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Simulating extreme sea levels at the Baltic Sea coast from synthetic cyclones

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Coastal areas are under rapid changes. Management to face flooding hazards in changing climate is of great significance due to the major impact of flooding events in densely populated coastal regions, where also important and vulnerable infrastructure is located. The sea level of the Baltic Sea is affected by internal fluctuations caused by wind, air pressure and seiche oscillations, and by variations of the water volume due to the water exchange between the Baltic Sea and the North Sea through the Danish Straits. The highest sea level extremes are caused by cyclones moving over the region. The most vulnerable locations are at the ends of the bays. St. Petersburg, located at the eastern end of the Gulf of Finland, has experienced major sea floods in 1777, 1824 and 1924.

In order to study the effects of the depths and tracks of cyclones on the extreme sea levels, we have developed a method to generate cyclones for numerical sea level studies. A cyclone is modelled as a two-dimensional Gaussian function with adjustable horizontal size and depth. The cyclone moves through the Baltic Sea region with given direction and velocity. The output of this method is the gridded data set of mean sea level pressure and wind components which are used as an input for the sea level model. The internal variations of the Baltic Sea are calculated with a numerical barotropic sea level model, and the water volume variations are evaluated using a statistical sea level model based on wind speeds near the Danish Straits. The sea level model simulations allow us to study extremely rare but physically plausible sea level events that have not occurred during the observation period at the Baltic Sea coast. The simulation results are used to investigate extreme sea levels that could occur at selected sites at the Finnish coastline.