Toward a new global carbon budget : challenges and role of land use emissions

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Publications

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opinion & comment

COMMENTARY:

The challenge to keep global warming below 2 °C

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The latest carbon dioxide emissions continue to track the high end of emission scenarios, making it even less likely global warming will stay below 2 °C. A shift to a 2 °C pathway requires immediate significant and sustained global mitigation, with a probable reliance on net negative emissions in the longer term.

On-going climate negotiations have recognized a "significant gap" between the current trajectory of global greenhouse-gas emissions and the "likely chance of holding the increase in global average temperature below 2 °C or 1.5 °C above pre-industrial levels"[1]. Here we compare recent trends in carbon dioxide (CO_2) emissions from fossil-fuel combustion, cement production and gas flaring with the primary emission scenarios used by the Intergovernmental Panel on Climate Change (IPCC). Carbon dioxide emissions are the largest contributor to long-term climate change and thus provide a good baseline to assess progress and examine consequences. We find that current emission trends continue to track scenarios that lead to the highest temperature increases. Further delay in global mitigation makes it increasingly difficult to stay below 2 °C.

Long-term emissions scenarios are designed to represent a range of plausible emission trajectories as input for climate change research[2,3]. The IPCC process has resulted in four generations of emissions scenarios[2]: Scientific Assessment 1990 (SA90)[4], IPCC Scenarios 1992 (IS92)[5], Special Report on Emissions Scenarios (SRES)[6], and the evolving Representative Concentration Pathways (RCPs)[7] to be used in the upcoming IPCC Fifth Assessment Report. The RCPs were developed by the research community as a new, parallel process of scenario development, whereby climate models are run using the RCPs while simultaneously socioeconomic and emission scenarios are developed that span the range of the RCPs and beyond[3].

It is important to regularly re-assess the relevance of emissions scenarios in light of changing global circumstances[3,8]. In the past, decadal trends in CO_2 emissions have responded slowly to changes in the underlying emission drivers because of inertia and path dependence in technical, social and political systems[9]. Inertia and path dependence are unlikely to be affected by short-term fluctuations[2,3,9] — such as financial crises[10] — and it is probable that emissions will continue to rise for a period even after global mitigation has started[11]. Thermal inertia and vertical mixing in the ocean, also delay the temperature response to CO_2 emissions[12]. Because of inertia, path dependence and changing global circumstances, there is value in comparing

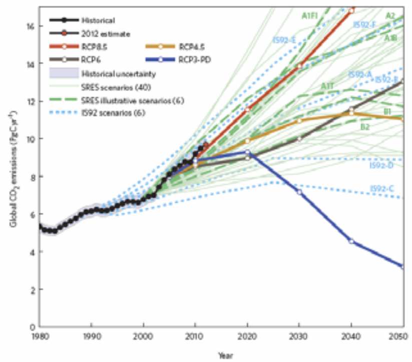

Figure 1 | Estimated CO_2 emissions over the past three decades compared with the IS92, SRES and the RCPs. The SA90 data are not shown, but the most relevant (SA90-A) is similar to IS92-A and IS92-F. The uncertainty in historical emissions is ±5% (one standard deviation). Scenario data is generally reported at decadal intervals and we use linear interpolation for intermediate years.

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This discussion paper is/has been under review for the journal Earth System Science Data (ESSD). Please refer to the corresponding final paper in ESSD if available.

The global carbon budget 1959–2011

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More information, data sources and data files at

www.globalcarbonproject.org

Fossil and Cement Emissions

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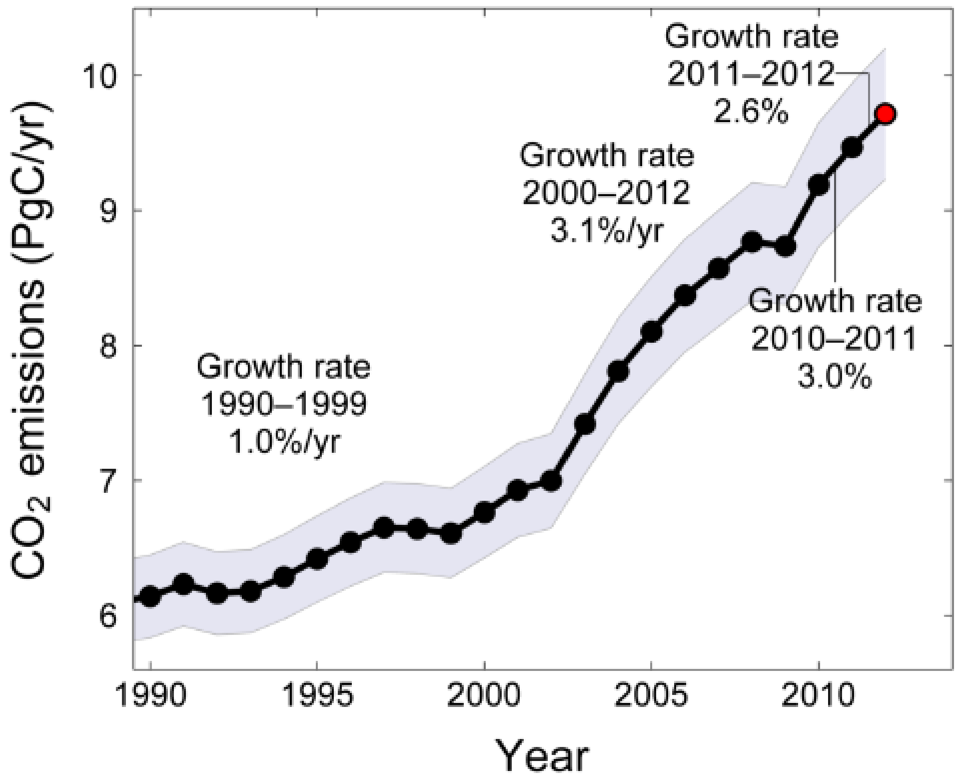
Global fossil and cement emissions: 9.5±0.5PgC in 2011, 54% over 1990

Estimate for 2012: 9.7±0.5PgC, 58% over 1990



Uncertainty is 5% for one standard deviation (IPCC "likely" range)

Source: Peters et al. 2012; Le Quéré et al. 2012; Global Carbon Project 2012; CDIAC Data

Observed Emissions and Emission Scenarios

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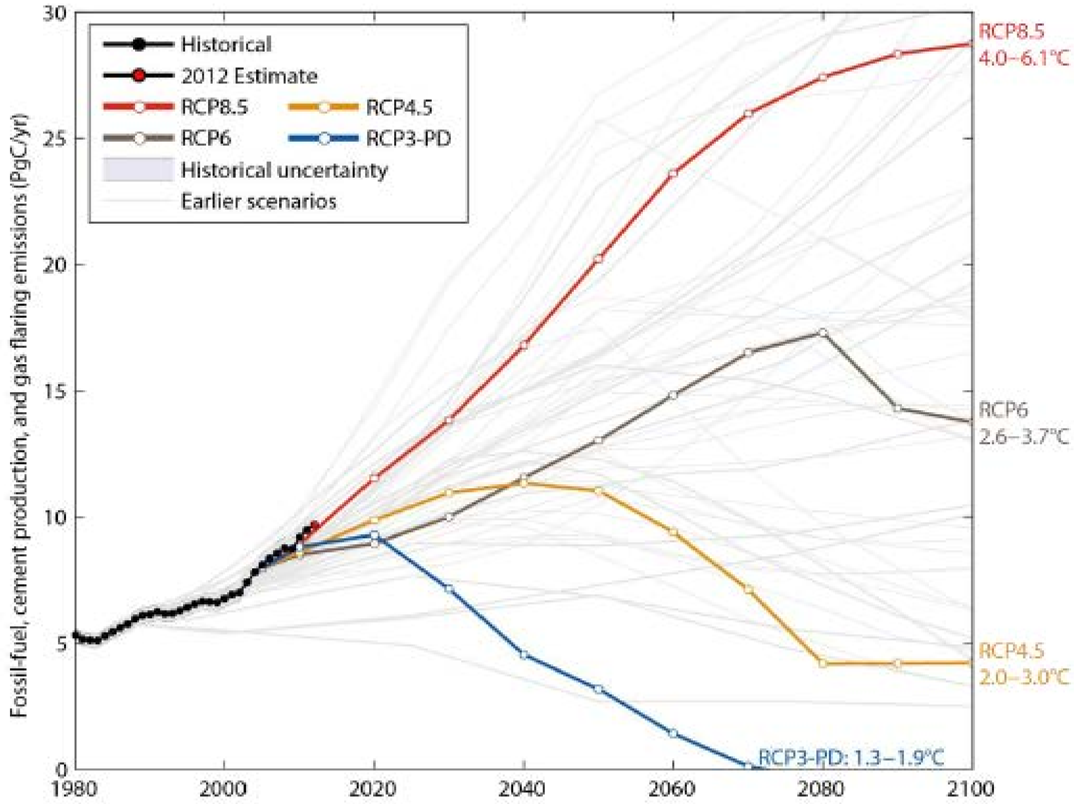
Emissions are heading to a 4.0-6.1°C "likely" increase in temperature

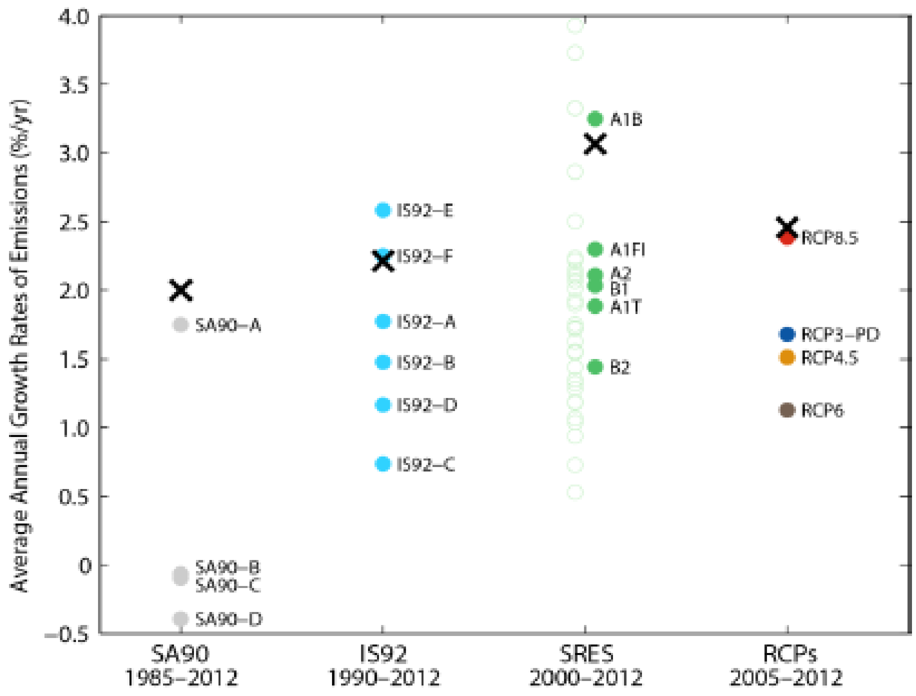
Considerable effect required to keep below 2°C



Source: Peters et al. 2012; Le Quéré et al. 2012; Global Carbon Project 2012; CDIAC Data

Observed Emissions and Emission Scenarios

Observed emissions (**X**) continue to track the top-end of all scenarios (●)



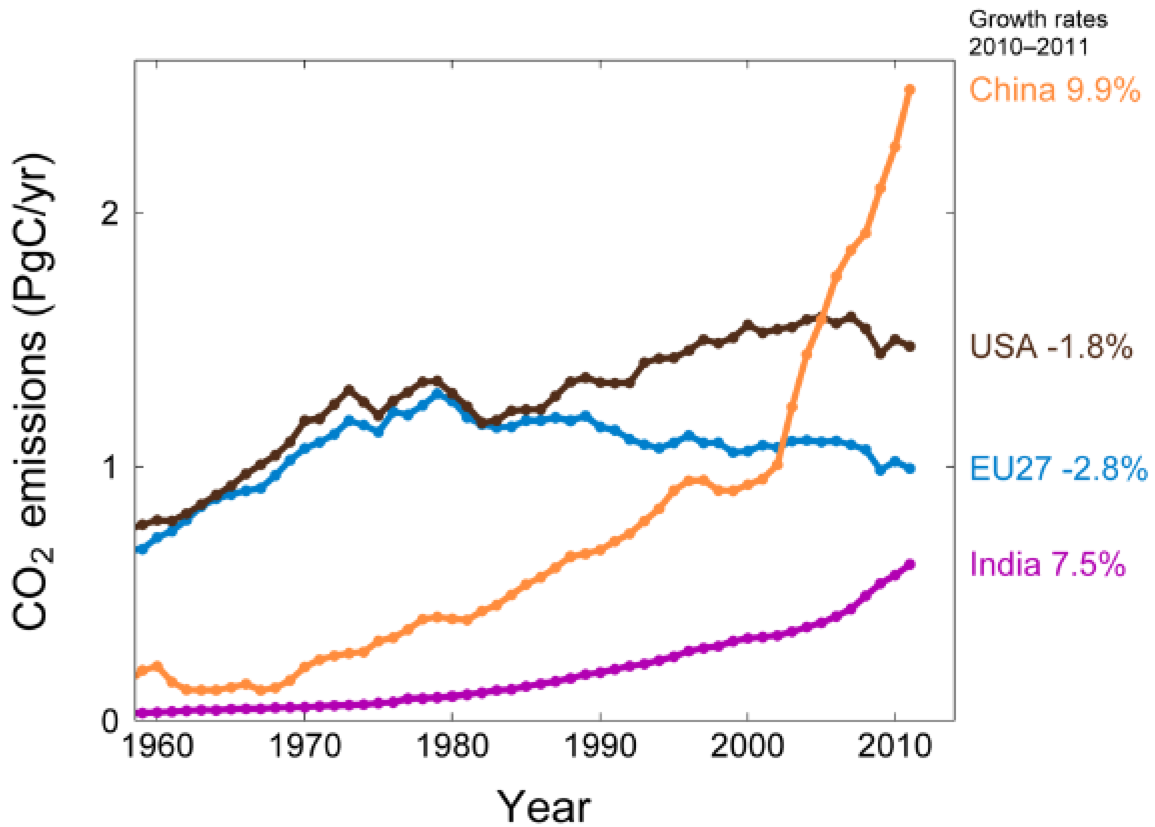
Crosses (**X**) : Historical emissions growth over the period in horizontal axis

Circles (●) : Scenario emissions growth over the period in horizontal axis

Source: Peters et al. 2012; Le Quéré et al. 2012; Global Carbon Project 2012; CDIAC Data

Top Fossil Fuel Emitters (Absolute)

Top emitters 2011: China (28%), United States (16%), EU27 (11%), India (7%)

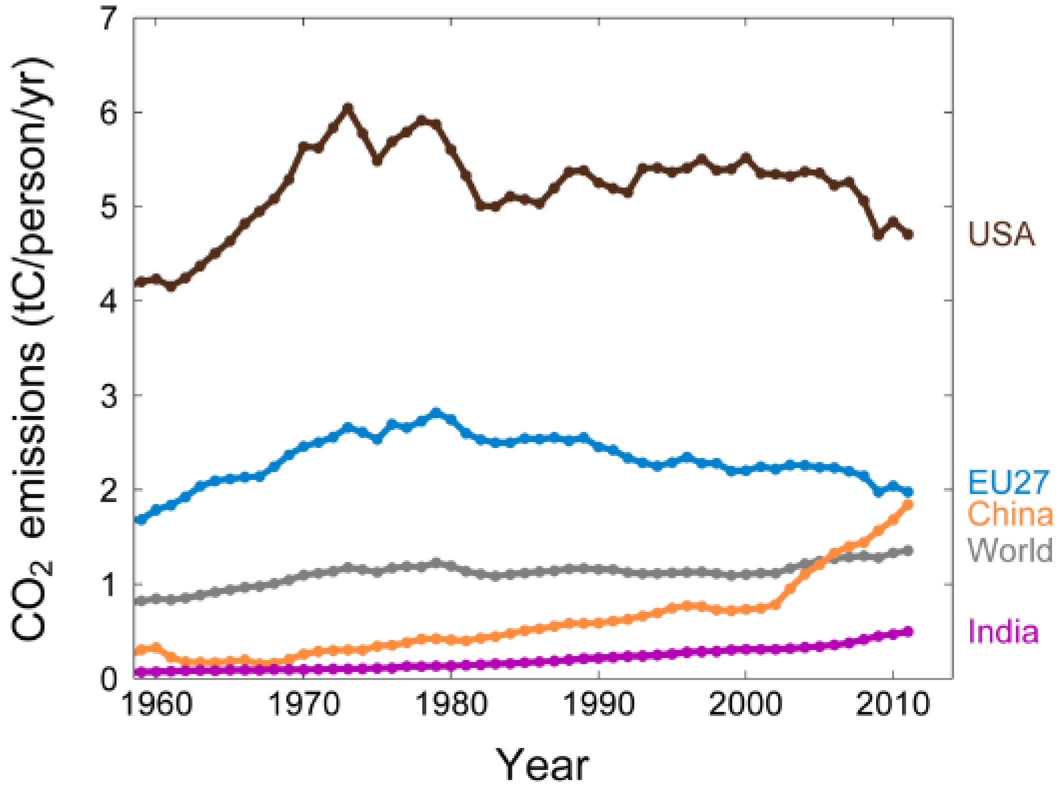


Growing gap between EU27 and USA due to emission decreases in Germany, Poland, and Romania.

Source: Le Quéré et al. 2012; Global Carbon Project 2012; CDIAC Data

Top Fossil Fuel Emitters (Per Capita)

Top emitters 2011: China (28%), United States (16%), EU27 (11%), India (7%)



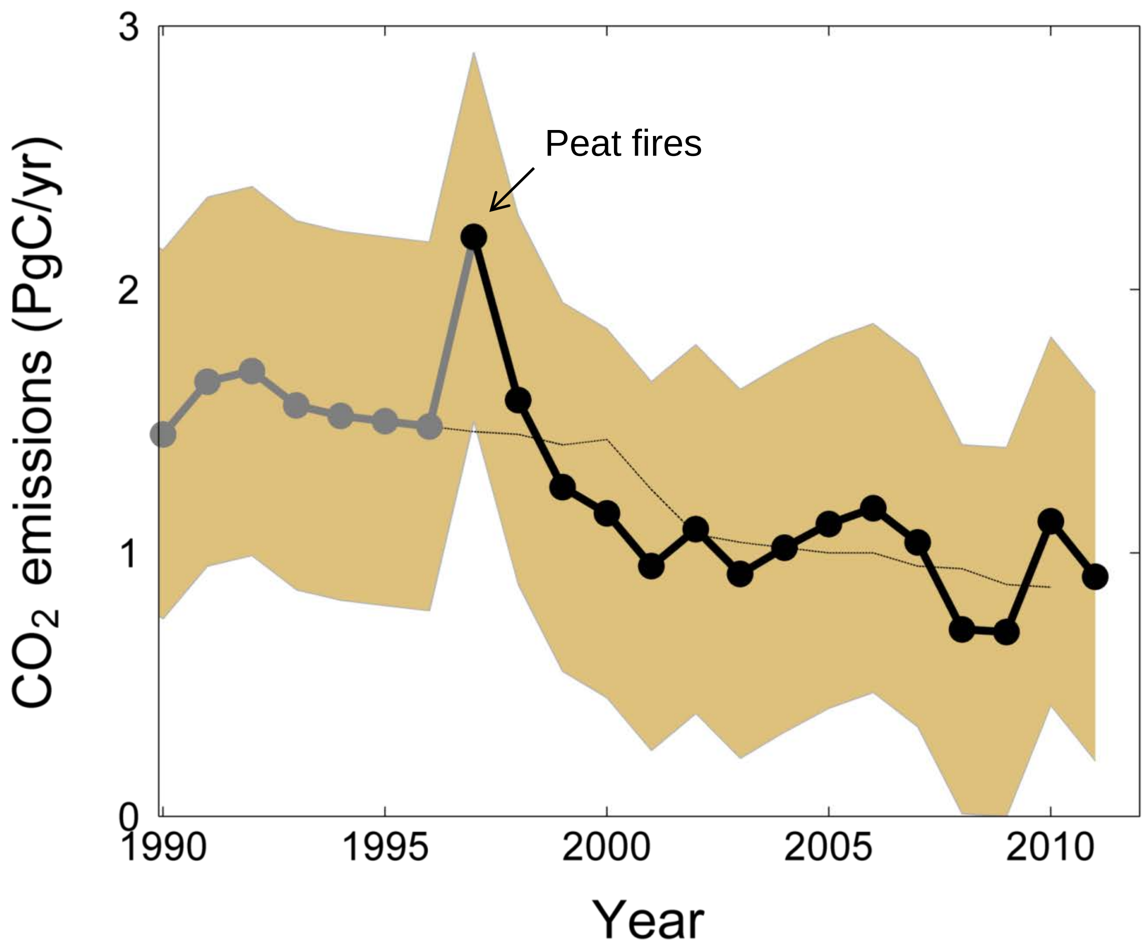
Source: Le Quéré et al. 2012; Global Carbon Project 2012; CDIAC Data

Land Use Change Emissions

Land-Use Change Emissions

Global land-use change emissions: 0.9±0.5PgC in 2011

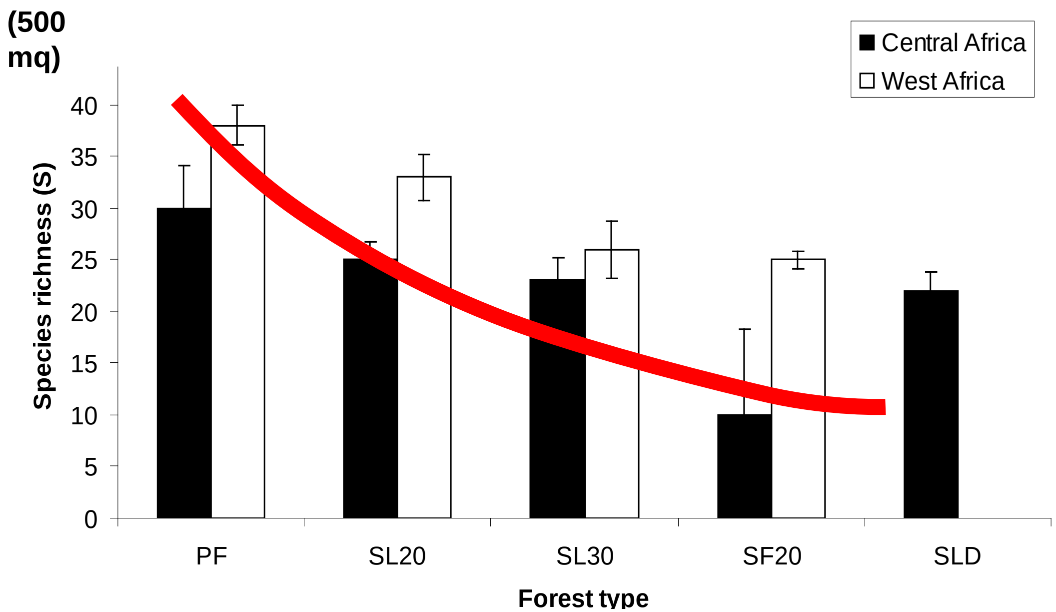
The data suggests a general decrease in emissions since 1990

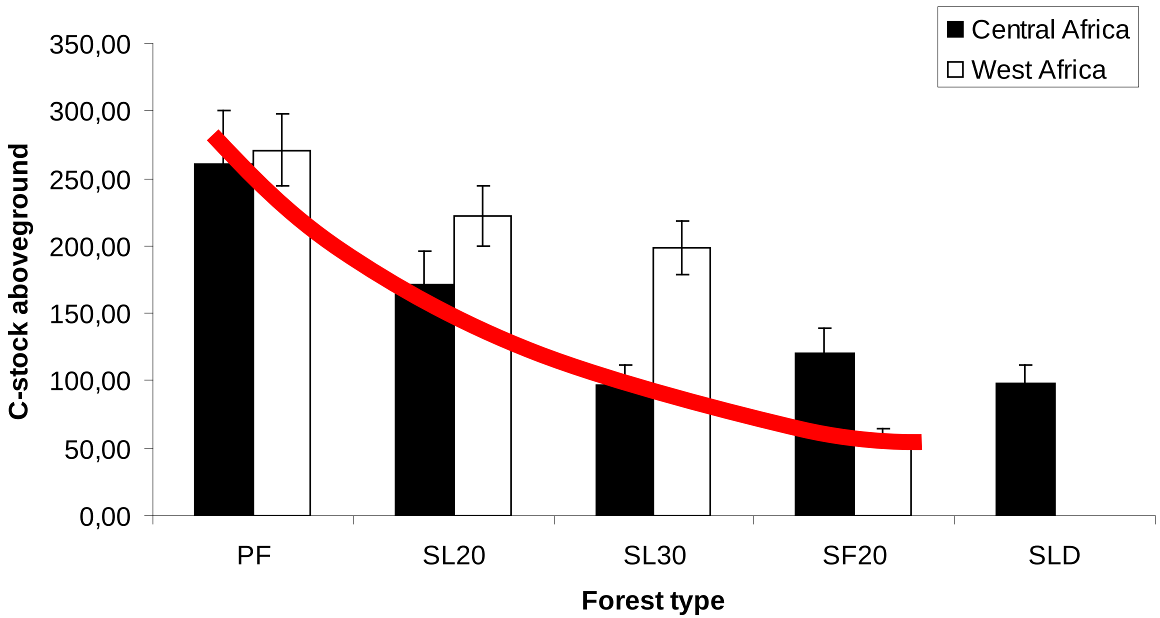


Black line: Includes management-climate interactions; Thin line: Previous estimate

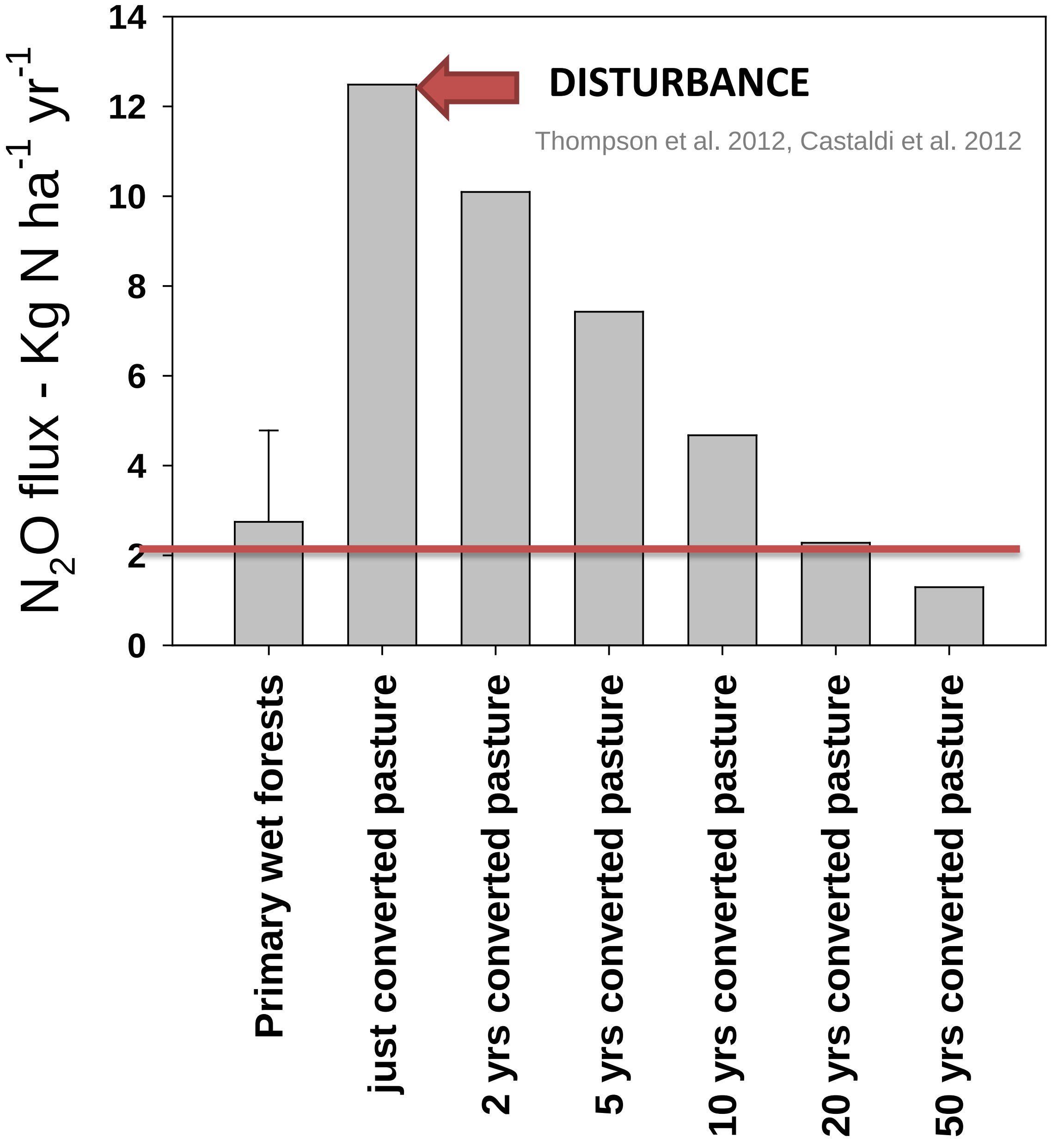
Source: Le Quéré et al. 2012; Global Carbon Project 2012

Persistent effects of logging on forest degradation (Cazzolla et al. 2012 submitted)





N2O emissions from tropical deforestation



Fate of Anthropogenic CO_2 Emissions (2002-2011 average)

8.3±0.4 PgC/yr 90%

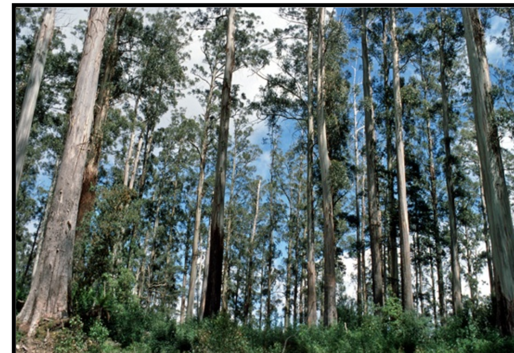
1.0±0.5 PgC/yr 10%

+

4.3±0.1 PgC/yr
46%

2.6±0.8 PgC/yr
28%

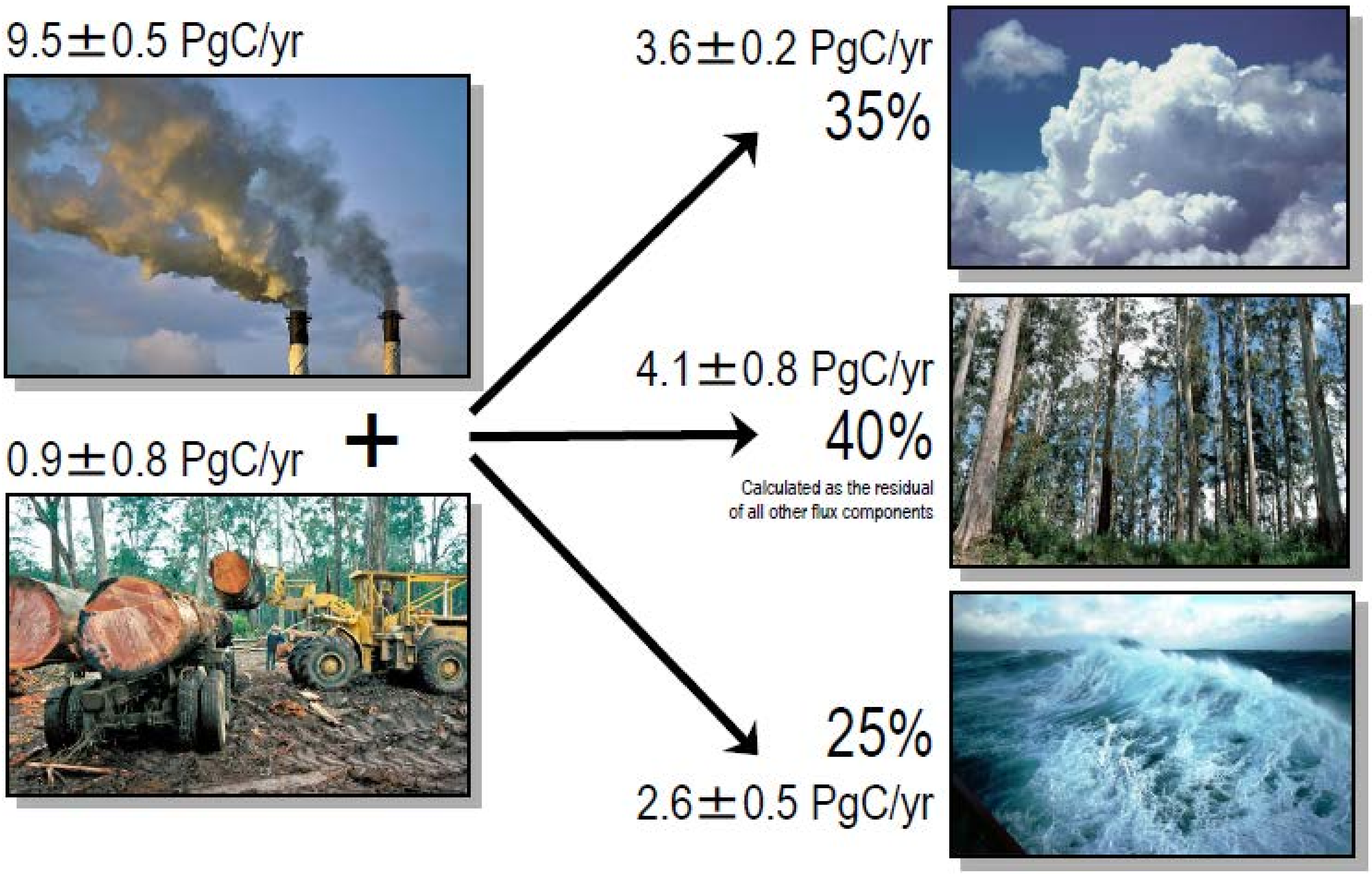
Calculated as the residual
of all other flux components



26%
2.5±0.5 PgC/yr

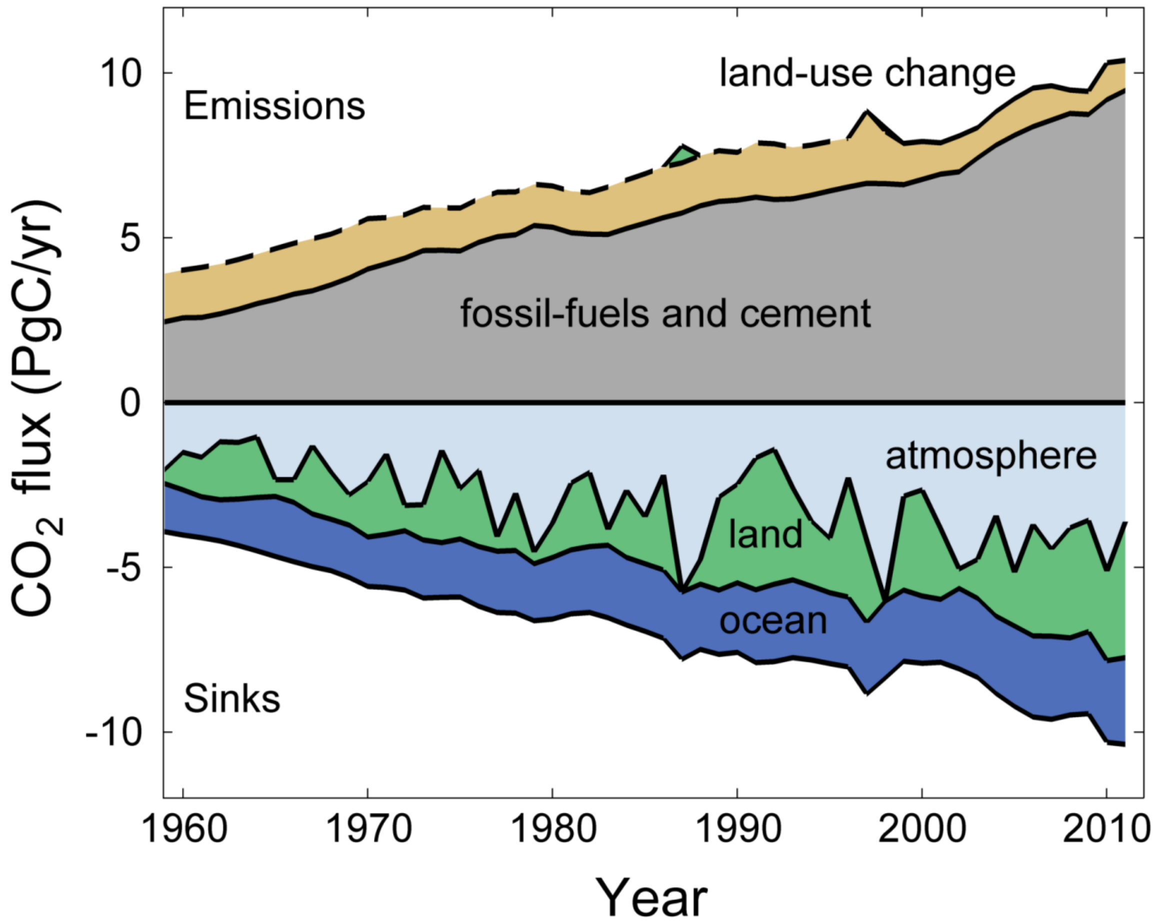
Source: Le Quéré et al. 2012; Global Carbon Project 2012

Fate of Anthropogenic CO_2 Emissions (2011)



Source: Le Quéré et al. 2012; Global Carbon Project 2012

Emissions to the atmosphere are balanced by the sinks
Averaged sinks since 1959: 44% atmosphere, 28% land, 28% ocean



The dashed land-use change line does not include management-climate interactions

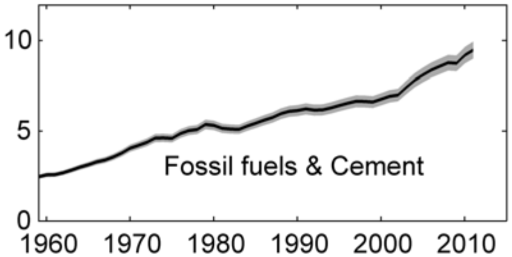
The land sink was a source in 1987 and 1998 (1997 visible as an emission)

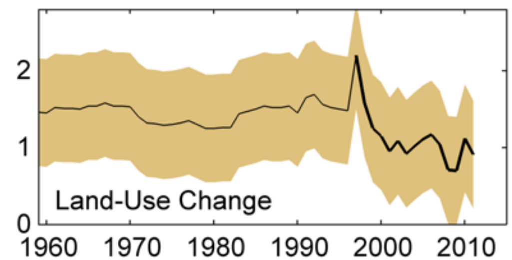
Source: Le Quéré et al. 2012; Global Carbon Project 2012

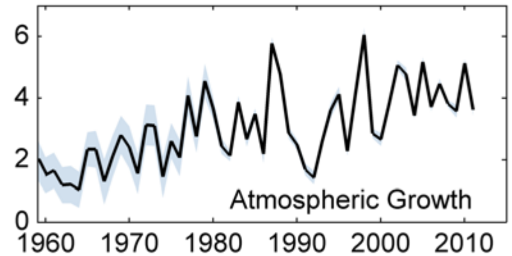
Changes in the Global Carbon Budget over Time

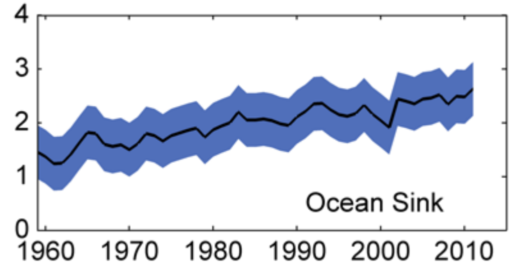
The sinks have continued to grow with increasing emissions

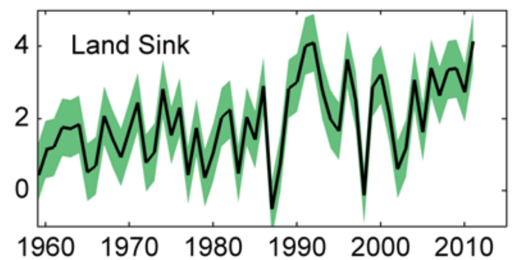
It is uncertain how efficient the sinks will be in the future





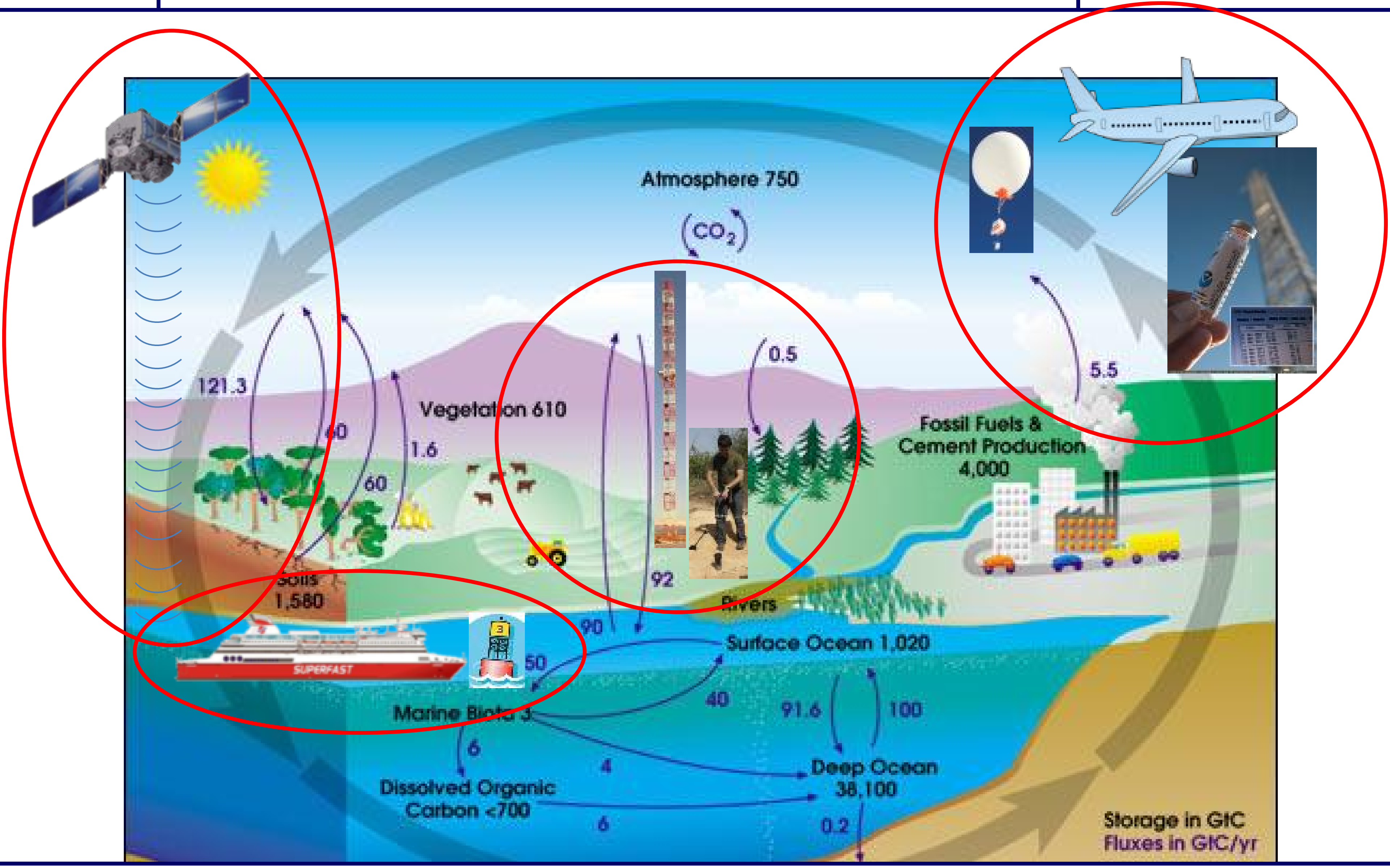




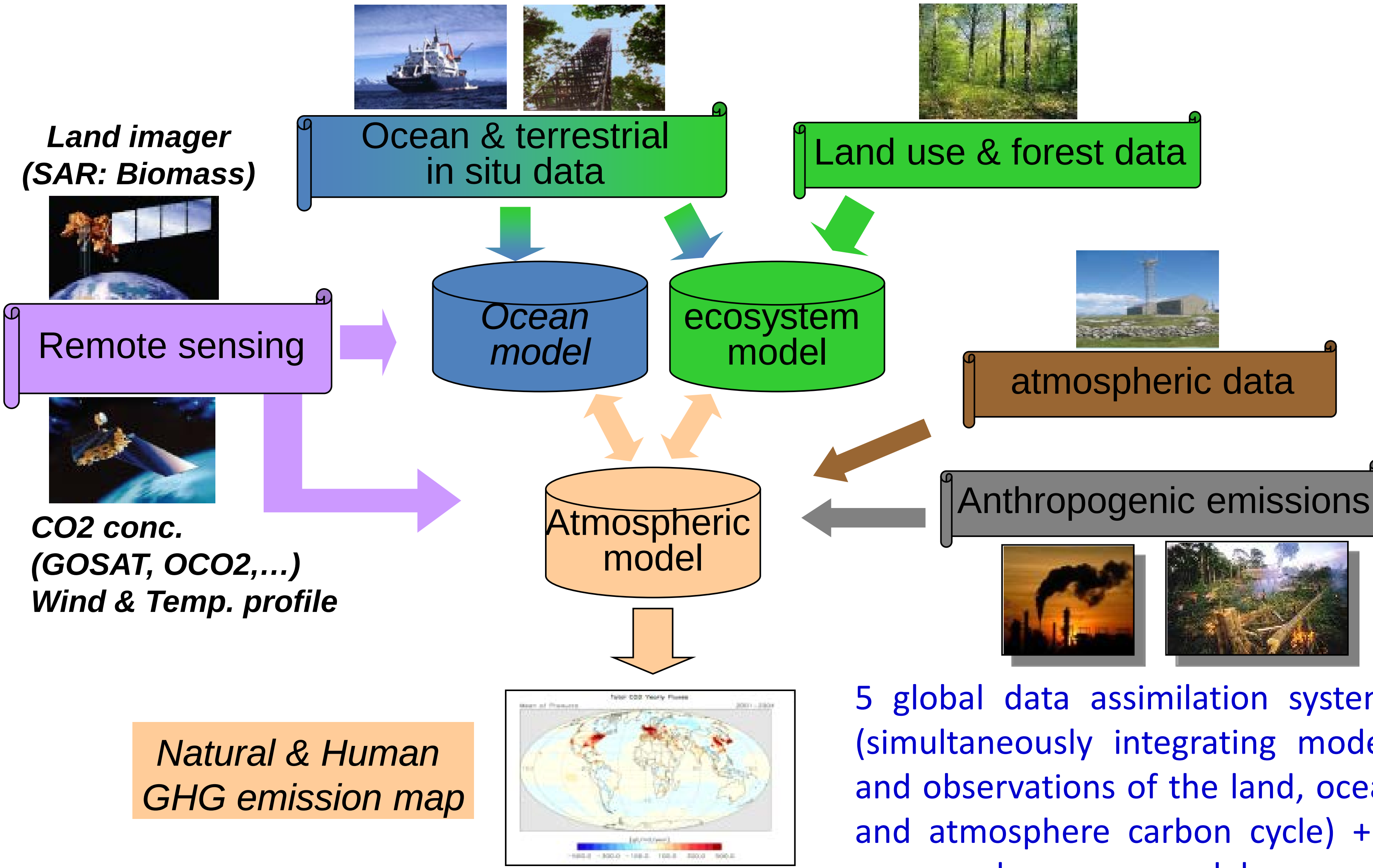


Source: Le Quéré et al. 2012; Global Carbon Project 2012

The Global Carbon Cycle



GEOCARBON
CCDAS



5 global data assimilation systems (simultaneously integrating models and observations of the land, ocean and atmosphere carbon cycle) + 2 ocean-only process models.

CONCLUSIONS 1/2

1. Progresses have been made on estimating the global carbon balance and its components but still uncertainties are rather high, particularly on land use emissions.

2. Uncertainty reduction is possible through the development of a carbon data assimilation system (CCDAS – GEOCARBON)

3. It is important to estimate the terrestrial carbon sink by direct observations and models (not as residual of LUC emissions)

4. Terrestrial carbon show an high spatial and temporal dynamics. It is important to continue to monitor and predict carbon budget components for their vulnerabilities and implications for climate policies.

CONCLUSIONS 2/2

5. Land use emissions show a decreasing trend, although with inter-annual and decadal variability.

6. We need to keep continuing the emission reductions from deforestation and degradation since negative emissions are required for keeping global warming within 2°C

7. There are still significant processes, related to LUC GHG emissions to be investigated : impacts of logging on forest degradation and N_2O emissions associated with LUC.