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Predicting location-specific extreme coastal floods in the future climate by introducing a probabilistic method to calculate maximum elevation of the continuous water mass caused by a combination of water level variations and wind waves

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Future coastal management continuously strives for more location-exact and precise methods to investigate possible extreme sea level events and to face flooding hazards in the most appropriate way. Evaluating future flooding risks by understanding the behaviour of the joint effect of sea level variations and wind waves is one of the means to make more comprehensive flooding hazard analysis, and may at first seem like a straightforward task to solve. Nevertheless, challenges and limitations such as availability of time series of the sea level and wave height components, the quality of data, significant locational variability of coastal wave height, as well as assumptions to be made depending on the study location, make the task more complicated.

In this study, we present a statistical method for combining location-specific probability distributions of water level variations (including local sea level observations and global mean sea level rise) and wave run-up (based on wave buoy measurements). The goal of our method is to obtain a more accurate way to account for the waves when making flooding hazard analysis on the coast compared to the approach of adding a separate fixed wave action height on top of sea level -based flood risk estimates. As a result of our new method, we gain maximum elevation heights with different return periods of the continuous water mass caused by a combination of both phenomena, “the green water”.

We also introduce a sensitivity analysis to evaluate the properties and functioning of our method. The sensitivity test is based on using theoretical wave distributions representing different alternatives of wave behaviour in relation to sea level variations. As these wave distributions are merged with the sea level distribution, we get information on how the different wave height conditions and shape of the wave height distribution influence the joint results.

Our method presented here can be used as an advanced tool to minimize over- and underestimation of the combined effect of sea level variations and wind waves, and to help coastal infrastructure planning and support smooth and safe operation of coastal cities in a changing climate.