Review of 'Model of Early Diagenesis in the Upper Sediment with Adaptable complexity – MEDUSA (v. 2): a time-dependent biogeochemical sediment module for Earth System Models, process analysis and teaching' by G. Munhoven

General comments

The author presents a description of a flexible novel 1D reactive transport model of early diagenesis MEDUSA in version 2. The description is quite concise and easy to read. Focus of the model description is rather on the coupling to global biogeochemical cycling models. The model and its documentation will be useful to the community. Publication in GMD would be most appropriate and hence I recommend the publication. I have only minor comments to ask the author for clearer descriptions regarding model feature and application.

(1) The model seems to apply different numerical schemes to different realms as inferred from Fig. 1. However, how the model does this is not 100% clear from the ms. Also, there seems to be some options that could affect the overall solution scheme/sequence, e.g., whether the model includes diffusion boundary layer or not; whether the advection is solved or not; whether the model tracks time or not, etc. Although the details are referred to the Supplement when relevant, a flow chart of the calculation scheme/sequence including branches for some important model options would be very helpful for the reader to grasp what is going on in the model.

(2) Pros and cons of options are discussed but it is not 100% obvious to the reader when to adopt which option. For example, in the ALL experiment, the author discussed the difference between the tracked time and actual time and the cause of it, but not sure when/why we should use the tracked time. Also, the author described that the implementation of mineral volume options (related to advection scheme) does not affect the overall results, which will make the reader to wonder when/why to adopt which option regarding mineral volumes. Furthermore, under what conditions should we adopt the option of DBL? As a model description paper, providing a conclusion on the options may not be obligation, but guiding the reader a little bit more could be desired.

Specific comments

Table 1: In my understanding $CaCO_3$ and clay are not vertically resolved in Archer's original model (1991); only porewater chemistry and OM are vertically resolved. How do you define the layer number when layer numbers are different between different species as is the case for Archer (1991)?

Line 248: Are you saying that one of solid species is treated as a dilatant material and does not necessarily complies with advection law (e.g., Eq. (1) + equation in line 205)? I thought iterative

implementation of Eqs. (1) and (6) and equation in line 205 could satisfy Eq. (4) (e.g., Archer et al., 2002).

Lines 258-270: Not sure whether the equations for different realms are solved at once or in a sequence with/without iterations. Is it appropriate to define a boundary condition for TRANSLAY as done for the above layers?

Line 327: Do you mean *w* is calculated time-explicitly but solids-solutes are calculated time-implicitly? Also, I suppose Newton iteration is conducted only in REACLAY and DBL? Do you separate calculations between REACLAY and DBL or at once?

Line 499: Is MEDUSA fully coupled to BEC (allowing exchange fluxes passed between the two models/modules) or are you just using the BEC output as boundary conditions and not returning any fluxes to BEC? The steady-state results of sedimentary profiles between the above two cases could different.

Table 3, cap. L1: Isn't 1L = $1dm^3$ universally correct? If so this does not have to be assumed?

<u>Technical comments</u>

Line 134: 'the sedimentary mixed' should be replaced with 'the sedimentary mixed layer'?

Line 453: Right parenthesis is missing.

Tables 1 and 2: 'BRNS-global' or 'BRNS-GLOBAL'?

Fig. 3 caption L2: %Opal should be red triangles?