Earth System Dynamics Discussions

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Comment on esd-2021-92

Anonymous Referee #1

Referee comment on "Resilience of UK crop yields to compound climate change" by Louise J. Slater et al., Earth Syst. Dynam. Discuss., https://doi.org/10.5194/esd-2021-92-RC1, 2022

Summary

The submitted manuscript describes a study of the historic link between extreme weather conditions and wheat yields in the United Kingdom (UK), extended with an analysis of relevant future weather changes. It is shown that mean yields have systematically increased over time, which can be explained by technological advances, but interestingly year-to-year variability of yield has also increased in recent decades (Fig 1c). The authors then set out an analysis in which correlations between various (extreme) weather indices for temperature and precipitation, across three important wheat growing stages, and end-of-season yield are investigated. They develop a simple scoring metric that describes some of the cumulative effect of weather conditions on yield. This analysis is extended by very high resolution climate model-based projections of future temperature and precipitation conditions under a high-emission scenario, and describes future weather conditions for wheat growing.

General remarks

Whilst I appreciate that the topic is of large societal relevance, I struggle to see where the manuscript answers its research questions or if promises delivered. The link between weather and agricultural impacts is highly complex and non-linear. The authors acknowledge this in their introduction, and set out on logical path of addressing the topic and ultimately provide specific wheat sector-relevant climate projections. I fear however that the relationships are of such highly complex nature, that the present analysis does not provide satisfactory answers to the questions posed.

The first research aim (finding statistical associations) results in Table 2. Only one of three regions shows any stat.significant relations (at p=0.05 level) between the weather indices and yield. The accompanying text leans very heavily on anecdotical evidence, which I fear

may lean towards overinterpretation of single events. To account for temporally compounding effects a simple scoring metric is developed (Fig 6), failing to take into account developments in agricultural science. Why haven't the authors followed their own advise (last sentence) and employed process-based crop models or AI methods to find robust relationships between weather and yield?

Then, the future climate projections are based on a single climate model. Though high-resolution modelling without doubt adds value, a multi-model perspective is needed to provide 'reliable' projections. I advise the authors to add a comparison of projections in CMIP6 or CORDEX to UKCP, such that readers may get a feeling of where these projections lie within the larger model-related uncertainty.
But more importantly, rather than analysing how crops respond to future weather conditions (which is what the title of this manuscript implies), changing weather conditions in three growing stages are discussed. Given the limited relationships between weather and yield that were found, does this really provide useful information for the UK agricultural sector?

Major points

Section 2.4 - In table 3 I see you have bias-corrected each ensemble member separately. Though I haven't worked with perturbed physics large ensembles, the normal procedure for bias correcting would be to do a single bias correction for all ensemble members, as differences are due to internal variability not indicative of different mean climates. Are the imposed physics changes so large that this is different in this case?

Section 3.2 - The relationships noted in this section are very anecdotical. Table 2 provides the quantitative correlation coefficients, which are only in a few cases statistically significant. Please add more quantitative evidence of the suggested relations, or note in the text that despite anecdotical evidence there is no statistical link. I think it is easy to overfit/overanalyse seemingly simple relations (e.g. wet conditions lead to low yield), when in reality the interactions between plant and weather is very complex and highly non-linear.

Line 295, line 318 - I hadn't noted evidence in the results section supporting the conclusion that increased inter annual yield variability is linked to "one-to-one correlations with temperature or precipitation extremes" or "the recent increase in yield volatility is associated with combined climate metrics". Please either emphasise this more in the results section, or remove from the conclusions.

I miss a discussion of the assumptions that went into this work, and how these assumptions might influence the results. One item would be the use of fixed-in-time growth stages, in reality these are weather dependent, and plant vulnerabilities to extreme temperatures or precipitation can thus be different from one July to another July (for example).

Minor points

Fig 1 caption - I very much dislike the bracket-way of scientific writing. There is no word limit in ESD, I strongly encourage the authors to rewrite their statement in two sentences. "Green (brown) labels indicate examples of years with anomalously high 485 (low) yields."

Line 50 - Indeed there is a lot of climate research into weather extremes, but there is a vast quantity of climate impact research as well in how these will influence for example crops. A slight rearrangement of this sentence is asked for. And maybe a few more recent examples from the literature (e.g. Ben-Ari et al 2018).

Line 85 - Please clarify "any incomplete crop growth stages", does this relate to gaps in the PR/TAS data, or too fast progression through the stage? If the latter, would that not be caused by climate extremes?

Line 104 - A model realistically simulating present-day climate is a requisite for making a seemingly reliable projection, but it is not guaranteed of course. The response to GHG forcing can still be very wrong. And since only RCP8.5 is used as forcing, further doubt on the 'credibility' of the projections is added (see e.g. Hausfather and Peters et al 2020). This does not discredit your analysis, but does put some limitations on the 'credibility of projections' made. Please add a sentence noting these issues (single model, single GHG scenario), maybe use the first paragraph of section 3.4 and remove it there.

Fig 2 - I originally thought the panels a-c showed the UK as a whole, only noting later that maybe the small region labels on the right count for all panels. Maybe add these inside the plot, or explicitly state this in the caption.

Line 154 - I don't understand why you would think those are related, on the one hand growth due to technology and on the other hand increased variance? I'd say for the first you have a very good argument, and the second is an interesting question indeed, with the link to increasing weather extremes as a good hypothesis.

Line 169, Fig 4/5 - These figures show a lot of data in a small panel. As you don't discuss any correlation between PR and TAS, why would you show them in this way? Wouldn't a 'simple' scatter plot between PR and yield better show this conclusion? Furthermore, yes-low yield years show an extreme PR in one of the seasons, but how many normal/high yield years do the same? E.g. from Table2 only EMYH in the production phase shows a statistically significant correlation between PR and yield. Then, what do the grey crosses add to the figure?

Table 2 - the horizontal line separating TAS and PR measures is one row too low.

Line 205 - Add here that the growing phases in real plants are determined by their growth, rather than calendar days. So a phase can last longer, to have the desired number of growing degree days for example, delaying the crop, but resulting in the expected yield. The calendar-fixed phases are a simplification of this proces.

Fig 6 - A few remarks: (i) Please separate the projections from the observed data, maybe in a second row of figures below the first one. (ii) I don't understand where the future yield data are coming from? The relationship of black circles and triangles and grey shading is surprisingly (doubtfully?) linear, and fully captures the eye of the reader. The dots show very much variability, by eye alone I doubt one would have been able to draw the correct regression line through them. (iii) please add fitted regression lines using observed data (I assume the statistics plotted are those lines), and maybe for the national subplot also show data from before 1990.

Section 3.4 - The section title is misleading, general forced climatic changes are discussed, not crop-specific climatic changes.

Line 245 - I imagine the UKCP lie in the upper/lower-percentiles of the full CMIP5/6 ensemble, but not fully outside? "UKCP simulations tend to sample greater future warming and drying in summer compared to the full…"

Fig 7 - I'm not sure this is the best way of showing the data. 10 lines on top of each other, plus the ensemble mean, and then for each the regression line. I had to zoom in to 500% to read the data. Maybe consider only showing with shading the min-P25-P50-P75-max across the ensemble, and the ensemble mean regression line? This would show less data, but I think more information.