Question 5.1

#Import library

```
> library(outliers)
> library(ggplot2)
```

#Import data

```
> data<- read.table("uscrime.txt",header=T)
> crime<- data[,"Crime"]
```

#Check the data (In total, 47data points in one dataset)

```
> crime
 [1]  791 1635  578 1969 1234  682  963 1555  856  705 1674  849  511  664  798  946  539  929  750 1225  742
439 1216  968  523 1993  342
[28] 1216 1043  696  373  754 1072  923  653 1272  831  566  826 1151  880  542  823 1030  455  508  849
```

For this experiment, it's important to set below hypothesis:

1. NULL hypothesis: The crime dataset is normally distributed.
2. Alternate hypothesis: The crime dataset is NOT normally distributed.

#Run Grubbs.Test on initial data.

```
#Test the right tail
> grubbs.test(crime,type=10)

        Grubbs test for one outlier
```

data: crime
G = 2.81287, U = 0.82426, p-value = 0.07887
alternative hypothesis: highest value 1993 is an outlier

#Test the left tail
> grubbs.test(crime,type=10,opposite=TRUE)

        Grubbs test for one outlier

data: crime
G = 1.45589, U = 0.95292, p-value = 1
alternative hypothesis: lowest value 342 is an outlier

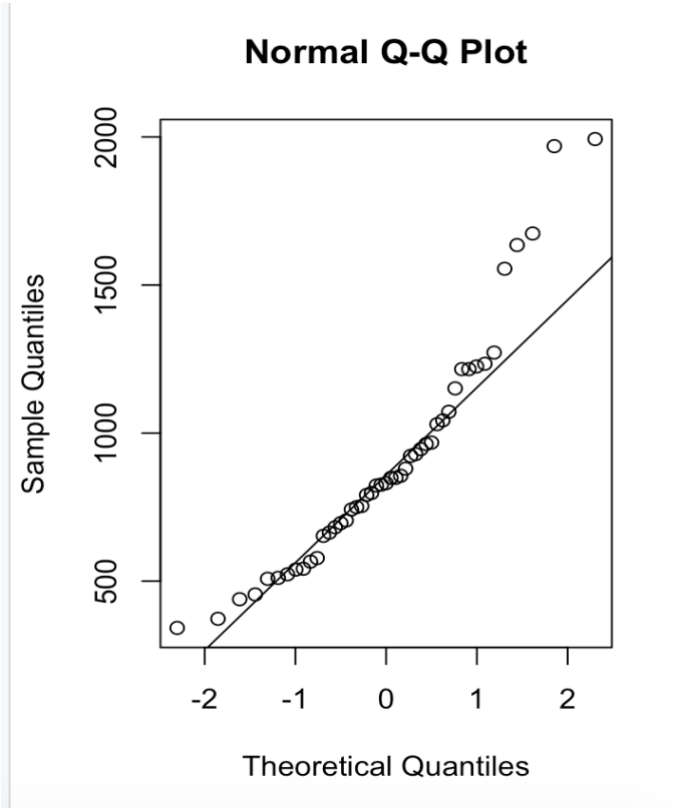
 # Result Analysis:

Since 0.07887 and 1, p-value for both tails respectively are greater than 0.05, it indicates that there is no outlier from this crime dataset, which means we don't reject Null hypothesis.

However, when using Grubbs.Test function, we assume the original data is normally distributed, which we haven't explore deeper on this assumption.

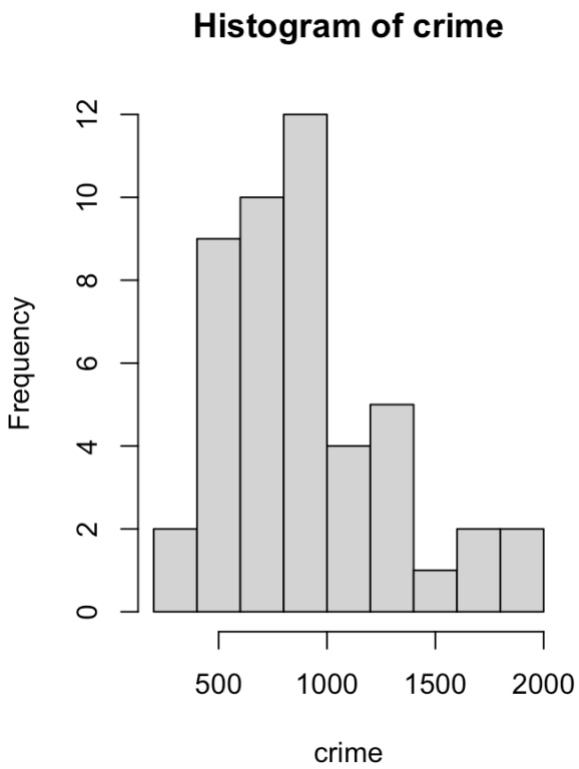
Firstly, we can take a look at below Normal QQ Plot.

> qqnorm(crime)
> qqline(crime)



#And histogram

>hist(crime)



From the QQ plot, it shows that most of the data points are falling along the QQ line (straight line) which infers they are normally distributed. And for histogram, it doesn't show a bell-shape which is an indicator for dataset not being normally distributed.

When diving deeper on this question, from statistical standpoint, we could utilize **Shapiro-Wilk Test** for Normality in R.

> shapiro.test(crime)

Shapiro-Wilk normality test

data: crime
W = 0.91273, p-value = 0.001882

As it shows that p-value is lower than 0.05, the data is not normal if the p-value is below 0.05. So we now know our variable is Not normally distributed.

Log transformation:

In order to ensure the assumption of Grubbs. Test is satisfied, we need to perform log transformation on our original dataset.

> log(crime)
[1] 6.673298 7.399398 6.359574 7.585281 7.118016 6.525030 6.870053 7.349231 6.752270 6.558198 7.422971 6.744059 6.236370 6.498282 6.682109
[16] 6.852243 6.289716 6.834109 6.620073 7.110696 6.609349 6.084499 7.103322 6.875232 6.259581 7.597396 5.834811 7.103322 6.949856 6.545350
[31] 5.921578 6.625392 6.977281 6.827629 6.481577 7.148346 6.722630 6.338594 6.716595 7.048386 6.779922 6.295266 6.712956 6.937314 6.120297

```
[46] 6.230481 6.744059
> crime_log<- log(crime)
> shapiro.test(crime_log)

        Shapiro-Wilk normality test

data:  crime_log
W = 0.98709, p-value = 0.8778
```

Since p-value 0.8778 > 0.05, crime_log is normally distributed.

Finally, we re-test the crime_log with Grubbs.Test.

```
> grubbs.test(crime_log,type=10)

        Grubbs test for one outlier

data:  crime_log
G = 2.16544, U = 0.89585, p-value = 0.6329
alternative hypothesis: lowest value 5.8348107370626 is an outlier

> grubbs.test(crime_log,type=10,opposite=TRUE)

        Grubbs test for one outlier

data:  crime_log
G = 2.12247, U = 0.89994, p-value = 0.712
```

alternative hypothesis: highest value 7.59739632021279 is an outlier

Conclusion: P-values for both tails are still greater than 0.05. Given that, we can conclude that there are no outliers in this dataset.

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?

CUSUM technique could be applied to detect change on my bedtime.

Since many people have suffered loss of sleep due to mounting pressure from their everyday life, a consistent amount of sleep can benefit our health and help us stay away from any potential chronical disease, such as hypertension or heart disease etc. Checking the daily bedtime hours and setting a change detection model to it could alert me from staying up late for a period time and get back on the right track.

According to CDC, the recommended amounts of sleep in every 24-hour period is 7 hours or more.

In order to choose the critical value(C in CUSUM) and threshold (T in CUSUM), we first need to have enough data points to analyze. The daily amount of sleep over the past 60 days (60 data points) would be a good starting point for exploring deeper.

Then, calculate the average amount the standard deviation(SD) of sleep over these 60 days. Use the recommended scheme to decide a starting point for C and T, which is C= SD/2 and T=SD*5. Visualize the daily amount via a line chart and an average line and check to see if the initial C and T give a sensible result and detect

the loss of sleep correctly. If not, adjusting the C and T value in the CUSUM formula until a more reasonable result surfaced. Then, the final C and T value could be used for future sleep deprivation detection.

Question 6.2.1

For the preparation of calculating CUSUM, we need to set the following parameters per year:

Mu = average temperature of July +August for each year, since In common sense, July and august are the most common month for summer. Given that, using average temperature for these 2 months as Mu will make my dataset more sensible to detect any changes between the break of summer and fall.

SD = standard deviation.
$C_N = SD_N/2$
$T = SD_N*5$

Then I calculate the CUSUM for each year from 1996 to 2015. See attached spreadsheet for detail.(I also uploaded the excel file in case you are interested in the formula :))

$CUSUM = MAX\{0, S_{t-1} + Mu - X_T - C\}$

DAY	1996		1997		1998		1999		2000	
01-Jul	98	0	86	0	91	0	84	0.76736803	89	0
02-Jul	97	0	90	0	88	0	82	3.53473607	91	0
03-Jul	97	0	93	0	91	0	87	1.3021041	93	0
04-Jul	90	0	91	0	91	0	88	0	95	0
05-Jul	89	0	84	0	91	0	90	0	96	0
06-Jul	93	0	84	0	89	0	91	0	96	0
07-Jul	93	0	75	6.8727464	93	0	82	2.76736803	96	0
08-Jul	91	0	87	1.74549281	95	0	86	1.53473607	91	0
09-Jul	93	0	84	0	95	0	87	0	96	0
10-Jul	93	0	87	0	91	0	87	0	99	0
11-Jul	90	0	84	0	91	0	82	2.76736803	96	0
12-Jul	91	0	88	0	86	0	77	10.5347361	93	0
13-Jul	93	0	86	0	88	0	73	22.3021041	91	0
14-Jul	93	0	90	0	87	0	81	26.0694721	93	0
15-Jul	82	3.33873361	91	0	91	0	81	29.8368402	93	0
16-Jul	91	0	91	0	87	0	86	28.6042082	93	0
17-Jul	96	0	89	0	90	0	82	31.3715762	91	0
18-Jul	95	0	89	0	91	0	87	29.1389443	97	0
19-Jul	96	0	89	0	95	0	88	25.9063123	100	0
20-Jul	99	0	90	0	91	0	90	20.6736803	99	0
21-Jul	91	0	89	0	91	0	90	15.4410484	93	0
22-Jul	95	0	84	0	89	0	91	9.20841642	96	0
23-Jul	91	0	87	0	91	0	93	0.97578445	87	0
24-Jul	93	0	88	0	91	0	93	0	82	4.64387997
25-Jul	84	1.33873361	89	0	86	0	91	0	75	16.2877599
26-Jul	84	2.67746722	89	0	88	0	93	0	82	20.9316399
27-Jul	82	6.01620082	91	0	80	5.03727865	93	0	88	19.5755199
28-Jul	79	12.3549344	91	0	88	2.07455731	93	0	91	15.2193999
29-Jul	90	7.69366804	89	0	89	0	93	0	89	12.8632798
30-Jul	91	2.03240165	88	0	90	0	97	0	87	12.5071598
31-Jul	87	0.37113526	72	9.8727464	86	0	99	0	86	13.1510398
01-Aug	86	0	80	11.7454928	86	0	96	0	86	13.7949197
02-Aug	90	0	84	9.61823921	82	3.03727865	93	0	81	19.4387997
03-Aug	84	1.33873361	88	3.49098562	84	4.07455731	88	0	84	22.0826797
04-Aug	91	0	89	0	86	3.11183596	89	0	88	20.7265596
05-Aug	93	0	88	0	90	0	91	0	91	16.3704396
06-Aug	88	0	84	0	89	0	93	0	91	12.0143196
07-Aug	91	0	84	0	89	0	93	0	91	7.65819956
08-Aug	84	1.33873361	80	1.8727464	86	0	93	0	91	3.30207953
09-Aug	90	0	73	10.7454928	82	3.03727865	91	0	96	0
10-Aug	89	0	80	12.6182392	87	1.07455731	90	0	95	0
11-Aug	88	0	86	8.49098562	88	0	96	0	89	0
12-Aug	86	0	88	2.36373202	84	1.03727865	98	0	89	0
13-Aug	84	1.33873361	88	0	86	0.07455731	97	0	89	0
14-Aug	86	0.67746722	87	0	80	5.11183596	98	0	89	0
15-Aug	89	0	88	0	82	8.14911461	93	0	94	0
16-Aug	90	0	91	0	86	7.18639327	93	0	97	0
17-Aug	91	0	91	0	84	8.22367192	96	0	99	0
18-Aug	91	0	89	0	87	6.26095057	98	0	101	0
19-Aug	90	0	89	0	90	1.29822922	98	0	101	0
20-Aug	89	0	88	0	79	7.33550788	89	0	97	0
21-Aug	90	0	82	0	84	8.37278653	91	0	87	0
22-Aug	91	0	79	2.8727464	87	6.41006518	91	0	86	0.64387997
23-Aug	91	0	81	3.74549281	87	4.44734384	90	0	88	0
24-Aug	91	0	82	3.61823921	88	1.48462249	80	4.76736803	92	0
25-Aug	84	1.33873361	84	1.49098562	90	0	82	7.53473607	92	0
26-Aug	88	0	87	0	91	0	89	3.3021041	90	0
27-Aug	84	1.33873361	90	0	89	0	88	0.06947214	90	0
28-Aug	86	0.67746722	90	0	90	0	90	0	92	0
29-Aug	88	0	91	0	93	0	91	0	92	0
30-Aug	84	1.33873361	91	0	93	0	91	0	88	0
31-Aug	82	4.67746722	88	0	91	0	84	0.76736803	87	0
01-Sep	80	10.0162008	88	0	87	0	88	0	79	7.64387997
02-Sep	73	22.3549344	91	0	84	1.03727865	91	0	81	13.2877599
03-Sep	87	20.693668	93	0	77	9.07455731	84	0.76736803	82	17.9316399
04-Sep	84	22.0324016	81	0.8727464	90	4.11183596	93	0	87	17.5755199
05-Sep	87	20.3711353	81	1.74549281	91	0	96	0	81	23.2193999
06-Sep	89	16.7098689	82	1.61823921	89	0	96	0	66	43.8632798
07-Sep	89	13.0486025	86	0	90	0	91	0	66	64.5071598
08-Sep	89	9.38733608	88	0	89	0	91	0	75	76.1510398
09-Sep	91	3.72606969	84	0	79	6.03727865	77	7.76736803	80	82.7949197
10-Sep	84	5.06480329	80	1.8727464	78	13.0745573	87	5.53473607	82	87.4387997
11-Sep	86	4.4035369	82	1.74549281	81	17.111836	87	3.3021041	84	90.0826797
12-Sep	88	1.74227051	86	0	84	18.1491146	87	1.06947214	86	90.7265596
13-Sep	78	9.08100412	87	0	89	14.1863933	86	0	87	90.3704396
14-Sep	79	15.4197377	87	0	87	12.2236719	87	0	86	91.0143196
15-Sep	86	14.7584713	88	0	87	10.2609506	89	0	80	97.6581996
16-Sep	82	18.0972049	88	0	88	7.29822922	81	3.76736803	75	109.30208
17-Sep	82	21.4359385	90	0	87	5.33550788	81	7.53473607	73	122.94596
18-Sep	78	28.7746722	88	0	82	8.37278653	82	10.3021041	73	136.589839
19-Sep	79	35.1134058	91	0	80	13.4100652	79	16.0694721	84	139.233719
20-Sep	79	41.4521394	95	0	82	16.4473438	68	32.8368402	87	138.877599
21-Sep	78	48.790873	89	0	82	19.4846225	79	38.6042082	77	148.521479
22-Sep	81	53.1296066	70	11.8727464	88	16.5219011	72	51.3715762	73	162.165359
23-Sep	84	54.4683402	80	13.7454928	84	17.5591798	75	61.1389443	81	167.809239
24-Sep	84	55.8070738	82	13.6182392	81	21.5964584	78	67.9063123	84	170.453119
25-Sep	87	54.1458074	66	29.4909856	82	24.6337371	81	71.6736803	82	175.096999
26-Sep	84	55.484541	70	41.363732	84	25.6710158	82	74.4410484	68	193.740879
27-Sep	79	61.8232746	64	59.2364784	87	23.7082944	78	81.2084164	71	209.384759
28-Sep	75	72.1620082	68	73.1092248	80	28.7455731	80	85.9757844	75	221.028639
29-Sep	72	85.5007418	77	77.9819712	75	38.7828517	77	93.7431525	73	234.672519
30-Sep	64	106.839475	86	73.8547176	75	48.8201304	71	107.510521	75	246.316399
01-Oct	66	126.178209	75	80.727464	86	47.857409	73	119.277889	77	255.960279
02-Oct	72	139.516943	73	89.6002104	78	54.8946877	75	129.045257	79	263.604159
03-Oct	84	140.855676	75	96.4729568	77	62.9319663	84	129.812625	82	268.248039
04-Oct	70	156.19441	78	100.345703	82	65.969245	71	143.579993	81	273.891919
05-Oct	66	175.533143	81	101.21845	82	69.0065236	73	155.347361	82	278.535799
06-Oct	64	196.871877	82	101.091196	73	81.0438023	71	169.114729	73	292.179679
07-Oct	60	222.210611	82	100.963942	82	84.0810809	73	180.882097	66	312.823559
08-Oct	78	229.549344	82	100.836689	69	100.11836	73	192.649465	55	344.467439
09-Oct	70	244.888078	80	102.709435	72	113.155638	72	205.416833	55	376.111319
10-Oct	72	258.226812	82	102.582182	73	125.192917	72	218.184201	64	398.755199
11-Oct	69	274.565545	82	102.454928	78	132.230196	73	229.951569	71	414.399079
12-Oct	69	290.904279	79	105.327674	78	139.267474	70	244.718937	73	428.042959
13-Oct	73	303.243012	80	107.200421	78	146.304753	64	265.486305	75	439.686839
14-Oct	79	309.581746	68	121.073167	75	156.342032	75	275.253673	75	451.330719
15-Oct	81	313.92048	63	139.945914	79	162.37931	73	287.021041	77	460.974599
16-Oct	80	319.259213	57	164.81866	78	169.416589	77	294.788409	80	467.618479
17-Oct	82	322.597947	66	180.691407	77	177.453867	80	299.555777	80	474.262359
18-Oct	66	341.93668	64	198.564153	78	184.491146	71	313.323145	80	480.906239
19-Oct	63	364.275414	69	211.436899	82	187.528425	66	332.090513	73	494.550119
20-Oct	68	381.614148	70	223.309646	75	197.565703	60	356.857881	73	508.193999
21-Oct	79	387.952881	70	235.182392	73	209.602982	64	377.625249	75	519.837879
22-Oct	81	392.291615	62	255.055139	63	231.640261	73	389.392617	79	527.481758
23-Oct	69	408.630348	63	273.927885	63	253.677539	57	417.159985	75	539.125638
24-Oct	73	420.969082	62	293.800631	72	266.714818	59	442.927353	75	550.769518
25-Oct	73	433.307816	75	300.673378	75	276.752097	64	463.694721	78	559.413398
26-Oct	75	443.646549	71	311.546124	79	282.789375	69	479.462089	75	571.057278
27-Oct	75	453.985283	57	336.418871	79	288.826654	75	489.229457	78	579.701158
28-Oct	81	458.324016	55	363.291617	79	294.863933	73	500.996825	80	586.345038
29-Oct	82	461.66275	64	381.164363	78	301.901211	72	513.764194	75	597.988918
30-Oct	82	465.001484	66	397.03711	82	304.93849	75	523.531562	77	607.632798
31-Oct	81	469.340217	60	418.909856	79	310.975769	75	533.29893	78	616.276678
T	42.7416962		46.5951166		32.0465683		48.6166422		47.5934584	
C	4.27416962		4.65951166		3.20465683		4.86166422		4.75934584	
MEAN	89.6129032		86.5322581		88.2419355		89.6290323		91.4032258	
SD	8.54833924		9.31902332		6.40931366		9.72332845		9.51869167	

DAY	2001		2002		2003		2004		2005		2006		2007		2008	
01-Jul	84	0	90	0	73	9.71683108	82	1.16852978	91	0	93	0	95	0	85	0
02-Jul	87	0	90	0	81	11.4336622	81	3.33705955	89	0	93	0	85	1.69297806	87	0
03-Jul	87	0	87	0	87	7.15049324	86	0.50558933	86	0	93	0	82	6.38595612	91	0
04-Jul	84	0	89	0	86	3.86732431	88	0	86	0	91	0	86	7.07893418	90	0
05-Jul	86	0	93	0	80	6.58415539	90	0	89	0	90	0	88	5.77191224	88	0
06-Jul	87	0	93	0	84	5.30098647	90	0	82	1.11717305	81	4.07091557	87	5.4648903	82	1.34309143
07-Jul	87	0	89	0	87	1.01781755	89	0	76	8.2343461	80	9.14183114	82	10.1578684	88	0
08-Jul	89	0	89	0	90	0	87	0	88	3.35151915	82	12.2127467	82	14.8508464	90	0
09-Jul	91	0	90	0	89	0	88	0	89	0	84	13.2836623	89	12.5438245	89	0
10-Jul	87	0	91	0	84	0	89	0	78	5.11717305	84	14.3545779	86	13.2368025	87	0
11-Jul	90	0	84	0.49663012	84	0	90	0	83	5.2343461	90	9.42549343	85	14.9297806	89	0
12-Jul	90	0	77	7.99326023	86	0	89	0	86	2.35151915	91	3.496409	87	14.6227587	93	0
13-Jul	86	0	82	10.4898904	87	0	91	0	84	1.4686922	91	0	86	15.3157367	85	0
14-Jul	82	0.62967709	88	6.98652047	84	0	91	0	87	0	91	0	84	18.0087148	88	0
15-Jul	82	1.25935419	91	0.48315059	86	0	84	0	84	0	91	0	81	23.7016928	89	0
16-Jul	84	0	93	0	88	0	84	0	85	0	91	0	86	24.3946709	89	0
17-Jul	87	0	93	0	88	0	84	0	89	0	93	0	89	22.087649	88	0
18-Jul	88	0	93	0	88	0	87	0	90	0	93	0	89	19.780627	90	0
19-Jul	90	0	93	0	88	0	84	0	89	0	96	0	88	18.4736051	91	0
20-Jul	87	0	91	0	88	0	88	0	89	0	93	0	86	19.1665831	94	0
21-Jul	84	0	95	0	89	0	89	0	90	0	93	0	86	19.8595612	95	0
22-Jul	87	0	91	0	86	0	89	0	91	0	91	0	79	27.5525393	92	0
23-Jul	90	0	89	0	81	1.71683108	93	0	91	0	86	0	82	32.2455173	87	0
24-Jul	84	0	87	0	82	2.43366216	95	0	90	0	87	0	87	31.9384954	88	0
25-Jul	82	0.62967709	84	0.49663012	84	1.15049324	89	0	92	0	88	0	87	31.6314734	89	0
26-Jul	88	0	86	0	87	0	87	0	94	0	93	0	87	31.3244515	87	0
27-Jul	90	0	89	0	87	0	84	0	92	0	95	0	90	28.0174296	90	0
28-Jul	84	0	91	0	89	0	89	0	90	0	96	0	89	25.7104076	93	0
29-Jul	89	0	91	0	88	0	87	0	83	0.11717305	91	0	87	25.4033857	92	0
30-Jul	89	0	88	0	84	0	89	0	78	5.2343461	91	0	92	20.0963637	90	0
31-Jul	87	0	90	0	88	0	90	0	84	4.35151915	94	0	90	16.7893418	88	0
01-Aug	84	0	93	0	84	0	91	0	82	5.4686922	95	0	92	11.4823199	89	0
02-Aug	84	0	91	0	84	0	90	0	86	2.58586525	95	0	92	6.17529792	92	0
03-Aug	84	0	91	0	84	0	91	0	88	0	97	0	94	0	91	0
04-Aug	86	0	91	0	82	0.71683108	91	0	91	0	98	0	97	0	91	0
05-Aug	88	0	93	0	84	0	90	0	88	0	96	0	96	0	92	0
06-Aug	84	0	97	0	82	0.71683108	84	0	86	0	89	0	98	0	94	0
07-Aug	86	0	87	0	84	0	81	2.16852978	80	3.11717305	97	0	98	0	90	0
08-Aug	88	0	87	0	84	0	82	3.33705955	82	4.2343461	96	0	100	0	86	0
09-Aug	87	0	86	0	86	0	84	2.50558933	85	2.35151915	95	0	103	0	85	0
10-Aug	88	0	88	0	87	0	75	10.6741191	83	2.4686922	96	0	103	0	85	0
11-Aug	86	0	89	0	84	0	82	11.8426489	87	0	88	0	100	0	88	0
12-Aug	86	0	91	0	81	1.71683108	80	15.0111787	88	0	84	1.07091557	90	0	81	2.34309143
13-Aug	81	1.62967709	91	0	87	0	77	21.1797084	86	0	81	5.14183114	100	0	81	4.68618287
14-Aug	87	0	89	0	89	0	82	22.3482382	90	0	87	3.21274672	99	0	84	4.0292743
15-Aug	84	0	88	0	90	0	82	23.516768	92	0	86	2.28366229	102	0	87	0.37236573
16-Aug	90	0	90	0	86	0	84	22.6852978	89	0	89	0	101	0	86	0
17-Aug	91	0	91	0	89	0	86	19.8538275	90	0	86	0	101	0	85	0
18-Aug	91	0	93	0	90	0	86	17.0223573	90	0	88	0	97	0	86	0
19-Aug	87	0	91	0	90	0	89	11.1908871	89	0	88	0	95	0	90	0
20-Aug	86	0	93	0	87	0	88	6.35941686	92	0	93	0	96	0	90	0
21-Aug	88	0	93	0	88	0	82	7.52794663	94	0	91	0	99	0	85	0
22-Aug	90	0	91	0	88	0	84	6.69647641	93	0	88	0	104	0	82	1.34309143
23-Aug	88	0	95	0	90	0	84	5.86500619	87	0	87	0	98	0	78	6.68618287
24-Aug	93	0	93	0	89	0	87	2.03353596	85	0	83	2.07091557	95	0	83	7.0292743
25-Aug	90	0	91	0	88	0	82	3.20206574	84	0	85	2.14183114	94	0	78	12.3723657
26-Aug	91	0	88	0	89	0	86	0.37059551	84	0	88	0	92	0	83	12.7154572
27-Aug	91	0	84	0.49663012	90	0	88	0	86	0	88	0	88	0	80	16.0585486
28-Aug	81	1.62967709	82	2.99326023	91	0	90	0	86	0	90	0	88	0	86	13.40164
29-Aug	86	0	82	5.48989035	89	0	87	0	85	0	90	0	89	0	89	7.74473147
30-Aug	81	1.62967709	78	11.9865205	88	0	88	0	85	0	88	0	89	0	89	2.0878229
31-Aug	82	2.25935419	77	19.4831506	89	0	87	0	85	0	80	5.07091557	86	0.69297806	88	0
01-Sep	80	4.88903128	84	19.9797807	88	0	82	1.16852978	85	0	85	5.14183114	84	3.38595612	81	2.34309143
02-Sep	75	12.5187084	84	20.4764108	86	0	80	4.33705955	88	0	86	4.21274672	83	7.07893418	85	0.68618287
03-Sep	73	22.1483855	89	15.9730409	87	0	81	6.50558933	87	0	85	4.28366229	88	5.77191224	83	1.0292743
04-Sep	81	23.7780626	95	5.46967105	87	0	82	7.6741191	85	0	88	1.35457786	91	1.4648903	85	0
05-Sep	90	16.4077397	93	0	84	0	84	6.84264888	81	2.11717305	83	3.42549343	89	0	88	0
06-Sep	88	11.0374168	91	0	73	9.71683108	81	9.01117865	81	4.2343461	85	3.496409	85	1.69297806	87	0
07-Sep	87	6.66709385	88	0	75	17.4336622	86	6.17970843	83	4.35151915	80	8.56732457	86	2.38595612	89	0
08-Sep	86	3.29677094	87	0	81	19.1504932	73	16.3482382	85	2.4686922	83	10.6382401	88	1.07893418	90	0
09-Sep	86	0	91	0	82	19.8673243	84	15.516768	86	0	83	12.7091557	89	0	88	0
10-Sep	89	0	95	0	79	23.5841554	84	14.6852978	84	0	85	12.7800713	89	0	87	0
11-Sep	87	0	95	0	80	26.3009865	84	13.8538275	84	0	84	13.8509869	89	0	83	0.34309143
12-Sep	84	0	90	0	81	28.0178175	81	16.0223573	86	0	82	16.9219024	86	0.69297806	87	0
13-Sep	84	0	75	9.49663012	84	26.7346486	79	20.1908871	88	0	70	31.992818	85	2.38595612	86	0
14-Sep	86	0	78	15.9932602	82	27.4514797	79	24.3594169	88	0	80	37.0637336	81	8.07893418	88	0
15-Sep	77	5.62967709	91	9.48989035	82	28.1683108	73	34.5279466	91	0	82	40.1346491	82	12.7719122	79	4.34309143
16-Sep	77	11.2593542	88	5.98652047	81	29.8851419	75	42.6964764	88	0	83	42.2055647	76	23.4648903	80	7.68618287
17-Sep	81	12.8890313	86	4.48315059	81	31.6019729	80	45.8650062	86	0	85	42.2764803	78	32.1578684	69	22.0292743
18-Sep	81	14.5187084	81	7.9797807	81	33.318804	79	50.033536	88	0	85	42.3473959	79	39.8508464	82	23.3723657
19-Sep	82	15.1483855	80	12.4764108	84	32.0356351	78	55.2020657	90	0	79	48.4183114	82	44.5438245	81	25.7154572
20-Sep	84	13.7780626	86	10.9730409	87	27.7524662	73	65.3705955	90	0	73	60.489227	81	50.2368025	79	30.0585486
21-Sep	86	10.4077397	84	11.4696711	82	28.4692973	75	73.5391253	90	0	75	70.5601426	78	58.9297806	75	38.40164
22-Sep	87	6.03741675	77	18.9663012	75	36.1861283	80	76.7076551	86	0	82	73.6310582	86	59.6227587	84	37.7447315
23-Sep	88	0.66709385	82	21.4629313	81	37.9029594	84	75.8761848	87	0	86	72.7019737	83	63.3157367	82	39.0878229
24-Sep	69	14.2967709	73	32.9595614	80	40.6197905	82	77.0447146	88	0	84	73.7728893	89	61.0087148	78	44.4309143
25-Sep	66	30.926448	69	48.4561915	82	41.3366216	81	79.2132444	85	0	75	83.8438049	87	60.7016928	82	45.7740058
26-Sep	72	41.5561251	75	57.9528216	82	42.0534526	79	83.3817742	77	6.11717305	78	90.9147204	84	63.3946709	80	49.1170972
27-Sep	75	49.1858022	75	67.4494518	82	42.7702837	72	94.5503039	86	3.2343461	79	96.985636	85	65.087649	77	55.4601886
28-Sep	78	53.8154793	79	72.9460819	73	52.4871148	78	99.7188337	85	1.35151915	81	101.056552	85	66.780627	86	52.8032801
29-Sep	71	65.4451564	73	84.442712	66	69.2039459	78	104.887363	85	0	70	116.127467	81	72.4736051	86	50.1463715
30-Sep	71	77.0748335	79	89.9393421	71	80.920777	80	108.055893	82	1.11717305	75	126.198383	79	80.1665831	86	47.4894629
01-Oct	75	84.7045106	82	92.4359722	72	91.637608	82	109.224423	83	1.2343461	83	128.269298	80	86.8595612	74	56.8325544
02-Oct	80	87.3341877	84	92.9326023	68	106.354439	82	110.392953	85	0	81	132.340214	82	91.5525393	74	66.1756458
03-Oct	81	88.9638648	84	93.4292325	66	123.07127	80	113.561483	83	0.11717305	82	135.411129	77	101.245517	80	69.5187372
04-Oct	80	91.5935419	82	95.9258626	77	128.788101	81	115.730012	85	0	84	136.482045	80	107.938495	83	69.8618287
05-Oct	79	95.223219	87	93.4224927	78	133.504932	80	118.898542	81	2.11717305	86	135.552961	81	113.631473	83	70.2049201
06-Oct	70	107.852896	86	91.9191228	75	141.221763	75	127.067072	72	13.2343461	76	144.623876	82	118.324451	82	71.5480115
07-Oct	68	122.482573	80	96.4157529	73	150.938595	75	135.235602	72	24.3515191	72	157.694792	83	122.01743	82	72.891103
08-Oct	79	126.11225	71	109.912383	73	160.655426	73	145.404131	73	34.4686922	72	170.765707	83	125.710408	72	84.2341944
09-Oct	66	142.741927	66	128.409013	73	170.372257	71	157.572661	70	47.5858652	79	176.836623	81	131.403386	75	92.5772858
10-Oct	73	152.371604	70	142.905643	73	180.089088	71	169.741191	77	53.7030383	80	181.907538	81	137.096364	77	98.9203773
11-Oct	75	160.001282	78	149.402273	66	196.805919	77	175.909721	82	54.8202113	80	186.978454	67	156.789342	78	104.263469
12-Oct	78	164.630959	84	149.898904	78	201.52275	73	186.078251	74	63.9373844	71	201.04937	72	171.48232	77	110.60656
13-Oct	78	169.260636	79	155.395534	78	206.239581	64	205.24678	77	70.0545574	62	224.120285	74	184.175298	77	116.949652
14-Oct	75	176.890313	68	171.892164	78	210.956412	63	225.41531	78	75.1717305	69	240.191201	78	192.868276	80	120.292743
15-Oct	75	184.51999	57	199.388794	69	224.673243	62	246.58384	79	79.2889035	70	255.262116	78	201.561254	81	122.635834
16-Oct	62	205.149667	66	217.885424	72	235.390074	71	258.75237	76	86.4060766	59	281.333032	76	212.254232	83	122.978926
17-Oct	60	227.779344	64	238.382054	68	250.106905	75	266.920899	75	94.5232496	71	295.403947	82	216.94721	69	137.322017
18-Oct	64	246.409021	68	254.878684	70	262.823736	73	277.089429	81	96.6404227	77	303.474863	77	226.640188	67	153.665109
19-Oct	71	258.038698	71	268.375314	75	270.540567	68	292.257959	83	96.7575957	76	312.545779	76	237.333166	65	172.0082
20-Oct	75	265.668375	73	279.871944	78	275.257399	71	304.426489	83	96.8747688	69	328.616694	75	249.026144	66	189.351292
21-Oct	79	269.298052	71	293.368575	84	273.97423	73	314.595019	80	99.9919418	69	344.68761	78	257.719122	72	200.694383
22-Oct	80	271.92773	64	313.865205	78	278.691061	73	324.763548	67	116.109115	70	359.758525	72	272.4121	68	216.037474
23-Oct	81	273.557407	59	339.361835	78	283.407892	70	337.932078	70	129.226288	53	391.829441	81	278.105079	62	237.380566
24-Oct	79	277.187084	68	355.858465	73	293.124723	73	348.100608	56	156.343461	56	420.900356	59	305.798057	54	266.723657
25-Oct	73	286.816761	60	380.355095	73	302.841554	78	353.269138	54	185.460634	55	450.971272	61	331.491035	67	283.066749
26-Oct	64	305.446438	68	396.851725	68	317.558385	79	357.437667	61	207.577807	62	474.042188	68	350.184013	70	296.40984
27-Oct	51	337.076115	69	412.348355	64	336.275216	81	359.606197	63	227.69498	66	493.113103	67	369.876991	59	320.752932
28-Oct	55	364.705792	75	421.844985	57	361.992047	78	364.774727	62	248.812153	63	515.184019	70	386.569969	50	354.096023
29-Oct	63	384.335469	75	431.341615	70	374.708878	75	372.943257	64	267.929326	72	528.254934	62	411.262947	59	378.439115
30-Oct	72	394.965146	68	447.838246	77	380.425709	78	378.111787	69	282.046499	73	540.32585	67	430.955925	65	396.782206
31-Oct	71	406.594823	60	472.334876	75	388.14254	82	379.280316	70	295.163672	68	557.396765	71	446.648903	67	413.125297
T	41.1225839		47.130473		35.0897537		33.3147022		38.6669792		48.9682636		45.1669936		43.6658599	
C	4.11225839		4.7130473		3.50897537		3.33147022		3.86669792		4.89682636		4.51669936		4.36658599	
MEAN	86.7419355		89.2096774		86.2258065		86.5		86.983871		89.9677419		91.2096774		87.7096774	
SD	8.22451678		9.4260946		7.01795075		6.66294045		7.73339584		9.79365273		9.03339872		8.73317197	

DAY	2009		2010		2011		2012		2013		2014		2015	
01-Jul	95	0	87	0.58387317	92	0	105	0	82	0	90	0	85	0.06471958
02-Jul	90	0	84	4.16774633	94	0	93	0	85	0	93	0	87	0
03-Jul	89	0	83	8.7516195	95	0	99	0	76	4.9754386	87	0	79	6.06471958
04-Jul	91	0	85	11.3354927	92	0	98	0	77	8.95087721	84	0.13974593	85	6.12943917
05-Jul	80	2.606307	88	10.9193658	90	0	100	0	83	6.92631581	86	0	84	7.19415875
06-Jul	87	0	89	9.50323899	90	0	98	0	83	4.90175442	87	0	84	8.25887834
07-Jul	86	0	94	3.08711216	94	0	93	0	79	6.87719302	89	0	90	3.32359792
08-Jul	82	0.606307	97	0	94	0	95	0	88	0	90	0	90	0
09-Jul	84	0	96	0	91	0	97	0	88	0	90	0	91	0
10-Jul	84	0	90	0	92	0	95	0	87	0	87	0	93	0
11-Jul	86	0	93	0	95	0	90	0	80	0.9754386	85	0	92	0
12-Jul	90	0	90	0	95	0	84	2.24478436	87	0	90	0	93	0
13-Jul	84	0	91	0	97	0	90	0	78	2.9754386	89	0	92	0
14-Jul	89	0	91	0	90	0	90	0	85	0	90	0	90	0
15-Jul	89	0	94	0	80	7.74409885	90	0	86	0	86	0	89	0
16-Jul	90	0	89	0	85	10.4881977	92	0	87	0	83	1.13974593	88	0
17-Jul	88	0	87	0.58387317	87	11.2322965	93	0	91	0	86	0	93	0
18-Jul	82	0.606307	83	5.16774633	89	9.97639539	93	0	87	0	82	2.13974593	92	0
19-Jul	80	3.21261399	90	2.7516195	94	3.72049424	91	0	90	0	85	1.27949186	91	0
20-Jul	82	3.81892099	91	0	91	0.46459309	84	2.24478436	86	0	76	9.41923779	93	0
21-Jul	86	0.42522799	94	0	92	0	90	0	87	0	82	11.5589837	93	0
22-Jul	84	0	95	0	94	0	95	0	85	0	83	12.6987296	92	0
23-Jul	87	0	97	0	92	0	97	0	84	0	88	8.83847558	88	0
24-Jul	88	0	94	0	92	0	97	0	86	0	87	5.97822151	91	0
25-Jul	90	0	95	0	90	0	98	0	89	0	88	2.11796744	90	0
26-Jul	92	0	95	0	94	0	98	0	86	0	89	0	91	0
27-Jul	90	0	93	0	94	0	97	0	82	0	92	0	92	0
28-Jul	89	0	90	0	90	0	97	0	86	0	90	0	94	0
29-Jul	85	0	94	0	93	0	94	0	86	0	82	2.13974593	93	0
30-Jul	82	0.606307	95	0	96	0	96	0	90	0	84	2.27949186	94	0
31-Jul	85	0	95	0	96	0	88	0	80	0.9754386	85	1.41923779	93	0
01-Aug	89	0	96	0	91	0	94	0	87	0	81	4.55898372	89	0
02-Aug	83	0	84	3.58387317	96	0	99	0	89	0	84	4.69872965	94	0
03-Aug	90	0	92	0	97	0	94	0	88	0	88	0.83847558	94	0
04-Aug	92	0	95	0	85	2.74409885	87	0	90	0	90	0	97	0
05-Aug	92	0	93	0	96	0	90	0	88	0	89	0	95	0
06-Aug	89	0	93	0	93	0	86	0.24478436	88	0	92	0	88	0
07-Aug	91	0	91	0	93	0	84	2.48956872	86	0	95	0	88	0
08-Aug	92	0	93	0	94	0	92	0	83	0	90	0	92	0
09-Aug	93	0	94	0	91	0	88	0	89	0	89	0	93	0
10-Aug	93	0	94	0	95	0	87	0	90	0	86	0	94	0
11-Aug	95	0	95	0	94	0	85	1.24478436	90	0	83	1.13974593	91	0
12-Aug	86	0	95	0	95	0	88	0	90	0	88	0	90	0
13-Aug	90	0	96	0	95	0	91	0	89	0	84	0.13974593	89	0
14-Aug	90	0	89	0	94	0	88	0	83	0	85	0	90	0
15-Aug	90	0	90	0	88	0	85	1.24478436	73	7.9754386	87	0	90	0
16-Aug	88	0	90	0	90	0	91	0	67	21.9508772	88	0	90	0
17-Aug	87	0	91	0	92	0	87	0	66	36.9263158	89	0	89	0
18-Aug	88	0	93	0	94	0	87	0	77	40.9017544	89	0	88	0
19-Aug	90	0	92	0	96	0	84	2.24478436	82	39.877193	86	0	89	0
20-Aug	88	0	93	0	93	0	84	4.48956872	84	36.8526316	89	0	88	0
21-Aug	88	0	93	0	94	0	88	2.73435307	84	33.8280702	92	0	89	0
22-Aug	85	0	94	0	98	0	84	4.97913743	88	26.8035088	93	0	92	0
23-Aug	81	1.606307	93	0	92	0	88	3.22392179	90	17.7789474	93	0	87	0
24-Aug	86	0	90	0	93	0	86	3.46870615	84	14.754386	88	0	89	0
25-Aug	87	0	89	0	95	0	85	4.7134905	82	13.7298246	84	0.13974593	84	1.06471958
26-Aug	90	0	90	0	99	0	90	0.95827486	82	12.7052632	86	0	86	0.12943917
27-Aug	83	0	89	0	95	0	90	0	86	7.68070185	88	0	85	0.19415875
28-Aug	75	7.606307	87	0.58387317	95	0	80	6.24478436	90	0	91	0	83	2.25887834
29-Aug	86	4.21261399	84	4.16774633	93	0	86	6.48956872	92	0	92	0	81	6.32359792
30-Aug	79	7.81892099	85	6.7516195	90	0	80	12.7343531	87	0	88	0	74	17.3883175
31-Aug	79	11.425228	89	5.33549266	92	0	89	9.97913743	90	0	89	0	84	18.4530371
01-Sep	71	23.031535	90	2.91936583	95	0	91	5.22392179	90	0	90	0	87	16.5177567
02-Sep	78	27.637842	91	0	96	0	89	2.46870615	84	0	90	0	90	11.5824763
03-Sep	79	31.244149	92	0	95	0	85	3.7134905	90	0	92	0	89	7.64719585
04-Sep	83	30.850456	84	3.58387317	80	7.74409885	77	12.9582749	89	0	82	2.13974593	92	0.71191543
05-Sep	83	30.456763	85	6.16774633	78	17.4881977	85	14.2030592	89	0	89	0	87	0
06-Sep	85	28.06307	90	3.7516195	75	30.2322965	85	15.4478436	88	0	91	0	85	0.06471958
07-Sep	84	26.669377	91	0.33549266	69	48.9763954	92	9.69262794	88	0	90	0	85	0.12943917
08-Sep	87	22.275684	93	0	73	63.7204942	88	7.93741229	91	0	84	0.13974593	84	1.19415875
09-Sep	84	20.881991	92	0	81	70.4645931	83	11.1821967	90	0	84	0.27949186	87	0
10-Sep	80	23.488298	94	0	84	74.2086919	84	13.426981	89	0	86	0	85	0.06471958
11-Sep	75	31.094605	96	0	86	75.9527908	83	16.6717654	89	0	90	0	86	0
12-Sep	81	32.700912	89	0	87	76.6968896	81	21.9165497	90	0	92	0	78	7.06471958
13-Sep	80	35.3072189	86	1.58387317	89	75.4409885	81	27.1613341	87	0	86	0	75	17.1294392
14-Sep	82	35.9135259	91	0	92	71.1850873	83	30.4061184	82	0	78	6.13974593	77	25.1941588
15-Sep	79	39.5198329	91	0	86	72.9291862	87	29.6509028	84	0	80	10.2794919	80	30.2588783
16-Sep	82	40.1261399	89	0	72	88.673285	86	29.8956872	89	0	86	8.41923779	79	36.3235979
17-Sep	73	49.7324469	95	0	79	97.4173839	83	33.1404715	79	1.9754386	86	6.55898372	83	38.3883175
18-Sep	80	52.3387539	93	0	77	108.161483	79	40.3852559	78	4.95087721	85	5.69872965	83	40.4530371
19-Sep	74	60.9450609	92	0	77	118.905582	81	45.6300402	84	1.92631581	84	5.83847558	87	38.5177567
20-Sep	81	62.5513679	96	0	82	124.64968	79	52.8748246	86	0	83	6.97822151	89	34.5824763
21-Sep	79	66.1576749	95	0	86	126.393779	85	54.1196089	73	7.9754386	87	4.11796744	77	42.6471958
22-Sep	84	64.7639819	92	0	80	134.137878	87	53.3643933	82	6.95087721	82	6.25771337	76	51.7119154
23-Sep	83	64.3702889	91	0	83	138.881977	81	58.6091777	82	5.92631581	77	13.3974593	81	55.776635
24-Sep	85	61.9765959	88	0	82	144.626076	78	66.853962	71	15.9017544	78	19.5372052	74	66.8413546
25-Sep	87	57.5829029	93	0	88	144.370175	82	71.0987464	67	29.877193	77	26.6769512	67	84.9060742
26-Sep	85	55.1892099	76	11.5838732	86	146.114274	86	71.3435307	78	32.8526316	74	36.8166971	71	98.9707938
27-Sep	80	57.7955169	81	18.1677463	84	149.858372	88	69.5883151	79	34.8280702	78	42.956443	71	113.035513
28-Sep	83	57.4018239	76	29.7516195	79	158.602471	86	69.8330994	77	38.8035088	74	53.0961889	75	123.100233
29-Sep	72	68.0081309	79	38.3354927	84	162.34657	84	72.0778838	76	43.7789474	71	66.2359349	77	131.164953
30-Sep	74	76.6144379	76	49.9193658	78	172.090669	72	86.3226682	77	47.754386	84	66.3756808	85	131.229672
01-Oct	76	83.2207449	79	58.503239	65	194.834768	75	97.5674525	82	46.7298246	86	64.5154267	71	145.294392
02-Oct	75	90.8270519	78	68.0871122	68	214.578867	72	111.812237	82	45.7052632	85	63.6551727	66	164.359111
03-Oct	76	97.4333589	68	87.6709853	75	227.322965	74	124.057021	82	44.6807018	78	69.7949186	66	183.423831
04-Oct	74	106.039666	67	108.254858	80	235.067064	82	128.301806	85	40.6561405	65	88.9346645	70	198.48855
05-Oct	62	126.645973	70	125.838732	83	239.811163	82	132.54659	84	37.6315791	71	102.07441	73	210.55327
06-Oct	71	138.25228	73	140.422605	81	246.555262	83	135.791374	84	34.6070177	78	108.214156	76	219.61799
07-Oct	79	141.858587	81	147.006478	79	255.299361	68	154.036159	74	41.5824563	82	110.353902	81	223.682709
08-Oct	80	144.464894	82	152.590351	78	265.04346	63	177.280943	72	50.5578949	86	108.493648	82	226.747429
09-Oct	85	142.071201	85	155.174224	72	280.787559	70	193.525727	76	55.5333335	86	106.633394	81	230.812148
10-Oct	74	150.677508	86	156.758097	68	300.531657	73	206.770512	80	56.5087721	86	104.77314	71	244.876868
11-Oct	77	156.283815	86	158.341971	65	323.275756	75	218.015296	79	58.4842107	86	102.912886	73	256.941588
12-Oct	66	172.890122	80	165.925844	73	338.019855	79	225.26008	81	58.4596493	85	102.052632	76	266.006307
13-Oct	73	182.496429	80	173.509717	74	351.763954	75	236.504865	82	57.4350879	85	101.192378	81	270.071027
14-Oct	66	199.102736	73	188.09359	77	362.508053	77	245.749649	77	61.4105265	75	110.332124	78	277.135746
15-Oct	61	220.709043	78	197.677463	80	370.252152	77	254.994434	68	74.3859651	69	125.47187	81	281.200466
16-Oct	61	242.31535	76	209.261336	84	373.99625	74	267.239218	74	81.3614037	70	139.611616	77	289.265185
17-Oct	51	273.921657	80	216.84521	85	376.740349	75	278.484002	72	90.3368423	80	143.751362	70	304.329905
18-Oct	55	301.527964	78	226.429083	80	384.484448	74	290.728787	73	98.3122809	76	151.891108	66	323.394625
19-Oct	61	323.134271	82	232.012956	67	405.228547	73	303.973571	63	116.28772	73	163.030853	64	344.459344
20-Oct	68	337.740578	77	242.596829	59	433.972646	71	319.218355	70	127.263158	73	174.170599	71	358.524064
21-Oct	71	349.346885	80	250.180702	63	458.716745	76	329.46314	72	136.238597	77	181.310345	76	367.588783
22-Oct	74	357.953192	78	259.764575	68	478.460844	79	336.707924	69	148.214035	70	195.450091	79	373.653503
23-Oct	72	368.559499	76	271.348449	70	496.204942	78	344.952708	63	166.189474	72	207.589837	81	377.718223
24-Oct	69	382.165806	81	277.932322	73	510.949041	79	352.197493	66	181.164913	74	217.729583	76	386.782942
25-Oct	65	399.772113	76	289.516195	76	522.69314	80	358.442277	56	206.140351	77	224.869329	71	400.847662
26-Oct	65	417.37842	85	292.100068	77	533.437239	80	364.687061	61	226.11579	84	225.009075	67	418.912381
27-Oct	60	439.984727	76	303.683941	79	542.181338	70	380.931846	69	238.091228	84	225.148821	56	447.977101
28-Oct	71	451.591034	74	317.267814	74	555.925437	56	411.17663	64	255.066667	77	232.288567	78	455.04182
29-Oct	75	459.197341	68	336.851688	59	584.669536	56	441.421415	75	261.042106	73	243.428313	70	470.10654
30-Oct	66	475.803648	71	353.435561	61	611.413634	56	471.666199	78	264.017544	68	259.568059	70	485.17126
31-Oct	69	489.409955	75	366.019434	65	634.157733	65	492.910983	74	270.992983	63	280.707805	62	508.235979
T	45.0659623		37.2257845		49.6557857		46.2618338		38.6327107		32.9573794		43.5463525	
C	4.50659623		3.72257845		4.96557857		4.62618338		3.86327107		3.29573794		4.35463525	
MEAN	87.1129032		91.3064516		92.7096774		90.8709677		84.8387097		87.4354839		89.4193548	
SD	9.01319246		7.44515689		9.93115714		9.25236677		7.72654215		6.59147588		8.70927051	

The cut off line for each year varies (SD_n*5). So below is the summary of unofficial summer happens in each year. In summary, I calculate the average of this 20 dates and come up with the final unofficial summer date is Sep 22.

Year	Cut off date
1996	21-Sep
1997	27-Sep
1998	29-Sep
1999	22-Sep
2000	07-Sep
2001	26-Sep
2002	25-Sep
2003	22-Sep
2004	15-Sep
2005	09-Oct
2006	20-Sep
2007	20-Sep
2008	24-Sep
2009	17-Sep
2010	29-Sep
2011	08-Sep
2012	20-Sep
2013	28-Sep
2014	26-Sep
2015	22-Sep
Average	22-Sep

Question 6.2.2

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

In 6.2.1, we conclude that unofficial summer end on Sep 20ish. In this question, since it asks the Atlanta's summer climate, so we place our focus solely on the average temperature in a series of time between July1- Sep 20ish.(before unofficial summer end)

Setting parameters:

Mu = average summer season (July1- Sep 20ish.) temperate for 20 years

SD = Standard deviation

C= SD/2

T= C*5

Mu	87.61862401
SD	2.05038968
C	1.02519484
T	10.2519484

we could see below table, as we run CUSUM on these 20 data points. The highest amount is 6.05 which happens in 2011. This amount is still less than our set T(10). So we need to tweak the parameter T to fit these data. We changed the T = SD*2= 4.1

Below is the result showing that summer climate is truly gotten warmer since 2011, as the data onward from 2011 hit our threshold
T = SD*2= 4.1.

Year	Cut off date	Average Summer climate	CUSUM-Detect an increase
1996	21-Sep	88.12195122	0
1997	27-Sep	85.88636364	0
1998	29-Sep	87.11111111	0
1999	22-Sep	88.63855422	0
2000	07-Sep	90.33823529	1.694416445
2001	26-Sep	85.42528736	0
2002	25-Sep	88.30232558	0
2003	22-Sep	85.21686747	0
2004	15-Sep	85.56578947	0
2005	09-Oct	86.02	0
2006	20-Sep	88.28395062	0
2007	20-Sep	89.69135802	1.047539175
2008	24-Sep	86.54117647	0
2009	17-Sep	85.82051282	0
2010	29-Sep	90.81111111	2.167292262
2011	08-Sep	91.82608696	5.349560368
2012	20-Sep	89.34567901	6.051420531
2013	28-Sep	84.58426966	1.991871345
2014	26-Sep	86.7816092	0.12966169
2015	22-Sep	88.06024096	0
Average	22-Sep		
	Mu	87.61862401	
	SD	2.05038968	
	C	1.02519484	
	T	4.100779359	