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Accounting for uncertainty in the propagation of dam break flood waves in the Rhone River: from hazards to risks

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Abstract

The safety of large dams is commonly verified resorting to deterministic approaches, according to which a number of scenarios designed to represent the main ways in which the infrastructures may fail.

Such approaches certainly provide valuable qualitative depictions of risk, but by no means quantitative ones. In fact, overall scenario probabilities are commonly unknown and a number of uncertainties neglected.

Here, an inclusive Monte Carlo probabilistic approach in which aleatory and epistemic uncertainties are accounted for is explored. To accomplish it constraining computational challenges associated with dam break flood wave routing were addressed [1].

STREST
Harmonized approach to stress tests for critical infrastructures against natural hazards

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ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
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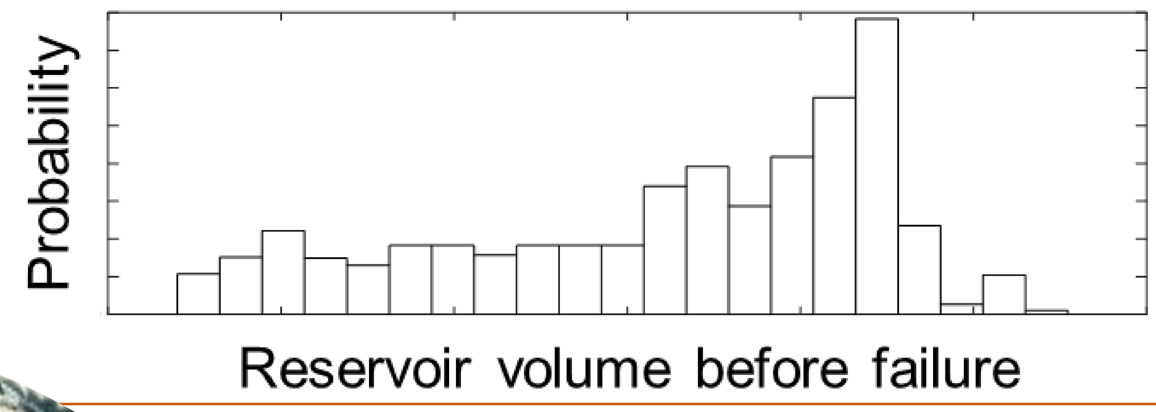
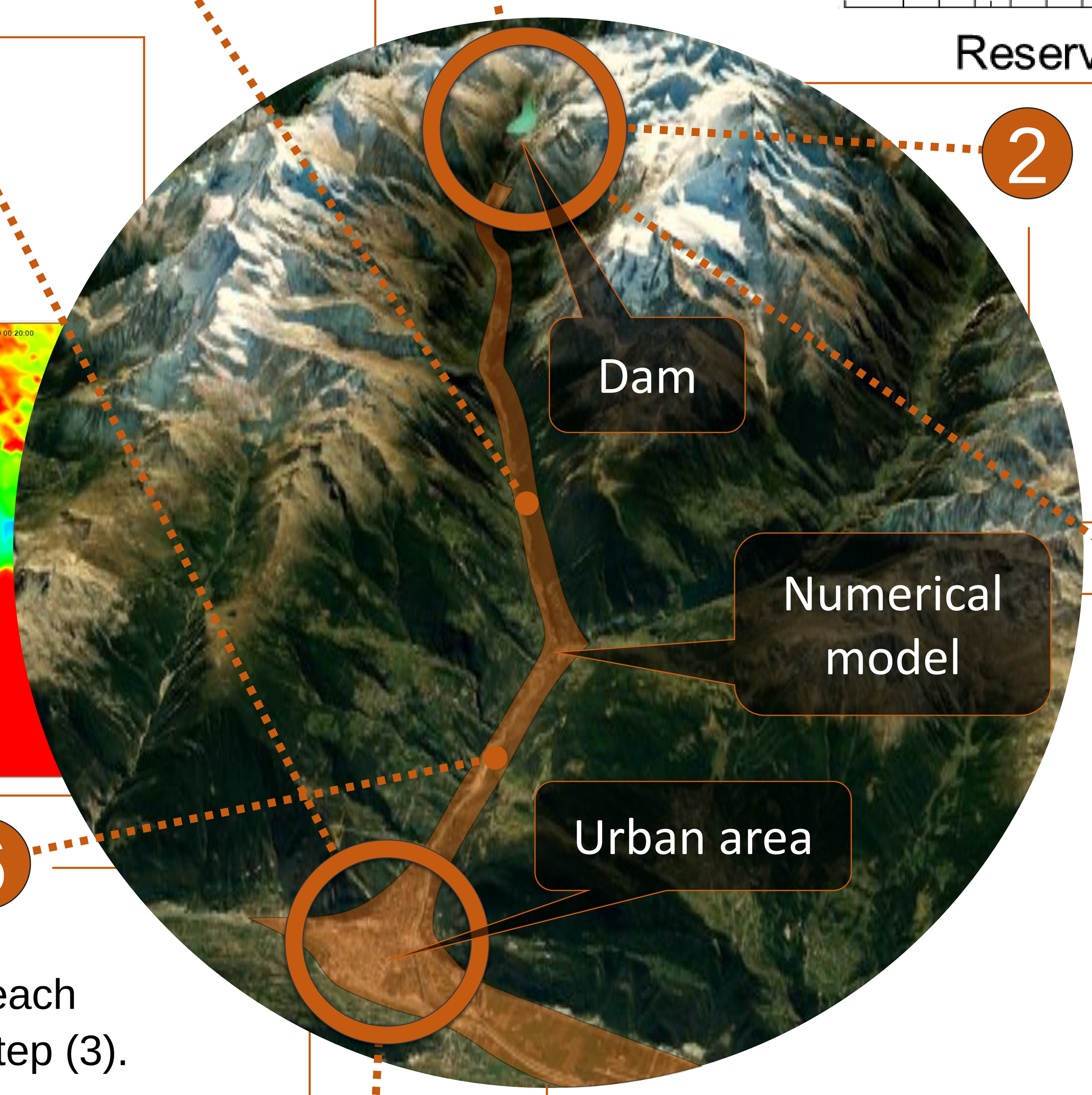
1 Failure occurrence and upstream flood conditions

Millions of years of operation of the system are simulated accounting for epistemic uncertainty, hazard coincidences, inter-actions, and intra-hazards. Failure probabilities and other data are obtained using the Generic Multi-Risk (GenMR) framework [2].



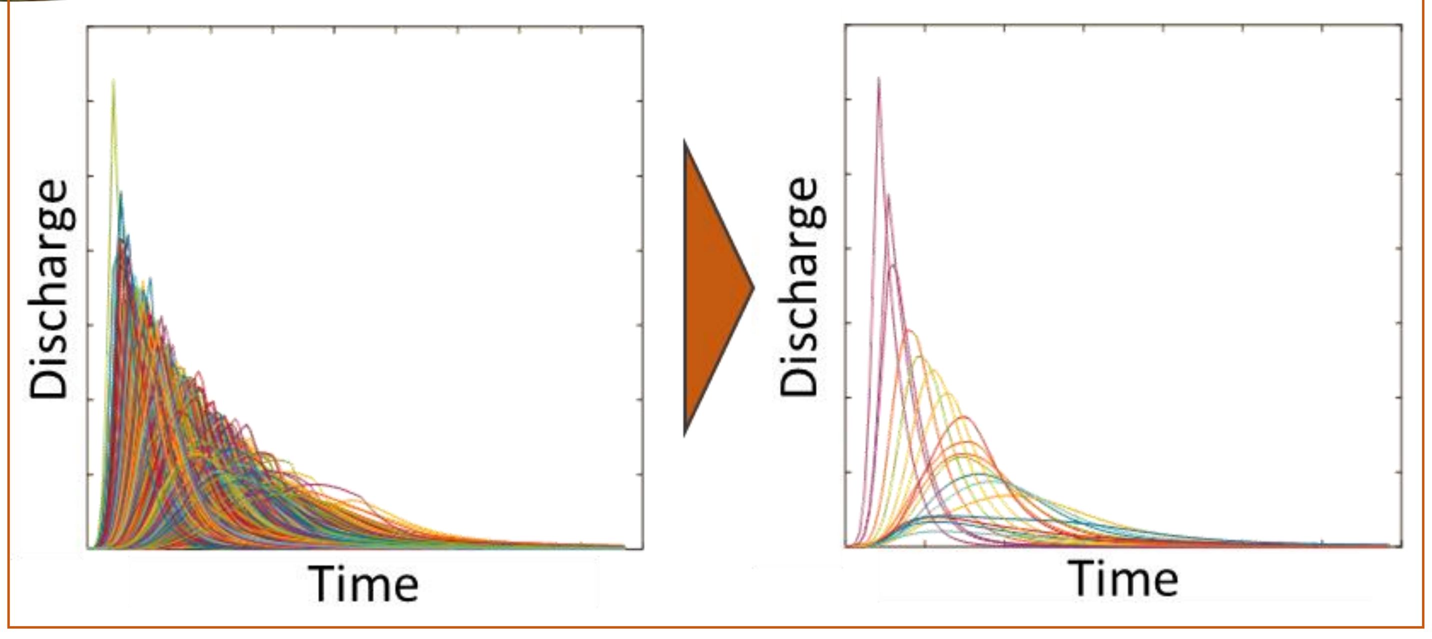


2 Breach formation

The methodology is applied to earthfill dams, where a large degree of uncertainty is associated with the formation of breaches [3].

3 Breach catalogue

Clustering is used to select a representative catalogue of breaches from which any breach can be derived. Detailed hydraulic simulations are only computed for the hydrographs derived from the catalogue.



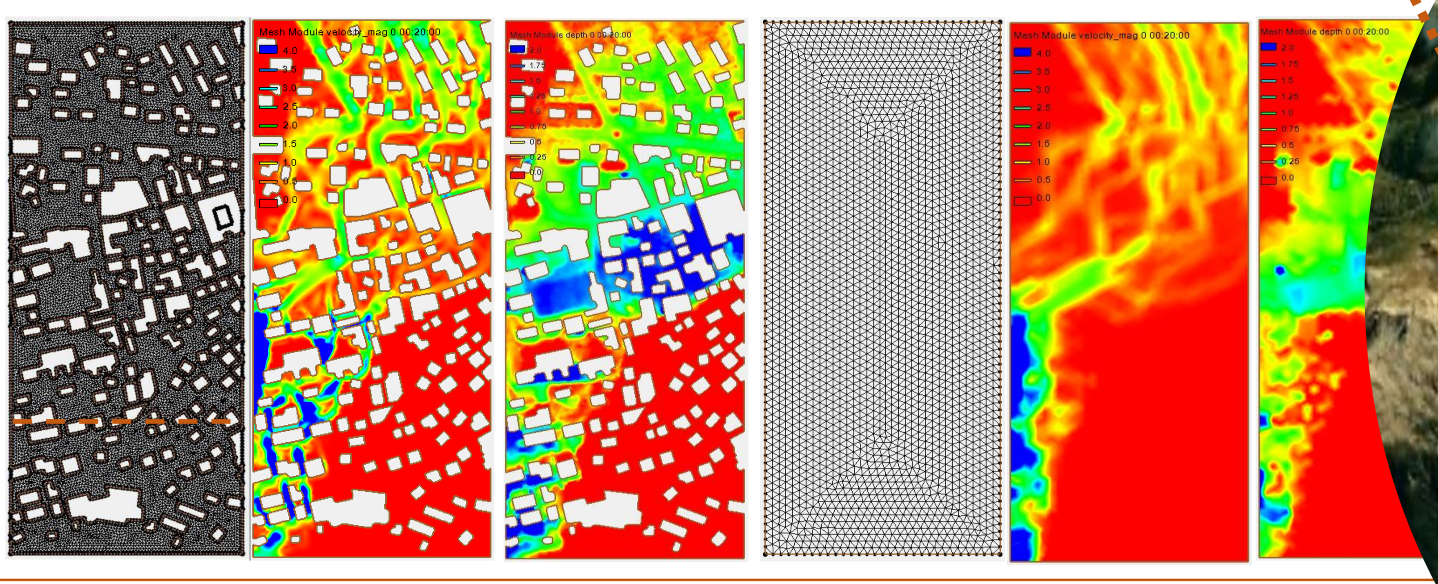
4 Numerical model for routing

Creation of a 1D/2D coupled numerical model using BASEMENT.

5 Numerical modelling of urban areas

Model roughness correction to obtain acceptable results with a relatively large mesh; thus faster to run.

$$K^* = K \cdot f(built\ area) \cdot g(built\ perimeter)$$



6 Numerical simulations and their interpolation

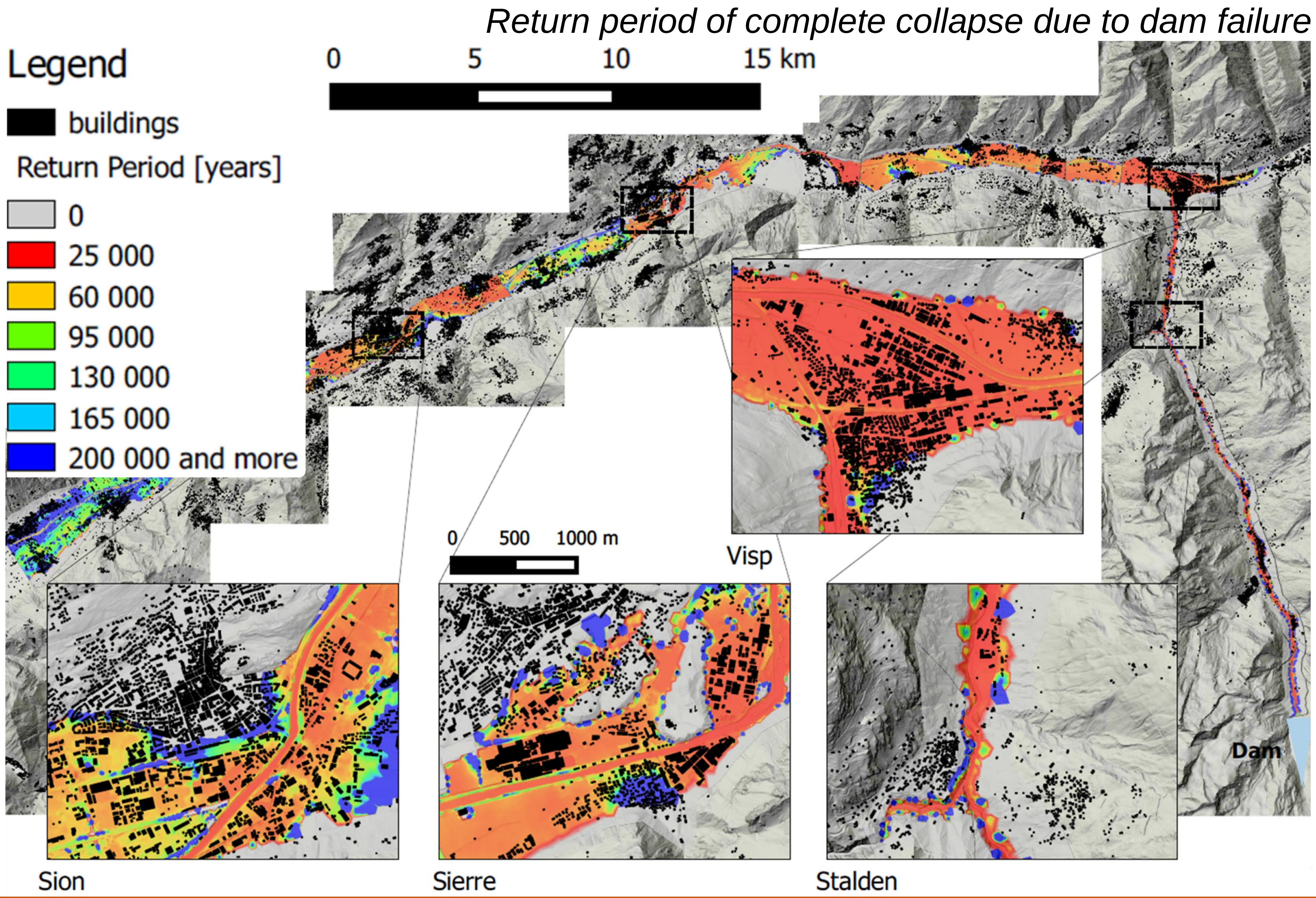
Detailed BASEMENT simulations are conduced for each breach derived from the failures within the catalogue computed in step (3).

Focusing on each parameter (e.g. max. depth, max. velocity) a regression is made for every possible breach and location over the inundated area.

7 Damage and risk assessment

Using fragility curves specific for building type and size [4] one can estimate damages. With frequency information from step (1) it is possible to compute formally sound risk estimates.

Return period of complete collapse due to dam failure



References

[1] Darcourt, A. 2016. Numerical simulation of dam break flood wave propagation in the Rhone River. From dam breach formation to loss assessment. M.Sc. Thesis. School of Architecture, Civil, and Environmental Engineering, École Polytechnique Fédérale de Lausanne.

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[3] Froehlich, D. C. 2008. Embankment Dam Breach Parameters and Their Uncertainties. Journal of Hydraulic Engineering doi:10.1061/(ASCE)0733-9429(2008)134:12(1708).

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