"Uncertainty in predictions of the ambient dose equivalent rates for 30 years following the Fukushima Daiichi nuclear power plant accident"

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Highlight data

Cumulative distribution functions for ecological half-life Time variations of ambient dose equivalent rates

Summary and future plans



Motivation

1. Our projects

To obtain the perspective of assessing the evolution of the long-term exposure situation after the Fukushima accident

2. Technical issues

Wide-area Cs contamination in the environment Prediction models for each land use



3. Improvements in this study

Prediction models: Bi-exponential functions using ecological half-life components

Analysis of the uncertainty in the predictions



Radiation monitoring campaigns for mapping





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Car-borne surveys inside the evacuation order areas under the comprehensive monitoring plan



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Car-borne survey

- Measurement of ambient dose equivalent rates and GPS data per every 3-10 seconds using KURAMA systems in a moving car
- Immediate data transfer through a cellular phone network
- Conversion of ambient dose equivalent rates inside a car to those outside of the car



KURAMA

Car-borne survey





Real-time display of car-borne survey data





Car-borne survey using KURAMA



Dose rates have decreased steadily. (Extending area for measurements using KURAMA.)



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Time changes of ambient dose equivalent rates



Ambient dose equivalent rates above roads decreases much faster than those at undisturbed flat fields.



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Prediction models for Cs distribution



 T_{fast} and T_{slow} represent ecological elimination constants for the same compartment.

So far, T_{fast} and α_{fast} have been evaluated using ambient dose equivalent rates from car-borne surveys.

Ecological half-life T_{fast} of Cs for land-use -Outside the evacuation order areas-

Evaluated using data from car-borne surveys and ALOS*.

Cumulative frequency distributions

Lognormal probability plots



The ecological half-life for fast component is useful to characterise local future within the 80 km radius of the Fukushima Daiichi nuclear power plant.

Ecological half-life T_{fast} of Cs for land-use -Inside the evacuation order areas-

Evaluated using data from car-borne surveys and ALOS.

Cumulative frequency distributions

Lognormal probability plots

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Based on whether or not the land use area falls under forest (deciduous and evergreen) areas.

The model parameters in forest areas are different from those in other areas.

Fractional distribution of fast component of -Outside the evacuation order areas-

Evaluated using data from car-borne surveys and ALOS

Cumulative frequency distributions

Normal probability plots

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ast



Differences in categories !

The fractional distribution of fast component largely depends on land use.

Fractional distribution of fast component component of fast component of the evacuation order areas-

Evaluated using data from car-borne surveys and ALOS.

Cumulative frequency distributions

Normal probability plots

fast



Based on whether or not the land use area falls under forest areas.

The model parameters for areas where human activities occur is changeable.

Validation of the long-term prediction models

Comparison between predictions and measurements The eighth vehicle-borne survey data (from Jun. 23 to Aug. 8, 2014)



Based on the seventh vehicle-borne survey data (from Nov. 5 to Dec. 12, 2013)

The predictions agree within a factor of 2 with the actual data.

Analysis of the uncertainty in the predictions

The uncertainties in predictions for the next 30 years after the accident were assessed using Monte Carlo simulation of model parameter variability



Comparison of relative ambient dose equivalent rate between predictions and measurements

Comparisons between predictions and measurements (1/2)

Relative ambient dose equivalent rates outside the evacuation order areas



The medians (the 50th percentile) of predictions are in good agreement with data through car-borne surveys.



Comparisons between predictions and measurements (2/2)

Restricted residence areas

Relative ambient dose equivalent rates inside the evacuation order areas

Difficult to return areas



Almost all of data through the car-borne surveys are within the prediction intervals.

Distribution maps of ambient dose equivalent rates -5 years later after the accident-



*Those distribution maps of ambient dose equivalent rates for the next 5, 10, 15, 30 years after the accident could be created on knowledge that had been obtained in a government-commissioned research project from the Nuclear Regulation Authority of Japan.

Distribution maps of ambient dose equivalent rates -10 years later after the accident-



*Those distribution maps of ambient dose equivalent rates for the next 5, 10, 15, 30 years after the accident could be created on knowledge that had been obtained in a government-commissioned research project from the Nuclear Regulation Authority of Japan.

90% CI upper limit value



Distribution maps of ambient dose equivalent rates -15 years later after the accident-



*Those distribution maps of ambient dose equivalent rates for the next 5, 10, 15, 30 years after the accident could be created on knowledge that had been obtained in a government-commissioned research project from the Nuclear Regulation Authority of Japan.

Distribution maps of ambient dose equivalent rates -30 years later after the accident-



*Those distribution maps of ambient dose equivalent rates for the next 5, 10, 15, 30 years after the accident could be created on knowledge that had been obtained in a government-commissioned research project from the Nuclear Regulation Authority of Japan.



Summary and future plans

Uncertainties in predictions for the next 30 years after the accident were assessed using Monte Carlo simulations.

- The ambient dose equivalent rates would be predicted within a factor of approximately 2.
- Distribution maps would be useful for follow-up of the radiological situation.

The prediction models will be updated using new ecological half-lives derived from car-borne, air-borne and survey meters.

This study was conducted in a government-commissioned research project. (Nuclear Regulatory Agency, Japan)

Radiological quality of the environment



using the changes in ambient dose equivalent rates.



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Precise land-use, land-cover map ⁽²⁵⁾ using the advanced land observing satellite "Daich" (JAXA)

Within the 80km radius of the Fukushima Daiichi NPP



Within the evacuation order areas



