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Use of model discrimination techniques to improve hydrologic models under ecological constraints: the case of the Maggia Valley, Southern Switzerland

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Model discrimination techniques are used to evaluate alternative conceptual models. Thorough consideration of alternative conceptual models is an important and often neglected step in the study of many natural systems, including groundwater systems. This means that many modelling efforts are less useful for system management than they could be because they exclude alternatives considered important by some stakeholders, which makes them vulnerable to criticism. Important steps include identifying reasonable alternative models and possibly using model averaging to improve predictions and measures of prediction uncertainty. Here we used the computer code MMA (Multi-Model Analysis) as a modelling tool to help: (1) model development, (2) make predictions, and (3) understand the physical processes most important to the system. We focus on the ability of a groundwater model constructed using MODFLOW to predict heads and flows in the Maggia Valley, Southern Switzerland, where connections between groundwater, surface water and ecology are of interest. Sixty-four alternative models were designed deterministically and differ in how the river, recharge, bedrock topography, and hydraulic conductivity are characterized. None of the models correctly represent heads and flows in the Northern and Southern part of the valley simultaneously. A cross-validation experiment was conducted to compare model discrimination results with the ability of the models to predict eight heads and three flows to the stream along three reaches midway along the valley where ecological consequences and, therefore, model accuracy are of great concern. Results suggest: (1) Model averaging appears to have improved prediction accuracy in the problem considered. (2) The most significant model improvements occurred with introduction of spatially distributed recharge and improved bedrock topography. (3) The simplest models poorly represented the system in the area of interest.