unine
Université de Neuchâtel
Centre d'hydrogéologie
et géothermie

MSc in Hydrogeology and Geothermics

Thesis topic proposal 2023

Gravimetry as a groundwater monitoring solution: Coupled numerical modelling (Project 1)

Context and objectives

Groundwater fluxes are generally the most uncertain quantities in hydrological models. Direct piezometric measurements give us information on the state of groundwater; however, the value of this information is often limited, especially when the hydraulic properties of the subsurface are very heterogeneous, such as in alpine and subalpine catchments.

Gravity is a fundamental physical force that can be used to measure changes in mass. The value of *g* is not constant across the Earth's surface and is not constant in time. By measuring these temporal changes in gravity, the method "time-lapse gravimetry" (TLG) can be applied to measure groundwater fluxes indirectly. Two big advantages of the method are that *a)* it is independent of subsurface hydraulic properties and *b)* it is sensitive to all changes in water storage. Gravimetry is a well-established technique, with relative accuracies on the order of a few parts per billion (~5×10^{-9} *g*); however, the use of time-lapse gravimetry to inform hydrogeological models is highly novel and still requires much research.

The project

Several MSc projects are possible within the context of the SNSF-funded RADMOGG project.

In order to better understand the scenarios where gravimetry may be an ideal groundwater monitoring tool, it is necessary to understand the sensitivity of the method in a variety of cases. In this project, we will numerically investigate two aspects the use of time-lapse gravimetry: 1) sensitivity to and 2) the "data worth" of TLG. To investigate sensitivity, a variety of 2-D and 3-D numerical models will be developed to demonstrate cases where changes in the water table result in minimal or even inverse changes to *g*. To investigate the "data worth" of TLG, both real and synthetic hydraulic datasets will be used. The corresponding changes in gravity at the surface will be calculated. Sequential inverse modelling and comparisons will be then be carried out using subsets of the data to determine the relative impacts on model prediction accuracy imparted by gravimetric and hydrological data.

We will use *python* together with finite element packages (e.g., *sfepy, flopy*) and inverse modelling/parameter optimisation packages (e.g., *pyEMU, FilterPy*). The student will also have the opportunity to participate in gravimetry field campaigns at sites in the Emmental and Vallon de Réchy.

Given satisfactory results, the publication of a journal article, co-authored by the student, is possible.

Supervision and collaboration

The project will be supervised by Dr. Landon Halloran in collaboration with PhD Student Nazanin Mohammadi. We will also collaborate with partners at METAS and CREALP.

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