HW3

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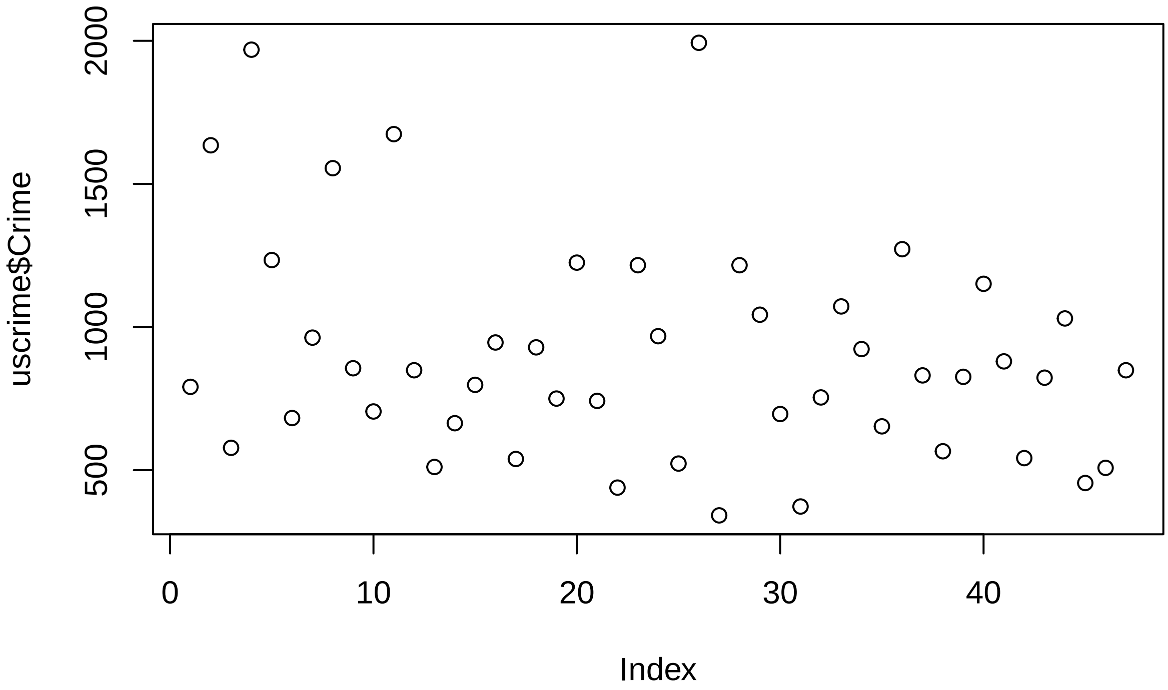
Question 5.1

Using crime data from the file uscrime.txt (http://www.statsci.org/data/general/uscrime.txt, description at http://www.statsci.org/data/general/uscrime.html), test to see whether there are any **outliers in the last column (number of crimes per 100,000 people)**. Use the grubbs.test function in the outliers package in R.

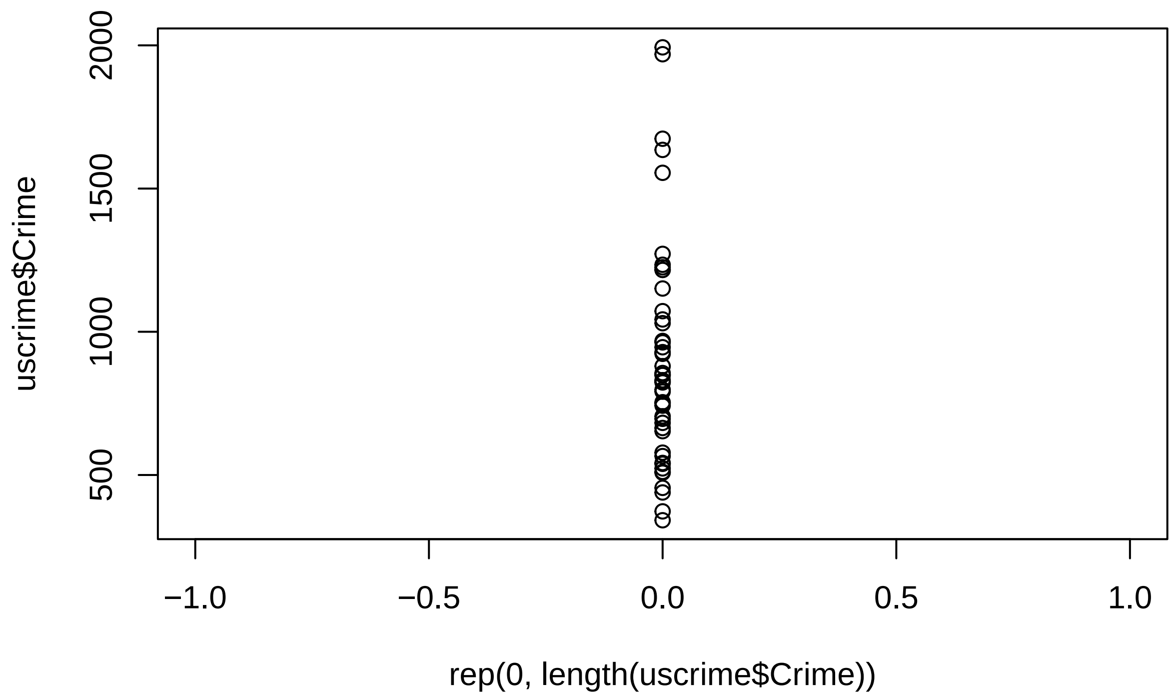
```
rm(list = ls())
set.seed(123)
library(outliers)

# ---------------------------- Load Data -------------------------------------

uscrime <- read.table("/Users/michaella/Downloads/hw3-FA23/uscrime.txt", stringsAsFactors = FALSE, heade
head(uscrime)
```

```
##      M So   Ed  Po1  Po2    LF   M.F Pop   NW    U1  U2 Wealth Ineq     Prob
## 1 15.1  1  9.1  5.8  5.6 0.510  95.0  33 30.1 0.108 4.1   3940 26.1 0.084602
## 2 14.3  0 11.3 10.3  9.5 0.583 101.2  13 10.2 0.096 3.6   5570 19.4 0.029599
## 3 14.2  1  8.9  4.5  4.4 0.533  96.9  18 21.9 0.094 3.3   3180 25.0 0.083401
## 4 13.6  0 12.1 14.9 14.1 0.577  99.4 157  8.0 0.102 3.9   6730 16.7 0.015801
## 5 14.1  0 12.1 10.9 10.1 0.591  98.5  18  3.0 0.091 2.0   5780 17.4 0.041399
## 6 12.1  0 11.0 11.8 11.5 0.547  96.4  25  4.4 0.084 2.9   6890 12.6 0.034201
##      Time Crime
## 1 26.2011   791
## 2 25.2999  1635
## 3 24.3006   578
## 4 29.9012  1969
## 5 21.2998  1234
## 6 20.9995   682
```

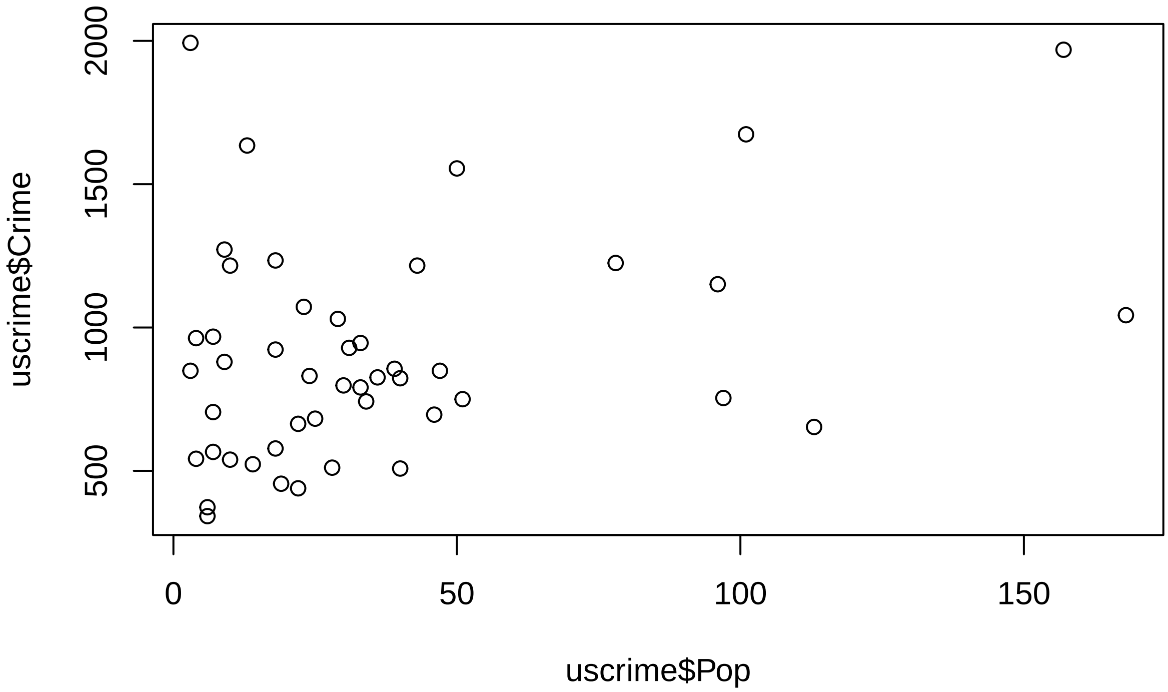
```
# Get a quick visualization of the data
plot(uscrime$Crime)
```




```
#Look at the distribution of the Crime column
plot(rep(0, length(uscrime$Crime)),uscrime$Crime )
```




```
# Visualization of population and crime (further look into outliers)
plot(uscrime$Pop, uscrime$Crime)
```



From the second plot, it looks like the outliers are located closer to 2000.

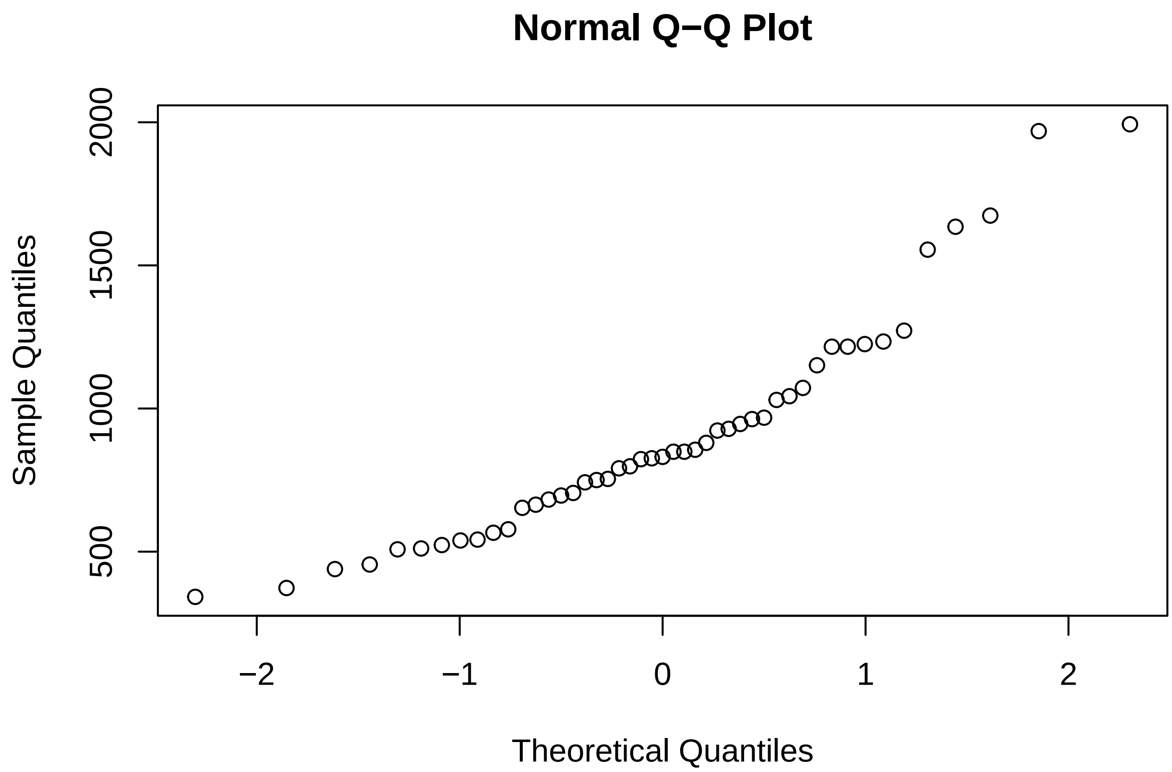
But what does the data distribution look like? The Shapiro-Wilk Normality test assesses whether the data follows a normal distibution.

- Null hypothesis :Data comes from a normal distribution
- Alternate Hypothesis: Data does not come from a normally-distributed population.
- p- value: 0.05

```
#Shapiro test
shapiro.test(uscrime$Crime)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  uscrime$Crime
## W = 0.91273, p-value = 0.001882
```

```
#QQ Plot
qqnorm(uscrime$Crime)
```



Since our resulting p-value of 0.001882 is < 0.05, we reject the null hypothesis. Meaning, the data does not follow a normal distribution. Our W test statistic indicate some deviation from normality ($0 =$ not normal, $1 =$normal), as reflected by the QQ Plot (i.e. not a perfect 45 degree line).

For the purpose of this assignment (Grubbs test assumes a normally-distributed data), we will ** assume normal distribution**.

Type = 11 is a test for two outliers on opposite tails, while Type = 10 tests for an outlier on one tail.

For a type = 11 Grubb's Test: - Null Hypothesis: Min AND Max are not both outliers, but one of them could be.

For a type = 10 Grubb's Test: -Null Hypothesis: There is no outlier in one tail. -

```
# -------------------- CRIME DATA OUTLIERS ----------------------

# Type 11
outlier_test_result_11 <- grubbs.test(uscrime$Crime, type=11)
outlier_test_result_11
```

```
##
##  Grubbs test for two opposite outliers
##
## data:  uscrime$Crime
## G = 4.26877, U = 0.78103, p-value = 1
## alternative hypothesis: 342 and 1993 are outliers
```

```r
# Type 10 (higher end of tail)
outlier_test_result_10 <- grubbs.test(uscrime$Crime, type=10)
outlier_test_result_10
```

```
##
##  Grubbs test for one outlier
##
## data:  uscrime$Crime
## G = 2.81287, U = 0.82426, p-value = 0.07887
## alternative hypothesis: highest value 1993 is an outlier
```

```r
# Type 10, Opposite = TRUE (i.e. lower end of tail)
outlier_test_result_11_opp <- grubbs.test(uscrime$Crime, type=10, opposite=TRUE)
outlier_test_result_11_opp
```

```
##
##  Grubbs test for one outlier
##
## data:  uscrime$Crime
## G = 1.45589, U = 0.95292, p-value = 1
## alternative hypothesis: lowest value 342 is an outlier
```

-For type = 11: with a p-value of 1, we reject the null hypothesis. I.e. the data is not identified as having two opposite outliers– in this case, 342 and 1993.

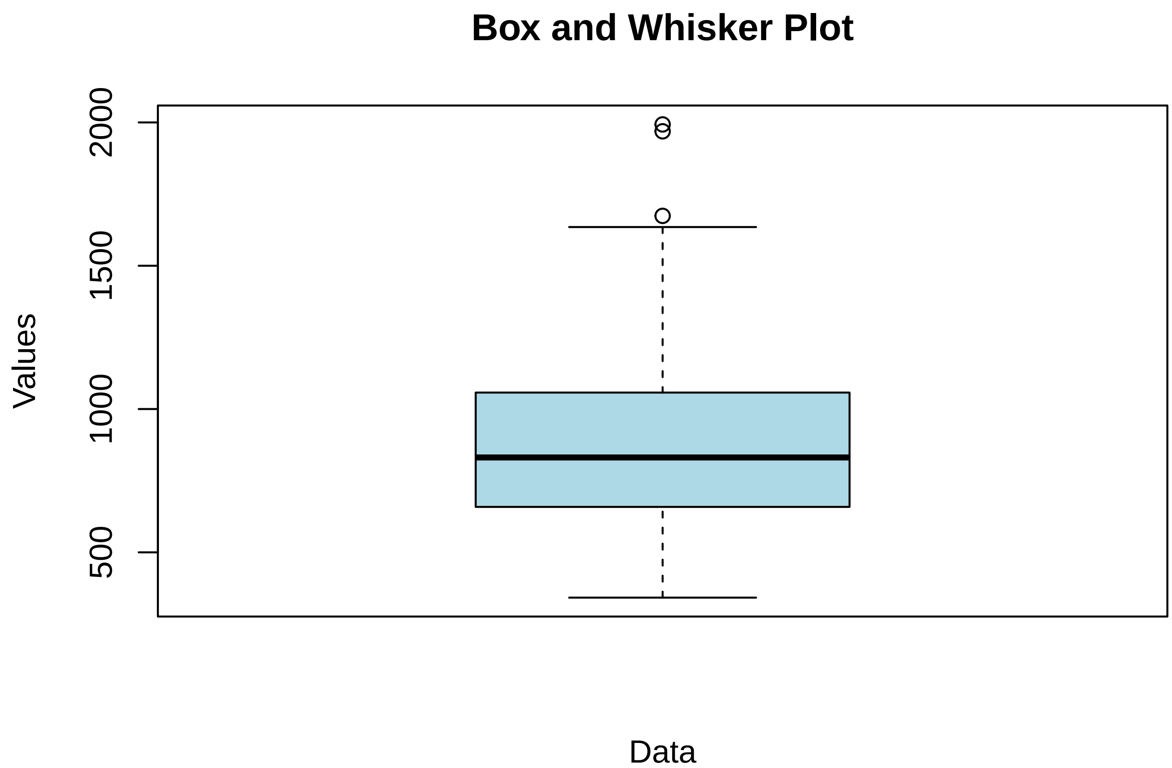
-For type = 10: with a p-value > 0.05, we reject the null hypothesis. I.e., the highest value 1993 is an outlier.

-For type= 10 & opposite = TRUE; the p-value > 0.05, so we also reject the null hypothesis. The lowest value 342 is an outlier.

These three experiments corroborate each other.

We can also estimate this through a box-and-whisker plot.

```r
# Create the box and whisker plot
crime_boxplot <- boxplot(uscrime$Crime,
        main="Box and Whisker Plot",  # Title of the plot
        xlab="Data",                  # Label for the x-axis
        ylab="Values",                # Label for the y-axis
        col="lightblue",             # Color of the boxes
        border="black",              # Border color of the boxes
        horizontal=FALSE             # Set to TRUE for horizontal plot
)
```




```
crime_boxplot
```

```
## $stats
##        [,1]
## [1,]  342.0
## [2,]  658.5
## [3,]  831.0
## [4,] 1057.5
## [5,] 1635.0
##
## $n
## [1] 47
##
## $conf
##          [,1]
## [1,] 739.0438
## [2,] 922.9562
##
## $out
## [1] 1969 1674 1993
##
## $group
## [1] 1 1 1
##
## $names
## [1] ""
```

The outliers in this case are:

```
crime_boxplot$out
```

```
## [1] 1969 1674 1993
```

Notice that although the Grubbs test resulted in 343 as an outlier, it did not appear as an output from our boxplot statistics. It added two more outlier values: 1969, and 1674 which are very close to the edge of the plot.

Question 6.1

Describe a situation or problem from your job, everyday life, current events, etc., for which a Change Detection model would be appropriate. Applying the CUSUM technique, how would you choose the critical value and the threshold?

- Brewing/Culturing: Using a change detection approach, carbon dioxide levels can be monitored to assess the health or activity of the yeast. Zero levels indicate that it has died, while increases indicate overgrowth that could cause congestion. To maintain a steady environment, the model can be used to alter additional parameters like temperature, pressure, or nutrition. The critical value would be calculated using the mean and standard deviation of carbon dioxide levels inside an ideal growing environment for the required cell density. The sensitivity will vary depending on the size of the brewery; a home brewer may not need to monitor them with the same level of sensitivity as a major GMP plant. The threshold would be determined by historical information that the brewmaster deemed adequate for considerations.Variables such as taste, metabolites, alcohol content, among others may affect this value.

Question 6.2.1

1. Using July through October daily-high-temperature data for Atlanta for 1996 through 2015, use a CUSUM approach to *identify when unofficial summer ends* (i.e., when the weather starts cooling off) each year.

C	8	<- Constant to modify sensitivity
T	24	<- Treshold

S_t values																				
mu	92.90	87.48	90.62	84.81	94.33	86.62	89.57	85.57	87.19	86.19	89.71	86.14	88.95	86.38	89.81	91.38	93.33	84.38	86.52	89.24
sd	3.78	3.91	2.54	4.60	3.01	2.58	4.26	3.87	2.96	3.96	4.58	3.14	3.01	3.97	4.04	3.88	5.06	4.27	3.82	3.90
Day / Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
01-Jul	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
02-Jul	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
03-Jul	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	2.2

For this problem, I used excel using the formula '=MAX(0,C87+($C6 $-$ *temps*!*B*81−C$2))' to calculate S_t. For the mu values, I took the median of the first 20 days of July. The standard deviations are taken from the same cells.

Generally, C is recommended to be ~ half of the standard deviation for moderate sensitivity, and T being ~ 5x the standard deviation.

The model was too sensitive and detected the cool-off season too early (ex. Start of August). So I manually tweaked these two values while keeping the guideline in mind.

Because this CUSUM approach is to make a judgment of when the weather starts cooling off, it is quite low-stakes. There is a bit of variation in our daily temperatures so we don't need a sensitive model to tell us summer is over too soon.

S_t values										
mu	92.90	87.48	90.62	84.81	94.33	86.62	89.57	85.57	87.19	86.19
sd	3.78	3.91	2.54	4.60	3.01	2.58	4.26	3.87	2.96	3.96
Day / Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
02-Sep	20.6	0.0	0.0	0.0	12.7	3.6	3.3	0.0	0.0	0.0
03-Sep	18.5	0.0	5.6	0.0	17.0	9.2	0.0	0.0	0.0	0.0
04-Sep	19.4	0.0	0.0	0.0	16.3	6.9	0.0	0.0	0.0	0.0
05-Sep	17.3	0.0	0.0	0.0	21.7	0.0	0.0	0.0	0.0	0.0
06-Sep	13.2	0.0	0.0	0.0	42.0	0.0	0.0	4.6	0.0	0.0
07-Sep	9.1	0.0	0.0	0.0	62.3	0.0	0.0	7.1	0.0	0.0
08-Sep	5.0	0.0	0.0	0.0	73.7	0.0	0.0	3.7	6.2	0.0
09-Sep	0.0	0.0	3.6	0.0	80.0	0.0	0.0	0.0	1.4	0.0
10-Sep	0.9	0.0	8.2	0.0	84.3	0.0	0.0	0.0	0.0	0.0
11-Sep	0.0	0.0	9.9	0.0	86.7	0.0	0.0	0.0	0.0	0.0
12-Sep	0.0	0.0	8.5	0.0	87.0	0.0	0.0	0.0	0.0	0.0
13-Sep	6.9	0.0	2.1	0.0	86.3	0.0	6.6	0.0	0.2	0.0
14-Sep	12.8	0.0	0.0	0.0	86.7	0.0	10.1	0.0	0.4	0.0
15-Sep	11.7	0.0	0.0	0.0	93.0	1.6	0.7	0.0	6.6	0.0
16-Sep	14.6	0.0	0.0	0.0	104.3	3.2	0.0	0.0	10.8	0.0
17-Sep	17.5	0.0	0.0	0.0	117.7	0.9	0.0	0.0	10.0	0.0
18-Sep	24.4	0.0	0.6	0.0	131.0	0.0	0.6	0.0	10.1	0.0
19-Sep	30.3	0.0	3.2	0.0	133.3	0.0	2.1	0.0	11.3	0.0
20-Sep	36.2	0.0	3.9	8.8	132.7	0.0	0.0	0.0	17.5	0.0
21-Sep	43.1	0.0	4.5	6.6	142.0	0.0	0.0	0.0	21.7	0.0
22-Sep	47.0	9.5	0.0	11.4	155.3	0.0	4.6	2.6	20.9	0.0
23-Sep	48.0	9.0	0.0	13.2	160.7	0.0	4.1	0.0	16.1	0.0
24-Sep	48.9	6.4	1.6	12.0	163.0	9.6	12.7	0.0	13.3	0.0
25-Sep	46.8	19.9	2.2	7.9	167.3	22.2	25.3	0.0	11.5	0.0
26-Sep	47.7	29.4	0.9	2.7	185.7	28.9	31.9	0.0	11.7	1.2
27-Sep	53.6	44.9	0.0	1.5	201.0	32.5	38.4	0.0	18.9	0.0
28-Sep	63.5	56.3	2.6	0.0	212.3	33.1	41.0	4.6	20.0	0.0
29-Sep	76.4	58.8	10.2	0.0	225.7	40.7	49.6	16.1	21.2	0.0
30-Sep	97.3	52.3	17.9	5.8	237.0	48.3	52.1	22.7	20.4	0.0
01-Oct	116.2	56.8	14.5	9.6	246.3	52.0	51.7	28.3	17.6	0.0
02-Oct	129.1	63.2	19.1	11.4	253.7	50.6	49.3	37.9	14.8	0.0
03-Oct	130.0	67.7	24.7	4.2	258.0	48.2	46.9	49.4	14.0	0.0

S_t values										
mu	89.71	86.14	88.95	86.38	89.81	91.38	93.33	84.38	86.52	89.24
sd	4.58	3.14	3.01	3.97	4.04	3.88	5.06	4.27	3.82	3.90
Day / Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
02-Sep	0.0	0.0	0.0	7.8	0.0	0.0	0.0	0.0	0.0	0.0
03-Sep	0.0	0.0	0.0	7.1	0.0	0.0	0.3	0.0	0.0	0.0
04-Sep	0.0	0.0	0.0	2.5	0.0	3.4	8.7	0.0	0.0	0.0
05-Sep	0.0	0.0	0.0	0.0	0.0	8.8	9.0	0.0	0.0	0.0
06-Sep	0.0	0.0	0.0	0.0	0.0	17.1	9.3	0.0	0.0	0.0
07-Sep	1.7	0.0	0.0	0.0	0.0	31.5	2.7	0.0	0.0	0.0
08-Sep	0.4	0.0	0.0	0.0	0.0	41.9	0.0	0.0	0.0	0.0
09-Sep	0.0	0.0	0.0	0.0	0.0	44.3	2.3	0.0	0.0	0.0
10-Sep	0.0	0.0	0.0	0.0	0.0	43.7	3.7	0.0	0.0	0.0
11-Sep	0.0	0.0	0.0	3.4	0.0	41.0	6.0	0.0	0.0	0.0
12-Sep	0.0	0.0	0.0	0.8	0.0	37.4	10.3	0.0	0.0	3.2
13-Sep	11.7	0.0	0.0	0.0	0.0	31.8	14.7	0.0	0.0	9.5
14-Sep	13.4	0.0	0.0	0.0	0.0	23.2	17.0	0.0	0.5	13.7
15-Sep	13.1	0.0	2.0	0.0	0.0	20.6	15.3	0.0	0.0	15.0
16-Sep	11.9	2.1	2.9	0.0	0.0	32.0	14.7	0.0	0.0	17.2
17-Sep	8.6	2.3	14.9	5.4	0.0	36.3	17.0	0.0	0.0	15.4
18-Sep	5.3	1.4	13.8	3.8	0.0	42.7	23.3	0.0	0.0	13.7
19-Sep	8.0	0.0	13.8	8.1	0.0	49.1	27.7	0.0	0.0	7.9
20-Sep	16.7	0.0	15.7	5.5	0.0	50.5	34.0	0.0	0.0	0.1
21-Sep	23.4	0.1	21.7	4.9	0.0	47.9	34.3	3.4	0.0	4.4
22-Sep	23.1	0.0	18.6	0.0	0.0	51.2	32.7	0.0	0.0	9.6
23-Sep	18.9	0.0	17.6	0.0	0.0	51.6	37.0	0.0	1.5	9.9
24-Sep	16.6	0.0	20.5	0.0	0.0	53.0	44.3	5.4	2.0	17.1
25-Sep	23.3	0.0	19.5	0.0	0.0	48.4	47.7	14.8	3.6	31.3
26-Sep	27.0	0.0	20.4	0.0	5.8	45.8	47.0	13.1	8.1	41.6
27-Sep	29.7	0.0	24.4	0.0	6.6	45.1	44.3	10.5	8.6	51.8
28-Sep	30.4	0.0	19.3	0.0	12.4	49.5	43.7	9.9	13.1	58.0
29-Sep	42.1	0.0	14.3	6.4	15.2	48.9	45.0	10.3	20.7	62.3
30-Sep	48.9	0.0	9.2	10.8	21.0	54.3	58.3	9.7	15.2	58.5
01-Oct	47.6	0.0	16.2	13.1	23.9	72.7	68.7	4.0	7.7	68.8
02-Oct	48.3	0.0	23.1	16.5	27.7	88.0	82.0	0.0	1.2	84.0
03-Oct	48.0	1.1	24.1	18.9	41.5	96.4	93.3	0.0	1.8	99.2

Figure 1: CUSUM Spreadsheet with conditional formatting, turning green when S_t is above the T =24.

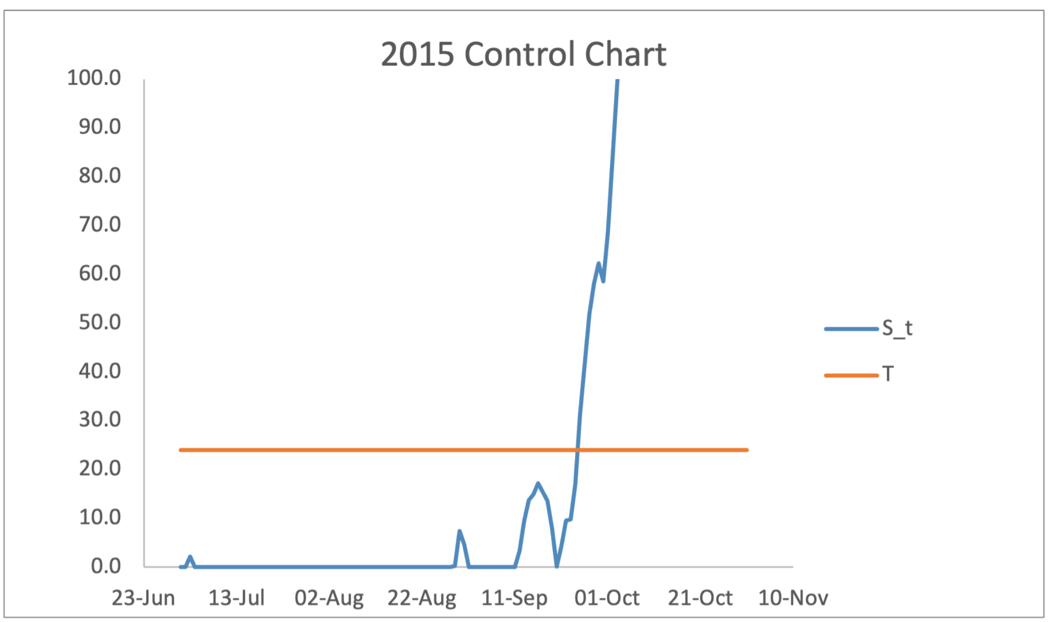


Figure 2: 2015 Control Chart. Y-axis limit is set to 100.

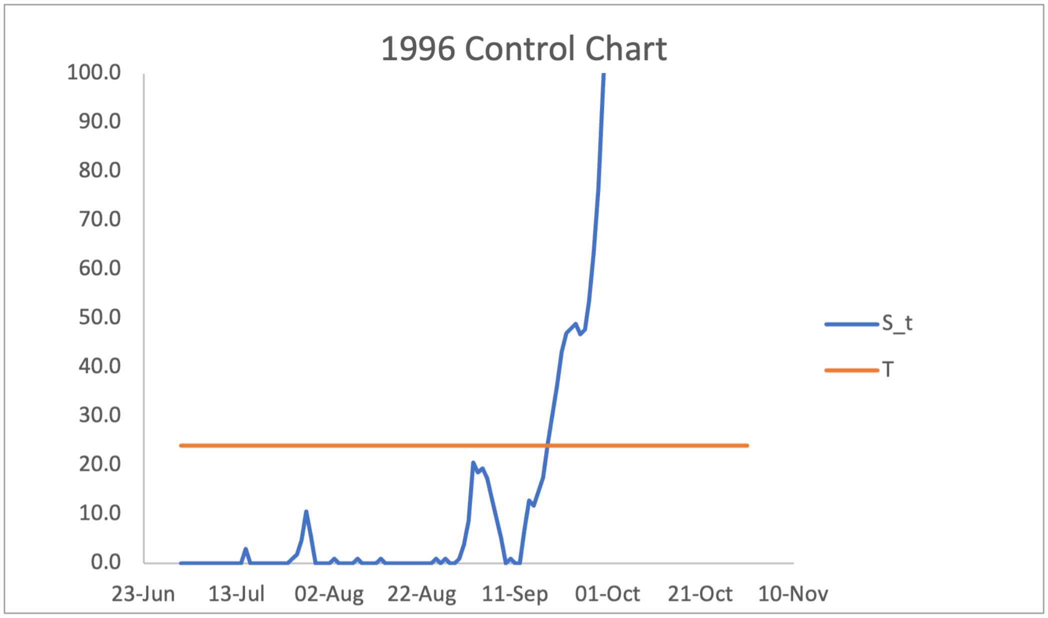


Figure 3: 1996 Control Chart. Y-axis limit is set to 100.

I settled with C = 8, and T = 24 while being mindful of the trade-off between how costly it is if the model takes a long time to change, and how costly it is when the model thinks it found a change that is not there.

Day / Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
row:	88	96	103	108	76	96	95	101	108	109	96	120	97	105	102	77	89	119	119	95
Value:	Sep-18	Sep-26	Oct-03	Oct-08	Sep-06	Sep-26	Sep-25	Oct-01	Oct-08	Oct-09	Sep-26	Oct-20	Sep-27	Oct-05	Oct-02	Sep-07	Sep-19	Oct-19	Oct-19	Sep-25
																		Average	99.95	
																		Date	30-Sep	

I took the row indexes of the dates and averaged them, which translated to roughly September 30 as an average cool-off time across 1996 to 2015. The individual dates for each year can be found on the image above.

Question 6.2.1

2. Use a CUSUM approach to make a judgment of *whether Atlanta's summer climate has gotten warmer in that time* (and if so, when).

For this problem, I used excel using the formula '=MAX(0,C9+(temps!B3-C6−C$2))' to calculate S_t. For the mu values, I took the median of the first 20 days of July. The standard deviations are taken from the same cells.

This time, I followed the guideline for C and T values better. As a result, I picked C = 3, and T = 17.

C	3		<- Constant to modify sensitivity																	
T	17		<- Treshold																	
S_t values																				
mu	92.90	87.48	90.62	84.81	94.33	86.62	89.57	85.57	87.19	86.19	89.71	86.14	88.95	86.38	89.81	91.38	93.33	84.38	86.52	89.24
sd	3.78	3.91	2.54	4.60	3.01	2.58	4.26	3.87	2.96	3.96	4.58	3.14	3.01	3.97	4.04	3.88	5.06	4.27	3.82	3.90
Day / Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
01-Jul	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

C	3		<- Constant to modify sensitivity
T	17		<- Treshold

S_t values																				
mu	92.90	87.48	90.62	84.81	94.33	86.62	89.57	85.57	87.19	86.19	89.71	86.14	88.95	86.38	89.81	91.38	93.33	84.38	86.52	89.24
sd	3.78	3.91	2.54	4.60	3.01	2.58	4.26	3.87	2.96	3.96	4.58	3.14	3.01	3.97	4.04	3.88	5.06	4.27	3.82	3.90
Day / Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
22-Jul	0.0	0.0	0.0	7.8	0.0	0.0	1.0	0.0	0.0	3.0	2.7	0.0	5.1	0.0	3.4	0.0	0.0	1.7	0.0	1.3
23-Jul	0.0	0.0	0.0	13.0	0.0	0.4	0.0	0.0	2.8	4.9	0.0	0.0	0.2	0.0	7.6	0.0	0.7	0.0	0.0	0.0
24-Jul	0.0	0.0	0.0	18.1	0.0	0.0	0.0	0.0	7.6	5.7	0.0	0.0	0.0	0.0	8.8	0.0	1.3	0.0	0.0	0.0
25-Jul	0.0	0.0	0.0	21.3	0.0	0.0	0.0	0.0	6.4	8.5	0.0	0.0	0.0	0.6	11.0	0.0	3.0	1.6	0.0	0.0
26-Jul	0.0	0.0	0.0	26.5	0.0	0.0	0.0	0.0	3.2	13.3	0.3	0.0	0.0	3.2	13.1	0.0	4.7	0.2	0.0	0.0
27-Jul	0.0	0.5	0.0	31.7	0.0	0.4	0.0	0.0	0.0	16.1	2.6	0.9	0.0	3.9	13.3	0.0	5.3	0.0	2.5	0.0
28-Jul	0.0	1.0	0.0	36.9	0.0	0.0	0.0	0.4	0.0	16.9	5.9	0.7	1.0	3.5	10.5	0.0	6.0	0.0	3.0	1.8
29-Jul	0.0	0.0	0.0	42.1	0.0	0.0	0.0	0.0	0.0	10.7	4.1	0.0	1.1	0.0	11.7	0.0	3.7	0.0	0.0	2.5
30-Jul	0.0	0.0	0.0	51.3	0.0	0.0	0.0	0.0	0.0	0.0	2.4	2.9	0.0	0.0	13.9	1.6	3.3	2.6	0.0	4.3
31-Jul	0.0	0.0	0.0	62.5	0.0	0.0	0.0	0.0	0.0	0.0	3.7	3.7	0.0	0.0	16.1	3.2	0.0	0.0	0.0	5.0
01-Aug	0.0	0.0	0.0	70.7	0.0	0.0	0.4	0.0	0.8	0.0	6.0	6.6	0.0	0.0	19.3	0.0	0.0	0.0	0.0	1.8
02-Aug	0.0	0.0	0.0	75.9	0.0	0.0	0.0	0.0	0.6	0.0	8.3	9.4	0.0	0.0	10.5	1.6	2.7	1.6	0.0	3.6
03-Aug	0.0	0.0	0.0	76.0	0.0	0.0	0.0	0.0	1.4	0.0	12.6	14.3	0.0	0.6	9.7	4.2	0.3	2.2	0.0	5.3
04-Aug	0.0	0.0	0.0	77.2	0.0	0.0	0.0	0.0	2.2	1.8	17.9	22.1	0.0	3.2	11.9	0.0	0.0	4.9	0.5	10.1
05-Aug	0.0	0.0	0.0	80.4	0.0	0.0	0.4	0.0	2.0	0.6	21.1	29.0	0.0	5.9	12.0	1.6	0.0	5.5	0.0	12.9
06-Aug	0.0	0.0	0.0	85.6	0.0	0.0	4.9	0.0	0.0	0.0	17.4	37.9	2.1	5.5	12.2	0.2	0.0	6.1	2.5	8.6
07-Aug	0.0	0.0	0.0	90.8	0.0	0.0	0.0	0.0	0.0	0.0	21.7	46.7	0.1	7.1	10.4	0.0	0.0	4.7	8.0	4.4
08-Aug	0.0	0.0	0.0	96.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	57.6	0.0	9.7	10.6	0.0	0.0	0.3	8.4	4.1
09-Aug	0.0	0.0	0.0	99.2	0.0	0.0	0.0	0.0	0.0	0.0	27.3	71.4	0.0	13.3	11.8	0.0	0.0	2.0	7.9	4.9
10-Aug	0.0	0.0	0.0	101.4	0.0	0.0	0.0	0.0	0.0	0.0	30.6	85.3	0.0	17.0	13.0	0.6	0.0	4.6	4.4	6.7
11-Aug	0.0	0.0	0.0	109.6	0.0	0.0	0.0	0.0	0.0	0.0	25.9	96.1	0.0	22.6	15.2	0.2	0.0	7.2	0.0	5.4
12-Aug	0.0	0.0	0.0	119.8	0.0	0.0	0.0	0.0	0.0	0.0	17.1	97.0	0.0	19.2	17.4	0.9	0.0	9.8	0.0	3.2
13-Aug	0.0	0.0	0.0	129.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	107.9	0.0	19.8	20.6	1.5	0.0	11.4	0.0	0.0
14-Aug	0.0	0.0	0.0	139.1	0.0	0.0	0.0	0.4	0.0	0.8	0.0	117.7	0.0	20.4	16.8	1.1	0.0	7.0	0.0	0.0
15-Aug	0.0	0.0	0.0	144.3	0.0	0.0	0.0	1.9	0.0	3.6	0.0	130.6	0.0	21.0	14.0	0.0	0.0	0.0	0.0	0.0
16-Aug	0.0	0.5	0.0	149.5	0.0	0.4	0.0	0.0	0.0	3.4	0.0	142.4	0.0	19.7	11.1	0.0	0.0	0.0	0.0	0.0
17-Aug	0.0	1.0	0.0	157.7	1.7	1.8	0.0	0.4	0.0	4.2	0.0	154.3	0.0	17.3	9.3	0.0	0.0	0.0	0.0	0.0
18-Aug	0.0	0.0	0.0	167.9	5.3	3.1	0.4	1.9	0.0	5.0	0.0	162.1	0.0	15.9	9.5	0.0	0.0	0.0	0.0	0.0
19-Aug	0.0	0.0	0.0	178.1	9.0	0.5	0.0	3.3	0.0	4.9	0.0	168.0	0.0	16.5	8.7	1.6	0.0	0.0	0.0	0.0
20-Aug	0.0	0.0	0.0	179.3	8.7	0.0	0.4	1.7	0.0	7.7	0.3	174.9	0.0	15.1	8.9	0.2	0.0	0.0	0.0	0.0
21-Aug	0.0	0.0	0.0	182.5	0.0	0.0	0.9	1.1	0.0	12.5	0.0	184.7	0.0	13.8	9.1	0.0	0.0	0.0	2.5	0.0
22-Aug	0.0	0.0	0.0	185.7	0.0	0.4	0.0	0.6	0.0	16.3	0.0	199.6	0.0	9.4	10.3	3.6	0.0	0.6	6.0	0.0
23-Aug	0.0	0.0	0.0	187.9	0.0	0.0	2.4	2.0	0.0	14.1	0.0	208.4	0.0	1.0	10.5	1.2	0.0	3.2	9.4	0.0
24-Aug	0.0	0.0	0.0	180.0	0.0	3.4	2.9	2.4	0.0	9.9	0.0	214.3	0.0	0.0	7.7	0.0	0.0	0.0	7.9	0.0
25-Aug	0.0	0.0	0.0	174.2	0.0	3.8	1.3	1.9	0.0	4.7	0.0	219.1	0.0	0.0	3.9	0.6	0.0	0.0	2.4	0.0
26-Aug	0.0	0.0	0.0	175.4	0.0	5.1	0.0	2.3	0.0	0.0	0.0	222.0	0.0	0.6	1.0	5.2	0.0	0.0	0.0	0.0
27-Aug	0.0	0.0	0.0	175.6	0.0	6.5	0.0	3.7	0.0	0.0	0.0	220.9	0.0	0.0	0.0	5.9	0.0	0.0	0.0	0.0
28-Aug	0.0	0.0	0.0	177.8	0.0	0.0	0.0	6.1	0.0	0.0	0.0	219.7	0.0	0.0	0.0	6.5	0.0	2.6	1.5	0.0
29-Aug	0.0	0.5	0.0	181.0	0.0	0.0	0.0	6.6	0.0	0.0	0.0	219.6	0.0	0.0	0.0	5.1	0.0	7.2	4.0	0.0
30-Aug	0.0	1.0	0.0	184.2	0.0	0.0	0.0	6.0	0.0	0.0	0.0	219.4	0.0	0.0	0.0	0.7	0.0	6.9	2.4	0.0
31-Aug	0.0	0.0	0.0	180.4	0.0	0.0	0.0	6.4	0.0	0.0	0.0	216.3	0.0	0.0	0.0	0.0	0.0	9.5	1.9	0.0
01-Sep	0.0	0.0	0.0	180.6	0.0	0.0	0.0	5.9	0.0	0.0	0.0	211.1	0.0	0.0	0.0	0.6	0.0	12.1	2.4	0.0
02-Sep	0.0	0.5	0.0	183.8	0.0	0.0	0.0	3.3	0.0	0.0	0.0	205.0	0.0	0.0	0.0	2.2	0.0	8.7	2.9	0.0
03-Sep	0.0	3.0	0.0	180.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	203.9	0.0	0.0	0.0	2.9	0.0	11.3	5.3	0.0
04-Sep	0.0	0.0	0.0	185.1	0.0	0.0	2.4	0.1	0.0	0.0	0.0	205.7	0.0	0.0	0.0	0.0	0.0	13.0	0.0	0.0
05-Sep	0.0	0.0	0.0	193.3	0.0	0.4	2.9	0.0	0.0	0.0	0.0	205.6	0.0	0.0	0.0	0.0	0.0	14.6	0.0	0.0
06-Sep	0.0	0.0	0.0	201.5	0.0	0.0	1.3	0.0	0.0	0.0	0.0	201.4	0.0	0.0	0.0	0.0	0.0	15.2	1.5	0.0
07-Sep	0.0	0.0	0.0	204.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	198.3	0.0	0.0	0.0	0.0	0.0	15.8	2.0	0.0
08-Sep	0.0	0.0	0.0	207.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	197.1	0.0	0.0	0.2	0.0	0.0	19.4	0.0	0.0
09-Sep	0.0	0.0	0.0	197.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	197.0	0.0	0.0	0.0	0.0	0.0	22.0	0.0	0.0

There were only two significant times when it got warmer: in 1999 and 1997. See the image below for each year's results.

Day / Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
row:				32							43	43		50	40			78		
Value:				24-Jul							04-Aug	04-Aug		11-Aug	01-Aug			08-Sep		
																		Average	47.6666667	
																		Date	09-Aug	

Figure 4: Average Dates for Warming