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Battling hydrological monsters: Distinguishing between data uncertainty, structural errors and numerical artifacts in rainfall-runoff modelling

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Confronted with frequently poor model performance, rainfall-runoff modellers have in the past blamed a plethora of sources of uncertainty, including rainfall and runoff errors, non-Gaussianities, model nonlinearities, parameter uncertainty, and just about everything else from Pandorra's box. Moreover, recent work has suggested astonishing numerical artifacts may arise from poor model numerics and confound the Hydrologist. There is a growing recognition that maintaining the lumped nebulous conspiracy of these errors is impeding progress in terms of understanding and, when possible, reducing predictive errors and gaining insights into catchment dynamics. In this study, we take the hydrological bull by its horns and begin disentangling individual sources of error. First, we outline robust and efficient error-control methods that ensure adequate numerical accuracy. We then demonstrate that the formidable interaction between data and structural errors, irresolvable in the absence of independent knowledge of data accuracy, can be tackled using geostatistical analysis of rainfall gauge networks and rating curve data. Structural model deficiencies can then begin being identified using flexible model configurations, paving the way for meaningful model comparison and improvement. Importantly, informative diagnostic measures are available for each component of the analysis. This paper surveys several recent developments along these research directions, summarized in a series of real-data case studies, and indicates areas of future interest.