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Coupling 1D hydrodynamic, dike breach and inundation model for flood risk assessment along the Elbe River

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Objectives and study area

Recent flood events, especially in August 2002, stress the necessity for comprehensive inundation risk assessment and for generation of flood risk maps and indication of the associated uncertainty.

Study objectives:

· Develop a modelling system for the simulation of inundation areas under consideration of dike breaches for extreme flood events (T=100, 200, 500, 1000)

· Assess an uncertainty range associated with the breach locations, inundation extent and flood intensity indicators

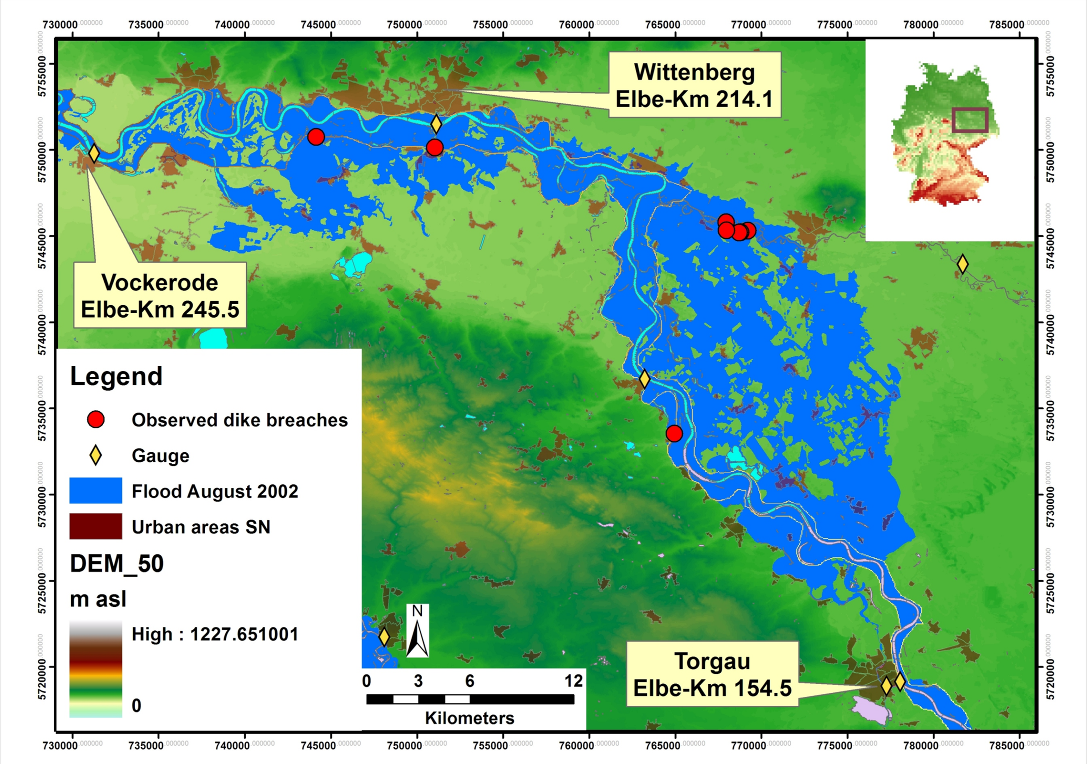

Figure 1. Study area: 91km Elbe reach between Torgau and Vockerode.

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Modelling system

A proposed methodology provides the flood hazard estimations for hinterland areas under dike breach conditions. Simulations of the continuous hydrologic load and of the inter-actions between hinterland and river channel allow the consideration of dependencies between dike sections in a multiple dike failure analysis.

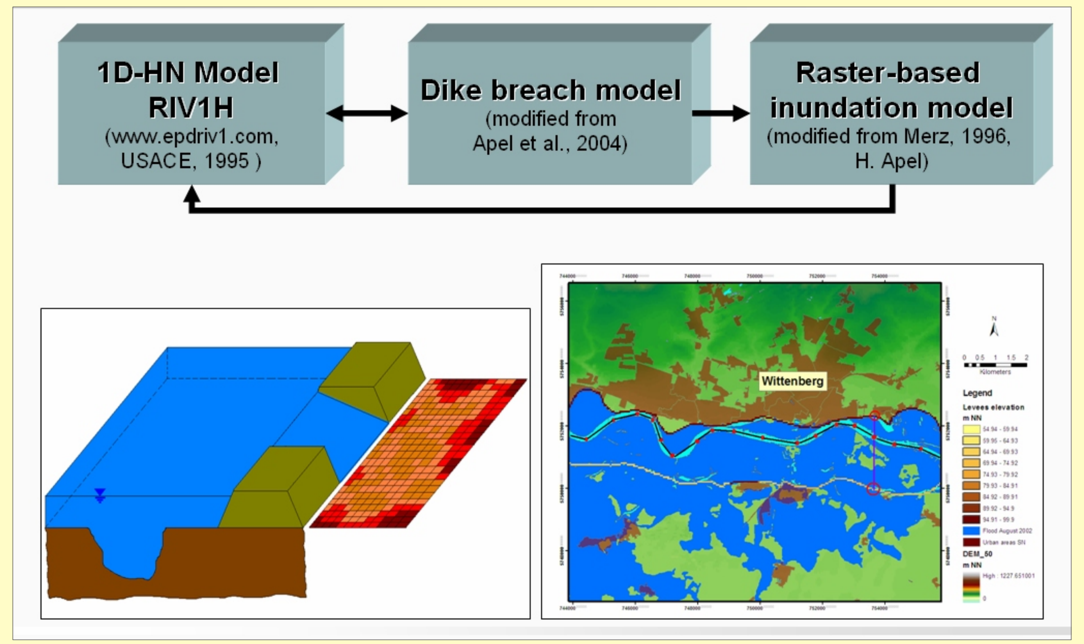

Figure 2. Modelling system concept and spatial discretization

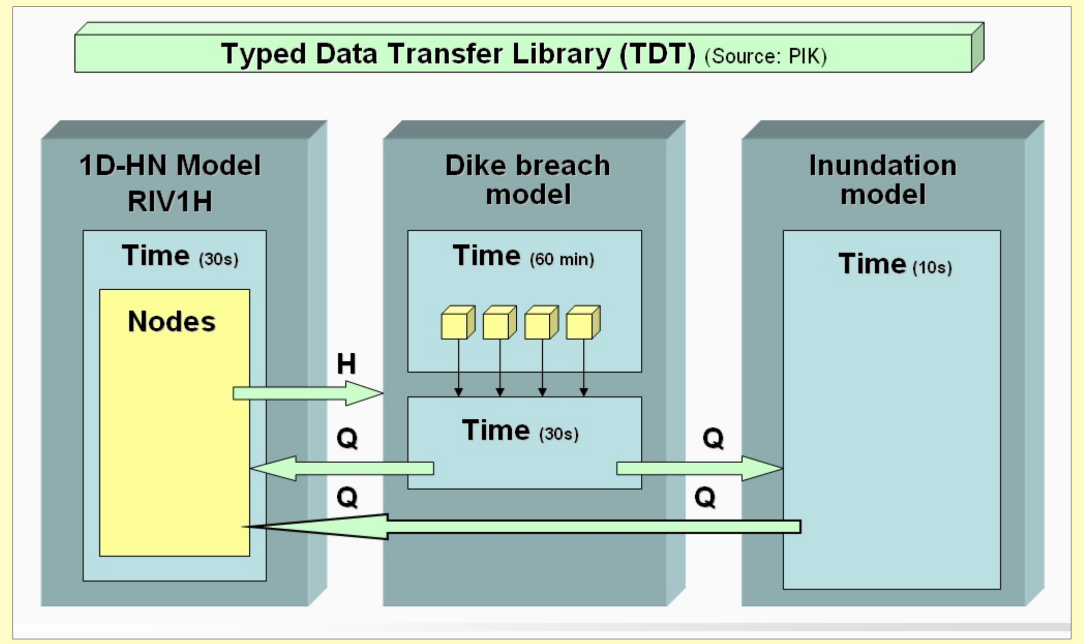

Figure 3: Schematical representation of the coupled models and exchange variables H (water level) and Q (discharge). The time iteration loops are given exemplarily and can be changed by the user.

A fully 1D finite-difference hydrodynamic model of the river channel is coupled with a deterministic dike breach model which is based on the critical overtopping criterion. A probabilistic approach based on fragility curves is under development. In case of a dike failure the outflow discharge through the breach is used as a boundary condition for the 2D storage cell inundation model based on continuity and diffusion wave equations discretized over the grid. The modelling codes are coupled using the TDT library providing an interface for data exchange between the models during runtime.

First results and interpretation

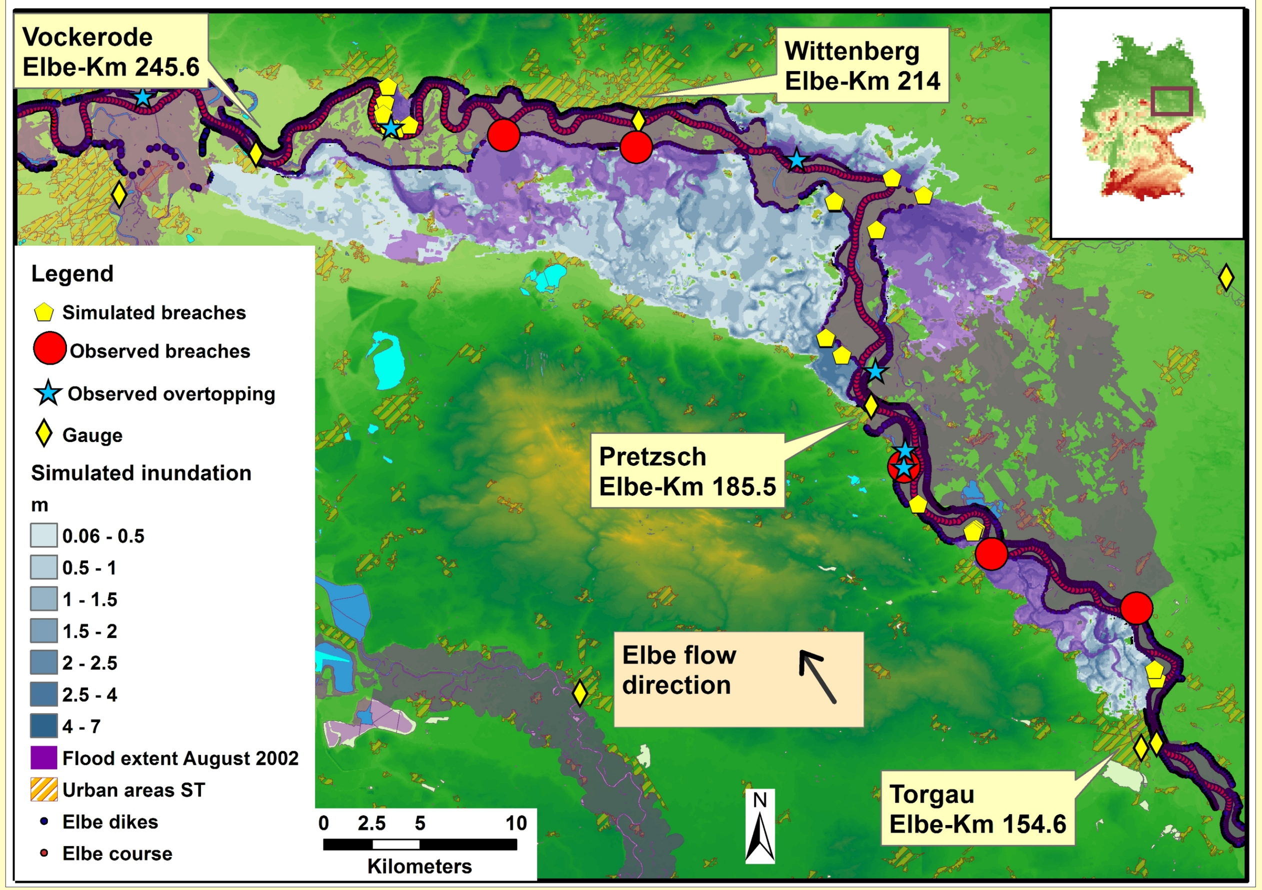

Figure 4. Maximum simulated inundation (Flood area index F = 25.2 %)

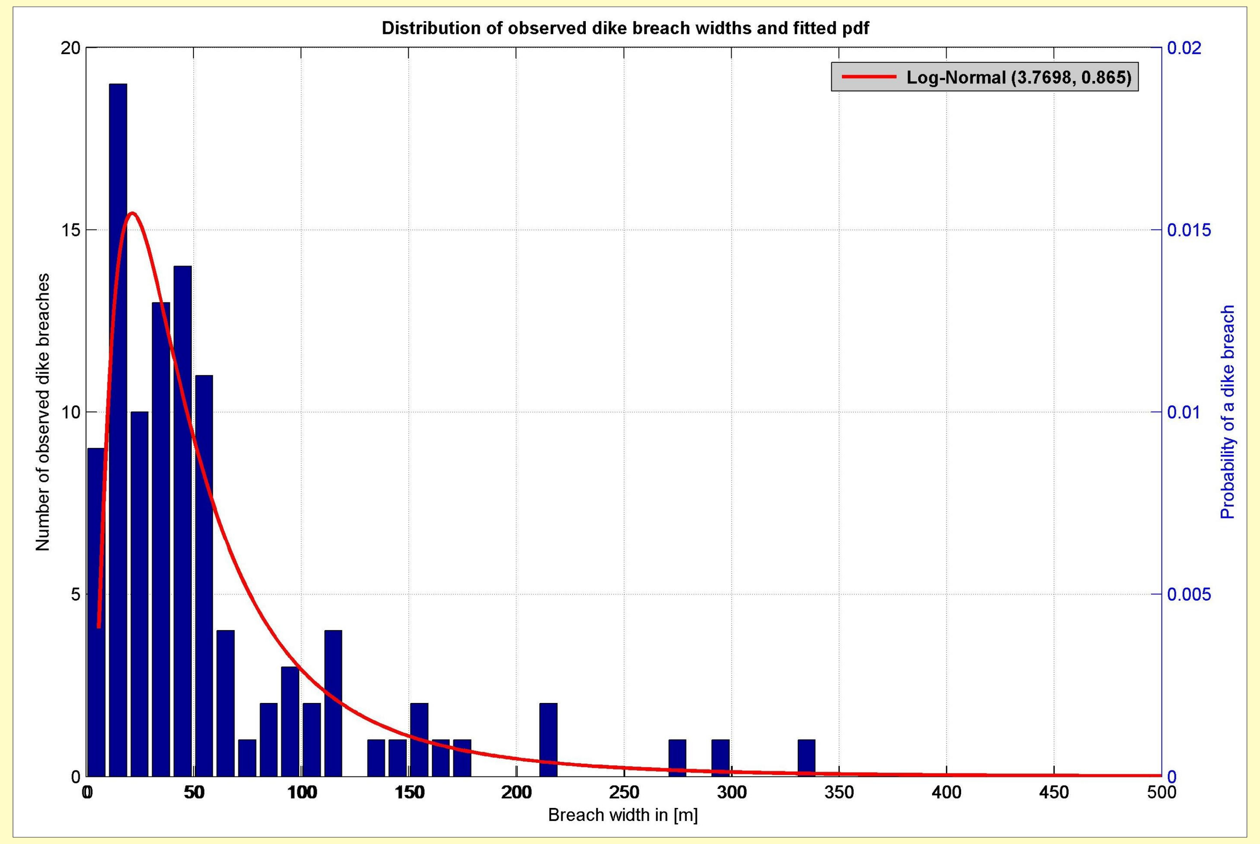

Figure 6. Observed dike breach width distribution and fitted Log-Normal pdf, tested with Chi[2]-Test and Kolmogorov-Smirnov-Test with 1% level of significance. Based on data from Gocht 2002 and Horlacher et al., 2005

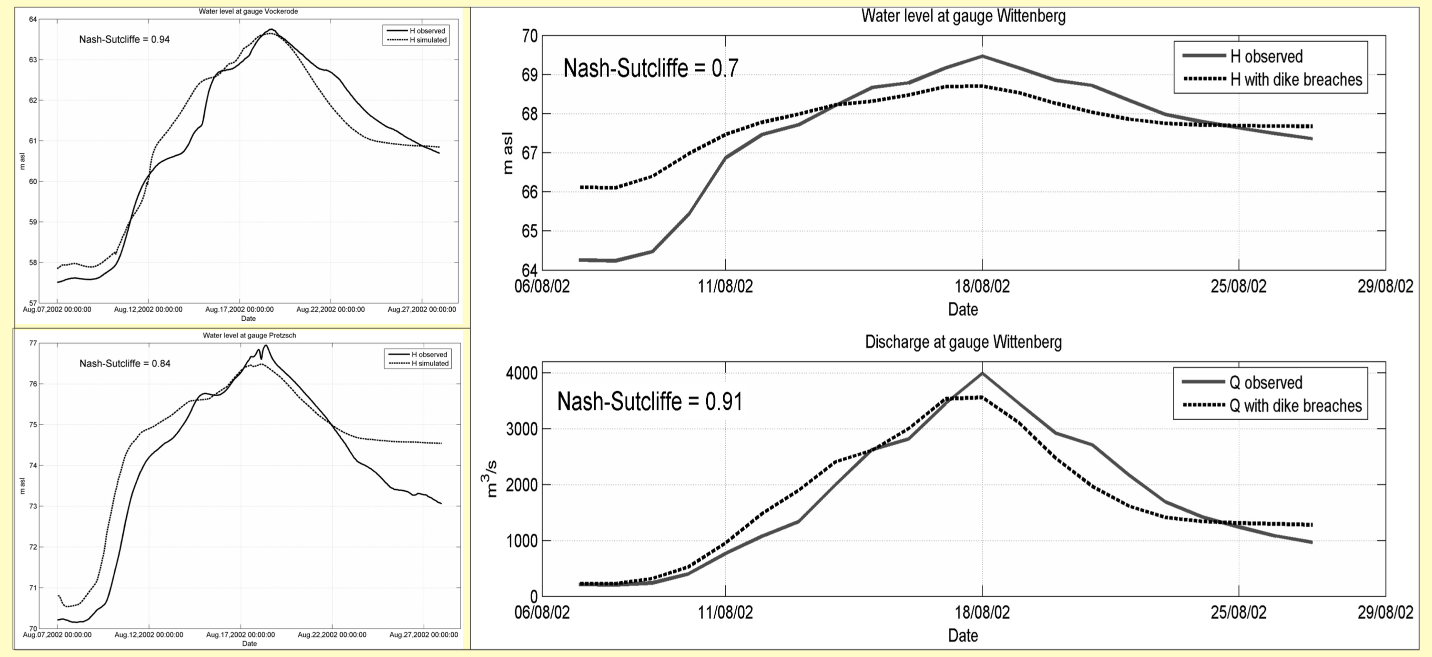

Figure 5. Comparison of water level and flow hydrographs

The modelling system is run to simulate the August flood in 2002. Several dike failures with the corresponding inundation areas have been simulated (Fig.4). (Flood area index F = 25.2%). Comparison of the water level and flow hydrographs indicates a good agreement (Fig.5). However, water levels are partly overestimated at low flows due to inaccurate cross-section profiles. The dike breach model represents the largest source of uncertainty in inundation extent modelling.

Log-Normal distribution (3.7698, 0.865) was fitted to the observed dike breach width distribution derived from 103 breaches in the German part of the Elbe catchement (Fig. 6). According to the Chi^2-Test and Kolmogorov-Smirnov-Test with the level of significance of 1% the Null-Hypothesis could not be rejected. The hypothesis that the data are distributed according to the Weibull distribution was rejected. The fitted distribution function will be used in probabilistic dike breach modelling within the Monte-Carlo simulation.

Further development

- Implementation of the Monte-Carlo framework for the modelling system with Latin-Hypercube sampling
- Development and application of the validation strategy for deterministic and probabilistic modelling system components
- Computation of the inundation areas for extreme flood scenarios and generation of hazard maps for specified return periods
- Uncertainty analysis with regards to the spatiotemporal distribution of dike breach locations, inundation extent and depth