R Notebook

```
library(TSA)
```

```
## Loading required package: leaps
## Loading required package: locfit
## locfit 1.5-9.1    2013-03-22
## Loading required package: mgcv
## Loading required package: nlme
## This is mgcv 1.8-22. For overview type 'help("mgcv-package")'.
## Loading required package: tseries
##
## Attaching package: 'TSA'
## The following objects are masked from 'package:stats':
##
##     acf, arima
## The following object is masked from 'package:utils':
##
##     tar
```

```
library(tseries)
library(astsa)
library(imputeTS)
```

```
##
## Attaching package: 'imputeTS'
## The following object is masked from 'package:tseries':
##
##     na.remove
```

```
library(tsoutliers)
library(xts)
```

```
## Loading required package: zoo
##
## Attaching package: 'zoo'
## The following object is masked from 'package:imputeTS':
##
##     na.locf
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

Original dataset

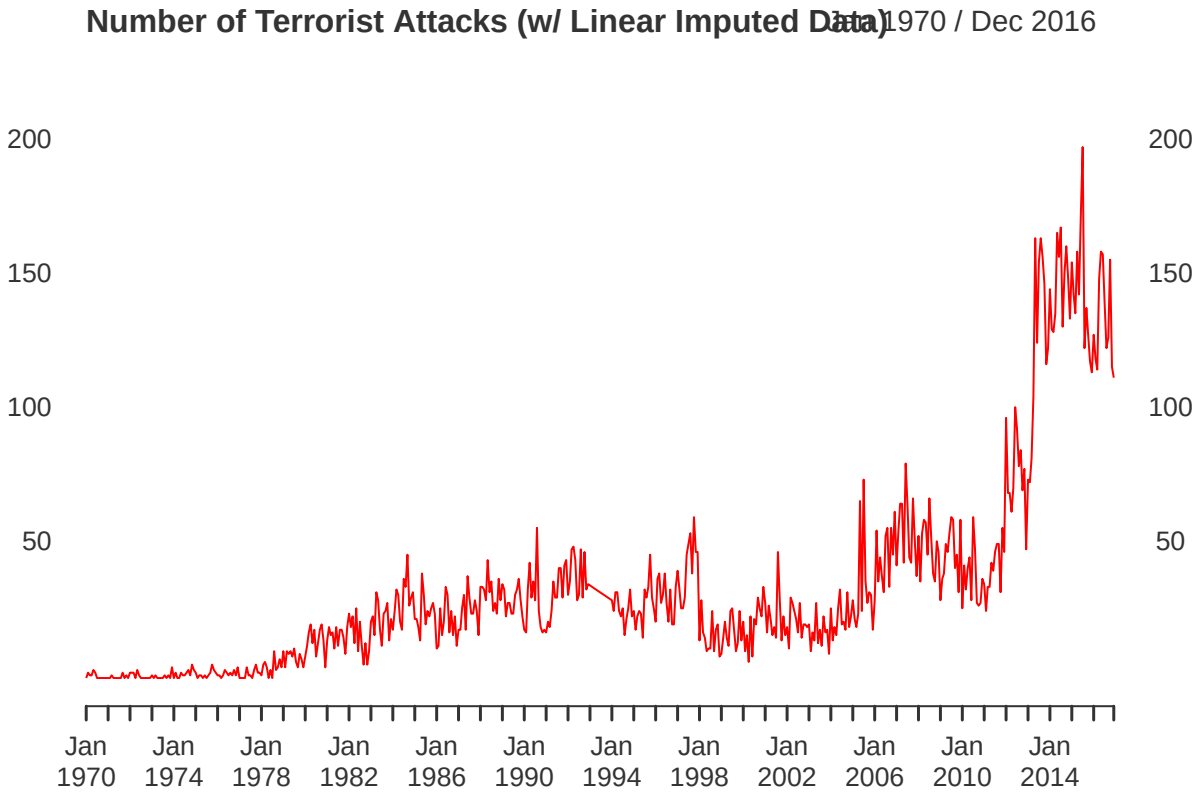
```
terror10 <-read.csv("input/editted_input1.csv")$num.attacks.with.kill.thresh
pdf("image/og_og_og.pdf")
plot(as.xts(ts(terror10, frequency = 12, start=1970)), main = "Number of Terrorist Attacks (unfiltered)
dev.off()
```

```
## pdf
##   2
```

Interpolating Data

Here we interpolate our missing data with a linear model.

```
terror2 <- read.csv("input/og_num_casualities_greater_than_10.csv")
terror3 <- na.interpolation(terror2$num.attacks.with.kill.thresh, option="linear")
plot(as.xts(ts(terror3, frequency = 12, start=1970)), main = "Number of Terrorist Attacks (w/ Linear Imp
```




```
pdf("image/og_ts.pdf")
lines(as.xts(ts(terror2$num.attacks.with.kill.thresh, frequency = 12, start=1970)), col="black", lwd=1.
dev.off()
```

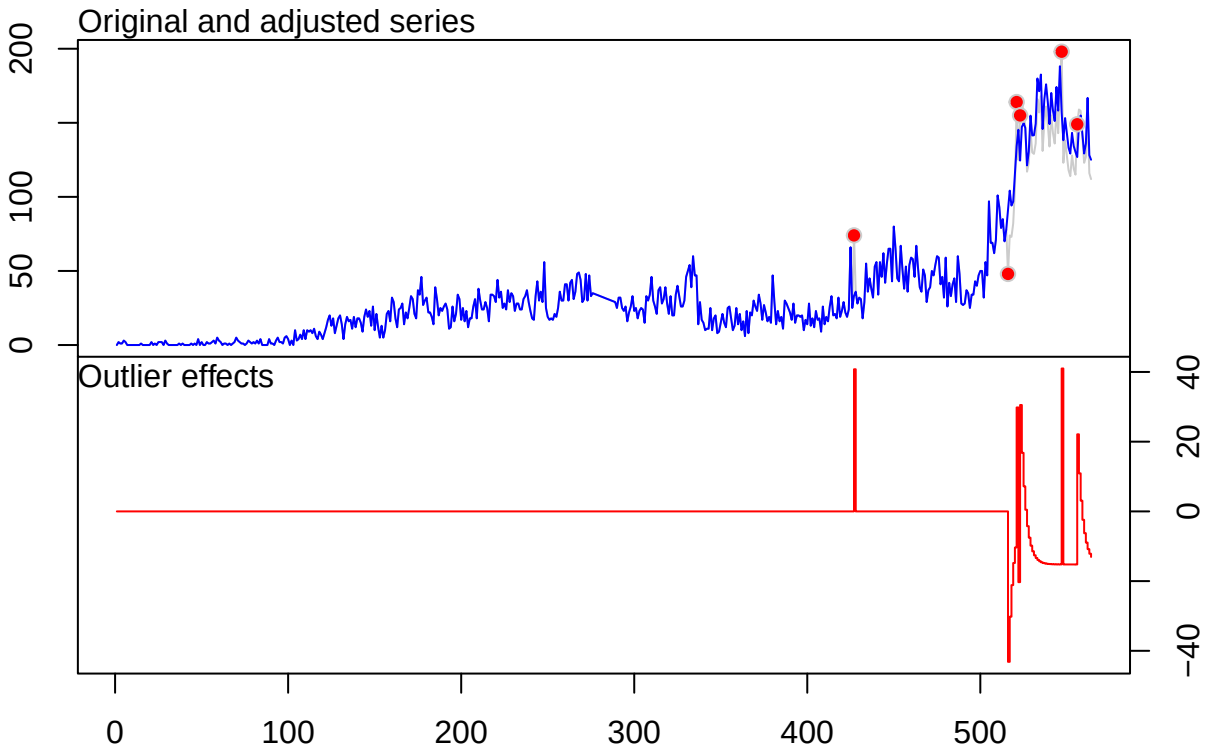
```
## pdf
##   2
```

Removing outliers

```
outlier_terror3 <- tso(ts(terror3), types = c("TC", "AO", "IO"))
```

```
## Warning in locate.outliers.oloop(y = y, fit = fit, types = types, cval =
## cval, : stopped when 'maxit.oloop = 4' was reached
```

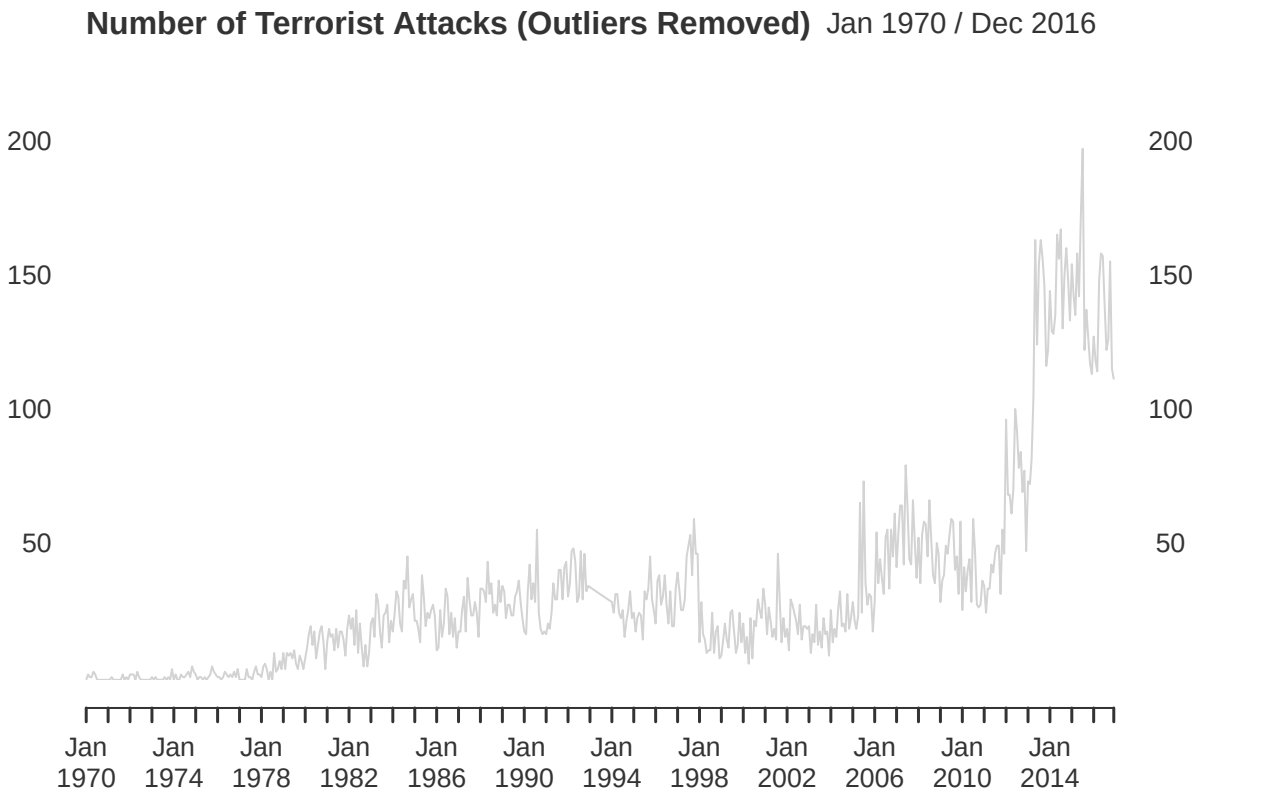
```
plot(outlier_terror3)
```



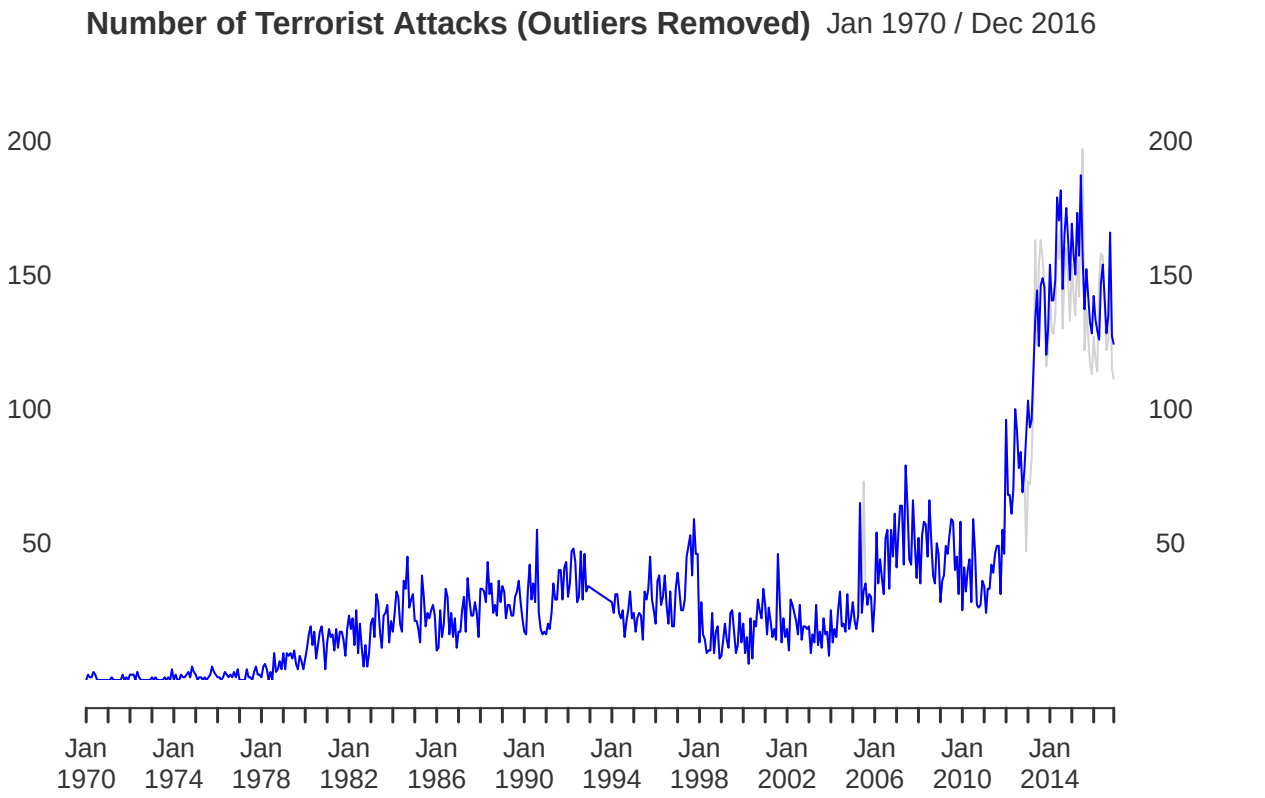

```
#plot outlier effects
pdf("image/outlier_effects.pdf")
plot(as.xts(ts(outlier_terror3$effects, frequency = 12, start=1970)), main = "Outlier Effects", major.f
dev.off()
```

```
## pdf
##   2
```

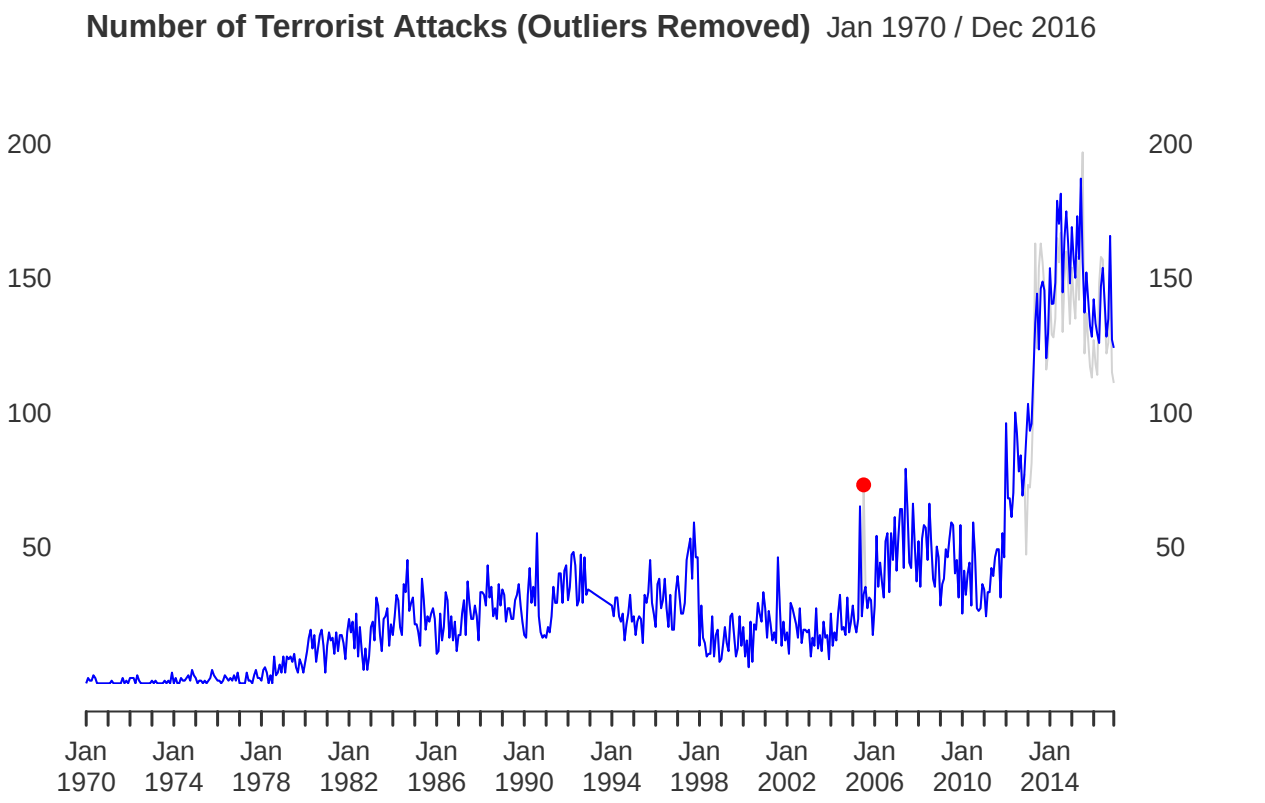
```
#Plot outlier time series
xts.terror3 <- as.xts(ts(terror3, frequency = 12, start=1970))
plot(as.xts(ts(terror3, frequency = 12, start=1970)), main = "Number of Terrorist Attacks (Outliers Rem
```



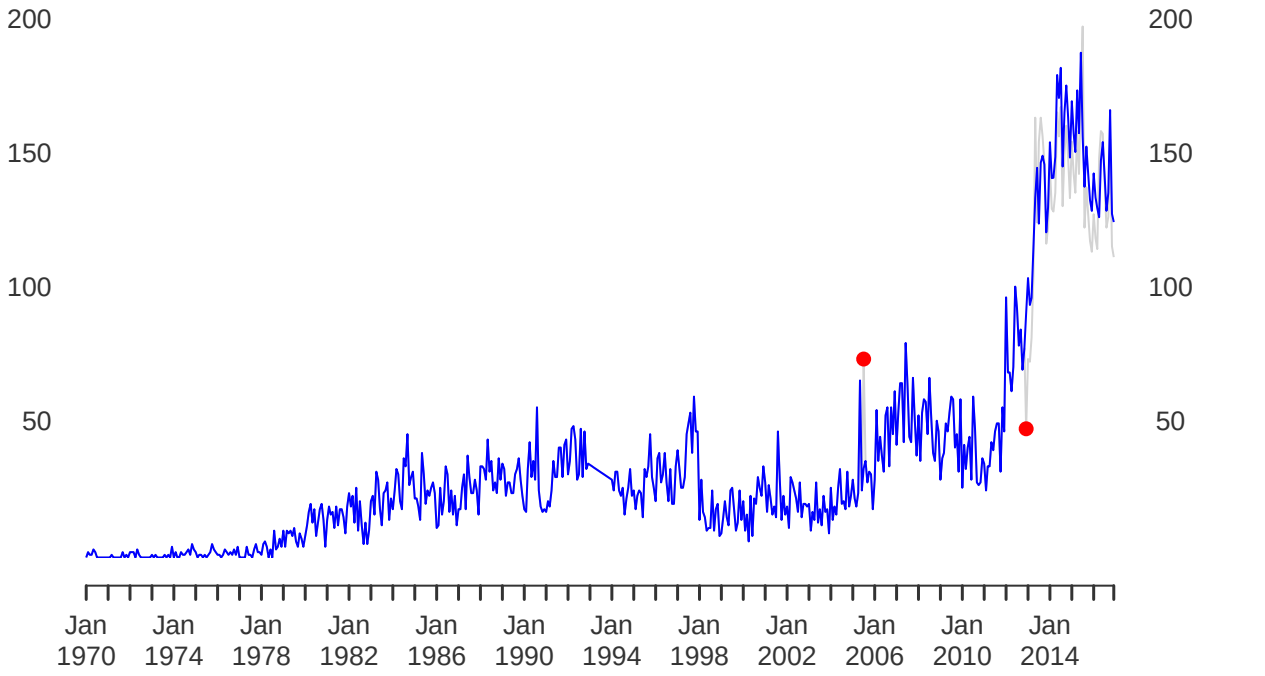

```
lines(as.xts(ts(outlier_terror3$yadj, frequency = 12, start=1970)), col="blue")
```



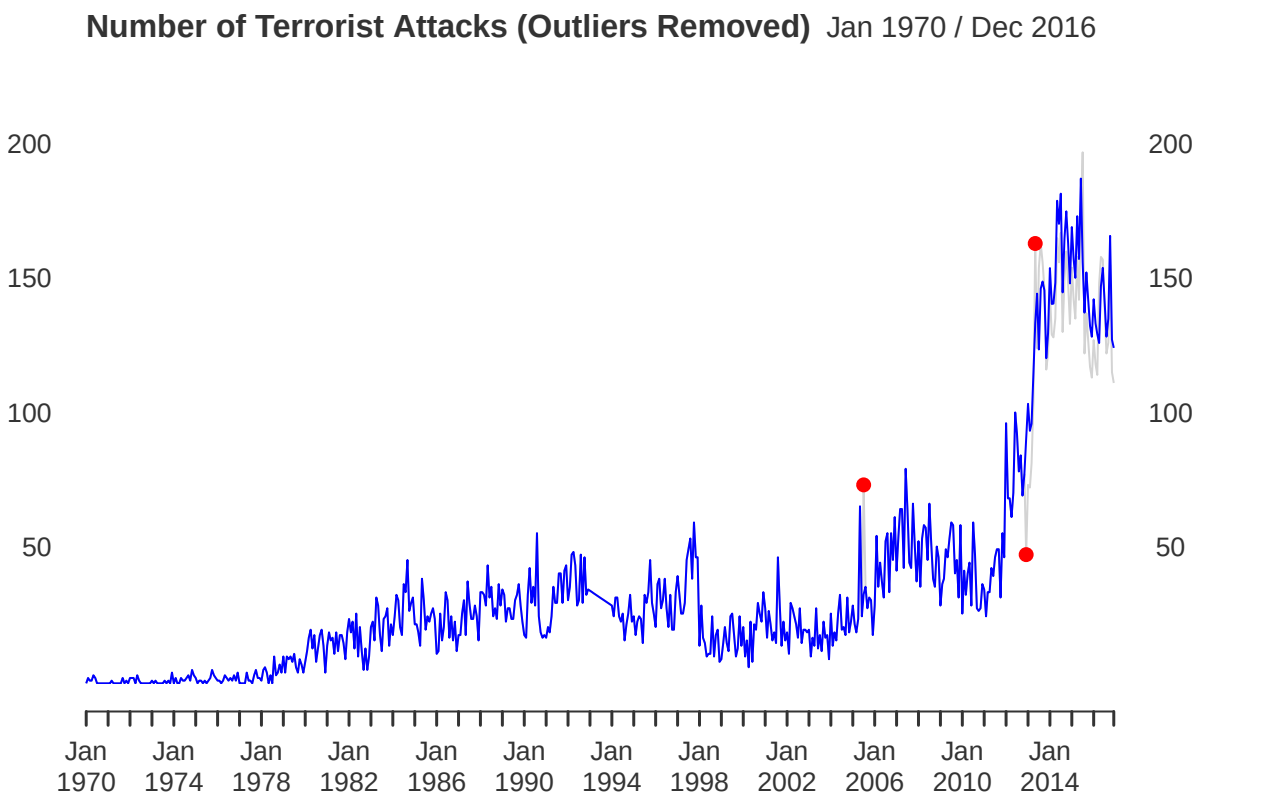
```
points(xts.terror3[427], col="red",pch=19, cex=1)
```



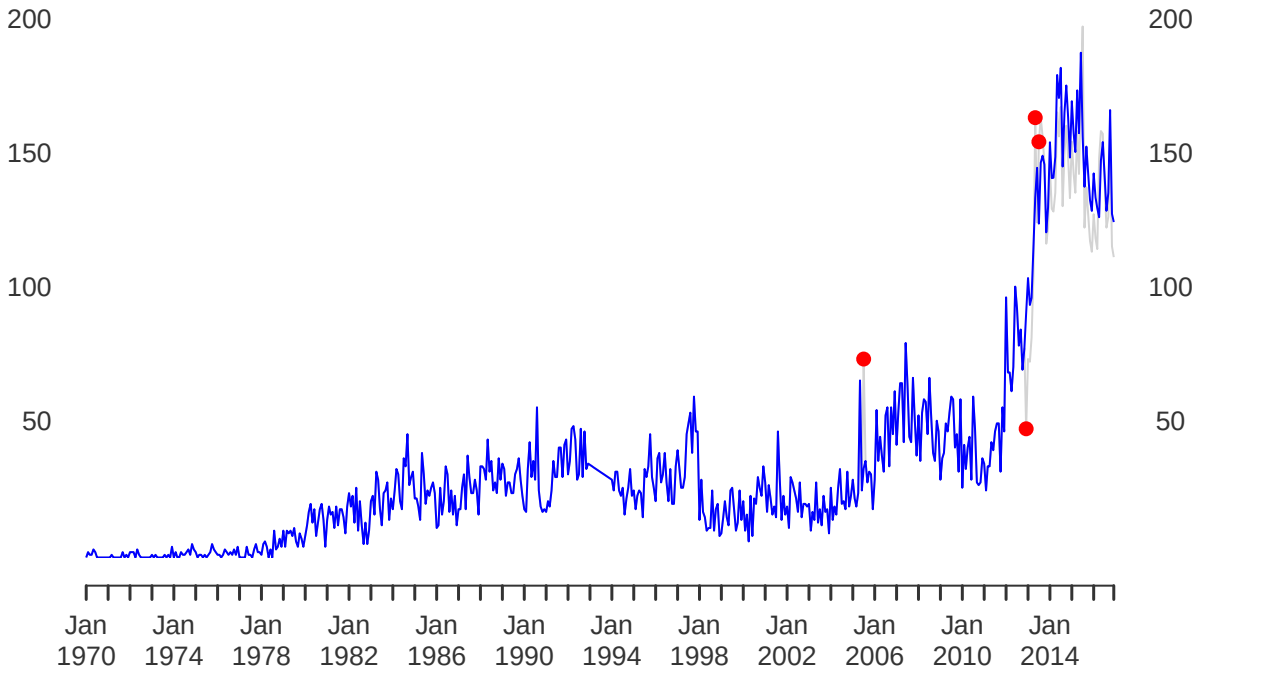

```
points(xts.terror3[516], col="red",pch=19, cex=1)
```



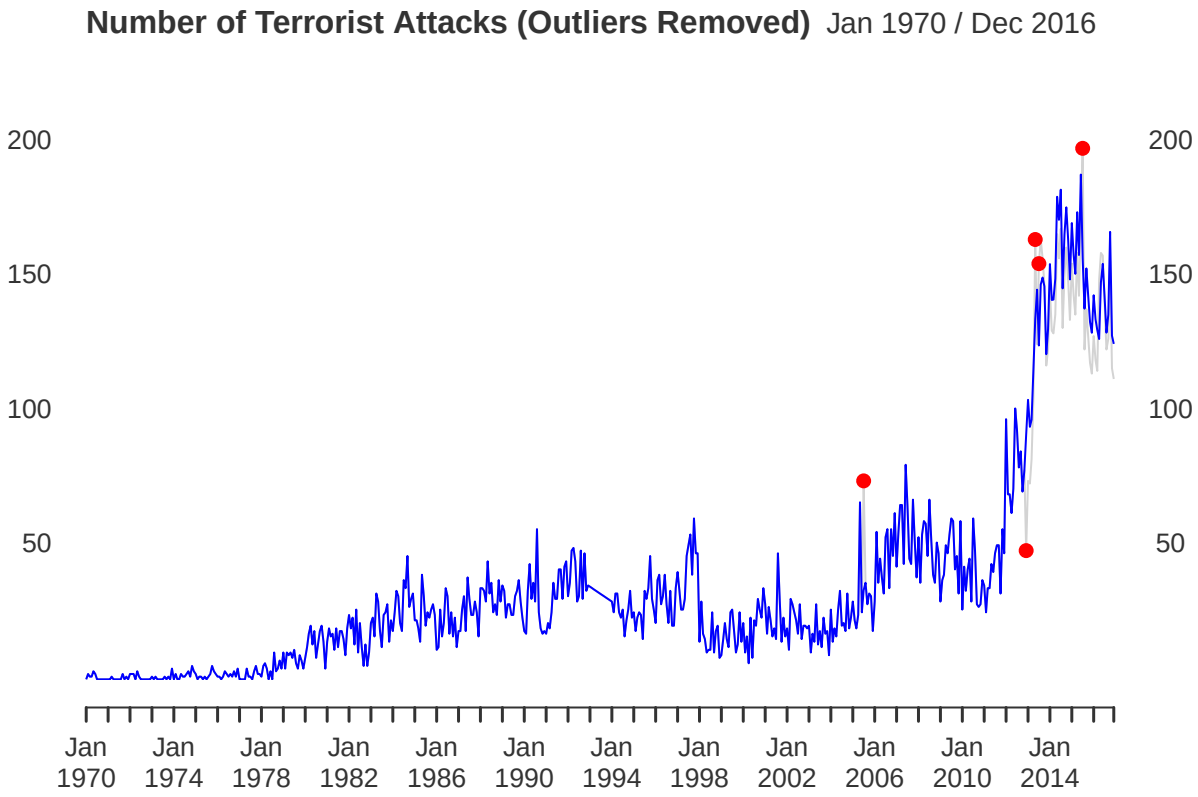
```
points(xts.terror3[521], col="red",pch=19, cex=1)
```




```
points(xts.terror3[523], col="red",pch=19, cex=1)
```



```
points(xts.terror3[547], col="red",pch=19, cex=1)
```




```
pdf("image/outlier_comparison.pdf")
points(xts.terror3[556], col="red",pch=19, cex=1)
dev.off()
```

```
## pdf
##   2
```

Making, Training, and Validation set

```
terror4 <- outlier_terror3$yadj

#terror3 <- na.kalman(terror2$num.attacks, model="auto.arima")
cuttoff.index <- length(terror4) - 48 #floor(0.1 * length(terror3))
cuttoff.index2 <- length(terror4) - 12
terror4.valid <- terror4[(cuttoff.index+1) :cuttoff.index2]
terror4.testing <- terror4[(cuttoff.index2 + 1): length(terror4)]
terror4 <- terror4[1: cuttoff.index]

#plot(as.xts(ts(terror4, frequency = 12, start=1970)), main = "Number of Terrorist Attacks (Training Se

#plot(as.xts(ts(terror4.valid, frequency = 12, start=1970)), main = "Number of Terrorist Attacks (Valid
```

Chasing Stationarity

```
#log_terror4 <- log(outlier_terror3$yadj)
adf.test(terror4)
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  terror4
## Dickey-Fuller = -2.3232, Lag order = 8, p-value = 0.4415
## alternative hypothesis: stationary
```

```
adf.test(diff(terror4))
```

```
## Warning in adf.test(diff(terror4)): p-value smaller than printed p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  diff(terror4)
## Dickey-Fuller = -10.222, Lag order = 8, p-value = 0.01
## alternative hypothesis: stationary
```

```
adf.test(diff(diff(terror4)))
```

```
## Warning in adf.test(diff(diff(terror4))): p-value smaller than printed p-
## value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  diff(diff(terror4))
## Dickey-Fuller = -14.146, Lag order = 8, p-value = 0.01
## alternative hypothesis: stationary
```

```
pdf("image/first_diff.pdf")
plot(as.xts(ts(diff(terror4), frequency = 12, start=1970)), main = "Number of Terrorist Attacks (First I
dev.off()
```

```
## pdf
##   2
```

```
pdf("image/second_diff.pdf")
plot(as.xts(ts(diff(diff(terror4)), frequency = 12, start=1970)), main = "Number of Terrorist Attacks (S
dev.off()
```

```
## pdf
##   2
```

```
#ts.plot(diff(terror4))
#ts.plot(diff(diff(terror4)))
```

```
pdf("image/acf_og.pdf")
acf(terror4, main="ACF of Training Data")
dev.off()
```

```
## pdf
##   2
```

```
pdf("image/pacf_og.pdf")
pacf(terror4, main="PACF of Training Data")
dev.off()
```

```
## pdf
##   2
```

```
pdf("image/acf_first_diff.pdf")
acf(diff(terror4), main="ACF of First Diff Training Data")
dev.off()
```

```
## pdf
##   2
```

```
pdf("image/pacf_first_diff.pdf")
pacf(diff(terror4), main="PACF of First Diff Training Data")
dev.off()
```

```
## pdf
##   2
```

```
pdf("image/acf_second_diff.pdf")
acf(diff(terror4), main="ACF of Second Diff Training Data")
dev.off()
```

```
## pdf
##   2
```

```
pdf("image/pacf_second_diff.pdf")
pacf(diff(terror4), main="PACF of Second Diff Training Data")
dev.off()
```

```
## pdf
##   2
```

Periodogram; Figuring out Seasonality

```
m = floor(sqrt(length(diff(terror4))))
pdf("image/raw_periodogram.pdf")
mvspec(diff(terror4), log="no", main="Raw Periodogram (First Difference)", cex.main=1.5)
dev.off()
```

```
## pdf
##   2
```

```
pdf("image/smooth_tapered_periodogram.pdf")
mvspec(diff(terror4), kernel('modified.daniell', m), log="no", taper=0.1, main="Smoothed and Tapered Pe
dev.off()
```

```
## pdf
##   2
```

```
pdf("image/raw_periodogram_2.pdf")
m = floor(sqrt(length(diff(diff(terror4)))))
mvspec(diff(diff(terror4)), log="no", main="Raw Periodogram (First Difference)", cex.main=1.5)
dev.off()
```

```
## pdf
##   2
```

```
pdf("image/smooth_tapered_periodogram_2.pdf")
mvspec(diff(diff(terror4)), kernel('modified.daniell', m), log="no", taper=0.1, main="Smoothed and Tape
dev.off()
```

```
## pdf
##   2
```

Finding which model to use

```
eacf(diff(terror4))
```

```
## AR/MA
##   0 1 2 3 4 5 6 7 8 9 10 11 12 13
## 0 x o x x o o o o o o o  o  o  x
## 1 x x o x o o o o o o o  o  o  o
## 2 x x x x o o o o o o o  o  o  o
## 3 x x x x o o o o o o o  o  o  o
## 4 x o o o o o o o o o o  o  o  o
## 5 x x o o o o o o o o o  o  o  o
## 6 x x o o o o o o o o o  o  o  o
## 7 x x o o o o o o o o o  o  o  o
```

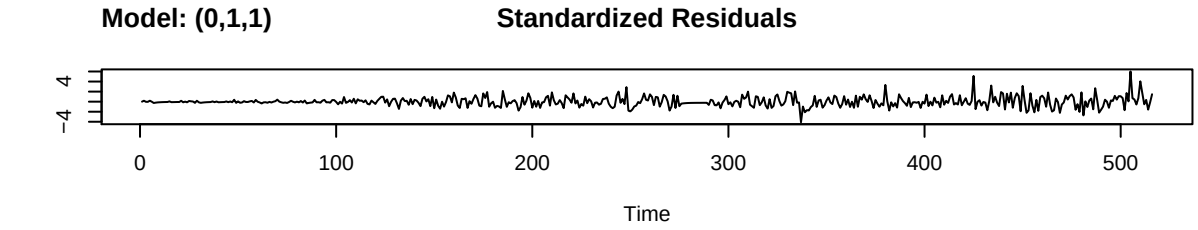
```
eacf(diff(diff(terror4)))
```

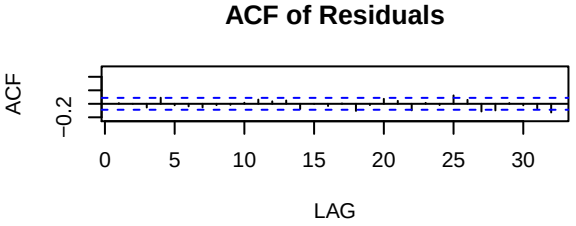
```
## AR/MA
##   0 1 2 3 4 5 6 7 8 9 10 11 12 13
## 0 x x x x o o o o o o o  o  o  x
## 1 x x x x o o o o o o o  o  o  o
## 2 x x x x o o o o o o o  o  o  o
## 3 x o o o o o o o o o o  o  o  o
## 4 x x o o o o o o o o o  o  o  o
## 5 x x o o o o x o o o o  o  o  o
## 6 x x x o o o o o o o o  o  o  o
## 7 x x o o o o o o o o o  o  o  o
```

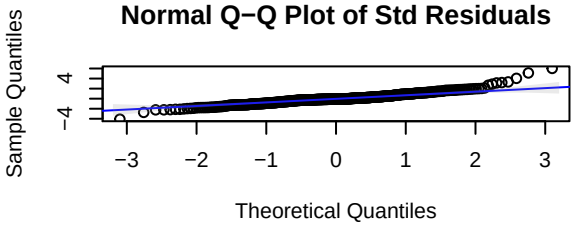
```
sarima(terror4, 0, 1, 1)
```

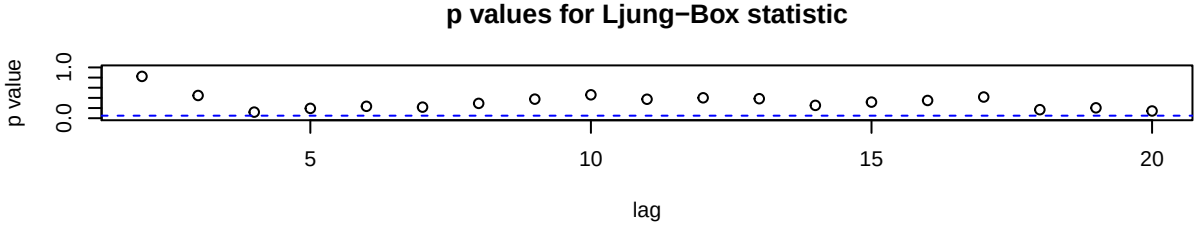
```
## initial  value 2.302665
## iter   2 value 2.148680
## iter   3 value 2.132396
## iter   4 value 2.128997
## iter   5 value 2.121714
## iter   6 value 2.120506
## iter   7 value 2.120430
## iter   8 value 2.120364
## iter   9 value 2.120362
## iter  10 value 2.120362
## iter  10 value 2.120362
## iter  10 value 2.120362
## final  value 2.120362
## converged
## initial  value 2.120944
```

```
## iter   2 value 2.120943
## iter   3 value 2.120942
## iter   3 value 2.120942
## iter   3 value 2.120942
## final  value 2.120942
## converged
```









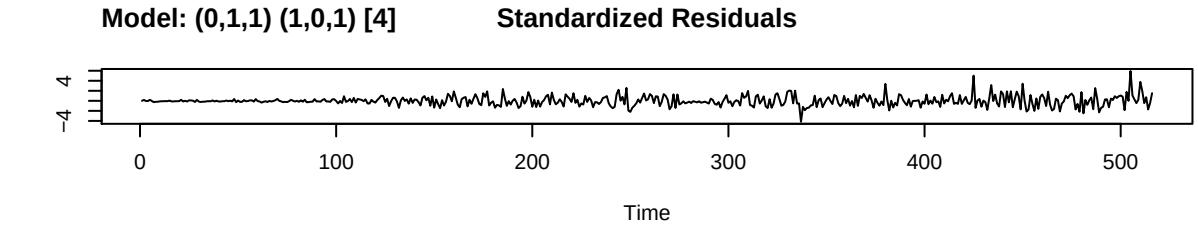

```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), xreg = constant, optim.control = list(trace = trc, REPORT = 1,
##     reltol = tol))
##
## Coefficients:
##           ma1  constant
##       -0.6746    0.1596
## s.e.   0.0336    0.1200
##
## sigma^2 estimated as 69.46:  log likelihood = -1823.04,  aic = 3652.08
##
## $degrees_of_freedom
## [1] 513
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -0.6746 0.0336 -20.0780  0.0000
## constant   0.1596 0.1200   1.3306  0.1839
##
```

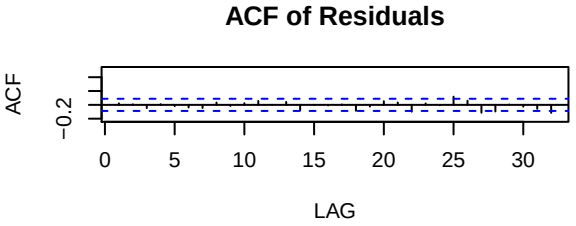
```
## $AIC
## [1] 5.248457
##
## $AICc
## [1] 5.252424
##
## $BIC
## [1] 4.264915
```

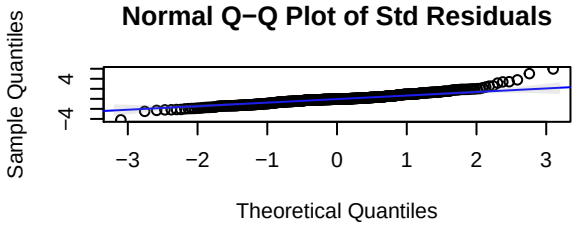
```
sarima(terror4, 0, 1, 1, 1, 0, 1, 4)
```

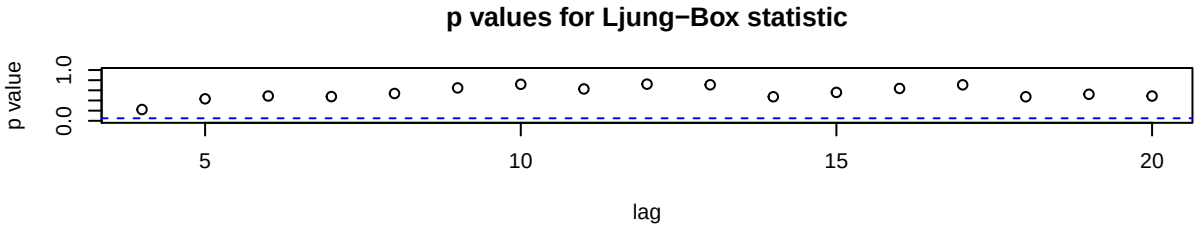
```
## initial  value 2.306485
## iter   2 value 2.160550
## iter   3 value 2.137688
## iter   4 value 2.128502
## iter   5 value 2.123569
## iter   6 value 2.120401
## iter   7 value 2.119951
## iter   8 value 2.119925
## iter   9 value 2.119914
## iter  10 value 2.119906
## iter  11 value 2.119902
## iter  12 value 2.119881
## iter  13 value 2.119531
## iter  14 value 2.119158
## iter  15 value 2.118895
## iter  16 value 2.118789
## iter  17 value 2.118773
## iter  18 value 2.118748
## iter  19 value 2.118211
## iter  20 value 2.116368
## iter  21 value 2.115097
## iter  22 value 2.114878
## iter  23 value 2.114721
## iter  24 value 2.114670
## iter  25 value 2.114631
## iter  26 value 2.114584
## iter  27 value 2.114555
## iter  28 value 2.114550
## iter  29 value 2.114550
## iter  29 value 2.114550
## final  value 2.114550
## converged
## initial  value 2.111537
## iter   2 value 2.111531
## iter   3 value 2.111529
## iter   4 value 2.111529
## iter   5 value 2.111529
## iter   6 value 2.111529
## iter   7 value 2.111528
## iter   8 value 2.111528
## iter   9 value 2.111528
## iter   9 value 2.111528
## iter   9 value 2.111528
## final  value 2.111528
```

```
## converged
```







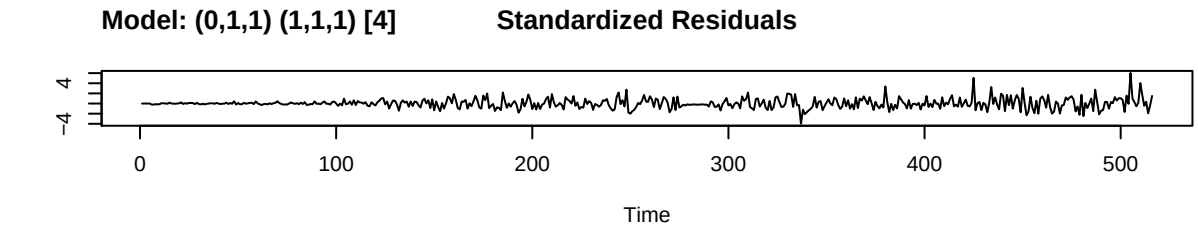


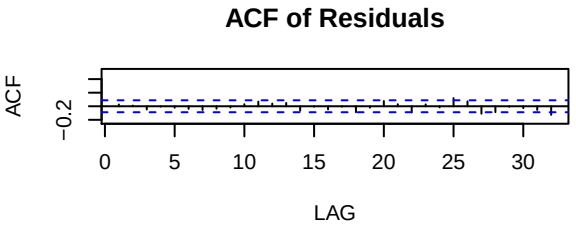

```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), xreg = constant, optim.control = list(trace = trc, REPORT = 1,
##     reltol = tol))
##
## Coefficients:
##           ma1     sar1    sma1  constant
##       -0.6863  -0.7178  0.8165    0.1595
## s.e.   0.0346   0.0962  0.0774    0.1212
##
## sigma^2 estimated as 68.13:  log likelihood = -1818.19,  aic = 3646.38
##
## $degrees_of_freedom
## [1] 511
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -0.6863 0.0346 -19.8500  0.0000
## sar1      -0.7178 0.0962  -7.4641  0.0000
## sma1       0.8165 0.0774  10.5431  0.0000
## constant   0.1595 0.1212   1.3163  0.1887
##
## $AIC
## [1] 5.236941
##
```

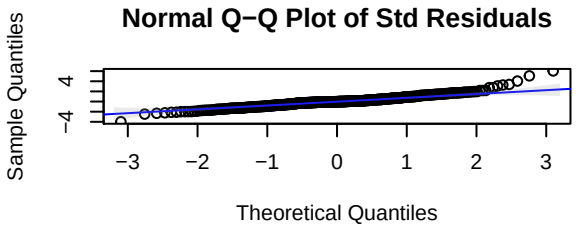
```
## $AICc
## [1] 5.241045
##
## $BIC
## [1] 4.269857
```

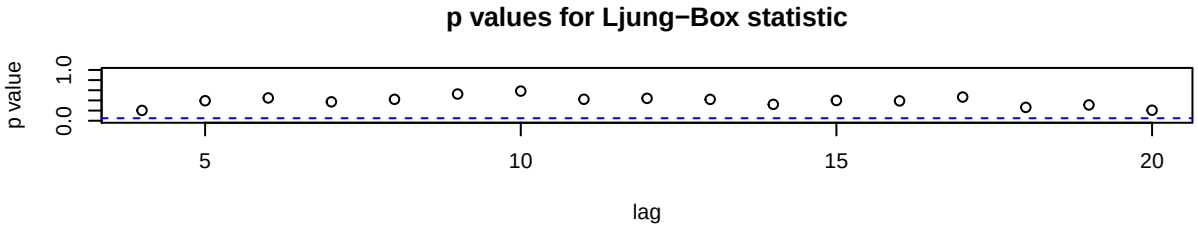
```
sarima(terror4, 0, 1, 1, 1, 1, 1, 4)
```

```
## initial  value 2.585951
## iter   2 value 2.295422
## iter   3 value 2.231925
## iter   4 value 2.195223
## iter   5 value 2.174548
## iter   6 value 2.150154
## iter   7 value 2.141586
## iter   8 value 2.141306
## iter   9 value 2.141144
## iter  10 value 2.141058
## iter  11 value 2.141057
## iter  11 value 2.141057
## iter  11 value 2.141057
## final  value 2.141057
## converged
## initial  value 2.141567
## iter   2 value 2.139146
## iter   3 value 2.138306
## iter   4 value 2.138235
## iter   5 value 2.138226
## iter   5 value 2.138226
## iter   5 value 2.138226
## final  value 2.138226
## converged
```







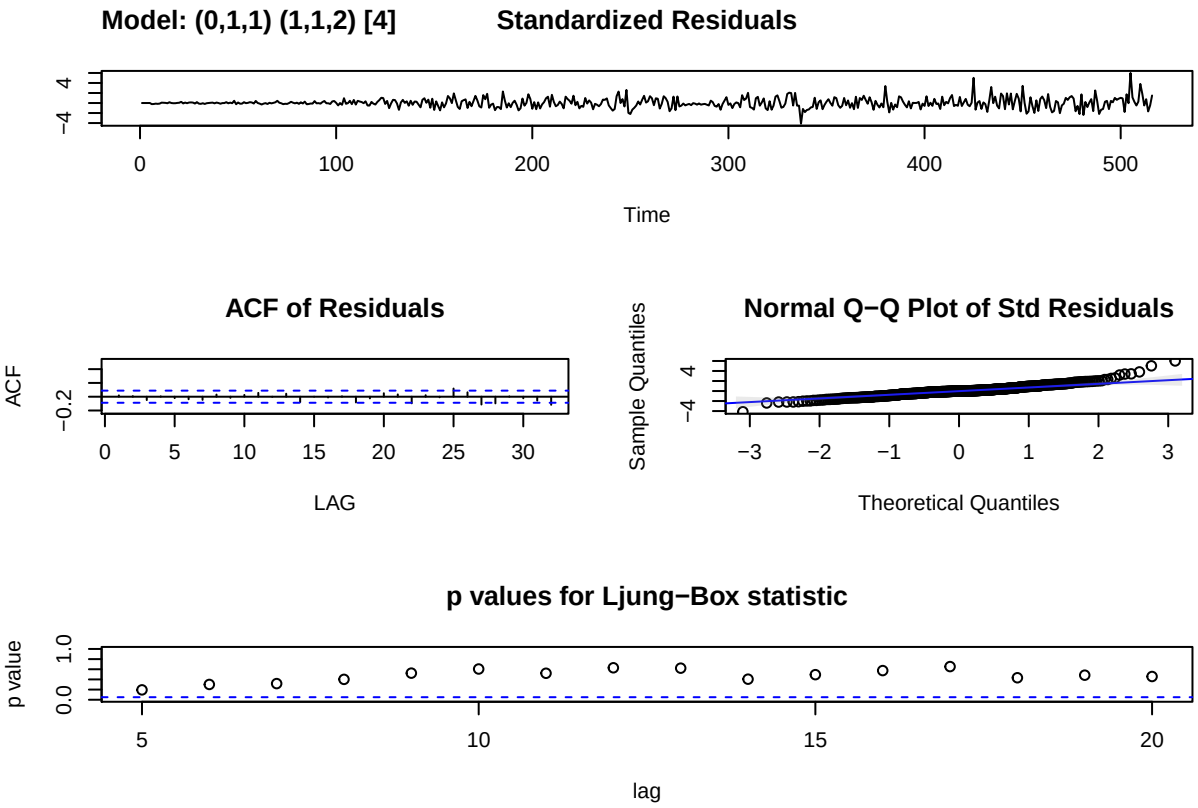



```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), include.mean = !no.constant, optim.control = list(trace = trc,
##     REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1    sar1     sma1
##       -0.6846  0.0988  -1.0000
## s.e.   0.0362  0.0450   0.0171
##
## sigma^2 estimated as 69.26:  log likelihood = -1817.71,  aic = 3643.42
##
## $degrees_of_freedom
## [1] 508
##
## $ttable
##      Estimate     SE  t.value p.value
## ma1   -0.6846 0.0362 -18.8959  0.0000
## sar1   0.0988 0.0450   2.1935  0.0287
## sma1  -1.0000 0.0171 -58.6006  0.0000
##
## $AIC
## [1] 5.249478
##
## $AICc
## [1] 5.253506
```

```
##
## $BIC
## [1] 4.274165
```

```
sarima(terror4, 0, 1, 1, 1, 1, 2, 4)
```

```
## initial  value 2.585951
## iter   2 value 2.271150
## iter   3 value 2.221817
## iter   4 value 2.190039
## iter   5 value 2.158348
## iter   6 value 2.137558
## iter   7 value 2.136854
## iter   8 value 2.134312
## iter   9 value 2.132861
## iter  10 value 2.132729
## iter  11 value 2.132550
## iter  12 value 2.130744
## iter  13 value 2.127256
## iter  14 value 2.126990
## iter  15 value 2.126819
## iter  16 value 2.126642
## iter  17 value 2.125945
## iter  18 value 2.125863
## iter  19 value 2.125557
## iter  20 value 2.125495
## iter  21 value 2.125487
## iter  22 value 2.125487
## iter  22 value 2.125487
## final  value 2.125487
## converged
## initial  value 2.133766
## iter   2 value 2.133364
## iter   3 value 2.133341
## iter   4 value 2.133331
## iter   5 value 2.133324
## iter   6 value 2.133285
## iter   7 value 2.133273
## iter   8 value 2.133272
## iter   8 value 2.133272
## iter   8 value 2.133272
## final  value 2.133272
## converged
```

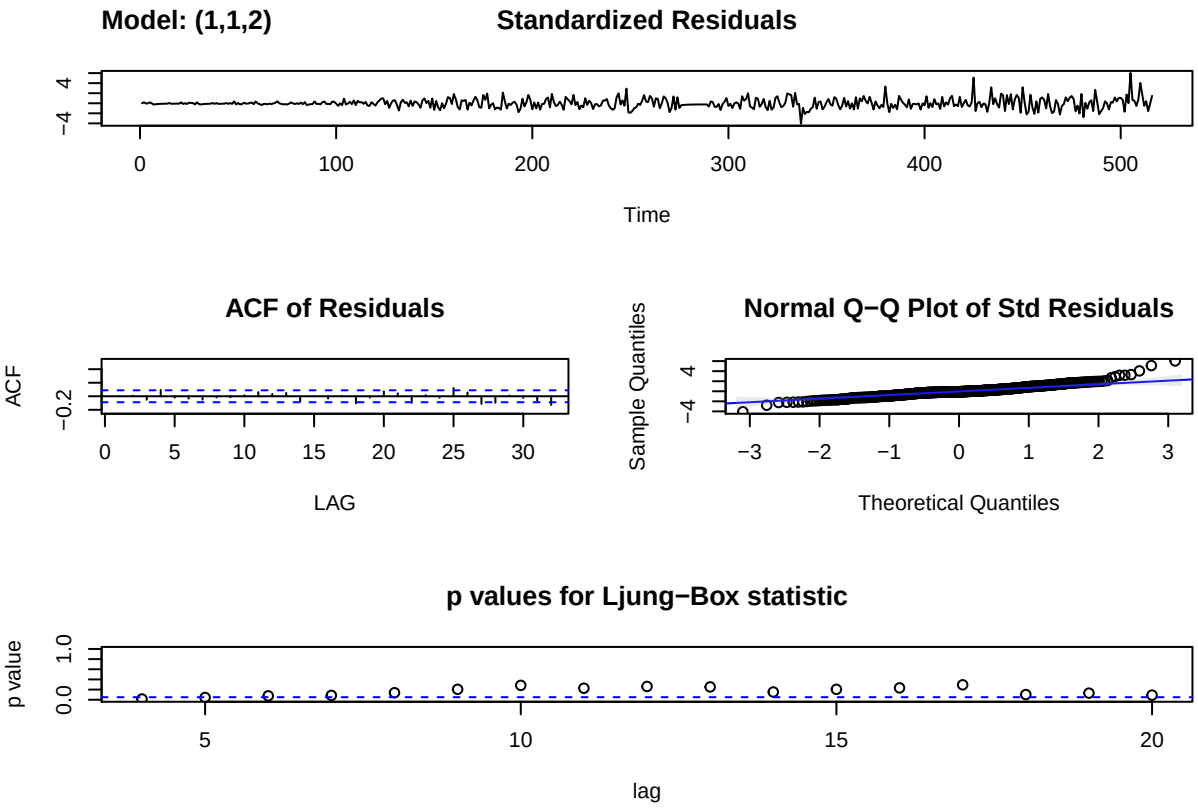



```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), include.mean = !no.constant, optim.control = list(trace = trc,
##     REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1     sar1     sma1     sma2
##       -0.6840  -0.7141  -0.1856  -0.8144
## s.e.   0.0348   0.0974   0.0807   0.0800
##
## sigma^2 estimated as 68.5:  log likelihood = -1815.18,  aic = 3640.36
##
## $degrees_of_freedom
## [1] 507
##
## $ttable
##      Estimate     SE  t.value p.value
## ma1   -0.6840 0.0348 -19.6474  0.0000
## sar1  -0.7141 0.0974  -7.3348  0.0000
## sma1  -0.1856 0.0807  -2.2985  0.0219
## sma2  -0.8144 0.0800 -10.1848  0.0000
##
## $AIC
## [1] 5.242331
##
## $AICc
```

```
## [1] 5.246435
##
## $BIC
## [1] 4.275247
```

```
sarima(terror4, 1, 1, 2)
```

```
## initial  value 2.303604
## iter   2 value 2.181765
## iter   3 value 2.126083
## iter   4 value 2.122470
## iter   5 value 2.121316
## iter   6 value 2.121288
## iter   7 value 2.121288
## iter   8 value 2.121288
## iter   9 value 2.121288
## iter  10 value 2.121287
## iter  11 value 2.121287
## iter  12 value 2.121287
## iter  13 value 2.121287
## iter  14 value 2.121286
## iter  15 value 2.121285
## iter  16 value 2.121281
## iter  17 value 2.121269
## iter  18 value 2.121254
## iter  19 value 2.121225
## iter  20 value 2.121201
## iter  21 value 2.121196
## iter  22 value 2.121196
## iter  23 value 2.121196
## iter  23 value 2.121196
## iter  23 value 2.121196
## final  value 2.121196
## converged
## initial  value 2.120809
## iter   2 value 2.120807
## iter   3 value 2.120807
## iter   3 value 2.120807
## iter   3 value 2.120807
## final  value 2.120807
## converged
```



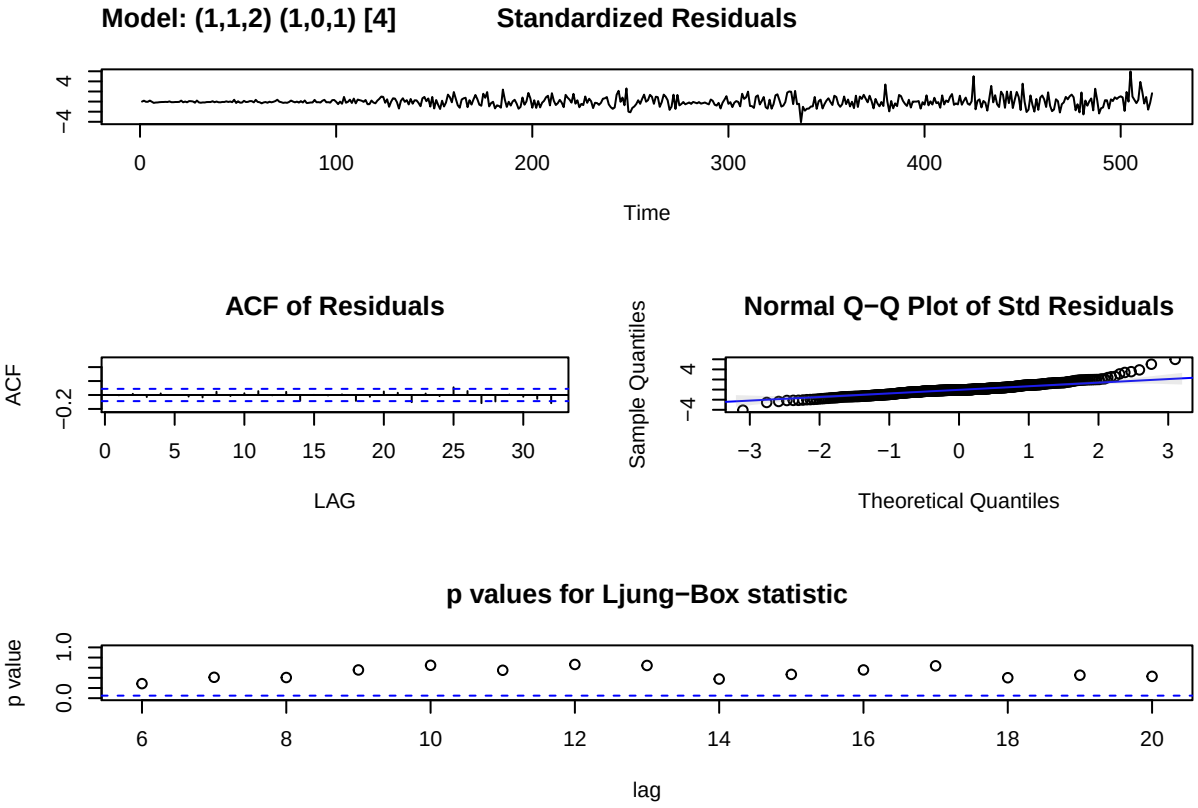

```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), xreg = constant, optim.control = list(trace = trc, REPORT = 1,
##     reltol = tol))
##
## Coefficients:
##          ar1      ma1      ma2  constant
##       0.0064  -0.6701  -0.0121    0.1591
## s.e.  1.0042   0.9926   0.6599    0.1179
##
## sigma^2 estimated as 69.44:  log likelihood = -1822.97,  aic = 3655.94
##
## $degrees_of_freedom
## [1] 511
##
## $ttable
##          Estimate     SE t.value p.value
## ar1        0.0064 1.0042  0.0064  0.9949
## ma1       -0.6701 0.9926 -0.6751  0.4999
## ma2       -0.0121 0.6599 -0.0184  0.9854
## constant   0.1591 0.1179  1.3492  0.1779
##
## $AIC
## [1] 5.255937
##
## $AICc
```

```
## [1] 5.260041
##
## $BIC
## [1] 4.288853
```

```
sarima(terror4, 1, 1, 2, 1, 0, 1, 4)
```

```
## initial  value 2.307451
## iter   2 value 2.204058
## iter   3 value 2.126118
## iter   4 value 2.123944
## iter   5 value 2.120684
## iter   6 value 2.120475
## iter   7 value 2.120374
## iter   8 value 2.120367
## iter   9 value 2.120339
## iter  10 value 2.120273
## iter  11 value 2.120113
## iter  12 value 2.119505
## iter  13 value 2.118322
## iter  14 value 2.118280
## iter  15 value 2.115656
## iter  16 value 2.115558
## iter  17 value 2.115420
## iter  18 value 2.115254
## iter  19 value 2.114946
## iter  20 value 2.114892
## iter  21 value 2.114761
## iter  22 value 2.114757
## iter  23 value 2.114756
## iter  24 value 2.114754
## iter  25 value 2.114741
## iter  26 value 2.114716
## iter  27 value 2.114657
## iter  28 value 2.114614
## iter  29 value 2.114611
## iter  30 value 2.114610
## iter  31 value 2.114600
## iter  32 value 2.114598
## iter  33 value 2.114597
## iter  34 value 2.114595
## iter  35 value 2.114592
## iter  36 value 2.114591
## iter  37 value 2.114590
## iter  38 value 2.114587
## iter  39 value 2.114580
## iter  40 value 2.114564
## iter  41 value 2.114560
## iter  42 value 2.114558
## iter  43 value 2.114552
## iter  44 value 2.114547
## iter  45 value 2.114540
## iter  46 value 2.114539
## iter  47 value 2.114538
## iter  48 value 2.114537
```

```
## iter  49 value 2.114534
## iter  50 value 2.114527
## iter  51 value 2.114514
## iter  52 value 2.114499
## iter  53 value 2.114490
## iter  54 value 2.114490
## iter  55 value 2.114490
## iter  56 value 2.114490
## iter  57 value 2.114489
## iter  58 value 2.114489
## iter  59 value 2.114489
## iter  59 value 2.114489
## iter  59 value 2.114489
## final  value 2.114489
## converged
## initial  value 2.110481
## iter   2 value 2.110475
## iter   3 value 2.110474
## iter   4 value 2.110473
## iter   4 value 2.110473
## iter   4 value 2.110473
## final  value 2.110473
## converged
```



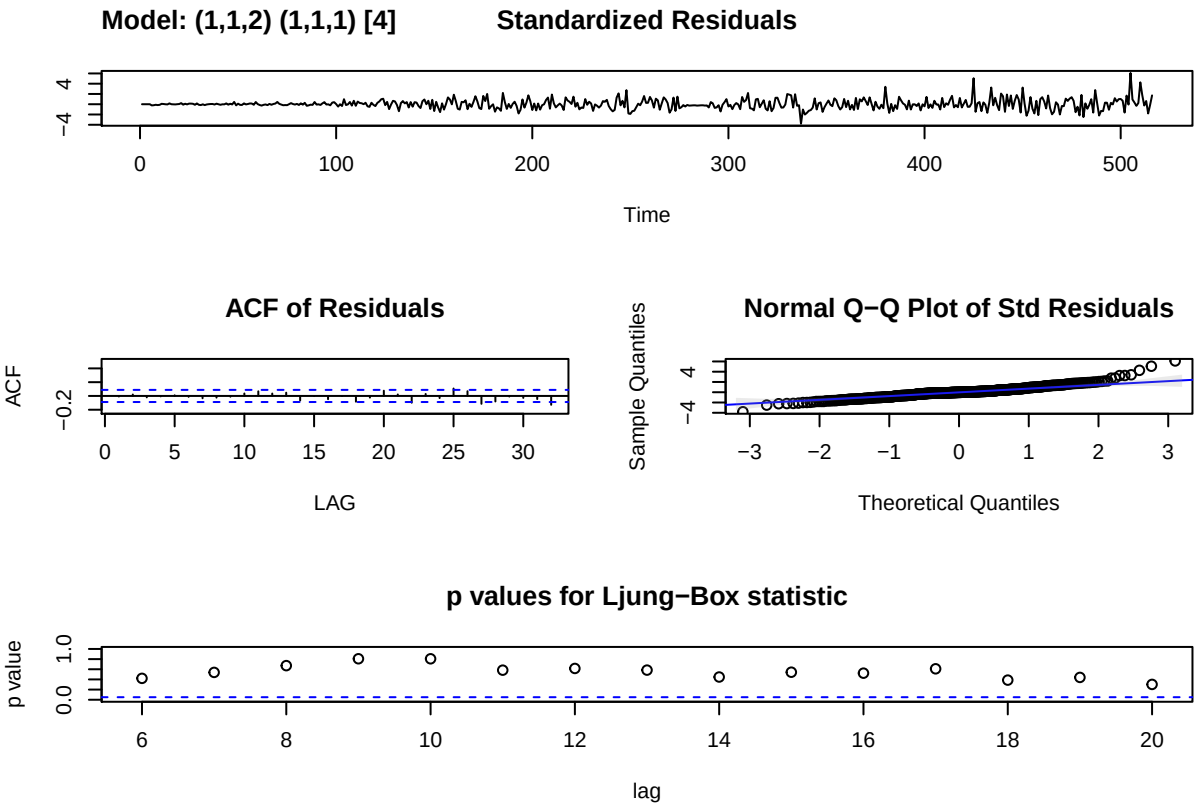

```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), xreg = constant, optim.control = list(trace = trc, REPORT = 1,
```

```
##     reltol = tol))
##
## Coefficients:
##          ar1      ma1     ma2     sar1    sma1  constant
##       0.5048  -1.1655  0.3073  -0.7013  0.8088    0.1580
## s.e.  0.5414   0.5504  0.3871   0.1014  0.0808    0.1112
##
## sigma^2 estimated as 67.99:  log likelihood = -1817.65,  aic = 3649.29
##
## $degrees_of_freedom
## [1] 509
##
## $ttable
##          Estimate     SE t.value p.value
## ar1        0.5048 0.5414  0.9324  0.3516
## ma1       -1.1655 0.5504 -2.1175  0.0347
## ma2        0.3073 0.3871  0.7938  0.4277
## sar1      -0.7013 0.1014 -6.9171  0.0000
## sma1       0.8088 0.0808 10.0109  0.0000
## constant   0.1580 0.1112  1.4203  0.1561
##
## $AIC
## [1] 5.242543
##
## $AICc
## [1] 5.246847
##
## $BIC
## [1] 4.291917
```

```
sarima(terror4, 1, 1, 2, 1, 1, 1, 4)
```

```
## initial  value 2.586933
## iter   2 value 2.313608
## iter   3 value 2.236307
## iter   4 value 2.190222
## iter   5 value 2.170202
## iter   6 value 2.160653
## iter   7 value 2.153824
## iter   8 value 2.143005
## iter   9 value 2.140794
## iter  10 value 2.139309
## iter  11 value 2.138297
## iter  12 value 2.138283
## iter  13 value 2.138256
## iter  14 value 2.138239
## iter  15 value 2.138099
## iter  16 value 2.137745
## iter  17 value 2.136357
## iter  18 value 2.135551
## iter  19 value 2.132692
## iter  20 value 2.131687
## iter  21 value 2.130851
## iter  22 value 2.130426
## iter  23 value 2.129721
```

```
## iter  24 value 2.129017
## iter  25 value 2.128149
## iter  26 value 2.128113
## iter  27 value 2.127993
## iter  28 value 2.126274
## iter  29 value 2.125847
## iter  30 value 2.125462
## iter  31 value 2.125163
## iter  32 value 2.125044
## iter  33 value 2.125028
## iter  34 value 2.125024
## iter  35 value 2.125024
## iter  35 value 2.125024
## iter  35 value 2.125024
## final  value 2.125024
## converged
## initial  value 2.136116
## iter   2 value 2.136070
## iter   3 value 2.135997
## iter   4 value 2.135991
## iter   5 value 2.135989
## iter   6 value 2.135989
## iter   7 value 2.135988
## iter   8 value 2.135987
## iter   9 value 2.135985
## iter  10 value 2.135983
## iter  11 value 2.135980
## iter  12 value 2.135978
## iter  13 value 2.135978
## iter  14 value 2.135978
## iter  14 value 2.135978
## iter  14 value 2.135978
## final  value 2.135978
## converged
```



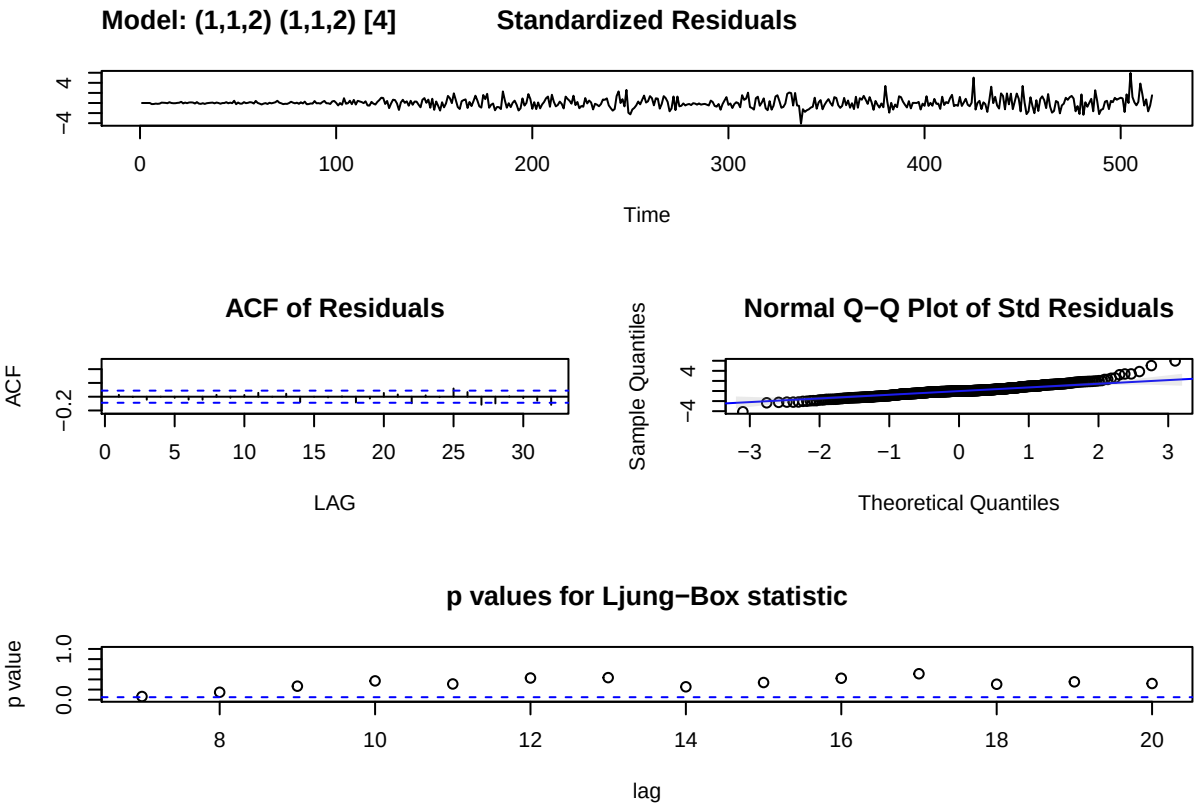

```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), include.mean = !no.constant, optim.control = list(trace = trc,
##     REPORT = 1, reltol = tol))
##
## Coefficients:
##          ar1      ma1     ma2    sar1     sma1
##       0.6052  -1.2584  0.3610  0.1332  -1.0000
## s.e.  0.3307   0.3418  0.2472  0.0504   0.0176
##
## sigma^2 estimated as 68.92:  log likelihood = -1816.56,  aic = 3645.12
##
## $degrees_of_freedom
## [1] 506
##
## $ttable
##      Estimate     SE  t.value p.value
## ar1    0.6052 0.3307   1.8302  0.0678
## ma1   -1.2584 0.3418  -3.6817  0.0003
## ma2    0.3610 0.2472   1.4603  0.1448
## sar1   0.1332 0.0504   2.6446  0.0084
## sma1  -1.0000 0.0176 -56.8115  0.0000
##
## $AIC
## [1] 5.252384
##
```

```
## $AICc
## [1] 5.25658
##
## $BIC
## [1] 4.293529
```

```
sarima(terror4, 1, 1, 2, 1, 1, 2, 4)
```

```
## initial  value 2.586933
## iter   2 value 2.289532
## iter   3 value 2.271176
## iter   4 value 2.230852
## iter   5 value 2.225996
## iter   6 value 2.209651
## iter   7 value 2.204810
## iter   8 value 2.190472
## iter   9 value 2.184118
## iter  10 value 2.178785
## iter  11 value 2.176119
## iter  12 value 2.172137
## iter  13 value 2.166308
## iter  14 value 2.164234
## iter  15 value 2.141397
## iter  16 value 2.133893
## iter  17 value 2.129958
## iter  18 value 2.129081
## iter  19 value 2.128562
## iter  20 value 2.128395
## iter  21 value 2.128087
## iter  22 value 2.127913
## iter  23 value 2.127812
## iter  24 value 2.127776
## iter  25 value 2.127771
## iter  26 value 2.127770
## iter  27 value 2.127768
## iter  28 value 2.127764
## iter  29 value 2.127755
## iter  30 value 2.127752
## iter  31 value 2.127750
## iter  32 value 2.127748
## iter  33 value 2.127746
## iter  34 value 2.127741
## iter  35 value 2.127737
## iter  36 value 2.127735
## iter  37 value 2.127733
## iter  38 value 2.127726
## iter  39 value 2.127708
## iter  40 value 2.127662
## iter  41 value 2.127488
## iter  42 value 2.127435
## iter  43 value 2.127375
## iter  44 value 2.127362
## iter  45 value 2.127347
## iter  46 value 2.127333
## iter  47 value 2.127317
```

```
## iter  48 value 2.127314
## iter  49 value 2.127312
## iter  50 value 2.127307
## iter  51 value 2.127296
## iter  52 value 2.127264
## iter  53 value 2.127228
## iter  54 value 2.127190
## iter  55 value 2.127175
## iter  56 value 2.127173
## iter  57 value 2.127169
## iter  58 value 2.127152
## iter  59 value 2.127148
## iter  60 value 2.127139
## iter  61 value 2.127132
## iter  62 value 2.127131
## iter  63 value 2.127131
## iter  64 value 2.127129
## iter  65 value 2.127127
## iter  66 value 2.127123
## iter  67 value 2.127121
## iter  68 value 2.127121
## iter  69 value 2.127121
## iter  70 value 2.127121
## iter  71 value 2.127121
## iter  72 value 2.127121
## iter  73 value 2.127120
## iter  74 value 2.127120
## iter  74 value 2.127120
## iter  74 value 2.127120
## final  value 2.127120
## converged
## initial  value 2.133693
## iter   2 value 2.133179
## iter   3 value 2.133153
## iter   4 value 2.133143
## iter   5 value 2.133139
## iter   6 value 2.133127
## iter   7 value 2.133103
## iter   8 value 2.133100
## iter   9 value 2.133100
## iter  10 value 2.133100
## iter  11 value 2.133099
## iter  12 value 2.133097
## iter  13 value 2.133092
## iter  14 value 2.133082
## iter  15 value 2.133082
## iter  16 value 2.133080
## iter  17 value 2.133080
## iter  18 value 2.133080
## iter  18 value 2.133080
## iter  18 value 2.133080
## final  value 2.133080
## converged
```

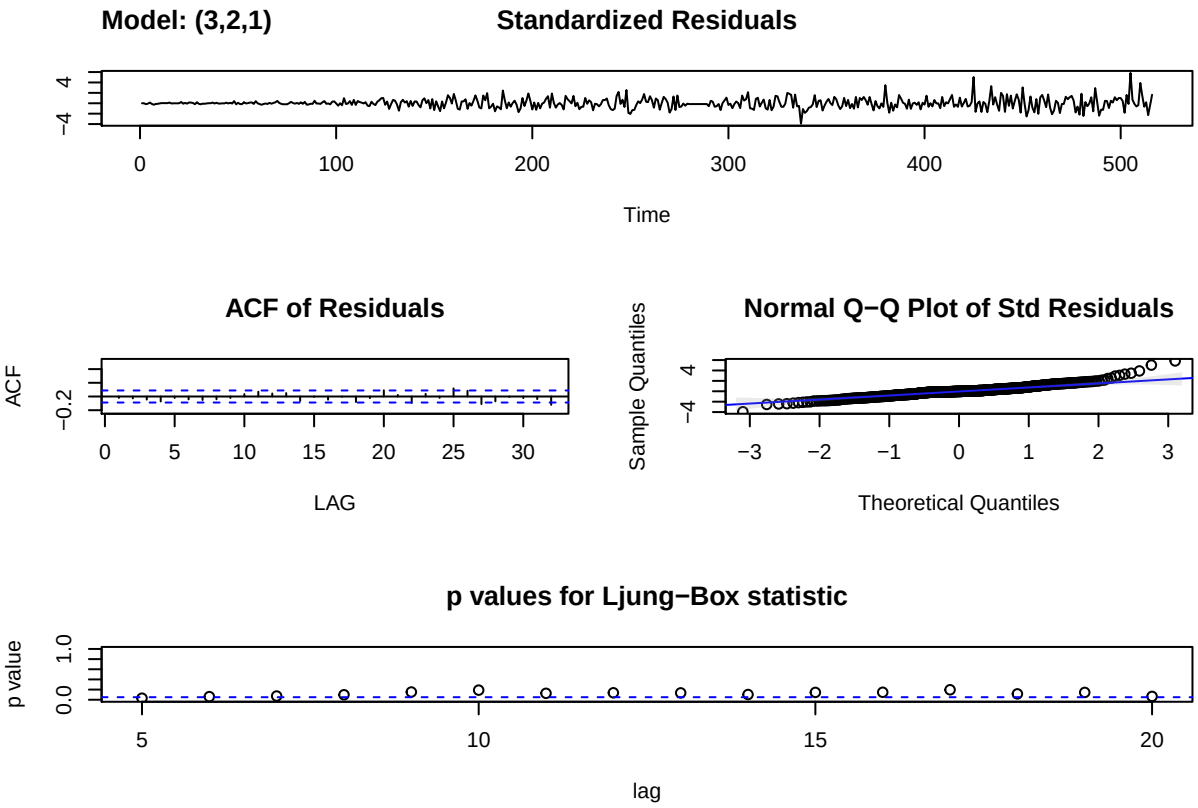



```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), include.mean = !no.constant, optim.control = list(trace = trc,
##     REPORT = 1, reltol = tol))
##
## Coefficients:
##           ar1     ma1      ma2     sar1     sma1     sma2
##       -0.8094  0.1185  -0.5406  -0.7206  -0.1827  -0.8172
## s.e.   0.2450  0.2505   0.1769   0.0978   0.0806   0.0798
##
## sigma^2 estimated as 68.49:  log likelihood = -1815.08,  aic = 3644.16
##
## $degrees_of_freedom
## [1] 505
##
## $ttable
##      Estimate     SE  t.value p.value
## ar1   -0.8094 0.2450  -3.3039  0.0010
## ma1    0.1185 0.2505   0.4730  0.6364
## ma2   -0.5406 0.1769  -3.0563  0.0024
## sar1  -0.7206 0.0978  -7.3717  0.0000
## sma1  -0.1827 0.0806  -2.2673  0.0238
## sma2  -0.8172 0.0798 -10.2401  0.0000
##
## $AIC
## [1] 5.24995
```

```
##
## $AICc
## [1] 5.254253
##
## $BIC
## [1] 4.299323
```

```
sarima(terror4, 3, 2, 1)
```

```
## initial  value 2.840480
## iter   2 value 2.455571
## iter   3 value 2.351180
## iter   4 value 2.325782
## iter   5 value 2.298898
## iter   6 value 2.273640
## iter   7 value 2.256917
## iter   8 value 2.248978
## iter   9 value 2.196491
## iter  10 value 2.179702
## iter  11 value 2.179511
## iter  12 value 2.158383
## iter  13 value 2.148335
## iter  14 value 2.139178
## iter  15 value 2.135772
## iter  16 value 2.132581
## iter  17 value 2.131080
## iter  18 value 2.131071
## iter  19 value 2.131057
## iter  20 value 2.131057
## iter  21 value 2.131057
## iter  21 value 2.131057
## iter  21 value 2.131057
## final  value 2.131057
## converged
## initial  value 2.131098
## iter   2 value 2.130029
## iter   3 value 2.129971
## iter   4 value 2.129957
## iter   5 value 2.129957
## iter   6 value 2.129957
## iter   6 value 2.129957
## iter   6 value 2.129957
## final  value 2.129957
## converged
```

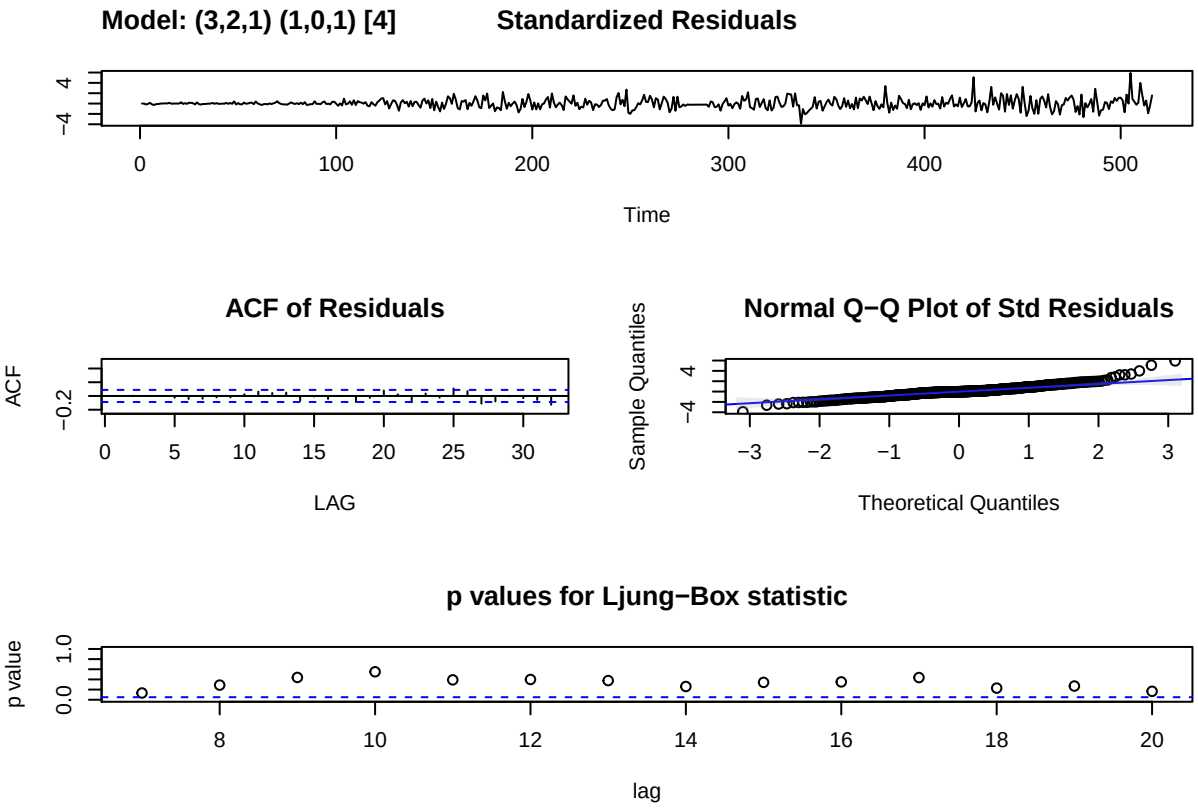



```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), include.mean = !no.constant, optim.control = list(trace = trc,
##     REPORT = 1, reltol = tol))
##
## Coefficients:
##           ar1      ar2      ar3      ma1
##       -0.6269  -0.3847  -0.2599  -1.0000
## s.e.   0.0427   0.0480   0.0427   0.0067
##
## sigma^2 estimated as 69.65:  log likelihood = -1824.13,  aic = 3658.26
##
## $degrees_of_freedom
## [1] 510
##
## $ttable
##     Estimate     SE   t.value p.value
## ar1  -0.6269 0.0427  -14.6848       0
## ar2  -0.3847 0.0480   -8.0136       0
## ar3  -0.2599 0.0427   -6.0899       0
## ma1  -1.0000 0.0067 -149.4769       0
##
## $AIC
## [1] 5.258995
##
## $AICc
```

```
## [1] 5.263099
##
## $BIC
## [1] 4.291911
```

```
sarima(terror4, 3, 2, 1, 1, 0, 1, 4)
```

```
## initial  value 2.844363
## iter   2 value 2.482293
## iter   3 value 2.376259
## iter   4 value 2.272013
## iter   5 value 2.250813
## iter   6 value 2.242087
## iter   7 value 2.233446
## iter   8 value 2.162949
## iter   9 value 2.144325
## iter  10 value 2.130368
## iter  11 value 2.128048
## iter  12 value 2.127675
## iter  13 value 2.127468
## iter  14 value 2.127450
## iter  15 value 2.127446
## iter  16 value 2.127445
## iter  17 value 2.127445
## iter  18 value 2.127444
## iter  19 value 2.127444
## iter  20 value 2.127444
## iter  21 value 2.127442
## iter  22 value 2.127439
## iter  23 value 2.127436
## iter  24 value 2.127435
## iter  25 value 2.127435
## iter  25 value 2.127435
## iter  25 value 2.127435
## final  value 2.127435
## converged
## initial  value 2.125921
## iter   2 value 2.125392
## iter   3 value 2.125357
## iter   4 value 2.125297
## iter   5 value 2.125121
## iter   6 value 2.124882
## iter   7 value 2.124481
## iter   8 value 2.124232
## iter   9 value 2.124108
## iter  10 value 2.124095
## iter  11 value 2.124091
## iter  12 value 2.124090
## iter  13 value 2.124090
## iter  13 value 2.124090
## iter  13 value 2.124090
## final  value 2.124090
## converged
```



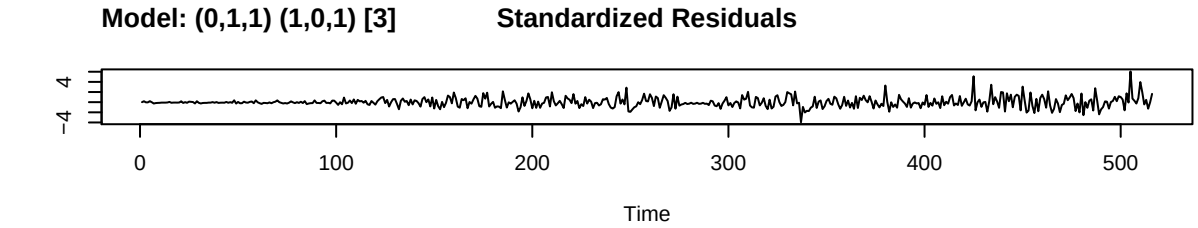

```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), include.mean = !no.constant, optim.control = list(trace = trc,
##     REPORT = 1, reltol = tol))
##
## Coefficients:
##           ar1      ar2      ar3      ma1    sar1     sma1
##       -0.6606  -0.4499  -0.3578  -1.0000  0.1631  -0.3109
## s.e.   0.0435   0.0538   0.0569   0.0107  0.2450   0.2369
##
## sigma^2 estimated as 68.75:  log likelihood = -1821.12,  aic = 3656.23
##
## $degrees_of_freedom
## [1] 508
##
## $ttable
##      Estimate     SE  t.value p.value
## ar1   -0.6606 0.0435 -15.1979  0.0000
## ar2   -0.4499 0.0538  -8.3572  0.0000
## ar3   -0.3578 0.0569  -6.2878  0.0000
## ma1   -1.0000 0.0107 -93.8839  0.0000
## sar1   0.1631 0.2450   0.6655  0.5061
## sma1  -0.3109 0.2369  -1.3122  0.1900
##
## $AIC
## [1] 5.253801
```

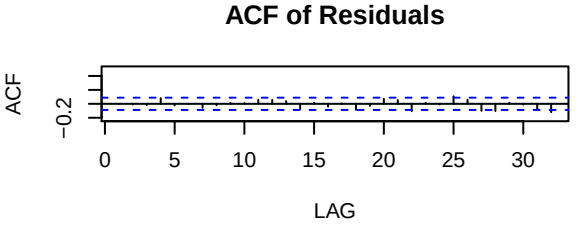
```
##
## $AICc
## [1] 5.258105
##
## $BIC
## [1] 4.303175
```

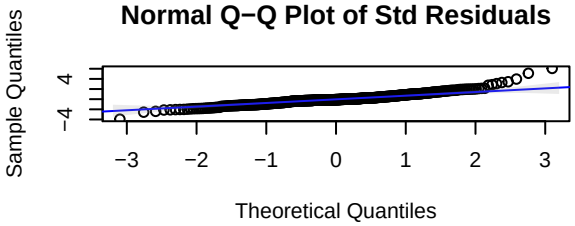
```
sarima(terror4, 0, 1, 1, 1, 0, 1, 3)
```

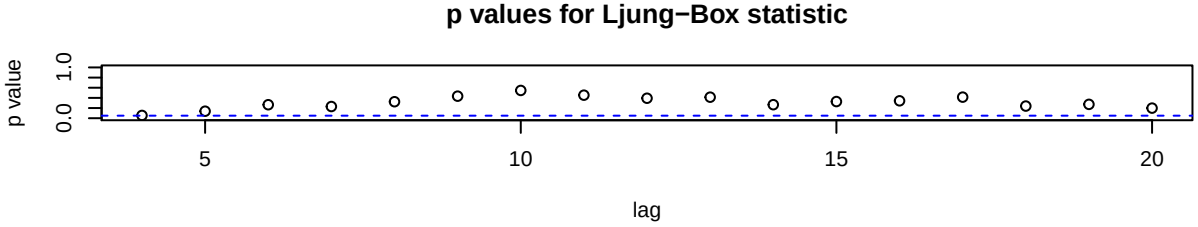
```
## initial  value 2.305540
## iter   2 value 2.149217
## iter   3 value 2.130859
## iter   4 value 2.122161
## iter   5 value 2.121837
## iter   6 value 2.121413
## iter   7 value 2.121413
## iter   8 value 2.121398
## iter   9 value 2.121392
## iter  10 value 2.121328
## iter  11 value 2.121311
## iter  12 value 2.121301
## iter  13 value 2.121295
## iter  14 value 2.121265
## iter  15 value 2.121182
## iter  16 value 2.120973
## iter  17 value 2.120737
## iter  18 value 2.120193
## iter  19 value 2.120160
## iter  20 value 2.120150
## iter  21 value 2.120144
## iter  22 value 2.120125
## iter  23 value 2.119700
## iter  24 value 2.119637
## iter  25 value 2.119590
## iter  26 value 2.119452
## iter  27 value 2.119208
## iter  28 value 2.118920
## iter  29 value 2.118896
## iter  30 value 2.118883
## iter  31 value 2.118774
## iter  32 value 2.118663
## iter  33 value 2.118609
## iter  34 value 2.118550
## iter  35 value 2.118542
## iter  36 value 2.118541
## iter  36 value 2.118541
## final  value 2.118541
## converged
## initial  value 2.116194
## iter   2 value 2.116191
## iter   3 value 2.116191
## iter   4 value 2.116191
## iter   5 value 2.116191
## iter   6 value 2.116189
## iter   7 value 2.116187
```

```
## iter   8 value 2.116186
## iter   9 value 2.116185
## iter   9 value 2.116185
## iter   9 value 2.116185
## final  value 2.116185
## converged
```









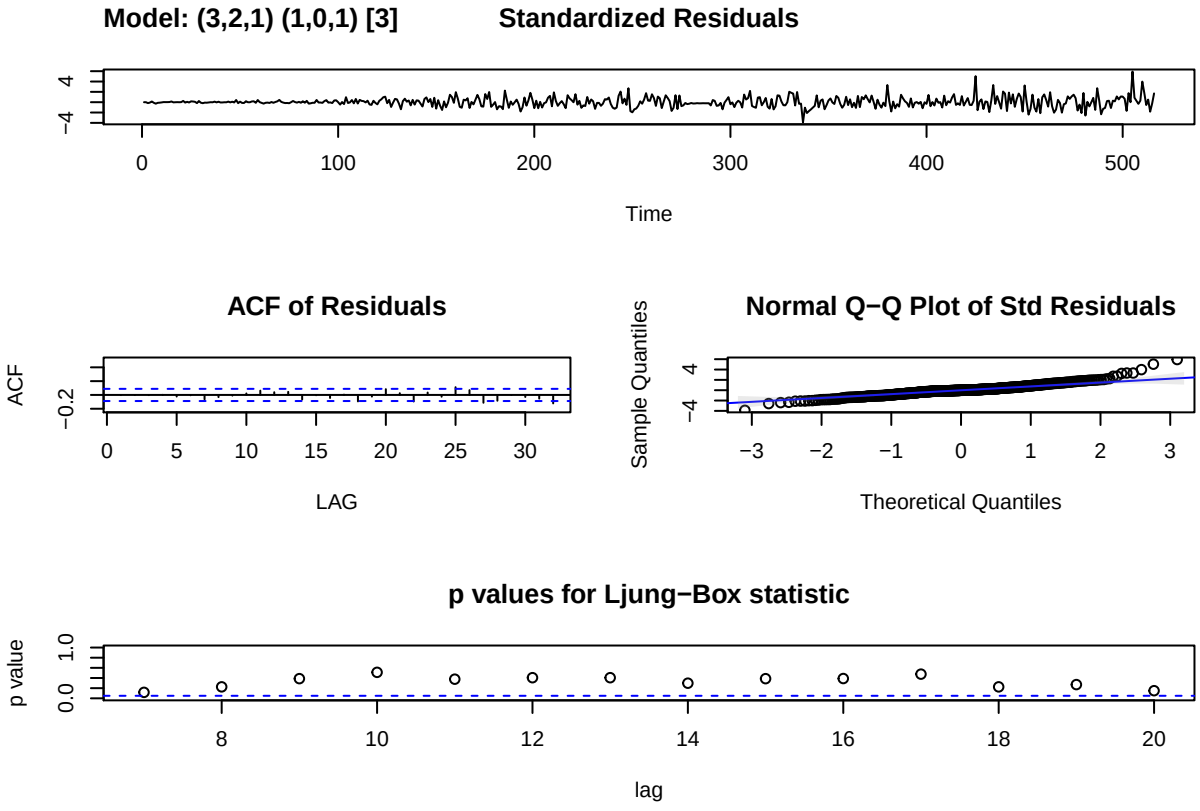

```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), xreg = constant, optim.control = list(trace = trc, REPORT = 1,
##     reltol = tol))
##
## Coefficients:
##           ma1    sar1     sma1  constant
##       -0.6617  0.8625  -0.9146    0.1422
## s.e.   0.0339  0.1004   0.0809    0.0799
##
## sigma^2 estimated as 68.77:  log likelihood = -1820.59,  aic = 3651.18
##
## $degrees_of_freedom
## [1] 511
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -0.6617 0.0339 -19.5432  0.0000
## sar1       0.8625 0.1004   8.5889  0.0000
## sma1      -0.9146 0.0809 -11.3071  0.0000
```

```
## constant   0.1422 0.0799   1.7787  0.0759
##
## $AIC
## [1] 5.246311
##
## $AICc
## [1] 5.250415
##
## $BIC
## [1] 4.279227
```

```
sarima(terror4, 3, 2, 1, 1, 0, 1, 3)
```

```
## initial  value 2.843378
## iter   2 value 2.512253
## iter   3 value 2.376225
## iter   4 value 2.316267
## iter   5 value 2.301231
## iter   6 value 2.282852
## iter   7 value 2.274573
## iter   8 value 2.187961
## iter   9 value 2.171490
## iter  10 value 2.159940
## iter  11 value 2.136502
## iter  12 value 2.130279
## iter  13 value 2.128695
## iter  14 value 2.128496
## iter  15 value 2.128196
## iter  16 value 2.128134
## iter  17 value 2.128044
## iter  18 value 2.128031
## iter  19 value 2.128027
## iter  20 value 2.128026
## iter  21 value 2.128024
## iter  22 value 2.128019
## iter  23 value 2.128010
## iter  24 value 2.128000
## iter  25 value 2.127993
## iter  26 value 2.127990
## iter  27 value 2.127990
## iter  27 value 2.127990
## final  value 2.127990
## converged
## initial  value 2.126492
## iter   2 value 2.125587
## iter   3 value 2.125566
## iter   4 value 2.125457
## iter   5 value 2.125379
## iter   6 value 2.125011
## iter   7 value 2.124671
## iter   8 value 2.124482
## iter   9 value 2.124369
## iter  10 value 2.124359
## iter  11 value 2.124349
## iter  12 value 2.124342
```

```
## iter  13 value 2.124337
## iter  14 value 2.124337
## iter  14 value 2.124337
## final  value 2.124337
## 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      ar3      ma1    sar1     sma1
##       -0.6570  -0.4395  -0.1295  -1.0000  0.1222  -0.3425
## s.e.   0.0443   0.0531   0.0738   0.0108  0.2051   0.1805
##
## sigma^2 estimated as 68.79:  log likelihood = -1821.24,  aic = 3656.49
##
## $degrees_of_freedom
## [1] 508
##
## $ttable
##      Estimate     SE  t.value p.value
## ar1   -0.6570 0.0443 -14.8275  0.0000
## ar2   -0.4395 0.0531  -8.2768  0.0000
## ar3   -0.1295 0.0738  -1.7541  0.0800
## ma1   -1.0000 0.0108 -92.6219  0.0000
```

```
## sar1   0.1222 0.2051   0.5960  0.5514
## sma1  -0.3425 0.1805  -1.8968  0.0584
##
## $AIC
## [1] 5.254339
##
## $AICc
## [1] 5.258642
##
## $BIC
## [1] 4.303713
```

```
pdf("image/best_model.pdf")
sarima(terror4, 0, 1, 1, 0, 0, 0, 0)
```

```
## initial  value 2.302665
## iter   2 value 2.148680
## iter   3 value 2.132396
## iter   4 value 2.128997
## iter   5 value 2.121714
## iter   6 value 2.120506
## iter   7 value 2.120430
## iter   8 value 2.120364
## iter   9 value 2.120362
## iter  10 value 2.120362
## iter  10 value 2.120362
## iter  10 value 2.120362
## final  value 2.120362
## converged
## initial  value 2.120944
## iter   2 value 2.120943
## iter   3 value 2.120942
## iter   3 value 2.120942
## iter   3 value 2.120942
## final  value 2.120942
## 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  constant
##       -0.6746    0.1596
## s.e.   0.0336    0.1200
##
## sigma^2 estimated as 69.46:  log likelihood = -1823.04,  aic = 3652.08
##
## $degrees_of_freedom
## [1] 513
##
## $ttable
```

```
##          Estimate     SE  t.value p.value
## ma1       -0.6746 0.0336 -20.0780  0.0000
## constant   0.1596 0.1200   1.3306  0.1839
##
## $AIC
## [1] 5.248457
##
## $AICc
## [1] 5.252424
##
## $BIC
## [1] 4.264915
```

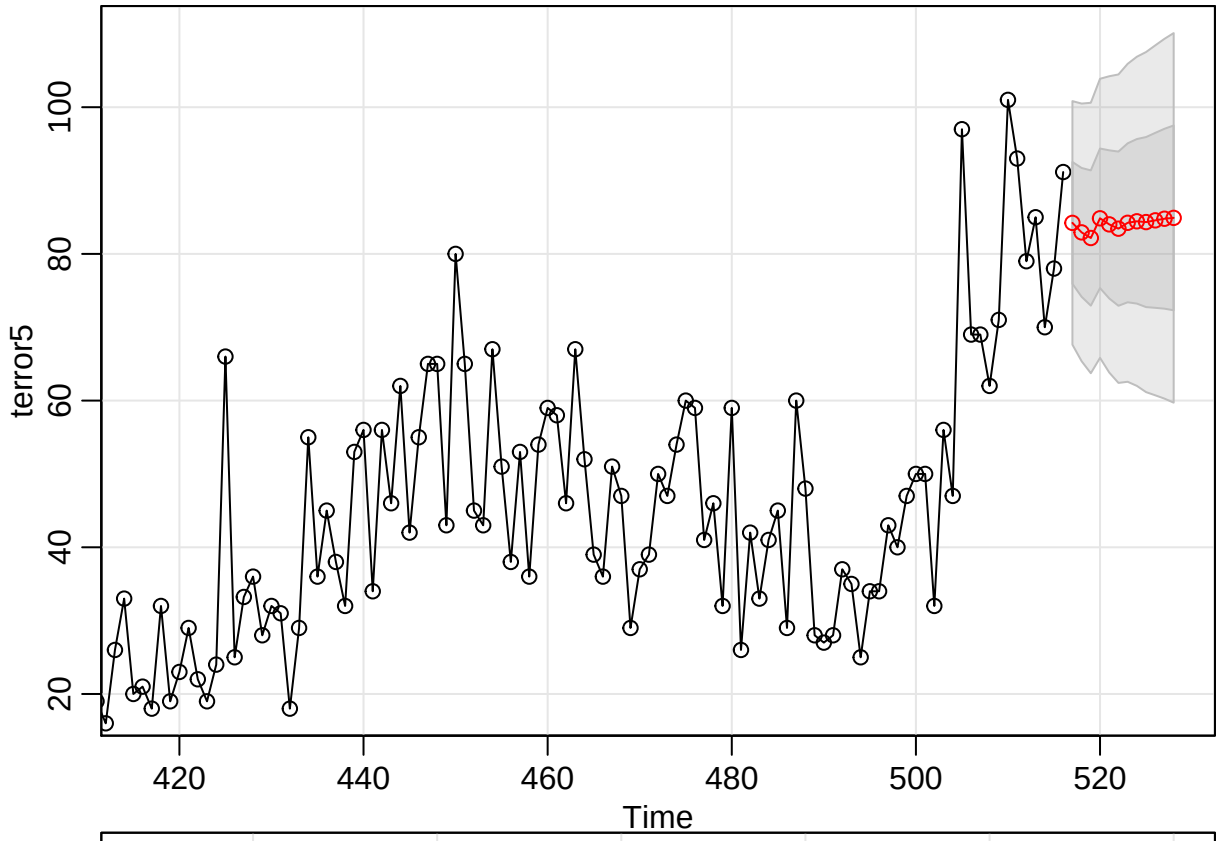
```
dev.off()
```

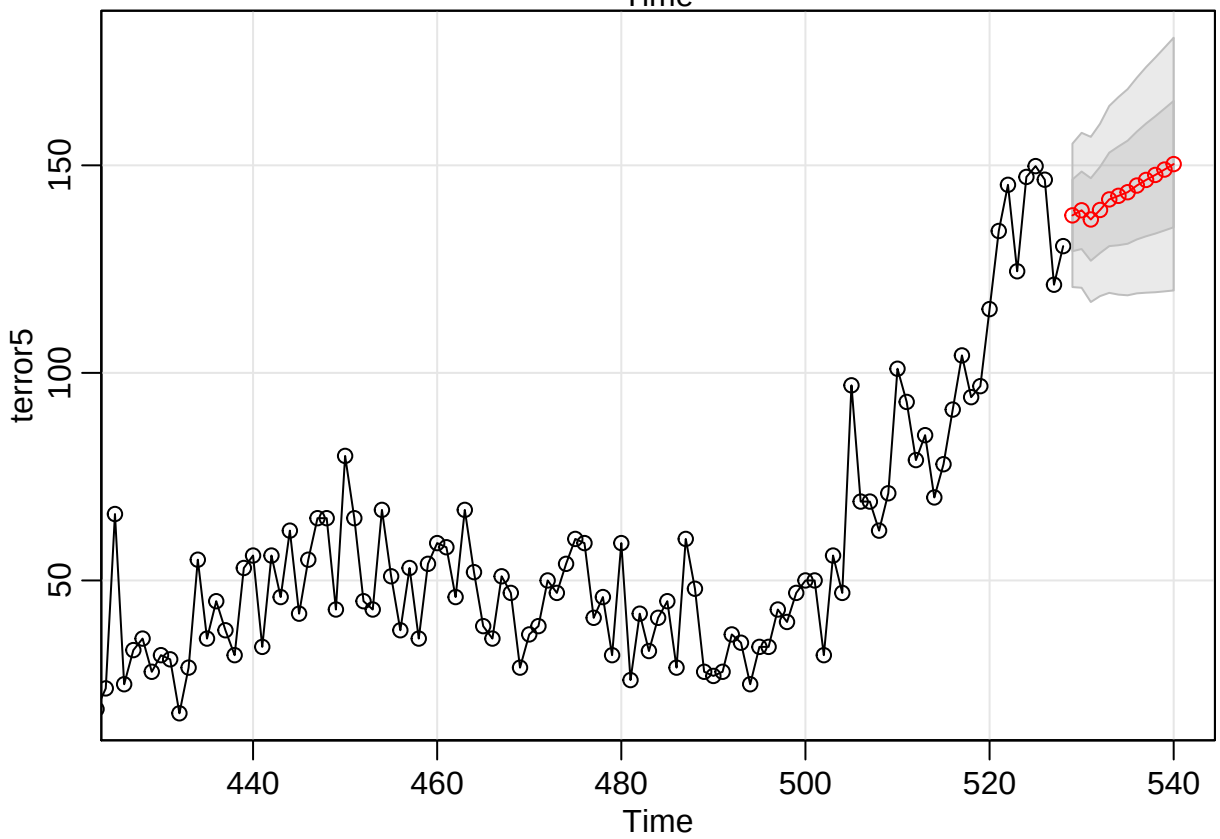
```
## pdf
##   2
```

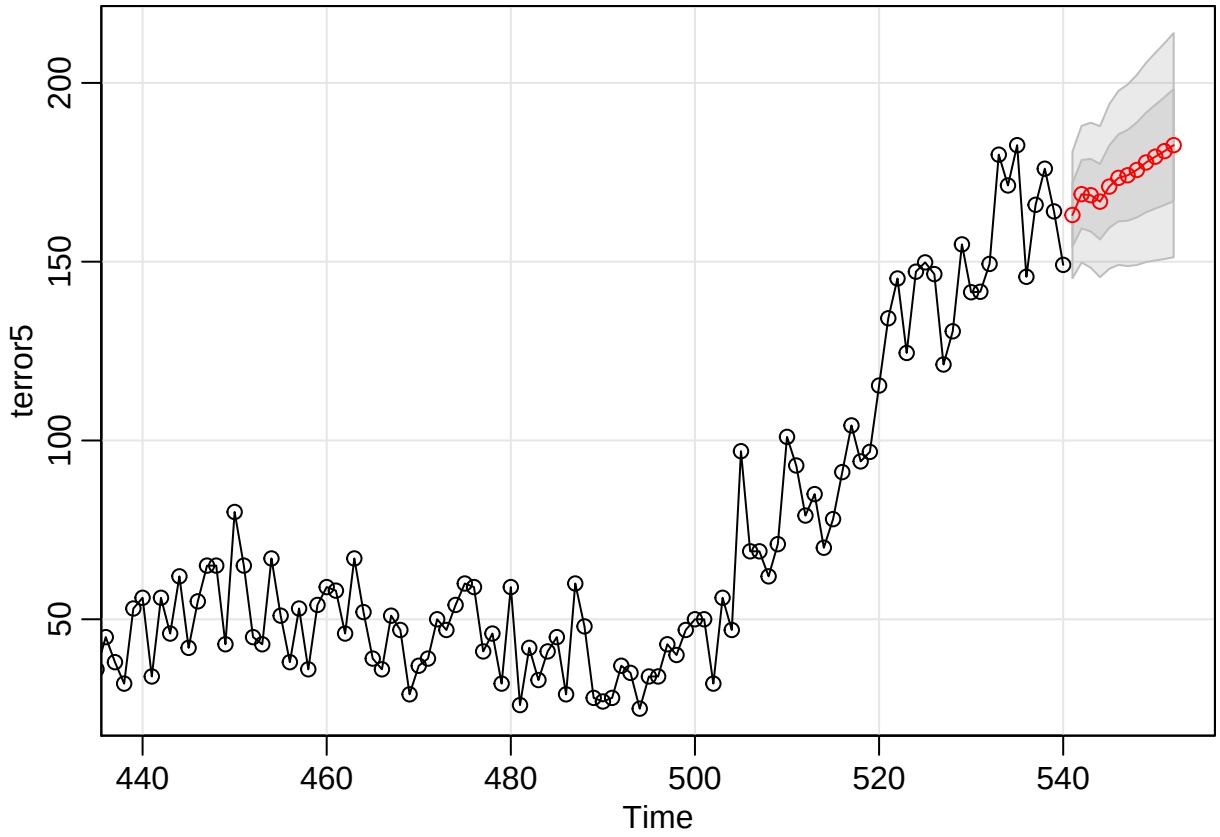
MSE calculations

change the model to see mse of different models.

```
#eacf(diff(diff(log_terror4)))
terror5 <- terror4
total_error <- 0
start_pts <- c(1, 13, 25)
for (i in start_pts)
{
  actual <- terror4.valid[i : (i + 11)]
  predicted <- sarima.for(terror5, 12, 3, 2, 1, 1, 0, 1, 3)$pred
  total_error <- total_error + sum((actual - predicted)^2)
  terror5 <- c(terror5, terror4.valid[i : (i + 11)])
}
```


terror5
20
40
60
80
100
420
440
460
480
500
520
Time


terror5
50
100
150
440
460
480
500
520
540
Time

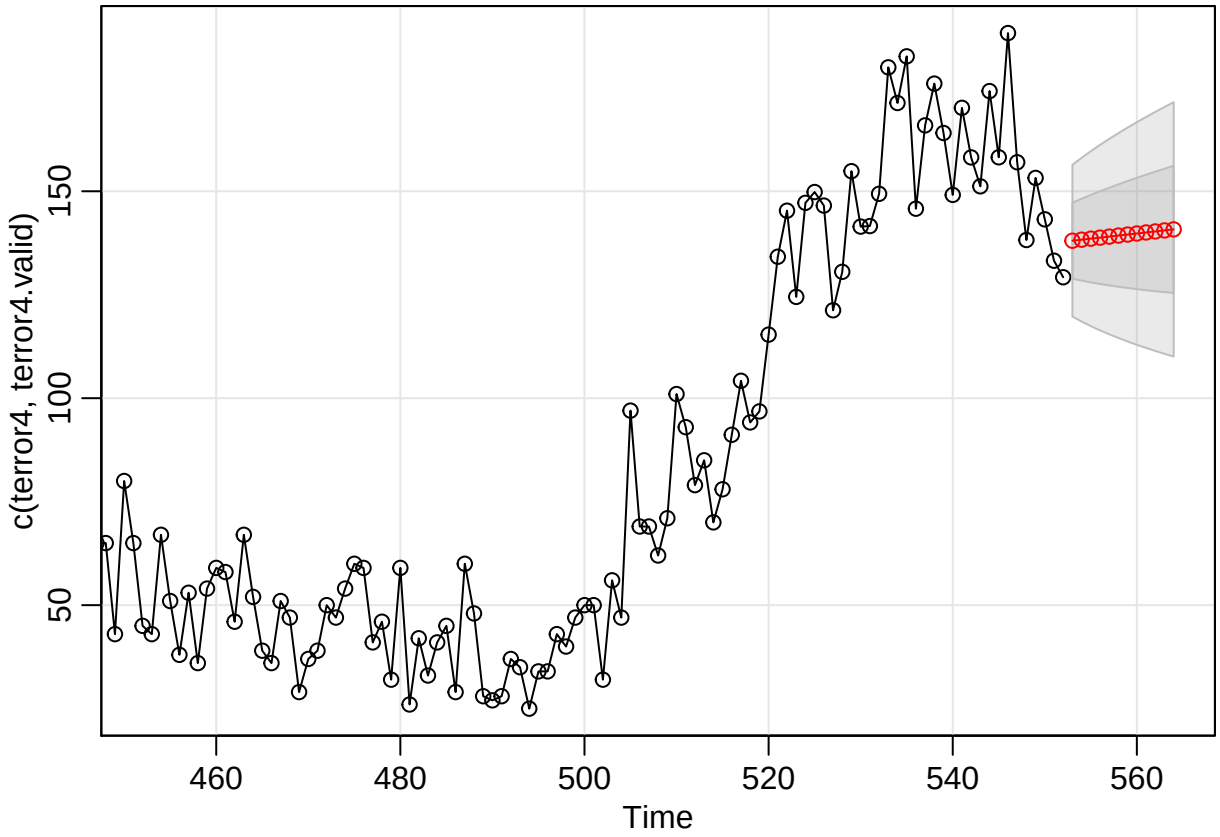



```
mse <- total_error / length(start_pts)
mse
```

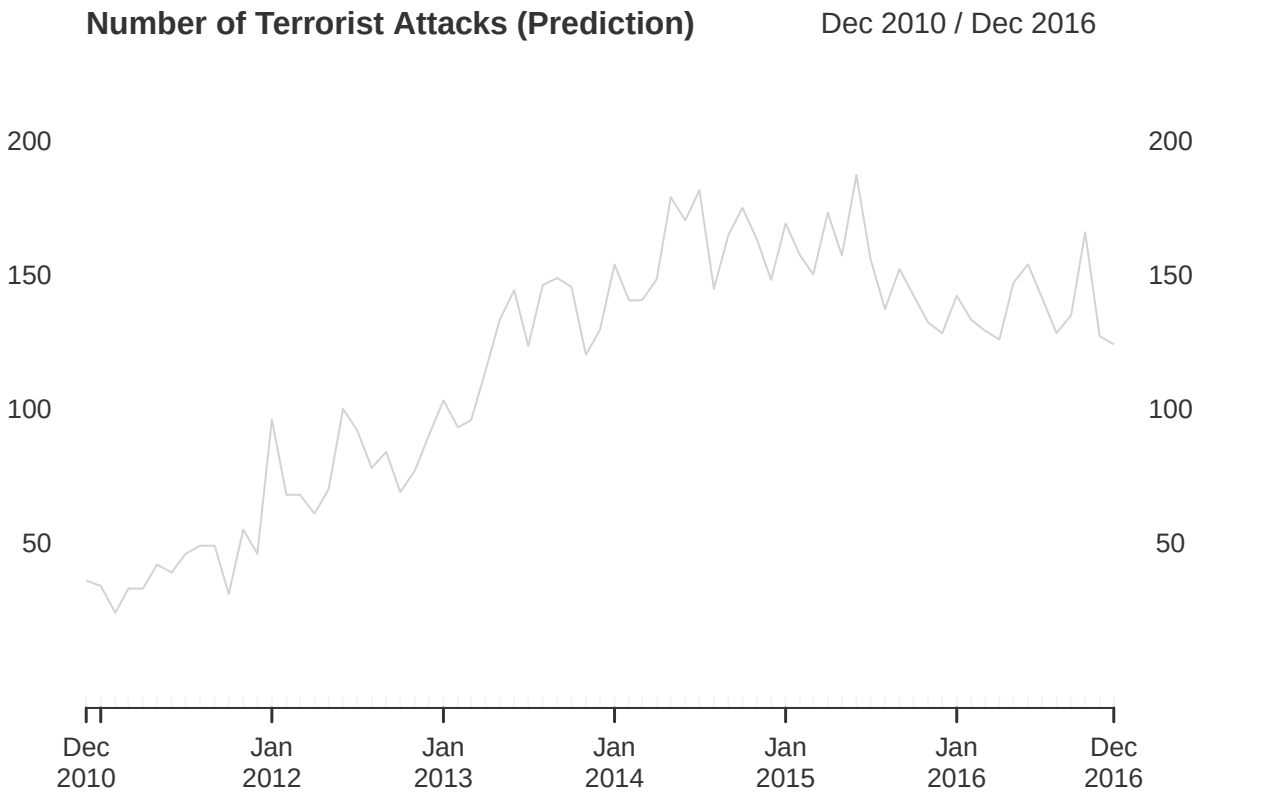
```
## [1] 13456.07
```

Predicting the future using our best model

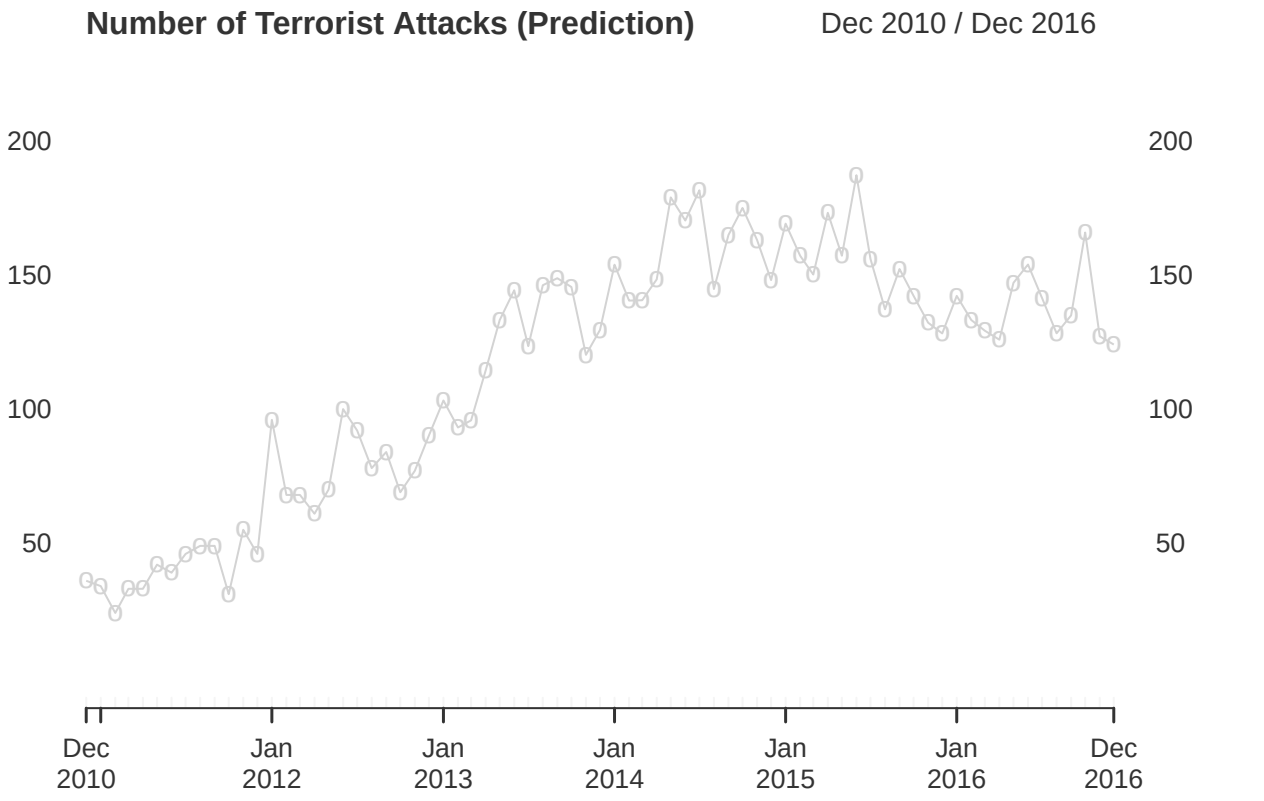
```
val <- sarima.for(c(terror4, terror4.valid), 12, 0, 1, 1, 0, 0, 0, 0)
```



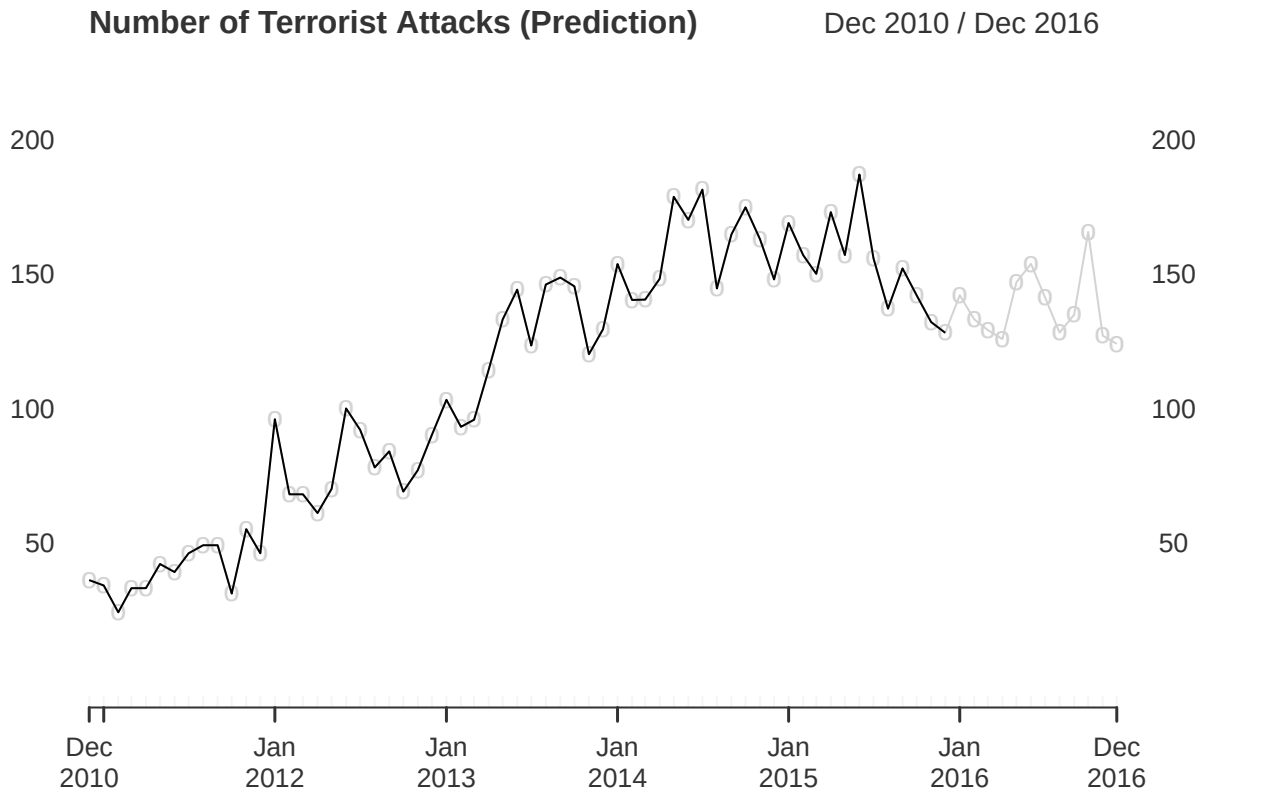

```
pred <-val$pred
err  <-val$se
total <- c(terror4, terror4.valid, terror4.testing)
par(cex.main = 2)
plot(as.xts(ts(total, frequency = 12, start=1970))[492:length(total)], main = "Number of Terrorist Atta
```



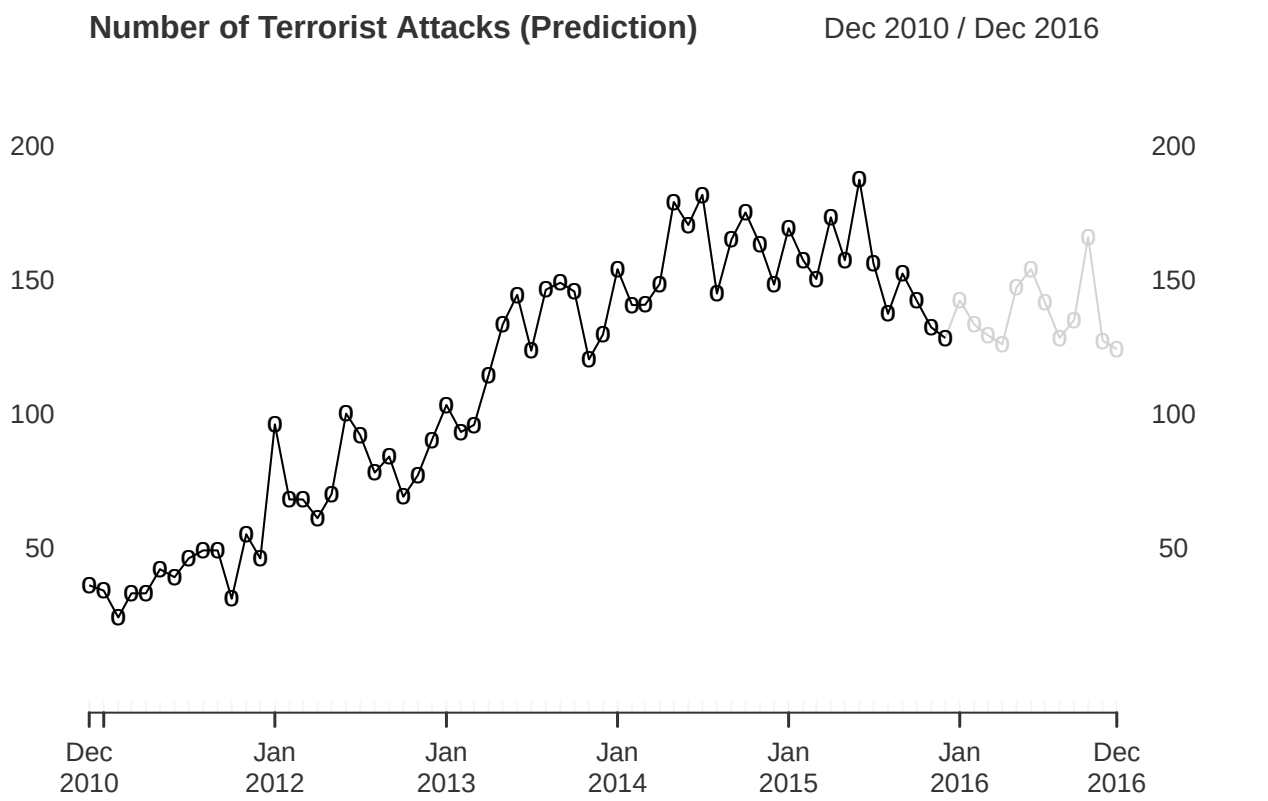

```
points(as.xts(ts(total, frequency = 12, start=1970)),col="lightgray",pch="o")
```



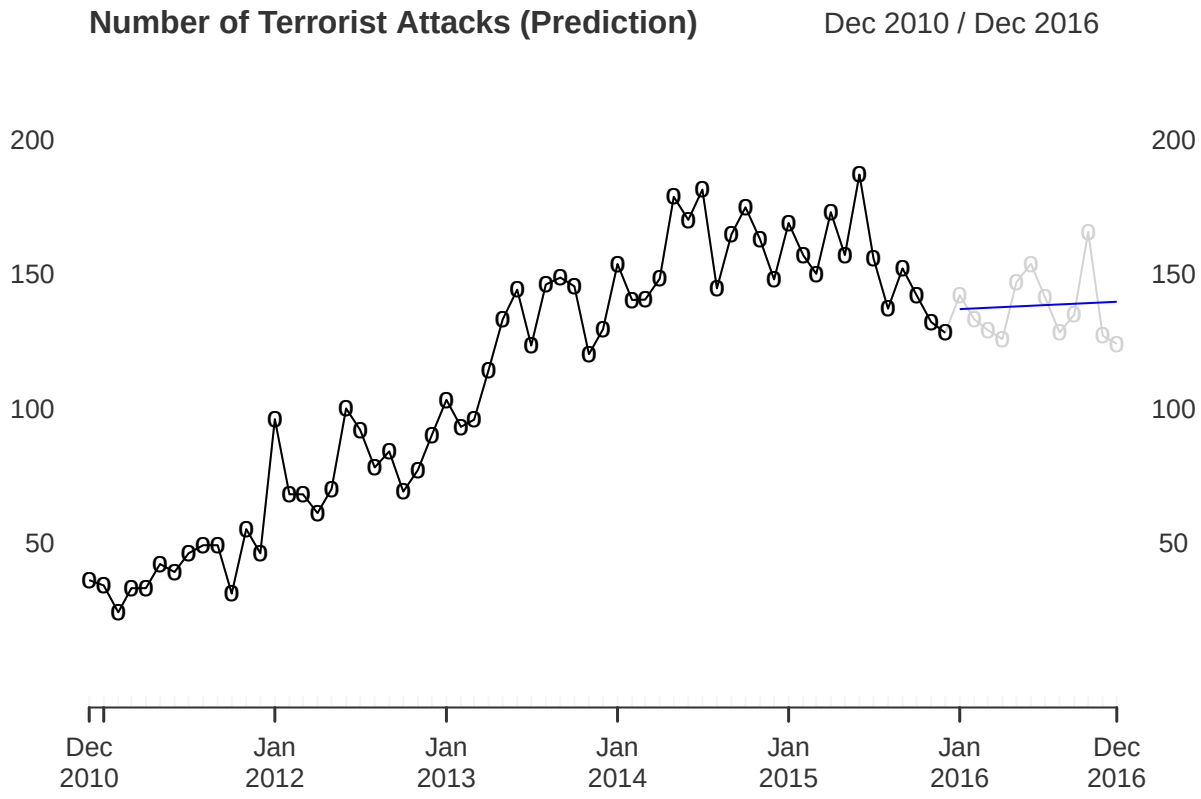
```
lines(as.xts(ts(c(terror4, terror4.valid), frequency = 12, start=1970)),col="black")
```



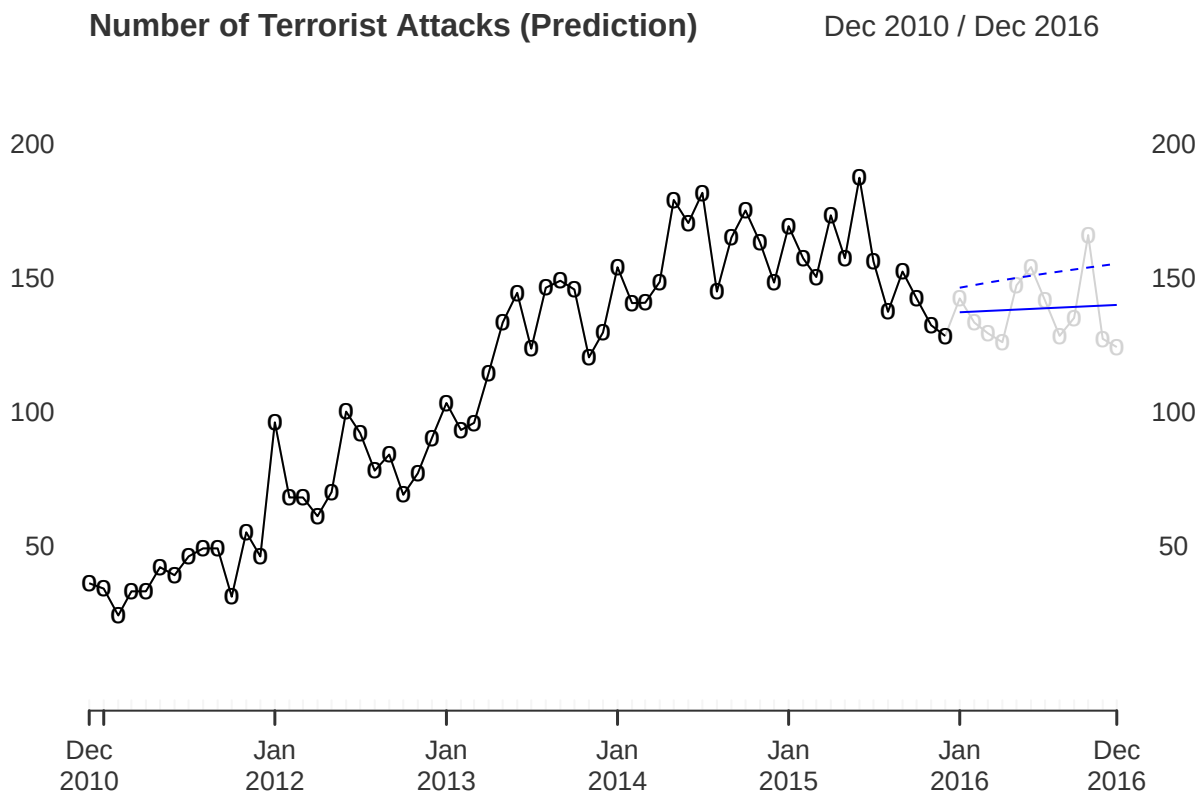

```
points(as.xts(ts(c(terror4, terror4.valid), frequency = 12, start=1970)),col="black",pch="o")
```



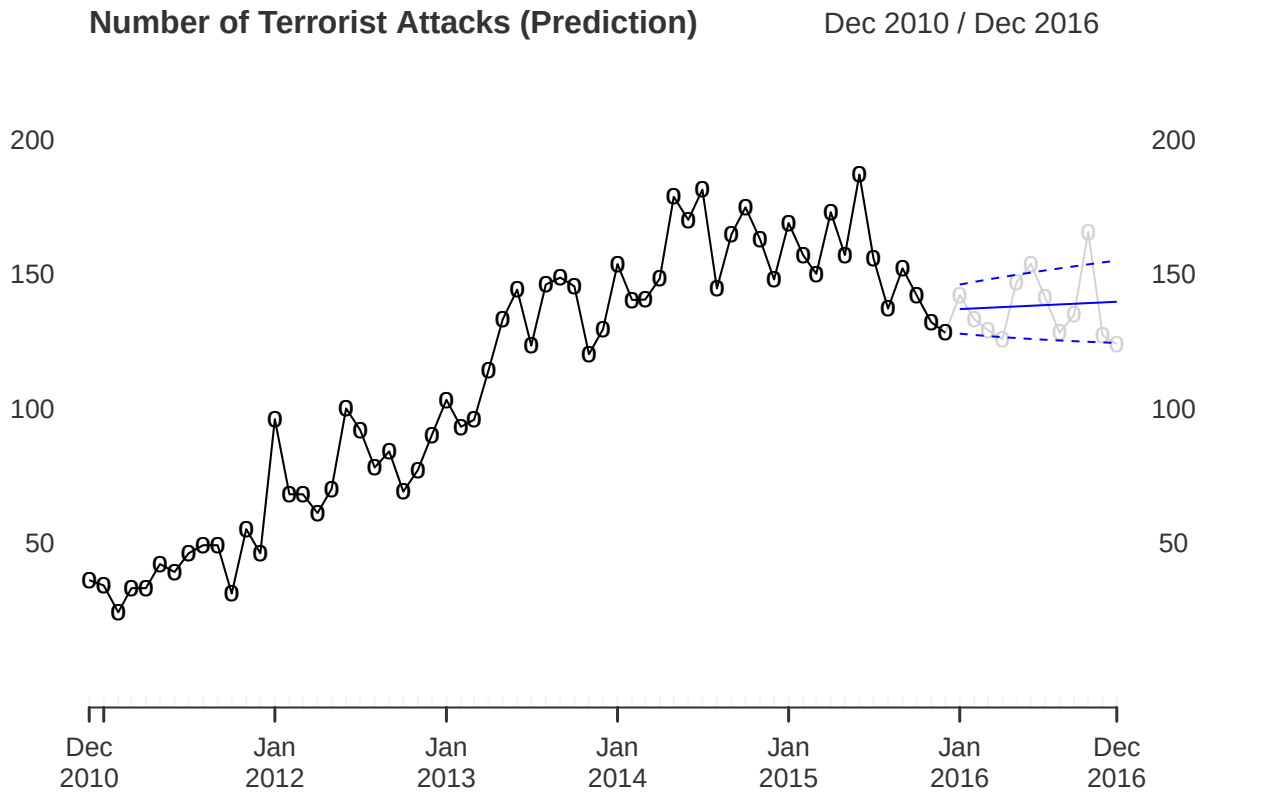
```
lines(as.xts(ts(pred, frequency = 12, start=2016)),col="blue")
```



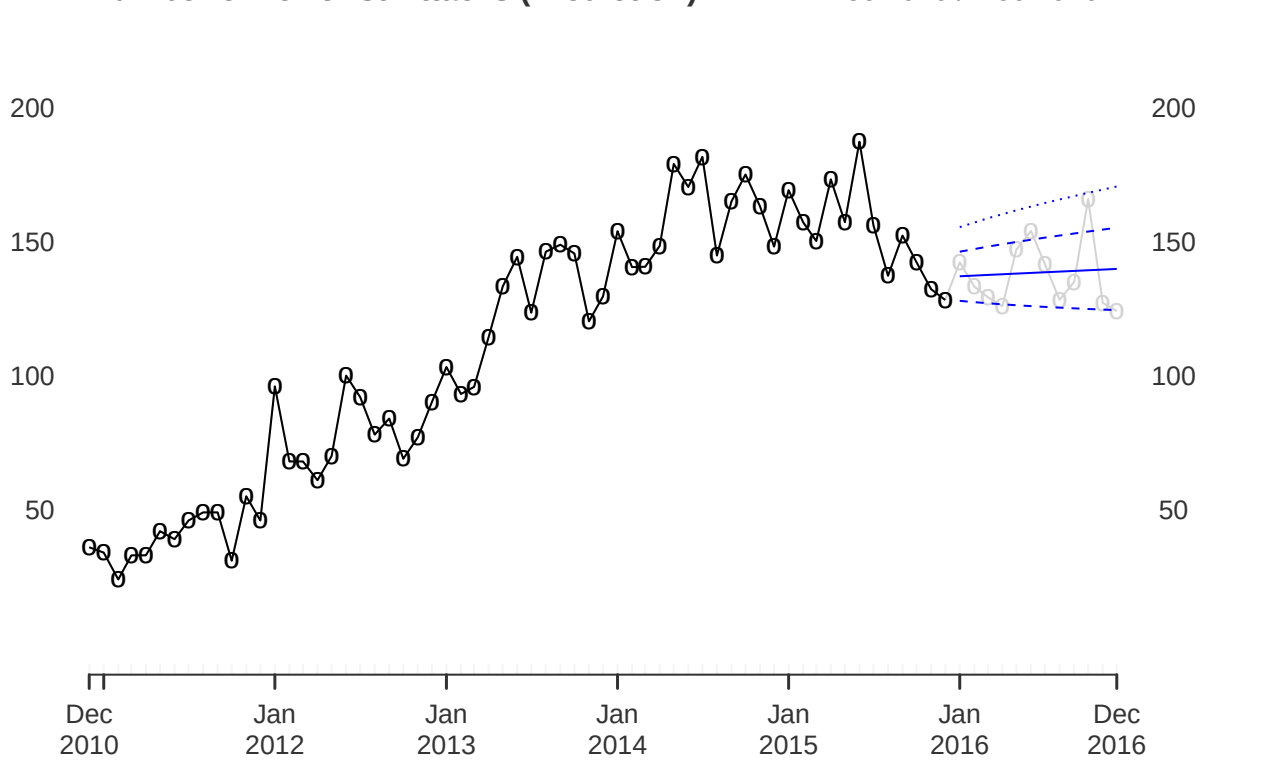

```
lines(as.xts(ts(pred + err, frequency = 12, start=2016)),col="blue", lty="dashed")
```



```
lines(as.xts(ts(pred - err, frequency = 12, start=2016)),col="blue", lty="dashed")
```




```
lines(as.xts(ts(pred + 2*err, frequency = 12, start=2016)),col="blue", lty="dotted")
```



```
pdf("image/prediction_on_testing.pdf")
lines(as.xts(ts(pred - 2*err, frequency = 12, start=2016)),col="blue", lty="dotted")
dev.off()
```

```
## pdf
##   2
```

```
mse <- sum((pred - terror4.testing)^2)
mse
```

```
## [1] 1821.601
```