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Dynamic Modelling of Aquifer Level Using Space-Time Kriging and Sequential Gaussian Simulation

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Geostatistical models are widely used in water resources management projects to represent and predict the spatial variability of aquifer levels. In addition, they can be applied as surrogate to numerical hydrological models if the hydrogeological data needed to calibrate the latter are not available. For space-time data, spatiotemporal geostatistical approaches can model the aquifer level variability by incorporating complex space-time correlations. A major advantage of such models is that they can improve the reliability of predictions compared to purely spatial or temporal models in areas with limited spatial and temporal data availability. The identification and incorporation of a spatiotemporal trend model can further increase the accuracy of groundwater level predictions. Our goal is to derive a geostatistical model of dynamic aquifer level changes in a sparsely gauged basin on the island of Crete (Greece). The available data consist of bi-annual (dry and wet hydrological period) groundwater level measurements at 11 monitoring locations for the time period 1981 to 2010. We identify a spatiotemporal trend function that follows the overall drop of the aquifer level over the study period. The correlation of the residuals is modeled using a non-separable space-time variogram function based on the Spartan covariance family. The space-time Residual Kriging (STRK) method is then applied to combine the estimated trend and the residuals into dynamic predictions of groundwater level. Sequential Gaussian Simulation is also employed to determine the uncertainty of the spatiotemporal model (trend and covariance) parameters. This stochastic modelling approach produces multiple realizations, ranks the prediction results on the basis of specified criteria, and captures the range of the uncertainty. The model projections recommend that in 2032 a part of the basin will be under serious threat as the aquifer level will approximate the sea level boundary.