bgd -11-C6438-2014

We would like to thank the referee for his remarks and respond to the remarks about our study, beginning with the general comments (Referee comments are presented in *italics*):

As pointed out by the authors, this approach does not provide really new results confirm the results previously found but introduced maize earliness as a key component of the analysis. In the Introduction authors pointed out sources of uncertainty in such an approach, but they do not use the model to quantify them; on the contrary the only focused on the differences in response due to genotype, without analyzing if it is the main source of variation.

We are aware that the general trend of crop growth in Germany or Central Europe is not contradicted by our approach. In this regard we would agree that no really "new" results are presented. However, our focus was to point out the different responses of the three varieties. The results clearly point towards different development paths, indicating that other study's should take these differences into account as well, as simply modeling "maize" might be an insufficient approach. As the varieties are run within the model using mostly identical variables (except for a difference in the required temperature sums), we can assume that the mentioned uncertainties can be more or less equally distributed over all three varieties.

The materials and methods does not justify the choices made in terms of time steps, scale space and sources of variability explained; the choice of climate scenario is not justified and in fact prevents comparisons to the existing literature; the growth model is selected but criticized its comparison to other potentially validated models is not made;

The choice of time steps and scale space are given by the used data, as described in the text. Spatial unit of modeling was a soil area as given by the official soil map of LS (1:50000). The time-step is annual, as there is one yield per year. Both were chosen as being the most basic considering the initial data.

We do not understand why the use of scenario A1B should prevent comparison to other studies, as it is commonly used and considered a "middle-of-road scenario". The original Wettreg climate dataset was devised in 2010 (or even earlier) by LS authorities for a variety of uses. If the referee is here referring to the use of more recent RCP scenarios we would agree that forthcoming studies might not be easily comparable. However, many studies on CC within LS are done and have been done using the A1B approach or even the same dataset (e.g. see Müller et al. 2012). Furthermore, as pointed out in the introduction, there is no agreement between most studies on which scenario should be used for similar approaches.

The choice for the crop model was made for its applicability on the amount and scale of study areas in combination with the validation of the model on sites in LS. The model developer is validating the model and it was not within the scope of this study to be a key part in this validation process, as we would then indeed have chosen a different data basis and/or modeling approach.

finally the choices of data processing were not explained too: why analyzing slopes, while trends may be nonlinear?

We did use slopes as an initial and easily comprehensible indicator for a possible trend. To emphasize the fact that there is not necessarily one linear trend throughout the entire century, we additionally

calculated linear trends at breaking points within the data (around 2030 or 2050, depending on the variety). These partial trends did indicate that while there seems to be a trend throughout the century, this may not be steady.

We even tested all time-series for non-linear fits in the time slices 2001-2099 as well as for 2001-2050, what was not mentioned in the text. We tested exponential, logarithmic, polynomial fits (2nd and 3rd order), potential and linear. It almost never made a difference if linear or other fits were used (e.g. over the century the R^2 for medium maize was 0,15 for the linear and 0,19 for a polynomial fit, thus we considered the difference neglectable).

Most importantly however, we did specifically test for trends in the data using two additional statistical tests. A rough estimation using a simple trend/noise (T/N) ratio was done, as well as a Mann-Kendall-Test which is a non-parametric test for trends. Thus we did explicitly test for non-linear trends and discussed the significance of the result.

Introduction

A long paragraph is spent to show maize production in LS is intended to biomass and energy production, without competing food crops. It can be shortened
Scenarios A1B, B1, B2 are cited: a word should be said on their respective interest and different consequences on maize crop

Maize for food and maize for feed/energy are different crops. As food maize production is neglectable in comparison in LS we did not include it in this study. We are however not sure if the referee is suggesting to go deeper into the general conflict between energy/feed crops and food crops?
The citing of different scenarios in the introduction is directly linked to other studies in the vicinity of LS which also gave estimations of future maize growth. Rough estimations/results from these studies are however given in our text.

If we did misunderstand the referee in one of these aspects we would kindly ask the editor to advise us on changes to be made within the introduction.

50.6t ha-1... unit (total fresh biomass; with what % DM); in other parts units should be given (9108; line19; wheat yields... in DM?)

These are official statistics from the Federal Statistical Office of Germany as given in the statistical yearbook. E.g. Dry Matter of maize is given at 35% (for LS we however did give the DM at 33% further below in the text). We added this information to the original introductory text.

-CC impacts from the literature are given at the end of the introduction: what is the new question addressed?

We indeed do address our question in the last paragraph of the introduction, referencing the study Southworth et al. (2000) who did test climate change impacts on different maize varieties. If this is insufficient we would kindly ask the editor to advise us on changes to be made.

Materials&Methods

2.1. Figure 1 is of no interest to the study. Instead, actual variability in maize crop cycle would help understand problems of maize in LS

We do think this is of interest, as it does not only show where the study area is located, but it gives an impression where yield changes might be of bigger importance (= those regions with a high production). We decided against showing t/ha, as those regions with potentially higher yields tend to use these excellent soils for wheat or similar high-demand crops instead of maize.

2.2. The ability of BioSTAR to account for CC should be specified ; for ex. How does it take high T° stresses or stade specific stresses into account? -the weaknesses of the model not analyzed, neither eventual bias o the results: is its prediction value enough to deal with genotype comparison?

BioStar uses mostly the same parameters for all three varieties. According to the model developer the only difference is the required temperature sum to reach a certain development stage. However, we are not the model developers. To our knowledge the implementation of more stress related processes (e.g. drought stress in critical growth phases) is aspired for future versions.

2.4. I wonder if a simpler way to address the question would be to select few contrasted climatic zones in LS

We agree, this would be a simpler approach indeed. However our initial idea was to test if small scale soil and climate interactions might exist that might be missed on a larger scale.

2.5. I do not understand the way you selected climatic variables that best explain yield variations? Interactions between variables are included?

In a first step several climatic variables have been used in a multivariate regression model. These gave results on the strength and significance of each variable relative to each other variable. The outcome can be seen in Fig.5 on the left: summer precipitation has a strong and significant influence on crop growth of all varieties. Fall temperatures have a relatively strong influence on the late variety, this is however not significant.

As this approach is prone to autocorrelation of the input variables, another run of multivariate models was conducted (right side). This time one model was run for each combination of climatic input variables at a single site (and redone for several thousand other random sites). The model (i.e. the combination of climatic variables) that did explain the outcome the best was then logged, e.g. yields of early maize throughout the century can be best explained on more than 95% of all sites by the variation of summer precipitation and CO_2 within a linear regression model alone.

3. Fig.2 is difficult to analyze, please reformat grouping seasons instead of periods

We think the figure gives a good oversight of climatic periods of 30 years for temperature and precipitation in LS. If this is not the case we would like to ask the editor to advise us if changes have to be made.

Results

4.1. how was the partitioning between periods done? Before and after 2050? What statistics helped to choose the threshold?
-are the defined slopes significantly different? Between genotypes? Between periods?
-are early, medium or late genotypes better adapted to some sites in LS? Now or in the future?

Model runs are time costly thus we limited our study to two runs: one spanning the entire century and one spanning until 2050. The first was our main question (development throughout the century). The second was chosen to give an idea when a change will happen. If a trend until 2099 is detected, but none until 2050, this hints strongly to a change in the second half of the century.
If the yield developments are represented as two linear trends in the century, one can find that these two trends are strongest when a break is made around 2030 or 2050. As 2050 seems to be relevant to all three varieties at least to some degree, but 2030 not, we decided to use this.

Significance was only determined for noise/trend ratios and the Mann-Kendall-Test. R^2 values are different for each variety and period. This is however mentioned in the article.

Also mentioned is that late varieties are not well adapted to the climate of LS, as the temperature sums are not sufficient today for full growth until maturity. Medium and early variety are equally well adapted. The future development can be seen in Fig.4, indicating that preferable sites will shift.

We would also like to emphasize again on the fact that we did not use single “genotypes” but groups that represent early, medium or late maize varieties.

4.2. If maps are nice to look at, the inter annual variability lacks, even though it is given in the text; perhaps is it the most important thing to a grower.

We addressed the issue of inter-annual variability. However it is not feasible to make maps for each year. We did intend to use Fig.3 as an optically clearer and more accessible way to interpret the yield variability between the years, so that a reader does not have to rely on the text passages about variability alone. We also agree that to a grower this is an important factor. However we did not think any more graphical representation would be necessary.

4.3. Please give the regression you selected rather than Fig 5; in particular, I did not understand at all the right part of the figure. Why not correlate directly a climatic water balance to test your assumption of dry summer importance in future yields?

If we would have only used a regression between yields and water balance, the question would have come up why we did not test for other variables. Then we would have to make a single regression with all/certain other variables.

In fact what we did was to use the multivariate regression so that all variables are tested and we would not have to make a regression of each. Using this approach we also avoided using a priori assumptions about the influence of the climatic variables. As we also tested the data only for the first half of the century, we could further test if there are climatic variables that gain or lose in importance over the course of the century.

Finally, at the end of the paper, we wonder if such a fine spatialized modeling work was necessary to give main trends.

We would like to mention again that our main focus was to determine potentially different development paths and regions for different maize varieties in the future. Though a mere general trend might also be derived from our results, this could have been done on a coarser scale. We could however show that regional differences exist, that the varieties can behave differently at different sites and that the choice of variety will play a crucial role in the future.