

## ***Interactive comment on* “Technical Note: A generic law-of-the-minimum flux limiter for simulating substrate limitation in biogeochemical models” by J. Y. Tang and W. J. Riley**

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**General comments** The goal of the note is to document a method of solving nutrient dynamics in biogeochemical models. Specially it focuses on improving numerical solutions of biogeochemical models (specifically soil model) so that 1) negative nutrient concentrations are not simulated and 2) serial access (i.e. microbes have first access, then plants) to nutrients is not required by the different nutrient consumers. These issues are motivated by specifics to the Community Land Model but can apply to other Earth system models and ecosystem models. Overall, improving the numeric methods associated with simulating nutrient uptake and limitation is important for the field

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of biogeochemical modeling and the authors show that different methods can lead to different answers.

**Response:** We thank the reviewer's appreciation of our effort. We address your comments point by point in the following.

**Comment:** It would be valuable to discuss model forms where the methods described are necessary and where they might not be as important. The Century model used in the manuscript is an example of a model without rate limitation kinetics (i.e. Michaelis–Menten kinetics) where the efficiency of N uptake does not scale with the inorganic N concentration. In this case method introduced in the manuscript is clearly important. In contrast, some ESMs and ecosystem models use rate limitation (i.e. Michaelis–Menten kinetics) to adjust the efficiency of N uptake rates so that as inorganic N concentrations get smaller the efficiency of N uptake rate declines. In this case, the methods described may not be as important because it is very rare that inorganic N concentration become negative (especially with an adaptive-time step ODE solver) and the competition between consumers is represented in the Michaelis-Menten parameters. See the LM3V (Gerber et al. 2010) and MEL (Rastetter et al. 2013) as examples.

**Response:** We thank the reviewer to point out the difference between Century's formulation and the MM based formulation. However, according to our experience with biogeochemical modeling, even MM based formulation will suffer from the same problem, especially when there are more than one substrates can limit the reaction rates. Essentially, when a certain substrate is of a small amount, its consumption rate as calculated from MM kinetics is a linear function of the substrate amount. When there are several reactions demanding the same substrate, for instance O<sub>2</sub> by all aerobic processes, negative substrate concentration will still occur if reaction rates are not limited. We therefore suggest the non-negativity issue is common to all sorts of biogeochemical models. We added this discussion in our revised manuscript.

**Other minor comments** Overall, the main message of the manuscript is clear but it

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is challenging to understand the specifics and to visualize how to apply the concepts because there are ambiguous subscripts and undefined concepts (see below)

Page 13401, Line 18: Define 'standard operator splitting approach'.

Greater detail in the use of subscripts and variables is needed. In particular:

- Page 13403: subscript  $i$  and  $m$  are not defined

- Page 13405: The pseudo code describes how  $q_n$  is calculated but the text does not describe how  $q_n$  is used or defines  $q_n$ . Please clarify. (note that  $q_n$  is also used in Appendix A for the loss rate – which is confusing)

- Page 13405: What does the  $k$  index refer to in the first for loop? Why use the  $n$  variable in the second for loop when the nomenclature in the text uses  $j$ ?

Page 13404, Line 18: This is the first time the term 'flux limiter' is used in the main text. Please define. Mechanistically how is the flux limiter used in the equations?

Page 13404, Line 24: Greater explanation is needed for why the  $S^-$  is used to control the flux limitation. The current explanation is not clear.

**Response:** Per your suggestion, in the revised manuscript, we clarified the above issues and rewrote our pseudo-code as F90 code with detailed comments for a better understanding to readers.

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**BGD**

12, C7401–C7403, 2015

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