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Linking of Regional Climate and Wave Models for the Assessment of Future Extreme Wave Conditions at the German Baltic Sea Coast

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Regional climate change will most likely affect the large-scale and local wind conditions. Especially in semi-enclosed seas, like e.g. the Baltic Sea, the local wind field over the sea mainly influences the local wave climate. Thus, the changes of the local wind fields can be linked to changes of the local wave climate, wave induced loads, and other wave induced processes, like e.g. the longshore sediment transport. It is important to study possible changes of the local extreme wave conditions due to the fact that extreme wave heights are used as input parameter for the design of new- and the assessment of existing coastal and flood protection structures.

This study aims to assess possible changes of future extreme wave heights at selected locations along the German Baltic Sea Coast based on transient, long-term time series of significant wave heights for past and future conditions (1961-2100). The sub goals of this study are: (i) to compare the bandwidth of changes of the extreme wave heights, (ii) to represent the uncertainty of the changes in bandwidth form, (iii) to validate the wave forecast/hindcast approach.

Two approaches are used for the forecast/hindcast of waves: (i) a hybrid approach that combines empirical wind-wave-correlations with stationary numerical simulations and (ii) non-stationary numerical simulations. Both approaches apply the numerical wave model SWAN.

As input for the calculation of the future wave climate, hourly wind fields from the regional climate model Cosmo-CLM forced by ECHAM5/MPI-OM are used. The data are available for two realisations each: (i) of the SRES emission scenarios A1B and B1 for the future conditions (2001-2100), (ii) of the 20th century observed emission scenario C20 for the past conditions (1961-2000).

Moreover, an additional hindcast of wave conditions is carried out based on wind fields from a high-resolution atmospheric reconstruction for Europe (1948-2012) using the same regional climate model.

Within a moving average extreme value analysis of the long-term time series by fitting different extreme value distribution functions to samples of 40 years of annual maximum significant wave heights, it was found that the changes of the future extreme wave heights depend on the approach used for the forecast/hindcast of waves. The bandwidth of the changes ranges between +0.5m and -0.5m of the extreme wave heights for a return period of 200 years and the log-normal extreme value distribution function.

The increase of extreme wave heights might have considerable effects on the constructional design of coastal and flood protection structures - such as breakwaters, sea dykes, and vertical walls - because the extreme wave heights are used as input parameter for the design and assessment of the structures.