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Assessing the hydrodynamic boundary conditions for integrated risk analyses along the German North Sea coastline

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Performing integrated risk analyses is one of the tasks for coastal engineers, which is becoming more and more important in recent years, as design methods including probabilistic analyses are continuously improving and in some areas already established. Thereby, the quality of the results of the risk analyses strongly depends on the quality of the input data, i.e. the considered hydrodynamic boundary conditions. In general, coastal structures are stressed by and do have to withstand different loading parameters, i.e. (i) the mean sea level and its long-term behavior, (ii) storm surges, and (iii) the wave conditions. This contribution is supposed to present advanced methods to assess these loading parameters within the frame of risk analyses. The main focus is on the statistical analyses, as it is not only necessary to consider a large number of scenarios stressing the coastal protection measures, but also to statistically assess the considered parameters in terms of joint probabilities.

The main results, which will be presented are as follows: A sea level reconstruction for the German Bight area and for the last 166 years is constructed from 13 individual tide gauges. From analyzing the time series, it is found that some periods of an accelerated sea level rise (SLR) occurred over the last 166 years. The last acceleration started in the 1970s with a post 1990 intensification, leading to high recent rates of SLR, with some differences along the coastline. As currently no reliable regional sea level projections are available for the German North Sea area, mostly the projections published by the Intergovernmental Panel on Climate Change are considered for design purposes. These global projections do not consider the significant regional differences in future sea level change, which are expected to occur. The long sea level reconstruction for the German Bight can directly be used to derive some projections for the near future (few decades) by applying simple extrapolation techniques. For longer time periods, numerical model studies have to be conducted, whereas the long sea level reconstruction can be used for validation.

Furthermore, a method to stochastically simulate storm surges for selected sites along the German North Sea coastline will be presented. With the stochastic storm surge generator it is possible so simulate a very large number (default: 10 mio.) of synthetic storm surge curves, which can directly be considered for the integrated risk analysis and, if needed, combined with some sea level rise scenarios. This significantly reduces the numerical (or empirical) computation requirements, which are usually necessary to provide a sufficient number of storm surge scenarios to be considered for risk analyses. To statistically assess the simulation results, the important parameter storm surge intensity (area between the surge curve and a selected threshold) is considered for the first time in combination with the storm surge water level. A 2-dimensional Copula model is applied, because the two considered parameters show some structure of dependence and are unequally distributed. In a last step, an extension of the statistical approach to additionally consider some selected wave parameters will be introduced.

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