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EPR modelling of groundwater level response to precipitation

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Data-driven approaches in groundwater hydrology have interesting applications in real case histories. Their advantage consists in the data requirement, that is often limited to time series of the state variables being modeled (e.g. the groundwater level) and forcing terms to the system (the precipitation). This data series have to be continuous and prolonged to ensure a good modeling result. Conversely, physically based models, in addition to time series data needed for calibration, require other substantial investment. Many aquifer parameters need to be detailed, such as hydraulic conductivity distribution, aquifer geometry and evapotranspiration rates. The authors have applied a recent symbolic regression technique, named Evolutionary Polynomial Regression (EPR) with interesting results, in forecasting and conceptual modelling of real hydrogeological systems. EPR limits the operators used for the symbolic regression to sum, product, power, logarithm, exponential. The resulting structure is an explicit mathematical relationship in the form of Polynomials with monomial terms that are a combination of the input-output variables at different time lags. Groundwater and precipitation time series are split into calibration and validation data sets, to ensure a good generalization capability to the models. The methodology's advantage lies in the model building procedure that is entirely based on time series data, and on the possibility of conceptualizing the physical insight into the process. Indeed, a set of best-fitting models consisting in symbolic expressions are determined at different structural complexity. The best one can be selected both based on the degree of adaptation to validation data and on the possibility to be used in the conceptual understanding of aquifer dynamics, in terms of response delay, effects of rainfall on recharge, water

level decay during drought. The EPR technique has been applied to model the shallow unconfined aquifer of Brindisi and the deep aquifer of Lecce (Apulia, Southern Italy), located in the wide calcareous basement of the region by using data from the Italian National Hydrographic Service. The shallow aquifer is characterized by more continuous water level records. In both cases results were interesting since a meaningful conceptual representation of the water table dynamics could be obtained. The forecast capability of the models built for the aquifer of Lecce is lower due to the high number of unrecorded periods in the piezometric time series. For the shallow aquifer of Brindisi more interesting results could be achieved both in terms of forecasting capability and conceptual modelling. Thus the proposed methodology allows to build a set of models to be used for forecasting purposes and, at the same time, to attempt a conceptualization of the system's dynamics by interpreting the symbolic expressions which are physically sound.