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Earth System Dynamics
Discussions

Interactive comment on "Projected changes in crop yield mean and variability over West Africa in a world 1.5 K warmer than the pre-industrial" *by* Ben Parkes et al.

Ben Parkes et al.

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We present the reviewer's comment, our response and the resultant change applied to the manuscript.

"Descriptions of each crop model can be found in the Supplemental material." (4:7) Please describe the linear model also.

With comments from other reviewers a longer description of the models including the linear model has been added to the main text of the paper. The content relating to the linear model is repeated below.

The linear models use a design that has been used in several previous studies Estes et al. (2013); Lobell and Burke (2010); Wang et al. (2016); Parkes et al. (2017). The models in this study use the robust linear fitting tools in MATLAB (Holland and Welsch, 1977) that are less sensitive to outliers than least squares fitting. The input data for the model have been polynomially detrended before fitting and the log of the yield was taken, this means the models produce relative changes in yield instead of absolute ones. The polynomial detrending used in the models is a two degree polynomial solved for each grid cell. The models solve the equation shown in Eqn 1 where a, b and c are constants for each grid cell and T and P are the seasonal mean temperature and total precipitation respectively. $Y_{it} = a_i + b_i T_{it} + c_i P_{it}$

It is mentioned that "The four crop models were driven using the outputs of the four bias corrected CORDEX-Africa RCM simulations as listed in table 1. The CORDEX-Africa simulations were driven by ten GCMs as part of CMIP5" (4:19). However, there is no discussion of the uncertainty due to climate forcing from the GCMs and RCMs. It seems important to provide some quantitative measure of it and compare it to the range of results from crop models under the same forcing, which by contrast is discussed extensively. The relative global warming between the two climates considered is 0.8 K (5:8). What about the local warming in W Africa, which is much more directly relevant here? What is the corresponding local precipitation change? It might be helpful to include a figure that shows the temperature and precipitation seasonal cycle and the modeled changes for the area considered.

These two comments are linked and have therefore been responded to together. A series of tables has been added to the SI showing the mean temperature change and IAV along with the change in total seasonal precipitation and IAV. The following descriptive text has been added from 2:28. The precipitation and temperature changes for growing season of maize in the grid cells where maize is analysed in the GCMs, RCMs and GCM-RCM pairings are shown in SI Tables 1-3. The mean temperature change across the 16 member GCM-RCM ensemble is +0.98 K with a model spread of 0.3 K.

The mean precipitation change across the ensemble is +0.65 cm/season with a model spread of 1.70 cm/season. This is a 1.2% increase in precipitation with a spread of 6%.

To simulate high temperature stress resistance the GLAM is rerun with the high temperature stress routine disabled" (6:22) but this situation is biologically impossible. How would the conclusions change if only more realistic stress adaptation were considered?

This is a limitation of the model and we have clarified this in the description of the model in the main text of the manuscript.

To simulate a crop resistant to high temperature stress GLAM is rerun with the high temperature stress routine disabled, a description of high temperature stress in flowering is found in Challinor et al (2005). Disabling the high temperature stress routine produces an unphysical crop and is used to give guidance on the importance of high temperature stress.

What is the meaning of "does not suffer from spread from the input data" (7:6)? Also, within the context of this work the "successful" performance of ORCHIDEE-Crop is not very encouraging, as it was run for only one of the three crops considered.

ORCHIDEE-Crop like GLAM has only been validated for maize, therefore it is only used for maize. The wording used should be rephrased to prevent confusion and the following text has been used in place.

ORCHIDEE-Crop replicates the observed IAV and in contrast with the other process based models, GLAM and Sarra-H. The mean yields however do show a significant bias.

The yield gains predicted herein need to be considered as part of longer term trends that show severe yield reductions as the 21stst [sic] century progresses." (8:7) It would be good to provide citations.

The spelling mistake has been corrected and the following references have been added

to the the sentence.

(Challinor et al.,2014; Knox et al., 2012)

Figures 4-6: It's impossible for the variability or failure rate to be less than zero. So the color scale should start no lower than zero.

In action to comments from other reviewers, the heatmaps have been removed and replaced new figures and tables. The remaining heatmaps are shown in Fig 1.

Figure 7 is hard to understand. The caption should explain "Impact in current climate" and "Impact of adaptation", and the mean yield and number of years between crop failures should probably be shown in different panels since they are fundamentally different quantities.

Figure 7 has been rebuilt as a single boxplot with a detailed caption explaining the content. With two boxplots it was not easy to see the difference between the adaptation methods. The new plot is shown in Fig 2. With the caption below

Efficacy of adaptation methods for maize in GLAM. HTS is high temperature stress adapted crops, Rw H shows crops with rainwater harvesting, HTS and Rw H shows both adaptation methods in use. Each box shows the fractional yield change relative to the unadapted crop with the boxplots showing the range across the 6 member GCM-RCM ensemble. The pairs of boxes show the relative change in yield for the adaptation method in the historic climate (left) and the future climate (right).

Tables 3-5: Please also include and discuss the region-wide mean change (production-weighted sum of the by-country changes).

The tables have been updated and new content inserted into the results and discussion sections of the manuscript.

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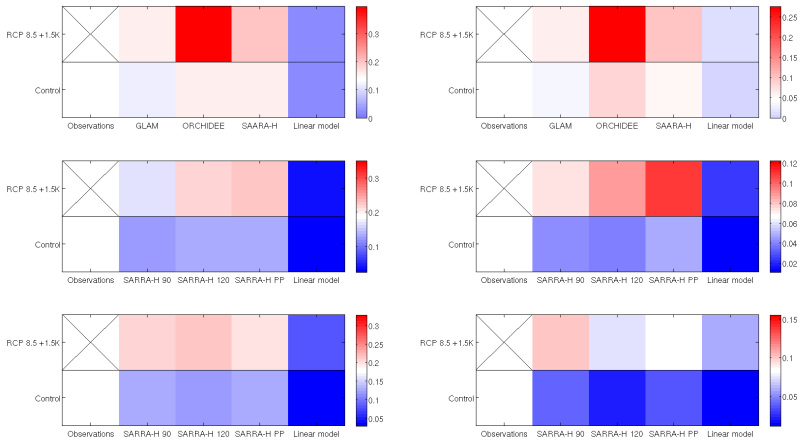
RCP 8.5 +1.5K
Control
Observations
GLAM
ORCHIDEE
SAARA-H
Linear model
SARRA-H 90
SARRA-H 120
SARRA-H PP

Fig. 1.

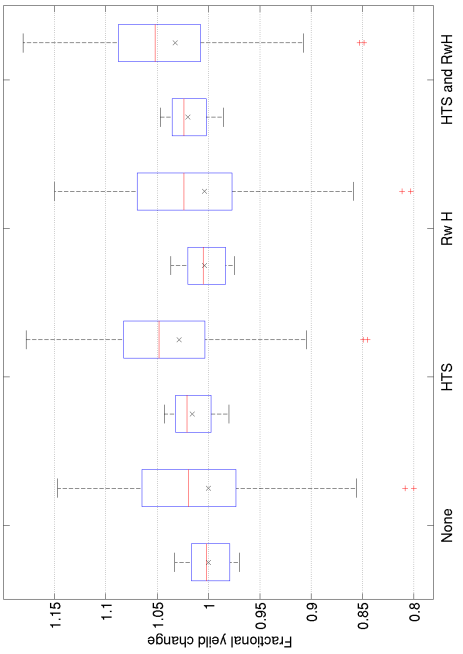
HTS and RwH
Rw H
HTS
None
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
Fractional yield change

Fig. 2.