Investigation on distribution of radioactive substances in Fukushima (5) Bayesian Hierarchical Methods for Spatiotemporal integration of Radiation Air Dose Rates

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Abstract

This study presents a Bayesian hierarchical method to integrate multiple types of radiation measurements and to estimate the spatiotemporal distribution of radiation air dose rates around the Fukushima Daiichi Nuclear Power Plant (FDNPP). The method incorporates the temporal evolution of dose rates by separating the log-linear decay trend and the fluctuations of air dose rates which are spatially correlated based on adjacent monitoring post data.

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

1. Introduction

Since the FDNPP accident in 2011, the radiation air dose rate data has been collected and archived extensively in the region. However, there has been a challenge to integrate different types of measurements (such as walk, car and airborne surveys as well as monitoring posts) and to estimate the radiation air dose rates over time which are highly heterogeneous over space. Recently, Wainwright et al. [1] developed a Bayesian hierarchical modeling approach to integrate multiscale datasets, and also to estimate the spatial distribution of air dose rates. In parallel, a data-driven environmental decay model has been developed to predict the decay of radiation air dose rates in the environment [2]. In this study, we aim to combine these Bayesian hierarchical approach and environmental decay models, and to develop a spatiotemporal data integration method for creating an integrated radiation air dose rate map over space and time.

2. Methods

We first analyzed the spatiotemporal variability of radiation dose rates within the 80 km-radius regions based on the fixed-point data and monitoring post data. We also quantified the linearly decreasing trend after 2014, as well as spatially correlated temporal variability among adjacent monitoring posts. We then applied the Bayesian estimation method sequentially over time to integrate airborne/car/walk survey data and monitoring post data.

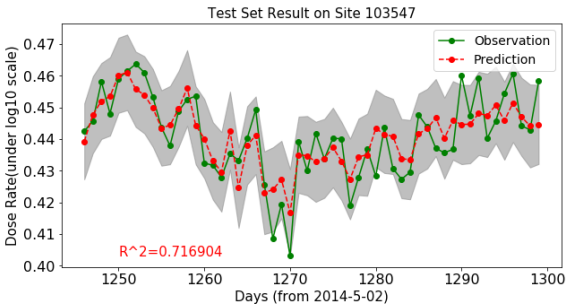

Figure 1. Estimated vs Observed radiation air dose rates for testing data set (days:1246 to 1300). The training set is from day 1096 to day 1246. The gray region is the confidence interval.

3. Results and Conclusion

We found that (1) under the logarithm scale, the dose rate time-series after 2014 can be spilt into a linear trend and the residual, (2) the linear trend is primarily dependent on the initial dose rate (in 2014), and (3) the fluctuation of radiation dose rates are spatially correlated among adjacent monitoring posts. Preliminary results (estimating the air dose rates at one monitoring post location based on six adjacent monitoring posts; Figure 1) show that the method can successfully estimate the air dose rates continuously over time at the location without monitoring posts

References

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