Review: Erfurt et al. Exploring the added value of a long-term multidisciplinary dataset in drought research – a drought catalogue for southwestern Germany dating back to 1801

Summary

This paper uses multiple datasets, including drought impacts, meteorological, hydrological and vegetation drought indices to identify droughts over ~220 years in Baden-Wuerttemberg (Germany). Drought impacts were assembled from the EDII and tambura.org and were categorised into agricultural, ecological and hydrological impacts. These were analysed alongside SPI, SPEI, tree ring data and flow percentiles from the Rhine and Danube to look at when droughts were identified (at three levels of severity) in each dataset. The events identified in each dataset were then combined to assess when droughts occurred in all datasets, and which indices identified droughts when others did not using a similarity index. The authors also compared the top 10 events identified between two time periods from 1900 and 1801, and found that there were many top 10 events in the early period between 1801 and 1900.

I believe this is an interesting, well written paper that provides a novel addition to the literature in the assessment and identification of droughts particularly due to the use of impact data. However, I do feel that the discussion could be strengthened and have noted a number of minor/more technical points that should be addressed before publication. But that these recommendations are minor, and therefore the paper can be published following minor revisions.

Decision: Accept with minor revisions

Major points

Although the title of the paper sets out the aim to explore the benefits of such a multidisciplinary approach for drought research, however I feel like the discussion would really benefit from a discussion of how these results and type of analysis is beneficial for real world applications or drought managers. In the UK for example, water companies must plan for droughts that are the worst on record (and actually now, worse than those on record using stochastic approaches), so having a good understanding of what droughts were severe, where and from what perspective is extremely important for the drought planning process. I am interested to see how this research will benefit water/drought management from the German perspective. The discussion could also be strengthened in terms out how the results compare to other studies in the region and how the droughts identified may differ in terms of their severity/impact – what was the effect of using multiple indices and the impacts here compared to these other studies?

Minor and technical points

L14: …Many studies have identified past drought events…

L43: It might be nice to add another one/two examples of the types of individual indices used here, as well as tree-ring based ones

L45: it felt like there was a word missing here, suggestion: …Different drought types characterised using a variety of indices…

Section 2.1: It might be nicer to use un-numbered sub-headings for each of the datasets here to make it easier for the reader to refer back to the section of interest

Figure 1: Overall I like this diagram, however have a few comments. 1) in the combined drought frequency index box you mention S1, S2, S3 events, but it's not clear from the rest of the diagram where this categorisation has come from (and I don't think is mentioned elsewhere in the paper) is there a typo here? If not, perhaps clarify? 2) The red arrows on the right of the diagram show the outcome of the meteorological, hydrological and vegetation drought indices feeding into the distinctiveness analysis, but the impact data also feed in to this section – amend the arrows to show how the impacts feed into the final part of the analysis.

L78: precipitation ~~sums~~ totals

L78-79: I think it makes sense for the station names to be earlier in the sentence, like this '…for two stations in Baden-Wuerttemberg (Rheinstetten-Karlsruche and Stuttgart, Figure 2), which provide the longest continuous time-series of the required variables.'

L79: It's not clear whether the 'required variables' mentioned in the first sentence are the same as the precipitation and temperature data mentioned in the second sentence – please clarify.

L95-96: You state that pine was also tested but not included because of their weak climate signal – do you have a reference or some analysis you can show (perhaps in the supplementary info) to support this?

L100: what is meant by 'appx.'?

L1157-119: You use three categories of impact (agriculture, ecology and hydrology), the EDII has ~14 categories, from what you've said I think that you have grouped EDII categories to create 3 groups of impacts, is this the case? Please clarify in the text.

Figure 2: It is quite difficult to see the colour of the points for the tree locations against the elevation layer – you could either make the elevation slightly transparent to make it paler or change the colour of the points (or both) to make it easier to read

L127: …US Drought Monitoring and Drought Impact R~~r~~eporter… – capital R needed for Reporter

L133: … estimated using ~~with~~ the Thornthwaite equation (which only… [Space missing between 'equation' and opening bracket]

L129-145: This section on the use and calculation of SPI and SPEI would benefit from a discussion of the distributions selected and the potential impact this choice may have had on the results – e.g. recent papers have tested appropriate distributions for such standardised indices Stagge et al. 2015 (https://doi.org/10.1002/joc.4267) and Svenssson et al. 2017 (https://doi.org/10.1002/2016WR019276). It isn't clear if a reference period was used, or whether data were standardised against the whole time series available – please clarify in the text.

L151: You mention that tree ring data were gathered from 70 locations, but from looking at Figure 2 there doesn't look to be 70 points representing tree stands – is this correct (or are there many overlapping points on the map?)

L174-176: This point isn't very clear (also mentioned in the comments for Figure 1) – perhaps worth adding a section to the diagram? If the diagram gets too big for the width of the page perhaps you could add it horizontally?

L154: remove space between 50 and % symbol

L189: Both similarity measures, *r* and *s*, were…. (r and s in italics)

L196-203: sorry this section is a bit unclear, particularly the last sentence of this paragraph. Do you mean that if one of the impact groups (e.g. tree rings) is removed, you identify 12 fewer events as these weren't identified in any of the other series? Please clarify.

L237-238: The order of the words in this sentence isn't quite right, suggestion: "For both the Rhine and the Danube, streamflow in the years 2003 and 2018 were marked as extremely low."

L240: What is the significance of the bold text here?

Figure 3: I wonder if part b might be better grouped so that all the SPI indices are together, all the SPEI indices together, all Rhine and all Danube together, with a small break or line between each group. Please add a title (as in 3a) or a yaxis label to 3c.

L270-276: It's not clear how you arrived at 17 years here from Figure 3c – please clarify. Perhaps you could mark on Figure 3c which years meet your criteria. (I think the criteria is more clearly explained in the caption for Figure 5).

L271: remove space between 25 and % symbol

Figure 5: Please explain what the numbers within each section of the rings refers to in the caption.

L302-303: This sentence doesn't read right, suggestion: The similarity index for each pair of datasets and the two periods showed some interesting patterns in the extreme droughts identified.

Figure 6 & Figure S7: group datasets/indices as suggested for Figure 3 (and all other relevant figures in Supplement). There are two grey colours on the plot, the caption indicates that grey = no extreme drought, but it doesn't say which grey this refers to. There's also some white cells in the plot – what does this mean? Please add to the legend to include white, pale grey and dark grey. The colour scale doesn't show much differentiation between colours, I recommend you add a colour to the scale (e.g. yellow) so it is easier to visually see the difference in relationship.

Figure 7: the caption is a bit unclear, I think you need to make it clear that each row shows the droughts that are identified when the group of indices are excluded from the analysis and therefore show the events unique to this group indices

L355: what's meant by double or triple drought years?

L386-388: can you comment on the changing anthropogenic influences in these catchments over time?

L417: ...ten drought events since 1900 and ~~respectively~~ since 1801 emphasised…

L420: you state here that you looked at negative impacts only, but I don't think you mention this in the data/methods section – it would be good to point this out, but also perhaps mentioning that there can be positive impacts of drought (e.g. on particular crops like strawberries)

L427: ''based on these indicators ~~following~~ 1950…

L428: could this also be a result of improved impact data in more recent times as well?

L449-450: …Trees in the study region are ~~indeed~~ sensitive to water deficiencies …

L496: Update reference to accepted version of the paper

Figures S1-S4: perhaps these could be added as a single 4 panel plot (i.e. 2x2 grid)

Figure S5: the numbers in the cells are a bit large and in some cases merge together – they would be made a bit clearer if the text was slightly smaller (for example, it is a better size in Fig S6). Also some of the colours are quite hard to read e.g. on the TIR Fir row (perhaps this is only an issue in the low quality review figure?) Please also add a label to the colour ramp legend to say what it is showing.

Figure S6: Please also add a label to the colour ramp legend to say what it is showing. Also some of the colours are quite hard to read e.g. on the TIR Fir row (perhaps this is only an issue in the low quality review figure?)