Modeling Changes in Aquifer Water-Levels in New Mexico Due to the Imbalance between Discharge and Recharge

New Mexico

Supercomputing Challenge

Final Report

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Team 35

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Executive summary:

The modeling of aquifers is very important to just about every human on Earth. Aquifer water is used for drinking, farming, manufacturing and numerous other things. So why, with so much importance thrown on to these bodies of underground water, do we know so little about them, like how much water is left in them or the how much longer they can sustain populations? Our model will show just how much water is in the aquifers, allowing us to plan ahead, take pre-emptive steps. The program uses easily found information like rainfall, soil permeability, human use, and human re-use to see how much water is being drawn from the aquifers. Our program will use differential equations to model more accurately, since our input variables can and would affect each other in real life. Our program is written Netlogo because it is useful in showing the system dynamics of this model.

Problem statement:

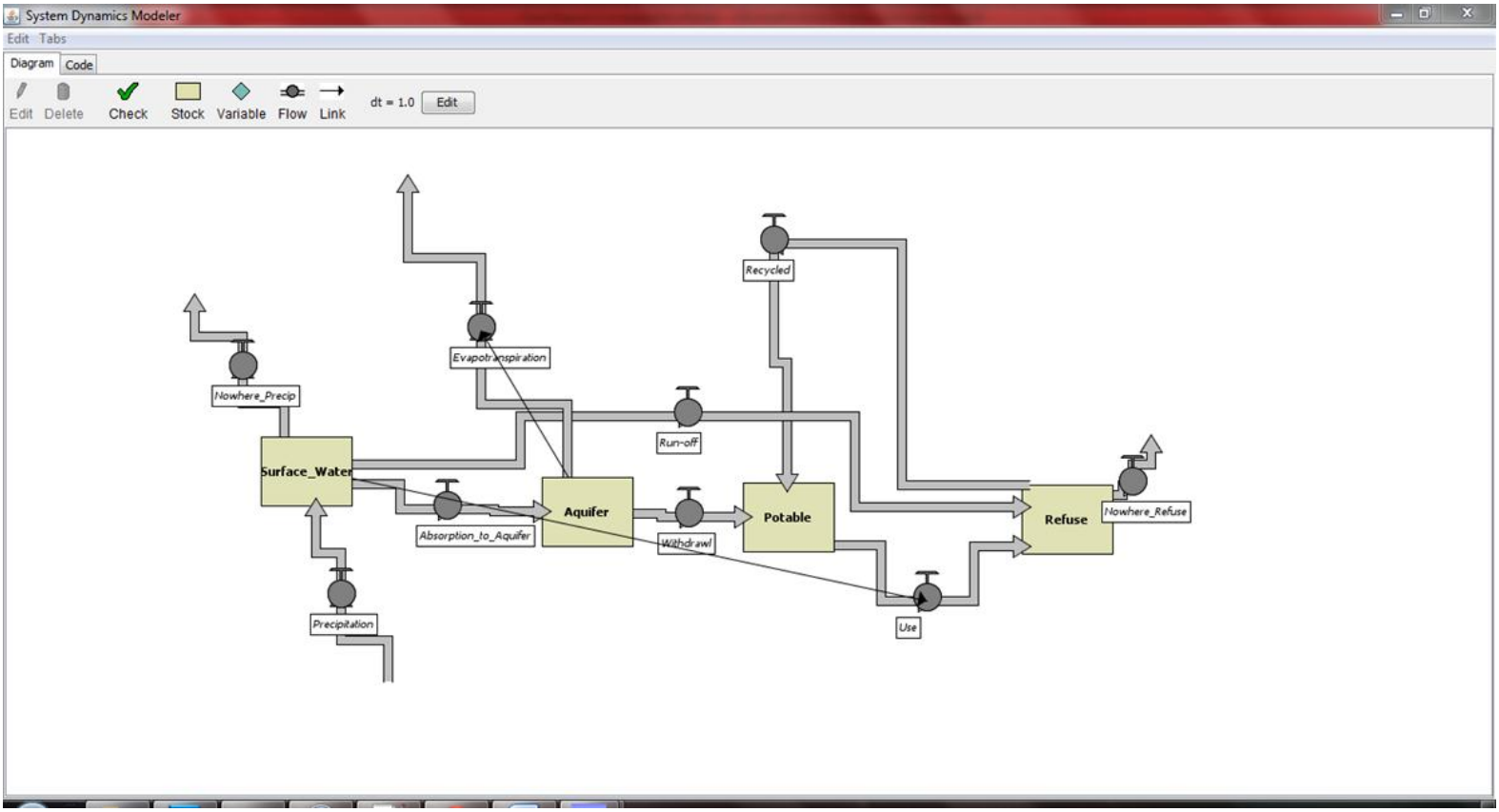
The imbalance of the aquifer recharge and discharge is a major problem here in New Mexico. Nearly all of our water comes from this aquifer, for a number of uses; drinking, agriculture, showering, etc... If the aquifer ran out of water, New Mexico would most likely be abandoned, with only a few people living off of the rivers.

Introduction to program:

Our program attempts to accurately model the change in the ground water level over time using easily found data like the area's population, average rainfall, and soil permeability. Our research revealed that aquifer level data is very difficult to find, since it is not one continuous, static structure. Therefore we decided to use ground water levels as an indication of how the aquifer in general might change over time. Our program models the changes in water levels using differential equations because many of the variables would affect each other, making a simple equation invalid after a few ticks in NetLogo. The figure below shows the average rainfall for New Mexico over the past century, with this, and many other variables filled in, the program we can basically determine what the future of the aquifer might look like, including when it will no longer be able to sustain a population.

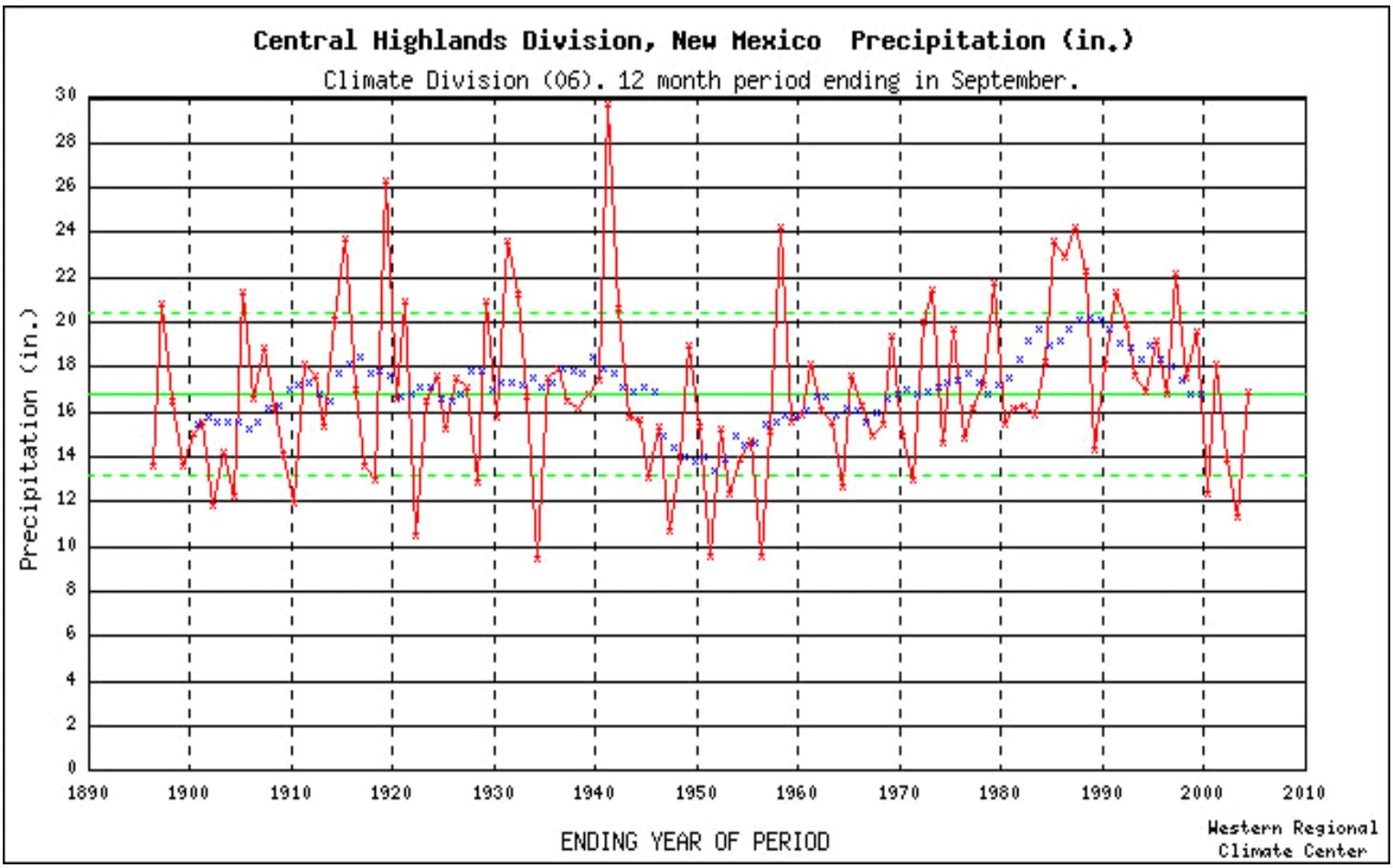
Software:

We used NetLogo as our primary programming software, along with its System Dynamics Modeling module. Below is a screenshot of the System Dynamics Modeler.



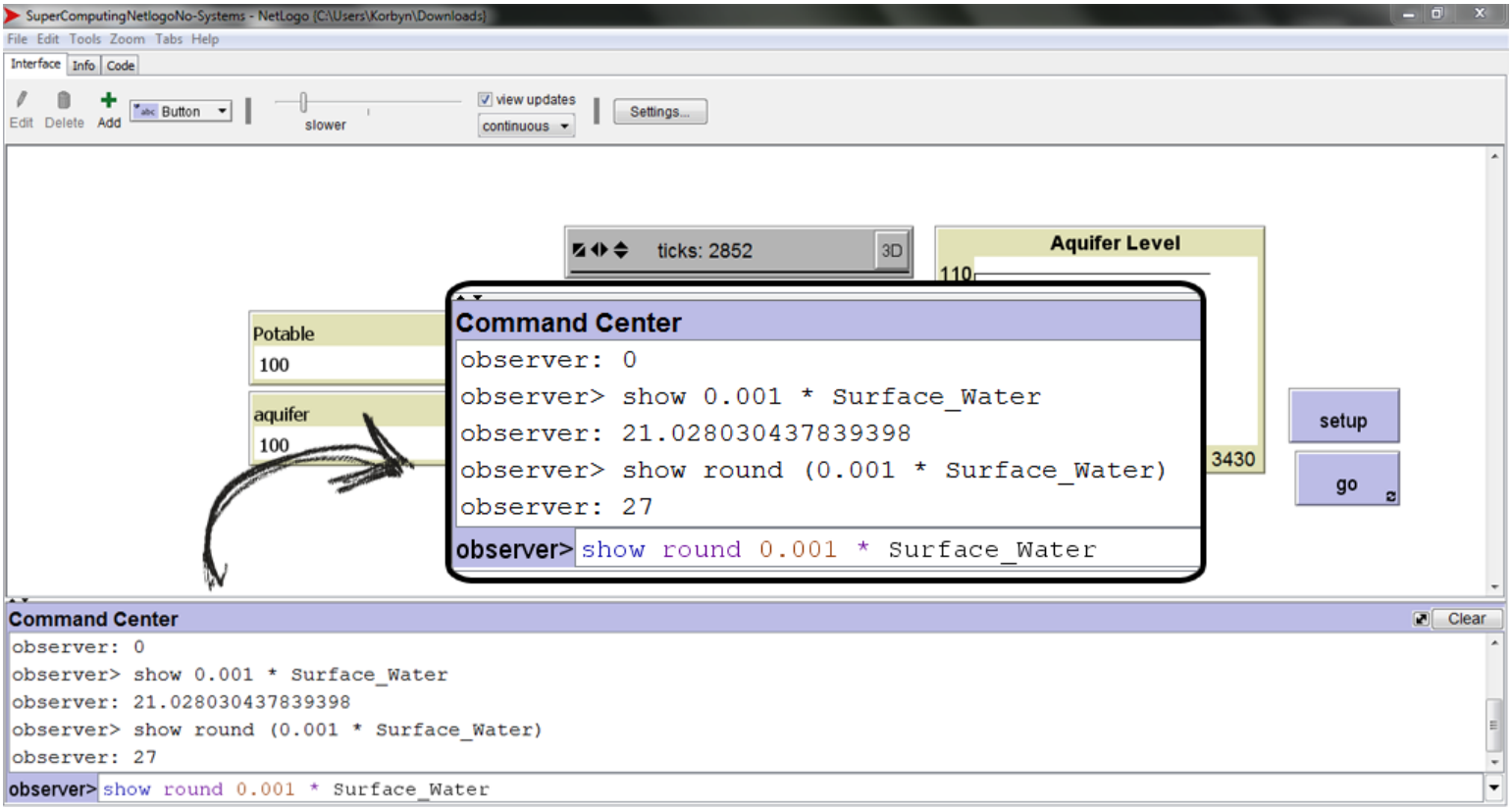
Results:

At this point our program is intended to accurately model the rates of recharge and discharge in any aquifer system. The program allows input of a few easily found variables.



Round-off errors:

Earlier in the program's development we did not factor for the round-off of large decimal numbers, and the program began to automatically round-off to what it saw fit, this caused the numbers to instantly collapse to 0 after a certain amount of ticks.



Computer order of operations:

We ran into this problem a lot, due to the program applying order of operations. We had the program round a value, but, the value was closest to 0, therefor it rounded to 0 and multiplied by the Surface Water variable, and we were left with an invalid result. You can see below when parentheses were applied the product was change significantly, by almost 6 whole numbers forward.

Time Steps:

We had to determine what each tick should be worth, in terms of increments of time and have it be a balance of both accuracy and computing speed. We are trying to get the program

down to a week by week scale, however we may have to use a monthly scale due to lack of data.

Team problems:

Originally our team had six members, although very early on, two members left due to timing conflict. Later in the year, about one half of the way two members left due to personal reasons. The two members left are what remain today.

Conclusion:

With this program, the modeling of groundwater levels related to any aquifer system is possible. Although all aquifer systems, such as, the Rio Grande aquifer is very complex it will continue to be very important to predict the amount of water that such systems can supply in the future from here in New Mexico all the way to the Guarani Aquifer in Brazil, Argentina, Paraguay and Uruguay since all of the people who live in these areas depend on the water that their aquifer provides.

Acknowledgements:

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