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Regional-scale integration of hydrological and geophysical data using Bayesian sequential simulation: application to field data

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Significant progress has been made with regard to the quantitative integration of geophysical and hydrological data at the local scale. However, extending corresponding approaches to the regional scale still represents a major challenge, yet is critically important for the development of groundwater flow and contaminant transport models. To address this issue, we have developed a regional-scale hydrogeophysical data integration technique based on a two-step Bayesian sequential simulation procedure. The objective is to simulate the regional-scale distribution of a hydraulic parameter based on spatially exhaustive, but poorly resolved, measurements of a pertinent geophysical parameter and locally highly resolved, but spatially sparse, measurements of the considered geophysical and hydraulic parameters. To this end, our approach first involves linking the low- and high-resolution geophysical data via a downscaling procedure before relating the downscaled regional-scale geophysical data to the high-resolution hydraulic parameter field. We present the application of this methodology to a pertinent field scenario, where we consider collocated high-resolution measurements of the electrical conductivity, measured using a cone penetrometer testing (CPT) system, and the hydraulic conductivity, estimated from EM flowmeter and slug test measurements, in combination with low-resolution exhaustive electrical conductivity estimates obtained from dipole-dipole ERT meausurements.