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Modelling peatland development in temperate alluvial environments

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It is well known that C accumulation rates are much higher when focusing on short-term measurement periods in areas with active peat growth when compared to the net C storage at longer timescales as obtained from palaeo-studies. When selecting effective management options that aim to sustain or increase rates of peat development and, hence, C sequestration, a detailed insight into the factors controlling C storage in peatlands at longer timescales is therefore required. Several peatland models have been developed to simulate long-term peatland development and such models thus can be a useful tool to evaluate the effect of environmental changes and management on peatland dynamics at centennial to millennial scales. Many of these models assume the peat to form in a geomorphically stable environment. However, for river floodplains these assumptions cannot always be made. In temperate Europe for example, many river floodplains have known phases of active peat growth throughout the Holocene, influenced by the local geomorphic dynamics of the river channel(s) and associated sediment dynamics. In addition, many restoration efforts in floodplain environments are accompanied by allowing the river channel(s) to behave more freely, with increased meandering and more natural channel dynamics. As these dynamics are currently lacking in peatland models, a detailed assessment of the interactions between river channel(s) and the adjacent peatland in terms of long-term peat growth and carbon accumulation remains difficult.

Here, we developed a new peatland model, specifically designed for alluvial environments, by modifying an existing local peat growth model (1D version of Digibog), coupled with a raster-based river basin hydrology model (STREAM). This model allows to assess the effect of changes in both the river hydrology and local river channel properties on alluvial peatland development and the associated carbon dynamics. The model was applied at two contrasting lowland river basins in northern Belgium, located in the European loess (Dijle river) and sand (Grote Nete river) belts. Local peat growth was simulated at an annual resolution over a period of 10,000 years under a range of climate and land cover scenarios, as well as varying river channel characteristics (number of channels, channel dimensions, channel roughness and channel slope).

The results demonstrate that changes in river discharge through regional climate or land cover changes have a negligible effect on the floodplain peat growth as these changes mostly affect the magnitude of peak discharges. In contrast, the configuration of the local river network such as the

number of river channels and their position relative to the peatland surface show to have a strong effect on the equilibrium peat thickness. Especially the number of drainage channels strongly affects the peat thickness with a fourfold reduction in number of channels leading to a threefold increase in simulated peat thickness. This demonstrates that limiting the number of drainage channels in a floodplain and raising the elevation of the channel bed can be effective strategies in stimulating floodplain peat formation and allow to quantify the long-term carbon sequestration potential of these different management practices.