3D temperature-distribution modeling over Japan Island using Neural Kriging and temperature-logging data

*Yusei Ieki[1], Katsuaki Koike[1]

1. Graduate School of Engineering, Kyoto University

Large increase of power generation using geothermal energy has become an important issue for reducing greenhouse gas emissions. Although supercritical geothermal power generation is expected to contribute to this increase, long lead time, development costs, and large risk hinder it. In addition, suitable locations for supercritical geothermal power generation are difficult to be identified. In order to solve these problems, it is indispensableto clarify the three-dimensional (3D) subsurface temperature distribution from the surface to deep depths over Japan Island. The most reliable data source for this estimation is temperature logging data, but both the depth range and number of the logging data are limited. Therefore, 3D temperature estimation is impossible through usual GIS-based methods. To enable this estimation, this study applies Deep Neural Network (DNN) and Neural Kriging (NK; Koike *et al*. 2001, *Math. Geol.*) that incorporates spatial correlation structure, quantified by semivariogram, into learning criterion of DNN. DNN is composed of five layers: one input, three hidden, and one output layers. The input data are coordinates and value of the temperature logging data and used as teacher data. One or two units are added to consider two type of temperature change with the depth:convective and conductive types. Because it is not suitable to express the spatial correlation structure of the logging data only one semivariogram over the wide area, the Japan Island is divided into four regions and four semivariograms are used for NK. The accuracy of the interpolation and extrapolation is evaluated by the Hold-out method.
With the above settings, 3D temperature models by DNN and NK are compared, and better accuracy of NK is confirmed for both the interpolation and extrapolation.Plausible features of temperature distribution by NK in consideration of the convective and conductive types are revealed, e.g. positional correlation between the hot zones and active volcanoes. A noteworthy point is that the critical points over 374 degrees in Celsius and 22.1 MPa are located at relatively shallow depths around the Nasu volcanic zone, Mt. Unzen, and Mt. Kirishima.

Keywords: temperature logging data, deep neural network, neural kriging, conductive type, convective type, critical point

