Carbon Budget

2007


Last update:
26 September 2008
1. Atmospheric CO₂ Concentration
2. CO₂ Emissions from Fossil Fuel and Cement
3. Drivers of Fossil Fuel Emissions
4. CO₂ Emissions from Land Use Change
5. Natural CO₂ Sinks
6. Summary of the Global Carbon Budget
1. Atmospheric CO$_2$ Concentration
Year 2007
Atmospheric CO₂ 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

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

2007 Fossil Fuel: 8.5 Pg C

1990 - 1999: 0.9% y\(^{-1}\)
2000 - 2007: 3.5% y\(^{-1}\)
Fossil Fuel Emissions: Actual vs. IPCC Scenarios

Raupach et al. 2007, PNAS (updated)
Regional Shift in Emissions Share

Percentage of Global Annual Emissions

- Annex B
- Non Annex B

FCCC
Kyoto Protocol Adopted
Kyoto Protocol Enter into Force
Current

J. Gregg and G. Marland, 2008, personal communication
Regional Share of Fossil Fuel Emissions

Cumulative Emissions [1751-2004]
Flux in 2004
Flux Growth in 2004
Population in 2004

D3-Least Developed Countries
D2-Developing Countries
India
China
FSU
Japan
EU
USA

Raupach et al. 2007, PNAS
3. Drivers of fossil fuel emissions
Carbon Intensity of the Global Economy

Kg Carbon Emitted to Produce 1 $ of Wealth

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<tr>
<td>Kg Carbon Emit. (Kg/US$)</td>
<td>0.35</td>
<td>0.30</td>
<td>0.25</td>
<td>0.20</td>
<td>0.15</td>
<td>0.10</td>
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Raupach et al. 2007, PNAS; Canadell et al. 2007, PNAS

Photo: CSIRO
Drivers of Anthropogenic Emissions

The graph illustrates the factors contributing to anthropogenic emissions from 1980 to 2005. The x-axis represents the years 1980 to 2005, while the y-axis shows the factor relative to 1990. The graph compares emissions, population, wealth (per capita GDP), and carbon intensity of GDP. The data is sourced from 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

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

[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

Carbon Emissions from Tropical Deforestation

2000-2007
1.5 Pg C yr\(^{-1}\)
(16% total emissions)
Regional Share of Emissions from Land Use Change

Regional Emissions from LUC&F

- **South & S.E. Asia**
  - Deforestation: 25%
  - C Flux: 41%
- **Tropical Africa**
  - Deforestation: 35%
  - C Flux: 17%
- **S. & Central America**
  - Deforestation: 40%
  - C Flux: 43%
5.

Natural CO$_2$ sinks
Fate of Anthropogenic CO₂ Emissions (2000-2007)

1.5 Pg C y⁻¹ + 7.5 Pg C y⁻¹

Atmosphere
4.2 Pg y⁻¹
46%

Land
2.6 Pg y⁻¹
29%

Oceans
2.3 Pg y⁻¹
26%

Canadell et al. 2007, PNAS (updated)
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$** annually if an equivalent sink had to be created using other climate mitigation options (based on the cost of carbon in the EU-ETS).
1. The rate of CO$_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

Emissions 1 tCO$_2$
400Kg stay

Emissions 1 tCO$_2$
450Kg stay
Efficiency of Natural Sinks

Land Fraction

Ocean Fraction

Canadell et al. 2007, PNAS
Causes of the Declined in the Efficiency of the Ocean Sink

- 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.
6. Summary of the global carbon budget
Human Perturbation of the Global Carbon Budget

Global Carbon Project (2008)
Human Perturbation of the Global Carbon Budget

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Human Perturbation of the Global Carbon Budget

Canadell et al. 2007, PNAS (updated to 2007)
Drivers of Accelerating Atmospheric CO₂

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)
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.
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 CO₂.

All these changes have led to an acceleration of atmospheric CO₂ growth 33% faster since 2000 than in the previous two decades, implying a stronger climate forcing and sooner than expected.