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Geoscientific Model Development Discussions

Interactive comment on "A multi-isotope model for simulating soil organic carbon cycling on an eroding landscape (WATEM_C v1.0)" *by* Zhengang Wang and Kristof Van Oost

Zhengang Wang and Kristof Van Oost

wangzhg33@mail.sysu.edu.cn

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The authors developed a soil carbon model with coupled processes of decomposition, advection-diffusion and erosion-deposition. The model includes all carbon isotopes and 137Cs. It is a great effort to include all the carbon isotopes in the model. I have several suggestions and concerns below hoping to improve the manuscript.

1.Lack of technical details in the methods section is obvious. To name a few: how did the authors implement plant type change (changes in input, roots and/or else?) how did the authors test Suess effect in the model?

Answer: A table on the description of various scenarios and how they were performed has been added (Table 2).

How did the authors simulate spatial variability?

Answer: The spatial variability is related to soil redistribution at the landscape scale. A paragraph has been added to describe in detail how the routing of runoff and soil particles are simulated in the model (Lines 142-145).

How did the authors determine the initial conditions of the model?

Answer: A detailed description of the procedure to estimate/set the initial profiles of 137Cs, C pools and C isotopic compositions has been added (Lines 270-280). We believe that this now provides sufficient information for the readers.

What are the depth and depth intervals of the model?

Answer: These are defined by parameters in the model code. Annotations have been added in the R script (reference_scenario.R) to explain the meanings of variables used in the codes. The R script file has been updated.

More descriptions are necessary for 137Cs dynamics, such as equations and parameter values.

Answer: Section 2.2.1 has been revised to include the lateral fluxes of 137Cs due to soil erosion. The decay of 137Cs (Eq. 21) has been added in section 2.2.5 (Lines 258-260).

2.A data-model comparison is necessary for model evaluation. I suggest a direct comparison between model outputs and data in figure 7 and figure 8. For example, plot them together.

Answer: Data presented in Figure 7 and Figure 8 (of last version) have been used for the model calibration together with C content data at these two study sites. The results derived from model calibration have been presented in Figure 1 and Figure 2 in the

revised manuscript. Changes have also been made in Methods (Lines 113-132, Lines 291-317), Results (Lines 336-342), and Discussion (Lines 452-453) sections.

3.Routine modeling activities such as sensitivity and uncertainty analysis are needed for model evaluations. Relative importance of the three main processes (decomposition, advection-diffusion, and erosion-deposition) need to be shown in some way.

Answer: Thank you for this valuable suggestion. In response to this comment, the Fourier Amplitude Sensitivity Test (FAST) has been applied to the model to explore the importance of C decomposition, advection-diffusion and erosion-deposition in controlling C, δ13C and Δ14C profiles. The results is presented in Figure 7. Changes have also been made in Methods (Lines 318-327), Results (Lines 366-377), Discussion (Lines 454-459) and Conclusion (Lines 486-488) sections.

4.An introduction and discussion of progress in model development in carbon isotopes would be very relevant.

Answer: A paragraph on a review of progress in model development in carbon isotopes have been added (Lines 91-102).

5.The results could use some more work. For example, I would not use current figure 1 as the first figure. It is not your central figure. I would first show some figures in model-data comparisons.

Answer: Figure 1 has been removed from the revised manuscript. Figures on model-data (Figures 1 and 2) has been shown first as suggested (see the reply to Point 2 above).

A few more comments:

1. What is WATEM_C short for? I did not find its full name throughout the text.

Answer: The abbreviation has been explained (Line 136).

2. Lines 100-105: L and S are slope steep and length factors, or the other way around?

Answer: It is the other way around, and it has been corrected (Line 145).

3. Line 211: developED

Answer: It has been corrected as suggested (Line 265).

4. Would a table be helpful for presenting all the modeling scenarios?

Answer: A table including descriptions and implementation of model scenarios has been added (Table 2). Relevant revisions has also been done in the text (Line 282).

5. A, S, and P in equations 7, 8, and 9: are not they carbon concentration (in the unit of for example, gC/m3) instead of carbon content? Because the authors model them with explicit depth. Please clarify.

Answer: The reviewer is correct that A, S and P should be the content of various C pools. Similarly, the unit of C input into a given depth has been changed from Mg C ha -1 yr-1 to Mg C yr-1 (Lines 182, and 183).

6. Equation18: the terms on the right side are supposed to be partial differentials and K(z) is supposed to be inside the second-order differential due to the fact that K changes with z.

Answer: Eq. 18 has been revised as suggested.

7. what are the K values for Fig.1c? and similar issues for other relevant figures.

Answer: Values of relevant parameters have been added in the figures (Figures 3-6 in the revised manuscript). We also extended Table 1 and added Tables 2 and 3 to display more information on parameter values of the model.

8.I am surprised to see lack of depth dependence of 13C in Scenario 1. (Fig. 3a). Could the slower decomposition and lower carbon input along depth result in changes in 13C with depth, like 12C and 14C? Please clarify.

Answer: Figure 6a (in the revised manuscript) shows the vertical variation of δ13C

values rather 13C content. In Scenario 1, slower decomposition and lower carbon input along depth result in changes in 13C with depth, but 12C has similar changes with soil depth, and therefore the 13C composition (δ13C) does not change with soil depth. A sentence has been added to explain this (Line 409).

9. Fig. 6 is difficult to read. I'd suggest the authors use colored scheme.

Answer: The figure has been changed to color maps (Figure 8 in the revised version).

10. Line 280: negligence instead of negelation

Answer: It has been replaced with neglection (Line 408).

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