Geoscientific
Model Development
Discussions

Interactive comment on "On the relationships between Michaelis–Menten kinetics, reverse Michaelis–Menten kinetics, Equilibrium Chemistry Approximation kinetics and quadratic kinetics" *by* J. Y. Tang

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J.Y. Tang in this paper show the relationship between the recently introduced Equilibrium Chemistry Approximation (ECA) kinetics with commonly used other formulation of substrate kinetics. This is an important topic and valuable to the modelling community, as this substrate kinetics is central to soil organic matter modelling.

While I strongly suggest to publish the paper, I give some constructively ment critiques that hopefully help to convey the message of the paper better to the reader.

My main points are

- Note that GM journal also addresses readers that do not have a very strong mathematical background. Please, give some more aid, so that the readers can follow the derivations (Some suggestion are given in the specific section below)

- Both the abstract and the main part of the paper present a mathematical treatment without sufficient user-aid on how to interpret the results. Why are the parametric sensitivities important? What does it mean for modelling the processes?

- Beware of confounding the concepts of microbial uptake and enzyme kinetics (e.g. p. 7680 ll line 14). The ECA, as I understood it, deals with enzymatic breakdown of soil organic matter (SOM) into smaller compounds. The Monod-Description of microbial uptake of these components has a different more empirical background. While with the assumption of enzymatic breakdown to be the limiting step, models can apply ECA also for microbial growth, the two concepts should be kept clear.

- ECA are based on total concentrations including the enzyme-substrate complex. Most SOM models are formulated on a more abstract level. How to deal with this practically? What are the consequences when total concentrations would be replaced by modelled pure concentrations or by pools in mass units? Under which conditions is this is viable?

1 General comments

The introduction is written well, and the importance becomes clear.

The main message of the paper to me is that ECA for one substrate-one enzyme is a mass-balanced approximation of the general QSS (quasi steady state) solution and

that generalizes both MM and RMM. The derivation (from eq. 11 to 12), however, is too condensed to be understood without more mathematical efforts. Did you generate the Taylor series at E=0 and S=0? Did you truncate second order terms of E and S? What does it mean to truncate for ϵ?

Can you, please, extend the explanation of the points at the end of section 2.1? To what and how is Eq. 12 applied? Is eq. 13 not just a re-statement of eq. 5? In what way does this form the tQSSA?

Maybe also move the equations of the parametric sensitivity analysis to the appendix and focus in the main text on the figures and their interpretation for modelling. Why were the sensitivities normalized? Especially why multiplied by the rates? How are these normalized sensitivities interpreted?

Section 3.2. can be shortened by noting that the sensitivities are 1- the sensitivities of 3.1. I could not follow derivation from eq. B2 to B3. When I insert v_{ECA} and K_{ES} in the second term on the right of B3, I arrived at a result different from B2. (to editor: I did not check Taylor expansion of eq. 10 nor Appendix A)

2 Specific comments

P.7670 L.1: suggest aid: By inserting [E] solved from (7) and [S] from (8) into (6) one arrives at the following quadratic equation.

P.7670 L.9, L12: Some more details are required.

P. 7671: L15: What does the error in parametric sensitivites mean for modelling?

P.7675 L.8: term predictions refers to sensitivities or reaction rates?

P.7675 L.14: Color scale in Fig. 1 goes to -9% instead of 5% in the text. What is the difference?

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Figs (1-3).d are hard to understand. Why do you apply log in single variables in the derivatives instead of log(sensitivity). Also with so much overplotting the figure is obscured. Where does the spread come from?

Two Typos after eq. B3 (Then, refer to eq. B3 instead of B2)

P.7680 L.13. Important sentence, but very long. Can be broken up.