Introduction to climate change

Minh Ha-Duong

CIRED, CNRS

Centre International de Recherche sur
l'Environnement et le Développement

We acknowledge the
kind sponsorship of:

Officience
Business Performance Services

VEOLIA
WATER

Introduction to climate change

1. Earth's climate is changing already
2. Expected impacts
3. Reducing CO2 emissions
4. Carbon value and market instruments

1. Earth’s climate is changing

Polar bear is unhappy of global warming

a) Arctic ice melting

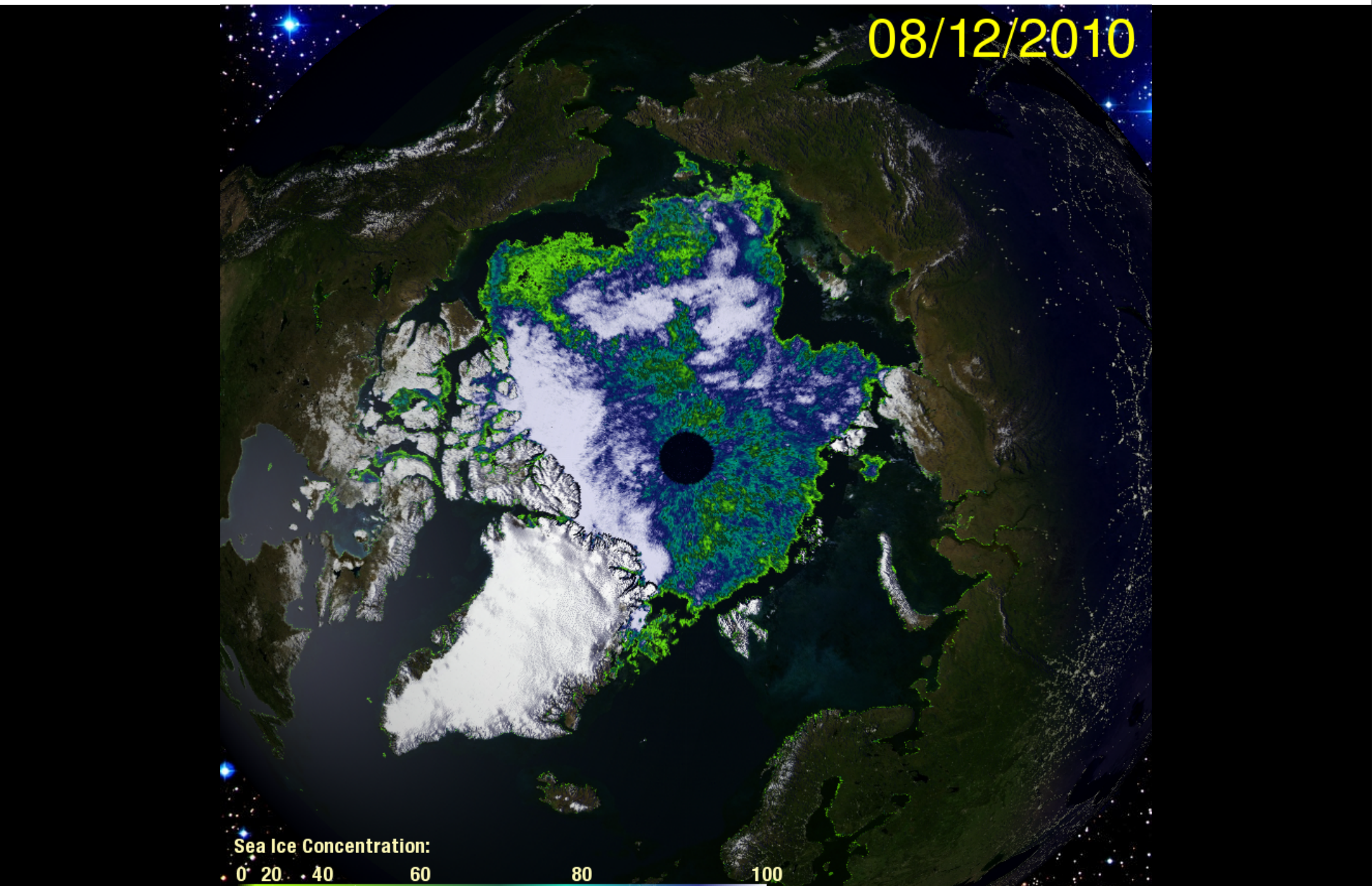
b) Global warming

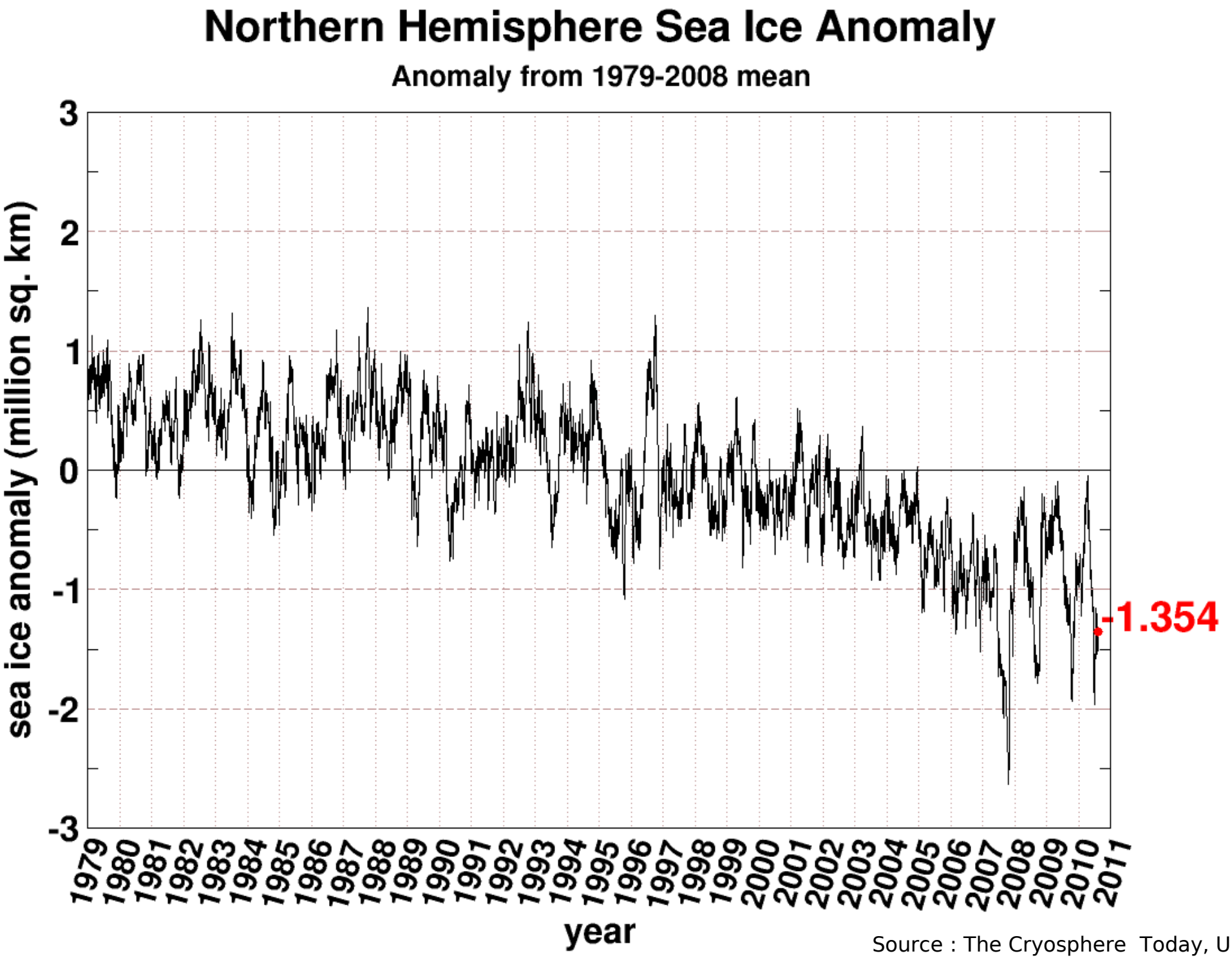
c) Greenhouse gases

d) Causality

a) Arctic ice sheet melting faster than expected

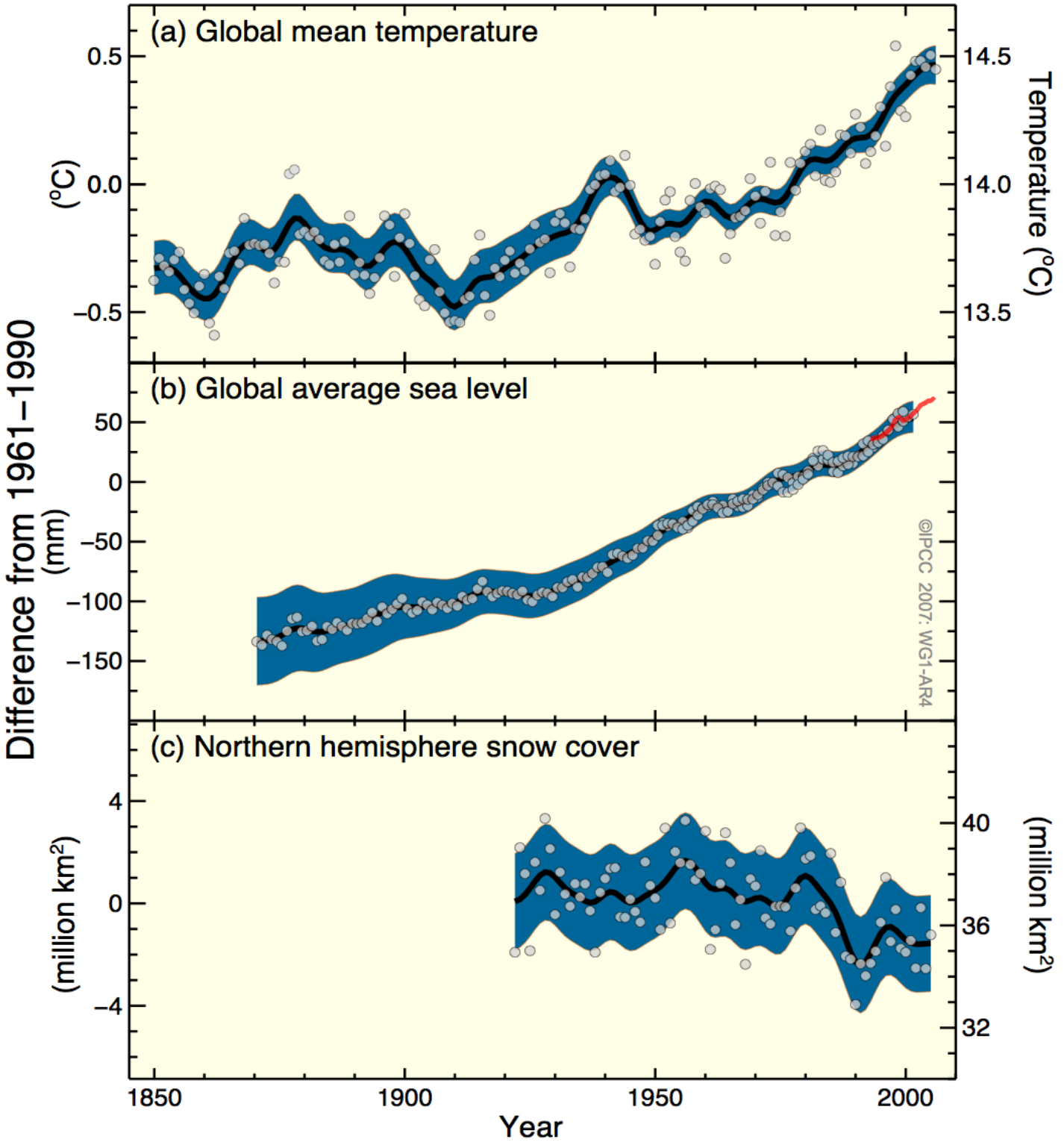
NorthWest passage open in September 2007 (Source: ESA)





Source : The Cryosphere Today, UIUC

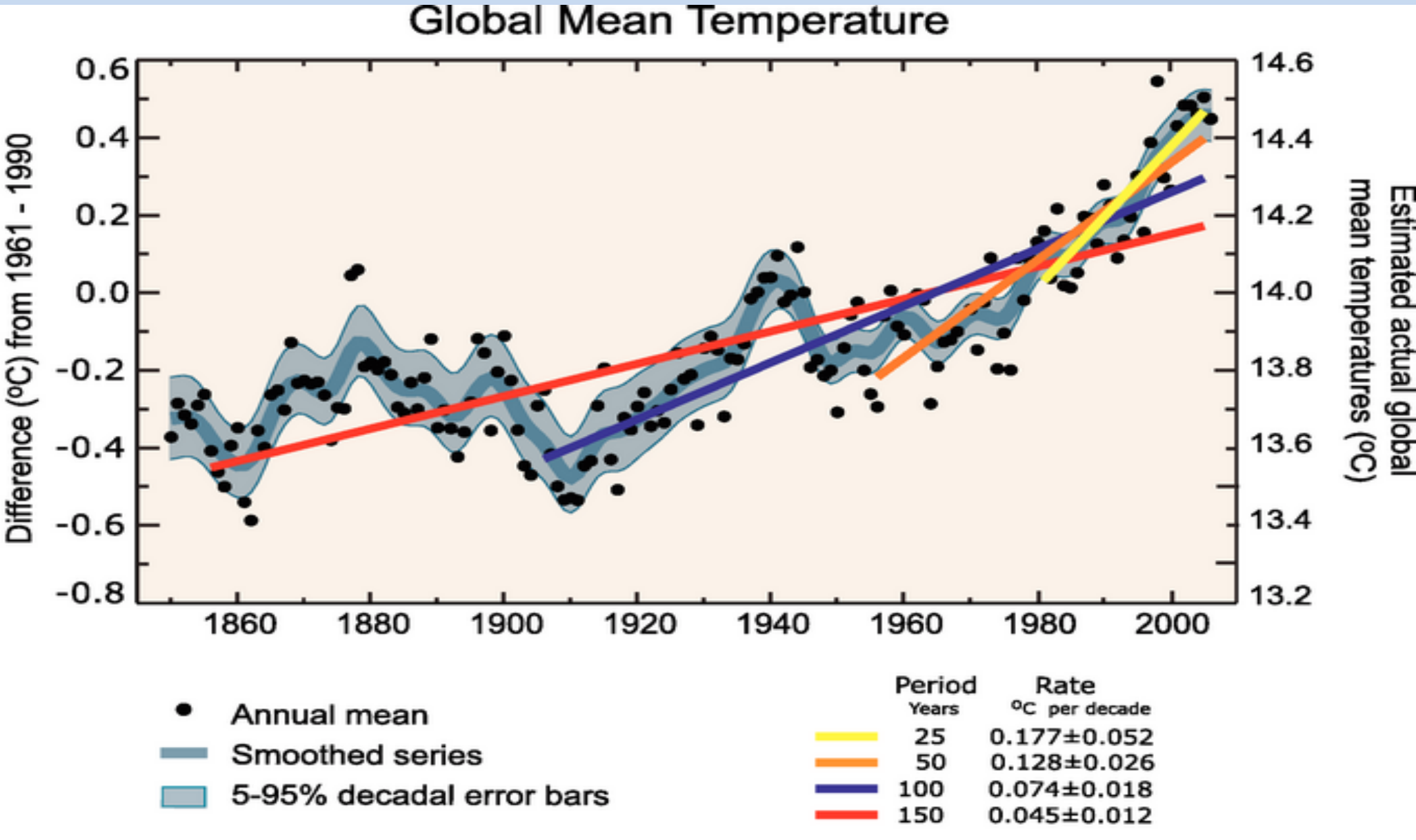
b) Evidence of global warming



Source : IPCC, 2007, AR4
WG I, Figure SPM 3

Global warming is accelerating

Source : IPCC 2007, A44, WG I, figure FAQ 1

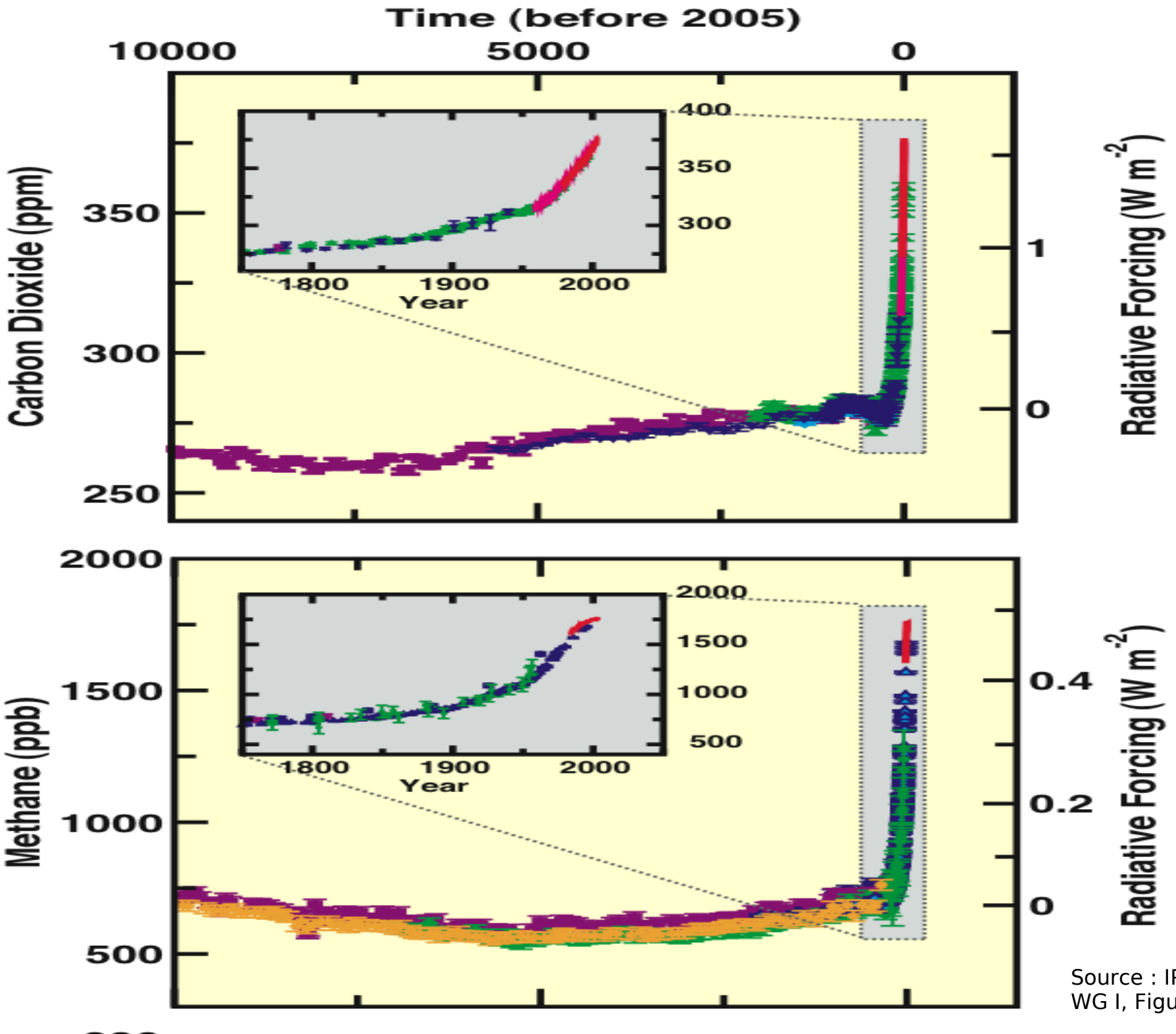


c) Greenhouse gases increase

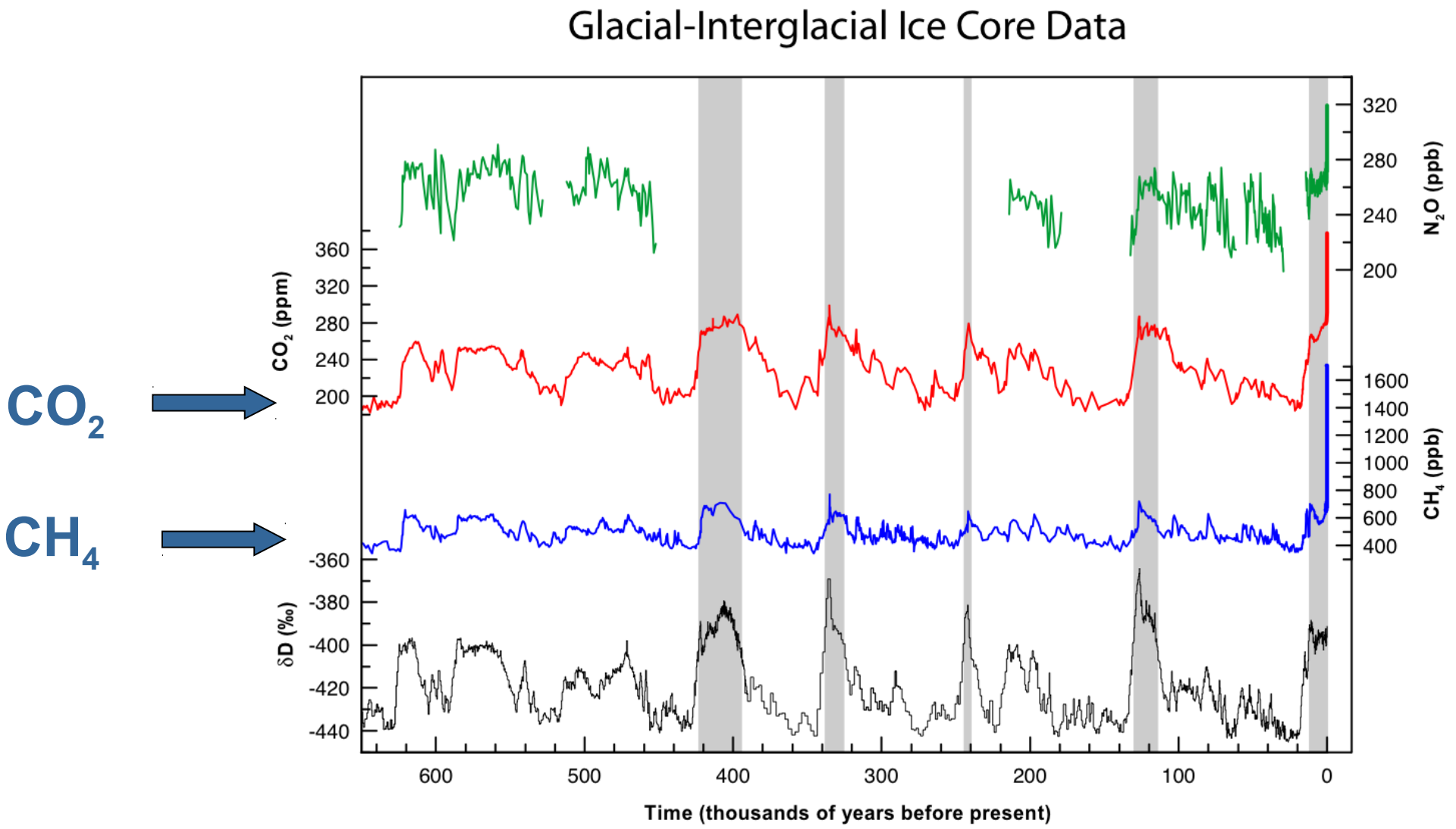
Concentrations of CO_2, CH_4, N_2O in the atmosphere are:

- Far above pre-industrial values
- Rapidly increasing since 1750, due to human activities

Radiative forcing has increased by 1.6 W/m² (CI: 0.4 – 2.4, source: IPCC AR4 WG1 TS2.5)



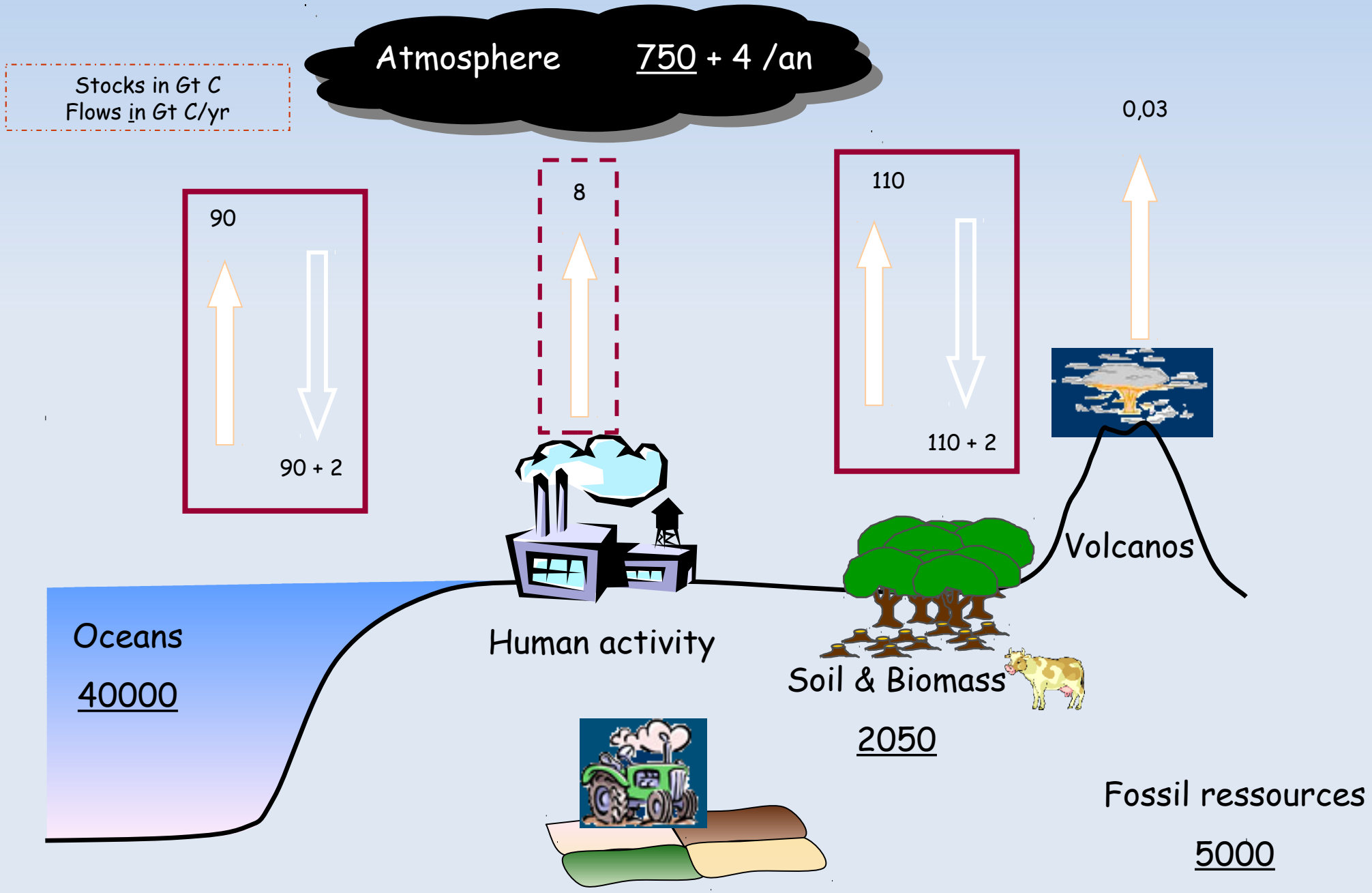
Source : IPCC, 2007, AR4 WG I, Figure SPM 1



Concentrations of CO_2 and CH_4 in 2005 exceed what has been seen since 650 000 years.

Source : IPCC, 2007, AR4 WG I, Figure TS.1

d) Humans caused GHG increase

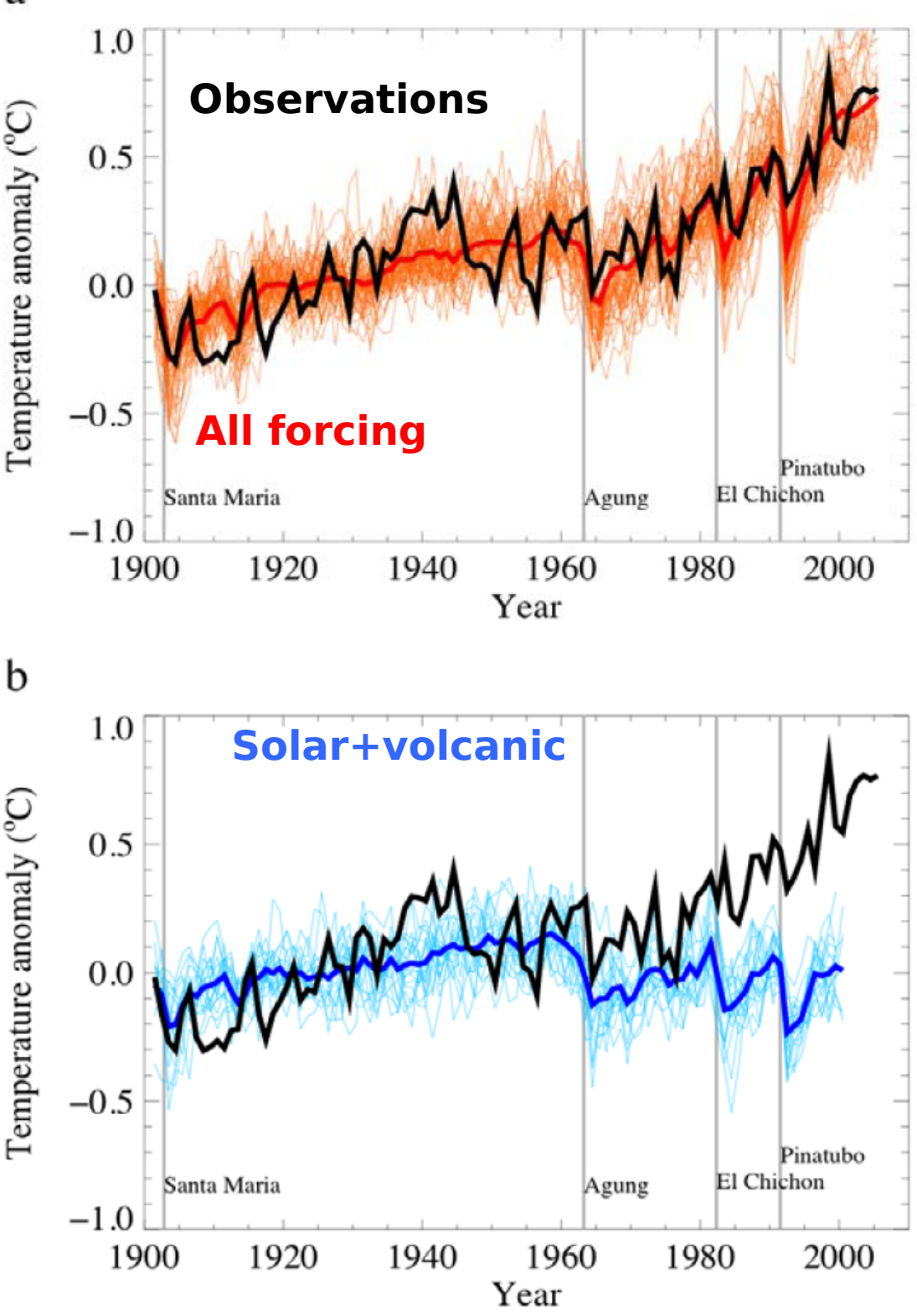


GHG increase caused climate change

- Observed changes (solid black line)

☑ Agree with responses expected from radiative forcing increase (top panel)

☒ Cannot be explained by other reasons (solar+volcanic)



Source : IPCC, 2007, AR4 WG I, Figure TS.23

IPCC conclusions

(2007, WGI, SPM, Understanding and attributing climate change)

Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.

Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns

2. Expected impacts

a) CO2 emissions scenarios

b) Greenhouse gases concentrations increase

c) Temperature and water cycle changes

d) Impacts on humans, ecosystems, economy

a) Emissions scenarios

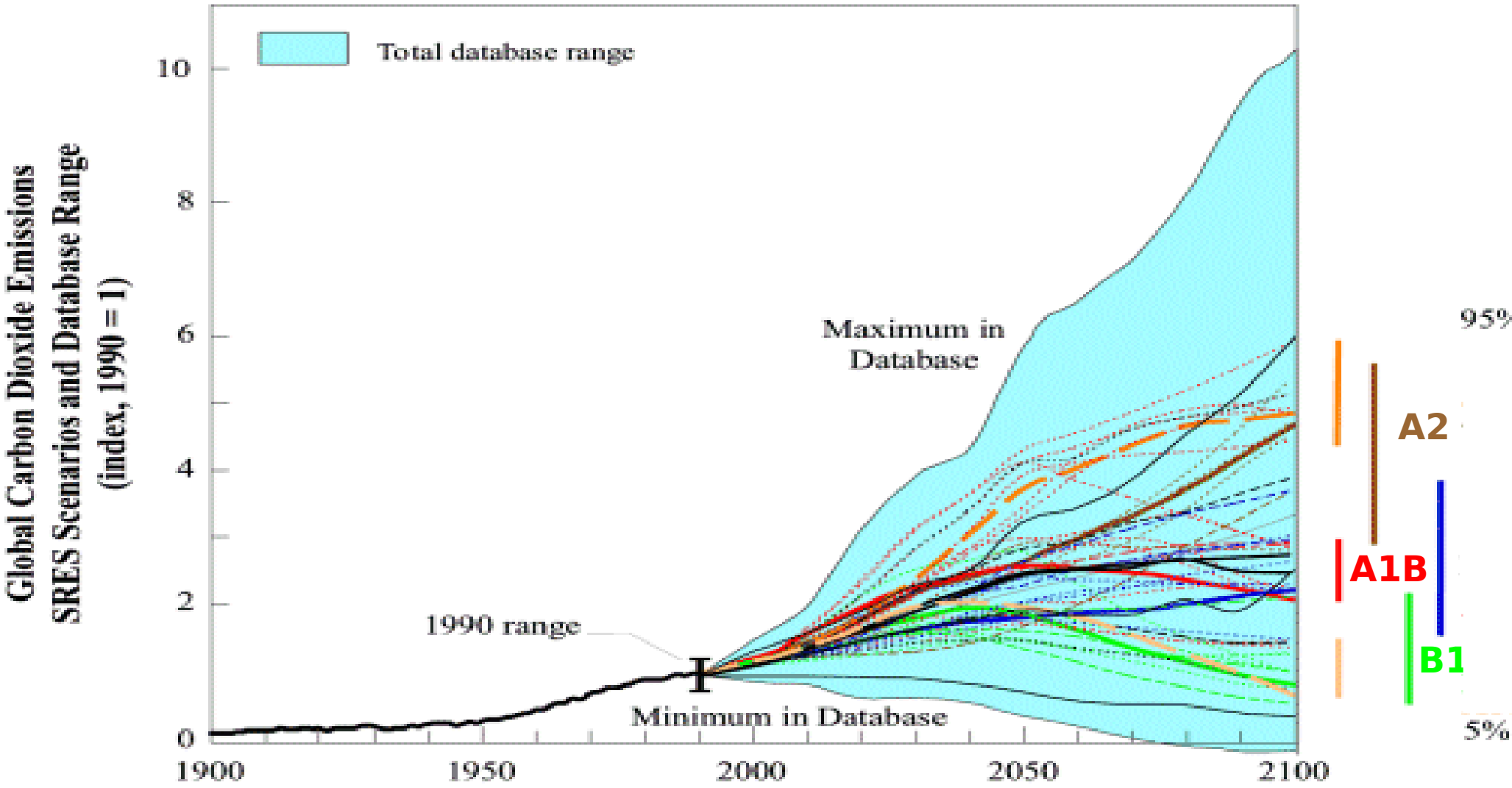
Storylines assuming no intervention

A2: Heterogenous world – High CO2 emissions
Slow globalization. Late demographic transition.
Lower technical progress & economic growth.

A1B: Convergence and growth – Medium CO2
Technological progress is balanced between fossil intensive and non-fossil energy sources.

B1: Internet age – Low CO2 emissions
Rapid changes toward a service and information economy, reductions in material intensity, introduction of clean and resource-efficient technologies.

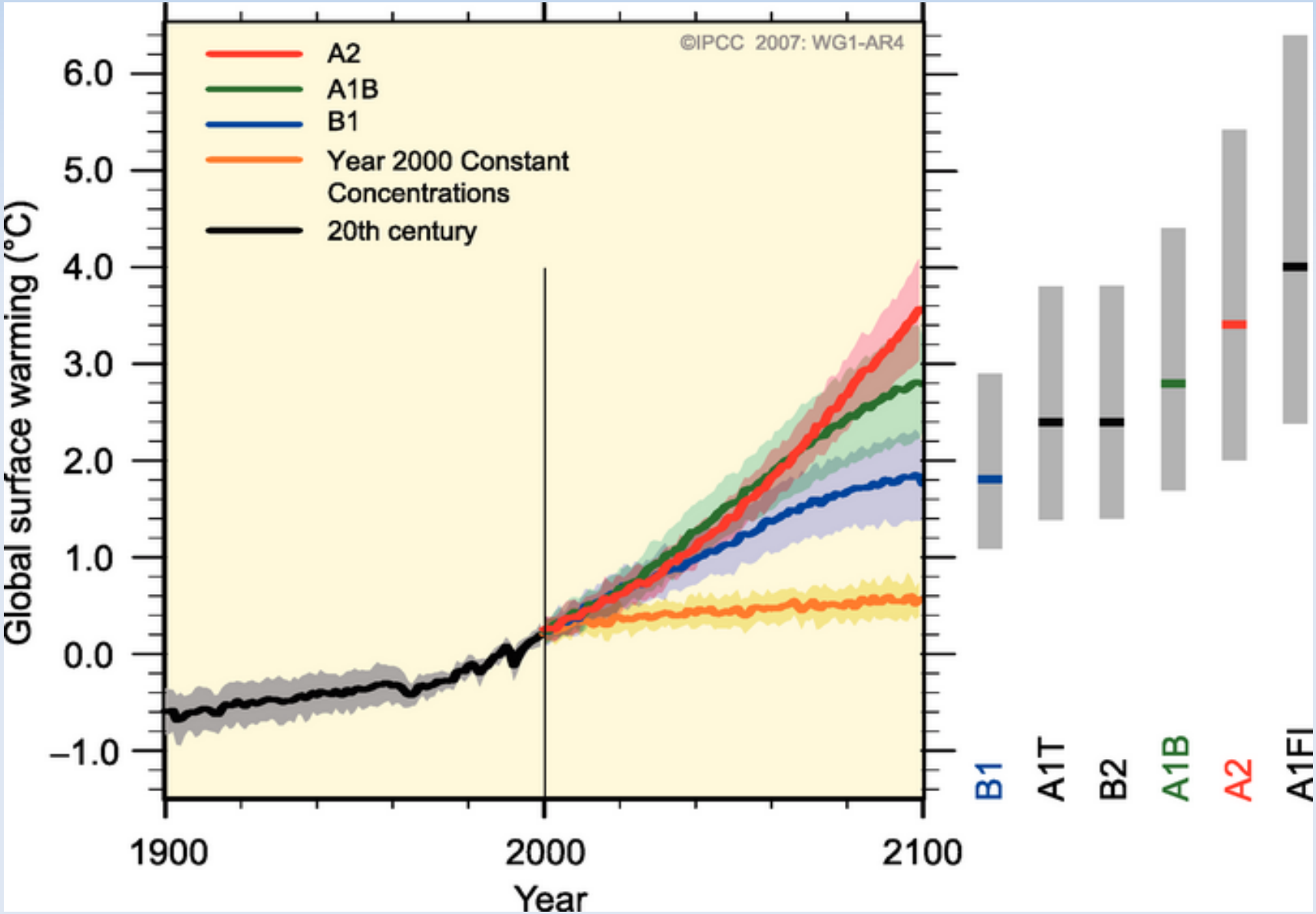
Global CO2 emissions simulations



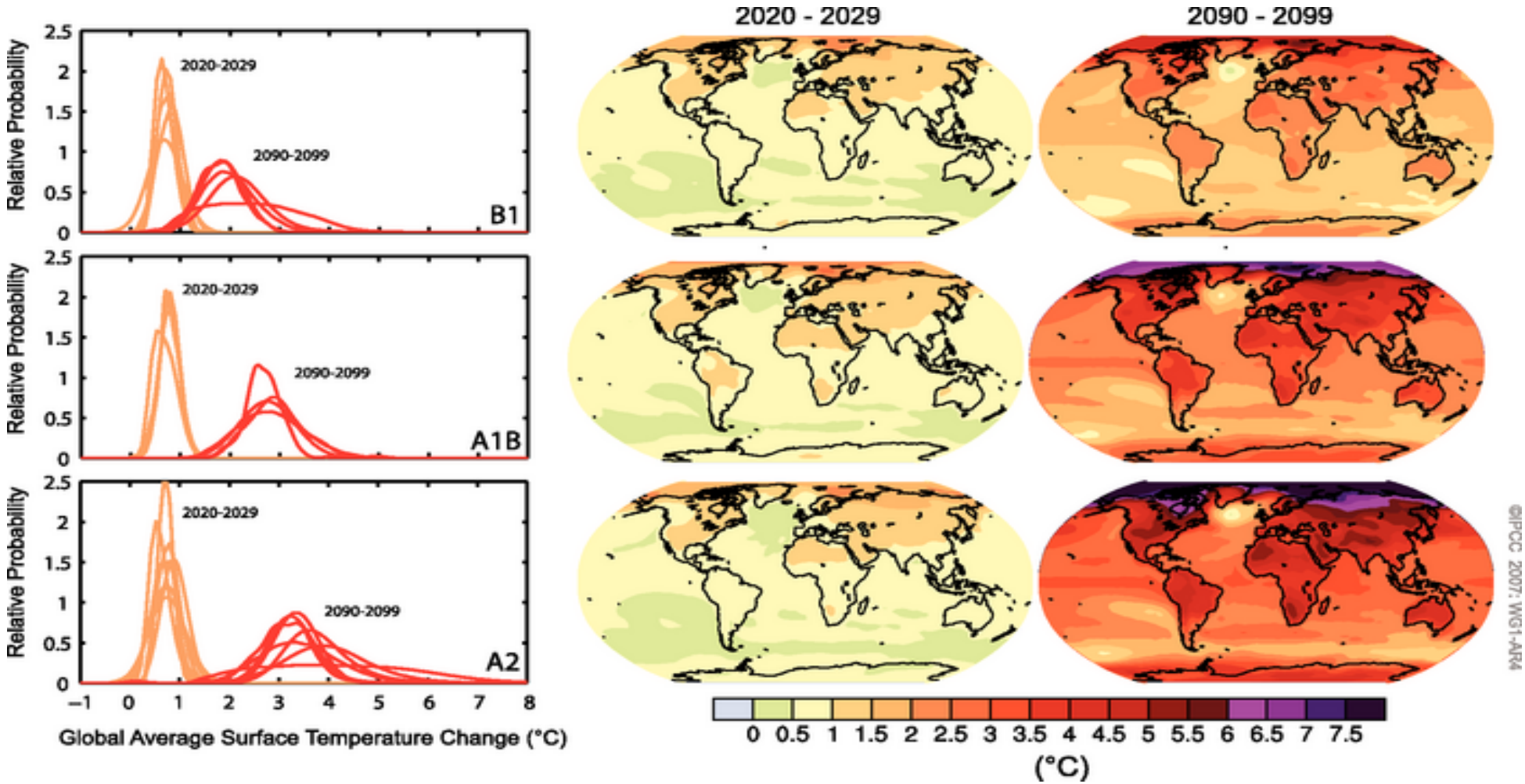
Source : IPCC, SRESI, Figure TS.7

c) Even B1 does not prevent +2°C

Source: IPCC 2007, AR4, WG 1, Figure SPM.5. Solid lines are multi-model global averages of surface warming (relative to 1980–1999) for the scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. Shading denotes the ±1 standard deviation range of individual model annual averages. The grey bars at right indicate the best estimate (solid line within each bar) and the likely range assessed for the six SRES marker scenarios.

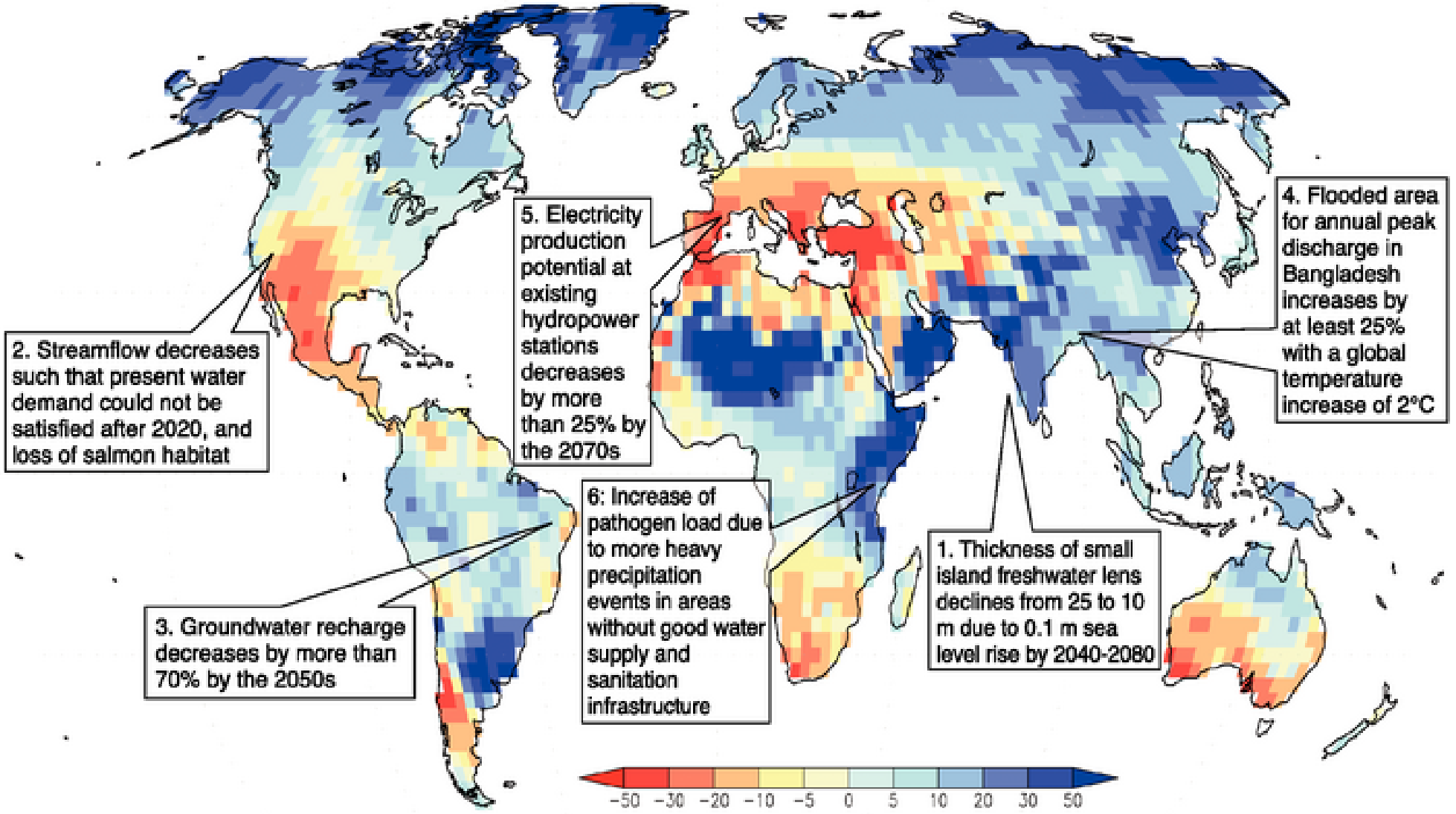


c) Projection of surface temperatures



IPCC 2007, AR4 WG 1 Figure SPM.6. Projected surface temperature changes for the early and late 21st century relative to the period 1980 to 1999. The central and right panels show the AOGCM multi-model average projections (°C) for the B1 (top), A1B (middle) and A2 (bottom) SRES scenarios averaged over the decades 2020 to 2029 (centre) and 2090 to 2099 (right). The left panel shows corresponding uncertainties as the relative probabilitiess.

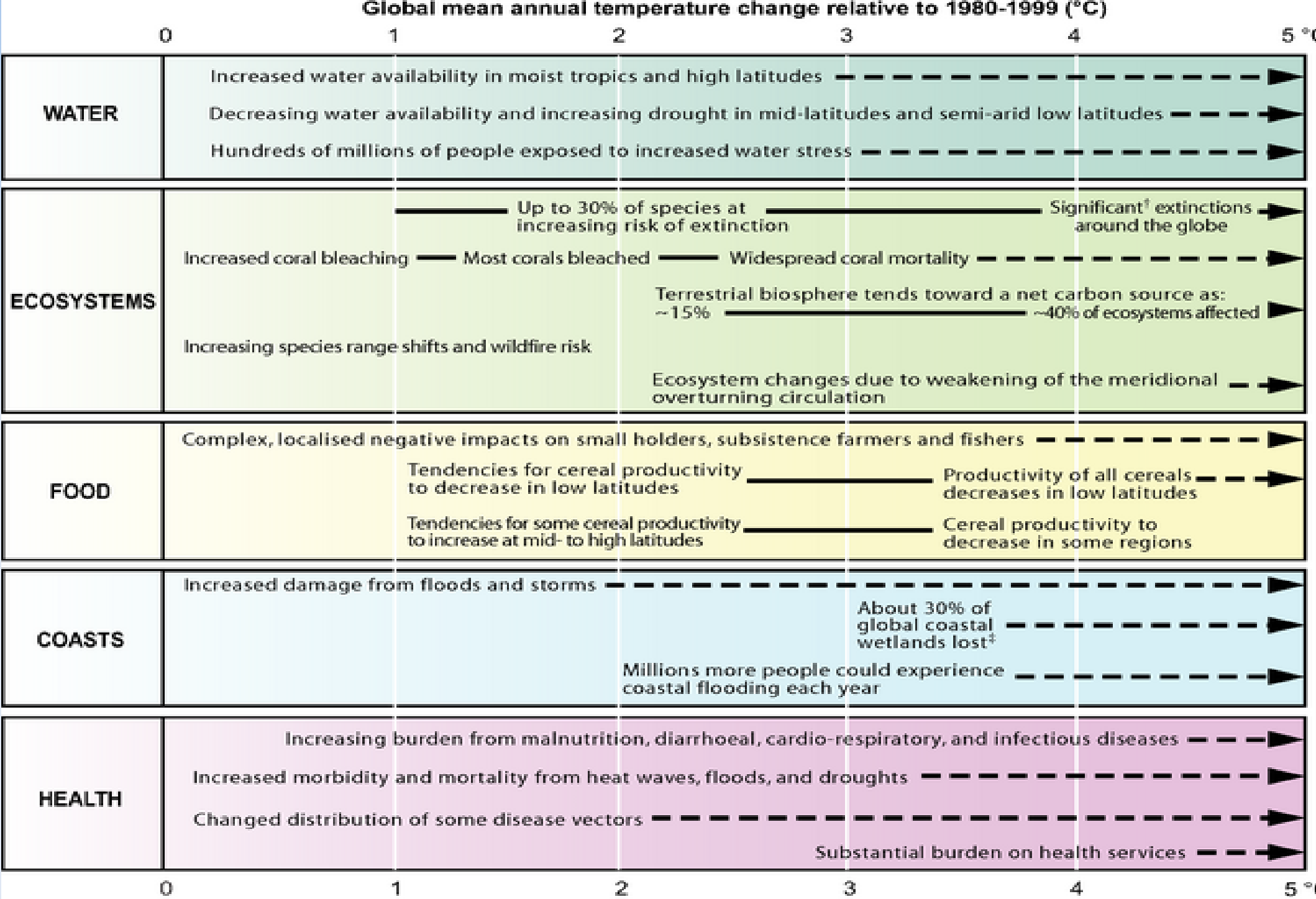
Impacts on freshwater



IPCC AR4 WG 2 Figure 3.8. Background map: Ensemble mean change of annual runoff, in percent, between present (1981 to 2000) and 2081 to 2100 for the SRES A1B emissions scenario (after Nohara et al., 2006).

d) What is a dangerous level of global warming?

- Still difficult to quantify
  - Local effects
  - Market and non-market impacts
  - Risk of larger, faster climate change
- Qualitative, global estimates
  - +4°C seems clearly dangerous
  - +2°C not necessarily safe



Source : IPCC 2007, AR4, WG2 figure SPM.2

† Significant is defined here as more than 40%.

‡ Based on average rate of sea level rise of 4.2 mm/year f

Conclusions on impact

- +2°C in 2100 is average in the B1 scenario
- Adaptation is already necessary
- Risk of larger, faster climate change

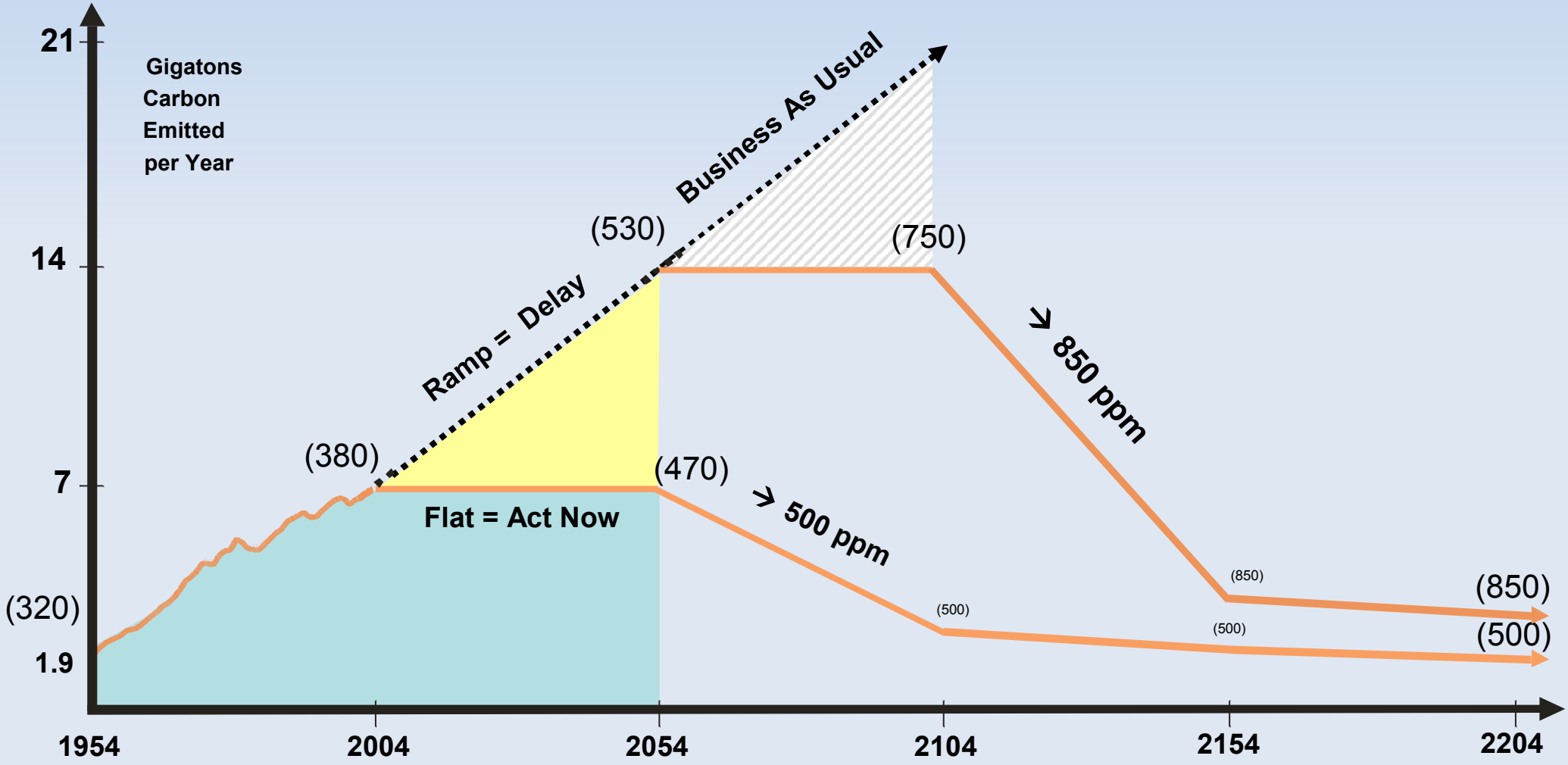
3. Reducing CO2 emissions

Toyota Prius, symbol of the revolution in car markets towards low emissions vehicles

Reaching peak CO_2 emissions

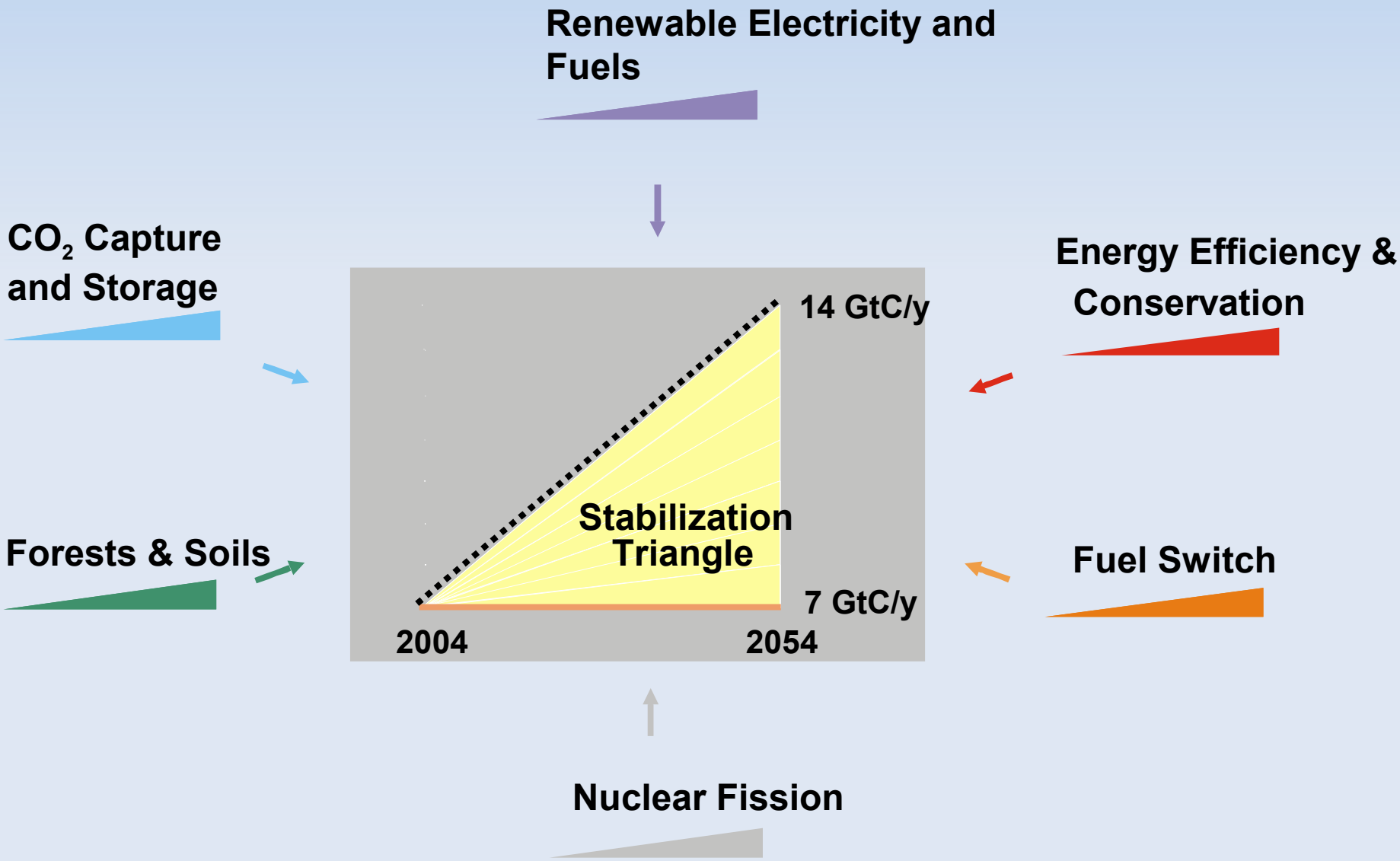
- Needed as soon as possible
- Feasible with existing technologies
- Barriers are economics and politics

a) We can target 550 ppm CO2
but only if emissions peak now



b) Technology & lifestyles options

All these can save up to 1GtC/yr in 2050

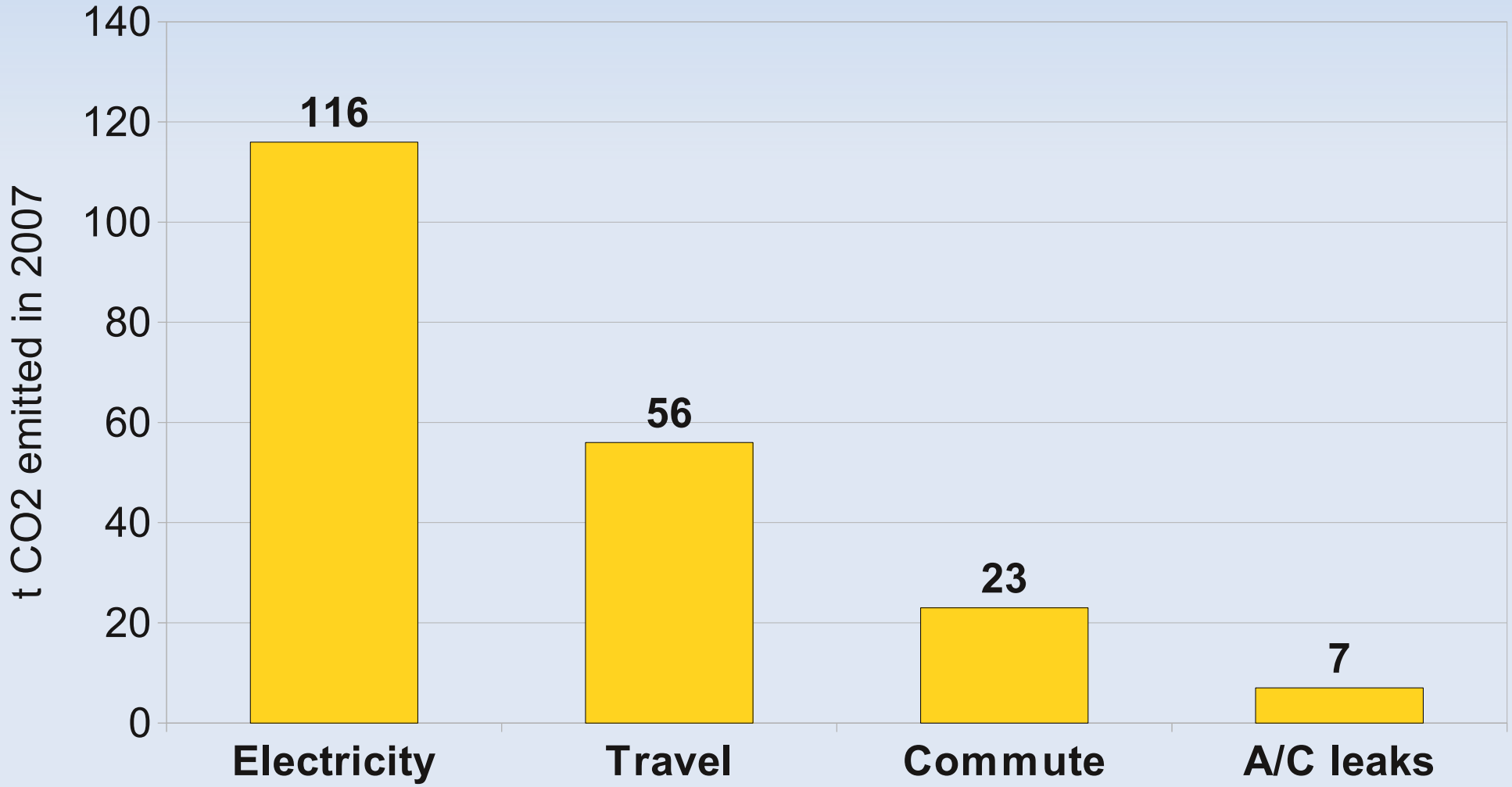


Mitigation already happens

CO2 reinjection in Sleipner natural gas field, Norway

Emissions reduction exercise

Advise a vietnamese outsourcing company, staff 90, to cut its 220 tCO2 carbon budget by 10%



A few ideas

2.3 t CO_2 per employee is already low

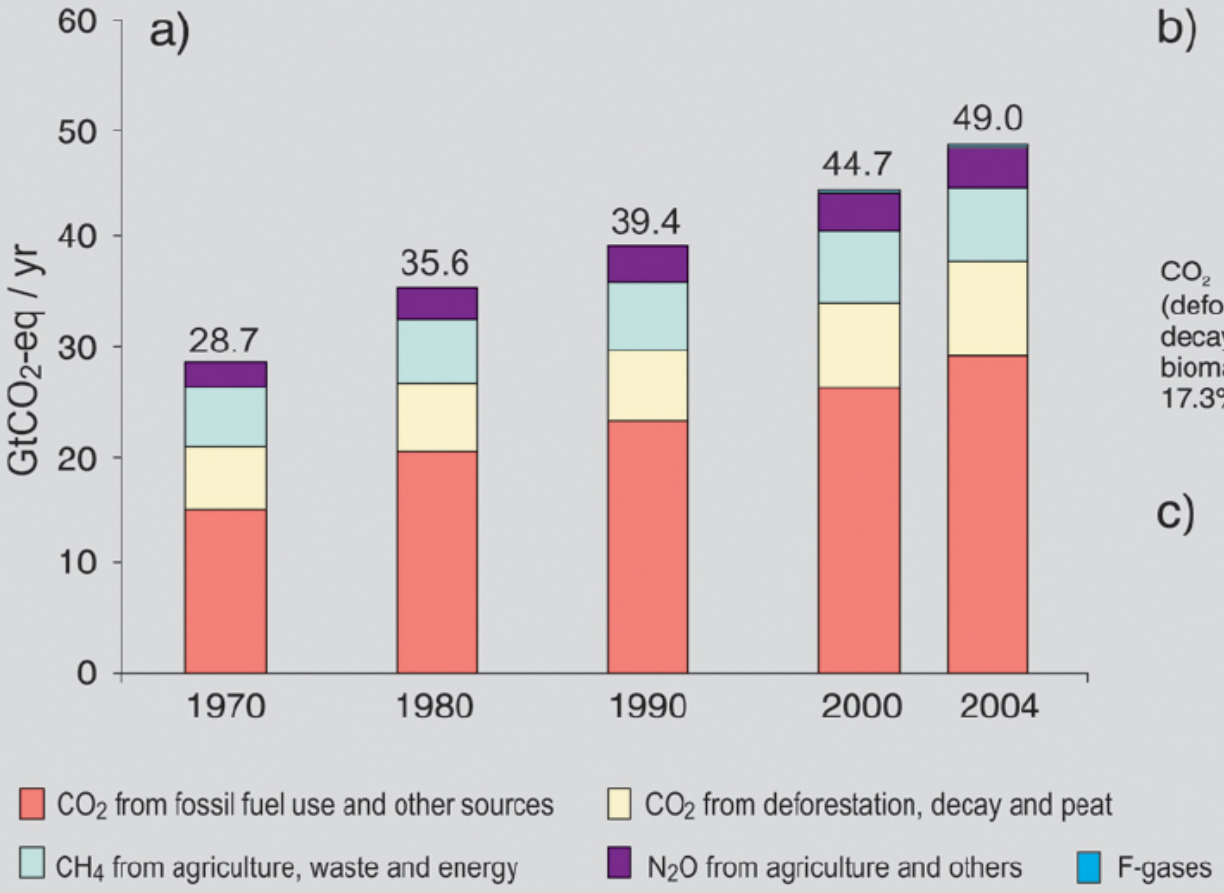
Barclays 3.5, Microsoft 5.3, Coca-Cola 54.4

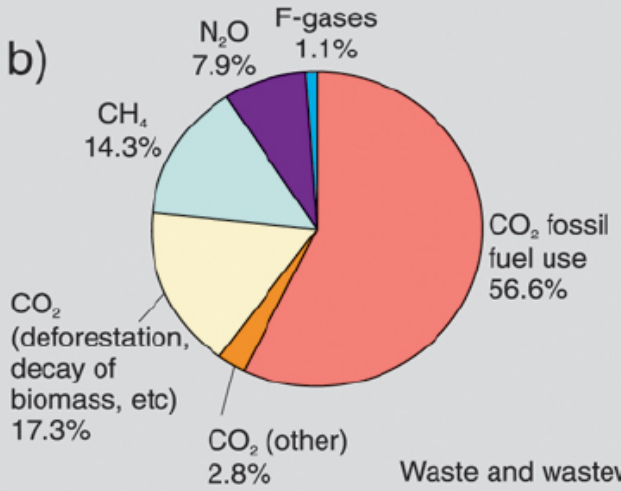
+1°C on A/C	= 7% energy savings
1 return trip to Europe less	= 6 t CO_2
Energy efficient hardware	
Power off after hours	
Ride-sharing	
CO_2 offsets	5.5 – 20 $/t

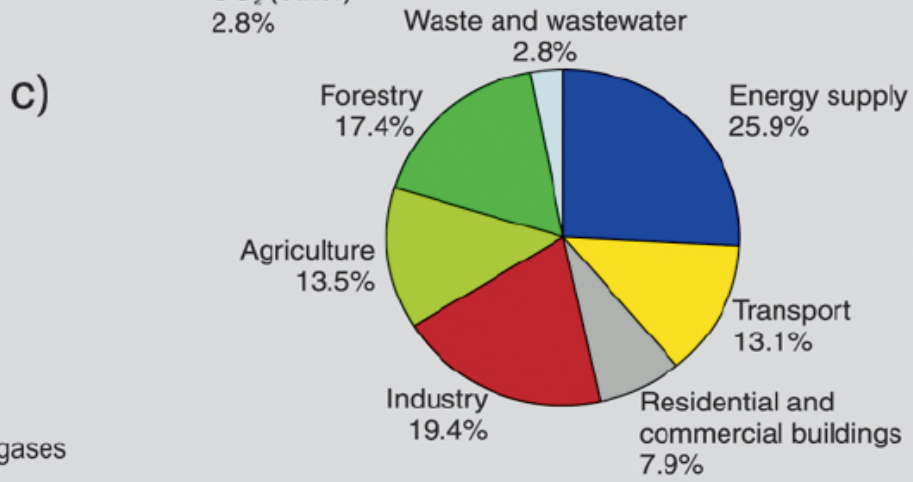
c) Political and economic challenge :
Acting at the global scale on the whole economy

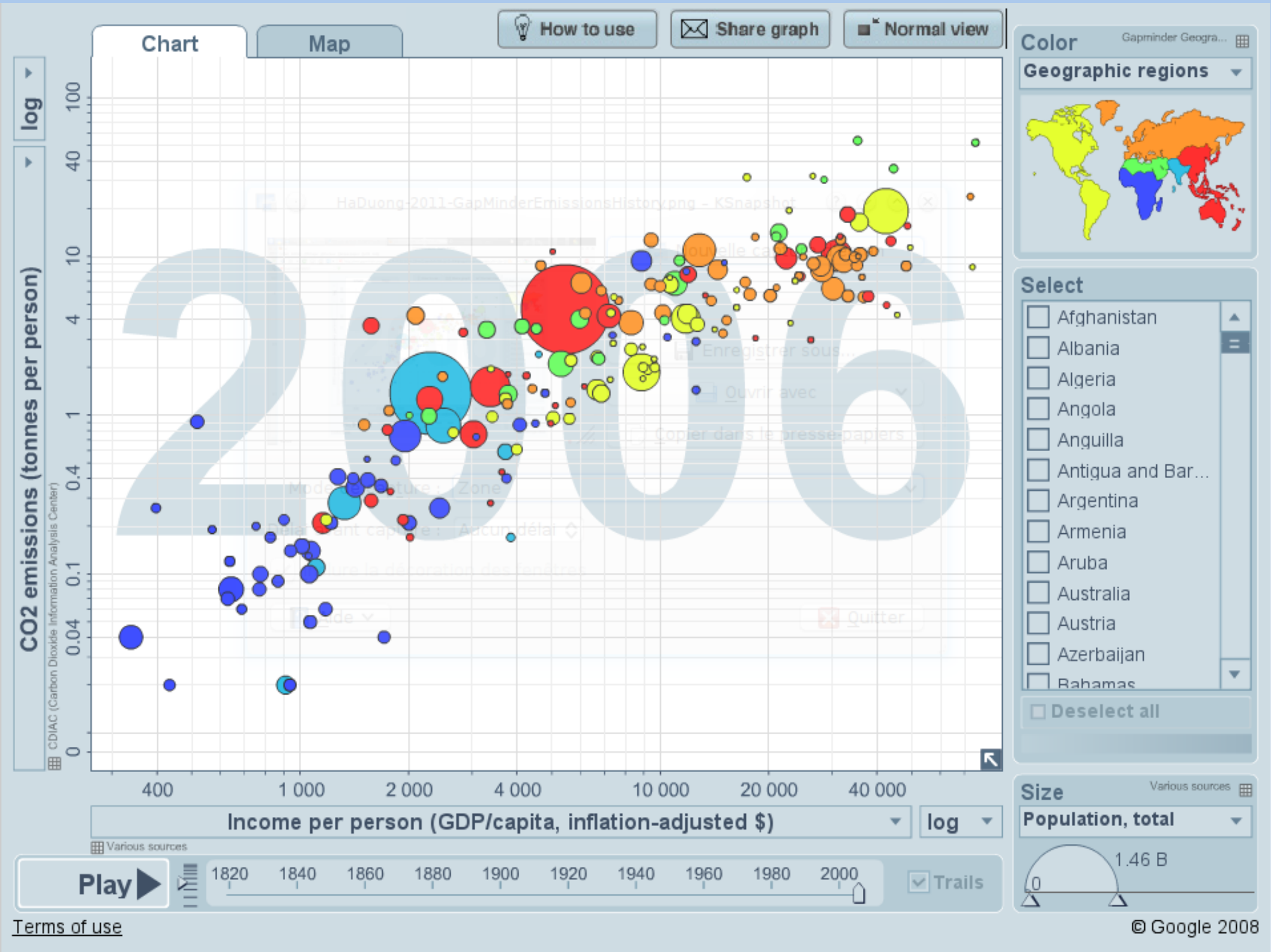
Source : Sokona (2009), Copenhaguen

Global anthropogenic GHG emissions have grown since pre-industrial times, with an increase of 70% between 1970 and 2004. Carbon dioxide is the larger contributor.








How to use
Share graph
Normal view
Chart
Map
Color
Gapminder Geogra...
Geographic regions
Select
Afghanistan
Albania
Algeria
Angola
Anguilla
Antigua and Bar...
Argentina
Armenia
Aruba
Australia
Austria
Azerbaijan
Bahamas
Deselect all
log
CO2 emissions (tonnes per person)
CDIAC (Carbon Dioxide Information Analysis Center)
0
0.04
0.1
0.4
1
4
10
40
100
2006
400
1 000
2 000
4 000
10 000
20 000
40 000
Income per person (GDP/capita, inflation-adjusted $)
log
Various sources
Size
Various sources
Population, total
1.46 B
0
Play
1820
1840
1860
1880
1900
1920
1940
1960
1980
2000
Trails
Terms of use
© Google 2008

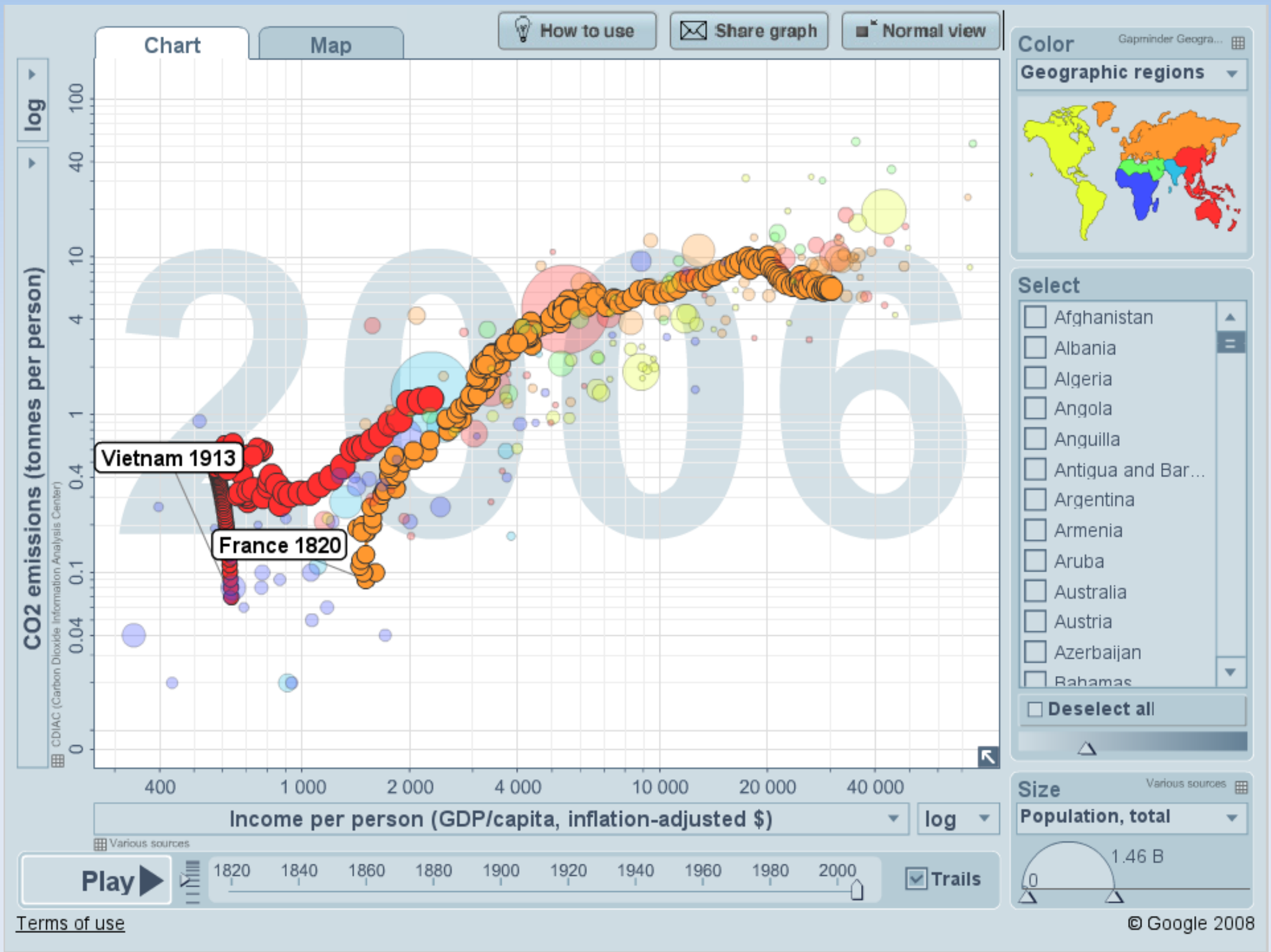


Chart
Map
How to use
Share graph
Normal view
Color
Gapminder Geogra...
Geographic regions
Select
Afghanistan
Albania
Algeria
Angola
Anguilla
Antigua and Bar...
Argentina
Armenia
Aruba
Australia
Austria
Azerbaijan
Bahamas
Deselect all
log
CO2 emissions (tonnes per person)
CDIAC (Carbon Dioxide Information Analysis Center)
0
0.04
0.1
0.4
1
4
10
40
100
2006
Vietnam 1913
France 1820
400
1 000
2 000
4 000
10 000
20 000
40 000
Income per person (GDP/capita, inflation-adjusted $)
log
Various sources
Size
Various sources
Population, total
1.46 B
0
Play
1820
1840
1860
1880
1900
1920
1940
1960
1980
2000
Trails
Terms of use
© Google 2008

Conclusions on technologies

- Need to peak CO2 emissions Real Soon Now
- Technically feasible, already started
- Compared to 1990, Europe wants to reduce by 30% in 2020. Factor 4 in 2050

4. CO2 value, CO2 markets

1. What is the value of CO2 ?
2. Market-based approaches in CO2 mitigation

The many meanings of carbon value

Carbon price: What has to be paid (to some public authority as a **tax** rate, or on some **emission permit** exchange) for the emission of 1 tonne of CO2 into the atmosphere. In the models and this Report, the carbon price is the **social cost of avoiding** an additional unit of CO2 equivalent emission. In some models it is represented by the **shadow price** of an additional unit of CO2 emitted, in others by the rate of carbon tax, or the price of emission-permit allowances. It has also been used in this Report as a **cut-off rate for marginal abatement** costs in the assessment of economic mitigation potentials. (IPCC, 2007)

1. Social cost of avoided damages

Each tonne of CO2 which is not released into the atmosphere means a little less climate change.

Not scientifically knowable:

- How to measure the value of ecosystems ?
- The value of life ?
- The value of risk reduction ?

2. Abatement cost

The cost of reducing CO2 emissions depends on :

- Scale : production line, plant, industry, country...
- Perimeter : technical, economic, macro, social
- CO2 or CO2 equivalent
- Observations or predictions ?
- Average, total, marginal ?
- Time schedule and technical progress

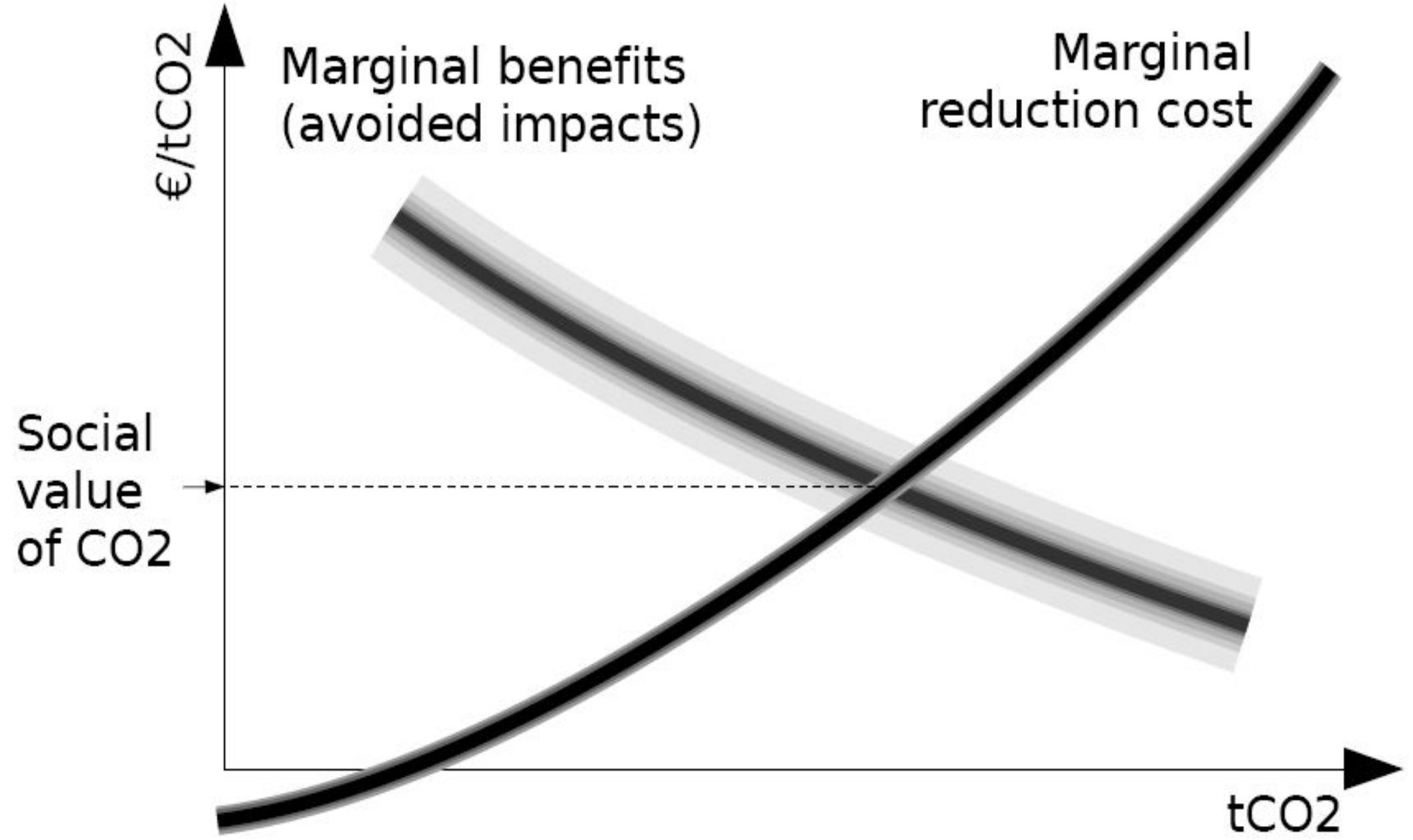
1t of CO2 = 5 to 80 $ (USD 2007) ?

An effective carbon-price signal could realise significant mitigation potential in all sectors. Modelling studies show that global carbon prices rising to US$20-80/tCO$_2$-eq by 2030 are consistent with stabilisation at around 550ppm CO$_2$-eq by 2100.

For the same stabilisation level, studies since the TAR that take into account induced technological change may lower these price ranges to US$5-65/tCO$_2$-eq in 2030.

IPCC, Barker et al., 2007: WGIII 3.3, 11.4, 11.5, SPM

3. (1+2) Social cost of carbon



SCC too uncertain for policy

In our view, the social value of carbon today is within a bracket of €1-1,000 per tonne of CO_2 and more likely somewhere between 5-200 €/tCO_2.

Scientists cannot (or should not) be more specific.

4. The « shadow » price

- Determination of a value for avoided CO2 necessarily becomes a political decision.
- Global talks so far about quantities (= quotas), but could come back to prices (= taxes)
- Taxes and quotas can be mixed.

Existing taxes (€/t CO2)

In France

Gas	265,0
Diesel	158,0
Liquefied gas	43,0
Heating fuel	21,0
Natural gas	5,8
Coal	3,5

Other Europe : Finland, Denmark ~ 20, Norway 40, Sweden 97. Climate Change Levy in UK, Green tax reform in Germany. Businesses pay less than households.

The French CO2 tax case

- The Planning bureau recommended **€27** / tCO2 increasing at 3% per year from 2005 onwards.
- Updated in 2008 at **€32**/tCO2, reaching **€100 in 2030** and increasing to €250/tCO2 in 2050 within a bracket from €150 to €350/tCO2.
- Government said start at **17€** / tCO2 then abandonned the tax idea.

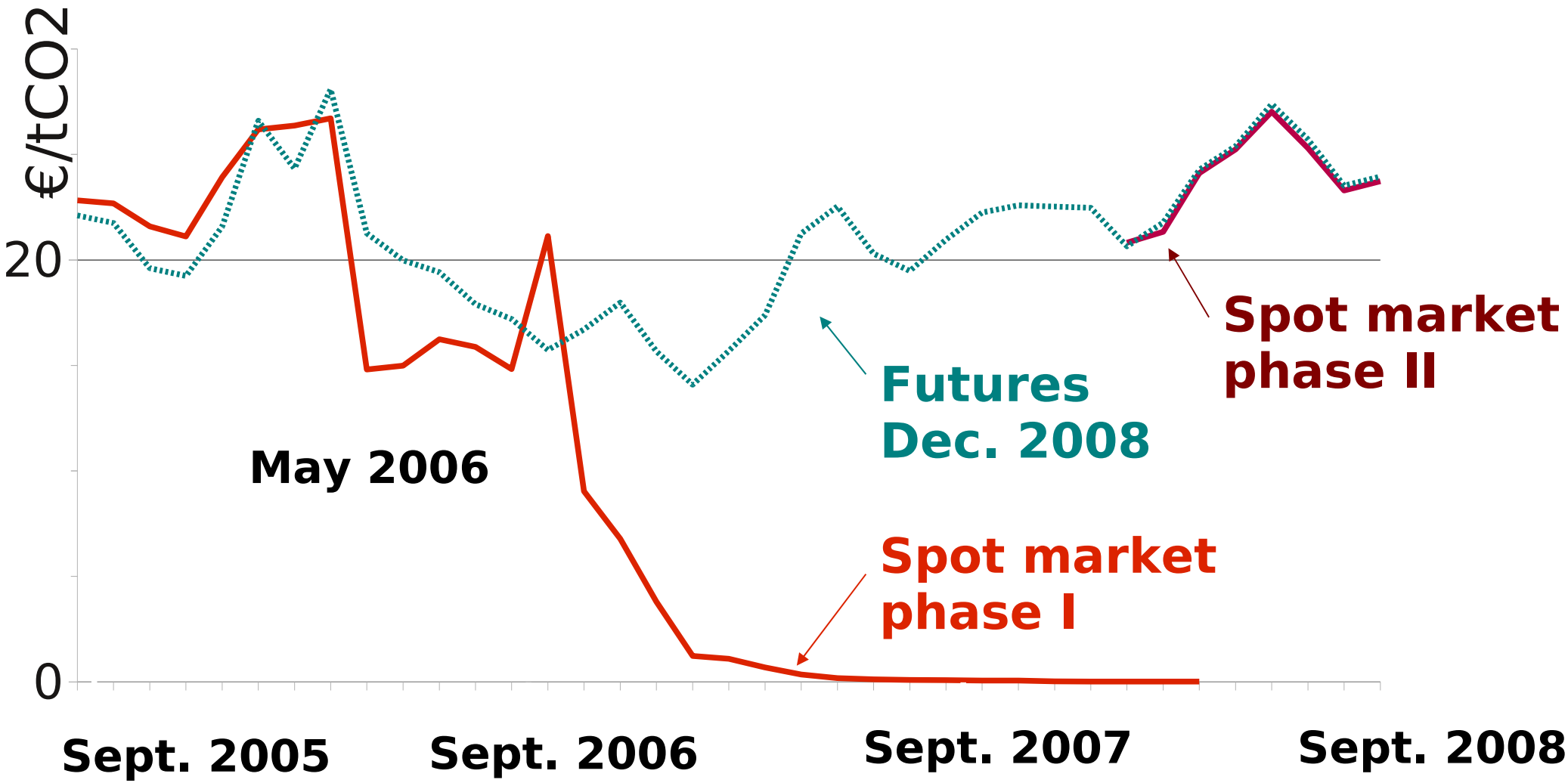
5. CO2 markets prices

- European Trading Scheme
- Clean Development Mechanism / Joint Implementation
- Retail market, voluntary reductions

European Trading Scheme

- In Europe, releasing CO2 into the atmosphere is regulated for large industrial emitters (thermal capacity > 20MW). An EUA (European Union Allowance), is a one-time authorisation to emit one tonne of CO2 into the atmosphere.
- In 2005, Member States allocated a provision of EUAs to their industrial concerns, covering approximately three years of activity.
- Companies who emitted more CO2 than their allowance had to buy extra EUAs from companies who had kept their emissions below their allotted level.

Price of a CO_2 emission permit in Europe



Source: Tendances Carbone, Mission Climat, CDC

Clean Development Mechanism

Finance emission reduction projects in a developing country.

For example, Scottish and Southern Energy PLC purchased two million Emission Reduction Certificates (CER), over a period of five years beginning in 2008, from the China Guodian Corporation in exchange for which the Chinese company contracted to build four new wind farms, each with a capacity of 50MW (less coal-fired power stations).

Markets links

CERs tend to be valuated with a 30 to 50% discount compared to the price of EUAs, depending on the quality of the project.

On the retail market, numerous websites for the sale of CO2 offsets are on line. Individuals pay around €15 / t CO2 to reliable sellers. Based on CERs which are not equal in quality.

Conclusion on CO2 markets

- Emissions trading used in other markets like SO2 in the US.
- Market prices ~€15 in EU, much less in the US
- Political prices higher, but realistically inserted in the global economy
- Not sufficient : R&D support, tax breaks for renewables & houseworks, higher norms

Conclusion

- Expect more global warming and sea level rise
- Adaptation needed, +2°C will be hard to avoid
- Politically difficult from top: it’s everybody problem
- Mitigation has already started