Reproducibility of surface wind and tracer transport simulations over complex terrain using 5, 3, and 1 km grid models

A21R-2688

Thomas T. Sekiyama and M. Kajino (*Meteorological Research Institute, Japan Meteorological Agency*)

Abstract

It was investigated that the reproducibility of surface wind and tracer transport simulations over complex terrain in wintertime using high-resolution (5-km, 3-km, and 1-km grid) weather and transport models, in which radioactive cesium (Cs-137) emitted from the Fukushima nuclear power plant was used as a tracer.

Fukushima has complex terrain, such as mountains and valleys. The model results were validated by observations collected from the national networks of the automated meteorological data acquisition system and the hourly air pollution sampling system.

The reproducibility depended on the model resolution, topographic complexity, and synoptic weather conditions. Higher model resolution led to higher reproducibility of surface winds, especially in mountainous areas when the Siberian winter monsoon was disturbed. In contrast, the model improvement was negligible or nonexistent over plain/coastal areas when the synoptic field was steady.

The statistical scores of the tracer transport simulations often deteriorated due to small errors in the plume locations. However, the higher-resolution models advantageously performed better transport simulations in the mountainous areas because of the lower numerical diffusion and higher reproducibility of the mass flux. The reproducibility of the tracer distribution in the valley of the Fukushima mountainous region was dramatically improved with increasing model resolution.

In conclusion, a higher-resolution model is definitely recommended for tracer transport simulations over mountainous terrain at least in the range of mesoscale model resolutions (commonly 1~10 km grids).

Models and Observation Data

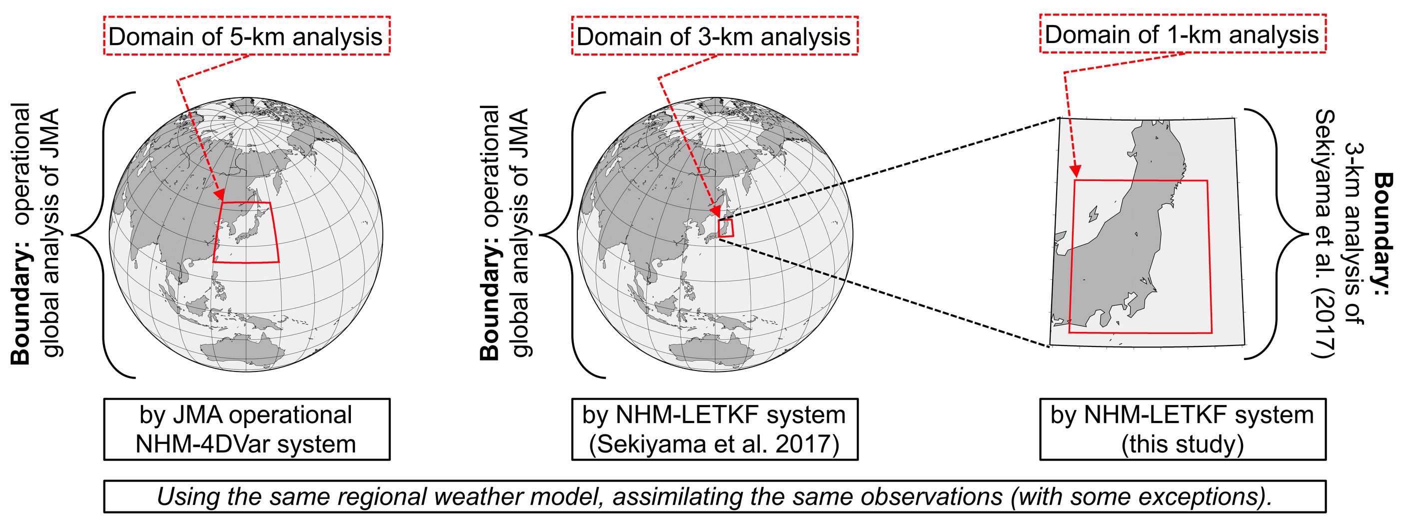

Fig.1. Domains of the 5-km, 3-km, and 1-km meteorological analyses in this study. NHM is a non-hydrostatic weather forecast model operated by the Japan Meteorological Agency. LETKF stands for "local ensemble transform Kalman filter."

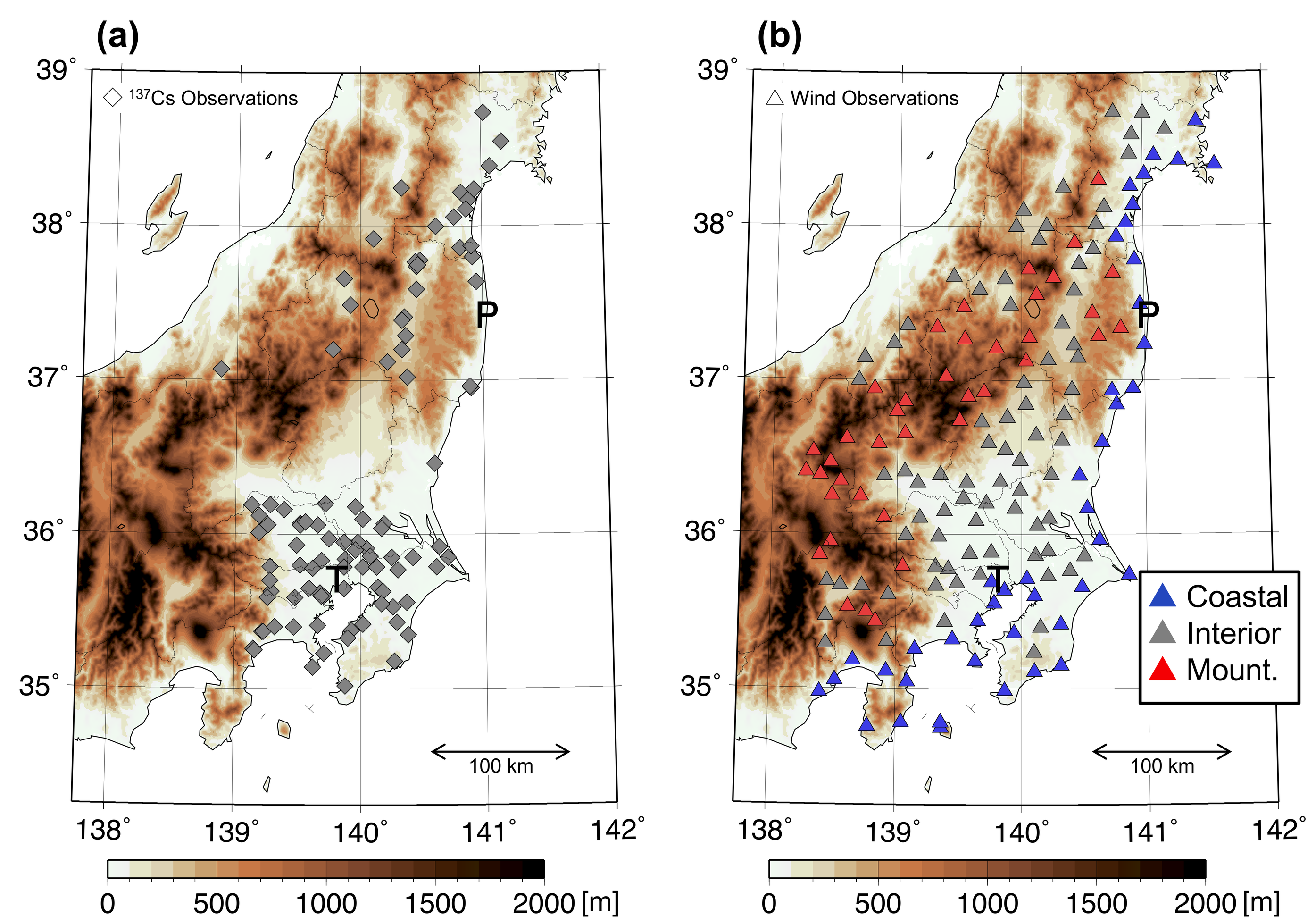

Fig.2. Observation stations used in this study for (a) surface Cs-137 concentrations provided by the "suspended particulate matter" sampling network and (b) surface winds provided by the national weather network. Capital letters P and T indicate the locations of the Fukushima Daiichi Nuclear Power Plant and Tokyo City, respectively. Brown shades indicate the elevations. Blue, gray, and red triangles represent coastal, interior, and mountainous stations, respectively.

Results (topography)

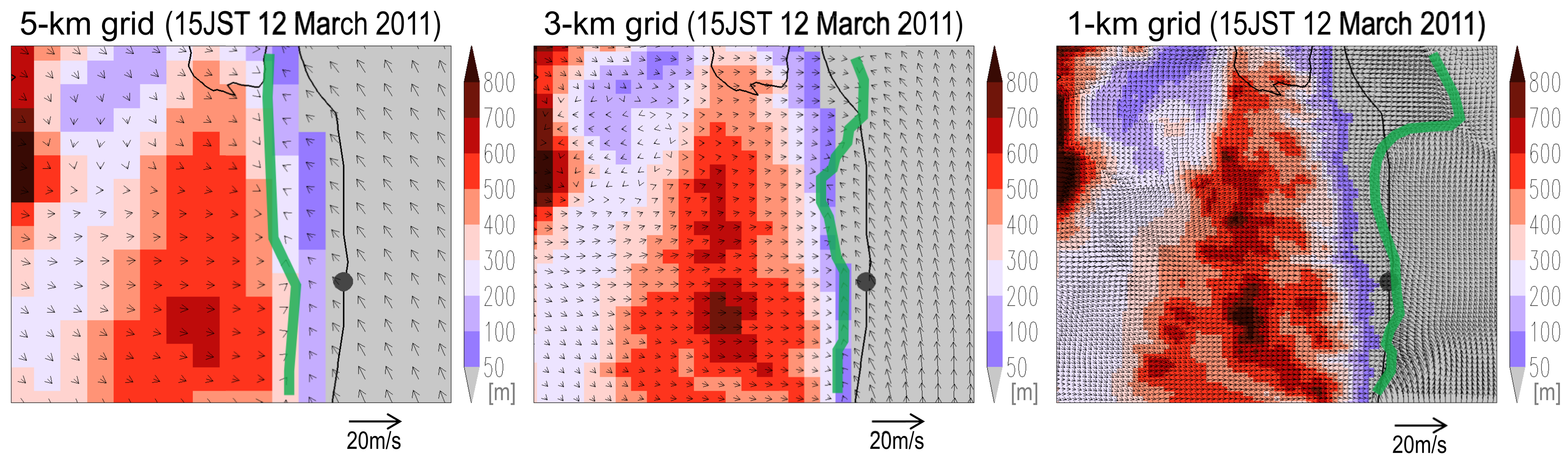

Fig.4. Fukushima topography depicted by the 5-km, 3-km, and 1-km grid resolutions. The filled black circle is the location of the the Fukushima Daiichi Nuclear Power Plant. Arrows and green lines indicate the surface wind vectors of the analyses and their convergence zones, respectively, at 15:00 [Japanese Standard Time (JST)] on 12 March 2011. Thin black lines depict the coastline and a prefectural borderline.

Results (surface wind)

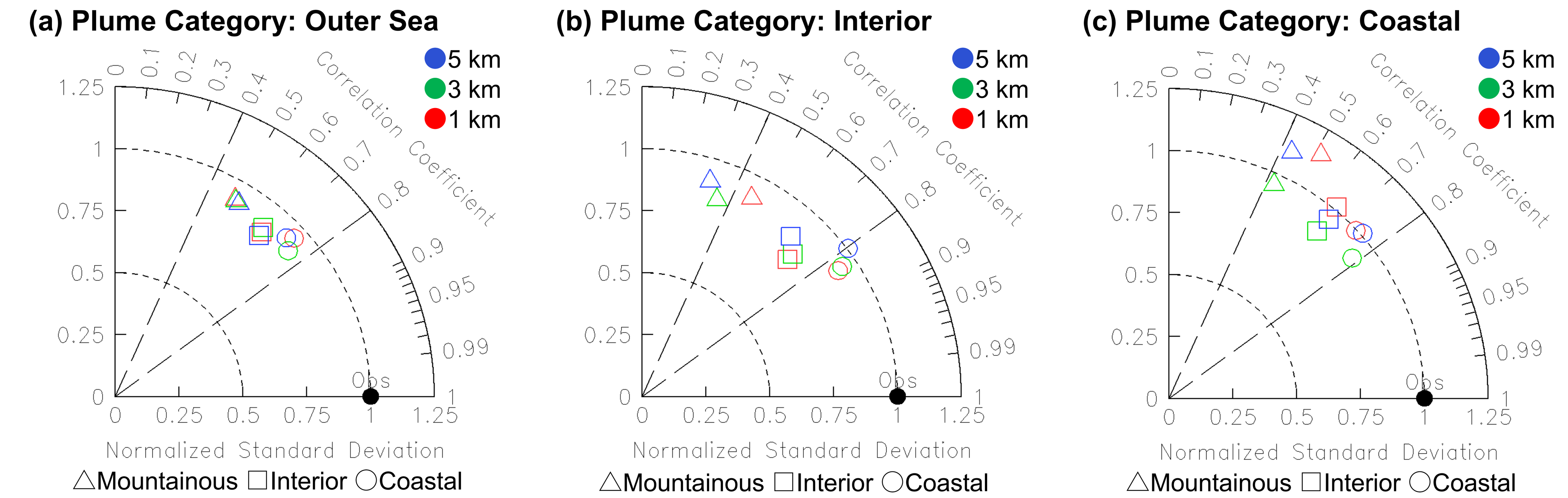

Fig.5. Taylor diagrams for a comparison of surface wind (U10) analyses to observations categorized as (a) outer-sea plume periods, (b) interior plume periods, and (c) coastal plume periods (see Fig. 3). Open triangles, squares, and circles indicate mountainous, interior, and coastal locations, respectively, for the surface wind (U10) observations. Blue, green, and red colors indicate 5-km, 3-km, and 1-km grid analyses, respectively. Black filled circles indicate observations.

Plumes and Synoptic Charts

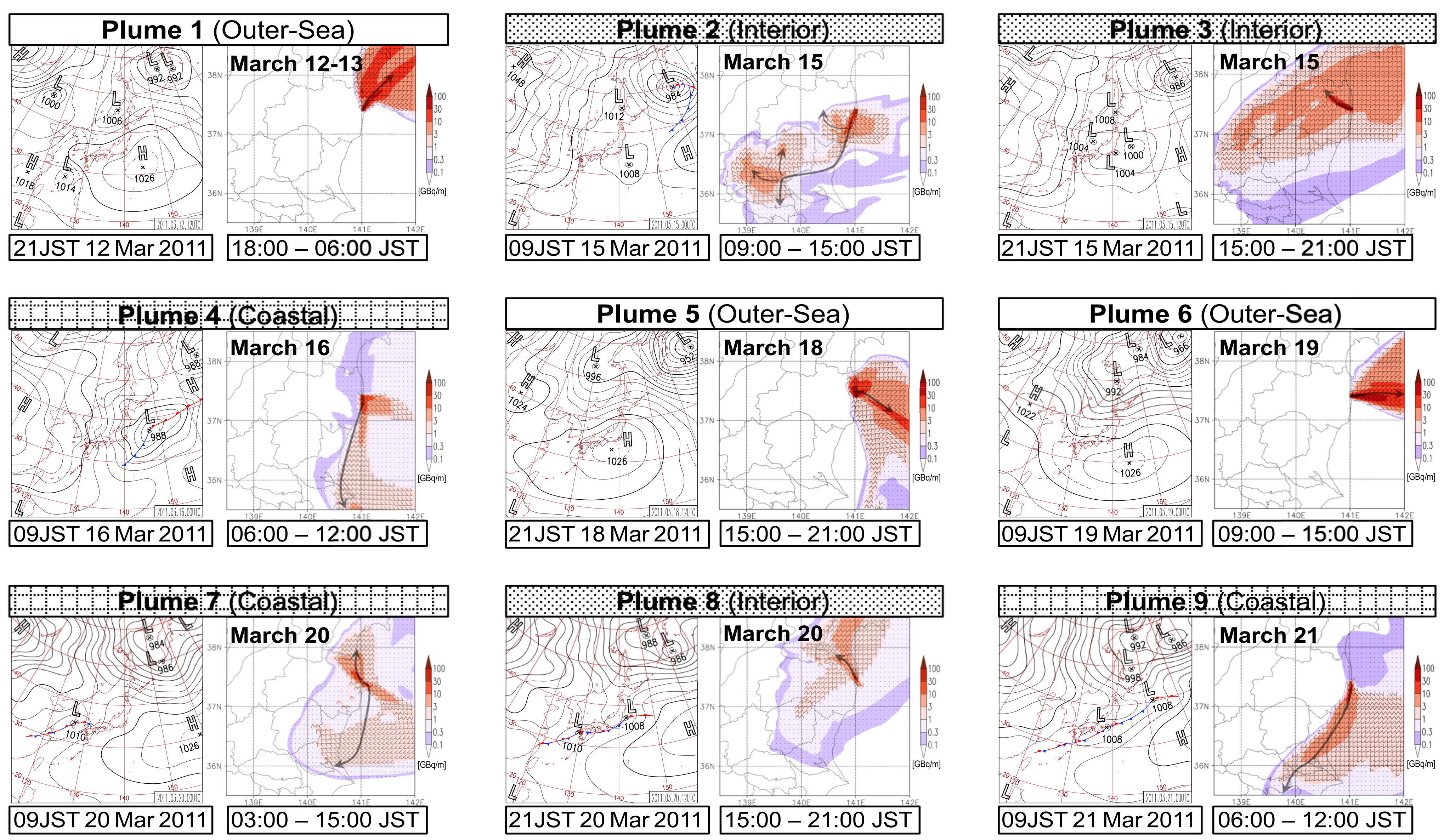

Fig.3. Surface weather charts (provided by the Japan Meteorological Agency) and Cs-137 mass fluxes (time- and column-integrated, reproduced from Sekiyama and Iwasaki 2018, *Tellus B*) for Plumes 1 to 9 (defined by Tsuruta et al. 2014).

Results (concentration)

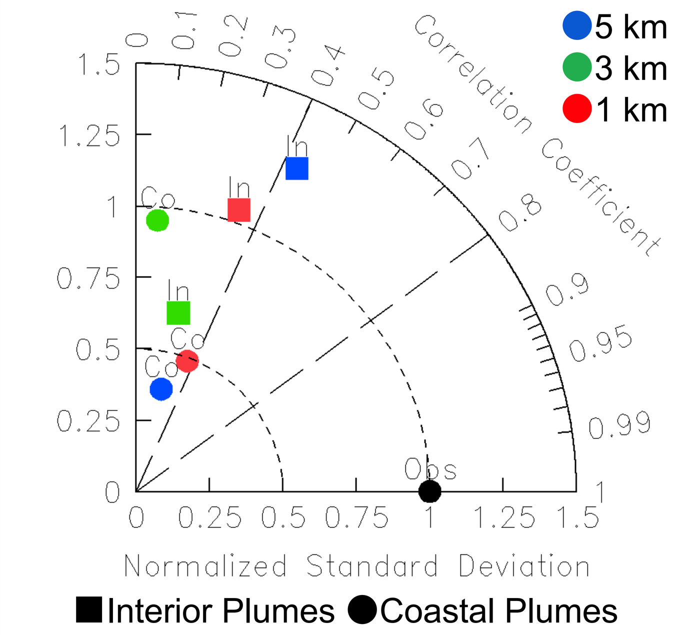

Fig.6. Taylor diagram for a comparison of Cs-137 concentration model results to "suspended particulate matter" sampling network observations. Colored filled squares and circles indicate statistics during interior and coastal plume periods (see Fig. 3), respectively. Blue, green, and red colors indicate 5-km, 3-km, and 1-km grid model results, respectively. A black filled circle indicates observations.

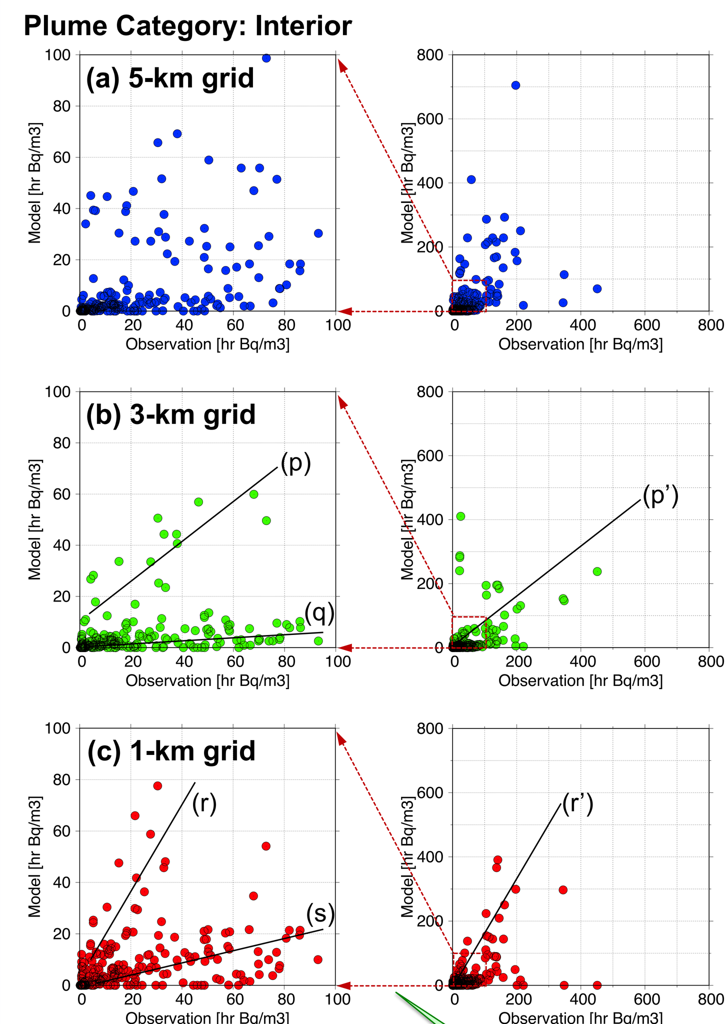

Fig.7. Scatter diagrams for a comparison between Cs-137 observations and transport model results at each station for the interior plume category. Plotted for (a) the 5-km grid model, (b) the 3-km grid model, and (c) the 1-km grid model. The concentrations are 6-hourly time-integrated at each station. The left panels [range: 0–100 h Bq m^{-3}] present the magnified views of the right panels [range: 0–800 h Bq m^{-3}].

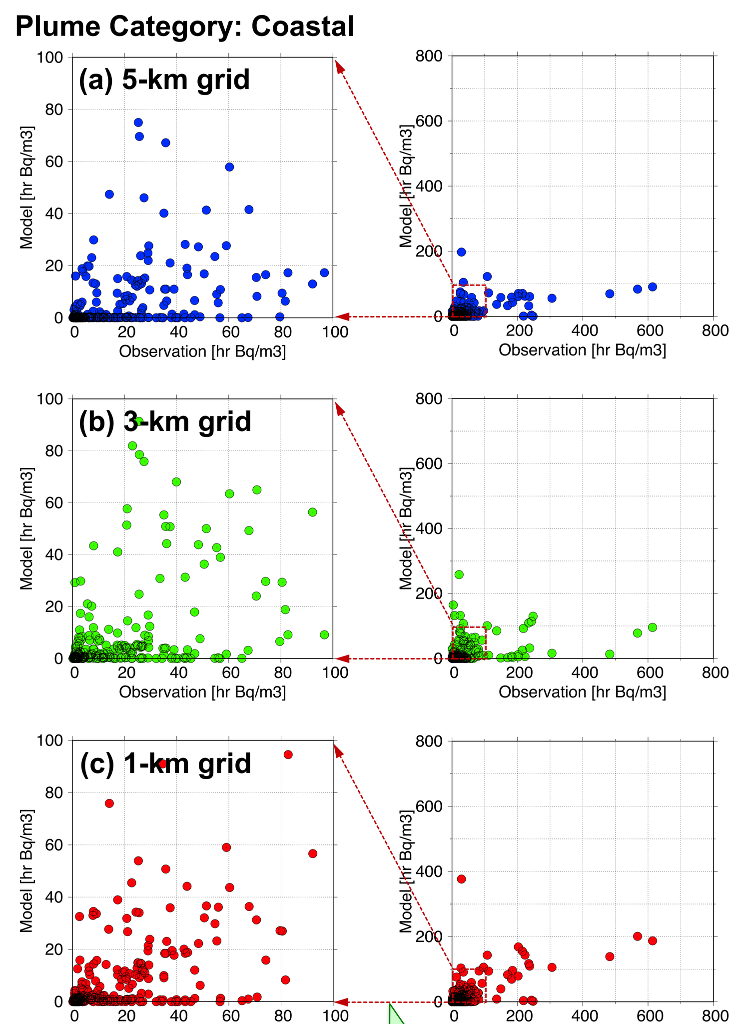

Fig.8. Same as Fig. 7 but for the coastal plume category.

Interior Plumes #2, #3, #8

Coastal Plumes #4, #7, #9

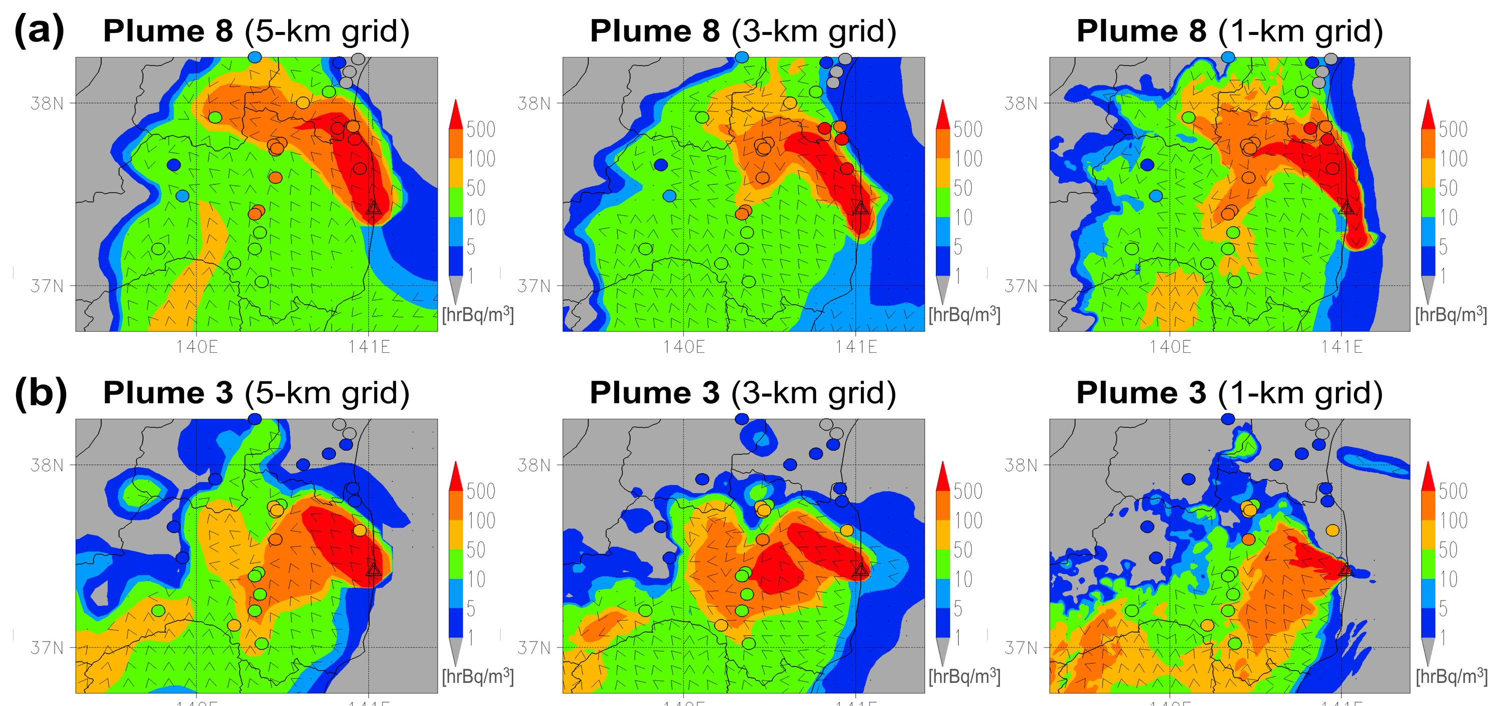

Fig.9. Geographical distributions of the 6-hour time-integrated surface Cs-137 concentration over the Fukushima region for the time periods of (a) Plume 8 and (b) Plume 3 (see Fig. 3). Shaded colors indicate the 5-km, 3-km, and 1-km grid model results. Color circles indicate the observations. Arrowheads indicate the direction of the 6-hour time-integrated mass flux (Sekiyama and Iwasaki 2018, *Tellus B*) at the ground surface in the models. The open triangle is the location of the nuclear power plant.

AGU Fall Meeting, 10 December 2019, San Francisco