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Application of multi-scale variography for inferring the spatial variability of the hydraulic conductivity of a sandy aquifer

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In the framework of the disposal of short-lived low- and intermediate-level radioactive waste in a near-surface disposal facility in Dessel (Belgium), extensive characterization of the hydraulic conductivity (K) in the shallow Neogene aquifer has been performed at a regional scale. In the last few years the small-scale heterogeneity has been additionally characterized by outcrop analogue, hydraulic direct push, and borehole core air permeameter studies. The gathered data now include a) more than 350 hydraulic conductivity measurements on samples from 8 cored boreholes, mostly reaching depths of ∼50 m and data at 2 m intervals, b) more than 5000 air permeability measurements on the same borehole cores, c) more than 250 cone penetration tests (CPTs) with depths down to 40 m and data at 2 cm intervals, d) over 100 dissipation tests performed during the CPT campaigns, e) 17 direct push injections loggings, 6 hydraulic profiling tool logs, and 6 direct push slug tests, f) several hundreds of air permeability measurements on outcrop analogues of the aquifer sediments, and g) numerous grain size analyses.
The current study aims to quantify the heterogeneity of K from the centimetre- to the kilometre-scale and to check the compatibility of the spatial variability revealed by the different datasets. This is achieved through gathering all K values (either direct measurements, calibrated relative K values, or K estimates from secondary data), and the use of variography to quantify spatial variability in terms of two-points geostatistics. The results are discussed, and the main differences between the different data sources are explained. In a final step, different multi-scale variogram models are proposed for capturing the main characteristics of multi-scale variability within the shallow Neogene aquifer in Belgium.