Base Flow Recession of Mountain Streams: Modelling aquifer recharge and groundwater-river exchange processes

Project framework

Glaciers, snowpack and groundwater are the main contributors to stream water during dry periods in mountainous regions. Typically, two distinct stream regimes can be observed in the field 1) the surface-flow dominated systems, with flashy streamflow regimes, rapid base flow recession and very low summer flows; and 2) the spring-fed watersheds, with a slow-responding streamflow regime, and a long and sustained base flow recession that maintains late summer streamflow through deep-groundwater contributions to high volume springs. Although the characterization of groundwater surface water exchange processes in mountainous context is critically needed for both environmental and water resource management purposes, it is currently poorly understood.

Objectives and Methodology

Hydrograph recession analysis during base flow regimes provides unique opportunities to test hypotheses for how mountain groundwater systems behave. Current theories established to interpret recession curves generally assume idealized homogeneous groundwater reservoirs. The role of structural heterogeneities is not taken into account and remains unresolved. The main objective of this master project is to identify the impact of vertical and horizontal aquifer compartmentalization on transient recession behaviors in mountain. The student will investigate, based on a numerical modeling approach, how these heterogeneities impact the groundwater flow partitioning at the watershed scale. She/He will then quantify and discuss the groundwater-river interaction processes associated to different scenarios of groundwater recharge: snow vs rain dominated recharge processes.

The student will also analyze stream recession behaviors in the Alps. She/He will 1) compile hydrological and geological data available for selected watersheds in Switzerland through existing databases, 2) perform classical analysis of hydrograph time series in order to describe the recession behaviors and hydraulic properties of catchments, 3) classify recession behaviors by structural contexts and 4) identify the main factors controlling stream recessions based on previous modelling results.

Training

The student will receive a unique training in time series analysis techniques as well as in modeling techniques used to simulate groundwater flow. She/He will interact with various researchers at ETH, Dr. Clément Roques being the principal advisor, as well with numerous international researchers through active collaborations already set-up on this topic (Oregon State University, University of Rennes). The student will gain important skills for a career in hydrology, geology, environmental research and engineering fields. For more information, please contact Dr. Clément Roques at clement.roques@erdw.ethz.ch, G5 NO building, http://www.clementroques.com/.
Figure 1: Preliminary modelling results of recession behavior in a compartmentalized aquifer with an example of stream flow recession observed in the Oregon Cascades, USA.

Some references: