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Pitfalls and improvements in hydrological calibration and predictive uncertainty analysis: Joint handling of heteroscedasticity and autocorrelation

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Residual errors of hydrological models are usually both heteroscedastic and autocorrelated. These error characteristics affect the information content of the data, and the reliability with which it can be extracted by the model calibration procedure. However, only a few studies have attempted to explicitly include heteroscedasticity and autocorrelation into the residual error model and jointly infer them with the hydrological model parameters. This technical note shows that applying autoregressive error models to raw heteroscedastic residuals, as done in some recent studies, can lead to unstable error models with poor predictive performance. This instability can be avoided by applying the autoregressive process to standardized residuals. The resulting calibration scheme produces much more reliable predictive distributions of streamflow, and captures quite well the autocorrelation of the residuals. The theoretical analysis is supported by empirical findings in three hydrologically distinct catchments. The case studies also highlight strong interactions between the parameters of autoregressive residual error models and the water balance parameters of the hydrological model. These insights are relevant for improving the calibration of hydrological models, extracting maximum information from the data, and more reliably reflecting the associated parameter and predictive uncertainties.