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

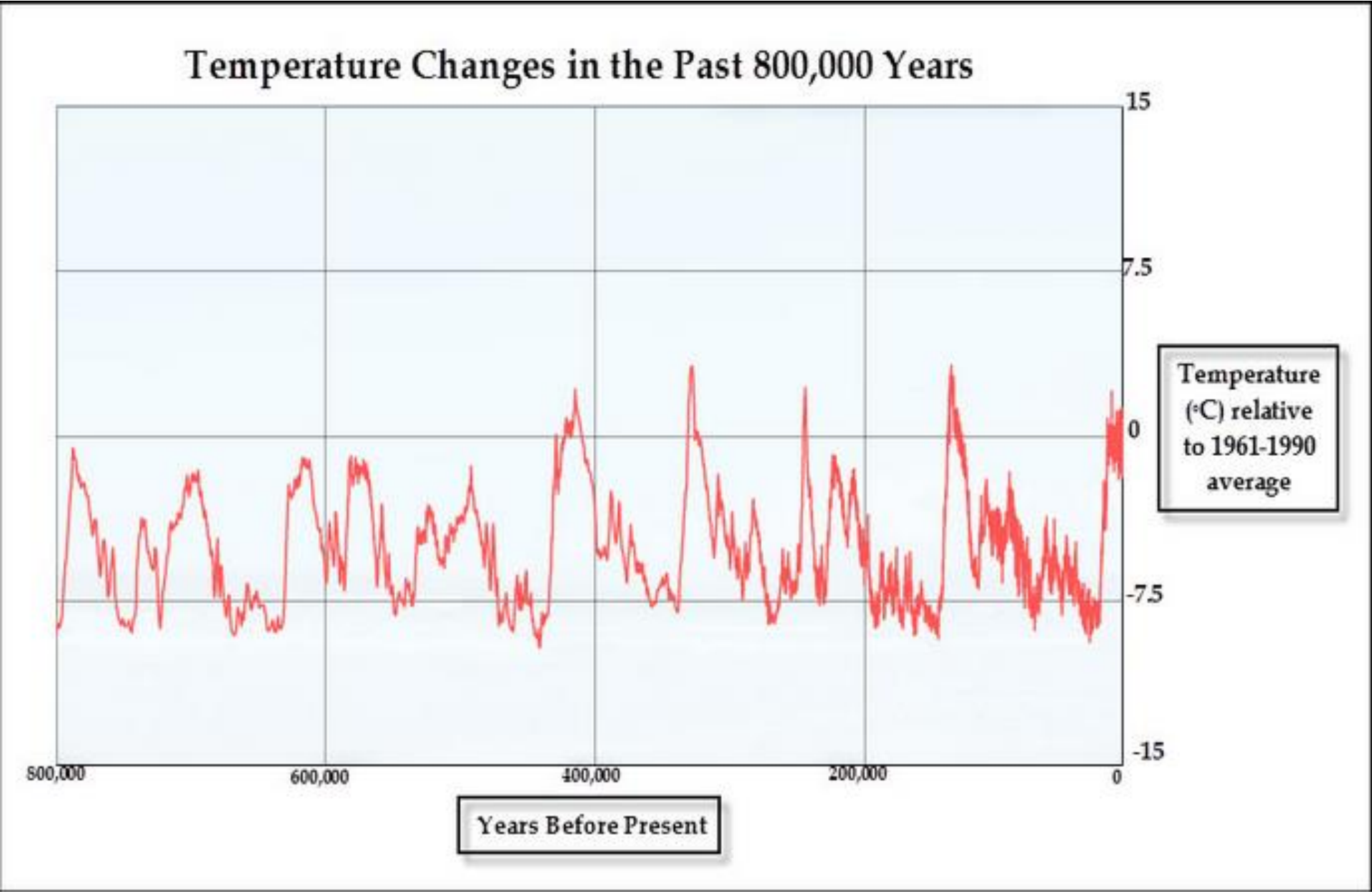
1) The planet´s temperature is rising

- Over the past 130 years the global average temperature has increased by 0,8°C (more than half of that in last 35 years)
- Ancient ice samples (from Antarctica and other places) are analysed – their layers are dated and gas bubles inside are analysed
  - CO2 concentration is measured by infrared spectroscopy or mass spectrometry
  - Isotope ratios of water molecules are measured to determine historical temperatures

1) The planet´s teperature 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



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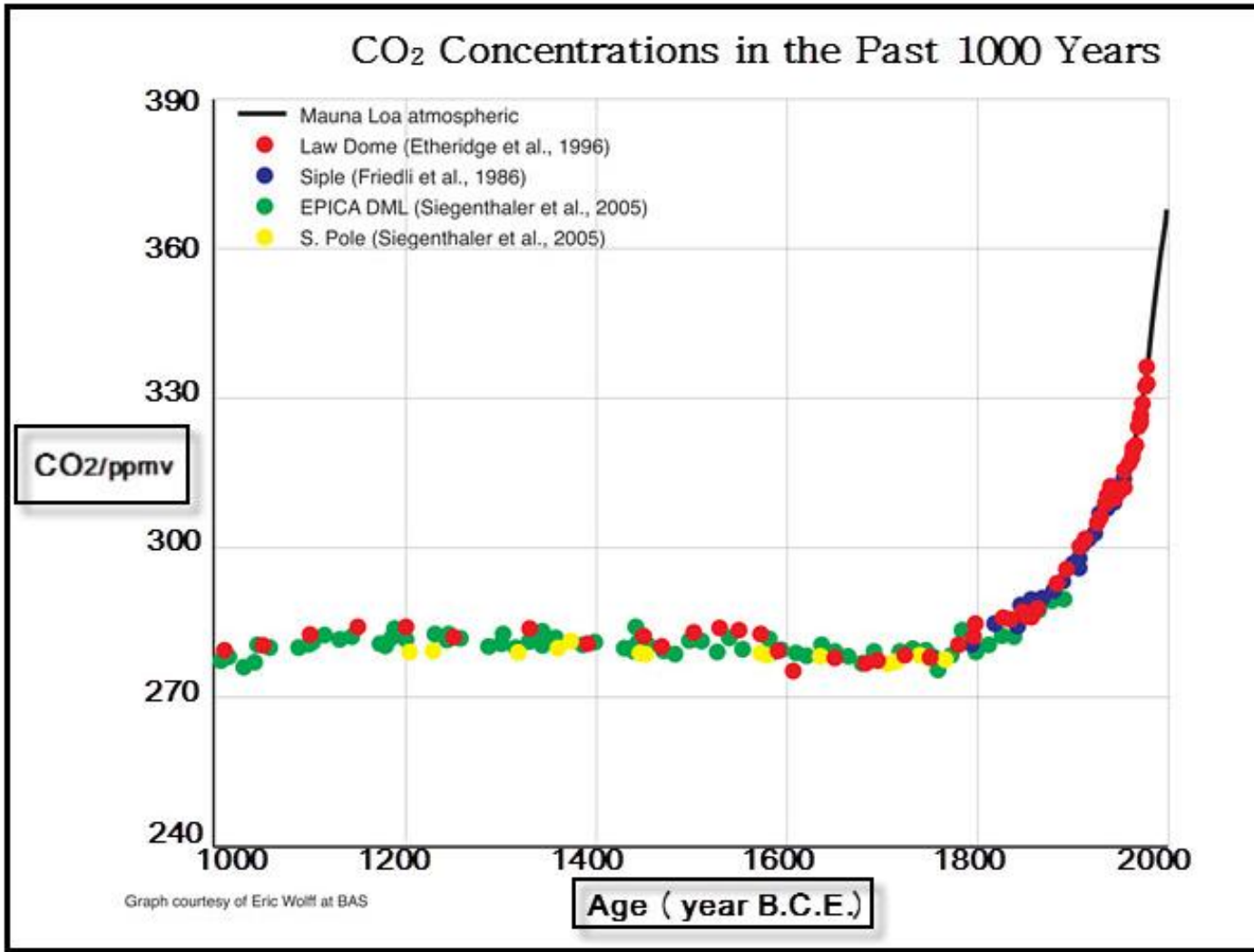
2) CO_2 level is increasing (also methane and nitrous oxide)

Rates of Change in the Past 250 Years



3) We are responsible for the increase in CO_2

- 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 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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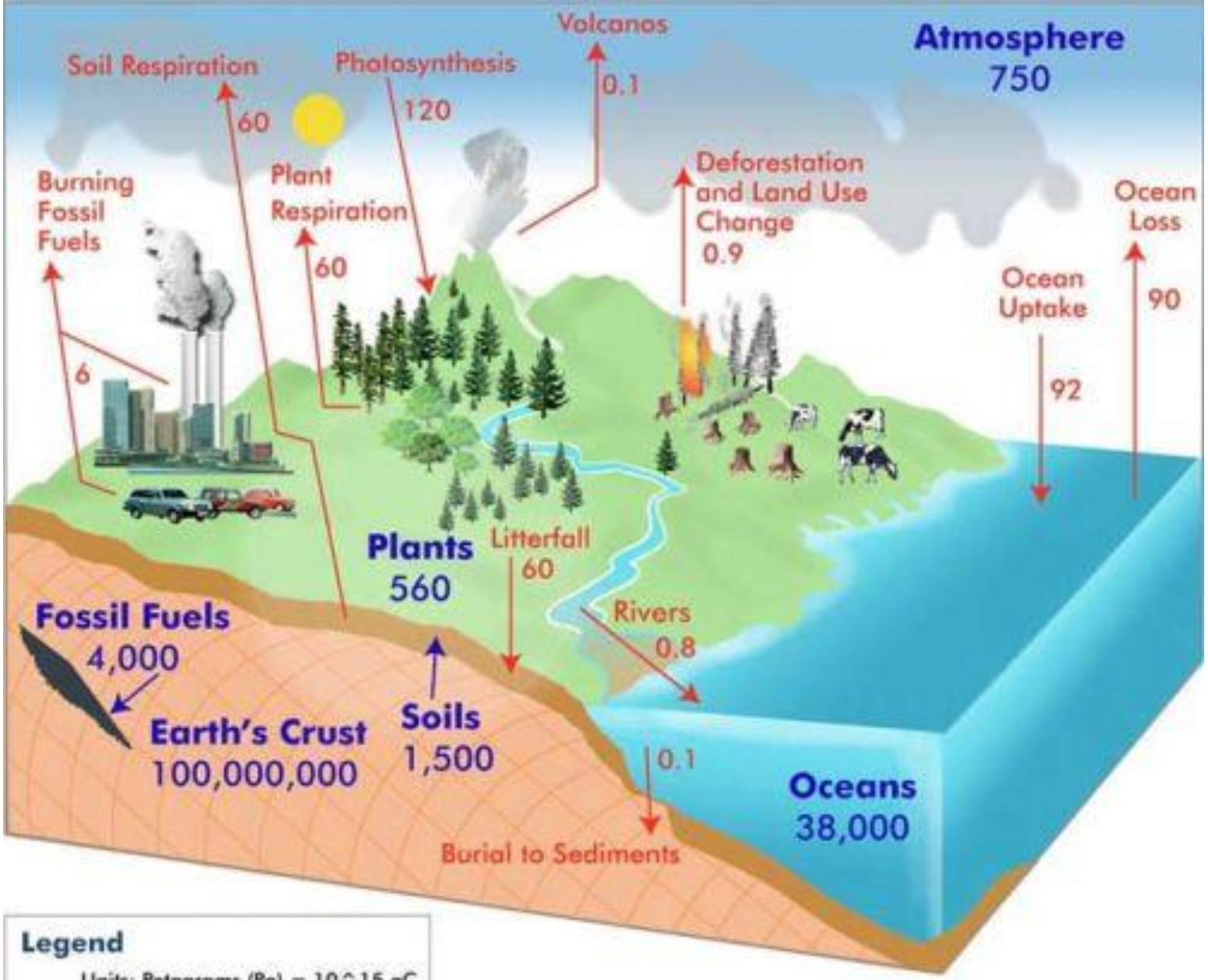
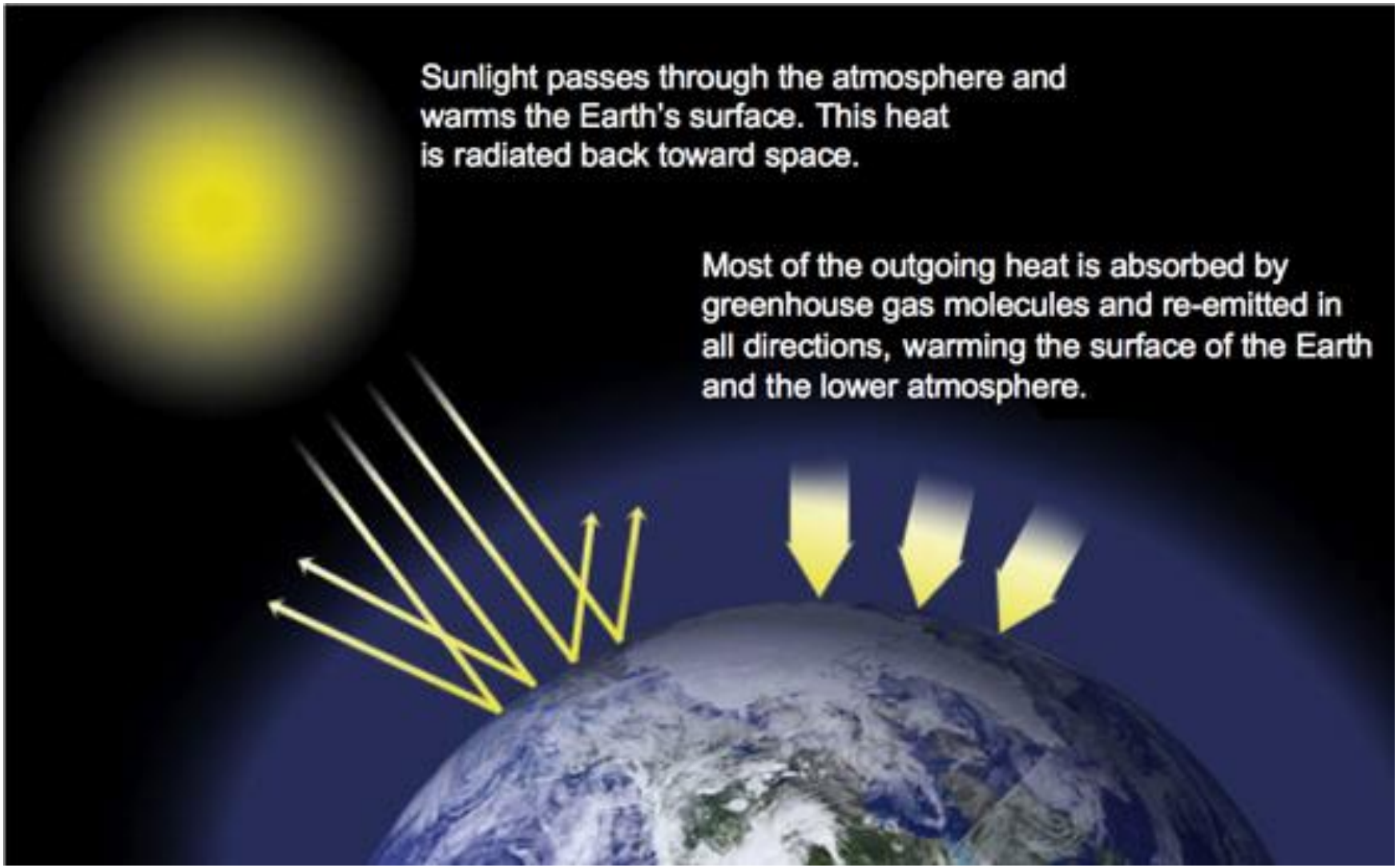


4) Increased CO_2 is the primary driver of greenhouse effect

- 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

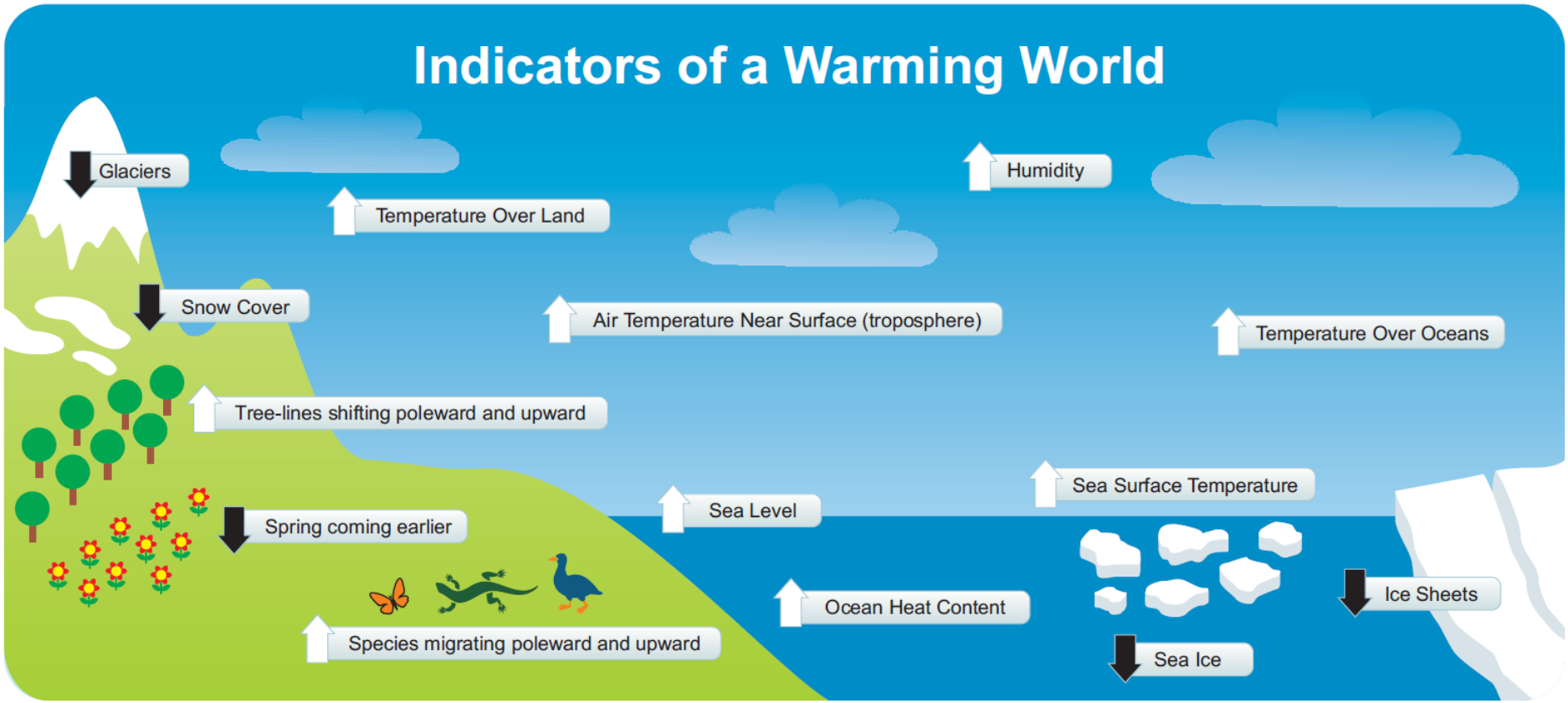
- CO2 traps infrared radiation (thermal radiation). Proven by laboratory experiments and satellites (satelit data from 1970; direct experimental evidence) that find less heat escaping out to space over the las few decades
- Temperature – average kinetic energy of the molecules within a substance = the more radiation trapped in the atmosphere the higher temperature is

Climate change explained

- The extra CO2 in the atmosphere amplified the original warming (positive feedback).

- Positive/negative feedbacks – examining different period throughout Earth´s history shows that positive feedbacks amplify any initial warming
- Positive feedback – warming keeps more water in the air and more wapour traps more heat
- Negative feedback – more water vapour causes more clauds, reflecting sunlight

Climate change explained



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

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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

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)
  - 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 sever droughts

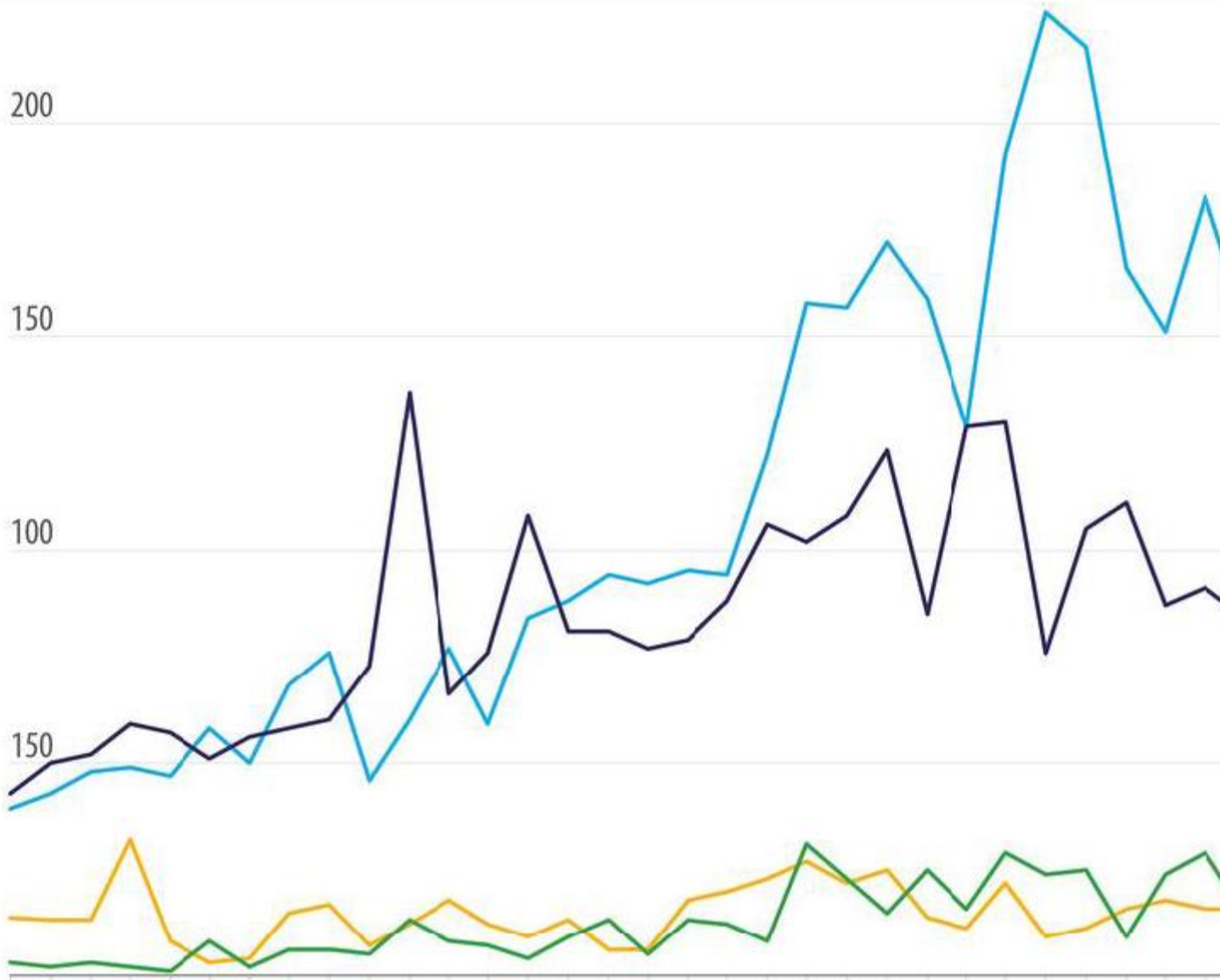
lumber of Climate-related Disasters Around the World (1980-2011)

3455 FLOODS

2689 STORMS

470 DROUGHTS

395 EXTREME TEMPS



UNISDR
nited Nations Office for Disaster Risk Reduction
ww.unisdr.org
d on 13 June 2012
OURCES
T - http://www.emdat.be/ - The OFDA/CRED International
r Database; Data version: 13 June 2012 - v12.07
itarian Symbol Set(2008):
ww.ungiwg.org/nap/guideline.php

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
FLOOD	39	43	48	49	47	58	50	68	76	46	60	77	59	84	88	94	92	95	94	122	158	157	172	159	129	193	226	218	166	151	188
STORM	43	50	52	59	57	51	56	58	60	73	137	66	76	108	81	81	77	79	88	106	102	108	123	85	129	130	76	105	111	87	9
DROUGHT	14	13	13	32	8	3	4	15	17	7	12	18	12	9	13	6	6	18	20	23	27	22	25	14	11	22	9	11	16	18	16
EXTREME TEMPERATURE	3	2	3	2	1	8	2	6	6	5	13	8	7	4	9	13	5	13	12	8	31	23	15	25	16	29	24	25	9	24	29

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
- Some others

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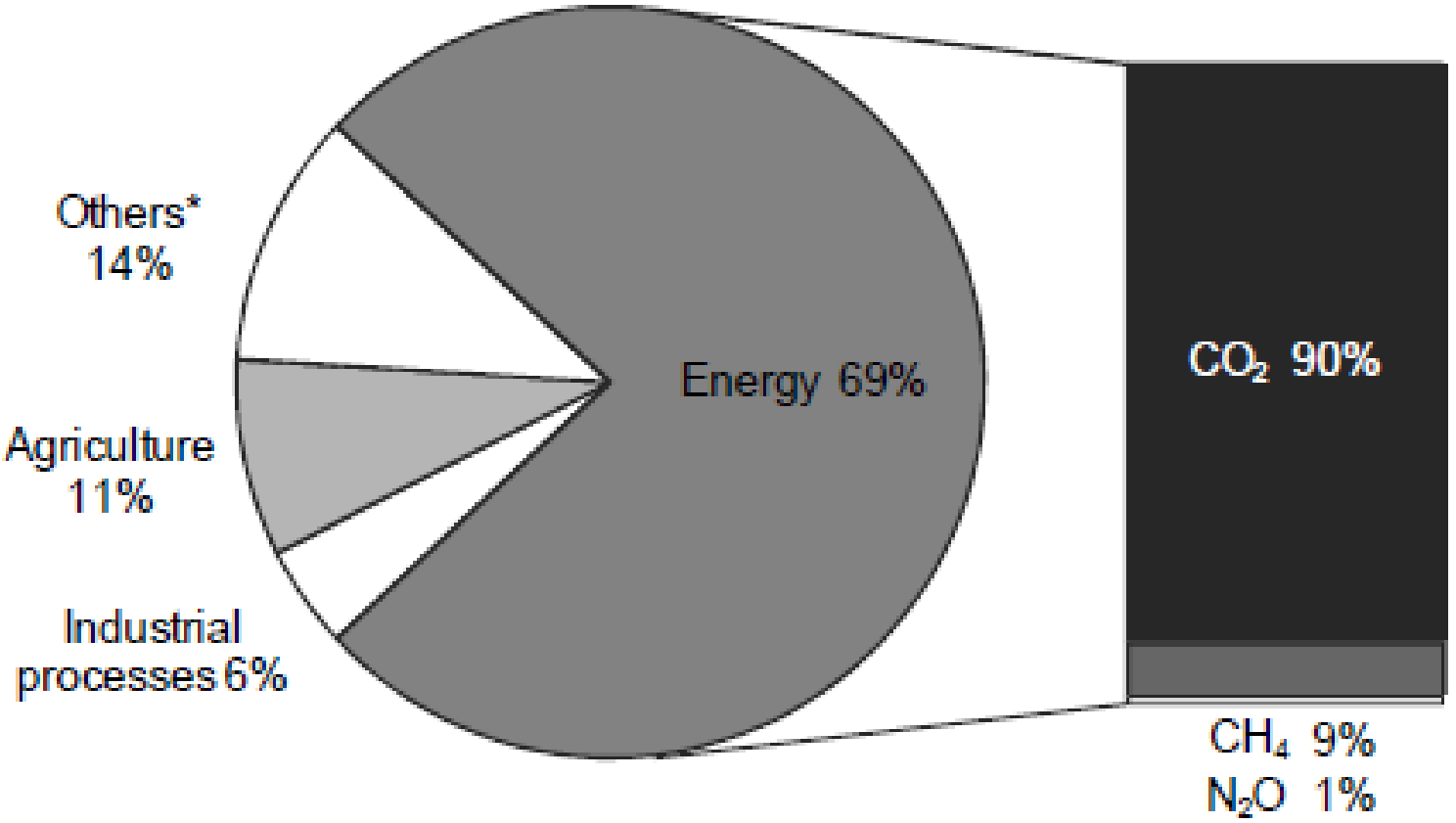
Summary

- 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 N_2O emissions from non-agricultural emissions of NO_x and NH_3, Waste, and Solvent Use.

Source: IEA estimates for CO_2 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

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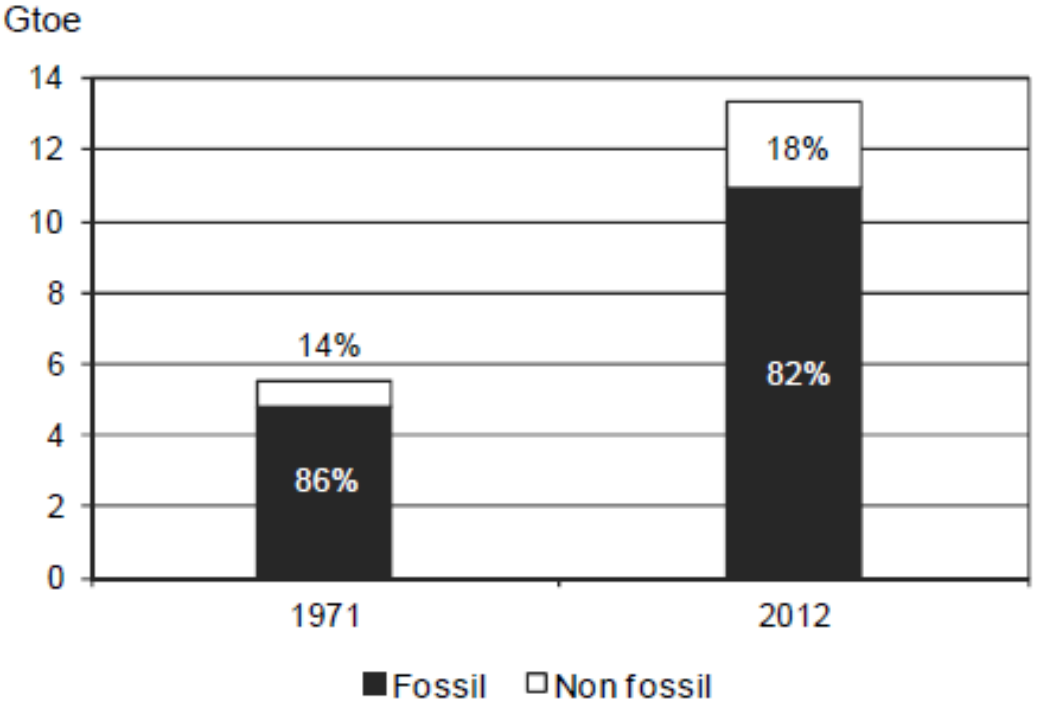
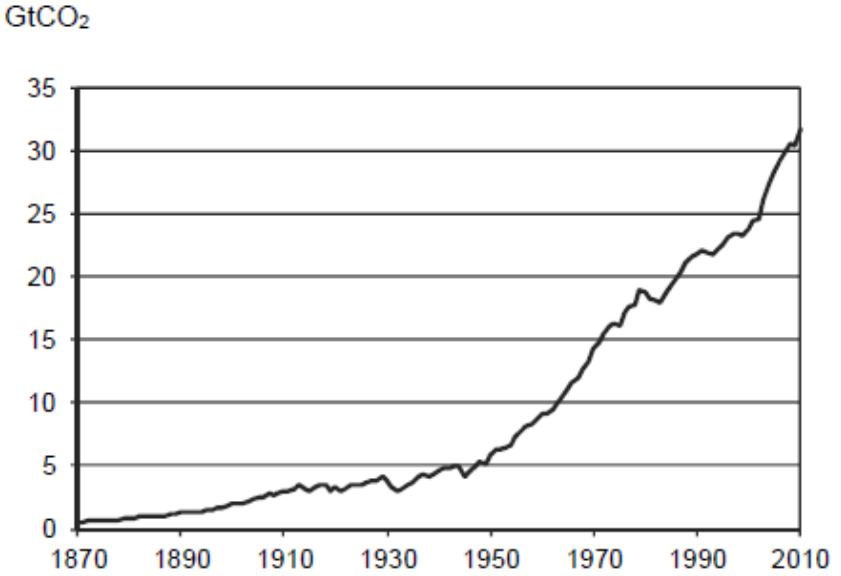
World primary energy supply



Trend in CO_2 emissions from fossil fuel combustion

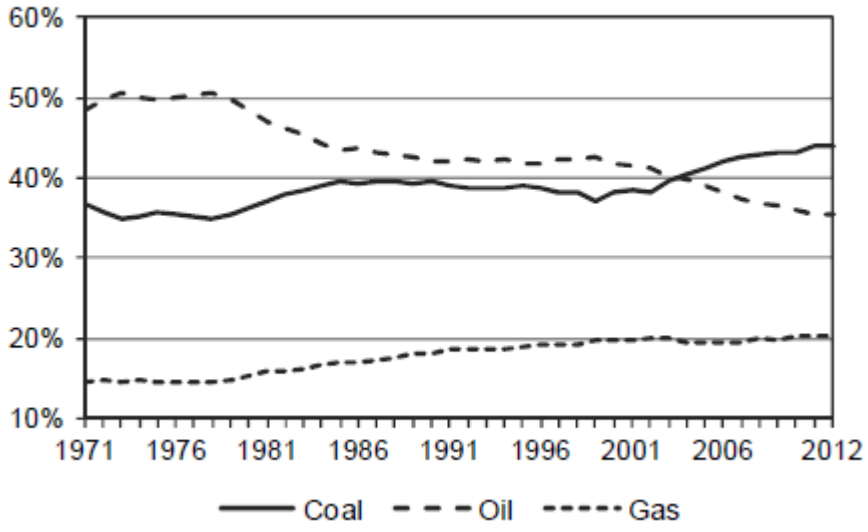


Source: Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, US Department of Energy, Oak Ridge, Tenn., United States.

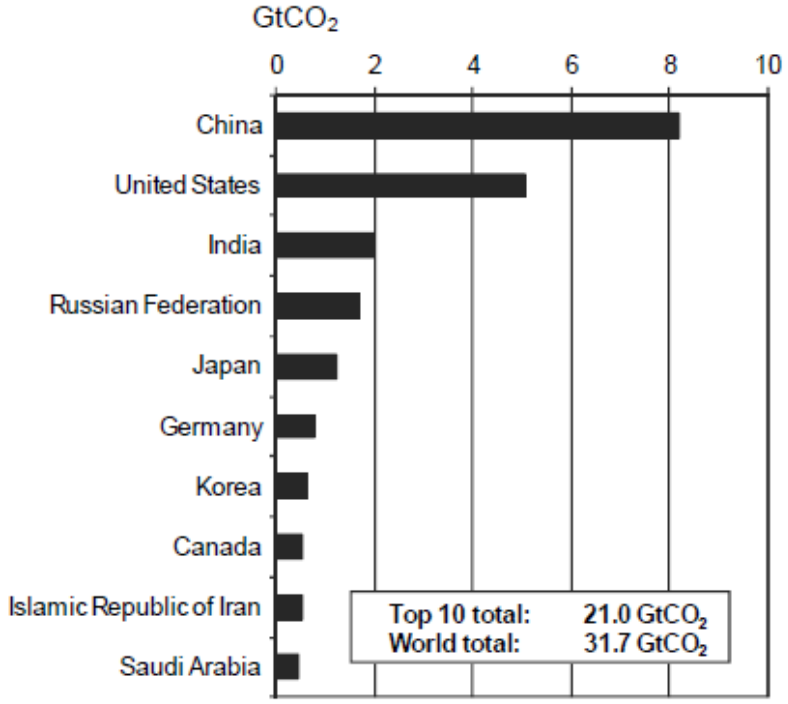
Recent trends in CO2 emission – energy perspective

- 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 CO_2 emissions



Top 10 emitting countries in 2012



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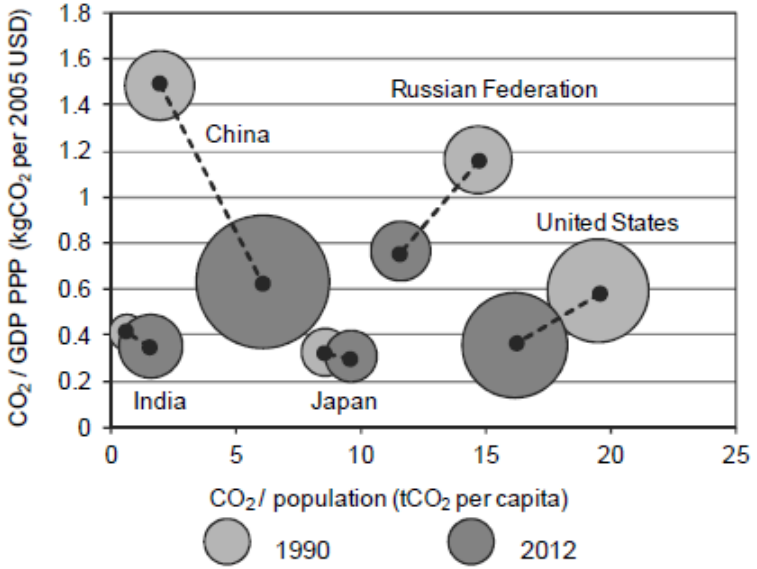
Recent trends in CO2 emission

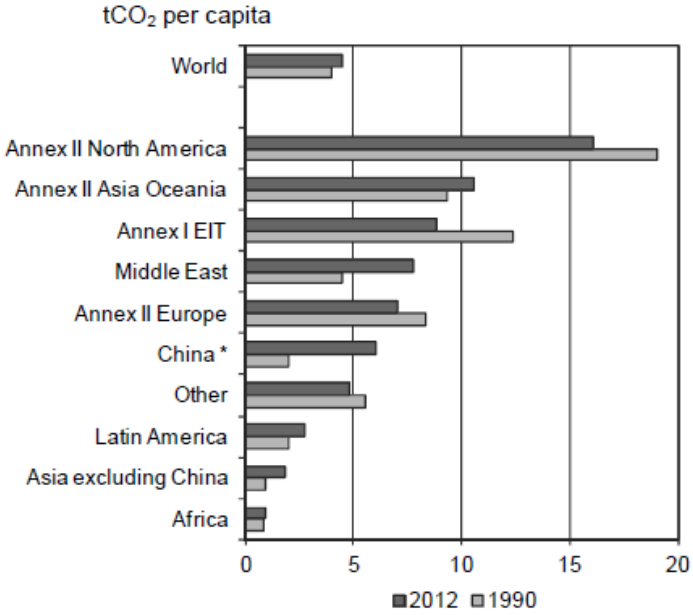
- Emissions per capita generally decrease in time accross regions
- All top five emitters reduced emissions per unit of GDP, while emissions per capita showed contrasting trends

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.

CO_2 emissions per capita by major world regions



* China includes Hong Kong, China.

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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

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