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Uncertainty analysis of atmospheric deposition simulation of radiocesium and radioiodine from Fukushima Daiichi Nuclear Power Plant

Yu Morino (1), Toshimasa Ohara (1), and Keiya Yumimoto (2)
(1) National Institute for Environmental Studies, Japan, (2) Meteorological Research Institute

Chemical transport models (CTM) played key roles in understanding the atmospheric behaviors and deposition patterns of radioactive materials emitted from the Fukushima Daiichi nuclear power plant (FDNPP) after the nuclear accident that accompanied the great Tohoku earthquake and tsunami on 11 March 2011. In this study, we assessed uncertainties of atmospheric simulation by comparing observed and simulated deposition of radiocesium (137Cs) and radioiodine (131I).
Airborne monitoring survey data were used to assess the model performance of 137Cs deposition patterns. We found that simulation using emissions estimated with a regional-scale (∼500 km) CTM better reproduced the observed 137Cs deposition pattern in eastern Japan than simulation using emissions estimated with local-scale (∼50 km) or global-scale CTM. In addition, we estimated the emission amount of 137Cs from FDNPP by combining a CTM, a priori source term, and observed deposition data. This is the first use of airborne survey data of 137Cs deposition (more than 16,000 data points) as the observational constraints in inverse modeling. The model simulation driven by a posteriori source term achieved better agreements with 137Cs depositions measured by aircraft survey and at in-situ stations over eastern Japan.
Wet deposition module was also evaluated. Simulation using a process-based wet deposition module reproduced the observations well, whereas simulation using scavenging coefficients showed large uncertainties associated with empirical parameters. The best-available simulation reproduced the observed 137Cs deposition rates in high-deposition areas (≥10 kBq m-2) within one order of magnitude.
Recently, 131I deposition map was released and helped to evaluate model performance of 131I deposition patterns. Observed 131I/137Cs deposition ratio is higher in areas southwest of FDNPP than northwest of FDNPP, and this behavior was roughly reproduced by a CTM if we assume that released 131I is more in gas phase than particles. Analysis of 131I deposition gives us better constraint for the atmospheric simulation of 131I, which is important in assessing public radiation exposure.