International workshop on dispersion and deopsition modeling for nuclear accident release
-transfer of science from academic to operational models-
March 2-4, 2015

Utilization of numerical atmospheric dispersion models for environmental emergency responses

Report from the Working Group of Meteorological Society of Japan (MSJ) on emergency response to atmospheric dispersion of accidental release of radioactive materials

Toshiki Iwasaki
Tohoku University

T. Iwasaki, H. Ishikawa, H. Kondo, Y. Suzuki, T. Sekiyama, T. Takemura, M. Takigawa, M. Chino, H. Tsuruta, T. Nakajima, H. Nakamura, H. Niino, M. Mikami, H. Yamasawa, S. Yoden and A. Watanabe

Most of this talk is found in Meteorological Society of Japan (MSJ), 2015: Utilization of numerical atmospheric dispersionmodels for environmental emergency response. Tenki, 62, 113-123 (inJapanese)

Background 1

For environmental emergency responses, the government prepared a numerical dispersion model, SPEEDI, to mitigate exposure.
(System for Prediction of Environmental Emergency Dose Information).

But SPEEDI's products were not utilized for exposure mitigation at the Fukushima accident.

SPEEDI has many uncertainties due to numerical errors arising from NWP, atmospheric diffusions and dry/wet depositions.

Emission Intensity, to be prescribed in the model, was not obtained at the Fukushima accident. Emergency Response Support System (ERSS), which was obliged to inform Emission Intensity, did not work.

Background 2

On 8th of October 2014, Nuclear Regulation Authority (NRA) stated: "SPEEDI should not be used for making decisions.   Evacuation should be based only on monitoring data, since the numerical prediction has serious uncertainties"

We did not agree with NRA. The WG urged discussions on how to utilize model products subject to uncertainties..

On 17th of December 2014, the WG submitted a report to the MSJ titled:
"Utilization of numerical atmospheric dispersion models for environmental emergency responses".

Considering the report, the MSJ made a proposal:
"A recommendation to establish the monitoring/predicting system of the atmospheric dispersion of radioactive materials",

Recommendation to establish the monitoring/predicting system of the atmospheric dispersion of radioactive materials

Rec 1 Numerical predictions of atmospheric dispersion should be utilized for environmental emergency responses.

Rec 2 Advanced monitoring/predicting systems should be established to enhance the combined use of observation/ model output data. Accurate observations at monitoring posts and predictions of spatiotemporal distributions are complementary to each other.

Rec 3 Exercises of operation/dissemination should be conducted frequently. Environmental emergency literacy should be educated to residents repeatedly.

Utilization of numerical dispersion models for environmental emergency responses

It is very important to consider the worst case scenario for disaster preventions.

Numerical models can provide an outlook of spatiotemporal distribution of radioactive materials. It is very useful for exposure mitigation, even though it is subject to various uncertainties.

Monitoring data is important to confirm actual contamination. However, the past data at limited number of monitoring sites are not enough to prevent exposure.

The model and monitoring data are complementary to each other.

Monitoring/prediction systems should be established to make the best combined use of observation/model output data.

Floating materials

We should take different measures against "floating materials in low-level air" and "deposited materials on the ground surface.

1. Floating materials tend to pass by rapidly. Therefore, we should be more careful about internal exposure through inhalation of contaminated air, rather than external exposure due to direct radiation from floating materials.

Use of Numerical prediction:
Predictions of surface air contamination help us to take timely action whether residents take indoor shelter or evacuate far away to safer regions. Also, we can let children take stable iodine.

Deposited materials

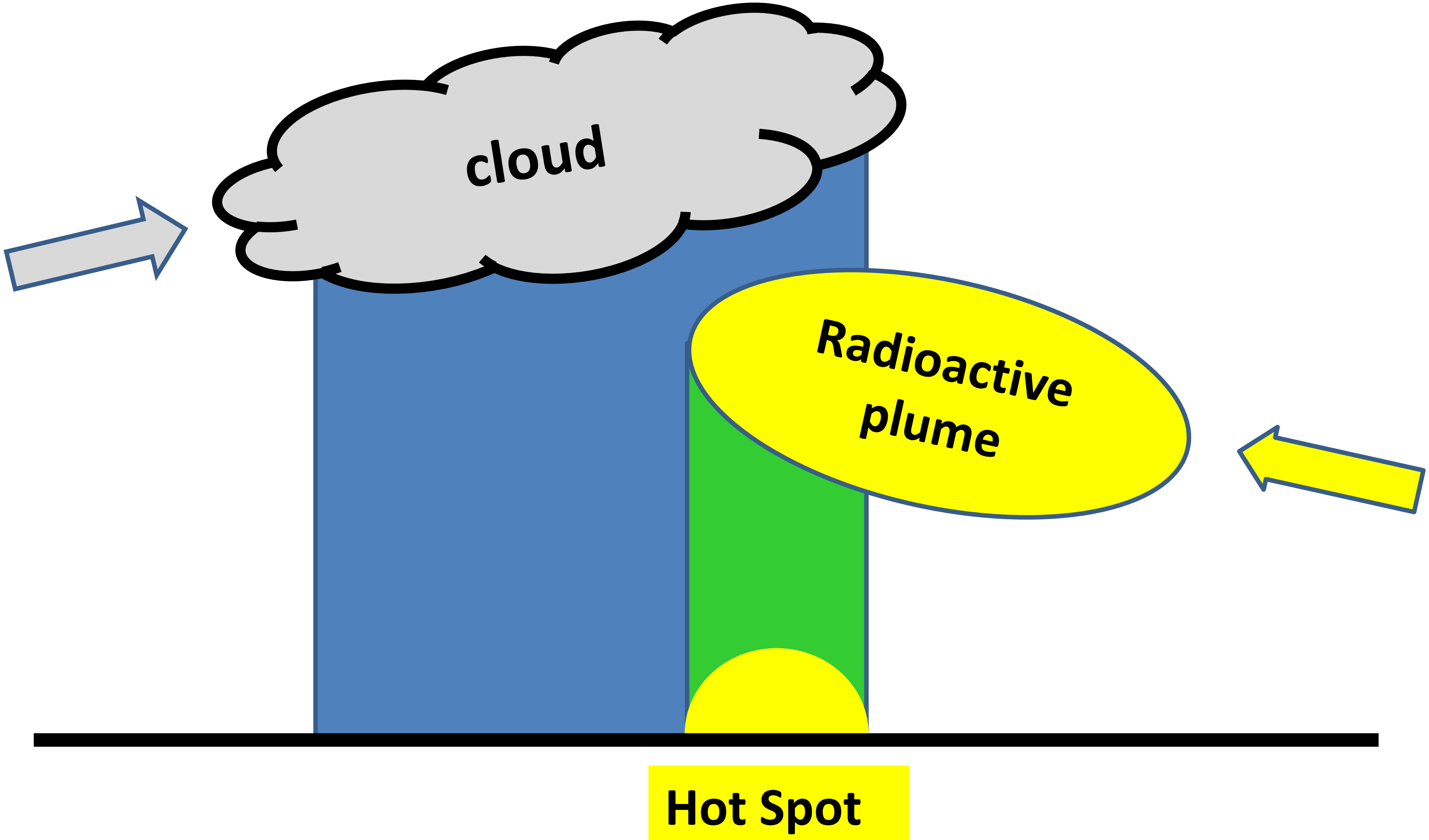
2. Dry depositions occur near the emission source, while wet depositions widely cause serious contamination through "gathering effects" of rain water. Radioactive materials are deposited on everything, i.e. the human body, ground, environment, water, food and goods. They cause exposure through internal and external radiations. They also contaminate food and goods and circulate in the society

Use of Numerical prediction:

Using predictions, we can warn to keep off the contaminated rain. Also, we can stop drinking possibly contaminated water and stop circulating possibly contaminated food and goods. After the valid time, we can effectively make adaptive monitoring.

Wet depositions

Hot spot formations due to “gathering effects” by rainwater



Wet depositions

Wet deposition can be directly simulated by the model, however, its prediction performance is not so good, because of the difficulty in precipitation forecast.

Instead, we recommend using predictions of total column materials in the air, which tell us the worst case scenario for wet deposition.

When the contaminated air is expected, we should take measures against the wet deposition.

After the valid time, unless it rains, no action is needed for wet deposition. If it rains, we can estimate the contamination area by overlaying the observed precipitation area on the expectation area of large total column materials. Then, we should make adaptive observation as soon as possible and take proper actions.

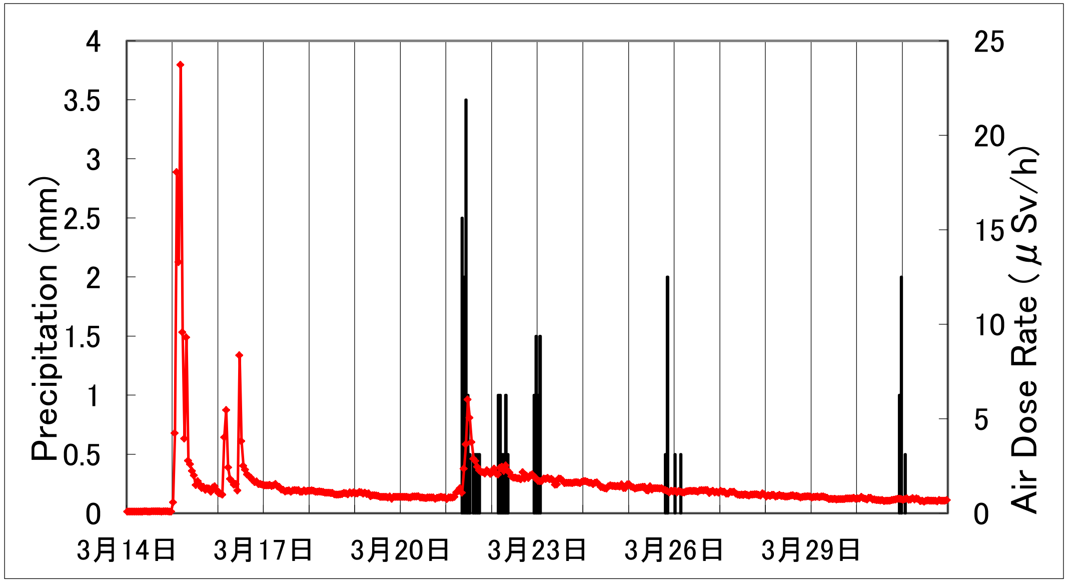
Case study of the Fukushima accident

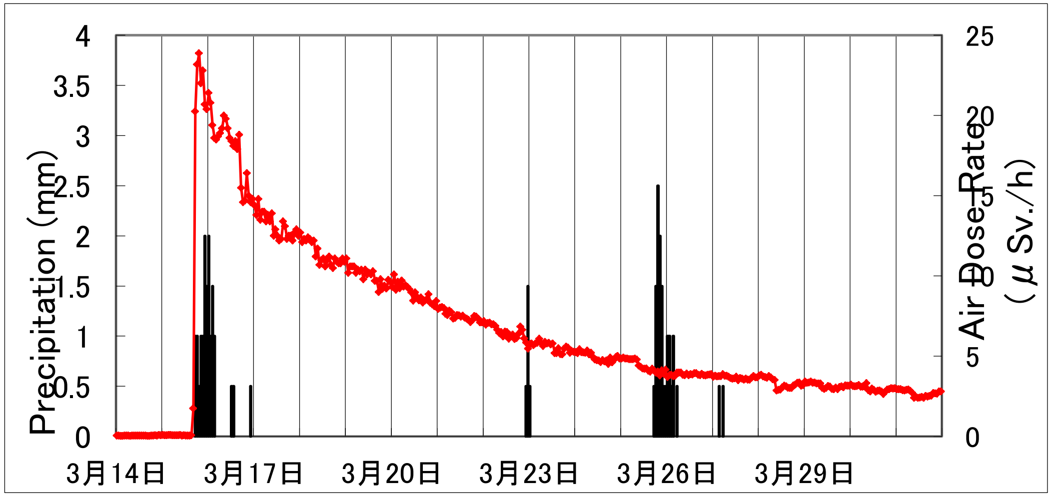
What could we have done?

Constant emission (1 Bq/h) is assumed.
Consider that emission intensity is hardly obtained in emergency cases.

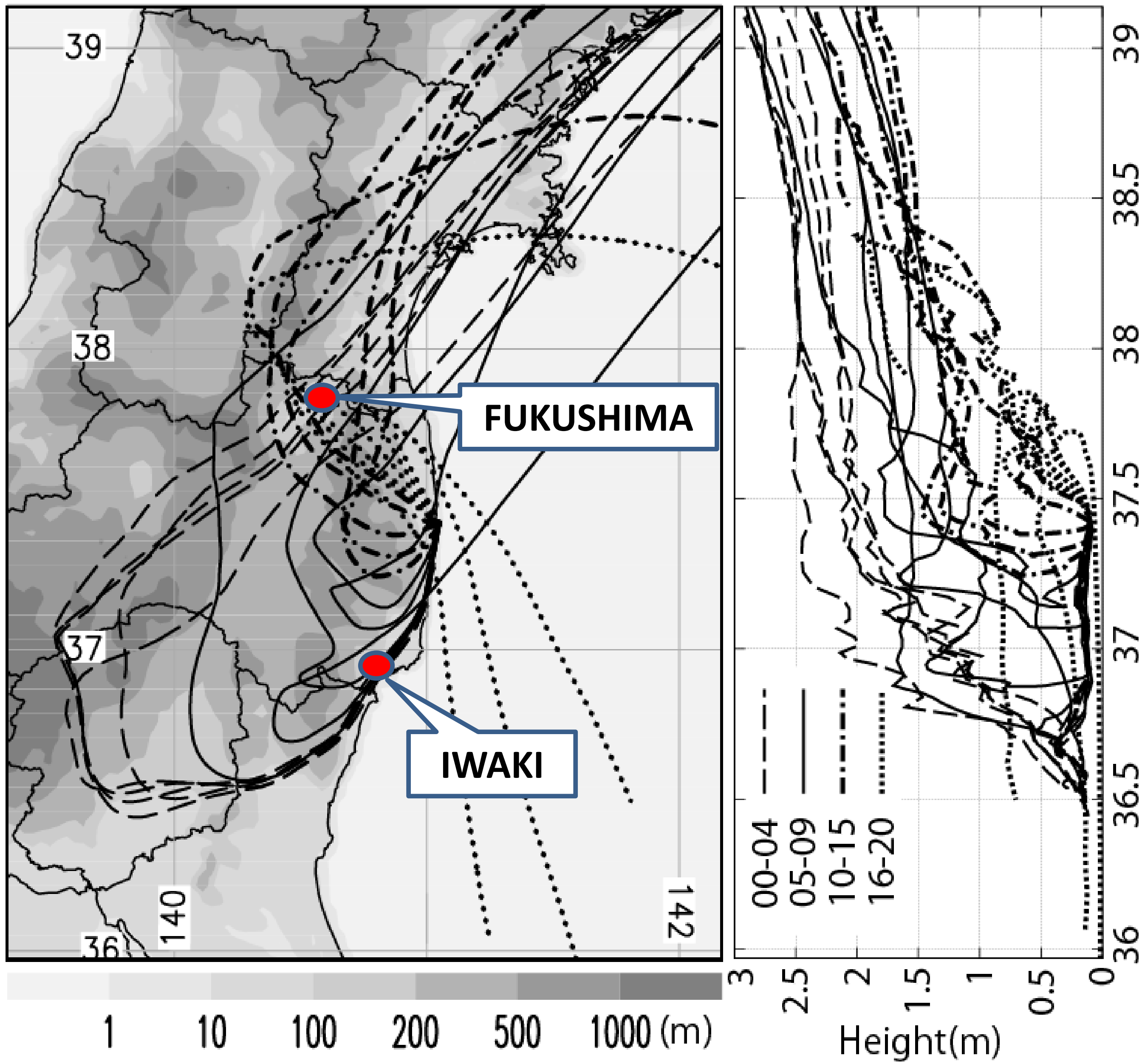
Case 1: 15-16, March, 2011

Computational results are found in Science Council of Japan, 2014: Report “A review of the model comparison of transportation and deposition of radioactive materials released to the environment as a result of the Tokyo Electric Power Company’s Fukushima Daiichi Nuclear Power Plant accident”, 103pp.

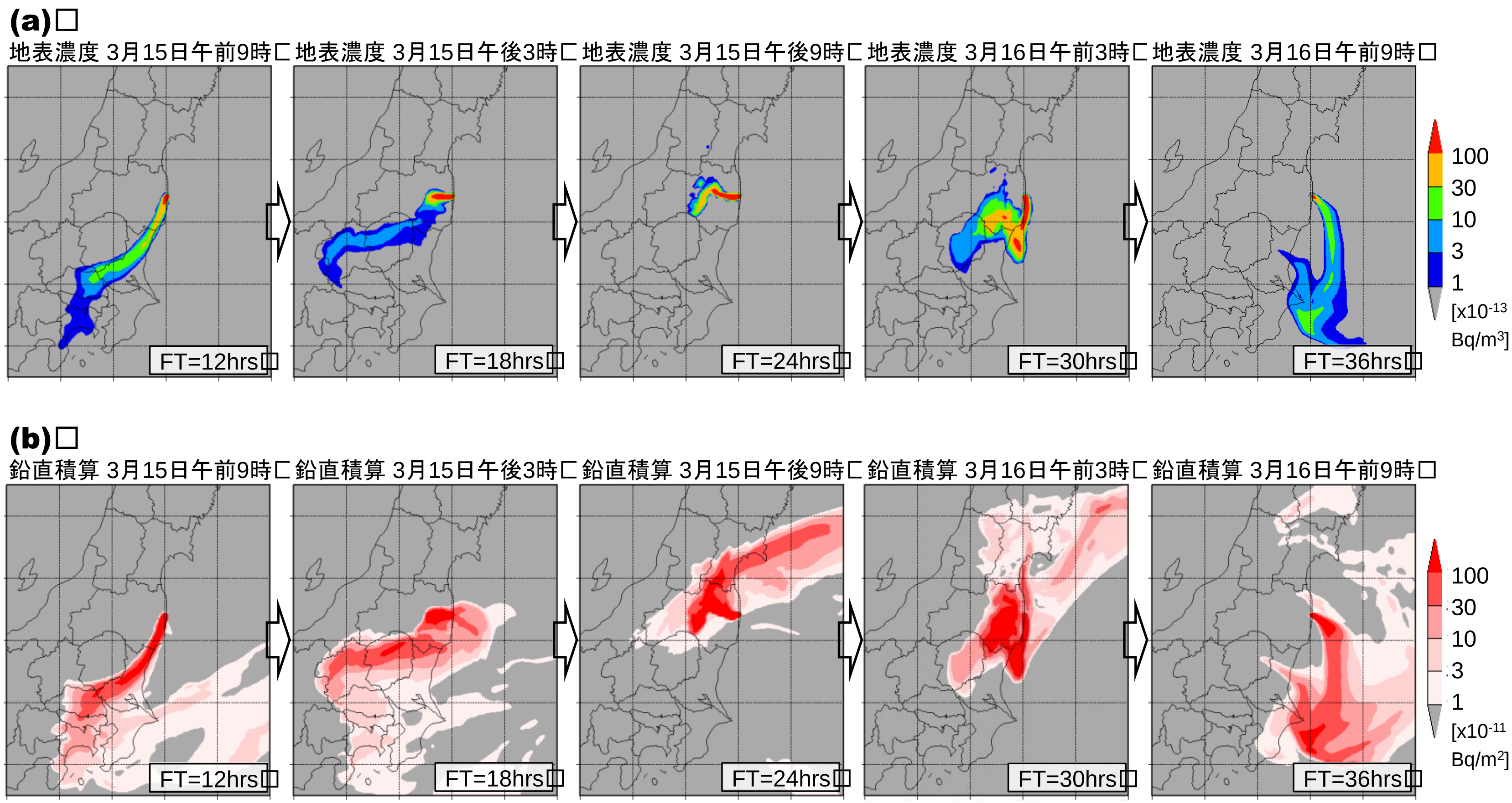




Air dose (μSv/h：red)and precipitation(mm/h：black). From 0JST, 14/March
Upper: Iwaki Bottom: Fukushima With courtesy of Dr. A. Watanabe.

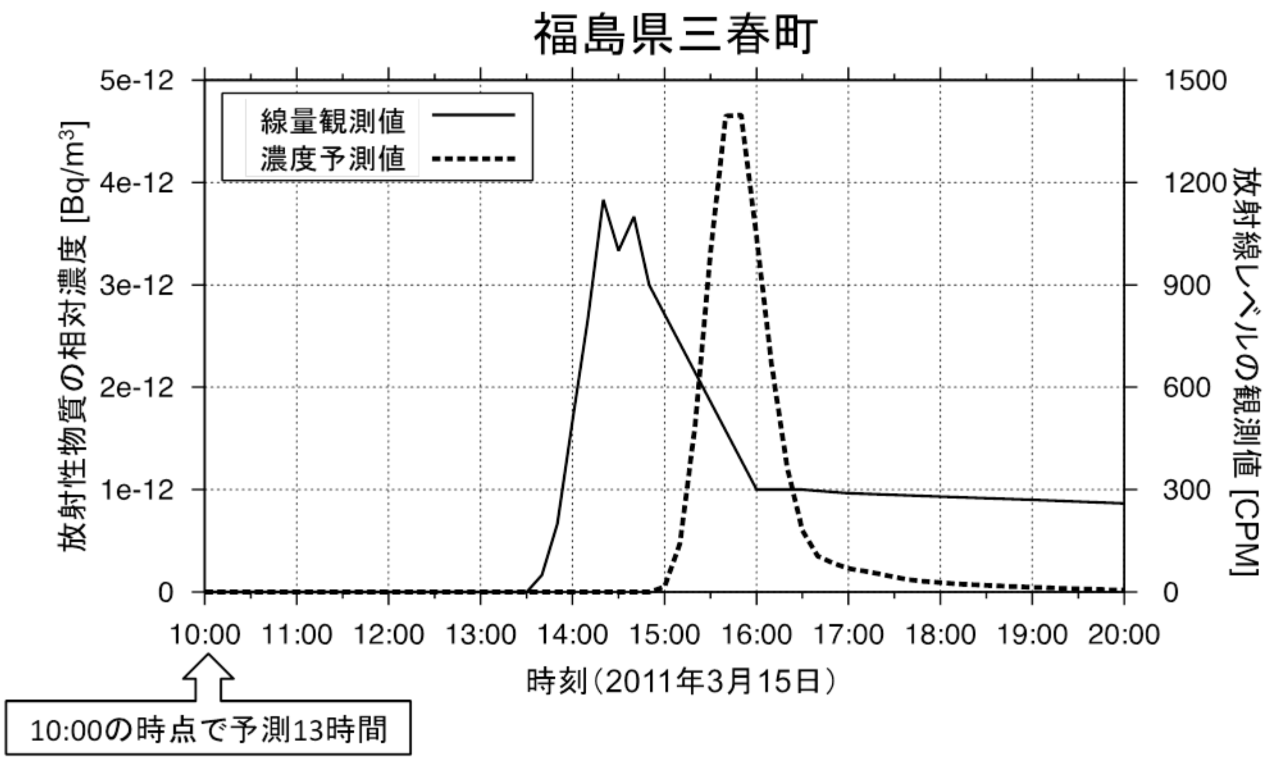


Air trajectories. From 00-20JST/15/Mar to 06JST/16/Mar.



Predictions of low-level (Upper) and column total (Lower) air contaminations of radioactive materials. The 12-36 hour predictions are performed from the initial conditions at 12JST/14/March/2011. Constant emission of 1 Bq/hour at the site of Fukushima Dai-ichi Nuclear Power Plant is assumed.

From Science Council of Japan (2014).



The sequences of monitoring (solid line) and predictions (dotted line) of the surface air contaminations of radioactive materials at Miharu Town, located westward away form the Power Plant. The prediction is performed from the initial conditions at 12JST/14/March/2011, assuming constant emission (1 Bq/hour).

Monitoring result was given by Koike, T. et al., 2014, J. Radiol. Prot., 34, 675, doi:10.1088/0952-4746/34/3/675.

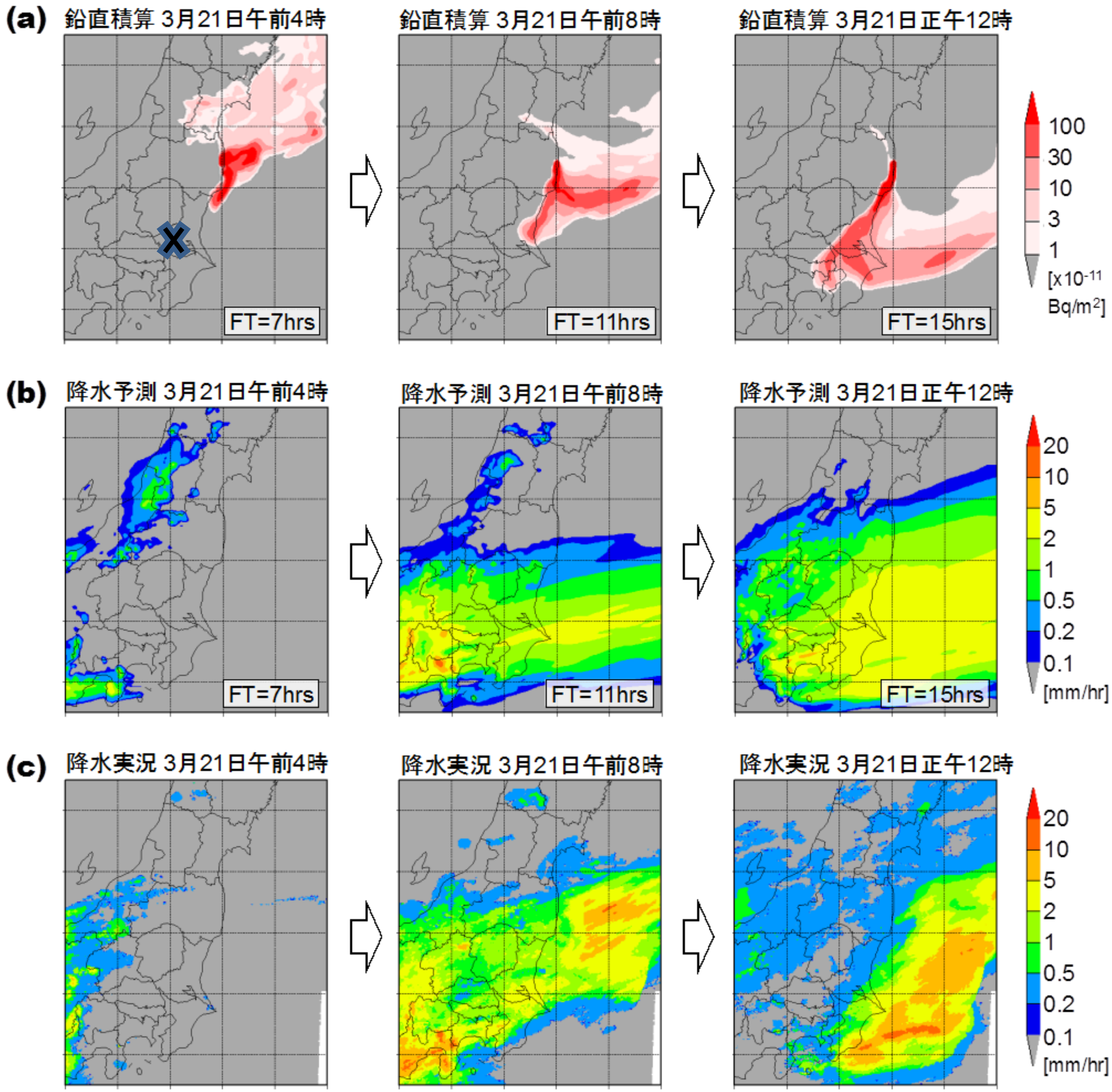
Case study of the Fukushima accident

What could we have done?

Constant emission (1 Bq/h) is assumed.
Consider that emission intensity is hardly obtained in emergency cases.

Case 2:   21, March, 2011

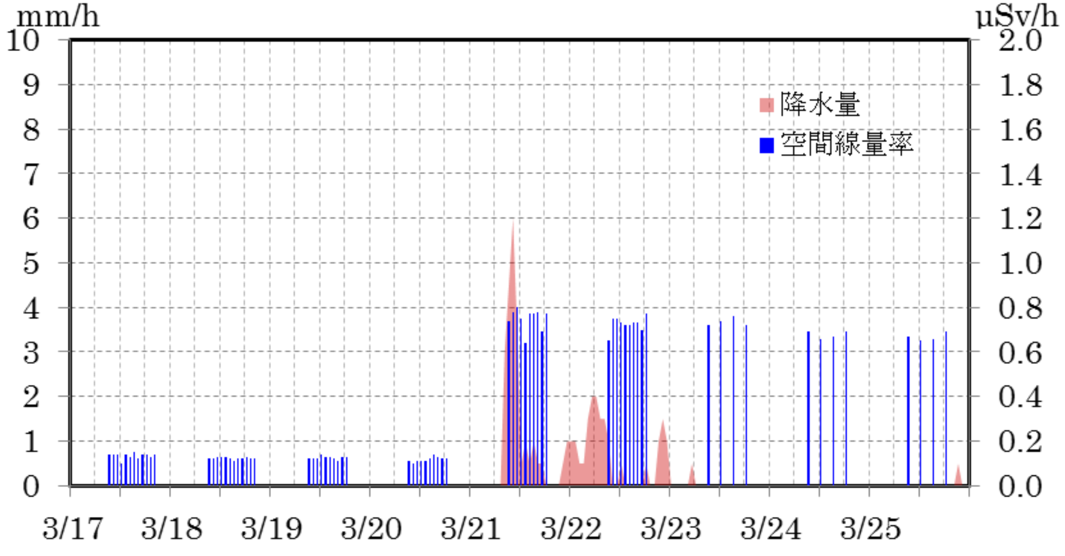
Computational results are found in Science Council of Japan, 2014: Report "A review of the model comparison of transportation and deposition of radioactive materials released to the environment as a result of the Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Plant accident", 103pp.



Predictions of column total (Upper) air contaminations of radioactive materials, predicted precipitation (Middle) and observed precipitation (Lower).

The 7-15 hour predictions from the initial conditions at 12JST/14/March/2011 are displayed. Constant emission of 1 Bq/hour at the site of Fukushima Dai-ichi Nuclear Power Plant is assumed.

From Science Council of Japan (2014).



Air dose (Blue lines) monitored at the Kashiwa campus of Tokyo University and precipitations at the Abiko AMEDAS (Automated Meteorological Data Acquisition System) Site. .

With courtesy of Dr. Y. Suzuki

Summary

To confirm what we could have done in the Fukushima accident, we made two case studies, assuming a constant emission.

Numerical dispersion models may have benefit to exposure mitigation for the surface air contamination and the wet deposition.

Prediction of column total materials give us the worst-case scenario for wet deposition. By overlaying the precipitation onto it, we can expect possibly contaminated area.

We should consider uncertainties of numerical predictions. In emergency cases, more serious contaminations should be assumed than the model predictions.