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Interactive comment on "A global scale mechanistic model of the photosynthetic capacity" *by* A. A. Ali et al.

Anonymous Referee #2

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I'm still confused about if the model needs total leaf nitrogen per unit leaf area (LNCa) and leaf mass per area (LMA) as input, after reading through the paper a couple of times and carefully tracing all the equations in appendixes. Thus, I have to discuss it in two cases: 1) the model needs the LNCa and LMA as input and 2) the model does NOT need the LNCa and LMA as input

CASE I: the model needs the LNCa and LMA as input

In Appendix A, the authors described total leaf nitrogen, structural N (as a function of LMA), and N storage. It seems the model needs the total leaf nitrogen per unit leaf area (LNCa) and leaf mass per area (LMA) as input. What the model does is to properly allocate the LNCa to different functional and storage components to get leaf's photosynthesis carbon gain maximized.

Since leaf nitrogen (i.e., LNCa in this paper) and LMA are good predictors of photosynthesis capacity, it's not surprising to see this model can explain more than 50% variances of Vcmax25 and Jmax25 (57% and 66%, respectively). I'd like to see the improvement of the predictions of Vcmax25 and Jmax25 from LUNA model comparing to those directly derived from LNCa and LMA. And, the authors should make it clear how they obtained the data of leaf Nitrogen and LMA at global scale.

CASE II: the model doesn't need the LNCa and LMA as input

In the main text, they said "the key drivers (temperature, radiation, humidity, CO2, and day length) (Lines 26∼27, Page 6220)". It seems the model doesn't need the LNCa and LMA as input. In this case, the Nitrogen supply is assumed to be unlimited or the leaf is infinitely small. The variables of total leaf nitrogen (LNCa), structural N, functional nitrogen (FNCa), and Nitrogen storage (Nstore) are not solvable according to the equations of this model if LNCa is unknown. The Nitrogen for light capture (Nlc), electron transport (Net), carboxylation (Ncb), and respiration (Nresp) can be obtained numerically only when the respiration rate increases faster than photosynthesis with Nlc. Otherwise there will be no equilibrium point (i.e., N for photosynthesis and respiration will go to infinitely large) and the model is not solvable. Thus, this model must be very sensitive to respiration parameters.

If it's this case, the model is useful for predicting potential Vcmax and Jmax according to the climatic variables. But the assumptions must be clearly stated and justified. As I can see from the paper, the assumptions include: there is only one leaf for each land unit and the leaf is very small; N is unlimited; Ra and photosynthes are functions of N, but Ra increases faster than photosynthesis with N.

The authors designed a set of parameters to constrain the relative abundances of Nlc, Net, Ncb, and Nresp. These parameters can be categorized into two classes: photosynthesis processes, and respiration processes. And they were fixed in this paper to make sure respiration increases faster than photosynthesis with leaf N. For a canopy, this pattern (i.e., respiration rate increases faster than photosynthesis with leaf N) is true because of the light gradient within the canopy. But I can't figure it out how it holds in a single leaf without other limitations. You can imagine that with each function apparatus, there is a set of Nlc, Net, Ncb, and Nresp and the carbon balance is positive (photosynthesis > respiration). If N is unlimited and no other limitations (e.g., structural limitations of a leaf), a leaf can have infinite such photosynthesis apparatuses and the carbon balance is still positive. Actually, whatever how many the apparatuses are, the ratio of respiration to photosynthesis is the same at given climatic conditions. I want the authors to explain it.

Interactive comment on Geosci. Model Dev. Discuss., 8, 6217, 2015.