INTERNATIONAL WORKSHOP AT FUKUSHIMA, JAPAN, ON DISPERSION AND DEPOSITION MODELING FOR NUCLEAR ACCIDENT RELEASES

Transfer of Science from Academic to Operational Models

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The workshop summarized here is the latest in a series of workshops (see Pullen et al. 2013; Bieringer et al. 2013) on atmospheric transport and dispersion modeling of the releases from the Fukushima Daiichi Nuclear Power Plant (FDNPP) following the 11 March 2011 earthquake and tsunami. On 8 October 2014, the Nuclear Regulation Authority (NRA) of Japan announced their decision that the atmospheric transport and dispersion model, System for Prediction of Environmental Emergency Dose Information (SPEEDI), will not be used for decision-making for evacuation planning following accidental releases of radionuclides (Nuclear Regulation Authority of Japan 2015). One of the reasons for this decision was the fact that significant uncertainties exist in atmospheric transport, dispersion, and deposition model predictions (Hatamura 2012). This workshop addressed these uncertainties and risk management issues in an attempt to improve the emergency response management systems in Japan and elsewhere. Experts from organizations operating emergency response systems, including dispersion and deposition models, for atmospheric releases at nuclear facilities in Japan, the United States, the United Kingdom, France, Germany, Australia, Denmark, and other countries participated in the discussion.

MODELING RADIONUCLIDES RELEASED FROM THE FUKUSHIMA DAIICHI NUCLEAR POWER PLANT

WHAT: Scientists from several countries met to discuss experiences modeling the releases from the Fukushima Daiichi Nuclear Power Plant, to compile the components of uncertainties, and to review procedures for communicating risk between the technical groups and decision-makers.

WHEN: 2–4 March 2015

WHERE: Fukushima University, Fukushima, Japan

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Abstracts of the invited speeches and poster presentations are on the workshop website (http://venus.iis.u-tokyo.ac.jp/english/workshop/newE.htm).

HIGHLIGHTS OF THE SESSIONS ON DAY 1.

Session topic. What are the types of modules used for estimating dry and wet deposition of radionuclides and what are the uncertainties in the parameters? Can we make recommendations for deposition modules and parameters to operational models?

In the opening remarks, the workshop organizers pointed out that considerable differences exist between the observed and modeled deposition values, and reference was made to the comprehensive studies of the FDNPP transport and dispersion issues by the Investigation Committee on the Accident at Fukushima Nuclear Power Stations of the Tokyo Electric Power Company (Hatamura 2012), by the Science Council of Japan (2014), and by Draxler et al. (2015). Four of the eight invited speakers on the first day discussed the deposition modules and uncertainties. Other presentations were on analyses of recent observations of radionuclides in Japan. For example, one addressed analysis of radiocesium concentrations recorded on filter tapes of suspended particulate matter (Tsuruta et al. 2014). Measurements were taken at 400 routine atmospheric monitoring stations in eastern Japan. Another presentation concerned the possibility of fog/cloud deposition (occult deposition) in the northern part of the Kanto area (Hososhima and Kaneyasu 2015).

The methods and parameters used for dry and wet deposition in operational models [e.g., the Methods for Estimation of Leakages and Consequences of Releases (MELCOR) Accident Consequence Code Systems (MACCS2; Bixler et al. 2013), Radical Assessment System for Consequence Analysis (RASCAL; Ramsdell et al. 2012), and Regional Atmospheric Transport Code for Hanford Emissions Tracking (RATCHET; Ramsdell et al. 1994)] were presented. An example was given of how the predictions of column (vertically integrated) concentrations of radionuclides could have been used to aid emergency response decisions during the period following the FDNPP accident. It was concluded that there is a need for additional field experiments, particularly regarding wet removal/deposition of radionuclides.

As explained during this session, the Meteorological Society of Japan (MSJ) disagreed with the decision concerning the use of the SPEEDI model that was made by the NRA on 8 October 2014 (Nuclear Regulation Authority of Japan 2015). MSJ (2015a,b) presented the following statements: 1) Numerical predictions of atmospheric dispersion should be utilized for environmental emergency responses. 2) Advanced monitoring/predicting systems should be established to enhance the use of observations and model predictions. Accurate observations at monitoring sites and predictions of spatiotemporal distributions are complementary. Also, 3) the experiences related to operation/dissemination of models and observations should be evaluated frequently. Local residents should be provided with frequent updates on procedures so as to enhance their understanding of the process.

After the invited presentations and following viewing of related poster presentations, participants were divided into two groups and discussed ways to reduce uncertainty in numerical models, especially the deposition modules. The group discussions are summarized as follows: 1) To better validate the model results using observations, more detailed information on sampling variability/errors should be presented. Especially, problems of local outliers should be checked. 2) The research community should collect or calculate the dry deposition velocities at sampling sites in the Fukushima area where both the deposition flux to the surface and the ambient concentrations of radionuclides are observed. In the analysis, observations affected by resuspension from the ground surface have to be considered separately. 3) Before discussing the superiority or inferiority of each wet-scavenging scheme, the research community should examine whether modeled meteorological fields (e.g., winds, precipitations, and temperatures) reproduce those observed. In particular, the uncertainties associated with meteorological model simulations of rain area and intensity and timing should be better determined. In addition, the differences between the precipitation fields observed by different types of radars should be studied. 4) Statistical significance of performance measures for current module evaluations should be checked carefully. The difference among the results using different wet-deposition modules may not be significant, and no modules seem to be a clear improvement over other modules. 5) Local-scale model simulations are important for decisions regarding evacuations. Most of Japanese radiological dispersion modelers have historically emphasized regional-scale modeling, and local-scale modeling of small-scale and mesoscale phenomena for scenarios such as the Fukushima case was not a high priority. From the point of view of the mass of radiological pollutants remaining in the cloud, deposition is less important for small-scale modeling than for regional-scale simulations. Finally, 6) the detailed meteorological observations, for example, winds, precipitation, and temperatures, taken during the period of the Fukushima accident have not yet been publicly released by the Japanese authorities. For the international research community, this database is crucial in the study of the radioactive deposition problem during the Fukushima accident.

HIGHLIGHTS OF THE SESSIONS OF DAY 2.

Session topic. What capabilities are necessary for an emergency response system for a nuclear accident resulting in releases to the atmosphere?

The morning session began with a series of invited presentations followed by poster presentations. The afternoon session was devoted to group discussions on three topics: source term estimation (STE), mobile monitoring systems, and risk communications. These three themes are essential ingredients to improve the current emergency response system in Japan.

The first presentation was an overview of risk communication procedures, emphasizing that the risk communication process should begin long before the actual occurrence of an emergency. It is important to build "trust" among decision-makers, model developers, stakeholders, local governments, and community residents. Lack of communication and trust became major concerns during the critical time period following the accident at the FDNPP. As discussed earlier, the Japanese operational atmospheric transport and dispersion model SPEEDI was not used for evacuation planning (Hatamura 2012). The Japanese government modified their procedures for evacuation planning so that the evacuation decision was determined mainly based on limited monitoring of dose rate, rather than the calculations of SPEEDI (Nuclear Regulation Authority of Japan 2015).

As easily imagined, the Japanese government decision not to use SPEEDI for evacuation planning created concerns among the Japanese meteorological community. A working group was formed under the MSJ and investigated the validity of the SPEEDI predictions. It was found that SPEEDI performed well as designed and according to its guidelines (e.g., Katata et al. 2015). The initial plume footprint prediction by SPEEDI was in approximate agreement with the footprint of the airborne measurements conducted later, and the absolute values were also in agreement with measurements (most were within an order of magnitude: FAC10 = 0.90–0.98) once the source term was corrected using monitored dose rate values.

Several international organizations (e.g., from the United States, United Kingdom, France, Denmark, Australia, and Germany) were engaged in the emergency response to the Fukushima episode from the earliest stage. In most of these exercises, the source term was calculated using the MELCOR code (Gauntt et al. 2001) plus information on reactor power and fuel burnup. In contrast, in Japan, the source term was estimated after the radioactive materials were released to the atmosphere, based on the dose measurements at monitoring stations (Chino et al. 2011; Terada et al. 2012; Kobayashi et al. 2013; Katata et al. 2015). Some of the available international modeling systems were used for decision support during the Fukushima nuclear accident (e.g., Stohl et al. 2012).

The afternoon session on day 2 was devoted to group discussions. Participants chose one of three themes: source term estimation, mobile monitoring system, or risk communications. Summaries of each group discussion are given below.

GROUP 1 DISCUSSION: SOURCE TERM ESTIMATION. The STE schemes were divided into three methods based on a 1) dispersion model (Stohl et al. 2012), 2) statistical model (Kalman filter and others) (Drews et al. 2004), and 3) core inventory model (Chang et al. 2012). Methods 1 and 3 were used by many organizations for the STE for the Fukushima nuclear accident. Although the methods were based on different calculation schemes, the calculated total amounts of emission were approximately the same order of magnitude, 10^{16}Bq (Cs-137). It was recommended that source intensities estimated by different STE methods be compared and the best value determined based on expert judgment.

Immediately following the Fukushima accident, there were some difficulties in obtaining and interpreting the monitoring data needed for the STE. It was suggested that the following data processing techniques would improve the accuracy of STE: 1) A data filtering technique is needed to separate the cloud-shine and the ground-shine components of the total radiation dose rate. 2) A data conversion technique needs to be applied to the spectrum of the radiation dose to calculate concentrations of specified nuclides. 3) A data averaging technique is needed to calculate instantaneous to long time (over 1 hour) averages. And 4) better quality control of monitoring data is needed. In addition to the measurements at fixed points, observations by mobile monitoring systems (e.g., airplanes, ships, and automobiles) were used to determine the contaminant level of radioactive materials in areas downwind of FDNPP.

GROUP 2 DISCUSSION: MOBILE MONITORING. In the event of an accident, access to measurements from mobile platforms (e.g., airborne or carborne gamma measurements) may supplement the fixed-position monitoring systems, allowing for deployment of emergency responders to downwind areas affected by the radioactive plume or to centers of population or economical interest. With a starting point based on the lessons learned from previous nuclear emergency exercises (Dowdall et al. 2014), and in particular from the Fukushima nuclear accident, the following recommendations resulted from the group discussion: 1) More monitoring systems (fixed position and mobile) were needed in the very early stages of the Fukushima nuclear accident. 2) Both model simulations and airborne measurements should be used to make decisions on where to deploy ground-based monitoring systems. However, preevent plans for the use of mobile systems including data handling and processing are necessary. 3) The platform and instrumentation should be consistent with the purpose of mobile measurements. In the early phase, focus should be on dose rate measurements for decisions on evacuation or sheltering. 4) Decisions regarding unambiguous definitions of values to be reported are very important. Standardization of methods for data acquisition is essential. 5) There is a constant need for exercises, training, and education. Finally, 6) methods for assuring international, nationwide, and interlocal governmental collaboration are necessary.

Group 3 discussion: Risk communications. The discussion assumed a broad definition of risk communications. It includes communications of potential risk from the time that a facility or activity is proposed. It includes preparation of emergency plans, discussions during development of consequence assessment models and procedures, and communication between the assessment team and decision-makers in the event of an accident, and ultimately it includes the decision-makers' communication of risk and protective action information with the public.

There was an extended discussion of the emergency communications channels in various countries. In the United States and other western countries, the responsibility and authority for consequence assessment and protective action decisions are vested in local governments because local authorities know the geographic area and the population potentially impacted by the event. Assistance and resources are supplied by higher levels of government as requested by the local response organization. In contrast, in Japan, the consequence assessment is provided by various agencies at the national level, and protective action decisions are made at the highest level (Hatamura 2012).

Fig. 1. Photo from 4 Mar 2015 bus excursion, showing an area where bags of contaminated soil (in large black bags) are kept before transport to a processing facility.

The group identified trust as the preeminent factor in risk communication. Communication between the technical groups performing consequence assessment (including model developers) and individuals tasked with making protective action decisions was identified as the weak link in the communications chain during an emergency. Indeed, it was determined that there were issues just in defining the information requirements. It was suggested that keys to developing trust and strengthening links included 1) preevent planning to coordinate response efforts, identify roles and resources, define communications channels, and assign responsibilities and authority; 2) continuing involvement of all stakeholders—facility operators, government agencies, model developers, consequence assessors, decision-makers, and the public—in discussions of risks and protective actions; and 3) periodic (frequent) exercises (for all those involved in the response to an emergency) to develop trust and maintain currency of plans.

DAY 3 BUS TOUR OF AREA AROUND FDNPP. On the third day of the workshop, a bus excursion was conducted to visit the areas close to the FDNPP that were impacted by the radiological releases. A photo from the trip is shown in Fig. 1. The black bags contain contaminated soil that has been scraped from the top 10 cm of agricultural fields. A local highway that passes within 2 km of FDNPP had just reopened after a lengthy and difficult period of cleanup of radioactive debris. In some areas the residents are still prohibited from returning to their homes. We were not allowed to leave the bus because of high radiation dosages outside.

FURTHER COMMENTS. More than four years have passed since the 2011 Great East Japan Earthquake and Tsunami that caused the failure of the FDNPP. The Japanese government estimates it may take over 40 years before the melted cores are removed from the reactor [Ministry of Economy Trade and Industry (METI) 2013]. Let us not forget the people who are still living in temporary housing. It is important to learn lessons from this unfortunate incident. This report is a part of our effort toward rebuilding a reliable emergency response system in Japan that should be continued in the future.

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