Geophysical Research Abstracts
Vol. 17, EGU2015-13605, 2015
EGU General Assembly 2015

Assessment of groundwater level estimation uncertainty using sequential Gaussian simulation and Bayesian bootstrapping

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Space-time geostatistical approaches can improve the reliability of dynamic groundwater level models in areas with limited spatial and temporal data. Space-time residual Kriging (STRK) is a reliable method for spatiotemporal interpolation that can incorporate auxiliary information. The method usually leads to an underestimation of the prediction uncertainty. The uncertainty of spatiotemporal models is usually estimated by determining the space-time Kriging variance or by means of cross validation analysis. For de-trended data the former is not usually applied when complex spatiotemporal trend functions are assigned. A Bayesian approach based on the bootstrap idea and sequential Gaussian simulation are employed to determine the uncertainty of the spatiotemporal model (trend and covariance) parameters. These stochastic modelling approaches produce multiple realizations, rank the prediction results on the basis of specified criteria and capture the range of the uncertainty. The correlation of the spatiotemporal residuals is modeled using a non-separable space-time variogram based on the Spartan covariance family (Hristopulos and Elogne 2007, Varouchakis and Hristopulos 2013).
We apply these simulation methods to investigate the uncertainty of groundwater level variations. The available dataset consists of bi-annual (dry and wet hydrological period) groundwater level measurements in 15 monitoring locations for the time period 1981 to 2010. The space-time trend function is approximated using a physical law that governs the groundwater flow in the aquifer in the presence of pumping. The main objective of this research is to compare the performance of two simulation methods for prediction uncertainty estimation. In addition, we investigate the performance of the Spartan spatiotemporal covariance function for spatiotemporal geostatistical analysis.

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Research supported by the project SPARTA 1591: “Development of Space-Time Random Fields based on Local Interaction Models and Applications in the Processing of Spatiotemporal Datasets”. “SPARTA” is implemented under the “ARISTEIA” Action of the operational programme Education and Lifelong Learning and is co-funded by the European Social Fund (ESF) and National Resources.