Geophysical Research Abstracts, Vol. 8, 02244, 2006
SRef-ID: 1607-7962/gra/EGU06-A-02244

Multi-scale modelling of land-use change and river training effects on floods in the Rhine

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The effects of land-use changes on floods in large scale basins is investigated by means of a multi-scale modelling study, where the hydrological cycle, in particular storm runoff generation of catchments of different sizes (macro, upper meso, lower meso scale) and different land-use (urban, agriculture, forest use) and morphological characteristics (e.g., different soil depths, different slopes) is simulated in a nested manner. The macro-scale covers the Rhine basin (excluding the alpine part), the upper meso-scale covers various tributaries of the Rhine (in particular the Neckar catchment) and the three lower meso-scale study areas (100 to 500 km^2) represent three different characteristic land-use patterns: the Lein catchment representing the agricultural land-use type, the Körsch catchment as a heavily urbanised area and the upper Lenne river, which is mainly covered by forest. Spatially distributed land-use change scenarios have been developed at all scales representing a likely development of land-use in the coming decades, such as an increase of urban areas (at the expense of agricultural areas) and the establishment of urban storm water retention and local infiltration measures. At the macro scale the land-use scenarios were complemented by scenarios of the planned controlled flood retention in polders. In addition, two meteorological scenarios were developed representing a meteorological forcing which exceeds the flood triggering rainfall and snowmelt situations observed until now. The results showed that the influence of land-use on storm-runoff is stronger for convective storm events with high precipitation intensities than for long advective storm events with low precipitation intensities, because only storm events associated with high rainfall intensities are at least partially controlled by the conditions of the land-cover and/or the soil-surface.

The simulated flood increase at the lower meso-scale for a scenario of rather strong, urbanisation is in the order in 0% and 4% for advective rainfall events, and10% to 30% for convective rain storms. The establishment of urban storm water retention and local infiltration measures yields reduction of flood peaks by same order of magnitudes as the increase due to urbanisation in catchments, i.e. can be significant only for convective rainstorms. Convective storm events, however, are hardly relevant for flood formation in the large river basins of Central Europe, because the extent of convective rainstorms is usually restricted to local occurrence. That is why land-use change effects at the macro scale in Central Europe are very small. E.g. at Cologne (catchment area of more then 100,000 km^2) land-use change may result in a difference of not more then 1cm to 5cm water level of the Rhine. Water retention measures in polders along the Upper and Lower Rhine under the given boundary conditions yield flood peak attenuation along the Rhine all the way down to the Dutch border of between 1 cm and 15 cm. The optimised and co-ordinated control of the polders can result in a considerably stronger decrease of the peaks.