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Interactive comment on "C_3 plants converge on a universal relationship between leaf maximum carboxylation rate and chlorophyll content" *by* Xiaojin Qian et al.

Anonymous Referee #2

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General comments The study by Qian et al. is in line with the long-last efforts in biogeoscience to constrain leaf photosynthetic capacity (Vcmax and Jmax). Previous studies have been trying to relate Vcmax and Jmax to climate, environmental variable and plant traits, but also found large discrepancy among plant functional types. This study made an innovative attempt to search for a convergence of Vcmax to chlorophyll content among 13 species of C3 plants. They collected leaf gas exchange data, leaf chlorophyll content (index) from three sites in China and one site in Canada, and conducted a linear regression between Vcmax and chlorophyll content. Their analysis showed that the 13 species across biomes and plant functional types have similar Vcmax-chlorophyll content relationships. Their data if made available will help expand

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the much-needed gas exchange data across the world.

Many important aspects of the methods in this study remain unclear. It is not explained why those species/sites were chosen and how representative are they to the terrestrial biosphere. What is the measurement temperature of leaf gas exchange and how the Vcmax and Jmax are temperature corrected? Details like these are important for reproduction of the results elsewhere. The linear regression analysis did not rule out the possibility of inter-species variation in the Vcmax-chlorophyll content relationship. And the data set is too small with very limited coverage of terrestrial ecosystems. The use of the word 'converge' is thus not conclusive. The empirical nature of this study suggests that a mechanistic understanding of the variation of photosynthetic capacity is still absent at global scales and the application of conclusions from this study should be within the species and sites tested.

There is an underlying chain of assumptions in this study. That is (1) Jmax should relate to chlorophyll content convergently among C3 species; (2) Jmax/Vcmax is generally a constant; (3) Vcmax thus should relate to chlorophyll content with a relationship that does not vary among species. The authors have not demonstrated assumption (1) being a widely accepted scientific fact. But Let's assume assumption (1) is true. As the authors noted, the Jmax/Vcmax could vary from 1 to 3 which is not a small change and could completely throw off the relationship between Vcmax and chlorophyll content, preventing a universal relationship. With a limited number of species tested in this study, it is difficult to separate the importance of Jmax/Vcmax. The chain of logic is inadequately supported. The attempt of finding physiological explanation of the Vcmax and chlorophyll content relationship is thus incomplete.

Overall, the concept of this article is interesting and important. The presentation of the content could include more details and analyses. The discussion could consider a more comprehensive comparison of literatures. The title and conclusions could benefit from less extrapolation. I suggest the paper could be more useful to the community after addressing these limitations. In the following, I will list the detailed comments for

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the consideration of the editor and authors.

Specific comments Overall: Consider subscribe ‘cmax‘ and ‘max’ in the terms ‘Vcmax’ and ‘Jmax’ L38: The authors mentioned ‘most classical biochemical models’ but did not provide citation. I suggest the authors to consider the work by Rogers et al. (2017). L64 -70: The authors used the word ‘chlorophyll’ without defining the exact meaning. As the authors are aware, chlorophyll content, chlorophyll index, and chlorophyll activity could be very different. I suggest the authors to clarify what is use by each study. L96-105: There is a valuable potential for the authors to validate the equation 1 (i.e., Chl and SPAD relationship; Markwell 1995) with the spectrophotometer method (Croft 2017). However, the authors used the empirical model from Markwell without considering whether the relationship applies to all their species. The SPAD measures the chlorophyll index which needs to be calibrated to each species/site to translate to leaf chlorophyll content. The adoption of Markwell equation needs justification. One tree species (white ash) presents in both Ontario and Beijing. Could the authors show how the chlorophyll content from two sites compare? L110: the conditions (leaf temperature, VPD, PAR) in the licor chamber as well as the outside air are important but missing. The soil moisture condition could also affect photosynthetic capacity (e.g., Keenan et al., 2010). I suggest the authors to also exclude the impact of soil moisture. L126-129: The content seems to belong to discussion more than result. Fig 2: The figure did not convincingly show chlorophyll content as a good predictor of Vcmax. The general patterns of the two variables are similar but that could be simple plant phenology. What is more important is the short-term variation of Vcmax, which chlorophyll content completely missed. This figure suggests to me that chlorophyll content is nothing but a proxy of leaf phenology, which one can derive from satellite vegetation index. More convincing evidence showing chlorophyll content could capture Vcmax variation is needed. L159-175: Initially, I got very confused by the information in this section. Later after reading the whole of discussion, it occurs to me this section is roughly an overview of theories to support the following discussions. I suggest the authors to reorganise this section, so that the connection of mentioning all those studies and to the

rest of discussion is clear. L236-238 and fig 3: A stable linear relationship between Vcmax and chlorophyll content across species does not necessarily means the variation among species does not have significant impacts of the slope. The plots of each species suggest to me that the model is biased but the bias (slope and interceptor) is slightly different in each species. The authors could consider a linear mixed effect model with species as random factor to rule out the impact of species. L257: The promise of the conclusion in this study could be readily used worldwide to estimate Vcmax is misleading. I agree this study is one step toward such an application, but a lot more data still needed before a generalisable relationship could be determined.

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