Impacts of riverine input on oceanic $^{137}$Cs derived from the Fukushima Dai-ichi Nuclear Power Plant accident

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A series of accidents at the Fukushima Dai-ichi Nuclear Power Plant following the Great East Japan Earthquake and tsunami of 11 March 2011 resulted in the release of radioactive materials to the ocean by two major pathways: direct release from the accident site and atmospheric deposition. A 6 years, regional-scale simulation of $^{137}$Cs activity in the ocean offshore of Fukushima was carried out by the Regional Ocean Model System (ROMS), the sources of radioactivity being direct release, atmospheric deposition, the inflow of $^{137}$Cs deposited into the ocean by atmospheric deposition outside the domain of the model, and river discharges.

Direct releases of $^{137}$Cs were estimated for 6 years after the accident by comparing simulated results and measured activities adjacent to the accident site. In addition, river discharge rates $^{137}$Cs were calculated by multiplication between river flow rate and $^{137}$Cs activity. River flow rates were simulated by a water circulation analysis model for each catchment. Temporal change of $^{137}$Cs activity both of particle and dissolved forms were measured at 8 rivers and normalized by the inventory of $^{137}$Cs in each catchment. $^{137}$Cs activity in other 4 rivers were estimated by the normalized $^{137}$Cs activity and inventories of catchments. After 2013, direct release and river discharge were dominant for input of $^{137}$Cs to the ocean. Apparent half-life of direct release and river discharge of were estimated to be about 1 year and 2 years, respectively.

Apparent half-life of measured $^{137}$Cs activity adjacent to 1F NPP was about 1 year, on the other hand, the ones in the coastal zone away from 1F NPP were about 2 years after 2013. Apparent half-life of simulated results with river discharge was in good agreement with the one in the coastal zone away from 1F NPP. River discharge affected on temporal change of $^{137}$Cs activity there. On the other hands, simulated $^{137}$Cs activities with river input were one order of magnitudes smaller than observations. This underestimation suggests modifications of river input process, such as estuary mixing process, removal from particle form $^{137}$Cs and inputs from small rivers around the 1F NPP.

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