A Multiscale Bayesian Data Integration Approach for Mapping Air Dose Rates around the Fukushima Daiichi Nuclear Power Plant

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Abstract: This study presents a multiscale data integration method to estimate air dose rates in the regional scale around the Fukushima Daiichi Nuclear Power Plant (NPP). We integrate three types of data: ground-based walk and car surveys, and airborne surveys, all of which have different scales, resolutions, spatial coverage, and accuracy. Results show that the method can successfully integrate three types of datasets in a consistent manner, and create an integrated map (including the confidence intervals) of air dose rates over the domain in high resolution.

Keywords: Mapping of air dose rates, Bayesian hierarchical model, Fukushima Daiichi NPP Accident, Geostatistics

1. Introduction

Monitoring of air dose rates (i.e., ambient dose equivalent rates) in the region around the Fukushima Daiichi NPP have been performed continuously since the accident. The measurements have been conducted using various techniques such as walk surveys using portable monitoring systems, car surveys, and airborne surveys. With many data survey types available, it has become clear that there are discrepancies among them in terms of measured air dose rates due to different levels of accuracy and different support scales. Recently, Wainwright et al. [1] proposed a Bayesian geostatistical approach to integrate multiscale datasets and to estimate the map of air dose rates in high resolution across the regional scale. Since we consider that the walk survey data are directly related to the exposure dose of individuals walking on the streets, we estimate the air dose rates equivalent to the walk survey data.

2. Methods

A Bayesian hierarchical model typically consists of a series of statistical sub-models mainly in two categories: data models and process models. The process models—in this context—describe the spatial pattern of air dose rates. A geostatistical model was used to represent this pattern. The data models connect this pattern and the actual data, given measurement errors, such as spatial averaging for a low-resolution airborne dataset. Once all the sub-models are developed, we can estimate the the map and its confidence interval, using sampling/optimization.

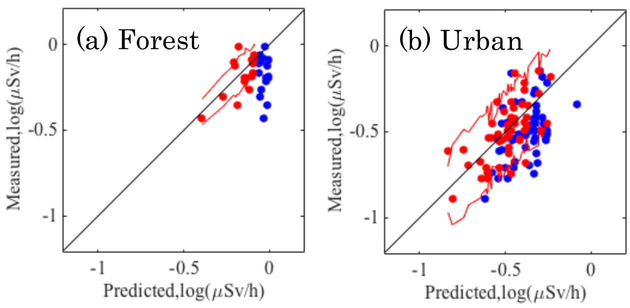

Figure 1. Predicted vs measured air dose rates. The red dots represent the predicted values based on the data integration method; the blue dots are the airborne data.

3. Results and Conclusion

We demonstrate our approach using the datasets collected near Fukushima City in November 2013. In Figure 1, the airborne data before the data integration (blue dots; the points excluded in the estimation) exhibit larger scatters and a systematic bias compared to the walk survey data. After the data integration, the predicted values are tightly distributed around the one-to-one lines and are mostly included in the 95% confidence interval. Particularly, the significant bias in the airborne data is corrected in the forested area (Figure 1a). Based on these results, we may argue that this method has successfully created the fine-resolution integrated map of air dose rates.

References

[1] Wainwright, H.M., A. Seki and K. Saito, A Multiscale Bayesian Data Integration Approach for Mapping Air Dose Rates around the Fukushima Daiichi Nuclear Power Plant, submitted to Journal of Environmental Radioactivity.