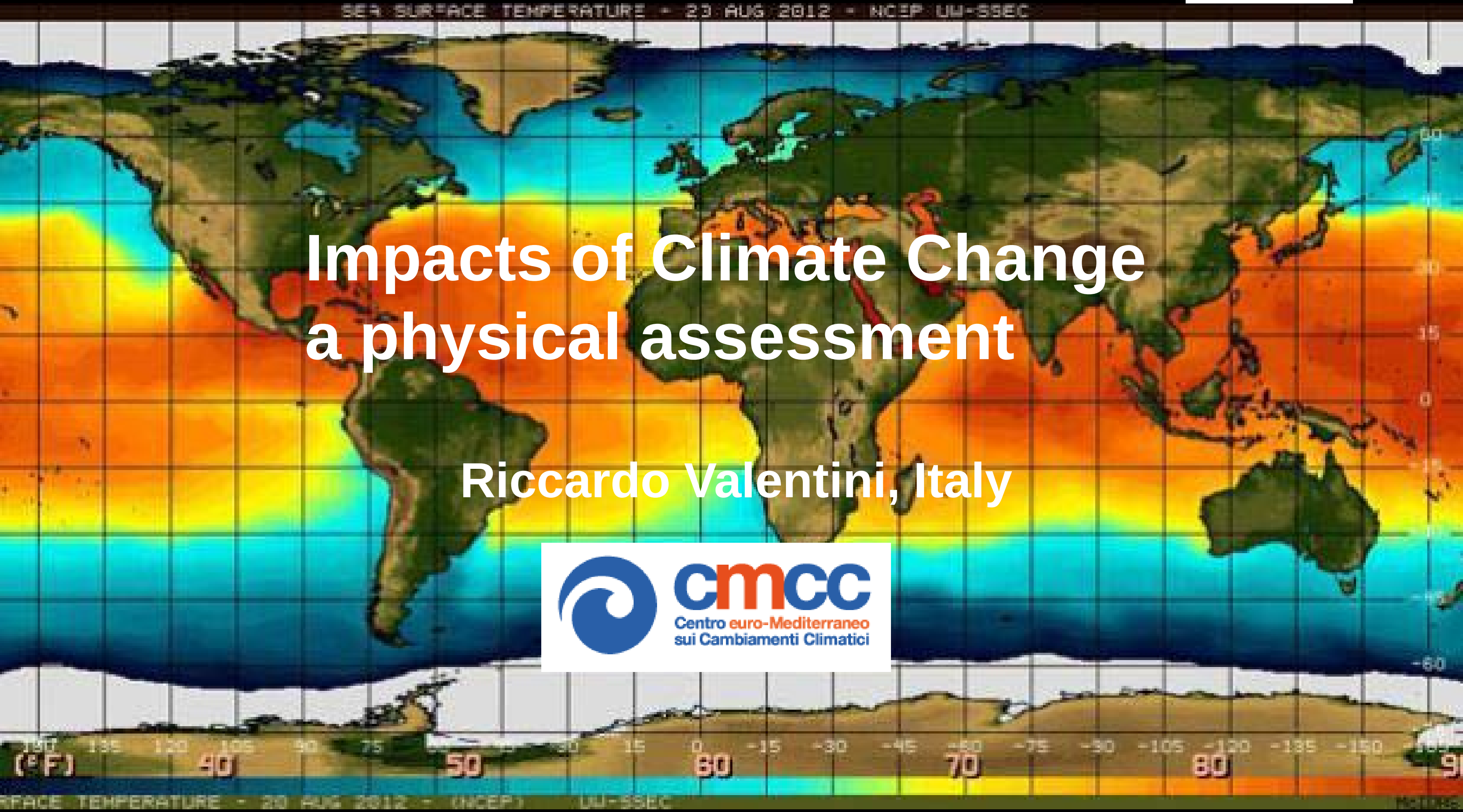
Impacts of Climate Change
a physical assessment

Riccardo Valentini, Italy



Publications

GEO CARBON

opinion & comment

COMMENTARY:

The challenge to keep global warming below 2 °C

Glen P. Peters, Robbie M. Andrew, Tom Boden, Josep G. Canadell, Philippe Ciais, Corinne Le Quéré, Gregg Marland, Michael R. Raupach and Charlie Wilson

The latest carbon dioxide emissions continue to track the high end of emission scenarios, making it even less likely global warming will stay below 2 °C. A shift to a 2 °C pathway requires immediate significant and sustained global mitigation, with a probable reliance on net negative emissions in the longer term.

On-going climate negotiations have recognized a "significant gap" between the current trajectory of global greenhouse-gas emissions and the "likely chance of holding the increase in global average temperature below 2 °C or 1.5 °C above pre-industrial levels"[1]. Here we compare recent trends in carbon dioxide (CO_2) emissions from fossil-fuel combustion, cement production and gas flaring with the primary emission scenarios used by the Intergovernmental Panel on Climate Change (IPCC). Carbon dioxide emissions are the largest contributor to long-term climate change and thus provide a good baseline to assess progress and examine consequences. We find that current emission trends continue to track scenarios that lead to the highest temperature increases. Further delay in global mitigation makes it increasingly difficult to stay below 2 °C.

Long-term emissions scenarios are designed to represent a range of plausible emission trajectories as input for climate change research[2,3]. The IPCC process has resulted in four generations of emissions scenarios[2]: Scientific Assessment 1990 (SA90)[4], IPCC Scenarios 1992 (IS92)[5], Special Report on Emissions Scenarios (SRES)[6], and the evolving Representative Concentration Pathways (RCPs)[7] to be used in the upcoming IPCC Fifth Assessment Report. The RCPs were developed by the research community as a new, parallel process of scenario development, whereby climate models are run using the RCPs while simultaneously socioeconomic and emission scenarios are developed that span the range of the RCPs and beyond[3].

It is important to regularly re-assess the relevance of emissions scenarios in light of changing global circumstances[3,8]. In the past, decadal trends in CO_2 emissions have responded slowly to changes in the underlying emission drivers because of inertia and path dependence in technical, social and political systems[9]. Inertia and path dependence are unlikely to be affected by short-term fluctuations[2,3,9] — such as financial crises[10] — and it is probable that emissions will continue to rise for a period even after global mitigation has started[11]. Thermal inertia and vertical mixing in the ocean, also delay the temperature response to CO_2 emissions[12]. Because of inertia, path dependence and changing global circumstances, there is value in comparing

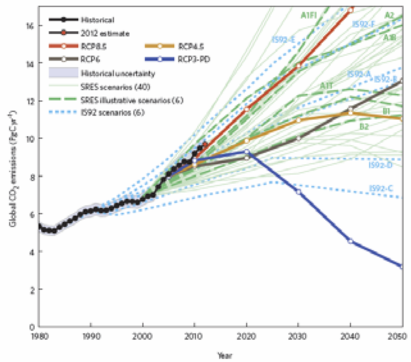


Figure 1 | Estimated CO_2 emissions over the past three decades compared with the IS92, SRES and the RCPs. The SA90 data are not shown, but the most relevant (SA90-A) is similar to IS92-A and IS92-F. The uncertainty in historical emissions is ±5% (one standard deviation). Scenario data is generally reported at decadal intervals and we use linear interpolation for intermediate years.

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Open Access Earth System Science Data Discussions

The global carbon budget 1959–2011

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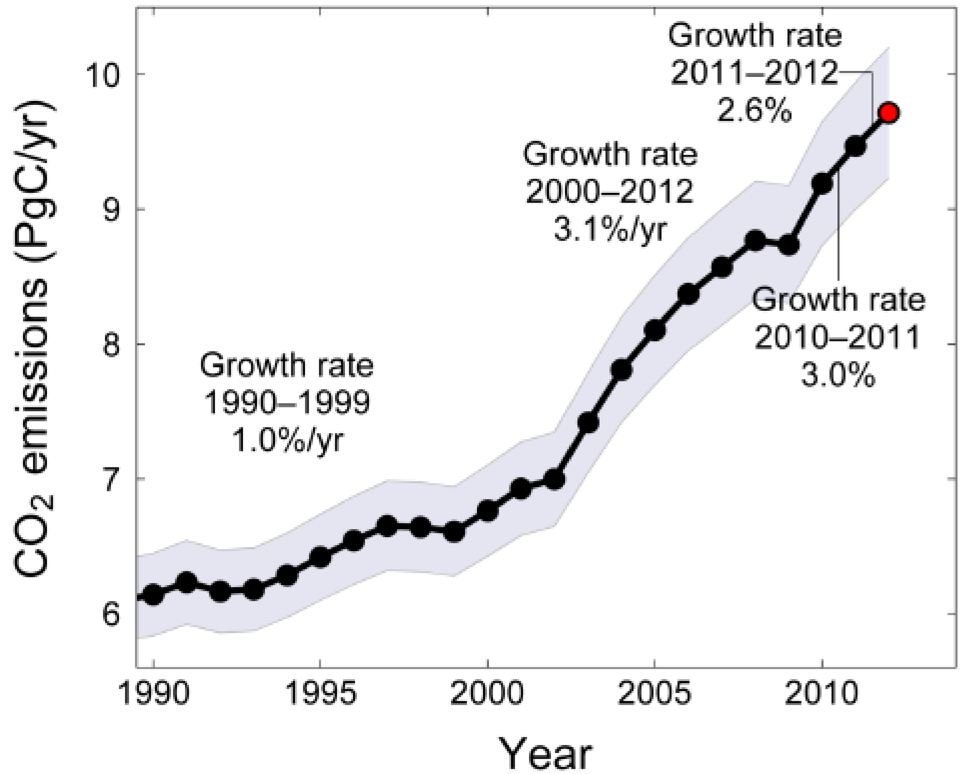
More information, data sources and data files at

www.globalcarbonproject.org

Fossil and Cement Emissions

Global fossil and cement emissions: 9.5±0.5PgC in 2011, 54% over 1990

Estimate for 2012: 9.7±0.5PgC, 58% over 1990

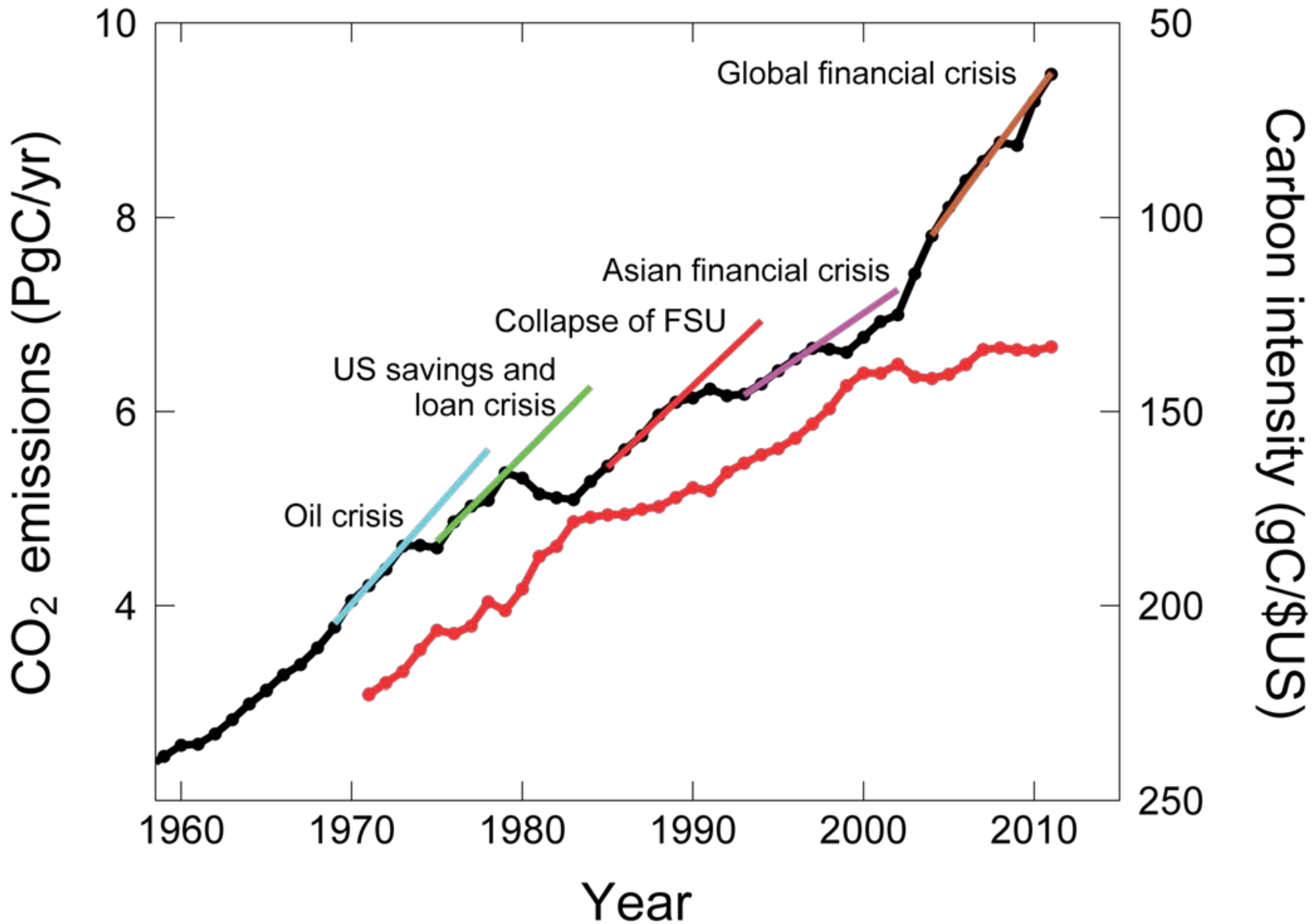


Uncertainty is 5% for one standard deviation (IPCC “likely” range)

Source: Peters et al. 2012; Le Quéré et al. 2012; Global Carbon Project 2012; CDIAC Data

Carbon Intensity of Economic Activity

The global financial crisis of 2008/2009 had no lasting effect on emissions
Carbon intensity has not improved with increased economic activity since 2005



Source: Peters et al. 2012a; Le Quéré et al. 2012; CDIAC Data; Global Carbon Project 2012

Observed Emissions and Emission Scenarios

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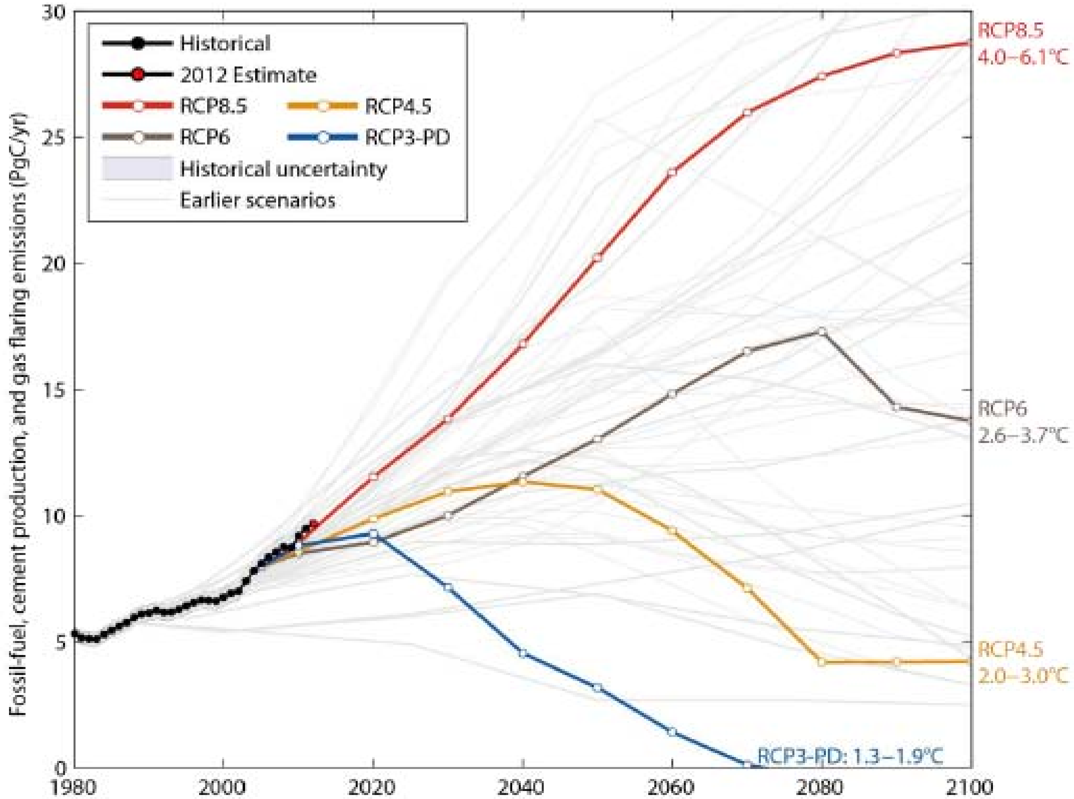
Emissions are heading to a 4.0-6.1°C "likely" increase in temperature

Considerable effect required to keep below 2°C



Source: Peters et al. 2012; Le Quéré et al. 2012; Global Carbon Project 2012; CDIAC Data

Observed Emissions and Emission Scenarios

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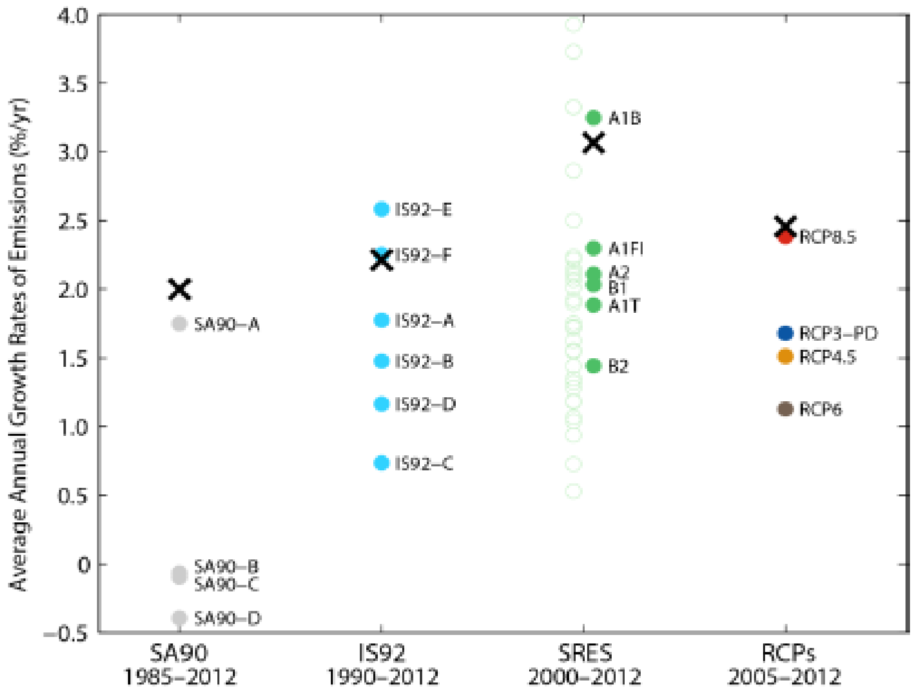
Observed emissions (**X**) continue to track the top-end of all scenarios (●)



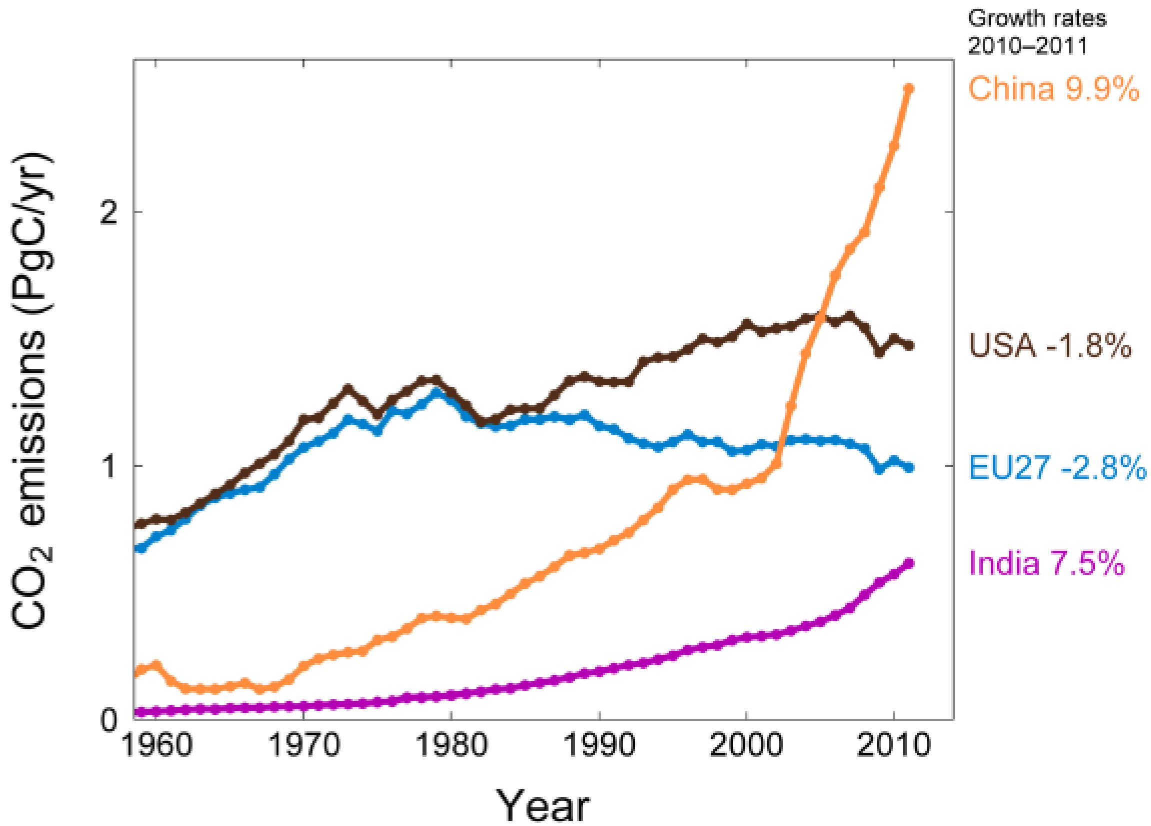
Crosses (**X**) : Historical emissions growth over the period in horizontal axis

Circles (●) : Scenario emissions growth over the period in horizontal axis

Source: Peters et al. 2012; Le Quéré et al. 2012; Global Carbon Project 2012; CDIAC Data

Top Fossil Fuel Emitters (Absolute)

Top emitters 2011: China (28%), United States (16%), EU27 (11%), India (7%)

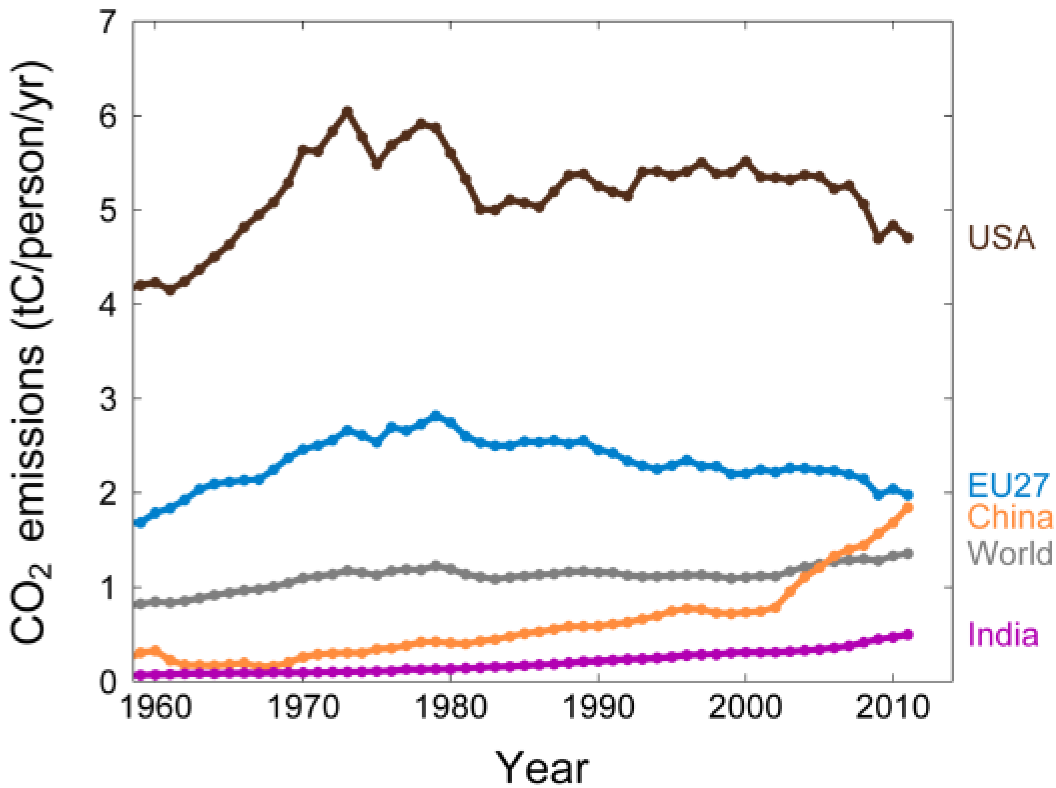


Growing gap between EU27 and USA due to emission decreases in Germany, Poland, and Romania.

Source: Le Quéré et al. 2012; Global Carbon Project 2012; CDIAC Data

Top Fossil Fuel Emitters (Per Capita)

Top emitters 2011: China (28%), United States (16%), EU27 (11%), India (7%)

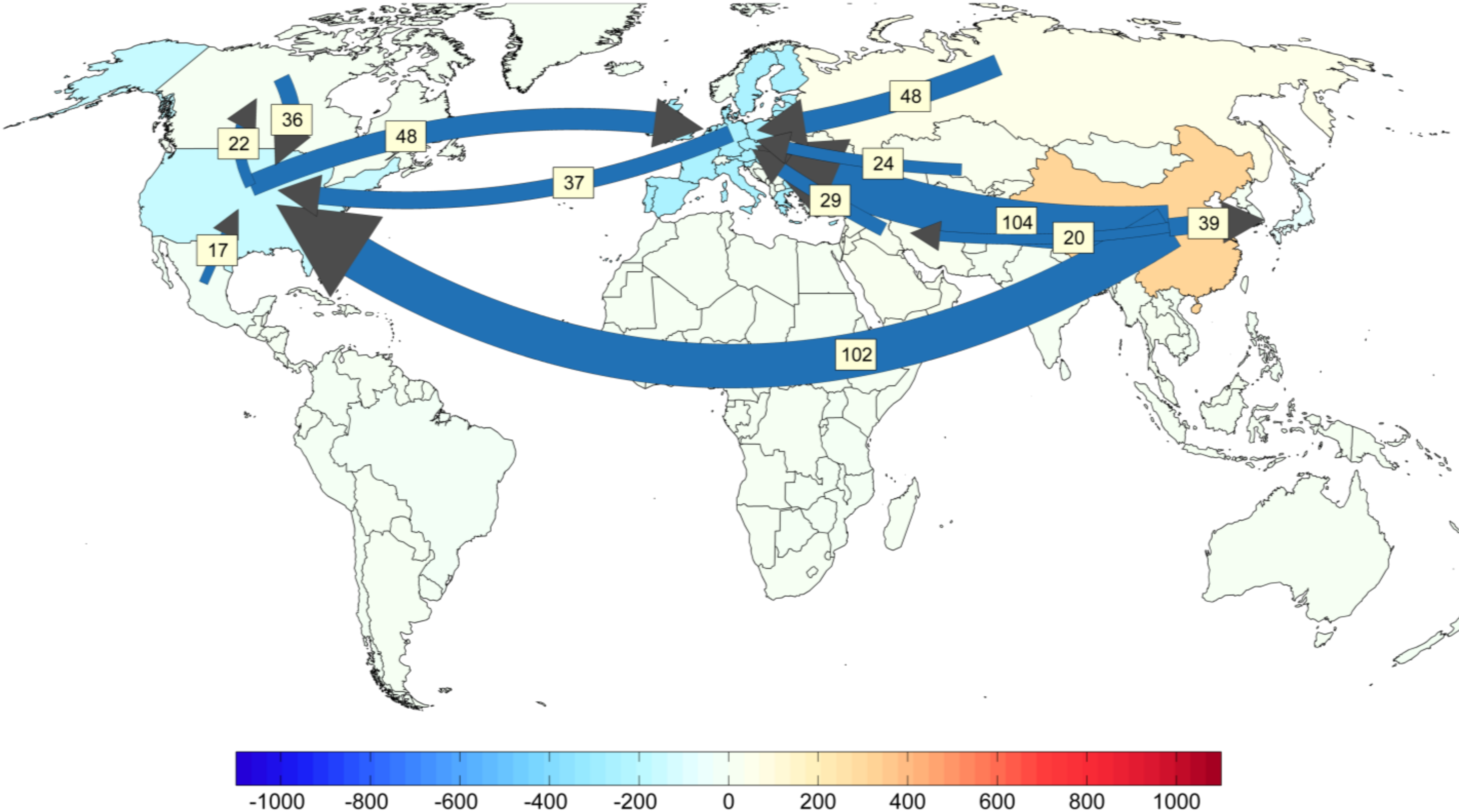


Source: Le Quéré et al. 2012; Global Carbon Project 2012; CDIAC Data

Major flows from Production to Consumption

Start of Arrow: fossil-fuel consumption (production)

End of arrow: goods and services consumption

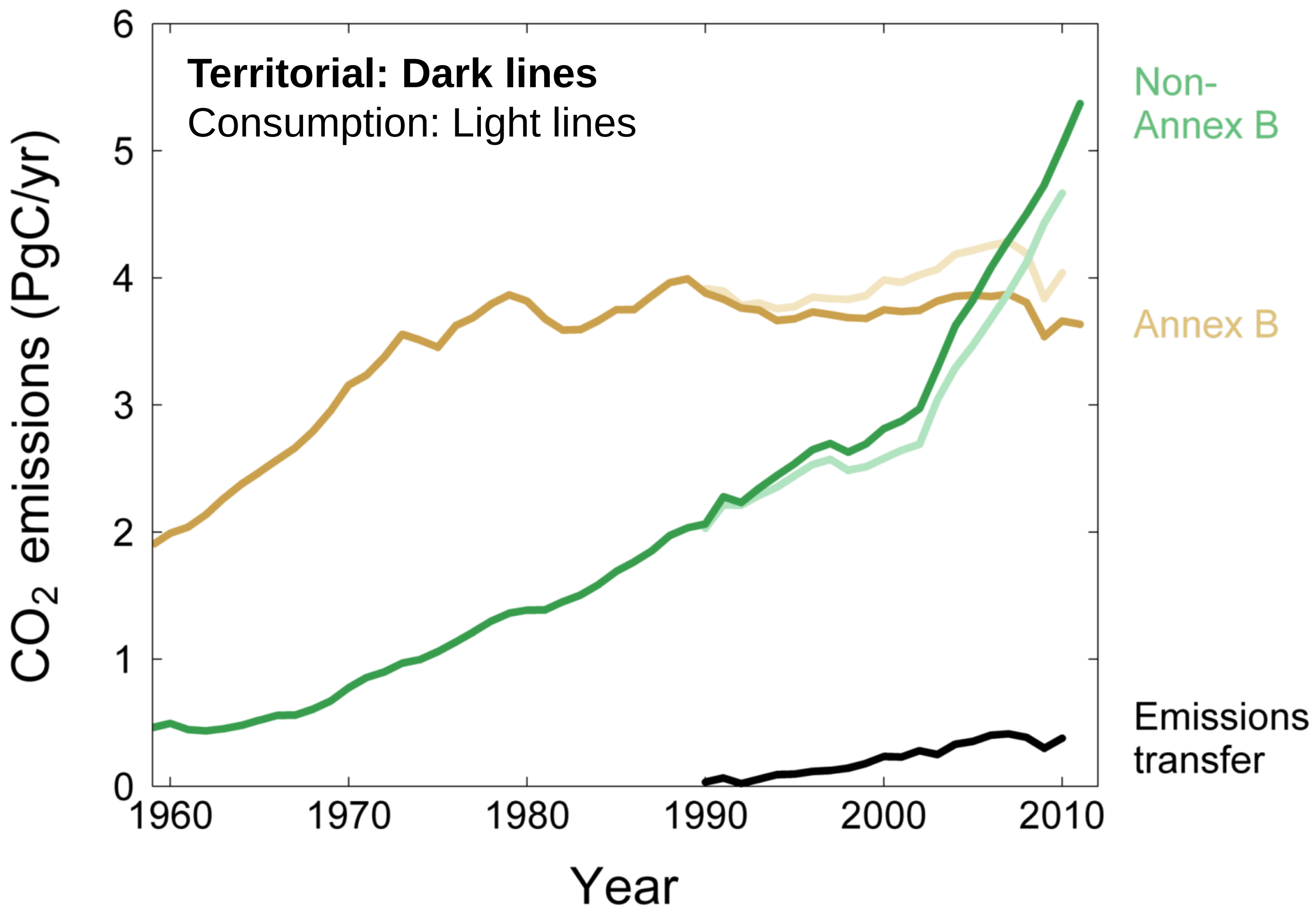


Values for 2007. EU27 is treated as one region. Units: TgC=PgC/1000

Source: Peters et al 2012b

Consumption emissions as per the Kyoto Protocol

The net emissions transfers into Annex B countries (black line) more than offsets the Annex B emission reductions achieved within the Kyoto Protocol



In Annex B, production/territorial-based emissions have had a slight decrease, consumption-based emissions have grown at 0.5%/yr, and emission transfers have grown at 10%/yr

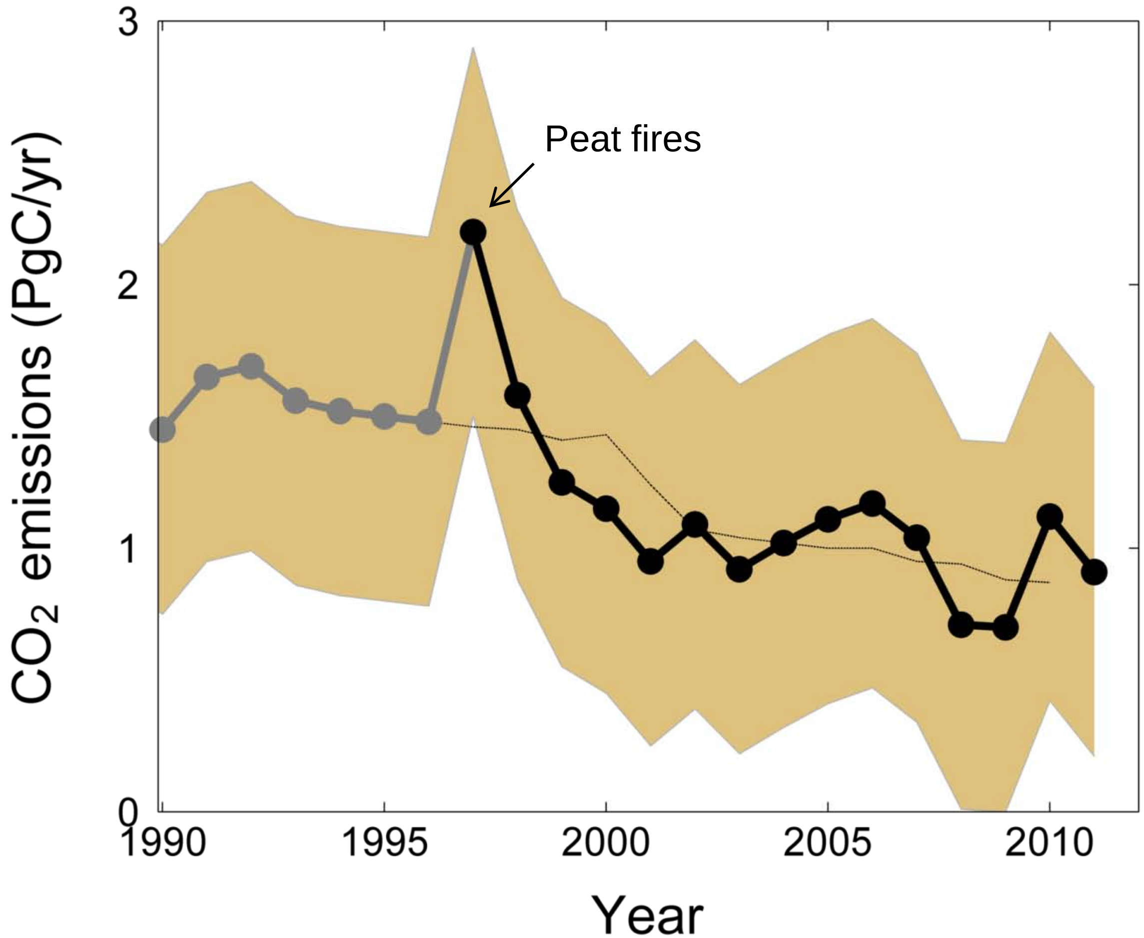
Source: Le Quéré et al. 2012; Peters et al 2011; Global Carbon Project 2012

Land Use Change Emissions

Land-Use Change Emissions

Global land-use change emissions: 0.9±0.5PgC in 2011

The data suggests a general decrease in emissions since 1990



Black line: Includes management-climate interactions; Thin line: Previous estimate

Source: Le Quéré et al. 2012; Global Carbon Project 2012

Fate of Anthropogenic CO_2 Emissions (2002-2011 average)

8.3±0.4 PgC/yr 90%

1.0±0.5 PgC/yr 10%

+

4.3±0.1 PgC/yr

46%

2.6±0.8 PgC/yr

28%

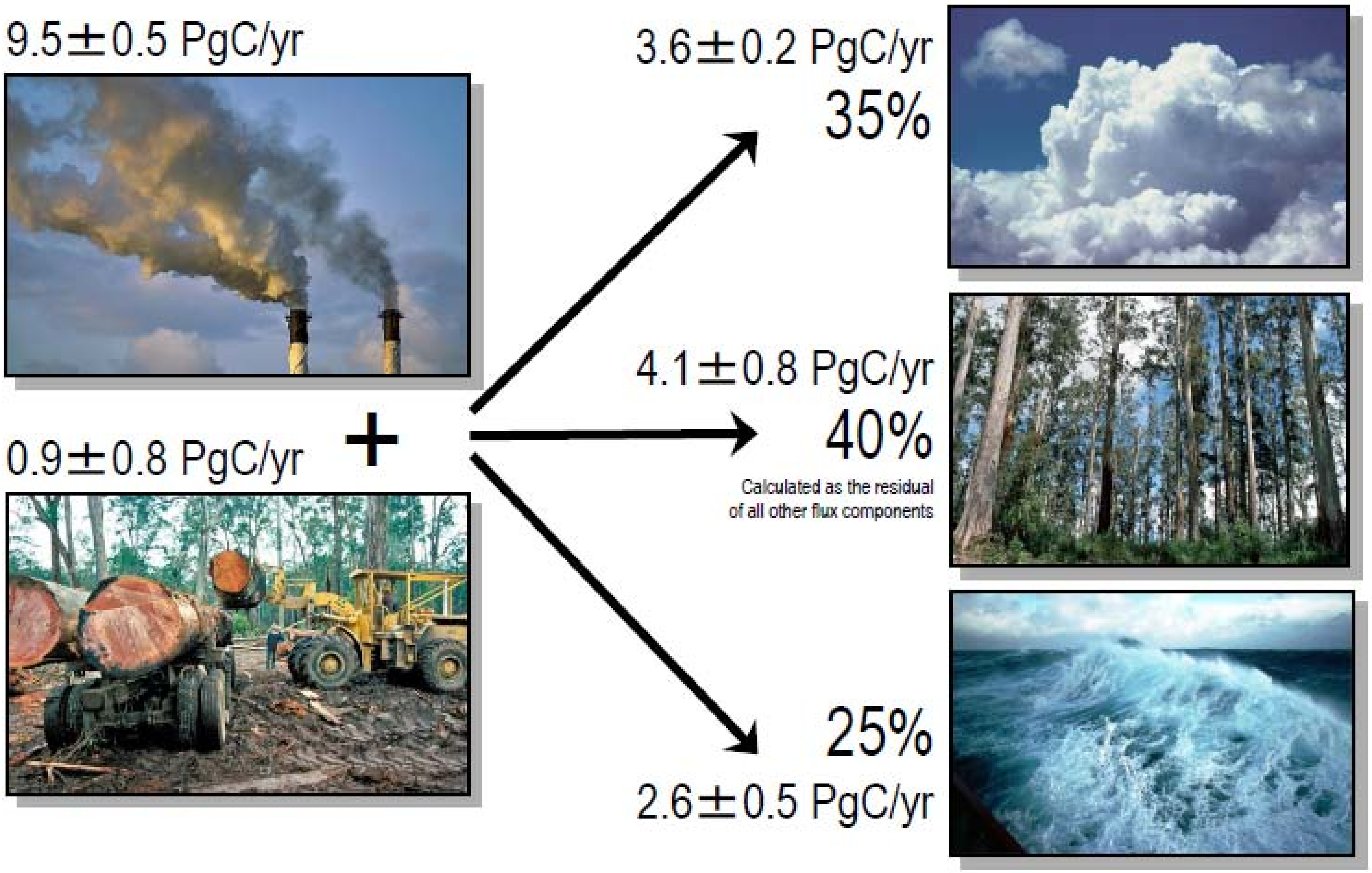
Calculated as the residual of all other flux components

26%

2.5±0.5 PgC/yr

Source: [Le Quéré et al. 2012](); [Global Carbon Project 2012]()

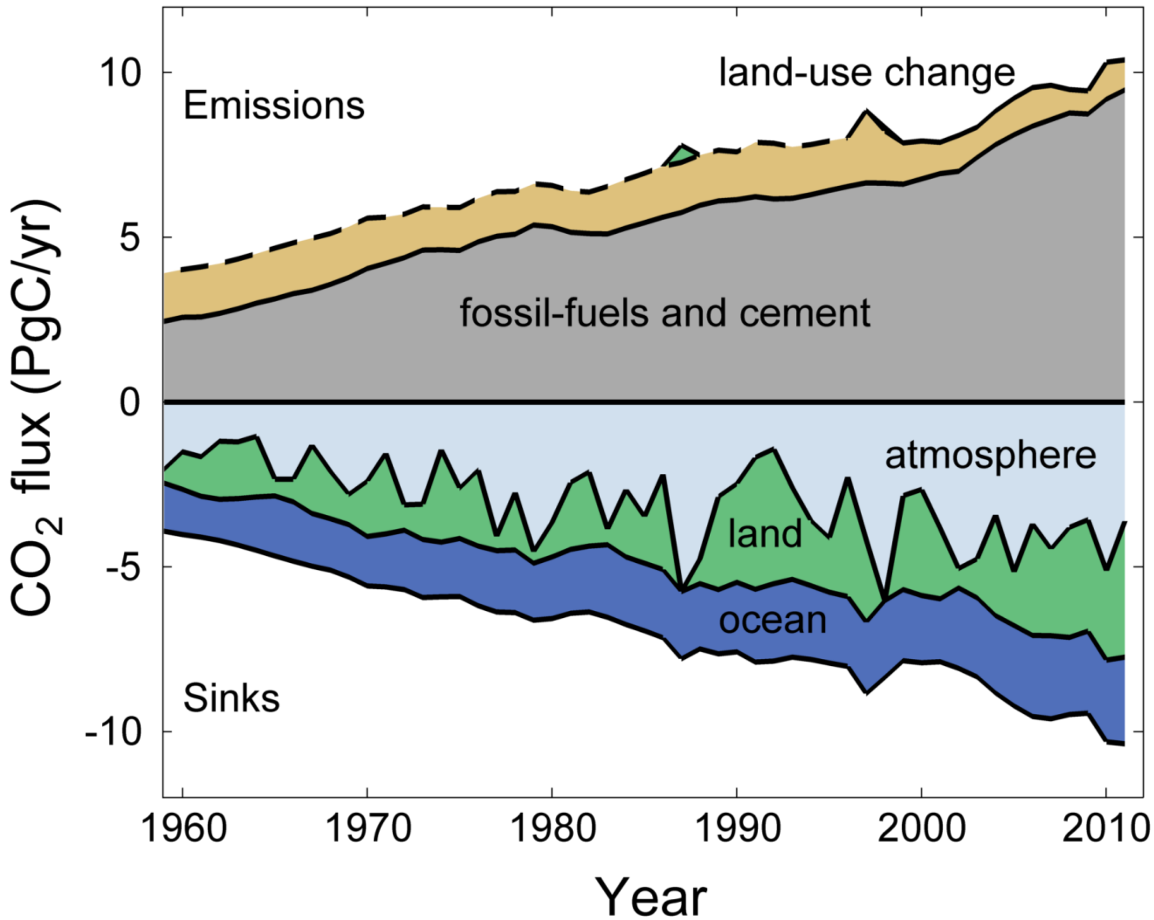
Fate of Anthropogenic CO_2 Emissions (2011)



Source: Le Quéré et al. 2012; Global Carbon Project 2012

Emissions to the atmosphere are balanced by the sinks

Averaged sinks since 1959: 44% atmosphere, 28% land, 28% ocean



The dashed land-use change line does not include management-climate interactions

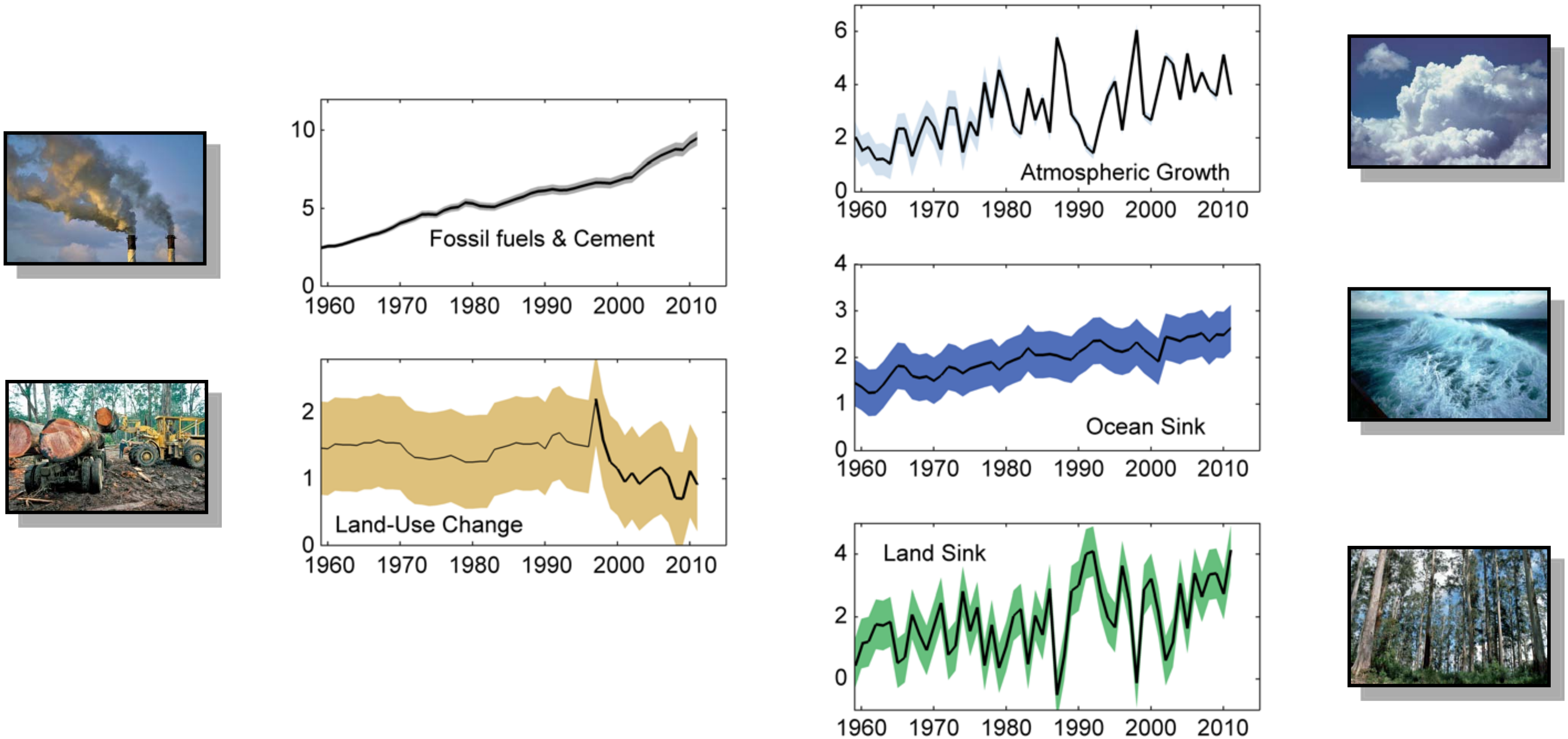
The land sink was a source in 1987 and 1998 (1997 visible as an emission)

Source: Le Quéré et al. 2012; Global Carbon Project 2012

Changes in the Global Carbon Budget over Time

The sinks have continued to grow with increasing emissions

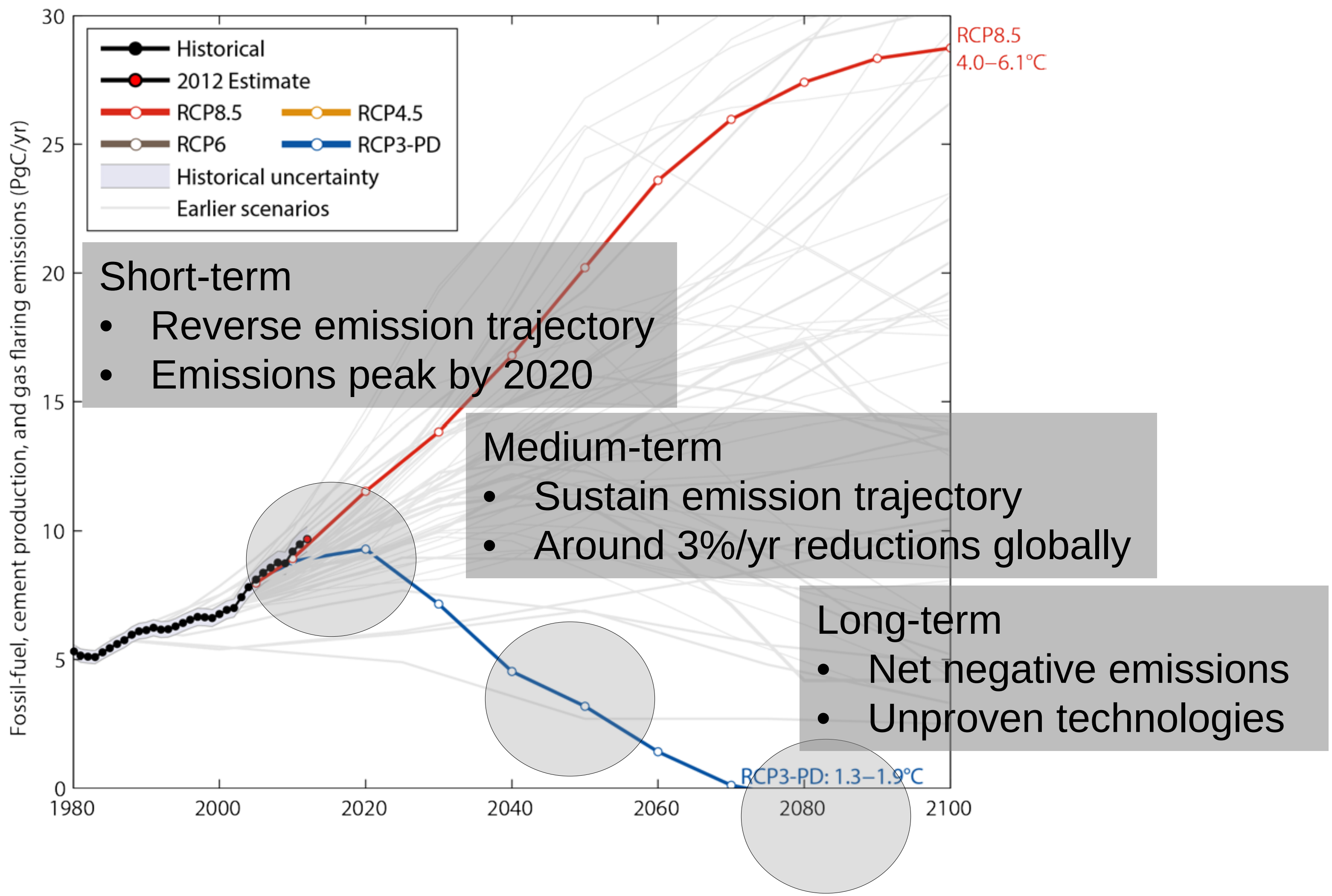
It is uncertain how efficient the sinks will be in the future



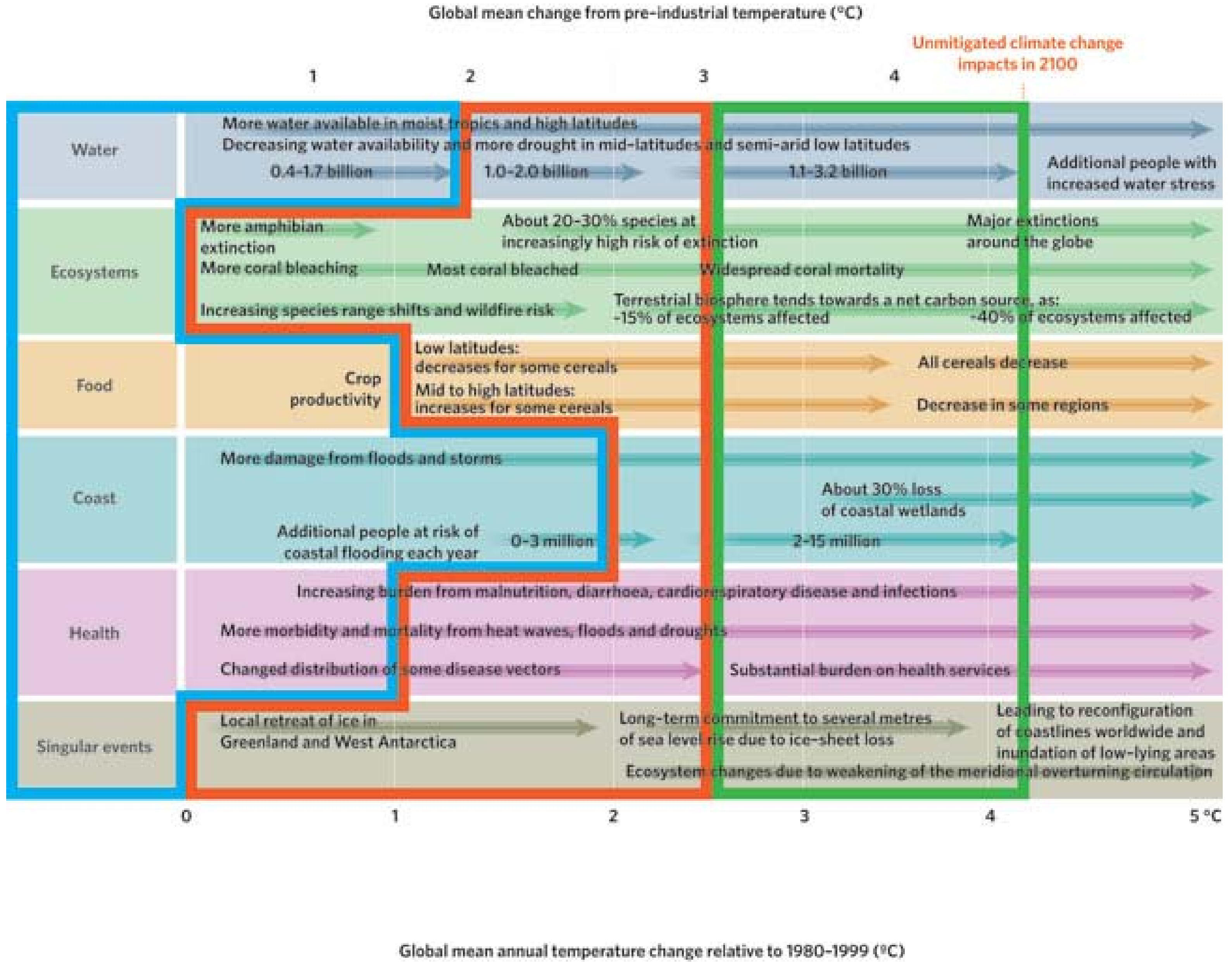
Source: [Le Quéré et al. 2012](); [Global Carbon Project 2012]()

Challenges to keep below 2ºC

An emission pathway with a “likely chance” to keep the temperature increase below 2ºC has significant challenges



Source: Peters et al. 2012a; Global Carbon Project 2012



Global mean change from pre-industrial temperature (°C)
Unmitigated climate change impacts in 2100
1
2
3
4
Water
More water available in moist tropics and high latitudes
Decreasing water availability and more drought in mid-latitudes and semi-arid low latitudes
0.4-1.7 billion
1.0-2.0 billion
1.1-3.2 billion
Additional people with increased water stress
Ecosystems
More amphibian extinction
About 20-30% species at increasingly high risk of extinction
Major extinctions around the globe
More coral bleaching
Most coral bleached
Widespread coral mortality
Increasing species range shifts and wildfire risk
Terrestrial biosphere tends towards a net carbon source, as:
~15% of ecosystems affected
~40% of ecosystems affected
Food
Crop productivity
Low latitudes: decreases for some cereals
All cereals decrease
Mid to high latitudes: increases for some cereals
Decrease in some regions
Coast
More damage from floods and storms
About 30% loss of coastal wetlands
Additional people at risk of coastal flooding each year
0-3 million
2-15 million
Health
Increasing burden from malnutrition, diarrhoea, cardiorespiratory disease and infections
More morbidity and mortality from heat waves, floods and droughts
Changed distribution of some disease vectors
Substantial burden on health services
Singular events
Local retreat of ice in Greenland and West Antarctica
Long-term commitment to several metres of sea level rise due to ice-sheet loss
Leading to reconfiguration of coastlines worldwide and inundation of low-lying areas
Ecosystem changes due to weakening of the meridional overturning circulation
0
1
2
3
4
5 °C
Global mean annual temperature change relative to 1980-1999 (°C)

MAIN ADAPTATION SECTORS

WATER

AGRICULTURE

TOURISM

INFRASTRUCTURE

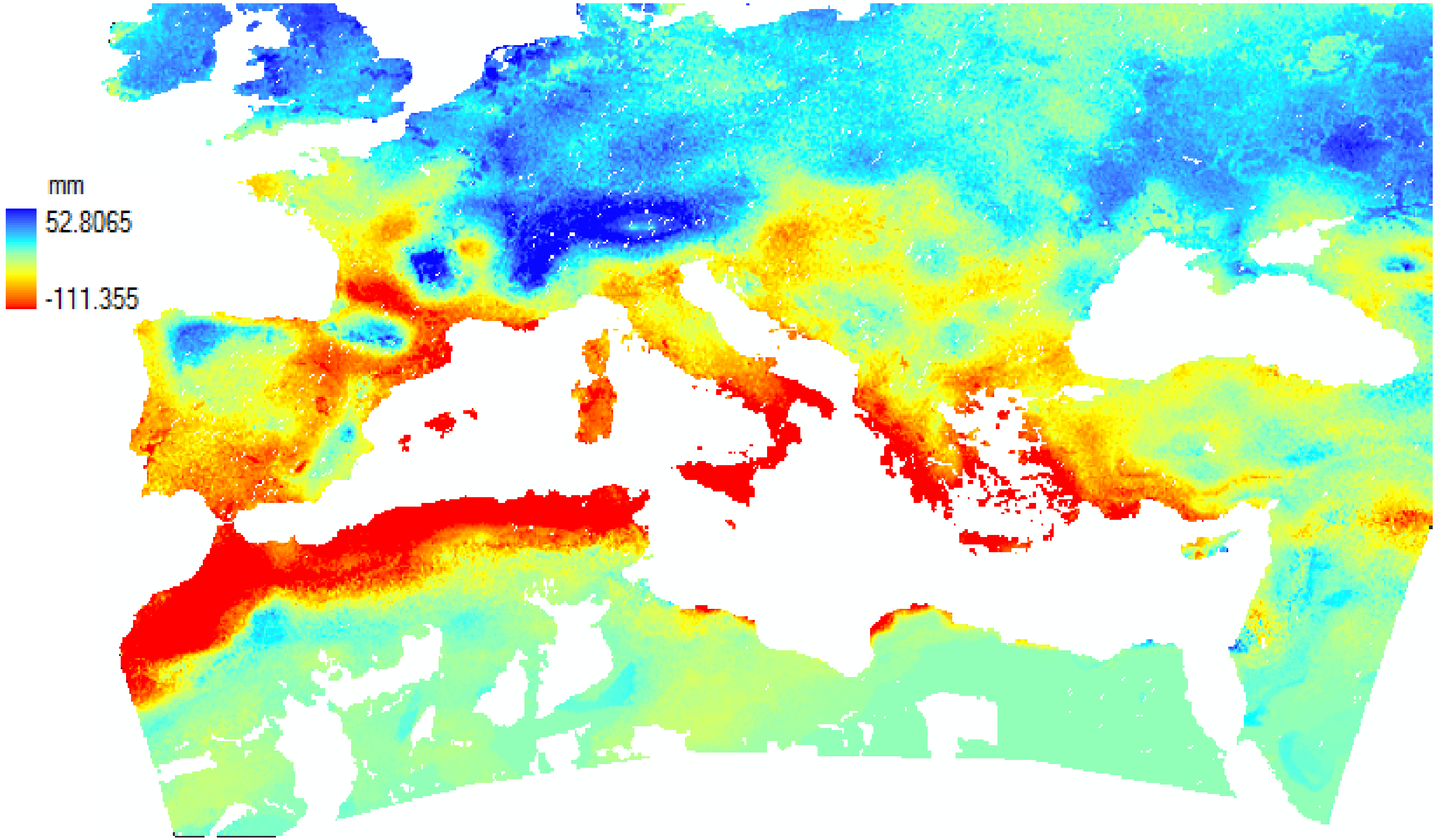
ENERGY PRODUCTION

HEALTH

BIODIVERSITY

CITIES

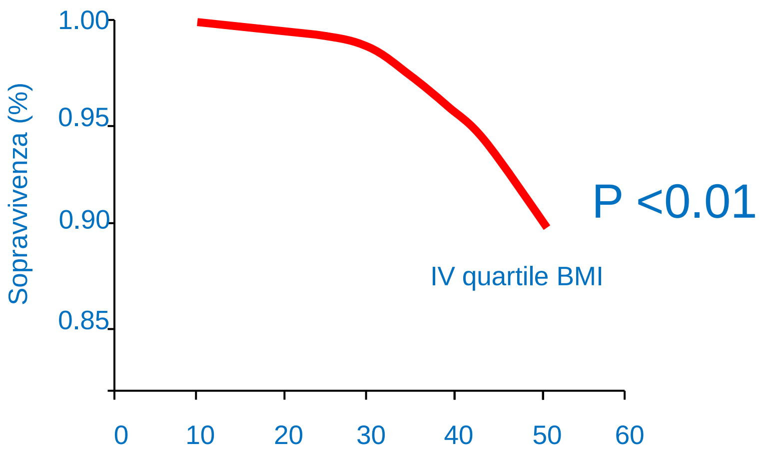
Spatial yearly Green Water anomalies

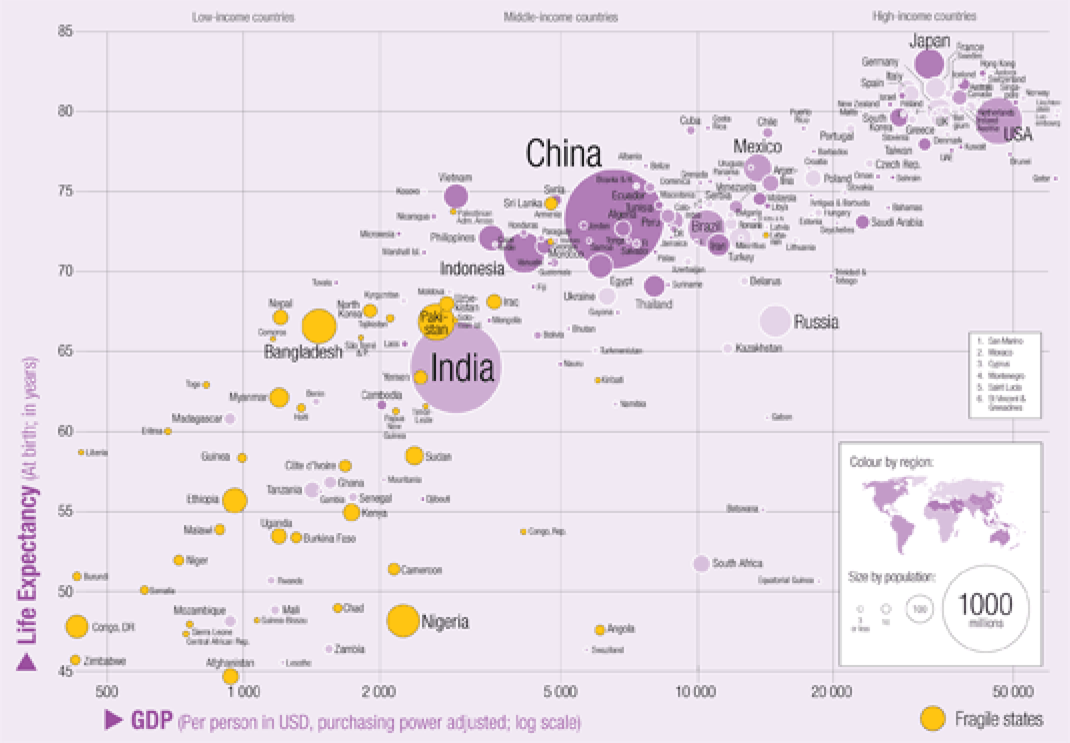


2021-2050 minus 1971-2000, whole ensemble average

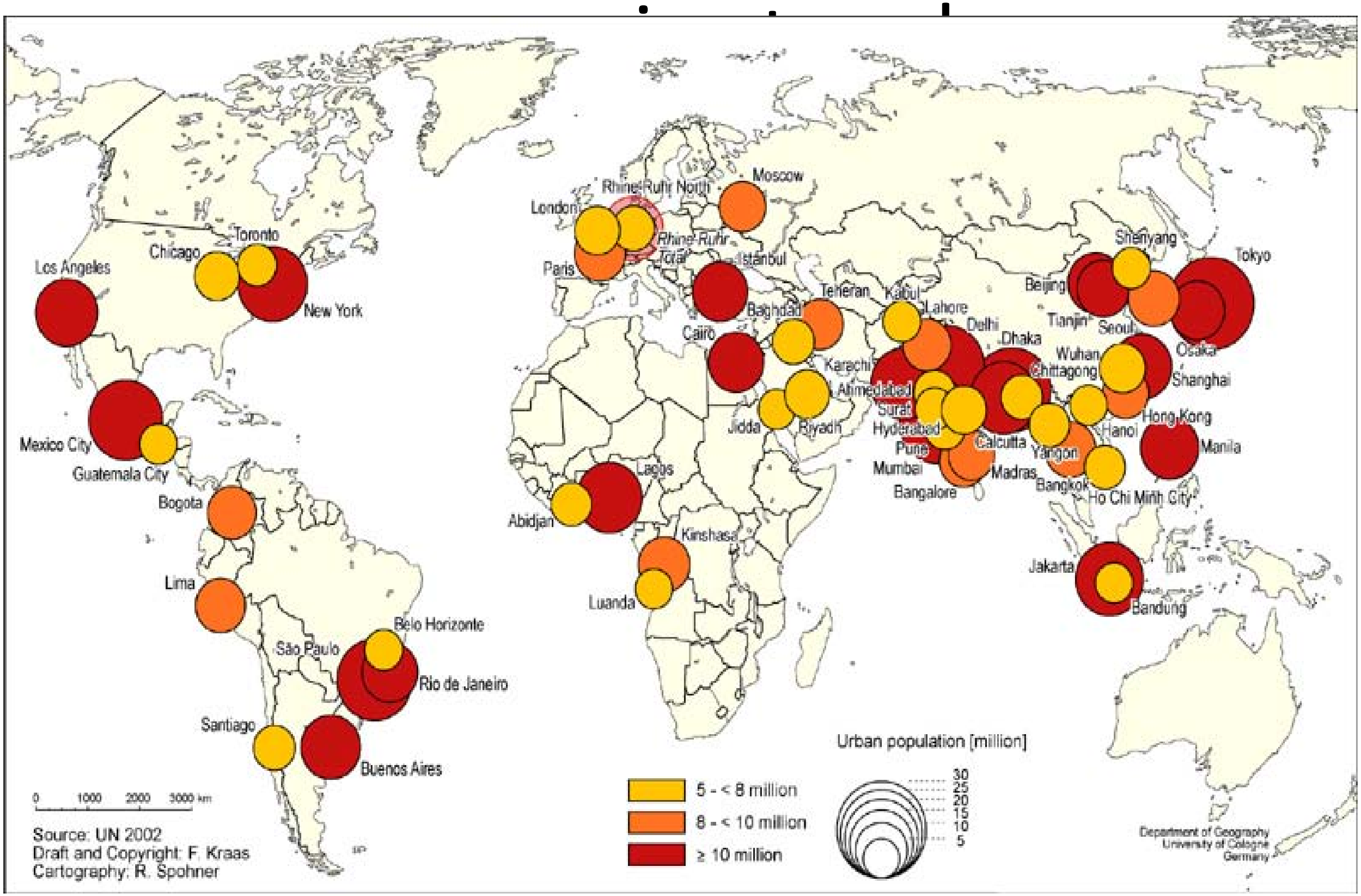
Food crisis or food unbalances…..

(two paradoxes)


1.00
0.95
0.90
0.85
Sopravvivenza (%)
0
10
20
30
40
50
60
P <0.01
IV quartile BMI


Low-income countries
Middle-income countries
High-income countries
85
80
75
70
65
60
55
50
45
Life Expectancy (At birth; in years)
500
1 000
2 000
5 000
10 000
20 000
50 000
GDP (Per person in USD, purchasing power adjusted; log scale)
Japan
USA
China
Mexico
Brazil
Indonesia
India
Pakistan
Bangladesh
Russia
Nigeria
South Africa
Colour by region:
Size by population:
1000 millions
Fragile states

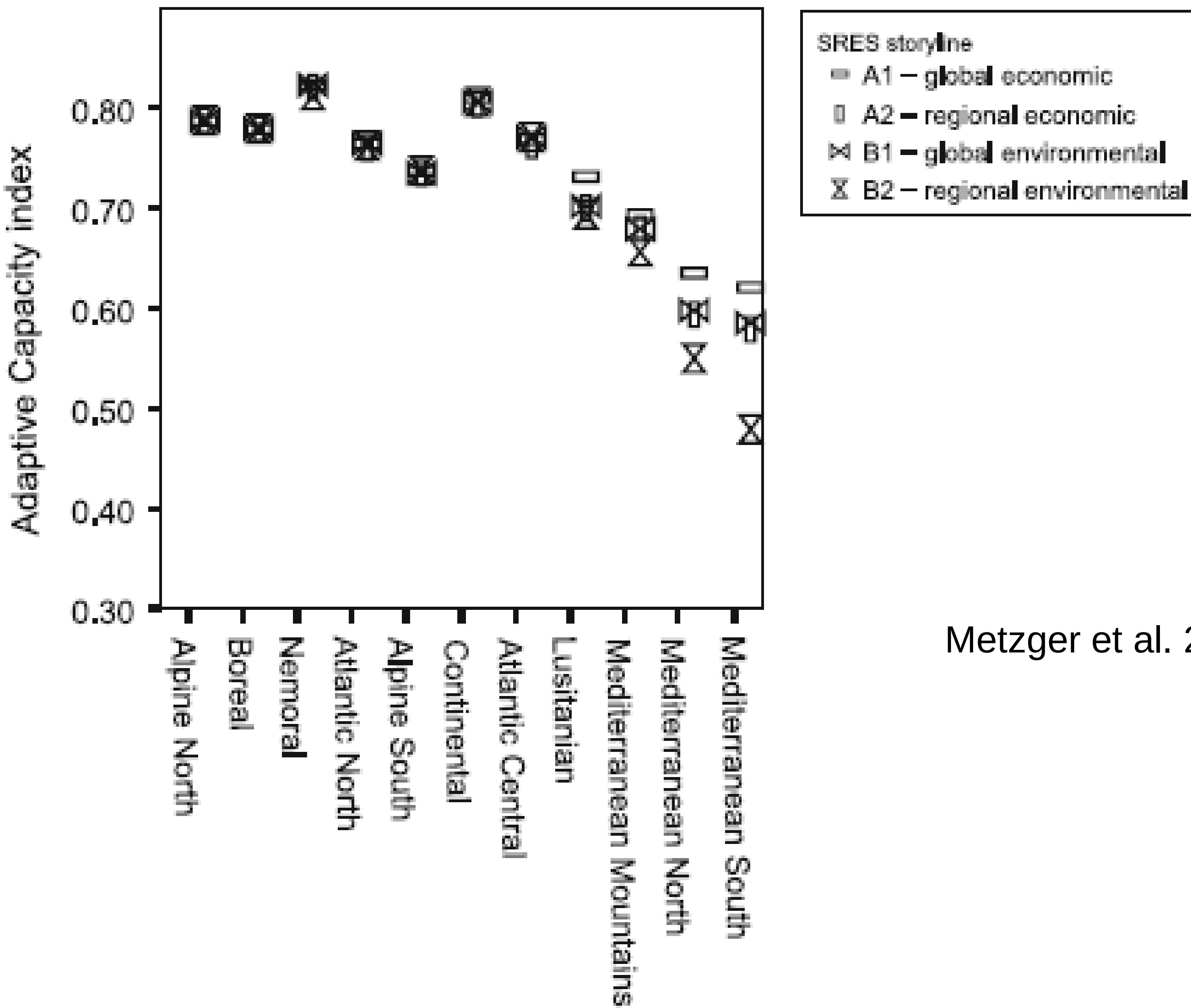
Megacities (>20 milion people)



The Urban Human

1. The need of higher production with less labour requirements
2. Food processing and transformation for feeding urban humans
3. Changes in cultural lifestyles and food consumption patterns
4. Food and packaging waste
5. Energy consumption
6. Volatility of prices
7. Climate change impacts on food production

Mean Adaptive Capacity per EnZ in 2080



Metzger et al. 2011

CONCLUSIONS

1. We are heading toward a RCP8.5 which implies a 4-6°C warming

2. Unlikely to stay below 2°C – may be with negative emissions/technologies, still risky

3. Adaptation is unavoidable. The question is how much in respect of mitigation

4. Cross-sectoral approaches are urgently needed as opposed to sectorial approaches

5. Reducing uncertainites through better and more accurate (spatial and temporal resolution) climate predictions is urgently needed