MASTER THESIS

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Three-dimensional numerical modelling of water flow over a rough channel bed

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Background

A three-dimensional numerical model is used to simulate the water flowfield over a rough channel bed, utilizing the open source computational fluid dynamics toolbox OpenFOAM. The geometry of the numerical model is a replication of a physical laboratory flume experiment with a gravel bed. The roughness of the channel bed is represented in the numerical model by generating a very fine computational grid fitted to the topography of the bed, explicitly resolving the shapes of the gravel structures. Three different turbulence modelling approaches are used: Reynolds-Averaged Navier-Stokes (RANS) based k ¡² and k ¡!, and a Large-Eddy Simulation (LES). A presentation of relevant theory is given. Tests are conducted to investigate the sensitivity of the numerical model approaches to changes in grid resolution, wall treatment, numerical schemes, time steps and sizes of simulation domains. The RANS test results show a low sensitivity, whereas the LES results show a larger variation. The latter behaviour is not fully understood, but is believed to be related to effects caused by the use of cyclic boundary conditions. Final simulations are set up based on the findings of the tests. Double-averaged velocity and turbulent kinetic energy profiles are computed for the respective simulations, and compared with data from a physical laboratory experiment. Reynolds shear stresses are also computed for LES. The simulation results are generally in reasonable agreement with experiment data.