Biogeosciences Discuss.,
doi:10.5194/bg-2016-377-AC1, 2016

Biogeosciences Discussions
Open Access
EGU

Interactive comment on "Transient Dynamics of Terrestrial Carbon Storage: Mathematical foundation and Numeric Examples" *by* Yiqi Luo et al.

Yiqi Luo et al.

yluo@ou.edu

Received and published: 22 November 2016

Dear Referee 1:

We greatly appreciate your comments on our manuscript. We have carefully studied your comments and revised the manuscript accordingly. Please note the line numbers and pages numbers in this letter are all refereed in the revised manuscript.

Hope you will find our revision and responses satisfactory.

Yiqi Luo On behalf of all the authors

Below we list our point-to-point responses to your comments:

Printer-friendly version

Discussion paper

[Comment] General remarks: The authors present a paper showing that a matrix equation can replicate the output of a comprehensive carbon cycle model. In particular they find that the force driving the ecosystem C storage is the C storage capacity. In general the article is well written and organized and fits into the scope of the journal. Using such a simple matrix equation as a physical emulator of comprehensive models has the potential to save a lot of computing time and gains a deeper understanding of the underlying mechanisms. The authors state in their summary that this would revolutionize model evaluations.

[Response] Thanks for the positive comment.

[Comment] I have some concern about this: The matrix equation has to be fitted to a simulation of the complex model with a specified fixed climate scenario. It would be interesting to know whether this parameter set can be used for a different climate scenario. In particular some parameters in the matrix equation are time-dependent and this time-dependence might change for different climate scenarios. Then the complex model can really be replaced by the matrix equation. Otherwise the matrix equation allows only a more convenient analysis of the model output. Non-linearities in the complex model might lead to a deviation from the linearized matrix representation. It would be nice if the authors could comment on that.

[Response] The physical emulator does not result from fitting the model to simulation of the complex model. It generates by organizing the carbon balance equations in the original model into a matrix form. So the physical emulator is not climate scenario-specific. Once developed, it is applicable to all climate scenarios.

We have revised the manuscript to clarify this point. For example, we revised the title of section 2.2 to be “TECO Model, its physical emulator, and numerical experiments”. We completely rewrote the third paragraph in that section to describe how we have developed the physical emulator of TECO in detail as:

“To support the mathematical analysis using eq. 1, we first developed a physical emu-

lator (i.e., the matrix representation of eq. 1) of the TECO model and then verified that the physical emulator can exactly represent simulations of the original TECO model. We first identified those parameter values in each of the C balance equations in the TECO model that are corresponding to elements in matrices A and K in eq. 1. The time-dependent variables for u(t), elements in vector B, and elements in matrix ξ(t) in the physical emulator were directly from outputs of the original TECO model. Then those parameter values and time-dependent variables were organized into matrices A, ξ(t), and K; vectors X(t), X_0, and B; and variable u(t). Those matrices, vectors, and variable were entered to matrix calculation to compute X'(t) using eq. 1. The sum of elements in calculated X'(t) is a 100% match with simulated net ecosystem production (NEP) with the TECO model (Fig. 1b)."

Hope this paragraph explains the physical emulator clearly. In addition, we will provide a webpage link to both the TECO model and its physical emulator for verification and uses.

[Comment] More specific remarks: Abstract: The authors are talking about a 3-D parameter space. These 3 parameters, however, are not simple scalars, but are itself vectors (e.g., residence time and storage potential).

[Response] we add elements of the vectors together to get the scalars before we plotted the 3D parameter space. We clarified this point in several places in the manuscript. For example,

One paragraph on page 14 (lines 318-322) on this point is:

"Note that sums of elements in vectors X(t), X_c (t), X_p (t), Xˆ' (t), and τ_E (t) are corresponding, respectively, to the whole ecosystem C stock, ecosystem C storage capacity, ecosystem C storage potential, net ecosystem production (NEP), and ecosystem residence time. In this paper, we do not use a separate set of symbols to represent those sums rather than express them wherever necessary. "

Also, the legend of Figure 1 explains this point:

“Panel b compares the original TECO model outputs with those from matrix equations for net ecosystem production (NEP = the sum of elements in X’(t) from eq. 1). Panel c compares the original TECO model outputs with those from matrix equations for ecosystem C storage (= the sum of elements in X(t) from eq. 2).”

[Comment] Page 4: The authors state that most carbon cycle models follow a mathematical formulation of ordinary differential equations. Many of the dynamic global vegetation models (DGVM) are ab initio formulated as a time discrete model calculating, e.g., NPP on a daily level and carbon allocation to different vegetation pools on annually using some (non-linear) allocation rules. Moreover, the authors should mention these DGVMs.

[Response] Thanks for the comments. It is not very clear with “are ab initio formulated.” That leaves some uncertainty about our understanding of this comment. Nevertheless, the time steps of NPP calculation and allocation do not affect Eq. 1. Indeed, eq. 1 is mainly about C transformation within land ecosystems before the carbon is respired. NPP is input of eq. 1.

We have successfully applied Eqs. 1 and 2 to LPJ-GUESS, a DGVM, as described in line 613.

[Comment] Page 9: The authors should describe which algorithms are necessary in order to develop the matrix equation from the output of the TECO model. In particular how they determined matrix A and K.

[Response] We wrote the physical emulator of the TECO model in matlab. But it can be developed in any other computer language. Basically, we have to understand the original model and identify those carbon balance equations. Then we organize those coefficients and parameters in matrix forms to develop the physical emulator. See our responses to your comment on emulator above. We have completely revised the

Printer-friendly version

Discussion paper

paragraph in Section 2.2 to describe how we developed the physical emulator of the TECO model.

[Comment] Technical comment: Page 29, line 586: A “to” is missing: The emulators allow us TO analyze: : :

[Response] Corrected as suggested.

[Comment] In summary the article is suitable for publication if the above-mentioned comments are incorporated.

[Response] Thank the referee for the support.

Interactive comment on Biogeosciences Discuss., doi:10.5194/bg-2016-377, 2016.

Printer-friendly version

Discussion paper