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HOW HAS CLIMATE CHANGE IMPACTED SUMMERTIME RAINFALL AMOUNTS IN NEBRASKA?

Erinn Richert
University of Nebraska-Lincoln

Disclaimer: The following thesis was produced in the Environmental Studies Program as a student senior capstone project.

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by

Erinn Richert

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Erinn Richert, B.S.

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Advisors: Dr. Betty Walter-Shea, Dr. Martha Shulski

Abstract

Recent weather events have led people to believe that climate change is the cause of them. El Niño Southern Oscillation, or ENSO, has a major influence, in certain parts of the United States. Climate models are predicting that there will be an increase of precipitation in the Midwestern United States. A previous study regarding the eastern portion of Nebraska investigated the impact of climate change on the precipitation schedule (Gershunov et al, 1997). For this study, three stations across Nebraska were investigated, one from the eastern, central, and western part of the state. Different statistical tests will be applied to look at the variance that may be present. Based on the trends found in the data, June and July are expecting to increase in precipitation while August is expecting to decrease. The statistical tests show that there is little variation between the months for the stations.

Introduction

Throughout the past decade, many people are quick to associate blame on climate change due to rising temperatures. But what most people do not understand is the role and impact of El-Niño Southern-Oscillation (ENSO). There are three phases of ENSO: El Niño, La Niña, and ENSO Neutral. During El Niño, winters are known to be warmer and drier in most of the United States, except in the southeast where winters tend to be wetter. During La Niña, most of the U.S. experiences cooler temperatures and above average precipitation while the southeast experiences below average precipitation. ENSO Neutral implies that there is very little change occurring for it to be an El Niño or a La Niña.

In the state of Nebraska, there is a precipitation gradient across the state from east to west. Between 1958 and 2007, there was a 15% increase in heavy precipitation events in the Midwest alone (Masters, 2012). There are clear trends that show the entire country should expect an increase in precipitation, especially in the Midwest. In late 2011, 56% of the country had experienced either a top 10% wettest year or a top 10% driest year. As the climate warms, models will predict that this type of pattern will continue to increase (Masters, 2012).

Previous studies have investigated variations in rainfall amounts to see if climate change has been a factor. The findings have shown that environmental changes related to human activities have changed the odds of heavier rainfalls. A study to estimate the space-time distribution of daily precipitation under climate change in eastern Nebraska analyzed atmospheric patterns and daily precipitation events (Matyasovszky et al, 1993). A highly variable spatial response to climate change was identified and most of the values reflected a somewhat wetter and more variable precipitation routine in eastern Nebraska compared to the rest of the state.

Climate change is expected to lead to more droughts and floods (Hu & Feng, 2001). There is no clear indication that climate change has had an impact on these events. Interannual variability of precipitation minus evaporation has been shown to increase almost everywhere across the globe, with a few exceptions (Hu & Feng, 2001).

In the Great Lakes basins and Midwest, 7- day and 1-year precipitation events occur more frequently during the summer (Kunkel et al, 1999). 7-day precipitation events are defined as events that occurred within a week, while 1-year events are defined as occurring within a year's time span. In other parts of the country, the precipitation events frequency varies between seasons.

The objective of this study is to see if ENSO has an impact on summertime precipitation in Nebraska. I want to see what the historical trend is and whether future precipitation will increase or decrease.

Materials and Methods

The area of study is the state of Nebraska. Meteorological data for the summer months of June, July, and August were accessed from three different weather stations across Nebraska: (1) Hartington (Figure 1), (2) Broken Bow (Figure 2), and (3) Lodgepole (Figure 3). These stations were selected because they had few data gaps within a 100 year period (1910 – 2010). Data were acquired from the High Plains Regional Climate Center (HPRCC), using the CLIMOD service. The data collected for each station includes maximum and minimum air temperature (Fahrenheit), daily precipitation totals (inches), hourly precipitation (inches), snowfall (inches), snow depth (inches), and winds (mph).

Several statistical tests were performed using the meteorological data to test for significant differences among the locations. These tests are: (1) the z-test, which is best used when data parameters are known, and (2) the t-test, commonly used when the test statistic, in this case the precipitation data, follows a normal distribution. The z-test will look at the distribution of the data in the second and third quartiles. The t-test will look at how closely related the data between two months are. The number of events per year will be totaled and plotted, and compared to ENSO events. A trend line will be included to look at historical trends. All statistical tests were run using Excel.

Results

June had the highest amount of rainfall out of the three months for the east and central locations while August had the higher amount by just 0.26 inches for Lodgepole. The data were sorted into quartiles. I included the minimum value for each month for each station since this value was different than the value for the 1st quartile. The minimum precipitation amounts for all stations were less than an inch and there are two instances where the minimum monthly value for a single year was zero inches (Lodgepole August, Hartington July). The 1st quartile ranged from 1.0-2.31 inches, the 2nd quartile ranged from 2.0-4.15 inches, the 3rd quartile ranged from 2.94-5.41 inches, and the 4th quartile ranged from 7.16-11.06 inches (Table 1 – 3); the value depended on location. With the individual analysis of each month for each station, June and July had positive trend lines while August had a decreasing trend line.

A departure from normal for the precipitation was calculated and then plotted to see how it compares to the ENSO trend (Figures 8 – 10). For the three locations, the two trends seem to follow each other; there are some instances where the two trends match up perfectly to each other. During El Niño years, precipitation amounts were low and during La Niña years, the precipitation amounts were high. However, there are a few cases where this does not hold true. In the late 1970s to the early 1990s for Hartington, the ENSO trend is much higher than the precipitation amount. I also plotted the extreme events with the ENSO trend to see if there would be any correlation (Figures 11 – 13). More of the extreme events happened in June for Lodgepole. The events seem to follow the ENSO trend, but it appears they do so a year or two later. Broken Bow had many extreme events in August at the beginning of the period, but during the ENSO period, June and July have the majority of events. Like Lodgepole, the events seem to follow the ENSO trend a year or two later. Hartington had a majority of the extreme events happen in June and August, and it follows the ENSO trend like the other two locations.

The T-test uses two different population means, in this case months, and looks at the variance in the samples. A two-tailed t-test distribution, with the type of the test being two-sample equal variance or homoscedastic was performed. This means that all of the variables have the same finite variance. With the T-test, I was expecting small numbers as the result. The small numbers would show that there is little variance in the data between the two months tested. I wanted to see how different the precipitation amount would be between months for the same station. The historical trends (Table 4) show that each month is different, so I wanted to test to see what the variances between the months are. Broken Bow and Hartington had small T-test results, but Lodgepole remained pretty close to 0.1 as a result. Because the results were small, this shows that there is little variance in between the two months sampled for the stations. Lodgepole shows that there is some variance within the precipitation amounts. In the future, I would like to perform this test for the same month across the three different stations to see how different they are from each other. I want to see what the variance is across stations instead of across months.

Discussion and Conclusion

It is expected to see an increase in precipitation in June and July, but expect a decrease in August, which already has a low precipitation total. This is based off of the historical trends, as well as the trend lines. However, the increase may not be as noticeable since the slopes are small. June had a higher trend than July and August, so it is expected to see a higher increase in this month compared to the other two. The trend lines for July and August started at the same point for Broken Bow and Lodgepole. While August shows a decrease for August, Lodgepole is showing an increase for August, although it is small and almost insignificant. The August trend line for Hartington starts out higher than the July trend line, but the two lines cross paths making July have a higher trend than August. The statistical tests show that there is little difference in the variance between months for the Hartington and Broken Bow stations. However, Lodgepole had higher t-test values, showing that there is some statistically significant difference in precipitation in the west as compared to the eastern and central stations. Results indicate the ENSO potentially has an impact on the summertime precipitation in Nebraska. Historical trends show a small increase of precipitation for the future, which could be in relation to rising temperatures. The departure from normal shows that there happens to be a correlation with the ENSO index. There appears to be a weak trend for El Niño years to produce lower amounts of precipitation while La Niña years produce higher amounts of precipitation. There is also a correlation between ENSO and extreme events. However, it takes a year or two for the effect to take place.

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Figures

Figure 1 – Location of Hartington, NE.

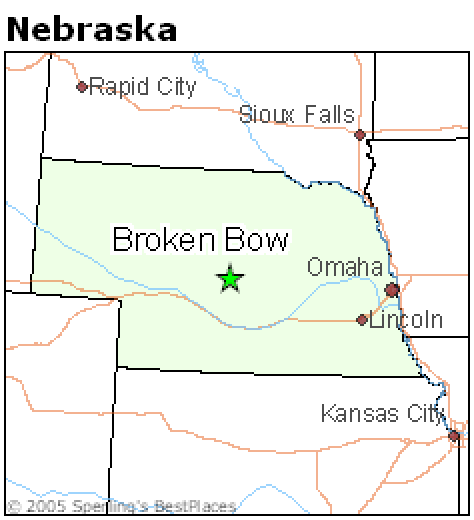

Figure 2 – Location of Broken Bow, NE.

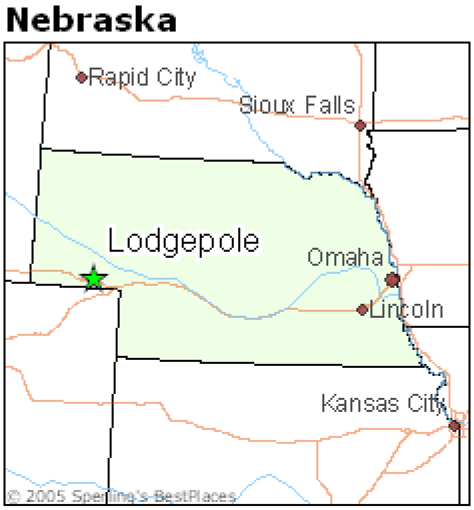

Figure 3 – Location of Lodgepole, NE.

Table 1 – Quartiles for Lodgepole, NE.

Quartile	June	July	August
Minimum	0.32	0.47	0.00
1st	1.67	1.45	1.14
2nd	2.57	2.28	2.00
3rd	3.76	3.03	2.94
4th/Maximum	9.68	7.16	9.94

Table 2 – Quartiles for Broken Bow, NE.

Quartile	June	July	August
Minimum	0.64	0.23	0.13
1st	2.25	1.75	1.60
2nd	3.42	2.95	2.33
3rd	4.87	4.17	3.40
4th/Maximum	10.33	9.06	9.89

Table 3 – Quartiles for Hartington, NE.

Quartile	June	July	August
Minimum	0.76	0.00	0.15
1st	2.31	1.67	1.69
2nd	4.15	2.48	2.57
3rd	5.41	4.01	4.03
4th/Maximum	11.06	10.97	10.33

Table 4 – Monthly precipitation trend per month per location.

	Lodgepole	Broken Bow	Hartington
June	0.0072	0.0071	0.0042
July	0.0058	0.0021	0.0042
August	0.001	-0.0067	-0.0032

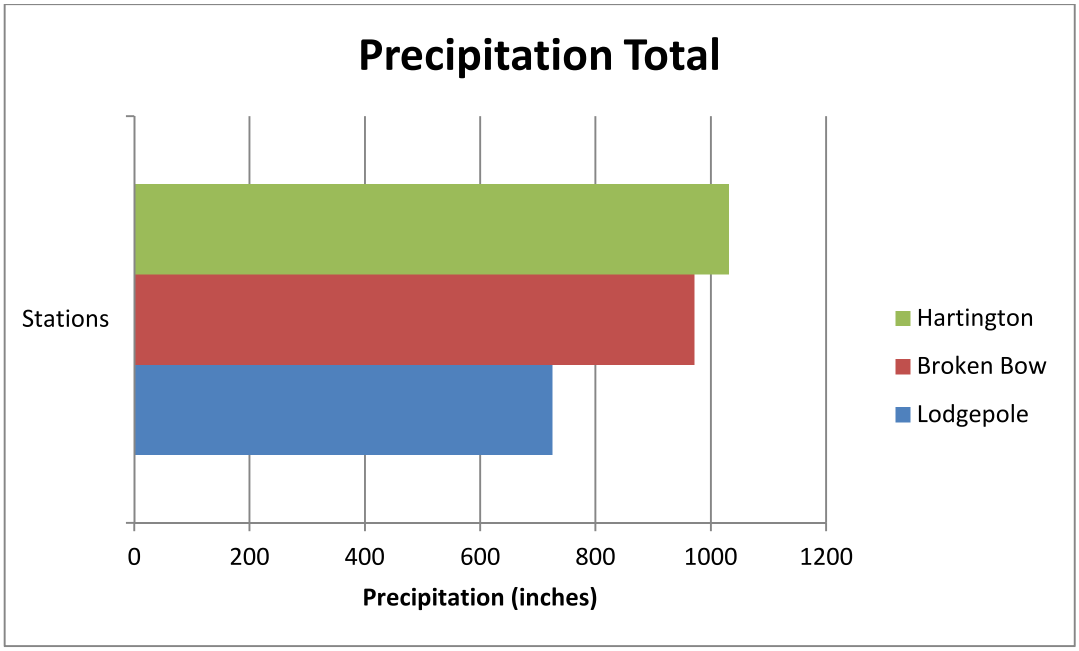

Figure 4 – Precipitation totals for all three locations over a 100 year time period.

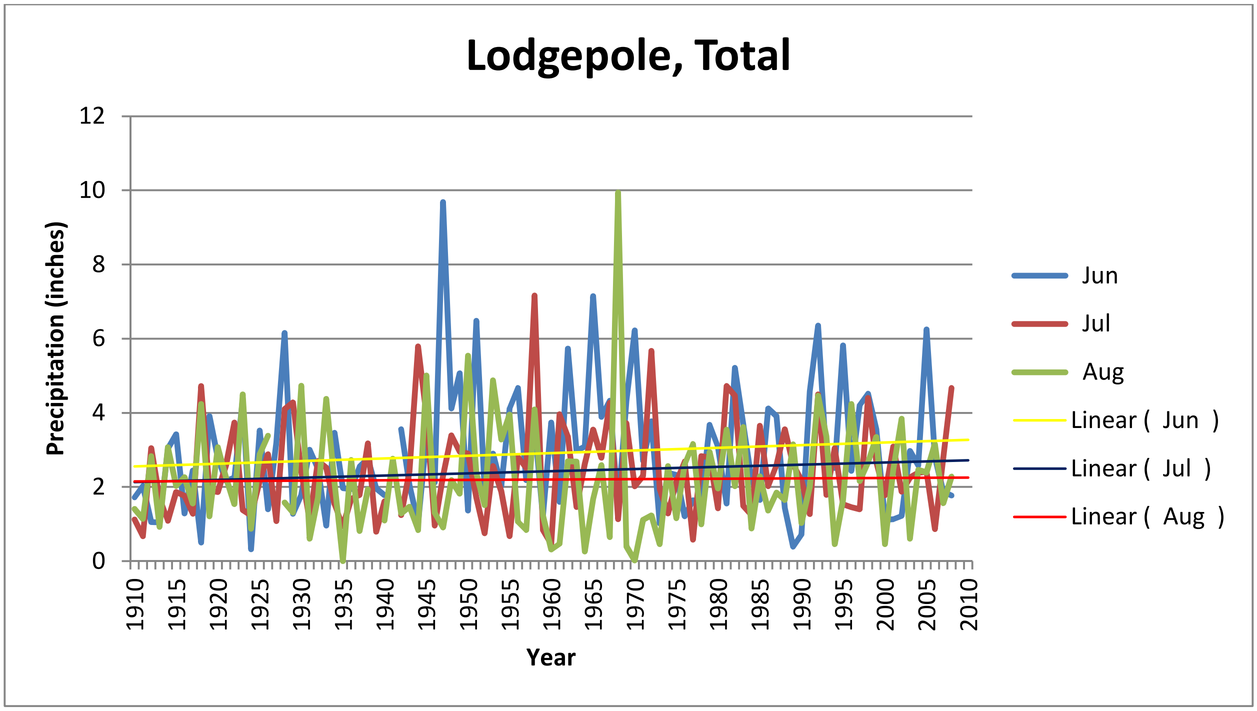

Figure 5 – The total monthly precipitation per month for Lodgepole.

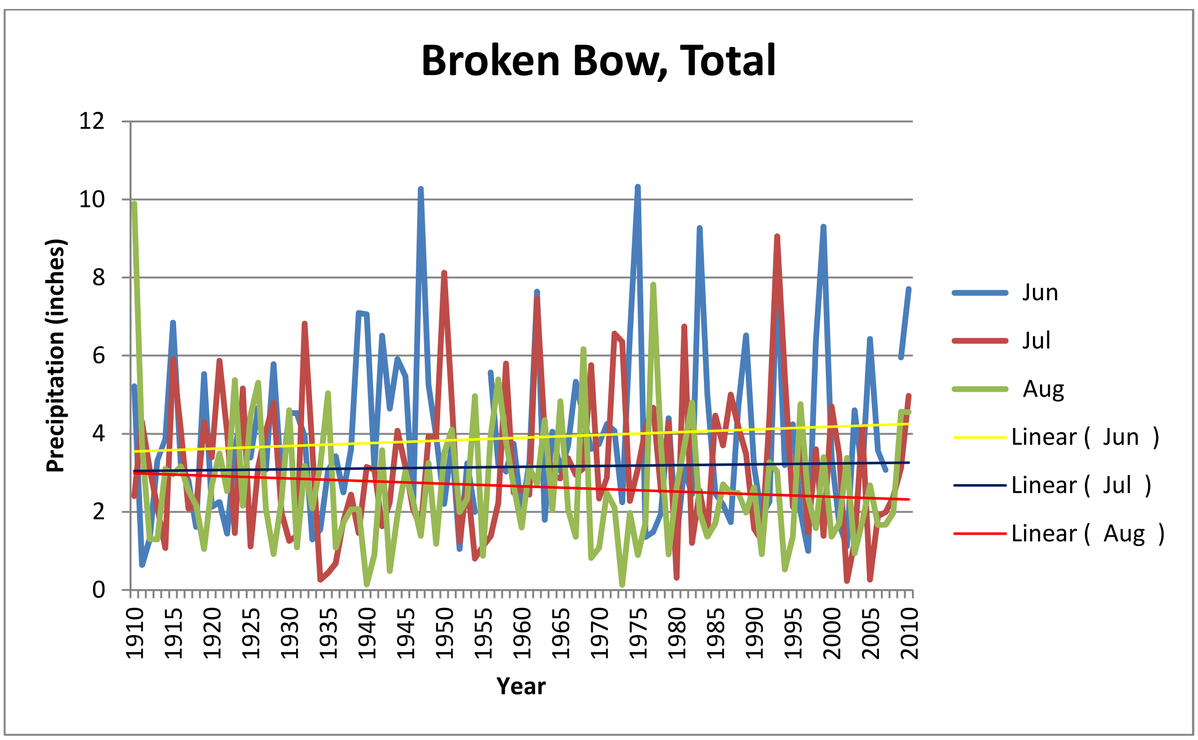

Figure 6 – The total monthly precipitation totals per month for Broken Bow.

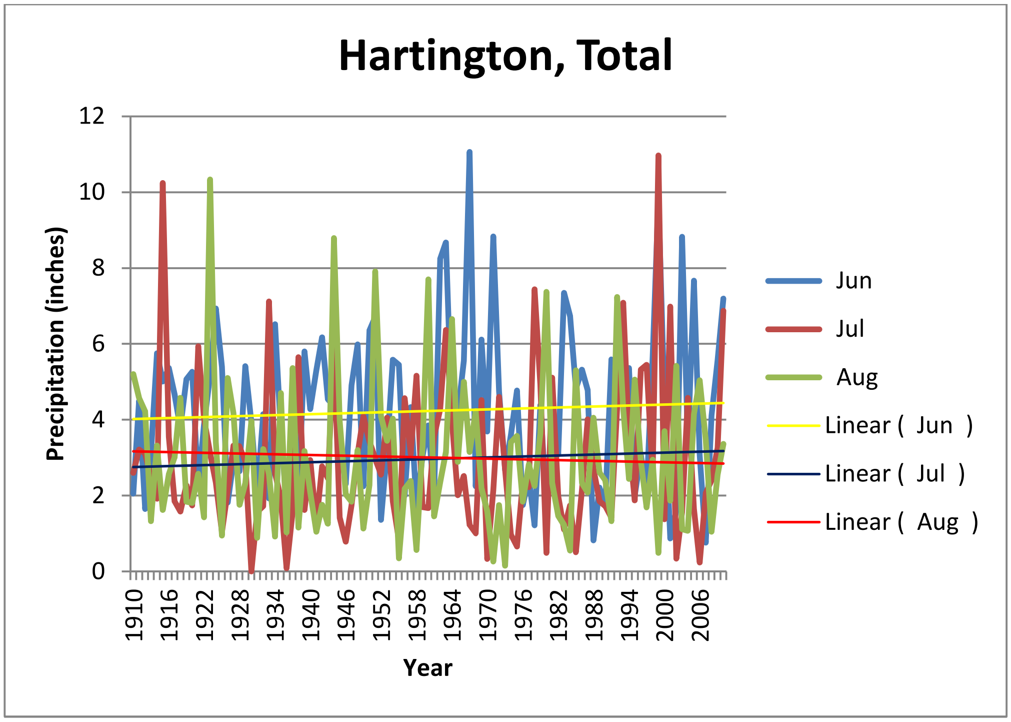

Figure 7 – The total monthly precipitation totals per month for Hartington.

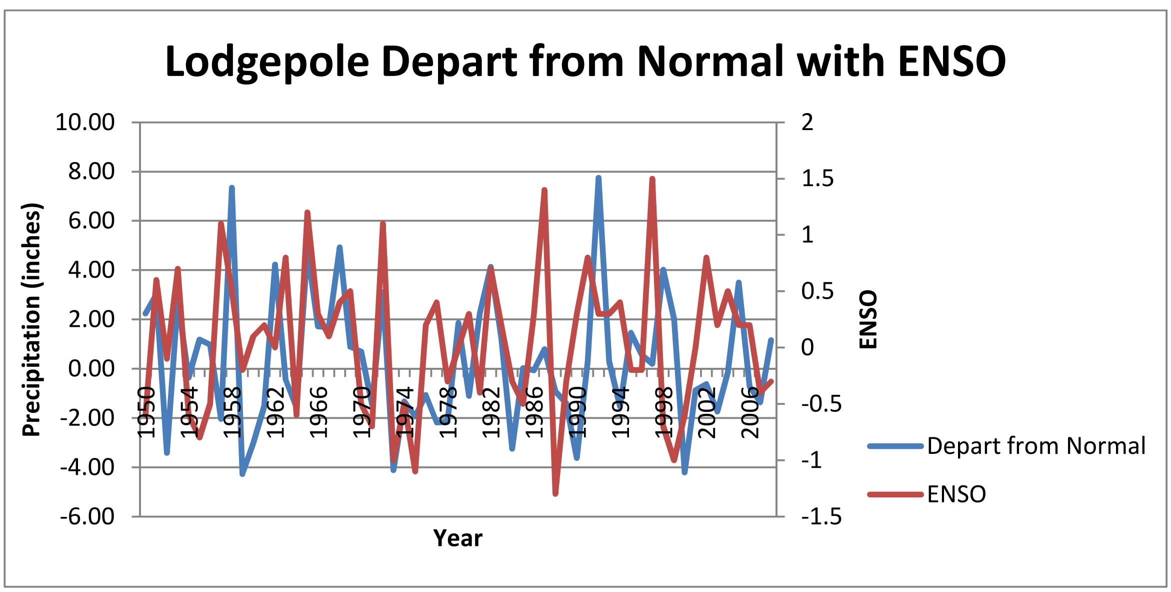

Figure 8 – Lodgepole precipitation plotted against ENSO trend.

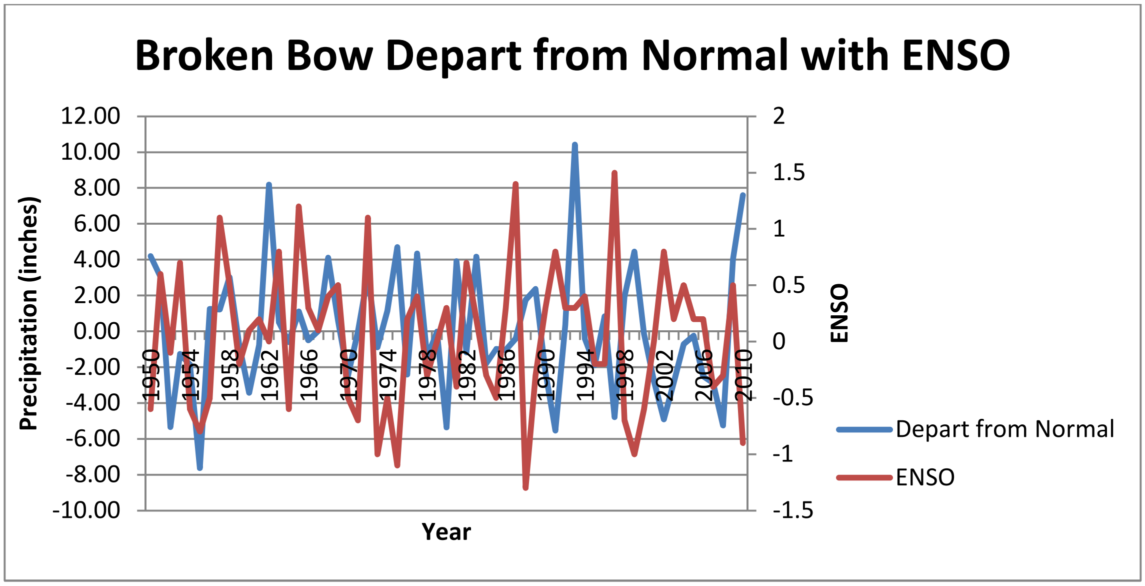

Figure 9 –Broken Bow precipitation plotted against ENSO trend.

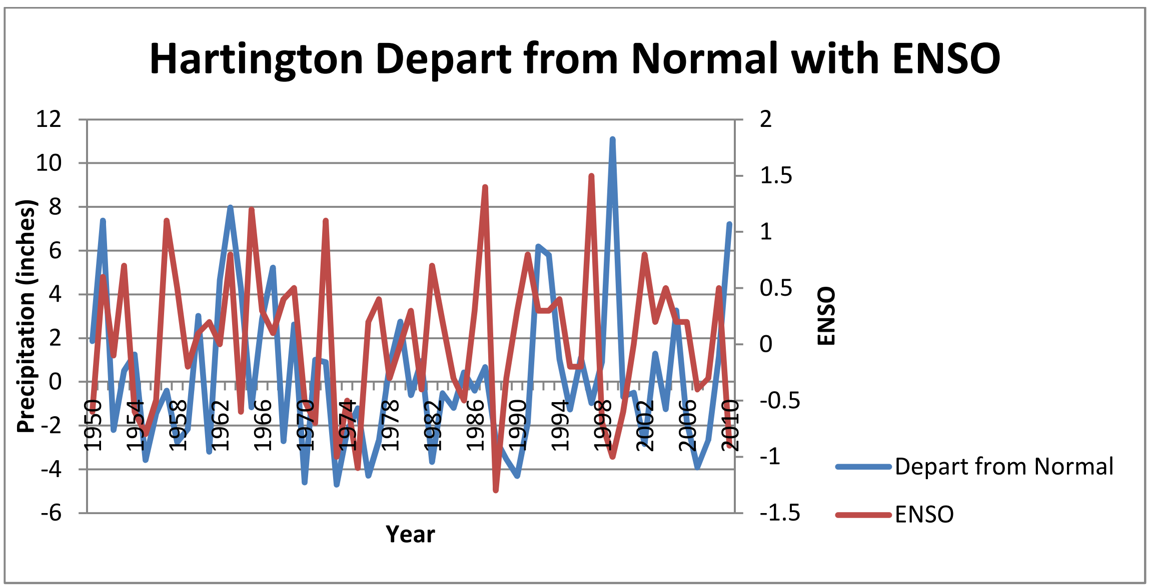

Figure 10 – Hartington precipitation plotted against ENSO trend.

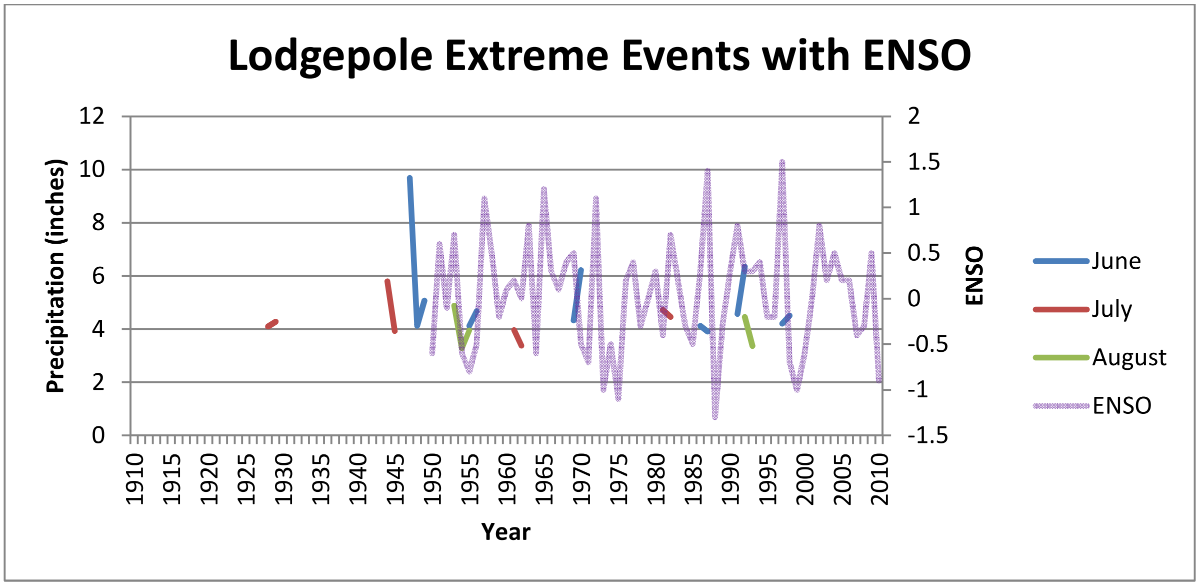

Figure 11 – Lodgepole's extreme events plotted against ENSO trend.

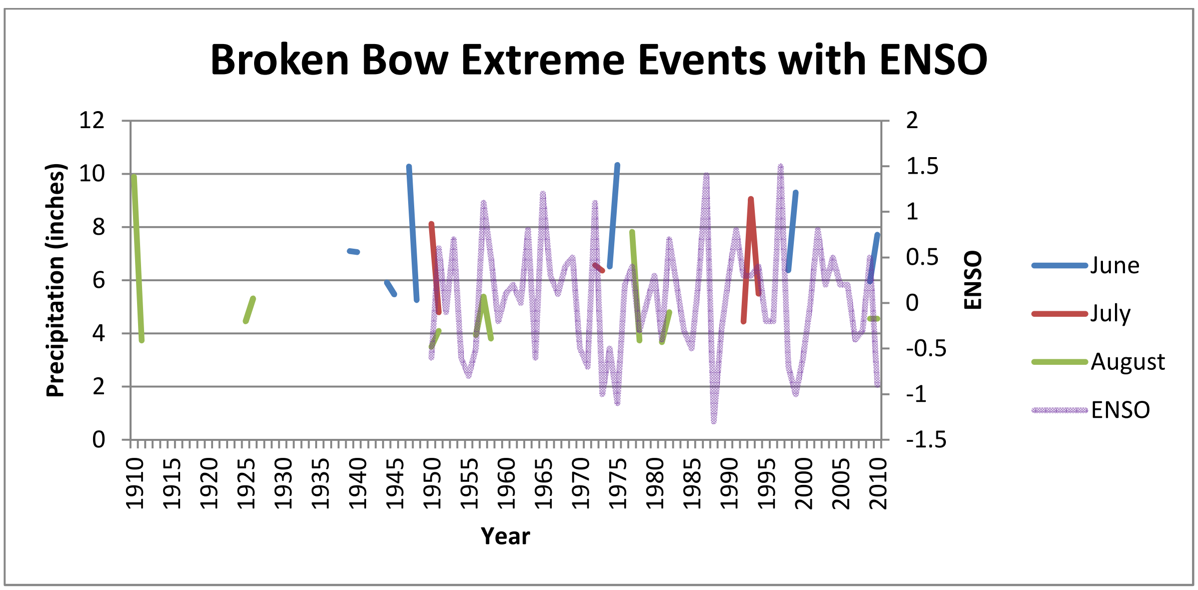

Figure 12 – Broken Bow's extreme events plotted against ENSO trend.

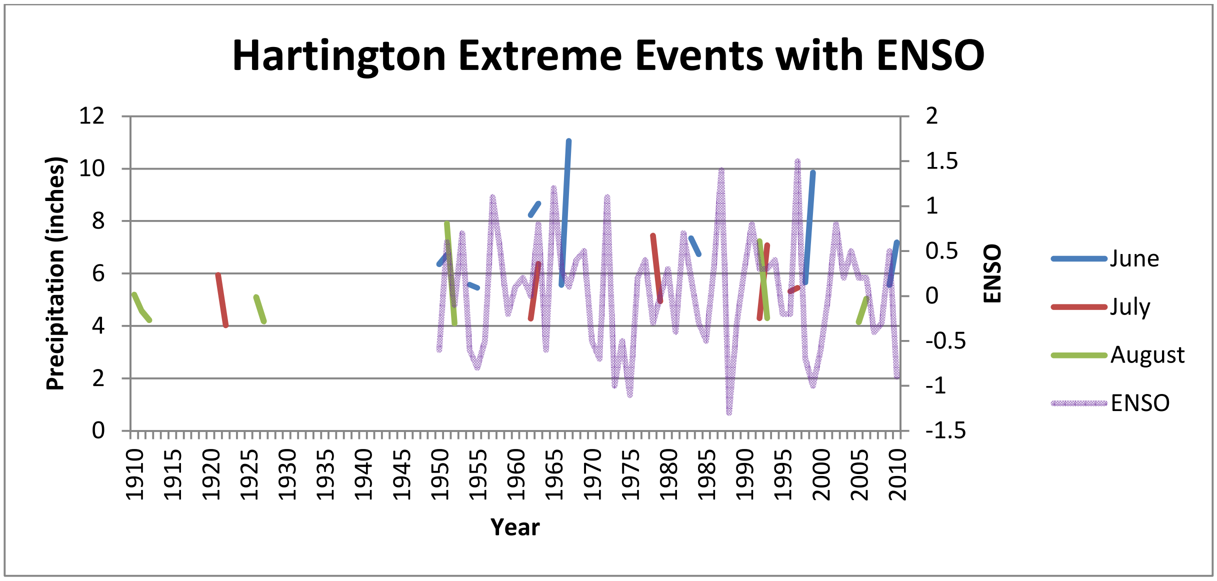

Figure 13 – Hartington's extreme events plotted against ENSO trend.