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A stochastic storm surge generator as a tool for integrated risk analyses

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Storm surges along the German North Sea coastline led to major damages in the past and the risk of inundation is expected to increase in times of a changing climate. The knowledge of the characteristics and statistics of possible storm surges is essential for the performance of integrated risk analyses, e.g. based on the source-pathway-receptor concept. The latter includes the storm surge simulation/analyses (source), modelling of dike/dune breach scenarios (pathway) and the quantification of potential losses behind the flood protection measures (receptor). In subproject 1b of the German joint research project XtremRisK (www.xtremrisk.de), a stochastic storm surge generator is developed for the selected investigation areas Sylt, as an example for an exposed island with high assets and the city of Hamburg, as an example for a megacity located in an estuary.

The input data for the multivariate model are high resolution sea level observations from tide gauges during extreme events. Based on 25 parameters (19 sea level parameters and 6 time parameters) observed storm surge hydrographs consisting of three tides are parameterised. Followed by the adaption of common parametric probability distribution functions and Monte-Carlo-Simulations, the final reconstruction applying cubic hermite interpolation leads to a large number (default: 100.000) of synthetic storm surge hydrographs with a one-minute resolution. The consideration of the results from empirical studies conducted in subproject 1a of the XtremRisK project and from the outcome of former research projects ensures physical consistency of the stochastic simulation results. A data set of 100.000 synthetic storm surge curves can potentially serve as the basis for a large number of applications. For integrated risk analyses, the storm surge events including high water levels exceeding the design water levels have to be considered. The synthetic events facing this criterion are of special interest for modelling dike/dune breach scenarios and the related direct and indirect losses.

The occurrence probabilities of the simulated storm surge events are estimated based on multivariate statistics, considering the parameters “peak water level” and “intensity (total area under the storm surge curve)”. In the past, most studies considered only the peak water levels during extreme events, which might not be the most important parameter in any cases. Here, a 2D-Archimedian copula model is used for the estimation of the joint probabilities of the selected parameters, accounting for the structures of dependence overlooking the margins. In coordination with subproject 1a, the results will be used as the input for the subprojects 2 to 4 of the XtremRisK project.

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