Université de Neuchâtel
Centre d'hydrogéologie et géothermie

MSc in Hydrogeology and Geothermics
Thesis topic proposal 2023

Complex or simple hydrogeological models? Exploring in which geomorphic contexts simple models provide reliable predictions.

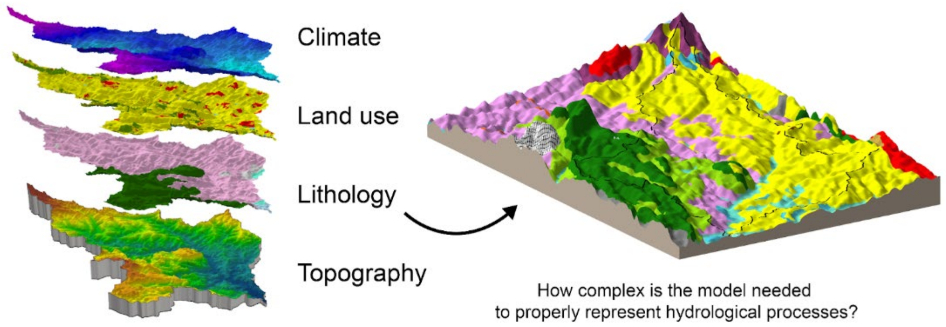
Context and objectives

Considering the wide range of spatial scales required to define water transfer (from leaf to basin), hydrological modeling strategies at catchment, regional and global scales rely on simplified assumptions to integrate the effects of surface and subsurface heterogeneities below a representative elementary area. In this context, the hillslope is classically considered as the elementary entity, where processes are characterized by effective geometric and hydrodynamic properties. However, studies have questioned such simplifications, which might introduce strong limitations in predicting streamflow dynamics, especially during baseflow. Simplifying or even neglecting processes may result in bias or systematic misrepresentation of processes, independent of the scale considered, such as interbasin fluxes (Liu et al., 2020), spatial and vertical distribution of flow paths (Clark et al., 2009; Harman et al., 2009; Rupp and Selker, 2005), influence of planform shape of elementary area on flow paths (Paniconi et al., 2003), and spatial variability of recharge and evapotranspiration (Hartmann et al., 2017; Jachens et al., 2020; Tashie et al., 2019). This leads to two motivating questions for this master project: 1) in which geological and geomorphological contexts are simplified effective representations likely to fail to describe water storage-discharge dynamics? And 2) conversely, in which contexts are such simplifications still acceptable?

Methodology

Different numerical models of different structures and complexity will be compared taking for reference a synthetic case scenario modelled with a fully coupled model that simulates all relevant hydrological processes at the catchment scale in a spatially distributed manner (Hydrogeosphere). The simplest model employed will be conceptual hydrological one, followed by established land-surface (e.g. SWAT, HYDRUS), hillslope scale 1D models (HS1D) and 3D models (SWAT-MODFLOW), and finally fully integrated surface water-groundwater models (HGS). While different in structure and complexity, the models will provide the same type of predictions, e.g. storage in the subsurface or outflow of a catchment, that will be used to assess the reliability of each approaches. The master thesis will provide advanced skills in the use of hydrogeological models for the simulation of groundwater flows and a strong expertise in their capabilities and limitations. It will also allow to master the whole modeling chain from the consideration of fundamental processes to the adaptation to multiple site configurations.

Supervision and collaboration



Supervision by Clément Roques, Ronan Abhervé, Philip Brunner (UniNE) and Jean-Raynald de Dreuzy (University of Rennes 1). Further information is available from Clément Roques, clement.roques@unine.ch