

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
```

```
Week4 <- read.table("temps.txt", header=TRUE, stringsAsFactors = FALSE)
```

```
head(Week4)
```

	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.
```

```
Week4_vec <- as.vector(unlist(Week4[,2:21]))
```

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

```
Week4_vec
```

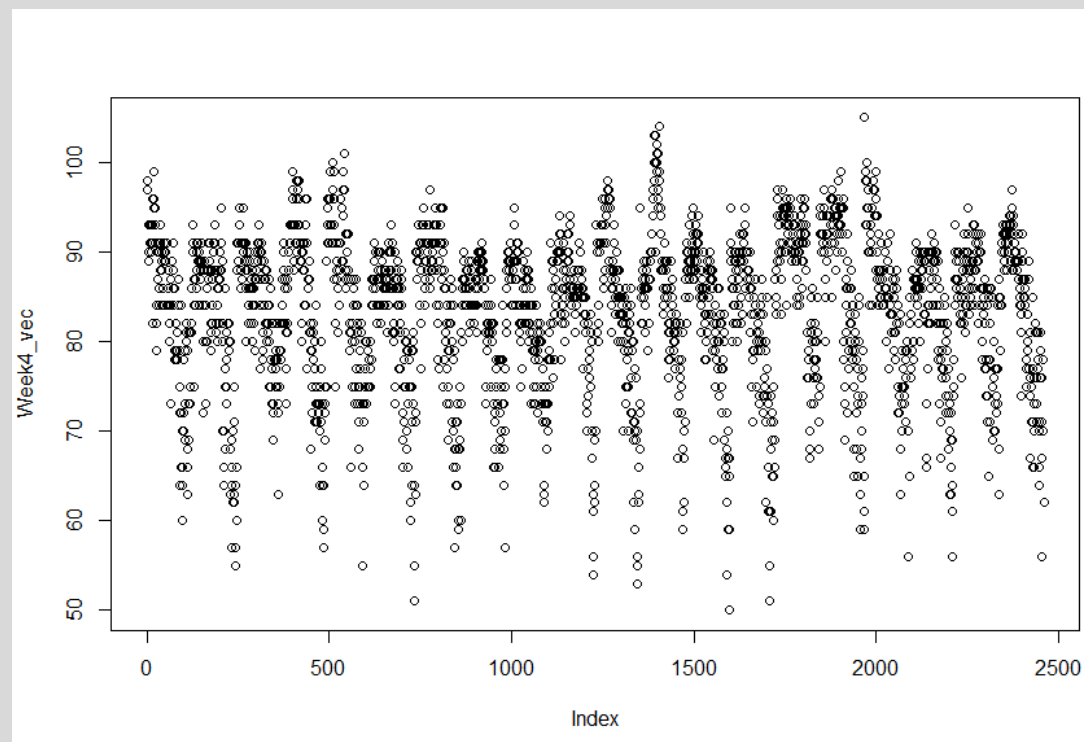
```
[1] 98 97 97 90 89 93 93 91 93 93 90 91 93 93 82 91 96 95
```

```
[19] 96 99
```

Checking the head of the new vector I created.

```
#Plotting the vector to determine how the data points look like.
```

```
plot(Week4_vec)
```



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

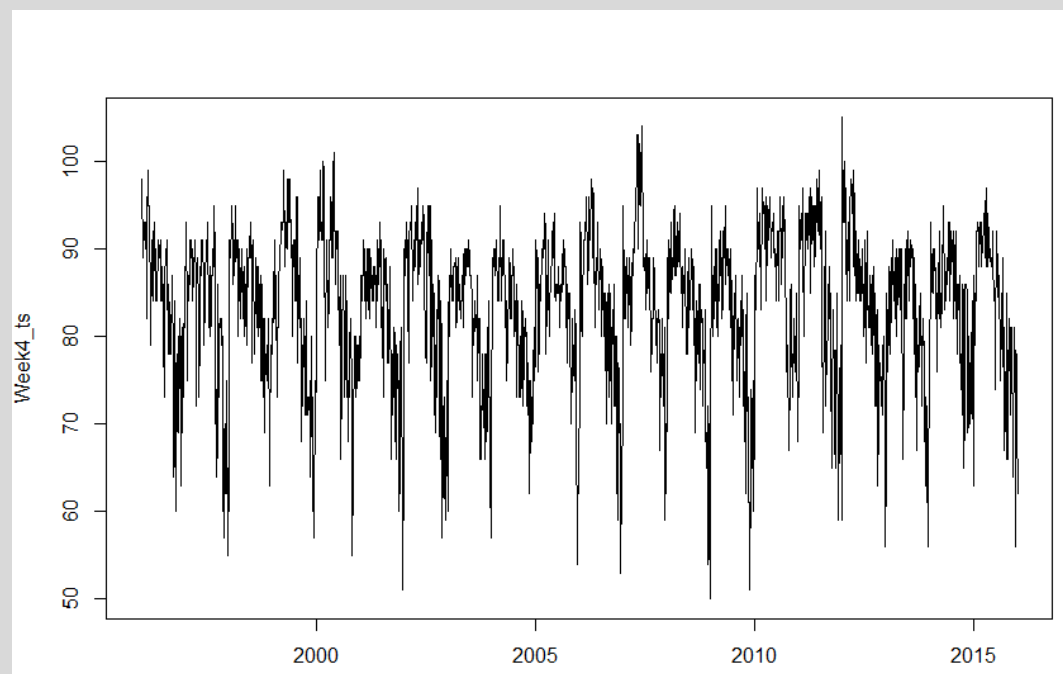
```
#Converting the vector to a time series object for 123 days
Week4_ts <- ts(Week4_vec, start=1996, frequency=123)
```

```
#Display the output of the time-series.
Week4_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(Week4_ts)
```



Plot looks correct. This plot is before smoothing.

```
#Computes Holt Winters filtering with a seasonal model
Week4_HW <- HoltWinters(Week4_ts, alpha=NULL, beta=NULL, gamma=NULL,
seasonal="multiplicative")
Week4_HW
```

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

Call:

```
HoltWinters(x = Week4_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

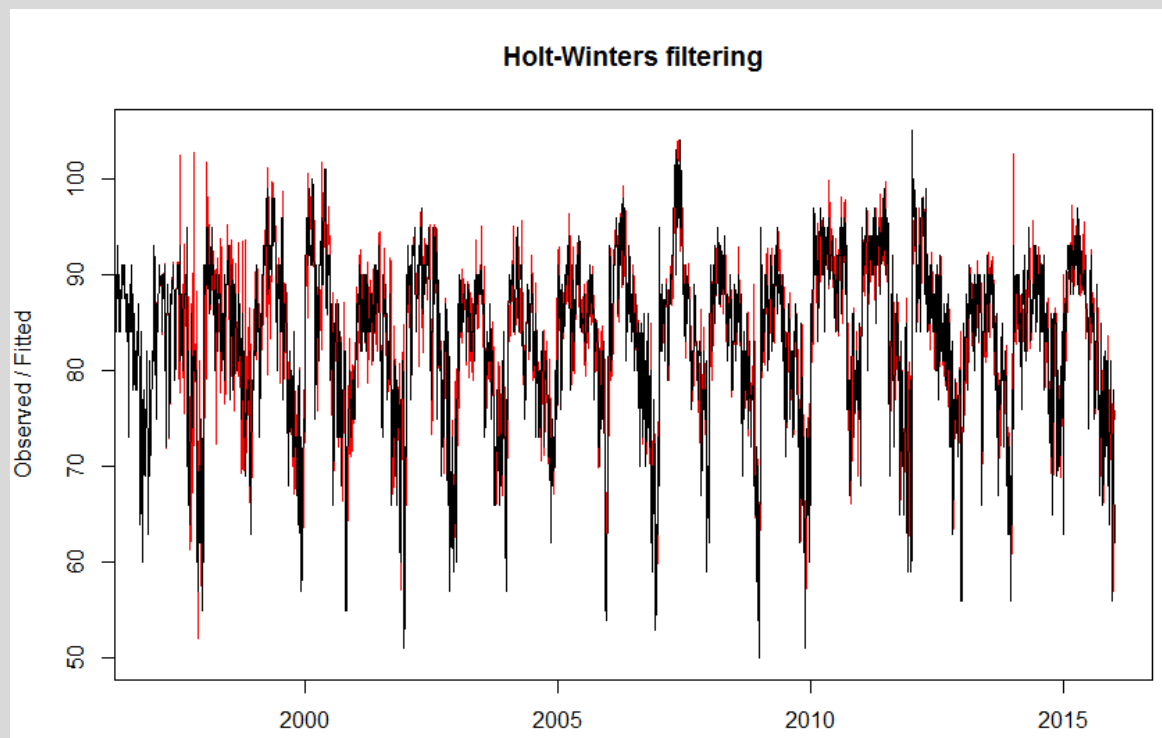
s122 0.851581233

s123 0.874038407

Shortened list. Converted Time Series to a HoltsWinter filter.

```
#Outputting a snippet of the data
tail(Week4_HW)
summary(Week4_HW)
plot(Week4_HW)
```

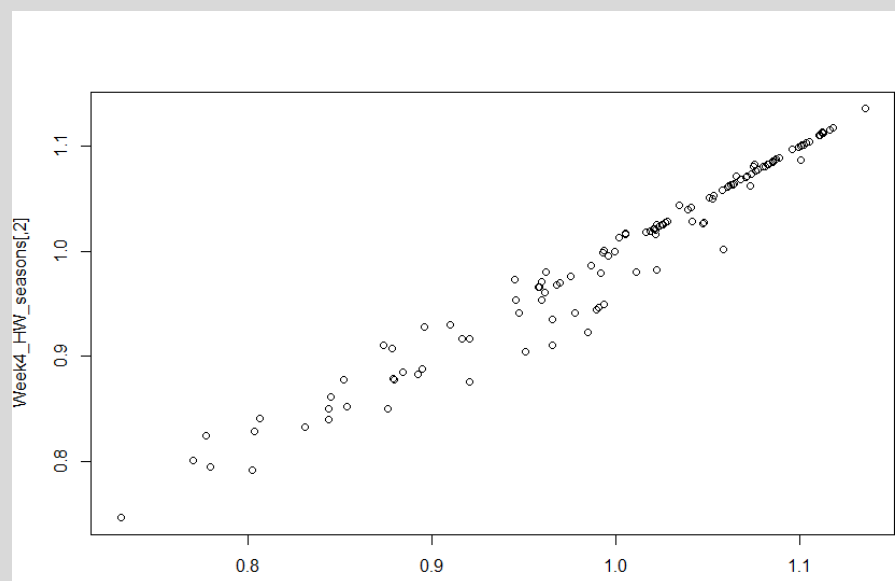
	Length	Class	Mode
fitted	9348	mts	numeric
x	2460	ts	numeric
alpha	1	-none-	numeric
beta	1	-none-	numeric
gamma	1	-none-	numeric
coefficients	125	-none-	numeric
seasonal	1	-none-	character
SSE	1	-none-	numeric
call	6	-none-	call



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

```
#Converting the fitted data into a matrix and outputting the data
Week4_HW_seasons <- matrix(Week4_HW$fitted[,4], nrow=123)
head(Week4_HW_seasons)
plot(Week4_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
```

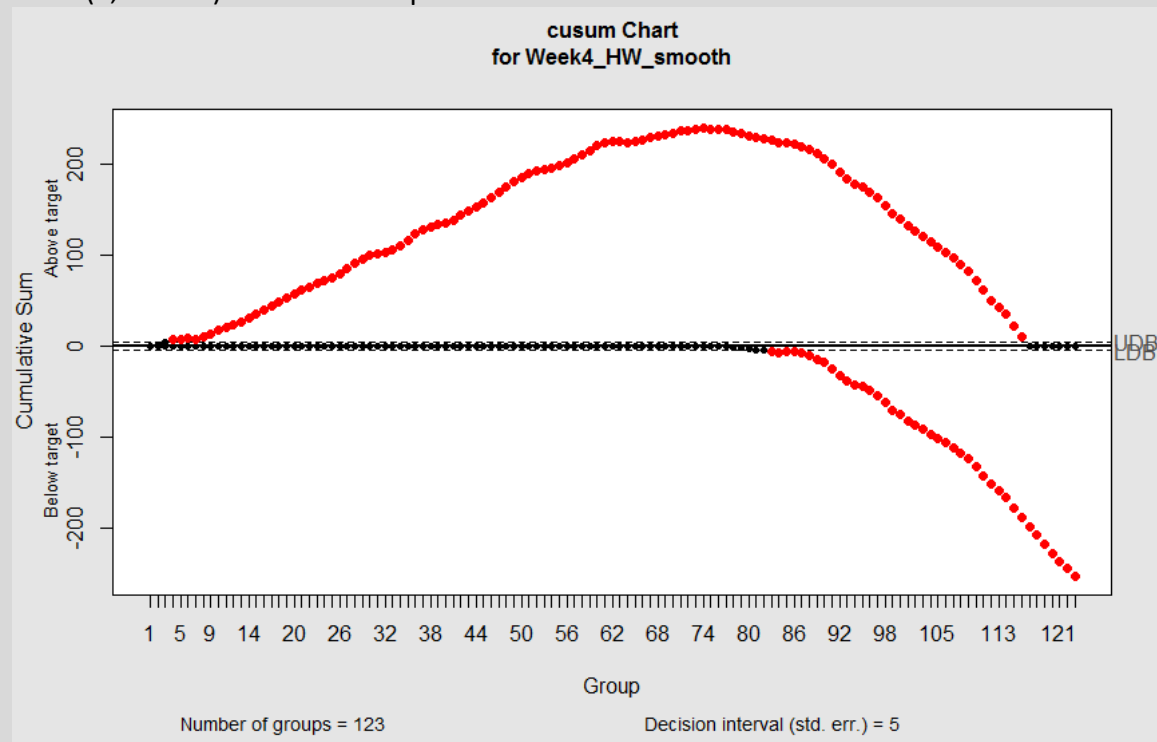


Checking if the seasonal data is relatively linear, and it does look linear. This makes sense because the longer time passes, the higher away the standard deviation is from the average value.

```
#Adding a smoothing function and performing a cusum
Week4_HW_smooth <- matrix(Week4_HW$fitted[,1], nrow=123)
Week4_HW_smooth
```

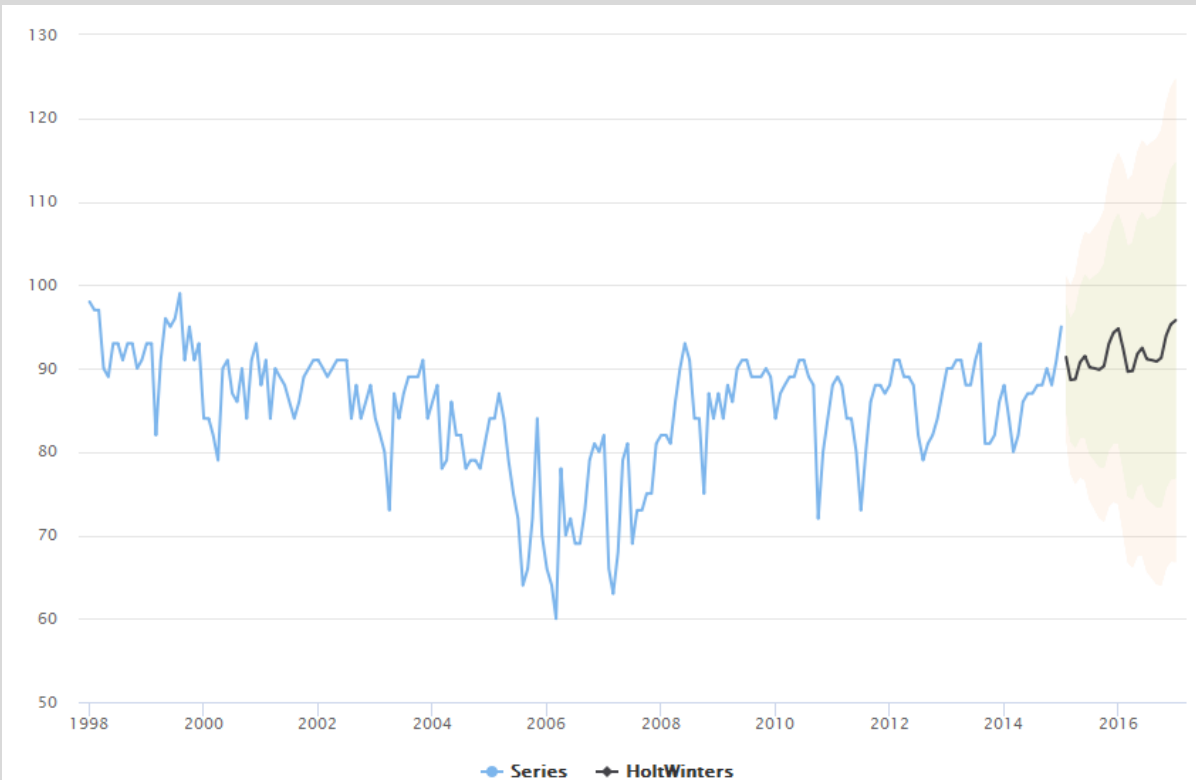
```
#Outputing the cusum of the smooth data
cusum(Week4_HW_smooth)
```

```
List of 14
 $ call      : language cusum(data = Week4_HW_smooth)
 $ type      : chr "cusum"
 $ data.name  : chr "Week4_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
Week4_ts_forecast <- ts(Week4_vec, start=1998, end=2015, frequency=12)
Week4_HW_forecast <- HoltWinters(Week4_ts_forecast)
hchart(forecast(Week4_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(Week4_HW_seasons)
write.csv(wholefile, file="Week4_HW.csv")
```

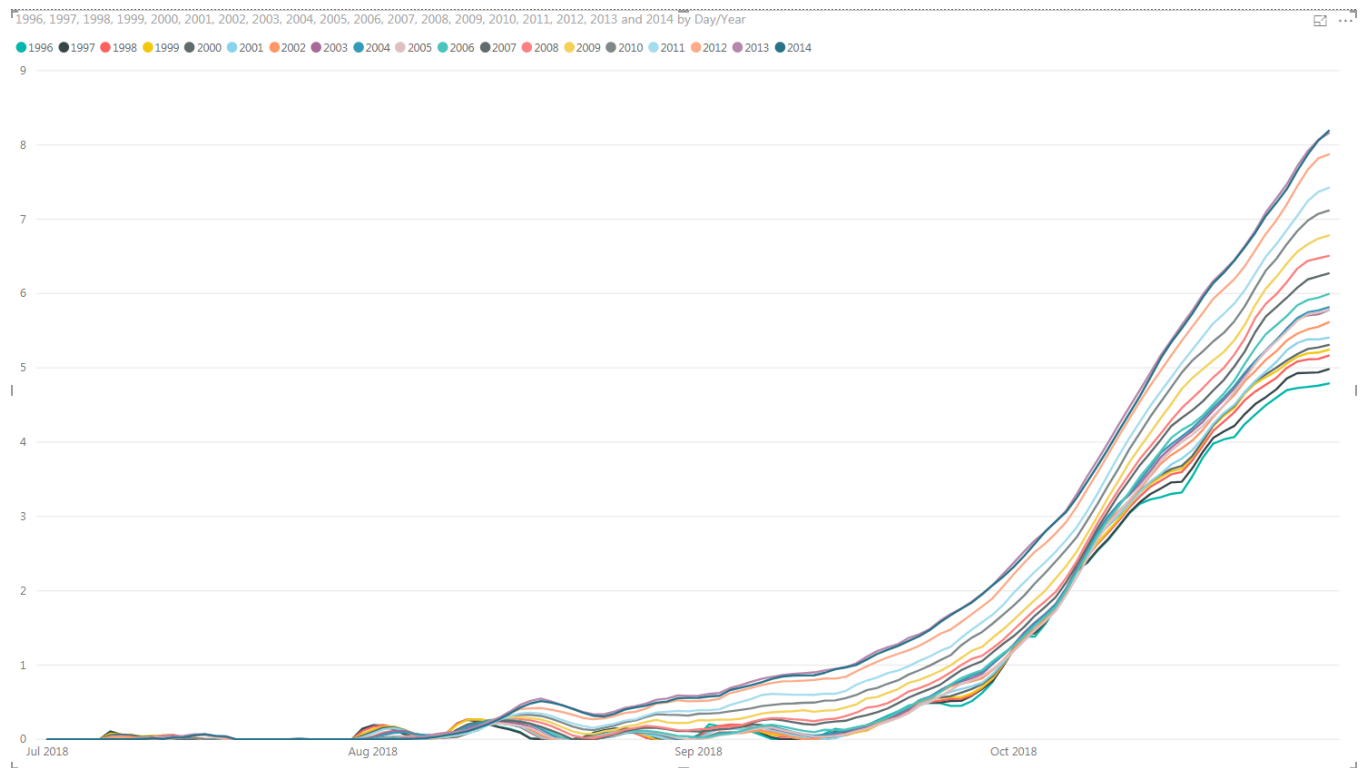
```
>
```

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

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.