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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Probabilistic modelling of the dependence between rainfed crops and drought hazard" *by* Andreia F. S. Ribeiro et al.

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We would like to thank the Referee#2 for his/her careful review and constructive feedback. We truly believe that the changes suggested by Referee #2 will enhance the quality of the manuscript. Author's responses follow below identified as AR next to the Referee#2 comments.

Referee#2- General comments: The topic of this study is highly relevant, as the Mediterranean area is in need of strategies to cope with weather-related risks, especially drought. The effort to characterize the drought –crop yield losses are therefore valuable. However, in my view, there is a major issue in this manuscript that should be addressed before publication. This is the lack of generalized conclusions. Analyses

are sound but the time and spatial extent and resolution of the data make difficult to extract general conclusions (I agree with Referee 1 on this issue). Even though, the paper would improve a lot if the authors focus on the findings to characterize risk related to drought on these Mediterranean conditions. Findings should be clearly formulated here in a way that the reader can understand what id the added value of the results, beyond the descriptive analysis of the plots at these specific areas.

AR: Thank you for the valuable general comments, in agreement with the two final specific comments. In order to improve the focus in the main findings we propose to follow the suggestion of the Referee #2 of addressing results, discussion and conclusion separately. Moreover, in agreement with Referee #1 and #2 we agree that the spatial and temporal resolutions are not clearly explained in the text and we propose to improve the writing in a revised version.

Referee#2- Specific comments: Abstract: the statement "the estimated conditional probabilities suggest that the likelihood of crop-loss under dry conditions is higher than under non-drought conditions" is pretty obvious for Mediterranean conditions and should not be selected as a main result of the study in the abstract. Please, reformulate to stress the added value of the findings.

AR: We agree to rephrase the main findings of the study focusing on the drought risk levels of wheat and barley. Particularly, the above referred abstract lines 18 and 19 in page 1 may be modified to: "Moreover, the estimated conditional probabilities suggest that the risk of wheat-loss and barley-loss increases 32.53%-32.6% and 31.63%-55.55%, respectively, when drought conditions are below the mild or moderate drought thresholds."

Referee#2: - Pag. 2 line 3 - This is not recent, It has been like this for decades now, as it is main concern in Mediterranean systems

AR: We agree and suggest rephrasing to "From both researcher's and stakeholder's perspective, the management of agricultural drought risk has been a challenging task for decades, mainly in regions dominated high precipitation variability and recurrent dry and warm episodes, such as the Mediterranean region and in particular the Iberian Peninsula (IP) (Martin-Vide and Lopez-Bustins, 2006; Sousa et al., 2011; Vicente-Serrano et al., 2014)."

Referee#2: - Pag. 3 line 6- Referred to which period?

AR: We believe that the Referee refers to Pag. 2 line 6. The significant negative trends are related to the period 1901–2012 in Páscoa et al. (2017a) and to 1901-2000 in Sousa et al. (2011). In order to be clearer, we propose rephrasing to: "Recent works have found significant negative trends of drought indexes in the IP based on long-term time-series including the entire 20th century, particularly in southern regions (Páscoa et al., 2017a; Sousa et al., 2011), and the expected declining of crop yields due to future warming conditions is being pointed out (Ferrise et al., 2011; Hernández-Barrera and Rodríguez-Puebla, 2017)."

Referee#2: - Pag. 2 lines 14-15 - Given that there are many studies using this methodology at the global scale, I would specify here the issues and flaws, but also the advantages, detected by the authors to enrich the discussion.

AR: Thank you for the kind suggestion. We propose rephrasing to the following in a revised version: "On the other hand, dynamical crop models describing the biological processes are one of the existing tools used to assess crop productivity, e.g. CERES (Crop Environment REsource Synthesis) models (Capa-Morocho et al., 2016; Hlavinka et al., 2010) and AquaCrop (Paredes et al., 2016; Vergni et al., 2015). These crop models are important tools in agrometeorological studies being able to compute irrigation requirements and yield simulations, and have been particularly useful for assessing the impacts of climate change on agricultural productions (Hlavinka et al., 2010). However, such models are limited in their ability to quantify the impact of climate variability on crop yields over larger scales (Estes et al., 2013) and the detailed representation of crop's biophysical interactions requires demanding parameterization settings and input data (Paredes et al. 2014; Giménez et al. 2016; Paredes et al. 2016). Thus, empirical modelling constitutes an alternative to represent the large-scale impacts of drought conditions in the agricultural sector (Vicente-Serrano et al. 2006; Matsumura et al. 2015; Kogan et al. 2015a) requiring lower computation costs than mechanistic modelling (Ferrise et al. 2011; Estes et al. 2013)."

Referee#2: - Pag. 4 line 6 - Somewhere in the paper the low resolution (0.5) of these data and its implications for analysis accuracy should be discussed and handled. Actually, the resolution used is not clear, as in line 19 4 km is mentioned. Please clarify.

AR: The resolution of the gridded datasets of SPEI and remote sensing indices is 0.5° and 4km, respectively. Spatial averages were computed for each provincial cluster, as a result of the exposure analysis performed to ensure that we are addressing the cereals response in the regions dominated by rainfed conditions, which are more vulnerable to droughts (Ribeiro et al., 2018). We agree that the spatial resolution is not clearly explained in the text, as also suggested by the Referee#1. Moreover, Referee#1 also suggested to shorten the data section, hence we repeat below the changes suggested to Referee#1 to rewrite from page 4 line 3 to 27 to the following: "Drought conditions were investigated using two types of indices: the hydro-meteorological drought indicator SPEI and the satellite-based Vegetation Condition Index (VCI) (Kogan 1990), the Temperature Condition Index (TCI) (Kogan 1995) and the Vegetation Health Index (VHI) (Kogan 1995). The monthly drought index SPEI gridded values, with spatial resolution of 0.5°, were computed based on precipitation and temperature values from the Climate Research Unit (CRU TS3.21), using a variety of time scales (1 to 12 months). The weekly global maps of VCI, TCI, and VHI were retrieved at 4km spatial resolution from NOAA's ftp server (ftp://ftp.star.nesdis.noaa.gov/pub/corp/scsb/wguo/data/VHP_4km/geo_TIFF/). While SPEI computation uses climatic water balance anomalies incorporating the role played by the evaporative demand on the occurrence of dry events (Vicente-Serrano et al., 2010), the remote sensing indices characterize the moisture, through the VCI, the temperature induced stress through the TCI and health of vegetation, through the VCI." Page 4 line 15 the sentence "Further spatial averages were computed for each cluster of provinces." and rephrase in Page 4 line 28 "The spatial averages of VCI, TCI, VHI and SPEI were computed for each provincial cluster and used for further modelling of the joint probability between the drought hazard and cereal yield anomalies."

Referee#2: Pag. 4, line 13 – With data from which data source? Please justify with Penman-FAO, in principle more accurate methods, is not used.

AR: The data source used to compute the reference evapotranspiration was obtained from the Climate Research Unit TS3.21 database, which includes monthly values of several climate variables on a global and high-resolution grid (0.5 $\times$ 0.5 degrees). Although the Penman-Monteith equation is considered the most robust method for the estimation of the reference evapotranspiration, this method needs a large number of variables, which are not always available. Among the methods that require fewer variables, Beguería et al. (2014) and Vicente-Serrano et al. (2014) recommend the use of the Hargreaves equation in our study area, instead of the Thornthwaite equation. Moreover, this database has been previously used by the authors (Páscoa et al., 2017a) which have also performed a comparison of the reference evapotranspiration using the three above-mentioned methods and the Hargreaves equation have shown a better correlation with the Penman-Monteith than the Thornthwaite method. For these reasons and considering the available data, the Hargreaves method was used in the present work to estimate the reference evapotranspiration.

Referee#2: -Pag. 4 line 29- More details should be provided on these models. This paper should be understandable without reading Ribeiro et al. (2018).

AR: Thank you for your comment, we propose to improve the writing in a revised version to the following: Remove from Page 4 line 15 the sentence "Further spatial averages were computed for each cluster of provinces." Rephrase in Page 4 line 28 -32 and page 5 line 1-2: "Considering the vegetative cycle of wheat and barley, and in accordance

with the results obtained by Ribeiro et al. (2018), the data of VCI, TCI, and VHI used in this work covered the period from week 35 (early September) to week 25 (late June), and data of SPEI covered January to June. The time-scales of SPEI chosen were 1 to 12 months. Spatial averages of all these indicators were computed for each provincial cluster and used for further modelling of the joint probability between the drought hazard and cereal yield anomalies. Stepwise regression models (95% confidence level) were established to select the time scales and months of SPEI, together with the weeks of VCI, TCI, and VHI better related with wheat and barley annual yield (Ribeiro et al. 2018). The selection of the most relevant drought indicator for each cereal and cluster was performed based on the largest absolute value of the standardized regression coefficients, in order to constitute pairs of cereal yield anomalies and drought indicators. Afterwards, for each cereal time series, the joint probability of yield anomalies and the selected drought indicator was estimated."

Referee#2: - Pag. 5 lines 2-6- This information is maybe more appropriate for the introduction. The rest of the section until 2.2 is not clear if it is meant as a summary of the data from Ribeiro et al. (2018) or it is new material with a preliminary analysis id data; if this is the case they should be in the result section.

AR: We agree that this information fits well in the introduction section. The rest of the section is the selection of the most relevant drought indicator for each cereal in each cluster (in order to perform the bivariate models) and as the Referee suggested we agree to move to the results section.

Referee#2: - Section 3.1. More examples for interpreting results in terms of consequences for crop losses-drought weather relationships - Section3.2. Please see my general comments. Maybe separating between results and discussion sections could help. Alternatively, a paragraph of descriptive results should be followed by an interpretation and then extracting generalized statements when possible. Part of this is done in the conclusions section (see below). - Conclusions: In my view, these are not really conclusions but a summary of the study or of the discussion. I would recommend addressing the discussion separately, and then to reduce and focus the conclusions section.

AR: Thank you for these last 3 suggestions. In a revised version addressing results, discussion and conclusion separately we aim to improve sections 3.1 and 3.2 with more examples of interpreting results in terms of crop losses related to drought conditions and conclusions emphasizing the main findings better pointed out.

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Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2019-37/nhess-2019-37-AC2-supplement.pdf

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