EGU24-8872, updated on 20 May 2024
https://doi.org/10.5194/egusphere-egu24-8872
EGU General Assembly 2024

Characterization and modeling of large-scale aquifer systems under uncertainty: methodology and application to the Po River aquifer system

Monica Riva, Andrea Manzoni, Rafael Leonardo Sandoval, Giovanni Michele Porta, and Alberto Guadagnini
Politecnico di Milano, Department of Civil and Environmental Engineering-DICA, Milano, Italy (monica.riva@polimi.it)

Large-scale groundwater flow models are key to enhance our understanding of the potential impacts of climate and anthropogenic factors on water systems. Through these, we can identify significant patterns and processes that most affect water security. In this context, we have developed a comprehensive and robust theoretical framework and operational workflow that can effectively manage complex heterogeneous large-scale groundwater systems. We rely on machine learning techniques to map the spatial distribution of geomaterials within three-dimensional subsurface systems. The groundwater modeling approach encompasses (a) estimation of groundwater recharge and abstractions, as well as (b) appraisal of interactions among subsurface and surface water bodies. We ground our analysis on a unique dataset that encompasses lithostratigraphic data as well as piezometric and water extraction data across the largest aquifer system in Italy (the Po River basin). The quality of our results is assessed against pointwise information and hydrogeological cross-sections which are available within the reconstructed domain. These can be considered as soft information based on expert assessment. As uncertainty quantification is critical for subsurface characterization and assessment of future states of the groundwater system, the proposed methodology is designed to provide a quantitative evaluation of prediction uncertainty at any location of the reconstructed domain. Furthermore, we quantify the relative importance of uncertain model parameters on target model outputs through the implementation of a rigorous Global Sensitivity Analysis. By evaluating the spatial distribution of global sensitivity metrics associated with model parameters, we gain valuable insights into areas where the acquisition of future information could enhance the quality of groundwater flow model parameterization and improve hydraulic head estimates. The comprehensive dataset provided in this study, combined with the reconstruction of the subsurface system properties and piezometric head distribution and with the quantification of the associated uncertainty, can be readily employed in the context of groundwater availability and quality studies associated with the region of interest. The approach and operational workflow are flexible and readily transferable to assist identification of the main dynamics and patterns of large-scale aquifer systems of the kind here analyzed.