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Sensitivity Analysis of Data-driven Groundwater Forecast to Hydro-climatic Controls in Irrigated Croplands

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In the last decades, advancements in computational science have greatly expanded the use of artificial neural networks (ANN) in hydrogeology, including applications to groundwater forecasts, variable selection, extended lead-times and regime-specific analysis for irrigation and water management in agriculture. However, performances of model forecasts are often treated as strictly deterministic, without considering their sensitivity to the intrinsic observational uncertainty and the inherent complexities of geophysical factors and management. The goal of this study is to implement a framework for assessing the sensitivity of groundwater level forecasts to input observational uncertainties. The analysis focuses on the High Plains aquifer in Nebraska (USA) and investigates forecasts sensitivity across space, time, and hydrological regimes. An ANN model is implemented for the 68 wells in the study area and is coupled to the PAWN sensitivity analysis (SA) framework (Pianosi and Wagener, 2015). The framework uses the difference between the unconditional and the conditional empirical distribution of the forecasts error to determine the relative contribution of each input to the errors variability. The selected hydroclimatic forcing inputs are rainfall, evapotranspiration, snowmelt, river flow, and groundwater measurements. To evaluate the contribution of each of these inputs to the performance of the ANN model, a sensitivity index is computed for each well: (1) over the whole time-series; (2) across the output sub-regions corresponding to water deficit and water surplus conditions; and (3) at each time step (time-varying sensitivity analysis). Analysis of the results shows that evapotranspiration and rainfall are the major sources of uncertainty across the study area, with the latter particularly relevant in water abundance conditions and the former in water scarcity. Employing time-varying sensitivity analysis allowed for identifying additional contributions of other uncertainty sources, such as snowmelt during March-April or river flow during the yearly peak in groundwater level.