Climate Change

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Team Number: 053
School Name: Jackson Middle School
Area of Science: Environmental
Project Title: Climate Change
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Mentors: Mr. Nick Bennett and
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Executive Summary:

What is climate change? How is climate change affecting us here in New Mexico? Is there a way to predict climate change? These are the questions we asked ourselves before we decided to track the weather patterns in Albuquerque. To help answer these questions we gathered research from the last 80 years and collaborated with Mr. Kerry M. Jones, a Warning Coordination Meteorologist with the NOAA National Weather Service. Then we started creating computer models to track the weather patterns. Finally, it was decided that Adam would use StarLogo Tng and Chris would use R to model our take on the project. We are hoping that our programs will show dramatic weather changes. Also, Adam's program could be used to explain climate change and its impact on animals as well as humans. Chris would like to see his program used to predict extreme temperature changes so people could be better prepared in the future.

Statement of Problem:

Climate change is a problem that is affecting people and the environment. Humans have to deal with drought conditions and higher than average temperatures. Some mammals are coming out of hibernation earlier while others are moving to higher altitudes. This project will show what effects ambient temperature and rainfall amounts have on our environment.

We are going to track the ambient highs, lows and average temperatures in the Albuquerque area. We are then going to track the precipitation highs, lows and average amounts for the same area to show a warming climate change. We chose the Albuquerque airport weather station as our weather relay station because it is the only one in this area to be in the same location for all 80 years. We concluded that this would allow our data to be the most accurate.

We will then use our data to create programs in both StarLogo Tng and R. Originally we were going to see which one can handle the data we enter the best and use that program as our model for climate change. However, as we got started we decided that Adam would keep working on StarLogo Tng to show how water amounts are affecting animals in our area, while Chris would work in R to show statically a climate warming change. One day we would like to see our programs used to educate people, of all ages, on climate change awareness.

Description of Problem:

How is climate defined? "Weather is a short-term condition. … Climate, however, is a long-term condition—the kind of weather that a region tends to have over many years (30 or more), including average temperatures and long-term totals for rainfall, sunshine, and wind conditions." (Nankin) With this definition in mind we set our sights on looking at ambient temperatures and precipitation amounts for the last 80 years in the Albuquerque area. It was important to narrow down our project because to study climate change accurately we would need many data sources and a lot more time. "For example, surface temperature measurements are taken by both human and automated instruments at fixed stations … temperatures at different heights in the atmosphere are obtained primarily from weather balloons and satellites." (National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council) For this reason the fixed automated weather station at the Albuquerque Airport (Sunport) was chosen. "The weather station at the Sunport is the only one in this area that has been in the same spot for the time frame you are looking at." (Jones)

Data was collected from the website weather underground as it was the only one we could find that was free. We collected data showing the ambient high, low, and average temperatures, the high, low, and average precipitation amounts, weather condition, and wind conditions from January 1931 thru December 2010. We are going to use the same data in both StarLogo Tng and R. We will show the relationship between ambient temperature and precipitation as they relate to climate change. Using R we will graph the average high and low temperatures, as well as, the

actual high and low temperatures for every day for the last 80 years. Using StarLogo Tng we will show how the climate affects the animal population.

After the climate data was collected we broke off into different computer models. Adam started creating predators in StarLogo Tng. He did this by finding the predator block in the StarLogo Tng menu. After the block was found he decided to make the predators into wolves and set up the steps required to make them move around. Chris started out by writing codes in NetLogo that would allow him to create a climate tracking program. He started with writing codes that allowed for a set up and run feature. Then he started adding codes that showed the average and actual high and low temperatures, as well as the average and actual high and low precipitation amounts, for the last 80 years. Creating these codes line by line was very time consuming so our mentor, Nick Bennett, suggested that Chris use the statistical program R. We took his suggestion and decided to do R modeling.

Meanwhile, Adam created prey in StarLogo Tng by finding the prey block in the menu button. He then made the prey look like rabbits. Next he created the commands for the prey to move around. Then Adam added the steps necessary for both predators and prey to lose energy while they moved around. After this step was completed random green patches were created for the prey to eat. When the prey steps on these patches they gain energy and the green patch loses all its energy. This turns the green patch black. At the same time predators are chasing the prey. When a predator catches the prey the prey's energy drops to zero and the predator gains some energy.

After the decision was made to create a program in R, the program was downloaded from the Internet. Chris then went back to the weather underground website to download each month for

the last 80 years in a Comma Delimited Format. That information was then transferred into Excel in a date, year, month, day format. Each month had to be done separately to make sure that the word wrap was turned off. Then all of this data was imported into R by creating the code rainfall <- read.delim (file.choose ()).

Adam continued to work on StarLogo Tng by creating a hidden landscaper to make water elements such as ponds and a river. The landscapers were created to only work during the set up step. First, the terrain for the ponds and rivers were set at a less than zero altitude. Then landscapers move across the terrain and stamp any patch they come to with an altitude of less than zero blue. If the patch is higher than zero in altitude the landscaper moves on. The landscapers keep moving across the terrain until they come to the edge of Spaceland. This is when the landscapers die.

To stop the water elements in StarLogo Tng from disappearing, a hidden rain cloud was also created. A cloud breed was created to form rain drops that then fell toward the terrain. When the rain drops got to be equal to or lower than the altitude of zero they turn the patch blue and die. If they hit an attitude higher than zero they just die and leave the patch the color it was. This allows the blue patches that form the ponds and rivers a chance to always have water in them.

Meanwhile, Chris was still writing codes in R. He created the arrow operator and a calculator function. Chris then wrote codes to show the temperature highs and lows. This is an example of the code that allows for high temperature to be displayed: rainfall $ Max.Temperature F [rainfall $ Max.Temperature F <- 100] < - NA This step was then repeated to write codes for the mean and low temperatures, as well as, the high, mean, and low precipitation amounts.

Adam then added the final step to his StarLogo Tng project by having both the prey and predators drink water. A code was created that told the prey or predator to stop when they come to a blue patch. The prey or predator then gains energy from the blue patch. The blue patch then turns black and dies. At this point the prey or predator turns 180° and moves away from that patch. This makes it so the prey or predator can't cross over the blue patches that form the ponds and river. At this time Adam is ready to show the StarLogo Tng model to the judges.

Chris then checked his R code by plotting the variables on a graph. He did this by creating a code that shows plots of months, to temperature or precipitation, amounts. This is an example of a yearly plot for precipitation: plot (x = rainfall $ MST [-1: (-length (rainfall $ MST) + 365)], y = rainfall $ precipitationIN (-1: (-length (rainfall $ MST) + 365)] This plot changes the 365 days of a year (times 80 years) into numbers on the x coordinates. This means that the first year has 365 days but second year starts on number 366 instead of number 1. This process is repeated until you have 29,220 days (you have to include leap year days when that year has 366 days instead of 365). Chris is now working on changing the suspect data into smaller than trace amounts. He hopes to have this completed before judging.

Results:

Adam found that the animals on his model had a very hard time living without a water supply. The predators tended to live longer than the prey without water. However, as soon as the prey died off the predators died too from a lack of food source. Adam expected the ecosystem to equal itself out after a period of time, but it never did. The predators always out lived the prey. Also, the water in this model never vanished because StarLogo Tng either crashed or all the prey died.

Chris found that some years the ambient temperature is above the average temperature and some years it is way below average. The same seems to be holding true for the precipitation amounts, as well, but not to the same extent. From what he has completed so far it shows that the Albuquerque area has entered into a warming climate cycle. However, he is left to wonder, if he was to collect and add data for 2011 how that data would change his findings. Those of us who live in the Albuquerque area know that in the month of February we hit record setting lows with days like February 3 coming in at -7°. (weather underground) Chris looked up the temperature of that day for this paper.

Conclusion Reached:

From his model Adam concluded that animals need water to survive. On the StarLogo Tng model the water was set up to always be the same amount and not change. He concluded that if the rain amounts remained the same or was less for a prolonged period of time that the animals would die. He thinks this might be the same result if too much water was added into the environment. Adam concluded that a stable climate is needed to keep the environment in balance.

From what Chris has completed so far he concludes that the Albuquerque area has entered into a warming climate change. This could mean big trouble for us if the area enters into another "megadrought". According to University of New Mexico scientist Peter Fawcett "The warmest temperatures in the record coincide with where the drought occurs. Those dry periods last for centuries to thousands of years." (Fleck) Warmer temperatures push our precipitation further north so this affects our precipitation amounts as well. This is an area of science that Chris thinks needs further investigating.

Next Steps:

Adam decided that if there was more time he would add trees to his StarLogo Tng model. This would allow him to see how the trees were affected by the water amounts. Would the trees die off fast or slow? Would the trees die off before the animals did? Also, would one type of tree survive longer then another type?

Chris decided that, given more time, he would finish adding the data that was collected for the conditions of the day. For example, he would add if it was sunny, cloudy, snowing, etc. He would then add the data for the wind conditions for all the days. With these two variables added Chris is interested to see if the plots still show a warming change or do things stay the same or show a cooling off change? Chris would also add the complete data for the 2011 year so far. As was stated earlier it would be interesting to see if that data would change the outcome of this project as well.

Most Significant Achievement:

Adam's most significant achievement was learning how to create an eco system. He thinks he got pretty close to making an equal eco system. This was the first time he has ever used StarLogo Tng so learning a computer language was an achievement also.

Chris' most significant achievement was seeing the lines of codes he created come to life on the computer screen. He has used both StarLogo Tng and NetLogo in the past but really enjoyed learning R. He has been able to study changing climate in the Albuquerque area and has learned about the devastating effects that can be caused to our climate by warmer temperatures. He was able to collect data and enter it into R to show others our warming climate change.

Recommendations:

Adam would recommend not spending so much time trying to make the eco system equal if he was to do this project again. Instead, he would make it sort of balanced with a little more water than a little less water. He would also add two different types of trees into this model. Other than that he would keep everything else the same.

Chris would recommend not starting out with a different program first. With a little research into programs in the beginning he would have found out that NetLogo was not the best program to use for this project. This extra step in the beginning would have saved a lot of time on duplicated work to make the data compatible with R. This would have given more time to learning R better so that when problems came up with it he would have known how to fix them or the questions to ask so someone else could help him fix them. Then, Chris would have had the time to add all the collected data into the R model to see a more complete outcome.

Acknowledgements:

Sponsoring Teacher: Mrs. Karen Glennon

Mentor: Mr. Nick Bennett

Mentor: Mr. James Hoebing

Sounding Board: Mr. Kerry M. Jones, Warning Coordination Meteorologist NOAA National Weather Service

Sounding Board: Mrs. Cherri Hoebing

Resources, Graphs, Software, and Codes Used:

References:

Adler, Joseph. R in a Nutshell. Sebastopol: O'Reilly, 2010.

Fleck, John. "Megadroughts." Albuquerque Journal 24 February 2011: front page -A2.

Jones, Kerry M. Warning Coordination Meteorologist NOAA National Weather Service Christopher M. Hoebing. 2010.

Nankin, Frances. Wonders of Weather. Boston: Kidsbooks, 2008.

National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council. Understanding and Responding to Climate Change. The National Academies, 2008.

NOAA National Oceanographic Data Center. October - March 2010-2011 <www.nodc.noaa.gov>.

The McGraw-Hill Company, Inc. "Earth Science." The McGraw-Hill Company, Inc. Earth Science. Columbus: McGraw-Hill Glencoe, 2005. pgs. 483 - 502.
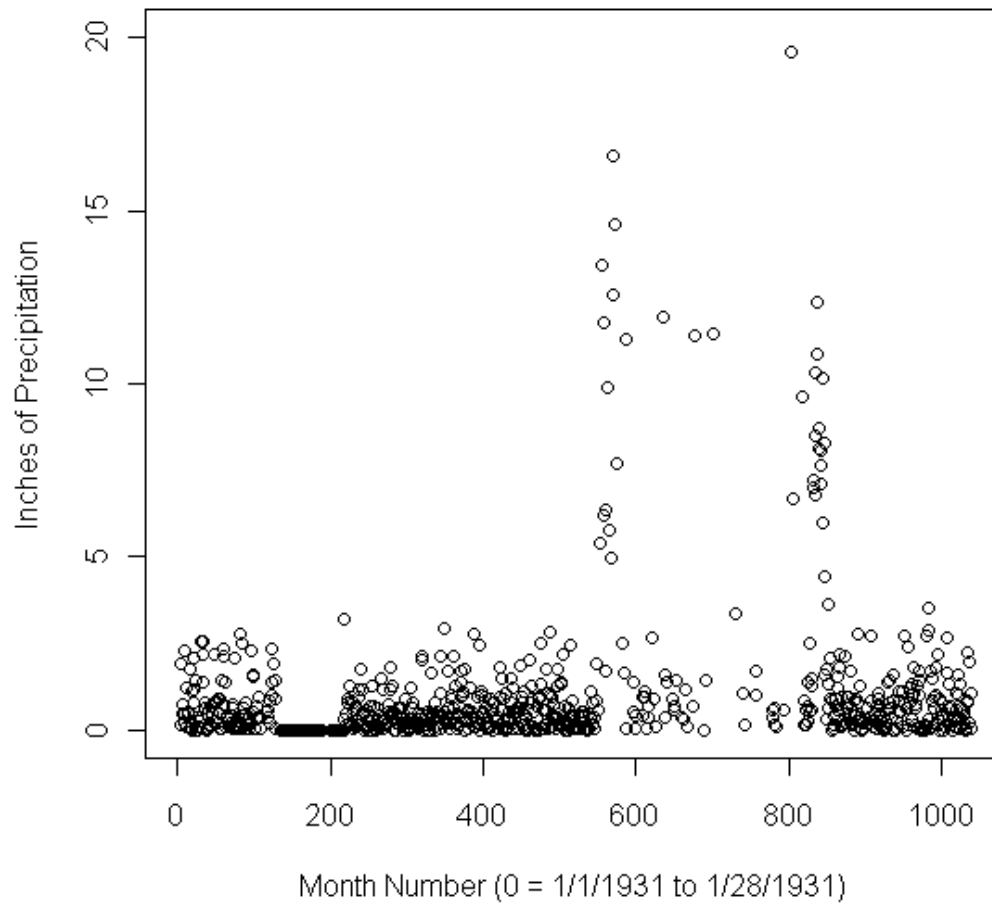
U.S. Environmental Protection Agency Climate Change. October - March 2010 - 2011 <www.epa.gov/climatechange>.

U.S. Environmental Protection Agency Climate Change. October - March 2010 - 2011 <www.epa.gov/climatechange/effects/eco_animals.html>.

U.S. Environmental Protection Agency Climate Change. October - March 2010 - 2011 <www.epa/climatechange/effects/extreme.html>.

weather underground. October - March 2010 - 2011 <www.wunderground.com>.
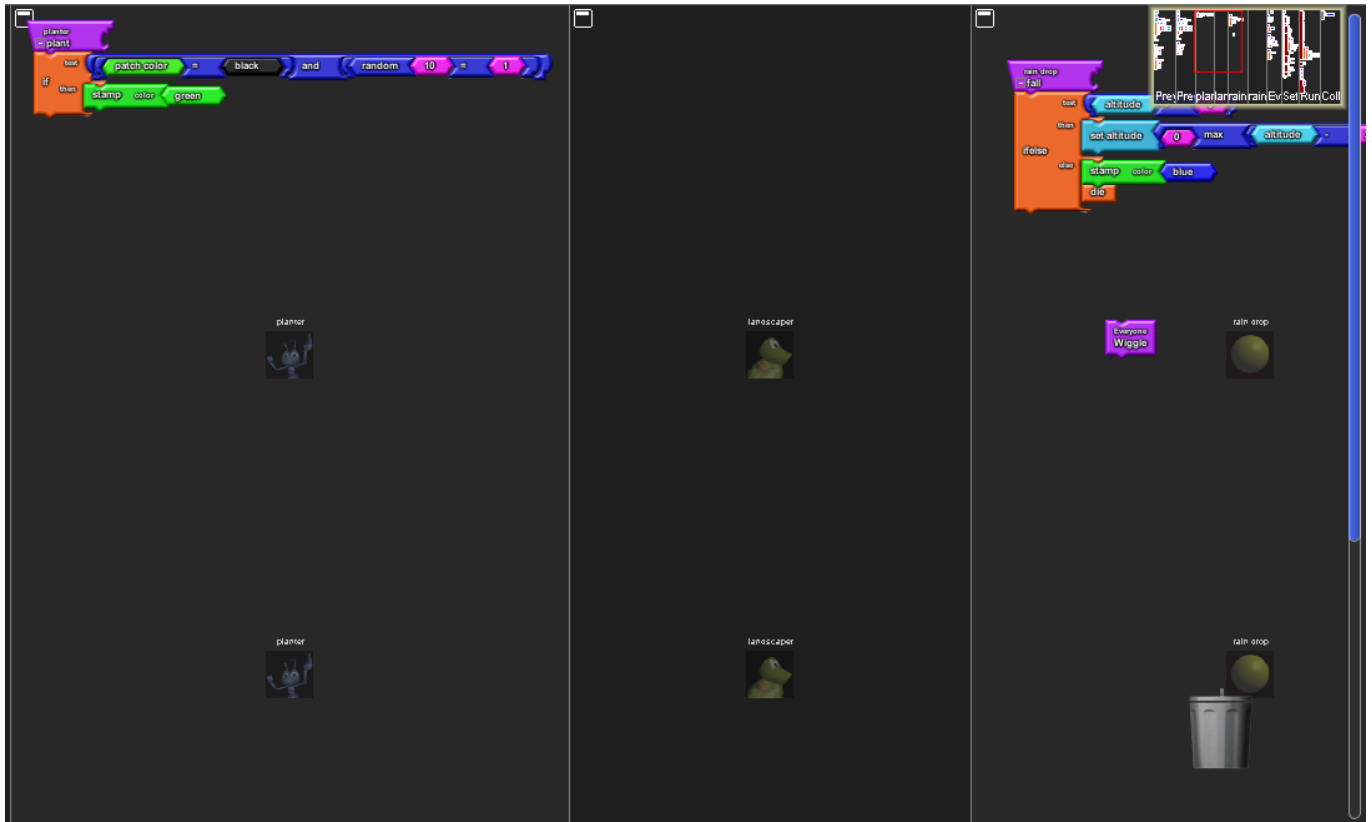
Graphs:

What R can show you. This is a graph of the amount of precipitation for the month of January

for the year 1931. As you can see it has suspect data because it shows precipitation amounts

well above 5 inches for a day in Albuquerque, NM. With us living in a desert area precipitation
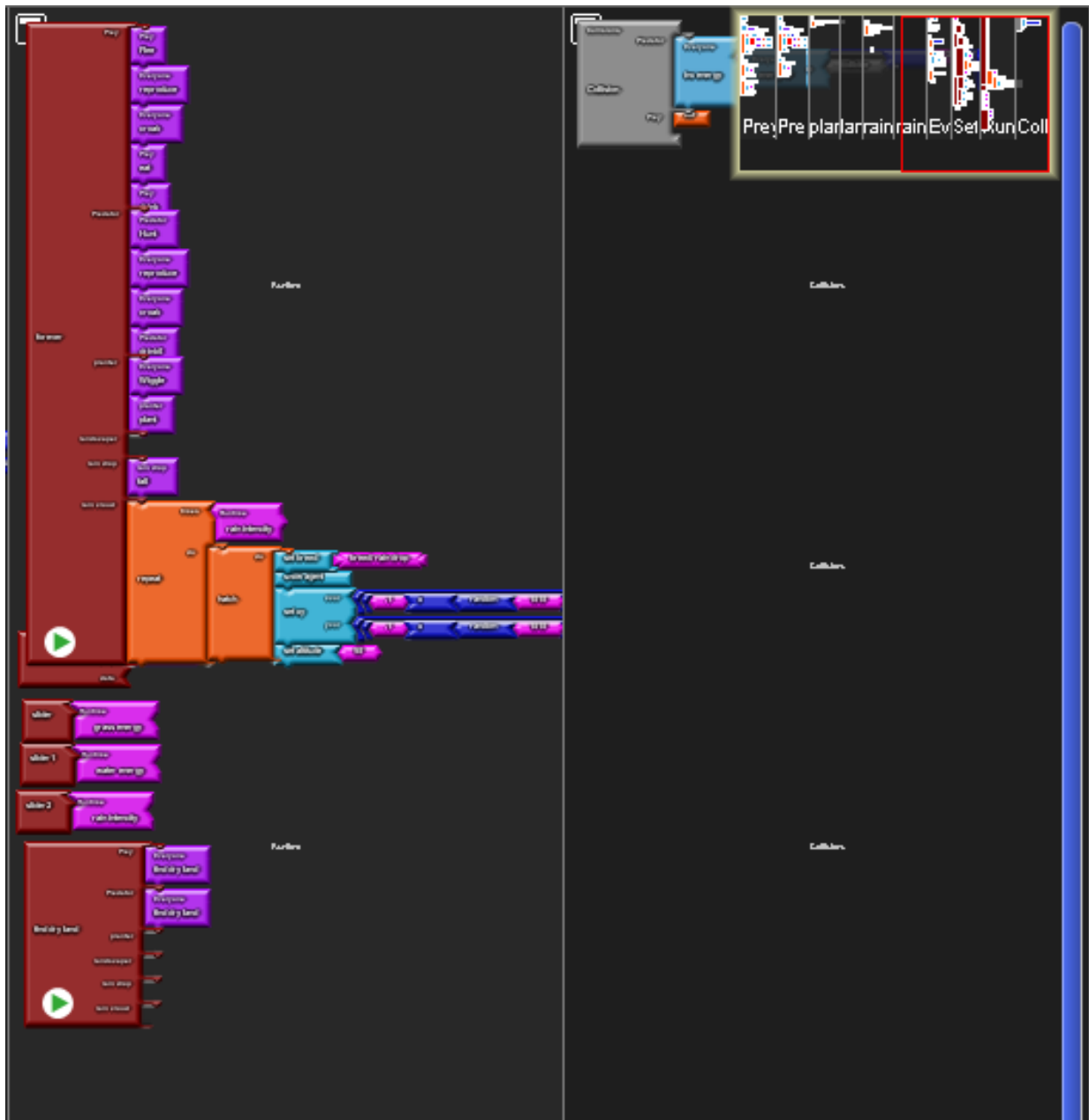
amounts like that would be an unlikely event.

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Codes Used:

StarLogo Tng:

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R Code:

```
rainfall <- read.delim(file.choose())

rainfall$MST <- as.Date(rainfall$MST)

rainfall <- rainfall [order(rainfall$MST), ]

rainfall$Max.TemperatureF[rainfall$Max.TemperatureF < -100] <- NA

rainfall$Min.TemperatureF[rainfall$Min.TemperatureF < -100] <- NA

rainfall$Mean.TemperatureF[rainfall$Mean.TemperatureF < -100] <- NA

rainfall$PrecipitationIn[rainfall$PrecipitationIn > 50] <- NA

# plot(x=rainfall$MST[-1:(-length(rainfall$MST)+365)], y=rainfall$PrecipitationIn[-1:(-length(rainfall$MST)+365)])

rainfall$month28 <- (as.POSIXlt(rainfall$MST)$year - 31) * 13 +
pmin(as.POSIXlt(rainfall$MST)$yday %/% 28, 12)

monthly.stats <- data.frame(month=0:(max(rainfall$month28)))

temp <- aggregate(x=rainfall$PrecipitationIn, by=list(rainfall$month28), FUN=sum)

monthly.stats$precip[temp$Group.1 + 1] <- temp$x

plot (x=monthly.stats$month, y=monthly.stats$precip ,ylim=c(0, 20), xlab="Month
Number (0 = 1/1/1931 to 1/28/1931)", ylab="Inches of Precipitation")
```