Hydrology and Earth System Sciences
Discussions

Hydrol. Earth Syst. Sci. Discuss., author comment AC2
https://doi.org/10.5194/hess-2021-572-AC2, 2022

Reply on RC2

William Rust et al.

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-AC2, 2022

We would like to thank Neil Macdonald 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 Neil Macdonald, along with our responses to each comment.

Comment #1: Greater clarity could be offered in the text in several places, the paper considers streamflow and groundwater series, not water resources, which includes additional data that are not discussed within the manuscript (e.g. lakes & reservoirs). In addition, it would be beneficial to be clear on the regional scope of the study, groundwater data from England (+Wales?) and streamflow data from the UK; in the abstract and conclusion inference is made to this being a European study, these need to be pulled back to UK, the clarity will help the reader.

Response to Comment #1: We agree that greater clarity is required when discussing water resources. We propose to add text to the introduction to make it clear that the water resources that are assessed and discussed throughout the paper are streamflow and groundwater, and not lakes and reservoirs.

Furthermore, we will add text to the introduction to make the regional scope of the study clear, i.e., that it is focusing on water resource in the UK, and we will adjust the text in the introduction and the conclusions to make it clear that this study fits into a wider European context but has only assessed data from the UK.

Comment #2: The study focuses on low flows, not droughts, nor extremes as no discussion of high flow events. This requires clarification throughout.

Response to Comment #2: We agree that more wording is needed as to our definition of droughts used in the paper, which will inform the use of the term drought throughout the paper.

We have specified at line 73- 76 that the paper is focusing on water resource extremes rather than hydrological extremes (with definitions given), however we agree that the methods of the paper focus on droughts. As such we will update the title and text to consider water resource droughts rather than extremes. The title has also been modified in response to comments from Reviewer #1.

Regarding seasonal low flows (or low levels in the case of groundwater), while we are undertaking an assessment on low-flow / level values, we are also assessing multi-year anomalies within these. As such, we are considering that multi-year below-average low flows are representative of hydrological drought. We agree that this aspect is not well addressed in the methods section, and we propose to add text here to improve this rationale.

Comment #3: Paragraph (lines 77-97) needs to make a clearer case for the relationship between NAO and streams/groundwater and multiannual periodicities, as the relationship between NAO and summer streamflow, when low flows are expected, is weak.

Response to Comment #3: We agree that more supporting literature could be included in this paragraph to better support the claims of a relationship between the NAO and low flows / droughts, at multiannual periodicities and how this differs from the annual-scale relationship. Additional text will be added to this paragraph to address this, along with improved supporting literature citations.

Comment #4: Aim and Objectives need revising, to reflect UK study, low flows not extremes and not studying European rainfall

Response to Comment #4: We agree that the aims and objectives could be clearer and more appropriate to the paper. As such we propose removing reference to "extremes" to focus on "droughts" (which will be previously defined), and reference to European rainfall will be removed.

Comment #5: In each case (streamflow and groundwater) 20-year series are included into the analysis, this study would be more robust if only longer series were included. 20 years is too short for multiannual analysis, consider >40 years.

Response to Comment #5: 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. We agree that this should be more clearly stated in the methodology section. However, the primary focus of this paper is the ~7.5 year periodicity, and given the 20-year minimum record length and the instantaneous nature of the wavelet transform, we believe that the results and conclusions are still valid.

Comment #6: You state there is no UK benchmark river flow series, there is, why not use this to overcome concerns you then note (https://doi.org/10.2166/nh.2017.058).

Response to Specific Comment #6: We did consider using the UKBN dataset, however since this represents 146 gauges this does leave some 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, these 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 text into the discussion to address the potential influence of anthropogenic activities.

Comment #7: typo on NAOI length line 168

Response to Comment #7: This will be corrected

Comment #8: The threshold sampling approach you apply does not identify droughts, but low flows. This might seem pedantic but is important. You need to present some indication of how many years are identified as low flow years for each station using this approach as low flow years.

Response to Comment #8: We agree that the distinction between low flows and droughts, in the case of streamflow, needs to be made clearer and text will be added to the methods section to address this. However, given general uncertainty in drought definition, we consider that the widely cited drought threshold methodology proposed in Peters (2003) is appropriate. In general, we are using this threshold approach to identify years in which streamflow are below a given threshold, and by extracting multiannual periodicities in this series, we identify multi-year periods of below-threshold streamflow.

Comment #9: I am concerned by the grouping of the results in section 4.1 together. We know that droughts are regionally coherent and often impact regions rather than the whole country, this will impact on low flows. There is also a skew towards stations of longer length and greater density in the SE with reducing length and frequency as you move north, this will skew your findings. This section would be much better if it was undertaken regionally, as you demonstrate the phased relationship to NAO for streamflow (Fig 5) is regionally highly variable. I actually think this is a really interesting section and further exploration of the regional low flow-NAO periodicity would be of interest and insightful, this could then be discussed further and would allow a more nuanced understanding to be garnered of regional patterns. You might expand the discussion of NAO track shifts too, based on the regionalisation, as the stronger consistent signal in north would suggest that that the change is consistent with that postulated by Comas-Bru & McDermott (2013). You can then assess whether the 7.5 years is consistent across regions. This is a key section and frames much of the rest of the results and discussion, as from this section you select the 7.5 year periodicity. Greater consistency is identified in groundwater-NAO phases, but this really only covers England, with a strong skew to SE again.

Response to Comment #9: We agree that splitting the streamflow spectra regionally would provide some very interesting results, however the intention of the figures 2 and 3 are to show general, wide-spread behaviours between the NAOI and the two water resource variables. Whereas the strength of the 7.5-year periodicities is explored in figure 7 for streamflow, and the regional assessment is undertaken from this figure in the discussion. The maximum and mean deviations of streamflow as a result of the 7.5 year periodicities are also reported in order to minimise any effect of varying record lengths between regions used in this study. Figure 1 does show that difference in regional record length is minimal, with the exception perhaps of Northern Ireland. Text will be added to the results section to make the purpose of these figures clear, as a measure of broad-scale water resource behaviour. Regarding the skew within the groundwater records (covering England and mostly the Chalk), we agree that there could be clearer text regarding the applicability of these results. As such cautionary text will be added to the discussion section to address this.

Regarding the influence of NAO track shifts, this is a well-made point and something that we have considered when preparing the discussion. However, as previous research has shown (Rust et al, 2021a), catchment processes affect a significant modulation on the strength of the 7-year periodicity in regional rainfall. As such, the signal presence in water resource records alone is insufficient to comment on regional NAO influences on meteorological variables, therefore we have not included this in the discussion.

References

Peters, E. Propagation of drought through groundwater systems - illustrated in the Pang (UK) and Upper-Guadiana (ES) catchments. Ph. D. thesis, Wageningen University. 2003

Rust, W., Cuthbert, M., Bloomfield, J., Corstanje, R., Howden, N., and Holman, I.: Exploring the role of hydrological pathways in modulating multi-annual climate teleconnection periodicities from UK rainfall to streamflow, Hydrol. Earth Syst. Sci., 25, 2223–2237, https://doi.org/10.1016/j.jhydrol.2014.05.052, 2021a.