GMD Review Response – Reviewer #1

The manuscript titled "Runoff Evaluation in an Earth System Land Model for Permafrost Regions" proposes a new framework using ATS simulations to optimize runoff coefficients, offering a more physically based alternative to traditional parameterizations in Earth system land models. Furthermore, the study explores the potential transferability of the optimized runoff coefficients across different Arctic watersheds. This work presents methodological innovations that are valuable for improving runoff simulation in permafrost-affected regions and holds implications for enhancing water resource management in high-latitude environments.

The manuscript is generally well-written, and contributes meaningfully to the field. However, there are several issues that should be addressed to improve the clarity and precision of the manuscript. I therefore recommend the manuscript a minor revision, by considering some comments and questions posed below.

Response: Thank you for taking the time to review our paper.

While the study proposes a broadly applicable framework, the current analysis is limited to only two watersheds in Alaska: the Sagavanirktok (Sag) River Basin and the Teller watershed. Given this limited spatial extent, the current title may overstate the geographic generalizability. A more precise title such as "Runoff evaluation of an Earth System land model in the permafrost region of Alaska" would better reflect the study's current scope.

Response: Thank you. We have adjusted the paper's title as follows: "Runoff Evaluation in an Earth System Land Model for Permafrost Regions in Alaska"

Please correct the unit formatting on Line 316: "km2" should be changed to "km^2" (with superscript).

Response: Thank you. We have corrected this typographic error.

Figure 6 attempts to illustrate the effect of changes in soil physical properties and snow thermal conductivity on runoff simulations within the ELM model. However, the current visualization makes it difficult for readers to extract meaningful comparisons. Consider redesigning the figure to improve visual clarity. For example, using grouped bars or difference plots to highlight contrasts between scenarios.

Response: We agree, and we have revised Figure 6 significantly in response (see below). In the caption of Figure 6, we now highlight that the barplot is showing the modeled (ELM) values, and the y axis is common for both modeled (histogram) and the observed Teller data (dashed line).

We added a Supplement to the paper with each year for Figure 6 shown in a separate panel (see below).

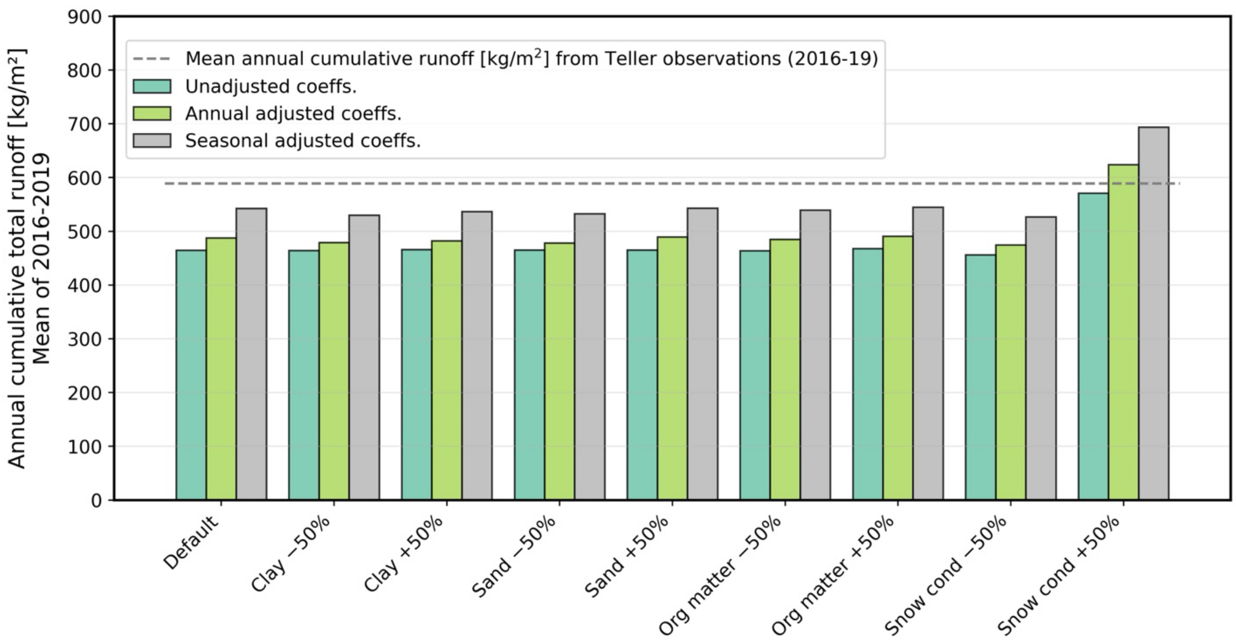

Figure R1.1. Revised Figure 6 from the article.

The new Figure 6 caption is as follows: Variations in annual cumulative total runoff from ELM simulations at the Teller27 watershed, Alaska for the mean of all years (2016-2019). Different bars groupings along the x-axis illustrate scenarios where parameters are reduced or increased from their default average values in ELM's soil physical property and snow thermal conductivity. Bar colours represent results with unadjusted coefficients (teal), annually adjusted coefficients (green), and seasonally adjusted coefficients (grey). The mean annual cumulative runoff from Teller observations (mean all years 2016-2019) is given in the dashed line.

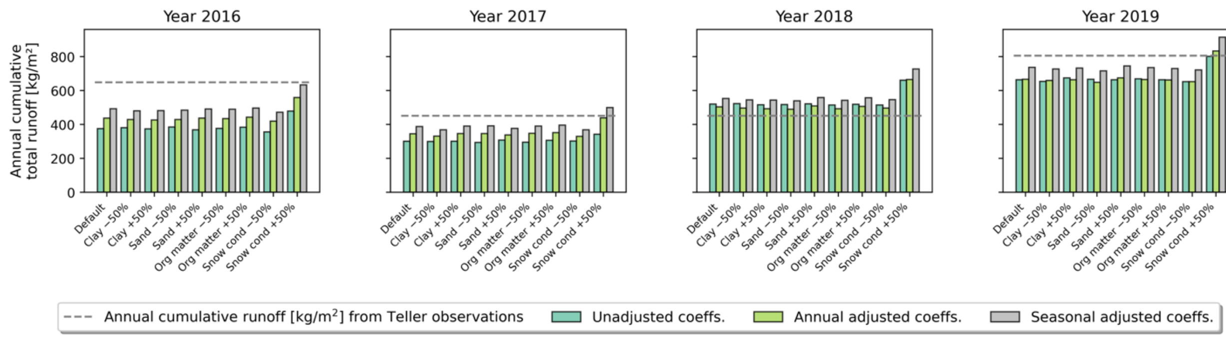

Figure R1.1. Revised Figure 6 from the article that will be included in a Supplement.

In Figure 7a, the legend partially obstructs key elements of the plot. Since subplots 7a and 7b share the same legend, a common external legend (e.g., placed to the right of the panel or beneath both subplots) would declutter the figures and enhance readability.

Response: Also agreed on this point. We have adjusted Figure 7 as you suggest.

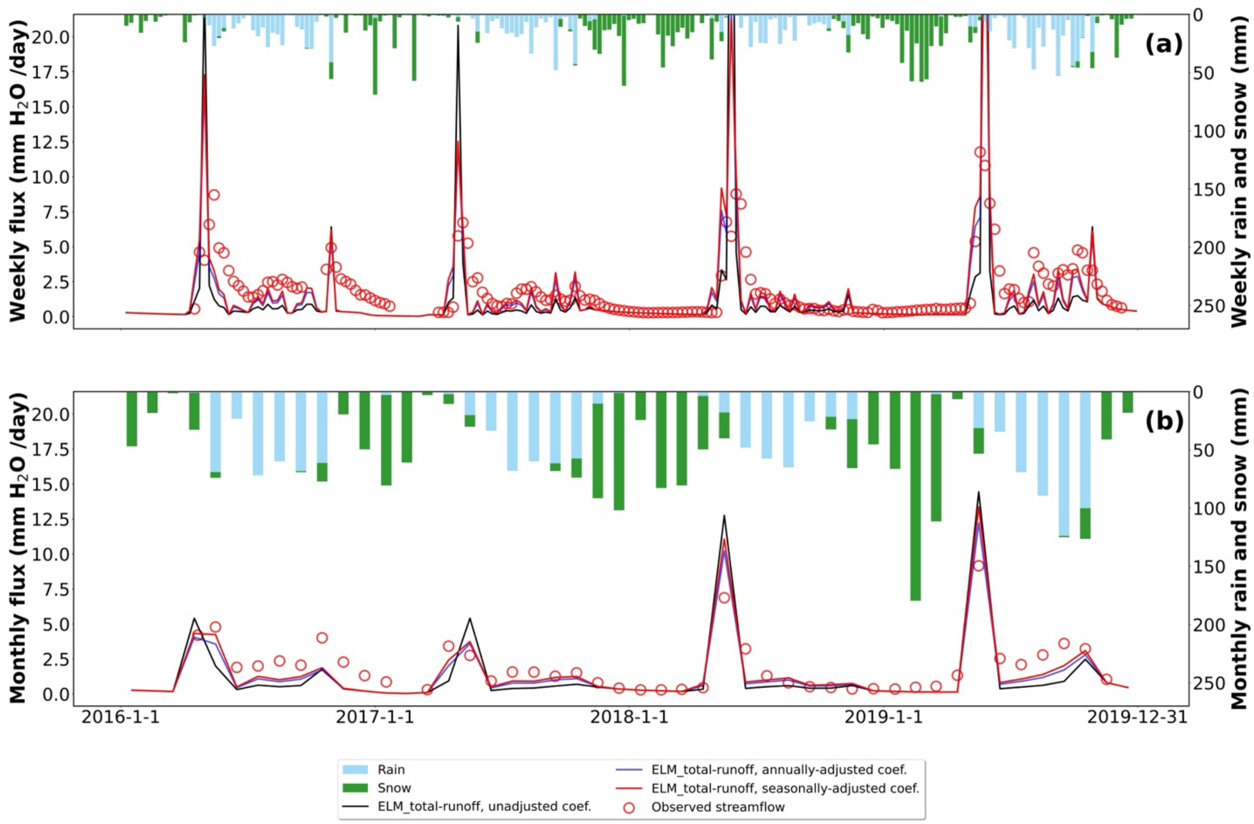

Figure R1.3. Revised Figure 7 from the article with a common legend below the figure.