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Application of multiple-point geostatistics to simulate the effect of small scale aquifer heterogeneity on the efficiency of Aquifer Thermal Energy Storage (ATES)

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Adequate aquifer characterization and simulation using heat transport models are indispensible for determining the optimal design for Aquifer Thermal Energy Storage (ATES) systems and wells. Recent model studies indicate that meter scale heterogeneities in the hydraulic conductivity field introduce a considerable uncertainty in the distribution of thermal energy around an ATES system and can lead to a reduction in the thermal recoverability. In this paper, the influence of centimeter scale clay drapes on the efficiency of a doublet ATES system and the distribution of the thermal energy around the ATES wells are quantified. Multiple-point geostatistical simulation of edge properties is used to incorporate the clay drapes in the models.

The results show that clay drapes have an influence both on the distribution of thermal energy in the subsurface and on the efficiency of the ATES system. The distribution of the thermal energy is determined by the strike of the clay drapes, with the major axis of anisotropy parallel to the clay drape strike. The clay drapes have a negative impact (3.3 – 3.6%) on the energy output in the models without a hydraulic gradient. In the models with a hydraulic gradient, however, the presence of clay drapes has a positive influence (1.6 – 10.2%) on the energy output of the ATES system. It is concluded that it is important to incorporate small scale heterogeneities in heat transport models to get a better estimate on ATES efficiency and distribution of thermal energy.