

# ***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 authors integrate remote sensing products (Normalized Difference Vegetation Index, land surface temperature, and precipitation), meteorological observations (nearsurface air temperature and precipitation), and crop yield data to

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assess the impacts of ENSO on quinoa and potato yield in the Bolivian Altiplano. The purpose of the study is to develop a statistical framework that can be employed to reduce drought impacts on agricultural production in a region where surface data are scarce. The study shows that the remote sensing products listed above are sufficiently accurate when compared against ground observations, and that the positive ENSO phase significantly decreases crop yields. The framework is then employed to identify hotspots that are most vulnerable to droughts. The MS presents a relevant contribution to drought-related risk assessments in a region that is poorly studied. My main concern is related to the bias correction of land surface temperature, as explained in the main comments below. Also, the presentation of the methods section requires some attention. I recommend considering the MS for publication in NHESD after major revision.

#### Main comments

- The authors assume that land surface temperature (LST) and near-surface air temperature should be equal. This is a misconception as both variables present different processes. LST directly follows from the Stefan-Boltzmann law and therefore depends on outgoing long wave radiation and surface emissivity. Nearsurface air temperature, on the other hand, is affected by other processes, such as turbulent heat fluxes. The authors use near-surface air temperature measurements to "bias correct" remotely-sensed LST using an approach by Zhou and Wang (2016). This does not make much sense, as LST and near-surface air temperature should differ. Furthermore, the cited study by Zhou and Wang (2016) actually uses ground measurements of LST rather than near-surface air temperature to bias correct remotely-sensed LST. I propose three alternative approaches to address this issue: the authors could (i) rerun their analysis using LST directly, (ii) find an approach how to spatially interpolate near-surface air temperature, or (iii) use an already existing air temperature data set that has been published elsewhere (e.g. data from the climate research unit).

Response: The database used previously in our manuscript was "global monthly

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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). In the revised version we now 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](http://climate.geog.udel.edu/~climate/html_pages/README.ghcn_ts2.html)). Furthermore, the air temperature database is now properly named along the manuscript.

- I suggest that the authors improve the presentation of the methods section by including the equations employed in their statistical framework (e.g. the NashSutcliffe efficiency (E) coefficient, POD, and FAR).

Response: The equations used for the statistical analysis were now included in the methods section and explicitly referred to throughout the manuscript.

Detailed comments

- P01L14 Please spell out ENSO before using the acronym.

Response: The El Niño Southern Oscillation (ENSO) is now spelled out at the first time that it is mentioned in the manuscript.

- P01L17 You write that "droughts can be better predicted using a combination of satellite imagery and ground-based available data". Better than ground-based available data alone? Please be explicit.

Response: The new version of the manuscript mentions: “The results show that droughts can be monitored using satellite imagery data when ground data are scarce or of poor data quality”.

- P01L18 You write that "satellite climate data were associated with" NDVI. This is a very vague formulation to outline your approach. Please be more precise

Response: The manuscript was modified and the new text includes: “...we tested the performance of satellite imagery products for providing vegetation, land surface

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temperature (LST), precipitation and air temperature data. With this information, we assessed drought impact on agriculture by associating vegetation with precipitation and air temperature”.

- P01L19 You started out your abstract on the topic of drought and are now jumping to "the crop production variability". Please find a more elegant way to include the topic of crop production variability. I would include this above when you describe the research problem.

Response: Now two main modifications were included in the manuscript to avoid confusion. Firstly, the title was modified to: “Drought impact in the Bolivian Altiplano agriculture associated with El Niño Southern Oscillation using satellite imagery data.” This includes agriculture as one of the focal points of our study. Secondly, in the abstract the following text was now included to be more specific about our contribution: “Drought is a major natural hazard in the Bolivian Altiplano that causes large agricultural losses, especially during a positive El Niño-Southern Oscillation (ENSO) phase. However, empirical data for drought assessment purposes in this area are scarce, spatially uneven distributed. Due to these limitations we tested the performance of satellite imagery products for providing vegetation, land surface temperature (LST), precipitation and air temperature data on a local level. With this information, the Normalized Difference Vegetation Index (NDVI) and LST were used to classify drought events, and associated with past ENSO phases. It was found that the most severe drought events generally occur during positive ENSO phase (El Niño years). We found a decrease in vegetation is mainly driven by low precipitation and high temperature rates, and we identify areas where losses will be most pronounced under such conditions. The results show that droughts can be monitored using satellite imagery data when ground data are scarce or of poor data quality. The results can be especially beneficial for emergency response operations and for enabling a pro-active approach to disaster risk management against droughts.”

- P01L19 You are jumping back and forth between methods and results. I think you

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could improve the readability of your abstract when you first outline your approach and then the results

Response: The abstract was modified, please see our response above.

- P01L21 I would replace "indicate" with "identify".

Response: Identify is now used instead.

- P02L02 I would include a reference here, e.g. UNDP, 2011: Tras las huellas del cambio climatico en Bolivia: Estado del arte del conocimiento sobre adaptacion al cambio climatico agua y seguridad alimentaria. United Nations Development Program - Bolivia, 144 pp

Response: The references UNDP, 2011; Garcia and Alavi, 2018 were now included in the text.

- P03L14 You could include a reference for SAMS here, e.g. Zhou, J., and K. M. Lau, 1998: Does a monsoon climate exist over South America? J. Climate, 11, 1020- 1040.

Response: The references Garreaud et al., 2003; Zhou and Lau, 1998 were included.

- P03L19 Please explain more clearly how exactly the gap filling was done.

Response: Data gaps were no longer filled, only in-situ precipitation and temperature data sets with less than 10% of missing data were considered for the analysis. This analysis was carried out relating the in-situ data with the satellite-based data of precipitation and temperature for pair-wise time series. This is mentioned in the section 2.2 Validation of satellite-based data products. We included more information to avoid confusion.

- P03L25 You mention the resolution three times. Please avoid redundancy

Response: Now, the resolution is mentioned only once.

- P04L14 Reformulate. I suggest you write "An E equal to 1 corresponds ..."

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Response: E is no longer used as a statistical measurement as other measures as suggested are now introduced.

- P04L08 I suggest you provide the equations for the Nash-Sutcliffe efficiency (E) coefficient, POD, and FAR

Response: All the equations used for the statistical accuracy measures were included in the revised manuscript. Please see Table 1.

- P06L10 This paragraph suggests that land surface temperature (LST) and near-surface air temperature should be equal. Please refer to my general comment above to address this misconception.

Response: Air temperature, no LST, was used as a predictor. However, it was wrongly named. Now, we have re-written the text and it is properly named in the manuscript (see also response to the main comments).

- P06L28 Delete "and the" or restructure sentence.

Response: "and the data set spans" was deleted from the text.

- P07L16 This sentence is vague. Do you mean NDVI grid cells? Also, NDVI does not "simulate" crop yield. Please rephrase.

Response: This sentence was removed.

- P07L20 Please define accumulated degree days.

Response: ADD is no longer used as a predictor, and the analysis now includes the 3-month time series of air temperature during the growing season instead. We explain the reasoning for that in more detail in the text.

- P07L22 Better than what?

Response: The text was modified to: "For this, only the NDVI grids at the agricultural land were selected".

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- P07L26 Spell out and define GDD here.

Response: GDD is no longer used in the analysis.

- P11L28 Please refer to my general comment above.

Response: Please see the main comment response.

- P11L30 Typo, replace  $p = 001$  with  $p = 0.01$ .

Response: The typo was corrected.

- P12L03 Please refer to my general comment above.

Response: Please see the main comment response.

- P15L18 I would move any discussion on insurance policy and drought mitigation to the discussion section.

Response: This information was moved to discussion section.

- P16L15 Avoid vague formulations such as "There are numerous cases in many countries". Also, it is not accurate to say that the impacts of ENSO are particularly strong in the mid-latitudes.

Response: This sentence was removed.

- Figure 01 please specify the percentiles, min, max, and outliers of the boxplots in the Figure caption. The same comment applies to Figure 5.

Response: Now included, e.g. lower and upper boundaries 25th (Q1) and 75th (Q3) percentiles, respectively, line inside box is median, lower and upper error lines 1.5 times the interquartile range (Q3 - Q1) from the top or bottom of the box, white circles data falling outside 1.5 times the interquartile range.

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Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., <https://doi.org/10.5194/nhess-2018-403>, 2019.

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