# Robust inversion for risk analysis – application to the failure of defences against flooding

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## ABSTRACT

The risk of coastal or fluvial flooding is aggravated by the failure of defences (either natural like dunes or artificial like dykes). The study of flood hazard on the Dutch River System illustrates this (Curran et al., 2019) along with several events that occurred in the last decade such as the hurricane Katrina in 2005 in New Orleans (Sills et al., 2008). The failure of defences is a factor of flooding risk whose importance will keep increasing in the future because of climate change.

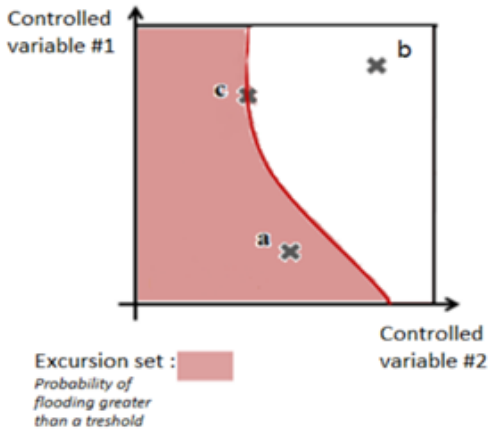
Our analysis of coastal and river flooding takes into account the following variables:
- Controlled variables, related to the geometry and location of the protective structures.
- Uncontrolled variables capturing the randomness of natural phenomena, such as hydrograph parameters for river flooding and offshore hydrodynamic conditions (e.g wave characteristics). These variables have known probabilistic laws.
- Drastically uncertain variables, that are uncontrolled but not well characterized either probabilistically or in regulations. They describe the location and time of the failure of the protective structures.

In this work, we investigate a mathematical procedure based on inversion to characterize the possible combinations of controlled parameters (named excursion set) that lead to flooding with a probability greater than a given threshold $\alpha$, which can be defined as a standard safety limit. This procedure aims at helping flooding risk prevention around industrial sites for instance.

Several questions are addressed:

- First, how to represent excursion sets when there are more than two controlled variables and some uncertain variables do not have a known density. The relationship between the random set and the quantile set is theoretically investigated.
- Second, the numerical simulations of the flooding are expensive to compute (typically several hours): metamodeling techniques (mainly kriging) combined with active learning (Bect et al, 2012) specifically dedicated to the estimate of the excursion set are used to reduce the computational cost.
- Third, the inversion needs to be robust in the sense that it needs to consider the random nature of the uncontrolled variables. We generalize previous studies that dealt with uncontrolled variables through a worst-

case scenario (Bacchi and Richet, 2019) by considering rare events.

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