

## ***Interactive comment on “Summary and synthesis of Changing Cold Regions Network (CCRN) research in the interior of western Canada – Part 2: Future change in cryosphere, vegetation, and hydrology” by Chris M. DeBeer et al.***

**Francesco Avanzi (Referee)**

francesco.avanzi@cimafoundation.org

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DeBeer et al present an exhaustive overview of future changes to the Critical Zone of NW Canada based on an interdisciplinary initiative, the Changing Cold Regions Network (CCRN). This overview comprises a rather detailed discussion of mechanisms driving impacts of a changing climate on precipitation, evapotranspiration, vegetation distribution and type, snow and ice accumulation and melt, and sub-surface water recharge, among others. The paper also describes advances made by CCRN in terms of new modeling approaches, and ultimately summarizes predicted future changes

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based on the gained new understanding and the improved models.

I concur with the other Reviewer that this is an interesting, substantial, and well written manuscript. Despite having only tangential knowledge of Canadian hydrology and more in general of high-latitude processes, I was able to follow the main line of reasoning with only occasional need for clarifications (see below). Thus, I recommend the editor to accept this paper after minor revisions, as outlined below.

### GENERAL COMMENTS

1. According to HESS guidelines, a review paper should "summarize the status of knowledge and outline future directions of research within the journal scope" ([https://www.hydrology-and-earth-system-sciences.net/about/manuscript\\_types.html](https://www.hydrology-and-earth-system-sciences.net/about/manuscript_types.html)). The paper is excellent in the way it summarizes the status of knowledge, but I think it would be even a more substantial contribution to the current literature if it included a specific section on future directions of research. What is left to understand after the substantial – and unifying – contribution provided by CCRN? Are there significant knowledge gaps that authors would recommend for future initiatives? Some of these knowledge gaps are already mentioned throughout the manuscript, but being more explicit on this in a dedicated section would sharpen the message of the paper and further enhance its impact.
2. I was intrigued by the following statement in the abstract and somewhere else in the main text: "It is essential to consider the underlying processes and base predictive models on the proper physics, especially under conditions of non-stationarity where the past is no longer a reliable guide to the future and system trajectories can be unexpected." I can only agree with this statement, as it points to the recurring hypothesis that improving process representation in models will ultimately translate into increased realism and performance. While this may appear axiomatic, in fact issues with equifinality and conceptual uncertainty in hydrology have often challenged this hypothesis. So I was wondering if authors could enrich their section about modeling improvements

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with some examples of cases when they related model failure to its failure to consider underlying processes, and possibly examples of cases when they succeeded in improving model performance by increasing its realism based on the numerous study plots and datasets they have collected. From a modeling point of view, doing so would add another compelling argument to this paper.

3. Relatedly, section 4 could be enriched by one paragraph discussing performance of these models for the current climate, given that the following Section 5 discusses future scenarios based on this modeling (is my understanding correct?).

#### SPECIFIC COMMENTS

- line 25 page 2: what do you mean with "freshwater ice cover"?

- line 41 page 2: see general comment 1

- line 21 page 4: maybe report some statistics here to give an idea of aridity?

- line 12-13 page 8: I missed an explanation of why in the Arctic earlier AND FASTER melt is predicted.

- Line 26ff page 8: rising temperatures may also alter the way long-wave radiation delays - or accelerates - melt (<https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/wrcr.20504>). Consider including this in details as you did at line 48 for shrub.

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