Ensemble simulations of a meteorological field and an aerosol plume dispersion validated by local surface wind and Cs-137 observations

T. T. Sekiyama[1], M. Kajino[1] and M. Kunii[1]

[1] Meteorological Research Institute (MRI), Japan Meteorological Agency (JMA), Tsukuba 3050052, Japan
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Presenting author email: tsekiyam@mri-jma.go.jp

A single-model initial-perturbed ensemble simulation for the meteorological field of Eastern Japan in March 2011 was performed in this study. Then, using the meteorological simulation results, we conducted the dispersion simulation of radioactive Cs-137 aerosols emitted by the Fukushima Daiichi nuclear power plant (FDNPP) accident.

The ensemble of the meteorological field was prepared by an ensemble-based data assimilation system that consisted of the Japan Meteorological Agency's non-hydrostatic weather-forecast model (JMA-NHM; with a 3 km horizontal resolution) and a four-dimensional local ensemble transform Kalman filter (4D-LETKF; with 20 ensemble members) in accordance with Sekiyama et al. (2015). The off-line radioactive Cs-137 aerosol dispersion model was developed by Adachi et al. (2013).

The meteorological ensemble simulation result was validated by local surface wind observations of the Japanese national weather observation network (called AMeDAS, cf. http://www.jma.go.jp/en/amedas/). The dispersion ensemble simulation result was validated by surface Cs-137 concentration observations of Tsuruta et al. (2014) and Oura et al. (2015). The Cs-137 concentration was reconstructed by measuring the residuals on the Suspended Particle Matter (SPM) sampling tapes of local prefectural governments.

The ensemble simulation provided probabilistic information for the plume dispersion. We found that a small ensemble spread of wind speed resulted in a large uncertainty in aerosol concentrations (shown in Figures 1 and 2; RSD stands for Relative Standard Deviation =σ/mean); i.e., the error in aerosol plume simulation was cumulative with the error in wind simulation. This finding implies that a high accuracy of dispersion simulation requires much higher accuracy of meteorological simulation, representing a limitation of deterministic simulations for analysing/predicting the location and intensity of aerosol plumes.

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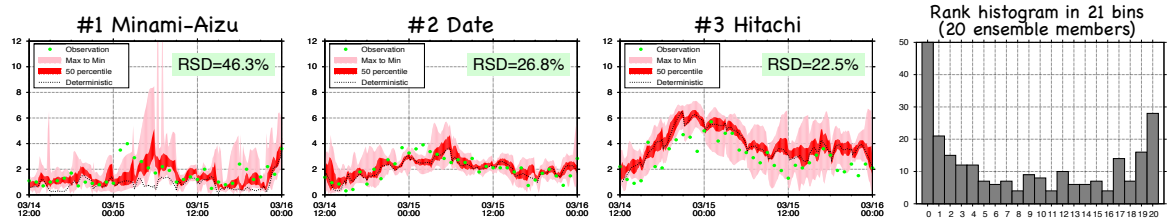

Figure 1. Comparison between the surface wind speed (U_{10}) observations and the ensemble simulation. (unit = m/s)

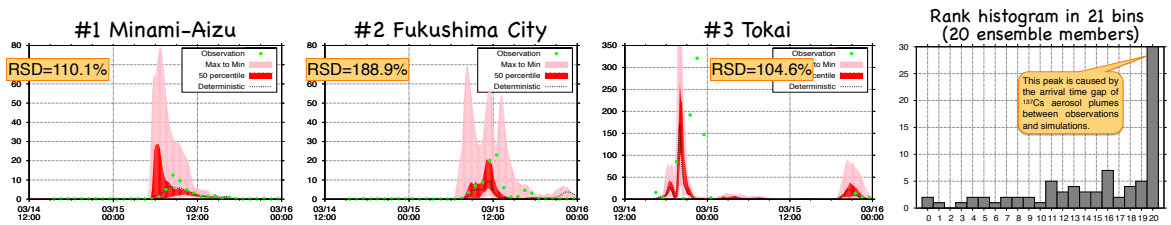

Figure 2. Comparison between the Cs-137 concentration observations and the ensemble simulation. (unit = Bq/m^3)