Homework4.R

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#Install Packages  
# warnings will be disabled  
options(warn=-1)  
rm(list = ls())  
library(IRkernel)  
library(forecast)

## Registered S3 method overwritten by 'quantmod':  
## method from  
## as.zoo.data.frame zoo

library(ggplot2)  
library(survMisc)

## Loading required package: survival

##   
## Attaching package: 'survMisc'

## The following object is masked from 'package:ggplot2':  
##   
## autoplot

## The following object is masked from 'package:forecast':  
##   
## autoplot

library(tidyverse)

## -- Attaching packages ----------------------------------------------------------------------------------------------------------------------------------------------- tidyverse 1.3.0 --

## v tibble 3.0.3 v dplyr 1.0.2  
## v tidyr 1.1.2 v stringr 1.4.0  
## v readr 1.3.1 v forcats 0.5.0  
## v purrr 0.3.4

## -- Conflicts -------------------------------------------------------------------------------------------------------------------------------------------------- tidyverse\_conflicts() --  
## x survMisc::autoplot() masks ggplot2::autoplot(), forecast::autoplot()  
## x dplyr::filter() masks stats::filter()  
## x dplyr::lag() masks stats::lag()

library(reshape)

##   
## Attaching package: 'reshape'

## The following object is masked from 'package:dplyr':  
##   
## rename

## The following objects are masked from 'package:tidyr':  
##   
## expand, smiths

library(ggfortify)

## Registered S3 methods overwritten by 'ggfortify':  
## method from   
## autoplot.Arima forecast  
## autoplot.acf forecast  
## autoplot.ar forecast  
## autoplot.bats forecast  
## autoplot.decomposed.ts forecast  
## autoplot.ets forecast  
## autoplot.forecast forecast  
## autoplot.stl forecast  
## autoplot.ts forecast  
## fitted.ar forecast  
## fortify.ts forecast  
## residuals.ar forecast

library(lubridate)

##   
## Attaching package: 'lubridate'

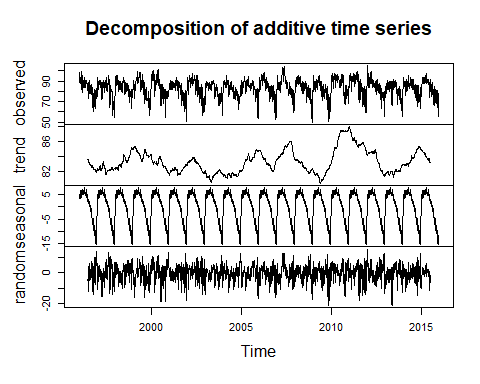
## The following object is masked from 'package:reshape':  
##   
## stamp

## The following objects are masked from 'package:base':  
##   
## date, intersect, setdiff, union

data <- read.table("temps.txt",stringsAsFactors = FALSE, header=TRUE)  
head(data[1:4,])

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

#convert the data into time series  
  
data\_vec <- as.vector(unlist(data[,2:21]))  
data\_ts <- ts(data\_vec, start = 1996, frequency = 123)  
  
plot(decompose(data\_ts))



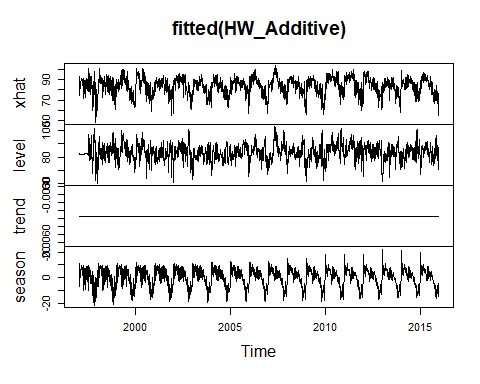
#Run single/double/tripe exponential smoothing  
#"The additive model is most appropriate if the magnitude of the seasonal  
#fluctuations or the variation around the trend-cycle does not vary with   
#the level of the time series. When the variation in the seasonal pattern,  
#or the variation around the trend-cycle, apprears to be proportional to the   
#level of the time series, then a multiplicative model is more appropriate.  
  
set.seed(1)  
#Holtwinter: using additive model  
HW\_Additive<- HoltWinters(data\_ts,seasonal="additive")  
summary(HW\_Additive)

## 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 3 -none- call

cat("HoltsWinter Additive method Results:\n\tBaseline factor alpha:", HW\_Additive$alpha,"\n\tTrend factor beta:",HW\_Additive$beta,"\n\tSeasonal factor gamma:",HW\_Additive$gamma,"\n\tSum of Squared Errors:", HW\_Additive$SSE,"\n")

## HoltsWinter Additive method Results:  
## Baseline factor alpha: 0.6610618   
## Trend factor beta: 0   
## Seasonal factor gamma: 0.6248076   
## Sum of Squared Errors: 66244.25

par(mfrow=c(1,2))  
plot(fitted(HW\_Additive))



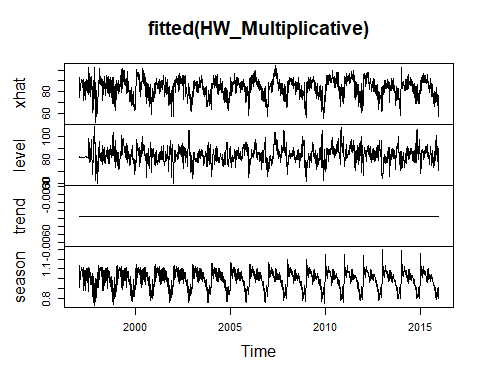
HW\_Multiplicative <- HoltWinters(data\_ts,alpha=NULL,beta=NULL,gamma=NULL,seasonal = "multiplicative")  
cat("HoltsWinter Multiplicative method Results:\n\tBaseline factor alpha:", HW\_Multiplicative$alpha,"\n\tTrend factor beta:",HW\_Multiplicative$beta,"\n\tSeasonal factor gamma:",HW\_Multiplicative$gamma,"\n\tSum of Squared Errors:", HW\_Multiplicative$SSE,"\n")

## HoltsWinter Multiplicative method Results:  
## Baseline factor alpha: 0.615003   
## Trend factor beta: 0   
## Seasonal factor gamma: 0.5495256   
## Sum of Squared Errors: 68904.57

summary(HW\_Multiplicative)

## 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

par(mfrow=c(1,2))  
plot(fitted(HW\_Multiplicative))



HW\_Multiplicative$fitted

## Time Series:  
## Start = c(1997, 1)   
## End = c(2015, 123)   
## Frequency = 123   
## xhat level trend season  
## 1997.000 87.23653 82.87739 -0.004362918 1.0526529  
## 1997.008 90.42182 82.15059 -0.004362918 1.1007422  
## 1997.016 92.99734 81.91055 -0.004362918 1.1354128  
## 1997.024 90.94030 81.90763 -0.004362918 1.1103378  
## 1997.033 83.99917 81.93634 -0.004362918 1.0252306  
## 1997.041 84.04496 81.93247 -0.004362918 1.0258379  
## 1997.049 75.06333 81.90115 -0.004362918 0.9165601  
## 1997.057 87.04945 81.85429 -0.004362918 1.0635250  
## 1997.065 84.02220 81.82134 -0.004362918 1.0269532  
## 1997.073 87.06445 81.80368 -0.004362918 1.0643665  
## 1997.081 84.05272 81.76208 -0.004362918 1.0280709  
## 1997.089 88.05141 81.72617 -0.004362918 1.0774531  
## 1997.098 86.03178 81.69246 -0.004362918 1.0531740  
## 1997.106 89.92787 81.66954 -0.004362918 1.1011777  
## 1997.114 90.89514 81.70546 -0.004362918 1.1125326  
## 1997.122 90.93680 81.75907 -0.004362918 1.1123128  
## 1997.130 88.91874 81.78965 -0.004362918 1.0872217  
## 1997.138 88.89374 81.83125 -0.004362918 1.0863634  
## 1997.146 88.86666 81.88704 -0.004362918 1.0852925  
## 1997.154 89.83703 81.95824 -0.004362918 1.0961900  
## 1997.163 88.79334 82.04531 -0.004362918 1.0823051  
## 1997.171 83.82979 82.15838 -0.004362918 1.0203980  
## 1997.179 87.02152 82.25660 -0.004362918 1.0579836  
## 1997.187 88.03833 82.23973 -0.004362918 1.0705653  
## 1997.195 89.02771 82.21335 -0.004362918 1.0829438  
## 1997.203 89.19019 82.19325 -0.004362918 1.0851855  
## 1997.211 91.19587 82.08110 -0.004362918 1.1111050  
## 1997.220 91.20560 81.96832 -0.004362918 1.1127526  
## 1997.228 89.13435 81.85032 -0.004362918 1.0890501  
## 1997.236 88.00292 81.77009 -0.004362918 1.0762812  
## 1997.244 71.84081 81.76406 -0.004362918 0.8786824  
## 1997.252 79.85674 81.87112 -0.004362918 0.9754477  
## 1997.260 83.92934 81.95708 -0.004362918 1.0241191  
## 1997.268 88.04492 81.99515 -0.004362918 1.0738392  
## 1997.276 88.94256 81.96506 -0.004362918 1.0851855  
## 1997.285 87.84357 81.99325 -0.004362918 1.0714083  
## 1997.293 83.78960 82.07868 -0.004362918 1.0208992  
## 1997.301 83.73355 82.20106 -0.004362918 1.0186973  
## 1997.309 79.86675 82.35756 -0.004362918 0.9698076  
## 1997.317 72.87791 82.43769 -0.004362918 0.8840830  
## 1997.325 79.86607 82.51826 -0.004362918 0.9679105  
## 1997.333 85.83089 82.59900 -0.004362918 1.0391824  
## 1997.341 87.84293 82.69472 -0.004362918 1.0623117  
## 1997.350 87.87486 82.78128 -0.004362918 1.0615865  
## 1997.358 87.04117 82.84942 -0.004362918 1.0506501  
## 1997.366 88.16633 82.82096 -0.004362918 1.0645974  
## 1997.374 91.26671 82.72051 -0.004362918 1.1033724  
## 1997.382 91.24096 82.56748 -0.004362918 1.1051055  
## 1997.390 89.10351 82.42902 -0.004362918 1.0810298  
## 1997.398 88.98271 82.36577 -0.004362918 1.0803932  
## 1997.407 87.97149 82.37125 -0.004362918 1.0680444  
## 1997.415 82.05789 82.38330 -0.004362918 0.9961028  
## 1997.423 79.16500 82.34320 -0.004362918 0.9614539  
## 1997.431 81.10871 82.23329 -0.004362918 0.9863768  
## 1997.439 82.12695 82.16115 -0.004362918 0.9996368  
## 1997.447 84.02904 82.07869 -0.004362918 1.0238164  
## 1997.455 87.04126 82.05688 -0.004362918 1.0607993  
## 1997.463 90.17163 82.02860 -0.004362918 1.0993291  
## 1997.472 90.29310 81.92822 -0.004362918 1.1021588  
## 1997.480 91.27188 81.76031 -0.004362918 1.1163944  
## 1997.488 91.24459 81.60617 -0.004362918 1.1181688  
## 1997.496 84.25877 81.46728 -0.004362918 1.0343206  
## 1997.504 80.51733 83.68744 -0.004362918 0.9621698  
## 1997.512 77.72033 88.46587 -0.004362918 0.8785779  
## 1997.520 102.39420 97.75726 -0.004362918 1.0474800  
## 1997.528 93.27164 92.23731 -0.004362918 1.0112615  
## 1997.537 88.82479 84.76990 -0.004362918 1.0478880  
## 1997.545 86.01454 80.17319 -0.004362918 1.0729176  
## 1997.553 83.68771 77.86767 -0.004362918 1.0748030  
## 1997.561 85.13833 79.18640 -0.004362918 1.0752229  
## 1997.569 88.92440 80.81884 -0.004362918 1.1003524  
## 1997.577 79.33060 78.06216 -0.004362918 1.0163060  
## 1997.585 81.68431 78.46287 -0.004362918 1.0411147  
## 1997.593 83.80257 78.64499 -0.004362918 1.0656396  
## 1997.602 75.52504 79.90881 -0.004362918 0.9451919  
## 1997.610 83.66133 87.37080 -0.004362918 0.9575911  
## 1997.618 93.22283 89.51067 -0.004362918 1.0415224  
## 1997.626 85.81989 86.42231 -0.004362918 0.9930795  
## 1997.634 87.21610 87.76806 -0.004362918 0.9937606  
## 1997.642 84.63587 89.48655 -0.004362918 0.9458405  
## 1997.650 87.87254 91.66960 -0.004362918 0.9586244  
## 1997.659 89.87110 93.67165 -0.004362918 0.9594715  
## 1997.667 91.86176 96.95482 -0.004362918 0.9475124  
## 1997.675 93.66411 95.09297 -0.004362918 0.9850192  
## 1997.683 82.06845 80.31377 -0.004362918 1.0219033  
## 1997.691 80.83164 79.06457 -0.004362918 1.0224060  
## 1997.699 84.41654 79.76301 -0.004362918 1.0583998  
## 1997.707 70.53082 69.05737 -0.004362918 1.0214010  
## 1997.715 65.96298 68.73340 -0.004362918 0.9597542  
## 1997.724 61.40063 67.47117 -0.004362918 0.9100865  
## 1997.732 62.84325 71.92642 -0.004362918 0.8737688  
## 1997.740 63.61506 81.88630 -0.004362918 0.7769120  
## 1997.748 79.91419 99.60184 -0.004362918 0.8023716  
## 1997.756 83.92780 95.83084 -0.004362918 0.8758309  
## 1997.764 90.12375 88.15305 -0.004362918 1.0224060  
## 1997.772 67.32195 79.05137 -0.004362918 0.8516698  
## 1997.780 69.67696 86.75778 -0.004362918 0.8031610  
## 1997.789 74.35139 95.42379 -0.004362918 0.7792060  
## 1997.797 74.14035 101.45623 -0.004362918 0.7307934  
## 1997.805 102.73294 108.06620 -0.004362918 0.9506866  
## 1997.813 80.78130 94.64961 -0.004362918 0.8535167  
## 1997.821 82.72991 94.08228 -0.004362918 0.8793765  
## 1997.829 78.91909 93.56745 -0.004362918 0.8434853  
## 1997.837 80.82615 95.80944 -0.004362918 0.8436521  
## 1997.846 84.30297 94.47386 -0.004362918 0.8923830  
## 1997.854 88.32901 91.50402 -0.004362918 0.9653480  
## 1997.862 77.73427 78.54847 -0.004362918 0.9896894  
## 1997.870 67.82727 69.38808 -0.004362918 0.9775676  
## 1997.878 62.68712 62.57211 -0.004362918 1.0019078  
## 1997.886 52.09185 64.60130 -0.004362918 0.8064136  
## 1997.894 56.72255 73.67857 -0.004362918 0.7699105  
## 1997.902 69.37749 83.48141 -0.004362918 0.8310966  
## 1997.911 81.04889 83.93770 -0.004362918 0.9656341  
## 1997.919 76.18954 76.89640 -0.004362918 0.9908639  
## 1997.927 57.53302 68.08496 -0.004362918 0.8450721  
## 1997.935 64.48533 72.05921 -0.004362918 0.8949479  
## 1997.943 63.00914 70.34694 -0.004362918 0.8957468  
## 1997.951 72.30786 78.57528 -0.004362918 0.9202878  
## 1997.959 71.50660 77.69691 -0.004362918 0.9203791  
## 1997.967 67.54725 67.99915 -0.004362918 0.9934182  
## 1997.976 60.54091 60.22706 -0.004362918 1.0052839  
## 1997.984 62.64525 62.33887 -0.004362918 1.0049851  
## 1997.992 63.87067 64.38745 -0.004362918 0.9920411  
## 1998.000 65.04516 61.98352 -0.004362918 1.0494684  
## 1998.008 84.87634 77.18905 -0.004362918 1.0996526  
## 1998.016 89.61560 78.93165 -0.004362918 1.1354197  
## 1998.024 88.47600 79.67715 -0.004362918 1.1104920  
## 1998.033 83.11178 81.07061 -0.004362918 1.0252328  
## 1998.041 88.00054 85.79813 -0.004362918 1.0257218  
## 1998.049 79.16627 86.39303 -0.004362918 0.9163964  
## 1998.057 101.73335 95.67263 -0.004362918 1.0633971  
## 1998.065 94.23796 91.77411 -0.004362918 1.0268958  
## 1998.073 98.14237 92.22613 -0.004362918 1.0641997  
## 1998.081 90.55054 88.09417 -0.004362918 1.0279344  
## 1998.089 95.18590 88.35871 -0.004362918 1.0773199  
## 1998.098 87.51833 83.11045 -0.004362918 1.0530916  
## 1998.106 91.83509 83.38738 -0.004362918 1.1013644  
## 1998.114 89.77962 80.68310 -0.004362918 1.1128040  
## 1998.122 90.49864 81.35319 -0.004362918 1.1124762  
## 1998.130 86.35333 79.41470 -0.004362918 1.0874318  
## 1998.138 88.52662 81.47273 -0.004362918 1.0866380  
## 1998.146 89.96005 82.86822 -0.004362918 1.0856367  
## 1998.154 93.99549 85.71895 -0.004362918 1.0966103  
## 1998.163 90.99112 84.03464 -0.004362918 1.0828372  
## 1998.171 85.78181 84.03533 -0.004362918 1.0208357  
## 1998.179 90.94522 85.96976 -0.004362918 1.0579282  
## 1998.187 92.05251 85.99724 -0.004362918 1.0704667  
## 1998.195 92.45980 85.38819 -0.004362918 1.0828725  
## 1998.203 88.63122 81.71507 -0.004362918 1.0846953  
## 1998.211 90.34555 81.35282 -0.004362918 1.1105995  
## 1998.220 84.10078 75.61953 -0.004362918 1.1122211  
## 1998.228 84.66499 77.77124 -0.004362918 1.0887025  
## 1998.236 86.32935 80.21570 -0.004362918 1.0762737  
## 1998.244 72.35333 82.30882 -0.004362918 0.8790938  
## 1998.252 89.62603 91.85149 -0.004362918 0.9758175  
## 1998.260 91.73385 89.56184 -0.004362918 1.0243014  
## 1998.268 89.88008 83.71316 -0.004362918 1.0737233  
## 1998.276 87.19187 80.34082 -0.004362918 1.0853337  
## 1998.285 85.37699 79.66109 -0.004362918 1.0718115  
## 1998.293 84.06971 82.30940 -0.004362918 1.0214407  
## 1998.301 86.92183 85.27353 -0.004362918 1.0193818  
## 1998.309 83.93596 86.52294 -0.004362918 0.9701495  
## 1998.317 77.67002 87.82703 -0.004362918 0.8843960  
## 1998.325 87.94583 90.83371 -0.004362918 0.9682535  
## 1998.333 93.79846 90.22858 -0.004362918 1.0396150  
## 1998.341 92.23253 86.79404 -0.004362918 1.0627131  
## 1998.350 87.09867 82.02543 -0.004362918 1.0619061  
## 1998.358 85.49378 81.38477 -0.004362918 1.0505450  
## 1998.366 83.17559 78.16428 -0.004362918 1.0641720  
## 1998.374 85.43211 77.48052 -0.004362918 1.1026890  
## 1998.382 85.91642 77.79289 -0.004362918 1.1044871  
## 1998.390 82.91302 76.72142 -0.004362918 1.0807639  
## 1998.398 85.39603 79.04273 -0.004362918 1.0804377  
## 1998.407 87.21678 81.65902 -0.004362918 1.0681176  
## 1998.415 76.60801 76.92359 -0.004362918 0.9959540  
## 1998.423 78.30412 81.48379 -0.004362918 0.9610294  
## 1998.431 85.82979 87.04428 -0.004362918 0.9860969  
## 1998.439 87.70479 87.76975 -0.004362918 0.9993096  
## 1998.447 90.03060 87.94707 -0.004362918 1.0237415  
## 1998.455 93.25608 87.92432 -0.004362918 1.0606929  
## 1998.463 95.17176 86.61186 -0.004362918 1.0988859  
## 1998.472 91.58039 83.15341 -0.004362918 1.1014004  
## 1998.480 91.77910 82.26658 -0.004362918 1.1156896  
## 1998.488 92.67801 82.93522 -0.004362918 1.1175336  
## 1998.496 86.74185 83.10805 -0.004362918 1.0437786  
## 1998.504 83.90163 85.61263 -0.004362918 0.9800646  
## 1998.512 79.43400 87.55253 -0.004362918 0.9073177  
## 1998.520 92.98923 90.64312 -0.004362918 1.0259324  
## 1998.528 79.47995 81.05389 -0.004362918 0.9806344  
## 1998.537 90.03013 87.64715 -0.004362918 1.0272394  
## 1998.545 93.68956 88.22344 -0.004362918 1.0620101  
## 1998.553 92.42281 85.50339 -0.004362918 1.0809808  
## 1998.561 91.07385 84.12062 -0.004362918 1.0827141  
## 1998.569 90.14966 82.93826 -0.004362918 1.0870062  
## 1998.577 78.00900 76.62568 -0.004362918 1.0181109  
## 1998.585 79.82644 76.61588 -0.004362918 1.0419640  
## 1998.593 82.82348 77.30419 -0.004362918 1.0714575  
## 1998.602 75.86386 77.97514 -0.004362918 0.9729781  
## 1998.610 83.29172 86.27391 -0.004362918 0.9654824  
## 1998.618 91.17418 88.63168 -0.004362918 1.0287367  
## 1998.626 85.98411 86.13190 -0.004362918 0.9983347  
## 1998.634 87.39493 87.36938 -0.004362918 1.0003423  
## 1998.642 83.07599 87.12222 -0.004362918 0.9536046  
## 1998.650 83.45434 86.42393 -0.004362918 0.9656881  
## 1998.659 81.74469 84.21965 -0.004362918 0.9706633  
## 1998.667 79.40697 84.37705 -0.004362918 0.9411455  
## 1998.675 79.40859 86.06713 -0.004362918 0.9226823  
## 1998.683 93.28728 91.78927 -0.004362918 1.0163684  
## 1998.691 88.35836 86.16519 -0.004362918 1.0255050  
## 1998.699 81.90533 81.74796 -0.004362918 1.0019785  
## 1998.707 83.41424 81.80171 -0.004362918 1.0197671  
## 1998.715 78.33457 82.15060 -0.004362918 0.9535990  
## 1998.724 81.54528 87.73482 -0.004362918 0.9294980  
## 1998.732 78.93023 86.70802 -0.004362918 0.9103449  
## 1998.740 69.29105 84.04851 -0.004362918 0.8244602  
## 1998.748 69.89014 88.30271 -0.004362918 0.7915226  
## 1998.756 85.64960 100.81551 -0.004362918 0.8496044  
## 1998.764 93.54797 95.27383 -0.004362918 0.9819302  
## 1998.772 74.51818 84.90514 -0.004362918 0.8777091  
## 1998.780 74.65890 90.14322 -0.004362918 0.8282655  
## 1998.789 76.00527 95.58976 -0.004362918 0.7951556  
## 1998.797 69.58630 93.26102 -0.004362918 0.7461805  
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## 2015.740 75.62055 81.18187 -0.004362918 0.9315457  
## 2015.748 80.02374 87.36978 -0.004362918 0.9159659  
## 2015.756 73.10783 81.30665 -0.004362918 0.8992100  
## 2015.764 67.60469 76.44098 -0.004362918 0.8844542  
## 2015.772 66.32808 75.32080 -0.004362918 0.8806587  
## 2015.780 71.00903 77.88070 -0.004362918 0.9118178  
## 2015.789 72.66636 79.21921 -0.004362918 0.9173327  
## 2015.797 69.87401 81.44980 -0.004362918 0.8579242  
## 2015.805 74.14417 89.42110 -0.004362918 0.8291979  
## 2015.813 78.97950 95.24329 -0.004362918 0.8292775  
## 2015.821 79.25176 96.73735 -0.004362918 0.8192837  
## 2015.829 73.18508 90.53873 -0.004362918 0.8083680  
## 2015.837 73.55236 90.39356 -0.004362918 0.8137296  
## 2015.846 75.26376 92.23908 -0.004362918 0.8160025  
## 2015.854 76.50674 96.55799 -0.004362918 0.7923755  
## 2015.862 77.01911 97.71263 -0.004362918 0.7882558  
## 2015.870 83.70215 100.81419 -0.004362918 0.8302976  
## 2015.878 82.46671 95.84553 -0.004362918 0.8604519  
## 2015.886 73.84518 86.93066 -0.004362918 0.8495149  
## 2015.894 67.17884 81.24680 -0.004362918 0.8268935  
## 2015.902 67.40786 78.87817 -0.004362918 0.8546292  
## 2015.911 73.84272 81.45876 -0.004362918 0.9065529  
## 2015.919 73.33840 82.91789 -0.004362918 0.8845166  
## 2015.927 75.12802 86.85003 -0.004362918 0.8650751  
## 2015.935 77.61628 91.02020 -0.004362918 0.8527777  
## 2015.943 73.71182 89.85022 -0.004362918 0.8204254  
## 2015.951 76.54551 87.81303 -0.004362918 0.8717307  
## 2015.959 69.70436 81.07435 -0.004362918 0.8598048  
## 2015.967 57.02909 71.26750 -0.004362918 0.8002607  
## 2015.976 72.14646 87.37935 -0.004362918 0.8257107  
## 2015.984 73.89293 85.77627 -0.004362918 0.8615051  
## 2015.992 75.83100 82.99285 -0.004362918 0.9137532

#Not sure why exactly the trend component is the same for every time period,  
#but it might be an average overall individual trend components.  
  
#Going to look at the seasonal factors.  
  
  
HW\_M\_seasonalfactor <-matrix(HW\_Multiplicative$fitted[,4],nrow=123)  
head(HW\_M\_seasonalfactor)

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

HW\_xhat <- matrix(HW\_Multiplicative$fitted[,1],nrow=123)  
rownames(HW\_xhat) <-data[,1]  
columns = colnames(data[,-2])  
colnames(HW\_xhat) <-columns[-1]  
  
  
head(HW\_xhat)

## X1997 X1998 X1999 X2000 X2001 X2002 X2003 X2004  
## 1-Jul 87.23653 65.04516 90.29613 83.39938 87.68863 78.07509 73.10059 87.27074  
## 2-Jul 90.42182 84.87634 85.44878 86.44444 84.78855 86.02384 72.13247 85.01878  
## 3-Jul 92.99734 89.61560 85.65942 92.85774 88.70570 90.23022 77.77739 82.68648  
## 4-Jul 90.94030 88.47600 84.80741 91.55309 86.98750 87.27931 83.52416 83.37312  
## 5-Jul 83.99917 83.11178 81.14293 88.80208 81.40681 86.06745 83.86090 83.64904  
## 6-Jul 84.04496 88.00054 85.21673 91.04477 81.83758 87.87757 78.93483 86.79140  
## X2005 X2006 X2007 X2008 X2009 X2010 X2011 X2012  
## 1-Jul 92.29714 78.50826 81.58696 84.72917 79.51855 86.74604 93.88371 82.30605  
## 2-Jul 92.85614 88.18138 88.52648 80.39548 85.65722 81.47324 87.43846 92.55001  
## 3-Jul 92.33884 92.43570 86.72311 84.53380 88.31357 82.29310 90.24836 91.18746  
## 4-Jul 87.29596 92.69774 83.30574 89.62822 88.56597 82.90566 93.69353 95.13130  
## 5-Jul 84.25223 90.58916 84.18954 89.27001 89.12501 80.92784 90.14667 94.60910  
## 6-Jul 85.75665 86.91496 82.21750 84.28967 79.32562 84.52016 88.67069 96.75445  
## X2013 X2014 X2015  
## 1-Jul 84.88750 102.54643 90.07756  
## 2-Jul 76.18707 89.57468 85.16854  
## 3-Jul 81.46207 88.15080 82.09161  
## 4-Jul 76.56780 87.11605 79.49314  
## 5-Jul 75.42085 85.20682 83.69666  
## 6-Jul 78.42462 83.25423 82.08838

S= c()  
std=c()  
DetectedDecreaseIndex = c()  
DetectedDecrease = c()  
S[0] = 0  
total = 0  
#finding a better T  
for(j in 1:ncol(HW\_xhat))  
{  
 std[j]= sd(HW\_xhat[,j])  
 total = total + std[j]  
}  
t= (total/ncol(HW\_xhat))\*3  
t

## [1] 24.4838

# Let c= 5 and T = 20  
# WE need to find when the temperature decreases so the summer ends.  
t=24  
C=5  
  
for(j in 2:ncol(HW\_xhat))  
{  
   
 for(i in 1:nrow(HW\_xhat))  
 {  
 S[i] = max(0,S[i-1]+(mean(HW\_xhat[,j])-HW\_xhat[i,j] - C))  
 if(S[i]>t)  
 {  
 DetectedDecreaseIndex[j-1] = i  
 DetectedDecrease[j-1]=S[i]  
 break  
 }  
 }  
}  
  
rows=rownames(HW\_xhat)  
cusum\_year = colnames(HW\_xhat)  
cusum\_decrease\_date = c()  
cusum\_c = c()  
cusum\_t =c()  
cusum\_st = c()  
cusum\_dt=c()  
temp=c()  
for(k in 1:length(DetectedDecreaseIndex))  
{  
   
 cusum\_decrease\_date[k] = HW\_xhat[DetectedDecreaseIndex[k],1]  
 cusum\_st[k]=DetectedDecrease[k]  
 cusum\_c[k] = C  
 cusum\_t[k] = t  
 cusum\_dt[k]=rows[DetectedDecreaseIndex[k]]  
 temp[k]=HW\_xhat[DetectedDecreaseIndex[k],k]  
}  
   
  
matrix.c = cbind(cusum\_year,cusum\_dt,temp,cusum\_st,cusum\_c,cusum\_t)  
colnames(matrix.c) = c("Year","Date","Ending Temperature", "Cusum S(t)", "C","Threshold")  
matrix.c = as.table(matrix.c)  
matrix.c

## Year Date Ending Temperature Cusum S(t) C Threshold  
## A X1997 11-Oct 78.9190894105648 24.8455839791495 5 24   
## B X1998 30-Sep 69.291047578795 26.6867353045359 5 24   
## C X1999 10-Sep 79.1866844600578 25.5316914278139 5 24   
## D X2000 29-Sep 69.5893423257103 24.4603950874326 5 24   
## E X2001 30-Sep 67.1563783984011 32.3680141545398 5 24   
## F X2002 2-Oct 79.3597049644767 30.1621407333443 5 24   
## G X2003 14-Oct 75.0176156665381 27.0386820586508 5 24   
## H X2004 9-Oct 72.4274638086104 27.2652810752102 5 24   
## I X2005 15-Oct 75.9827836778864 32.9201637926231 5 24   
## J X2006 14-Oct 66.6294848951239 27.7403908386628 5 24   
## K X2007 21-Oct 74.8352760309822 32.397072249358 5 24   
## L X2008 7-Oct 76.4756047418944 33.8227128042536 5 24   
## M X2009 2-Oct 74.6014312642295 24.5363976996178 5 24   
## N X2010 3-Oct 77.8689297870613 26.1190004599661 5 24   
## O X2011 8-Oct 74.1899206832538 32.5988594083823 5 24   
## P X2012 21-Oct 76.5073212181581 24.7777685778158 5 24   
## Q X2013 30-Sep 72.1794608892659 26.7466238546176 5 24   
## R X2014 28-Sep 75.3604036983112 28.4196926845551 5 24   
## S X2015 11-Oct 78.9190894105648 24.8455839791495 5 24