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Large-scale flood risk assessment considering river-dike-floodplain interactions and related spatial risk redistribution

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Fluvial processes such as attenuation or superposition of flood waves in river networks, natural and human-controlled floodplain storage or failure of flood defences may considerably shape the spatio-temporal pattern of flood hazard and risk. These interactions between different fluvial processes are particularly important for risk assessment for policy making and reinsurance industry, yet are not considered in models at large-scales. This research intends to develop the modelling tools and analysis techniques to quantify large-scale effects of fluvial processes (e.g. floodplain storage effects) and particularly of dike failures on the evolution of flood patterns in a large basin. The model developed will be applied to the Rhine river basin.

This research builds on an existing flood risk model, the Regional Flood Model (RFM) developed at the GFZ, that consists of a chain of process-based sub-models each one of them representing a major component of the flood risk chain, i.e. a multisite weather generator, a hydrological model, a 1D hydrodynamic river model, a 2D overbank inundation model and a flood loss model for economic damage. The underlying concept of RFM is based on the 'derived flood risk' approach which aims at determining flood risk curves, here economic damage vs. frequency, directly from long simulated damage time series (e.g. 10 000 years). Very long continuous simulations are required to capture a sufficiently large number of flood events representing the natural variability of inundation-generating processes. RFM will be further developed by enhancing the capabilities of the 1D hydrodynamic scheme, now limited to the propagation of flood waves at the reach-scale, towards a consistent whole-basin approach. Based on geomorphological empirical relations, simplified rectangular channel cross-sections in the Rhine basin have been estimated which was a basic requirement of a more realistic hydraulic approach. This was accomplished by assuming the bankful discharge in the network as the one-in-two year peak discharge and estimating it using flow time series, fitting a power law drainage area vs. bankful discharge curve in the basin, and using hydraulic geometry power laws that link the bankful discharge to cross-section properties so as to find average bankful depth estimates in the whole network. Then, the possibility of dike failures will be accounted for by adding a flood defense reliability module that will test the resistance of each dike segment defined in the basin with respect to the load exerted by overflowing the flood waves. The results obtained with the different model versions developed during the course of the research, i.e. with a whole-basin hydraulic approach and with dike failures, will be compared to assess the influence of the river-dike-floodplain interactions on the flood risk.