Climate Change

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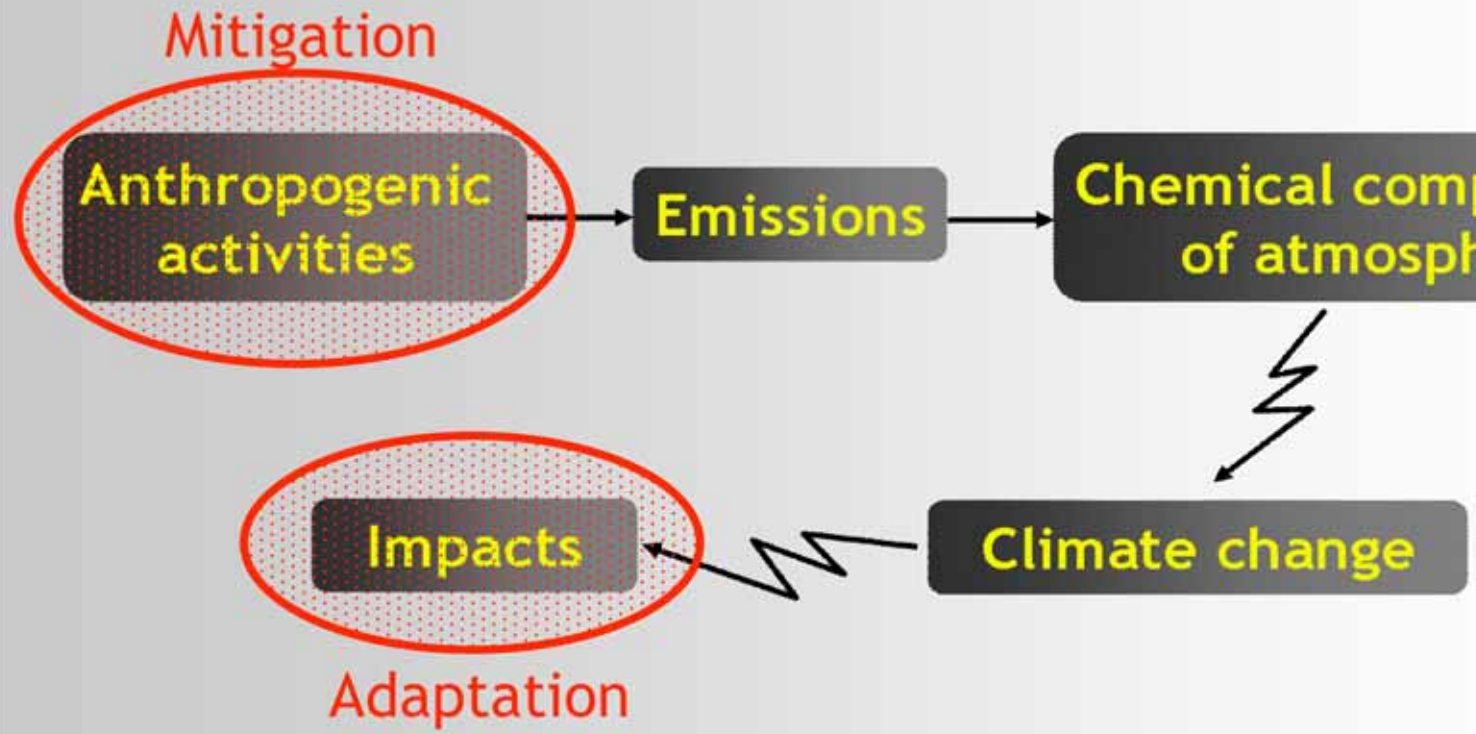
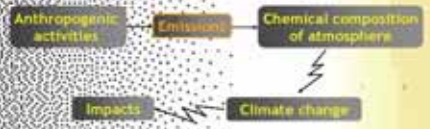
The Causal Chain

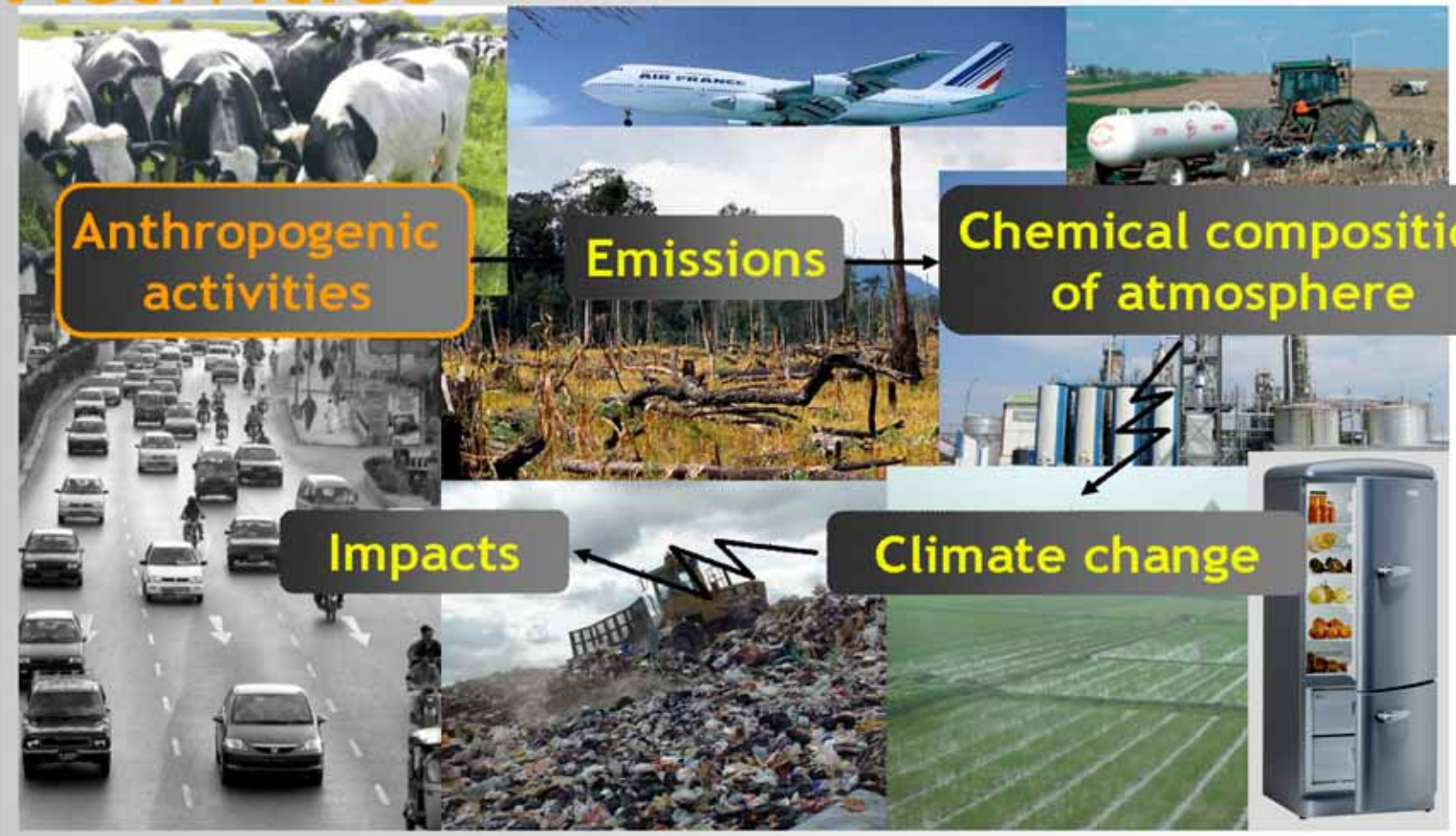


Main Greenhouse Gases

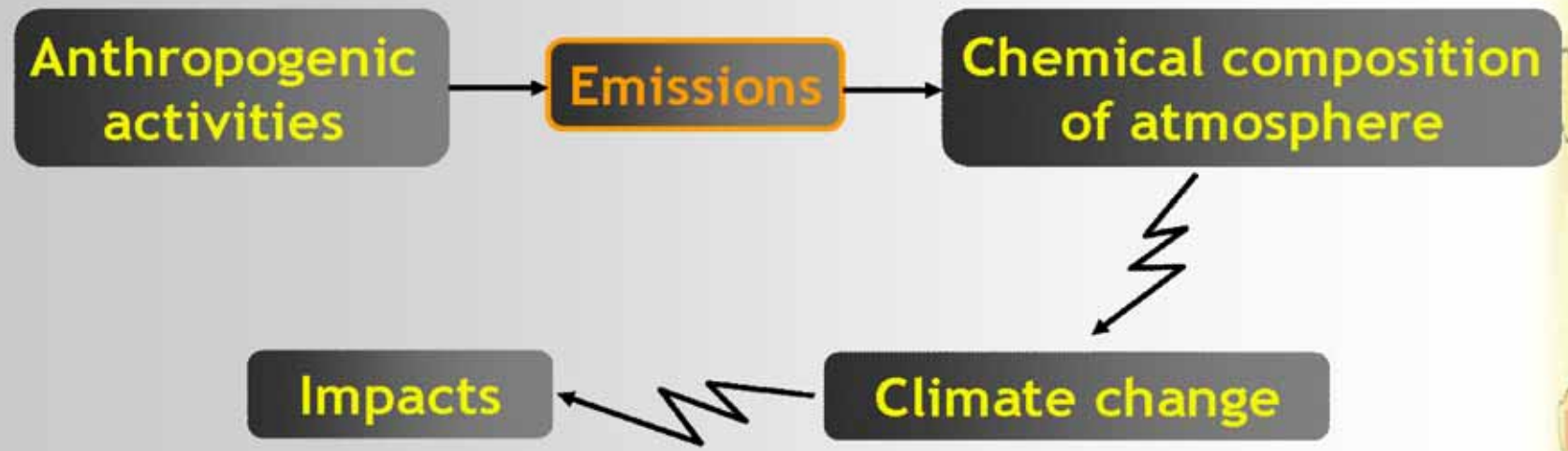


Greenhouse gases	Chemical formula	Global Warming Potential (GWP for 100 year time horizon)
Carbon dioxide	CO_2	1
Methane	CH_4	23
Nitrous oxide	N_2O	296
F-Gases (Fluorinated species)	HFCs /PFCs/ SF_6	variable (SF_6: 222000)

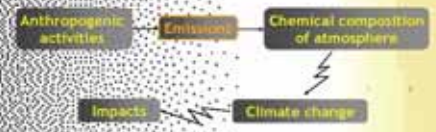
Anthropogenic Activities



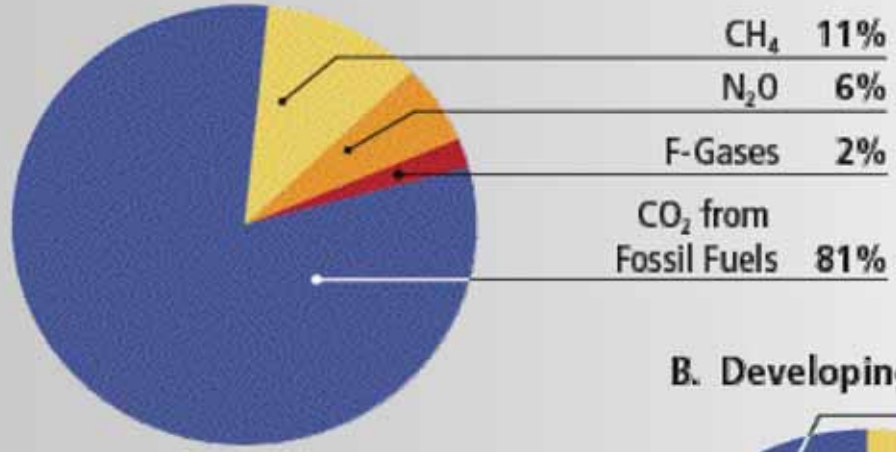
Emission


Anthropogenic activities
Emissions
Chemical composition of atmosphere
Climate change
Impacts

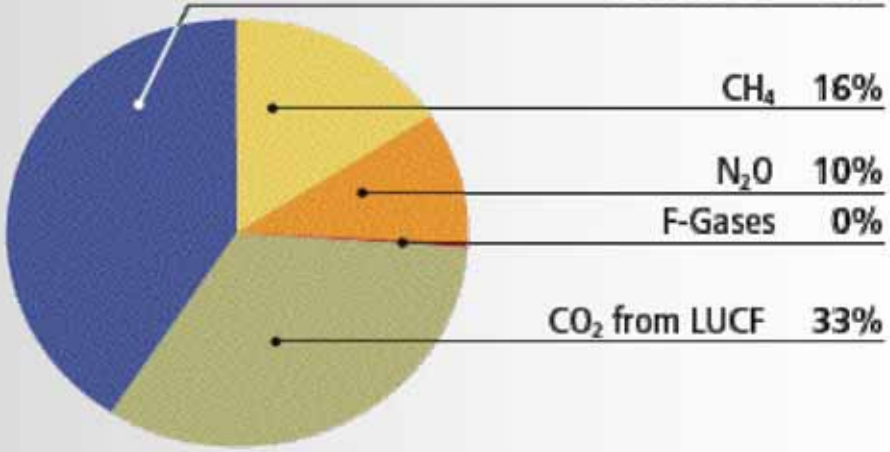
Shares of emitted GHGs
(CO_2-eq weighted)



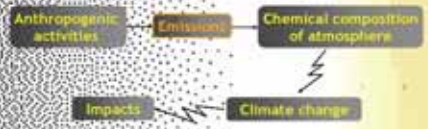
A. Developed Countries



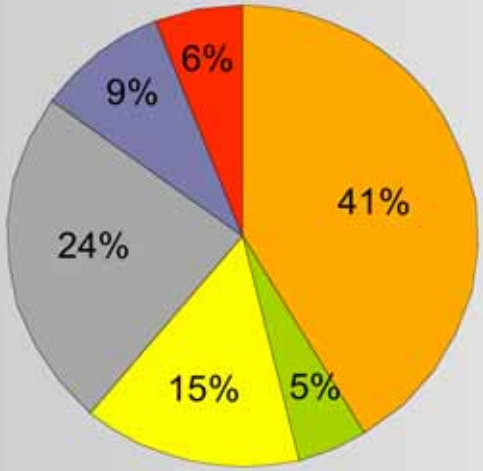
B. Developing Countries



CO_2 Emissions by Sector

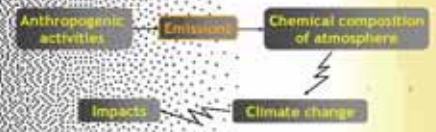


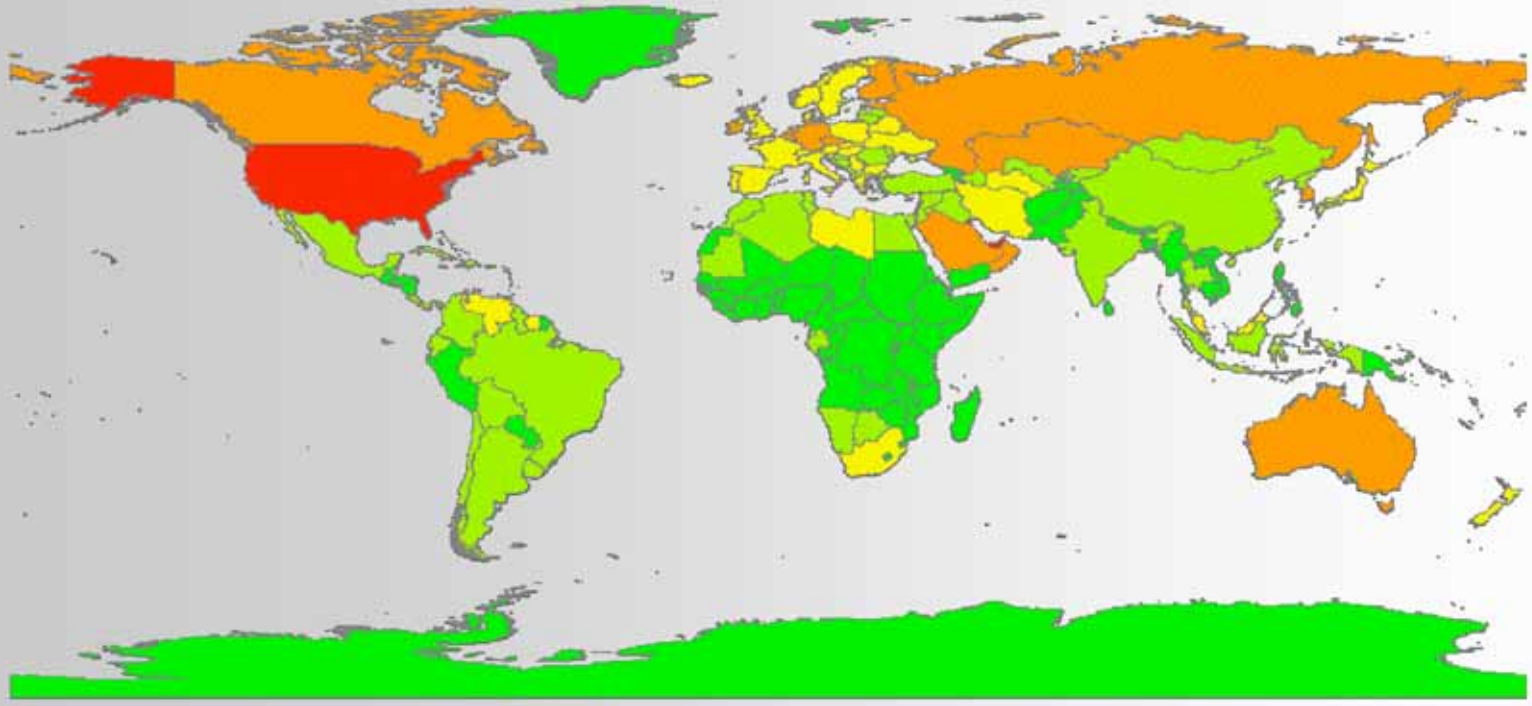
Developed Countries (2001)



- Public Electricity & Heat Production
- Other Energy Industries
- Manufacturing Indust. & Construction
- Transport
- Residential
- Other Commercial, Public, and Agricultural Sectors

CO_2-Emissions, World





kg CO2 per capita and year

- 0 - 1000
- 1001 - 5000
- 5001 - 10000
- 10001 - 20000
- 20001 - 30000

Global CO_2 emissions in the year 2002

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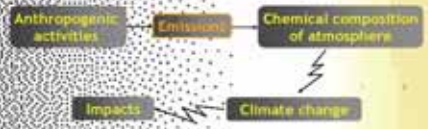
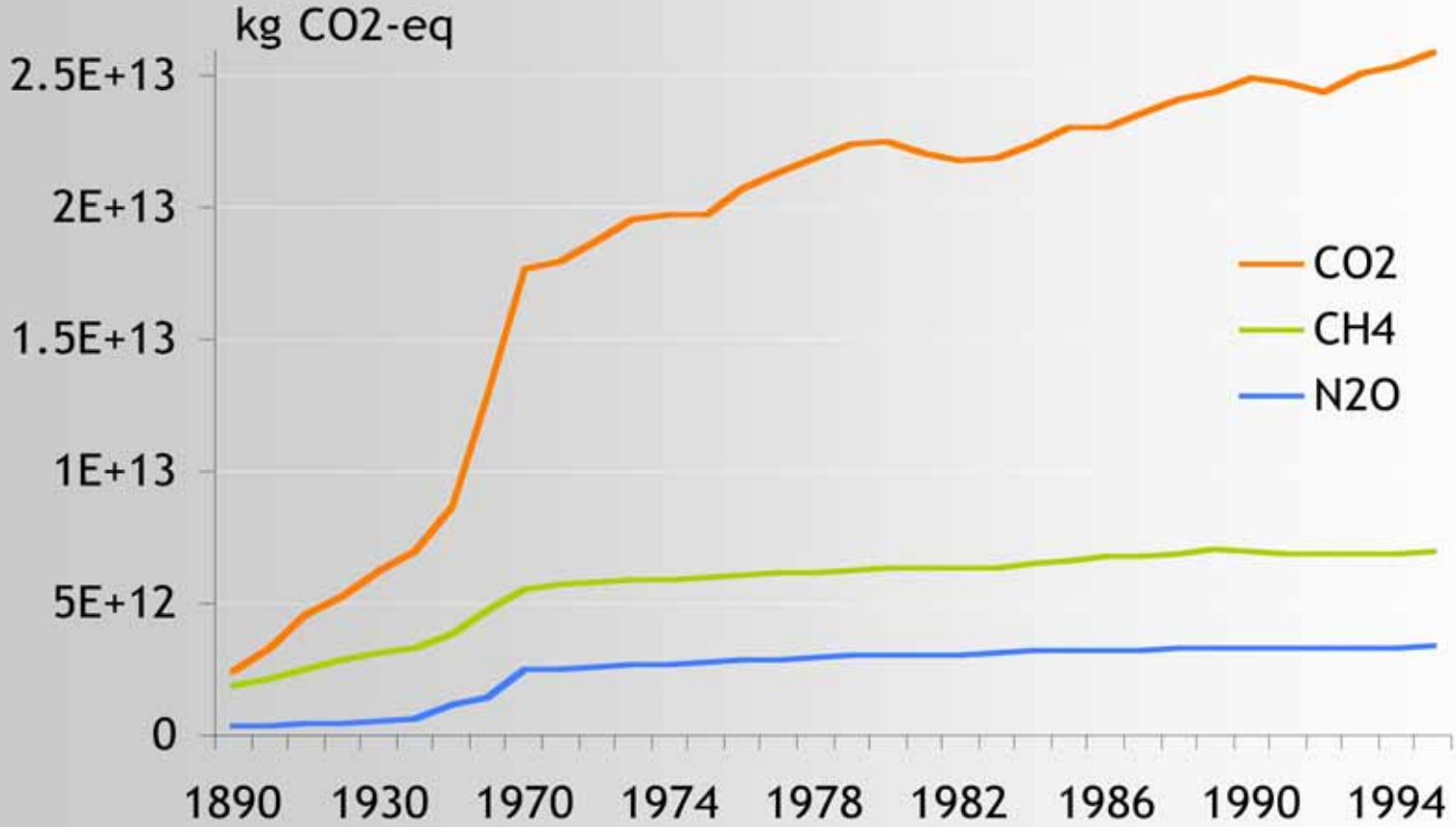
GHG Emissions since 1890





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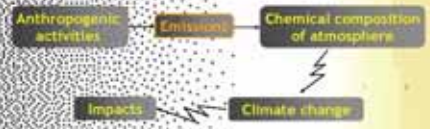
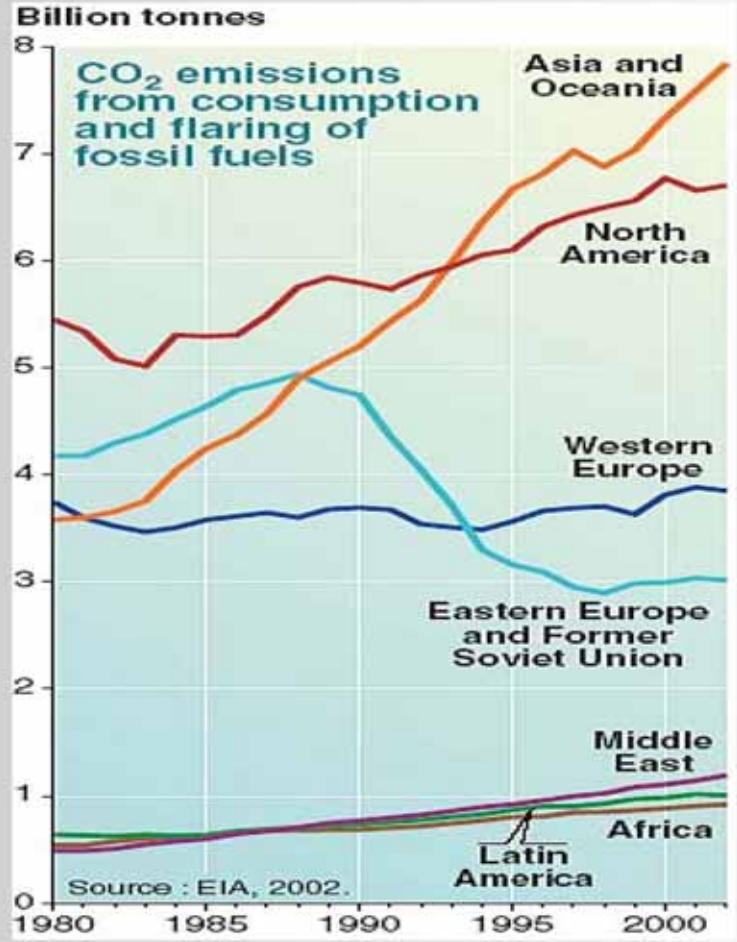
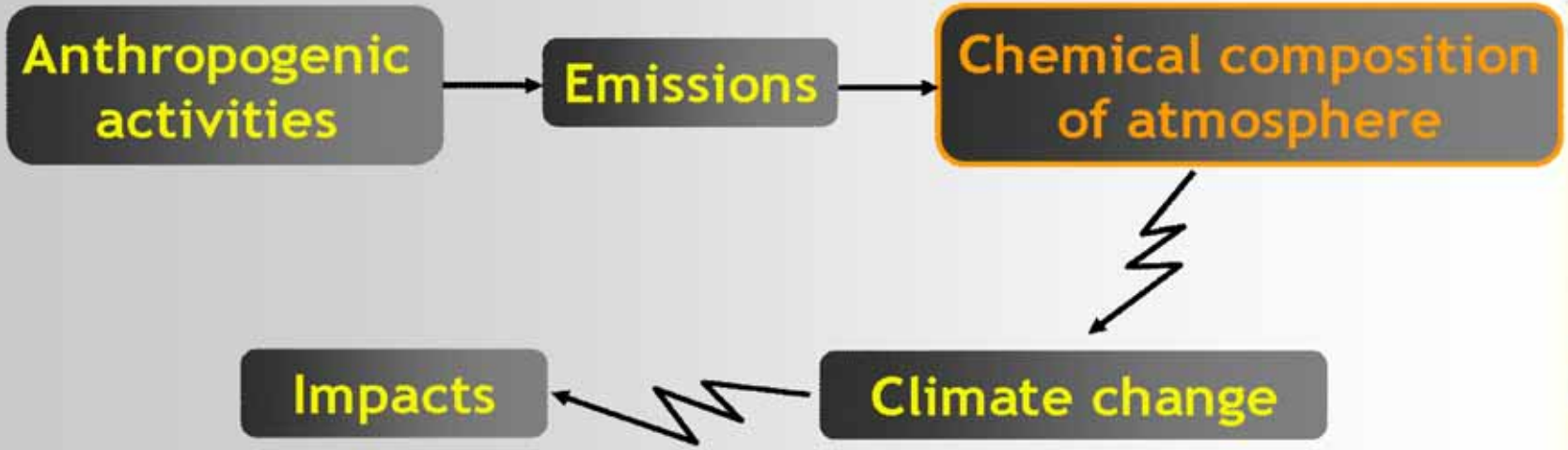
CO_2 Emissions since 1890

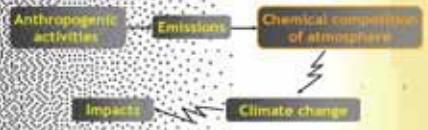


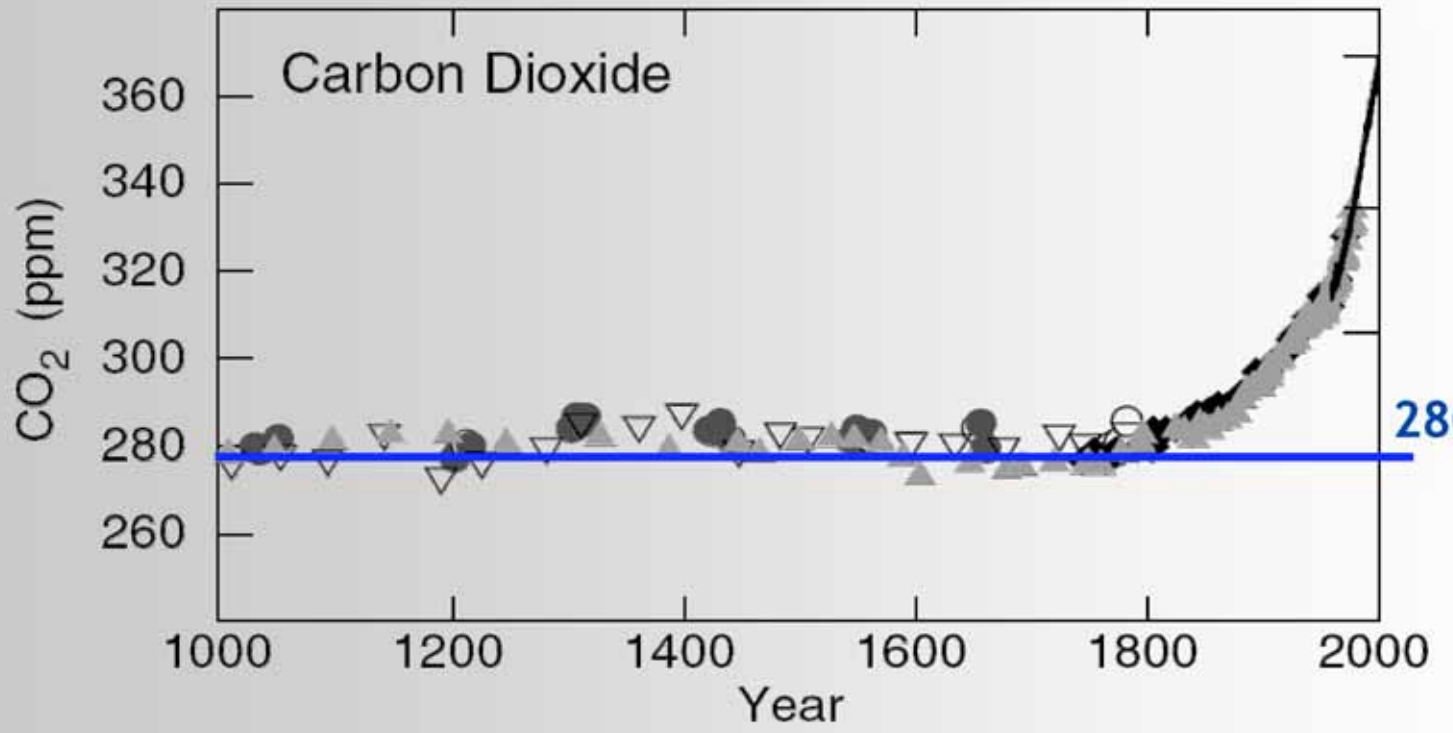


Composition of Atmosphere



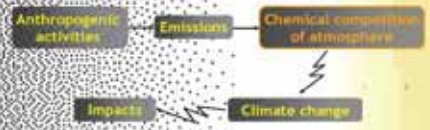
CO_2 Concentration preindustrial

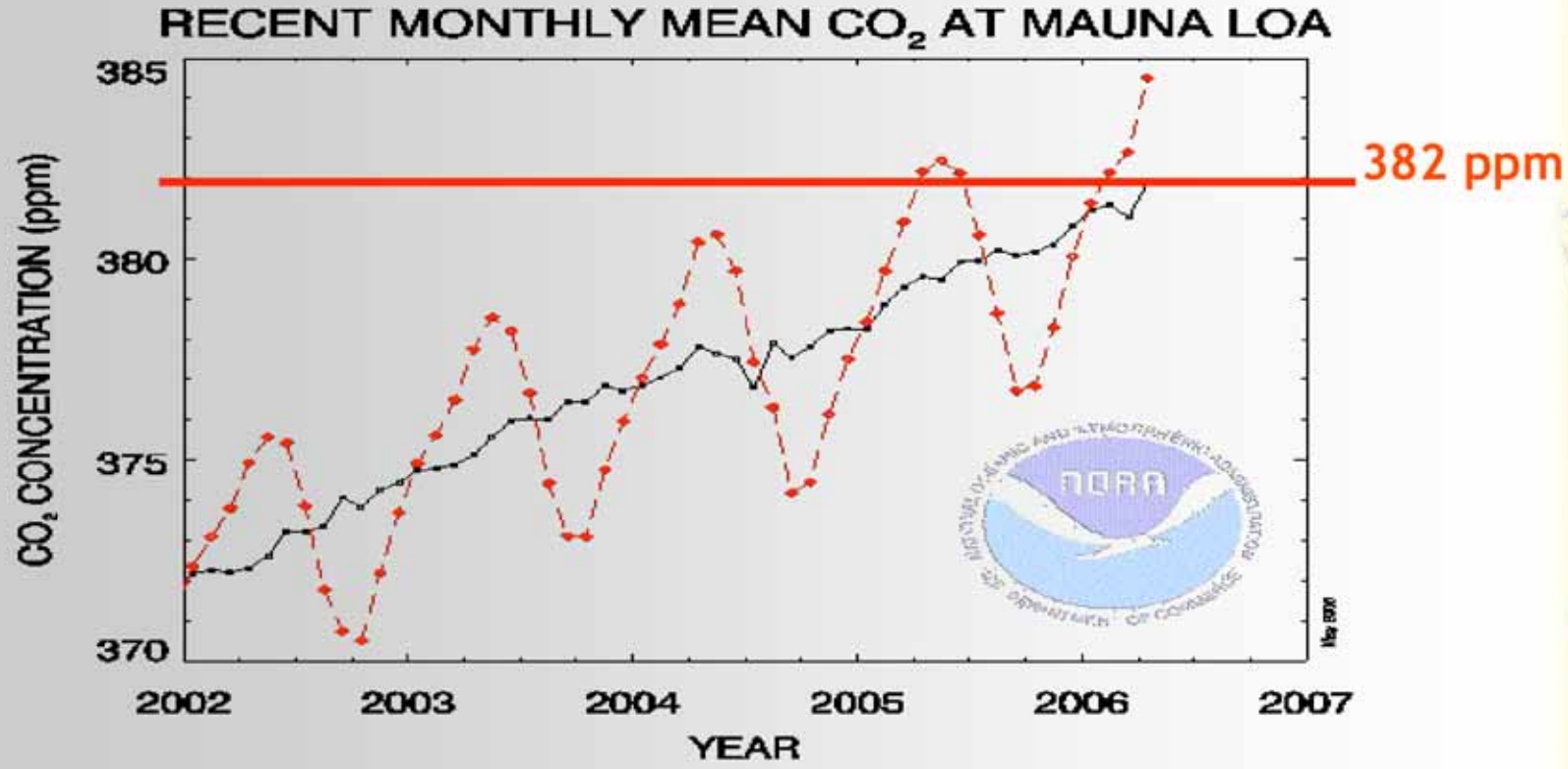




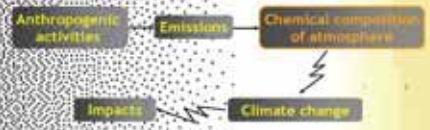
280 ± 10 ppm

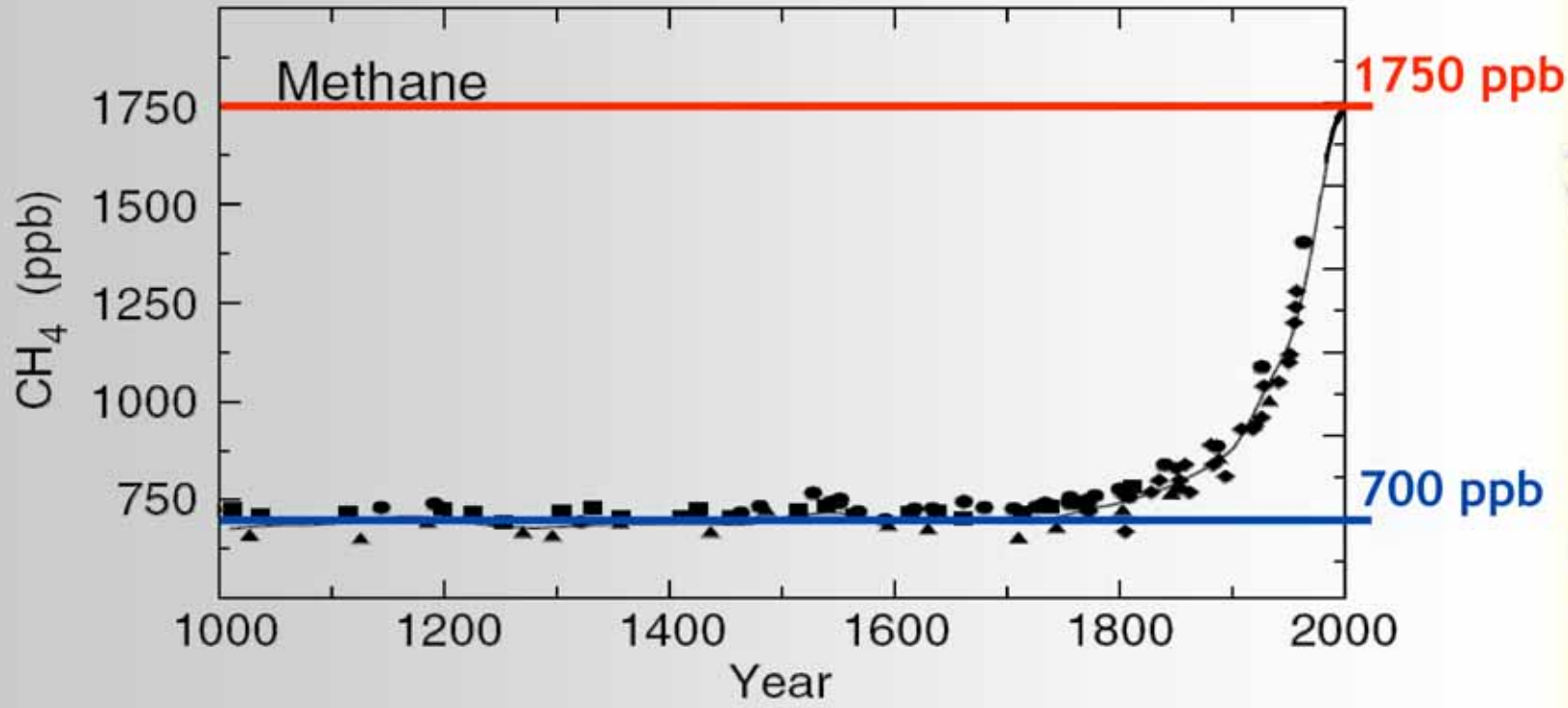
CO_2 Concentration 2006



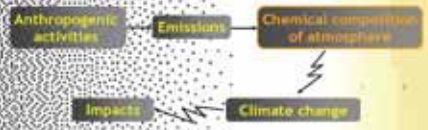


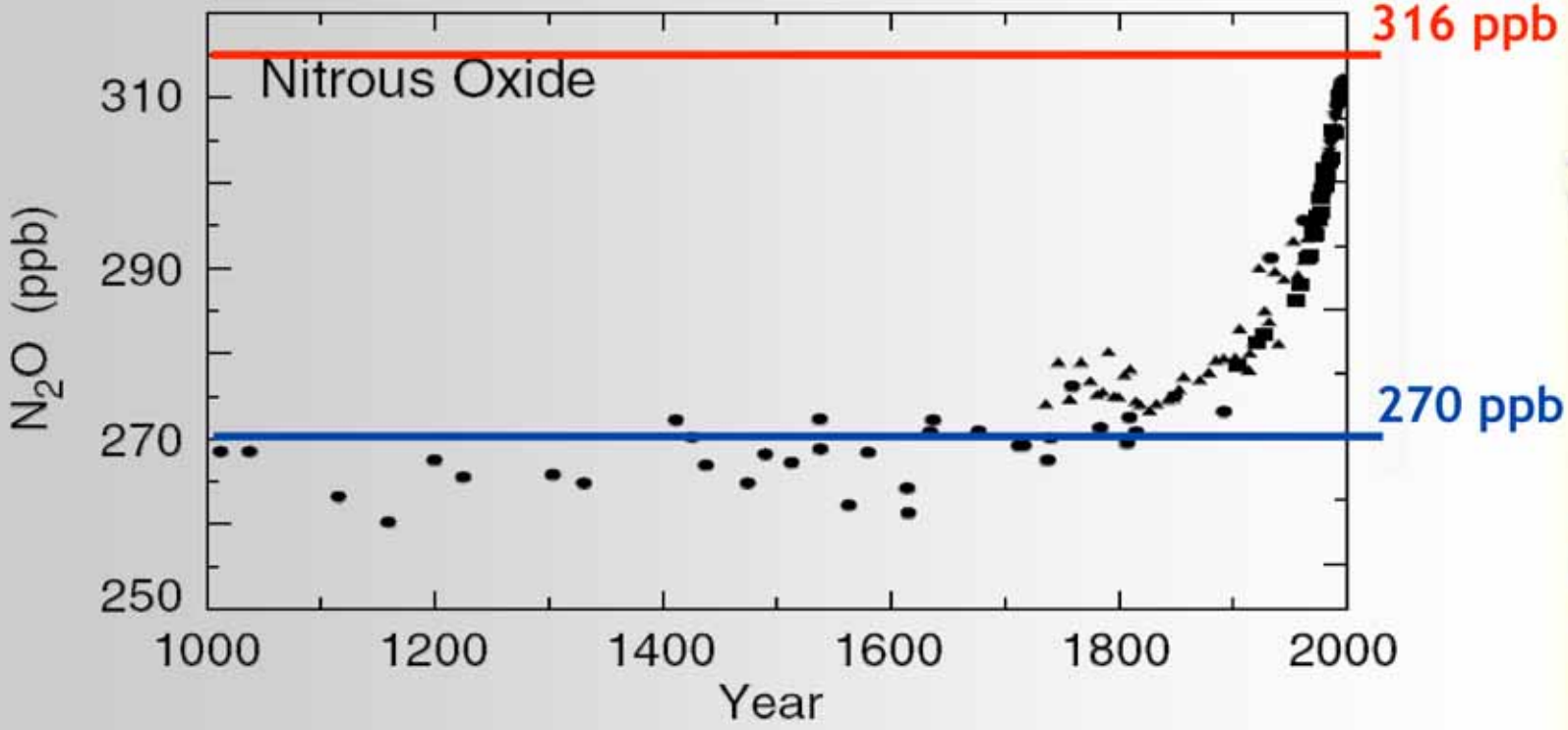
CH_4 Concentration



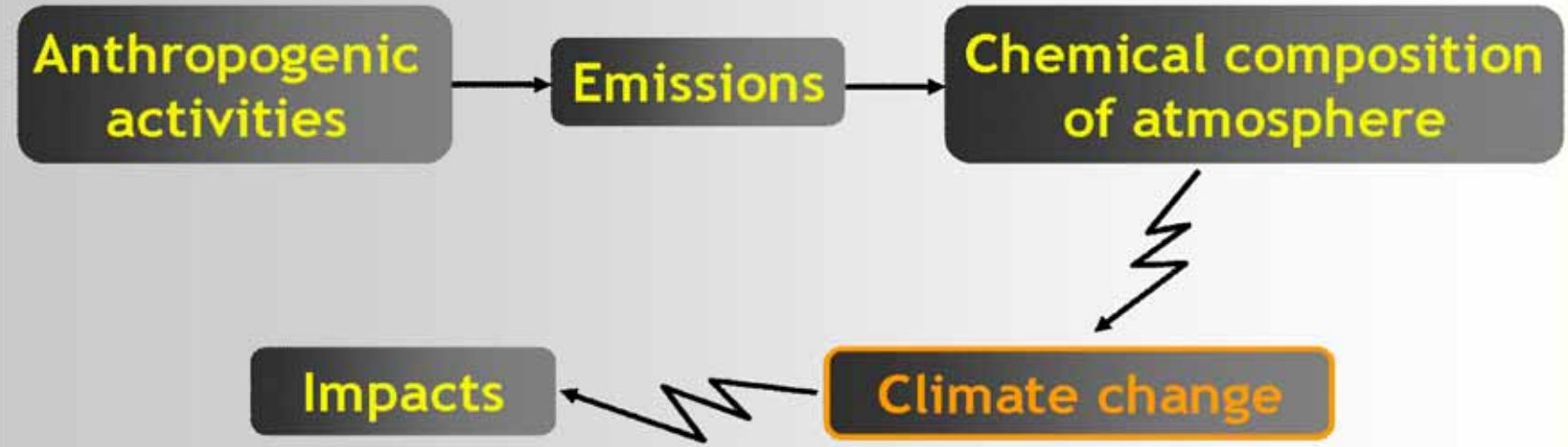


N_2O Concentration

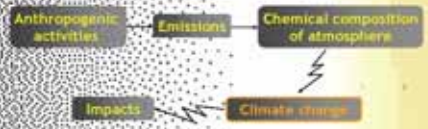




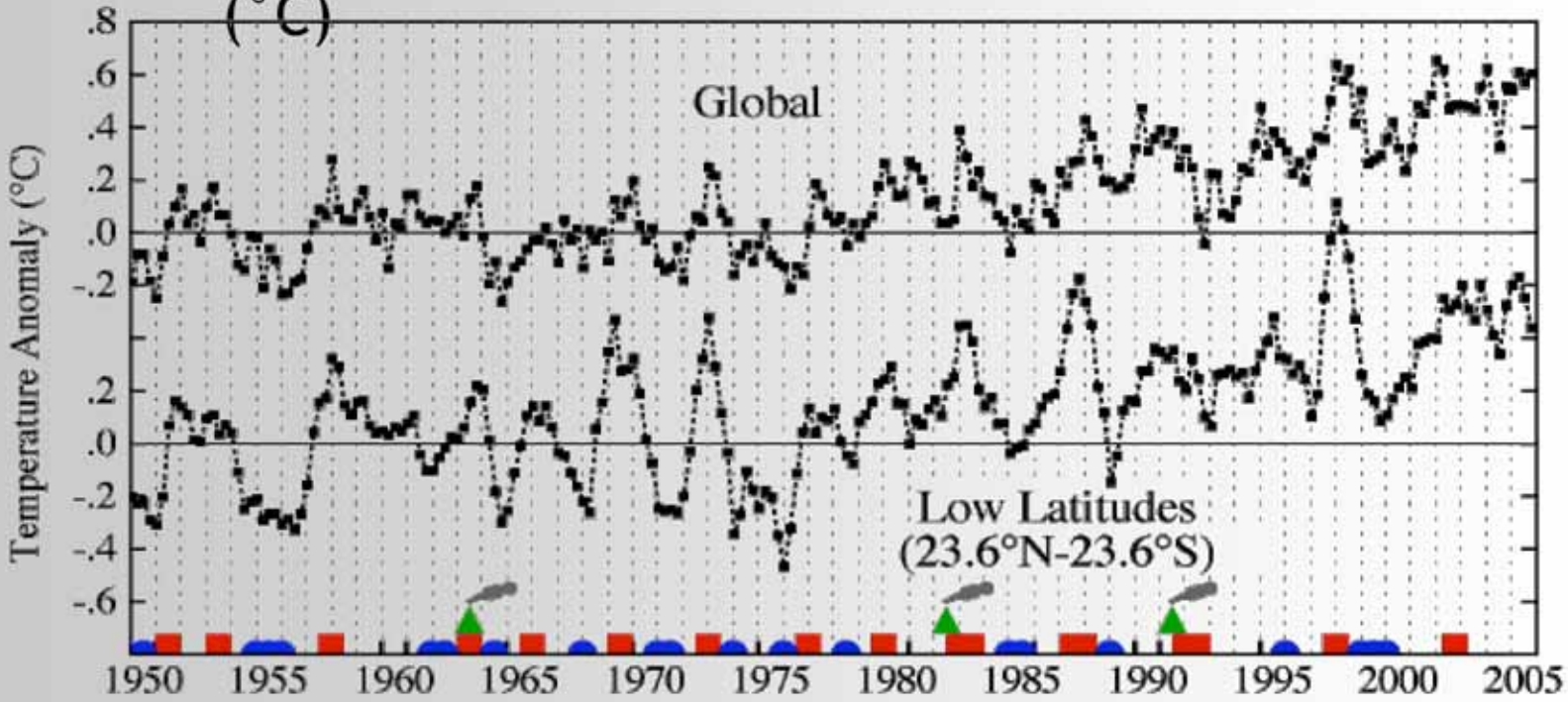
Climate Change



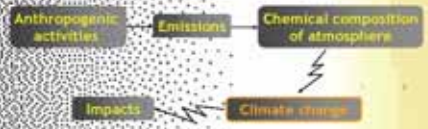
Global Temperature



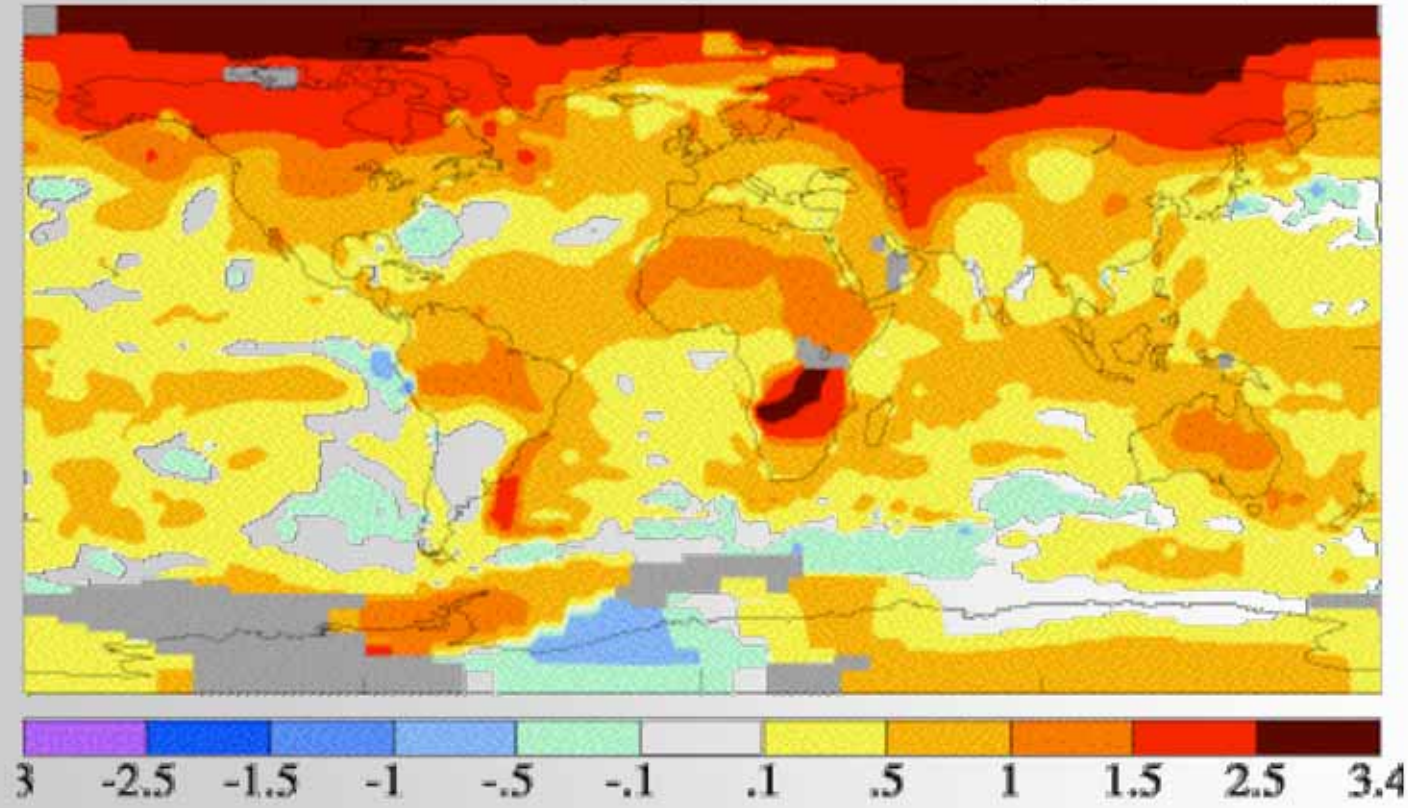
Global-Mean Surface Temperature Anomaly



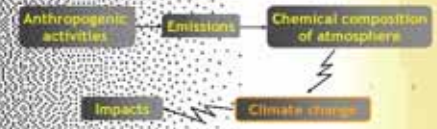
Temperature Anomaly for 2005



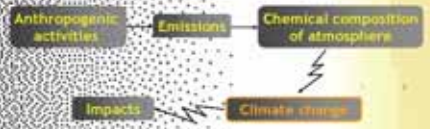
Global Surface Temperature Anomaly 2005 (°C)



Precipitation

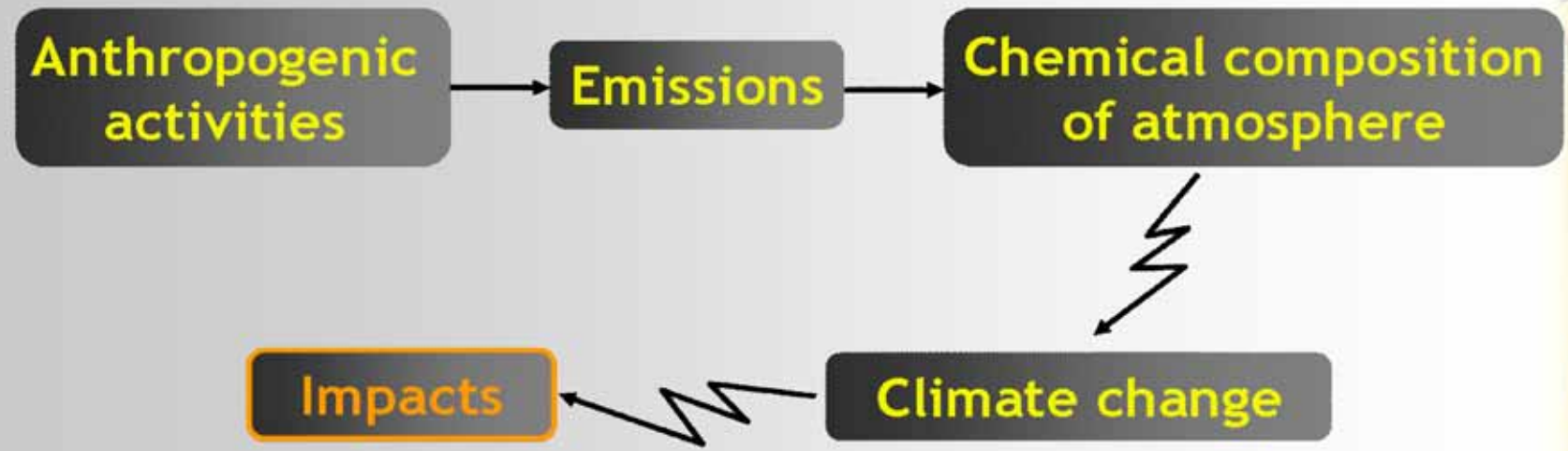


Main Climate Changes



Surface air temperature	increased 0.6°C in the past three decades
Cold/frost days	decreased for nearly all land areas during the 20th century
Continental precipitation	Increased by 5–10% over the 20th century in the Northern Hemisphere
Satellite temperature measurements	show earth warming of 0.06-0.26°C per decade

Impacts


Anthropogenic activities
Emissions
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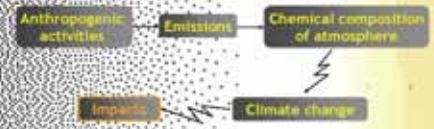
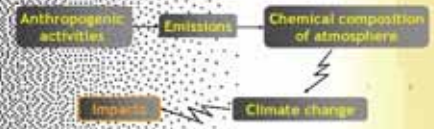
Glacier retreat



Rhone Glacier, Swizterland

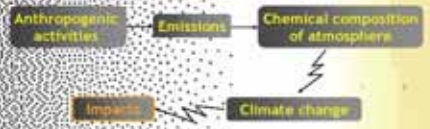
Arctic Sea Ice Shrinkage



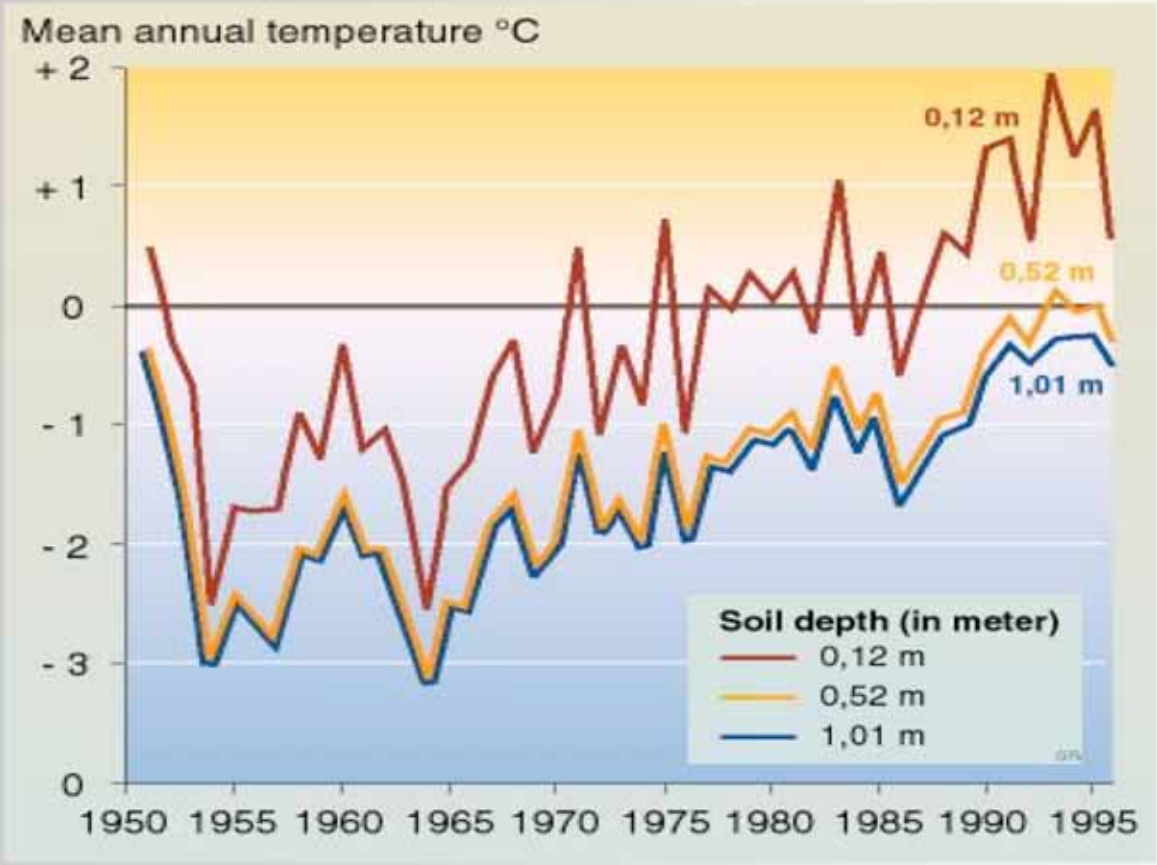
1979

2005

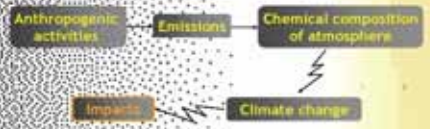
Permafrost Temperatures



Change in permafrost temperatures at various depths in Fairbanks (Alaska)

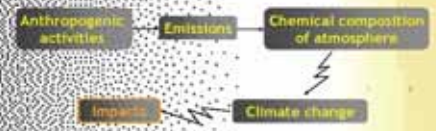


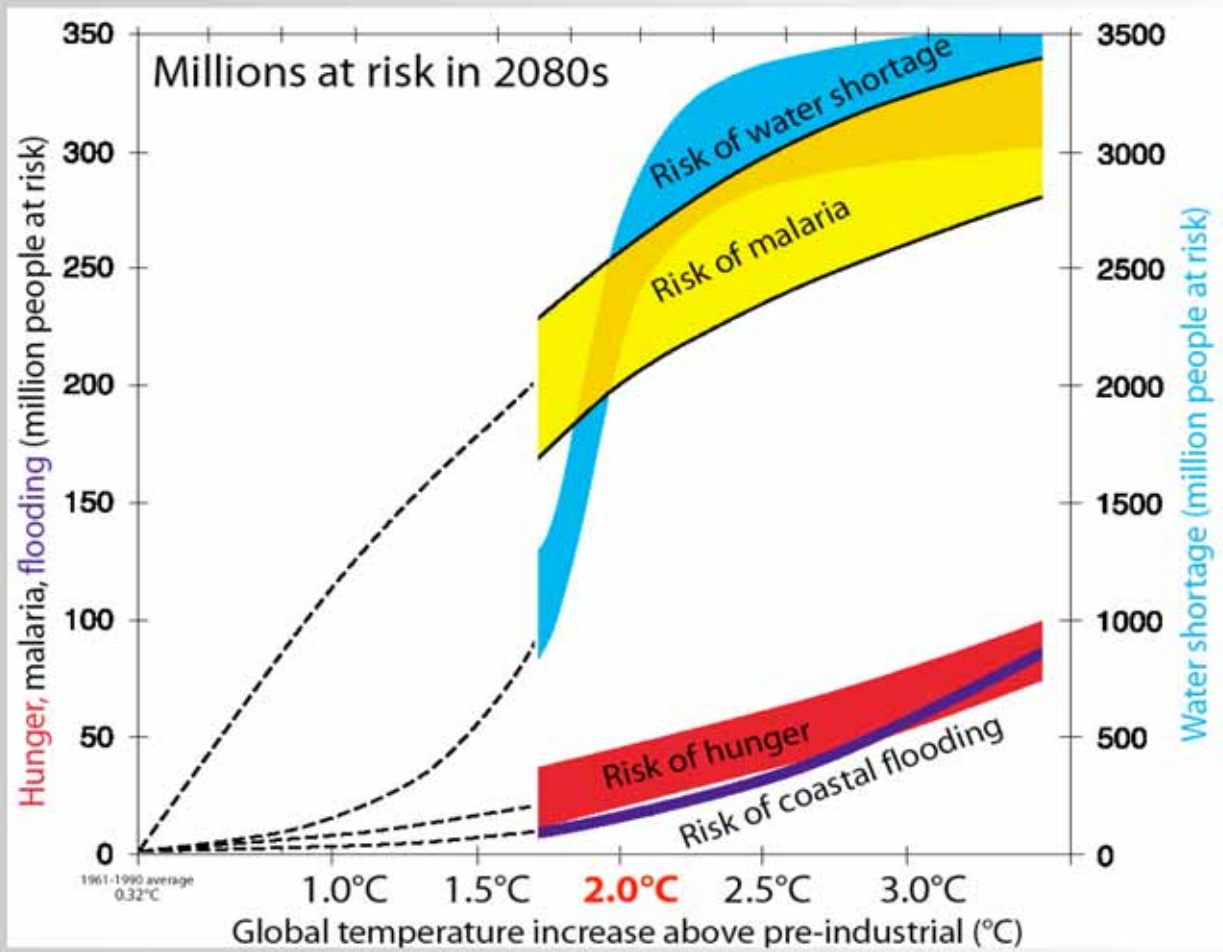
Overview of Impacts



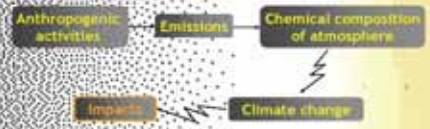
Global mean sea level	Increased at an average annual rate of 1 to 2 mm during the 20th century.
Snow cover	Decreased in area by 10% since global observations became available from satellites in the 1960s (*very likely*).
Permafrost	Thawed, warmed, and degraded in parts of the polar, sub-polar, and mountainous regions.
El Niño events	Became more frequent, persistent, and intense during the last 20 to 30 years compared to the previous 100 years.
Breeding, flowering, and migration	Earlier plant flowering, earlier bird arrival, earlier dates of breeding season, and earlier emergence of insects in the Northern Hemisphere.
Coral reef bleaching	Increased frequency, especially during El Niño events.
Duration of ice cover of rivers and lakes	Decreased by about 2 weeks over the 20th century in mid- and high latitudes of the Northern Hemisphere
Non-polar glaciers	Widespread retreat during the 20th century.

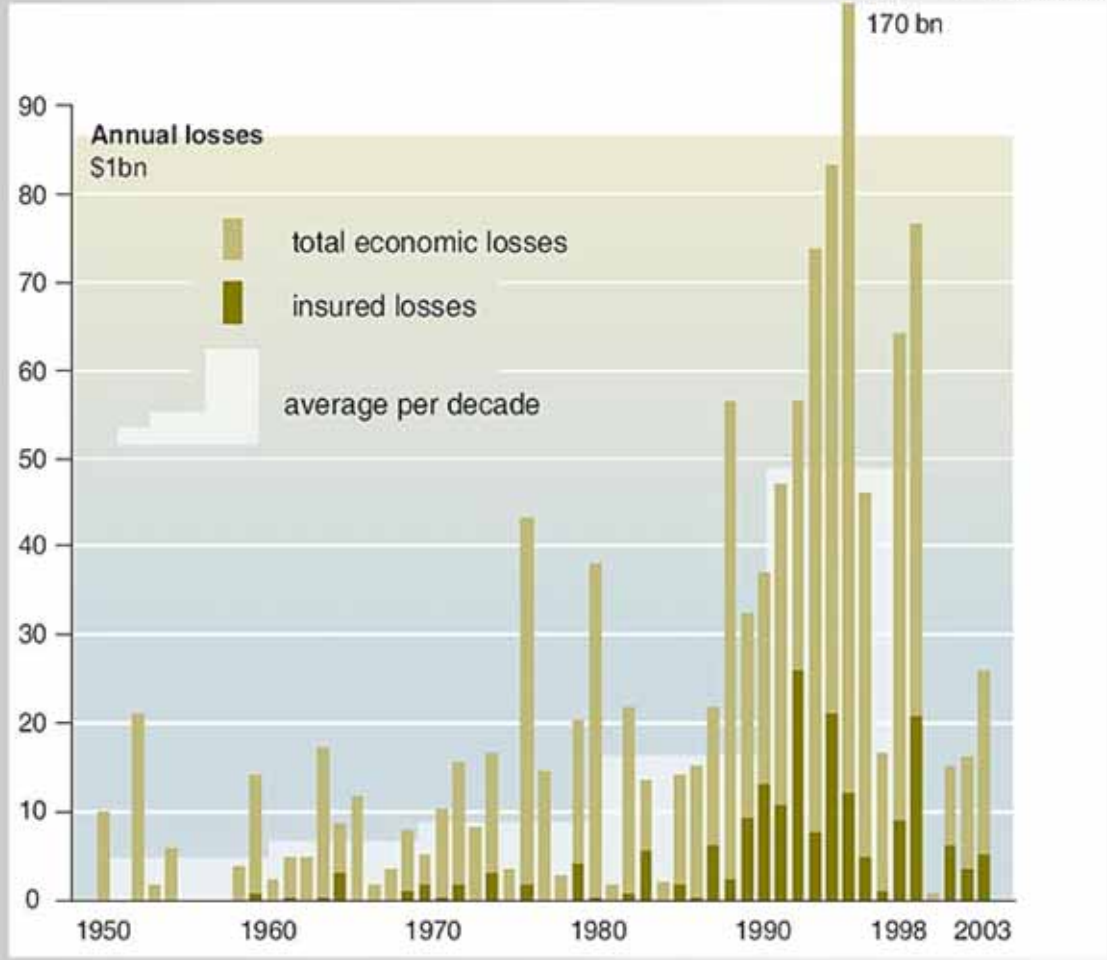
Socio-economic Impacts



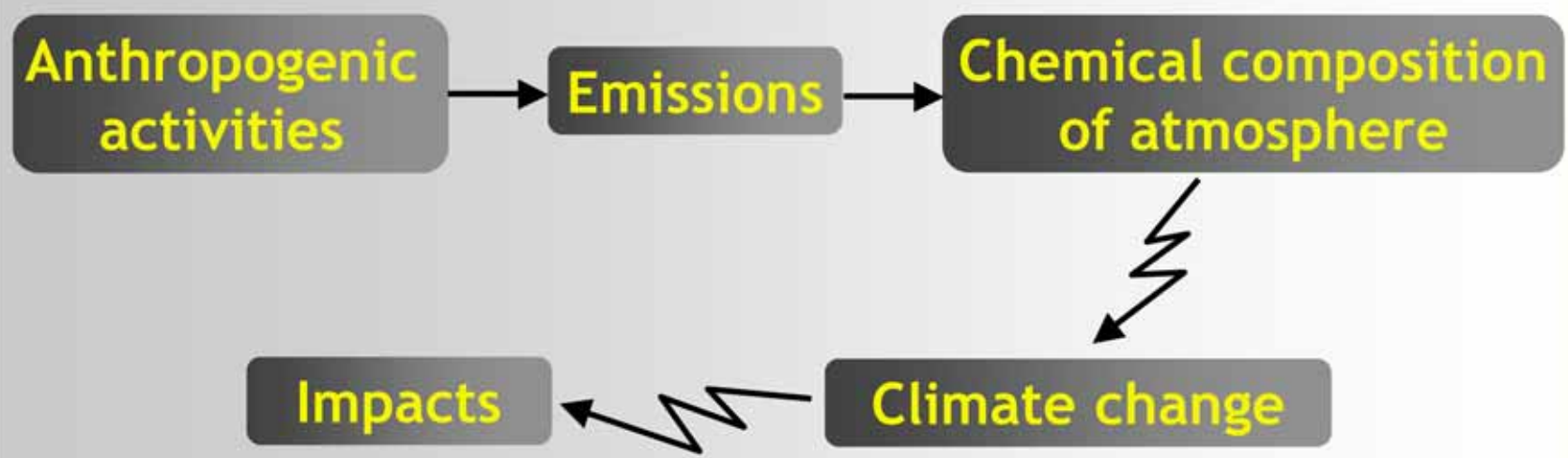


Costs of extreme Events

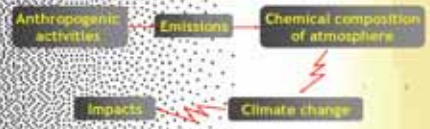




Causal Relationship

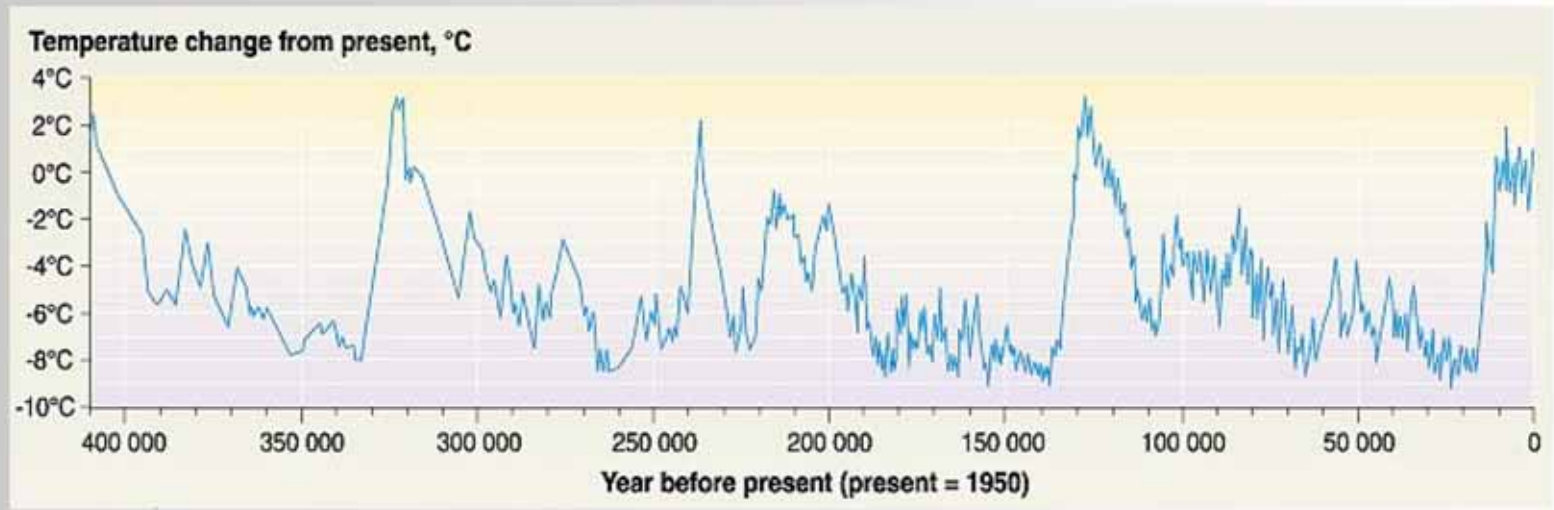


Are Human responsible?

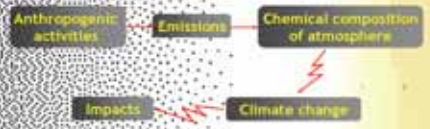


Natural influences on the earth climate

- Orbital variations — variation cycle 40'000 to 100'000 years
- Tectonic activity — variations take millions of years
- Volcanoes — influence for a few years after eruption
- Solar variability — slow variations in solar output and 11 years - cycle
- Internal variability — oscillation of 1-2 years



Are Human responsible?



- orbital variations
- tectonic processes

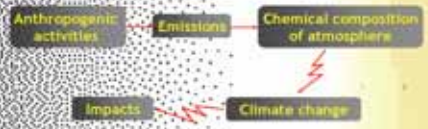
→ too slow to cause the changes of the last few years

- volcanic eruptions
- changes in solar output
- internal variability

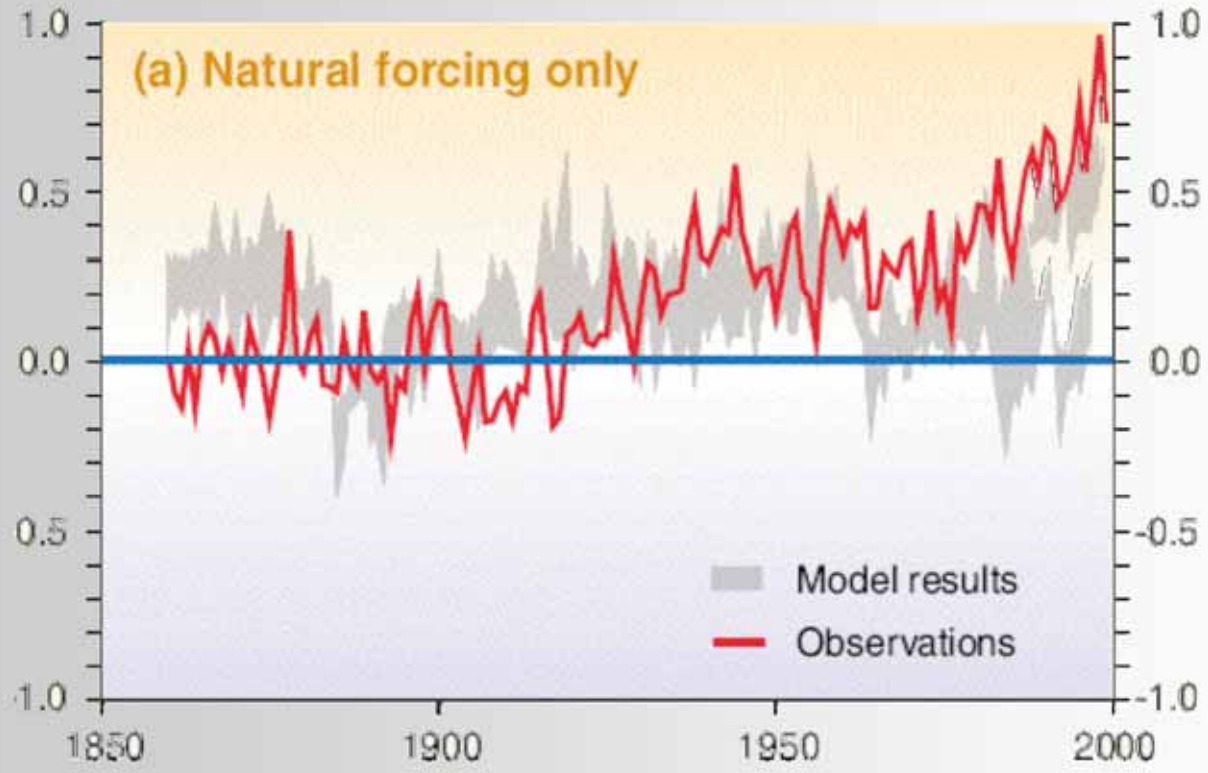
→ unlikely to contributed more than a small fraction of the rapid warming of the past few decades

➡ **With climate models the potential causes can be evaluated and compared more precisely**

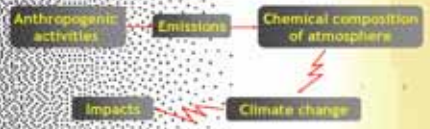
Observed and modeled Climate Change



Annual global mean temperature anomalies since 1850 (°C)



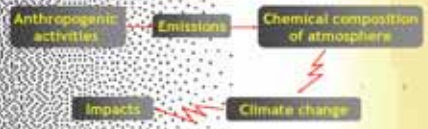
Are Human responsible?



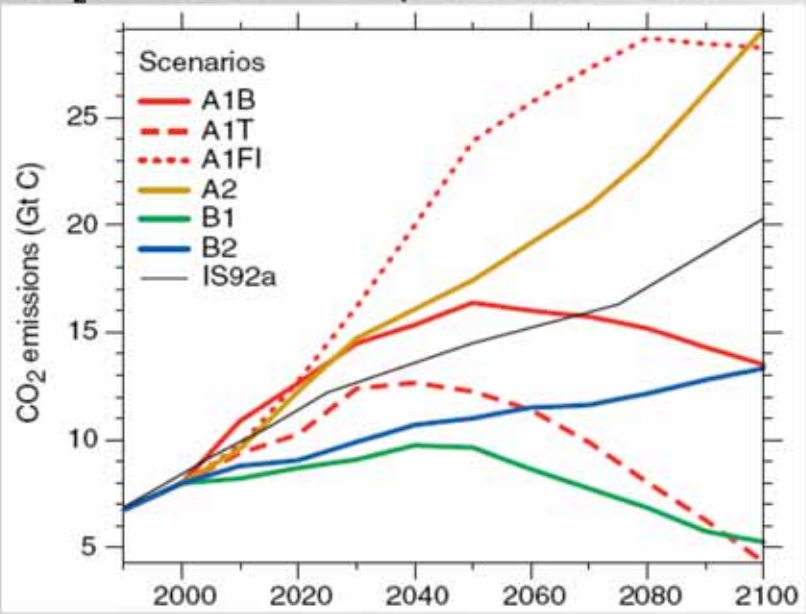
"The Balance of evidence suggests that there is a discernible human influence on global climate"

Conclusion of the International Panel of Climate Change Second Assessment Report (IPPC, 1996)

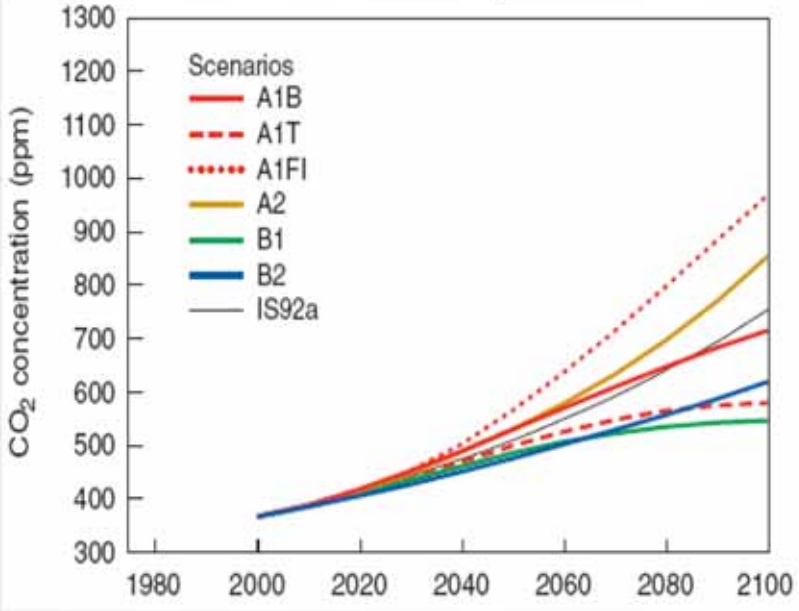
Prediction: Scenarios



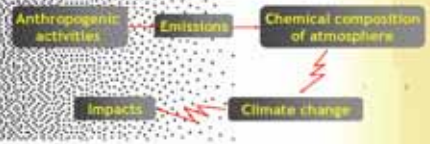
CO_2 emission from present to 2100

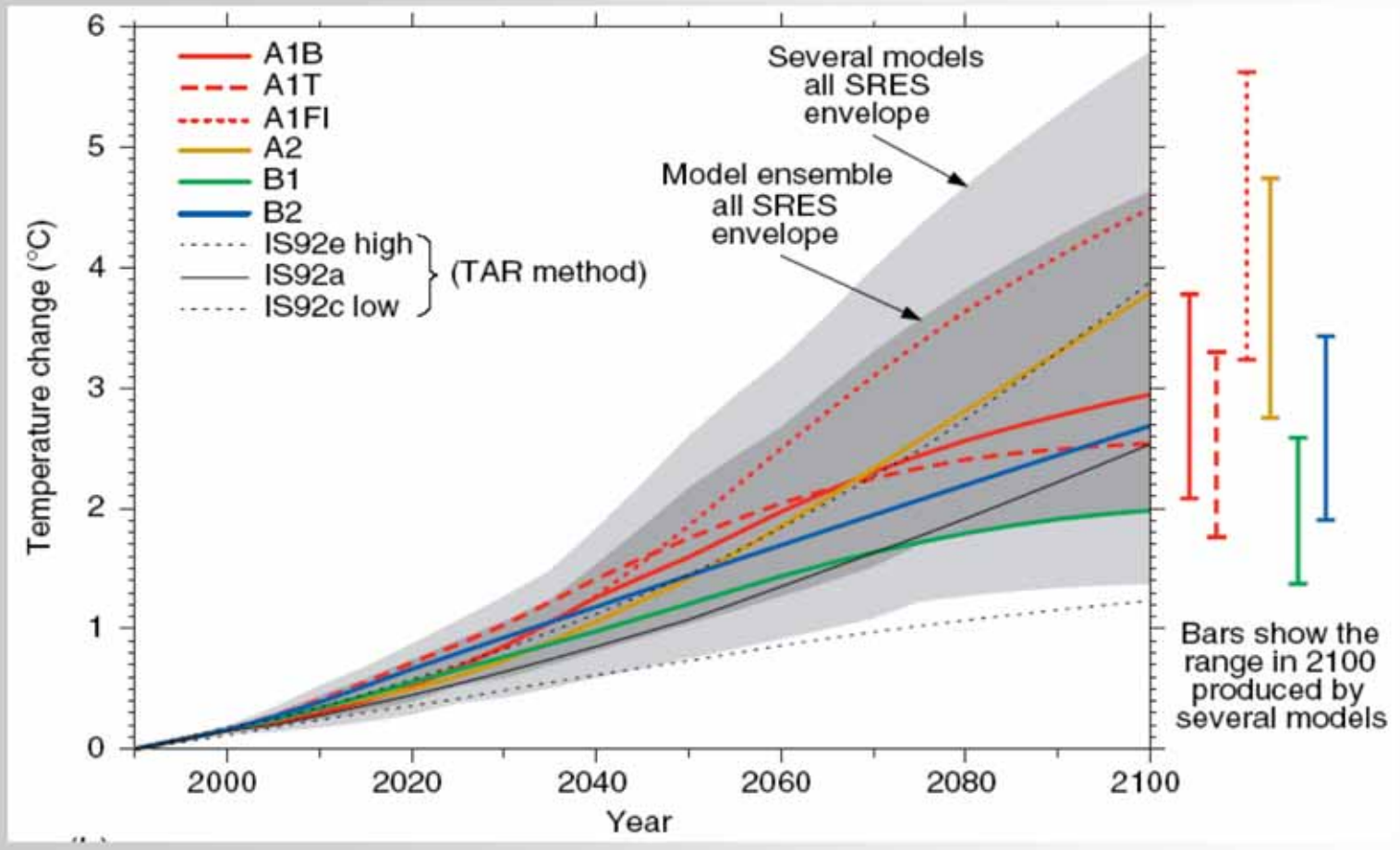


CO_2 concentration from present to 2100

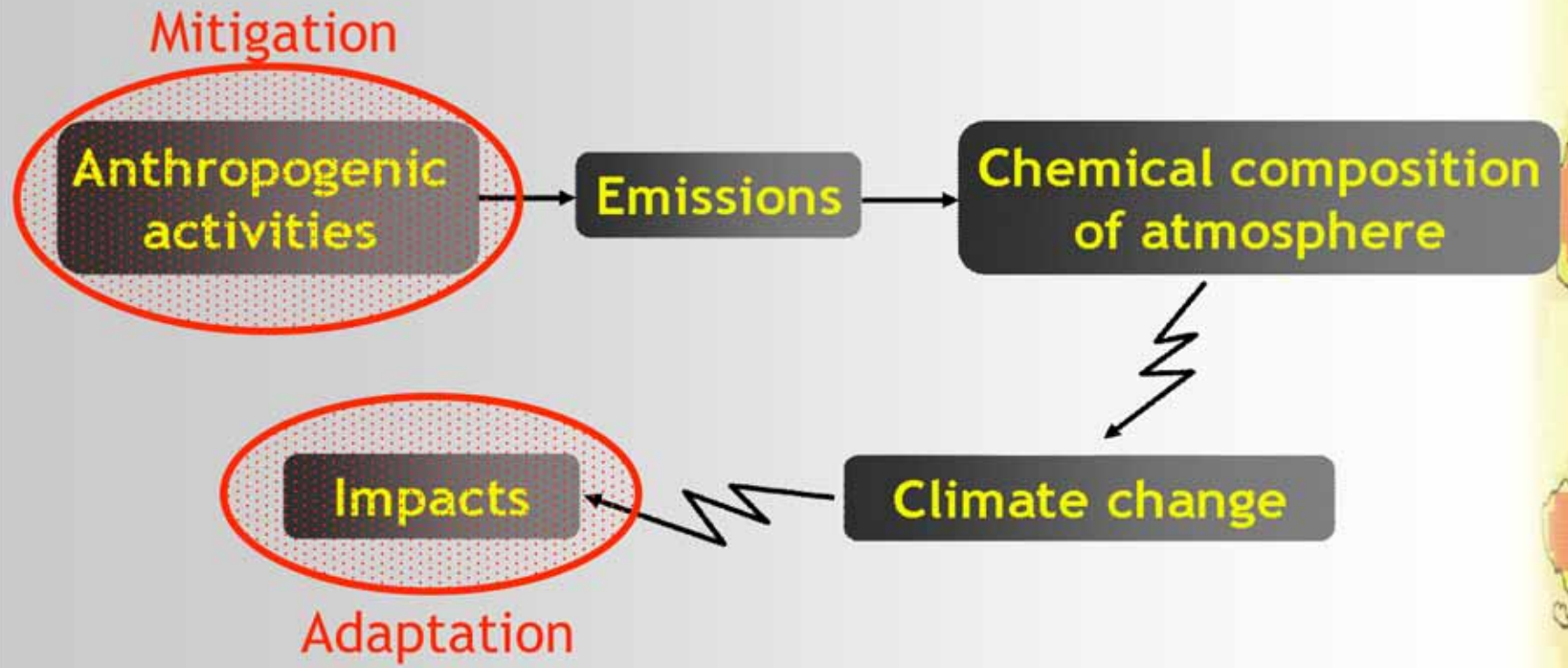


Temperature Prediction





The two main Policies



UNFCCC and Kyoto Protocol

Mitigation

1992
Rio Conference

↓

UNFCCC
United Nations Framework
Convention on Climate Change

↓

1997
Kyoto Protocol
Mitigation Commitment

Examples of Adaptation

Adaptation

Impact	Technical Adaptation	Behavioral Adaptation
Thermal stress	Urban planning to reduce heat island effects, air conditioning	Clothing, siesta
Extreme weather events	Urban planning, storm shelters	Use of storm shelters
Vector-borne diseases	Vector control, vaccination, impregnated bed nets	Water storage practices
Water-borne diseases	Genetic/molecular screening of pathogens, improved water treatment (e.g., filters), improved sanitation (e.g., latrines)	Washing hands and other hygiene behavior Use of pit latrines

Thank you!