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# Modeling dispersal of land-derived suspended radionuclides in the Fukushima coast

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Several oceanic dispersal modeling have been conducted on dissolved radionuclides leaked at the Fukushima Dai-ichi Nuclear Power Plant (FNPP). These models normally consider scenarios where the direct release of radionuclides from the FNPP and atmospheric deposition as the secondary source. In the present study, we view freshwater discharge from the rivers as a missing piece for the inventory of the radionuclides in the ocean. The land-derived input introduces a time lag behind the direct release through hydrological process because these radionuclides mostly attach to suspended particles (sediments) that are transported quite differently to the dissolved matter in the ocean. Therefore, we develop a sediment transport model consisting of a multi-class non-cohesive sediment transport model, a wave-enhanced bed boundary layer model and a stratigraphy model proposed by Blaas et al. (2007) incorporated into ROMS. A 128 x 256 km domain with the grid resolution of dx = 250 m centered at the FNPP is configured as a test bed within the existing dx = 1 km domain (Uchiyama et al., 2012, 2013). Three classes of sediments, viz., fine sand, silt and clay fractions, are considered here. The bed skin stress is evaluated by a combined wave-current stress model of Soulsby (1995) with the wave field computed with a SWAN spectral wave model at dx = 1 km embedded in the JMA GVP-CWM wave reanalysis. A total of 20 rivers inclusive of the 6 major rivers located in the domain are considered as point sources of the sediments. The daily-averaged freshwater discharges from the 20 rivers are evaluated with a surface runoff model HYDREEMS (Toyoda et al., 2009). Sediment volume fluxes from the rivers are then calculated with an empirical L'-Q' (discharge to sediment flux) relation proposed by Takekawa et al. (2013). Fraction of three sediment classes in the riverine discharge is determined empirically based on the outcome of a USLE-based river sediment modeling conducted by JAEA.

The developed model successfully reproduces the dispersal of the land-derived sediments and their recirculation processes associated with resuspension and deposition in the Fukushima coast for 4 months after the accident. The discharged sediments can be transported about 50 km from the shore with prominent patchiness of deposition and erosion near the mouth of each river. For instance, the offshore region of the mouth of the Niida River is evaluated to be erosion dominated, consistently with the measurement. Misumi et al. (2014) estimate suspended 137Cs concentration in the bed with considering static adsorption and desorption of 137Cs between the seawater and the bed sediments based on the dissolved 137Cs model result of Tsumune et al. (2012). The inferred bed 137Cs agrees well with the observation in the shallow area, whereas substantially underestimated in the offshore area at depth deeper than 200 m. They attribute the reason of the underestimate to the 137Cs due to sediment transport that is omitted in their model. We carefully diagnose our model results and find that although the clay-class sediments reach the deeper area, the time-integrated deposition is merely about 0.002 kg/m2 that is considered to be a minor fraction. Therefore, it is suggested that detritus and debris of organic matters rather than land-derived minerals likely cause the offshore 137Cs deposition. We further examine nearshore dispersal patterns and quantify the inventory of 137Cs attached to the sediments originated from the land by applying the empirical power law for 137Cs concentration as a function of specific surface area of the suspended particles proposed by Onda et al. (2014).

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