Wave simulations for Heligoland.

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Along with temperature, pressure and precipitation the investigation of 'wave climate' plays an important role in the climate change studies. The extreme wave behavior is of especially great importance due to possible impacts on economics. Understanding trends in occurrences of such events and their future prediction should be considered in the development of coastal areas. In our work we are trying to reconstruct the past and make some projections for the future wave climate in the vicinity of Heligoland Island (German Bight) [2]. The results of the simulations are supposed to be used for analysis of wave extreme events [3]. The most important characteristics that are to be obtained from the simulations are the intensity and frequency of such events (based on the simulated data for the past decades), which can then be exploited in the development and improvement of the coastal protection facilities. Another purpose of such a study is an investigation of the climate change impacts on the coastal wave climate in the North Sea and sensitivity of the wave extremes to different global climate scenarios.

For wave modeling we use the so called K-Model, which is a spectral wave model based on the energy balance equation in terms of energy action density [1]. The model takes into account the time dependent wind field, time varying current-field, variable depth field and time dependent energy flow across the boundaries. It has been adapted for small scale and shallow water applications and tuned for a high performance parallel computer to enable long term forecasting. We are able to treat a domain of 13x16 km around the island (which area is approx. 1 sq. km) with equidistant (100m) spatial resolution and open boundaries for time scales of decades. The boundary conditions have been obtained from the HIPOCAS project [4].

The assessment of model relevance to our problem and sensitivity of the model output to forcing fields has been one of the most important issues.

To check the reliability of the model we have produced a wave hindcast for October 1998 and compared some integrated wave parameters (significant wave height (HS), different periods, etc.) with the measurements from local buoy and radar station. Fig.1 shows wave height curves. It can be seen that for the most part of the considered period observations and model results are in good agreement with each other. The root mean square error between model-buoy is 0.47 and model-radar - 0.72. Wave peak direction (Fig.2) and Tm2 period (not shown) are also reproduced quite good.

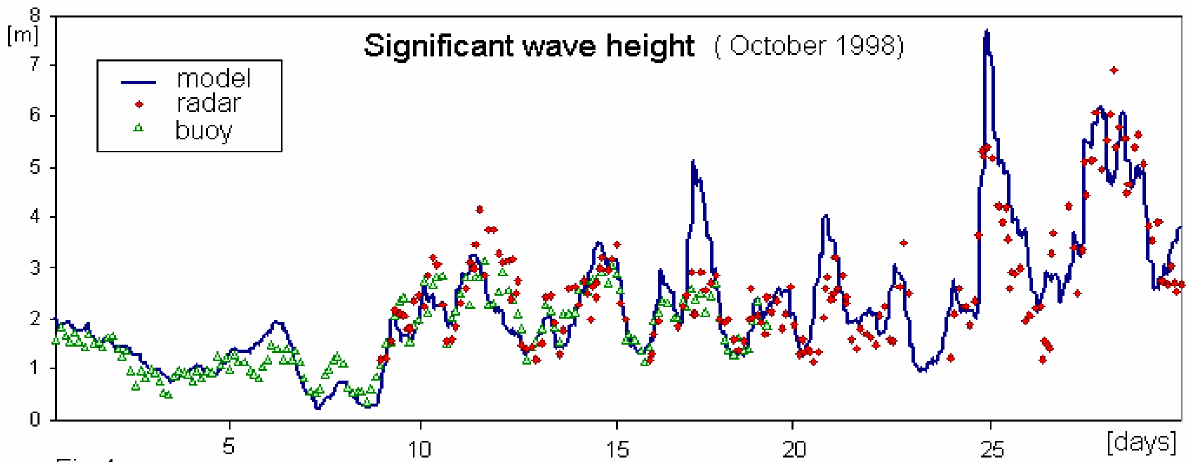

Fig.1

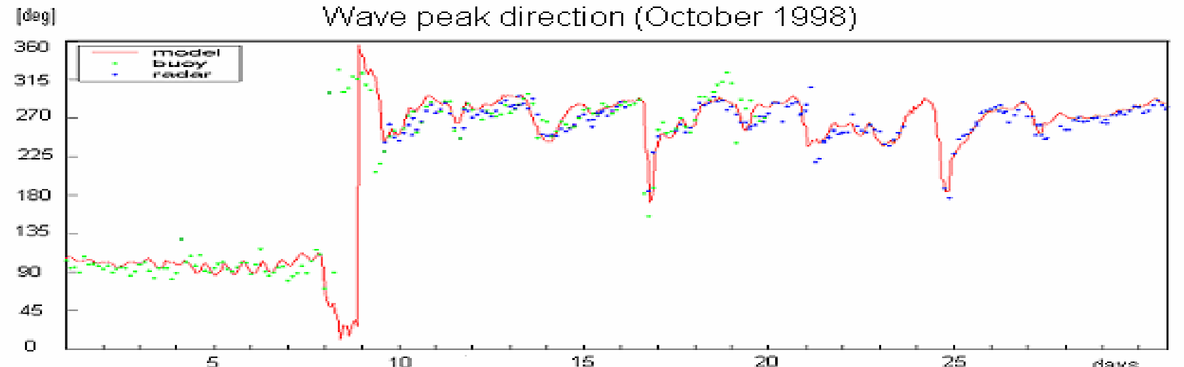

Fig.2

Other tests have been done to estimate the share of influence of different input fields on the integrated wave parameters. This information allows to omit from the model some time consuming but unimportant for our applications processes. So, the model shows that the presence of a current field (the currents in the considered domain are rather stable and driven mainly by tides, their speed does not exceed 1.5 m/s) results in a wave height change of about 10cm near the shore which is about 5 percents of the entire wave height for that moment. Wave periods calculated with currents have strong tidal signal, which is abandoned in the without-current case but after daily smoothing the two cases give almost the same results. So, the current influence in this area is not significant. Simulations with changeable and constant depth have more pronounced difference, within 200 m from the coast line there are about 40 cm higher waves during high tide (wave height is about 3 m). This can be mainly explained by the shoaling effect. This shows the necessity of the variable depth in the model. The last test demonstrates the importance of wind and boundary energy input (Fig.3). Wind component is important because waves are not fully developed on the boundaries and respond to the wind energy within the considered area. Boundary input is more crucial, especially in the case of westerly storms. It seems that waves driven only by local wind couldn't be higher then 2m just because of the small domain area and boundary energy inflow explain more than a half of the wave height. It is especially important to use realistic boundary conditions for our simulations.

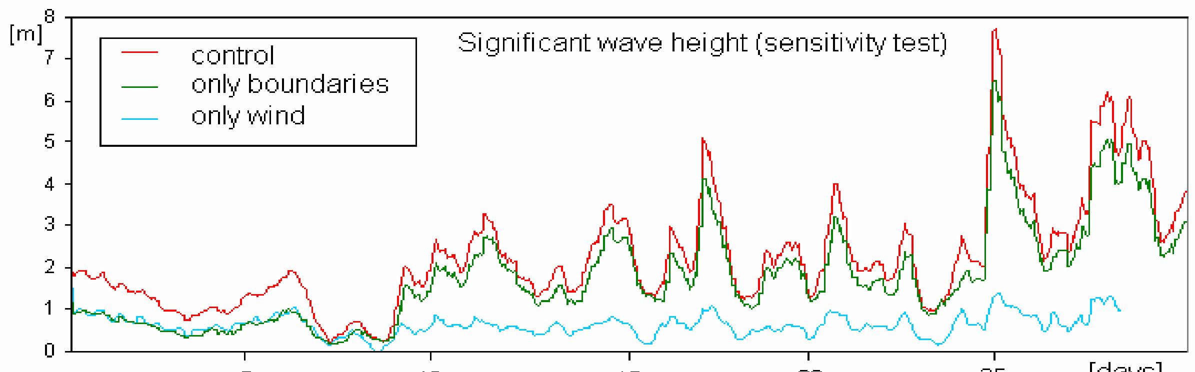

Fig.3

Literature

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[4] Weisse, R., H. Günther, and F. Feser, 2002: A 40-year high-resolution wind and wave hindcast for the Southern North Sea, *Proceedings, 7th International Workshop on Wave Hindcasting and Forecasting*, Banff, Canada, 2002, 97-104.