Estimation of $^{137}$Cs inventories by a global ocean general circulation model for the global database interpolation

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Artificial radionuclide $^{137}$Cs has been supplied into the ocean by global fallout due to atmospheric nuclear weapons tests since 1945, releases from reprocessing plants since 1952, and most recently by fallout and discharge due to the Fukushima Dai-ichi Nuclear Power Plant (1F NPP) accident since 2011. $^{137}$Cs activities measured for scientific purposes as well as environmental health and safety monitoring have been summarized in a historical database by IAEA. The spatio-temporal density of the observations varies widely, therefore simulation by an ocean general circulation model (OGCM) can be helpful in the interpretation of these observations. We used the Parallel Ocean Program version 2 (POP2) of the Community Earth System Model version 2 (CESM2). The horizontal resolution is 1.125 degrees in longitude and 0.28 to 0.54 degrees in latitude. The simulation period was from 1945 to 2030, and the atmospheric conditions were forced to cycle through repeating normal years. The purposes of this study are to investigate the effect of the release from the reprocessing plants on the distribution of $^{137}$Cs activity by global fallout in the Atlantic Ocean, and the effect of the release derived from the 1F NPP accident on the one by global fallout in the Pacific Ocean.

The simulated $^{137}$Cs activities were in good agreement with the observed data in the database in the Atlantic Ocean and the Pacific Ocean. The simulated $^{137}$Cs activity immediately after each release event in the North Pacific were inconsistent with the observed one because of the inadequate reproduction of the Kuroshio Current in this quasi-resolution ocean model. However, the influence of the dilution effect is expected to become smaller as the time after the release increases. The influence of the $^{137}$Cs activity by release from the reprocessing plant on the one by global fallout in the Atlantic Ocean is limited to the northeast coast of the European continent and the Marginal Seas. It was also suggested that $^{137}$Cs activity by global fallout made detection difficult since the 1990s. The influence of the $^{137}$Cs activity by the 1F NPP on the one by global fallout was found to be broadened by the Kuroshio extension area and extended to the California coast. This distribution was similar to that of the one by global fallout. However, there are few observed data off the California coast after 2011. It was also suggested that $^{137}$Cs activity by global fallout has made detection difficult since the 2020 in the Pacific Ocean.
Even after 2020, it is still possible to detect $^{137}$Cs activity by global fallout in the global ocean. The difference in the vertical distribution between the Pacific and Atlantic oceans reflects the ocean circulation, which is useful for the validation of ocean general circulation models. There is still room for improvement in setting the input conditions to the ocean for each event.