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Probabilistic flood hazard maps under consideration of dike failures

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A methodology combining a full 1D hydrodynamic model of the river channel with a dike breach model due to overtopping and a 2D raster-based inundation model is proposed for probabilistic flood hazard assessment. The modules are coupled using the Typed Data Transfer (TDT) library providing an interface for data exchange between models at runtime. The system is embedded in a Monte-Carlo framework and simulates the flooding of a 91 km reach of the Elbe River between Torgau (Elbe-km 154.6) and Vockerode (Elbe-km 245.6) on a High Performance Cluster (HPC). A 1D hydrodynamic model is setup for the Elbe channel and adjacent floodplains between the dikes and calibrated on a number of high flow events. To each dike segment of 500 m length a fragility curve is assigned. This curve indicates the probability of dike breaching due to overtopping as a function of overtopping height and duration. It was constructed on the basis of load-resitance failure model as a result of Monte-Carlo simulation based on dike geometry parameters and their variability. In case of a dike failure the outflow discharge through the breach serves as a boundary condition for the storage cell inundation model that calculates the inundation of the dike hinterland. The back coupling between the dike breach and the 1D channel model is realized to correctly represent the flood wave reduction in a river due to the outflow at the breach. The modelling of continuous hydraulic load under unsteady flow conditions and interactions between the process components at runtime allow to account for the temporal component in dike breach sequencing and thus to consider dependencies between discrete dike segments. A series of probabilistic flood hazard maps was produced as an output of a Monte-Carlo simulation for a synthetic 300-year flood event. The dike breach widths and the dike breach probability conditioned by the fragility curves were considered as stochastic variables in a modelling process. The dike breach width was

assumed to follow a log-normal distribution. This distribution was fitted to the breach widths recorded during the August 2002 flood in the Elbe catchment. The computed flood hazard maps represent the inundation binary pattern and the flood intensity indicators, such as inundation depth, rate of water rise and inundation duration. A probability value assigned to each raster indicates a probability of not exceeding a value of the intensity indicator in each raster cell. The computed quantile maps corresponding to the probabilities of 5% and 95% indicate a range of variation in the output variables. This variation is stipulated by the stochastisity of the dike failure and breach development processes. Vulnerable dike sections prone to failure due to overtopping can be identified as a result of the Monte-Carlo analysis. The resulting flood hazard maps can be utilized in a meso-scale flood risk assessment.