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Enhanced carbonate and silicate weathering accelerates recovery from fossil fuel CO_2 perturbations

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Increasing atmospheric CO_2 and surface temperatures should increase carbonate and silicate weathering rates, directly via warming, and indirectly via the CO_2 fertilisation effect enhancing plant productivity. This enhanced weathering should in turn increase alkalinity input to the ocean and accelerate long-term CO_2 uptake. The negative feedback involving silicate weathering is widely invoked to explain the long-term stability of the climate over Earth history, but carbonate weathering is little considered because it is balanced by carbonate deposition on geologic timescales. To examine their potential role in the response to anthropogenic perturbation, we added silicate and carbonate weathering, and carbonate sediments to an existing global carbon cycle and surface temperature model, and subjected it to a range of long-term fossil fuel emissions scenarios, spanning 1,100–15,000GtC in total.

Our model experiments suggest that amplified carbonate and silicate weathering will greatly accelerate CO_2 removal from the atmosphere 10-100kyr after the fossil fuel perturbation. For emissions of $\geq$7,350GtC that dissolve all carbonate sediments, enhanced carbonate and silicate weathering accelerate subsequent CO_2 removal from the atmosphere by up to a factor of 4. For 1,100–4,000GtC emissions, enhanced weathering accelerates CO_2 removal by a factor of 1.5–2.5. Carbonate and silicate weathering make roughly equal contributions to accelerating the transient response, but only silicate weathering can reduce the long-term steady state for atmospheric CO_2 back towards the pre-industrial level, and this takes >1Myr. If the effects of land-use change persist on this timescale and tend to reduce weathering rates (e.g. by transforming areas of forest to pasture or cropland), then the final steady state CO_2 is above the pre-industrial ~280ppmv. This in turn could prevent future glaciations indefinitely.