Scale effect on the determination of the spatial correlation factor used in Markov random field

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Abstract

The stratigraphic model plays a fundamental role in earth science, geology, and geotechnical engineering. However, a 100% correct stratigraphic model is not always obtained, and stratigraphic model uncertainty is difficult to quantify. Recently, stochastic Markov random field (MRF) has been used to simulate a series of probabilistic stratigraphic models, which can provide information for evaluating stratigraphic uncertainty. One of the main parameters in MRF simulations is the spatial correlation factor, denoted as a, which controls the geometry and evaluates the uncertainty of the stratigraphic model. In practice, calibrating a for MRF simulations for a given site is a difficult process, and it may be different depending on the sampling scales of the geological profiles and borehole densities (defined as the number of boreholes per unit length of a sampling profile). Although some studies have already investigated the influence of a on MRF simulations and proposed calibration methods for it, there is seldom literature discussing the effects of changing the sampling profile size and borehole density on determining a.

This study presents the scale effect of the spatial correlation factor (a) when using MRF by studying the impact of various profile sizes and borehole densities on its determination. Two geological profiles are used to create the synthetic population profiles in the Taipei Basin. One is a geological profile in the N-S direction, referred to as Case 1, and the other is a geological profile in the E-W direction, referred to as Case 2. First, the two synthetic stratigraphic models (SSM) were generated using MRF, based on the calibrated borehole data for Case 1 and Case 2, respectively. Then, a series of sampling profiles were obtained by cutting equal-sized profiles uniformly from the SSMs of Case 1 and Case 2, respectively. A set of conditional and observational boreholes are uniformly dispersed in the sampling profiles. Conditional boreholes are used for MRF simulations, and observational boreholes are used for the determination

of *a* by comparing the likelihoods of MRF predictions under various *a* values at the observational boreholes. The *a* with the maximum likelihood of MRF prediction was selected for the spatial correlation length for that profile. One-thousand geological model realizations were generated by MRF for each *a*, borehole density, and sampling profile. The mean, coefficient of variation (COV), and 95% confidence interval of *a* were then calculated for each borehole density and sampling profile.

The following findings are drawn. Firstly, for Case 1 and Case 2, the means of *a* doesn't have significant changes for the different sampling sizes. In both cases, the values range approximately from 77~89 m. This shows that the distribution of *a* may present isotropy in the Taipei Basin. Secondly, the coefficient of variation (COV) of various *a* values decreases with increasing sampling size for both cases. The representative elementary sizes (RES) of *a* for both cases could be further determined based on the acceptable COV of *a*. Thirdly, for *a* influenced by borehole density, *a* increases with decreasing borehole density.

Keywords: Markov random field, Stratigraphic model uncertainty, Scale effect, Spatial correlation factor, Representative elementary size.