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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Drought risk in the Bolivian Altiplano associated with El Niño Southern Oscillation using satellite imagery data" *by* Claudia Canedo-Rosso et al.

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We want to thank the reviewer for his continued support, detailed comments, and valuable recommendations. Each suggestions was discussed in detail and we have rewritten the paper accordingly. We have also improved the clarity and correctness of phrasing throughout our manuscript. Please find our detailed responses to the reviewer comments below.

GENERAL COMMENT

The paper is focused in the study of drought risk generated by climatic variables during

ENSO occurrences and it is oriented to agricultural issues and related impacts on Bolivian Andes. For the last, the authors used potato and quinoa crop measurement data, to be related with temperature and precipitation information on ENSO composite periods. Additionally, the document assessed the detection of specific drought hotspot areas in base the NDVI vegetation index. Crops were related with NDVI variability, and the last was linked with climate variables as precipitation and accumulated degree day data. In general, the document is oriented to impacts on agriculture generate by droughts during strong El Niño events.

MAIN COMMENTS

- The authors didn't clarify their risk definition, for example, in front to an extreme drought even during any kind of warm ENSO phase, the risk can be very low or cero if the direct affected population has very low vulnerability. Then, the mention of risk implies knowledge about the conception of risk, vulnerability and hazardous events (i.e., the danger amount), which are not well described in the current document.

Response: The reviewed manuscript focuses on drought impact in the Bolivian Altiplano agriculture associated with El Niño Southern Oscillation using satellite imagery data. The aim is to provide information to support disaster risk management using satellite imagery. It is tested/compared to empirical observations so that it can be used for risk reduction of crop production losses. We focus on the severity of drought events. The severity drought is described in the manuscript (please see the results section, Tables 4 and 5, and appendix Fig. A1-A3).

- Lack of good bibliography review.

Response: Previous related studies were reviewed in more detail and relevant information is included in the manuscript, please see reference section.

- P1 section 1. The general idea is the impacts of ENSO in agriculture and food security, but there is not so much to risk

Response: As mentioned above, considering that the manuscript focuses on drought impact on agriculture associated with ENSO. The manuscript title and content now describe more accurately the study approach.

- P3 L4. The title is covering a lot of issues. Risk is not only studied on agricultural context. My suggestion is to change the title to something like “Agricultural drought impacts during the ENSO over the Bolivian Altiplano”.

Response: Thank you for the suggestion.The title was modified to “Drought impact in the Bolivian Altiplano agriculture associated with El Niño Southern Oscillation using satellite imagery data”

- P3 L23. CHIRPS is a good dataset for precipitation information, since it is a mixed observation product (satellite products, station data, etc.), but here is necessary to indicate the problems using it over Andes or over South America. Several papers are pointing out that the CHIRPS across the Andes overestimate/underestimate in lower/higher values, respectively.

Paredes-Trejo et al. 2016. Intercomparison of improved satellite rainfall estimation with CHIRPS gridded product and rain gauge data over Venezuela. https://doi.org/10.20937/ATM.2016.29.04.04

Paredes-Trejo et al. 2017. Validating CHIRPS-based satellite precipitation estimates in Northeast Brazil. https://doi.org/10.1016/j.jaridenv.2016.12.009

Rivera et al. 2018. Validation of CHIRPS precipitation dataset along the Central Andes of Argentina. https://doi.org/10.1016/j.atmosres.2018.06.023

Response: Thank you for the references. They were very helpful. The manuscript now indicates the uncertainties of using satellite-based precipitation data, and the recommended references are included in the results section.

- P4 L3. The LST-NDVI association is usually used for drought monitoring, then why didn’t the authors explain nothing about it in the introduction and/or in the section 2.1?

Karnieli et al., 2010. Use of NDVI and Land Surface Temperature for Drought Assessment: Merits and Limitations. https://doi.org/10.1175/2009JCLI2900.1

Response: The manuscript now includes more information about NDVI and LST as relevant drought indicators. Moreover, the classification of drought using NDVI and LST is now included in detail as well (see sections 2.3 and 3).

- P5 L5. Since the raw data have cyclicity/periodicity parts, then the 0.7 Spearman correlation should represent a very low association or linearity. Before to start the comparison, it is necessary that the authors remove the cyclicity/periodicity parts from the assessed information.

Response: To avoid errors from periodicity, the accuracy measures of the satellite-based data products of precipitation and air temperature were defined for each month of the time series (see sections 2.3 and 3).

- P6 L10. The LST definition is different that the gauged air temperature from weather stations. LST is defined by Stephan-Boltzmann law, and on the other hand, the air temperature is defined by climate patterns and process. Moreover, as before indicated, the LST-NDVI relationship is a good method for monitoring drought, more than air temperature – NDVI. The authors should work with the LST but need to improve the correction procedure with some in ground LST measurements or other alternative way.

Response: The database used previously was “a global monthly land surface air temperature” from the Global Historical Climatology Network and the Climate Anomaly Monitoring System (GHCN and CAMS) defined by Fan and van den Dool (2008). For the modified manuscript, we used the monthly air temperature dataset from University of Delaware developed by Willmott and Matsuura (see http://climate.geog.udel.edu/∼climate/html_pages/README.ghcn_ts2.html). Now, the air temperature database is properly named along the manuscript.

- P7 L8. The crop yield vs NDVI is given values on 0.6 Spearman correlation, and it is

yielding a little ambiguous result, the authors should bring information like, for example, how much is the explained variance of this relationship? i.e., How much does the NDVI explain the yield?

Response: The reviewed manuscript does not include the association of crop yield and NDVI as a technique to discard NDVI grids. In contrast, we now assume that NDVI generally simulates properly the crop production. This is because the elimination of NDVI grids from the agricultural land could ignore relevant information. As well, we want to avoid some uncertainties originated from the crop yield dataset. For instance, the crop yield data do not take in consideration the crop rotation that are represented by different crops in the same area across sequenced growing seasons. We include the limitations as well as advantages using this approach in the discussion section and also provide some ways forward in that regard.

- P7 section 2.4. Was only a set of 2 predictors that were assessed in the regression analysis? if not, which are the other discarded predictors in the regression analysis? more than see the statistical results, the Authors should explain the physical reasons why the others preselected predictors were considered as potential predictors and why they were discarded.

Response: This text is now included in the manuscript: “For the study, we assumed that NDVI simulates the stages of the crop phenological stages that is from September to April (Fig. 1). Precipitation was selected as predictor for its relevance on water availability for vegetation growth. Precipitation is the main source of water in the Altiplano because only 9 percent of the Bolivian cropped surface area is irrigated (INE, 2015). Air temperature is a relevant variable due to its involvement on photosynthetic and respiration processes (Karnieli et al., 2010).” We also discussed the results now in more detail.

- P9 section 3. The data analysis should be done after to remove the cyclicity/periodicity of the data, to be comparable between them.

Response: To avoid errors originated from cyclicity/periodicity, now the analysis is developed for each month for the accuracy measures of satellite/based data products and the classification of drought. The stepwise regression between NDVI and climate variables were developed using a standardized 3-month time series. “Previous to the stepwise regression analysis, the 3-month time series of NDVI, satellite precipitation and satellite air temperature were standardized”.

- P10 L7. This could be moved to conclusion section.

Response: The text was modified (see sections 3 and 4).

- P10 L8. “all dataset had acceptable bias” this affirmation is something subjective since the bias can be between 15% to 35%, then it is far to be considered as an acceptable bias. More than the references indicated for the authors (those can show values acceptable in other context), Can the authors show any way or calculation to corroborate that that range of bias is “acceptable”? Another option, in my point of view, is removed this assumption.

Response: Now the text includes: “Summarizing these observations we conclude that CHIRPS-rainfall dataset is an adequate alternative in case of lack of gauged data or in case of poor data quality. However, it should be noted that such data still must be used with caution considering the uncertainties due to the under or overestimation of precipitation along the heterogeneous topography of the Altiplano (see Paredes-Trejo et al., 2016; Paredes-Trejo et al., 2017; Rivera et al., 2018).”

And:

“In conclusion, the satellite air temperature data product perform adequately from November to April. Similar to the precipitation data, the application of satellite air temperature data must take into account the potential errors due to the estimation uncertainties, mainly during winter season”.

- P11 L27. Again, the LST temperature has a different physical definition than air

temperature. Moreover, the LST- ENSO relationship is given as the ENSO alters the air temperature patterns globally, and that air temperature influences vegetation and agricultural productivity (Glennie and Anyamba, 2018), then on ground level, additionally that air temperature, the vegetation cover, albedo, and soil properties (and others) are affecting the ground temperature generated by emitted radiation on the ground. This means that the ENSO-LST and ENSO- air temperature teleconnections have different mechanisms, then the correction of LST with air temperature has not sense since we expect to assess the crop yields. Hence, the suggestion that the LST underestimation could be due to elevation and/or cloud cover is not correct too. Glennie and Anyamba, 2018. Midwest agriculture and ENSO: A comparison of AVHRR NDVI3g data and crop yields in the United States Corn Belt from 1982 to 2014. https://doi.org/10.1016/j.jag.2017.12.011

Response: As mentioned above the database used in the analysis was air temperature, however it was misnamed, now it is properly named along the text. Moreover, now we employed another air temperature data base that is the monthly air temperature dataset from University of Delaware developed by Willmott and Matsuura (http://climate.geog.udel.edu/∼climate/html_pages/README.ghcn_ts2.html).

- P12 L25-L26. This phrase is ambiguous. Something that the authors can do is to calculate the explained variance per each predictor, and it associates with location coordinates.

Response: This text was removed, and now the results show the findings using the spatial coordinates (see Fig. 5).

- P13 L5-L6. Although the lag values are expected to be between 3 or 4 months, the lag differences between precipitation and vegetation per location can be explained on base to local landscape elements (e.g., Yarleque et al. 2016). Yarleque, C., M. Vuille, D. R. Hardy, A. Posadas, and R. Quiroz (2016), Multiscale assessment of spatial precipitation variability over complex mountain terrain using a high-resolution spatiotem-

poral wavelet reconstruction method, J. Geophys. Res. Atmos., 121, 12,198–12,216, doi:10.1002/2016JD025647.

Response: Thank you for the useful reference, it is now included in the results section of the manuscript.

- P13 L11-L12. “The hours of sun required for crop development could be the explanation for these results” It is true in part, see me previous comment. On this Andes region is necessary consider aquifer or ground water level changes (i.e., moisture on ground level) from Mountainous regions to flatter/lower elevation areas.

Response: The manuscript now mentions the findings of Yarleque et al. (2016).

- P14 L4. Here was linked a generated index with sea surface temperature anomalies against the crop yield signal with anomalies+ periodicity/cyclicity?. If this is the case, then I expect that the results bring a kind of non-physical statistical information.

Response: Now the analysis includes the classification of drought using NDVI and LST. The drought events were analyzed and compared with ENSO phases. The classification of drought was developed for each month to avoid errors from periodicity.

- Figure 5. In this figure is given boxplots with only the 1982-1983 strong El Niño case as outlier, the rest of cases for quinoa and potato are given a non-statistical difference with other years, since the rest of cases are intercepting the range of the boxplots, i.e., between the maximum and minimum possible values, contradicting the conclusions of the authors.

Response: This figure is no longer in the manuscript. More information to avoid confusion in regards to results found was included.

- P16 L1. How is the “magnitude of assistance” calculated/estimated?

Response: This sentence was modified to “Our approach can enable a pro-active approach to disaster risk management against droughts.”

DETAILED COMMENTS

- P6 L7. Four or three? P6 L7. “but not the satellite not and” changes to “but not the satellite and”. P8 L5. “potato was 4âŮęC and 3âŮęC for quinoa” changes to “potato and quinoa were 4âŮęC and 3âŮęC, respectively” P8 L10. What’s “5 percent level” exactly mean? P9 L7. “with” changes to “during”. P9 L11. Add “strong” before that “El Niño” P9 L12. Add “strong” before that “El Niño”. P12 L7. Remove “is”. P12 L11. “. And” Changes to “, and”. P14 L7. “warm” changes to “strong”. P15 L2. Add “strong” before that “El Niño”. P15 L9. Add “strong” before that “El Niño”. P15 L20. Remove “is”.

Response: All the detailed comments from page 6 to page 15 were modified following the referee suggestions.

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