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Evaluating future flooding risks by using a probabilistic approach to include wave height distributions in sea level variations

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Assessing sea flood risks has an essential role in future coastal planning as climate change drives forward the global sea level rise. Safe planning of land utilization and building in coastal areas requires capability to estimate sea level behaviour all the way to 100–200 years ahead. The coastal effect of the sea level is always affected also by the wave conditions, which may vary greatly depending on location. An archipelago acts as an efficient shield against the largest waves penetrating to the shoreline. However, part of the energy of the waves passes through the archipelago and coastal wave height conditions, depending for example on the shape of the shoreline and topography of the seabed, must be evaluated close to the shore separately.

The probability of high sea level and wind generated high waves occurring simultaneously is lower than the probability of one of the components occurring alone. Summing the maximum sea level and maximum wave height components together can thus lead to an overestimation of the joint effect. For this reason a method based on probability distributions is reasonable and preferable. In this study, a method of combining sea level and wave height distributions using a location specific probability approach is introduced. First estimates of the joint effect of high sea level and high waves at several locations at the archipelago area on the southern coast of Finland are presented.

Constructing sea level scenarios including the effect of wind waves until the end of the century demands knowledge of both sea level and wave height variability in the past, and global mean sea level predictions for the future. In our study, an estimate of short-term sea level variability is based on 30 years (1982–2011) of hourly data from the Helsinki tide gauge located on the coast of the Gulf of Finland. Future predictions for the long-term mean sea level changes at Helsinki are based on scenarios taking into account the global mean sea level rise, local land uplift, and changes in the Baltic Sea water balance. Wave statistics in turn are based on individual wave buoy measurements conducted at several sites on the coast off Helsinki during 2012–2014.

The method developed in this study is a new tool for evaluating extreme sea level events including the effect of high sea level jointly with high wave height. The method can be applied to any coastal areas where sufficient sea level and wave data are available. The probabilistic approach used here gives a possibility to evaluate the risk levels of different infrastructures on the coast for the present and for the future.