

## Carbon Futures

Large and sustained mitigation is required to keep global average warming below 2°C

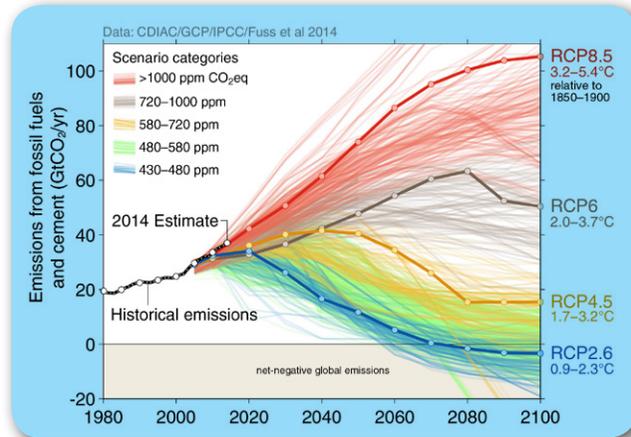


Figure 6: Emissions are on track for 3.2-5.4°C 'likely' increase in average temperature (since pre-industrial). Source: Fuss et al 2014, CDIAC, IPCC, Global Carbon Budget 2014

- Cumulative emissions of CO<sub>2</sub> largely determine global surface warming by the late 21<sup>st</sup> century and beyond.
- The latest update of the Global Carbon Budget shows that future CO<sub>2</sub> emissions cannot exceed 1,200 billion tonnes CO<sub>2</sub> for a likely (66%) chance of keeping average warming under 2°C (since pre-industrial times)
- At current rates of CO<sub>2</sub> emissions the 'quota' would be used within a generation (about 30 years)
- A large part of all known fossil fuel reserves may need to remain untapped to keep average warming under 2°C

## About Us

The **Global Carbon Project** (GCP) is a global research platform. It assists scientists in establishing the knowledge base for supporting policy debate and action to slow the rate of increase of greenhouse gases in the atmosphere. GCP works under the auspices of the International Geosphere and Biosphere Programme (IGBP) and Future Earth.

The **Surface Ocean CO<sub>2</sub> Atlas** (SOCAT) is an activity of the marine carbon research community. It provides data products of surface ocean CO<sub>2</sub>.

**CARBOCHANGE** is a Collaborative Project funded by the European Commission's Seventh Framework Programme to investigate the role of the ocean in the uptake of carbon under changing climate conditions.

Multiple organisations and research groups contribute to achieving the aims of the GCP, SOCAT and CARBOCHANGE. This summary was compiled by R Moriarty<sup>1</sup>, DCE Bakker<sup>1</sup>, RM Andrew<sup>2</sup>, GP Peters<sup>2</sup>, C Le Quéré<sup>1</sup>, the 2014 Global Carbon Budget Team and SOCAT contributors.

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## Links

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

### Global Carbon Budget 2014 was published in:

**Le Quéré et al (2014)** Global Carbon Budget 2014 (in discussion). *ESSDD*, doi:10.5194/essdd-7-521-2014

**Friedlingstein et al (2014)** Persistent growth of CO<sub>2</sub> emissions and implications for reaching climate targets. *Nature Geoscience*, doi:10.1038/ngeo2248

### SOCAT version 2 data products were published in:

**Bakker et al (2014)** An update to the Surface Ocean CO<sub>2</sub> Atlas (SOCAT version 2). *ESSDD*, doi:10.5194/essd-6-69-2014.

### Other references:

- Boden et al (2013)** CDIAC, [cdiac.ornl.gov/trends/emis/meth\\_reg.html](http://cdiac.ornl.gov/trends/emis/meth_reg.html)
- Dlugokencky and Tans (2013)** NOAA-ESRL, [www.esrl.noaa.gov/gmd/ccgg/trends/](http://www.esrl.noaa.gov/gmd/ccgg/trends/)
- Fuss et al (2014)** *Nature Climate Change*, doi:10.1038/nclimate2392
- Giglio et al (2014)** *Journal Geophysical Research*, doi:10.1002/jgrg.20042
- Houghton et al (2012)** *Biogeosciences* doi:10.5194/bg-9-5125-2012
- Joos et al (2013)** *Atmospheric Chemistry and Physics*, doi: 0.5194/acp-13-2793-2013
- Keeling et al (1976)** *Tellus*, doi: 10.1111/j.2153-3490.1976.tb00701.x
- Khatiwala et al (2013)** *Biogeosciences*, doi:10.5194/bg-10-2169-2013
- Landschützer et al (2014)**, *Global Biogeochemical Cycles*, doi:10.1002/2014GB004853
- Pfeil et al (2013)** *ESSD*, doi:10.5194/essd-5-125-2013
- Raupach et al (2014)** *Nature Climate Change*, doi:10.1038/nclimate2384
- Rödenbeck et al (2014)** *Biogeosciences*, doi:10.5194/bg-11-4599-2014
- Sabine et al (2013)** *ESSD*, doi:10.5194/essd-5-145-2013
- Stocker et al (2013)** *WGI, AR5, IPCC*, [www.ipcc.ch/report/ar5/wg1/](http://www.ipcc.ch/report/ar5/wg1/)

## Global Carbon Budget Ocean Carbon Sink

### Global Carbon Cycle

Carbon dioxide (CO<sub>2</sub>) is a greenhouse gas emitted to the atmosphere by human activities, mainly from burning fossil fuels and cement production, and from deforestation and other land-use change. The emitted CO<sub>2</sub> is either absorbed by the ocean and land, or it remains in the atmosphere.

### Key Messages

- CO<sub>2</sub> emissions from human activities, the main contributor to global climate change, are set to rise again in 2014 reaching 40 billion tonnes CO<sub>2</sub>
- The natural carbon 'sinks' on land and in the ocean absorb on average 55% of the total CO<sub>2</sub> emissions, thus slowing the rate of global climate change
- Increasing CO<sub>2</sub> in the oceans is causing ocean acidification

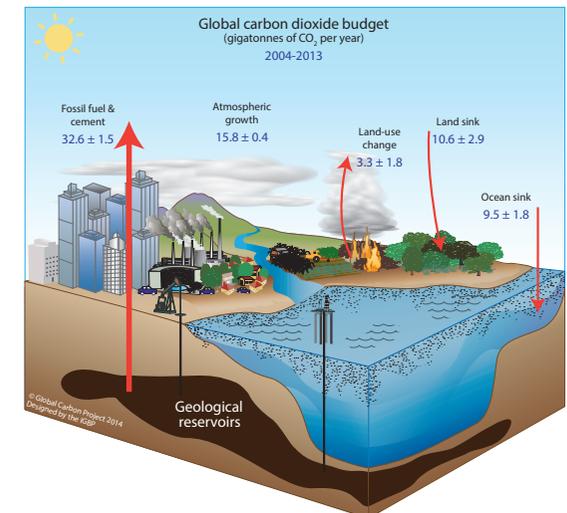


Figure 1: Schematic representation of the perturbation of the global carbon cycle caused by human activities, averaged globally for the decade 2004-2013. Source: Le Quéré et al 2014, Global Carbon Budget 2014

## Atmospheric CO<sub>2</sub> Concentration

The concentration of CO<sub>2</sub> in the atmosphere continues to increase

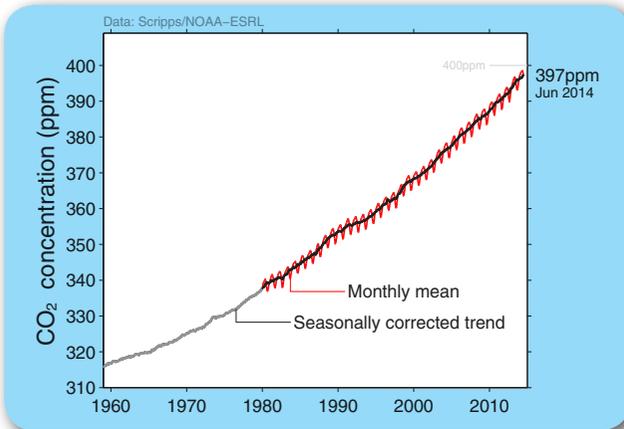


Figure 2: Evolution of globally averaged surface atmospheric CO<sub>2</sub> concentration (in parts per million). Source: NOAA-ESRL after 1980 and Scripps Institution of Oceanography before 1980, Global Carbon Budget 2014

- Atmospheric CO<sub>2</sub> concentration increased by 43% since pre-industrial times, a level unprecedented in at least the last 800,000 years
- Atmospheric CO<sub>2</sub> concentration increased by 2 parts per million (ppm) per year on average in the last decade (2004-2013), equivalent to an increase of 20 billion tonnes CO<sub>2</sub> in 2013 alone
- Daily averages went above 400 ppm for the first time at the Mauna Loa Observatory in May 2013
- CO<sub>2</sub> monitoring at Mauna Loa began in 1958 and constitutes the longest record of direct atmospheric CO<sub>2</sub> measurements

## Ocean Carbon Sink

The ocean absorbed one quarter of the total CO<sub>2</sub> emissions from human activities each year

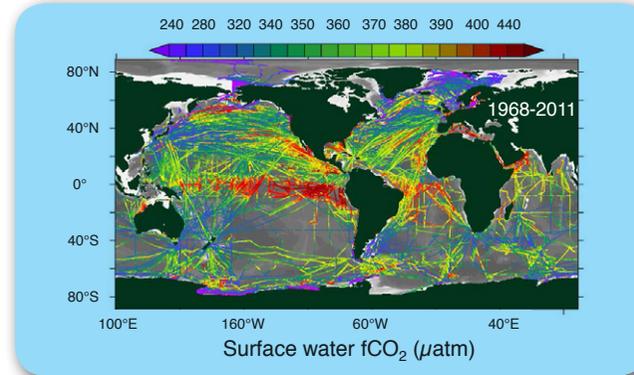


Figure 3: Distribution of CO<sub>2</sub> observations in the Surface Ocean CO<sub>2</sub> Atlas. Source: Bakker et al. 2014

- The Surface Ocean CO<sub>2</sub> Atlas (SOCAT) provides a comprehensive, 44 year record of 10.1 million surface water CO<sub>2</sub> measurements for the world's oceans and coastal seas
- SOCAT enables detection of changes in the ocean carbon sink and in ocean acidification
- The ocean absorbed about 10.6 billion tonnes CO<sub>2</sub> in 2013, 27% of total emissions
- Further uptake of CO<sub>2</sub> by the ocean will increase ocean acidification

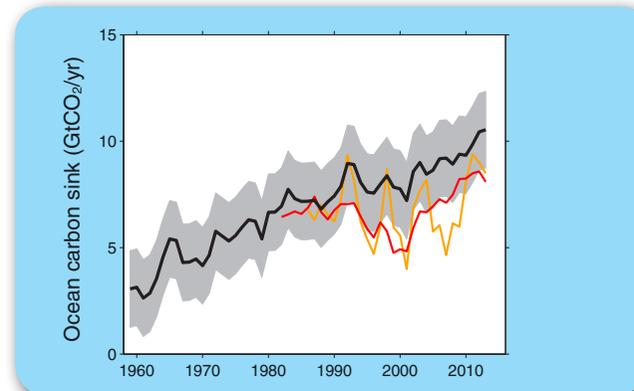


Figure 4: Estimates of the ocean carbon sink are made from models combined with long-term observations (black, uncertainty in grey shading) and from other methods using the Surface Ocean CO<sub>2</sub> Atlas (red and orange). Source: Rödenbeck et al 2014, Landschützer et al 2014, Global Carbon Budget 2014

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

Emissions are split between the atmosphere, land and ocean

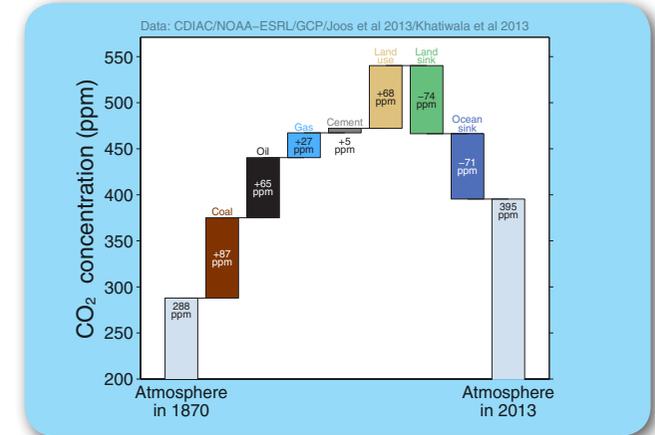


Figure 5: Cumulative contributions to CO<sub>2</sub> emissions from fossil fuels, cement and land-use change, and their division among the land, ocean and atmosphere from 1870 to 2013. Source: based on data from CDIAC, NOAA-ESRL, Houghton et al 2012, Giglio et al 2013, Joos et al 2013, Khatiwala et al 2013, Global Carbon Budget 2014. Figure concept from Shrink That Footprint

- All components of the carbon cycle have grown since 1959 except CO<sub>2</sub> emissions from land-use change
- Global emissions of CO<sub>2</sub> from burning fossil fuels and cement production reached 36 billion tonnes CO<sub>2</sub> in 2013 and are projected to reach 37 billion tonnes CO<sub>2</sub> in 2014, 65% above 1990 levels
- Global emissions of CO<sub>2</sub> from deforestation and other land-use change were about 3.3 billion tonnes CO<sub>2</sub> in 2013
- The land carbon sink is particularly sensitive to climate and is the primary cause of the large interannual variability observed in atmospheric CO<sub>2</sub>

