Water Depth Analysis

Team 2

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Introduction

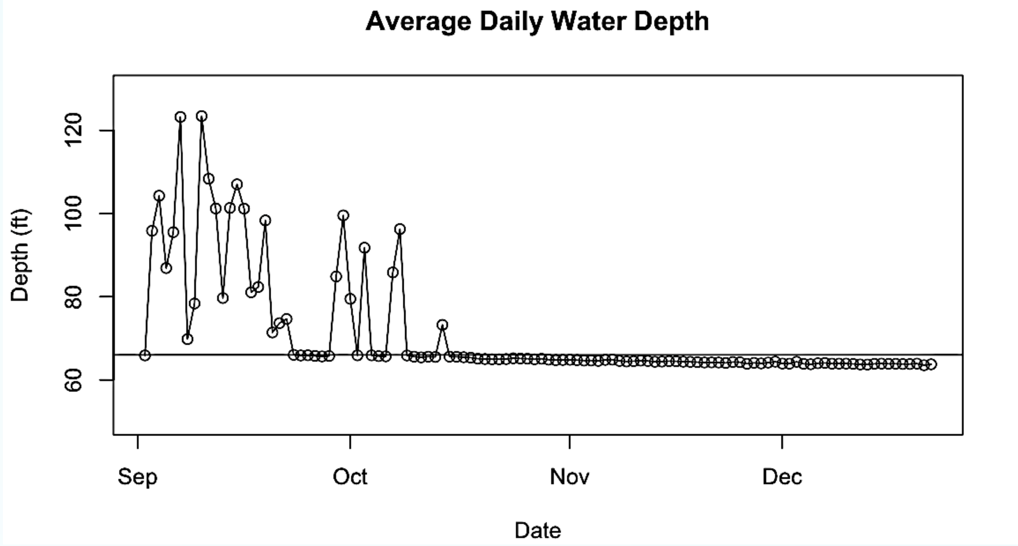
Via Viaanix, an IoT solutions company, we had the opportunity to examine data containing aquifer depth levels from September 2 to December 22, 2022. While the data set itself did not contain the location of the measurements nor other variables such as precipitation, temperature, and agricultural usage, we were able to pull data from other sources and make inferences to fill in the missing pieces. Our goal was to create a multiple models based on various situations to predict future aquifer depths.

Data Preparation

Viaanix's data set contained 107,322 aquifer depth observations spanning the last four months of 2022. For supplementary data, we pulled daily temperature and precipitation data from wundergound.com for Scottsbluff, NE, which we used as a control location given its proximity to the Ogallala Aquifer. Next, we matched the two data sets by downsampling the aquifer depth data using the daily average and joined it with the supplementary data. Simple data cleaning strategies such as searching for n/a values and removing extraneous variables were also performed.

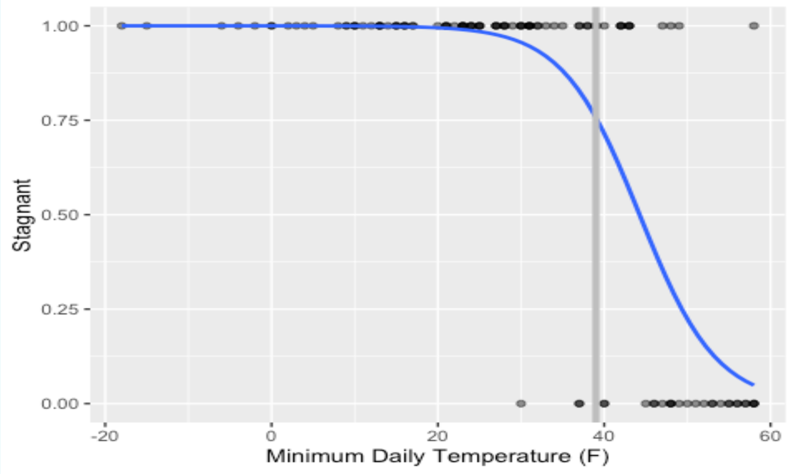
Process

When looking at the plot aquifer depth plot vs date, we quickly noticed that once the aquifer depth fell below 66 feet -- which happens around October 15 – it became stagnant.

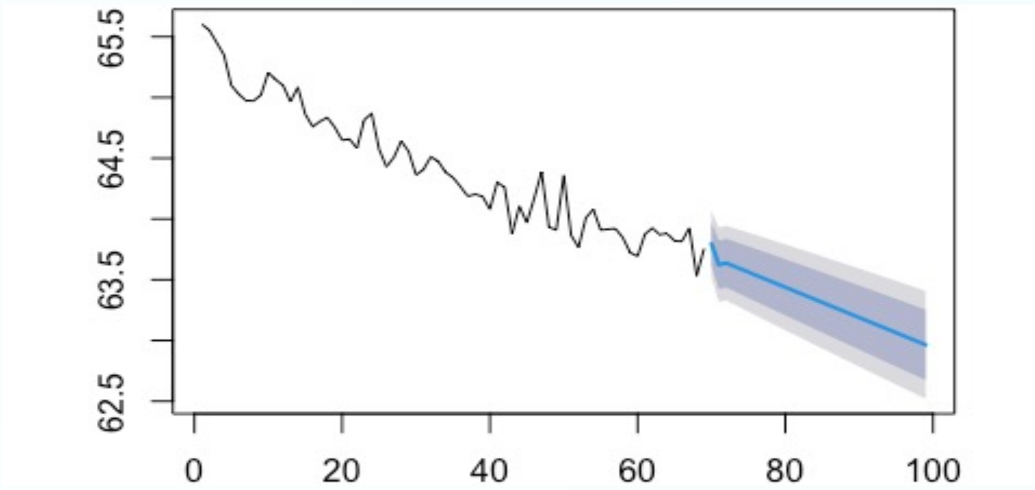


We had a few predictions as to why this may be the case. 1) Most crops tend to be harvested from late August to early November. 2) In mid October, temperatures began to drop which causes the ground to become too hard for water to percolate into the aquifer. We decided to examine the second option and find out at what air temperature aquifer levels become stagnant.

First, we created a Boolean variable, stagnant, depending on if the aquifer depth was above or below 66 feet. Using the minimum temperature by day, we created a logistic regression model with stagnant as the response. Using a calculated threshold of .757, we calculated the minimum temperature per day at which aquifer depths tend to stagnate. We found that temperature to be 39 degrees.



We then broke the data into two parts 1) where the aquifer levels fluctuate (before October 15) and 2) where the aquifer levels are stagnant (after October 15). We then fit two models based on the two new data sets. For the data prior to October 15, we fit an AR(2) model with a first difference. Additionally, for this data, we also fit an AR(1) model using precipitation and temperature as covariates. However, neither precipitation nor temperature were significant predictors or aquifer depth. For the aquifer depths after October 15, a MA(3) model with drift and a first difference was taken (which suggests the aquifer depth was not truly stagnant, but rather decreasing slowly). Forecasts from this model also show how aquifer depths will continue to decrease unless something, likely temperature, changes.



Findings, Error, & Future Study

- When the minimum daily temperature is 39 degrees or less, water depth tends to be roughly stagnant. As such, a model predicting water depth for the warmer months would not do well during the winter and vice versa.
- Since we had data from only four months, we were unable to account for seasonality within a single model.
- Surprisingly, precipitation and temperature were not significant predictors of aquifer depth. This is likely due to us not having an exact geographic location for the aquifer depth measurements.
- Future studies should incorporate more potential variables such as water run-off and have consistency throughout measurements. Additionally, models other than ARIMA such as ETS or a neural network using LSTM could be used.

Recommendations

- To recharge the aquifer during winter, run-off should be collected, and a manual pump should be used instead of relying on percolation.