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Carbon Budget 2008

GCP-Global Carbon Budget Consortium

Artist Impression of the Human Perturbation of the Carbon Cycle

GCP-Carbon Budget2008 Consortium

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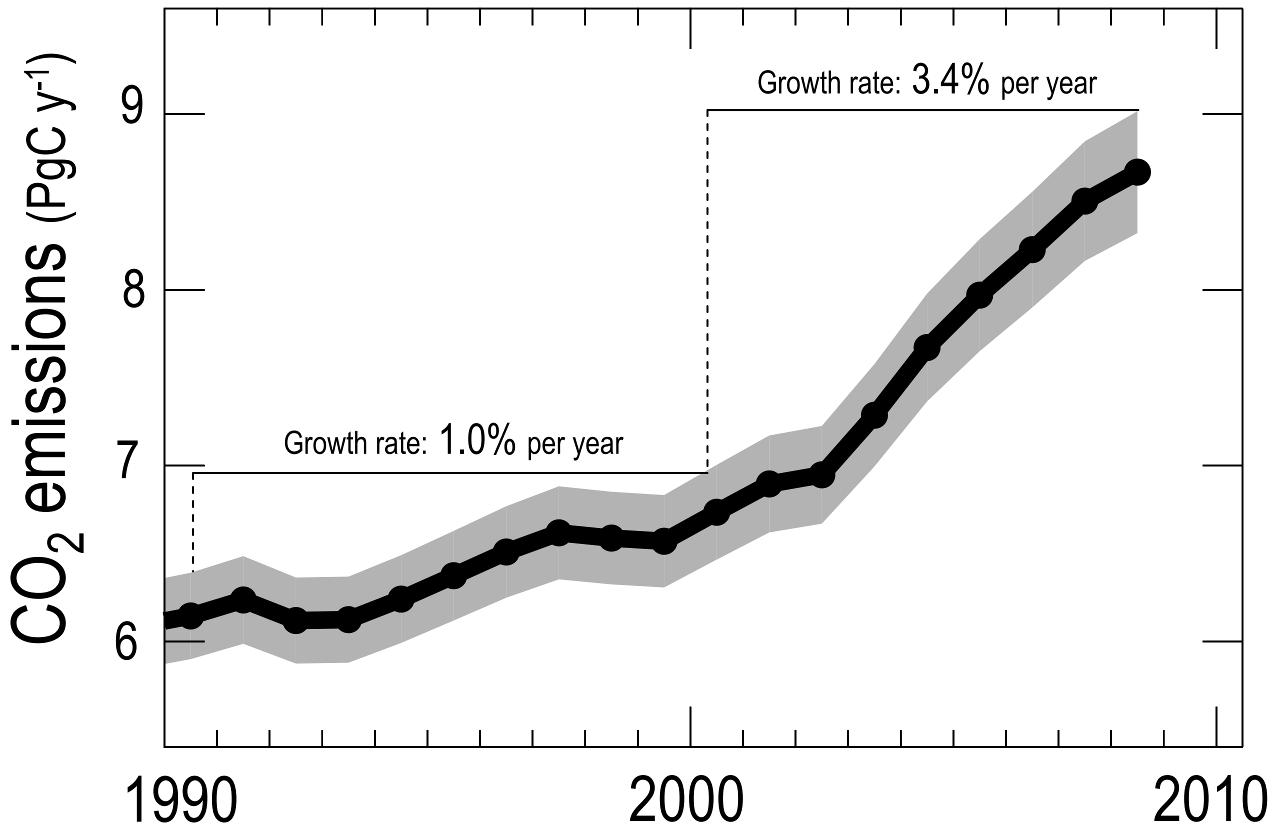
Fossil Fuel Emissions and Cement Production

[1 Pg = 1 Petagram = 1 Billion metric tonnes = 1 Gigatonne = $1x10^{15}$g]



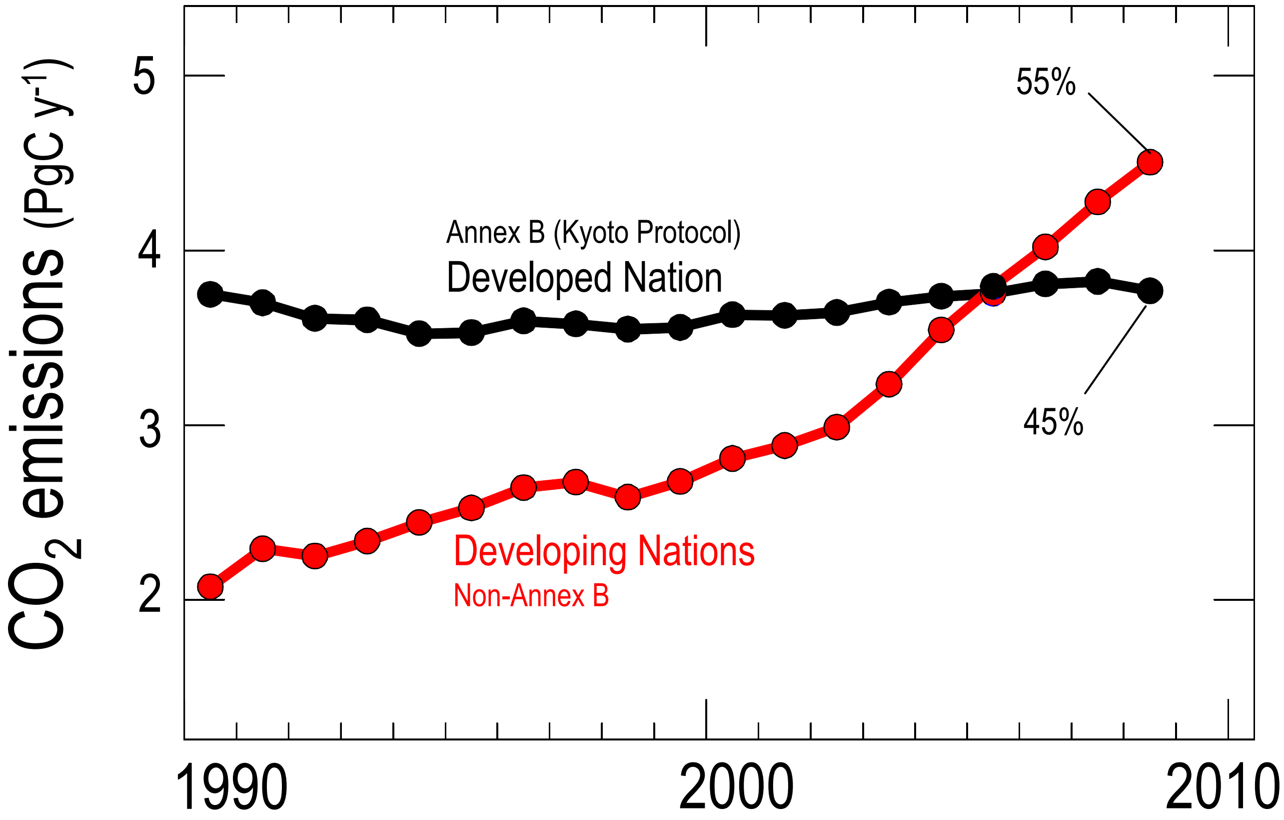
2008:
Emissions: 8.7 PgC
Growth rate: 2.0%
1990 levels: +41%

2000-2008
Growth rate: 3.4%

Global Carbon Project

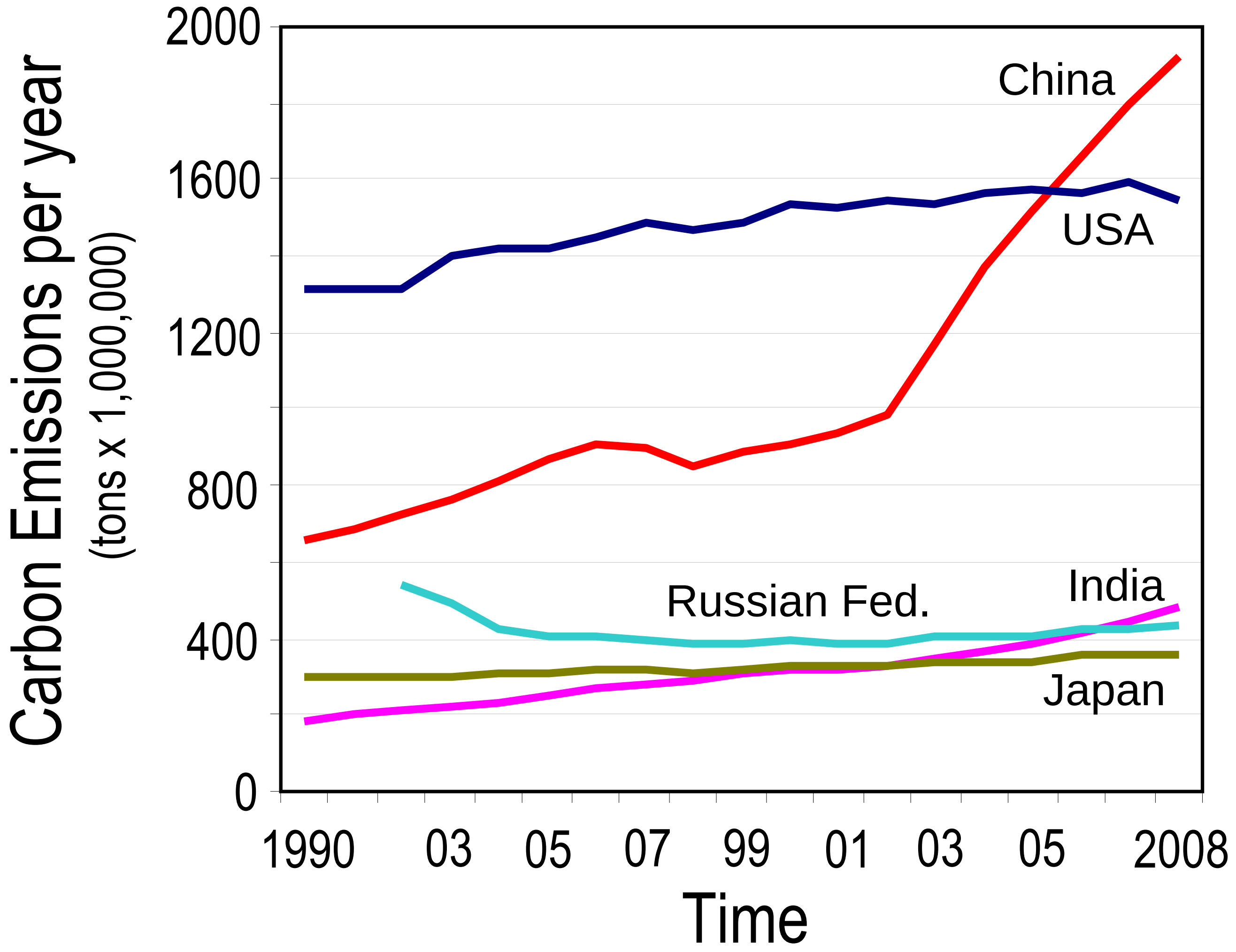
Le Quéré et al. 2009, Nature Geoscience; CDIAC 2009

CO_2 Fossil Fuel Emissions

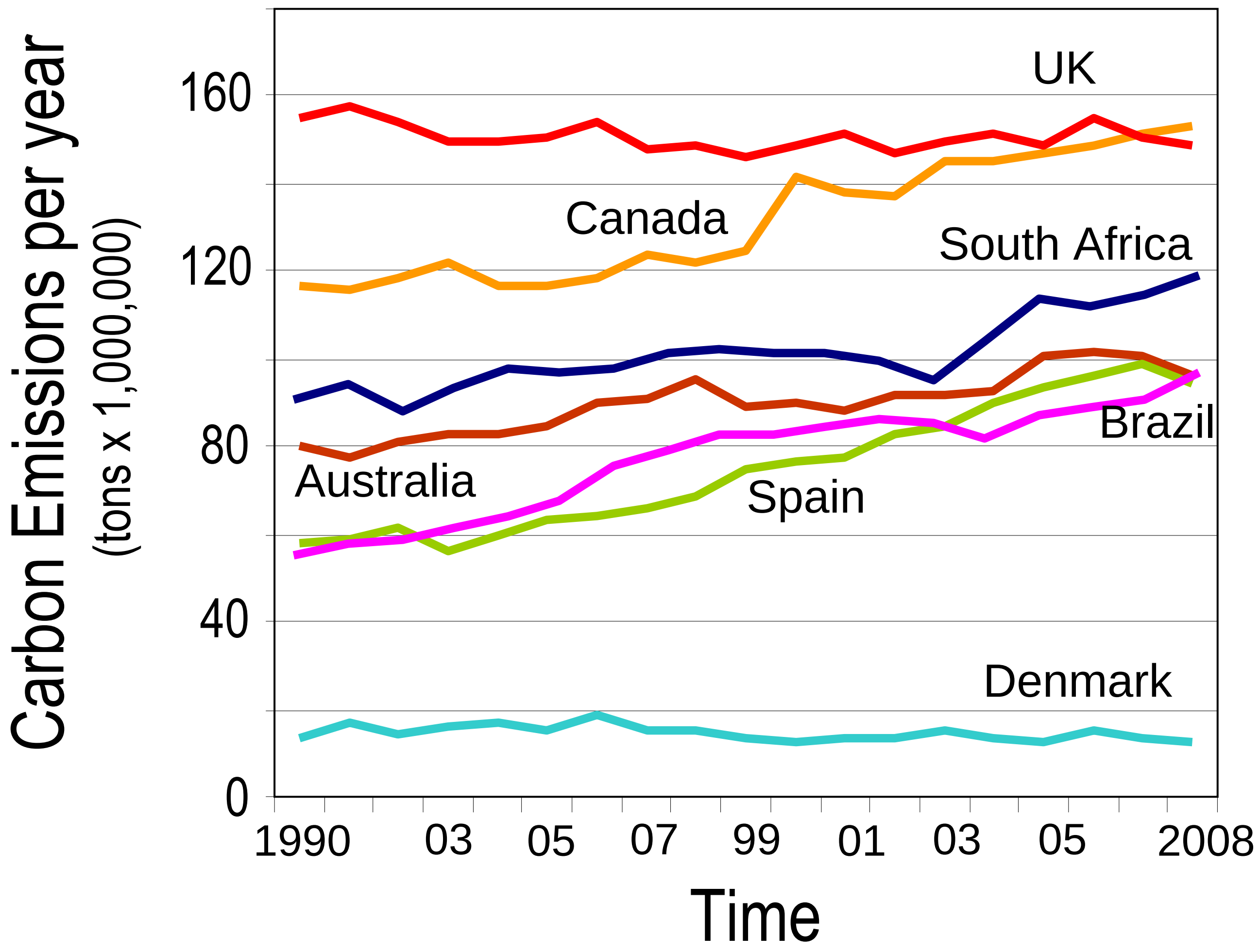


Le Quéré et al. 2009, Nature Geoscience; CDIAC 2009

Fossil Fuel Emissions: Top Emitters (>4% of Total)



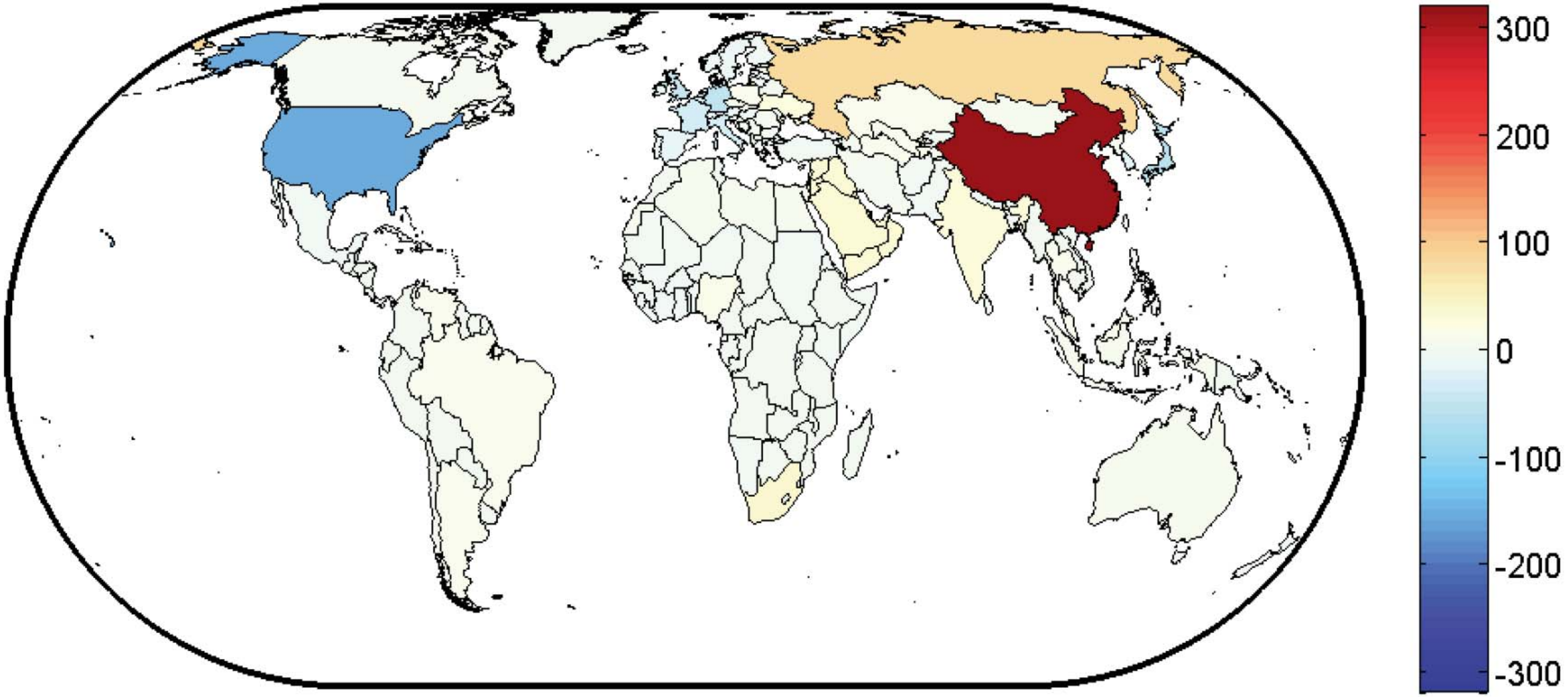
Fossil Fuel Emissions: Profile Examples (1-4% of Total)



Balance of Emissions Embodied in Trade (BEET)

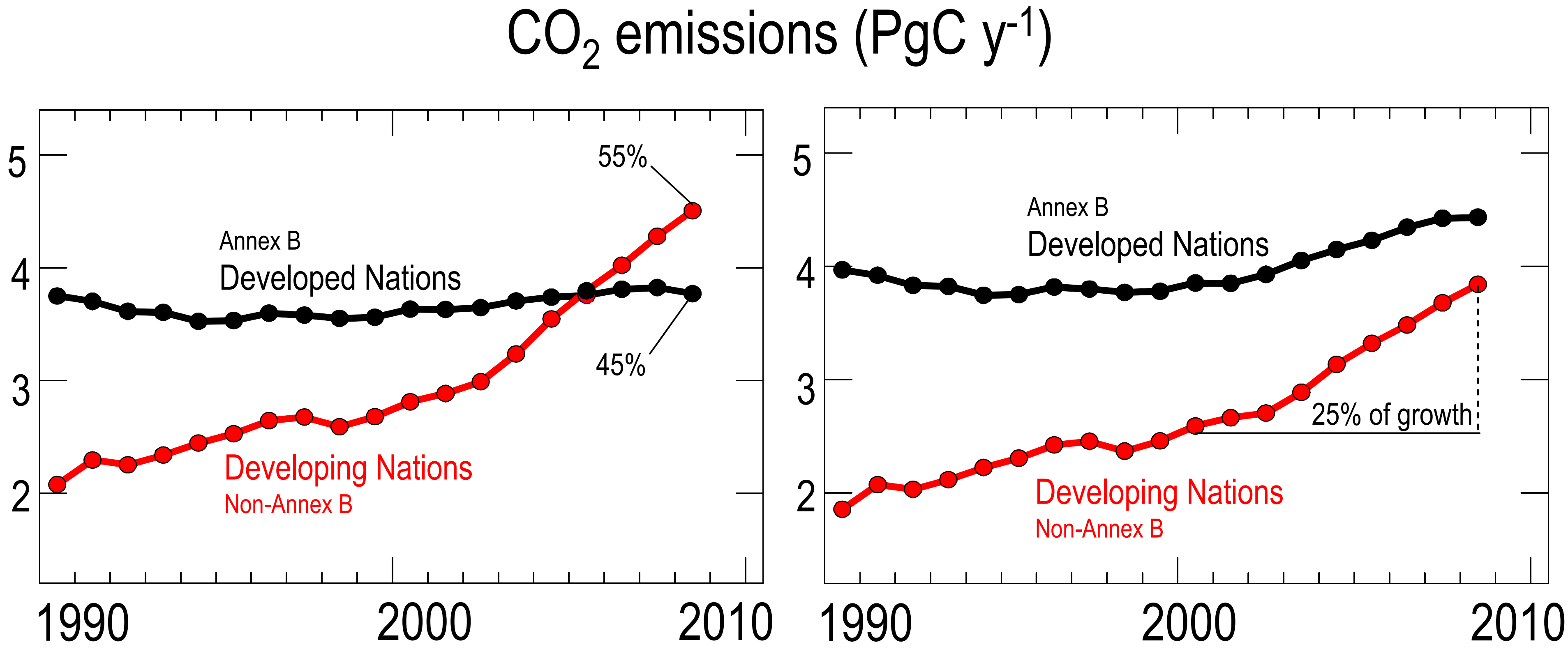
Year 2004

Warm colors → Net exporters of embodied carbon
Cold colors → Net importers of embodied carbon



Peters and Hertwich 2008, Environ, Sci & Tech., updated

Transport of Embodied Emissions



Global Carbon Project 2009; Le Quéré et al. 2009, Nature Geoscience; Data: Peters & Hetwich 2009; Peters et al. 2008; Weber et al 2008; Guan et al. 2008; CDIAC 2009

Cumulative Fraction of Total FF Emissions 2008

Number of Countries	Country	Cumulative Fraction
1	China	.232
2	USA	.419
3	India	.477
4	Russia	.530
5	Japan	.573
6	Germany	.599
7	Canada	.617
8	UK	.633
9	South Korea	.652
10	Iran	.668
20	Poland	.800
50 (2005)	Belarus	.941
100 (2005)	Moldova	.992
210		1.00

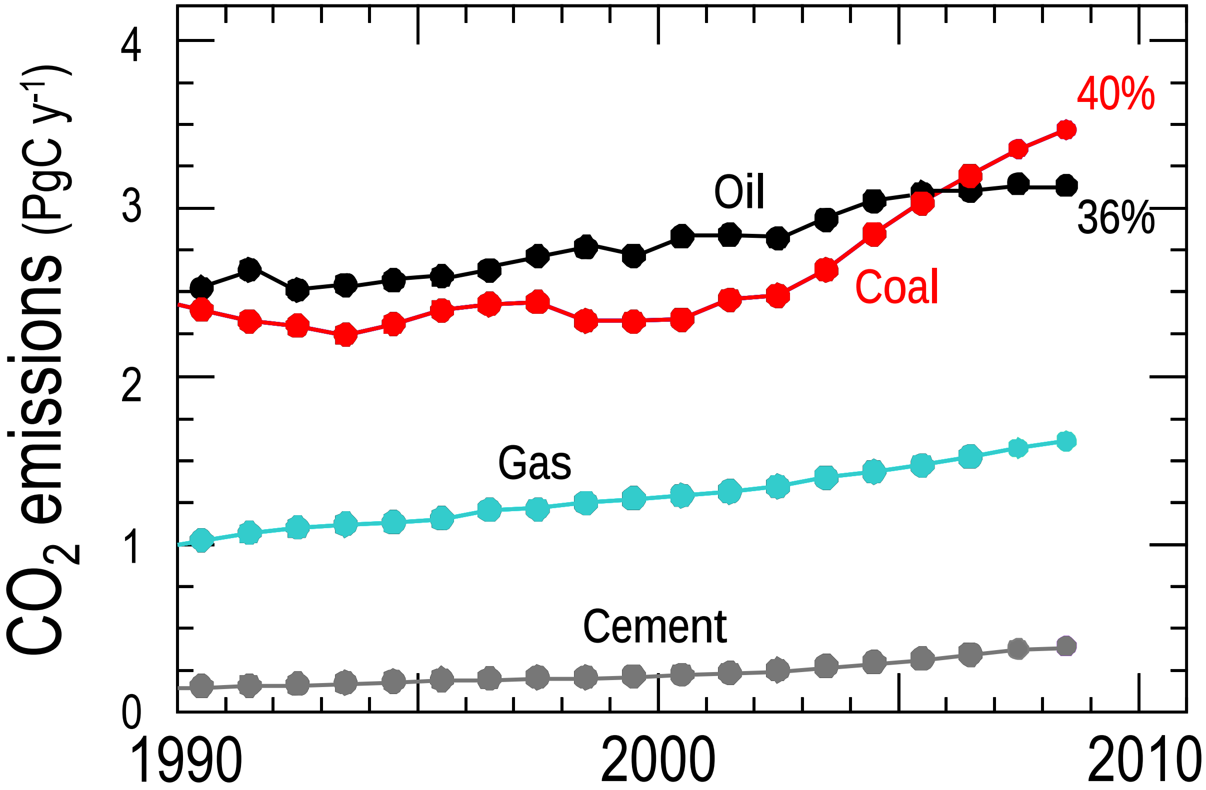
3 countries
50% Global Emissions

10 countries
2/3 Global Emissions

Top 5 + EU
80% Global Emissions

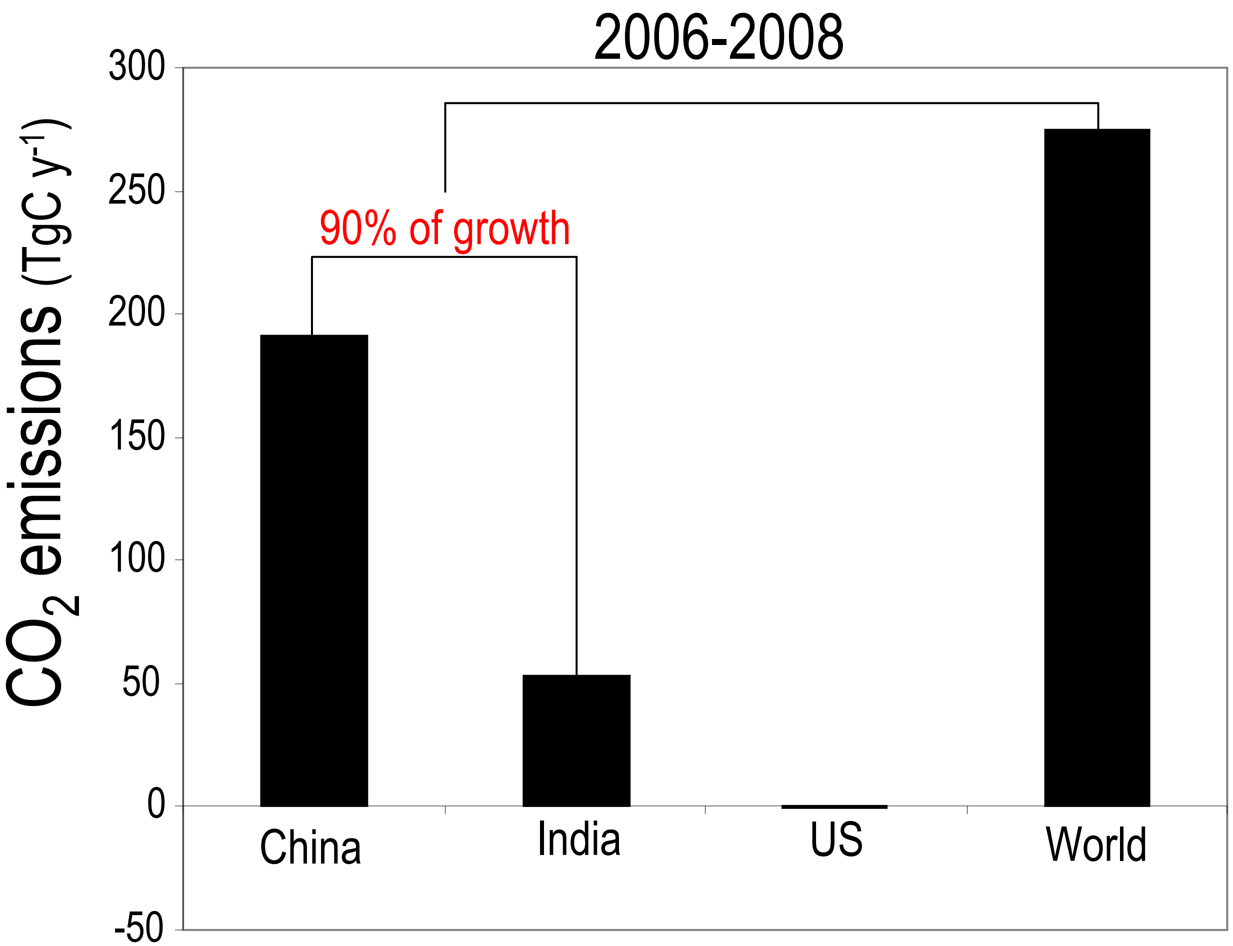
Gregg Marland, CDIAC 2009

Components of FF Emissions



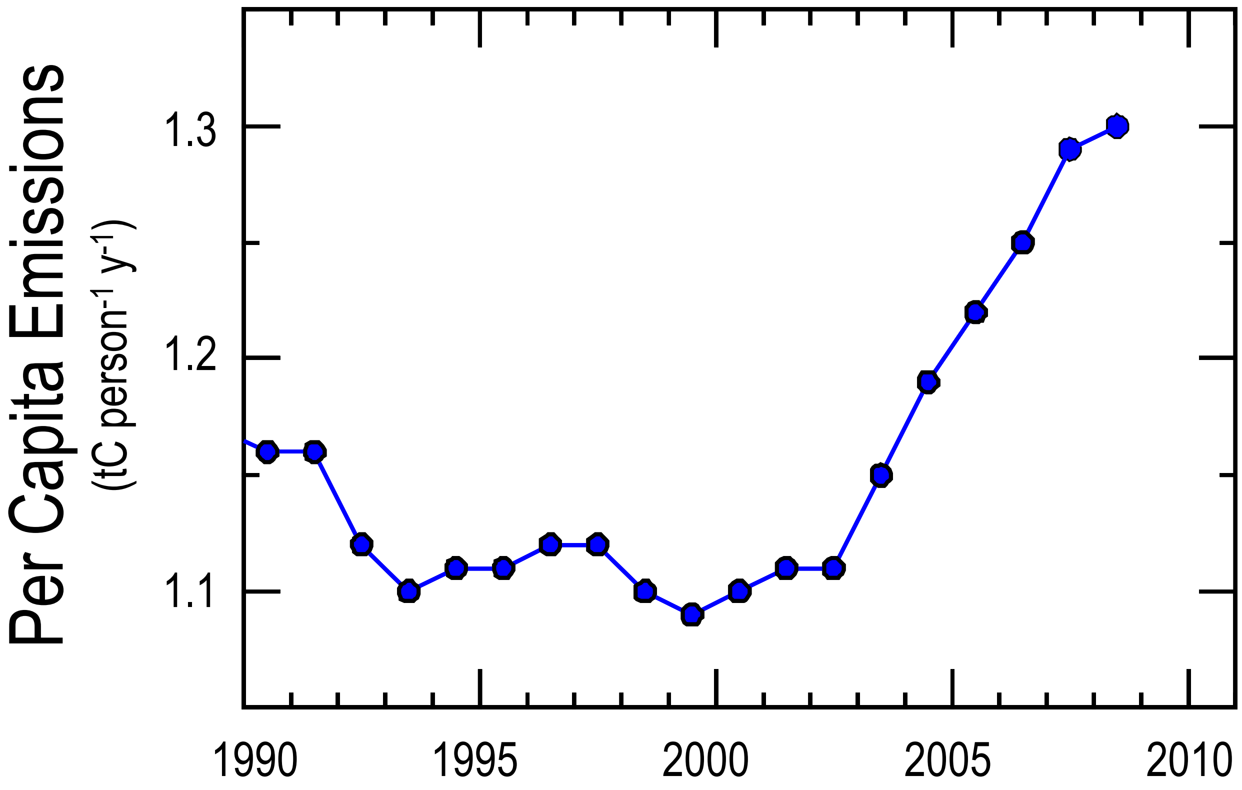
Le Quéré et al. 2009, Nature Geoscience

Change in CO_2 Emissions from Coal Emissions



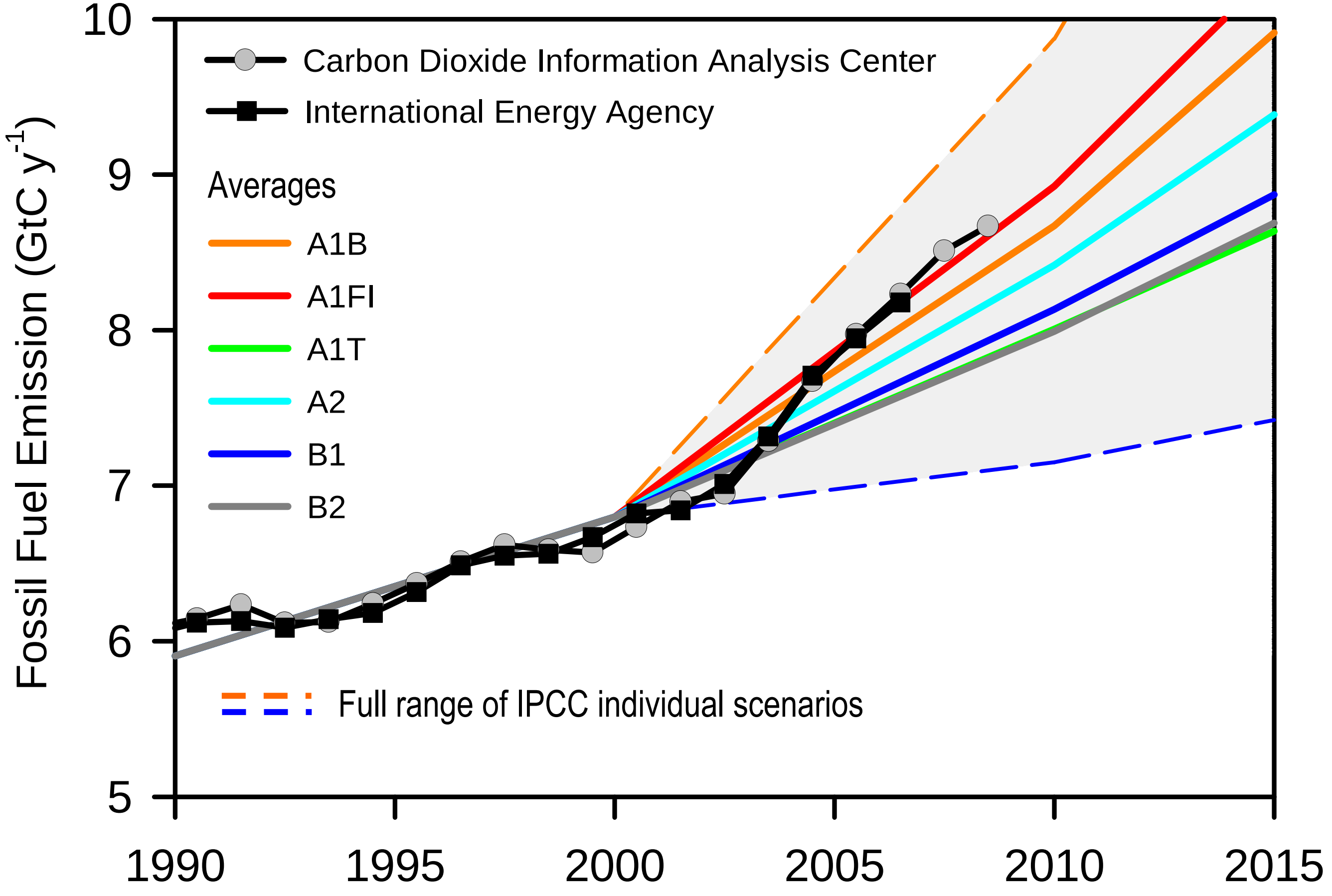
CDIAC 2009; Global Carbon Project 2009

Per Capita CO_2 Emissions



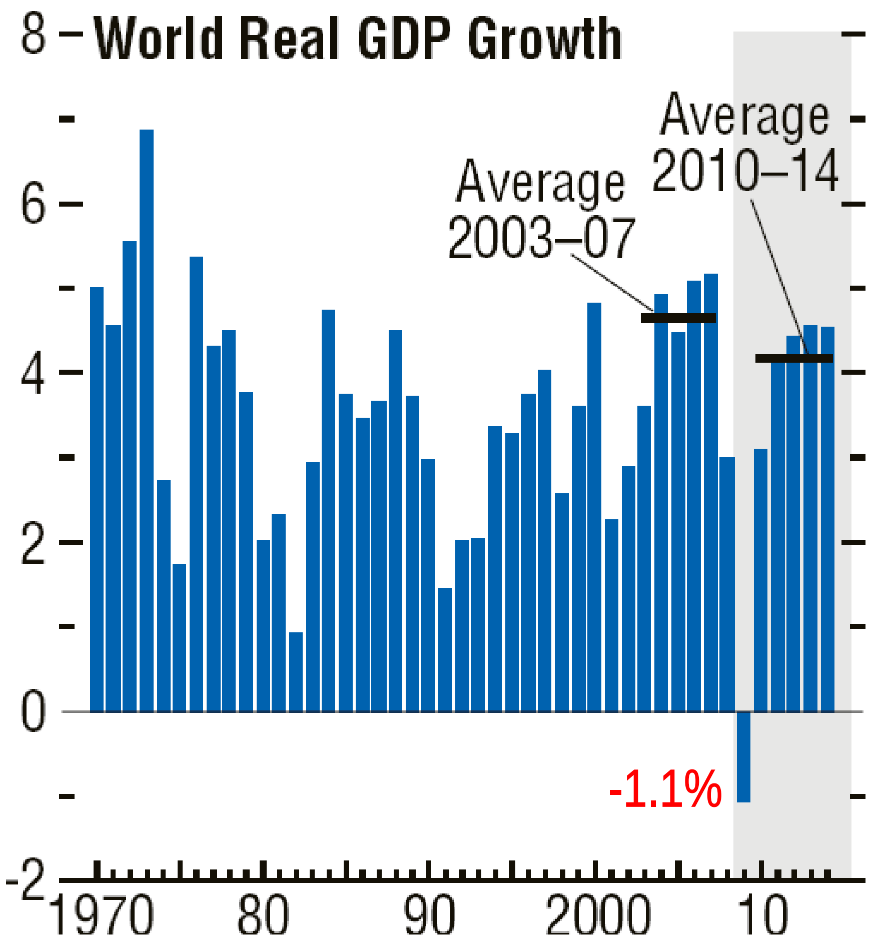
Developed countries continue to lead with the highest emission per capita

Fossil Fuel Emissions: Actual vs. IPCC Scenarios

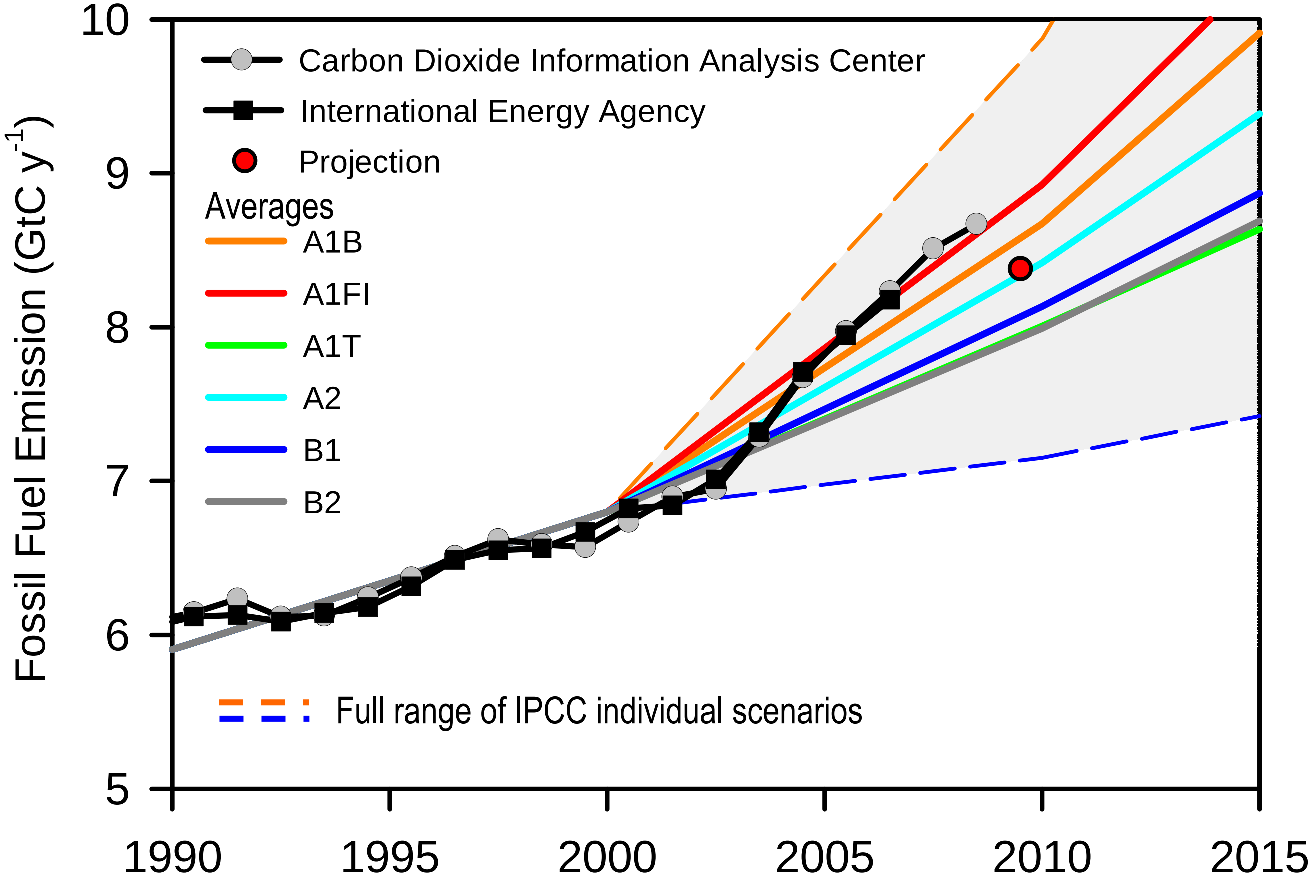


Raupach et al. 2007, PNAS, updated; Le Quéré et al. 2009, Nature Geoscience; International Monetary Fund 2009

Economic Crisis Impact on World GDP Growth

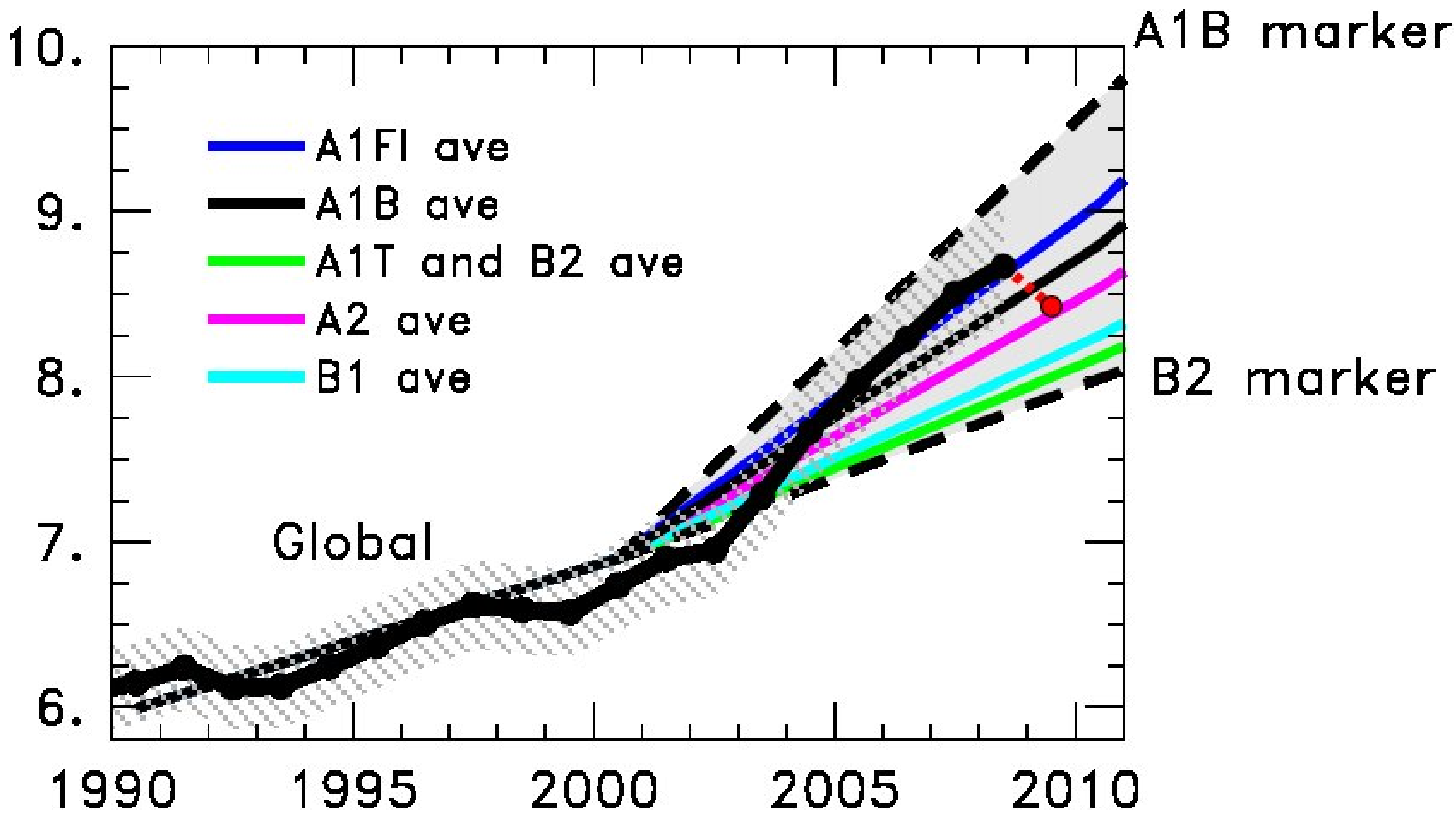


Fossil Fuel Emissions: Actual vs. IPCC Scenarios



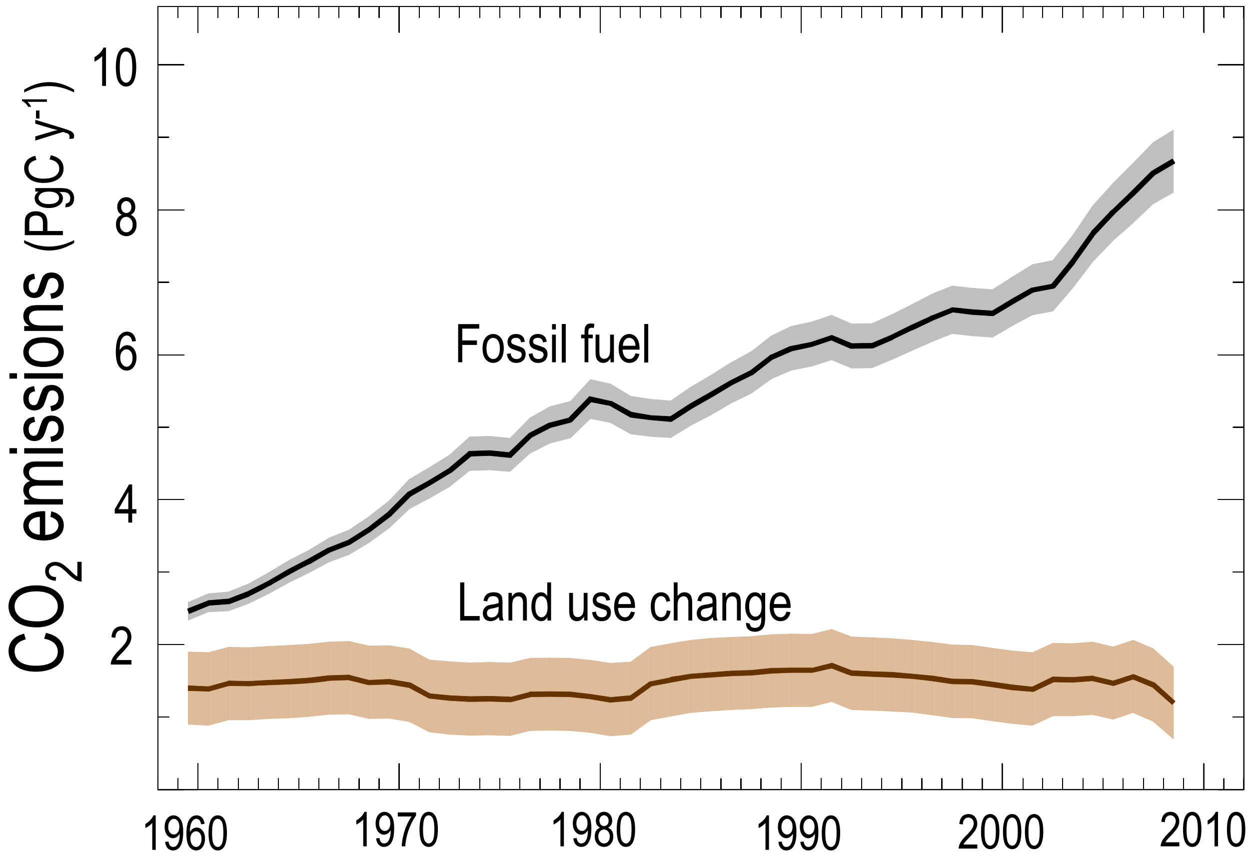
Projection 2009
Emissions: -2.8%
GDP: -1.1%
C intensity: -1.7%

Raupach et al. 2007, PNAS, updated; Le Quéré et al. 2009, Nature Geoscience; International Monetary Fund 2009



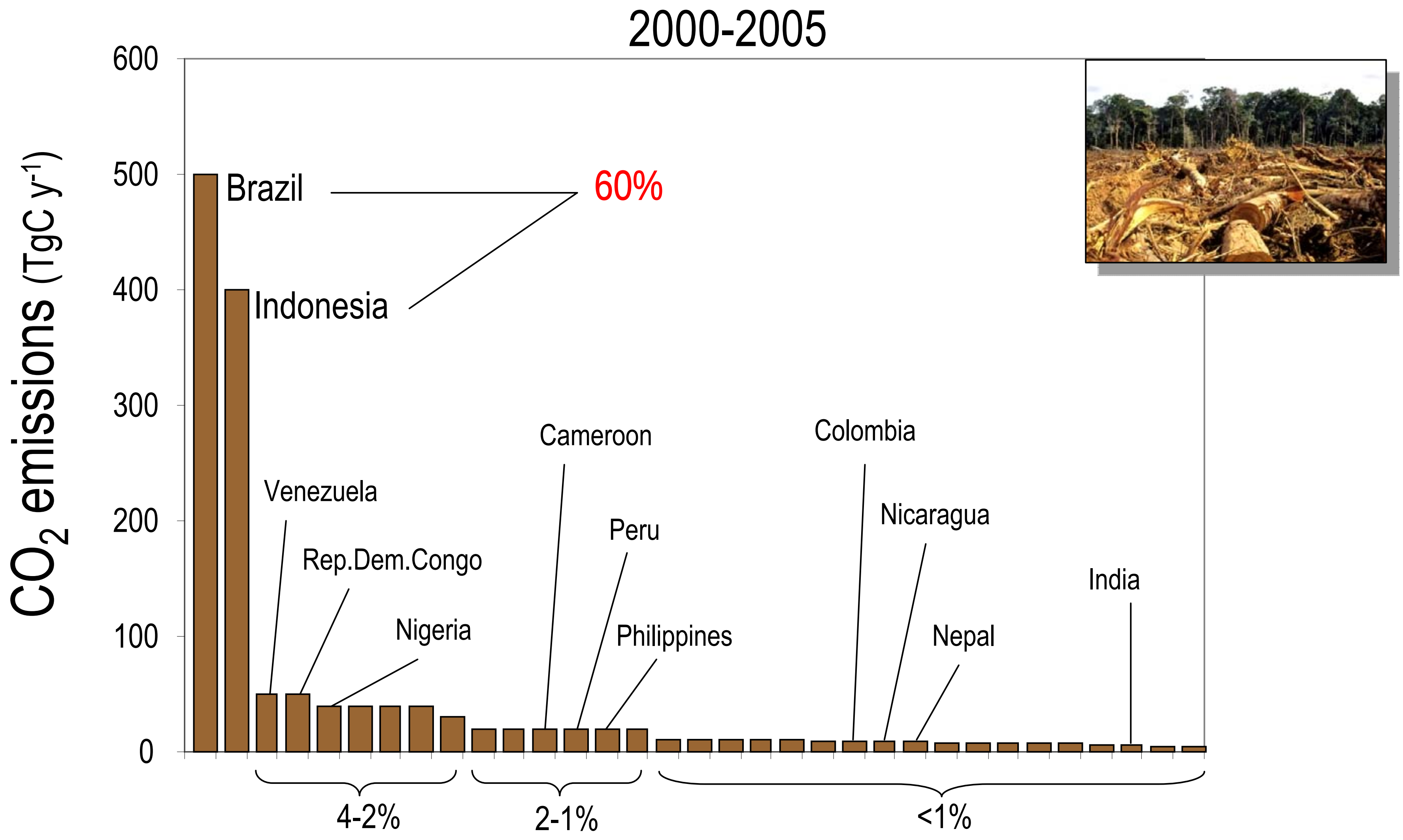
Modified from Le Quéré et al. 2009

CO_2 Emissions from Land Use Change



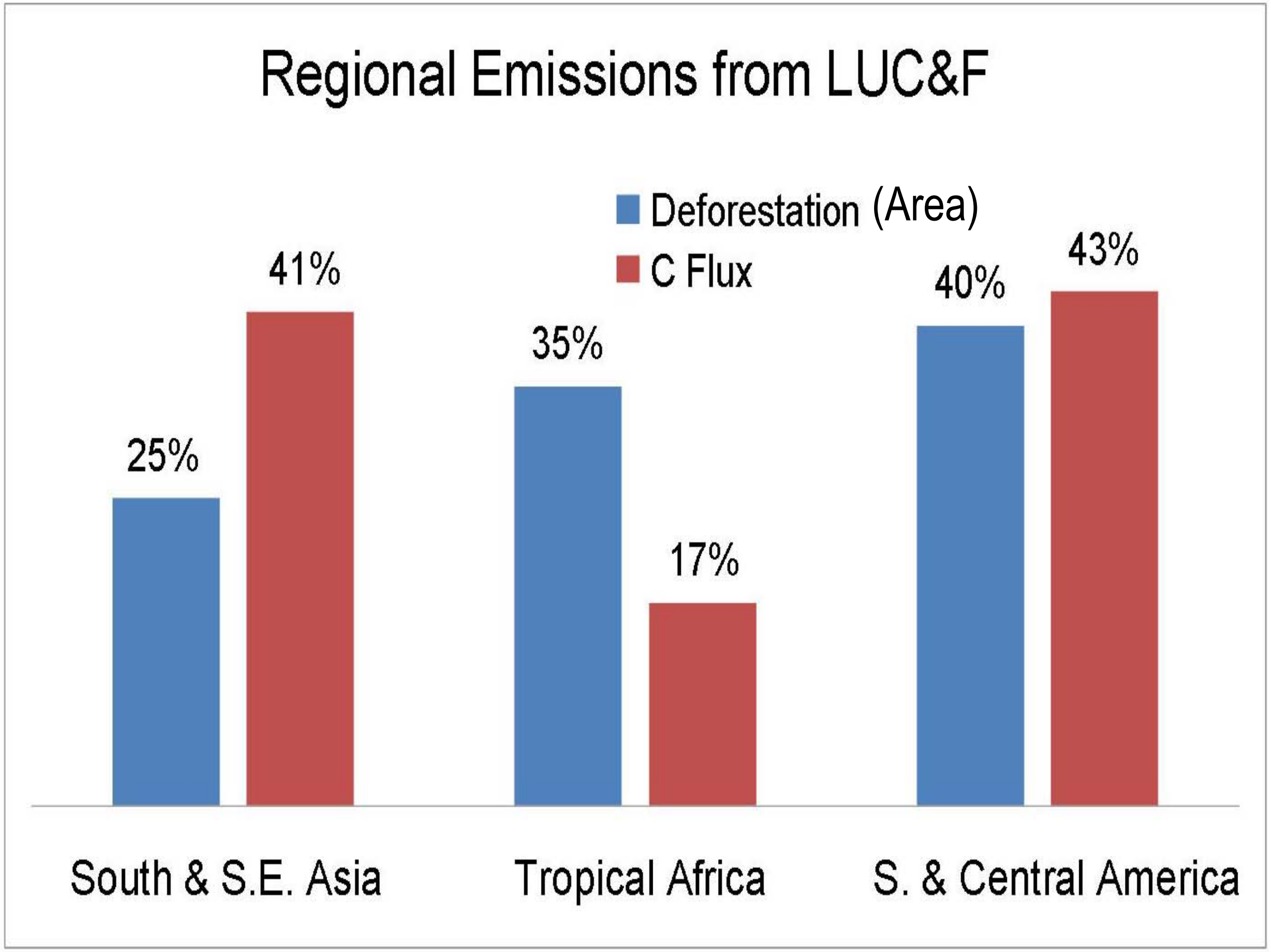
Le Quéré et al. 2009, Nature Geoscience; Data: CDIAC, FAO, Woods Hole Research Center 2009

Net CO_2 Emissions from LUC in Tropical Countries



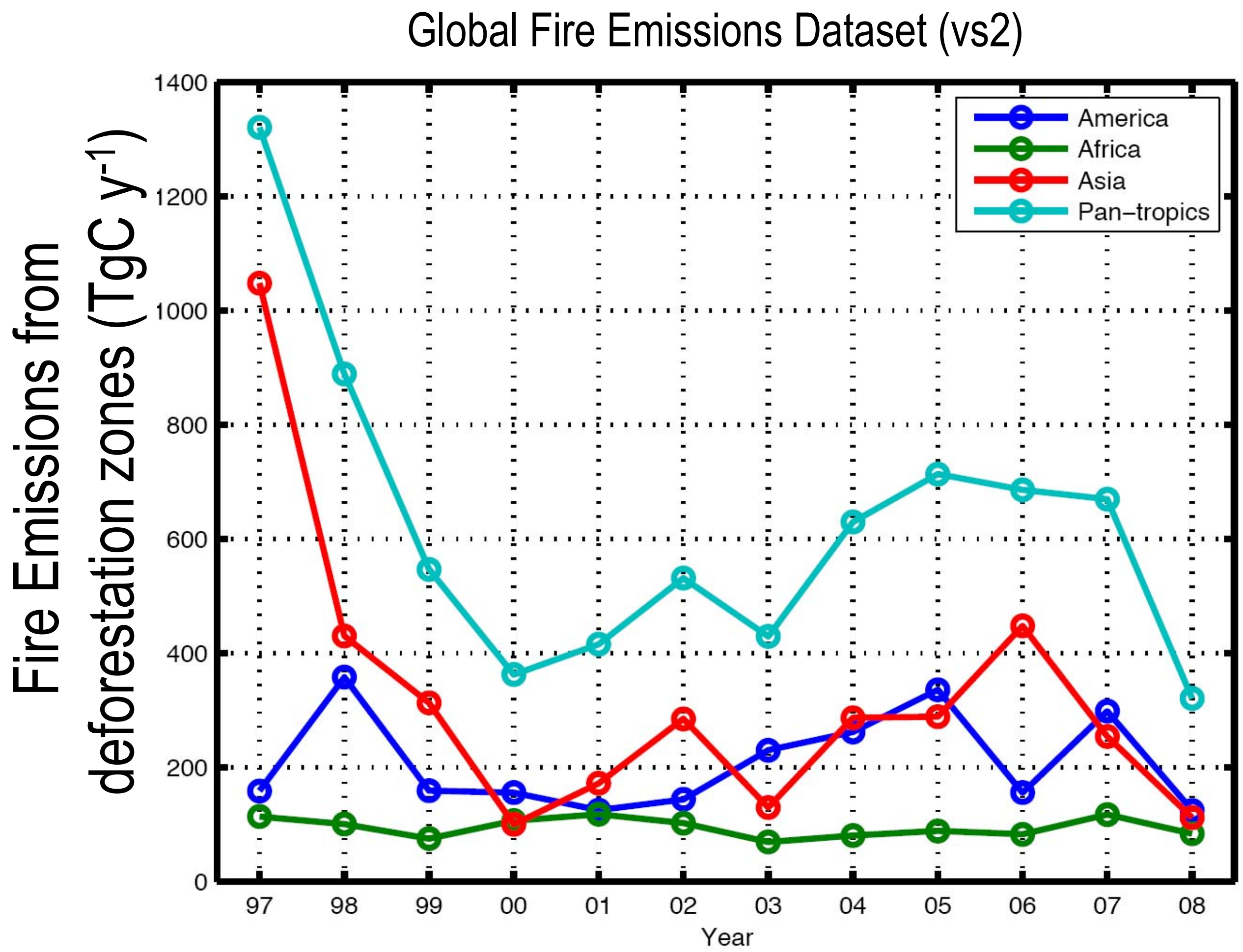
RA Houghton 2009, unpublished; Based on FAO Global Forest Resource Assessment

Emissions from Land Use Change (2000-2005)



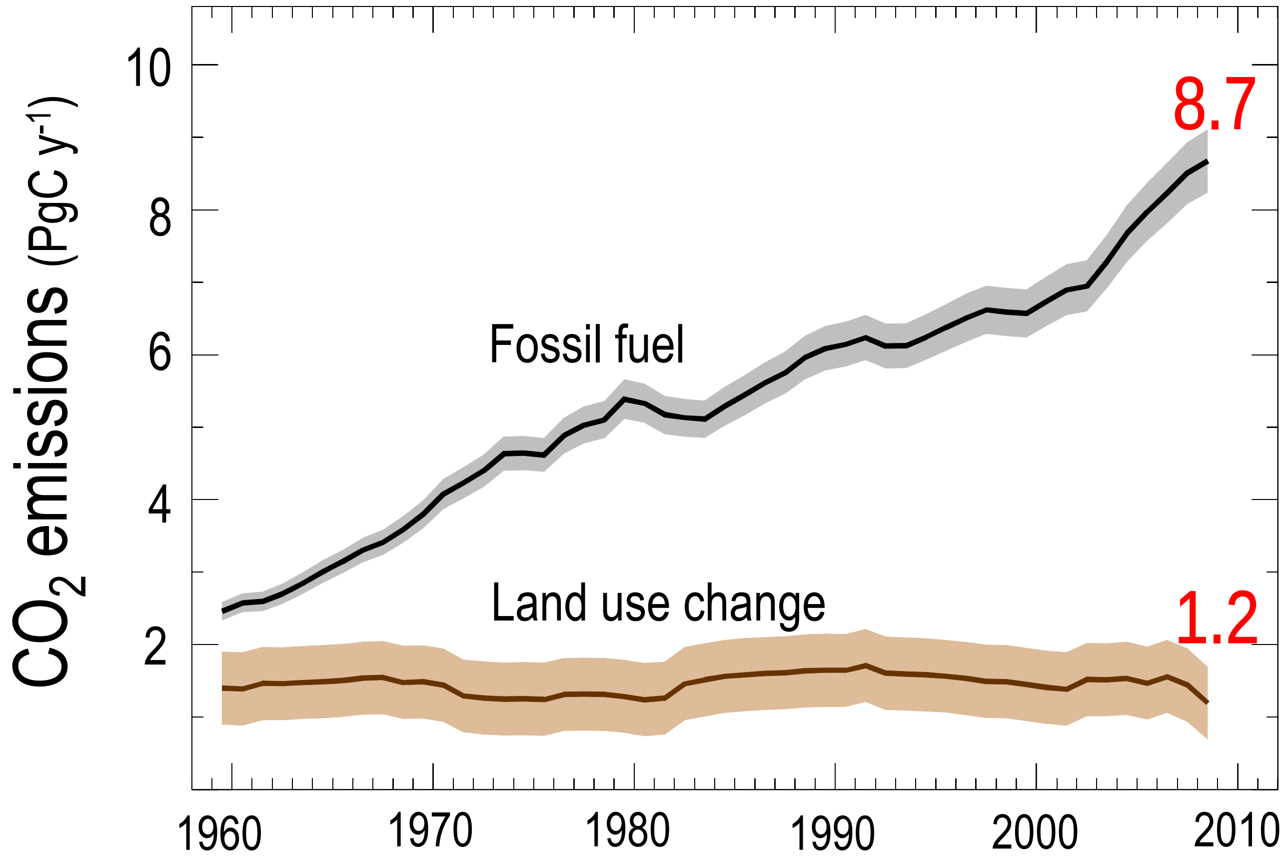
Canadell et al. 2009, Biogeosciences

Fire Emissions from Deforestation Zones



van der Werf et al. 2006, Atmospheric Chemistry and Physics, updated

Total Anthropogenic Emissions 2008



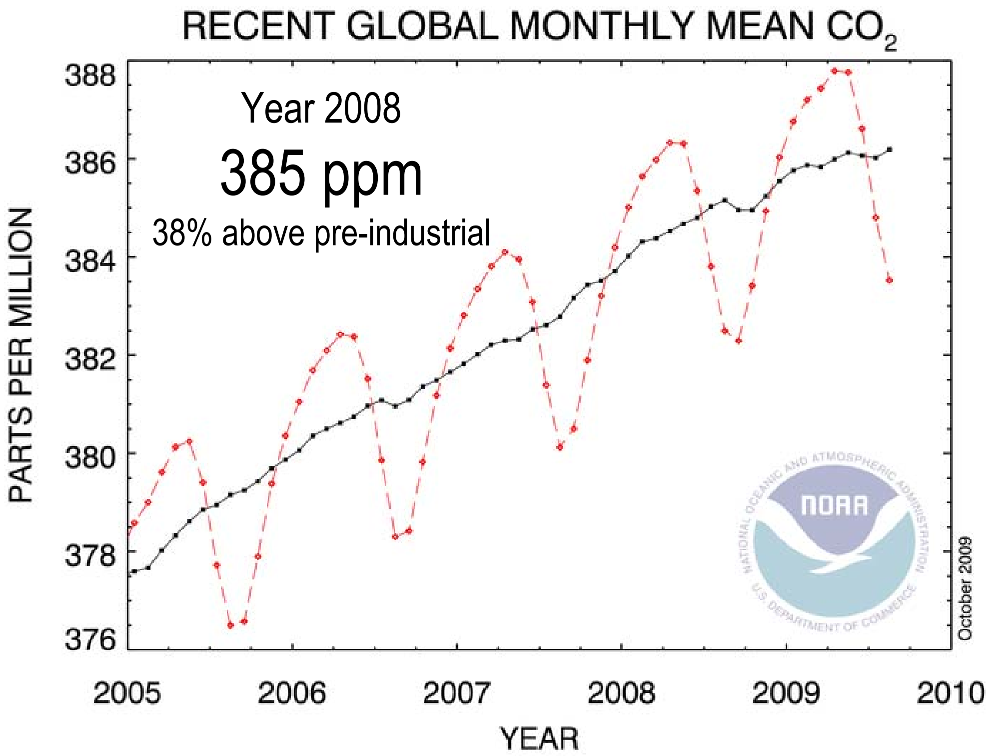
9.9 PgC

12% of total anthropogenic emissions

Global Carbon Project

Le Quéré et al. 2009, Nature Geoscience; Data: CDIAC, FAO, Woods Hole Research Center 2009

Atmospheric CO_2 Concentration



Annual Mean Growth Rate	
2008	1.79
2007	2.12
2006	1.77
2005	2.41
2004	1.62
2003	2.22
2002	2.40
2001	1.85
2000	1.24

1970 – 1979: 1.3 ppm y^{-1}

1980 – 1989: 1.6 ppm y^{1}

1990 – 1999: 1.5 ppm y^{-1}

2000 - 2008: 1.9 ppm y^{-1}

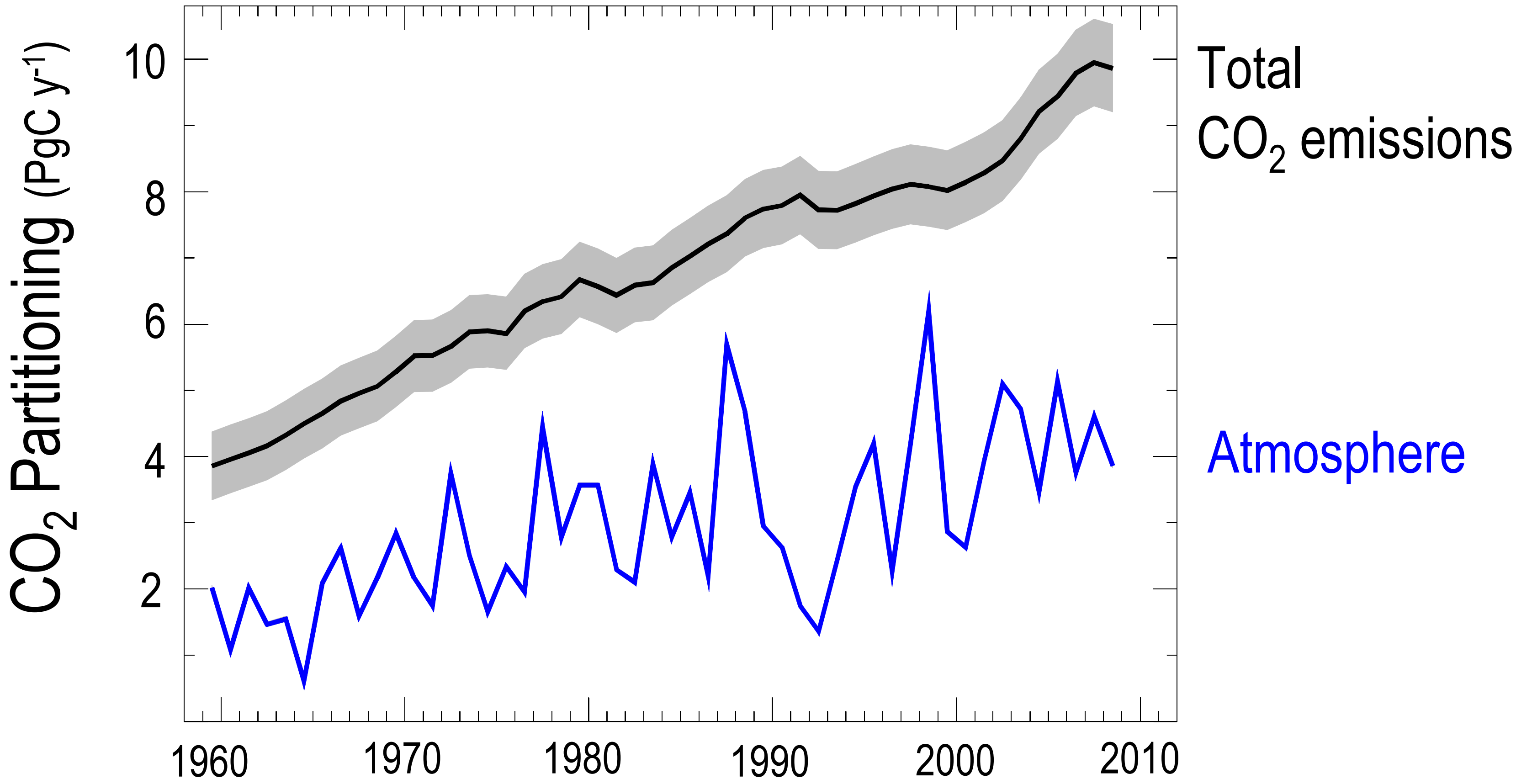
Data Source: Pieter Tans and Thomas Conway, NOAA/ESRL

Global Carbon Project

Earth System Science Partnership DIVERSITAS GLOBAL IGBP CHANGE IHDP WCRP World Climate Research Programme

Key Diagnostic of the Carbon Cycle

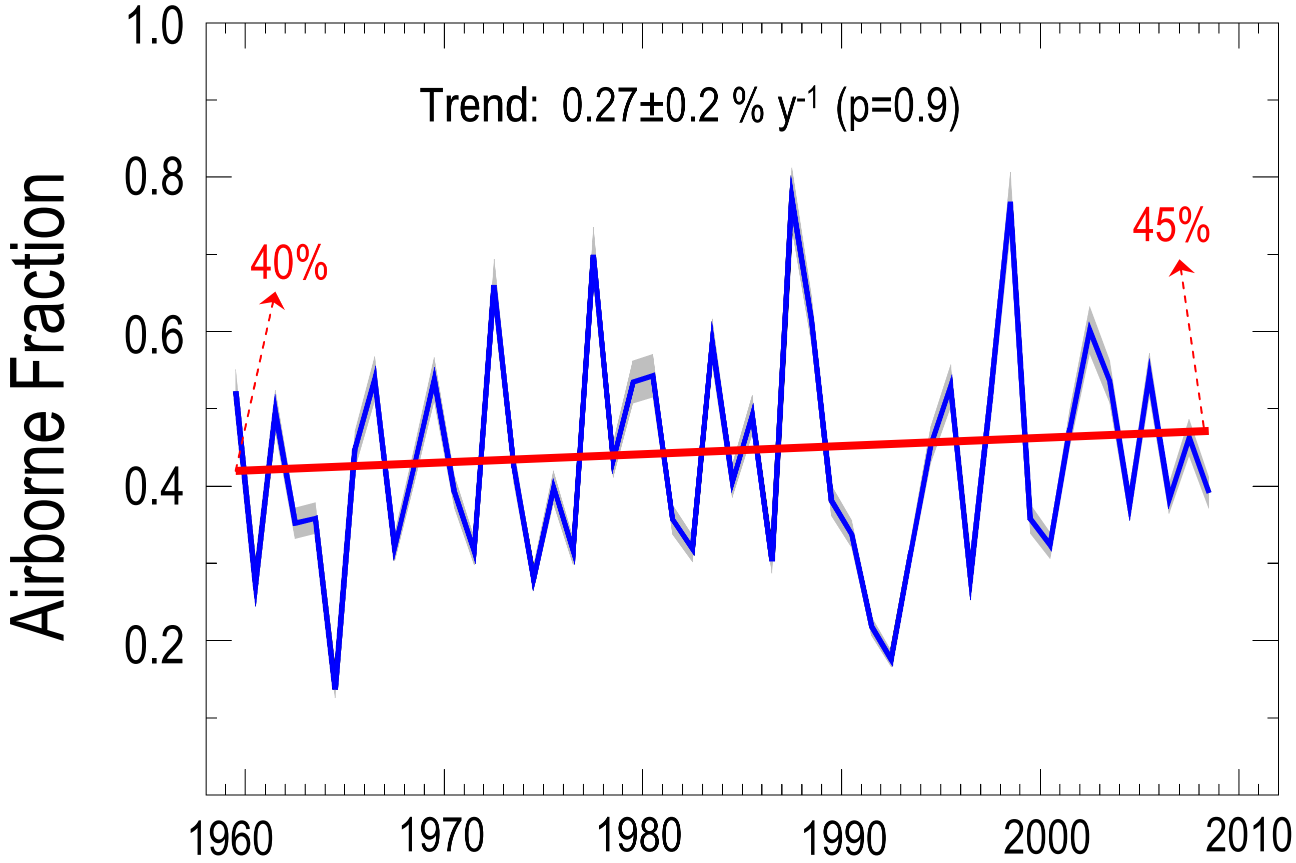
Evolution of the fraction of total emissions that remain in the atmosphere



Data: NOAA, CDIAC; Le Quéré et al. 2009, Nature Geoscience

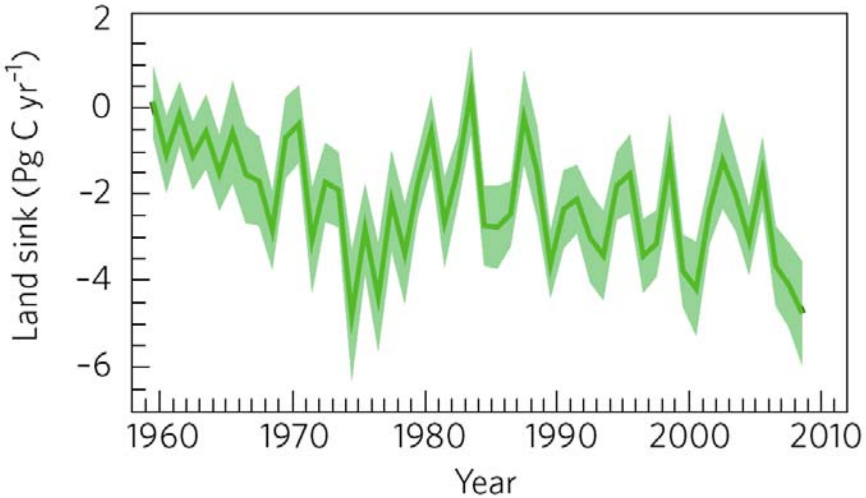
Airborne Fraction

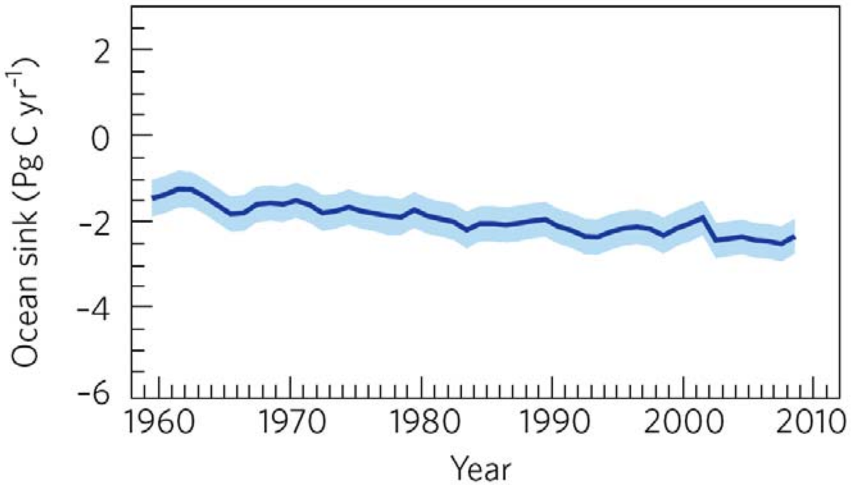
Fraction of total CO_2 emissions that remains in the atmosphere



Le Quéré et al. 2009, Nature Geoscience; Canadell et al. 2007, PNAS; Raupach et al. 2008, Biogeosciences

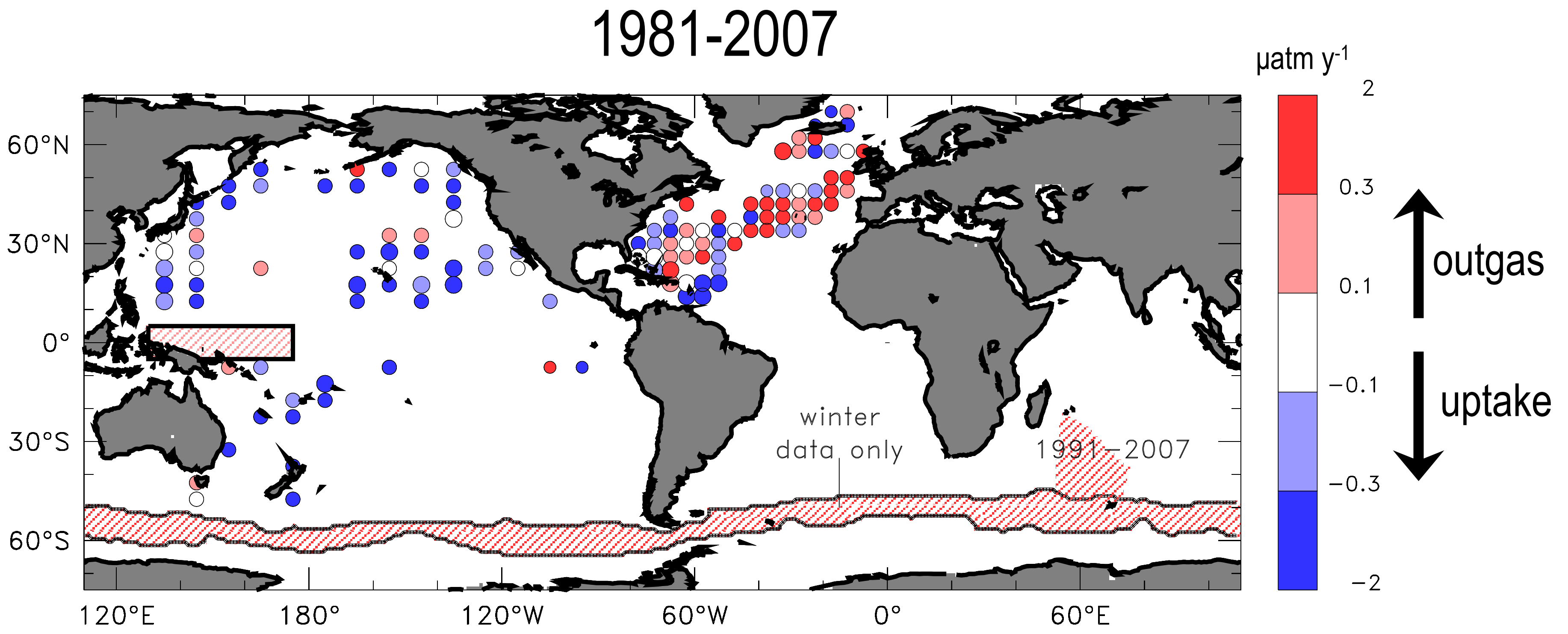
Modelled Natural CO_2 Sinks





Le Quéré et al. 2009, Nature Geoscience

Estimated Trends in Sea-Air pCO_2



Le Quéré et al. 2009, Nature Geoscience

Possible Reasons for a Positive Trend in Airborne Fraction

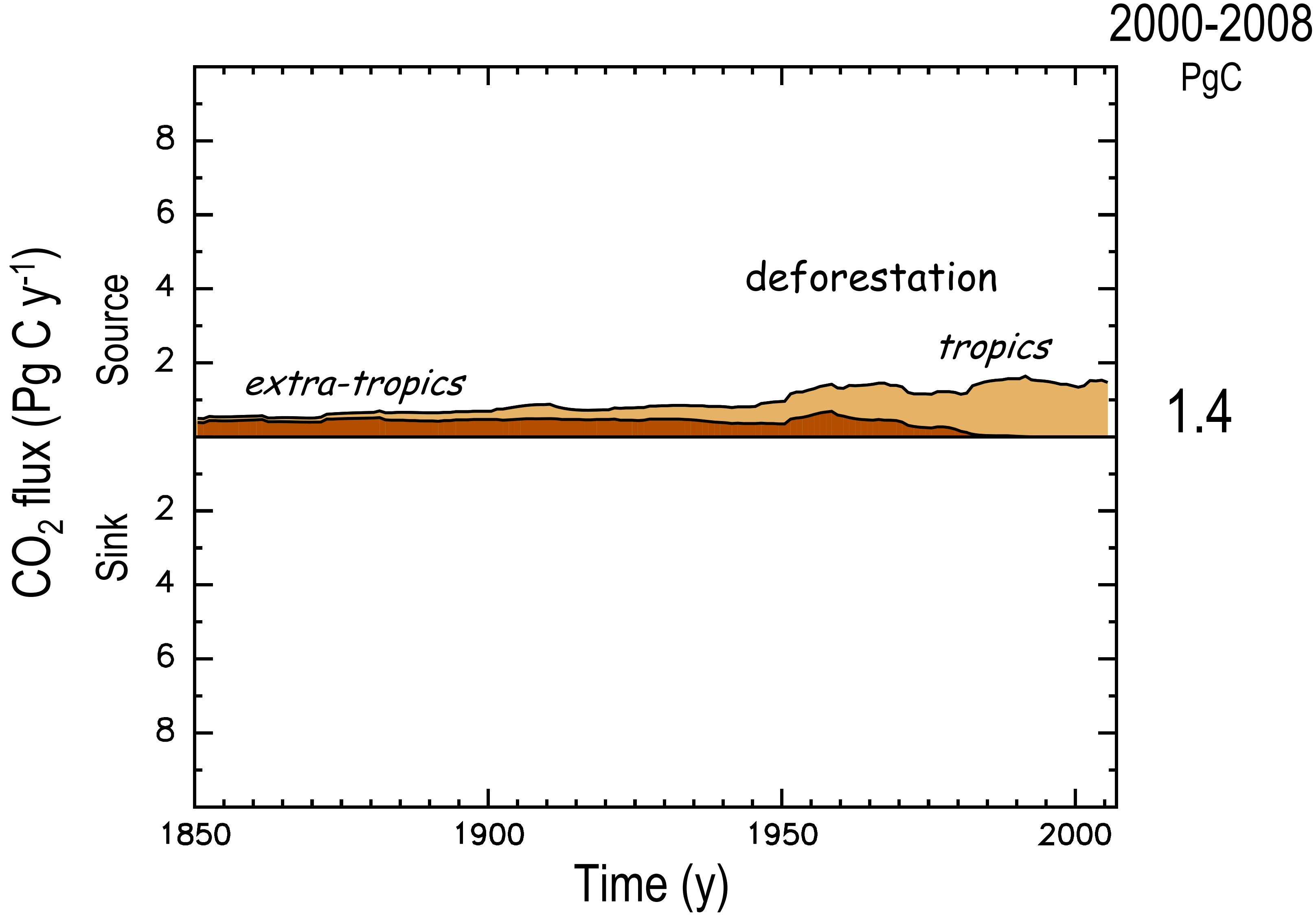
- Emissions are rising faster than the time scales regulating the rate of uptake by sinks.

- Sinks are becoming less efficient at high CO_2
  - Land: saturation of the CO_2 fertilization effect
  - Ocean: decrease in [carbonate] which buffers CO_2

- Land and/or ocean sinks are responding to climate change and variability.

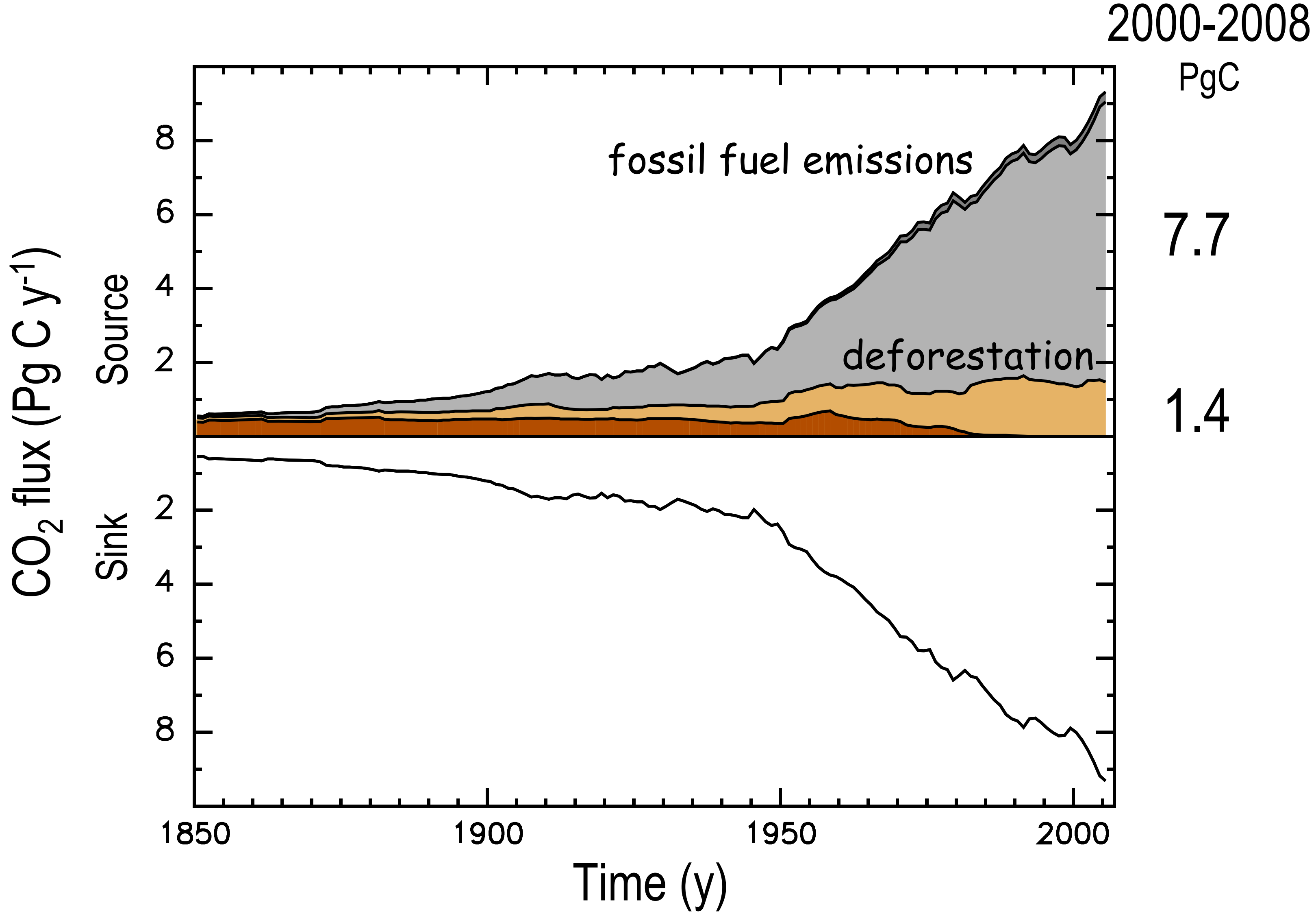
- We are missing sink processes in models that are contributing to the observed changes.

Human Perturbation of the Global Carbon Budget



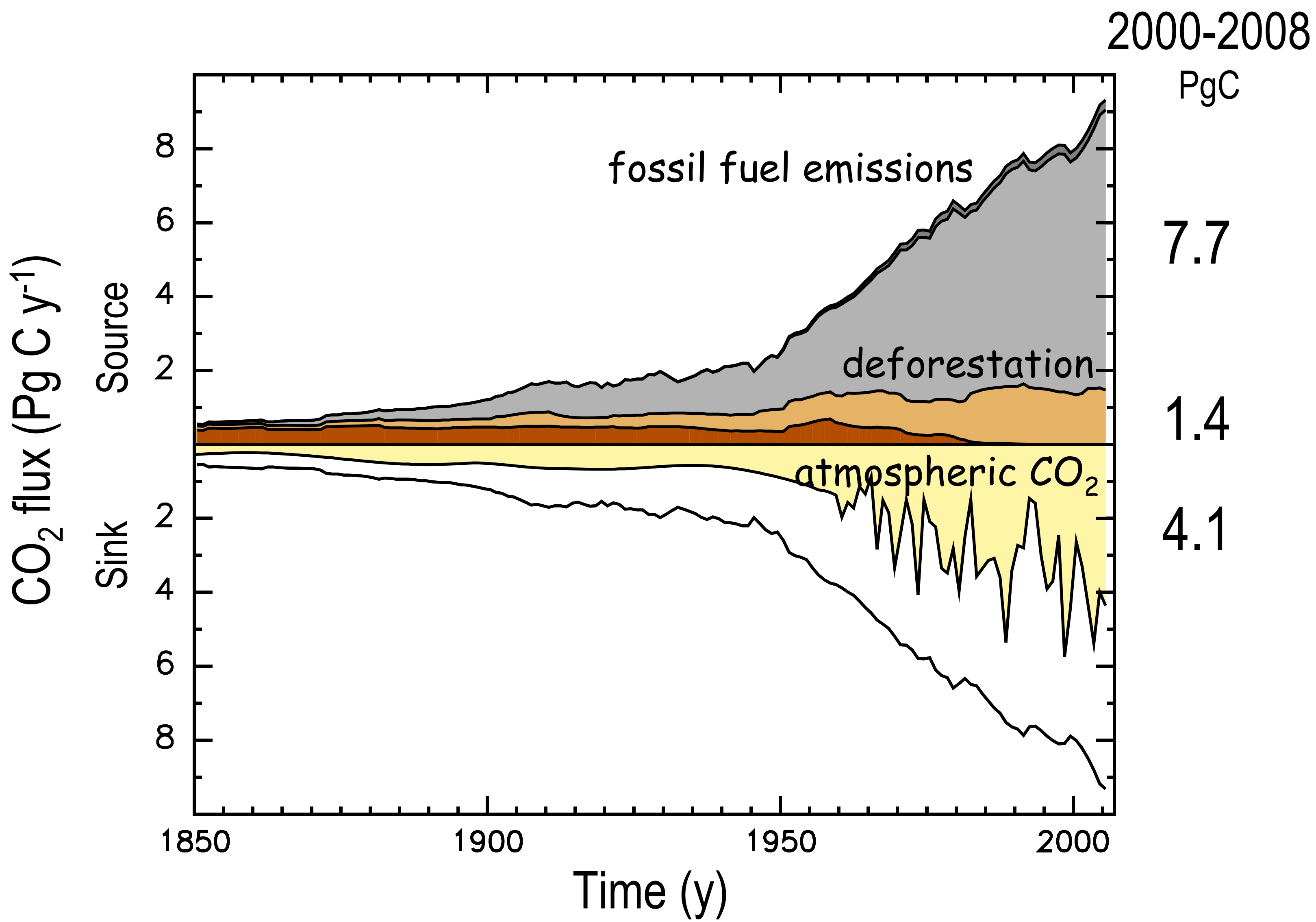
Global Carbon Project 2009; Le Quéré et al. 2009, Nature Geoscience

Human Perturbation of the Global Carbon Budget



Global Carbon Project 2009; Le Quéré et al. 2009, Nature Geoscience

Human Perturbation of the Global Carbon Budget



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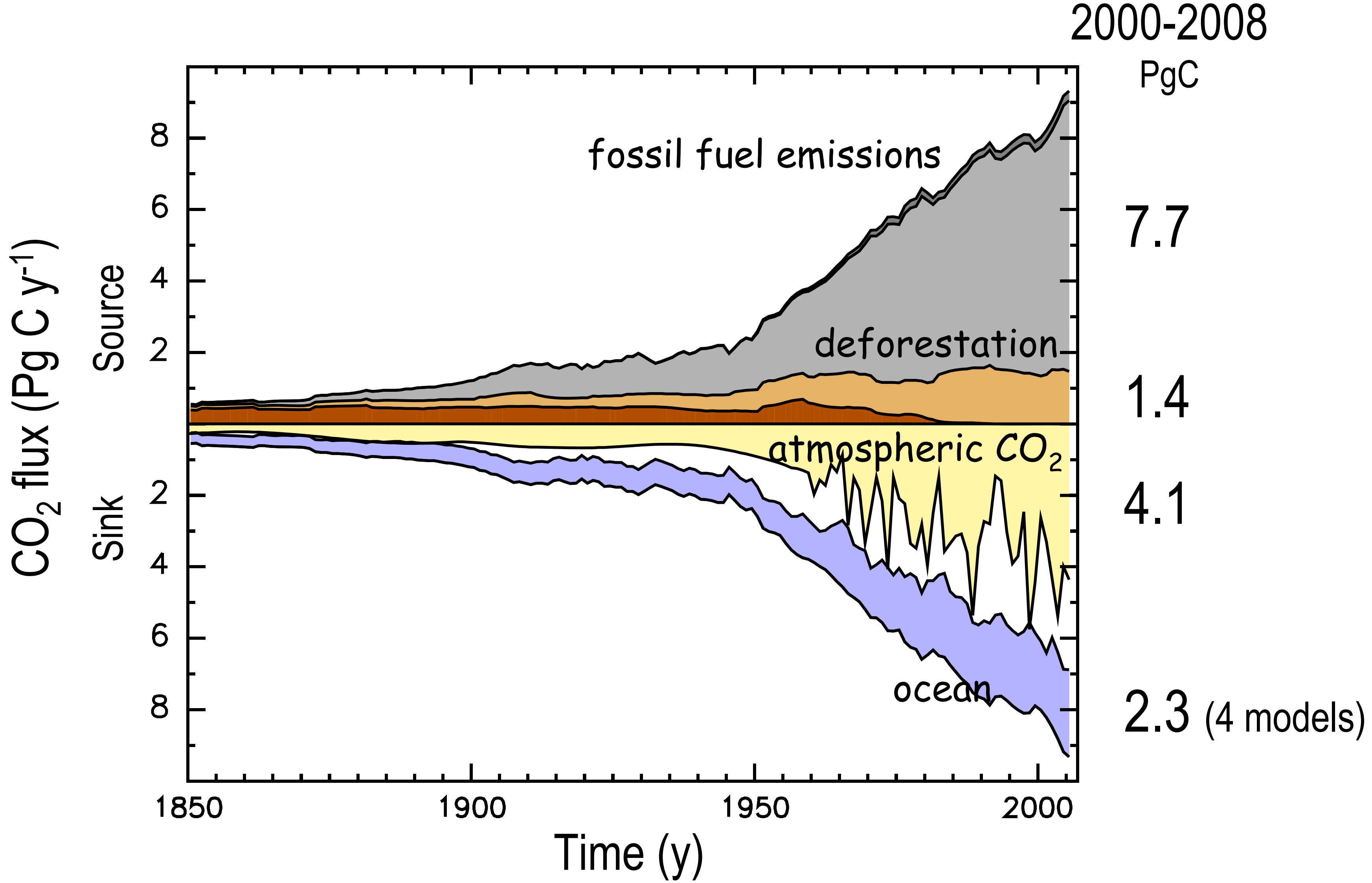
Human Perturbation of the Global Carbon Budget

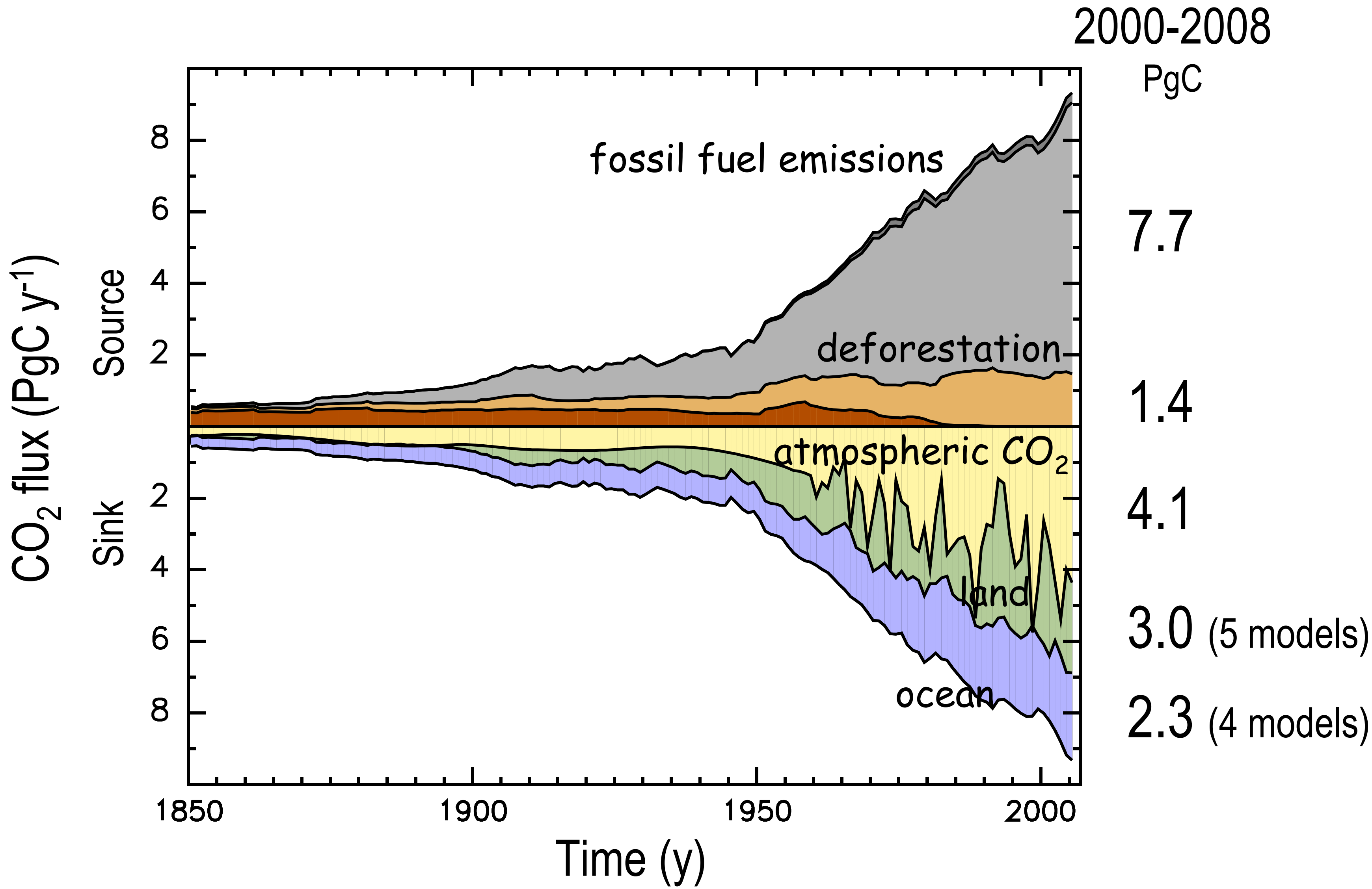


Global Carbon Project

Global Carbon Project 2009; Le Quéré et al. 2009, Nature Geoscience

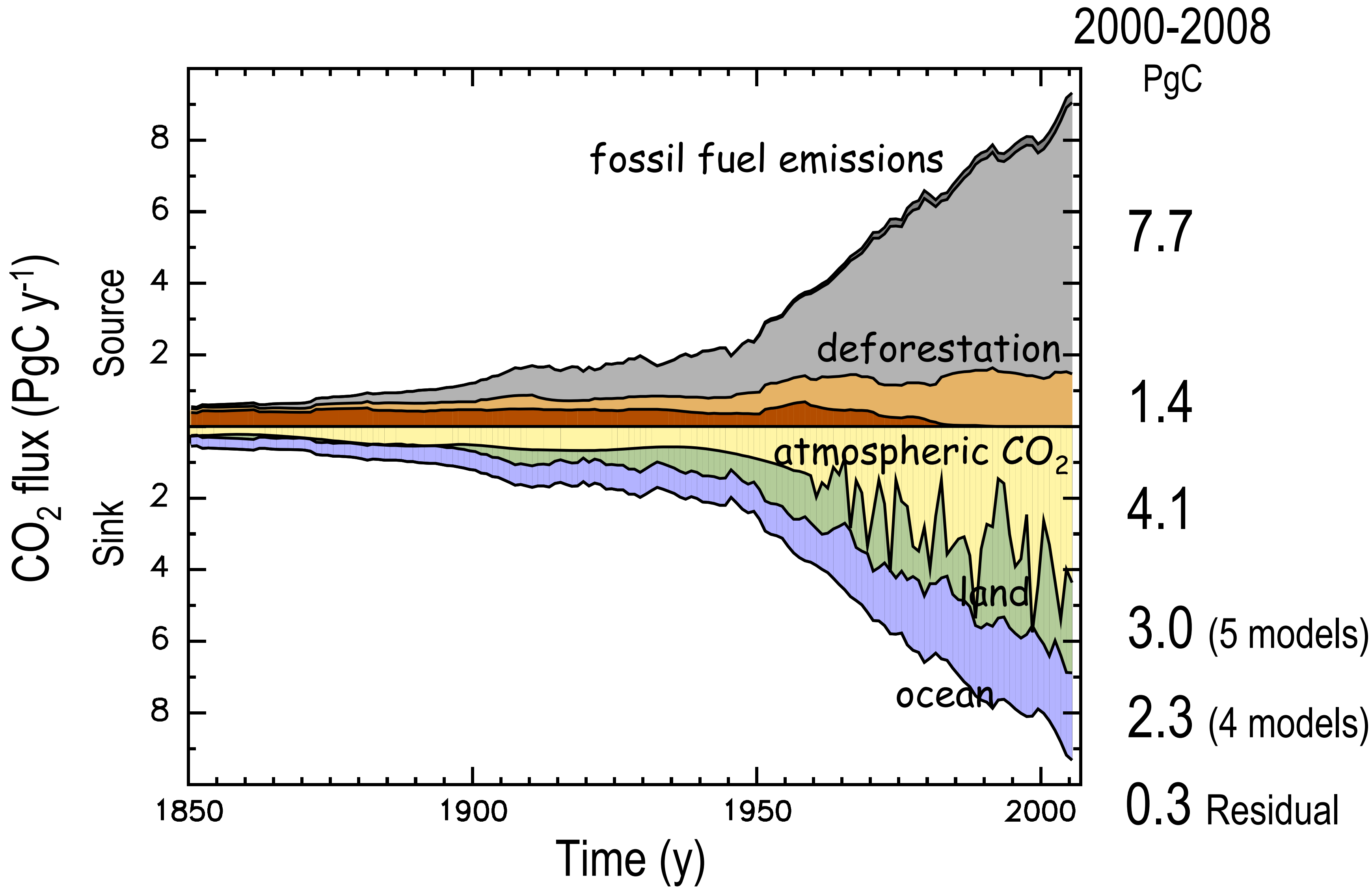
IHDP WCRP

Human Perturbation of the Global Carbon Budget



Global Carbon Project 2009; Le Quéré et al. 2009, Nature Geoscience

Human Perturbation of the Global Carbon Budget



Global Carbon Project 2009; Le Quéré et al. 2009, Nature Geoscience

Fate of Anthropogenic CO_2 Emissions (2000-2008)

1.4 PgC y^{-1}

+

7.7 PgC y^{-1}

4.1 PgC y^{-1}

45%

3.0 PgC y^{-1}

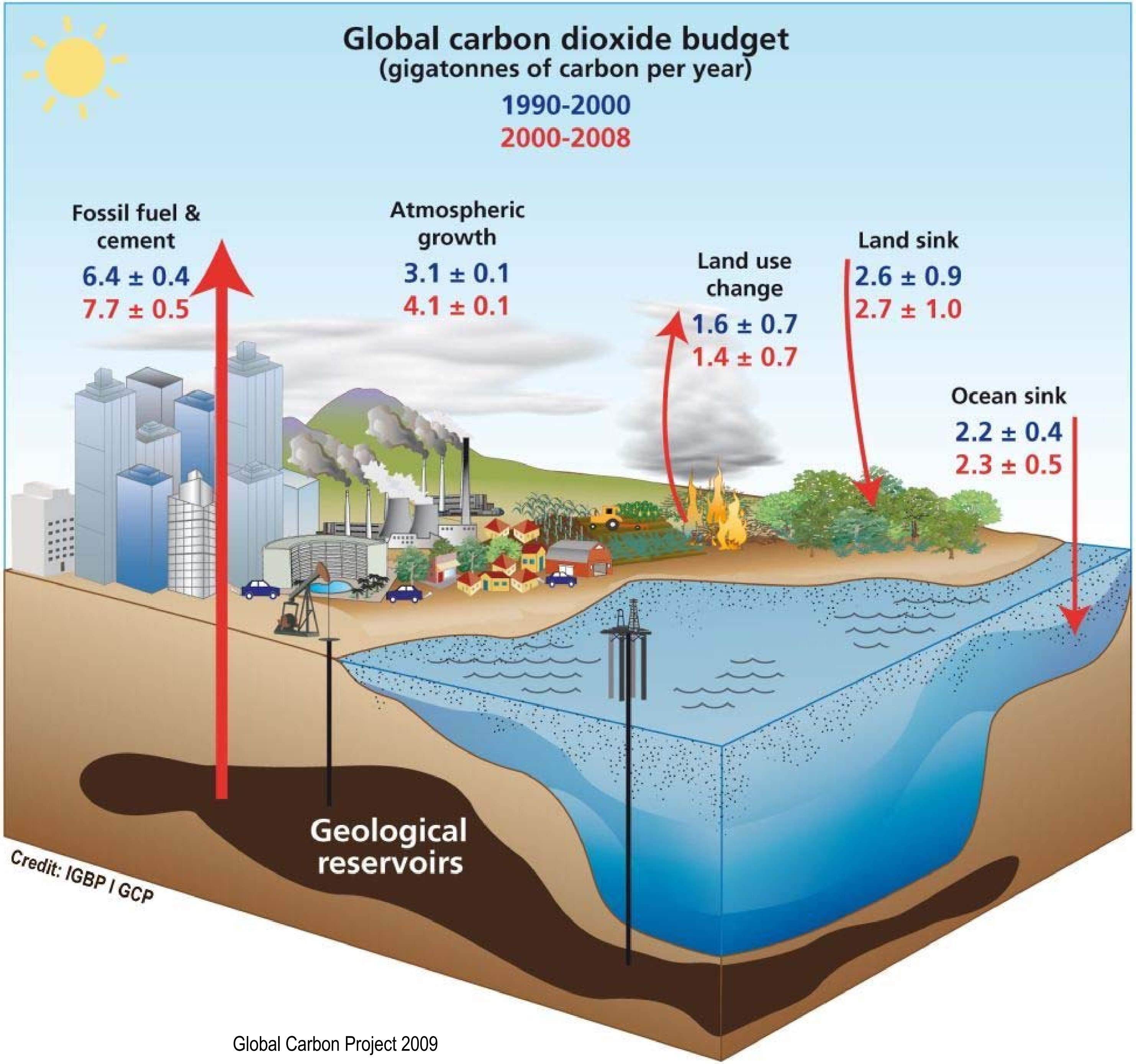
29%

26%

2.3 PgC y^{-1}

Global Carbon Project

Le Quéré et al. 2009, Nature Geoscience; Canadell et al. 2007, PNAS, updated



Global Carbon Project 2009

Conclusions

- The efficiency of the natural sinks has being declining over the last 60 years, a trend not fully captured by climate models.
- The human perturbation of the carbon cycle continues to grow strongly and track the most carbon intensive scenarios of the IPCC. The economic crisis will likely have a transitional impact on the growth of CO_2 emissions and a undetectable effect on the growth of atmospheric CO_2 (because the much larger inter-annual variability of the natural sinks).

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- van der Werf GR, Randerson JT, Giglio L, Collatz GL, Kasibhatla PS, Arellano AF, Jr (2006) Interannual variability in global biomass burning emissions from 1997 to 2004. Atmos. Chem. Phys. 6: 3423–3441.

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