Modeling of Nonlinear Hydrodynamics of the Coastal Areas of the Black Sea by the Chain of the Proprietary and Open Source Models

Igor Kantardgi (1), Mark Zheleznyak (2), Raisa Demchenko (2), Pavlo Dykyi (2), Sergei Kivva (2), Pavlo Kolomiets (2), and Maxim Sorokin (2)

(1) Moscow State Civil Engineering University, Hydraulic Structures, Moscow, Russian Federation (kantardgi@yandex.ru),
(2) Institute of Mathematical Machines and Systems, National Academy of Sciences of Ukraine, Kiev, Ukraine
(mark@immsp.kiev.ua)

The nearshore hydrodynamic fields are produced by the nonlinear interactions of the shoaling waves of different time scales and currents. To simulate the wind wave and swells propagated to the coasts, wave generated near shore currents, nonlinear-dispersive wave transformation and wave diffraction in interaction with coastal and port structure, sediment transport and coastal erosion the chains of the models should be used. The objective of this presentation is to provide an overview of the results of the application of the model chains for the assessment of the wave impacts on new construction designed at the Black Sea coasts and the impacts of these constructions on the coastal erosion/ accretion processes to demonstrate needs for further development of the nonlinear models for the coastal engineering applications.

The open source models Wave Watch III and SWAN has been used to simulate wave statistics of the dedicated areas of the Black Sea in high resolution to calculated the statistical parameters of the extreme wave approaching coastal zone construction in accordance with coastal engineering standards. As the main tool for the costal hydrodynamic simulations the modeling system COASTOX-MORPHO has been used, that includes the following models. HWAVE –code based on hyperbolic version of mild slope equations., HWAVE-S – spectral version of HWAVE., BOUSS-FNL - fully nonlinear system of Boussinesq equations for simulation wave nonlinear –dispersive wave transformation in coastal areas. COASTOX-CUR - the code provided the numerical solution of the Nonlinear Shallow Water Equations (NLSWE) by finite-volume methods on the unstructured grid describing the long wave transformation in the coastal zone with the efficient drying –wetting algorithms to simulate the inundation of the coastal areas including tsunami wave runup. Coastox -Cur equations with the radiation stress term calculated via near shore wave fields simulate the wave generated nearhore currents. COASTOX-SED - the module of the simulation of the sediment transport in which the suspended sediments are simulated on the basis of the solution of 2-D advection –diffusion equation and the bottom sediment transport calculations are provided the basis of a library of the most popular semi-empirical formulas. MORPH – the module of the simulation of the morphological transformation of coastal zone based on the mass balance equation, on the basis of the sediment fluxes, calculated in the SED module. MORPH management submodel is responsible for the execution of the model chain "waves- current- sediments – morphodynamics- waves". The open source model SWASH has been used to simulate nonlinear resonance phenomena in coastal waters.

The model chain was applied to simulate the potential impact of the designed shore protection structures at the Sochi Olympic Park on coastal morphodynamics, the wave parameters and nonlinear oscillations in the new ports designed in Gelenddjik and Taman at North-East coast of the Black Sea. The modeling results are compared with the results of the physical modeling in the hydraulic flumes of Moscow University of Civil Engineering.