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North Sea wave and storm surge conditions for an ensemble of climate change scenarios: an integrated analysis

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The North Sea region is one of the most densely populated and economically important areas in Europe. Long-term changes in storm conditions which may be caused by anthropogenic climate change could have significant impact on the coasts, human safety and offshore activities. To address the range and uncertainty of such climate induced changes, we compare simulated wind wave and storm surge statistics for four future climate realizations with two corresponding reference climates. New 140-year-long transient simulations for waves and water levels were driven by the same wind and air pressure fields, regionalized from global climate simulations, to consistently analyze the combined variations of storm surge levels and wave heights. The ensemble of simulations consists of two emission scenarios (IPCC A1B and B1) and two different initial conditions. As the most potential harm to human lives and to coastal and offshore infrastructure is eventually cause by extreme events of storm surge and wave heights, the statistical analysis is focused on changes in the upper percentiles.

The climate change signals for wave and storm surge heights in the North Sea are spatial and temporal heterogeneous. The overall signals show an increase of the future long-term 99 percentiles in the southeastern North Sea towards the end of this century. In the German Bight this increase can be up to 40 cm and up to 20 cm for significant wave and storm surge heights, respectively, for the period 2071-2100 relatively to 1961-1990. In the western parts of the North Sea a decrease is generally simulated. This shift to higher values in the eastern regions of the North Sea is consistent with a change of the wind regime. Temporal variations on decadal time scales in the southeastern North Sea are large compared to the superimposed increase towards the end of this century. The spatial and temporal similarities and differences between wave and storm surge changes as well as between the four climate projections will be discussed. To further enhance the ensemble four climate projections for 2071-2100 consisting of the emission scenarios A2 and B2 and two different global climate models are used for comparison. Special emphasis is given to the uncertainties which should be taken into account in climate impact research.