Recent Carbon Trends and the Global Carbon Budget

updated to 2006

GCP-Global Carbon Budget team:
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Last update: 13 June 2008

Outline

1. Recent global carbon trends (2000-2006)
2. The perturbation of the global carbon budget (1850-2006)
3. The declining efficiency of natural CO_2 sinks
4. Attribution of the recent acceleration of atmospheric CO_2
5. Conclusions and implications for climate change

1.

Recent global carbon trends

Anthropogenic C Emissions: Land Use Change

Borneo, Courtesy: Viktor Boehm

Tropical deforestation

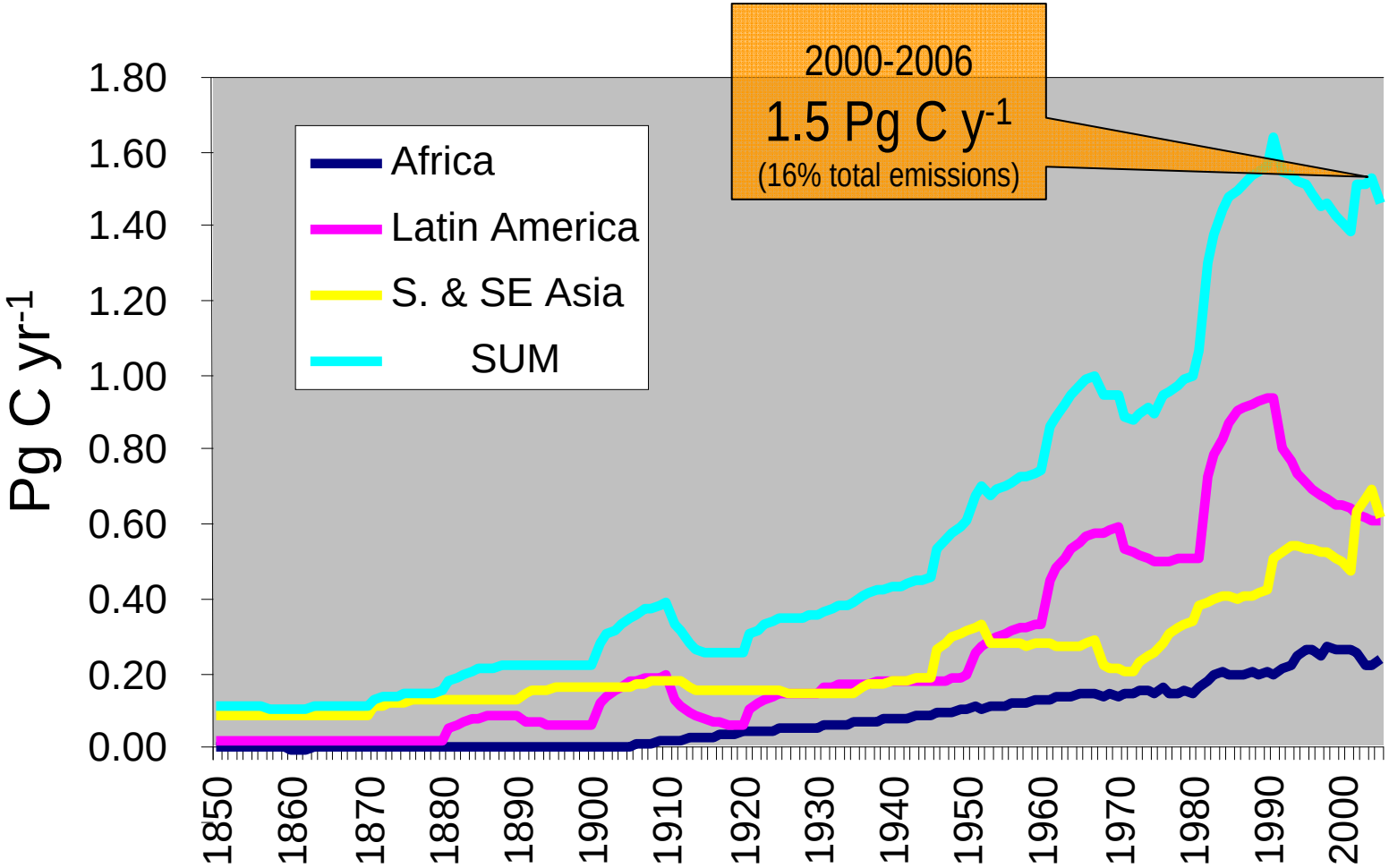
13 Million hectares each year

	2000-2005
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}

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

Anthropogenic C Emissions: Land Use Change

Carbon Emissions from Tropical Deforestation

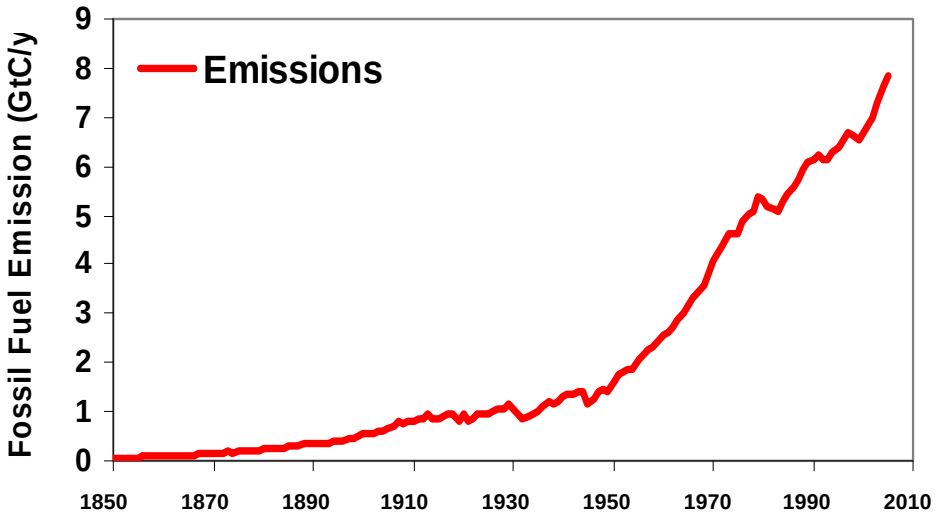


Houghton, unpublished

Anthropogenic C Emissions: Fossil Fuel

2006 Fossil Fuel: 8.4 Pg C

[2006-Total Anthrop. Emissions:8.4+1.5 = 9.9 Pg]

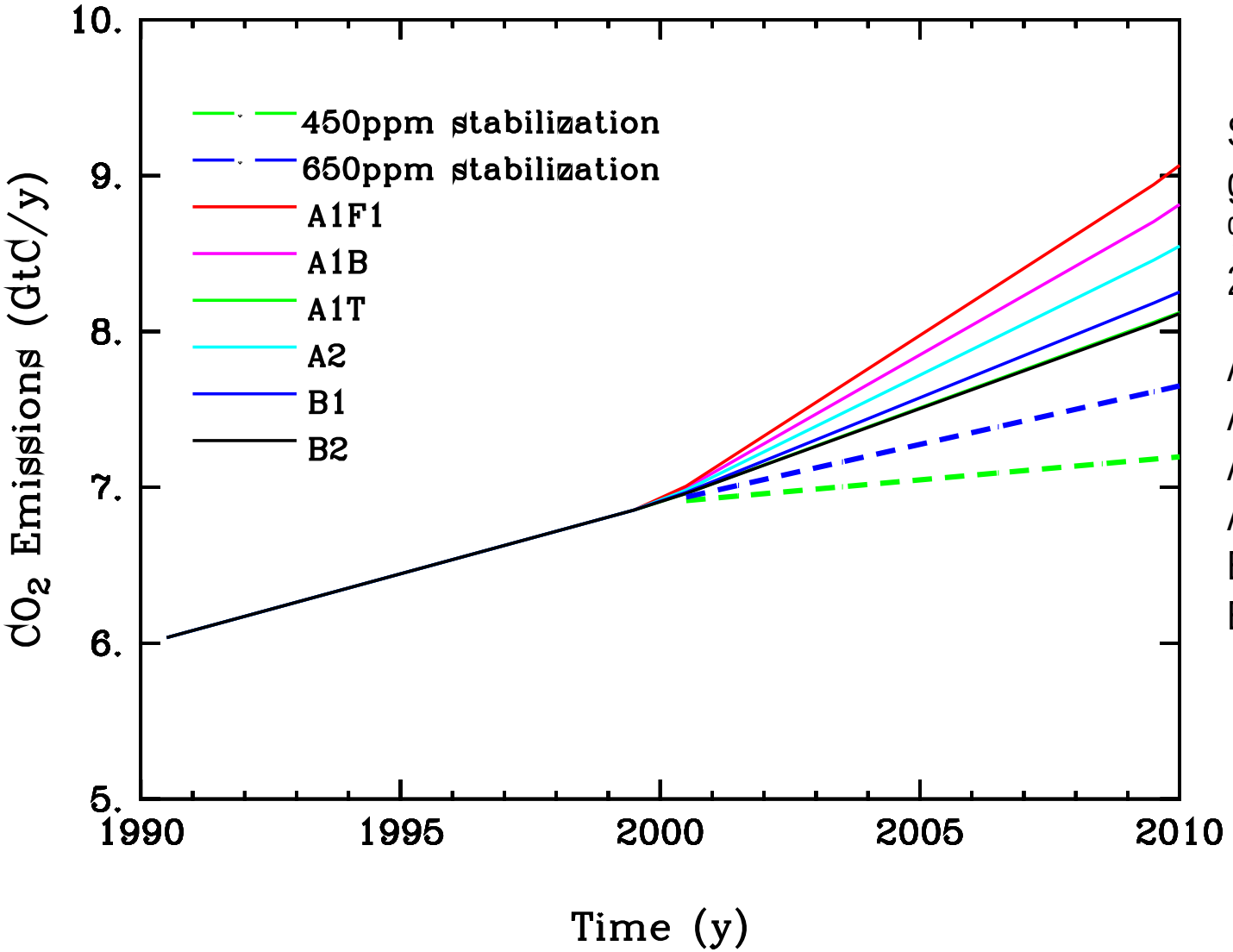


1990 - 1999: 1.3% y^{-1}

2000 - 2006: 3.3% y^{-1}

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

Trajectory of Global Fossil Fuel Emissions

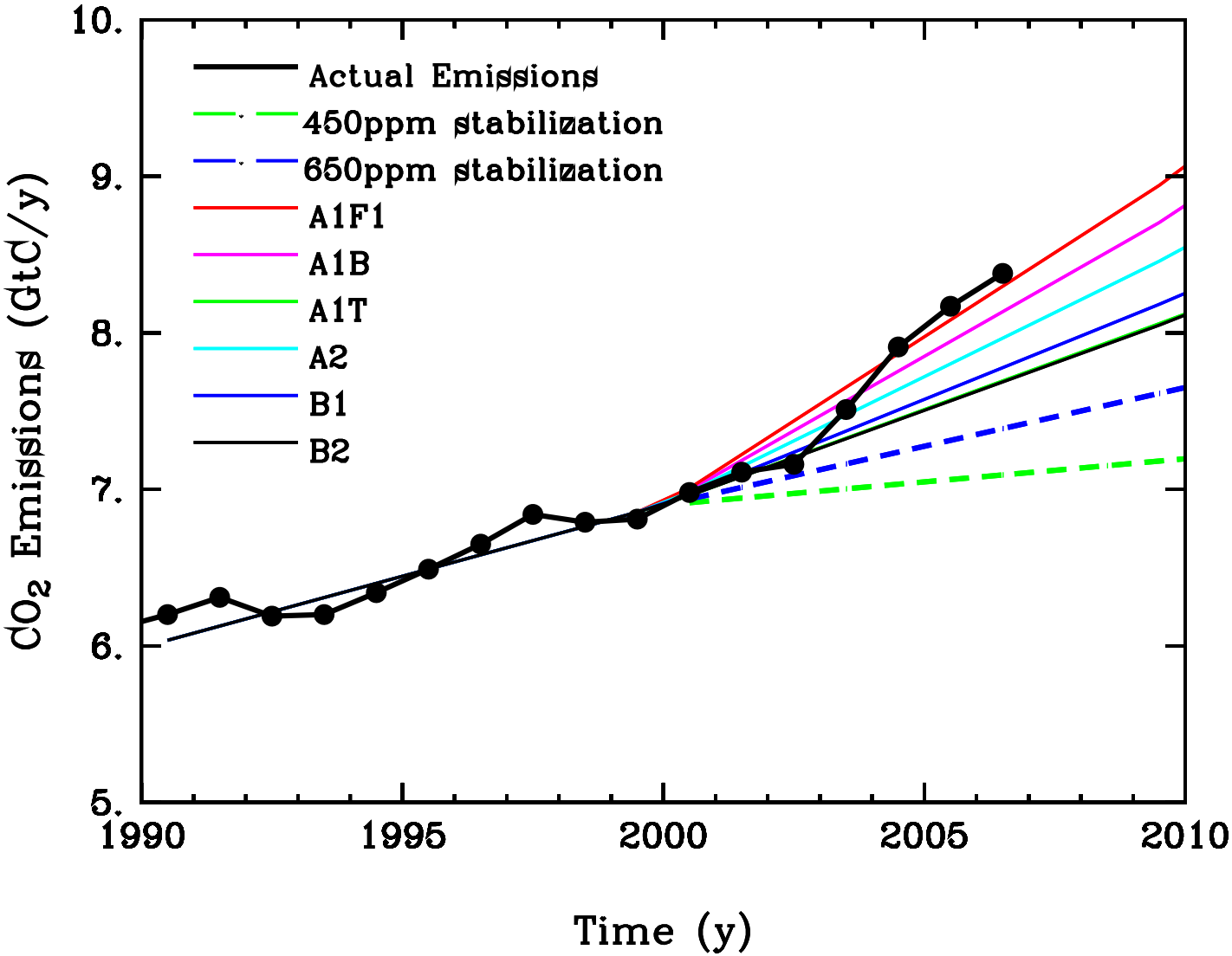


SRES (2000) growth rates in % y^{-1} for 2000-2010:

A1B: 2.42
A1FI: 2.71
A1T: 1.63
A2: 2.13
B1: 1.79
B2: 1.61

Raupach et al. 2007, PNAS

Trajectory of Global Fossil Fuel Emissions



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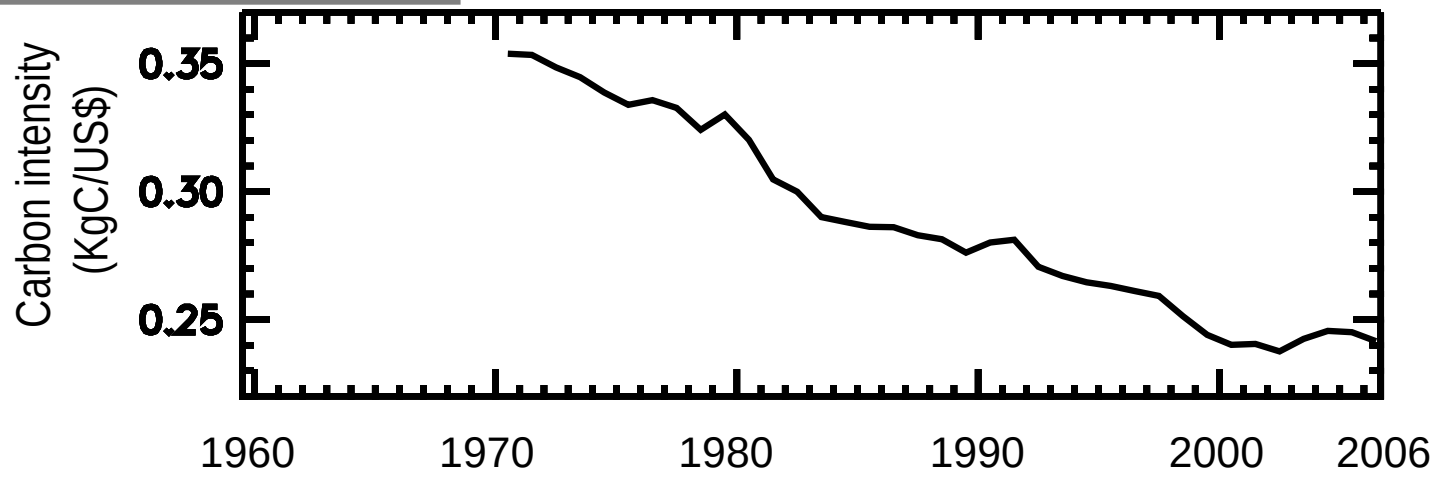
Observed 2000-2006 3.3%

Raupach et al. 2007, PNAS

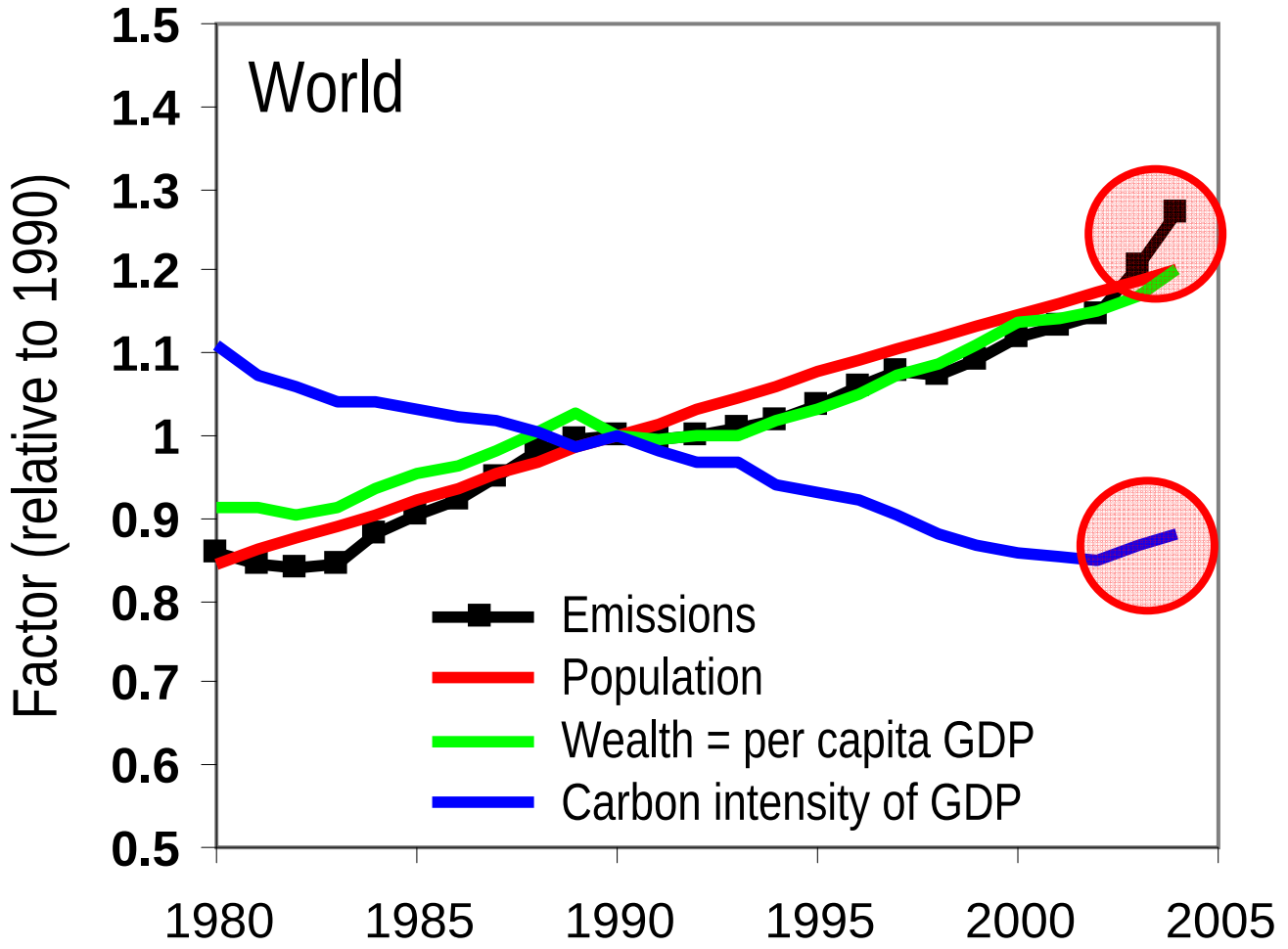
Carbon Intensity of the Global Economy

Photo: CSIRO



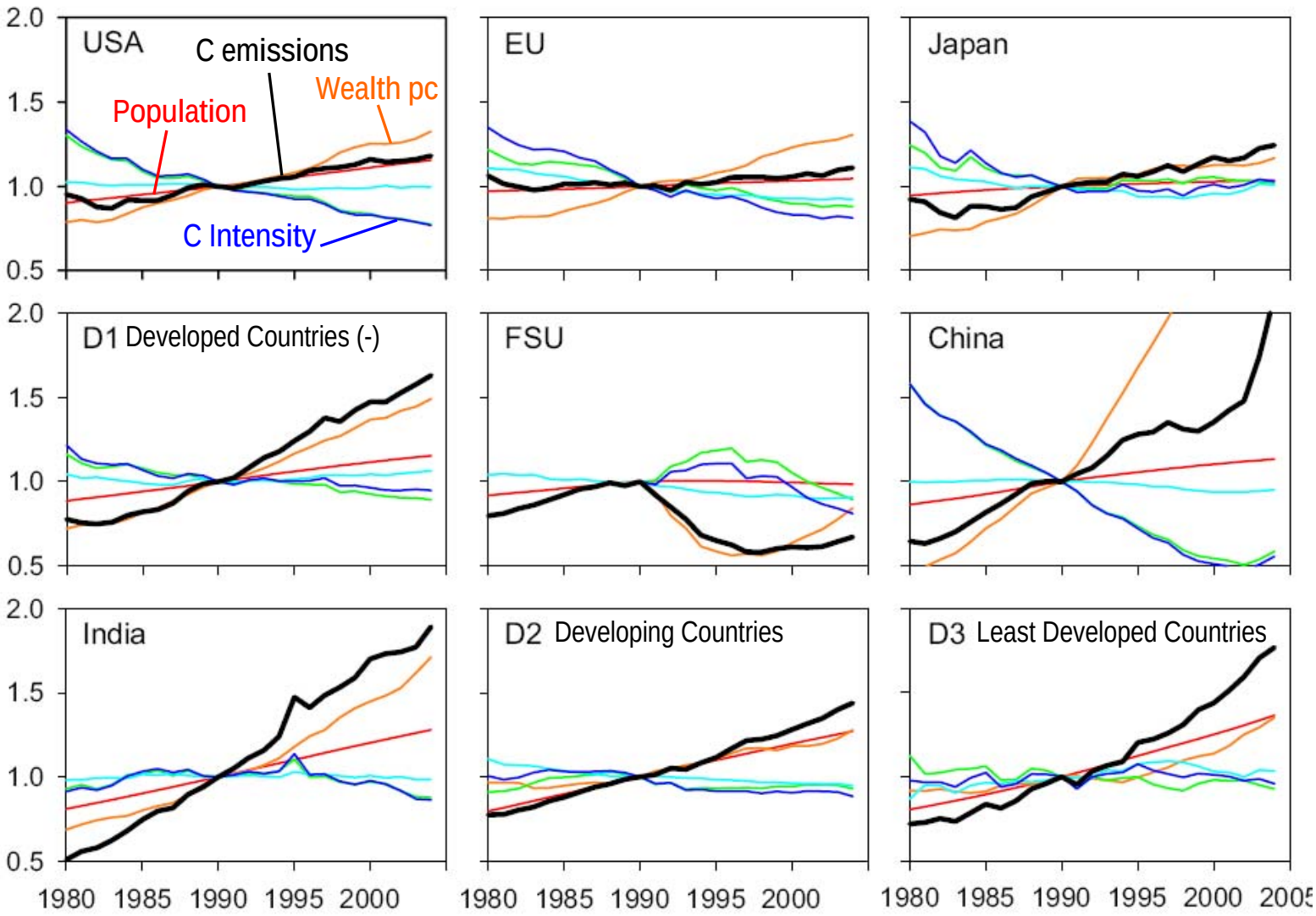
Canadell et al. 2007, PNAS

Drivers of Anthropogenic Emissions



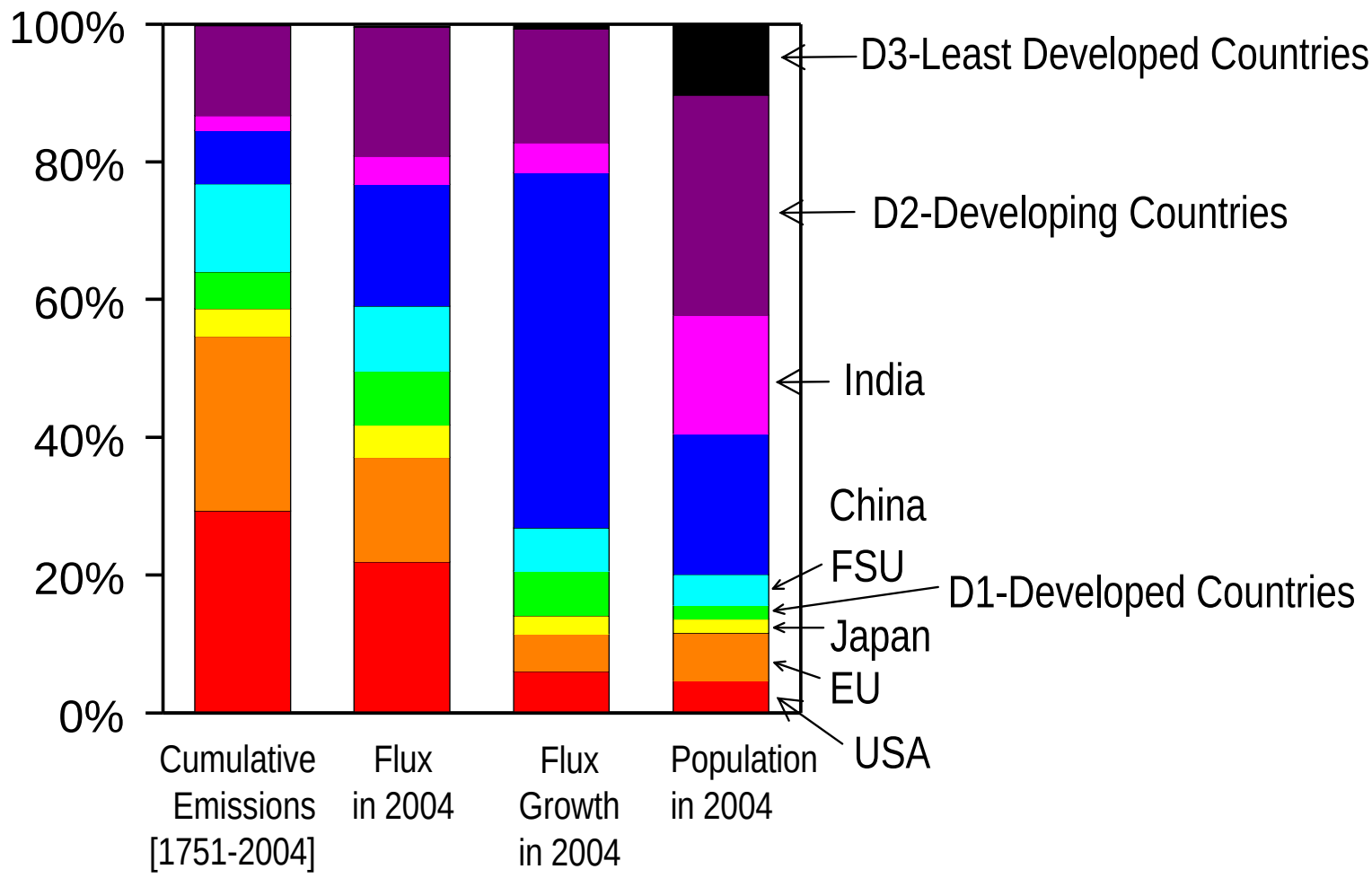
Raupach et al 2007, PNAS

Regional Pathways (Kaya identity)



Raupach et al 2007, PNAS

Anthropogenic C Emissions: Regional Contributions



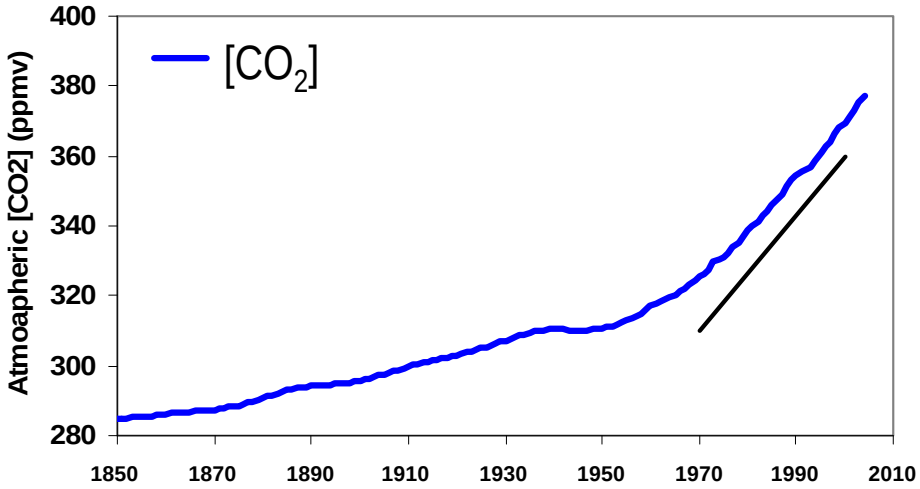
Raupach et al. 2007, PNAS

Atmospheric CO_2 Concentration

Year 2007
Atmospheric CO_2 concentration:

382.6 ppm

35% above pre-industrial



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

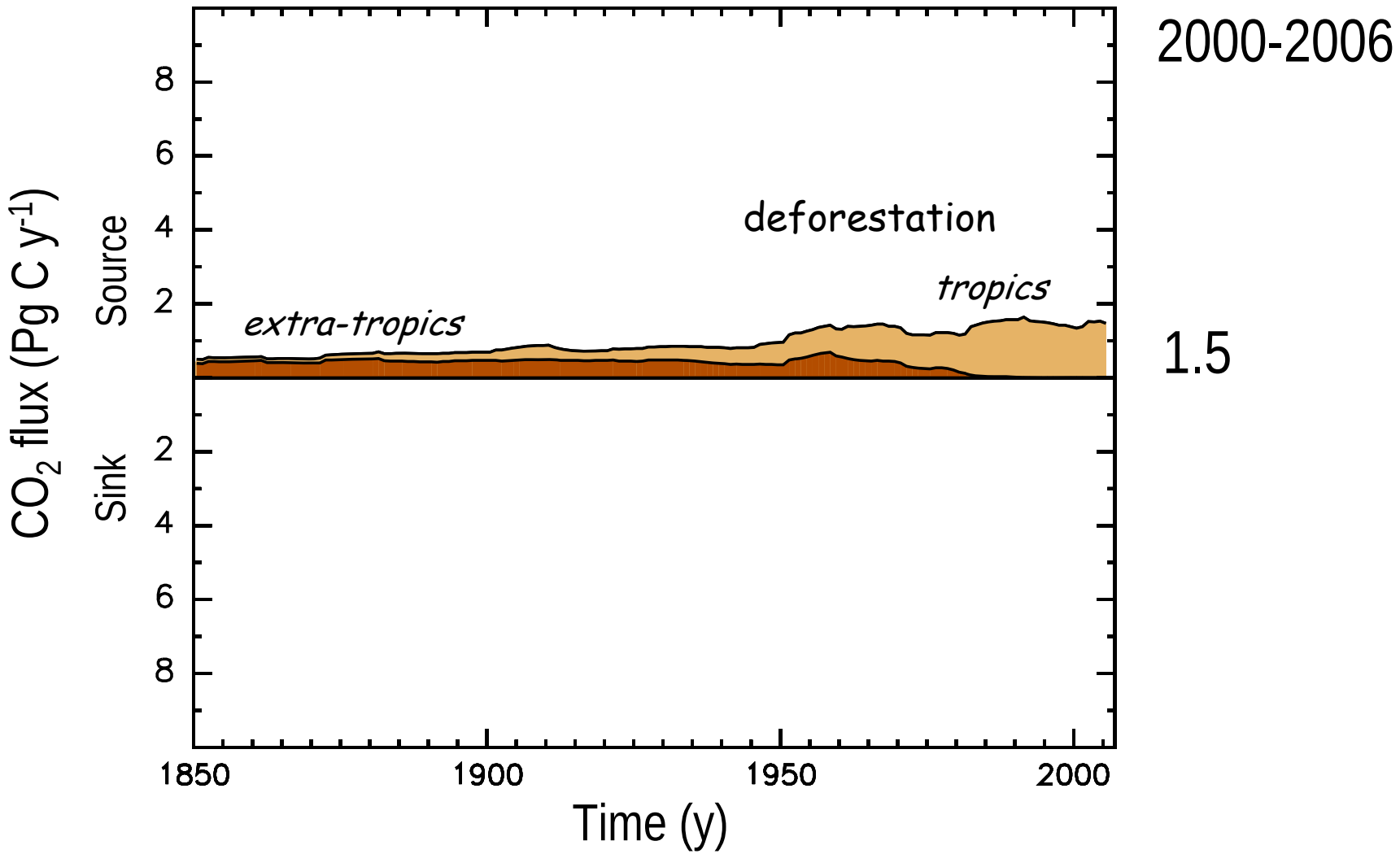
2000 - 2006: 1.9 ppm y^{-1}

NOAA 2007; Canadell et al. 2007, PNAS

2.

The perturbation of the global carbon cycle (1850-2006)

Perturbation of Global Carbon Budget (1850-2006)



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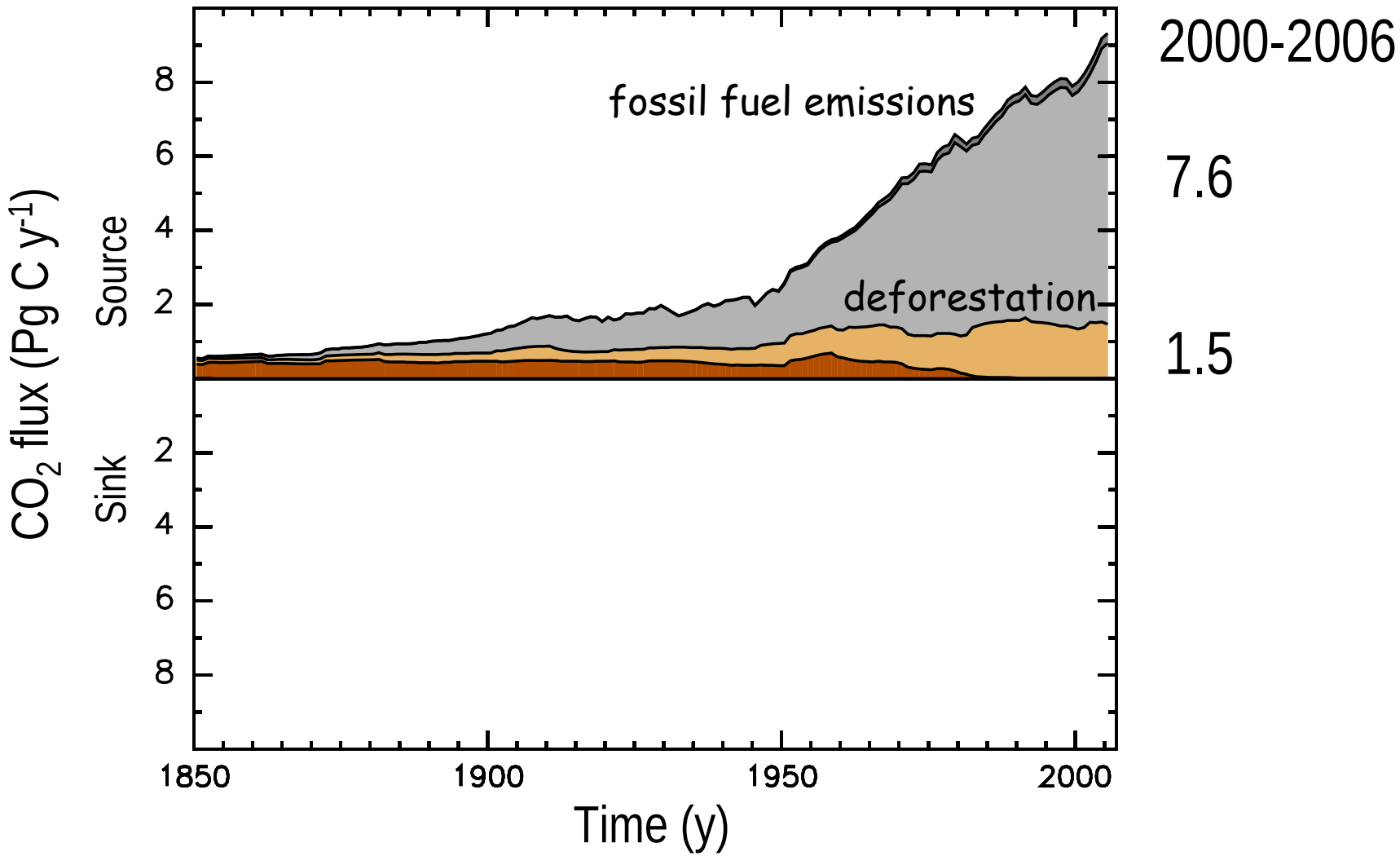

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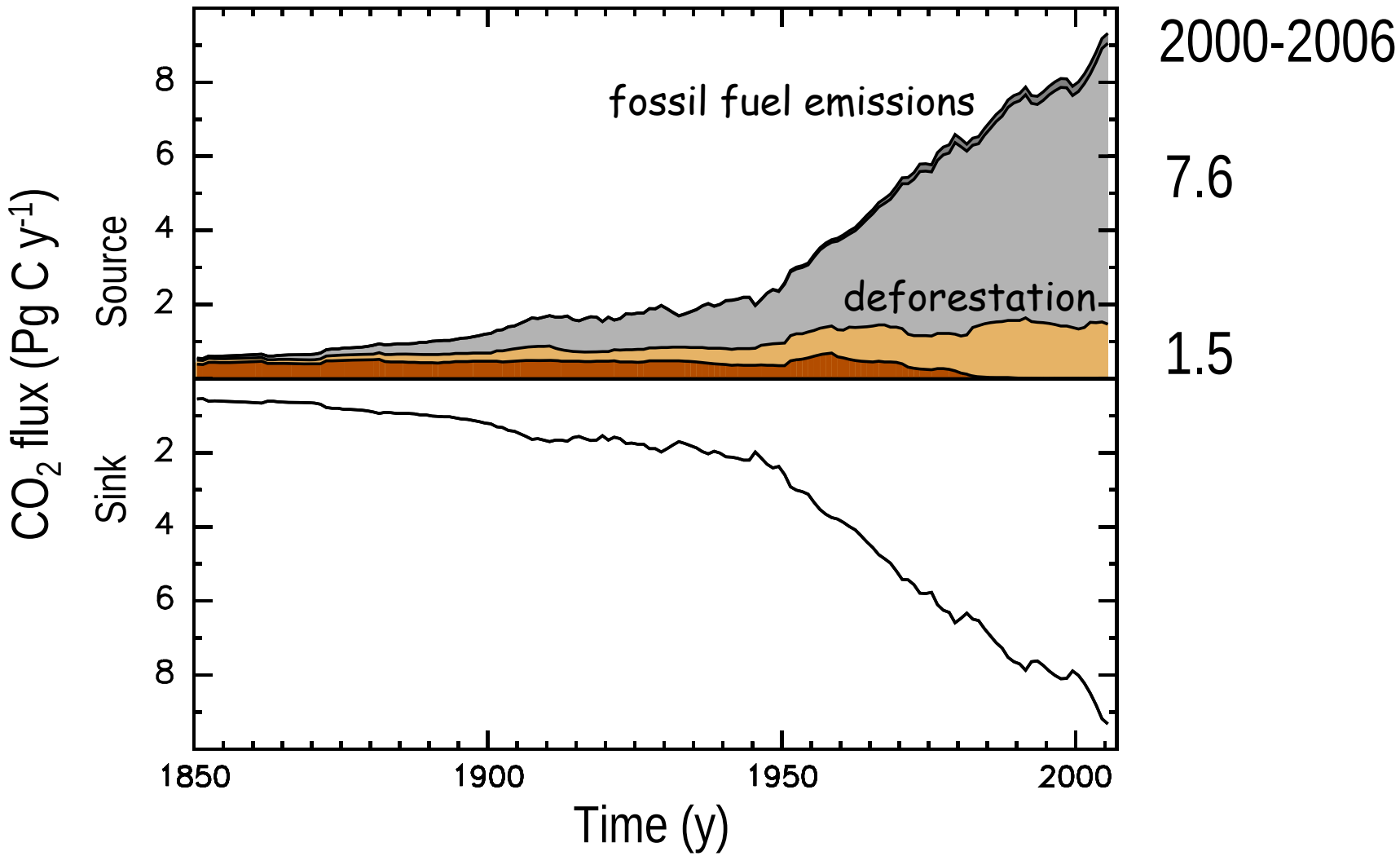

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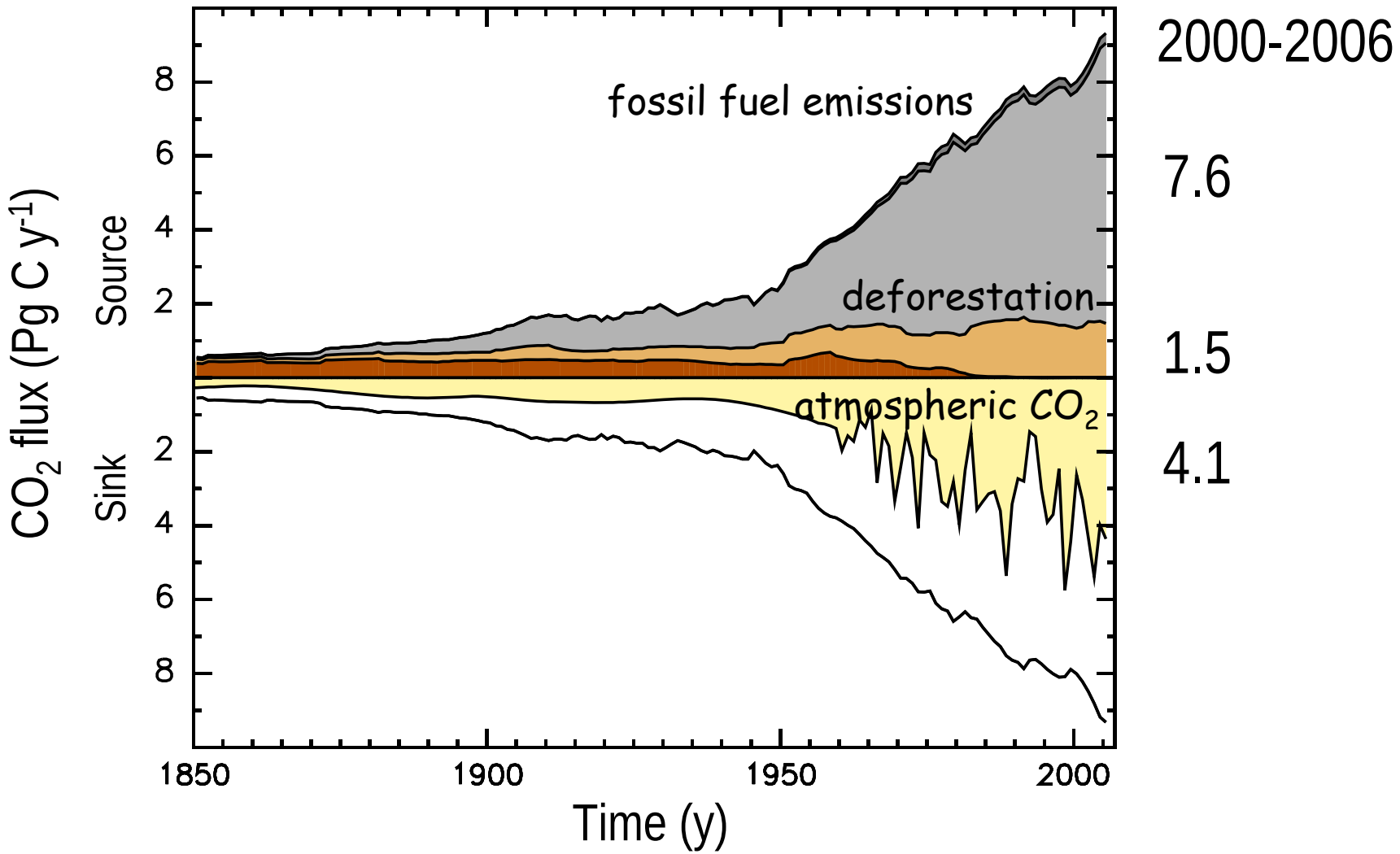

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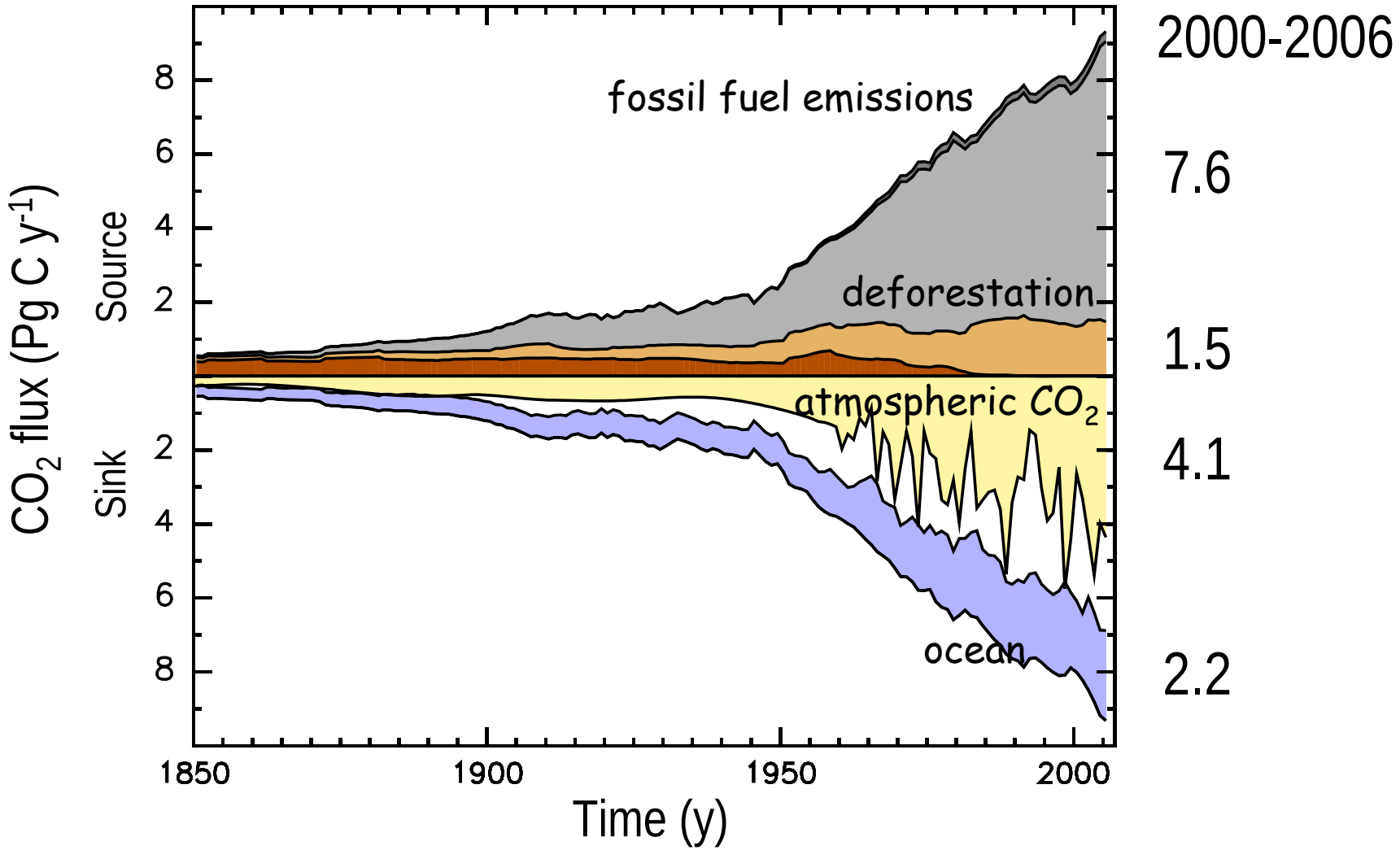

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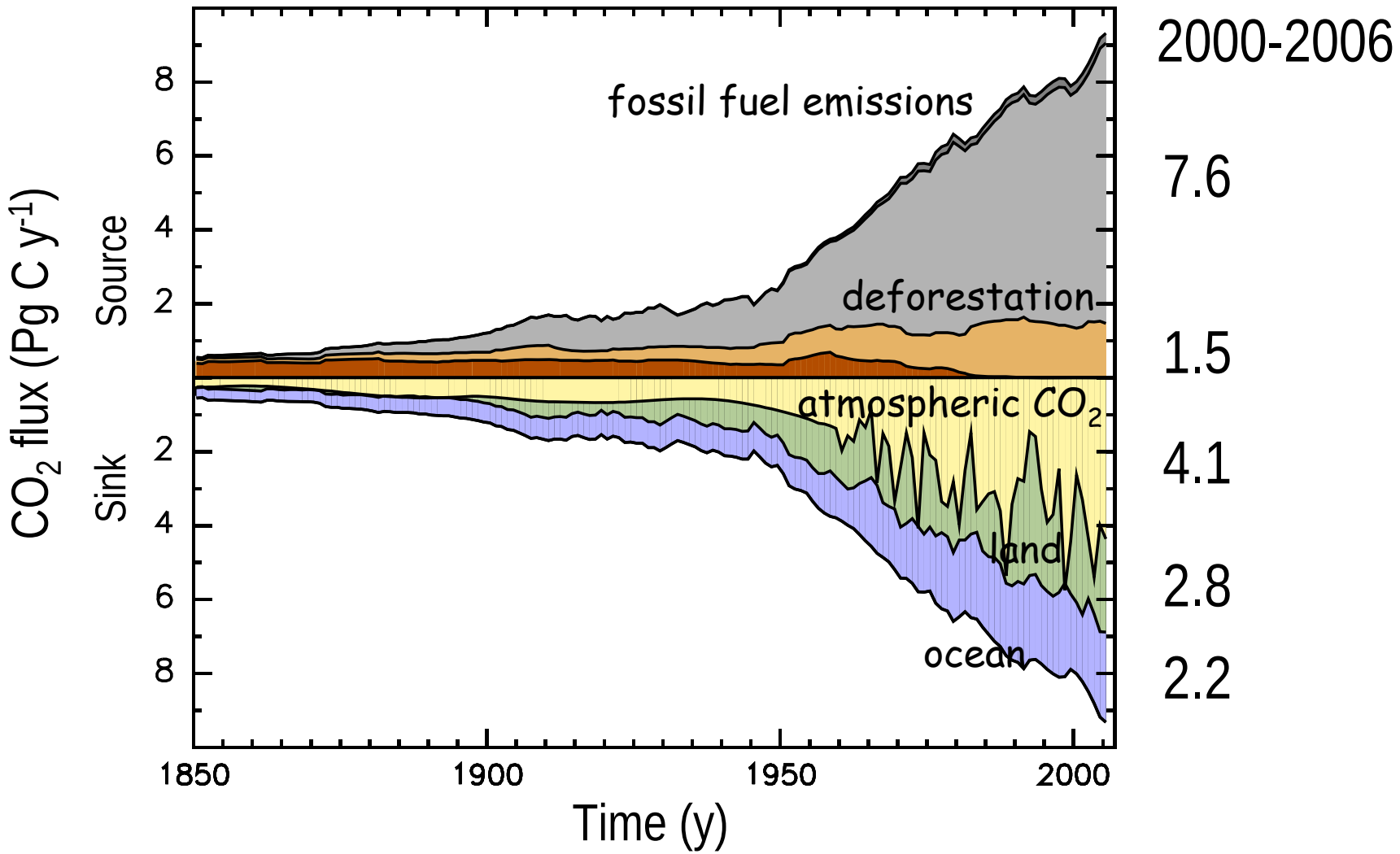
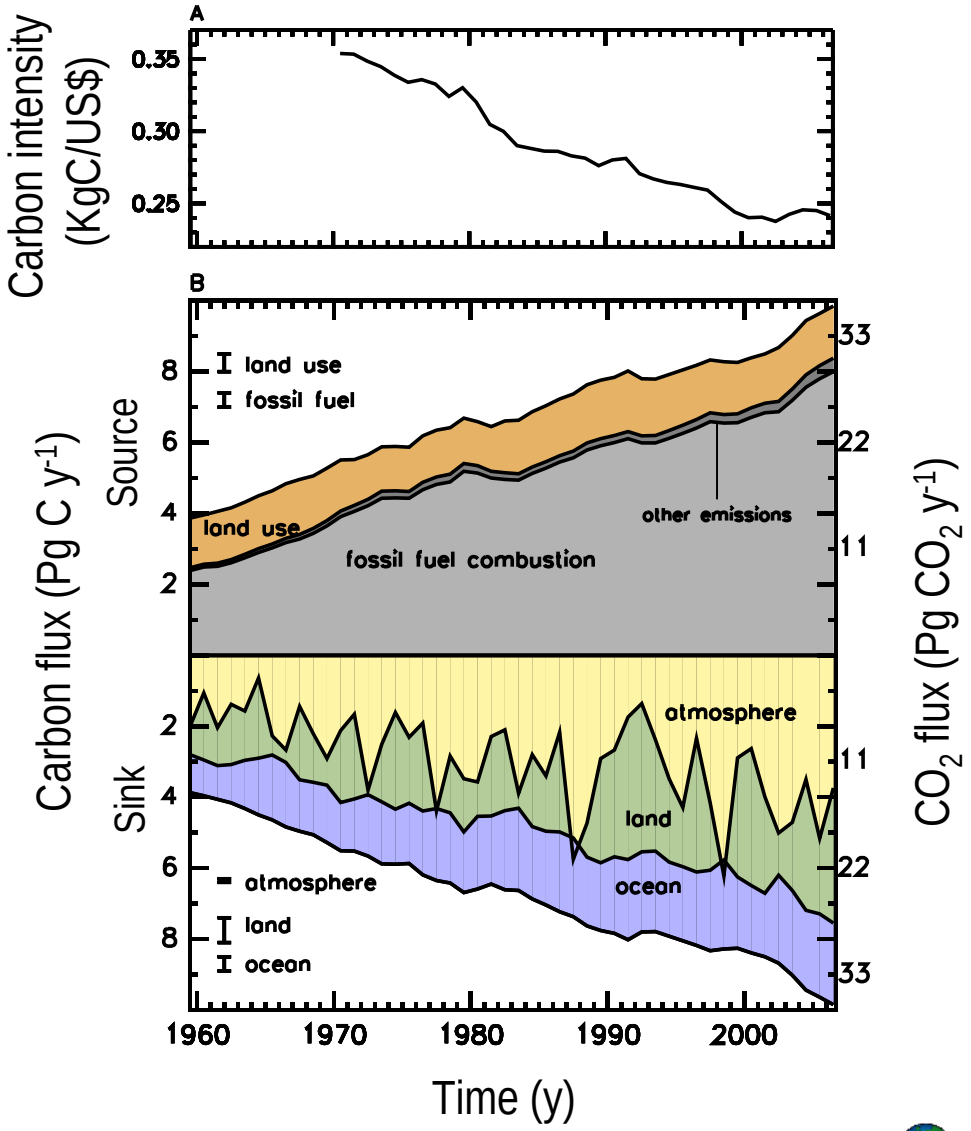


Le Quéré, unpublished; Canadell et al. 2007, PNAS

Perturbation of the Global Carbon Budget (1959-2006)



Canadell et al. 2007, PNAS

3.

The declining efficiency of natural sinks

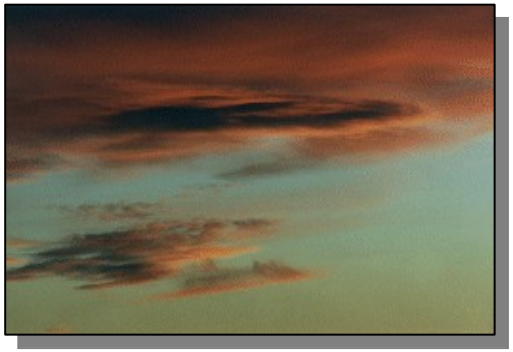
Fate of Anthropogenic CO_2 Emissions (2000-2006)

1.5 Pg C y^{-1}

+

7.6 Pg C y^{-1}

4.1 Pg y^{-1}
Atmosphere
45%



2.8 Pg y^{-1}
Land
30%

2.2 Pg y^{-1}
Oceans
25%

Canadell et al. 2007, PNAS

Climate Change at 55% Discount

Natural sinks absorb 5 billions tons of CO_2 globally every year, or 55% of all anthropogenic carbon emissions.

Canadell et al. 2007, PNAS

Natural Sinks: Large Economic Subsidy

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

Canadell & Raupach 2008, Science

Factors that Influence the Airborne Fraction

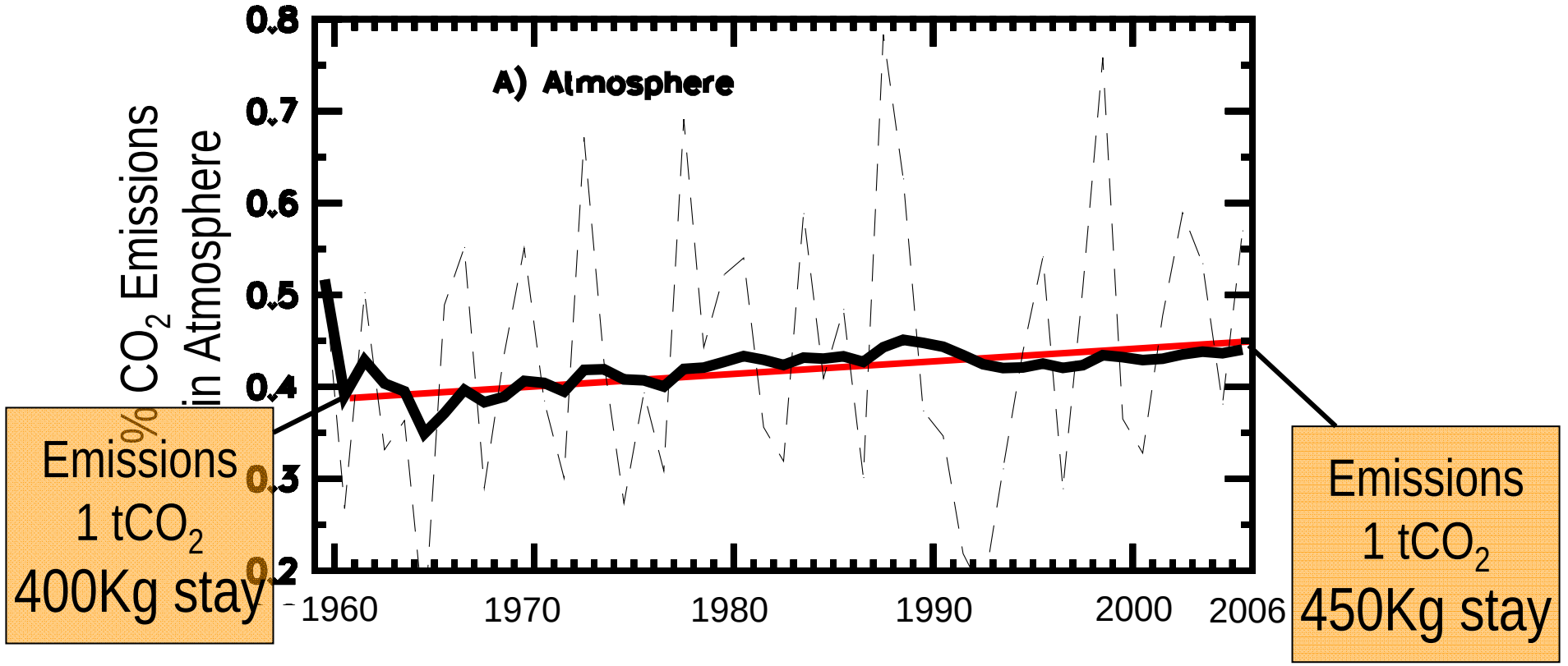
1. The rate of CO_2 emissions.

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, …

Canadell et al. 2007, Springer; Gruber et al. 2004, Island Press

Decline in the Efficiency of CO_2 Natural Sinks

Fraction of anthropogenic emissions that stay in the atmosphere

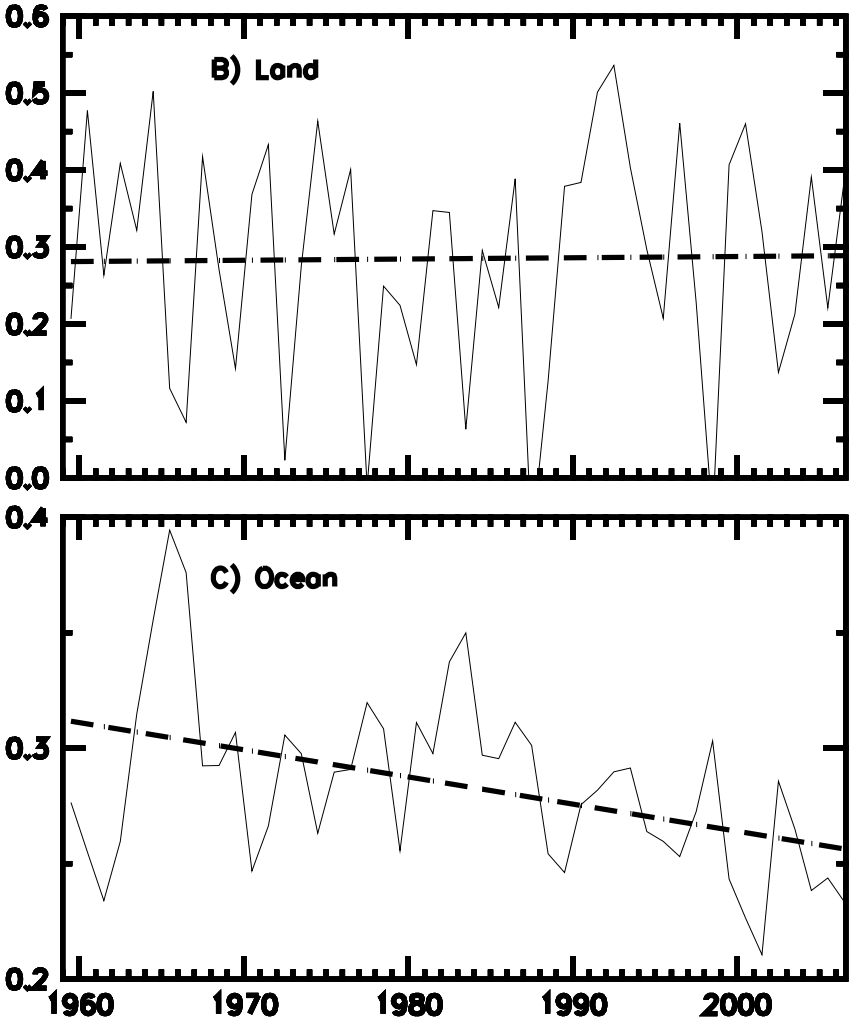


Canadell et al. 2007, PNAS

Efficiency of Natural Sinks

Land Fraction

Ocean Fraction



Canadell et al. 2007, PNAS

Causes of the Declined in the Efficiency of the Ocean Sink

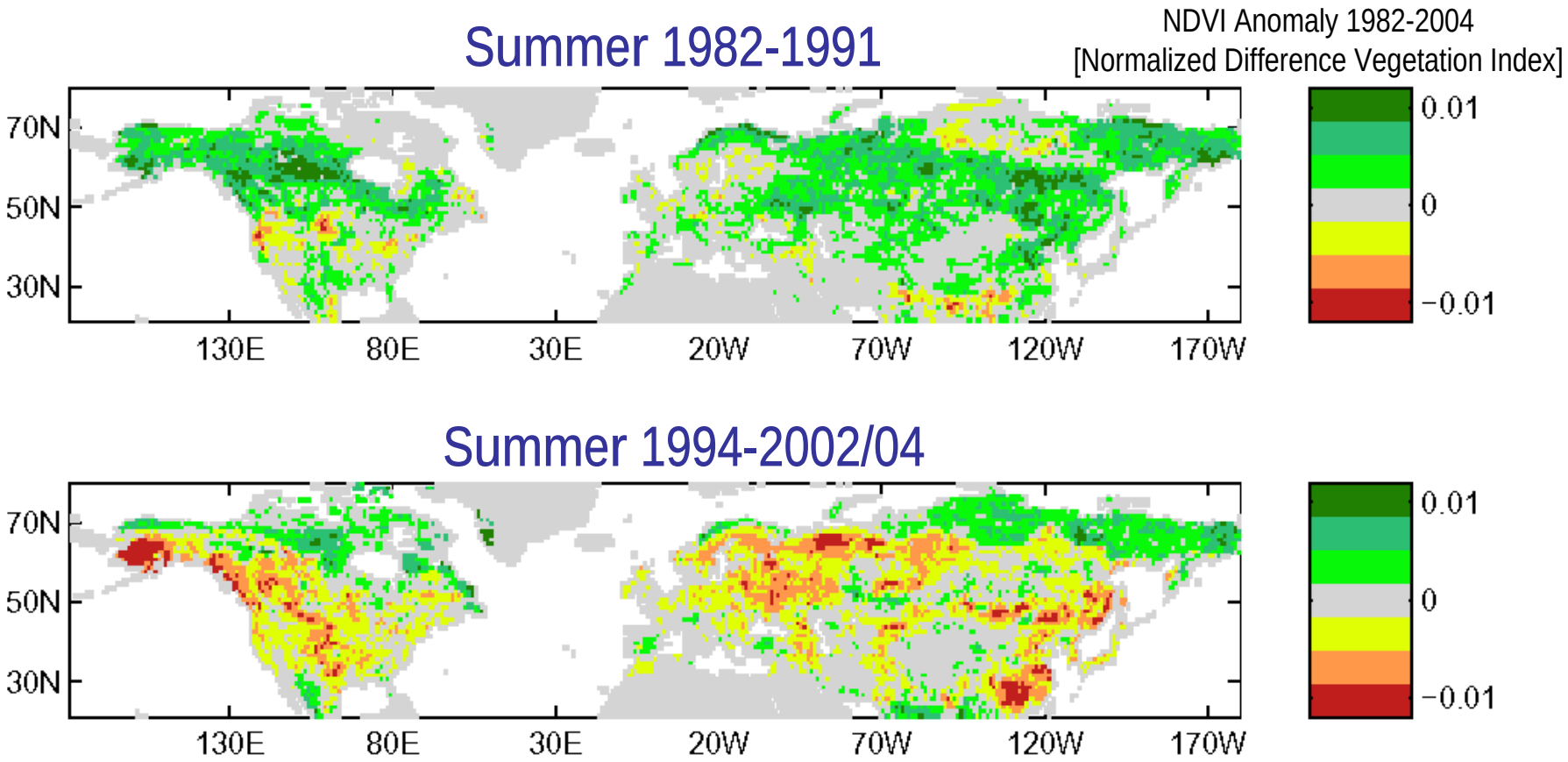
Credit: N.Metzl, August 2000, oceanographic cruise OISO-5

- 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

Drought Effects on the Mid-Latitude Carbon Sinks

A number of major droughts in mid-latitudes have contributed to the weakening of the growth rate of terrestrial carbon sinks in these regions.



Angert et al. 2005, PNAS; Buermann et al. 2007, PNAS; Ciais et al. 2005, Science

4.

Attribution of the recent acceleration of atmospheric CO_2

Attribution of Recent Acceleration of 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 - 2006: 1.9 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

Canadell et al. 2007, PNAS

5.

Conclusions and implications for climate change

Conclusions (i)

Since 2000:

- The growth of carbon emissions from fossil fuels has tripled compared to the 1990s and is exceeding the predictions of the highest IPCC emission scenarios.

- Atmospheric CO_2 has grown at 1.9 ppm per year
  (compared to about 1.5 ppm during the previous 30 years)

- The carbon intensity of the world's economy has stopped decreasing (after 100 years of doing so).

Conclusions (ii)

- The efficiency of natural sinks has decreased by 10% over the last 50 years (and will continue to do so in the future), implying that the longer we wait to reduce emissions, the larger the cuts needed to stabilize atmospheric CO_2.
- All of these changes characterize a carbon cycle that is generating stronger climate forcing and sooner than expected.

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