

Phd offer : robust identification of excursion sets with application to flooding risk

Administrative information

Keywords (5 max)	uncertainty, data science, adaptive learning, flooding risk
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Doctoral school	ED 488 SIS

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Application deadline : May 31 2020

Summary

The risk of coastal flooding is aggravated by the failure of coastal defences (either natural like dunes or artificial like dykes), see an introduction to the context by Jonkman et al. (2008); Curran et al. (2019); Muller et al. (2016). In numerical simulations, such processes are typically accounted for by defining a set of scenarii describing for instance the possible spatial location, time duration, erosion height / width of the failures. In the current PhD, we propose to develop a systematic mathematical procedure to characterize the possible combinations of conditions (named excursion set) that lead to flooding. It involves the inversion of the numerical models that simulate the floods. In order to alleviate the computational cost of this task, we build upon the combination of metamodelling techniques (kriging/Gaussian processes) and active learning specifically dedicated to the estimation of excursion set (see Bect et al., 2012; Chevalier et al., 2014; Azzimonti et al., 2016). Richet and Bacchi (2019) and Rohmer et al. (2012) provide two examples of application of such techniques in the domain of flooding. The PhD aims at improving the existing methods in two ways: (1) methodologically, by making the inversion robust to extreme-but-rare events and accounting for uncertainties in the numerical models; (2) operationally, by assessing how this approach can help in the communication and the management of the risk through better high dimensional visualization of the excursion set and the decomposition of the uncertainties. The application cases will focus on marine (BRGM) and river (IRSN) flooding. The PhD candidate will participate to the continuation of the OQUAIDO collaborative project (<http://chaire-mathematiques-appliquees.emse.fr/>) and benefit from numerous interactions with other researchers in the same scientific domain.

Partnership

The PhD is a collaboration between 3 partners :

- The BRGM – DRP/R3C team (<https://www.brgm.eu/>) ;
- The IRSN - BERIG team (<https://www.irsn.fr/EN/Pages/home.aspx>) ;
- The LIMOS laboratory (<https://limos.fr/> , UMR CNRS 6158).

Candidate profile

The candidate should:

- Hold a master's degree in applied mathematics: probability/statistics, machine learning, data science, optimization,...
- Have a strong background in scientific programming using (Python, Matlab/Octave, R for example)
- Have English skills allowing scientific communication (oral/reading/writing)

Related bibliography

Azzimonti, D., Bect, J., Chevalier, C., & Ginsbourger, D. (2016). Quantifying uncertainties on excursion sets under a Gaussian random field prior. *SIAM/ASA Journal on Uncertainty Quantification*, 4(1), 850-874.

Yann Richet, Vito Bacchi (2019). Using an inversion algorithm for the optimization of civil defense against flooding: application to bi-dimensional numerical model of the Garonne River. *Frontiers in Environmental Science*. accepted

Bect, J., Ginsbourger, D., Li, L., Picheny, V., & Vazquez, E. (2012). Sequential design of computer experiments for the estimation of a probability of failure. *Statistics and Computing*, 22(3), 773-793.

Chevalier, C., Bect, J., Ginsbourger, D., Vazquez, E., Picheny, V., & Richet, Y. (2014). Fast parallel kriging-based stepwise uncertainty reduction with application to the identification of an excursion set. *Technometrics*, 56(4), 455-465.

Curran, A., de Bruijn, K. M., Klerk, W. J., & Kok, M. (2019). Large Scale Flood Hazard Analysis by Including Defence Failures on the Dutch River System. *Water*, 11(8), 1732.

Jonkman, S. N., Kok, M., & Vrijling, J. K. (2008). Flood risk assessment in the Netherlands: A case study for dike ring South Holland. *Risk Analysis: An International Journal*, 28(5), 1357-1374.

Muller, H., Van Rooijen, A., Idier, D., Pedreros, R., & Rohmer, J. (2016). Assessing storm impact on a French coastal dune system using morphodynamic modeling. *Journal of Coastal Research*, 33(2), 254-272.

Rohmer, J., & Idier, D. (2012). A meta-modelling strategy to identify the critical offshore conditions for coastal flooding. *Natural Hazards and Earth System Sciences*, 12(9), 2943-2955.