
ONE
WORLD

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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.

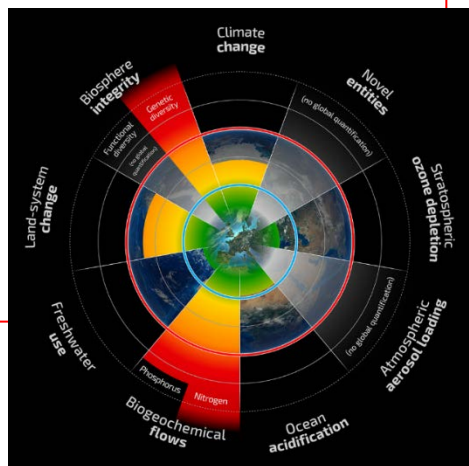
Boundary: Atmospheric CO_2 concentration no higher than 350 ppm

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?

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 Arhenius – hypothesis on enhancement of GH effect due to increase of CO_2 in the atmosphere as a consequence of fosil fuels combustion

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

CC - history

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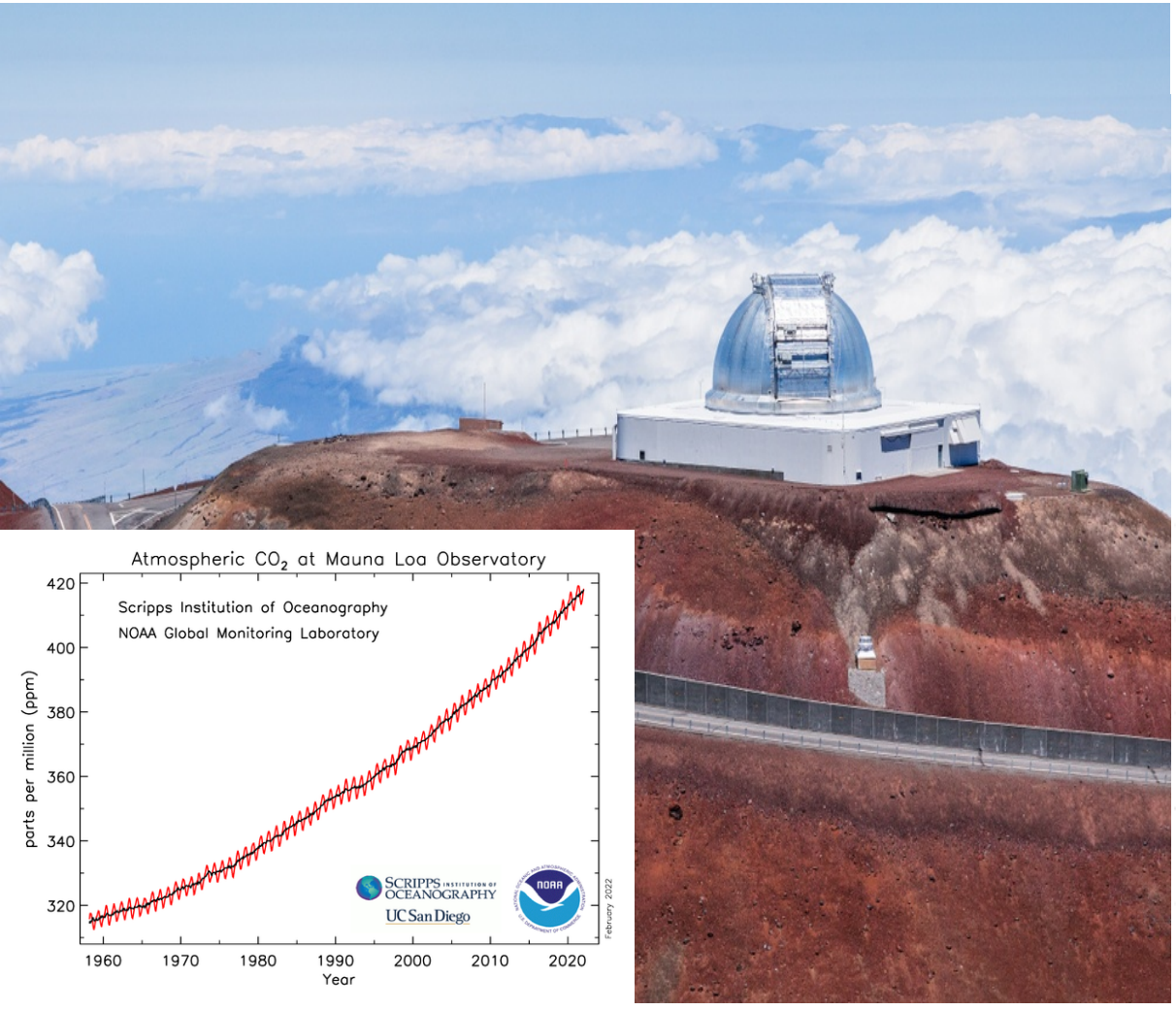
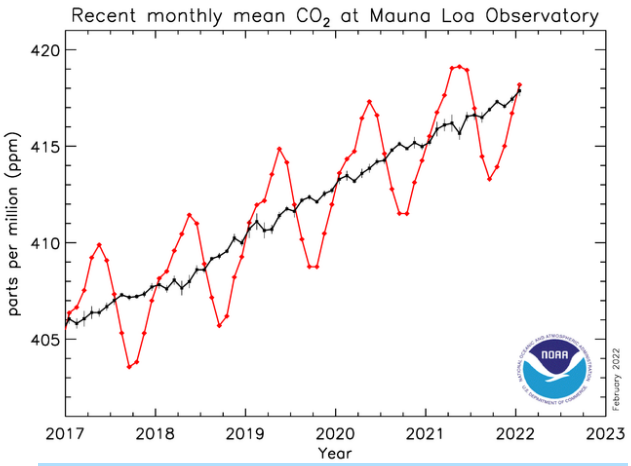
- the prognosis on increase of the temperature by several °C when GHG concentration doubles is still valid

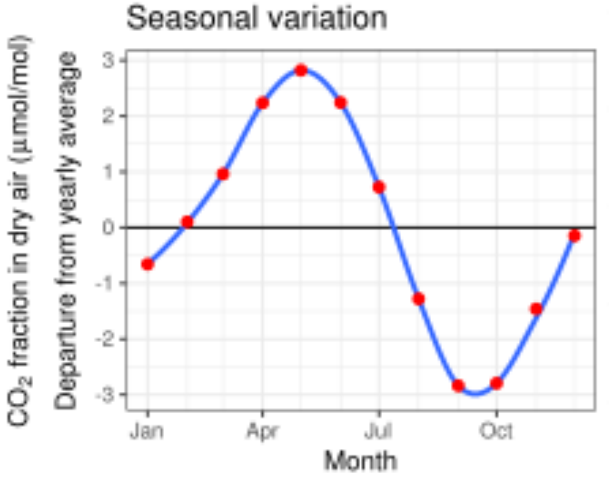
1957 – oceanographer Roger Revelle and chemist Hans Suess shown that oceans can not absorb entire CO_2 produced by people

"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)

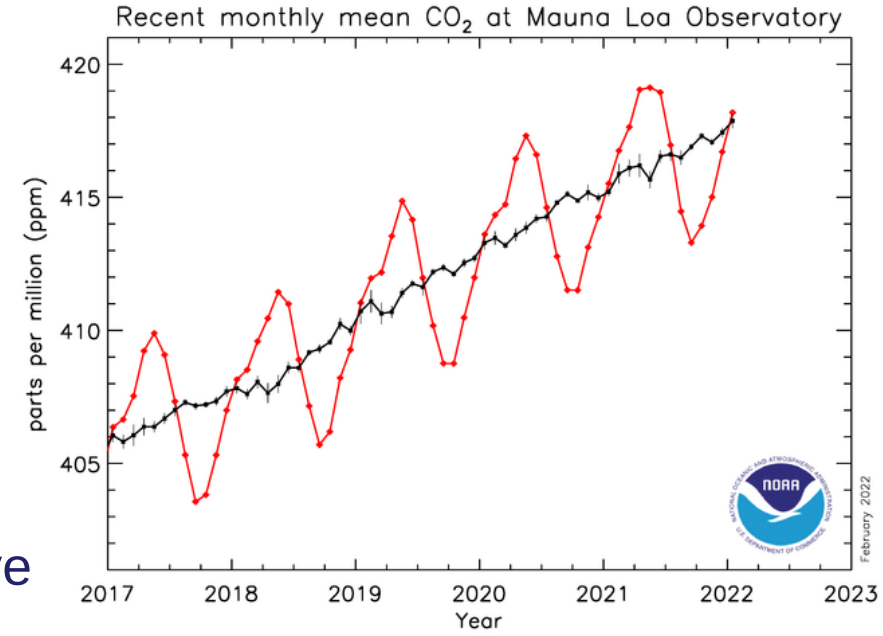






What do you think about the seasonal variation of CO2? What is the reason for increase in summer and decrease in autumn?

- Increase from October to May
  -  +  give off CO_2
- 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 an 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

How Do Greenhouse Gases Actually Work?

What is the average temperature on Earth?

- 33 °C
- 0 °C
- 15 °C
- -2 °C
- None of the above

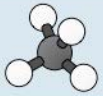
Total Results: 0

What is the average temperature on Earth?

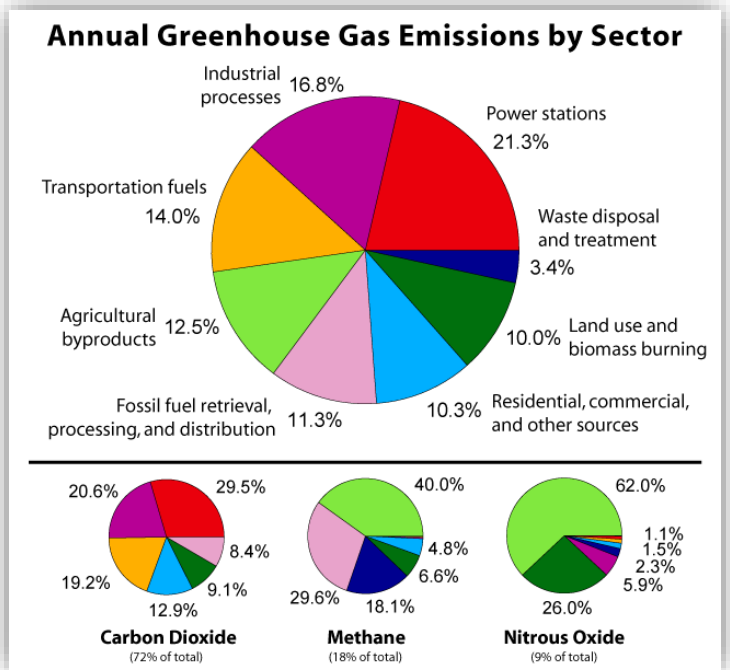
- 33 °C
- 0 °C
- 15 °C
- -2 °C
- None of the above

Greenhouse Gasses (GH) in the atmosphere

- the most important GHG is water vapour - $H_2O(g)$ that creates some 2/3 of greenhouse effect
- however $H_2O(g)$ 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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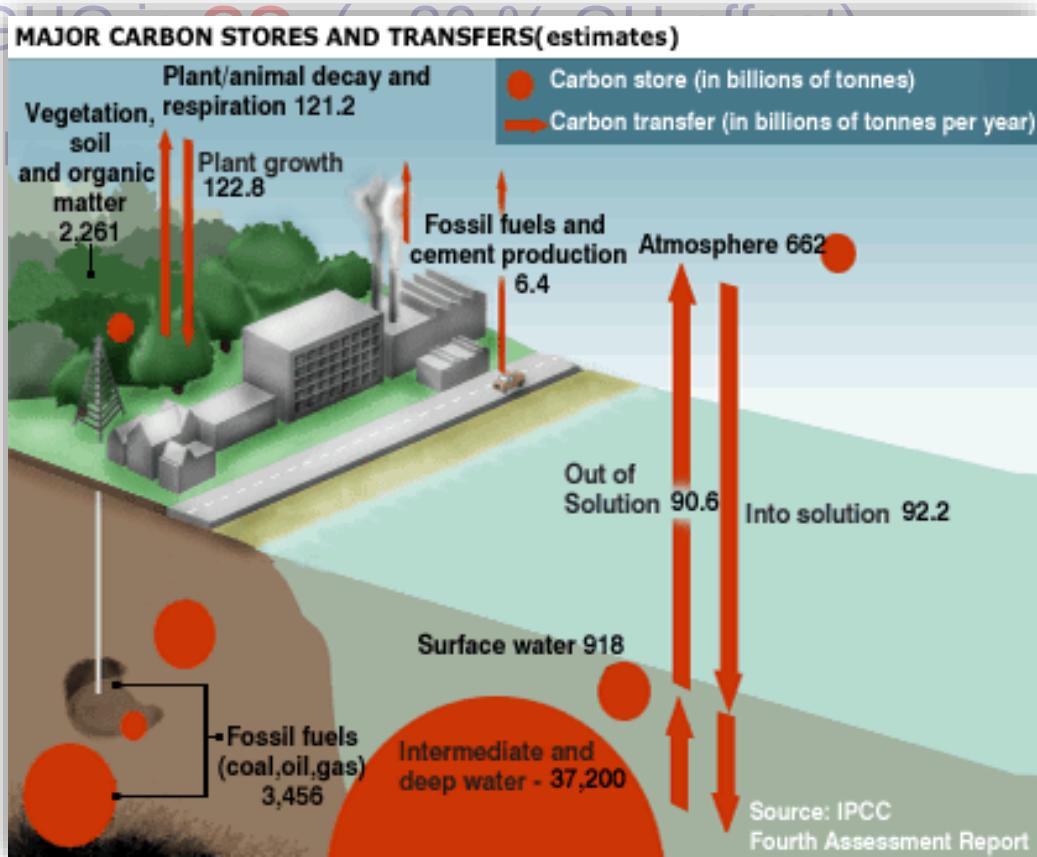
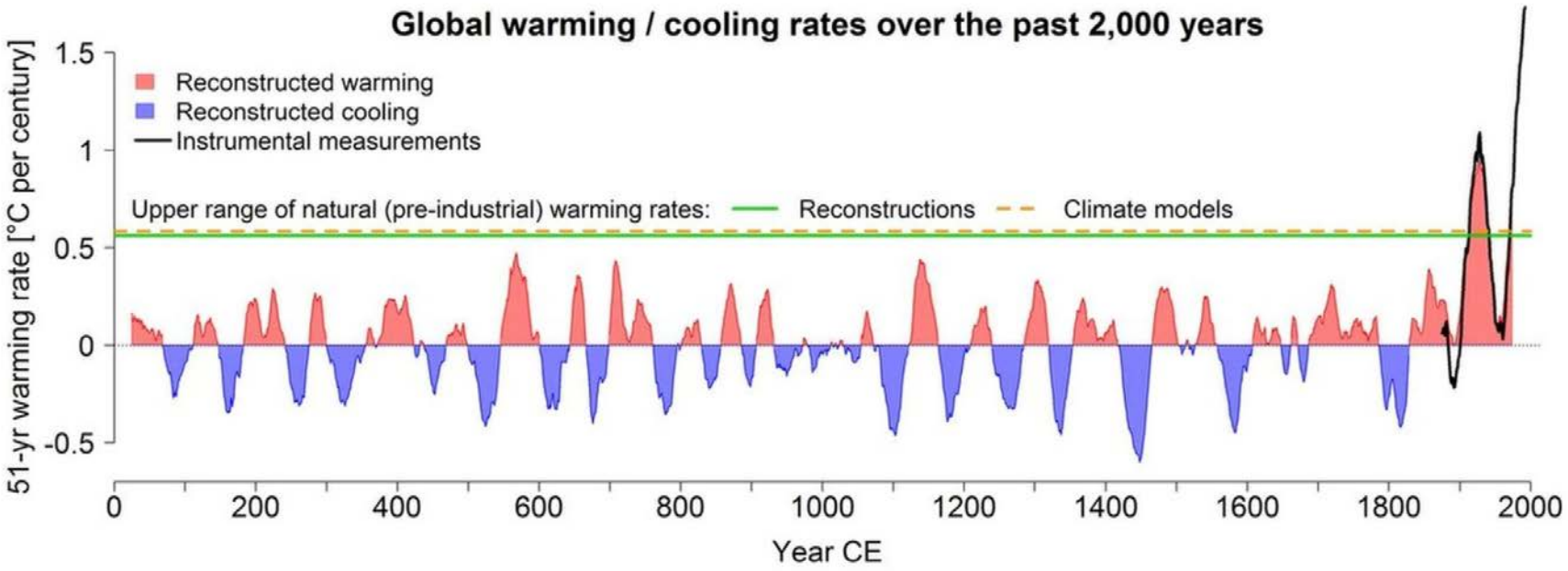
- second most important GHG is CO_2 (~ 20 % GH effect)
- last 13 % of GH effect – [illegible]

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

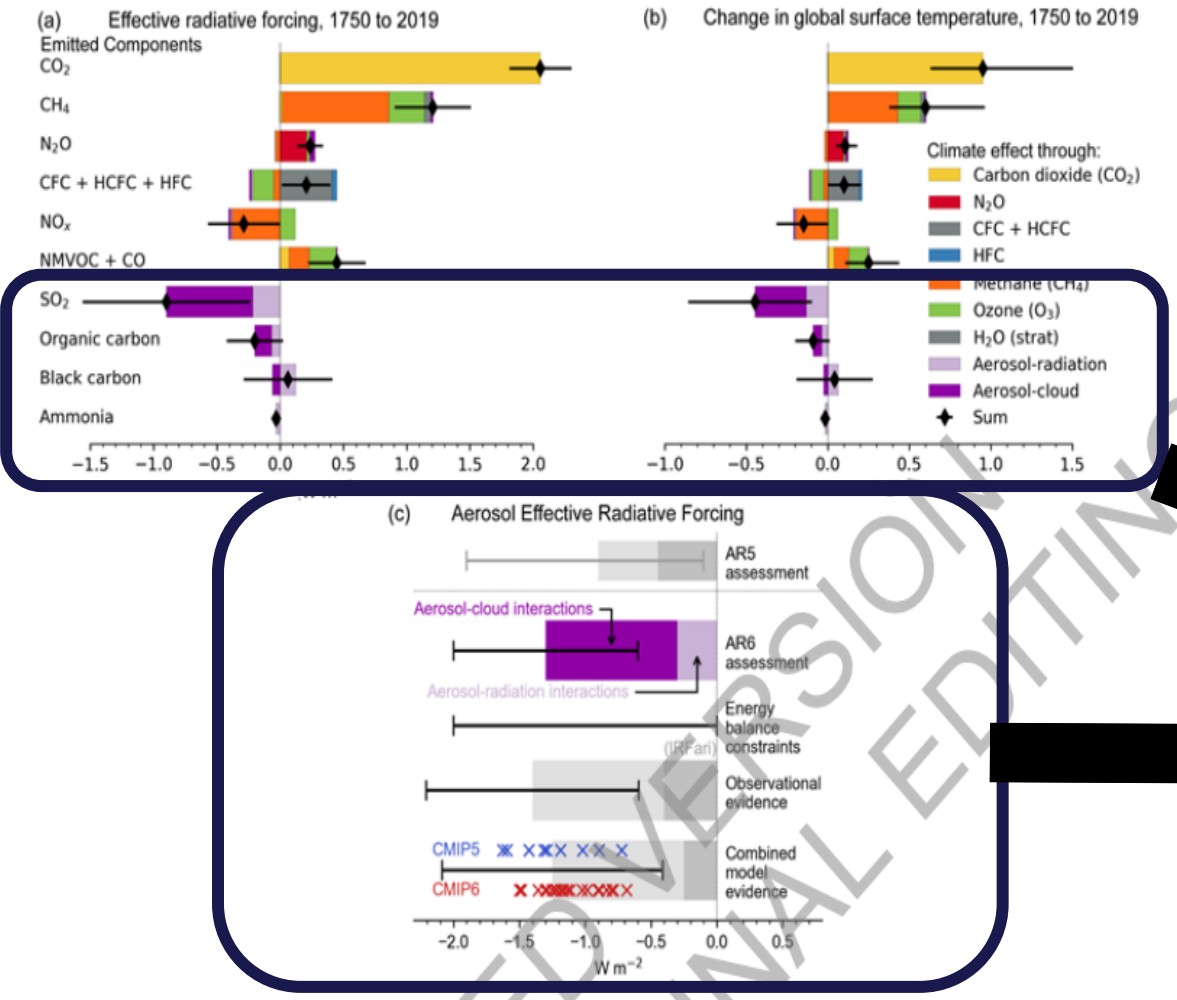


Figure TS.15: **Contribution to ERF and b) global surface temperature change from component emissions between 1750 to 2019 based on CMIP6 models and c) net aerosol effective radiative forcing (ERF) from different lines of evidence.** *The intent of the figure is to show advances since AR5 in the*

?

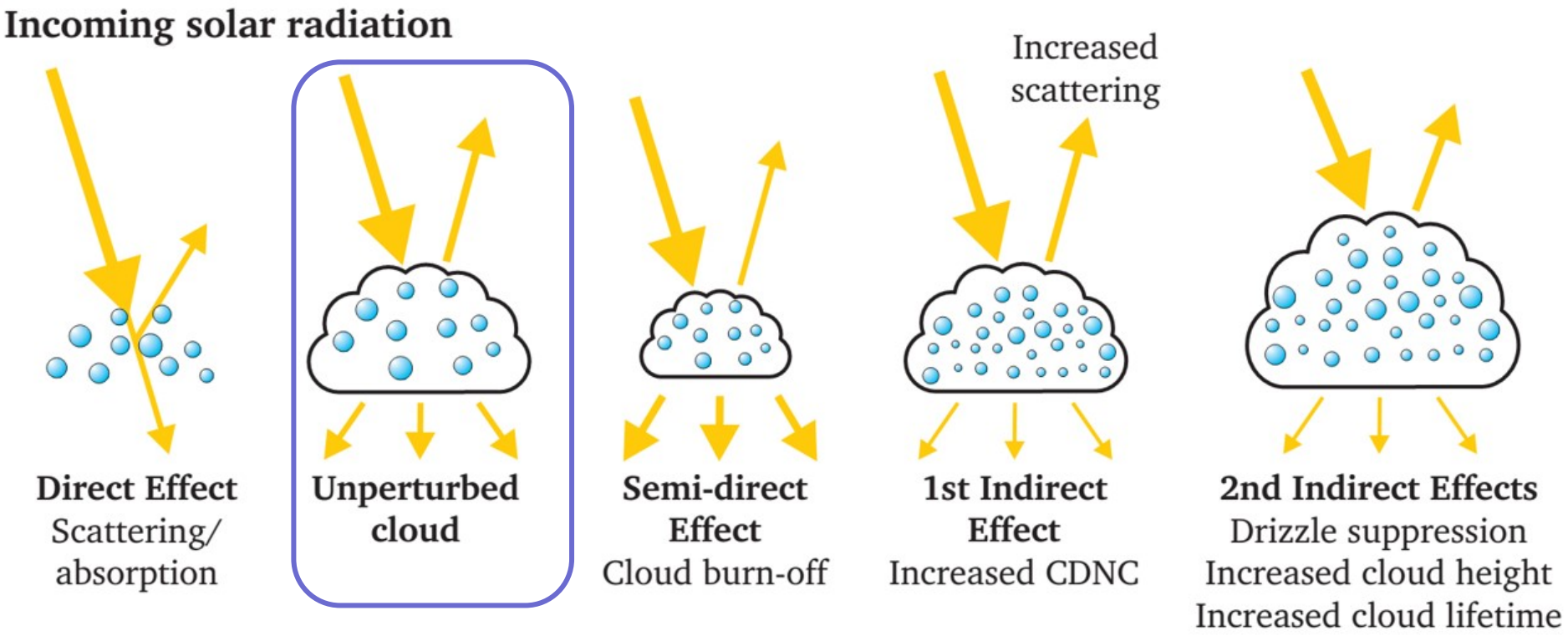
One of the biggest uncertainities in estimation of climate models

?

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



TINY BY SIZE, HUGE BY IMPORTANCE

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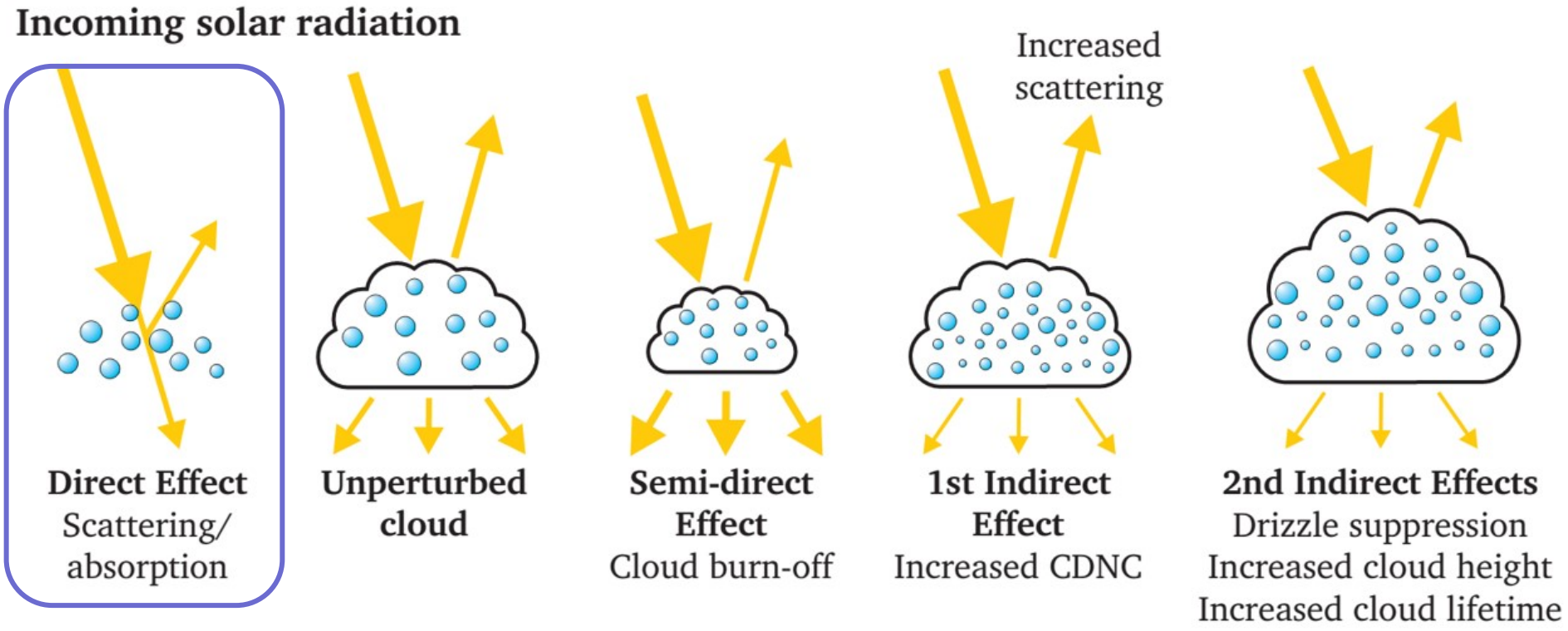

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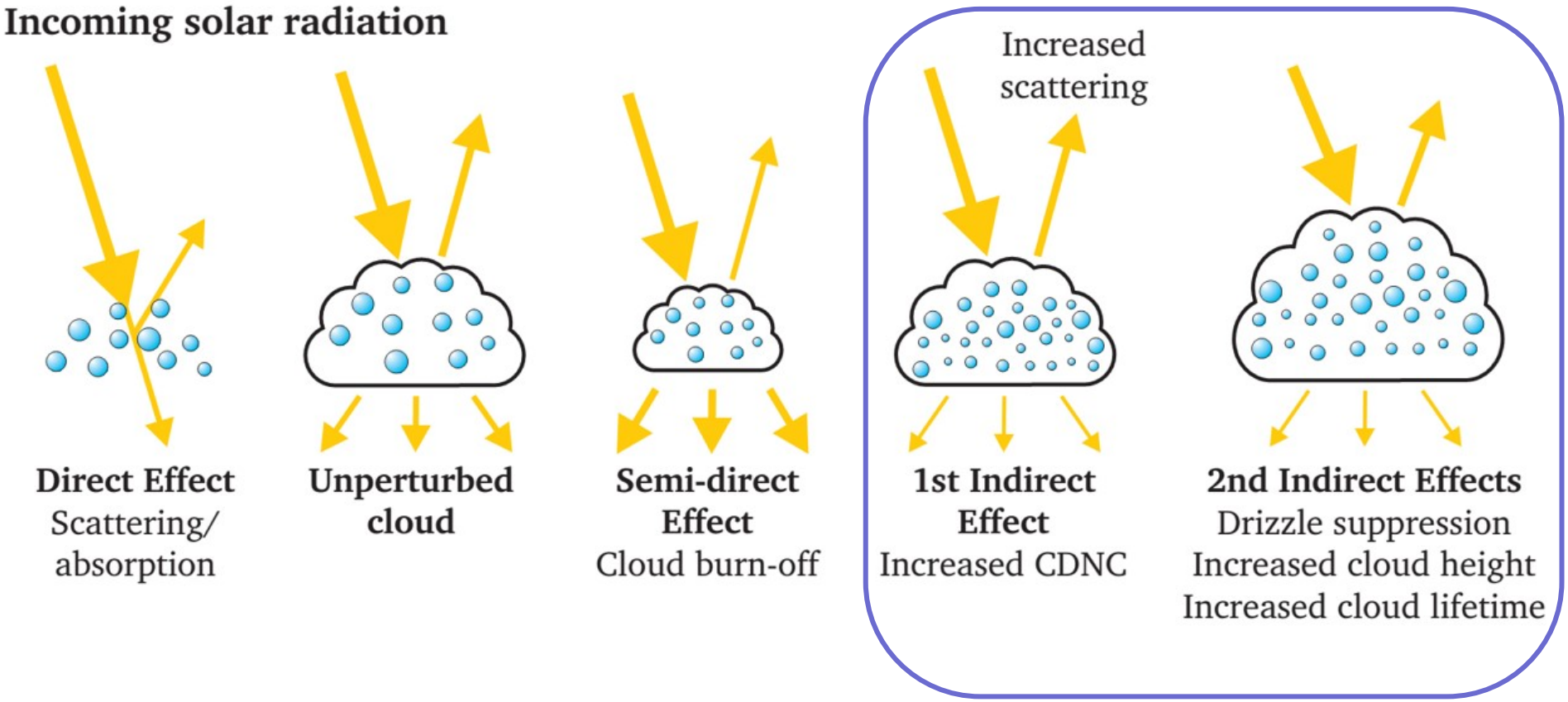

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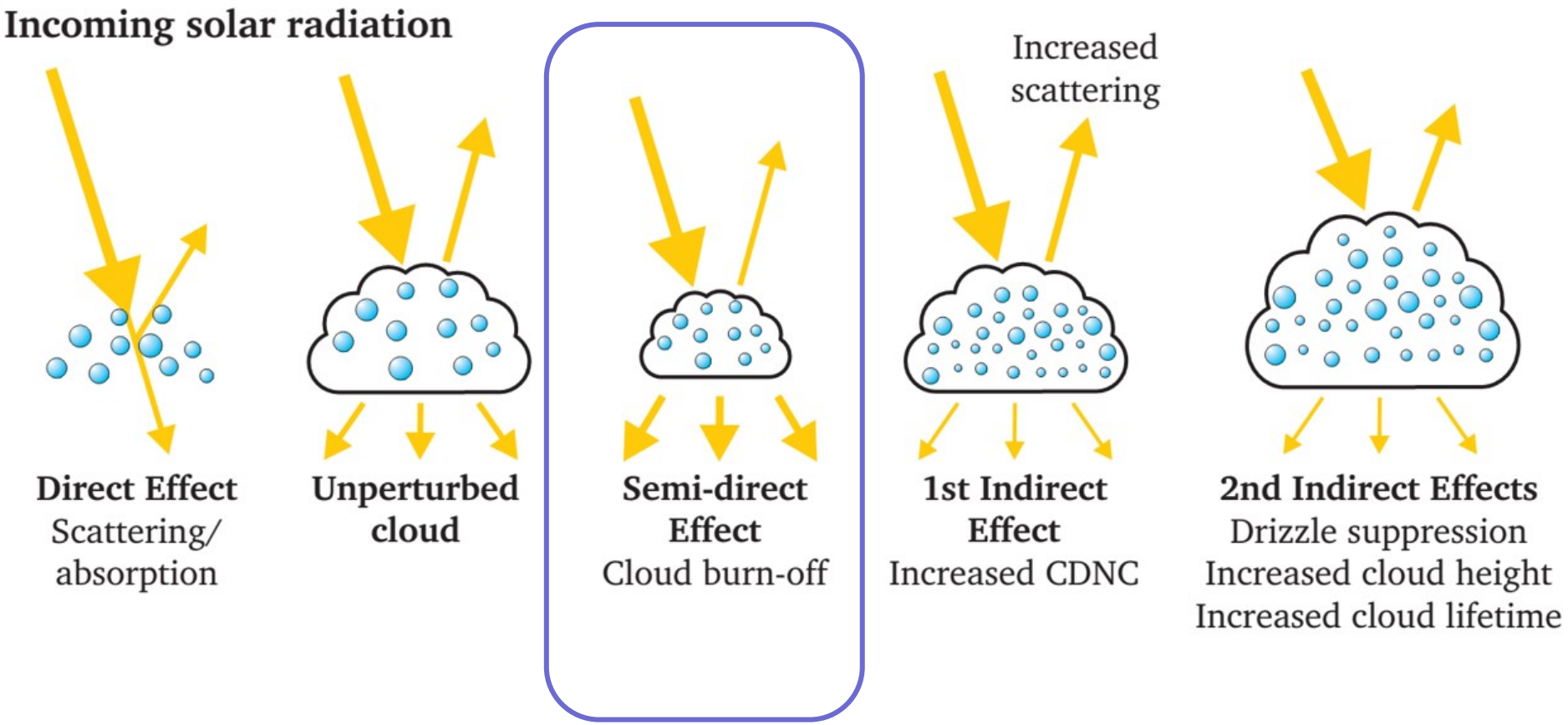
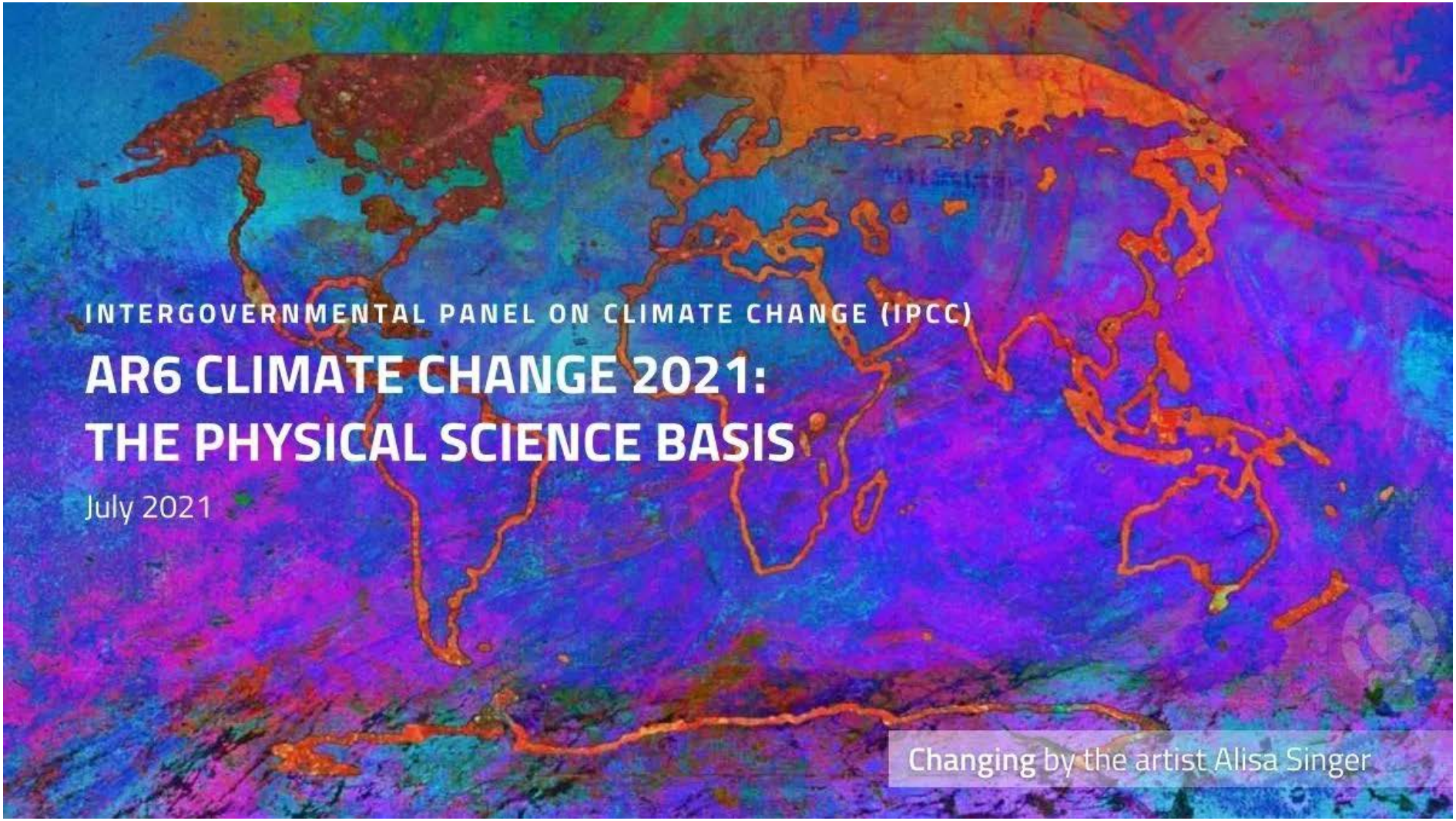
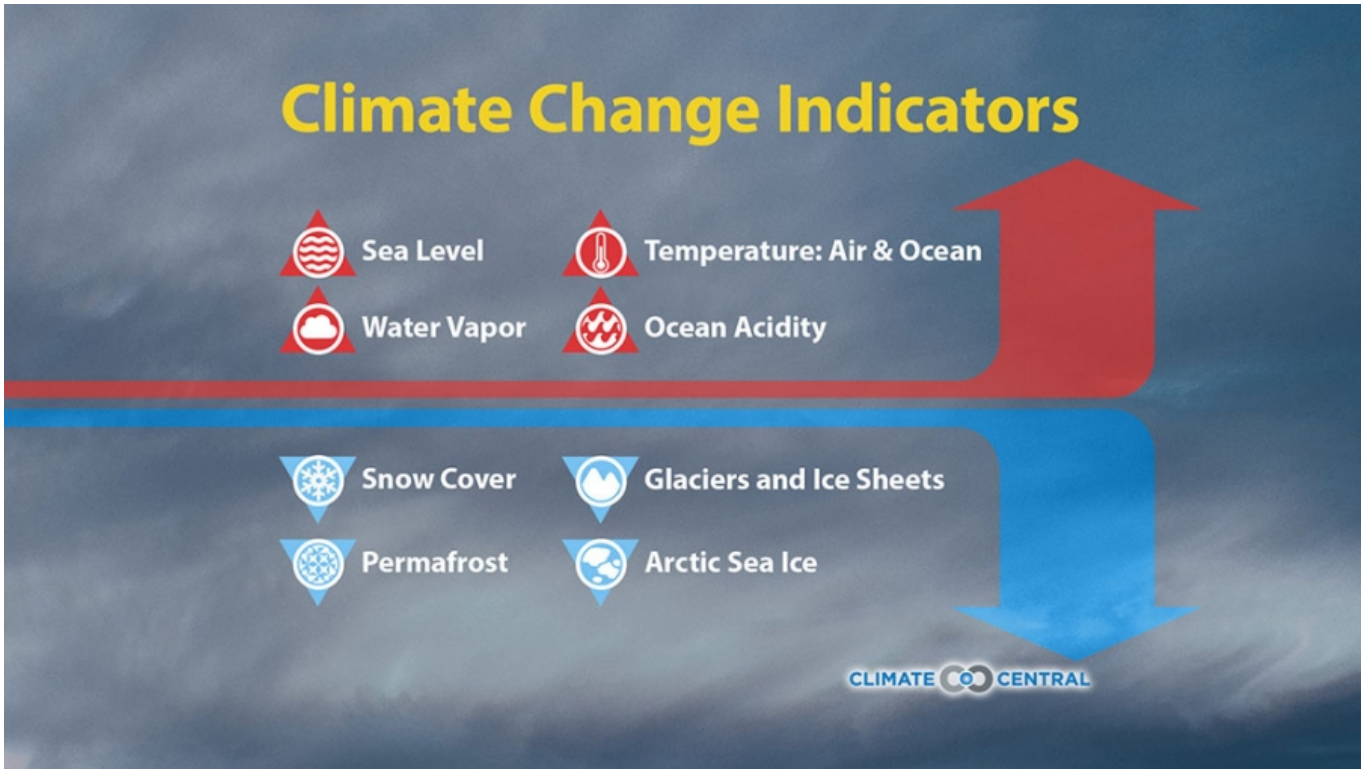



INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)
AR6 CLIMATE CHANGE 2021:
THE PHYSICAL SCIENCE BASIS
July 2021
Changing by the artist Alisa Singer

CC indicators

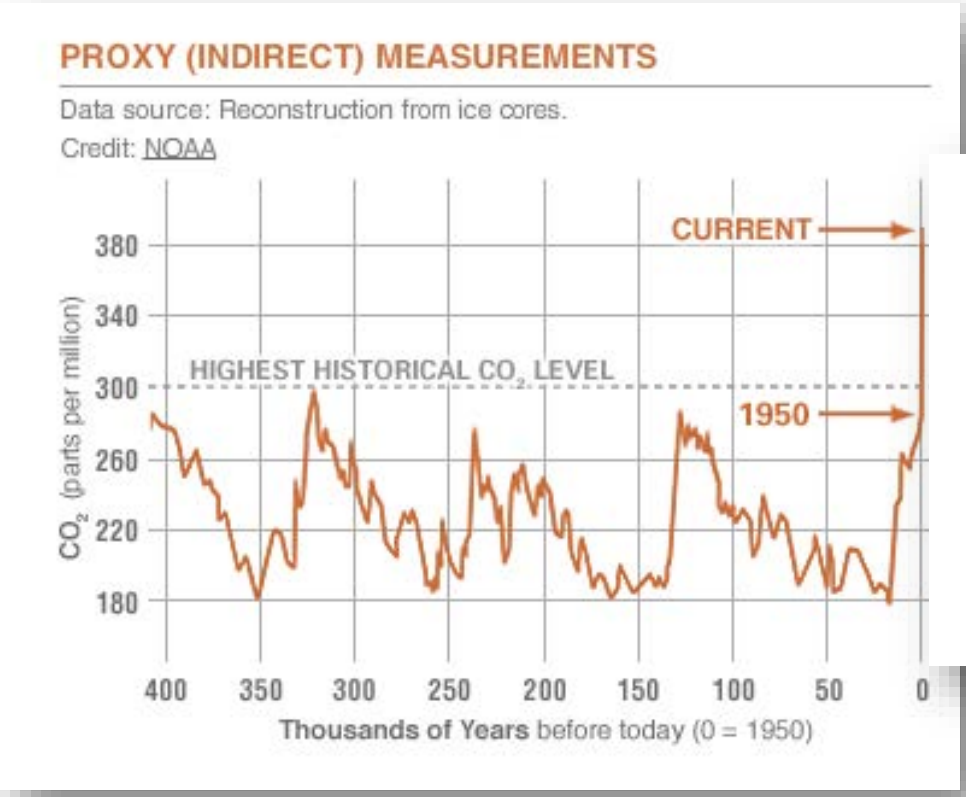


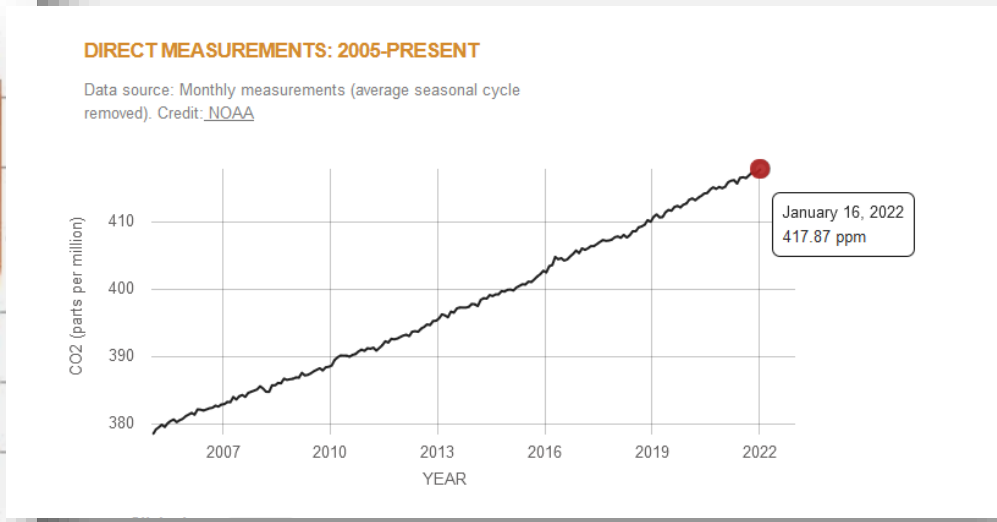
Increase of CO_2 level

- CO_2 level increased more than >40 % since pre-industrial level

- level of other greenhouse gases increases as well

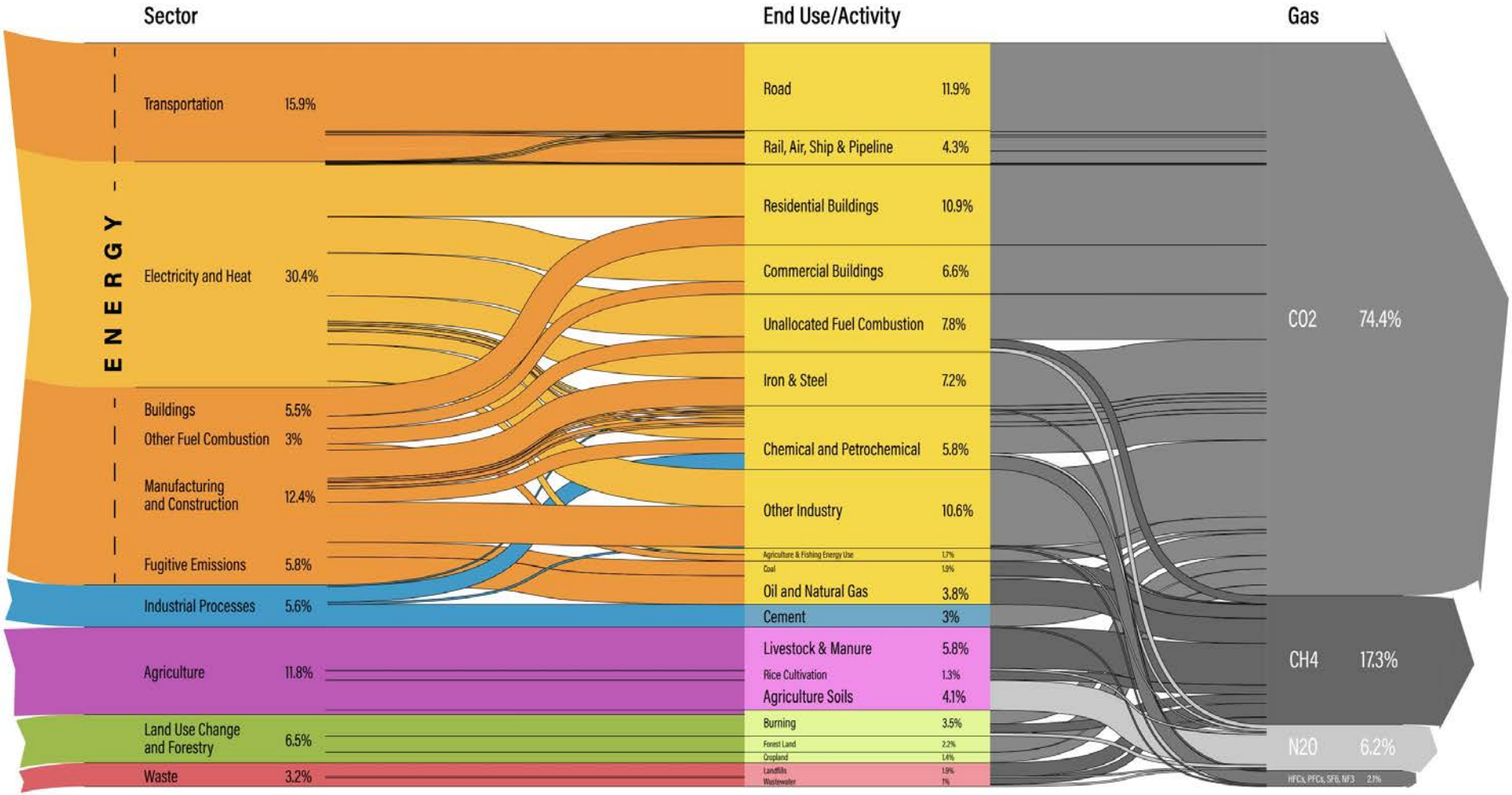
- main source of this increase is **fosil fuels combustion + deforestation**





World Greenhouse Gas Emissions in 2016

Total: 49.4 $MtCO_2$

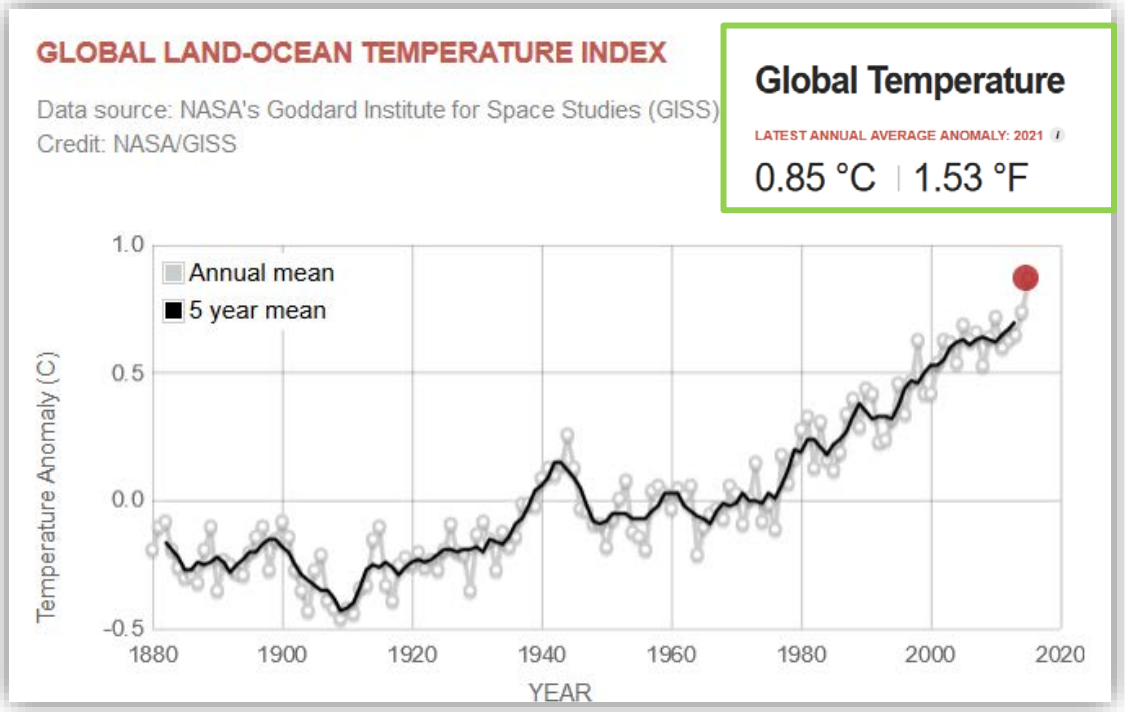


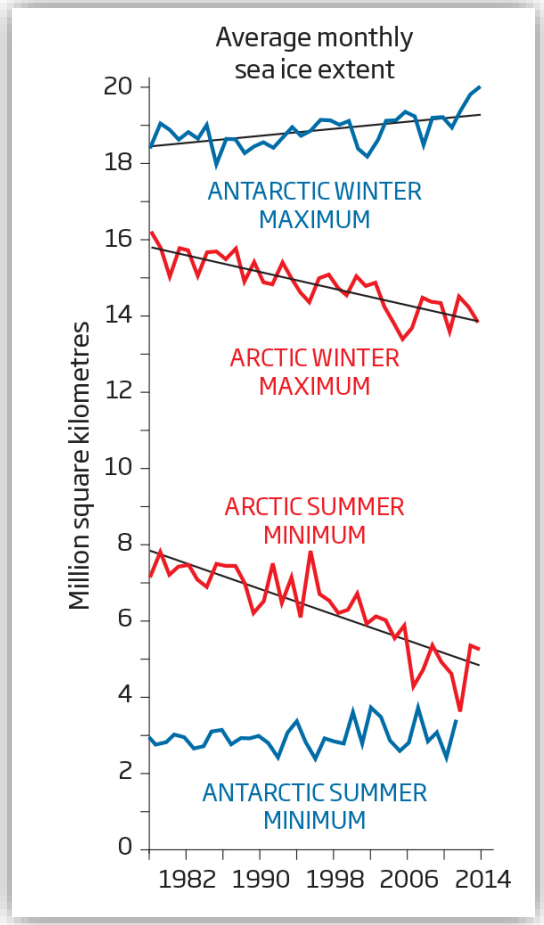
Source: Greenhouse gas emissions on Climate Watch. Available at: https://www.climatewatchdata.org

WORLD RESOURCES INSTITUTE

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





Less ice in the Arctic ocean

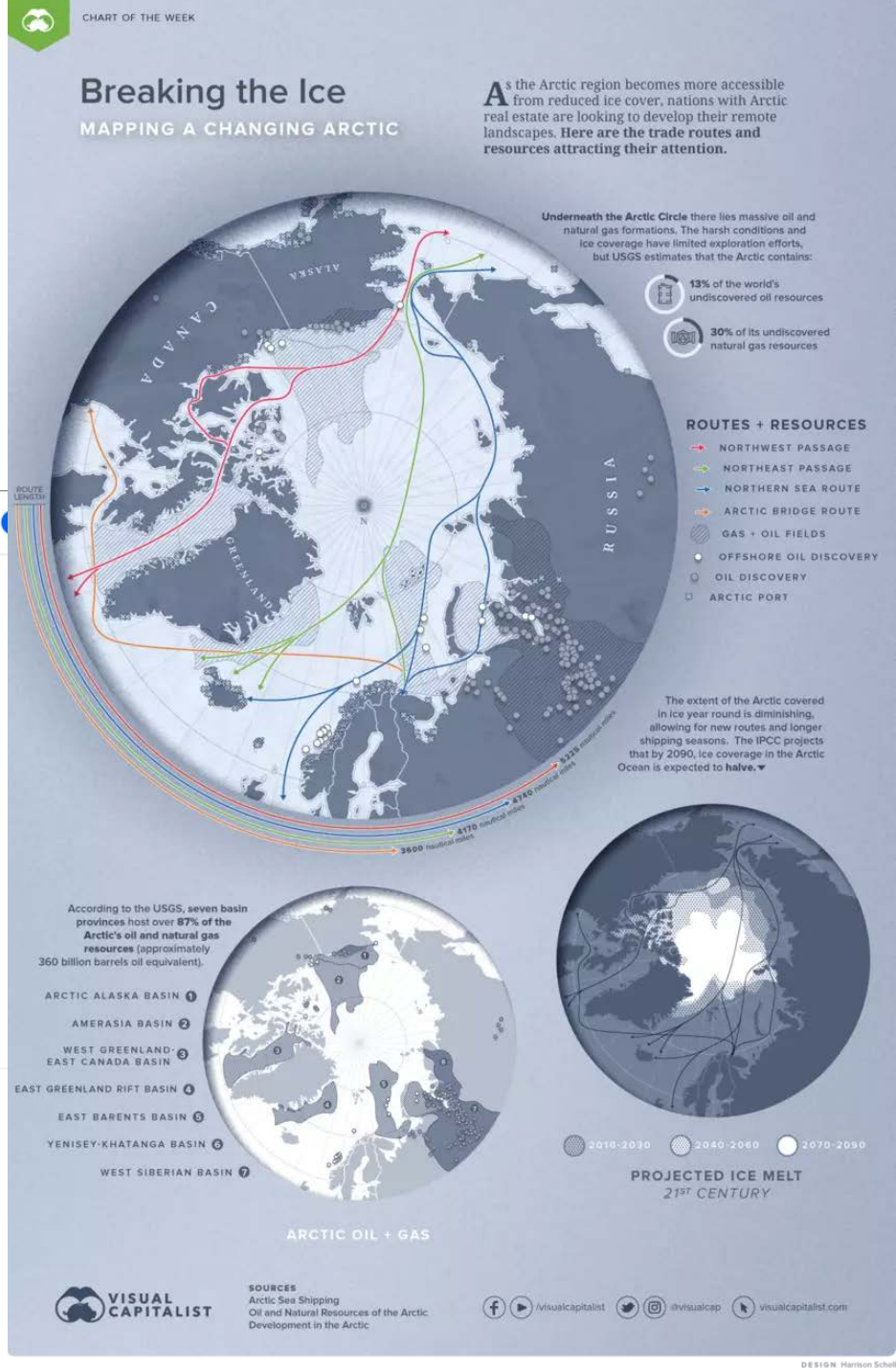
- new naval routes from Europe to Asia

WORLD ECONOMIC FORUM

Global Agenda | Arctic | Future of the Environment | Geo-economics

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

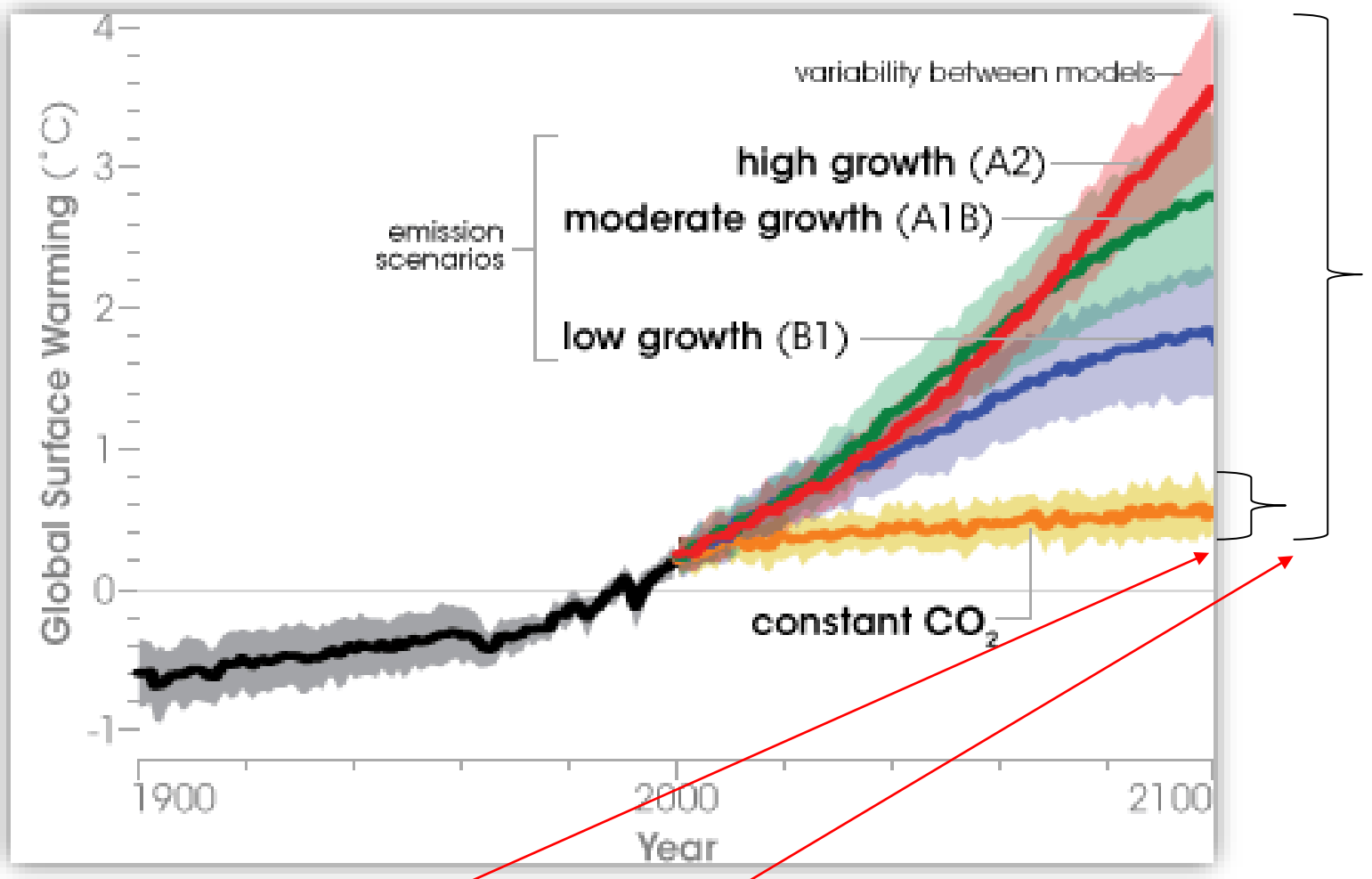
With financial gains to be exploited, will the world have enough restraint to resist damaging this landscape? Image: Unsplash/Valeriia Bugaiova



Glacier calving in Arctic ocean

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

Temperature rise scenarios to 2100

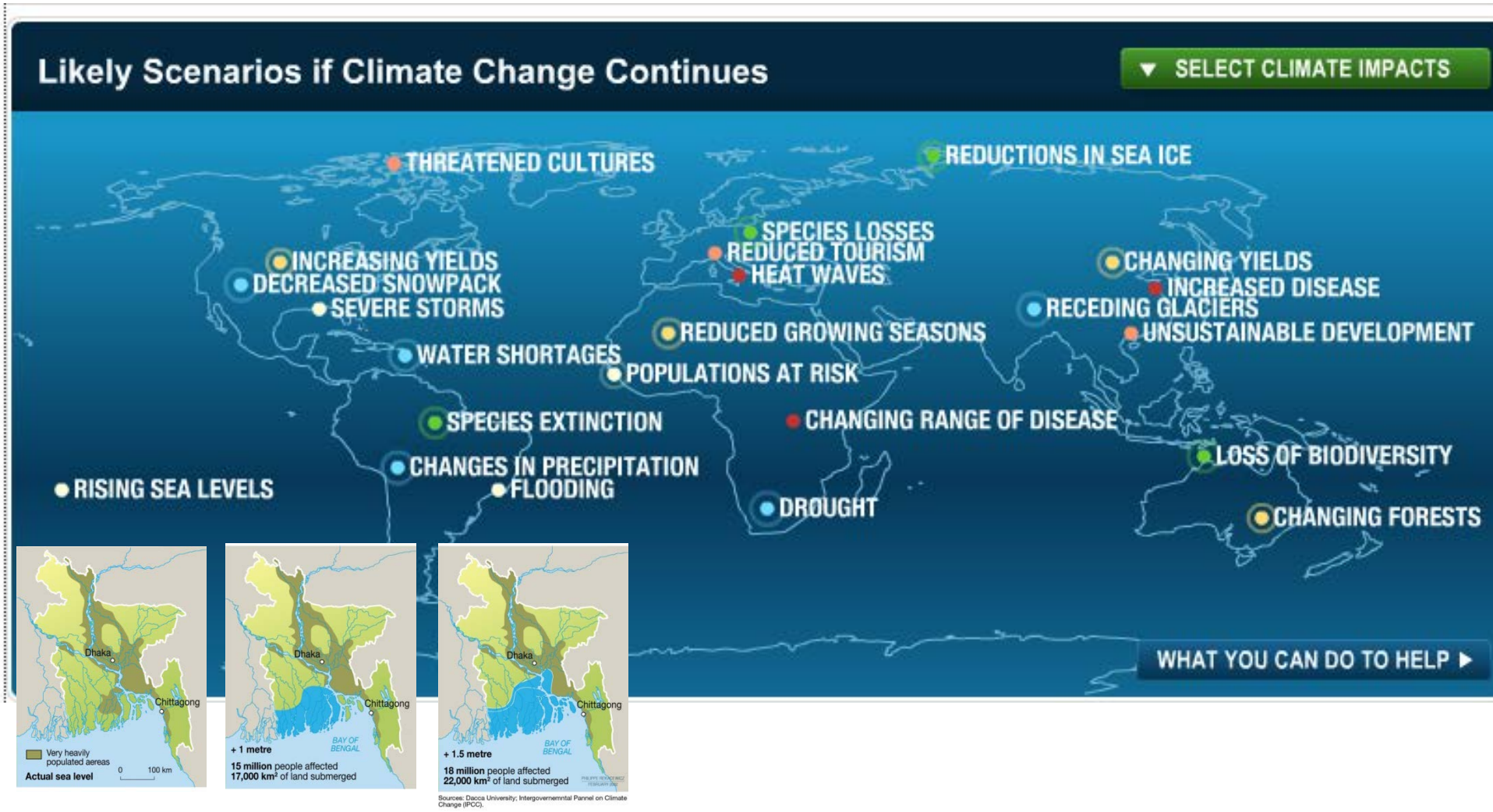


- scientific vs. political uncertainty

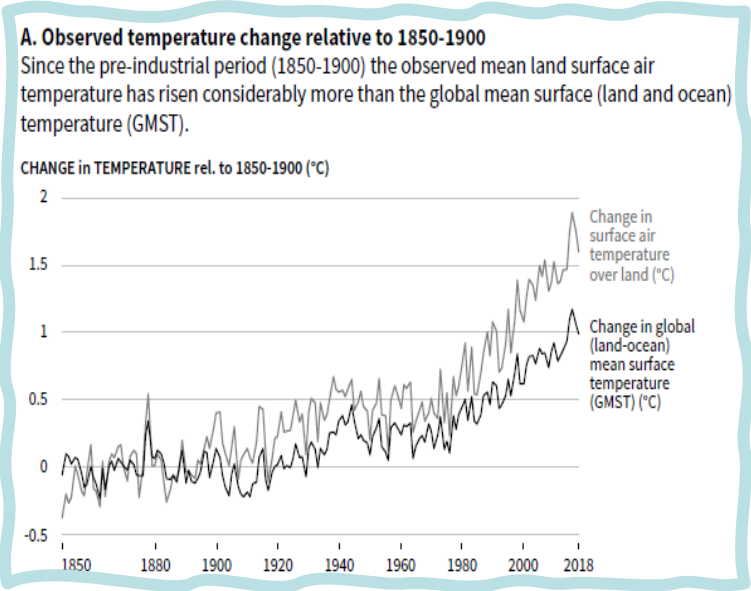
CC consequences

Consequences of CC

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



Consequences of CC



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

- **CHANGES OF BIODIVERSITY**
-
-

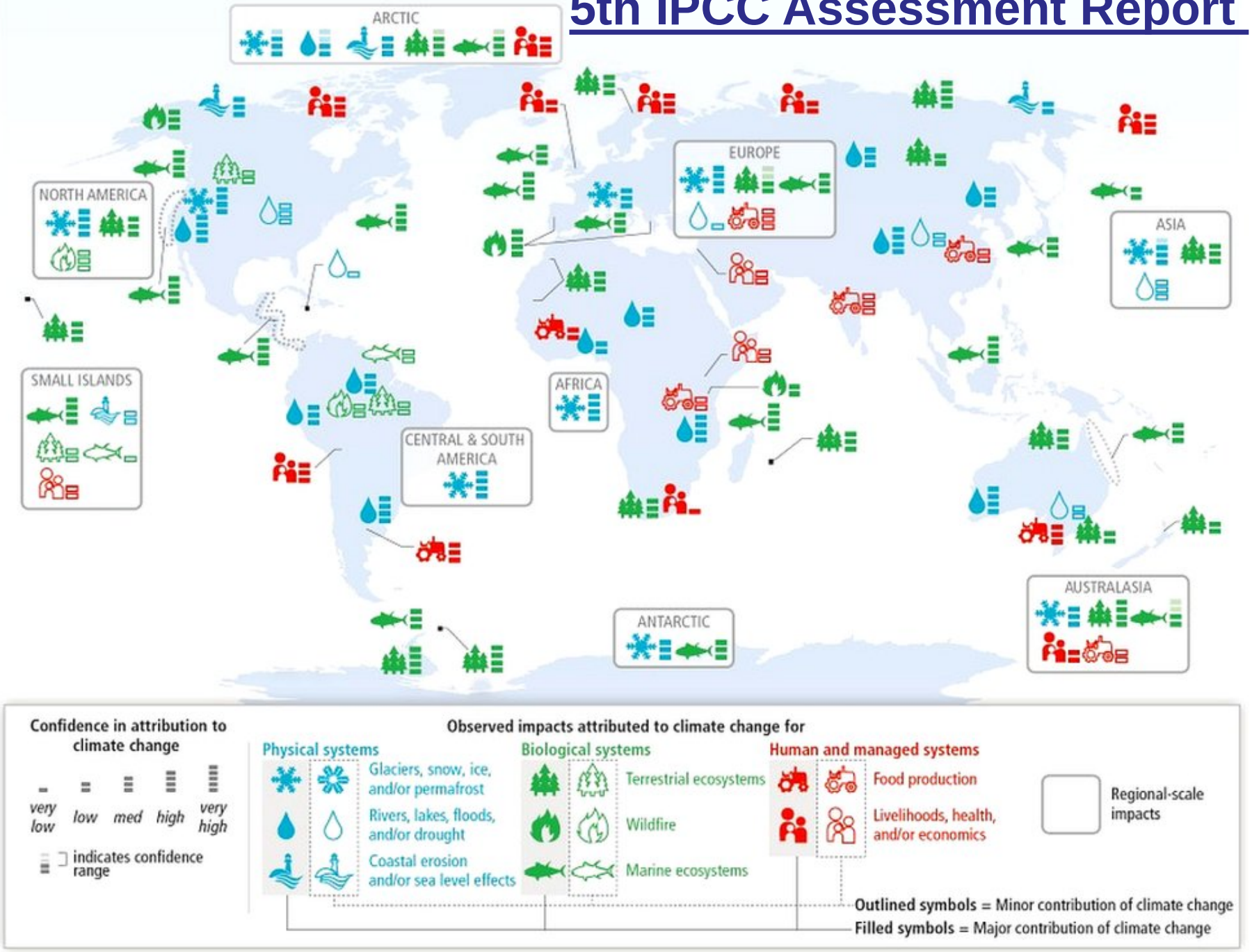
higher vegetation cover (Asia, Europe, S Am, SE Australia)

-

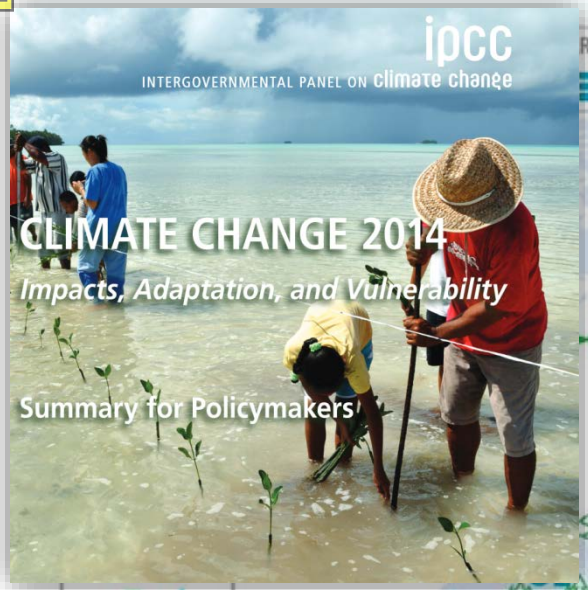
drying of vegetation (N Eurasia, Central Asia, Congo Basin)

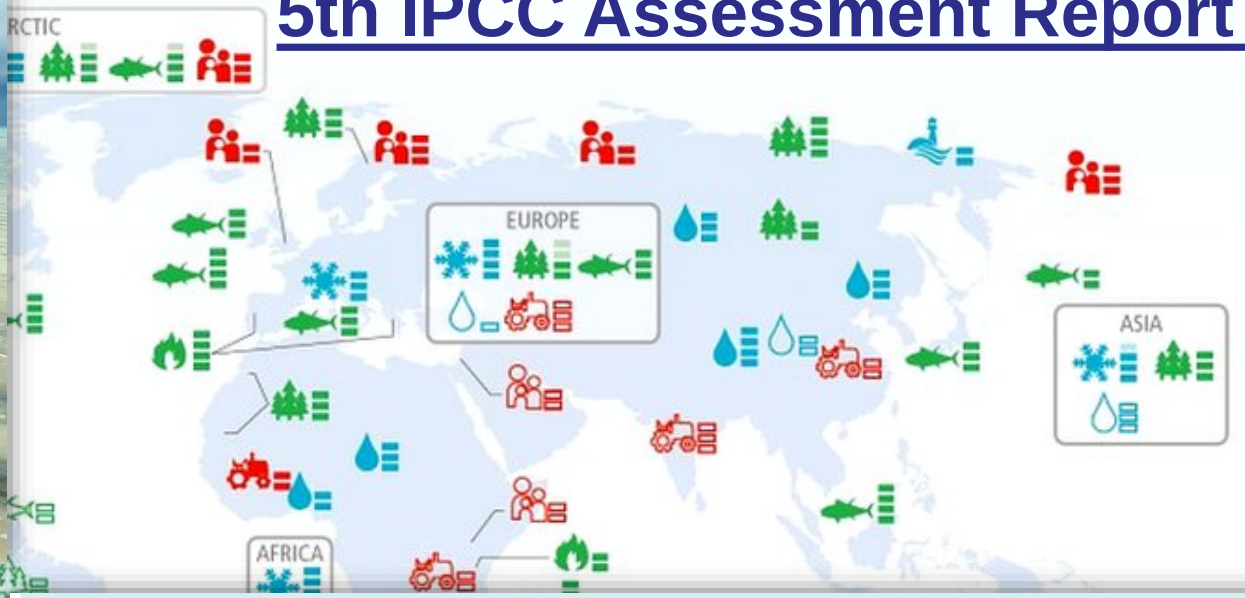
(2019)

5th IPCC Assessment Report

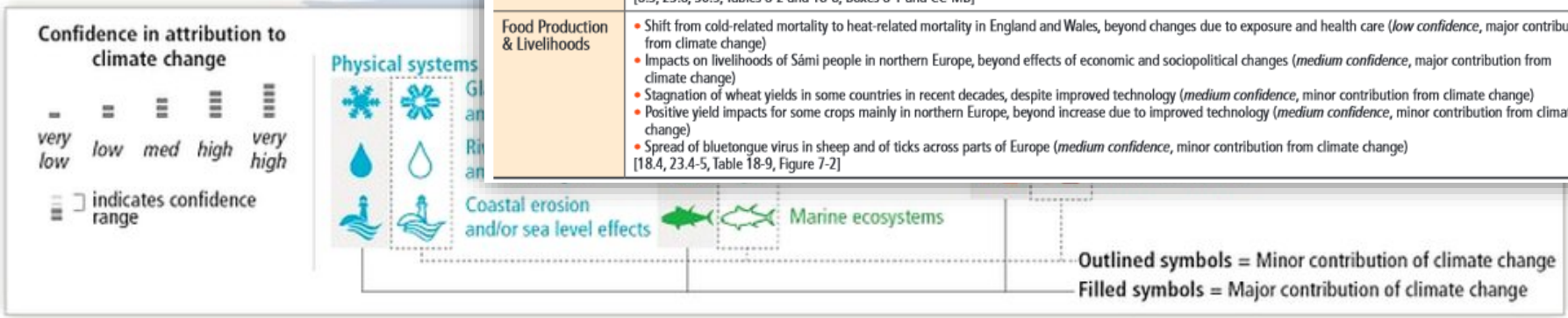


5th IPCC Assessment Report





Europe	
Snow & Ice, Rivers & Lakes, Floods & Drought	• Retreat of Alpine, Scandinavian, and Icelandic glaciers (*high confidence*, major contribution from climate change) • Increase in rock slope failures in western Alps (*medium confidence*, major contribution from climate change) • Changed occurrence of extreme river discharges and floods (*very low confidence*, minor contribution from climate change) [18.3, 23.2-3, Tables 18-5 and 18-6; WGI AR5 4.3]
Terrestrial Ecosystems	• Earlier greening, leaf emergence, and fruiting in temperate and boreal trees (*high confidence*, major contribution from climate change) • Increased colonization of alien plant species in Europe, beyond a baseline of some invasion (*medium confidence*, major contribution from climate change) • Earlier arrival of migratory birds in Europe since 1970 (*medium confidence*, major contribution from climate change) • Upward shift in tree-line in Europe, beyond changes due to land use (*low confidence*, major contribution from climate change) • Increasing burnt forest areas during recent decades in Portugal and Greece, beyond some increase due to land use (*high confidence*, major contribution from climate change) [4.3, 18.3, Tables 18-7 and 23-6]
Coastal Erosion & Marine Ecosystems	• Northward distributional shifts of zooplankton, fishes, seabirds, and benthic invertebrates in northeast Atlantic (*high confidence*, major contribution from climate change) • Northward and depth shift in distribution of many fish species across European seas (*medium confidence*, major contribution from climate change) • Plankton phenology changes in northeast Atlantic (*medium confidence*, major contribution from climate change) • Spread of warm water species into the Mediterranean, beyond changes due to invasive species and human impacts (*medium confidence*, major contribution from climate change) [6.3, 23.6, 30.5, Tables 6-2 and 18-8, Boxes 6-1 and CC-MB]
Food Production & Livelihoods	• Shift from cold-related mortality to heat-related mortality in England and Wales, beyond changes due to exposure and health care (*low confidence*, major contribution from climate change) • Impacts on livelihoods of Sámi people in northern Europe, beyond effects of economic and sociopolitical changes (*medium confidence*, major contribution from climate change) • Stagnation of wheat yields in some countries in recent decades, despite improved technology (*medium confidence*, minor contribution from climate change) • Positive yield impacts for some crops mainly in northern Europe, beyond increase due to improved technology (*medium confidence*, minor contribution from climate change) • Spread of bluetongue virus in sheep and of ticks across parts of Europe (*medium confidence*, minor contribution from climate change) [18.4, 23.4-5, Table 18-9, Figure 7-2]



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

Keeping Your Cool on the Climate Debate with Bjorn Lomborg

54 588 zhliadnutí • 10. 3. 2021

1,1 TIS. 68 ZDIEĽANIE ULOŽIŤ

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

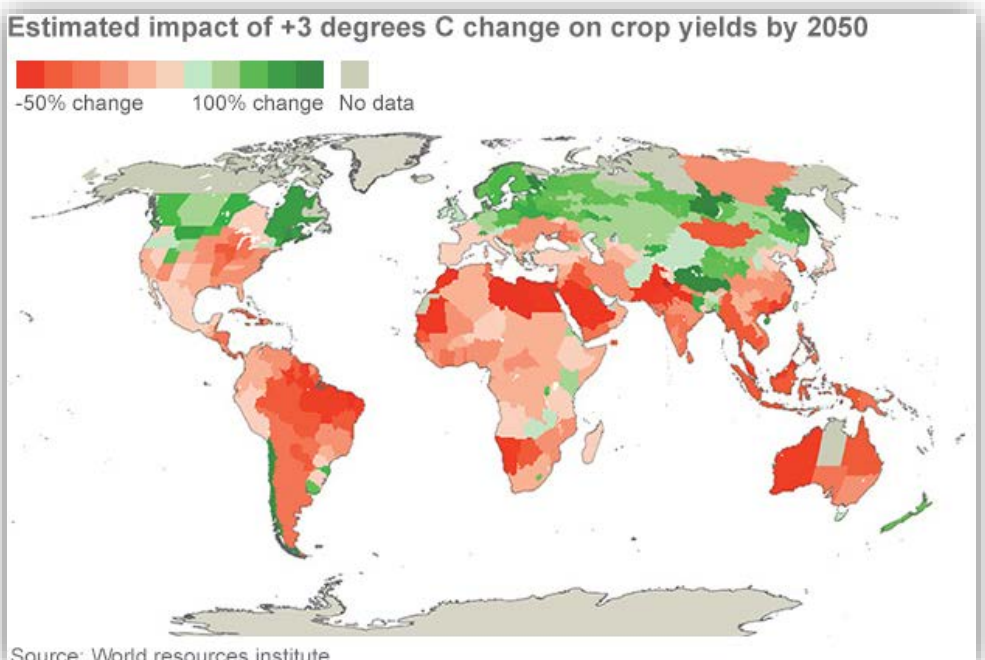
„...more heat will damage crop growth in many warmer climates, but it means better agricultural production in cold countries. And, CO_2 is a fertiliser — commercial greenhouses pump in extra CO_2 to grow bigger tomatoes. So overall, we can expect agriculture to gain from global warming in the short and medium term...“ B. Lomborg

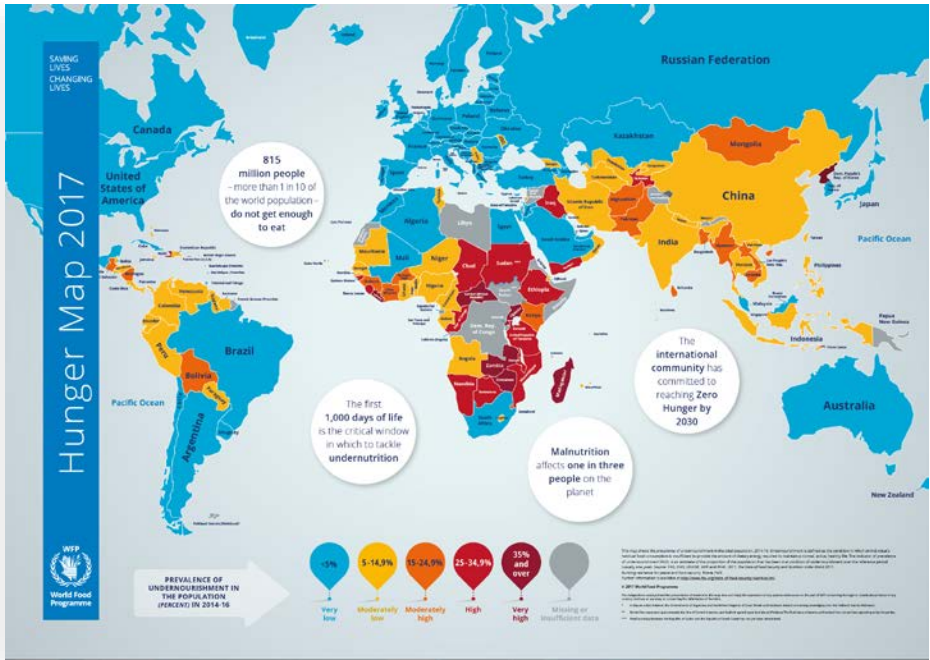
Let´s discuss!

Moral dimension of CC

„...more heat will damage crop growth in many warmer climates, but it means better agricultural production in cold countries. And, CO_2 is a fertiliser — commercial greenhouses pump in extra CO_2 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



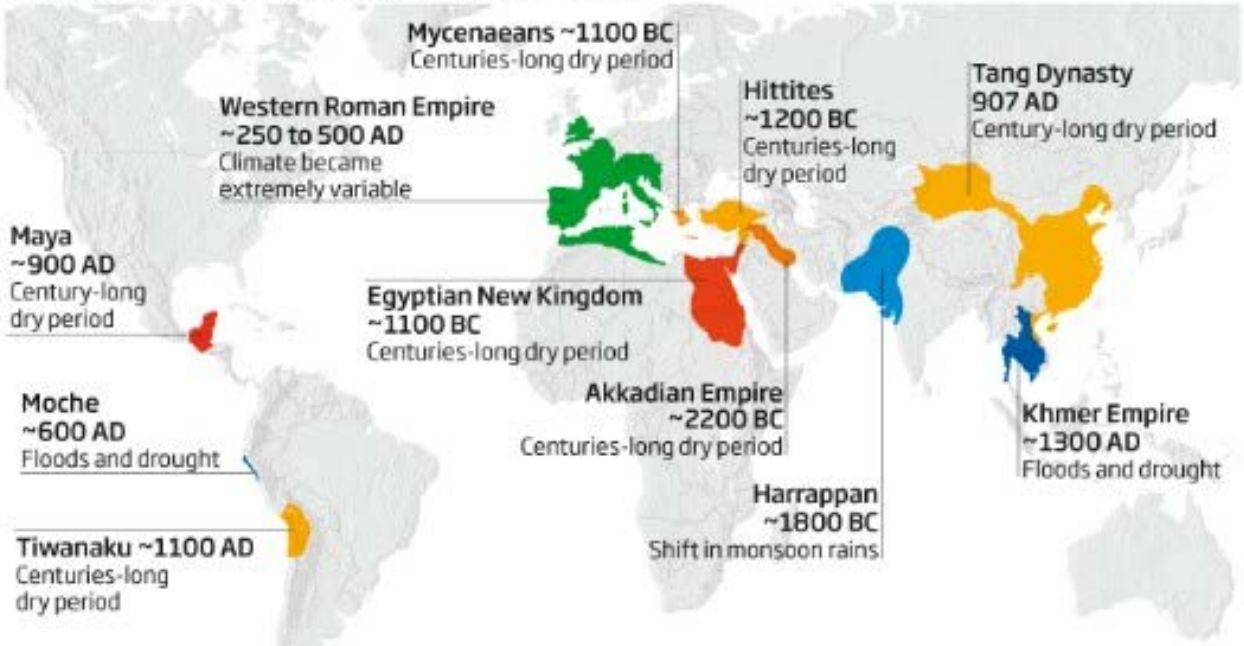


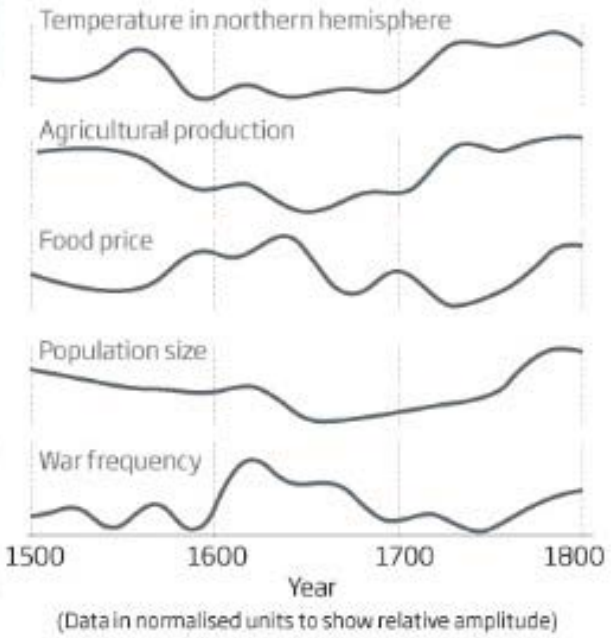
Climate change: The great civilisation destroyer?

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

More than coincidence?

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?

The Nobel Peace Prize 2007

Intergovernmental Panel on Climate Change , Al Gore

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.

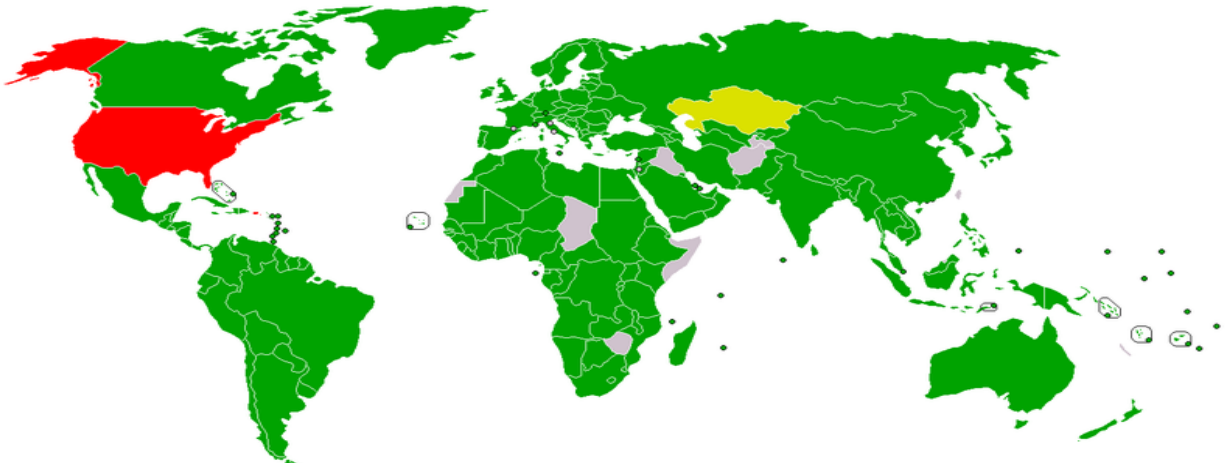
Prize share: 1/2

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"*

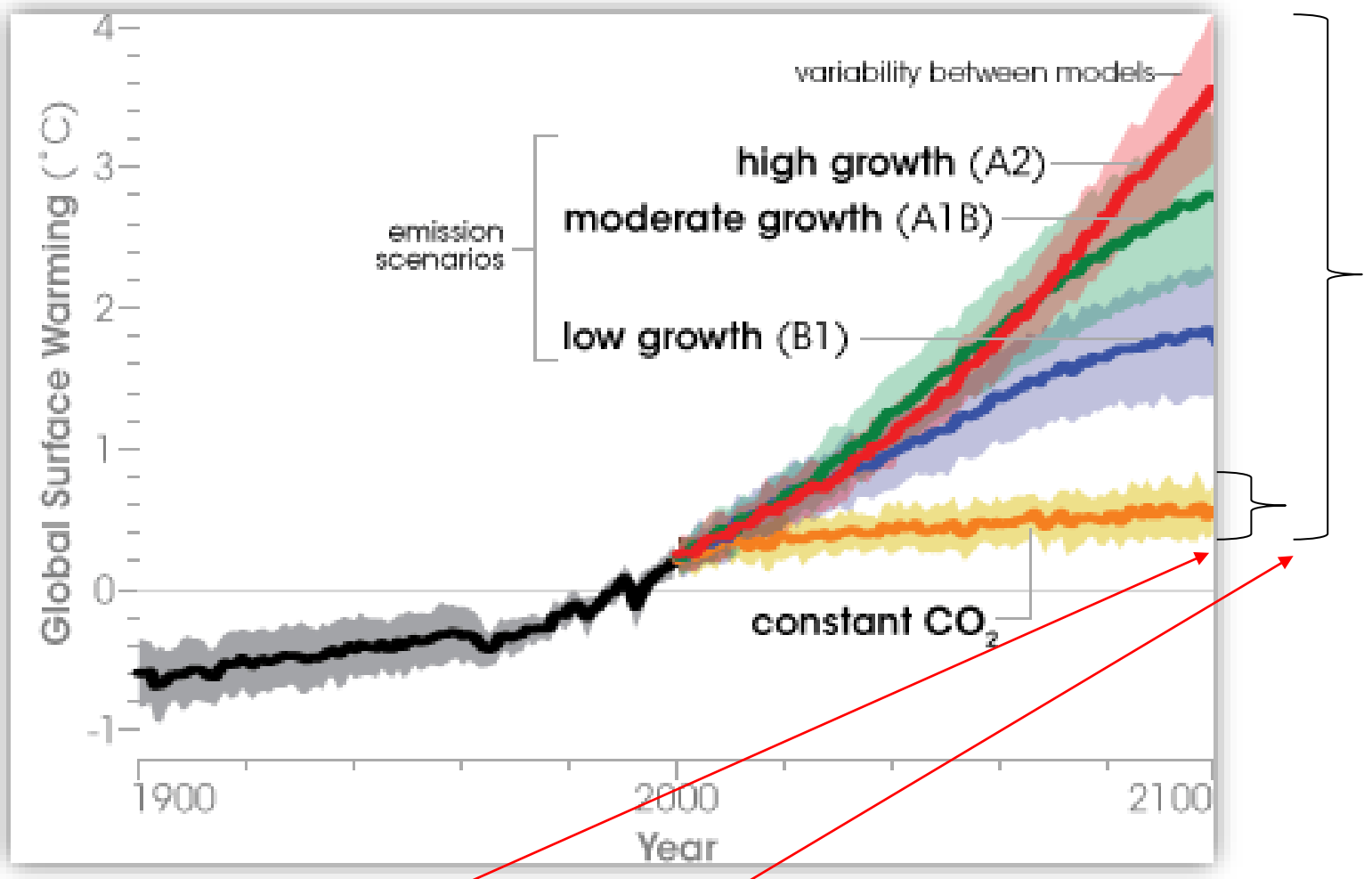
Politics on CC

- main aim – decrease the GHG emissions, mainly CO_2
- 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 CO_2 emission (2010)



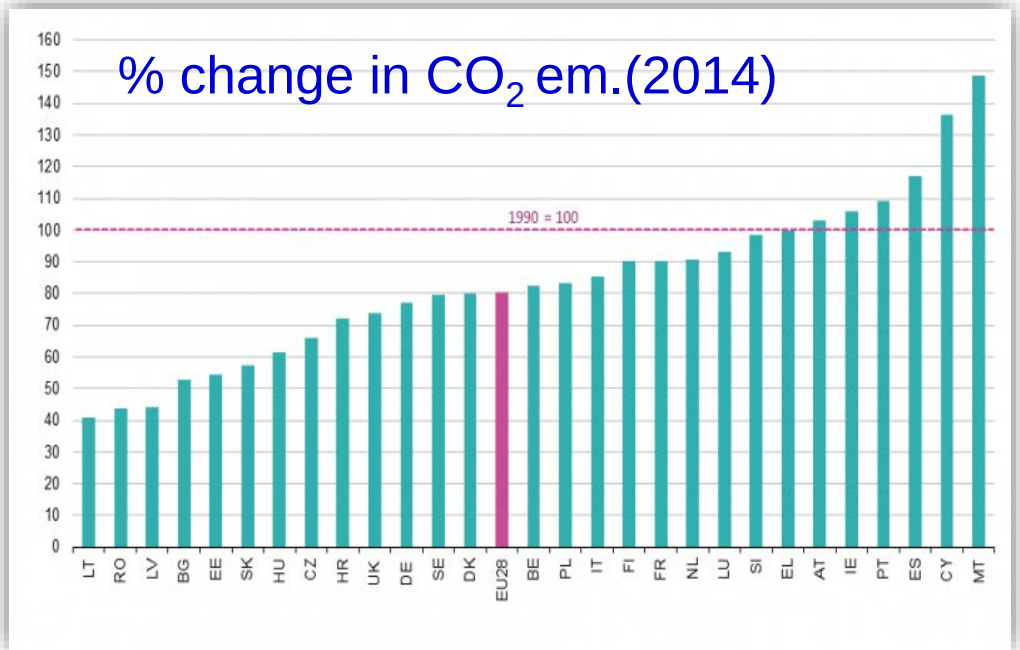
Temperature rise scenarios to 2100

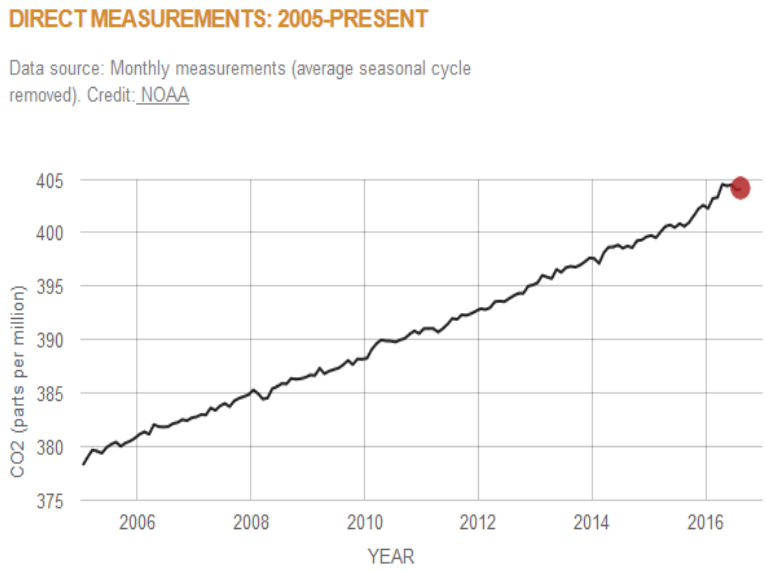


- scientific vs. political uncertainty

Kyoto protocol – result (2012)

- industrial countries (Annex I countries with Kyoto targets) reduced their emissions for 24.2 % ! (much more than promissed target 5.2 %)
- however, emission in other countries have risen so fast, that global CO_2 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





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 CO_2 emmisions?

- 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 CO_2 - 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/

Atmospheric Chemistry and Physics Discussions

N_2O release from agro-biofuel production negates global warming reduction by replacing fossil fuels

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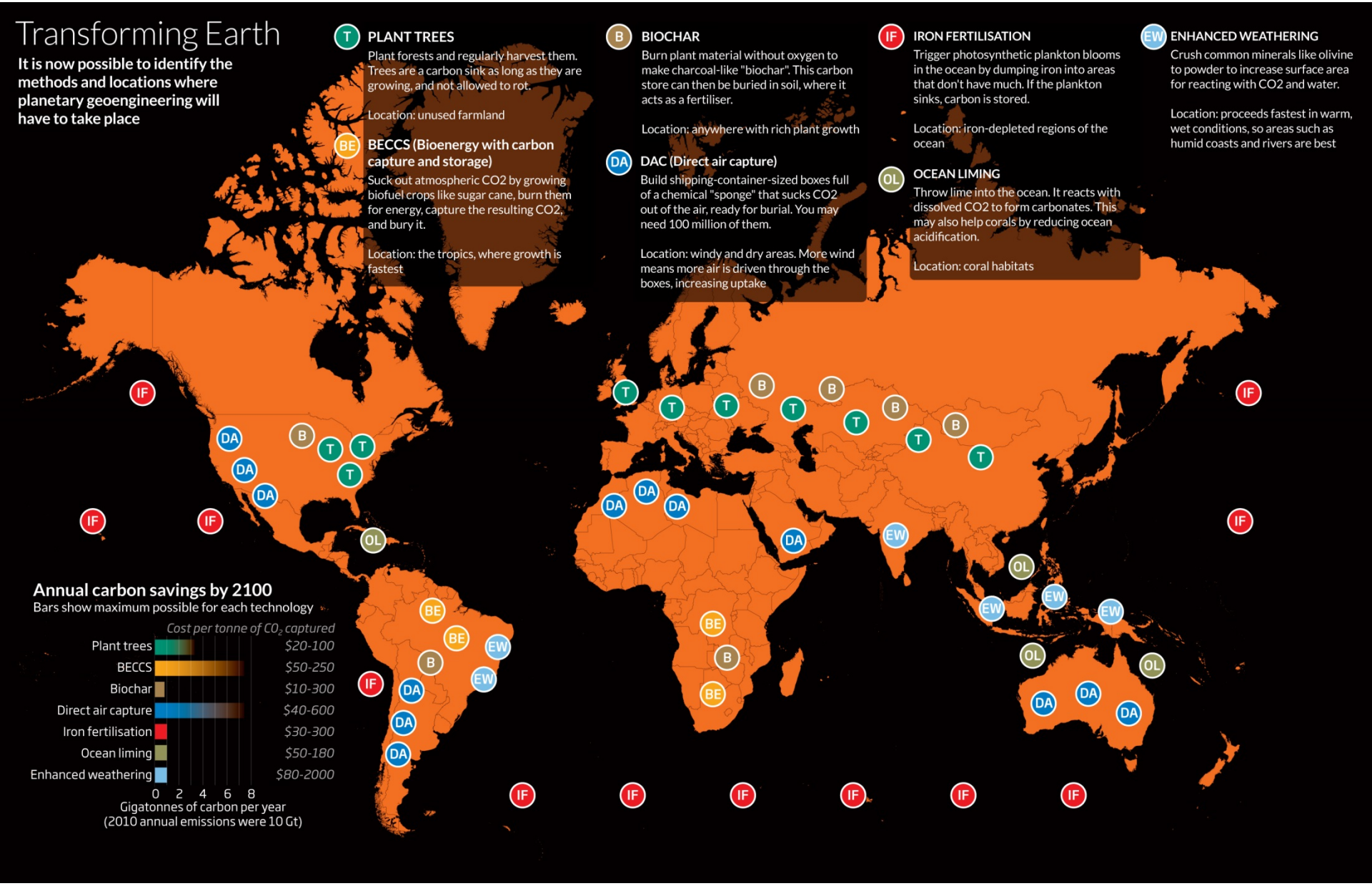
Geo-egineering – types and opportunities



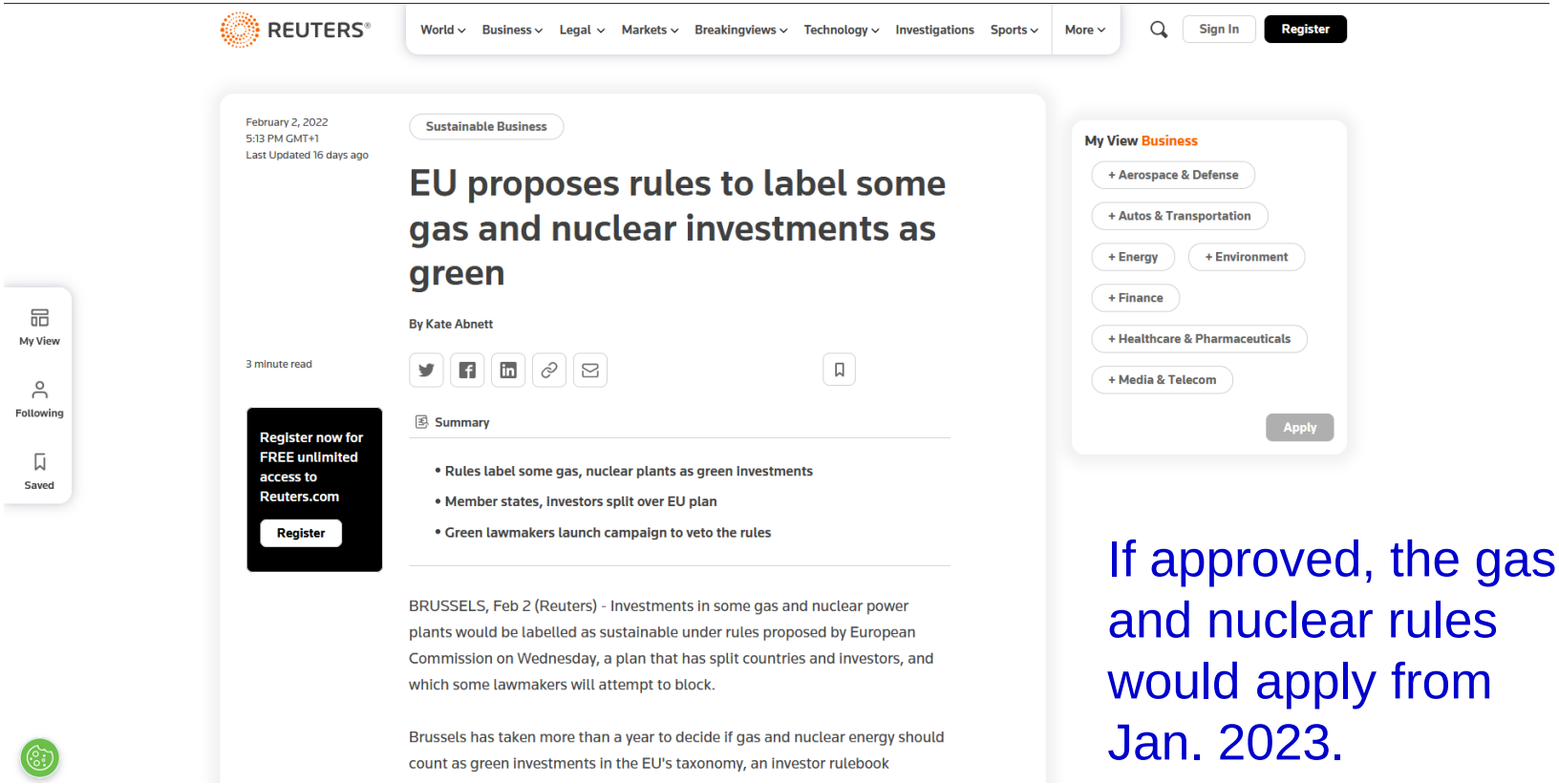
According to the Convention on Biological Diversity (CBD), all the geo-egineering applications are banned

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?



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