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Transport of the Cs-134 activity derived from Fukushima Dai-ichi Nuclear Power Plant in the North Pacific Ocean

Takaki Tsubono[1], Kazuhiro Misumi[2], Daisuke Tsumune[2], Michio Aoyama[3], and Katsumi Hirose[4]
[1]Central Research Institute of Electric Power Industry, Abiko, Japan (tsubono@criepi.denken.or.jp)
[2]Central Research Institute of Electric Power Industry, Abiko, Japan
[3]Tsukuba University
[4]Sophia University

We conducted the ensemble simulation of Cs-134 activity in the North Pacific Ocean (NPO) water after the Fukushima Dai-ichi Nuclear Power Plant (1F NPP) by setting four different passive tracers corresponding to the fluxes of the Cs-134 activity; 1. Cs_DD for Cs-134 activity directly discharged from the coast of the 1F NPP (Tsumune et al., 2013), 2. Cs_ADN for the activity derived from the atmospheric deposition (Aoyama et al, 2015) northern from 36°N, 3. Cs_ADKE for that in the Kuroshio Extension area from 32°N or 36°N, 4. Cs_ADS for that southern from 32°N. The totals of the Cs_DD, Cs_ADN, Cs_ADKE and Cs_ADS in the NPO in May 2011 are 5.6, 8.7, 1.0 and 0.6 PBq respectively, suggesting that the impact was dominant northern from 36°N in the NPO. The sum of four tracers showed comparable to the Cs-134 activity from all the fluxes in previous study with the correlation coefficient of 0.99 and the RMS of 5 Bq m^{-3} in 2011 and 0.99 and 0.1 Bq m^{-3} in 2012, except for the area of Japanese coast near the 1F NPP in which the rapid increase in the direct discharge flux produced the different negative values due to the dispersive error of the difference scheme. Since the Cs-134 activity diminishes in time due to the short half life of about 2 years, the abundance ratio was calculated for the investment of the meridional and vertical transport. The abundance ratio of the whole Cs-134 activities showed that although almost all the Cs-134 activity existed in the surface layer above 200m depth after the accident, the ratio in the intermediate layer from 200m to 600m depth increased and exceeded 50 percent since 2017. Moreover the ratio in the intermediate layer southern from 32°N exceeded the 25 percent since 2017, suggesting that more than 25 percent of the Cs-134 activity in the surface layer northern to the 36°N in early period after the accident were transported to the southern and deep in 2017. While the abundance ratio of Cs_DD and Cs_ADN in the intermediate layer showed an increase like a logarithmic function shape, the ratio of the Cs_DD, 60 percent, was larger than that of the Cs_ADN, 50 percent, in 2021. Moreover, the abundance ratio in 2011 showed the 70 percent of Cs_DD and Cs_ADN existed in the intermediate layer southern to the 32 °N, suggesting a large amount of both the Cs_DD and Cs_ADN were transported southern and deep in 2021.