Implementing regional downscaling capability in the STEAMER radionuclide dispersion prediction system based on multi-nested ROMS model

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Oceanic regional downscaling capability was implemented into Short-Term Emergency Assessment system of Marine Environmental Radioactivity (STEAMER) developed by Japan Atomic Energy Agency (JAEA) to enable us to predict more realistically the oceanic dispersion of radionuclides at higher spatiotemporal resolutions for broader applications. The system consisted of double-nested Regional Ocean Modeling System (ROMS) with tidal forcing embedded in the Multivariate Ocean Variational Estimation system for the Western North Pacific (MOVE-WNP), assimilative reanalysis/forecast product and an oceanic radionuclide dispersion model SEA-GEARN developed by JAEA. Surface wind stress was provided by the Grid Point Value of the Global Spectral Model (GPV-GSM) atmospheric reanalysis/forecast while surface heat and freshwater fluxes are from the Comprehensive Ocean-Atmosphere Data Set (COADS) monthly climatology. Ten principal tidal constituents from the TPXO 7.0 global tidal reanalysis were additionally imposed on the sea surface height as boundary condition along the perimeter to include barotropic tides and the resultant intrinsic baroclinic tides. The horizontal grid spacing was decreased from ~10 km in the outermost MOVE-WNP, to 3 km in the intermediate ROMS-L1 model, and further down to 1 km in the innermost ROMS-L2 model. The model results showed reasonable agreement with tidal observations. The system was used to comparatively examine downscaling and tidal effects on the dispersion of radionuclides hypothetically released from the Fukushima Daiichi Nuclear Power Plant. The simulated dissolved ^{137}Cs distribution had seasonal variability and was different from that obtained using coarser-resolution models because downscaling enhanced both horizontal and vertical mixing. Temporal ^{137}Cs fluctuations were slightly amplified as a result of the suppression of horizontal mixing and enhancement of vertical mixing by tides. In addition, the submesoscale effects strengthened the three-dimensional ^{137}Cs fluctuations by $<$10 times, while the tidal effects promoted slightly increased the intensity of three-dimensional ^{137}Cs fluctuations by approximately 3-30%. This indicated that the submesoscale effects substantially surpassed tidal forcing in oceanic mixing in the coastal margin off Fukushima.

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