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Materials(Data)

Distribution of Dose Rates Due to Fallout from the Fukushima Daiichi Reactor Accident

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A number of dose rate data taken after the Fukushima Daiichi reactor accident occurred have been collected through official websites of prefectural governments. Subtracting natural background dose rates from these data, contributions due to fallout alone were evaluated. A train-borne survey was carried out to verify the accuracy of the contour map. The dose rate variation pattern obtained by the survey coincided fairly well with that of the map.

Key Words : dose rate, map, fallout, Fukushima Daiichi Nuclear Power Station

1. Introduction

For the purpose of presenting a contour map showing γ-ray dose rates due to radioactivities released by the Fukushima nuclear reactor accident, a total of 821 data have been collected through official websites of prefectural governments. Background γ-ray dose rates are subtracted from these data to derive increments above background levels. Next, an inverse distance weighted technique is applied to the background-subtracted data to obtain a contour map. Finally, train-borne measurements are compared with the map data in order to verify the validity of the map.

2. Basic data

Table 1 gives a list of uniform resource locators where we cited to collect basic data. Figure 1 shows the sites surveyed by the prefectural governments listed in Table 1. The measurements were carried out during the period 21 May − 4 August, 2011.

Table 1 Websites accessed for collecting basic data

http://www.pref.aomori.lg.jp/
http://www.pref.iwate.jp/
http://www.pref.miyagi.jp/
http://www.pref.akita.lg.jp/
http://www.pref.yamagata.jp/
http://wwwcms.pref.fukushima.jp/
http://www.pref.ibaraki.jp/
http://www.pref.tochigi.lg.jp/
http://www.pref.gunma.jp/
http://www.pref.saitama.lg.jp/
http://www.pref.chiba.lg.jp/
http://www.metro.tokyo.jp/
http://www.pref.kanagawa.jp/
http://www.pref.niigata.lg.jp/
http://www.pref.yamanashi.jp/
http://www.pref.nagano.jp/
http://www.pref.shizuoka.jp/
http://www.pref.toyama.jp/
http://www.pref.gifu.lg.jp/
http://www.pref.aichi.jp/
http://radioactivity.mext.go.jp/ja/monitoring_by_prefecture_survey_meter/

The original data were taken with various types of survey-meters. We, however, just accept the values of original data, assuming that these instruments have already been calibrated adequately (Approximation 1).

Those data are represented in units of Gy or

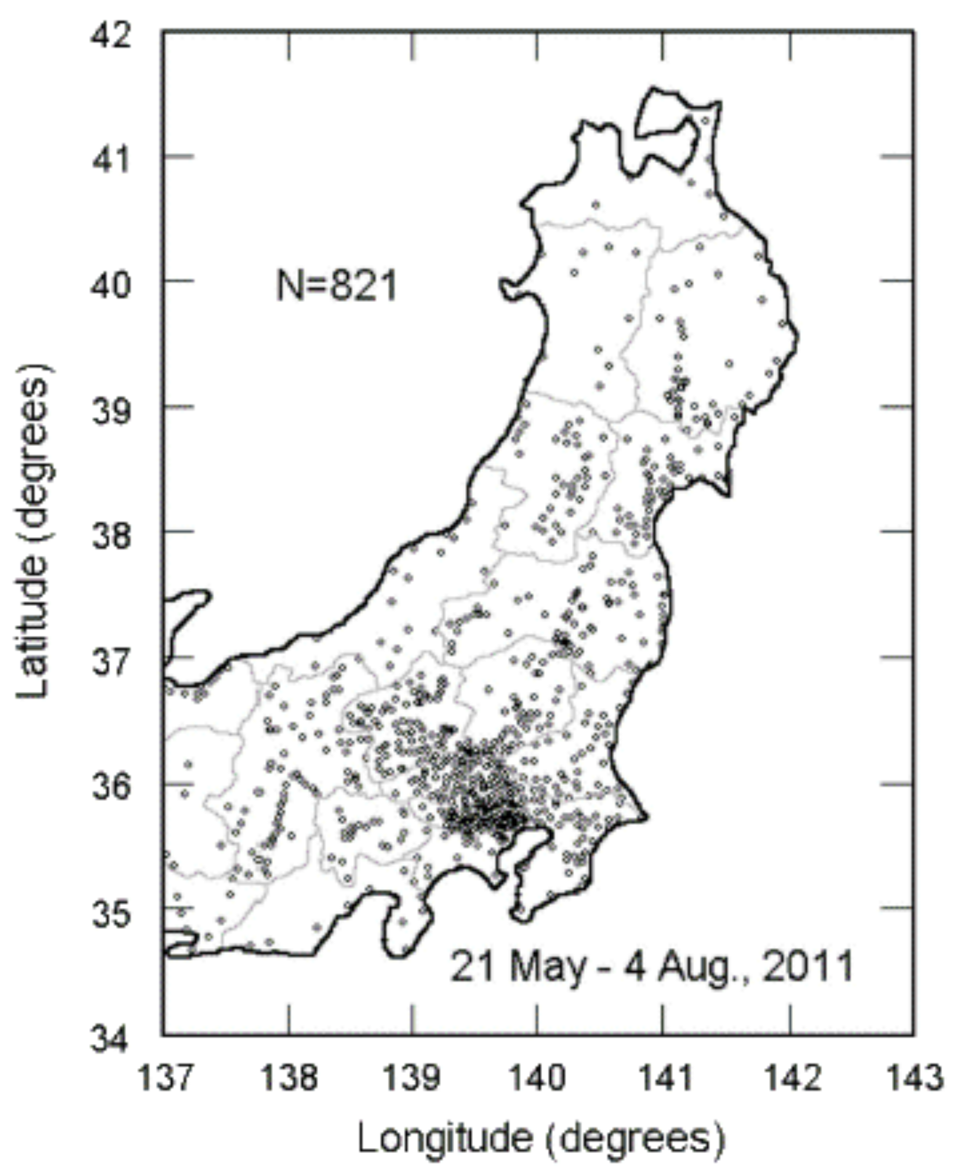

Fig. 1 Map showing the surveyed sites.

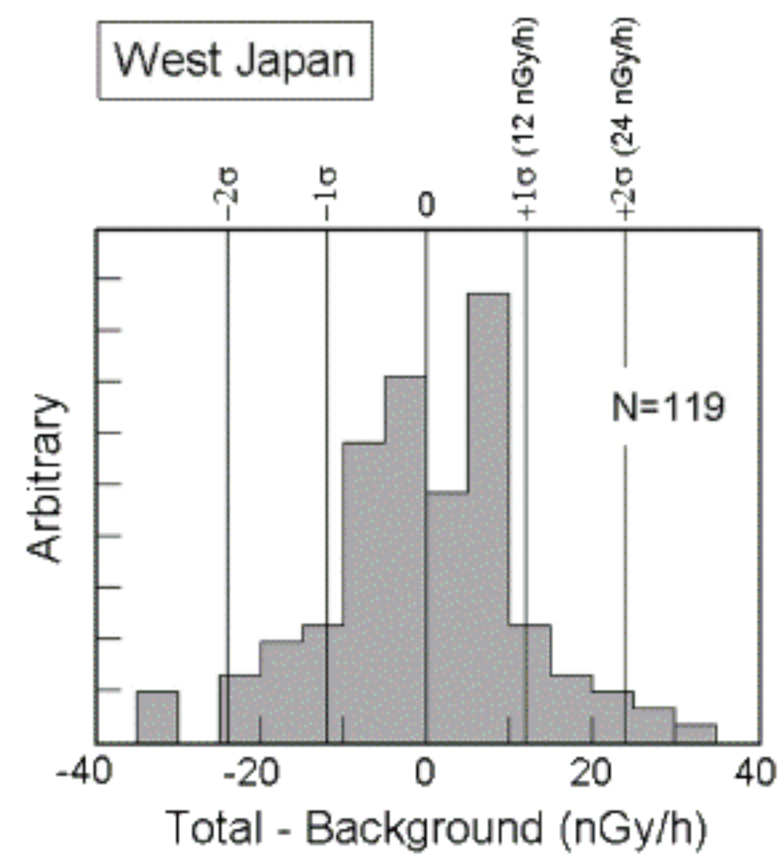

Fig. 2 Frequency distribution of the residuals after background subtraction in west Japan.

Sv. As for Sv, we use a conversion factor 0.82 evaluated by Moriuchi et al.[1] to convert it into Gy. Although the value 0.82 is for a natural environmental γ-ray spectrum, we adopt this as an approximate value for the fallout spectrum, too (Approximation 2).

In order to evaluate the dose rate due to fallout alone, we have to subtract a background γ-ray dose rate from a total dose rate at each site. Minato[2] has given a map showing background γ-ray dose rates in the Japanese Islands. These data were taken on/over soil surfaces. On the other hand, the prefectural governments' surveys were performed at a variety of situations in addition to soil, e.g., park, school-ground, and paved-road. Nevertheless, we use Minato's background data (Approximation 3) for convenience, since it is difficult to derive a universal regression formula for converting the prefectural data into the corresponding soil dose rates.

The fallout data were unified in this way. However, those data may include errors to some degree because of the above-mentioned three approximations. Let us check the magnitude of error caused by these approximations.

It is believed that there is extremely little influence of the Fukushima fallout on west Japan. Hence, we can examine the error due to subtraction of background from total dose rate using the data taken in the prefectures of west Japan (at longitudes less than 136.5 degrees). Figure 2 shows the frequency distribution. The data of west Japan were collected through the official website of the ministry of education, culture, sports, science and technology of Japan (See the bottom row of Table 1), which were taken after the accident. A standard deviation of the distribution amounts to 12 nGy/h.

3. Map

Figure 3 shows the contour map drawn by means of the inverse distance weighted method, where the weight is inversely proportional to the fifth power of the distance for the entire data[2]. Here, the dose rate level is divided into 8 groups for convenience, where 1σ (12 nGy/h) and 2σ (24 nGy/h) levels mentioned just above are also included.

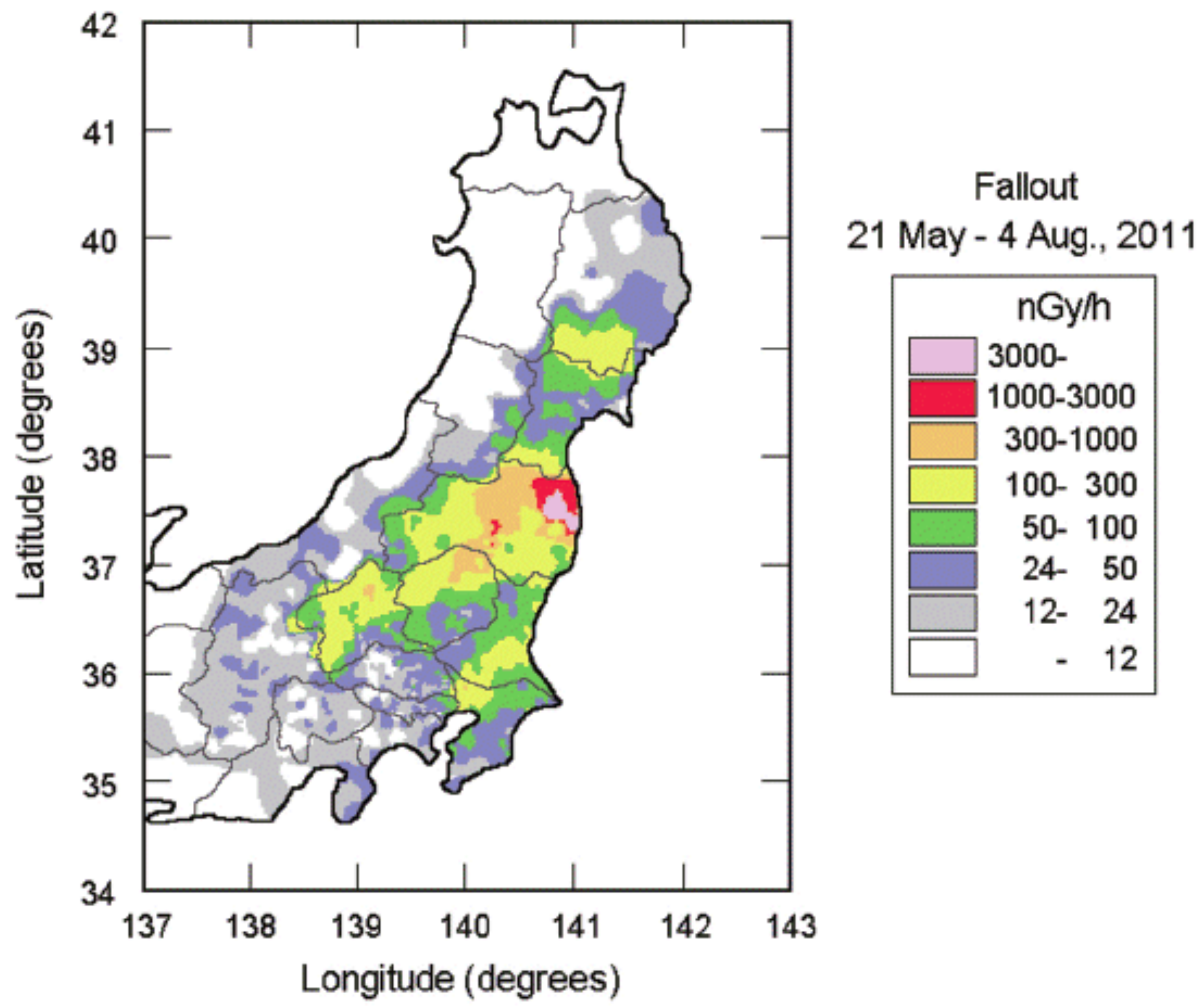

Fig. 3 Contour map of the fallout γ-ray dose rates 1 m above ground level (Refer to Fig. 2 as for the division of dose rates in the legend).

4. Comparison with traine-borne measurements

Figure 4 shows a comparison between the contour map obtained in this study and data taken with Tohoku Shinkansen (Bullet train)[3]. The background dose rates in Fig. 4 b) had been measured before the accident occurred. We notice a great increase between Utsunomiya and Sendai stations. Rapid decreases within this section are due to shielding effect by tunnels. On the other hand, in the background γ-ray measurements inside the tunnels, the dose rates increase considerably because of the geometrical condition of natural radioactivity, which are seen here and there in the background data in Fig. 4 b).

The natural gamma and fallout dose rates are reduced markedly by a train body[4]. In addition, the fallout dose rate due to an infinite plane source measured on an elevated railroad is lower than on an ordinary one because of the difference in height from the source. Taking into account these factors, it may be all right to judge that the spatial variation pattern of the residual dose rate after background subtraction coincides fairly well with that of the map data. It should be also noted that a small rise around Ichinoseki station is found in both the map and the train-borne data.

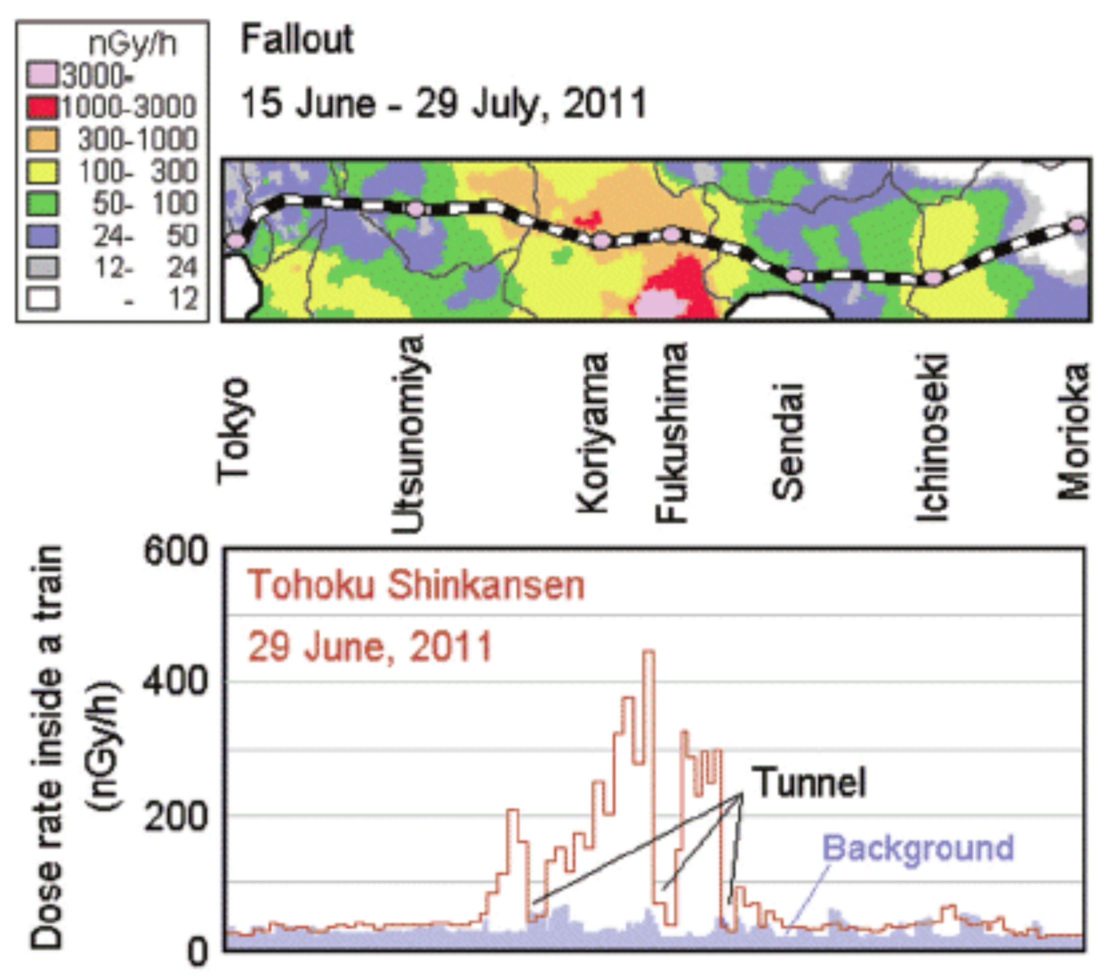

Fig. 4 Comparison between the contour map a) and Shinkansen data b).

5. Concluding remark

Considering the time elapsed from the accident (11 March, 2011), the data presented here are due mainly to ^{134}Cs and ^{137}Cs. Imanaka et al.[5] and Hohara et al.[6] reported that the content of ^{134}Cs is nearly the same level as that of ^{137}Cs in the field. This means that the dose rate ratio, $^{134}Cs/^{137}Cs$, amounts to about 2.6 according to ICRU Report[7]. This information would enable us to use the same pattern as Fig. 3 for roughly predicting future levels by changing the numerals given in the legend after calculating the decay of both nuclides.

References

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2) Minato, S., *J. Geogr.*, **115**, 87-95 (2006) (in Japanese)
3) Minato, S. and Shibayama, M., in press, *Isotope News*, **692** (2011) (in Japanese)
4) Minato, S., Kodaira, K. and Ito, M., *RADIOISOTOPES*, **44**, 330-334 (1995)
5) Imanaka, T., Endo, S., Sugai, M. and Ozawa, S., *Kagaku*, **81**, 594-600 (2011) (in Japanese)
6) Hohara, S., Inagaki, M., Kojima, K., Yamanishi, H., Wakabayashi, G., Sugiyama, W. and Itoh, T., *Nippon Genshiryoku Gakkai Wabun Ronbunshi*, **10**, 145-148 (2011) (in Japanese)
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要　　旨

福島第一原子力発電所事故起因の放射性降下物による線量率の分布

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福島第一原子力発電所事故後に実施された放射線サーベイ値を都道府県の公式ウェブサイトから収集した。この値から当該地点の自然放射線量率を差し引いて放射性降下物のみによる寄与分の分布を求めた。分布の等高線の精度を検証するために東北新幹線による走行サーベイを行った。走行サーベイの線量率変化パターンは沿線の等高線値とよく一致した。