

Interactive comment on “Rankings of extreme and widespread dry and wet events in the Iberian Peninsula between 1901–2016” by Margarida L. R. Liberato et al.

Referee comments by Anonymous Referee #3

Main comments: The manuscript presents a new method for ranking regional extremes of persistent, widespread drought and wet events that considers different time scales. While there are some good points in the manuscript, it lacks in discussion where the authors could put things in context.

Reply: We acknowledge the reviewer for the support and constructive comments, which will definitively contribute to improving the revised manuscript. We agree with the reviewer that a more in depth discussion may be provided, including the topics mentioned by the reviewer below. We also agree that we must emphasize why developing such a ranking is fundamental for future research on (dry and wet) extremes – either from the impact perspective, for understanding the physical mechanisms behind each of these events, for the attribution to climate (natural or forced) variability or to climate change, for the development of future risk assessments... In this regard the authors would like to stress that a lot of publications have been published in the last two decades covering these topics, including many co-authored by some of us in terms of physical mechanism (e.g. Garcia-Herrera et al. 2007, Trigo et al. 2013, Vicente-Serrano et al. 2011) or in terms of impacts (e.g. Gouveia et al., 2009, 2012 Páscoa et al., 2017, Andreia et al., 2018). In any case, after this ranking is established, additional investigation on these research topics may be performed.

However, we would like to stress that the scope of this paper is, as stated in the introduction (lines 100-105):

“In summary the main goals of this paper are to:

- (i) present a tool which allows identifying regional extremes of persistent, widespread dry and wet periods, at different time scales;
- (ii) build a comprehensive dataset of rankings of the most extreme, prolonged, widespread drought and wet periods on Iberia (...)

Specific questions that need to be addressed are:

1.

Can you show that this method using SPEI performs better for the Iberian Peninsula?

How does it compare with other indices (say SPI) for the same purpose?

REPLY: We understand the reviewer’s curiosity. In light of our results and the sensitivity analysis performed on the impact of different thresholds to define dry and wet events, using different indices will certainly change the positions of the events, as it is highlighted (lines 158-162) when analysing rankings at different timescales (and for the same index). Once again, we do not intend to show that this method performs better using one or another index for the Iberian Peninsula or other region – we will stress this point in the discussion section.

Once the methodology is established, one of the interesting studies that may be performed is, precisely, to study how the ranking’s positions compare when using other indices (say SPI). This analysis could open new perspectives to the understanding the dynamics behind the of the most

extreme and widespread dry and wet events in the Iberian Peninsula. Eventually the behaviour is different between wet and dry extremes? By applying to different regions and indices the research on the most extreme events may be developed.

However, we would like to highlight that for this manuscript we could either apply SPEI or other indices; this work does not aim at comparing or assess extremes (wet and dry) using different indices. This is a relevant topic, but it is not the scope here. We will include more on this information, namely mentioning works performed with SPEI and other indices on IP (Gouveia et al., 2017, Pascoa et al. 2017a, 2017b, Ribeiro et al., 2018).

Can you validate its applicability for the outcomes (hydrological/ ecological/ agricultural) on different time-scales?

REPLY: Please see the answer to previous comments.

It should be fairly easy to show like Vicente-Serrano et al., 2012 did (for global and continental scales) that SPEI is better than SPI (and PDSI) for various applications. I wonder if it is true for the Iberian Peninsula also?

REPLY: Some of this manuscript co-authors have already performed a set of works comparing SPEI and SPI results for Mediterranean and PI in particular (Gouveia et al. 2017, Pascoa et al., 2018, among others). We will include this information in the manuscript:

“Several authors have performed drought characterization and assessment of impacts, namely on vegetation dynamics (Gouveia et al., 2016, Liberato et al., 2018) and on crops production and yield (Pascoa et al. 2017a, 2017b, Ribeiro et al., 2018). The SPEI and SPI were used in order to identify drought severity and intensity and both indices are able to identify the severest and longest events. Although the recent issues raised due to the uncertainties on AED computation (Domínguez-Castro et al., 2019; Vicente-Serrano et al., 2020), some works highlighted the ability of SPEI to identify tendencies towards to dryer conditions on Iberian Peninsula (Vicente-serrano et al., 2014, Spinoni et al., 2015, Coll et al., 2016, Páscoa et al. 2017).”

- Domínguez-Castro, F, Vicente-Serrano, SM, Tomás-Burguera, M, *et al.* High spatial resolution climatology of drought events for Spain: 1961–2014. *Int J Climatol.* 2019; 39: 5046– 5062. <https://doi.org/10.1002/joc.6126>
- Coll J., E. Aguilar, and L. Ashcroft, “Drought variability and change across the Iberian Peninsula,” *Theoretical and Applied Climatology*, vol. 130, no. 3-4, pp. 901–916, 2016.
- Páscoa P, Gouveia CM, Russo A, Trigo RM (2017a) Drought Trends in the Iberian Peninsula over the Last 112 Years. *Advances in Meteorology* Volume 2017, Article ID 4653126, 13 pages <https://doi.org/10.1155/2017/4653126>
- Páscoa P., C. M. Gouveia, A. Russo, R. M. Trigo (2017b) The role of drought on wheat yield interannual variability in the Iberian Peninsula from 1929 to 2012. *Int J Biometeorol*, 61:439-451 DOI: 10.1007/s00484-016-1224-x

- Ribeiro, A. F. S., Russo, A., Gouveia, C.M., Páscoa, P. (2018). Modelling drought-related yield losses in Iberia using remote sensing and multiscale indices, *Theor Appl Climatol*, doi:10.1007/s00704-018-2478-5
- Spinoni J., G. Naumann, J. Vogt, and P. Barbosa, “European drought climatologies and trends based on a multi-indicator approach,” *Global and Planetary Change*, vol. 127, pp. 50–57, 2015.
- Vicente-Serrano S. M., J.-I. Lopez-Moreno, S. Begueria et al., “Evidence of increasing drought severity caused by temperature rise in southern Europe,” *Environmental*
- Vicente-Serrano, SM, Domínguez-Castro, F, Murphy, C, et al. (2020) “Long-term variability and trends in meteorological droughts in Western Europe (1851–2018)”. *Int J Climatol.*; 1– 28. <https://doi.org/10.1002/joc.6719>

2.

The question of ranking also needs more exploration. Does a top ranking translate into maximum impacts on the indicators (agriculture/ streamflow etc.) for the relevant time-scale?

Can this be shown in an analysis?

REPLY: We acknowledge the reviewer for identifying the importance of establishing a methodology for building a ranking on the extreme and widespread dry and wet events in the Iberian Peninsula (which may be replicated to any other study region). We agree that this and all the questions raised below are very relevant and interesting research questions, and these are some of the research questions that motivated us to identify that there is not a ranking of extreme and widespread dry and wet events, yet. And only after this ranking is established will we be able to perform research on all other research topics mentioned by the reviewer.

Therefore, we will change the manuscript and explain better the motivation and scope of the paper. We will also justify better the relevance and novelty of this study, which is presenting a methodology for building rankings of extreme and widespread dry and wet events, for several timescales, whatever indices datasets are used (in this case we used SPEI).

Additionally, we will include a discussion section to stress some of the identified caveats, advantages and disadvantages of this methodology. Finally, we will refer some highlights, topics that need more exploration, research questions which may be addressed in the future after a ranking dataset is published.

“The years ranked in the first places either for the drought or wet events have been object of study in several previous works (Gouveia et al., 2009, 2012, Garcia-Herrera et al., 2007, Trigo et al., 2013, Sousa et al., 2011), namely concerning with their impacts on vegetation dynamics (Gouveia et al., 2009, Liberato et al., 2017, Gouveia et al., 2016, 2017) and on crop productions and yield (Pascoa et al., 2017b, Ribeiro et al., 2019).”

3.

The temporal variation in the indices (especially in Figures 3 & 4) described as “There is a clear temporal clustering of most extreme drought episodes, particularly with a large concentration between 1943 and 1957 and a second group after 1975”.

REPLY: We agree with the reviewer. We must improve the discussion of these results and some literature review may be added to give some clues on this clustering of drought events towards the end of the data period.

“Páscoa and co-authors (2017) evaluate the long-term evolution of drought in the Iberian Peninsula using both SPEI and SPI at 12-month time scales computed using data from the Climatic Research Unit (CRU) database for the period of 1901–2012 and for three subperiods: 1901–1937, 1938–1974, and 1975–2012. Both indicators agree in identifying the most intense and long dry episodes during the 1940, 1950 and after the 1980 decades. They also identify the 1960s and 1970s as predominantly wet whereas the 1910s and 1930s showed shorter wet and dry periods (Vicente-Serrano et al., 2006). The recent 2004/2005 and 2011/2012 extreme drought events are also clearly evident on all indices used (Páscoa et al., 2017). These were also highlighted in the works by González-Hidalgo et al. (2018), Domínguez-Castro et al. (2019) and Vicente-Serrano et al. (2020).”

4. Some analysis should be done (or connections to existing studies made) to analyze the role of modes of variability on decadal or multidecadal or inter-annual (such as the NAO by Vicente-Serrano et al. (2011) time-scales.

REPLY: We agree, again, with the reviewer. This is another important research question to develop in a future work. In fact some preliminary studies related with the relationship between teleconnections and drought/wet events have been already published by some of the co-authors of the present study (Gouveia et al., 2008, Sousa et al., 2011; Bastos et al., 2016).

Moreover, we will include a small paragraph with literature review and discussion in the revised version of the manuscript.

- Bastos A, Janssens IA, Gouveia CM, Trigo RM, Ciais P, Chevalier F, Peñuelas J, Rodenbeck C, Piao S, Friedlingseim P, Running SW (2016) European CO₂ sink influenced by NAO and East-Atlantic Pattern coupling, *Nature Communications*, 7, 10315. DOI: 10.1038/NCOMMS10315
- Gouveia C., Trigo R.M., DaCamara C.C., Libonati R., Pereira J.M.C. (2008) The North Atlantic Oscillation and European vegetation dynamics. *International Journal of Climatology*, DOI: 10.1002/joc.1682.
- Sousa PM, Trigo RM, Aizpurua P, Nieto R, Gimeno L, Garcia-Herrera R, (2011) Trends and extremes of drought indices throughout the 20th century in the Mediterranean. *Nat. Hazards Earth Syst. Sci.* 11: 33–51, doi: 10.5194/nhess-11-33-2011.

Are there any studies carried out over a larger region - like say the Mediterranean – that one can make a connection to?

REPLY:

To the best of our knowledge, this is the first and only paper to present a methodology to rank extreme, widespread (dry and wet) events. This is the novelty. There are many studies carried out for larger regions on droughts, on precipitation events at daily scales, using meteorological or gridded datasets covering the entire Mediterranean basin (e.g., Sousa et al., 2011, Gouveia

et al., 2017) or more single sectors (Gouveia et al., 2009, 2012, 2016, Trigo et al., 2011, Páscoa et al. 2020). However, to the best of our knowledge there are no other widespread, extreme rankings than those published by our group (please see Ramos et al. 2014; 2017 and references therein) and these are mostly focused on precipitation. Moreover, it should be stressed that the main drought or wet events described in the papers mentioned (and other) correspond to the years ranked in the first positions.

- Gouveia CM, Bistnas I, Liberato MLR, Bastos A, Koutsias N, Trigo RM (2016) The outstanding synergy between drought, heatwaves and fuel on the 2007 Southern Greece exceptional fire season, *Agricultural and Forest Meteorology*, 218-219, 135-145. DOI: 10.1016/j.agrformet.2015.11.023
- Gouveia CM, Trigo RM, Berguería S, Vicente-Serrano SM (2017) Drought impact on vegetation activity in the Mediterranean region: an assessment using remote sensing data and multi-scale drought indicators, *Global and Planetary Change*, 151, 15-27. DOI: 10.1016/j.gloplacha.2016.06.011
- Páscoa P, Gouveia CM, Russo AC, Bojariu R, Vicente-Serrano SM, Trigo RM (2020) Drought impacts on vegetation in southeastern Europe, *Remote Sensing*, 12 (13), 2156. DOI: 10.3390/rs12132156
- Ramos AM, Trigo RM, and Liberato MLR. (2014) A ranking of high-resolution daily precipitation 381 extreme events for the Iberian Peninsula. *Atmospheric Science Letters* 15: 328–334. DOI: 10.1002/asl2.507, 2014
- Ramos AM, Trigo RM, Liberato MLR (2017) Ranking of multi-day extreme precipitation events over the Iberian Peninsula, *International Journal of Climatology*, 37 (2), 607-620. DOI: 10.1002/joc.4726
- Trigo RM, Gouveia CM, Barriopedro D (2010) The intense 2007-2009 drought in the Fertile Crescent: Impacts and associated atmospheric circulation, *AGRICULTURAL AND FOREST METEOROLOGY*, 150 (9), 1245-1257. DOI: 10.1016/j.agrformet.2010.05.006

5.

Is the clustering of drought events towards the end of the data period in any way connected to climate change? There are numerous studies that have already documented drying of the Mediterranean under climate change.

REPLY: We cannot easily reply to this relevant question. In fact, some of the co-authors are preparing a manuscript about the subject that will be submitted soon. Moreover, from the reviewers' comments we verify that the scope of this manuscript is not clearly stated.

This manuscript does not aim at characterizing droughts in the Iberian Peninsula; it does not aim at assessing the climate change signal or the dependence and/or attribution of these extremes (wet or dry) on climate change or on the different variability modes.

We agree that all these are very relevant and interesting research questions, and these are some of the research questions that motivated us to identify that there is not a ranking of extreme and widespread dry and wet events, yet. And only after this ranking is established will we be able to perform more research on all other research topics mentioned above.

As the reviewer mentions, there are numerous studies that have already documented drying of the Mediterranean under climate change; there are also many studies for the Iberian Peninsula,

which climate is different. This is therefore an important research topic which is out of the scope of this paper.

However, we agree that we should improve the discussion of these results and some literature review may be added to this clustering of drought events towards the end of the data period (as previously stated on reply to point 3).

Other suggestions:

Numerous grammatical mistakes that can be easily fixed in a modern word processor.

Many thank you for your positive feedback!