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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Historic hydrological droughts 1891–2015: systematic characterisation for a diverse set of catchments across the UK" *by* Lucy J. Barker et al.

Anonymous Referee #1

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The study is in the scope of HESS. I suggest moderate revisions. Figures could be improved (i.e. more clarity, highlight figure message). All together a valuable contribution to the hydrological community!

Major comments

A. The paper has a considerable inconsistency in terms of citation style. Please check all the citations to make sure that e.g. Authors et al. (2019), (Authors et al., 2019) and so on is used in a consistent way. This will improve the readability of the paper! Some examples are listed in the technical comments.

B. The reference Legg and McCarthy (prep.) (P05L09) is really problematic for me. As

the readers have no chance to access this paper and "preparation" is for me different to "is submitted", the authors should at least give a short description of what is done in the Legg and McCarthy paper. After all, the model is fed by this data and therefore it is important to understand how meteorological data there is "rescued and digitized". The same is partly true for Smith et al. (2019) as this paper is still under review, isn't it? I suggest to give the reader whenever possible at least a brief description of data/method etc. instead of referring to unpublished studies. I can understand that this is not always easy to do, but it seems to be important to give the reader the chance to understand what has been done. It is also hard to understand how well the model performed (P6L18-L24) in detail, as no further information is given: Here my question is, how valuable is the modelling regarding low flows and streamflow droughts? Here more justification is needed.

C. Regarding the model GR4J I have some concerns regarding the details of the modelling approach. The 4-parameter version is used, if I understand the details in the give references correctly. From Smith et al. (2018) I cannot learn much about the 4 parameters and the functioning, Smith et al. (2019) certainly gives more information on the parameters, but how do you justify that this modelling approach is appropriate for your study propose (i.e. non-stationarity, long series, appropriate for low flows in different seasons)? Especially the slow component and its model representation is of great interest, as the slowest (groundwater) box in the model and its parameterization have potentially a high impact on drought characteristics (such as intensity, duration, deficit). Please comment on this issue (i.e. parameter sensitivity). Are there studies proofing that GR4J is a valuable modeling approach for low flow and drought analysis? Excluding snow and snowmelt processes might be reasonable, but that means that these processes are not relevant for low flows and streamflow droughts in none of the study catchments?

D. A provocative comment: You stated that historical droughts have been more severe than recent droughts (i.e. observed droughts) and a historical assessment is important

to better understand the potential drought magnitude in a region/country. Contrary to that, I would argue that the use of water is adjusted to the water availability of the last, let's say, max. 30-40 years. All water users can only use available water and changes in water availability on a time scale of 3-4 decades influences (of course!) the water uses/water users. So, why is The Long Drought at the beginning of the last century relevant for the water users today? If you show these nice heatmaps with drought severity over 125 years you should also show a heatmap of uncertainty (i.e. comparison between observation period after 1950s and model period before 1950s) (cf. P25L05). Here, I speculate that the uncertainty assessment will soften your statements about historical drought magnitude, duration, intensity.

Minor comments

- P02L05-10: How is the statement "historical records are still of fundamental importance in drought planning" justified? From my perspective Brown et al. highlights the lack of historical analysis, but the authors also referred to other studies in paper. However, I suggest to strengthen the study motivation here with more details on the value of historical data or analysis.
- P06L17-20: Would be helpful to give some more information about the criteria used to evaluate the performance.
- P06L26-30: What is the justification to select particularly these nine case study catchments? It is also not clear why case study catchments are used?
- P02L11: Just a suggestion: Are there some reference studies that have investigated major, severe droughts in UK? Could the paragraph better be linked to the P03L15-25) where some historical investigations have been listed?
- P02L20: Is it warm/dry or warm and dry weather?
- P07L04: "end-month"? Is this the same as "right-aligned"?

- Sect 2.2.: I get the idea to have a short- and a long-term analysis (3 and 12 months). However, have you tested other accumulation periods? Is 12 month long enough to capture also long-term anomalies in the slowly reacting, GW-dominated systems in South East England? As events with "less than three months were removed" (is this <3 month or $\leq$3 month?), I wonder why the SSI-3 is used (as also a "seasonal focus" of the study is stated (P07L29) (see also comment below).
- What means "broadly north to south" exactly (P09L04)? Have you tried the heatmap with squares instead of rectangles (and with a fine border/stroke around the squares; this could improve the clarity of the graph, perhaps.). It would be also interesting to sort the catchments within each geographical group. North-to-south is perhaps not really hydrological meaningful; what about a sorting along a low flow metric (e.g. Q90/Q50) to highlight differences in on-set and termination?
- Fig.4: Are the differences between maximum intensity (dot size) and mean deficit (colors) discussed?
- I am not an expert for historical droughts in UK, but is "The Long Drought" really a 20 year event without drought termination / interruptions? From Fig. 3 and Fig 10a, I have the impression that there are also a lot of "yellow" and "white" segments in the heatmap (e.g. 1904 wasn't really a dry year).
- Fig. 6 is really a nice idea, but it is hard to understand and it take me a while to understand the encodings used in the Figure. I suggest to use a UK-matrix with 9 columns (i.e. events) and 4 rows (i.e. drought characteristics). Then in each subplot all catchments with mild grey dots overplotted by the top ranking catchments in black color. Would improve the clarity of the Fig.
- Would be interesting to quantify the differences between the MCW2007 drought magnitude and the (more severe) droughts on catchment or regional scale (Sect

4.1), e.g. what is the difference of a very critical drought situation in a specific catchment compared to the “national” drought magnitude?

- The authors stated that SSI-3 and SSI-12 are a good choice to identify different drought types (P23). Is this a general recommendation for other studies (3- and 12-months)? If not, what might be a good (and sufficient) set of different SSI-n to capture the variability of historical droughts?
- Sect 4.3 is a little bit long and could be more condensed. The authors discussed potential limitations of their work (e.g. non-stationarity, model uncertainty), but here I missed a clear link to the (own) study results.

Technical comments

1. P06L05: Smith et al. (2019) also assessed
2. P06L09: by Smith et al. (2018)
3. P06L11: Low Flow Benchmark Network (LFBN).
4. P06L17: reconstructed by Smith et al. (2018), which include the LFBN, performed
5. For readers from outside UK a short explanation of “Anglian” would be helpful (P09L23).
6. P11L03-04: two times “accumulation period”?
7. lower maximum intensity is more severe? (P11L04/05). Terms should be revised here.

8. Fig.4: The 45 degree axis labels are hard to read, thin grid lines or a lollipop graph instead of bubble graph could improve the readability. If you referred to pre-obs and obs-period than a vertical line to distinguish both periods would be beneficial. Have you tried a lollipop chart here, i.e. vertical lines between dots and x-axis might improve the readability?
9. Remove leading white spaces in (*Figure 5. . .) on page 12.

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