5D geostatistics for directional variables: application in geotechnics to the simulation of the linear discontinuity frequency

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Résumé

In geotechnics and geomechanics, many rock mass properties are quantified by numerical variables defined by the observation or the testing of a borehole core sample. The value measured depends not only on the in-situ geographic coordinates of the sample, but also on the in-situ borehole direction. Interpolating such numerical variables in space without accounting for their directionality may produce misleading results, insofar as the interpolated values are representative of the rock mass properties along the sampling directions and not necessarily along other directions. A solution to this issue is to regionalize the geotechnical variables in a five-dimensional space, consisting of the three-dimensional Euclidean space crossed with the unit 2-sphere, in order to account for both their geographic and directional variations. Spatial correlation analysis can be performed easily under an assumption of stationarity in the three-dimensional Euclidean space and isotropy on the sphere, so that the covariance or the variogram between two data only depends on their geographic and angular separations. The fitting of nested separable covariance functions eases the search for a valid spatial correlation model and for algorithms to simulate the geotechnical variables in the above-defined five-dimensional space. The concepts are applied to the modeling of the linear frequency of weak veins in a Chilean porphyry copper deposit, where the importance of accounting for directionality is demonstrated. Regionalized azimuthal projections are introduced as a visualization tool for structural geologists and geotechnicians to map the directional variations of the weak vein frequency at given locations in the geographic space.

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