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Source term estimation of atmospheric discharge during the Fukushima Daiichi Nuclear Power Station accident by Bayesian inversion with multi-scale dispersion simulations

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Source term estimation studies using atmospheric dispersion simulations and environmental measurements have been carried out for the atmospheric discharge during the Fukushima Daiichi Nuclear Power Station (FDNPS) accident in March 2011. There are issues that these source terms estimated from dispersion simulations with different spatial scale (several 10km to global) and various type of measurement data (atmospheric concentration, surface deposition amount, air dose rate, etc.) have discrepancy in total release amount. In this study, we attempted to estimate source terms of radioactive cesium and iodine by an optimization method of release rates based on Bayesian inference using multi-scale dispersion simulations from regional to hemispheric scale and various environmental measurements compositely. In the dispersion simulations, meteorological fields were calculated by the Weather Research and Forecasting model (WRF) developed by the National Center for Atmospheric Research in USA. The meteorological input data, Grid Point Value (GPV) by the Japan Meteorological Agency, were used for initial and boundary conditions of WRF calculations. The Lagrangian particle dispersion model GEARN developed by Japan Atomic Energy Agency were used for calculation of atmospheric transport and deposition of radionuclides. To make source-receptor matrix used in the Bayesian analysis, we preliminary constructed a database of air concentration and surface deposition from calculations assuming unit release rate (1Bq h-1) for all unit release time segments (1h) within the release period from 12 March to 31 March in 2011. The database was constructed for multiple scales; 190km-square area (1km resolution) around FDNPS, 570km-square area in East Japan (3km resolution), and 11,000km-square area in the northern hemisphere (54km resolution). We used various measurement data for the optimization of source term. From measurements in Japan, we used air concentration data by dust samplings, surface deposition map by airborne monitoring, daily fallout data, and hourly air concentration by analyzing suspended particulate matter (SPM) collected at air pollution monitoring stations. From worldwide measurements, air concentrations of Cs-137 at stations of the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) were used. With the release rate in March 2011 estimated by our previous works as prior source term in Bayesian analysis, we conducted an optimization test using these prototype databases and the multiple environmental measurements, and confirmed the validity and effectiveness of the method. Furthermore, information about the influence on the optimization results of the measurement type was obtained by sensitivity analysis which limits the measurement data to each measurement type. In future, we plan to improve the database of dispersion simulation outputs by enhancement of reproducibility of meteorological calculation.