Changing characteristics of runoff and freshwater export from watersheds draining northern Alaska

Michael Rawlins *et al*.

Rawlins *et al*. have submitted a revised version of a manuscript previously submitted to The Cryosphere. The authors present a modified version of the Pan-Arctic Water Balance Model to include better representation for freeze-thaw processes and to dynamically simulate the insulative properties of a snowpack, both of which are important cold region hydrological processes. The updated version of the model is presented as the Permafrost Water Balance Model (PWBM v3). A major concern among reviewers of the initial version was the lack of model validation with observation data. In the revised version, the authors have included model validation for an additional river (Colville). The authors proceed to use PWBM v3 to simulate runoff over a 30 year (1981-2010) period and use those results to discuss hydrological changes in northern Alaska.

I feel that this manuscript has been improved significantly over the original version and commend the authors on the effort that has been put into the revisions. This manuscript highlights major hydrological changes that are occurring in northern rivers, especially during the winter months and is an important contribution to the hydrological community. I recommend publication following the suggestions outlined below.

Model Validation:

Although improvements to this section have been made, there is still uncertainty as to how the model performs. Given the errors in timing of the spring freshet between observed and simulated runoff in the Kuparuk River, reviewers suggested including additional model validation. The authors have included the Colville River, but these data depict large errors in the volume of summer runoff (rationale is provided by the authors on lines 600-605). The authors have not included model evaluation metrics (although rationale for omitting them is given) leaving average error, correlation, and visual interpretation of the hydrographs as the only ways to assess model performance. I would like to see model performance (simulated vs observed) plotted for individual years instead of aggregated over large time periods (9 and 30 years for Colville and Kuparuk respectively). This would allow the reader to assess how the model performs in response to individual events. A suggestion would be a figure similar to Figure 6a and b in Krogh *et al*., (2017).

Minor comments (note: line numbers are associated with the revised version that documents changes from previous version):

125-129: The additional information on observed snow survey data is appreciated. I suggest the authors include an additional sentence briefly outlining the basic methodology used in Stuefer *et al*., 2013 (*e.g.* SWE data were collected using depth-integrated density and snow depth measurements across 50 m snow survey transects at a ratio of 10:1 depth to density measurements.)

330-334: If simulated runoff is more conservative (lower variability), it does not follow that the model would over-estimate when runoff is high and underestimate when runoff is low. Would this not imply that the maximum simulated values should be higher than the observed maximum values and the lowest simulated values should be lower than the observed values?

558-560: I would suggest including a sentence discussing possible subsurface flow through taliks in continuous permafrost as a possible routing mechanism arising from permafrost thaw.

594-595: Can you briefly describe the characteristics of the basins showing the shifts to earlier discharge? If the date of maximum discharge across the entire basin is only marginally significant, and there are significant increases in some sub-basins, then it would follow that there would be no change in other sub-basins. It would also be worth including other relevant literature in this discussion (*e.g.* Shi *et al*., 2015 found a delay in spring discharge timing in the western Canadian Arctic). An expansion to this part of the discussion would better frame the results of this study within the context of the literature.

References:

Krogh, S.A., Pomeroy, J.W., & Marsh, P. (2017). Diagnosis of the hydrology of a small Arctic basin at the tundra-taiga transition using a physically based hydrological model, *Journal of Hydrology*, 550: 685-703, doi: 10.1016/j.hydrol.2017.05.042.

Shi, X., Marsh, P., & Yang, D. (2015). Warming spring air temperatures, but delayed spring streamflow in an Arctic headwater basin, *Environmental Research Letters*, 064003, doi: 10.1088/1748-9326/10/6/064003.