The authors' responses are shown in red text below or next to each reviewer's comments.

We thank Referee #1 for the comments; below we give the reply to the comments

COMMENT #

The paper introduces a fine-scale parameterization scheme based on a landscape model using 30-m DEM data. The paper futher assesses the hydrological impacts of the fine-scale parameterization scheme compared to a coarse one based on outdated datasets (e.g., FAO soil data and SNAP vegetation cover) in a perfmafrost-dominated 100-km2 catchment. The results show that the streamflow estimates from the smallscale parameterization match the observations slightly better (but still rather poorly), which is kind of obvious. Of course using 9-km FAO data to parameterize a 100-km2 catchment is not going to work and I don't see why anyone would think otherwise. It is also a shame that the approach is tested in only one very small catchment, how much better does the approach work in considerably larger catchments?

> We agree with the reviewer on the general comments. This study introduces a method by which small-scale hydrological properties that are related to the presence or absence of permafrost can be represented in a large-scale hydrological model. These small-scale hydrological properties are not well represented in land surface datasets of different spatial resolution, including the recent high resolution soil property dataset by Hengl et al. (2017). The primary reason we used the FAO soil property and the SNAP vegetation cover datasets is the fact that meso-scale hydrological modeling at regional scale basins largely depend on these products. Our end goal is also to improve hydrological modeling of the Interior Alaska using the approach developed in this study. Indeed, there are several finer scale vegetation and soil property data sets. However, all of them do not show the landscape heterogeneity between permafrost and permafrost-free soils, especially the soil property data sets.
>
> We acknowledge this study is conducted in a very small scale experimental watershed. This watershed is the only watershed where basin scale observed permafrost distribution and vegetation cover exist in the region. This allowed us to develop a methodology to reproduce the soil hydraulic properties and vegetation cover map that can be incorporated

into a distributed hydrological model. It would have been better to do the parameterization at a larger basin if the small-scale measurements exist. However, as suggested by reviewer, the methodology will be tested at a reginal scale watershed in the second phase of the project.

COMMENT #

In the abstract, it is stated that the two parameterizations “capture most the peak and low flows with similar accuracy in both sub-basins” and then after it states that “on average, the small-scale parameterization improves the total runoff simulation approximately by up to 50% in the LowP sub-basin and 10% in the HighP sub-basin”. Which one is true?

This part indicates the average improvement of runoff simulation in two sub-basins where this study was conducted. The two sub-basins are the permafrost dominated (HighP) and the nearly permafrost-free (LowP) sub-basins. Compared to the large-scale parameterization, the small scale parameterization improves the total runoff simulation by up to 50 % in the LowP sub-basin and by up to 10% in the HighP sub-basin. This implies the improvement is larger in the LowP sub-basin compared to the improvement in the HighP sub-basin.

COMMENT #

On page 13 it is stated that there is a “lack of high spatial resolution soil data in the region”. The SoilGrids250m dataset might perhaps be useful (http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0169748).

We thank the reviewer for the suggestion. While this dataset has high resolution soil texture information, it still does not show any observed soil hydraulic property variations between permafrost and permafrost-free soils. Our effort is to introduce the soil hydrological properties that are modified by permafrost. In the Interior Alaska, soils with similar texture have different soil hydraulic properties between permafrost underlain and permafrost free soils. In our approach, however, we were able to reproduce the permafrost distribution map from the high resolution DEM data and then represent permafrost soil hydraulic properties in hydrological models.

COMMENT #

Page 13: "All soil parameters are regridded to 1/64th degree". How? Nearest neighbour? Bilinear?

> Bilinear interpolation was used to resample the course resolution soil property data to the 1/64th degree model resolution. It is corrected to "resampled to 1/64th degree using the bilinear interpolation" in the revised manuscript.

COMMENT #

So the catchments cover like a single grid cell of the 9-km resolution FAO map. Then how come there is finer-scale spatial variability visible in Figure 4a?

> The map is updated in the revised manuscript. The problem was created during legend creation. However, as pointed out in the comment, the entire basin displays the same soil hydraulic conductivity value in Figure 4a.

COMMENT #

Page 19: Why is only the large-scale parameterization used for the calibration? Wouldn't it be more fair to re-calibrate for both the small- and large-scale parameterizations?

> Thank you for raising this point. We had the same feeling. However, in order to see the extent the small-scale parametrization improves hydrological simulation, we prefer not to recalibrate the model again. If we calibrate with the small-scale parameterization, clearly, the lumped parameters will not be the same. So, the improvement could be partly due to calibration. However, if we use the same calibration parameter, any difference made between simulations is 100% due to the variation in the parameterization scenarios. Hence, we preferred not to re-calibrate the model.

COMMENT #

Might be worth mentioning that lumped catchment values are derived using the calibration.

> We addressed this comment in the revised manuscript.

“After the lumped sub-basin baseflow generation parameter values are derived by calibration, validation of the model with the large-scale and small-scale parameterization schemes were conducted by comparing the observed and simulated runoff at the outlets of LowP and HighP sub-basin for 2005 to 2008.”

COMMENT #

"Values between 1.0 and 0.0 are widely considered to be acceptable levels of model performance”. This is not true. Although it depends on the situation, I suppose values >0.5 can generally be considered acceptable.

We agree with the reviewer. Higher values of NSE are generally acceptable depending on the location of the study area. We modified our argument in the revised manuscript as follow.

“While values larger than 0.0 can be considered as acceptable levels of model performance (Krause et al., 2005; Schaefli & Gupta, 2007), values approaching 1.0 are more preferred depending on the study area. NSE uses of the mean observed value as a reference (Schaefli & Gupta, 2007). Hence, factors that affect the mean value observed streamflow will have a stronger effect on the values NSE. In the Interior Alaska, lower value of NSE can be acceptable due to the large uncertainties of mean observed streamflow, which is resulted from aufeis related measurement errors at beginning of snowmelt runoff season (Bolton, 2006). NSE of below zero indicates that the mean observed streamflow is better predictor than the simulated runoff (Krause et al., 2005)”.

COMMENT #

Figure 6a: The observed streamflow time series look kind of strange, in 2006 in particular the streamflow looks truncated. Could this be due to ice blockage or?

The streamflow response in most of the permafrost free (LowP sub-basin in this case, Figure 6a) areas is generally flat. Most of the snowmelt and rainfall is infiltrated to the lower soil yarer (Kane, 1980; Kane & Stein, 1983), stored in the tree trunk during snowmelt season (Young-Robertson et al., 2016), and transpired (Cable & Bolton, 2012;

Cable et al., 2014; Young-Robertson et al., 2016). However, in the permafrost-affect soils (HighP sub-basin, Figure 6c), the runoff response is fast and flushy due to the impermeable permafrost layer that blocks water from infiltrating to the lower layer. Hence the strange look of the observed streamflow in Figure 6a is not due to the ice blockage but to the higher infiltration and transpiration loss compared to runoff loss.

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