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Interactive comment on "High-resolution forest carbon flux mapping and monitoring in the Pacific Northwest with time since disturbance and disturbance legacies inferred from remote sensing and inventory data" *by* Huan Gu et al.

Anonymous Referee #1

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General comments

The manuscript aims to address current issues in constraining forest C dynamics and stocks in relation to multiple different types and intensity of disturbance. The authors combine a range of data including national inventories, management databases, airborne and space-borne remote sensing. These data are then combined / utilized through both statistical (yield curves) and simulation based modelling (CASA) approaches. As such the manuscript is highly relevant and well within scope of Biogeosciences and I believe will ultimately be published in Biogeosciences. However I

believe there is additional scientific value that should be drawn from the current analysis and a substantial re-write to improve readability prior to publication. The following general comments are split broadly between scientific and presentation.

Globally C stored in forests is split roughly equally between woody biomass and soil organic matter (e.g. Pan et al 2011). However the manuscript focuses on estimates of above ground biomass stocks and disturbance to these stocks, lacking any analysis or discussion of soil carbon stocks. I recognize that the authors report net ecosystem productivity (defined as NEP = NPP-Rh), but I would prefer you to distinguish between accumulation and losses between the live biomass and dead organic matter. Or state clearly why not given that you are reporting ecosystem scale values. Also I do not believe that the authors have extracted all relevant information for the above ground biomass stocks. For example in Section 3.4 L29 The authors state "Spatial variations in mean annual NEP are noticeably correlated with the time since disturbance, forest type group, and site productivity strata...". This could be shown more clearly in an x$\sim$y plot and / or this "noticeable" correlation could be explicitly quantified to distinguish the relative importance of the drivers. Further detail follows in the specific comments section.

The overall writing style of the manuscript needs to improved to benefit the flow of reading and in particular clarity. For example the methods overview needs to be clearer as to the overall structure of the analysis and their connections. The authors provide extensive detail on the data sources and what information they provide, however the fact that these data will used as constraints or drivers in the CASA model is not made clear until the final section before the results in Section 2.3.1. This is particularly confusing as all the description of data given is in reference to above ground biomass while at the same time stating that the results from the analysis are the net ecosystem productivity. Moreover the number of words in both the methods and results sections dedicated to the various disturbance maps produced appears disproportionate given that the title and the conclusions imply that C stocks and dynamics are the primary focus. I would

consider way to simplify this information and attempt to move some of it into the supplementary material. Also I note that Figures 10 and 11 do not feature in the results section at all, instead are used to introduce new information in the discussion which is inappropriate. These figures should be introduced in the results section of they could be moved to the supporting information.

Specific comments

The following comments are broken down into Abstract, Introduction, Methods, Results, Discussion and Conclusion sections. General comments on each section will be followed by specific comments with page (P) and line (L) numbers.

Abstract The abstract could be made to flow more easily and make clear that the analysis is feeding into a C-cycling model that represents both the live and dead carbon pools. This will reduce confusion between described / yield curves used which constrain above ground biomass while at the same time reporting a net ecosystem value.

Introduction All relevant information appears to be present in the introduction, however not all of the information is clear. I would recommend the use of topic-sentences to improve clarity of your message for each paragraph. Moreover there are a number of sentences where the wording is awkward to read.

P2L29 "...remote sensing techniques..." should include "...remote sensing (RS) techniques" as RS is used later. P2L30 "...remote sensing techniques provide..."

P2L32 "Such products miss small scale events and extend only so far back in time..." awkward wording. Please reconsider e.g. "However, RS products frequency miss small scale events and only cover the last several decades..." P3L8 "...provide a way forward to capture at least some of the information that is missing but needed..." awkward wording, Please reconsider rewording.

P3L9 – L20 The final paragraph would be a good place to make a clear statement of the studies objective (key questions) and novelty. However the final paragraph here

mixes further introduction and aims. This could be split and made clearer.

Methods The methods are very long (which I accept may be required) and would benefit from an improved overview section. Where possible the methods sections would benefit from moving some material to the supplementary material to improve focus.

P3L25 "...recent disturbance..." how recent? P3L28 "...terms "time since disturbance" and "stand age" " would it be possible to pick one of these terms and use it consistently? P3L29 "It was inferred..." possibly "Stand age was inferred..." would be clearer? P3L30 "The (yield?) curves were sampled from FIA data and specific to forest type and group and site productivity class." Is this information known in all cases? If not, what is assumed in their place?

P4L1 "Net ecosystem productivity (NEP)" prior to this point all data / methods mentioned implies that this study is focusing on above ground biomass only. A link to CASA needs to be made earlier to make this clear. P4L13 It would be useful to have a table with the different data sources listed and state the data and time period they cover.

P5L1 "These assumptions...been reported in the literature." Long sentence, can you break some of the sentences with lists, multiple concepts or conditions down. P5L5-10 Consider making this list in a table P5L11-12 "The target year...was 2010". Possibly make this point earlier say in the overview or introduction aims? P5L23 "age class from ..." how many age classes, are all equal in size? P5L25 All other units are given as SI. Please do so here too. Also it is odd that up until now forest biomass as been discussed, here you have swapped into volume. Can you convert or is there a reason for this?

P6L1 "Differences in forest masks..." which forest masks? Which products you are using? P6L2 "These were replaced by the mean biomass of other undisturbed pixels..." The distributions of stand age in Figure 11 are not Gaussian, would the median be better or is there little difference? P6L12-13 Again SI units please. P6L24 "In reality

fhigh is almost always between 0 and 1." Can you say what the mean value is or distributional information? Something more informative.

P7L4 This is the first mention of the CASA model. Please provide a brief description of the mode and how it works. This is needed given that you make reference to its process representation in the discussion P11L1-5. Also what is the model time step used. Over what period is CASA simulating these forests (prior to 2010)? which meteorological drivers are used (e.g. ERA-Interim, GFS)? How realistic are the spin up pool sizes relative to field estimates in undisturbed pixels. Your estimate of C loss in response to disturbance will partially dependent on soil losses which will also be dependent on their initial magnitude after spin up (e.g. Exbrayat et al., 2014). If this information is available in the cited literature please make this clear. P6L10 "...curves describing carbon fluxes and stocks..." which stocks / fluxes where are they? P6L15 "This study emphasized the use of NEP curves. Fig. 5 ..." Figure 5 seems to show that C losses do no occur whereas losses do occur in the results (Table 2) as presumably soil and litter C is being decomposed and undergoing mineralisation. So where is the C source represented?

Results

What is the primary focus of the manuscript? A large part of the results section is taken up with a description of the various input maps into the analysis. Much of it seems like it should be in the methods sections as a description of the inputs or could be moved to the supporting information. Unless these are actually new numbers derived from the combination of multiple maps. At the moment it is not clear. Possibly an overview could be given to the results as it takes a lot of reading before you get to any information on the estimates of biomass stocks.

P9L11-12 "...these curves yielded a smoothed fit to the inventory data rather than showing a saw-toothed increase with stand age." Here are you referring to saw-toothed due to managed thinning or stem mortality events? P9L23 "Uncertainty on the time since disturbance forest pixels is not currently available from disturbance products and

this was not mapped" Could the uncertainty in the yield curves on growth since disturbance be included? How strongly do the yield curves constrain CASA? P9L29 "Spatial variations in mean annual NEP are noticeably correlated with..." Why not actually correlate them to quantify this? A new x$\sim$y figure might be useful here too. P9L30-31 "...weaker carbon sinks in the eastern, drier portion of the study area..." Again this could be show in an x$\sim$y plotting soil moisture / precipitation against C sink strength to quantify.

P10L6 "Forestlands free of recent disturbance..." could be "Undisturbed forests are..." just trying to be consistent with the terms you use.

Discussion

P10L21-23 Awkward sentence please rephrase / breakdown into smaller parts. P10L25-26 Odd place the begin new paragraph. You appear to be continuing your point from the first paragraph. P10l27 It is not clear what you mean. Are you talking about how the stand-level biomass estimate was calculated or how the real world stand was managed / grew? P10L29 "...or also from a recent disturbance that reduced biomass to the current level." I think you need a reference here. P10L30 "...varies depending on the type of stand-replacing disturbance". Are you referring to e.g. clear felling vs fire?

P11L1-4 Currently you have not described the model used to provide required background for these statements. P11L4 "...initial rise through stand initialization." Are you talking about early phases of forest growth? How long does initialization take? P11L9 "...which are sure to have errors." Are there any estimates of this error? P11L9-13 Should this not be first introduced in the methods section if these describe errors between field information and the maps you have used to constrain your model. Also, is there a bias associated with these errors? If so, how do you expect these biases to impact your analysis. Might a bias here impact the differing conclusions between here and your previous works? P11L27-28 Introducing new information in figures which are

not described in the results. This should not be the case. If the figure and comparison is really needed then it should be included in the results and be part of the experimental design. or could be moved to SI.

P12L12-15 New analysis should not be introduced in the discussion. Also Figure 11 did not appear in the results either. Again, if these comparison and figure is needed then make it part of the experimental design and introduce it in the results section first. P12L14-15 "...distribution agrees well with that for our undisturbed..." poor working rephrase. P12L18, P13L4,L18 Multiple definitions of what is a young forest. Can you reconcile these? P12L22 "A portion of this difference can be attributed to smaller net carbon losses..." If I understand correctly here you mean greater loss / more negative? Comparing between -4 TgC and -7 TgC? Not clear. P12L31-33 Is the PNW region representative of forestry in the US? P13L19 Good to see some comparison with other studies. Are there any more available to broaden the discussion?

Figures

All of the figure captions need to be expanded to make clear where the data / analysis from each figure comes from and any key features. Also there appears to be substantial repetition of the disturbance figure. Can the figures be re-arrange to minimize this / move some of these maps to the SI.

Figure 5. These NEP do not show C loss, even though your analysis does. These figures reinforce the confusion between whether or not you are analysis the C balance of the ecosystem as a whole or just the live biomass. If you are analyzing the whole ecosystem the NEP would surely be negative directly after disturbance due to litter and soil C turnover?

Figure 10. In your analysis are "Years Since Disturbance" and "Stand Age" the same thing? If so why in the same figure are you referring to this by different names. Particularly as in the caption you refer to both as "Stand age".

References

Exbrayat, J.F., Pitman, A.J. and Abramowitz, G. Response of microbial decomposition to spin- up explains cmip5 soil carbon range until 2100. Geoscientific Model Development, 7(6): 2683–2692, 2014. doi: 10.5194/gmd-7-2683-2014

Pan, Y., Birdsey, R.A., Fang, J. et al. A Large and Persistent Carbon Sink in the World's Forests. Science, 333(6045):988–993, 2011. doi: 10.1126/science.1201609.

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