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Biogeosciences
Discussions

Interactive comment on "Influence of landscape heterogeneity on spatial patterns of wood productivity, wood specific density and above ground biomass in Amazonia" *by* L. O. Anderson et al.

L. O. Anderson et al.

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Comments to reviewer 2: bgd-6-S873-FGerard

Reviewer's Comment 1, bias: From a team of experts who are currently developing a sampling strategy for biodiversity monitoring in Europe I learned that the most popular approach for ensuring 'representative'; sampling is by means of stratified random sampling. The stratification is often introduced to reduce within stratum variability and strata are also used as the reporting unit. It is clear that the RAINFOR sites and the sample plots were not positioned following a stratified random sampling scheme.

Author's comment: The RAINFOR plot network have been assembled by drawing together existing plots that were set up for botanical or forestry studies, and hence we have to accept what we have and explore how much bias this may introduce, which is the purpose of this paper. In order to make this more clear, we have changed the text: Introduction, page 4, second paragraph, lines 102 to 112.

Reviewer's Comment: So as the authors correctly observe, there is a good chance there may be bias. From wikipedia: 'A biased sample is a statistical sample of a population in which some members of the population are less likely to be included than others. If entire segments of the population are excluded from a sample, then there are no adjustments that can produce estimates that are representative of the entire population. But if some groups are underrepresented and the degree of underrepresentation can be quantified, then sample weights can correct the bias.' So basically to test bias the authors, should check (1) if some members of the population are less likely to be included then others and (2) if entire segments of the population are excluded. The next step, if no segments of the population have been excluded, could then involve a correction of the bias by quantifying the degree of underrepresentation and weighting the samples accordingly. The population here are the forests of Amazonia. The reporting units (for which estimates are being produced) which could also be interpreted as one possible tratification of Amazonia are: eastern, middle and western Amazonia. No longitudinal coordinates are given to identify the boundaries between these regions but the ownership of the sample plots to the regions is given. Based on that information (Table2): 25 plots (3 sites) in the western, 16 plots (1 site) in the middle and 4 plots (1 site) in the eastern region, I would say the sample is biased unless the heterogeneity of the regions and thus the variability of the reported parameters (biomas, wood productivity and wood density) increases from east to west. Also as a direct consequence of using one 10kmx 10km EO window per site the number of windows used to represent these regions (3,1, 1) are introducing a bias! This bias could be corrected by weigh-

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ing the EO windows with the area covered by the three regions they represent but no boundaries are given for these regions.

Author's comment: We would suggest that this comment misunderstands our approach to assessing bias. Our question is not 'how well are we representing the geographical entirely of the forests of Amazonia?' (we clearly cannot hope to with such a small set), but 'how well are we capturing the landscape of each site? with landscape being defined as the EO window at each site. Our follow-on question is then, 'could biased sampling within each local landscape artificially generate the east-west trends that we see between sites?' In this study, we showed that sampled western regions of the Amazon appear more heterogeneous than central and eastern areas (in which only the Terra Firme forest type were identified, and further sub-divided into plateau and valley forests using topographic data). Based on the maps generated and taking into account how representative the vegetation type is in which the plot is embedded for each site, we have normalized each regions by its own heterogeneity, detecting then the macro-regional pattern of the parameter evaluated. Therefore, the number of plots per site, or the number of sites per region would not introduce a bias, but a higher number of sites or plots per region would provide better spatial representation of the forests heterogeneity. For instance, in western Amazonia, there are Alluvial terrain forest types, that present higher wood productivity than western Terra Firme plots or Terra Firme forests in central and eastern Amazonia. Stratifying the landscape per vegetation type, we have shown that even with not including those vegetation formations, the difference between western and eastern Amazonian study sites is persistent.

Reviewer's Comment 2, stratification: How are the boundaries of eastern, middle and western Amazonia actually being defined. I suspect in the mind of the authors the distinction is more complex than a longitudinal coordinate. So which other climatic, geographical, topographical etc... characteristics are being used ? The authors mention soil type, inundation patterns, and elevation. Why not produce such a stratification (however crudely it may be) to revisit the bias question?

Author's comment: We adopt the definitions of west, central and eastern Amazon regions that have been used in previous RAINFOR papers (Baker et al., 2004, Malhado et al., 2009 this issue, ter Steege et al., 2006). This division partially reflects concentrations of research sites (west = Andean countries, central = state of Amazonas, east = state of Para), and also has been shown to link to edaphic properties (western soils are generally younger and less infertile). RAINFOR studies have been showing that forest structure and dynamics are closely linked to edaphic properties (e.g. Malhi et al 2004, Quesada et al this issue). To attend the Reviewers comment, we have changed the text in the manuscript (See page 5, lines 126 to 136). There is no analysis of climatic variability or the impacts of terrain topography on the measurements of the biophysical parameters in this study; therefore it is not used for defining the macro-regions. The influence of climatic parameters in the forest dynamics is discussed in Malhi et al. (2004). The variability of forest types combined with the elevation data is presented in the final map for each site and the size of each class is taken into account for calculating the weighed means per region. Therefore both parameters (vegetation type and topography) represent the stratification evaluated in this study.

Baker, T. R., Phillips, O. L., Malhi, Y., Almeida, S., Arroyo, L., Di Fiore, A., Killeen, T., Laurance, S. G., Laurance, W. F., Lewis, S. L., Lloyd, J., Monteagudo, A., Neill, D. A., Patino, S., Pitman, N. C. A., Silva, N., and V´ asquez MartInez, R.: Variation in wood density determines spatial patterns in Amazonian forest biomass, Global Change Biol., 10, 545-562, 2004.

Malhado ACM., Whittaker RJ., Malhi Y., Ladle RJ., ter Steege H., Aragão LEOC., Quesada CA., Araujo AM., Phillips OL., Peacock J., Lopez-Gonzalez G., Baker TR., Butt N., Anderson LO., Arroyo L., Almeida S., Higuchi N., Killeen T., Monteagudo A., Neill D., Pitman N.,Prieto A., Salomão R., Silva N., Vásquez Martínez R., Laurance WF, Alexiades, MN., Ramírez A H. Spatial distribution and functional significance of leaf lamina shape in Amazonian forest trees. Biogeosciences Discussions; 2009; 6: 2125-2162.

Malhi Y, Baker TR, Phillips OL, Almeida S, Alvarez E, Arroyo L, Chave J, Czimczik CI,

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Quesada, C. A. , J. Lloyd, M. Schwarz, T. R. Baker, O. L. Phillips, S. Patiño, C. Czimczik, M. G. Hodnett, R. Herrera, A. Arneth, G. Lloyd, Y. Malhi, N. Dezzeo, F. J. Luizão, A. J. B. Santos, J. Schmerler, L. Arroyo, M. Silveira, N. Priante Filho, E. M. Jimenez, R. Paiva, I. Vieira, D. A. Neill, N. Silva, M. C. Peñuela, A. Monteagudo, R. Vásquez, A. Prieto, A. Rudas, S. Almeida, N. Higuchi, A. T. Lezama, G. López-González, J. Peacock, N. M. Fyllas, E. Alvarez Dávila, T. Erwin, A. di Fiore, K. J. Chao, E. Honorio, T. Killeen, A. Peña Cruz, N. Pitman, P. Núñez Vargas, R. Salomão, J. Terborgh, and H. Ramírez: Regional and large-scale patterns in Amazon forest structure and function are mediated by variations in soil physical and chemical properties. Biogeosciences Discuss., 6, 3993-4057, 2009.

ter Steege H, Pitman NCA, Phillips OL, Chave J, Sabatier D, Duque A, Molino JF, Prevost MF, Spichiger R, Castellanos H,von Hildebrand P, Vasquez R.: Continental-scale patterns of canopy tree composition and function across Amazonia. Nature 443:444-447, 2006.

Reviewer's Comment 3, forest types and EO: If forest type has an impact on the variability of the reported parameters, then ideally the EO windows which are used to map the forests should be randomly placed within this biogeographical/environmental stratification to correctly capture the degree of forest type heterogeneity within a stratum. I realise this is a though proposition for the Amazonian area if the aim is to accurately map forest type classes identified from in situ knowledge. However if the only aim was to capture the spatial variability in forest reflectances using the hypothesis that in (i) tropical environments the spectral characteristics of a vegetation type is strongly correlated to the physiognomic characteristics of that vegetation type and (ii) differences in physiognomies have a strong relationship with the reported parameters, then an intelligent unsupervised classification should be enough to capture within stratum variability and assess bias.It is not clear which of the two options was implemented.

Author's comment: The positioning of the EO window was defined to ensure that all the plots for a given site were included in the analysis, making the most use of the already scarce field information in the Amazon.The combined use of a set of classification algorithms was defined as the methodological approach in order to detect as many forest types as possible in a high density and heterogeneous region. For instance, algorithms based on a 'pixel by pixel' classification method, such as a histogram algorithm, could not separate the two types of Terra Firme in Western Amazon, while a clustering algorithm, based on the distances among different groups of pixels (Mahalanobis distance) and taking into account statistical attributes for each class (covariance matrix and average vector to estimate the central value of each class)succeed in picking up this variability in the forest type, confirmed by the field data (Allpahuayo site).

Changes in the text were maid to clarify this point: Section 3.3, page 7, lines 193 to 214.

Field ecologists have observed a great variability in Terra Firme forests, not depicted by the medium and low spatial resolution remote sensing data (e.g. CBERS, Landsat satellites). Therefore, in this research we assumed that if there is a significant spectral difference among vegetation types, captured by the classification algorithms, then the vegetation physiognomy is distinct. However we cannot assume that (i) there is no variability within apparently homogeneous areas detected by the remote sensor, nor that (ii) two distinct vegetation formations in the field cannot present the same spectral characteristic. The topographic data were used to further characterize this variability without introducing false detections, as differences in forest species composition and dynamics in plateaus are known to be different from valleys (e.g. Chambers et al., 2001).

Changes in the text were maid to clarify this point: Section 3.3, page 7, lines 193 to 214.

Chambers, J.Q.; Santos, J.; Ribeiro, R.J.; Higuchi, N., 2001, Tree damage, allometric relationships, and above-ground net primary production in central. Amazon forest. Forest Ecology and Management,117, p. 149-. 167.

Reviewer's Comment 4, Two main forest types ... and the rest?: The authors only focus on the mapping and distribution of two main forest types and the variability (spectral, elevation, soil) within these types. What are the statistical implications of not considering the whole 'forest' population and how is that incorporated in the weighted average calculations?

Author's comment: We re-wrote the part of the methods section* of the paper to make clear that although many different forest physiognomies were mapped, mainly Terra Firme forests and forests over alluvial terrain from the Pleistocene** were considered in the weighted analysis. This is because 33 plots are located in two types of Terra Firme, 9 are located in three types of Paleovarzea geological formation (alluvial terrain from the Pleistocene) and 2 plots in other formations; therefore no field information was available for the other vegetation formations. Hence we are able to only attempt to assess bias in sampling of the terra firme and alluvial terrain forest landscape,not the entire landscape (we do not have enough samples in other landscapes to do this). Terra firme forests and forests over alluvial terrain account for 73% and 9% of total area in our study landscapes. We have introduced text to explain this subtlety.

* Manuscript page 10, sub item 3.4, second paragraph, lines 279 to 288.

** see answer to next comment.

Reviewer's Comment 5, class definitions and classification systems: The authors propose to focus on the spatial distribution of two forest types: Terra Firme and Alluvial Terrian forests. The criteria used to define such forest types can vary depending on which classification system is used (floristic, physiognomic, ecological). It is really important to specify clearly the class criteria used in this work to ensure the readers and authors hold the same forest image in their minds. Labeling spectral classes using forest classes which are not clearly defined leads to confusion and misunderstandings. Table 3 confirms this, listing the worst type of class definitions I have seen for some time: 'alluvial forest physiognomy with the spectral property... however without inundation periods also located in Holocene/Pleistocene alluvial formations'. For example, what is meant by 'alluvial forest physiognomy'

Author's comment: In addition to the use UN Land Cover Classification System (LCCS*) for labelling the vegetation physiognomies for attending the Reviewer, the authors decided to keep and improve the description in Table 3. The combination of both classes and description takes advantage of the international nomenclature for land cover types, and further explore in two other resolutions (remote sensing higher resolution than the LCCS map (LCCS map has 300m spatial resolution, Landsat image, used in this study have 30m spatial resolution, and field observation) for a more complete and accurate vegetation types description for a such heterogeneous region.

For instance, vegetation formations over Paleovarzea geomorphologycal structure have a very particular texture in the Landsat image, and therefore any person interested to know what it represents can use this study as a basis to interpret the data, without needing any processing/normalization of the remote sensing data. In addition, field data observations are presented, and in this research, classification algorithms differentiated vegetation types with singular dynamics: e.g. in the Cuzco Amazonico plots - there are plots located in alluvial terrains that do not present a inundation seasonality, and plots that do. In this case, only a classification that is a mix of spectral features and field data can explore the richness and diversity of the region.

To make the classification/description of the vegetation types more clear, the authors have changed Table 3.

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See page 8, lines 221 to 250. See also Table 3.

* Bicheron P., Defourny P., Brockmann C., Schouten L.,Vancutsem C., Huc M., Bontemps S., Leroy M., Achard F., Herold M., Ranera F., Arino O. Globcover, ESA / ESA GlobCover Project, 2008. On-line: http://ionia1.esrin.esa.int/index.asp.

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