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Calibration strategies for distributed hydrological models using qualitative knowledge of spatially variable process characteristics.

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This paper reports on our experience of calibrating a distributed hydrological model for the Rangitaiki River basin in New Zealand. This work is being undertaken as part of a project to develop a new nationwide flood early-warning system, where the hydrological model will be used to forecast river flows based on inputs from a numerical weather prediction model. The Rangitaiki basin provides a test case in which to investigate strategies for calibrating the model, i.e. choosing optimum model parameters for each sub-basin within the main catchment, based on limited information from flow gauges.

Calibration of such a model is a challenging task because of the large number of model parameters which could be adjusted (multiple model parameters for multiple sub-basins). A common approach is to first estimate the parameters based on physical catchment information such as soil type and land cover. We then calibrate the model based on observed river flow records by applying a set of “parameter multipliers” to the model parameters in each sub-basin. This significantly reduces the dimensionality of the optimization problem, but can result in a spatial distribution of model parameters that is inconsistent with known spatial differences in hydrological processes. More thoughtful calibration strategies are needed, especially in river basins where the geology is heterogeneous.

The Rangitaiki provides an interesting test case for this work, in that the geology of the western half of the river basin is pumice, which responds slowly to rain events; while the geology of the eastern half of the river basin is greywacke, which responds rapidly to rain events. This knowledge cannot be translated directly into values for model parameters; instead we seek to use the qualitative information to inform our calibration strategy. Several different methods were tested, using transforms of the parameter frequency distribution to alter the a-priori parameters assigned to sub-catchments throughout the river basin. The spatial parameters may be modified en masse, or modified in clusters according to geographic location or sub-catchment geology. Results show that spatial variability in model parameters is necessary to produce realistic streamflow simulations both at the basin outlet and at interior points in the basin. The required complexity of the calibration strategy depends on the reasonableness of a-priori parameter estimates—if a-priori model parameters are constant across all sub-catchments, then more complex calibration methods are needed to reproduce spatial variability in runoff responses. The results of the analysis are currently being used to design a methodology to estimate model parameters for all river basins throughout New Zealand.