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Comparing long-term geomorphic model outcomes with sediment archives highlights the need for high-resolution Holocene land cover reconstructions

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During the last decade, several global land cover reconstructions have been produced that enable to quantify human impact on the landscape since the introduction of agriculture. Application of these land cover maps in geomorphic models potentially allows to estimate the anthropogenic impact on sediment fluxes and thus to reconstruct changes in landscape morphology through time. However, current land cover reconstructions face some drawbacks. First of all, their low spatial resolution (i.e. 5 arc-minutes at best) questions their use in geomorphic models, as sub-catchment vegetation patterns play an important role in sediment dynamics. Existing global land cover reconstructions also do not differentiate the typology of human impact (cropland, grazing land, disturbed forests), although the susceptibility of different anthropogenic land uses towards erosion varies greatly. Finally, the various land cover reconstructions differ significantly regarding the estimated intensity of human impact for the preindustrial period. In this study, we assessed the performance of a spatially distributed erosion and sediment redistribution model that operates at high resolution (100 m) to the quality and spatial resolution of input land cover maps.

This was done through a comparison of two sets of model runs. Firstly, low-resolution land cover (expressed as percentage of non-natural vegetation) maps were resampled to a spatial resolution of 100 m without differentiation of non-natural vegetation types. For the second set of model runs, estimated non-natural vegetation was differentiated in areas of cropland and grassland, and spatially allocated to a high-resolution grid (100 m) using a logistic model that relates contemporary land cover classes to slope, soil characteristics, landforms and distance to rivers. For both land cover maps, different scenarios for the ratio between cropland and grassland were simulated. Analyses were performed for several time periods throughout the Holocene, for the Scheldt River Basin (19,000 km2) in Belgium and northern France.

Results indicate that low-resolution land cover information, regardless of the considered cropland/grassland ratio, leads to largely overestimated sediment fluxes when compared to field-based sediment budgets. Allocation of land cover to a higher spatial resolution yields far better results. Variations in model outcomes are related to differences in landscape connectivity between allocated and non-allocated land cover. These results point towards the need for higher-resolution land cover maps that incorporate the patchiness of vegetation at relevant scales regarding geomorphic processes. Also, model results with allocated and non-allocated land cover maps differ greatly for different cropland/grassland ratios. This indicates that there is not only a need for land cover reconstructions at high spatial resolution, but also that differentiation between cropland and grassland is essential for accurate geomorphic modeling. Further improvements in land cover reconstructions are thus needed before reliable quantitative estimates of anthropogenic impact on soil profiles and sediment redistribution can be simulated at continental scales. Detailed historic sediment budgets can provide an important tool not only for validating but also for reconstructing land cover histories.