Problem 1:

Exponential smoothing can be used to identify the clogging of air filters used in engines (locomotives, car, etc). For each air filter, the differential pressure is recorded each minute. We could build an exponential smoothing model for each air filter including cyclic effects and we could see the trend of how quickly the air filter clogs over the course of time.

In [1]:
```
#reading the data
data <- read.table('./temps.txt', header = T)
```

In [2]:
```
head(data)
```

DAY	X1996	X1997	X1998	X1999	X2000	X2001	X2002	X2003	X2004	⋯	X2006	X2007	X20
1-Jul	98	86	91	84	89	84	90	73	82	⋯	93	95	
2-Jul	97	90	88	82	91	87	90	81	81	⋯	93	85	
3-Jul	97	93	91	87	93	87	87	87	86	⋯	93	82	
4-Jul	90	91	91	88	95	84	89	86	88	⋯	91	86	
5-Jul	89	84	91	90	96	86	93	80	90	⋯	90	88	
6-Jul	93	84	89	91	96	87	93	84	90	⋯	81	87	

In [3]:
```
num_rows = nrow(data)
```

In [4]:
```
data <- as.vector(unlist(data[,:21]))
```

In [5]:
```
time_series <- ts(data,start=1996,frequency=num_rows)
```

In [7]:
```
#performing single exponential smoothing
single_exp <- HoltWinters(time_series, beta = F, gamma = F)
```

In [8]:
```
single_exp
```

```
Holt-Winters exponential smoothing without trend and without seasonal
component.

Call:
HoltWinters(x = time_series, beta = F, gamma = F)

Smoothing parameters:
 alpha: 0.8388021
 beta : FALSE
 gamma: FALSE

Coefficients:
      [,1]
a 63.30952
```

In [9]:
```
double_exp <- HoltWinters(time_series, gamma = F)
```

In [10]:
```
double_exp
```

```
Holt-Winters exponential smoothing with trend and without seasonal com
ponent.

Call:
HoltWinters(x = time_series, gamma = F)

Smoothing parameters:
 alpha: 0.8445729
 beta : 0.003720884
 gamma: FALSE

Coefficients:
        [,1]
a 63.2530022
b -0.0729933
```

It can be seen that beta is very close to zero. Hence there is no significant trend.

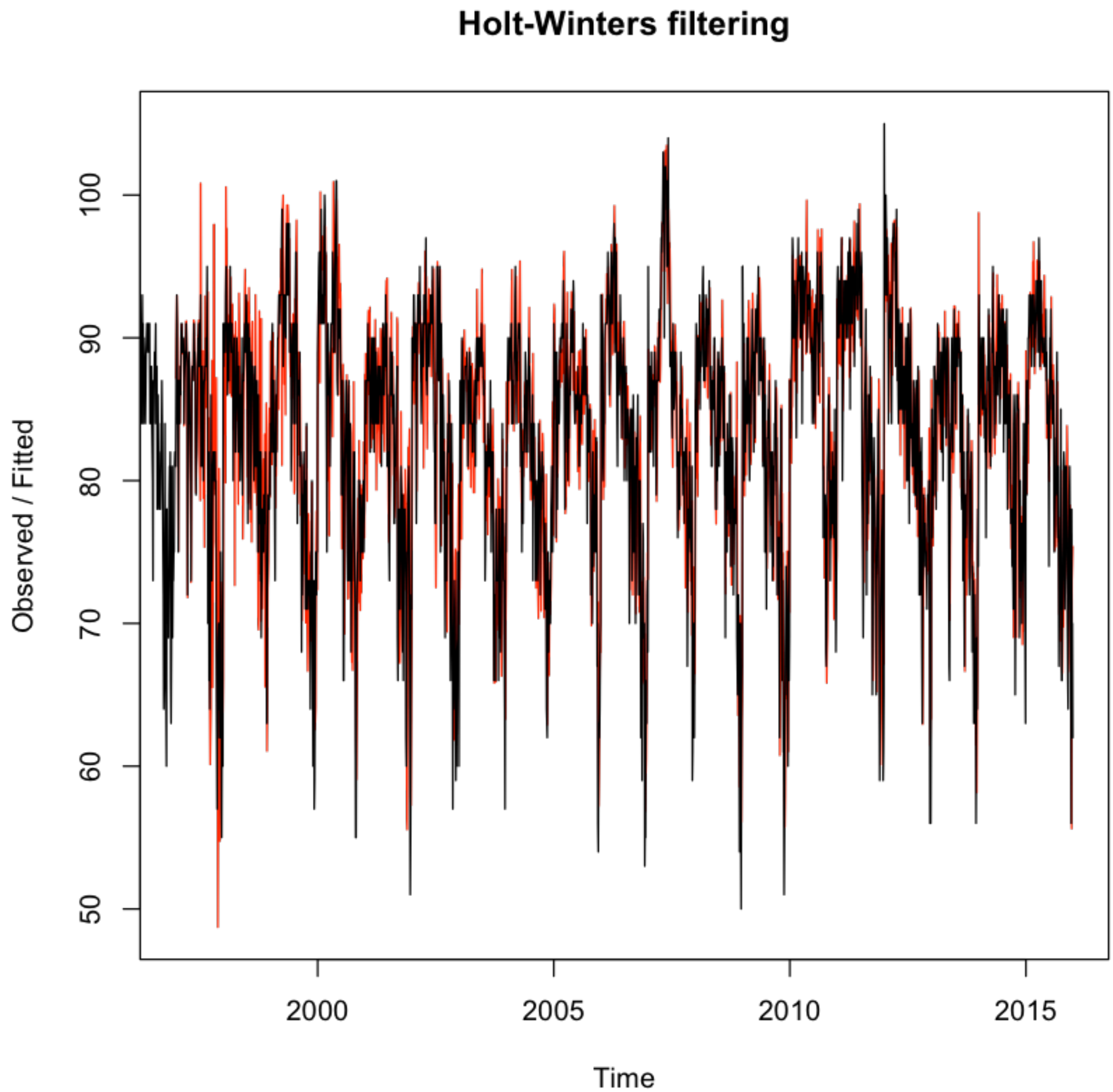
In [11]:
```
#triple exponential model with additive seasonal effects.
triple_exp_add <- HoltWinters(time_series, seasonal = 'additive')
```

In [12]:
```
triple_exp_add
```

```
Holt-Winters exponential smoothing with trend and additive seasonal c
omponent.

Call:
HoltWinters(x = time_series, seasonal = "additive")

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
```

Again, the beta is zero. Suggesting no significant trend.

In [13]:
```
plot(triple_exp_add)
```



In [14]:
```
triple_exp_mul <- HoltWinters(time_series, seasonal = "multiplicative")
```

In [15]:
```
triple_exp_mul
```

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

Call:
HoltWinters(x = time_series, 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
s3     1.159509551
s4     1.175247483
```

no significant trend observed again.

In all the above models, the trend is zero, suggesting there isn't a significant increase or decrease over the years.

quite confused with nrow argument here. TA used ncol = 123. But the plot of seasonal factors dont make sense to me. When we print the output of HoltWinter for seasonal = Multiplicative we see that the seasonal factors are decreasing. This behaviour is not achieved for ncol =123 Hence, I decided to use nrow = 123. I would be more than happy to know the correct approach. I also believe the seasonal factors should decrease in a given year.

In [16]:
```
mat <- matrix(triple_exp_mul$fitted[,4], nrow = 123)
```

In [17]:
```
write.csv(mat, file = 'SF.csv')
```

In [19]:
```
mat1 <- matrix(triple_exp_mul$fitted[,4], ncol = 123)
```

In [20]:
```
write.csv(mat1, file = 'SF1.csv')
```

I have attached two additional files. One when CUSUM is performed for mat (i.e. nrow = 123) and other is CUSUM for mat1 (i.e. ncol = 123). I feel the right way to use is nrow = 123. I'm not sure how to interpret the results for ncol = 123.

For ncol = 123, no clear change is detected for different values of C and T. But when we use CUSUM on nrow = 123, change is detected each year around 1st October - 7th October. Not a significant change over the years, hence we can say summers are not getting longer.

In [ ]:

```

```