
ONE
WORLD

II. Climate Change (CC)

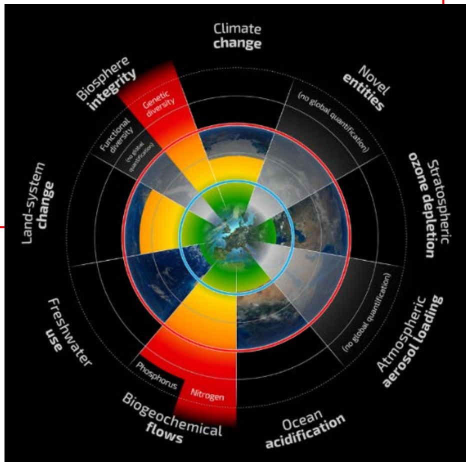
Earth System process	Control variable	Threshold avoided or influenced by slow variable	Planetary Boundary (zone of uncertainty)	State of knowledge*
Climate change	Atmospheric CO_2 concentration, ppm; Energy imbalance at Earth's surface, $W\ m^{-2}$	Loss of polar ice sheets. Regional climate disruptions. 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 (2020) : 413 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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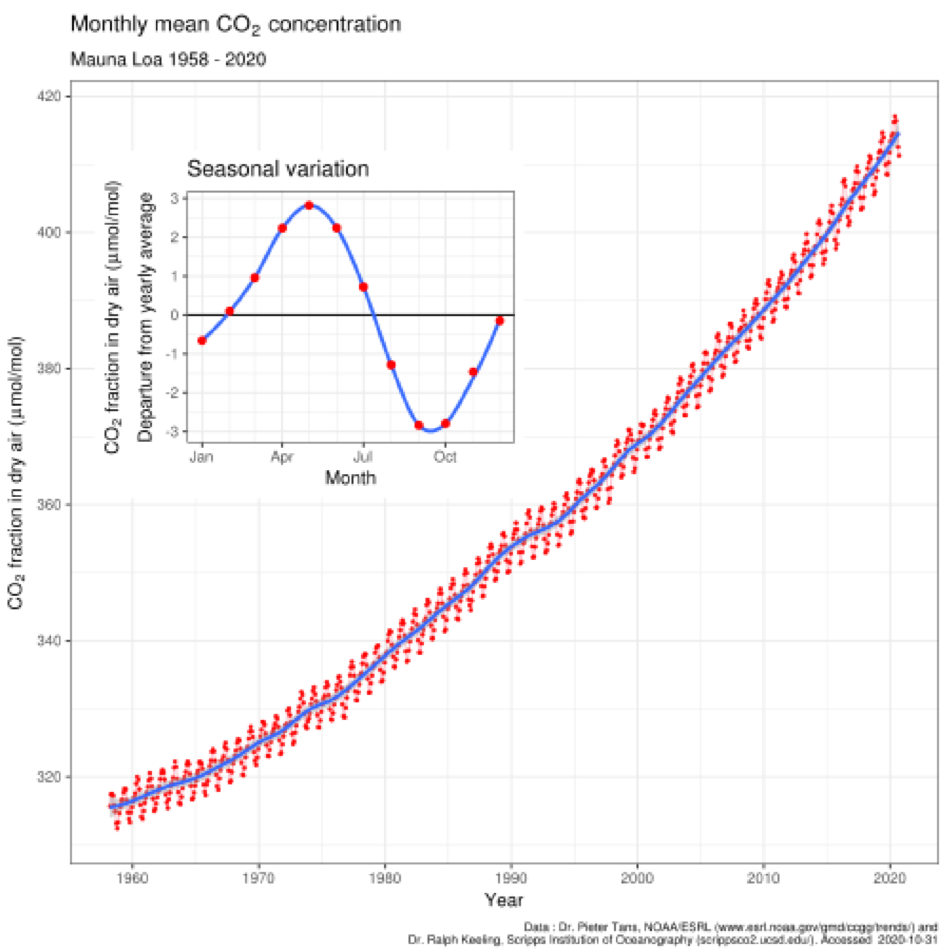
1957 – oceanographer Roger Revelle and chemist Hans Suess shown that oceans can not absorb entire CO_2 produced by people

"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)



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

2005 – Kyoto Protocol

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

2016, 4.11. – Paris Treaty came into force

2022 - 6th IPCC report (synthesis)

Greenhouse Effect an global Climate Change

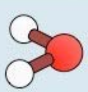
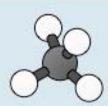
- Greenhouse effect (GE) – natural atmospheric effect essential for life on the Earth

- GE dampens temperature fluctuation between day and night and thus provides favorable conditions for life

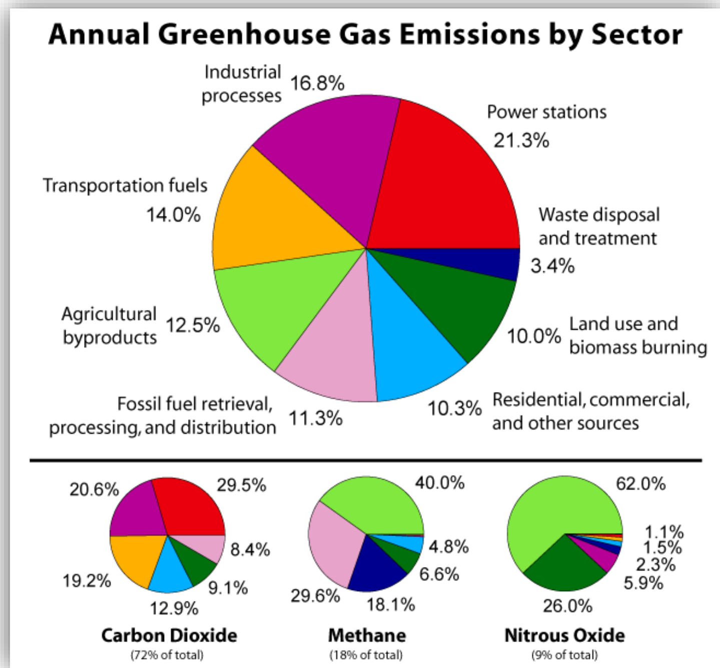
How Do Greenhouse Gases Actually Work?

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



Greenhouse Gasses (GH) in the atmosphere

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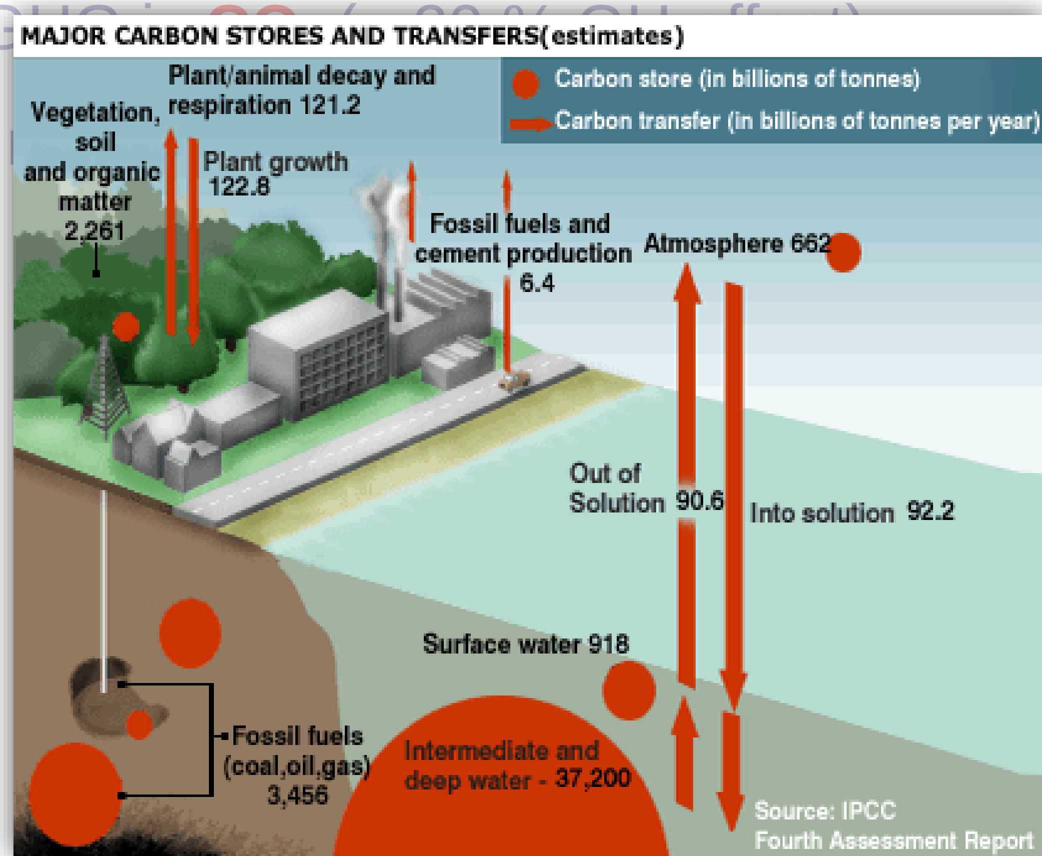
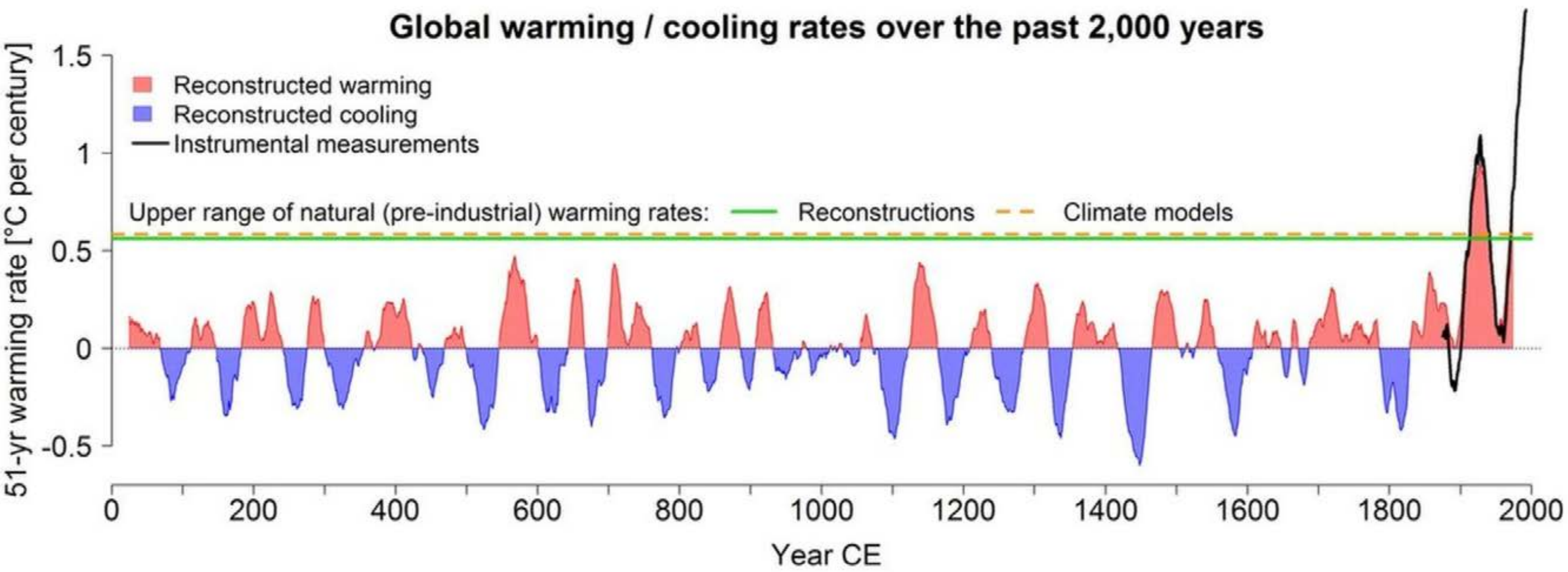
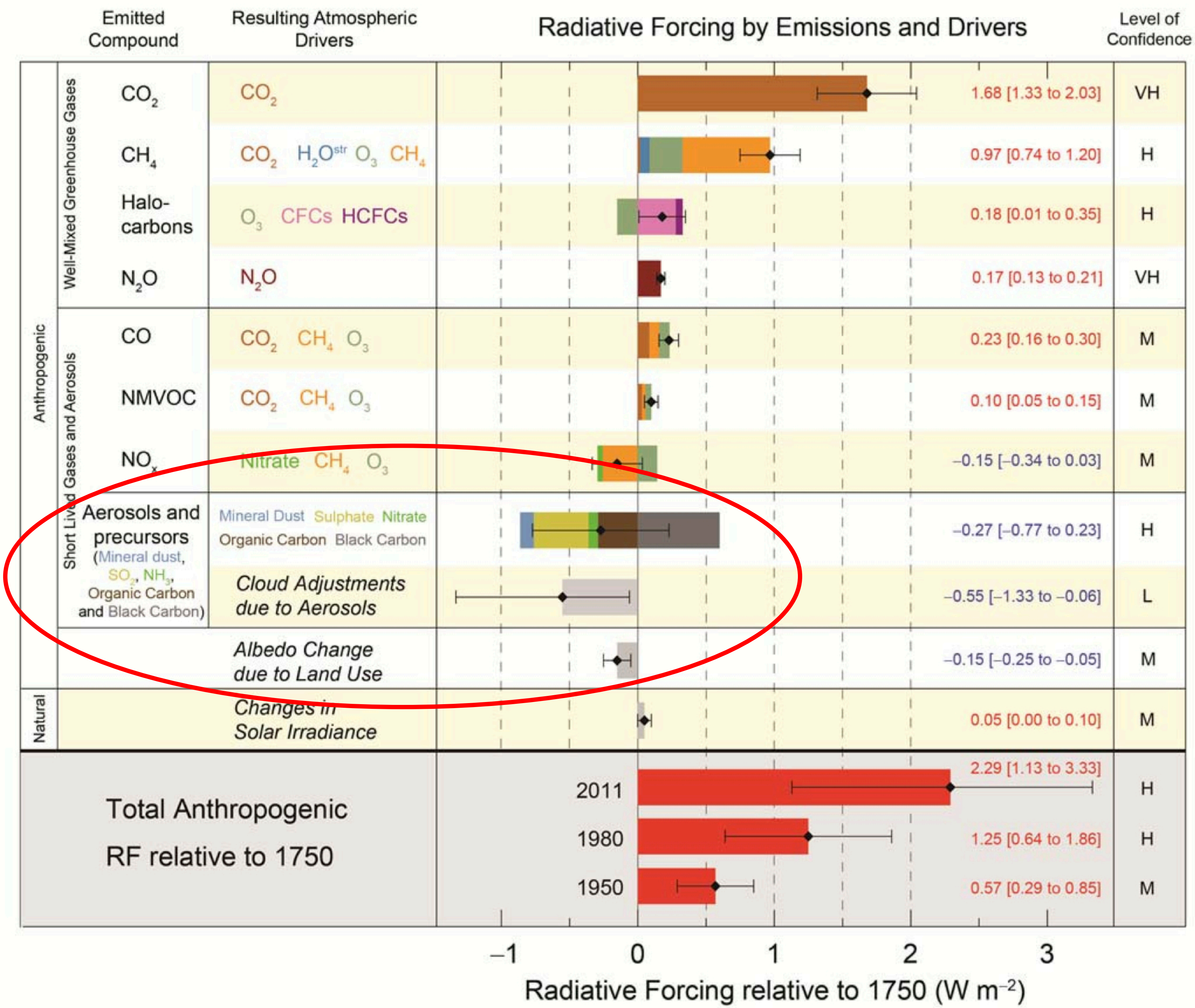


Problem

- 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

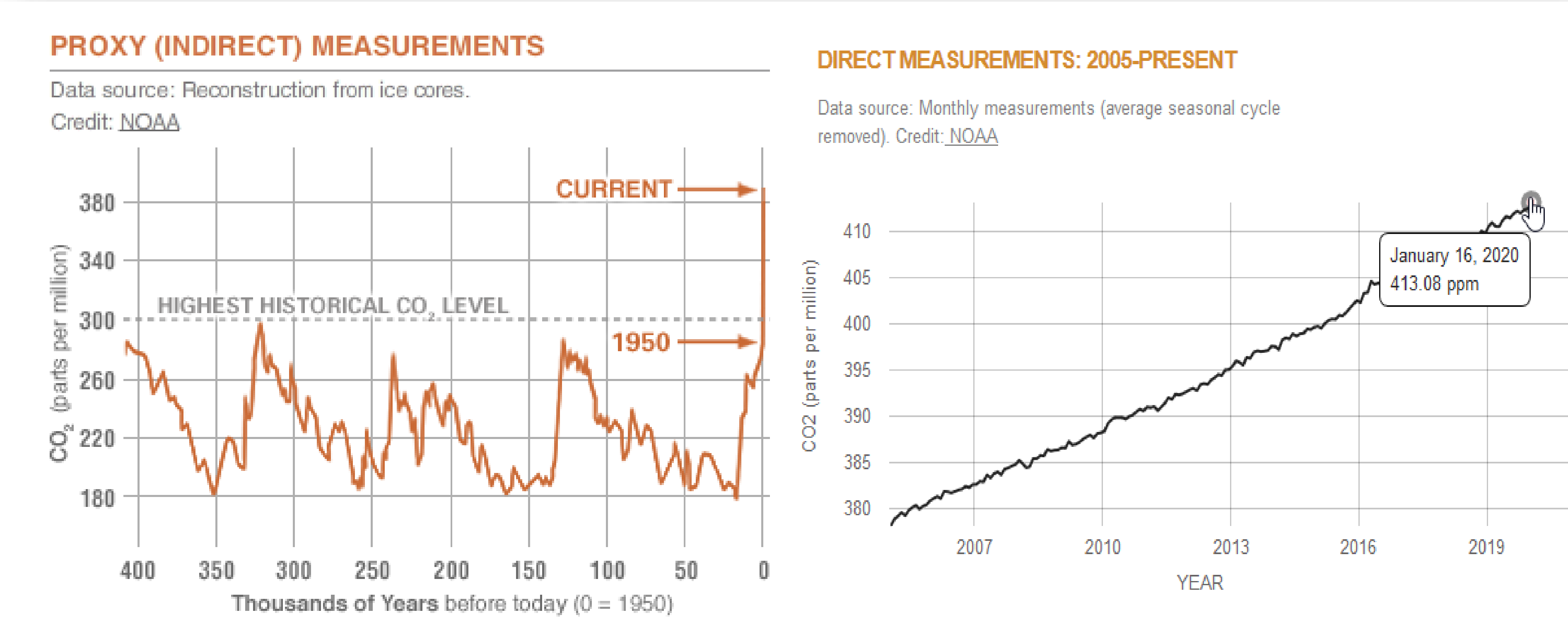


Emitted Compound
Resulting Atmospheric Drivers
Radiative Forcing by Emissions and Drivers
Level of Confidence
Anthropogenic
Well-Mixed Greenhouse Gases
Short Lived Gases and Aerosols
CO2
CO2
1.68 [1.33 to 2.03]
VH
CH4
CO2 H2Ostr O3 CH4
0.97 [0.74 to 1.20]
H
Halo-carbons
O3 CFCs HCFCs
0.18 [0.01 to 0.35]
H
N2O
N2O
0.17 [0.13 to 0.21]
VH
CO
CO2 CH4 O3
0.23 [0.16 to 0.30]
M
NMVOC
CO2 CH4 O3
0.10 [0.05 to 0.15]
M
NOx
Nitrate CH4 O3
−0.15 [−0.34 to 0.03]
M
Aerosols and precursors (Mineral dust, SO2, NH3, Organic Carbon and Black Carbon)
Mineral Dust Sulphate Nitrate Organic Carbon Black Carbon
−0.27 [−0.77 to 0.23]
H
Cloud Adjustments due to Aerosols
−0.55 [−1.33 to −0.06]
L
Albedo Change due to Land Use
−0.15 [−0.25 to −0.05]
M
Natural
Changes in Solar Irradiance
0.05 [0.00 to 0.10]
M
Total Anthropogenic RF relative to 1750
2011
2.29 [1.13 to 3.33]
H
1980
1.25 [0.64 to 1.86]
H
1950
0.57 [0.29 to 0.85]
M
−1
0
1
2
3
Radiative Forcing relative to 1750 (W m−2)

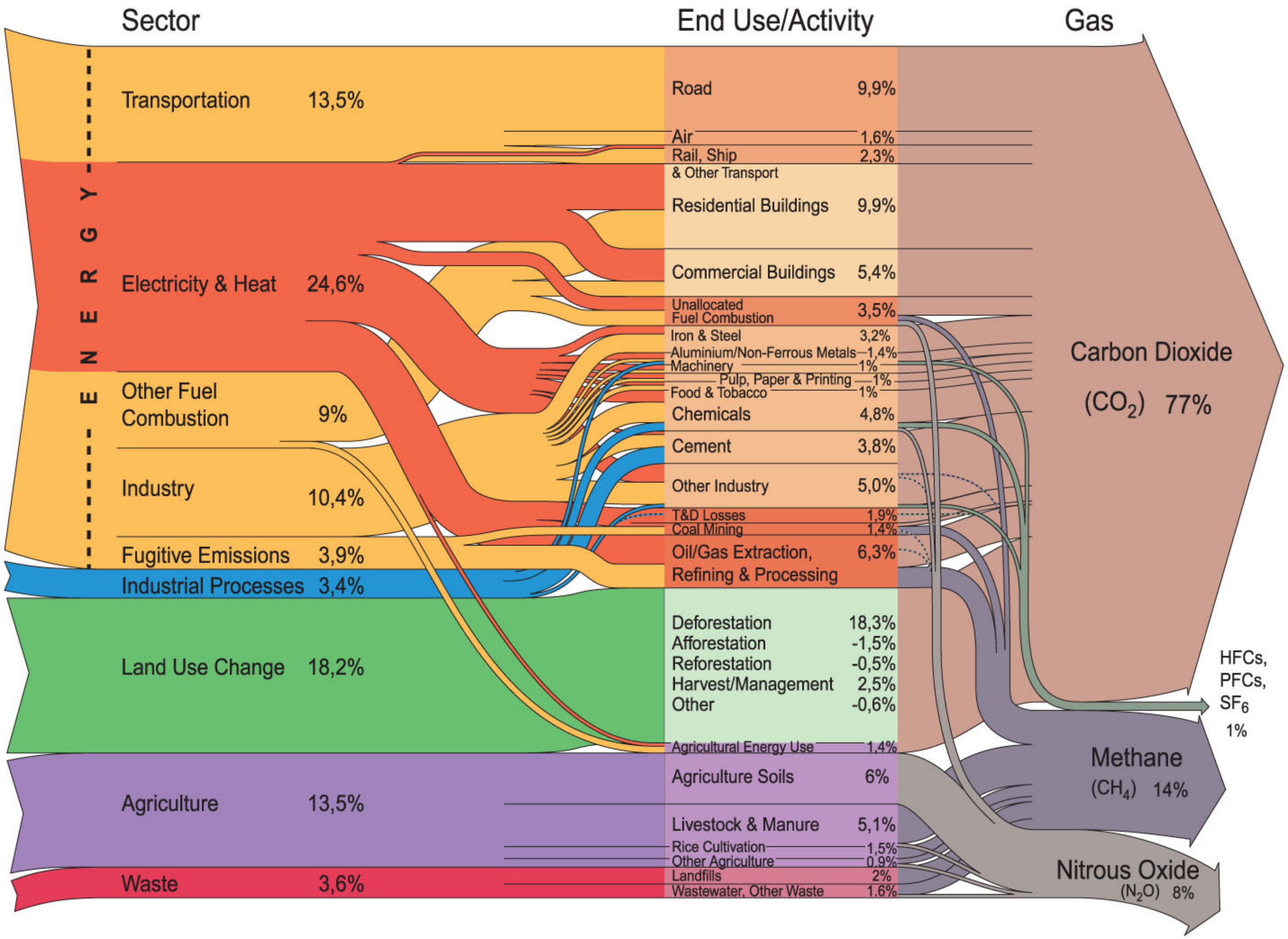
CC indicators

Increase of CO_2 level

- CO_2 level increased more than >25 % since 1950
- level of other greenhouse gases increases as well
- main source of this increase is fosil fuels combustion



World Greenhouse gas emissions by sector

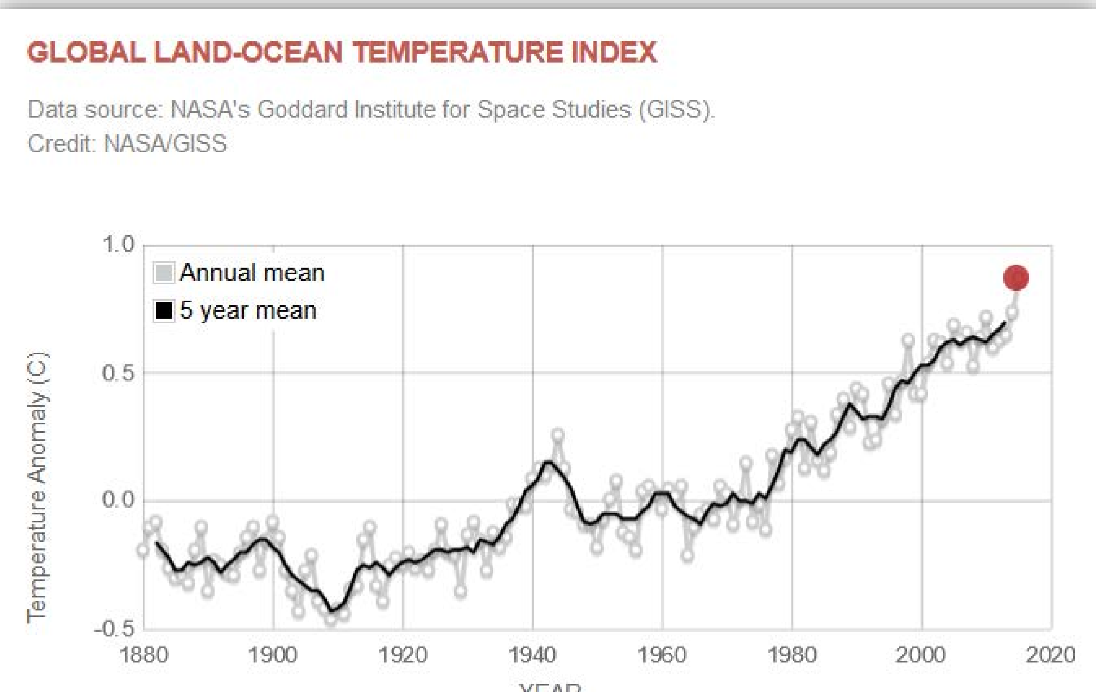


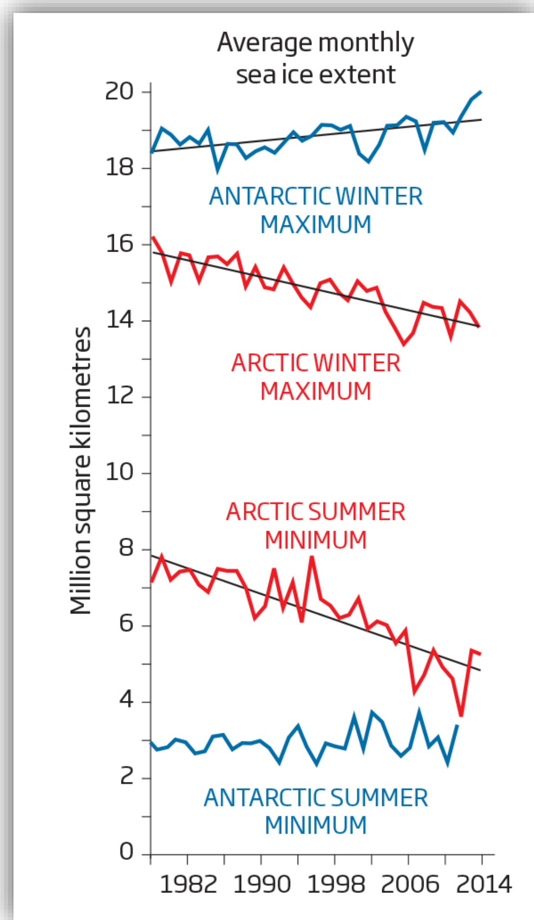
All data is for 2000. All calculations are based on CO_2 equivalents, using 100-year global warming potentials from the IPCC (1996), based on a total global estimate of 41 755 $MtCO_2$ equivalent. Land use change includes both emissions and absorptions. Dotted lines represent flows of less than 0.1% percent of total GHG emissions.

Source: World Resources Institute, Climate Analysis Indicator Tool (CAIT), Navigating the Numbers: Greenhouse Gas Data and International Climate Policy, December 2005; Intergovernmental Panel on Climate Change, 1996 (data for 2000).

Other indicators (variables) of CC

- changes in temperature
- changes in ice cover in Arctic ocean
- changes in ice cover in North and South pole
- sea level rise





Less ice in the Arctic ocean

- new naval routes from Europe to Asia

iDNES.cz / Zprávy

Pondělí 29. září 2014. Michal | Přihlásit

iDNES.cz › Zprávy | Kraje | Sport | Kultura | Ekonomika | Bydlení | Technet | Ona | Revue | Auto | Další

Domácí | Zahraniční | Černá kronika | Očima čtenářů | Počasí | MF DNES | Komerční články

Ledy tají, lodě testují severní cestu z Asie do Evropy

10. září 2009 10:05

Projet s nákladem euroasijský kontinent přes Severní ledový oceán se zdá být dobrý nápad. Ušetříte peníze i dny cesty, které by spolkla cesta přes Suezský průplav. Nyní se o to pokouší první západní rejdařství. Proč až nyní, když jsou výhody tak zřejmé? Ona toti nechtěla příliš spolupracovat.

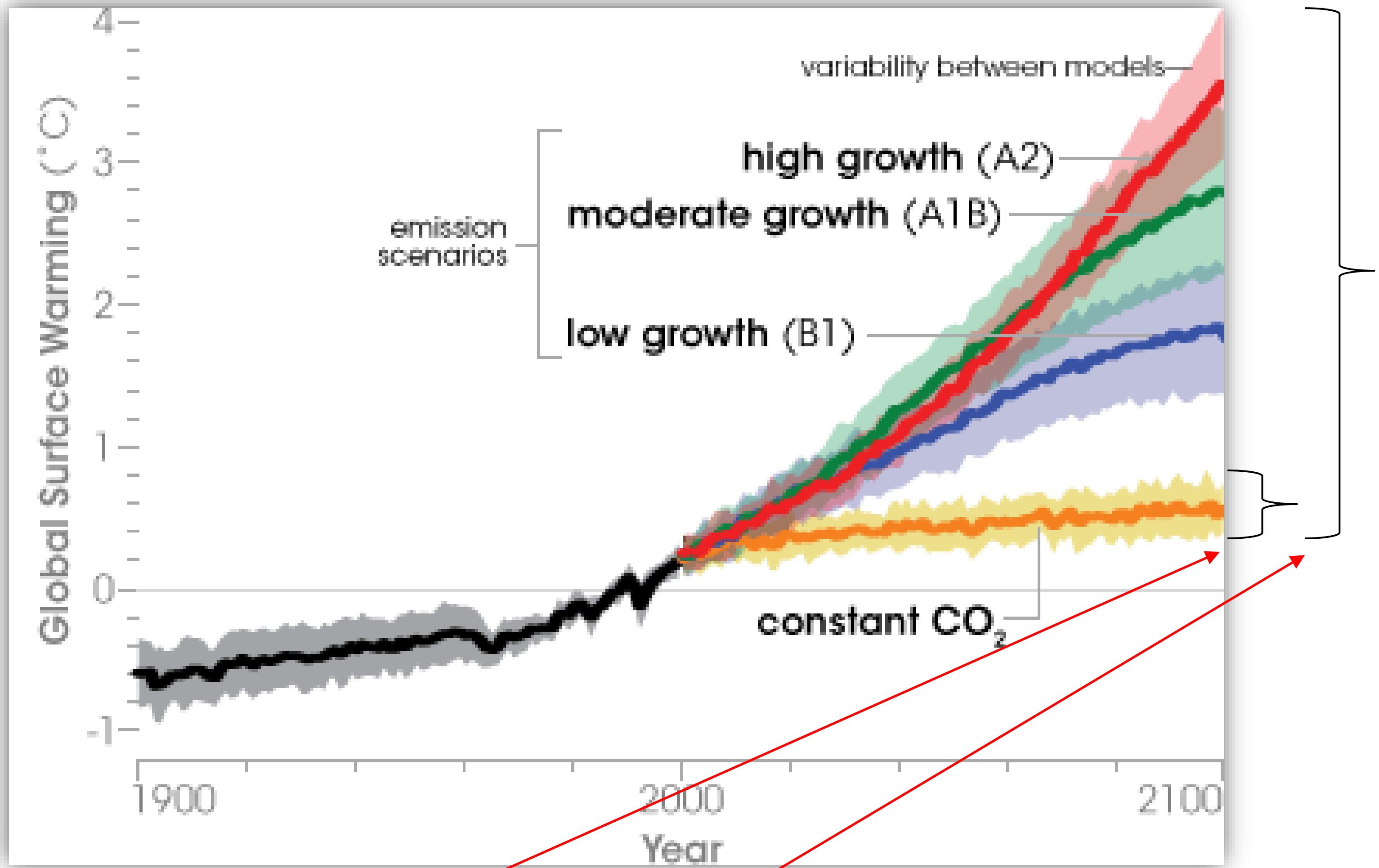
Dvě nákladní lodě hamburského rejdařství v Barentsově moři. | foto: Beluga Shipping

Cestu uvolnilo až globální oteplování, kvůli němuž již severní vody nezůstávají v jedné neproniknutelné krustě ledu, ale roztávají a rozpadají se tak, že jimi propluje nejen ledoborec, ale i nákladní loď. Alespoň v určitém období roku a na většině cesty.

Glacier calving in Arctic ocean

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

Temperature rise scenarios to 2100

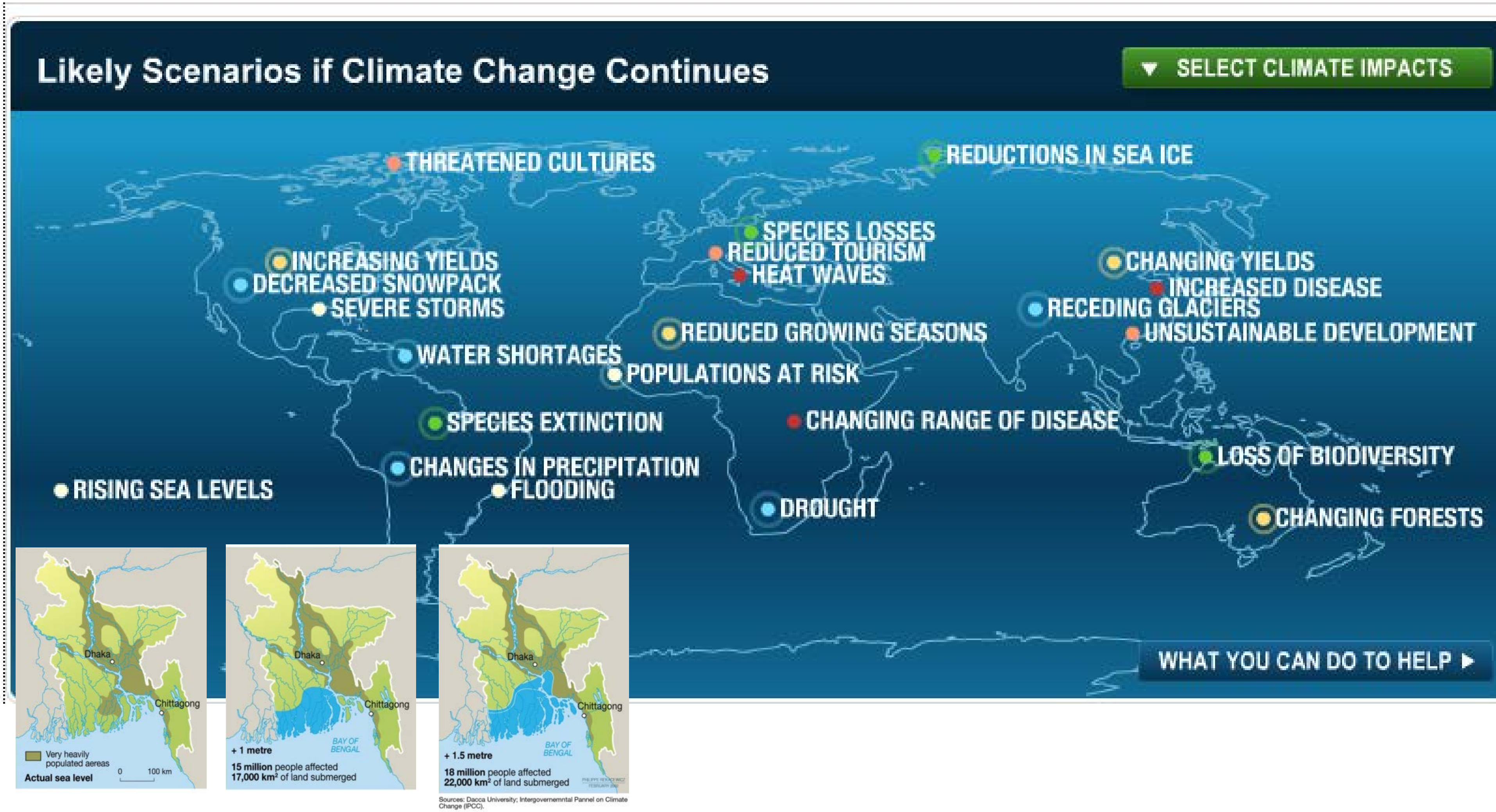


- scientific vs. political uncertainty

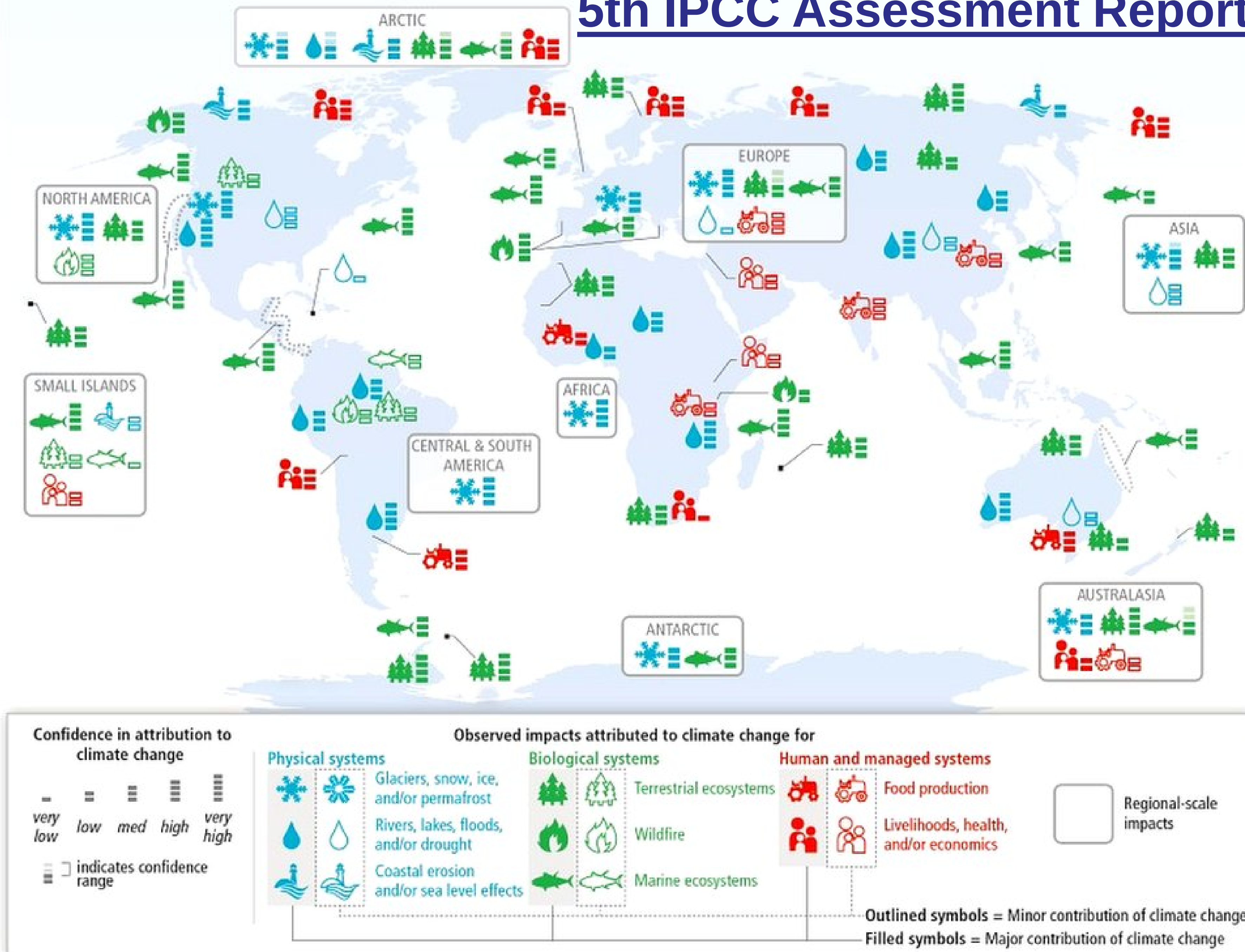
CC consequences

Consequences of CC

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



5th IPCC Assessment Report



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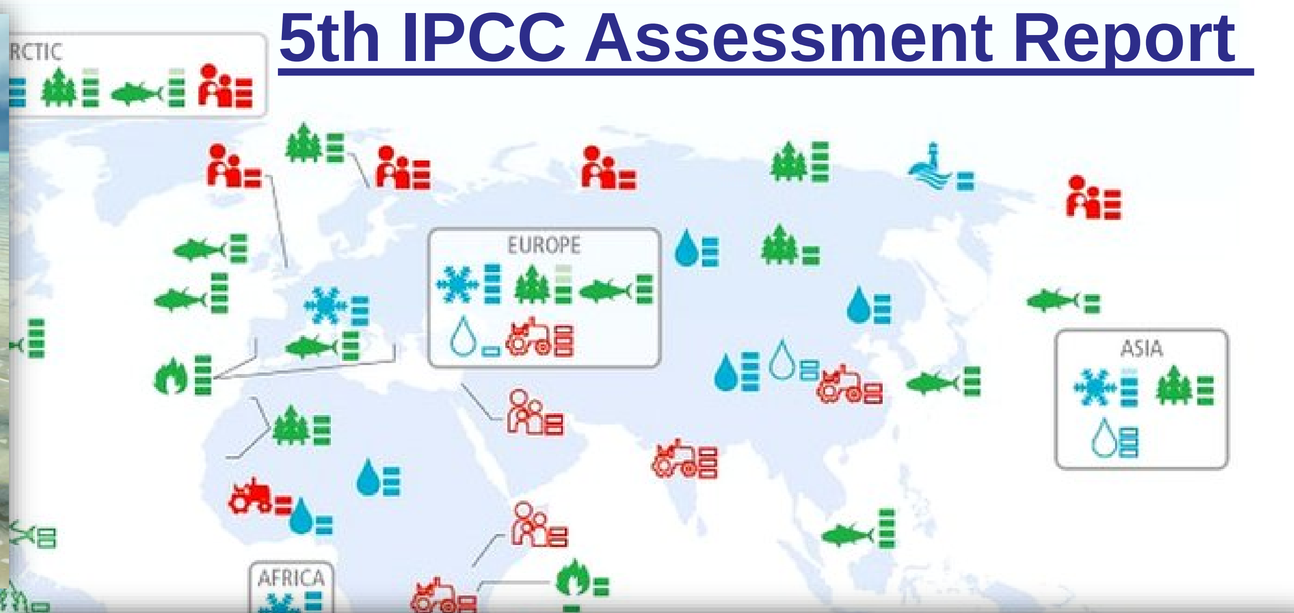
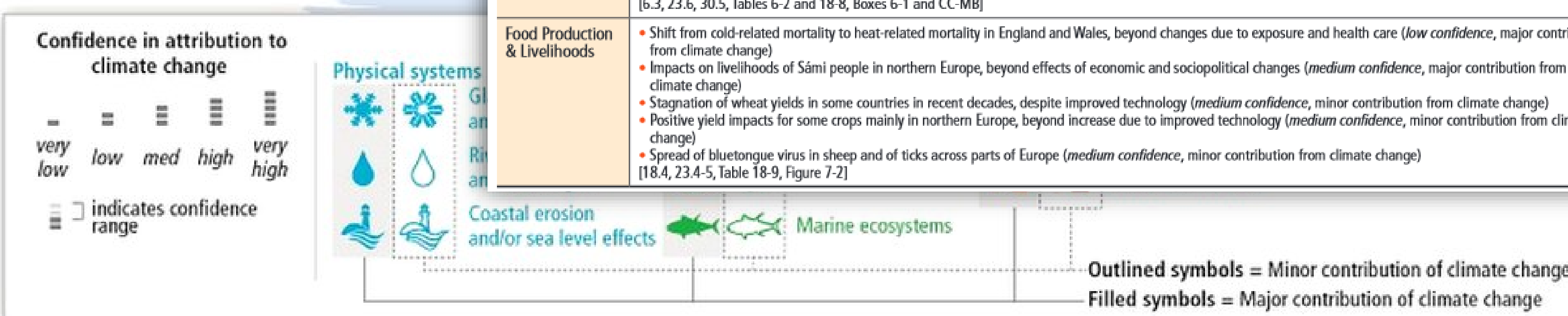


Europe	
Snow & Ice, Rivers & Lakes, Floods & Drought	• Retreat of Alpine, Scandinavian, and Icelandic glaciers (*high confidence*, major contribution from climate change) • Increase in rock slope failures in western Alps (*medium confidence*, major contribution from climate change) • Changed occurrence 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

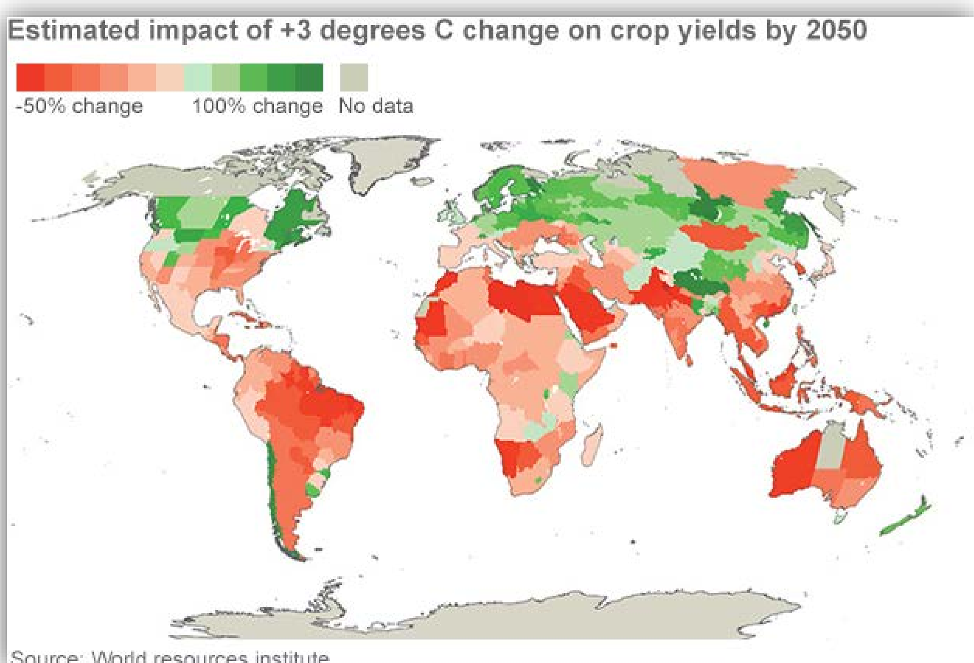
CC - controversy

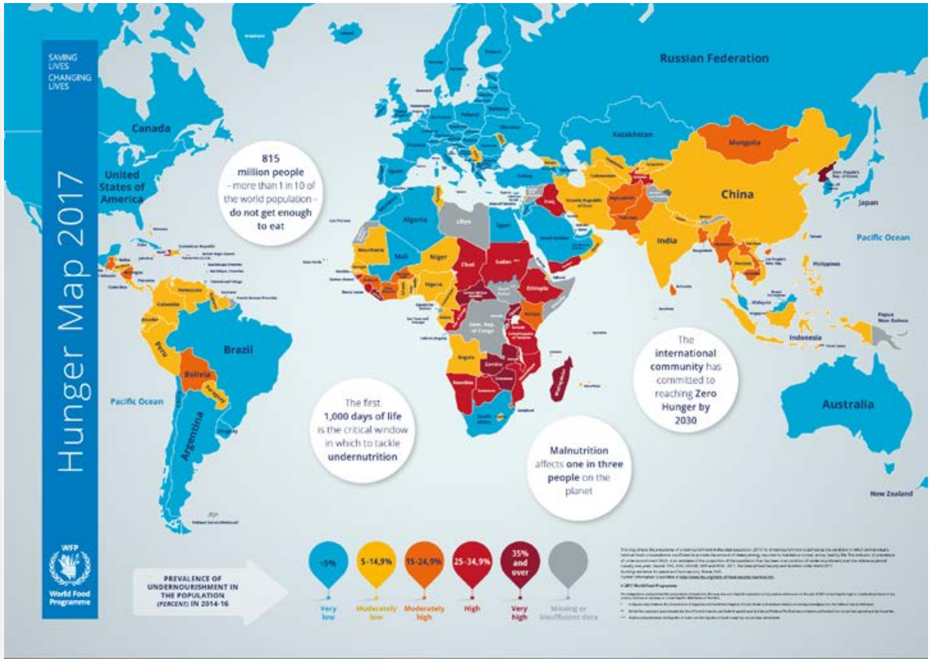
https://www.youtube.com/watch?v=0Te5al2APrQ

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

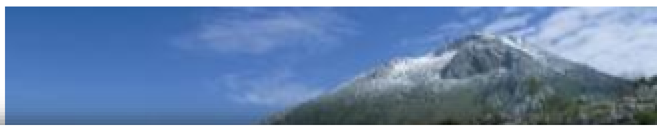




HISTORIES 1 August 2012

Climate change: The great civilisation destroyer?

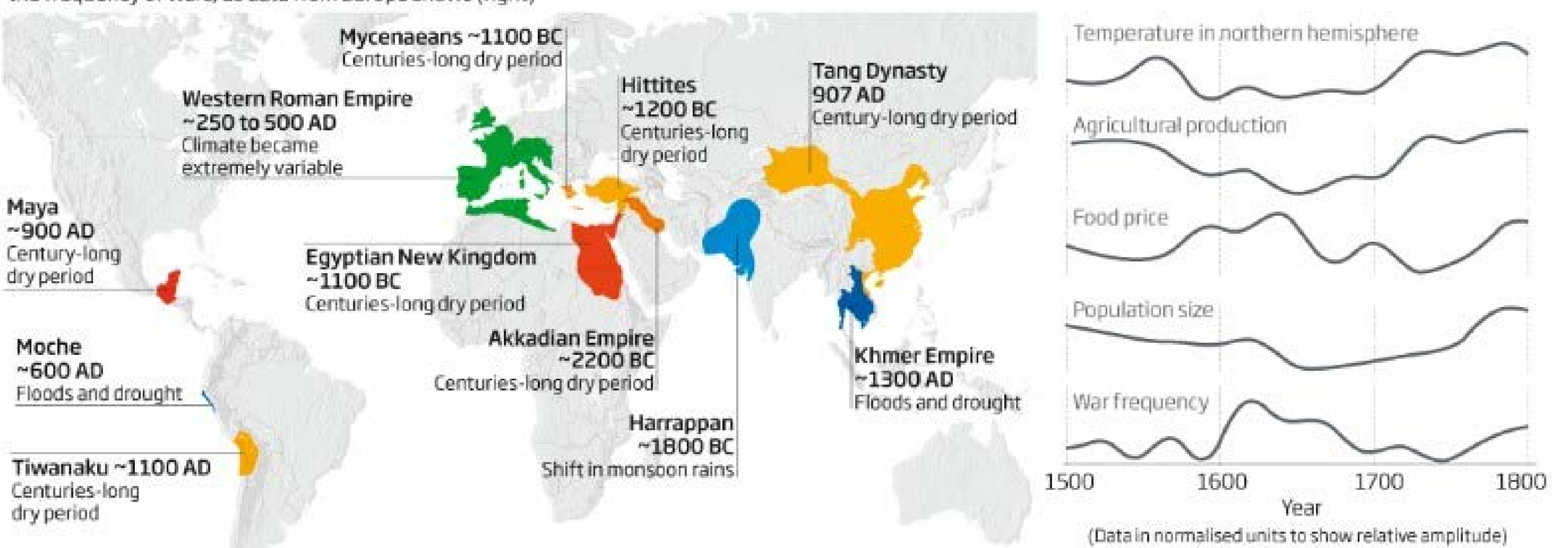
War and unrest, and the collapse of many mighty empires, often followed changes in local climes. Is this more than a coincidence?



More than coincidence?

©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?

The Nobel Peace Prize 2007

Intergovernmental Panel on Climate Change , Al Gore

The Nobel Peace Prize 2007

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

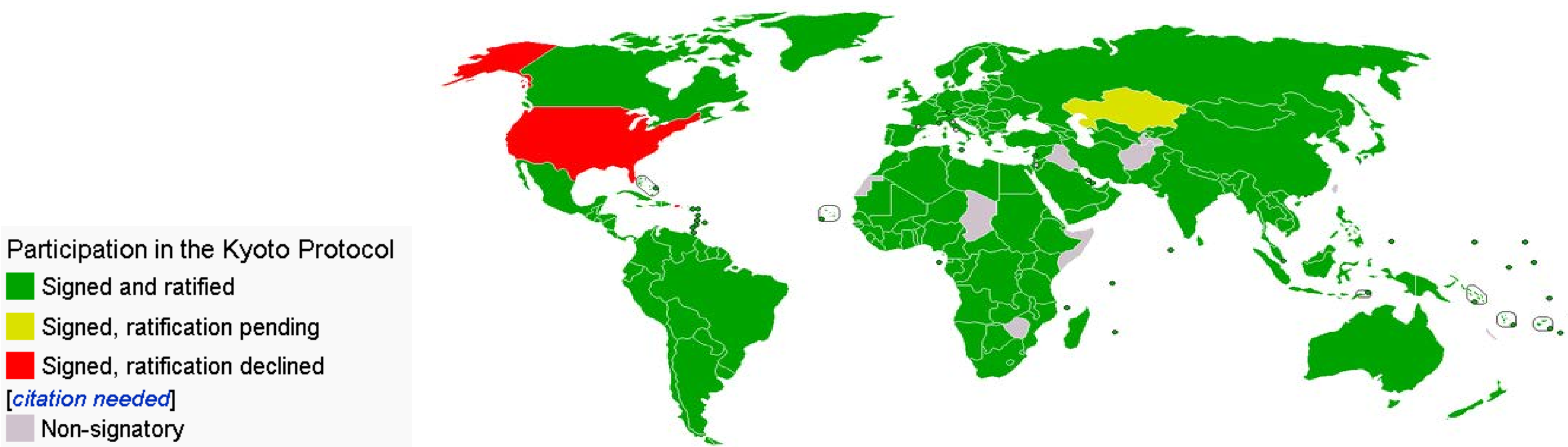
- main aim – decrease the GHG emissions, mainly CO_2

- 1992: UN Framework Convention on Climate Change

- 1997: Kyoto protocol (in force from 2005)

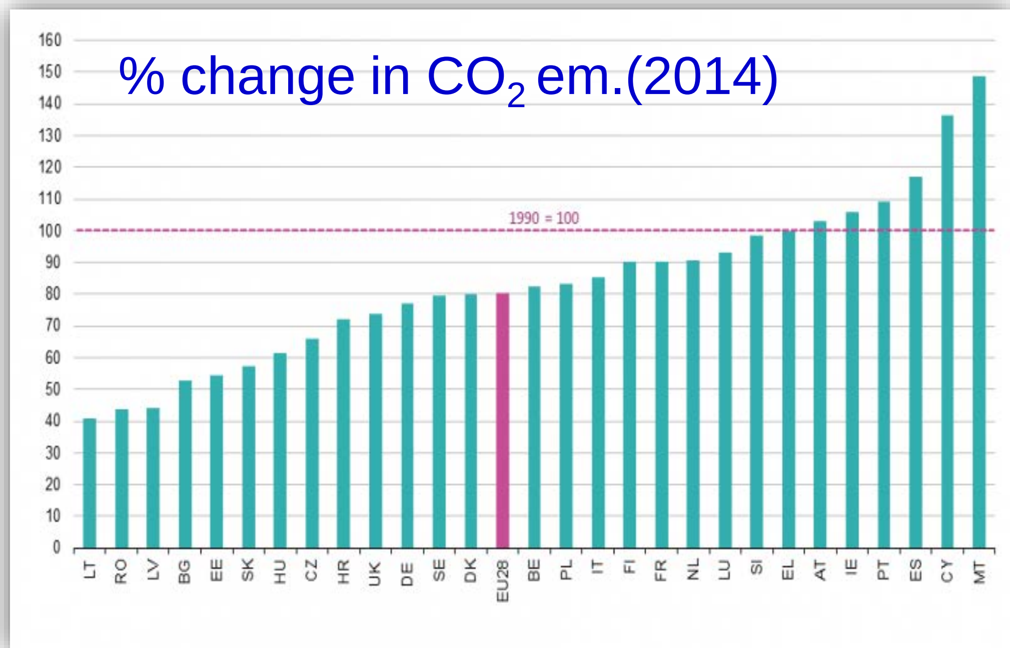
- industrial countries should decrease their GHG emissions untill the year 2012 for 4.2 % compared to the year 1990
- different threshold for different countries (e.g. EU 8%)

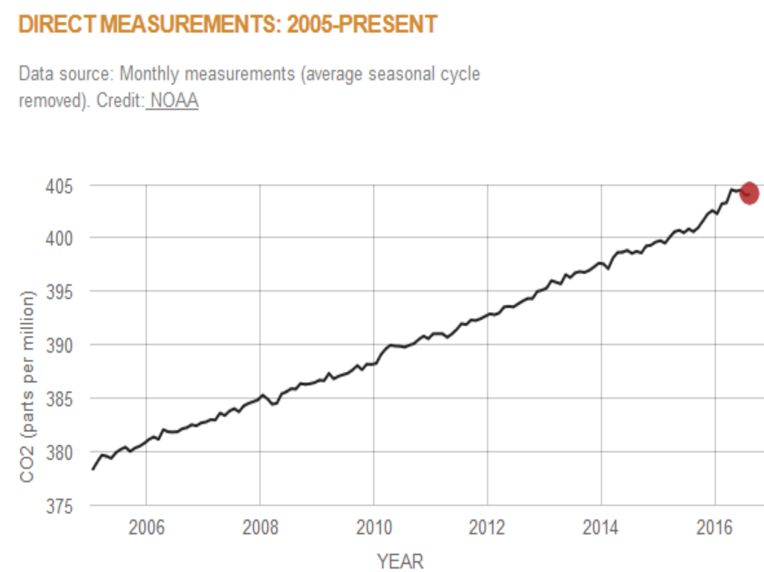
- however, industrial countries (Annex I countries with Kyoto targets) contributed „only“ with 24 % of global CO_2 emission (2010)



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





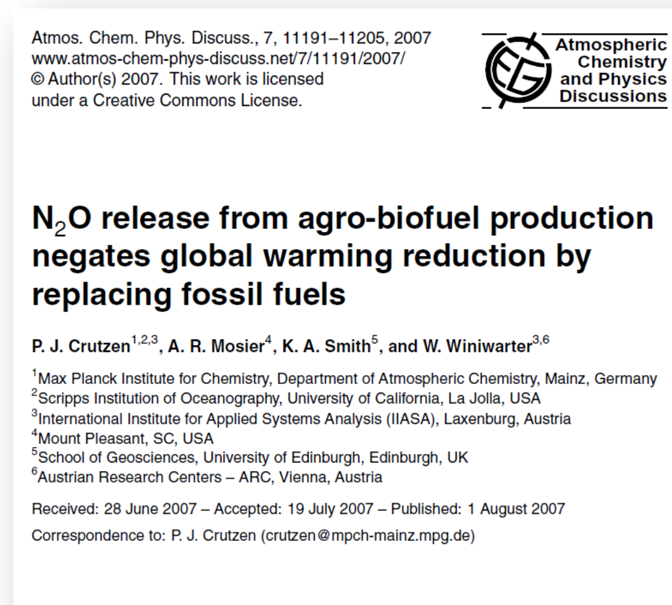
Paris treaty (2015)

- continuation of the prolonged Kyoto protocol (2020)
- aim: Limit the temperature rise not more than 2 °C compared to pre-industrial era
- 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...



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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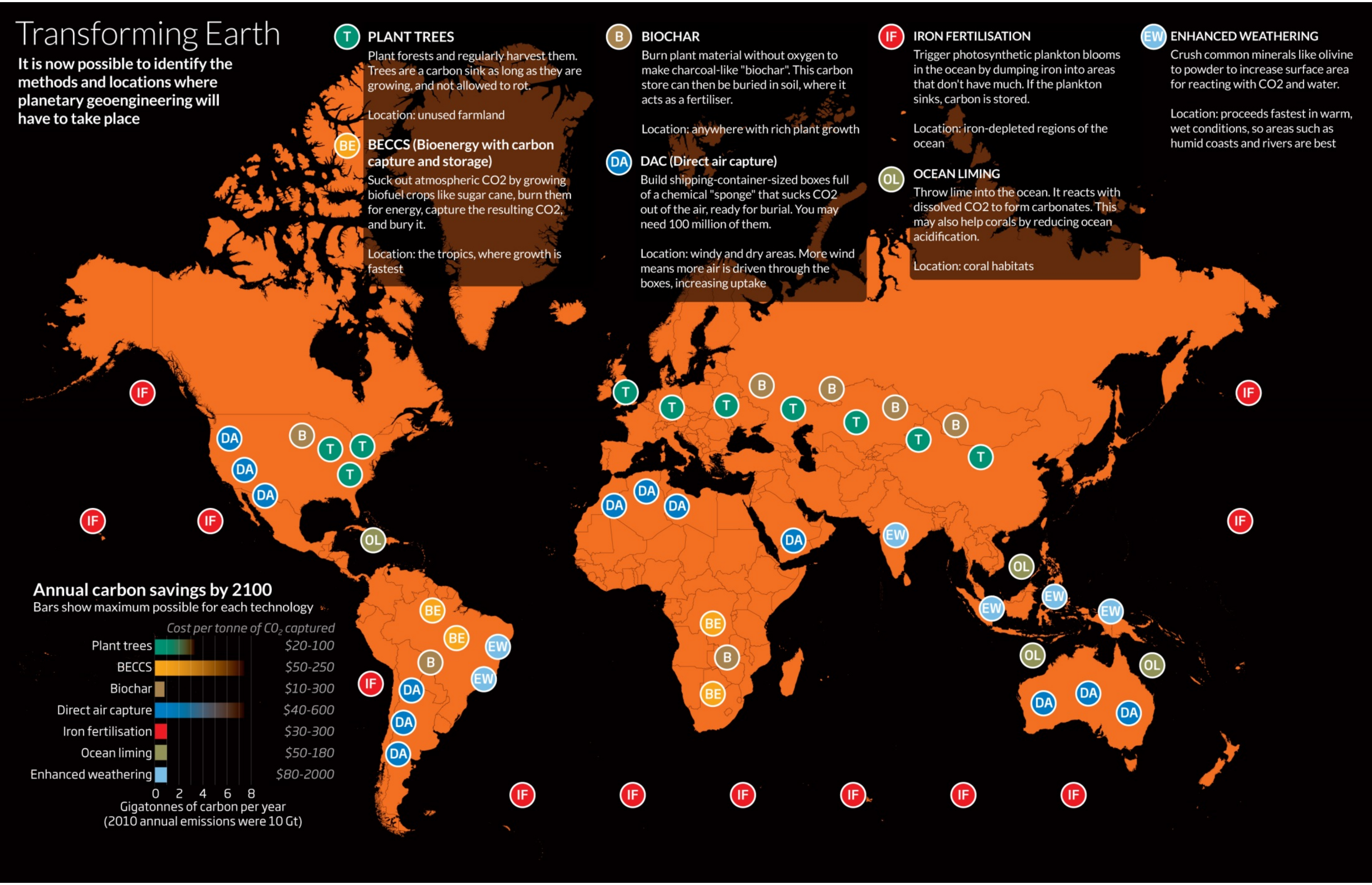
- Geo-engineering?

Geo-egineering – types and opportunities



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

Greta and Fridays for Future