

Authors' replies to the Reviewer of HESS-2023-218

Dear Dr. Micha Werner,

Please find enclosed the revised manuscript entitled “60-years drought analysis of meteorological data in the western Po river Basin”. We thank you for your comments, which have been very helpful to better the quality of our work. In particular, we have made many changes to the text improving the clarity of writing and we have partly changed the figures insuring more consistency between colour scales (as in Figure 3 of the revised manuscript) and greater differentiation between ranges of values (as in Figure 4 of the revised manuscript). We have addressed all your suggestions (as seen in the red/blue highlights in the track-change file provided), and we would like to offer more complete responses to some of them, in *italic* below.

“Even though the change is less significant than the one obtained by analysing the indices themselves.”. It is not so clear what is meant with this sentence.

The sentence was meant to convey the difference between the results obtained from studying trends in the drought indexes' series (SPI/SPEI) and in the drought run characteristics calculated from those series. The manuscript has been changed for better clarity.

Mention is made of drought impacts being diversified. Whilst I agree this is the case, the discussion in this section is primarily on the hazard dimension of drought risk, and not on the consequence (impact) dimension. So, the diversification of drought impacts does not follow from the discussion. I would suggest to rephrase this such that the focus remains on dimensions of drought hazard.

We have changed the manuscript as to not mention impacts, but rather “drought characteristics” and “the frequency of occurrence of drought periods of a certain magnitude” (see Line 68-69 of the revised manuscript).

There is discussion that a threshold value of -1 is used to identify drought events, and then in Figure 2 it is mentioned that this is not used in this study. This is somewhat confusing. Please clarify. It may be useful to be clearer on how a drought event is identified. As I understand it, if one or more months have an index value of below -1, then all preceding and following months are considered the same event, until a positive (or zero) index value is reached.

We have rephrased the explanation of the local drought period definition, citing immediately the inclusion of the onset/offset (i.e. months with negative index values preceding and following the months under the threshold, see Lines 224-227 of the revised manuscript). Furthermore, we have changed Figure 2, excluding the panel showing the method not used in the paper as to limit redundancy, and we have instead added a panel to better explain the region-wide drought event definition (see the response to the next comment).

I assume that each cell is first evaluated if it is in a condition of drought (i.e. the local drought is evaluated first), before the regional analysis is done. This means that mention of the condition being below -1 is not quite correct as in the previous it was described how drought conditions were identified at the local level, which can include some values between 0 and -1.

Our definition of region-wide drought events follows that of the cited paper at Lines 245 of the revised manuscript, which uses a simple -1 threshold in order to define cells in drought conditions (other citations present in the previous manuscripts were omitted, in order to be more concise as they were both based on González-Hidalgo et al., 2018). The choice to maintain this procedure was done for consistency with the cited paper. We have made this different mode explicit, see Lines 245-8. Furthermore, the choice to use a temporal aggregation through the inclusion of months with some cells in drought conditions before/after the months with more than 25% of the cells in drought conditions is done to mimic the aggregation done by González-Hidalgo et al., 2018. The aggregation through this analytic method can be easily applied in our case due to the limited study area.

While I understand that a regional drought event is considered to persist when less than 25% of the area, similar to the temporal persistence for the local analysis, it would appear to me that the spatial correlation of the areas is relevant. Would this approach not inflate the length of drought periods spatially for regional areas that have a higher climatic variability, such as the more rugged regions?

We thank for this very relevant comment and the opportunity to address it. While we acknowledge the possibility of overextending the length of region-wide drought events for the areas with a higher climatic variability, we did not find this happening in our case. For example, see the two attached figures below, showing the percentage of time in which each cell has been part of region-wide drought events. In general, it appears that the alpine chain is not more likely to be part of the events compared to other areas, even in cases where events span the whole region.

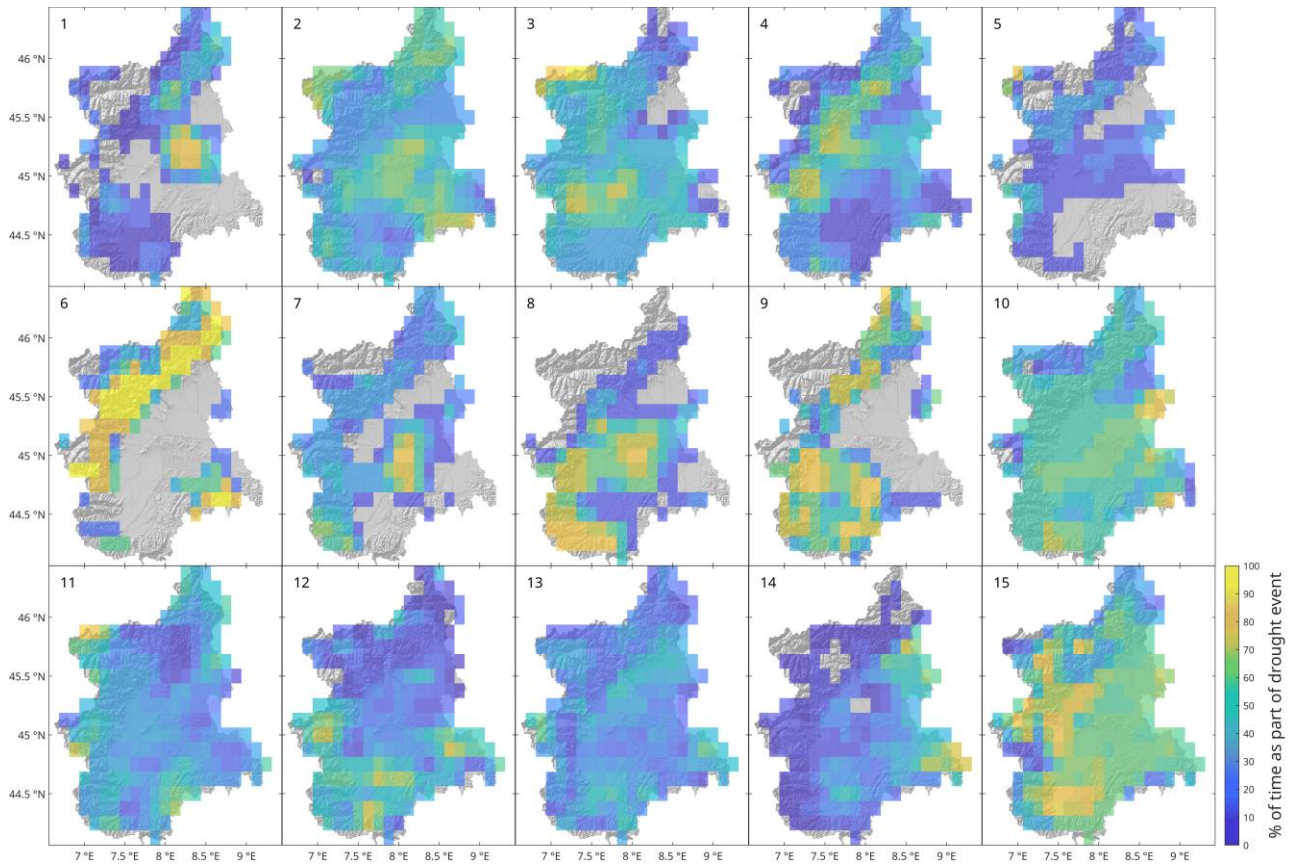


Figure 1: Percentage of time in which each cell is part of region-wide drought events calculated through SPI-12. The numbers refer to the events shown in Figure A3 of the revised manuscript.

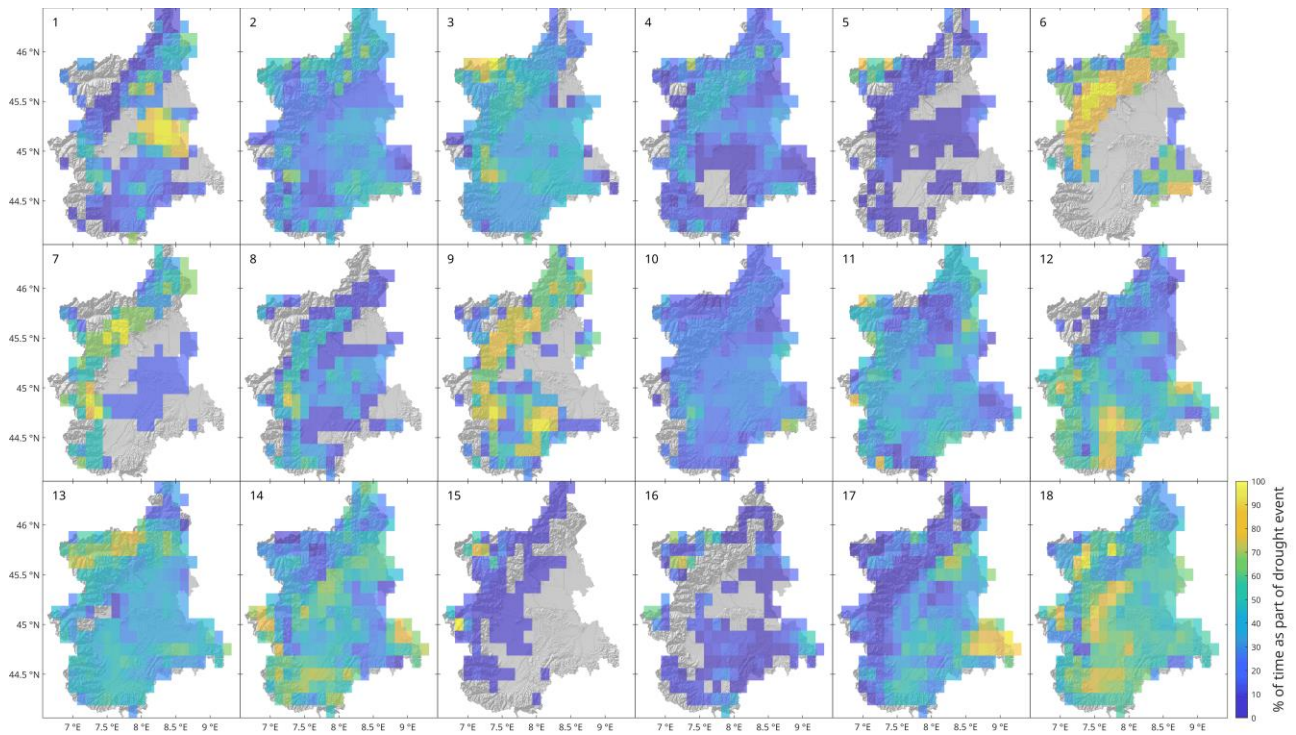


Figure 2: Percentage of time in which each cell is part of region-wide drought events calculated through SPEI-12. The numbers refer to the events shown in Figure A3 of the revised manuscript.

L328-330: Note that some of these results are trivial. There are by definition less frequent drought events when comparing SPI-3 and SPI-12, or SPEI-3 and SPEI-12 as the longer averaging window smooths the signal, resulting in attenuation and pooling.

That drought events at the longer time scale are longer though less frequent is again somewhat trivial as it is inherent to the method.

We agree with the comment and have decided to keep these observations on the data but making explicit that this result is to be expected (see Line 322 of the revised manuscript as well as Line 398). Furthermore, we have changed Figure 4 in order to make it more readable, using two different colour ramps for 3 and 12 month drought characteristics.

Figure 5: This figure is somewhat confusing. In the text it is noted that there is an on average increase or decrease depending on the indicator. This means that there are cells that also show the opposite trend of that indicator. But the figure shows only where there is an increase (upper panels) or a decrease (lower panels). Should this not also display those cells (using the appropriate symbol?). Of perhaps clarify in the text that only the one direction is shown.

L372: Mention is made of a higher number of shorter duration droughts are found in the alpine chain. But this cannot be seen in the figure (see comment above) as it shows only increase in length. This is somewhat confusing as the figure does not corroborate the text.

We have decided to overhaul Figure 5 in order to make it more readable and clearer, representing both types of changes (higher/lower severity and longer/shorter duration) in each panel and dividing between drought characteristic and drought index studied. Furthermore, the mean cited in the text of the Figure refers to the mean over the first and the second period in which the series was divided. The text has been amended as to make this clearer.