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Stepwise improvement of topography driven conceptual model structures in the Mahurangi catchment, New Zealand

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Lumped hydrological models are often faster, easier to implement and less sensitive to equifinality than distributed models. Lumped models are however subject to a loss of spatial information and process representation. Landscape classification in different hydrological units might be a solution to retain maximum simplicity while taking into account readily available spatial information in a lumped way through parallel conceptual models. This would possibly enable to represent processes in a more realistic way in order to obtain the right answers for the right reasons. The different classes identified are hillslope, terrace and wetland and their dominant hydrological mechanism are storage excess subsurface flow, groundwater recharge / subsurface flow and saturation excess overland flow respectively. Each class has a dominant function and therefore a different process conceptualization. These classes are derived based on threshold values for height above the nearest drainage (HAND) and slope. The optimal model structure is found through a stepwise improvement of the model concept and enables hypotheses testing and improved catchment behavior understanding. Realism of the different model structures evaluated was assessed through eight evaluation criteria: Nash-Sutcliffe efficiencies during winter periods and summer periods, Nash-Sutcliffe efficiency of the log of the flows during summer period; flow duration curve (of the log of the flows); autocorrelation and runoff coefficient during summer and winter periods. This approach was applied in the Mahurangi River catchment in New Zealand. Other indications supporting the idea of landscape classification were assessed during correlation analyses made between the percentage of each class in the 28 subcatchments of the Mahurangi and hydrological signatures such as runoff coefficient and rising and declining limb densities. Indications supporting the idea of landscape classification were found during correlation analyses relating the percentage of the different classes in the 28 subcatchments of the Mahurangi catchment and the rising and declining limb densities. The rising and declining limb densities increased as the percentage of wetland increased in the catchment. Relatively large values for the rising and declining limb densities are characteristic for the fast needle-shape response expected in the wetland. The realism of the best topography driven model structure was comparable to that of HBV based on consistency and performance of eight evaluation criteria during the validation period. The model also seemed to represent processes originating from the different parts of the landscape in a realistic way: during very high peaks, most runoff originated from the hillslope (subsurface flow) and the wetland (saturation excess overland flow) gave a smaller peaky response. However, some aspects such as timing and realism in the evaporation time series can still be improved in the conceptualization of the three classes model hillslope-terrace-wetland. Furthermore, similar behavior was found for the classes hillslope and terrace and therefore combining them into one class might yield a decreased complexity and an improved performance.