Future Wave Climate Projections at the German Baltic Sea Coast on the Basis of the Regional Climate Model Cosmo-CLM

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1. Introduction

In this study future wave conditions are presented that provide a data basis for a scenario based assessment of the effects of regional climate change on the functional and constructional design of coastal protection structures but also for the assessment of the potential long-term morphological development of the German Baltic Sea coastline.

2. Method

A wave model for the area of the Western Baltic Sea is set up using the 3rd generation spectral wave model SWAN (Booij et al., 1999) with a high temporal and horizontal resolution. The local wave model is nested into a coarse wave model for the whole Baltic Sea. The coarse model is run by the Helmholtz-Zentrum Geesthacht (Groll et al., 2013) using the wave model WAM (Hasselmann et al., 1988).

As input data both wave models use dynamically downscaled near-surface wind (Lautenschlager et al., 2009) from the regional climate model Cosmo-CLM (Rockel et al., 2008) The wave parameters (significant wave height, mean wave direction and different wave periods) are calculated for the future (2001-2100) and actual conditions (1961-2000) on the basis of the SRES emission scenarios A1B and B1 (Nakićenović et al., 2000).

To extract the climate change signal, the relative changes of both annual and seasonal average significant wave heights between two reference periods (1961-1990, 1971-2000) and the future values for the scenarios 2050 (2021-2050) and 2100 (2071-2100) are calculated.

Moreover the relative changes of extreme significant wave heights with a return period of 200 years are calculated and assed for time periods of 40 years at selected locations along the German Baltic Sea coast using methods of extreme value analysis.

3. Results

The results show in general increases of the annual average significant wave heights at locations exposed to westerly winds (cp. Figure 1, top and bottom). The largest increases occur for the SRES emission scenario A1B.

Moreover the changes of the average significant wave heights are depending on the season and are within the range of +1% to +9% compared for the future (2071-2100) with actual conditions (1971-2000). The smallest changes occur during summer and the largest changes occur during winter (cp. Figure 1, bottom).

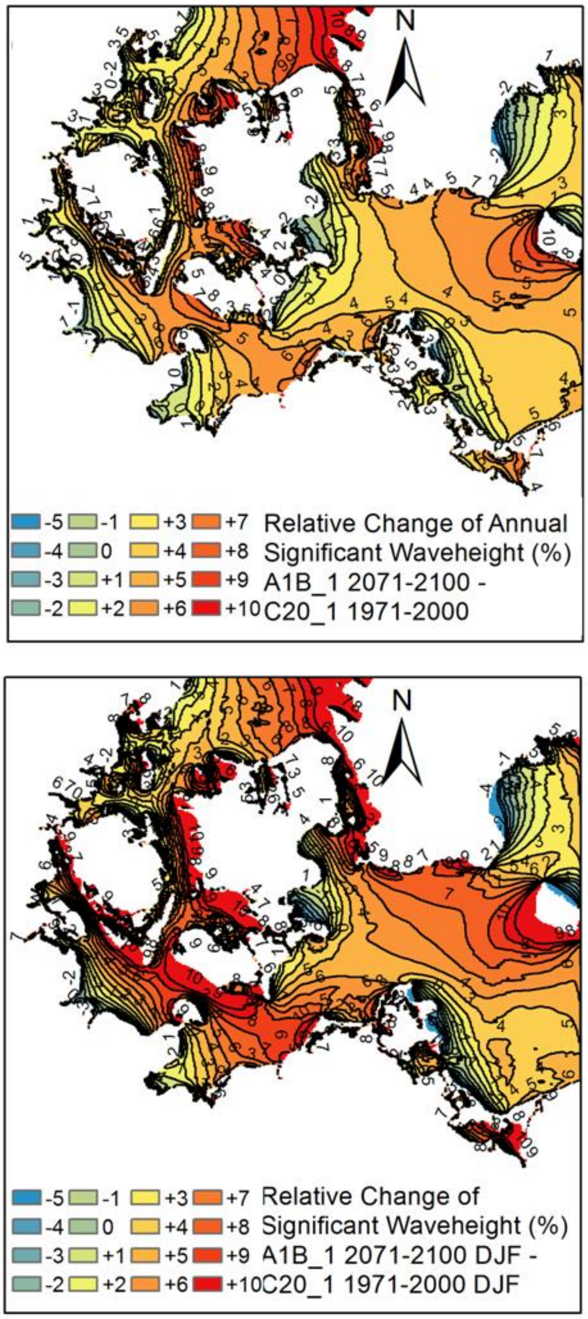

Figure 1. Changes of the annual average significant wave heights (top) in the area of the Western Baltic Sea and changes during winter (bottom) for the first realisation of the SRES emission scenario A1B to the end of the 21st century (2071-2100) compared to actual conditions (1971-2000).

The annual mean wave directions change within the range of 3° to 6° towards more wave westerly directions.

In contrast, at locations exposed to easterly winds, the annual average significant wave heights can change down to -2% and the changes of the annual mean wave directions are within the range of 1° to 2° towards more easterly directions.

The climate change signal for the average wave conditions is more dominant to the end of the 21st century (2071-2100) than compared with other future scenarios (e.g. scenario 2050: 2021-2050).

The results from the local wave model are in good agreement with the results from the coarse wave model for the whole Baltic Sea using the same wind input data (Groll et al., 2013).

The changes of extreme wave events are within the range of -15% to +15% and are depending on the location, emission scenario, realisation and the future time period which is used for the comparison to the actual conditions.

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References

Booij, N., Ris, R.C. and Holthuijsen, L.H. (1999). A third-generation wave model for coastal regions. Part I - Model description and validation. Journal of Geophysical Research, 104, C4, 7649-7666.

Groll, N., Hünicke B. and Weisse, R. (2013): Baltic Sea wave conditions under climate change scenarios. 7th Study Conference on BALTEX, Borgholm, Sweden 2013. (In press, Oceanologica)

Hasselmann, S., Hasselmann, K., Bauer, E., Janssen, P.A.E.M., Komen, G.J., Bertotti, L., Lionello, P., Guillaume, A., Cardone, V.C., Greenwood, J.A., Reistad, M., Zambresky, L. and Ewing, J.A. (1988). The WAM model ¬ a third generation ocean wave prediction model. J. Phys. Oceanogr. 18, 1775-1810.

Lautenschlager, M., Keuler, K., Wunram, C., Keup-Thiel, E., Schubert, M., Will, A., Rockel, B. and Boehm, U. (2009). Climate Simulation with CLM. Climate of the 20th Century run no.1-3, Scenario A1B run no.1-2, Scenario B1 run no.1-2 , Data Stream 3: European region MPI-M/MaD. World Data Centre for Climate.

Nakićenović, N., Alcamo, J., Davis, G., de Vries, B., Fenhann, J., Gaffin, S., Gregory, K., Grübler, A., Jung, T.Y., Kram, T., La Rovere, E.L., Michaelis, L., Mori, S., Morita, T., Pepper, W., Pitcher, H., Price, L., Raihi, K., Roehrl, A., Rogner, H.-H., Sankovski, A., Schlesinger, M., Shukla, P., Smith, S., Swart, R., van Rooijen, S., Victor, N. and Dadi, Z. (2000). Emissions Scenarios. A Special Report of Working Group III of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge and New York, 599 pp.

Rockel, B., Will, A. and Hense, A. (eds.) (2008). Special Issue: Regional climate modelling with COSMO-CLM (CCLM). Meteorologische Zeitschrift, Vol. 17.