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Statistical scaling of equivalent hydraulic conductivities of a fractured rock system

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The study is aimed at exploring features statistical scaling associated with spatial distributions equivalent hydraulic conductivities of a fractured reservoir. We consider a sample area located in the sedimentary reservoir belonging to the Grigna limestone massif (Northern Italy, near Lecco). The outcropping rock mass is analyzed through in situ geological-structural surveys to collect data yielding the hydraulic characterization of the fractured medium along a strip spanning an area of 2 x 23 m2. Fractured rock masses are typically heterogeneous and very anisotropic systems, water flow being ruled by the geometric (dip and dip direction, spacing, persistence and connectivity) and mechanical (aperture, filling and roughness) characteristics of discontinuities (i.e. stratification and foliation planes, as well as fractures and faults). Based on the collected data, the components of the equivalent hydraulic conductivity tensor of each joint sets are evaluated at two diverse observation scales, resulting in an accessible high-quality data set. A geostatistical approach is then used to quantitatively assess features of statistical scaling of equivalent conductivities and their (spatial) increments. We do so by relying on an interpretive model depicting the target (random) field as a generalized sub-Gaussian process. This approach has been shown to be capable of capturing well-documented evidences of statistical scaling in both porous and fractured media. Our results further support the ability of the considered sub-Gaussian model to characterize the observed scaling features and the possibility of modeling multi-scale heterogeneity patterns of fractured reservoirs. Our results are key to infer the main statistics of groundwater flow and transport in these systems and support decision-making under uncertainty in the context of a variety of application-oriented scenarios, including, e.g., tunnel inflow assessment, slope stability analysis, and/or protection of mountain springs.