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Using fixed process-oriented model structures as a starting point for hydrological research

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A breakthrough in observational techniques and catchment information availability is needed in order to significantly advance hydrological modelling from its current state of the art. This is especially true of subsurface processes which are difficult to study and whose observations are relatively rare in comparison with the availability of surface data. The set of available components to build model structures is not very large and unfortunately there are very few new components in development.

Testing new hypotheses and improving process understanding is usually associated with data-rich research watersheds. However, calibrating model structures or parameters to a specific data set does not necessarily ensure the right choices because of: 1) a limited set of possible model components, 2) considerable informational uncertainty/errors, and 3) available advanced techniques of calibration which permit an overly wide choice of parameter values and combinations. To construct a range of model structures from very simple to sophisticated for testing, does not seem an efficient, reasonable or practical exercise, as it is already well known that that overly complex structures cannot be parameterised and that overly simple model structures will fail under conditions of extreme natural environments, such as arid and cold regions where the processes interactions are more nonlinear and complicated and in extreme events such as droughts and flooding. Simple structures are also less likely to deal correctly with changing climate and land use or be able to take advantage of new information technologies and process understanding. It would seem more reasonable to adjust existing, tested model structures so that they are consistent with the scales of hydrological processes and the availability of parameter information.

In this situation the following actions can advance hydrological modelling from its current state:
1) The hydrological community should find the courage to leave some old, discredited theories and ideas in the past; instead of continuing to constructing model structures from non-physically-based blocks and conceptual simplifications, maintaining an understanding of the general processes combined with high-quality observational data may give a rise to new insights.
2) The convenience of some mathematical approaches should not take priority over the understanding of the processes.
3) New model structures should be carefully verified by independent data on similar watersheds (even if only runoff is available).
4) Model structure, where this is flexible, should not fully rely on calibration techniques to find "optimal structures". Rational intellectual calibration of model parameters and decisions on appropriate model structures based on hydrological principles can be used if supported by an understanding of the underlying processes.
5) Reasonably developed, process-oriented, robust, fixed model structures can be a good starting point for hydrological research and will provoke serious consideration of the hydrological system and deficiencies in its description. For instance, the limitations of fixed model structures may point out new directions in observations that are necessary to more properly implement the model and form the basis of enhanced collaborations between modellers and experimentalists.

This presentation will show how a single process-based model with fixed distributed structure (The Hydrograph model, developed in Russia) was used to investigate the processes in very different environments of the US like semi-arid snow-dominated mountainous Dry Creek watershed in Idaho, two small watersheds of the very flat Red River of the North in the Great Plains, and three mountainous basins in California. The model successes and failures will be presented accompanied with the analysis of necessary and possible directions of changes to its structure and parameterisations.