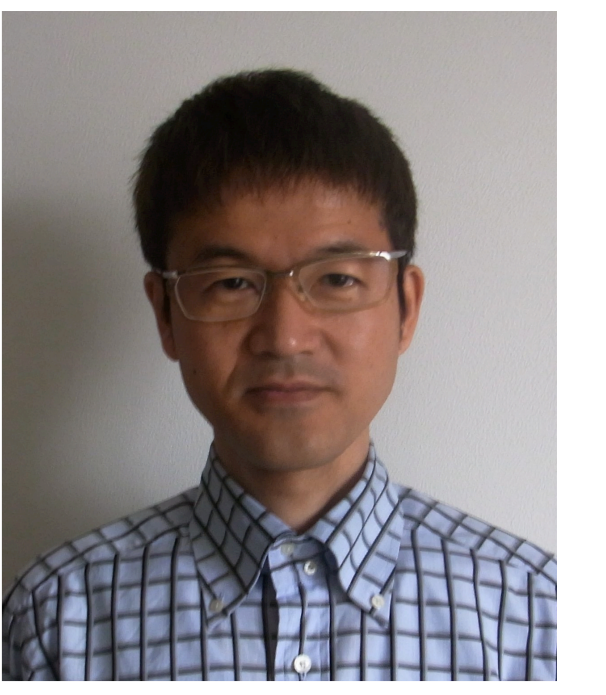


Development of The NIRS External Dose Calculation System for the Fukushima Residents Affected by The Nuclear Power Plant Accident



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Introduction

The great east Japan earthquake occurred on 11 March 2011 in the Tohoku District of Japan. After the quake, big tsunamis rushed to the coast of Fukushima, including the site of the Fukushima Dai-ichi Nuclear Power Plant. By the tsunamis, the emergency generators of electricity of NPP lost their ability. Subsequently, the reactors of NPS stopped, and the hydrogen explosions occurred emitting radionuclides including Cs-134, Cs-137, I-131, and so on.

After the accident, Fukushima prefectural government and Fukushima medical university planned the health management survey for the Fukushima residents and have performed in cooperation with National Institute of Radiological Sciences (NIRS). NIRS developed the external dose calculation system based on the dose rate maps and the action data of the residents during the period of 12 March – 11 July, 2011.

Methods

The dose rate maps and action data of the residents during the period were used to estimate external doses in the NIRS calculation system. The data of the maps were based on the calculated doses by using the System for Prediction of Environmental Emergency Dose Information (SPEEDI) based on the MELCOR simulation data calculated by the Nuclear and Industrial Safety Agency for March 12-14 and monitoring data for March 15 – July 11 reported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT). The background dose rates measured before the accident were subtracted from the dose values of the maps.

Conversion Coefficient

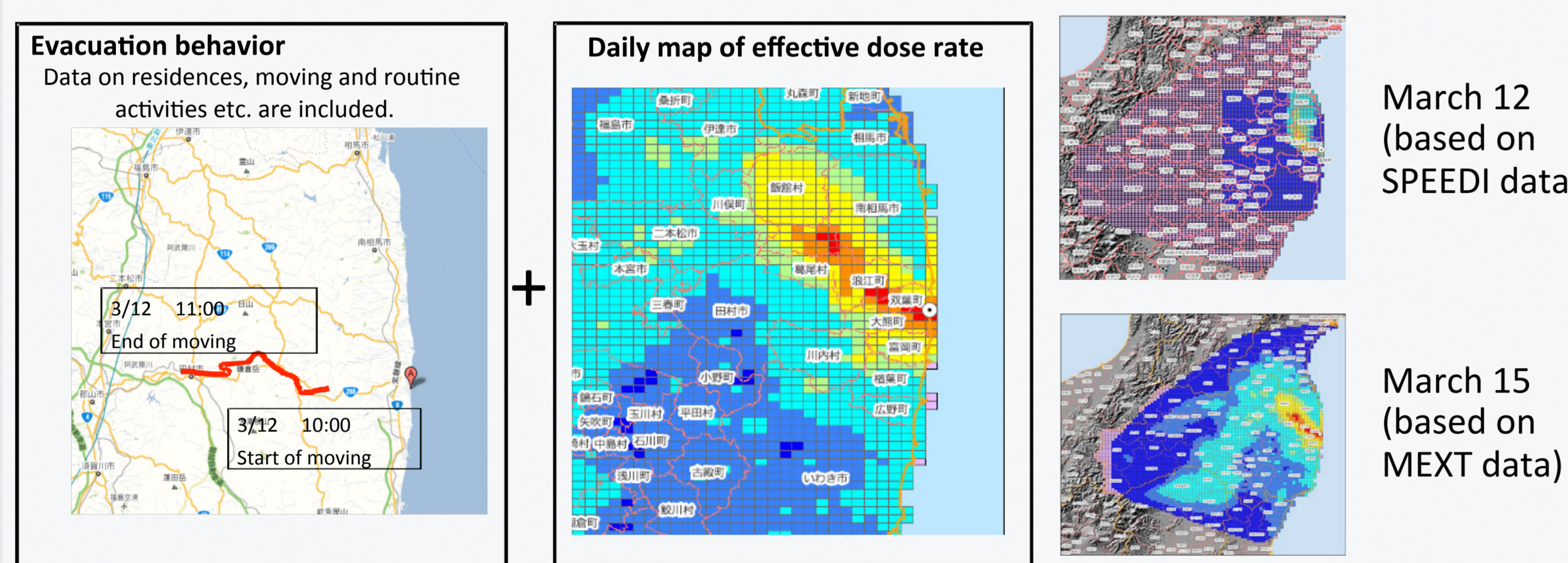
SPEEDI data: Effective dose
MEXT monitoring data: Ambient dose equivalent

Table: Conversion coefficient from ambient dose equivalent, $H^*(10)$ to effective dose (ISO), E for a nuclide based on ICRP74

Nuclide, X	Xe-133	Te-129m	Te-132	I-131	I-132	Cs-134	Cs-137
C_x	0.44	0.30	0.48	0.53	0.59	0.58	0.57

"0.6" was adopted in this system by rounding "0.59", which is the maximum value in the table given above, to the tenth.

Activity Data and Dose Rate Maps



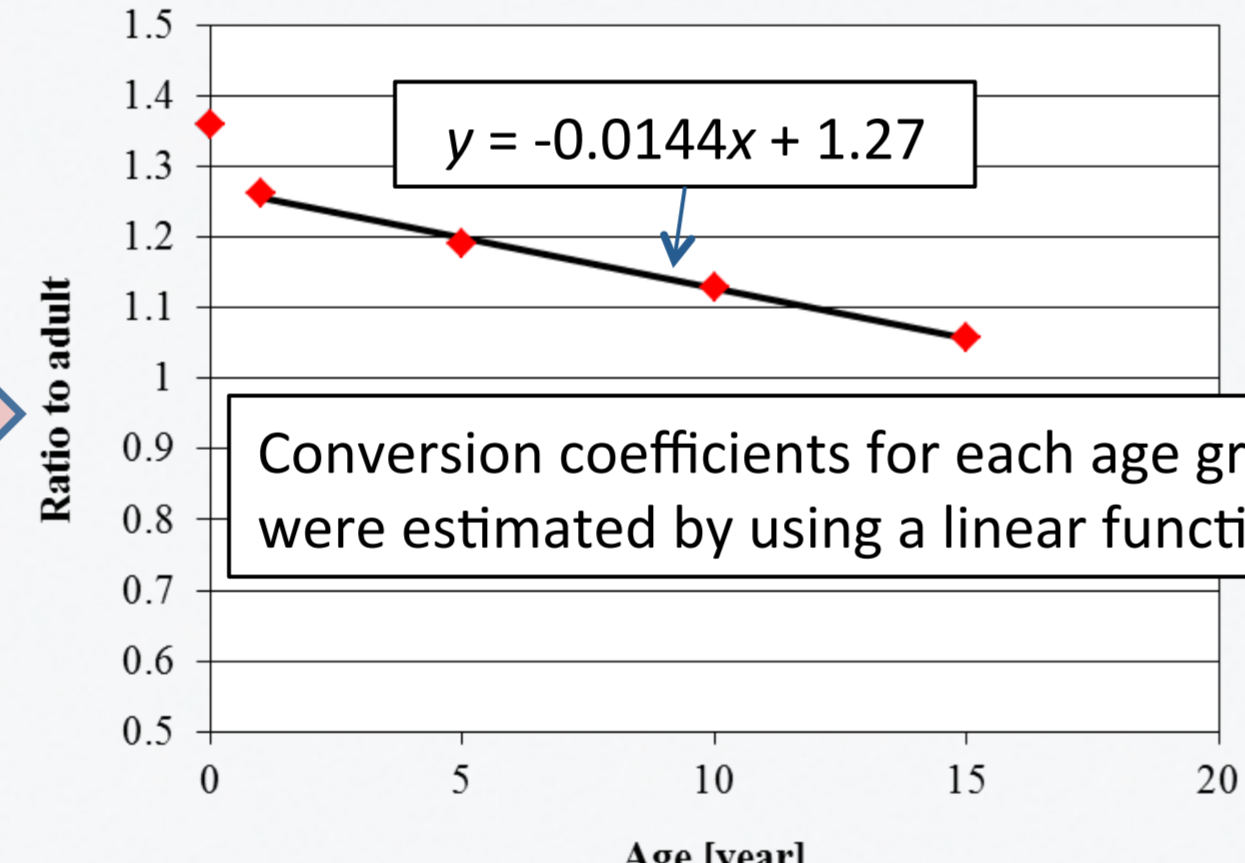
Definition of mesh size:

2 km x 2 km corresponding to the size divided the second mesh defined by Geospatial Information Authority of Japan.

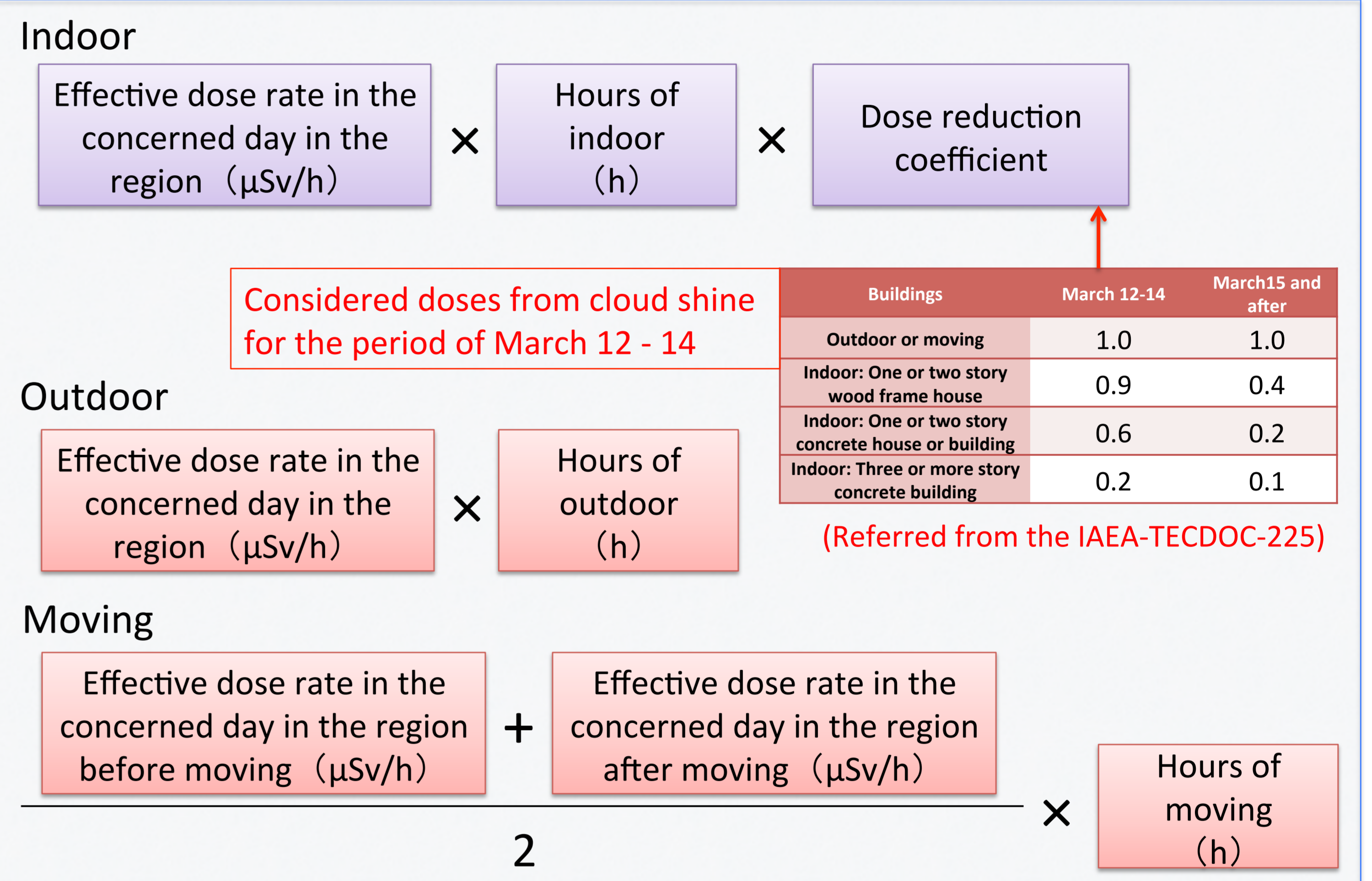
Conversion Coefficients for Infants and Children

Ratio of $H^*(10)$ to $E(ISO)$ conversion coefficient to adult based on ICRP74

Nuclide, X	Age					
	0	1	5	10	15	Max.
Xe-133	1.30	1.23	1.16	1.11	1.01	
Te-129m	1.29	1.21	1.15	1.10	1.03	
Te-132	1.36	1.26	1.19	1.13	1.06	
I-131	1.33	1.24	1.18	1.12	1.05	
I-132	1.29	1.21	1.15	1.11	1.04	
Cs-134	1.29	1.21	1.16	1.11	1.04	
Cs-137	1.30	1.21	1.16	1.10	1.04	
Max.	1.36	1.26	1.19	1.13	1.06	



Dose Calculations



Subtraction of BG

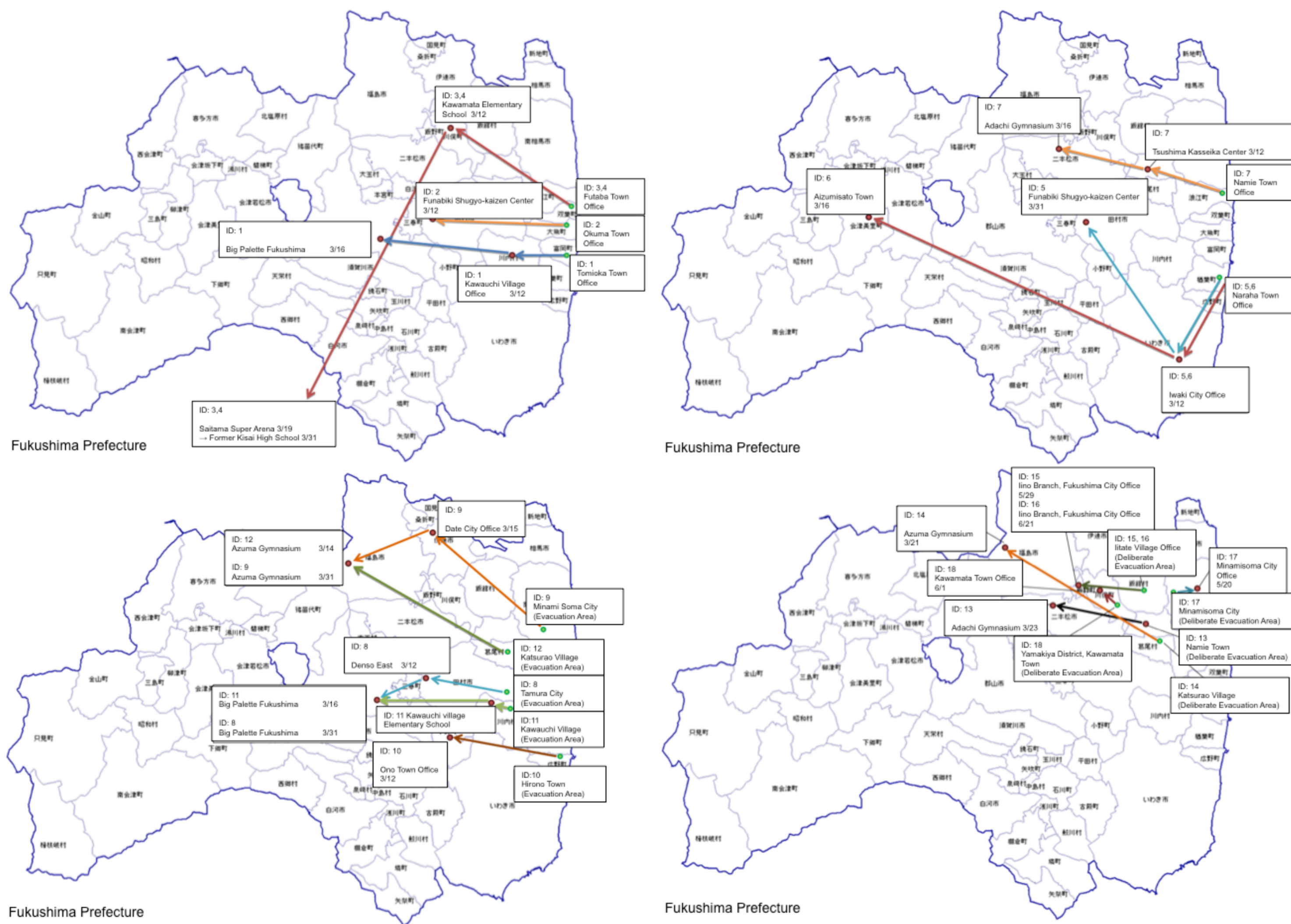
Fukushima city	Koriyama city	Shirakawa city	Aizuwakamatsu city	Minamiaizu town	Minamisoma city	Taira in Iwaki city
0.04	0.04-0.06	0.04-0.05	0.04-0.05	0.02-0.04	0.05	0.05-0.06

- Adopted the median 0.04 $\mu\text{Gy/h}$ from the data
- The dose rate above means air kerma rate. The conversion coefficients from air kerma to effective dose were calculated by using the same method of the conversion from ambient dose equivalent to effective dose $\Rightarrow 0.75 [\text{Sv/Gy}]$
- Adopted $0.04 \times 0.75 = 0.03 \mu\text{Sv/h}$ as the background effective dose rate in the normal situation

External Dose (effective dose: mSv)

Results 1: 18 Evacuation Patterns

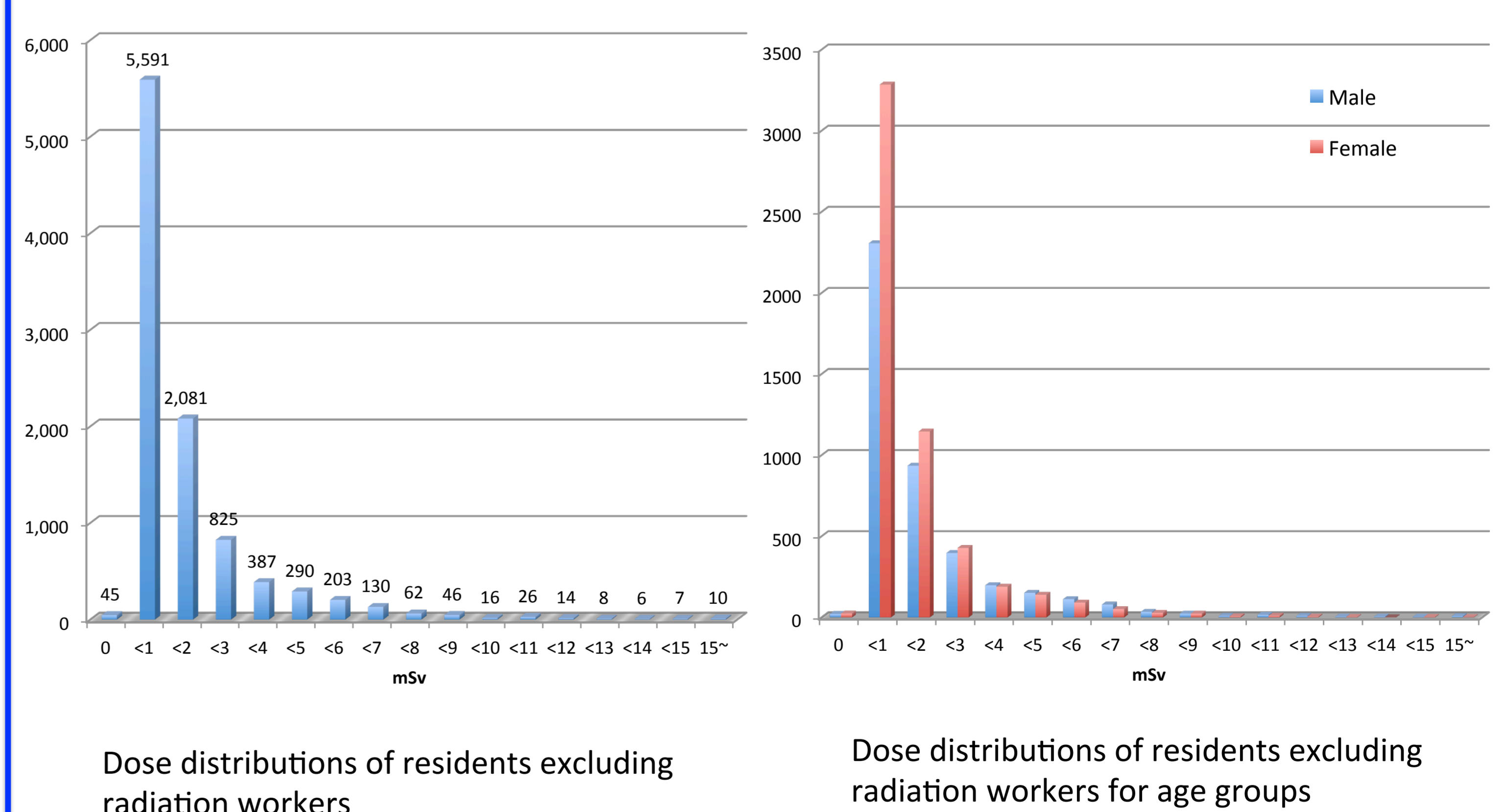
For grasping the exposure levels of the external doses of the residents, 18 evacuation patterns were assumed by NIRS before using the survey data of the residents. The results shows that the exposure levels of the residents who evacuated from the area within 20 km radius from the NPS were less than several mSv, and that the levels of the residents from the deliberate evacuation area were less than 20 mSv.



Evacuation			
from the area within 20 km		from "deliberate evacuation area"	
Patten No.	Estimated Dose (mSv)	Patten No.	Estimated Dose (mSv)
1	0.76	13	4.8
2	0.94	14	0.84
3	0.22	15	5.5
4	0.23	16	6.2
5	0.3	17	1.8
6	0.25	18	3
7	2		
8	0.77		
9	1.5		
10	0.18		
11	0.74		
12	0.71		

Results 2: Fukushima Survey

Based on the calculated data by the NIRS system, Fukushima prefectural government and Fukushima Medical University reported the external exposures of the 10,468 of the residents on Feb. 20, 2012. About 58% of the estimated doses of the residents were less than 1mSv. The dose levels of more than 99% residents were 10 mSv. The maximum dose were 23.0 mSv of the residents excluding radiation workers.



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