Experiences and Lessons Learned from Measuring and Assessing Individual External Doses during Post-Accident Recovery in Fukushima

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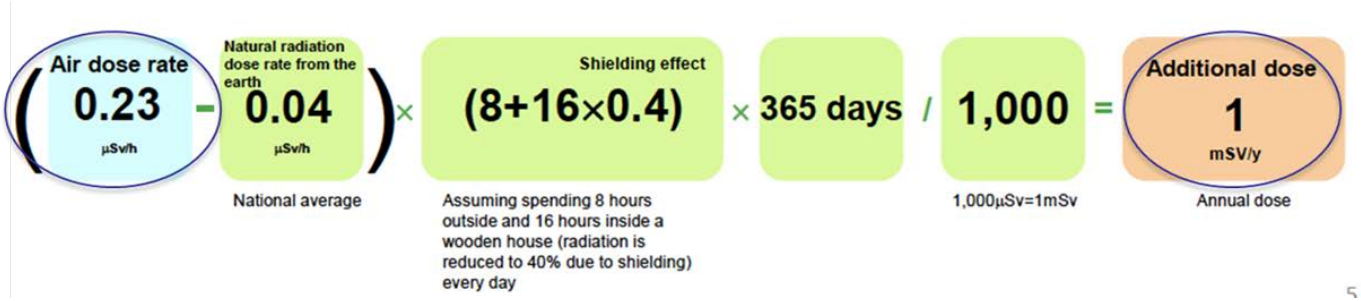
- Overview of D-shuttle Study on Measuring, and Assessing Individual External Doses in Fukushima

- Lessons and Some Caveats for Measuring, Assessing and Communicating Individual External Doses in the affected areas

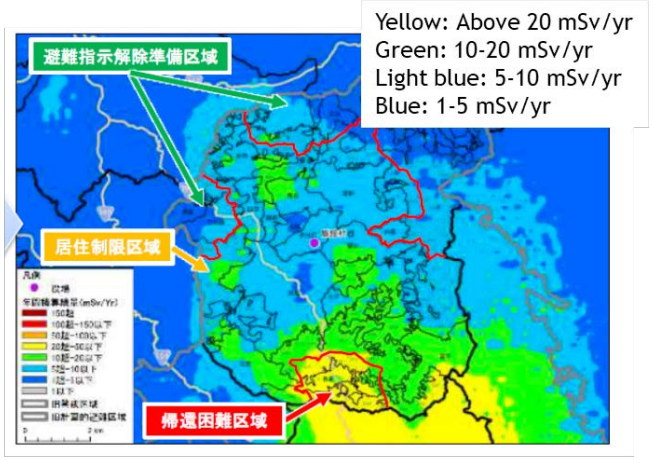
Correctly understand and assess realistic individual external doses are important

- The “additional effective dose” greatly influence the decisions regarding the decontamination and evacuation areas and timing for lifting the evacuation order



- The government proposed to use personal dosimeter for practical measures for evacuees to return to their homes (e.g., NRA 2013, MOE 2014).

- Accurate information on individual external doses is needed by the authorities and by affected residents

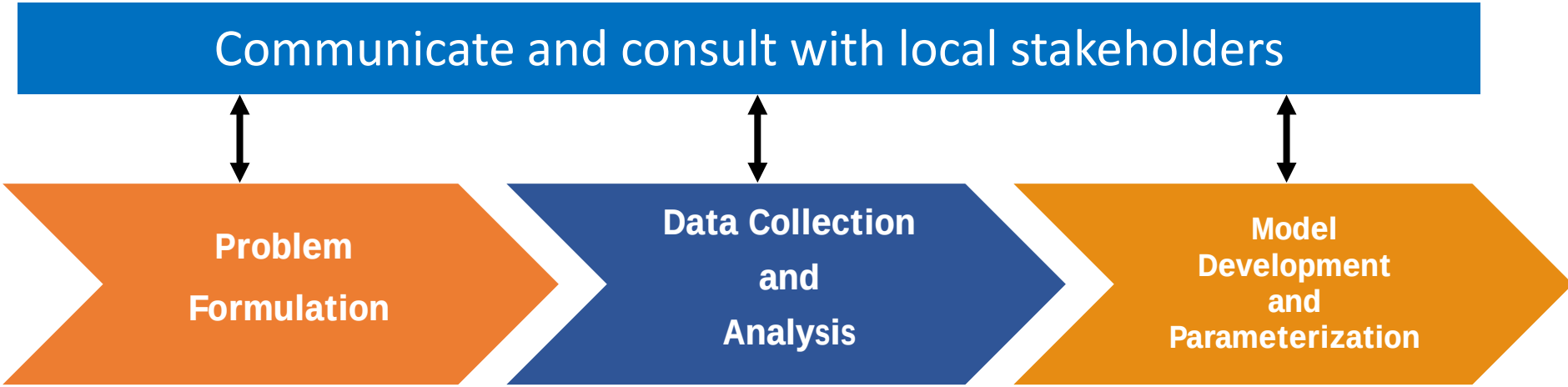


A figure used in a residents briefing in June 2016 in litate village by the gov.

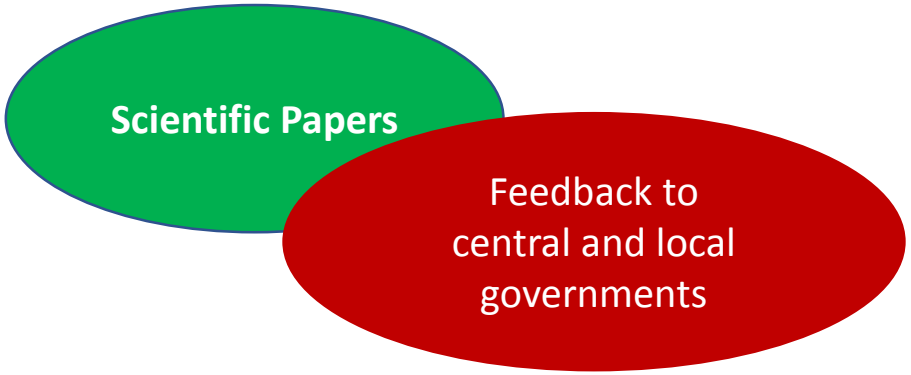
Our Study Objectives

- Understand the realistic individual external doses of individuals in the affected areas (both non-evacuation and evacuation zones)
- Elucidate the relationships between individual external doses with activity patterns and ambient doses (based on airborne monitoring data)
- Establish a pragmatic estimation tool to assess and manage the individual external doses
- Investigate the participants' responses to their measured individual external dose and radiological conditions

Our Pragmatic Study has Dual Purposes



To aware of his/her own dose and to utilize for self-protection or making lifestyle choices



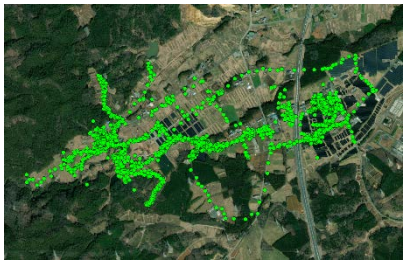
To obtain dose distribution of the population

What kinds of data were collected ?

Data collection periods :

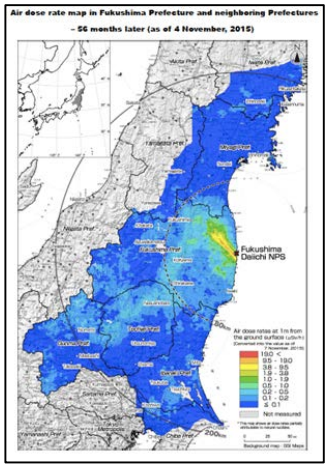
approximately 7 – 14 days (Sep. 2013 – Oct. 2019)

- Individual external dose
  → D-shuttle (hourly dose, μSv/h)



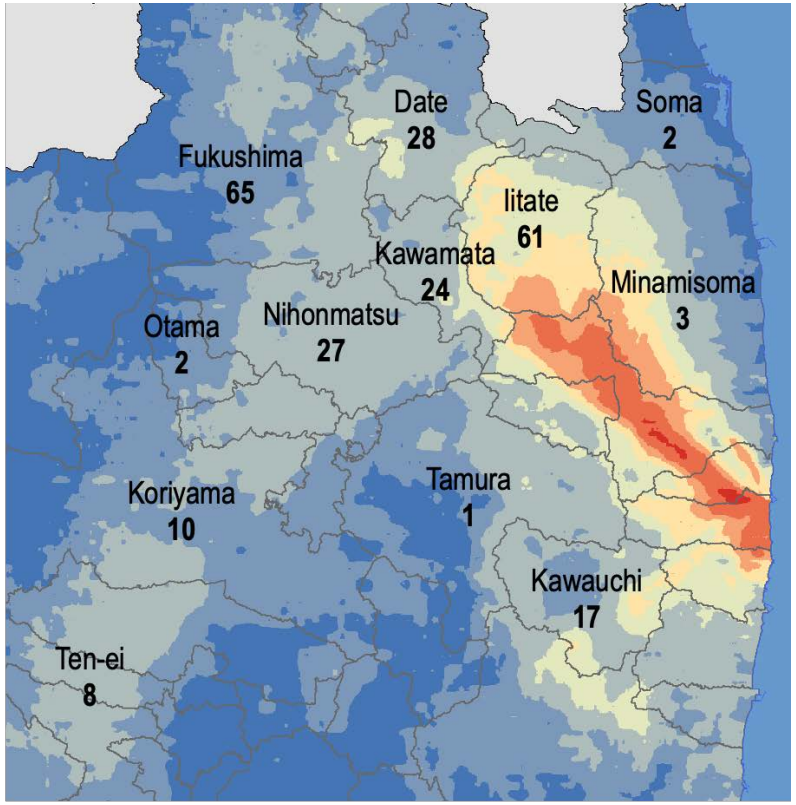
- Location and activity-patterns of individuals
  → GPS receiver and time-activity diary

- Ambient dose rate
  → Airborne monitoring conducted by
  Nuclear Regulation Authority, Japan
  → On-site measurements



Study participants and area

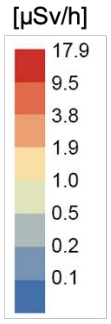
Support of local residents is essential for the data collection stage



2013: 50 (0)
2014: 96 (16)
2015: 76 (55)
2016: 15 (15)
2019: 17(17) (+ 279)

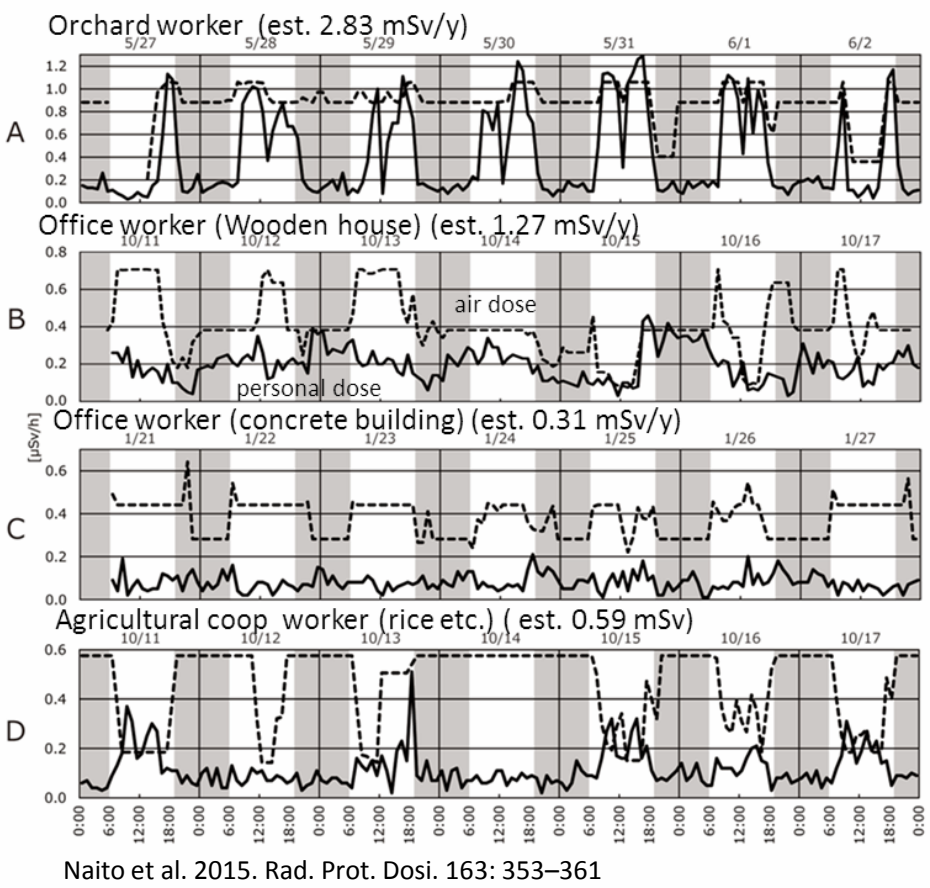
To date, approximately 300 Fukushima residents participated in our study

Ambient dose rate is based on 10th Airborne Monitoring Survey (2018.Nov.15)



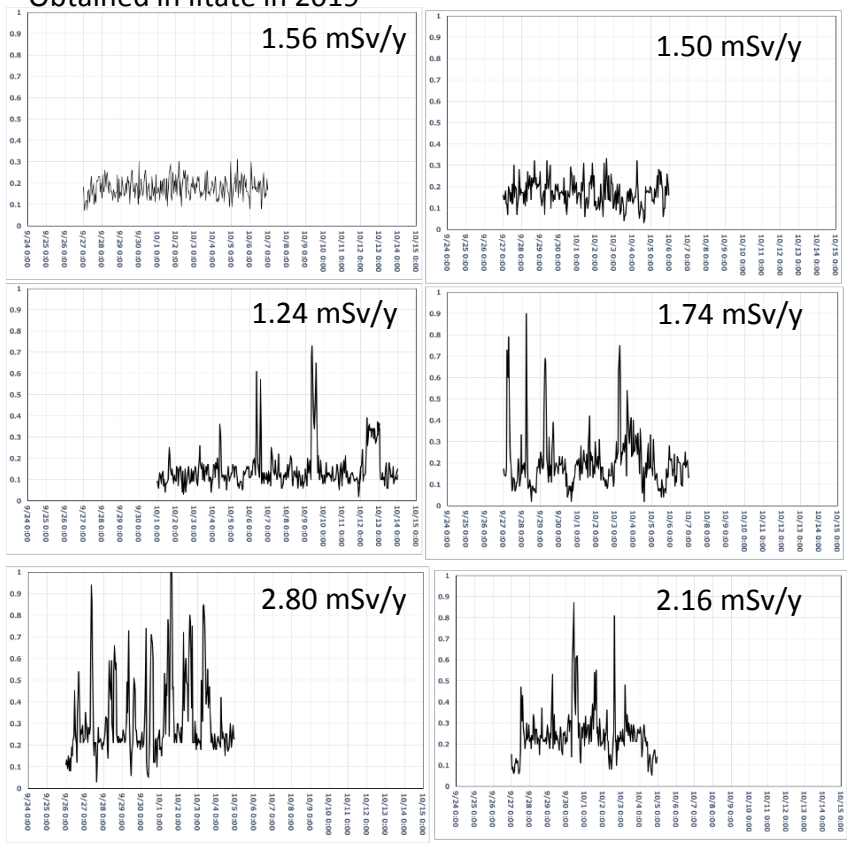
This study was approved by the Committee for Ergonomic Experiments in the AIST.
Written informed consents were obtained from all participants prior to conducting the study.

Individual external dose profiles vary depending on activity patterns and locations of individuals



Naito et al. 2015. Rad. Prot. Dosi. 163: 353–361

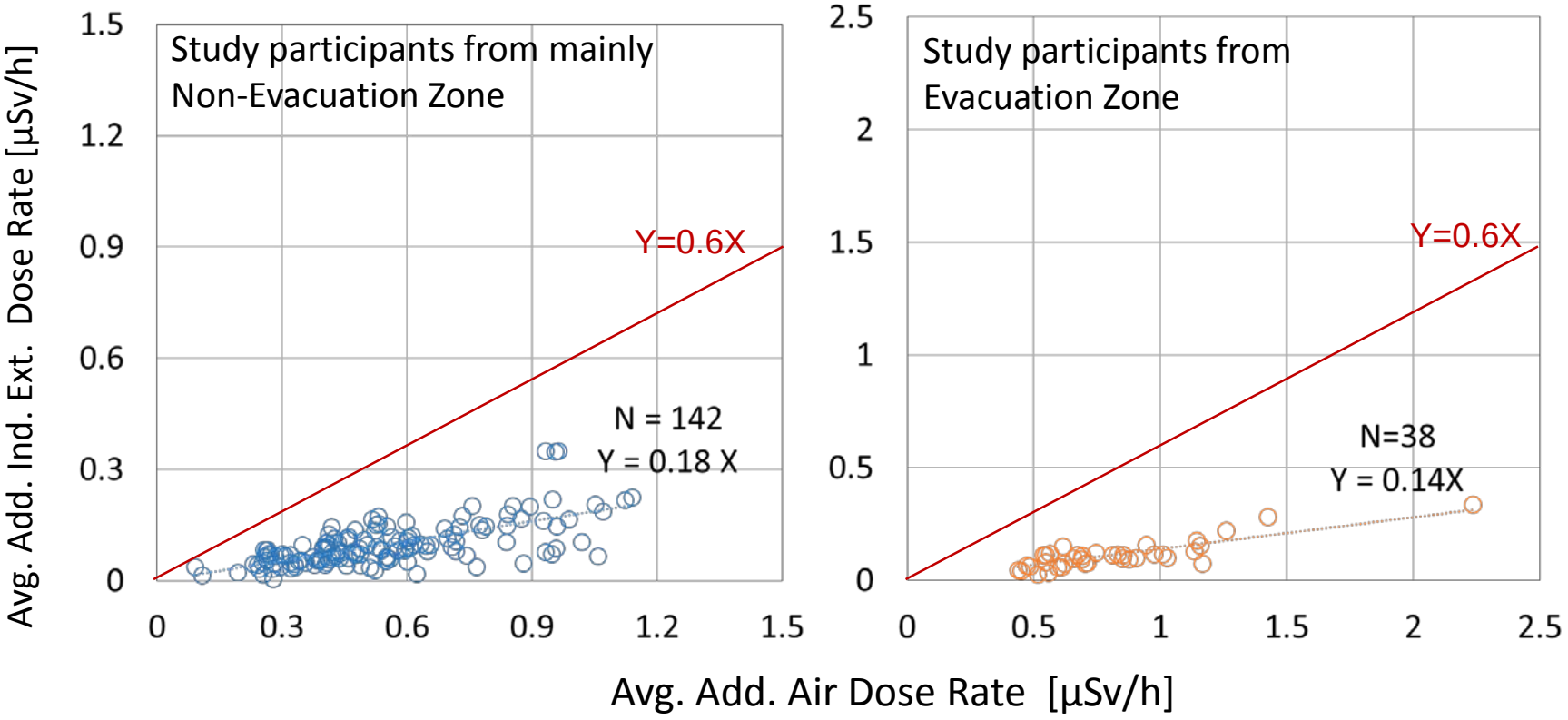
Obtained in Iitate in 2019



Personal dosimeter such as D-shuttle provides easy-to-understand information for residents to know the radiation situation in their daily life.

Relationship between individual external dose and airborne based ambient dose

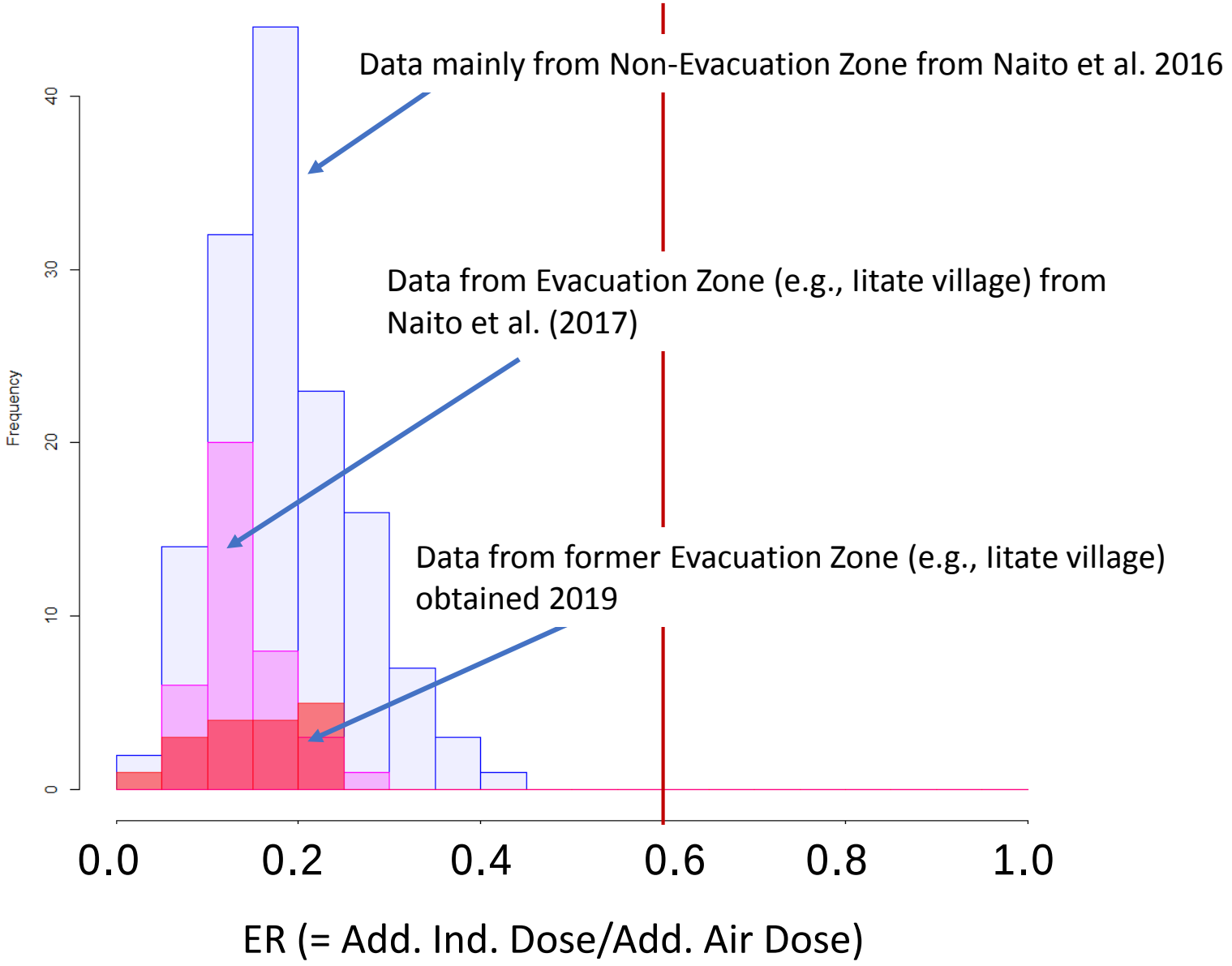
Expressed as hourly dose on average of times spent during all study periods



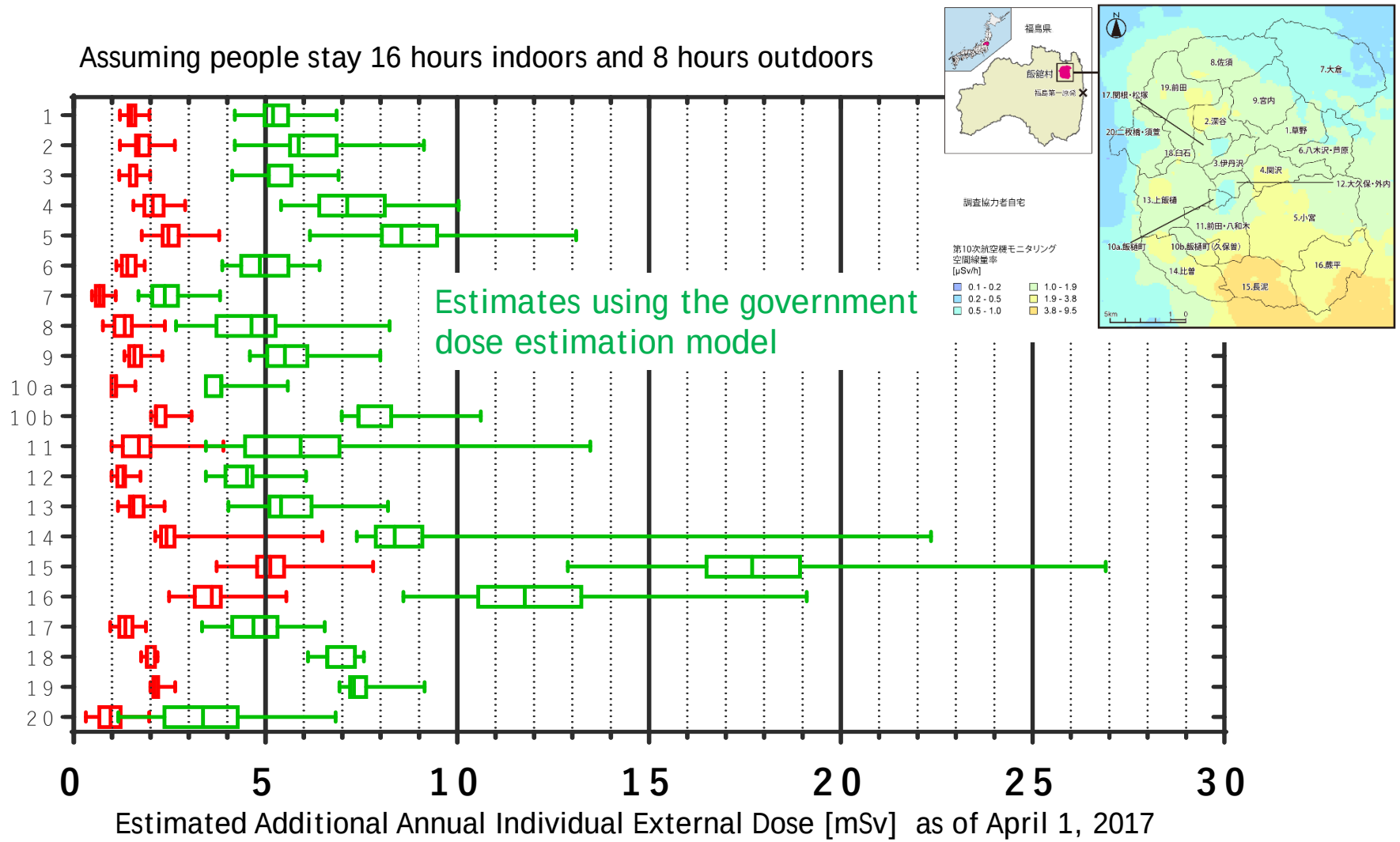
Individual external dose << Corresponding airborne-based ambient dose

Naito and Uesaka. 2018. Annals of ICRP
Based on data in Naito et al. 2016. PloS one 11 e0158879 and Naito et al. 2017. J. Radiol. Prot. 37 606–22

Distributions of Exposure Ratios (ER)



The estimates of individual external doses based on the result from our study were well below the estimates calculated by the government model



Our research results were used as a reference scientific evidence by local and national authorities to understand realistic individual external dose levels in the evacuation areas

Based on Naito et al. 2017. J. Radiol. Prot. 37 606–22

The most recent dose assessment of external exposure among returnees to former evacuation zones

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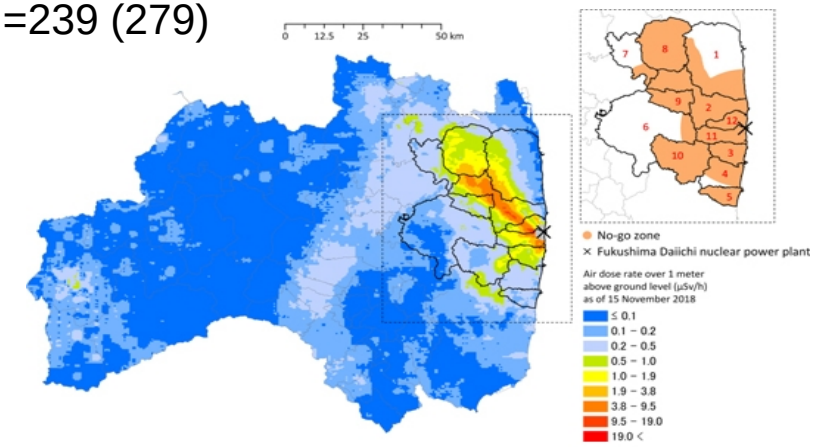
IOP Publishing | Society for Radiological Protection — Journal of Radiological Protection
J. Radiol. Prot. 40 (2020) 1–18 (18pp) https://doi.org/10.1088/1361-6498/ab46ba

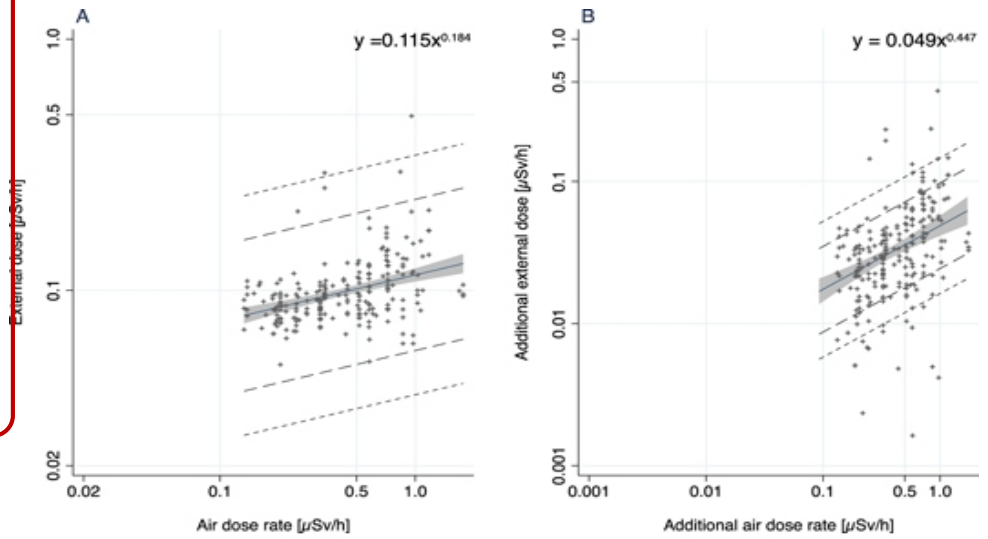
Low dose of external exposure among returnees to former evacuation areas: a cross-sectional all-municipality joint study following the 2011 Fukushima Daiichi nuclear power plant incident

Shuhei Nomura[1,2,3,7], Michio Murakami[4,7], Wataru Naito[5], Tetsuo Yasutaka[5], Toyoaki Sawano[1,6] and Masaharu Tsubokura[1,6,8]

N=239 (279)

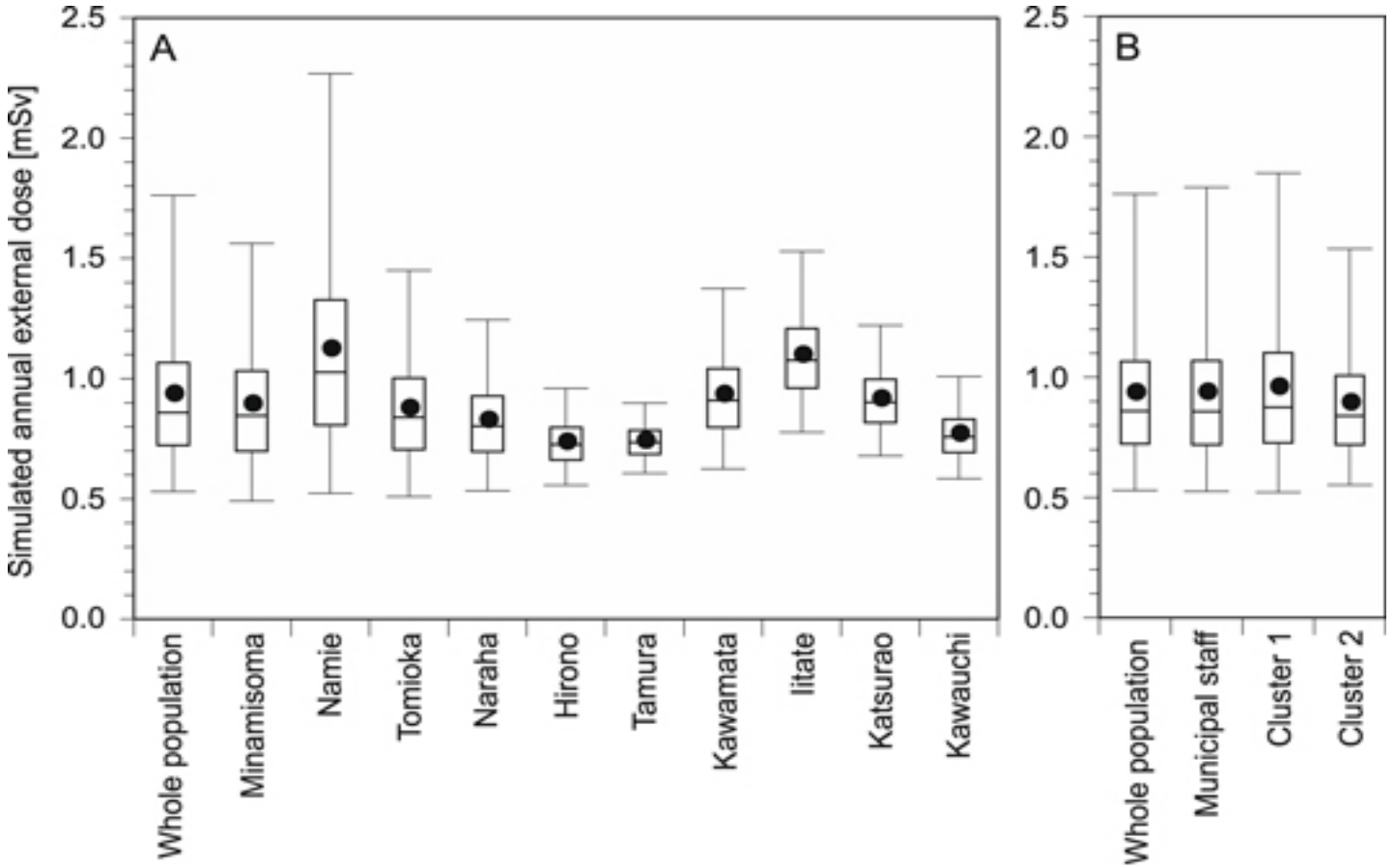


(B) Annual dose (mSv)	Mean	SD	Median	IQR	Min	Max
Minamisoma	0.99	0.69	0.85	0.21	0.59	4.33
Namie	1.09	0.51	0.86	0.31	0.69	2.60
Tomioka	0.87	0.30	0.76	0.40	0.46	1.55
Naraha	0.82	0.23	0.80	0.18	0.56	1.81
Hirono	0.74	0.12	0.73	0.12	0.44	1.02
Tamura	0.75	0.09	0.74	0.12	0.62	0.92
Kawamata	0.97	0.25	0.99	0.24	0.63	1.70
Iitate	1.12	0.24	1.16	0.43	0.73	1.56
Katsurao	0.90	0.15	0.89	0.13	0.66	1.27
Kawauchi	0.76	0.12	0.74	0.15	0.60	1.03
Total	0.90	0.37	0.83	0.23	0.44	4.33



The individual doses were statistically significantly correlated with the air dose rate detected through government airborne monitoring.

The most recent dose assessment of external exposure among returnees to former evacuation zones



Monte Carlo simulations demonstrated that the mean of the annual dose including exposure from natural sources in 2019 was 0.93 (95% uncertainty interval 0.53–1.76) mSv

Nomura et al 2020 J. Radiol. Prot. 40 1 doi:10.1088/1361-6498/ab49ba

Participants' responses to the measured individual external doses and their radiological conditions

- Does any radiation dose level make you feel secure? (What are the reasons?)

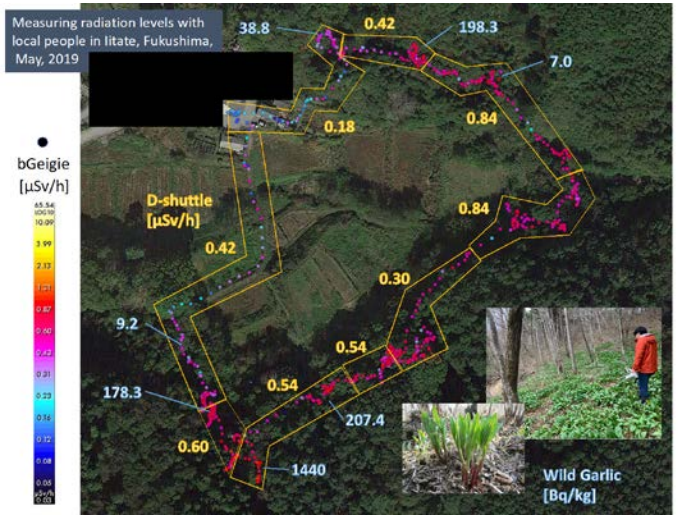
- What type of radiation information do you need to return to your home in the evacuation zone?
- What do you think of your personal dose level (obtained by D-shuttle)?
- Do you feel secure when you see your own personal dose data?
- Is your radiation condition an important element for your decision to return to your home after lifting the evacuation order?

Naito and Uesaka. 2018. J Annals of the ICRP. 47(3-4) . 241-253

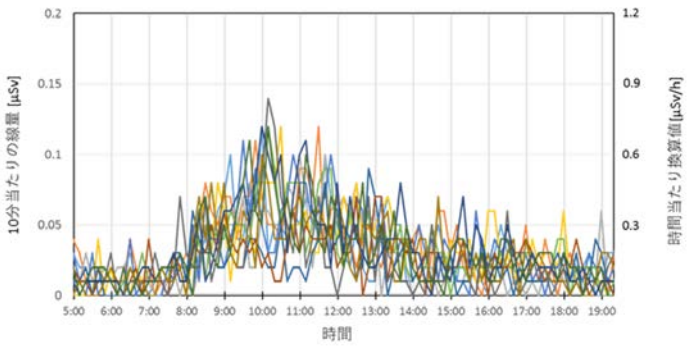
Individual external dose measurement using personal dosimeter such as D-shuttle play a versatile role in Post Accident Recovery for residents and authorities

Opportunities:

- Understanding realistic radiological situation in their life
- Answering actual concerns from the affected residents for everyday life
- Self-protection and lessening the anxiety against radiation



- Selection of effective radiation dose mitigation strategies
- Estimation of more realistic future individual external dose
- Necessity for further radiation reduction measures



Naito and Uesaka. 2018. J Annals of the ICRP. 47(3-4) . 241-253

Some caveats for measuring, assessing and communicating individual external dose

- Complicated dose quantities and units for radiation protection caused confusion among the general public and even among experts and regulators

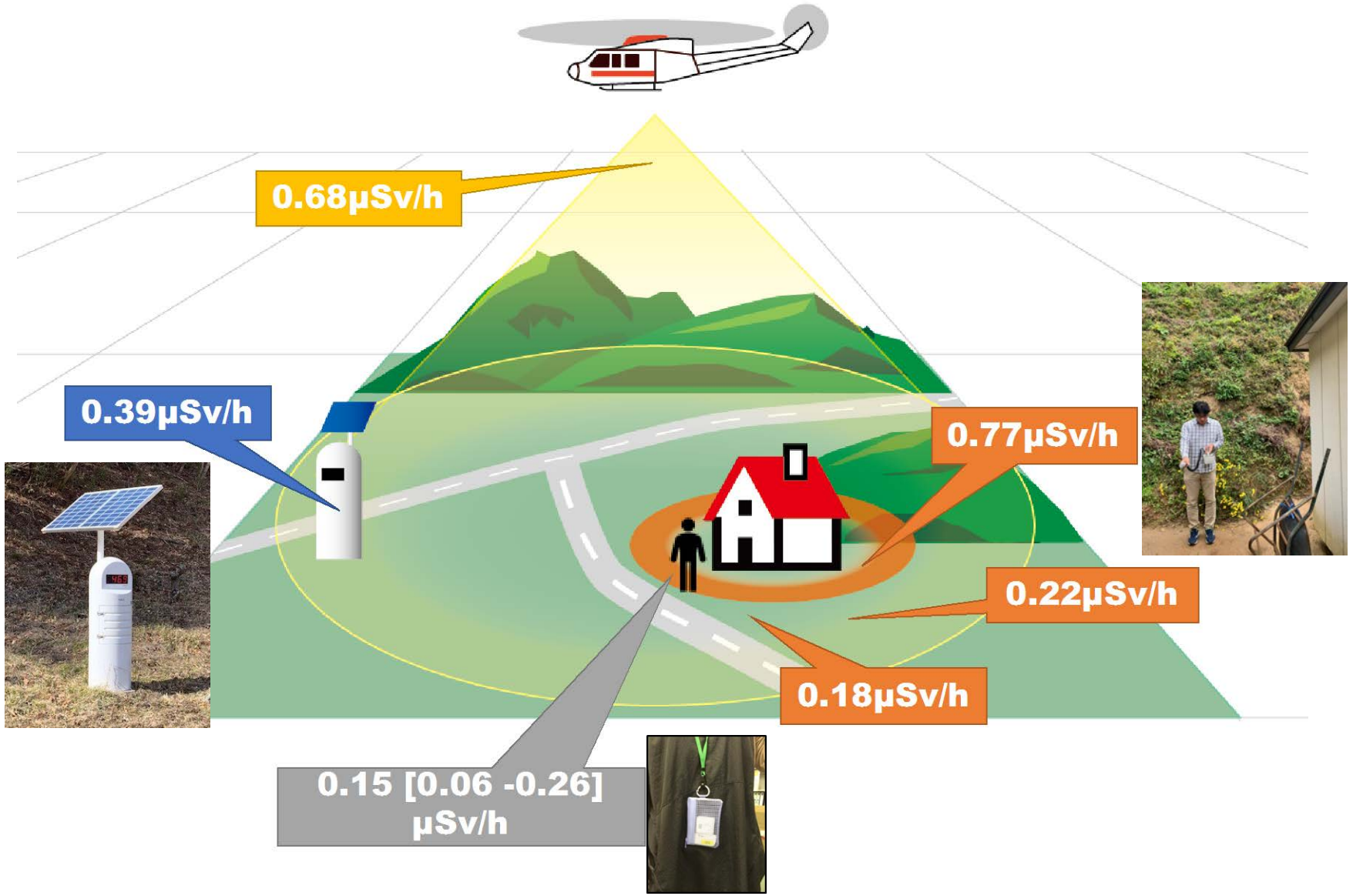
- Providing specific solutions to reduce individual external dose based on measurements may be difficult

- Once the regulatory decisional reference values (e.g., 1 mSv/y, 100 bq/kg) were set and penetrated to the public, it is very difficult to change or moderate these initial reference values

- People buy detectors and carry out measurements,
  (and sharing data on social networks…)
  (may cause incommensurate reactions)

Naito and Uesaka. 2018. J Annals of the ICRP. 47(3-4) . 241-253

An Example of radiation dose measurements in a mesh of former evacuation zone



Measurement of Individual External Dose by the affected people could be a double-edged sword

If measured values are	Lower (e.g., below **1mSv/y**)	• (Self) measurements are effective to solve problems • Effective for lessening the anxiety against radiation (Comparing with the reference value is effective) • (Some residents were concerned when the peak dose was greater than the reference value in their time series data)
	Higher (e.g., above **1mSv/y**)	• (Self) Measurements may cause problems • Maybe increase the anxiety against radiation (Comparing with the reference value may not be effective) • Feel regret their decisions made to evacuate from or return to home

Not just measuring, it is necessary to

- Properly and promptly communicate the result of the measurement or assessment to the stakeholders (ideally by trained specialists)
- Prepare customized approach (e.g., appropriate counseling) responding to anxiety among the residents caused after informing the results of measurement
- Share the purposes of measurements and develop plans for communicating and responding to anticipated or unanticipated results among stakeholders before conducting measurement
- If needed, provide (maybe implement) risk reduction options (the support of authorities may be needed)
- Utilize the individual dosimetry data to better understand realistic individual dose distribution of the population with care of personal information

Summary

- Personal dosimeter such as D-shuttle play a versatile role in post accident recovery for residents and authorities in the affected areas
- Ample studies exist to understand and estimate more realistic individual external doses for those who returned or will return to the former evacuation zones
- The use of personal dosimetry such as D-shuttle by the affected people could be a double-edged sword
- Effectively utilizing individual dose measurement data during the post-accident recovery phase requires for the stakeholders to understand and share the meaning of measurement data and prepare appropriate mechanism to responding to the residents' concerns caused after communicating the measurement data

Acknowledgements – Thanks -

- Local residents who participated in our study
- Local officials from Iitate village and Kawamata town
- Makoto Miyazaki, Yujirou Kuroda, Hideki Ishii