Referee #3

General comments

This paper uses a rather impressive dataset of nearly 10,000 observations of tree height and 2,500 observations of crown area on 162 tree species located in Barro Colorado Island, Panamá. The main results are: (i) light-demanding species attained taller heights at comparatively smaller diameters as juveniles and had shorter asymptotic heights at larger diameters as adults, and (ii) the use of saturating functional forms and the incorporation of functional traits in tree allometric models is a promising approach to improve estimates of forest biomass and productivity. Apart from my reservations about the data collection and some mostly minor suggestions on presentation and understanding, the manuscript is very readable and the presentation is clear. However, the novelty of the present study compared to previous studies has not come across very clear to me.

> AR: We appreciate the feedback provided and took advantage of the suggestions raised by the reviewer to prepare an improved version of the manuscript. We included all the new references suggested, framing and discussing our results in the context of previous work. We have also emphasized the novel aspects of this study, which provides a sound methodological approach that enabled us to simultaneously examine species variation in tree allometry in relation to functional traits and to compare alternative scaling models.

The first research question (How is interspecific variability in allometric scaling of tree height and crown area related to tree species functional traits, in particular wood density and measures of shade tolerance?) has been strongly studied in tropical forests, for example the study of Poorter et al. (2003, 2006) from Liberia and Bolivia, Iida et al. (2011) from Malaysia, Loubota Panzou et al. (2018) from Congo. This first research question should focus on the notion of convergence in tree allometry of coexisting tropical tree species that is not widely supported by previous studies, except for the paper Iida et al. (2011).

> AR: We revised the introduction to better frame the questions pursued in the manuscript. We now reference the work by Poorter et al (2006) earlier in the manuscript and indicate that they pursued similar questions (as di Ilda et al. 2011). We also revised the reference list to add the work by Loubota et al. (2018), which was published after this manuscript was submitted. This recent publication in a leading journal demonstrates that the first research question remains of interest, and we kept this question in its current form. We agree that convergence (or lack thereof) in tree allometries is an interesting topic, and we address this in the discussion section, as in the previous version. In our view, this question can be best addressed through analyses that encompass multiple sites, and is thus beyond the scope of this study).

The two last research questions have been studied in tropical forests (Fayolle et al., 2016; Ledo et al., 2016; Sullivan et al., 2018; Mensah et al., 2018). This study should focus on the effects of species or functional groups on the estimation of biomass and carbon stocks. The authors have studied the consequences of height-diameter allometry on the estimation of biomass and carbon stocks. The consequences of crown area allometry could be interesting in the estimation of biomass and carbon stocks using the allometric equation of Ploton et al. (2016).

> AR: We revised the introduction to include the suggested citations, some of which were already mentioned later in the manuscript (Fayolle et al 2016; Ledo et al. 2016, Sullivan et al. 2018). The recent

publication of these studies demonstrates that there is still wide interest in the questions pursued in this study. We believe that our methods and results contribute usefully to the ongoing debate about which allometric model should be employed to describe tree height and crown area. We hope that the addition of the suggested references and the minor edits clarify this point. We agree that it would be interesting to address the consequences of crown area allometries for biomass and carbon stocks, but we preferred to stick with our simpler approach of only addressing the consequences of height allometries. There is a huge body of literature dealing with AGB estimation, with a corresponding variety of methods and equations. The models by Chave et al (2014) that require only diameter, height and wood density are based on the largest database of AGB measurements available (an order of magnitude above the number of trees measured to develop Ploton et al. 2016 models), and are some of the most widely used. The aim of the comparison presented in Fig 4 and in Table 3 was to highlight how height saturation and species variation interact to affect AGB estimation. The use of a model including crown area would not alter our conclusions. In our opinion, it might even distract readers from the main message; in the end, our data set analyzed does not include biomass measurements and thus cannot clarify which model is truly better.

Specific comments

Page 1

The title is a bit unclear to me, because this aims to study the interspecific variation in tree allometry and its consequences on the estimation of biomass and carbon stocks.

AR: As commented above, the analyses of biomass were just included to highlight the impact of model choice in tree allometric studies. However, the main subject of the manuscript lies is the adequacy of alternative allometric models and the relationship of allometric parameters to ecological traits across species.

Lines 23-24 “Our results provide an improved basis for parameterizing tropical tree functional types in vegetation models” I found “tree functional types” to be a little unclear.

CHANGE: We revised the term to “Plant functional types (PFTs)” and included a citation to (Prentice et al., 1992)

I found the lines 26-27 are unclear.

CHANGE: *Allometric scaling ~~encapsulates emergent~~ describes how evolutionary and physical constraints on plant morphology and performance vary as a function of size ~~that vary with organism size~~ (Niklas, 1994).*

Page 2

Line 8: What do you mean by “tree dimensions”? A non-specialized audience (i.e. readers who are highly familiar with the literature on comparative tree biology/ architecture) is likely to not specifically understand what the authors are talking about.

AR: We included the following examples the first time tree dimension was mentioned to avoid any confusion;

CHANGE: […] *scaling of tree dimensions –e.g. tree height or crown area– with trunk diameter.*

I found the paragraph (Lines 17-26) to be a little bit lacking in detail. First, I think the authors could include some examples of previous studies on the interspecific variation in tropical tree height and crown allometries. Secondly, the authors could include the information’s on the relation between tree allometry and life-history traits. Lastly, the effects of species-specific or functional groups on the estimation of biomass should be developed in this section.

AR: We revised this paragraph to include references to previous work and summarized materials already included in the discussion to provide more background about the expected effect of functional traits on tree allometry;

CHANGE: *Allometric studies of tropical trees have highlighted differences in growth and morphology that define distinct life history strategies (Clark and Clark, 1992; Poorter et al 1996). These differences contribute to species coexistence and play a key role in successional trajectories (Wright, 2002; Chazdon, 2014; Falster et al., 2017). Approaches pooling data across species inherently fail to recognize species heterogeneity in allometric scaling and limit the potential to identify and define plant functional groups. Pooling data across species also tends to over represent locally abundant species unless appropriate methods like hierarchical models are employed to account for unbalanced sampling. Species differ systematically in allometric relationships, suggesting that these differences reflect underlying interspecific variation in life-history, physiology, morphology, and/or phylogeny (Westoby et al., 2002; Adler et al., 2014). Hierarchical approaches based on functional traits can provide a useful approach for capturing this interspecific variation in tree allometry (Dietze et al., 2008; Iida et al., 2011). Several studies have found regeneration light requirements and/or wood density to be related to tree height and/or crown size across species, suggesting that these are good candidates for inclusion in a hierarchical model (Iida et al. 2012, 2014; Loubota Panzou et al. 2018; Poorter et al. 2006; Wright et al. 2010).*

Page 3

Line 8: “the vegetation is moist tropical forest”. Please specify the forest type: deciduousness forest or evergreen forest?

AR: *The forest is semideciduous.*

CHANGE: *tropical moist deciduous forest*

Line 10: ". . . with trunk diameter of 1 cm or larger . . ." What do you mean by "trunk larger"?

CHANGE: revised to *trunk diameter of at least 1 cm*.

Line 16: I propose the "tree measurements" rather than "allometric data".

CHANGE: Subsection title revised to: *2.2 Tree measurements*

Lines 16-25: this paragraph lacks of details on the data collection. I would like the authors' give more information on the compilation of these seven datasets.

AR: We edited the text to provide more details, and retain the reference to Table S1 in the Supplementary Material, which provides additional details on methods as well as sample sizes for each dataset. We also revised figure S1 in the supplement to include the average number of trees sampled per species and the extreme values as requested by R#2.

CHANGE: *We used a compilation of seven datasets collected in the BCI 50 ha plot and one dataset from the adjacent Gigante peninsula (see Table S1 for further details). The datasets cover different size classes and combine measurements made with different, albeit standard, methods. Depending on the dataset and tree size, tree heights were measured with a telescoping pole (smaller trees only), with a laser rangefinder using the sine or tangent method (Larjavaara and Muller-Landau 2013), or from the difference between phothotogrammetric estimation of canopy surface elevation and a digital elevation model obtained from airborne lidar (only fully sun-exposed trees). Crown areas were from ground-based measurements of crown radii, or from delimiting fully sun-exposed crowns in high-resolution aerial photos.*

Page 7

Lines 5-12: the authors may add the names of species of low height or crown area and high height or crown area.

CHANGE: *The tallest species was* Dipteryx oleifera *(maximum height 57.4 m), and the largest crown areas were found in* Ceiba pentandra *(1404 m^2). Among big trees (DBH>80 cm),* Guazuma ulmifolia *presented the shortest tree (28.2 m), and* Poulsenia armata *the smallest crown area (179 m^2).*

Line 14: ". . . with dependence. . ." please reworded

CHANGE: Rephrased to: *The best tree height model combined a generalized Michaelis-Menten (gMM) function (Fig. 1a) with species specific parameters modeled as a linear function of sapling growth rates.* ~~*with dependence of species specific parameters on sapling growth rates.*~~

Page 9

Lines 16-17: "Past work suggests that mechanical resistance to self- or wind-loading cannot explain tree height allometries, as trees are generally much shorter for a given diameter than the limits based on static mechanical constraints (Niklas, 2007)". This is disconnected from your results.

AR: This sentence appears in a paragraph discussing mechanisms underlying tree height allometries, and it rules out one of the common hypothesis to explain tree height saturation with diameter.

Page 10

Lines 12-13: Blanchard et al. (2016) study the variation inter-sites in tree allometry. Please see the reference Lines et al. (2012).

AR: Good point,

CHANGE: We have removed the reference to Blanchard et al. (2016) from this sentence on interspecific variation in tree allometry, and added the reference to Lines et al (2012).

Page 12

Lines 30-31: This last sentence isn't necessary.

CHANGE: Removed.

Page 24

This Fig.4 isn't necessary.

AR: We see Figure 4 as a useful illustration of the mechanisms underlying the differences in plot-level biomass estimates, and choose to retain it.

References

Prentice, I. C., Cramer,W., Harrison, S. P., Leemans, R., Monserud, R. A., and Solomon, A. M.: A Global Biome Model Based on Plant Physiology and Dominance, Soil Properties and Climate, J. Biogeogr., 19, 117–134, 1992.