homework_4

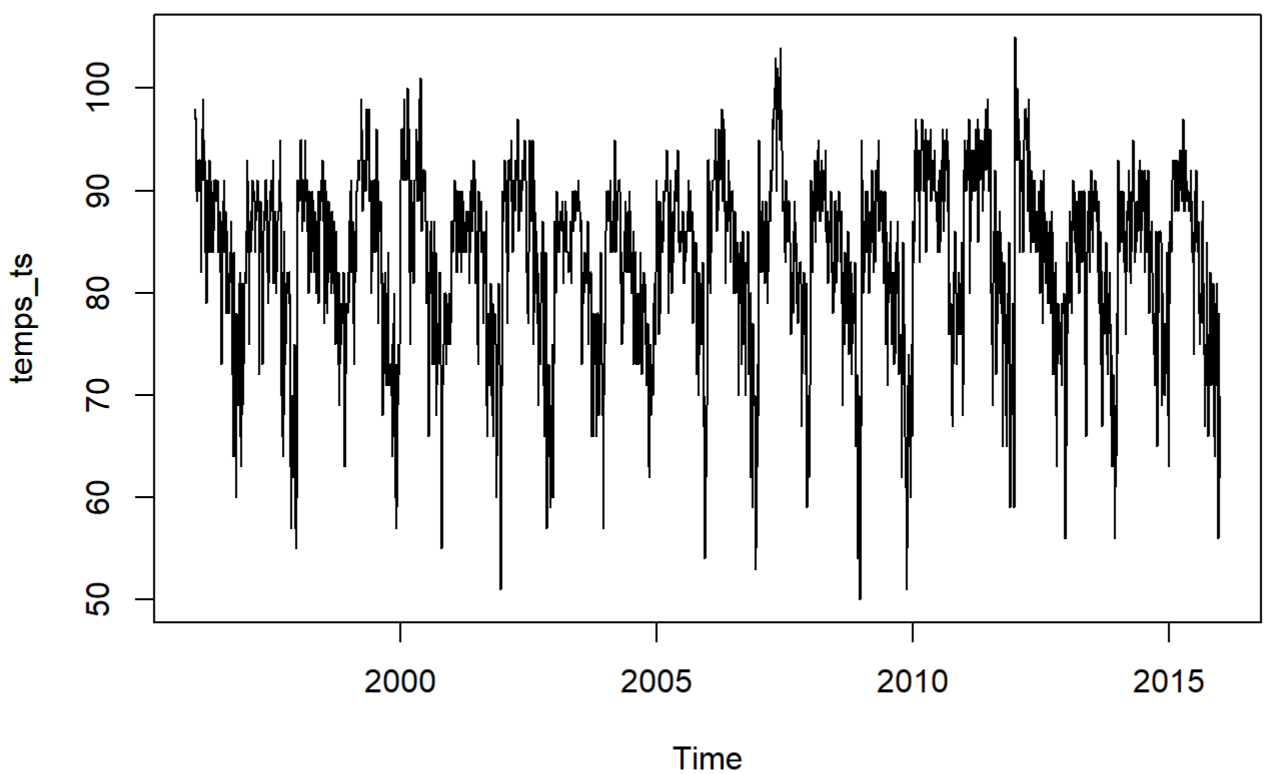
Quetion 7.1

I have done some work in forecasting demand for a certain online retailers who focuses on specialty product. The data I would need is the past sales records. Given the specialty nature of the product, the sales was limited to a very specific market, which is doesn't not have much volitility in its demand. Given the data has less randomness, then I would expect the alpha to be closer to 1 than it is to 0. Because with less randomness, we can trust what we see in Xt more than S(t-1).

Question 7.2

load and transform data

```
temps <- read.table("temps.txt",
                    stringsAsFactors = FALSE,
                    header = TRUE)
temps_vec <- as.vector(unlist(temps[,2:21]))
temps_ts <- ts(temps_vec, start=1996, frequency = 123)
plot(temps_ts)
```



Single exponential smoothing

```
temps_single <- HoltWinters(temps_ts,
                            alpha = NULL,
                            beta = FALSE,
                            gamma = FALSE)
print(temps_single)
```

```
## Holt-Winters exponential smoothing without trend and without seasonal component.
##
## Call:
## HoltWinters(x = temps_ts, alpha = NULL, beta = FALSE, gamma = FALSE)
##
## Smoothing parameters:
##  alpha: 0.8388021
##  beta : FALSE
##  gamma: FALSE
##
## Coefficients:
##       [,1]
## a 63.30952
```

```
print(paste("SSE: ",temps_single$SSE))
```

```
## [1] "SSE:  56198.0955314733"
```

Double exponential smoothing with trend

```
temps_double <- HoltWinters(temps_ts,
                            alpha = NULL,
                            beta = NULL,
                            gamma = FALSE)
print(temps_double)
```

```
## Holt-Winters exponential smoothing with trend and without seasonal component.
##
## Call:
## HoltWinters(x = temps_ts, alpha = NULL, beta = NULL, gamma = FALSE)
##
## Smoothing parameters:
##  alpha: 0.8445729
##  beta : 0.003720884
##  gamma: FALSE
##
## Coefficients:
##         [,1]
## a 63.2530022
## b -0.0729933
```

The beta is close to 0, which suggests little to no trend.

```
print(paste("SSE: ", temps_double$SSE))
```

```
## [1] "SSE:  56572.537568114"
```

Triple exponential smoothing with trend and seasonality

```
temps_triple <- HoltWinters(temps_ts,
                            alpha = NULL,
                            beta = NULL,
                            gamma = NULL)
print(temps_triple)
```

```
## Holt-Winters exponential smoothing with trend and additive seasonal component.
##
## Call:
## HoltWinters(x = temps_ts, alpha = NULL, beta = NULL, gamma = NULL)
##
## Smoothing parameters:
##  alpha: 0.6610618
##  beta : 0
##  gamma: 0.6248076
##
## Coefficients:
##               [,1]
## a     71.477236414
## b     -0.004362918
## s1    18.590169842
## s2    17.803098732
## s3    12.204442890
## s4    13.233948865
## s5    12.957258705
## s6    11.525341233
## s7    10.854441534
## s8    10.199632666
## s9     8.694767348
## s10    5.983076192
## s11    3.123493477
## s12    4.698228193
## s13    2.730023168
## s14    2.995935818
## s15    1.714600919
## s16    2.486701224
## s17    6.382595268
## s18    5.081837636
## s19    7.571432660
## s20    6.165047647
## s21    9.560458487
## s22    9.700133847
## s23    8.808383245
## s24    8.505505527
## s25    7.406809208
## s26    6.839204571
## s27    6.368261304
## s28    6.382080380
## s29    4.552058253
## s30    6.877476437
## s31    4.823330209
## s32    4.931885957
## s33    7.109879628
## s34    6.178469084
## s35    4.886891317
## s36    3.890547248
## s37    2.148316257
## s38    2.524866001
## s39    3.008098232
```

```
## s40    3.041663870
## s41    2.251741386
## s42    0.101091985
## s43   -0.123337548
## s44   -1.445675315
## s45   -1.802768181
## s46   -2.192036338
## s47   -0.180954242
## s48    1.538987281
## s49    5.075394760
## s50    6.740978049
## s51    7.737089782
## s52    8.579515859
## s53    8.408834158
## s54    4.704976718
## s55    1.827215229
## s56   -1.275747384
## s57    1.389899699
## s58    1.376842871
## s59    0.509553410
## s60    1.886439429
## s61   -0.806454923
## s62    5.221873550
## s63    5.383073482
## s64    4.265584552
## s65    3.841481452
## s66   -0.231239928
## s67    0.542761270
## s68    0.780131779
## s69    1.096690727
## s70    0.690525998
## s71    2.301303414
## s72    2.965913580
## s73    4.393732595
## s74    2.744547070
## s75    1.035278911
## s76    1.170709479
## s77    2.796838283
## s78    2.000312540
## s79    0.007337449
## s80   -1.203916069
## s81    0.352397232
## s82    0.675108103
## s83   -3.169643942
## s84   -1.913321175
## s85   -1.647780450
## s86   -5.281261301
## s87   -5.126493027
## s88   -2.637666754
## s89   -2.342133004
## s90   -3.281910970
## s91   -4.242033198
## s92   -2.596010530
## s93   -7.821281290
```

```
## s94   -8.814741200
## s95   -8.996689798
## s96   -7.835655534
## s97   -5.749139155
## s98   -5.196182693
## s99   -8.623793296
## s100 -11.809355220
## s101 -13.129428554
## s102 -16.095143067
## s103 -15.125436350
## s104 -13.963606549
## s105 -12.953304848
## s106 -16.097179844
## s107 -15.489223470
## s108 -13.680122300
## s109 -11.921434142
## s110 -12.035411347
## s111 -12.837047727
## s112  -9.095808127
## s113  -5.433029341
## s114  -6.800835107
## s115  -8.413639598
## s116 -10.912409484
## s117 -13.553826535
## s118 -10.652543677
## s119 -12.627298331
## s120  -9.906981556
## s121 -12.668519900
## s122  -9.805502547
## s123  -7.775306633
```

```
print(temps_triple$SSE)
```

```
## [1] 66244.25
```

Again the beta is 0, so it suggests there is no trend.

Triple exponential smoothing with multiplicative seasonal

```
temps_triple_m <- HoltWinters(temps_ts,
                              alpha = NULL,
                              beta = NULL,
                              gamma = NULL,
                              seasonal = "multiplicative")
print(temps_triple_m)
```

```
## Holt-Winters exponential smoothing with trend and multiplicative seasonal component.
##
## Call:
## HoltWinters(x = temps_ts, alpha = NULL, beta = NULL, gamma = NULL,     seasonal = "multiplica
tive")
##
## Smoothing parameters:
##  alpha: 0.615003
##  beta : 0
##  gamma: 0.5495256
##
## Coefficients:
##              [,1]
## a    73.679517064
## b    -0.004362918
## s1    1.239022317
## s2    1.234344062
## s3    1.159509551
## s4    1.175247483
## s5    1.171344196
## s6    1.151038408
## s7    1.139383104
## s8    1.130484528
## s9    1.110487514
## s10   1.076242879
## s11   1.041044609
## s12   1.058139281
## s13   1.032496529
## s14   1.036257448
## s15   1.019348815
## s16   1.026754142
## s17   1.071170378
## s18   1.054819556
## s19   1.084397734
## s20   1.064605879
## s21   1.109827336
## s22   1.112670130
## s23   1.103970506
## s24   1.102771209
## s25   1.091264692
## s26   1.084518342
## s27   1.077914660
## s28   1.077696145
## s29   1.053788854
## s30   1.079454300
## s31   1.053481186
## s32   1.054023885
## s33   1.078221405
## s34   1.070145761
## s35   1.054891375
## s36   1.044587771
## s37   1.023285461
## s38   1.025836722
```

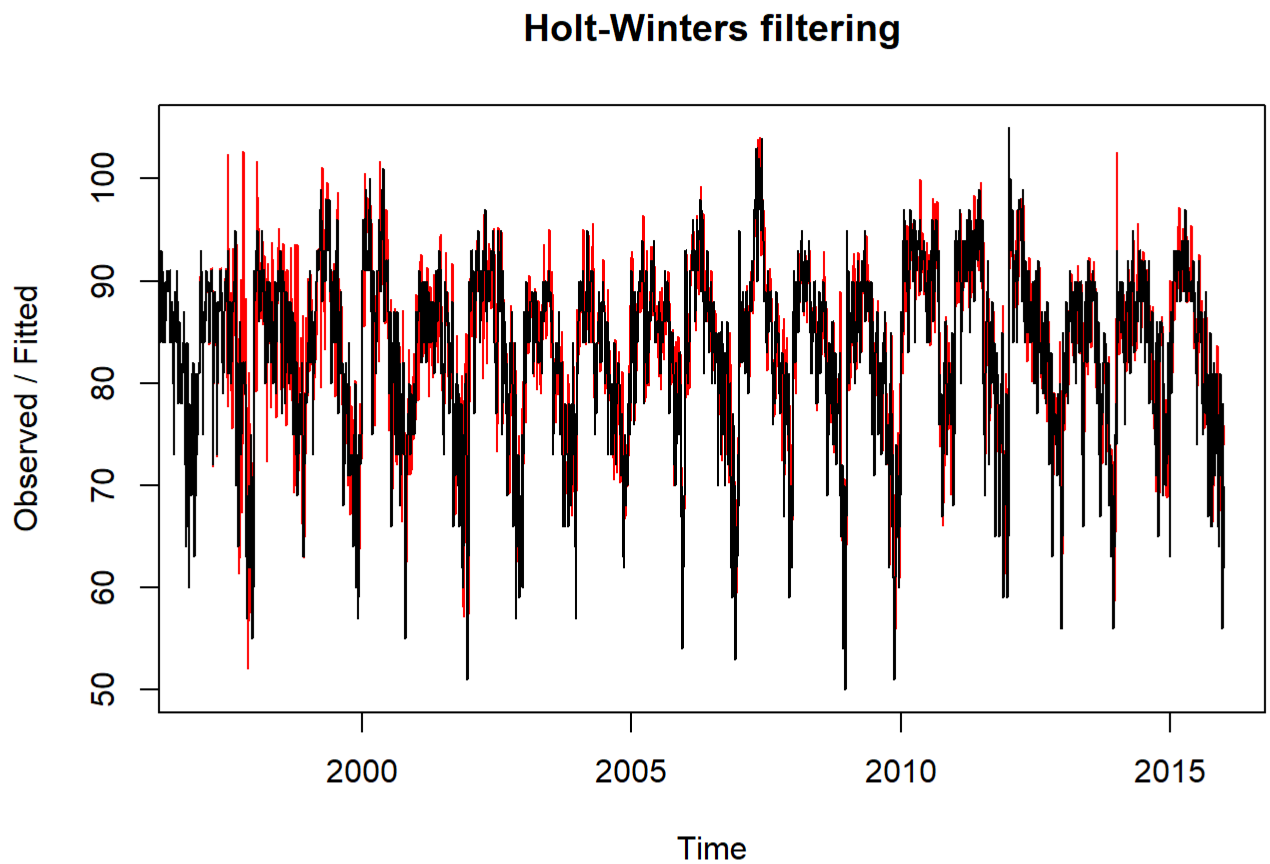
```
## s39   1.031075732
## s40   1.031419152
## s41   1.021827552
## s42   0.998177248
## s43   0.996049257
## s44   0.981570825
## s45   0.976510542
## s46   0.967977608
## s47   0.985788411
## s48   1.004748195
## s49   1.050965934
## s50   1.072515008
## s51   1.086532279
## s52   1.098357400
## s53   1.097158461
## s54   1.054827180
## s55   1.022866587
## s56   0.987259326
## s57   1.016923524
## s58   1.016604903
## s59   1.004320951
## s60   1.019102781
## s61   0.983848662
## s62   1.055888360
## s63   1.056122844
## s64   1.043478958
## s65   1.039475693
## s66   0.991019224
## s67   1.001437488
## s68   1.002221759
## s69   1.003949213
## s70   0.999566344
## s71   1.018636837
## s72   1.026490773
## s73   1.042507768
## s74   1.022500795
## s75   1.002503740
## s76   1.004560984
## s77   1.025536556
## s78   1.015357769
## s79   0.992176558
## s80   0.979377825
## s81   0.998058079
## s82   1.002553395
## s83   0.955429116
## s84   0.970970220
## s85   0.975543504
## s86   0.931515830
## s87   0.926764603
## s88   0.958565273
## s89   0.963250387
## s90   0.951644060
## s91   0.937362688
## s92   0.954257999
```

```
## s93   0.892485444
## s94   0.879537700
## s95   0.879946892
## s96   0.890633648
## s97   0.917134959
## s98   0.925991769
## s99   0.884247686
## s100  0.846648167
## s101  0.833696369
## s102  0.800001437
## s103  0.807934782
## s104  0.819343668
## s105  0.828571029
## s106  0.795608740
## s107  0.796609993
## s108  0.815503509
## s109  0.830111282
## s110  0.829086181
## s111  0.818367239
## s112  0.863958784
## s113  0.912057203
## s114  0.898308248
## s115  0.878723779
## s116  0.848971946
## s117  0.813891909
## s118  0.846821392
## s119  0.819121827
## s120  0.851036184
## s121  0.820416491
## s122  0.851581233
## s123  0.874038407
```

```
print(paste("SSE: ", temps_triple_m$SSE))
```

```
## [1] "SSE:  68904.5693317477"
```

```
plot(temps_triple_m)
```



Export seasonality for cusum analysis in excel

```
head(temps_triple_m$fitted)
```

```
##          xhat    level        trend   season
## [1,] 87.23653 82.87739 -0.004362918 1.052653
## [2,] 90.42182 82.15059 -0.004362918 1.100742
## [3,] 92.99734 81.91055 -0.004362918 1.135413
## [4,] 90.94030 81.90763 -0.004362918 1.110338
## [5,] 83.99917 81.93634 -0.004362918 1.025231
## [6,] 84.04496 81.93247 -0.004362918 1.025838
```

```
head(temps_triple_m$fitted[,4])
```

```
## [1] 1.052653 1.100742 1.135413 1.110338 1.025231 1.025838
```

```
temps_season <- matrix(temps_triple_m$fitted[,4], nrow = 123)
write.csv(temps_season,
          file = "temps_cusum.csv")
```

Excel summary

Using a C value of 0.12 and T value of 0.2, I observed unofficial end date of summer as highlighted in red in the excel sheet. Based on this observation, there is not a lot of fluntuation of end dates from year to year. Therefore, I conclude that the unofficial end of summer has not gotten later over the 20 years of our observation.