EGU2020-11349
https://doi.org/10.5194/egusphere-egu2020-11349
EGU General Assembly 2020

Simulating stable water isotope derived information with the aid of artificial neural network applied on independent multivariate events

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Abstract In recent years, stable isotopes of water have become a well-known tool to investigate runoff generation processes. The proper estimation of stable water isotope concentration dynamics based on a set of independent multivariate variables would allow the quantification of event water fraction in stream water even at times when no direct measurements of isotopes are available. Here we estimate stable water isotope concentrations and derived event water fractions in stream water over 40 precipitation events. A mobile field laboratory was set up to measure high-resolution (20 min) stable isotopes of water by laser spectrometry. Artificial neural networks (ANN) were established to model the same information. We consider precipitation and antecedent wetness hydrometrics such as precipitation depth, precipitation intensity and soil moisture of different depths as independent variables measured in the same high-temporal resolution. An important issue is the reduction of the deviation between observations and simulations in both the training and testing set of the network. In order to minimize this difference, various combinations of variables, dimensionalities of the training and testing sets and ANN architectures are studied. A k-fold cross validation analysis is performed to find the best solution. Further constraints in the iteration procedure are considered to avoid overfitting. The study was carried out in the Schwingbach Environmental Observatory (SEO), Germany. Results indicate a good performance of the optimized model, in which the dynamics of the isotope concentrations and the estimated event water fractions in the stream water were estimated. Compared to a multivariate linear model, the ANN-based model clearly outperformed the estimations showing the smallest deviation. The optimum network consists of 2 hidden nodes with a 5-dimensional input set. This strongly suggests that ANN-based models can be used to estimate and even forecast the dynamics of the isotope concentrations and event water fractions for future precipitation events.