



Global Carbon Budget

2013

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Publications

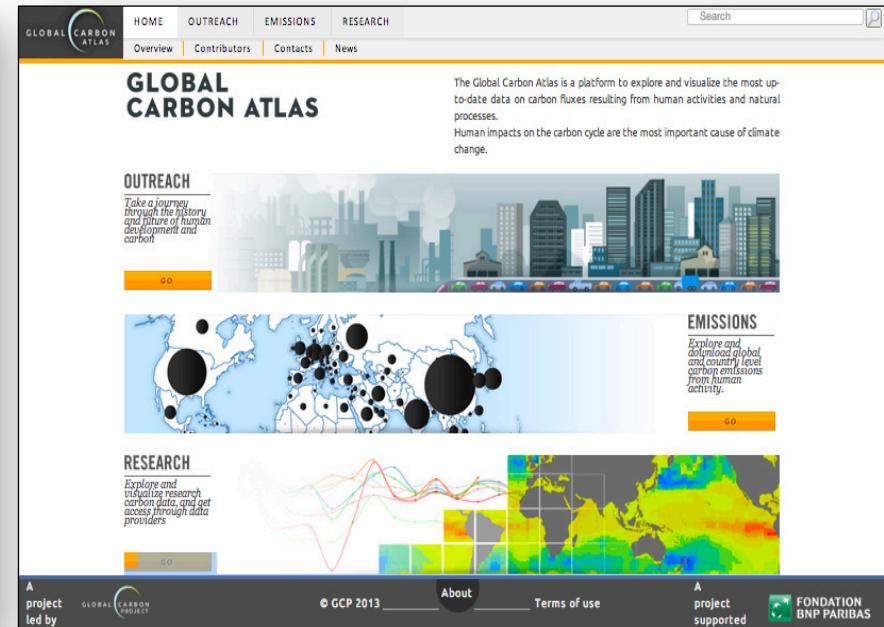
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**Earth System
Science
Data**

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Global carbon budget 2013

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More information, data sources and data files at
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All the data is shown in GtC

1 Gigatonne (Gt) = 1 billion tonnes = 1×10^{15} g = 1 Petagram (Pg)

1 kg carbon (C) = 3.664 kg carbon dioxide (CO₂)

1 GtC = 3.664 billion tonnes CO₂ = 3.664 GtCO₂

Disclaimer

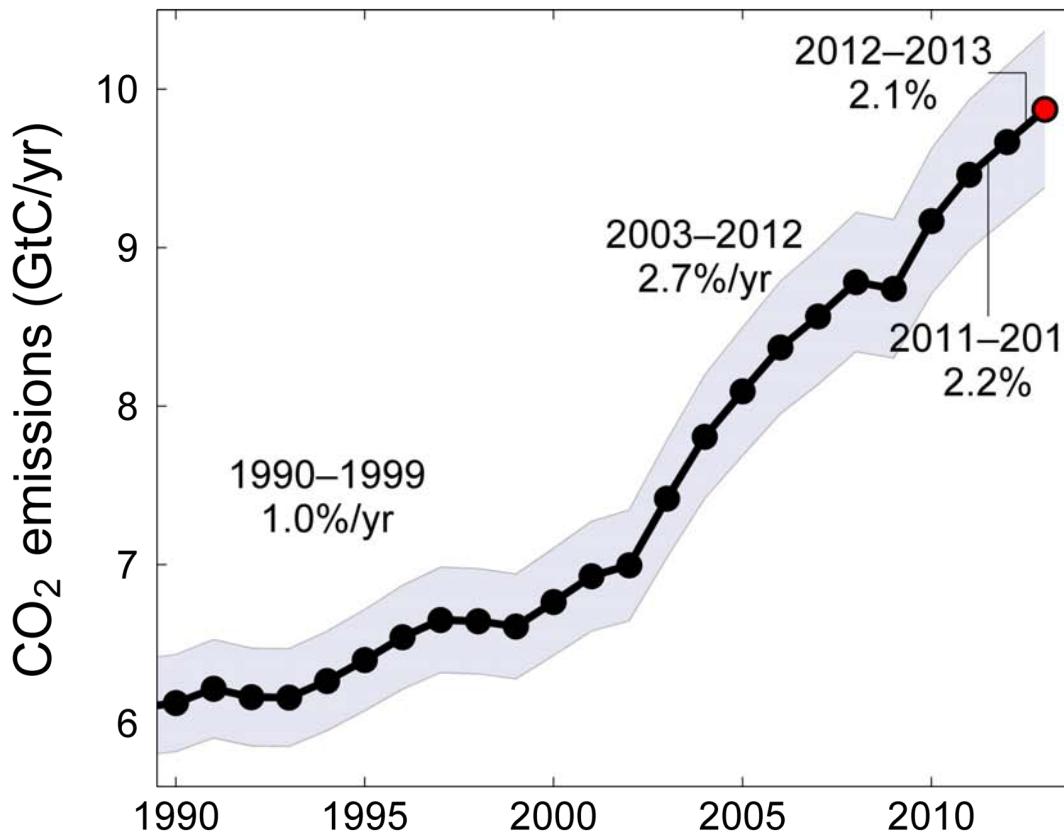
The Global Carbon Budget and the information presented here are intended for those interested in learning about the carbon cycle, and how human activities are changing it. The information contained herein is provided as a public service, with the understanding that the Global Carbon Project team make no warranties, either expressed or implied, concerning the accuracy, completeness, reliability, or suitability of the information.

Fossil Fuel and Cement Emissions

Fossil Fuel and Cement Emissions

Global fossil fuel and cement emissions: 9.7 ± 0.5 GtC in 2012, 58% over 1990

- Projection for 2013 : 9.9 ± 0.5 GtC, 61% over 1990



2013
9.9 GtC



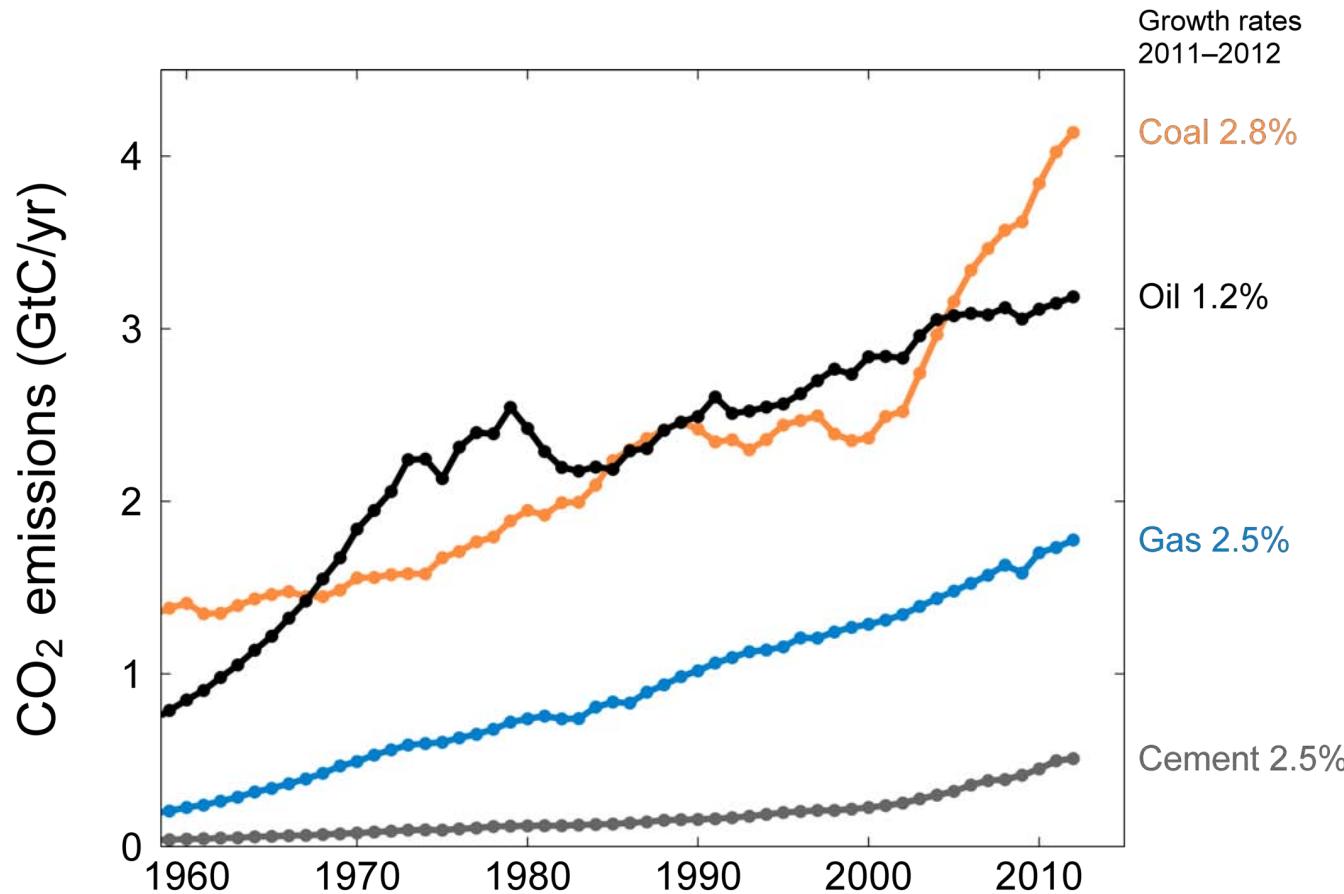
Uncertainty is $\pm 5\%$ for one standard deviation (IPCC "likely" range)

With leap year adjustment: 2012 growth rate is 1.9% and 2013 is 2.4%

Source: [Le Quéré et al 2013](#); [CDIAC Data](#); [Global Carbon Project 2013](#)

Emissions from Coal, Oil, Gas, Cement

Share of global emissions in 2012:
coal (43%), oil (33%), gas (18%), cement (5%), flaring (1%, not shown)

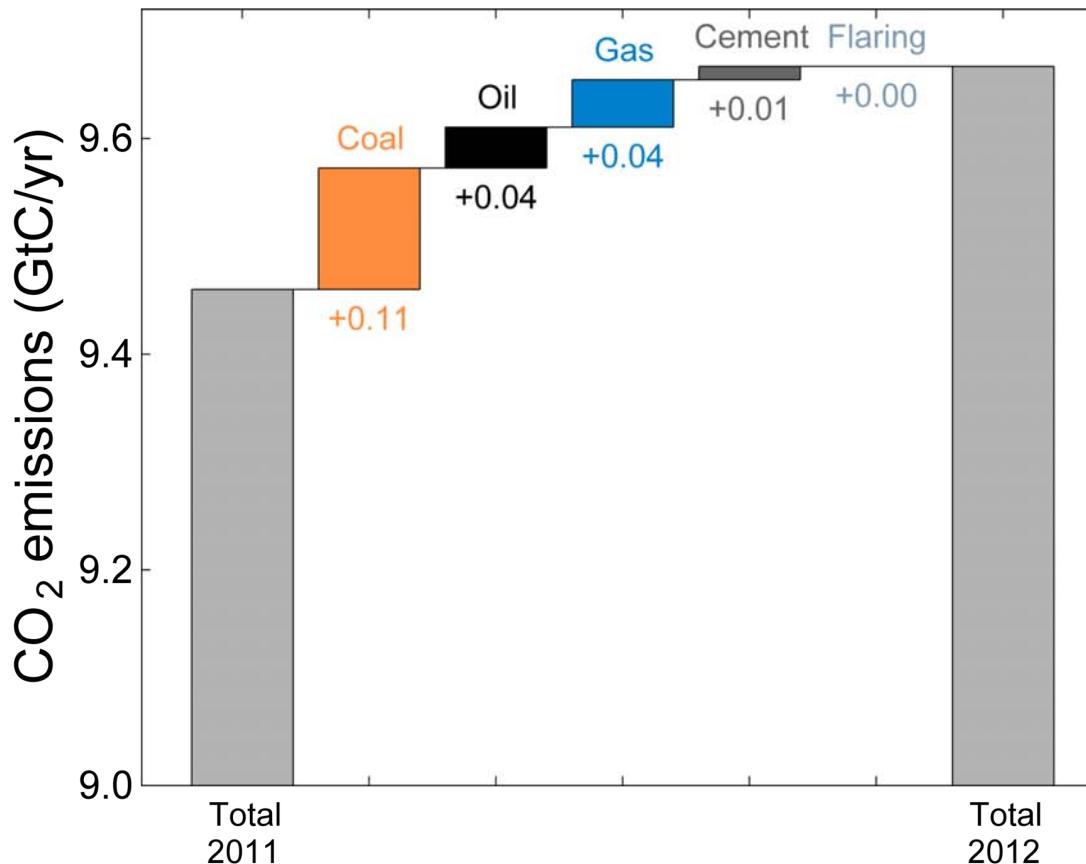


With leap year adjustment in 2012 growth rates are: coal 2.5%, oil 0.9%, gas 2.2%, cement 2.2%.

Source: [CDIAC Data](#); [Le Quéré et al 2013](#); [Global Carbon Project 2013](#)

Fossil Fuel and Cement Emissions Growth 2012

Coal accounted for 54% of the growth in global emissions in 2012, oil (18%), gas (21%), and cement (6%).



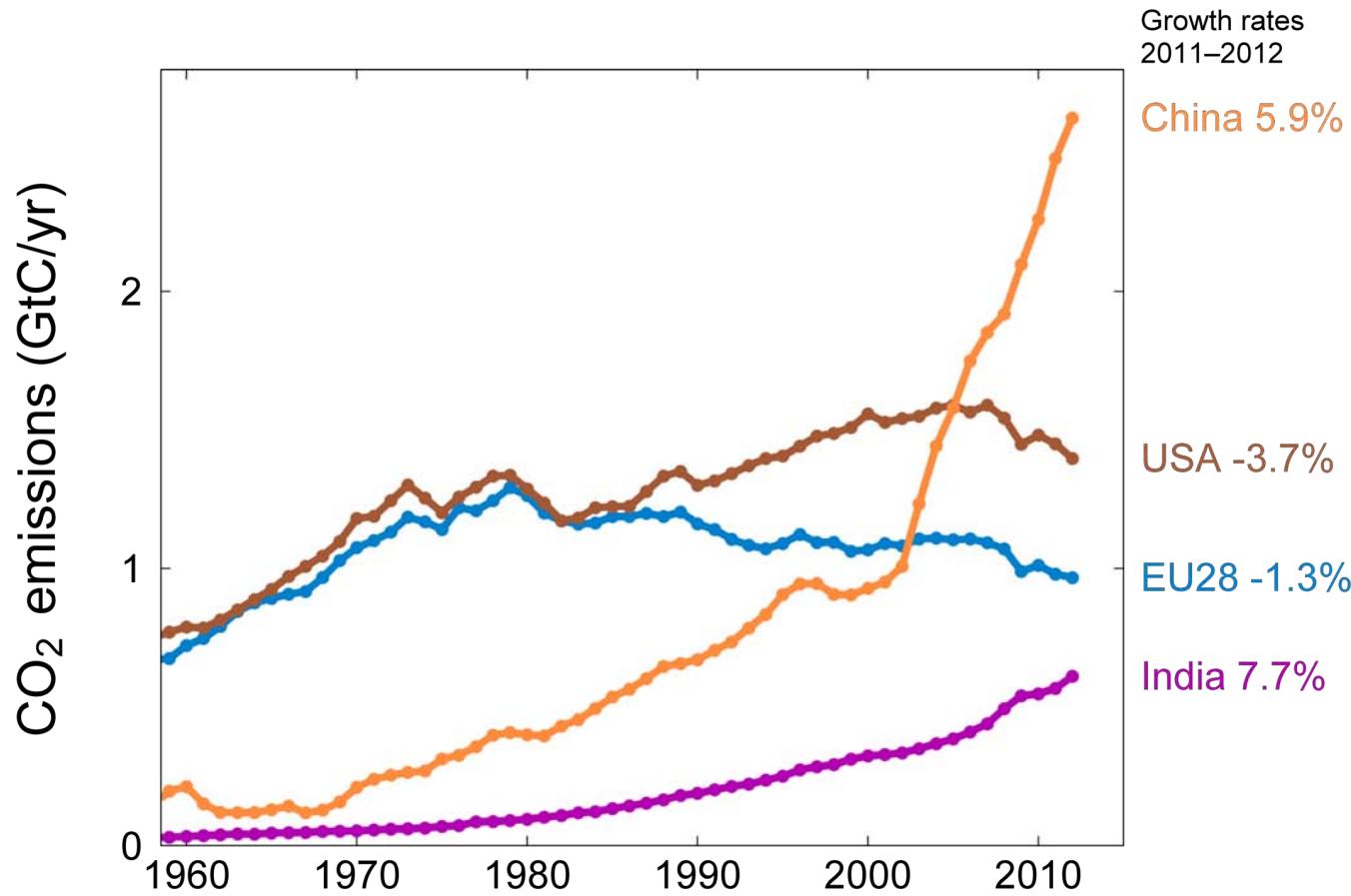
Many countries increased dependence on coal in 2012:

Emissions from coal grew 4.2% in Germany, 5.6% in Japan, 3.0% in the EU28, 10.2% in India.

Source: [CDIAC Data](#); [Le Quéré et al 2013](#); [Global Carbon Project 2013](#)

Top Fossil Fuel Emitters (Absolute)

Top four emitters in 2012 covered 58% of global emissions
China (27%), United States (14%), EU28 (10%), India (6%)



With leap year adjustment in 2012 growth rates are: China 5.6%, USA -4.0%, EU -1.6%, India 7.4%.

Source: [CDIAC Data](#); [Le Quéré et al 2013](#); [Global Carbon Project 2013](#)

Fossil Fuel and Cement Emissions Growth 2012

China accounted for 71% of the global emissions growth in 2012, India 21%, Japan 11%.

The USA contributed to a decrease in emissions.

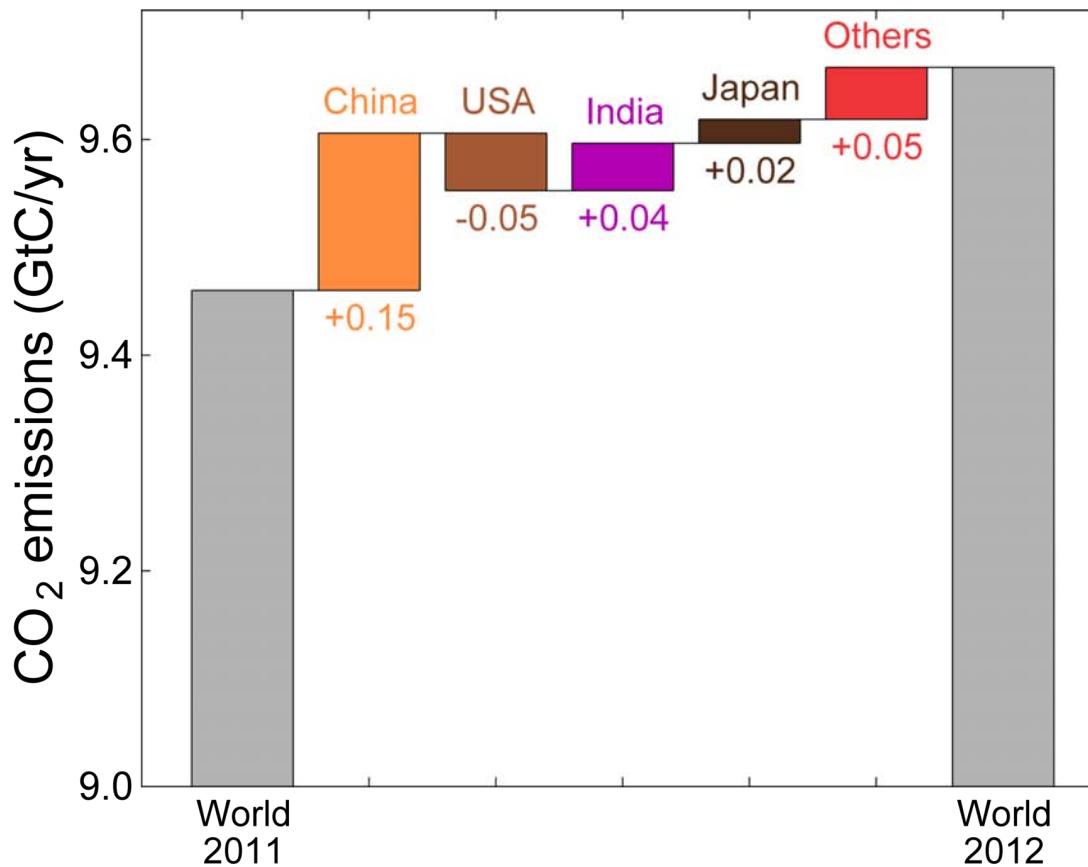


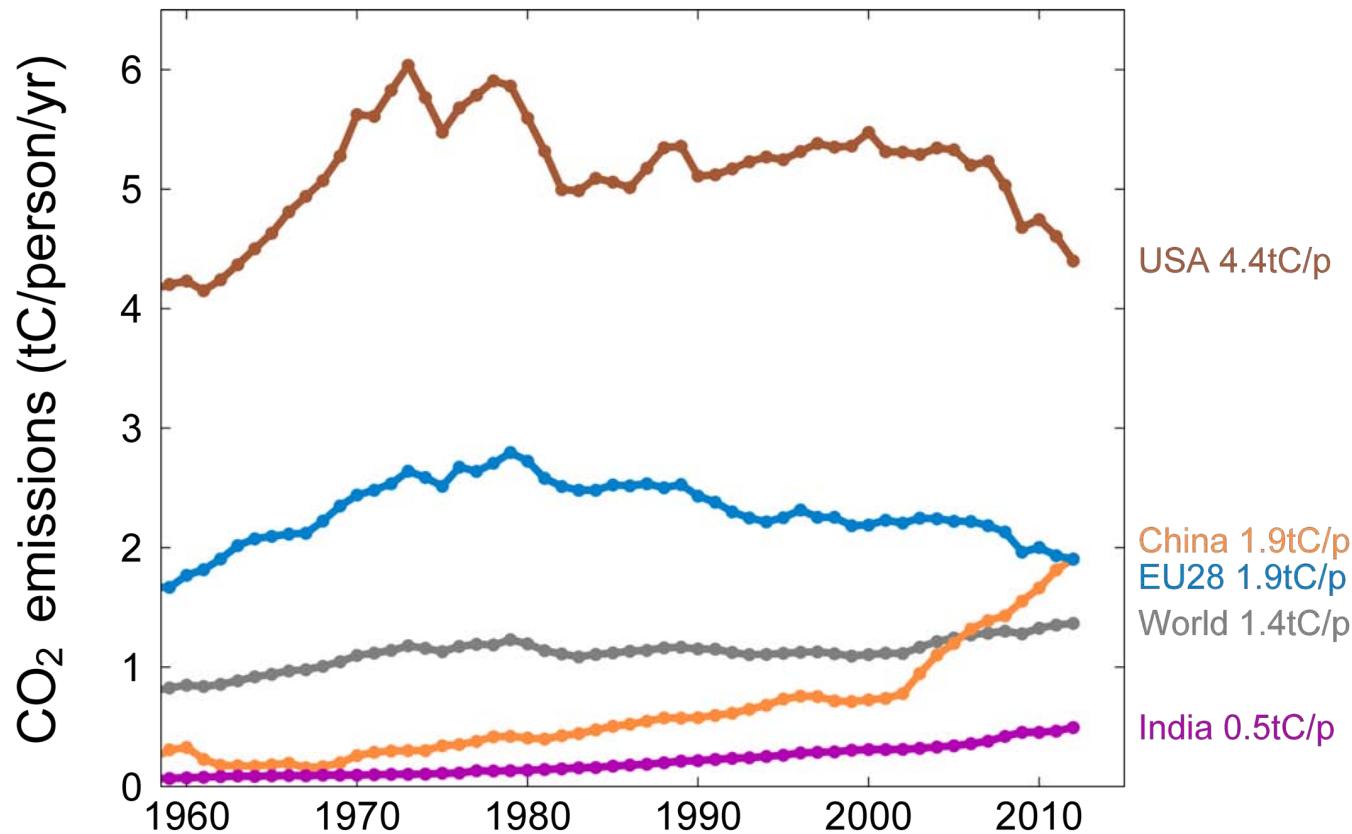
Figure shows the top four countries contributing to emissions changes in 2012

Source: [CDIAC Data](#); [Le Quéré et al 2013](#); [Global Carbon Project 2013](#)

Top Fossil Fuel Emitters (Per Capita)

Average per capita emissions in 2012

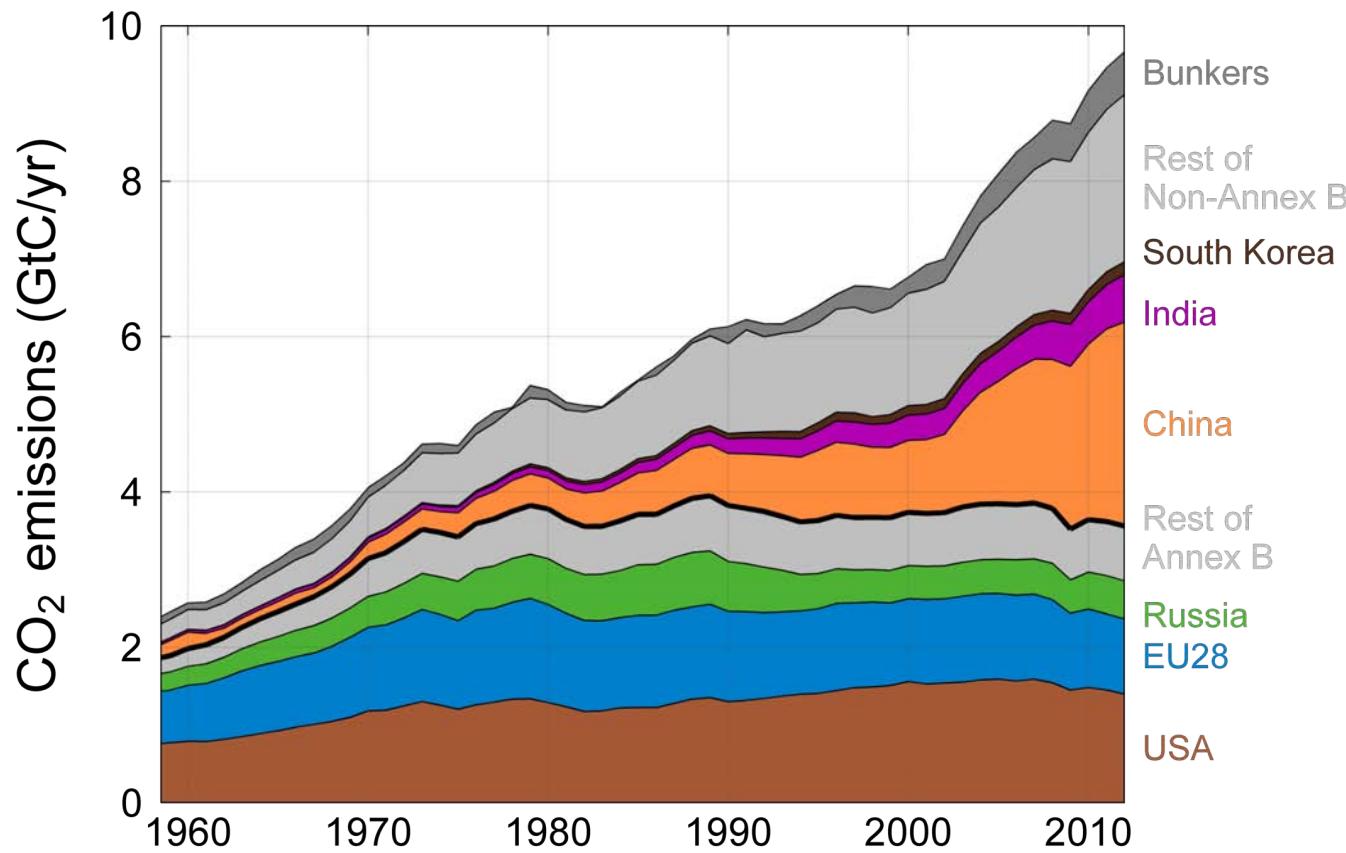
China is growing rapidly and the US is declining fast



Breakdown of Global Emissions by Country

Emissions from Annex B countries have slightly declined

Emissions from non-Annex B countries have increased rapidly in recent years

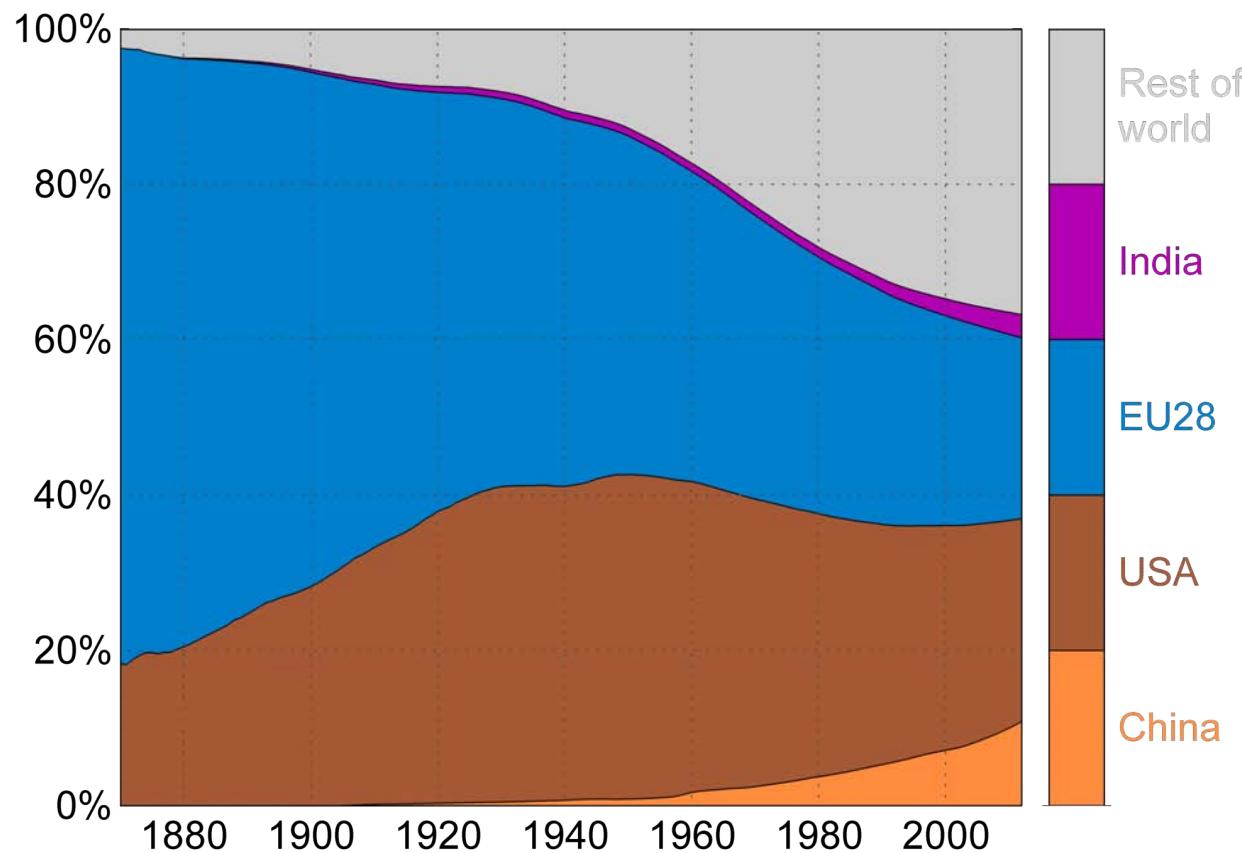


Annex B countries have emission commitments in the Kyoto Protocol

Source: [CDIAC Data](#); [Le Quéré et al 2013](#); [Global Carbon Project 2013](#)

Historical Cumulative Emissions by Country

Cumulative emissions from fossil-fuel and cement were distributed (1870–2012): USA (26%), EU28 (23%), China (11%), and India (4%) covering 64% of the total share



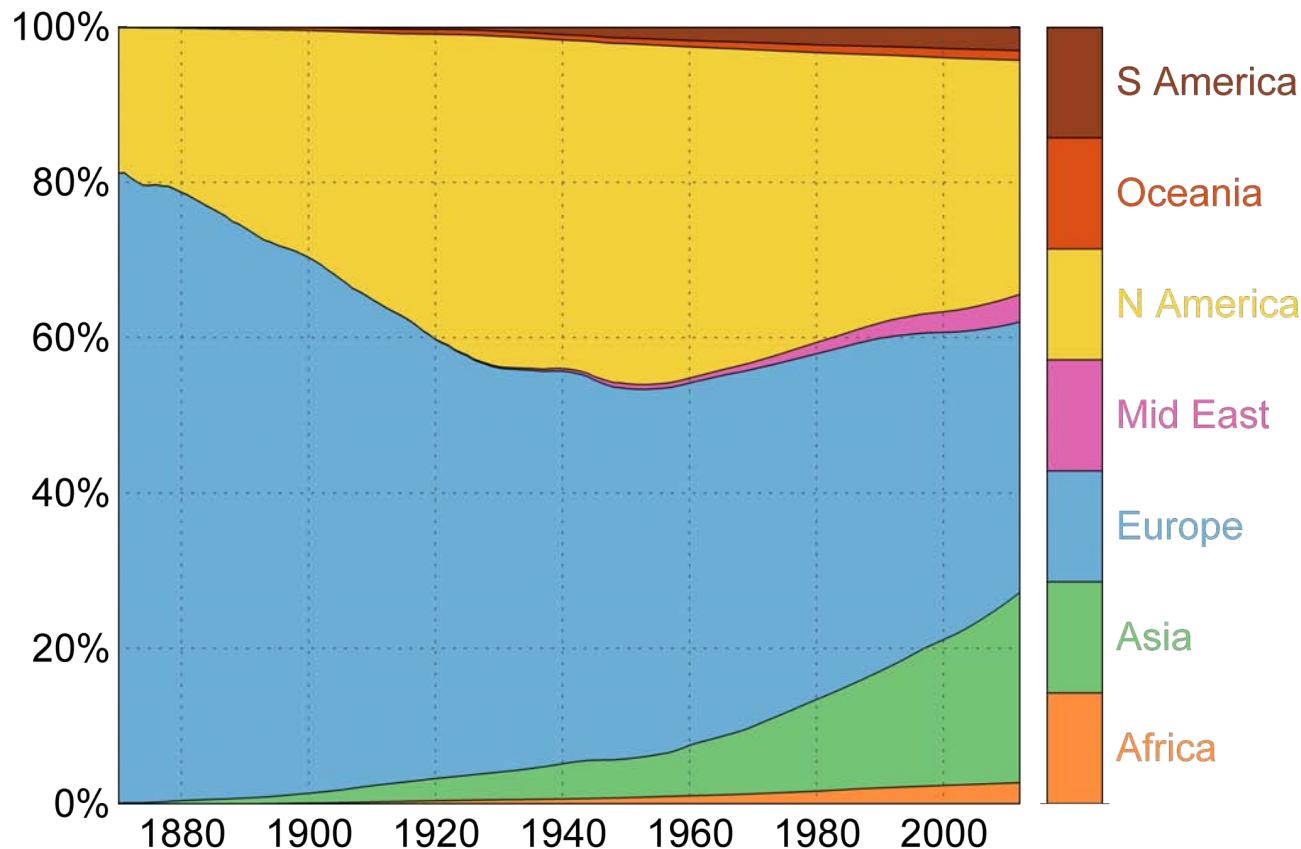
Cumulative emissions (1990–2012) were distributed USA (20%), EU28 (15%), China (18%), India (5%)

Source: [CDIAC Data](#); [Le Quéré et al 2013](#); [Global Carbon Project 2013](#)

Historical Cumulative Emissions by Region

Cumulative emissions from fossil-fuel and cement (1870–2012)

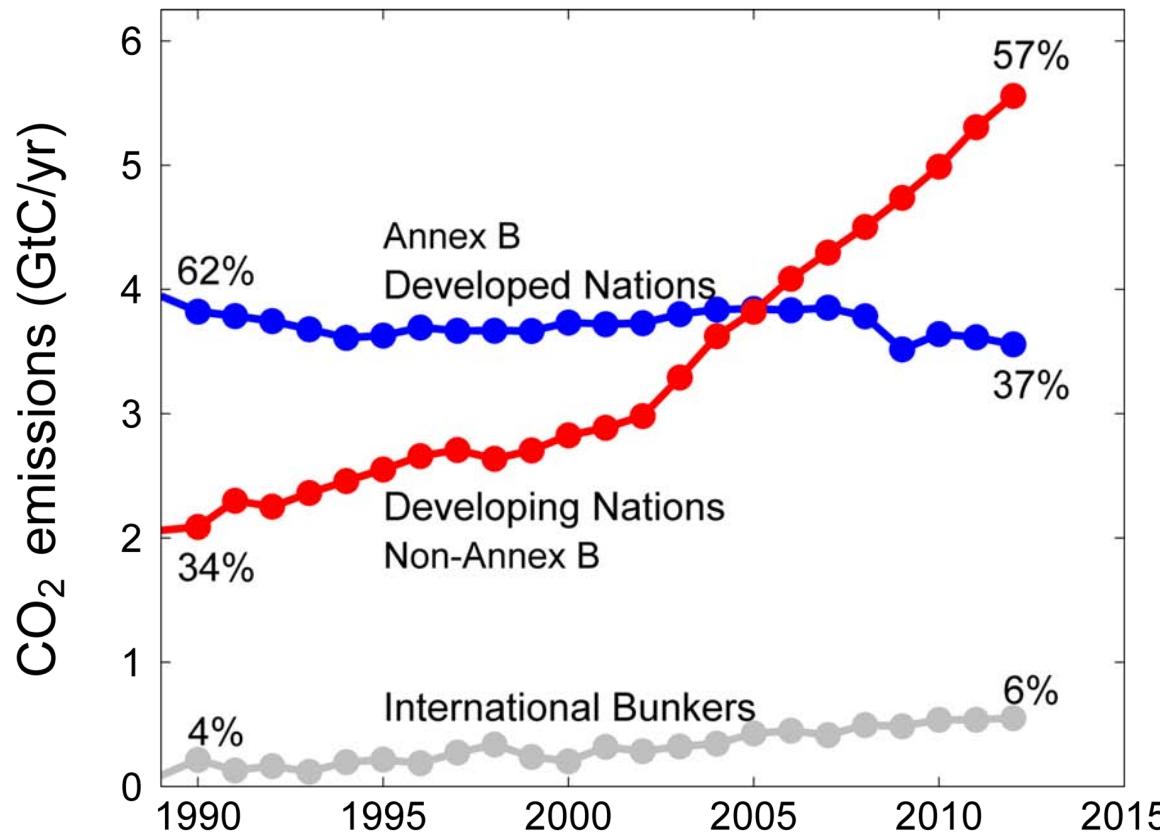
North America and Europe responsible for most cumulative emissions, but Asia growing fast



Territorial Emissions as per the Kyoto Protocol

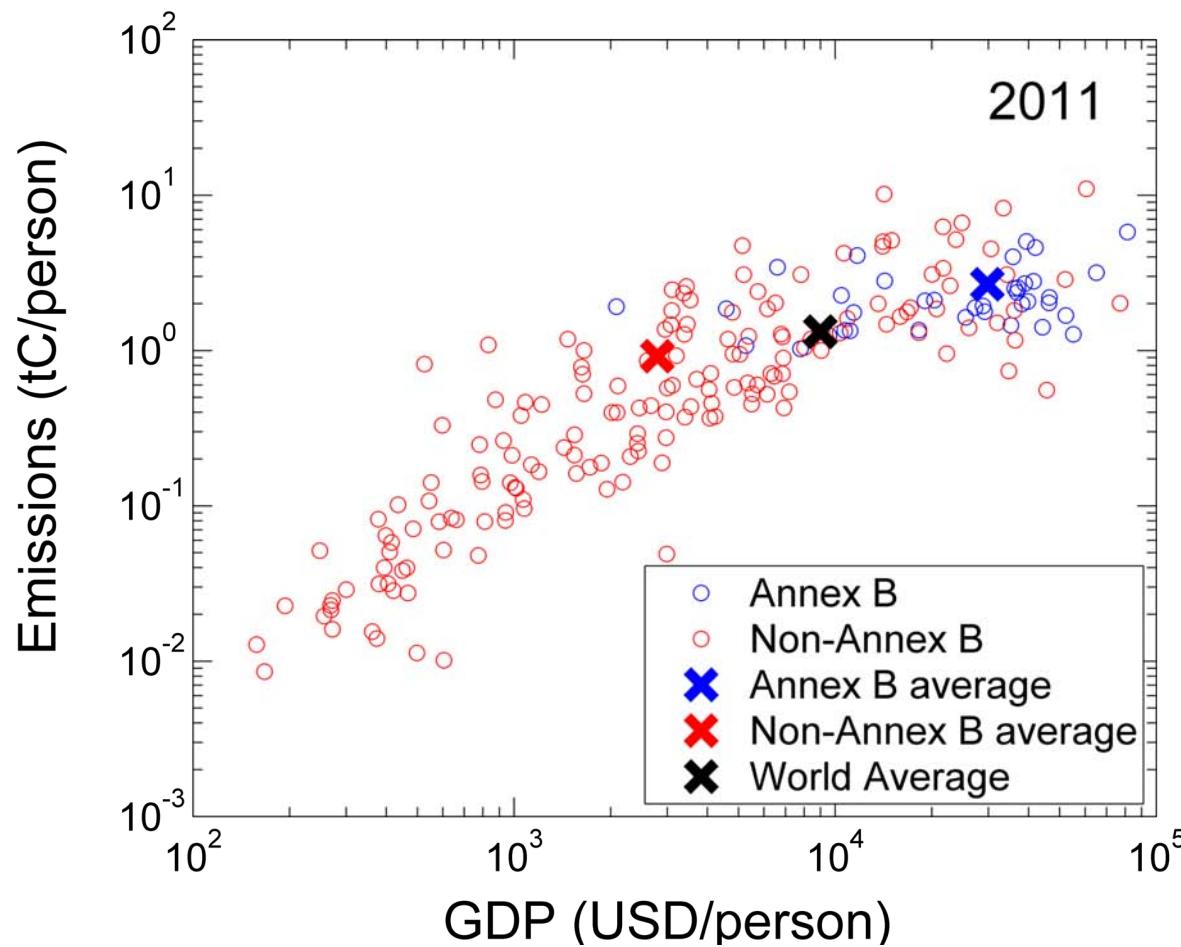
The Kyoto Protocol was negotiated in the context of emissions in 1990

The global distribution of emissions is now starkly different



Annex B versus non-Annex B Countries

Annex B countries have emission reduction commitments in the Kyoto Protocol
Annex B countries do not necessarily have highest economic activity per capita

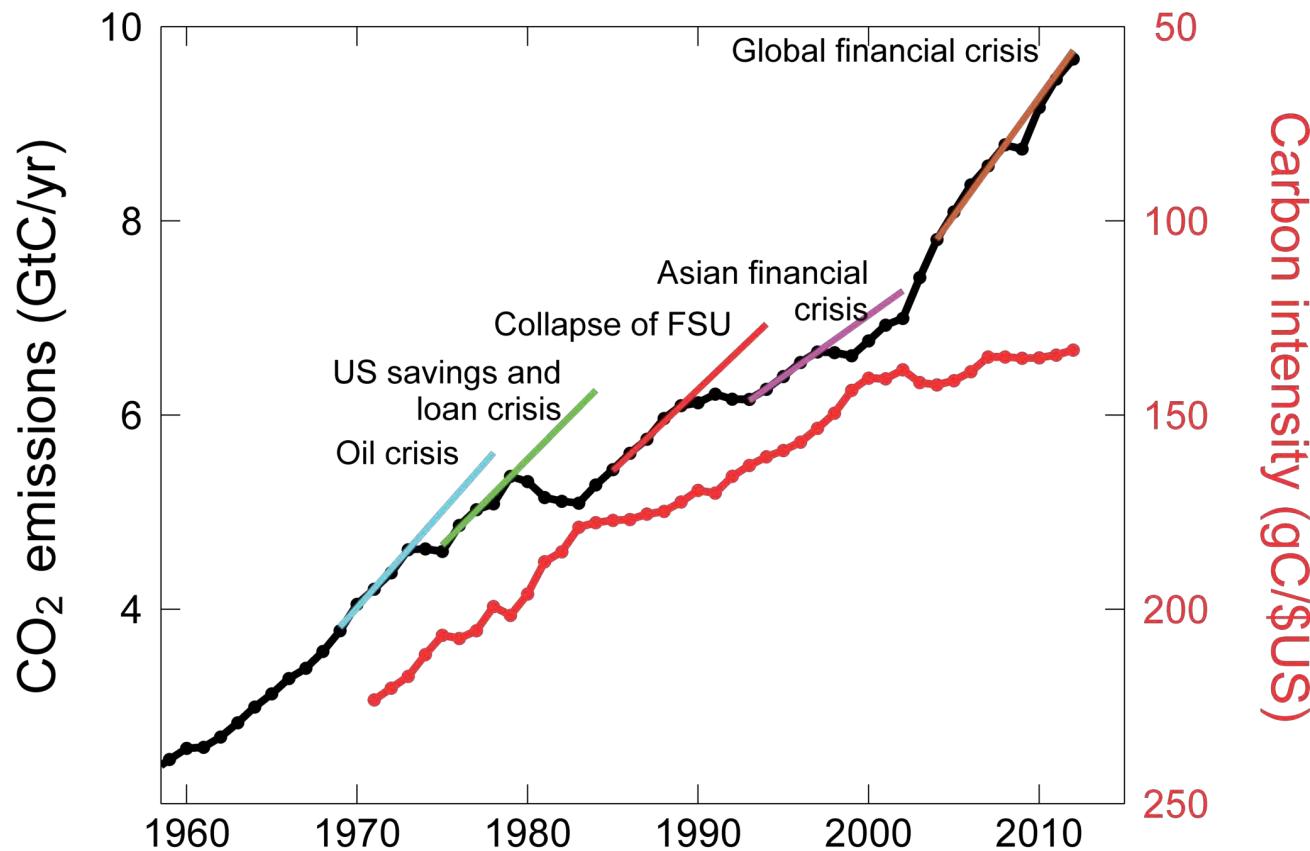


GDP is measured in Market Exchange Rates

Source: [CDIAC Data](#); [Unstats](#); [Global Carbon Project 2013](#)

Carbon Intensity of Economic Activity

The global financial crisis of 2008–2009 had no lasting effect on emissions
Carbon intensity has had minimal improvement with increased economic activity since 2005



Key Statistics

Emissions 2012

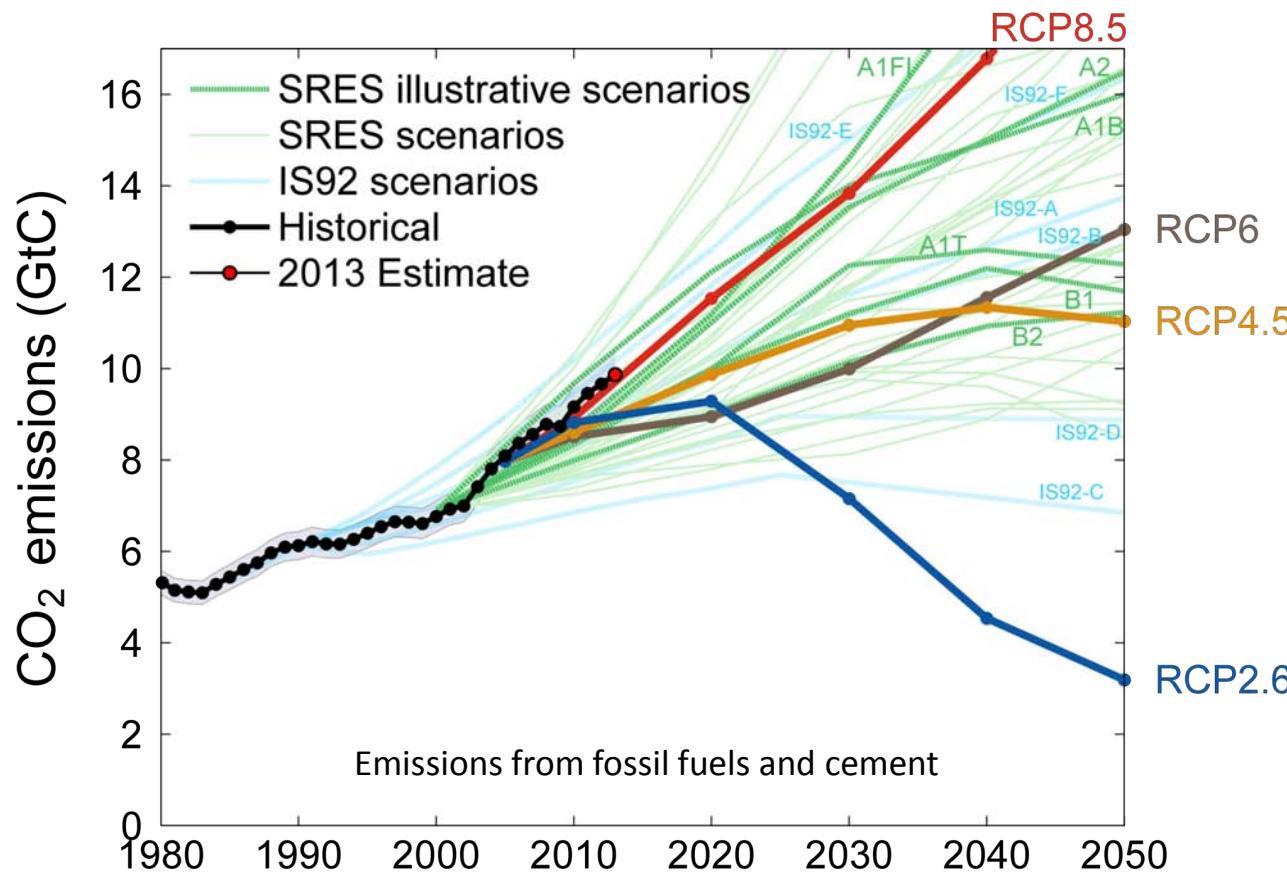
Region/Country	Per capita tC per person	Total		Growth 2012	
		Gt C	%	Gt C	% per year
Global (with bunkers)	1.4	9.7	-	0.21	2.2
Developed Countries (Annex B)					
Annex B	3.0	3.60	37	-0.058	-1.6
USA	4.6	1.40	14	-0.053	-3.7
Russian Federation	3.4	0.50	5.0	-0.001	-0.2
Japan	2.5	3.40	3.5	0.022	6.9
Germany	2.4	0.20	2.1	0.004	1.8
Canada	4.0	0.14	1.4	-0.001	-0.6
Developing Countries (non-Annex B)					
Non-Annex B	0.9	5.6	57	0.251	4.7
China	1.8	2.6	27	0.146	5.9
India	0.5	0.61	6.3	0.044	7.7
South Korea	3.4	0.17	1.7	0.002	1.1
Iran	2.1	0.16	1.7	0.005	3.1
Saudi Arabia	4.6	0.14	1.4	0.008	5.9
International Bunkers					
Aviation and Shipping	-	0.55	6	0.014	2.5

Source: [CDIAC Data](#); [Le Quéré et al 2013](#); [Global Carbon Project 2013](#)

Observed Emissions versus Emissions Scenarios

Observed Emissions and Emissions Scenarios

The IPCC has been associated with four generations of emission scenarios
Emissions tracking the higher scenarios

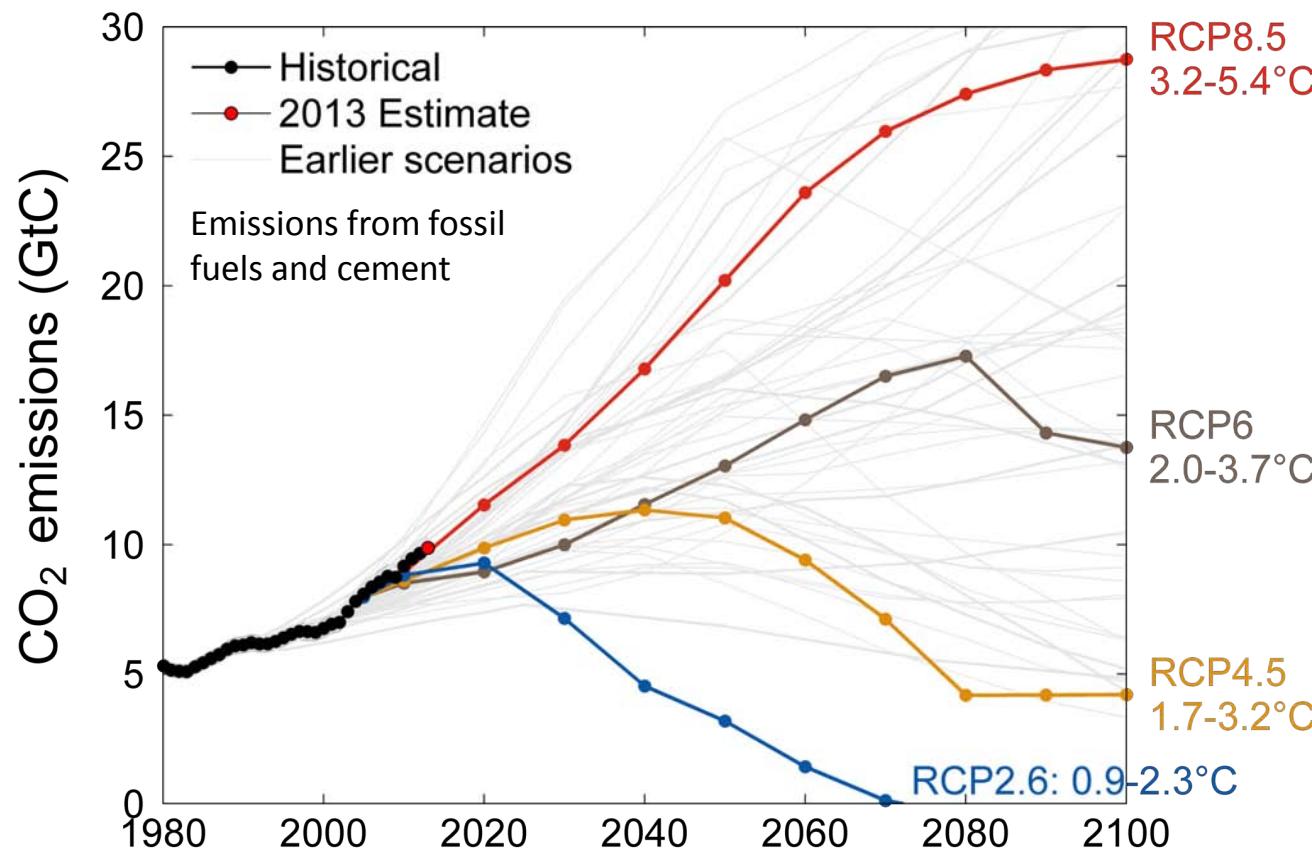


Main periods of use: SA90 (1990–1992, not shown), IS92 (1992–2000), SRES (2000–2012), RCPs (2012+)

Source: [Peters et al. 2012a](#); [CDIAC Data](#); [Global Carbon Project 2013](#)

Observed Emissions and Emissions Scenarios

Emissions are on track for 3.2–5.4°C “likely” increase in temperature above pre-industrial
Large and sustained mitigation is required to keep below 2°C

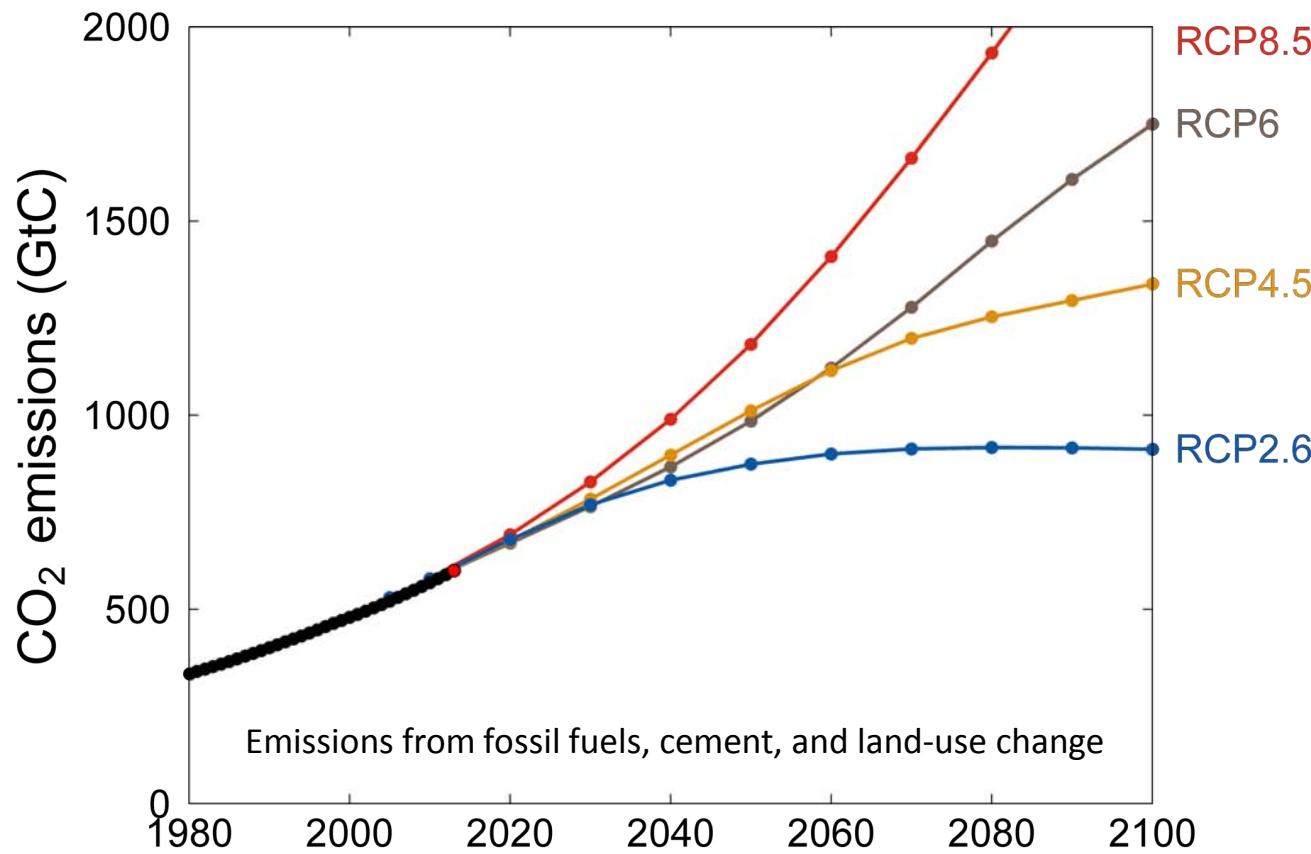


Linear interpolation is used between individual data points

Source: [Peters et al. 2012a](#); [CDIAC Data](#); [Global Carbon Project 2013](#)

Cumulative Emissions and Scenarios

For a “likely” chance to keep warming less than 2°C since the period 1861–1880, requires cumulative CO₂ emissions to stay below 1000GtC, or 790GtC when allowing for non-CO₂



Cumulative emissions 1870–2013 are 550 ± 60 GtC; 70% from fossil fuels and cement, 30% from land-use change

Cumulative emissions from 1750–1870 are highly uncertain, with about 50 GtC with 90% from land-use change

Source: [CDIAC Data](#); [Le Quéré et al 2013](#); [Global Carbon Project 2013](#)

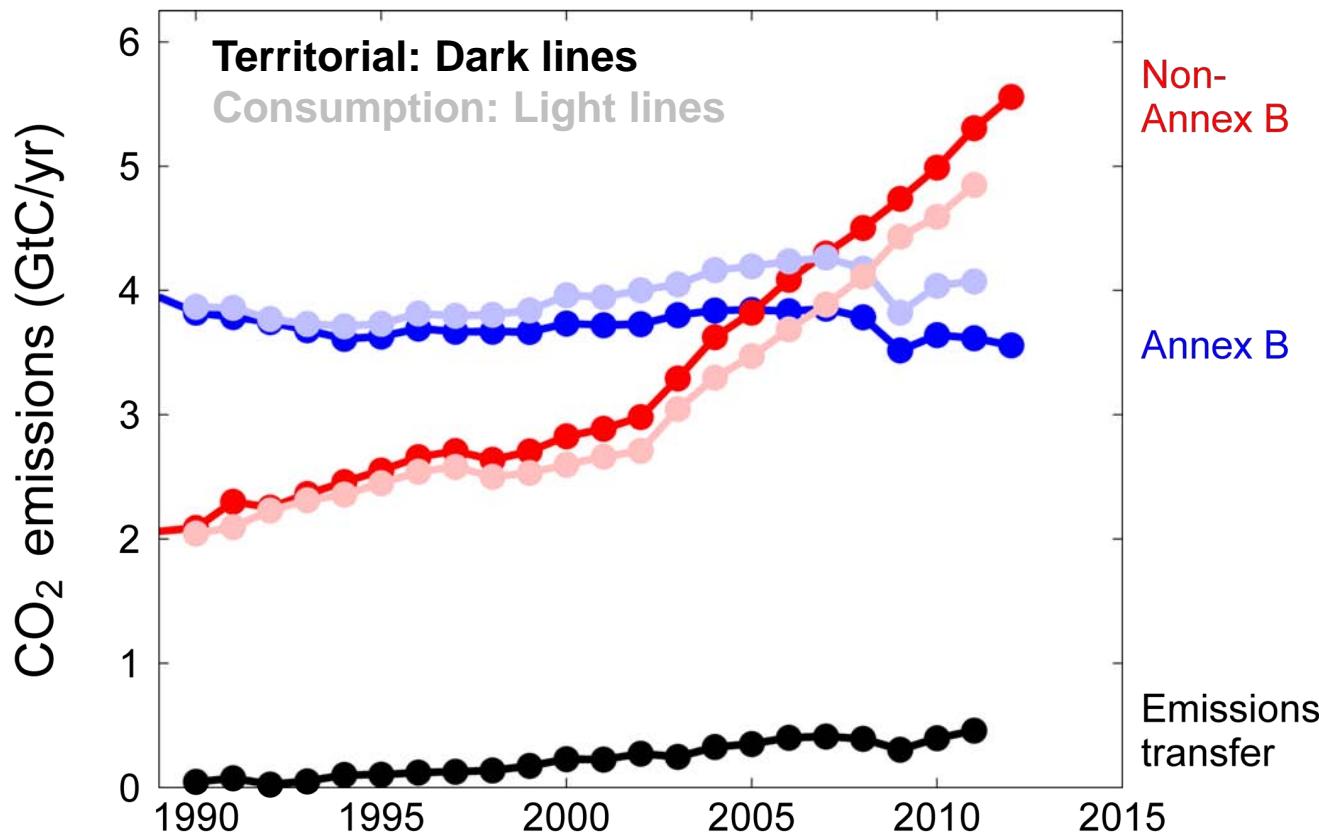
Consumption-based Emissions

Consumption-based emissions allocate emissions to the location that goods and services are consumed

Consumption-based emissions = Production/Territorial-based emissions minus emissions embodied in exports plus the emissions embodied in imports

Consumption Emissions 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-based emissions have had a slight decrease.

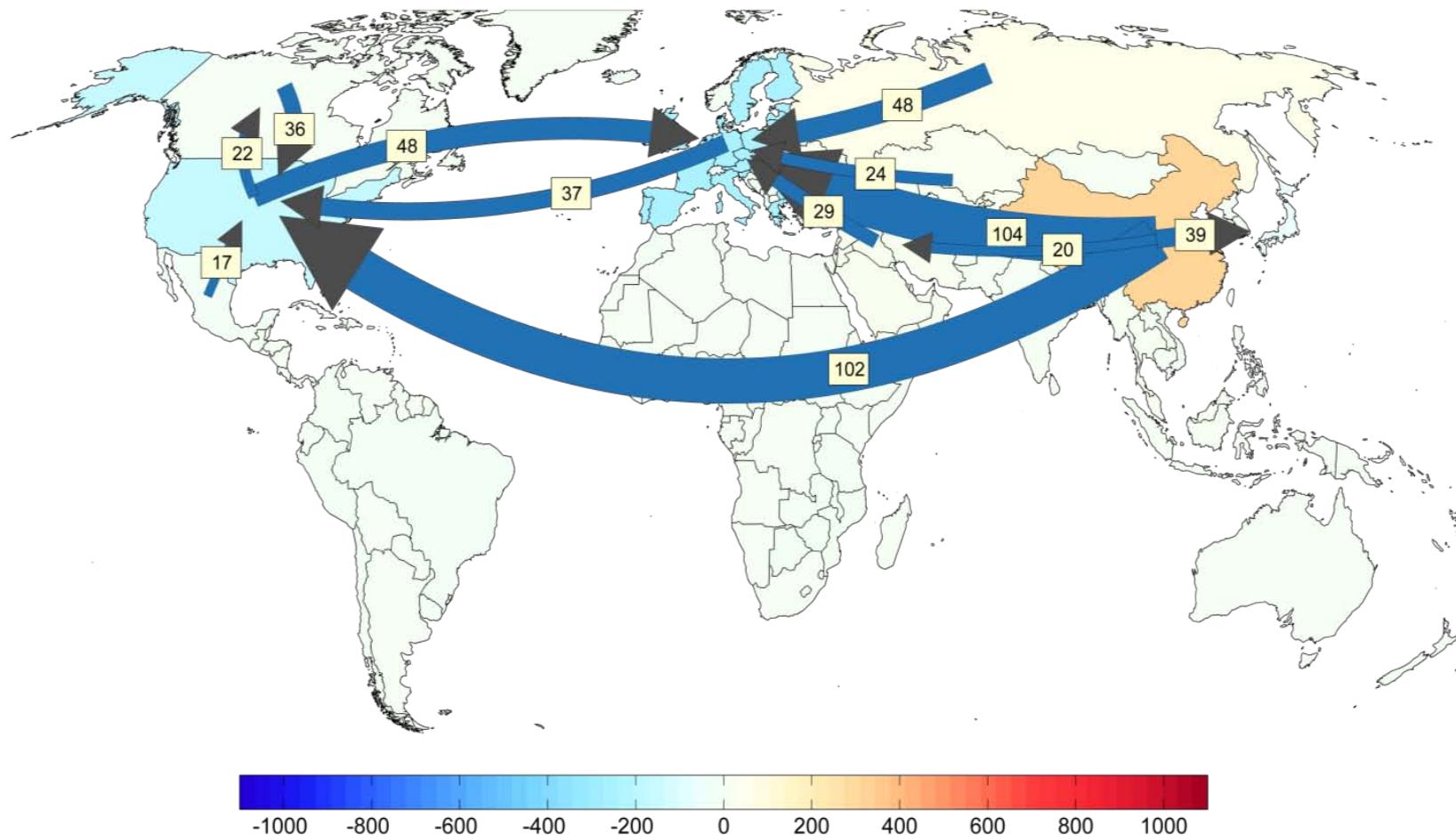
Consumption-based emissions have grown at 0.5% per year, and emission transfers have grown at 12% per year

Source: [Le Quéré et al 2013](#); [Peters et al 2011](#); [Global Carbon Project 2013](#)

Major Flows from Production to Consumption

Start of Arrow: fossil-fuel combustion

End of arrow: goods and services consumption



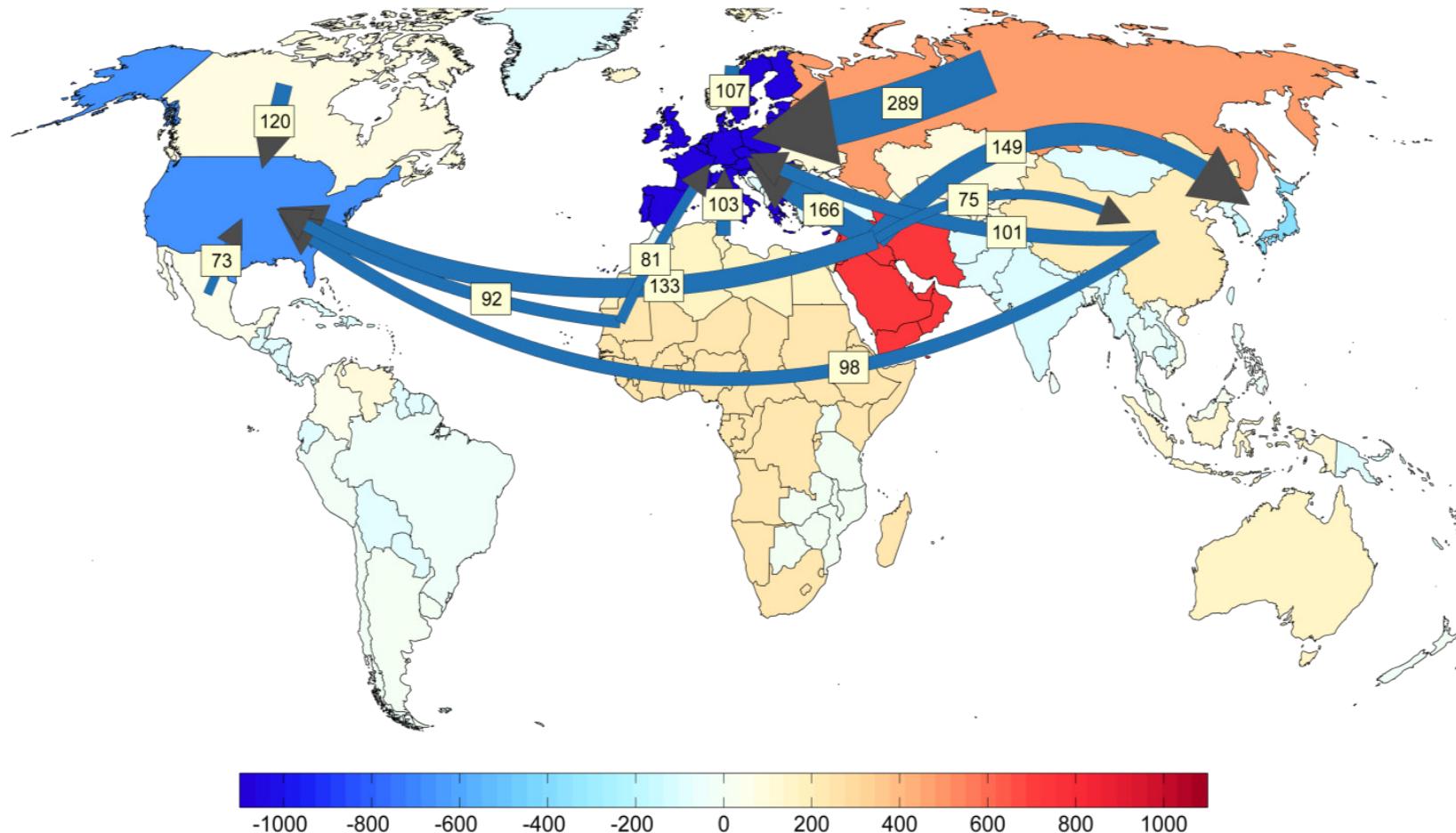
Values for 2007. EU27 is treated as one region. Units: TgC=GtC/1000

Source: [Peters et al 2012b](#)

Major Flows from Extraction to Consumption

Start of Arrow: fossil-fuel extraction

End of arrow: goods and services consumption

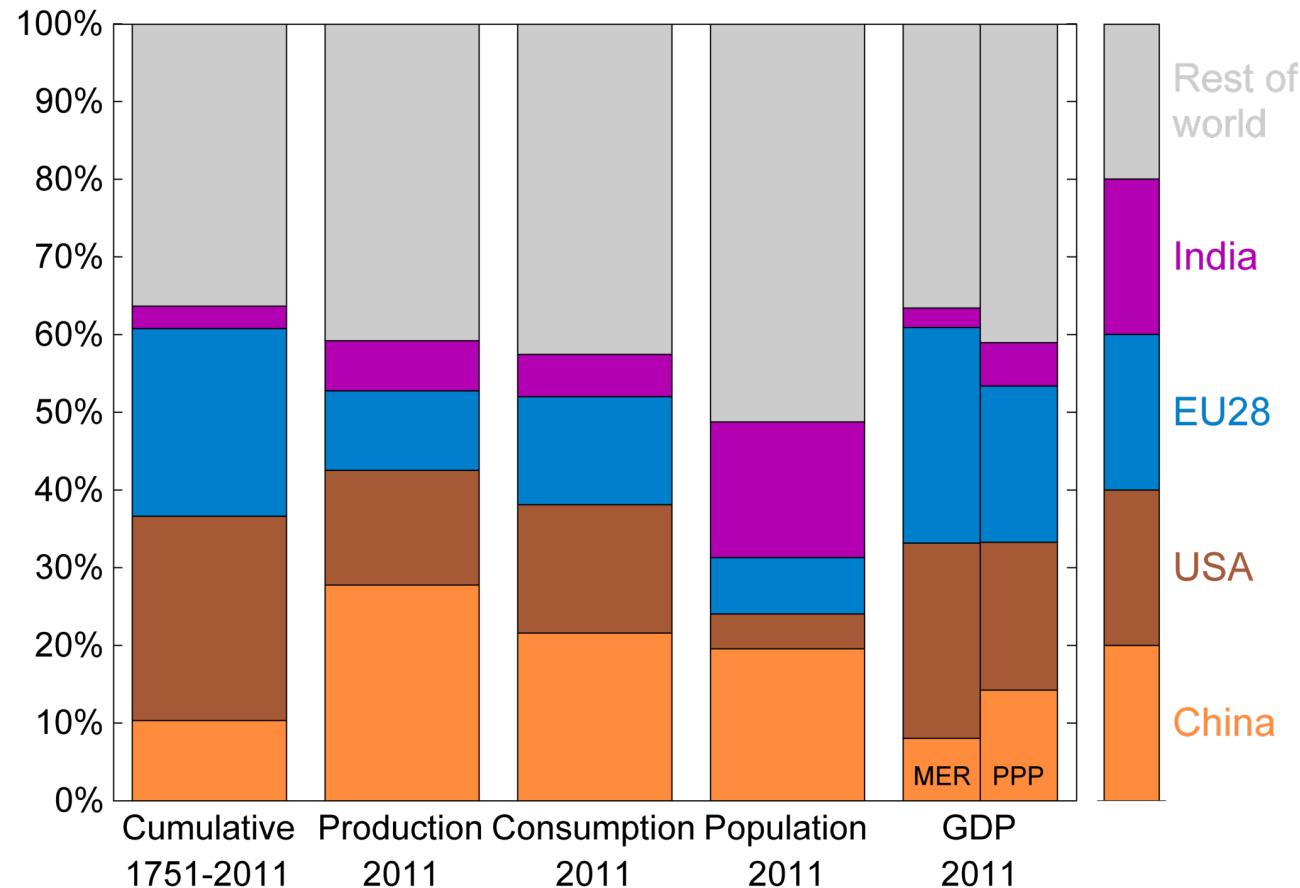


Values for 2007. EU27 is treated as one region. Units: TgC=GtC/1000

Source: [Peters et al 2012b](#)

Alternative Ranking of Countries

Depending on perspective, the importance of individual countries changes



GDP: Gross Domestic Product in Market Exchange Rates (MER) and Purchasing Power Parity (PPP)

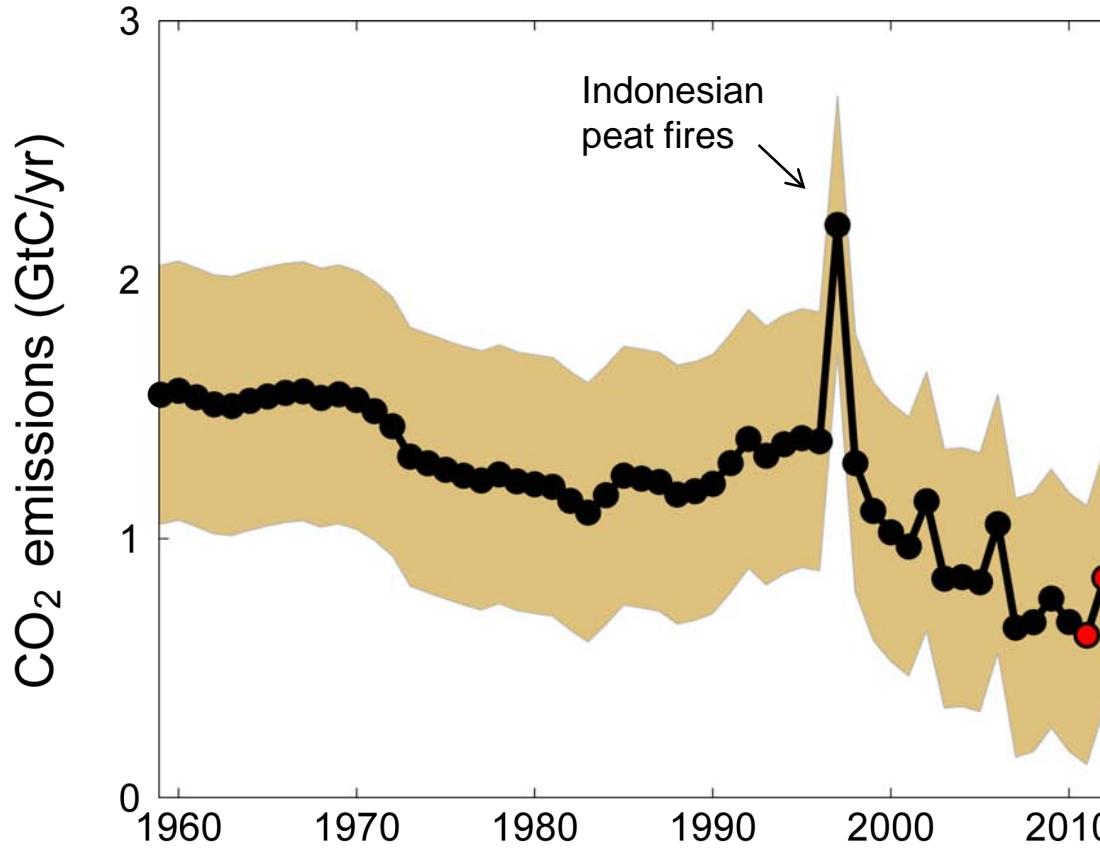
Source: [CDIAC Data](#); [Le Quéré et al 2013](#); [Global Carbon Project 2013](#)

Land-Use Change Emissions

Land-Use Change Emissions

Global land-use change emissions are estimated 0.8 ± 0.5 GtC during 2003–2012

The data suggests a general decrease in emissions since 1990

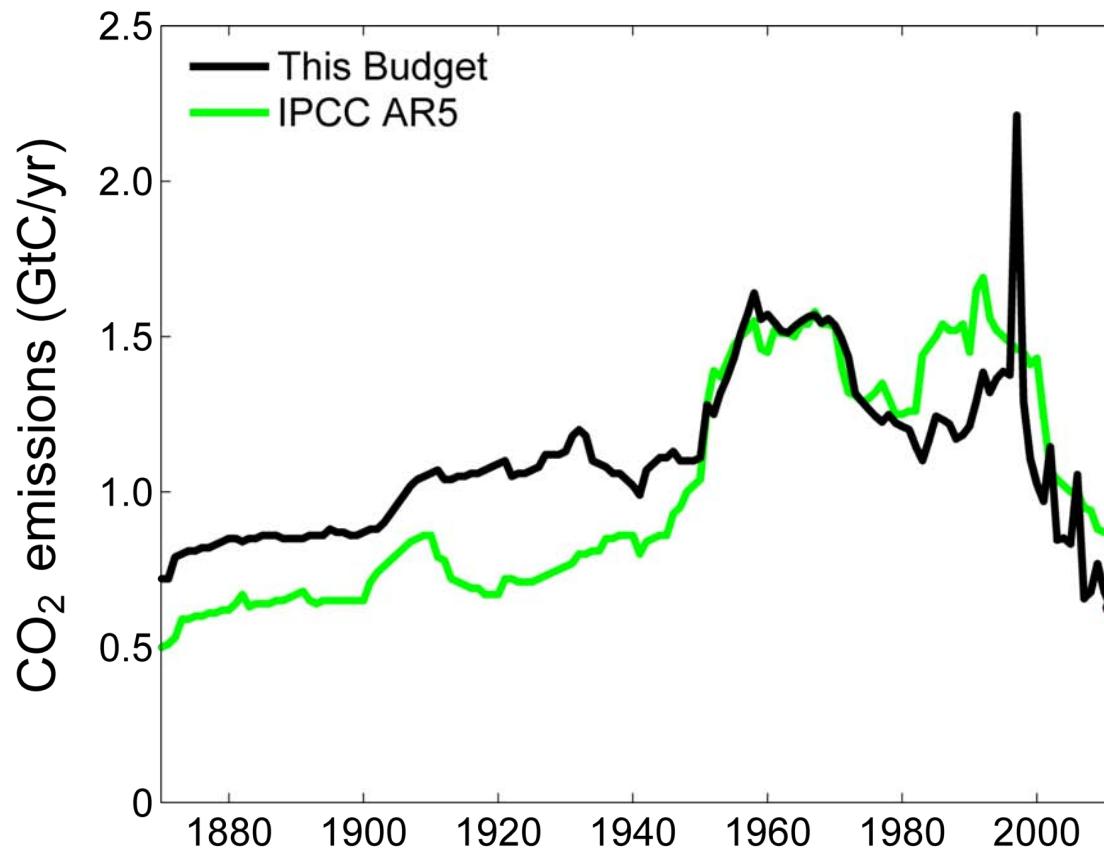


2011 and 2012 are extrapolated estimates

Source: [Le Quéré et al 2013](#); Houghton & Hackler (in review); [Global Carbon Project 2013](#)

Uncertainty in Land-Use Change Emissions

Uncertainty in land-use change is large, particularly in early years.
This budget uses updated estimates, and has higher cumulative emissions than the IPCC AR5.



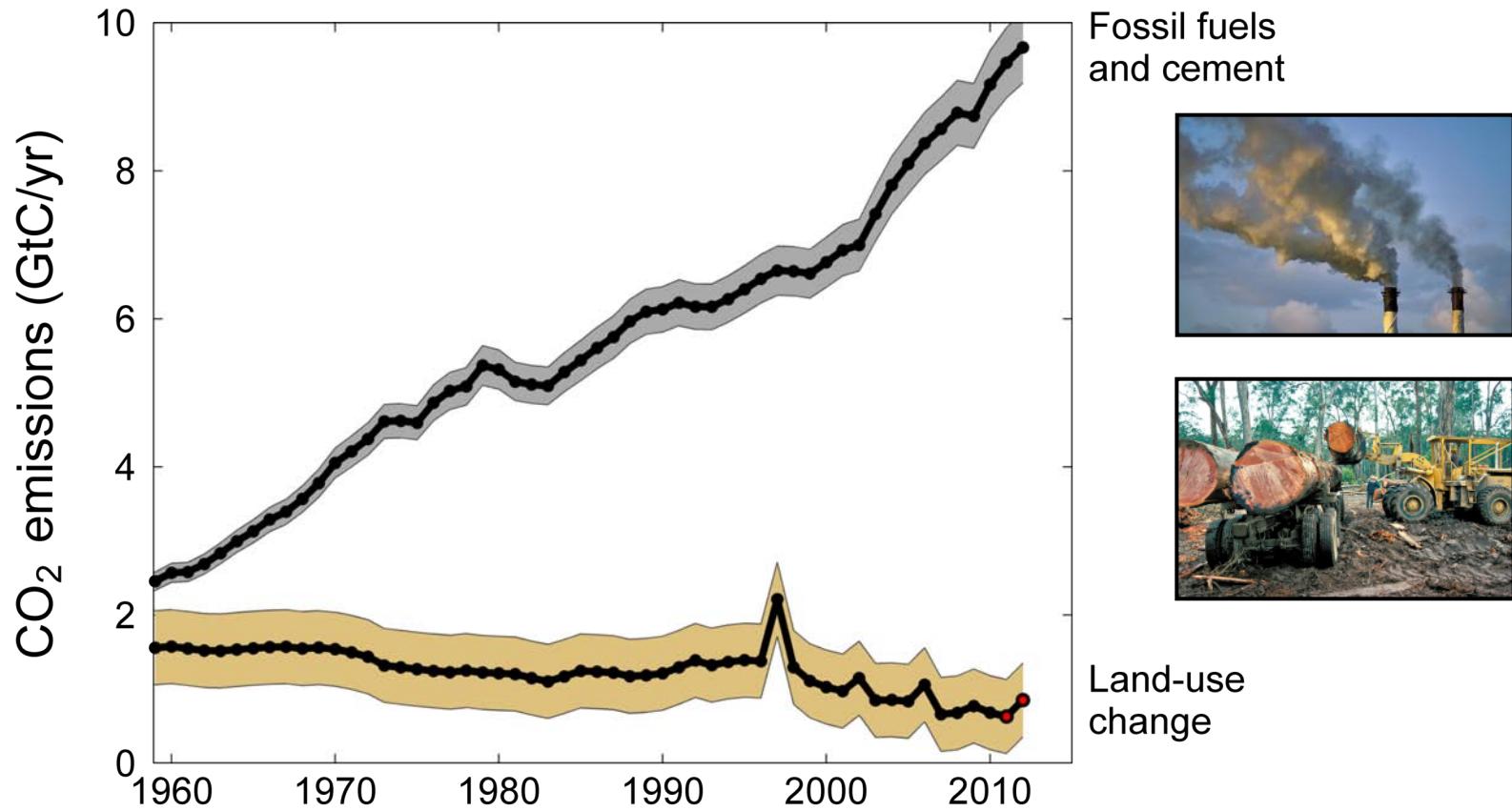
Cumulative emissions 1870–2011: 155 ± 55 GtC (this budget), 145 ± 60 GtC (IPCC)

Source: [Le Quéré et al 2013](#); Houghton & Hackler (in review); [Global Carbon Project 2013](#)

Total Global Emissions

Total global emissions: 10.5 ± 0.7 GtC in 2012, 43% over 1990

Percentage land-use change: 38% in 1960, 17% in 1990, 8% in 2012

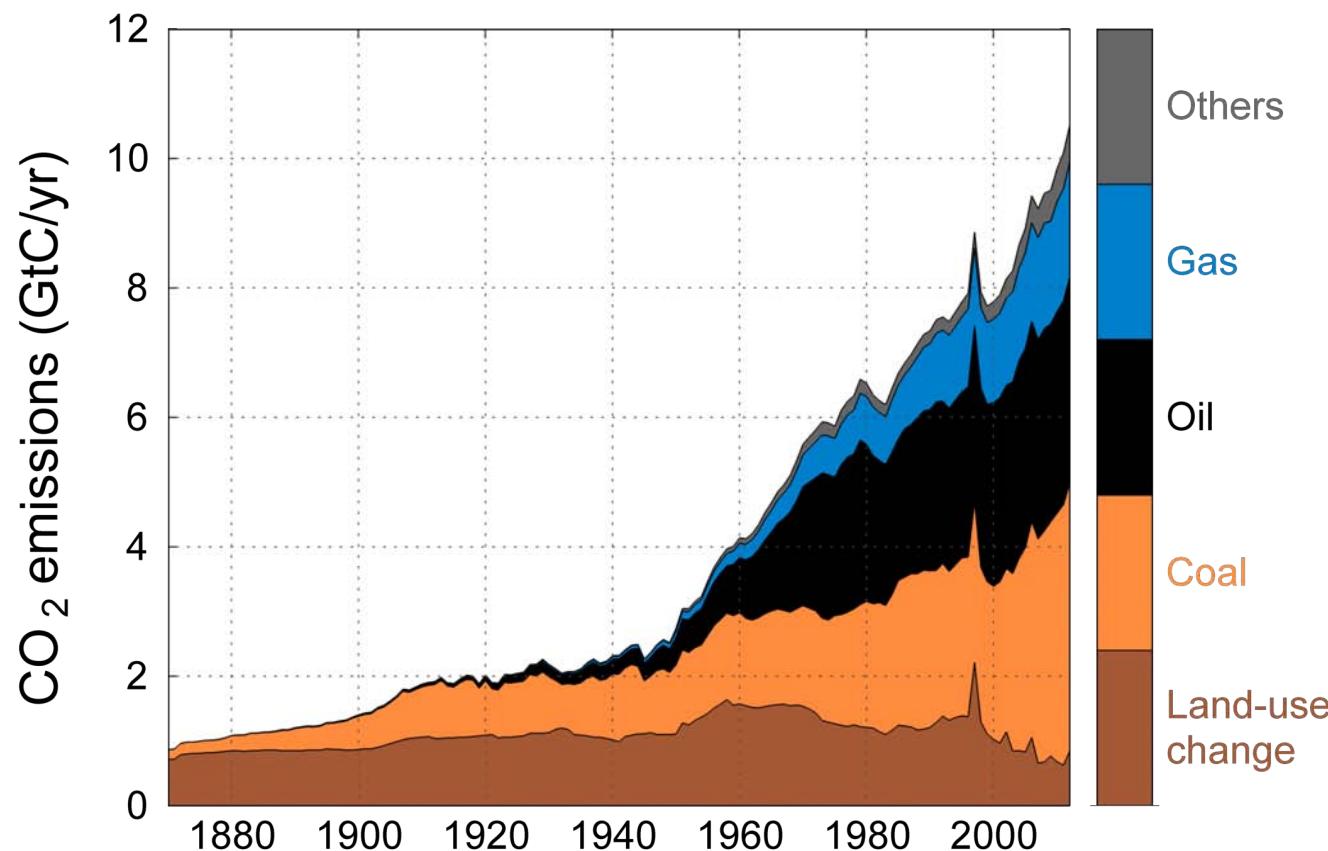


Land use emissions in 2011 and 2012 are extrapolated estimates

Source: [Le Quéré et al 2013](#); [CDIAC Data](#); Houghton & Hackler (in review); [Global Carbon Project 2013](#)

Total Global Emissions by Source

Land-use change was the dominant source of annual emissions until around 1950
Coal consumption continues to grow strongly



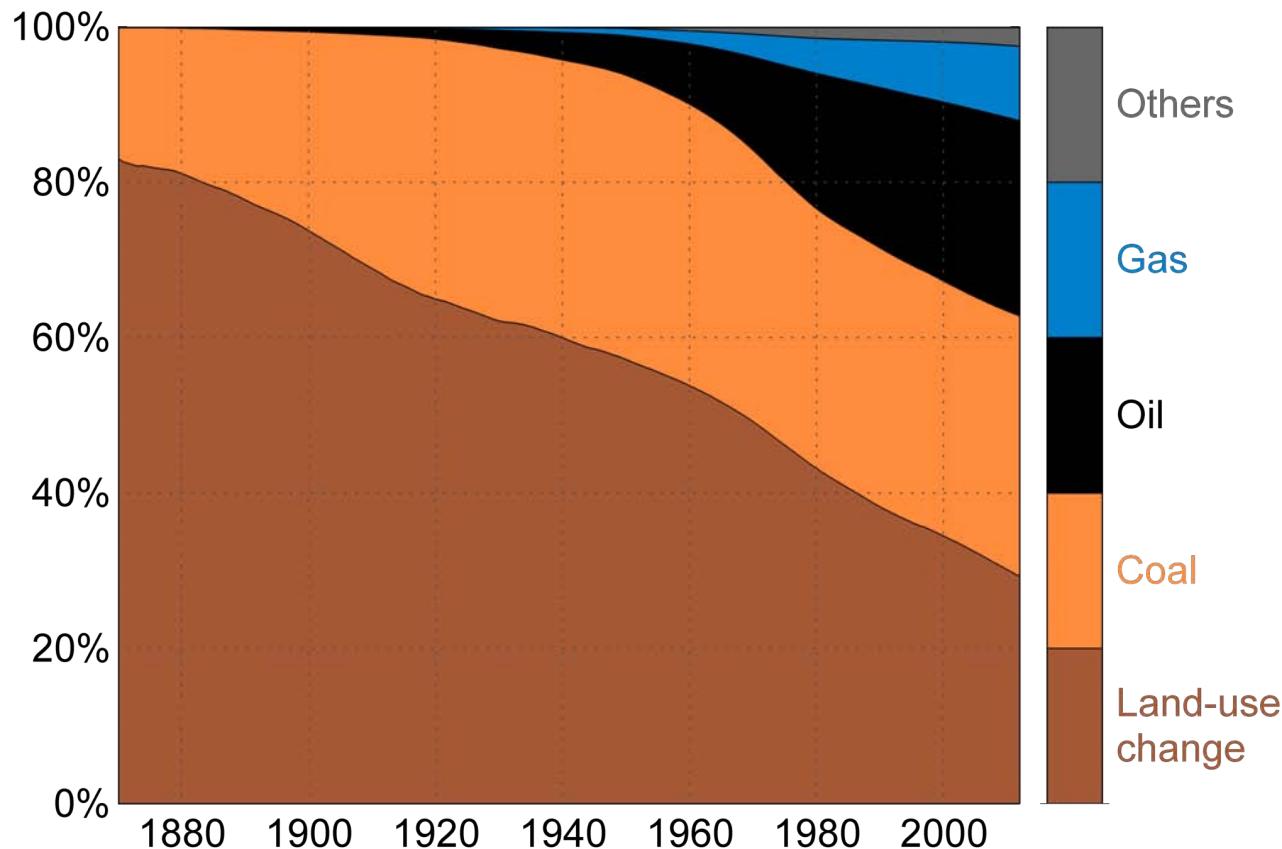
Others: Emissions from cement production and gas flaring.

Source: [CDIAC Data](#); Houghton & Hackler (in review); [Global Carbon Project 2013](#)

Historical Cumulative Emissions by Source

Despite reductions in land-use change, it represents about 29% of cumulative emissions in 2012

Coal represents about 34%, oil 25%, gas 10%, and others 2%



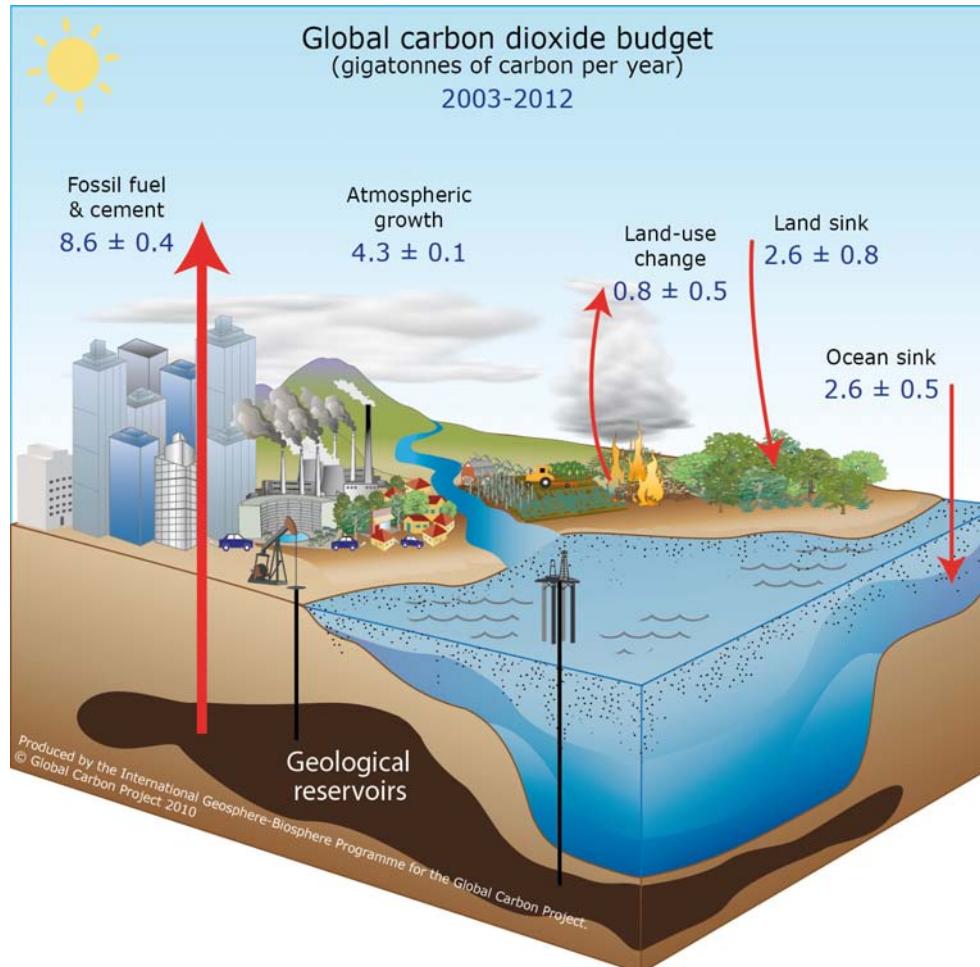
Others: Emissions from cement production and gas flaring.

Source: [CDIAC Data](#); Houghton & Hackler (in review); [Global Carbon Project 2013](#)

Closing the Carbon Budget

Anthropogenic Perturbation of the Global Carbon Cycle

Perturbation of the global carbon cycle caused by anthropogenic activities, averaged globally for the decade 2003–2012 (GtC/yr)



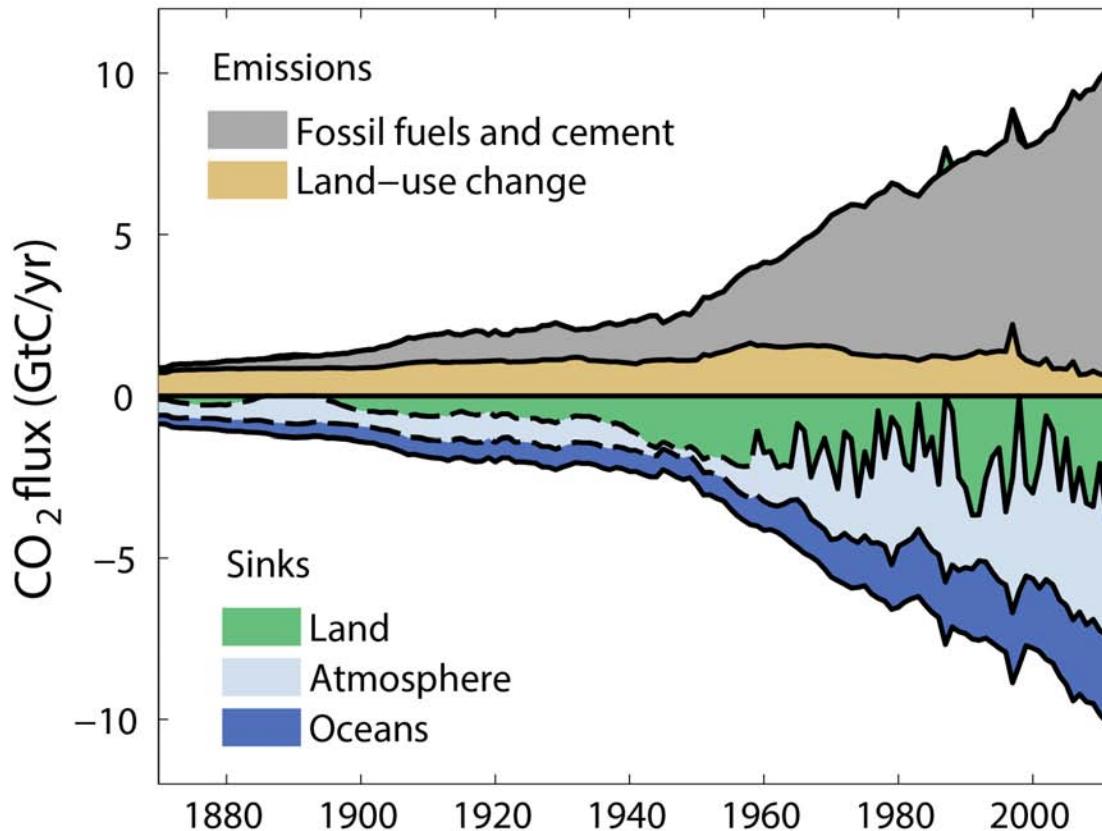
Source: [Le Quéré et al 2013](#); [CDIAC Data](#); [NOAA/ESRL Data](#); [Global Carbon Project 2013](#)

Global Carbon Budget

Emissions to the atmosphere are balanced by the sinks

Average sinks since 1870: 41% atmosphere, 31% land, 28% ocean

Average sinks since 1959: 45% atmosphere, 28% land, 27% ocean



Source: [CDIAC Data](#); Houghton & Hackler (in review); [NOAA/ESRL Data](#); [Joos et al 2013](#); [Khatiwala et al 2013](#); [Le Quéré et al 2013](#); [Global Carbon Project 2013](#)

Global Carbon Budget

The cumulative contributions to the Global Carbon Budget from 1750
Contributions are shown in parts per million (ppm)

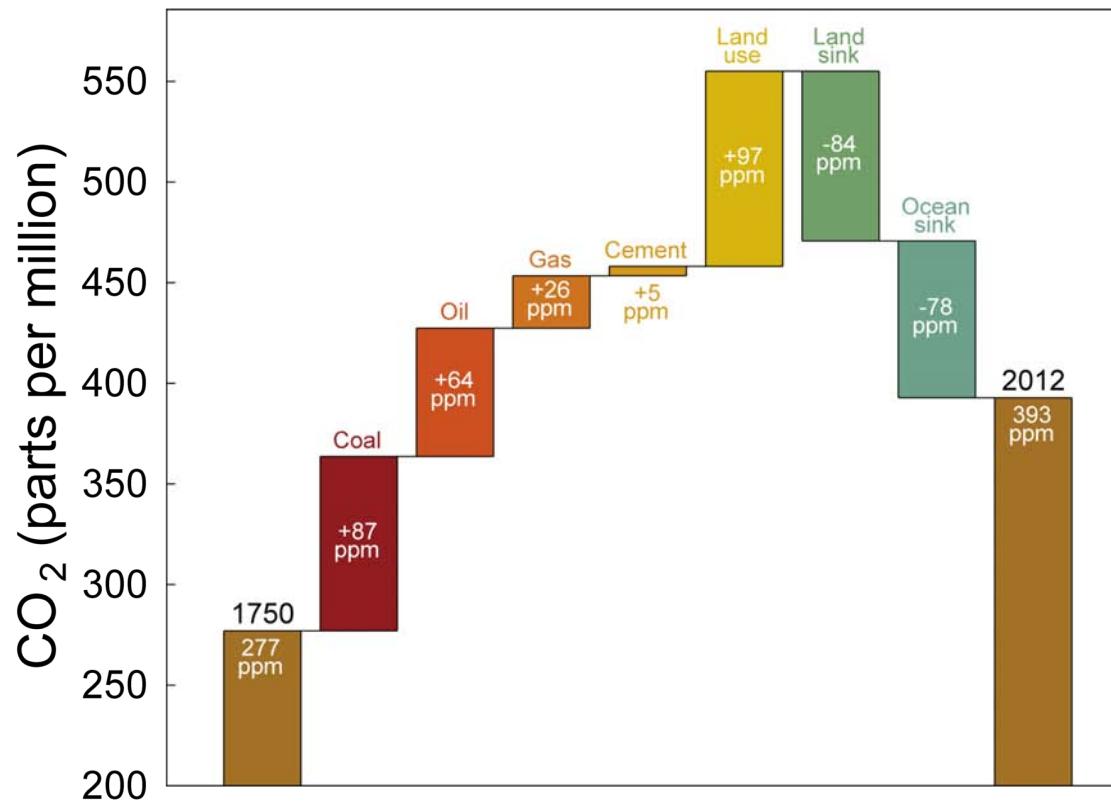
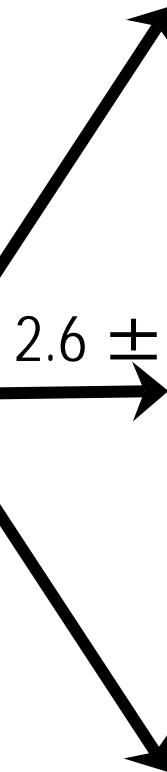


Figure concept from [Shrink That Footprint](#)

Source: [Le Quéré et al 2013](#); [NOAA/ESRL Data](#); [CDIAC Data](#); Houghton & Hackler (in review); [Global Carbon Project 2013](#)

Fate of Anthropogenic CO₂ Emissions (2003-2012 average) $8.6 \pm 0.4 \text{ GtC/yr}$ 92% $0.8 \pm 0.5 \text{ GtC/yr}$ 8% $4.3 \pm 0.1 \text{ GtC/yr}$ 45%

+

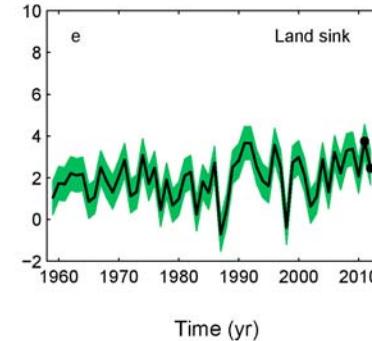
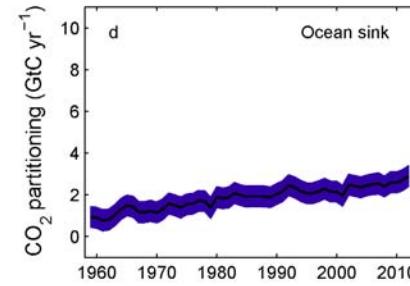
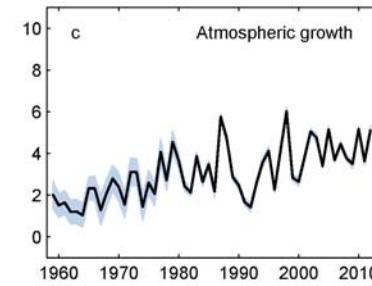
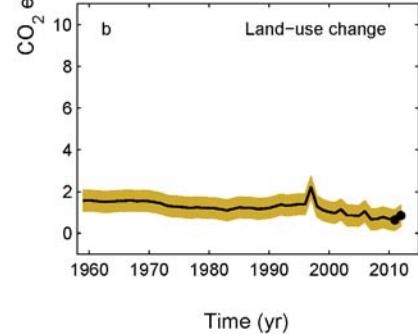
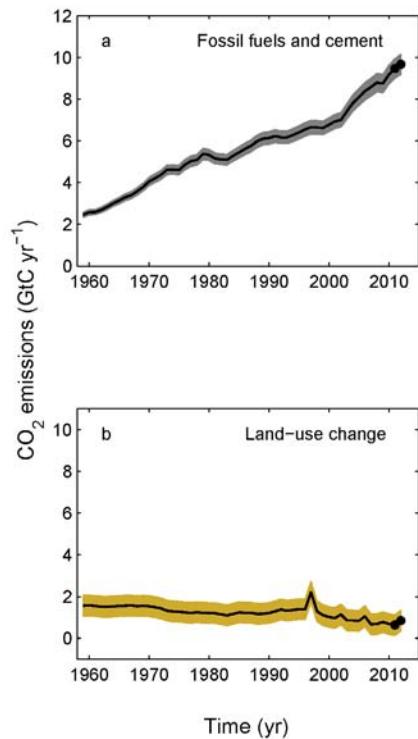
 $2.6 \pm 0.5 \text{ GtC/yr}$ 27% $2.6 \pm 0.8 \text{ GtC/yr}$ 27%

Calculated as the residual
of all other flux components



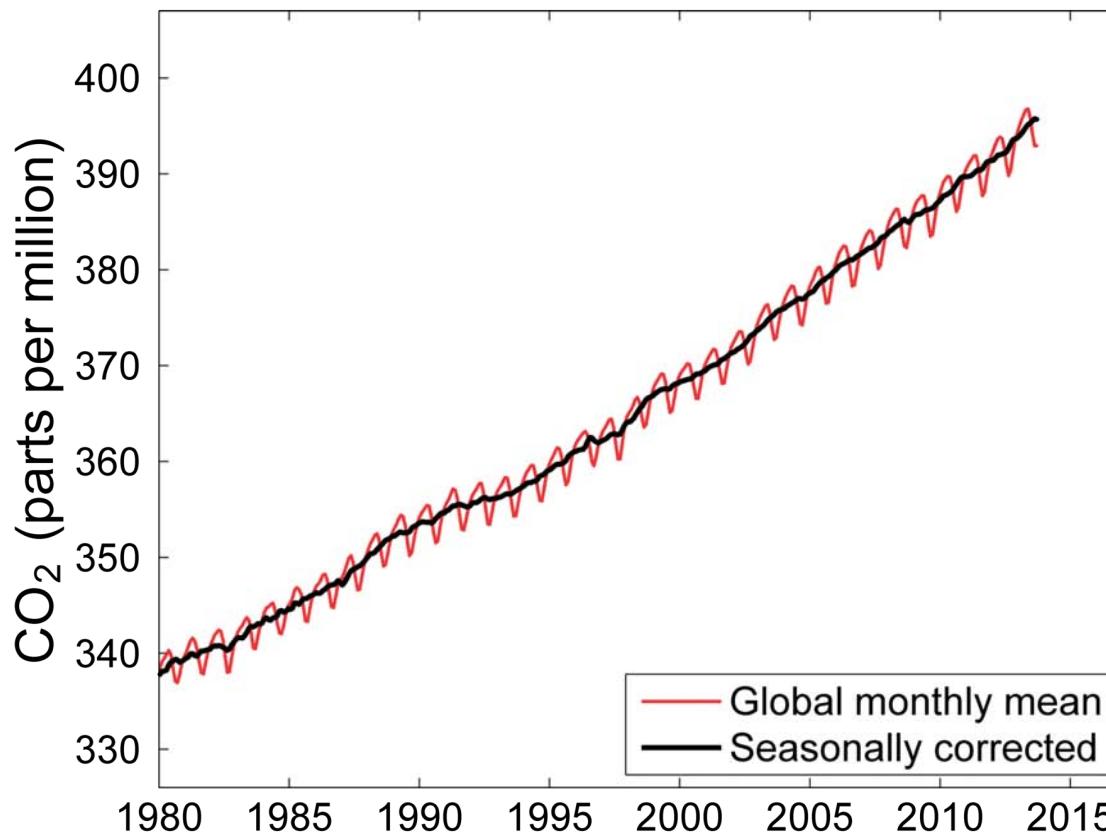
Changes in the Budget over Time

The sinks have continued to grow with increasing emissions, but climate change will affect carbon cycle processes in a way that will exacerbate the increase of CO₂ in the atmosphere



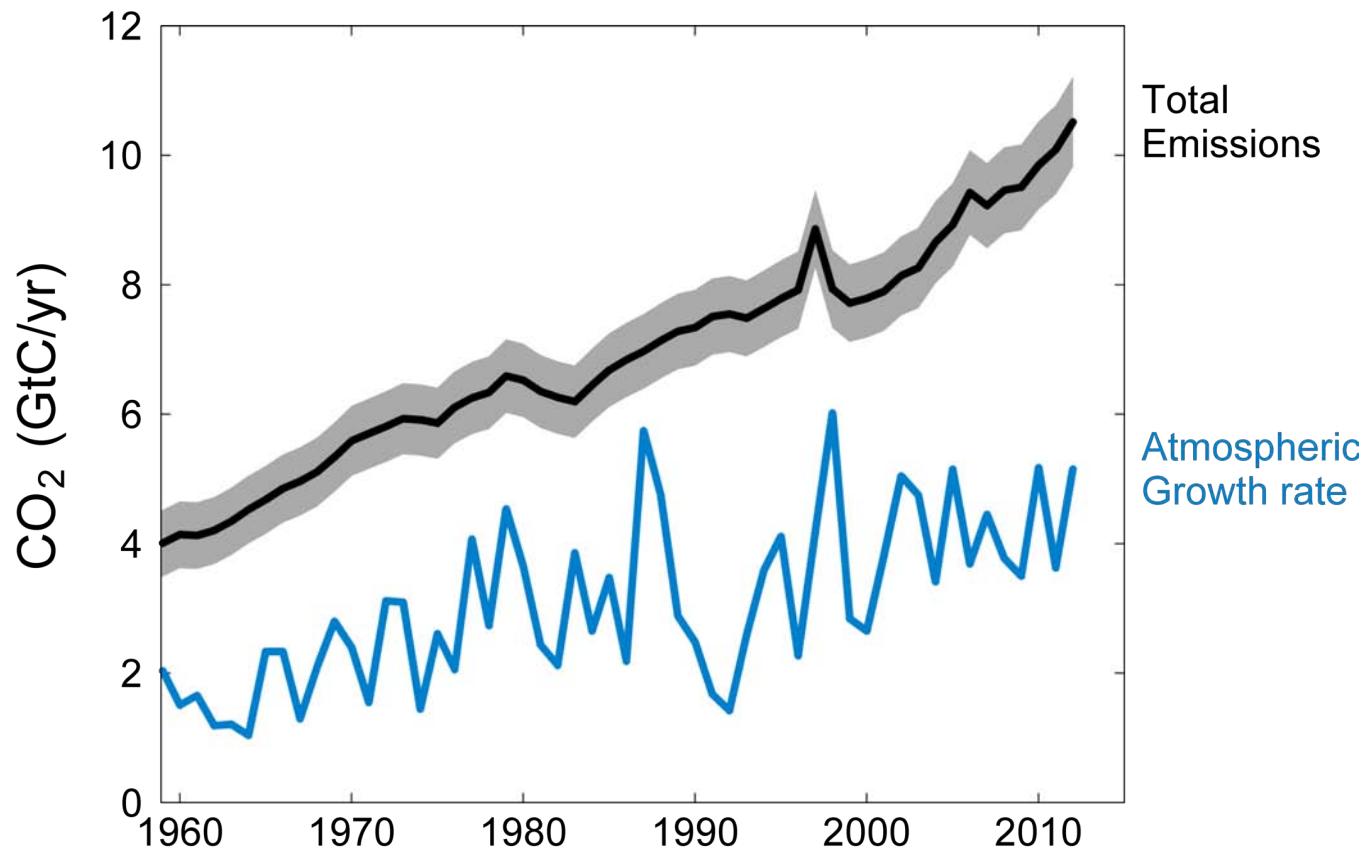
Atmospheric Concentration

The pre-industrial (1750) atmospheric concentration was around 277ppm
This increased to 393ppm in 2012, a 42% increase



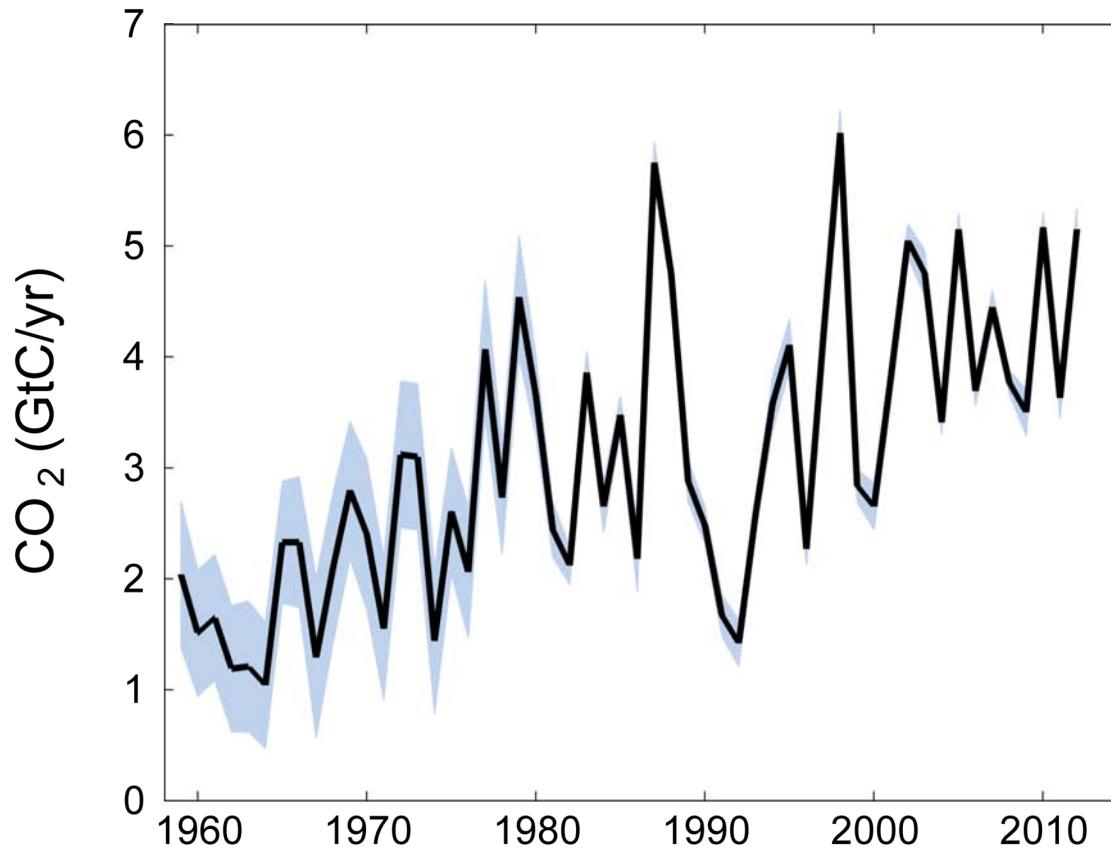
Atmospheric Growth Rate

The atmospheric concentration growth rate has had a steady increase



Atmospheric Growth Rate

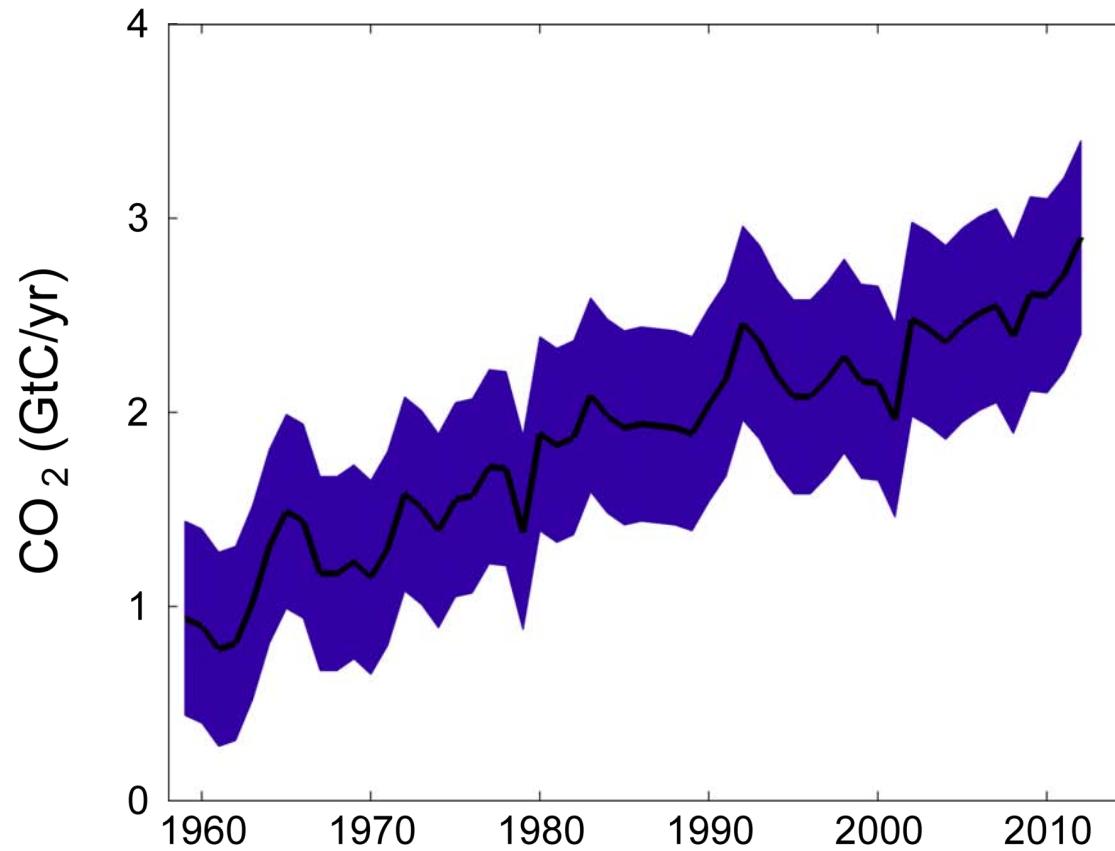
The atmospheric concentration growth rate has had a steady increase
 $4.3 \pm 0.1 \text{ GtC/yr}$ for 2003–2012, $5.2 \pm 0.1 \text{ GtC/yr}$ in 2012



Ocean Sink

Ocean carbon sink continues to increase

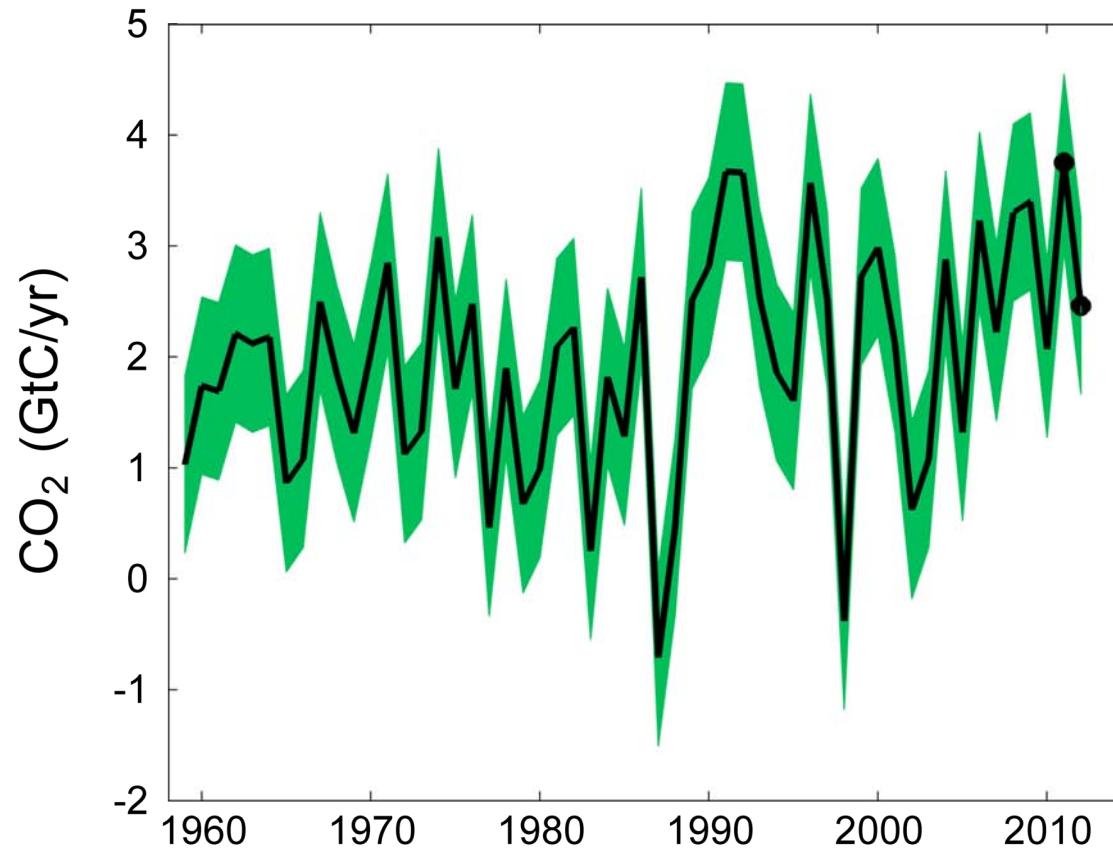
$2.6 \pm 0.5 \text{ GtC/yr}$ for 2003–2012, $2.9 \pm 0.5 \text{ GtC/yr}$ in 2012



Terrestrial Sink: Residual

Residual sink is increasing with time. Large interannual variability

$2.6 \pm 0.8 \text{ GtC/yr}$ for 2003–2012, $2.5 \pm 0.9 \text{ GtC/yr}$ in 2012

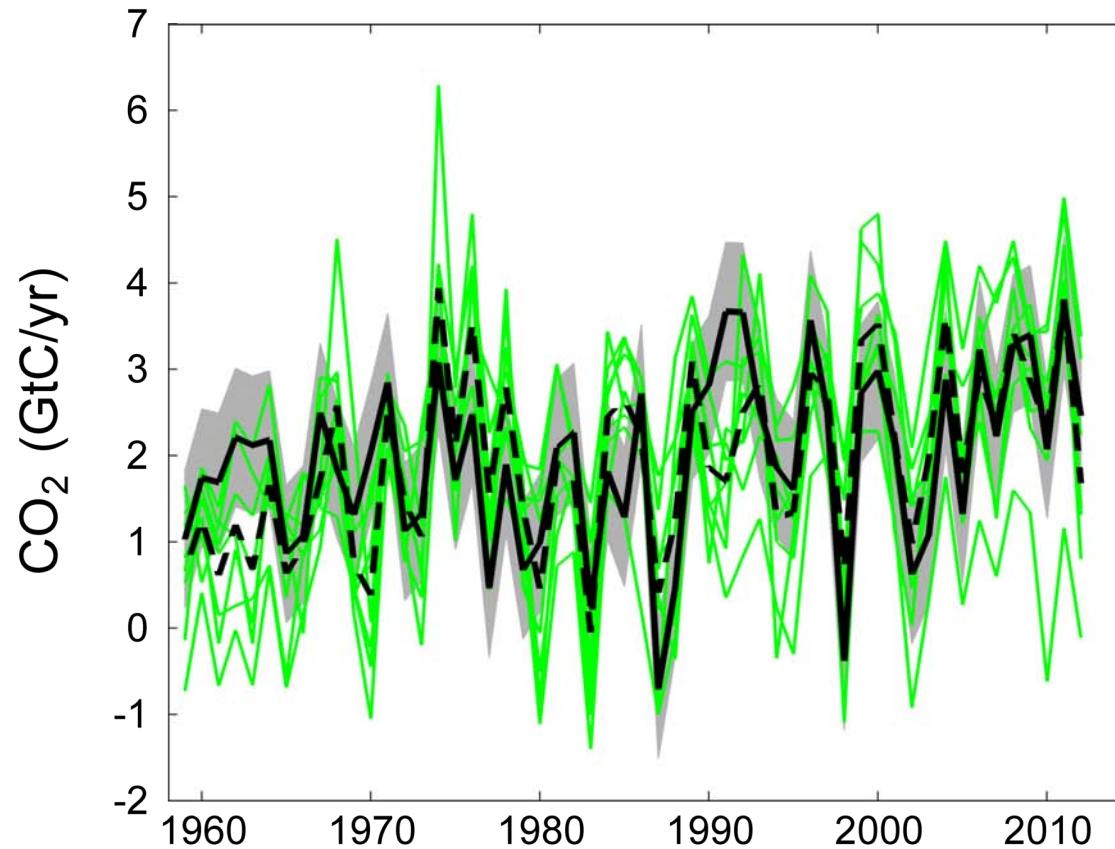


2011 and 2012 are extrapolated estimates

Source: [Le Quéré et al 2013](#); [Global Carbon Project 2013](#)

Terrestrial Sink: DGVMs

Terrestrial sink from DGVMs is consistent with the residual sink estimated from the carbon budget
 $2.7 \pm 1.0 \text{ GtC/yr}$ for 2003–2012, $1.7 \pm 1.2 \text{ GtC/yr}$ in 2012



DGVM: Dynamic Global Vegetation Model

Source: [Le Quéré et al 2013](#); [Global Carbon Project 2013](#)

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