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Modeling the impacts of climate changes and anthropogenic land use on fluvial and sediment dynamics in the Dijle catchment during the Holocene

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Field based studies in the European loess belt often indicate an important influence of land use change on Holocene sediment dynamics, whereas the influence of climatic variations is unclear. The objectives of this study are to model the influence of land use and climatic variation on both sediment and water dynamics during the Holocene for the Dijle catchment in the Belgian loess belt. The Watem/Sedem model, a spatially distributed soil erosion and sediment redistribution model, was used to model past sediment dynamics under the influence of land cover changes and climatic variations, while the STREAM runoff discharge model was used to model past runoff dynamics. Based on archeological and historical data, land use was reconstructed for several periods: pristine land cover, Neolithic Period, Roman Period, 1300 CE, 1650 CE, 1775 CE (historical map), 2000 CE (corine land cover map). Climatic data were obtained from the ECBilt-CLIO-ECODE model. The scenarios with climate and land use for a given period were combined with a sensitivity analyses, in which climate and land use were independently varied.

Validation of the Watem/Sedem modeling results is based on a time differentiated sediment budget for the Dijle catchment. The results indicate that soil erosion rates increase with increasing cropland area from ca 4 Mg km^{-2} a^{-1} (pristine situation) to ca 500 Mg km^{-2} a^{-1}(medieval period and 18^{th} century). They decrease again to 260 Mg km^{-2} a^{-1} for the contemporary period due to a decrease in cropland area and an increase in built up area. Changes in erosion rates and landscape connectivity result in variations in hillslope delivery ratios (HSDR): the HSDR for a pristine land cover is ca 90%, while it varies between 40% and 60% for agricultural landscapes. Differences can be explained by variations in the hillslope-fluvial system connectivity. When comparing current soil erosion rates with rates for the Early Holocene, modeling results show that land cover changes are responsible for a 6000% increase in soil erosion, while climatic variations are responsible only for an additional 6% increase.

Runoff discharge was calibrated using contemporary runoff data. Modeling results show that average runoff discharge only slightly increased over the Holocene (+6%), due to land use changes. There is a more important increase in peak runoff discharge (Q_{99}), mainly due to increase in cropland and built up area (+147%), but also due to climatic changes (+13%). Contrary to the sediment fluxes, the recent increase in built-up area and decrease in cropland has resulted in a further increase in peak discharges. Land use changes have a dominant influence on the sediment and water dynamics of this catchment compared to climate change. This is especially true for the sediment dynamics, which was much more influence by the environmental changes then the runoff dynamics. During the last few hundred years, sediment and runoff dynamics became decoupled, and differ in their reaction on the increase of built up area. In addition, a strong scale dependency can be observed in the geomorphic response to environmental change, which is related to the non-linear behavior of the system and complex long-term interactions between sediment sources and sinks. Land use changes had a much more pronounced influence on colluvial deposits (+ 34 000%) then on alluvial deposits (+3550 %). This scale dependency has important implications for the use of sedimentary archives as a proxy for environmental change.