Carbon Futures

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

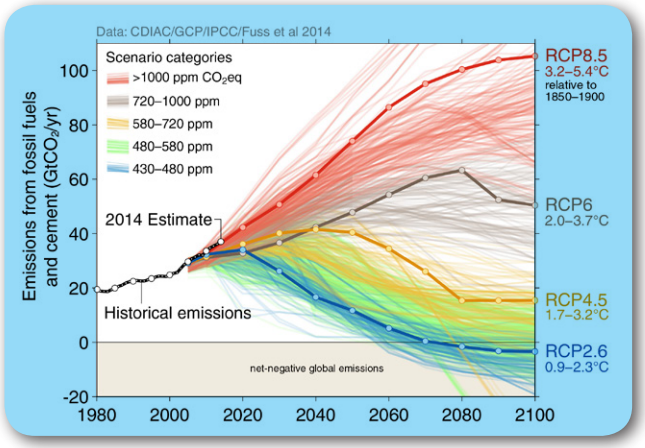

Figure 6: Emissions are on track for 3.2-5.4ºC 'likely' increase in average temperature (since pre-industrial). Source: Fuss et al 2014, CDIAC, IPCC, Global Carbon Budget 2014

- Cumulative emissions of CO_2 largely determine global surface warming by the late 21st century and beyond.
- The latest update of the Global Carbon Budget shows that future CO_2 emissions cannot exceed 1,200 billion tonnes CO_2 for a likely (66%) chance of keeping average warming under 2ºC (since pre-industrial times)
- At current rates of CO_2 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 2ºC

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_2 Atlas** (SOCAT) is an activity of the marine carbon research community. It provides data products of surface ocean CO_2.

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[1], DCE Bakker[1], RM Andrew[2], GP Peters[2], C Le Quéré[1], the 2014 Global Carbon Budget Team and SOCAT contributors.

[1] School of Environmental Sciences, University of East Anglia, Norwich, UK,
[2] Center for International Climate and Environmental Research - Oslo (CICERO), Norway

Acknowledgements: We thank all people who provided the data and analysis used here. DCEB and CLQ were supported by the EC project CARBOCHANGE (264879) and RM by GEOCarbon (283080). GPP and RMA were supported by the Norwegian Research Council (236296). Some statements are from the IPCC WGI Summary for Policymakers key statements.

Links

www.globalcarbonproject.org 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_2 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_2 Atlas (SOCAT version 2). *ESSD*, doi:10.5194/essd-6-69-2014.

Other references:

Boden et al (2013) CDIAC, cdiac.ornl.gov/trends/emis/meth_reg.html
Dlugokencky and Tans (2013) NOAA-ESRL, 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/

GLOBAL CARBON project

Global Carbon Budget
Ocean Carbon Sink

Global Carbon Cycle

Carbon dioxide (CO_2) 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_2 is either absorbed by the ocean and land, or it remains in the atmosphere.

Key Messages

- CO_2 emissions from human activities, the main contributor to global climate change, are set to rise again in 2014 reaching 40 billion tonnes CO_2
- The natural carbon 'sinks' on land and in the ocean absorb on average 55% of the total CO_2 emissions, thus slowing the rate of global climate change
- Increasing CO_2 in the oceans is causing ocean acidification

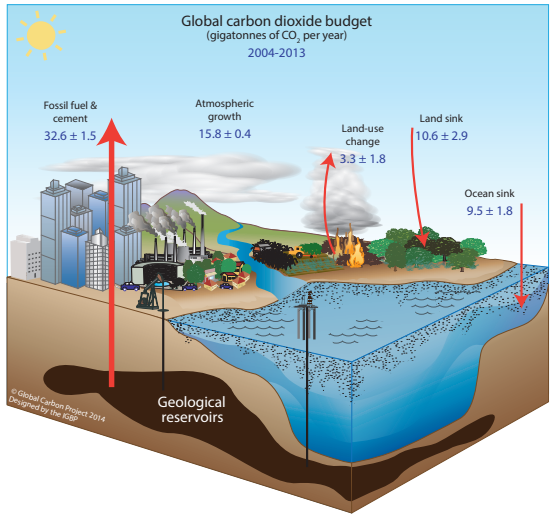

Figure 1: Schematic representation of the perturbation of the global carbon cycle caused by human activities, averaged globally for the decade 2004-2013. Source: Le Quéré et al 2014, Global Carbon Budget 2014

SOCAT
· SURFACE OCEAN CO_2 ATLAS ·

Atmospheric CO_2 Concentration

The concentration of CO_2 in the atmosphere continues to increase

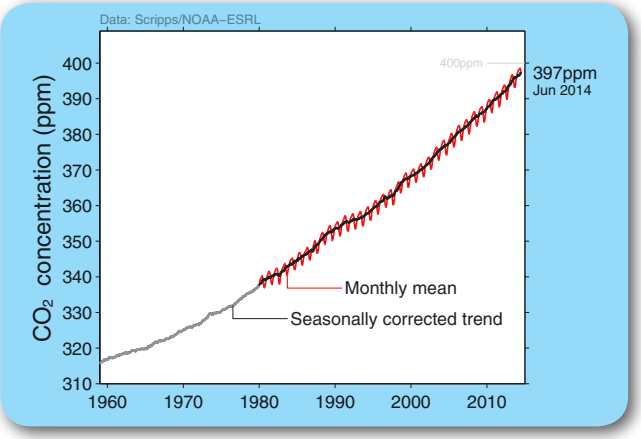

Figure 2: Evolution of globally averaged surface atmospheric CO_2 concentration (in parts per million). Source: NOAA-ESRL after 1980 and Scripps Institution of Oceanography before 1980, Global Carbon Budget 2014

- Atmospheric CO_2 concentration increased by 43% since pre-industrial times, a level unprecedented in at least the last 800,000 years
- Atmospheric CO_2 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_2 in 2013 alone
- Daily averages went above 400 ppm for the first time at the Mauna Loa Observatory in May 2013
- CO_2 monitoring at Mauna Loa began in 1958 and constitutes the longest record of direct atmospheric CO_2 measurements

Ocean Carbon Sink

The ocean absorbed one quarter of the total CO_2 emissions from human activities each year

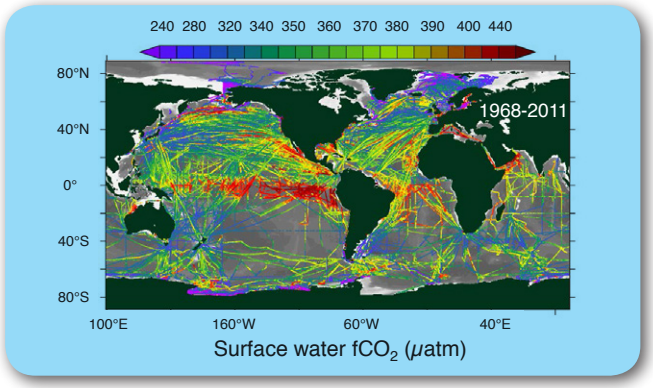

Figure 3: Distribution of CO_2 observations in the Surface Ocean CO_2 Atlas. Source: Bakker et al. 2014

- The Surface Ocean CO_2 Atlas (SOCAT) provides a comprehensive, 44 year record of 10.1 million surface water CO_2 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_2 in 2013, 27% of total emissions
- Further uptake of CO_2 by the ocean will increase ocean acidification

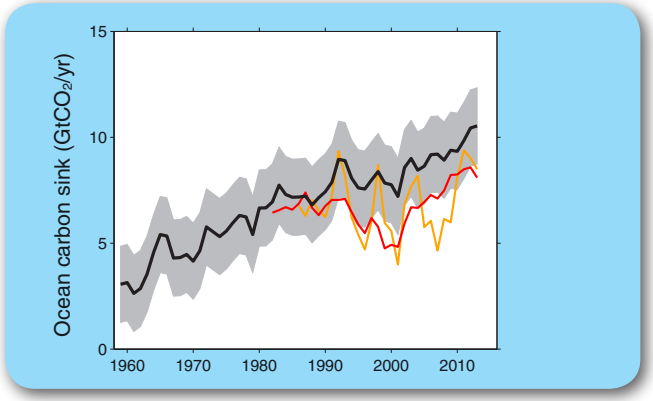

Figure 4: Estimates of the ocean carbon sink are made from models combined with long-term observations (black, uncertainty in grey shading) and from other methods using the Surface Ocean CO_2 Atlas (red and orange). Source: Rödenbeck et al 2014, Landschützer er al 2014, Global Carbon Budget 2014

Natural CO_2 Sinks

Emissions are split between the atmosphere, land and ocean

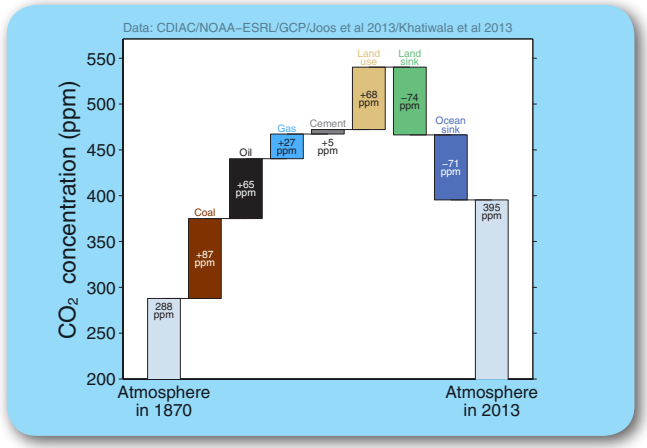

Figure 5: Cumulative contributions to CO_2 emissions from fossil fuels, cement and land-use change, and their division among the land, ocean and atmosphere from 1870 to 2013. Source: based on data from CDIAC, NOAA-ESRL, Houghton et al 2012, Giglio et al 2013, Joos et al 2013, Khatiwala et al 2013, Global Carbon Budget 2014. Figure concept from Shrink That Footprint

- All components of the carbon cycle have grown since 1959 except CO_2 emissions from land-use change
- Global emissions of CO_2 from burning fossil fuels and cement production reached 36 billion tonnes CO_2 in 2013 and are projected to reach 37 billion tonnes CO_2 in 2014, 65% above 1990 levels
- Global emissions of CO_2 from deforestation and other land-use change were about 3.3 billion tonnes CO_2 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_2

CARBOCHANGE