



PREVENT Project supporting SIDS and LDCs climate negotiators

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Ocean Acidification: Causes and Consequences

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Summary

- As CO₂ concentration in the atmosphere rises, more CO₂ is absorbed by the oceans, increasing the acidity of the oceans.
- An increase in ocean acidity has been observed.
- Higher ocean acidity reduces the ability of coral species to sequester calcium, which is vitally required for growth and maintenance of coral reefs;
- Corals around the world are likely to stop growing once atmospheric CO₂ concentration rises above approximately 450 ppm and will start dissolving above 550 ppm.
- Significant, reduced reef calcification due to acidification has been observed since 1990 in some regions. Stabilizing CO₂ concentrations well below 450 ppmv seems critical for the long-term survival of coral reef ecosystems.
- Current proposals associated with the Copenhagen Accord imply 450 ppmv CO₂ concentrations being reached by the late 2030s in about 30 years.
- The CO₂ concentration was about 278 ppm in pre-industrial times (mid 19th century) and had risen to about 355 ppm in 1990, and as of 2008, was around 386 ppm¹.
- Deep reductions of global CO₂ emissions, peaking in the next decade and dropping to far below half of 1990 levels by 2050, are needed to keep CO₂ concentration below 450 ppmv.
- If multiple stressors are included, including high ocean surface-water temperature events, sea-level rise and deterioration in water quality, a CO₂ level of below 350 ppm is required for the long-term survival of coral reefs.

Technical Background

Of current anthropogenic CO₂ emissions, about 30% is absorbed by the oceans, in response to the higher CO₂ concentration of the atmosphere (Denman et al., 2007 in IPCC AR4). The net absorption by the oceans will stop when the equilibrium is restored at the ocean's surface. This will only occur gradually after the atmospheric concentration ceases to rise.

¹ ftp://ftp.cmdl.noaa.gov/ccg/co2/trends/co2_annmean_mlo.txt

The acidity of the ocean waters rises when additional CO₂ is absorbed. The atmospheric CO₂ concentration has surpassed 380 ppm recently, which has led to an increase of the ocean's acidity, estimated at a reduction of 0.1 units of pH since pre-industrial levels (Meehl et al., 2007 in IPCC AR4). Note that a *lower* pH value indicates *higher* acidity. Reduced reef calcification due to acidification has been observed in the last decade (Cooper *et al.*, 2008; De'ath *et al.*, 2009; Tanzil *et al.*, 2009). IPCC AR4 projections for SRES scenarios indicate a further increase of the ocean's acidity of 0.14 to 0.35 units of pH over the 21st Century (Meehl et al., 2007 in IPCC AR4). "Oceanic pH projections decrease at a greater rate and to a lower level than experienced over the past 20 million years" (Fischlin et al., 2007 in IPCC AR4).

Higher acidity of ocean waters leads to reduced availability of calcium carbonate (aragonite), the resource vital for coral species and ecosystems to build skeletons and shells. Especially vulnerable are warm-water coral reefs, cold-water corals and ecosystems in the Southern Ocean. Identified impacts of reduced pH on these systems are a reduction in coral calcification (reduced growth), coral skeleton weakening and strong temperature dependence (potentially increasing the risk of bleaching due to rising temperature of surface waters) (Fischlin et al., 2007 in IPCC AR4).

Recent research estimates that if atmospheric CO₂ reaches 450 ppm, coral reefs around the world will slow down growth considerably and at 550 ppm will start to dissolve (Cao & Caldeira, 2008; Silverman *et al.*, 2009). This is pictured in figure 1.

The effects of acidification have already been observed and will gradually worsen as acidification increases. Hence, reduced growth, coral skeleton weakening and increased temperature dependence will start to affect coral reefs below 450 ppm. Stabilization of atmospheric CO₂ concentration well below 450 ppm is therefore required to ensure the long-term survival of coral reefs and other calcifying ecosystems. A deterioration of coral reefs will have negative impacts on dependent species, fisheries, coastal protection and tourism in many AOSIS regions, as well as in other countries with coral reef systems.

Current proposals for emission reductions for the years 2020 and 2050 by both Annex and non-Annex I Parties (Rogelj *et al.*, 2010) are insufficient to keep the CO₂ concentration below a level of 550, let alone 450 ppm (see figure 2). By contrast, the CO₂ concentration has about an even chance of remaining below 450 ppm for a feasible low-emission pathway (van Vuuren *et al.*, 2007) included in the range of scenarios developed for assessment in the IPCC 5th assessment report (Representative Concentration Pathways – RCPs²). Global CO₂ emissions are reduced to 55% below 1990 by 2050 in this scenario. Lower emissions may be economically and technologically feasible (e.g. van Vuuren *et al.*, 2008) and are needed for a higher than 50% chance that CO₂ concentrations remain below 450 ppm. In addition, by achieving negative CO₂ emissions in the second half of the 21st Century, such scenarios may also draw down CO₂ concentrations to lower levels quickly.

A scenario that is consistent with a 1.5°C warming limit may start to approach a CO₂ concentration of 350 ppm by the end of this century. A recent assessment concluded a CO₂ level of below 350 ppm is required for the long-term survival of coral reefs, if multiple stressors are included, like high ocean surface-water temperature events, sea-level rise and deterioration in water quality (Veron *et al.*, 2009).

² <http://www.iiasa.ac.at/web-apps/tnt/RcpDb>

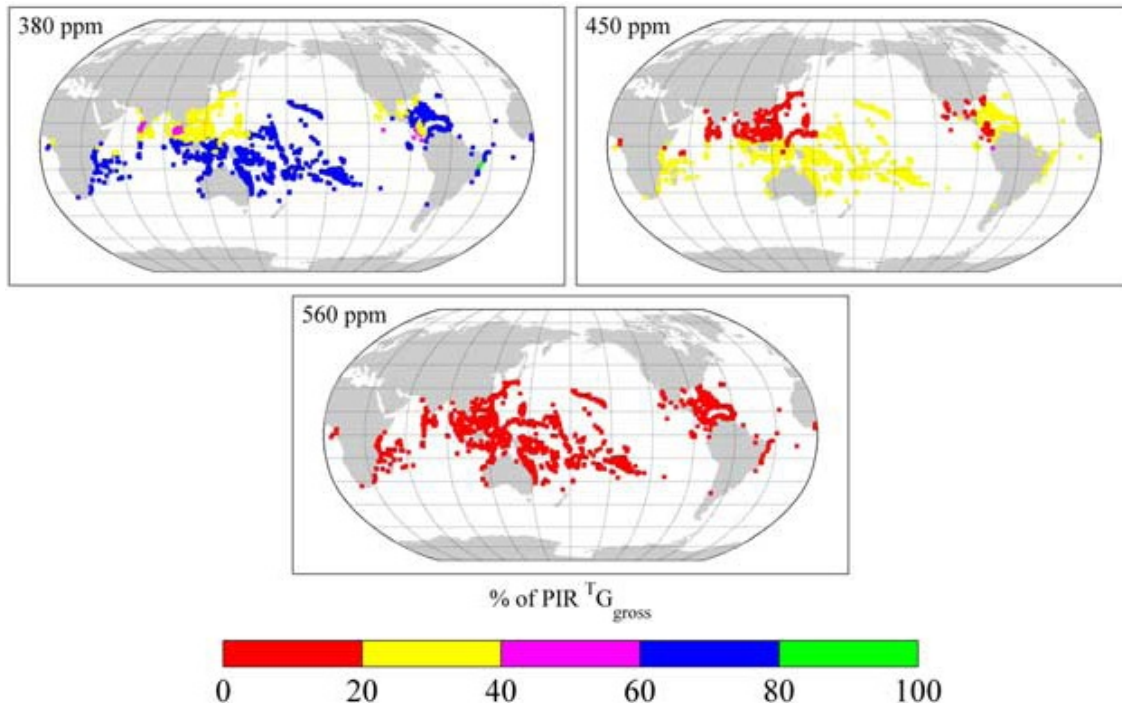


Figure 1. The impact of increasing atmospheric CO₂ concentration on the growth rate of coral reefs. Current locations of coral reefs are indicated by coloured dots, the colour of which shows the projected growth rate in percent of pre-industrial growth rate. At about 550 ppm the growth rate of coral reefs worldwide is less than 20% of pre-industrial values (Source: Silverman et al., 2009).

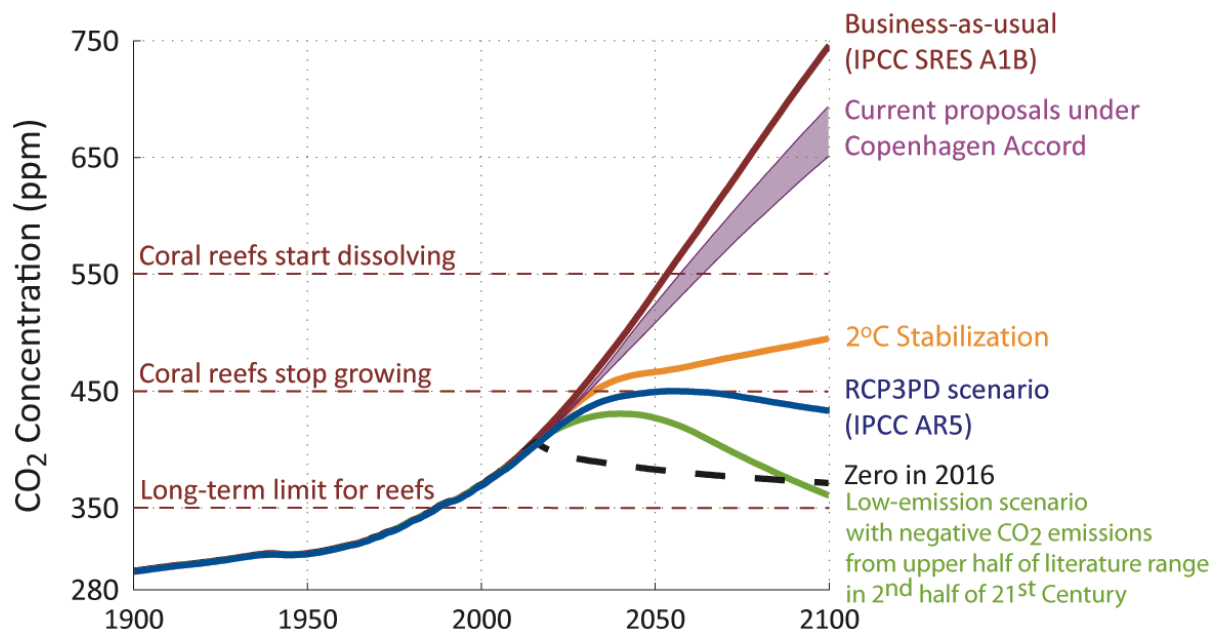


Figure 2. A CO₂ concentration of 550 ppm is exceeded by the 2050s in a business-as-usual projection (Nakicenovic et al., 2000) and by the 2060s in a pathway including current emission reduction proposals by Annex I and non-Annex I Parties (Rogelj et al., 2010 and www.climateactiontracker.org). By contrast, low-emission scenarios like RCP3PD, developed for IPCC AR5 (van Vuuren et al., 2007), or a 1.5°C/350 ppm scenario (green curve) consistent with AOSIS emission reduction proposals, may keep CO₂ concentration below 450 ppm and draw it down to lower levels, because of negative CO₂ emissions in the second half of the 21st century. In the latter case the decrease in CO₂ concentration can be more rapid than under natural removal of CO₂ from the atmosphere, as depicted by the hypothetical scenario that reduces global emissions to zero abruptly in the year 2016 (black dashed).

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