Predicting the End of Summer with Temperatures from Atlanta

```
#Clear List, load libraries
rm(list = ls())
library(qcc)
library(forecast)
library(highcharter)
set.seed(5)

#Pull in temps data and view the head of the data
EoS <- read.table("temps.txt", header=TRUE, stringsAsFactors = FALSE)
head(EoS)
```

```
    DAY X1996 X1997 X1998 X1999 X2000 X2001 X2002 X2003
1 1-Jul    98    86    91    84    89    84    90    73
2 2-Jul    97    90    88    82    91    87    90    81
3 3-Jul    97    93    91    87    93    87    87    87
4 4-Jul    90    91    91    88    95    84    89    86
5 5-Jul    89    84    91    90    96    86    93    80
6 6-Jul    93    84    89    91    96    87    93    84
  X2004 X2005 X2006 X2007 X2008 X2009 X2010 X2011 X2012
1    82    91    93    95    85    95    87    92   105
2    81    89    93    85    87    90    84    94    93
3    86    86    93    82    91    89    83    95    99
4    88    86    91    86    90    91    85    92    98
5    90    89    90    88    88    80    88    90   100
6    90    82    81    87    82    87    89    90    98
  X2013 X2014 X2015
1    82    90    85
2    85    93    87
3    76    87    79
4    77    84    85
5    83    86    84
6    83    87    84
```

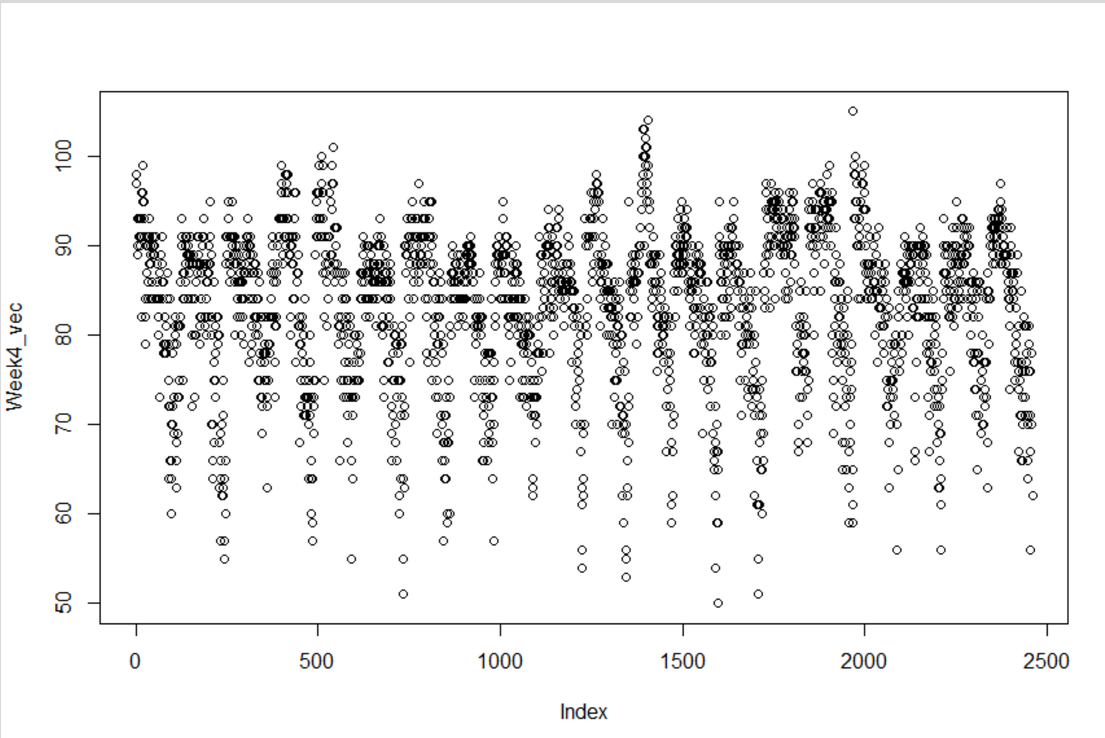
Display header of the data for me to check the first 5 days of July temperatures.

```
#Converting the table into a vector list.
EoS_vec <- as.vector(unlist(EoS[,2:21]))

#Display the output of the vector.
EoS_vec
```

```
[1] 98 97 97 90 89 93 93 91 93 93 90 91 93 93 82 91 96 95
[19] 96 99
```

Checking the head of the new vector I created.

```
#Plotting the vector to determine how the data points look like.
plot(EoS_vec)
```



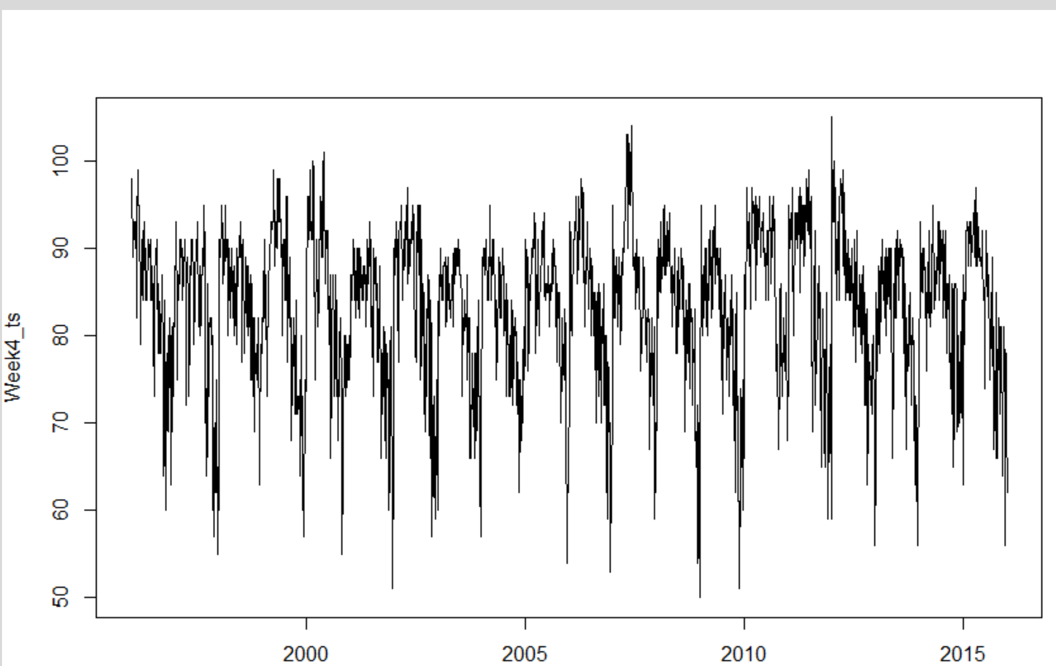
Plotted the vector to confirm that the data looks correctly and it does. It looks cyclical because the summer heats then cools.

```
#Converting the vector to a time series object for 123 days
EoS_ts <- ts(EoS_vec, start=1996, frequency=123)

#Display the output of the time-series.
EoS_ts
```

```
Time Series:
Start = c(1996, 1)
End = c(2015, 123)
Frequency = 123
…
…
…
[987]  86  88  90  90  89  87  88  89  90  89  91  91  84  84
 [ reached getOption("max.print") -- omitted 1460 entries ]
```

Too much output to print out so output is shortened. I can use this information to check for the Time Series.

```
#Plotting the time series.
plot(EoS_ts)
```



Plot looks correct. This plot is before smoothing.

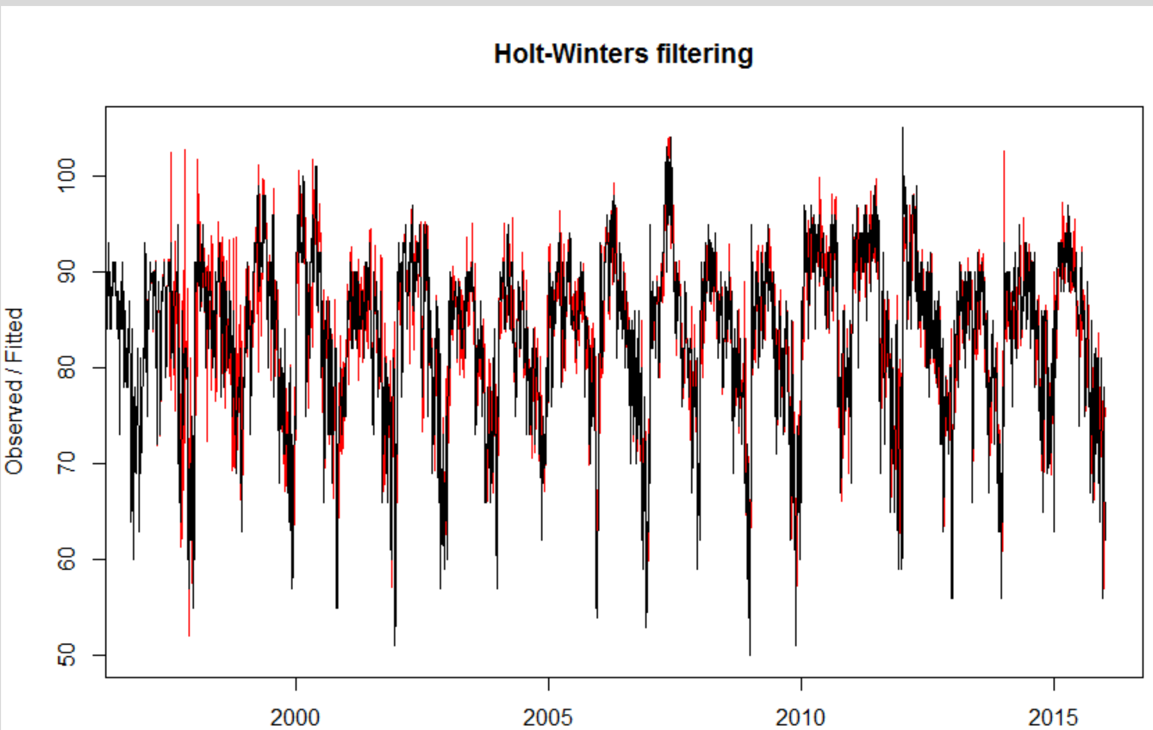
```
#Computes Holt Winters filtering with a seasonal model
EoS_HW <- HoltWinters(EoS_ts, alpha=NULL, beta=NULL, gamma=NULL, 
seasonal="multiplicative")
EoS_HW
```

```
Holt-Winters exponential smoothing with trend and multiplicative seasonal component.

Call:
HoltWinters(x = EoS_ts, alpha = NULL, beta = NULL, gamma = NULL,     seasonal = 
"multiplicative")

Smoothing parameters:
 alpha: 0.615003
 beta : 0
 gamma: 0.5495256

Coefficients:
            [,1]
a    73.679517064
b    -0.004362918
s1    1.239022317
s2    1.234344062
…
…
…
s120  0.851036184
s121  0.820416491
s122  0.851581233
s123  0.874038407
```

Shortened list. Converted Time Series to a HoltsWinter filter.

```
#Outputting a snippet of the data
tail(EoS_HW)
summary(EoS_HW)
plot(EoS_HW)
```

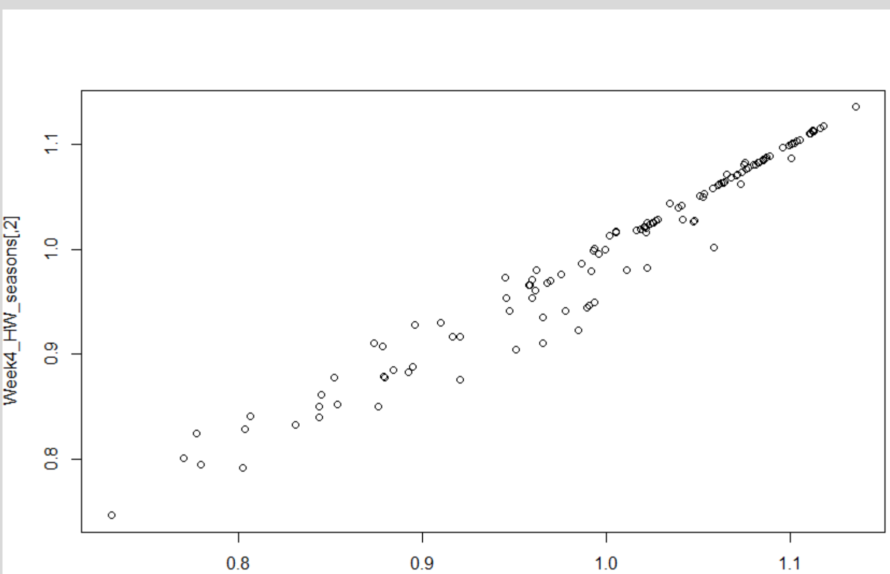
```
            Length Class  Mode
fitted       9348   mts    numeric
x            2460   ts     numeric
alpha           1   -none- numeric
beta            1   -none- numeric
gamma           1   -none- numeric
coefficients  125   -none- numeric
seasonal        1   -none- character
SSE             1   -none- numeric
call            6   -none- call
```



Added a smoothing model in red. The original data is in black.

```
#Converting the fitted data into a matrix and outputting the data
EoS_HW_seasons <- matrix(EoS_HW$fitted[,4], nrow=123)
head(EoS_HW_seasons)
plot(EoS_HW_seasons)
```

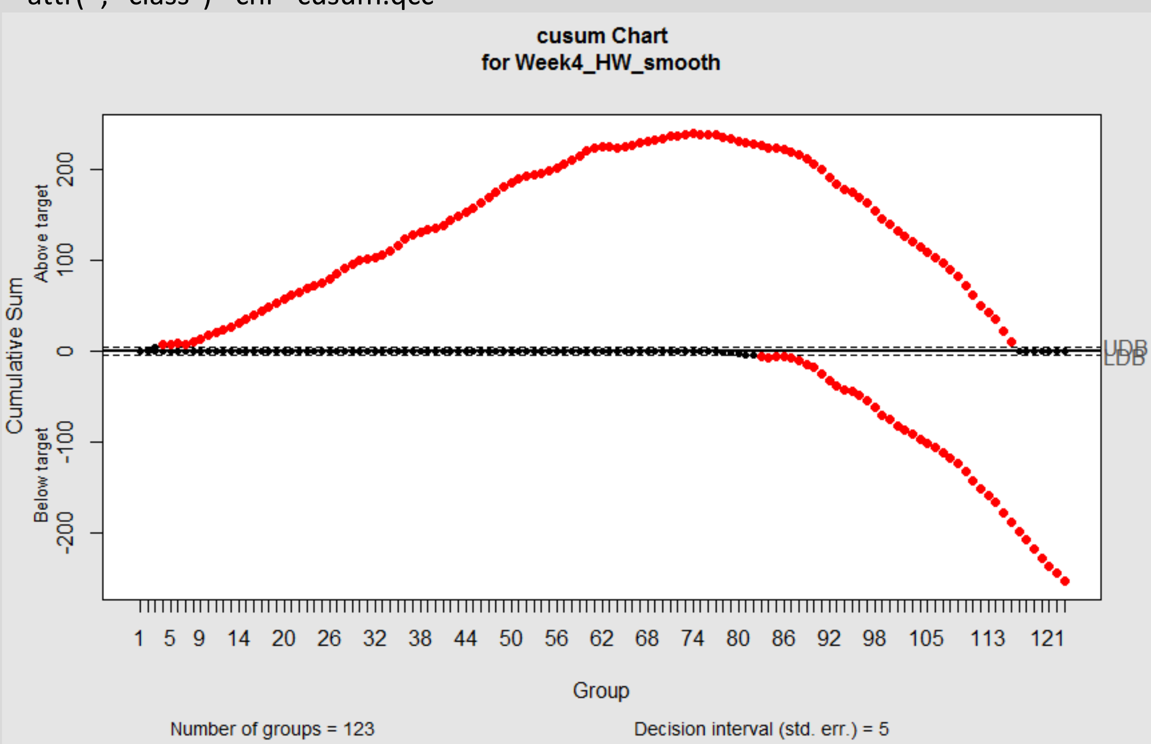
```
        [,1]     [,2]     [,3]     [,4]     [,5]     [,6]     [,7]     [,8]     [,9]    [,10]    [,11]    [,12]    [,13]
[1,] 1.052653 1.049468 1.120607 1.103336 1.118390 1.108172 1.140906 1.140574 1.125438
1.122063 1.161415 1.198102 1.198910
[2,] 1.100742 1.099653 1.108025 1.098323 1.110184 1.116213 1.126827 1.154074 1.142187
1.131889 1.144549 1.134661 1.153433
[3,] 1.135413 1.135420 1.139096 1.142831 1.143201 1.138495 1.129678 1.156092 1.165657
1.147982 1.149459 1.135756 1.153310
[4,] 1.110338 1.110492 1.117079 1.125774 1.134539 1.126117 1.130758 1.137722 1.150639
1.146992 1.142497 1.150162 1.151169
[5,] 1.025231 1.025233 1.044684 1.067291 1.084725 1.097239 1.115055 1.103877 1.120818
1.133733 1.132167 1.142714 1.139244
[6,] 1.025838 1.025722 1.028169 1.042340 1.053954 1.067494 1.080203 1.094312 1.102680
1.092178 1.075766 1.088547 1.082185
        [,14]    [,15]    [,16]    [,17]    [,18]    [,19]
[1,] 1.243012 1.243781 1.238435 1.300204 1.290647 1.254521
[2,] 1.165431 1.172935 1.190735 1.191956 1.219190 1.228826
[3,] 1.155197 1.157286 1.169773 1.189915 1.172309 1.169045
[4,] 1.157751 1.163844 1.159343 1.166605 1.167993 1.158956
[5,] 1.112909 1.132435 1.132045 1.145230 1.168161 1.170449
[6,] 1.103092 1.115071 1.118575 1.121598 1.134962 1.145475
```



Checking if the seasonal data is relatively linear, and it does look linear. This makes sense because the longer time passes, the higher away the standard deviation is from the average value.

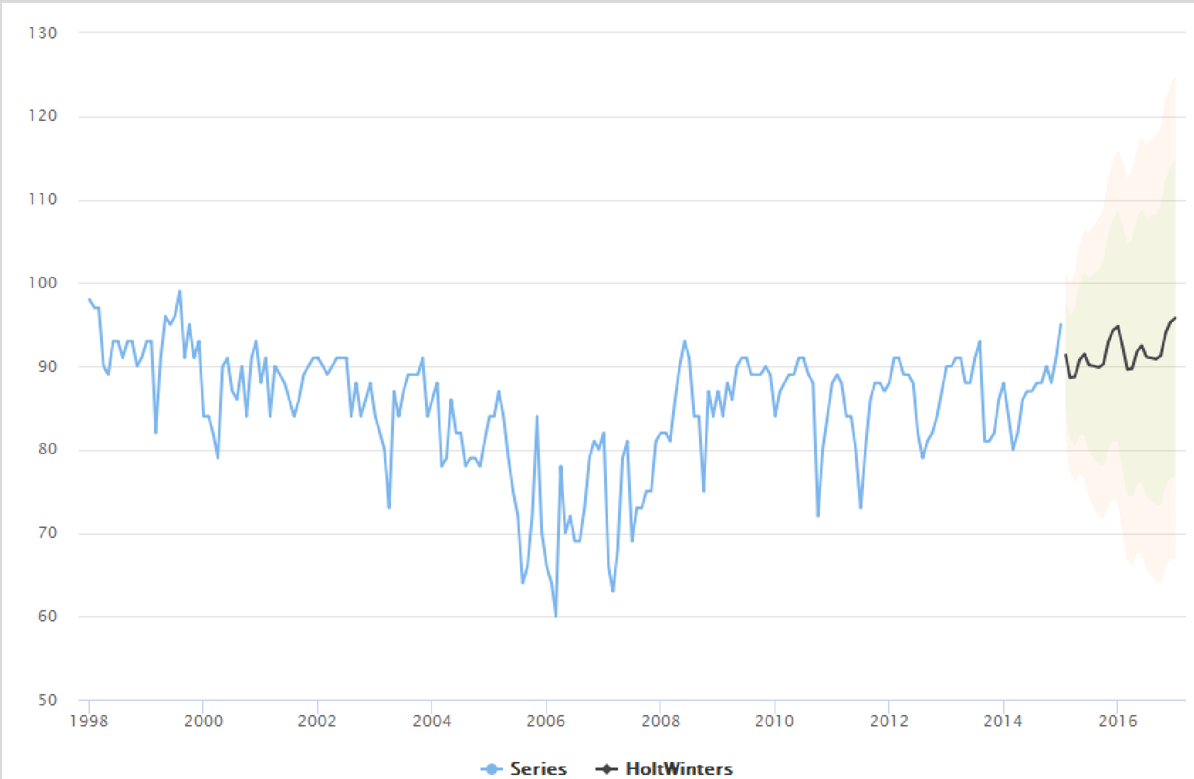
```
#Adding a smoothing function and performing a cusum
EoS_HW_smooth <- matrix(EoS_HW$fitted[,1], nrow=123)
EoS_HW_smooth

#Outputing the cusum of the smooth data
cusum(EoS_HW_smooth)
```

```
List of 14
 $ call           : language cusum(data = EoS_HW_smooth)
 $ type            : chr "cusum"
 $ data.name       : chr "EoS_HW_smooth"
 $ data            : num [1:123, 1:19] 87.2 90.4 93 90.9 84 ...
  ..- attr(*, "dimnames")=List of 2
 $ statistics      : Named num [1:123] 84.7 85.4 87.4 87 85.2 ...
  ..- attr(*, "names")= chr [1:123] "1" "2" "3" "4" ...
 $ sizes           : int [1:123] 19 19 19 19 19 19 19 19 19 19 ...
 $ center          : num 83.4
 $ std.dev         : num 5.3
 $ pos             : num [1:123] 0.6 1.8 4.61 7.12 8.17 ...
 $ neg             : num [1:123] 0 0 0 0 0 ...
 $ head.start      : num 0
 $ decision.interval: num 5
 $ se.shift        : num 1
 $ violations      :List of 2
 - attr(*, "class")= chr "cusum.qcc"
```



The cusum looks right as it reaches a height around September and cools off.

```
#Attempt to use forecasting on HoltWinters to predict future temperatures
EoS_ts_forecast <- ts(EoS_vec, start=1998, end=2015, frequency=12)
EoS_HW_forecast <- HoltWinters(EoS_ts_forecast)
hchart(forecast(EoS_HW_forecast, h=24))
```



I wanted to predict the temperature for the future two years (2016 – 2017) from 2015. As expected, there is an upwards trend which can be seen as a pattern on an analysis I performed on Excel and PowerBI. The increase in temperature is slight.

```
#Saving the fitted matrix onto an excel file for futher analysis
wholefile <- data.frame(EoS_HW_seasons)
write.csv(wholefile, file="EoS_HW.csv")
```

```
>
```

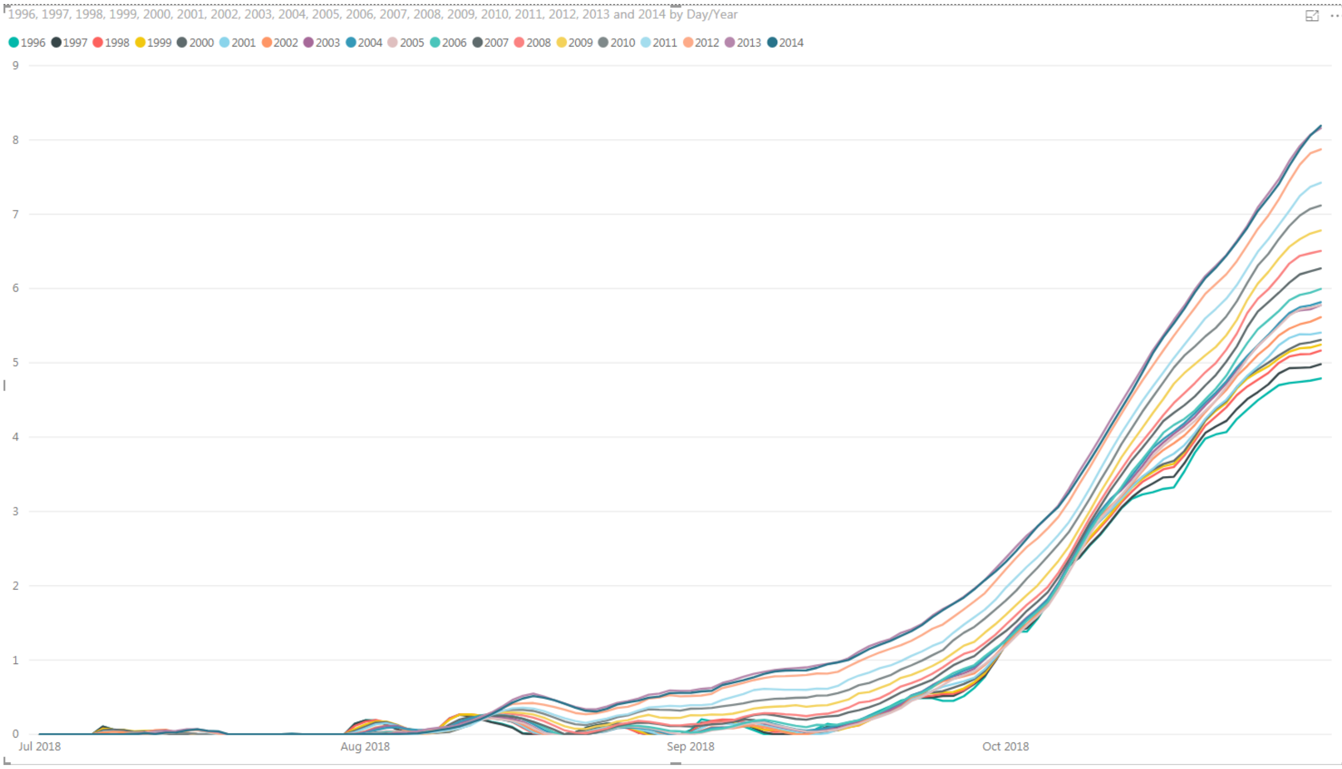
Writing the seasons data onto a csv file. I will show some output of the excel file.

C	0.05																		
T	2																		
S_t values																			
mu	1.071666	1.071521	1.074245	1.075091	1.075512	1.075558	1.077176	1.079374	1.079775	1.07811	1.08035	1.082471	1.08452	1.086303	1.089119	1.090984	1.094606	1.097235	1.096731
sd	0.042231	0.042279	0.039451	0.040783	0.042613	0.040339	0.043668	0.044323	0.043397	0.040136	0.040126	0.042136	0.043358	0.04662	0.048384	0.050344	0.058924	0.059181	0.057328
Day/Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7-Jul	0.105106	0.105124	0.077258	0.077517	0.055123	0.033734	0.024706	0	0	0	0	0	0	0	0	0	0	0	0
8-Jul	0.063247	0.063248	0.053628	0.066424	0.066599	0.041362	0.035371	0	0	0	0	0	0	0	0	0	0	0	0
9-Jul	0.057959	0.057872	0.049229	0.060779	0.057211	0.03008	0.027843	0	0	0	0	0	0	0	0	0	0	0	0
10-Jul	0.015259	0.015193	0.026428	0.041927	0.033184	0.018508	0.016339	0.00456	0	0.020947	0.011477	0.006686	0.004441	0	0.006422	0	0	0	0
11-Jul	0.008854	0.008779	0.021663	0.04833	0.03926	0.015765	0.03028	0.020643	0.009733	0.022399	0	0.002052	0	0	0	0	0.000265	0.017431	0.015388
12-Jul	0	0	0	0.043212	0.043674	0.017179	0.057412	0.042223	0.030358	0.029055	0	0	0	0	0	0	0.011615	0.016462	0.004599
13-Jul	0	0	0	0.035506	0.045262	0.028121	0.063864	0.049762	0.035948	0.036524	0.006018	0.007167	0.022201	0.027314	0.020707	0.010488	0.01361	0.041621	0.022754
14-Jul	0	0	0	0	0	0	0.02596	0.031232	0.02248	0.019099	0	0.006507	0.022756	0.022959	0.022256	0.02986	0.030169	0.047088	0.026914
15-Jul	0	0	0	0	0	0	0	0	0	0.000206	0	0.005949	0.021429	0.021238	0.016872	0.060639	0.059736	0.068933	0.054385
16-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.006101	0.053085	0.057256	0.069323	0.069241
17-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.025843	0.035959	0.044636	0.04734
18-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.008147	0.028745	0.041103
19-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22-Jul	0.001268	0.000685	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25-Jul	0	0	0	0	0	0	0.007576	0.000971	0.009477	0	0	0	0	0	0	0	0	0	0
26-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31-Jul	0.142984	0.142427	0.113719	0.073711	0.049346	0.02889	0.007161	0	0	0	0	0	0	0	0	0	0	0.007106	0
1-Aug	0.189202	0.18813	0.170712	0.134149	0.103593	0.081644	0.041439	0.032487	0.016046	0.004807	0	0	0	0	0	0	0	0	0
2-Aug	0.186749	0.185349	0.195256	0.174373	0.158553	0.135897	0.093875	0.081818	0.058279	0.026594	0.014954	0.007691	0	0.003106	0.026156	0.008146	0	0	0
3-Aug	0.134575	0.133146	0.161262	0.172913	0.164453	0.152222	0.118641	0.112626	0.08818	0.045433	0.028754	0.015669	0.006777	0	0.010521	0	0	0	0
4-Aug	0.071056	0.069333	0.103339	0.131299	0.124203	0.120936	0.102122	0.114197	0.095916	0.045339	0.029867	0.011705	0.006131	0	0	0.014891	0.032306	0.021558	0.005258
5-Aug	0.021313	0.019042	0.04389	0.073954	0.063318	0.062739	0.051581	0.074101	0.070116	0.030196	0.024337	0.009195	0.00345	0	0	0	0.02287	0.023501	0.007234
6-Aug	0.02208	0.019122	0.034462	0.050851	0.032063	0.036741	0.013482	0.04418	0.059437	0.024473	0.038402	0.017209	0.005813	0.009042	0.008926	0.008627	0.041376	0.0421	0.014871
7-Aug	0.025049	0.021261	0.034244	0.044087	0.019077	0.016796	0.012895	0.035041	0.061613	0.040648	0.040662	0.020931	0.01902	0.018825	0.02496	0.024194	0.06662	0.072535	0.031554
8-Aug	0.076907	0.072632	0.083368	0.081269	0.045214	0.027545	0.025588	0.043107	0.067983	0.045199	0.045961	0.02308	0.036423	0.032791	0.037477	0.036092	0.065606	0.088739	0.057005
9-Aug	0.21449	0.209756	0.213132	0.195364	0.130345	0.097509	0.087516	0.089953	0.101498	0.06384	0.065543	0.033532	0.054813	0.048434	0.051638	0.057858	0.092277	0.102886	0.077333
10-Aug	0.268245	0.263023	0.271342	0.265712	0.201173	0.163269	0.14744	0.143605	0.172464	0.125387	0.117897	0.077097	0.095742	0.084746	0.084832	0.08201	0.12249	0.126879	0.108758
11-Aug	0.250729	0.244929	0.270106	0.268937	0.234032	0.207208	0.192395	0.197974	0.215359	0.15978	0.17436	0.136754	0.145243	0.127395	0.124487	0.120269	0.167263	0.167904	0.156305
12-Aug	0.210083	0.203736	0.252872	0.252825	0.234353	0.21906	0.207749	0.232686	0.255257	0.19363	0.228284	0.215775	0.23445	0.226929	0.21316	0.197476	0.23412	0.2304	0.204383
13-Aug	0.170163	0.163351	0.218067	0.22503	0.215815	0.222595	0.215395	0.23553	0.275696	0.219775	0.273177	0.251925	0.285291	0.281815	0.272905	0.260066	0.291158	0.291781	0.269904
14-Aug	0.141178	0.134326	0.206637	0.209643	0.201616	0.200441	0.206328	0.224519	0.261	0.203873	0.259524	0.251019	0.291576	0.30048	0.319603	0.314019	0.35404	0.371306	0.344463
15-Aug	0.098247	0.091675	0.169921	0.18916	0.17089	0.178042	0.192579	0.209897	0.24596	0.182559	0.244164	0.235665	0.275579	0.295268	0.330095	0.35097	0.407776	0.462615	0.426433
16-Aug	0.016541	0.010506	0.089933	0.125708	0.105655	0.107668	0.131859	0.170932	0.206824	0.15265	0.21209	0.210667	0.256217	0.286949	0.330289	0.360071	0.416849	0.518134	0.483254
17-Aug	0	0	0.014976	0.049235	0.026752	0.027116	0.055637	0.099962	0.137411	0.089842	0.164834	0.170713	0.22557	0.266719	0.31516	0.347929	0.421529	0.547532	0.516025
18-Aug	0	0	0	0	0	0	0	0.019411	0.059735	0.015485	0.09504	0.119422	0.17889	0.226021	0.277583	0.312548	0.400034	0.508601	0.493239
19-Aug	0	0	0	0	0	0	0	0	0	0	0.025539	0.063269	0.116362	0.165073	0.226416	0.261402	0.368124	0.459731	0.460607
20-Aug	0	0	0	0	0	0	0	0	0	0	0	0	0.052887	0.108726	0.172088	0.216257	0.331391	0.413744	0.412086
21-Aug	0.025563	0.025567	0.009099	0.00289	0.022578	0.007928	0	0	0	0	0	0	0.023824	0.076284	0.137164	0.179479	0.287746	0.369629	0.358665
22-Aug	0.085775	0.086058	0.051179	0.036383	0.059858	0.032056	0.022849	0.01665	0.009645	0.001712	0.003746	0	0.015753	0.0713	0.12497	0.153843	0.26992	0.337559	0.317785
23-Aug	0.121064	0.121481	0.086506	0.072667	0.092458	0.065361	0.04578	0.033804	0.024256	0.025596	0.027573	0.026235	0.048135	0.10777	0.154296	0.184327	0.284273	0.336893	0.307024
24-Aug	0.143093	0.143692	0.110732	0.125425	0.131595	0.091967	0.075316	0.063467	0.04321	0.051202	0.064187	0.068926	0.078085	0.12824	0.184192	0.213381	0.314682	0.37478	0.344665
25-Aug	0.140943	0.141471	0.111309	0.137809	0.147553	0.115052	0.105892	0.097599	0.085066	0.092218	0.102589	0.112814	0.131168	0.17174	0.23053	0.252677	0.35705	0.424223	0.401111
26-Aug	0.10181	0.102299	0.080373	0.100607	0.127861	0.1035	0.113254	0.11022	0.095334	0.107953	0.116642	0.140212	0.153751	0.190938	0.255346	0.271658	0.371444	0.449034	0.428579
27-Aug	0.024146	0.024934	0.021435	0.048318	0.086017	0.069662	0.103358	0.104945	0.088164	0.100476	0.114827	0.158184	0.181043	0.234398	0.299944	0.319759	0.414084	0.481334	0.455076
28-Aug	0	0	0	0	0.017353	0.037465	0.086657	0.090376	0.070114	0.083596	0.098542	0.154149	0.170807	0.262857	0.338625	0.36219	0.482982	0.533407	0.493542
29-Aug	0	0	0	0	0	0	0.023149	0.044388	0.037522	0.056187	0.074962	0.135675	0.146655	0.227757	0.331491	0.372409	0.497238	0.549599	0.509397
30-Aug	0	0	0	0	0	0	0	0.003108	0	0.019203	0.047955	0.11266	0.123675	0.220548	0.328287	0.38356	0.527844	0.591154	0.554668
31-Aug	0	0	0	0	0	0	0	0	0	0	0.039938	0.111022	0.121316	0.220985	0.320363	0.378506	0.512645	0.584267	0.556994
1-Sep	0.059496	0.041456	0.036694	0.016205	0.026367	0.017243	0	0	0	0	0.022938	0.104952	0.135529	0.257122	0.345513	0.392217	0.516165	0.588642	0.559751
2-Sep	0.202584	0.155659	0.142964	0.095634	0.091926	0.084456	0.048611	0.042212	0.039957	0.02016	0.033228	0.117567	0.142899	0.255298	0.346802	0.39299	0.522876	0.611862	0.578096
3-Sep	0.17677	0.151247	0.183012	0.156771	0.149356	0.149841	0.096808	0.087023	0.081014	0.054852	0.065025	0.134851	0.163572	0.268134	0.357124	0.404637	0.546782	0.625296	0.586606
4-Sep	0.187174	0.192133	0.201229	0.166993	0.156669	0.148925	0.090255	0.092347	0.090941	0.073001	0.079539	0.141595	0.169953	0.264934	0.378305	0.462763	0.62277	0.690831	0.663247
5-Sep	0.160952	0.186414	0.195909	0.15719	0.166068	0.132507	0.080636	0.097106	0.092616	0.089239	0.10874	0.170811	0.18833	0.278304	0.396772	0.503312	0.655489	0.730335	0.695019
6-Sep	0.109701	0.145925	0.169748	0.134237	0.200525	0.157038	0.104815	0.151181	0.143143	0.134051	0.148946	0.219667	0.232704	0.311597	0.417564	0.541953	0.693782	0.774078	0.729919
7-Sep	0.056564	0.086464	0.119106	0.102927	0.194984	0.158725	0.119551	0.175392	0.159894	0.149558	0.183405	0.257536	0.267652	0.347883	0.447929	0.596378	0.730754	0.81504	0.770113
8-Sep	0.003007	0.025271	0.065927	0.058399	0.134986	0.116311	0.095628	0.147818	0.178328	0.161042	0.196611	0.272956	0.285562	0.363487	0.462665	0.612941	0.760506	0.842288	0.814712
9-Sep	0	0	0.033951	0.063704	0.111244	0.091687	0.0654	0.116122	0.134822	0.124589	0.172607	0.256608	0.28331	0.373468	0.477572	0.607403	0.780276	0.867212	0.846644
10-Sep	0.00536	0.00341	0.04011	0.050673	0.085944	0.058801	0.023518	0.085956	0.100089	0.095006	0.142419	0.232001	0.269815	0.379207	0.483149	0.600478	0.78314	0.879779	0.859121
11-Sep	0	0	0.019179	0.028605	0.056028	0.032046	0	0.056125	0.068674	0.063846	0.11538	0.207739	0.261652	0.392909	0.492318	0.60024	0.790119	0.891238	0.860546
12-Sep	0	0	0	0	0.008569	0	0	0.031948	0.05106	0.037199	0.096121	0.196834	0.245025	0.370698	0.494916	0.599243	0.799683	0.901143	0.861833
13-Sep	0.076474	0.048542	0.019054	0.010196	0.004238	0	0.032843	0.046534	0.065651	0.035851	0.128584	0.22552	0.267171	0.386548	0.521421	0.615768	0.818786	0.927349	0.895652
14-Sep	0.140549	0.104581	0.068965	0.048631	0.03413	0.016442	0.052755	0.068689	0.086452	0.048297	0.124214	0.239534	0.278081	0.39317	0.523593	0.613134	0.818059	0.948508	0.942042
15-Sep	0.120692	0.097364	0.074727	0.054977	0.060018	0.061625	0.063124	0.083293	0.119488	0.06757	0.131948	0.250456	0.313273	0.430669	0.554814	0.652067	0.841586	0.971747	0.96897
16-Sep	0.149279	0.12055	0.095756	0.093671	0.113211	0.116494	0.11105	0.128919	0.160273	0.10749	0.162188	0.294649	0.358396	0.467924	0.596151	0.733561	0.913437	1.023585	1.000895
17-Sep	0.177184	0.141728	0.120618	0.125127	0.157912	0.153197	0.154734	0.173957	0.190511	0.143497	0.191742	0.325566	0.42564	0.552634	0.661507	0.7916	0.982354	1.11193	1.074198
18-Sep	0.25301	0.209644	0.193892	0.188958	0.220251	0.20888	0.222432	0.238525	0.248318	0.191986	0.236577	0.36638	0.444045	0.570157	0.692233	0.83352	1.044767	1.187664	1.148914
19-Sep	0.316051	0.265477	0.261127	0.261922	0.263294	0.250916	0.275717	0.287528	0.300895	0.236434	0.297181	0.415926	0.487251	0.62536	0.748551	0.889879	1.103	1.238173	1.206638
20-Sep	0.378245	0.316334	0.314069	0.352111	0.332484	0.309482	0.321429	0.327288	0.35827	0.288665	0.371905	0.487354	0.558093	0.677887	0.794984	0.926425	1.152058	1.282886	1.25764
21-Sep	0.452399	0.396709	0.390795	0.40907	0.413944	0.37976	0.390184	0.402384	0.427474	0.352397	0.437788	0.562862	0.644331	0.760229	0.872767	0.985766	1.198572	1.365008	1.324535
22-Sep	0.489046	0.495547	0.472555	0.501414	0.519103	0.473665	0.496803	0.522327	0.524203	0.44927	0.512763	0.621393	0.688756	0.80036	0.928735	1.055529	1.258902	1.413872	1.38686
23-Sep	0.488808	0.500699	0.503236	0.539455	0.552779	0.516077	0.543488	0.572933	0.570762	0.503424	0.559137	0.676196	0.745221	0.856249	0.991392	1.115649	1.334573	1.483709	1.470236
24-Sep	0.488068	0.496715	0.52102	0.555028	0.563937	0.589337	0.636522	0.661698	0.655174	0.579507	0.633874	0.735578	0.815868	0.919986	1.064719	1.189393	1.421417	1.597107	1.576821
25-Sep	0.451334	0.516257	0.543042	0.567876	0.581081	0.640455	0.713173	0.736559	0.734026	0.662295	0.738991	0.834565	0.902374	0.997084	1.133266	1.245864	1.478522	1.685453	1.670178
26-Sep	0.451599	0.51801	0.546011	0.569204	0.628246	0.676538	0.746187	0.779634	0.791073	0.745272	0.824202	0.929977	0.999941	1.094497	1.265614	1.366599	1.57973	1.761142	1.75847
27-Sep	0.513511	0.585932	0.595762	0.619522	0.677316	0.712672	0.782122	0.820182	0.857586	0.7965	0.881863	0.996477	1.082649	1.193716	1.367367	1.476182	1.682022	1.852849	1.840731
28-Sep	0.62509	0.677955	0.694279	0.7039	0.743708	0.762818	0.819639	0.885141	0.911413	0.848523	0.93241	1.053277	1.126446	1.245979	1.446045	1.576701	1.78846	1.961119	1.952123
29-Sep	0.772988	0.78913	0.818073	0.825014	0.856143	0.878072	0.933363	1.014331	1.023957	0.94739	1.051348	1.17116	1.228701	1.368677	1.558443	1.67956	1.900005	2.076482	2.075063
30-Sep	1.017742	0.986191	1.00418	1.012368	1.022734	1.034662	1.067738	1.137949	1.137869	1.06174	1.15827	1.286424	1.339875	1.481641	1.67882	1.810252	2.060462	2.227569	2.190248
1-Oct	1.237036	1.216189	1.203095	1.20477	1.202048	1.197937	1.215723	1.277883	1.266433	1.184055	1.258457	1.390104	1.475676	1.609073	1.800374	1.972846	2.222438	2.375719	2.321013
2-Oct	1.382871	1.388105	1.394723	1.391211	1.380502	1.359157	1.36824	1.438344	1.418669	1.323622	1.392281	1.514958	1.609832	1.743998	1.935668	2.113956	2.377934	2.52895	2.468534
3-Oct	1.382131	1.427695	1.478272	1.474725	1.476542	1.463924	1.482792	1.571523	1.559419	1.465383	1.530488	1.662052	1.742634	1.875947	2.096731	2.255106	2.521661	2.675905	2.630811
4-Oct	1.552127	1.571506	1.607248	1.626963	1.621868	1.60466	1.625234	1.688265	1.680504	1.585479	1.650557	1.783423	1.85814	2.00111	2.2396	2.38329	2.636179	2.792489	2.796883
5-Oct	1.770632	1.764762	1.78698	1.800505	1.786484	1.765838	1.773107	1.824526	1.816911	1.726386	1.784135	1.913628	1.985545	2.165389	2.39615	2.525942	2.773023	2.929352	2.931797
6-Oct	2.013092	1.991126	2.022888	2.027956	2.019611	2.004166	1.994508	2.035231	2.024034	1.940226	2.003383	2.114074	2.174317	2.332598	2.553927	2.683901	2.925637	3.080306	3.061195
7-Oct	2.303964	2.266466	2.275574	2.270063	2.277915	2.263907	2.256309	2.290676	2.26931	2.179069	2.249483	2.347248	2.397844	2.524831	2.721221	2.855023	3.131443	3.298832	3.250002
8-Oct	2.374944	2.383644	2.455423	2.462195	2.521388	2.486656	2.509621	2.544689	2.524427	2.426408	2.499188	2.592668	2.660154	2.76752	2.944914	3.071992	3.367764	3.539911	3.467535
9-Oct	2.543093	2.553404	2.632614	2.647765	2.730005	2.726312	2.771026	2.806016	2.789397	2.692121	2.748644	2.845872	2.912793	3.006016	3.172933	3.311493	3.594503	3.762814	3.684989
10-Oct	2.685382	2.697199	2.784029	2.80861	2.878166	2.882366	2.945404	3.001234	3.001097	2.89831	2.960445	3.068651	3.138623	3.257206	3.417429	3.567735	3.838024	3.994482	3.912436
11-Oct	2.863563	2.868431	2.942349	2.967093	3.013911	3.018795	3.074034	3.169585	3.167346	3.05972	3.135263	3.292646	3.362584	3.485878	3.650017	3.81645	4.081246	4.237041	4.150799
12-Oct	3.041577	3.050389	3.118965	3.147992	3.177322	3.169671	3.206514	3.286974	3.305728	3.220844	3.325317	3.487576	3.567308	3.72532	3.902685	4.053149	4.311821	4.467352	4.383801
13-Oct	3.17086	3.189475	3.266852	3.321215	3.340956	3.328531	3.369076	3.439252	3.483713	3.391039	3.531516	3.688805	3.772236	3.927458	4.120047	4.270609	4.542322	4.697273	4.614529
14-Oct	3.227178	3.300403	3.396676	3.435768	3.464719	3.466624	3.542807	3.608173	3.662275	3.563155	3.699567	3.854795	3.941536	4.123195	4.341417	4.485487	4.760437	4.930498	4.868885
15-Oct	3.259154	3.377159	3.479698	3.528786	3.561066	3.574721	3.7087	3.797825	3.854336	3.74668	3.878011	4.031592	4.116342	4.322932	4.540365	4.681049	4.963605	5.167094	5.12736
16-Oct	3.303253	3.457721	3.566075	3.608281	3.637354	3.699299	3.826053	3.928775	3.973677	3.885222	4.058584	4.21706	4.296161	4.51259	4.738248	4.870391	5.166655	5.370012	5.343794
17-Oct	3.323011	3.466484	3.597554	3.64139	3.679502	3.776428	3.917799	4.044326	4.077749	4.001926	4.162999	4.326687	4.458648	4.717634	4.93598	5.063968	5.364451	5.5754	5.530073
18-Oct	3.538263	3.647397	3.752852	3.795243	3.813073	3.892261	4.02055	4.149678	4.186379	4.098542	4.244702	4.429404	4.591841	4.861502	5.096817	5.243662	5.553418	5.768311	5.727289
19-Oct	3.790018	3.867892	3.949855	3.996424	4.013513	4.05586	4.163121	4.273722	4.321645	4.218258	4.358046	4.54798	4.726162	4.981259	5.220531	5.419742	5.738583	5.984649	5.947126
20-Oct	3.980588	4.056747	4.153873	4.217784	4.230647	4.24729	4.337472	4.429357	4.467261	4.354847	4.508405	4.696408	4.872741	5.101084	5.355878	5.599954	5.928724	6.168634	6.139228
21-Oct	4.036619	4.143033	4.277252	4.354768	4.379836	4.391414	4.491255	4.56817	4.600799	4.493438	4.653295	4.835698	4.998223	5.213756	5.470399	5.725718	6.059399	6.305915	6.279406
22-Oct	4.067422	4.217782	4.401573	4.45991	4.486889	4.503146	4.635367	4.72386	4.751232	4.674767	4.827014	5.017202	5.177628	5.371561	5.626067	5.864181	6.19196	6.450493	6.441621
23-Oct	4.244015	4.378179	4.5646	4.654112	4.673303	4.673175	4.821359	4.906886	4.934375	4.854097	5.056353	5.220009	5.392753	5.577479	5.827701	6.04656	6.367817	6.640301	6.623277
24-Oct	4.370733	4.512226	4.682157	4.788606	4.817982	4.825102	4.958432	5.067427	5.092307	5.057171	5.265965	5.481302	5.670552	5.847339	6.075057	6.27225	6.58248	6.845703	6.81723
25-Oct	4.496653	4.605714	4.771558	4.875301	4.911705	4.948938	5.107661	5.224568	5.23728	5.229742	5.452402	5.689889	5.861434	6.06633	6.308983	6.495183	6.8019	7.091255	7.043536
26-Oct	4.598031	4.710508	4.864179	4.952065	5.001535	5.078421	5.223308	5.36592	5.375147	5.356212	5.573077	5.814706	5.990274	6.222082	6.465674	6.663094	6.98259	7.277046	7.218536
27-Oct	4.699317	4.856784	4.999325	5.058158	5.099128	5.236349	5.368702	5.527705	5.527076	5.493972	5.696074	5.94295	6.15387	6.404706	6.66514	6.85456	7.200517	7.469825	7.405463
28-Oct	4.727565	4.928962	5.084899	5.148924	5.185125	5.334934	5.459831	5.662507	5.671228	5.636303	5.841986	6.079255	6.336	6.561521	6.841066	7.045573	7.44566	7.714617	7.651933
29-Oct	4.743947	4.933459	5.114357	5.196269	5.253769	5.385013	5.518425	5.705603	5.747617	5.719456	5.914258	6.190264	6.440398	6.663026	6.981596	7.245576	7.66795	7.916068	7.872953
30-Oct	4.760628	4.938972	5.120348	5.20615	5.275055	5.381212	5.552704	5.720658	5.77416	5.742614	5.944506	6.230578	6.474412	6.740168	7.072906	7.368057	7.81953	8.068878	8.058179
31-Oct	4.790253	4.981663	5.16492	5.244707	5.30951	5.406574	5.614754	5.776651	5.816023	5.77595	5.994828	6.2699	6.506468	6.781593	7.117876	7.423782	7.873235	8.157958	8.191157

The data spans from July to October where the red marks the end of summer. As we can see, the end of summer has been end earlier or that temperatures have been rising over the years which has caused the standard deviation to rise as the years pass.

18-Sep	0.25301	0.209644	0.193892	0.188958	0.220251	0.20888	0.222432	0.238525	0.248318	0.191986	0.236577	0.36638	0.444045	0.570157	0.692233	0.83352	1.044767	1.187664	1.148914
19-Sep	0.316051	0.265477	0.261127	0.261922	0.263294	0.250916	0.275717	0.287528	0.300895	0.236434	0.297181	0.415926	0.487251	0.62536	0.748551	0.889879	1.103	1.238173	1.206638
20-Sep	0.378245	0.316334	0.314069	0.352111	0.332484	0.309482	0.321429	0.327288	0.35827	0.288665	0.371905	0.487354	0.558093	0.677887	0.794984	0.926425	1.152058	1.282886	1.25764
21-Sep	0.452399	0.396709	0.390795	0.40907	0.413944	0.37976	0.390184	0.402384	0.427474	0.352397	0.437788	0.562862	0.644331	0.760229	0.872767	0.985766	1.198572	1.365008	1.324535
22-Sep	0.489046	0.495547	0.472555	0.501414	0.519103	0.473665	0.496803	0.522327	0.524203	0.44927	0.512763	0.621393	0.688756	0.80036	0.928735	1.055529	1.258902	1.413872	1.38686
23-Sep	0.488808	0.500699	0.503236	0.539455	0.552779	0.516077	0.543488	0.572933	0.570762	0.503424	0.559137	0.676196	0.745221	0.856249	0.991392	1.115649	1.334573	1.483709	1.470236
24-Sep	0.488068	0.496715	0.52102	0.555028	0.563937	0.589337	0.636522	0.661698	0.655174	0.579507	0.633874	0.735578	0.815868	0.919986	1.064719	1.189393	1.421417	1.597107	1.576821
25-Sep	0.451334	0.516257	0.543042	0.567876	0.581081	0.640455	0.713173	0.736559	0.734026	0.662295	0.738991	0.834565	0.902374	0.997084	1.133266	1.245864	1.478522	1.685453	1.670178
26-Sep	0.451599	0.51801	0.546011	0.569204	0.628246	0.676538	0.746187	0.779634	0.791073	0.745272	0.824202	0.929977	0.999941	1.094497	1.265614	1.366599	1.57973	1.761142	1.75847
27-Sep	0.513511	0.585932	0.595762	0.619522	0.677316	0.712672	0.782122	0.820182	0.857586	0.7965	0.881863	0.996477	1.082649	1.193716	1.367367	1.476182	1.682022	1.852849	1.840731
28-Sep	0.62509	0.677955	0.694279	0.7039	0.743708	0.762818	0.819639	0.885141	0.911413	0.848523	0.93241	1.053277	1.126446	1.245979	1.446045	1.576701	1.78846	1.961119	1.952123
29-Sep	0.772988	0.78913	0.818073	0.825014	0.856143	0.878072	0.933363	1.014331	1.023957	0.94739	1.051348	1.17116	1.228701	1.368677	1.558443	1.67956	1.900005	2.076482	2.075063
30-Sep	1.017742	0.986191	1.00418	1.012368	1.022734	1.034662	1.067738	1.137949	1.137869	1.06174	1.15827	1.286424	1.339875	1.481641	1.67882	1.810252	2.060462	2.227569	2.190248
1-Oct	1.237036	1.216189	1.203095	1.20477	1.202048	1.197937	1.215723	1.277883	1.266433	1.184055	1.258457	1.390104	1.475676	1.609073	1.800374	1.972846	2.222438	2.375719	2.321013
2-Oct	1.382871	1.388105	1.394723	1.391211	1.380502	1.359157	1.36824	1.438344	1.418669	1.323622	1.392281	1.514958	1.609832	1.743998	1.935668	2.113956	2.377934	2.52895	2.468534
3-Oct	1.382131	1.427695	1.478272	1.474725	1.476542	1.463924	1.482792	1.571523	1.559419	1.465383	1.530488	1.662052	1.742634	1.875947	2.096731	2.255106	2.521661	2.675905	2.630811
4-Oct	1.552127	1.571506	1.607248	1.626963	1.621868	1.60466	1.625234	1.688265	1.680504	1.585479	1.650557	1.783423	1.85814	2.00111	2.2396	2.38329	2.636179	2.792489	2.796883
5-Oct	1.770632	1.764762	1.78698	1.800505	1.786484	1.765838	1.773107	1.824526	1.816911	1.726386	1.784135	1.913628	1.985545	2.165389	2.39615	2.525942	2.773023	2.929352	2.931797
6-Oct	2.013092	1.991126	2.022888	2.027956	2.019611	2.004166	1.994508	2.035231	2.024034	1.940226	2.003383	2.114074	2.174317	2.332598	2.553927	2.683901	2.925637	3.080306	3.061195
7-Oct	2.303964	2.266466	2.275574	2.270063	2.277915	2.263907	2.256309	2.290676	2.26931	2.179069	2.249483	2.347248	2.397844	2.524831	2.721221	2.855023	3.131443	3.298832	3.250002
8-Oct	2.374944	2.383644	2.455423	2.462195	2.521388	2.486656	2.509621	2.544689	2.524427	2.426408	2.499188	2.592668	2.660154	2.76752	2.944914	3.071992	3.367764	3.539911	3.467535
9-Oct	2.543093	2.553404	2.632614	2.647765	2.730005	2.726312	2.771026	2.806016	2.789397	2.692121	2.748644	2.845872	2.912793	3.006016	3.172933	3.311493	3.594503	3.762814	3.684989
10-Oct	2.685382	2.697199	2.784029	2.80861	2.878166	2.882366	2.945404	3.001234	3.001097	2.89831	2.960445	3.068651	3.138623	3.257206	3.417429	3.567735	3.838024	3.994482	3.912436
11-Oct	2.863563	2.868431	2.942349	2.967093	3.013911	3.018795	3.074034	3.169585	3.167346	3.05972	3.135263	3.292646	3.362584	3.485878	3.650017	3.81645	4.081246	4.237041	4.150799
12-Oct	3.041577	3.050389	3.118965	3.147992	3.177322	3.169671	3.206514	3.286974	3.305728	3.220844	3.325317	3.487576	3.567308	3.72532	3.902685	4.053149	4.311821	4.467352	4.383801
13-Oct	3.17086	3.189475	3.266852	3.321215	3.340956	3.328531	3.369076	3.439252	3.483713	3.391039	3.531516	3.688805	3.772236	3.927458	4.120047	4.270609	4.542322	4.697273	4.614529
14-Oct	3.227178	3.300403	3.396676	3.435768	3.464719	3.466624	3.542807	3.608173	3.662275	3.563155	3.699567	3.854795	3.941536	4.123195	4.341417	4.485487	4.760437	4.930498	4.868885
15-Oct	3.259154	3.377159	3.479698	3.528786	3.561066	3.574721	3.7087	3.797825	3.854336	3.74668	3.878011	4.031592	4.116342	4.322932	4.540365	4.681049	4.963605	5.167094	5.12736
16-Oct	3.303253	3.457721	3.566075	3.608281	3.637354	3.699299	3.826053	3.928775	3.973677	3.885222	4.058584	4.21706	4.296161	4.51259	4.738248	4.870391	5.166655	5.370012	5.343794
17-Oct	3.323011	3.466484	3.597554	3.64139	3.679502	3.776428	3.917799	4.044326	4.077749	4.001926	4.162999	4.326687	4.458648	4.717634	4.93598	5.063968	5.364451	5.5754	5.530073
18-Oct	3.538263	3.647397	3.752852	3.795243	3.813073	3.892261	4.02055	4.149678	4.186379	4.098542	4.244702	4.429404	4.591841	4.861502	5.096817	5.243662	5.553418	5.768311	5.727289
19-Oct	3.790018	3.867892	3.949855	3.996424	4.013513	4.05586	4.163121	4.273722	4.321645	4.218258	4.358046	4.54798	4.726162	4.981259	5.220531	5.419742	5.738583	5.984649	5.947126
20-Oct	3.980588	4.056747	4.153873	4.217784	4.230647	4.24729	4.337472	4.429357	4.467261	4.354847	4.508405	4.696408	4.872741	5.101084	5.355878	5.599954	5.928724	6.168634	6.139228
21-Oct	4.036619	4.143033	4.277252	4.354768	4.379836	4.391414	4.491255	4.56817	4.600799	4.493438	4.653295	4.835698	4.998223	5.213756	5.470399	5.725718	6.059399	6.305915	6.279406
22-Oct	4.067422	4.217782	4.401573	4.45991	4.486889	4.503146	4.635367	4.72386	4.751232	4.674767	4.827014	5.017202	5.177628	5.371561	5.626067	5.864181	6.19196	6.450493	6.441621
23-Oct	4.244015	4.378179	4.5646	4.654112	4.673303	4.673175	4.821359	4.906886	4.934375	4.854097	5.056353	5.220009	5.392753	5.577479	5.827701	6.04656	6.367817	6.640301	6.623277
24-Oct	4.370733	4.512226	4.682157	4.788606	4.817982	4.825102	4.958432	5.067427	5.092307	5.057171	5.265965	5.481302	5.670552	5.847339	6.075057	6.27225	6.58248	6.845703	6.81723
25-Oct	4.496653	4.605714	4.771558	4.875301	4.911705	4.948938	5.107661	5.224568	5.23728	5.229742	5.452402	5.689889	5.861434	6.06633	6.308983	6.495183	6.8019	7.091255	7.043536
26-Oct	4.598031	4.710508	4.864179	4.952065	5.001535	5.078421	5.223308	5.36592	5.375147	5.356212	5.573077	5.814706	5.990274	6.222082	6.465674	6.663094	6.98259	7.277046	7.218536
27-Oct	4.699317	4.856784	4.999325	5.058158	5.099128	5.236349	5.368702	5.527705	5.527076	5.493972	5.696074	5.94295	6.15387	6.404706	6.66514	6.85456	7.200517	7.469825	7.405463
28-Oct	4.727565	4.928962	5.084899	5.148924	5.185125	5.334934	5.459831	5.662507	5.671228	5.636303	5.841986	6.079255	6.336	6.561521	6.841066	7.045573	7.44566	7.714617	7.651933
29-Oct	4.743947	4.933459	5.114357	5.196269	5.253769	5.385013	5.518425	5.705603	5.747617	5.719456	5.914258	6.190264	6.440398	6.663026	6.981596	7.245576	7.66795	7.916068	7.872953
30-Oct	4.760628	4.938972	5.120348	5.20615	5.275055	5.381212	5.552704	5.720658	5.77416	5.742614	5.944506	6.230578	6.474412	6.740168	7.072906	7.368057	7.81953	8.068878	8.058179
31-Oct	4.790253	4.981663	5.16492	5.244707	5.30951	5.406574	5.614754	5.776651	5.816023	5.77595	5.994828	6.2699	6.506468	6.781593	7.117876	7.423782	7.873235	8.157958	8.191157

Here is a larger view of the data which has already been smoothed.



This is the standard deviation graph of the temperatures over the years plotted on PowerBI. As we can see the standard deviation, which is compared to its own year average, has been steadily increasing. This fact, coupled with the fact that temperatures are trending up, is that summer are getting hotter and the end of October may also be getting cooler. Since it is not getting cooler in October, this means that summer is ending later because summer temperature is rising.