Meridional and Vertical Transport of the simulated ^{134}Cs activity from Fukushima Dai-ichi Nuclear Power Plant in the North Pacific Ocean

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We investigated the meridional and vertical transport of the ^{134}Cs activity in the North Pacific Ocean (NPO) water after the Fukushima Dai-ichi Nuclear Power Plant (1F NPP) accident using four tagged tracer corresponding to the fluxes of the ^{134}Cs activity; 1. Cs_DD for ^{134}Cs 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) north of 36˚N, 3. Cs_ADKE for that in the Kuroshio Extension area from 32˚N or 36˚N, 4. Cs_ADS for that south of 32˚N. The total amounts of the Cs_DD, Cs_ADN, Cs_ADKE and Cs_ADS for the models in the NPO in May 2011 are 5.6, 8.7, 1.0 and 0.6 PBq respectively, suggesting that the impact was dominant north of 36˚N in the NPO. We conducted the five-ensemble simulation of ^{134}Cs activity in the North Pacific Ocean (NPO) water and calculated the average of the abundance ratio corresponding to the area same as that for the tagged fluxes. Before the investigation of the ratio, we checked the sum of four tagged ^{134}Cs activity and obtained that the sum were comparable to the ^{134}Cs activity previously calculated using all the fluxes 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 coastal area near the 1F NPP in which the rapid increase in the direct discharge flux caused the dissimilar negative values due to the dispersive error of the difference scheme.

The abundance ratio of the whole ^{134}Cs activities showed that although almost all the^{134}Cs activity existed in the surface layer above 200m depth after the accident, the ratio in the intermediate layer from 200m to 600m depth had increased and exceeded 50 percent since 2017. While the ratio in the surface layer showed that the ratio north of 36˚N (south of 32˚N) was decreasing (increasing) from 80% (0 %) in 2011 to 30% (65 %) in 2021, the ratio in the intermediate layer showed that the ratio in the Kuroshio Extension was decreasing (increasing) from 80% (10 %) in 2011 to 10% (70 %) in 2021.

While the 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. The 70 (35%) of Cs_DD and Cs_ADN existed in the area south of the 32 ˚N (in the intermediate water), suggesting a large amount of both the Cs_DD and Cs_ADN have been transported southern across the Kuroshio Extension and deeper.

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