Investigation on distribution of radioactive substances in Fukushima
(18) Spatiotemporal Integration of Radiation Dose Rate Data across Scales

*Haruko Wainwright[1], Dajie Sun[2], Akiyuki Seki[3], Hiroshi Takemiya[3] and Kimiaki Saito[3]
[1]Lawrence Berkeley National Lab., [2]University of California, Berkeley, [3]Japan Atomic Energy Agency

Abstract

This study aims to develop an approach 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). We first investigated the spatial heterogeneity of environmental decay rates across the region based on car-survey datasets, and then developed the Kalman filter-based method to estimate the air dose rates at a given time and space based on walk, car and airborne surveys as well as monitoring post data.

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

1. Introduction

The radiation air dose rates have been critical to guide evacuation, the return of residents, decontamination and others, since the FDNPP accident in 2011 [1]. There have been significant efforts to integrate different types of measurements [2] as well as to characterize the reduction of dose rates in the environment [1]. However, there are significant challenges in describing the spatial heterogeneity of the environmental decay. In this study, we aim to (1) characterize the spatial heterogeneity of the environmental decay across the region, and then to (2) estimate the air dose rates over time and space based on the spatial heterogenous decay rates.

2. Methods

We first defined the environmental decay rate as the linear trend (i.e., slope) of the log-air dose rates after 2014. We then analyzed the spatial variability of the decay rates within the 2017 evacuation zone. We used a machine learning method, Random Forest, to quantify the decay rates as a function of initial dose rates, soil types, and land use types and others. We then applied the Kalman filter method to estimate the dose rates over space and time based on the integrated maps [2] and monitoring post data, including this spatially heterogeneous environmental decay rates.

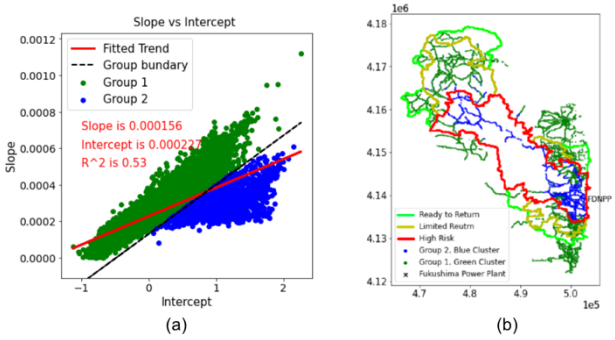

Figure 1. (a) Correlations between the slope (i.e., decay rate) vs intercept (i.e., initial dose rate), and (b) the spatial distribution of two clusters in (a).

3. Results and Conclusion

We found that the environmental decay rates (i.e., slope) is mainly dictated by the initial dose rates, although the land use and soil types have minor effects. In addition, the dependency on the initial dose rates has a clear difference between the difficult-to-return zone and ready-to-return zone in 2017 (Figure 1), suggesting that the dependency could be related to the evacuation status and human activities. We then integrated this spatially heterogeneous environmental decay rates into the estimation algorithm to estimate air dose rates between 2014 and 2017.

References

[1] Saito, K. et al. (2019). Summary of temporal changes in air dose rates and radionuclide deposition densities in the 80 km zone over five years after the Fukushima Nuclear Power Plant accident. Journal of environmental radioactivity, 210, 105878.

[2] Wainwright, H. M. et al. (2017). A multiscale Bayesian data integration approach for mapping air dose rates around the Fukushima Daiichi Nuclear Power Plant. Journal of Environmental Radioactivity, 167, 62-69.