Submission code: MZMDY7WMA4

Sequential indicator simulation using transiogram functions

Júlio Hoffimann (Arpeggeo), Igor Oliveira (Invision Geofísica)

Sequential indicator simulation using transiogram functions

Introduction

Sequential indicator simulation (SIS) is widely employed in the oil and gas industry to generate realizations of sedimentary facies. Traditionally, it is formulated using multivariate variogram functions, which are unable to capture the asymmetric transitions between facies often observed in carbonate reservoirs (Purkis *et al*., 2012). To address this limitation, and improve model interpretability, Carle and Fogg (1996) introduced transiogram functions. Despite their practical advantages, support for SIS based on transiograms is still lacking in most geostatistical software. In this work, we review key theoretical developments on the subject and present simulation examples produced with the open-source GeoStats.jl software (Hoffimann, 2018).

Method

Under stationarity assumptions, the transiogram function $t_{ij}(h)$ represents the transition probability from facies i to facies j at a lag vector h. It is defined in terms of the indicator formalism as

$$t_{ij}(h) = Pr\{I_j(x + h) = 1 | I_i(x) = 1\}$$

where I_i and I_j are indicator functions that equal 1 when the respective facies is present at locations x or $x + h$, and 0 otherwise. Unlike variograms, transiograms can be asymmetric, i.e., $t_{ij}(h) \neq t_{ji}(h)$, making them more suitable for modeling directional facies transitions observed in many geological settings.

SIS with transiogram functions is formulated by replacing the traditional CoKriging system, based on variogram or covariance functions, with a system based on transition probabilities. This shift introduces both computational and numerical challenges: the size of the linear system increases with the number of facies, and the resulting matrices can be rank-deficient, requiring careful solution strategies.

Results and Conclusions

Our implementation of SIS with transiogram functions is consistent with the underlying geostatistical theory. The realizations reproduce the prescribed transiogram models and facies proportions, up to ergodic fluctuations, and honor conditioning data from vertical wells. Furthermore, the implementation scales to large industrial datasets, demonstrating its practical applicability.

SIS based on transiogram functions offers a powerful alternative for modeling asymmetric facies transitions, particularly relevant for complex carbonate systems such as pre-salt reservoirs. This method enhances the geological realism of facies models and is computationally tractable.