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Spatial Analysis and Modeling of Environmental Radiation Data

Juyoul Kim
FNC Technology Co., Ltd. Main Bldg. 516, Seoul National University Research Park, San 4-2, Bongcheon7-Dong, Gwanak-Gu, Seoul, Korea 151-818, gracemi@fnctech.com

1. Introduction

An IERNet (Integrated Environmental Radiation Monitoring Network, http://iernet.kins.re.kr) has been maintained to monitor the environmental radiation level and radioactivity concentration in South Korea since 1967 [1,2]. The roles of IERNet are to monitor environmental radiation nationwide during normal times and to serve as an early warning system for possible radiation risk to the public in case of nuclear terrorism or severe accidents at nuclear power plants (NPPs). Environmental radiation monitoring facilities consist of 1 CRMS (Central Radiation Monitoring Station), 12 RRMS (Regional Radiation Monitoring Stations), and 25 UMP (Unmanned Monitoring Posts) as shown in Figure 1.

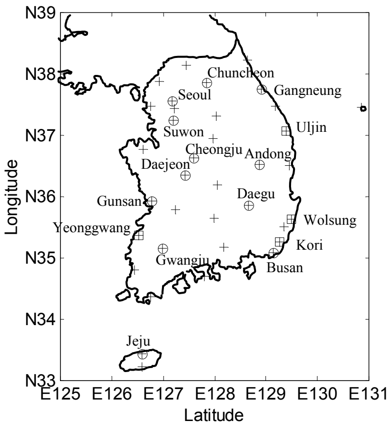

Figure 1. Environmental radiation monitoring locations in South Korea (circles are RRMS, crosses are UMP, and squares are NPPs).

2. Methods and Results

Geostatistics is a body of methods useful for understanding and modeling the spatial variability inherent in a process of interest. Although it has its origins in mining, geostatistics is now a basic part of many scientific disciplines including soil science, hydrology, agriculture, and environmental engineering. Central to the theory of geostatistics is the idea that measurements taken at locations close together tend to be more alike than values observed at locations farther apart. Geostatistics provides methods for quantifying this spatial correlation and for incorporating it in statistical estimation and inference.

A fundamental concept of geostatistics is the use of quantitative measures of spatial correlation, commonly expressed by variogram. The interpolation technique, known as kriging, is a method for making the best linear unbiased estimation (BLUE) of regionalized variables at unsampled locations using the structural properties of the variogram and the initial set of measured data. Here, the emphasis is set on local accuracy, i.e., closeness of estimate to the actual, but unknown value, without any regard for the global statistical properties of the estimates. Geostatistical routines from the software package GSLIB are used to analyze spatial variability of external gamma-dose rate and annual collective dose rate, which are the important environmental radiation metrics [3].

The plots in Figure 2 and 3 display contour maps for the spatial variability of external gamma-dose rate and annual collective dose rate, respectively. Regional distribution of external gamma-dose rate shows that higher values are located in the midsection of the country than in the southern part because of different component parts of lithosphere; Granite and gneiss are the dominant rocks in the midsection, while sedimentary rock is main component in the south. No peculiar increase of radiation level around NPPs is observed and all the monitored dose rates are below the limit of annual natural radiation exposure rate of 2.4 mSv/yr (≈ 31 μR/h).

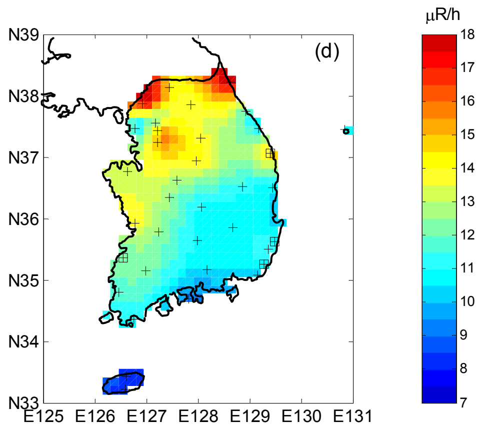

Figure 2. Kriging map for annual mean of external gamma-dose rate in 2003; crosses are monitoring stations and squares are NPP sites.

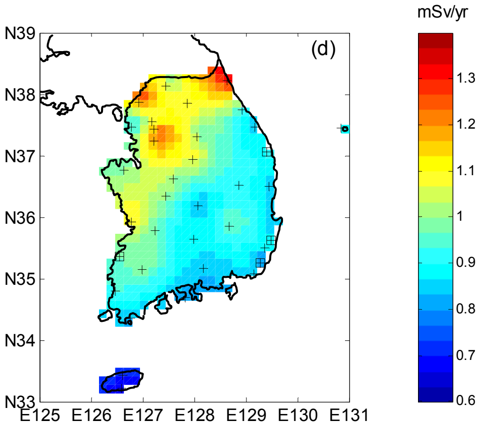

Figure 3. Kriging map for annual collective dose rate in 2003; crosses are monitoring stations and squares are NPP sites.

3. Conclusion

Geostatistical visualization of environmental radiation is a very powerful approach to explore and understand the spatial variability of environmental radiation data, and it can also help to improve public understanding of radiation. Spatial patterns of environmental radiation can be described quantitatively in terms of variogram and kriging, which are based on the idea that statistical variation of data is a function of distance.

REFERENCES

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[3] C. V. Deutsch and A. G. Journel, GSLIB: Geostatistical Software Library and User's Guide, Oxford University Press, New York, 1998.