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Forecasting karst water level using time series analysis tools and variography in the Transdanubian Range, Hungary

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The main karst reservoir of the Transdanubian Range in Hungary is a complex, thick carbonate system, which can be characterized by hydraulic continuity. Economically, it is one of the most important water resources in Hungary. In this regional karst aquifer artificial water extraction took place between 1950-1990, resulting in the drastic decrease – in some central locations by tens of meters - of karst water level. In 1990 mining stopped in the area, along with water extraction; as a result, the karst water levels began to rise, leading to economic and technical-engineering problems, as well. In this special hydrogeological situation it would be necessary to attempt to make reliable long-term forecasts for the water level recovery of the area. The more accurate prediction of the potential water levels may help in decision-making in water resource management.

The aims of the study were (i) to group the hydrographs based on their patterns, (ii) to assess whether the karst water levels of the Transdanubian Range can be forecast with “classic time series methods”, i.e. trend estimation and forecasting, and if the individual forecasts for the wells are successful, then (iii) to determine the spatial relationship between the measured and predicted water levels and interpolate (krieg) maps of the forecast karst water levels.

Hierarchical cluster analysis was used for the grouping, allowing to distinguish which time series did, or did not, display the effects of the recovery following the cessation of mining, and furthermore, within these, those wells with differing temporal patterns. For a better understanding of the nonlinear process of recovery, a trend function was sought which best describes the rise in water levels as a result of the recovery. Therefore, different types of trend function were fitted. The fitted “classical” trend functions (e.g. linear, logarithmic, polynomial) forecast a water level increase such as cannot occur under normal circumstances. Thus, 10 different types of growth curves were fitted and evaluated based on R^2 and SSE (Sum of Squared Errors). With that function, which describes the recovery process the best, the karst water levels in the wells were predicted for January of 2020 and January of 2025. As a final step, variogram analysis was performed for the last measured time horizon (January 2016), and the two forecast time horizons. Spatial correlation is observed in the forecast karst water levels, they can therefore be used to obtain interpolated (kriged) maps. The most important result of the research is, that using the logistic trends, the possibility of expanding the number of the methods which may be used in forecasting groundwater levels. Furthermore, the forecasted groundwater level maps are helpful tools for the governmental agencies by some measures related to the increase of water level.