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RISS Research Institute of Science for Safety and Sustainability

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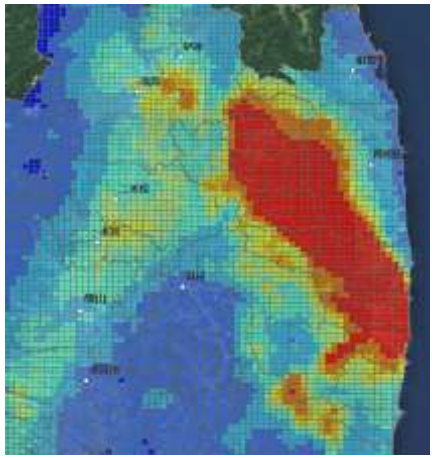
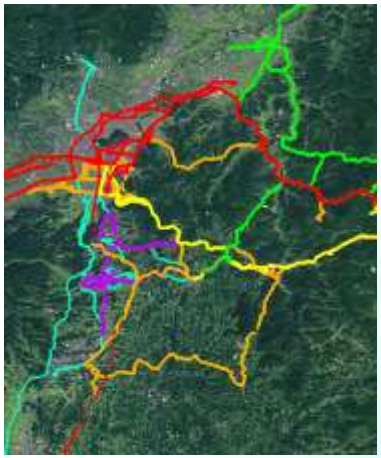
The Role of Individual Dosimetry for Affected Residents in Post Accident Recovery - From the Fukushima Experience

Research Institute of Science for Safety and Sustainability (RISS)

National Institute of Advanced Industrial Science and Technology (AIST),

Wataru Naito, Motoki Uesaka





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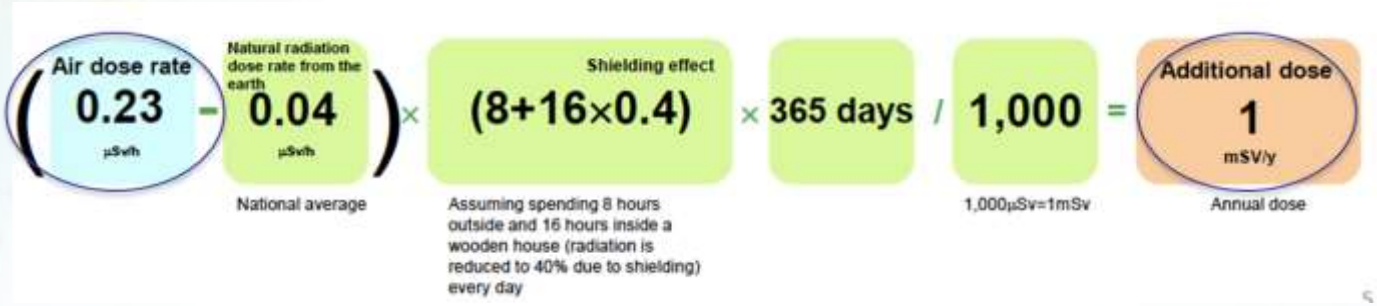
Decisions regarding the decontamination and evacuation areas have been determined on the basis of “air dose rate” with a simple equation with conservative assumptions

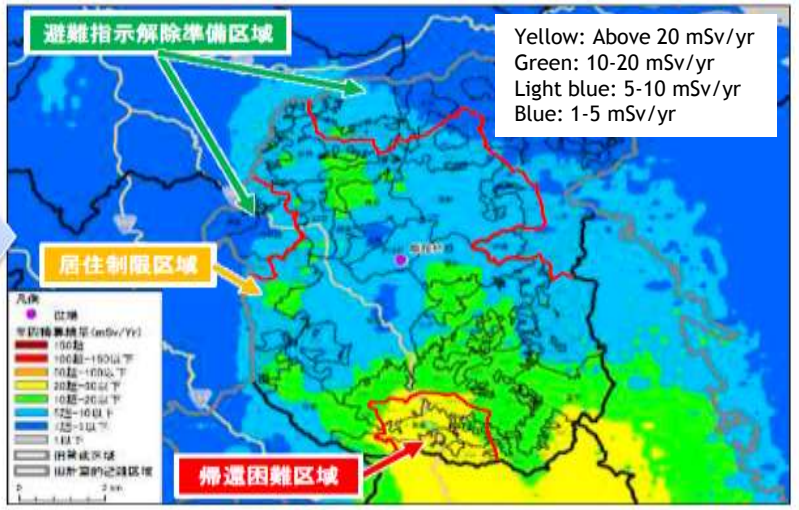
The government has designed the **decontamination works** and the **criteria for the evacuation and lifting the evacuation orders** on the basis of **additional (individual external) dose** estimates using the simple model proposed by the Ministry of Environment.



The long-term goal under the Decontamination policy is to reduce additional annual dose to **1 mSv.**

The criteria for lifting the evacuation order is **20 mSv** or less.

An annual exposure of 1 mSv (air dose rate of 0.23 μSv/h) has been recognized as a **‘safe’ level by the public.**



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

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Correctly understand and assess realistic individual external doses are important

There are gaps between individual external doses obtained by personal dosimeters and the individual doses estimated by the simple model.

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

Monitoring post

Real-time dosimeter

Airborne radiation monitoring

http://jolisfukyu.tokai-sc.jaea.go.jp/fukyu/mirai-en/2012/1_6.html

Glass Badge Dosimeter

http://www.minpo.jp/pub/topics/jishin2011/2011/07/post_1501.html

Accurate information on individual external doses is needed by the government policymakers, by people providing health care and radiation dose mitigation advice, and especially by affected citizens.

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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

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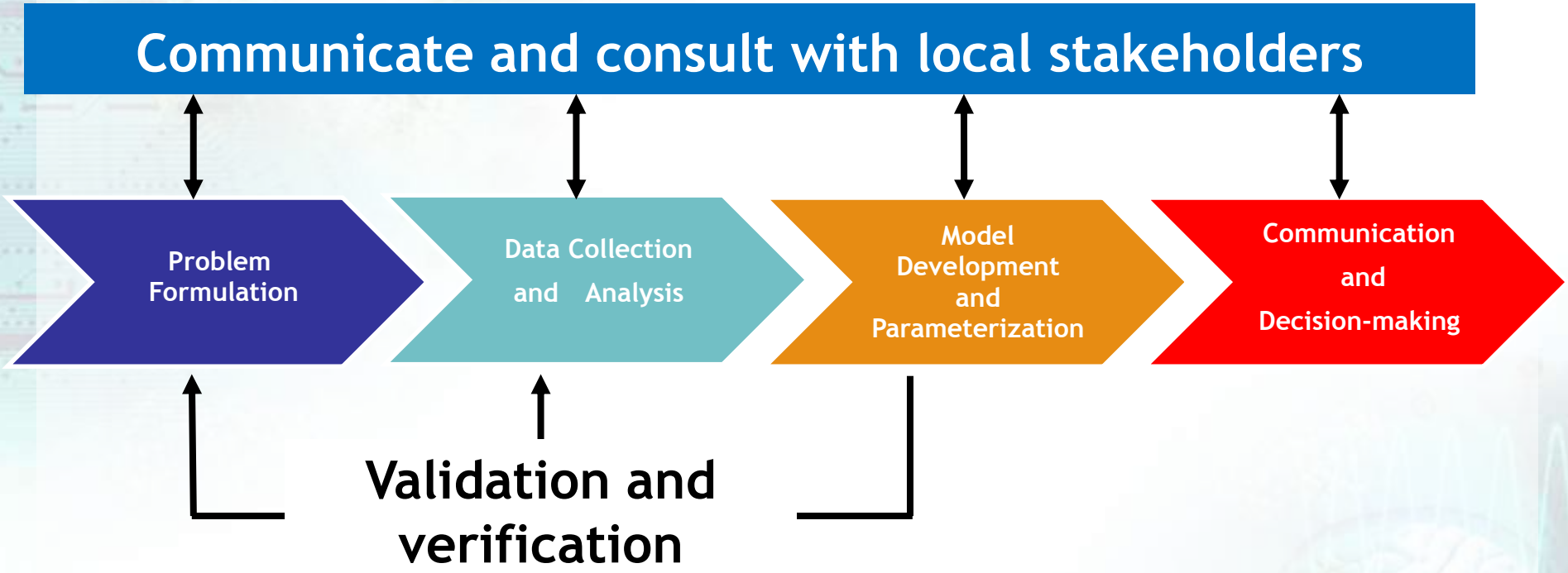
Framework of our individual external dose measurement, assessment and communication research



Communicate with various stakeholders (e.g., local residents, government and municipality) throughout all stages of the study

Support of local residents is essential for the data collection stage

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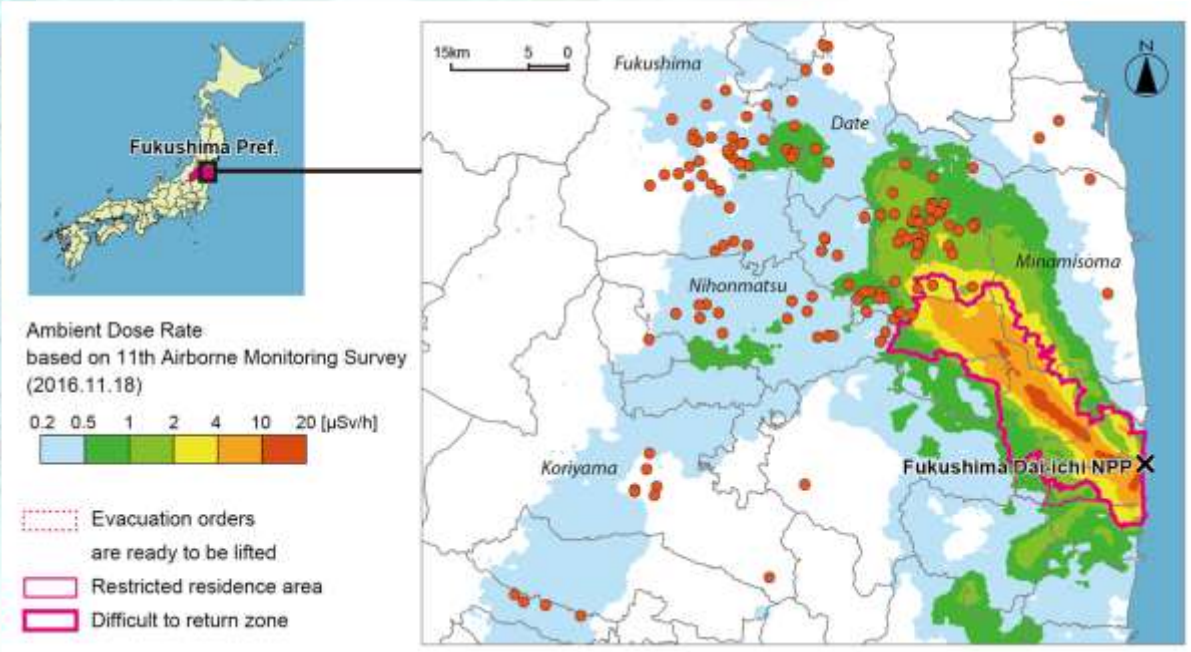
Study participants and area



● Participants' residence
— Evacuation zone (2015)

Number of participants
(residents in evacuation zone)

2013: 50 (0)
2014: 96 (16)
2015: 76 (55)
2016: 15 (15)

To date, approximately 250 Fukushima residents participated in our study

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.

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What kinds of data were collected ?

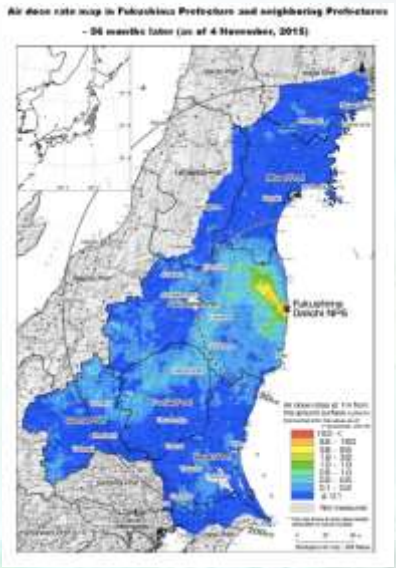
Data collection periods :

approximately 7 – 14 days (Sep. 2013 – May 2016)

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

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

- Air dose rate
  → Airborne monitoring conducted by Nuclear Regulation Authority, Japan



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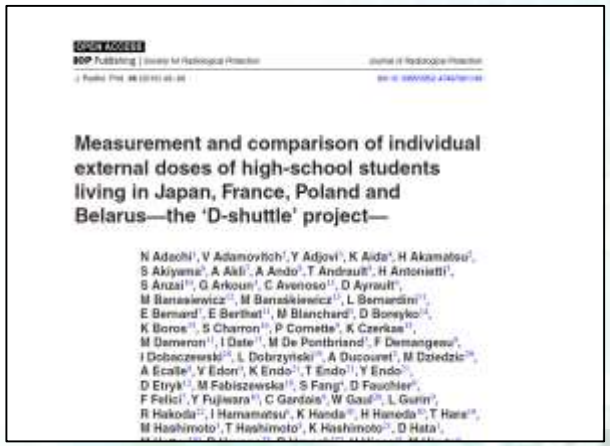
A Well-Designed Personal Dosimeter - D-shuttle-

- Developed by AIST, and produced by Chiyoda Technol. Inc.
  - ✓ Long battery life: 1 year
  - ✓ Monthly, Daily and Hourly dose trend
  - ✓ Light and compact size
  - ✓ Designed to detect gamma-ray
- D-shuttle has been used for several municipalities in Fukushima

(More than 30,000 were distributed to date)



Measurement and comparison of individual external doses of high-school students living in Japan, France, Poland and Belarus—the 'D-shuttle' project—

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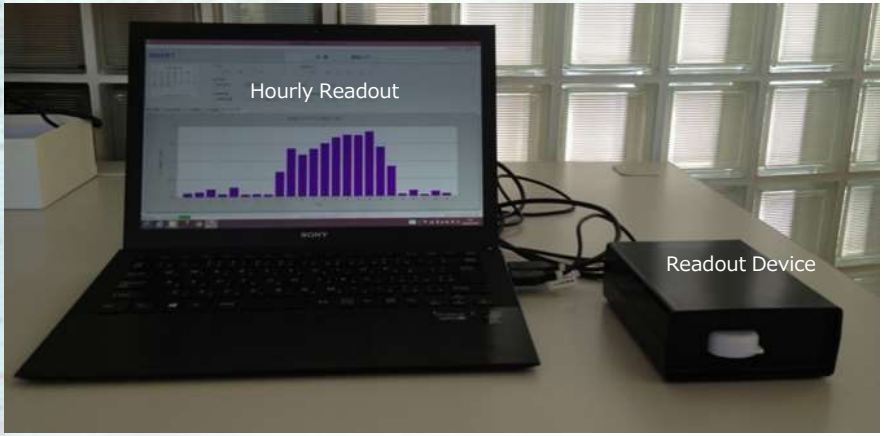
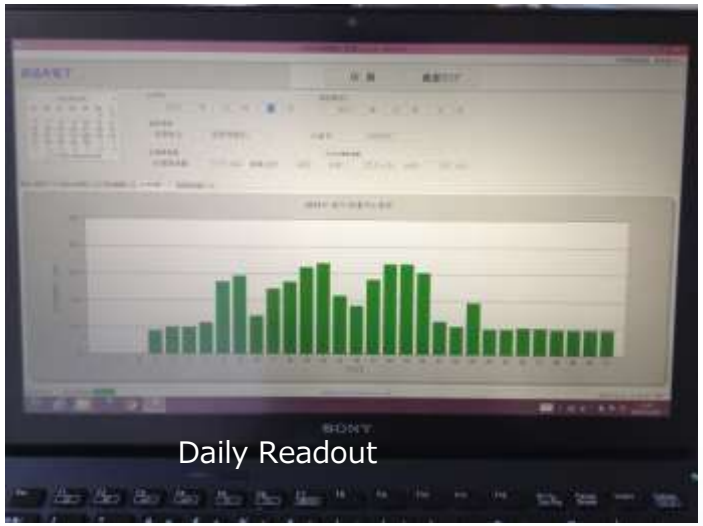
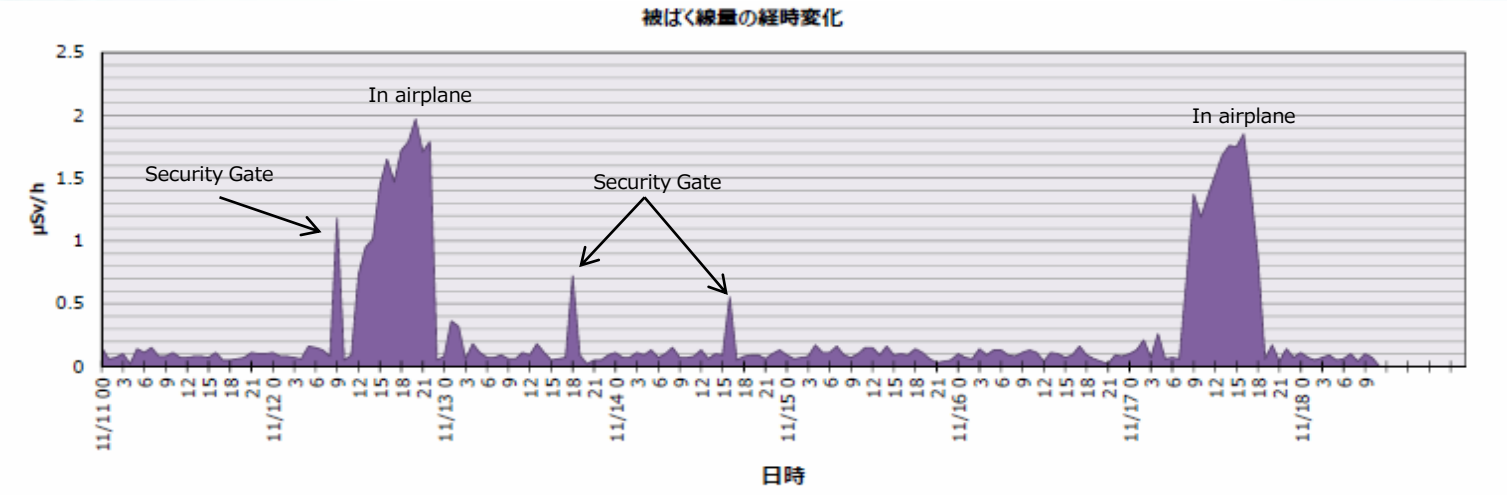
Readout from D-shuttle







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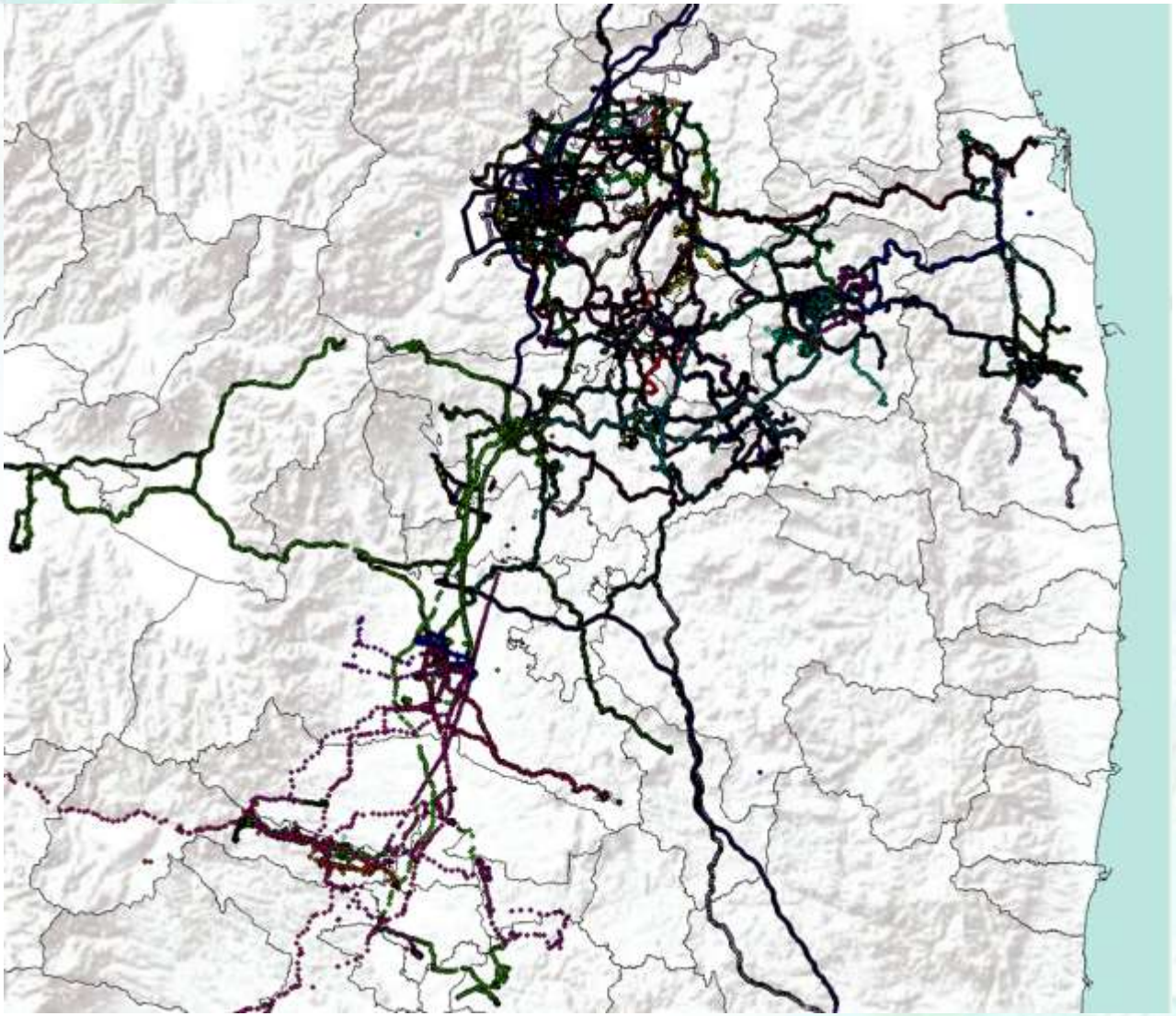
Examples of Readout from GPS

i-gotU GT-600
（MobileAction Technology, Inc.）
Set to record latitude and longitude every 5 seconds



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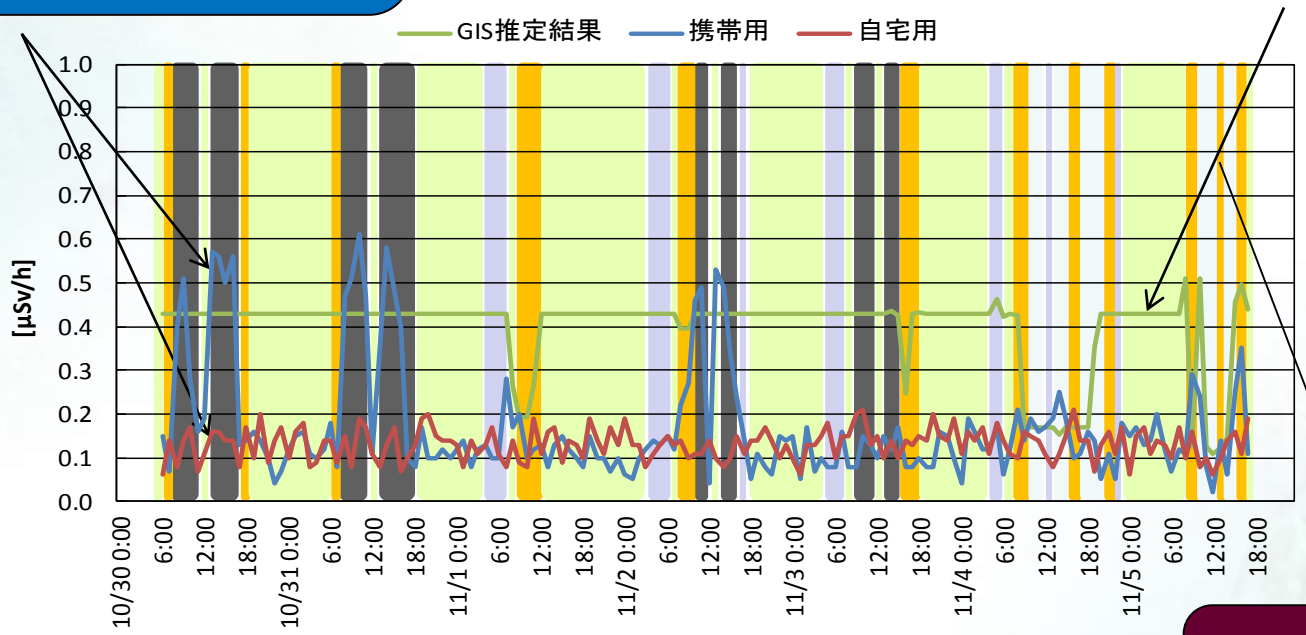
Integration of individual external dose, air dose and time-activity patterns using GPS/GIS

Hourly Individual External Dose (D-shuttle)

Air dose rate (Airborne monitoring)



Time-activity diary

Home | Inside | Transportation | Outside

GPS data

Spatial-temporal radiation exposure assessment using D-Shuttle with GPS/GIS technologies allowed for identification of peak exposure locations/times

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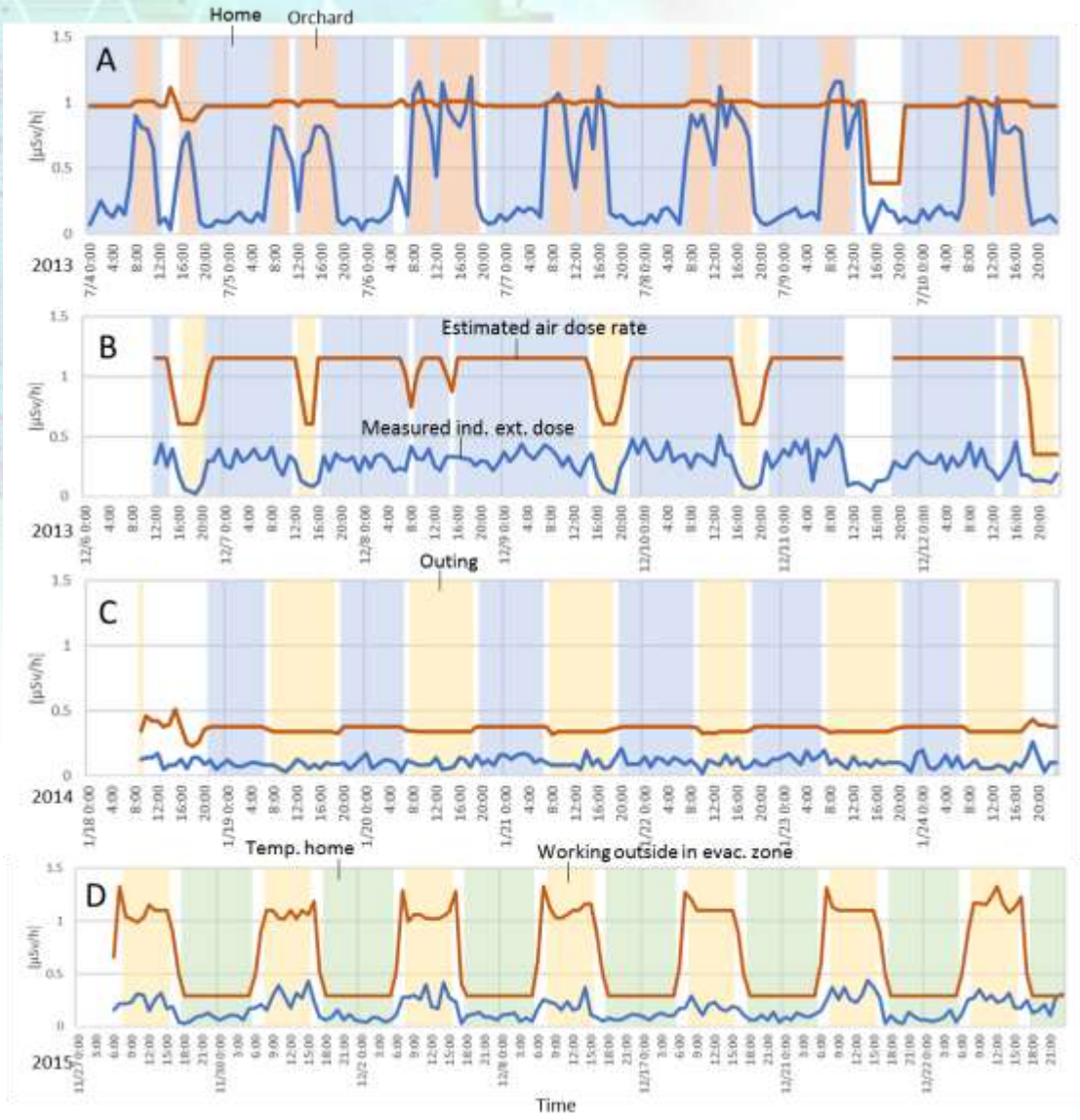
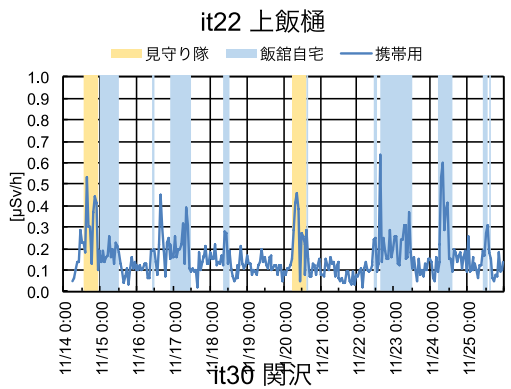
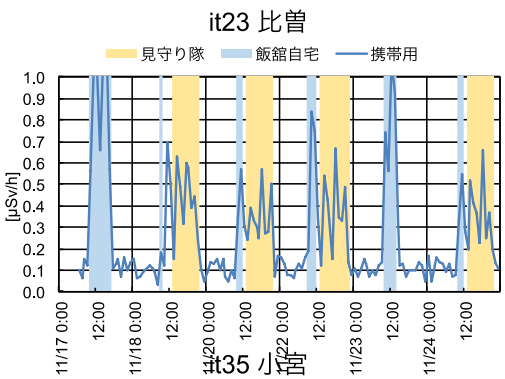
Examples of individual external dose profiles obtained by D-shuttle

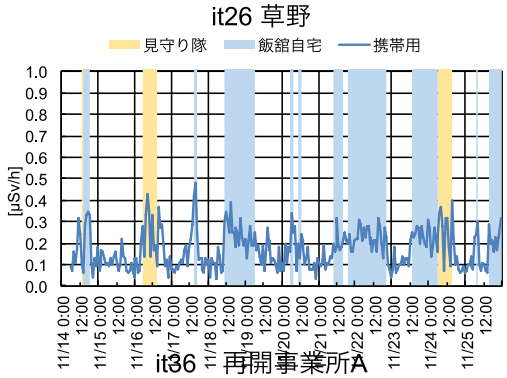


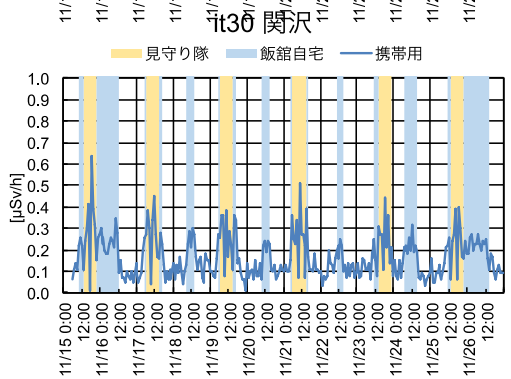
- ✓ External dose profiles vary depending on activity patterns and locations of individuals.

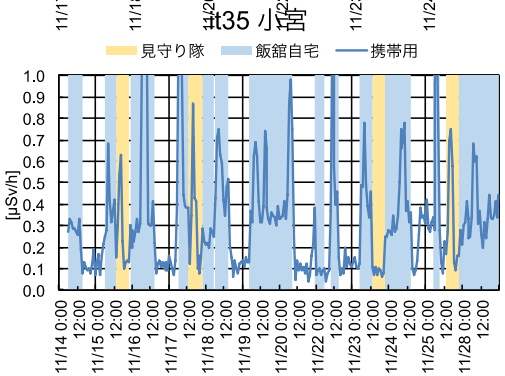
Examples of individual external dose profiles obtained by D-shuttle in Iitate village, 2015

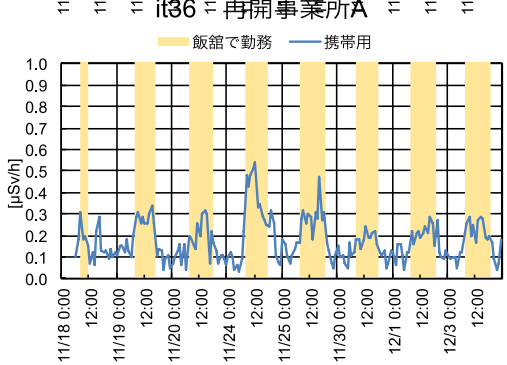


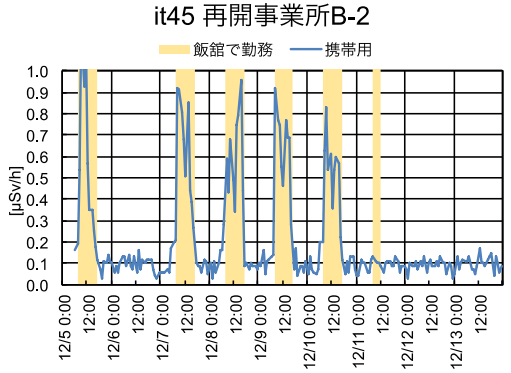


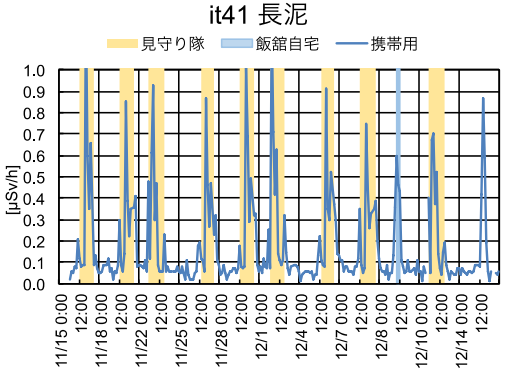












Horizontal axis : date

Vertical axis : dose [μSv/h]

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

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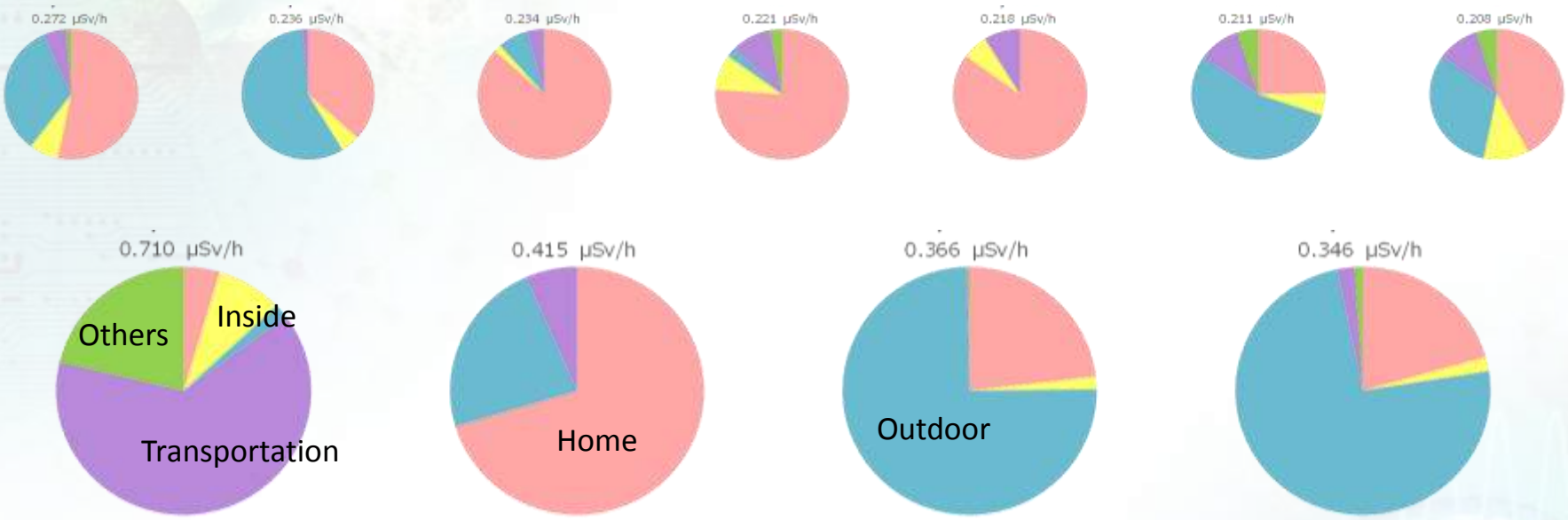
Examples of the source contributions to the accumulated dose for individuals



Personal dosimetry data with time-activity pattern information make it possible to identify source contributions to the total external dose.

Identifying contributions to the total external doses are important in determining effective dose reduction measures

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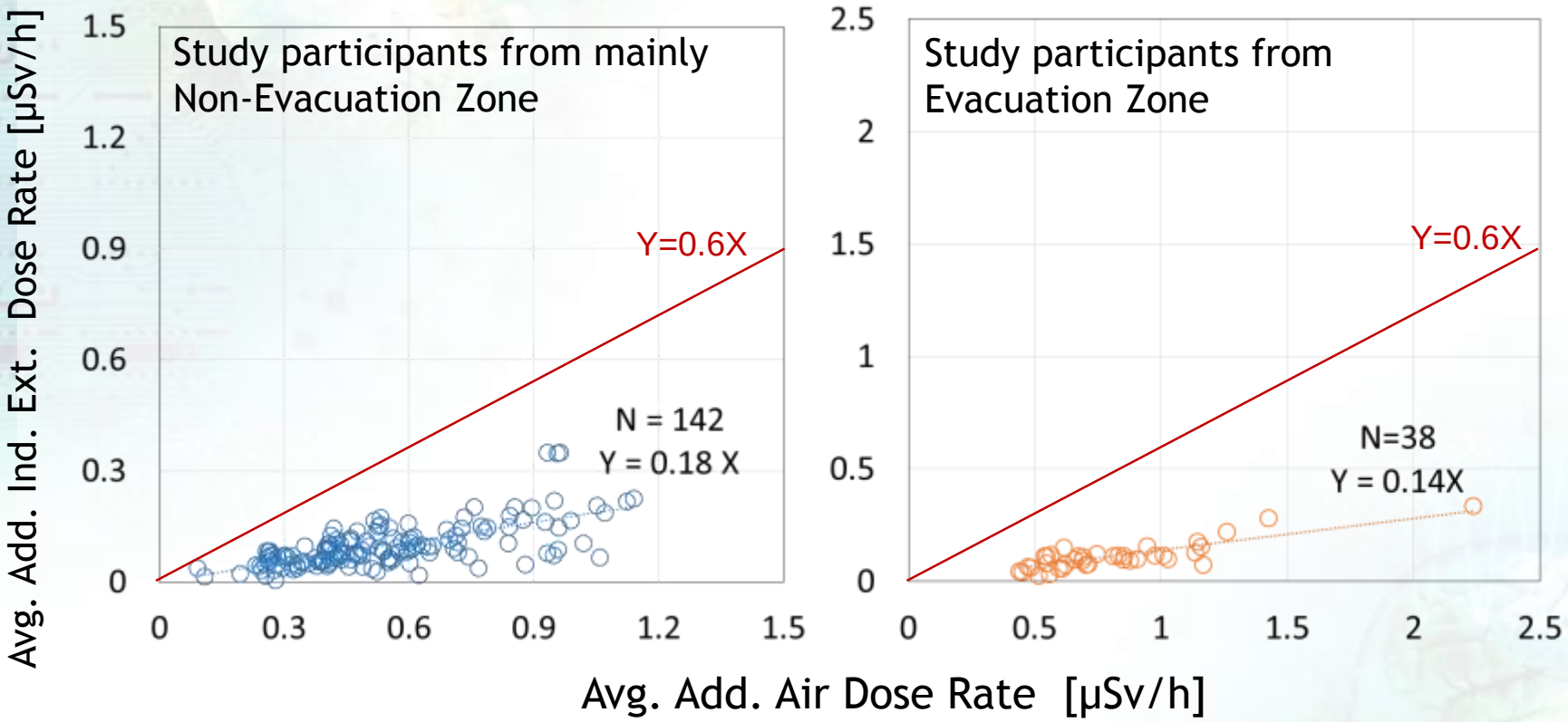
Relationship between individual external dose and ambient dose

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



Additional individual external doses obtained by D-shuttle were 0.18 and 0.14 times on average of the corresponding cumulative air doses based on the airborne monitoring for non-evacuation zone and evacuation zone, respectively.

Naito et al. 2016, 2017

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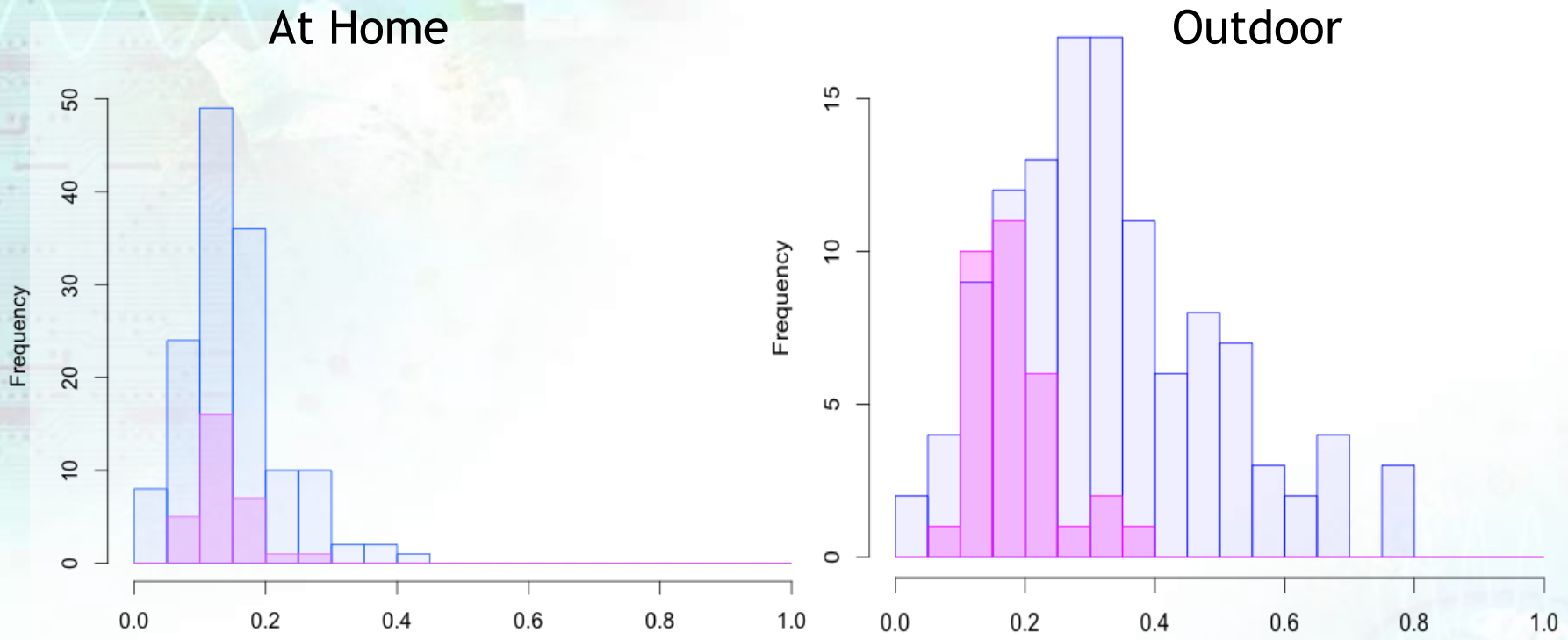
Distributions of Exposure Ratios (ER) for times spent at home and outdoor



ER (= Add. Ind. Dose/Add. Air Dose)

Purple : Data from Evacuation Zone (i.e., Iitate village) from Naito et al. (2017)
Blue : Data from Non-Evacuation Zone from Naito et al. 2016

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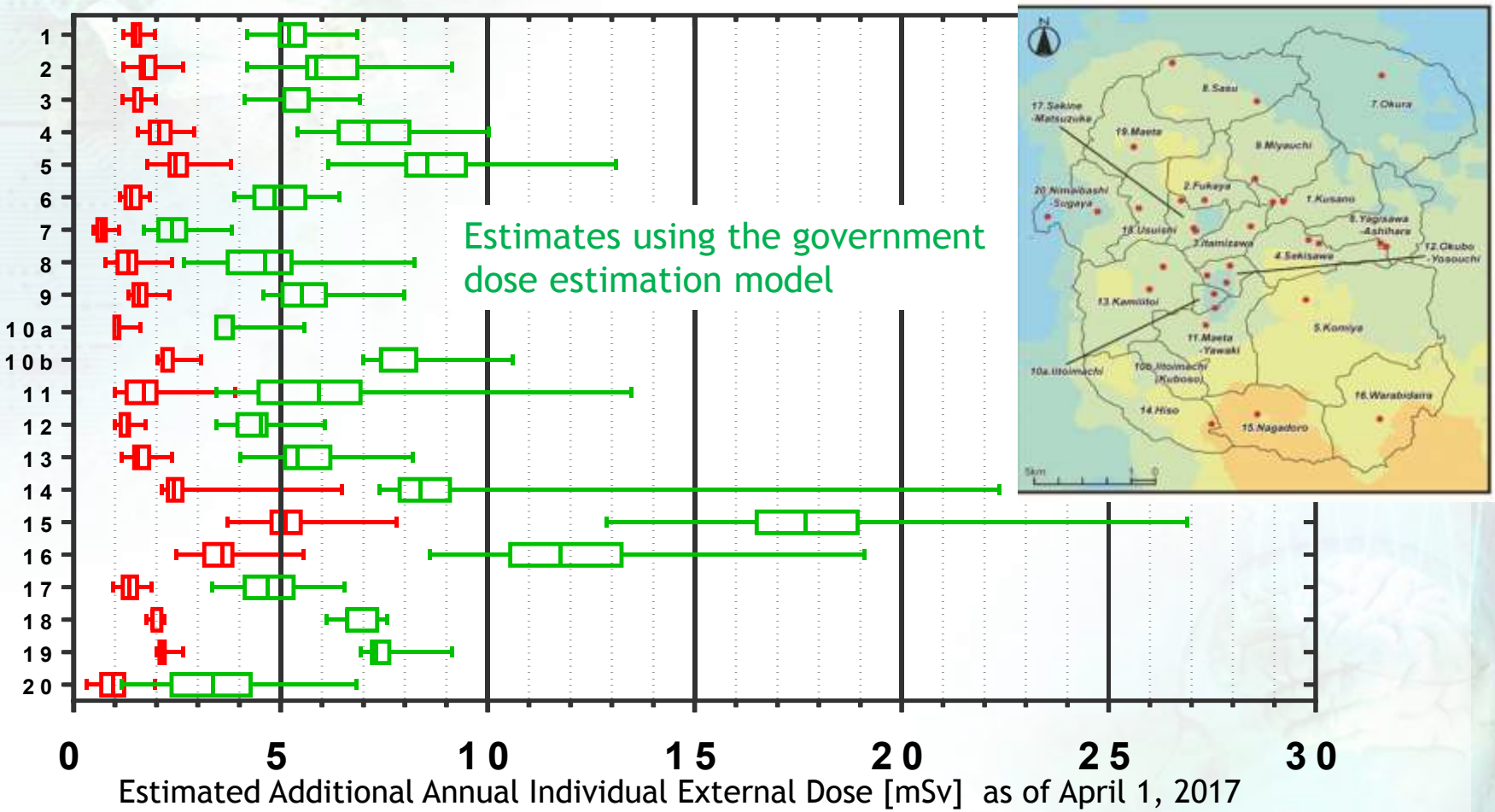
Distribution of Estimated Additional Individual External Doses in different administrative districts of the Iitate

Naito et al. (2017)

Assuming people stay 16 hours indoors and 8 hours outdoors



The estimates of individual external doses based on the result from our study were about ¼ of the estimates calculated by the government dose estimation model.

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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?)**
  - **1 mSv/yr** (e.g., because the government indicates this level is safe, in non-evacuation areas)
  - 2 mSv, but considering my grandchild, probably 1 mSv/yr would be better
  - I feel secure with the current levels (2-3 mSv)
  - **I don't care**
  - **5 mSv** (e.g., because this level is a realistic goal for the village)

- **What type of radiation information do you need to return to your home in the evacuation zone?**
  - **Future radiation dose** after returning to the village and its potential effects
  - **Personal dose information**, not just data from a monitoring post in the vicinity
  - **Information that helps my children and grandchildren understand** they can safely visit litate
  - How long I can stay outdoors safely
  - **Information to judge what data is accurate and trustworthy**

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

- **What do you think of your personal dose level (obtained by D-shuttle)?**
  - Higher than expected. I want to return, but achieving 1mSv-yr seems like a far goal; I request more decontamination efforts
  - Lower than expected, but 2-3 times higher than Fukushima City (at a temporary house)
  - Lower than expected (when I stayed in the village, I tried to stay inside my house)
  - It's my first time to see time trend of my dose, and it makes me feel secure
  - I understand differences between dose levels during times spent indoor and outdoor, overall it doesn't affect my way of living in Iitate.
  - I don't know (it is difficult to judge) because I have no information to compare it with
- **Do you feel secure when you see your own personal dose data?**
  - Measured data will surely help me understand and feel secure about radiation exposure around my house, but I haven't decided to return to my home
  - I don't know because I don't have any criteria for safety
  - I was relieved to know about locations where higher radiation levels were measured
  - I must accept the current level because I need to return to my home in Iitate anyway

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

- **Is the your radiation condition an important element for your decision to return to your home in Iitate after lifting the evacuation order?**
  - I used to worry about the radiation situation in Iitate, but I do not worry now
  - I feel secure after my doctor said the radiation level around my home is not a problem
  - Yes, 1 mSv is an important element for my decision to return to Iitate (considering other family members)

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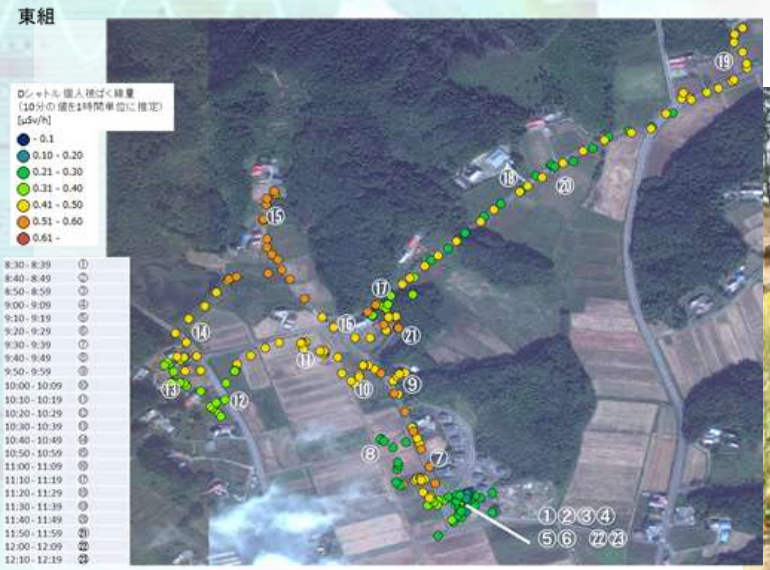
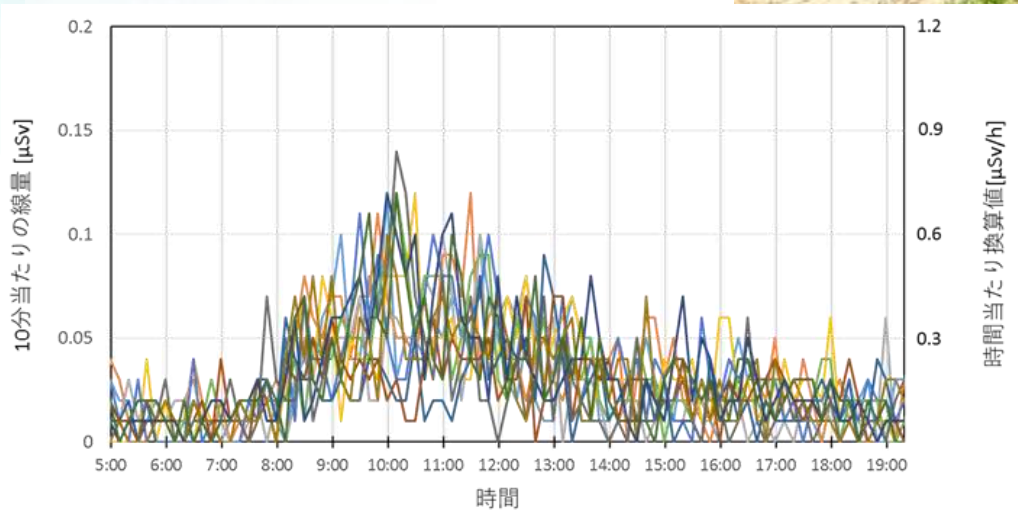
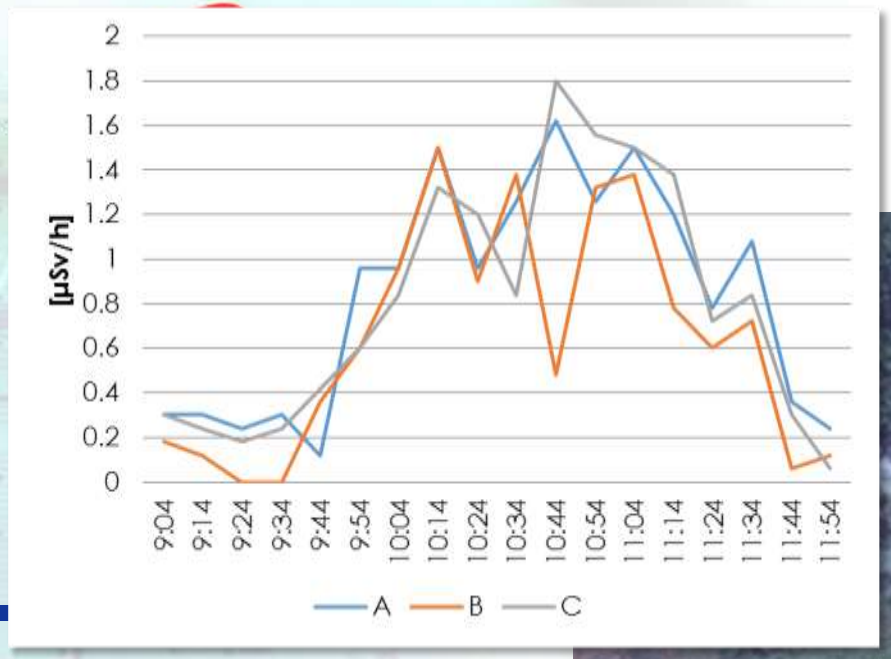
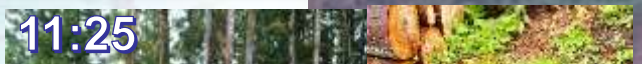
Other D-shuttle Examples: Measuring and sharing radiological situations with local people in Iitate









Measurements while collecting edible mountain plants in Iitate

[µSv/h]
- 0.12 - 0.30
- 0.31 - 0.60
- 0.61 - 1.00
- 1.01 - 1.30
- 1.31 - 1.62

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Individual dosimetry such as D-shuttle play a versatile role in Post Accident Recovery for residents and authorities

- Understanding realistic radiological situation in their life
- Self-protection and lessening the anxiety against radiation
- Selection of effective radiation dose mitigation strategies
- Estimation of future individual external dose
- Necessity for further radiation reduction measures
- Answering actual concerns from the affected residents for everyday life

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Caveats for the use of personal dosimetry in the post-accident recovery

- Differences between personal attitudes toward measurement data. Even when measurement values were the same, some participants felt relieved and some felt uneasy.
- Some residents were concerned when the peak dose was greater than the reference value in their time series data.
- Providing specific solutions for the affected residents to reduce individual external dose based on measurements may be difficult.

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Caveats for the use of personal dosimetry in the post-accident recovery

- Once the regulatory decisional reference value was set and penetrated to the public, it is very difficult to change or moderate the initial reference value
- The “Long-term” goal of 1 mSv (0.23 μSv/h) on the basis of a conservative assumption made a great impact on :
  - People’s lifestyle in the non-evacuation areas
  - People’s decision to return to the evacuation areas
  - Costs of decontaminations and time to lifting the evacuation order
- Difficult to explain :
  - Why is above 1 mSv and below 20 mSv/yr OK ?
  - Why we have to accept risk above 1 mSv/yr?
  - What is an acceptable level of risk, and how is an acceptable level of risk determined ?

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Not just measuring, but also important to prepare

- The system and human resource responding to anxiety of the residents caused after informing the results of measurement
- The system or mechanism responding to the results of measurement to provide (maybe implement) external dose reduction options by the support of authorities
- The system for authorities to utilize the individual dosimetry data to better understand realistic individual dose distribution of the population with care of personal information.

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Summary

- Use of individual dosimetry (D-shuttle) to measure, assess and communicate the individual external dose for residents and authorities in the affected areas
- Individual dosimetry play a versatile role in post accident recovery for residents and authorities in the affected areas
- Effectively utilizing individual dose measurement data during the post-accident recovery phase requires the preparedness responding to the measurement results

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Acknowledgements – Thanks -

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- Local officials from Iitate village and Kawamata town
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