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Biogeosciences
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Interactive comment on "Integrated radar and lidar analysis reveals extensive loss of remaining intact forest on Sumatra 2007–2010" *by* M. B.Collins and E. T. A. Mitchard

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ALSO PROVIDED AS A PDF DOCUMENT IN THE SUPPLEMENT ATTACHMENT

We thank reviewer #2 for their time and careful consideration of our paper. Following the reviewer's numbering: 1. We have revised the text to discuss the impact of small plots and thank the referee for the reference, which we have now included in the paper. We could certainly improve our calibrations were more data from large plots available from the region. However, the lack of large plots for calibration remains a major issues for remote sensing more generally. It should be noted that the relationships we detect here between Lorey's height and AGB, and GLAS footprint based Lorey's height and

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radar backscatter, are identical in form and similar in parameter to those described elsewhere (Saatchi et al. 2011, Mitchard et al. 2012). 2. We have discussed the rationale for condensing the GLAS shots into 26 classes in terms of the loss of variation within each class in the methods section 2.4.1. and appreciate the reviewers concern with this point. However there are many more small value than high value GLAS shots, so regression based on the whole dataset would be biased towards the fit in smaller values. By contrast, we're not trying to investigate the precise details of the inter-relation of the variables, but instead create the best functional relationship between the two to allow prediction of height from radar backscatter. We provide below histograms of the datasets, showing the bias in lower values of Lorey's height:

Figure 1.

Averaging data within bins and then fitting regressions is normal procedure when trying to produce functional relationships between variables. It is common practice in fields such as engineering, and produces strong, unbiased, predictive relationships. We are not suggesting the resulting r-squared values should be used to predict the strength of the relationship between our GLAS data and HV backscatter, nor that errors can be propagated from the graph: but we do believe that the regression technique here is appropriate. 3. We intend to measure the impact of deforestation across a range of forest classes, but calibrate our remote sensing data using plot information from a peat swamp forest. We included the secondary forest in order to obtain a better functional relationship between the radar backscatter and AGB. i.e. we would ideally like a full distribution of AGB data against which to compare a distribution of backscatter intensity data, rather than choosing a subset of high biomass forest areas, and a subset of backscatter values. This allows for more sensitivity in the final analysis since not all pixel backscatter values are at the threshold for biomass quantification. In addition, this builds the corpus of research which illustrates the relationships between forest biomass and backscatter intensity across a range of values. There is no evidence from these data that the functional backscatter-biomass response differs between secondary and peat swamp forest: this certainly warrants further investigation, but with no evidence to the contrary does not negate our current analysis.

4. This point concerning the inter-annual calibration of backscatter intensity was also raised by referee 4, and is clearly fundamental to the analysis we have presented. We appreciate the concern that the results of the process improve the relative approximation of data over pseudo-invariant features. As such we present data extracted over stable forest in Berbak National Park, as outlined in green in the image below (UTM48S):

Figure 2

Based upon these stable areas, we provide graphical analyses as suggested which shows the distribution of pixel values before and after the normalisation procedure. We will include this in the body of the text for the final paper:

Figure 3

5. Point five concerns (a) the consideration of errors in the calculation of plot biomass; and (b) errors in the inter-annual calibrations of the HV backscatter. On the first point, in section 3.5.2. we do ascribe a >20% error to plot level biomass estimations, which we think accounts for the errors that derive from plot-level biomass calculations and potential errors deriving from regional differences. We have updated the text to reflect this. With regards (b), as we have illustrated above, the relative normalisation procedure appears to have been highly effective over stable forest areas, and thus we have no added a further term. However we understand the reviewers' point and we will acknowledge in the main body of our revised text that this remains a source of uncertainty that is difficult to quantify, due to natural variation in the target (forest). In future work with extensive, re-measured field plots we hope to be able to fully address this issue.

Response to specific comments, listed by line order: p.8574 17-20: We have adapted the text accordingly to reflect the integration of lidar data 22-24: We are working here from the basis that market failure is the absolute fundamental problem in deforestation, and indeed all environmental problem; and that the direct and indirect drivers of deforestation arise because of these market failures. If markets were perfect, and externalities actually priced into the decision making process over land use (e.g. the costs of soil fertility, biodiversity and water provision loss), then we would not observe the socially sub-optimal levels of deforestation that we do today. Perhaps this is too much of an economics-focussed argument to make in BioGeosciences, so we have changed the text to "yet markets fail to value them full, leading to multiple direct and indirect drivers of the extensive deforestation (complete removal of tree cover) and forest degradation (removal of a proportion of forest biomass)". 24: sentence changed as above p.8575 10-23: UN-REDD added 24:25: changed to 'will' p.8576 8-10 and 25-26: we mention that this is less of a problem at P-band on line 25. We have corrected the launch date to 2020, and have included the reference, gratefully received, thank you. p.8580 15-16: we think that this method will be able to detect forest degradation, by selecting smaller change thresholds, within a system where the errors have been reduced, allowing for greater sensitivity in change detection. p.8582 9:11- dates added 18-19 units added p.8584 6-7 removed 'an initial' 11-12: we used the ESA GLOBCover data, dated 2009, to remove GLAS ICESat shots which were over pixels which were non-forest areas as classified in GLOBCover. We will clarify this in the text. 17: This document was produced using LaTeX so figure ordering and automatic. We will need to liaise with the typesetters to resolve this. Thank you for highlighting the problem. 19: we have corrected the equation in the text

p.8589 1-6 The procedure successfully masked out pixels that were changing along the river margins. The remainder of the changing pixels, particularly the larger areas of plantation occur in swamp but not as heavily flooded areas; that is to say not the entire study area floods during the wet season. This improved our confidence in the result in terms of removing false positives. 16-18. The points with lower AGB and height may well be secondary forest. However, at these levels of biomass and height there is an overlap with plantations, which are not the focus of this study. We felt it was appropriate

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to exclude these areas in the analysis or to count them as largely deforested since such a dramatic reduction in backscatter will involve the removal of the large trees wherein the majority of biomass and hence carbon is stored (Slik et al., 2013). Nevertheless, the inclusion of auxiliary data (e.g. a classification using high-resolution optical imagery from 2007) may help in other analyses to distinguish between natural and plantation forests at least in the first time period. However the work was completed under a PhD programme without a budget for purchase of high-resolution optical data, and this work thus shows what can be produced without relying on such data. We have changed the text to reflect that there are in fact 26 bins as the reviewer points out. Thank you. p. 8592 6-7 sentence changed to 'relatively little high biomass forest' Figure 4: we have re-drawn the figure along the lines suggested:

Figure 4.

p. 8594. 7-9 We re-drawn figure 3 in order to display confidence intervals as suggested, now using ggplot2 in R and displaying 95% confidence intervals on regression line.

Figure 5

27-28: We took the 20.3% error rate as a published error rate that would serve as an indicative value for the errors that occur in forest plot biomass estimation, including errors in height measurements and their relationships with AGB, and the problems with not having any specific allometric equations for peat swamp forests – this is a matter of ongoing research in Indonesia. p. 8597 12-16 We have changed the text to 42 plots.

References Slik, J. W. F., Paoli, G., McGuire, K., Amaral, I., Barroso, J., Bastian, M., Blanc, L., Bongers, F., Boundja, P., Clark, C., Collins, M., Dauby, G., Ding, Y., Doucet, J.-L., Eler, E., Ferreira, L., Forshed, O., Fredriksson, G., Gillet, J.-F., Harris, D., Leal, M., Laumonier, Y., Malhi, Y., Mansor, A., Martin, E., Miyamoto, K., Araujo-Murakami, A., Nagamasu, H., Nilus, R., Nurtjahya, E., Oliveira, Á., Onrizal, O., Parada-Gutierrez, A., Permana, A., Poorter, L., Poulsen, J., Ramirez-Angulo, H., Reitsma, J., Rovero, F., Rozak, A., Sheil, D., Silva-Espejo, J., Silveira, M., Spironelo, W., ter Steege, H., Stevart, T., Navarro-Aguilar, G. E., Sunderland, T., Suzuki, E., Tang, J., Theilade, I., van der Heijden, G., van Valkenburg, J., Van Do, T., Vilanova, E., Vos, V., Wich, S., Wöll, H., Yoneda, T., Zang, R., Zhang, M.-G. and Zweifel, N. (2013), Large trees drive forest aboveground biomass variation in moist lowland forests across the tropics. Global Ecology and Biogeography, 22: 1261–1271. doi: 10.1111/geb.12092

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/12/C6990/2015/bgd-12-C6990-2015-supplement.pdf

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Interactive comment on Biogeosciences Discuss., 12, 8573, 2015.

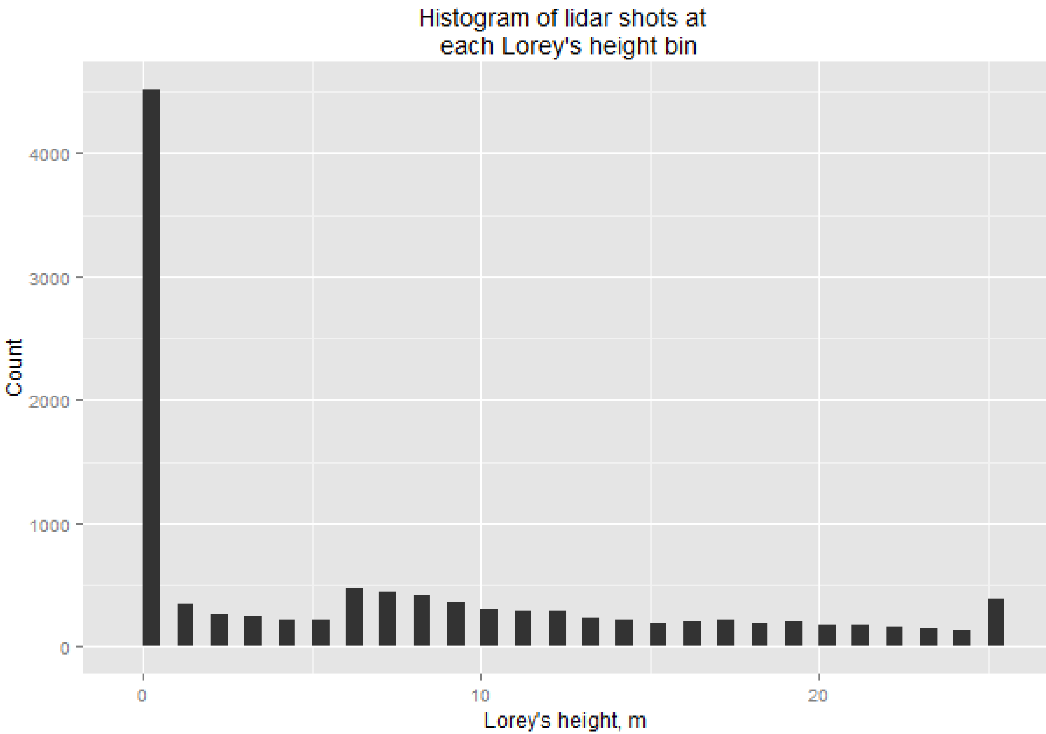

Fig. 1.

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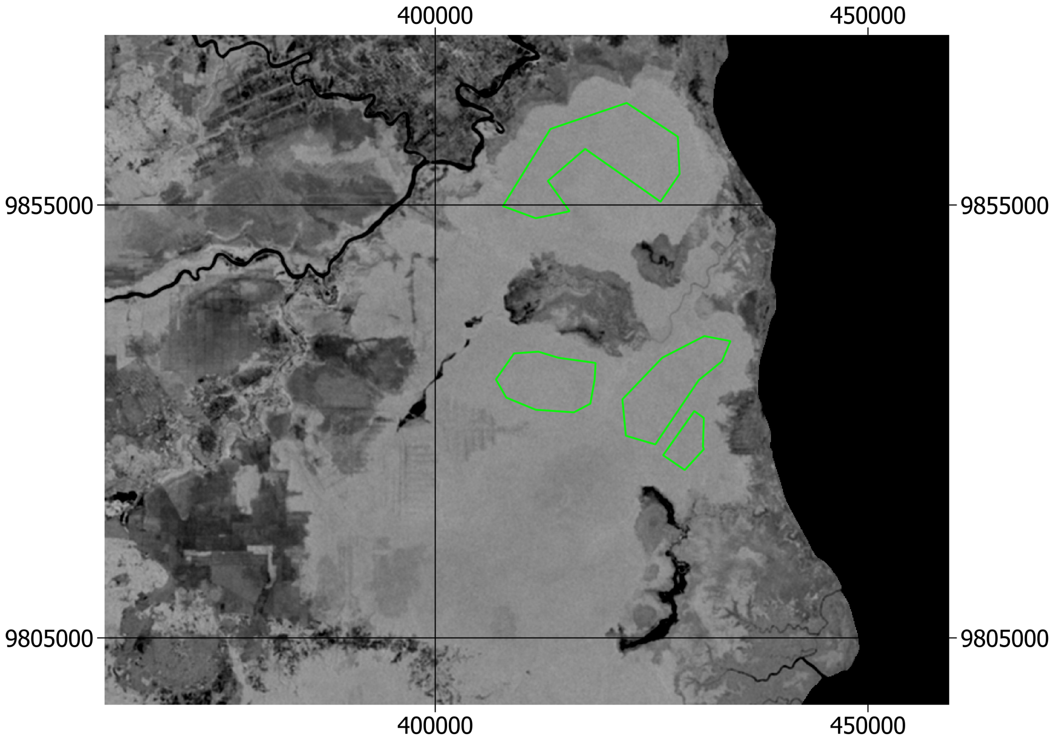

Fig. 2.

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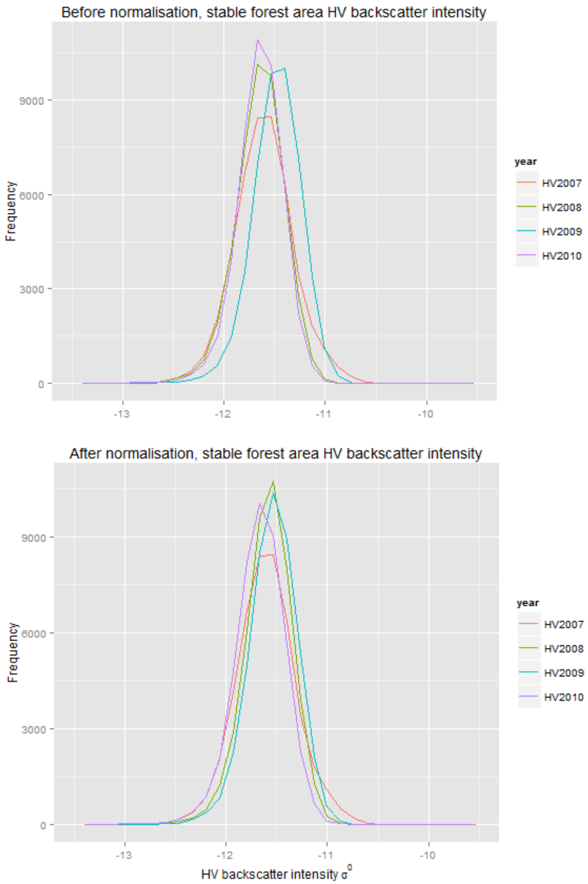

Before normalisation, stable forest area HV backscatter intensity
Frequency
9000
6000
3000
0
-13
-12
-11
-10
year
HV2007
HV2008
HV2009
HV2010
After normalisation, stable forest area HV backscatter intensity
Frequency
9000
6000
3000
0
-13
-12
-11
-10
HV backscatter intensity σ0
year
HV2007
HV2008
HV2009
HV2010

Fig. 3.

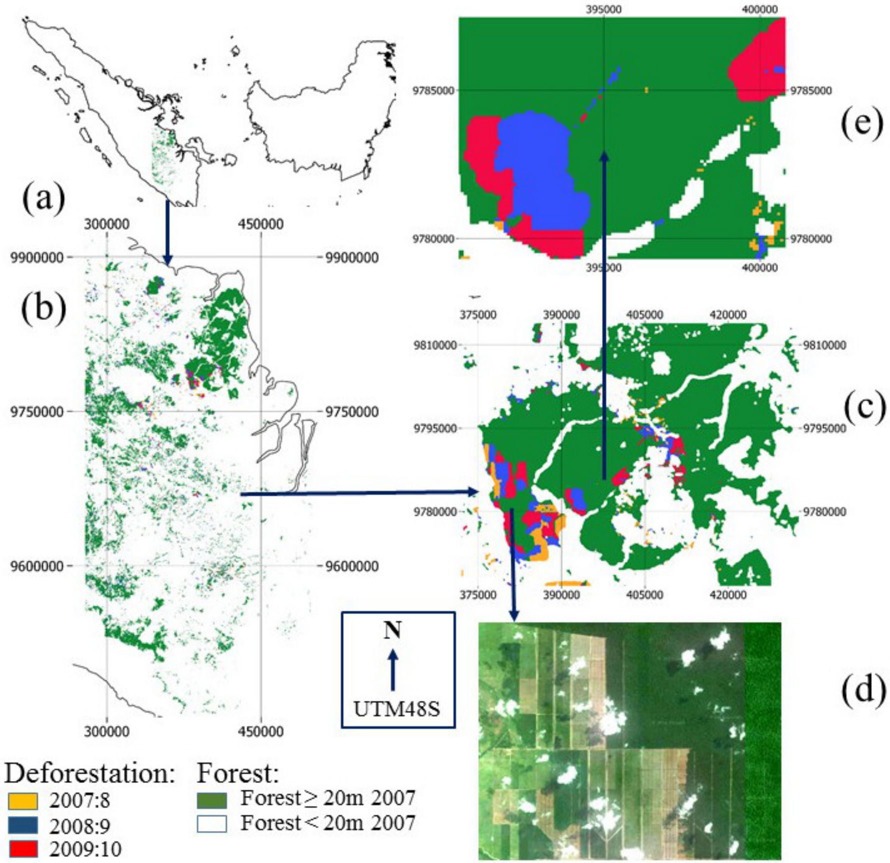

Fig. 4.

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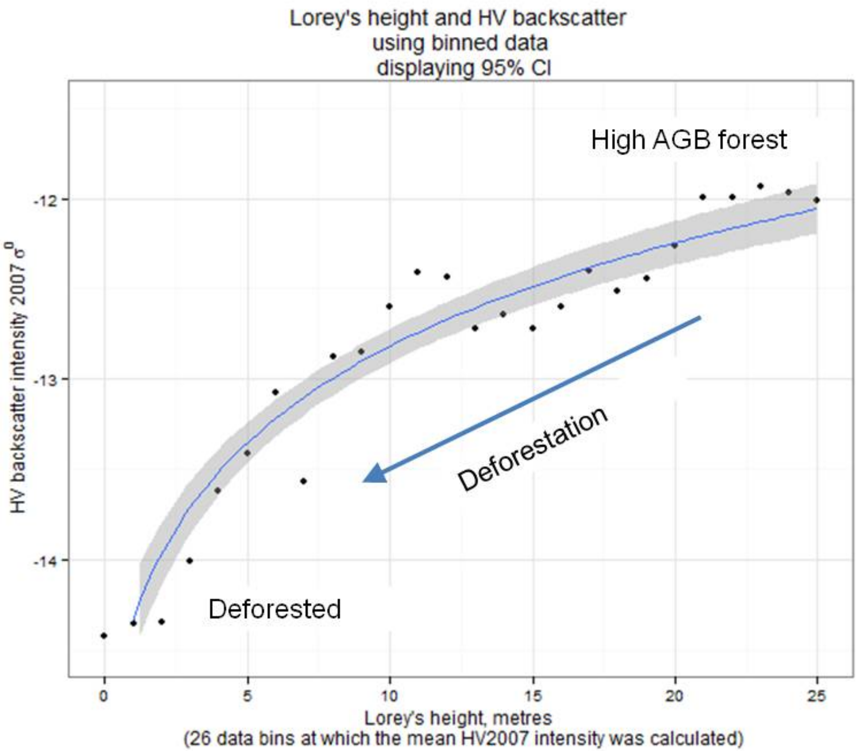

Fig. 5.