

Hydrol. Earth Syst. Sci. Discuss., author comment AC1  
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## Reply on RC1

William Rust et al.

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Author comment on "The importance of non-stationary multiannual periodicities in the North Atlantic Oscillation index for forecasting water resource drought" by William Rust et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2021-572-AC1>, 2022

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We would like to thank Anonymous Referee #1 for their detailed review comments. We found them to be insightful, and, through our responses to them set out below, we believe that they have resulted in a much-improved paper. Below are the general and specific comments from Anonymous Referee #1, along with our responses to each comment.

**General Comment #1:** The record length looks like around 40 years on average, is it relatively short for periodicity analysis?

**Response to General Comment #1:** The continuous wavelet transform provides an instantaneous measure of periodicity strength within a time series and, as such, does not necessarily require data lengths that are multiple times longer than the periodicity being examined, unlike singular spectrum analysis, for example. We agree that this could be more clearly stated in the methodology section, and that caveats should be put into the discussion when considering the longer periodicities (for instance the ~ 16-year periodicity). However, the primary focus of this paper is the ~7.5 year periodicity, and given the typically 40 year record length and the instantaneous nature of the wavelet transform, we believe that the results and conclusions are valid.

**General Comment #2:** Many of the stations are located in heavily urbanized regions, which means they may have significant artificial influence such as ground and surface water abstraction, effluent return, river regulation, and impounding reservoir (introduce another layer of uncertainty on the top of observation uncertainty). By including or excluding these stations might give very different results.

**Response to General Comment #2:** Over the period of analysis there have been both changes in regulatory and water resource management practices and the latter will not have been applied in a consistent manner over all the catchments. Given this we might expect anthropogenic effects to add noise to the observations, but there is no reason to expect that they should impart a systematic signal or bias to the data and so systematically effect the observations or results. Counter to this, there is a precedent in literature for exacerbation of climatic cycles by anthropogenic processes which may affect the amplitude of the annual cycle (due to, for example, irrigation uses) but have less impact on multiannual cycles

We will add text to the discussion section to highlight both of these points, and further highlight that future work should be undertaken on near-natural catchments to compare

with the results here to better quantify the potential impacts of these processes.

**General Comment #3:** It might be better to integrate the results section and discussion section since they are closely interlinked.

**Response to General Comment #3:** Although there may be some benefit in integrating the results and discussion sections, we believe there is a considerable degree of digestion required of the results 'as a whole' in order to draw out the key discussion points, which might be lost or become unclear if these two sections were to be combined. We have therefore kept them separate.

**Specific Comment #1:** L2 (& L73-76): in the title, water resource extremes could be interpreted as flood AND drought, however, the paper only addressed drought. The title does not correctly reflect the contents of the paper.

**Response to Specific Comment #1:** We agree with this observation and propose changing "water resource extremes" in the title to "water resource drought". We also propose to remove the sentence addressing this between Lines 73 and 76.

**Specific Comment #2:** L16: 'particularly in Europe'? – this also applies to other regions as indicated in many literatures.

**Response to Comment #3:** We agree that this opening sentence is unclear and propose changing to "Drought forecasting and early warning systems for water resource extremes are increasingly important tools in water resource management in Europe, where increased population density and climate change are expected to place greater pressures on water supply"

**Specific Comment #4:** L159-161: might consider the UKBN dataset – a subset of NRFA stations that were considered near-natural with minimal human influence?

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.

OR might use Factors Affecting Runoff (F.A.R.) codes published on the NRFA website to exclude stations that have huge human influence?

<https://nrfa.ceh.ac.uk/content/catchment-summary-information>

**Response to Specific Comment #4:** We did consider using the UKBN dataset but the limited number of gauges (146) leaves regions of the UK with relatively sparse coverage. Furthermore, we anticipate, that while there may be some exacerbation of periodicity strength as a result of climate-induced abstractions, other processes such as effluent discharge or river regulation are likely to introduce noise to the data and not alter the frequency distribution. We do however acknowledge that this is not clear in the existing text and will add new text into the discussion to address the potential influence of anthropogenic activities.

**Specific Comment #5:** L168: the available period for NAOI is 1899-2021?

**Response to Specific Comment #5:** This is a typing error and will be corrected to 1899.

**Specific Comment #6:** L201: do you mean Eq.1 here? Please check the equation numbers throughout the paper.

**Response to Specific Comment #6:** We agree that line 201 is unclear and would propose to change this to "...methodology given by equation 5 from Peters (2003)"

**Specific Comment #7:** L232: what wavelet power can tell? Please clarify.

**Response to Specific Comment #7:** The power is used as an absolute measure of strength of the frequency spectrum, for ease of comparison across the continuous wavelet spectrum. We propose to add text in around Line 232 to explain the purpose of this absolute measure.

**Specific Comment #8:** L242: punctuation mark is missing.

**Response to Specific Comment #8:** This typing error will be corrected.

**Specific Comment #9:** L367: it's not clear why 7.5-year periodicity is selected here, though the reason was provided in section 5, could consider refining the paper structure.

**Response to Specific Comment #9:** Agreed. We will add text in at Line 367 to specify that the 7.5-year periodicity is dominant across the period assessed.

**Specific Comment #10:** L429 & 435: 'F' is not shown in Figures 2 and 3, and 'E' is not visible in Figure 3.

**Response to Specific Comment #10:** This figure will be corrected to ensure the 'E' and 'F' labels are visible

**Specific Comment #11:** L594: could you please justify why choose the summer season?

**Response to Specific Comment #11:** Summer months have been selected in order to best capture the driest part of water resources annual cycle across a broad range of water resource records assessed in the study. We agree that this could be better explained and we will add text to the methodology section to ensure this is clear.

**Specific Comment #12:** L669: are there any limitations of the work worth acknowledging?

**Response to Specific Comment #12:** Based on previous comments, we agree that more acknowledgement is required of the potential impacts of anthropogenic influence on the water resource records used. As such, we will add text to the discussion to highlight this.

**Specific Comment #13:** L699: CORD means Cranfield Online Research Data? Please provide the expanded form.

**Response to Specific Comment #13:** Agreed, we will add the expanded form of this acronym.