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Interactive comment

Interactive comment on "Topography significantly influencing low flows in snow-dominated watersheds" *by* Qiang Li et al.

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Reviewer's Comments: In this paper, Li et al. present evidence that certain topographic indices are useful to describe the variability in low flows between watersheds with snow-dominated hydrological regimes in the Southern Interior of British Columbia, Canada. The authors arrive at this conclusion by analyzing 22 different topographic indices and comparing them to flow statistics in the different watersheds. Using factor analysis, half of the original number of topographic indices was found to be non-redundant and together describe more than 90% of the variance in the watersheds. By building multiple regression models of these indices to explain the variability in flow statistics, the authors identified a set of five indices which were especially useful to compare watersheds when low flow assessments are conducted. These topographic

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indices were perimeter, surface area, openness, terrain characterization index, and slope length factor.

The topic of this study has actually been discussed during recent years of drought where I work in Sweden. Different authorities have been looking for ways to map streams with high risk of drying out during prolonged periods of dry weather. The results of this study add nicely to the already existing knowledge on the subject, i.e., the risk of a stream drying out increases with decreasing catchment area, decreasing winter precipitation, increasing ratio between evapotranspiration and precipitation, absence of lakes and wetlands, and decreasing soil depth. Not all of Sweden has snowmelt-dominated hydrology, so the findings would have to be verified across a wider spectrum of landscapes and climatology, but this would be interesting to pursue in the near future.

The general conclusion that "topographic ruggedness/roughness acts to sustain low flows" warrants further investigation to become practically useful. Earlier studies have indicated that riparian areas play a central role in streamflow generation, and it is difficult to relate this finding directly to the work done in this study. There has also been evidence that, during dry periods, topographic controls on drainage may be surpassed by local (evaporative) controls, making much of the watershed "disconnected" from the hydrologic network. Nevertheless, the study by Li et al. brings up interesting linkages between topography and hydrology not previously explored.

Response: Thanks for your comments on our manuscript. It is commonly accepted that climate, land use or land cover, and topography are the three major drivers that affect hydrological responses. This study examines how different hydrological variables response to topography alone, which fills the knowledge gap between topography and hydrology.

General comments:

1)The ratio of annual PET/P (Figure S4 in the supplement) is useful in a broad sense, but the effect of evapotranspiration on the water balance varies greatly between winter and summer. This causes summer precipitation to be "less valuable" to water storage in the catchment compared to winter precipitation. In able to distinguish this, i.e., identifying years with more/less effective precipitation, I recommend that PET/P is analyzed monthly instead of annually.

Response: Thanks for your constructive comments. In this study, we selected 28 watersheds in the snow hydrology-dominated region, and concluded that topography plays a more dominant role in low flows. Of selected watersheds, low flows often occur in summer (June-September). Therefore, we suggest that the PET/P in summer can provide more valuable information than that from monthly data. Here is the revised Fig. S5 in the revised manuscript.

Figure S5 Temporal variations of the average summer (June-September) precipitation (P), potential evapotranspiration (PET), and dryness index (PET/P) in the study watersheds from 1989 to 1996.

2)The results of this study are somewhat difficult to translate to practical meaning as many of the topographic indices can be quite abstract to many readers. In the discussion part of the paper, the authors should consider to supplement the reasoning around the different indices with examples that illustrate what the indices measure in reality, e.g., examples of landscapes with low vs. high index values. This is not absolutely necessary but would stimulate discussions about the findings of the study.

Response: We fully understand the point. Numerous topographic indices (TIs) have been developed for various purposes, and therefore not all TIs are closely related to flow regimes. In this study, we determined five TIs that have higher contributions to low flows than other TIs. Of the selected TIs, the perimeter is the easiest one to measure and visualize. The others derived from ArcGIS are hard to measure in the field and also abstract to readers. However, our study provides valuable information in understanding topographic control on hydrological processes, especially for low flows in a watershed.

Our final goal is to provide a watershed sensitivity map based on integration of various selected TIs in our future studies, which can provide a practical guide for resource planning and management. As suggested, we will add detailed explanations of TIs in Table 1 and in the discussion section for our revision.

Specific comments: 3)Lines 121-122. Each annual flow variable was standardized with annual (P), but flows may be more related to (P-ET) which better describes the effective precipitation.

Response: Yes, the effective precipitation is a good indicator for hydrological variables, especially for annual runoff. In this study, we were investigating how topography controls different magnitudes of daily flows. In our study watersheds, evapotranspiration was not consistent throughout the year, but dominant in the summer. If flow variables were standardized by the effective precipitation, the standardized flows may be overestimated in the summer and underestimated in the winter. This would introduce more uncertainties into the assessment. In addition, streamflows are usually normalized by precipitation in literature. Therefore, we think that precipitation is a relatively better indicator than effective precipitation for our study objective.

4)Lines 217-218. Please rephrase "[: : :] are mainly driven by small return periods of precipitation events of relatively short durations".

Response: Here is the revision. Line 217-218: Low flows occur in the later summer (late August) and winter (October to February), and are mainly driven by groundwater discharges and small amounts of precipitation.

5)Supplement Table S7-S8. In extreme years (1994 dry, 1996 wet) hardly any of the TIs are significantly correlated to Q90, but almost all are correlated to Q100. Why?

Response: Thanks for pointing this out. To answer this question, we revisited the hydrology data in the selected watersheds. We found that flow magnitudes at the Q90 in 1994 and 1996 in most watersheds occurred in the winter (October-February) (Please also see Figure S5 in Supplementary Material). Our correlation tests (Table S7) indicates that topography plays a minor role in Q90% As such, hydrological responses are mainly controlled by the combined effects of climate and topography. In contrast, Q100 in the majority of watersheds occurs in the late summer (August and September). Table S8 suggests that topography is significantly related to Q100 indicating that the role of topography plays a more dominant role in minimum flows. We will add more discussion in the revised manuscript to clarify this issue.

6)Supplement Table S8. Consider changing Q100 to Qmin to avoid confusion with the main text.

Response: Thanks. We will revise them accordingly.

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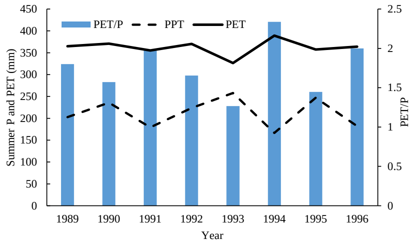

Figure S5 Temporal variations of the average summer (June-September) precipitation (P), potential evapotranspiration (PET), and dryness index (PET/P) in the study watersheds from 1989 to 1996.

Fig. 1. Figure S5 Temporal variations of the average summer (June-September) precipitation (P), potential evapotranspiration (PET), and dryness index (PET/P) in the study watersheds from 1989 to 1996

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