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Modelling of Cs-137 transport in the nearshore zone of Fukushima –Daiichi NPP under the combined action of waves, currents and fluxes of sediments

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The number of marine modelling studies of radionuclide transport in the Pacifica ocean was performed after the accident at the Fukushima Daiichi Nuclear Power Plant (FD NPP). However, even for the coastal areas of Japan radionuclide dynamics were simulated mainly on the distances larger than 1 km offshore. We provided the modelling for the alongshore zone at 30 km around FD NPP on the basis of two-dimensional model COASTOX and coastal wind wave model SWAN.
COASTOX is based on the depth-averaged Navier Stokes equations (Shallow Water Equations). The radiation stress terms describing the influence of the nearshore wave transformation and breaking on nearshore currents are included in the equations of the water movement. The open source model SWAN is used to simulate the transformation of the wind wave fields in the coastal areas. The radionuclide transport submodel describes the fate of radionuclides in three interacting phases - in solution, in suspended sediments, and in bottom depositions. The 2-D depth-averaged advection-diffusion equations with sink-source terms are used to describe the transport of suspended sediments, the radionuclide transports in solute and in suspended sediments. It also calculates the dynamics of the bottom deposition contamination and describes the rate of sedimentation and resuspension as a function of the difference between the actual and the equilibrium concentration of suspended matter depending on the transport capacity of the flow. For describing the adsorption/desorption and diffusion contamination transfer in the systems "solution - suspended sediments" and "solution - bottom deposition" the parameterization of non-reversible adsorption processes is used. COASTOX has good computational performance due to the implementation of the finite volume scheme on the unstructured grid and MPI (Message Passing Interface) parallelization.
The hydrodynamics and wind wave modules of the modelling chain were tested and calibrated on the basis of the tide gage and wind wave gage stations of the area.
The results of the modelling of the atmospheric deposition and the assessments of the direct release to the ocean from FD NPP are used as the source term of 137Cs in the modelling studies.
The results of the simulation of the first 4 years after the accident are compared with the data on the contamination of marine bottom. Future dynamics of bottom concentration of 137Cs is predicted on the basis of the several scenarios of the wind storms consequences in the region.