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Characterisation of conceptual uncertainty through alternative model development

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Hydrogeological conceptual models are collections of hypotheses describing the understanding of groundwater systems and they are considered one of the major sources of uncertainty in groundwater flow and transport modelling. A common method for characterising the conceptual uncertainty is the multi-model approach, where alternative plausible conceptual models are developed and evaluated.
A literature review have shown that only few guidelines for developing alternative conceptual models exist. Therefore linguistic uncertainty occur in what is considered conceptual uncertainty and a variety of methods to develop alternative conceptual models have been applied. In the interpretation testing approach alternative models are developed by asking different teams to develop the most likely conceptual model based on the same data set. In the complexity testing approach alternative models are generated by gradually increasing or decreasing the complexity of the same base conceptualisation. Finally, in the hypothesis testing approach the same team of modellers aim to maximise the difference between alternative conceptualisations, while still adhering to the same data set.
The goal of the multi-model development process is to define a mutually exclusive, collectively exhaustive range of models, although this is unachievable. We argue that only the hypothesis testing approach attempt to achieve both. In the interpretation testing strategy alternative models may be almost identical because they are developed by different teams that define their best interpretation and in the complexity testing strategy only the complexity of a single conceptualisation is tested. Applying the interpretation and complexity testing strategy may therefore give a false sense of confidence in predictions because many similar models are used, given the impression a large part of the model space has been uncovered.
The interpretation and complexity testing strategy do not attempt to sample a collectively exhaustive model space either. However, in the hypothesis testing approach by making bold hypotheses about a groundwater system the range of conceptualisations considered can be widened and thus reducing the risk of conceptual surprise and improving the robustness of the groundwater assessments.