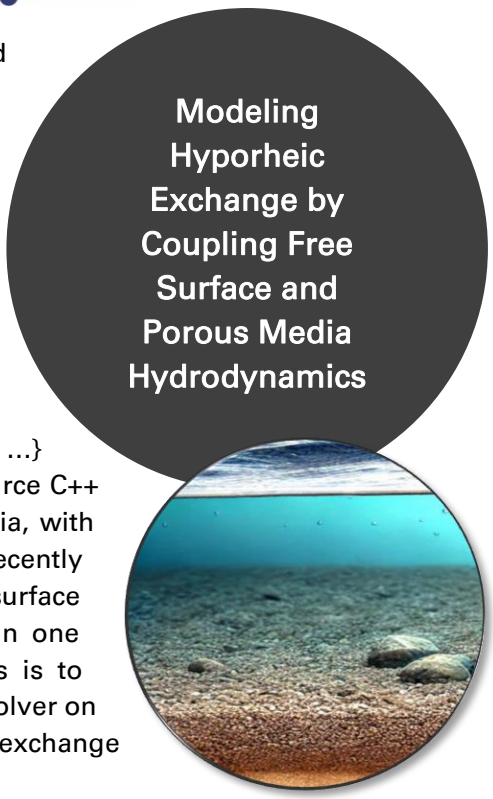
Universität Stuttgart

IWS Institute for Modelling Hydraulic and Environmental Systems

M.Sc Topic

"Modeling Hyporheic Exchange by Coupling Free Surface and Porous Media Hydrodynamics"



Background

Hyporheic exchange describes the mixing of surface water and groundwater in riverbeds. It is a critical process for aquatic ecosystems, influencing nutrient cycling, water quality, and habitat conditions. However, current models mostly treat surface and subsurface flows separately, limiting our ability to simulate these vital interactions.

DuMu^x – DUNE for Multi-{Phase, Component, Scale, Physics, …} flow and transport in porous media – is a powerful open-source C++ framework for simulating flow and transport in porous media, with modules for multiphase flow, reactive transport, and since recently also shallow-water flow. Yet, the coupling of free-surface hydrodynamics (e.g., river currents) with subsurface flow in one model remains an open challenge. The goal of this thesis is to develop and validate a novel coupling of a free-surface flow solver on top of the porous-media flow modules to simulate hyporheic exchange processes.

Therefore, this thesis is aimed at extending DuMu^x to enable two-way interaction between surface (river) and groundwater (porous media) flows. Using real-world datasets from the Inn and Isar Rivers, the coupled model will be tested against observed surface-subsurface exchange patterns. This project will advance an important environmental modeling capability, improving predictions of oxygen transport, water quality, and fish habitat conditions. It offers a unique opportunity to gain hands-on experience in CFD, ecohydrology, and open-source development, all while addressing a key ecological challenge.

Thesis Overview

1. Familiarize with DuMu^x and its solvers for porous media and shallow-water hydrodynamics.
2. Familiarize with the DuMu^x code environment for developers.
3. Conceptualize and implement the free-surface depth-averaged solver application to replace the atmospheric boundary conditions in the current state of the porous media DuMu^x solver.
4. Run the code with field data collected in different rivers in the past years, with different porosity attributes of the riverbed.
5. Create a release, substantiate code documentation, and a technical report (i.e., Master's thesis)

Required Skills

1. Understanding of porous media (LH2 lectures) and fluvial (LWW lectures) hydraulics.
2. Coding skills in C++ are an advantage.

Apply now!

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This thesis can be written in English or German.