19th EAN WORKSHOP
26th - 28th November 2019 - Athens

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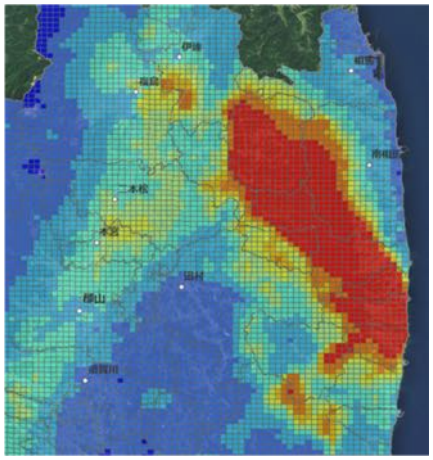
D-shuttle for the collection, capitalization and broadcasting of radiological data after radiological events

Wataru Naito, AIST, Japan

Pascal CROÜAIL, CEPN, France



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Correctly understand and assess realistic individual external doses are important after radiological event

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

Monitoring post

Real-time dosimeter

Airborne radiation monitoring

http://jolis/fukyu.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.

The government proposed to use personal dosimeter for a practical measures for evacuees to return to their homes.

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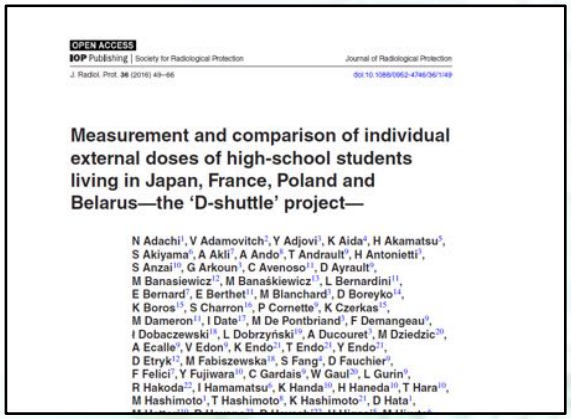
An Innovative Personal Dosimeter - D-shuttle-

AIST's own miniaturization and energy efficiency technologies using microelectromechanical systems (MEMS) made it possible to develop a compact design dosimeter

- 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 many municipalities and researches in Fukushima



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IOP Publishing | Society for Radiological Protection — Journal of Radiological Protection
J. Radiol. Prot. 36 (2016) 49–66 — doi:10.1088/0952-4746/36/1/49

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

N Adachi[1], V Adamovitch[2], Y Adjovi[3], K Aida[4], H Akamatsu[5], S Akiyama[6], A Akli[7], A Ando[8], T Andrault[9], H Antonietti[3], S Anzai[10], G Arkoun[3], C Avenoso[11], D Ayrault[9], M Banasiewicz[12], M Banaśkiewicz[13], L Bernardini[11], E Bernard[7], E Berthet[11], M Blanchard[3], D Boreyko[14], K Boros[15], S Charron[16], P Cornette[9], K Czerkas[15], M Dameron[11], I Date[17], M De Pontbriand[3], F Demangeau[9], I Dobaczewski[18], L Dobrzyński[19], A Ducouret[3], M Dziedzic[20], A Ecalle[9], V Edon[7], K Endo[21], T Endo[21], Y Endo[21], D Etryk[12], M Fabiszewska[18], S Fang[4], D Fauchier[9], F Felici[7], Y Fujiwara[10], C Gardais[9], W Gaul[22], L Gurin[9], R Hakoda[23], I Hamamatsu[4], K Handa[10], H Haneda[10], T Hara[10], M Hashimoto[1], T Hashimoto[5], K Hashimoto[21], D Hata[1],

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Specifications

Dosimeter

Radiation detected	Gamma-ray
Calibration	Calibrated by ^{137}Cs gamma-ray
Detector	Silicon semiconductor
Measurement range	Total dose : 0.1μSv to 99.9999mSv
Alarm	The LED in the dosimeter will flash to report high dose rate
Memory	Record hourly dose
Power	One lithium battery (with special connector)
Battery life	Approx. 1 year (when dose is read with indicator twice a day)
Size	Approx. 68mm(H)×32mm(W)×14mm(D)
Mass	Approx. 23g
Delivery system	Dose is set to zero when dosimeter is shipped out from our calibration facility

Chiyoda Technol. (2013)

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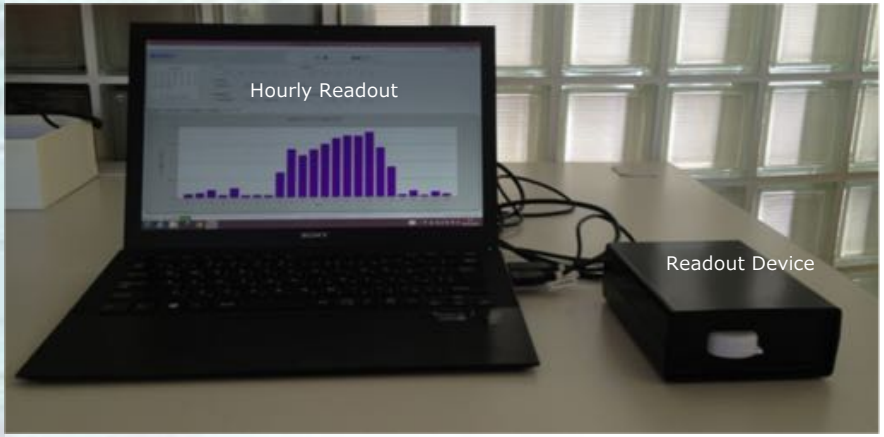
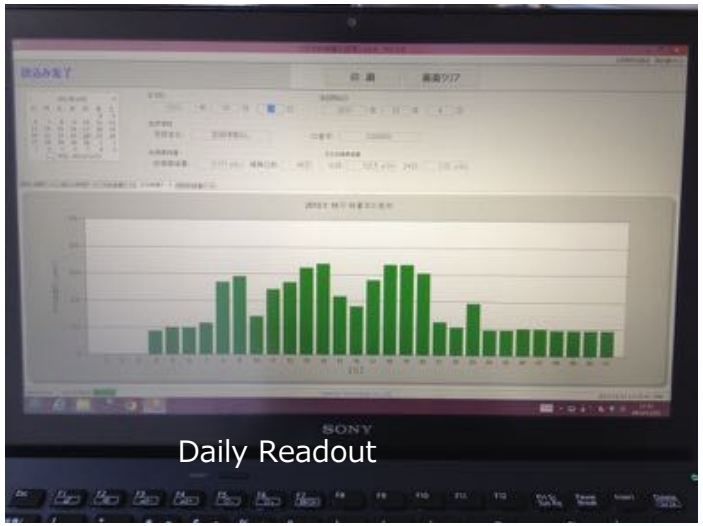
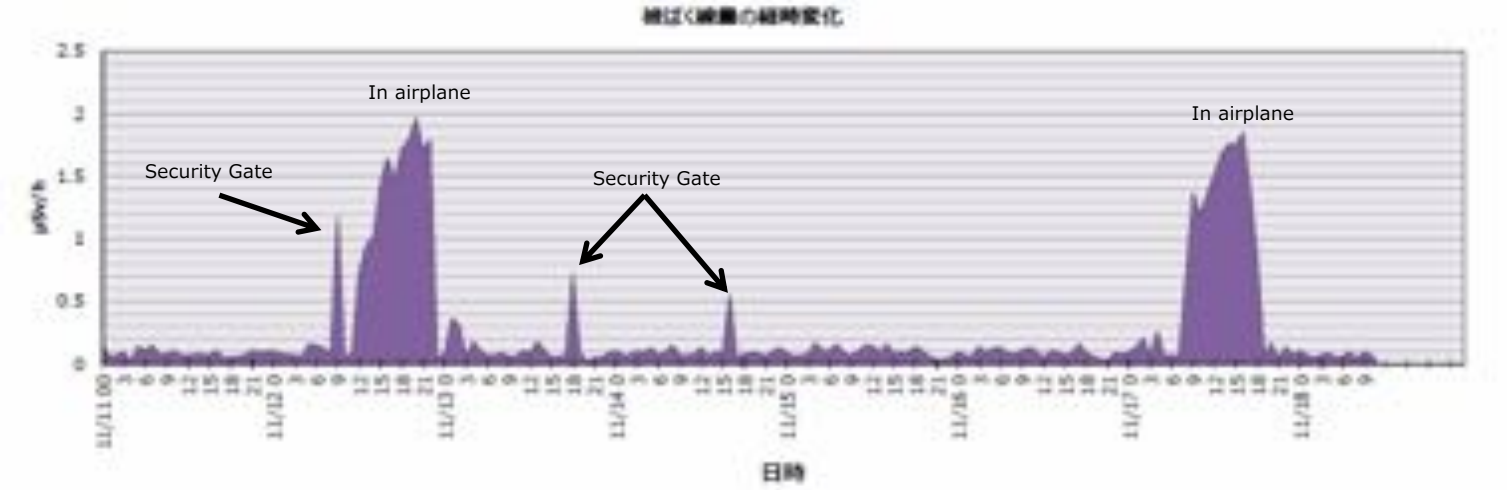
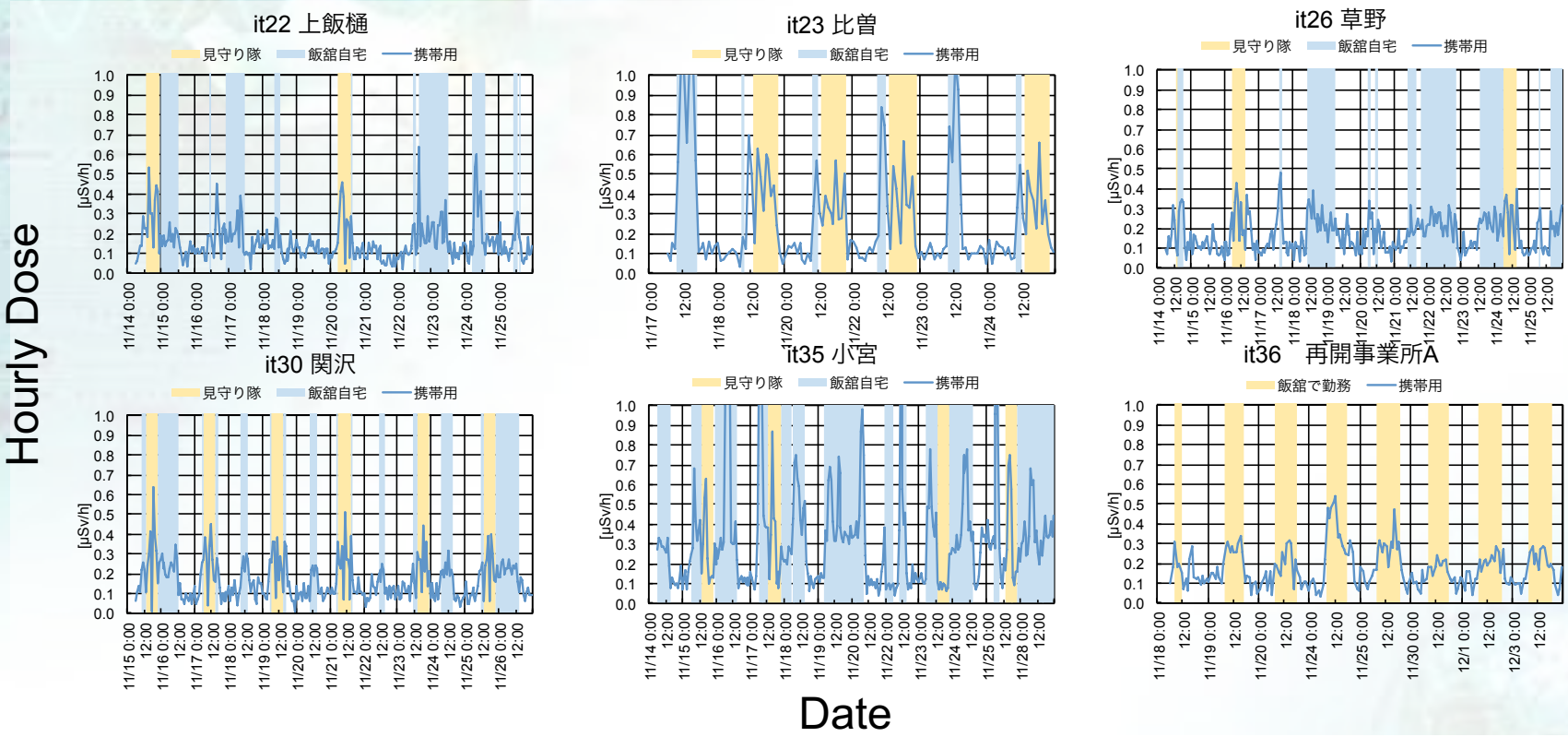
Readout from D-shuttle



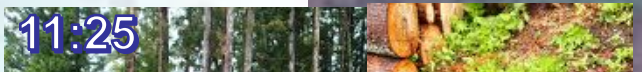




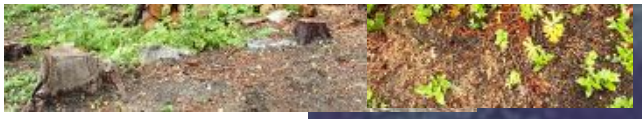
Examples of individual external dose profiles obtained by D-shuttle in Iitate village, Fukushima



- External dose profiles vary depending on activity patterns and locations of individuals.
- D-shuttle provides reliable information for residents to understand the radiation situation in their daily life.



Measuring individual dose using D-shuttle while picking mountain plants in mountain



[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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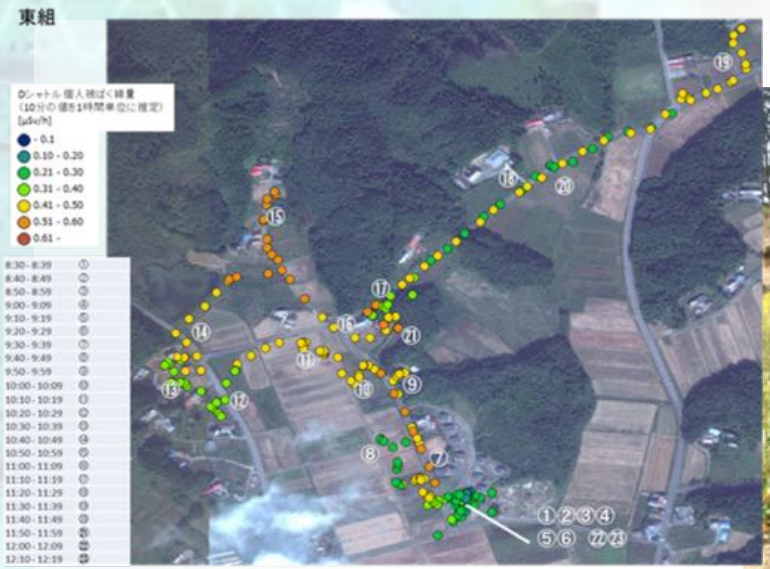
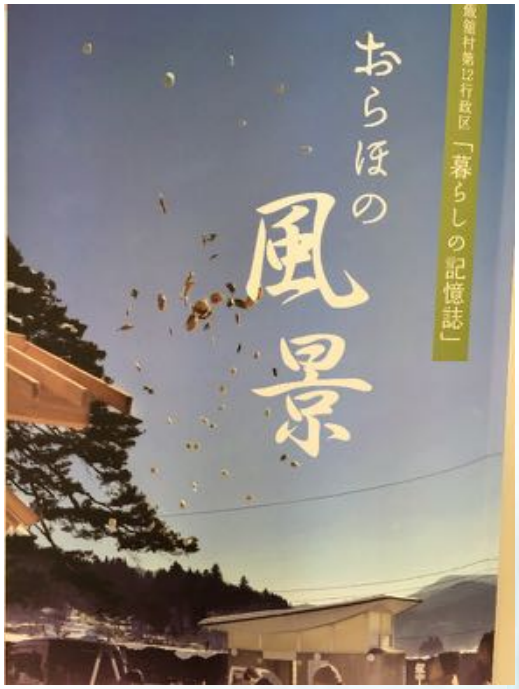
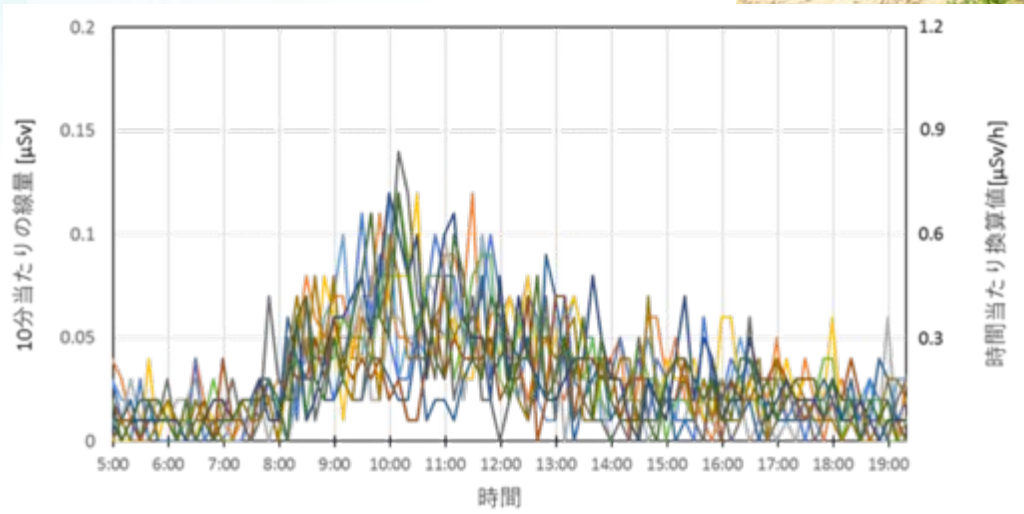
Measuring and sharing radiological situations with local people in litate



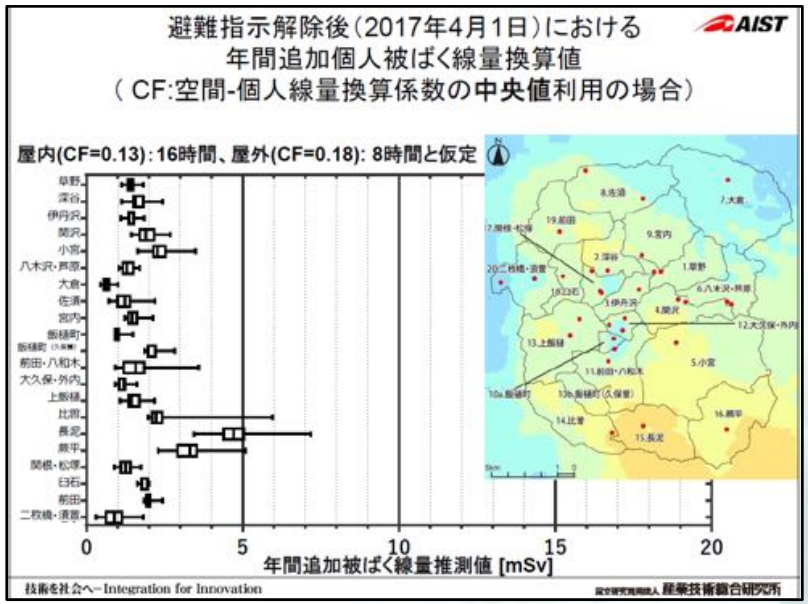




D-Shuttle measurements provide a scientific evidence to support regulatory decisions

Predicted annual additional external doses of farmers living Yamakiya, Kawamata-town

District	Predicted annual additional external dose 〔mSv〕		
	April, 2016	September, 2016	April, 2017
1 区	1.3 [0.8 - 1.8]	1.2 [0.7 - 1.7]	1.1 [0.7 - 1.6]
甲2区	1.5 [0.8 - 2.3]	1.4 [0.8 - 2.2]	1.3 [0.7 - 2.0]
乙2区	1.6 [1.1 - 2.3]	1.5 [1.0 - 2.2]	1.4 [0.9 - 2.1]
3 区	1.1 [0.6 - 1.7]	1.0 [0.6 - 1.6]	1.0 [0.5 - 1.5]
4 区	1.0 [0.6 - 1.6]	0.9 [0.5 - 1.5]	0.9 [0.5 - 1.4]
5 区	1.1 [0.5 - 1.9]	1.1 [0.5 - 1.8]	1.0 [0.5 - 1.7]
6 区	1.6 [0.9 - 2.3]	1.5 [0.8 - 2.2]	1.4 [0.8 - 2.1]
7 区	1.8 [1.0 - 2.5]	1.7 [1.0 - 2.4]	1.6 [0.9 - 2.3]
甲8区	1.2 [0.6 - 2.4]	1.2 [0.5 - 2.2]	1.1 [0.5 - 2.1]
乙8区	2.9 [1.2 - 5.2]	2.7 [1.1 - 5.0]	2.6 [1.1 - 4.6]
9 区	0.8 [0.5 - 1.4]	0.8 [0.5 - 1.3]	0.7 [0.5 - 1.2]



Our results based on D-shuttle were used as a reference scientific evidence by local (e.g., Iitate village and Yamakiya, Kawamata-town) and national (e.g., NRC) authorities to understand realistic individual external dose levels in the evacuation areas

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Evaluatedose levels from external exposure among returnees to former no-go zones after the government lifted the evacuation orders using D-shuttle

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IOP Publishing | Society for Radiological Protection Journal of Radiological Protection
J. Radiol. Prot. 00 (2019) 1–18 (18pp)

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

N=239 (279)

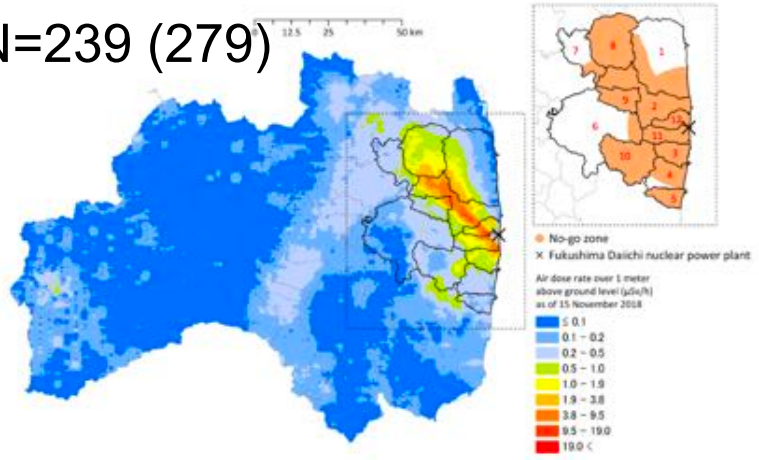


Figure 1. Geographical scope of the location of 12 municipalities in Fukushima Prefecture. 1: Minamisoma City, 2: Namie Town, 3: Tomioka Town, 4: Naraha Town,

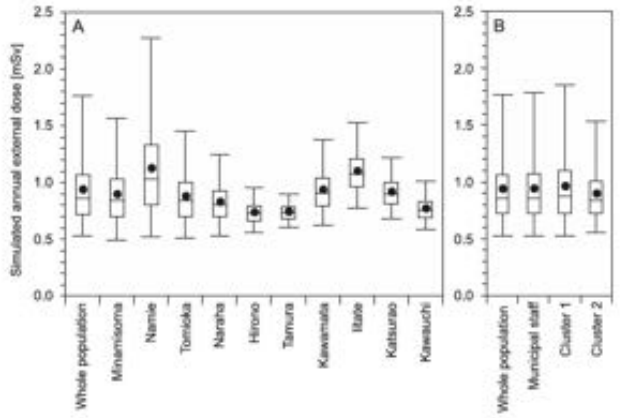


Figure 4. Box plots of the distributions of the MC simulated annual external doses. (A) The whole population and each municipality and (B) subgroups. The box plots show 95% uncertainty intervals (2.5th and 97.5th percentiles: whiskers) as well as 25th, median (50th), and 75th percentiles (box). Closed circles represent mean doses.

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

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

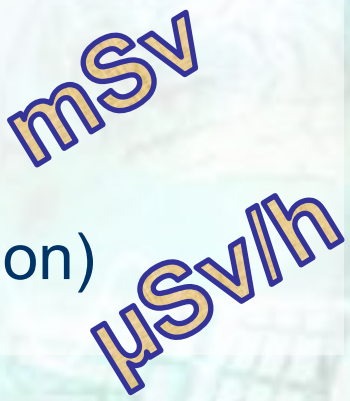
Nomura et al.(In Press)

Citizen Science project

- Analyze the variability of dose and dose rates at the scale of a village
- Allow young local people to tackle the present situation
- Develop radiation protection culture of the population within the village

Analysis of external dose profiles (D-Shuttle)

Measurement of ambient doserates (OpenRadiation)



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Location of Kamaryn village (in Belarus)

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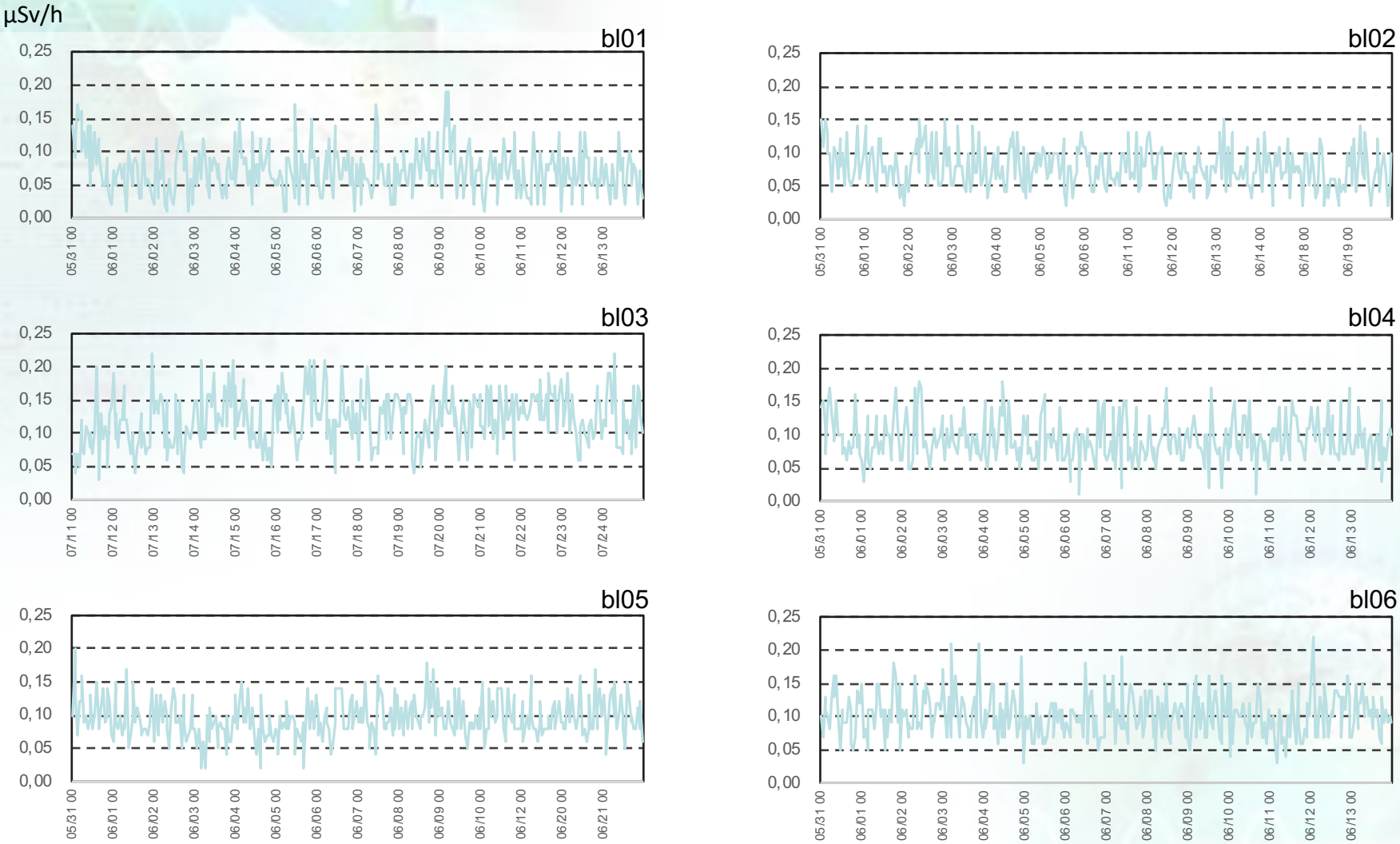
Understanding variability of individual external doses using D-shuttle in Komarin, Belarus



No strange (or concerned) time series variations

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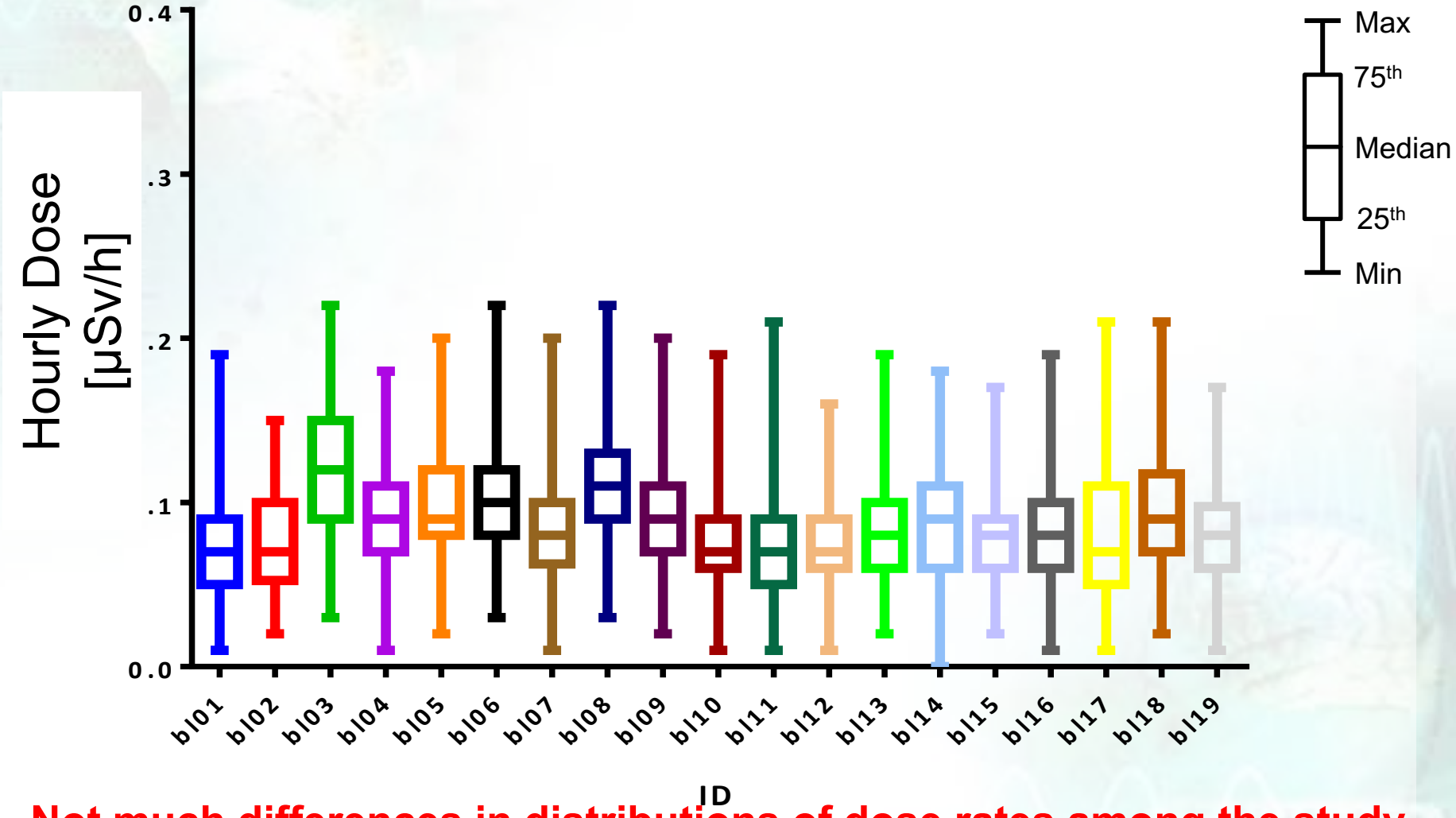
Comparison of Individual External Doses for the Study Participants in Komarin



Not much differences in distributions of dose rates among the study participants

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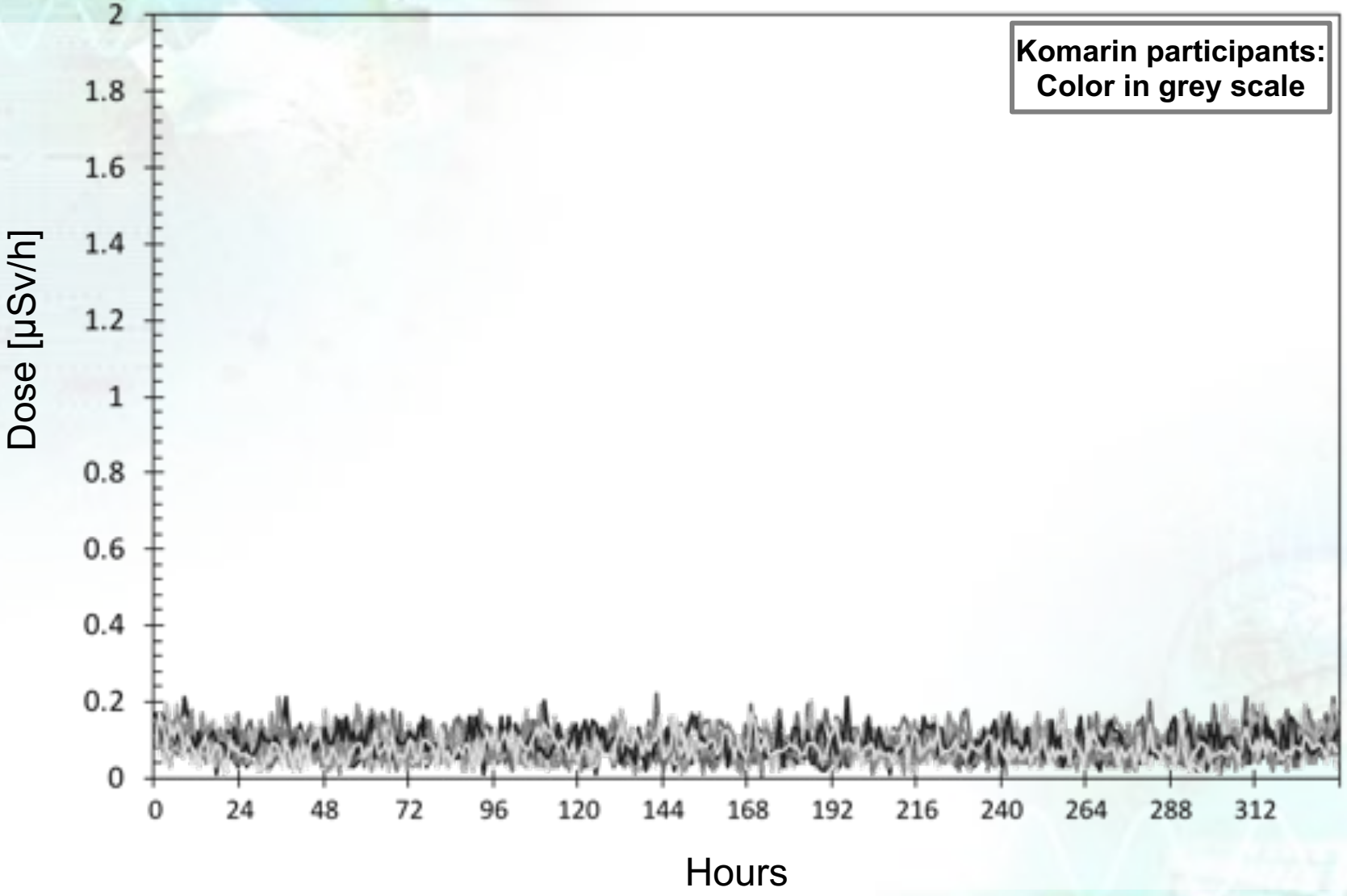
Comparaison des profils de doses externes à Komarin et à Fukushima （Quelques Exemples - 1/4)



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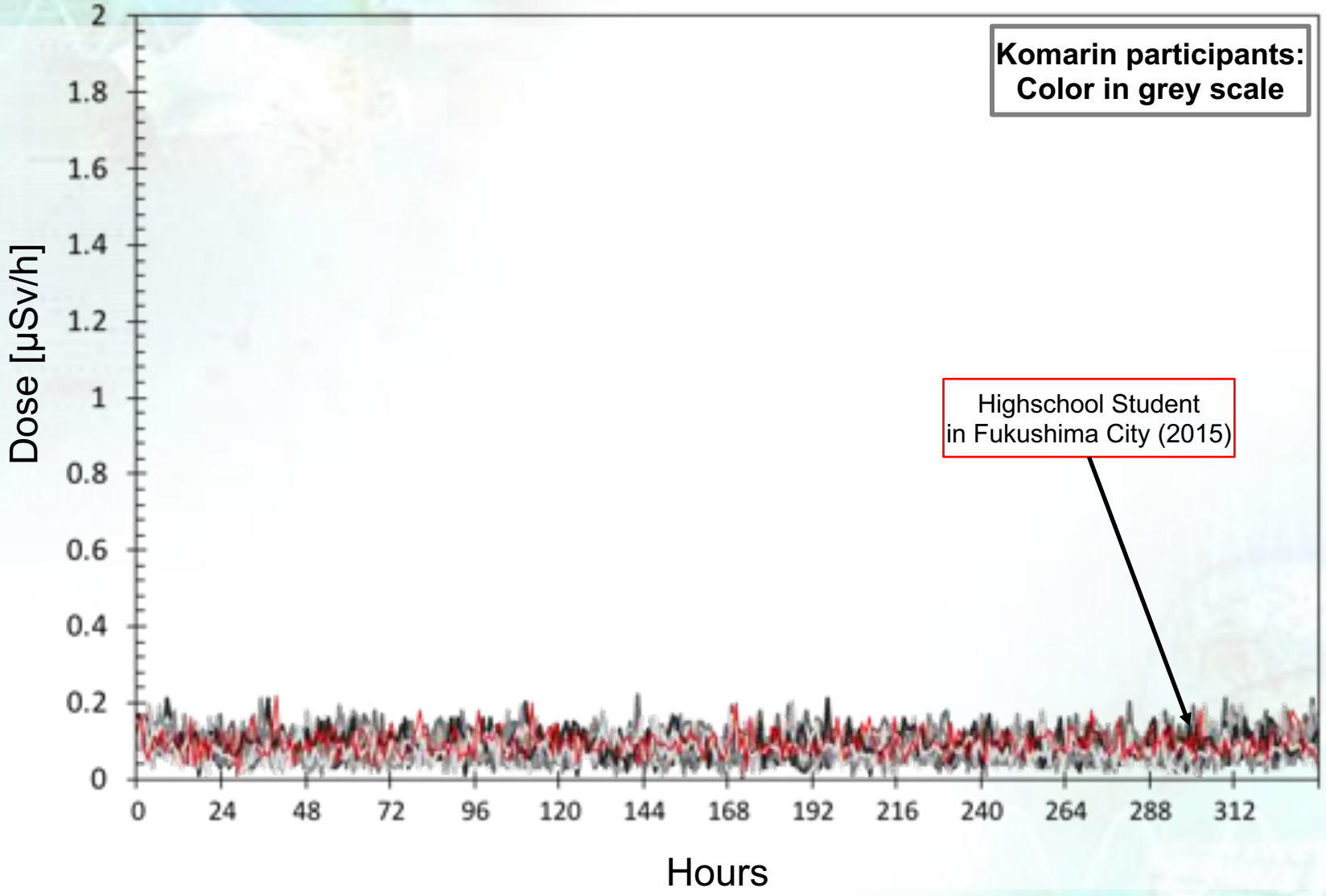
Comparaison des profils de doses externes à Komarin et à Fukushima (Quelques Exemples - 2/4)



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Comparaison des profils de doses externes à Komarin et à Fukushima (Quelques Exemples - 3/4)

Komarin participants: Color in grey scale

Arboriculteur à Date City (2013)

Etudiant à Fukushima City (2015)

Dose [μSv/h]

2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0

0 24 48 72 96 120 144 168 192 216 240 264 288 312

Hours

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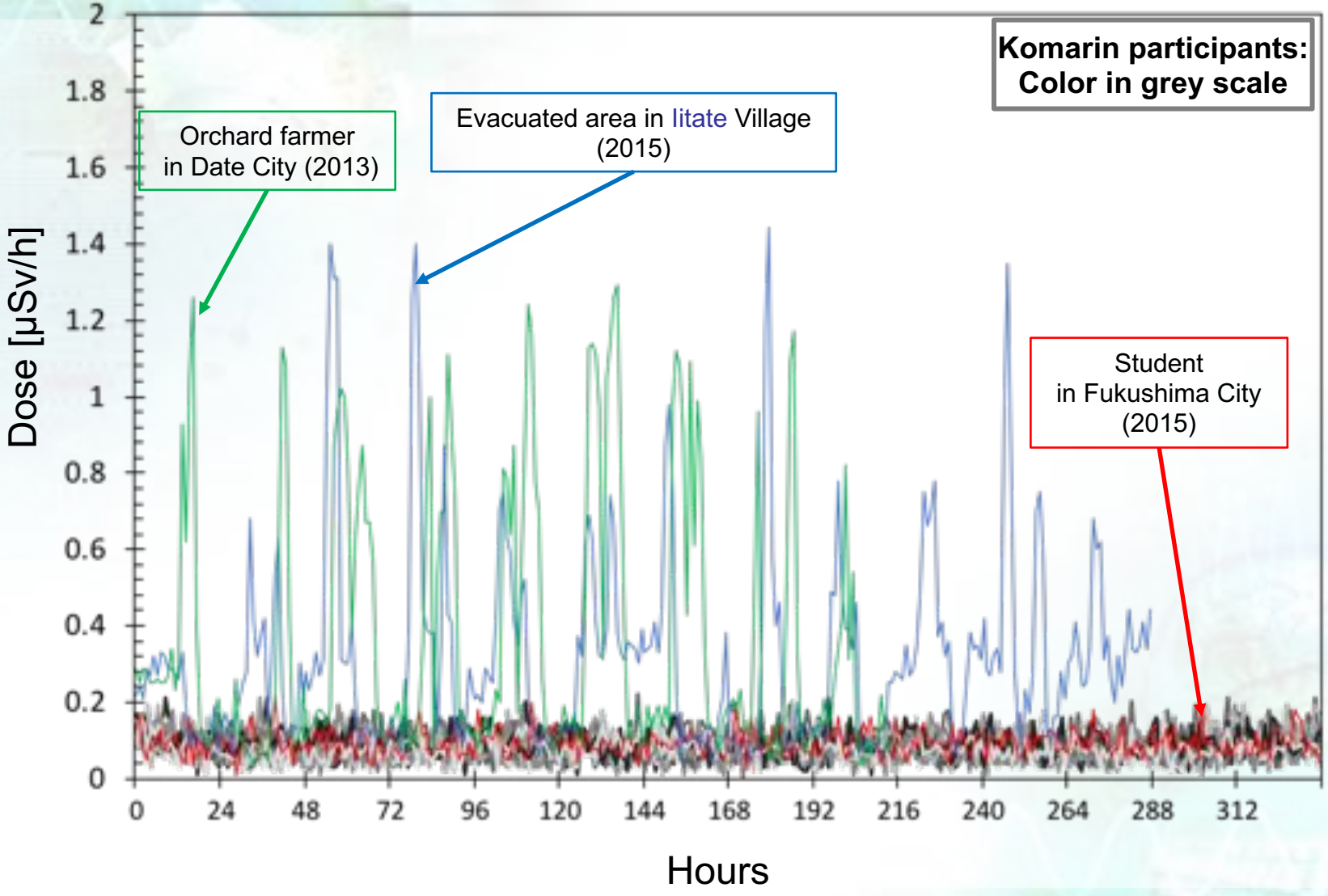
Comparaison des profils de doses externes à Komarin et à Fukushima (Quelques Exemples - 4/4)



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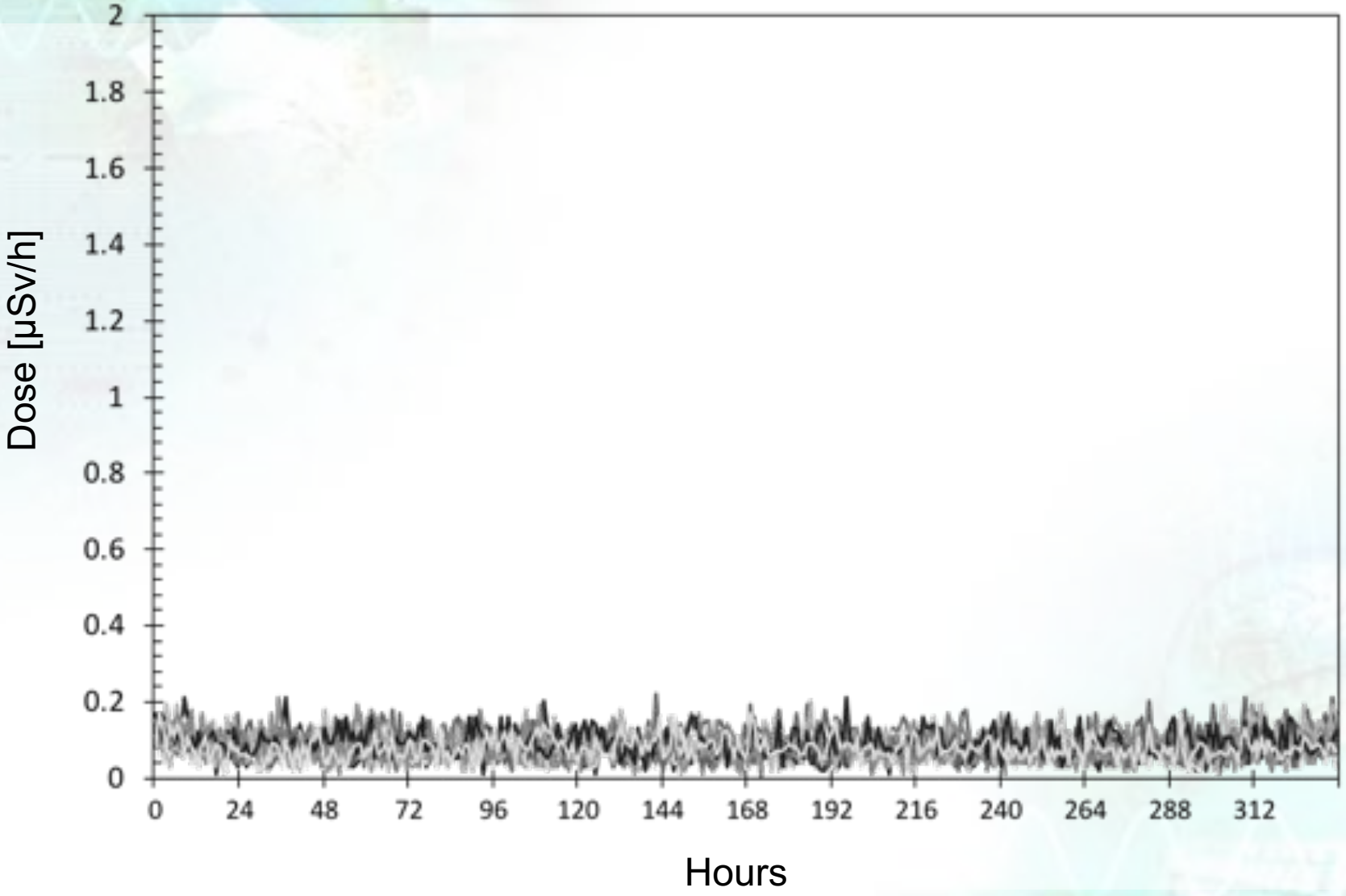
Profils de doses externes à Komarin



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The open radiation project

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How open radiation works?

Sensor (Radiameter)

Bluetooth

- Kit (do it yourself)
- User friendly

Mobile phone App.

Public Application Programme Interface
openradiation.net

Map

Data access

Data files

Database

-
Opensource
- Opendata

Website

- Crowdsourcing

openradiation.org

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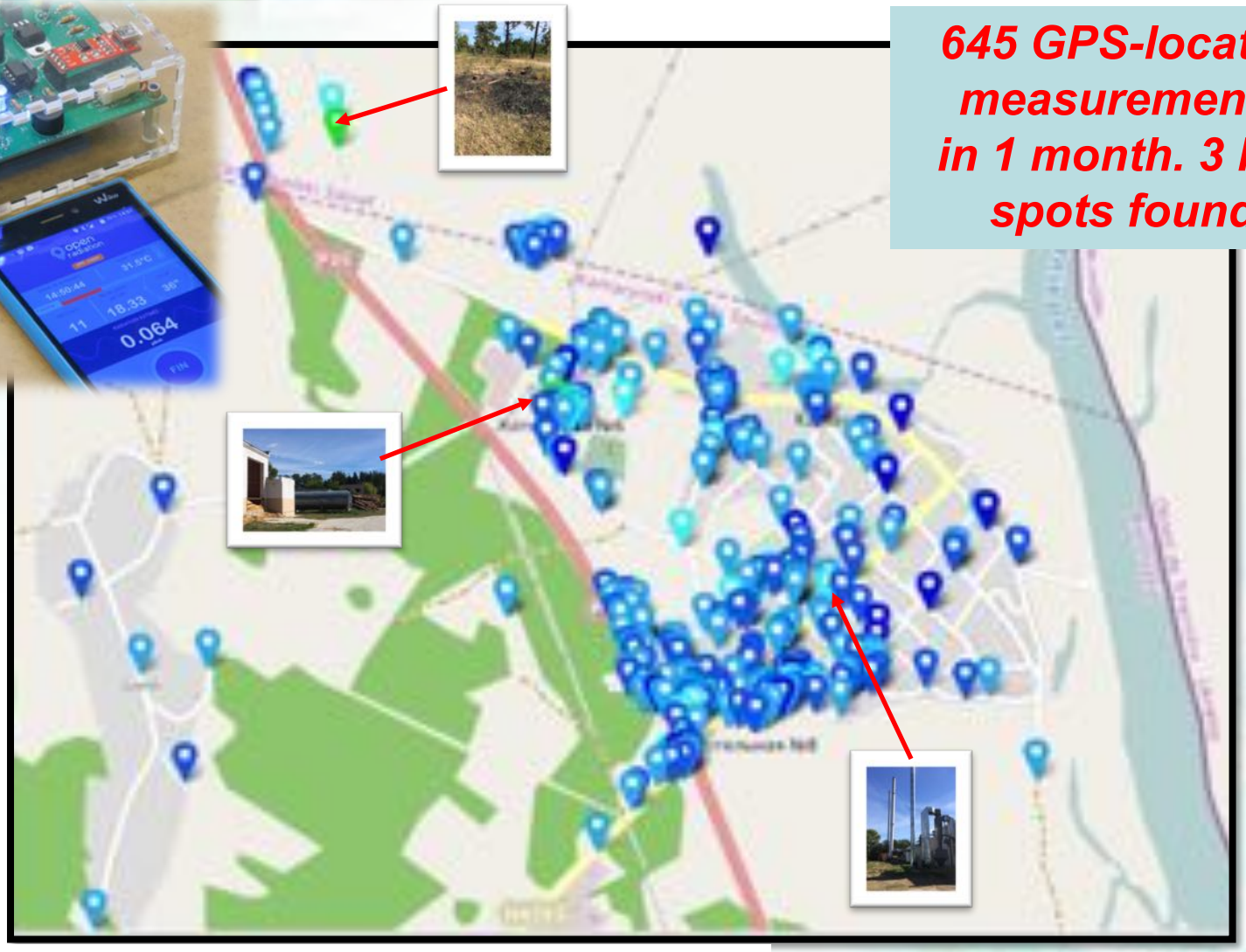
Village mapping

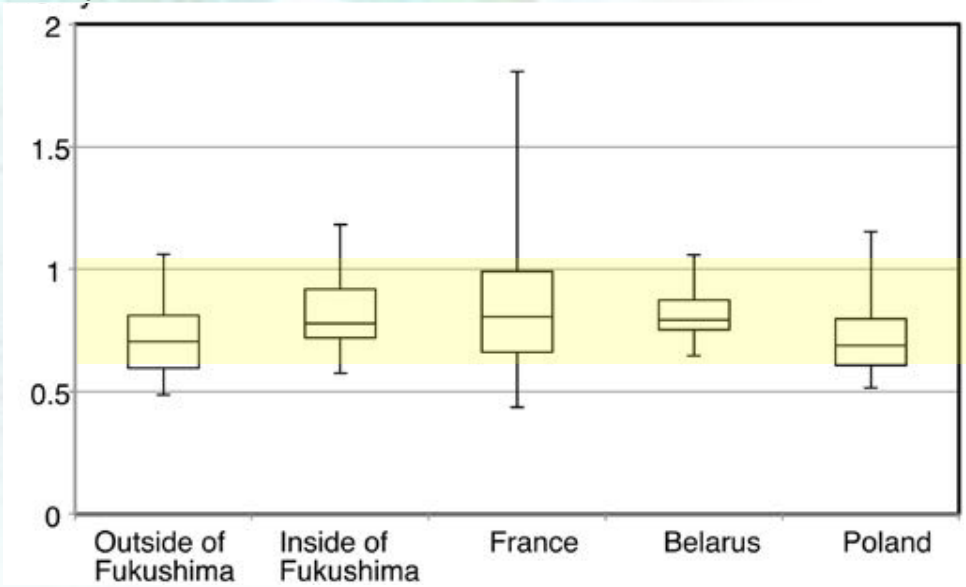


645 GPS-located measurements in 1 month. 3 hot spots found

Each dot represents one measurement at a single place

Comparison of Individual External Doses (Annual Dose) with the results of the Previous Study

mSv/year



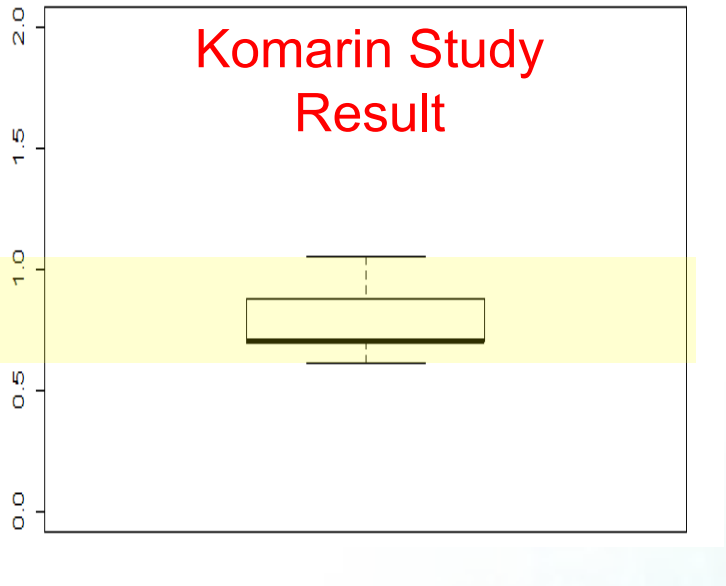


Figure 9 from Measurement and comparison of individual external doses of high-school students living in Japan, France, Poland and Belarus—the 'D-shuttle' project—
N Adachi et al 2016 J. Radiol. Prot. 36 49 doi:10.1088/0952-4746/36/1/49

Individual external doses in Komarin (including natural radiation) are well within the range of estimated annual doses due to the terrestrial background radiation level of other regions.

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D-shuttle play a versatile role after the Fukushima accident for residents and authorities

- Understanding realistic radiological situation in their life
- Answering actual concerns from the affected residents for everyday life
- Fostering self-protection and improving the selection of effective radiation dose mitigation strategies
- Lessening the anxiety against radiation
- Giving a new role to experts and authorities (backing, interpretation, support, financing) who have to work with people at risk.
- Estimation of more realistic future individual external dose
- Necessity for further radiation reduction measures
- Improving radiation protection culture (and its transgenerational passage)