Geophysical Research Abstracts
Vol. 16, EGU2014-11276, 2014
EGU General Assembly 2014


# Detailed source term estimation of atmospheric release during the Fukushima Dai-ichi nuclear power plant accident by coupling atmospheric and oceanic dispersion models

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Temporal variations of release amounts of radionuclides during the Fukushima Dai-ichi Nuclear Power Plant (FNPP1) accident and their dispersion process are essential to evaluate the environmental impacts and resultant radiological doses to the public. Here, we estimated a detailed time trend of atmospheric releases during the accident by combining environmental monitoring data and coupling atmospheric and oceanic dispersion simulations by WSPEEDI-II (Worldwide version of System for Prediction of Environmental Emergency Dose Information) and SEA-GEARN developed by the authors. New schemes for wet, dry, and fog depositions of radioactive iodine gas ($I_2$ and $CH_3I$) and other particles (I-131, Te-132, Cs-137, and Cs-134) were incorporated into WSPEEDI-II. The deposition calculated by WSPEEDI-II was used as input data of ocean dispersion calculations by SEA-GEARN. The reverse estimation method based on the simulation by both models assuming unit release rate (1 Bq $h^{-1}$) was adopted to estimate the source term at the FNPP1 using air dose rate, and air sea surface concentrations. The results suggested that the major release of radionuclides from the FNPP1 occurred in the following periods during March 2011: afternoon on the 12th when the venting and hydrogen explosion occurred at Unit 1, morning on the 13th after the venting event at Unit 3, midnight on the 14th when several openings of SRV (steam relief valve) were conducted at Unit 2, morning and night on the 15th, and morning on the 16th. The modified WSPEEDI-II using the newly estimated source term well reproduced local and regional patterns of air dose rate and surface deposition of I-131 and Cs-137 obtained by airborne observations. Our dispersion simulations also revealed that the highest radioactive contamination areas around FNPP1 were created from 15th to 16th March by complicated interactions among rainfall (wet deposition), plume movements, and phase properties (gas or particle) of I-131 and release rates associated with reactor pressure variations in Units 2 and 3.