

# Interactive comment on “Historical drought patterns over Canada and their relation to teleconnections” by Zilefac Elvis Asong et al.

**Anonymous Referee #1**

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We thank the reviewer for reviewing in detail our manuscript and providing extremely useful and constructive comments and insights especially on the data sources, uncertainties associated to PET estimation methods and the mechanisms/physical processes responsible for drought occurrence over Canada in response to different large-scale climate indices used in this study. Please find below our replies to comments and remarks. Comments are listed first (in black) followed by replies (in blue). Where appropriate, all changes in the revised manuscript are marked in blue.

**General comments:** This study conducted a nation-scale analysis of drought condition in Canada. With different techniques for spatial pattern and temporal trend, the trends and their teleconnection with large-scale atmospheric indices were presented. Overall, the paper is well structured and analyzed. It can be published subject to the following revisions.

Thank you for agreeing with our methodological framework and recommending that the manuscript be published subject to the following revisions.

**My major concern** is that this paper should add a section for discussion. The results should be compared with the other regions or countries since this is nation-scale study.

As you may notice we did combine the results and discussion under Section 3. This allowed us to present results and discuss particularities for easy understanding to a broader readership. In the last few paragraphs of this Section we give an overall discussion of the study, how the findings relate to previous studies as well as recommendations for future investigations.

The uncertainties related to the PET method and data sources should be discussed.

As recommended, we have added the following text to section 3.6: ‘In addition, only one PET estimation method was used in this study and its selection was constrained by data availability during the study period. We recommend the use of other simple or complex methods to calculate PET and assess their impact on drought analysis over Canada. In terms of data sources, the findings reported here should be validated against other data sets such as re-analysis products.’

The mechanism why the drought condition is related to large-scale atmospheric indices should be discussed. Please find detailed information from the specific comments.

We thank the reviewer for raising this important point. However, unraveling the teleconnection mechanisms that induce historical regional drought modes over Canada in response to, say, the Madden–Julian oscillation (MJO) and Rossby wave train was beyond the scope of this study. It would be interesting to investigate such mechanisms and how they contribute to the onset, growth, persistence, propagation and termination of drought events.

**Specific comments:** It is better to change the title as ‘Historical drought patterns over Canada and their teleconnections with...’

We have changed the title to ‘Historical drought patterns over Canada and their teleconnections with large-scale climate signals’

The way the authors describe the importance of this study should be changed. If you always emphasize that the important part of this study is to analyze Canada, it will be regarded as a regional study. Contributions to the scientific community should be highlighted. For example, cold and arid region hydrology under the background of global warming, this is a good topic.

We acknowledge the fact that it is important to illustrate this work through the lens of the international scientific community. You may have noticed that we started the introduction by discussing drought from a global perspective, then narrowing the study to Canada, one of the core cold regions on which this Special Issue is based. Nonetheless, we have other manuscripts being prepared (for this Special Issue) that address the concerns due to global warming and place cold regions hydrology within the international scientific and climate change context.

The method used to calculate PET probably influences the estimated drought condition since SPEI is the difference between P and PET. In general, the Hargreaves method used in this study underestimates PET compared with the PM method. The authors should realize and discuss the potential impacts from the method selection.

Thank you. We have now added the following text to the end of section 3.6:

‘In addition, only one PET estimation method was used in this study and its selection was constrained by data availability during the study period. We recommend the use of other simple or complex methods to calculate PET and assess their impact on drought analysis over Canada since the Hargreaves method is known to underestimate PET relative to Penman–Monteith method (McMahon et al., 2013). In terms of data sources, the findings reported here should be validated against other data sets such as re-analysis products.’

Section 2.4 to 2.6. It is not necessary to give details about these methods since they are very popular. They can be combined into one section to say how you are going to use them.

To ensure the paper is standalone, we have summarized how we used these methods under various sections. You will notice that little has been said about the actual mathematical/statistical derivations behind the methods.

The drought conditions are closely related to large-scale atmospheric indices. Why? It is better to present some mechanism for these relationships.

In Line 97 and thereafter, we have reviewed some of the relationships that have been found between hydroclimate variability and teleconnections over North America. As indicated earlier, however, unraveling the teleconnection mechanisms that induce historical regional drought modes over Canada in response to, say, the Madden–Julian oscillation (MJO), and Rossby wave train was beyond the scope of this study. However, much effort has been put into this area of research across Canada. For example,

Li, Z., Li, Y., Bonsal, B., Manson, A. H., and Scaff, L.: Combined Impacts of ENSO and MJO on the 2015 Growing Season Drought over the Canadian Prairies, *Hydrol. Earth Syst. Sci. Discuss.*, <https://doi.org/10.5194/hess-2018-56>, in review, 2018

Szeto, K., X. Zhang, R.E. White, and J. Brimelow, 2016: The 2015 Extreme Drought in Western Canada. *Bull. Amer. Meteor. Soc.*, **97**, S42–S46, <https://doi.org/10.1175/BAMS-D-16-0147.1>

The authors used two data sources, what are the differences for the results? What would you recommend for data selection?

As this is a very important issue, the last paragraph of the 'Summary and conclusions' Section:

'The foregoing analysis has indicated the need to consider various observational data sets in drought characterization, given the uncertainty in data. In terms of trends, the ANUSPLIN data set indicated a higher tendency for drought over the study period relative to CANGRD. Furthermore, irrespective of the time scale of accumulation, ANUSPLIN tends to reveal more drought severity compared to CANGRD although the correlation between the time series of the two data sets from each of the homogenous drought sub-regions is very strong. Therefore, further applications using other gridded data sets to verify the role played by the spatial resolution of the input data on regional drought patterns are recommended'

We concluded based on findings in this study that ANUSPLIN tends to reveal more drought severity relative to CANGRD and recommend the validation of these results against other gridded estimates such as re-analysis products.

Thank you.