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Interactive comment on "Assessing uncertainties in global cropland futures using a conditional probabilistic modelling framework" *by* K. Engström et al.

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We would like to thank both reviewers for their suggestions, and will address these in the revised manuscript. We detail the changes made below.

Response to reviewer 2:

Dear authors, The manuscript provides an interesting insight into the source and magnitude of uncertainty surrounding global crop-land areas under different SSP scenarios. You provide a detailed methodology to quantify uncertainty ranges for various socio-economic parameters.

Reply: Thanks for these supporting comments.

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Discussion paper

However, I feel the complex methodology is not easy to follow from the way the manuscript is currently structured. My additional comments:

Reply: The method section will be restructured, introducing the modelling framework first. This will enable the reader to get an overview of the entire approach, before we present the more detailed model-set up descriptions and parameter estimates. We clarified the yield description in section 2.2 (previously 2.1) and section 2.4.3, which we think addresses comments 1-4.

1. Does the LPJ-GUESS model used to derive actual and potential yields contain a representation of crop response to heat stress? Under climate scenarios modelled (particularly RCP8.5) temperature changes in several countries will result in certain crops becoming unviable.

Reply: The heat stress implementation is limited to a shortened growing season and increased respiration and lowered photosynthesis, which we clarified in the revised text.

2. Do actual yields from LPJ-GUESS consider the influence of pests and diseases, and how the influence of this may change over time under different climate scenarios?

Reply: The initial actual yields for the year 2000 were derived by scaling LPJ-GUESS actual yields to Mueller et al. Actual yields in Mueller et al. (2012) are observed yields (based on FAOSTAT, national census agencies and agricultural surveys, see (Monfreda et al., 2008)) and are naturally influenced by pests and diseases. As you point out, the influence of pests and diseases might change differently for different climate scenarios, but this was not considered in our study.

3. Following from comments 1 and 2, is the LPJ-GUESS model overestimating actual crop yields (and perhaps potential)? Given that you state agricultural land use is highly sensitive to uncertainties in crop yield growth rates how does this impact your results?

Reply: Initial actual crop yields are not overestimated due to the applied scaling, but

could potentially be overestimated when reported to FAOSTAT. The increase in actual (and potential) yield is derived from the LPJ-GUESS runs and might be optimistic due to the assumed CO2 fertilization.

4. You state scaling factors have been applied to both LPJ-GUESS yields (P3 L24) and yield calculated by PLUM (P3 L30) but it is unlikely that these factors should be constant through time.

Reply: As described in the response earlier, the first scaling establishes differences in yields (actual vs. potential), while the second scaling accounts for potential minor differences in yields from Mueller compared to FAOSTAT. The area of irrigated cropland vs. rain-fed cropland could change over time and result in stronger changes of actual yield. In future work, irrigation scenarios could be included to address this limitation of our study, as well as other management options such as changes in amount and type of fertilisation.

5. The probabilistic futures F1-F5 are not clearly linked to specific SSPs. I also think the manuscript would benefit from a description of each SSP (even if only very brief) within the manuscript in addition to those in the appendix.

Reply: We will introduce the F1-F5 in the introduction and clarify the linkage to the SSPs (p. 2, l. 30). We added a brief description of each SSP.

6. Whilst the study has considered uncertainty of socio-economic variables in great detail, it's unclear how indirect climate uncertainties have been incorporated within the study, for instance, uncertainty within the yield modelling. The study concludes that uncertainties arising from climate variability do not strongly affect the range of global cropland futures but perhaps uncertainty in climate influences are under-represented in the methodology? For the two sets of monte-carlo simulations 3600 runs have been conducted for purely socio-economic parameter investigation (or 720 per SSP) and in conjunction with the 4 RCPs this number increases to 7200 (or 1440 per SSP). So the sampling across an individual SSP-RCP matrix is sparser in comparison.

Reply: We performed one set with 3600 runs using the mean yield of each SSP for each SSP (3600 runs per SSP) and in a second set we did 7200 runs (per SSP), assessing additionally to the socio-economic uncertainties the uncertainties arising from the SSP-RCP matrix and the GCM variability. We clarified this in the revised manuscript.

7. P13 L3: This sentence is confusing. From the previous description of the methodology it seems simulations under RCP8.5 were conducted based on the probability of this scenario within SSPs. Yet this sentence indicates the potential impact of RCP8.5 is under-represented (links to previous comment).

Reply: You are correct; the impact of a high emission pathway is not fully assessed. However, the purpose of this exercise was not to purely assess the impact of each emission pathway on cropland, but to create plausible and consistent cropland futures which address the uncertainties within each scenario. We clarified this in the text.

8. The discussion should explore further why F2, 4 and 5 strongly converge, and why F1 and F3 diverge, linking this to SSP storylines.

Reply: We would like to point out that this was done in section 3.2.

9. Fig 4: It is difficult to distinguish between scenarios in this image, even in colour.

Reply: We added scenario labels next to each line in order to increase clarity.

References Monfreda, C., Ramankutty, N., Foley, J.A. (2008) Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000. Global Biogeochemical Cycles 22. Mueller, N. D., Gerber, J. S., Johnston, M., Ray, D. K., Ramankutty, N., and Foley, J. A. (2012) Closing yield gaps through nutrient and water management, Nature, 490, 254-257.

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