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Geoscientific
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Interactive comment on "The Rock Geochemical Model (RokGeM) v0.9" *by* G. Colbourn et al.

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This contribution deals with the description of a new sub-model of GENIE aiming at simulate the weathering fluxes to the ocean. I have several issues that should be discussed prior to publication (major revision).

General comment

I fully understand that long term simulations requires to keep the description of weathering processes at a simple level, so that the system can be fastly integrated. But weathering is a complex process that deserves a careful modeling, especially if we want to catch its dynamic at the millenia timescale. Indeed, at the million year timescale, one can more or less trust the parametric laws linking weathering to the main environmental parameters (here runoff and lithology), assuming that the weathering system is always close to a steady-state. But at shorter timescale (<million years), the weathering sys-

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tem is always out of steady-state (variable weathering profile thickness, vegetal cover, mineralogical composition of the weathering profile, ...), and process-based models should be used to simulate the dynamic response of weathering to environmental forcing, which may be highly non linear.

Other major points

1) a similar method (modeling continental weathering at the global scale with a 2D spatial resolution) has been developped in the recent years by Donnadieu and co-authors. They built the GEOCLIM model which couples a 3D GCM (an EMIC in earlier version, then a GCM) with a box model for the ocean, and includes a 2D weathering model (Donnadieu et al., 2004, 2006; Goddéris et al., 2008; Donnadieu et al., 2009). GEOCLIM is a kind of an ESM for the geological past. I think that the authors should have a look at these publications. The point is that water is the first order controlling parameter of weathering, well before land plants or whatever. This is an obvious point: no water, no mineral dissolution. Donnadieu et al. (2004; 2006) and Goddéris et al. (2008) have demonstrated the critical role played by the 2D runoff pattern on continental weathering and hence on the geological carbon cycle. But on page 2017, the authors mention that GENIE is producing an overly uniform runoff above the continental surfaces. Can you produce a map of the present day runoff calculated by GENIE ? If the runoff pattern is wrong, nothing can be said about the dynamic of weathering. I think improving the runoff calculation should be undertaken together with implementing a continental weathering model. 2) Page 2023, eq 7 : instead of using the old contribution of Brady et al. (1991), you should use the more recent works by Dessert et al. (2003) for basalts and Oliva et al. (2003) for granites. Both papers are providing apparent activation energies for silicate weathering based on field measurements instead of extrapolating laboratory experiments. 3) Equation 6 is surprising : the higher the temperature, the higher the carbonate weathering. But when temperature rises, carbonate solubility decreases, producing a decrease in carbonate dissolution. I'm wandering whether there is not a coeval change in runoff (increasing with temperature,

GMDD

5, C654–C657, 2012

in a very simplistic scheme) behind this equation, or some biological effects. Can you check ? 4) Regarding the fertilization by CO2 and its impact on weathering (eq 14). To my knowledge, nobody knows precisely where this equation is coming from. Looking at the most complete description of the equation (in Berner, 2004), it is said this is a "Michaelis-Menton equation", "used as a simple first approximation for a process that is poorly understood" (page 25 in Berner, 2004). I would not trust so much this equation. Especially since it depends only on the CO2 pressure in the atmosphere. Water has an important role to play here. Whatever the CO2, there will be no fertilization without water. Water should be accounted for in such a complex model as GENIE. See Beaulieu et al. (2010) for the link between silicate weathering and fertilization of land plants, with water cycle response (stomatal closure at high CO2 resulting in reduced evapotranspiration and enhanced drainage of the weathering profiles). Also, on page 2034, eq 18: does it mean that when CO2 rises, productivity rises everywhere on Earth in the same proportion ? This does not consider the drift of ecosystems, which is accounted in other models (Donnadieu et al., 2009). I think that assuming a overall rise of the impact of land plants on weathering with CO2 is unrealistic, and is rather a modeller trick to ensure a strong negative feedback between CO2 and weathering in order to limit CO2 fluctuations at the million year timescale. Another interesting work on the link between land plants and weathering at the global scale is the Taylor et al. (2012) paper. Overall, the description of the link between the continental biosphere and weathering is too rough and not enough constrained in the present contribution. 5) The future use of the weathering model is not really clear to me. The lithological distribution is not known for the distant past, especially for Permian and Devonian times. Consequently, their model which is based on the relationship between runoff and weathering for each lithological type cannot be applied. Are they planning to use the rough global method described in the paper ? Conceptually, does this differ from 0D models such as GEOCARB ? In fact, two models are described in this contribution : a 0D and a 2D models. The authors should clarify which model will be used for which case study.

Minor points

GMDD

5, C654–C657, 2012

1) page 2009. “This process is known as terrestrial neutralisation”. The process the authors are describing is known as continental weathering. This is the common name for this process. Same on page 2021. 2) You should not cite a paper in preparation (see Archer comment): Colbourn et al. 2012. 3) Page 2036: Beaulieu et al. (2012) explore with the B-WITCH model the impact of a CO2 doubling on weathering for the Mackenzie river. An important conclusion of this work is that carbonate weathering drives the response of the weathering system at the anthropocene timescale. Silicate weathering response is of secondary importance. 4) Page 2041 : the Devonian terrestrialization and its impact on weathering and the global carbon cycle has been already explored with a coupled 3D GCM, biospheric model and a 2D weathering scheme (Le Hir et al, 2011).

References

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