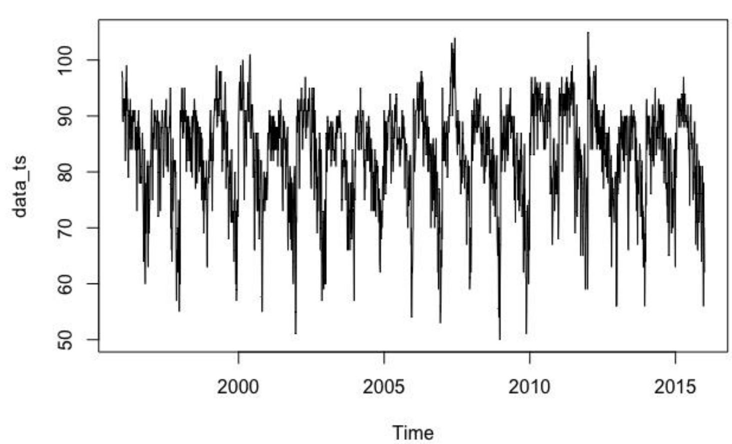
Question 7.1
Describe a situation or problem from your job, everyday life, current events, etc., for which exponential smoothing would be appropriate. What data would you need? Would you expect the value of α (the first smoothing parameter) to be closer to 0 or 1, and why?

As a financial advisor, I would use exponential smoothing to forecast the monthly returns of a client's investment portfolio. The data I would need is the historical monthly returns of the investment portfolio over a given time period. I could use these historical returns to estimate future performance, taking into account that recent returns may be more relevant than older returns, but both old and recent still matter. I would expect the value of alpha to be closer to 0. This is because more often than not, long term trends and stability are more important to most client's portfolios than short term fluctuations (which would be if alpha was closer to 1).

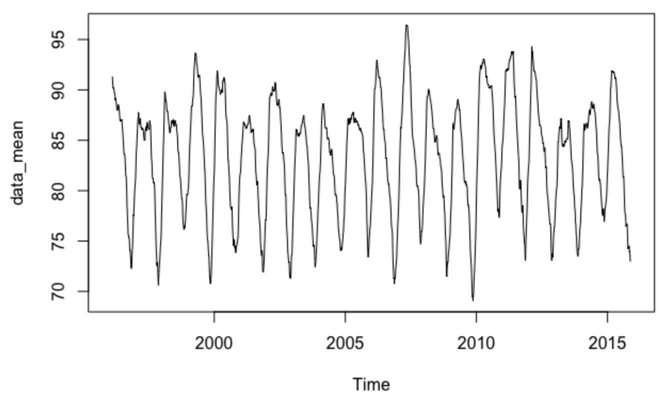
Question 7.2
Using the 20 years of daily high temperature data for Atlanta (July through October) from Question 6.2 (file temps.txt), build and use an exponential smoothing model to help make a judgment of whether the unofficial end of summer has gotten later over the 20 years. (Part of the point of this assignment is for you to think about how you might use exponential smoothing to answer this question. Feel free to combine it with other models if you'd like to. There's certainly more than one reasonable approach.)

Note: in R, you can use either HoltWinters (simpler to use) or the smooth package's es function (harder to use, but more general). If you use es, the Holt-Winters model uses model="AAM" in the function call (the first and second constants are used "A"dditively, and the third (seasonality) is used "M"ultiplicatively; the documentation doesn't make that clear).

Using HoltWinters, it does not look like the unofficial end of summer has gotten later over the 20 year period in the data set. After loading the data into R, I put the data into a time series function. The image this function produced is below:



Looking at this time series data, it looks like the data keeps a fairly steady pattern within the same values of the rest. In order to see this more clearly, I wanted to create a smoothed-out graph that got rid of the noise of the time series graph. To do this, I used the rollmean function in R. The graph this created is shown below:



Visually, it looks like each peak and valley occur within the same ranges of time as the rest. There are a couple years that go either shorter or longer, but overall, there is no one time period where the unofficial end of summer changes after it. I then ran a HoltWinters function on the time series data to see what the smoothing parameters looked like. After running, beta had a value of 0. This indicated that there was no trend only in the data. This means that there is no time period in the data that shows temperature getting warmer or cooler than the rest of the data. Alpha, the level component, had a value of around 0.66 and gamma, the seasonal component, had a value of around 0.63 as well. It was interesting to see how much the graphs can show in terms of trends without running the HoltWinters function yet. I am interested to see what the graphs and values of alpha, beta, and gamma would have looked like if there was a point where the unofficial end of summer got later.

R Code and Output:

```
> set.seed(123)

> data <- read.table("temps.txt", header = TRUE)

> head(data)

   DAY X1996 X1997 X1998 X1999 X2000 X2001 X2002 X2003 X2004 X2005 X2006 X2007
X2008 X2009 X2010 X2011

1 1-Jul   98   86   91   84   89   84   90   73   82   91   93   95   85   95   87   92

2 2-Jul   97   90   88   82   91   87   90   81   81   89   93   85   87   90   84   94

3 3-Jul   97   93   91   87   93   87   87   87   86   86   93   82   91   89   83   95

4 4-Jul   90   91   91   88   95   84   89   86   88   86   91   86   90   91   85   92

5 5-Jul   89   84   91   90   96   86   93   80   90   89   90   88   88   80   88   90

6 6-Jul   93   84   89   91   96   87   93   84   90   82   81   87   82   87   89   90

  X2012 X2013 X2014 X2015

1   105   82   90   85

2    93   85   93   87

3    99   76   87   79

4    98   77   84   85

5   100   83   86   84

6    98   83   87   84

> data <- data[,-1]

> data <- as.vector(unlist(data))

> data_ts <- ts(data, frequency = 123, start = 1996)

> data_ts

Time Series:

Start = c(1996, 1)
```

```
End = c(2015, 123)

Frequency = 123

  [1] 98 97 97 90 89 93 93 91 93 93 90 91 93 93 82 91 96 95 96 99 91 95 91 93 84

 [26] 84 82 79 90 91 87 86 90 84 91 93 88 91 84 90 89 88 86 84 86 89 90 91 91 90

 [51] 89 90 91 91 91 84 88 84 86 88 84 82 80 73 87 84 87 89 89 89 91 84 86 88 78

 [76] 79 86 82 82 78 79 79 78 81 84 84 87 84 79 75 72 64 66 72 84 70 66 64 60 78

[101] 70 72 69 69 73 79 81 80 82 66 63 68 79 81 69 73 73 75 75 81 82 82 81 86
90

[126] 93 91 84 84 75 87 84 87 84 88 86 90 91 91 89 89 89 90 89 84 87 88 89 89
91

[151] 91 89 88 72 80 84 88 89 88 84 84 80 73 80 86 88 88 87 88 91 91 89 89 88
82

[176] 79 81 82 84 87 90 90 91 91 88 88 91 93 81 81 82 86 88 84 80 82 86 87 87
88

[201] 88 90 88 91 95 89 70 80 82 66 70 64 68 77 86 75 73 75 78 81 82 82 82 80
82

[226] 82 79 80 68 63 57 66 64 69 70 70 62 63 62 75 71 57 55 64 66 60 91 88 91
91

[251] 91 89 93 95 95 91 91 86 88 87 91 87 90 91 95 91 91 89 91 91 86 88 80 88
89

[276] 90 86 86 82 84 86 90 89 89 86 82 87 88 84 86 80 82 86 84 87 90 79 84 87
87

[301] 88 90 91 89 90 93 93 91 87 84 77 90 91 89 90 89 79 78 81 84 89 87 87 88
87

[326] 82 80 82 82 88 84 81 82 84 87 80 75 75 86 78 77 82 82 73 82 69 72 73 78
78

[351] 78 75 79 78 77 78 82 75 73 63 63 72 75 79 79 79 78 82 79 84 82 87 88 90
91

[376] 82 86 87 87 82 77 73 81 81 86 82 87 88 90 90 91 93 93 91 93 93 93 93 97
99
```

[401] 96 93 88 89 91 93 93 93 91 90 96 98 97 98 93 93 96 98 98 89 91 91 90 80
82

[426] 89 88 90 91 91 84 88 91 84 93 96 96 91 91 77 87 87 87 86 87 89 81 81 82
79

[451] 68 79 72 75 78 81 82 78 80 77 71 73 75 84 71 73 71 73 73 72 72 73 70 64
75

[476] 73 77 80 71 66 60 64 73 57 59 64 69 75 73 72 75 75 89 91 93 95 96 96 96
91

[501] 96 99 96 93 91 93 93 93 91 97 100 99 93 96 87 82 75 82 88 91 89 87 86 86
81

[526] 84 88 91 91 91 91 96 95 89 89 89 89 94 97 99 101 101 97 87 86 88 92 92 90
90

[551] 92 92 88 87 79 81 82 87 81 66 66 75 80 82 84 86 87 86 80 75 73 73 84 87
77

[576] 73 81 84 82 68 71 75 73 75 77 79 82 81 82 73 66 55 55 64 71 73 75 75 77
80

[601] 80 80 73 73 75 79 75 75 78 75 78 80 75 77 78 84 87 87 84 86 87 87 89 91
87

[626] 90 90 86 82 82 84 87 88 90 87 84 87 90 84 82 88 90 84 89 89 87 84 84 84
86

[651] 88 84 86 88 87 88 86 86 81 87 84 90 91 91 87 86 88 90 88 93 90 91 91 81
86

[676] 81 82 80 75 73 81 90 88 87 86 86 89 87 84 84 86 77 77 81 81 82 84 86 87
88

[701] 69 66 72 75 78 71 71 75 80 81 80 79 70 68 79 66 73 75 78 78 75 75 62 60
64

[726] 71 75 79 80 81 79 73 64 51 55 63 72 71 90 90 87 89 93 93 89 89 90 91 84
77

[751] 82 88 91 93 93 93 93 91 95 91 89 87 84 86 89 91 91 88 90 93 91 91 91 93
97

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 [776] 87 87 86 88 89 91 91 89 88 90 91 93 91 93 93 91 95 93 91 88 84 82 82 78
77

 [801] 84 84 89 95 93 91 88 87 91 95 95 90 75 78 91 88 86 81 80 86 84 77 82 73
69

 [826] 75 75 79 73 79 82 84 84 82 87 86 80 71 66 70 78 84 79 68 57 66 64 68 71
73

 [851] 71 64 59 68 60 68 69 75 75 68 60 73 81 87 86 80 84 87 90 89 84 84 86 87
84

 [876] 86 88 88 88 88 88 89 86 81 82 84 87 87 89 88 84 88 84 84 84 82 84 82 84
84

 [901] 86 87 84 81 87 89 90 86 89 90 90 87 88 88 90 89 88 89 90 91 89 88 89 88
86

 [926] 87 87 84 73 75 81 82 79 80 81 84 82 82 81 81 81 84 87 82 75 81 80 82 82
82

 [951] 73 66 71 72 68 66 77 78 75 73 73 73 73 66 78 78 78 69 72 68 70 75 78 84
78

 [976] 78 73 73 68 64 57 70 77 75 82 81 86 88 90 90 89 87 88 89 90 89 91 91 84
84

 [ reached getOption("max.print") -- omitted 1460 entries ]

> plot(data_ts)

> pacman::p_load(zoo)

> data_mean = rollmean(data_ts,30,fill = NA, allign = "right")

> plot(data_mean)

> data_holt <- HoltWinters(data_ts)

> data_holt

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


Call:

HoltWinters(x = data_ts)
```

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