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Quantifying the bottle neck of marine CO_2 uptake

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Invasion of anthropogenic CO_2 into the ocean is well known to change the buffer behaviour of seawater and reduce the oceans' capacity to further take up additional anthropogenic CO_2. However, this 'buffer erosion feedback' remains unquantified, mainly for the lack of suitable modelling approaches.

Here we use an ocean-atmosphere biogochemical model to quantify the dominant feedbacks that control marine CO_2-uptake between pre-industrial and yr 2100 for four representative concentration pathways (RCP 2.6 to RCP 8.5). We find that for the business-as-usual RCP 8.5 climate scenario, climate and carbon concentration feedbacks reduce the marine CO_2-uptake by about 50% (equivalent to -551 Gt C) compared to an idealised model case without climate change feedbacks on marine CO_2 uptake and with a CO_2 buffer behaviour kept constant at pre-industrial conditions. About 90% of the uptake reduction can be attributed to the erosion of the surface ocean CO_2 buffer capacity. About 8% reduction is associated with the combined effect of buffer reduction and climate feedbacks, and only about 3% of the uptake reduction can be directly attributable to the net effect of all climate change feedbacks implemented in our model. Surface ocean CO_2-buffer erosion is hence the bottle neck and gate keeper of marine CO_2 uptake. This is of particular relevance for human interventions, which are intended to artificially enhance marine CO_2-uptake (ocean negative emission technologies, ONET). As an example, we discuss how the CO_2-buffer erosion controls the efficiency of coastal alkalinisation. We further propose our modelling approach, which can be easily adopted to other climate models, as a tool to evaluate the fundamental controls of ONETs.