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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.

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Gerry Spraggs - short comment
Author Response

An excellent and interesting paper and good to see a national scale analysis of historic drought. I have some general comments which I hope may be helpful:

Gerry, thank you for kind words and we are glad you found our paper on historic

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hydrological droughts interesting. We have responded to each comment in turn below in bold.

In the abstract you could say '108 near natural catchments'. I think it would be useful for water managers to know up-front the type of catchment you are analysing as they deal with a whole range of catchment conditions..

Agreed, in the abstract of the revised paper we will include that this study uses near-natural catchments (P1L19).

page6 lines9-16 To expand on the previous comment, much of the time water resource planning has to deal with non-natural flows. For this situation your method would require naturalisation of recorded flow series before model calibration and flow series extension. Alternatively, model calibration with artificial influences included. It's obviously achievable but a longer procedure with more room for introducing error.

This is certainly a good point, and the modelling approach used by Smith et al. (2018, 2019) does not explicitly account for human influences. However, it does a reasonable job at modelling influenced flows. However, here we assess drought severity in near natural catchments, i.e. the natural variability, and as we allude to in the Discussion P25L27-31 further analysis is needed, however, in the revised version of the manuscript we will mention the need for inclusions of human influences (as well as groundwater) to assess the impact of droughts on water resources.

page6 line23 Would it be worth appending a list in the supplement of the 108 catchments shown in Figure 1? I found myself trying to work out which Anglian catchments were used and others may want to do the same in other parts of the UK..

If the editor feels it is appropriate we could add a list of catchments to the supplementary information. Additionally, there is a list of catchments in the metadata of Barker et al. (2018) which includes a flag as to whether they are in the Low Flow Benchmark Network, however this is the full 115 catchments, and without cross referencing with Smith et al. (2018) it would not be possible to establish which 7 catchments were excluded from this study (as they didn't meet the highest performance criteria as described by Smith et al. (2019)).

Figure 2. The Maximum Intensity appears be dimensioned in units of time. Should it be defined by say a horizontal dotted line from the lowest SSI point (-2) to the Y axis, plus a vertical line (with arrowheads at each end) from the dotted line to SSI zero line? The dimension would then be SSI.

We will adjust this figure in the revised paper to make it clear Maximum Intensity refers to the lowest SSI value within an event and does not have a time dimension.

page14 lines7-8 1989-90 was severe in East Anglia, particularly for groundwater. So are you saying '...with the latter being particularly severe for the 1990s as a whole'?

We will clarify this in the revised paper – we meant to say that in Anglian Region events ranked highly (and were therefore severe) in the 1990s. When looking at Fig S3b, events in the early half of the 1990s and late 1990s rank highly in terms of accumulated deficit.

Figure 6. Looking at Anglian region it is clear that use of different characteristics identifies different droughts i.e.1891-1910, 1920-22, 1975-6, 1990-92. Water resource modelling often shows that there is sometimes very little difference between major droughts when it comes to defining system yield for use in the supply-demand balance. If you

look at Fig. 10 of our 2015 paper you can see that simulated reservoir drawdown at Grafham was very similar for 4 droughts: 1920-1, 1933-4, 1944-7 and 1975-6. Tweaks to the WR model parameters, e.g. frequency of supply restrictions, have been shown to invoke one or other of these droughts as critical. The point I'm making is that only by simulating a WR system over the whole historic series (behavioural analysis) will the critical drought be found - I think you say this later in the paper!

Here we were concerned with which hydrological droughts were the most severe without the effect of management and without considering their impacts on water resources, society or the environment etc. We feel this is an important first step before impacts can be fully assessed. As you point out, we make this point later in the paper (P25L15-31). It would be an interesting next step to run the reconstructions through supply system models to assess the impact of these droughts on water supplies at the national scale.

page20 line11 better to stick with 'near natural catchments'?

Agreed, we will change this in the revised paper.

page22 lines5-6 we found 1989-92 to be the most severe in the north of the Anglian region, including the Lud catchment, not the whole region (2015 paper Table 2). It ranked only 9th for Alton in Suffolk. But as you point out: different method, different durations.

Apologies for this generalisation, we removed some of the detail at the last minute and we lost this clarification, we will make it clear this refers to the Lud only in the revised paper (which is the only catchment which overlaps between the two studies).

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page23 lines 6-10 1943-46 drought significant in west of Anglian region (2015 paper abstract and Table 2 for Grafham 24 months period)

In the revised paper we will add that 1943-1946 was identified as significant by Spraggs et al. (2015) here.

page24 lines12-13 Extending the hydrological series back from 1920 to 1800 did not introduce different critical droughts - they all remained post-1920 (2015 paper Table 3). It didn't change the approach or methodology, so could you delete 'approaches' and just say '...planning in particular water...'?

Thank you for pointing this out, we will remove 'approaches' in the revised manuscript.

page 24 lines17-21 Totally agree! I noted this in our 2015 paper Conclusions point 6.

Indeed, we can add a reference to Spraggs et al. (2015) here in the revised paper.

page 25 lines15-22 'non-stationarities in catchment response or land use change' may not be an issue for water resource planning. Current or projected future (planned) artificial catchment influences can be added to an extended naturalised series for use in water resource models. Catchment change etc. would of course be important for corroboration with documentary evidence.

We appreciate that historic changes in catchment response or land use change may not an issue for water resources planning, but as we state here, modelling approaches do not account for changes in land use etc. over time and as such it is an important caveat to make for the reconstructed flows as they may not fully represent the past. It is also an important reason as to why the maintenance of long-term records and the digitisation and rescue of data are of critical

importance for hydrology.

The first referee questions why the choice of 3 and 12 month SSI. From the water resources planning and management perspective longer droughts have been a concern, notably during the 2010-12 episode, with the ever increasing impact of global warming. So, although drought structure under a changing climate is conjectural, 24 and 36 month SSI would be interesting!

We will note the importance of longer accumulation periods for water resources (particularly in the south-east of England) in the discussion of the revised paper. We will also note that results and data for additional accumulation periods can be viewed in the UK Hydrological Drought Explorer (https://shiny-apps.ceh.ac.uk/hydro_drought_explorer/) in the revised paper on P24L25.

And a few typos:

Thank you for spotting these typos, we will correct them in the revised manuscript.

page2 line34 'quantify and understand'?
page8 line12 delete the ', they'
page 12 line20 you use the word 'record' when technically the earlier data is not recorded, so perhaps say 'period'? Anywhere else in paper?
page16 line14 'major droughts for'?
page17 line18 1890-1910
page17 line 21 'regularly'
page17 line29 At
page23 line19 Should it be Figure 5 or 7?

Kind regards, Gerry Spraggs

Thank you again for your very helpful comments Gerry, we will work these into the revised version of the manuscript.

References

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