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# *Interactive comment on* "Technical Note: An efficient method for accelerating the spin-up process for process-based biogeochemistry models" *by* Yang Qu et al.

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First, the section 2.2 is the core of this work, so the equations need more details and a double check. The equations (15) and (15a) are the fundamental equations in this method, but it is unclear how these two equations were derived from (12) and (13), respectively. One major reason for the confusion is that the authors introduced thek-1/2 as a half time step. I encourage the authors to more carefully double check the equations."

Response: In this revision, we clarified the definition of half-step Jacobian matrix J and the way to compute it. In our model, process rates depend on temperature and the



process rate constants are time dependent. Index k-1/2 is introduced due to solving x(k)-x(k-1)= $\tau$*(g(k-1/2)*x(k-1)+h(k-1/2)), which, as reviewer noted, would be commonly written as x(k)-x(k-1)= $\tau$*(g(k-1)*x(k-1)+h(k-1)) in a purely explicit scheme. However, it can be shown that using process rates at midpoint (k-1/2) is no less accurate than in purely explicit form with (k-1), which is obvious for h(k-1/2). The term h(k-1/2) simply represents the value at the half-time step for function h. For Section 2.2, we revised it to show how each step is being done and how the next step is related to previous time step.

Second, even the equations are all corrected, it is the authors' obligation to illustrate that how this approach could be adopted by other models. As we know, the structure of biogeochemistry in TEM used in this work is much simpler than those in many global land-surface models. For example, there are only two C pools and three N pools (see page 4), this makes the mathematical solution for the steady state much easier than those century-type models. I suggest the authors to add a section to discuss how their approach could be used in other models

Response: In this revision, we stated that "We consider our method is a general approach to accelerate the spin-up process for process-based biogeochemistry models. As long as the governing equations of the models can be formulated as the form in eq. (9), the algorithm could be adopted accordingly".

Third, the authors compared their new approach to the semi-analytical spin-up (SASU) method. The SASU method has shown that using analytical approach can dramatically save the spin-up time. However, many models still use the traditional methods of long-term iteration or some others, such as the accelerated decomposition (please see the technical note for the CLM4.5/5). The reason is that coding the analytical methods into the original model is time consuming. It would be great to see whether this method can save more time than those widely-used simple methods.

Response: We do consider our approach could be used for process-based models

with various structures. To accelerate the spin-up for multiple soil carbon pool models with relatively simple and linear decomposition processes, to implement our method is relatively easy, but will take a great amount of computing time to equilibrate. For models such as CLM, multiple methods have been tested to accelerate their spin-up process, but the direct analytical solution might be time-consuming to achieve. We added some discussion in the end of the Discussion section about this in this revision.

Forth, as shown in the Table 2, it seems the original TEM model reached the steady state very fast (âĹij200-500 years). This might be due to the short turnover times in the model (or the B components in the equation 16). Obviously the turnover of soil C is very slow at northern high latitudes. So it is not clear how the method will perform if the parameterizations for the soil module is realistic.

Response: Relatively quick spin up in TEM is due to the absence of slow soil carbon pool(s) as TEM has only one soil box (pool). Because soil carbon pools and litter pool are aggregated in TEM, the carbon turnover rates are dictated by fast turnover of litter pool, thus equilibration is faster than in CASA (Potter et al., 1993) or CENTURY (Parton et al., 1992) models. Accordingly, the benefit of our cyclo-stationary problem solver is less visible than in the case when it takes 2000 years or more to reach equilibrium. From eq. (17), we could see that our model performs stably for every grid in spite of the turnover rate, as the computation cost for LU decomposition is relatively stable. Added References: Potter, C. S., J. T. Randerson, C. B. Field, P. A. Matson, P. M. Vitousek, H. A. Mooney, and S. A. Klooster, 1993, Terrestrial ecosystem production: A process model based on global satellite and surface data, Global Biogeochemical Cycles, 7(4):811-841. Parton, W.J., B. McKeown, V. Kirchner, and D.S. Ojima. 1992. CENTURY Users Manual. Colorado State University, NREL Publication, Fort Collins, Colorado, USA.

Please also note the supplement to this comment:
https://www.biogeosciences-discuss.net/bg-2018-98/bg-2018-98-AC2-supplement.zip



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