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Interactive comment on "A multi-model analysis of teleconnected crop yield variability in a range of cropping systems" *by* Matias Heino et al.

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We thank the editor and the reviewer for their careful evaluation of our manuscript and their constructive comments that helped us to improve the manuscript considerably. We have taken all the comments carefully into consideration when revising the paper. Please find our detailed responses to the review comments below. The main revisions include: 1) Assessing the sensitivity of crop yields to these oscillations by using a multivariate ridge regression framework, which controls for the co-variability of the oscillations; 2) Including an assessment about growing season weather teleconnections, and reflecting on how they relate to our main results; 3) Re-defining the allocation of annual growing seasons, so that the understanding of the teleconnections is better reflected in the analyses.

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Responses to comments made by the editor:

R2.1.: This manuscript describes a regression analysis that seeks to identify the global spatial response of modeled crop yields to global teleconnection pattern index variations. The ability of the authors' analysis to quantify the role of irrigation in damping the oscillations of crop yield due to climate variability seems potentially important.

A2.1.: Firstly, we want to thank the editor for the overall positive view of our study. We agree with the editor that the data used in this study provides important insights into the role of irrigation in damping climate impacts on crop productivity.

R2.2.: However, the results show some surprisingly strong responses in areas far afield from the action centers of some of the teleconnection patterns. For example, a strong response in the yield of maize to the Indian Ocean Dipole is observed along the US-Canadian border, while a strong response in the yield of maize and soybeans to the North America Oscillation is observed in Southeastern Australia. These are surprising, since I can't find any evidence of a significant relationship between the IOD and sensible weather in North America, or between the NAO and sensible weather in Australia in global maps of these teleconnection patterns. It seems likely that these results are spurious, an accidental result of the large number of regions being modeled.

A2.2.: The editor is correct that due to the large number of areas being modelled, some false positives for our statistical tests are expected. However, we don't make any conclusions or recommendations based on our analysis alone, but reflect on how our results relate to the current knowledge before drawing conclusions.

Also, in addition to analyzing how crop yields vary with these oscillations, we have now included analyses about the sensitivity (using multivariate ridge regression) of temperature and soil moisture anomalies to these oscillations (Figure S2-S3). Based on these results, there seems to be a statistical relationship between IOD and weather in North America (see also Fig. 21 in Saji and Yamagata 2003) as well as between NAO and temperature conditions in Australia.

R2.3.: Before recommending this work for publication in Earth System Dynamics, I would like to see the a deeper exploration of the reliability of the relationships displayed. For example, it would be good see some scatterplots of the index values versus more directly relevant meteorological factors in each region (growing season length or precipitation) and of these factors versus yield, as well as between yield and index values, to get a sense of the predictive power of the relationships.

A2.3.: We agree with the editor that it is important to analyse the reliability of our results, and therefore already in the original submission, we included a relatively thorough analysis about the uncertainty of our results related to the gridded crop model ensemble used here (especially Figure 3).

As described above, we have now included an assessment about how soil moisture and temperature variability is related to these oscillations. Further, as the analysis includes over 500 spatial units, instead of providing scatter plots about the relationships, we provide the R2 values for the regression results (Figure S13), which show that e.g. in Australia a substantial proportion of crop yield variability can be explained with the oscillations studied here. More extensive exploration of relationships with directly relevant meteorological factors is out of scope, as it risks giving the reader the impression that we understand the mechanisms involved better than we actually do.

R2.4.: Some other simple statistical tests would also be helpful. It would be good to see the whether the patterns of response of yield to teleconnection pattern presented in figures 1 and 2 are consistent when the timeseries are split into two parts (first half and second half).

A2.4.: We want to thank the editor for the suggestion. However, the statistical significance of the sensitivity values is already assessed by bootstrapping, which means that, for each spatial unit, we have calculated the regression for 1000 sub-samples of the crop yield data (explained in Page 7, Lines 20-22). This is a more thorough alternative to split-sample testing, and we therefore expect to find statistically significant sensitivity

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values in the same areas even if the time series is split in half.

R2.5.: Finally, the authors should discuss at greater length the relative predictability of the various teleconnection patterns and how that convolves with level of uncertainty in the unlagged annual relationships presented here. If the NAO can only be predicted a few months in advance, what remaining skill is available for forecasting of the NAO's associated crop yield variability in advance of the harvest? It's one thing to note that if a strong NAO will be present, crop yields in some parts of the world will be a few percent above normal, but how much knowledge of crop yield anomalies is left if we only know that there's a 20% higher than normal chance of a strong NAO index averaged over next growing season?

A2.5.: We fully agree that there is a long way to go before reliable forecasting is possible. This study only provides background knowledge on the (possible) existence of relationships. We have added a paragraph discussing the usefulness and limitations of our results in mitigating climate impacts on crop yields and society. In the paragraph we e.g. state that: "In Australia, there is significant potential to utilize the information of IOD along with ENSO, to understand crop yield fluctuations, as they can explain a large proportion of local crop yield variability (Fig. S13, Yuan and Yamagata 2015). – However, the quality of predictions of this type would naturally depend on the skill of the climate forecasts as well as the strength of the teleconnection. This study only provides a first assessment of correlations, and further work is needed before reliable forecasts can be provided. "(page 16, Lines 10-16).

References:

Saji, N. H. and Yamagata, T.: Possible impacts of Indian Ocean dipole mode events on global climate, Climate Research, 25, 151-169, 2003.

Yuan, C. and Yamagata, T.: Impacts of IOD, ENSO and ENSO Modoki on the Australian winter wheat yields in recent decades, Scientific reports, 5, 2015.

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