



Real-Time Flood Mapping Considering Dike Breaching

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Floods resulting from dike breaches pose significant risks to infrastructure and human safety. This study presents a comprehensive approach for real-time flood mapping, by combining machine-learning-based hydrological models and hydraulic simulations to estimate flood extent and impact following a dike breach in a network of waterways. The methodology integrates climate data, AI-driven hydrological predictions, efficient river flow models, and real-time flood mapping.

The procedure begins with the acquisition of meteorological data, including precipitation observations and forecasts (disaggregated at an hourly resolution). This data is updated at each triggering of the calculation to reflect the most current meteorological conditions. The precipitation data are then fed into an AI-based hydrological model, to predict river discharge values with a 24-hour lead time at key streamflow stations. These discharge predictions constitute the upstream boundary conditions for an efficient 1D staggered-grid hydraulic model of the network of waterways.

The hydraulic model simulates flow processes within the main channels. It is coupled to a model for the morphodynamic evolution of dike breaches. This model is semi-empirical and lumped, to account for the multi-scale nature of the breach process, in which certain failure mechanisms (e.g., slope failures) occur on much smaller spatial scales than those controlling flow dynamics in the channels and floodplains. By using a lumped model for the breach, the need for refining the computational grid in the near-field of the breach is reduced, while still capturing the main effects of complex geotechnical and sediment transport processes involved in dike failures.

The hydraulic model outputs, including computed water levels in the main channel, are used in conjunction with fragility functions representing the resistance of the earth-filled dikes, to determine the likelihood of dike breaches at potential breach locations. For each breach scenario, pre-computed results of a detailed 2D hydraulic model are used to assess the inundation depth, flow velocity, and flood extent across the floodplains. This enables creating dynamic danger maps that are crucial for identifying assets at-risk and estimating impacts (monetary damages). These outputs support the evaluation of potential mitigation measures, such as adjusting weir operations to divert floodwaters from vulnerable areas or redirecting flows toward alternate channels.

The novel procedure proposed here is demonstrated on a case study involving critical waterways in Belgium connecting the Meuse River to the Sea Port of Antwerp. The focus is set on a particular canal segment due to the high population density and presence of industrial infrastructures in the floodplains.

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