Dear Reviewer,

We thank you for your review and constructive comments. We hope that you find our responses satisfactory to the points that you make. Our suggested response or actions are in italics.

1a) If the authors are trying to determine the presence of human influences on hydrological drought, they should know the natural or reference influence to drought, i.e., the base hydroclimatic and basin characteristics. The authors do a rigorous hydroclimatic analysis in the way that their "paired" basins are same in size, close to each other, have same PET values, same P values. They have no similar geological characteristics but the authors are aware of this.

However, even though as the authors suggest, finding completely natural basins is difficult, their "isolation of the human influence" is coarse and undocumented, without properly accounting for differences of land use and water use between basins and without considering all the land use and water use already existing in the "natural" catchments.

Groundwater abstraction is not the only human effect that can influence drought characteristics. Just by looking in google earth at the Dun River upstream of Hungeford, UK, I see a basin that is completely agricultural, with barely any patch of natural vegetation. Since land cover/use is a control of water partitioning and runoff (Sterling et al., 2013), I don't know how "natural" is this basin. Additionally, by a quick search in google earth, I see that the river is also completely regulated by embankments and check dams/levies from beginning to end. Since flow regulation alters the partitioning of water and hence runoff (Jaramillo and Destouni, 2015), your reference conditions in terms of intra-annual variability and quantity of flow are already altered by regulation.

This means that your natural catchments are already affected and not eligible for a paired analysis for the purpose you need them. I would look harder for other basins with no water use/regulation and more pristine land covers to represent the "natural" condition, in the UK or abroad. Articles such as (Dynesius and Nilsson, 1994; Jaramillo and Destouni, 2015; Lehner et al., 2011; Nilsson et al., 2005) could help. The Authors can also choose instead of a "paired" analysis of catchments a paired analysis of two groups of catchments, this would make the analysis more robust.

The reviewer makes an important comment about classifying the natural catchments as fully natural, and it has made us to reconsider the terminology used in our work to help represent this better. Whilst we fully agree with the reviewers comment, it is extremely difficult to find completely natural catchments that are similar enough to the influenced catchments. There are hardly any truly pristine catchments in the UK and most other regions across the world that are, headwater catchments, where there is no water use/regulation and pristine land cover. Furthermore, any pristine catchments are likely to be incomparable with the "human" catchments because of their different geology and climate. To address this, we propose to change the concept in our manuscript from a "natural" catchment, due to issues stated above, and instead refer to the catchment as "benchmark" to better represent this. We think that changing our terminology would strengthen the work introduced in this manuscript and show the representation and extent of human-influence better in a human-modified world.

In regards to the choice of the UK catchments – The Dun is one of the UK benchmark catchments (Harrigan et al., 2018), therefore it is considered as a "natural" catchment by the Centre for Hydrology and Ecology and we are confident in using it as a comparison pair. Crucially, the catchment does not need to be completely natural to be used in a paired catchment setting as long as you can isolate the influence you are interested in quantifying. Agriculture, land use and river regulation affects both catchments, so that if there is any influence this would be similar in both catchments and the comparison would still be valid. The main difference in the Kennet is the groundwater abstraction. Furthermore, in terms of the land cover/regulation on the River Dun, we argue that these factors have a minimal impact on low flows compared to climatic controls and water abstraction.

In regards to the choice of Australian catchments – we find that only the human-influenced catchment, Cox, has agriculture associated to it (Green et al., 2011): "The main land use in this region is a combination of grazing and dryland cropping with agriculture". Whereas, the benchmark catchment used, Cockburn, is described as "the area is mainly used for grazing with some dryland cropping and horticulture" (Green et al., 2011).

We propose adding some of these details about the catchments, their land uses and similarities into the revised paper to show this clearly, especially the change of terminology from "natural" catchment to "benchmark" catchment [information to be added to section 3.2].

1b) Furthermore, the authors say that one of the basins suffers from groundwater abstractions while the other one doesn't, at least, for the UK pair. There is no quantification of this, how much, where, since when ground water abstraction in the human affected basin? Any evidence that in the other basin there is no groundwater abstraction, are you sure of this?

The authors should check this for the Australian case too.

Unfortunately we do not have the exact numbers that can be shared for the groundwater abstractions (information protected by privacy laws). For the UK, there have been many reports focusing on abstractions on the River Kennet and sustained pressure from local groups to reduce groundwater abstractions in the region. We will expanding on our first sentence in section 3.2 to include some of this information below.

Since the early 1990s Thames Water have abstracted water from the borehole at Axford, Wiltshire (close to Hungerford), to supply homes and businesses in Swindon and the Kennet valley (http://www.riverkennet.org/campaigns/abstraction-at-axford). Groundwater abstraction amounts are quoted to be 13,100 m^3/day at Axford (https://utilityweek.co.uk/thames-waters-river-kennet-abstraction-to-fall/). "Over-abstraction – this applies particularly to the Axford where the adverse impacts of abstraction have been proven, and a solution agreed… There have been other reviews of abstraction impacts in the Kennet Valley, and the impact of over-abstraction is a localised but important issue. Groundwater – the groundwater status in the catchment is poor. This is because there is not always enough groundwater to keep surface waters flowing" (Kennet Catchment Management Plan, 2012, p.5). "Water abstraction to meet the increased demand for water from

urban expansion and increased living standards has reduced the flow in the river." (Kennet Catchment Management Plan, 2012, p.14)

For Australia, the human influenced catchment, Cox, Ivkovic et al. (2014) have shown that the catchment is subject to heavy groundwater abstractions. Annual aquifer abstraction rates are quoted to be 11245 ML/yr (Barrett, 2012), whereas annual aquifer abstraction licenses for Cockburn are 4481 ML/yr (O'Rourke, 2010). Please note that definitions may differ slightly between the two reports: O'Rourke (2010) might be quoting entitlements, which may be higher than actual abstractions.

2) Include some statistics of land use and water use in the Description of the area. Also, improve Figure 2, to show more information on each catchment.

We will provide more information about land use in both paired catchments (e.g. information given in response to the first point).

Figure 2 we aimed to keep the information simple and clear, therefore Figure 2 was designed to show the location of the paired catchments and the station information. Whilst the UK has some detailed information about land use and water use, the same level of information is not available for Australian discharge stations. Furthermore, land use data is much harder to access and to include because of the usually higher spatial variability than precipitation, PET and geology. We can endeavour to look further into the possibility of visualising land use information on Figure 2; or instead we can overlay either topography, precipitation or geology in the revised version to help give the best visual of the catchments. We will also look to zoom in closer on the two Australian catchments in the Australian insert. We are reluctant to include any data from national datasets because the resolution of data is not detailed enough for the catchment scale. This said, we will include land use in our Table 1 to show that it is a consideration for catchment selection.

3. The authors should put some statistical significance tests to support further their results.

Whilst this would be a useful suggestion, unfortunately there are not enough data points in our analysis for statistical significance tests. We believe that quantifying the percentage change due to the human influence for the overall drought characteristics and showing the basic descriptive statistics of average, maximum and total duration and deficit volumes already provides very relevant information. We considered doing an event-by-event based analysis, but that proved to be impossible, partly because the input data is different for both catchments leading to variations between events. Thus, taking a more holistic look at the average, maximum and total drought duration and deficit over the entire time series is the most robust, and scientifically acceptable, information that we can provide. To perform statistical significance tests we would need more (replicate) catchment pairs, which is beyond the scope of this paper.

So I like the idea, but a more thorough selection of catchments including land and water use conditions needs to be included in the study

Thanks for your summary of the review. We hope that we sufficiently addressed this under items 1 and 2. We believe that adding this information will help to provide the right level of detail for the reader, and the change of terminology from "natural" catchment to "benchmark" catchment will help to show how this approach works in the Anthropocene.

References

Green, D., Petrovic, J., Moss, P. & Burrell, M., 2011. Water resources and management overview: Namoi catchment, Sydney: NSW Office of Water.

Harrigan, S., Hannaford, J., Muchan, K., Marsh, T. J. 2018. Designation and trend analysis of the updated UK Benchmark Network of river flow stations: the UKBN2 dataset. Hydrology Research, 49(2): 552-567

Kennet Catchment Management Plan. 2012. Kennet Catchment Partnership, http://www.kennetcatchment.org/wp-content/uploads/2015/09/Kennet-Catchment-Plan-December-2012-revision-2.pdf

NSW, G. 2018. Department of Primary Industries: Office of Water. [Online] Available at: http://realtimedata.water.nsw.gov.au/water.stm

O'Rourke, M. 2010. Peel Valley Catchment; Groundwater Status Report – 2010, NSW Office of Water, Sydney

Barret, C. 2010. Upper Namoi Groundwater Source - Status Report 2011, NSW Office of Water, Sydney