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Hydrological change during the last 600 years as observed from landscape analysis and historical maps: a case study from the Nete catchment, Campine area, NE-Belgium

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Reliably predicting the future state of the hydrological system under transient climate and land use conditions is a major challenge. Hydrological models are usually calibrated and validated for a short time period (e.g. 30 years), for conditions that are similar to today's. In order to test model performance for future (unverifiable) projections, palaeohydrological modelling is first needed to build confidence in model output under different conditions. One of the major challenges of palaeohydrological modelling is the acquisition of verification data that is representative for the past state(s) of the hydrological system. Here, we present the reconstructed evolution of the groundwater table depth over the last six centuries, in a sandy interfluvium (20 km^2 with altitude varying between 16 m and 28 m a.s.l.) of the Nete catchment.

For periods before 1770 AD, the altitude (depth) of blown-out surfaces in the drift sand landscape is used as a proxy for the average highest groundwater level. These surfaces are generally interpreted as the lower limit for wind erosion. Soil profiles investigations where these surfaces are overblown by younger drift sand show that they were created in the time period between ca. 1400 AD and 1600 AD. For younger periods, historical maps were analysed for the presence of surface water features, such as fens (shallow lakes that are groundwater fed in this sandy landscape under temperate climate), marshes and wetlands.

The results clearly show declining water levels in the second half of the 19th century, i.e. between 1854 AD and 1909 AD. The decline is most pronounced for the higher areas of the interfluve (drift sand landscape) and becomes less clear towards the floodplains. The amount of groundwater level decline is 1-2 m on average.

The cause for the synchronous groundwater level drop seems to be linked to land use and land cover changes during that period. In the time interval between 1854 AD and 1909 AD, the total length of drains increased from 2 km to 25 km, while land cover changed from 80% heathland and almost no trees to only 20% heathland and 50% coniferous forest. Available palaeoclimate records suggest that there is no correlation between groundwater level change and average annual temperature or precipitation. Furthermore, population density seems to be uncorrelated with the observed hydrological changes.

Internal consistency checks are performed and found satisfactory. For example, the high groundwater levels predicted by the blown-out surfaces for 1400-1600 AD are confirmed by surface water features on younger historical maps ($\sim$1770 AD and $\sim$1850 AD). Indeed, pollen analysis, topographical maps and climate records show that land cover and climate did not change significantly throughout the period 1400 AD to 1850 AD.

We conclude that the proposed methods are useful tools to gather verification data (i.e. groundwater table depth) for palaeohydrological modelling in the European sand belt during the last millenium.