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Modelling of Tsunami Inundation in 2011 at the Sites of Three Nuclear Power Plants - Onagawa, Fukushima Daiichi and Fukushima Daini

Oleksandr Pylypenko[1], Mark Zheleznyak[2], Raisa Demchenko[1], Sergii Kivva[1], Maxim Sorokin[1], and Pavlo Dykyi[1]
[1]Institute of Mathematical Machines and Systems Problems, Environmental Modelling Department, Kiev, Ukraine (oi.pylypenko@gmail.com)
[2]Institute of Environmental Radioactivity, Fukushima University, Japan (zheleznyak.m@gmail.com)

The coastal areas of three nuclear power plants (NPP) in the Tohoku region of Japan were impacted by the tsunami waves of the earthquake on 11 March 2011. The overtopping of the tsunami protective dikes of Fukushima Daiichi NPP and inundation of the NPP site was followed by the nuclear accident with a large scale environmental contamination. The site of the “sister” NPP Fukushima Daini at 10 km southward from Fukushima Daichi was also inundated by waters of similar depths; however, quick reconstruction the emergency energy supply of the reactors has prevented a nuclear accident on this site. Onagawa NPP located 115 km North-East of Fukushima Daiichi is the closest NPP to the epicenter of the earthquake – the source of tsunami waves. The tsunami protection dike of this NPP was not overtopped.

To simulate the consequences of the radioactive contamination of the coastal waters at Fukushima Daiichi NPP we use the modelling system that includes the module of the numerical solution of the nonlinear shallow water equation (SWE). This module can also be used for the modelling of tsunami propagation and inundation of the coastal areas. For the testing of the SWE module, we provided the modeling of the tsunami propagation and coastal inundation in at the coast of Miyagi and Fukushima prefectures from Onagawa to Iwaki 11 March 2011. The presented part of the work includes the results of the model verification and analyses of the dynamics of the inundation of the sites of three NPPs.

The development of the 2D model COASTOX has started after the Chernobyl accident for simulations radionuclide transport in the rivers at ChNPP (Zheleznyak et al, 1989-2000). The hydrodynamic module is based on the shallow water equations. The 2-D depth-averaged advection-diffusion equations with sink source terms are used to describe the transport of suspended sediments and radionuclide in solute and with suspended sediments. The contemporary version of COASTOX code is based on the solution of 2-D shallow water equations on unstructured triangular grids using the Finite Volume Method with the verified possibilities for the modelling of wetting-drying flows. We implement a Godunov-type flux calculation scheme with approximate HLLC or Roe methods of solving a Riemann problem. The shock waves are resolved

by using TVD flux limiting. COASTOX code includes two finite-difference algorithms for the numerical solution of sediment and radionuclide transport equations: explicit and implicit. For the solution of erosion-deposition equation and bottom contamination equation source, terms in transport equations are treated implicitly. The numerical code is parallelized for the CPU multi-processors systems and GPU. The SWE module was tested for the river floodplain inundation for the number of the cases and for the simulation of the radionuclide wash off from the floodplain of the Pripyat river at Chernobyl NPP. The model was implemented for the Tohoku coast on a grid of 2 million cells. The modelling results were compared with the published tsunami gage data. The dynamics of the inundation of three NPPs sites were analyzed.