

# 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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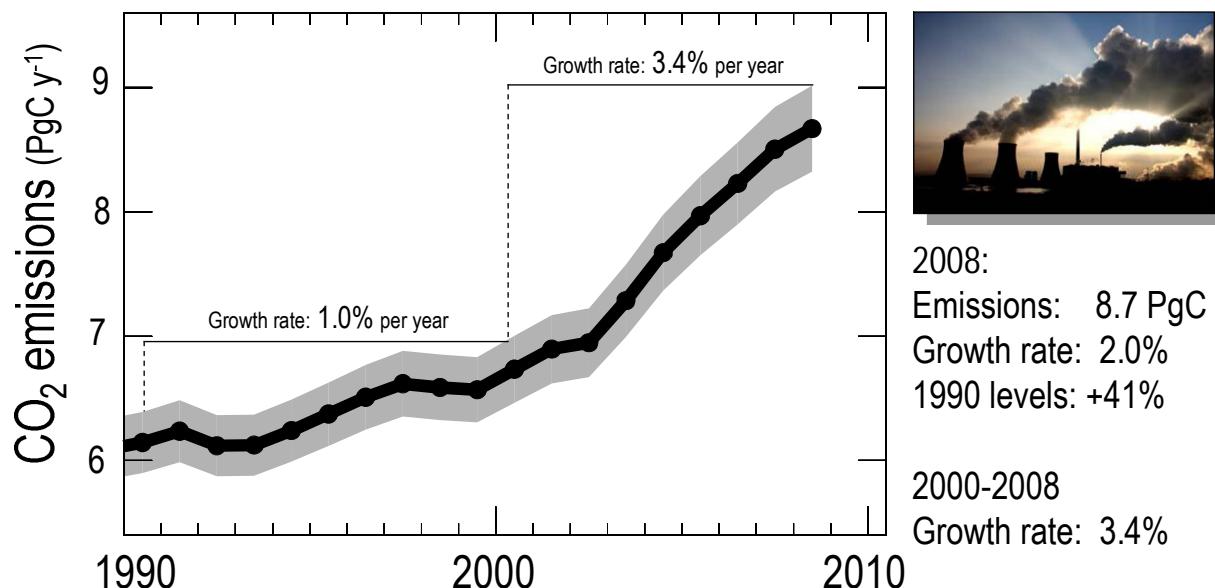
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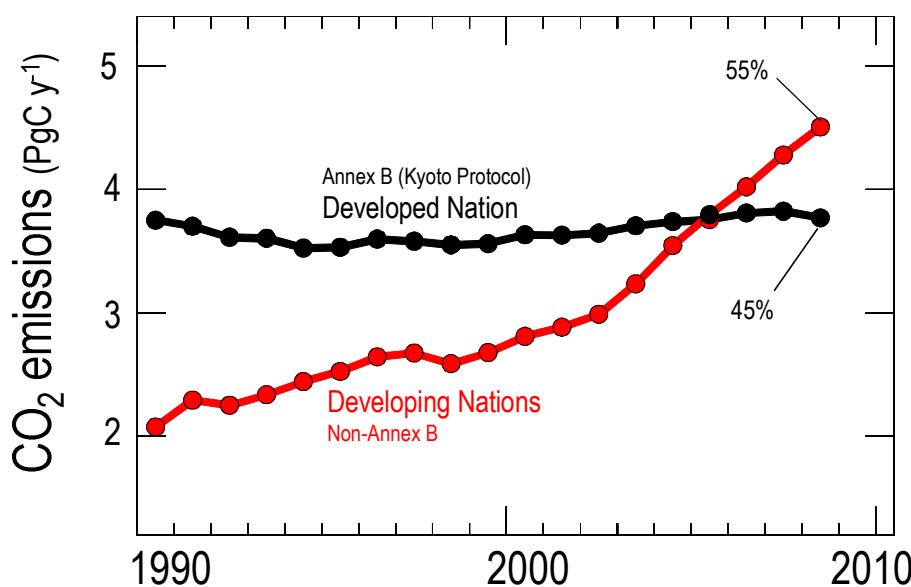


## Fossil Fuel Emissions and Cement Production

[1 Pg = 1 Petagram = 1 Billion metric tonnes = 1 Gigatonne =  $1 \times 10^{15}$  g]



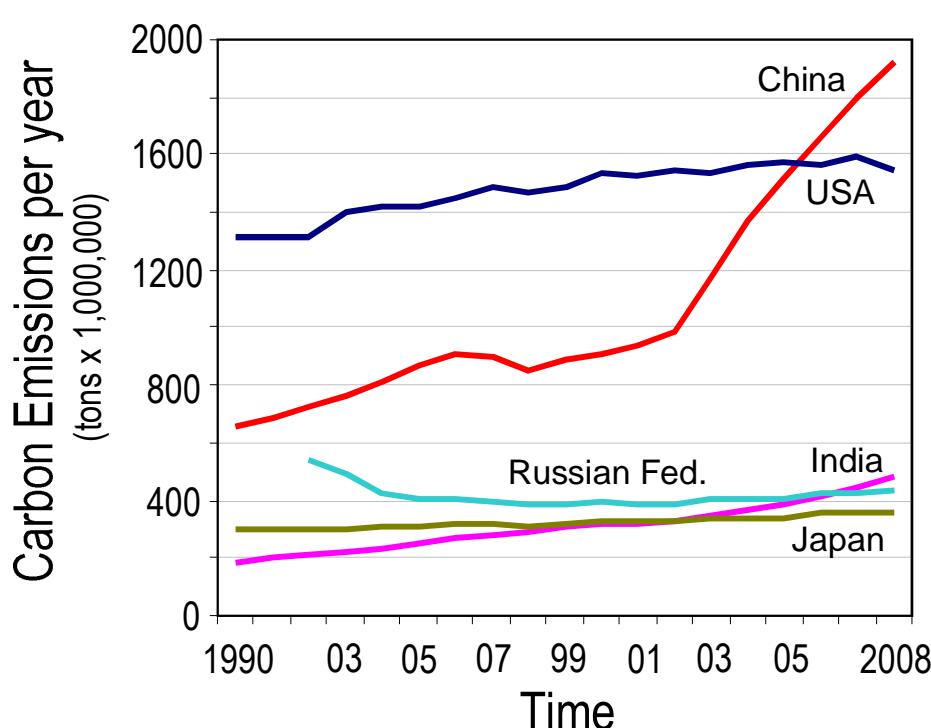
# CO<sub>2</sub> Fossil Fuel Emissions



Le Quéré et al. 2009, Nature-geoscience; CDIAC 2009



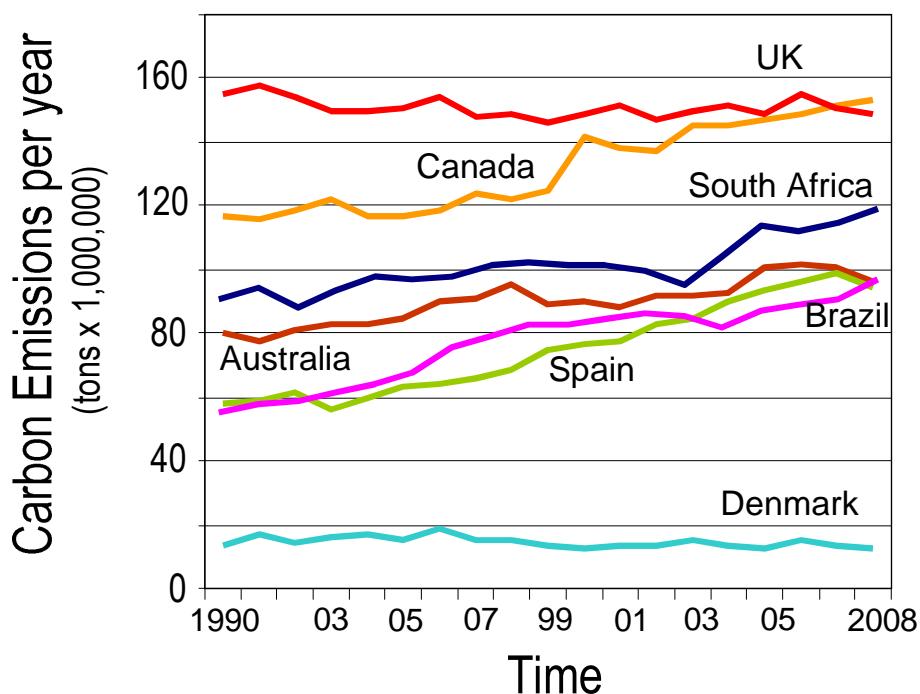
## Fossil Fuel Emissions: Top Emitters (>4% of Total)



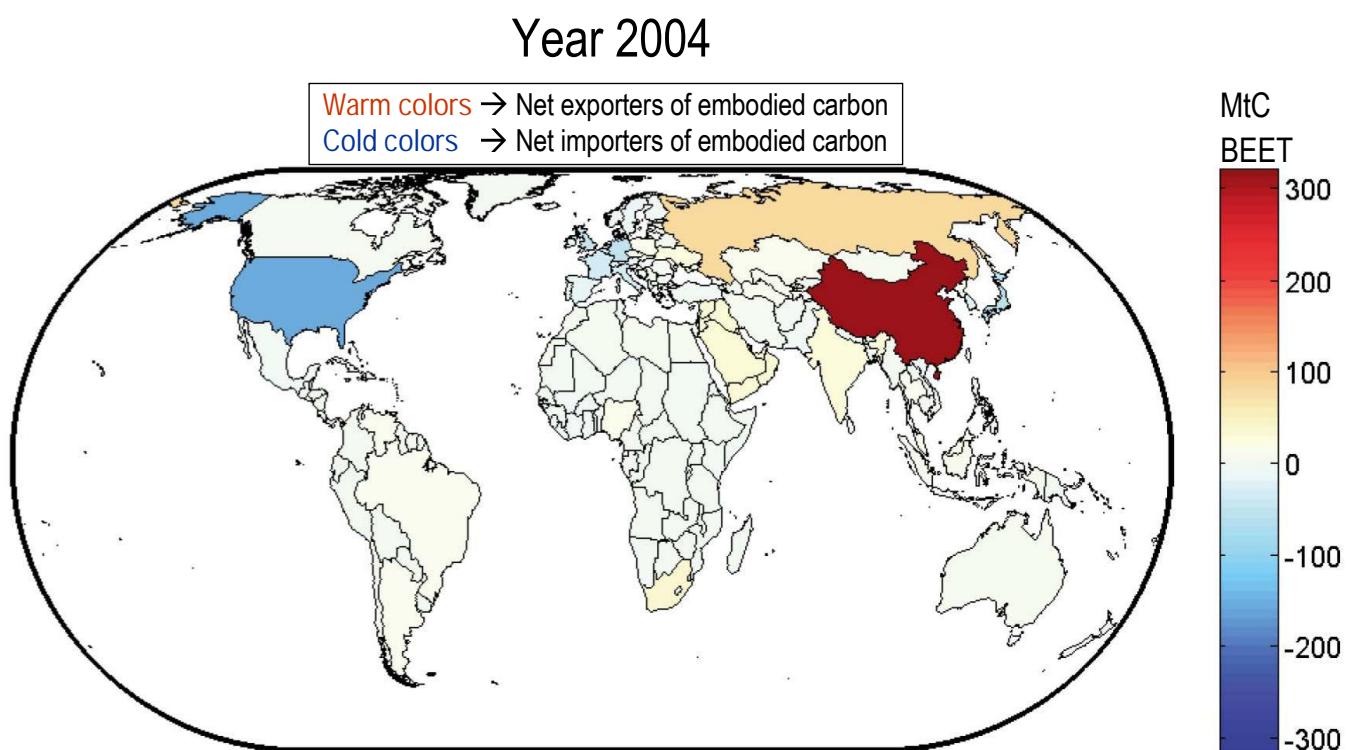
Global Carbon Project 2009; Data: Gregg Marland, CDIAC 2009



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

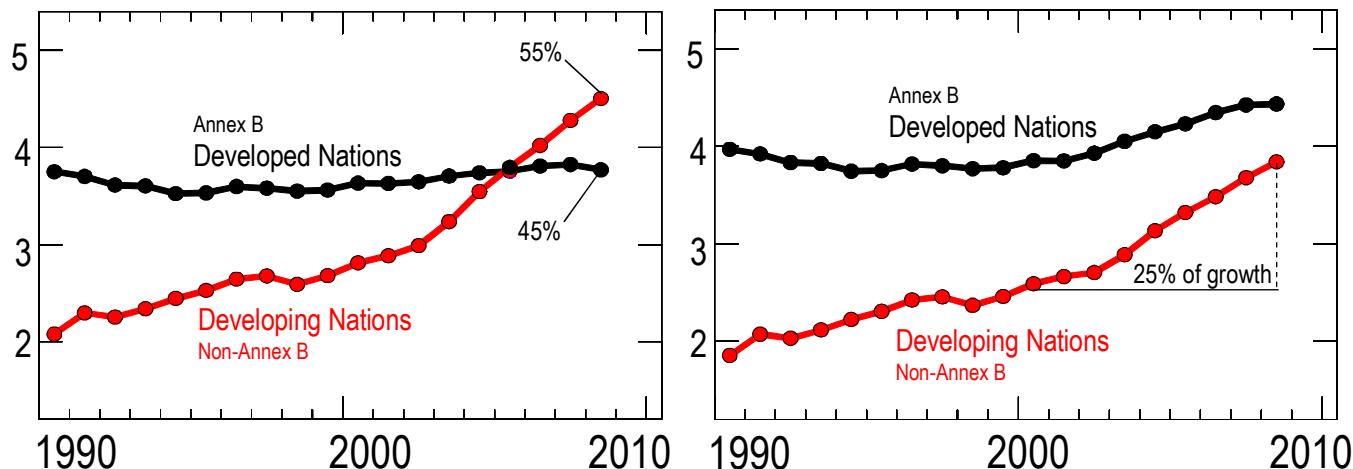


## Balance of Emissions Embodied in Trade (BEET)



# Transport of Embodied Emissions

$\text{CO}_2$  emissions ( $\text{PgC y}^{-1}$ )



Global Carbon Project 2009; Le Quéré et al. 2009, Nature-geoscience; Data: Peters & Hettwich 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

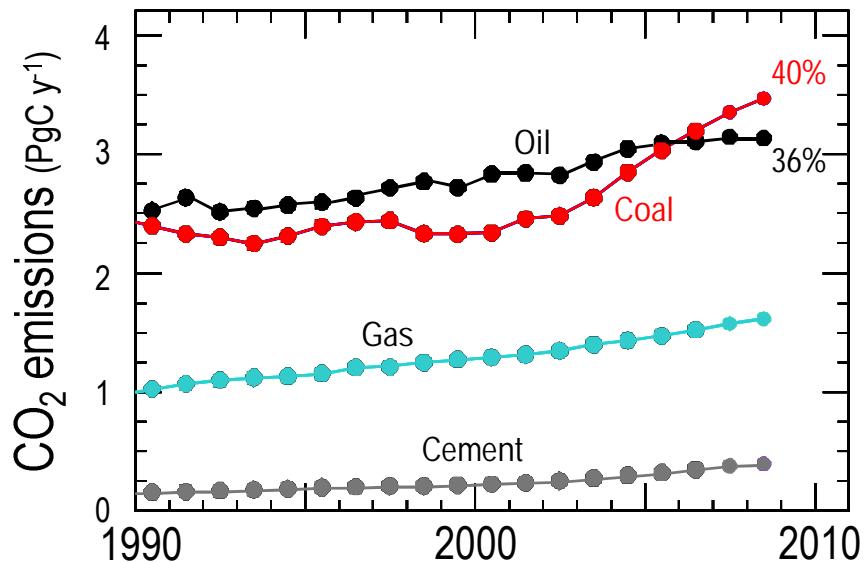
10 countries  
2/3 Global Emissions

Top 5 + EU  
80% Global Emissions

Gregg Marland, CDIAC 2009



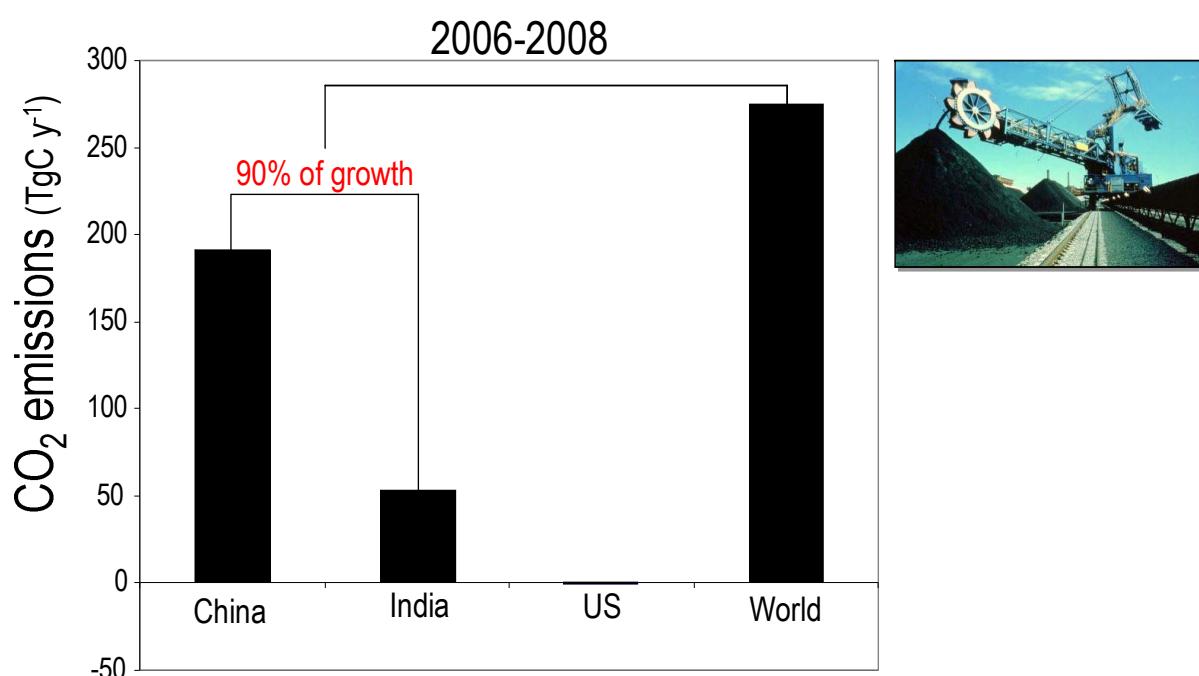
# Components of FF Emissions



Le Quéré et al. 2009, Nature-geoscience



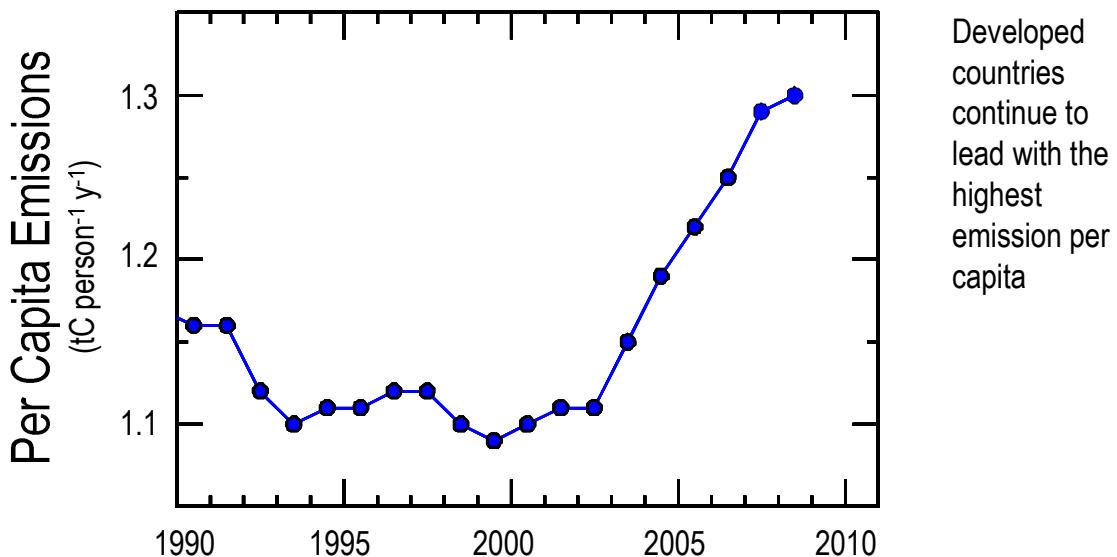
## Change in CO<sub>2</sub> Emissions from Coal Emissions



CDIAC 2009; Global Carbon Project 2009



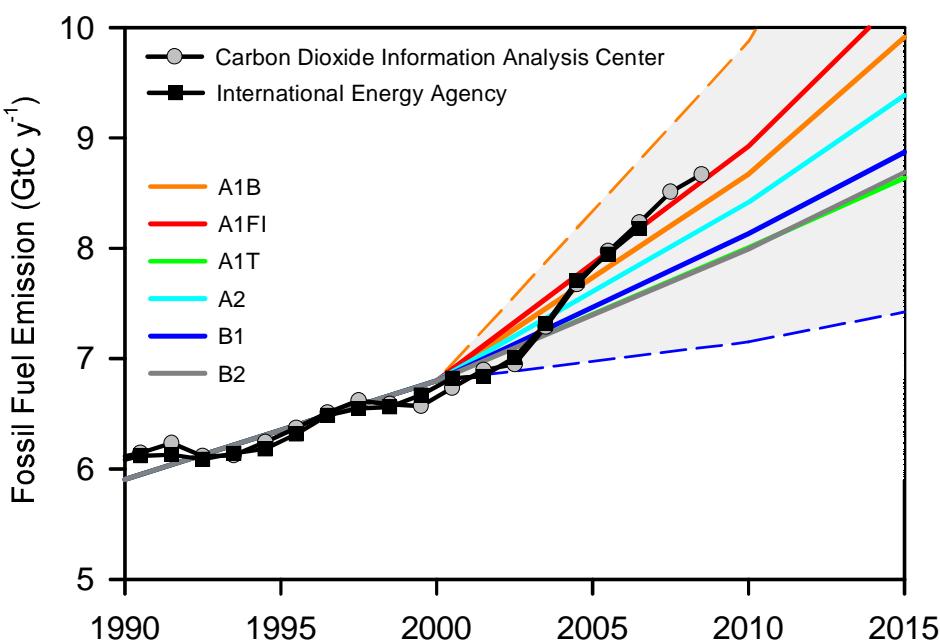
# Per Capita CO<sub>2</sub> Emissions



Le Quéré et al. 2009, Nature-geoscience; CDIAC 2009



## Fossil Fuel Emissions: Actual vs. IPCC Scenarios

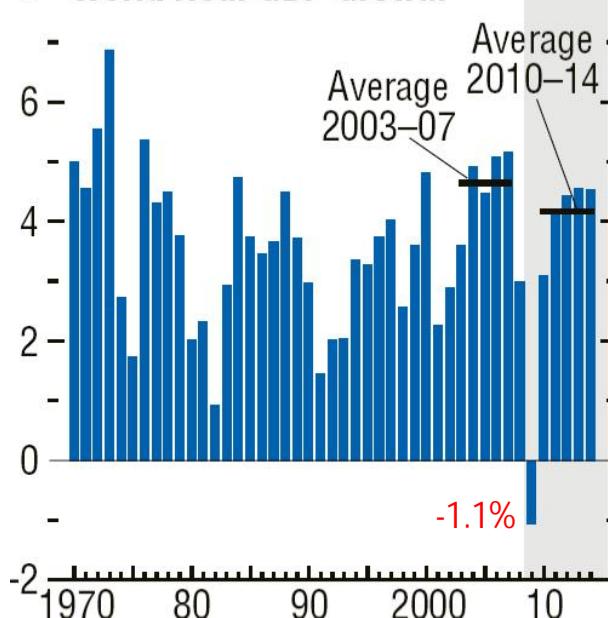


Raupach et al. 2007, PNAS, updated; Le Quéré et al. 2009, Nature-geoscience; International Monetary Fund 2009



# Economic Crisis Impact on World GDP Growth

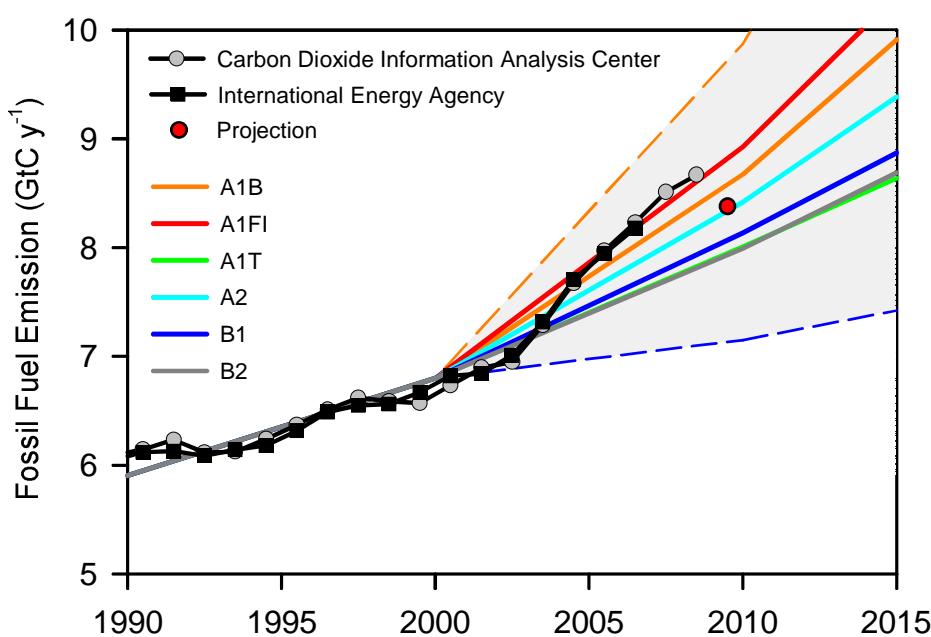
8 - World Real GDP Growth



International Monetary Fund, October 2009



## Fossil Fuel Emissions: Actual vs. IPCC Scenarios



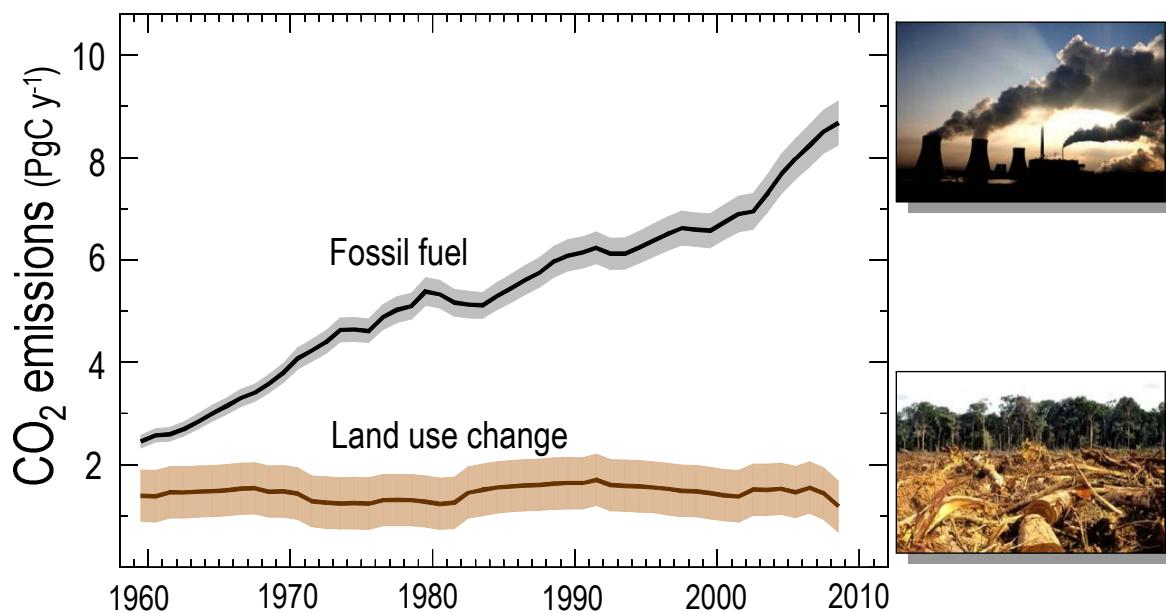
Projection 2009  
Emissions: -2.8%  
GDP: -1.1%  
C intensity: -1.7%



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



# CO<sub>2</sub> Emissions from Land Use Change



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

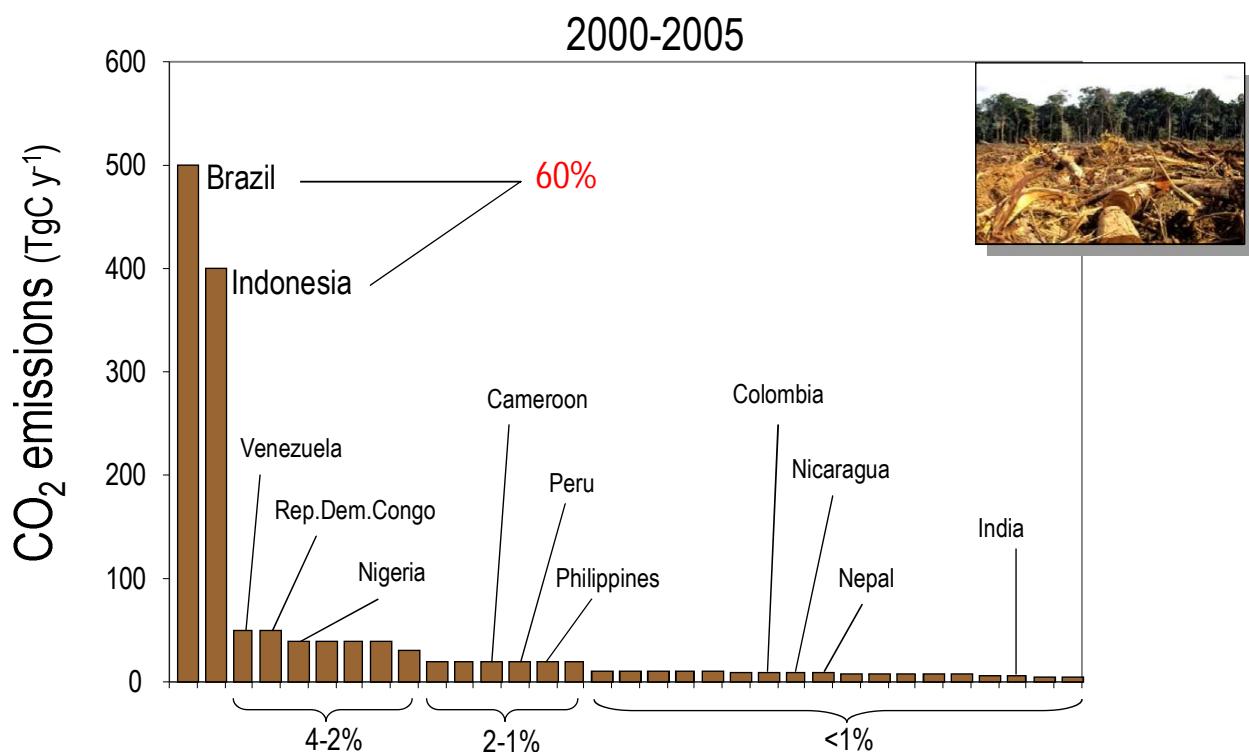


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## Net CO<sub>2</sub> Emissions from LUC in Tropical Countries



RA Houghton 2009, unpublished; Based on FAO land use change statistics

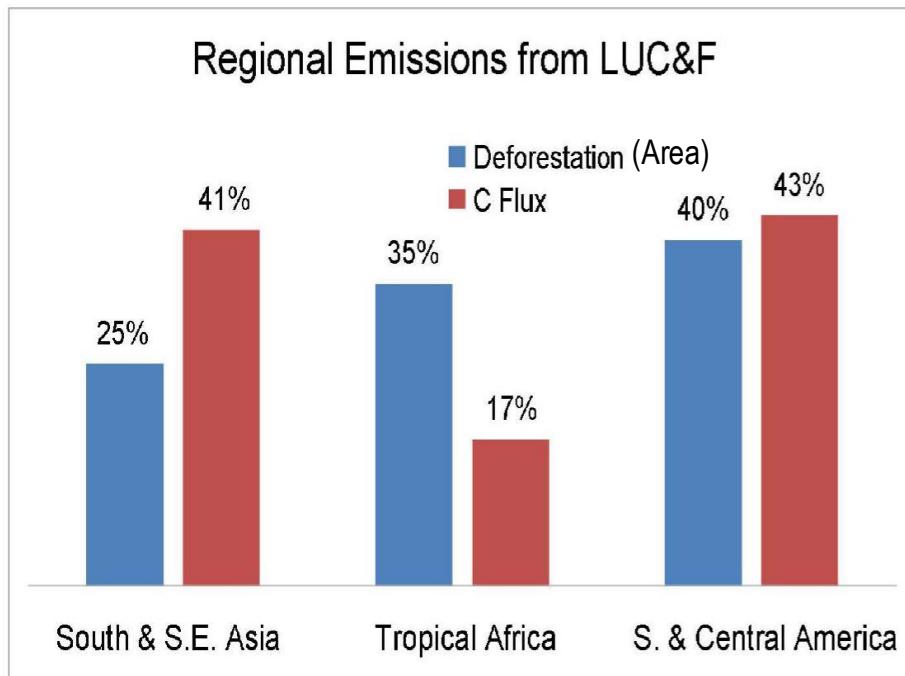


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# Emissions from Land Use Change (2000-2005)



Canadell et al. 2009, Biogeosciences

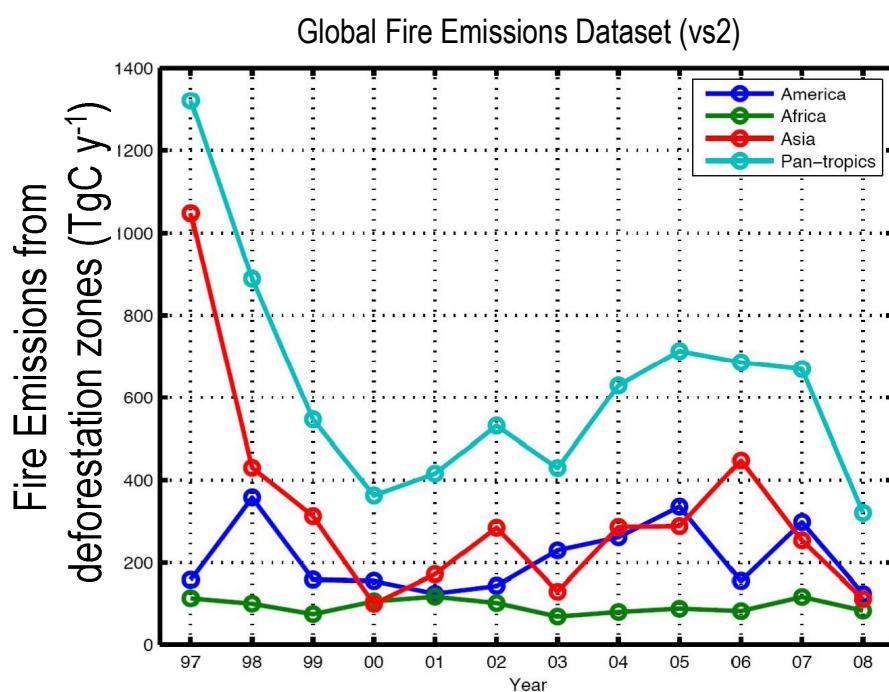


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## Fire Emissions from Deforestation Zones



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

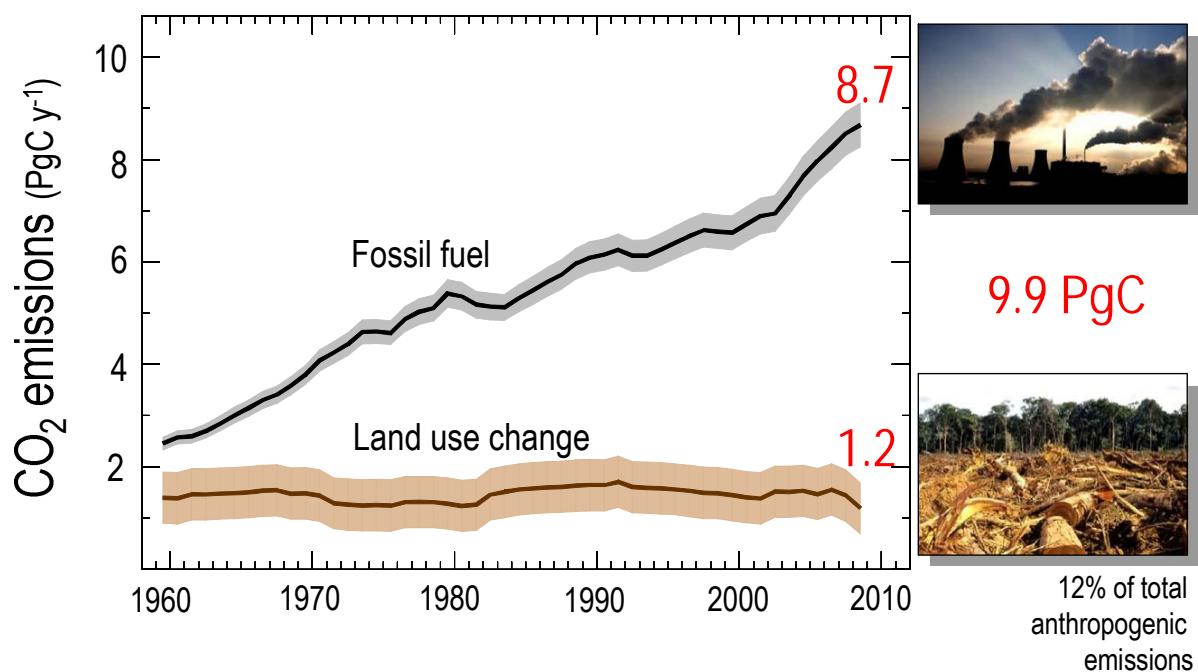


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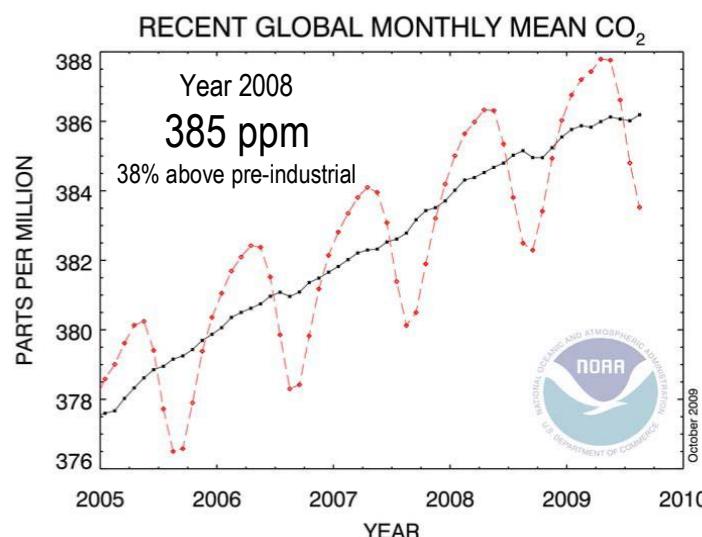
# Total Anthropogenic Emissions 2008



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



## Atmospheric $\text{CO}_2$ Concentration



Period	Rate ( $\text{ppm y}^{-1}$ )
1970 – 1979	1.3
1980 – 1989	1.6
1990 – 1999	1.5
2000 - 2008	1.9

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

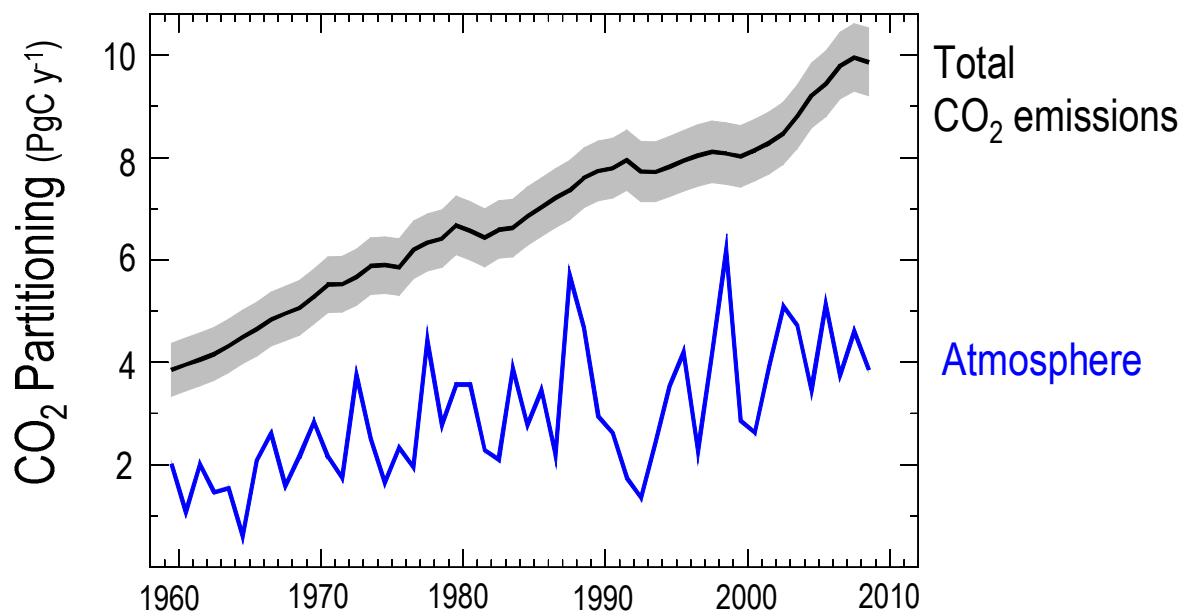


Data Source: Pieter Tans and Thomas Conway, NOAA/ESRL



# Key Diagnostic of the Carbon Cycle

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

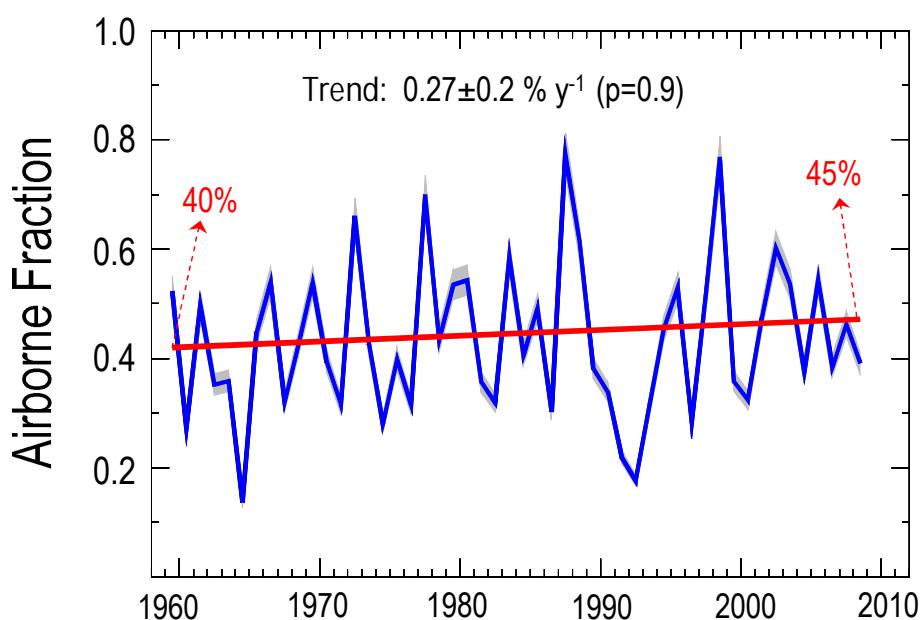


Data: NOAA, CDIAC; Le Quéré et al. 2009, Nature-geoscience



## Airborne Fraction

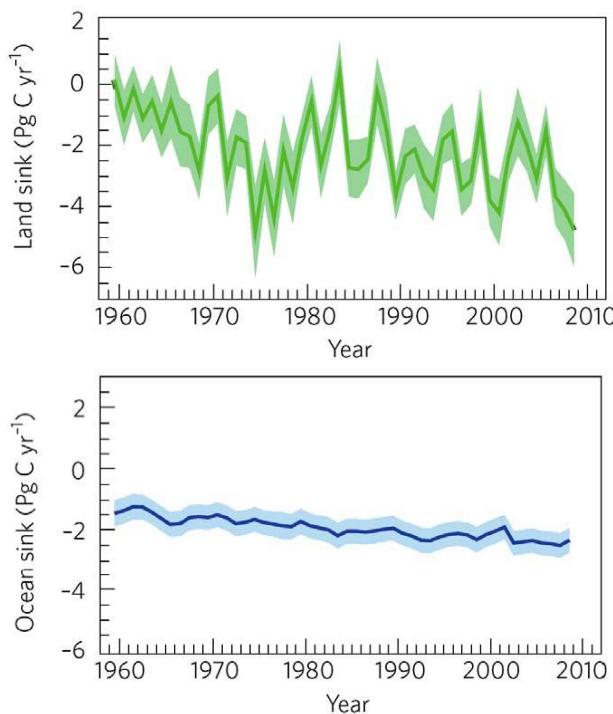
Fraction of total CO<sub>2</sub> emissions that remains in the atmosphere



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



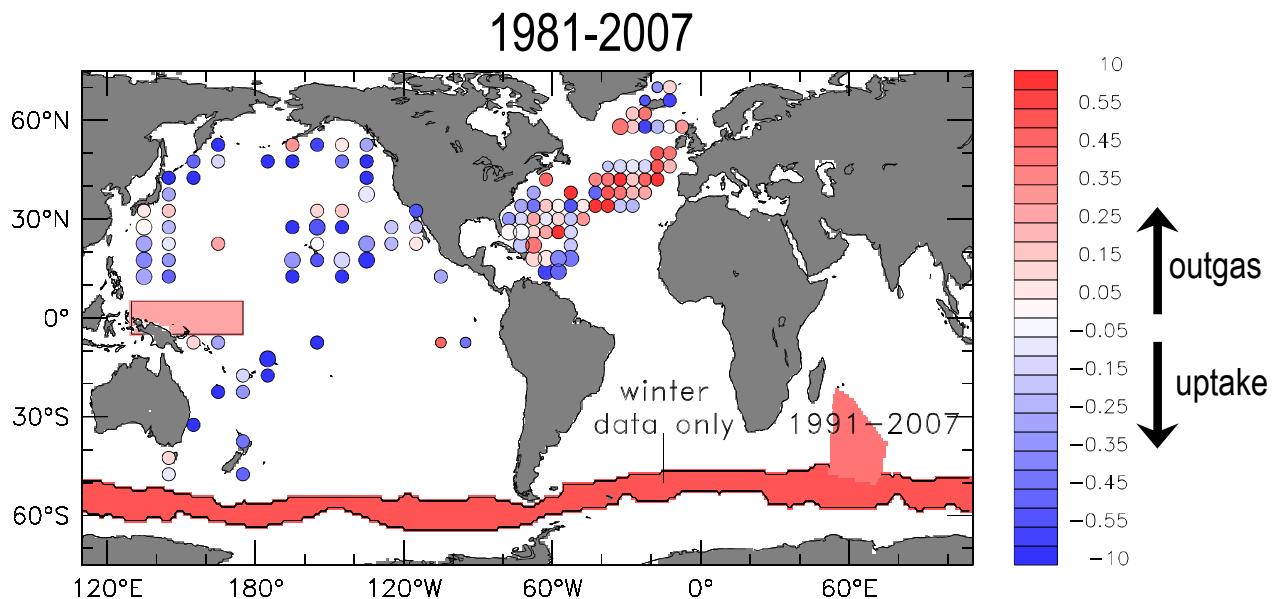
# Modelled Natural CO<sub>2</sub> Sinks



Le Quéré et al. 2009, Nature-geoscience



## Estimated Trends in Sea-Air pCO<sub>2</sub> ( $\mu\text{atm}$ )



Le Quéré et al. 2009, Nature-geoscience

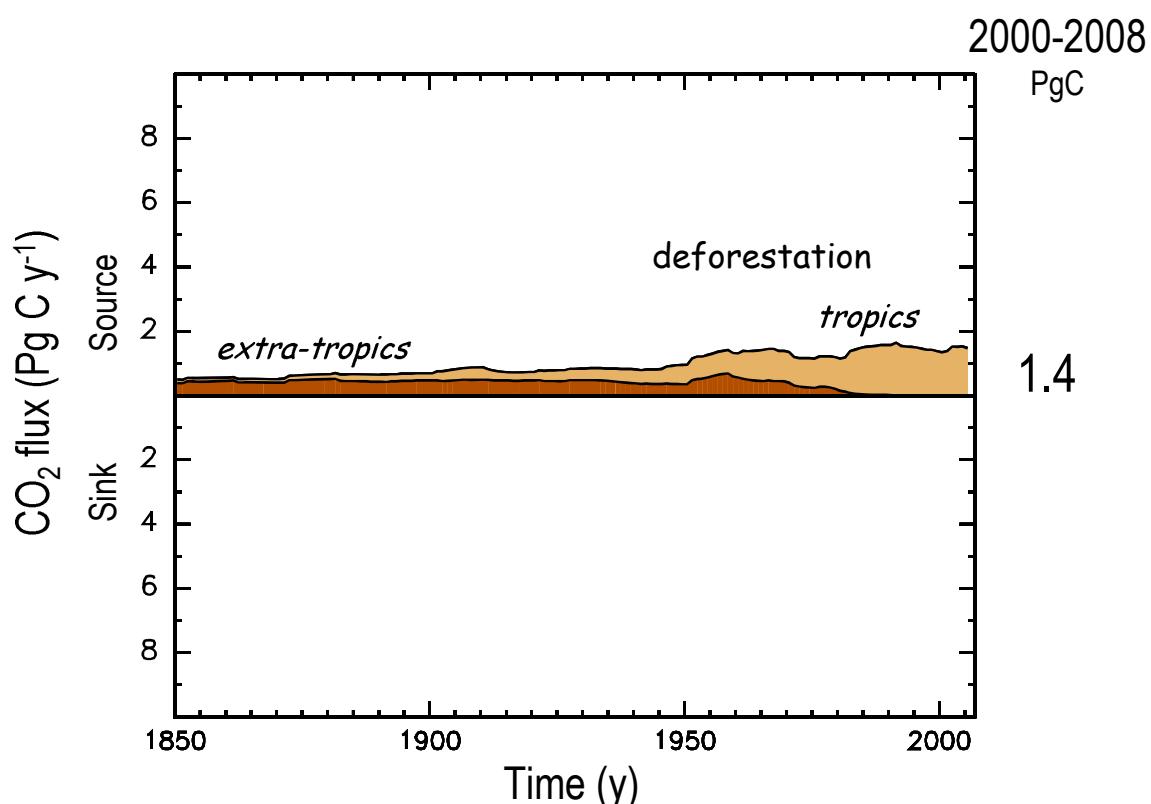


# Possible Reasons for a Positive Trend in Airborne Fraction

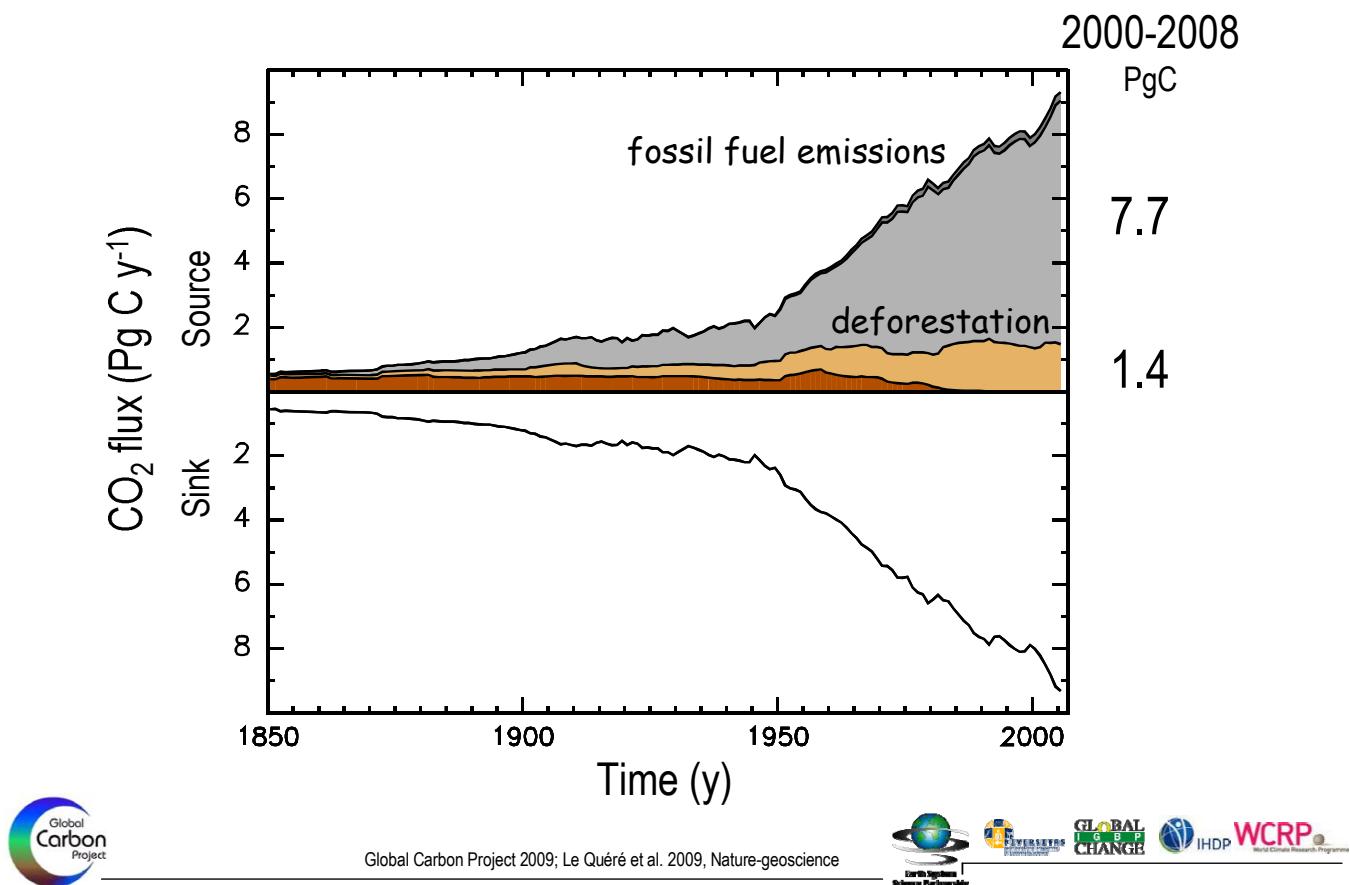
- Emissions are rising faster than the time scales regulating the rate of uptake by sinks.
- Sinks are becoming less efficient at high CO<sub>2</sub>
  - Land: saturation of the CO<sub>2</sub> fertilization effect
  - Ocean: decrease in [carbonate] which buffers CO<sub>2</sub>
- Land and/or ocean sinks are responding to climate change and variability.
- We are missing sink processes in models that are contributing to the observed changes.



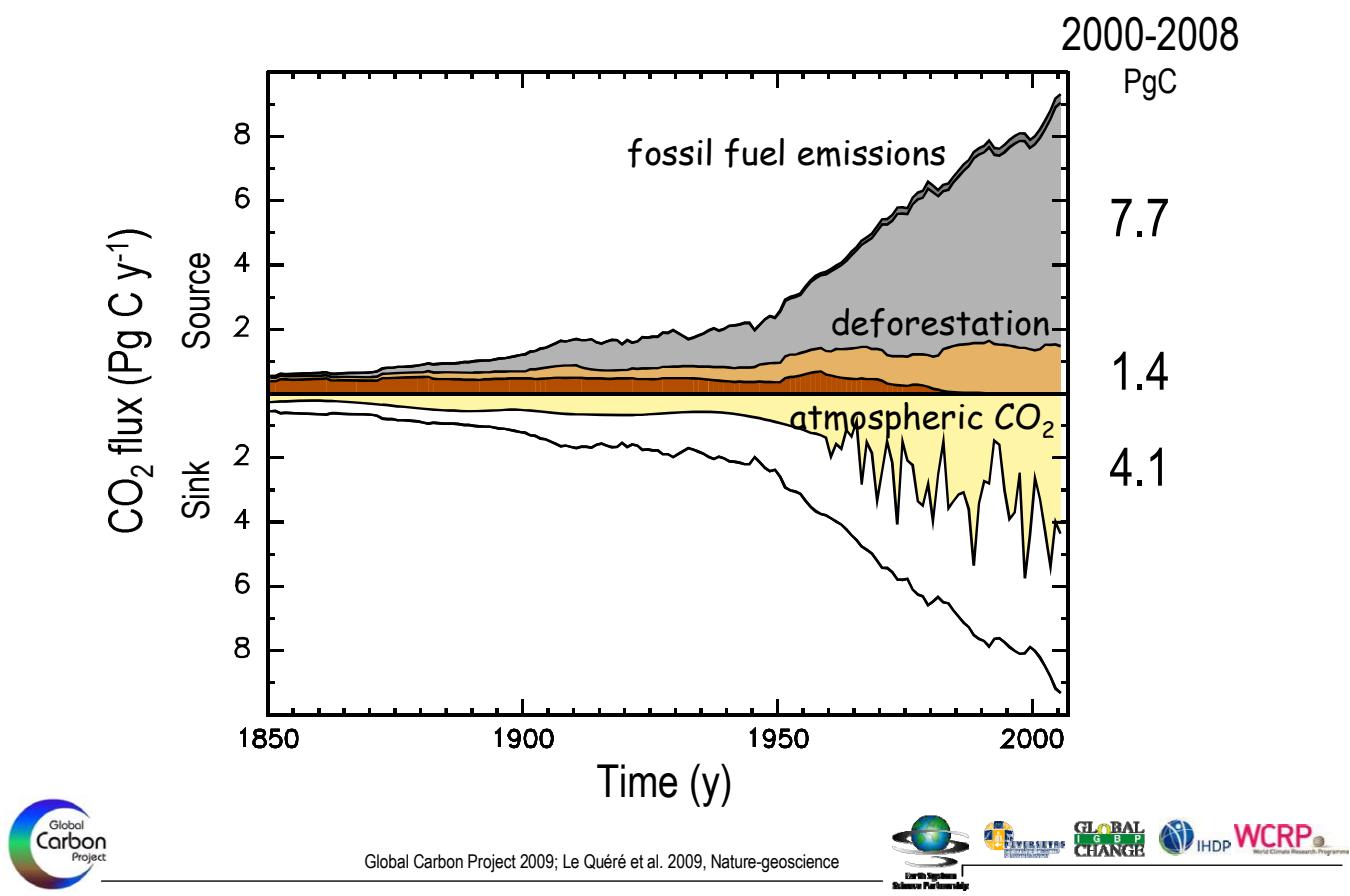
## Human Perturbation of the Global Carbon Budget



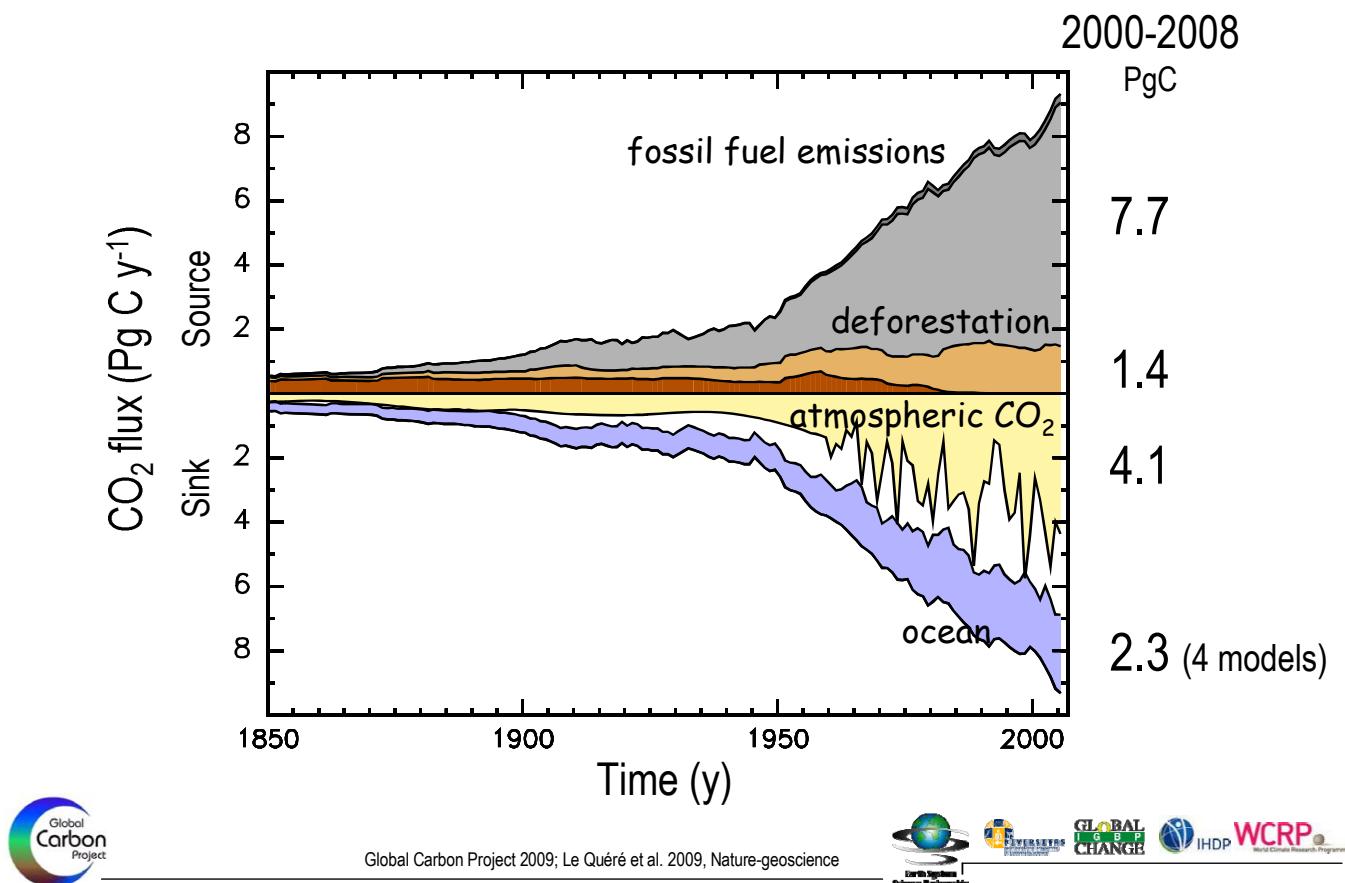
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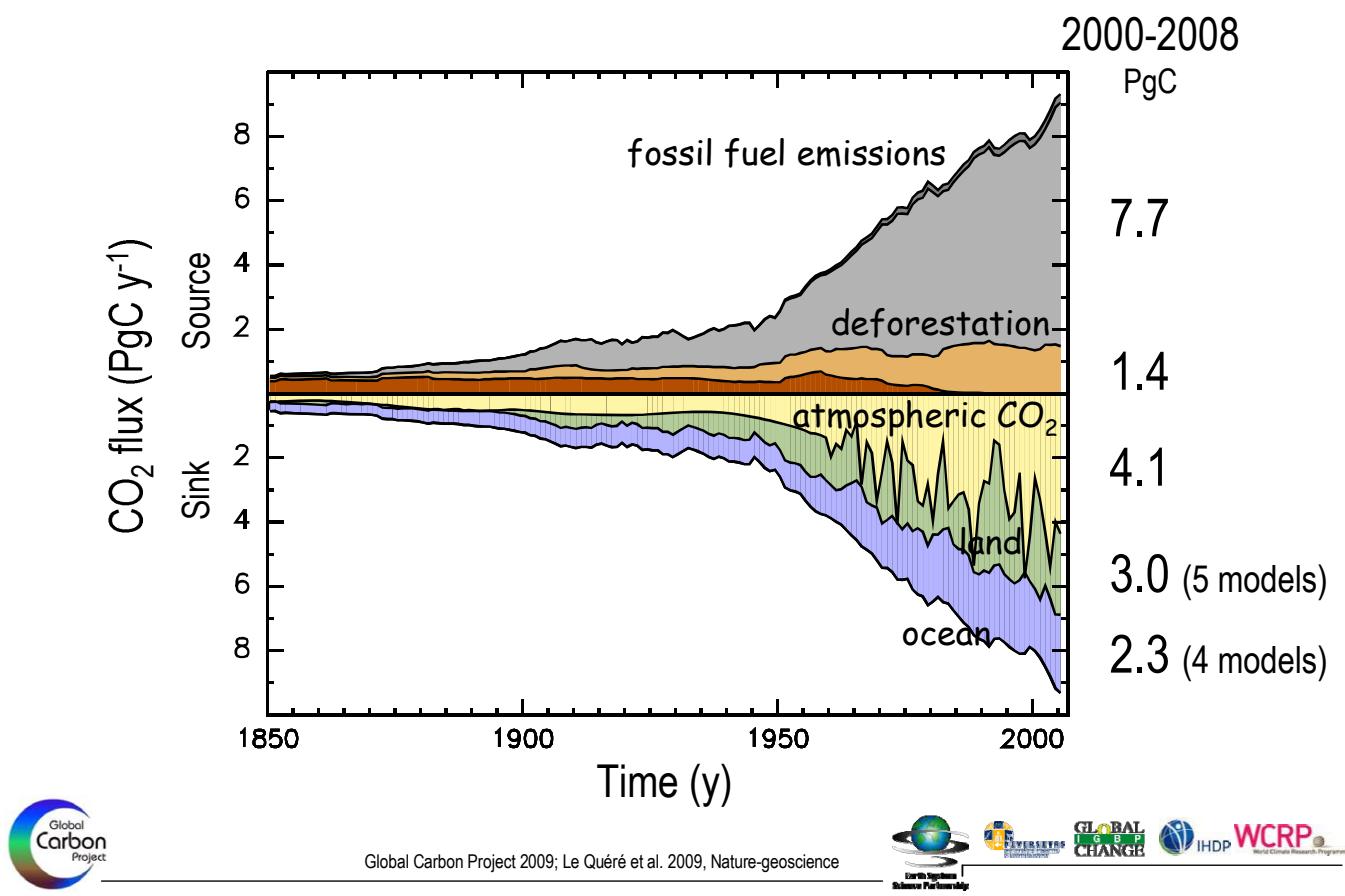
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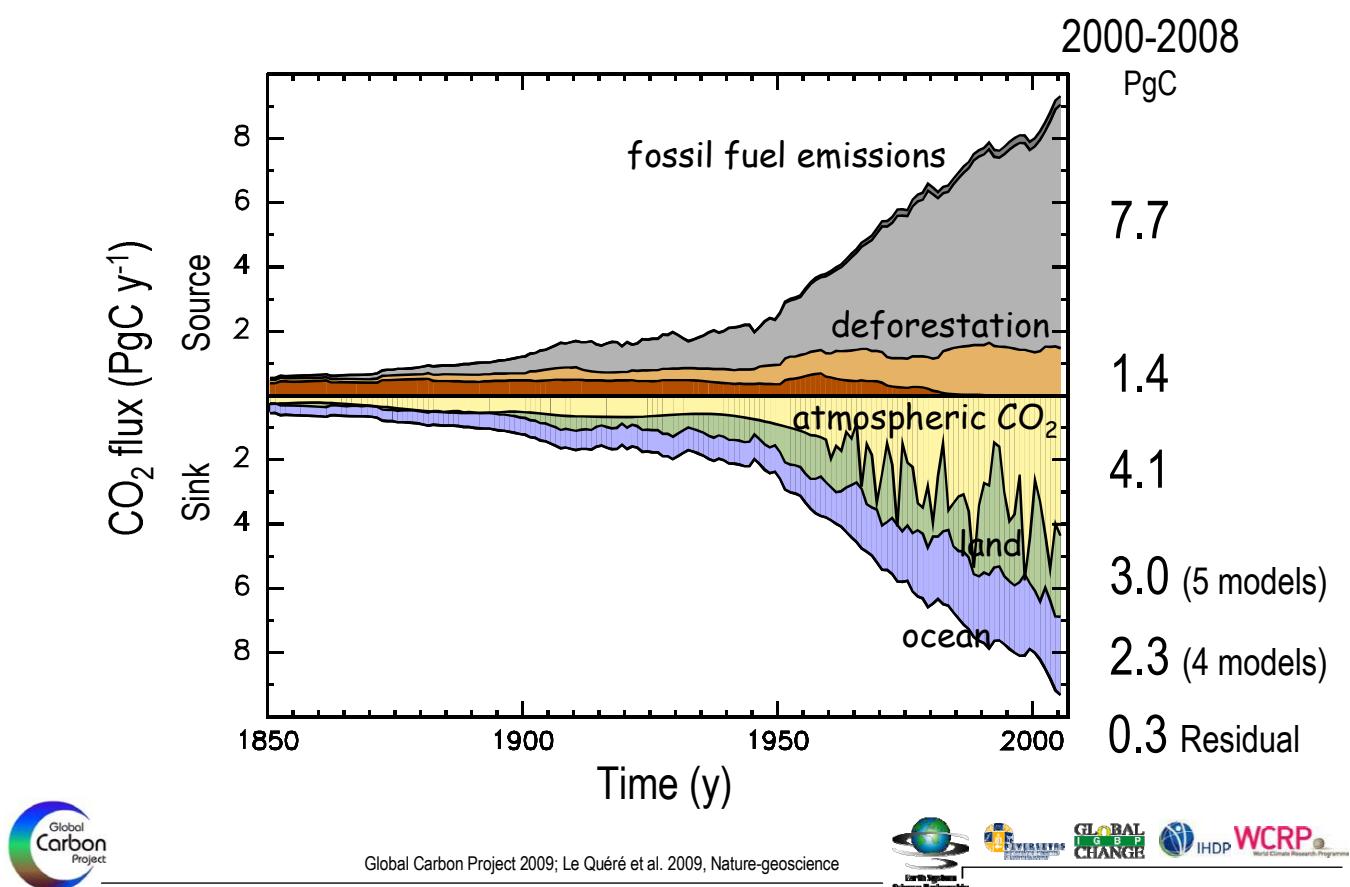
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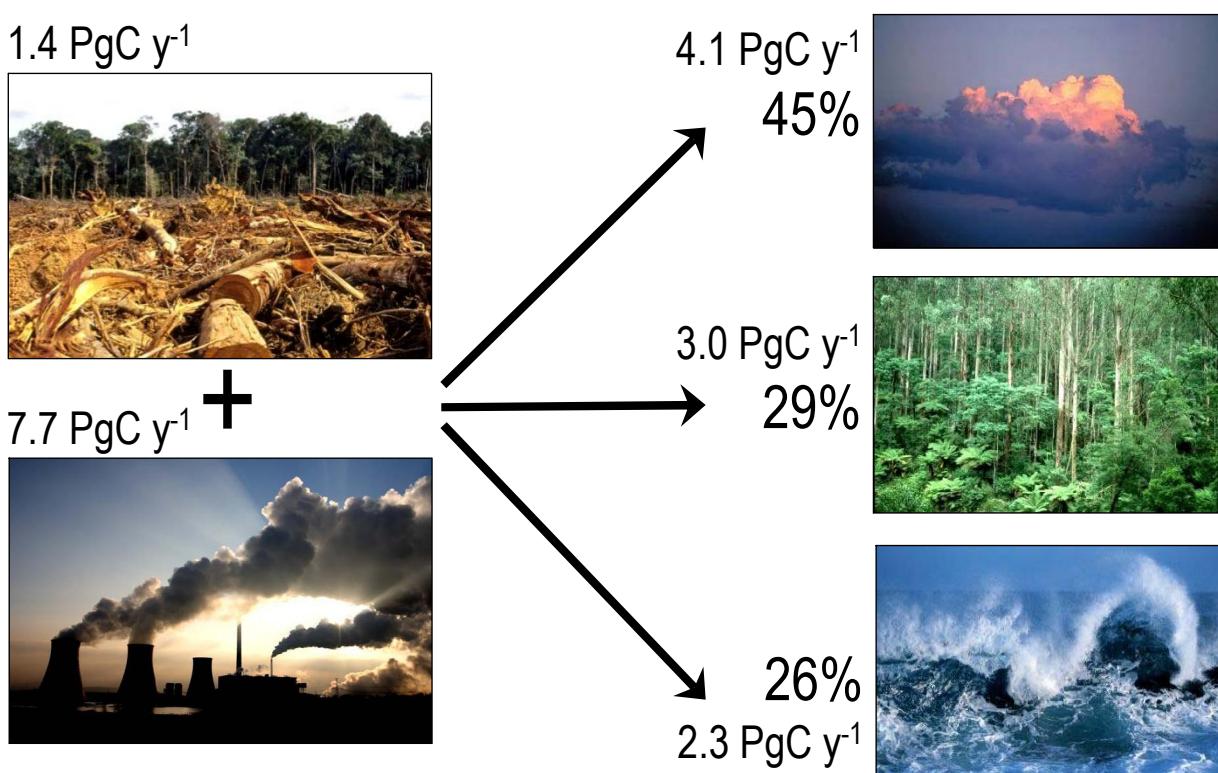
# Human Perturbation of the Global Carbon Budget

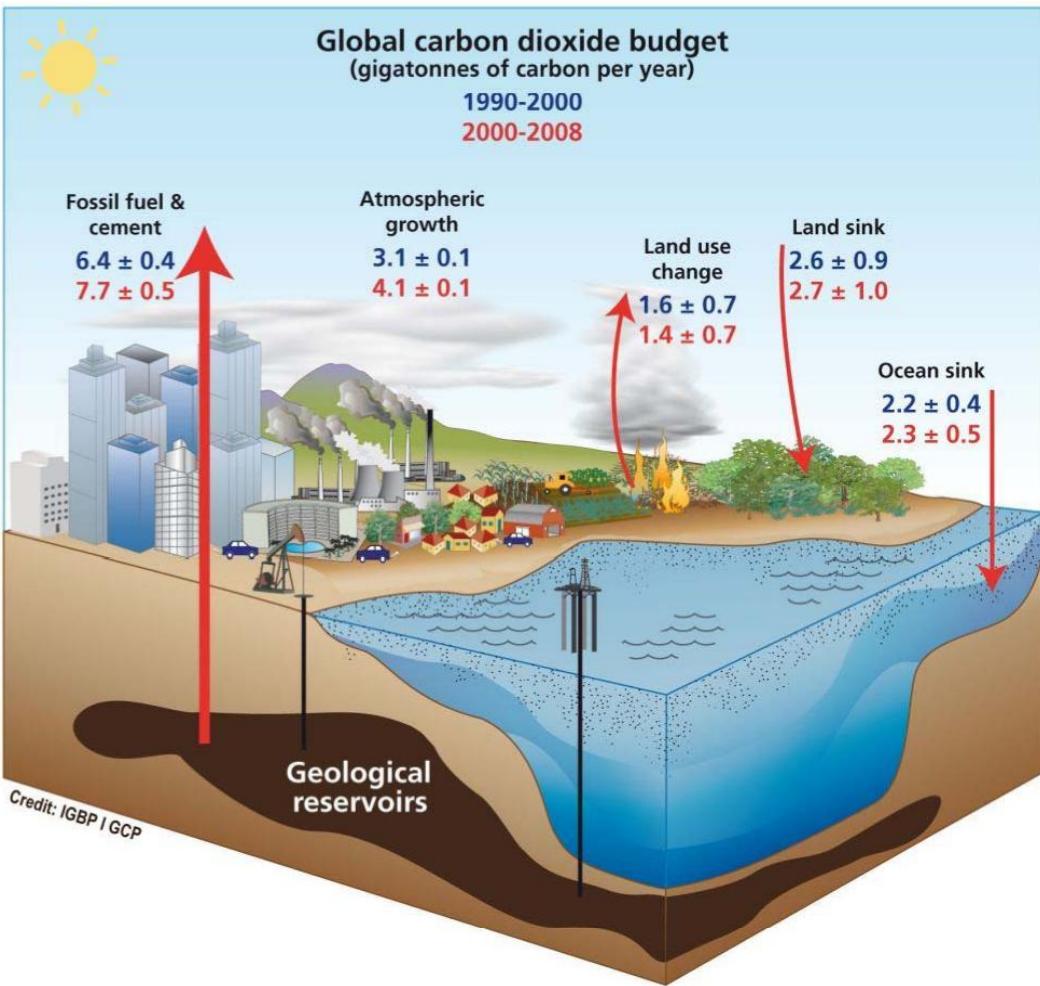


# Human Perturbation of the Global Carbon Budget



## Fate of Anthropogenic CO<sub>2</sub> Emissions (2000-2008)





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## Conclusions

- The efficiency of the natural sinks has been 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<sub>2</sub> emissions and a undetectable effect on the growth of atmospheric CO<sub>2</sub> (because the much larger inter-annual variability of the natural sinks).

# References cited in this ppt

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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.



[www.globalcarbonproject.org](http://www.globalcarbonproject.org)