Climate change and fossil fuels

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Explaining the climate change

- *„How could scientists predict the climate in 100 years when they cannot predict the weather tomorrow?“*
- Climate: atmospheric conditions over a long period of time (years to centuries).
- Weather: short time (minutes to weeks).
- Consequences for prediction – climate undergoes more gradual change (than weather) and is easier to predics.

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1) The planet´s temperature is rising

- Over the past 130 years the global average temperature has increased by 0,8°C (more than half of that in last 35 years).
- Ocean accounts for more than 90% of the energy accumulated between 1971-2010.
- Ancient ice samples (from Antarctica and other places) – their layers are dated and gas bubles inside are analysed.
    - CO_2 concentration is measured by infrared spectroscopy or mass spektromectry.
    - Isotope ratios of water molecules are measured to determine historical temperatures.

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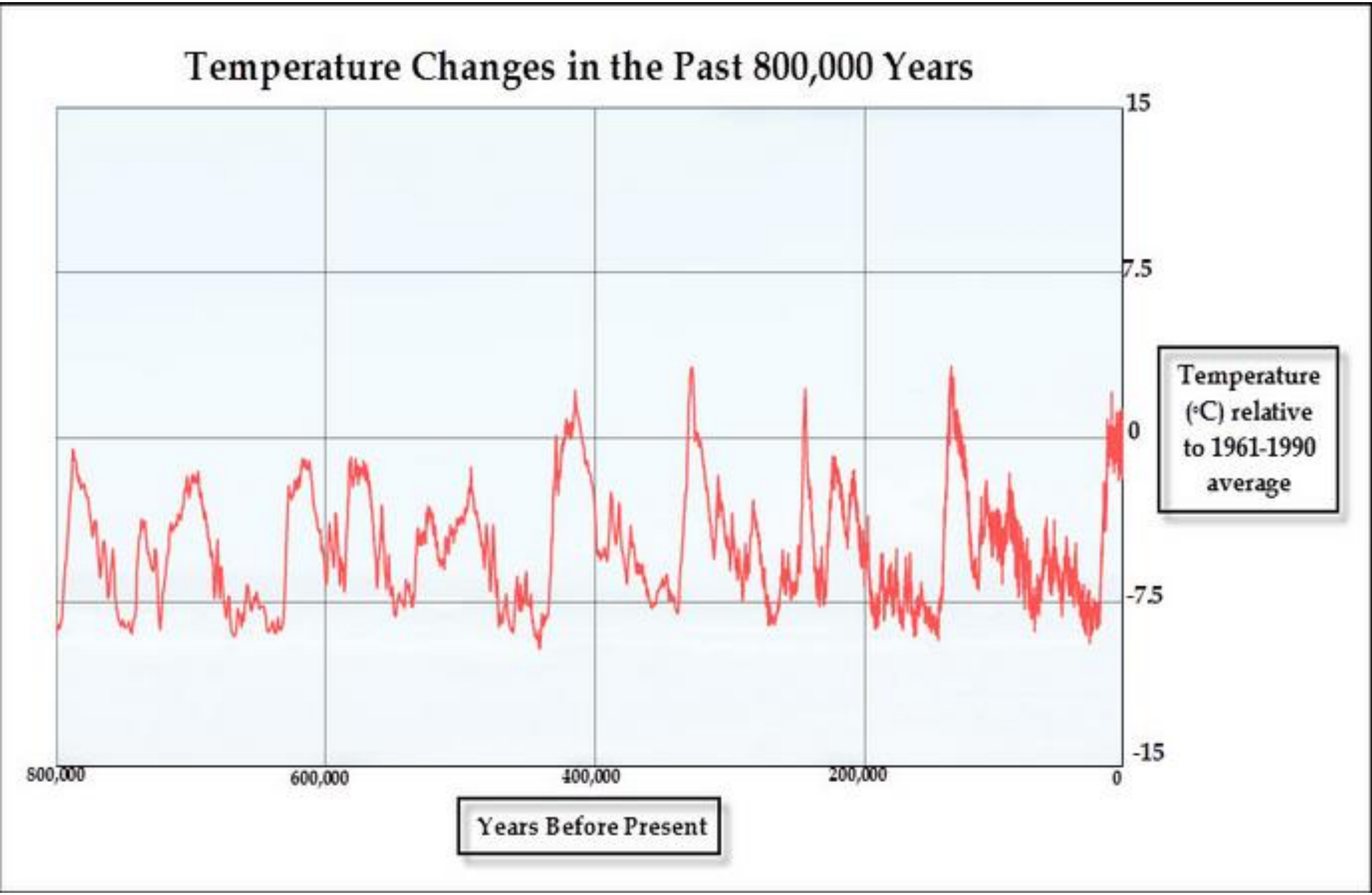
The planet´s temperature is rising

- Earth´s climate has always fluctuated. The cooler period – ice ages or glacial periods, the warmer period – interglacial periods.
  - Orbital variations
  - Solar output
  - Volcanism
  - Plate tectonics
- The rate of change has become more dramatic since the Industrial Revolution = anthropogenic origins.
  - Problems with adaptation – the change is too fast.



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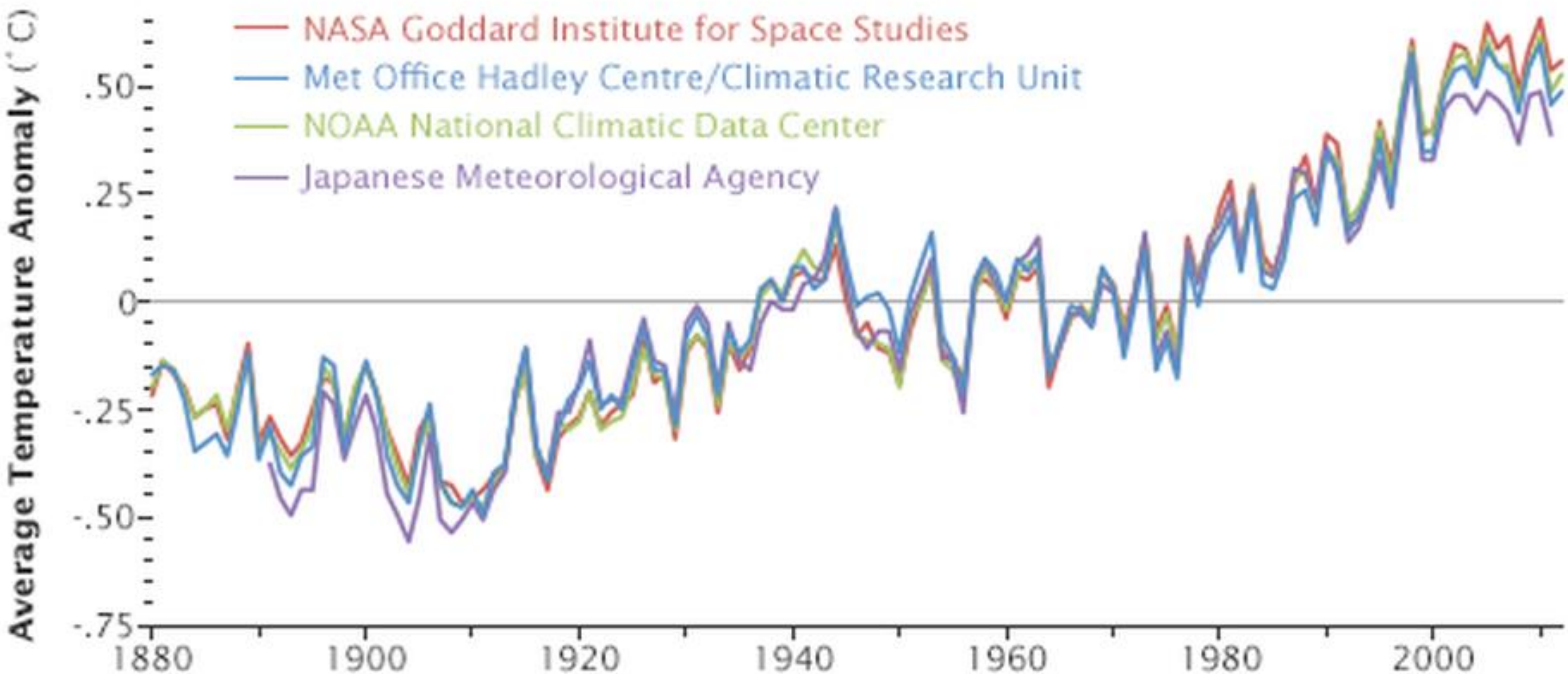

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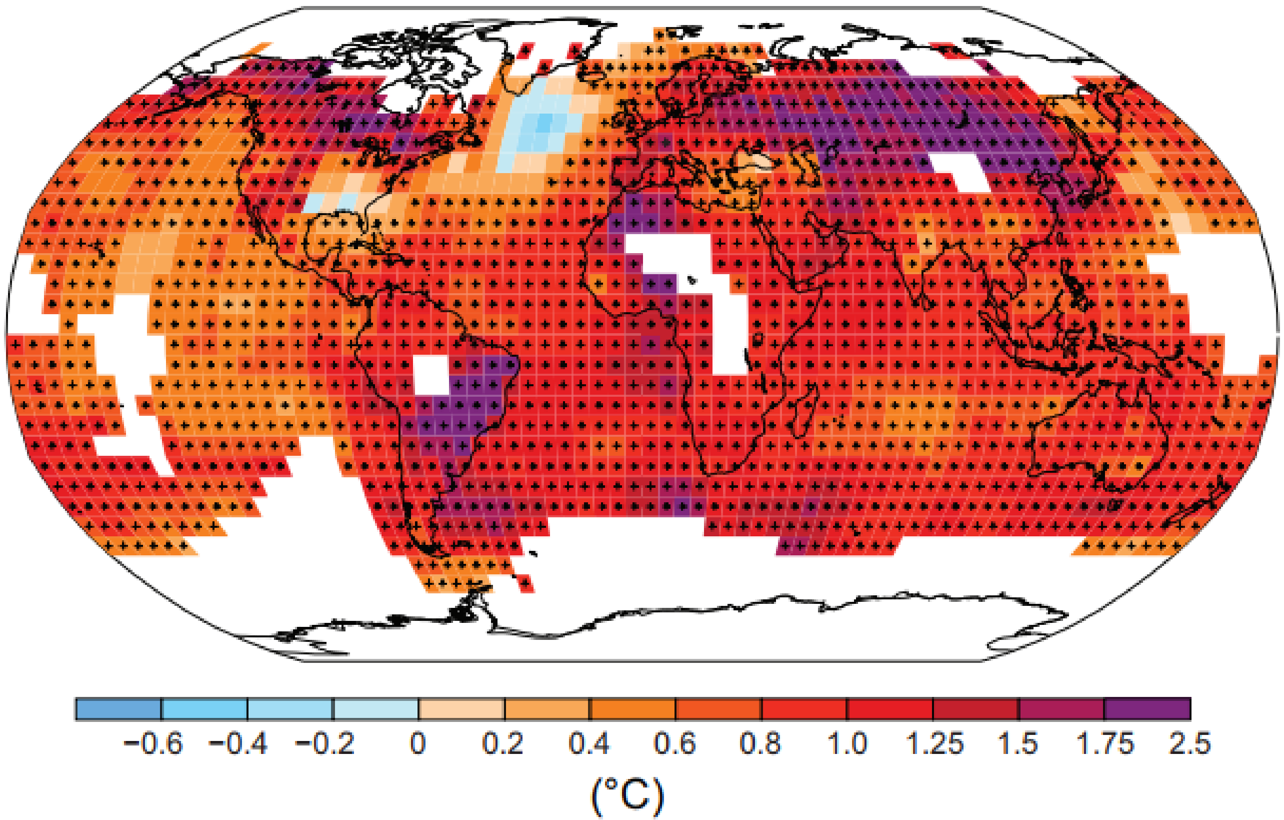
Observed change in surface temperature 1901 - 2012



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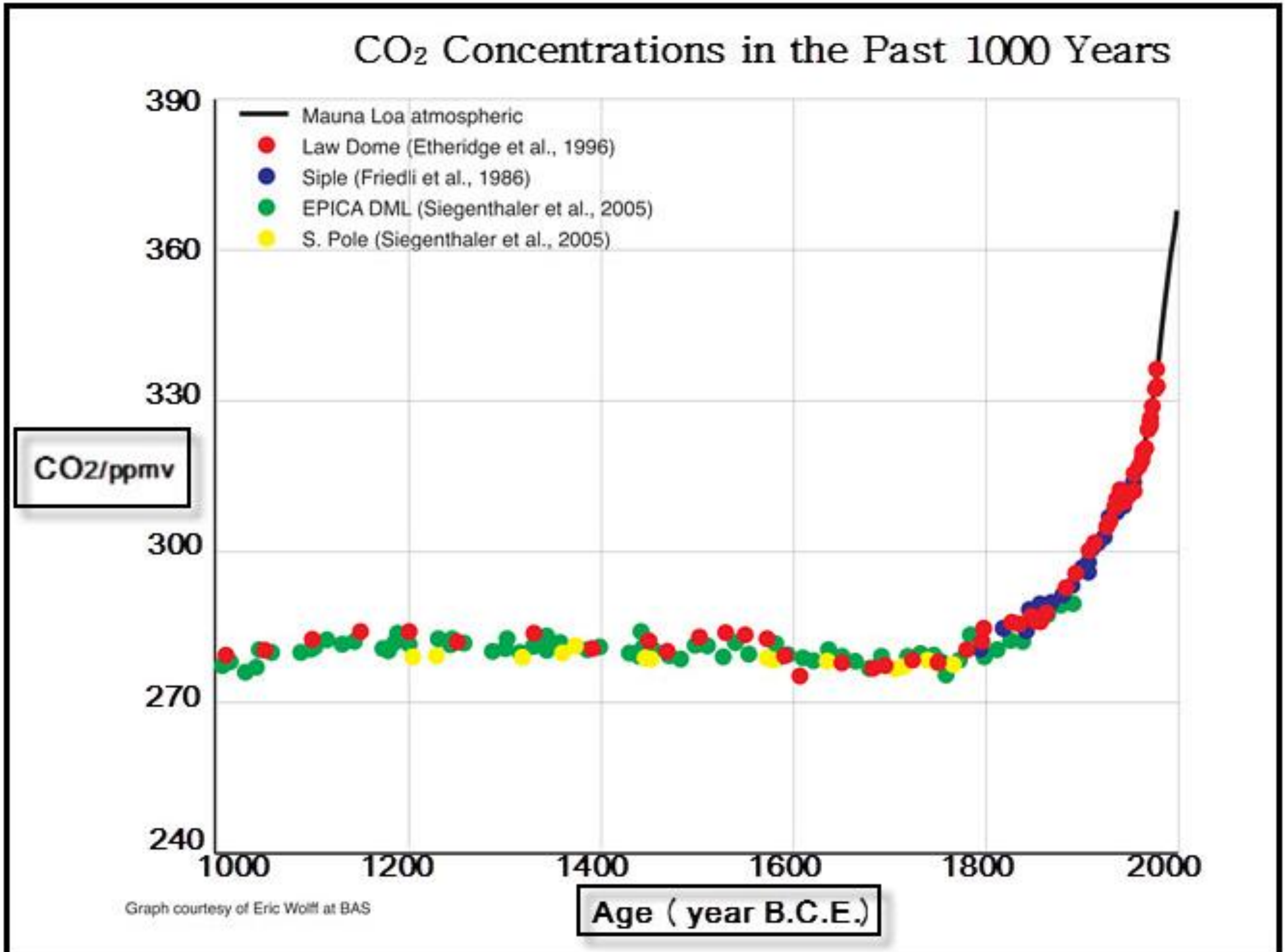
2) CO_2 level is increasing (also methane and nitrous oxide)

- CO_2 concentration increased by 40% since pre-industrial time. The ocean absorbed about 30% of this increase, causing ocean acidification.
- Also methane (150% increase) and nitrous oxide (20%).



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3) We are responsible for the increase in CO_2

- Human CO_2 emissions (20 billion tons/y) are small compared to natural emission (776 billion tons/y).
- But natural absorptions (788 billion tons/y) roughly balance natural emisssions.
- Carbon 12 isotope to carbon 13 isotope ratio increases (isotope = different atoms with the same chemical behavior but with different masses).

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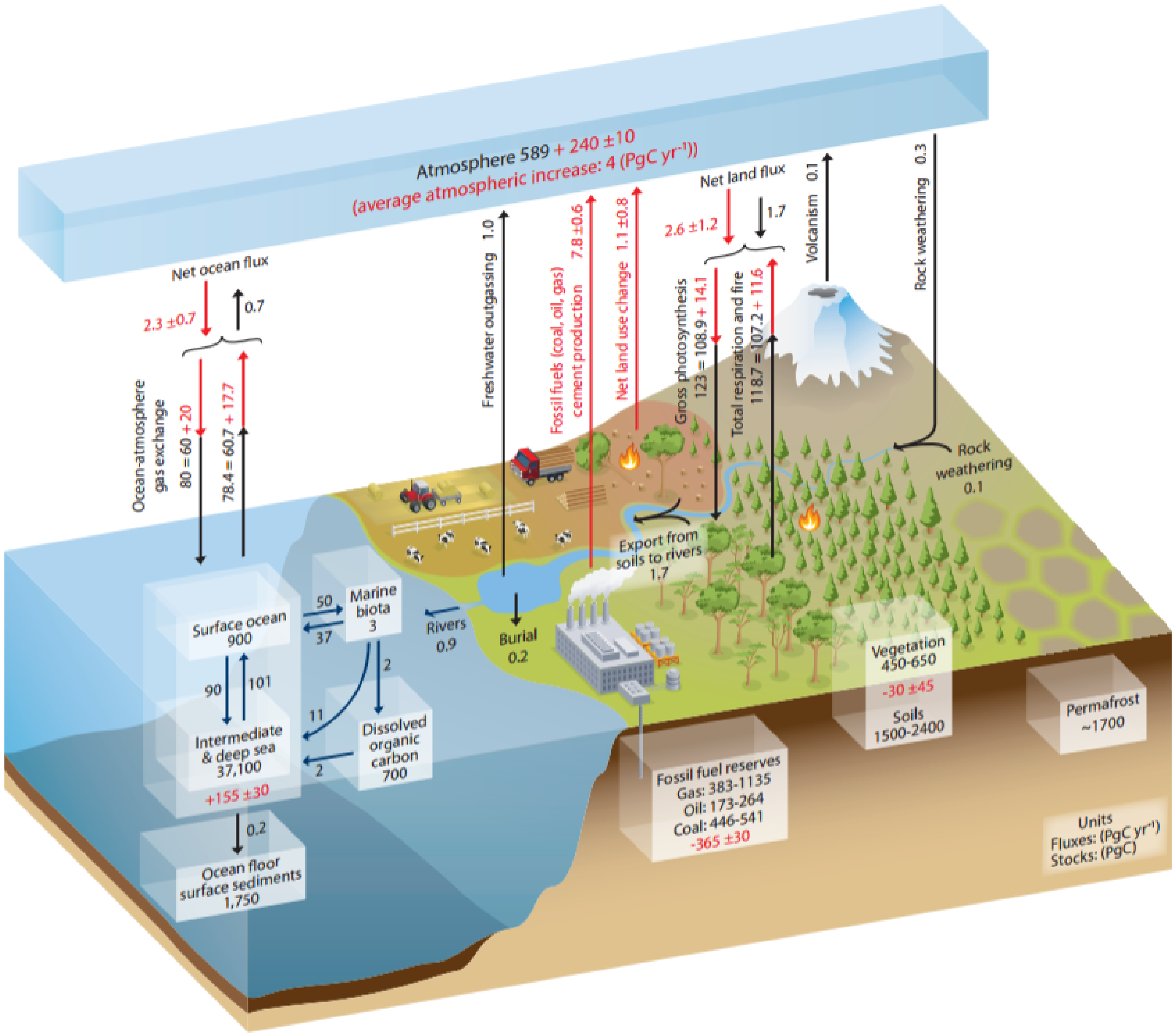

Global carbon cycle. Numbers represent reservoir mass (carbon stocks) and annual carbon exchange fluxes. Black numbers and arrows indicate reservoir mass and exchange fluxes estimated for the time prior to the Industrial Era (about 1750). Red indicate annual anthropogenic fluxes averaged over the 2000-2009.

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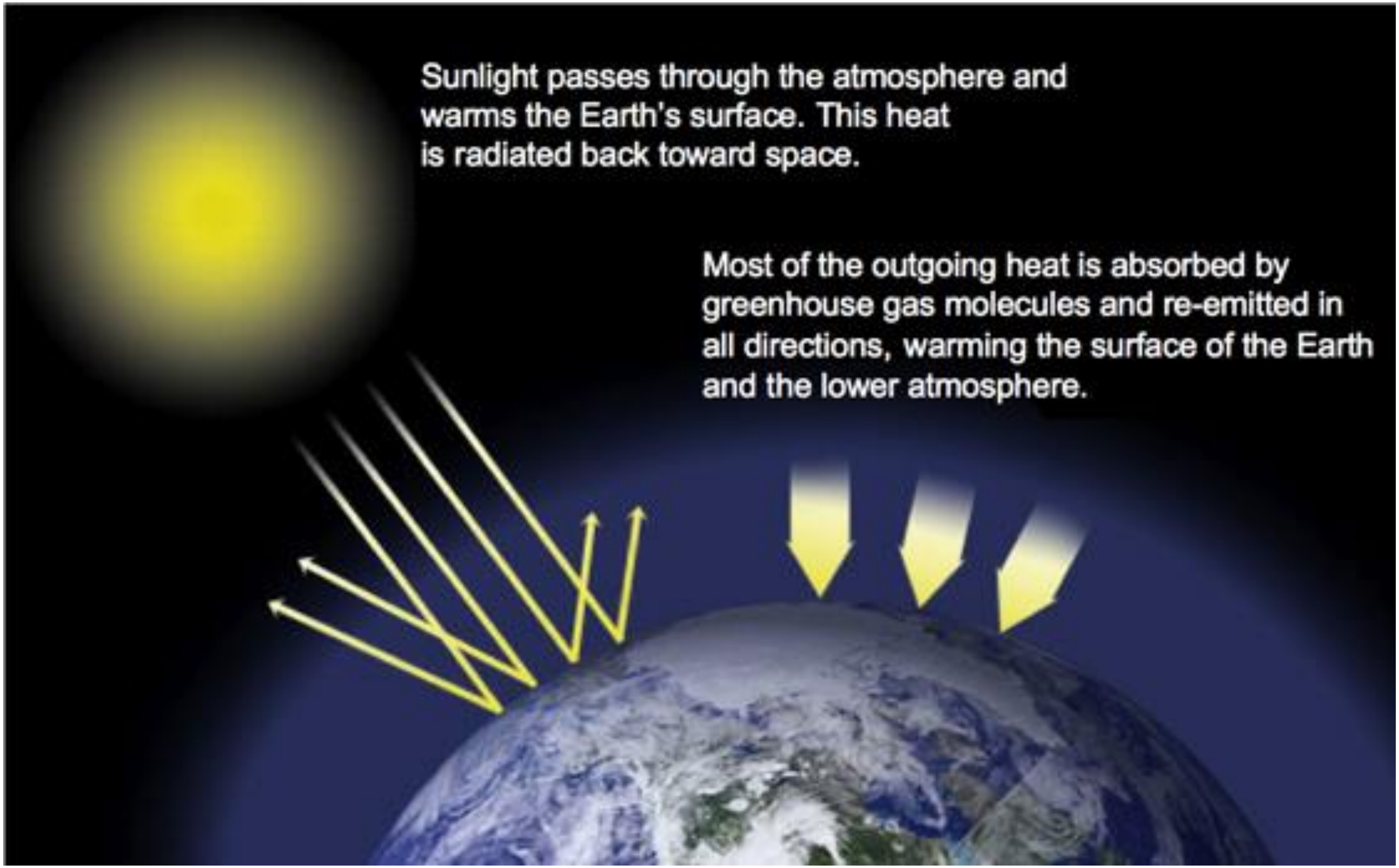
4) Increased CO_2 is the primary driver of greenhouse effect

- Inbound solar radiation has short wavelenghts and high energy contents. This radiation passes through the atmosphere. Some energy is absorbed by the ground (warming it up). Some energy is reflected back to the space.
- That reflected radiation has lower energy levels and longer wavelengths. 80% of the outgoing radiation is trapped in the lower troposphere.
- Energy trapped in the troposphere wams the surface.
- More GHGs in the atmosphere trap more outbound solar radiation, thus warming the planet – anthropogenic climate change.


Sunlight passes through the atmosphere and warms the Earth's surface. This heat is radiated back toward space.
Most of the outgoing heat is absorbed by greenhouse gas molecules and re-emitted in all directions, warming the surface of the Earth and the lower atmosphere.

4) Increased CO_2 is the primary driver of greenhouse effect

- CO2 traps infrared radiation (thermal radiation). Proven by laboratory experiments and satellites (satelit data from 1970; direct experimental evidence) that find less heat escaping out to space over the las few decades.

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Climate change controversy

- Positive/negative feedbacks – examining different period throughout Earth´s history shows that feedbacks amplify or diminish any initial warming.
- Positive feedback
  - Warming keeps more water in the air and more wapour traps more heat
  - Warming releases carbon (methane) in the arctic – from thawing permafrost. Or from hydrates (water ice containing methane in its structure).
  - Drying rainforest, forest fires. Desertification.
  - Albedo feedback.
- Negative feedback
  - More water vapour causes more clauds, reflecting sunlight.
  - Increase in the overal amount of greenery – increased plants photosynthesis

Summary

- Earth´s climate has undergone changes over long periods of time (several ice ages, period of warming).
- Previous changes were dramatic but gradual (thousands of years).
- Today´s change is extremely fast and the pace is increasing. Until 250 years ago the highest rate of temperature increase recorded was approximately 0,003°C/y. For the last ten years, it is 0,017°C
- Global warming vs. climate change. The first suggests that Earth´s climate is warming on average, but it is not fully true. Factors such as precipitation and evaporation are also changing. And these changes often affect climate patterns elsewhere in the world.

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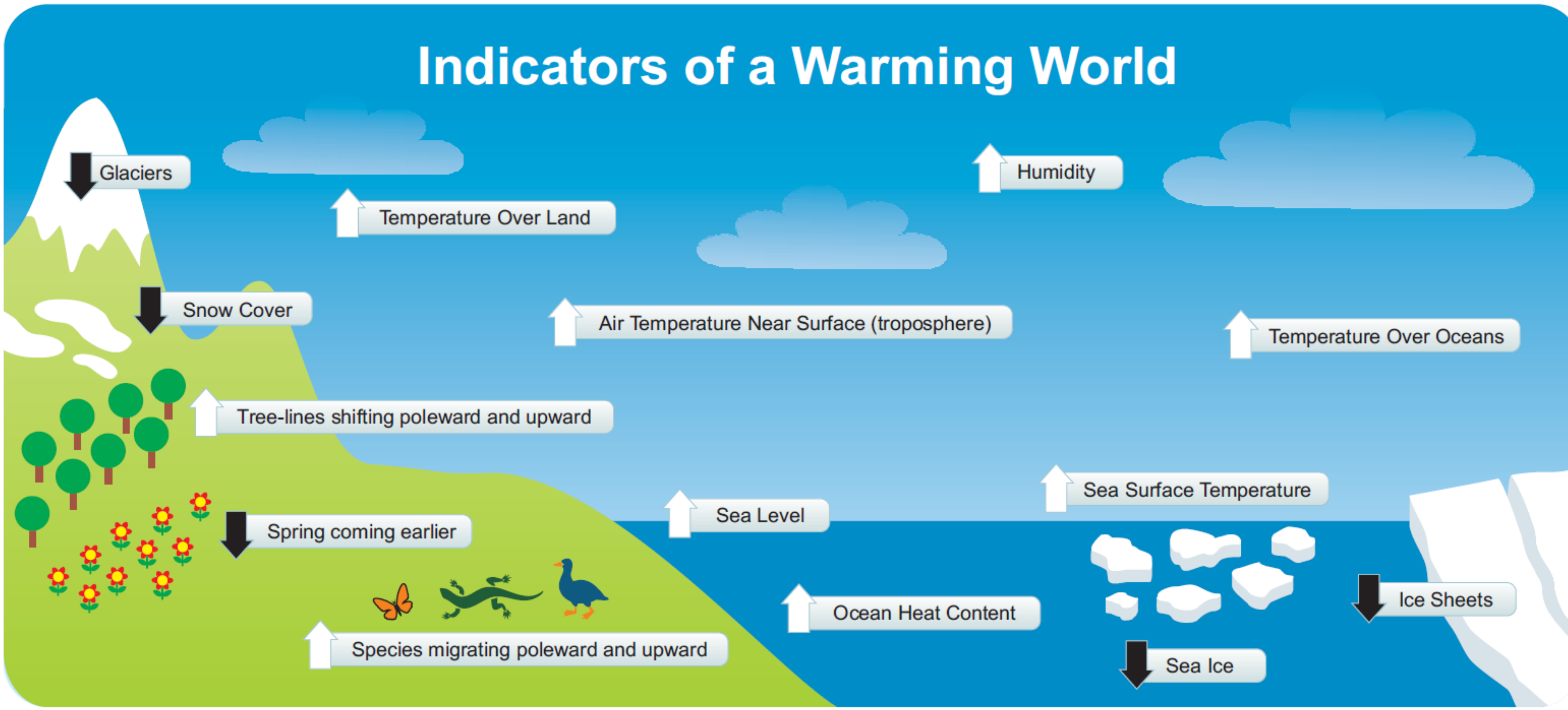
Summary

- There is scientific consensus on
  - correlation between the concentration of CO_2 and temperature.
  - that humans release anthropogenic compounds into the environment, resulting in previously unseen rises in atmospheric gas concentrations and temperature.
- There is continuous debate on
  - the proportion of changes caused by this anthropogenic compound vs. other causes.



Parmesan & Yohe 2003[32], NOAA[34]

Recent trends in CO_2 emission – energy perspective

- Steady level of CO2 (280 ppm) in the pre-industrial era; in 2013 396 ppm (40% higher than in the mid-1800s). Average growth of 2 ppm/y.
- Significant increases in levels of methane and nitrous oxide.
- The use of energy represents by far the largest source of emissions.

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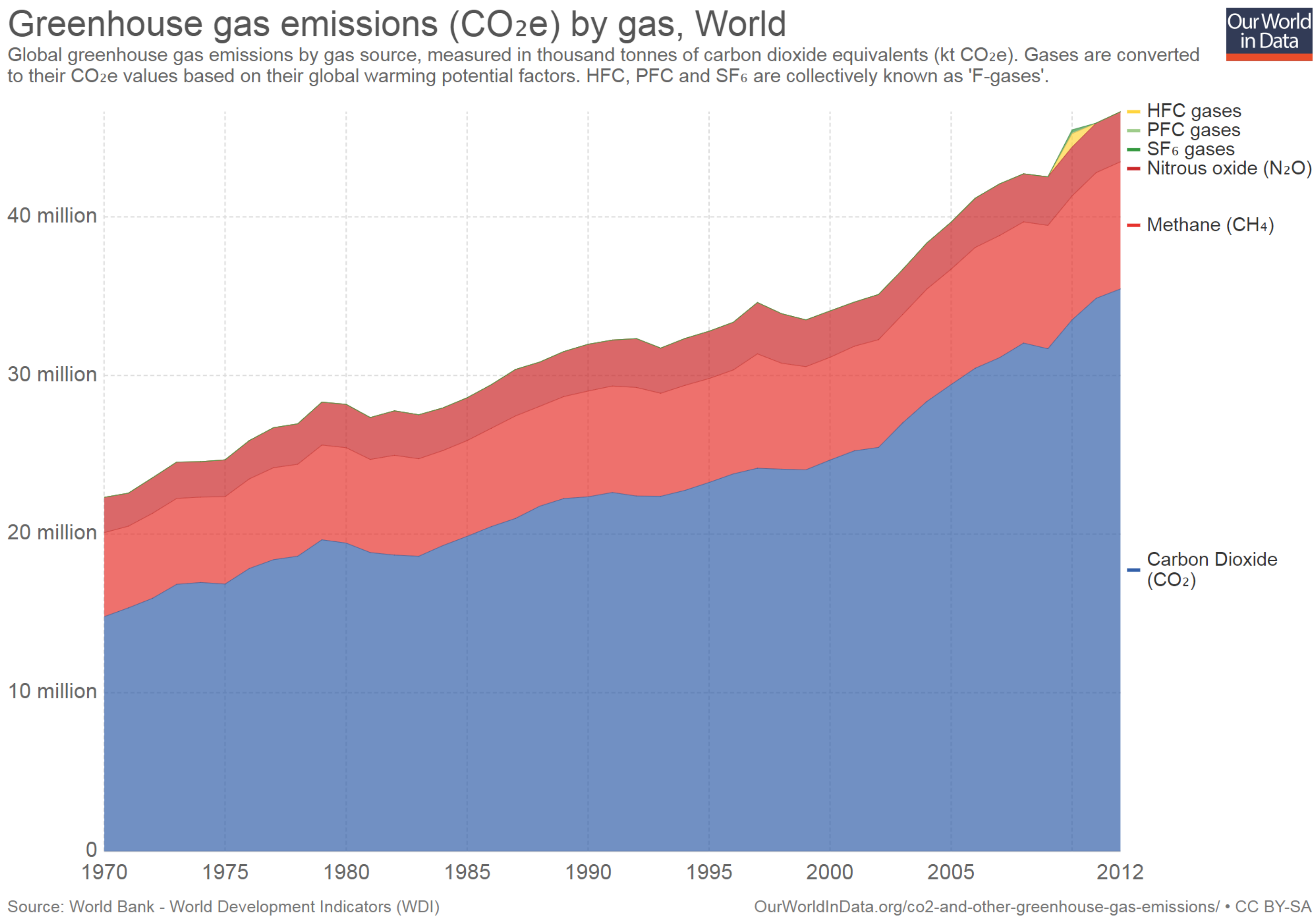

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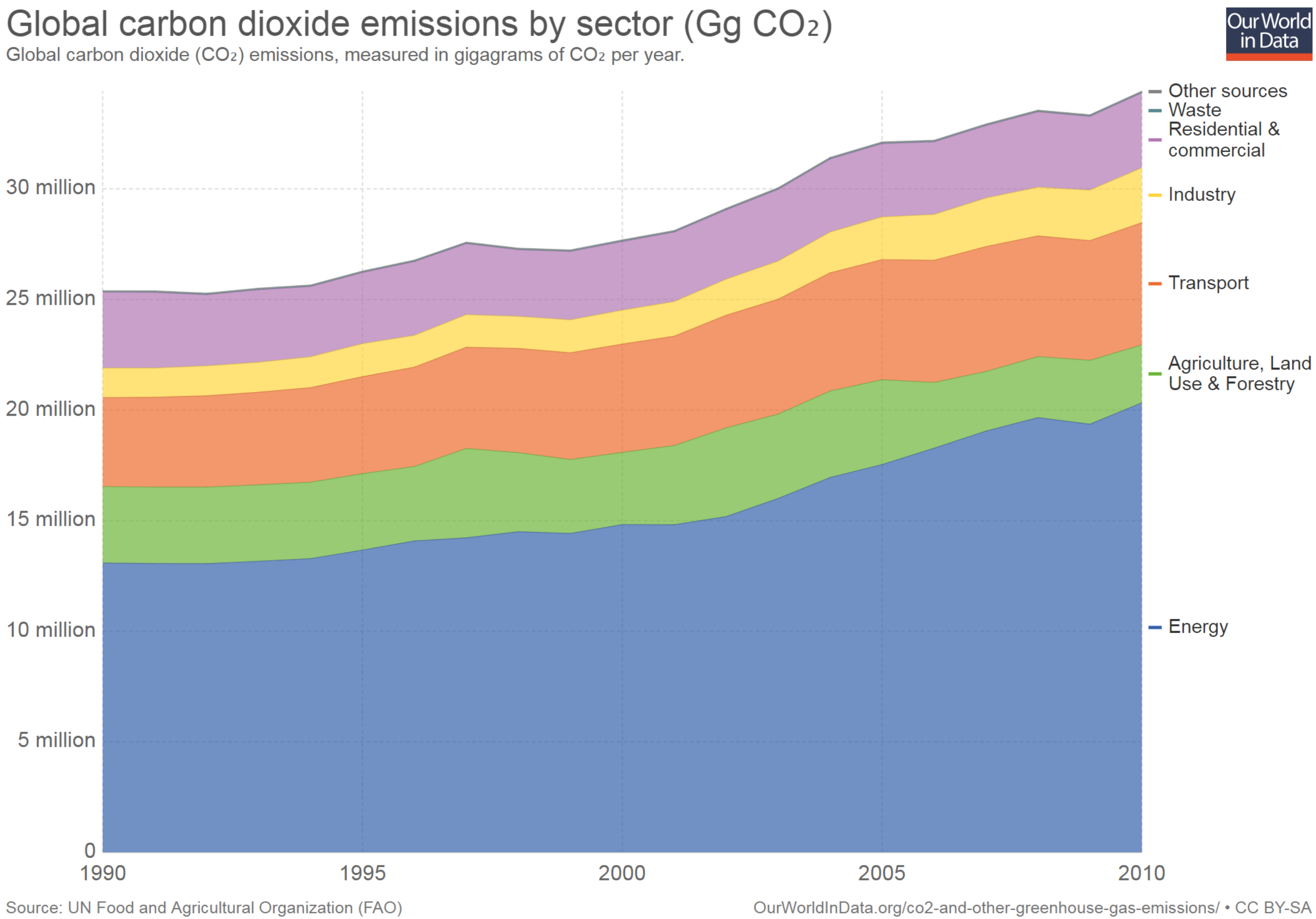

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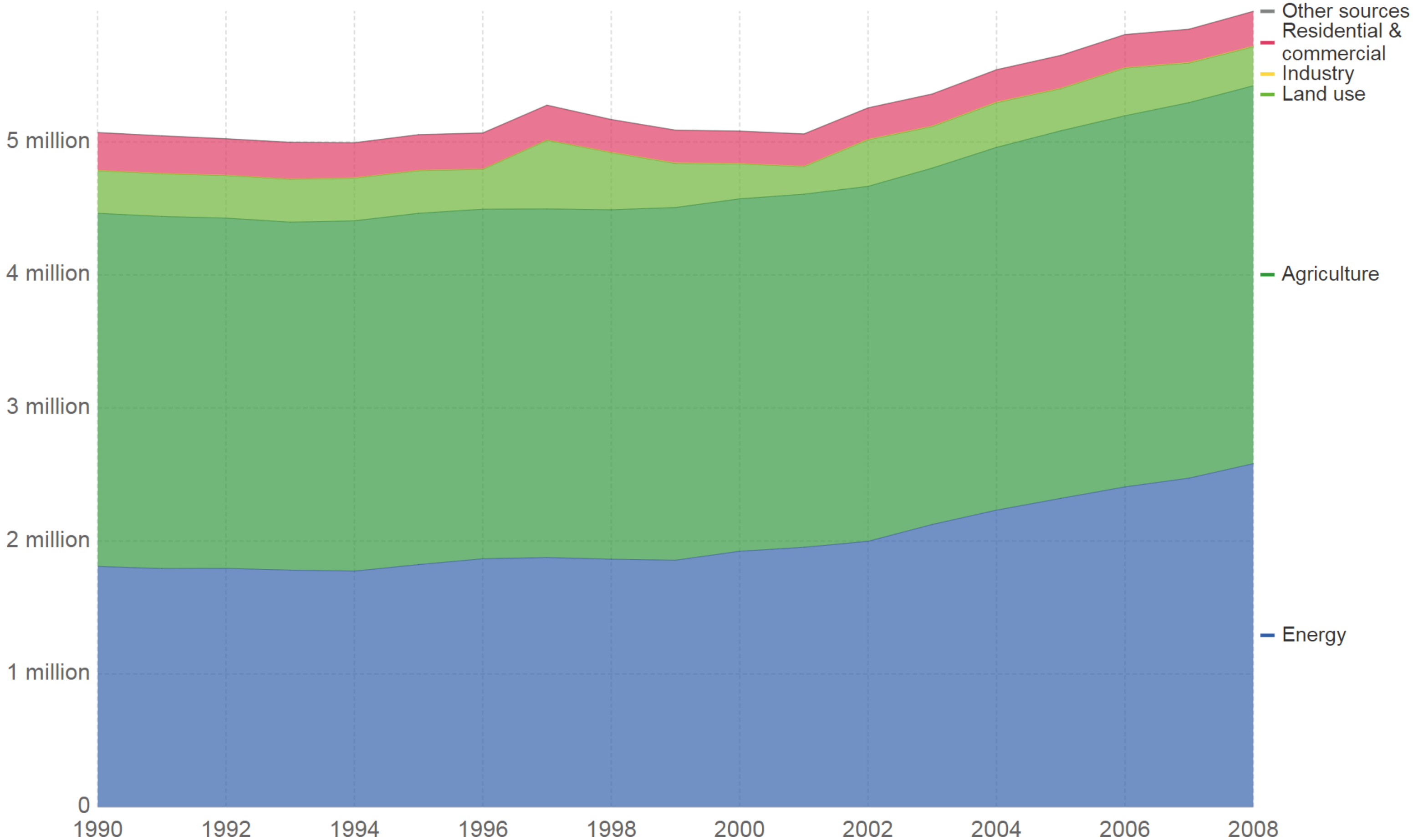
Methane emissions by sector (Gg CO_2e)

Breakdown of total global methane (CH_4) emissions by sector, measured in gigagrams of carbon-dioxide equivalents (CO_2e). Carbon dioxide equivalents measures the total greenhouse gas potential of the full combination of gases, weighted by their relative warming impacts.



Source: UN Food and Agricultural Organization (FAO)

OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/ • CC BY-SA

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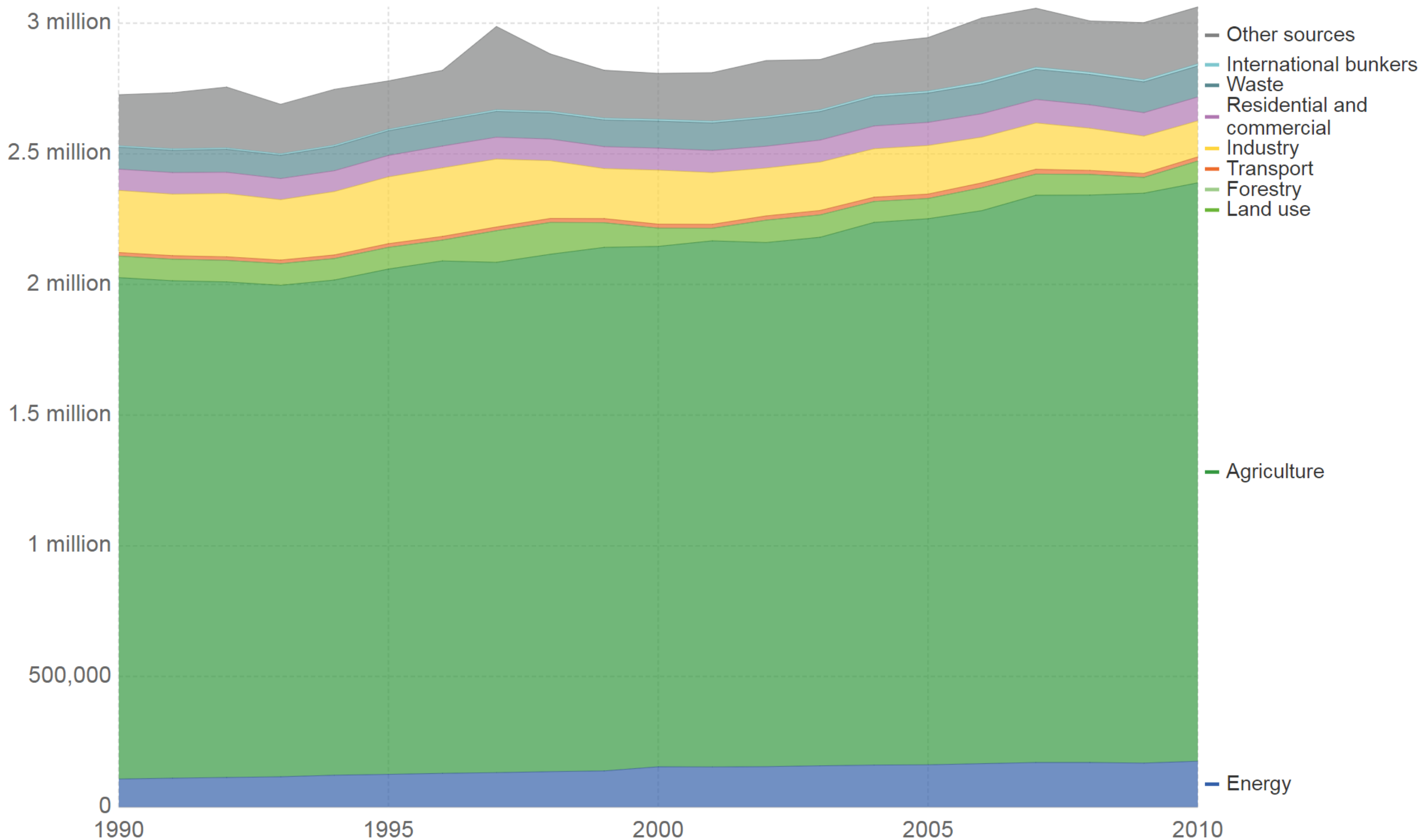
Nitrous oxide emissions by sector (Gg CO_2e), World

Breakdown of total global nitrous oxide (N_2O) emissions by sector, measured in gigagrams of carbon-dioxide equivalents (CO_2e). Carbon dioxide equivalents measures the total greenhouse gas potential of the full combination of gases, weighted by their relative warming impacts.



Source: UN Food and Agricultural Organization (FAO)

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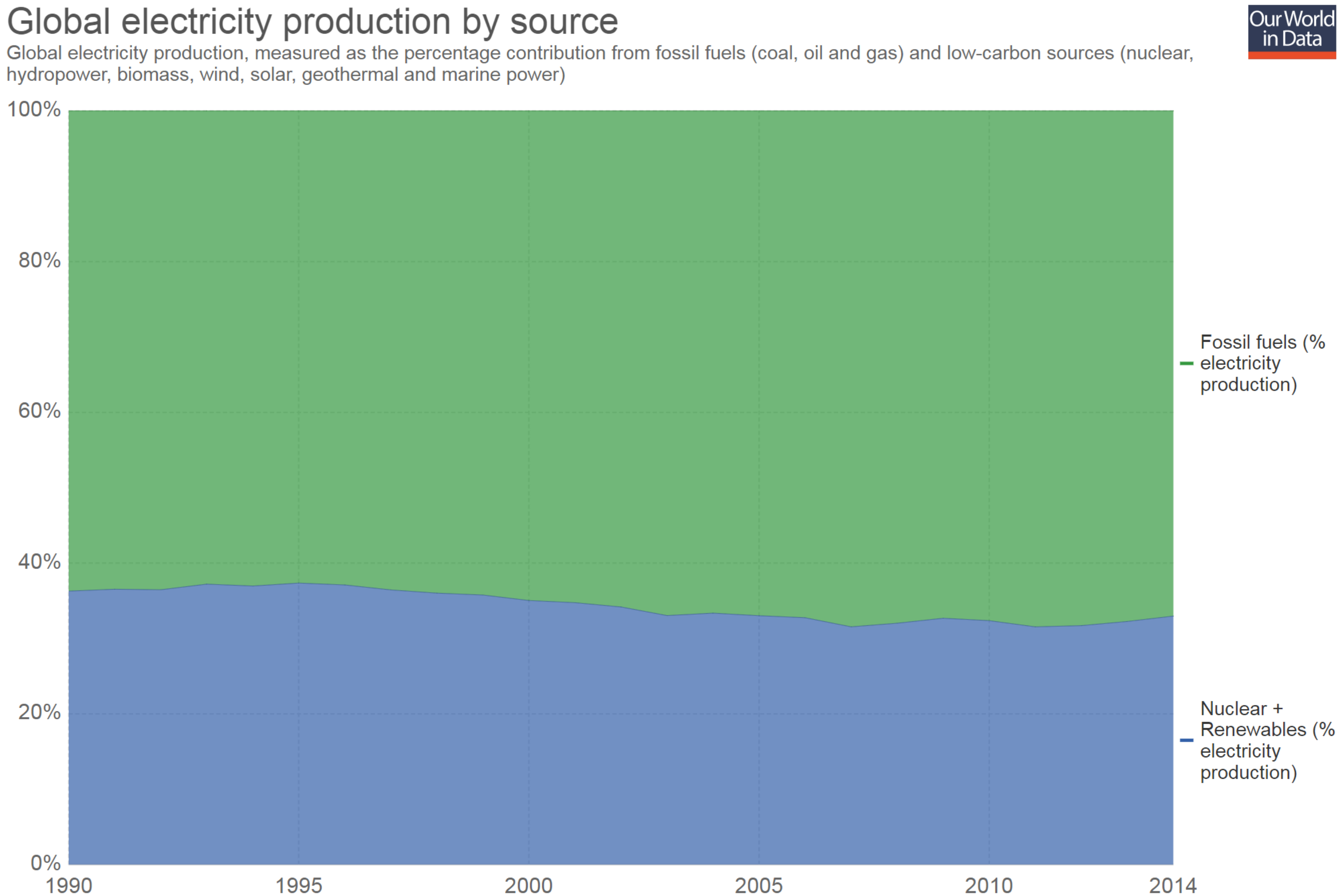
Global electricity production by source

Global electricity production, measured as the percentage contribution from fossil fuels (coal, oil and gas) and low-carbon sources (nuclear, hydropower, biomass, wind, solar, geothermal and marine power)



Source: World Bank- World Development Indicators (WDI)

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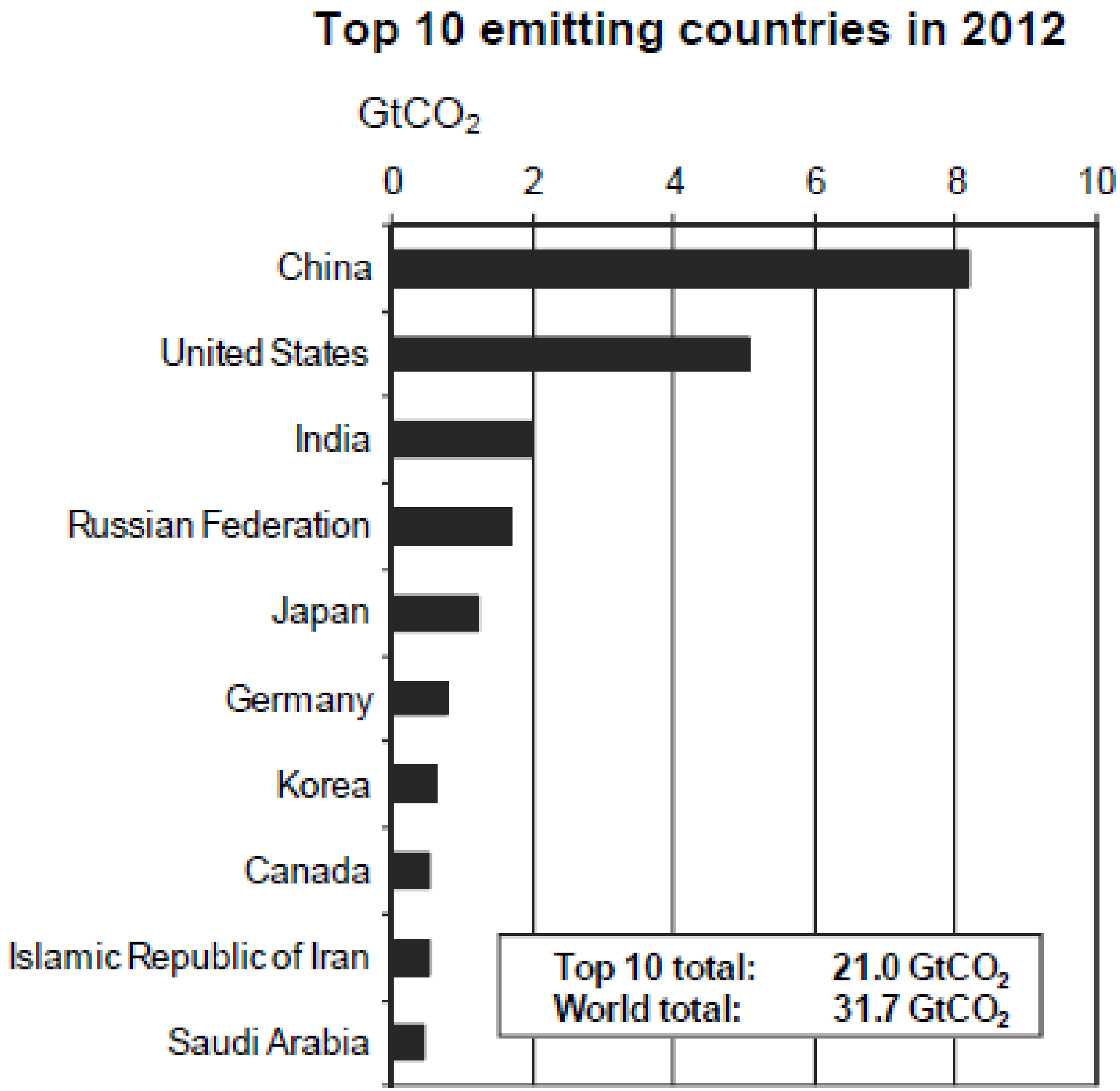
Recent trends in CO_2 emission – energy perspective

- In the last decade the coal have replaced oil as the largest source of CO_2 emissions.
- The top 10 emitting countries account for 2/3 of global CO_2 emissions.



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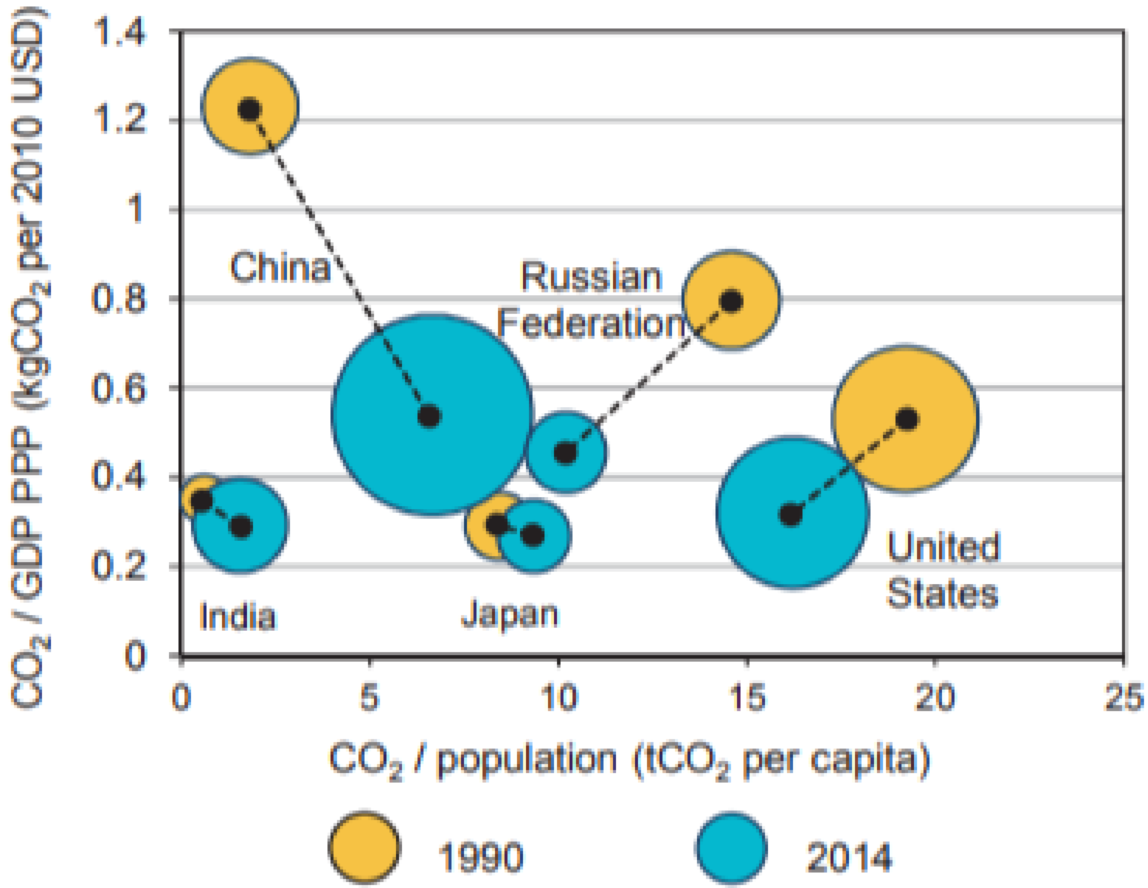
Recent trends in CO2 emission

- Emissions per capita generally decrease in time accross regions.
- All top five emitters reduced emissions per unit of GDP, while emissions per capita showed contrasting trends.

Figure 15. Trends in CO_2 emission intensities for the top five emitting countries*



* The size of the circle represents the total CO_2 emissions from the country in that year.

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Summary

- Economic growth strongly linked to consumption of fossil fuels.
- Substitution of fossil fuels is essential but extremely difficult.

Climate change impacts

- Melting ice
  - The vast majority of the world´s glaciers are melting faster than are replenished.
  - 1/3 of North Pole´s ice sheets melted since 90s.
- Accelerated sea level rise, increase coastal flooding
  - 20 cm in the last century (40% thermal expansivity, 60% melting of the land ice).
  - Actual rate 3mm/y.
  - Problem for low-lying communities (i.e. Bangladesh).

Climate change impacts

- Increase in extreme weather events
  - Climate change increases certain types of extreme weather events – heat waves, coastal flooding, extreme precipitation events, more severe droughts.
  - Temperature – average kinetic energy of the molecules within a substance = the more radiation trapped in the atmosphere the higher temperature is.

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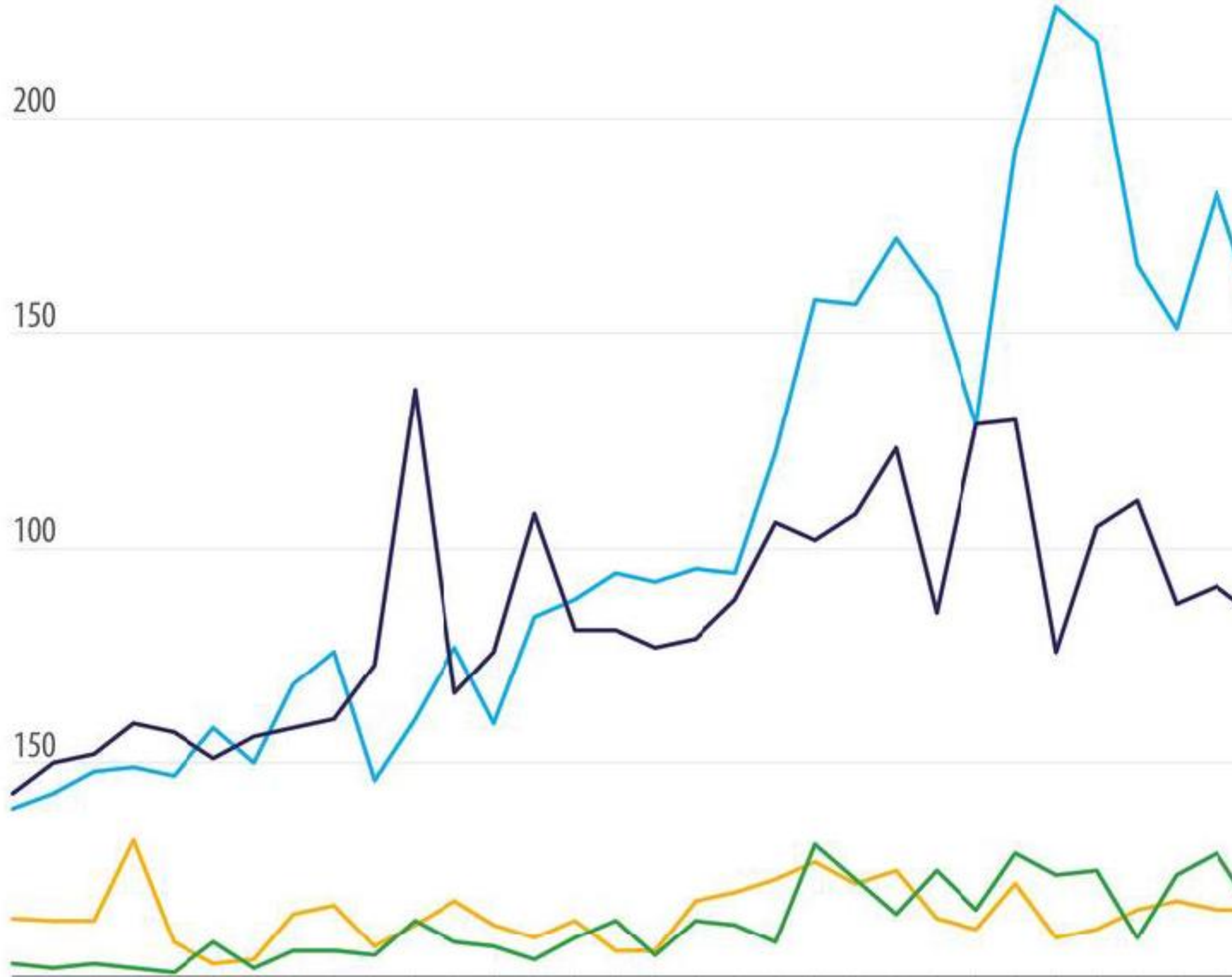
Number of Climate-related Disasters Around the World (1980-2011)

3455 FLOODS

2689 STORMS

470 DROUGHTS

395 EXTREME TEMPS



	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
FLOOD	39	43	48	49	47	58	50	68	76	46	60	77	59	84	88
STORM	43	50	52	59	57	51	56	58	60	73	137	66	76	108	81
DROUGHT	14	13	13	32	8	3	4	15	17	7	12	18	12	9	13
EXTREME TEMPERATURE	3	2	3	2	1	8	2	6	6	5	13	8	7	4	9

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
FLOOD	94	92	95	94	122	158	157	172	159	129	193	226	218	166	151	188
STORM	81	77	79	88	106	102	108	123	85	129	130	76	105	111	87	9
DROUGHT	6	6	18	20	23	27	22	25	14	11	22	9	11	16	18	16
EXTREME TEMPERATURE	13	5	13	12	8	31	23	15	25	16	29	24	25	9	24	29

UNISDR
nited Nations Office for Disaster Risk Reduction
www.unisdr.org

d on 13 June 2012

OURCES

T - http://www.emdat.be/ - The OFDA/CRED International
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itarian Symbol Set(2008):
www.ungiwg.org/map/guideline.php

Climate change impacts

- Health impacts
  - Increased air pollution, a longer and more intense allergy seasons, the spread of insect-borne diseases, more frequent heat waves, flooding = costly risks to public health.
- Food problems and water
  - According to IPCC 1°C = 65 million people starving.
  - Increase of the temperature of more than 2°C = 3 billion people without water supply.
  - Between 18-35% of plant and animal species is committed to extinction by 2050 (oceans are absorbing much of the CO_2 in the air, which leads to ocean acidification – destabilising the whole oceanic food chain). An estimated 1 billion people depend on the ocean for more than 30% of their animal protein.
  - Climate refugees.
- And others…

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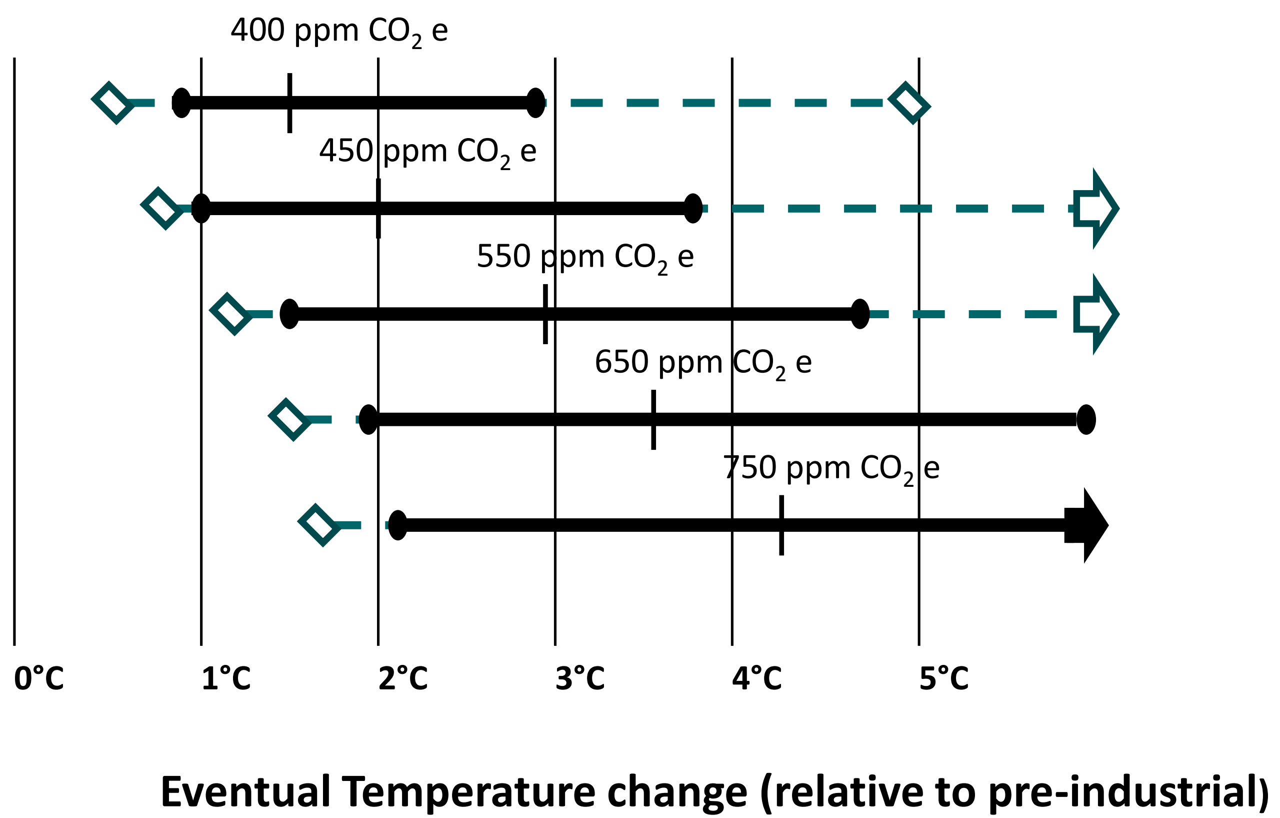
The Relationship Between the Level of Greenhouse Gas Stabilization and Eventual Temperature Change



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Possible Effects of Climate Change

	Eventual Temperature Rise Relative to Pre-Industrial Temperatures				
Type of Impact	**1°C**	**2°C**	**3°C**	**4°C**	**5°C**
Freshwater Supplies	Small glaciers in the Andes disappear, threatening water supplies for 50 million people	Potential water supply decrease of 20–30% in some regions (Southern Africa and Mediterranean)	Serious droughts in southern Europe every 10 years. 1–4 billion more people suffer water shortages	Potential water supply decrease of 30–50% in southern Africa and Mediterranean	Large glaciers in Himalayas possibly disappear, affecting ¼ of China's population
Food and Agriculture	Modest increase in yields in temperature regions	Declines in crop yields in tropical regions (5–10% in Africa)	150–550 million more people at risk of hunger. Yields likely to peak at higher latitudes	Yields decline by 15–35% in Africa. Some entire regions out of agricultural production	Increase in ocean acidity possibly reduces fish stocks
Human Health	At least 300,000 die each year from climate–related diseases. Reduction in winter mortality in high latitudes	40–60 million more exposed to malaria in Africa	1–3 million more potentially people die annually from malnutrition	Up to 80 million more people exposed to malaria in Africa	Further disease increase and substantial burdens on health care services
Coastal Areas	Increased damage from coastal flooding	Up to 10 million more people exposed to coastal flooding	Up to 170 million more people exposed to coastal flooding	Up to 300 million more people exposed to coastal flooding	Sea-level rise threatens major cities such as New York, Tokyo, and London
Ecosystems	At least 10% of land species facing extinction. Increased wildfire risk	15–40% of species potentially face extinction	20–50% of species potentially face extinction Possible onset of collapse of Amazon forest	Loss of half of Arctic tundra Widespread loss of coral reefs	Significant extinctions across the globe

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Climate change impacts by region

	People affected each year by 2080s by storm surges with sea-level rise of about 38cm assuming constant protection mechanisms (evolving protection mechanisms)[a]	*Estimated climate refugees due to sea-level rise (slr)*[b]	*Vulnerability to tropical cyclones*[c]	*People at risk of water stress by 2085 due to a temperature increase of 2–3 (depending on population level)*[d]	*Estimates related to drought and water stress*[e]	*Additional number of people at risk of hunger by the 2080s*[f]
Africa	Southern Mediterranean: 13 million (6 million) West Africa: 36 million (3 Million) East Africa: 33 million (5 million)	Egypt: 12 million by 2050 Nigeria: 6–11 million by 2050	Southeast Africa: low to moderate risk	North Africa: 155–599 million South and East Africa: 15–529 million West Africa: 27–517 million	14 African countries currently experience water scarcity. Expected to rise to 24 countries by 2030	Total: 23–200
Asia	South Asia: 98 million (55 million) Southeast Asia: 43 million (21 million)	Bangladesh: 26 million by 2050 China: 73 million India: 20 million by 2050	Major urban centers: moderate to high risk South Asia: moderate risk East Asia: moderate to high risk South East Asia: moderate to high risk	South Asia: 39–812 million West Asia: 95–492 million Central Asia: 14–228 million East Asia: 41–1577 in worst case scenario	Millions at risk due to the glacier melt in the Himalayas. 50–60 percent of world population live in the larger Himalaya-Hindu Kush region and could be affected by water stress	West Asia: 5–134 million Southeast Asia: 2–44 million

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Climate change impacts by region

Latin America	N/A	Venezuela: 56,000 assuming 1m slr and no adaptation measures Uruguay: 13,000 assuming 1m slr and no adaptation measures	Central America: low to high risk Northern Latin America: low risk	Central America: 5–246 million South America: 72–272 million in the worst-case scenario	Glacier melt in the South American Andes could cause water stress under 37 million people by 2010 and 40 million by 2050	Total: 5–85 million
Small island states	Caribbean: 1,350,000 (560,000) Indian Ocean: 920 thousand (460,000) Pacific: 290,000 (160,000)	1 million	Caribbean: low to moderate risk Indian Ocean: low to moderate risk Pacific: low to high risk	Caribbean: 0–73 million	Water availability could become too low during low rainfall seasons	N/A.

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