

Abstract

Using multi-scale model systems optimized based on parameterization makes it possible to obtain universal tools for reliable forecasts of wave and storm effects, the products of which can be adapted to areas of interest and needs while maintaining the operational mode of issued forecasts. The research to develop a system of tools for reliable forecasting of wave conditions and their potential effects in the Baltic Sea area, taking into account the varying conditions of the seabed and the Polish coast, was based on this assumption. The research presents an original solution to the use of multi-scale modelling by coupling the SWAN (Simulating WAVes Nearshore) wave model with the assimilated COSMO (Consortium for Small-scale Modeling) meteorological model and models from the ALADIN (Aire Limitée Adaptation dynamique Développement InterNational) family in the selected, during optimization, ST6 physics parameterization to forecast wave conditions in the southern Baltic Sea and the effects of storms in the Polish coastal area. The study implemented the COSMO wind-field-powered SWAN model system for the Baltic Proper area and selected the optimal physics - ST6 through multi-stream verification of generated wave forecasts. Using the chosen previously physics, wave (SWAN) and meteorological (ALADIN: ALARO and AROME) model systems were implemented and validated in two stages, i.e. first by selecting the optimal parameterization including calibration configurations, and then by identifying the consistency of wave forecasts for the developed model systems under varying coastal and seabed conditions. Application of the developed high-resolution model system: SWAN ST6-AROME in the southern Baltic Sea area domain enabled its coupling with a sediment transport model (SWANOneSed) and a shore wave run-up model using the Ruggiero formula. The transport model was qualitatively verified by determining the convergence of the directions of change (modelled and observed) and the convergence of the amount of sediment transported at different coastal locations. To predict the extent of the inundated shore, a quantitative assessment was made using high-resolution satellite data and model results

The study's results indicate the applicability of the developed model systems using ST6 physics in the southern Baltic area. In addition, the model systems, fed by the ALARO and AROME wind fields, provide a tool for reliable wave forecasting under varying conditions and, through their coupling with sediment transport models and wave run-up on the shore, for forecasting the effects of extreme events on the coastal zone. It was also shown that feeding the high-resolution model (SWAN ST6-AROME) with boundary conditions from the mesoscale model (SWAN ST6-ALARO) did not significantly improve the forecast results. Considering the operational mode of forecasting, independent operation of the two model systems is recommended. The entirety of the developed model systems forms a complementary and compatible system of tools for wave forecasting and storm warning, which are crucial for the safety of navigation as well as the coastal zone.