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Interactive comment on "The importance of terrestrial weathering changes in multimillennial recovery of the global carbon cycle: a two-dimensional perspective" *by* Marc-Olivier Brault et al.

Anonymous Referee #1

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Brault et al. built spatially explicit parameterization schemes of continental weathering into the UVic Earth system model of intermediate complexity. Changes in weathering rate are parameterized based on rock types, changes in surface temperature, terrestrial primary production, river runoff, and atmospheric CO2. Then the UVic model is used to project long-term changes in the global carbon cycle under assumed anthropogenic CO2 emission scenarios. Simulation results using spatially explicit weathering schemes are compared with those parameterizing weathering flux using global mean variables. In general, it is found that the terrestrial weathering has a negligible effect on the ocean biogeochemistry and climate change on the timescales from decades to

centuries, but become much more important on multimillennial timescales. This finding is qualitatively in line with earlier modeling studies that incorporates a 0D weathering component.

The novelty of this study is the representation of terrestrial weathering on each model grid cell, which is an improvement over earlier studies using 0D weathering scheme. Given the large uncertainty of the weathering parameterization schemes (The authors did a nice job in discussing those uncertainties, though) and the model-simulated changes in relevant variables over the timescale of many thousands of years, it is difficult to make an assessment of how reliable the quantitative results are. Nevertheless, this work is one of the few Earth system modeling studies that provides a long-term projection of the global carbon cycle and climate with a spatially explicit weathering component. This manuscript is well written. I recommend its publication with a few minor comments.

Specific comments:

The six-page introduction is a comprehensive review of the rock weathering processes, in particular the modeling studies of weathering effect on the carbon cycle. This kind of introduction is useful for broad readers to understand the weathering effect. However, this type of introduction might be too lengthy to fit the journal. The authors may need to condense it.

Page 3, lines 10-11: "However, there have been but very few quantitative assessments of its impacts on carbon cycling and ocean biogeochemistry.."

"very few quantitative assessment" is not an objective statement. There are actually quite a number of existing modeling studies, as cited in the following section, on the effect of rock weathering on the carbon cycle.

Page 11, lines 4-5 "The UVic ESCM also includes a fully coupled global carbon cycle, which consists of inorganic carbon chemistry and land-surface exchanges of CO2

(Ewen et al., 2004)"

"land-surface exchanges of CO2" should be "air-sea exchange of CO2"

Page 15, lines 16-17: "and on par with previous estimations of pre-industrial global weathering intensity."

Some references should be given here for the data-based estimate of pre-industrial global weathering intensity.

Page 19, lines 14-15: " Weathering is calculated in each individual land grid cell, and routed to the coastal ocean as fluxes of alkalinity and dissolved inorganic carbon"

It would be helpful to elaborate a bit more of how the river routing is done in the UVic model.

Page 21, " Pre-industrial steady-state weathering was obtained by integrating the model for over 20,000 years under year 1800 boundary conditions ... However, the fixing of deep ocean alkalinity and dissolved inorganic carbon (DIC) content would have required as much as 105 model years – an impossibly long simulation time given the level of complexity of the UVic model."

It would be useful to show something like time series of ocean-mean DIC and alkalinity to see how far the system is away from equilibrium after 20,000 years of spinup.

Page 25, lines 22-23, please explain how the carbon burial rates depend on temperature.

Page 30, line 22; page 31, lines 1-2: "Alkalinity flux from C1 exceeded that of other model versions towards the end of the simulation period as the slower carbon removal resulted in much warmer surface conditions compared to other model versions."

How does alkalinity flux relate to surface temperature in the model?

Pages 32-35: One important caveat that is not discussed here is the lack of nutrient

limitation in the UVic terrestrial module, which could have important implication for the prediction of primary production over long time scales and the resulting effect on modeled change in weathering.

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