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Factor-based Geostatistics for Groundwater Modeling

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Analysis of groundwater levels is an important stage preceding modeling the filtration and migration processes in the hydro-geological environment. The boundary conditions are due to a pressure field, which strongly depends on groundwater levels, their spatial and temporal variability.
Hydro-physical measurements are usually performed at a set of unhomogeneously spatially distributed wells according to some temporal scheme. Thus, it is an irregular spatio-temporal data set with a whole luggage of problems concerning organization of a spatio-temporal metrics system. These problems also affect modeling of a spatio-temporal correlation structure. There are different ways how to overcome these problems and obtain a reasonable model of spatio-temporal correlation structures. But still all these approaches are limited in future forecasting features.
This work proposes an alternative approach – a factor-based space-time geostatistics. This method opens a set of possibilities concerning future modeling: possibility to use additional information to present different future scenario, characterization of uncertainty, probabilistic description of critical events.
The basic idea is to replace a system of spatially correlated wells by a set of independent factors compressing data with a possibility of back transformation at the prescribed level of accuracy. Factors can be obtained by principle component analysis, independent sources and artificial neural network with a “bottle-neck”. The selection of a method depends on the features of initial data and the process under study.
All factors are time series nevertheless how they were obtained. A set of factors contains the main features of the groundwater level patterns. Groundwater levels modeling and forecasting is performed through modeling of these time series. This work considers three different stochastic approaches for modeling and forecasting of time series with hydrological origins: stochastic process with a deterministic polynomial and periodic trend; geostatistical stochastic model; stochastic simulations with a non-linear model (for example, a multilayer perceptron) of a trend. These methods allow taking into the account additional information, for example, on precipitation
All approaches are illustrated on real data.