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Identifying Aquifer Recharge Signatures Using Unsupervised Machine Learning: A Case Study of the Pajarito Plateau, NM

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The Pajarito Plateau shallow aquifer is a crucial resource for Los Alamos town, New Mexico. Changes of the shallow aquifer level could have a large environmental impact where water scarcity can concentrate pollutants and negatively affect the local ecosystem. The shallow aquifer recharge is poorly understood because of the area's complex geology, and is extremely sensitive to climate change. Traditionally, the recharge (source) amount is determined with a parameter estimation study using hydrogeological models. These models require the input of climate data (temperature, precipitation estimates), topographic data, soil and vegetation data, geologic data (rock formation permeabilities, faults, etc.), and huge computational resources. To circumvent these limitations we investigate the use of non-negative matrix factorization
with customized k-means clustering (NMFk), an unsupervised machine learning model, to identify climate source signatures and their effect on groundwater fluctuations. NMFk only requires temporal hydraulic head data from wells to obtain a set of potential signatures. Therefore, it has the advantage of relatively brief data acquisition and processing times, as well as short model run-times. The resulting source signatures represent the effect of precipitation on the aquifer levels; we match these signature profile(s) to observed climate signatures (i.e., average precipitation, snowmelt) to understand the relationships between the competing water sources. The machine learning model results show the influence of each signature at each well. Moreover, using signature intensities for each well, we found that snowmelt on the Pajarito Plateau and a combination of snowmelt and storm runoff from the higher elevation areas adjacent to the plateau are the main drivers for the shallow aquifer recharge. Moving forward, the NMFk model results will be combined with climate models to construct more accurate hydrogeologic models. These models will help understand how the aquifer could be affected by future climate change.

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References

Primary authors: AHMMED, Bulbul (Los Alamos National Laboratory); HOBBS, Noah (Los Alamos National Laboratory)

Presenter: HOBBS, Noah (Los Alamos National Laboratory)

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