



Interactive comment on “The global forest above-ground biomass pool for 2010 estimated from high-resolution satellite observations” by Maurizio Santoro et al.

Anonymous Referee #1

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Santoro et al eloquently describe their global maps of [woody] forest biomass in a way that is both thorough and approachable. Unlike previous biomass maps, they leverage global SAR composites to first generate a map of growing stock volume, from which they then generate an additional map of the biomass density. As I understand it, this approach contrasts with those used to generate previous forest biomass maps which have instead used more direct approaches that are thus more correlative and perhaps, then, less reliable. Santoro and colleagues also generate an uncertainty map, making their product distinct from its predecessors in that regard; I particularly appreciate the transparency this affords the product. Overall, I commend the authors for a well written

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paper and robust product.

I am admittedly not an expert on non-optical remote sensing and would thus characterize my feedback below as more representative of a potential end user. While I can't speak much to the methods Santoro et al use, I do feel this perspective is important given the number and breadth of biomass maps that have been published in the last 10+ years. Below, I have identified several minor issues that I feel should be addressed to ensure that users like myself properly understand and interpret these data. Some are inevitably a matter of opinion and I respect that the authors may feel differently. Overall, though, I think this manuscript and the data it described will (at last!) be great contributions to our field.

Minor Comments:

Line 87 – Baccini et al. (2017) would seem to be an appropriate reference for forest degradation.

Line 85 – Gibbs et al. (2007) would seem to be an appropriate reference for REDD.

Line 86 – You might also consider mentioned less conventional potential applications like attaining co-benefits from the CBD (e.g. Soto-Navarro et al. 2020).

Line 91 – The authority you seem to give the Bar-On estimate seems odd given that your maps could theoretically be used to improve their estimate. I would suggest (though, I do not require) that you change the language here to imply that Bar-On's estimate is speculative. Something like "Previous estimates have suggested that...". I would also explicitly describe the Bar-On estimate as a *carbon* stock estimate. By contrast, you map biomass (i.e. dry mass). If that distinction isn't made clear, readers may mistakenly compare your estimate to that of Bar-On which would not be inaccurate. Finally, I suggest that you report the Bar-On estimate in units of PgC (like you do later in the paper when presenting your own results) instead of GtC.

Line 94 – The body of this paragraph is a bit discordant with its first sentence. I think

your aim here is to say that biomass estimates are uncertain. If that's correct, I think you could do so more effectively. You might do so by changing the second and third sentences to something like: "However, our knowledge of the terrestrial biomass stock is relatively uncertain (Houghton et al. 2009). This uncertainty is well illustrated by the variance among forest biomass estimates: Pan et al..." Otherwise the transition from discussing total biomass C stocks (e.g. Bar-On and Houghton) to forest biomass C stocks (e.g. Pan, FRA) is an abrupt logical leap.

Line 105 – “Observable”: do you mean “variable”? This is a term I haven't seen before.

Line 105 – “AGB”: From this point forward, I think you're using AGB to implicitly refer to woody AGB (or the biomass of trees). If so, It's worth making that explicitly here. Many less-knowledgeable users of these maps mis-interpret them as representing the AGB of all plants rather than just that of trees and that leads to underestimates. I recommend explicitly defining it here (or earlier). Something like: "AGB (which hereafter we use to refer to aboveground biomass exclusively in forest trees)". And/or changing subsequent mention of "AGB" to "forest AGB". Do you use a certain definition of for forest/woody biomass? E.g. the FAO definition, A certain height, Etc.? If so, it would be worth stating that somewhere (if not here).

Line 115 – Baccini et al. (2012) represents 2007 and Baccini et al. (2017) represents even more recent years.

Line 118 – The year of the Erb reference should be 2018

Line 180 – I think you specifically mean investigations targeting *direct* estimation.

Line 198 – The last sentence of this brief paragraph is awkward. Consider rephrasing.

Line 298 – Does your uncertainty layer represent the standard deviation, as you say here, or the standard error? Below it sounds like you're propagating standard errors and the GlobBiomass website lists the uncertainty layer as representing the standard error (<https://globbiomass.org/wp->

content/uploads/GB_Maps/Globbiomass_global_dataset.html). Whichever it is, please make it abundantly clear here in the text and make sure your description is accurate and consistent throughout the manuscript (and beyond).

Line 391 – It may also be worth comparing to regional/national AGB maps? Users often want to know whether it is appropriate to use global products to answer local questions. Obviously such a comparison wouldn't be comprehensive but even just showing for a few areas how well your map agrees with local products, might give users a sense of appropriate confidence or caution. This could also instead be done in the discussion if there are studies that have already made these comparisons with your data. One short comment on this manuscript notes that there is at least one such comparison that has been done in the U.S. Perhaps there are others as well and thus no need to do an extra analysis?

Line 407 – Again, is “standard deviation” correct here?

Figure 2 – How would you explain the areas with $\sim 100\%$ uncertainty? You don't mention these in the text but I suggest that you do. Are these areas that underwent a land cover change (fire, forest clearing, etc.) c.2010? Or does the model just do a poor job predicting biomass in certain areas (e.g. those with sparse woody vegetation)? It would likely help users to know this. Also, in my examination of your data, uncertainty can exceed the mean estimate (i.e. $CV > 100\%$). How would you explain this to users? Is this a sign that error is not normally distributed? Also, this possibility should be indicated in the figure, either by allowing the colour-bar to surpass 100% or by changing the max label to something like "100+".

Line 418 – It would be prudent to state explicitly here (or wherever you report your first result) that the unit you're using is Mg of *dry matter* rather than carbon. Users occasionally assume that biomass maps are reporting carbon stocks.

Line 469 – I feel like your downplaying the fact that your mapped estimates saturate at high values. This is important for users to know and should be stated more frankly than

saying "albeit more gently". Without euphemism: "you underestimate high biomass stocks". So, the highest value you give above (757 Mg/ha) for the U.S. Pacific Northwest is likely a gross underestimate? You could illustrate the degree to which that might be true by referencing a field measured estimate from that region. In general, I don't mean to imply that this is fatal issue (every biomass map seems to have this problem) but you should be as transparent about it as possible about it.

Line 476 – The filled circles nicely show the saturation effect.

Line 495 – The highest estimate you give above (757 Mg/ha) is from the *temperate* rainforest of the U.S. Pacific Northwest. That would seem to contradict this statement.

Line 503 – I suggest breaking this discussion of the uncertainty layer out into a separate subsection (even if brief). Hardly any biomass maps are accompanied by an error layer so this could be viewed as a real strength of yours. As I've noted above (in the context of Figure 2), I think there are simple ways you could elaborate on this a bit to help users understand what it represents and how to use it.

Line 540 – I believe the FRA provides separate estimates for planted vs. natural forests. Are you considering both together here? If so, please make that clear in the text. I'm not sure about the 2010 FRA, but the 2015 version also considers "woodlands" separately. Presumably all of these categories fall under the purview of your map?

Line 557 – Mainly? It seems like a substantial portion could be due to your underestimates of high biomass.

Line 642 – At the U.S. state level, Spawn et al (2020) appear to compare your maps (separate from their modifications) to the U.S. FIA and show good agreement (see their figure 9). They don't employ the CCI Land Cover map in their comparisons so seemingly support your hypothesis that the difference is explained by the CCI map and not your biomass predictions?

Line 654 – I think "illustrating" is more appropriate, here, than "indicating".

Line 684 – The statement about minimal biomass at high latitudes warrants a citation.

Line 749 – I think you're saying, here, that if you further account for the woody biomass in non-forest CCI land cover classes, the total estimate increases? Please clarify in the text.

Line 751 – Here you're saying that your maps show 600 Pg of *woody* biomass. This is the number readers might improperly compare to the Bar-On *carbon* estimate you note in your introduction section – I'd make it abundantly clear here that this is 600 Pg of *dry biomass*, not carbon to prevent any unjust comparisons with Bar-On or others. This may also be an opportune place to mention the maps by Spawn et al. (2020) which use your woody biomass and additional maps of non-woody biomass to generate a total AGB (and separate BGB) estimate. Users may want to know when when/why one is more appropriate than the other. Whether here or elsewhere (perhaps the last paragraph?), I'd suggest (though, don't require) you make appropriate recommendations. Spawn et al. may also help put your number in appropriate context (i.e. make it more comparable to Bar-On).

Line 773 – please add “woody” before “AGB”.

Overall, fantastic work!

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