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HYDRUS 2-D water balance simulations in a changing drift sand landscape: a realistic case from the last millennium in the Campine area, northern Belgium

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Climate, soils and vegetation are known to exert strong controls on the water balance in a given area. The role of geomorphological processes, however, is generally overlooked in hydrological studies. In this study, the impact of landscape evolution, including geomorphological processes, is being assessed using HYDRUS 2-D simulations. A realistic sequence of consecutive landscape development stages during the last millennium in the Campine area was taken to investigate the potential role of changing landscapes on the water balance. The sequence is based on a detailed landscape reconstruction of a small interfluve in the Nete basin (Campine area, northern Belgium), following a study of sediment-soil profiles using classical geomorphological techniques, optically stimulated luminescence dating, palynology and historical archives. At least four distinctive phases in the topography-soil-vegetation system have been identified: around ca. 1000 a BP, 500 a BP, 250 a BP and 150 a BP. The sequence is characterised by progressive destruction of the soil catena (podzol profile) and vegetation, and an overall increase in relief intensity due to heavy use of land, until the landscape became stabilized ca. 150 a BP. In parallel, soil hydraulic properties were measured and used for parameterization of the HYDRUS simulations.

For each stage of the sequence, a two-dimensional landscape was drawn in HYDRUS-2D using the reconstructed information on vegetation, topography, soil horizons and soil hydraulic properties. The impact of changes in this geomorphological system on water balance was then evaluated by applying a 30-year time series of climate observations. Using the same recent climate data for the different stages allows to focus on the effect of geomorphological and land use changes on evapotranspiration, runoff and groundwater recharge.

In general, the results show that soil development and/or erosion alone would have had only very limited impact on the water balance during the last millennium. In contrast, the effect of topographical and vegetation changes may have had a significant influence on water flow and storage. Further research will, amongst others, focus on the interpretation and selection of field data (e.g., fossilized soil moisture indicators, small scale run-off patterns, etc.) to validate and further refine the model.