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Human-induced Geomorphic Changes caused by Coal Mining: The Example of Mining Subsidence in the Ruhr District (Germany)

Stefan Harnischmacher
Department of Geography, University of Marburg, Marburg, Germany (stefan.harnischmacher@geo.uni-marburg.de)

For the first time, an area-wide and large-scale calculation of differences in elevation between 1892 and today was conducted for the Ruhr District (Germany), a metropolitan region influenced by subsidence due to deep-seam coal mining starting in the middle of the 19th century. Elevation data on historical maps from 1892 was digitised with the help of a Geographic Information System and the interpolated historical surface was intersected with a current Digital Elevation Model, in order to calculate the differences in elevation. As a result, the highest values of elevation differences, amounting to more than 25 m, were observed within the coal-fields of the former coal mine "Zollverein" which is distinguished for its long mining history and its World Heritage status. A comparison of single reliable elevation data, derived from surface levelling data of the land registry office, with the interpolated values from 1892 reveals an astonishing correlation with differences of not more than 1 m.

Two examples from the cities of Essen and Dortmund analysed in detail reveal that not only depressions but also elevation features are affected by mining subsidence. These kinds of surface transformations are not visible in the field without a comparison of digital topographical models. The change detections allow for a correlation with mining activities, because most of the mining subsidence areas are located next to a former coal mine. Furthermore, tectonic features of the Carboniferous strata are reflected by the location of subsidence areas, since they are located along synclines with a gentle dip of coal seams or confined by the location of predominant faults.

The average amount of surface lowering was calculated for all maps digitised and analysed, resulting in a mean net value of 1.6 m or 13.9 mm per year (1892-2007) for the total area un-der investigation (2,827 km^2). Even that mean surface lowering rate exceeds nearly all of the highest denudation rates of river catchments in the world. And the highest documented denudation rate of 20.6 mm per year for the catchment of the river Huangfuchuan, a tributary to the Yellow River in China, is only half that of the mean surface lowering rate observed for the city of Gelsenkirchen (45.1 mm per year), located in the central Ruhr District with an area of 105 km^2 and strongly affected by coal mining activities. However, this attempt of a comparison between mining-induced geomorphic changes and landscape dynamics at least offers an impression of the intensity of human impacts on the ground surface in the Anthropocene, bearing in mind the different time-scales.