

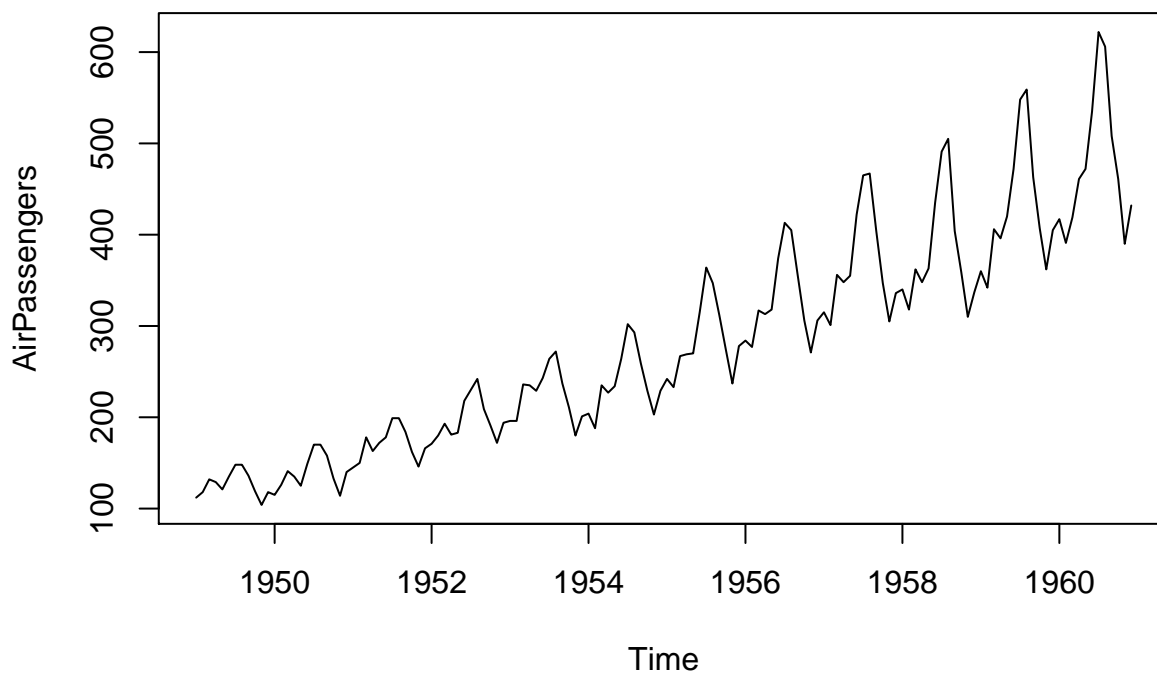
TimeSeries

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Pruebas series de tiempo de Time Series Analysis and its applications

```
# Plot AirPassengers
plot(AirPassengers)
```



```
# View the start and end dates of AirPassengers
start(AirPassengers)
```

```
## [1] 1949    1
```

```
end(AirPassengers)
```

```
## [1] 1960   12
```

```
# Use time(), deltat(), frequency(), and cycle() with AirPassengers
time(AirPassengers)
```

```
##           Jan      Feb      Mar      Apr      May      Jun      Jul
## 1949 1949.000 1949.083 1949.167 1949.250 1949.333 1949.417 1949.500
## 1950 1950.000 1950.083 1950.167 1950.250 1950.333 1950.417 1950.500
## 1951 1951.000 1951.083 1951.167 1951.250 1951.333 1951.417 1951.500
## 1952 1952.000 1952.083 1952.167 1952.250 1952.333 1952.417 1952.500
## 1953 1953.000 1953.083 1953.167 1953.250 1953.333 1953.417 1953.500
## 1954 1954.000 1954.083 1954.167 1954.250 1954.333 1954.417 1954.500
## 1955 1955.000 1955.083 1955.167 1955.250 1955.333 1955.417 1955.500
## 1956 1956.000 1956.083 1956.167 1956.250 1956.333 1956.417 1956.500
## 1957 1957.000 1957.083 1957.167 1957.250 1957.333 1957.417 1957.500
```

```
## 1958 1958.000 1958.083 1958.167 1958.250 1958.333 1958.417 1958.500
## 1959 1959.000 1959.083 1959.167 1959.250 1959.333 1959.417 1959.500
## 1960 1960.000 1960.083 1960.167 1960.250 1960.333 1960.417 1960.500
##           Aug      Sep      Oct      Nov      Dec
## 1949 1949.583 1949.667 1949.750 1949.833 1949.917
## 1950 1950.583 1950.667 1950.750 1950.833 1950.917
## 1951 1951.583 1951.667 1951.750 1951.833 1951.917
## 1952 1952.583 1952.667 1952.750 1952.833 1952.917
## 1953 1953.583 1953.667 1953.750 1953.833 1953.917
## 1954 1954.583 1954.667 1954.750 1954.833 1954.917
## 1955 1955.583 1955.667 1955.750 1955.833 1955.917
## 1956 1956.583 1956.667 1956.750 1956.833 1956.917
## 1957 1957.583 1957.667 1957.750 1957.833 1957.917
## 1958 1958.583 1958.667 1958.750 1958.833 1958.917
## 1959 1959.583 1959.667 1959.750 1959.833 1959.917
## 1960 1960.583 1960.667 1960.750 1960.833 1960.917
```

```
deltat(AirPassengers)
```

```
## [1] 0.08333333
```

```
frequency(AirPassengers)
```

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

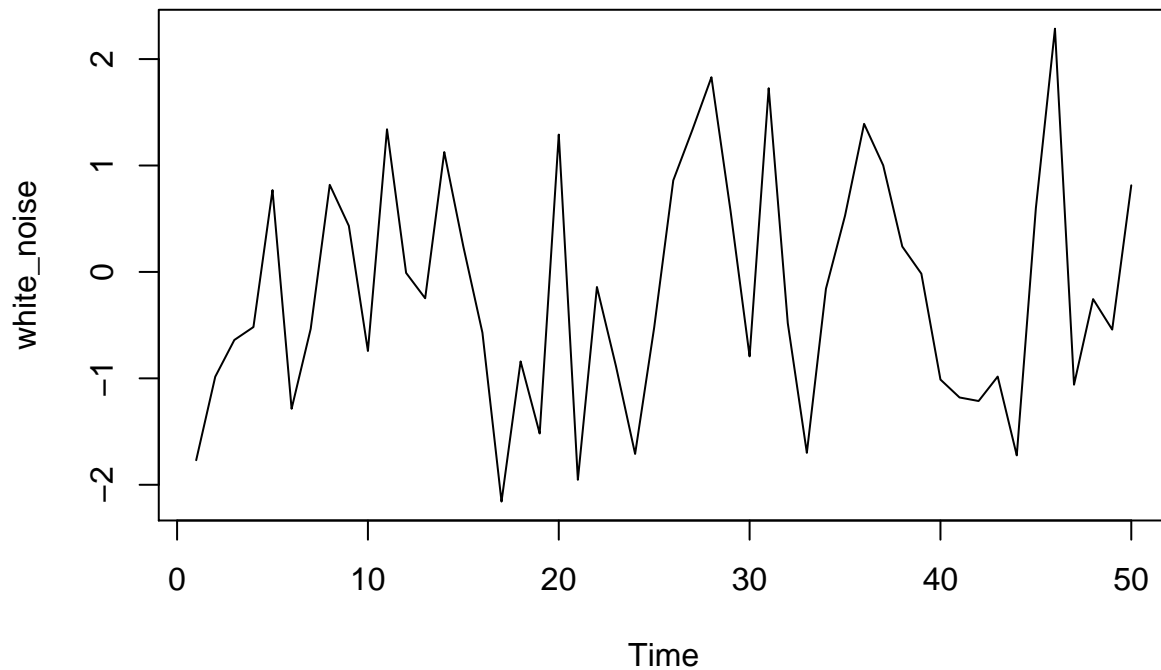
```
cycle(AirPassengers)
```

```
##           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
```

```
# Simulate a WN model with list(order = c(0, 0, 0))
white_noise <- arima.sim(model = list(order = c(0,0,0)), n = 50)

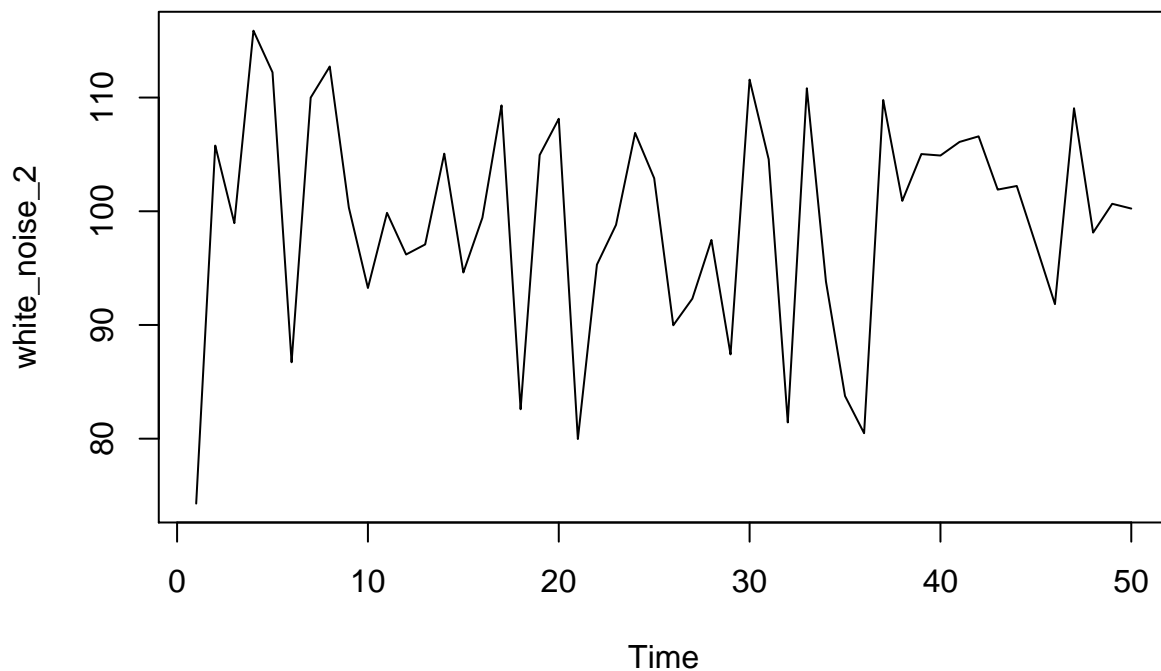
# Plot your white_noise data

ts.plot(white_noise)
```



```
# Simulate from the WN model with: mean = 100, sd = 10
white_noise_2 <- arima.sim(model = list(order = c(0,0,0)), n = 50, mean = 100, sd = 10)

# Plot your white_noise_2 data
ts.plot(white_noise_2)
```



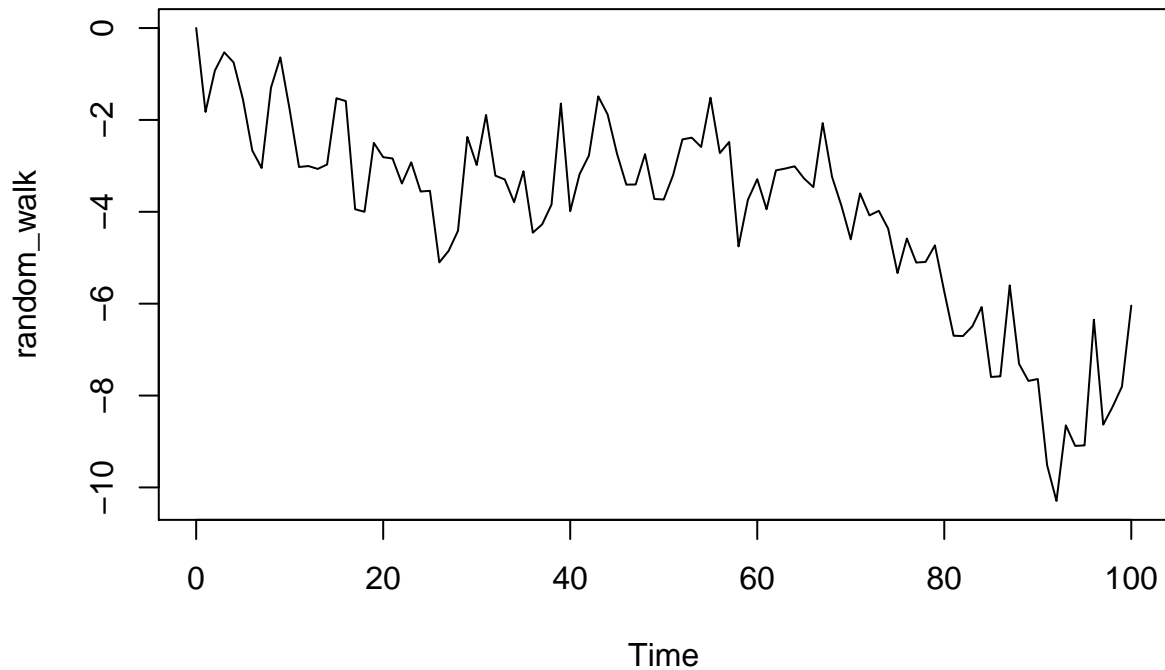
cambios en una serie de tiempo de Random Walk siguen un comportamiento de White noise.

```
# Generate a RW model using arima.sim
random_walk <- arima.sim(model = list(order = c(0, 1, 0)) , n = 100)

# Plot random_walk
```

Los

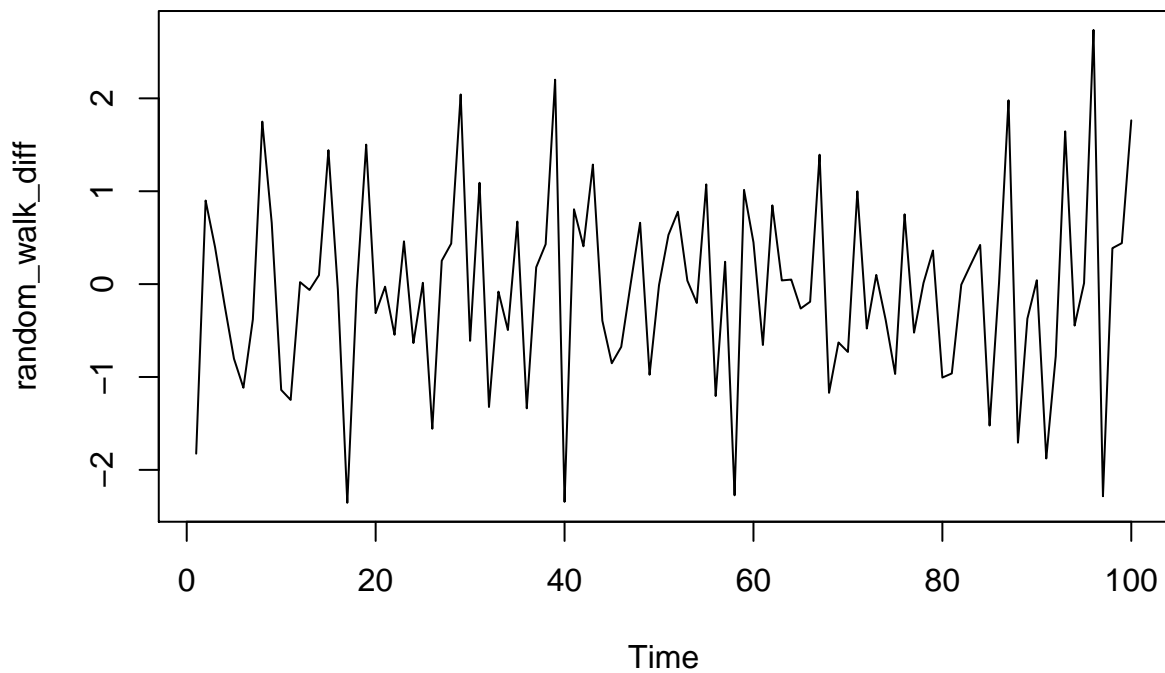
```
ts.plot (random_walk)
```



```
# Calculate the first difference series  
random_walk_diff <- diff(random_walk)
```

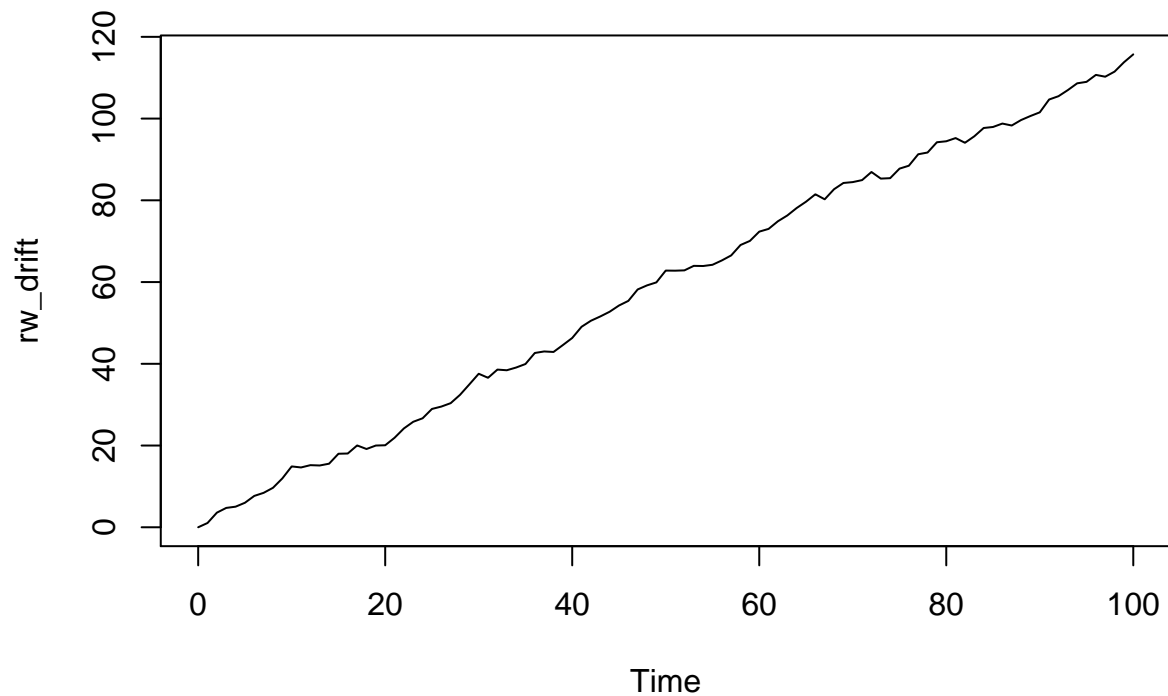
```
# Plot random_walk_diff
```

```
ts.plot(random_walk_diff)
```

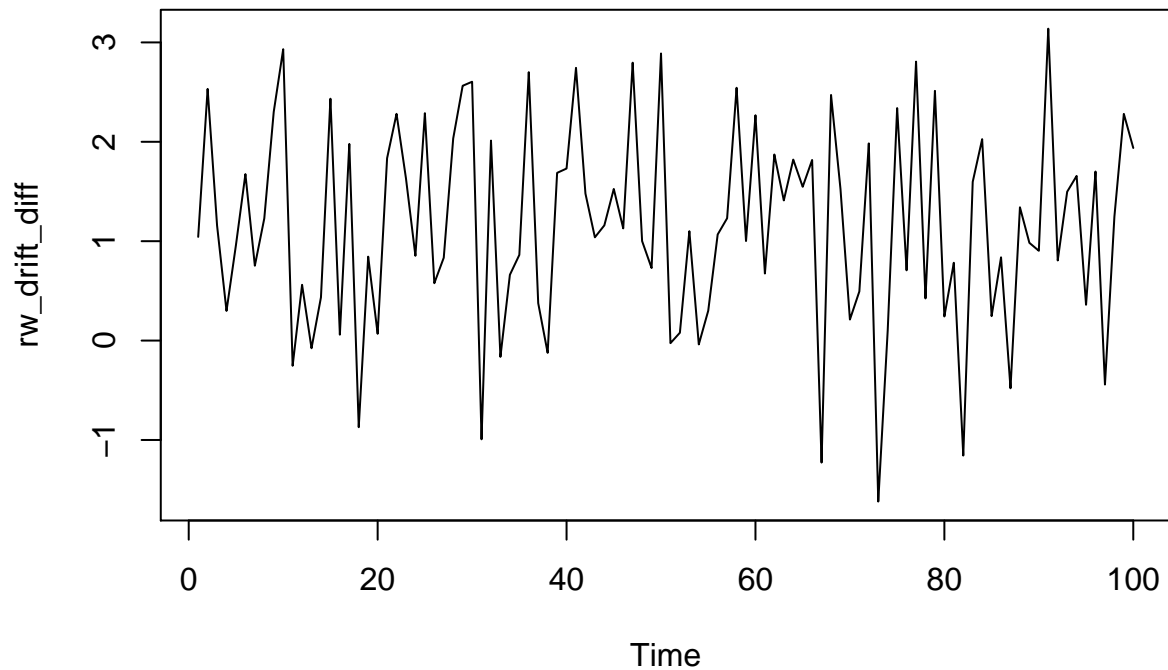


```
# RANDOM WALK WITH DRIFT
```

```
# Generate a RW model with a drift using arima.sim  
rw_drift <- arima.sim(model = list(order = c(0, 1, 0)), n = 100, mean = 1)  
  
# Plot rw_drift  
ts.plot(rw_drift)
```



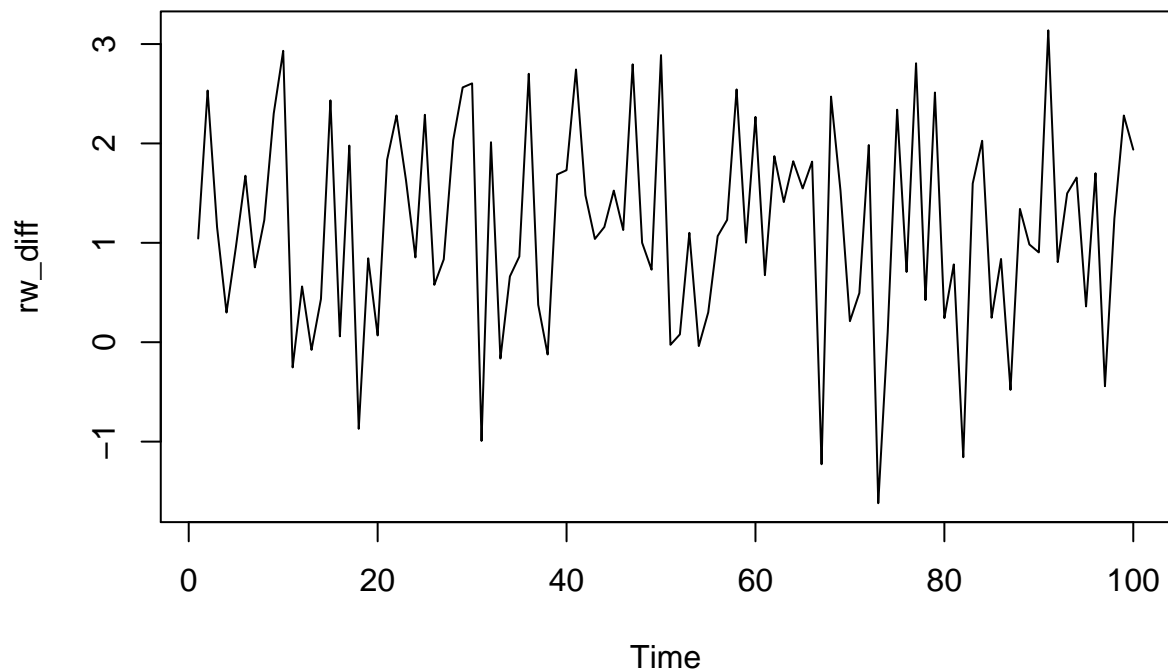
```
# Calculate the first difference series  
rw_drift_diff <- diff(rw_drift)  
  
# Plot rw_drift_diff  
ts.plot(rw_drift_diff)
```



```
random_walk <- rw_drift

# Difference your random_walk data
rw_diff <- diff(random_walk)

# Plot rw_diff
plot.ts(rw_diff)
```



```
# Now fit the WN model to the differenced data
model_wn <- arima(rw_diff, order = c(0, 0, 0))
```

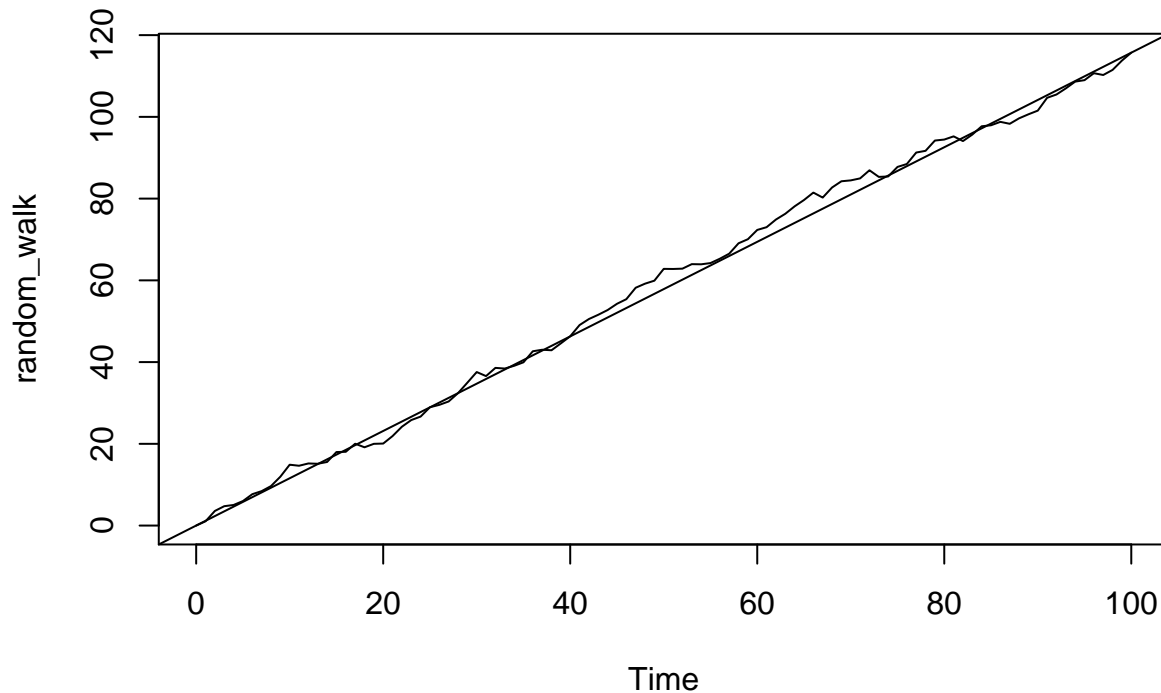
```

# Store the value of the estimated time trend (intercept)
int_wn <- model_wn$coef

# Plot the original random_walk data
ts.plot(random_walk)

# Use abline(0, ...) to add time trend to the figure
abline(0,int_wn)

```



```

# RANDOM WALK CON Y SIN DRIFT (Estationarity)
#
# The white noise (WN) and random walk (RW) models are very closely related. However, only the RW is al
#
# Recall that if we start with a mean zero WN process and compute its running or cumulative sum, the re

# Use arima.sim() to generate WN data
white_noise <- arima.sim(model = list(order = c(0, 0, 0)), n = 100)

# Use cumsum() to convert your WN data to RW
random_walk <- cumsum(white_noise)

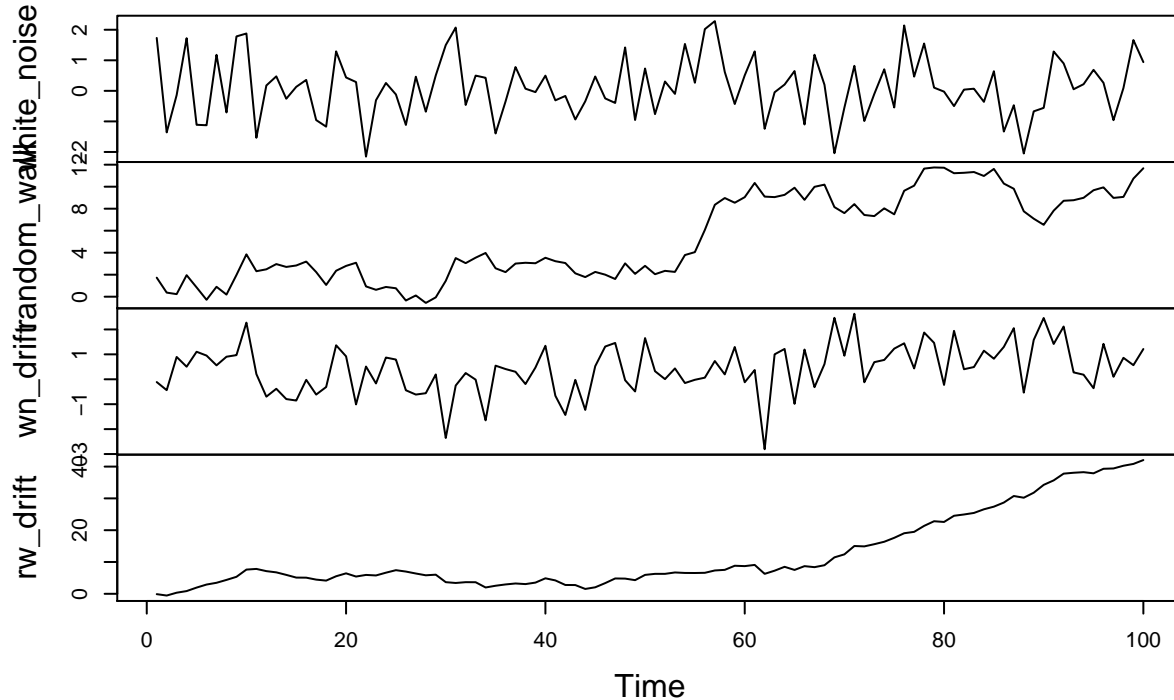
# Use arima.sim() to generate WN drift data
wn_drift <- arima.sim(model = list(order = c(0, 0, 0)),mean=0.4, n = 100)

# Use cumsum() to convert your WN drift data to RW
rw_drift <- cumsum(wn_drift)

# Plot all four data objects
plot.ts(cbind(white_noise, random_walk, wn_drift, rw_drift))

```

cbind(white_noise, random_walk, wn_drift, rw_drift)



```
#
# # Generate means from eu_percentreturns
# colMeans(eu_percentreturns)
#
# # Use apply to calculate sample variance from eu_percentreturns
# apply(eu_percentreturns, MARGIN = 2, FUN = var)
#
# # Use apply to calculate standard deviation from eu_percentreturns
# apply(eu_percentreturns, MARGIN = 2, FUN = sd)
#
# # Display a histogram of percent returns for each index
# par(mfrow = c(2,2))
# apply(eu_percentreturns, MARGIN = 2, FUN = hist, main = "", xlab = "Percentage Return")
#
# # Display normal quantile plots of percent returns for each index
# par(mfrow = c(2,2))
# apply(eu_percentreturns, MARGIN = 2, FUN = qqnorm, main = "")
# qqline(eu_percentreturns)

# pairs(eu_stocks)

# MODELOS AUTOREGRESIVOS:

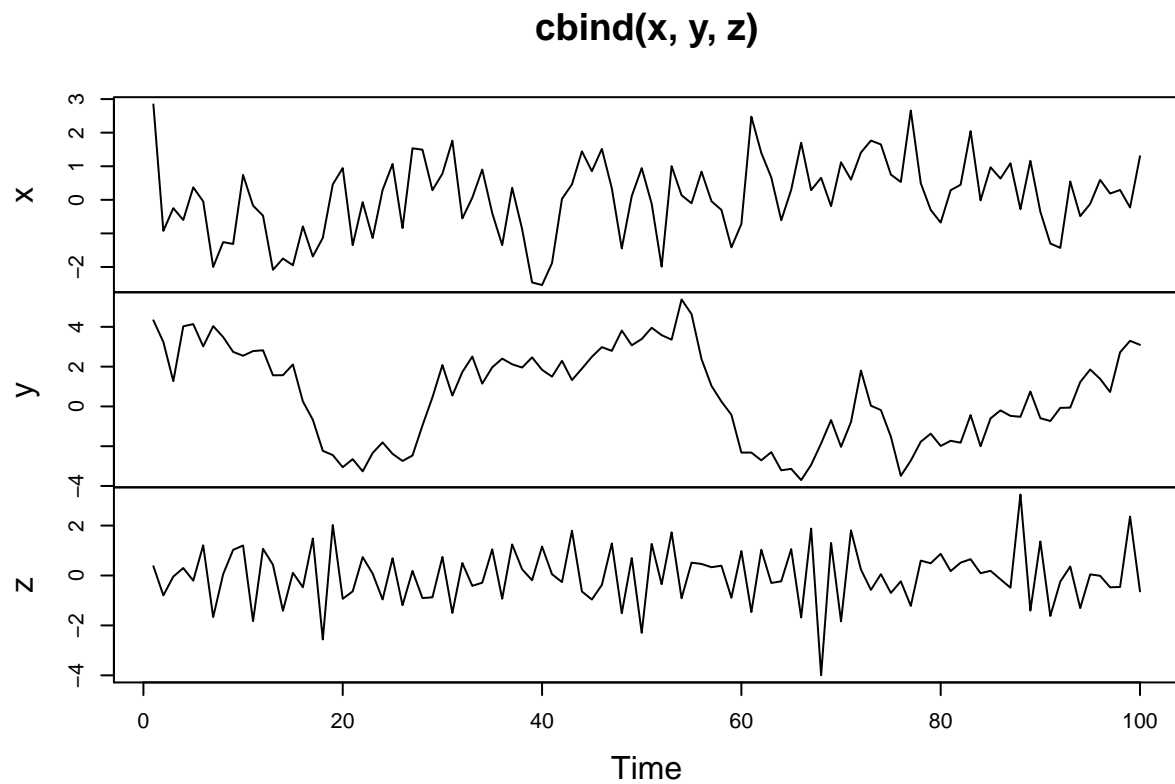
# Simulate an AR model with 0.5 slope
x <- arima.sim(model = list(ar = 0.5), n = 100)

# Simulate an AR model with 0.9 slope
y <- arima.sim(model = list(ar = 0.9), n = 100)
```



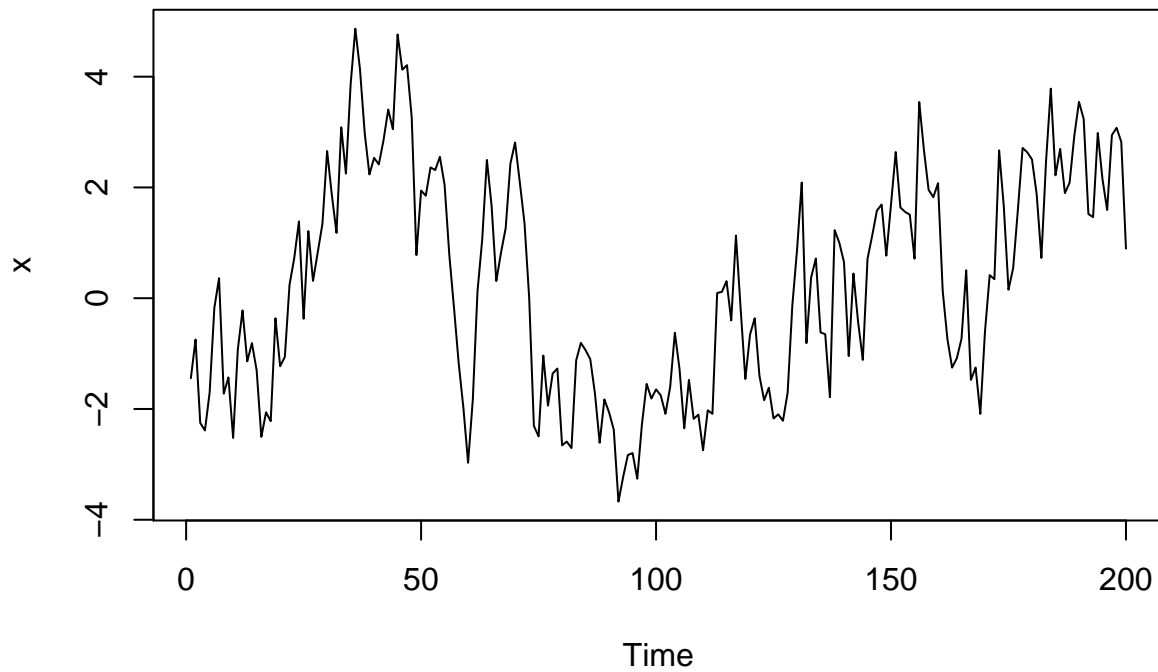
```
# Simulate an AR model with -0.75 slope
z <- arima.sim(model = list(ar = -0.75), n = 100)

# Plot your simulated data
plot.ts(cbind(x, y, z))
```



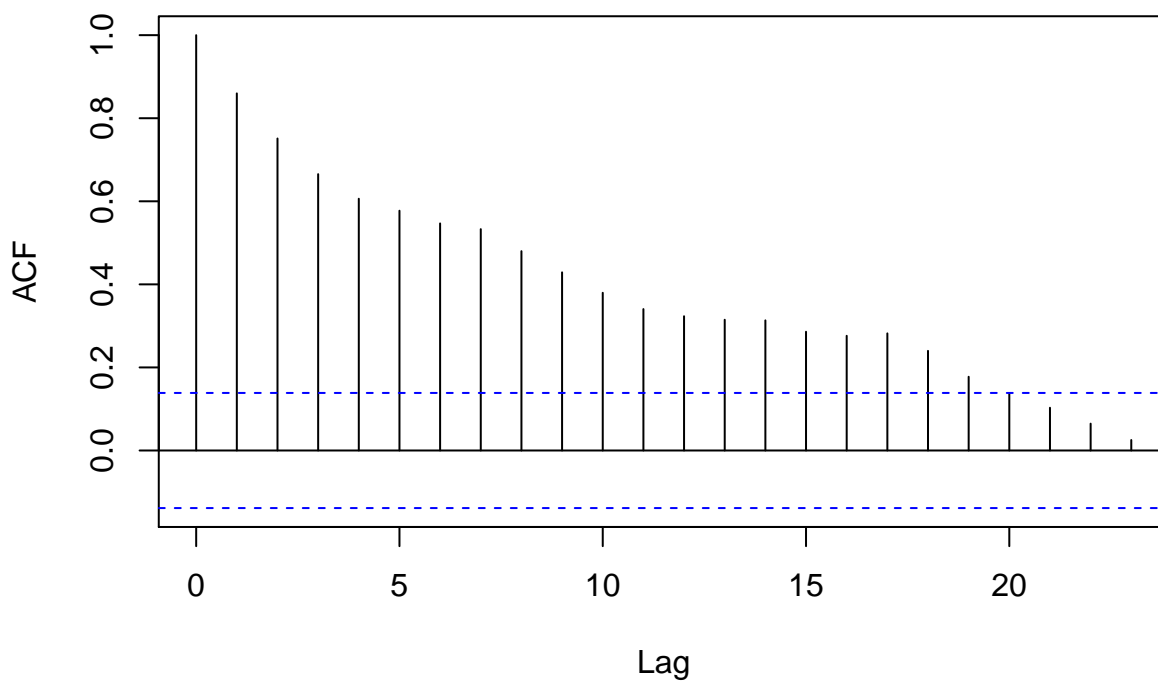
```
##### COMPARAR MODELOS AR con RandomWalks

# Simulate and plot AR model with slope 0.9
x <- arima.sim(model = list(ar = 0.9), n = 200)
ts.plot(x)
```

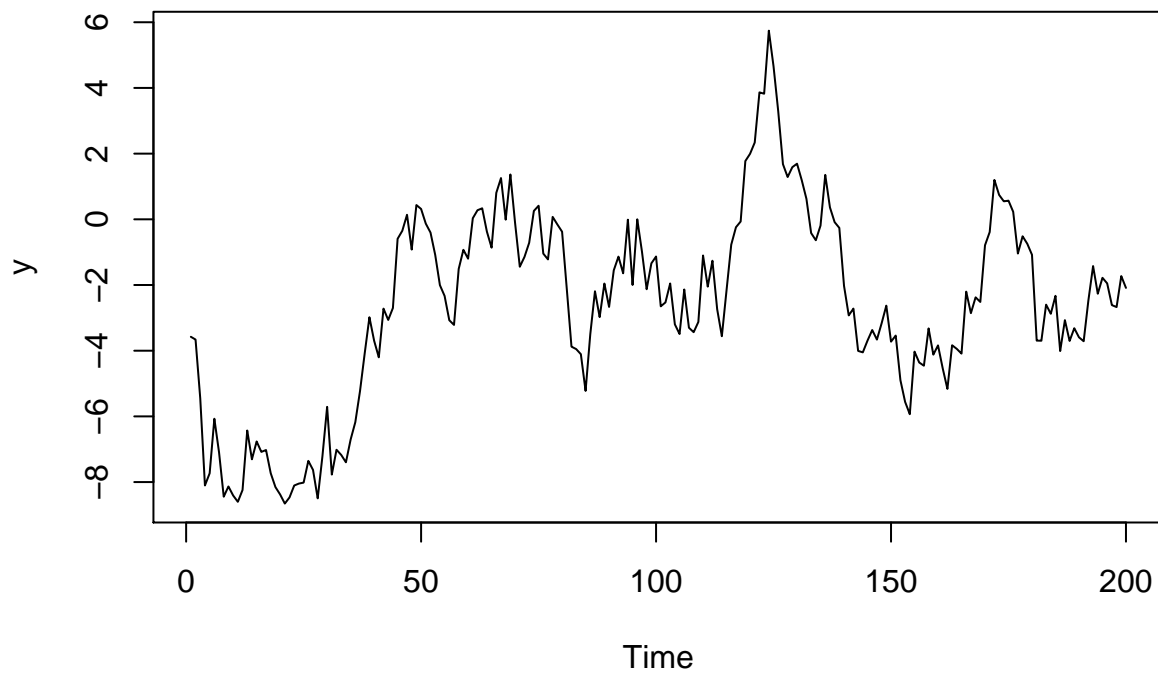


```
acf(x)
```

Series x

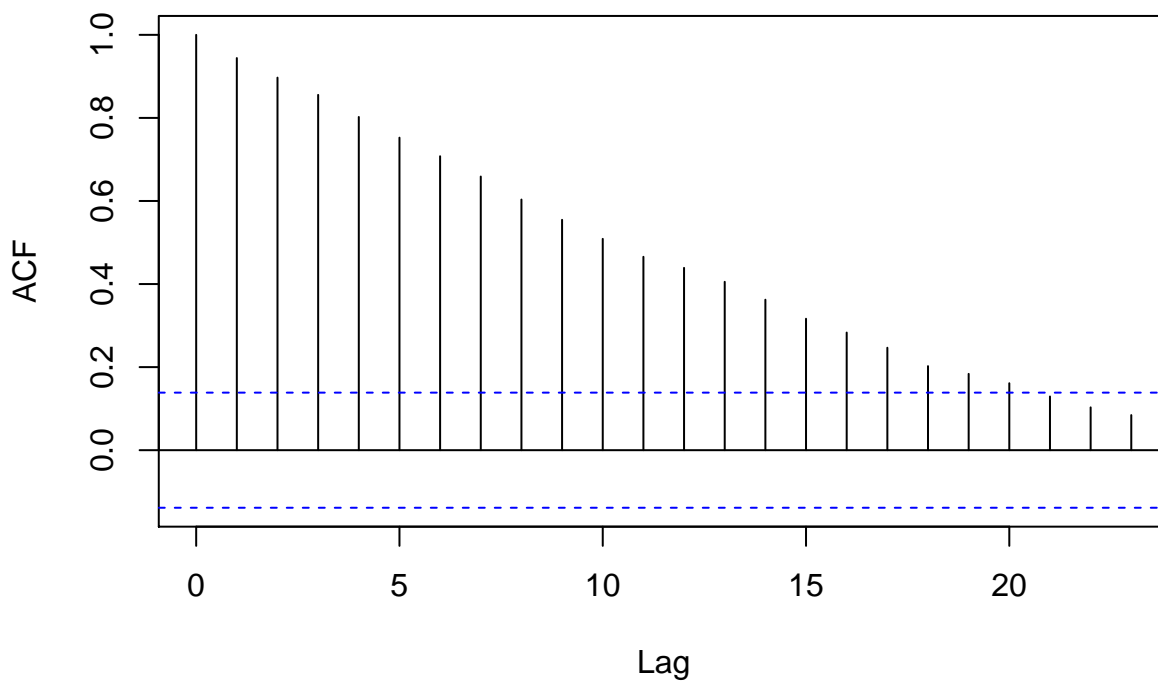


```
# Simulate and plot AR model with slope 0.98
y <- arima.sim(model = list(ar = 0.98), n = 200)
ts.plot(y)
```

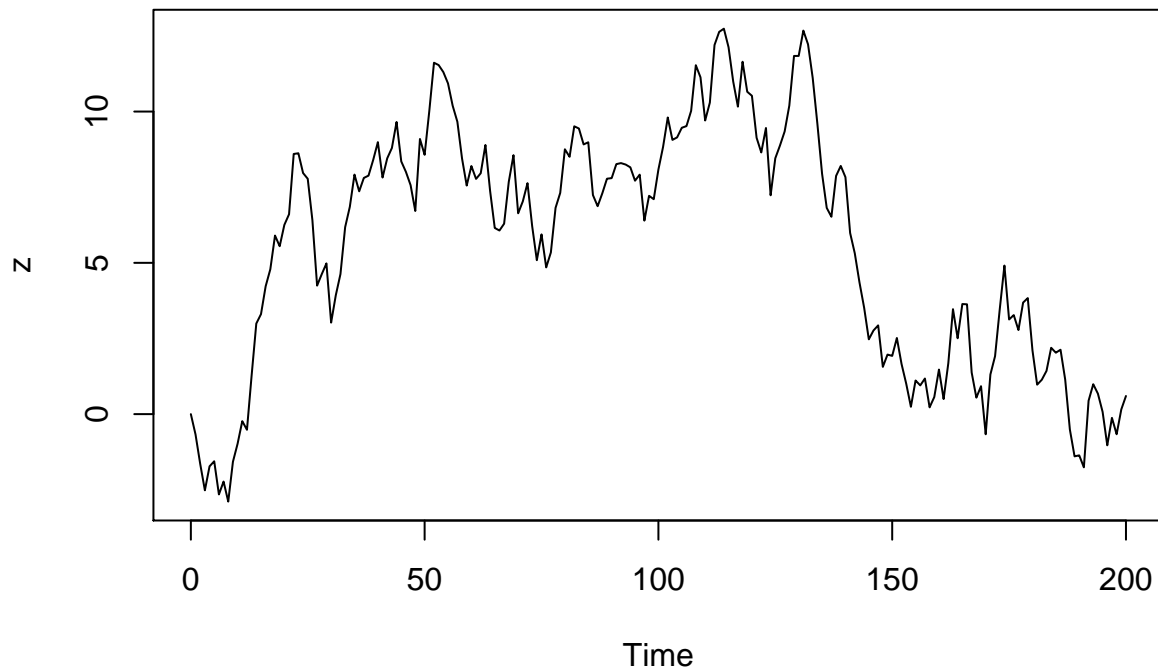


```
acf(y)
```

Series y

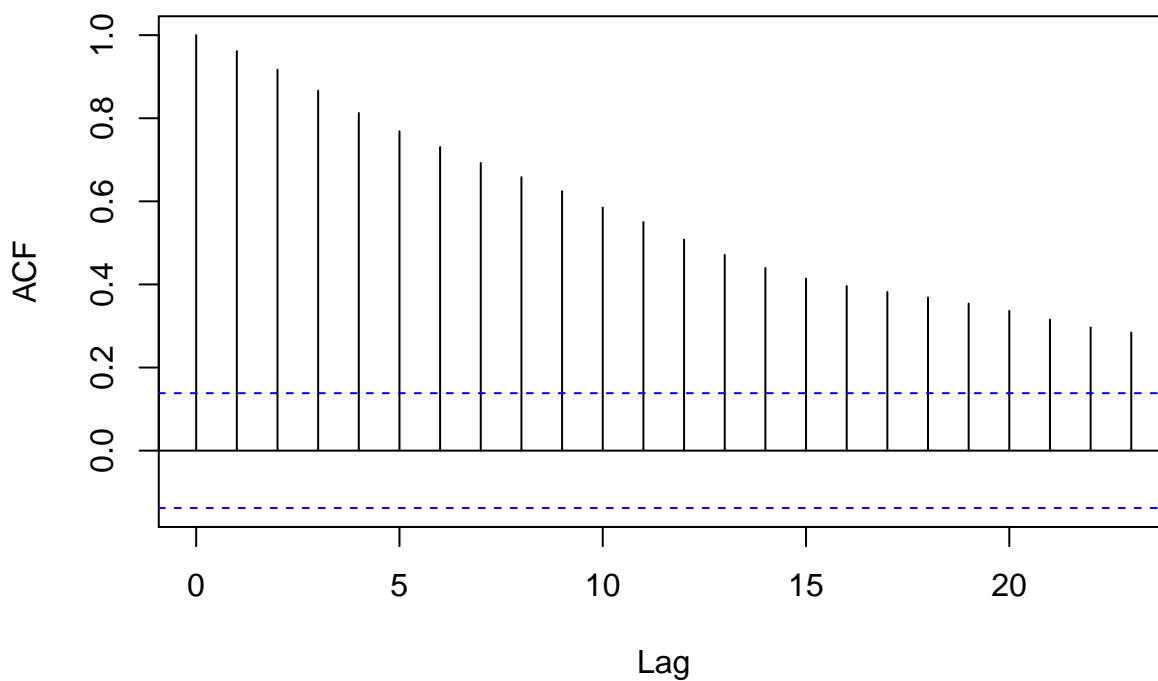


```
# Simulate and plot RW model
z <- arima.sim(model = list(order = c(0, 1, 0)), n = 200)
ts.plot(z)
```



```
acf(z)
```

Series z



```
## AJUSTAR UN AR
## Fit an AR model to Nile
AR_fit <- arima(Nile, order = c(1,0,0))
print(AR_fit)
#
## Use predict() to make a 1-step forecast
```

```

# predict_AR <- predict(AR_fit)
#
# # Obtain the 1-step forecast using $pred[1]
# predict_AR$pred[1]
#
# # Use predict to make 1-step through 10-step forecasts
# predict(AR_fit, n.ahead = 10)
#
# # Run to plot the Nile series plus the forecast and 95% prediction intervals
# ts.plot(Nile, xlim = c(1871, 1980))
# AR_forecast <- predict(AR_fit, n.ahead = 10)$pred
# AR_forecast_se <- predict(AR_fit, n.ahead = 10)$se
# points(AR_forecast, type = "l", col = 2)
# points(AR_forecast - 2*AR_forecast_se, type = "l", col = 2, lty = 2)
# points(AR_forecast + 2*AR_forecast_se, type = "l", col = 2, lty = 2)

# # AJUSTAR UN MA
# Generate MA model with slope 0.5
x <- arima.sim(model = list(ma = 0.5), n = 100)

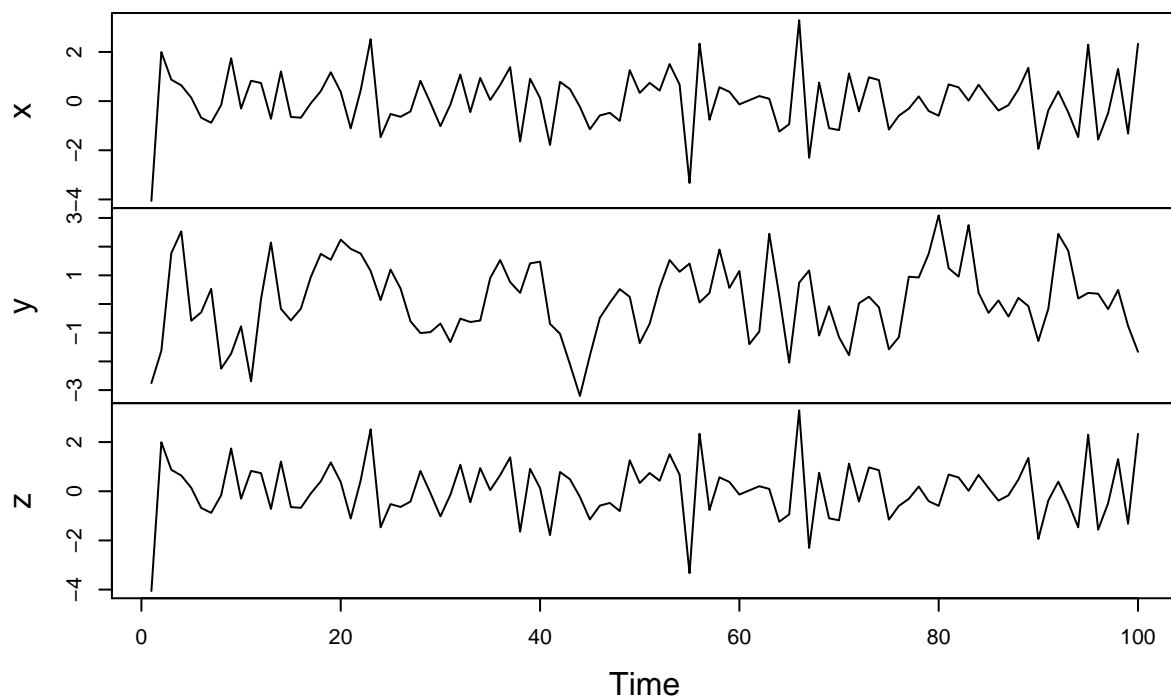
# Generate MA model with slope 0.9
y <- x <- arima.sim(model = list(ma = 0.9), n = 100)

# Generate MA model with slope -0.5
z <- x <- arima.sim(model = list(ma = -0.5), n = 100)

# Plot all three models together
plot.ts(cbind(x, y, z))

```

cbind(x, y, z)



```

# # # Ajustando un MA
#
# # Make a 1-step forecast based on MA
# predict_MA <- predict(MA, n.ahead = 1)
#
# # Obtain the 1-step forecast using $pred[1]
# predict_MA$pred[1]
#
# # Make a 1-step through 10-step forecast based on MA
# predict(MA, n.ahead = 10)
#
# # Plot the Nile series plus the forecast and 95% prediction intervals
# ts.plot(Nile, xlim = c(1871, 1980))
# MA_forecasts <- predict(MA, n.ahead = 10)$pred
# MA_forecast_se <- predict(MA, n.ahead = 10)$se
# points(MA_forecasts, type = "l", col = 2)
# points(MA_forecasts - 2*MA_forecast_se, type = "l", col = 2, lty = 2)
# points(MA_forecasts + 2*MA_forecast_se, type = "l", col = 2, lty = 2)

```

Pruebas series de tiempo de Time Series Analysis and its applications course

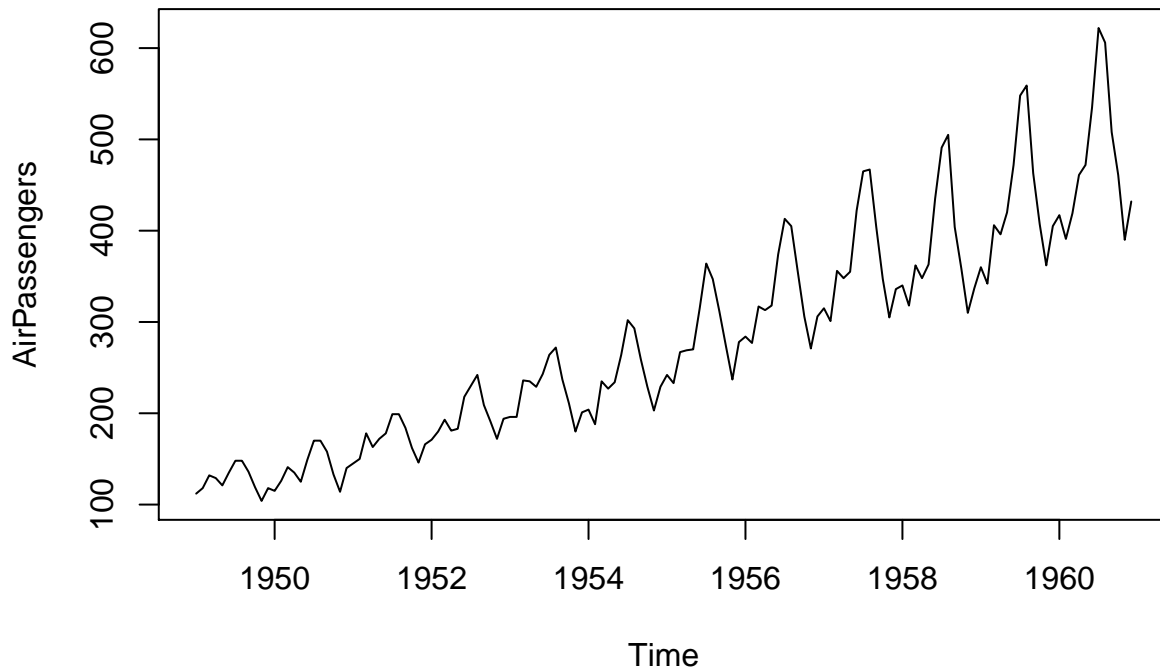
```

# # R Arima base

# View a detailed description of AirPassengers
help(AirPassengers)

# Plot AirPassengers
ts.plot(AirPassengers)

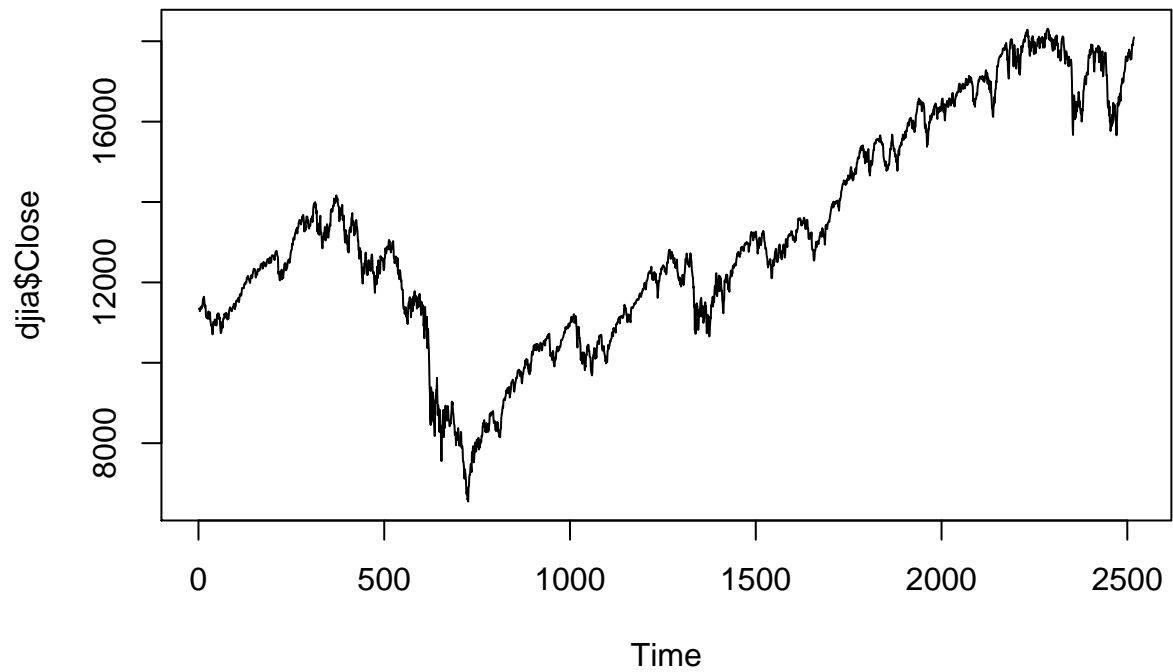
```



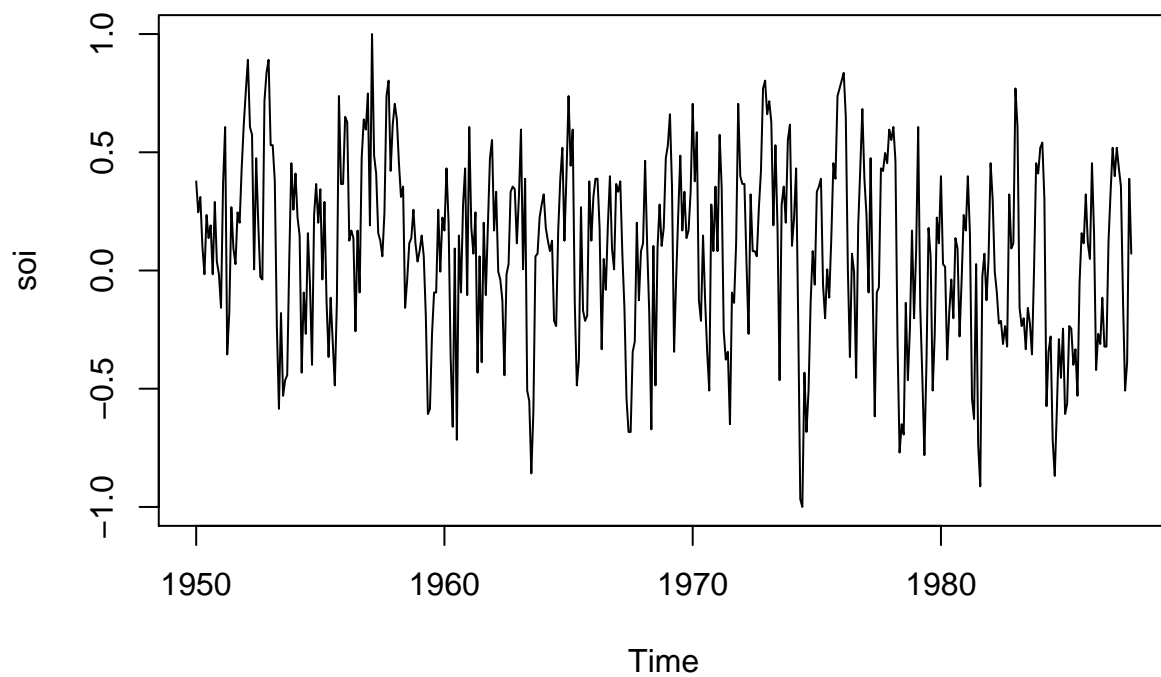
```

# Plot the DJIA daily closings
ts.plot(djia$Close)

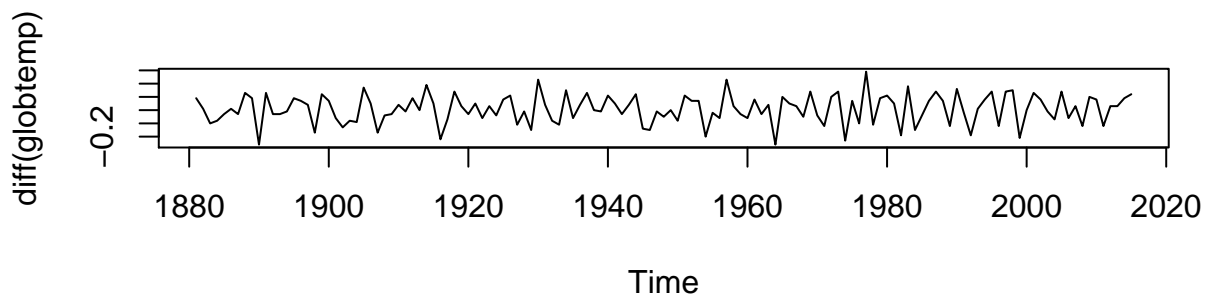
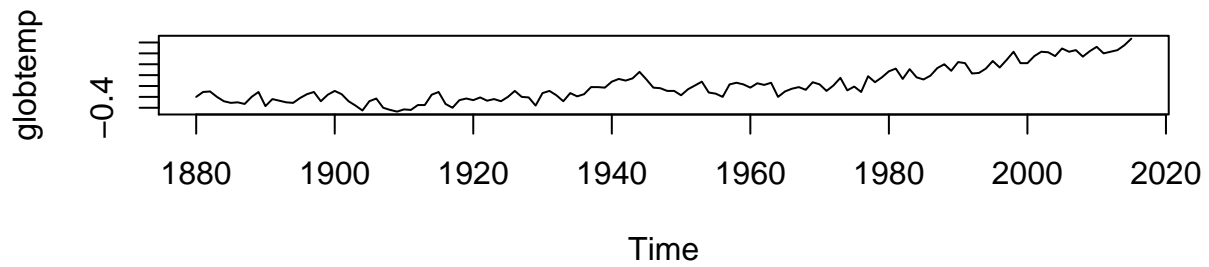
```



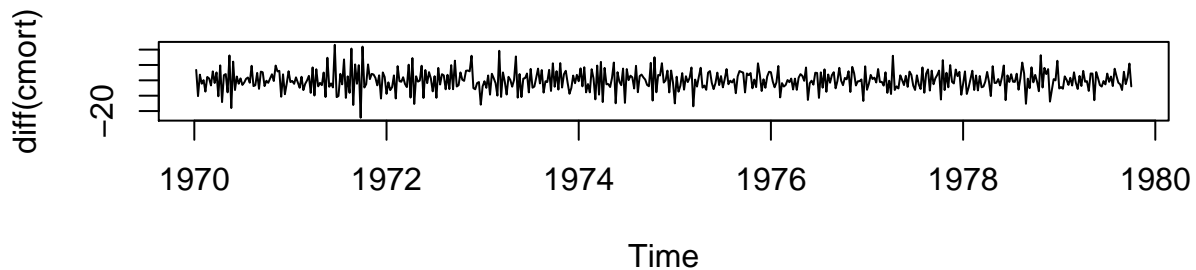
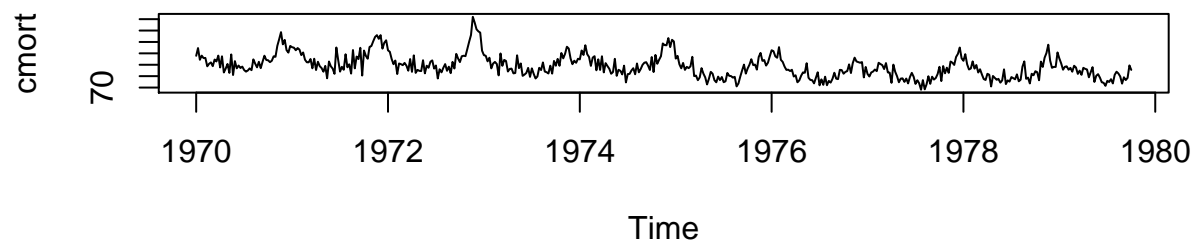
```
# Plot the Southern Oscillation Index
plot(soi)
```



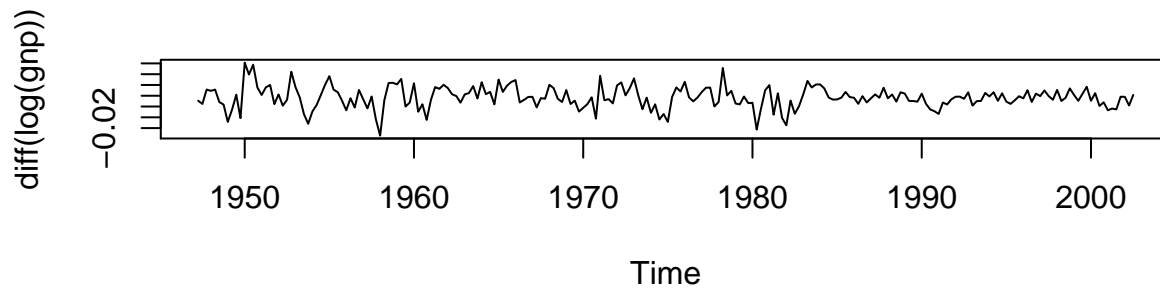
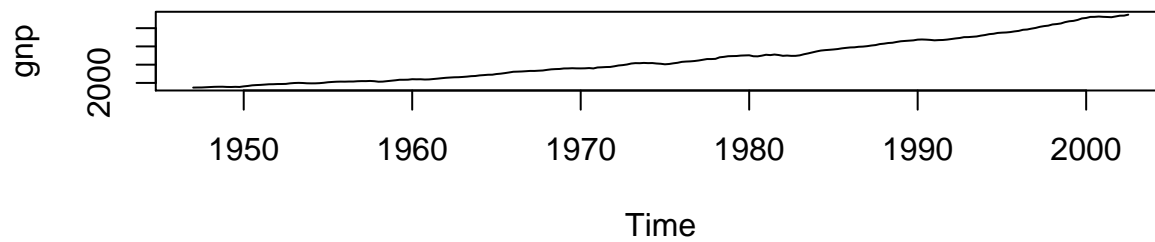
```
# Plot globtemp and detrended globtemp
par(mfrow = c(2,1))
plot(globtemp)
plot(diff(globtemp))
```



```
# Plot cmort and detrended cmort
par(mfrow = c(2,1))
plot(cmort)
plot(diff(cmort))
```

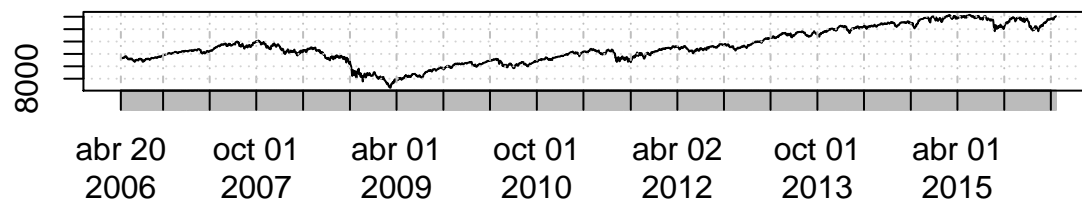


```
# Plot GNP series (gnp) and its growth rate
par(mfrow = c(2,1))
plot(gnp)
plot(diff(log(gnp)))
```

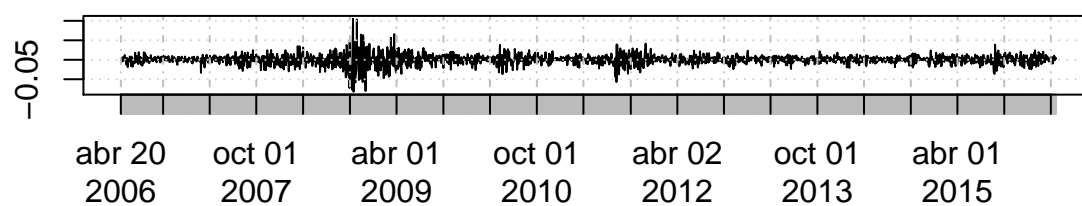



```
# Plot DJIA closings (djia$Close) and its returns
par(mfrow = c(2,1))
plot(djia$Close)
plot(diff(log(djia$Close)))
```

djia\$Close



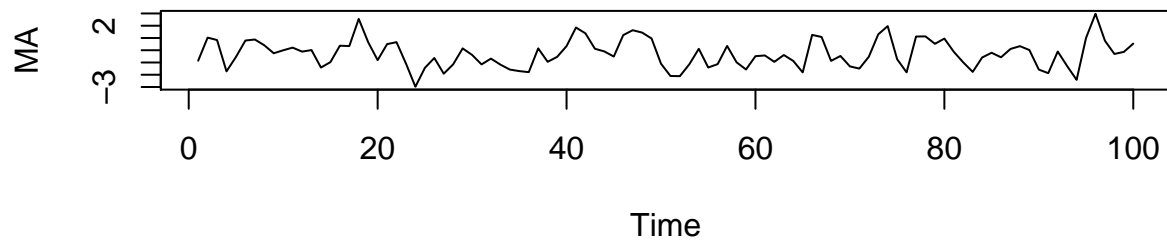
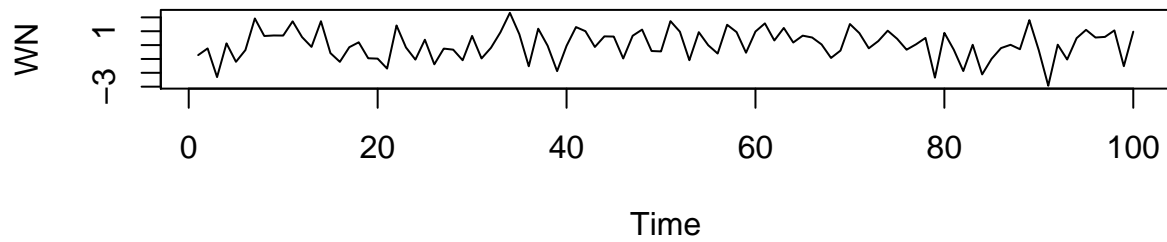
diff(log(djia\$Close))



```
##SIMULAR MA & AR
```

```
# Generate and plot white noise
WN <- arima.sim(model=list(order=c(0,0,0)),n=100)
plot(WN)
```

```
# Generate and plot an MA(1) with parameter .9
MA <- arima.sim(model=list(order=c(0,0,1), ma = 0.9),n=100)
plot(MA)
```

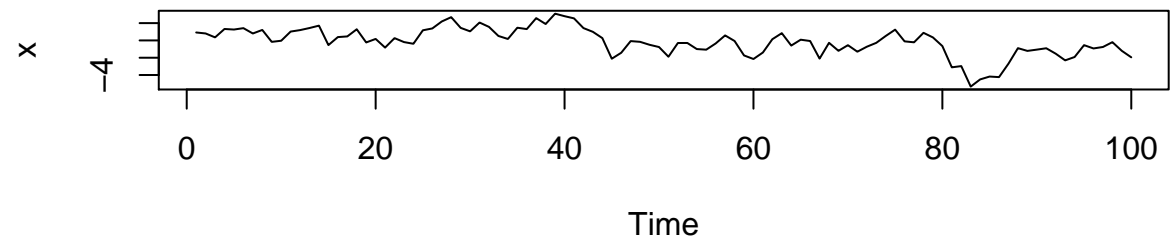
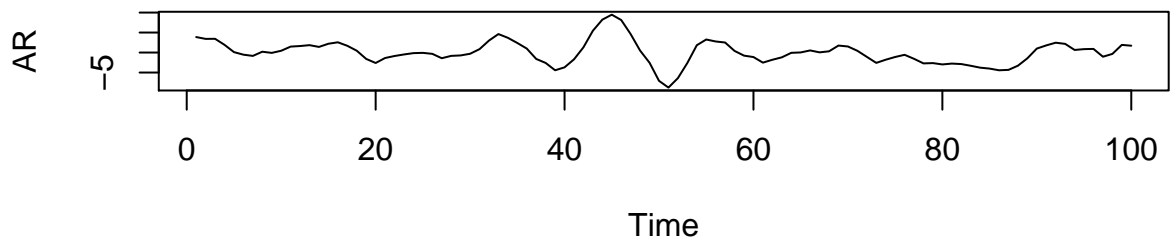


```
# Generate and plot an AR(2) with parameters 1.5 and -.75
AR <- arima.sim(model=list(order=c(2,0,0), ar =c(1.5,-0.75)),n=100)
plot(AR)
```

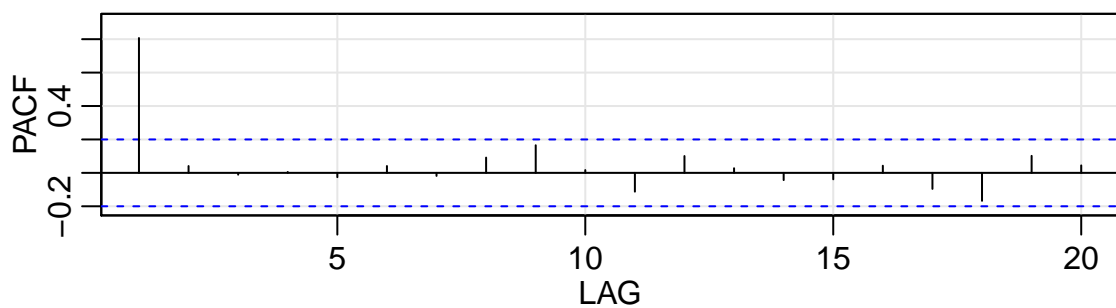
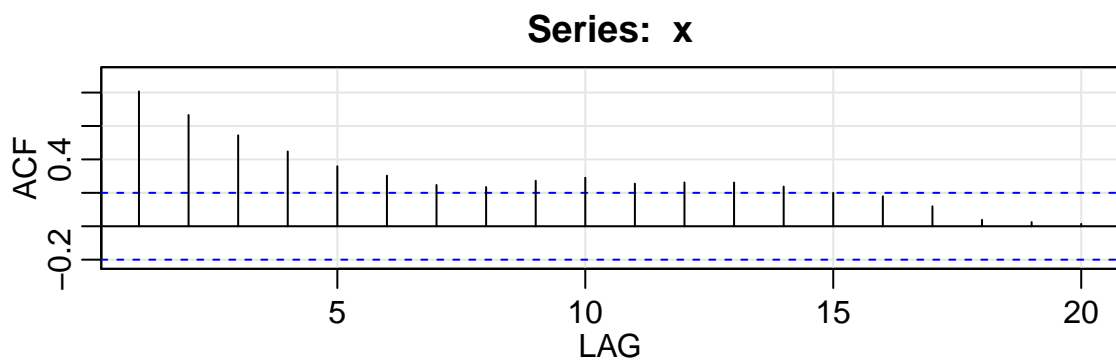
```
# # SIMULAR Y AJUSTAR AR
```

```
# Generate 100 observations from the AR(1) model
x <- arima.sim(model = list(order = c(1, 0, 0), ar = .9), n = 100)

# Plot the generated data
plot(x)
```



```
# Plot the sample P/ACF pair
acf2(x)
```

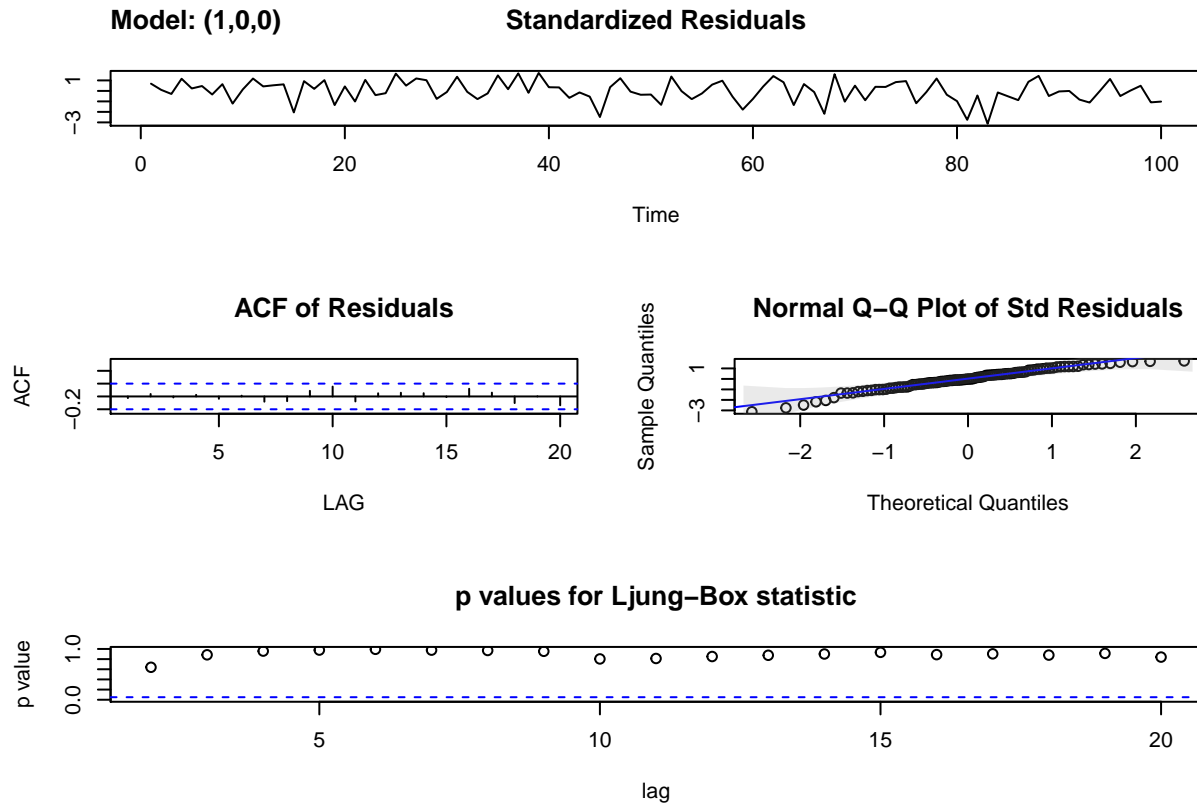


```
##      ACF  PACF
## [1,] 0.81  0.81
## [2,] 0.67  0.04
## [3,] 0.54 -0.01
## [4,] 0.45  0.01
## [5,] 0.36 -0.03
```

```
## [6,] 0.30 0.04
## [7,] 0.25 -0.02
## [8,] 0.23 0.09
## [9,] 0.27 0.17
## [10,] 0.29 0.02
## [11,] 0.25 -0.11
## [12,] 0.26 0.10
## [13,] 0.26 0.03
## [14,] 0.24 -0.04
## [15,] 0.20 -0.04
## [16,] 0.18 0.04
## [17,] 0.12 -0.10
## [18,] 0.04 -0.17
## [19,] 0.02 0.10
## [20,] 0.01 0.04
```

```
# Fit an AR(1) to the data and examine the -table
sarima(x, 1, 0, 0)
```

```
## initial value 0.466492
## iter 2 value -0.076978
## iter 3 value -0.077049
## iter 4 value -0.077135
## iter 5 value -0.077266
## iter 6 value -0.077355
## iter 7 value -0.077367
## iter 8 value -0.077370
## iter 9 value -0.077370
## iter 10 value -0.077373
## iter 11 value -0.077373
## iter 12 value -0.077373
## iter 13 value -0.077373
## iter 13 value -0.077373
## iter 13 value -0.077373
## final value -0.077373
## converged
## initial value -0.074037
## iter 2 value -0.074101
## iter 3 value -0.074305
## iter 4 value -0.074317
## iter 5 value -0.074328
## iter 6 value -0.074328
## iter 7 value -0.074328
## iter 8 value -0.074328
## iter 8 value -0.074328
## iter 8 value -0.074328
## final value -0.074328
## converged
```



```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), xreg = xmean, include.mean = FALSE, optim.control = list(trace = trc,
##     REPORT = 1, reltol = tol))
##
## Coefficients:
##      ar1      xmean
##      0.8131  -0.1804
## s.e.  0.0571   0.4739
##
## sigma^2 estimated as 0.8526:  log likelihood = -134.46,  aic = 274.92
##
## $degrees_of_freedom
## [1] 98
##
## $ttable
##      Estimate      SE t.value p.value
## ar1      0.8131 0.0571 14.2280 0.0000
## xmean   -0.1804 0.4739 -0.3807 0.7043
##
## $AIC
## [1] 0.8805238
##
## $AICc
## [1] 0.9030238
##
```

```
## $BIC
## [1] -0.06737275
```

```
## aJUSTAR MA(2)
```

```
# astsa is preloaded
```

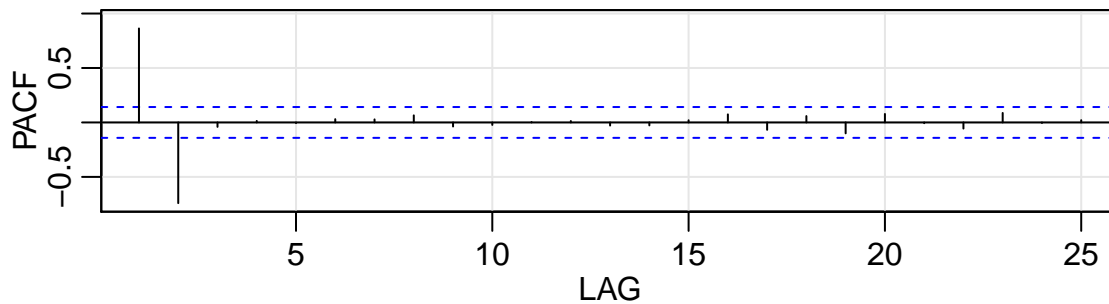
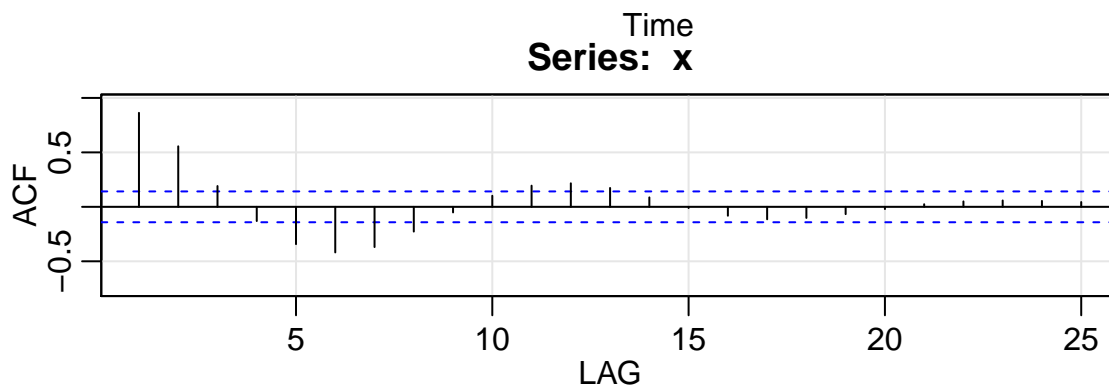
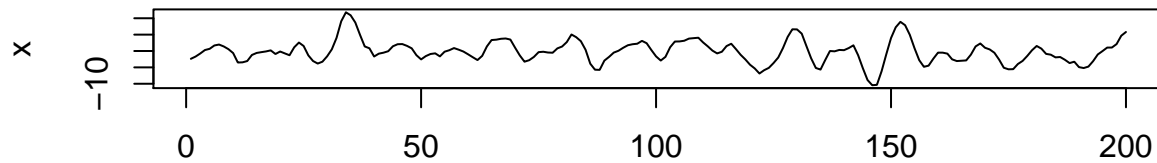
```
x <- arima.sim(model = list(order = c(2, 0, 0), ar = c(1.5, -.75)), n = 200)
```

```
# Plot x
```

```
plot(x)
```

```
# Plot the sample P/ACF of x
```

```
acf2(x)
```

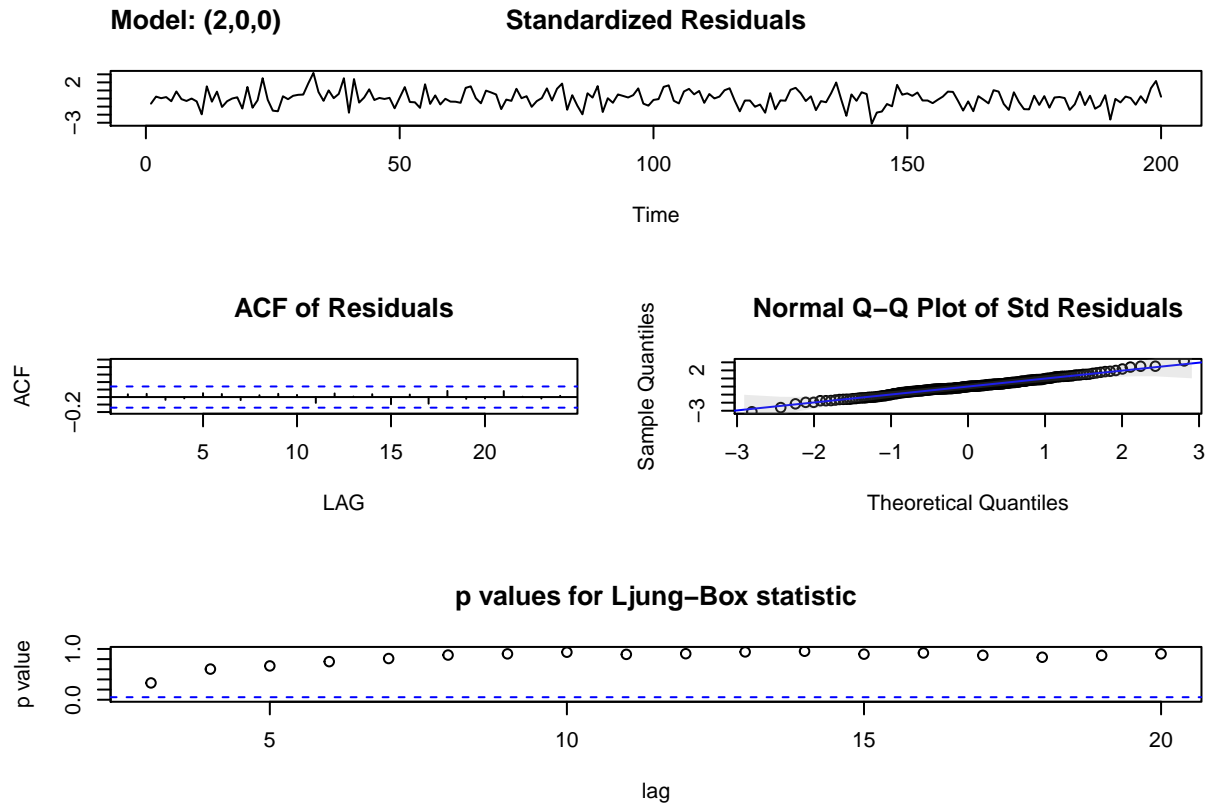


```
##      ACF  PACF
## [1,] 0.86 0.86
## [2,] 0.56 -0.74
## [3,] 0.19 -0.04
## [4,] -0.13 0.01
## [5,] -0.34 -0.01
## [6,] -0.42 0.03
## [7,] -0.37 0.03
## [8,] -0.23 0.07
## [9,] -0.05 -0.04
## [10,] 0.10 -0.02
```

```
## [11,] 0.19 0.00
## [12,] 0.22 0.01
## [13,] 0.17 -0.03
## [14,] 0.09 -0.03
## [15,] -0.01 0.02
## [16,] -0.08 0.07
## [17,] -0.11 -0.07
## [18,] -0.10 0.06
## [19,] -0.07 -0.10
## [20,] -0.02 0.08
## [21,] 0.02 -0.01
## [22,] 0.05 -0.06
## [23,] 0.06 0.09
## [24,] 0.05 -0.01
## [25,] 0.04 0.02
```

```
# Fit an AR(2) to the data and examine the t-table
sarima(x,2,0,0)
```

```
## initial value 1.244086
## iter 2 value 1.098327
## iter 3 value 0.671403
## iter 4 value 0.397384
## iter 5 value 0.256210
## iter 6 value 0.089845
## iter 7 value 0.065778
## iter 8 value 0.042251
## iter 9 value 0.042244
## iter 10 value 0.042216
## iter 11 value 0.042207
## iter 12 value 0.042206
## iter 13 value 0.042206
## iter 13 value 0.042206
## iter 13 value 0.042206
## final value 0.042206
## converged
## initial value 0.046921
## iter 2 value 0.046887
## iter 3 value 0.046862
## iter 4 value 0.046861
## iter 5 value 0.046861
## iter 6 value 0.046861
## iter 6 value 0.046861
## iter 6 value 0.046861
## final value 0.046861
## converged
```



```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), xreg = xmean, include.mean = FALSE, optim.control = list(trace = trc,
##     REPORT = 1, reltol = tol))
##
## Coefficients:
##          ar1      ar2      xmean
##      1.5607 -0.7909 -0.1924
## s.e.  0.0427  0.0427  0.3193
##
## sigma^2 estimated as 1.08:  log likelihood = -293.16,  aic = 594.32
##
## $degrees_of_freedom
## [1] 197
##
## $ttable
##      Estimate      SE  t.value p.value
## ar1      1.5607 0.0427  36.5888  0.0000
## ar2     -0.7909 0.0427 -18.5287  0.0000
## xmean   -0.1924 0.3193  -0.6025  0.5475
##
## $AIC
## [1] 1.106776
##
## $AICc
## [1] 1.117802
```

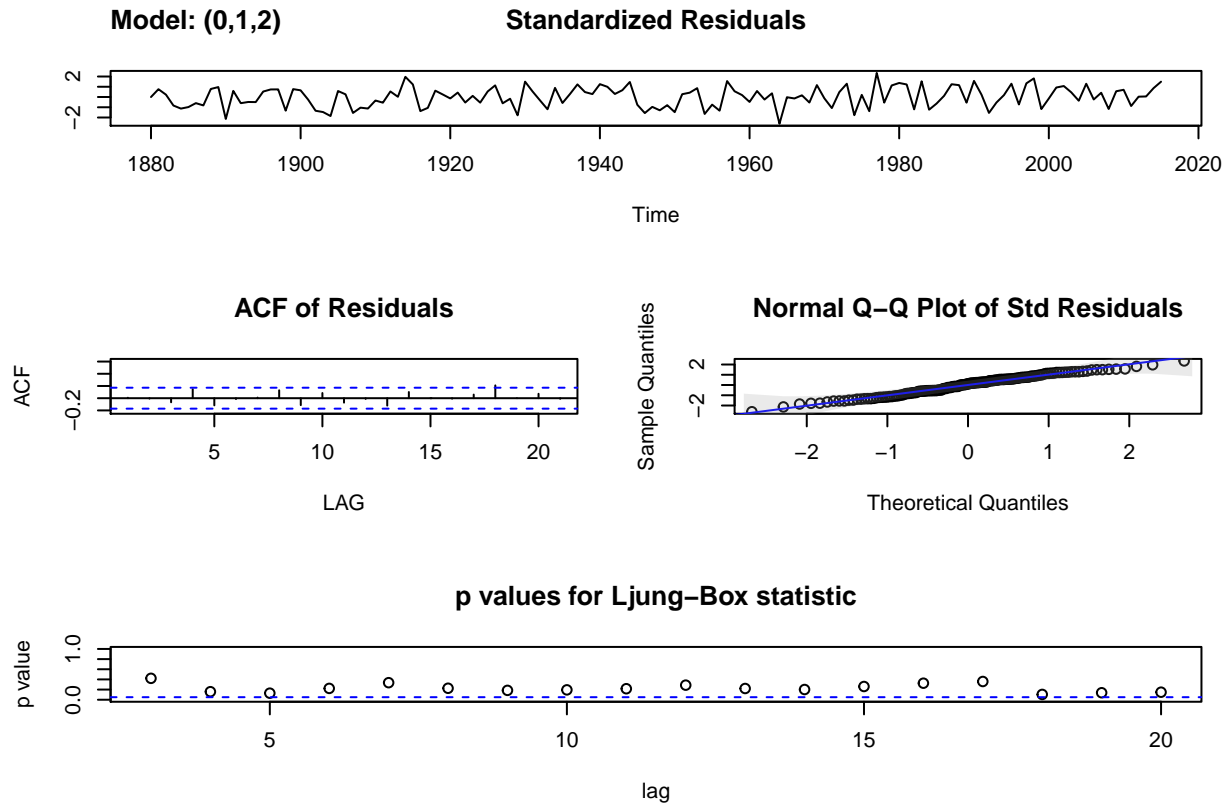


```

##
## $BIC
## [1] 0.1562506
# # # SIMULANDO ARIMAS
# Fit an ARIMA(0,1,2) to globtemp and check the fit
sarima(globtemp, 0, 1, 2)

## initial value -2.220513
## iter 2 value -2.294887
## iter 3 value -2.307682
## iter 4 value -2.309170
## iter 5 value -2.310360
## iter 6 value -2.311251
## iter 7 value -2.311636
## iter 8 value -2.311648
## iter 9 value -2.311649
## iter 9 value -2.311649
## iter 9 value -2.311649
## final value -2.311649
## converged
## initial value -2.310187
## iter 2 value -2.310197
## iter 3 value -2.310199
## iter 4 value -2.310201
## iter 5 value -2.310202
## iter 5 value -2.310202
## iter 5 value -2.310202
## final value -2.310202
## converged

```



```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), xreg = constant, optim.control = list(trace = trc, REPORT = 1,
##     reltol = tol))
##
## Coefficients:
##          ma1          ma2    constant
##       -0.3984   -0.2173     0.0072
## s.e.    0.0808    0.0768    0.0033
##
## sigma^2 estimated as 0.00982:  log likelihood = 120.32,  aic = -232.64
##
## $degrees_of_freedom
## [1] 133
##
## $ttable
##           Estimate      SE t.value p.value
## ma1         -0.3984 0.0808 -4.9313  0.0000
## ma2         -0.2173 0.0768 -2.8303  0.0054
## constant     0.0072 0.0033  2.1463  0.0337
##
## $AIC
## [1] -3.579224
##
## $AICc
## [1] -3.562273
```

```

##
## $BIC
## [1] -4.514974

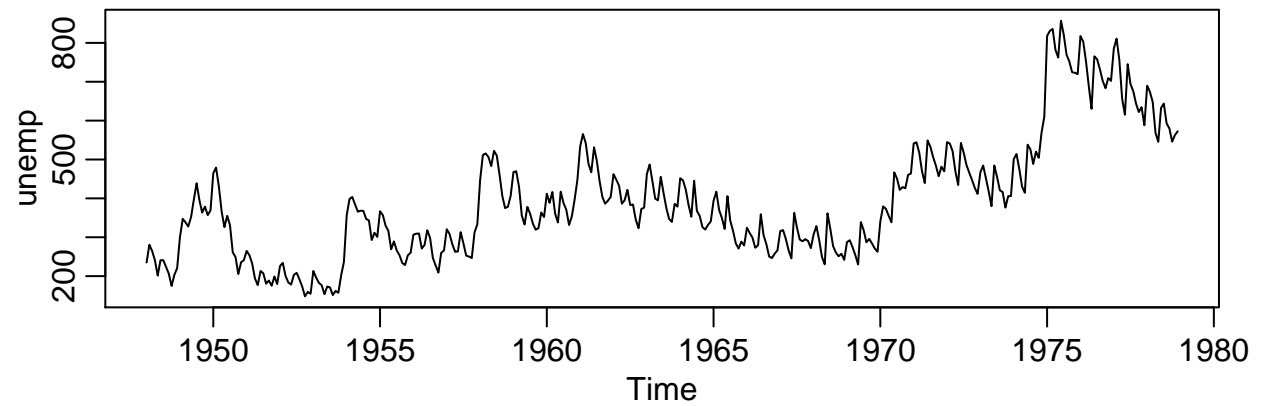
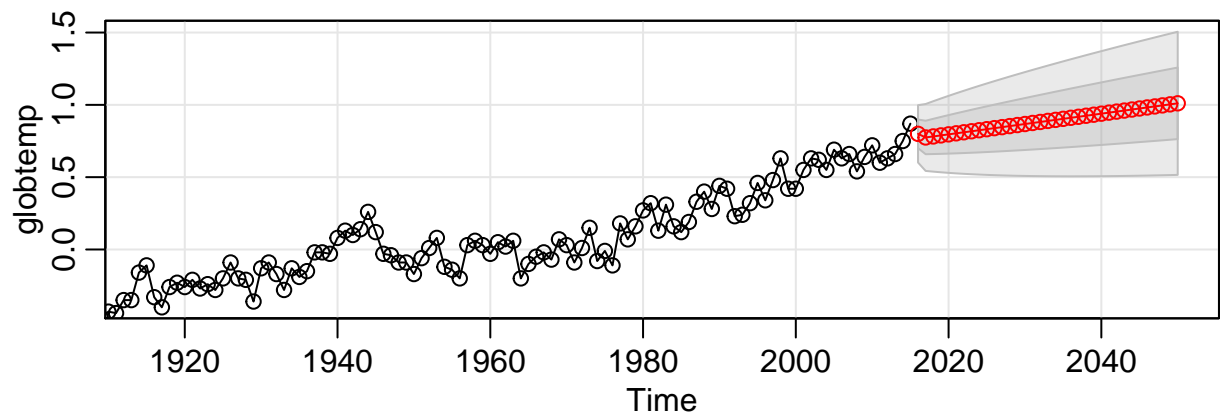
# Forecast data 35 years into the future
sarima.for (globtemp,n.ahead = 35, p = 0, d = 1, q = 2)

## $pred
## Time Series:
## Start = 2016
## End = 2050
## Frequency = 1
## [1] 0.7995567 0.7745381 0.7816919 0.7888457 0.7959996 0.8031534 0.8103072
## [8] 0.8174611 0.8246149 0.8317688 0.8389226 0.8460764 0.8532303 0.8603841
## [15] 0.8675379 0.8746918 0.8818456 0.8889995 0.8961533 0.9033071 0.9104610
## [22] 0.9176148 0.9247687 0.9319225 0.9390763 0.9462302 0.9533840 0.9605378
## [29] 0.9676917 0.9748455 0.9819994 0.9891532 0.9963070 1.0034609 1.0106147
##
## $se
## Time Series:
## Start = 2016
## End = 2050
## Frequency = 1
## [1] 0.09909556 0.11564576 0.12175580 0.12757353 0.13313729 0.13847769
## [7] 0.14361964 0.14858376 0.15338730 0.15804492 0.16256915 0.16697084
## [13] 0.17125943 0.17544322 0.17952954 0.18352490 0.18743511 0.19126540
## [19] 0.19502047 0.19870459 0.20232164 0.20587515 0.20936836 0.21280424
## [25] 0.21618551 0.21951471 0.22279416 0.22602604 0.22921235 0.23235497
## [31] 0.23545565 0.23851603 0.24153763 0.24452190 0.24747019

### SERIES DE TIEMPO ESTACIONALES

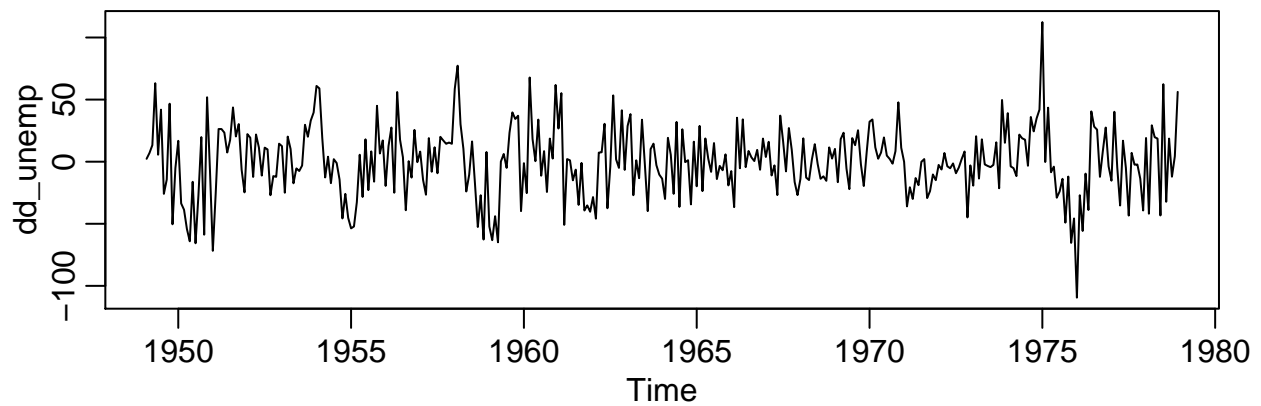
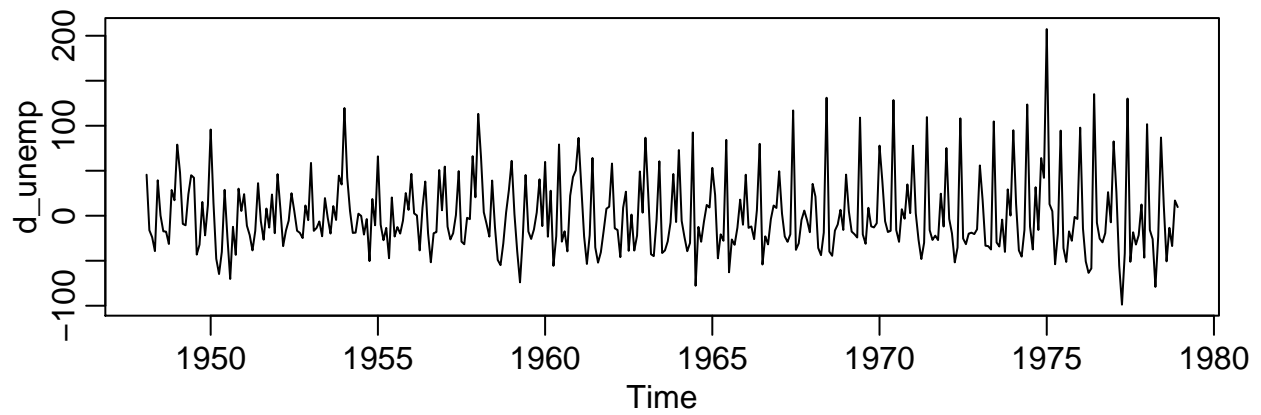
# Plot unemp
plot(unemp)

```

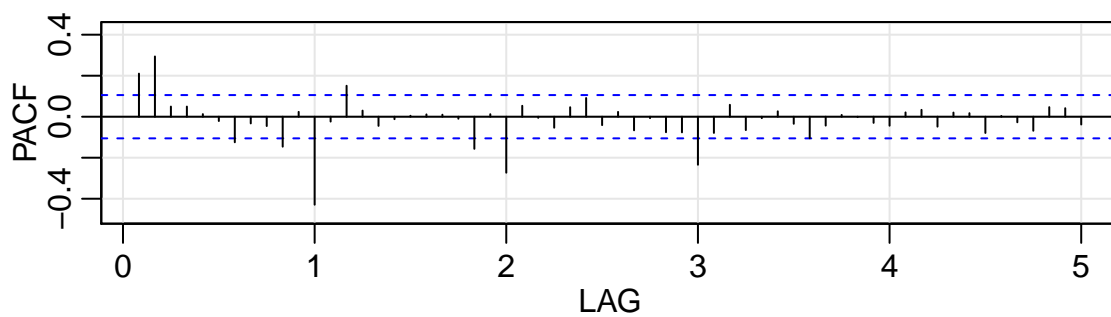
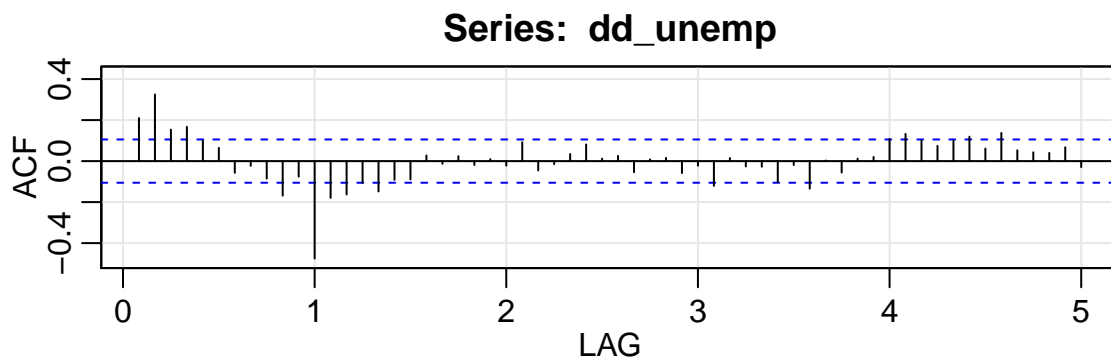


```
# Difference your data and plot it
d_unemp <- diff(unemp)
plot(d_unemp)

# Seasonally difference d_unemp and plot it
dd_unemp <- diff(d_unemp, lag = 12)
plot(dd_unemp)
```



```
# Plot P/ACF pair of fully differenced data to lag 60
dd_unemp <- diff(diff(unemp), lag = 12)
acf2(dd_unemp, max.lag = 60)
```



##		ACF	PACF
##	[1,]	0.21	0.21
##	[2,]	0.33	0.29
##	[3,]	0.15	0.05
##	[4,]	0.17	0.05
##	[5,]	0.10	0.01
##	[6,]	0.06	-0.02
##	[7,]	-0.06	-0.12
##	[8,]	-0.02	-0.03
##	[9,]	-0.09	-0.05
##	[10,]	-0.17	-0.15
##	[11,]	-0.08	0.02
##	[12,]	-0.48	-0.43
##	[13,]	-0.18	-0.02
##	[14,]	-0.16	0.15
##	[15,]	-0.11	0.03
##	[16,]	-0.15	-0.04
##	[17,]	-0.09	-0.01
##	[18,]	-0.09	0.00
##	[19,]	0.03	0.01
##	[20,]	-0.01	0.01
##	[21,]	0.02	-0.01
##	[22,]	-0.02	-0.16
##	[23,]	0.01	0.01
##	[24,]	-0.02	-0.27
##	[25,]	0.09	0.05
##	[26,]	-0.05	-0.01
##	[27,]	-0.01	-0.05
##	[28,]	0.03	0.05
##	[29,]	0.08	0.09
##	[30,]	0.01	-0.04
##	[31,]	0.03	0.02
##	[32,]	-0.05	-0.07
##	[33,]	0.01	-0.01
##	[34,]	0.02	-0.08
##	[35,]	-0.06	-0.08
##	[36,]	-0.02	-0.23
##	[37,]	-0.12	-0.08
##	[38,]	0.01	0.06
##	[39,]	-0.03	-0.07
##	[40,]	-0.03	-0.01
##	[41,]	-0.10	0.03
##	[42,]	-0.02	-0.03
##	[43,]	-0.13	-0.11
##	[44,]	0.00	-0.04
##	[45,]	-0.06	0.01
##	[46,]	0.01	0.00
##	[47,]	0.02	-0.03
##	[48,]	0.11	-0.04
##	[49,]	0.13	0.02
##	[50,]	0.10	0.03
##	[51,]	0.07	-0.05
##	[52,]	0.10	0.02
##	[53,]	0.12	0.02

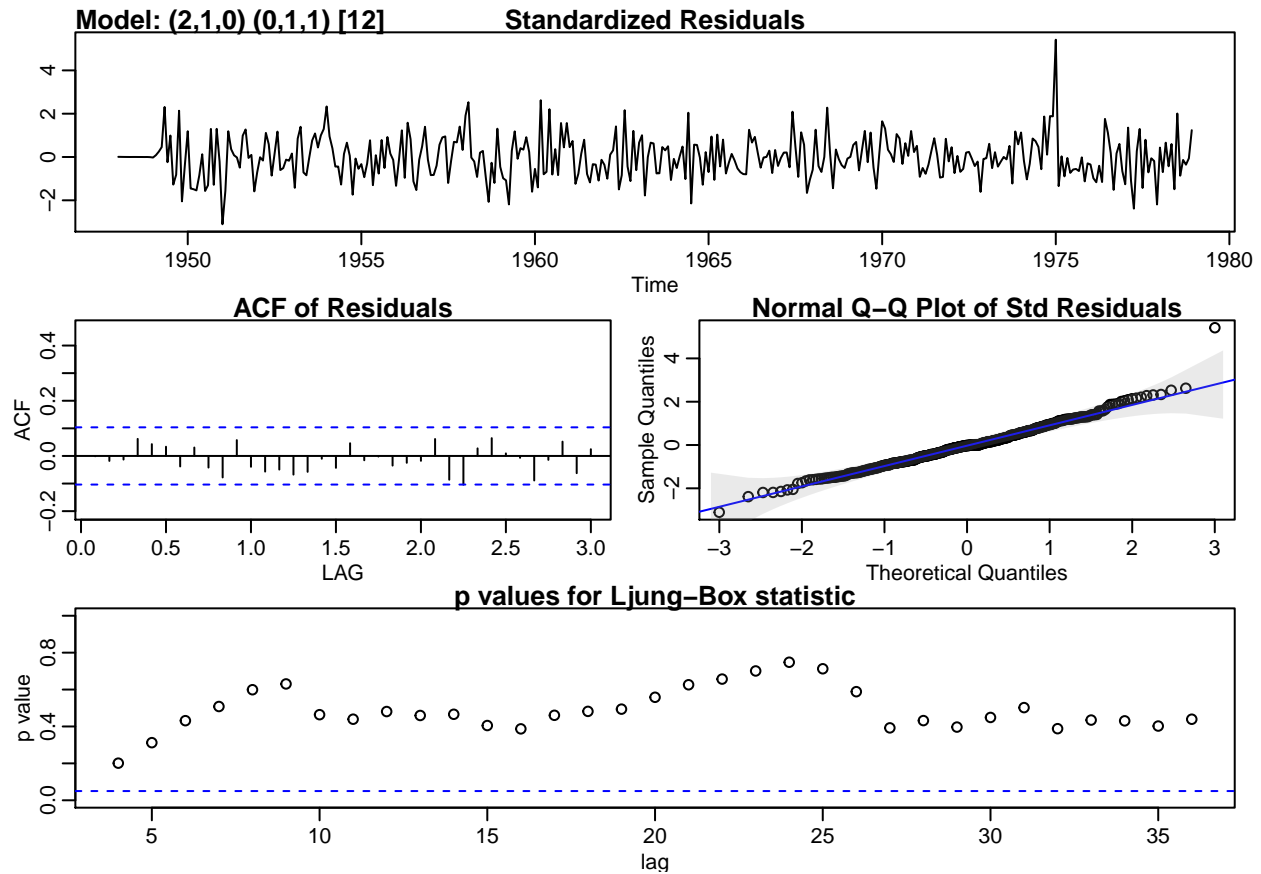
```

## [54,] 0.06 -0.08
## [55,] 0.14 0.00
## [56,] 0.05 -0.03
## [57,] 0.04 -0.07
## [58,] 0.04 0.05
## [59,] 0.07 0.04
## [60,] -0.03 -0.04

# Fit an appropriate model
sarima(unemp,2,1,0,0,1,1, S=12)

## initial value 3.340809
## iter 2 value 3.105512
## iter 3 value 3.086631
## iter 4 value 3.079778
## iter 5 value 3.069447
## iter 6 value 3.067659
## iter 7 value 3.067426
## iter 8 value 3.067418
## iter 8 value 3.067418
## final value 3.067418
## converged
## initial value 3.065481
## iter 2 value 3.065478
## iter 3 value 3.065477
## iter 3 value 3.065477
## iter 3 value 3.065477
## final value 3.065477
## converged

```



```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), include.mean = !no.constant, optim.control = list(trace = trc,
##     REPORT = 1, reltol = tol))
##
## Coefficients:
##          ar1      ar2      sma1
##      0.1351  0.2464 -0.6953
## s.e.  0.0513  0.0515  0.0381
##
## sigma^2 estimated as 449.6:  log likelihood = -1609.91,  aic = 3227.81
##
## $degrees_of_freedom
## [1] 369
##
## $ttable
##      Estimate      SE  t.value p.value
## ar1    0.1351 0.0513   2.6326 0.0088
## ar2    0.2464 0.0515   4.7795 0.0000
## sma1  -0.6953 0.0381 -18.2362 0.0000
##
## $AIC
## [1] 7.12457
##
```



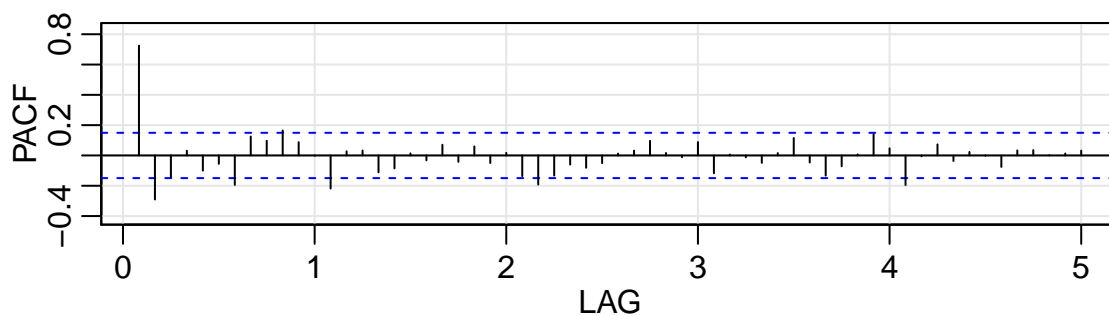
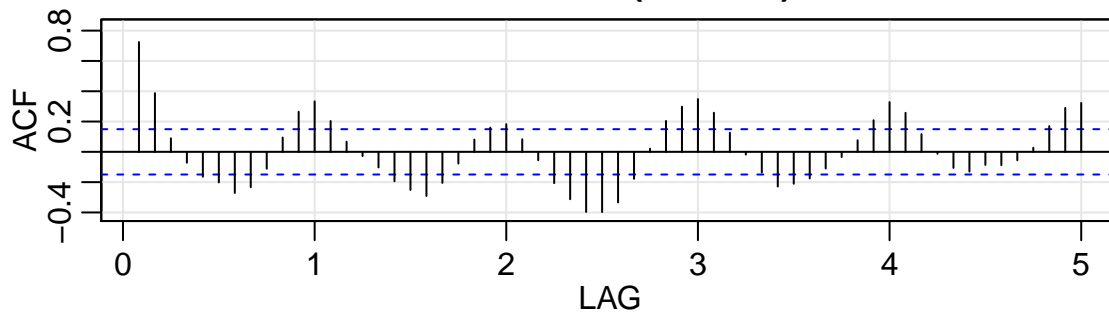
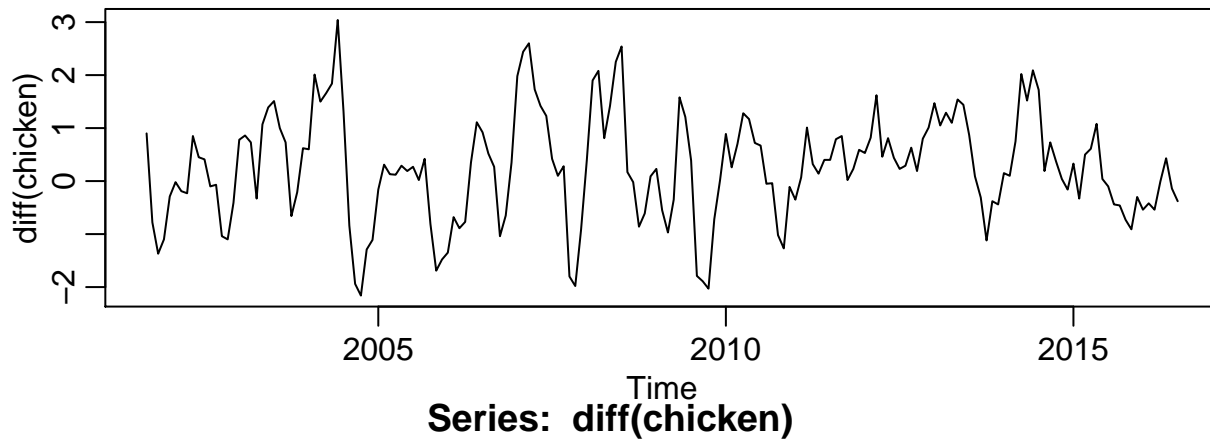
```
## $AICc
## [1] 7.130239
##
## $BIC
## [1] 6.156174
```

```
# Plot differenced chicken
```

```
plot(diff(chicken))
```

```
# Plot P/ACF pair of differenced data to lag 60
```

```
acf2(diff(chicken), max.lag = 60)
```



```
##      ACF  PACF
## [1,] 0.72 0.72
## [2,] 0.39 -0.29
## [3,] 0.09 -0.14
## [4,] -0.07 0.03
## [5,] -0.16 -0.10
## [6,] -0.20 -0.06
```

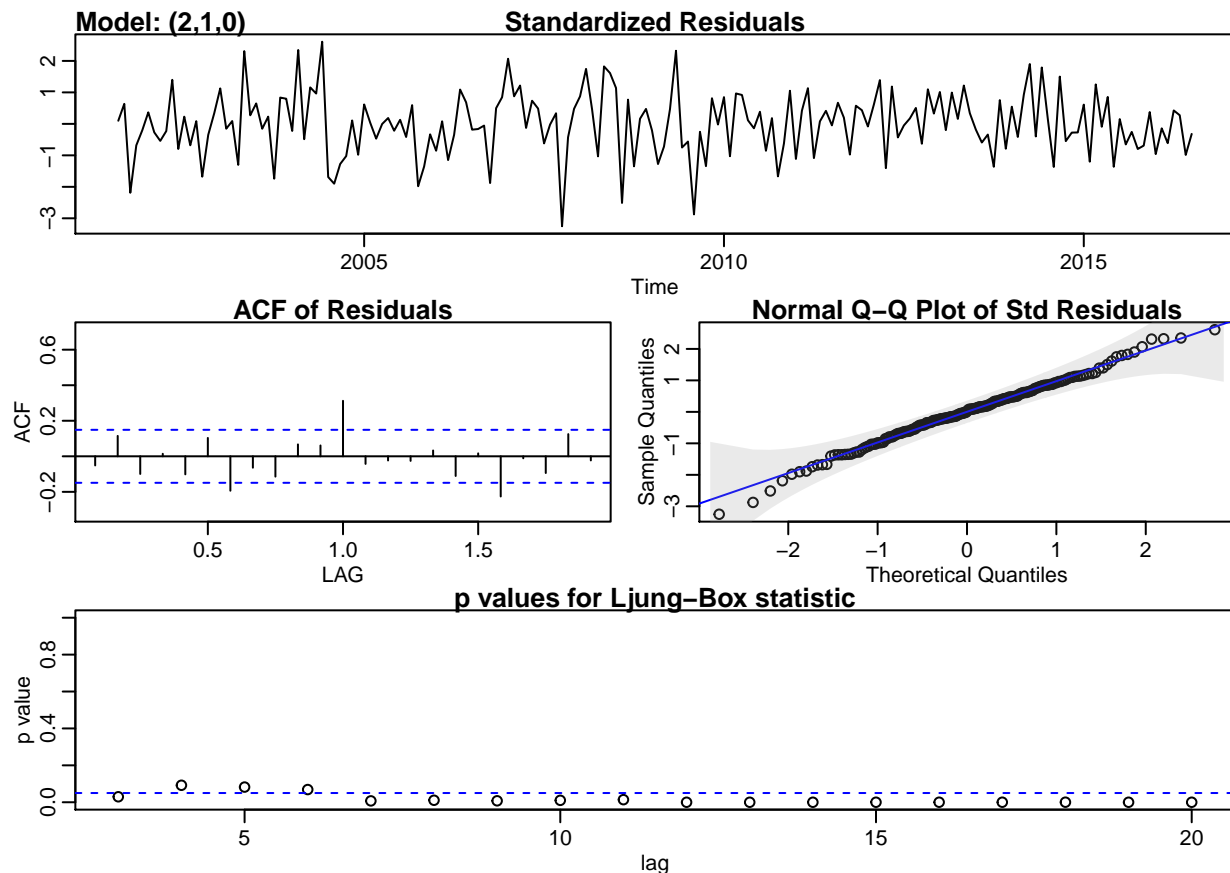
```

## [7,] -0.27 -0.19
## [8,] -0.23  0.12
## [9,] -0.11  0.10
## [10,]  0.09  0.16
## [11,]  0.26  0.09
## [12,]  0.33  0.00
## [13,]  0.20 -0.22
## [14,]  0.07  0.03
## [15,] -0.03  0.03
## [16,] -0.10 -0.11
## [17,] -0.19 -0.09
## [18,] -0.25  0.01
## [19,] -0.29 -0.03
## [20,] -0.20  0.07
## [21,] -0.08 -0.04
## [22,]  0.08  0.06
## [23,]  0.16 -0.05
## [24,]  0.18  0.02
## [25,]  0.08 -0.14
## [26,] -0.06 -0.19
## [27,] -0.21 -0.13
## [28,] -0.31 -0.06
## [29,] -0.40 -0.08
## [30,] -0.40 -0.05
## [31,] -0.33  0.01
## [32,] -0.18  0.03
## [33,]  0.02  0.10
## [34,]  0.20  0.02
## [35,]  0.30 -0.01
## [36,]  0.35  0.09
## [37,]  0.26 -0.12
## [38,]  0.13  0.01
## [39,] -0.02 -0.01
## [40,] -0.14 -0.05
## [41,] -0.23  0.02
## [42,] -0.21  0.12
## [43,] -0.18 -0.05
## [44,] -0.11 -0.13
## [45,] -0.03 -0.07
## [46,]  0.08  0.01
## [47,]  0.21  0.14
## [48,]  0.33  0.05
## [49,]  0.26 -0.20
## [50,]  0.12 -0.01
## [51,] -0.01  0.07
## [52,] -0.11 -0.04
## [53,] -0.13  0.02
## [54,] -0.09  0.00
## [55,] -0.09 -0.08
## [56,] -0.06  0.03
## [57,]  0.03  0.04
## [58,]  0.17  0.00
## [59,]  0.29  0.01
## [60,]  0.32  0.03

```

```
# Fit ARIMA(2,1,0) to chicken - not so good  
sarima(chicken, 2,1,0)
```

```
## initial value 0.001863  
## iter 2 value -0.156034  
## iter 3 value -0.359181  
## iter 4 value -0.424164  
## iter 5 value -0.430212  
## iter 6 value -0.432744  
## iter 7 value -0.432747  
## iter 8 value -0.432749  
## iter 9 value -0.432749  
## iter 10 value -0.432751  
## iter 11 value -0.432752  
## iter 12 value -0.432752  
## iter 13 value -0.432752  
## iter 13 value -0.432752  
## iter 13 value -0.432752  
## final value -0.432752  
## converged  
## initial value -0.420883  
## iter 2 value -0.420934  
## iter 3 value -0.420936  
## iter 4 value -0.420937  
## iter 5 value -0.420937  
## iter 6 value -0.420937  
## iter 6 value -0.420937  
## iter 6 value -0.420937  
## final value -0.420937  
## converged
```

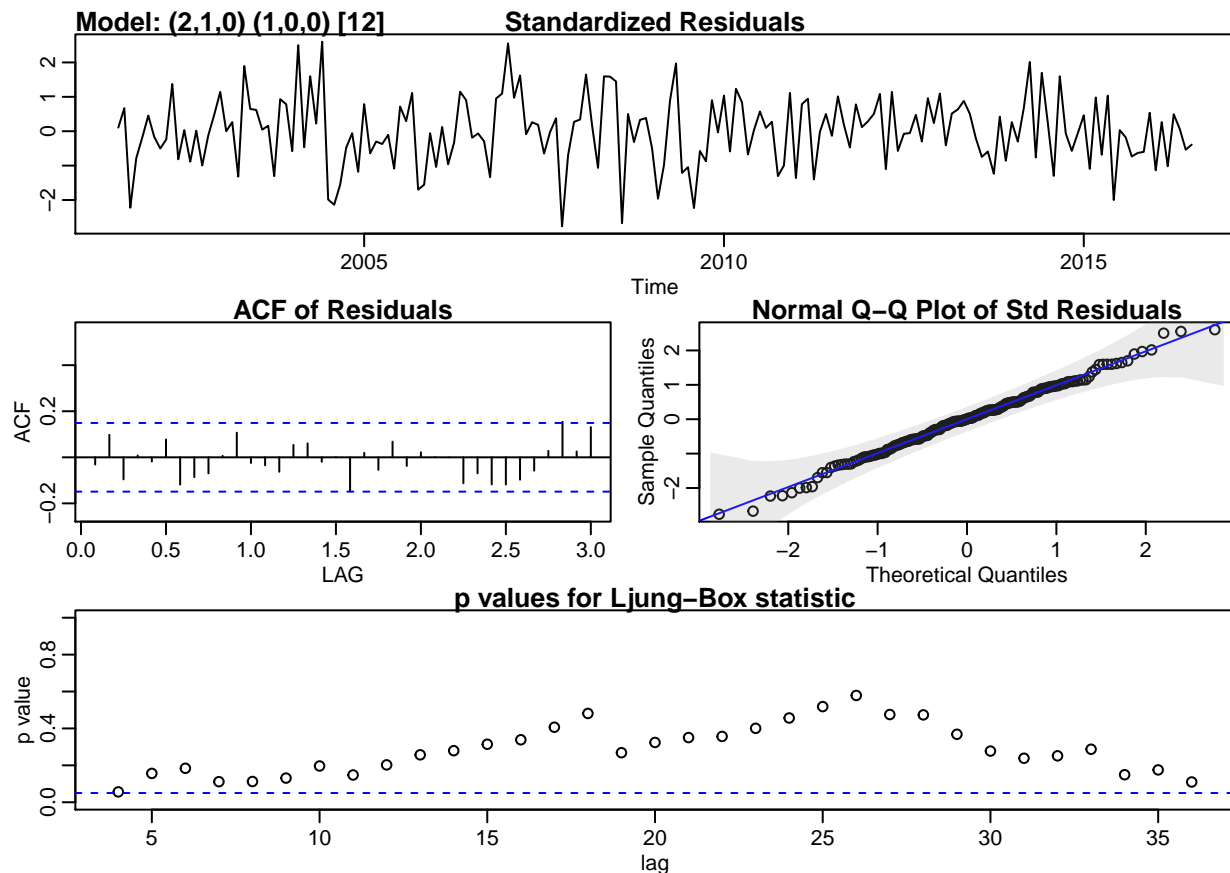


```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), xreg = constant, optim.control = list(trace = trc, REPORT = 1,
##     reltol = tol))
##
## Coefficients:
##          ar1      ar2  constant
##          0.9494 -0.3069   0.2632
## s.e.    0.0717   0.0718   0.1362
##
## sigma^2 estimated as 0.4286:  log likelihood = -178.64,  aic = 365.28
##
## $degrees_of_freedom
## [1] 177
##
## $ttable
##           Estimate      SE t.value p.value
## ar1         0.9494 0.0717 13.2339 0.0000
## ar2        -0.3069 0.0718 -4.2723 0.0000
## constant    0.2632 0.1362  1.9328 0.0549
##
## $AIC
## [1] 0.1861622
##
```

```
## $AICc
## [1] 0.1985432
##
## $BIC
## [1] -0.7606218
```

```
# Fit SARIMA(2,1,0,1,0,0,12) to chicken - that works
sarima(chicken,2,1,0,1,0,0,12)
```

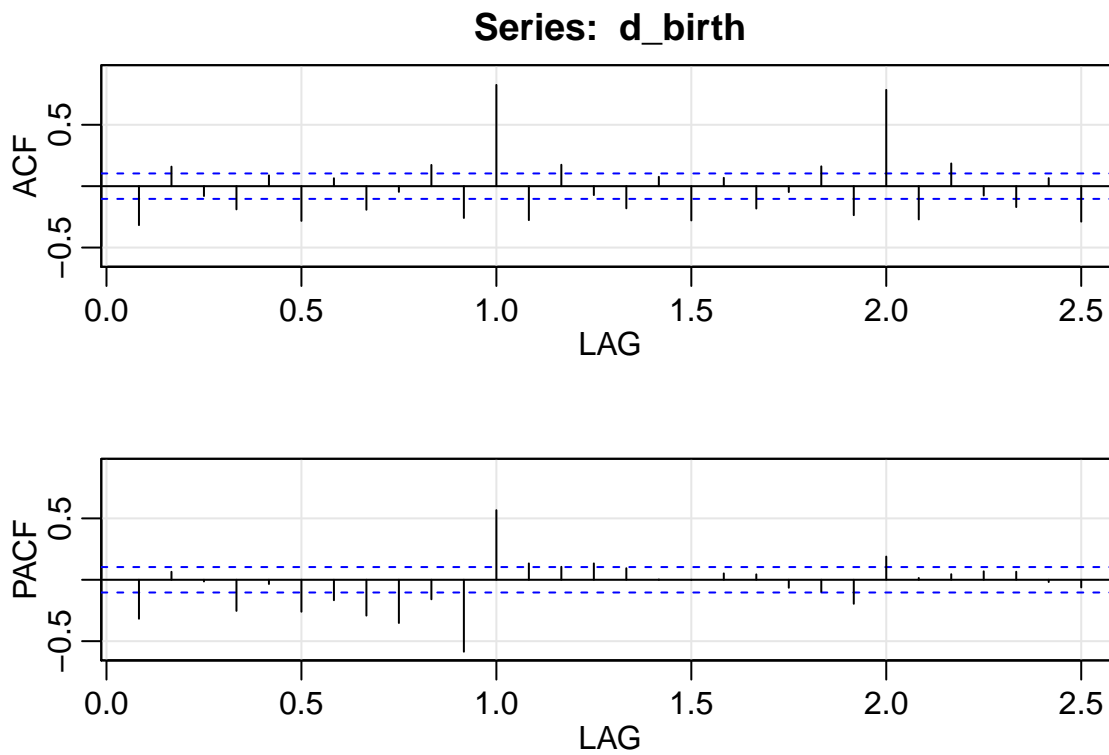
```
## initial value 0.015039
## iter 2 value -0.226398
## iter 3 value -0.412955
## iter 4 value -0.460882
## iter 5 value -0.470787
## iter 6 value -0.471082
## iter 7 value -0.471088
## iter 8 value -0.471090
## iter 9 value -0.471092
## iter 10 value -0.471095
## iter 11 value -0.471095
## iter 12 value -0.471096
## iter 13 value -0.471096
## iter 14 value -0.471096
## iter 15 value -0.471097
## iter 16 value -0.471097
## iter 16 value -0.471097
## iter 16 value -0.471097
## final value -0.471097
## converged
## initial value -0.473585
## iter 2 value -0.473664
## iter 3 value -0.473721
## iter 4 value -0.473823
## iter 5 value -0.473871
## iter 6 value -0.473885
## iter 7 value -0.473886
## iter 8 value -0.473886
## iter 8 value -0.473886
## iter 8 value -0.473886
## final value -0.473886
## converged
```



```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), xreg = constant, optim.control = list(trace = trc, REPORT = 1,
##     reltol = tol))
##
## Coefficients:
##          ar1      ar2      sar1  constant
##          0.9154 -0.2494  0.3237   0.2353
## s.e.  0.0733   0.0739  0.0715   0.1973
##
## sigma^2 estimated as 0.3828:  log likelihood = -169.16,  aic = 348.33
##
## $degrees_of_freedom
## [1] 176
##
## $ttable
##           Estimate      SE t.value p.value
## ar1          0.9154 0.0733 12.4955 0.0000
## ar2         -0.2494 0.0739 -3.3728 0.0009
## sar1          0.3237 0.0715  4.5238 0.0000
## constant     0.2353 0.1973  1.1923 0.2347
##
## $AIC
## [1] 0.0842377
```

```
##
## $AICc
## [1] 0.09726452
##
## $BIC
## [1] -0.8448077
##### Natalidad US
```

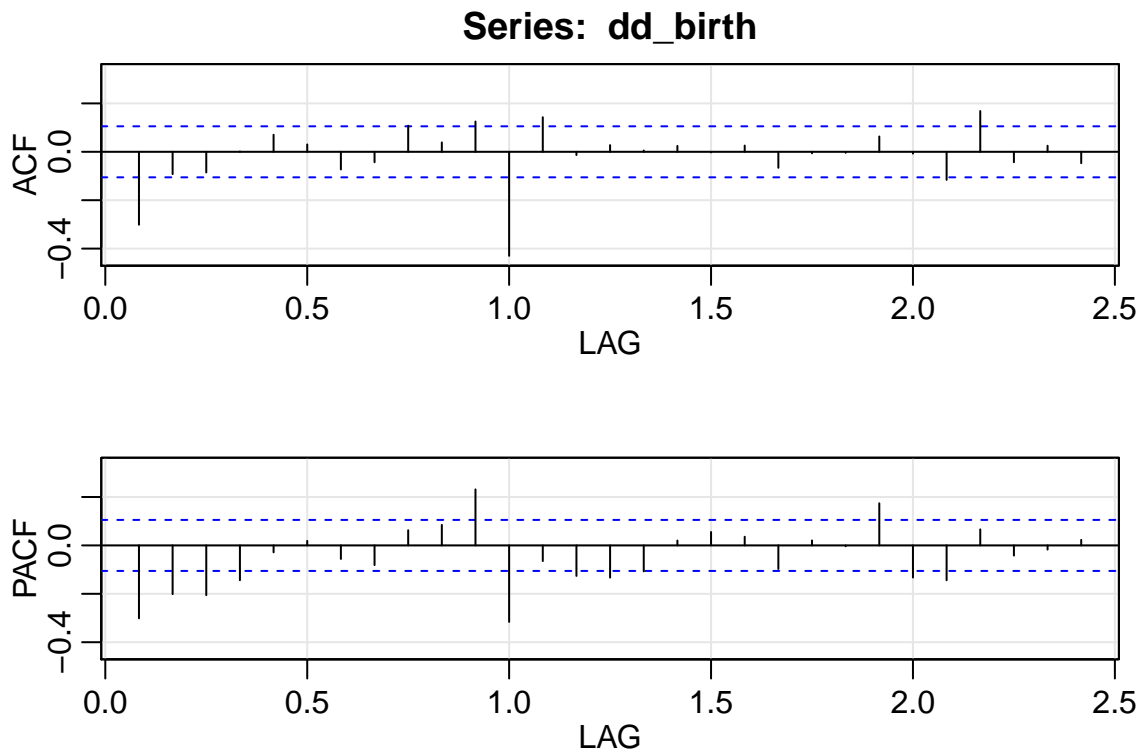
```
# Plot P/ACF to lag 60 of differenced data
d_birth <- diff(birth)
acf2(d_birth)
```



	ACF	PACF
[1,]	-0.32	-0.32
[2,]	0.16	0.06
[3,]	-0.08	-0.01
[4,]	-0.19	-0.25
[5,]	0.09	-0.03
[6,]	-0.28	-0.26
[7,]	0.06	-0.17
[8,]	-0.19	-0.29
[9,]	-0.05	-0.35
[10,]	0.17	-0.16
[11,]	-0.26	-0.59
[12,]	0.82	0.57
[13,]	-0.28	0.13
[14,]	0.17	0.11
[15,]	-0.07	0.13
[16,]	-0.18	0.09
[17,]	0.08	0.00

```
## [18,] -0.28  0.00
## [19,]  0.07  0.05
## [20,] -0.18  0.04
## [21,] -0.05 -0.07
## [22,]  0.16 -0.10
## [23,] -0.24 -0.20
## [24,]  0.78  0.19
## [25,] -0.27  0.01
## [26,]  0.19  0.05
## [27,] -0.08  0.07
## [28,] -0.17  0.07
## [29,]  0.07 -0.02
## [30,] -0.29 -0.06
```

```
# Plot P/ACF to lag 60 of seasonal differenced data
dd_birth <- diff(d_birth, lag = 12)
acf2(dd_birth)
```



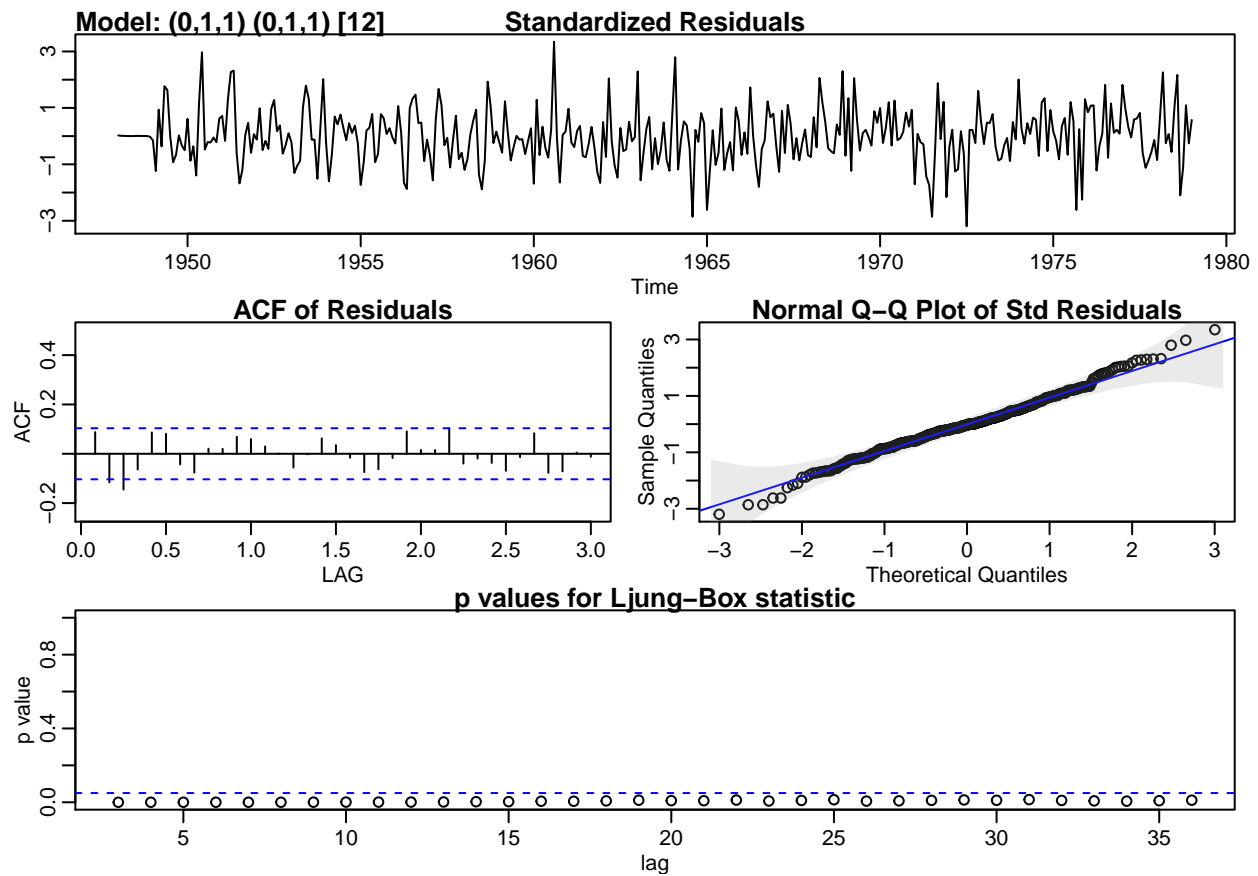
```
##      ACF  PACF
## [1,] -0.30 -0.30
## [2,] -0.09 -0.20
## [3,] -0.09 -0.21
## [4,]  0.00 -0.14
## [5,]  0.07 -0.03
## [6,]  0.03  0.02
## [7,] -0.07 -0.06
## [8,] -0.04 -0.08
## [9,]  0.11  0.06
## [10,]  0.04  0.08
## [11,]  0.13  0.23
## [12,] -0.43 -0.32
```



```
## [13,] 0.14 -0.06
## [14,] -0.01 -0.13
## [15,] 0.03 -0.13
## [16,] 0.01 -0.11
## [17,] 0.02 0.02
## [18,] 0.00 0.06
## [19,] 0.03 0.04
## [20,] -0.07 -0.10
## [21,] -0.01 0.02
## [22,] 0.00 0.00
## [23,] 0.06 0.17
## [24,] -0.01 -0.13
## [25,] -0.12 -0.14
## [26,] 0.17 0.07
## [27,] -0.04 -0.04
## [28,] 0.03 -0.02
## [29,] -0.05 0.02
```

```
# Fit SARIMA(0,1,1)x(0,1,1)_12. What happens?
sarima(birth,0,1,1,0,1,1,12)
```

```
## initial value 2.219164
## iter 2 value 2.013310
## iter 3 value 1.988107
## iter 4 value 1.980026
## iter 5 value 1.967594
## iter 6 value 1.965384
## iter 7 value 1.965049
## iter 8 value 1.964993
## iter 9 value 1.964992
## iter 9 value 1.964992
## iter 9 value 1.964992
## final value 1.964992
## converged
## initial value 1.951264
## iter 2 value 1.945867
## iter 3 value 1.945729
## iter 4 value 1.945723
## iter 5 value 1.945723
## iter 5 value 1.945723
## iter 5 value 1.945723
## final value 1.945723
## converged
```

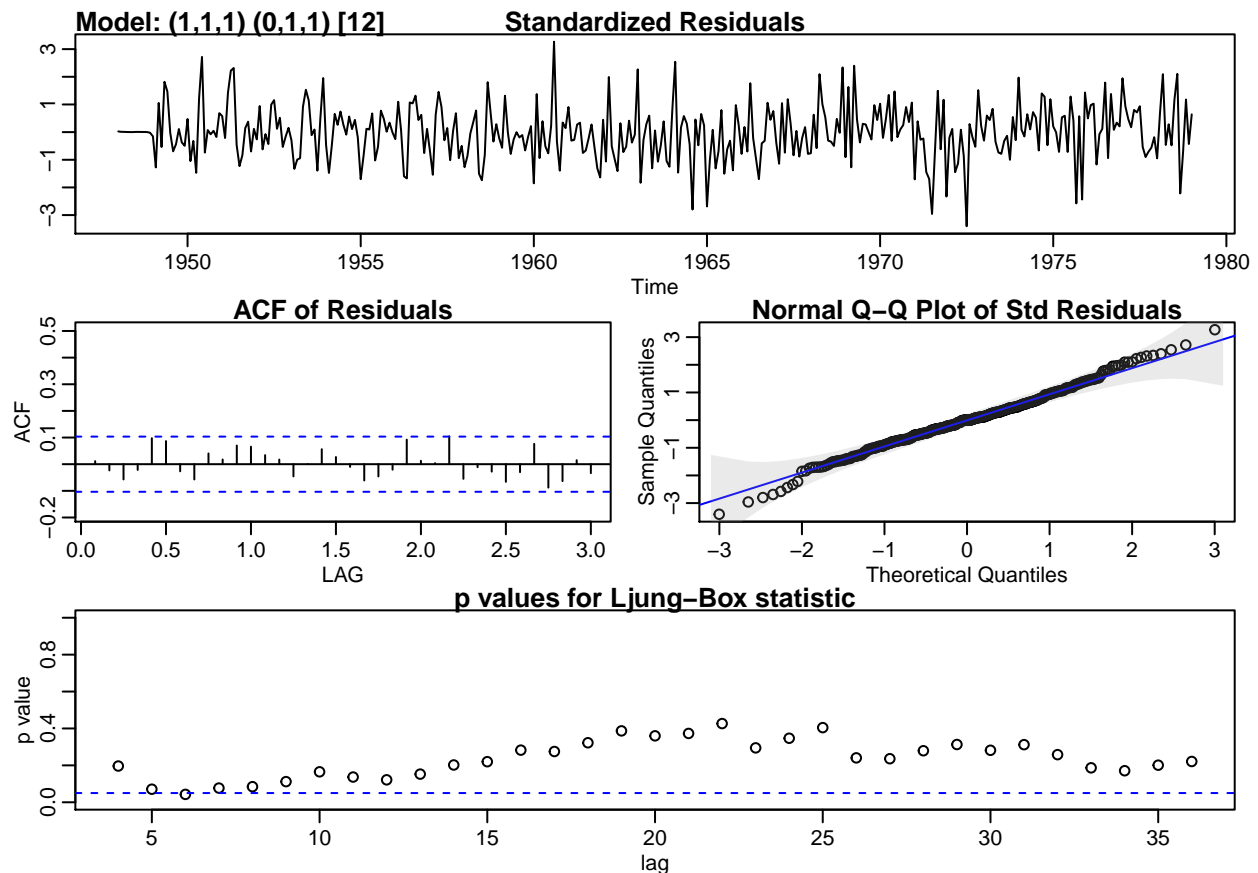


```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), include.mean = !no.constant, optim.control = list(trc = trc,
##     REPORT = 1, reltol = tol))
##
## Coefficients:
##          ma1      sma1
##       -0.4734 -0.7861
## s.e.   0.0598  0.0451
##
## sigma^2 estimated as 47.4:  log likelihood = -1211.28,  aic = 2428.56
##
## $degrees_of_freedom
## [1] 371
##
## $ttable
##      Estimate      SE  t.value p.value
## ma1   -0.4734 0.0598  -7.9097      0
## sma1  -0.7861 0.0451 -17.4227      0
##
## $AIC
## [1] 4.869388
##
## $AICc
```

```
## [1] 4.874924
##
## $BIC
## [1] 3.890415
```

```
# Add AR term and conclude
sarima(birth,1,1,1,0,1,1,12)
```

```
## initial value 2.218186
## iter 2 value 2.032584
## iter 3 value 1.982464
## iter 4 value 1.975643
## iter 5 value 1.971721
## iter 6 value 1.967284
## iter 7 value 1.963840
## iter 8 value 1.961106
## iter 9 value 1.960849
## iter 10 value 1.960692
## iter 11 value 1.960683
## iter 12 value 1.960675
## iter 13 value 1.960672
## iter 13 value 1.960672
## iter 13 value 1.960672
## final value 1.960672
## converged
## initial value 1.940459
## iter 2 value 1.934425
## iter 3 value 1.932752
## iter 4 value 1.931750
## iter 5 value 1.931074
## iter 6 value 1.930882
## iter 7 value 1.930860
## iter 8 value 1.930859
## iter 8 value 1.930859
## final value 1.930859
## converged
```



```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), include.mean = !no.constant, optim.control = list(trace = trc,
##     REPORT = 1, reltol = tol))
##
## Coefficients:
##          ar1      ma1      sma1
##      0.3038 -0.7006 -0.8000
## s.e.  0.0865  0.0604  0.0441
##
## sigma^2 estimated as 45.91:  log likelihood = -1205.93,  aic = 2419.85
##
## $degrees_of_freedom
## [1] 370
##
## $ttable
##      Estimate      SE  t.value p.value
## ar1    0.3038 0.0865   3.5104  5e-04
## ma1   -0.7006 0.0604  -11.5984  0e+00
## sma1  -0.8000 0.0441  -18.1302  0e+00
##
## $AIC
## [1] 4.842869
##
```

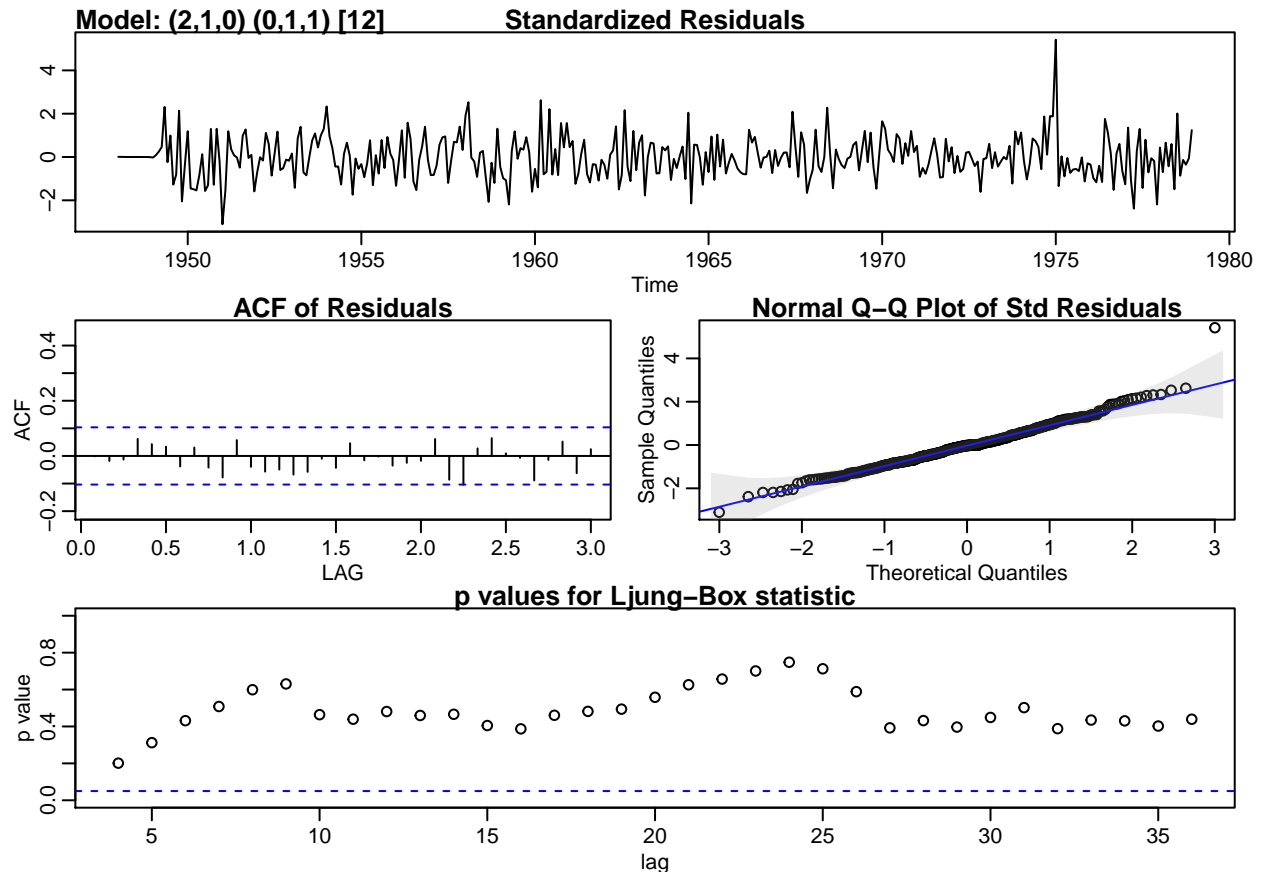
```

## $AICc
## [1] 4.848523
##
## $BIC
## [1] 3.87441
## FORECASTING SEASONAL DATA

# Fit your previous model to unemp and check the diagnostics
sarima(unemp, 2,1,0,0,1,1,12)

## initial value 3.340809
## iter 2 value 3.105512
## iter 3 value 3.086631
## iter 4 value 3.079778
## iter 5 value 3.069447
## iter 6 value 3.067659
## iter 7 value 3.067426
## iter 8 value 3.067418
## iter 8 value 3.067418
## final value 3.067418
## converged
## initial value 3.065481
## iter 2 value 3.065478
## iter 3 value 3.065477
## iter 3 value 3.065477
## iter 3 value 3.065477
## final value 3.065477
## converged

```

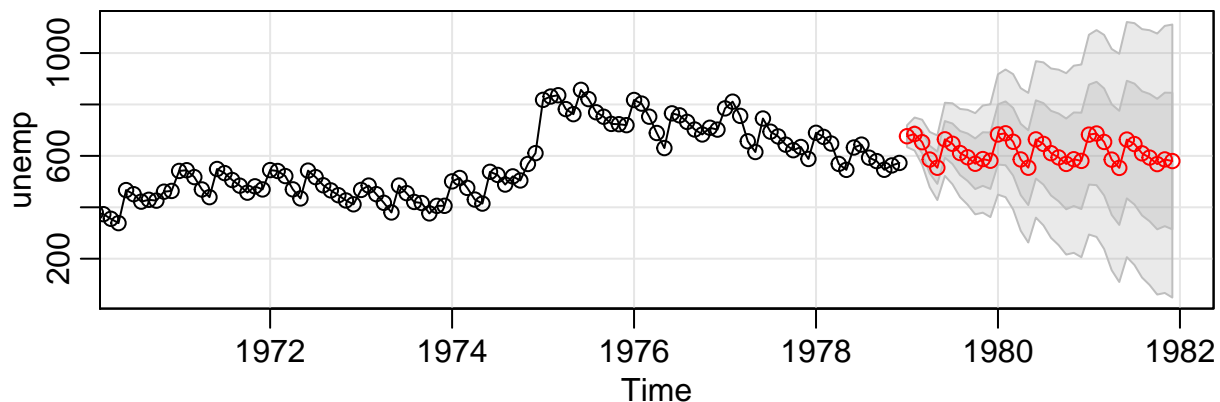


```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), include.mean = !no.constant, optim.control = list(trace = trc,
##     REPORT = 1, reltol = tol))
##
## Coefficients:
##          ar1      ar2      sma1
##          0.1351  0.2464 -0.6953
## s.e.  0.0513  0.0515   0.0381
##
## sigma^2 estimated as 449.6:  log likelihood = -1609.91,  aic = 3227.81
##
## $degrees_of_freedom
## [1] 369
##
## $ttable
##      Estimate      SE  t.value p.value
## ar1    0.1351 0.0513   2.6326  0.0088
## ar2    0.2464 0.0515   4.7795  0.0000
## sma1  -0.6953 0.0381 -18.2362  0.0000
##
## $AIC
## [1] 7.12457
##
```

```
## $AICc
## [1] 7.130239
##
## $BIC
## [1] 6.156174

# Forecast the data 3 years into the future
sarima.for(unemp,n.ahead = 36,2,1,0,0,1,1,12)

## $pred
##           Jan      Feb      Mar      Apr      May      Jun      Jul
## 1979 676.4664 685.1172 653.2388 585.6939 553.8813 664.4072 647.0657
## 1980 683.3045 687.7649 654.8658 586.1507 553.9285 664.1108 646.6220
## 1981 682.6406 687.0977 654.1968 585.4806 553.2579 663.4398 645.9508
##           Aug      Sep      Oct      Nov      Dec
## 1979 611.0828 594.6414 569.3997 587.5801 581.1833
## 1980 610.5345 594.0427 568.7684 586.9320 580.5249
## 1981 609.8632 593.3713 568.0970 586.2606 579.8535
##
## $se
##           Jan      Feb      Mar      Apr      May      Jun      Jul
## 1979 21.20465 32.07710 43.70167 53.66329 62.85364 71.12881 78.73590
## 1980 116.99599 124.17344 131.51281 138.60466 145.49706 152.12863 158.52302
## 1981 194.25167 201.10648 208.17066 215.11503 221.96039 228.64285 235.16874
##           Aug      Sep      Oct      Nov      Dec
## 1979 85.75096 92.28663 98.41329 104.19488 109.67935
## 1980 164.68623 170.63839 176.39520 181.97333 187.38718
## 1981 241.53258 247.74268 253.80549 259.72970 265.52323
```

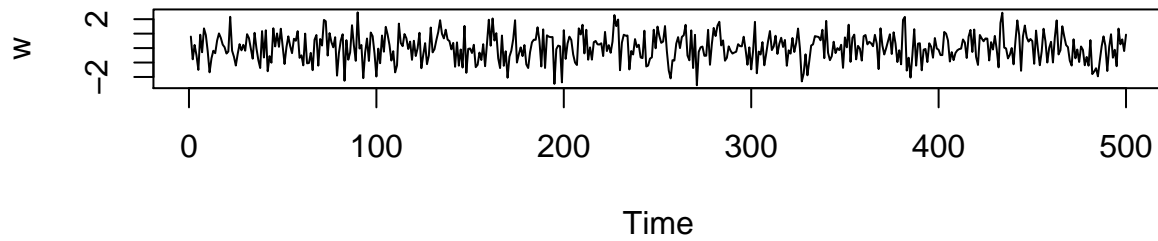


Pruebas series de tiempo de Time Series Analysis and its applications text

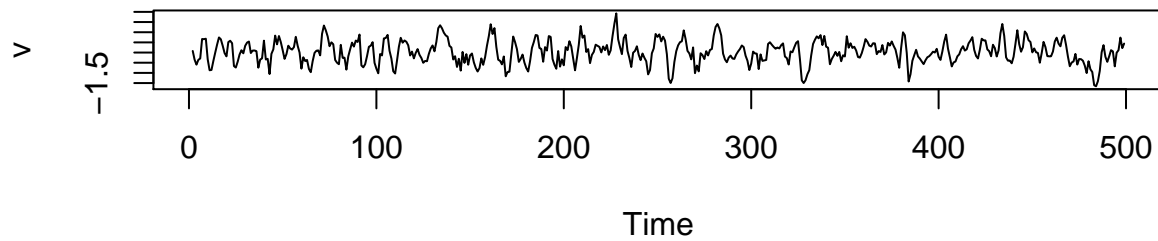
Página 13 Moving Average

```
w = rnorm(500,0,1)
v = filter(w, sides = 2, rep(1/3,3))
par(mfrow=c(2,1))
plot.ts(w,main = "white noise")
plot.ts(v, main = "moving average")
```

white noise



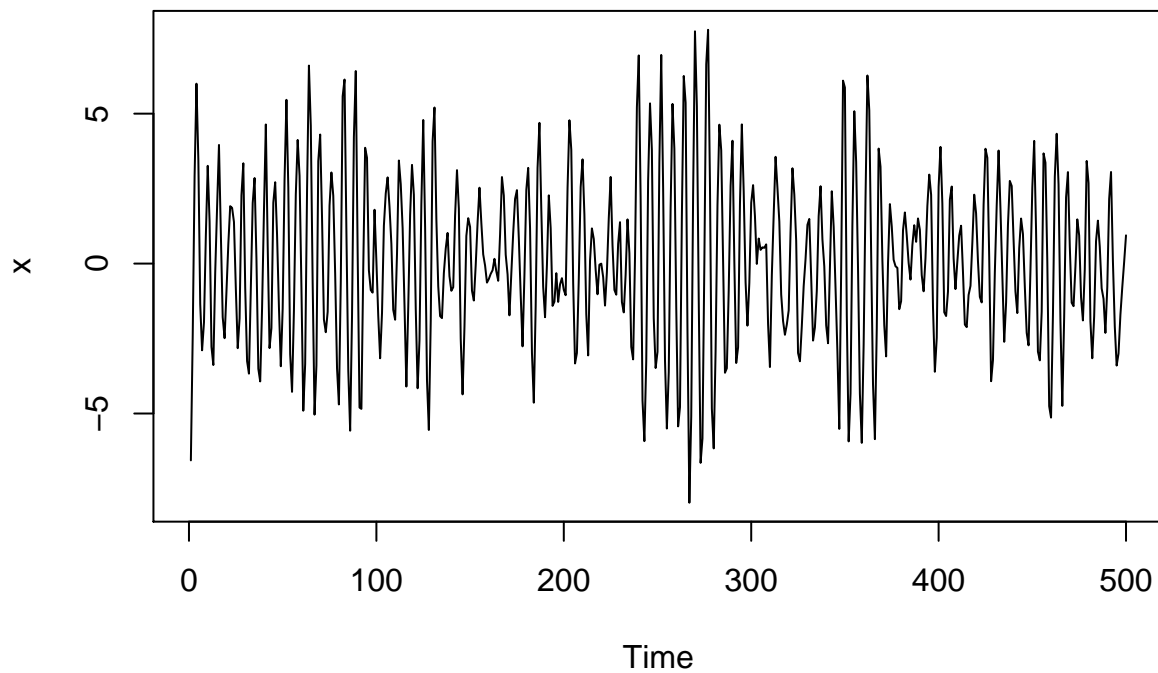
moving average



Autoregesivo

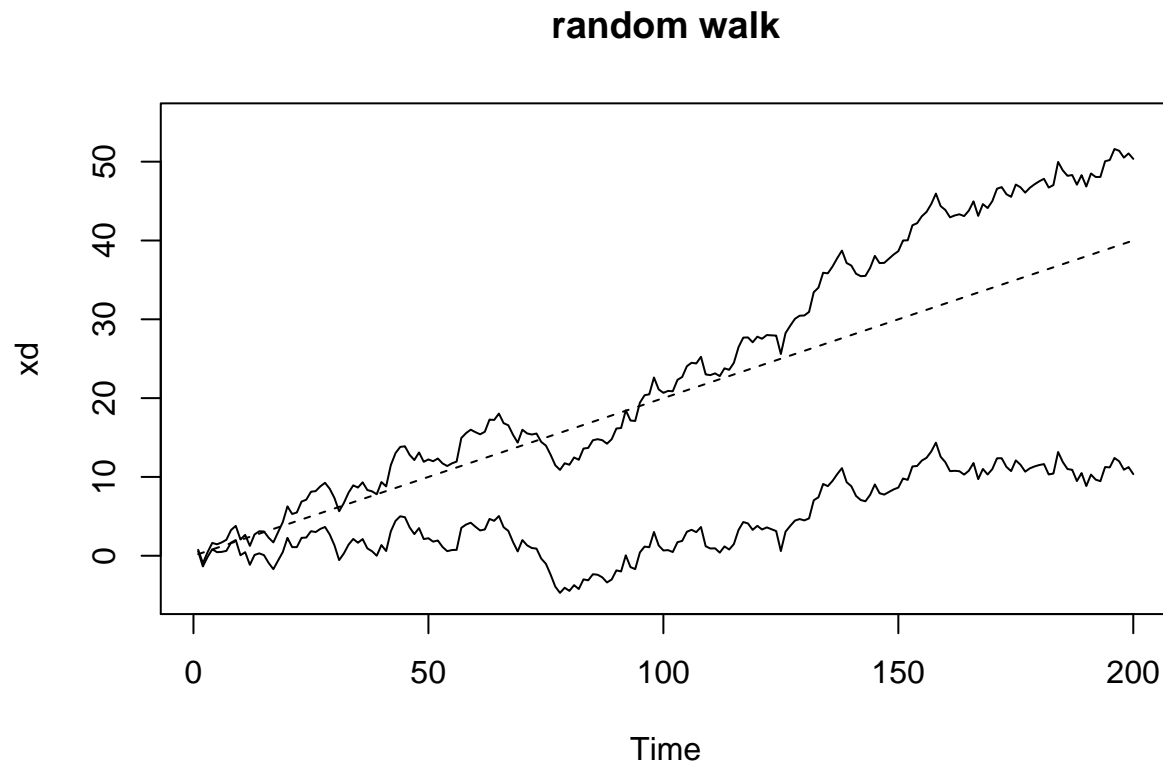
```
w = rnorm(550,0,1)
x = filter(w, filter = c(1,-0.9), method = "recursive")[-(1:50)]
plot.ts(x, main = "autoregression")
```

autoregression



Autoregressivo con drift

```
set.seed(154)
w = rnorm(200,0,1); x = cumsum (w)
wd = w + .2; xd = cumsum(wd)
plot.ts(xd, ylim = c(-5,55), main = "random walk")
lines(x); lines(0.2*(1:200), lty = "dashed")
```

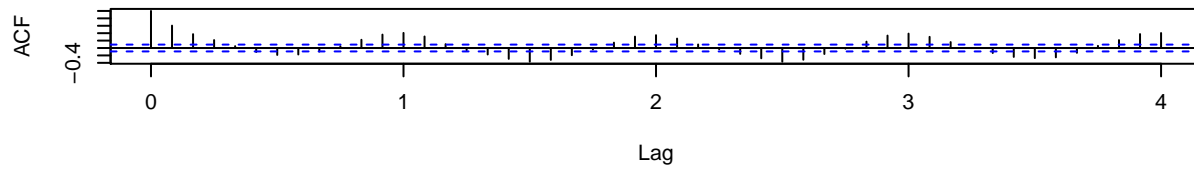


ACF

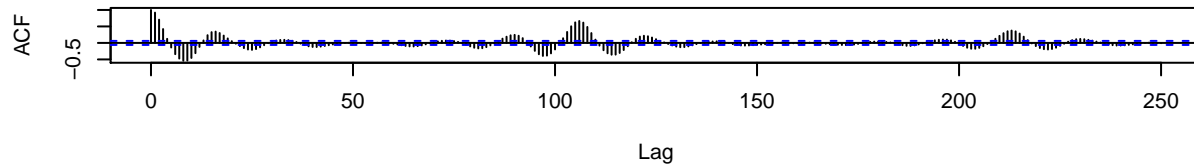
```
par(mfrow = c(3,1))
acf(soi, 48, main = "Southern Oscillation Index")
acf(speech, 250)

par(mfrow=c(3,1))
```

Southern Oscillation Index

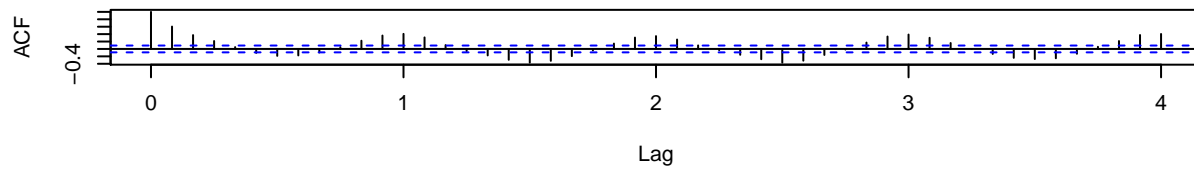


Series speech

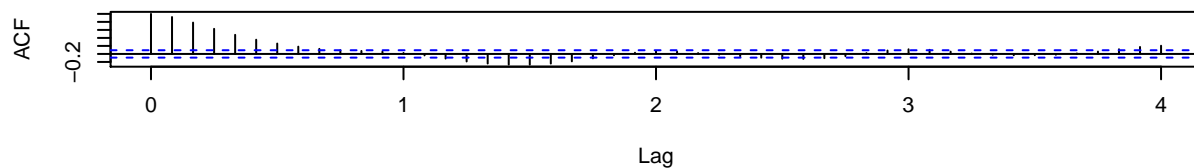


```
acf(soi, 48, main="Southern Oscillation Index")
acf(rec, 48, main="Recruitment")
ccf(soi, rec, 48, main="SOI vs Recruitment", ylab="CCF")
```

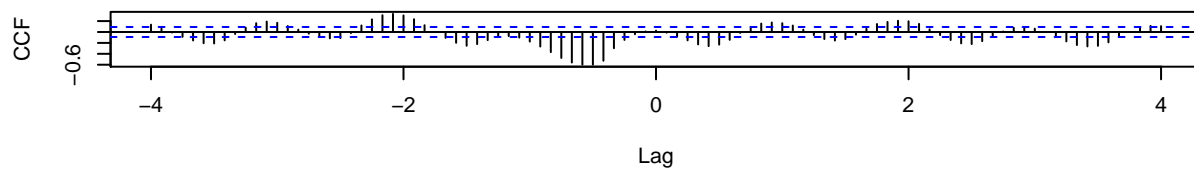
Southern Oscillation Index



Recruitment



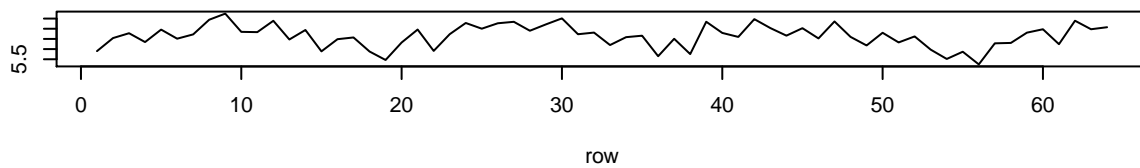
SOI vs Recruitment



```
# Varios vectores
```

```
persp(1:64, 1:36, soiltemp, phi=30, theta=30, scale=FALSE, expand=4, ticktype="detailed", xlab="rows", ylab="columns", zlab="soiltemp")
plot.ts(rowMeans(soiltemp), xlab="row", ylab="Average Temperature")
```

Average Temperature



temperature