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Interactive comment on "Watershed classification for the Canadian prairie" *by* Jared D. Wolfe et al.

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General response

We would like to thank the three reviewers for their insights on our manuscript. Many of the suggestions were constructive and will contribute towards building a stronger study. A few comments were shared among the reviewers. These shared comments were: (1) utilizing observed data more effectively to evaluate potential differences in class hydrological response, (2) elaborating on the new knowledge gained from the current study, and in particular the relevance to an international audience, and (3) increase detail on the methods and evaluation of the CCA. We summarize how we will address these common comments here, and provide additional responses to each individual reviewer in the sections that follow.

Specifically, we will consider the appropriate use of available independent data to eval-

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uate the separation among our clusters, and potentially resampling approaches to assess class membership. We must emphasize, however, that previous attempts to establish, or validate classes based on measures of streamflow data suffer real limitations due to the hydrological setting with the Prairies, which features a wetland-dominated landscape and spill-fill dynamics. Alternatives to streamflow data are sparse or non-existent, and this scarcity is central to the motivation of our study. We seek to differentiate among watersheds within the Prairie and to do so in a way that connects to decision-making at local scales, as explained in our Introduction. However, with recognition of these limitations, we believe that independent assessment of the classes (Reviewer 2) will strengthen our approach. Expanding on Figure 8 is one way to address the concern. We will re-evaluate how we can use observed hydrometric data and the across class patterns.

Regarding international relevance, we can place more emphasis on the use of our classification for serving as a basis more parametrizing hydrological models that provide insight into hydrological response on a more localized (100km2) scale than what is given by ecoregions (see response to Referee #1). Highlighting how our approach addresses these concerns will also emphasize “new knowledge” provided by our work to an international audience, especially to arid regions that might face similar challenges where stream networks are not well-developed.

Technical questions related to the Canonical Correlation Analysis are outlined in our responses to Referee #1 and #3. We will clarify the use of the “study watersheds” and associated observed data to the CCA. We can also provide justification for the inclusion of this procedure in our analysis, in turn providing added detail to our methods.

Response to Referee #1 - Summary

We thank Referee #1 for their helpful comments on our manuscript. We respond to the suggestions individually below and where appropriate, we indicate how we intend to enhance clarification in the text. In the summary, we address three key comments

from Referee #1: (1) reflecting ecoregions in the Prairies as units for eco-hydrological response, (2) clarification on datasets used, and (3) utilization of the 11 watershed for comparison to classes.

Referee #1 drew attention to the past use of ecoregions as units to describe regional eco-hydrology. In particular, they ask how the present study offers new insight. Our analysis provides a quantitative approach that evaluates physio-geographical variables of watersheds and the organization of smaller scale watersheds into broader arrangements (i.e., classes). Although some class boundaries might align with those of ecoregions, others do not. In addition, we sought to identify watersheds that exhibit similar characteristics, or classes, that are transferable across the Prairies. Here, we summarize 7 classes based on watershed areas of $\sim$100km2, which is a finer scale than that offered by ecoregions. We also include additional information that are not incorporated in ecoregion classification, such as wetland size distribution parameters and tillage practices, which directly affect hydrological dynamics of Prairie watersheds. However, we recognize comparing ecoregions to our findings, particularly the spatial extent, can provide geographical context for international audiences, as well as offer the opportunity to discuss our approach in the context of ecoregions, which are used across disciplines. We intend to amend the Discussion to include pertinent references, as well as perhaps provide a visual representation of local ecoregions (e.g., additional figure or amend Figure 1). We can also emphasize the use of our classification as serving as a basis more parametrizing hydrological models that provide insight into hydrological response on a more localized (100km2) scale, which is more relevant to managers working at this spatial extent.

Referee #1 asked for added clarification in our descriptions of surficial geology (Line 205) and soil zone (Line 208) datasets. We appreciate the reviewer's insights and believe added detail here will strengthen our manuscript. Amelioration among surficial geology definitions was performed by grouping more defined classification into broader categories describing depositional features. Grouping was performed by com-

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paring definition of each feature type using the provincial government metadata and informed by advice from a colleague in geology. We acknowledge that these are broad groupings and working with a framework used coherently across the provinces would be ideal. However, for our current purposes, these broad descriptions were useful in capturing a variation across at least broad geological settings. In addition, it is true that hummocky landforms are associated with glacial till deposits (Line 412). However, the landforms dataset describes forms that include aspects of surficial geology, relief, among others. Therefore the two datasets are related. We feel that both datasets offer information on local geography. The hummocky landform designation is particularly useful for characterizing landscape influences on depressional storage and overland flow.

In regards to soil zones, we recognize that the “colour” is only a descriptor and the function of the soils are different among soils types. Importantly, soils develop under specific climatic conditions, geology, and vegetation, and these considerations are implicit in the data that we used. We will add clarification to the sentence, and elsewhere as appropriate, to elaborate that these data extend beyond just “colour”. We also note that soil texture class was also used to describe soil characteristics.

We appreciate the suggestion for utilizing observed data more effectively within our study. In particular, Referee #1 references the “11 study watershed”. We note the “study watersheds” in Line 473 is misleading. Here, we are referring collectively to the 4100+ watersheds used in the clustering analysis. However, the 11 streamflow stations were only used in the CCA. We will edit the sentence for clarity, and we will consider how we might incorporate observed data to compare the identified classes. An issue using observed data is that the reference watersheds do not necessarily compare to our scale, and the premise of the approach of our study is based on the limitations of previous approaches. The 11 stations are those with good quality streamflow data, while they are also at a scale that is not completely representative of prairie watersheds. In particular, the stations to not represent those watersheds not connected to

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well-drained, stream-dominated systems, such as Interior Grasslands class. In these cases, the 11 stations would not be an appropriate comparison. We can therefore try to seek alternatives to providing an example of the hydrological behaviour or differences among classes. We can utilize more remotely-sensed wetland data (as shown in Fig. 8) or jack-knife approaches to evaluating watershed class membership. We will evaluate the benefits of potential alternatives as we revise our manuscript and consider the three reviewer comments.

Finally, we appreciate the technical suggestions given by Referee #1. We will incorporate these edits into our manuscript.

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