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Assessing the effect of the geomorphological complexity of glacier forefields on the multi-temporal water dynamics will provide better future models

Tom Müller[1], Bettina Schaefli[2], and Stuart Lane[1]
[1]Institute of Earth Surface Dynamics, University of Lausanne, Lausanne, Switzerland, (tom.muller.1@unil.ch)
[2]Institute of Geography, University of Bern, Bern, Switzerland (bettina.schaefli@giub.unibe.ch)

The river discharge of recently deglaciated headwater catchments shows strong variations at daily, seasonal and annual time-scales. These cycles are susceptible to changes in the near future due to rapid glacier retreat combined with warmer winters and earlier snowmelt. Low discharges, in particular, are not only driven by climatic conditions but are filtered by a number of geomorphological features, which are also rapidly evolving with glacier debuttressing, sediment transport and vegetation onset. Future water availability as well as discharge extremes of future deglaciated forefields can therefore only be explained by considering the co-evolution of both local climate and catchment geomorphology. Many hydrological predictions for high Alpine catchments fail to take into account such combined effects, which are relevant in better predicting winter low flow, as well as the recession behavior in autumn and potentially even peak flow events induced by later summer rainfall. These extremes are however of significant importance for ecosystem development on proglacial margins as well as for the management of hydropower, in particular of high elevation water. In this study, we propose a detailed analysis of the yearly groundwater and river stage fluctuations of the proglacial zone of the Otemma glacier, one of the largest glaciers of the Swiss Alps. By decomposing the water fluctuations and comparing them with climate forcing, we analyze the role of key landscape features in smoothing and delaying the different water inputs. Using additional datasets of daily water electrical conductivity and water isotopes a finer description of the hydrological functions of these features is achieved. A perceptual model is then proposed, showing how the different water signals driven by climate are modified by the local geomorphology. We finally propose a new metric which encapsulates the hydrological effects of these landscape features and should allow for a better assessment of the filtering effect at the catchment-scale of the different water input signals. Using such a simple metric and the perceptual model should help in building or assessing more realistic hydrological models where the complex hydro-geomorphological interactions are better represented.