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Installation of System at Hirosaki University, Japan, for Estimating Radionuclide Atmospheric Dispersion Levels

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Numerical simulation assessment via an atmospheric transport and dispersion model (ATDM) has proven extremely useful for efficiently estimating the impacts resulting from nuclear incidents. In August 2015, Hirosaki University was designated as Japan's national center for radiation emergency medicine and it is expected that the University will continue to play an integral role in the estimation of catastrophic-event influences per the use of ATDM simulations. Such simulations will help to conduct proper diagnoses and treatments for the general public in response to such emergency situations. In support of such endeavors, Hirosaki University has recently focused upon an ATDM simulation system developed by a project of the Interdisciplinary Study on Environmental Transfer of Radionuclides from the Fukushima Daiichi Nuclear Power Plant Accident. This simulation system is able to estimate radionuclide influences via the use of a common notebook without the need for extensive calculations. In this paper, the current installation and deployment status of the ATDM system at Hirosaki University are described.

Key words: atmospheric transport and dispersion model, radionuclides, emergency medicine

1. Introduction

Following the Fukushima Daiichi Nuclear Power Plant (FDNPP) accident, a numerical simulation was conducted by an atmospheric transport and dispersion model (ATDM simulation) for assessing the influences of the FDNPP accident in support of various research studies; resultantly, the importance and utility of such simulations were recognized[1, 2]. For assessing an emergency situation immediately after an incident, the ATDM simulation serves as a robust tool for determining areas that have been significantly affected by radionuclides on the basis of actual conditions. Subsequent measures for protection against radiation exposure can be recommended on the basis of ATDM simulation results, with potential influences on inhabitants within significantly affected areas accurately estimated. ATDM simulation assessments are thus useful for protecting the general public from radioactive contamination that can follow a radiation-related accident or malevolent action.

In August 2015, Hirosaki University received the designation as two separate types of national centers for Japan: (1) an Advanced Radiation Emergency Medicine Support Center and (2) a Nuclear Disaster Medical Care/General Support Center[3]. If a future nuclear or radiation accident was to occur, it is anticipated that Hirosaki University will be able to expeditiously estimate potential influences immediately after such an incident to proficiently conduct proper diagnoses and treatments for

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Table 1. Expediential condition for an "example incident."

Items	Expediential condition
Season	Spring (Popular tourist season)
Location	Hirosaki City
Grid	Longitude:138–143° E with 0.125° resolution Latitude: 38–43° N with 0.1° resolution Height: 0–50 m above ground level
Lagrangian particles	Travel range(Longitude): 138–143° E Travel range(Latitude): 38–43° N Travel range(Height): from ground surface to 500 hPa Number of emitted particles: 1000/h
Meteorological parameters[1]	Utilization data: Forecast data (39 h: 0:00 on May 3 to 15:00 on May 4) on GPV-MSM at 0:00 on May 3, 2016 Utilization interval: 3 h
Emission of radionuclides[1]	Radionuclides: ^{137}Cs Emission rate: 1×10^{12} Bq/h Emission time: from 0:00 to 6:00 on May 3, 2016 Emission type: continuous emission Emission point : Hirosaki Castle, 25-m height from the ground
Integrated period for calculation[1]	From 0:00 May 3, 2016 to 15:00 May 4, 2016

[1] UTC (Coordinated Universal Time)

the general public against radiation exposure[3]. Therefore, it is important that Hirosaki University eventually fully implements an ATDM simulation system that is able to efficiently estimate influences due to such accidents. In this paper, the current installation and deployment status of the ATDM system at Hirosaki University are described.

2. ATDM simulation system at Hirosaki University

A source code of ATDM simulation developed by a project of the Interdisciplinary Study on Environmental Transfer of Radionuclides from the Fukushima Daiichi Nuclear Power Plant Accident (ISET-R)[2, 4] was recently employed at Hirosaki University (Hereinafter referred to as the ISET-R ATDM simulation). A Lagrangian type model for source emissions, diffusion, dry deposition, and wet deposition is adopted on the ISET-R ATDM simulation. The diffusion, dry deposition, and wet deposition of Lagrangian particles for the ISET-R ATDM simulation are based on several meteorological models for the advection and diffusion of radioactive plumes and resulting wet/dry depositions[5-7]. In light of experiments resulting from the FDNPP accident, high-performance equipment cannot be worked on in future emergency situations owing to social dislocations and physical damage. Therefore, the estimation of potential radiological influences for such an event should optimally be performed via the use of "simple equipment" such as a common notebook. The ISET-R ATDM simulation can estimate radiological influences per the use of a common notebook, i.e., without extensive calculations, owing to the assumption that fundamental meteorological parameters (i.e., initial data) such as humidity, temperature, vector wind, precipitation, and barometric pressure have a linear relation with time[5]. It has been reported that the distribution and total amount of land-based ^{137}Cs deposition observed by actual measurements from the FDNPP accident were mainly consistent with that obtained via the ISET-R ATDM simulation with current knowledge[2]. The grid point value mesoscale model (GPV-MSM) of the Japan Meteorological Agency is utilized as fundamental meteorological data for the ISET-R ATDM simulation. The GPV-MSM covers 120–150 °E and 23–47 °N and provides meteorological variables from 1000 to 100 hPa (pressure levels) with a horizontal grid resolution of approximately 11 km (longitude and latitude resolutions = 0.125° and 0.1°) and the variables on the surface with the resolution (longitude and latitude resolutions = 0.0625° and 0.05°)[2, 8]. The data on the GPV-MSM can be obtained from a database supported by the Research Institute for Sustainable Humanosphere, Kyoto University[9]. This database is updated every few hours and is available from most recent time (T) to T + 39 h. The transaction time for a subject calculation ultimately depends on the condition of the calculation itself. For a simulation representing one month of a "common condition," it takes approximately 10 min to complete an assessment[5].

3. Calculation example

As a potentially realistic example of an ATDM simulation, dispersion and deposition levels of radionuclides released by a hypothetical malevolent action (i.e., an intentional

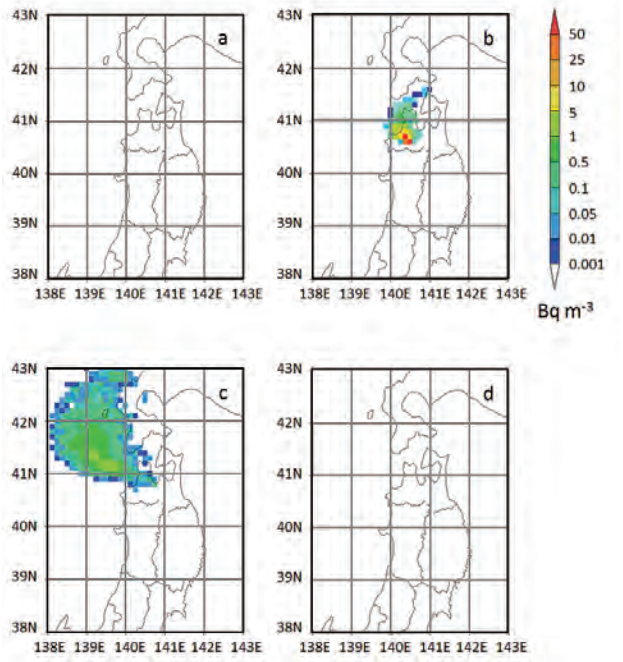

Fig. 1. Concentration of ^{137}Cs in the surface layer for an ATDM simulation in the expediential condition (a: May 3, 2016 at 0:00; b: May 3, 2016 at 06:00; c: May 3, 2016 at 12:00; d: May 4, 2016 at 15:00).

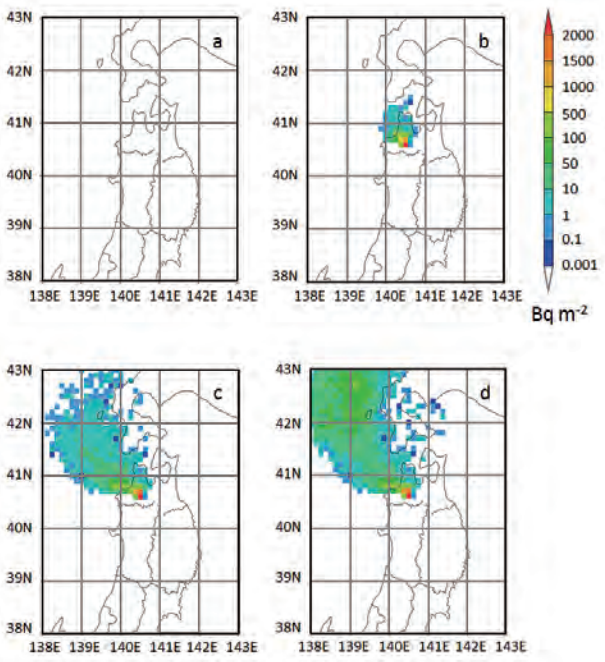

Fig. 2. Deposition (sum of dry and wet depositions) of ^{137}Cs on the ground for an ATDM simulation in the expediential condition (a: May 3, 2016 at 0:00; b: May 3, 2016 at 06:00; c: May 3, 2016 at 12:00; d: May 4, 2016 at 15:00).

destructive act) in Hirosaki City were calculated. The associated expediential conditions for the calculation are shown in Table 1 and its results are shown in Figures 1 and 2. The quantity of deposition in the upper area of Hirosaki City was determined as relatively high because the primary wind directions were southerly and easterly for this subject case. Moreover, it was expected that onsite emergency-response headquarters and medical offices would be established in the south area of Hirosaki City because of the contamination. In addition, it was expected that the residents of Hirosaki City's upper area would evacuate to a safe distance via trains (Ohu Railline, Tohoku Shinkansen) or cars (National Route 7 and Tohoku Expressway) at a prompt juncture following radioactive plume passage (more than 12 h after incident occurrence). In the case of such an emergency, Hirosaki University would immediately provide the results obtained from ATDM simulations to the medical agencies at hand.

4. Future work

Currently, indirectly obtained meteorological parameter data are used for ATDM simulations conducted at Hirosaki University. To efficiently and accurately perform ATDM simulations on the basis of real-time meteorological information, there is a need for direct data acquisition via employment of online data services.

For ATDM simulations conducted through Hirosaki University, it is assumed that meteorological parameter data consistently maintain a linear relationship with time (i.e., the time axis) to perform simulation exercises without the need for extensive supporting calculations. In the future, however, Hirosaki University will consider the employment of a "precision system" for ATDM simulations that include extensive calculations. This precision system would improve spatial grid resolutions on the simulations and would be utilized for constructing regional disaster prevention plans within each local government/province as well as would be able to validate important meteorological parameters on the simulations such as dry/wet deposition velocity rates by comparing actual observation values in various environments.

Moreover, in the future, Hirosaki University will continue to consider the "estimation procedure" for determining potential influences resulting from radiological incidents at facilities (e.g., nuclear power plants and naturally occurring radioactive materials (NORM) industrial plants) per ATDM simulations. Such efforts are expected to contribute to the continuing establishment of protocols on how to best treat a patient on the basis of external and internal exposure levels estimated from the ATDM simulation.

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Conflict of Interest Disclosure

The authors declare that they have no conflicts of interest.

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