The influence of the waves in the areas near the port

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Abstract. The paper investigates the influence of the waves in the areas of Constanta port and the North of Mamaia resort sandy coast. The port has an asymmetric design that protects them from the sea. This study analyses the port' influence on the waves, the wave driven current and the sediment transport patterns. The harbour is on a sandy coast consisting of sand with d_{50}=0.70 mm (where d50 is diameter of sand particle) and s_g=0.75 m in the entire area (where s_g is significant wave height). Irregular, directional waves move towards the coast from 270_0 (West direction). Waves move over a water level corresponding to MWL=1m. The wave characteristics at the offshore boundary are H_{m0}=1.61 m (where H_{m0} is average wave height) and T_p=10.00 s (where T_p is the wave period). We are looking at an area that spans 10 000 m in the long-shore direction and 2500 m in the cross-shore direction. It is used the wave simulation with MIKE 21 PMS, and the hydrodynamic simulation with MIKE 21 HD. Irregular, directional waves are added at the offshore boundary of the wave model. The frequency spectrum is of JONSWAP type, but around the mean direction of wave propagation (270^0) a $\cos^n$ distribution of wave energy is used. At the other open boundaries symmetry boundary conditions are used. The wave simulation takes wave breaking into the consideration. The bed roughness is not considered. In this study, it is of interest to examine how the presence of the harbour influences the waves, the wave-driven current and the sediment transport patterns. When simulating of the wave driven currents with MIKE 21 HD we use constant values of velocity and Manning number all over the model area. The time slots are set to five seconds and the simulation runs for ten hours to ensure stable conditions. Finally the data are visualized flow, level and influence over the area of the coast.

1. Introduction

One of the most important elements in sediment transport and coastal zones are inshore currents and waves that they generate.

Most coastal areas dissipate power comes from wind generated waves and dispersion and transport of pollutants in coastal areas, brackish and sediment transport, erosion of coast lines and the formation of sand bars are some of the results from this dissipate energy in the coastal zones [1, 2]. The waves and the currents they generate are therefore the primary factors in the transport and deposit of sediments. Dislodges the material swells and suspended above the sea bed, and captures this material and the currents they carry along the beaches. The main parameters that characterize the waves are wave height (H_m) and period (T_p). They depend on the speed and duration of the winds and waves that generate the distance which waves are generated. Types of surfing at the beach and their seasonal variation are known as the wave climate. Deep-water waves are long and have a sinusoidal shape. However, as the waves come into shallow water propagation speed and degrease in length and the height there of and the sharp peaks of their growing up so the waves will consists of sharp ridges separated by flat areas. This transformation of the waves starts from the depths at which the waves “feel the seabed ". The corresponding depth at which to start the process is about half the length of the wave. The entries into shallow water waves are subject to refraction through ridges tend to become parallel to the contours of the seabed [3, 6, 8]. At the same time, the process of diffraction wave causes a transfer of energy, along the crest of waves, high waves from small ones. For coastal areas, with straight parallel strokes, the refraction decreases the angle between the direction of propagation of the wave and the normal to the line of the coast, and diffraction is causing a scattering of energy along the ridge. Accordingly, changes in the height and direction of waves along the coast are depending on the period of waves, their direction and contour of the seabed.

Coastal zones are dynamic environments (figure1) that change consistently under the action of natural factors, the ratio between the processes of erosion and accretion causing shoreline configuration for various time intervals [5, 6]. The waves in this area contribute directly to the processes of erosion, acting via mechanical abrasion processes in areas of beach and surf, by displacing the particles of sediment it carries in the offshore areas.

Another important phenomenon that manifests itself in coastal areas is the action of longitudinal currents carrying significant amounts of sediment along the shoreline, changing the look and feel of the beach. In the event of storms or extreme, large volumes of sediment are brought about in a state of suspension and beach areas will be subject to such a process of degradation much more intensely.

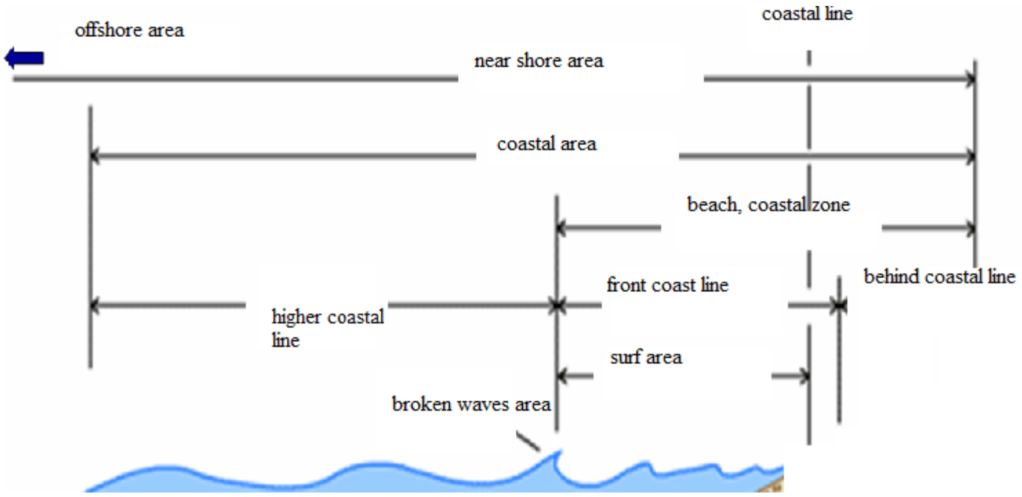


Figure 1. The general structure of coastal zone [9].

1.1. Establish a study area coordinates

The bathymetry of area in study. The paper investigates the influence of the waves in the areas of Constanta port and the North of Mamaia resort sandy coast. The port has an asymmetric design that protects them from the sea. This study analyses the port’ influence on the waves, the wave driven current and the sediment transport patterns. The harbour is on a sandy coast consisting of sand with d_{50}=700.10^{-3} [m] and s_g=750.10^{-3}[m] in the entire area. Irregular, directional waves move towards the coast from 270^0 (West direction). Waves move over a water level corresponding to MWL=1[m]. The wave characteristics at the offshore boundary are H_{m0} =1.61 [m] and T_p=10.00 [s]. We are looking at an area that spans 8 000...10 000 [m] in the long-shore direction and 2 500....2800 [m] in the cross-shore direction. It is used the wave simulation with MIKE 21 PMS, and the hydrodynamic simulation with MIKE 21 HD. First, establish a study area coordinates. The next step is choosing the design of the system data of the study; start Mesh generator (Mike 0) and import boundary data *(Import boundary)* with files in xyz, *(import scatter data)* and obtain the geometry of the land (figure 2). After this, insert the nodes and point properties and choose the study polygon. Export mesh, introduce the number of nodes and the simulation time and generate the flow model.

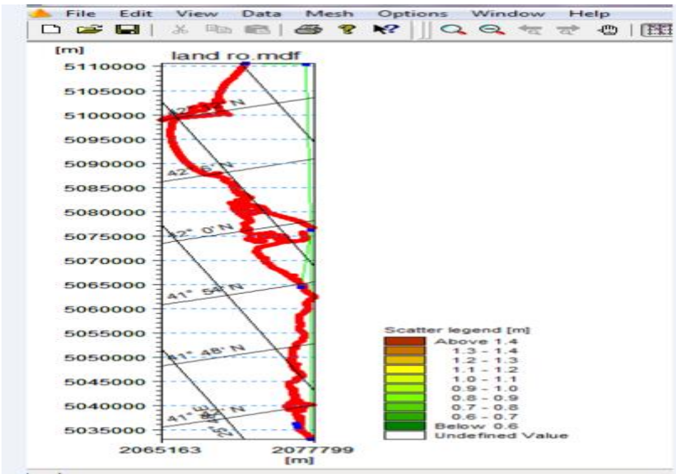


Figure 2. The geometry of the study.

Wind set-up. The wind speed is constant, [35 m/s] and wind direction is 270^0 (West direction) (figure 3). The value of wind friction coefficient is 2526.10^{-6}.

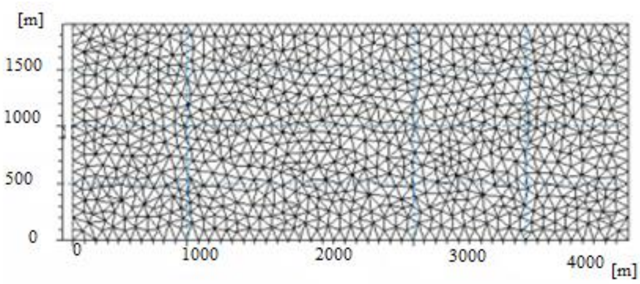


Figure 3. Wind set-up.

The configuration of domain study. The domain of problem is presented in the figure 4:

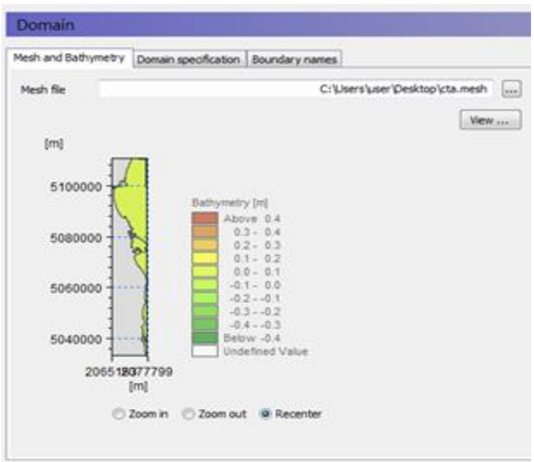


Figure 4. The configuration of domain study.

1.2.The equations of flow

Wind conditions. The driving force due to this wind is calculated equation (1) [1]:

$$c_w = \frac{\rho_{air}}{\rho_{water}} W^2 \tag{1}$$

where cw is the coefficient of wind friction, ρ is the density and W is the wind velocity.

The Wind Friction. The flow is characterized by a flow resistance defined on Chezy number between the limits: Cf = 98.10-4(rocks) and Cf = 3.10-3(fine sand) [2].

We consider Courant number equation (2) [3, 10]:

$$C_R = c\frac{\Delta t}{\Delta x} \tag{2}$$

where: c is the celerity, Δt the time step and Δx the grid spacing. The celerity for tidal wave is calculated equation (3) [3, 10]:

$$c = \sqrt{gh} \tag{3}$$

where: g is gravity and h is the water depth. The maximum value which we can correctly use depend on our bathymetry [1, 2, 3, 4].

Eddy viscosity. In the momentum equations we must consider momentum fluxes due to turbulence, vertical integration and subgrid scale fluctuations. The formulation of the eddy viscosity [3, 4, 10] in the equations is implemented in two ways: flux formulation equation (4) and velocity formulation equation (5):

$$\frac{\partial}{\partial x}\left\{E\frac{\partial P}{\partial y}\right\}_{x.momentum} \tag{4}$$

where P - the flux in the Ox-direction and E-the eddy viscosity coefficient;

$$\frac{\partial}{\partial x}\left\{h\cdot E\frac{\partial u}{\partial x}\right\}+\frac{\partial}{\partial y}\left\{h\cdot E\frac{\partial u}{\partial y}\right\} \tag{5}$$

where u-the velocity in the Ox-direction and h-the water depth.

The eddy viscosity coefficient E can be specified on the Smagorinsky concept [8, 9] equation (6):

$$E = C_s^{\,2}\Delta^2\sqrt{\left(\frac{\partial U}{\partial x}\right)^2+\frac{1}{2}\left(\frac{\partial U}{\partial y}+\frac{\partial V}{\partial x}\right)+\left(\frac{\partial V}{\partial y}\right)} \tag{6}$$

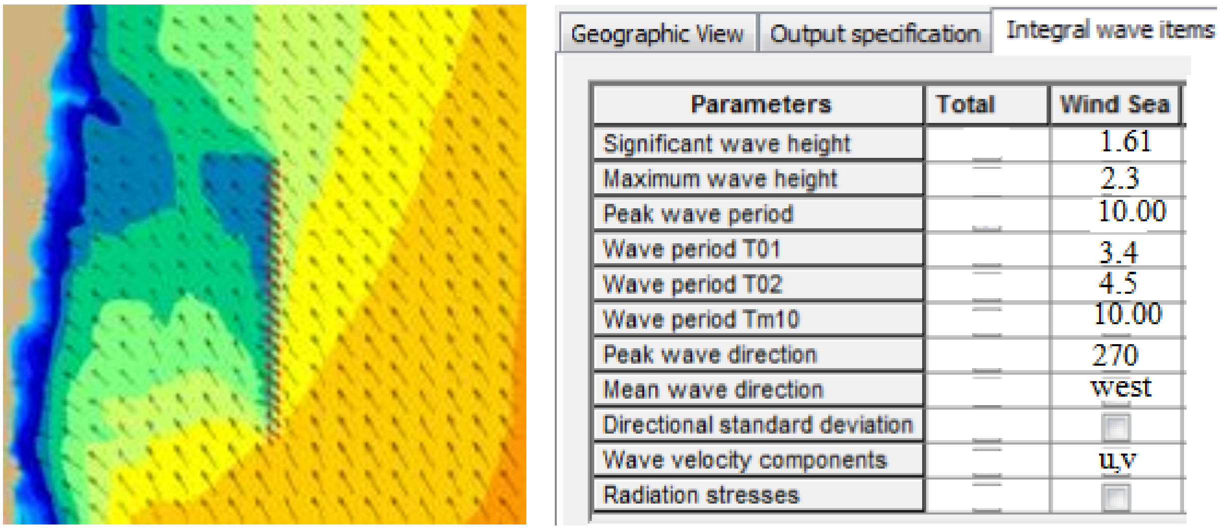
where U,V are depth-averaged velocity components in the Ox- and Oy-direction, Δ is the grid spacing [5] and Cs = 0.25....1.0 (we choose 0.28). We can optimized the study with the Smagorinsky formulas for the shear stresses (equation (7)) [9, 10]:

$$\frac{\partial}{\partial x}\left(hE\frac{\partial U}{\partial x}\right)+\frac{\partial}{\partial y}\left[\frac{1}{2}hE\left(\frac{\partial U}{\partial y}+\frac{\partial V}{\partial x}\right)\right] \quad (7)$$

which is in agreement with technical recommendations [4, 5, 8, 10] (the Smagorinsky formulation, the Smagorinsky factor Cs).

2. Results

We studied the hydrodynamics of the waves in the areas and obtained wind forcing, spectral waves, waves breaking, significant wave height, peak period, mean wave direction. The final results are presented in the table and graphical template (figure 5a, b).



Parameters	Total	Wind Sea
Significant wave height	—	1.61
Maximum wave height	—	2.3
Peak wave period	—	10.00
Wave period T01	—	3.4
Wave period T02	—	4.5
Wave period Tm10	—	10.00
Peak wave direction	—	270
Mean wave direction	—	west
Directional standard deviation	—	☐
Wave velocity components	—	u,v
Radiation stresses	—	☐

Figure 5. The evolution of waves.

3. Conclusions

The wave simulation takes wave breaking into the consideration. The bed roughness is not considered. In this study, it is of interest to examine how the presence of the harbour influences the waves, the wave-driven current and the sediment transport patterns. It can be seen that the results provided by the JONSWAP MIKE are generally acceptable, but becomes less accurate as the bathymetry gets more complicated. Larger data errors model is due to a patchy bathymetry and some goals in data interpolation [6, 9]. The simulation runs for ten hours to ensure stable conditions.

The obtained results have highlighted the patchy field of three dimensional currents in the shallow area, showing the existence of important gradients on vertical direction, determine both speed differences and bathymetric gradients that exist in flow direction at different levels, in particular in the areas of characteristic coastal slope breaking South, rocky bottomed in the sector South of the Capul Tuzla to Vama Veche. Finally the data are visualized flow, level and influence over the area of the coast.

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