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Multi-criteria evaluation of hydrological models

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Over the last years, there is a tendency in the hydrological community to move from the simple conceptual models towards more complex, physically/process-based hydrological models. This is because conceptual models often fail to simulate the dynamics of the observations. However, there is little agreement on how much complexity needs to be considered within the complex process-based models. One way to proceed to is to improve understanding of what is important and unimportant in the models considered.

The aim of this ongoing study is to evaluate structural model adequacy using alternative conceptual and process-based models of hydrological systems, with an emphasis on understanding how model complexity relates to observed hydrological processes. Some of the models require considerable execution time and the computationally frugal sensitivity analysis, model calibration and uncertainty quantification methods are well-suited to providing important insights for models with lengthy execution times.

The current experiment evaluates two version of the Framework for Understanding Structural Errors (FUSE), which both enable running model inter-comparison experiments. One supports computationally efficient conceptual models, and the second supports more-process-based models that tend to have longer execution times. The conceptual FUSE combines components of 4 existing conceptual hydrological models. The process-based framework consists of different forms of Richard's equations, numerical solutions, groundwater parameterizations and hydraulic conductivity distribution.

The hydrological analysis of the model processes has evolved from focusing only on simulated runoff (final model output), to also including other criteria such as soil moisture and groundwater levels. Parameter importance and associated structural importance are evaluated using different types of sensitivity analyses techniques, making use of both robust global methods (e.g. Sobol') as well as several alternative local sensitivity analysis methods. The latter methods can yield similar results, however they are much more computationally frugal than the global methods and often are better suited to analysis of complex models. Simple models are used to compare the global and local methods, and insights used to interpret results for complex model for which the local methods are much more convenient.

The analyses are carried out for a medium-sized catchment (200 km^2) in the Belgian Ardennes, for which meteorological, fluxnet data, in situ soil moisture and groundwater time series are available.