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The importance of terrestrial weathering for climate system modelling on extended timescales: a study with the UVic ESCM

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The chemical erosion of carbonate and silicate rocks is a key process in the global carbon cycle and, through its coupling with calcium carbonate deposition in the ocean, is the primary sink of carbon on geologic timescales. The dynamic interdependence of terrestrial weathering rates with atmospheric temperature and carbon dioxide concentrations is crucial to the regulation of Earth's climate over multi-millennial timescales. However any attempts to develop a modeling context for terrestrial weathering as part of a dynamic climate system are limited, mostly because of the difficulty in adapting the multi-millennial timescales of the implied negative feedback mechanism with those of the atmosphere and ocean. Much of the earlier work on this topic is therefore based on box-model approaches, abandoning spatial variability for the sake of computational efficiency and the possibility to investigate the impact of weathering on climate change over time frames much longer than those allowed by traditional climate system models. As a result we still have but a rudimentary understanding of the chemical weathering feedback mechanism and its effects on ocean biogeochemistry and atmospheric CO_2.

Here, we introduce a spatially-explicit, rock weathering model into the University of Victoria Earth System Climate Model (UVic ESCM). We use a land map which takes into account a number of different rock lithologies, changes in sea level, as well as an empirical model of the temperature and NPP dependency of weathering rates for the different rock types. We apply this new model to the last deglacial period (c. 21000BP to 13000BP) as well as a future climate change scenario (c. 1800AD to 6000AD+), comparing the results of our 2-D version of the weathering feedback mechanism to simulations using only the box-model parameterizations of Meissner et al. [2012]. These simulations reveal the importance of two-dimensional factors (i.e. changes in sea level and rock type distribution) in the role of the weathering negative feedback mechanism on multi-millennial timescales.