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Modeling of long term diffusion of radioactive materials, and levy flight simulation considering topical wind direction

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The environment around Fukushima has been contaminated by radioactive materials leaked from the Fukushima 1 Nuclear Power Plant, following the Tohoku earthquake and tsunami on 11 March 2011. Cs-134 and Cs-137 adhered to the ground surface and remain polluting surrounding environment because they have a long half-life. In addition, they diffuse gradually due to resuspension. In this study, we propose the simulation model suited for the long-term diffusion prediction of them, which has not studied enough, and verify the applicability of our model by comparing with measured data.

The ground surface concentration of Cs-134 and Cs-137 has been attenuated in a proportion to the power of the distance from the release point in Fukushima. In addition, concentration in the atmosphere has been attenuated following the same law in Chernobyl data. The exponent of distance from release point was about 1 on average in Fukushima. The exponent of distance is constant, regardless of the unit of distance. Levy flight is known as diffusion model showing the power law. A Levy flight equals a random walk in which the step-lengths have a probability distribution function of the power. Therefore, we conducted levy flight simulation regarding the existence probability of the particle as the surface concentration. We reproduced surface concentration on 5 November 2011 by using the initial condition data for 5 July 2011[1]. We used measured data of wind direction in the each step-direction of levy flight because of the wind direction is not isotropic.

The result is shown in Fig. As the result of the simulations, we succeeded in predicting the concentration more accurately than the case in which only decay of radioactive materials was considered. The simulation was the most accurate especially using exponent value 1. More accurate predictions will become possible to study further.

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