# Estimating impacts of direct release and riverine discharge on oceanic $^{137}Cs$ derived from the Fukushima Dai-ichi Nuclear Power Plant accident by an regional ocean model

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A series of accidents at the Fukushima Dai-ichi Nuclear Power Plant (1F NPP) following the Great East Japan Earthquake and tsunami of 11 March 2011 resulted in the release of radioactive materials to the ocean. Measured $^{137}Cs$ activities in the coastal zone adjacent to the 1F NPP are still higher than the one before the accident because sources to the ocean are still existing. The Regional Ocean Model System (ROMS) was employed for regional-scale simulation of $^{137}Cs$ activity in the ocean offshore of Fukushima, 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 release of $^{137}Cs$ was estimated for 7 years after the accident by comparing simulated results and measured activities adjacent to the accident site. In addition, riverine discharge rates $^{137}Cs$ were also estimated by multiplication between river flow simulation rate and measured $^{137}Cs$ activities. Simulated atmospheric deposition to the ocean was employed by atmospheric transport model. Inflow of $^{137}Cs$ from boundary sections was set by the results of the North Pacific scale ocean model. Sensitivity experiments were carried out to investigate the contributions of each source to measured $^{137}Cs$ activities in the ocean. We focused on the term from 2013 to 2016 because there were few data in the river before 2012, and also focused on dissolved $^{137}Cs$ because most of $^{137}Cs$ is dissolved form in the ocean.

Simulated $^{137}Cs$ activity attributable to direct release were in good agreement with measured data in the coast zone adjacent to the 1F NPP, because the effect of direct release was dominant from 2013 to 2016. On the other hands, simulated results attributable to inflow from boundary sections were slightly underestimated to the measured data offshore area. This suggests that recirculation of subducted $^{137}Cs$ to the surface layer was underestimated in the North Pacific model. Apparent half-life of direct released and river discharged $^{137}Cs$ activity were estimated to be about 1 year and 2 years, respectively. And apparent half-life of inflow of $^{137}Cs$ activity was much longer due to time scale of dilution process in the North Pacific. Apparent half-life of each source should be similar to the measured one attributable to each source. Apparent half-life of measured $^{137}Cs$ activity adjacent to the 1F NPP was about 1 year, on the other hand, the ones increased with increasing distance from the 1F NPP. Apparent half-life of measured data was about 2 years in front of the Uda river mouth where is far from the 1F NPP. Although $^{137}Cs$ activity in this area was mainly affected by the river input, simulated $^{137}Cs$ activities with river input were one fifth of observations. There is a brackish lagoon, Matsukawa-ura in front of Uda river mouth. The observed $^{137}Cs$ activities in the Matsukawa-ura were 3-5 times larger than the one in the Uda river. This suggests the removal process from particle $^{137}Cs$ to dissolved form in the brackish lagoon may be important.

 

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