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.

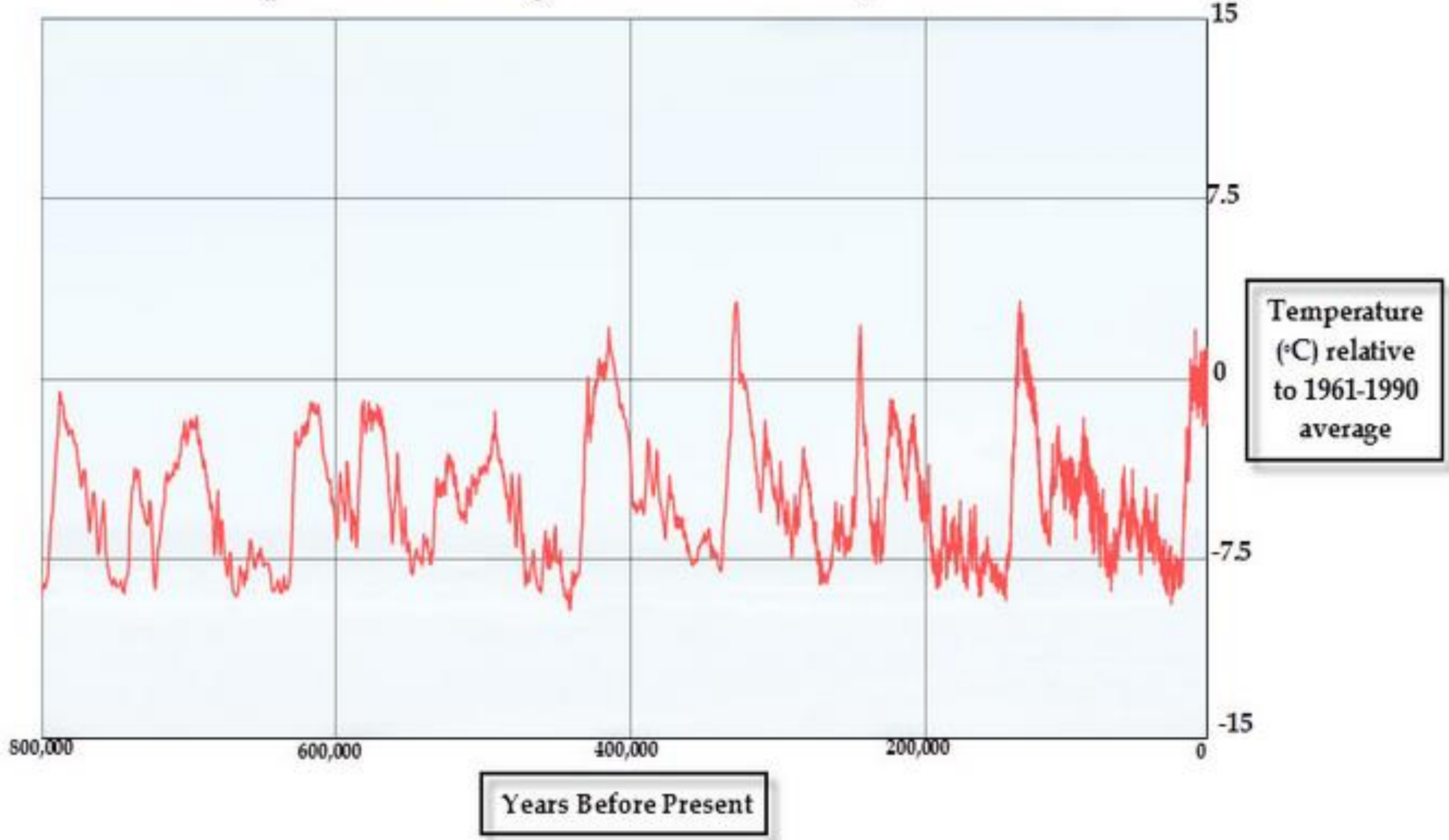
1) The planet´s temperature is rising

- 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.
  - CO2 concentration is measured by infrared spectroscopy or mass spektromectry.
  - Isotope ratios of water molecules are measured to determine historical temperatures.

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

Temperature Changes in the Past 800,000 Years



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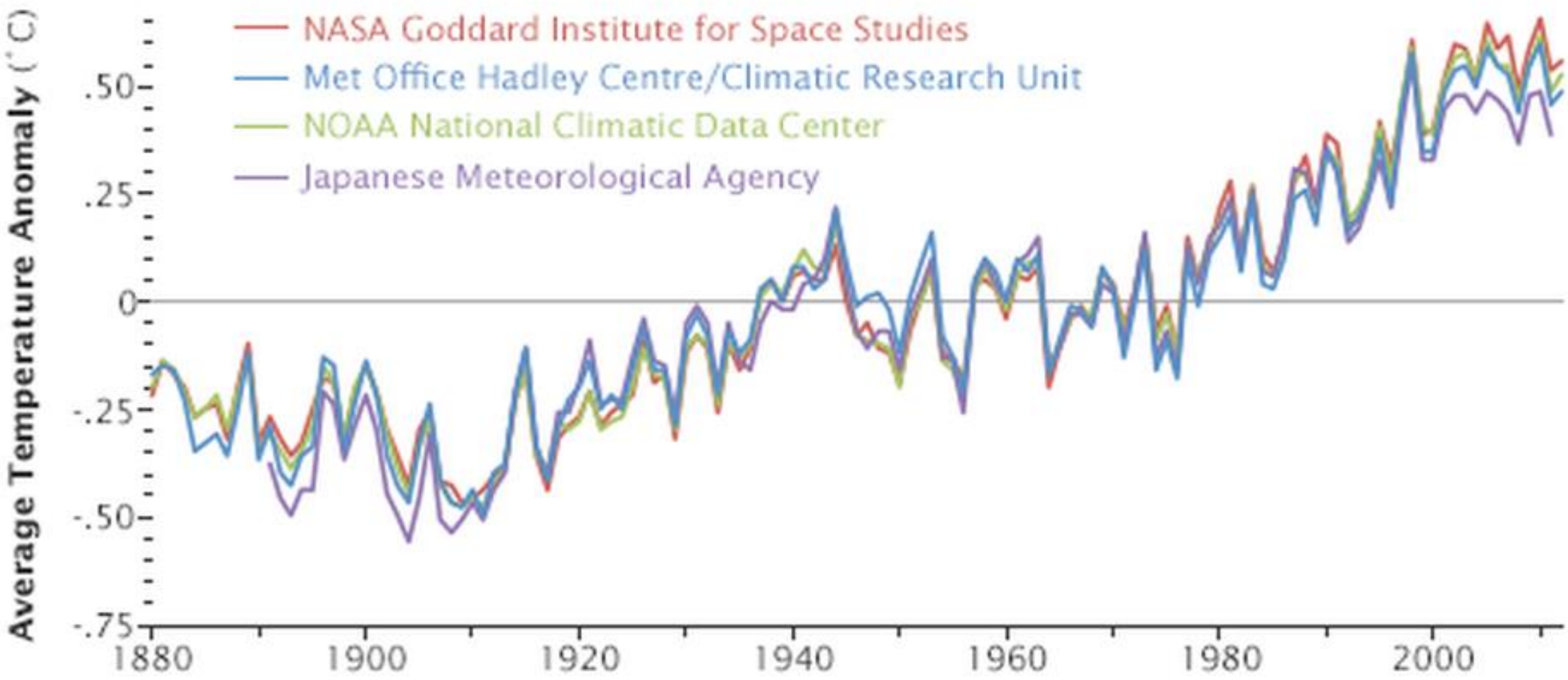
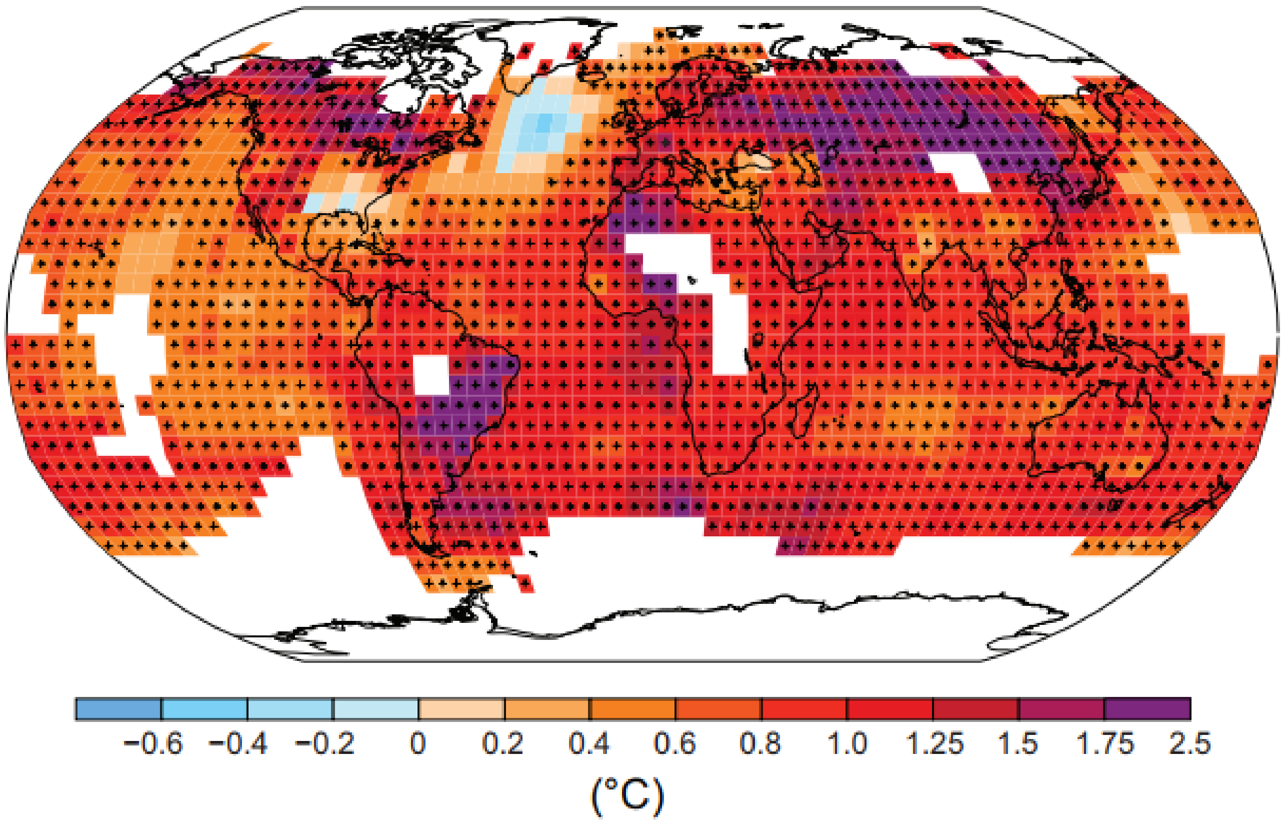


NASA Goddard Institute for Space Studies
Met Office Hadley Centre/Climatic Research Unit
NOAA National Climatic Data Center
Japanese Meteorological Agency
Average Temperature Anomaly (°C)
.50
.25
0
-.25
-.50
-.75
1880
1900
1920
1940
1960
1980
2000

Observed change in surface temperature 1901 - 2012



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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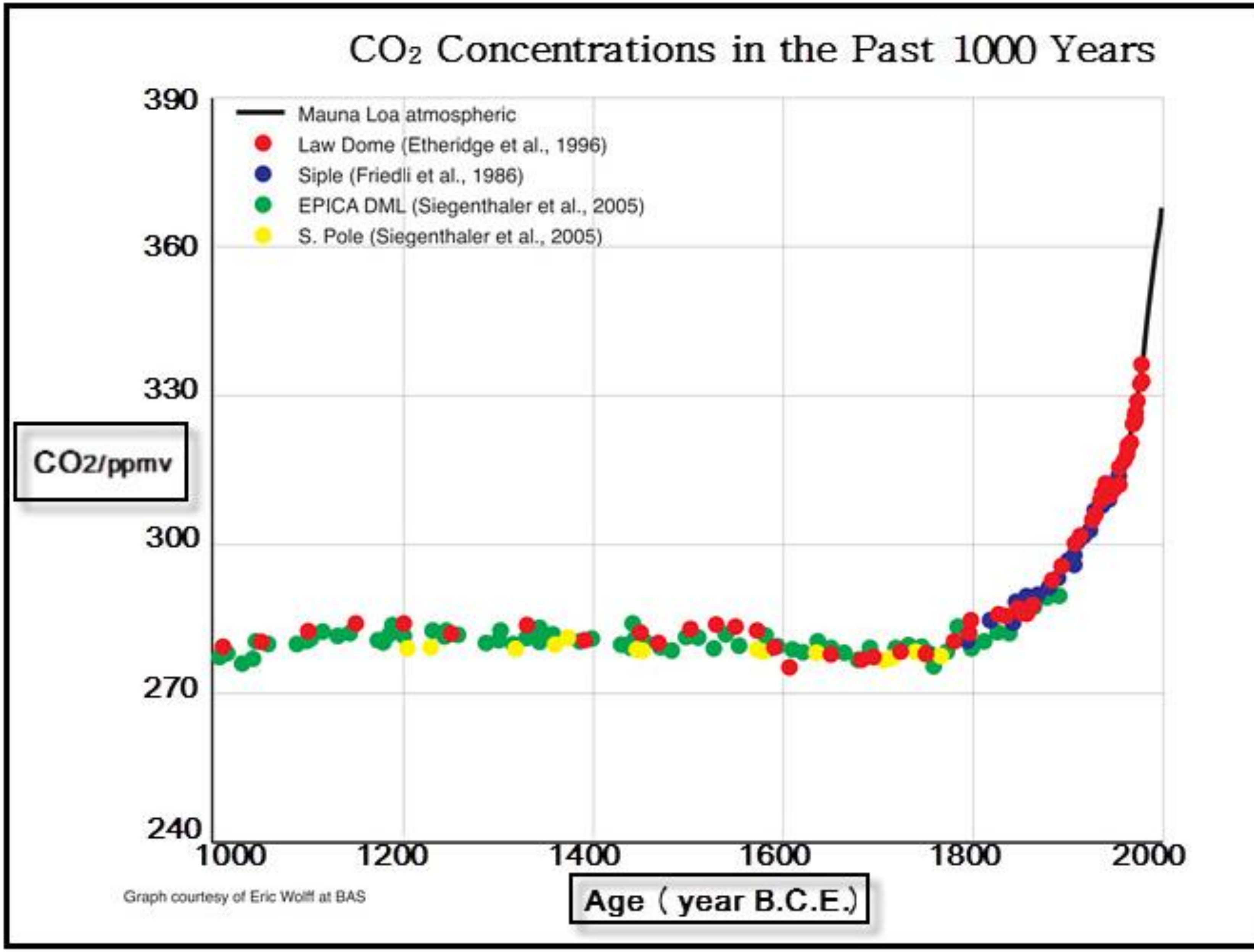

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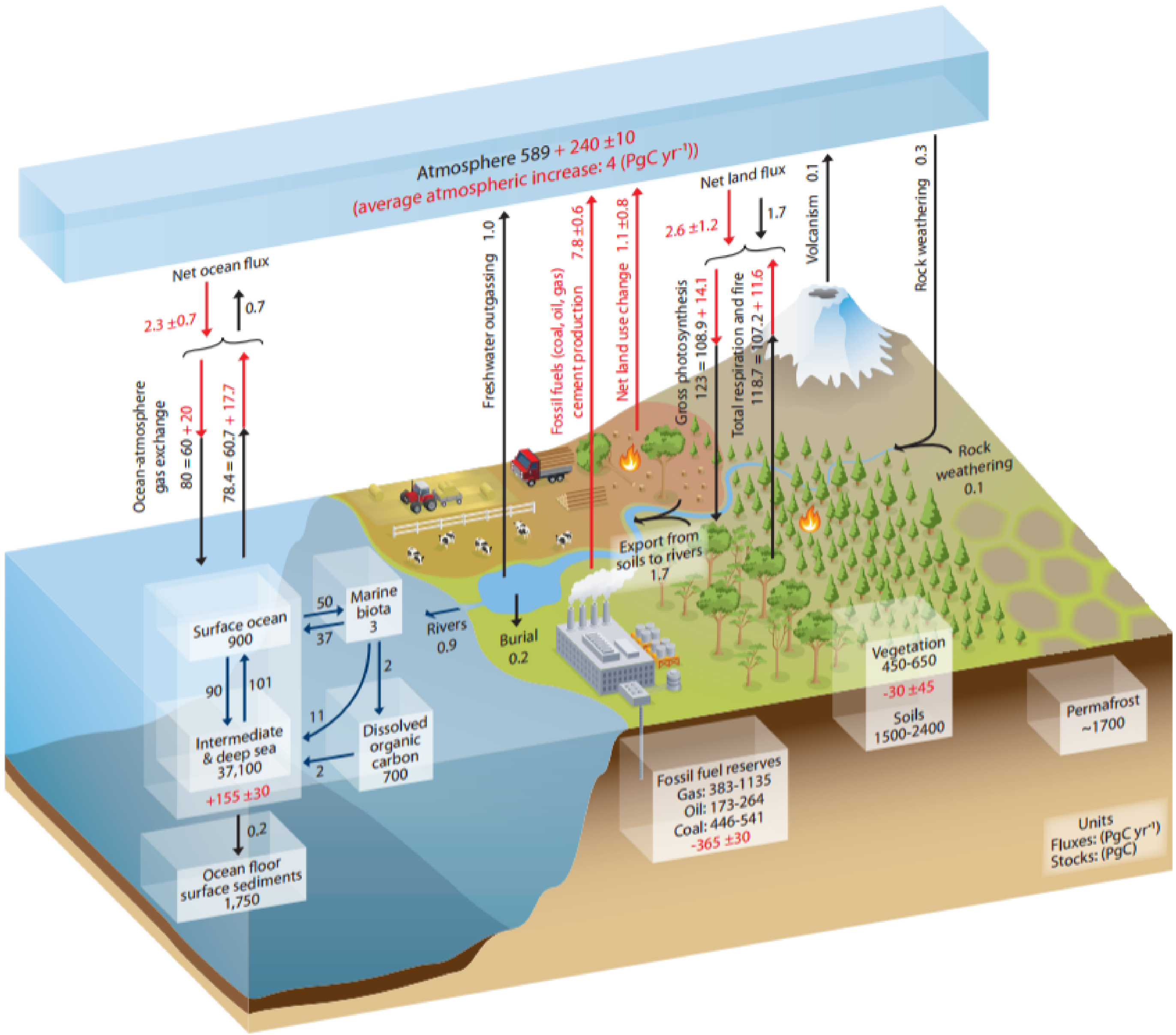
3) We are responsible for the increase in CO_2

- Human CO_2 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 emisssions.
- Carbon 12 isotope to carbon 13 isotope ratio increases (isotope = different atoms with the same chemical behavior but with different masses).



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 antrhropogenic fulxes averaged over the 2000-2009.

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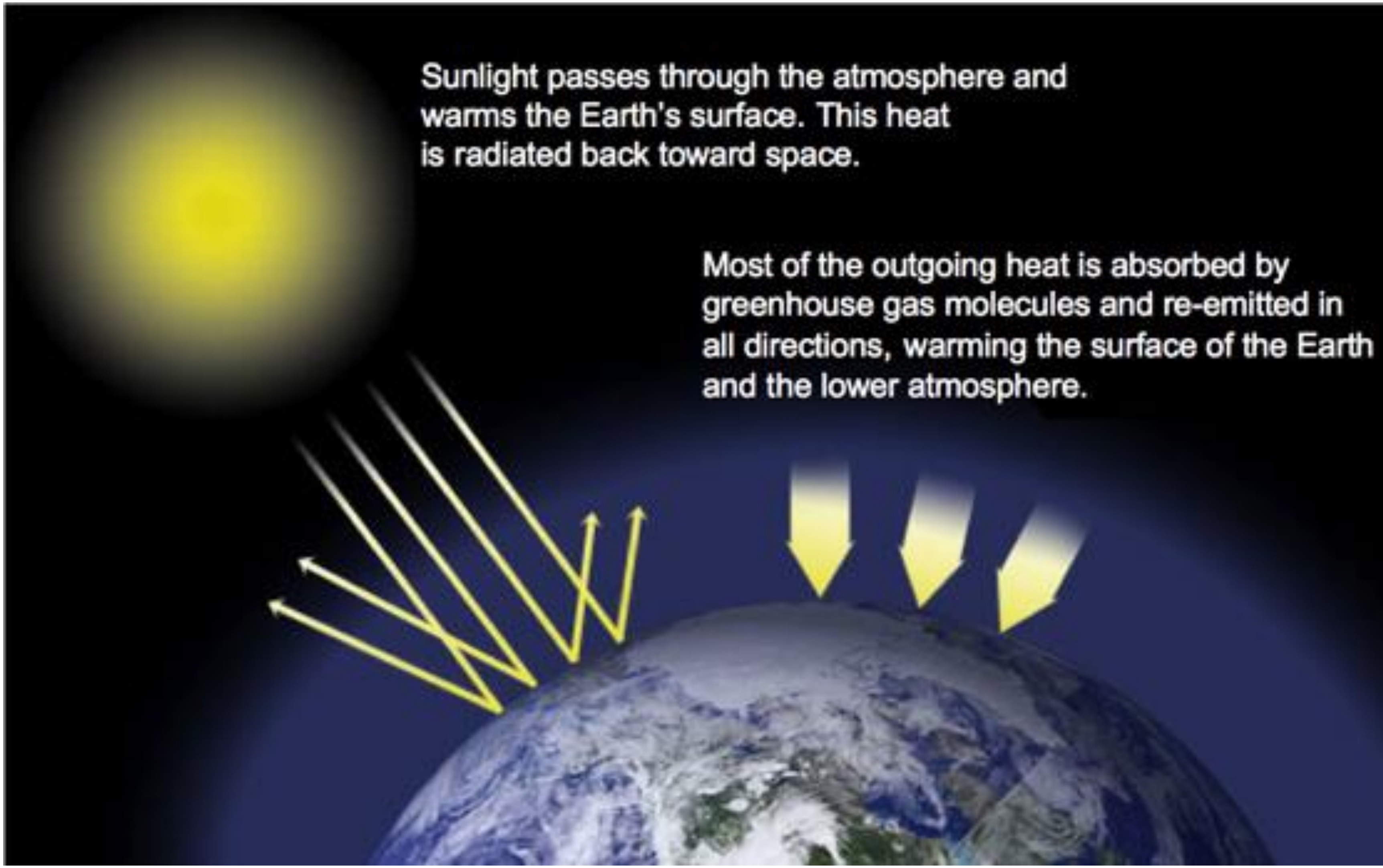
4) Increased CO_2 is the primary driver of greenhouse effect

- 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.



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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.

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

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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.

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.

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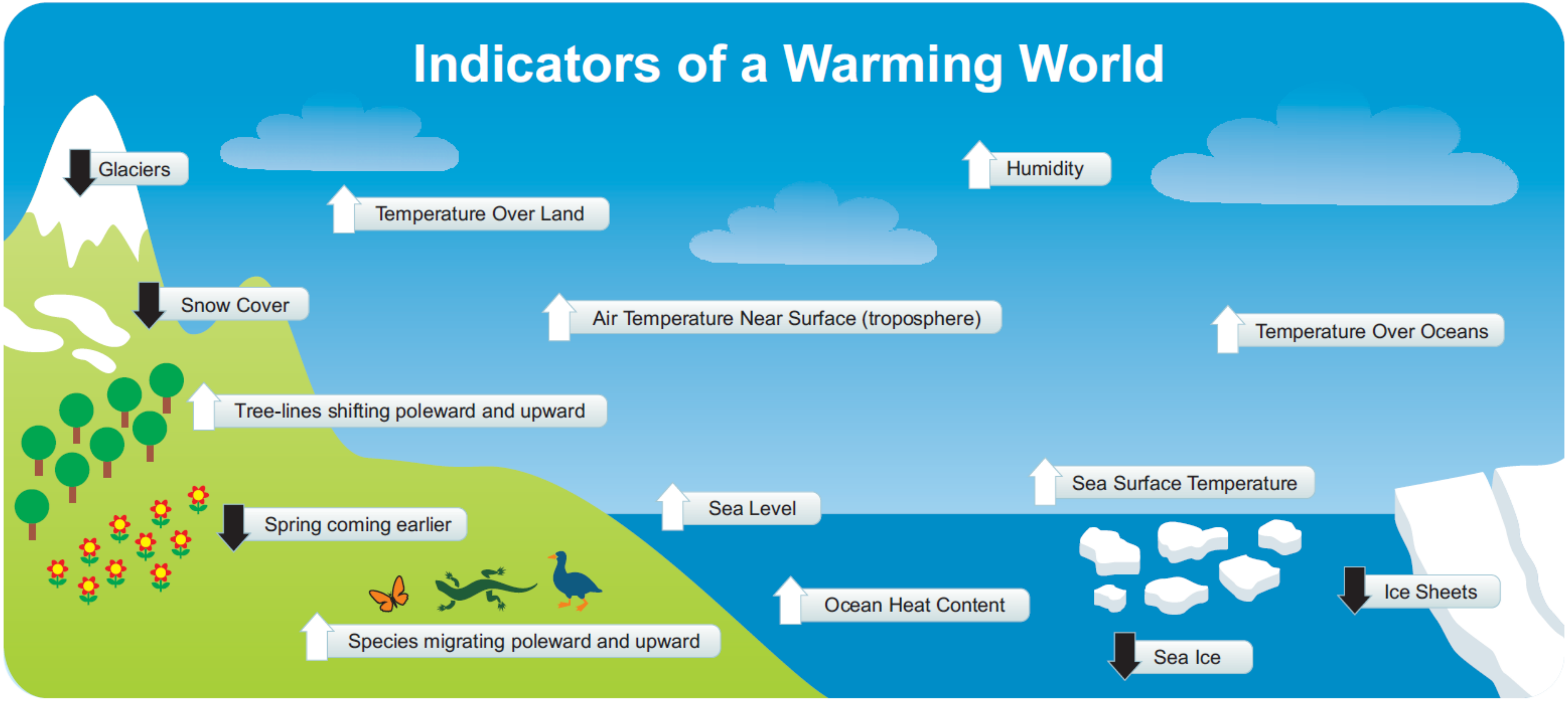

Parmesan & Yohe 2003[32], NOAA[34]

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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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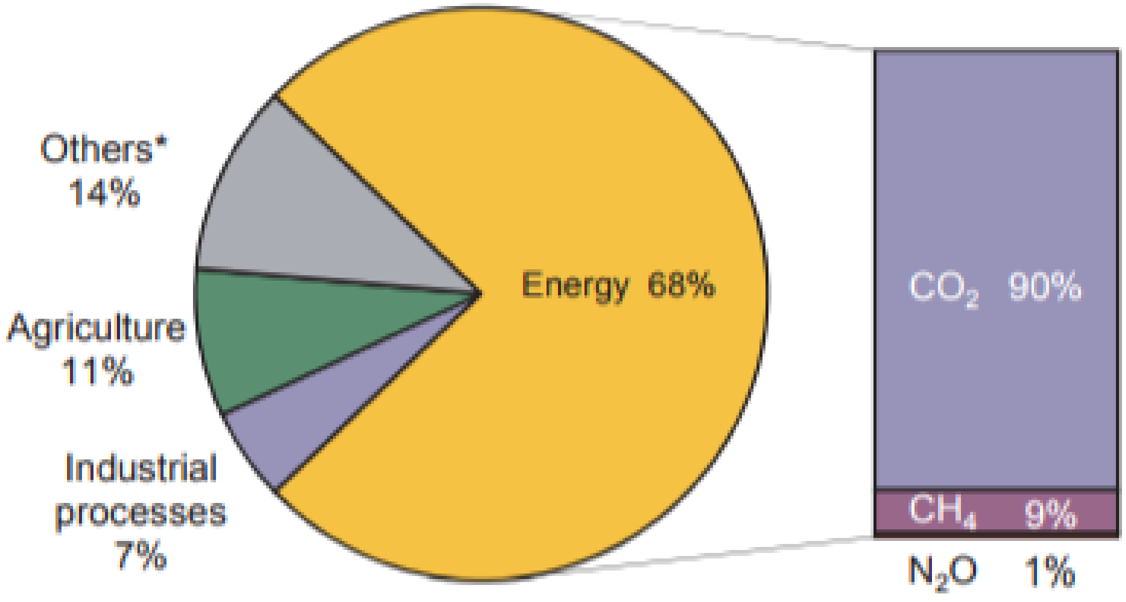
Estimated shares of global anthropogenic GHG



* Others include large-scale biomass burning, post-burn decay, peat decay, indirect N_2O emissions from non-agricultural emissions of NO_x and NH_3, Waste, and Solvent Use.

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Recent trends in CO_2 emission – energy perspective

- Fossil fuels account for most of the world energy supply (82% of the global energy supply in 2012).
- Since 1870, CO_2 emissions from fuel combustion have risen exponentially.
- Since the Industrial Revolution, annual CO_2 emissions from fuel combustion increased from near zero to almost 32 $GtCO_2$ in 2012.

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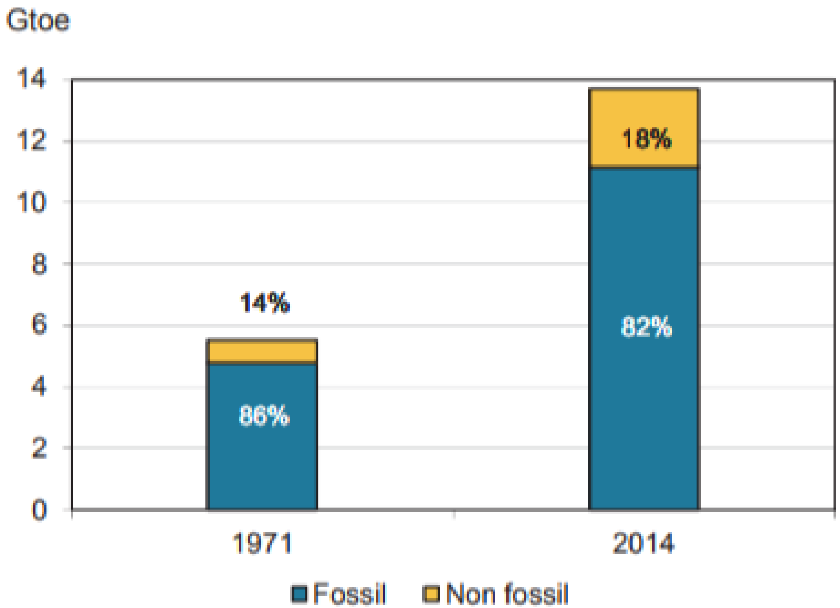
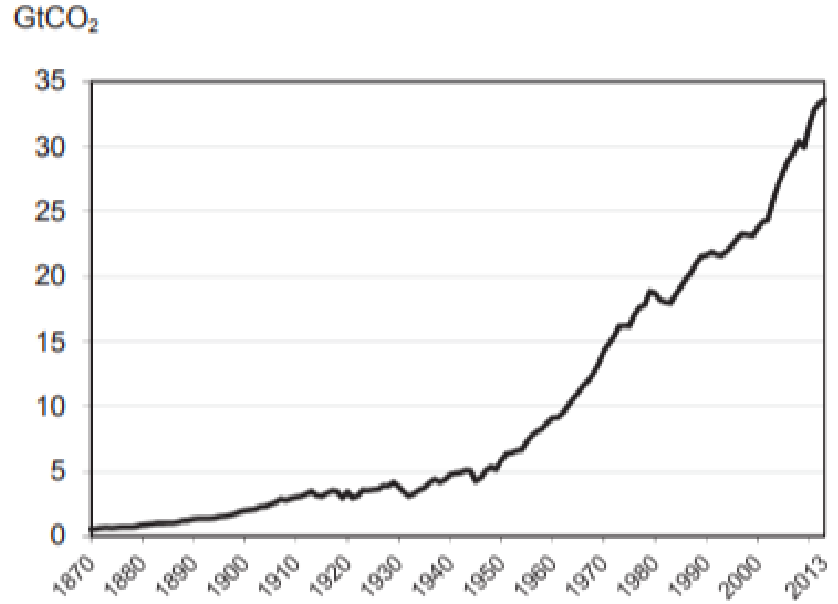
Figure 2. World primary energy supply*



* World primary energy supply includes international bunkers. In this graph, non-renewable waste is included in Fossil.

Figure 3. Trend in CO_2 emissions from fossil fuel combustion



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

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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.

Top 10 emitting countries in 2012

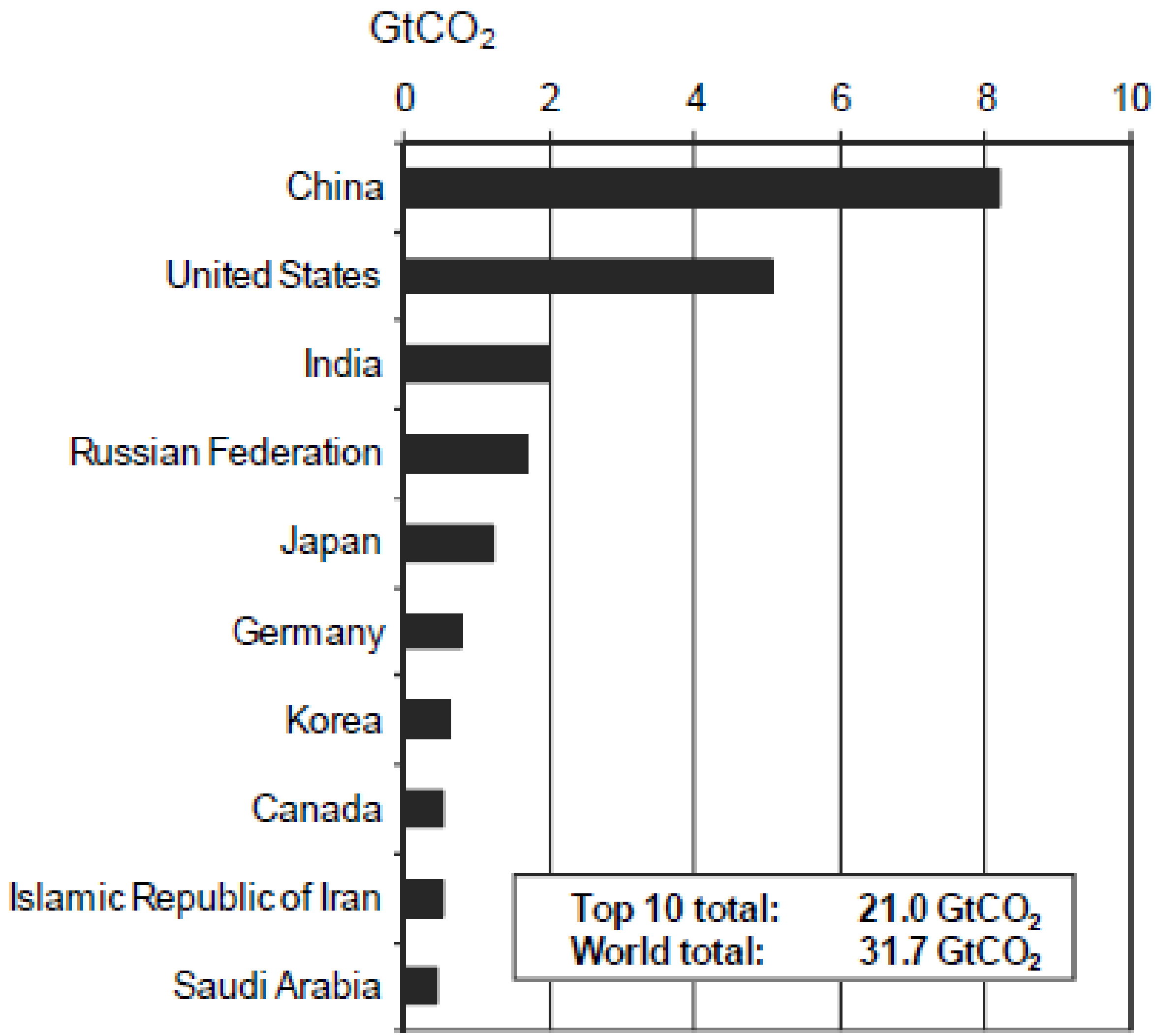

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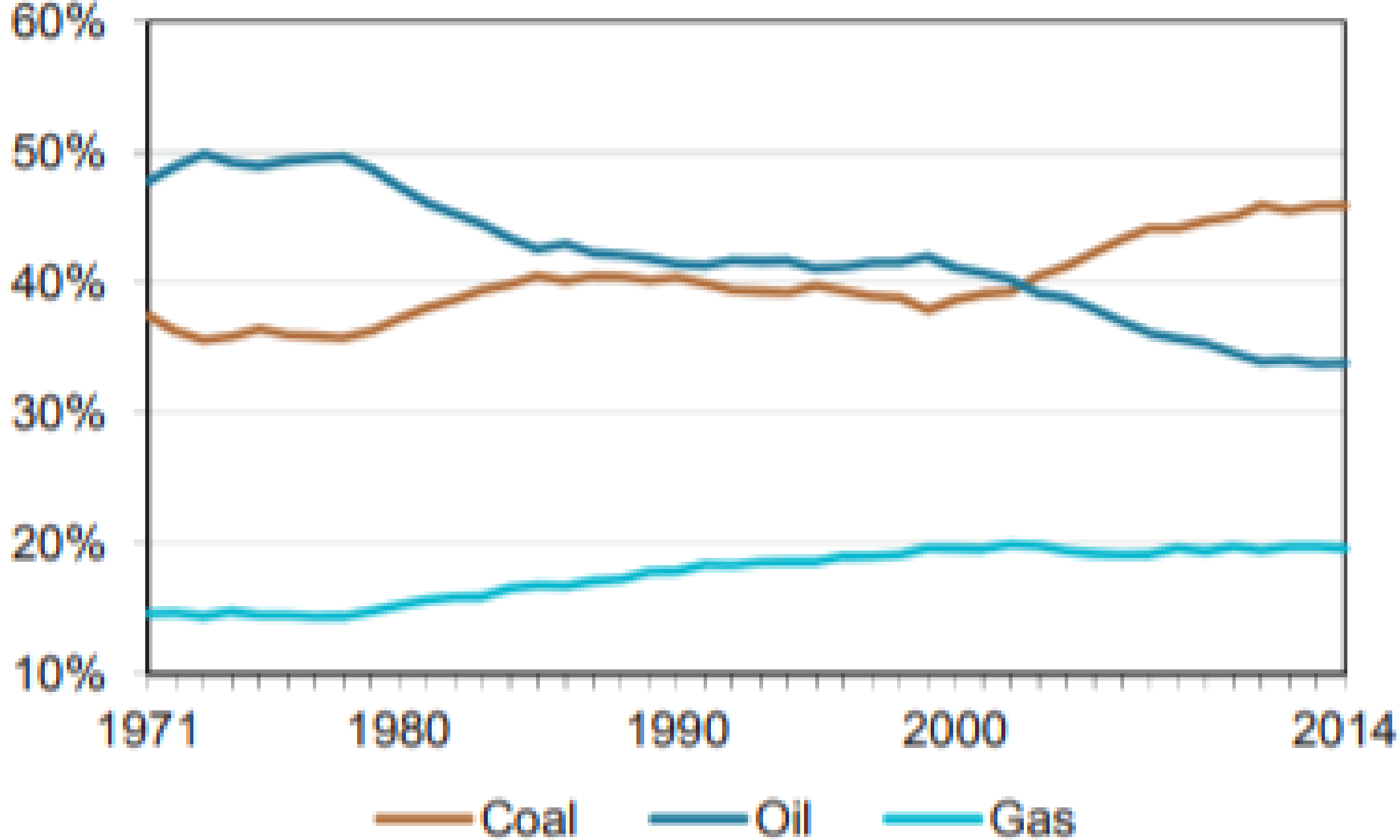
Figure 7. Fuel shares in global CO_2 emissions



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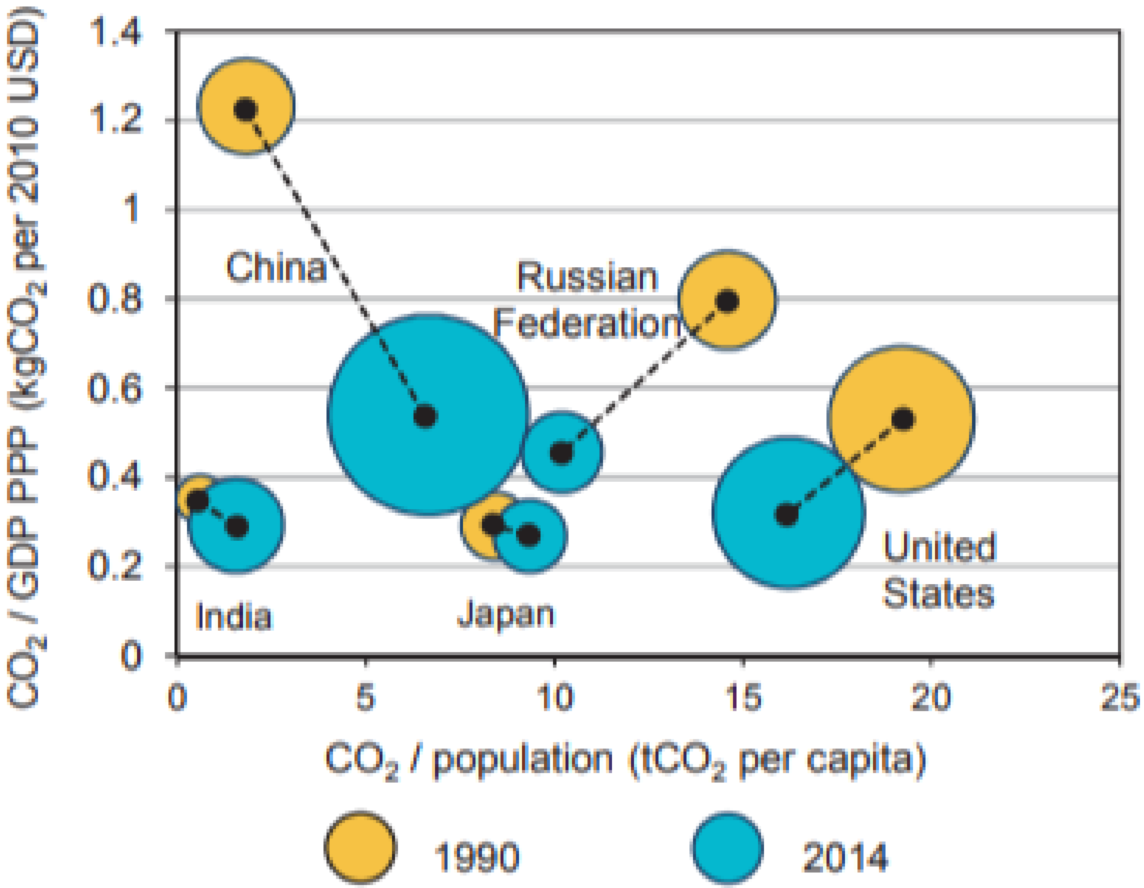
Recent trends in CO2 emission

- 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.

Summary

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

Sources

- IEA: CO_2 Emission from Fuel Combustion
- IPCC: Climate Change 2013: The Physical Science Basic

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