Title: Changing Characteristics of Runoff and Freshwater Export From Watersheds Draining Northern Alaska

Authors: Michael A. Rawlins et al.

General Comments:

This paper evaluates how discharge (surface/subsurface flow) and active layer thaw is changing across the North Slope of Alaska and NW Canada. It uses a detailed permafrost water balance model to simulate flow and examine changes in the active layer across 42 catchments in this continuous permafrost area. Overall the objectives of the paper are clearly outlined**.** Model performance is compared with measured runoff data, namely the Kuparak watershed. The authors' model was not able to capture large discharge peaks and time of simulated spring snowmelt runoff was 10 days earlier than observed estimates. Overall, the authors provide adequate explanation for model inconsistencies, and indicate that better performance may be tied to an improved understanding of lag effects (e.g. antecedent moisture conditions), landscape micro-topography (surface storage), soil type and soil organic content. They also demonstrate that large tracts of the North Slope area are thawing, which is leading to slightly higher cold season discharge, and earlier snowmelt ~ 4 days. They link their modelled and observed results to recent arctic discharge and groundwater flow studies occurring elsewhere (e.g. Middle Lena Basin) and biogeochemistry. Overall, this paper is interesting and furthers our understanding of runoff and ground thaw changes across the Alaskan North Slope and NW Canada. The paper could be improved by a model flow-chart and further details on model parameter choices (e.g. effective velocity) (please see below for further comments).

Specific Comments:

1) Line 28. Do you mean in 24 of 42 study basins? Also, it would be worthwhile to have a table of the 42 study basins describing basin areas, elevation range and locations (latitude/longitude). Perhaps, this site information could be placed into a Supplementary Table or an Appendix.

2) Line 38. Can you add subsurface flow to the list of keywords.

3) Line 76. Do you mean increased hydrological connectivity instead of hydrological conductivity? If the ground thaws, then the flow of water further down in the active layer is usually much slower than it is in the near surface or when the active layer is frozen, and overland flow occurs.

4) Line 98. You can just put NW Canada.

5) Line 104. Just put NW Canada. Please take out extreme, and also just use NW, instead of northwest, since you used NW in Line 98.

6) Line 106. In your map, please indicate some major communities: Utqiakvik, Prudoe Bay (or Sagavanirktok) and perhaps a Canadian northern community too.

7) Line 107. Again, it would be good to have a list of these 42 watersheds, particularly information on their catchment size, location of outlets and source for discharge information (e.g. USGS, Water Survey of Canada), etc.

8) Line 180. Could you clarify what you mean by 'transient ponded surface evaporation'?

9) Lines 197-198. I don't understand what you mean by …. 'Following initial assessments we increased soil carbon amounts by 10% in areas of sandy soils….' Was this based on model runs or on the research from Nicolsky et al. (2017). Please clarify-thank you!

10) Lines 204-209. I don't understand what you are doing in lines 204-209. Can you provide more details for adjusting evaporation and runoff functions?

11) Line 219. It is not clear why you set the effective velocity at 0.175. Can you provide additional justification here for this parameter?

12) Lines 256-268. Interesting that simulated freshet leads observed freshet by 10 days, indicating that your snowmelt routine and routing are likely too fast. Does your snowmelt routine take into account a snowpack cold content, which can slow down melt progression? Along stream channels does your model account for the effects of channel snow or snow dams, which can pond meltwater and slow down runoff? Small terrestrial ponds can open up quickly too during snowmelt, and can retain much overland flow, especially if they have sufficient storage (low snow year, or antecedent storage conditions). I do realize that you mentioned lag effects in the system but a 10 day spread in modelled versus simulated results appears to be on the high side.

13) Line 296. Is cold season discharge simulated for the basins? It was not clear to me whether these data were modelled or measured. Low flows can have large uncertainties due to the ice cover, so how confident are you in these results?

14) Lines 342-343. I don't have access to Figure S6. Could this supplementary figure be added to the paper?

15) Lines 352-353. What is going on in the one basin where you see a large shift in maximum peak discharge?

16) Line 365. I think that 'Arctic' should be arctic here.

17) Line 370. Can you clarify what you mean by 'insufficient surface storages in the mode'? Do you mean pond storage, or depression storage arising from hummock/hollow micro-topography?

18) Lines 371-372. Yes, I agree. You need to improve your surface storage sub-routine, especially if you are losing near-surface ground ice, as your landscape micro-topography is probably evolving.

19) Lines 402-406. Can you clarify your statement about the role of permafrost and the link between your study and that of the Lena River. It wasn't quite clear to me, even after I read the Gautier et al. (2018) paper. They appeared to indicate that the size of the spring freshet was more important in controlling the maximum and minimum ratio rather than an increase in fall groundwater flow.

20) Line 424. It should be 'exert'

Technical Corrections:

1) Check over references. Some of the titles have all caps, others not. Some of the page numbers for recent journal articles should be double checked.

2) Table 1. Figure S2 indicated in the Figure title is not available. I did not have access to it or it is missing.

3) Table 2. You may as well list the details for all 42 catchments.

4) Figure 1. Can you add the air temperature to Figure 1, and can you show the ratio of snow to rainfall in the bar diagram for precipitation.

5) Figure 4. Is this modelled discharge or observed discharge. Perhaps, clarify in the figure title-thank you!

6) A flow chart of your permafrost water balance model would be most helpful.