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Natural springs' protection and probabilistic risk assessment under uncertain conditions

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We introduce, develop and test a novel Groundwater Probabilistic Risk Model, GPRM, aimed at assessing (and preventing) negative issues related to water resources management and exploitation. We apply GPRM to a highly heterogeneous regional field case, located in Northern Italy. Different risk pathways are presented formally forming a fault tree model, which enables identification of all basic events contributing to an (undesired) system failure. The latter is quantified in terms of depletion of a natural springs system representing a key feature of the considered groundwater system. The proposed GPRM allows to include the effect of multiple sources of uncertainty in our knowledge and description of the system on the evaluation of the overall probability of system failure due to different pumping schemes. In this context, we consider two probabilistic models based on different reconstruction of the aquifer geological structure. In each conceptual model, hydraulic conductivity associated with the geomaterials composing the aquifer and the boundary conditions are affected by uncertainty. Our results demonstrate that the application of GPRM to the field case allows (i) to quantify the risk associated with springs depletion due to increasing exploitation of the aquifer; (ii) to quantify how different sources of uncertainty (conceptual model uncertainty and model parameters' uncertainty) affects this risk; (iii) to determine the optimal pumping scheme; and (iv) to identify the most vulnerable springs, where depletion first occurs.