A NEW METHOD FOR COUPLING ONE- AND TWO-DIMENSIONAL RIVER AND FLOODPLAIN MODELS TO PREDICT THE IMPACTS OF DIKE BREAKS

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Any forecasting of the effects of floods has to balance between accuracy and efficiency. The complexity ranges from simply intersecting a plane representing the water surface with a Digital Elevation Model for estimating the flooded area on the one hand to full solutions of the Navier-Stokes equations on the other. Techniques that use two-dimensional, depth-averaged form of the Navier-Stokes equations incline high computational costs and are generally not applicable for near real-time purposes (Bates *et al*, 2003). However, the sophistication of flood inundation modelling has increased in line with model developments and increased computational resources. Nevertheless, it is still an open question, if simpler models may provide similar levels of predictive ability (Bates & De Roo, 2000). The paper focuses on the development and testing of a one-dimensional hydrodynamic model and a simplified two-dimensional flood inundation model. The fluxes at the interface are calculated with a new empirical approach. Flow in the main channel is described by the one-dimensional Saint-Venant equations for conservation of mass and momentum and floodplain overflow is simulated with a raster based storage cell method.

Discharge Q_{br} through the breach can be written as a Poleni-like formula. The discharge becomes a function of water depth on the floodplain h_{fp}, width of the gap in the dike b_{br}, the influence length b_i (Fig. 1), the gravitational force g and velocity U_r. A normalized dike breakage parameter $\mu^* = f(\beta, Fr)$ describes the influence of the dike breakage. Thus, the parameter μ containing all energy losses is then the product of $\mu_0 = 0.577$ as the maximum theoretical value and the introduced parameter μ^*:

$$\mu = \mu_0 \cdot f(\beta,\ Fr) = \mu_0 \cdot \mu^* \quad (1)$$

The following set of equations is the result of analyzed synthetic dike break scenarios for the River Rhine and show a high correlation coefficient of $R^2 = 0.87$ (see Fig. 2):

$$\xi = 0,4 \cdot \sqrt{Fr} \cdot \left(\frac{b_i}{b_{br}} \right)^2 \quad (2)$$

$$\mu^* = 0.1146 \cdot \ln(\xi) + 0.6895 \quad (3)$$

$$Q_{br} = \tfrac{2}{3} \cdot 0.577 \cdot \mu^* \cdot \sqrt{2g} \cdot b_{br} \cdot h_{fp}^{3/2} \quad (4)$$

While the average error of results with constant μ^*=1.0 is about 125 % compared to performed depth-integrated numerical simulations, the results of the developed dike-break approach differ only about an average of 24 % from results of preliminary performed two-dimensional simulations.

Thus, the possibility of combining one- and two-dimensional models using the new approach is a great improvement compared with current methods to calculate flooded areas with extrapolated water levels from one-dimensional models.

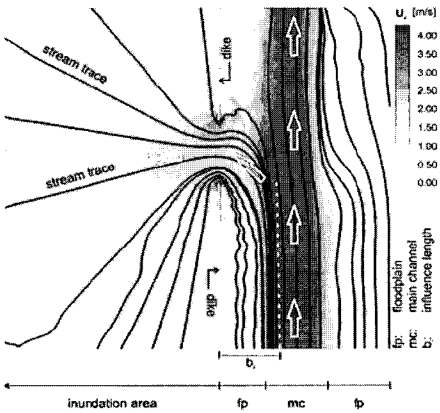

Fig. 1 The influencing channel width

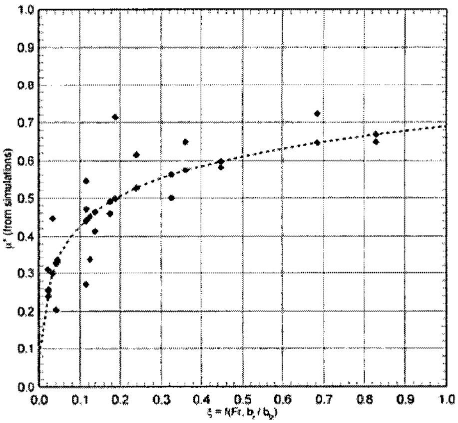

Fig. 2 Correlation between and the dike break parameter μ*

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