Biogeosciences Discuss., 10, C9417–C9422, 2014
www.biogeosciences-discuss.net/10/C9417/2014/

Biogeosciences Discussions
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Interactive comment on "Tropical montane forests are a larger than expected global carbon store" *by* D. V. Spracklen and R. Righelato

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Received and published: 7 April 2014

We thank the editor for the opportunity to respond to reviewer comments and for taking the time to consider a revised manuscript. We also thank J. Homeier for his time and for the detailed comments on our manuscript. We respond to these comments in detail below. To guide the review process, reviewer comments are in italics, our responses are in normal text and additions to the manuscript are marked in red.

We believe that our manuscript has been improved by this process and we hope that it may be acceptable for publication.

General comments

This manuscript contributes to a better understanding of the important role of TMFs

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in carbon storage. Based on remote sensing data the authors show that land-surface area of TMFs is globally about 40of carbon stored in TMFs. Some minor corrections of the present version could improve the present version.

Specific comments

It becomes not clear how AGB data have been synthesized. Could you describe the selection of data sources? And I think it is important to mention which allometric equations were used to calculate AGB in your data sources (probably mostly the equations of Chave et al. 2005 that were not developed for montane forests) and to critically show limitations of AGB estimation (e.g. not including tree heights in the Chave-equations could lead to overestimation of AGB in TMFs).

We have added a description of how we selected data sources (section 2.1): "We synthesised peer reviewed studies of AGB storage in TMFs, where AGB had been estimated from studies of forest plots either using established allometric equations or regressions whose development is described by the authors. We defined TMFs as forests between latitudes of 23.5oN and 23.5oS and at altitudes $\geq$ 1000 m a.s.l. We used AGB data from intact tropical forest sites with little or no sign of human disturbance, described variously as "primary" or "old growth". We also included secondary forest sites where the last disturbance was thought to be at least 40 years old. Where available we also synthesised topographical (elevation and slope angle) and climatological variables (annual mean temperature and annual mean rainfall) for the same plots. AGB was typically reported per unit area of the Earth's surface although some studies reported AGB per unit planimetric area. For the latter, we used information on slope angle to convert AGB to a surface area basis."

We now include information on allometric equations used in each study. This has been added to Table 1 and is briefly discussed in a new section (Section 3.1.1 Methodological Issues):

"First, we explored the impact of methodological issues (forest plot area and the use

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of different allometric equations) on the estimated AGB reported by the studies. Table 1 gives details on the TMF plot studies synthesised in this analysis. Across our TMF dataset, the average total forest plot area was 0.68 ha (median = 0.3 ha). Here, the total forest plot area is calculated as the cumulative area of the forest plots for each study at a specific elevation. Previous work has suggested that small plot size may result in overestimates of AGB (Clark et al., 2001). Our synthesised TMF plots do not show such a bias: mean AGB in TMF with total plot area $<$ 0.25 ha was 243 t ha-1 (n=44) compared to 295 t ha-1 (n=50) in TMF with total plot area $\geq$ 0.25 ha, with no significant difference with respect to plot area (Student's t-test, P$>$0.05). In fact, there was a small positive relationship between plot size and AGB within TMF although the correlation was not significant ($r^2 = 0.04; P>0.05$).

Next we explored how the choice of allometric equation might have affected the estimated AGB. Many of the studies we synthesised estimated AGB using established allometric equations based on Chave et al. (2005). The majority of the TMF studies in our dataset used allometric equations based on tree diameter and tree height (n=71), with fewer studies estimating AGB based only on tree diameter (n=20). We found that the mean AGB in TMF studies where allometric equations included diameter and height (239 t ha-1, n=71) was significantly less (Student's t-test, P$<$0.01) than in studies where the allometric equation was based on tree diameter and did not include tree height (373 t ha-1, n=20). We repeated this analysis at the regional scale. We found that mean AGB in the neotropics was not significantly different (P$>$0.05) for studies that included both tree diameter and height (232 t ha-1, n=40), compared to studies that only included diameter (266 t ha-1, n=13). This was in contrast to Asia, where mean AGB was significantly less (P$<$0.01) in studies that included diameter and height (227 t ha-1, n=27) compared to studies that only included diameter (460 t ha-1, n=4). However, we note that there were few studies in Asia that only included diameter.

Our analysis suggests that allometric equations that are not specifically developed for TMF and only include tree diameter, could overestimate AGB. In the following analysis

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we used data from all the TMF studies. Where necessary, we demonstrate that this selection does not affect our overall conclusions."

Technical corrections

18895, l11: more recent references (replacing Lieberman et al.): e.g. Benner et al. 2010, Bruijnzeel et al. 2010.

We have changed the references as suggested.

18895, l17-24: additional recent studies covering two altitudinal gradients from the Ecuadorian Andes: Leuschner et al. 2013, Unger et al. 2012, Unger et al. 2013.

We have added reference to recent studies as suggested.

18896, first paragraph: you should mention the range in plot size in the included studies.

We have included plot size (where available) in Table 1. We include a short analysis of plot size and show that biomass estimates are not biased in plots with small area (see above).

18898, l17: Girardin et al. (2014) found the decline in AGB with elevation only in 3 out of 6 of their transects.

Corrected as suggested.

18899, l13-14: additional references for effects of nutrient availability on AGB and productivity: Unger et al. 2012, Homeier et al. 2012.

Additional references added as suggested.

18899, l23-25: many studies show a decrease of woody species richness with elevation but there seems to be no general trend and a peak at mid-elevations has not been recorded frequently.

We remove the statement on a peak in diversity at mid-elevations and replace with:

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“Change in woody species richness, which often declines with increasing elevation, has potential implications for carbon storage.”

18899, l25-27: see also Unger et al. 2012.

Added reference to Unger et al. (2012) as suggested.

18902, l9-14: Variation of AGB seems to depend a lot on topography and related soil conditions too, so from our results from the S Ecuadorian Andes (comparing AGB at different slope positions and elevations) we find no effect of slope angle on AGB but a decrease of AGB from lower slope to upper slope with equally high variance in AGB at all elevations.

18902, l17-18: add (or replace Leuschner et al 2007) by Leuschner et al 2013. Added as suggested.

18902, l21-23: Bruijnzeel et al. (2010) compiled the major threats to TMFs and Homeier et al. (2012) gave an example for the effects of increasing nutrient inputs.

Reference added as suggested.

Table 1: Plot size could be included in this table. Another important data is the equation that was used to calculate AGB.

Plot size and equation used to calculate AGB were added to the table as suggested.

Additional references:

Benner et al. (2010) Nutrient cycling and nutrient limitation in tropical montane cloud forest. in: Bruijnzeel et al. (eds.) Tropical montane cloud forests: Science for Conservation and Management. Cambridge University Press, Cambridge. 90-100.

Bruijnzeel et al. (2010) Tropical montane cloud forests: state of the knowledge and sustainability perspectives in a changing world. in: Bruijnzeel et al. (eds.) Tropical montane cloud forests: Science for Conservation and Management. Cambridge Uni-

versity Press. 691-740.

Homeier et al. (2012) Tropical Andean forests are highly susceptible to nutrient inputs - Rapid effects of experimental N and P addition to an Ecuadorian montane forest. PLoS ONE 7(10), e47128.

Leuschner et al. (2013) The carbon balance of tropical mountain forests along an altitudinal transect. in: Bendix, J. et al. (eds.) Ecological Studies Vol. 221, Springer Verlag, Berlin, Heidelberg, New York, chapter 10., pp 117-139.

Unger et al. (2012) Effects of soil chemistry on tropical forest biomass and productivity at different elevations in the equatorial Andes. Oecologia 170, 263-274.

Unger et al.. (2013) Relationships among leaf area index, below-canopy light availability and tree diversity along a transect from tropical lowland to montane forests in NE Ecuador. Trop. Ecol. 54(1), 33-45.

Unger et al. (2010) Variability of indices of macronutrient availability in soils at different spatial scales along an elevation transect in tropical moist forests (Ecuador). Plant Soil 336, 443-458.

Interactive comment on Biogeosciences Discuss., 10, 18893, 2013.