Exploiting combinations of hydrological model structures to improve streamflow simulation

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The use of multi-model ensembles has been widely adopted by the meteorological
community as a means of improving short-term weather and seasonal climate fore-
casts. In contrast, little work has been carried out within the hydrological community
to explore the benefits of multi-model ensembles (MME) for hydrological simula-
tions. Some recent studies have however shown that there is potential for improving
stream flow predictions using MME's. One explanation for this is that different model
structures better represent different parts of the catchment flow response to rainfall.
This suggests that ensembles derived from different models provide an opportunity to
improve hydrological simulation and forecasts that deserves further investigation.

In this study a general hydrological framework is used to develop different hydrolog-
ical model structures for a single catchment from the US National Weather Service
DMIP study. The different model structures are used to explore how combinations
of model structures can be used to improve hydrological simulations. In particular
this study addresses two questions. Firstly do simple combinations of these model
structures improve our ability of represent the catchment processes compared to the
individual model structures? Secondly , if so why and is it possible to identify opti-
mal combinations of model structures that together that better explain the catchment
response to rainfall. To answer these questions the performance of different combina-
tions were analyzed. Optimisation methods were used to find the "best" linear combi-
nation of model structures and their performance evaluated using a split sample test-
ing strategy. This also provides a means to identify which model structures provide

significant contributions to accurate hydrological simulation. Interestingly, a simple combination of all the model structures outperformed any single model and a simple lumped model structure appeared to explain a significant part of the catchment response. However the most significant benefits from multiple models are the ability to identify model structures that can better represent different parts of the hydrograph and as estimation of uncertainty related to model structure.