Earth Syst. Sci. Data Discuss.,
https://doi.org/10.5194/essd-2019-57-AC2, 2019

Interactive comment on "Paleo-hydrologic reconstruction of 400 years of past flows at a weekly time step for major rivers of Western Canada" *by* Andrew R. Slaughter and Saman Razavi

Andrew R. Slaughter and Saman Razavi

a.slaughter@ru.ac.za

Received and published: 12 November 2019

Comment 1

"The authors use R2 to select the best MLR model. Did they consider possible over-parameterization and multicollinearity? Analyzing the standard errors and metrics such as information criteria (e.g. AIC) can identify the optimal models more reliably."

We first would like to thank the reviewer very much for his/her time and the constructive comments. The selection of the number of regressors are based on a former study with

the same data (Razavi et al. 2016) where Akaike Information Criterion was used. This limited the risk of over-parametrization and over-fitting. Of course, there is always some level of collinearity among the tree ring chronologies. We note that we also applied principal component analysis (PCA) to the tree-ring chronologies and compared the results of MLR with and without PCA (this comparison is not reported), but didn't find any noticeable difference. We will make sure that these points are clear in the revised manuscript.

Comment 2 "It is mentioned that "weekly flow distribution of the selected reference flow period can be used to construct the weekly flows". By doing so, the variability in the reconstructed flow will be similar to the reference flow variability, correct? Please discuss how/if this assumption can undermine the estimated variability of reconstructed flows? How does it account for possible recent trends due to the anthropogenic climate change effects?"

The reviewer brings up an important point with this comment. Given the nature of annual tree growth rings, the intra-year variability of flows cannot be determined from tree-ring reconstructed flows. It is assumed that the reconstructed weekly flows will contain the long-term inter-year variability of flows as represented in the tree-ring data, but intra-year variability will be based on the variability of the reference flow, scaled to the biennial reconstructed flow. From a water resources modelling perspective, this longer-term variability is arguably more important to represent than intra-year variability; for example, it would be persistent long-term droughts that challenge the robustness of water resource systems.

Comment 3 "The study focuses on matching the variation and persistence between the observed flow in the reference period and the reconstructed flow. I wonder whether historical/ recent physical processes could have distorted this similarity? For example, recent climate change trends are much stronger compared to the historical periods (prior to the reference period)"

The reviewer's comment here highlights an important potential confounding factor in the analysis. Indeed, with increasing snow melt under a warming climate, the underlying statistical properties of flow in a water tower-driven catchment such as the Saskatchewan River basin may indeed change considerably compared to the pre-reference period. However, since the reference period used ended in 2000, which is now almost 20 years ago, we must assume that the more recent climate change trends were absent or at least much weaker prior to the turn of the century. The paper has been adapted to highlight this important point.

Comment 4 “P5/L8: I suggest discussing briefly the cause(s) for persistence in tree-ring chronologies and based on that justify why the multi-year approach will overcome the problem. Related to this, how about the role of teleconnection signals, which can affect the records over multiple years.”

The persistence in the tree-ring chronologies is a mixture of the persistence in the climate signal and the biological carry-over effects of trees. The latter refers to the fact that, for example, trees can tolerate water shortage in a dry year and grow well if the preceding year was wet. This effect diminishes for a longer time scale. The study of Razavi et al. (2016) has showed this. The teleconnection signals typically occur in concert with precipitation in the region, and thus with water availability for tree growth. Therefore, tree-ring chronologies and their respective streamflow reconstructions should carry the teleconnection signals. We have included some discussion of this in the paper.

Comment 5 “P6/L15-16- It matches the first moment (i.e. the mean). How about higher moments like the variance?”

The author is referring to this sentence specifically: “The weekly distribution of flows in the selected biennial reference flow period is then used to construct the weekly flow reconstruction scaled to have the same biennial average as the original reconstructed biennial flow.” The author brings up an important point with this comment. As shown

in Fig. 5 and Fig. 6, the disaggregation approach used was successful in replicating the variance in the reference flow within the reconstructed flow. The variance of the weekly reconstructed flow was in fact assessed during the study to be similar to that of the reference flow. The paper has been adapted to make this finding more explicit.

Comment 6 “Figure 2, step 3- I wonder how much the yearly average is affected by seasonal variations? i.e. it is possible that larger flow values have the highest influence?”

The author makes an important point with this comment. At this point in the disaggregation, a relationship between the reconstructed flows and reference flows at a biennial scale is being made. Therefore, the seasonal variation at this point is not considered. We note that three rings provide no meaningful information on sub-annual variability. However, the influence of these much larger flows can be carried into the reconstructed weekly flows during step 4 in Figure 2.

Comment 7 onwards: “Technical corrections” “P2/L22- Please clarify the "effects of past climate change" as the anthropogenic effects are mainly observed after the 20th century. Related to this, the next line indicates “high long-term variability” of reconstructions, which should be mainly representative of internal variability”.

Earth has always experienced strong climate change effects in the past unrelated to anthropogenic effects. Of course these effects have been intensified in the Anthropocene. Please refer to for example to Cohn and Lins (2005) and Razavi et al. (2015).

Cohn, T. A., & Lins, H. F. (2005). Nature's style: Naturally trendy. Geophysical research letters, 32(23).

Comment 8 “P2/L32: Please remove “that must be confronted”

We thank the reviewer for this comment. We have adapted the paper as requested.

Comment 9 “P3/L2: Use either “streamflow” or “stream flow” throughout the paper.”

The paper has now been corrected in this regard.

Comment 10

"P3/L2: Is an R2 value of 0.76 low considering that it is based on an indirect estimate of streamflow?"

We thank the reviewer for bringing up this point. The sentence has been adapted to reflect mostly lower R2 values but some relatively strong relationships.

Comment 11

"P3/L23: What does "many uncertainties" imply? Large uncertainties or many sources of uncertainties? If the latter, please provide a few others and add references."

We implied the latter, and the manuscript will be adapted to include examples and citations.

Comment 12 "P5/L20: What are the chronology predictors?"

These refer to tree-ring stations used in the MLR models. The paper will be adapted to make this clearer.

Comment 13

"P6/L9-10- Statement is not clear"

We will ensure that this statement is re-written for improved clarity.

Comment 14

"P7/L6-7- I suggest rephrasing this statement for example "...smaller variability compared to...because of ...""

We appreciate the reviewer's suggestion and the paper will be corrected in this regard.

Comment 15

"P8/L7- the frequency of what?"

The reviewer highlights an error on our part. Since this is a flow duration curve and nota frequency curve, we should refer to duration and not frequency. We will correct this error in the paper.

Comment 16

"P8/L12- I think qstd should be in the denominator and qmean in the nominator" We will double check whether this equation is written correctly in the manuscript.

Comment 17

"Table 1- Please spell out the predictors before or after the table. How was the predictor selection performed? and how did the authors consider multicollinearity?"

We will ensure that the MLR equations are described more carefully. The selection of the number of regressors was based on a former study with the same data (Razavi et al. 2016) that used the Akaike Information Criterion, thereby limiting the risk of over-parametrization and over-fitting. We also applied PCA to the tree-ring chronologies and compared the results of MLR with and without PCA, but didn't find any noticeable difference.

Comment 18 "P15/L4- In the introduction, it is mentioned that one of the challenges of current approaches is the low R2 values (0.37–0.76). It implied that this issue was addressed in the study, however current results are within this range. Please clarify"

We thank the reviewer for highlighting this point. Our study did not aim to improve the regression fits within MLR models describing the relationships between tree-ring chronologies and naturalised flow. Rather, the paper introduces a method that firstly constructs these relationships between tree-ring chronologies and naturalised flow in a way that preserves persistence properties and variability of hydrological time series. Further, the study introduces a novel method of disaggregating biennial reconstructed flow to weekly flows. The uncertainty, firstly in the relationships between tree-ring chronologies and naturalised flow, and secondly within the disaggregation technique, is addressed through an ensemble approach, by producing a range of viable MLR models for individual catchments and multiple plausible flow time series within the disaggregation. We will ensure that this point is clear in our revised paper.

Interactive comment on Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2019-57, 2019.