

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 predict.

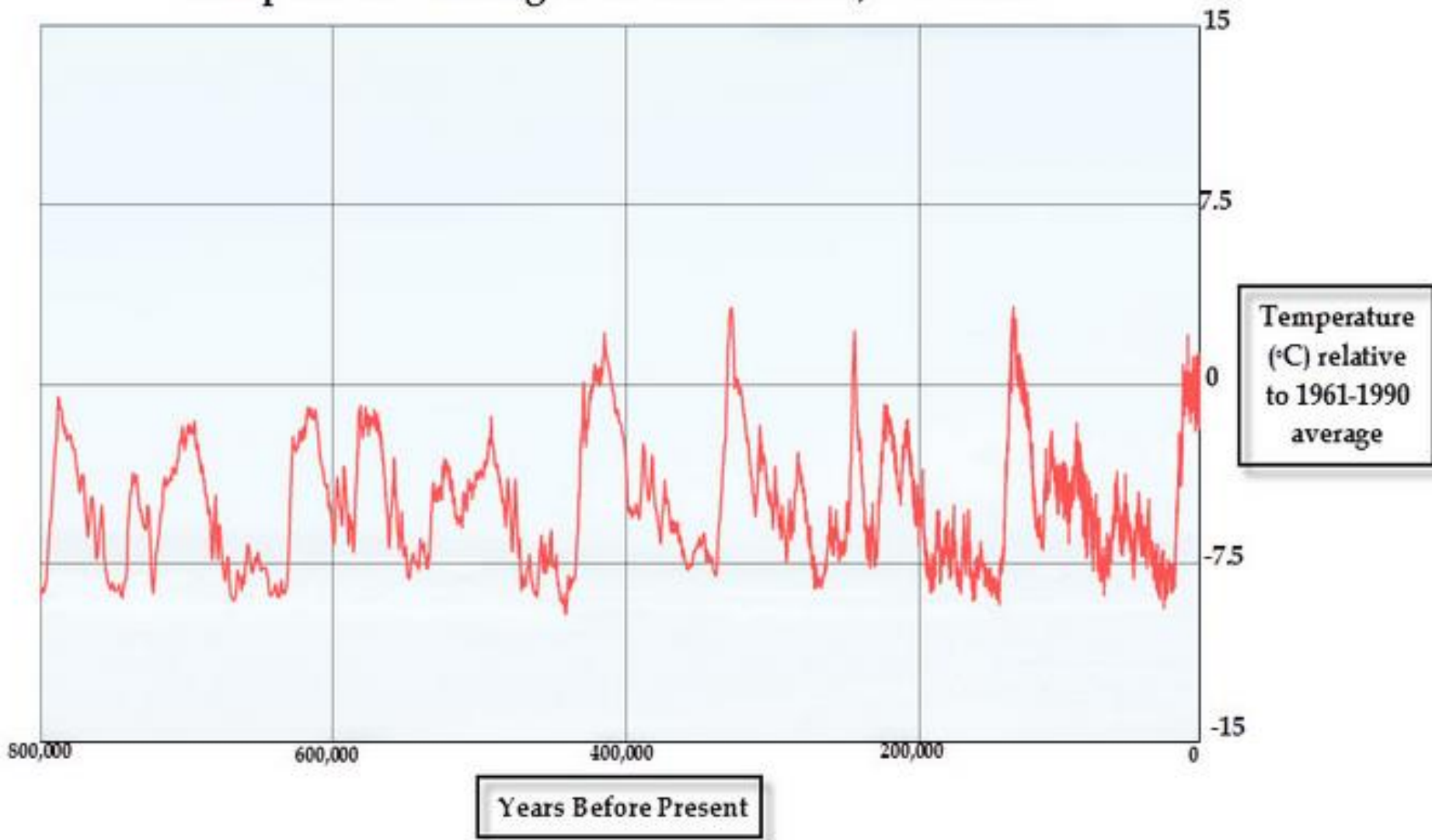
1) The planet's temperature is rising

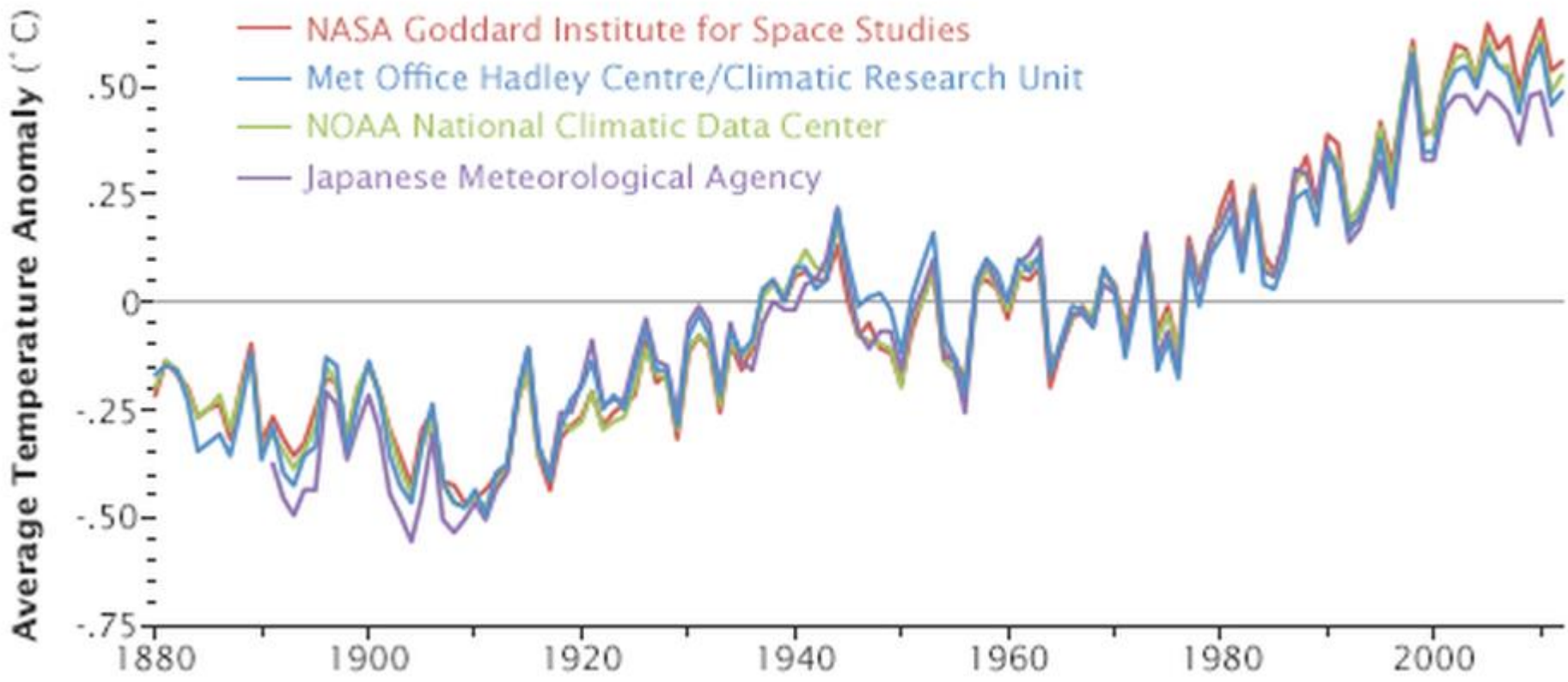
- Over the past 130 years the global average temperature has increased by $0,8^{\circ}\text{C}$ (more than half of that in last 35 years).
- Ancient ice samples (from Antarctica and other places) are analysed – their layers are dated and gas bubbles inside are analysed.
 - CO_2 concentration is measured by infrared spectroscopy or mass spectrometry.
 - Isotope ratios of water molecules are measured to determine historical temperatures.

1) 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.
- The rate of change has become more dramatic since the Industrial Revolution = anthropogenic origins.

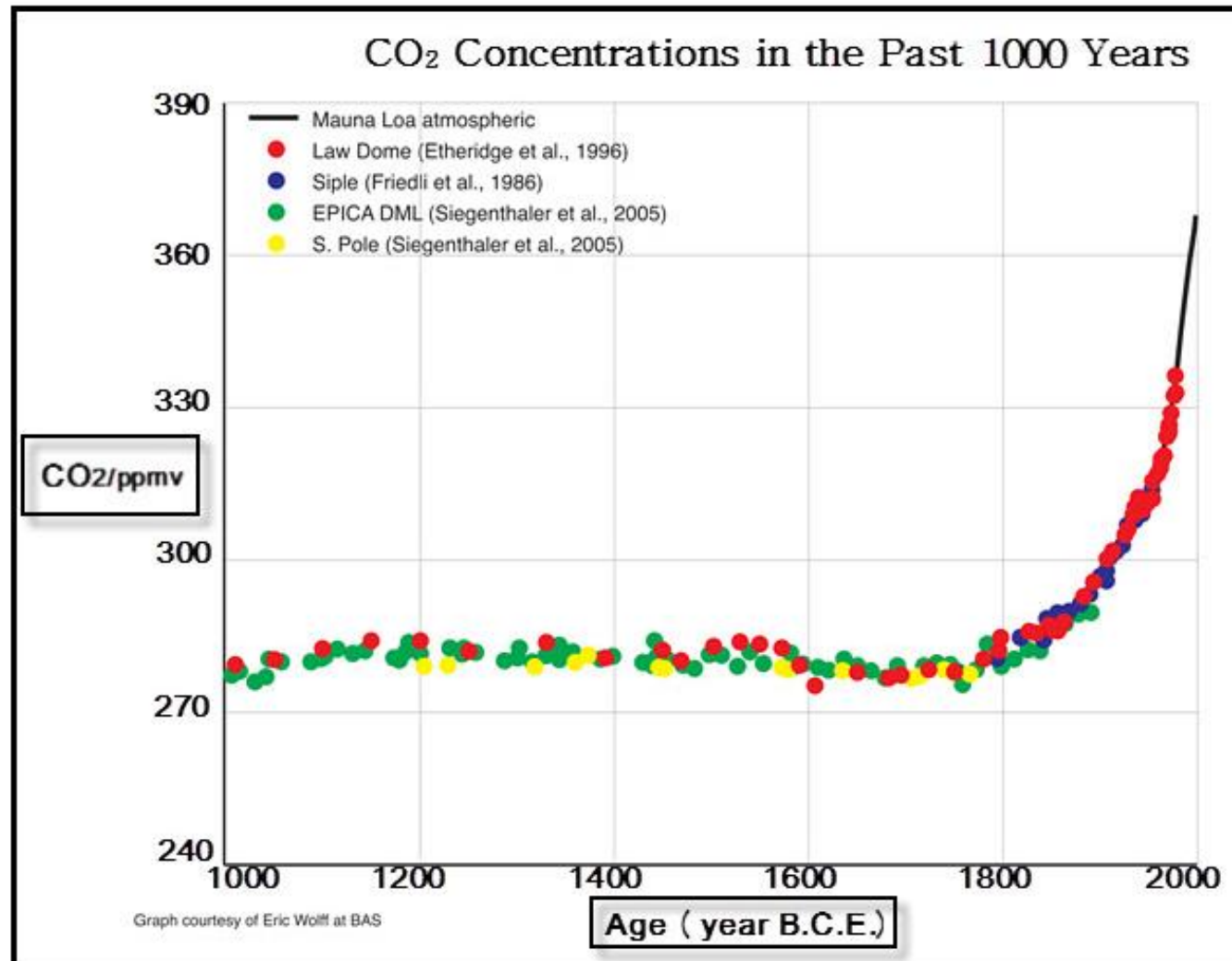
Temperature Changes in the Past 800,000 Years





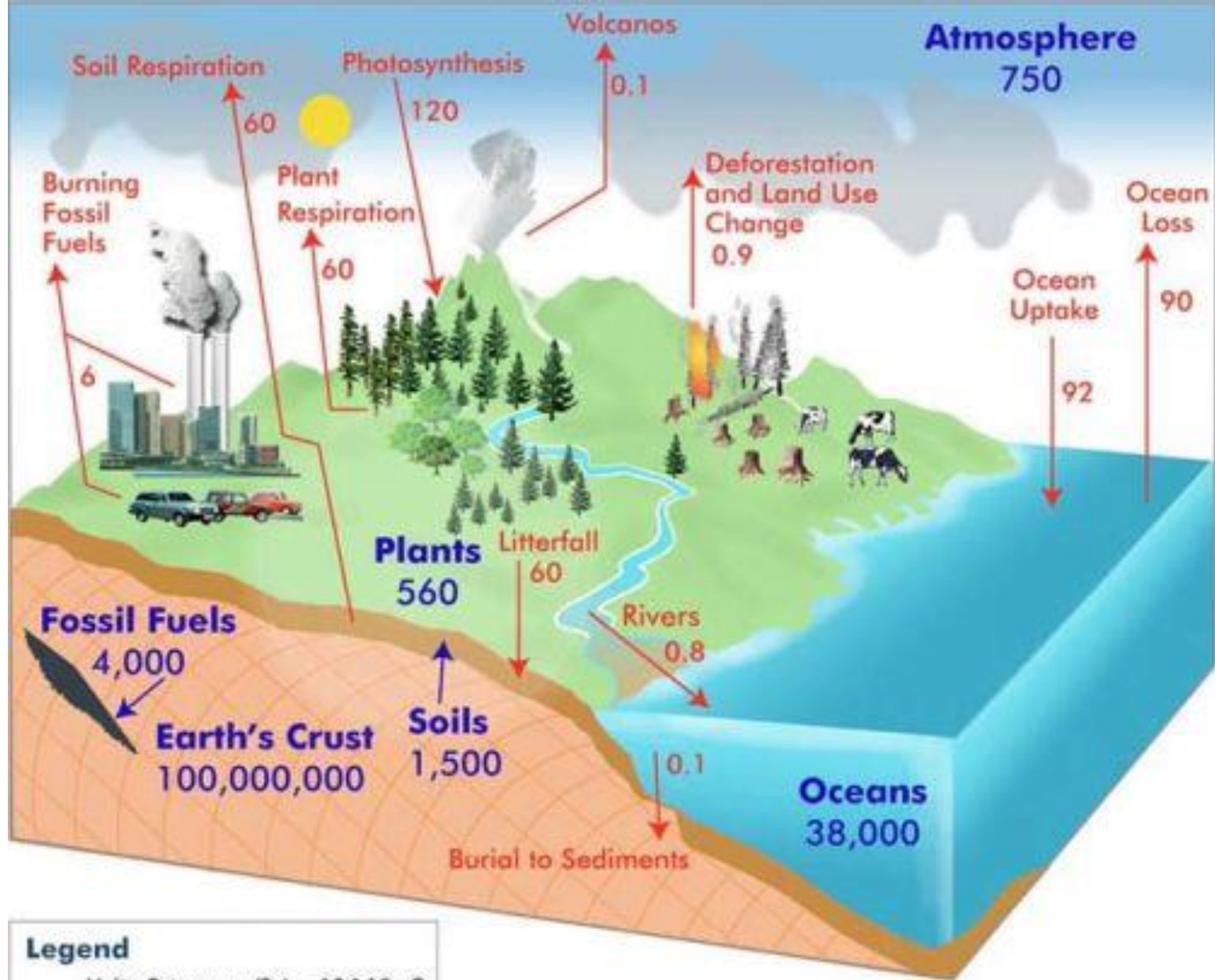
2) CO₂ level is increasing (also methane and nitrous oxide)

Rates of Change in the Past 250 Years



3) We are responsible for the increase in CO₂

- Human CO₂ emissions (20 billion tonnes/y) are small compared to natural emission (776 billion tonnes/y).
- But natural absorptions (788 billion tonnes/y) roughly balance natural emissions.
- Carbon 12 isotope to carbon 13 isotope ratio increases (isotope = different atoms with the same chemical behavior but with different masses).



Legend

Units: Petagrams (Pg) = 10^{15} gC

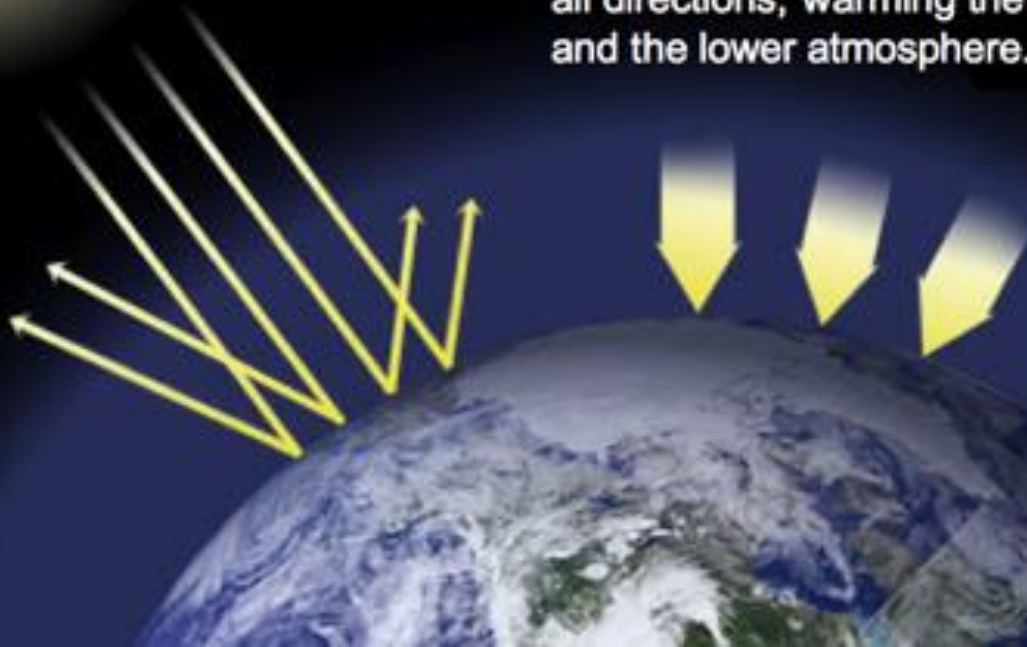
- Pools: Pg
- Fluxes: Pg/year

4) Increased CO₂ is the primary driver of greenhouse effect

- Inbound solar radiation has short wavelengths 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 warms 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 CO₂ is the primary driver of greenhouse effect

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

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 vapour traps more heat
- Negative feedback – more water vapour causes more clouds, reflecting sunlight.

Summary

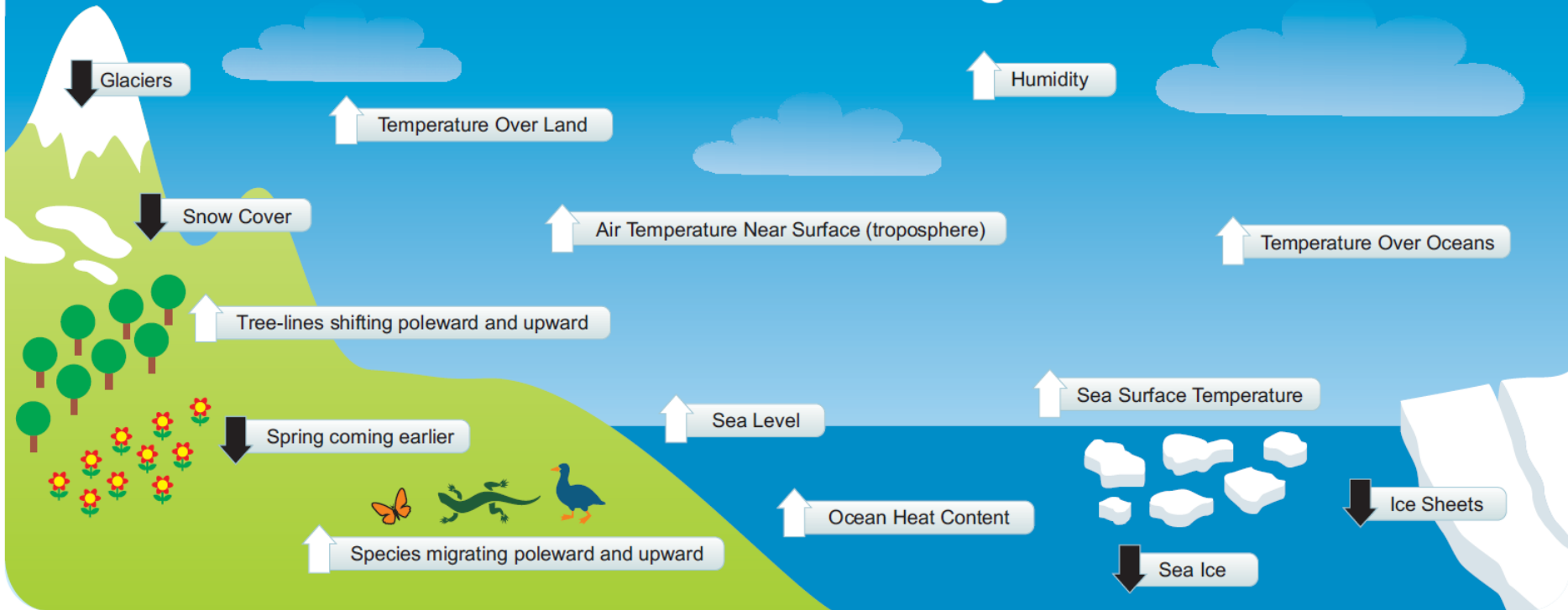
- Earth's climate has undergone changes over long periods of time (several ice ages, period of warming).
- Previous changes were dramatic but gradual (thousands of years).
- Today's change is extremely fast and the pace is increasing. Until 250 years ago the highest rate of temperature increase recorded was approximately $0,003^{\circ}\text{C}/\text{y}$. For the last ten years, it is $0,017^{\circ}\text{C}$
- 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.

Summary

- There is scientific consensus on
 - correlation between the concentration of CO₂ 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.

Climate change explained

Indicators of a Warming World



Parmesan & Yohe 2003³², NOAA³⁴

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.
- Increase in extreme weather events
 - Climate change increases certain types of extreme weather events – heat waves, coastal flooding, extreme precipitation events, more severe droughts.

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.

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

 **3455**
FLOODS

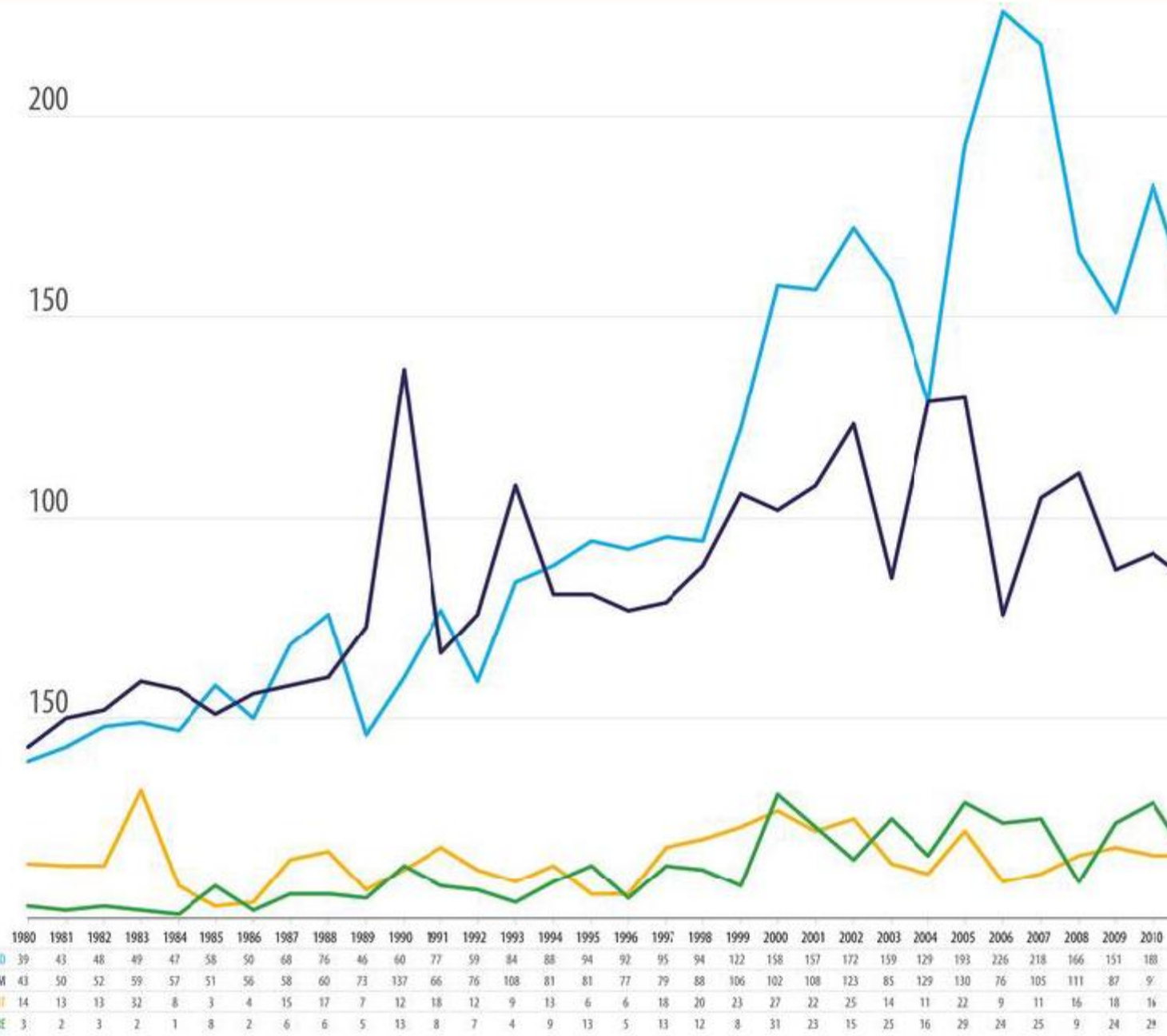
 **2689**
STORMS

 **470**
DROUGHTS

 **395**
EXTREME TEMPS

 **UNISDR**
United Nations Office for Disaster Risk Reduction
www.unisdr.org

on 13 June 2012
SOURCES
- <http://www.emdat.be/> - The OFDA/CRED International
Database; Data version: 13 June 2012 - v12.07
- www.unisdr.org/
- www.unisdr.org/
- www.unisdr.org/



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 CO₂ 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...

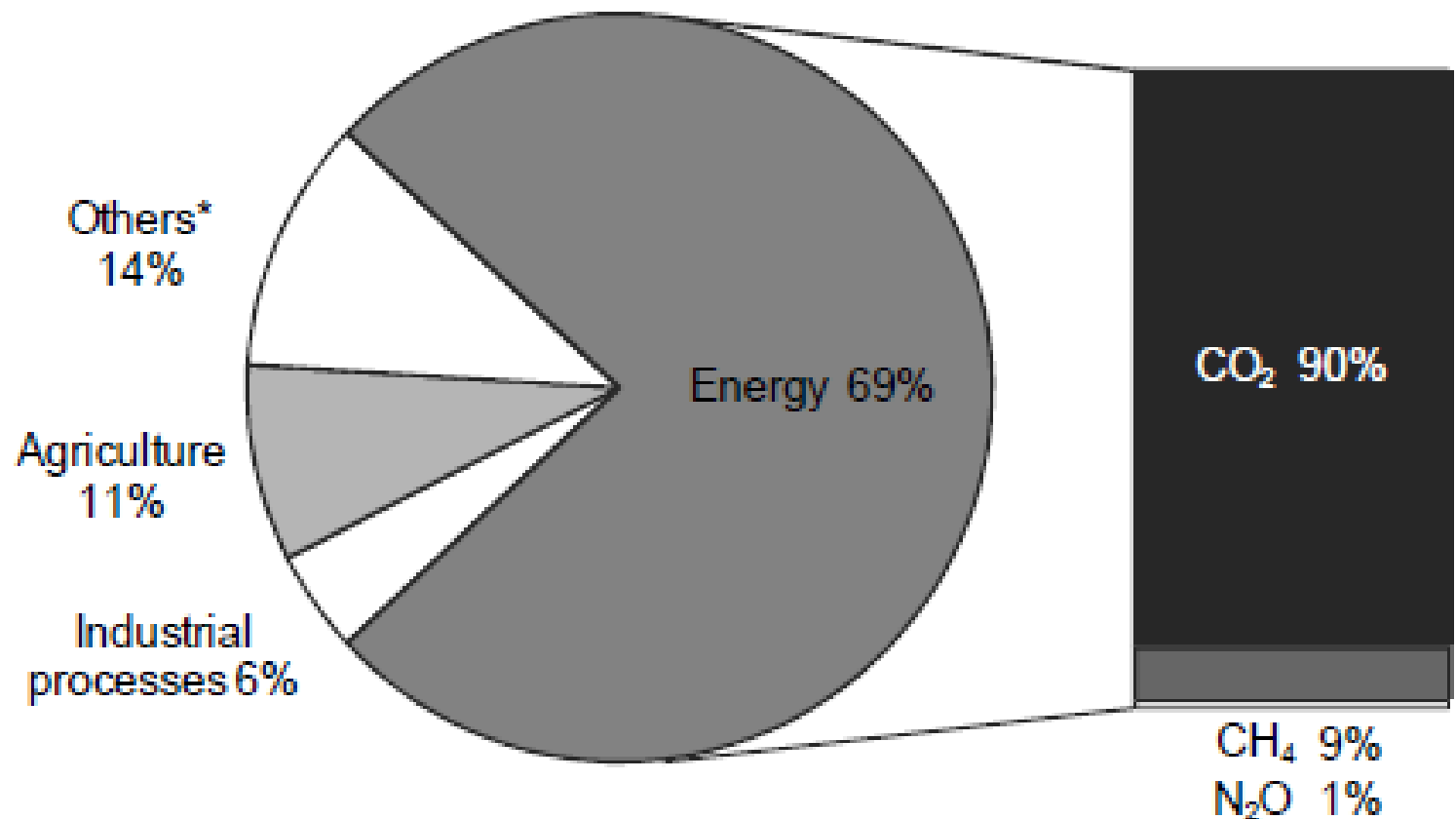
Summary

- Rich will adapt and poor will suffer.

Recent trends in CO₂ 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.

Shares of global anthropogenic GHG, 2010*



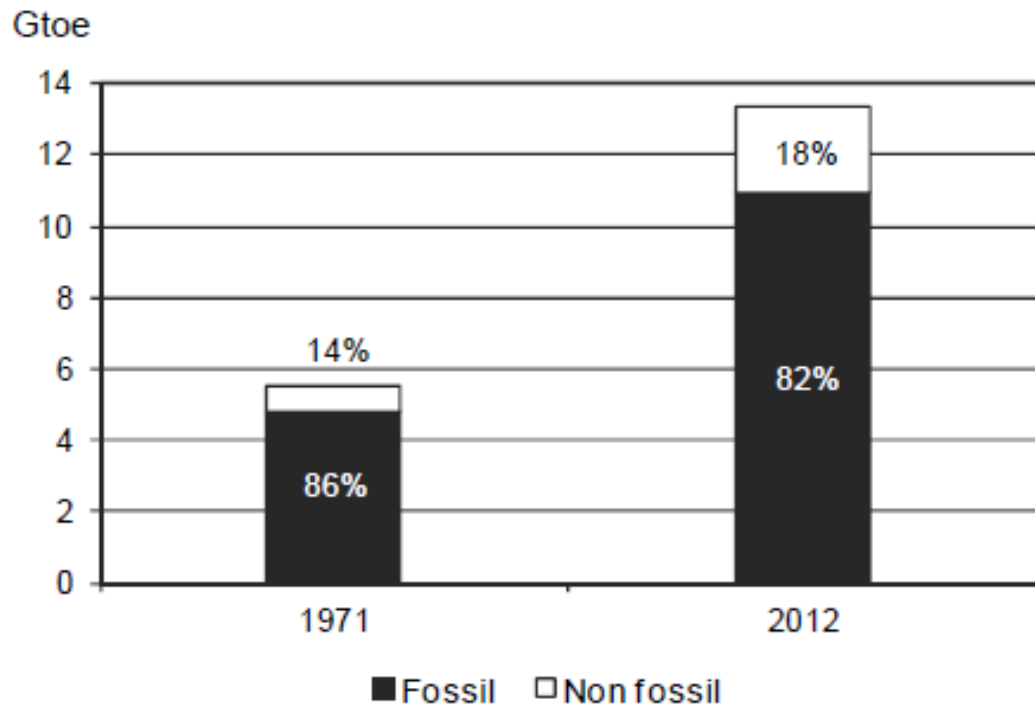
* Others include large-scale biomass burning, post-burn decay, peat decay, indirect N₂O emissions from non-agricultural emissions of NO_x and NH₃, Waste, and Solvent Use.

Source: IEA estimates for CO₂ from fuel combustion and EDGAR 4.2 FT2010 estimates for all other sources.

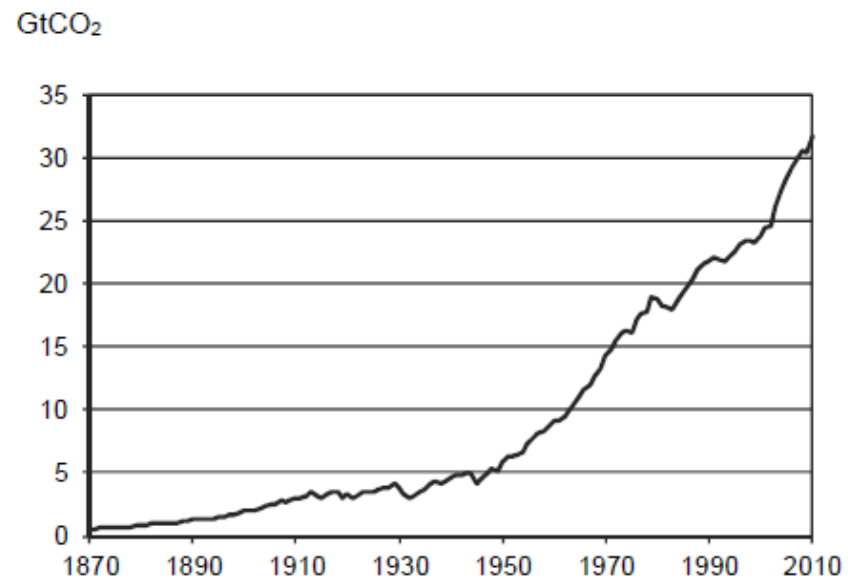
Recent trends in CO₂ emission – energy perspective

- Fossil fuels account for most of the world energy supply (82% of the global energy supply in 2012).
- Since 1870, CO₂ emissions from fuel combustion have risen exponentially.
- Since the Industrial Revolution, annual CO₂ emissions from fuel combustion increased from near zero to almost 32 GtCO₂ in 2012.

World primary energy supply



Trend in CO₂ emissions from fossil fuel combustion

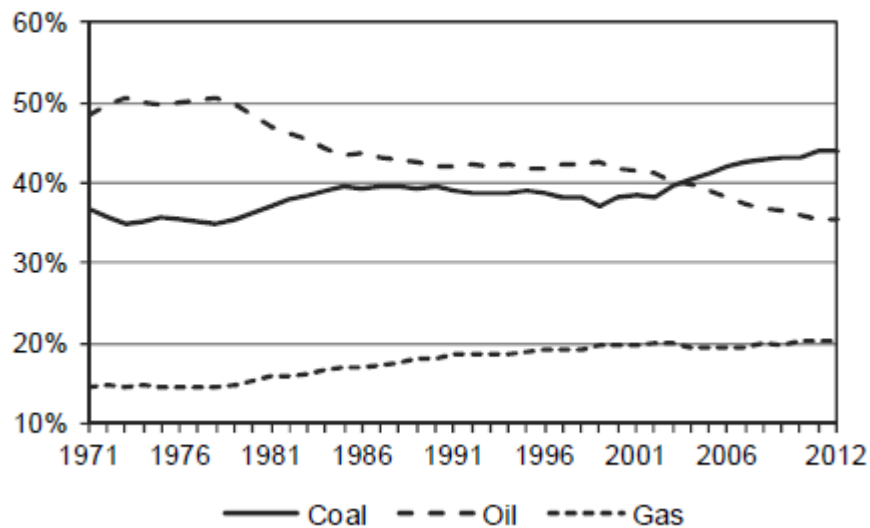


Source: Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, US Department of Energy, Oak Ridge, Tenn., United States.

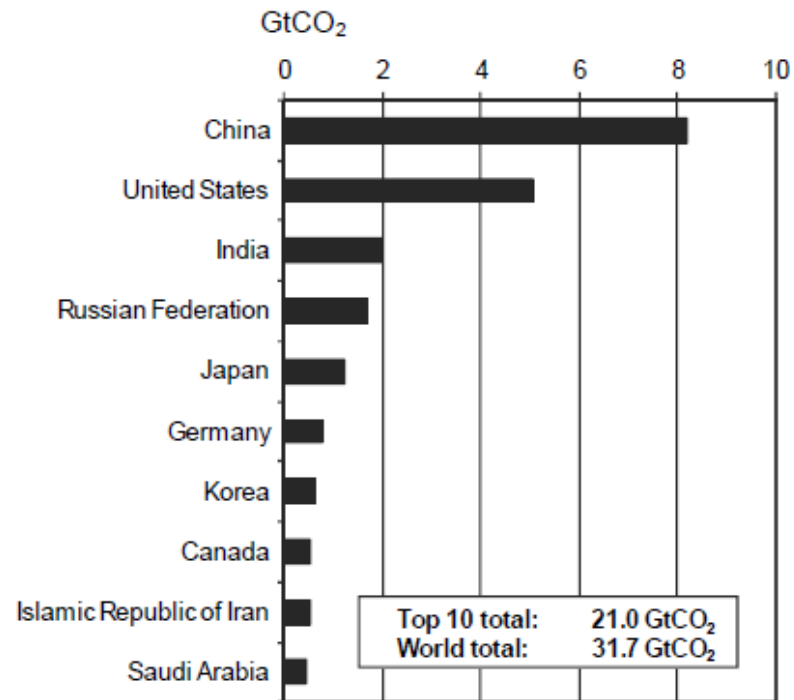
Recent trends in CO2 emission – energy perspective

- In the last decade the coal have replaced oil as the largest source of CO2 emissions.
- The top 10 emitting countries account for 2/3 of global CO2 emissions.

Fuel shares in global CO₂ emissions



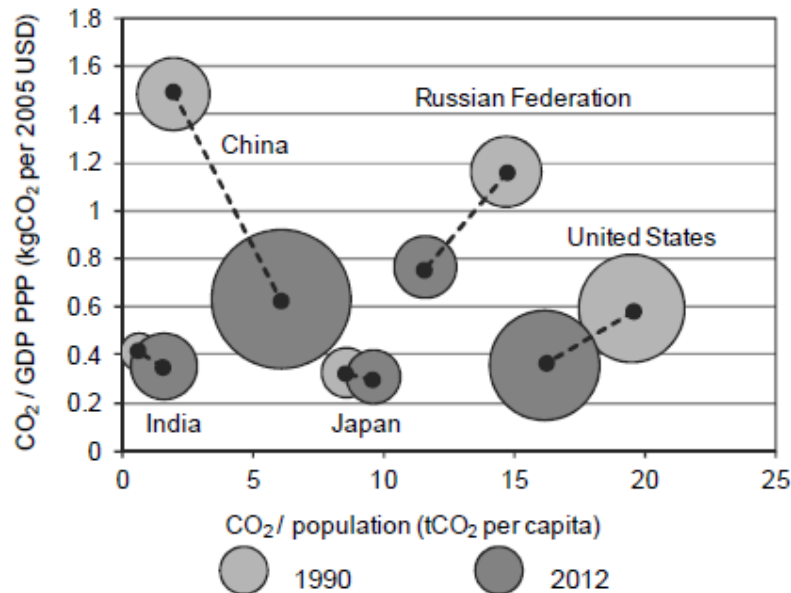
Top 10 emitting countries in 2012



Recent trends in CO2 emission

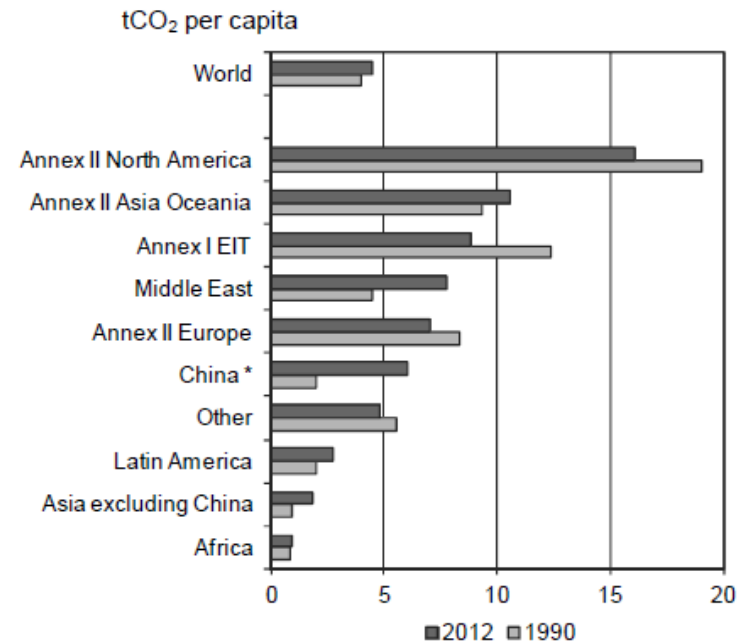
- Emissions per capita generally decrease in time accross regions.
- All top five emitters reduced emissions per unit of GDP, while emissions per capita showed contrasting trends.

Trends in CO₂ emission intensities for the top five emitting countries*



* The size of the circle represents the total CO₂ emissions from the country in that year.

CO₂ emissions per capita by major world regions



* China includes Hong Kong, China.

Summary

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

Sources

- IEA: CO₂ Emission from Fuel Combustion