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Groundwater level forecasting using an artificial neural network trained with particle swarm optimization.

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The purpose of this study is to examine the use of particle swarm optimization algorithm in order to train a feed-forward multi-layer artificial neural network, which can simulate hydraulic head change at an observation well.

Particle swarm optimization is a relatively new evolutionary algorithm, developed by Eberhart and Kennedy (1995), which is used to find optimal solutions to numerical and quantitative problems. Three different variations of particle swarm optimization algorithm are considered, the classic algorithm with the improvement of inertia weight, PSO-TVAC and GLBest-PSO. The best performance among all the algorithms was achieved by GLBest-PSO, where the distance between the overall best solution found and the best solution of each particle plays a major role in updating each particle's velocity.

The algorithm is implemented using field data from the region of Agia, Chania, Greece. The particle swarm optimization algorithm shows an improvement of 9.3% and 18% in training and test errors respectively, compared to the errors of the back propagation algorithm. The trained neural network can predict the hydraulic head change at a well, without being able to predict extreme and transitional phenomena. The maximum divergence from the observed values is 0.35m.

When the hydraulic head change is converted into hydraulic head, using the observed hydraulic head of the previous day, the deviations of simulated values from the actual hydraulic head appear comparatively smaller, with an average deviation of 0.041m.

The trained neural network was also used for midterm prediction. In this case, the hydraulic head of the first day of the simulation is used together with the hydraulic head change derived from the simulation. The values obtained by this process were smaller than the observed, while the maximum difference is approximately 1m. However, this error, is not accumulated during the two hydrological years of simulation, and the error at the end of the simulation period is minimal.

Finally, climate change scenarios were examined, based on the prediction that on the island of Crete during the period of 2010-2040, it will be a 12($\pm$25)% average reduction in precipitation and a 1.9($\pm$0.9)^{o}C increase in mean temperature (Tsanis et al., 2011). In order to study these scenarios, data time series were created for the period 2010-2020, using a stochastic weather generator for three cases (best, worst and average case scenarios). The prediction results indicate a significant negative effect on the groundwater level only for the worst case scenario (37% reduction in precipitation), while in the other cases the results vary from neutral to positive.

References:

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