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Modeling Groundwater Levels with Space-Time Geostatistics

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This work considers application of space-time geostatistics to modeling groundwater level around a geological nuclear waste storage. Radiological safety is closely connected with hydrological situation at the site. And ground water level monitoring is the most important aspect describing the hydrological situation. The site under study has two separated groundwater horizons contaminated by the nuclear wastes. They present different structure of temporal dynamics of the groundwater level: one horizon is deep enough not to show any kinds of seasonal periodicity; the other on the contrary presents strong seasonal dependence. But the both groundwater horizons show rather short temporal correlation range (measured in days). The problem is to map hydrogeologic situation for any moment.

In this work groundwater level mapping is performed using space-time geostatistics. Space-time correlation structure is modeled by combining separate spatial and temporal correlation components using product-sum approach. This approach is very good for practical application because of its simplicity and low number of theoretical limitations. Geostatisticsl model was validated using specially selected validation data set. Obtained validation results allow to perform mapping for any temporal cut during the monitoring period.

But the short temporal correlation range complicates forecasting mapping by the standard space-time geostatistical approach. To move forward with mapping one can use results obtained during previous steps, but such approach requires lots of additional calculations for reasonable forecasting period.

In this work is considered the other approach based on stochastic simulations for time series. It is supposed that each temporal cut of the groundwater level can be presented by a set of independent principle components. For each component a stochastic model is constructed. This model allows to generate stochastic realizations of the component. And thus, under the assumption of preserving the main characteristics of the process in the following period, these realizations can be considered as possible forecasts of the components. A set of single realizations presenting all separate components allows to construct a realization of the hydrogeological situation in monitoring wells with not more then 5% error. This approach allows to estimate sets of stochastic realizations of the groundwater level for the forecasting period with required temporal steps.

Using principle components instead of real monitoring data allows to simplify calculations. The number of principle components is smaller then the number of monitoring wells, and also principle components are independent, what is not correct about the monitoring wells. Also application of principle components opens the possibility to use additional information correlated with the groundwater level and presented as a time series, for example a precipitation data.

The described approach was applied for groundwater level forecasting for two different hydrogeologic horizons. It was tested on the already known period. Different methods to build principle components (linear and not linear) were considered. Also different approaches for stochastic simulations for the time series were used.