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Multiple-scale integration of hydrological and geophysical data through Bayesian sequential simulation

P. Ruggeri (1), E. Gloaguen (2), J. Irving (1), and K. Holliger (1)
(1) Institute of Geophysics, Lausanne, Switzerland (paolo.ruggeri@unil.ch), (2) INRS, Québec, Québec, Canada

Significant progress has been made with regard to the quantitative integration of geophysical and hydrological data at the local scale. However, extending the corresponding approaches to the regional scale represents a major, and as-of-yet largely unresolved, challenge. To address this problem, we have developed a downscaling methodology based on a Bayesian sequential simulation approach. The basic objective of this methodology is to estimate the value of the regional hydraulic conductivity field based on sparse high-resolution measurements of the hydraulic and electrical conductivities as well as low-resolution estimates of the electrical conductivity obtained from surface-based electrical resistivity tomography data. The in situ relationship between the hydraulic and electrical conductivities is described through a non-parametric multivariate kernel density function. The overall viability of our approach is tested and verified by performing and comparing flow and transport simulations through the original and downscaled hydraulic conductivity fields. Our results indicate that the proposed procedure does indeed allow for obtaining faithful estimates of the regional-scale hydraulic conductivity structure and correspondingly reliable predictions of the transport characteristics over relatively long distances.