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Artificial Intelligence Decision Support System for Groundwater Management under Climate Change: Application to Mornag Plain in Tunisia

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Abstract

This paper aims to study the impact of climate change on groundwater levels in the Mornag plain in Tunisia. Indeed, in the last few decades, aquifers all over the world have experienced notable water level variability due to the spatiotemporal variability of rainfall and temperature. Therefore, for reliable groundwater management in a climate change context, it is mandatory to analyze and estimate its level variability. In this study, we focus on the plain of Mornag, located in the southeast of Tunisia, since it represents 33% of the national agricultural production. From this point, we have collected historical piezometric and pluviometric data covering the period 2005–2017. Knowing the pluviometric data, our goal is to predict the piezometric one. This issue has already been studied using classical numerical groundwater modeling such as Modflow and Feflow. Despite the fact that the results are unsatisfactory, these techniques are data and time-consuming. To address all of these shortcomings, we propose using two artificial intelligence (AI) approaches: the Extreme Gradient Boosting (XGBoost) approach, which has demonstrated excellent performance in the literature, and the well-known in our context, which involves the use of a Long-Short Term Memory (LSTM) Neural Network. For better results, we have added supplementary features to our dataset, such as the cluster zone (zones with the same characteristics) and the Standardized Precipitation Index (SPI), which can identify drought at different time scales. Both approaches have been executed entirely on the GPU for time acceleration. Compared with traditional existing methods, they have both shown a high level of accuracy, which confirms their adequacy for groundwater level forecasting. The proposed prediction models will be used for evaluating the repercussions of climate change on groundwater levels under the different scenarios RCP 4.5 and RCP 8.5 for the period of 2017–2090. It will be evaluated for three future periods: 2017–2040 (short term), 2041–2065 (medium term), and 2066–2090 (long term). The analysis of the future results using AI will be considered as a new decision support system used to optimize the management of our limited resources in order to satisfy the needs of the population in terms of drinking water and agricultural production.

Keywords: Climate Change, Decision Support System, Deep Learning, Forecasting, Groundwater Level, Machine Learning.