Monthly Trends in Maxima of Low Temperatures in Georgia, USA

by

Waleed De Jesus Navarro

(Under the Direction of Lynne Seymour)

Abstract

The monthly maxima of daily low temperatures in the state Georgia are investigated using data from 43 stations taken from the Georgia Automated Environmental Network (GAEMN). Bootstrap methods for time series data are used to model the distribution of the maximum of the low temperatures for each month at each station. The mean and standard deviation of each distribution are then used to standardize each station's data to determine trends. Rates of increase and/or decrease along the distributions are presented along with significance levels. To display the results, contour plots of Georgia are created for each month with the use of a weighted head-banging spatial-smoothing analysis to account for the significance of the trends.

Index words: moving block sub-sampling, bootstrap, correlation, time series, standardize, weighted-headbanging, climate change

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Chapter 1

Introduction and Data

Temperature trends are always controversial issues. One may hear about it with respect to global warming, global cooling, changing weather patterns, etc. Whether these changes in trends are significant or minimal, they affect the lives of individuals daily. Temperature changes affect the state of Georgia greatly since agriculture is a major industry. Some of Georgia's major products include peanuts, pecans, cotton, tobacco, soybeans, corn, hay, oats, sweet potatoes, and of course peaches. Any change in temperature has the potential to hinder production of these products, which could also have a significant impact on economic trends. For these reasons, USDA plant hardiness maps are readily available to determine what type of plants can be grown in each area of the United States. The maps (Figure 1.1) are organized by zones to distinguish between the possible choices of plants (Masters, 2012).

A comparison of the 2012 USDA Plant Hardiness Zone Map with the 1990 version (Figure 1.1) shows all hardiness zones creeping northward suggesting a warming climate trend since plants growing in warmer climates are now able to grow in areas that used to have colder climates. While these maps depict warming in the overall climate, the rate of warming is not examined.

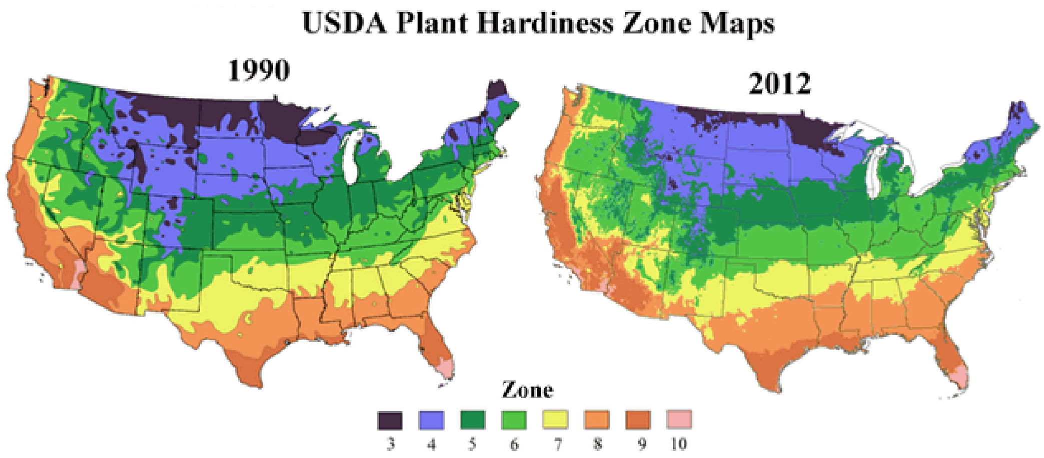

Figure 1.1: 1990 vs. 2012 Plant Hardiness Maps

The objective of this research is to determine whether there are significant changes in the maxima of the low temperatures in the state of Georgia, and to identify where those changes are occurring. Much of the analysis done here is inspired by temperature trend articles by Lund, Seymour, and Kafadar (2001) and Lu, Lund, and Seymour (2005). The maxima of the low temperatures are investigated because cooler temperatures are warming much faster than warmer temperatures so any trends might be much easier to detect. Also, extreme temperatures can tell a more comprehensive and compelling story when examined more closely. Furthermore, the results are divided into seasons since each season has displayed varying results in the aforementioned articles.

The data and its source are discussed in further detail below. The smaller size of the data available for this study and its complex dependence leads to the use of a moving-block sub-sampling bootstrap method for time series data. More on the bootstrap method is discussed in Chapter 2 along with standardization methods to determine any changes in the temperature trends and their significance. Results, discussion, and conclusions are discussed in Chapter 3 along with very illuminating geographic maps displaying the findings of this research. Finally, Appendix A contains the monthly trends and their significance along with rate translations to celcius. Appendix B contains plots of the monthly trends organized by season within each station.

1.1 The Data

The data used in this study are taken from The Georgia Automated Environmental Monitoring Network (GAEMN). The GAEMN is an extensive network of automated weather stations in the state of Georgia developed beginning in 1991 by the College of Agricultural and Environmental Sciences at the University of Georgia. It currently consists of 81 weather stations collecting up to 66 weather variables at each station roughly every 15 minutes (GAEMN, 2012). The amount of available data vary by station due to new stations being installed as more funding becomes available. More information about the GAEMN can be found at www.griffin.uga.edu/aemn/AEMN.htm.

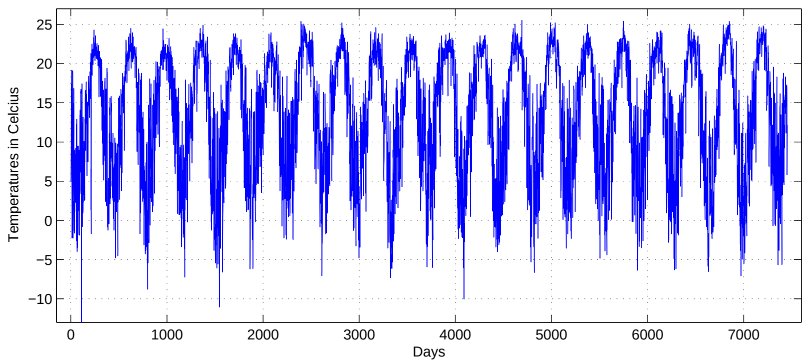

Figure 1.2: Low Temperatures for Tifton, GA

The variable of interest in this study is the monthly maximum of the daily low air temperatures. An example of available data for the Tifton station is presented in Figure 1.2. Daily minima are taken from a midnight to midnight time frame on the celcius measurement scale. The quality of the data is excellent. However, to avoid extremely small sample sizes, only stations containing at least 10 full consecutive years are included in the analysis. Furthermore, partial months (usually occurring when stations are first installed) are discarded to avoid any discrepancies when taking the maximum of each month.

After imposing the restrictions on the dataset, a total of 43 stations are used in this analysis. Figure 1.3 shows the locations of these stations - one can see a nice distribution of the stations throughout Georgia. The earliest recorded data are from the fall of 1991 and the latest is from March 2012 (totaling a duration of 10 years to a little over 20 years). Seasonality in both mean and variance is obvious in Figure 1.2. These are accounted for in the statistical analysis. Although a minimum of 10 years of data is arbitrarily chosen, a minimum of 9 years only increases the number of stations by 7 to 50, a minimum of 8 increases the total number of stations to 56, and a minimum of 7 increases the total number to 61. Although one would like to have as much data as possible, the spatial distribution of the 43 stations is very good and bootstrapping from much smaller sample sizes may reduce the quality of the results.

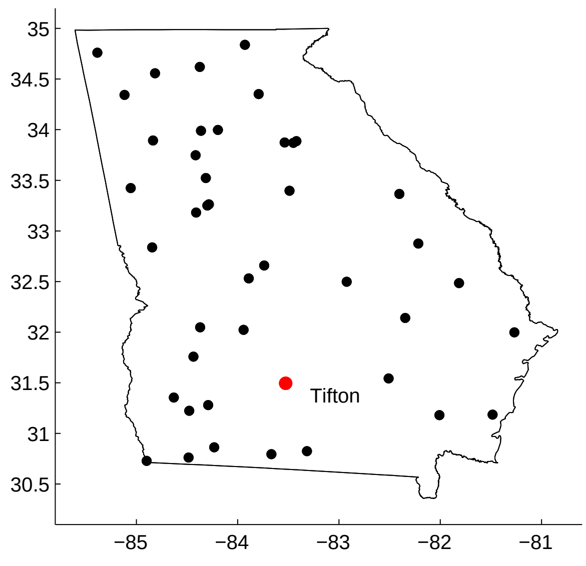

Figure 1.3: Station Locations

Chapter 2

Methods

2.1 A Seasonal Moving-Block Bootstrap

With time series data, there is a complex dependence between observations over time. Figure 2.1 shows the autocorrelation and partial autocorrelation plots of the data from the Tifton station. There is a heavy time series dependence because of the trend, at least in the ACF. Simple bootstrap methods assuming independent and identically distributed observations are not appropriate in this case. Instead, a moving block sub-sampling bootstrap (MBB) method is used because of its ability to preserve the original autocorrelation structure of the series, including any seasonal component that may be present in the data (Politis, 1999).

The idea behind any bootstrap method is to investigate the true underlying distribution through resampling - in our case, the monthly maximum of the low temperatures. Bootstrap methods allow one to easily investigate a problem while avoiding oversimplification (Davison, 1997). The bootstrap replaces the the cumulative distribution function (CDF) with the empirical distribution which puts equal probabilities n^{-1}, where n is the total number of observations, at each sample value y_j. The empirical distribution function (EDF) $\hat{F}$ is defined as the sample proportion

$$\hat{F}(y) = \frac{\#\{y_j \leq y\}}{n}$$

where $\#\{A\}$ is the number of times event A occurs (Davison, 1997).

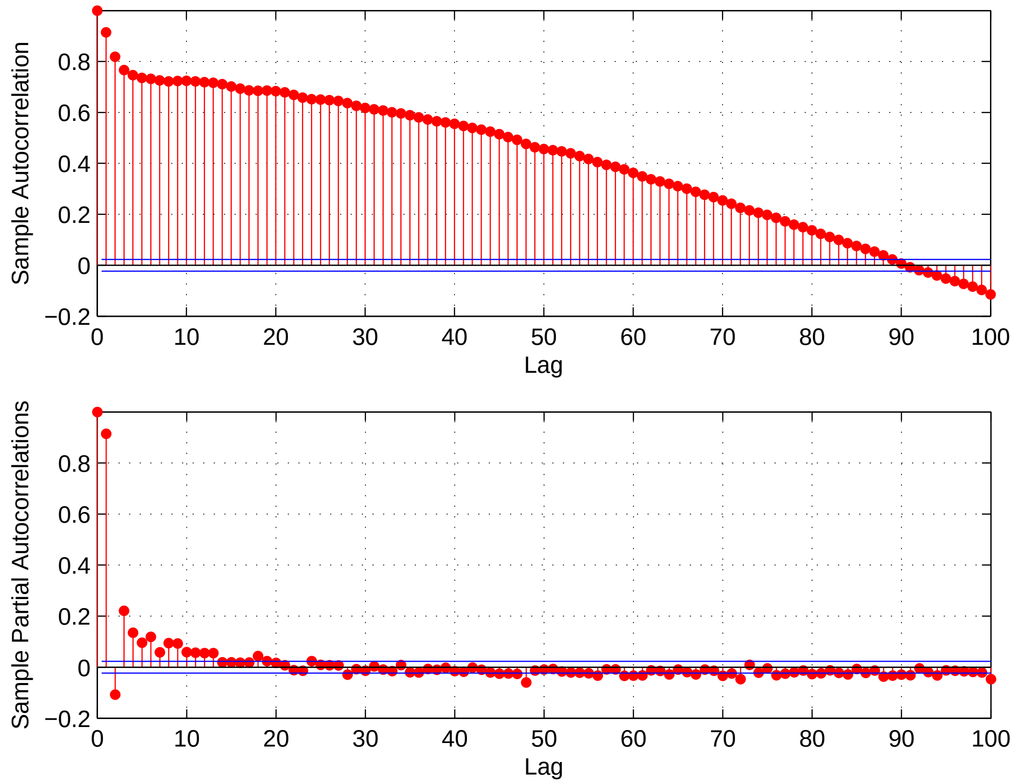

Figure 2.1: ACF and PACF for data from Tifton, GA

To employ the MBB, the data for each station is first seasonally standardized before it is sampled. This is accomplished in layers. First, a least squares line is fitted and subtracted from the series, leaving a set of residuals. Then a sine function of the form

$$\hat{z} = a * sin(b * t + c)$$

is fitted and subtracted from the residuals, leaving a second set of residuals. In this case, $a = 9.1284, b = 0.0172, c = -2.7794$, $\hat{z}$ is the predicted residual, and t is the day number. The illustrations in Figure 2.2 show the least squares line that is fitted and subtracted from the original data, followed by the sinusoidal function that is fitted and and subtracted from the first set of residuals.

The last step in seasonally standardizing the data is to divide each observation by the standard deviation of the month the observation belongs to. The result is a detrended series of correlated residuals from which one can take samples. Figure 2.3 shows the result of the standardization process for the Tifton station along with its autocorrelation and partial autocorrelation plots. One can see a reduction in the spikes in the ACF and PACF plots once the series is detrended. It should be noted that further reduction in the spikes are possible by increasing the number of parameters in the sine function, but this has no ready interpretation for the data.

To illustrate the procedure, consider June, which has 30 days. The MBB can commence by randomly sampling a block of 30 consecutive observations from the standardized data. Each block of 30 days from within the first year is sampled with equal probability to simulate a month of correlated noise. For example, suppose the block $e_{241}, ..., e_{270}$ is randomly chosen to simulate a June month for the Tifton station. The block is reseasonalized by multiplying the standard deviation of June, adding back the fitted sine function, and finally adding back the line. Once the bootstrapped June has been constructed, a maximum is taken: this is the boostrapped maximum low temperature for June. To preserve seasonal correlation in the series, the next block sampled is one corresponding to the same date the following year, i.e. $e_{606}, ..., e_{636}$, $e_{1002}, ..., e_{1032}$, ..., $e_j, ..., e_{j+30}$. Tifton has 20 June observations, so that many are sampled with this consecutive seasonal MBB construction.

A maximum monthly low temperature is boostrapped 20,000 times per month for each station. Figure 2.4 presents boxplots of the 20 actual maximums (left) and the 20,000

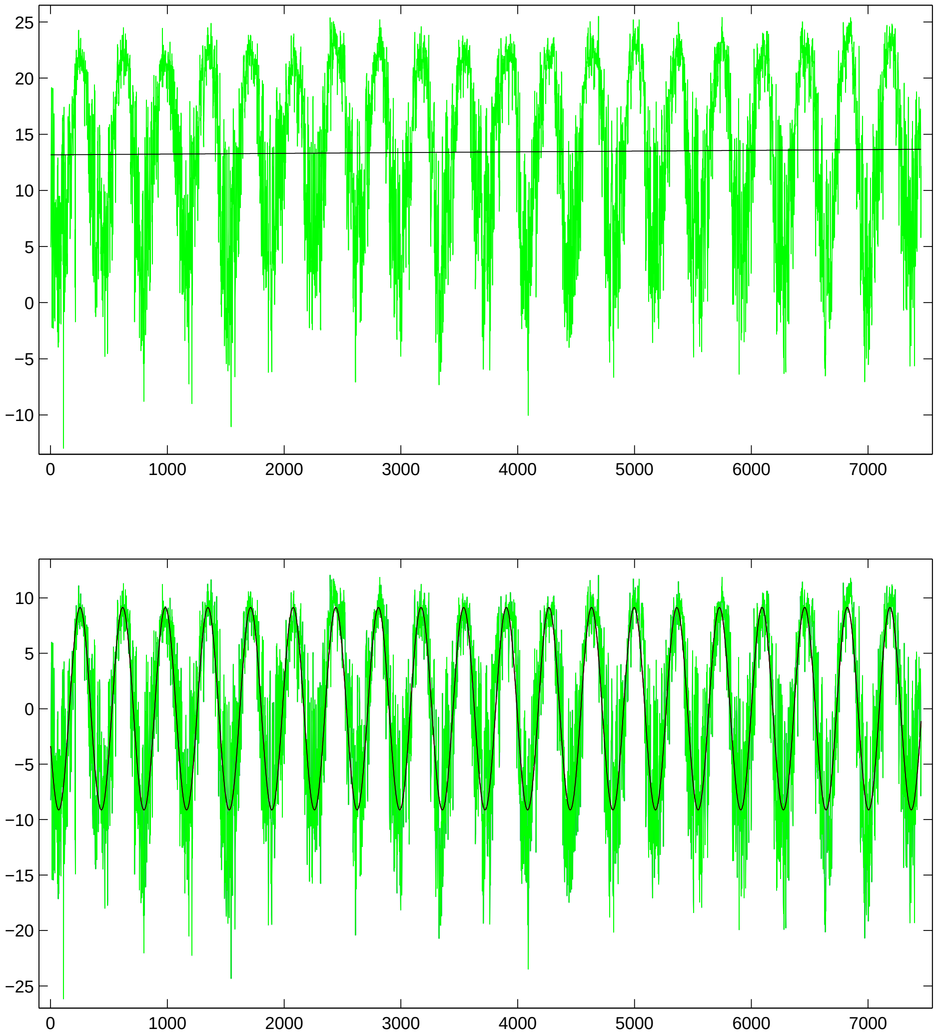

Figure 2.2: Detrending of data from Tifton, GA. Plot 1 shows the grand mean that is subtracted and plot 2 shows the sinusoid that is subtracted in order to detrend the data as much as possible.

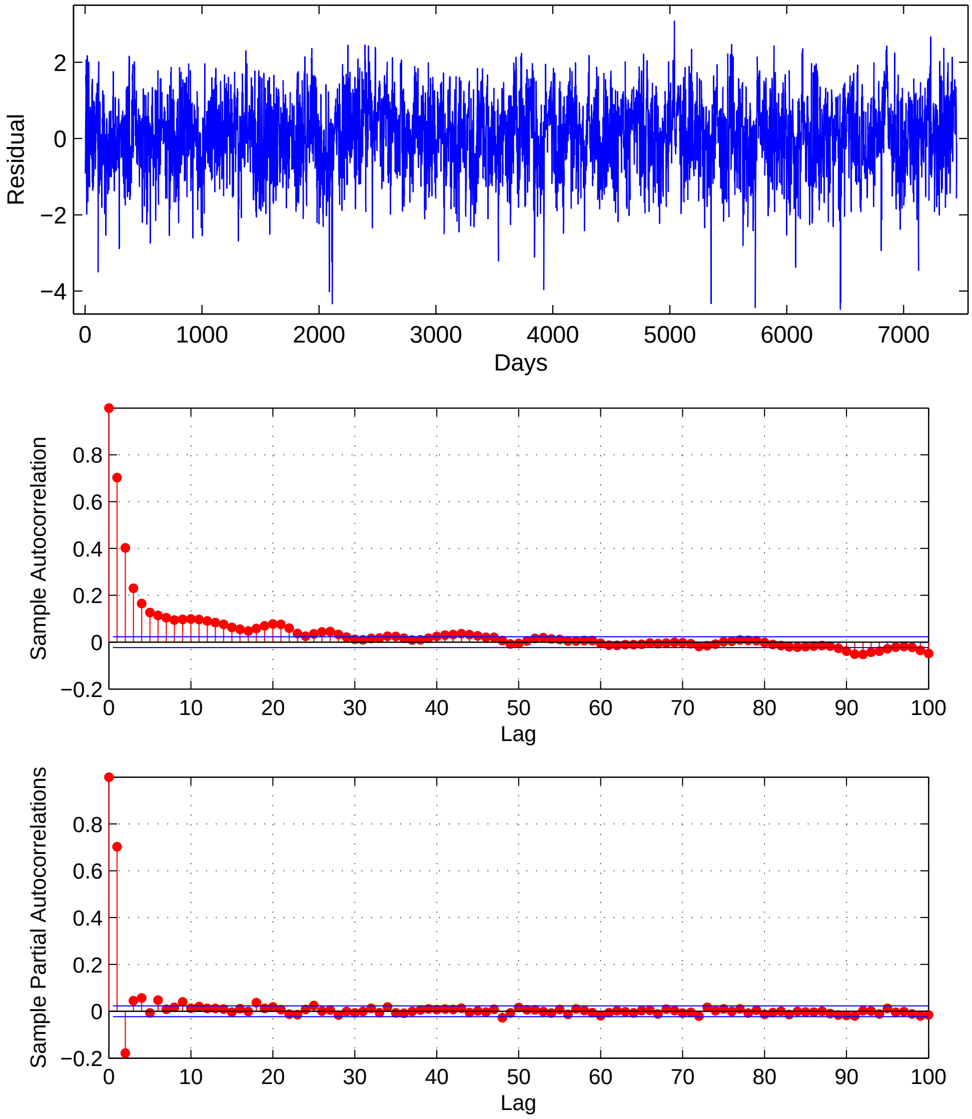

Figure 2.3: Correlated Residuals and Autocorrelation Structure for Tifton, GA. Plot 1 shows the detrended data from Tifton and Plot 2 and 3 show the ACF and PACF of the detrended series which show a great reduction of the time series dependence, thus preparing the data for the Moving Block Sub-sampling Bootstrap.

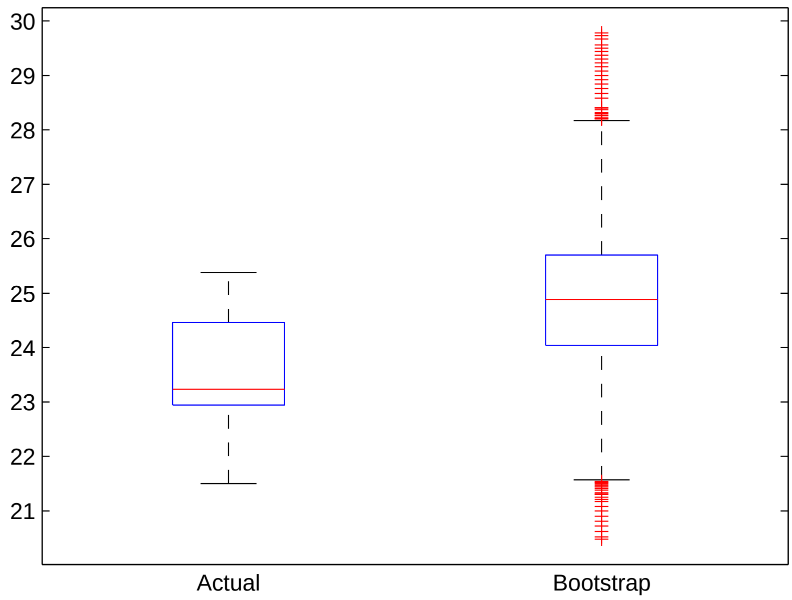

Figure 2.4: Actual Maximum vs. Bootstrap Maximum for June at Tifton, GA station. The boxplot of the actual data contains the data points available for June from 1992 until 2011. The bootstrap boxplot contains the 20,000 bootstrapped values.

bootstrap maximums (right) for June at the Tifton station. One can see the bootstrap distribution of the June maximum low temperatures and a few outliers in red. This process is repeated for all months at all stations. Once this is done, investigation of the bootstrap distribution can begin.

2.2 Exploring the Bootstrap Distribution of the Maximum of Low Temperatures

Since the bootstrap distribution of the maximum low temperatures is an estimate for the true population distribution, the bootstrap distribution is used to determine the rate at which the actual maximum low temperatures are changing. Figure 2.5 shows the distribution of the bootstrap values more closely for June in Tifton.

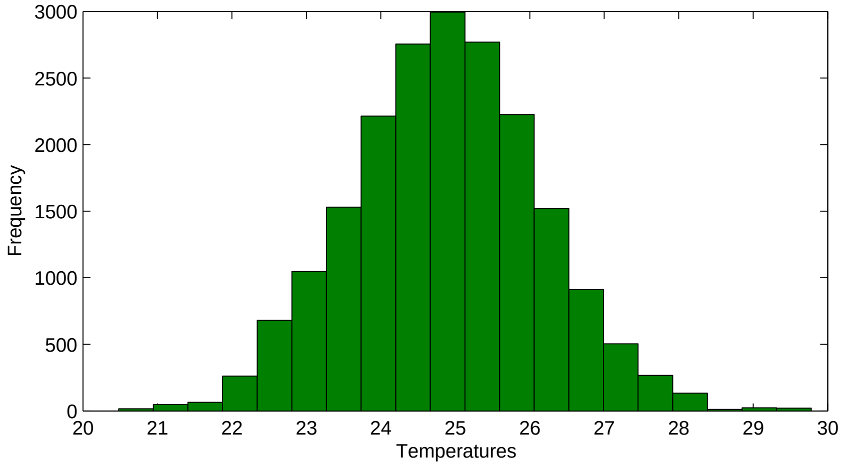

Figure 2.5: June Bootstrap Distribution for Tifton, GA

The bootstrap mean and standard deviation can be used to standardize the actual temperatures in preparation for analysis. Standardization allows one to "normalize" the values, transforming them to similar smaller scales. After this, a trend line is fitted and the slope is tested for significance using t-statistics, mainly because of its robustness. The values are standardized using the formula

$$Z = \frac{x - \mu}{\sigma}$$

where x is the actual recorded maximum low in a given year, μ is the mean of the boostrap distribution, and σ is the standard deviation of the boostrap distribution. For June in Tifton, GA, $\mu = 24.8782$ and $\sigma = 1.2563$. The resulting calculations are summarized in Table 2.1.

Year	Actual June Maximum Lows	Standardized June Maximum Lows
1992	22.50	-1.8931
1993	23.00	-1.4951
1994	24.44	-0.3488
1995	22.89	-1.5826
1996	23.00	-1.4951
1997	21.50	-2.6890
1998	25.38	0.3994
1999	22.30	-2.0523
2000	23.04	-1.4632
2001	23.39	-1.1846
2002	23.55	-1.0573
2003	22.74	-1.7020
2004	24.48	-0.3170
2005	23.94	-0.7468
2006	23.55	-1.0573
2007	23.08	-1.4314
2008	23.07	-1.4393
2009	25.03	0.1208
2010	24.97	0.0730
2011	24.71	-0.1339

Table 2.1: June Standardized Values for Tifton, GA

Once the bootstrapped Z-scores of the actual maxima are derived, one can estimate a trend for the Z-scores over time. A line of the form

$$Z = \beta_0 + \beta_1 t \ + \epsilon$$

where β_1 (the slope and value of interest to this study) determines the rate at which the Z-score changes over time. Figure 2.6 displays a plot of the Tifton Z-scores for June along with its trend line. Fitting a regression line also produces a corresponding significance for its slope. The slope of the trend line, the corresponding standard error, and its p-value are 0.0617, 0.0281, and 0.0413, respectively. The slope of 0.0617 indicates that the Z-scores of the maximum of the low temperatures at the Tifton station are advancing farther into the tail of their distribution over time.

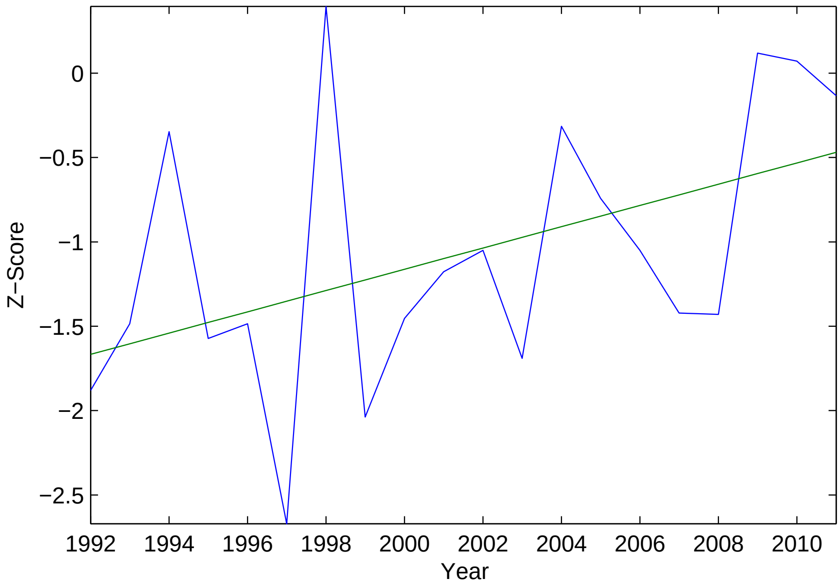

Figure 2.6: June Standardized Trend for Tifton, GA

To translate the slope of the Z-scores back to °C (Celcius), the respective bootstrap standard deviation that was used to standardize the values previously are multiplied with the slope. For easy understanding, the rates will be translated into the rate of change per decade. For instance, a slope of 0.0617 for June in Tifton translates to a change of 0.7976°C per decade for June at the Tifton station. For a complete list of translations to °C/decade, see Appendix A.

2.3 Weighted Head-Banging

Analysis for each month and each station using the methods in the previous sections produced a trend estimate and its standard error. These trends are summarized and spatially smoothed using the weighted head-banging algorithm, which is a form of median smoothing. The goal is to create maps that smooth out the results by accounting for location and reliability of the neighboring stations (Mungiole, Pickle, Simonson, 1999).

A weighted median smoothing algorithm is carried out by first selecting a station such as Tifton then selecting the desired level of smoothing. In this case, 7 nearly collinear triples of stations, with Tifton being in the center, are selected for smoothing. Seven triples provide a nice level of smoothing in this case. Angles greater than or equal to 135 degrees works best according to Hansen (Mungiole, et al., 1999). Next, the two endpoint values for each triple are examined. The low values are placed in a "low screen" and the high values are placed in a "high screen."

After separating the low values and high values, sort the observations in each screen so that $x_{(1)} \leq x_{(2)} \leq ... \leq x_{(m)}$, where m in this case is 7, and the weights $w_{(j)}$ (standard errors) remain paired with the corresponding observations. A cumulative sum of the reordered weights is then calculated:

$$S_k \;=\; \Sigma_{j=1}^{k}\, w_{(j)}, \quad k = 1, ..., 3$$

The index location, b, of the weighted median is the smallest value of k such that S_k is at least half of the total sum of the weights:

$$b \;=\; min\{k|S_k \geq S_m/2\}$$

If S_b is greater than $S_m/2$, the weighted median value is given by $x_{(b)}$ (Mungiole, et al., 1999). Once the weighted median is selected for each screen, an iteration of the weighted median algorithm described above is undertaken between the final values of the "low screen", "high screen", and the value for Tifton.

For example, the 7 nearest points surrounding the Tifton station are selected and any set of triples that form an angle of 135 degrees or greater is included in the smoothing process.

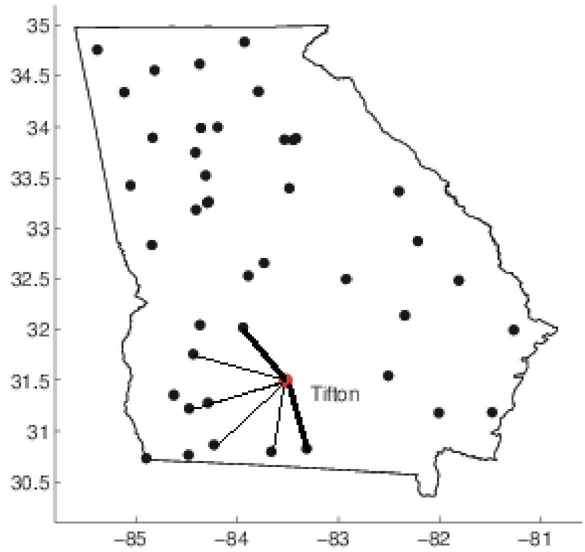

Figure 2.7: Example of Weighted Headbanging Smoother. Only triples with angles greater than 135 degrees are used in a weighted median selection.

Since there is only one collection of triples in this example, the weighted median selection process is only carried out between the values at the Cordele, Tifton, and Valdosta stations. The °C per decade and corresponding weight for the Tifton station are 0.7976 and 0.0281, respectively. The "low screen" contains the values for Valdosta station which are 0.7657 and 0.0462. The "high screen" are the values for Cordele station which are 0.9007 and 0.0543. The weighted median selection algorithm requires that the values are first sorted: 0.7657 (0.0462), 0.7976 (0.0281), 0.9007 (0.0543). The cumulative sum of the weights are: 0.0462, 0.0743, 0.1286. Since $0.0743 \geq 0.1286/2$, the weighted median is 0.7976°C/decade. The value remains unchanged, which suggests that this area of the map requires no smoothing.

If there had been more than one set of triples, the low values of the endpoints in each triple are placed in the "low screen" and the high values are placed in the "high screen." Then, the weighted median algorithm described above is applied to each screen before a weighted median is selected between the values of the station, "high screen," and "low screen".

For stations on corners or edges, triples are linearly extrapolated (Mungiole, et al. 1991). Figure 2.8 shows a comparison between the contour map of the raw trends of the change in °C/decade versus a smoothed map on the right of the figure. One can see differences depicting the effects of the smoothing process, especially in the northern and southernmost areas of the maps. Head-banging methods effectively preserve general features such as edges and ridges while downweighing any outliers (Lu, et al., 2005).

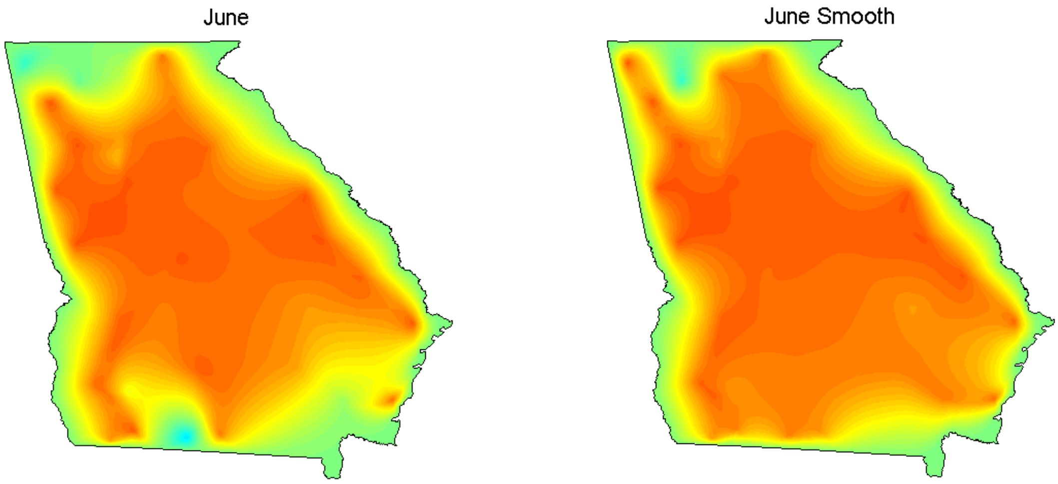

Figure 2.8: Raw Map vs. Spatially Smoothed Map

Chapter 3

Results

This section discusses and summarizes the findings after implementing the methods given in Chapter 2. For organizational purposes, the results are summarized by seasons. Winter months are defined as December, January, and February; spring as March, April, and May; summer as June, July, and August; and fall as September, October, and November. Levels of significance are presented in this section followed by a presentation of the rates of warming or cooling. Similar scales for presentations are maintained in order to distinguish results more easily. Tables containing the actual significance of the warming and the rate at which the temperatures changes are in Appendix A. Graphs of these trends are in Appendix B.

3.1 Significance

Figure 3.1 presents boxplots of the raw significance (p-values) of rate changes for each month. The end of the spring season all the way through the beginning of the fall season shows the most significant changes. On a monthly basis, the most significant are June and August, which suggests more significant changes in the maxima.

Rate increases are especially significant in August with a median p-value of 0.0148. The months surrounding winter have p-values that are not very significant, with mean values being greater than 0.5.

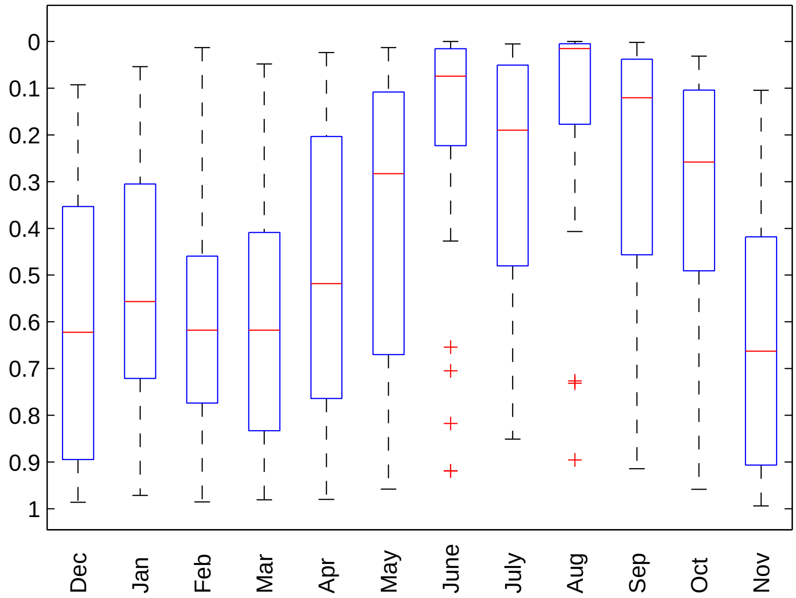

Figure 3.1: Box-plot of P-Values for Trends

To see where warming and cooling are significant, the p-values are plotted and used to construct contour maps. Figure 3.2 shows the contour plots of the raw p-values. Data are interpolated linearly using a 'nearest neighbor' method and the color scale used is uniform across all months. Warming areas are colored in shades of red while cooling areas are shaded in blue. To show areas that are cooling on the map, p-values are multiplied by -1 for stations that detected a decreasing trend. The smoothed contour maps of the significance level are shown in Figures 3.3 through Figure 3.6.

Winter significances are shown in Figure 3.3. In December, there is a warming trend just as depicted in the boxplots presented previously, especially in the southeastern section

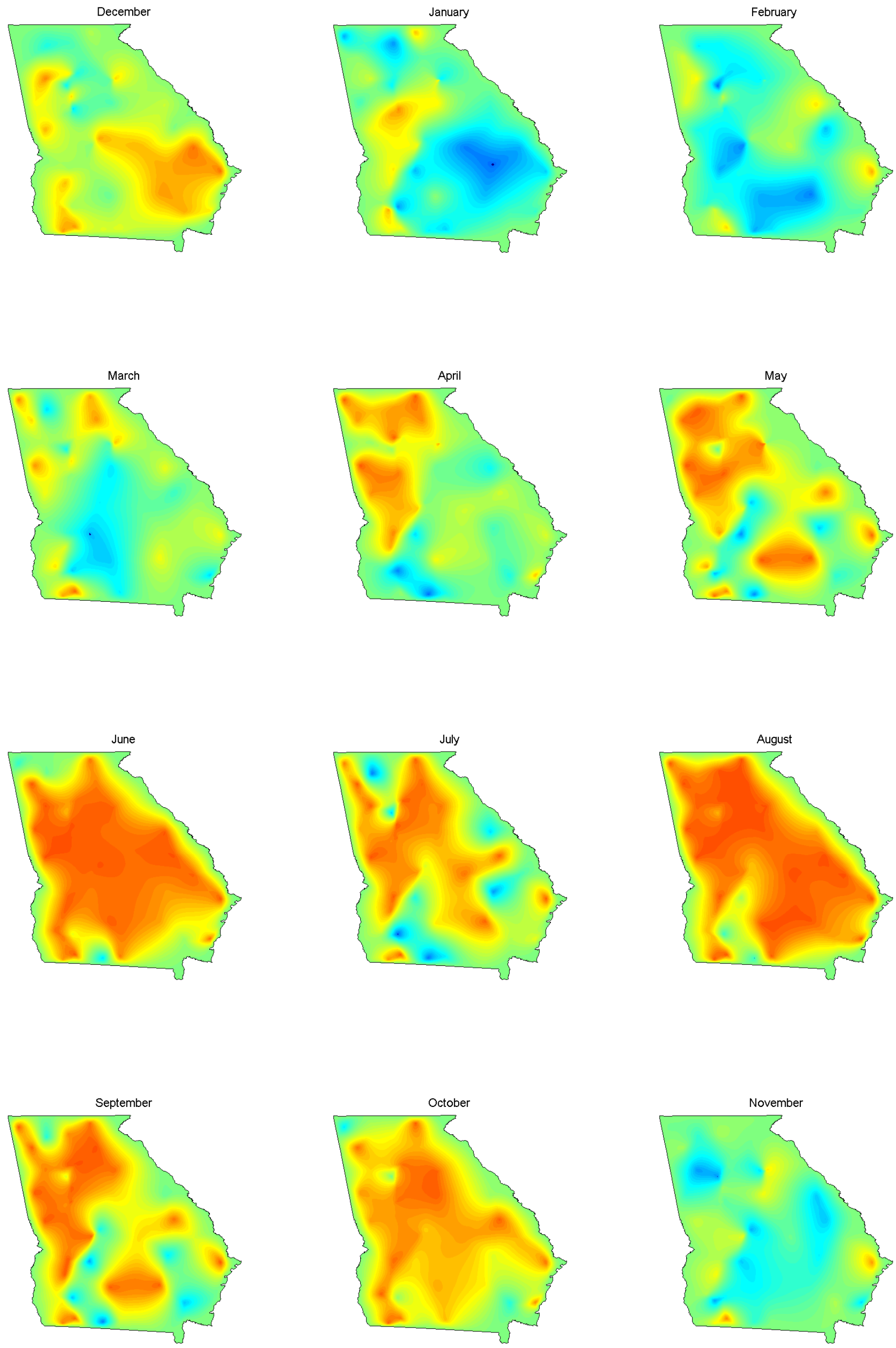

Figure 3.2: Raw P-Values of Trends in Z-Scores

(around Statesboro and Savannah station) of Georgia. There is also mild cooling in January and February and smaller areas - compared to December - with evidence of warming.

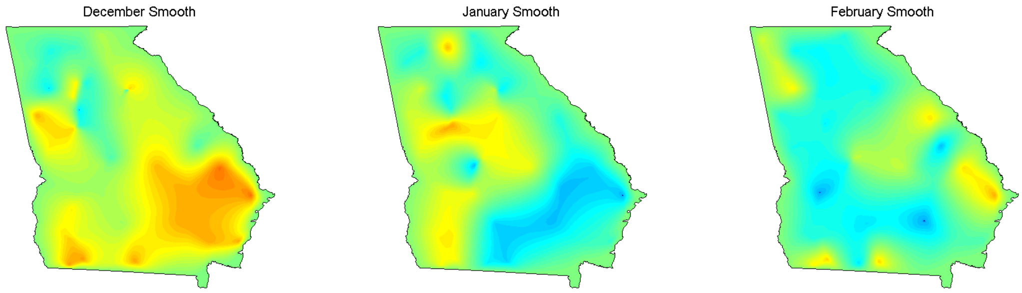

Figure 3.3: Smoothed P-Values of Warming and Cooling, Winter.

The significance of warming increases begin in the month of April and is more prevalent in May (Figure 3.4). The deeper colors of red depict strongly significant warming, especially in the surrounding areas of Atlanta. These more significant changes demonstrated by the results in the spring months were also found in average monthly temparatures in Lund, Seymour, and Kafadar (2001), and Lu, Lund, and Seymour (2005).

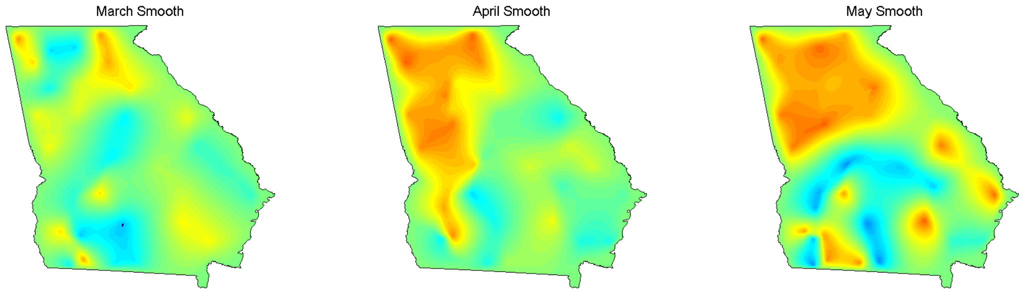

Figure 3.4: Smoothed P-Values of Warming and Cooling, Spring.

The smoothed maps in Figure 3.5 show very significant warming in the the summer months. June and August especially show the most areas in the State of Georgia with higher significance of the change in temperatures. The month of July shows slightly less significance of warming than June and August with some stations registering cooling trends.

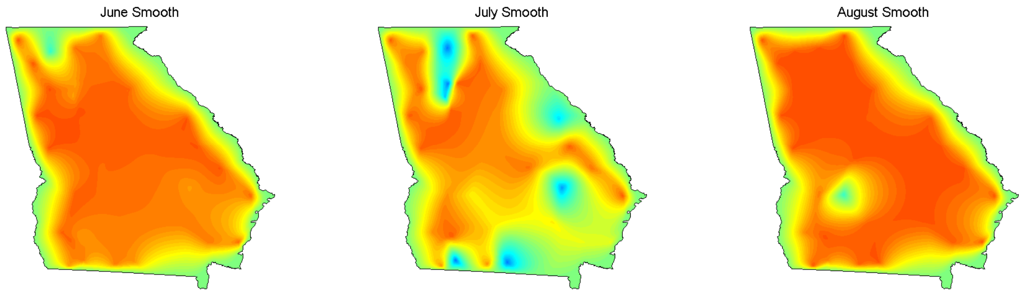

Figure 3.5: Smoothed P-Values of Warming and Cooling, Summer.

The high values of significance diminish in the fall months. The fall months display slightly less significant values especially in the month of September. The warming significance begins to diminish even more so in October and values show a cooling trend in November (Figure 3.6).

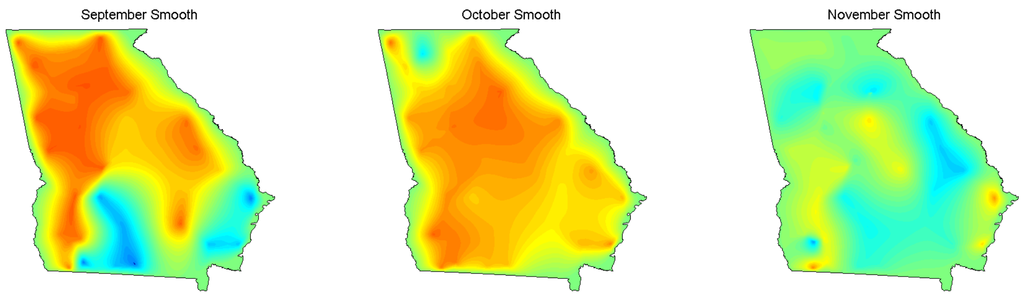

Figure 3.6: Smoothed P-Values of Warming and Cooling, Fall.

3.2 Rates

Figure 3.7 presents the rates of change in °C/decade converted from the Z-scores. Once again, the months are organized according to seasons, beginning with the winter months. The rates are mostly warming, especially in the spring and summer months. Cooling trends are evident in January, February, and November.

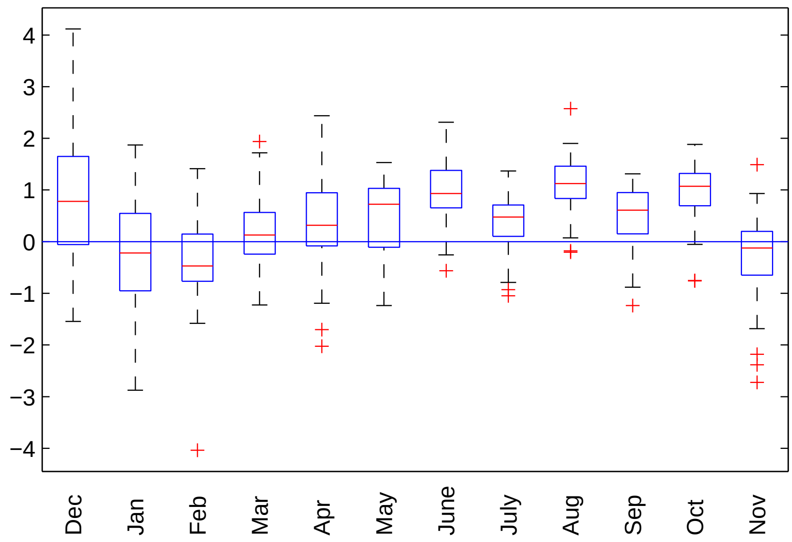

Figure 3.7: Standardized Rate of Changes in Temperatures

The contour plots in Figure 3.8 depict the raw rates of change °C/decade, organized by month. Once again, shades of red indicate a warming trend while shades of blue indicate cooling trends. The darker the shade, the higher the rate of change. The spatially smoothed contour plots are shown in Figure 3.9 through Figure 3.12; the plots are smoothed using the standard errors of the rates of change.

The southeastern area (around Statesboro) of the smoothed contour plot for December (Figure 3.9) shows a considerably high warming rate in comparison to other months. According to the significance contour plot, this rate change is also significant. The other winter

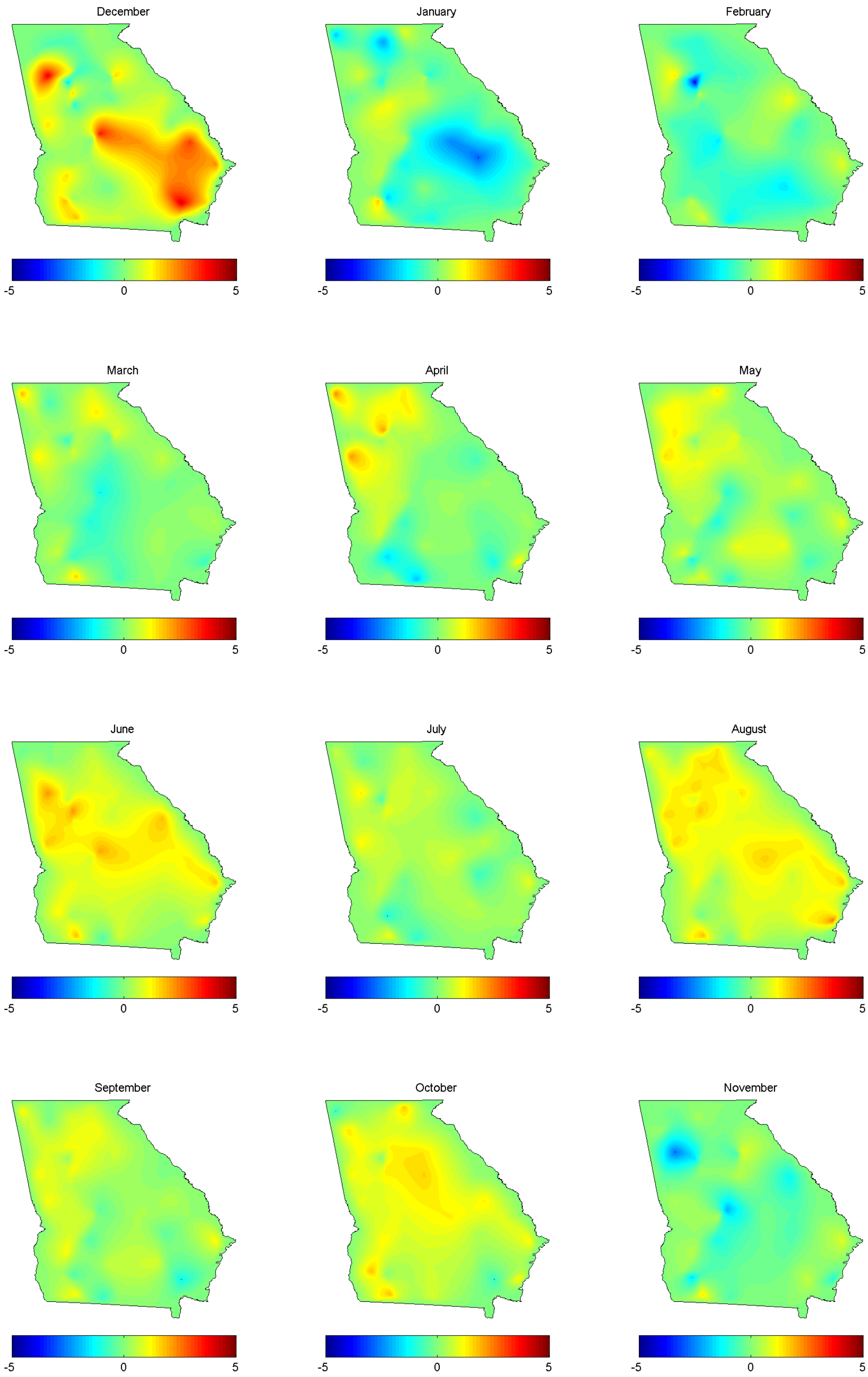

Figure 3.8: Rates of Cooling and Warming, Raw Trends.

months show slight decreases (mean of -0.2540°C/decade and -0.3795°C/decade for January and February, respectively) in cooling. However, these trends are not deemed to be very significant.

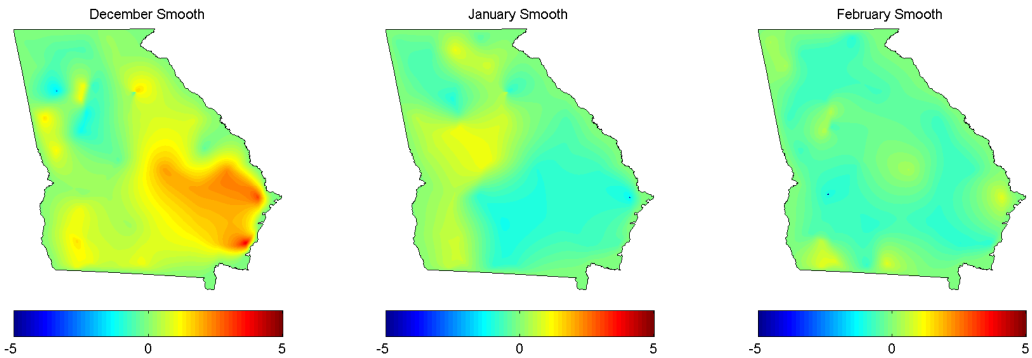

Figure 3.9: Smoothed Warming and Cooling Rates, Winter.

Overall warming trends are more pronounced beginning in May and continues through the summer and most of the fall months (Figures 3.10, 3.11, and 3.12). These changes in temperatures, although rising only at average rates of 0.4202°C/decade for May, 1.0055° for June, 0.3537° for July, 1.1261° for August, 0.5053° for September, and 0.3329° for October, are more significant with p-values which register almost at zero (0) for many stations in June and August.

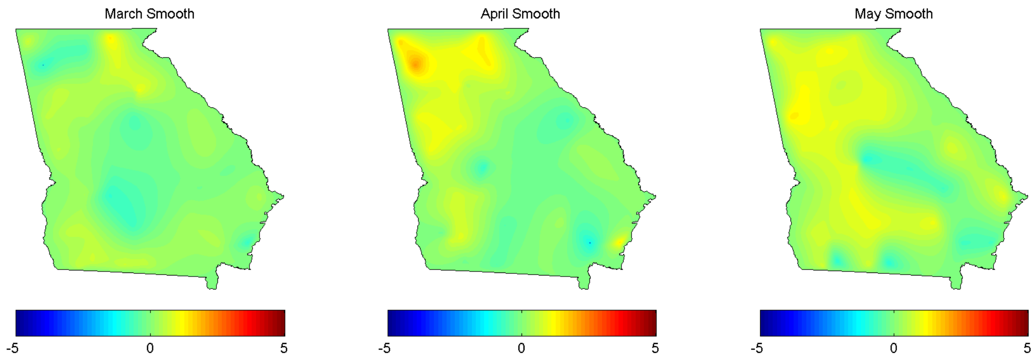

Figure 3.10: Smoothed Warming and Cooling Rates, Spring.

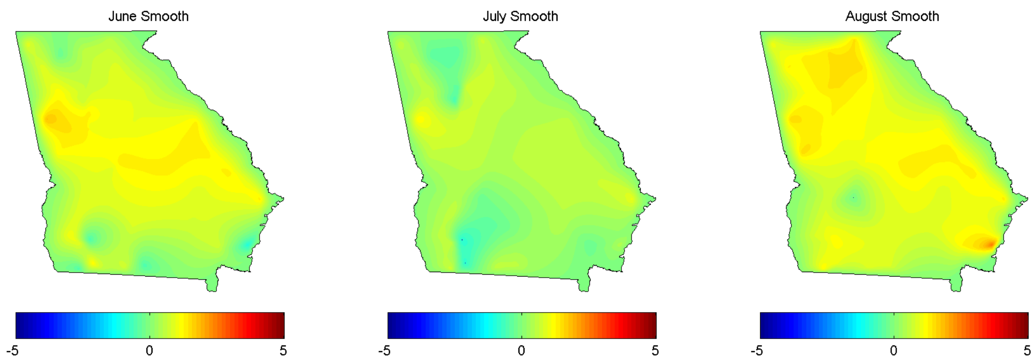

Figure 3.11: Smoothed Warming and Cooling Rates, Summer.

The month of November (Figure 3.12) shows cooling at an average rate of -0.3188°C/decade in areas of the state. However, these rates are not quite as significant as other months. The greatest significance registers at 0.1044 and the average significance for the month of November is 0.6412 - not very significant at all.

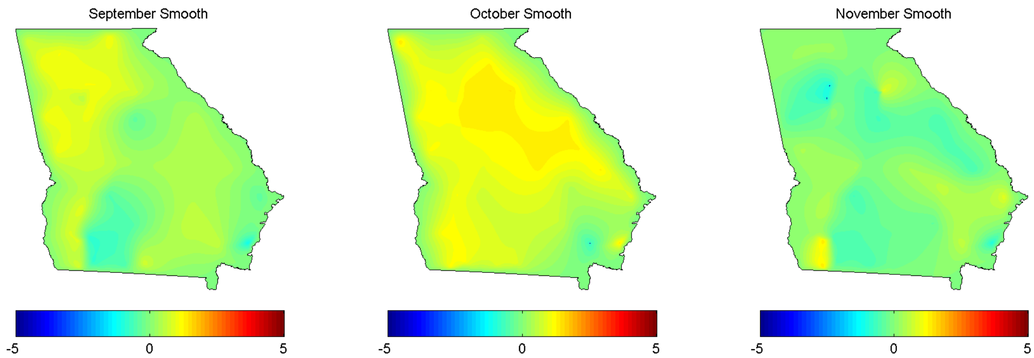

Figure 3.12: Smoothed Warming and Cooling Rates, Fall.

3.3 Discussion

Many avenues were taken to determine the best possible way to analyze the data. Examining monthly trends while assuming each observation was identically and independently distributed (i.i.d.) and creating bootstrap distributions with that assumption produced large cooling and warming trends which were unrealistic.

A model-based time series bootstrapping method was attempted. Although creating models for each individual station would give more accurate predictions, an overall analysis would have proven to be extremely time consuming and difficult to employ. Simple AR(1) and MA(1) models were attempted and used in the model-based bootstrap, however, it was clear that there are more complex models needed for each station.

Although the results of the initial analysis of the model-based bootstrap were better than the initial i.i.d bootstrap, the moving block bootstrap method produced the best results. No time series modelling was necessary although it still allows one to preserve the natural autocorrelation structure of the data at each station. It also produced a much better bootstrap distribution since the simulation was sampled only from the original series, unlike model-based sampling which essentially creates new models. At first, no seasonality was preserved in the sub-sampling procedure to determine if there is a difference. Once the seasonal component was included, slight differences between 0.0001 and 0.1 were detected in the results and could not be ignored.

Overall, the results produced by the moving block sub-sampling method produced smaller slopes which are more realistic and more indicative of actual trends in temperatures that are comparable to previous studies such as Lund, Seymour, and Kafadar (2001) and Lu, Lund, and Seymour (2005).

3.4 Overall Conclusions

There is evidence of overall warming throughout the state of Georgia. The average rates of change in the monthly maximum low temperatures are -0.3346°C/decade in the winter, 0.4792°C/decade in the spring, 0.6175°C/decade in the summer, and 0.3049°C/decade in the fall. The increases at the end of the spring, during the summer, and the beginning of the fall months are found to be more significantly increasing than others. These increases could indicate that the spring and fall months are disappearing and summer seasons are getting longer in the state of Georgia. It should be noted that rates of change detected at some stations may be increasing/decreasing too quickly which may be attributed to small sample sizes. When more data is available at the newer stations, it would be interesting to reexamine the geographic maps and see what new information may be revealed when more stations and larger sample sizes are considered.

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Appendix A

Appendix A contains output from the analysis of each station organized by month. The slope of the standardized values from each station are shown in the second column. Standard errors, t-statistics, and p-values are in the following columns. Finally, a translation of each rate of change in the Z-scores to °C/decade along with sample size is available in the last two columns. For ease, stations with significant findings are printed in bold.

Station	Slope	SE	T-Stat	p-value	°C/decade	Sample Size
Alma	-0.0306	0.0295	-1.0386	0.3135	-0.8863	19
Arlington	0.0023	0.0461	0.0496	0.9611	0.0710	16
Atlanta	-0.0326	0.0491	-0.6645	0.5180	-1.0546	16
Attapulgus	0.0140	0.0320	0.4364	0.6677	0.4468	20
Blairsville	0.0313	0.0334	0.9374	0.3610	1.0336	20
Williamson	0.0391	0.0370	1.0585	0.3046	1.1239	19
Brunswick	-0.0226	0.0569	-0.3966	0.6993	-0.6451	13
Byron	-0.0313	0.0732	-0.4279	0.6778	-0.9566	12
Cairo	0.0209	0.0390	0.5354	0.6014	0.6575	15
Calhoun	-0.0178	0.0389	-0.4575	0.6528	-0.5153	20
Pine Mountain	0.0170	0.0364	0.4665	0.6476	0.5203	17
Camilla	-0.0594	0.0424	-1.3999	0.1850	-1.8279	15
Cordele	-0.0438	0.0411	-1.0669	0.3054	-1.3593	15
Dallas	0.0273	0.0828	0.3299	0.7483	0.8084	12
Dawson	0.0174	0.0371	0.4685	0.6462	0.5571	17
Dearing	-0.0199	0.0560	-0.3555	0.7284	-0.5708	14
Griffin-Dempsey	0.0343	0.0318	1.0797	0.2945	1.0162	20
Dixie	-0.0295	0.0427	-0.6894	0.5037	-0.9308	14
Dublin	-0.0868	0.0506	-1.7162	0.1098	-2.5154	15
Johns Creek	-0.0080	0.0333	-0.2391	0.8141	-0.2211	18
Dunwoody	-0.0166	0.0369	-0.4488	0.6605	-0.5963	16
Eatonton	0.0217	0.0363	0.5991	0.5565	0.6225	20
Ellijay	-0.0729	0.0521	-1.3986	0.1853	-2.2836	15
Rome	0.0015	0.0404	0.0362	0.9715	0.0429	20
Fort Valley	0.0158	0.0314	0.5040	0.6207	0.4846	19
Gainesville	-0.0059	0.0364	-0.1627	0.8728	-0.1751	18
Griffin	0.0432	0.0299	1.4416	0.1657	1.2718	21
Jonesboro	0.0113	0.0458	0.2466	0.8088	0.3226	16
LaFayette	-0.0605	0.0509	-1.1886	0.2531	-1.9762	17
Midville	-0.0135	0.0284	-0.4753	0.6400	-0.3596	21
Nahunta	-0.0225	0.0762	-0.2951	0.7754	-0.7564	10
Newton	0.0610	0.0545	1.1194	0.2868	1.8709	13
Plains	0.0174	0.0270	0.6439	0.5278	0.5036	20
Savannah	-0.0268	0.0301	-0.8882	0.3861	-0.7901	20
Lake Seminole-FL	0.0573	0.0493	1.1617	0.2723	1.7734	12
Statesboro	-0.0499	0.0440	-1.1351	0.2741	-1.3745	17
Tifton	0.0011	0.0256	0.0412	0.9676	0.0301	21
Valdosta	-0.0344	0.0394	-0.8745	0.3977	-1.1500	15
Vidalia	-0.0985	0.0464	-2.1208	0.0537	-2.8746	15
Roopville	-0.0118	0.0400	-0.2943	0.7726	-0.3618	17
Watkinsville-Hort	-0.0339	0.0490	-0.6906	0.5011	-0.9587	16
Watkinsville-UGA	0.0101	0.0397	0.2552	0.8015	0.2855	20
Watkinsville-USDA	0.0199	0.0283	0.7023	0.4915	0.7733	20

Table A-1: January Trends

Station	Slope	SE	T-Stat	p-value	°C/decade	Sample Size
Alma	-0.0584	0.0343	-1.6992	0.1075	-1.5823	19
Arlington	-0.0212	0.0472	-0.4491	0.6602	-0.5951	16
Atlanta	**-0.1406**	**0.0488**	**-2.8809**	**0.0129**	**-4.0386**	16
Attapulgus	0.0048	0.0260	0.1860	0.8545	0.1511	20
Blairsville	-0.0057	0.0320	-0.1770	0.8614	-0.1669	21
Williamson	-0.0154	0.0344	-0.4485	0.6591	-0.4052	20
Brunswick	-0.0181	0.0738	-0.2451	0.8109	-0.4599	13
Byron	0.0048	0.0818	0.0587	0.9544	0.1325	12
Cairo	0.0319	0.0402	0.7942	0.4413	0.9104	15
Calhoun	-0.0273	0.0396	-0.6898	0.4991	-0.7414	20
Pine Mountain	-0.0254	0.0497	-0.5114	0.6165	-0.7373	17
Camilla	-0.0172	0.0443	-0.3879	0.7044	-0.4696	15
Cordele	-0.0275	0.0538	-0.5114	0.6176	-0.7486	15
Dallas	0.0523	0.0899	0.5824	0.5732	1.4105	12
Dawson	-0.0225	0.0392	-0.5739	0.5745	-0.6637	17
Dearing	0.0418	0.0584	0.7153	0.4881	1.1055	14
Griffin-Dempsey	-0.0110	0.0380	-0.2905	0.7748	-0.3073	20
Dixie	-0.0507	0.0429	-1.1815	0.2603	-1.4347	14
Dublin	0.0132	0.0495	0.2665	0.7940	0.3446	15
Johns Creek	-0.0373	0.0462	-0.8074	0.4313	-0.9792	18
Dunwoody	-0.0229	0.0464	-0.4932	0.6295	-0.7474	16
Eatonton	-0.0096	0.0364	-0.2639	0.7948	-0.2662	20
Ellijay	-0.0372	0.0609	-0.6099	0.5525	-0.9846	15
Rome	0.0121	0.0338	0.3596	0.7234	0.3471	20
Fort Valley	-0.0516	0.0317	-1.6265	0.1222	-1.5247	19
Gainesville	-0.0211	0.0398	-0.5320	0.6025	-0.5000	17
Griffin	-0.0250	0.0352	-0.7091	0.4869	-0.6829	21
Jonesboro	0.0177	0.0593	0.2976	0.7704	0.4626	16
LaFayette	-0.0009	0.0488	-0.0187	0.9853	-0.0272	17
Midville	-0.0308	0.0304	-1.0131	0.3237	-0.7752	21
Nahunta	-0.0317	0.1134	-0.2791	0.7873	-0.9624	10
Newton	0.0231	0.0645	0.3586	0.7266	0.6484	13
Plains	-0.0381	0.0329	-1.1565	0.2618	-1.0388	21
Savannah	0.0359	0.0342	1.0477	0.3086	0.9581	20
Lake Seminole-FL	0.0433	0.0678	0.6381	0.5378	1.1773	12
Statesboro	-0.0033	0.0437	-0.0765	0.9400	-0.0840	18
Tifton	-0.0351	0.0303	-1.1583	0.2611	-0.9525	21
Valdosta	-0.0296	0.0380	-0.7782	0.4504	-0.8621	15
Vidalia	-0.0164	0.0522	-0.3134	0.7589	-0.4279	15
Roopville	0.0208	0.0463	0.4495	0.6595	0.6000	17
Watkinsville-Hort	-0.0264	0.0533	-0.4945	0.6286	-0.6560	16
Watkinsville-UGA	-0.0254	0.0379	-0.6695	0.5117	-0.6586	20
Watkinsville-USDA	-0.0025	0.0282	-0.0902	0.9291	-0.0878	20

Table A-2: February Trends

Station	Slope	SE	T-Stat	p-value	°C/decade	Sample Size
Alma	0.0122	0.0238	0.5121	0.6152	0.3182	19
Arlington	0.0253	0.0356	0.7109	0.4888	0.6888	16
Atlanta	-0.0297	0.0521	-0.5703	0.5782	-0.8625	16
Attapulgus	0.0207	0.0180	1.1481	0.2659	0.6223	20
Blairsville	0.0286	0.0277	1.0340	0.3141	0.8868	21
Williamson	0.0026	0.0320	0.0803	0.9369	0.0715	20
Brunswick	-0.0362	0.0415	-0.8703	0.4027	-0.8681	13
Byron	-0.0426	0.0636	-0.6694	0.5184	-1.2255	12
Cairo	**0.0606**	**0.0278**	**2.1801**	**0.0482**	**1.7193**	**15**
Calhoun	-0.0215	0.0266	-0.8108	0.4275	-0.6138	21
Pine Mountain	0.0174	0.0352	0.4952	0.6276	0.5223	17
Camilla	-0.0314	0.0339	-0.9278	0.3704	-0.8293	15
Cordele	-0.0375	0.0363	-1.0327	0.3206	-1.0368	15
Dallas	0.0119	0.0667	0.1788	0.8616	0.3685	12
Dawson	0.0111	0.0276	0.4012	0.6940	0.3272	17
Dearing	0.0219	0.0467	0.4685	0.6479	0.6204	14
Griffin-Dempsey	0.0007	0.0290	0.0258	0.9797	0.0223	20
Dixie	-0.0007	0.0298	-0.0244	0.9809	-0.0200	15
Dublin	-0.0059	0.0357	-0.1667	0.8702	-0.1664	15
Johns Creek	0.0153	0.0362	0.4233	0.6777	0.4472	18
Dunwoody	0.0091	0.0325	0.2807	0.7830	0.3509	16
Eatonton	-0.0197	0.0263	-0.7484	0.4639	-0.5943	20
Ellijay	0.0096	0.0496	0.1929	0.8498	0.2874	16
Rome	0.0190	0.0253	0.7525	0.4615	0.5814	20
Fort Valley	-0.0119	0.0233	-0.5077	0.6178	-0.3421	20
Gainesville	0.0479	0.0396	1.2087	0.2455	1.4037	17
Griffin	0.0032	0.0275	0.1155	0.9093	0.0913	21
Jonesboro	0.0278	0.0406	0.6842	0.5050	0.8188	16
LaFayette	0.0593	0.0419	1.4153	0.1774	1.9360	17
Midville	-0.0082	0.0233	-0.3514	0.7291	-0.2213	21
Nahunta	-0.0041	0.0659	-0.0626	0.9516	-0.1230	10
Newton	-0.0072	0.0431	-0.1663	0.8710	-0.1951	13
Plains	-0.0090	0.0220	-0.4108	0.6858	-0.2455	21
Savannah	0.0141	0.0261	0.5406	0.5954	0.4043	20
Lake Seminole-FL	0.0180	0.0442	0.4075	0.6922	0.4878	12
Statesboro	0.0049	0.0279	0.1749	0.8633	0.1276	18
Tifton	-0.0190	0.0206	-0.9229	0.3676	-0.5000	21
Valdosta	-0.0250	0.0363	-0.6894	0.5027	-0.7125	15
Vidalia	0.0040	0.0374	0.1064	0.9169	0.1039	15
Roopville	0.0429	0.0340	1.2614	0.2264	1.3559	17
Watkinsville-Hort	0.0365	0.0415	0.8780	0.3947	1.0556	16
Watkinsville-UGA	-0.0082	0.0273	-0.3006	0.7671	-0.2336	20
Watkinsville-USDA	0.0081	0.0177	0.4566	0.6534	0.3245	20

Table A-3: March Trends

Station	Slope	SE	T-Stat	p-value	°C/decade	Sample Size
Alma	0.0032	0.0242	0.1325	0.8961	0.0796	19
Arlington	-0.0078	0.0360	-0.2165	0.8320	-0.2007	15
Atlanta	0.0032	0.0373	0.0857	0.9330	0.0829	15
Attapulgus	-0.0033	0.0323	-0.1013	0.9205	-0.0891	19
Blairsville	**0.0490**	**0.0221**	**2.2156**	**0.0398**	**1.4178**	**20**
Williamson	0.0346	0.0233	1.4832	0.1563	0.9111	19
Brunswick	0.0617	0.0647	0.9539	0.3626	1.4671	12
Byron	-0.0018	0.0570	-0.0309	0.9760	-0.0455	11
Cairo	0.0010	0.0399	0.0255	0.9801	0.0273	14
Calhoun	0.0247	0.0282	0.8767	0.3922	0.6585	20
Pine Mountain	0.0376	0.0304	1.2393	0.2356	1.0603	16
Camilla	-0.0674	0.0406	-1.6617	0.1224	-1.7035	14
Cordele	-0.0330	0.0398	-0.8288	0.4234	-0.8442	14
Dallas	0.0039	0.0628	0.0615	0.9523	0.1055	11
Dawson	0.0274	0.0250	1.0948	0.2921	0.7487	16
Dearing	-0.0252	0.0420	-0.6001	0.5606	-0.6687	13
Griffin-Dempsey	0.0392	0.0249	1.5719	0.1344	1.0740	19
Dixie	**-0.0788**	**0.0347**	**-2.2711**	**0.0424**	**-2.0242**	**14**
Dublin	0.0124	0.0382	0.3256	0.7499	0.3271	15
Johns Creek	0.0159	0.0319	0.4985	0.6254	0.4409	17
Dunwoody	**0.0585**	**0.0256**	**2.2881**	**0.0395**	**2.1957**	**15**
Eatonton	-0.0024	0.0176	-0.1392	0.8908	-0.0684	20
Ellijay	0.0389	0.0342	1.1383	0.2755	1.1125	15
Rome	0.0388	0.0320	1.2110	0.2424	1.0667	19
Fort Valley	0.0177	0.0208	0.8537	0.4052	0.4705	19
Gainesville	0.0505	0.0378	1.3353	0.2031	1.3488	16
Griffin	0.0361	0.0221	1.6350	0.1194	0.9548	20
Jonesboro	0.0285	0.0395	0.7232	0.4824	0.7961	15
LaFayette	**0.0801**	**0.0329**	**2.4305**	**0.0291**	**2.4376**	**16**
Midville	0.0085	0.0253	0.3358	0.7409	0.2143	20
Nahunta	-0.0404	0.0778	-0.5194	0.6175	-1.1915	10
Newton	-0.0346	0.0517	-0.6701	0.5180	-0.9045	12
Plains	0.0352	0.0253	1.3927	0.1807	0.8923	20
Savannah	0.0106	0.0272	0.3914	0.7004	0.2975	19
Lake Seminole-FL	-0.0094	0.0507	-0.1863	0.8560	-0.2385	12
Statesboro	0.0063	0.0448	0.1410	0.8897	0.1534	17
Tifton	0.0109	0.0218	0.5004	0.6229	0.2579	20
Valdosta	-0.0177	0.0332	-0.5334	0.6035	-0.4734	14
Vidalia	-0.0124	0.0411	-0.3009	0.7686	-0.3020	14
Roopville	**0.0751**	**0.0295**	**2.5440**	**0.0234**	**2.2221**	**16**
Watkinsville-Hort	0.0152	0.0418	0.3629	0.7225	0.4021	15
Watkinsville-UGA	0.0122	0.0271	0.4511	0.6576	0.3184	19
Watkinsville-USDA	0.0233	0.0177	1.3192	0.2046	0.9125	19

Table A-4: April Trends

Station	Slope	SE	T-Stat	p-value	°C/decade	Sample Size
Alma	**0.0567**	**0.0232**	**2.4415**	**0.0259**	**1.0396**	**19**
Arlington	0.0522	0.0447	1.1679	0.2638	1.0468	15
Atlanta	-0.0048	0.0303	-0.1584	0.8765	-0.0936	15
Attapulgus	0.0387	0.0191	2.0236	0.0590	0.7796	19
Blairsville	**0.0608**	**0.0221**	**2.7542**	**0.0131**	**1.4871**	**20**
Williamson	0.0441	0.0261	1.6882	0.1096	0.9312	19
Brunswick	-0.0066	0.0498	-0.1316	0.8979	-0.1119	12
Byron	-0.0520	0.0531	-0.9790	0.3532	-1.0155	11
Cairo	0.0503	0.0356	1.4138	0.1828	1.0024	14
Calhoun	**0.0556**	**0.0211**	**2.6421**	**0.0166**	**1.1926**	**20**
Pine Mountain	0.0402	0.0266	1.5119	0.1528	0.8618	16
Camilla	-0.0217	0.0384	-0.5656	0.5813	-0.4189	15
Cordele	-0.0580	0.0395	-1.4681	0.1658	-1.1293	15
Dallas	0.0594	0.0535	1.1106	0.2955	1.3773	11
Dawson	-0.0034	0.0355	-0.0946	0.9259	-0.0662	17
Dearing	-0.0059	0.0573	-0.1022	0.9205	-0.1126	13
Griffin-Dempsey	**0.0586**	**0.0239**	**2.4546**	**0.0252**	**1.2840**	**19**
Dixie	-0.0534	0.0330	-1.6198	0.1312	-0.9925	14
Dublin	0.0204	0.0450	0.4538	0.6574	0.4225	15
Johns Creek	0.0246	0.0281	0.8760	0.3949	0.5598	17
Dunwoody	0.0262	0.0233	1.1203	0.2829	0.8186	15
Eatonton	0.0325	0.0328	0.9906	0.3350	0.7232	20
Ellijay	0.0345	0.0324	1.0654	0.3061	0.8625	15
Rome	0.0536	0.0279	1.9172	0.0722	1.2232	19
Fort Valley	0.0125	0.0265	0.4706	0.6439	0.2500	19
Gainesville	0.0079	0.0316	0.2489	0.8071	0.1888	16
Griffin	**0.0509**	**0.0225**	**2.2598**	**0.0365**	**1.0459**	**20**
Jonesboro	0.0360	0.0336	1.0702	0.3040	0.8304	15
LaFayette	-0.0053	0.0439	-0.1207	0.9056	-0.1332	16
Midville	0.0413	0.0272	1.5176	0.1465	0.8084	20
Nahunta	-0.0309	0.0708	-0.4357	0.6745	-0.7115	10
Newton	-0.0626	0.0548	-1.1434	0.2795	-1.2360	12
Plains	0.0325	0.0276	1.1783	0.2540	0.6011	20
Savannah	0.0482	0.0253	1.9076	0.0735	1.0488	19
Lake Seminole-FL	-0.0146	0.0340	-0.4299	0.6764	-0.2608	12
Statesboro	0.0061	0.0466	0.1302	0.8981	0.1186	17
Tifton	**0.0604**	**0.0246**	**2.4537**	**0.0246**	**1.0483**	**20**
Valdosta	0.0014	0.0253	0.0538	0.9579	0.0264	15
Vidalia	-0.0373	0.0408	-0.9137	0.3789	-0.6697	14
Roopville	**0.0655**	**0.0242**	**2.7023**	**0.0164**	**1.5309**	**17**
Watkinsville-Hort	0.0023	0.0423	0.0541	0.9576	0.0507	16
Watkinsville-UGA	0.0437	0.0257	1.6994	0.1075	0.8961	19
Watkinsville-USDA	0.0298	0.0180	1.6540	0.1165	0.9647	19

Table A-5: May Trends

Station	Slope	SE	T-Stat	p-value	°C/decade	Sample Size
Alma	0.0393	0.0337	1.1669	0.2594	0.4311	19
Arlington	0.1107	0.0563	1.9662	0.0710	1.2964	15
Atlanta	0.0448	0.0468	0.9554	0.3568	0.6021	15
Attapulgus	0.0414	0.0338	1.2271	0.2365	0.5209	19
Blairsville	0.0341	0.0207	1.6464	0.1170	0.5873	20
Williamson	**0.0981**	**0.0258**	**3.8040**	**0.0014**	**1.3739**	**19**
Brunswick	0.1320	0.0662	1.9946	0.0741	1.4448	12
Byron	**0.1843**	**0.0535**	**3.4421**	**0.0074**	**2.0827**	**11**
Cairo	**0.1544**	**0.0525**	**2.9404**	**0.0124**	**1.9042**	**14**
Calhoun	-0.0025	0.0240	-0.1031	0.9190	-0.0359	20
Pine Mountain	**0.1299**	**0.0225**	**5.7717**	**0.0000**	**1.7993**	**17**
Camilla	0.0270	0.0589	0.4585	0.6542	0.2886	15
Cordele	0.0765	0.0543	1.4080	0.1826	0.9007	15
Dallas	**0.1614**	**0.0335**	**4.8142**	**0.0010**	**2.2636**	**11**
Dawson	**0.0906**	**0.0370**	**2.4520**	**0.0269**	**1.1324**	**17**
Dearing	**0.1639**	**0.0570**	**2.8758**	**0.0151**	**1.8423**	**13**
Griffin-Dempsey	**0.0975**	**0.0234**	**4.1706**	**0.0006**	**1.3845**	**20**
Dixie	-0.0553	0.0672	-0.8223	0.4269	-0.5633	14
Dublin	0.1107	0.0622	1.7815	0.0982	1.3811	15
Johns Creek	0.0466	0.0258	1.8060	0.0898	0.7108	18
Dunwoody	0.0320	0.0268	1.1959	0.2531	0.6450	15
Eatonton	0.0453	0.0260	1.7453	0.0980	0.6803	20
Ellijay	0.0099	0.0422	0.2353	0.8176	0.1604	15
Rome	**0.0621**	**0.0197**	**3.1604**	**0.0057**	**0.9314**	**19**
Fort Valley	0.0698	0.0381	1.8314	0.0846	0.8533	19
Gainesville	0.0364	0.0240	1.5151	0.1493	0.8604	18
Griffin	0.0683	0.0341	2.0032	0.0596	0.9377	21
Jonesboro	**0.1458**	**0.0310**	**4.7053**	**0.0003**	**2.3106**	**16**
LaFayette	-0.0156	0.0405	-0.3859	0.7050	-0.2571	17
Midville	**0.0991**	**0.0338**	**2.9319**	**0.0089**	**1.3309**	**20**
Nahunta	0.0122	0.1165	0.1046	0.9192	0.1612	10
Newton	0.0784	0.0473	1.6562	0.1287	0.7958	12
Plains	**0.0799**	**0.0358**	**2.2294**	**0.0388**	**0.9526**	**20**
Savannah	**0.1229**	**0.0339**	**3.6279**	**0.0021**	**1.8470**	**19**
Lake Seminole-FL	**0.1906**	**0.0695**	**2.7412**	**0.0208**	**1.6336**	**12**
Statesboro	0.0988	0.0481	2.0525	0.0580	1.3417	17
Tifton	**0.0617**	**0.0281**	**2.1973**	**0.0413**	**0.7976**	**20**
Valdosta	0.0726	0.0462	1.5716	0.1401	0.7657	15
Vidalia	0.0851	0.0710	1.1980	0.2541	0.8798	14
Roopville	**0.0785**	**0.0288**	**2.7280**	**0.0156**	**1.2483**	**17**
Watkinsville-Hort	0.0619	0.0383	1.6180	0.1280	0.9324	16
Watkinsville-UGA	**0.0690**	**0.0315**	**2.1884**	**0.0429**	**0.9556**	**19**
Watkinsville-USDA	**0.0530**	**0.0209**	**2.5398**	**0.0211**	**1.1244**	**19**

Table A-6: June Trends

Station	**Slope**	**SE**	**T-Stat**	**p-value**	**°C/decade**	**Sample Size**
Alma	0.0788	0.0384	2.0519	0.0559	0.5621	19
Arlington	0.0256	0.0583	0.4395	0.6676	0.1939	15
Atlanta	-0.0713	0.0736	-0.9691	0.3502	-0.6064	15
Attapulgus	0.0757	0.0571	1.3266	0.2022	0.6056	19
Blairsville	**0.0554**	**0.0256**	**2.1616**	**0.0444**	**0.6880**	**20**
Williamson	0.0493	0.0361	1.3655	0.1899	0.4537	19
Brunswick	0.0444	0.0929	0.4783	0.6427	0.4322	12
Byron	0.0402	0.1046	0.3844	0.7096	0.3600	11
Cairo	**0.1297**	**0.0460**	**2.8219**	**0.0154**	**1.1699**	**14**
Calhoun	-0.0400	0.0228	-1.7547	0.0963	-0.4265	20
Pine Mountain	**0.1466**	**0.0447**	**3.2793**	**0.0051**	**1.2875**	**17**
Camilla	**-0.1254**	**0.0441**	**-2.8434**	**0.0138**	**-1.0468**	**15**
Cordele	-0.0280	0.0569	-0.4919	0.6310	-0.2518	15
Dallas	0.1461	0.0647	2.2570	0.0504	1.3682	11
Dawson	0.0759	0.0485	1.5652	0.1384	0.6103	17
Dearing	-0.0814	0.1012	-0.8046	0.4381	-0.6588	13
Griffin-Dempsey	**0.0816**	**0.0371**	**2.1988**	**0.0412**	**0.7402**	**20**
Dixie	-0.1164	0.0597	-1.9495	0.0750	-0.9284	14
Dublin	0.1014	0.0597	1.6975	0.1134	0.8482	15
Johns Creek	**0.0703**	**0.0329**	**2.1389**	**0.0482**	**0.7678**	**18**
Dunwoody	0.0114	0.0406	0.2797	0.7841	0.1325	15
Eatonton	0.0436	0.0331	1.3141	0.2053	0.4228	20
Ellijay	0.0079	0.0414	0.1917	0.8509	0.0914	15
Rome	**0.0582**	**0.0233**	**2.4947**	**0.0232**	**0.6311**	**19**
Fort Valley	0.0572	0.0465	1.2285	0.2360	0.4598	19
Gainesville	0.0645	0.0330	1.9554	0.0682	0.7176	18
Griffin	0.0498	0.0396	1.2578	0.2237	0.4236	21
Jonesboro	**0.1012**	**0.0332**	**3.0458**	**0.0087**	**1.0903**	**16**
LaFayette	0.0540	0.0359	1.5048	0.1531	0.6603	17
Midville	0.0779	0.0371	2.0966	0.0504	0.5935	20
Nahunta	0.0239	0.1150	0.2076	0.8407	0.2273	10
Newton	-0.0202	0.0733	-0.2749	0.7890	-0.1367	12
Plains	**0.0823**	**0.0377**	**2.1824**	**0.0426**	**0.6239**	**20**
Savannah	**0.0973**	**0.0391**	**2.4877**	**0.0235**	**1.0246**	**19**
Lake Seminole-FL	0.1139	0.1233	0.9243	0.3771	0.7615	12
Statesboro	-0.0116	0.0386	-0.3000	0.7683	-0.1147	17
Tifton	0.0237	0.0383	0.6189	0.5438	0.1517	20
Valdosta	-0.0438	0.0622	-0.7036	0.4941	-0.3021	15
Vidalia	-0.1140	0.0854	-1.3343	0.2069	-0.7899	14
Roopville	0.0453	0.0425	1.0668	0.3029	0.4772	17
Watkinsville-Hort	0.0757	0.0450	1.6828	0.1146	0.7674	16
Watkinsville-UGA	0.0507	0.0398	1.2729	0.2202	0.5461	19
Watkinsville-USDA	0.0468	0.0308	1.5177	0.1475	0.5826	19

Table A-7: July Trends

Station	Slope	SE	T-Stat	p-value	°C/decade	Sample Size
Alma	**0.1055**	**0.0393**	**2.6874**	**0.0156**	**0.8595**	**19**
Arlington	0.0626	0.0643	0.9724	0.3486	0.6104	15
Atlanta	0.0763	0.0785	0.9718	0.3489	0.7875	15
Attapulgus	**0.1326**	**0.0380**	**3.4898**	**0.0026**	**1.2867**	**20**
Blairsville	**0.1029**	**0.0253**	**4.0754**	**0.0007**	**1.4985**	**20**
Williamson	**0.0895**	**0.0338**	**2.6443**	**0.0170**	**1.0549**	**19**
Brunswick	**0.2462**	**0.0795**	**3.0957**	**0.0113**	**2.5748**	**12**
Byron	0.1184	0.1360	0.8703	0.4068	1.0955	11
Cairo	**0.1879**	**0.0466**	**4.0348**	**0.0017**	**1.8989**	**14**
Calhoun	0.0298	0.0246	1.2126	0.2410	0.3774	20
Pine Mountain	**0.1494**	**0.0274**	**5.4513**	**0.0001**	**1.6525**	**17**
Camilla	-0.0176	0.0493	-0.3576	0.7264	-0.1786	15
Cordele	0.0066	0.0490	0.1338	0.8956	0.0739	15
Dallas	**0.1078**	**0.0469**	**2.2993**	**0.0443**	**1.4269**	**12**
Dawson	0.0883	0.0637	1.3874	0.1856	0.8267	17
Dearing	0.0613	0.0529	1.1581	0.2694	0.6073	14
Griffin-Dempsey	**0.1021**	**0.0290**	**3.5155**	**0.0025**	**1.1929**	**20**
Dixie	-0.0227	0.0647	-0.3513	0.7315	-0.2046	14
Dublin	**0.1599**	**0.0460**	**3.4777**	**0.0041**	**1.6900**	**15**
Johns Creek	**0.0961**	**0.0308**	**3.1189**	**0.0066**	**1.2895**	**18**
Dunwoody	**0.1027**	**0.0320**	**3.2147**	**0.0068**	**1.6207**	**15**
Eatonton	**0.0736**	**0.0270**	**2.7304**	**0.0137**	**0.9129**	**20**
Ellijay	**0.1033**	**0.0316**	**3.2671**	**0.0061**	**1.4475**	**15**
Rome	**0.0829**	**0.0212**	**3.9098**	**0.0010**	**1.1005**	**20**
Fort Valley	0.0785	0.0506	1.5530	0.1388	0.7696	19
Gainesville	**0.0943**	**0.0306**	**3.0858**	**0.0071**	**1.4657**	**18**
Griffin	**0.0991**	**0.0332**	**2.9821**	**0.0077**	**1.1240**	**21**
Jonesboro	**0.1331**	**0.0324**	**4.1130**	**0.0011**	**1.8418**	**16**
LaFayette	**0.0906**	**0.0334**	**2.7163**	**0.0159**	**1.2841**	**17**
Midville	**0.1344**	**0.0346**	**3.8807**	**0.0011**	**1.3780**	**20**
Nahunta	0.1273	0.1169	1.0887	0.3080	1.2836	10
Newton	0.0814	0.0881	0.9241	0.3753	0.7071	13
Plains	**0.1294**	**0.0417**	**3.1053**	**0.0061**	**1.2298**	**20**
Savannah	**0.1534**	**0.0329**	**4.6643**	**0.0002**	**1.8191**	**19**
Lake Seminole-FL	0.1319	0.0851	1.5491	0.1524	1.0259	12
Statesboro	**0.1166**	**0.0400**	**2.9130**	**0.0107**	**1.3672**	**17**
Tifton	**0.1063**	**0.0346**	**3.0738**	**0.0065**	**0.8604**	**20**
Valdosta	**0.1038**	**0.0441**	**2.3569**	**0.0348**	**0.9211**	**15**
Vidalia	0.0878	0.0539	1.6289	0.1293	0.7066	14
Roopville	**0.1131**	**0.0411**	**2.7532**	**0.0148**	**1.5657**	**17**
Watkinsville-Hort	**0.1216**	**0.0359**	**3.3930**	**0.0044**	**1.5450**	**16**
Watkinsville-UGA	**0.0851**	**0.0368**	**2.3101**	**0.0337**	**0.9505**	**19**
Watkinsville-USDA	**0.0677**	**0.0283**	**2.3898**	**0.0287**	**1.0754**	**19**

Table A-8: August Trends

Station	**Slope**	**SE**	**T-Stat**	**p-value**	**°C/decade**	**Sample Size**
Alma	0.0506	0.0243	2.0824	0.0527	0.7882	19
Arlington	0.0174	0.0319	0.5435	0.5960	0.3196	15
Atlanta	0.0079	0.0221	0.3561	0.7271	0.1362	16
Attapulgus	0.0484	0.0311	1.5548	0.1374	0.8544	20
Blairsville	0.0337	0.0190	1.7685	0.0939	0.7671	20
Williamson	0.0252	0.0193	1.3035	0.2098	0.4909	19
Brunswick	-0.0099	0.0509	-0.1942	0.8499	-0.1423	12
Byron	-0.0218	0.0390	-0.5573	0.5909	-0.3855	11
Cairo	0.0750	0.0361	2.0754	0.0601	1.2701	14
Calhoun	-0.0069	0.0147	-0.4698	0.6441	-0.1459	20
Pine Mountain	**0.0630**	**0.0172**	**3.6654**	**0.0023**	**1.1868**	**17**
Camilla	-0.0317	0.0320	-0.9899	0.3403	-0.5789	15
Cordele	-0.0265	0.0218	-1.2152	0.2459	-0.5075	15
Dallas	0.0449	0.0290	1.5493	0.1524	0.9510	12
Dawson	**0.0697**	**0.0245**	**2.8400**	**0.0124**	**1.2056**	**17**
Dearing	-0.0024	0.0217	-0.1100	0.9142	-0.0429	14
Griffin-Dempsey	**0.0437**	**0.0157**	**2.7810**	**0.0123**	**0.8386**	**20**
Dixie	-0.0527	0.0299	-1.7618	0.1035	-0.8833	14
Dublin	0.0213	0.0280	0.7621	0.4596	0.3964	15
Johns Creek	**0.0536**	**0.0161**	**3.3319**	**0.0042**	**1.1350**	**18**
Dunwoody	**0.0410**	**0.0151**	**2.7112**	**0.0178**	**1.1582**	**15**
Eatonton	0.0148	0.0191	0.7764	0.4476	0.3086	20
Ellijay	0.0346	0.0272	1.2691	0.2267	0.7986	15
Rome	**0.0365**	**0.0164**	**2.2258**	**0.0390**	**0.8055**	**20**
Fort Valley	**0.0358**	**0.0168**	**2.1283**	**0.0482**	**0.6104**	**19**
Gainesville	**0.0467**	**0.0125**	**3.7323**	**0.0018**	**1.1409**	**18**
Griffin	0.0221	0.0157	1.4084	0.1752	0.4234	21
Jonesboro	**0.0559**	**0.0243**	**2.2978**	**0.0375**	**1.2243**	**16**
LaFayette	**0.0556**	**0.0229**	**2.4243**	**0.0284**	**1.2402**	**17**
Midville	0.0276	0.0161	1.7152	0.1035	0.4801	20
Nahunta	-0.0722	0.0727	-0.9936	0.3495	-1.2358	10
Newton	0.0222	0.0397	0.5595	0.5870	0.3896	13
Plains	**0.0576**	**0.0193**	**2.9767**	**0.0081**	**0.9465**	**20**
Savannah	**0.0755**	**0.0205**	**3.6738**	**0.0019**	**1.3118**	**19**
Lake Seminole-FL	0.0384	0.0382	1.0028	0.3396	0.5986	12
Statesboro	0.0093	0.0257	0.3638	0.7211	0.1672	17
Tifton	0.0423	0.0202	2.0987	0.0502	0.6294	20
Valdosta	0.0081	0.0238	0.3411	0.7385	0.1436	15
Vidalia	-0.0253	0.0351	-0.7212	0.4846	-0.3958	14
Roopville	**0.0498**	**0.0177**	**2.8173**	**0.0130**	**1.0966**	**17**
Watkinsville-Hort	0.0424	0.0227	1.8655	0.0832	0.8443	16
Watkinsville-UGA	0.0316	0.0194	1.6311	0.1202	0.5929	20
Watkinsville-USDA	0.0277	0.0151	1.8353	0.0840	0.7958	19

Table A-9: September Trends

Station	**Slope**	**SE**	**T-Stat**	**p-value**	**°C/decade**	**Sample Size**
Alma	0.0156	0.0257	0.6058	0.5527	0.4093	19
Arlington	0.0626	0.0294	2.1295	0.0529	1.8421	15
Atlanta	-0.0021	0.0270	-0.0778	0.9391	-0.0543	17
Attapulgus	**0.0430**	**0.0198**	**2.1651**	**0.0441**	**1.1882**	**20**
Blairsville	**0.0580**	**0.0260**	**2.2290**	**0.0388**	**1.7862**	**20**
Williamson	0.0292	0.0271	1.0751	0.2974	0.8251	19
Brunswick	0.0602	0.0411	1.4656	0.1735	1.4273	12
Byron	0.0382	0.0463	0.8262	0.4280	1.1322	12
Cairo	0.0669	0.0423	1.5838	0.1392	1.8804	14
Calhoun	0.0121	0.0260	0.4655	0.6472	0.3572	20
Pine Mountain	0.0351	0.0293	1.1967	0.2500	1.0162	17
Camilla	0.0017	0.0318	0.0529	0.9586	0.0493	15
Cordele	0.0233	0.0334	0.6983	0.4973	0.7057	15
Dallas	0.0424	0.0542	0.7824	0.4521	1.2853	12
Dawson	0.0382	0.0303	1.2602	0.2268	1.1179	17
Dearing	0.0058	0.0480	0.1217	0.9051	0.1624	14
Griffin-Dempsey	0.0491	0.0280	1.7515	0.0969	1.3502	20
Dixie	0.0101	0.0371	0.2724	0.7900	0.2864	14
Dublin	0.0444	0.0375	1.1826	0.2582	1.3029	15
Johns Creek	0.0449	0.0263	1.7075	0.1070	1.3543	18
Dunwoody	0.0251	0.0255	0.9863	0.3420	1.0179	15
Eatonton	**0.0544**	**0.0233**	**2.3369**	**0.0312**	**1.6372**	**20**
Ellijay	0.0222	0.0429	0.5170	0.6138	0.7061	15
Rome	0.0499	0.0280	1.7828	0.0915	1.4925	20
Fort Valley	0.0342	0.0253	1.3549	0.1932	0.9389	19
Gainesville	0.0216	0.0230	0.9404	0.3610	0.6883	18
Griffin	0.0397	0.0243	1.6352	0.1185	1.0703	21
Jonesboro	0.0470	0.0332	1.4138	0.1793	1.4475	16
LaFayette	-0.0248	0.0336	-0.7387	0.4715	-0.7527	17
Midville	0.0484	0.0238	2.0358	0.0568	1.3155	20
Nahunta	-0.0242	0.0501	-0.4831	0.6419	-0.7582	10
Newton	0.0349	0.0371	0.9423	0.3663	1.0451	13
Plains	0.0487	0.0253	1.9247	0.0702	1.2678	20
Savannah	0.0462	0.0268	1.7223	0.1032	1.3028	19
Lake Seminole-FL	0.0327	0.0508	0.6430	0.5347	0.8629	12
Statesboro	0.0319	0.0329	0.9686	0.3481	0.8762	17
Tifton	0.0263	0.0257	1.0237	0.3196	0.6381	20
Valdosta	0.0290	0.0304	0.9537	0.3576	0.8636	15
Vidalia	0.0130	0.0328	0.3973	0.6976	0.3493	15
Roopville	0.0374	0.0302	1.2414	0.2335	1.1799	17
Watkinsville-Hort	0.0459	0.0328	1.3998	0.1833	1.3209	16
Watkinsville-UGA	0.0551	0.0273	2.0171	0.0589	1.4753	20
Watkinsville-USDA	0.0337	0.0184	1.8280	0.0852	1.3105	19

Table A-10: October Trends

Station	Slope	SE	T-Stat	p-value	°C/decade	Sample Size
Alma	-0.0100	0.0289	-0.3472	0.7327	-0.2830	19
Arlington	0.0075	0.0417	0.1800	0.8599	0.2146	15
Atlanta	-0.0571	0.0412	-1.3862	0.1874	-1.6038	17
Attapulgus	0.0137	0.0246	0.5577	0.5839	0.4170	20
Blairsville	0.0016	0.0355	0.0443	0.9652	0.0494	20
Williamson	-0.0026	0.0333	-0.0775	0.9392	-0.0726	19
Brunswick	-0.0385	0.0449	-0.8565	0.4118	-1.0587	12
Byron	-0.0749	0.0635	-1.1807	0.2650	-2.1794	12
Cairo	0.0528	0.0357	1.4780	0.1632	1.4911	15
Calhoun	-0.0143	0.0357	-0.4018	0.6926	-0.4260	20
Pine Mountain	0.0128	0.0439	0.2907	0.7753	0.3706	17
Camilla	-0.0223	0.0326	-0.6824	0.5070	-0.6532	15
Cordele	-0.0389	0.0430	-0.9052	0.3818	-1.1564	15
Dallas	-0.0912	0.0674	-1.3537	0.2056	-2.7259	12
Dawson	0.0163	0.0304	0.5361	0.5998	0.4762	17
Dearing	-0.0472	0.0513	-0.9202	0.3756	-1.3400	14
Griffin-Dempsey	-0.0013	0.0308	-0.0422	0.9668	-0.0366	20
Dixie	-0.0205	0.0477	-0.4296	0.6751	-0.5908	14
Dublin	-0.0035	0.0363	-0.0972	0.9240	-0.1039	15
Johns Creek	-0.0058	0.0491	-0.1182	0.9074	-0.1642	18
Dunwoody	-0.0269	0.0441	-0.6105	0.5521	-1.0432	15
Eatonton	0.0160	0.0323	0.4966	0.6255	0.4845	20
Ellijay	0.0080	0.0536	0.1497	0.8833	0.2507	15
Rome	0.0042	0.0344	0.1224	0.9039	0.1262	20
Fort Valley	0.0120	0.0266	0.4518	0.6571	0.3430	19
Gainesville	-0.0045	0.0441	-0.1010	0.9208	-0.1257	18
Griffin	-0.0051	0.0265	-0.1921	0.8497	-0.1436	21
Jonesboro	0.0052	0.0508	0.1030	0.9194	0.1535	16
LaFayette	-0.0042	0.0441	-0.0943	0.9261	-0.1240	17
Midville	-0.0204	0.0210	-0.9748	0.3419	-0.5858	21
Nahunta	0.0199	0.0981	0.2029	0.8443	0.6358	10
Newton	-0.0572	0.0421	-1.3573	0.2019	-1.6830	13
Plains	0.0055	0.0259	0.2127	0.8340	0.1544	20
Savannah	0.0313	0.0257	1.2176	0.2400	0.9328	19
Lake Seminole-FL	-0.0844	0.0473	-1.7858	0.1044	-2.3850	12
Statesboro	-0.0002	0.0299	-0.0079	0.9938	-0.0066	17
Tifton	-0.0122	0.0209	-0.5808	0.5686	-0.3258	20
Valdosta	-0.0013	0.0323	-0.0407	0.9681	-0.0404	15
Vidalia	-0.0231	0.0342	-0.6750	0.5115	-0.6361	15
Roopville	-0.0178	0.0399	-0.4455	0.6628	-0.5560	16
Watkinsville-Hort	0.0330	0.0497	0.6647	0.5170	0.9285	16
Watkinsville-UGA	-0.0241	0.0303	-0.7935	0.4378	-0.6702	20
Watkinsville-USDA	-0.0004	0.0278	-0.0151	0.9882	-0.0162	17

Table A-11: November Trends

Station	Slope	SE	T-Stat	p-value	°C/decade	Sample Size
Alma	0.0523	0.0461	1.1348	0.2722	1.4649	19
Arlington	0.0395	0.0647	0.6099	0.5524	1.1443	15
Atlanta	-0.0535	0.0804	-0.6651	0.5176	-1.5436	16
Attapulgus	0.0351	0.0296	1.1850	0.2514	1.1062	20
Blairsville	0.0086	0.0457	0.1876	0.8533	0.2598	20
Williamson	-0.0018	0.0566	-0.0322	0.9747	-0.0504	19
Brunswick	0.0578	0.0858	0.6739	0.5143	1.6538	13
Byron	0.1239	0.1092	1.1343	0.2831	3.5594	12
Cairo	0.0618	0.0508	1.2175	0.2451	1.8918	15
Calhoun	-0.0197	0.0394	-0.5013	0.6222	-0.5557	20
Pine Mountain	0.0502	0.0497	1.0091	0.3289	1.5118	17
Camilla	0.0079	0.0601	0.1321	0.8969	0.2354	15
Cordele	0.0104	0.0780	0.1329	0.8963	0.2996	15
Dallas	0.1441	0.0975	1.4769	0.1705	3.9825	12
Dawson	0.0495	0.0540	0.9159	0.3742	1.5213	17
Dearing	0.0320	0.1077	0.2968	0.7717	0.8824	14
Griffin-Dempsey	-0.0057	0.0501	-0.1134	0.9110	-0.1553	20
Dixie	0.0253	0.0638	0.3961	0.6990	0.7782	14
Dublin	0.0816	0.0835	0.9770	0.3464	2.3168	15
Johns Creek	-0.0319	0.0646	-0.4937	0.6283	-0.8528	18
Dunwoody	0.0356	0.0573	0.6207	0.5455	1.2214	15
Eatonton	-0.0122	0.0502	-0.2427	0.8109	-0.3382	20
Ellijay	-0.0220	0.0723	-0.3051	0.7651	-0.6543	15
Rome	-0.0059	0.0448	-0.1318	0.8966	-0.1669	20
Fort Valley	0.0010	0.0541	0.0177	0.9861	0.0274	19
Gainesville	0.0027	0.0624	0.0426	0.9666	0.0669	18
Griffin	-0.0451	0.0496	-0.9105	0.3739	-1.2260	21
Jonesboro	0.0599	0.0777	0.7710	0.4536	1.6385	16
LaFayette	-0.0019	0.0600	-0.0316	0.9752	-0.0571	17
Midville	-0.0016	0.0519	-0.0315	0.9752	-0.0442	21
Nahunta	0.1223	0.1085	1.1270	0.2924	4.1176	10
Newton	0.0618	0.0734	0.8418	0.4178	1.8511	13
Plains	0.0058	0.0472	0.1239	0.9028	0.1584	20
Savannah	0.0787	0.0442	1.7823	0.0926	2.3881	19
Lake Seminole-FL	0.0129	0.0905	0.1424	0.8899	0.3709	11
Statesboro	0.1119	0.0650	1.7224	0.1055	3.1703	17
Tifton	-0.0045	0.0381	-0.1176	0.9077	-0.1221	21
Valdosta	0.0243	0.0571	0.4258	0.6778	0.7868	14
Vidalia	0.0763	0.0750	1.0175	0.3275	2.1907	15
Roopville	0.0393	0.0655	0.5992	0.5586	1.2340	16
Watkinsville-Hort	0.0631	0.0819	0.7701	0.4540	1.6651	16
Watkinsville-UGA	-0.0100	0.0544	-0.1832	0.8567	-0.2606	20
Watkinsville-USDA	0.0152	0.0571	0.2656	0.7942	0.5118	17

Table A-12: December Trends

Appendix B

Appendix B contains graphical representations of the standardized values at each station, organized by season, along with their trend lines. The x and y axes list the years vs the Z score values.

Figure B-1: Alma Station

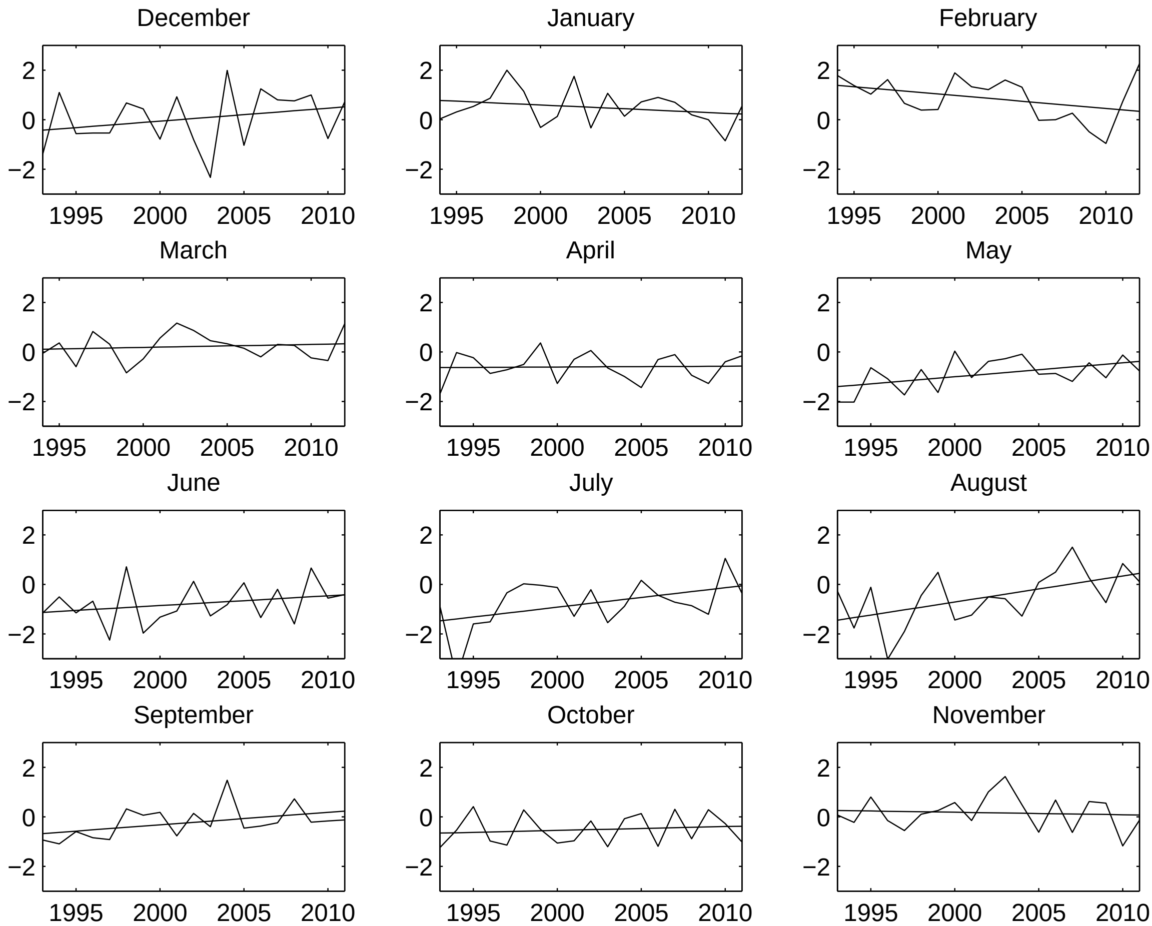

Figure B-2: Arlington Station

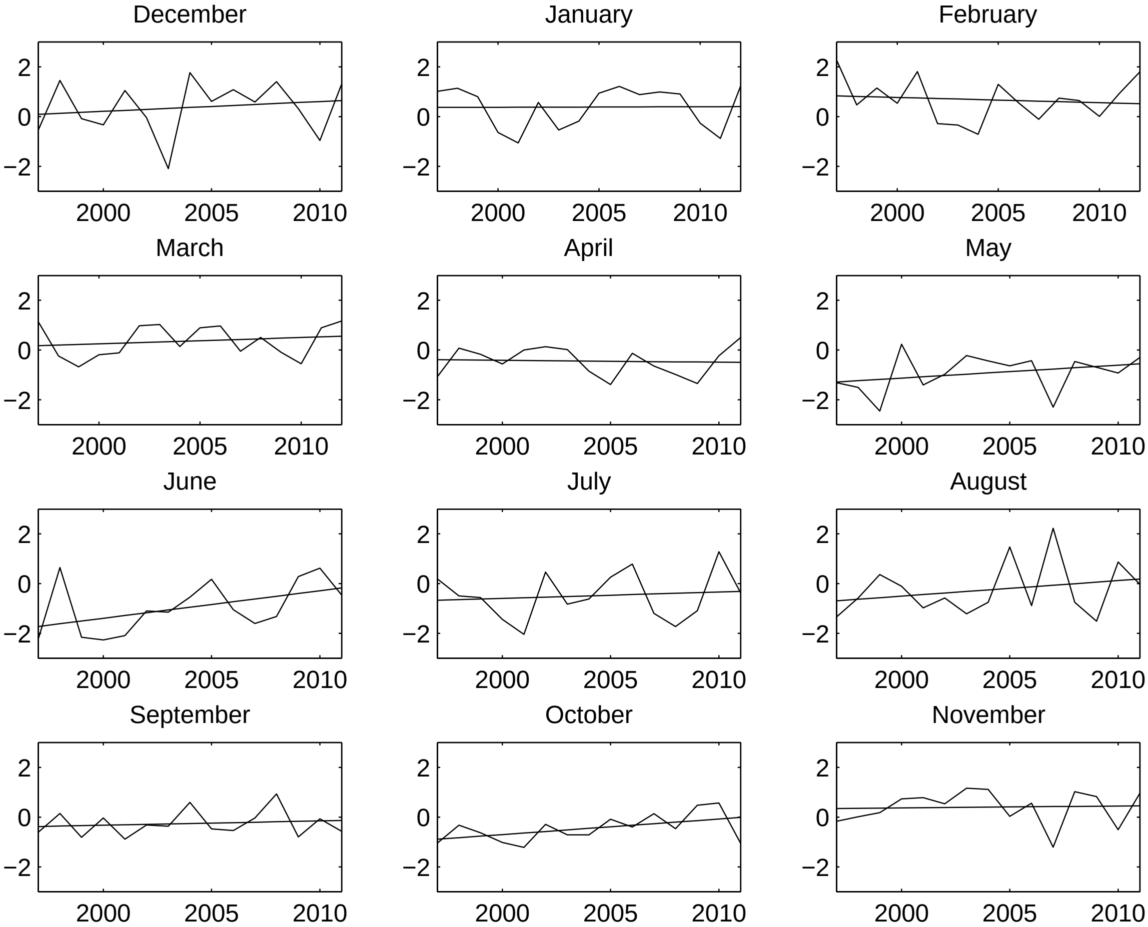

Figure B-3: Atlanta Station

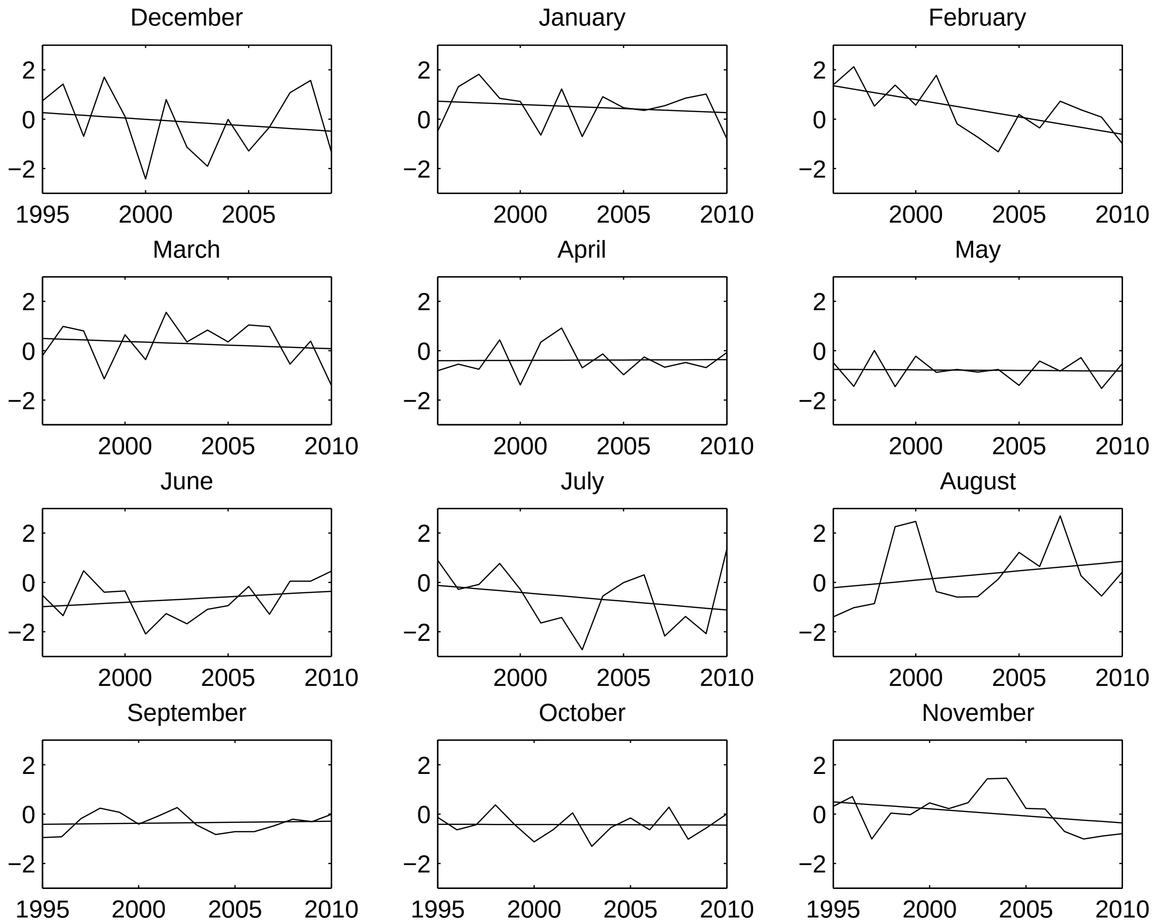

Figure B-4: Attapulgus Station

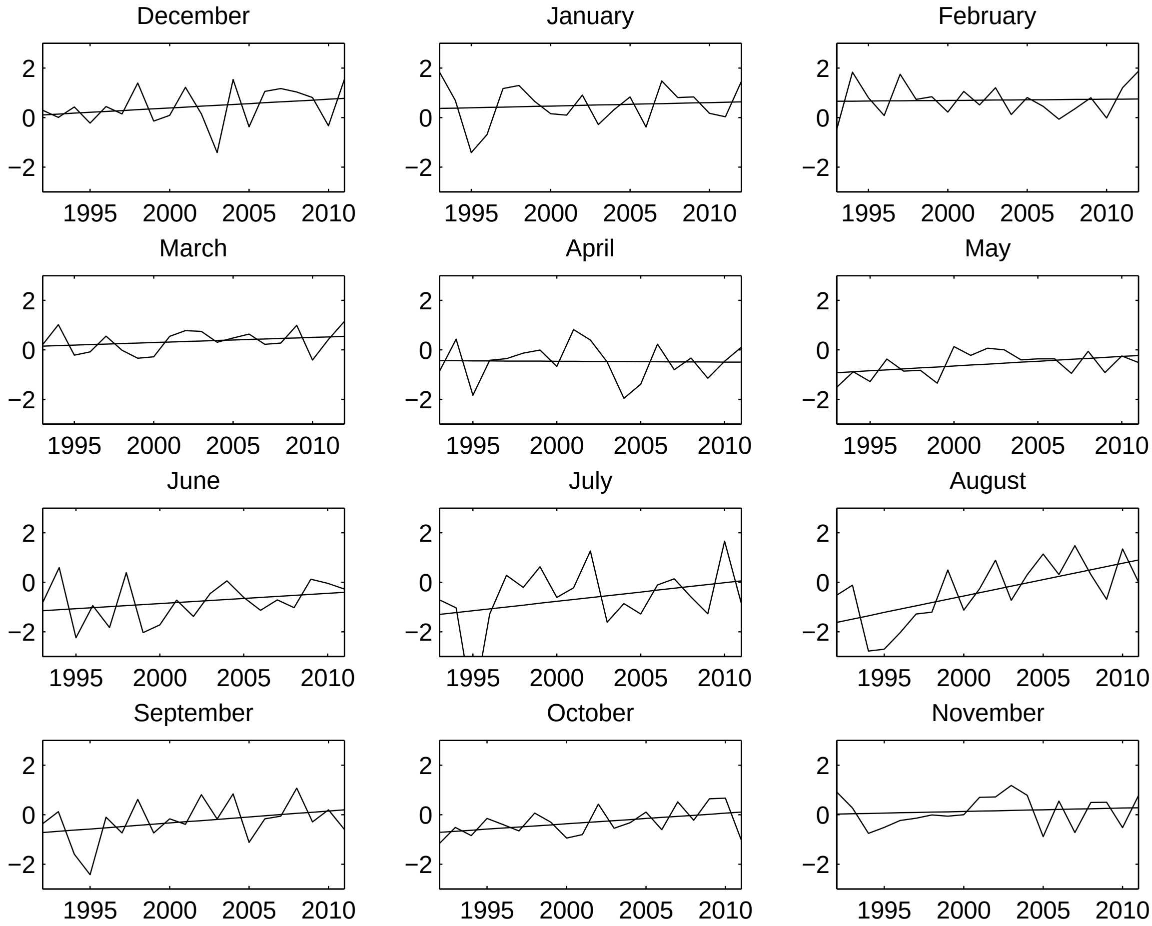

Figure B-5: Blairsville Station

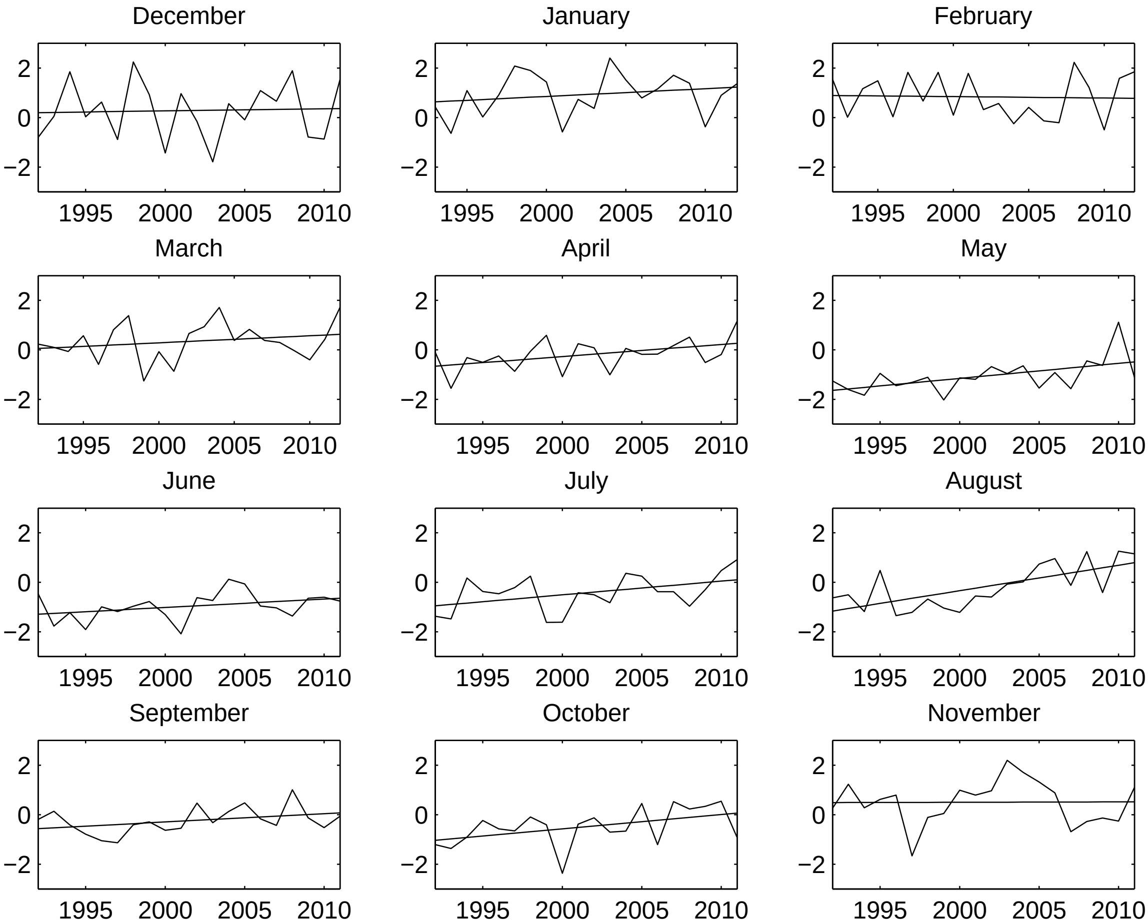

Figure B-6: Williamson Station

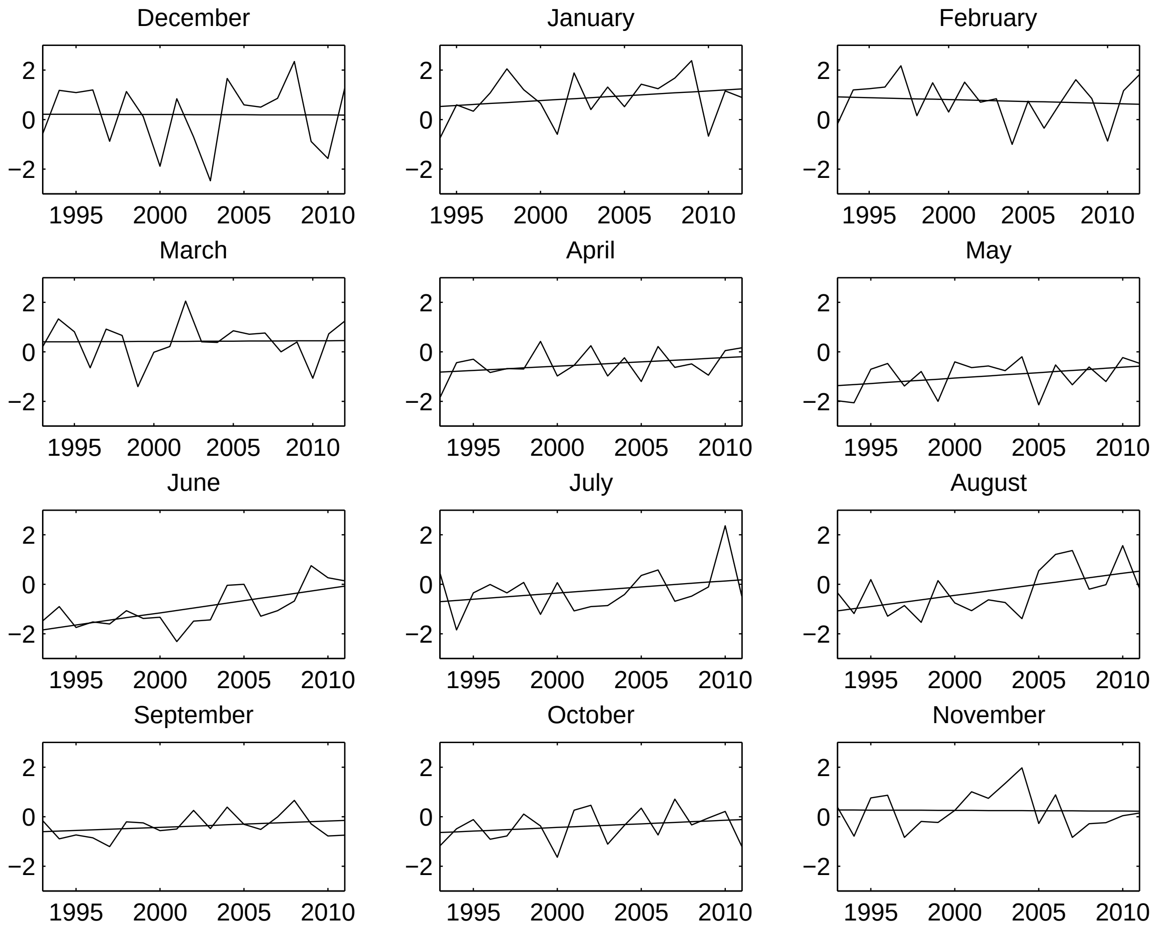

Figure B-7: Brunswick Station

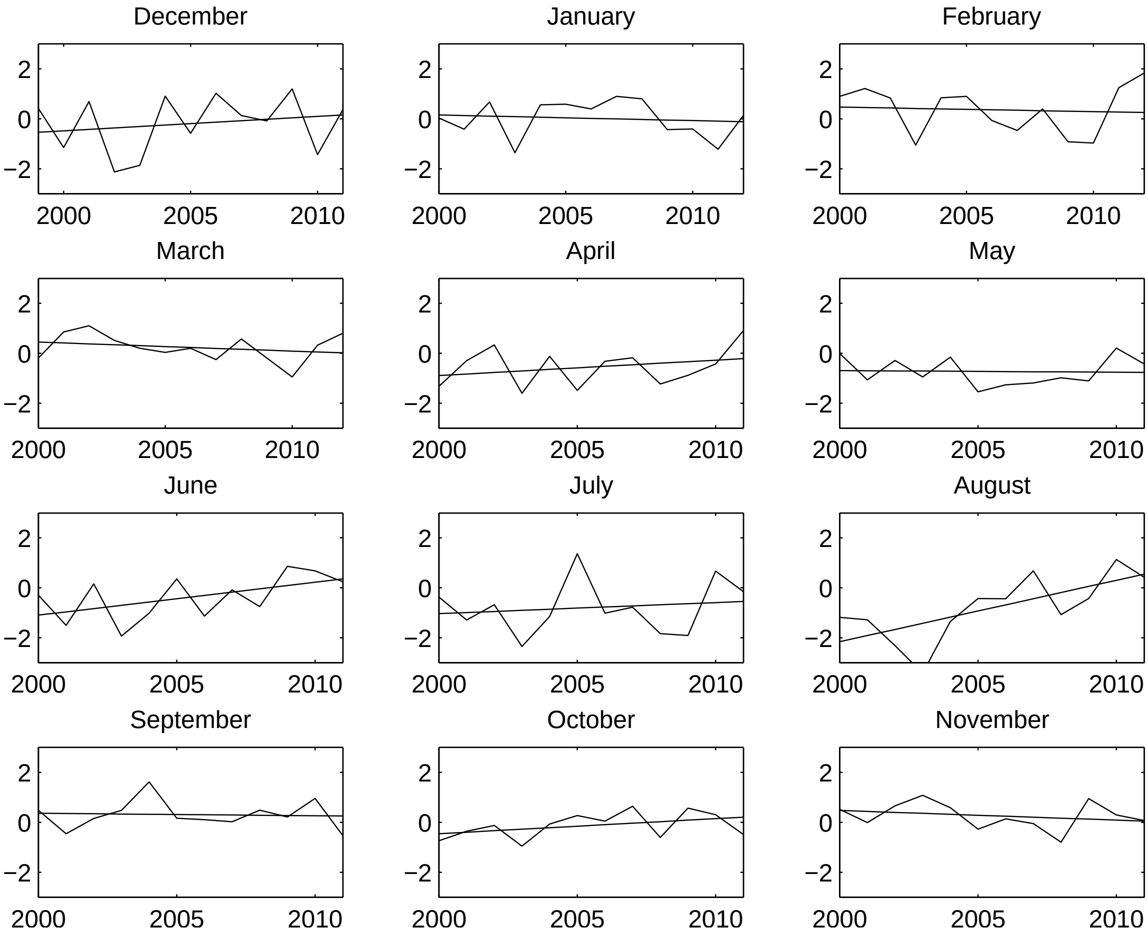

Figure B-8: Byron Station

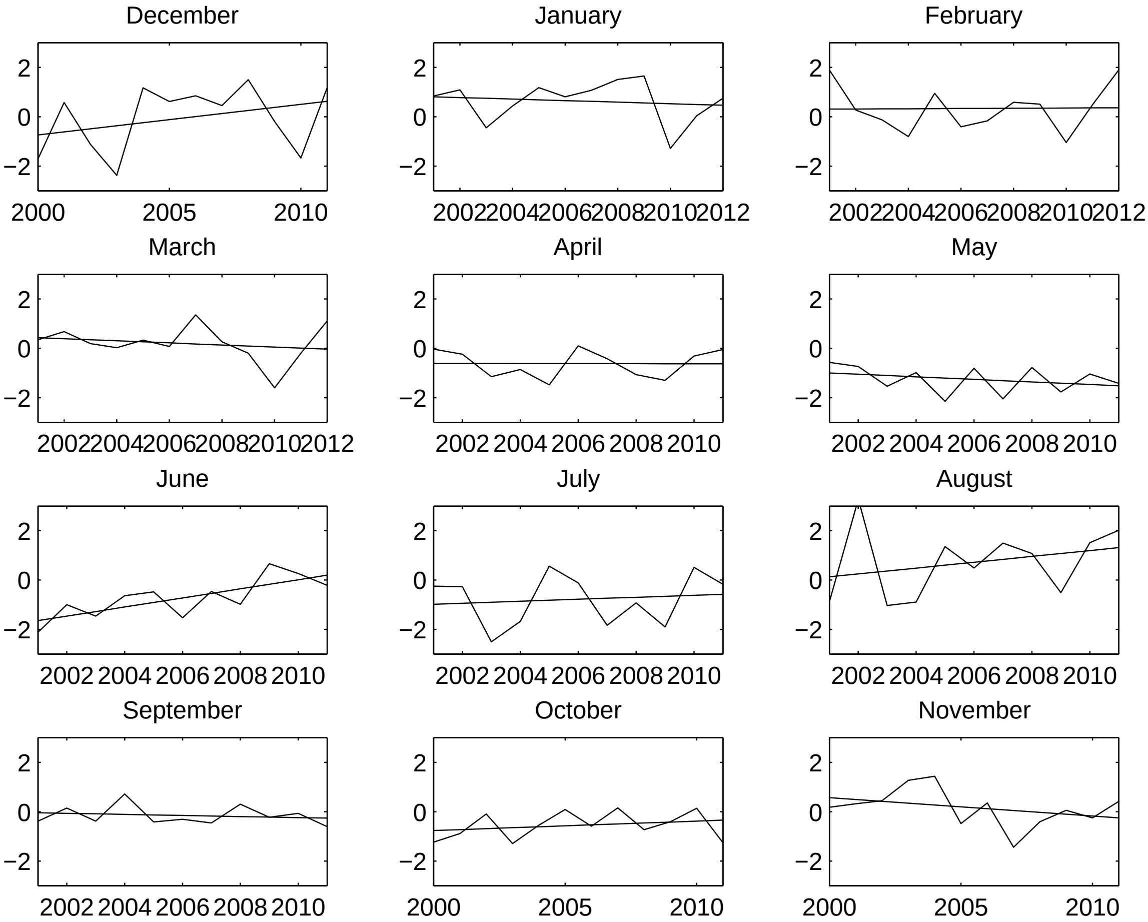

Figure B-9: Cairo Station

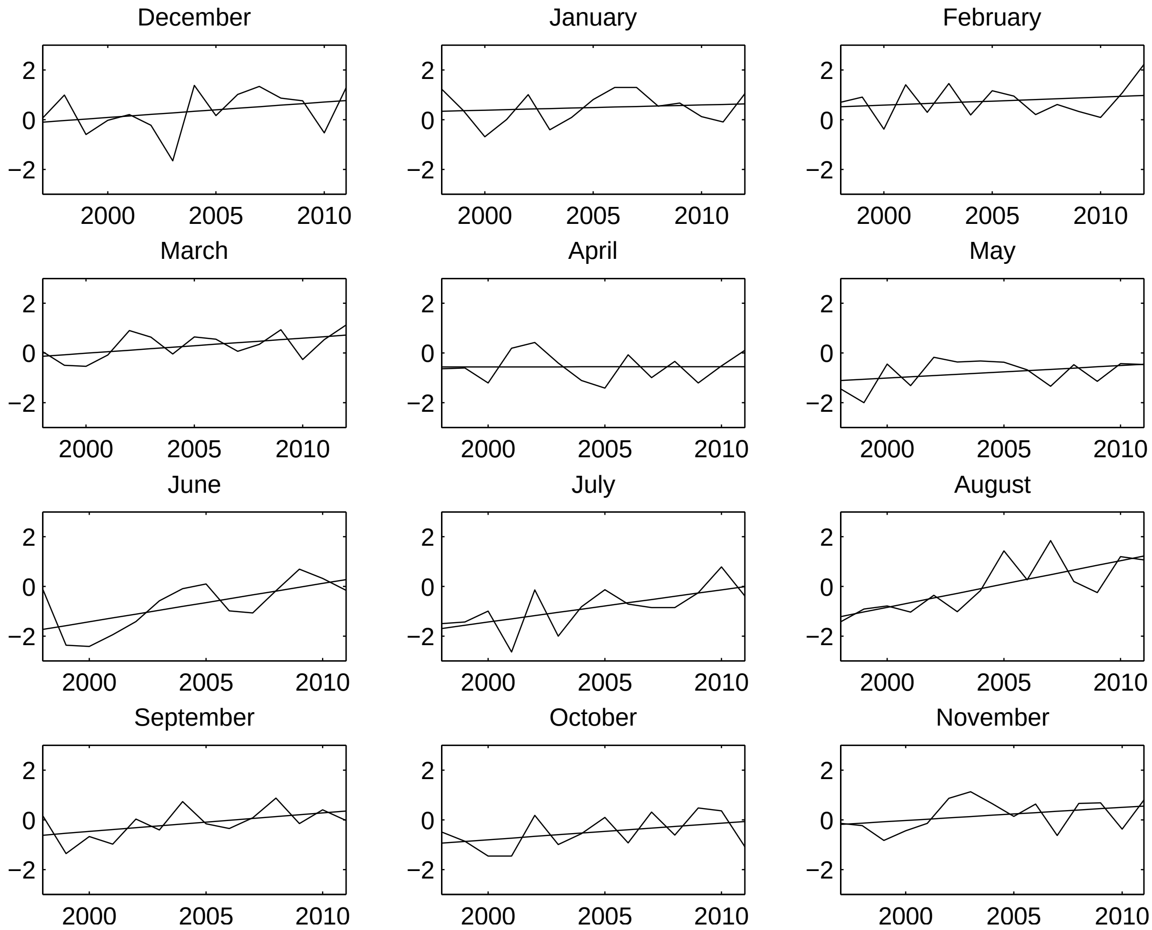

Figure B-10: Calhoun Station

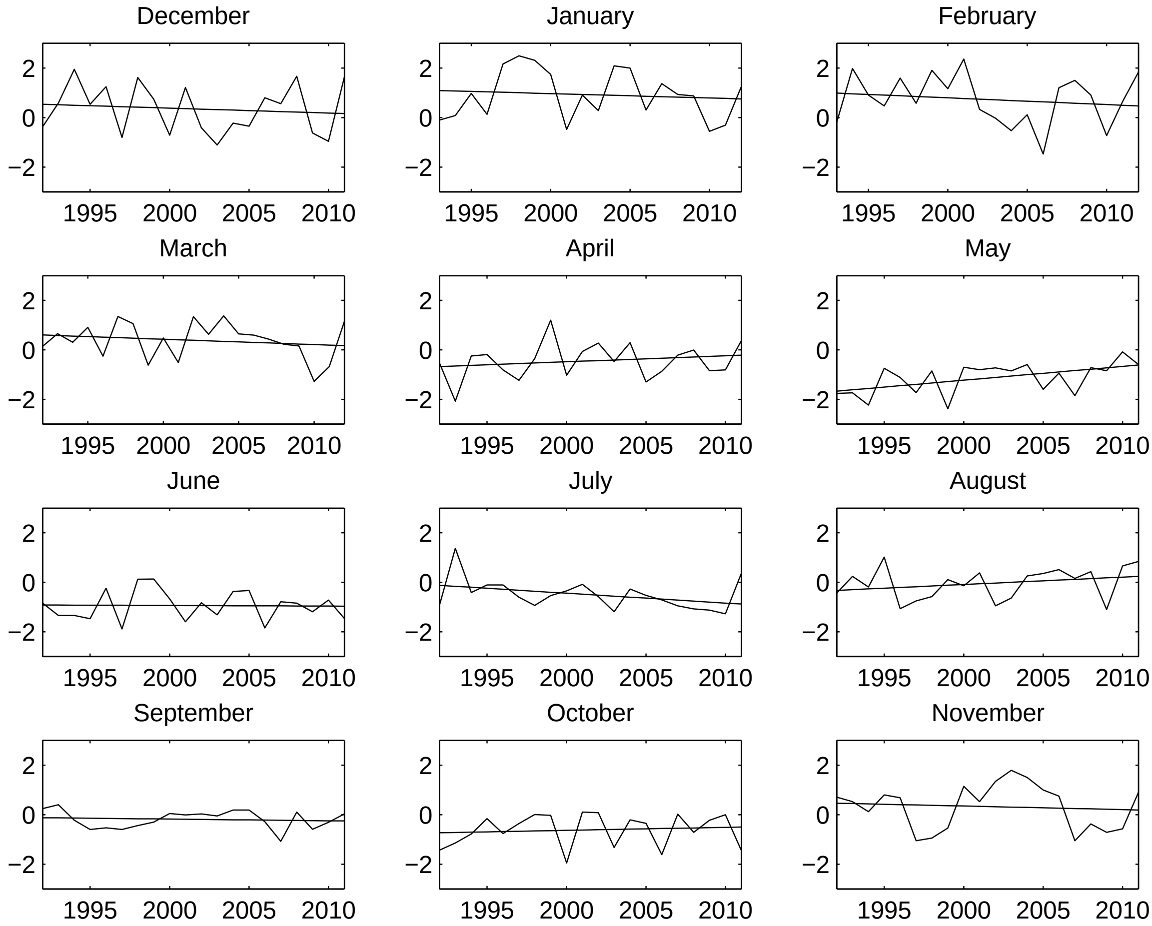

Figure B-11: Callaway Station

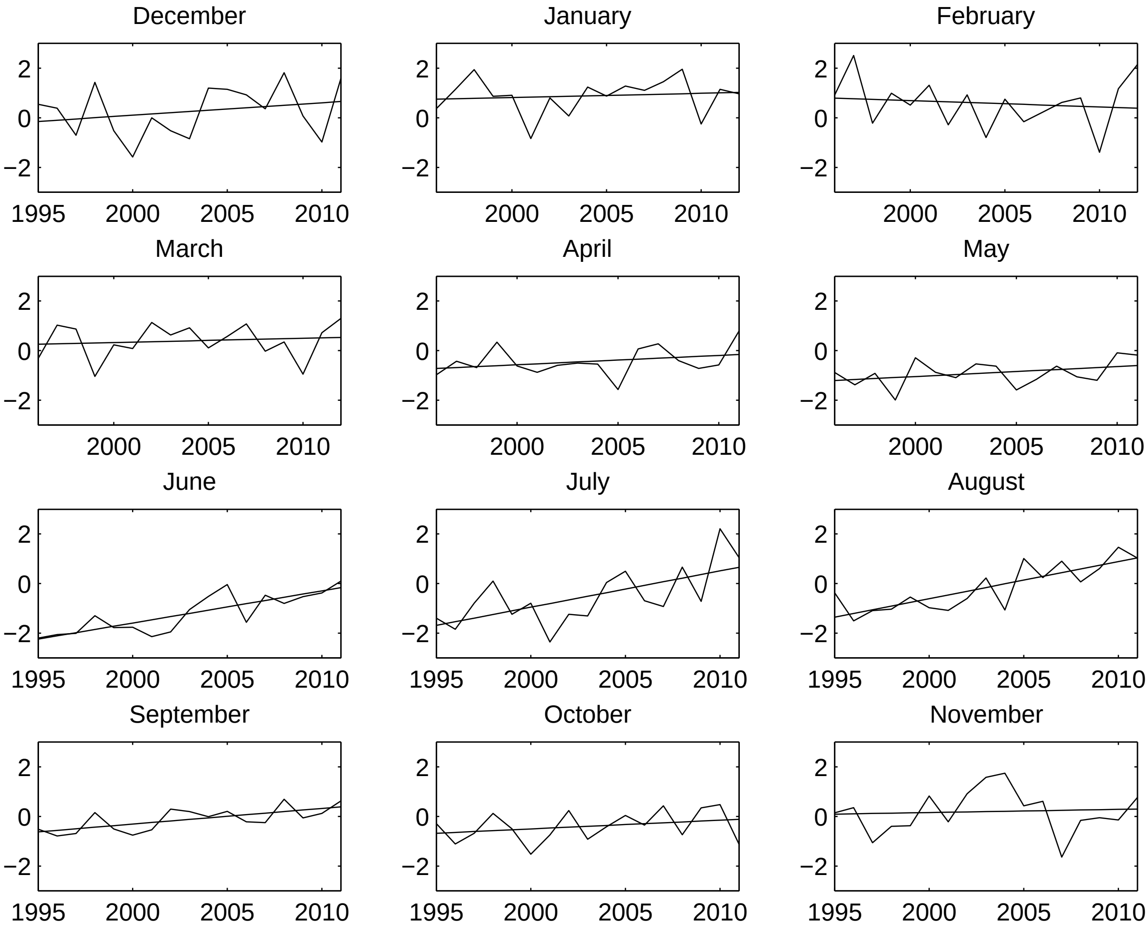

Figure B-12: Camilla Station

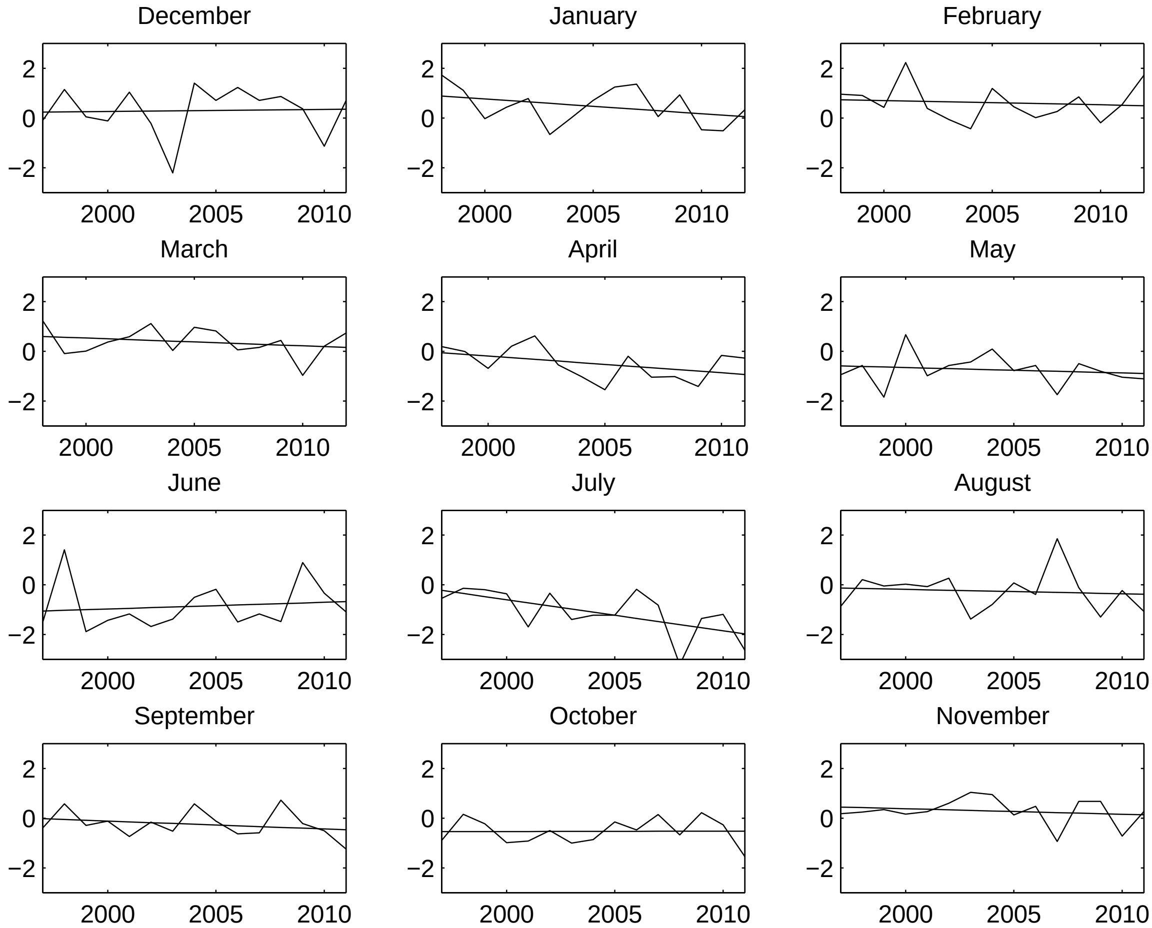

Figure B-13: Cordele Station

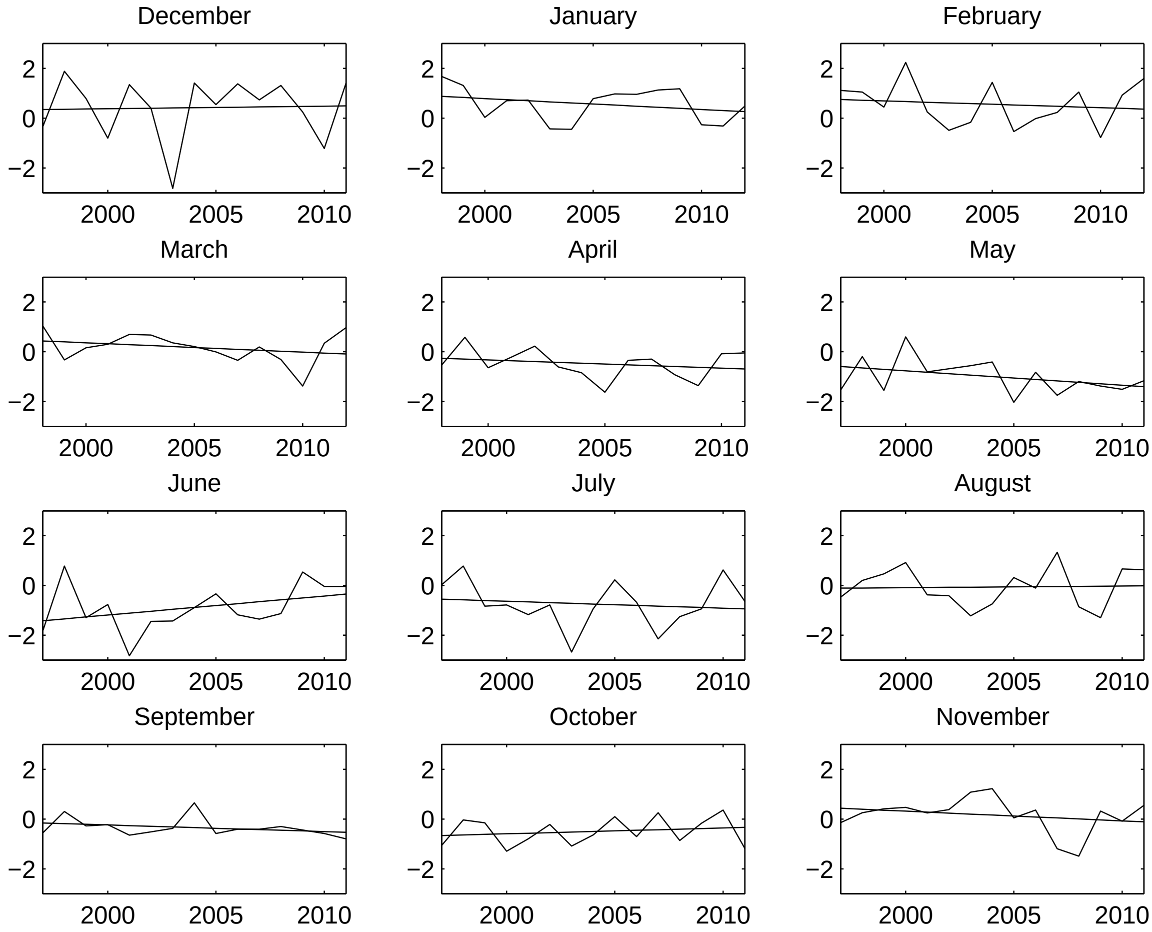

Figure B-14: Dallas Station

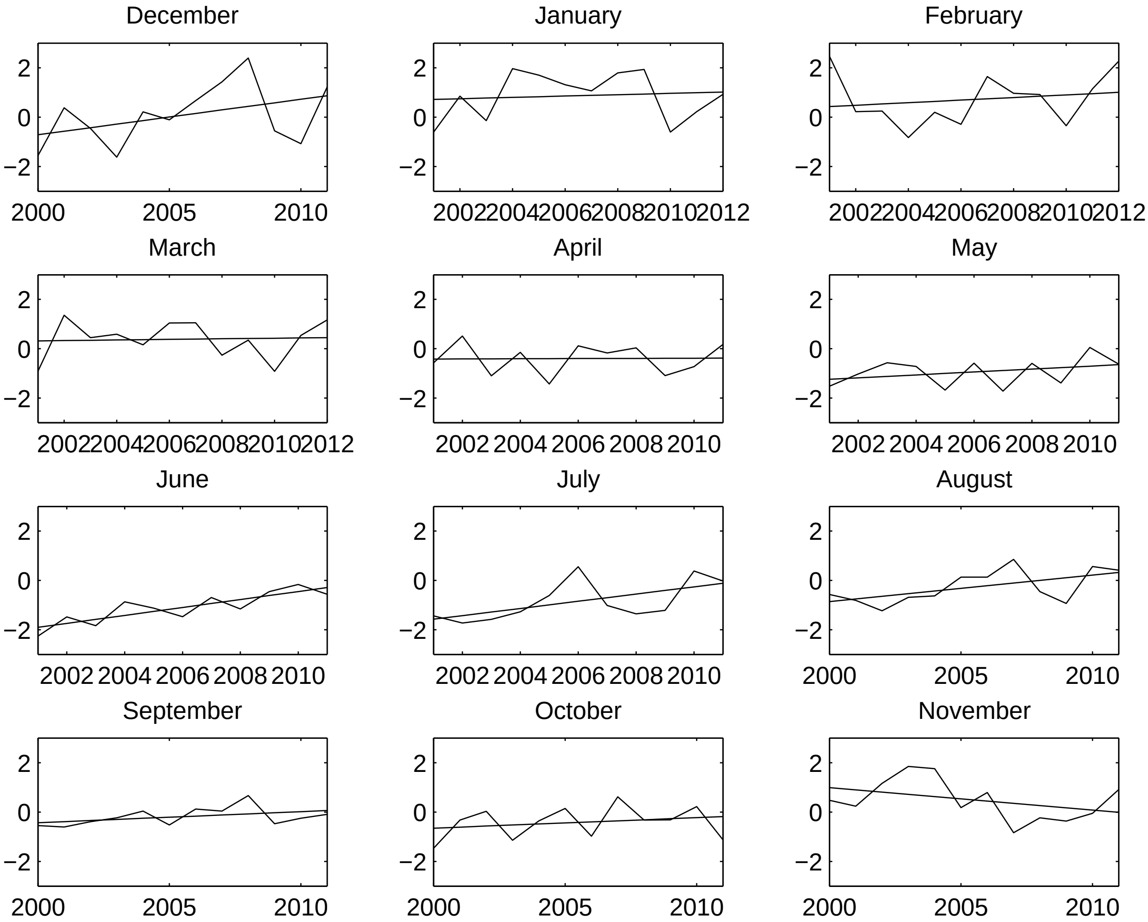

Figure B-15: Dawson Station

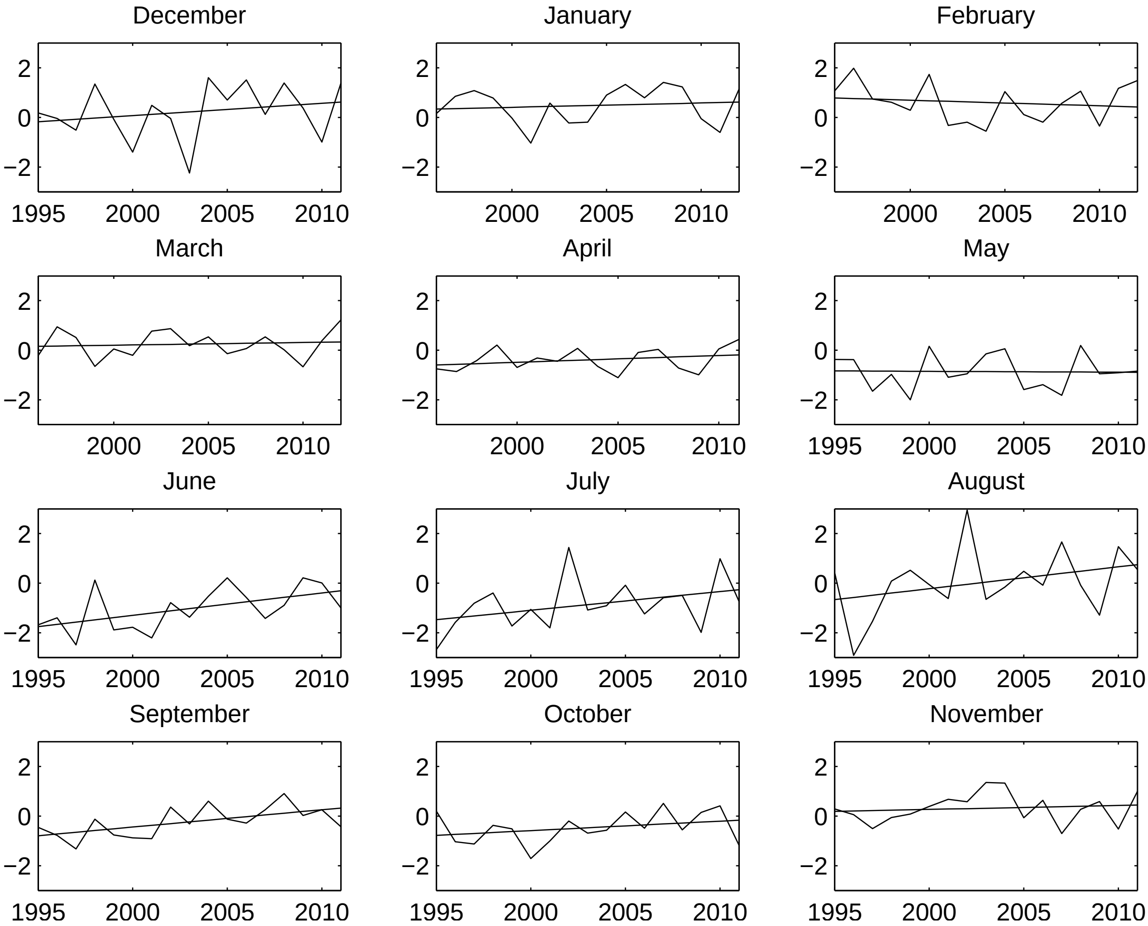

Figure B-16: Dearing Station

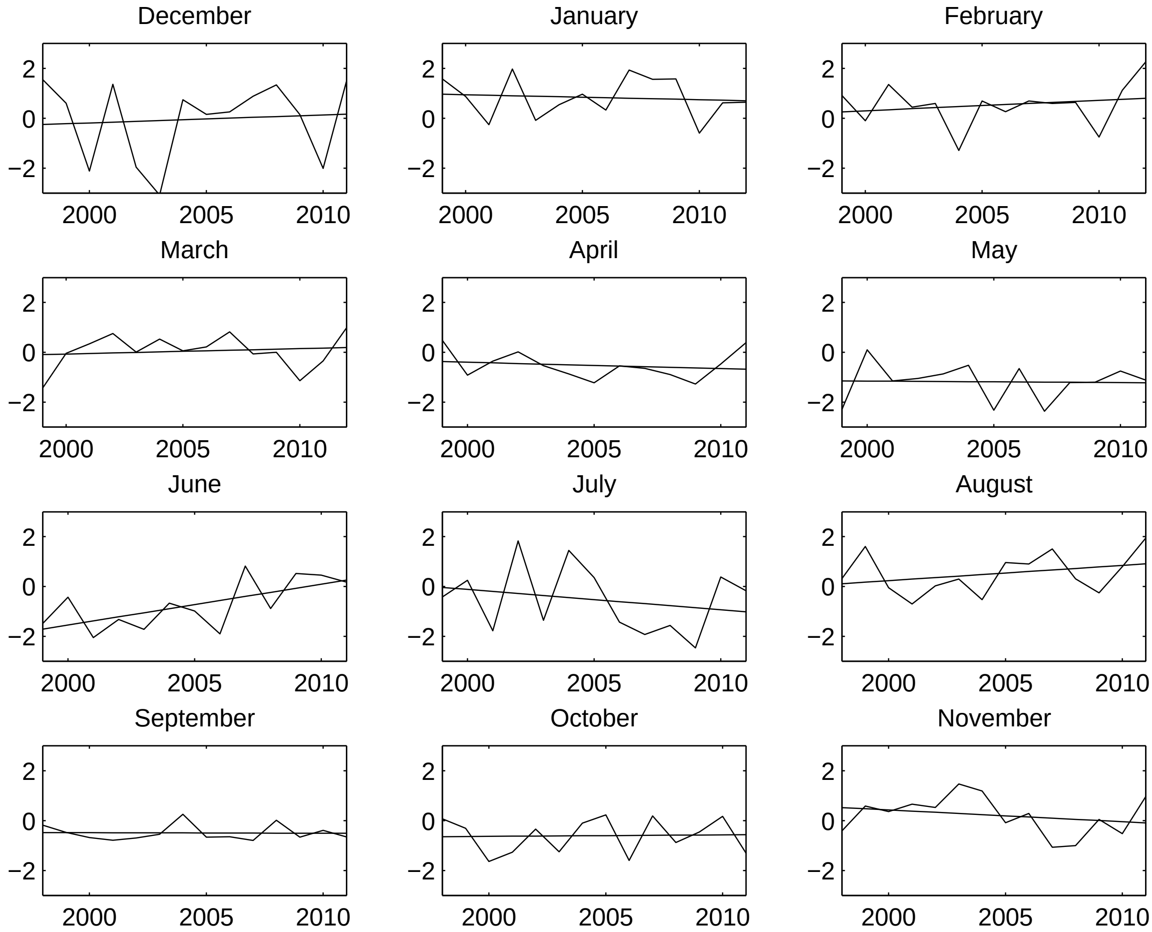

Figure B-17: Dempsey Station

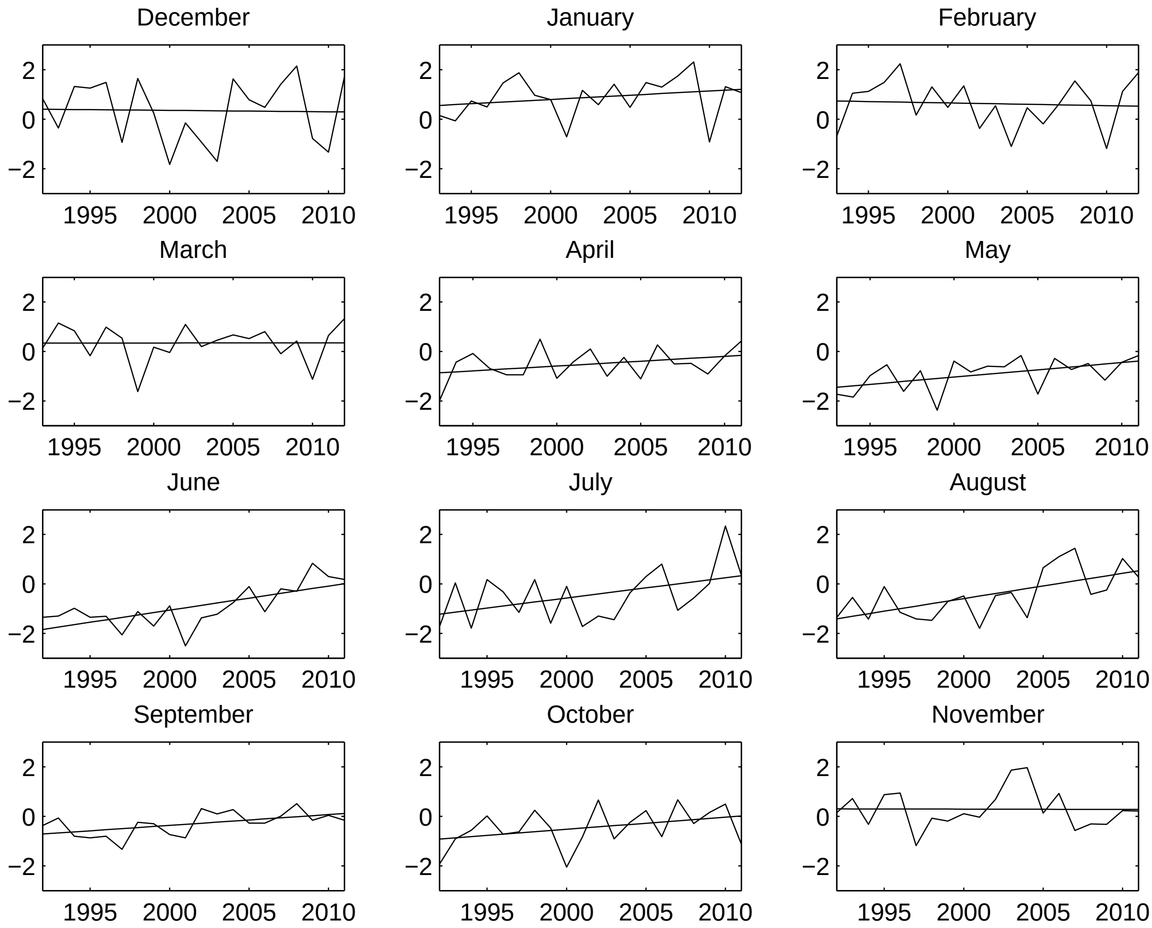

Figure B-18: Dixie Station

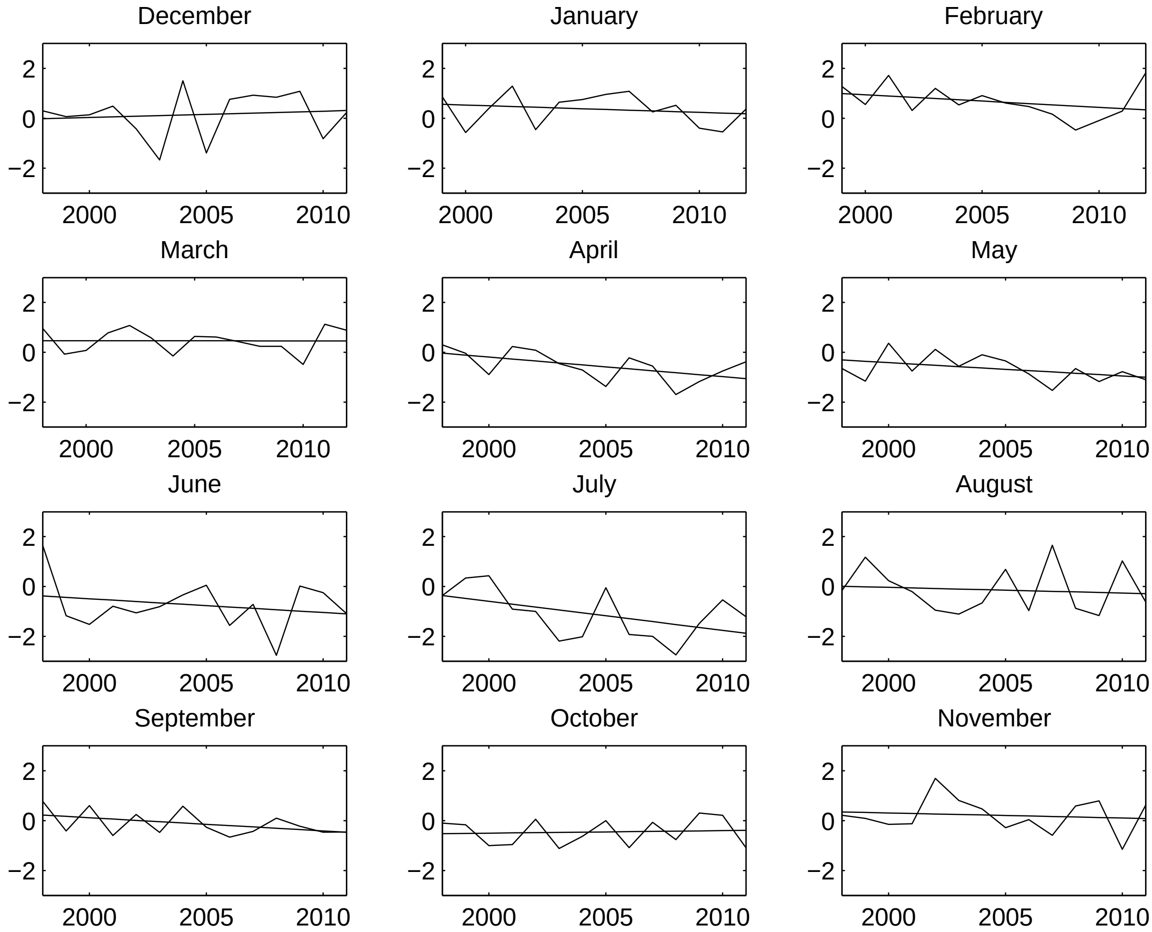

Figure B-19: Dublin Station

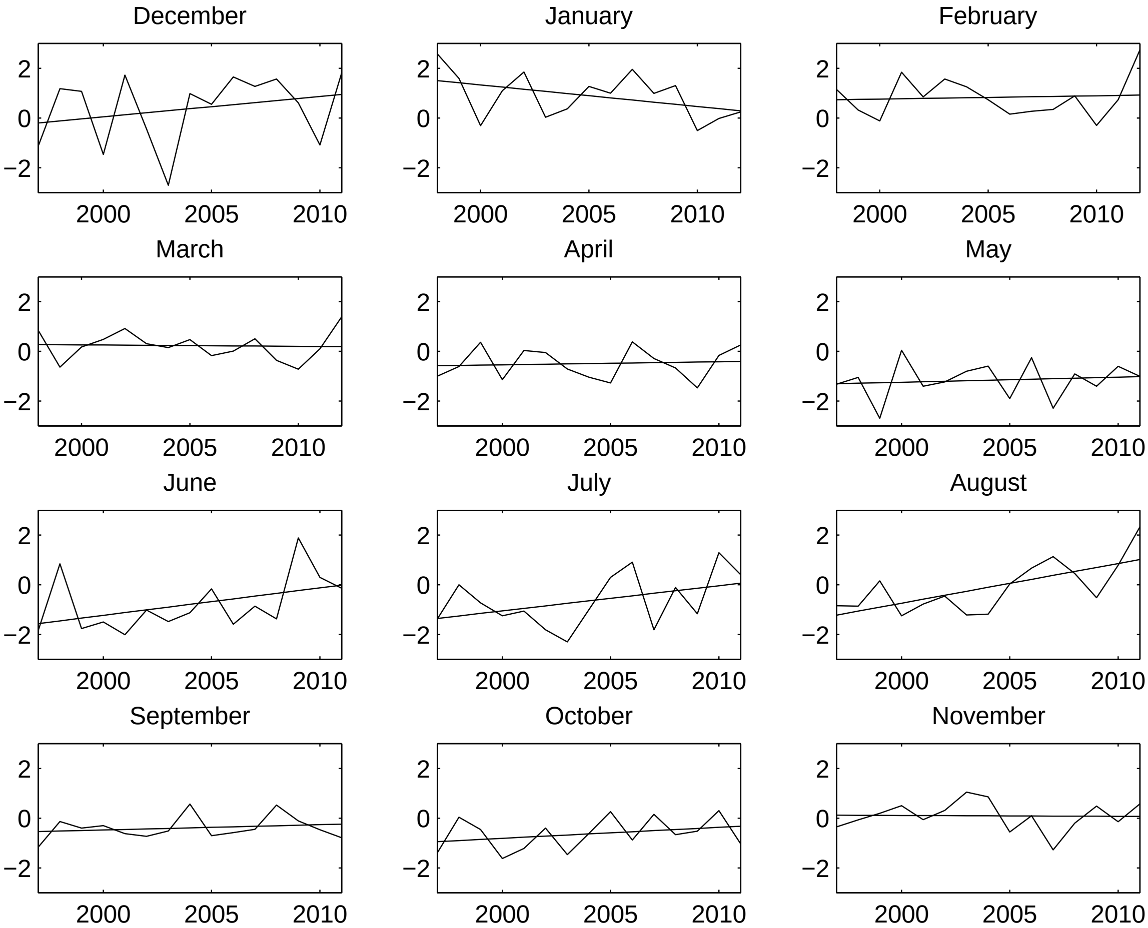

Figure B-20: Duluth Station

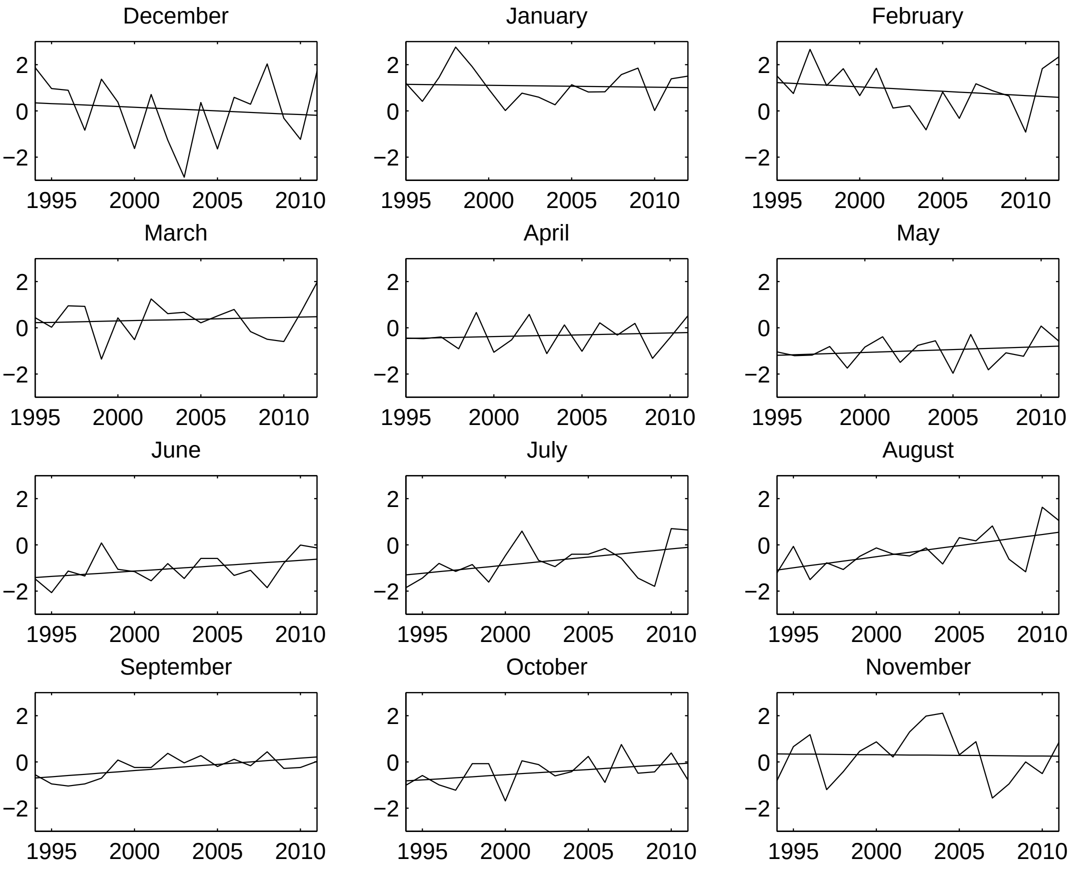

Figure B-21: Dunwoody Station

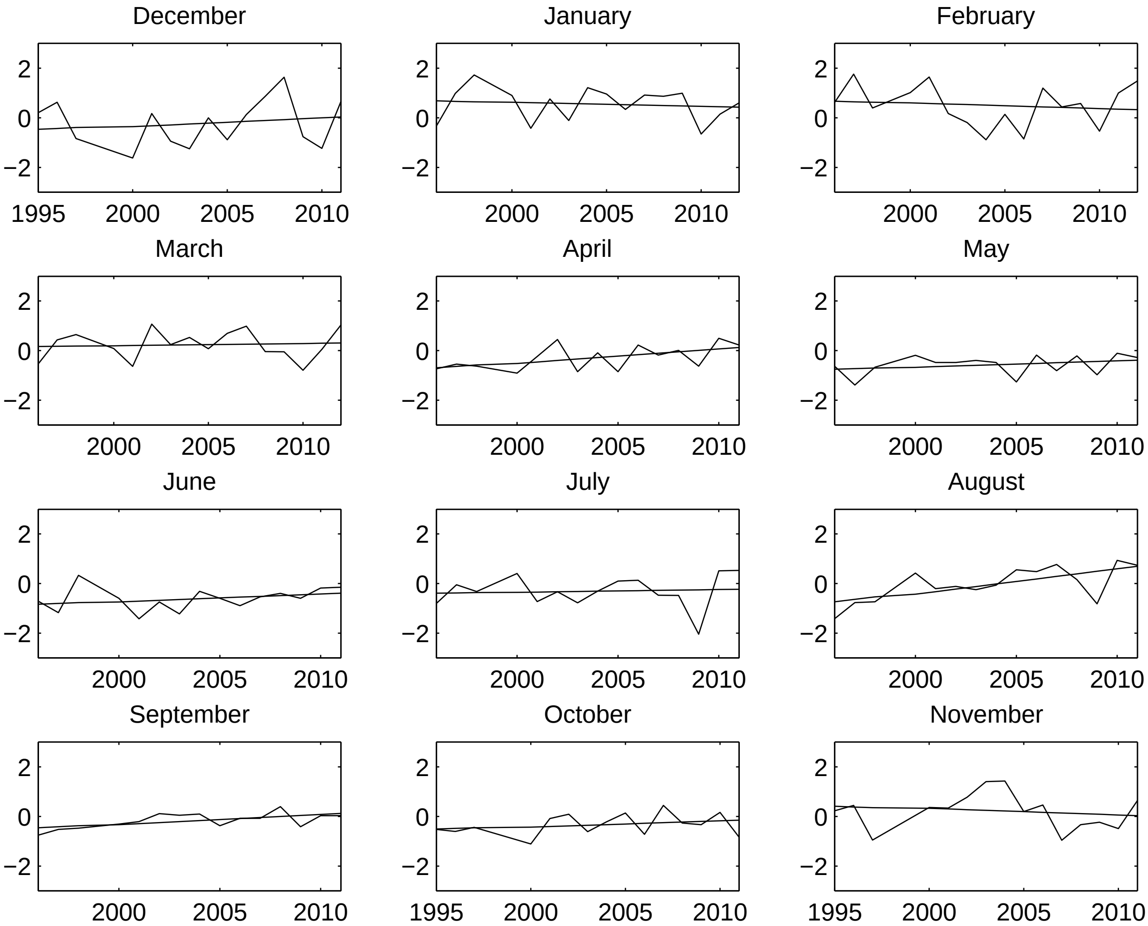

Figure B-22: Eatonton Station

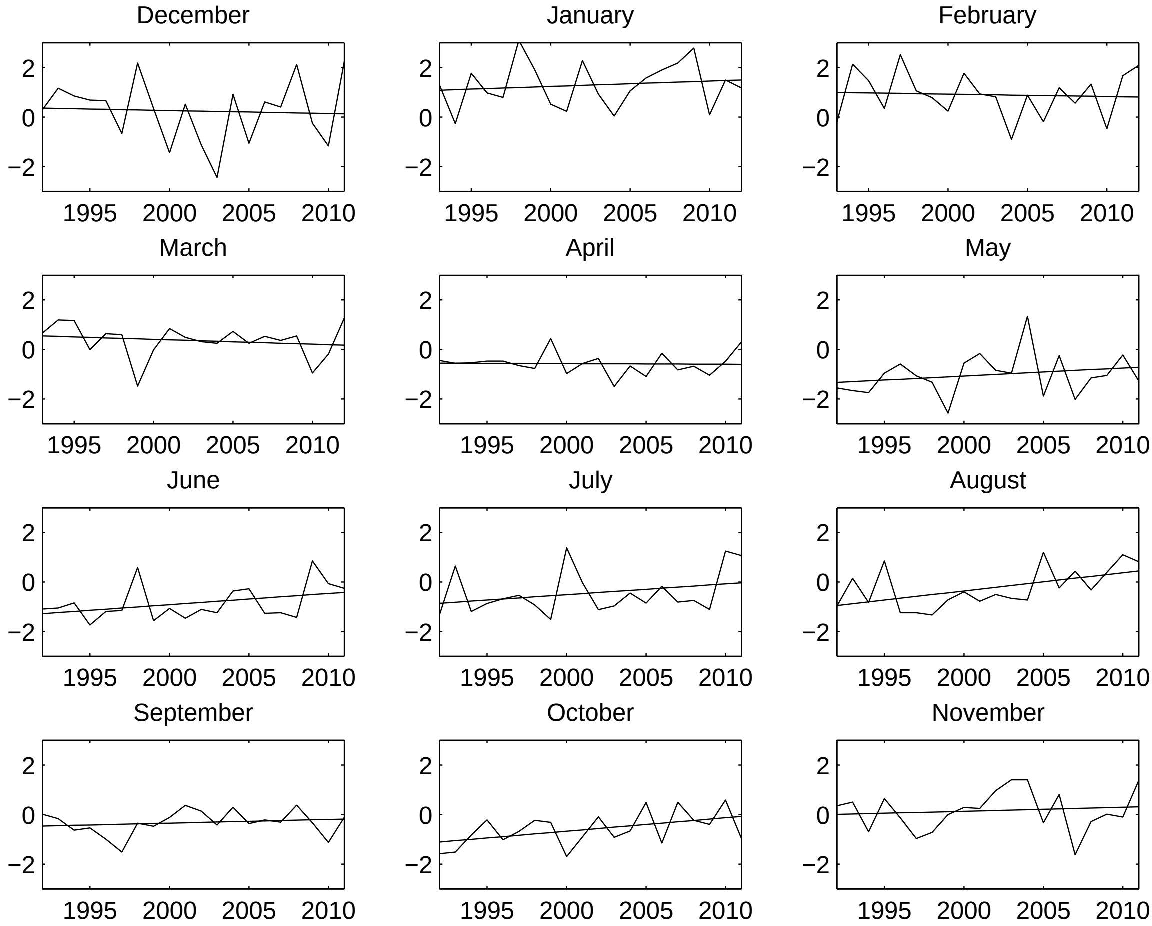

Figure B-23: Ellijay Station

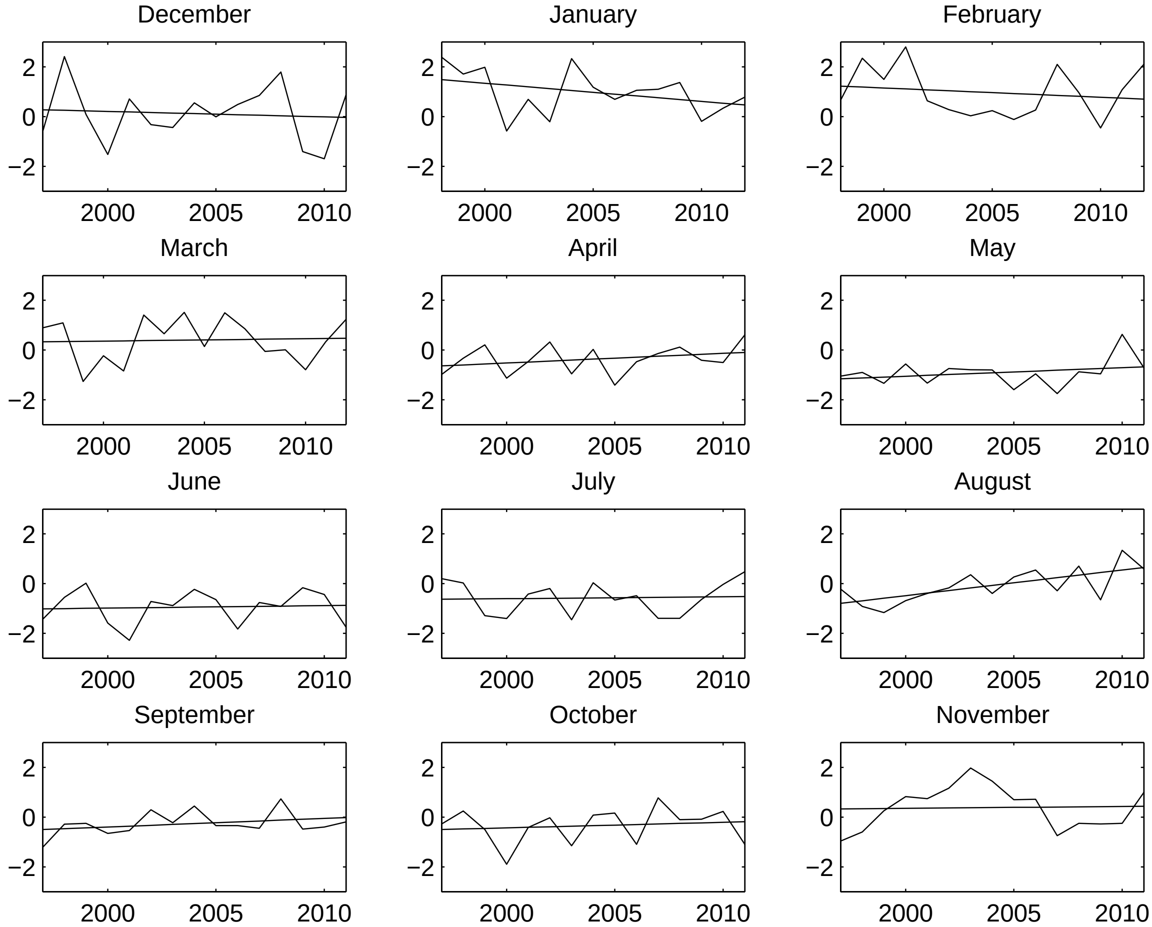

Figure B-24: Floyd Station

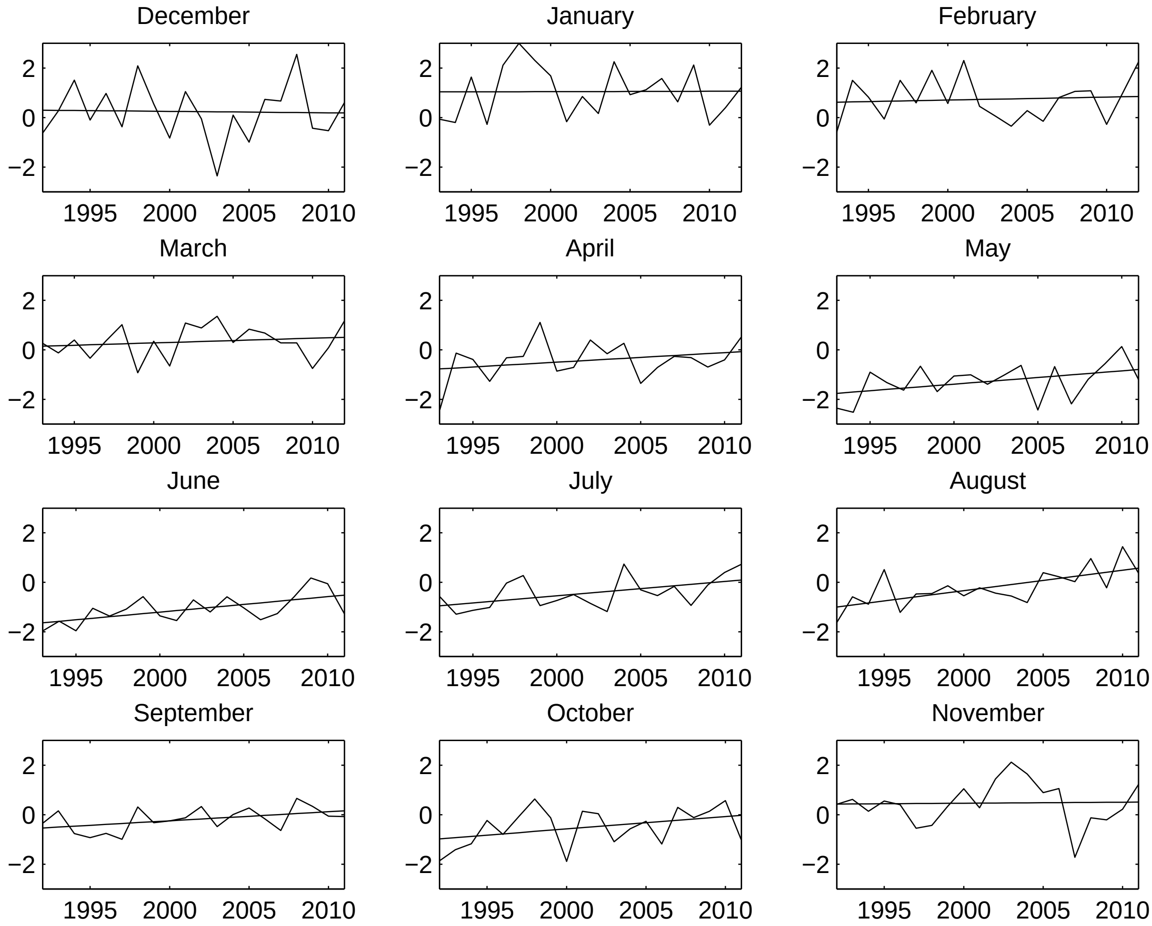

Figure B-25: Fort Valley Station

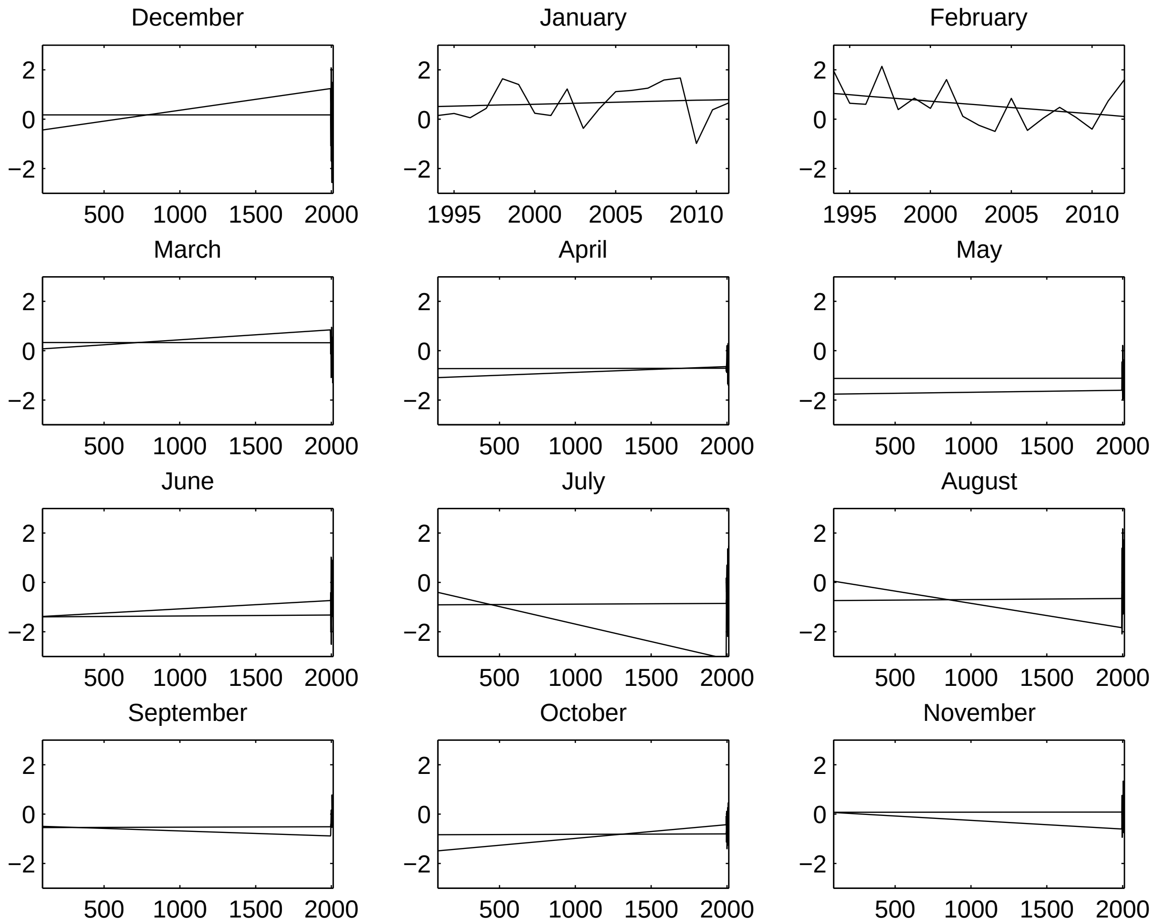

Figure B-26: Gainesville Station

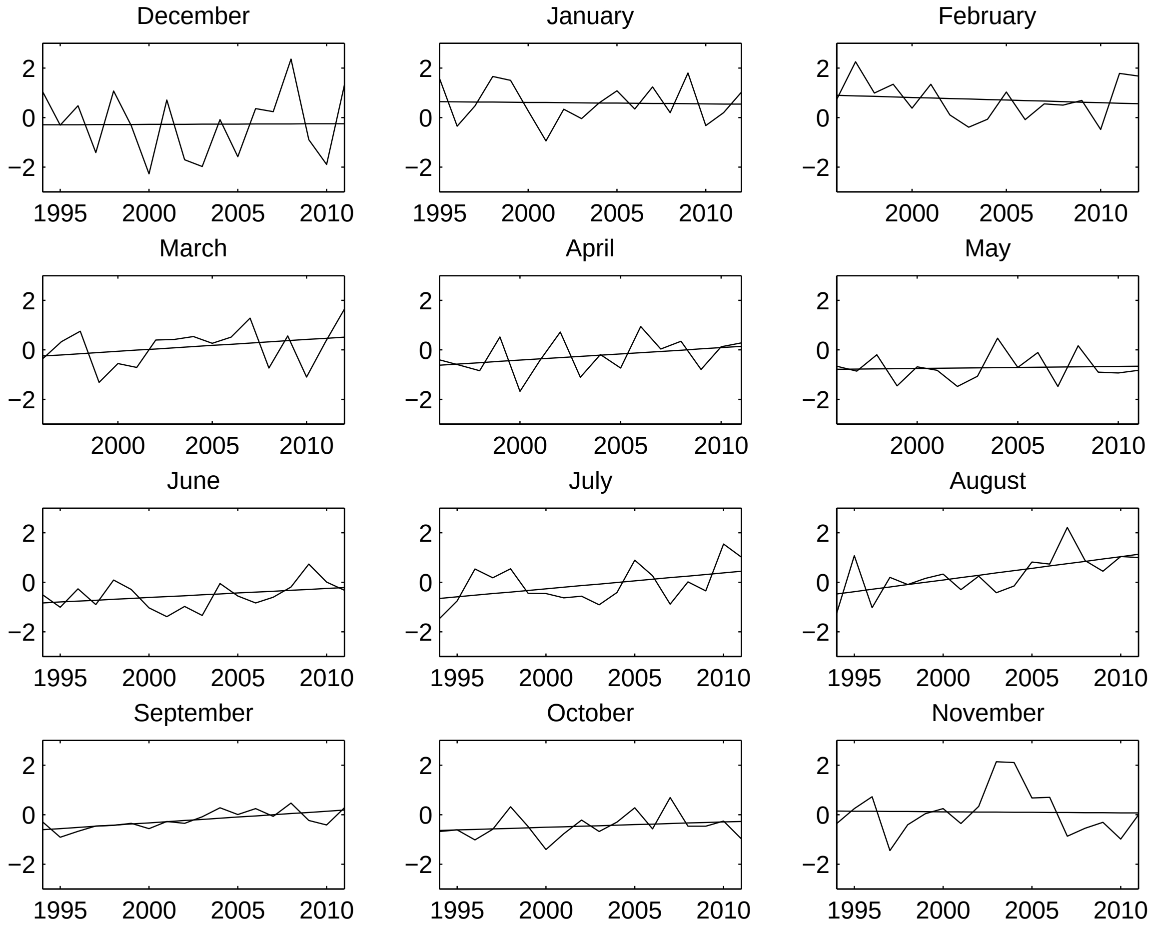

Figure B-27: Griffin Station

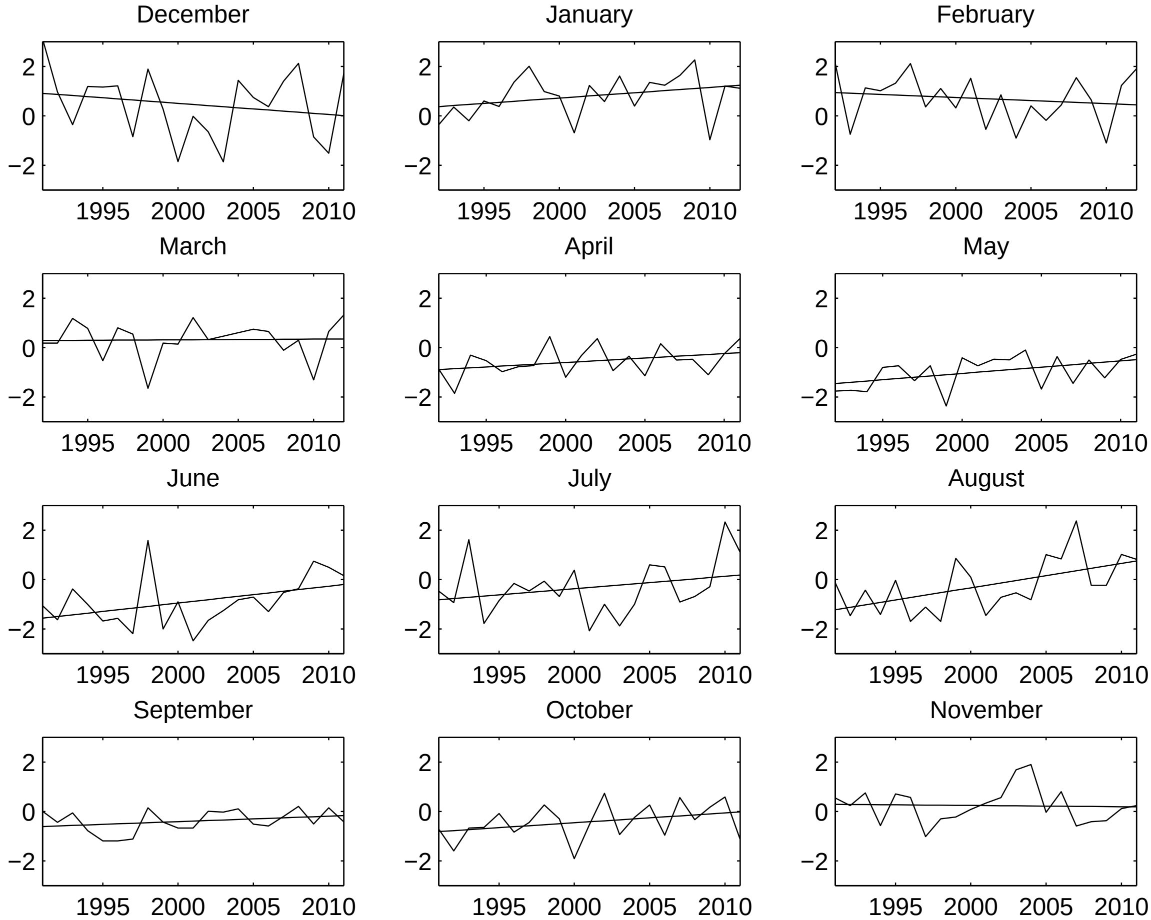

Figure B-28: Jonesboro Station

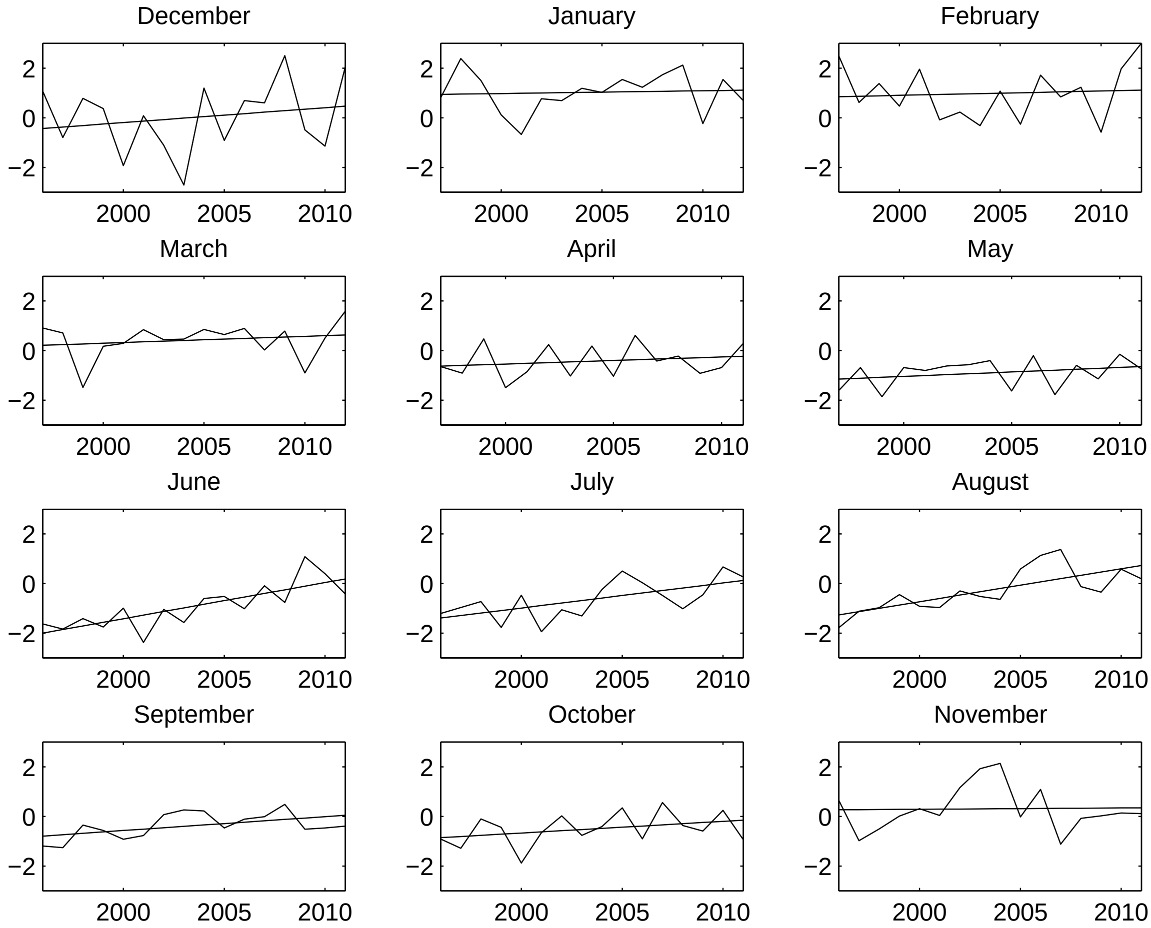

Figure B-29: Lafayette Station

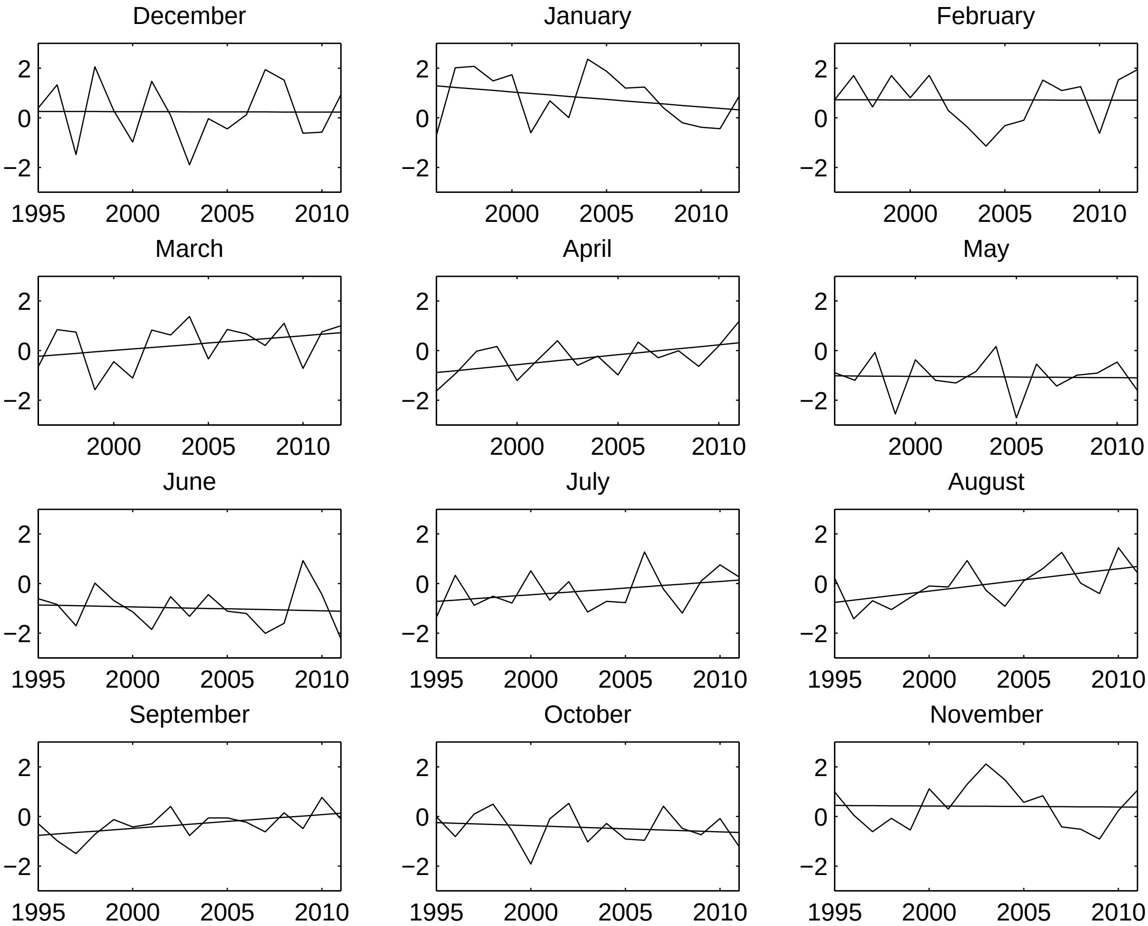

Figure B-30: Midville Station

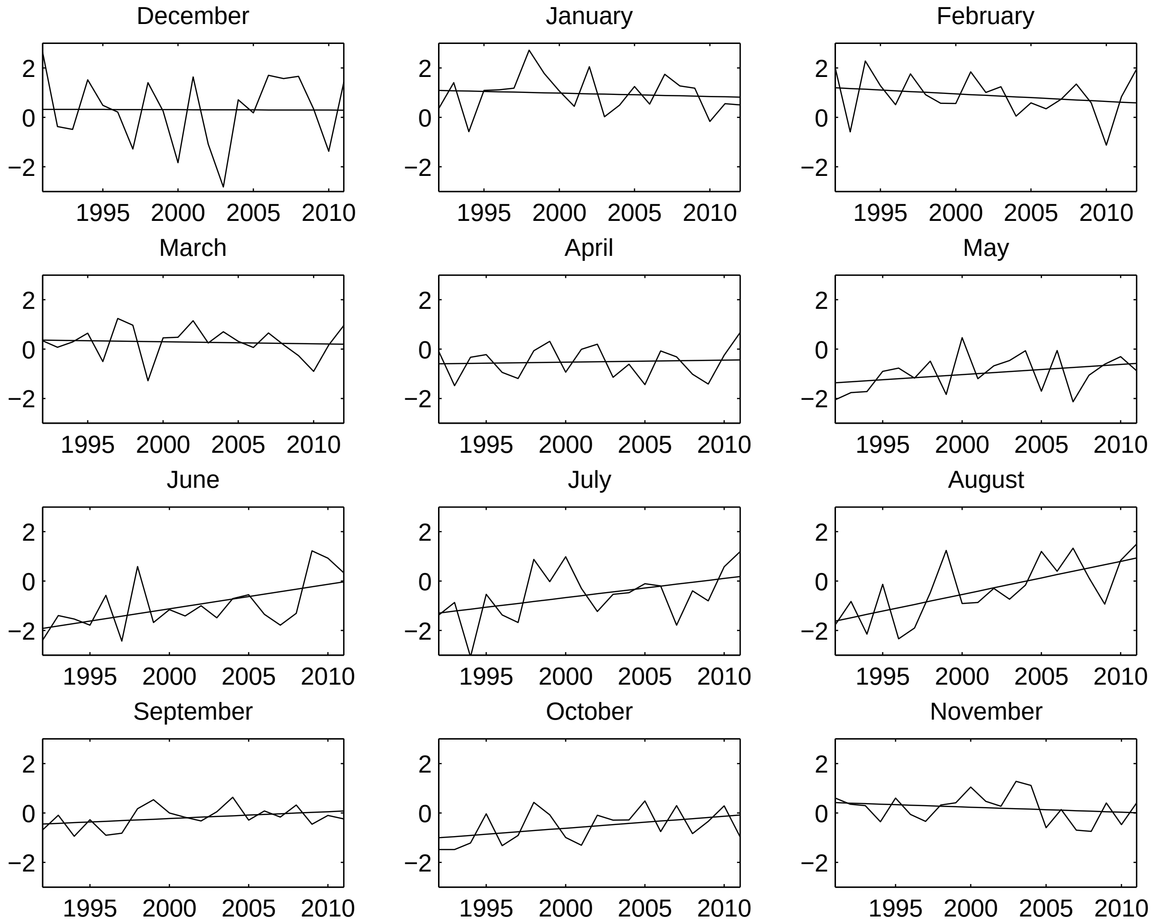

Figure B-31: Nahunta Station

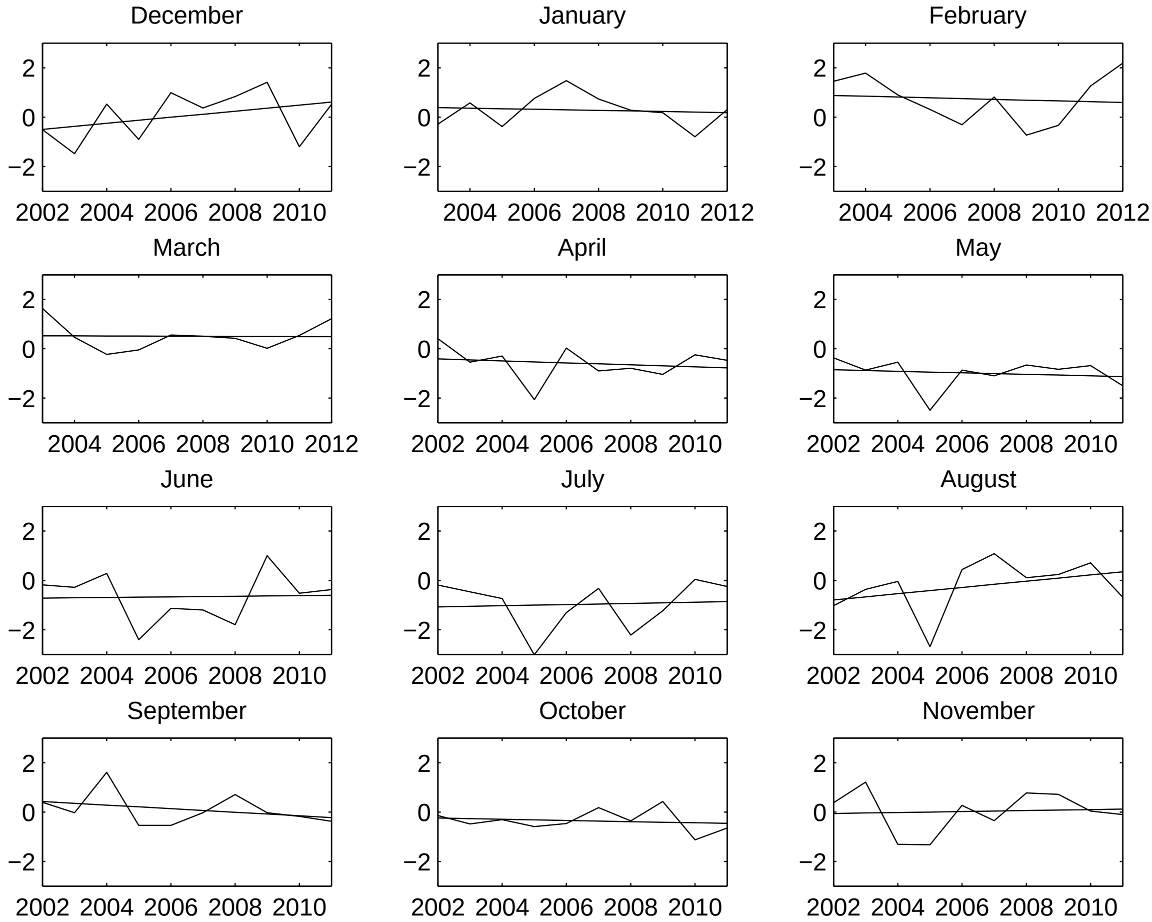

Figure B-32: Newton Station

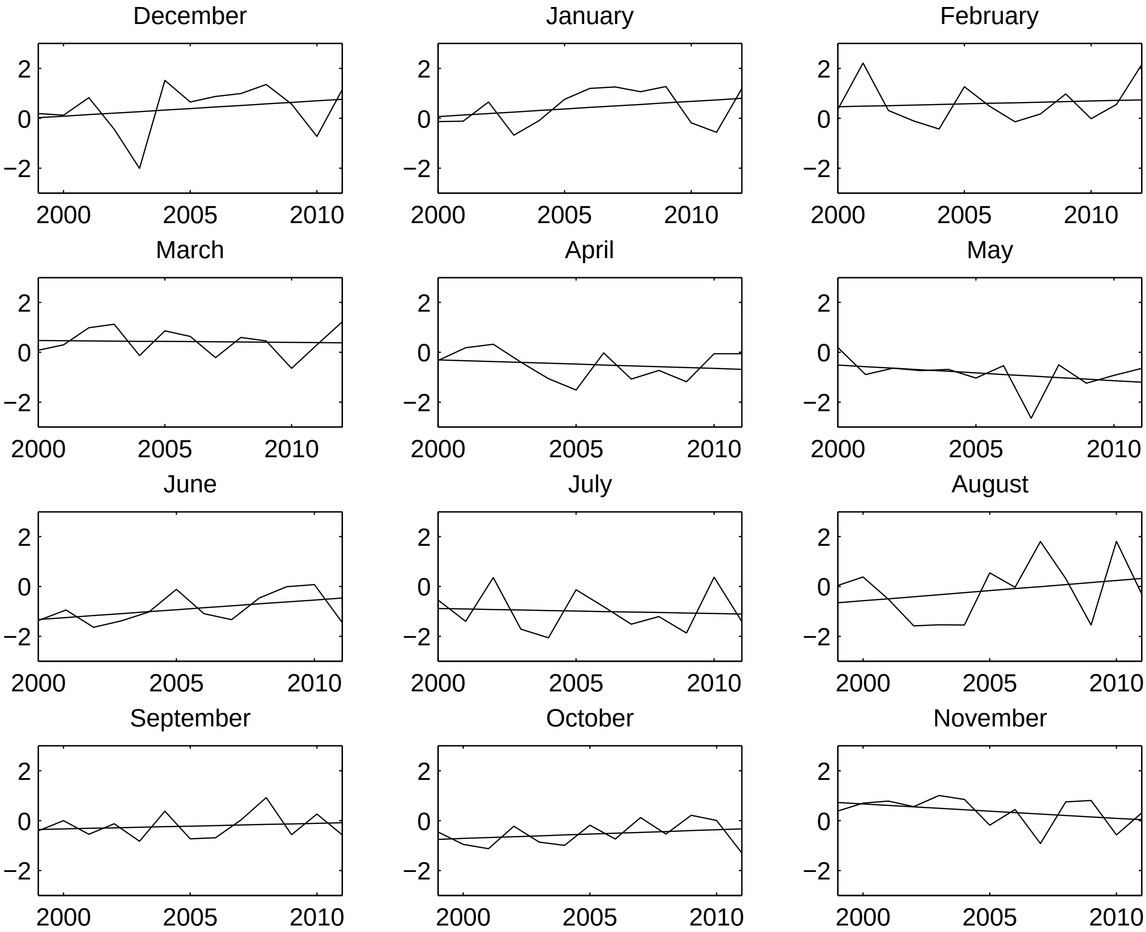

Figure B-33: Plains Station

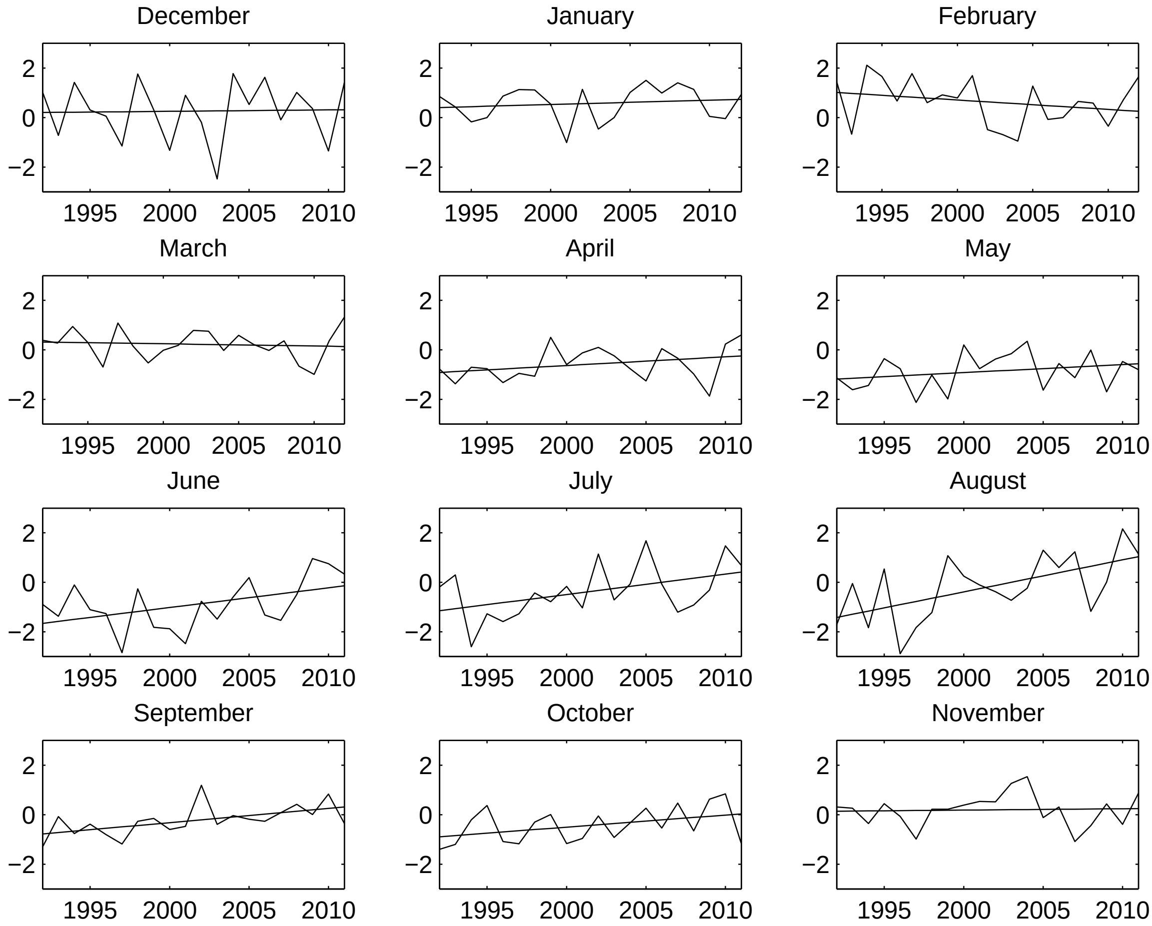

Figure B-34: Savannah Station

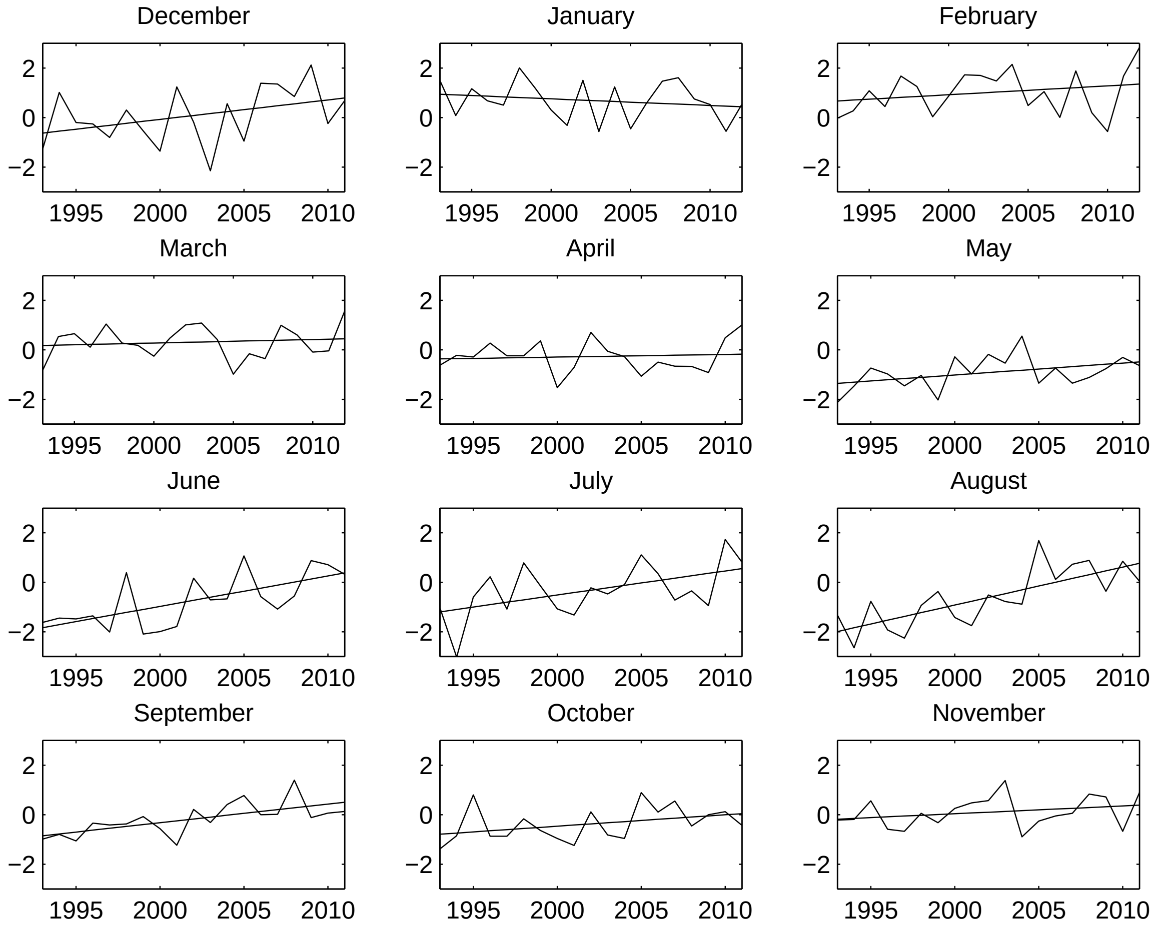

Figure B-35: Sneads Station

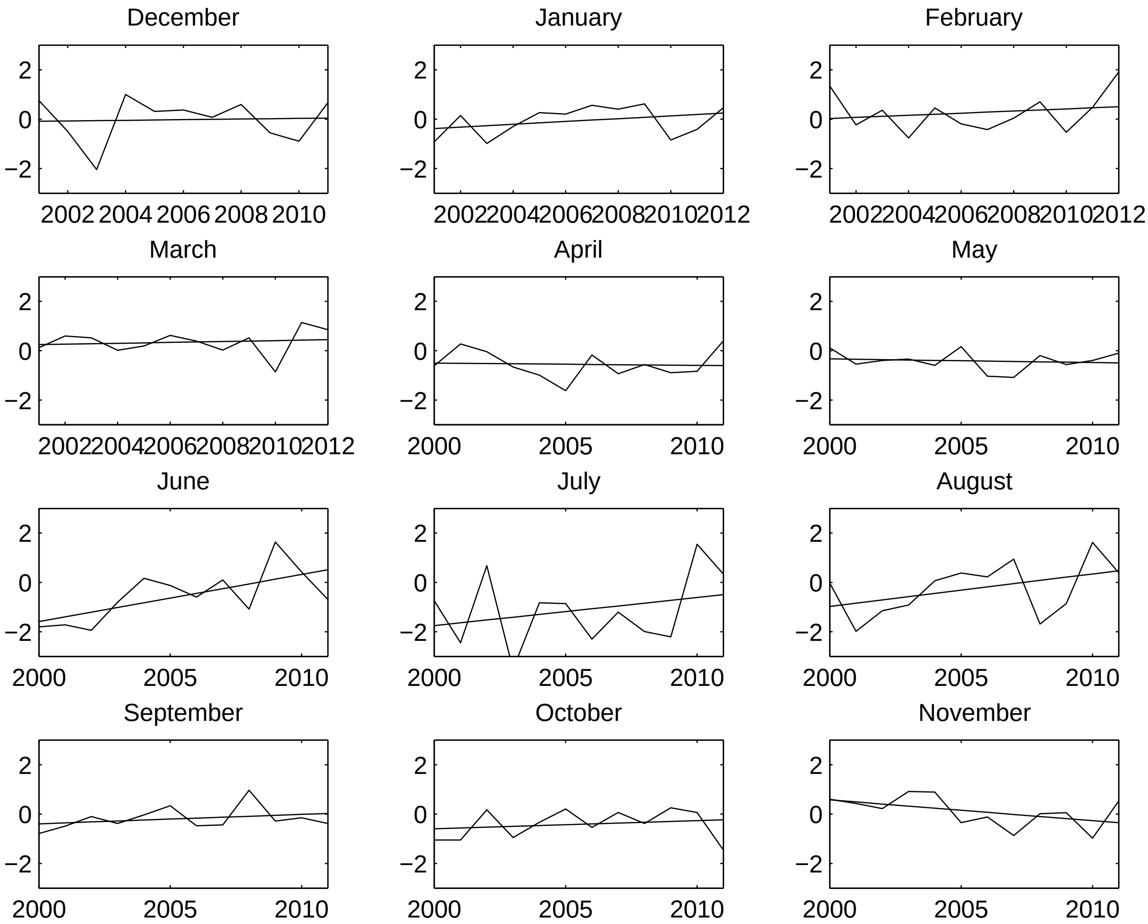

Figure B-36: Statesboro Station

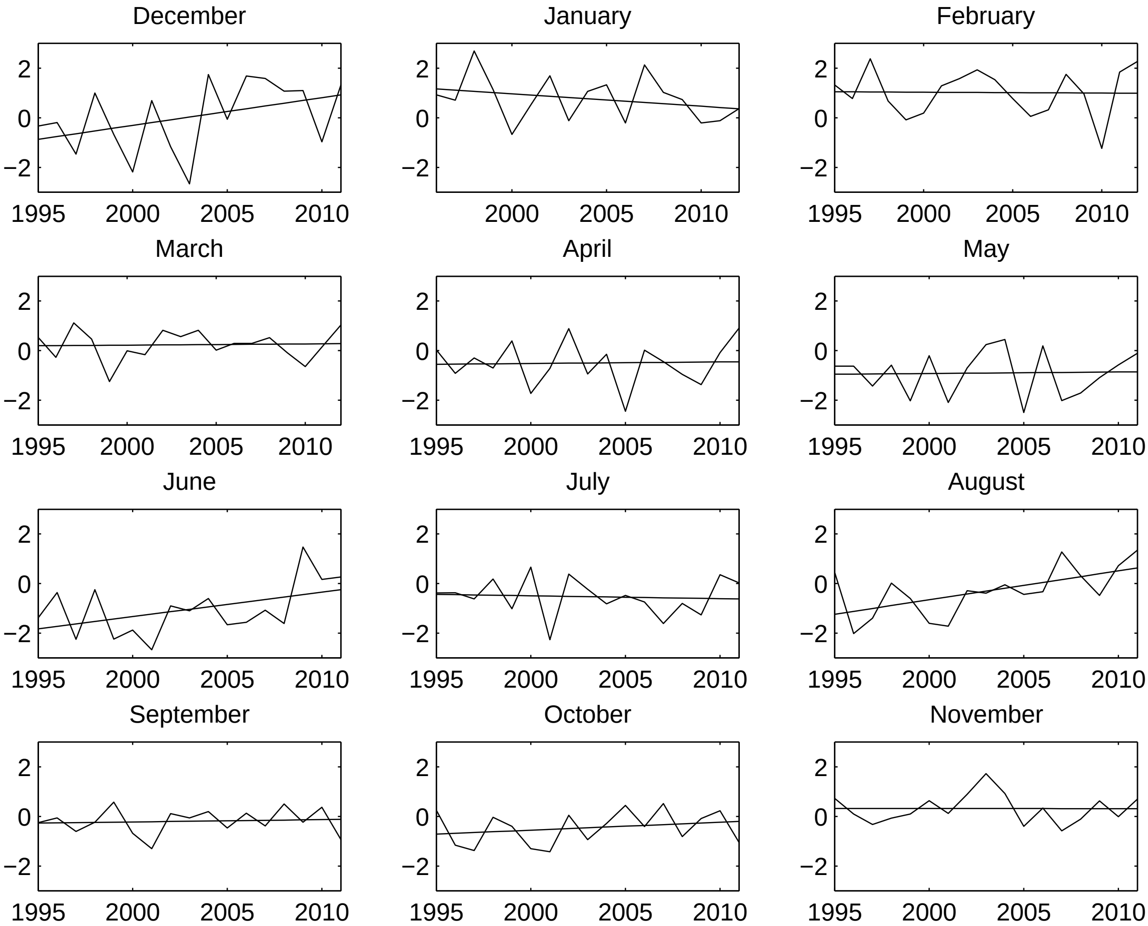

Figure B-37: Tifton Station

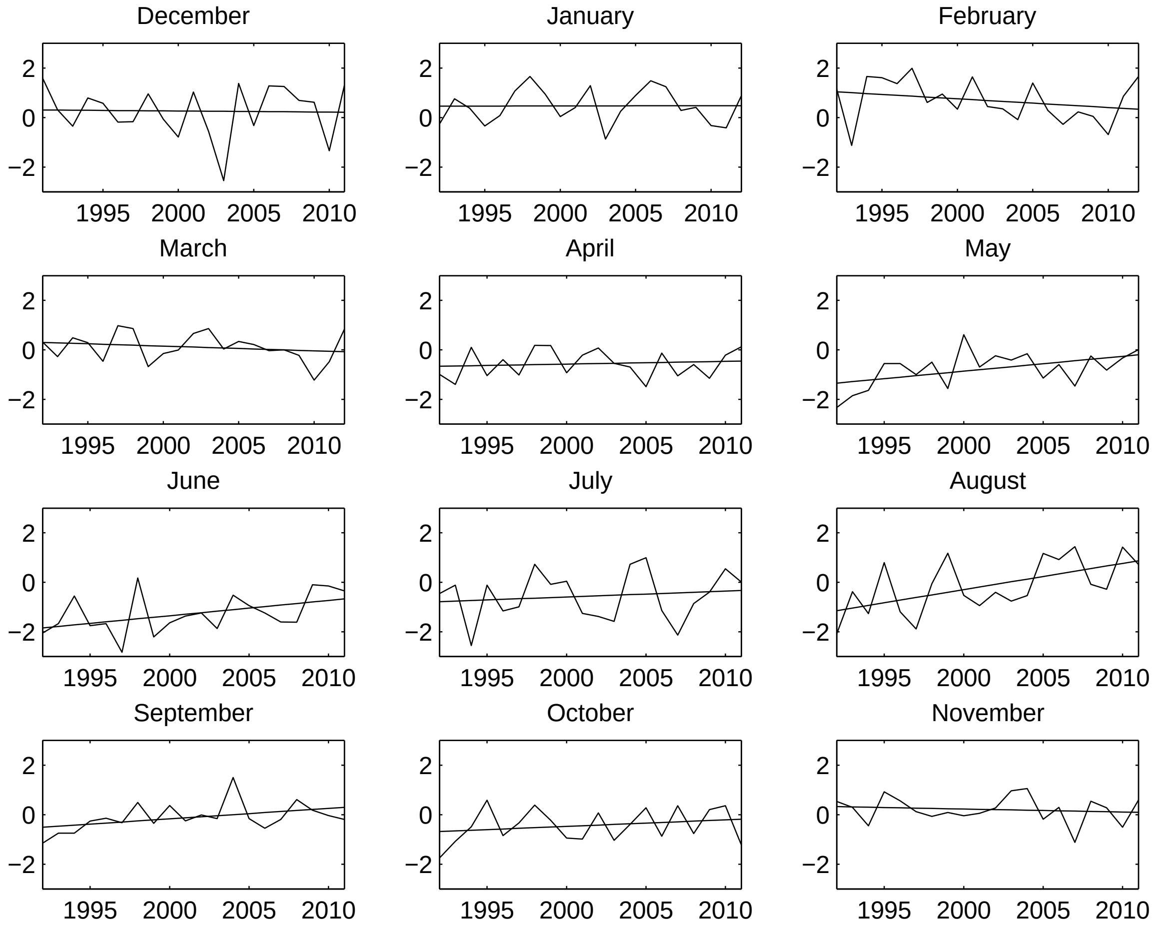

Figure B-38: Valdosta Station

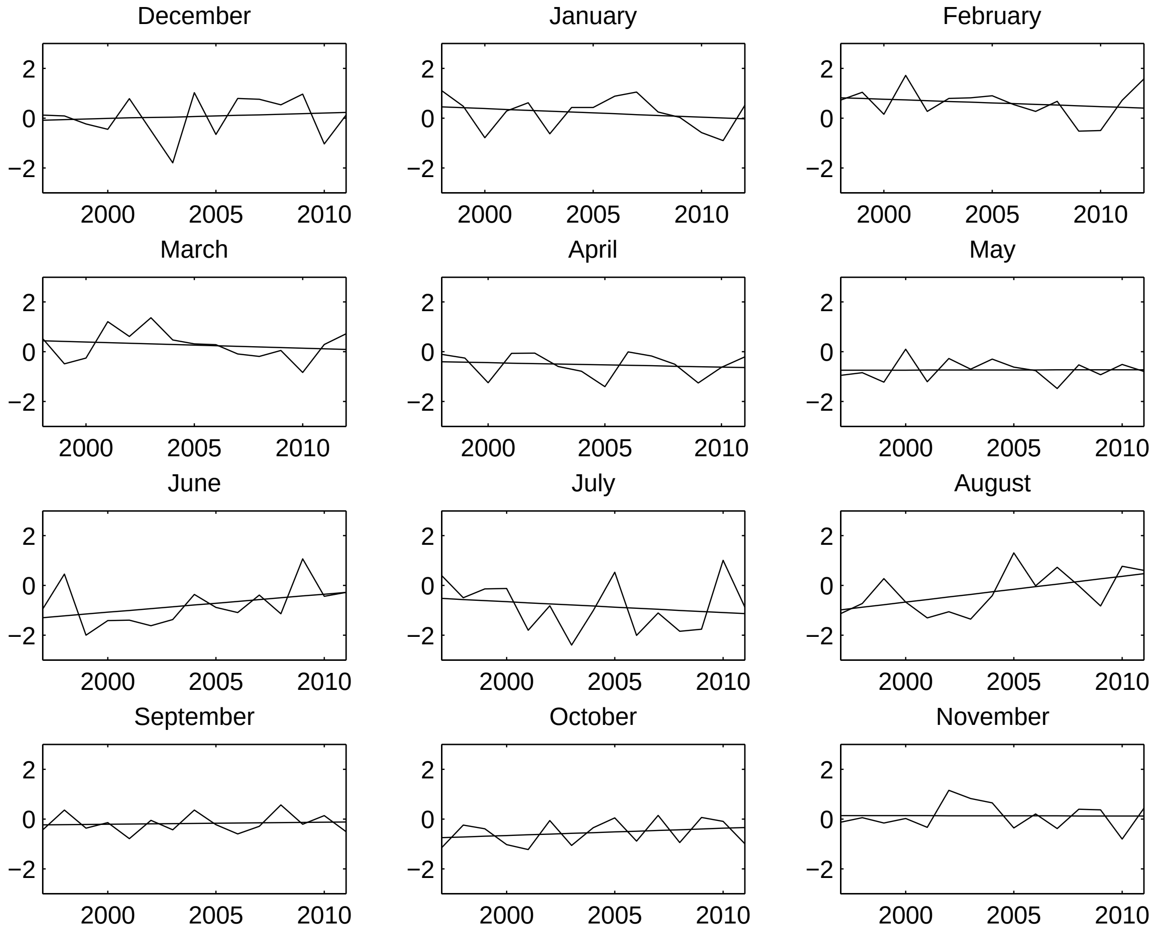

Figure B-39: Vidalia Station

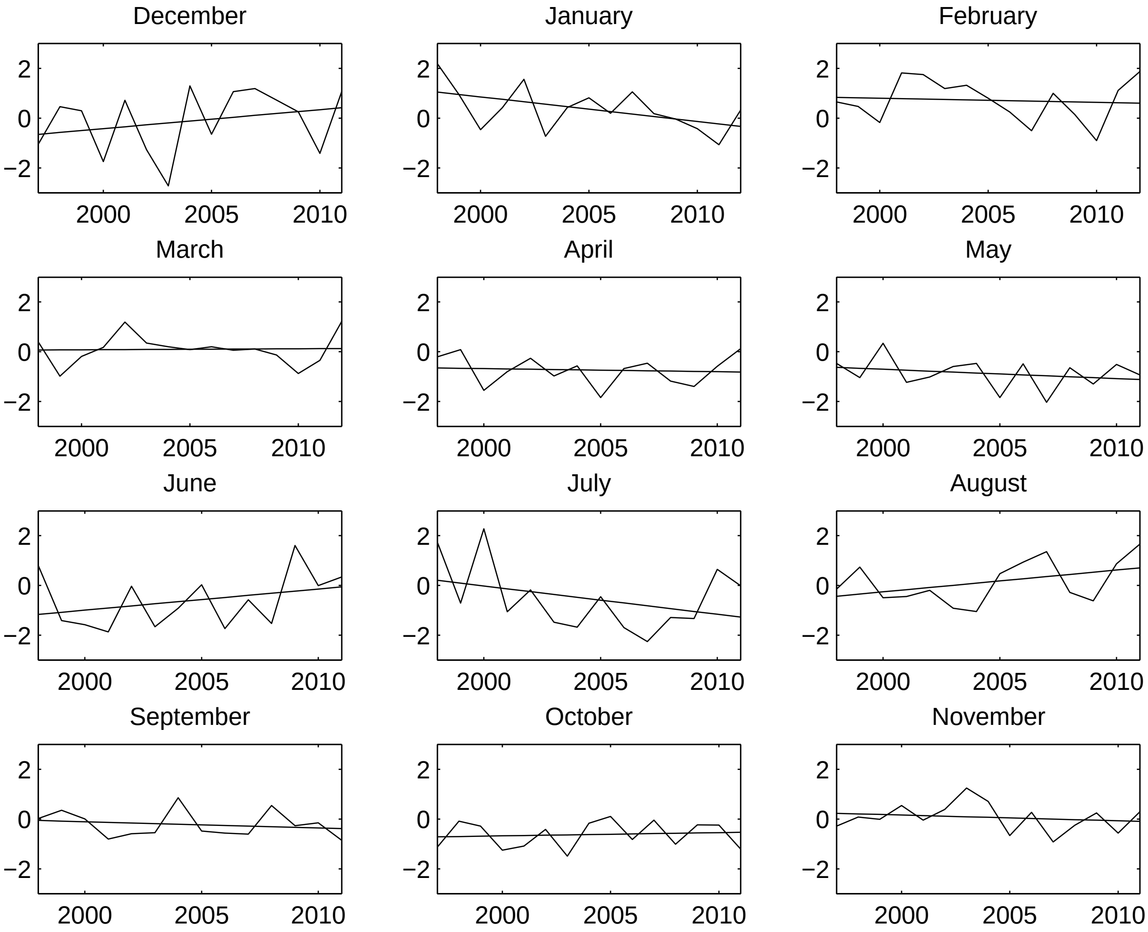

Figure B-40: Roopville Station

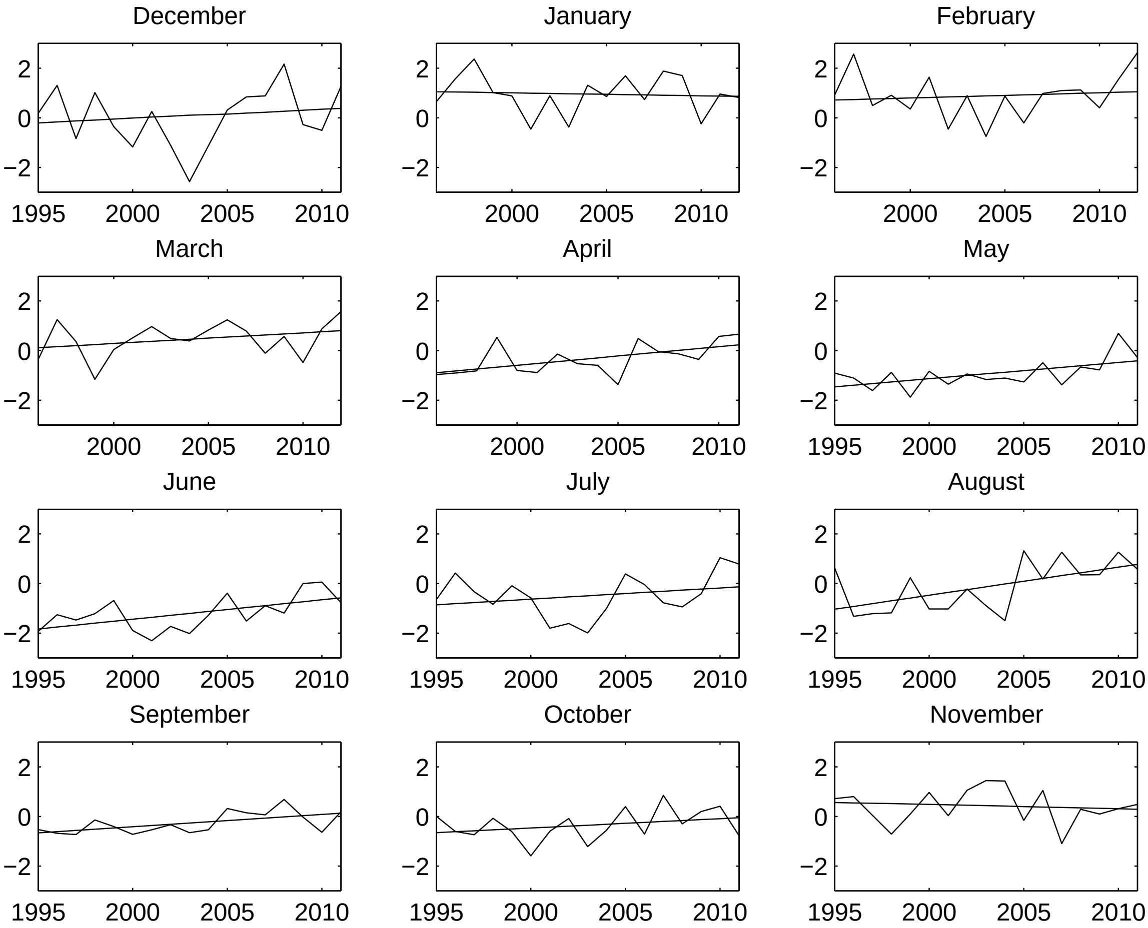

Figure B-41: Watkinsville-Hort Station

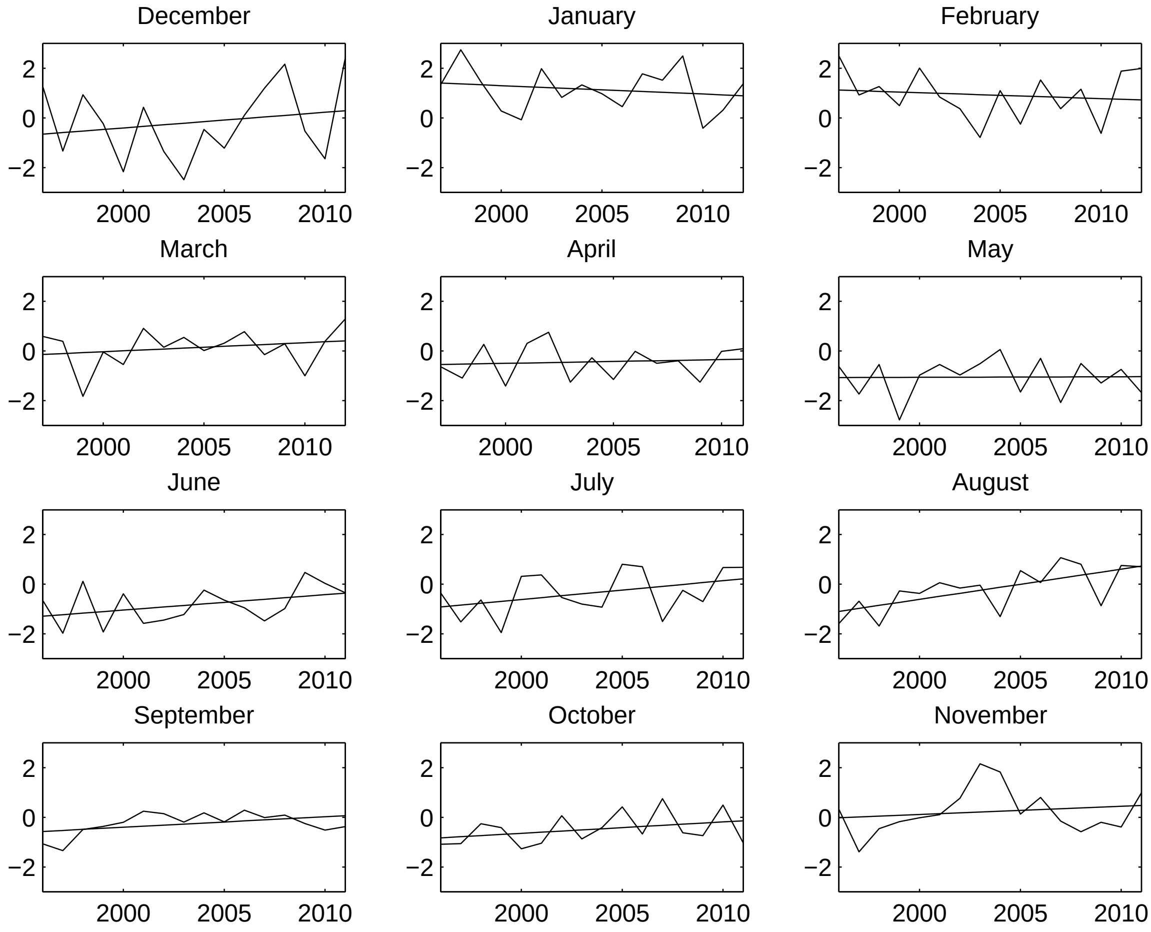

Figure B-42: Watkinsville-UGA Station

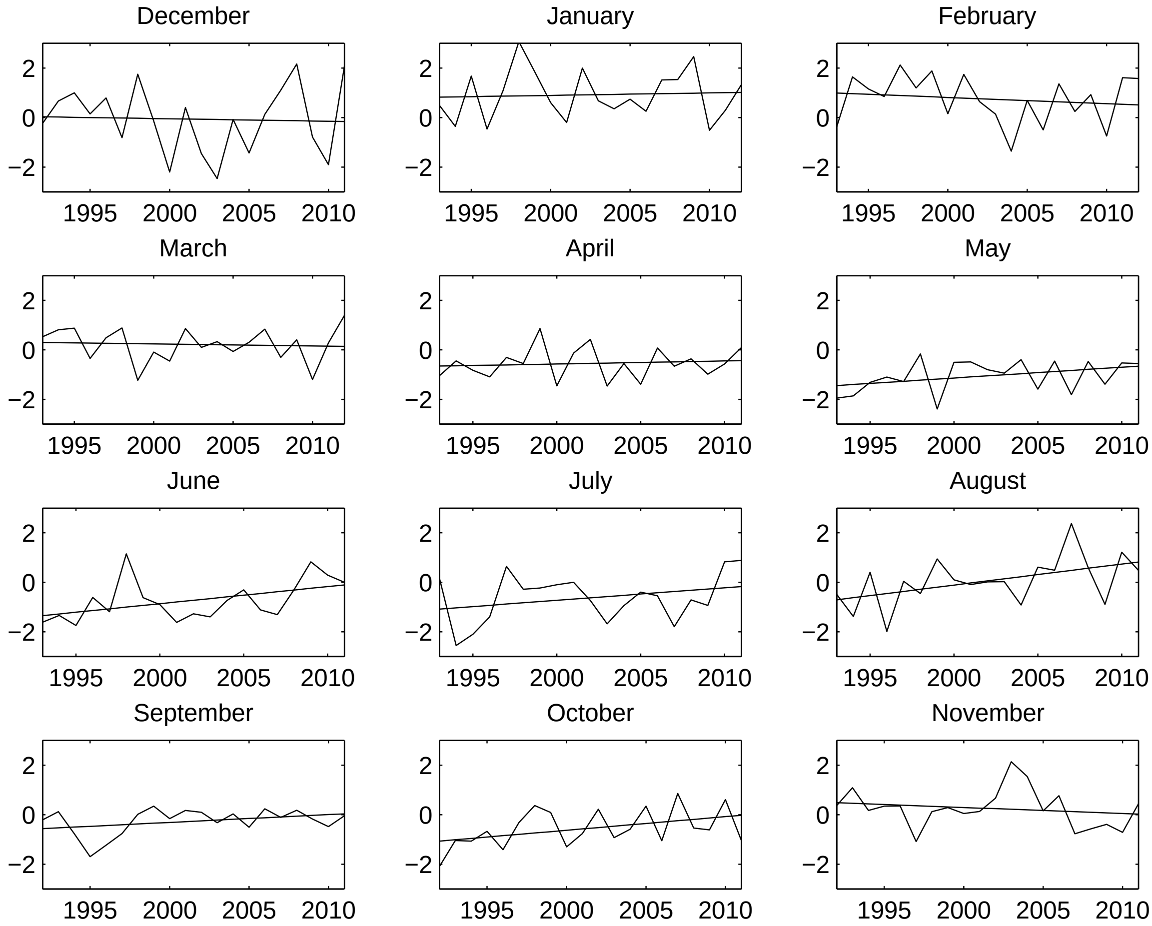

Figure B-43: Watkinsville-USDA Station