EGU22-2374, updated on 14 Aug 2022
https://doi.org/10.5194/egusphere-egu22-2374
EGU General Assembly 2022
© Author(s) 2022. This work is distributed under
the Creative Commons Attribution 4.0 License.

How does thawing permafrost change groundwater discharge? A case study from southern Siberia

Li Han[1], Hotaek Park[2], and Lucas Menzel[1]
[1]Heidelberg University, Professorship in Hydrology and Climatology, Department of Geography, Heidelberg, Germany (li.han@uni-heidelberg.de)
[2]Institute of Arctic Climate and Environmental Research, JAMSTEC, Yokosuka, Japan

In permafrost environments, groundwater recharge and groundwater flow are strongly affected by seasonal thawing and freezing cycles, the depth of the active layer, and the spatial coverage of permafrost. In such areas, groundwater is an important supply to the regional water resources, especially during the cold season when the frozen ground strongly restricts the water flows close to the ground and the runoff in rivers. However, due to absent or very limited groundwater observations in the permafrost domain, in combination with remoteness and harsh environments such as in Siberia, key processes and factors that control the subsurface dynamics on the large scale are not well understood yet. In a warming climate, the storage and movement of water in the subsurface system are expected to be altered through degrading permafrost and changing underground connections. However, due to the lack of corresponding studies, assumptions in this regard are very speculative.

Based on long-term daily river flow records (1950-2010) of large southern Siberian catchments (about 1,600,000 km² in total) with different permafrost conditions, we investigate the historical variations in magnitude, timing, and duration of low flow (as an indicator of groundwater dynamics) during the winter period. Our results show that the magnitude of low flow in the catchments has increased during 1950-2010, with the most considerable rise being noticed in the late 30-years period since 1980. Furthermore, we also found that the occurrence of the minflow (i.e., the minimum value of low flow) fluctuates between early and late winter in the catchments with sparse permafrost coverage. In contrast, in the catchments where continuous permafrost prevails, the minflow always occurs in late winter. Finally, for the catchments underlain by discontinuous permafrost, the timing of minflow shows relatively stable conditions in the earlier 30-year period. However, it starts fluctuating between early and late winter during the latter 30 years when a significant rise in low flow is observed. Given the unprecedented warming over the last decades in southern Siberia, these significant changes in both the magnitude and timing of low flow could be induced by the altered surface water-groundwater interactions that are triggered by the degrading permafrost. Overall, our results provide insights into the potential evolutions in the large-scale groundwater dynamics over varied temporal and spatial distributions of permafrost under a warming climate.