

Interactive comment on “Changes in crop yields and their variability at different levels of global warming” by Sebastian Ostberg et al.

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Authors evaluate the potential of a simple modelling framework to reproduce the geographical distribution of changes in crop yield based on solely the change the global mean temperature (Δ GMT) and change in atmospheric CO₂ concentration. This simple modelling framework is calibrated based on results from five spatially explicit process-based crop models that are driven with data from five Earth system model (ESM) for four future RCP scenarios. The potential uses of such a tool are obvious for impact studies but in its current form the manuscript is somewhat difficult to follow. As a reader, I felt several clarifications are needed. In particular, I wasn't able to completely follow the three emulator models used to reproduce the results from the full crop models and still unclear how the different temperature bins come into picture. In addition,

C1

it would be helpful for a reader if the plots and graphics were bit more readable as suggested in comments below.

I also have comments marked on an annotated version of the manuscript which I attach as a supplement. Most comments from my hand written notes are summarized below except the minor comments for which I request you to see the attached annotated version of your manuscript. Hope my hand writing is easily readable.

Specific comments

Page 3, lines 100-105. I find it difficult to believe that spatially explicit crops models (driven with spatially explicit climate information even though it may require some kind of scaling) will be worse off than the approach presented in this manuscript.

Page 4, lines 133-135. “The simulated impacts of climate and CO₂ changes on global and regional crop yields are shown to be related to global mean temperature change, and to be largely independent of the emissions scenario”. There is a bit of circular argument here and then later on in Figure 4 where most of the variance in crop yield is explained by crop models. I think, by choosing a specified Δ GMT you have made Δ GMT independent of emission scenarios and ESMs. What remains scenario and ESM dependent is the year when this specified Δ GMT is reached. Results from climate models show that the typical spatial pattern of temperature change is also similar across ESMs – that is higher warming over land than over ocean and higher warming at high latitudes than in tropics. Combined with specified Δ GMT this means that it is somewhat expected that most of the variance in crop yield will be explained by crop models.

Section 2. page 4.) Please 1) specify the time period of projections, 2) introduce the four RCPs and what they imply (i.e. low, medium and high emissions scenarios), 3) introduce CMIP5 a bit more and 4) provide 1 or 2 sentence about how bias correction is done.

C2

Table 1. page 5. The description of “Fertilizer use” needs to be made more consistent across the five crop models. For example, for LPJ-GUESS I am not sure what does “no consideration of spatial and temporal changes in nutrient limitation” means. Does this mean nutrient constraints are not considered or a specified fertilizer application rate is assumed for all times and all parts of the world.

Page 7, lines 200-221. What is MIRCA 2000? Is this an observation-based product?

Figure 3 and for other similar figures. Please consider putting the figure titles (Maize, Rice, Soybeans and Wheat) in horizontal format and a bigger font size as suggested in the annotated manuscript. Also, as a reader I was wondering what are the limits on the horizontal colour bar. I found the colour bar a bit difficult to interpret. If the white colour represents yield change of less than $\pm 5\%$ then how can light blue and light red colours represent changes of more than 50%. For example, +6% will likely be indicated by light blue colour but this is not more than 50%.

Page 12, lines 333-334, “To quantify the extent of the CO₂ induced scenario dependence and its potential reduction at each grid point . . .”. I am unable to understand what do “CO₂ induced scenario dependence” and “potential reduction” refer to. There are two possible aspects here and I am not sure which one is right in his context. The first is that of CO₂ fertilization – is this what is being referred to in this sentence. Second, note that just like by choosing a specified Δ GMT of 2.5 degree Celsius the dependence on emissions scenario and ESM has been reduced Δ GMT is also related to change in atmospheric CO₂ concentration. Is this what is being referred to here? Page 13. Equations (1) and (2) are the crux of the paper. Yet, I unable to understand how these equations are used. Perhaps if more equations were used to describe each and every term of these equations it would have been easier to follow them. For example, the change in yield is actually a two-dimensional quantity (i.e. it depends on the geographical location) at a given time (represented by i in equations 1 and 2). Perhaps if (t) can be used to represent time and not as subscript and if these equations were written again properly it would be easier to understand the objective of these equations. I am

C3

also unable to appreciate if equation (1) and (2) were applied at each individual grid cell or to the time series of globally-summed yield. In this context, I am also unable to understand what do the different temperature bins refer to.

In Figures 6 and 7, the absolute changes in yield are small (since they are mostly white in colour) yet the percentage changes are huge because those percentage changes are corresponding to small absolute values (as mentioned in the manuscript). Perhaps if the percentage changes can be masked over regions of low crop yields then these figures will be much more easier to interpret than the current percentage change figures. Alternatively, maybe the colour scale for figures with absolute yield changes can be changed and the percentage change figures can be removed.

Page 18, lines 439-442. “While approach (b) requires a pair of crop model simulations – one with time-varying pCO₂ and one with fixed pCO₂, approach (a) only requires the default simulations with time-varying pCO₂”. I wasn’t able to appreciate this. So perhaps this should be mentioned earlier on where the three emulator approaches are presented.

Page 20, line 485-486. While shown in Lotze-Campen et al., 2008 please include the map of the 10 world regions in this manuscript as well.

Page 20, line 486-487. “Compared to potential yields, using production gives less weight . . .”. Please introduce (if necessary) and differentiate yield from production. Not all readers can be expected to appreciate this difference between the two.

Figure 10. It is very hard to see the thin lines corresponding to each RCP. Please consider including thick lines for say 8 or 10 year moving average values which would likely yield a more fair comparison with values from the emulators which do not account for the effect of climate variability on crop yield. Also, please consider using a different set of colours for the four RCPs. The green and the blue seem very similar and the orange and red are pretty close colours.

C4

Page 23, lines 541-544. I am unable to understand this. Also, I am unsure how there can be any variance attributed to CO₂ effects. If this refers to the CO₂ fertilization effect – doesn't CO₂ changes gradually in all RCP scenarios. So yes, while there is a trend in specified CO₂, there is not year-to-year variability. Or, am I misinterpreting this.

I think, it should be made clear in the manuscript that the emulators do not capture the year-to-year variability but rather the long term trend in crop yield.

Please also note the supplement to this comment:

<https://www.earth-syst-dynam-discuss.net/esd-2017-69/esd-2017-69-EC1-supplement.pdf>

Interactive comment on Earth Syst. Dynam. Discuss., <https://doi.org/10.5194/esd-2017-69>, 2017.