Geophysical Research Abstracts
Vol. 17, EGU2015-9824, 2015
EGU General Assembly 2015

Multiple-scenario spatial modeling of Holocene anthropogenic land cover changes and evaluation against archaeological, palynological and geomorphological records: an example for the Dijle catchment (Belgian loess belt)

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Holocene anthropogenic land cover reconstructions have recently been created at a variety of spatial scales and resolutions and using different methodologies and proxies. However, considerable discrepancies among these reconstructions, as well as their often limited levels of spatial and thematic detail and the uncertainties resulting from equifinality in proxy records, restrict the potential for application in other research fields. There is thus a need for new methodological approaches that integrate different sources of data at a high spatial resolution. This study presents the methodological framework and first results of a multiple-scenario and multi-proxy land cover allocation model that is applied to the Belgian Dijle catchment (ca. 760 km^2) and aims to contribute to a better understanding of the evolution of anthropogenic land use patterns and intensity in the NW European loess area throughout the Holocene.

In the first part of the model, a series of hypothetical, time-independent land cover patterns is modeled based on a multi-objective allocation algorithm, including natural vegetation, cropland and pasture, and taking into account the land's natural suitability for agricultural land use and conservative ranges of values for input parameters such as settlement density, minimum inter-settlement distance, deforestation rates, and the specialization towards arable land or pasture. This results in a few tens of thousands of land cover maps, which are assumed to cover virtually every possible anthropogenic land cover pattern for the Holocene Dijle catchment.
Subsequently, to arrive at realistic land cover scenarios in the Dijle catchment for distinct cultural periods from the Neolithic onwards, the modeled scenarios are evaluated against three sources of time-differentiated, empirical data:

1. archaeological records serve to validate modeled settlement densities and patterns;
2. application of the modeled land cover maps in a pollen dispersal and deposition model (Humpol) allows to compare the resulting simulated pollen compositions to available palynological records for different time periods;
3. available field-based spatio-temporal sediment budgets are compared to simulated sediment redistribution patterns obtained through application of all modeled land cover scenarios in a geomorphic model (Watem/Sedem).

Land cover scenarios showing good agreement with each proxy record for a given time period are considered realistic and may, after feed-back to the model's input parameters and expert analysis, provide new insights in the occupation history and the magnitude and spatial distribution of past agricultural land use in the Belgian loess belt.

The presented method is applicable to any area with sufficient data availability. A major advantage of the independent allocation model and multi-proxy scenario evaluation approach, is that it deals with equifinality issues associated with the use of palynological or geomorphological proxy records solely. As such, it also provides a tool to evaluate available large-scale Holocene land cover reconstruction data sets that were obtained through e.g. population and land per capita estimates or pollen-based reconstruction models, whether or not spatially explicit.