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A sediment transport model for analyzing the environmental dynamics of radionuclides in estuarine and coastal oceans

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Several oceanic dispersal modeling have been conducted by multiple institutions on dissolved radionuclides leaked at the Fukushima Dai-ichi Nuclear Power Plant (FNPP). Among others, we developed a multi-nesting oceanic model at the lateral grid resolution down to 1 km and performed the comprehensive dispersal reanalysis of the direct release of ^{137}Cs from FNPP occurred in March and April 2011 (Uchiyama *et al*., 2013, *J. JSCE*). The model reveals that the current field on the continental shelf off Fukushima varied with surface wind stress and largely confined in the narrow coastal strip by about 30 km offshore. The spectral coherence analysis suggests that predominant alongshore transport of nuclides is caused by coastal jets on the shelf, presumably as forced shelf waves associated with the alongshore component of the wind stress. The coastal dispersal of the radionuclides is affected not only by direct release but also by atmospheric fallout (deposition) and discharge from the rivers. The last process introduces a time lag behind the direct release with hydrological process because the nuclides mostly attach to suspended particles (sediments) that are transported quite differently to the dissolved matter in the ocean.

In the present study, an Eulerian sediment transport model as an active tracer conservation equation with a prescribed settling velocity added to the vertical advection term, a wave-enhanced bed boundary layer model and a simple stratigraphy model proposed by Blaas *et al*. (2007) are implemented into ROMS (Shchepetkin and McWilliams, 2005, 2008). Three classes of sediments, viz., fine sand, silt and clay fractions, are considered here. The modeling procedure is approximately the same as Uchiyama *et al*. (2013), whereas the third embedding is done at the horizontal resolution dx of 250 m within the existing 1-km domain to develop the triple nested configuration forced by the assimilative JCOPE2 reanalysis (Miyazawa et al., 2009) as the outer-most boundary conditions. Thus the grid refinement occurs from JCOPE2 (dx ~ 10 km) to ROMS-L1 (dx = 3 km), to ROMS-L2 (dx = 1 km), and finally to ROMS-L3 (dx = 250 m). Sediments are taken into account in ROMS-L3 model carried out for March through August 2011. The bed skin stress is evaluated by a combined wave-current stress model of Soulsby (1995) with the wave field computed by a SWAN spectral wave modeling at dx = 1 km embedded in the JMA GVP-CWM spectral wave reanalysis. The bathymetry is provided by the 50-m resolution dataset compiled by Japan's Cabinet Office. The initial distributions of fractions of the marine bed sediment classes are estimated with an optimally interpolated field of the observations reported by Miyagi and Fukushima Prefectures (1991, 2013). Daily discharges of 6 major rivers and 14 minor rivers in the L3 domain are provided from the hydrological surface water model HYDREEMS conducted in CRIEPI. An empirical, mean relation between river discharge and sediment flux based on Takekawa *et al*. (2013) is employed for estimating the section-averaged sediment flux at each river mouth. Fraction of sediment classes in the river water is estimated from a USLE based river model conducted by JAEA (2013). The passive tracer is additionally considered to track dissolved ^{137}Cs released from FNPP as the direct release, whereas its absorption and desorption to the sediments (i.e., suspended ^{137}Cs) are not considered yet.

We intend to talk at the conference on initial dispersal of dissolved ^{137}Cs at dx = 250 m, extent of the land-derived sediments from each river mouth, resuspension and recirculation of the deposited bed sediments during storm conditions, in conjunction with corresponding oceanic states. We will further touch on potential distribution of suspended and dissolved ^{137}Cs if absorption and desorption occur.

Keywords: multi-class sediment transport model, radioactive cesium 137, multiple nesting approach, ROMS (Regional Oceanic Modeling System)