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Implementation and implications of macrophyte reconfiguration in hydraulic river modeling

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In lowland rivers, abundant macrophyte growth can often be observed. The aquatic vegetation has an impact on the flow by creating friction which results in increased water levels and decreased flow velocities. At the same time submerged macrophytes are susceptible to hydrodynamic forces of the water. Their morphology is therefore often flexible and streamlined so that it enables reconfiguration (i.e. bending of macrophytes with water flow) and decreases potential damage at high flow velocities. Knowledge of these mutual interactions is crucial in order to model water flow in vegetated rivers. A correct estimation of flow velocity and water height is indispensable for the calculation of hydraulic, ecological and geomorphological parameters.

The total resistance to water flow in a river can be described by a Manning coefficient. This value is influenced by river characteristics as well as by the presence of macrophytes. In this study a simple method is developed to quantify the resistance created by macrophytes after reconfiguration of their canopy. In order to achieve this we derive model formulations and plant parameters for three different macrophyte species and compare model simulation with measured flow velocity data for two case studies.

Furthermore, the effect of macrophyte reconfiguration is investigated by modeling the same case studies with and without the implementation of macrophyte reconfiguration. It was found that the local resistance created by the vegetation was overestimated when reconfiguration was not considered. This resulted in an overestimation of stream velocity adjacent to the vegetation and an underestimation of the stream velocity within and behind the vegetation. Another effect was a higher water level gradient and consequently a higher Manning coefficient in the scenario without reconfiguration compared to the scenario with reconfiguration.

Reconfiguration had also an influence on ecological and geomorphological parameters. It was found that the distribution of the residence time had a broader range of values in the model without reconfiguration compared to the model with reconfiguration. The residence time is an important parameter to quantify ecological functions of a river, such as denitrification. When reconfiguration was neglected, the denitrification capacity was overestimated with 5.7% and the drag force acting on the vegetation was overestimated by a factor of 1.6. As a direct result of higher stream velocities in the scenario without reconfiguration, the bed shear stress was high enough to cause erosion of sediment grain sizes between 0.1 and 0.2 mm whereas the stream velocities calculated with reconfiguration did not induce erosion. The median grain size of the studied river is 0.167 mm.