Preliminary estimation of 2-month accumulated radiological doses over Japan due to radionuclides discharged into the atmosphere in the Fukushima Daiichi nuclear power plant accident

Preliminary estimation of 2-month accumulated radiological doses over Japan due to the Fukushima Daiichi nuclear power plant accident was carried out by WSPEEDI (Worldwide version of SPEEDI). Since this simulation is based on the preliminary estimation of release rates of radionuclides, it does not ensure the actual doses. However, this technical report provides reference information on distribution of doses based on current available data.

1. Calculation conditions

Calculation domain:	Covers the whole Japan with 10 km resolution
Calculation period:	From 12 March to 12 May, 2011
Meteorological data:	GPV (Grid Point Value) data by Japan Meteorological Agency
Topographical data:	10 km grid surface elevation and land-use data
Radionuclides:	^{131}I, ^{132}I, ^{134}Cs, ^{137}Cs
Release rate:	Based on the preliminary estimated source term reported by the Nuclear Safety Commission of Japan. Constant release rates after 15 April are used because of no reference data. The report on preliminary estimated source term is published as follows:

M. Chino *et al.*, "Preliminary Estimation of Release Amount of ^{131}I and ^{137}Cs Accidentally Discharged from the Fukushima Daiichi Nuclear Power Plant into the Atmosphere," *J. Nuc. Sci. Technol.*, 48[7], 1129-1134 (2011).

2. Important notice to understand the result correctly (be sure to read the following lines)

- This estimation of doses is based on the assumption that one is staying out of doors all the time. Since doses are lower in doors, estimated doses are generally higher than the actual ones.
- The yearly accumulated doses cannot be derived by multiplying these two-month accumulated doses by six. Since doses for the following 10 months are much lower than these estimations, more accurate estimations should be done based on the measurement.
- Since the calculation grid with 10 km resolution cannot resolve narrow plumes within 50 km area from the release point, calculation results within this area have not enough accuracy.
- In external dose calculation over the sea, the contribution of ground shine is included in the same manner as over the land by assuming that deposited radionuclides stay at the sea surface of the same point. Since radionuclides deposited on the sea are deluted by the oceanic dispersion in the actual condition, the estimation of external dose on the sea has little meaning.
- In the preliminary estimated source term reported to the Nuclear Safety Commission of Japan,

instantaneous increases of release rates caused by release events, such as hydrogen explosions at Unit 1 and 3 during the period from 12 to 14 March, are not estimated. Although these lacks of release rates cause underestimations of doses, these influences are rather little considering the dominant wind direction toward the sea during this period.

- Concerning the constant release rates after 15 April, it is considered that the actual release rates were lower than the constant values and the estimated doses have some overestimations. However, these discrepancies are negligible.
- Noble gases and other short-lived radionuclides, which contribute to external dose during the early release phase, are not considered in this estimation, because release rates of these radionuclides have not been estimated. Although this causes the underestimation of external dose in the early release phase, this influence is considered to be small in long term estimations of doses.
- The accuracy of WSPEEDI calculation is evaluated in the past validation studies that it can predict most of the measurements within factor of five by using correct release rates.

3. Preliminary estimation of external effective dose for two months after the accident

Preliminary estimation of external effective dose for two months after the accident is shown in Fig. 1. An overview of this result is as follows.

- The area with dose value over 1 mSv is limited within the eastern part of Fukushima Prefecture. The result is consistent with monitoring data by MEXT, for example 1.012 mSv at Sugitsuma-cho in Fukushima city (62 km northwest from the plant, accumulated from 24 March to 12 May), 16.32 mSv at Nagadoro in Iitate mura (33 km northwest from the plant, accumulated from 23 March to 12 May), 28.68 mSv at Akauki in Namie machi (31 km northwest from the plant, accumulated from 23 March to 12 May), although the calculated values are larger because of longer accumulation period from 12 March.
- The area with dose value over 0.01 mSv, much smaller value than the yearly dose limit for public (1 mSv) includes Kanto district to southern part of Tohoku district. In comparison with the monitoring data by MEXT, the calculation result show the same tendency in distribution pattern of dose, although there seems some overestimations around the areas from Yamagata Prefecture to mountain regions of Niigata Prefecture and from southern part of Fukushima to northern part of Ibaraki Prefecture.

4. Preliminary estimation of internal effective dose of ^{131}I for two months after the accident

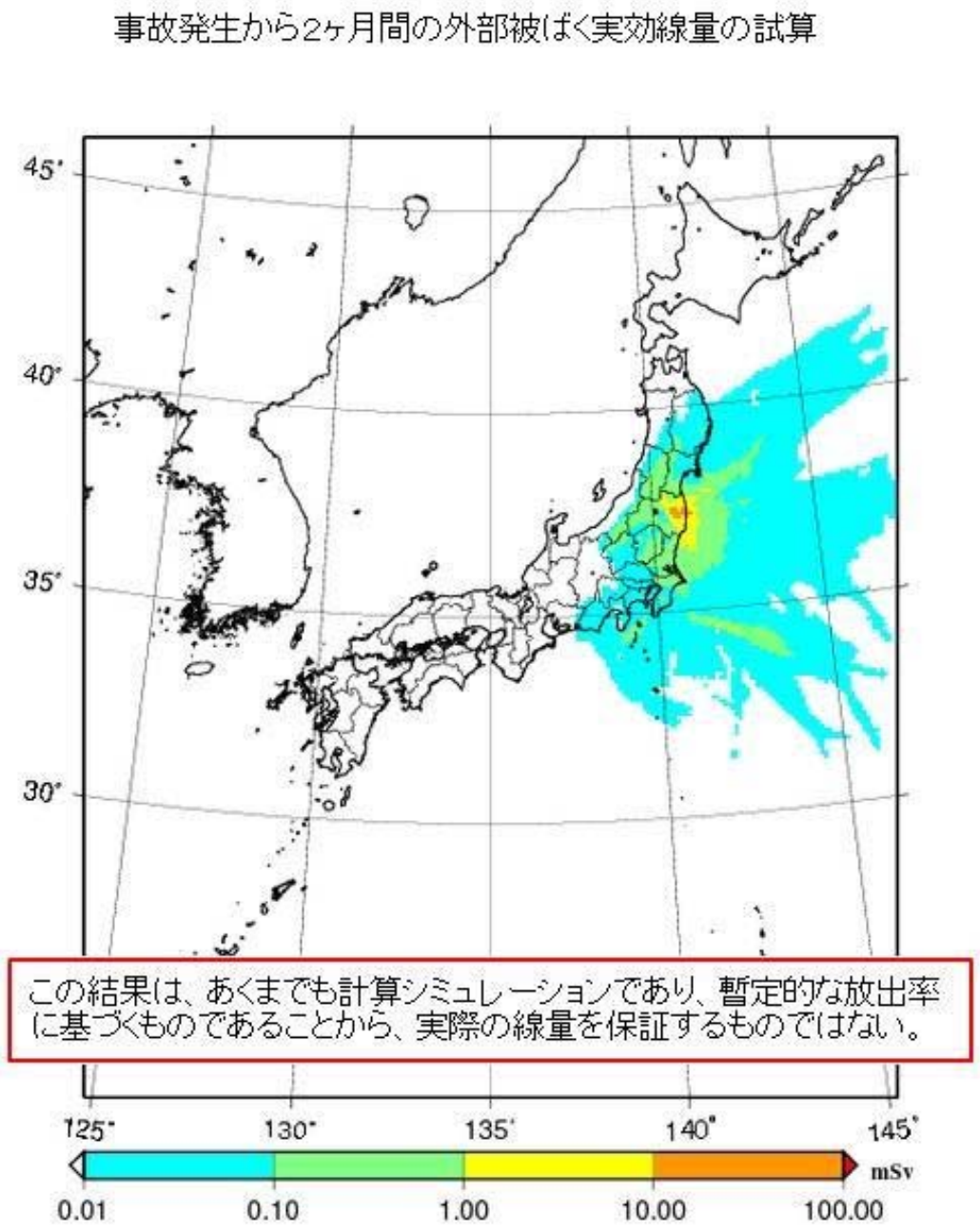
Preliminary estimation of internal effective dose of ^{131}I for two months after the accident is shown in Fig. 2. An overview of this result is as follows.

- The area with dose value over 1 mSv is limited within the eastern part of Fukushima Prefecture. The dose area is smaller than the external one.
- The area with dose value over 0.01 mSv also covers smaller area including middle and eastern part of Kanto district to southern part of Tohoku district. The difference in distribution pattern of dose

from the external dose is mainly caused by the difference in amounts of radionuclides contributing to doses and the exposure pathway.
Similar to the result for external dose, there seems a tendency of overestimation around the areas from Yamagata Prefecture to Niigata Prefecture and from southern part of Fukushima to northern part of Ibaraki Prefecture.

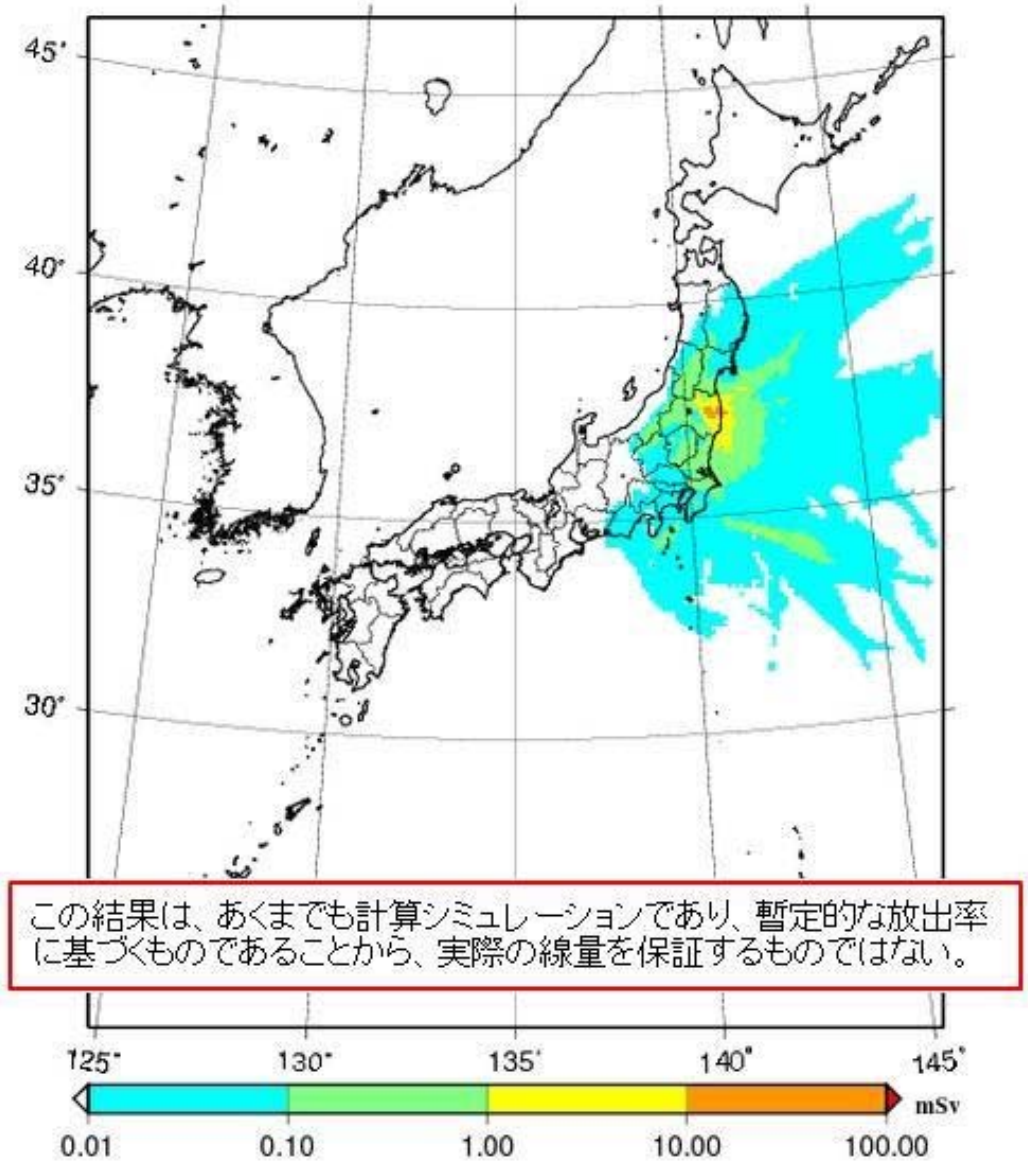
5. Future work

As already mentioned, these results are preliminary estimation based on limited information. We are planning to update these estimations by using more data and publish the results in research papers.



Temporal change of dose distribution (movies): AVI format (119 MB), WMV format (6MB)

How to see the movie: The spatial distribution of dose is shown by color shade, and the movement of radioactive plume is shown by red contours of surface concentration (Bq/m3). The Universal Time Constant (UTC) is presented at the top (Japanese Standard Time: +9 hours). After April, the external dose continues to increase slightly due to dose contribution from deposited radionuclides.



Temporal change of dose distribution (movies): AVI format (123 MB), WMV format (6MB)

How to see the movie: The spatial distribution of dose is shown by color shade, and the movement of radioactive plume is shown by red contours of surface concentration (Bq/m3). The Universal Time Constant (UTC) is presented at the top (Japanese Standard Time: +9 hours).