

## ***Interactive comment on “Uncertainty sources in simulated ecosystem indicators of the 21st century climate change” by Jarmo Mäkelä et al.***

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Mäkelä et al. quantify the contribution of different uncertainty sources (climate, RCP, management, model parameters) on uncertainty in predictions of various ecosystem indicators made by two ecosystem models throughout the 21st century.

The topic of the study is timely, and relevant for the field. It also fits well to Biogeosciences. I believe that the study is overall sound. More effort, however, could be spent on discussing the implications of the results for vegetation modeling and climate change research. I also had some questions regarding the quantification of input uncertainties and some other aspects of the methodology (see details below), which should be considered by the authors.

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=== General comments ===

1) The abstract does a fine job at describing the methods and results, but the motivation and the implications could be better worked out. The same point could also be made about the main part of the paper - relevance / insight could be better worked out in introduction / conclusion.

2) The way input uncertainties were quantified should be more systematically described and justified. Taking the example of management: you consider two management scenarios, which you effectively consider equally likely. On which basis were those chosen? I assume that there are more options for management. Regarding the RCPs – your analysis seems to put equal weights on all 3 RCPs, so you consider them equally likely? It's OK if your uncertainty ranges are chosen “ad hoc”, but it should be clear if you interpret those as a probabilistic, or just as a range of options. It seemed to me that in several parts of the discussion, you interpreted the results more like a sensitivity analysis (as in: through management, we can change a lot) than an uncertainty analysis.

3) Maybe I missed it, but you never explained the reason for using 2 models – I'm also asking because the model (structure) could of course also be seen as a source of uncertainty, but it seems you don't view it that way?

4) I appreciate that there is no ideal method to attribute back the output uncertainty to the inputs, but the CCA certainly has some limitations due to its linearity assumptions. In <https://www.sciencedirect.com/science/article/abs/pii/S0378112717304371>, we use a random forest for the same problem. There are some caveats for this approach as well, in particular if there is collinearity between input variables, but it might be a more robust alternative if nonlinearity is an issue.

Specific comments

1 THE forest -> consider deleting "the"

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2 ongoing -> redundant?

4 The logical connection between the increase of CO<sub>2</sub> and the necessity to do this study was not clear to me. Aren't the changes you are analyzing here mostly driven by climate change (which is of course created by CO<sub>2</sub> increase)?

8 Stages – you mean points in time?

9 indicators of climate change -> I wouldn't say that these are climate change indicators, maybe just "ecosystem indicators"?

11 This sounds weird – do you mean: the uncertainty induced by the climate model . . .

14 One would usually expect some kind of conclusion / summary at this point

16 delete "and"

16 I think this paragraph would be easier to understand if you would start with the topic, which is that there is agreement that climate is changing, but uncertainty about the magnitude

24 Again, motivation not quite clear to me.

87 How can they have good performance and at the same time represent well the variation of models? This seems to be a contradiction

98 Overall, the explanation about the selection of the climate models didn't sound particularly convincing to me. Why would it be scientifically beneficial to have climate models from different continents? The only concern is that the selection you make is not representative of the distribution of climate models as a whole. If you would shortly state that this is not the case, that would fine for me

101 I would recommend active voice: we used the model . . . for these parts

105 You mean the "parameter uncertainty"? Because model uncertainty includes more

105 The parameter description is hard to understand. Also, I assume what you did is

to have these 100 parameter combinations, and then you cross them with the other options in a full factorial design? This could be better explained, and also why you choose to do this, as opposed to drawing parameter values from the posterior for all model runs.

106 Parameter uncertainties?

109 I think it should have been called like this all the time, because model uncertainty could be read as structural uncertainty

135 One could think about introducing a subsection explaining and comparing the 4 sources of uncertainty here

138 Why 2000 vs. 6000? Maybe explain how the numbers come about.

159 Well, the uncertainty has to be caused by something, right?

160 I think it would be good to shortly explain the interpretation of the RD index here or before. The reader should be able to interpret the figures without referring to the appendix

166 Maybe some introductory sentence here that explains why we next look at this?

Fig. 3 Although I understand the reason why you present it like this, it is slightly confusing to have the site on the y axis, and the variable as title of the figure

179 Not sure if bifurcation is really the best word for it. Just because it is used so often in a slightly different context in maths

195 I was struggling to see the motivation for this section, in the context of uncertainty – isn't this all more about describing climatic trends?

202 well, given that the model is (I think deterministic), it must be explained by the input uncertainties. It seems to be rather that there is no linear correlation that could be picked up by the CCA?

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Fig. 9 the site labels are very hard to spot

249 Similar, really? The two models look quite different to me in Fig. 1. Also, Fig. 9 looks to me as if there are quite some differences between the models

264 It seems to me that you interpret the results here more like a sensitivity analysis than an uncertainty analysis. In an UA, we wouldn't have the choice to change management, it's uncertain.

272 I'm a bit surprised – are these models suitable to understand changes in snow melting periods? Of so, by what mechanism would that occur, increased LAI?

281 Again, this would seem to me an interpretation of a SA, not UA

291 next 4 lines: I didn't understand what you mean here

295 I don't understand how you can deduce this from Fig. 4 / 7 – isn't the KDE showing the combined other uncertainties, not just the parametric?

317 when they are correlated, they could also be both wrong in the same way

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