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A novel heteroscedastic error model for a fully distributed groundwater flow model

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Abstract: In hydrological modelling, it is often observed that the error on the simulated flow values is heteroscedastic. In order to obtain homoscedastic errors, researchers have been applying transformations of the flow values (e.g. a Box-Cox transformation) within their model calibration procedure or have introduced an error model within a Bayesian framework for parameter estimation and uncertainty analysis. Transient numerical groundwater flow models are also affected by different sources of uncertainty. Nevertheless, the possible heteroscedasticity of the errors on the simulated groundwater levels has been mostly neglected when performing uncertainty analysis for these types of models. Therefore, we introduce a novel heteroscedastic error model for groundwater level predictions within a general and flexible Bayesian framework. In this way, we can consider the heteroscedasticity of the groundwater level error along with the parameter uncertainty. Moreover, we can also analyze these two sources of uncertainty in combination with input uncertainty. The proposed methodology is applied on a fully distributed physically-based groundwater flow model of an overexploited aquifer in Bangladesh. The results of the study confirm that the heteroscedasticity of the groundwater level error should be considered and that it has an effect on the model predictions and parameter distributions. It is also shown that the observation coverage of the parameter uncertainty band increases from 1.5 % to 8.5 % when the heteroscedasticity is explicitly taken into account along with model parameter uncertainty.

Keywords: Groundwater flow model; Bayesian approach; heteroscedasticity; uncertainty quantification.