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Numerical investigation of scale influences on hydrodynamics and morphodynamics in a groyne field experiment

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Large physical experiments require - among others - scaling of channel geometry and sediments in order to fit to the available laboratory infrastructure. In this study, scaling effects were investigated with the help of a 3D numerical model (RSim-3D) and a coupled sediment transport model (iSed). Numerical experiments were based on the geometries of two physical scale experiments conducted at the University of Natural Resources and Life Sciences, Vienna, Austria. The large-scale experiments (1:1) were conducted in an open-air research channel with a channel width of 5 m. The small-scale experiments (1:5) were performed inside the Hydraulic Engineering Laboratory with a flume width of 1 m. The large-scale experiments (1:1) include sediments typical for the Austrian Danube River in the section East of Vienna and the small-scale experiments were conducted with a sediment size scaled by 1:5. Results from the physical scale experiments including a submerged and attracting groyne layout with varying groyne heights and water levels were used for calibration and validation of the numerical models. Numerical model results were analyzed with respect to scale influences. In contrast to the relatively small influence of scale on the determined normalized flow velocities, normalized turbulent kinetic energy was found to increase by up to 10 times within the outdoor research channel (1:1) in comparison to the smaller scale (1:5). Moreover, the scale effect was larger in the main stream than in the groyne field. Morphodynamic equilibrium was affected by the scale of the experiment, too, leading to enhanced erosions in the 1:1 scale experiment. The findings are relevant for future hydraulic engineering measures investigated by physical scale experiments and will help to avoid underestimations of hydrodynamic and morphodynamic processes induced by scale influences.