

Interactive comment on “Invited Perspective: What Lies Beneath a Changing Arctic?” by Jeffrey M. McKenzie et al.

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The paper by McKenzie and co-authors brings together leaders in cryohydrogeology to provide an invited perspective on how thawing permafrost will influence groundwater in cold regions. They touch on a number of key issues and then present recommendations for future research. Perspective papers are always worthwhile, as it makes the reader reflect on the opinions expressed and more thoughtfully consider issues that may have been ignored by the broader community. They argue that cryohydrogeology should be included more in transdisciplinary research initiatives. Very fair.

There is little doubt that groundwater is a critical aspect for understanding hydrological and chemical change in permafrost regions as the world warms. The authors state

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that it has been limited work in the past decade (line 114), but the issue of permafrost thaw and changes to groundwater has in fact been of interest for many decades now, and while cryohydrogeology is a new term, Van Everdingen, Michel, and others made strong advances in this field over three decades ago. Ultimately, and I agree with the authors, very few people actually study northern groundwater. In contrast to ecological studies in the north, there has not been an 'explosion' of research in hydrogeology (or hydrology for that matter), and in some ways this has deprived earth system modellers and others of a more nuanced understanding of change.

I very much enjoyed reading this article. There have been good review articles on this topic, yet this one is more of an 'agenda setting' document which is nice. That said, and in the spirit of discussion, I have a number of comments that I would like the authors to consider. Perhaps they believe they are out of scope, but this is simply what came to mind after reading the manuscript several times.

+ Is it important to mention that other changes, notably precipitation phase, rate and timing may influence baseflow? This along with the unknown effects of vegetation change? People have long argued that thawing permafrost influences baseflow (of course), but are there other mechanisms that can explain some of this?

+ The authors indicate that earth system models (largely land surface models with biogeochemical processes included) ignore cryohydrogeology. This is largely true! However, cryohydrogeology models largely ignore land surface and biogeochemical processes (particularly with regard to carbon). Surely it is not just the ESM's fault here. Parameterization and incorporation of processes into larger ESM are often incongruent with the granularity that hydrogeological models operate. My comment here is that is this really someone ignoring the issue or not having appropriate tools/guidance on how to address it?

+ Similarly, there are hydrogeological models that ignore freezing/thawing processes that are widely used. This group is well aware of this as they are associated with inter

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comparison projects.

+ There is a recent LSM-based paper (Teuful and Sushama 2019) that discusses infrastructure and permafrost thaw. I am curious as to why it is not included on the list? Is it because the LSM largely simulates something that has never been seen and permafrost scientists do not believe the results? This of course reveals my bias for field investigations to advance our understanding of processes. I am often bemused by LSM outputs with sweeping and startling results that are often model artifacts.

+ Would it be helpful to define Arctic? Simply because the issues discussed here are perhaps even more pressing in the subarctic.

+ On Line 85 you state 'rapidly changing groundwater conditions'. Can the authors give an indication of how rapid is rapid? Climate is changing rapidly which immediately affects surface hydrology - can an indication of 'how far behind' the subsurface is be touched upon.

I fully recommend this paper to be published in The Cryosphere. The comments above simply reflect my thoughts upon reading the manuscript and are meant to 'prod' the authors a bit.

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