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Groundwater vulnerability to climate variability: modelling experience and field observations in the lower Magra Valley (Liguria, Italy)

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The aquifer of the Lower Magra Valley (SE Liguria, Italy) extends in a flat plain, where two main rivers (Magra and Vara) flow. These rivers are characterized by a wide variation of water level and water chemical composition (TDS, Cl and SO4) due to the combination of rainfall regime and the presence of thermal springs in the inner part of the catchment area. Groundwater flow is apparently controlled by stream water infiltration, which affects both water levels and water quality. In particular, the wide range of variation of some particular chemical species in the stream water influences the groundwater chemistry on a seasonal basis. In the area of interest, there is an important well-field, which supplies most of the drinking water to the nearby city of La Spezia. In this context, the groundwater system is exposed to a high degree of vulnerability, both in terms of quality and quantity. This study is aimed to develop a predictive flow and transport model in order to assess the vulnerability s.l. of the Magra Valley aquifer system and to evaluate its behaviour in awaited climate scenarios. A flow and transport model was developed by using MODFLOW and MT3DMS codes, and it's been calibrated in both steady state and transient conditions. The model confirmed the importance of the Magra river in the water balance and chemical composition of the extracted groundwater. In addition, a data-driven modelling approach was applied in order to determine boundary conditions (e.g. rivers and constant head or general head boundaries) of the physical model under hypothetic future climate scenarios. For this purpose, fully synthetic datasets have been generated as a training set of the data-driven scheme, with input variables inspired by selected climate models and input/output relationships estimated by past observations.

An experimental run of the flow-transport model for 30 years ahead was performed, based on such hypothetic scenarios. This approach highlighted how the groundwater flow of the studied aquifer is highly vulnerable and sensitive to climate conditions.