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Biogeosciences Discussions

Interactive comment on "An empirical model simulating long-term diurnal CO_2 flux for diverse vegetation types" *by* M. Saito et al.

M. Saito et al.

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Anonymous Referee #1

Thank you your careful reading. The manuscript was substantially revised with new analyses, as advised. Our responses are as follows.

1. To general comments

   We agree with the referee #1 that application of the model to different ecosystems, which are not used to construct the model, is needed to validate and check the model capability. So we applied the model to 10 AmeriFlux and four AsiaFlux sites, and these results are mentioned in the text in Section 3.

2. P. 4002 L. 26: Discuss why parameters should vary. Fung et al. succeed in adjusting rather they noticed that using the adjustment provided a better fit. A fully mechanistic explanation of this phenomenon is lacking.

   We revised the manuscript as follows; “Model parameter adjustment is necessary to improve fit with the atmospheric observations Fung et al. (1987), for example, adjusting the seasonal cycle amplitude by modifying the value of the Q_{10} temperature coefficient for ecosystem respiration.”

3. P. 4003, L. 27: Some colloquial wording, and the narrow footprint is subjective.

   We removed this sentence.

4. P. 4004, L. 17: Write tundra ecosystems instead of tundras.

   We appreciate this comment and revised the manuscript as advised.

5. P. 4004, L. 26: The application of the GSOD is new to me, please provide the basic background and some specifics of its application here.

   We added detailed descriptions on the GSOD as follows; “The GSOD is a product of the Integrated Surface Data provided by the National Climate Data Center, and includes 13 daily summary parameters over 9000 global stations.”

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6. P. 4005, L. 20: Fixing the theta parameter at 0.9 diminishes its usefulness. The rectangular hyperbola is the non-rectangular hyperbola for theta = 1. Is this then the pseudo-rectangular hyperbola? Why was 0.9 chosen? Admittedly, convergence problems may result from attempting to fit this parameter at high frequencies, but testing the assumption of theta = 0.9 would be useful and will impact results.

   As mentioned, we frequently failed in the parameter fitting of θ due to convergence problem. The reason why we chose $\theta = 0.9$ is that the value of 0.9 is widely used by previous studies (e.g., Kosugi et al., 2005; Saigusa et al., 2008), and performs well in these studies.

7. P. 4005, L. 24: Other papers familiar to the authors suggest that least absolute deviations rather than least squares is the appropriate cost function for fitting model parameters to eddy covariance data. This will make fitting a four parameter model more difficult because it decreases the topography of the parameter space. Was LAD tested?

   In this study, we estimated seasonal variations of parameters for 24 ecosystem sites using an standard program, which uses the least squares for parameter fitting. We have no experience and did not test the least absolute deviations technique.

8. P. 4006, L. 5: Be consistent with abbreviations. Choose either Pmax or beta.

   We agree with the referee's suggestion, and use only Pmax.

9. 4006, L. 21: Why is equation 4 an increasing function of VPD?

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As shown in old Table 2, all of a_{FV} in Eq. (4) are negative numbers, and F_{V} decreases with increase in $\mathrm{VPD_a}$. But we agree that negative a_{FV} in Eq. (4) confuses readers, and thus, we revised Eq. (4).

10. P. 4006, Eq. (2): Multiplicative reduction functions have little empirical or mechanistic basis despite their wide application in ecological modelling (noting the Leibigs Law formation in equation 5). Is there evidence that Pmax (i.e. beta) follows this functional response?

    In the absence of empirical function to formulate Pmax, we decided to use this multiplicative function of temperature and VPD. We added the description on Eq. (2) and new Figs. 1 and 2 to show the dependence of Pmax on temperature and VPD.

11. P. 4007, L. 28: The correlation of Pmax and alpha may simply be the result of poor model fit when using the least-squares cost function [see the appendix in (Palmroth et al. 2005). Plot for example the degree of correlation between Pmax and alpha against r2 of the model fit.].

    We admit that the correlation of Pmax and α may, in part, be the result of poor model fitting. We now mention this in Section 3.1.

12. P. 4008. Eq. (8): Why is this relationship expressed as a fraction of NPP? The original (Lloyd and Taylor 1994) reference does not do this.

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The answer to this comments can be found at P.2008, line 13 in old manuscript. But we revised Eq. (8).

13. P. 4009, L. 9: Close parentheses.

    Thank you your careful reading.

14. P. 4010, L. 5: I'm confused about this passage. NPP can be, but need not be, estimated using mean annual temperature or precipitation. These models usually fit poorly if timing is important, and it usually is.

    First, the unstressed maximum P_{max} shown in old Fig. 4a is computed from the observation data, not from Eq. (6). Details are described at P. 4007, line 1 in old manuscript. Second, seasonal course of Pmax in this model is demonstrated from temperature and VPD stresses (Eq. 2), does not depend on P_{max}^{PM}.

15. P. 4010, L. 12: If slope is the same at the plant-level, what is it, and is there a relationship with LAI? It would be interesting to test if there is evidence for this relationship being universal.

    We appreciate the comments, but we did not have any evidence of a relationship with LAI.

16. P. 4011, L. 6: thence is not in common usage.

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We appreciate this comment and revised the manuscript.

17. P. 4011, L. 25: Wilson and Baldocchi 2000 argue that there is seasonal parameter variability due to leaf age and N. Katul et al. 2003 argue for a fundamental relationship between hydrology and parameter variability. List these examples and others rather than the text, which is obvious.

    We appreciate this comment. In this revised manuscript, we added new analyses and results to reply the comments from referees and editor, and revised most of this section. In this process, we removed this sentence.

18. P. 4012: Is soil moisture or water deficit potential explanations for the savanna and grassland results?

    Soil moisture and water deficit may be critical determinant of vegetation photosynthesis especially for savanna ecosystems. We newly present new Fig. 10, which shows seasonal variations of LAI and precipitation at a savanna site.

19. P. 4013: The description of model fit is largely qualitative.

    We added results of regression analysis in Section 3.

20. P. 4013, L. 25: The uncertainty in measurement here is almost certainly due to instrument self-heating (Burba et al. 2008) if an open-path gas analyzer is used at this site. (I do not have the resources to check this as I write.)

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As advised, a part of the random measurement error may be caused by the instrument surface heat in the open-path infrared gas analyzer. Although the sentence at P.4013 line 25 in old manuscript were removed due to the revision, we cited the study of Burba et al. (2008) in Section 3.2 in the revised manuscript.

21. P. 4014, L. 10: More work could be done on quantifying when, post-disturbance, grasslands can be effectively modelled.

    We agree with the referee, and in this revised manuscript, we modeled the diurnal variation of NEE at grassland using the non-disturbed data. This new result was mentioned in Section 3.

22. P. 4014, L. 16: Add species composition to the list of factors to test.

    We appreciate this suggestion, but this sentence was removed due to the revision.

23. P. 4014, L. 24: Again, the model comparison is qualitative. Focusing on examples of poor model fit here and elsewhere does not lend confidence to the approach.

    The Nocturnal RE subsection was substantially revised with new analyses. We added descriptions and figures about RE in Section 3.

24. Fig. 1: Plot this figure with Pmax on the abscissa as NPP is related to this variable, an ecosystem characteristic, rather than the other way around.

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We do not agree with the referee in this point. Old Fig. 1 (new Fig. 3) is an example to show the relationship of NPP and P_{max}^{PM} described in Eq. (6).

25. Fig. 2: Write grasslands one standard deviation from mean and Duke Forest.

    We added values of r2 in new Figs. 4 and 5b

26. Fig. 7: The fit is often poor at extremes, exhibiting sometimes strange curvature. Is the VPD model (equation 4) responsible?

    As discussed in this revised manuscript, the proposed model failed to predict the NEE variations at the site with the rapid changes in LAI. Strange curvature shown in old Fig. 7 is mainly due to this problem.

27. Fig. 8: This site is impacted substantially by the sensor heating effect described in (Burba et al. 2008). What were the air temperatures during the period, and is there evidence that the sensor was heated by solar radiation to be substantially above air temperature?

    Average air temperature was 7.4°C and minimum temperature was 2.4°C, during the period between DOY 191 and 197, 2004. In this period, maximum net radiation was over 400 W m^{-2}. Sensor heating may be one of the cause for the random measurement error shown in old Fig. 8. However, since the instrument heating of open-path sensor can yield unreasonable CO_2 uptake signals under low temperature conditions, CO_2 release observed during daytime can not be explained only by sensor heating problem.

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References

Burba, G. G., McDermitt, D. K., Grelle, A., Anderson, D. J., and Xu, L.: Addressing the influence of instrument surface heat exchange on the measurements of CO_2 flux from open-path gas analyzers, Global Change Biol., 14, 1854–1876, 2008.

Fung, I. Y., Tucker, C. J., and Prentice, K. C.: Application of Advanced Very High Resolution Radiometer vegetation index to study atmosphere-biosphere exchange of CO_2, J. Geophys. Res., 92, 2999–3015, 1987.

Kosugi, Y., Tanaka, H., Takanashi, S., Matsuno, N., Ohta, N., Shibata, S., and Tani, M.: Three years of carbon and energy fluxes from Japanese evergreen broad-leaved forest, Agric. For. Meteorol., 132, 329–343, 2005.

Saigusa, N., Yamamoto, S., Hirata, R., Ohtani, Y., Ide, R., Asanuma, J., Gamo, M., Hirano, T., Kondo, H., Kosugi, Y., Li, S., Nakai, Y., Takagi, K., Tani, M., and Wang, H.: Temporal and spatial variations in the seasonal patterns of CO_2 flux in boreal, temperate, and tropical forests in East Asia, Agric. For. Meteorol., 148, 700–713, 2008.