Emissions de CO_2 et objectifs climatiques

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The atmospheric concentration of carbon dioxide (CO_2) has increased to levels unprecedented in at least the last 800,000 years. CO_2 concentrations have increased by 40% since pre-industrial times, reaching 393 ppm in 2011. The milestone concentration of 400ppm will be reached with in the next couples of years. The increase in atmospheric CO_2 concentration is due to anthropogenic CO_2 emissions, primarily fossil fuel emissions and secondarily net land use change emissions.

Annual CO_2 emissions from fossil fuel combustion and cement production were 8.6 ± 0.4 GtC/yr averaged over 2003–2012, with an estimate of 9.9 GtC/yr in 2013, almost 60% above the 1990 level. The current growth rate of fossil fuel emissions is about 2% per year, largely due to the growth in emissions from Asian emerging economies (Emission growth rate is 5.9% per year, for China, 7.7% for India). Per capita emissions for China and EU28 are comparable (1.9 tC/person), 35% above the world average.

Annual net CO_2 emissions from anthropogenic land use change were 0.8 ± 0.5 GtC/yr on average during 2003 to 2012, with small negative trends over the last couple of decades. Confidence in land use changes CO_2 emissions is significantly lower than for emissions from fossil fuel use.
For 2013, total anthropogenic CO_2 emissions (from fossil fuel and land use activities) are estimated to amount 10.7 ± 0.7 GtC/yr, more than 90% arising from fossil fuel sources.

When cumulated over the historical period (defined here as 1870 up to 2013) CO_2 emissions from fossil fuel combustion and cement production have released 380 ± 20 GtC to the atmosphere, while deforestation and other land use change are estimated to have released 160 ± 55 GtC. Altogether, cumulative anthropogenic emissions since 1870 amounts to 540 ± 60 GtC. Emissions prior to 1870 are negligible for fossil fuel activities; early historical land use change activities are poorly quantified. The current best estimate for CO_2 emissions associated to land use changes is about 30GtC prior to 1870.

Of these 540 GtC emitted in the atmosphere since 1870, 220 ± 5 GtC have accumulated in the atmosphere, leading to the observed increase of CO_2 concentration (from about 285ppm to 393 ppm). Ocean and land absorbed respectively 150 ± 20 GtC and 170 ± 65 GtC. The increase in carbon content in the ocean caused ocean acidification.

The increase in atmospheric CO_2 is the dominant driver of the observed increase in the Earth radiative forcing. The estimated current radiative forcing is 2.3 W/m^2 (relative to 1750), of which 1.8 W/m^2 (about 80%) is due to the increase in atmospheric CO_2 concentration, largely contributing to the observed change in the climate system.

Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions. Climate change will affect carbon cycle processes in a way that will exacerbate the increase of CO_2 in the atmosphere. The carbon cycle response to future climate and CO_2 changes can be viewed as two strong and opposing feedbacks; a positive concentration–carbon feedback, due to the increase in land and ocean carbon storage in response to elevated CO_2, and a negative climate–carbon feedback due to the reduction in land and ocean carbon storage in response to climate change. Models agree on the sign, globally negative, of land and ocean response to climate change but show low agreement on the magnitude of this response, especially for the land. It is *virtually certain* that the increased storage of carbon by the ocean will increase acidification in the future, continuing the observed trends of the past decades.

The total amount of anthropogenic CO_2 released in the atmosphere since pre-industrial (often termed cumulative carbon emission, although it applies only to CO_2 emissions) is a good indicator of the atmospheric CO_2 concentration and hence of the global warming response. Cumulative emissions of CO_2 largely determine global mean surface warming by the late 21st century and beyond. The ratio of global mean surface temperature change to total cumulative anthropogenic carbon emissions is called the transient climate response to cumulative carbon emission (TCRE). This quantity is relatively constant and independent of the scenario, but is model dependent, as it is a function of the model cumulative airborne fraction of carbon and the transient climate response. TCRE is likely between 0.8°C to 2.5°C per 1000 PgC, for cumulative carbon emissions less than about 2000 GtC until the time at which temperatures peak.

For the Earth System Models simulations driven by CO_2 concentrations, representation of the land and ocean carbon cycle allows quantification of the fossil fuel emissions compatible with the RCP scenarios. Between 2012 and 2100, these models results imply cumulative compatible fossil fuel emissions of 270 [140 to 410] GtC for RCP2.6, 780 [595 to 1005] GtC for RCP4.5, 1060 [840 to 1250] GtC for RCP6.0 and 1685 [1415 to 1910] GtC for RCP8.5. For RCP2.6, the Earth System Models estimate an average 50% (range 14 to 96%) emission reduction by 2050 relative to 1990 levels. By the end of the 21st century, about half of the models infer emissions slightly above zero, while the other half infer a net removal of CO2 from the atmosphere.

Based on the assessment of TCRE, limiting the warming caused by anthropogenic CO_2 emissions alone (i.e., ignoring other radiative forcings) to be likely (probability of at least 66%) less than 2°C since the period 1861–1880 requires cumulated anthropogenic CO_2 emissions to be below about 1000 PgC since 1870. Higher emissions in earlier decades therefore imply lower or even negative emissions later on. Accounting for non-CO_2 forcings also contributing to peak warming, reduces these compatible carbon emissions to about 790 GtC. As mentioned earlier, about 540 GtC have been emitted already, leaving about 250 GtC for the future to likely limit global warming below 2°C. That equates to about 25 years at the current level of CO_2 emissions (10GtC/year).