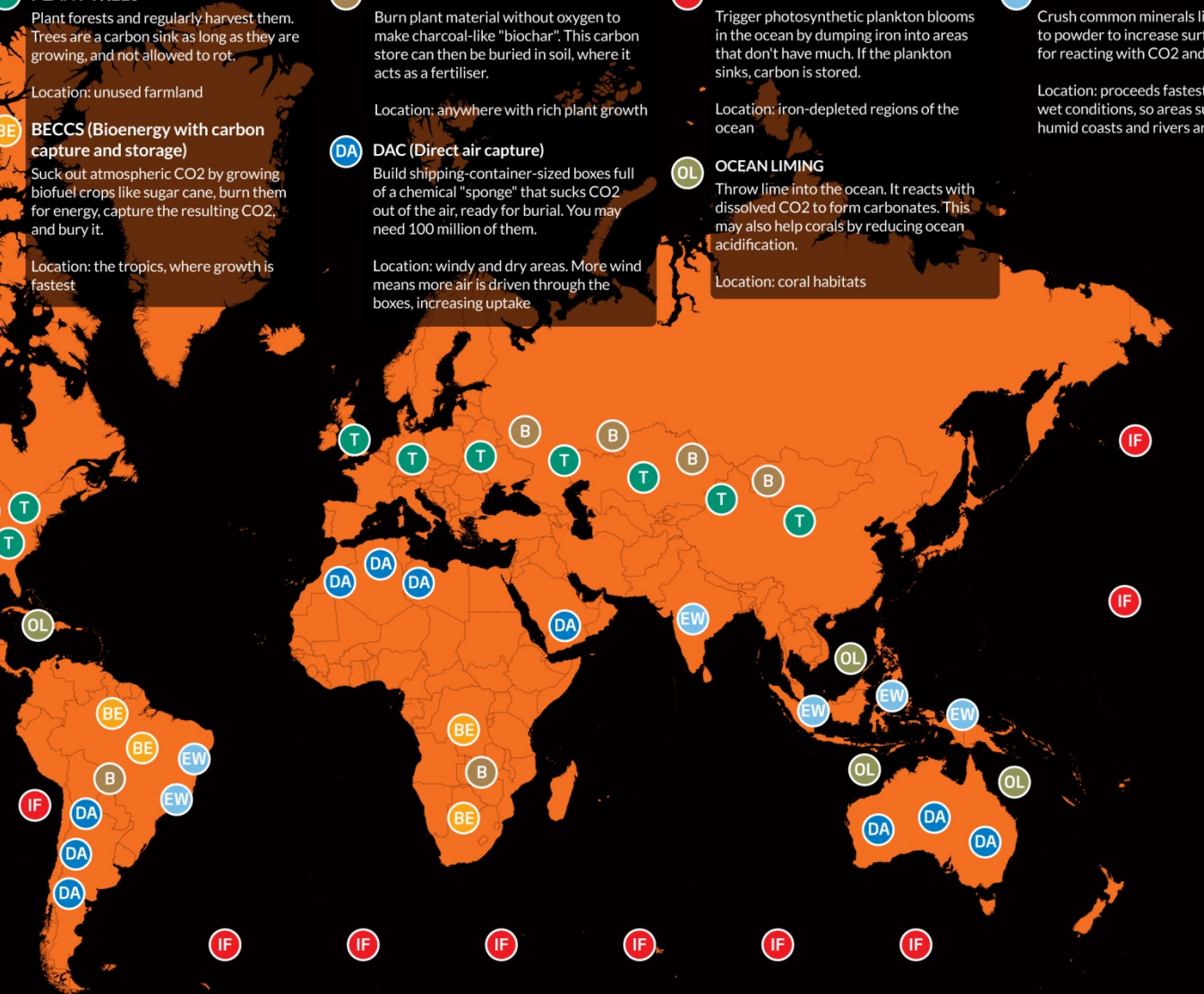
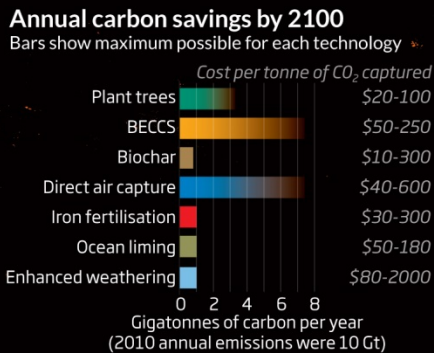
B BIOCHAR
 Burn plant material without oxygen to make charcoal-like "biochar". This carbon store can then be buried in soil, where it acts as a fertiliser.
 Location: anywhere with rich plant growth

DA DAC (Direct air capture)
 Build shipping-container-sized boxes full of a chemical "sponge" that sucks CO2 out of the air, ready for burial. You may need 100 million of them.
 Location: windy and dry areas. More wind means more air is driven through the boxes, increasing uptake

IF IRON FERTILISATION
 Trigger photosynthetic plankton blooms in the ocean by dumping iron into areas that don't have much. If the plankton sinks, carbon is stored.
 Location: iron-depleted regions of the ocean

OL OCEAN LIMING
 Throw lime into the ocean. It reacts with dissolved CO2 to form carbonates. This may also help corals by reducing ocean acidification.
 Location: coral habitats

EW ENHANCED WEATHERING
 Crush common minerals like olivine to powder to increase surface area for reacting with CO2 and water.
 Location: proceeds fastest in warm, wet conditions, so areas such as humid coasts and rivers are best



Transform Earth

It is now possible to use various methods and technologies to remove CO2 from the atmosphere. These methods and technologies have to take into account the planetary geology and biology. They have to take into account the planetary geology and biology.

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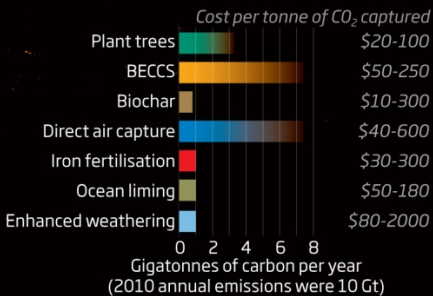
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Location: coral habitats

According to the Convention on Biological Diversity (CBD), all the geo-engineering applications are banned

Annual carbon savings by 2100

Bars show maximum possible for each technology



European Green Deal (December 2019)

Striving to be the first climate-neutral continent



- The European Commission adopted a set of proposals to make the EU's climate, energy, transport and taxation **policies fit for reducing net greenhouse gas emissions by at least 55% by 2030**, compared to 1990 levels.

Right choice?

The screenshot shows the Reuters website interface. At the top, there's a navigation bar with categories like World, Business, Legal, Markets, Breakingviews, Technology, Investigations, Sports, and More. A search bar and 'Sign In'/'Register' buttons are also present. The main article is dated February 2, 2022, at 5:13 PM GMT+1, and was last updated 16 days ago. It's categorized under 'Sustainable Business'. The headline is 'EU proposes rules to label some gas and nuclear investments as green', written by Kate Abnett. A '3 minute read' indicator is shown. Below the headline is a 'Summary' section with three bullet points: 'Rules label some gas, nuclear plants as green investments', 'Member states, investors split over EU plan', and 'Green lawmakers launch campaign to veto the rules'. The main text starts with 'BRUSSELS, Feb 2 (Reuters) - Investments in some gas and nuclear power plants would be labelled as sustainable under rules proposed by European Commission on Wednesday, a plan that has split countries and investors, and which some lawmakers will attempt to block.' A 'My View Business' sidebar on the right offers various industry filters like Aerospace & Defense, Autos & Transportation, Energy, Environment, Finance, Healthcare & Pharmaceuticals, and Media & Telecom. A 'Register now for FREE unlimited access to Reuters.com' pop-up is visible on the left side of the article.

If approved, the gas and nuclear rules would apply from Jan. 2023.

- **Gas plants must switch to run on low-carbon gases by 2035**
- **New nuclear plants must receive construction permits before 2045 to get a green investment label, and be located in a country with a plan and funds to safely dispose of radioactive waste by 2050.**

SYSTEM CHANGE, NOT CLIMATE CHANGE

