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High-resolution modelling of vegetation-flow interactions and river flooding under climate change

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The hydrodynamic characteristics of in-stream vegetation can significantly alter river flow conveyance, notably through a reduction in local velocity and increases in flow depth, which has implications for nature-based flood mitigation. Research suggests a warmer climate will alter the growth cycle of vegetation, extending periods of high growth to coincide with periods of increased precipitation, increasing fluvial flood risk as precipitation events increase in intensity and frequency under climate change. Hydraulic modelling can complement management strategies by capturing complex flow-vegetation interactions for hypothetical climate scenarios to enhance the understanding of the impact vegetation and climate change has on flood risk. However the impact of precipitation events on vegetated rivers and the influence climate change will have on the resulting flood risk is yet to be addressed using 3D numerical modelling techniques.

Telemac 3D is an open-source solver suite capable of simulating open-channel free surface flow at reach scales. This study used Telemac 3D to study seasonal vegetation changes on flow for a single reach of the River Blackwater, UK, to assess the accuracy to which vegetation-flow interactions were represented. Calibration consisted of modifying a vegetation bulk drag coefficient until best-fit between measured and simulated flow quantities was achieved. Flow scenarios were based on the climate model ensembles provided by available hydrological model datasets using the RCP8.5 emission scenario in the literature. The results indicate that the model accurately predicts changes to complex open-channel flow and is representative of observed vegetation-flow dynamics, such as the local reduction in the 3D velocity field. This work has potentials for flood mitigation strategies utilising nature-based approaches: informing the management of flood-prone reaches or the selective use of in-stream vegetation to promote flood detention.