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Modelling and forecasting monthly and daily river discharge data using hybrid models and considering autoregressive heteroscedasticity

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Hybrid modelling, used for simulation and forecasting of hydrological time series, involving both process-based and data-driven types of models combines the available domain knowledge and process physics with the recent advances in data driven tools.

In this way, complex hydrological processes can be modelled and forecasted by decomposing the problem into several smaller sub – problems and using process physics based models where these are most appropriate, and data dictated tools (such as ANN, time series models or traditional statistics) for the residual data, when necessary. The fitting and forecasting performance of such models have to be explored case based.

So far, only a few attempts to apply various nonlinear time series models within such a framework were reported in the hydrological modelling literature. This contribution presents results concerning the possibility to use GARCH type of models for such purposes.

More specifically, error time series from two hydrological conceptual models were analyzed (applied on time series measured from the Hron and Morava Rivers in Slovakia), concentrating on the improvement of the modelling and forecasting performance of these models. The goal of investigation was to try to expand the knowledge in the time series modelling of hydrological model error time series with the aim to test and develop appropriate methods for various time steps from the GARCH family of models. In order to achieve this, following steps were taken:
1. The presence of heteroscedasticity was verified in time series.
2. A model from the GARCH family was fitted on the data, comparing the fit with a fit of an ARMA model.
3. One – step – ahead forecasts from the fitted models were produced, performing comparisons.

The investigation of model properties and performances was thoroughly tested under various conditions of their future practical applications. In general, heteroscedasticity was present in the majority of the error time series of the hydrological models. However, the GARCH family of models proved to be suited in removing it only in daily time step. The basic GARCH model was not applicable on any of the time series. In all other investigated cases, the EGARCH(1,1) model had to be used. Unlike in econometric time series, where the so called leverage effect (i.e. the series reacts more strongly to negative changes) is present and pointed out by this model, here the data tends to react more strongly on positive changes.

In this particular case it was found, that the general property of hydrological processes, that the rise of discharge is rainfall driven (a highly nonlinear chaotic intermittent process) and the decrease of discharge is ruled by the damping effects of the water storage in the driven system (catchment or river reach), is present also in the hydrological model error series. This shows, that the modelling and forecasting of floods (pulse like rising discharge) is a more demanding task than that of droughts (slowly decreasing flows). Even though the GARCH models did show partial improvements in the modelling and forecasting of flows, they still have several serious disadvantages (such as high sensitivity to the chosen fitting period) and possible further use should be further investigated. These results are of importance with respect to future attempts of modelling of error time series of hydrological models in such hybrid frameworks. They underpin the need of a non-mechanistic approach in the

case based analysis of such data and the physical interpretation of statistical modelling results.