General comment to the reviewer: Thank you very much for carefully reading through the manuscript and providing the constructive comments. The original comments of the reviewer are highlighted in red and our responses are in black. When text is copied directly from the revised paper the words are italicized.

Comment 1: 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.

RESPONSE: CASE I is applicable to the LUNA model. For clarification, we have added the following component into the model description section:

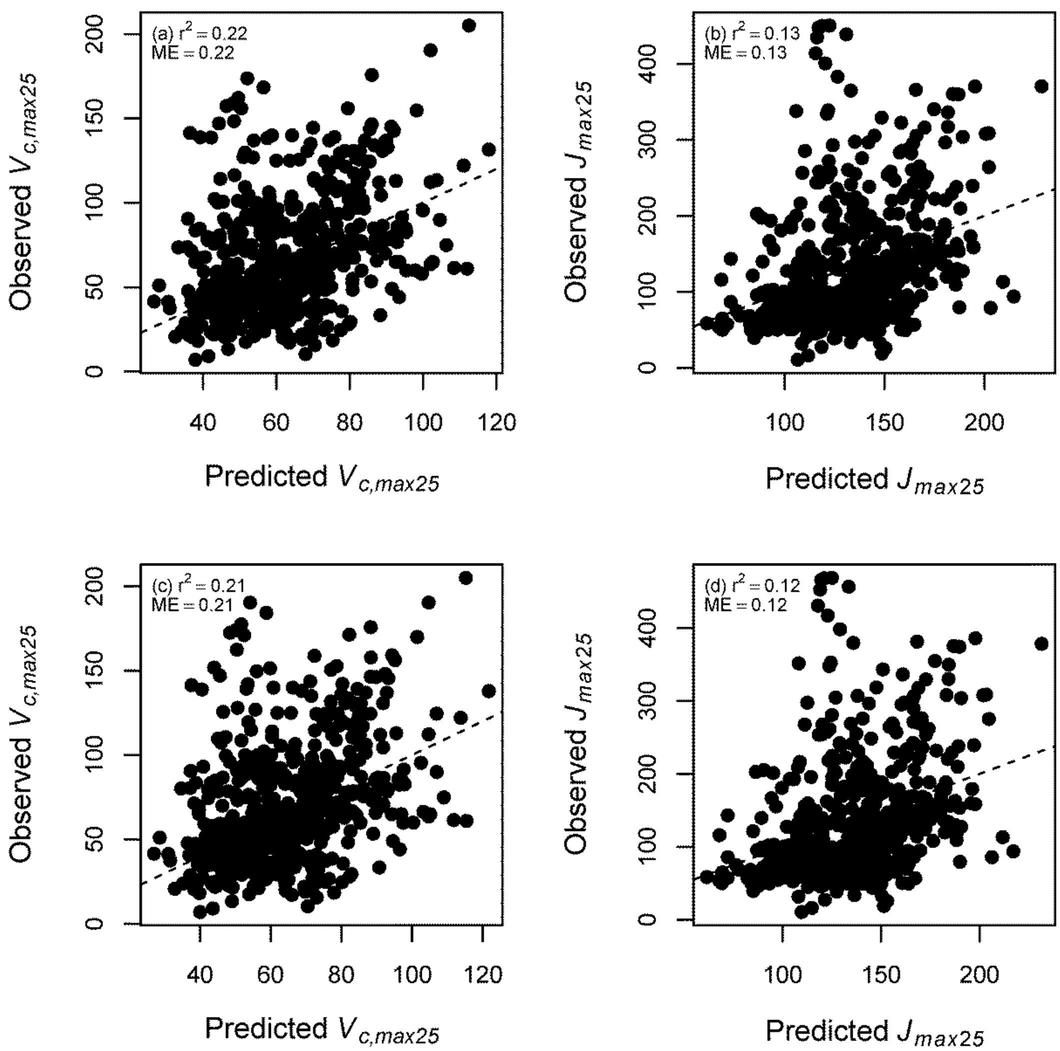
"The model uses area-based leaf nitrogen content and different environmental conditions (temperature, CO_2, radiation, relative humidity and day length) as model inputs and predicts $V_{c,max\ 25}$ and J_{max25} based on the optimal amount of nitrogen allocated to different processes."

Following the suggestions of comparing LUNA model with a statistical model only with LNCa and leaf mass per unit area (LMA), we have added the improvement of the predictions of $V_{c,max25}$ and J_{max25} from LUNA model comparing to those directly derived from LNCa and LMA in the first paragraph of discussion on "model limitation".

"*….The assumption that nitrogen is allocated according to optimality principles explained a large part of variability in $V_{c,max25}$ (~ 55%) and in J_{max25} (~ 65%) at the global scale, regardless of the temperature response functions used. It also captured well the seasonal cycles and the PFT-specific values of $V_{c,max25}$ and J_{max25} (Fig. S3-5).* ***It has a much improved fitting to the data in comparison to a multi-linear regression model using LNC_a and LMA as predictors, which only explained ~22% of the variance in observed $V_{c,max25}$ (Fig. S12 a, d) and ~13% of the variance in observed J_{max25} (Fig. S12b, d) for both temperature response functions.*** *These results suggest our model is able to capture many of the key components of the drivers of $V_{c,max25}$ and J_{max25} across the globe both in space as well as in time.*"

See the new figure is shown below:

Figure S12 *Percentage of variations (r^2, ME; model efficiency) in observed $V_{c,max25}$ (μmol CO_2 m^{-2} s^{-1}) explained by modeled $V_{c,max25}$ (a; TRF1, c; TRF2) and in observed J_{max25} (μmol electron m^{-2} s^{-1}) explained by modeled J_{max25} (b; TRF1, d; TRF2) by using a multi-linear regression over leaf nitrogen content (g N/m^2 leaf) and the leaf mass per unit area (g dry mass /m^2 leaf). The nitrogen allocation model was run with the environmental variables, leaf mass per leaf area, and the leaf nitrogen contents by using TRF1. TRF1 was a temperature response function that considered the potential for acclimation to growth temperature. The r^2 is derived by a linear regression between observed and modeled values. The dashed line is the 1:1 line.*



We have added the following section in the data section of revised paper for clarification on how we collected the data:

"…*Specifically, we conducted a literature search on Google Scholar to locate publications that included words "$V_{c,max}$" or "J_{max}" and also contained "leaf nitrogen content" , "maximum carboxylation rate" , "maximum electron transport rate" , "leaf mass per area", or "specific leaf area". Individual values of $V_{c,max}$, J_{max}, area-based leaf nitrogen content (LNC_a, g N/m^2 leaf) and leaf mass per unit leaf area (LMA, g dry mass/ m^2 leaf) were then obtained by digitizing data from the literature.* "

Comment 2: 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 of 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.

RESPONSE: CASE II does NOT apply to our model. That is, the LUNA model needs the LNCa and LMA as inputs.