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The estimation of marine flooding probability relies on the necessary integration of the probability laws, including extremes, of the sea condition variables (wave characteristics, offshore water level, etc., with potential correlation among them) over the function (denoted *f*) that defines the inland consequences, typically in terms of water height. To do so, the ideal strategy should combine two key ingredients: (1) high fidelity full process based numerical models to provide accurate simulations of storm responses and a proper estimation of *f*; (2) Monte Carlo-based sampling methods to enable a practical integration. The bottleneck of this strategy is the large number (>10,000s) of combinations of offshore hydrodynamic conditions whose responses in terms of inundation should be evaluated using the full-process-based model. A direct approach is hardly achievable due to the computation time cost of a single full process based model run (typically ranging from a few minutes to several hours depending on the flooding processes). A possible alternative can rely on the use of a metamodel (*aka* surrogate, response surface, etc.), that replaces the long-running numerical code by a statistical emulator that learn *f* using a limited number of computer experiments (typically 100-200).
To study the feasibility of this strategy, we focus on the Boucholeurs site along the French Atlantic coast (close to La Rochelle), which is particularly exposed to overflow processes; the most illustrative event being the 2010 winter storm Xynthia. The following steps are followed: (1) Coastal flooding processes are simulated using the finite-difference MARS model including some in-house developments to account for specificities of local flooding (hydraulic processes around culverts and weirs; breaching effect). A single model run takes ~30-60 minutes of computation; (2) Two hundreds of synthetic scenarios are simulated by varying the main characteristics of time-varying offshore conditions (simplified but realistic): surge peak, tide maximum level, phase difference between surge and tide, time characteristics of the surge increase/decrease denoted TIDec; (3) A meta-model of type “random forest” is then built to learn the relationship between these offshore conditions and the water height at four given key locations (camping, holiday camp, marshland, road); (4) A stochastic generator is set up to jointly sample the extreme surge values with the TIDec features using the probabilistic law and dependency model learned from the analysis of the La Rochelle-La Pallice tide gauge measurements; (5) Due to the low computation time cost of the metamodel, the storm response of 10,000s of random samples is evaluated to finally estimate the flooding probability at the four locations. In addition to the technical practicability, we further discuss the pros and cons of such a strategy compared to the most common approach, consisting in selecting the scenarios to be run from the extreme statistics of the offshore conditions.