Uncertainty in the weathering feedback: implications for Earth system recovery to carbon release

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Silicate weathering acts as a key negative feedback in restoring atmospheric pCO_2 and stabilizing Earth's climate over timescales of tens of thousands to millions of years. Various parameterizations of the silicate weathering feedback have been proposed and utilized in carbon cycle models – including dependence on atmospheric pCO_2 levels, global temperature, the intensity of the global hydrological cycle, global land surface productivity, and the surface distribution of various rock types. Assumptions about the long term (10^4-10^5 yr) sensitivity of atmospheric pCO_2, ocean carbonate chemistry and global temperature to carbon release past, present, and future rely on accurate understanding of the strength of this crucial negative Earth system feedback.

Here we present a critical evaluation of the implications of various parameterizations of the weathering feedback for reconstructing the Earth system response to carbon release. Using the Earth system model cGENIE, we employ multiple weathering parameterizations in different model configurations (simulating both an ice-free and modern climate) and perturb the system with carbon release over timescales meant to approximate both anthropogenic release and slower carbon release across past warming analogs (e.g. the 'hyperthermals' of the early Cenozoic). In addition to tracking the response of atmospheric pCO_2, surface ocean pH, and global temperature, we also evaluate impacts on the proxies often used to reconstruct carbon release events – including the evolution of the carbon isotopic composition of the atmosphere and ocean and changes in sedimentary $CaCO_3$ burial (the ultimate fate of sequestered CO_2). We compare these results to available records across multiple Paleogene hyperthermals as an additional metric for evaluating the various parameterizations.