Estimation of radioactive release resulting from Fukushima Dai-ichi NPS accident

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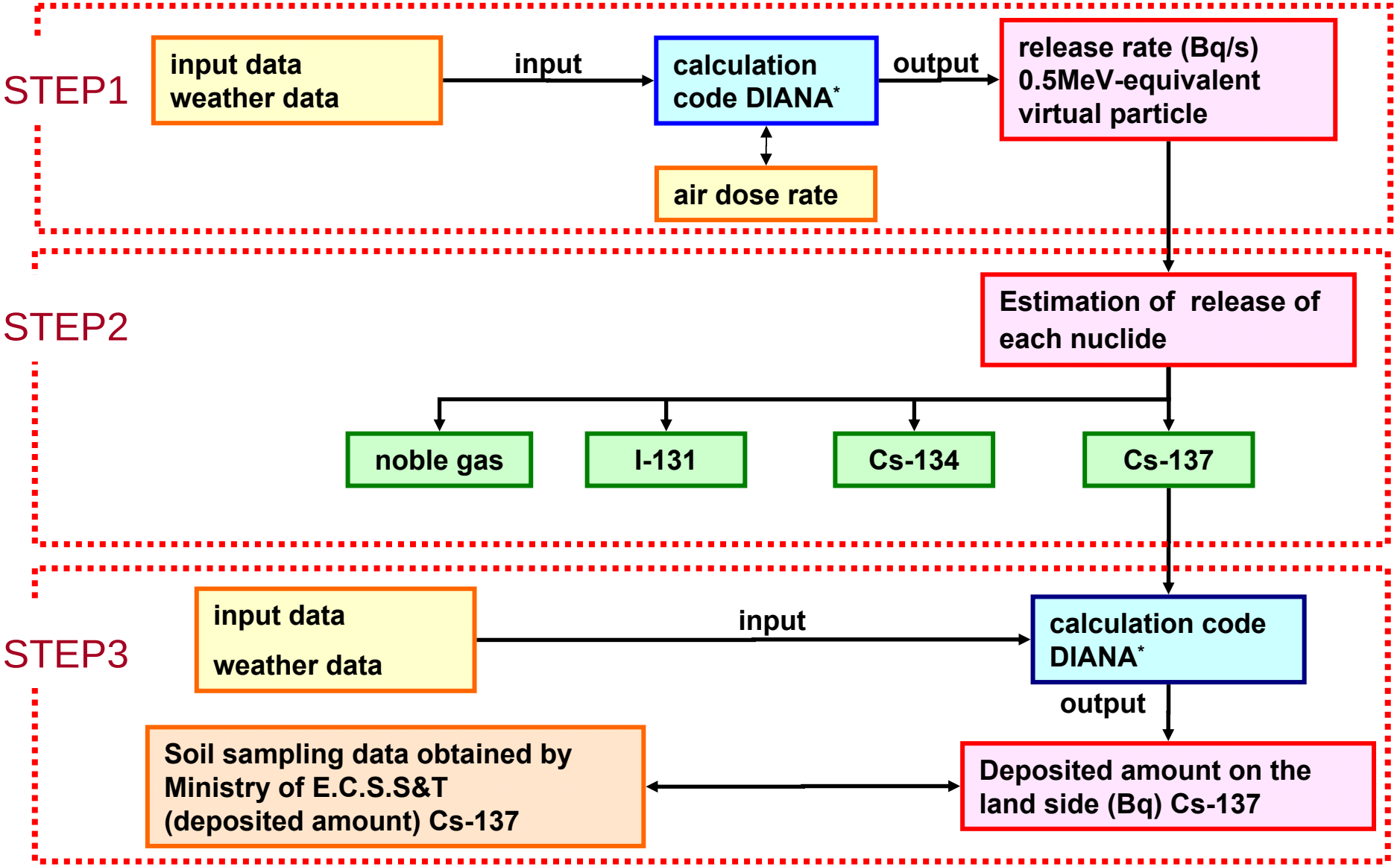
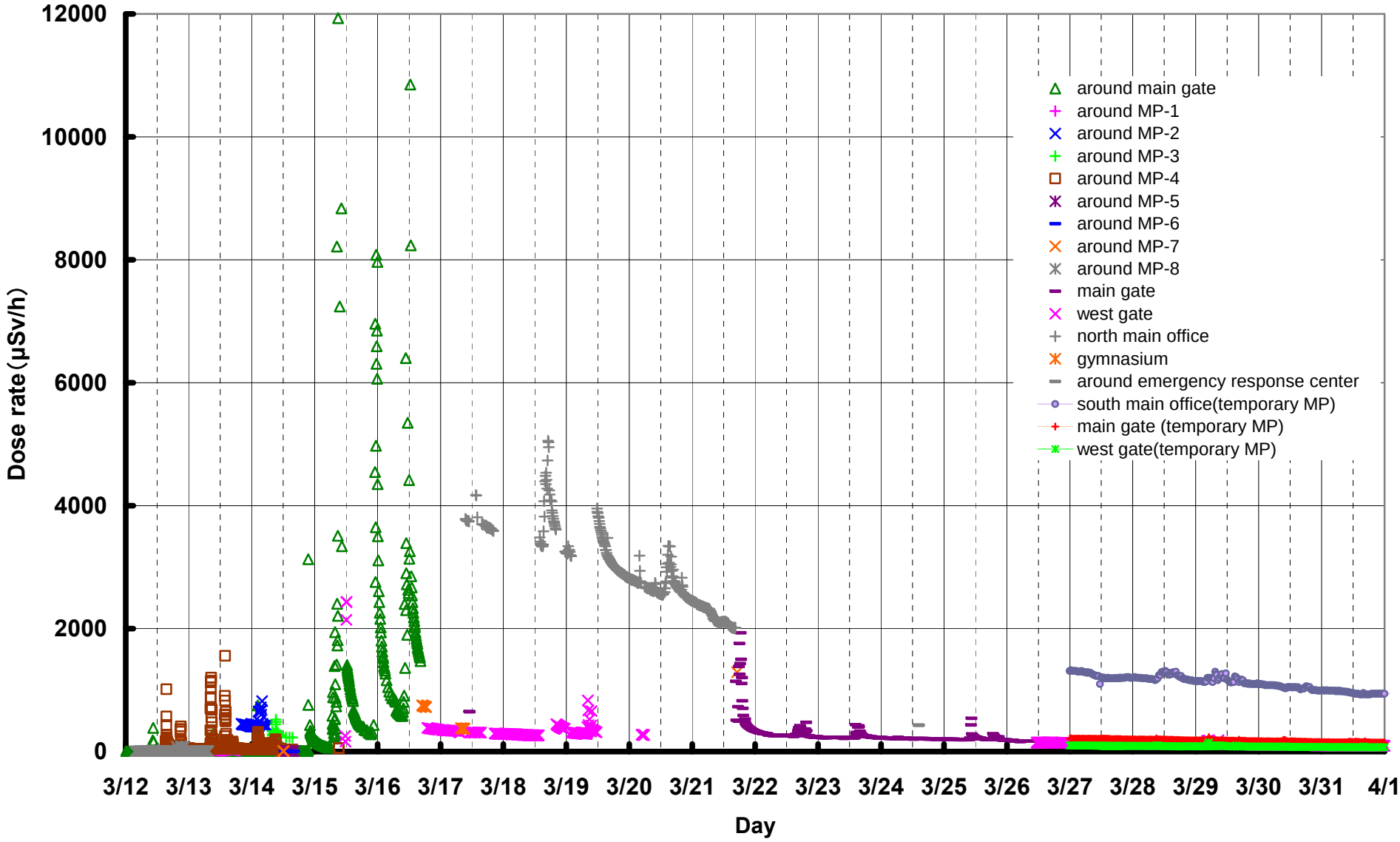
1. Flowchart for Estimation



DIANA : Dose Information Analysis for Nuclear Accident

1.1 Fukushima-Daiichi site map

1.2 Measured air dose rate data



- Measured by monitoring car in power station

1.3 Weather data & DIANA

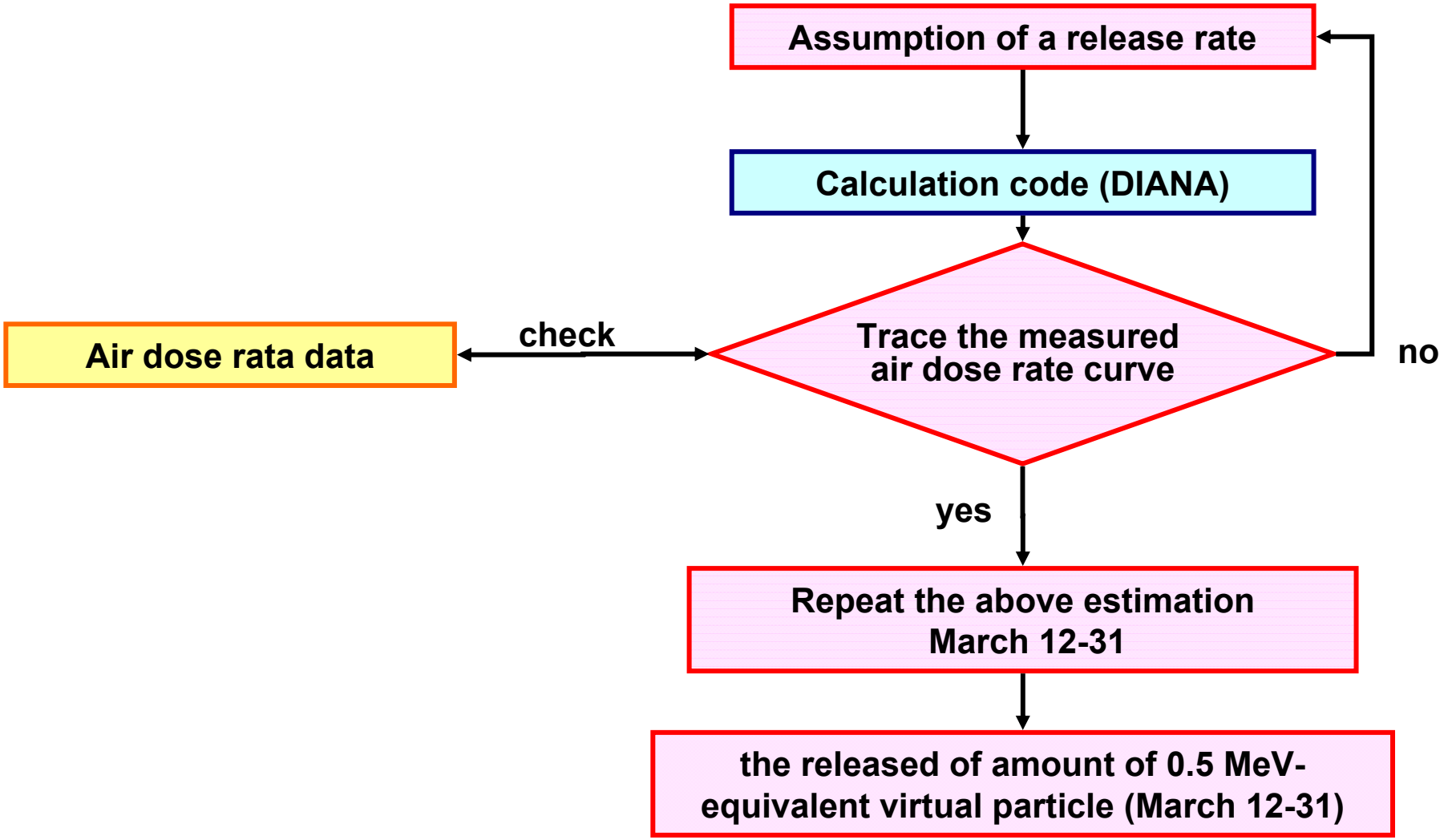
Weather data

- the wind direction & wind speed (measured by monitoring car)
- precipitation (by Japan Meteorological Agency)

DIANA

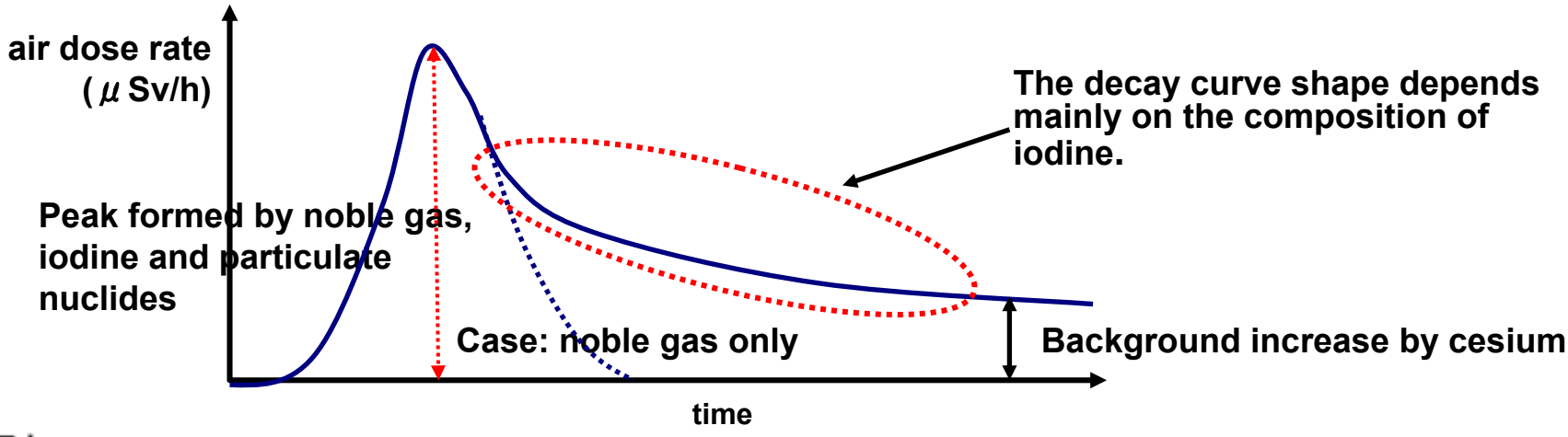
- DIANA : Dose Information Analysis for Nuclear Accident
- assessment domain :
  - 30km on the land side × 50km north-to-south line
  - 20km on the sea side × 50km north-to-south line
- calculation step : 10-minutes intervals
- release point : one point
- Capable of assessing the air dose rate at a specified location and time by inputting the release rate of 0.5 MeV-equivalent virtual particle and weather data.
- Capable of assessing the amount of deposition on soil at a specified location and time by inputting the release rate of the iodine and particulate nuclides and weather data.

1.4 Flowchart of the estimation for 0.5MeV-equivalent virtual particle



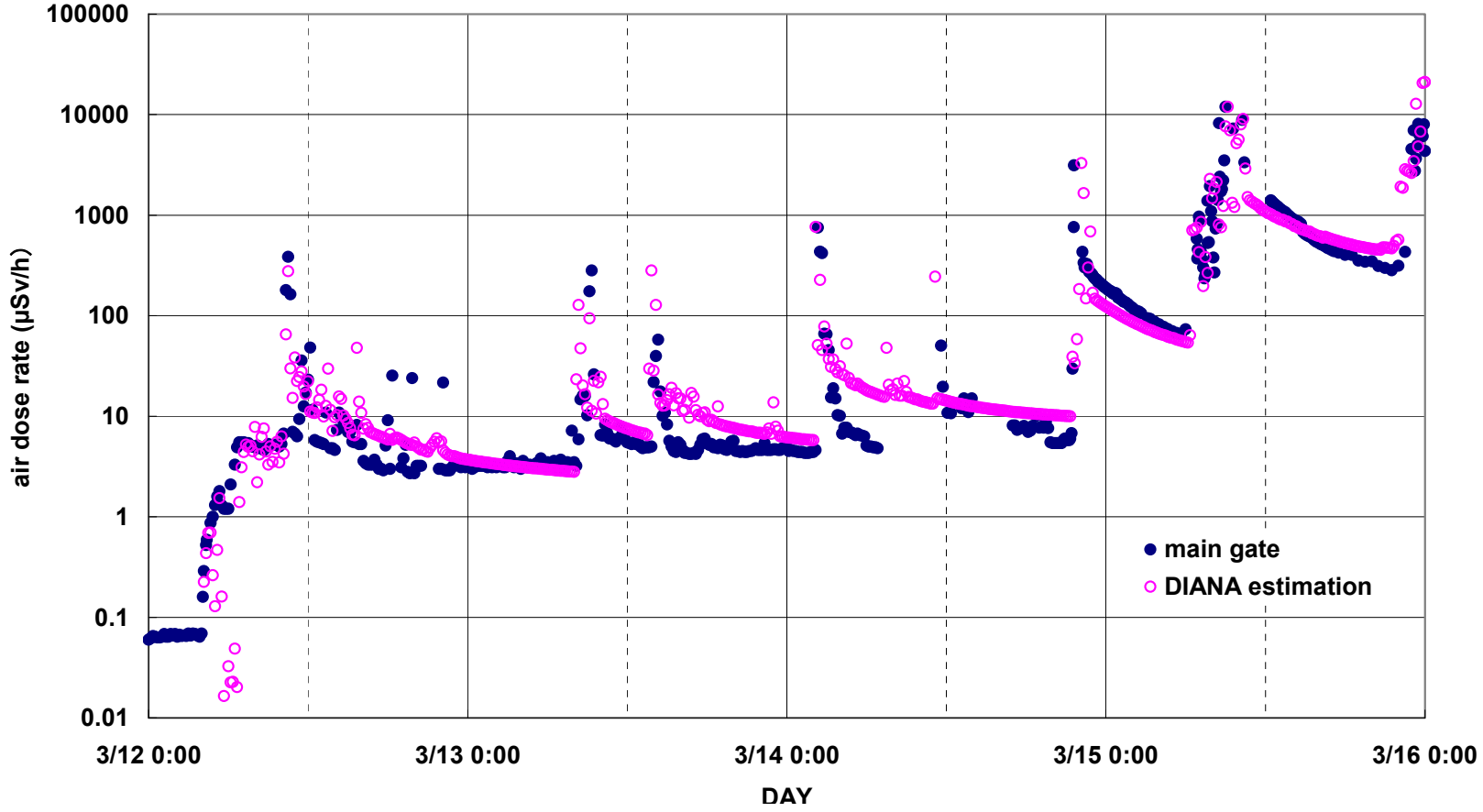
1.5 Estimation of release of each nuclide【1/2】

- Contamination of observation area are caused by deposition of iodine and cesium.
- Deposition of iodine and cesium increases the background dose rate around the observation area. (main contributors are iodine and cesium)
- The deposited iodine and particulate nuclides decay according to their half life period.
- To estimate the portion of noble gas, iodine and cesium in the plume, we varied the ratio and calculated by DIANA until we could reconstruct the curve of the measured dose rate.



1.5 Estimation of release of each nuclide 【2/2】

- The results of an examination of ratio of the susceptibility of the radioactive nuclides to release showed that the ratio of noble gases, iodine and cesium was 100:10:1

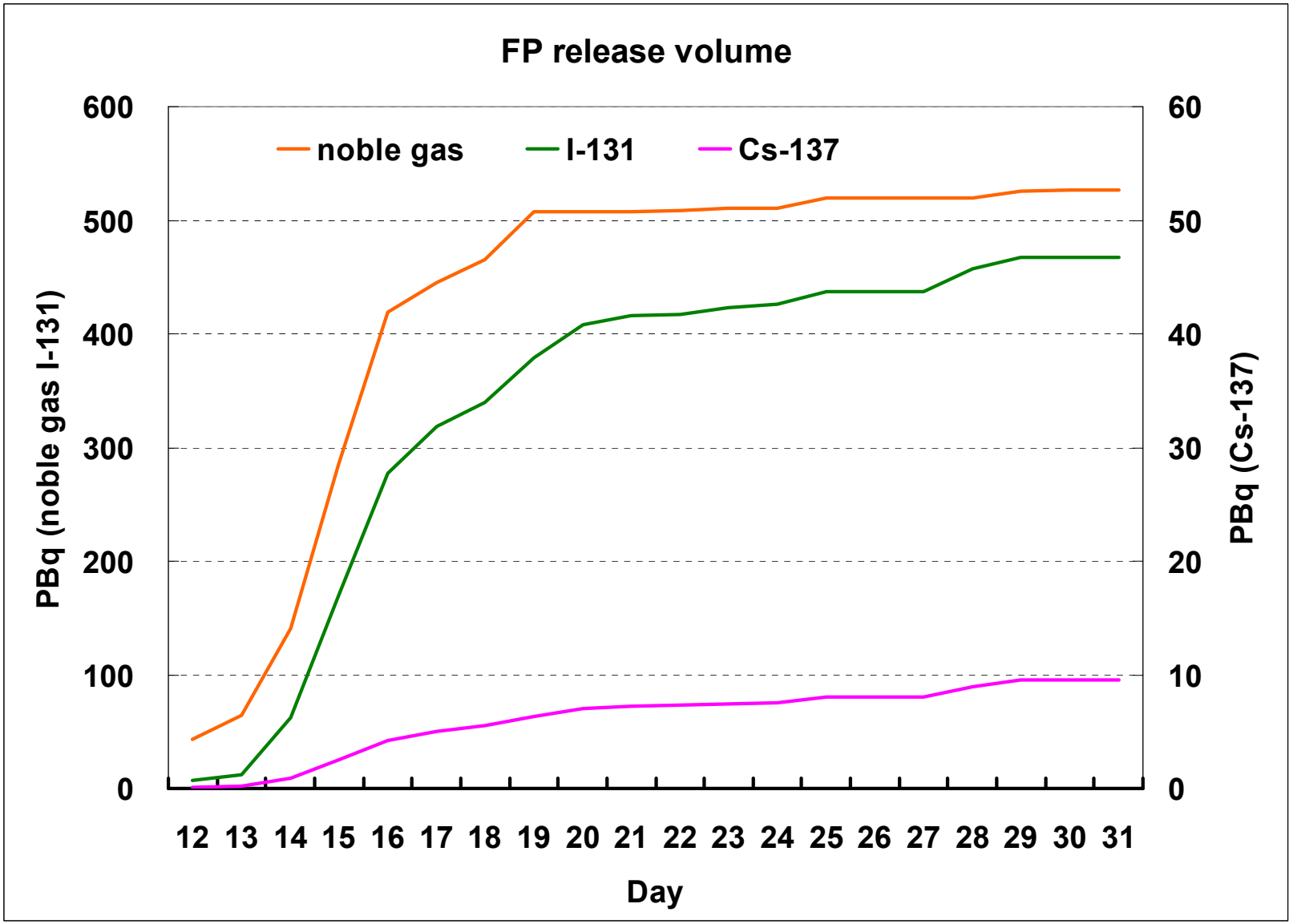


2.1 Result of FP release volume

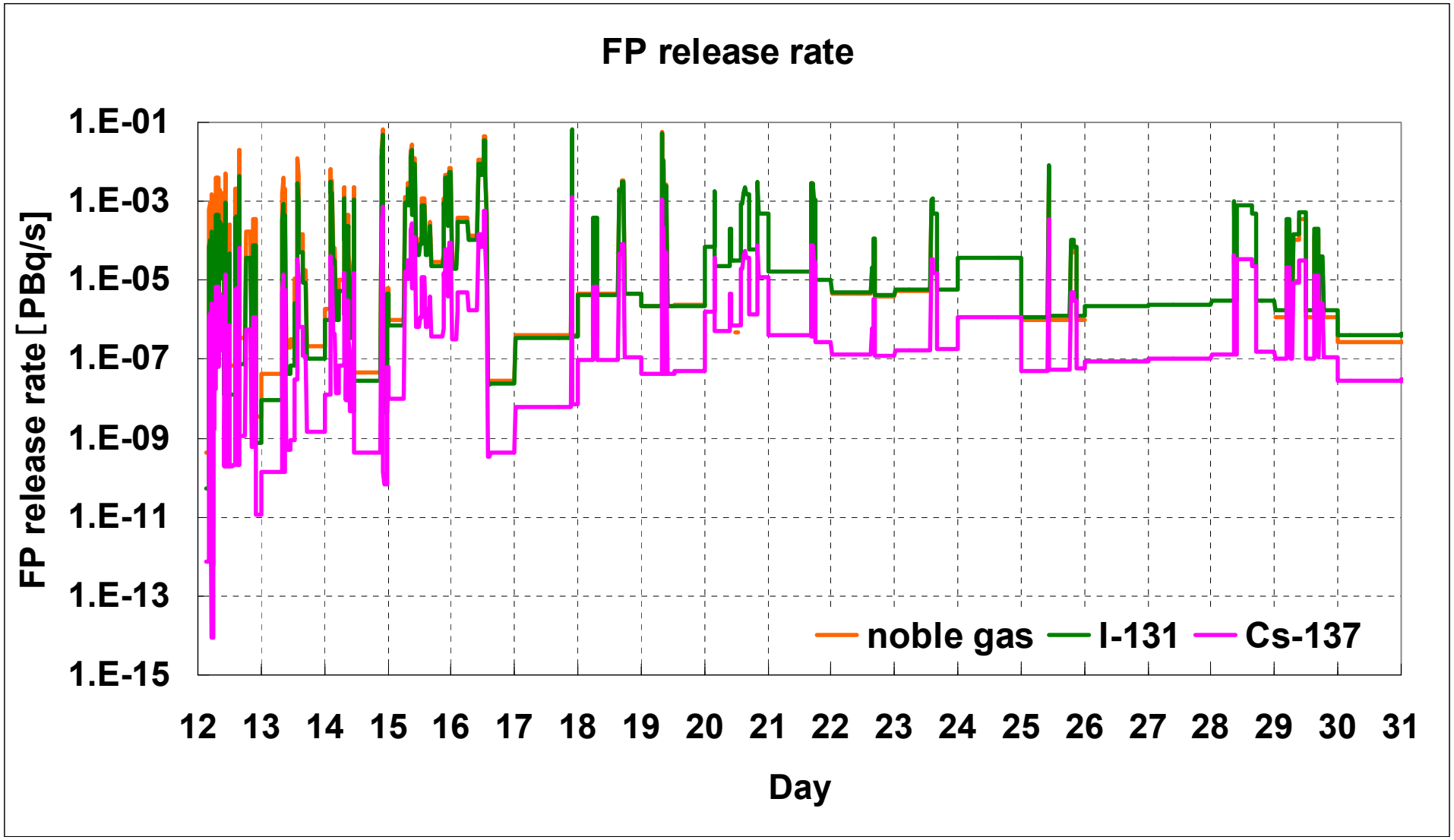
noble gas	I-131	Cs-134	Cs-137
500PBq	500PBq	10PBq	10PBq

- Since the amount of radioactive materials that has been released into the atmosphere from April on is less than 1% of the amount released in March, the period for which the amount released into the atmosphere is estimated is set between March 12 and March 31,2011.
- 1PBq(peta Becquerel)=1,000trillion Bq=10^{15}Bq
- The value estimated by TEPCO is rounded off to one decimal place ,being a figure in Bq at the time of released.

2.2 Time variation of Amount Released



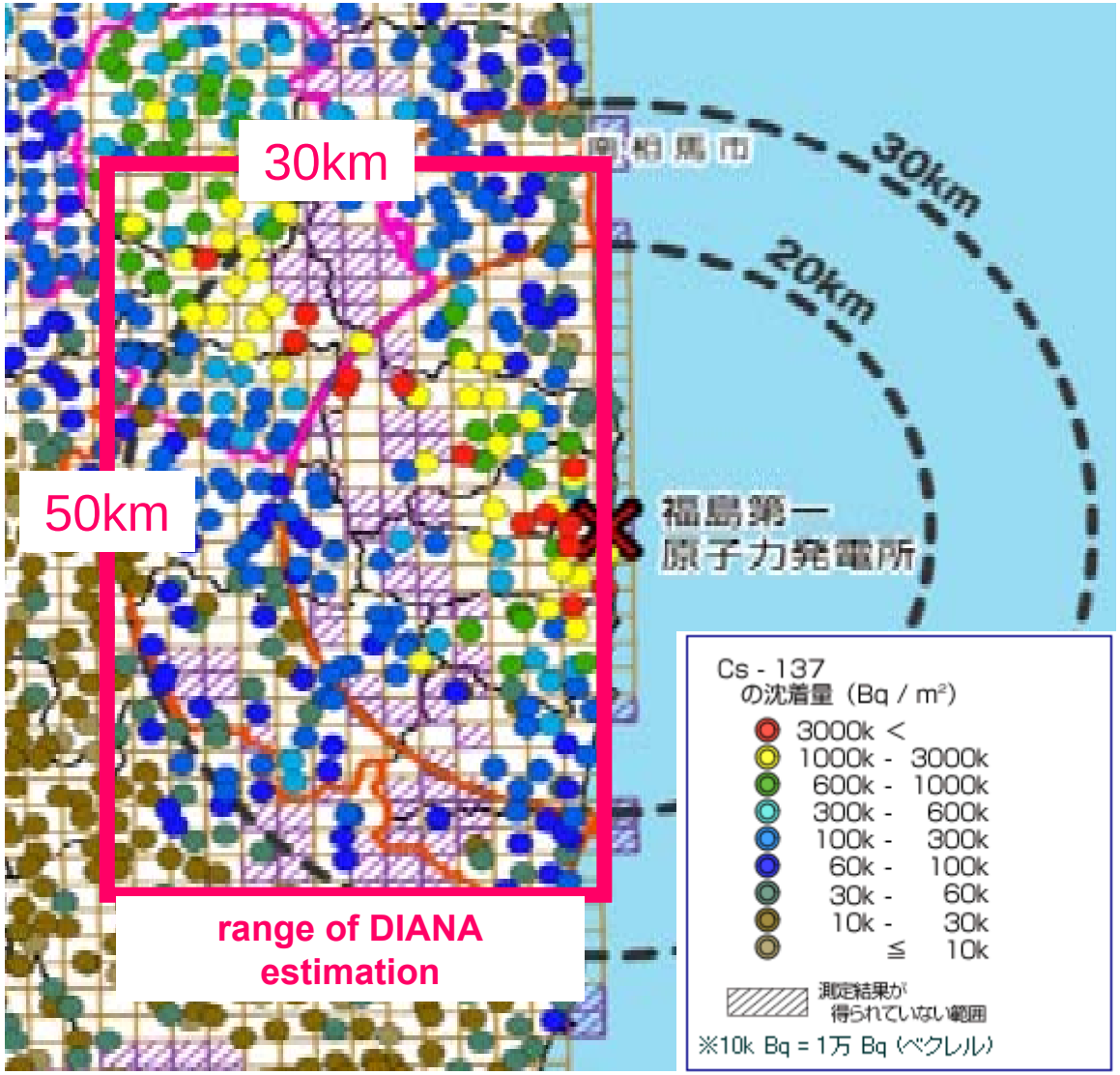
2.2 Result of Investigations on FP release rate



3. FP release volume 【vent & explosion】

unit	time	event	release volume (PBq)			
			noble gas	I-131	Cs-134	Cs-137
1	3.12 14:00～	vent	4	0.7	0.01	0.01
	3.12 15:36	explosion	10	3	0.05	0.04
3	3.13 09:00～	vent	1	0.3	0.005	0.003
	3.13 12:00～	vent	<0.04	<0.009	<0.0002	<0.0001
	3.13 20:00～	vent	<0.003	<0.001	<0.00002	<0.00002
	3.14 06:00～	vent	<0.003	<0.001	<0.00002	<0.00002
	3.15 16:00～	vent	<0.003	<0.001	<0.00002	<0.00002
	3.16 02:00	vent	<0.003	<0.001	<0.00002	<0.00002
	3.17 21:00	vent	<0.003	<0.001	<0.00002	<0.00002
	3.18 05:00～	vent	<0.003	<0.001	<0.00002	<0.00002
	3.20 11:00	vent	<0.003	<0.001	<0.00002	<0.00002
	3.14 11:01	explosion	1	0.7	0.01	0.009
Sub total vent & explosion			20	4	0.09	0.06
Total between March 12 and March 31			500	500	10	10

4. Deposition Cs-137



Deposition Cs-137
PBq / (50km × 30km)

Survey Data	1PBq
DIANA estimation	1PBq

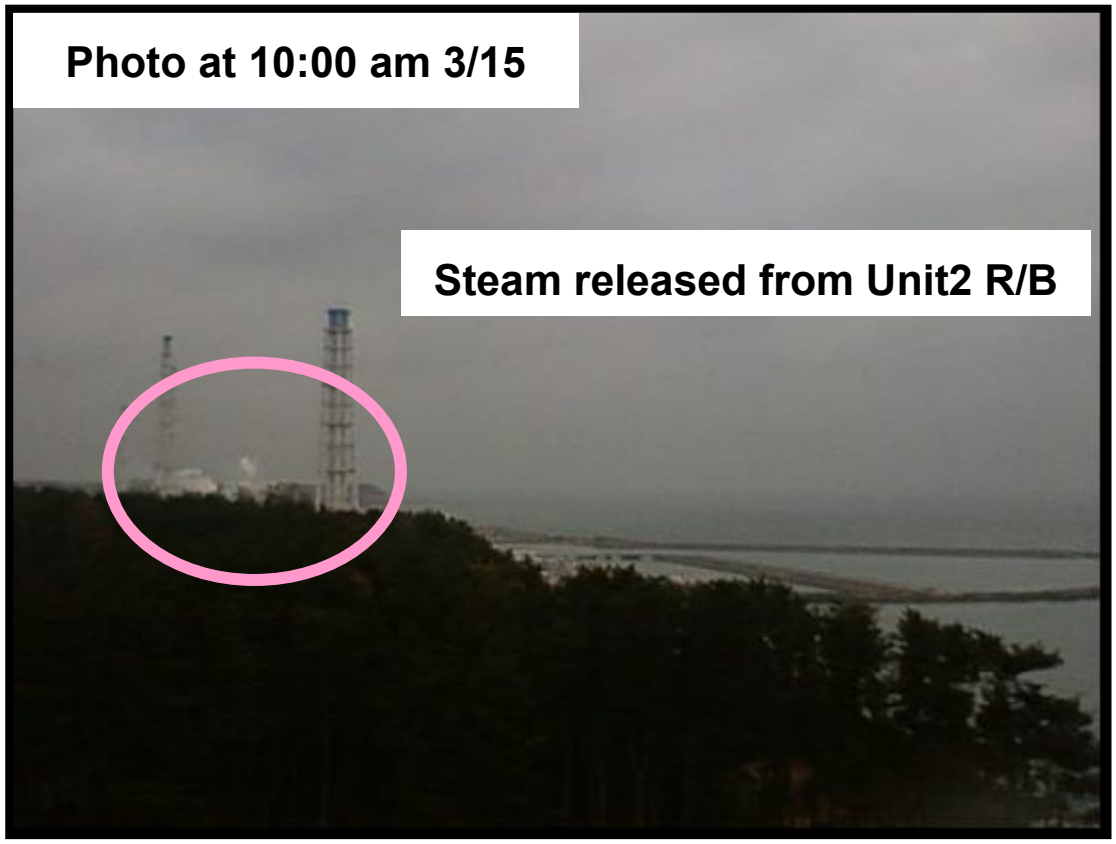
Soil sampling data & range of DIANA estimation

5.Estimation results of other Organization

Organization	release volume unit : PBq			
	noble gas	I-131	Cs-134	Cs-137
TEPCO 5.24.2012	500	500	10	10
JAEA 4.12.2011 & 5.12.2011	-	150	-	13
JAEA 8.22.2011	-	130	-	11
JAEA 3.6.2012	-	120	-	9
NISA 4.12.2011	-	130	-	6.1
NISA 6.6.2011	-	160	18	15
NISA 2.16.2012	-	150	-	8.2
IRSN	2000	200	30	
Chernobyl NPP	6500	1800	-	85

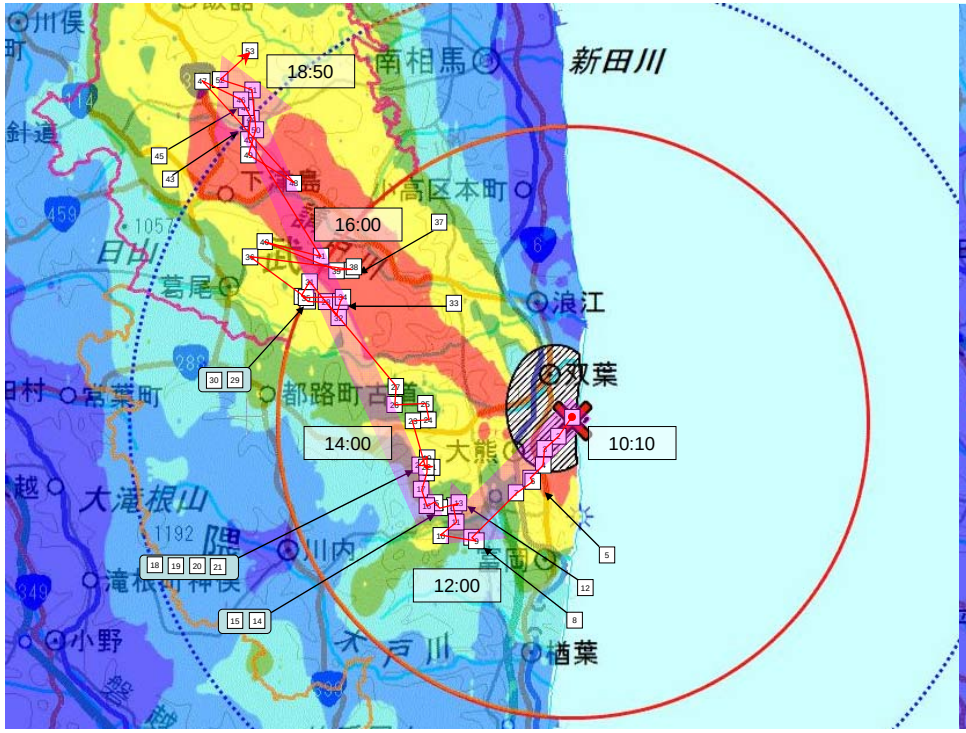
JAEA : Japan Atomic Energy Agency
NISA : Nuclear and Industrial Safety Agency
IRSN : Institut de Radioprotection et de Sûreté Nucléaire

6. Cause of Contamination of NW region【1/3】

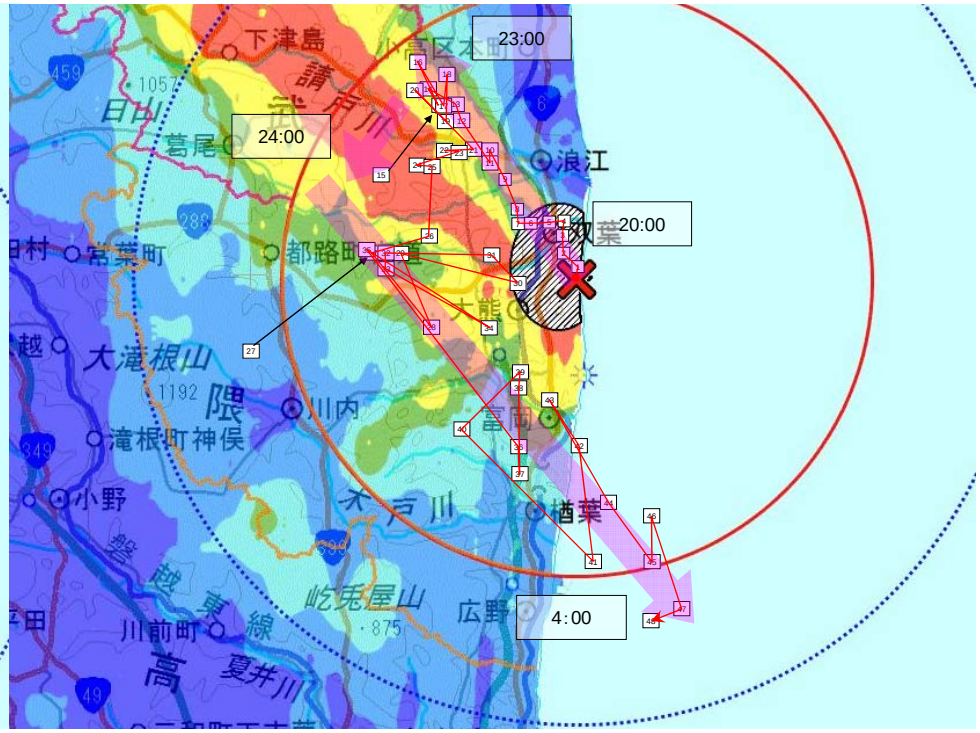


- Air dose rate showed rapid increase around 10:00 am on 3/15 but there were no plant operation like venting.
- This picture shows the steam release from Unit 2 around 10:00 am on 3/15.

6. Cause of Contamination of NW region【2/3】



Trajectory of the plume released from Unit 2 at 10:00am 3/15.



Trajectory of the plume released from Unit 2 at 8:00pm 3/15.

- These pictures indicate that the plume released from Unit 2 on 3/15 located NW region from evening to midnight.

6. Cause of Contamination of NW region【3/3】

Weather radar around Fukushima Pref. at 11:00pm 3/15.

- According to the weather radar,
  around NW region it was raining from evening to midnight on 3/15.
- We concluded the main cause of the contamination of NW region was **the uncontrolled release from Unit 2.**

7. Summary & Uncertainty

- Cs-137
  - Almost **equivalent** to those announced by other institutions.
- I-131
  - Our result ended up being **three times greater** than those of other institutions.
  - A factor contributing to this difference is thought to be that **the ratio of susceptibility of the radioactive nuclides to release** was assumed to be a fixed ratio.
- From changes in the air dose rate data at **one location** within the power station premises at each time during the assessment period, DIANA was used to assess the release rate such that the air dose rate data was reproduced.
- Data was used for **16 directions** as measured by monitoring cars.
- In light of DIANA specifications, the location of release at each time during the assessment period is limited to **one location**.
- Data from nearby **AMEDAS** observation points was used.

8.1 Case study “uncertainty of estimation”

Sorting according to Nuclide

Ratio of the susceptibility of radioactive nuclides to release

Ratio of radioactivity rate (iodine and cesium)

Reference

“Journal of Environmental Radioactivity Volume 112, October 2012, Pages 141-154”

Atmospheric discharge and dispersion of radio nuclides during the Fukushima Dai-ichi Nuclear Power Plant accident. Part II: verification of the source term and analysis of regional-scale atmospheric dispersion

JAEA Hiroaki Terada, Genki Katata, Masamichi Chino, Haruyasu Nagai

Table 2
Release period, release duration, ^{131}I release rate, **$^{131}I/^{137}Cs$ radioactivity ratio**, release height, and references in which each source term was estimated or refined, for the period between 5 JST on March 12 and 0 JST on May 1, 2011.
The values in parentheses are from Chino et al. (2011).

8.2 Result of Case study

unit : PBq

	noble gas : iodine[note1]	noble gas	I-131	Cs-134	Cs-137
Result (5.24.2012) [note2]	100:10	500	500	10	10
JAEA's ratio application	100:10	500	400	40	30
	100: 1	700	400	30	20

note1 : ratio of the susceptibility of radioactive nuclides to release

note2 : The estimation result (P8) pressed by TEPCO at 5.24.2012

- Estimation of I-131
  - Estimation of the results of these cases (JAEA's ration application) was not the result of greatly reduced compared with previous results of the evaluation of the case.
- Remaining uncertainty
  - **16 directions** as measured by monitoring cars
  - DIANA **specifications**