Nat. Hazards Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/nhess-2018-356-AC1, 2019

Natural Hazards and Earth System Sciences
Discussions
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EGU

Interactive comment on "A high-resolution spatial ass essment of the impacts of drought variability on vegetation activity in Spain from 1981 to 2015" *by* S. M. Vicente-Serrano et al.

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Received and published: 31 January 2019

Referee #1 This manuscript aims to assess the sensitivity of vegetation types to drought across Spain, using a high-resolution (1.1 km) spatial dataset of the Normalized Difference Vegetation Index (NDVI) and the Standardized Precipitation Evapotranspiration Index (SPEI) for Spain for the period from 1981 to 2015. In particular, an analysis of the drought time scales at which vegetation activity aims to show the highest response to drought severity at different moments of the year. The study is exhaustive, taking advantage of the two high resolution datasets computed by the authors, the methods are adequate and the results are in accordance with previous works

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and are discussed in a detailed way. The overall context of the subject is very important in Mediterranean and Iberian context, taking in account the importance of drought subject for the region within the context of warming tendency. Therefore, the work seems to be appropriate for this journal. However, some aspects could be improved in order to increase the intelligibility and readability of the paper.

We strongly appreciate the positive comment on the manuscript by the reviewer#1. Really she/he has appreciated that this study contains a considerable amount of work, including the use of high resolution datasets and different spatial-temporal analysis.

MAJOR As I said the subject and results of this manuscript are of great interest for a wide range of readers. However, the reading of the paper is very tiring, the number of figures in the manuscript and supplementary information is 'astronomic', the figures are really small, the axis information and titles are unreadable and the results and discussion is really hard to follow. Nevertheless, I recognize that present these results is a very hard task. Therefore, my next comments are suggestion that may increase the readability and increase the number or interested readers that should be attracted to the important results of the manuscript.

We have reduced some parts of the results section and removed around $\frac{1}{2}$ of the supplementary figures that were not very informative.

The semi-monthly analysis is interesting and aimed to take advantage of the higher temporal resolution of the datasets. However, the temporal changes in correlation are slow and I do not see the add-value of presenting 24 graphs instead of 12. As a matter of fact, the graphs for each month are very similar and if you increase the size of the figures (taking in account that you may present only one figure for each month, e.g., 2nd January, 2nd Feb,. . .) the analysis will be much more easy.

We understand this comment but given the high temporal resolution of both climate and NDVI datasets, it would be a pity to reduce the temporal resolution of the data. Usually these analysis are done at monthly resolution, but really the motivation of this choice is

usually the availability of the data, which is usually available at the monthly resolution. Nevertheless, here we had access to a high temporal resolution data, which allows identifying very interesting patterns, difficult to be observed with data at the monthly resolution. An excellent example is the seasonal transitions in the relationships between the spatial patterns of aridity (and temperature) and the correlations between the SPEI and the sNDVI. These plots clearly show that the changes in the role of drought on the vegetation activity show a seasonal transition, which is clearly appreciated using a detailed temporal resolution (semi-monthly). For this reason we prefer to maintain the analysis at the original temporal resolution better than focusing on specific semi-monthly periods.

Another issue related with the 12 new bigger figures is the possibility ′ of presenting all the land cover inside each graph, maybe with different colours. This allows a better comparison between land covers and reduce drastically the number of figures in supplementary information.

Really we understand that we are including a high amount of figures in our ms. But we are mostly making use of supplementary information. Of course, in the main manuscript we do not describe in depth these figures but we provide the main results. Moreover, we do not think possible to include in a single figure the information corresponding to the different land cover scatter plots since they are already containing different colors. In any case, we have reduced the number of supplementary figures in $\frac{1}{2}$.

The result section is very exhaustive and ′ hard to follow. Please consider to resume. We have removed some sections of the text but also some figures from the supplementary information that were not very informative.

The discussion and conclusions section ′ is very long and also hard to follow, although with a huge amount of very interesting points. I would suggest to separate discussion from conclusion and introduce sub sections in discussion in order to organized the

main findings.

We appreciate this comment. We have including different sub-headings in the discussion section but also developed a new section that states the main conclusions of the manuscript.

I also would suggest to add in conclusion section some paragraphs highlighting the new insights of this work in comparison with previous ones and the usefulness and need of this type of analysis.

We have included an independent conclusions section in which the different main findings obtained in the manuscript are clearly stated.

Furthermore, some methodological issues are not very clear. 1) (Lines 189-193) The authors said "computed the atmospheric evaporative demand (AED), reference evapotranspiration (ETo), and the Standardized Precipitation Evapotranspiration Index (SPEI)." Please explain the advantage of using AED AND ET0. Which is used to computed SPEI? SPEI in Vicente-Serrano eta al., 2010 is computed using PET. What is the difference between AED and ET0? Which method is used to compute AED? Maybe the readers of the journal are not very familiarized with these differences and should understand the biophysical add value of using AED. Please clarify the innovation of this new approach and the need of this innovation. Additionally, in several figures (e.g. Figure 8) the author mentioned AED in figure caption and ET0 is written in axis. Please try make it more consistent.

The ETo is one of the forms in which we can express the AED. The potential evaporation is a form of the AED. The pan evaporation is also a form of the AED (which can be estimated using the PenPan model or measured by means of evaporation pans). But the ETo is also a form of the AED since it includes a constant surface resistance. The ETo can be compared spatially and temporally and it only depends of meteorological factors. To avoid any possible misleading by the readers we have clarified this issue in the revised manuscript:

"Based on this gridded dataset, we computed the atmospheric evaporative demand (AED) and the Standardized Precipitation Evapotranspiration Index (SPEI). We used the reference evapotranspiration (ETo) as the most realibale way of estimating the AED. ETo was calculated using the physically based FAO-56 Penman-Monteith equation (Allen et al., 1998)."

In addition, we have removed the term AED in different parts of the manuscript and replaced by ETo.

2) (Lines 170-172): Please clarify which variable is really used for the correlation assessment: is it the standardized NDVI (sNDVI) or NDVI magnitude with residuals? Figure captions mentioned sNDVI. I am confused with these definitions. Please clarify and justify those options with more clarity and detail. This has been justified in the revised manuscript:

"Correlations with the drought dataset were based on the sNDVI."

3) (Lines 220-223): Why CLC2000 and not the most recent version? The land cover is not static, are always changing. The classification of 2000 does not represent the average state of land cover during the period, Please, justify this choice taking in account this changeable character of land cover. As the authors have removed the pixels that they say are corresponding to land cover change, I would suggest to use the versions of CLC for 1990, 2000, 2006 and 2012 and considered only the pixels that are corresponding to unchangeable land covers, as coded using CLC.

As we justified in the manuscript, we have chosen the CLC2000 because it is the most representative over the entire study period. The suggestion by the reviewer of using different land cover maps do not solve the problem of having a baseline for the beginning of the study period (1981). Moreover the selection of the pixels that have not showed a land cover change would strongly reduce the analysed surface area since in a period of 30 years the land cover change processes that are recorded in Mediterranean areas may affect large regions (see e.g. Lasanta and Vicente-Serrano,

2012). There are several land cover changes processes which are not characterized by an abrupt change in the land cover type. Of course, we are aware that possible abrupt modifications of the land cover type could affect the relationship between the SPEI and the sNDVI. For this reason we removed those pixels characterized by abrupt changes (quantified by means of the selection of a high value in the magnitude of change of the sNDVI, e.g. non-irrigated arable lands transformed to irrigated lands, urbanization, etc.) ,but we maintained those that showed more gradual changes. In any case this did not affect the quality of our analysis since before the temporal correlations were calculated for each time series we removed the trend of the series (both for SPEI and sNDVI).

4) (Lines 159- 166): What means strong changes in NDVI? The author said “the annual NDVI higher than 0.05 units or an increase higher than 0.15 units between 1981 and 2015”, but what does it means in terms of variability (in terms of std). Why do you choose this value? Please fundament the choice. This was explained in more depth in the manuscript. As indicated, these thresholds were defined after an exploratory analysis and in areas in which we have strong knowledge in relation to the occurrence of abrupt changes in the land cover, such as the creation of new irrigated lands:

“In order to limit the possible impact of changes in land cover on the dependency between drought and vegetation cover, we assumed that strong changes in NDVI can be seen as an indicator of changes in land cover. As such, those pixels with strong changes in NDVI during the study period were excluded from the analysis. These pixels were defined after an exploratory analysis in which we tested different thresholds. In specific, we excluded those pixels, which exhibited a decrease in the annual NDVI higher than 0.05 units or an increase higher than 0.15 units between 1981 and 2015. The spatial distribution of these pixels (not shown here) concurs well with the areas identified in earlier studies over Spain in which it was an abrupt modification of the land cover type (e.g. creation of new irrigated lands) (Lasanta and Vicente-Serrano, 2012; Vicente-Serrano et al., 2018).”

5) Please clarify what means the time-scales between 1- and 48-semi-months? Did you compute SPEI with a bi-monthly accumulation? In line 202 you said that "the SPEI was calculated for the common 1- to 24-month time scales". please explain the difference between both computation approaches and the advantage of the last one (bi-monthly accumulation). What is the advantage of doing this instead of computing the monthly mean of NDVI? I do not see the add value of this approach

In the revised manuscript we have clarified that the 1- to 24-month time scales correspond to 1- to 48- semi-monthly periods:

“In this work, the SPEI was calculated for the common 1- to 24-month time scales but here given the semi-monthly availability of the data, we calculated the corresponding 1- to 48- semi-monthly time-scales.”

6) Figures: For the majority of the figures in the manuscript and supplementary information is not possible to read the axis of the figures. The axis number, the axis titles and the titles of figures are not readable at all. Please increase the font size (probably only for the bottom and left figures in order to save space). Supp Figure 5: provide a title for each graph Figure 12: the tile of previous figures should be like the ones in this figure (e.g., 1st Jan, 2nd Jan,...). This will increase significantly the readability of figures.

We have increased the size of the fonts for the different figures and added axis labels in all of the cases.

7) (Lines 454-458): Difficult to follow. Please consider to rephrase.

The sentences have been rephrased.

8) (Lines 505-507): Difficult to follow. Please consider to rephrase.

Rephrased.

9) (Lines 555): When? in spring and autumn. Please consider to rephrase, clarifying

and detailing.

We have detailed that the comments refer to the cold season.

10) (Lines 585-589): Very good point!

Thanks a lot for this comment.

11) (Lines 607-609): Another important finding of this work!

Thanks again.

MINOR 1) (Line 22): rephrase ‘a another newly developed. . .’

Rephrased

2) (Line 57): move the data of access to the reference list

Data access moved to references.

3) (Line 157): rephrase ‘In out attemp’

Replaced: “in order to. . .”

4) (Line 158): NDVI or sNDVI

NDVI is correct in this case.

5) (Line 353): make the sentence consistent with the figure caption. Is it P-AED or P-ET0

AED has been replaced by ETo throughout the manuscript.

6) (Line 359): “July to August” or July to September???

Replaced

7) (Line 388): “March to April” or March to May???

Replaced. âĂČ

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