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Assessment of lumped physically-based numerical models of dyke breaching

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Failure of fluvial dykes often leads to devastating consequences in the protected areas. Overtopping flow is, by far, the most frequent cause of failure of fluvial dykes. Numerical modeling of the breaching mechanisms and induced flow is crucial to assess the risk and guide emergency plans.

Various types of numerical models have been developed for dam and dyke breach simulations, including 2D and 3D morphodynamic models (e.g., *Voltz et al.*, 2017 ; *Dazzi et al.*, 2019 ; *Onda et al.*, 2019). Nevertheless, simpler models are a valuable complement to the detailed models, since they enable fast multiple model runs to test, e.g. a broad range of possible breach locations or to perform uncertainty analysis. Moreover, unlike statistical formulae, physically-based lumped models are reasonably accurate and remain interesting in terms of process-understanding (*Wu*, 2013 ; *Zhong et al.*, 2017 ; *Yanlong*, 2020).

Nonetheless, existing lumped physically-based models were developed and tested mostly in frontal configurations, i.e. for the case of breaching of an embankment dam and not a fluvial dyke. Despite similarities in the processes, the breaching mechanisms involved in the case of fluvial dykes differ due to several factors such as a loss of symmetry and flow momentum parallel to the breach (*Rifai et al.*, 2017). Therefore, there is a need to assess the transfer of existing lumped physically-based models to configurations involving fluvial dyke breaching.

Here, we have developed a modular computational modeling framework, in which we are able to implement various physically-based lumped models of dyke breaching. In this framework, we started with our own implementation of the model presented by *Wu* (2013) and we incorporated a number of changes to the model. Next, we evaluated the model performance for a number of laboratory and field tests covering both frontal (*Frank*, 2016; *Hassan and Morris*, 2008) and fluvial (*Rifai et al.*, 2017; 2018; *Kakinuma and Shimizu*, 2014) configurations. The modular framework we have developed proves also particularly suitable for testing the sensitivity and uncertainties arising from assumptions in the model structure and parameters.