Carbon Budget 2007

GCP-Global Carbon Budget team: Pep Canadell, Philippe Ciais, Thomas Conway, Christopher B. Field, Corinne Le Quéré, Richard A. Houghton, Gregg Marland, Michael R. Raupach

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26 September 2008

Outline

1. Atmospheric CO_2 Concentration
2. CO_2 Emissions from Fossil Fuel and Cement
3. Drivers of Fossil Fuel Emissions
4. CO_2 Emissions from Land Use Change
5. Natural CO_2 Sinks
6. Summary of the Global Carbon Budget

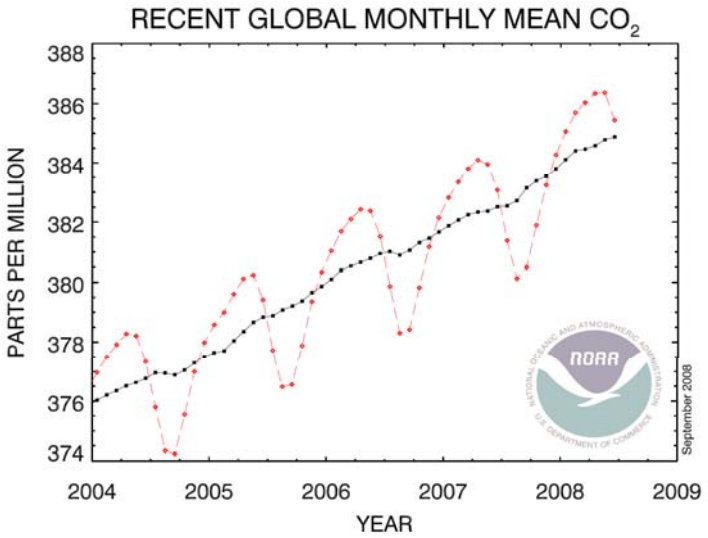
1.
Atmospheric CO_2 Concentration

Atmospheric CO_2 Concentration

Year 2007
Atmospheric CO_2 concentration:

383 ppm

37% above pre-industrial



1970 – 1979: 1.3 ppm y^{-1}
1980 – 1989: 1.6 ppm y^{1}
1990 – 1999: 1.5 ppm y^{-1}

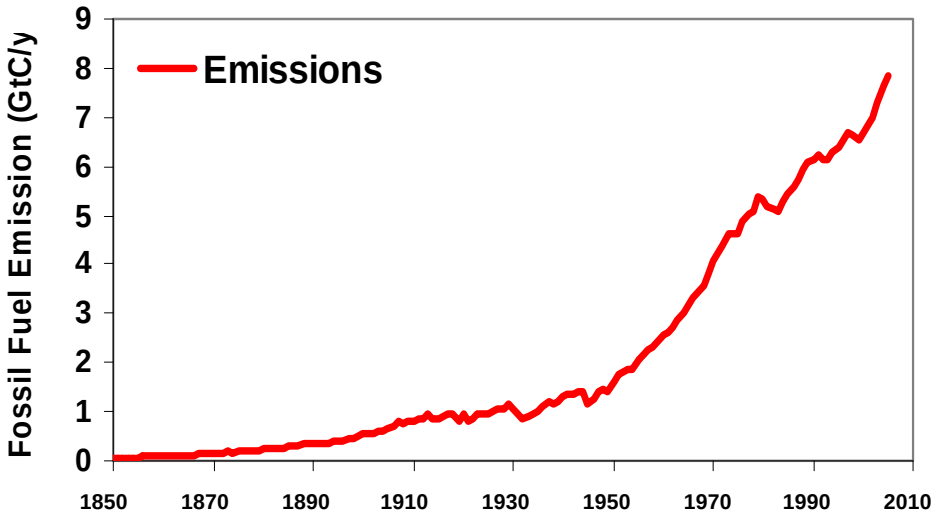
2000 - 2007: 2.0 ppm y^{-1}
2007: 2.2 ppm y^{-1}

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

2.
Emissions from Fossil Fuel and Cement

Emissions from Fossil Fuel + Cement

2007 Fossil Fuel: 8.5 Pg C

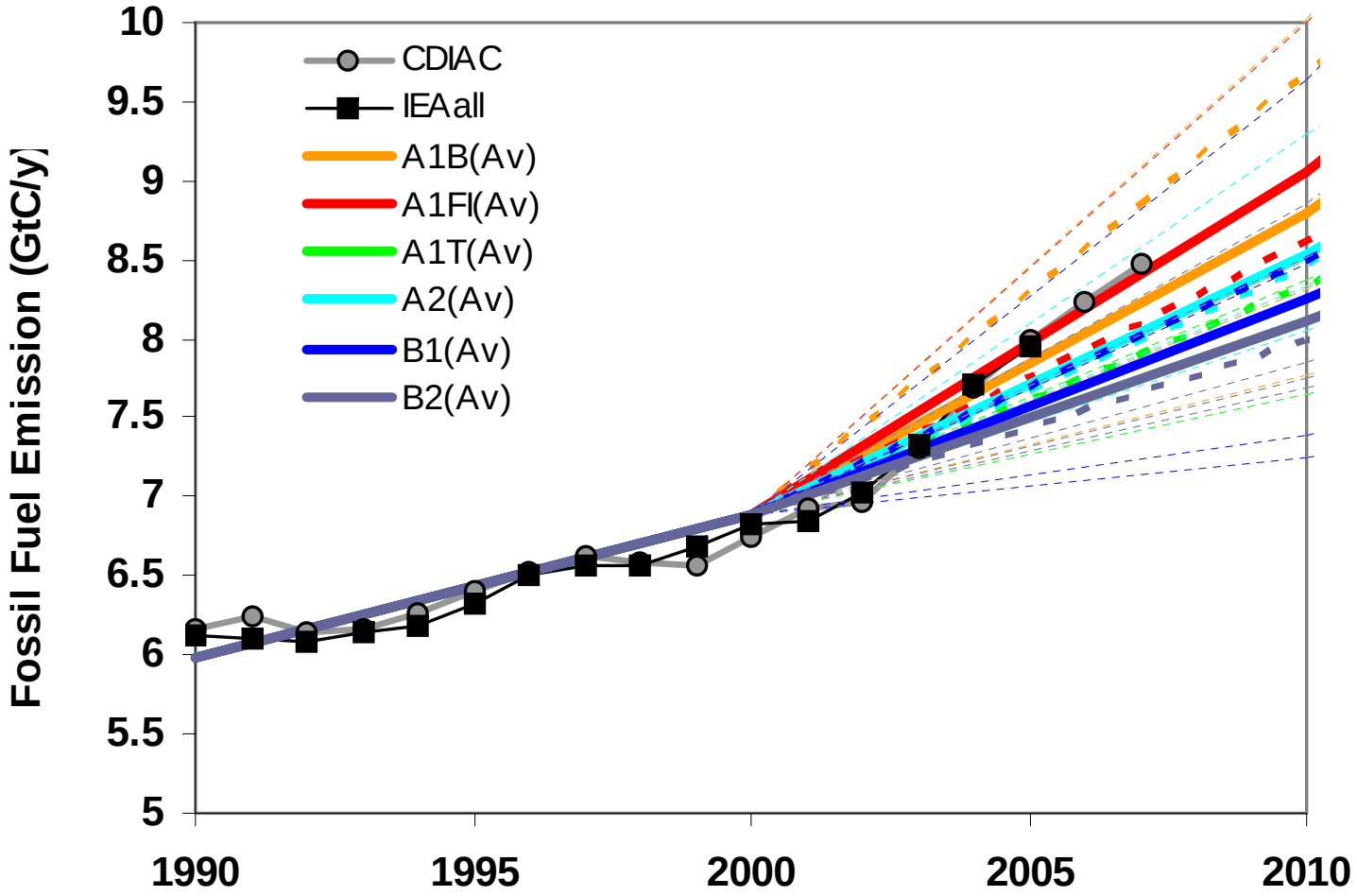


1990 - 1999: 0.9% y^{-1}

2000 - 2007: 3.5% y^{-1}

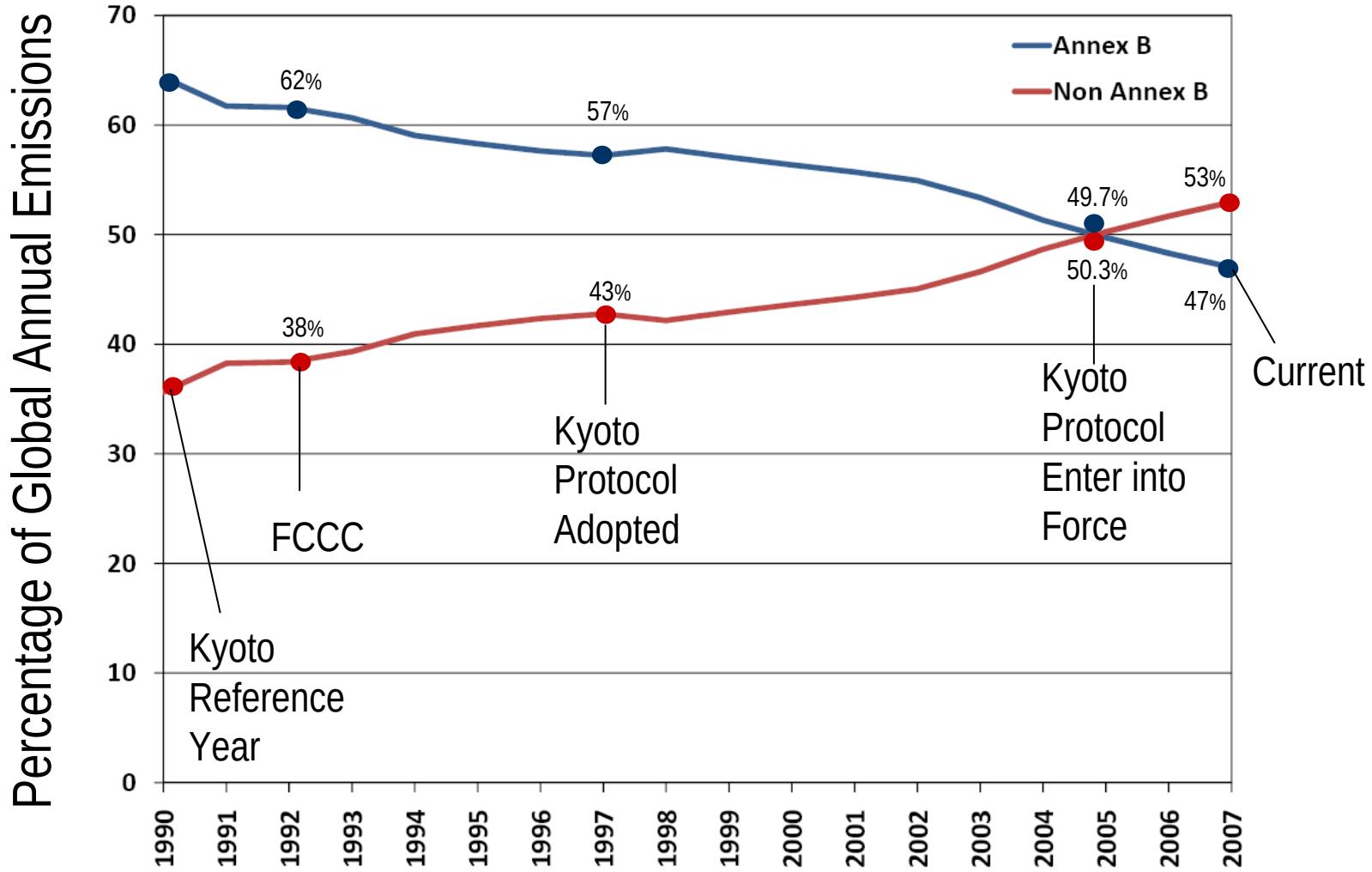
Data Source: G. Marland, T.A. Boden, R.J. Andres, and J. Gregg at CDIAC

Fossil Fuel Emissions: Actual vs. IPCC Scenarios



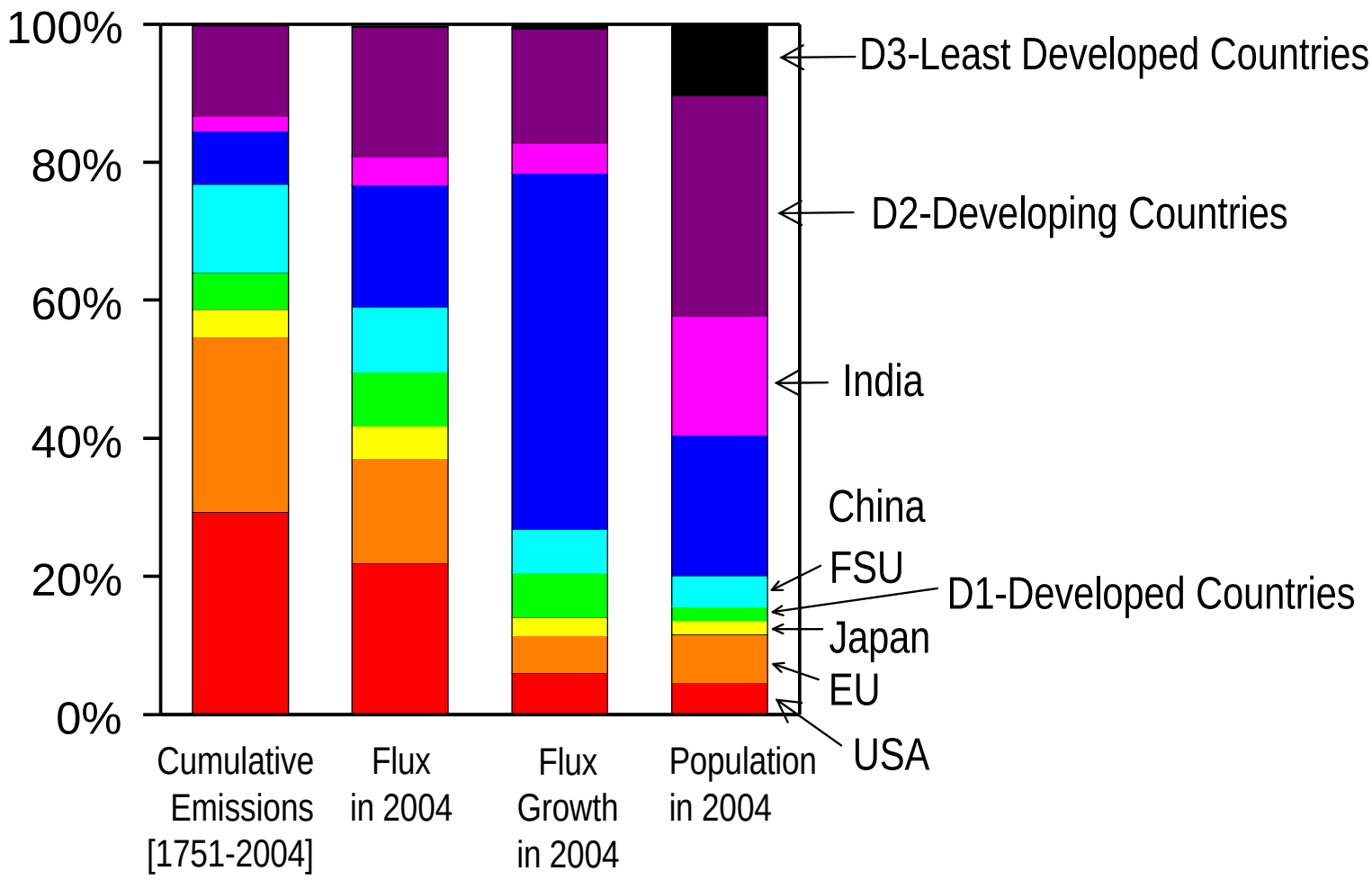
Raupach et al 2007, PNAS (updated)

Regional Shift in Emissions Share



J. Gregg and G. Marland, 2008, personal communication

Regional Share of Fossil Fuel Emissions

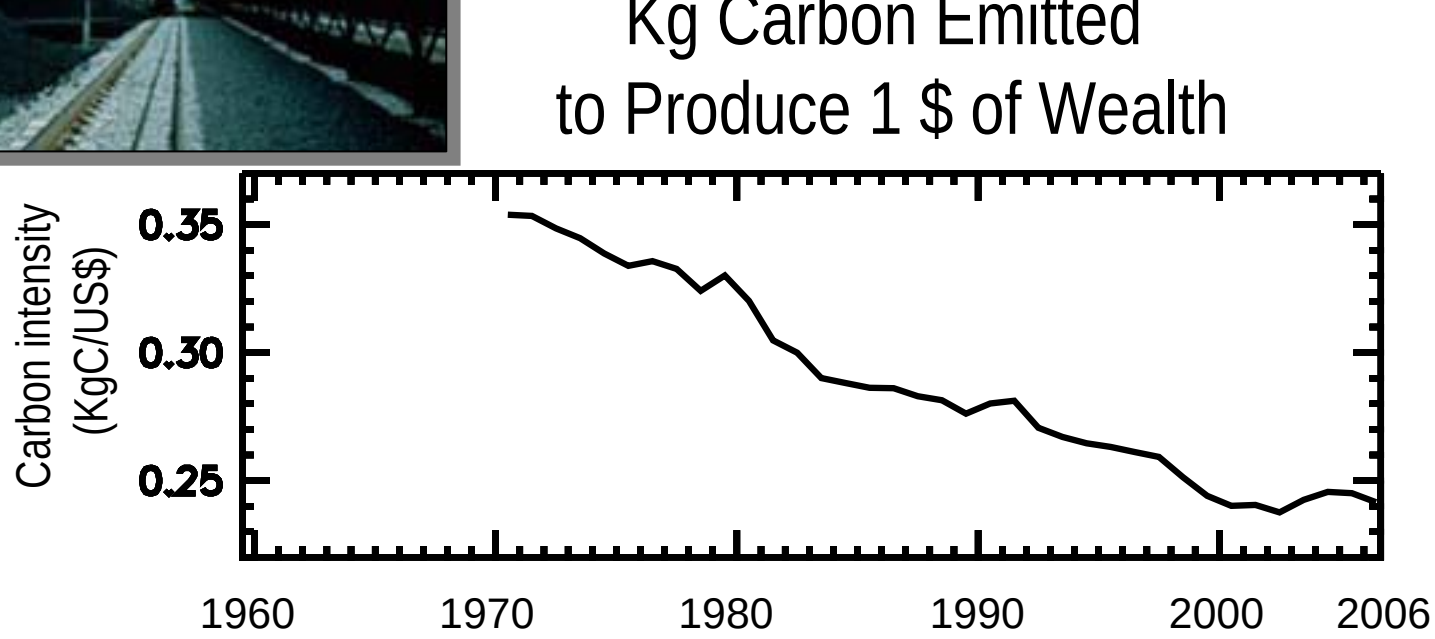


Raupach et al. 2007, PNAS

3.
Drivers of fossil fuel emissions

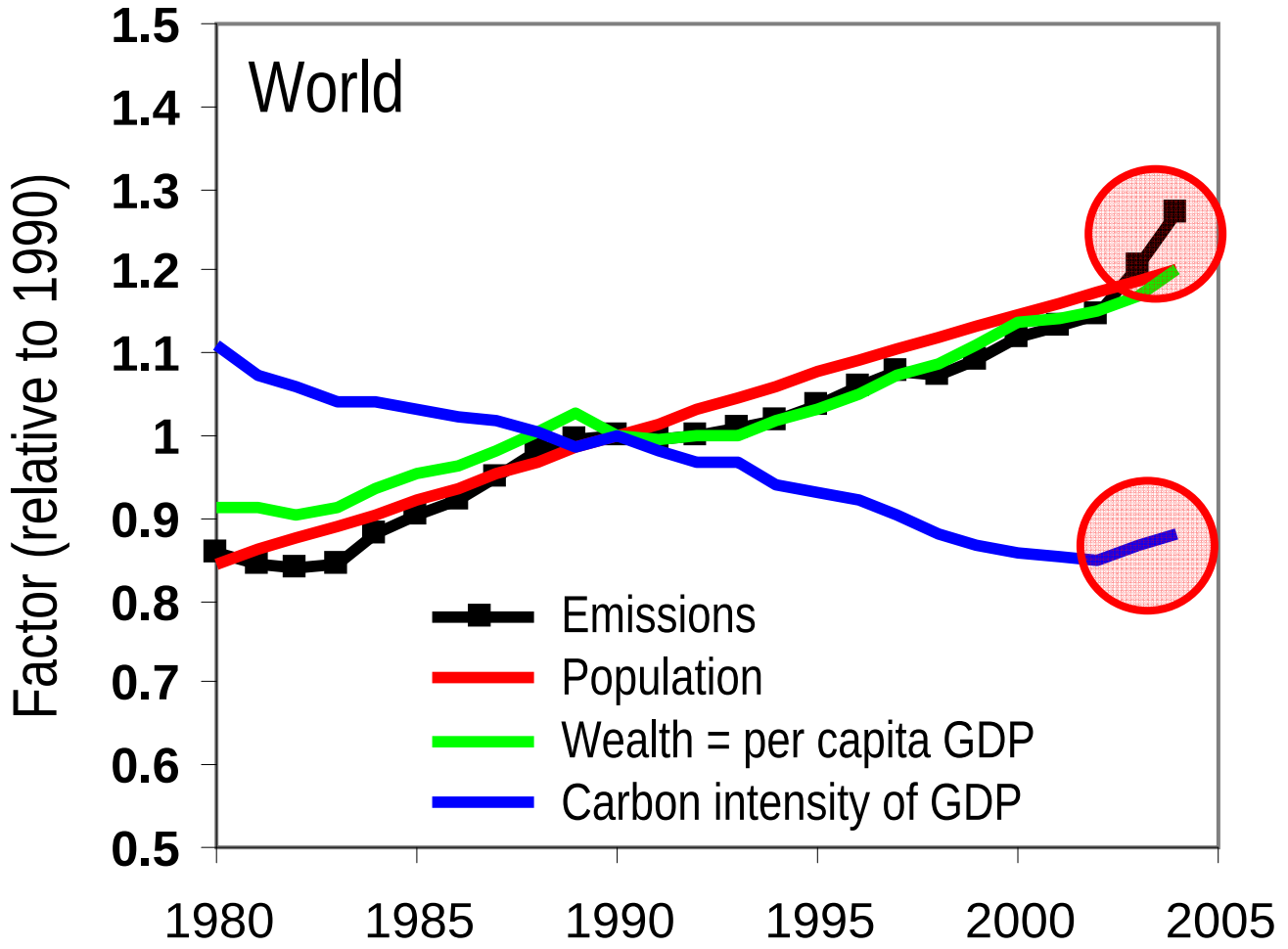
Carbon Intensity of the Global Economy

Photo: CSIRO



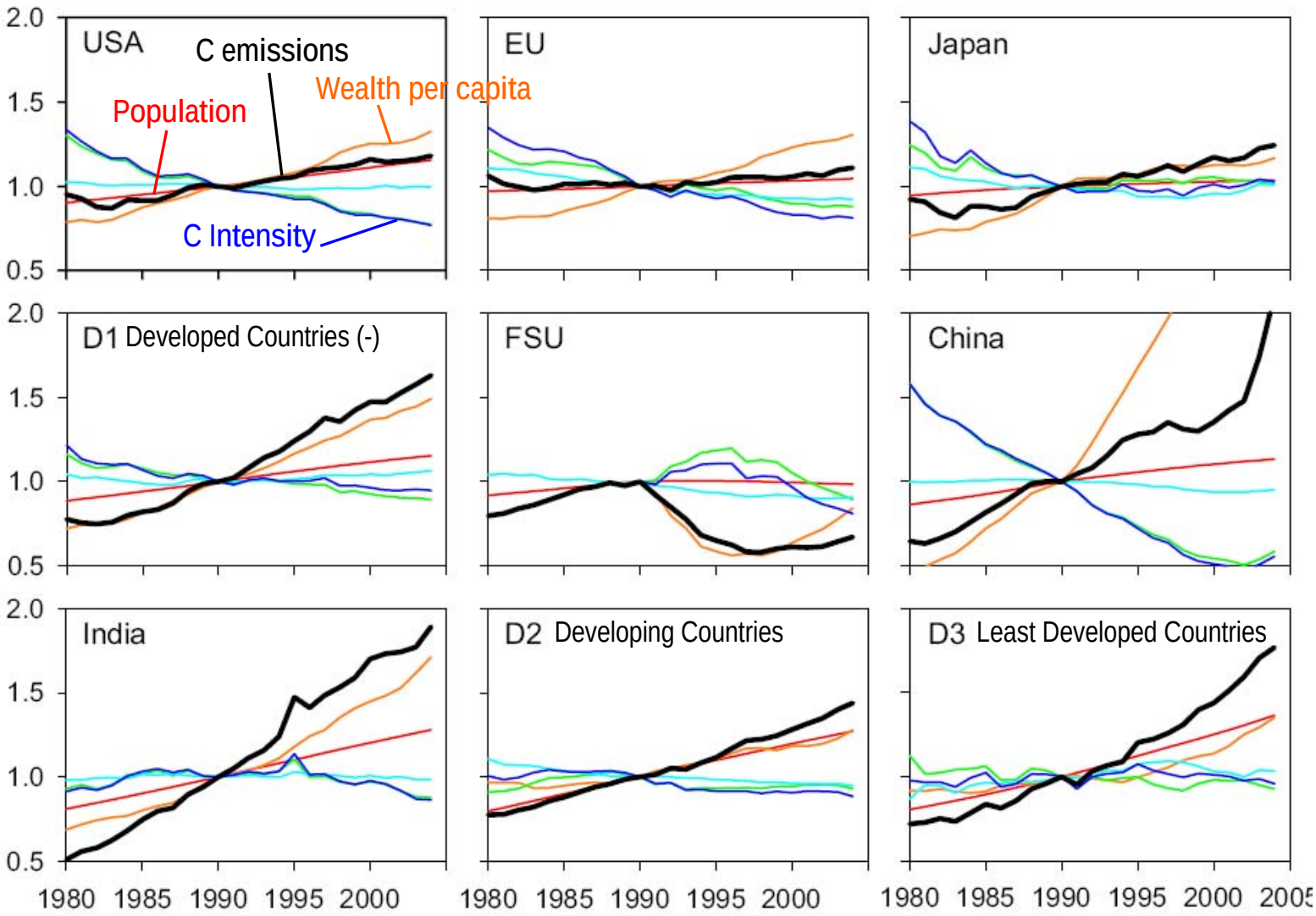
Raupach et al. 2007, PNAS; Canadell et al. 2007, PNAS

Drivers of Anthropogenic Emissions



Raupach et al 2007, PNAS

Regional Emission Pathways



Raupach et al 2007, PNAS

4.
Emissions from Land Use Change

Carbon Emissions from Land Use Change

Borneo, Courtesy: Viktor Boehm

Tropical deforestation

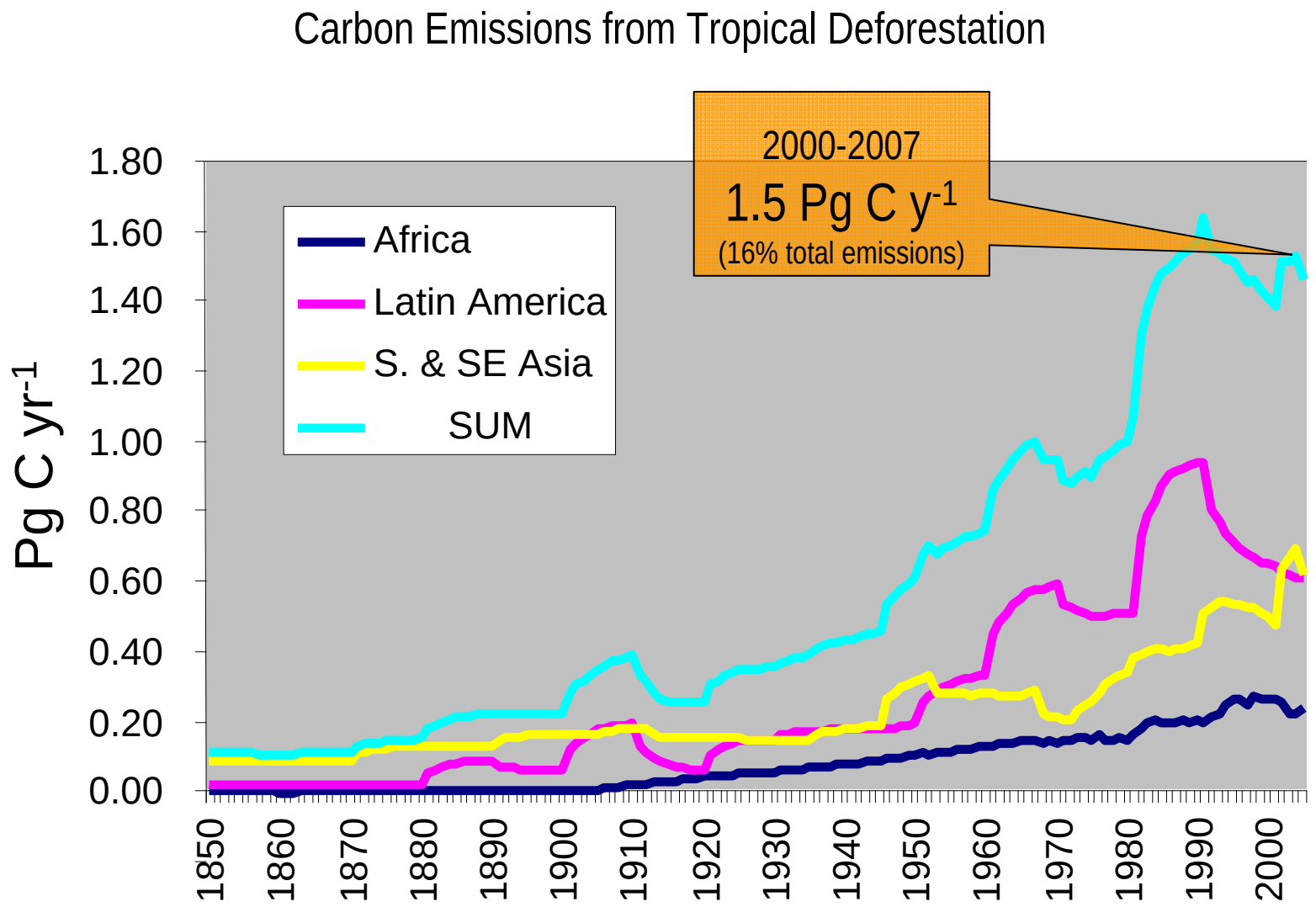
13 Million hectares each year

	2000-2007
Tropical Americas	0.6 Pg C y^{-1}
Tropical Asia	0.6 Pg C y^{-1}
Tropical Africa	0.3 Pg C y^{-1}
	1.5 Pg C y^{-1}

[2007-Total Anthropogenic Emissions:8.5+1.5 = 10 Pg]

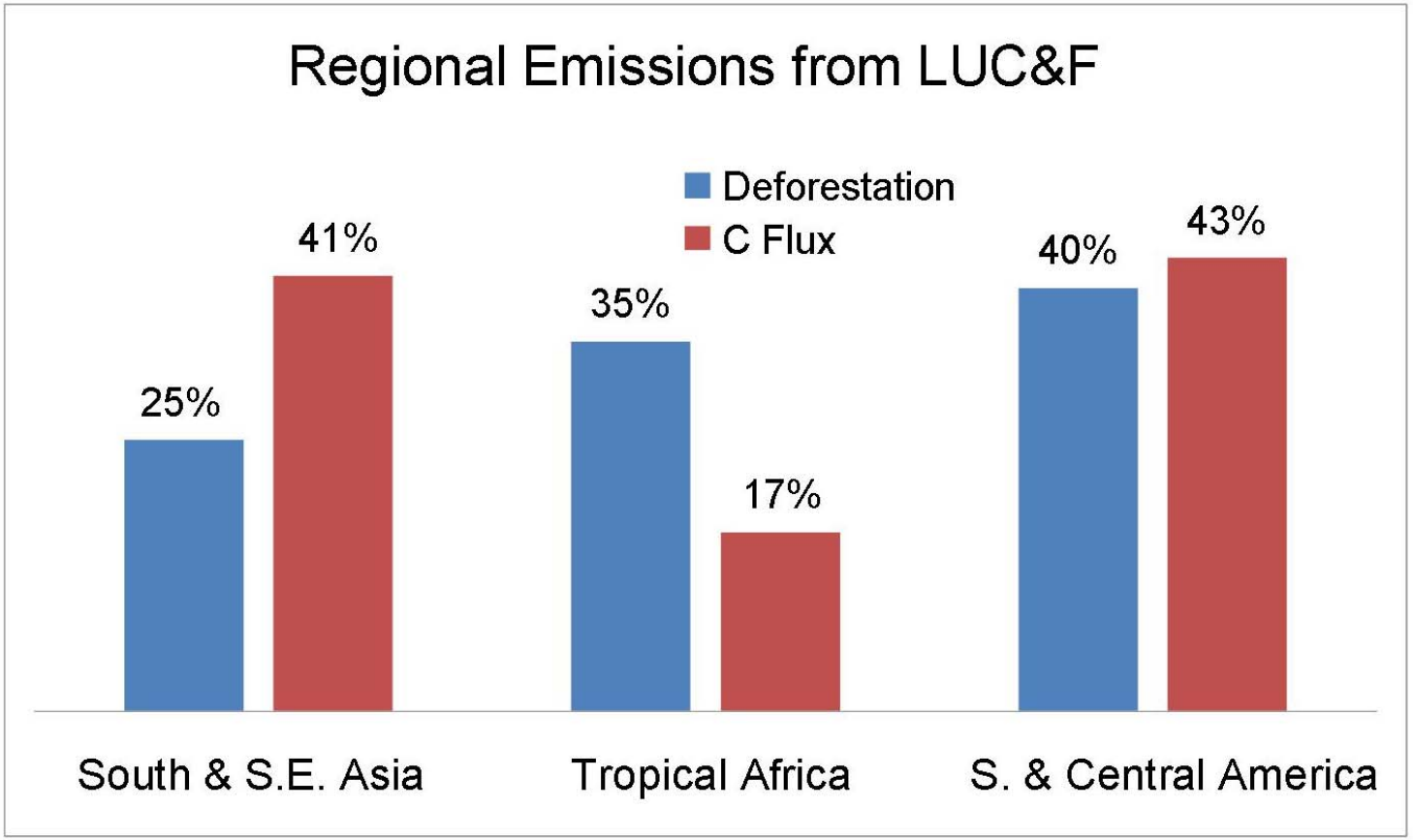
Canadell et al. 2007, PNAS; FAO-Global Resources Assessment 2005

Historical Emissions from Land Use Change



R.A. Houghton, unpublished

Regional Share of Emissions from Land Use Change



Canadell, Raupach, Houghton, 2008, Biogeosciences, submitted

5.

Natural CO_2 sinks

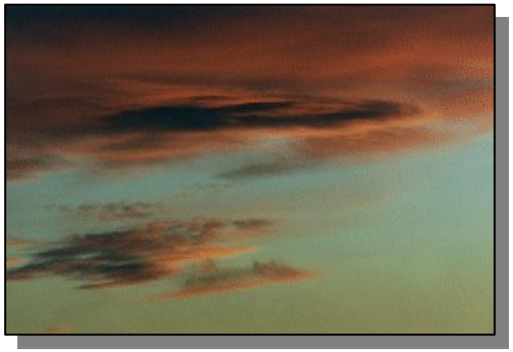
Fate of Anthropogenic CO_2 Emissions (2000-2007)

1.5 Pg C y^{-1}

+

7.5 Pg C y^{-1}

4.2 Pg y^{-1}
Atmosphere
46%



2.6 Pg y^{-1}
Land
29%

2.3 Pg y^{-1}
Oceans
26%

Canadell et al. 2007, PNAS (updated)

Climate Change at 55% Discount

Natural CO_2 sinks absorb 55% of all anthropogenic carbon emissions slowing down climate change significantly.

They are in effect a huge subsidy to the global economy worth half a trillion US$ annually if an equivalent sink had to be created using other climate mitigation options (based on the cost of carbon in the EU-ETS).

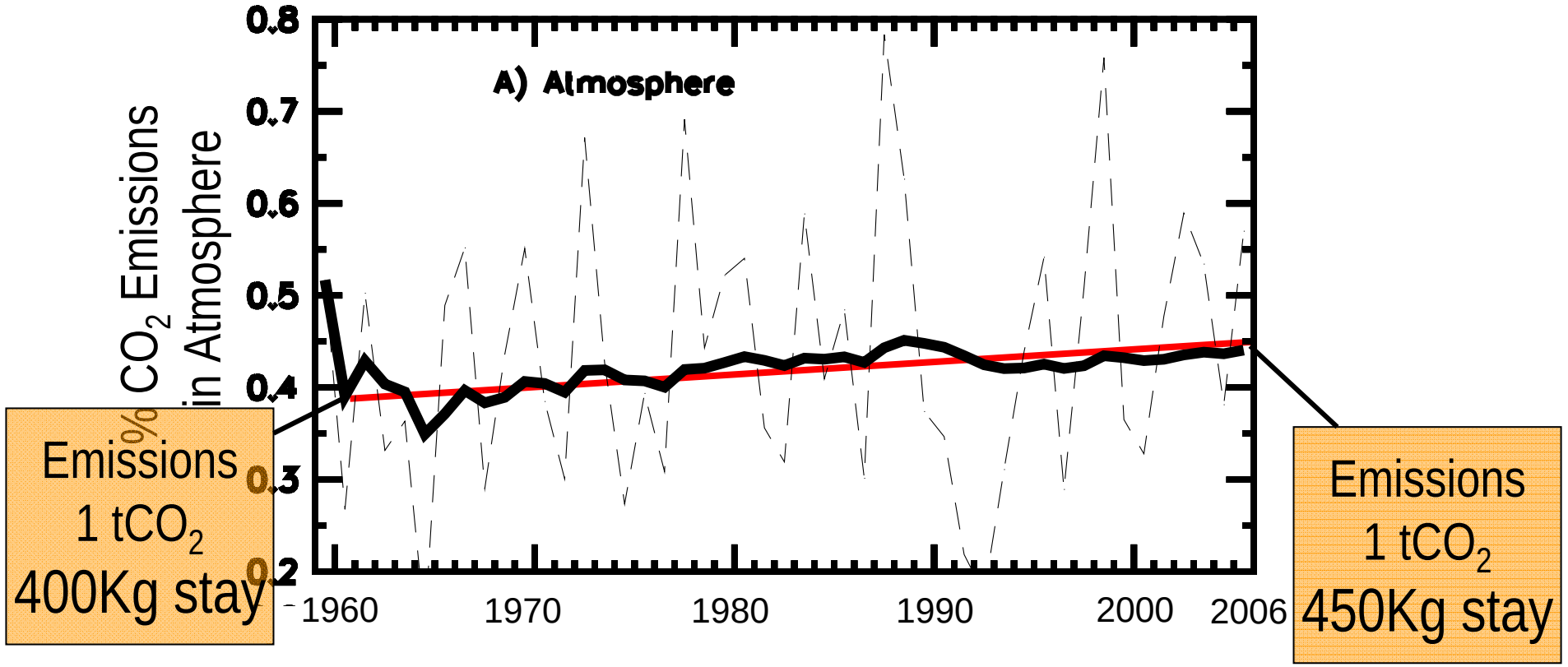
Factors that Influence the Airborne Fraction

1. The rate of CO_2 emissions.

2. The rate of CO_2 uptake and ultimately the total amount of C that can be stored by land and oceans:
   - Land: CO_2 fertilization effect, soil respiration, N deposition fertilization, forest regrowth, woody encroachment, …
   - Oceans: CO_2 solubility (temperature, salinity),, ocean currents, stratification, winds, biological activity, acidification, …

Decline in the Efficiency of CO_2 Natural Sinks

Fraction of all anthropogenic emissions that stay in the atmosphere

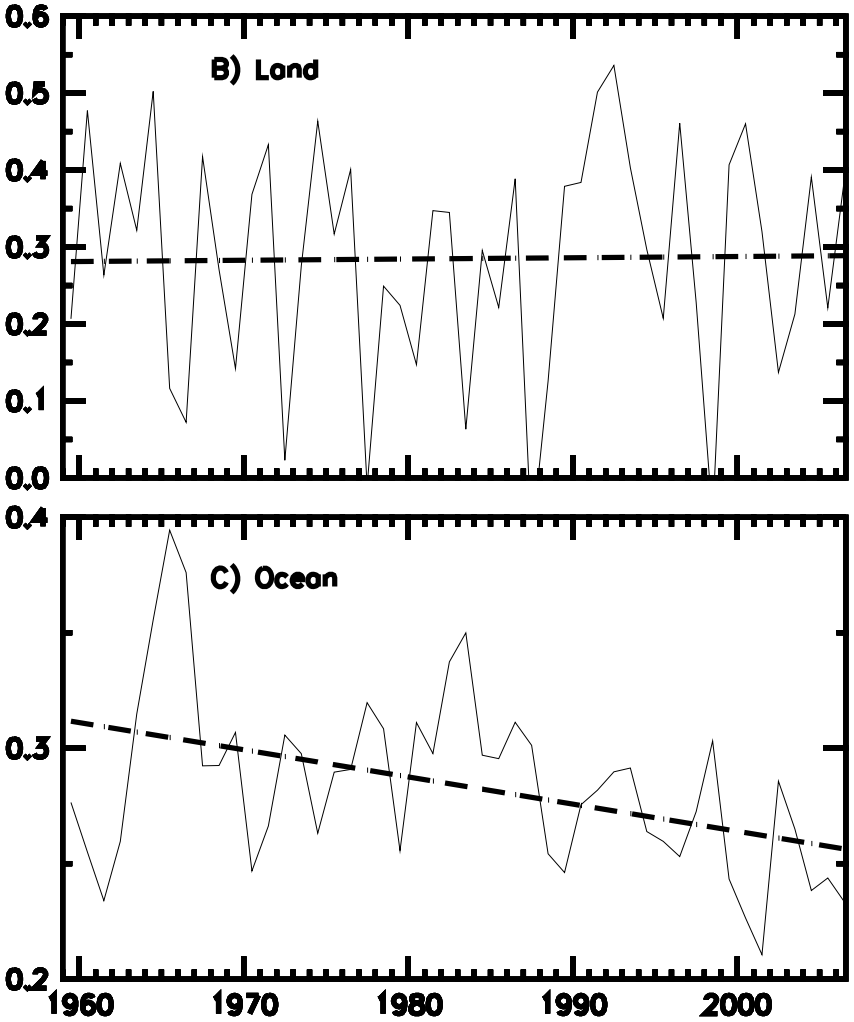


Canadell et al. 2007, PNAS

Efficiency of Natural Sinks

Land Fraction

Ocean Fraction



Canadell et al. 2007, PNAS

Causes of the Declined in the Efficiency of the Ocean Sink

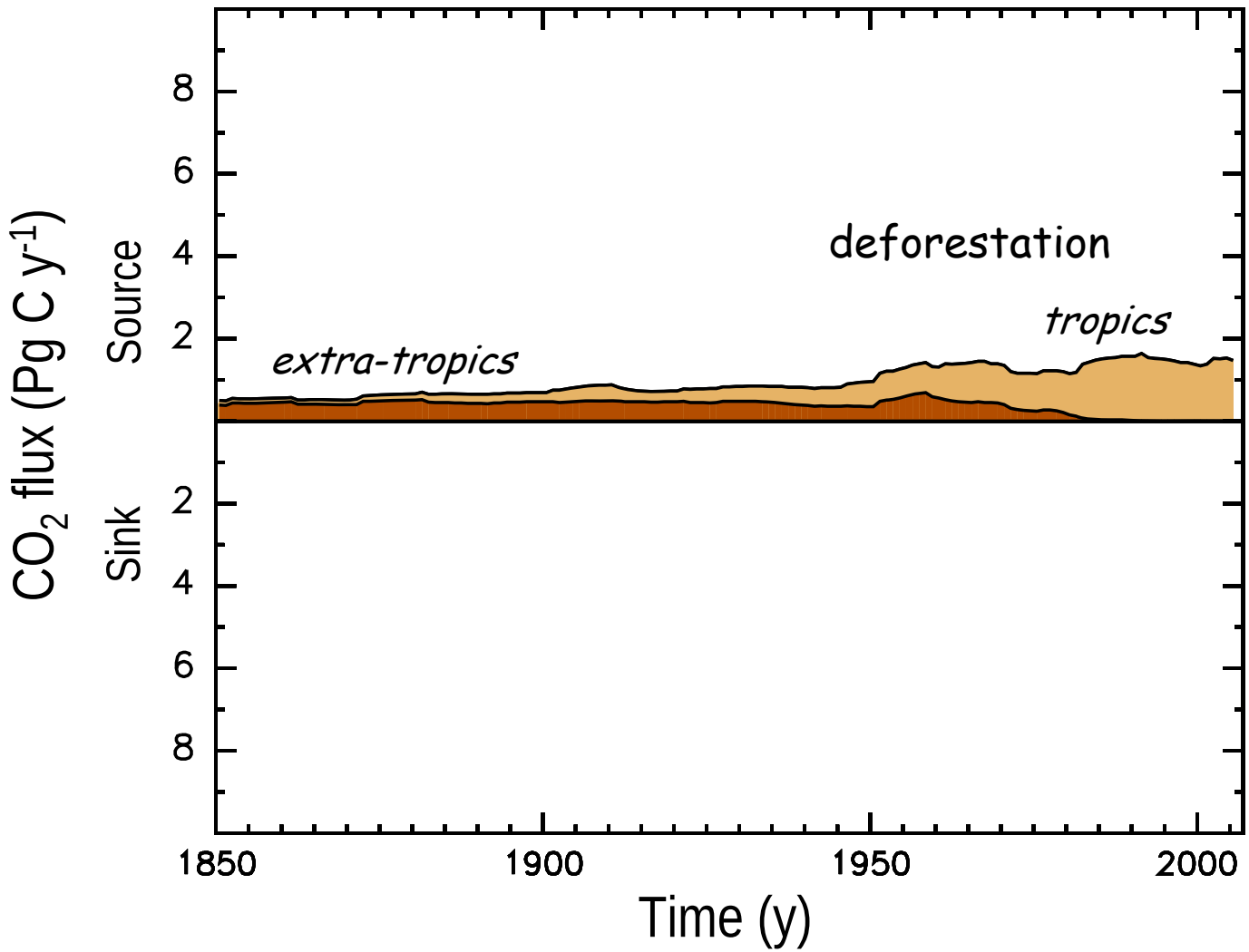
Credit: N.Metzl, August 2000, oceanographic cruise OISO-5

- Part of the decline is attributed to up to a 30% decrease in the efficiency of the Southern Ocean sink over the last 20 years.
- This sink removes annually 0.7 Pg of anthropogenic carbon.
- The decline is attributed to the strengthening of the winds around Antarctica which enhances ventilation of natural carbon-rich deep waters.
- The strengthening of the winds is attributed to global warming and the ozone hole.

Le Quéré et al. 2007, Science

6.
Summary
of the global carbon budget

Human Perturbation of the Global Carbon Budget

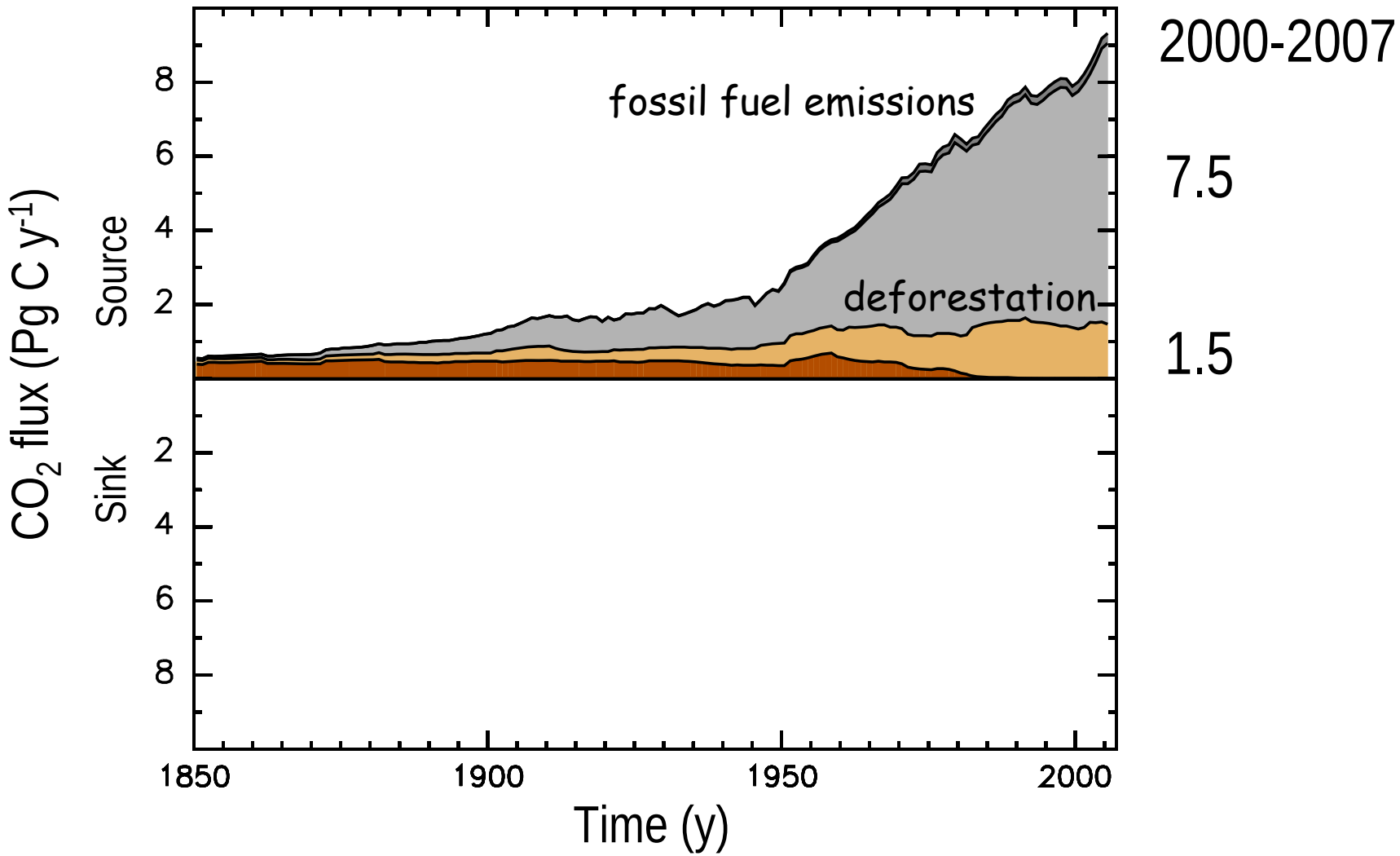


2000-2007

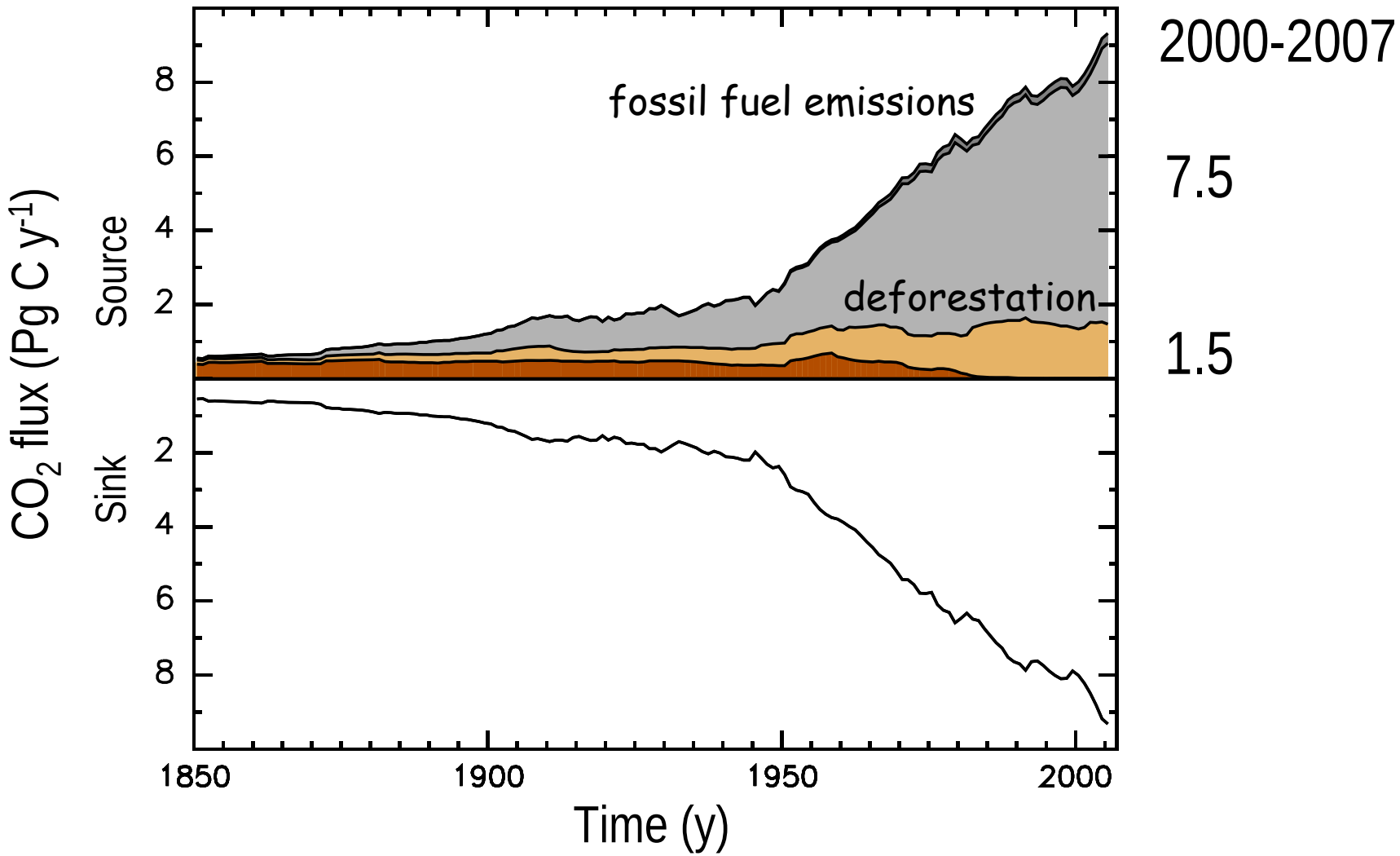
1.5

Global Carbon Project (2008)

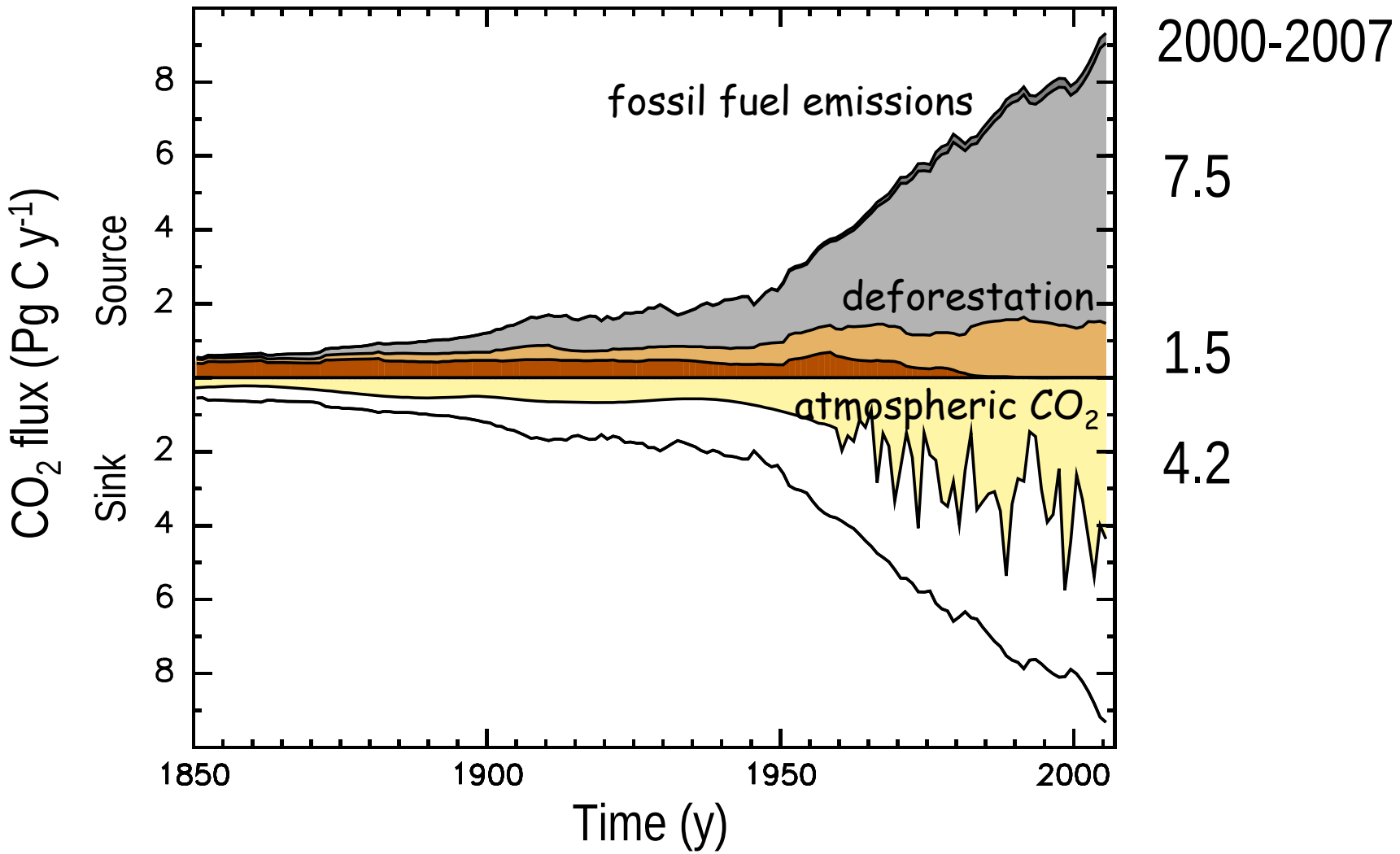
Human Perturbation of the Global Carbon Budget



Human Perturbation of the Global Carbon Budget



Human Perturbation of the Global Carbon Budget



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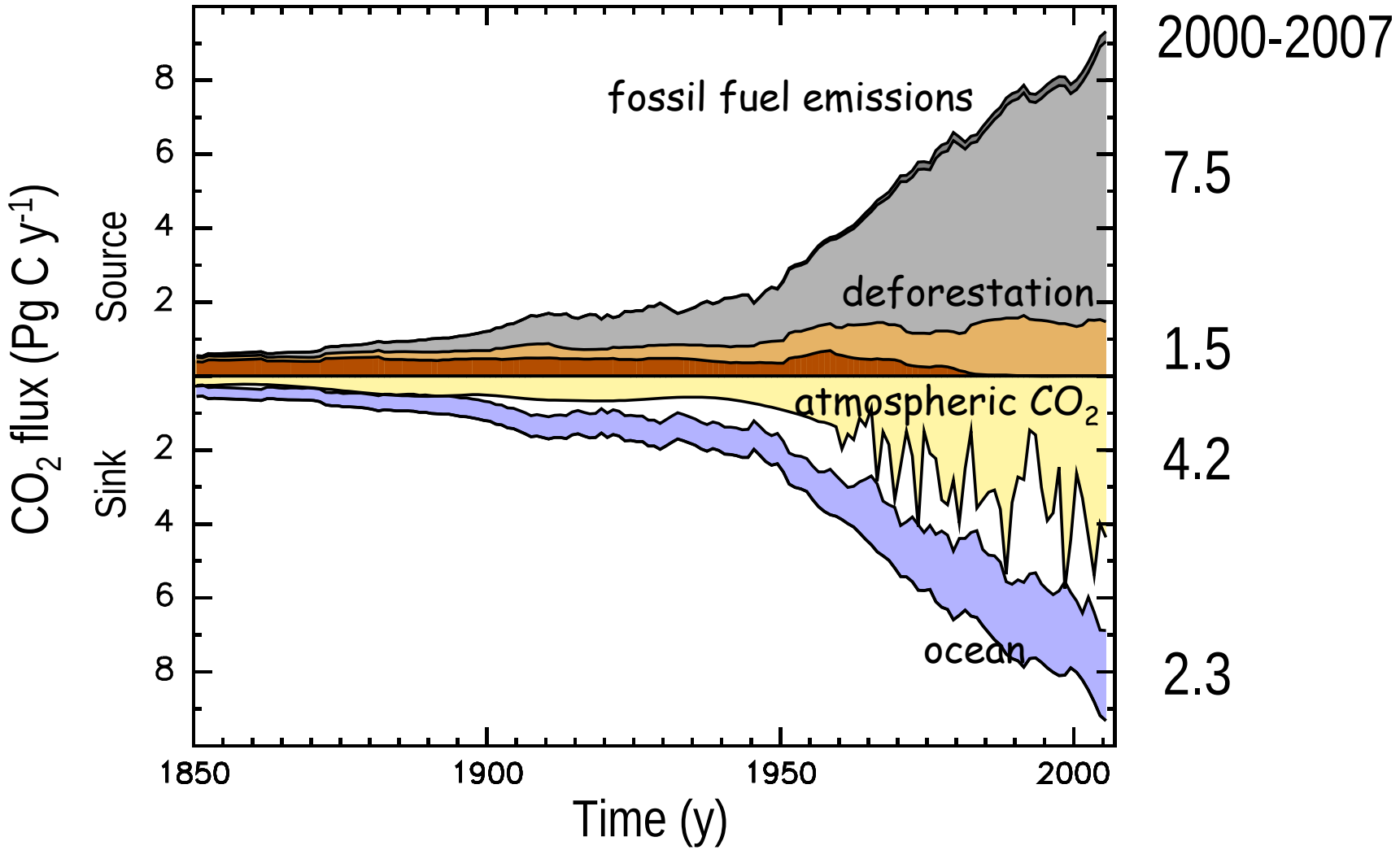

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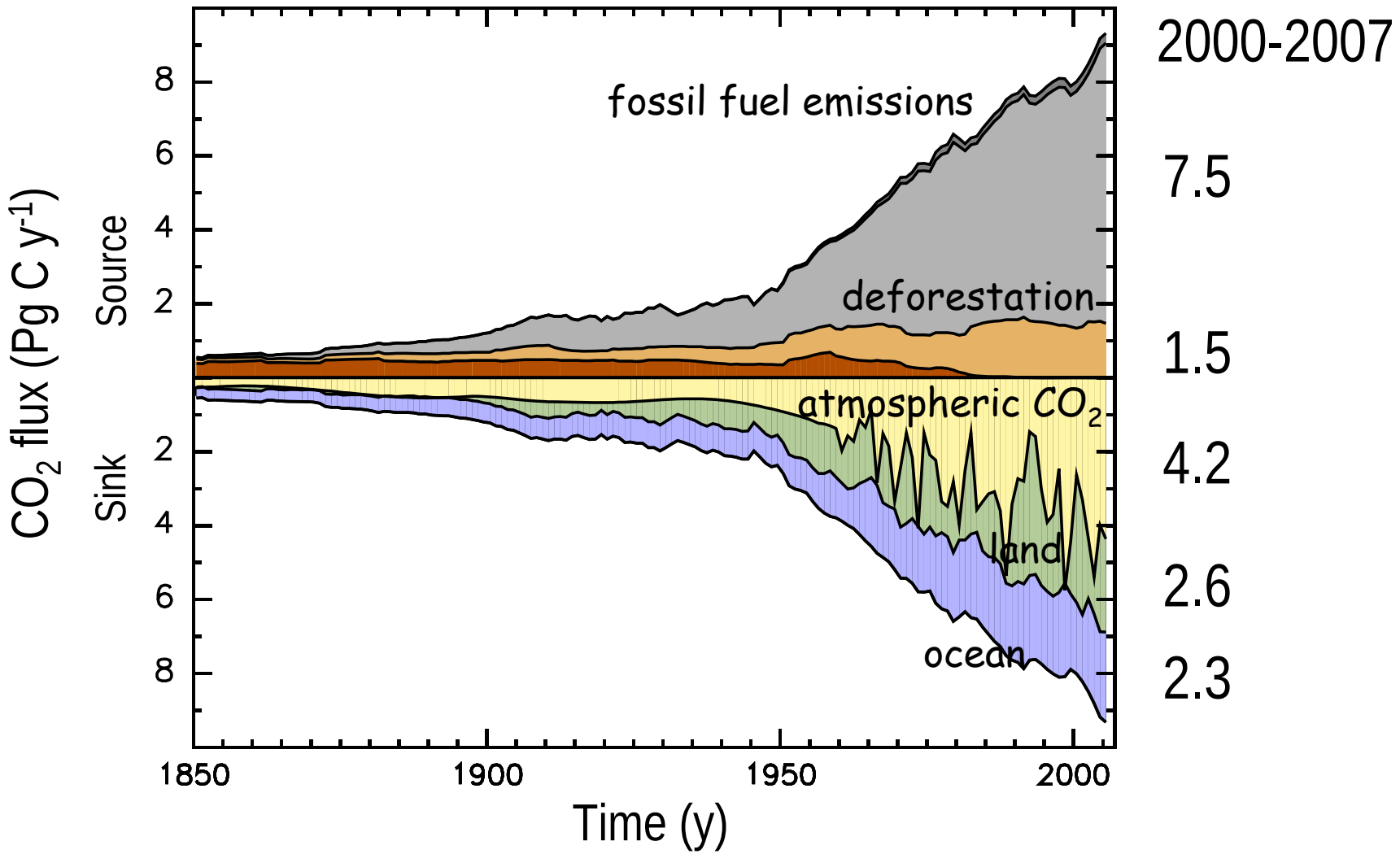
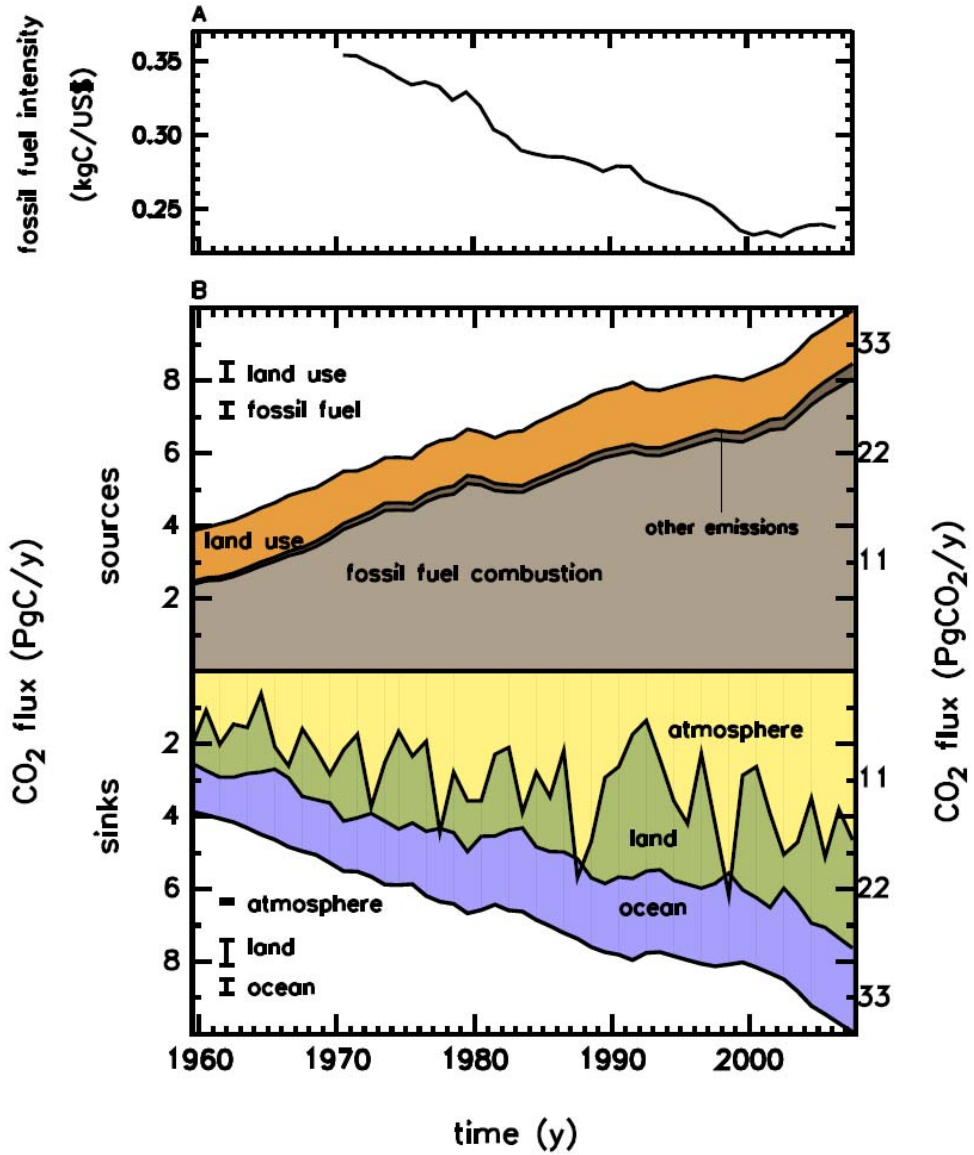


Human Perturbation of the Global Carbon Budget



Canadell et al. 2007, PNAS (updated to 2007)

Drivers of Accelerating Atmospheric CO_2

1970 – 1979: 1.3 ppm y^{-1}
1980 – 1989: 1.6 ppm y^{1}
1990 – 1999: 1.5 ppm y^{-1}

2000 - 2007: 2.0 ppm y^{-1}

To:
- Economic growth
- Carbon intensity
- Efficiency of natural sinks

65% - Increased activity of the global economy

17% - Deterioration of the carbon intensity of the global economy

18% - Decreased efficiency of natural sinks

(calculations based on the period 2000-2006)

Canadell et al. 2007, PNAS

Conclusions (i)

- Anthropogenic CO_2 emissions are growing x4 faster since 2000 than during the previous decade, and above the worst case emission scenario of the Intergovernmental Panel on Climate Change (IPCC).

- Less Developed Countries are now emitting more carbon than Developed Countries.

- The carbon intensity of the world's economy is improving slower than previous decades.

Conclusions (ii)

- The efficiency of natural sinks has decreased by 5% over the last 50 years (and will continue to do so in the future), implying that the longer it takes to begin reducing emissions significantly, the larger the cuts needed to stabilize atmospheric CO_2.

- All these changes have led to an acceleration of atmospheric CO_2 growth 33% faster since 2000 than in the previous two decades, implying a stronger climate forcing and sooner than expected.

www.globalcarbonproject.org info@globalcarbonproject.org