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How do storage and drainage processes influence extreme floods in the Swiss Alps?

Maarten Smoorenburg (1), Nina Volze (1), Michael Margreth (1,2), Simon Scherrer (3), and Felix Naef (1)

(1) ETH Zürich, Institute of Environmental Engineering, Groundwater and Hydromechanics, Zürich, Switzerland (maartensmoorenburg@gmail.com), (2) Soilcom GmbH, Zurich, Switzerland, (3) Scherrer AG, Reinach, Switzerland

Comparison of extreme flood runoff hydrographs in steep mountainous catchments in the Swiss Alps reveals large differences in the capability of catchments to dampen runoff formation. In some catchments a dampened runoff response is observed with a threshold-like reaction to very extreme rainfall inputs, whereas in other catchments this threshold-like behavior is already observed during much smaller storms, or has not been observed at all. The threshold-like behavior makes estimation of flood risks with long return periods highly uncertain. Therefore, understanding of dampening mechanisms is key to assessing catchment vulnerability to extreme events.

We present typical flood responses in various mountainous catchments and try to explain what types of geomorphological features have enough storage potential to cause the observed dampening of the runoff formation. The dampened reaction at the catchment scale results from the spatial distribution of these geomorphological features in the landscape and how water is stored and drained. For better understanding of the storage and drainage processes and timescales, we have measured runoff in springs and headwater catchments dominated by geomorphological features with large storage potential, such as talus slopes, moraines and deep-seated creeping landmasses. Additional insights were obtained from a large scale sprinkling experiment on a creeping landmass slope (135 m^2) and groundwater observations in its fissured-rock subsurface. The measurements show how these geomorphological features, even in steep terrain, may hold water long enough to cause a dampened flood response.

To transfer these insights to the catchment scale, a mapping scheme was developed to delineate the areas with large storage potential and rank their drainage intensity. The mapping scheme benefits much from combing new data sources like high resolution digital elevation models (2 m by 2 m), aerial photographs and detailed geo(morpho)logical maps. The scheme was used to produce dominant runoff process maps in catchments with varying degrees of dampening of the flood runoff formation. A conceptual hydrological model for flood runoff simulation was developed based on these maps and the processes relevant for runoff formation. The parameterization of the model was based on observed behavior at smaller scales and the model performance was evaluated at the catchment scale. It was found that the distribution of large storages can explain the observed differences in runoff generation in the studied catchments.

Also, it was researched whether these large storages are responsible for sustaining baseflow during extremely low flow conditions. Recession analysis shows that this is possible, but that other factors may also govern the low flow behavior.