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BASEveg: A modelling framework integrating vegetation dynamics and river hydro-morphodynamic processes

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Riparian vegetation and river hydro-morphodynamic processes are strongly interconnected by feedback mechanisms that act at various spatial and temporal scales. Such feedbacks affect water and sediment fluxes along river channels and across floodplains, in turn shaping the river planform style and vegetation structure. In the face of profound changes in climate and increasing anthropogenic pressure, the quantification of these processes is paramount to understand future river dynamics and better design restoration projects and management solutions.

Despite recent advances in river eco-morphodynamic modelling, numerical models including feedbacks between plants, flow, and sediment transport in rivers are still limited. Here we introduce BASEveg, a modelling framework that allows combining the freeware tool BASEMENT, simulating river hydro-morphodynamic processes, and an open-source python module for vegetation growth simulations. The model structure and implementation follow the basic assumption that morphodynamic processes and vegetation growth occur at very different timescales. We consider that over long periods of time the riverbed is essentially stable because of the low flow discharges and modifies only when discharges peak, generating erosion and deposition processes. When the discharge is low enough to expose bare surfaces, vegetation can grow undisturbed until the next high discharge peak. During this time, plants can be uprooted by the flow or buried under sediments.

Here we present a model test case based on the Alpine Rhine river, Switzerland, to illustrate the main functionalities and potentials of BASEveg. The vegetation growth module simulates the plant growth rate depending on the water table level fluctuations during low flow, vegetative periods. This results in a vegetation distribution that well compares with observations and previous modelling results. We show also how the vegetation pattern and riverbed topography co-evolve depending on species-specific traits, which can be simulated within the model. Although the model includes experimental features that still require proper data for calibration and validation, it represents an important step towards the integration of river hydro-morphodynamic processes and vegetation dynamics in common 2D numerical models. The model can be used to understand long-term river morphological trajectories depending on the hydrological regime and climate forcing, helping the design of river restoration projects and management practices.