

Third Lab Assignment

assignment3.R

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```
# Airpassengers dataset
library(forecast)

library(timeSeries)

data("AirPassengers")
View(AirPassengers)
plot(AirPassengers)

class(AirPassengers)

## [1] "ts"

start(AirPassengers)

## [1] 1949    1

end(AirPassengers)

## [1] 1960    12

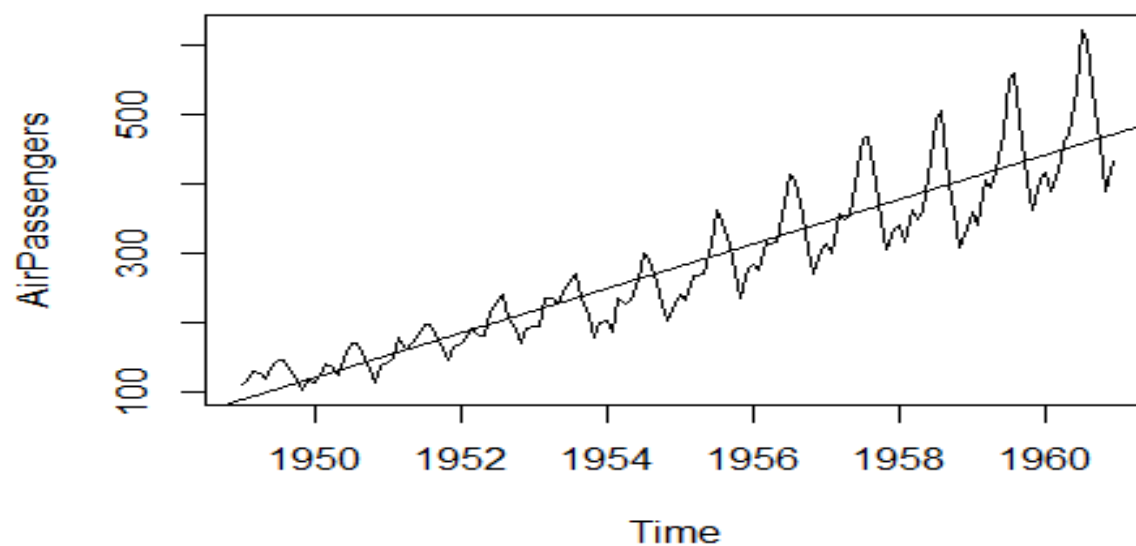
frequency(AirPassengers)

## [1] 12

summary(AirPassengers)

##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  104.0   180.0   265.5   280.3   360.5   622.0

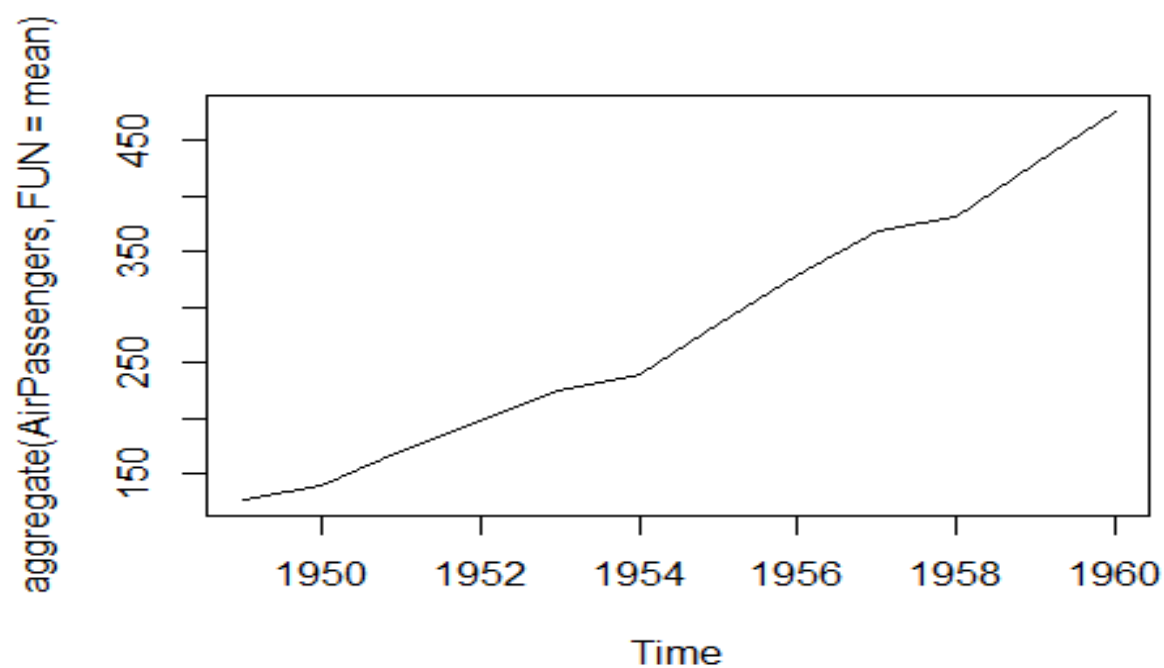
plot(AirPassengers)
abline(reg=lm(AirPassengers~time(AirPassengers)))
```



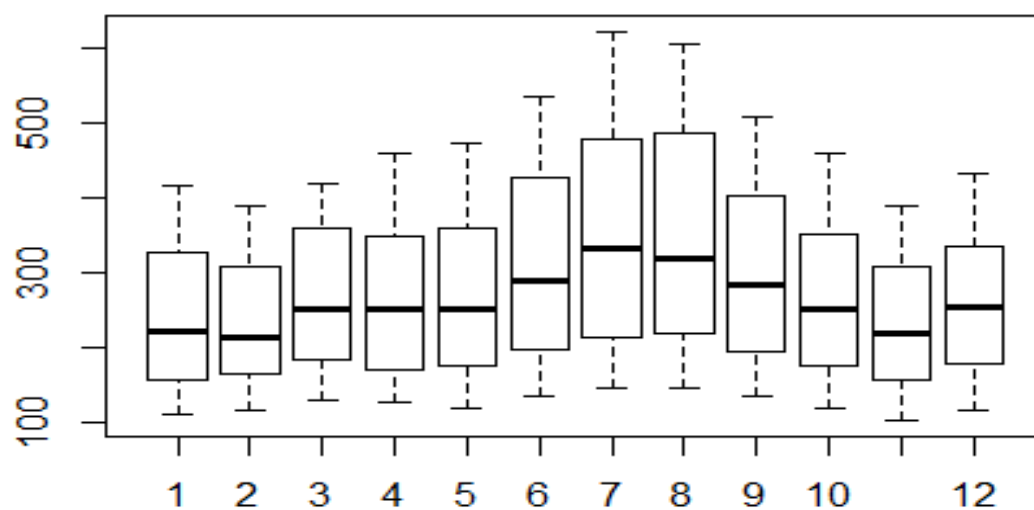
```
cycle(AirPassengers)
```

```
##      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
## 1949   1   2   3   4   5   6   7   8   9  10  11  12
## 1950   1   2   3   4   5   6   7   8   9  10  11  12
## 1951   1   2   3   4   5   6   7   8   9  10  11  12
## 1952   1   2   3   4   5   6   7   8   9  10  11  12
## 1953   1   2   3   4   5   6   7   8   9  10  11  12
## 1954   1   2   3   4   5   6   7   8   9  10  11  12
## 1955   1   2   3   4   5   6   7   8   9  10  11  12
## 1956   1   2   3   4   5   6   7   8   9  10  11  12
## 1957   1   2   3   4   5   6   7   8   9  10  11  12
## 1958   1   2   3   4   5   6   7   8   9  10  11  12
## 1959   1   2   3   4   5   6   7   8   9  10  11  12
## 1960   1   2   3   4   5   6   7   8   9  10  11  12
```

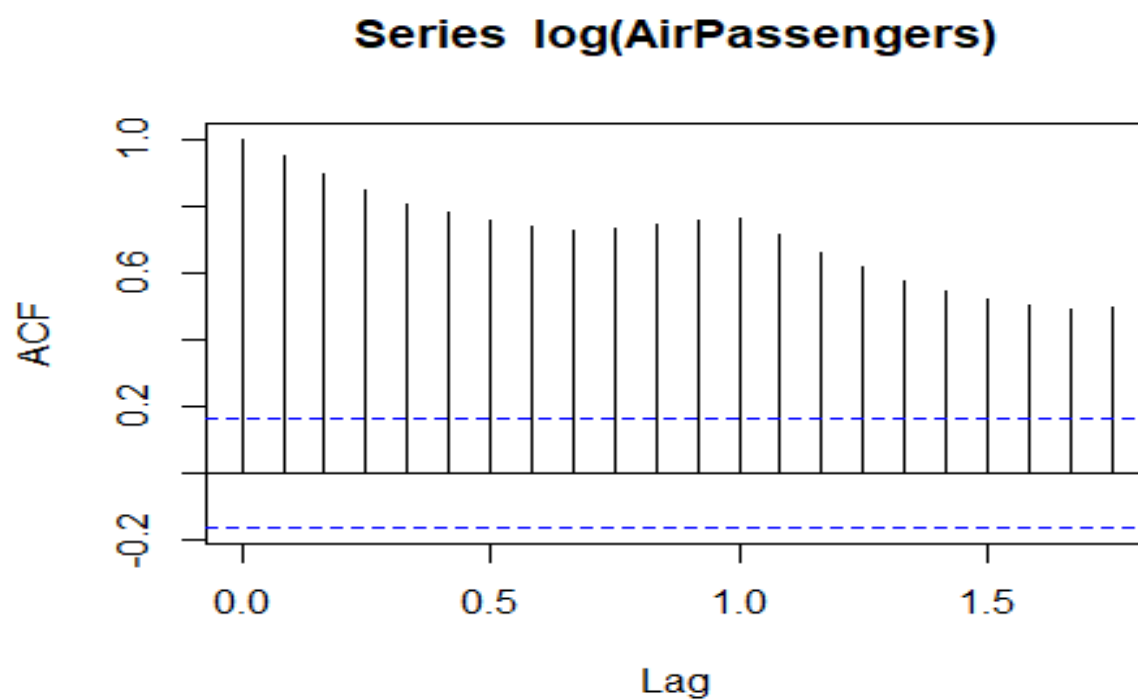
```
plot(aggregate(AirPassengers,FUN=mean))
```



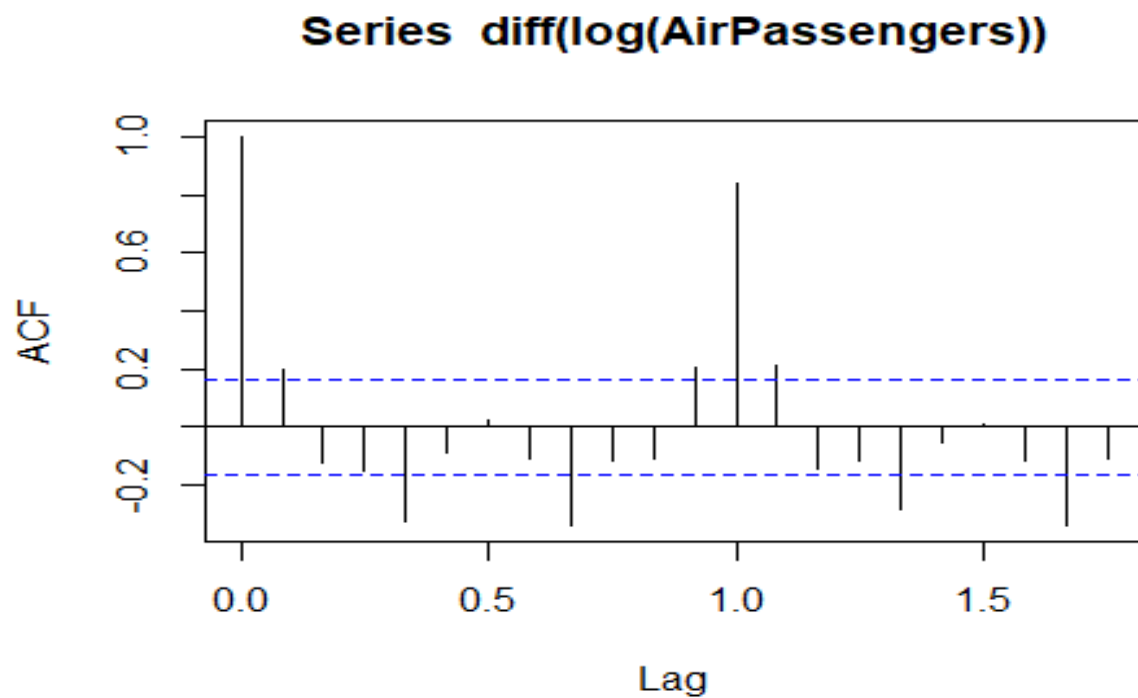
```
boxplot(AirPassengers~cycle(AirPassengers))
```



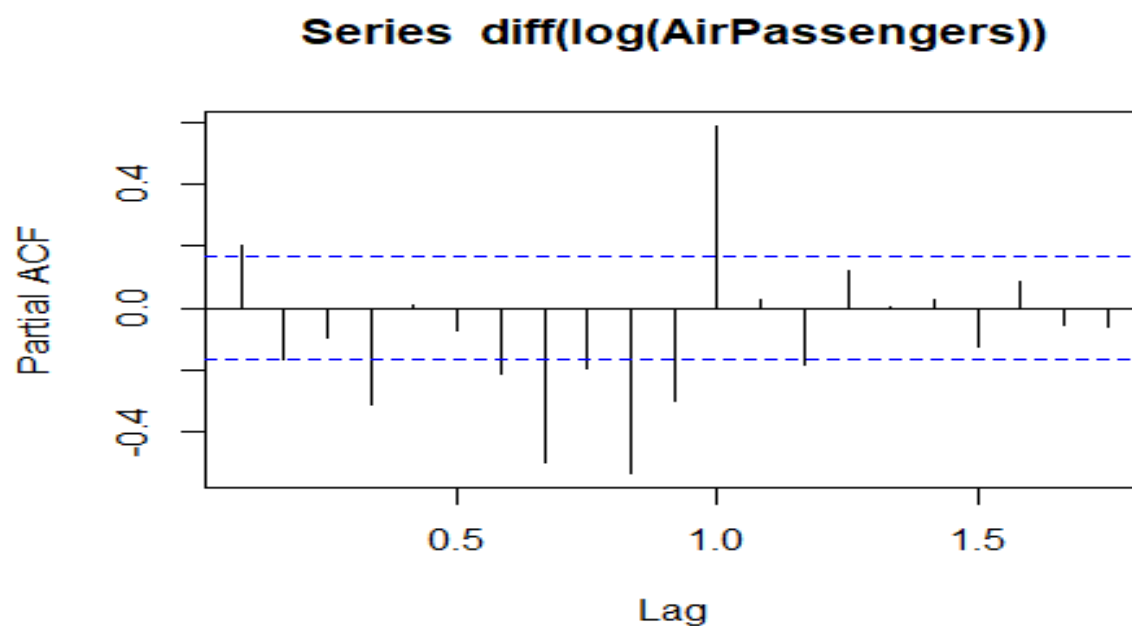
```
acf(log(AirPassengers))
```



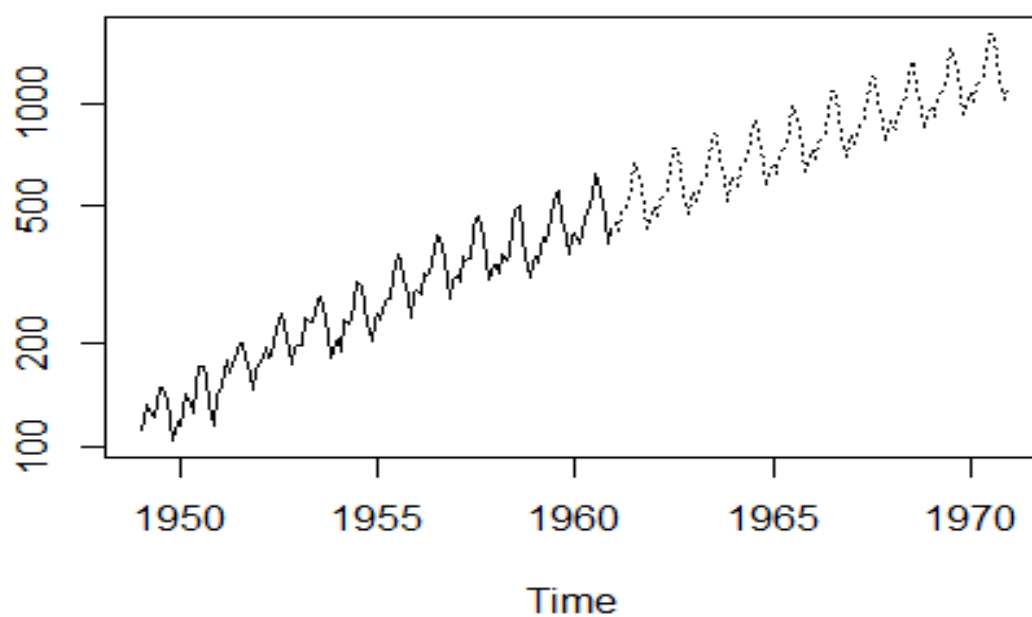
```
acf(diff(log(AirPassengers)))
```



```
pacf(diff(log(AirPassengers)))
```

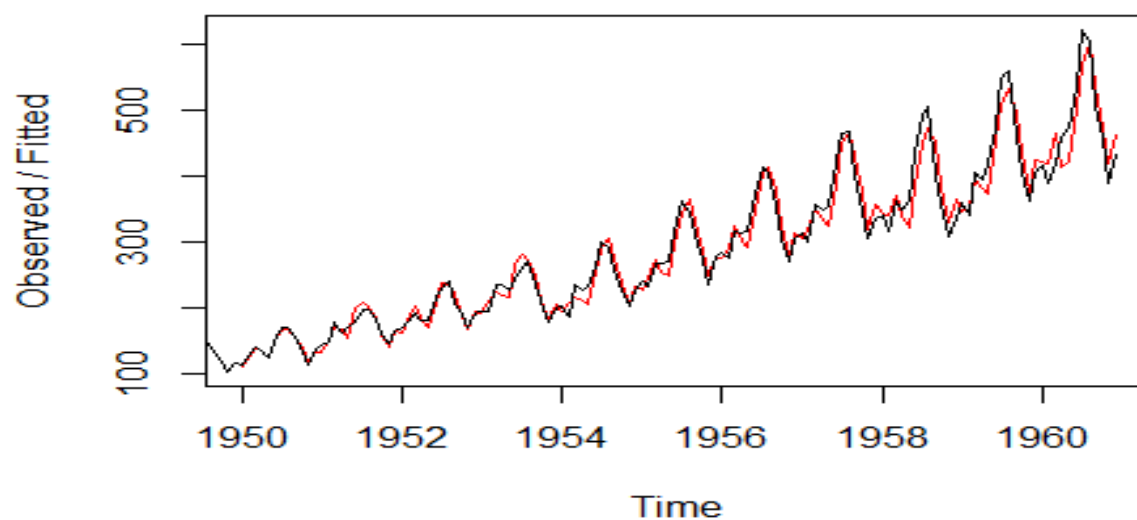


```
fit <- arima(log(AirPassengers), c(0, 1, 1),
             seasonal = list(order = c(0, 1, 1), period = 12))
pred <- predict(fit, n.ahead = 10*12)
ts.plot(AirPassengers, 2.718^pred$pred, log = "y", lty = c(1,3))
```



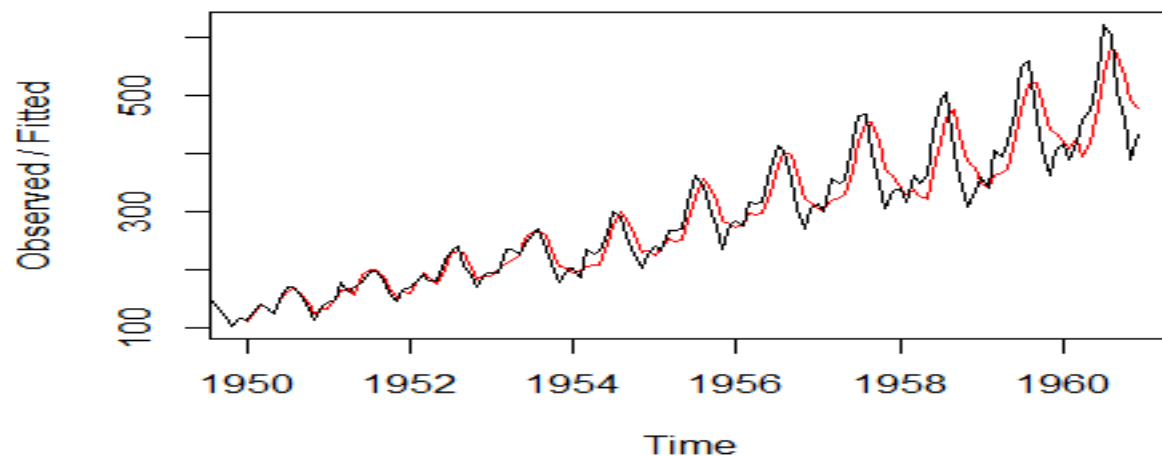
```
h1 <- HoltWinters(AirPassengers, alpha="0.5", beta=0.3, gamma=0.2, seasonal =
"multiplicative")
plot(h1)
```

Holt-Winters filtering



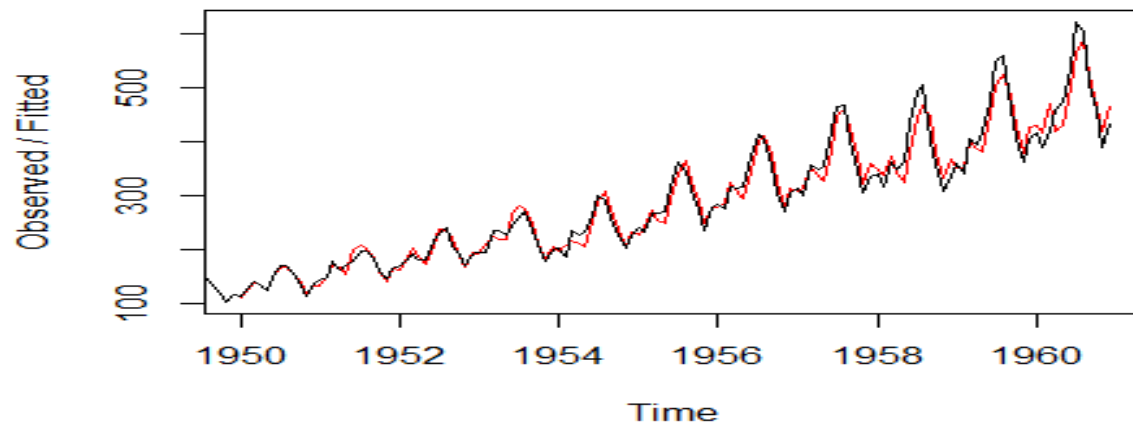
```
h2 <- HoltWinters(AirPassengers, alpha="0.5", beta=0.3, gamma=0.2, seasonal =
"additive")
plot(h2)
```

Holt-Winters filtering



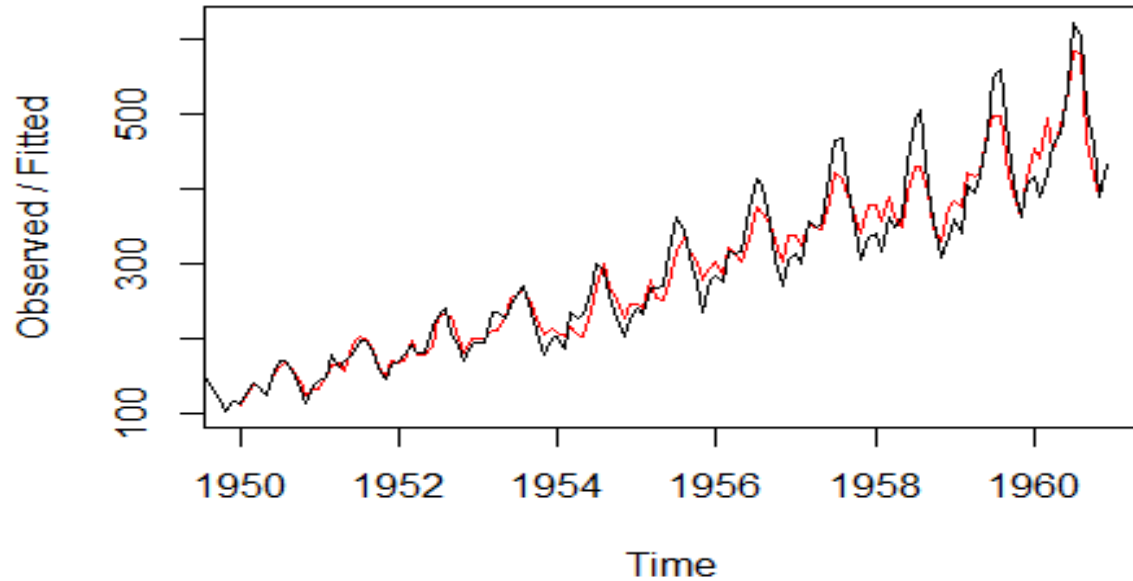
```
h3 <- HoltWinters(AirPassengers, alpha="0.5", beta=0.3, gamma=NULL, seasonal
= "multiplicative")
plot(h3)
```

Holt-Winters filtering



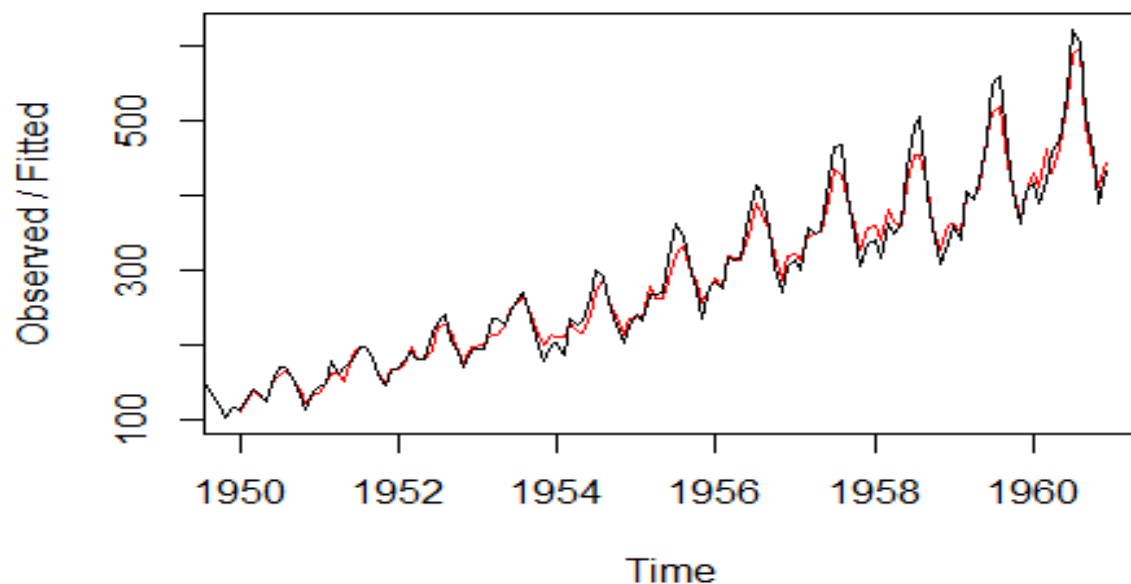
```
h3 <- HoltWinters(AirPassengers, alpha="0.5", beta=0.3, gamma=NULL, seasonal  
= "additive")  
plot(h3)
```

Holt-Winters filtering



```
h4 <- HoltWinters(AirPassengers, alpha="0.5", beta=NULL, gamma=NULL, seasonal  
= "additive")  
plot(h4)
```

Holt-Winters filtering



```
predict(h4)
```

```
##           Jan
## 1961 455.7067
```

```
predict(h4, n.ahead = 12)
```

```
##           Jan           Feb           Mar           Apr           May           Jun           Jul
## 1961 455.7067 439.3487 488.9996 516.4954 524.6679 582.4770 652.6906
##           Aug           Sep           Oct           Nov           Dec
## 1961 631.9450 527.6073 473.0967 412.6361 460.1758
```

```
predict(h1, n.ahead = 12)
```

```
##           Jan           Feb           Mar           Apr           May           Jun           Jul
## 1961 454.0631 448.3313 517.3658 506.3646 491.2708 543.5584 586.9933
##           Aug           Sep           Oct           Nov           Dec
## 1961 566.7703 485.9691 429.5541 376.6006 426.5524
```

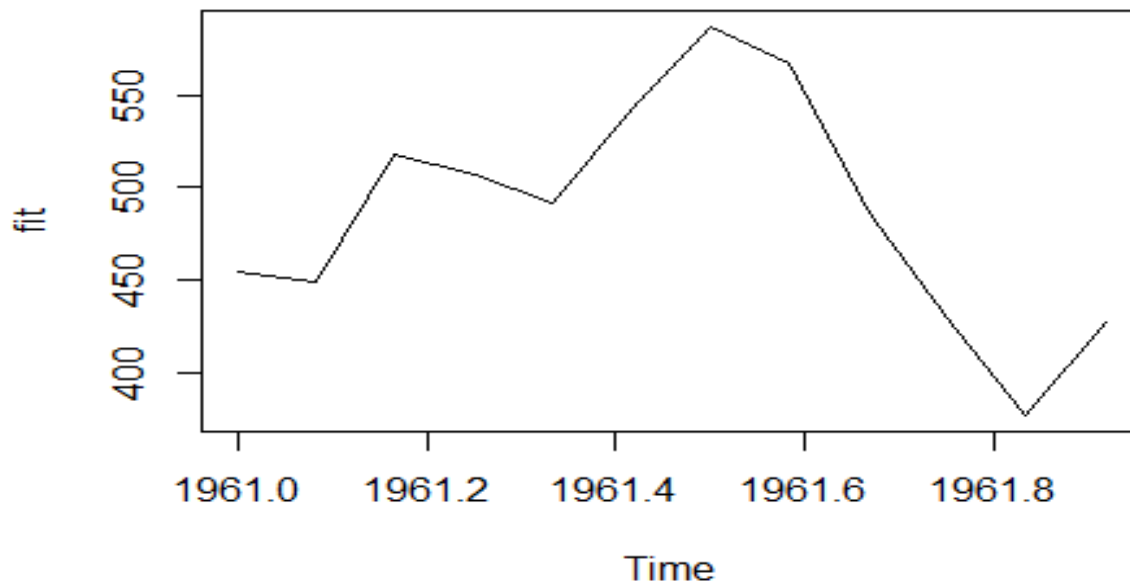
```
predict(h1, n.ahead = 120)
```

```
##           Jan           Feb           Mar           Apr           May           Jun           Jul
## 1961 454.0631 448.3313 517.3658 506.3646 491.2708 543.5584 586.9933
## 1962 435.7003 430.1390 496.3010 485.6775 471.1318 521.1996 562.7647
## 1963 417.3375 411.9467 475.2362 464.9904 450.9928 498.8407 538.5362
## 1964 398.9747 393.7544 454.1714 444.3033 430.8538 476.4819 514.3076
## 1965 380.6119 375.5621 433.1066 423.6163 410.7148 454.1230 490.0791
## 1966 362.2491 357.3698 412.0417 402.9292 390.5758 431.7642 465.8505
```



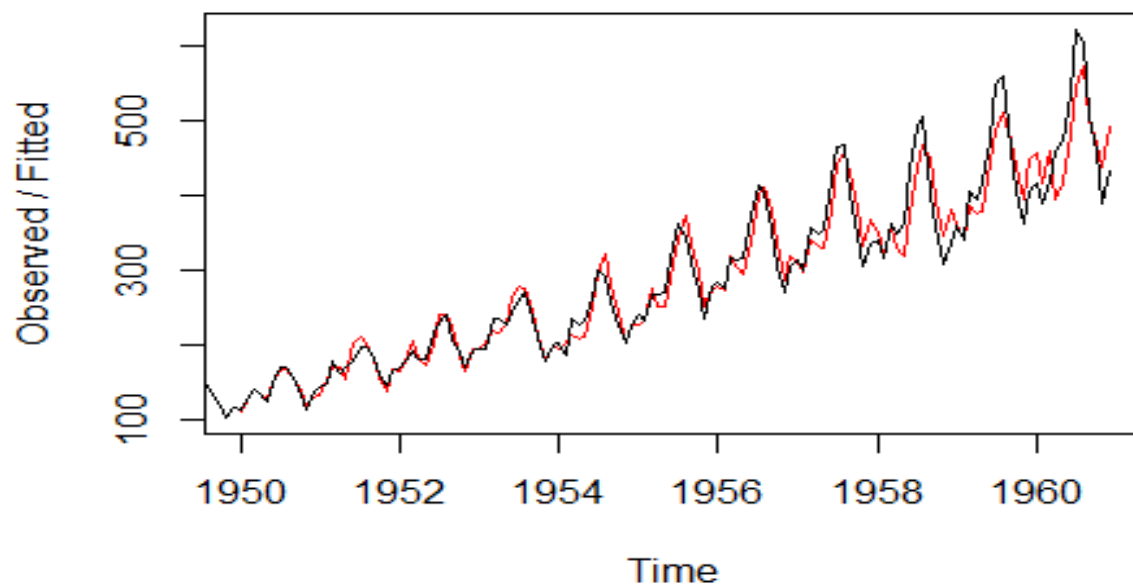
```
## 1967 343.8863 339.1775 390.9769 382.2421 370.4368 409.4053 441.6220
## 1968 325.5235 320.9851 369.9121 361.5550 350.2978 387.0465 417.3934
## 1969 307.1607 302.7928 348.8473 340.8679 330.1588 364.6877 393.1649
## 1970 288.7979 284.6005 327.7825 320.1809 310.0198 342.3288 368.9363
##           Aug       Sep       Oct       Nov       Dec
## 1961 566.7703 485.9691 429.5541 376.6006 426.5524
## 1962 543.2957 465.7714 411.6391 360.8393 408.6381
## 1963 519.8211 445.5737 393.7241 345.0780 390.7237
## 1964 496.3465 425.3761 375.8091 329.3167 372.8094
## 1965 472.8720 405.1784 357.8941 313.5554 354.8951
## 1966 449.3974 384.9808 339.9790 297.7941 336.9807
## 1967 425.9228 364.7831 322.0640 282.0328 319.0664
## 1968 402.4482 344.5855 304.1490 266.2715 301.1520
## 1969 378.9736 324.3878 286.2340 250.5102 283.2377
## 1970 355.4991 304.1902 268.3190 234.7489 265.3234
```

```
p1 <- predict(h1, n.ahead = 12)
plot(p1)
```



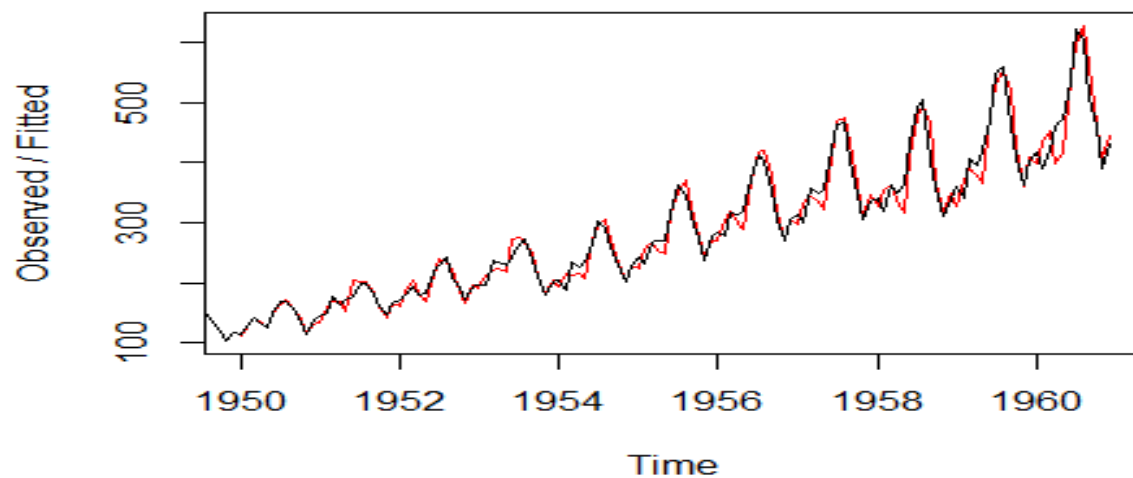
```
h5 <- HoltWinters(AirPassengers, alpha=0.5, beta=0.5, gamma=0.5, seasonal =
"multiplicative")
plot(h5)
```

Holt-Winters filtering



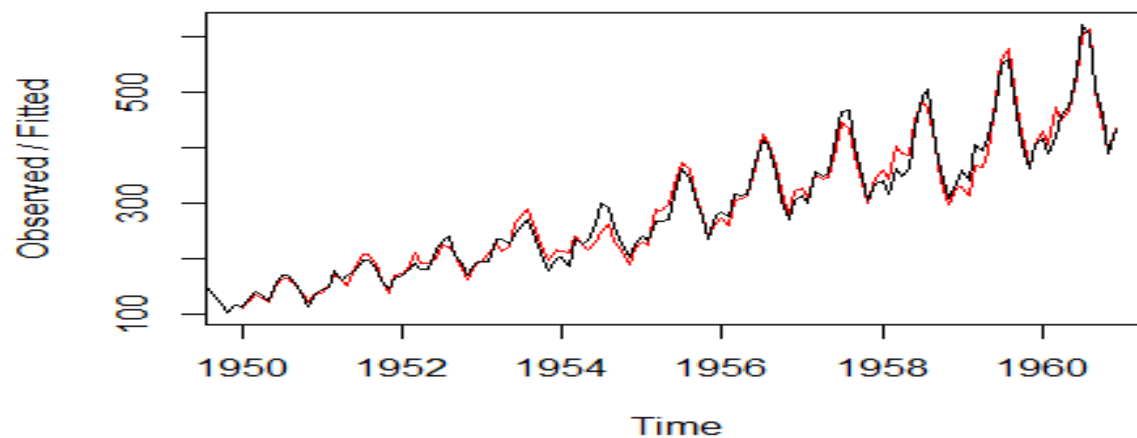
```
h5 <- HoltWinters(AirPassengers, alpha=0.75, beta=0.2, gamma=0.1, seasonal =  
"multiplicative")  
plot(h5)
```

Holt-Winters filtering



```
h6 <- HoltWinters(AirPassengers, alpha=0.1, beta=0.5, gamma=0.8, seasonal =  
"multiplicative")  
plot(h6)
```

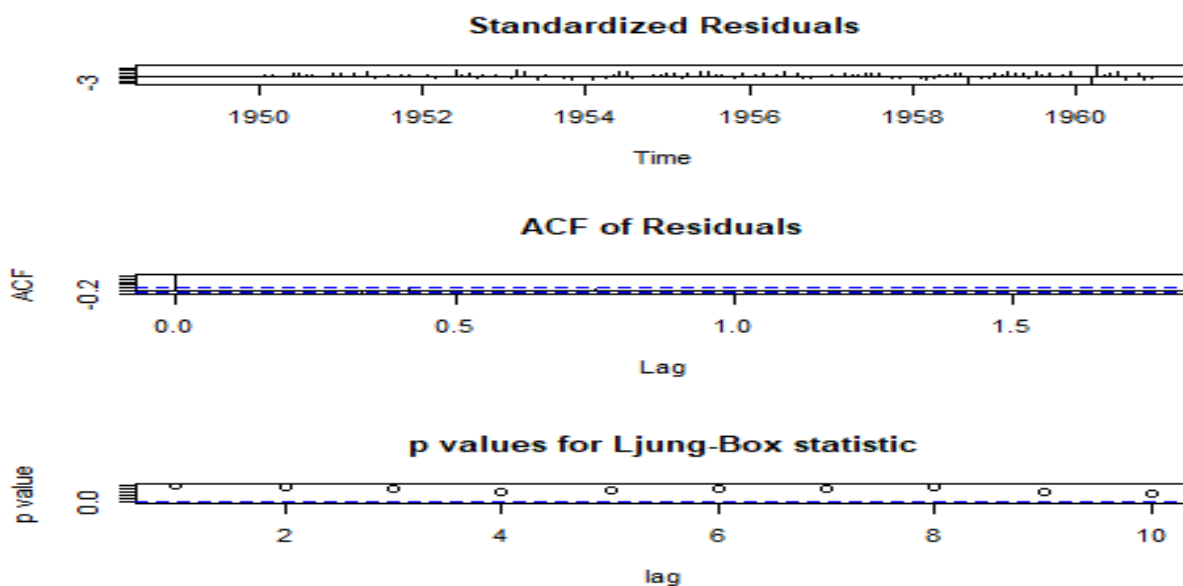
Holt-Winters filtering



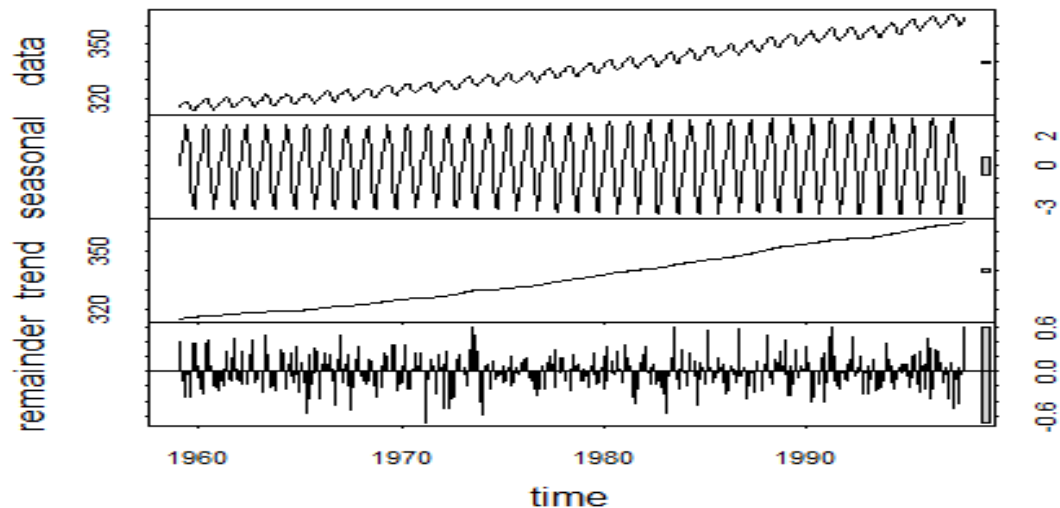
```
m1 <- auto.arima(AirPassengers)
confint(m1)

##           2.5 %      97.5 %
## ar1  0.42190083  0.7700606
## ar2  0.04186402  0.3866851
## ma1 -1.03911157 -0.9246429

tsdiag(m1)
```



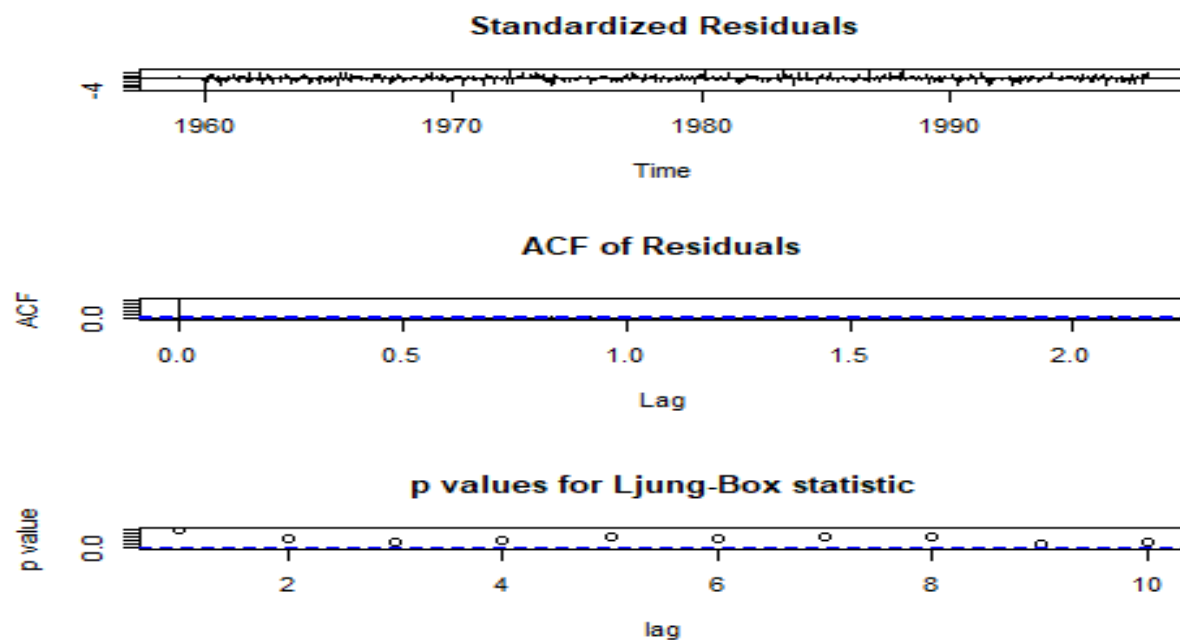
```
data("CO2")
m <- stl(co2, s.window = 12)
plot(m)
```



```
m2 <- auto.arima(co2)
confint(m2)
```

```
##           2.5 %      97.5 %
## ar1  -0.01864467  0.5324457
## ma1  -0.82060727 -0.3488421
## sar1 -1.70122774  0.6033431
## sma1 -1.37931560  0.8552593
## sma2 -1.45673544  0.4321064
```

```
tsdiag(m2)
```



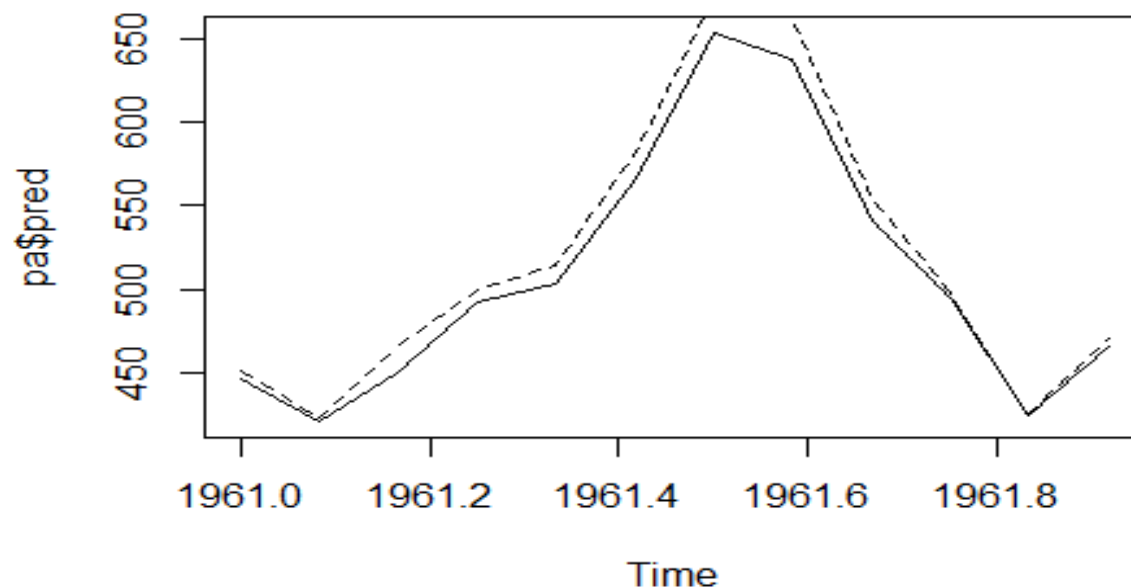
```
# comparing two models, HoltWinters and ARIMA
```

```
ph <- predict(h6, n.ahead = 12)
```

```
pa <- predict(m1, n.ahead = 12)
```

```
plot(pa$pred)
```

```
lines(ph, lty="dashed")
```



```
#####  
# time series of the number of births per month in New York city is seasonal  
#with a peak every summer and trough every winter
```

```
births <- scan("http://robjhyndman.com/tsdldata/data/nybirths.dat")
```

```
View(births)
```

```
# To make time series dataset
```

```
birthstimeseries <- ts(births, frequency=12, start=c(1946,1))
```

```
start(birthstimeseries)
```

```
## [1] 1946    1
```

```
end(birthstimeseries)
```

```
## [1] 1959   12
```

```
frequency(birthstimeseries)
```

```
## [1] 12
```

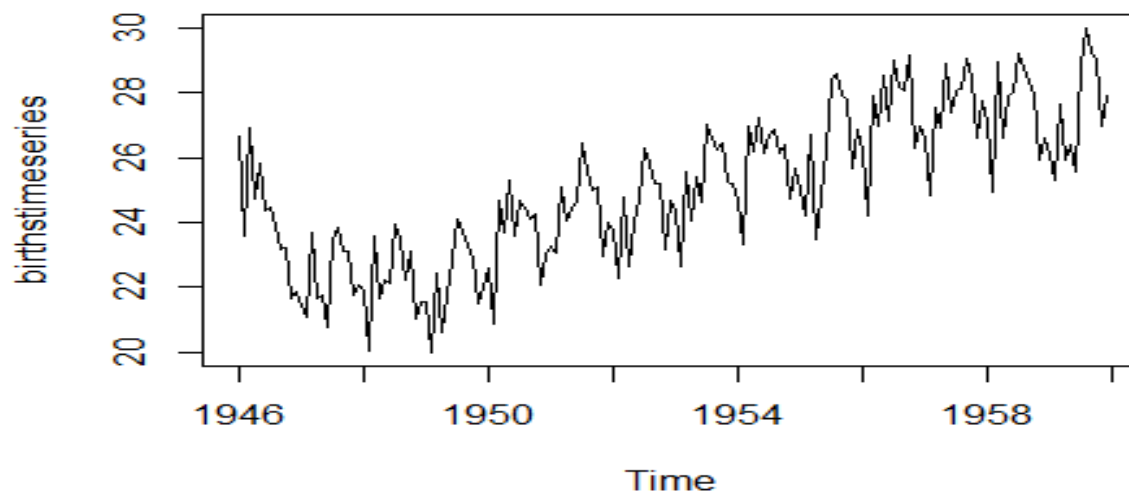
```
class(birthstimeseries)
```

```
## [1] "ts"

cycle(birthstimeseries)

##      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
## 1946   1  2  3  4  5  6  7  8  9 10 11 12
## 1947   1  2  3  4  5  6  7  8  9 10 11 12
## 1948   1  2  3  4  5  6  7  8  9 10 11 12
## 1949   1  2  3  4  5  6  7  8  9 10 11 12
## 1950   1  2  3  4  5  6  7  8  9 10 11 12
## 1951   1  2  3  4  5  6  7  8  9 10 11 12
## 1952   1  2  3  4  5  6  7  8  9 10 11 12
## 1953   1  2  3  4  5  6  7  8  9 10 11 12
## 1954   1  2  3  4  5  6  7  8  9 10 11 12
## 1955   1  2  3  4  5  6  7  8  9 10 11 12
## 1956   1  2  3  4  5  6  7  8  9 10 11 12
## 1957   1  2  3  4  5  6  7  8  9 10 11 12
## 1958   1  2  3  4  5  6  7  8  9 10 11 12
## 1959   1  2  3  4  5  6  7  8  9 10 11 12

plot(birthstimeseries)
```



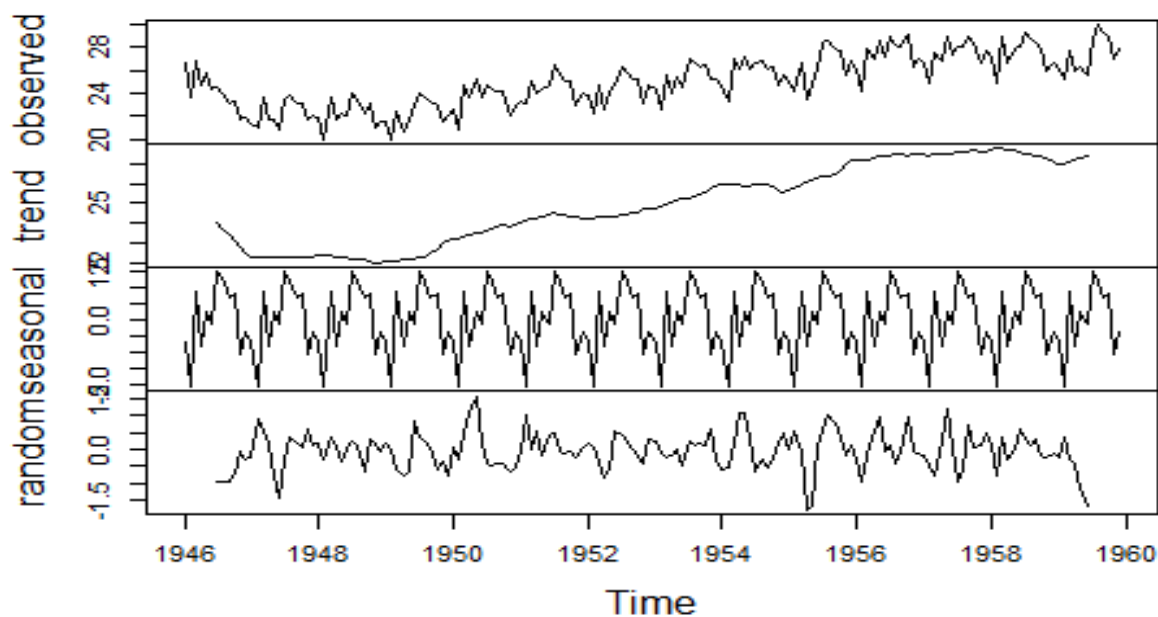
```
# decompose() function
birthstimeseriescomponents <- decompose(birthstimeseries)
birthstimeseriescomponents$seasonal

##      Jan      Feb      Mar      Apr      May      Jun
## 1946 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556
## 1947 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556
## 1948 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556
## 1949 -0.6771947 -2.0829607  0.8625232 -0.8016787  0.2516514 -0.1532556
```

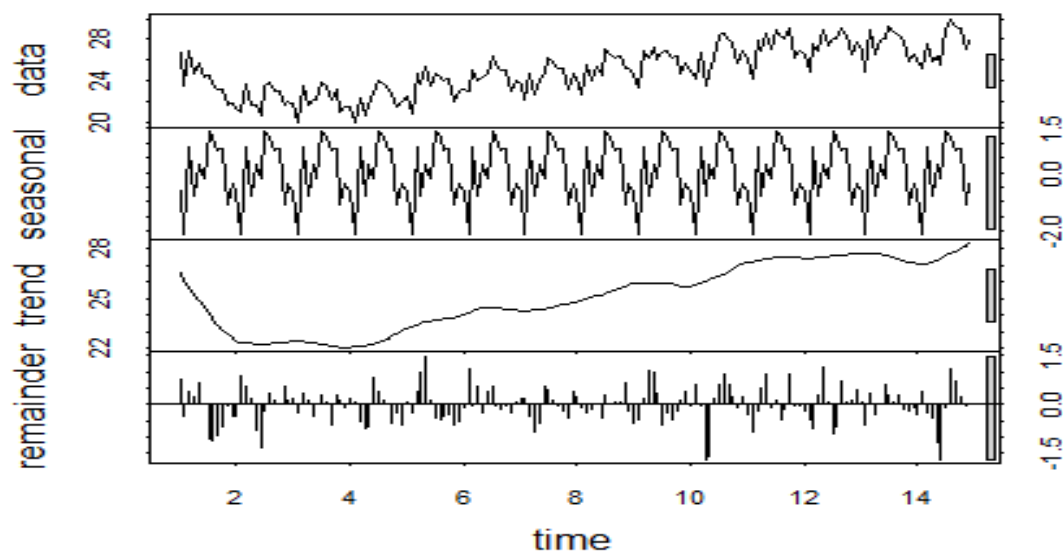
```
## 1950 -0.6771947 -2.0829607 0.8625232 -0.8016787 0.2516514 -0.1532556
## 1951 -0.6771947 -2.0829607 0.8625232 -0.8016787 0.2516514 -0.1532556
## 1952 -0.6771947 -2.0829607 0.8625232 -0.8016787 0.2516514 -0.1532556
## 1953 -0.6771947 -2.0829607 0.8625232 -0.8016787 0.2516514 -0.1532556
## 1954 -0.6771947 -2.0829607 0.8625232 -0.8016787 0.2516514 -0.1532556
## 1955 -0.6771947 -2.0829607 0.8625232 -0.8016787 0.2516514 -0.1532556
## 1956 -0.6771947 -2.0829607 0.8625232 -0.8016787 0.2516514 -0.1532556
## 1957 -0.6771947 -2.0829607 0.8625232 -0.8016787 0.2516514 -0.1532556
## 1958 -0.6771947 -2.0829607 0.8625232 -0.8016787 0.2516514 -0.1532556
## 1959 -0.6771947 -2.0829607 0.8625232 -0.8016787 0.2516514 -0.1532556
##          Jul      Aug      Sep      Oct      Nov      Dec
## 1946 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
## 1947 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
## 1948 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
## 1949 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
## 1950 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
## 1951 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
## 1952 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
## 1953 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
## 1954 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
## 1955 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
## 1956 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
## 1957 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
## 1958 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
## 1959 1.4560457 1.1645938 0.6916162 0.7752444 -1.1097652 -0.3768197
```

```
plot(birthstimeseriescomponents)
```

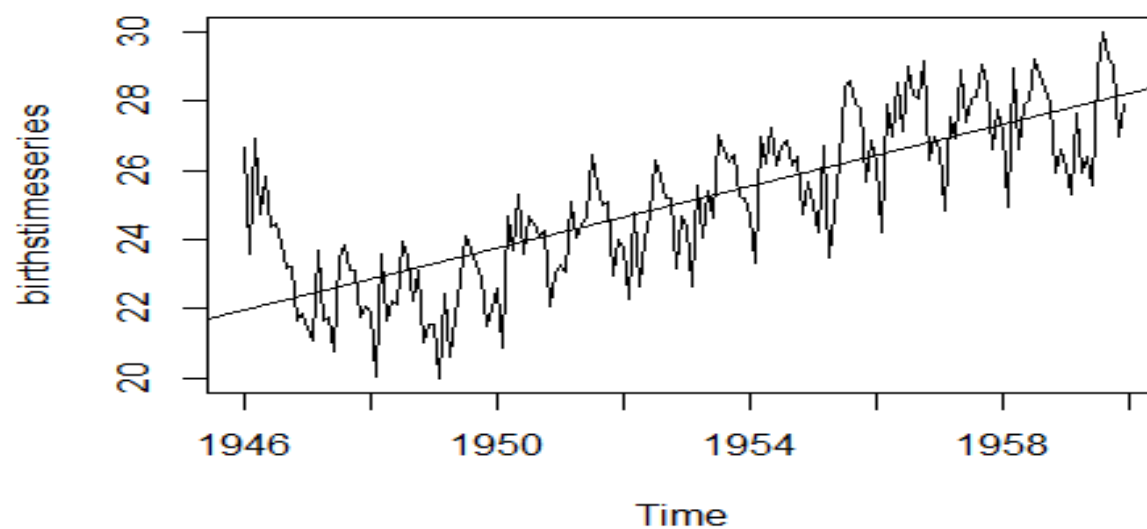
Decomposition of additive time series



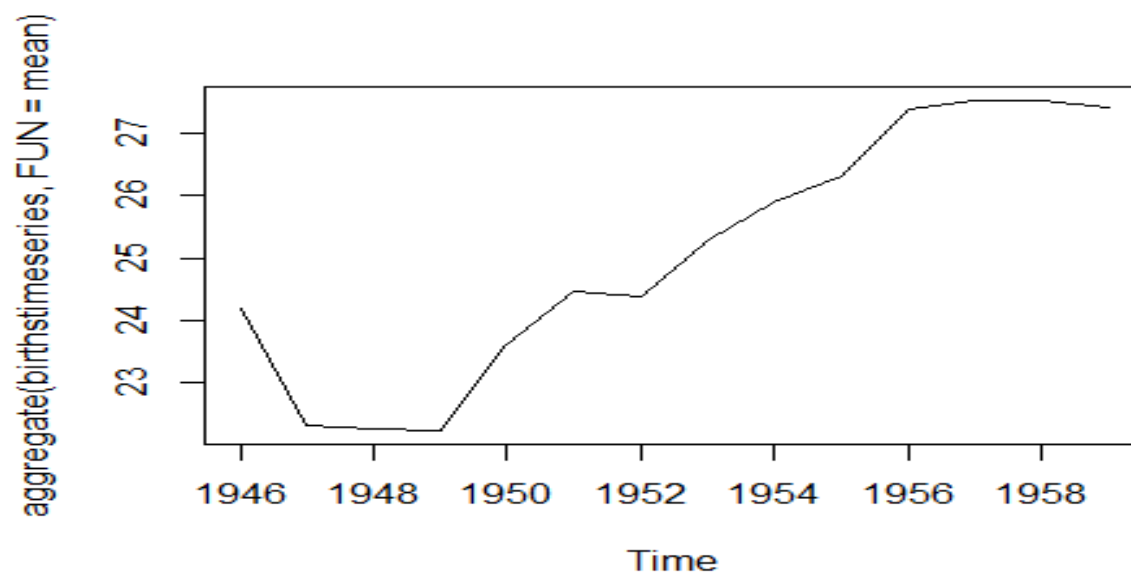
```
# stl function
ts_beer = ts(birthstimeseries, frequency = 12)
stl_beer = stl(ts_beer, "periodic")
plot(stl_beer)
```



```
# regression line linear model
plot(birthstimeseries)
abline(reg = lm(birthstimeseries~time(birthstimeseries)))
```

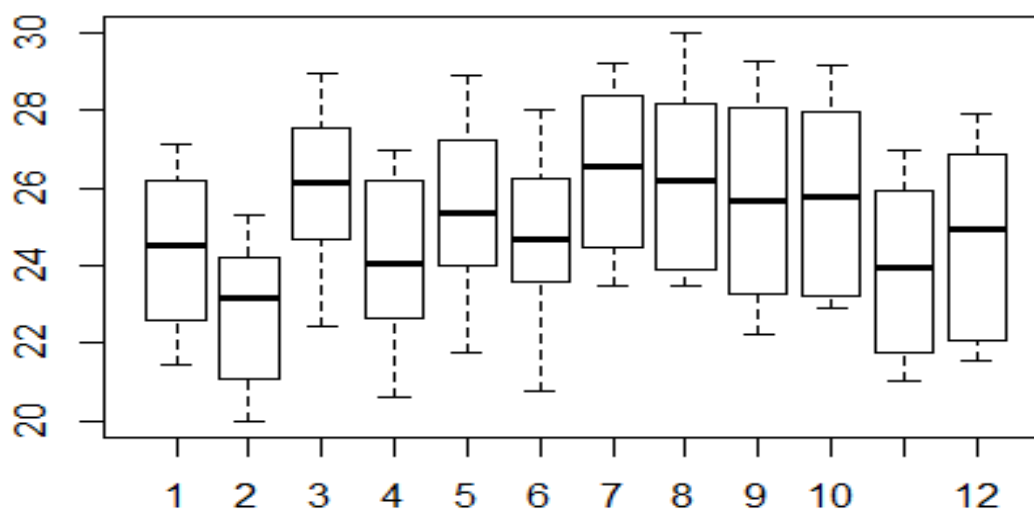



```
plot(aggregate(birthstimeseries, FUN = mean))
```



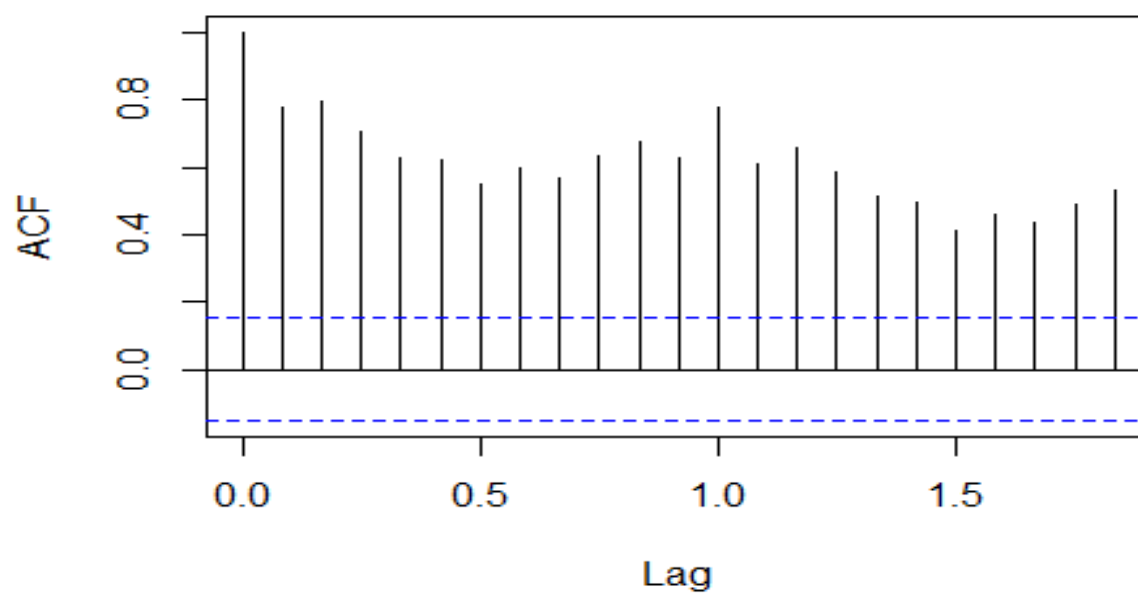
```
# monthly boxplot
```

```
boxplot(birthstimeseries~cycle(birthstimeseries))
```

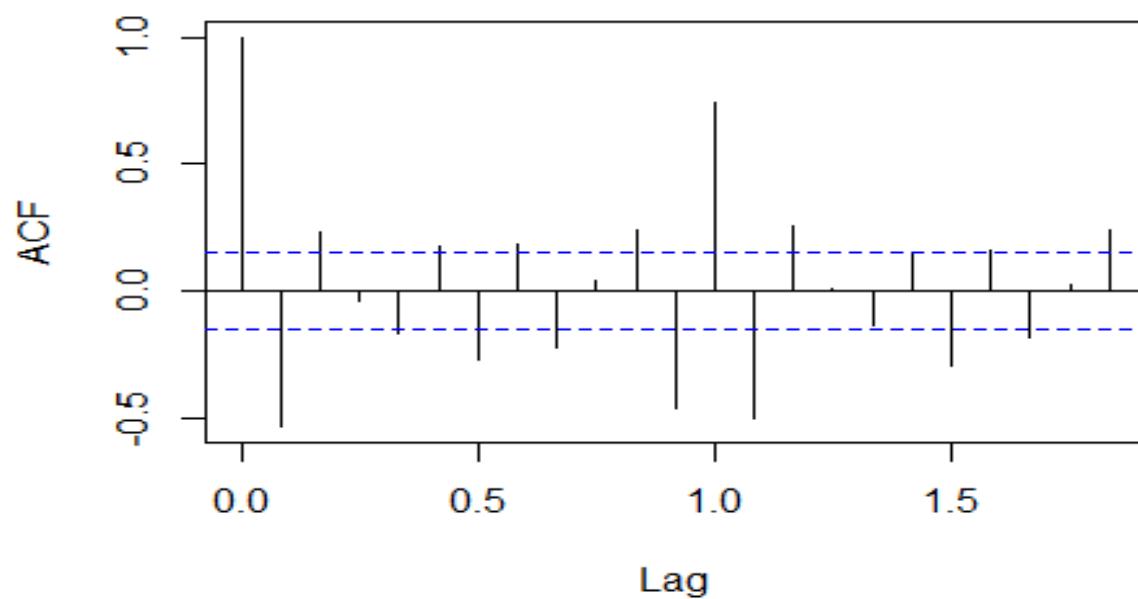


```
# auto correlation function, partial correlation function
```

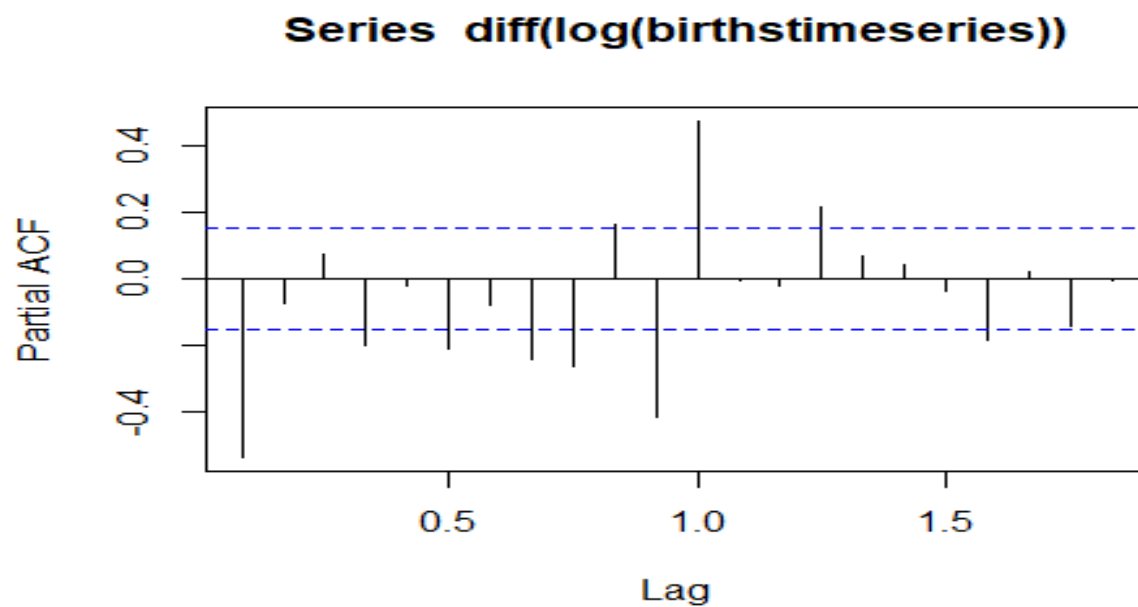
```
acf(log(birthstimeseries))
```

Series log(birthstimeseries)

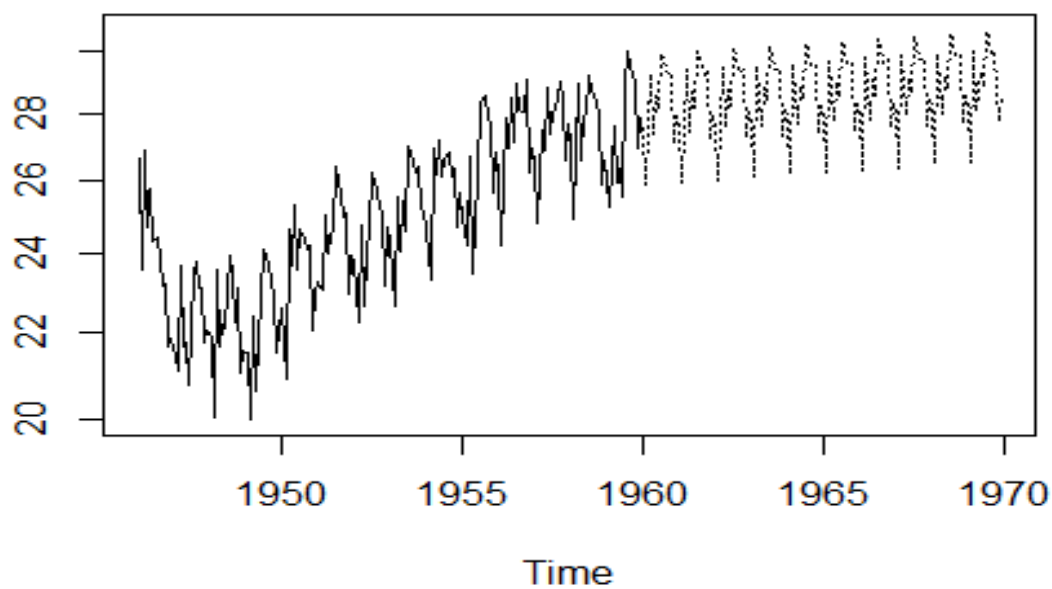
```
acf(diff(log(birthstimeseries)))
```

Series diff(log(birthstimeseries))

```
pacf(diff(log(birthstimeseries)))
```



```
#ARIMA auto regression and moving avarage
fit <- arima(log(birthstimeseries), c(0, 1, 1),
             seasonal = list(order = c(0, 1, 1), period = 12))
pred <- predict(fit, n.ahead = 10*12)
ts.plot(birthstimeseries, 2.718^pred$pred, log = "y", lty = c(1,3))
```



```

birthstimeseriesforecasts <- HoltWinters(birthstimeseries)
birthstimeseriesforecasts

## Holt-Winters exponential smoothing with trend and additive seasonal
component.
##
## Call:
## HoltWinters(x = birthstimeseries)
##
## Smoothing parameters:
##  alpha: 0.4823655
##  beta : 0.02988495
##  gamma: 0.563186
##
## Coefficients:
##           [,1]
## a    28.04366357
## b      0.04199921
## s1   -0.78546221
## s2   -2.19944507
## s3    0.87813012
## s4   -0.65164728
## s5    0.63427267
## s6    0.21182821
## s7    2.23177191
## s8    2.17167733
## s9    1.52077678
## s10   1.16900861
## s11  -0.97500043
## s12  -0.18636055

birthstimeseriesforecasts$fitted

##           xhat    level    trend    season
## Jan 1947 23.13579 23.81055 -0.1567618007 -0.51798958
## Feb 1947 21.83089 22.83531 -0.1812218860 -0.82319792
## Mar 1947 23.90724 22.29623 -0.1919165635  1.80292708
## Apr 1947 21.58463 22.00869 -0.1947742244 -0.22928125
## May 1947 21.51602 21.85461 -0.1935580066 -0.14503125
## Jun 1947 20.43661 21.77488 -0.1901562399 -1.14811458
## Jul 1947 22.44490 21.74120 -0.1854799895  0.88917708
## Aug 1947 22.51935 22.05453 -0.1705728887  0.63538542
## Sep 1947 22.50969 22.51328 -0.1517657072  0.14817708
## Oct 1947 22.96787 22.64867 -0.1431840736  0.46238542
## Nov 1947 21.63717 22.57404 -0.1411352421 -0.79573958
## Dec 1947 22.07360 22.49168 -0.1393790022 -0.27869792
## Jan 1948 21.19997 22.35201 -0.1393876391 -1.01264664
## Feb 1948 21.39990 22.56814 -0.1287630591 -1.03947671
## Mar 1948 23.37769 21.78099 -0.1484386874  1.74513652
## Apr 1948 21.38490 21.73497 -0.1453781694 -0.20468564

```

## May 1948	21.51060	21.72807	-0.1412395136	-0.07623722
## Jun 1948	20.74546	21.92999	-0.1309843042	-1.05354663
## Jul 1948	23.54300	22.46348	-0.1111264103	1.19064384
## Aug 1948	23.45914	22.54868	-0.1052593374	1.01572363
## Sep 1948	22.68217	22.46506	-0.1046127180	0.32172372
## Oct 1948	22.53900	22.14619	-0.1110156146	0.50381900
## Nov 1948	21.46350	22.32605	-0.1023230358	-0.76022309
## Dec 1948	21.64158	22.02861	-0.1081540864	-0.27887258
## Jan 1949	20.98044	21.88737	-0.1091426894	-0.79778543
## Feb 1949	20.51366	22.05200	-0.1009610948	-1.43737755
## Mar 1949	23.40193	21.70327	-0.1083657450	1.80702947
## Apr 1949	20.87973	21.12318	-0.1224630574	-0.12098948
## May 1949	20.87790	20.87302	-0.1262792355	0.13115420
## Jun 1949	20.40721	21.17272	-0.1135488865	-0.65195982
## Jul 1949	23.48037	22.24907	-0.0779889821	1.30929384
## Aug 1949	23.43170	22.47189	-0.0689990677	1.02880023
## Sep 1949	22.68327	22.55547	-0.0644393843	0.19223775
## Oct 1949	23.39370	22.77019	-0.0560966877	0.67960929
## Nov 1949	21.53807	22.47933	-0.0631127424	-0.87814461
## Dec 1949	22.04476	22.40701	-0.0633876120	-0.29886513
## Jan 1950	21.63809	22.33409	-0.0636724899	-0.63232879
## Feb 1950	21.09947	22.73634	-0.0497484903	-1.58712202
## Mar 1950	24.05671	22.58748	-0.0527104614	1.52193909
## Apr 1950	22.59204	22.83398	-0.0437686872	-0.19816416
## May 1950	23.67204	23.31162	-0.0281862050	0.38860044
## Jun 1950	24.14110	24.07836	-0.0044300653	0.06716922
## Jul 1950	25.28334	23.80472	-0.0124752973	1.49109716
## Aug 1950	24.59658	23.49687	-0.0213025088	1.12101085
## Sep 1950	23.74439	23.40679	-0.0233578809	0.36095236
## Oct 1950	24.08539	23.56558	-0.0179144329	0.53772340
## Nov 1950	22.72882	23.62803	-0.0155126980	-0.88370330
## Dec 1950	22.97205	23.30148	-0.0248080600	-0.30462622
## Jan 1951	22.91054	23.28582	-0.0245348767	-0.35074332
## Feb 1951	21.77674	23.44287	-0.0191080068	-1.64702205
## Mar 1951	25.73946	24.03746	-0.0007678348	1.70276886
## Apr 1951	23.82329	23.71666	-0.0103319146	0.11696086
## May 1951	24.67119	23.80942	-0.0072511778	0.86902159
## Jun 1951	23.57957	23.68582	-0.0107279825	-0.09552975
## Jul 1951	25.51717	24.19964	0.0049478806	1.31258419
## Aug 1951	25.75289	24.65503	0.0184094962	1.07944500
## Sep 1951	25.09588	24.60838	0.0164650350	0.47103538
## Oct 1951	25.18693	24.58535	0.0152847303	0.58629375
## Nov 1951	23.50602	24.56353	0.0141758088	-1.07168370
## Dec 1951	24.02351	24.31625	0.0063623670	-0.29910163
## Jan 1952	24.06686	24.30211	0.0057495433	-0.24099556
## Feb 1952	22.90391	24.17817	0.0018737848	-1.27612819
## Mar 1952	25.37635	23.87426	-0.0072643681	1.50935418
## Apr 1952	23.74026	23.57693	-0.0159331572	0.17926269
## May 1952	23.80016	23.03316	-0.0317073795	0.79871006
## Jun 1952	23.28454	23.09206	-0.0289996476	0.22148371

## Jul 1952	25.34043	23.76368	-0.0080618116	1.58481886
## Aug 1952	25.25245	24.20690	0.0054248405	1.04012210
## Sep 1952	24.94488	24.48416	0.0135487385	0.44716604
## Oct 1952	25.20684	24.62560	0.0173706022	0.56386800
## Nov 1952	23.42675	24.63919	0.0172576413	-1.22969517
## Dec 1952	24.23069	24.52874	0.0134411353	-0.31149478
## Jan 1953	24.47287	24.77194	0.0203074314	-0.31937515
## Feb 1953	23.29754	24.73973	0.0187380145	-1.46092934
## Mar 1953	25.78659	24.44322	0.0093169443	1.33404499
## Apr 1953	24.21204	24.34566	0.0061226848	-0.13973989
## May 1953	25.13683	24.27940	0.0039598150	0.85346860
## Jun 1953	25.07837	24.42526	0.0082003678	0.64491022
## Jul 1953	26.07896	24.21959	0.0018089646	1.85755984
## Aug 1953	25.88965	24.67002	0.0152158893	1.20441194
## Sep 1953	25.58078	25.03078	0.0255424312	0.52445571
## Oct 1953	25.98485	25.38781	0.0354490591	0.56158359
## Nov 1953	24.38888	25.65343	0.0423274418	-1.30687649
## Dec 1953	25.99125	26.10920	0.0546832789	-0.17263746
## Jan 1954	25.46444	25.77257	0.0429887904	-0.35111351
## Feb 1954	23.80597	25.42607	0.0313491415	-1.65145193
## Mar 1954	26.50885	25.21529	0.0241130038	1.26944738
## Apr 1954	25.31509	25.46763	0.0309336920	-0.18347968
## May 1954	26.90784	25.92494	0.0436757055	0.93922543
## Jun 1954	26.67805	26.11436	0.0480315233	0.51565667
## Jul 1954	28.06288	25.89418	0.0400157587	2.12868849
## Aug 1954	26.71338	25.27968	0.0204556986	1.41324592
## Sep 1954	26.12717	25.37954	0.0228287611	0.72479775
## Oct 1954	26.13822	25.41435	0.0231867253	0.70068534
## Nov 1954	24.52333	25.55368	0.0266576761	-1.05700401
## Dec 1954	25.29159	25.67134	0.0293774065	-0.40913547
## Jan 1955	25.34053	25.89194	0.0350919130	-0.58650249
## Feb 1955	23.99020	25.75795	0.0300389027	-1.79778857
## Mar 1955	27.34901	25.90800	0.0336255059	1.40738237
## Apr 1955	25.73747	25.63870	0.0245724784	0.07420246
## May 1955	25.59120	24.57193	-0.0080421066	1.02731327
## Jun 1955	24.49995	24.16632	-0.0199233622	0.35355362
## Jul 1955	26.71359	24.97561	0.0048575211	1.73312479
## Aug 1955	27.26496	25.77512	0.0286057075	1.46123643
## Sep 1955	27.22709	26.44722	0.0478365034	0.73203687
## Oct 1955	27.65501	26.82640	0.0577385980	0.77087848
## Nov 1955	26.00395	26.94635	0.0595980033	-1.00200282
## Dec 1955	26.61751	26.85596	0.0551155314	-0.29357082
## Jan 1956	26.40840	27.03818	0.0589139317	-0.68868968
## Feb 1956	25.33566	27.00477	0.0561547942	-1.72525658
## Mar 1956	27.78614	26.52180	0.0400431456	1.22430271
## Apr 1956	26.08004	26.62351	0.0418862542	-0.58536330
## May 1956	27.93893	27.09710	0.0547875612	0.78703827
## Jun 1956	28.35352	27.43555	0.0632649298	0.85469819
## Jul 1956	29.17212	26.91298	0.0457570914	2.21338510
## Aug 1956	28.76019	26.86703	0.0430164218	1.85014141

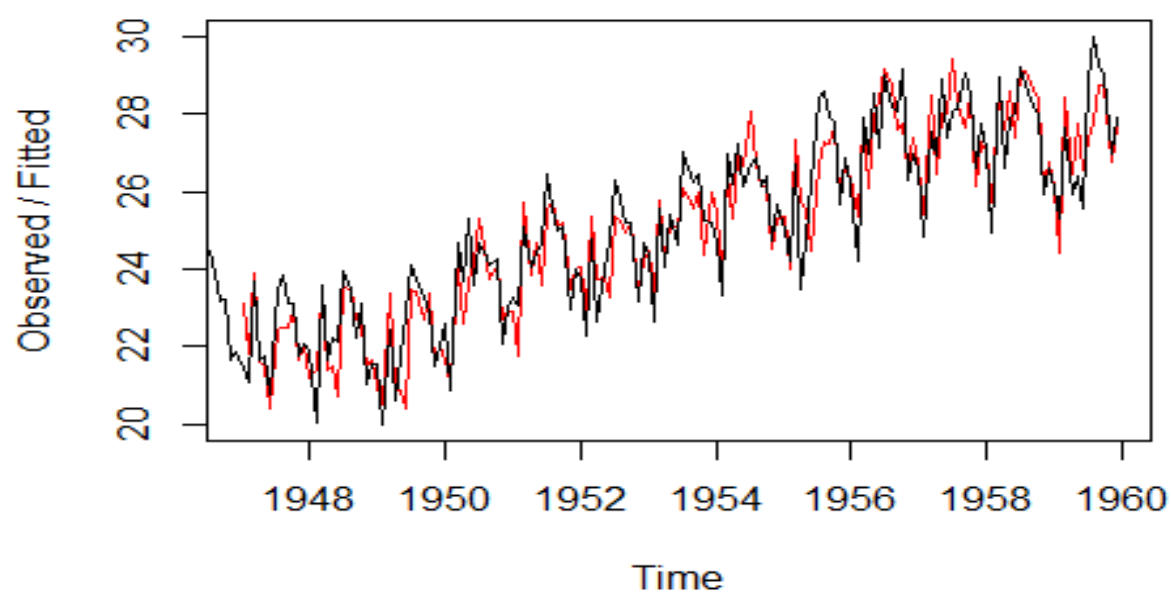
```

## Sep 1956 27.59166 26.62488 0.0344942058 0.93228724
## Oct 1956 27.73302 26.88335 0.0411879146 0.80848129
## Nov 1956 26.57005 27.60129 0.0614124953 -1.09265199
## Dec 1956 27.36873 27.52810 0.0573898623 -0.21675566
## Jan 1957 26.70875 27.40135 0.0518870166 -0.74448780
## Feb 1957 25.39455 27.39548 0.0501607281 -2.05108295
## Mar 1957 28.48586 27.18200 0.0422819008 1.26157596
## Apr 1957 26.47371 26.76948 0.0286901907 -0.32445977
## May 1957 27.99512 27.00187 0.0347777126 0.95847636
## Jun 1957 28.01066 27.46252 0.0475048213 0.50063663
## Jul 1957 29.40715 27.21064 0.0385577620 2.15796045
## Aug 1957 28.29879 26.60179 0.0192099671 1.67779637
## Sep 1957 27.62947 26.54488 0.0169353277 1.06765432
## Oct 1957 28.50093 27.24607 0.0373840821 1.21748361
## Nov 1957 26.13842 27.27528 0.0371399679 -1.17400182
## Dec 1957 27.26772 27.55147 0.0442839832 -0.32803988
## Jan 1958 27.09278 27.82116 0.0510200910 -0.77939858
## Feb 1958 25.73227 27.89110 0.0515854734 -2.21041672
## Mar 1958 28.57945 27.55280 0.0399339466 0.98671039
## Apr 1958 27.62186 27.77775 0.0454630421 -0.20135163
## May 1958 28.57143 27.32500 0.0305738671 1.21585707
## Jun 1958 27.38769 27.04665 0.0213418113 0.31969997
## Jul 1958 29.16468 27.36769 0.0302982619 1.76668940
## Aug 1958 29.09204 27.42901 0.0312255063 1.63179627
## Sep 1958 28.80721 27.29959 0.0264246263 1.48119011
## Oct 1958 28.36518 27.13201 0.0206265839 1.21254688
## Nov 1958 25.93499 26.94995 0.0145694775 -1.02952818
## Dec 1958 26.77585 26.95343 0.0142379999 -0.19181536
## Jan 1959 26.13602 26.89201 0.0119768814 -0.76796484
## Feb 1959 24.44010 26.87503 0.0111116615 -2.44604591
## Mar 1959 28.41601 27.29418 0.0233057207 1.09852546
## Apr 1959 26.46276 26.95281 0.0124074859 -0.50245588
## May 1959 27.75255 26.71836 0.0050301842 1.02915692
## Jun 1959 26.55633 26.07000 -0.0144962780 0.50082655
## Jul 1959 27.33398 25.57732 -0.0287868334 1.78544109
## Aug 1959 27.81504 26.28705 -0.0067164116 1.53470793
## Sep 1959 28.72300 27.33428 0.0247808156 1.36393612
## Oct 1959 28.74117 27.61858 0.0325363622 1.09005383
## Nov 1959 26.78196 27.78175 0.0364405634 -1.03623166
## Dec 1959 27.72144 27.91951 0.0394683600 -0.23754203

```

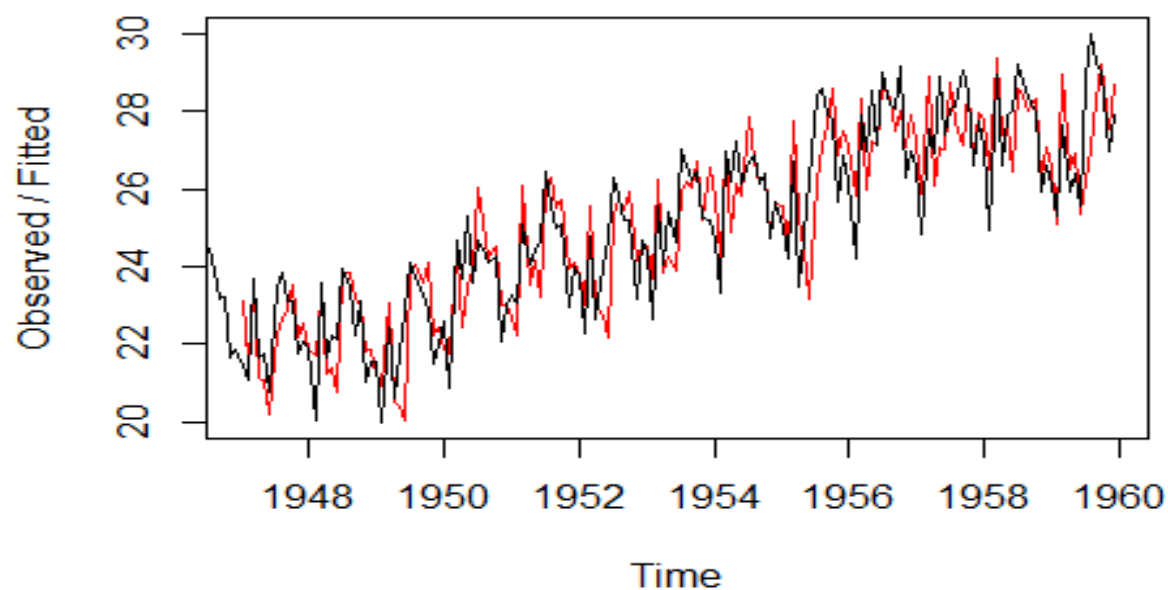
```
plot(birthstimeseriesforecasts)
```

Holt-Winters filtering



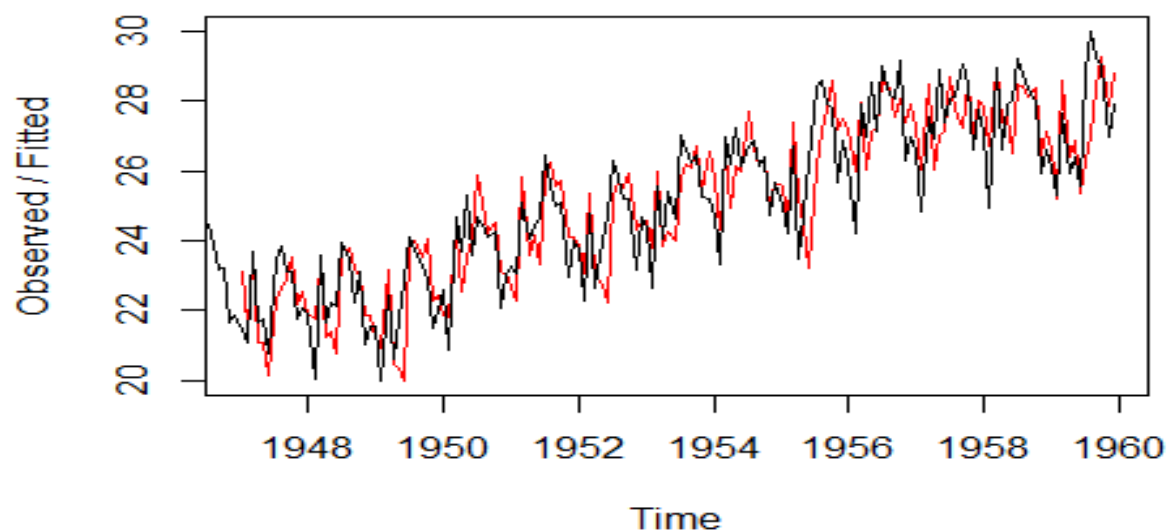
```
h1 <- HoltWinters(birthstimeseries, alpha="0.5", beta=0.3, gamma=0.2,  
seasonal = "multiplicative")  
plot(h1)
```

Holt-Winters filtering



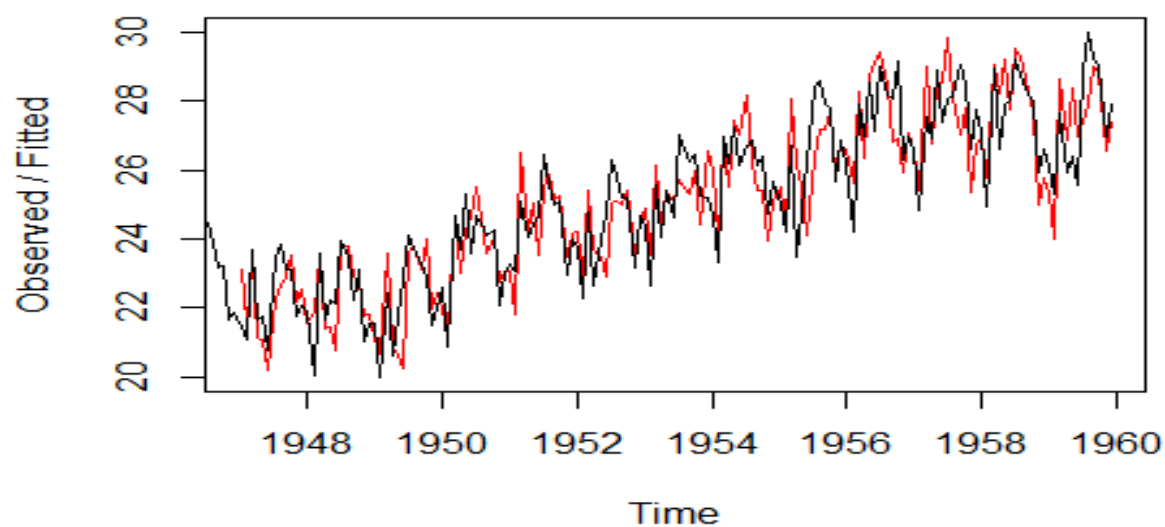

```
h2 <- HoltWinters(birthstimeseries, alpha="0.5", beta=0.3, gamma=0.2,  
seasonal = "additive")  
plot(h2)
```

Holt-Winters filtering



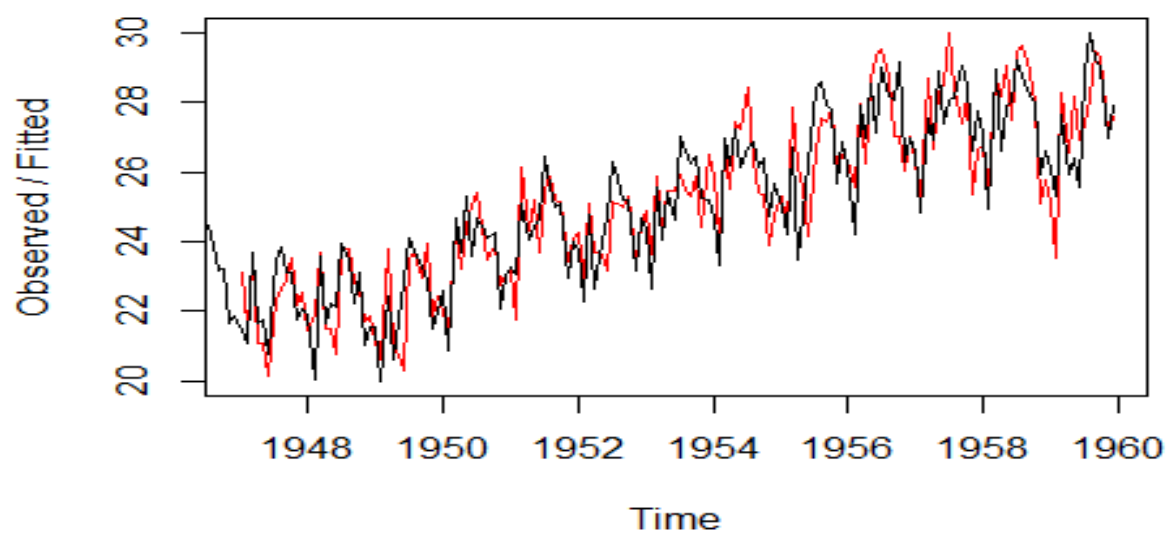
```
h3 <- HoltWinters(birthstimeseries, alpha="0.5", beta=0.3, gamma=NULL,  
seasonal = "multiplicative")  
plot(h3)
```

Holt-Winters filtering



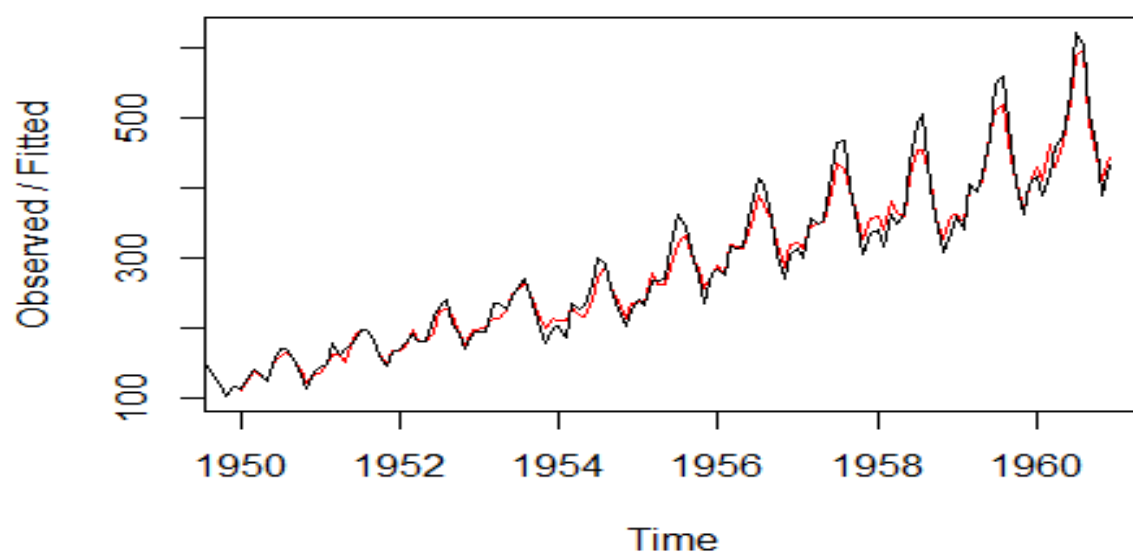
```
h3 <- HoltWinters(birthstimeseries, alpha="0.5", beta=0.3, gamma=NULL,  
seasonal = "additive")  
plot(h3)
```

Holt-Winters filtering



```
h1 <- HoltWinters(birthstimeseries, alpha="0.5", beta=NULL, gamma=NULL,  
seasonal = "additive")  
plot(h4)
```

Holt-Winters filtering



```
predict(h4)
```

```
##           Jan
## 1961 455.7067
```

```
predict(h4, n.ahead = 12)
```

```
##           Jan      Feb      Mar      Apr      May      Jun      Jul
## 1961 455.7067 439.3487 488.9996 516.4954 524.6679 582.4770 652.6906
##           Aug      Sep      Oct      Nov      Dec
## 1961 631.9450 527.6073 473.0967 412.6361 460.1758
```

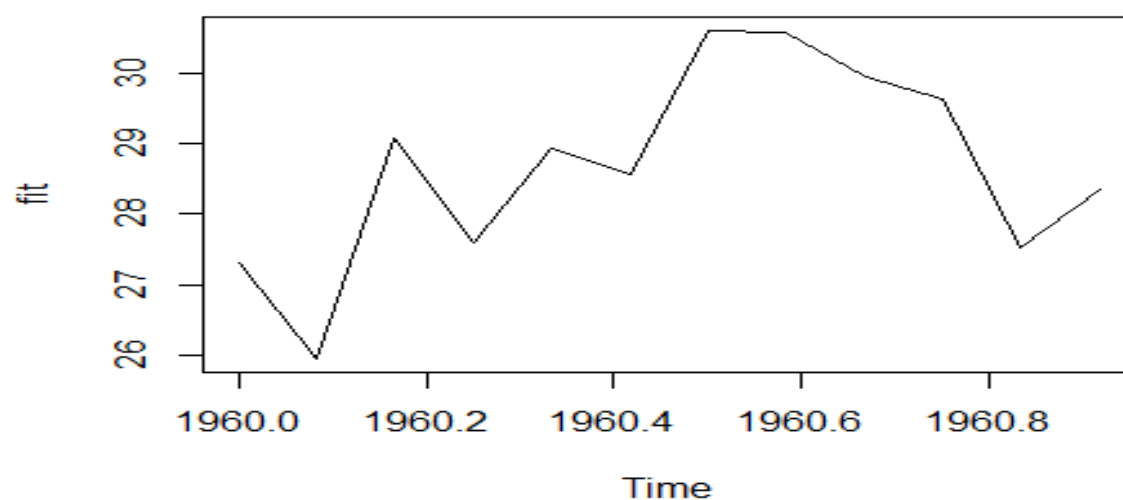
```
predict(h1, n.ahead = 12)
```

```
##           Jan      Feb      Mar      Apr      May      Jun      Jul
## 1960 27.30973 25.94509 29.07503 27.59975 28.93623 28.55882 30.61298
##           Aug      Sep      Oct      Nov      Dec
## 1960 30.57737 29.95399 29.63707 27.53124 28.36080
```

```
predict(h1, n.ahead = 120)
```

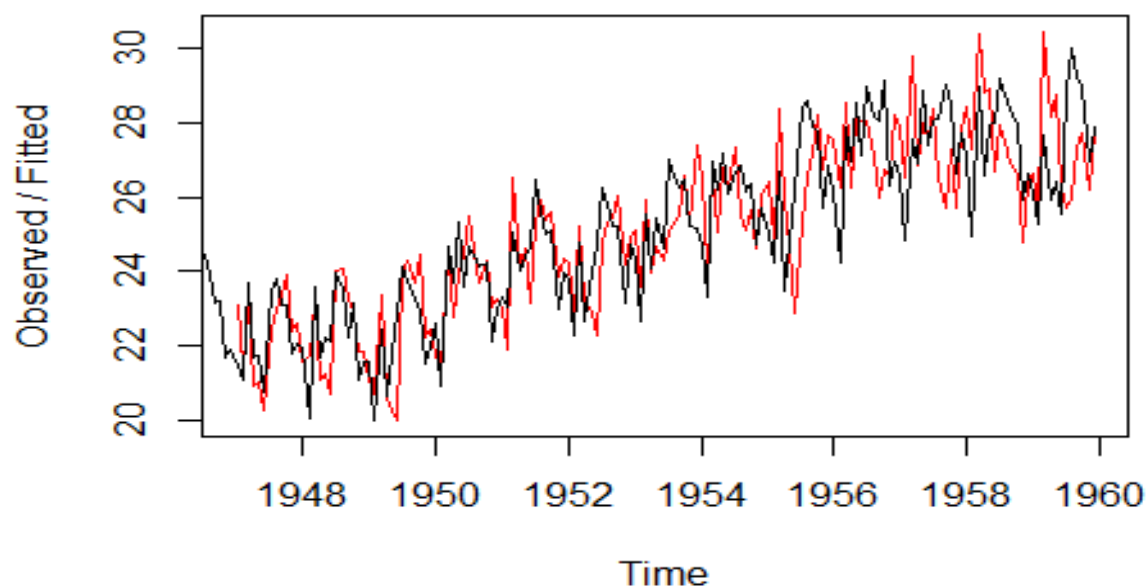
```
##           Jan      Feb      Mar      Apr      May      Jun      Jul
## 1960 27.30973 25.94509 29.07503 27.59975 28.93623 28.55882 30.61298
## 1961 27.80938 26.44473 29.57468 28.09939 29.43587 29.05847 31.11262
## 1962 28.30902 26.94438 30.07432 28.59904 29.93552 29.55811 31.61226
## 1963 28.80866 27.44402 30.57397 29.09868 30.43516 30.05776 32.11191
## 1964 29.30831 27.94367 31.07361 29.59833 30.93481 30.55740 32.61155
## 1965 29.80795 28.44331 31.57325 30.09797 31.43445 31.05704 33.11120
## 1966 30.30760 28.94295 32.07290 30.59761 31.93409 31.55669 33.61084
## 1967 30.80724 29.44260 32.57254 31.09726 32.43374 32.05633 34.11048
## 1968 31.30688 29.94224 33.07218 31.59690 32.93338 32.55597 34.61013
## 1969 31.80653 30.44188 33.57183 32.09655 33.43303 33.05562 35.10977
##           Aug      Sep      Oct      Nov      Dec
## 1960 30.57737 29.95399 29.63707 27.53124 28.36080
## 1961 31.07702 30.45364 30.13671 28.03089 28.86045
## 1962 31.57666 30.95328 30.63636 28.53053 29.36009
## 1963 32.07630 31.45292 31.13600 29.03017 29.85974
## 1964 32.57595 31.95257 31.63565 29.52982 30.35938
## 1965 33.07559 32.45221 32.13529 30.02946 30.85902
## 1966 33.57523 32.95186 32.63493 30.52910 31.35867
## 1967 34.07488 33.45150 33.13458 31.02875 31.85831
## 1968 34.57452 33.95114 33.63422 31.52839 32.35796
## 1969 35.07417 34.45079 34.13386 32.02804 32.85760
```

```
p1 <- predict(h1, n.ahead = 12)
plot(p1)
```



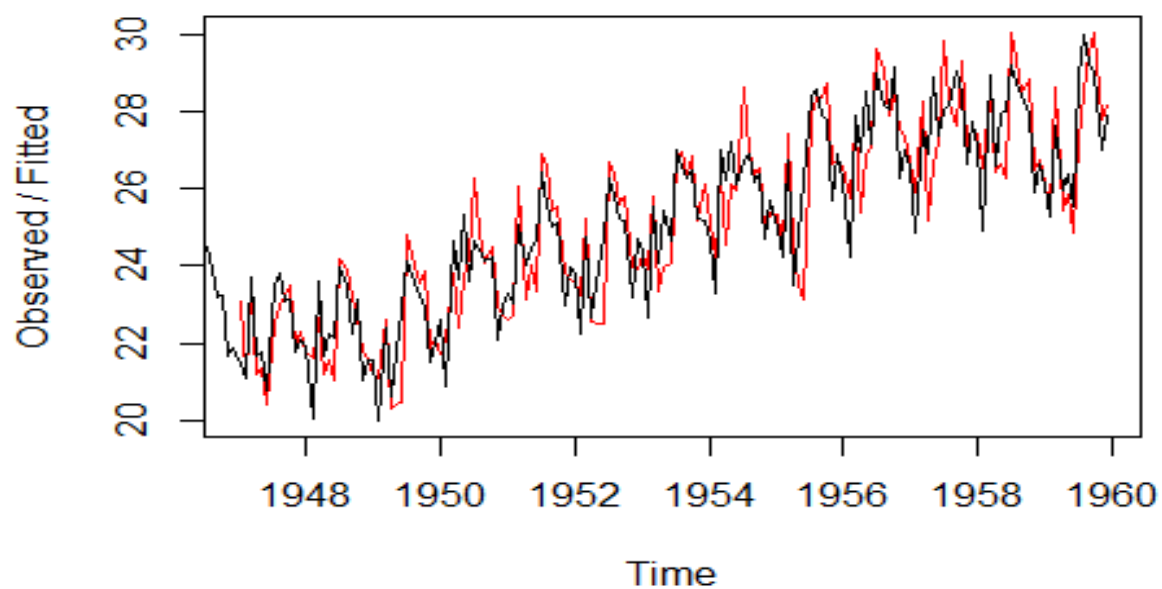
```
h5 <- HoltWinters(birthstimeseries, alpha=0.5, beta=0.5, gamma=0.5, seasonal
= "multiplicative")
plot(h5)
```

Holt-Winters filtering



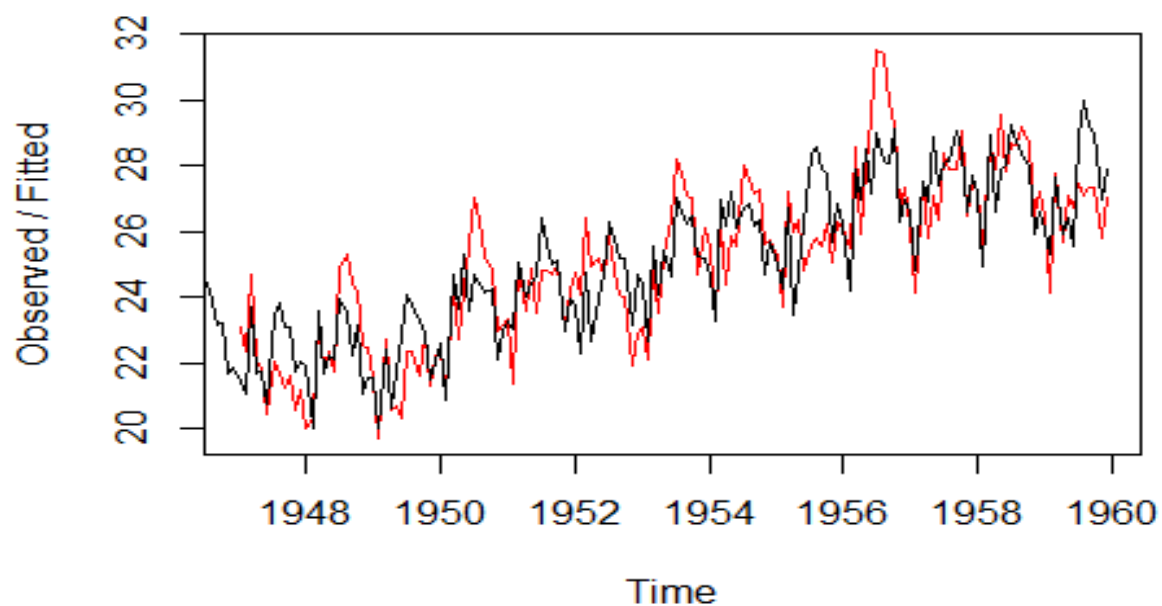
```
h5 <- HoltWinters(birthstimeseries, alpha=0.75, beta=0.2, gamma=0.1, seasonal
= "multiplicative")
plot(h5)
```

Holt-Winters filtering



```
h6 <- HoltWinters(birthstimeseries, alpha=0.1, beta=0.5, gamma=0.8, seasonal  
= "multiplicative")  
plot(h6)
```

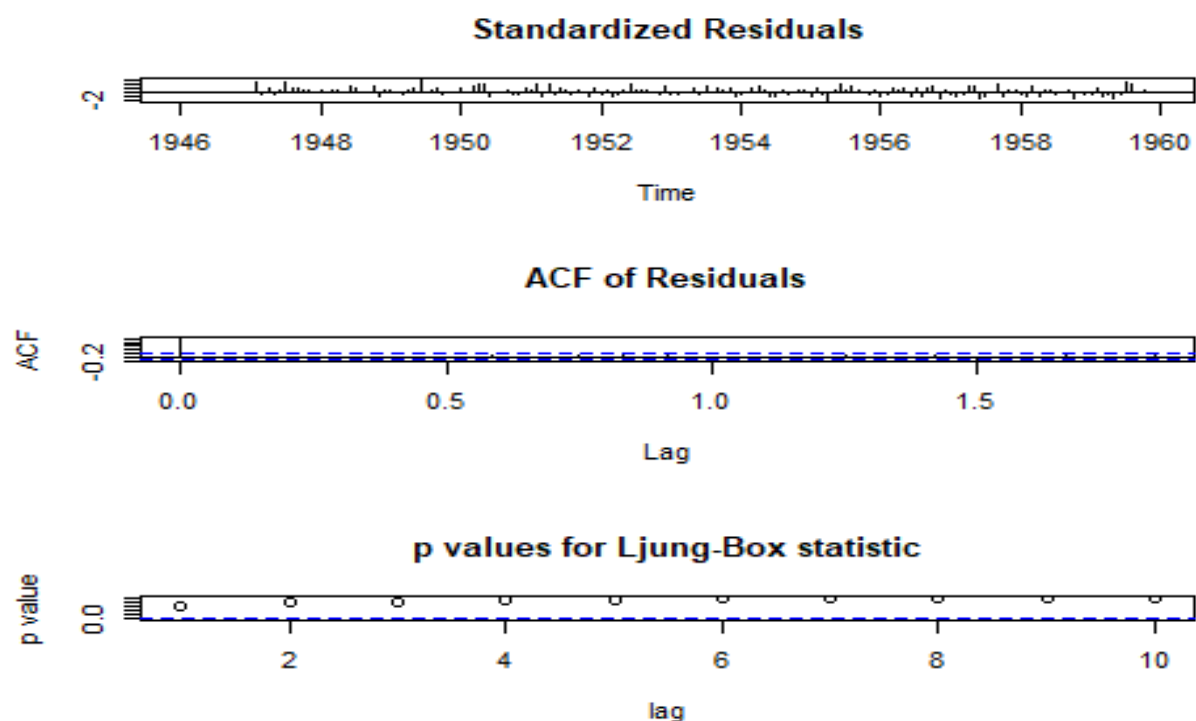
Holt-Winters filtering



```
m1 <- auto.arima(birthstimeseries)
confint(m1)
```

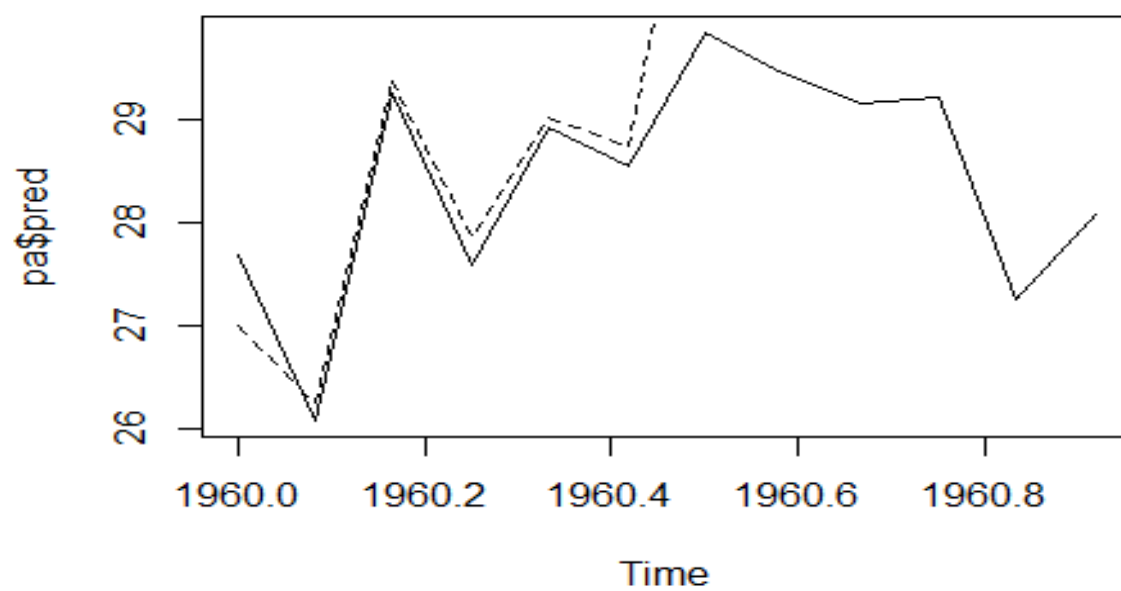
```
##           2.5 %       97.5 %
## ar1    0.06514048  1.24260156
## ar2   -0.93009076  0.02204818
## ma1   -1.35815024 -0.09294612
## ma2   -0.31106945  0.81745702
## sar1  -0.43580962 -0.04963254
## sma1  -1.04013427 -0.65012924
```

```
tsdiag(m1)
```



```
# comparing two models, HoltWinters and ARIMA
```

```
ph <- predict(h6, n.ahead = 12)
pa <- predict(m1, n.ahead = 12)
plot(pa$pred)
lines(ph, lty="dashed")
```



#####