STATS 207 Project RMD

```r
library(astsa)
library(forecast)
```

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

##
## Attaching package: 'forecast'

## The following object is masked from 'package:astsa':
##
##     gas
```

```r
library(tseries)
library(Metrics)
```

```
##
## Attaching package: 'Metrics'

## The following object is masked from 'package:forecast':
##
##     accuracy
```

```r
library(xts)
```

```
## Loading required package: zoo

##
## Attaching package: 'zoo'

## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

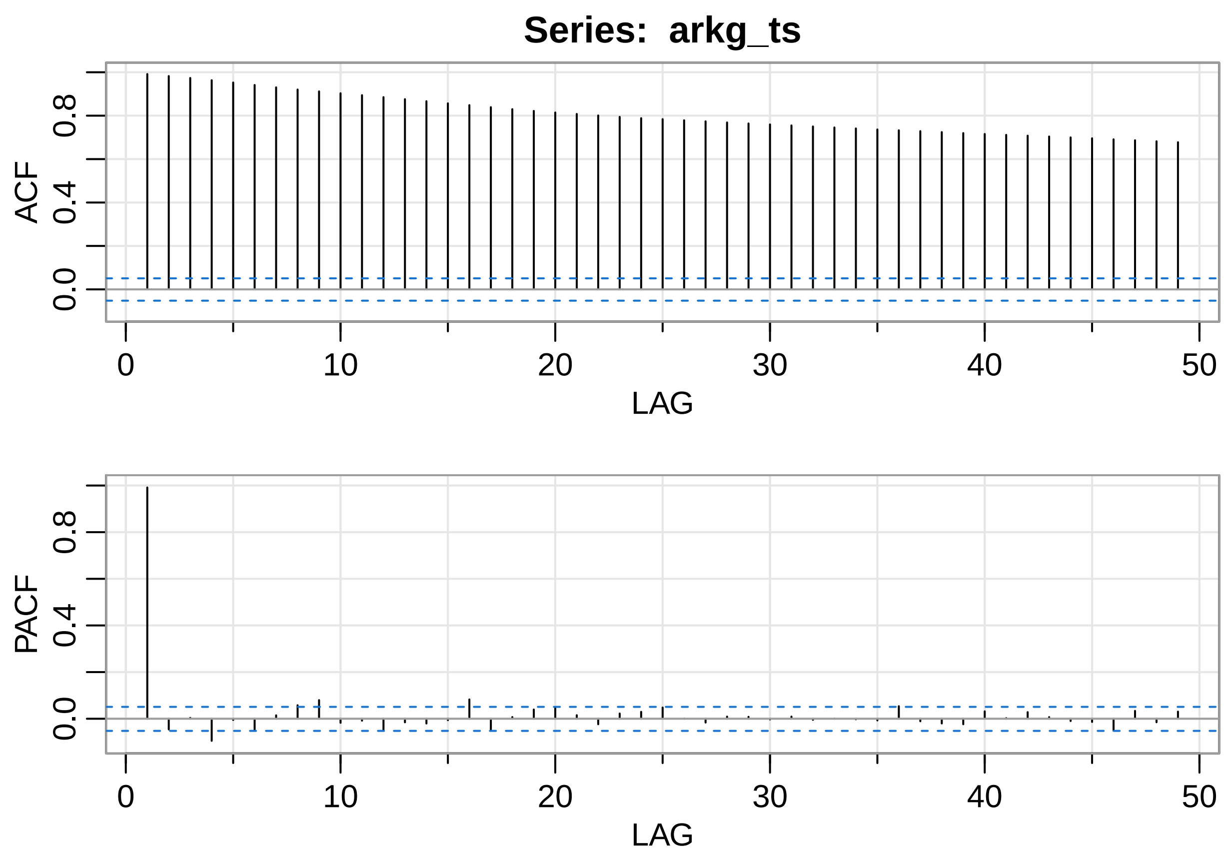
```r
library(dlm)

## Import data and preprocess data
## We use the closing data here
arkg <- read.csv('arkg.csv')
arkg$Date <- as.Date(arkg$Date)
arkg_ts <- xts(arkg$Close, arkg$Date)
arkg2021 <- read.csv('arkg2021.csv')
full_ark <- read.csv('ARKGFULL.csv')
full_ark$Date <- as.Date(full_ark$Date)
fulla_ts <- as.ts(full_ark$Close, full_ark$Date)

qqq <- read.csv('qqq.csv')
```

```r
qqq$Date <- as.Date(qqq$Date)
qqq_ts <- xts(qqq$Close, qqq$Date)
qqq2021 <- read.csv('qqq2021.csv')
full_qqq <- read.csv('QQQFULL.csv')
full_qqq$Date <- as.Date(full_qqq$Date)
fullq_ts <- as.ts(full_qqq$Close, full_qqq$Date)

schf <- read.csv('schf.csv')
schf$Date <- as.Date(schf$Date)
schf_ts <- xts(schf$Close, schf$Date)
schf2021 <- read.csv('schf2021.csv')
full_schf <- read.csv('SCHFFULL.csv')
full_schf$Date <- as.Date(full_schf$Date)
fulls_ts <- as.ts(full_schf$Close, full_schf$Date)

vt <- read.csv('vt.csv')
vt$Date <- as.Date(vt$Date)
vt_ts <- xts(vt$Close, vt$Date)
vt2021 <- read.csv('vt2021.csv')
full_vt <- read.csv('VTFULL.csv')
full_vt$Date <- as.Date(full_vt$Date)
fullv_ts <- as.ts(full_vt$Close, full_vt$Date)

xlf <- read.csv('xlf.csv')
xlf$Date <- as.Date(xlf$Date)
xlf_ts <- xts(xlf$Close, xlf$Date)
xlf2021 <- read.csv('xlf2021.csv')
full_xlf <- read.csv('XLFFULL.csv')
full_xlf$Date <- as.Date(full_xlf$Date)
fullx_ts <- as.ts(full_xlf$Close, full_xlf$Date)
```

```r
## ARKG Plotting and ARIMA Fitting
plot(arkg_ts)
```

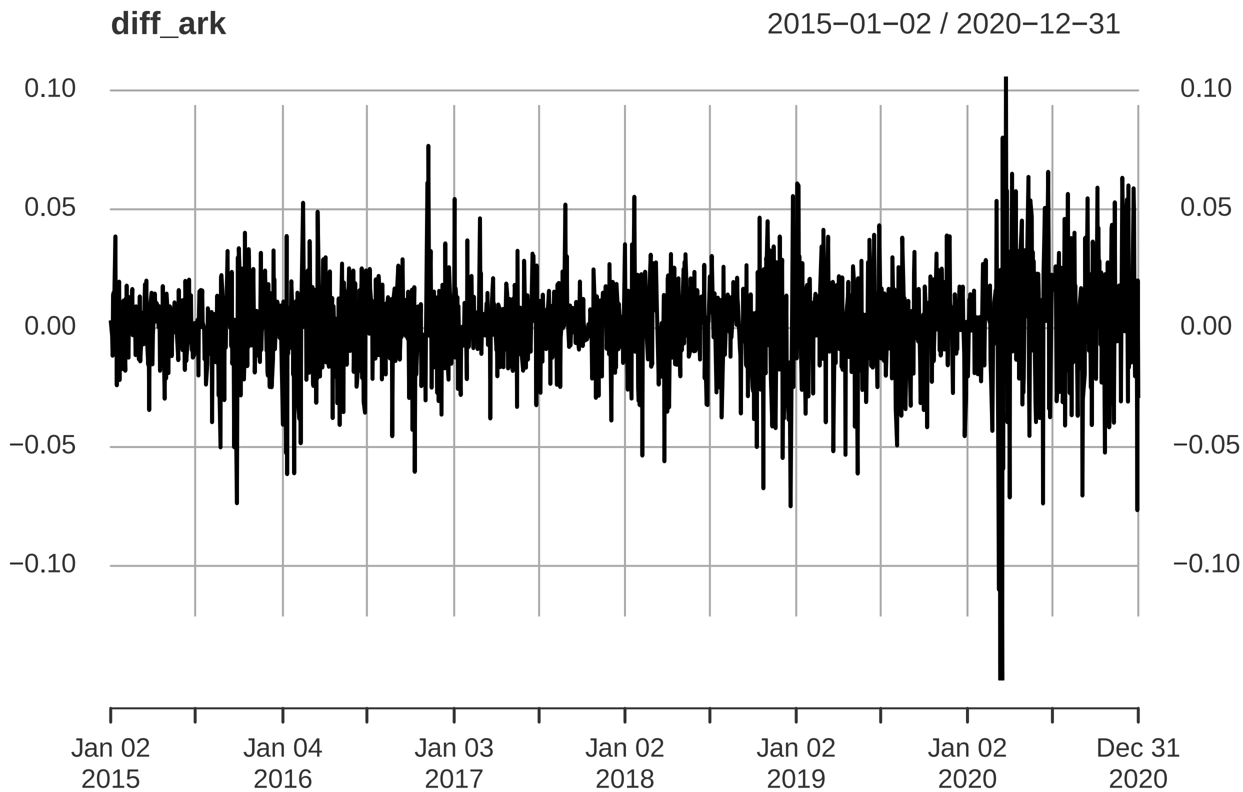

arkg_ts
2014−12−31 / 2020−12−31
100
80
60
40
20
Dec 31 2014
Dec 01 2015
Dec 01 2016
Dec 01 2017
Dec 03 2018
Dec 02 2019
Nov 30 2020

```
acf2(arkg_ts)
```

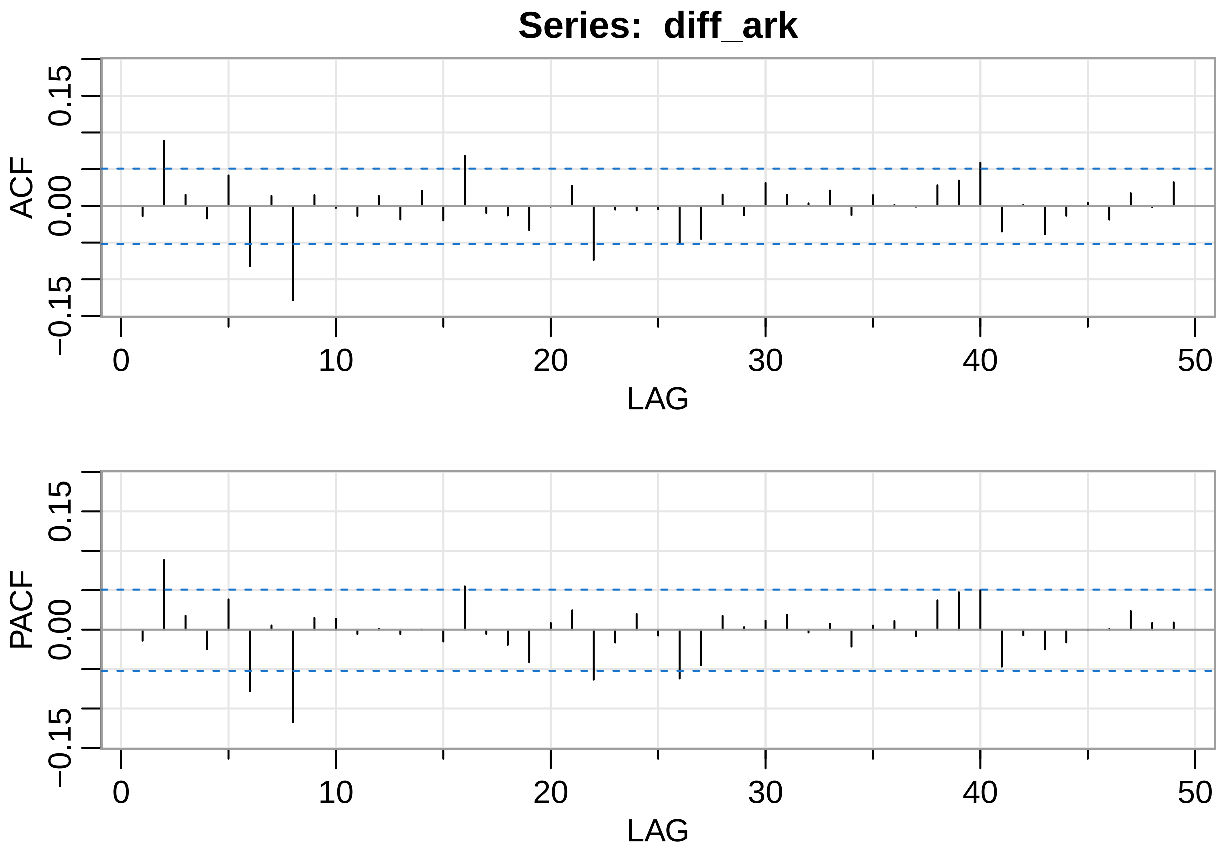



```
##      [,1]  [,2] [,3]  [,4]  [,5]  [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13]
## ACF  0.99  0.98 0.97  0.96  0.95  0.94 0.93 0.92 0.91  0.90  0.89  0.89  0.88
## PACF 0.99 -0.05 0.00 -0.09 -0.01 -0.05 0.01 0.06 0.08 -0.02 -0.01 -0.05 -0.02
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25]
## ACF   0.87  0.86  0.85  0.84  0.83  0.82  0.81  0.81  0.80  0.79  0.79  0.78
## PACF -0.02 -0.01  0.08 -0.05  0.01  0.04  0.05  0.02 -0.02  0.02  0.03  0.05
##      [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36] [,37]
## ACF   0.78  0.77  0.77  0.76  0.76  0.76  0.75  0.75  0.74  0.74  0.73  0.73
## PACF  0.00 -0.02  0.01  0.01  0.00  0.01  0.00  0.00  0.00 -0.01  0.05 -0.01
##      [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48] [,49]
## ACF   0.72  0.72  0.72  0.71  0.71  0.70  0.70  0.70  0.69  0.69  0.68  0.68
## PACF -0.02 -0.02  0.03  0.00  0.03  0.01 -0.01 -0.01 -0.05  0.03 -0.02  0.03
```

```r
diff_ark <- diff(log(arkg_ts))
diff_ark <- diff_ark[!is.na(diff_ark)]
plot(diff_ark)
```




```
acf2(diff_ark)
```

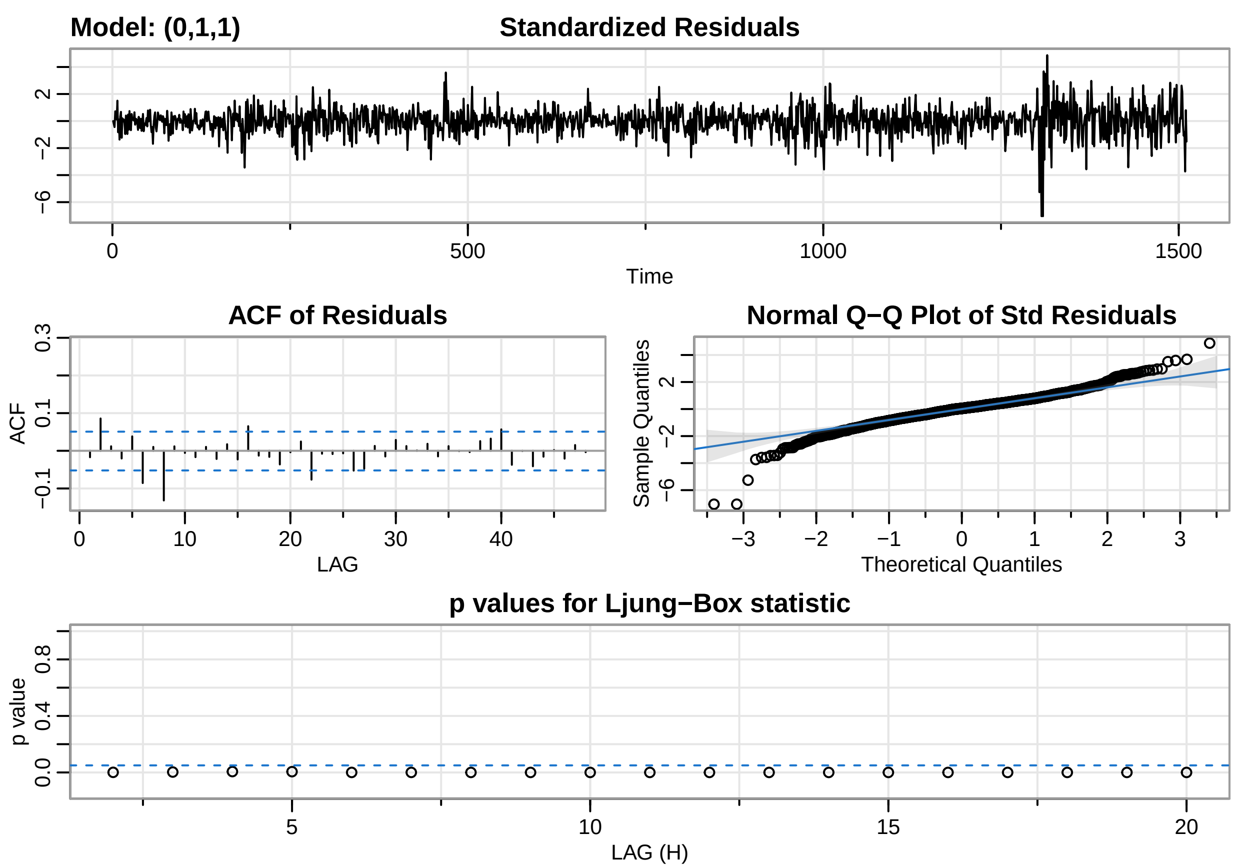



```
##       [,1] [,2] [,3]  [,4] [,5]  [,6] [,7]  [,8] [,9] [,10] [,11] [,12] [,13]
## ACF  -0.01 0.09 0.02 -0.02 0.04 -0.08 0.01 -0.13 0.01  0.00 -0.01  0.01 -0.02
## PACF -0.01 0.09 0.02 -0.02 0.04 -0.08 0.01 -0.12 0.02  0.01 -0.01  0.00 -0.01
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25]
## ACF   0.02 -0.02  0.07 -0.01 -0.01 -0.03  0.00  0.03 -0.07 -0.01 -0.01  0.00
## PACF  0.00 -0.02  0.05 -0.01 -0.02 -0.04  0.01  0.02 -0.06 -0.02  0.02 -0.01
##      [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36] [,37]
## ACF  -0.05 -0.04  0.02 -0.01  0.03  0.01     0  0.02 -0.01  0.01  0.00  0.00
## PACF -0.06 -0.05  0.02  0.00  0.01  0.02     0  0.01 -0.02  0.01  0.01 -0.01
##      [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48] [,49]
## ACF   0.03  0.03  0.06 -0.03  0.00 -0.04 -0.01     0 -0.02  0.02  0.00  0.03
## PACF  0.04  0.05  0.05 -0.05 -0.01 -0.03 -0.02     0  0.00  0.02  0.01  0.01
```

```
mod1 <- sarima(diff_ark, 0, 1, 1)
```

```
## initial  value -3.494691
## iter   2 value -3.728554
## iter   3 value -3.773105
## iter   4 value -3.812297
## iter   5 value -3.822536
## iter   6 value -3.834261
## iter   7 value -3.837134
## iter   8 value -3.840091
## iter   9 value -3.842498
## iter  10 value -3.845329
```

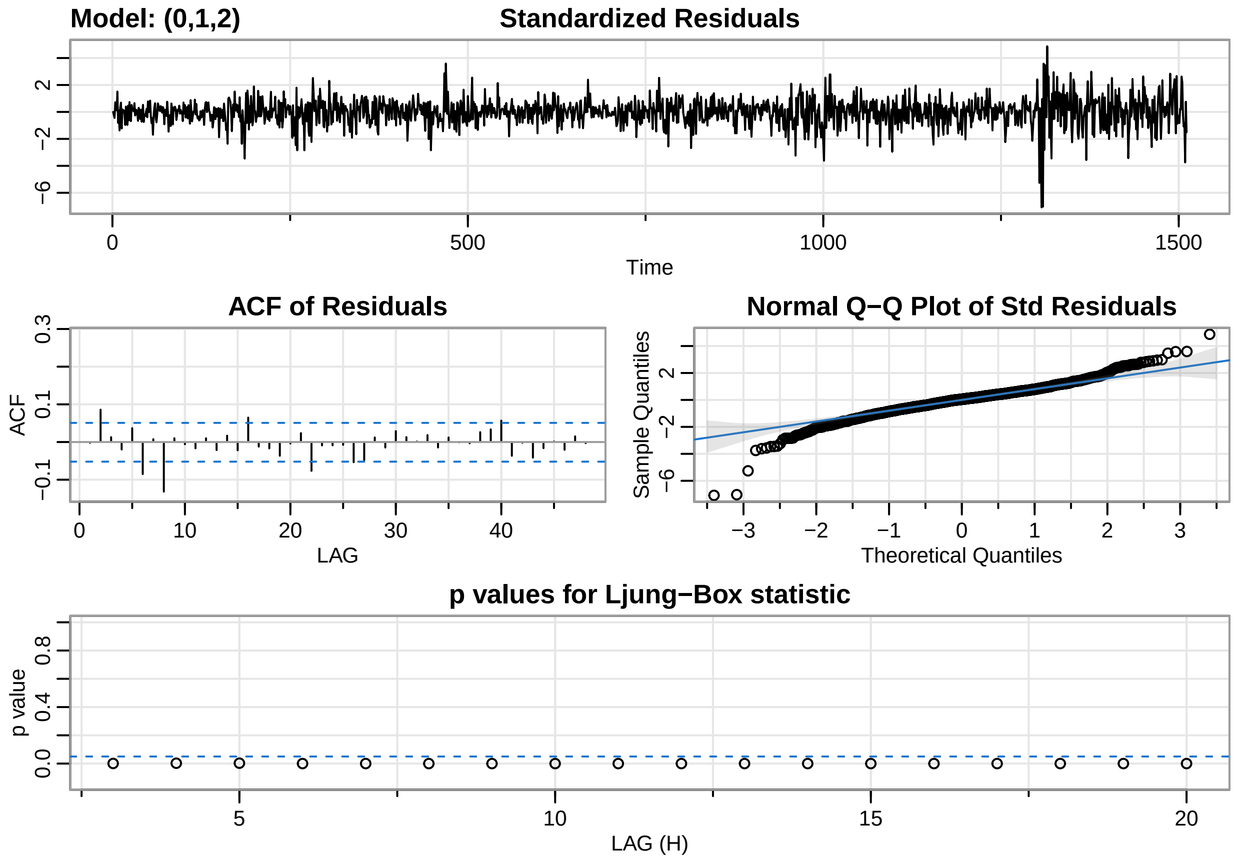
```
## iter  11 value -3.845933
## iter  12 value -3.846311
## iter  13 value -3.846387
## iter  14 value -3.846487
## iter  15 value -3.846509
## iter  16 value -3.846516
## iter  16 value -3.846516
## iter  16 value -3.846516
## final  value -3.846516
## converged
## initial  value -3.846024
## iter   2 value -3.846111
## iter   3 value -3.846404
## iter   4 value -3.846803
## iter   5 value -3.846881
## iter   6 value -3.846894
## iter   6 value -3.846894
## final  value -3.846894
## converged
```




```
mod2 <- sarima(diff_ark, 0, 1, 2)
```

```
## initial  value -3.494691
## iter   2 value -3.718010
## iter   3 value -3.775588
```

```
## iter   4 value -3.836484
## iter   5 value -3.837701
## iter   6 value -3.840629
## iter   7 value -3.842361
## iter   8 value -3.844046
## iter   9 value -3.844565
## iter  10 value -3.845853
## iter  11 value -3.846411
## iter  12 value -3.846422
## iter  13 value -3.846424
## iter  14 value -3.846601
## iter  15 value -3.846620
## iter  16 value -3.846621
## iter  17 value -3.846621
## iter  17 value -3.846621
## iter  17 value -3.846621
## final  value -3.846621
## converged
## initial  value -3.846114
## iter   2 value -3.846220
## iter   3 value -3.846618
## iter   4 value -3.846799
## iter   5 value -3.846988
## iter   6 value -3.847007
## iter   7 value -3.847008
## iter   7 value -3.847008
## iter   7 value -3.847008
## final  value -3.847008
## converged
```

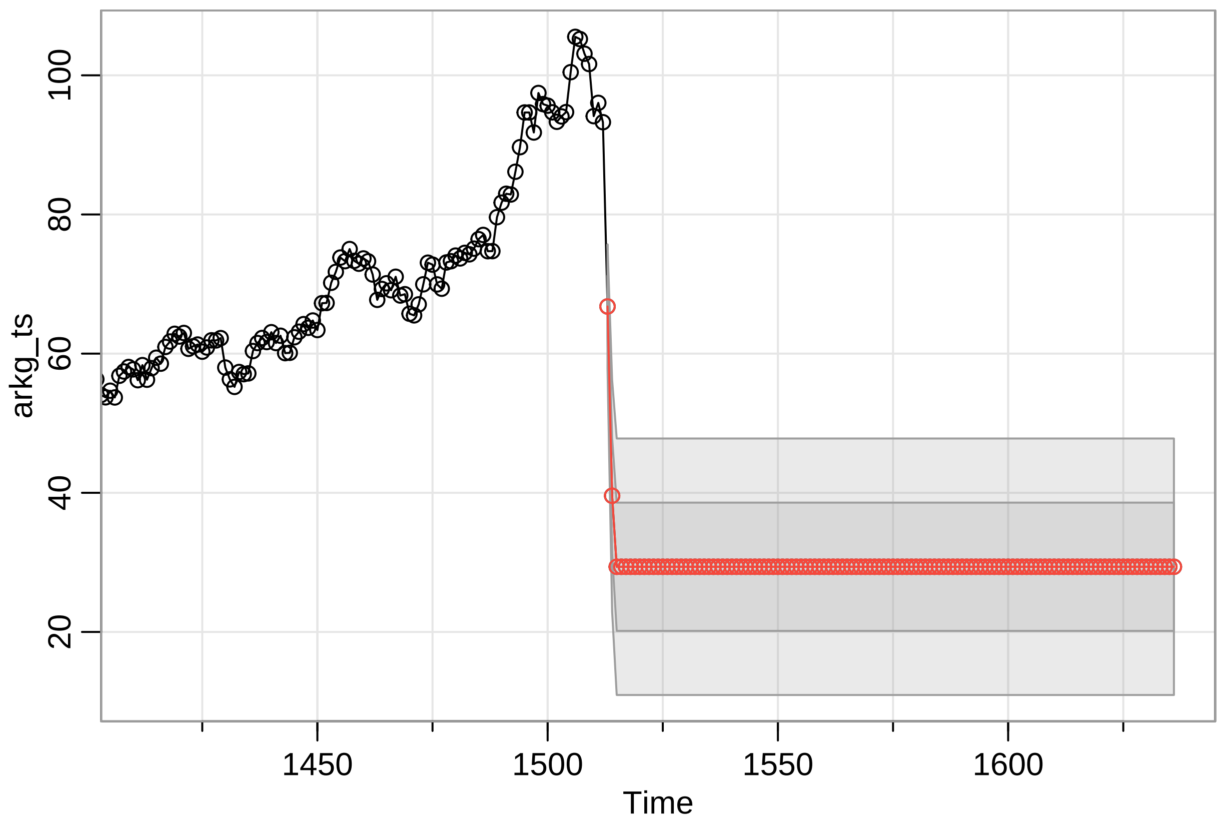



```
mod2
```

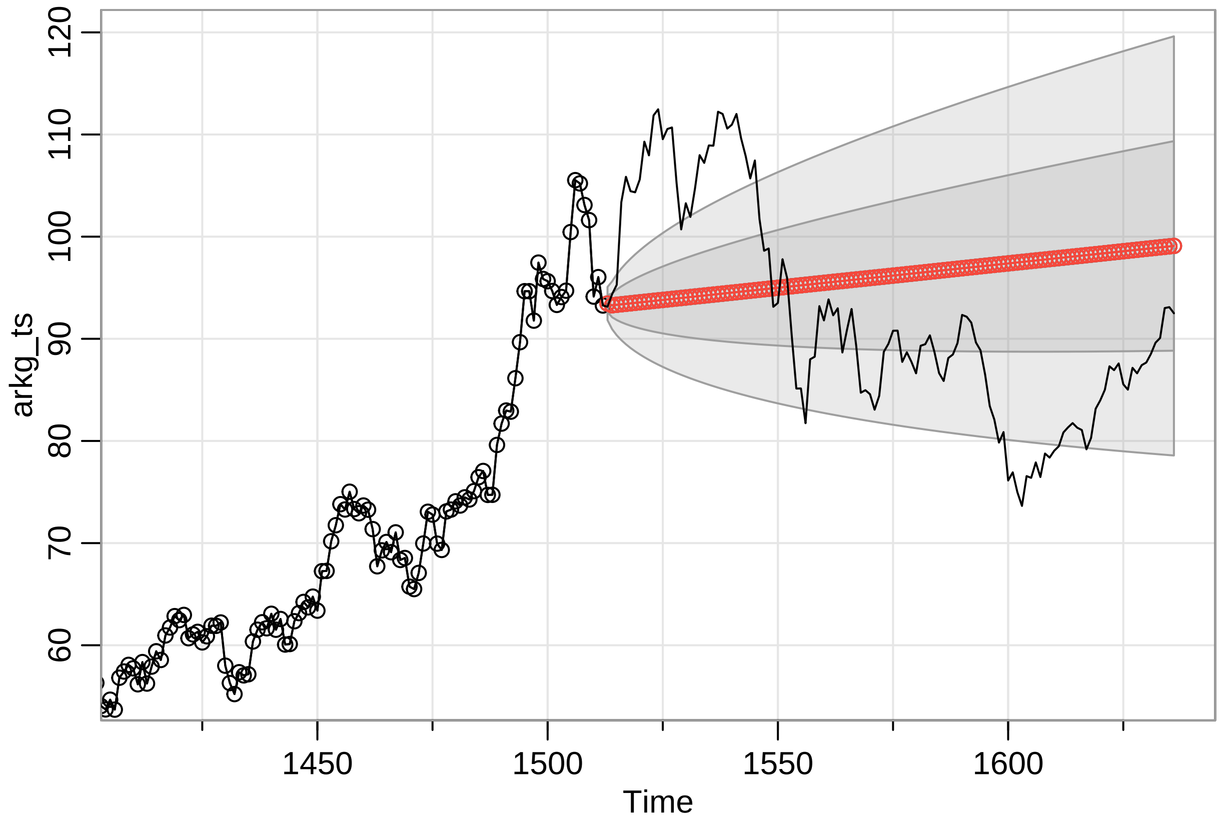
```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##             ma1     ma2  constant
##         -1.0139  0.0139         0
## s.e.     0.0239  0.0238         0
##
## sigma^2 estimated as 0.0004533:  log likelihood = 3666.39,  aic = -7324.77
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -1.0139 0.0239 -42.4304  0.0000
## ma2        0.0139 0.0238   0.5824  0.5604
## constant   0.0000 0.0000   0.1017  0.9190
##
## $AIC
```

```
## [1] -4.850841
##
## $AICc
## [1] -4.850831
##
## $BIC
## [1] -4.836749
```

```r
preds1 <- sarima.for(arkg_ts, 124, 0, 0, 2)
```




```r
preds2 <- sarima.for(arkg_ts, 124, 0, 1, 2)
lines(fulla_ts)
```



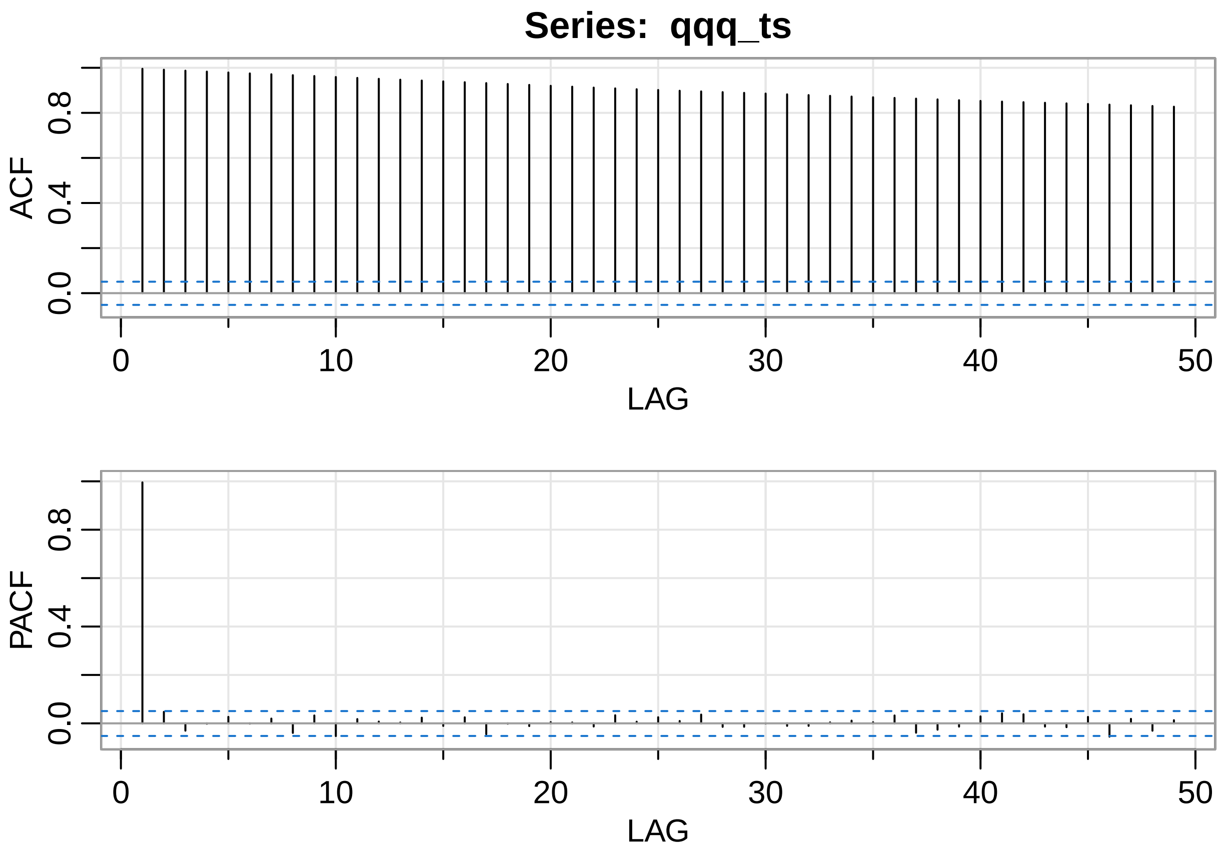

```r
sqrt(mse(arkg2021$Close, preds2$pred)) ## Second model MSE
```

```
## [1] 12.45466
```

```r
## QQQ Plotting and ARIMA Fitting
plot(qqq_ts)
```

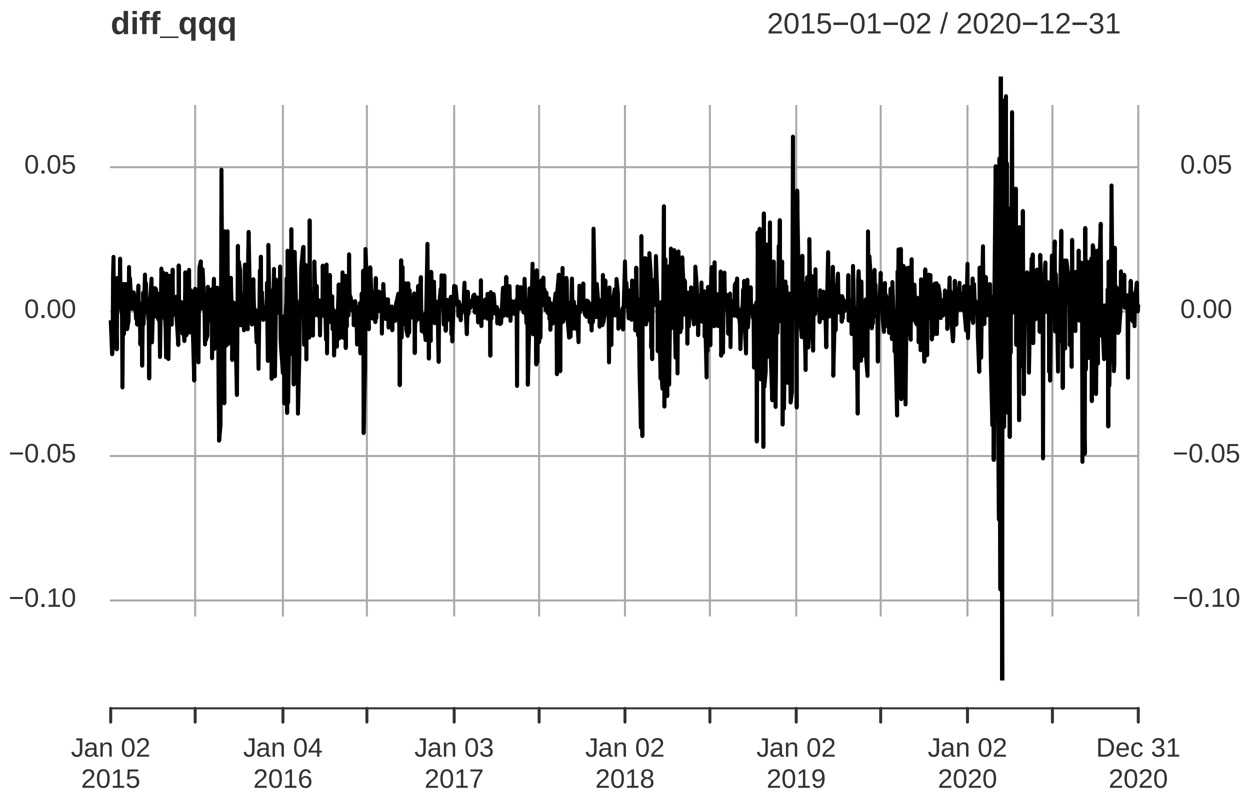

qqq_ts
2014−12−31 / 2020−12−31
300
250
200
150
100
Dec 31 2014
Dec 01 2015
Dec 01 2016
Dec 01 2017
Dec 03 2018
Dec 02 2019
Nov 30 2020

```
acf2(qqq_ts)
```

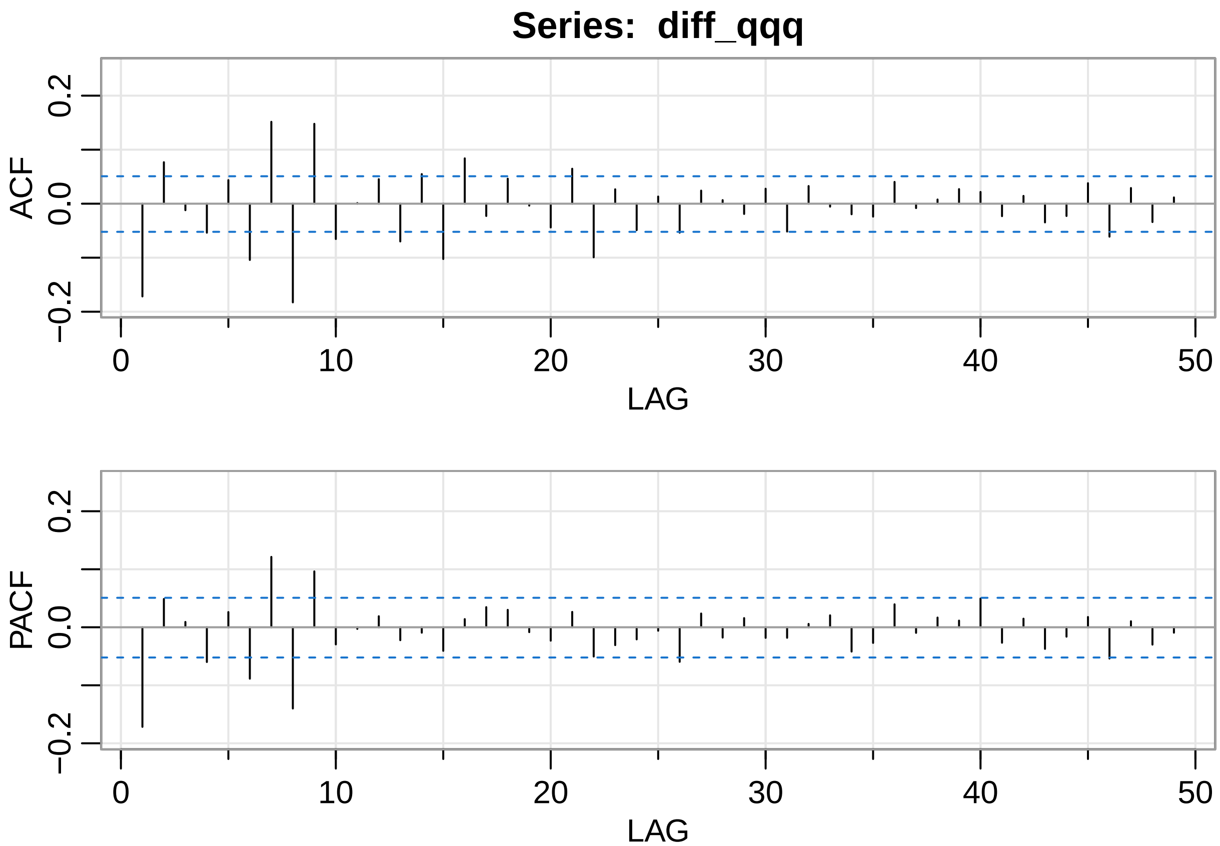



```
##       [,1] [,2]  [,3] [,4] [,5] [,6] [,7]  [,8] [,9] [,10] [,11] [,12] [,13]
## ACF      1 0.99  0.99 0.98 0.98 0.98 0.97  0.97 0.96  0.96  0.96  0.95  0.95
## PACF     1 0.05 -0.03 0.00 0.03 0.00 0.02 -0.04 0.03 -0.05  0.02  0.01  0.00
##       [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25]
## ACF    0.94  0.94  0.94  0.93  0.93  0.92  0.92  0.92  0.91  0.91  0.90  0.90
## PACF   0.02 -0.01  0.03 -0.04  0.00 -0.01  0.01  0.00 -0.01  0.03  0.01  0.03
##       [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36] [,37]
## ACF    0.90  0.90  0.89  0.89  0.89  0.88  0.88  0.88  0.87  0.87  0.87  0.86
## PACF   0.01  0.04 -0.01 -0.01  0.00 -0.01 -0.01  0.00  0.01  0.00  0.03 -0.04
##       [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48] [,49]
## ACF    0.86  0.86  0.85  0.85  0.85  0.84  0.84  0.84  0.84  0.83  0.83  0.83
## PACF  -0.03 -0.01  0.03  0.04  0.04 -0.01 -0.02  0.03 -0.05  0.02 -0.03  0.01
```

```
diff_qqq <- diff(log(qqq_ts))
diff_qqq <- diff_qqq[!is.na(diff_qqq)]
plot(diff_qqq)
```




```
acf2(diff_qqq)
```

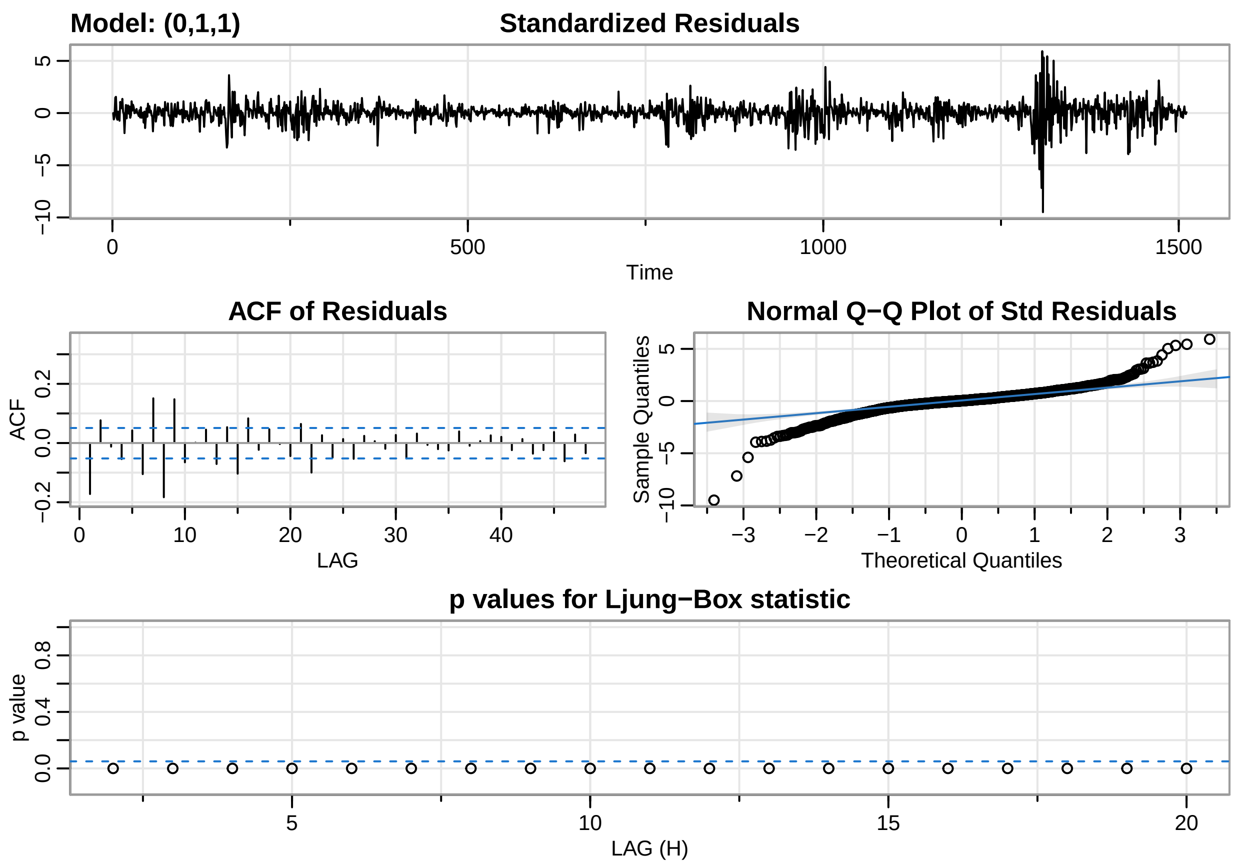



```
##       [,1] [,2]  [,3]  [,4] [,5]  [,6] [,7]  [,8] [,9] [,10] [,11] [,12] [,13]
## ACF  -0.17 0.08 -0.01 -0.05 0.04 -0.10 0.15 -0.18 0.15 -0.07     0  0.05 -0.07
## PACF -0.17 0.05  0.01 -0.06 0.03 -0.09 0.12 -0.14 0.10 -0.03     0  0.02 -0.02
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25]
## ACF   0.05 -0.10  0.08 -0.02  0.05  0.00 -0.04  0.06 -0.10  0.03 -0.05  0.01
## PACF -0.01 -0.04  0.01  0.03  0.03 -0.01 -0.02  0.03 -0.05 -0.03 -0.02 -0.01
##      [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36] [,37]
## ACF  -0.05  0.02  0.01 -0.02  0.03 -0.05  0.03 -0.01 -0.02 -0.02  0.04 -0.01
## PACF -0.06  0.02 -0.02  0.02 -0.02 -0.02  0.01  0.02 -0.04 -0.03  0.04 -0.01
##      [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48] [,49]
## ACF   0.01  0.03  0.02 -0.02  0.01 -0.03 -0.02  0.04 -0.06  0.03 -0.03  0.01
## PACF  0.02  0.01  0.05 -0.03  0.01 -0.04 -0.02  0.02 -0.05  0.01 -0.03 -0.01
```

```r
sarima(diff_qqq, 0, 1, 1)
```

```
## initial  value -3.876257
## iter   2 value -4.165599
## iter   3 value -4.238204
## iter   4 value -4.261436
## iter   5 value -4.285537
## iter   6 value -4.290863
## iter   7 value -4.292023
## iter   8 value -4.294171
## iter   9 value -4.297026
## iter  10 value -4.298272
```

```
## iter  11 value -4.298453
## iter  12 value -4.298618
## iter  13 value -4.298642
## iter  14 value -4.298646
## iter  14 value -4.298646
## final  value -4.298646
## converged
## initial  value -4.298799
## iter   2 value -4.298807
## iter   3 value -4.299144
## iter   4 value -4.299779
## iter   5 value -4.299895
## iter   6 value -4.299980
## iter   6 value -4.299980
## final  value -4.299980
## converged
```



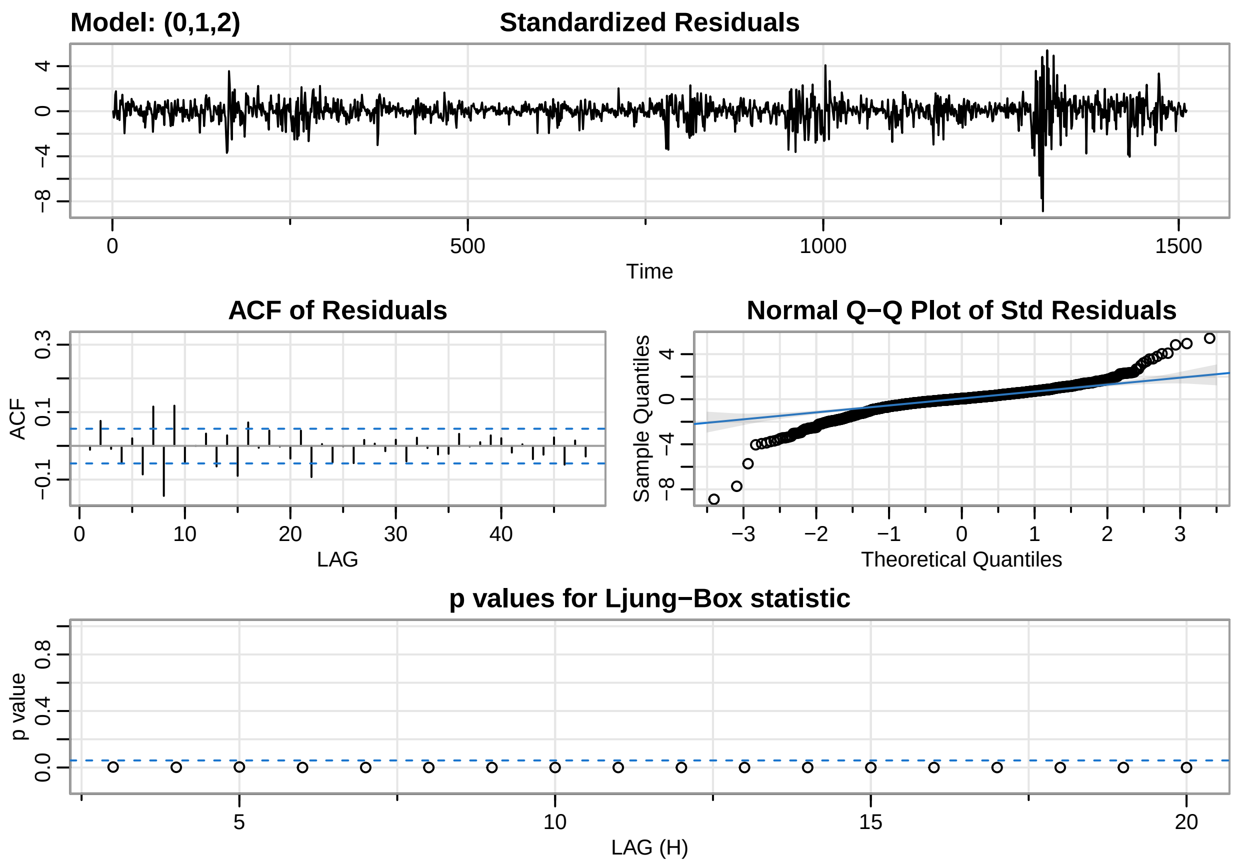

```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
```

```
##           ma1  constant
##       -0.9999         0
## s.e.   0.0020         0
##
## sigma^2 estimated as 0.0001832:  log likelihood = 4350.37,  aic = -8694.75
##
## $degrees_of_freedom
## [1] 1508
##
## $ttable
##          Estimate    SE   t.value p.value
## ma1       -0.9999 0.002 -506.2908  0.0000
## constant   0.0000 0.000    0.0321  0.9744
##
## $AIC
## [1] -5.75811
##
## $AICc
## [1] -5.758104
##
## $BIC
## [1] -5.74754
```

```r
qmod <- sarima(diff_qqq, 0, 1, 2)
```

```
## initial  value -3.876257
## iter   2 value -4.150019
## iter   3 value -4.222018
## iter   4 value -4.271358
## iter   5 value -4.284517
## iter   6 value -4.291556
## iter   7 value -4.302123
## iter   8 value -4.302356
## iter   9 value -4.302782
## iter  10 value -4.302894
## iter  11 value -4.310986
## iter  12 value -4.311426
## iter  13 value -4.311455
## iter  14 value -4.311466
## iter  15 value -4.311467
## iter  15 value -4.311467
## final  value -4.311467
## converged
## initial  value -4.311889
## iter   2 value -4.311993
## iter   3 value -4.312241
## iter   4 value -4.312509
## iter   5 value -4.313016
## iter   6 value -4.313217
## iter   7 value -4.313314
## iter   8 value -4.313334
## iter   9 value -4.313334
## iter  10 value -4.313334
## iter  11 value -4.313337
```

```
## iter  12 value -4.313337
## iter  12 value -4.313337
## iter  12 value -4.313337
## final  value -4.313337
## converged
```

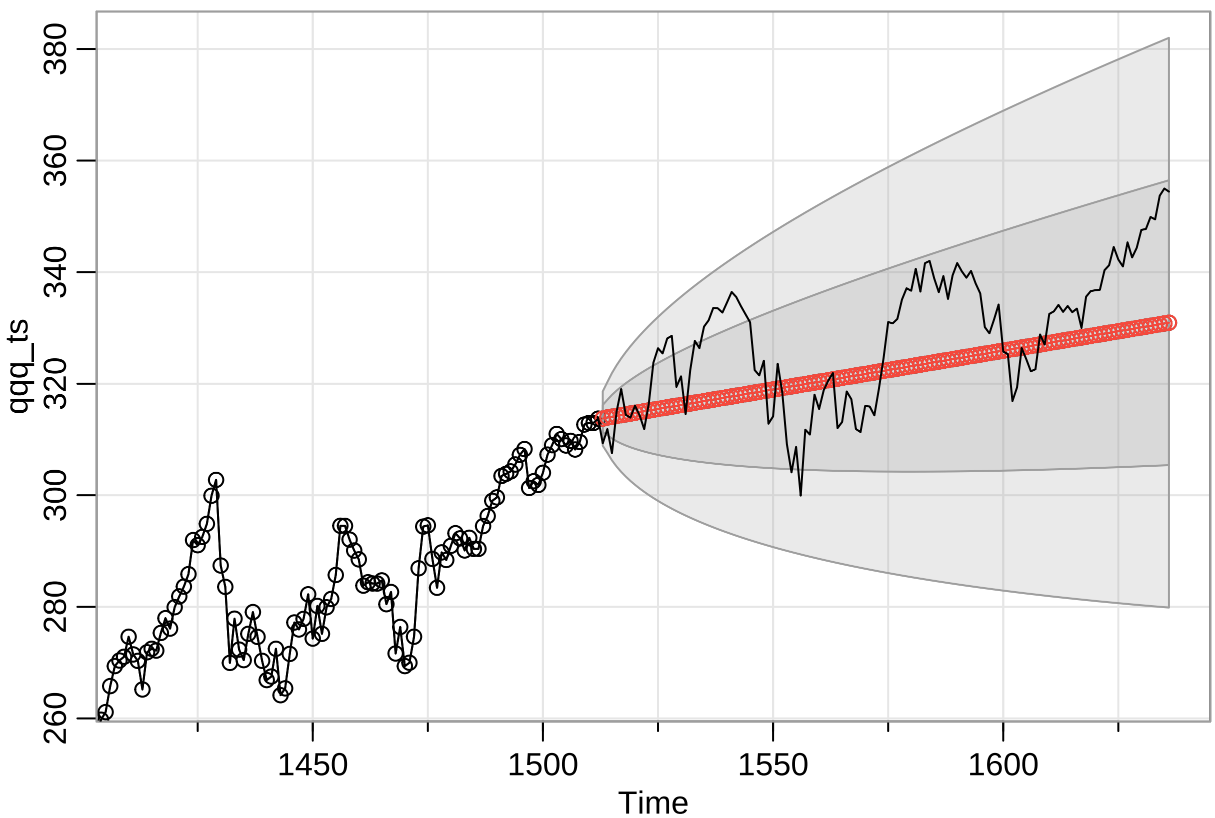



```
qmod
```

```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1     ma2  constant
##       -1.1538  0.1538         0
## s.e.   0.0240  0.0239         0
##
## sigma^2 estimated as 0.0001784:  log likelihood = 4370.54,  aic = -8733.08
##
## $degrees_of_freedom
## [1] 1507
##
```

```
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -1.1538 0.0240 -48.0532  0.0000
## ma2        0.1538 0.0239   6.4301  0.0000
## constant   0.0000 0.0000   0.0322  0.9743
##
## $AIC
## [1] -5.783499
##
## $AICc
## [1] -5.783488
##
## $BIC
## [1] -5.769406
```

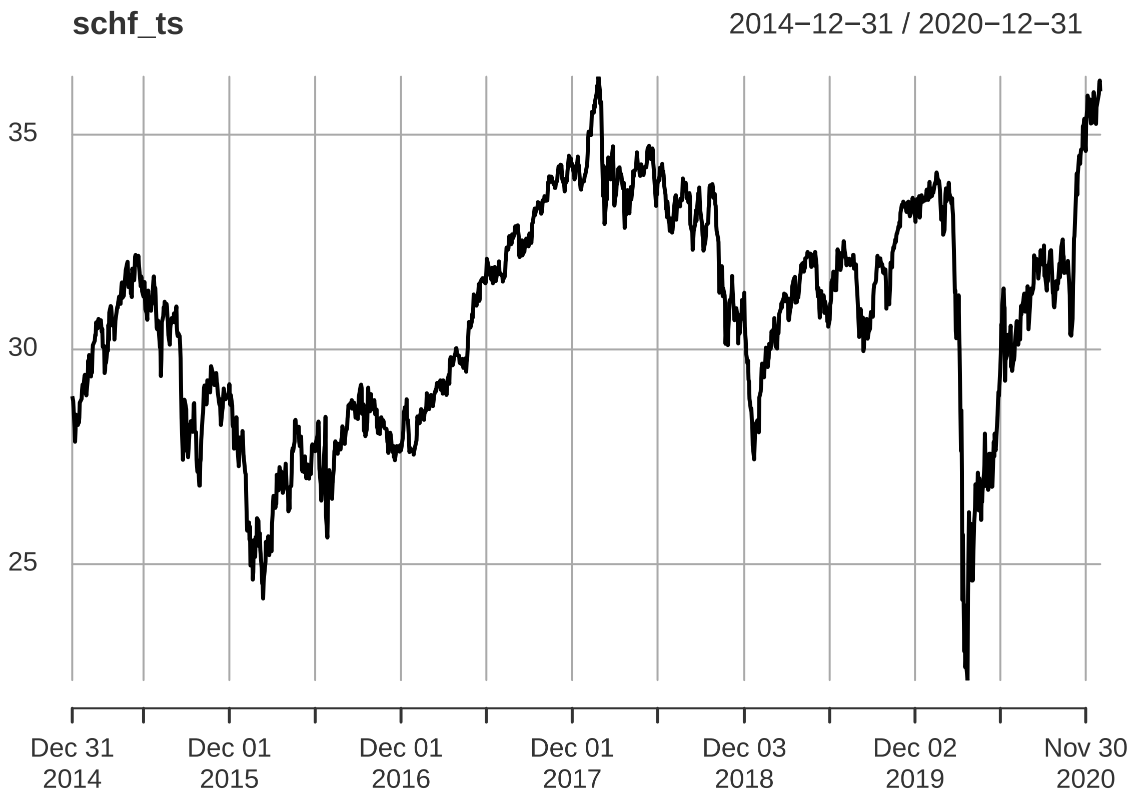
```
qpreds2 <- sarima.for(qqq_ts, 124, 0, 1, 2)
lines(fullq_ts)
```



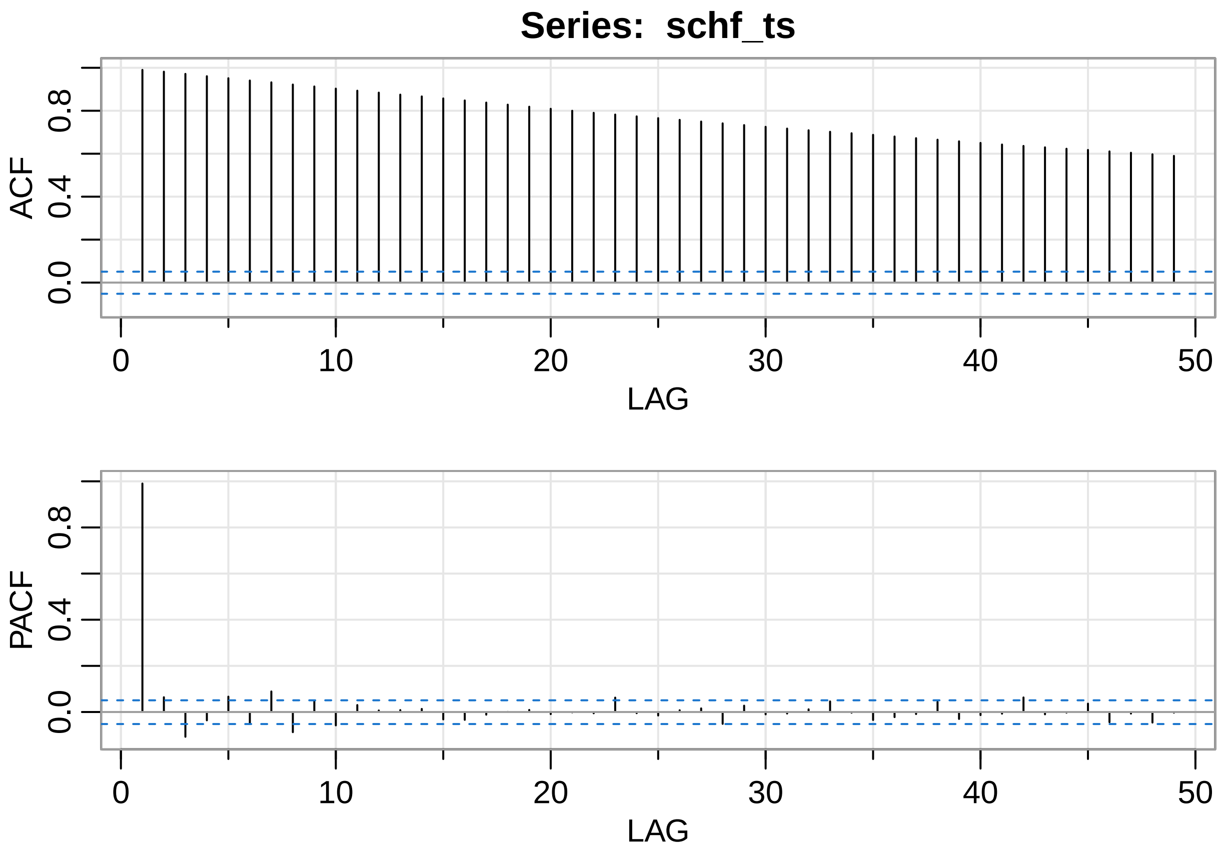

```
sqrt(mse(qqq2021$Close, qpreds2$pred)) ## Second model MSE
```

```
## [1] 10.89804
```

```r
## SCHF Plotting and ARIMA Fitting
plot(schf_ts)
```

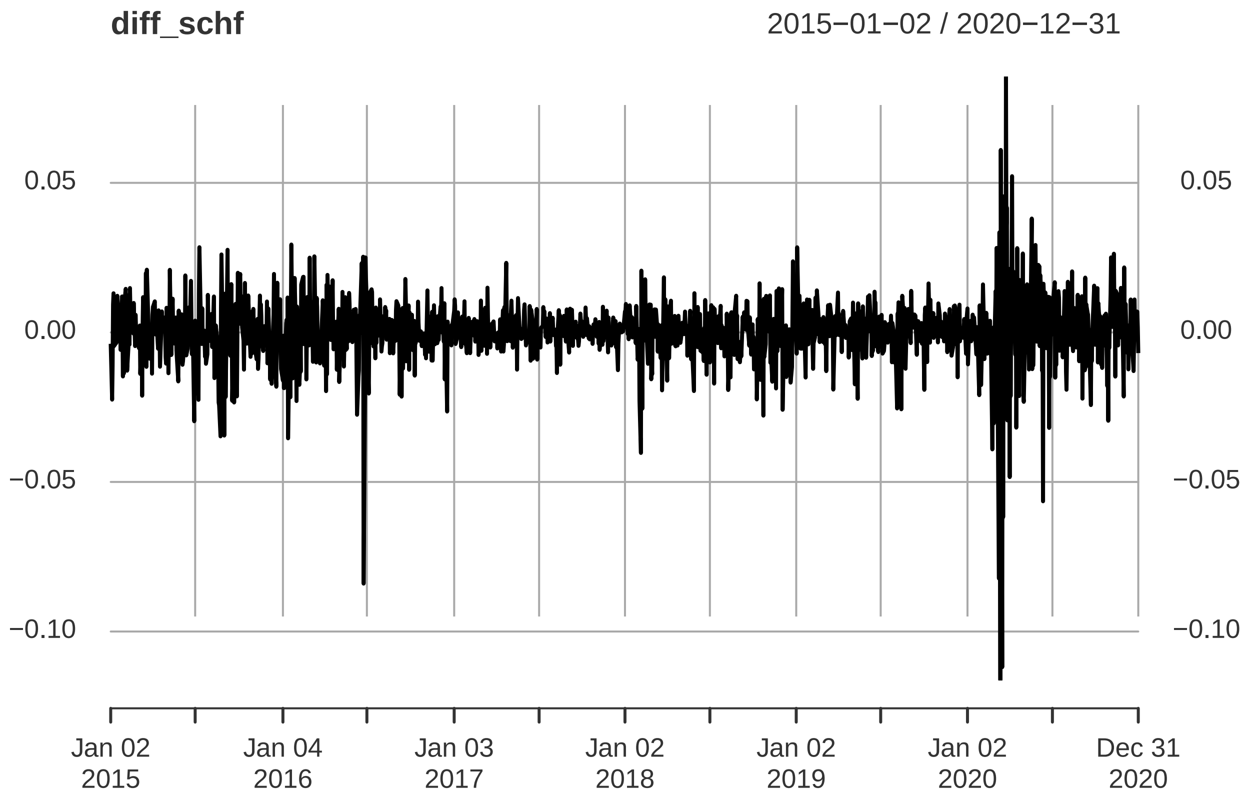



```r
acf2(schf_ts)
```

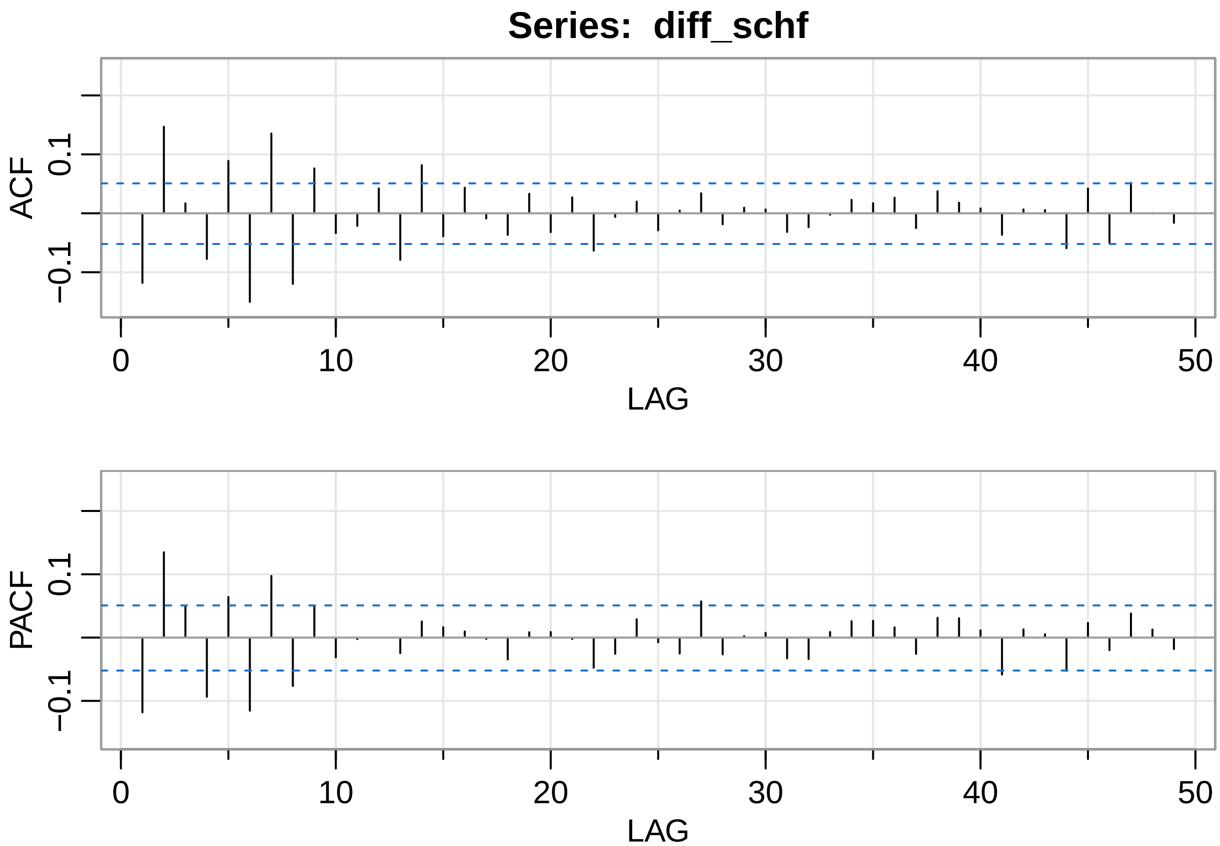



```
##       [,1] [,2]  [,3]  [,4] [,5]  [,6] [,7]  [,8] [,9] [,10] [,11] [,12] [,13]
## ACF   0.99 0.98  0.97  0.96 0.95  0.94 0.93  0.92 0.91  0.90  0.89  0.88  0.88
## PACF  0.99 0.06 -0.11 -0.04 0.07 -0.05 0.09 -0.09 0.05 -0.06  0.03  0.01  0.01
##       [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25]
## ACF    0.87  0.86  0.85  0.84  0.83  0.82  0.81   0.8  0.79  0.78  0.77  0.77
## PACF   0.01 -0.03 -0.03 -0.01  0.00  0.01 -0.01   0.0 -0.01  0.06 -0.01 -0.02
##       [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36] [,37]
## ACF    0.76  0.75  0.74  0.73  0.73  0.72  0.71  0.70   0.7  0.69  0.68  0.67
## PACF   0.01  0.02 -0.05  0.03 -0.01 -0.01  0.01  0.05   0.0 -0.03 -0.02 -0.01
##       [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48] [,49]
## ACF    0.67  0.66  0.65  0.64  0.64  0.63  0.62  0.62  0.61  0.60  0.60  0.59
## PACF   0.04 -0.03 -0.01 -0.01  0.06 -0.01  0.00  0.04 -0.04 -0.01 -0.05  0.00
```

```r
diff_schf <- diff(log(schf_ts))
diff_schf <- diff_schf[!is.na(diff_schf)]
plot(diff_schf)
```




```
acf2(diff_schf)
```

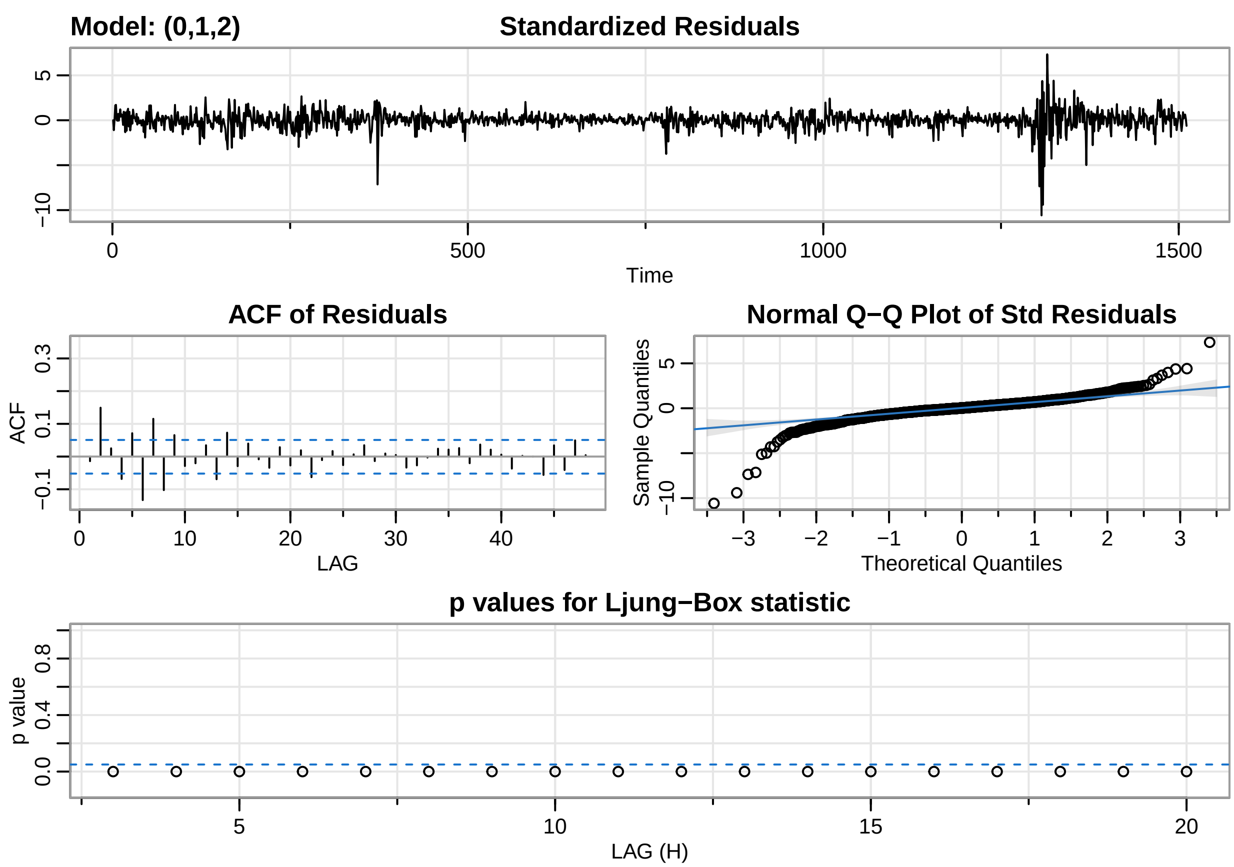



```
##       [,1] [,2] [,3]  [,4] [,5]  [,6] [,7]  [,8] [,9] [,10] [,11] [,12] [,13]
## ACF  -0.12 0.15 0.02 -0.08 0.09 -0.15 0.14 -0.12 0.08 -0.03 -0.02  0.04 -0.08
## PACF -0.12 0.13 0.05 -0.09 0.06 -0.12 0.10 -0.08 0.05 -0.03  0.00  0.00 -0.02
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25]
## ACF   0.08 -0.04  0.04 -0.01 -0.04  0.03 -0.03  0.03 -0.06 -0.01  0.02 -0.03
## PACF  0.03  0.02  0.01  0.00 -0.03  0.01  0.01  0.00 -0.05 -0.03  0.03 -0.01
##      [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36] [,37]
## ACF   0.00  0.03 -0.02  0.01  0.01 -0.03 -0.02  0.00  0.02  0.02  0.03 -0.03
## PACF -0.03  0.06 -0.03  0.00  0.01 -0.03 -0.03  0.01  0.03  0.03  0.02 -0.03
##      [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48] [,49]
## ACF   0.04  0.02  0.01 -0.04  0.01  0.01 -0.06  0.04 -0.05  0.05  0.00 -0.02
## PACF  0.03  0.03  0.01 -0.06  0.01  0.01 -0.05  0.02 -0.02  0.04  0.01 -0.02
```

```
smod <- sarima(diff_schf, 0, 1, 2)
```

```
## initial  value -4.064798
## iter   2 value -4.339665
## iter   3 value -4.383031
## iter   4 value -4.400938
## iter   5 value -4.424616
## iter   6 value -4.457550
## iter   7 value -4.460531
## iter   8 value -4.461563
## iter   9 value -4.461819
## iter  10 value -4.462098
```

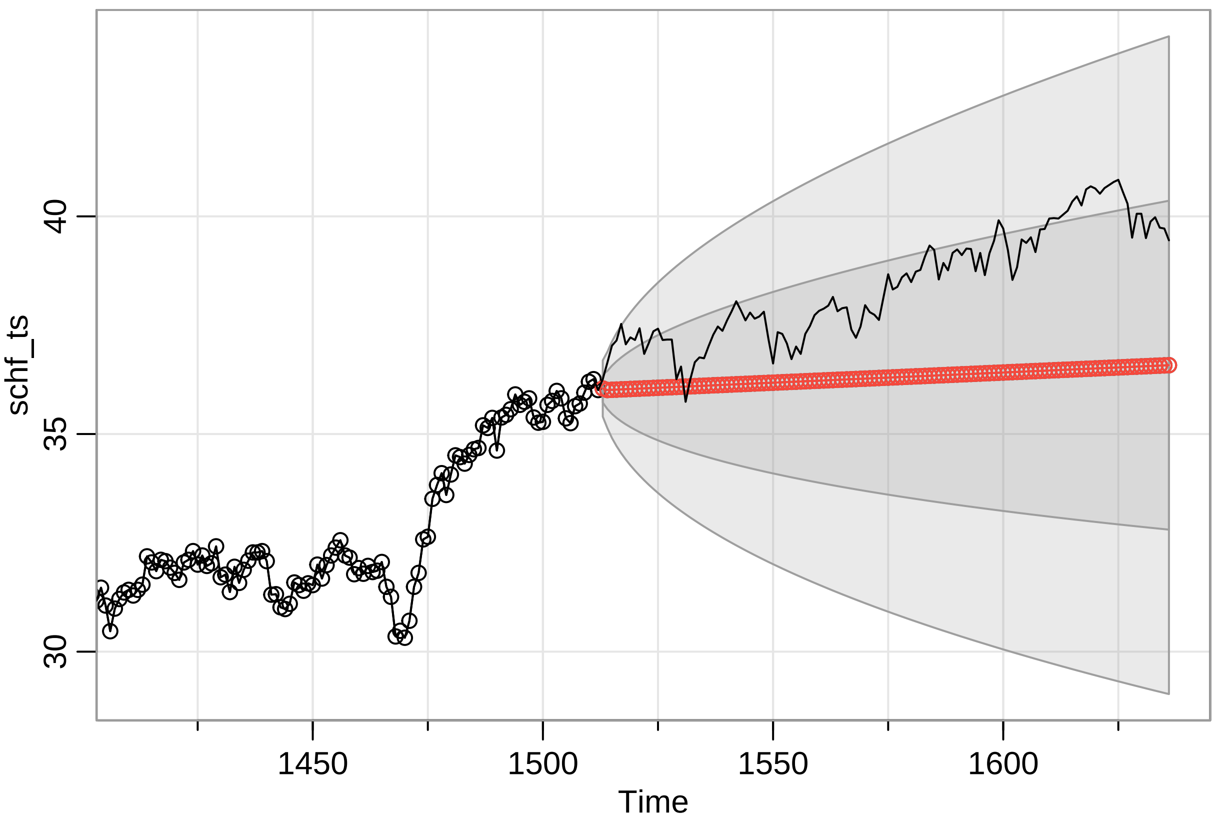
```
## iter  11 value -4.464603
## iter  12 value -4.467164
## iter  13 value -4.467208
## iter  14 value -4.467246
## iter  15 value -4.467250
## iter  16 value -4.467251
## iter  17 value -4.467251
## iter  17 value -4.467251
## iter  17 value -4.467251
## final  value -4.467251
## converged
## initial  value -4.468462
## iter   2 value -4.468608
## iter   3 value -4.469548
## iter   4 value -4.469663
## iter   5 value -4.469751
## iter   6 value -4.470046
## iter   7 value -4.470090
## iter   8 value -4.470145
## iter   9 value -4.470148
## iter  10 value -4.470148
## iter  11 value -4.470150
## iter  11 value -4.470150
## iter  11 value -4.470150
## final  value -4.470150
## converged
```



```r
smod
```

```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1     ma2  constant
##       -1.0913  0.0913         0
## s.e.   0.0226  0.0225         0
##
## sigma^2 estimated as 0.0001304:  log likelihood = 4607.33,  aic = -9206.66
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -1.0913 0.0226 -48.2466  0.0000
## ma2        0.0913 0.0225   4.0590  0.0001
## constant   0.0000 0.0000   0.0105  0.9916
##
## $AIC
## [1] -6.097125
##
## $AICc
## [1] -6.097114
##
## $BIC
## [1] -6.083033
```

```r
spreds2 <- sarima.for(schf_ts, 124, 0, 1, 2)
lines(fulls_ts)
```

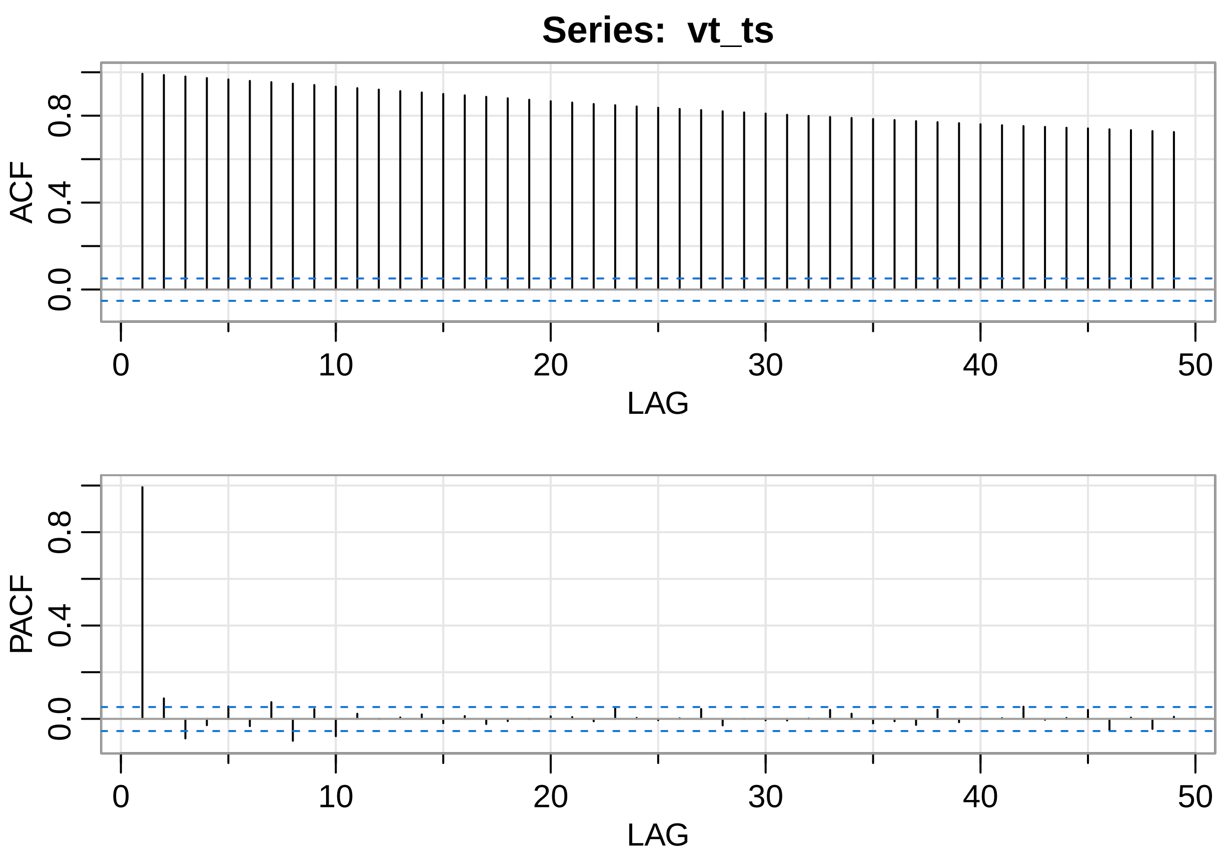



```r
sqrt(mse(schf2021$Close, spreds2$pred)) ## Second model MSE
```

```
## [1] 2.414427
```

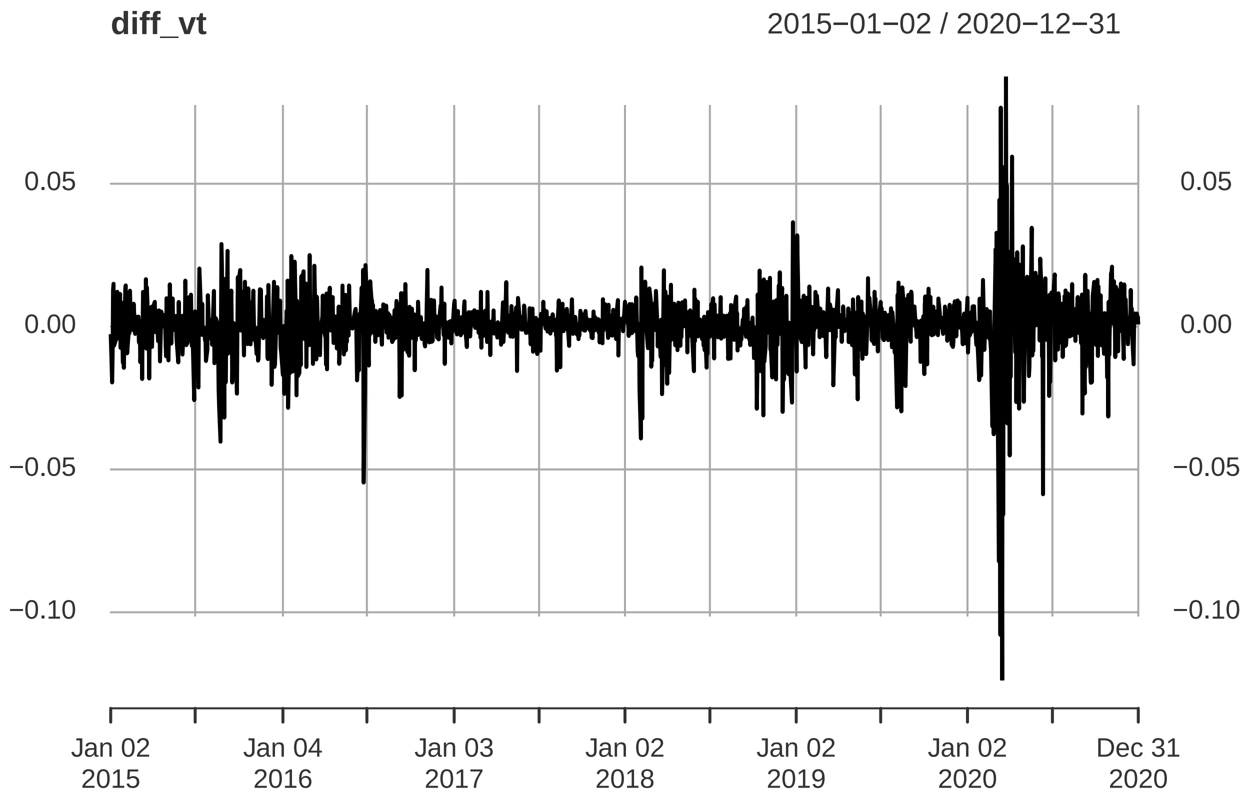
```r
plot(vt_ts)
```


```r
acf2(vt_ts)
```

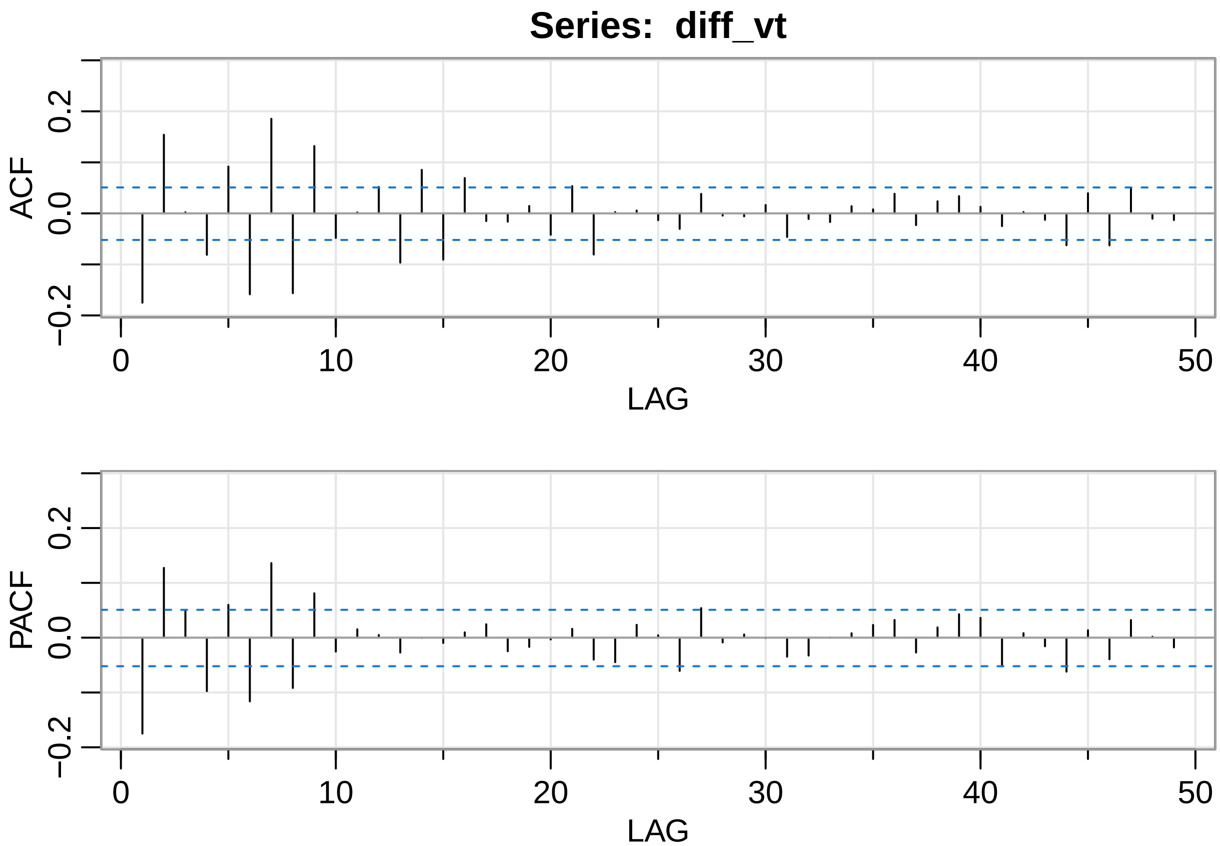



```
##       [,1] [,2]  [,3]  [,4] [,5]  [,6] [,7]  [,8] [,9] [,10] [,11] [,12] [,13]
## ACF  0.99 0.99  0.98  0.97 0.97  0.96 0.95  0.95 0.94  0.93  0.93  0.92  0.91
## PACF 0.99 0.09 -0.08 -0.03 0.05 -0.03 0.07 -0.09 0.04 -0.07  0.02  0.00  0.01
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25]
## ACF   0.91  0.90  0.89  0.89  0.88  0.87  0.87  0.86  0.85  0.85  0.84  0.84
## PACF  0.02 -0.02  0.01 -0.02 -0.01  0.00  0.01  0.01 -0.01  0.05  0.00 -0.01
##      [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36] [,37]
## ACF   0.83  0.83  0.82  0.82  0.81  0.80   0.8  0.79  0.79  0.78  0.78  0.78
## PACF  0.00  0.04 -0.03  0.00 -0.01 -0.01   0.0  0.04  0.02 -0.02 -0.01 -0.03
##      [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48] [,49]
## ACF   0.77  0.77  0.76  0.76  0.75  0.75  0.74  0.74  0.74  0.73  0.73  0.72
## PACF  0.04 -0.01  0.00  0.00  0.05  0.00  0.00  0.04 -0.05  0.01 -0.04  0.01
```

```
diff_vt <- diff(log(vt_ts))
diff_vt <- diff_vt[!is.na(diff_vt)]
plot(diff_vt)
```


diff_vt
2015−01−02 / 2020−12−31
0.05
0.00
−0.05
−0.10
0.05
0.00
−0.05
−0.10
Jan 02 2015
Jan 04 2016
Jan 03 2017
Jan 02 2018
Jan 02 2019
Jan 02 2020
Dec 31 2020

```
acf2(diff_vt)
```

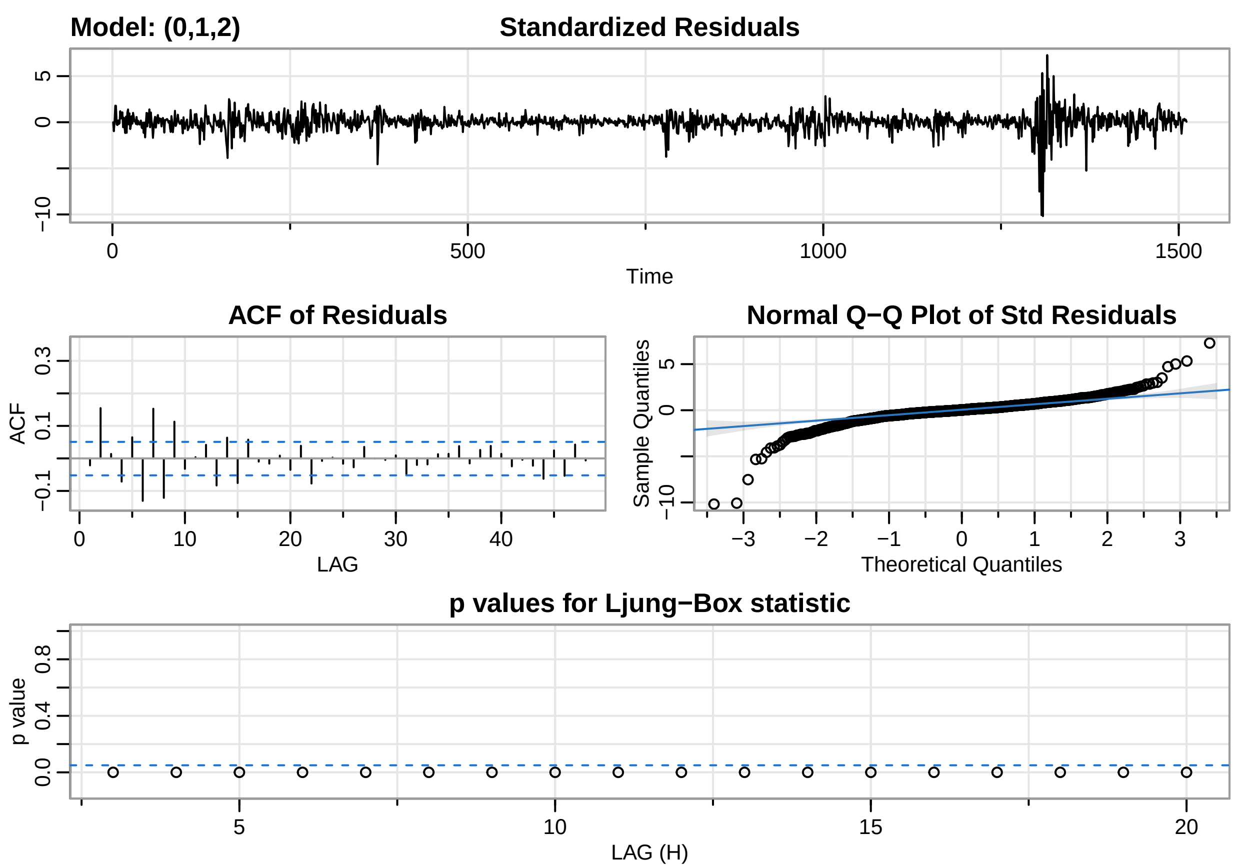



```
##       [,1] [,2] [,3]  [,4] [,5]  [,6] [,7]  [,8] [,9] [,10] [,11] [,12] [,13]
## ACF  -0.18 0.15 0.00 -0.08 0.09 -0.16 0.19 -0.16 0.13 -0.05  0.00  0.05 -0.10
## PACF -0.18 0.13 0.05 -0.10 0.06 -0.12 0.14 -0.09 0.08 -0.03  0.02  0.00 -0.03
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25]
## ACF   0.09 -0.09  0.07 -0.02 -0.02  0.01 -0.04  0.05 -0.08  0.00  0.01 -0.01
## PACF  0.00 -0.01  0.01  0.02 -0.02 -0.02  0.00  0.02 -0.04 -0.04  0.02  0.00
##      [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36] [,37]
## ACF  -0.03  0.04  0.00 -0.01  0.02 -0.05 -0.01 -0.02  0.01  0.01  0.04 -0.02
## PACF -0.06  0.05 -0.01  0.01  0.00 -0.03 -0.03  0.00  0.01  0.02  0.03 -0.03
##      [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48] [,49]
## ACF   0.02  0.03  0.01 -0.02  0.00 -0.01 -0.06  0.04 -0.06  0.05 -0.01 -0.01
## PACF  0.02  0.04  0.04 -0.05  0.01 -0.02 -0.06  0.01 -0.04  0.03  0.00 -0.02
```

```
vmod <- sarima(diff_vt, 0, 1, 2)
```

```
## initial  value -4.036952
## iter   2 value -4.333060
## iter   3 value -4.378436
## iter   4 value -4.409178
## iter   5 value -4.462623
## iter   6 value -4.464755
## iter   7 value -4.465657
## iter   8 value -4.466995
## iter   9 value -4.467319
## iter  10 value -4.467725
```

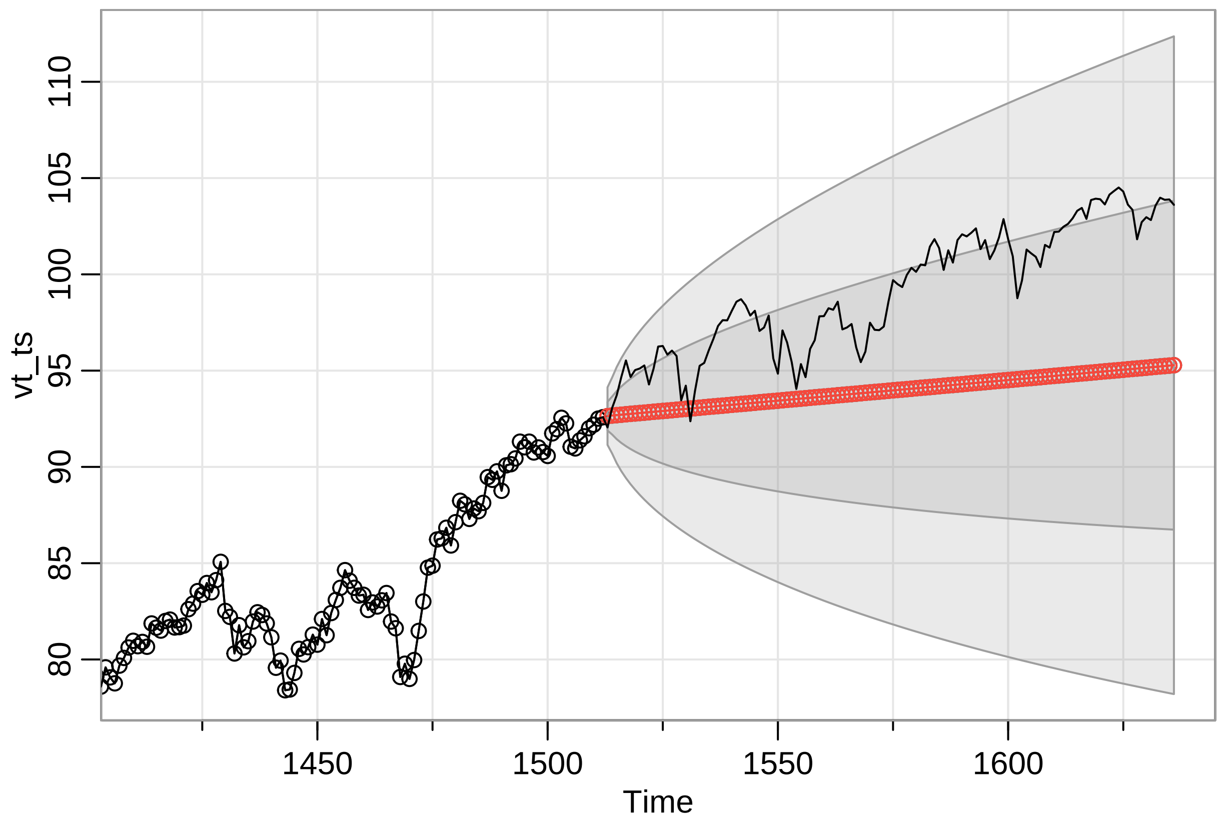
```
## iter  11 value -4.469342
## iter  12 value -4.470935
## iter  13 value -4.472006
## iter  14 value -4.472236
## iter  15 value -4.472391
## iter  16 value -4.472408
## iter  17 value -4.472422
## iter  18 value -4.472504
## iter  19 value -4.472513
## iter  20 value -4.472514
## iter  20 value -4.472514
## iter  20 value -4.472514
## final  value -4.472514
## converged
## initial  value -4.472685
## iter   2 value -4.472800
## iter   3 value -4.473127
## iter   4 value -4.473649
## iter   5 value -4.473813
## iter   6 value -4.473924
## iter   7 value -4.473936
## iter   8 value -4.473936
## iter   8 value -4.473936
## final  value -4.473936
## converged
```



```r
vmod
```

```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1     ma2  constant
##       -1.1363  0.1363         0
## s.e.   0.0225  0.0224         0
##
## sigma^2 estimated as 0.0001294:  log likelihood = 4613.05,  aic = -9218.09
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -1.1363 0.0225 -50.5600   0.000
## ma2        0.1363 0.0224   6.0966   0.000
## constant   0.0000 0.0000   0.0176   0.986
##
## $AIC
## [1] -6.104697
##
## $AICc
## [1] -6.104686
##
## $BIC
## [1] -6.090604
```

```r
vpreds2 <- sarima.for(vt_ts, 124, 0, 1, 2)
lines(fullv_ts)
```

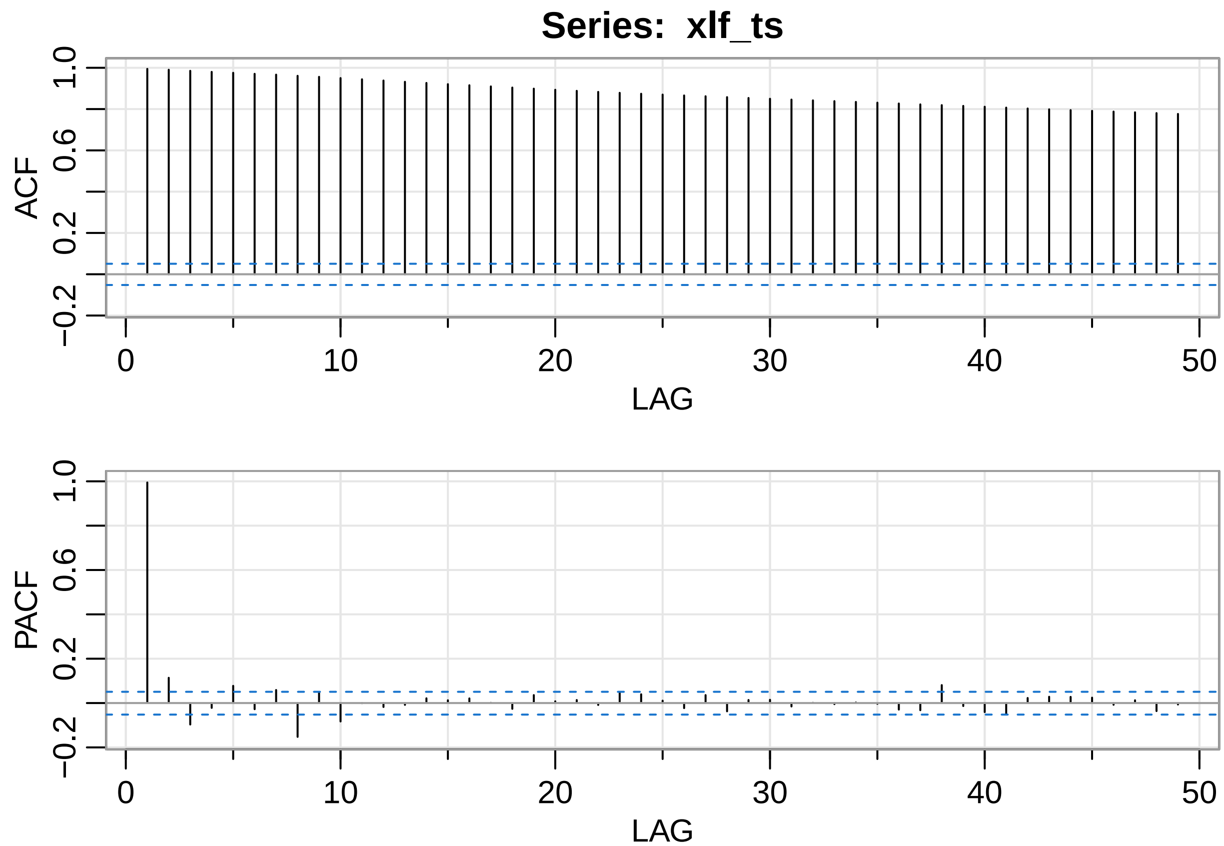



```
sqrt(mse(vt2021$Close, vpreds2$pred)) ## Second model MSE
```

```
## [1] 5.76737
```

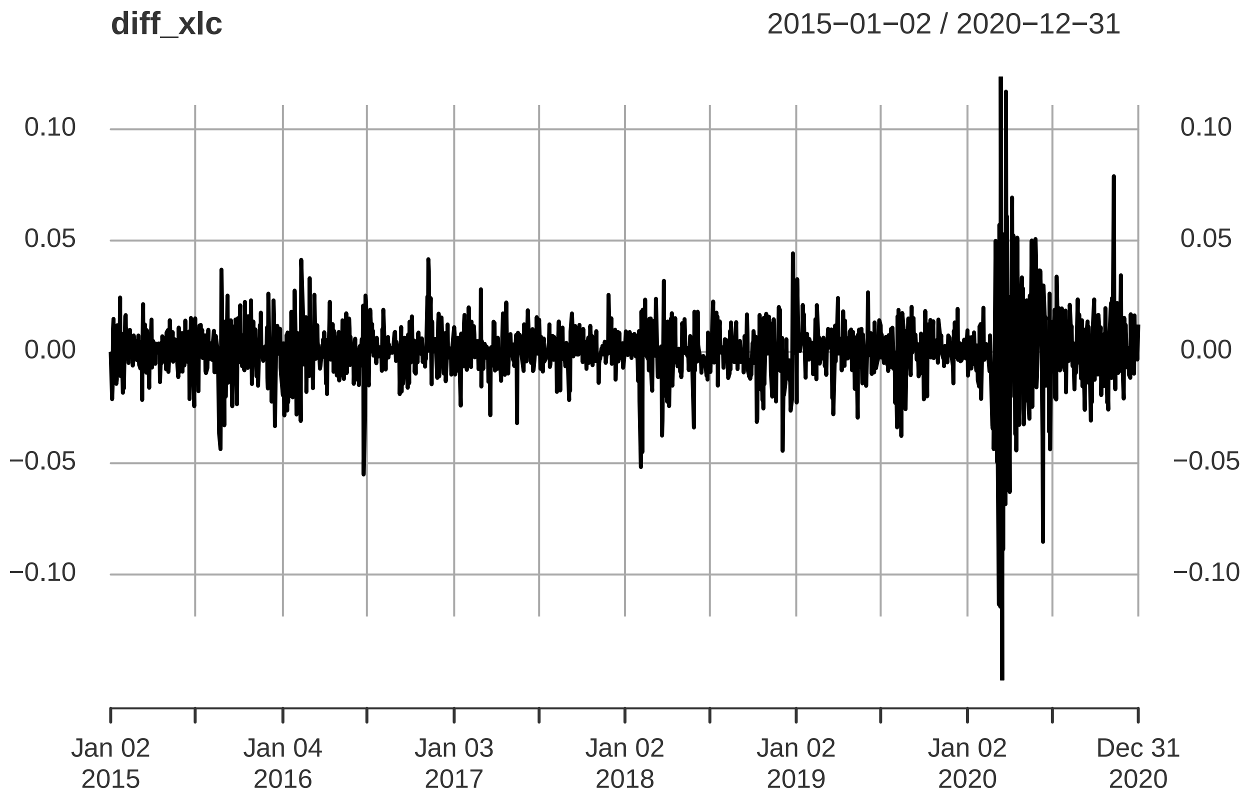
```r
plot(xlf_ts)
```


```r
acf2(xlf_ts)
```

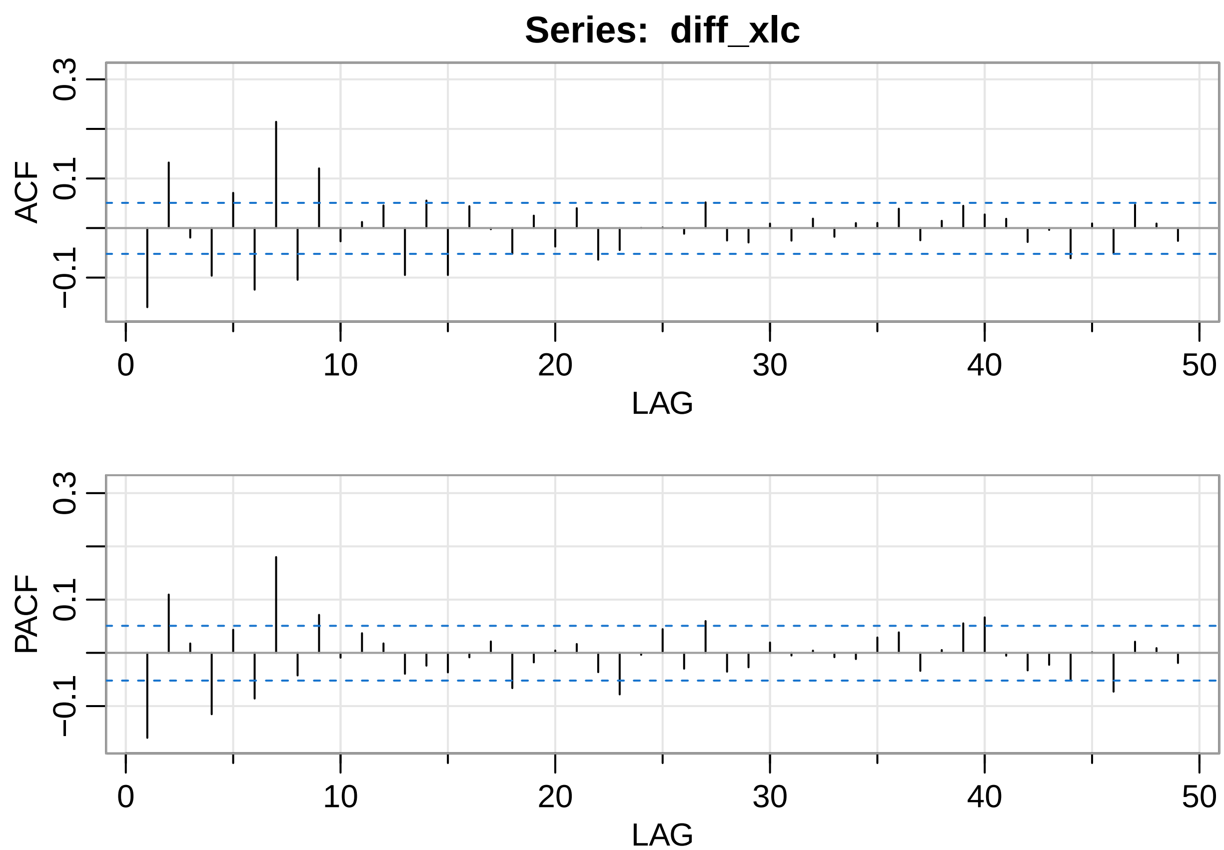



```
##      [,1] [,2]  [,3]  [,4] [,5]  [,6] [,7]  [,8] [,9] [,10] [,11] [,12] [,13]
## ACF  0.99 0.99  0.99  0.98 0.98  0.97 0.97  0.96 0.96  0.95  0.94  0.94  0.93
## PACF 0.99 0.11 -0.10 -0.02 0.08 -0.03 0.06 -0.15 0.05 -0.08  0.00 -0.02 -0.01
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25]
## ACF   0.93  0.92  0.92  0.91  0.90  0.90  0.89  0.89  0.88  0.88  0.87  0.87
## PACF  0.02  0.01  0.02  0.00 -0.03  0.04  0.01  0.01 -0.01  0.05  0.04  0.01
##      [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36] [,37]
## ACF   0.87  0.86  0.86  0.85  0.85  0.85  0.84  0.84  0.83  0.83  0.83  0.82
## PACF -0.02  0.04 -0.04  0.01  0.01 -0.02  0.00  0.00  0.00  0.00 -0.03 -0.03
##      [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48] [,49]
## ACF   0.82  0.82  0.81  0.81  0.80  0.80  0.79  0.79  0.79  0.78  0.78  0.78
## PACF  0.08 -0.01 -0.04 -0.05  0.02  0.03  0.03  0.02 -0.01  0.01 -0.04 -0.01
```

```r
diff_xlf <- diff(log(xlf_ts))
diff_xlc <- diff_xlf[!is.na(diff_xlf)]
plot(diff_xlc)
```




```
acf2(diff_xlc)
```

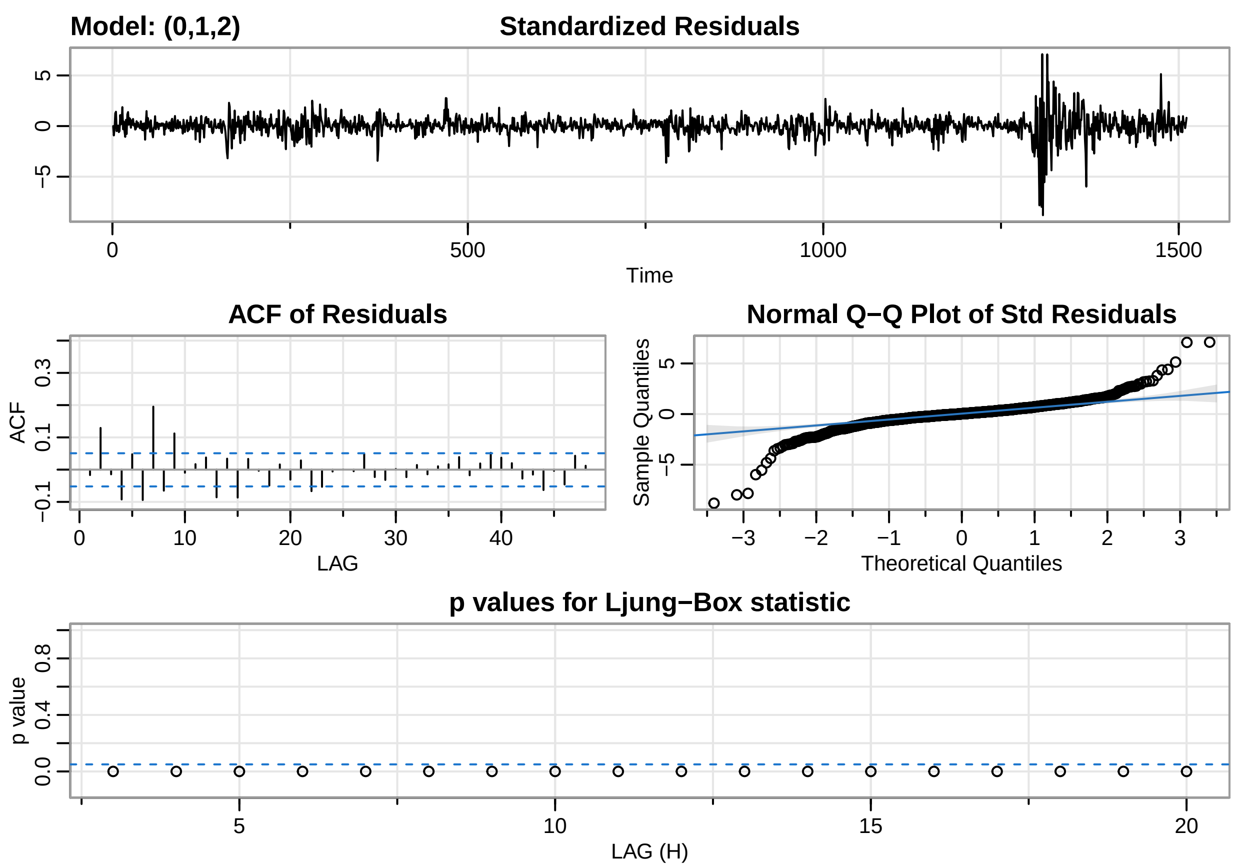



```
##       [,1] [,2]  [,3]  [,4] [,5]  [,6] [,7]  [,8] [,9] [,10] [,11] [,12] [,13]
## ACF  -0.16 0.13 -0.02 -0.10 0.07 -0.12 0.21 -0.10 0.12 -0.03  0.01  0.05 -0.09
## PACF -0.16 0.11  0.02 -0.12 0.04 -0.09 0.18 -0.04 0.07 -0.01  0.04  0.02 -0.04
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25]
## ACF   0.06 -0.09  0.04  0.00 -0.05  0.03 -0.04  0.04 -0.06 -0.04     0  0.00
## PACF -0.02 -0.04 -0.01  0.02 -0.07 -0.02  0.00  0.02 -0.04 -0.08     0  0.04
##      [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36] [,37]
## ACF  -0.01  0.05 -0.03 -0.03  0.01 -0.03  0.02 -0.02  0.01  0.01  0.04 -0.02
## PACF -0.03  0.06 -0.04 -0.03  0.02 -0.01  0.00 -0.01 -0.01  0.03  0.04 -0.03
##      [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48] [,49]
## ACF   0.01  0.04  0.03  0.02 -0.03  0.00 -0.06  0.01 -0.05  0.05  0.01 -0.03
## PACF  0.01  0.06  0.07 -0.01 -0.03 -0.02 -0.05  0.00 -0.07  0.02  0.01 -0.02
```

```r
xmod <- sarima(diff_xlc, 0, 1, 2)
```

```
## initial  value -3.756573
## iter   2 value -4.035086
## iter   3 value -4.083385
## iter   4 value -4.108818
## iter   5 value -4.133822
## iter   6 value -4.159273
## iter   7 value -4.167111
## iter   8 value -4.177253
## iter   9 value -4.177646
## iter  10 value -4.181190
```

```
## iter  11 value -4.181474
## iter  12 value -4.181636
## iter  13 value -4.181647
## iter  14 value -4.187319
## iter  15 value -4.189098
## iter  15 value -4.189098
## iter  15 value -4.189098
## final  value -4.189098
## converged
## initial  value -4.184562
## iter   2 value -4.184727
## iter   3 value -4.184965
## iter   4 value -4.185003
## iter   5 value -4.185006
## iter   6 value -4.185009
## iter   7 value -4.185010
## iter   7 value -4.185010
## iter   7 value -4.185010
## final  value -4.185010
## converged
```

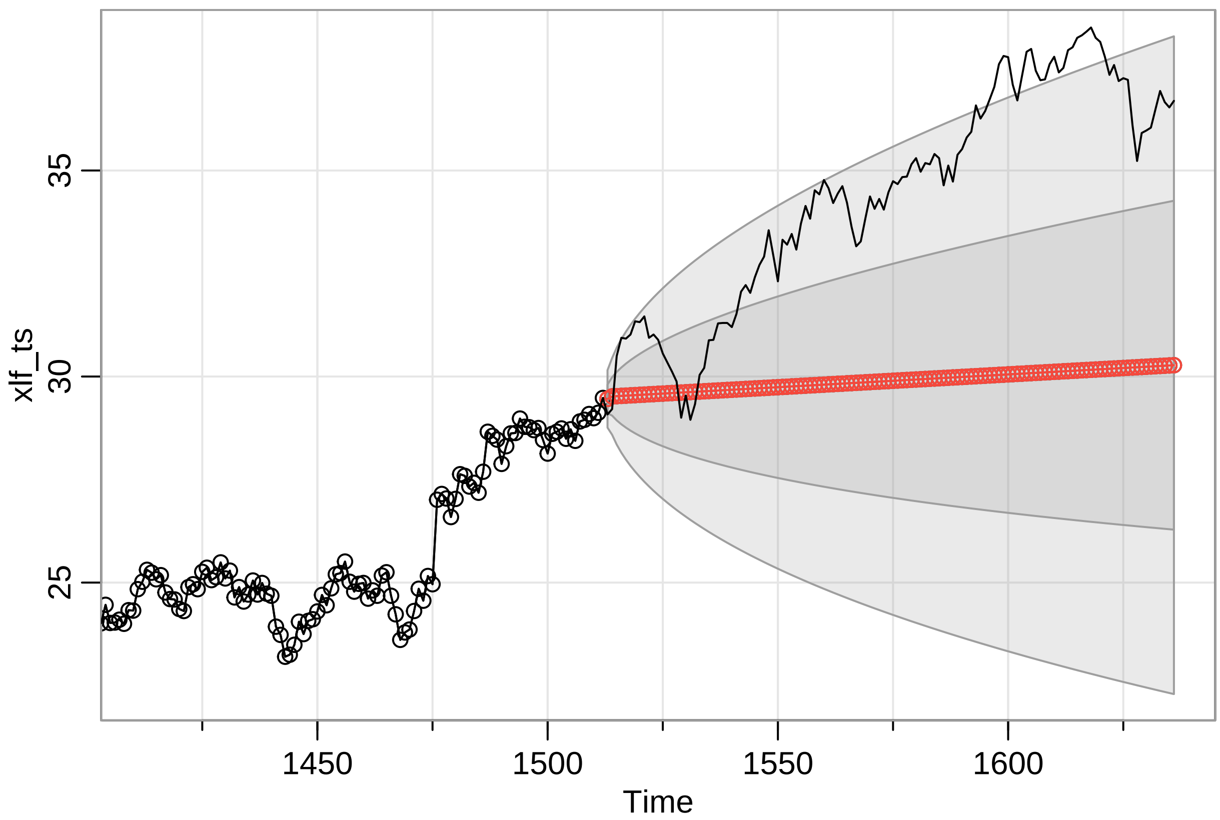



```
xmod
```

```
## $fit
##
```

```
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1    ma2  constant
##       -1.1290  0.129         0
## s.e.   0.0231  0.023         0
##
## sigma^2 estimated as 0.0002305:  log likelihood = 4176.77,  aic = -8345.53
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1        -1.129 0.0231 -48.9226   0.000
## ma2         0.129 0.0230   5.6202   0.000
## constant    0.000 0.0000   0.0050   0.996
##
## $AIC
## [1] -5.526844
##
## $AICc
## [1] -5.526834
##
## $BIC
## [1] -5.512752
```

```
xpreds2 <- sarima.for(xlf_ts, 124, 0, 1, 2)
lines(fullx_ts)
```



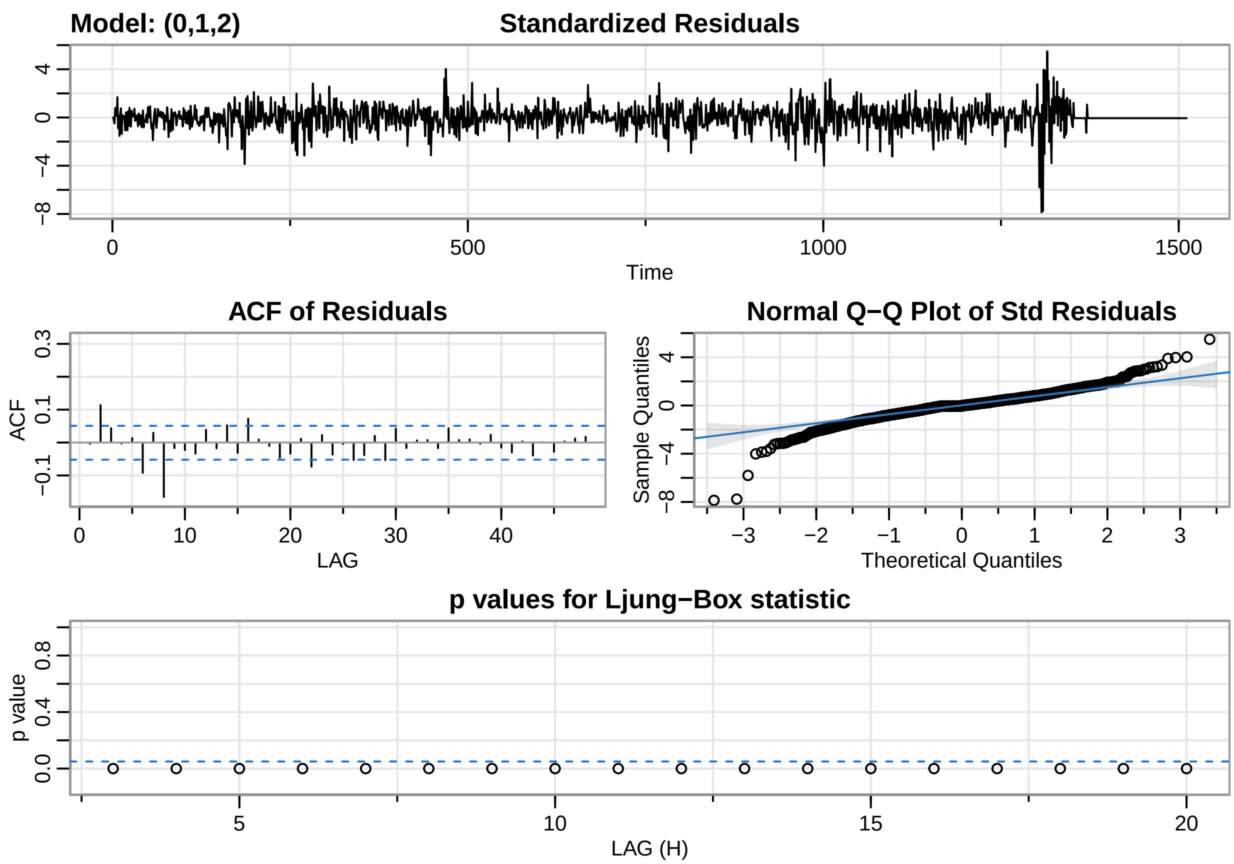

```
sqrt(mse(xlf2021$Close, xpreds2$pred)) ## Second model MSE
```

```
## [1] 5.125477
```

```
## Same procedure but including clipping over all datasets
## Clip values:
## - IQR(series) +
## - 90th percentile value
## - mean(series) +
arkg_ts1 <- ifelse(arkg_ts > (IQR(arkg_ts) + quantile(arkg_ts, 0.75)), IQR(arkg_ts) + quantile(arkg_ts,
qqq_ts1 <- ifelse(qqq_ts > (IQR(qqq_ts) + quantile(qqq_ts, 0.75)), IQR(qqq_ts) + quantile(qqq_ts, 0.75)
schf_ts1 <- ifelse(schf_ts > (IQR(schf_ts) + quantile(schf_ts, 0.75)), IQR(schf_ts) + quantile(schf_ts,
vt_ts1 <- ifelse(vt_ts > (IQR(vt_ts) + quantile(vt_ts, 0.75)), IQR(vt_ts) + quantile(vt_ts, 0.75), vt_t
xlf_ts1 <- ifelse(xlf_ts > (IQR(xlf_ts) + quantile(xlf_ts, 0.75)), IQR(xlf_ts) + quantile(xlf_ts, 0.75)

arkg_ts2 <- ifelse(arkg_ts > quantile(arkg_ts, 0.9), quantile(arkg_ts, 0.9), arkg_ts)
qqq_ts2 <- ifelse(qqq_ts > quantile(qqq_ts, 0.9), quantile(qqq_ts, 0.9), qqq_ts)
schf_ts2 <- ifelse(schf_ts > quantile(schf_ts, 0.9), quantile(schf_ts, 0.9), schf_ts)
vt_ts2 <- ifelse(vt_ts > quantile(vt_ts, 0.9), quantile(vt_ts, 0.9), vt_ts)
xlf_ts2 <- ifelse(xlf_ts > quantile(xlf_ts, 0.9), quantile(xlf_ts, 0.9), xlf_ts)

arkg_ts3 <- ifelse(arkg_ts > (mean(arkg_ts) + quantile(arkg_ts, 0.75)), mean(arkg_ts) + quantile(arkg_t
qqq_ts3 <- ifelse(qqq_ts > (mean(qqq_ts) + quantile(qqq_ts, 0.75)), mean(qqq_ts) + quantile(qqq_ts, 0.7
schf_ts3 <- ifelse(schf_ts > (mean(schf_ts) + quantile(schf_ts, 0.75)), mean(schf_ts) + quantile(schf_t
vt_ts3 <- ifelse(vt_ts > (mean(vt_ts) + quantile(vt_ts, 0.75)), mean(vt_ts) + quantile(vt_ts, 0.75), vt
```

```
xlf_ts3 <- ifelse(xlf_ts > (mean(xlf_ts) + quantile(xlf_ts, 0.75)), mean(xlf_ts) + quantile(xlf_ts, 0.75

## ARKG Models
diff_a1 <- diff(log(arkg_ts1))
diff_a1 <- diff_a1[!is.na(diff_a1)]
diff_a2 <- diff(log(arkg_ts2))
diff_a2 <- diff_a2[!is.na(diff_a2)]
diff_a3 <- diff(log(arkg_ts3))
diff_a3 <- diff_a3[!is.na(diff_a3)]

camod1 = sarima(diff_a1, 0, 1, 2)
```

```
## initial  value -3.596182
## iter   2 value -3.835266
## iter   3 value -3.883725
## iter   4 value -3.920871
## iter   5 value -3.929137
## iter   6 value -3.945613
## iter   7 value -3.950852
## iter   8 value -3.951080
## iter   9 value -3.952151
## iter  10 value -3.953212
## iter  11 value -3.954131
## iter  12 value -3.955180
## iter  13 value -3.955419
## iter  14 value -3.955426
## iter  14 value -3.955426
## final  value -3.955426
## converged
## initial  value -3.955068
## iter   2 value -3.955266
## iter   3 value -3.955651
## iter   4 value -3.955872
## iter   5 value -3.955925
## iter   6 value -3.955942
## iter   7 value -3.955942
## iter   8 value -3.955942
## iter   8 value -3.955942
## final  value -3.955942
## converged
```



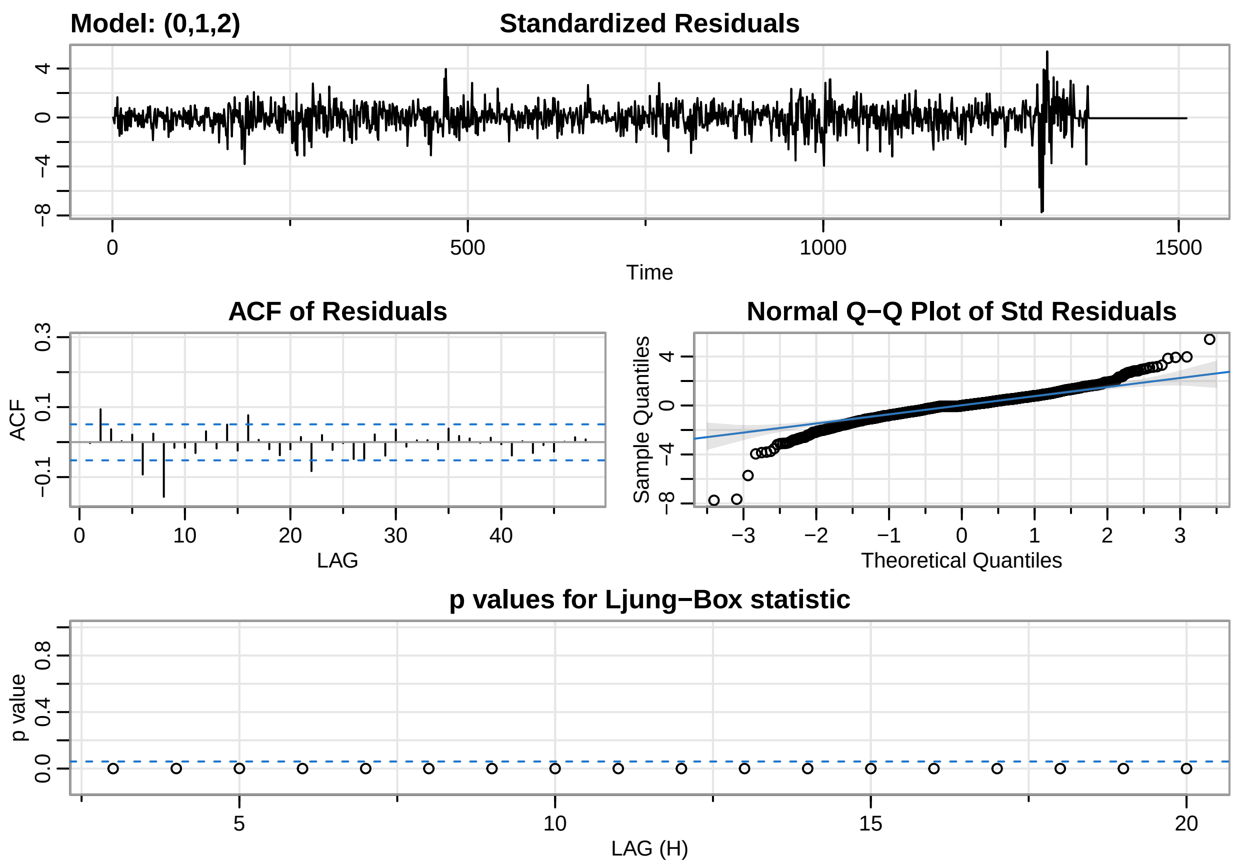

```
camod1
```

```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1     ma2  constant
##       -1.0245  0.0245         0
## s.e.   0.0233  0.0232         0
##
## sigma^2 estimated as 0.0003646:  log likelihood = 3830.88,  aic = -7653.75
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -1.0245 0.0233 -44.0540  0.0000
## ma2        0.0245 0.0232   1.0592  0.2897
## constant   0.0000 0.0000   0.0322  0.9743
##
## $AIC
```

```
## [1] -5.06871
##
## $AICc
## [1] -5.068699
##
## $BIC
## [1] -5.054618
```

```r
camod2 = sarima(diff_a2, 0, 1, 2)
```

```
## initial  value -3.583212
## iter   2 value -3.815951
## iter   3 value -3.871391
## iter   4 value -3.916606
## iter   5 value -3.935681
## iter   6 value -3.935898
## iter   7 value -3.936547
## iter   8 value -3.938008
## iter   9 value -3.939031
## iter  10 value -3.939681
## iter  11 value -3.940231
## iter  12 value -3.940434
## iter  13 value -3.940476
## iter  14 value -3.940497
## iter  15 value -3.940612
## iter  16 value -3.940633
## iter  16 value -3.940633
## iter  16 value -3.940633
## final  value -3.940633
## converged
## initial  value -3.940240
## iter   2 value -3.940417
## iter   3 value -3.940814
## iter   4 value -3.941070
## iter   5 value -3.941117
## iter   6 value -3.941132
## iter   7 value -3.941132
## iter   8 value -3.941132
## iter   8 value -3.941132
## final  value -3.941132
## converged
```



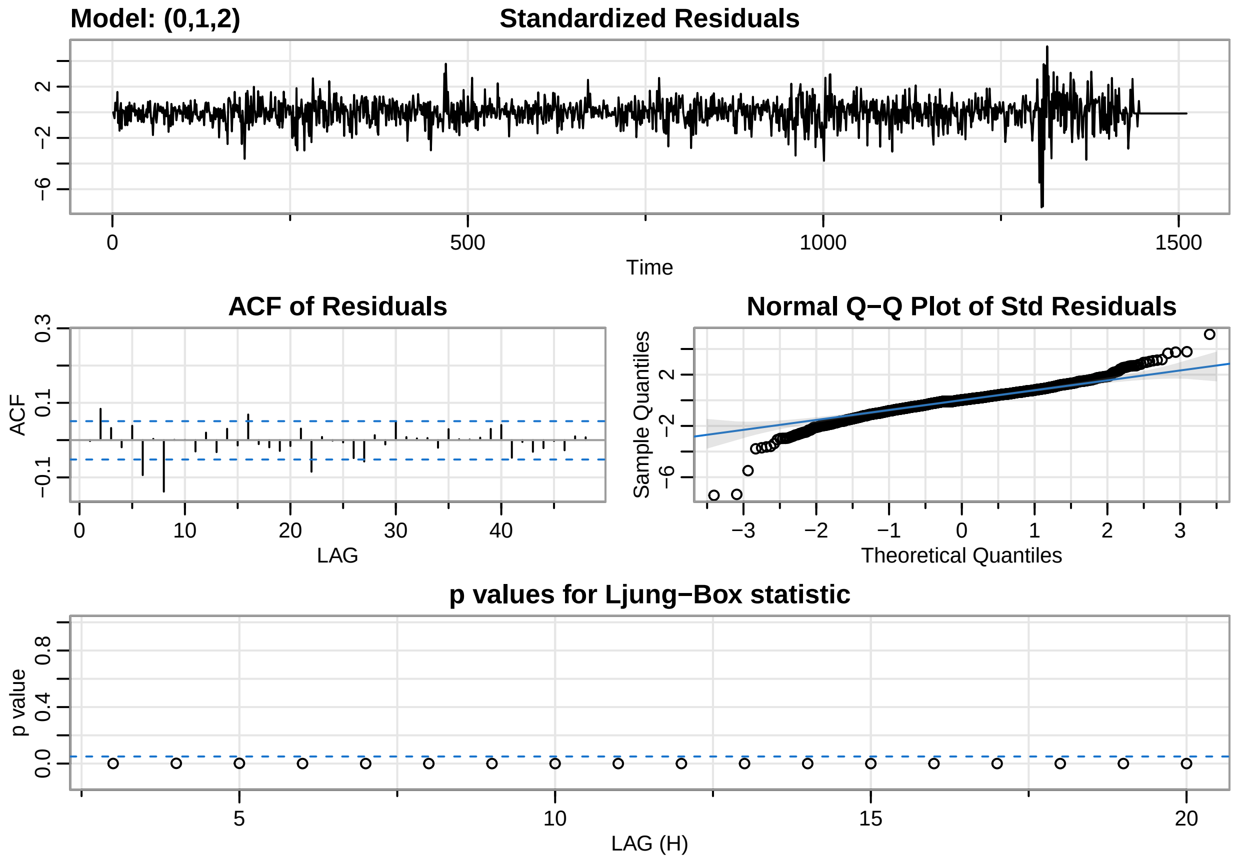

```
camod2
```

```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1     ma2  constant
##       -1.0223  0.0223         0
## s.e.   0.0236  0.0236         0
##
## sigma^2 estimated as 0.0003755:  log likelihood = 3808.51,  aic = -7609.03
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -1.0223 0.0236 -43.2302  0.0000
## ma2        0.0223 0.0236   0.9468  0.3439
## constant   0.0000 0.0000   0.0362  0.9711
##
## $AIC
```

```
## [1] -5.03909
##
## $AICc
## [1] -5.039079
##
## $BIC
## [1] -5.024997
```

```
camod3 = sarima(diff_a3, 0, 1, 2)
```

```
## initial  value -3.539955
## iter   2 value -3.768170
## iter   3 value -3.825687
## iter   4 value -3.882706
## iter   5 value -3.887697
## iter   6 value -3.890718
## iter   7 value -3.890812
## iter   8 value -3.891329
## iter   9 value -3.893137
## iter  10 value -3.895046
## iter  11 value -3.895316
## iter  12 value -3.895360
## iter  13 value -3.895383
## iter  14 value -3.895383
## iter  15 value -3.895388
## iter  15 value -3.895388
## iter  15 value -3.895388
## final  value -3.895388
## converged
## initial  value -3.894964
## iter   2 value -3.895104
## iter   3 value -3.895496
## iter   4 value -3.895766
## iter   5 value -3.895884
## iter   6 value -3.895895
## iter   7 value -3.895896
## iter   8 value -3.895896
## iter   8 value -3.895896
## final  value -3.895896
## converged
```




```
camod3
```

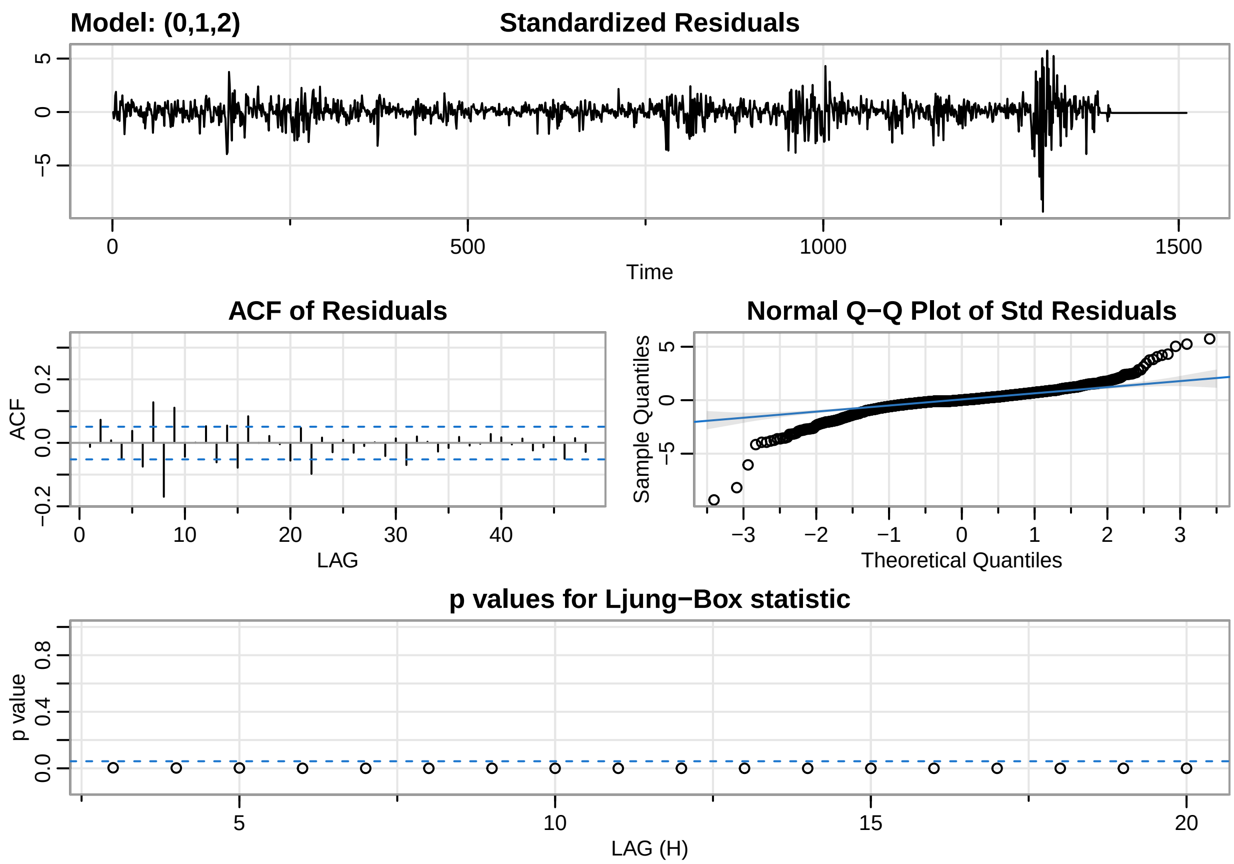
```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1     ma2  constant
##       -1.0193  0.0193         0
## s.e.   0.0239  0.0238         0
##
## sigma^2 estimated as 0.0004111:  log likelihood = 3740.21,  aic = -7472.41
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -1.0193 0.0239 -42.7253  0.0000
## ma2        0.0193 0.0238   0.8102  0.4179
## constant   0.0000 0.0000   0.0611  0.9513
##
## $AIC
```

```
## [1] -4.948617
##
## $AICc
## [1] -4.948606
##
## $BIC
## [1] -4.934525
```

```r
## QQQ Models
diff_q1 <- diff(log(qqq_ts1))
diff_q1 <- diff_q1[!is.na(diff_q1)]
diff_q2 <- diff(log(qqq_ts2))
diff_q2 <- diff_q2[!is.na(diff_q2)]
diff_q3 <- diff(log(qqq_ts3))
diff_q3 <- diff_q3[!is.na(diff_q3)]

cqmod1 = sarima(diff_q1, 0, 1, 2)
```

```
## initial  value -3.925407
## iter   2 value -4.205582
## iter   3 value -4.283653
## iter   4 value -4.324041
## iter   5 value -4.331429
## iter   6 value -4.346176
## iter   7 value -4.349310
## iter   8 value -4.350301
## iter   9 value -4.353829
## iter  10 value -4.354754
## iter  11 value -4.356545
## iter  12 value -4.358203
## iter  13 value -4.362534
## iter  14 value -4.364856
## iter  15 value -4.364976
## iter  16 value -4.365129
## iter  17 value -4.366374
## iter  18 value -4.366881
## iter  19 value -4.367020
## iter  20 value -4.367036
## iter  21 value -4.367074
## iter  22 value -4.367075
## iter  23 value -4.367075
## iter  23 value -4.367075
## iter  23 value -4.367075
## final  value -4.367075
## converged
## initial  value -4.367767
## iter   2 value -4.367952
## iter   3 value -4.368556
## iter   4 value -4.368714
## iter   5 value -4.369474
## iter   6 value -4.369513
## iter   7 value -4.369525
## iter   8 value -4.369526
## iter   8 value -4.369526
```

```
## final  value -4.369526
## converged
```



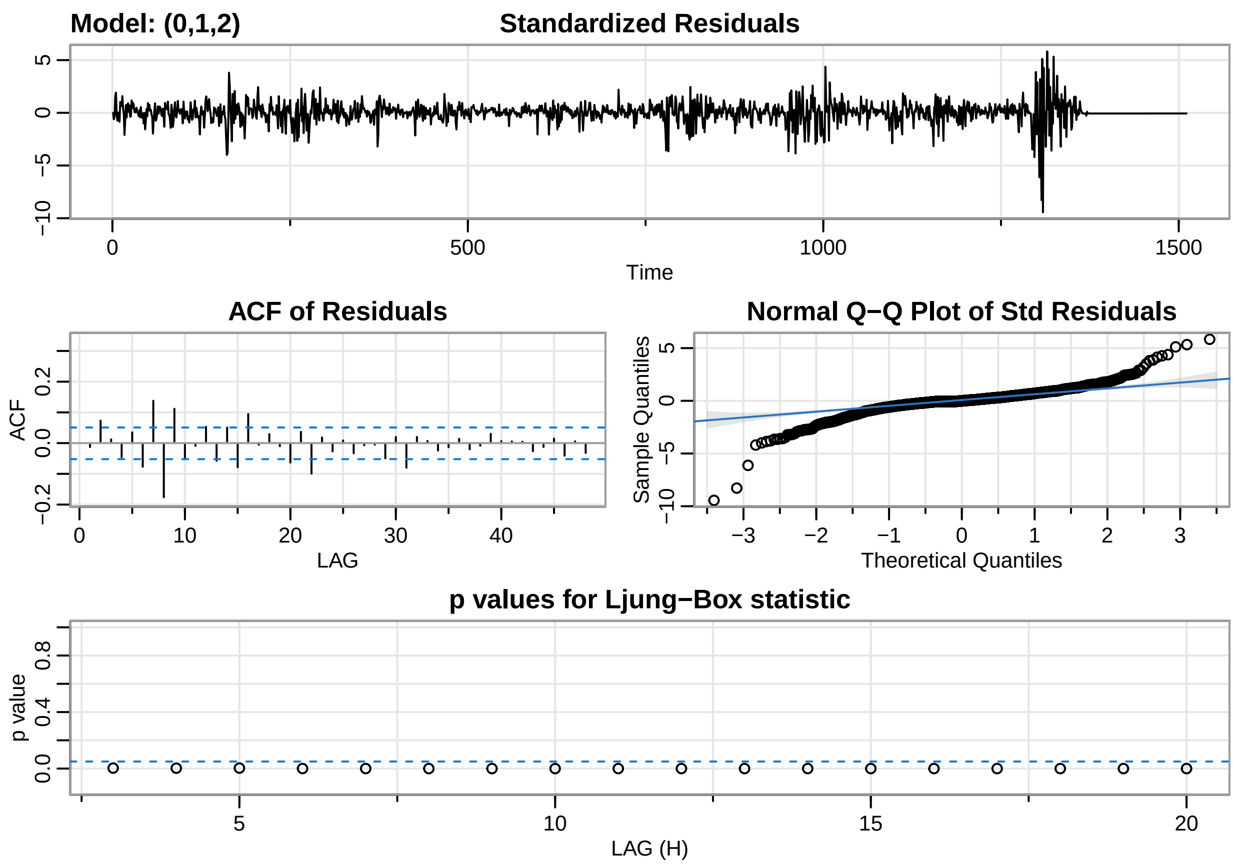

```
cqmod1
```

```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1     ma2  constant
##       -1.1649  0.1649         0
## s.e.   0.0239  0.0238         0
##
## sigma^2 estimated as 0.0001594:  log likelihood = 4455.39,  aic = -8902.77
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -1.1649 0.0239 -48.7726  0.0000
```

```
## ma2        0.1649 0.0238   6.9292  0.0000
## constant   0.0000 0.0000   0.0139  0.9889
##
## $AIC
## [1] -5.895876
##
## $AICc
## [1] -5.895866
##
## $BIC
## [1] -5.881784
```

```r
cqmod2 = sarima(diff_q2, 0, 1, 2)
```

```
## initial  value -3.938847
## iter   2 value -4.220157
## iter   3 value -4.298763
## iter   4 value -4.335341
## iter   5 value -4.366899
## iter   6 value -4.369980
## iter   7 value -4.370702
## iter   8 value -4.372668
## iter   9 value -4.372706
## iter  10 value -4.372999
## iter  11 value -4.379592
## iter  12 value -4.381020
## iter  13 value -4.381024
## iter  14 value -4.381025
## iter  14 value -4.381025
## iter  14 value -4.381025
## final  value -4.381025
## converged
## initial  value -4.381790
## iter   2 value -4.381989
## iter   3 value -4.382581
## iter   4 value -4.382722
## iter   5 value -4.383581
## iter   6 value -4.383601
## iter   7 value -4.383608
## iter   8 value -4.383608
## iter   8 value -4.383608
## final  value -4.383608
## converged
```



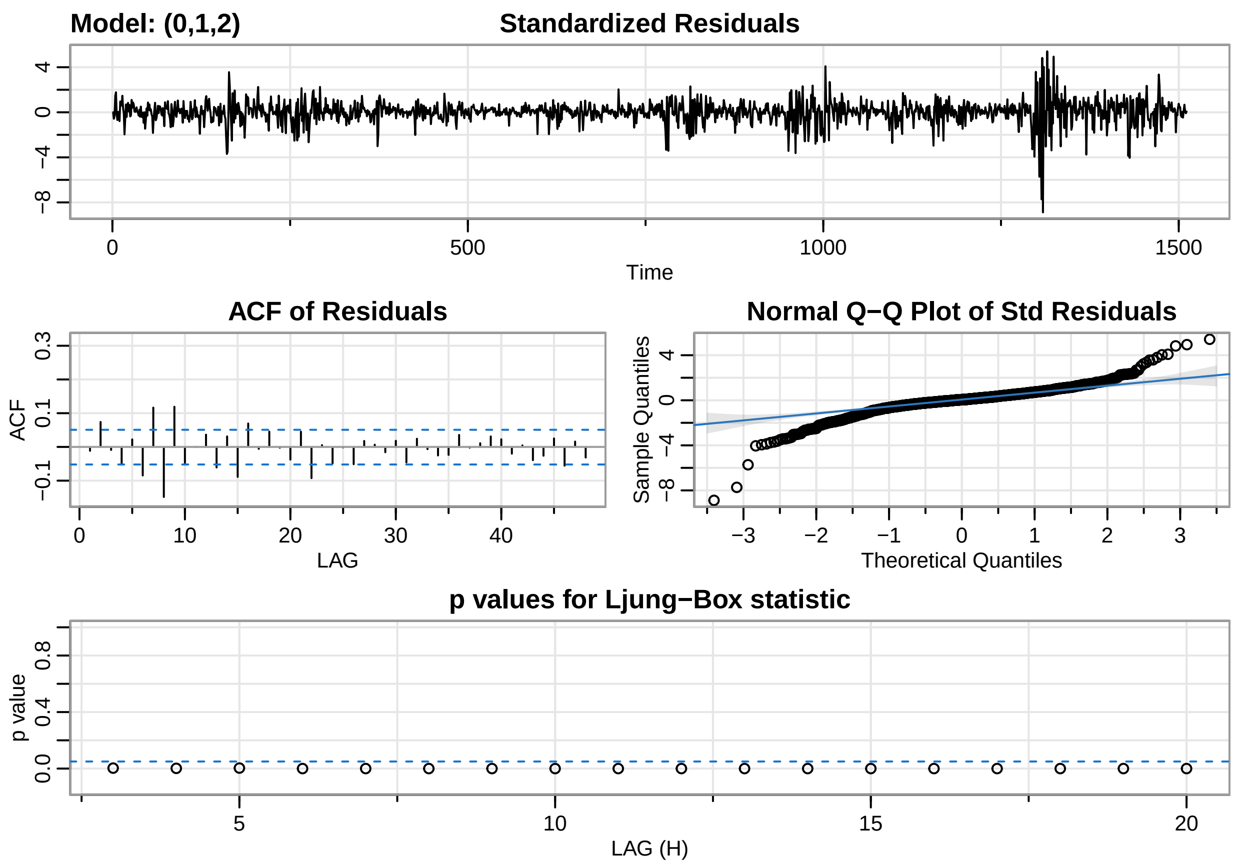

```
cqmod2
```

```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1     ma2  constant
##       -1.1657  0.1657         0
## s.e.   0.0238  0.0237         0
##
## sigma^2 estimated as 0.000155:  log likelihood = 4476.65,  aic = -8945.3
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -1.1657 0.0238 -48.9025  0.0000
## ma2        0.1657 0.0237   6.9781  0.0000
## constant   0.0000 0.0000   0.0058  0.9954
##
## $AIC
```

```
## [1] -5.924042
##
## $AICc
## [1] -5.924031
##
## $BIC
## [1] -5.909949
```

```r
cqmod3 = sarima(diff_q3, 0, 1, 2)
```

```
## initial  value -3.876257
## iter   2 value -4.150019
## iter   3 value -4.222018
## iter   4 value -4.271358
## iter   5 value -4.284517
## iter   6 value -4.291556
## iter   7 value -4.302123
## iter   8 value -4.302356
## iter   9 value -4.302782
## iter  10 value -4.302894
## iter  11 value -4.310986
## iter  12 value -4.311426
## iter  13 value -4.311455
## iter  14 value -4.311466
## iter  15 value -4.311467
## iter  15 value -4.311467
## final  value -4.311467
## converged
## initial  value -4.311889
## iter   2 value -4.311993
## iter   3 value -4.312241
## iter   4 value -4.312509
## iter   5 value -4.313016
## iter   6 value -4.313217
## iter   7 value -4.313314
## iter   8 value -4.313334
## iter   9 value -4.313334
## iter  10 value -4.313334
## iter  11 value -4.313337
## iter  12 value -4.313337
## iter  12 value -4.313337
## iter  12 value -4.313337
## final  value -4.313337
## converged
```



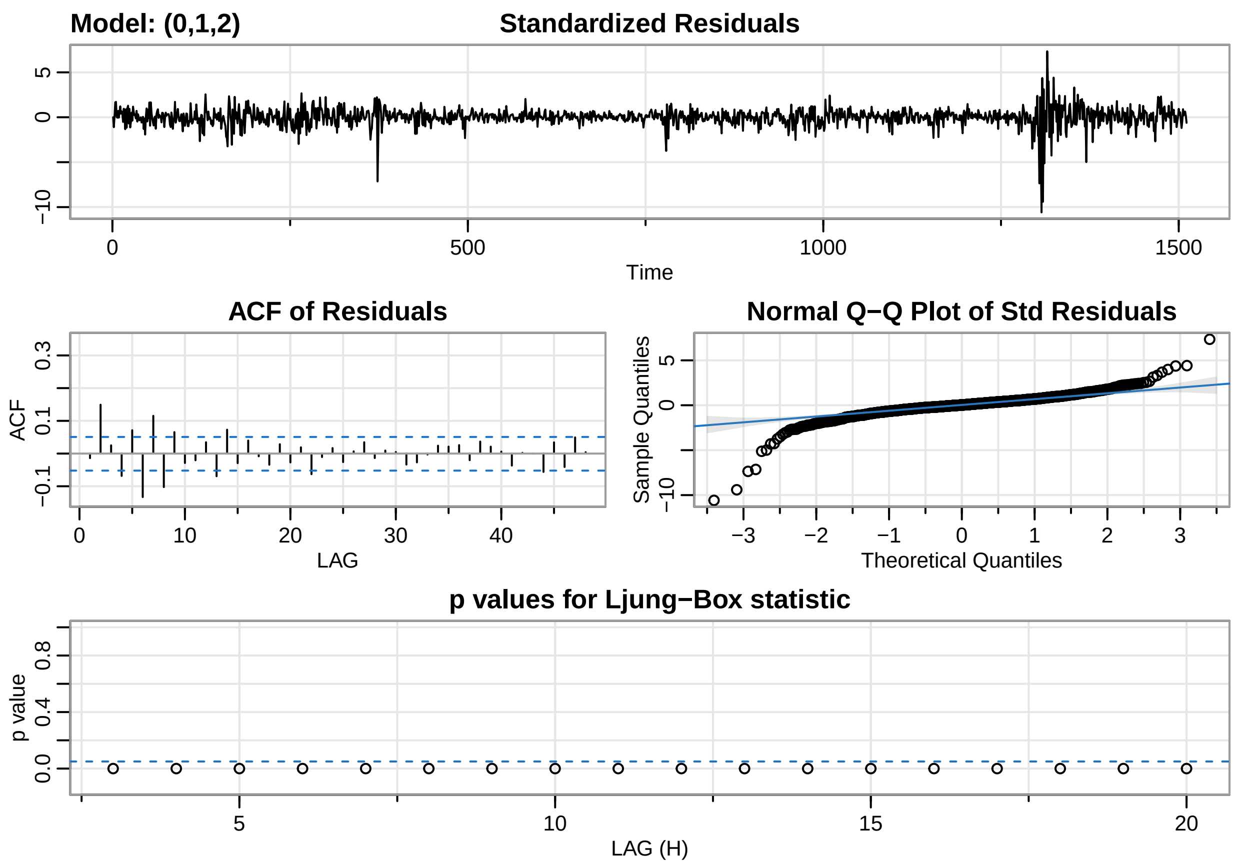

```
cqmod3
```

```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1     ma2  constant
##       -1.1538  0.1538         0
## s.e.   0.0240  0.0239         0
##
## sigma^2 estimated as 0.0001784:  log likelihood = 4370.54,  aic = -8733.08
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -1.1538 0.0240 -48.0532  0.0000
## ma2        0.1538 0.0239   6.4301  0.0000
## constant   0.0000 0.0000   0.0322  0.9743
##
## $AIC
```

```
## [1] -5.783499
##
## $AICc
## [1] -5.783488
##
## $BIC
## [1] -5.769406
```

```r
## SCHF Models
diff_s1 <- diff(log(schf_ts1))
diff_s1 <- diff_s1[!is.na(diff_s1)]
diff_s2 <- diff(log(schf_ts2))
diff_s2 <- diff_s2[!is.na(diff_s2)]
diff_s3 <- diff(log(schf_ts3))
diff_s3 <- diff_s3[!is.na(diff_s3)]

csmod1 = sarima(diff_s1, 0, 1, 2)
```

```
## initial  value -4.064798
## iter   2 value -4.339665
## iter   3 value -4.383031
## iter   4 value -4.400938
## iter   5 value -4.424616
## iter   6 value -4.457550
## iter   7 value -4.460531
## iter   8 value -4.461563
## iter   9 value -4.461819
## iter  10 value -4.462098
## iter  11 value -4.464603
## iter  12 value -4.467164
## iter  13 value -4.467208
## iter  14 value -4.467246
## iter  15 value -4.467250
## iter  16 value -4.467251
## iter  17 value -4.467251
## iter  17 value -4.467251
## iter  17 value -4.467251
## final  value -4.467251
## converged
## initial  value -4.468462
## iter   2 value -4.468608
## iter   3 value -4.469548
## iter   4 value -4.469663
## iter   5 value -4.469751
## iter   6 value -4.470046
## iter   7 value -4.470090
## iter   8 value -4.470145
## iter   9 value -4.470148
## iter  10 value -4.470148
## iter  11 value -4.470150
## iter  11 value -4.470150
## iter  11 value -4.470150
## final  value -4.470150
## converged
```



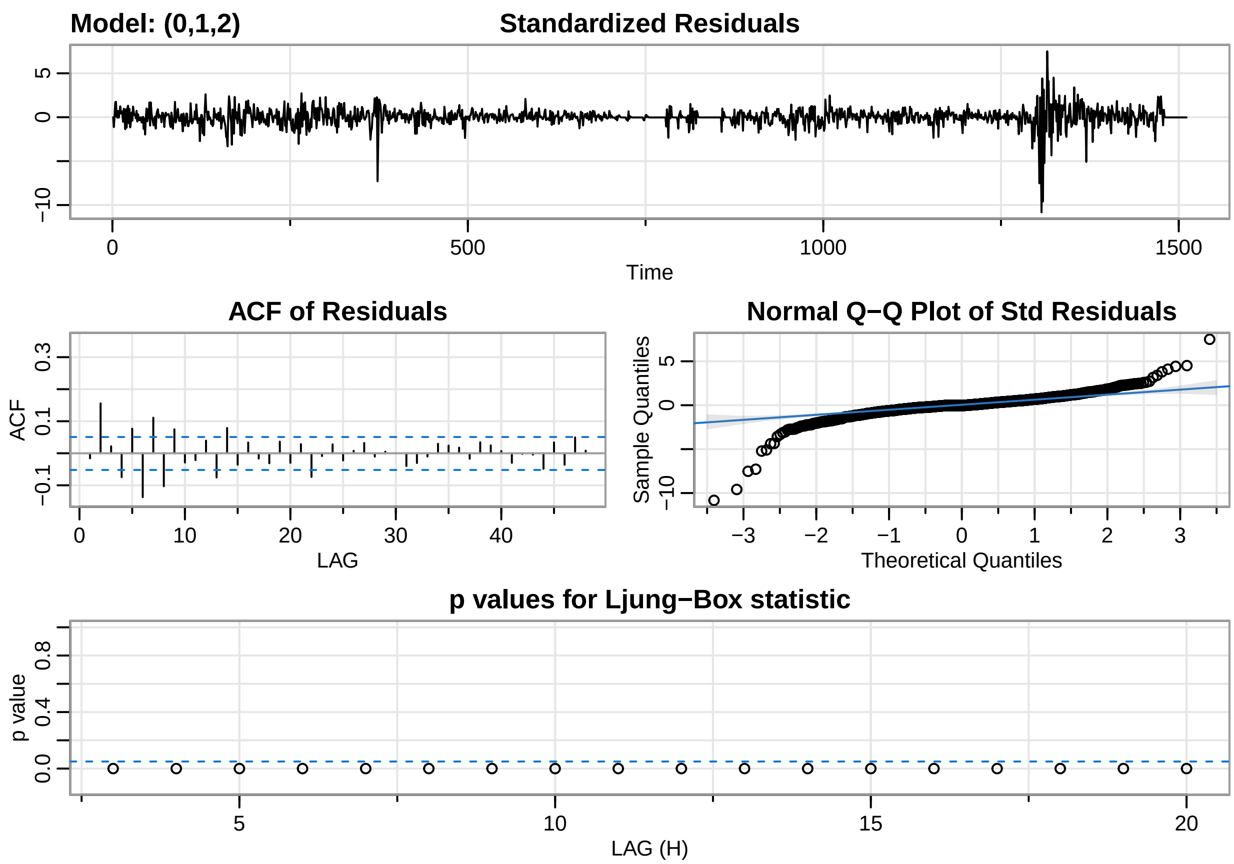

```
csmod1
```

```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1     ma2  constant
##       -1.0913  0.0913         0
## s.e.   0.0226  0.0225         0
##
## sigma^2 estimated as 0.0001304:  log likelihood = 4607.33,  aic = -9206.66
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -1.0913 0.0226 -48.2466  0.0000
## ma2        0.0913 0.0225   4.0590  0.0001
## constant   0.0000 0.0000   0.0105  0.9916
##
## $AIC
```

```
## [1] -6.097125
##
## $AICc
## [1] -6.097114
##
## $BIC
## [1] -6.083033
```

```r
csmod2 = sarima(diff_s2, 0, 1, 2)
```

```
## initial  value -4.082861
## iter   2 value -4.361543
## iter   3 value -4.403214
## iter   4 value -4.421450
## iter   5 value -4.446953
## iter   6 value -4.484267
## iter   7 value -4.485064
## iter   8 value -4.485816
## iter   9 value -4.485846
## iter  10 value -4.485946
## iter  11 value -4.487897
## iter  12 value -4.488815
## iter  13 value -4.489010
## iter  14 value -4.489035
## iter  15 value -4.489041
## iter  16 value -4.489041
## iter  17 value -4.489041
## iter  18 value -4.489042
## iter  18 value -4.489042
## iter  18 value -4.489042
## final  value -4.489042
## converged
## initial  value -4.490432
## iter   2 value -4.490587
## iter   3 value -4.491721
## iter   4 value -4.492086
## iter   5 value -4.492224
## iter   6 value -4.492297
## iter   7 value -4.492333
## iter   8 value -4.492335
## iter   8 value -4.492335
## final  value -4.492335
## converged
```



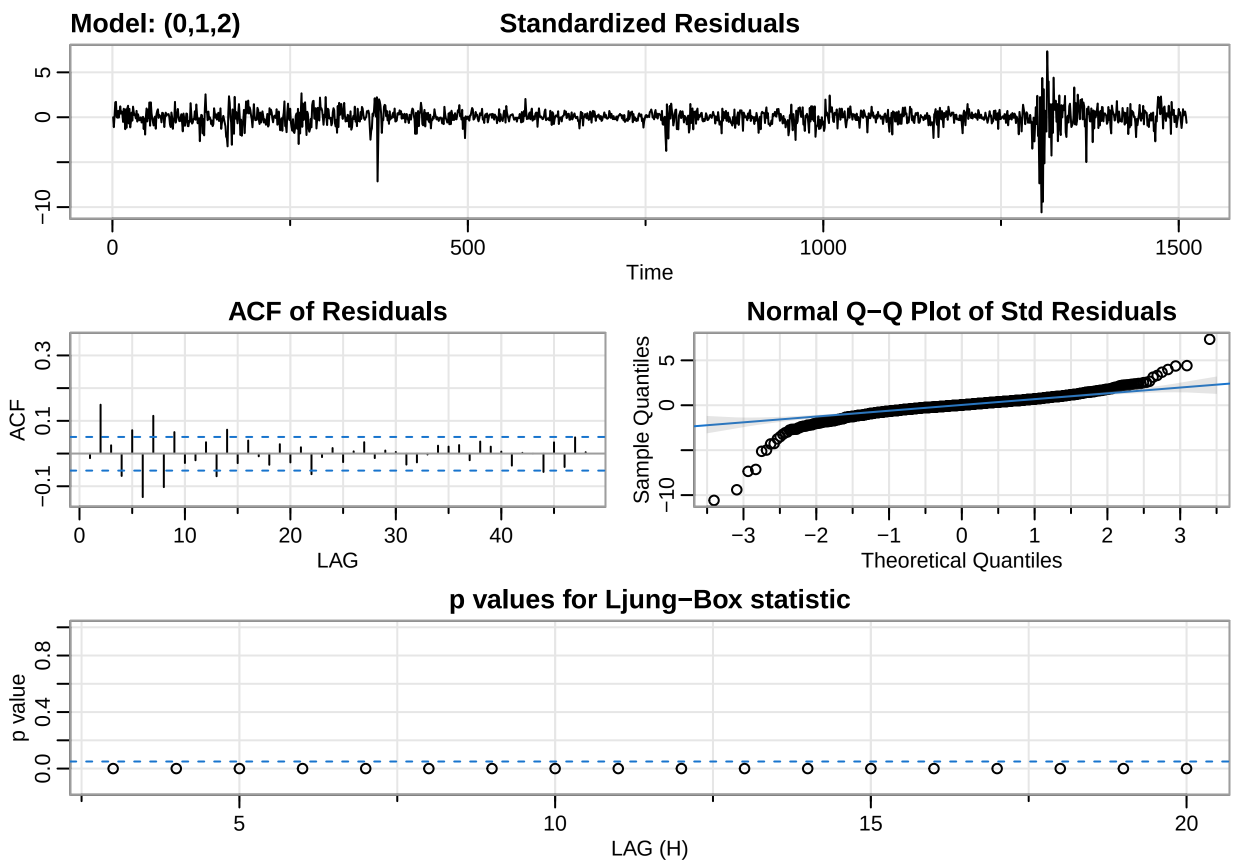

```
csmod2
```

```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1     ma2  constant
##       -1.0961  0.0962         0
## s.e.   0.0225  0.0224         0
##
## sigma^2 estimated as 0.0001247:  log likelihood = 4640.83,  aic = -9273.66
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -1.0961 0.0225 -48.7459  0.0000
## ma2        0.0962 0.0224   4.2962  0.0000
## constant   0.0000 0.0000   0.0049  0.9961
##
## $AIC
```

```
## [1] -6.141495
##
## $AICc
## [1] -6.141484
##
## $BIC
## [1] -6.127402
```

```
csmod3 = sarima(diff_s3, 0, 1, 2)
```

```
## initial  value -4.064798
## iter   2 value -4.339665
## iter   3 value -4.383031
## iter   4 value -4.400938
## iter   5 value -4.424616
## iter   6 value -4.457550
## iter   7 value -4.460531
## iter   8 value -4.461563
## iter   9 value -4.461819
## iter  10 value -4.462098
## iter  11 value -4.464603
## iter  12 value -4.467164
## iter  13 value -4.467208
## iter  14 value -4.467246
## iter  15 value -4.467250
## iter  16 value -4.467251
## iter  17 value -4.467251
## iter  17 value -4.467251
## iter  17 value -4.467251
## final  value -4.467251
## converged
## initial  value -4.468462
## iter   2 value -4.468608
## iter   3 value -4.469548
## iter   4 value -4.469663
## iter   5 value -4.469751
## iter   6 value -4.470046
## iter   7 value -4.470090
## iter   8 value -4.470145
## iter   9 value -4.470148
## iter  10 value -4.470148
## iter  11 value -4.470150
## iter  11 value -4.470150
## iter  11 value -4.470150
## final  value -4.470150
## converged
```



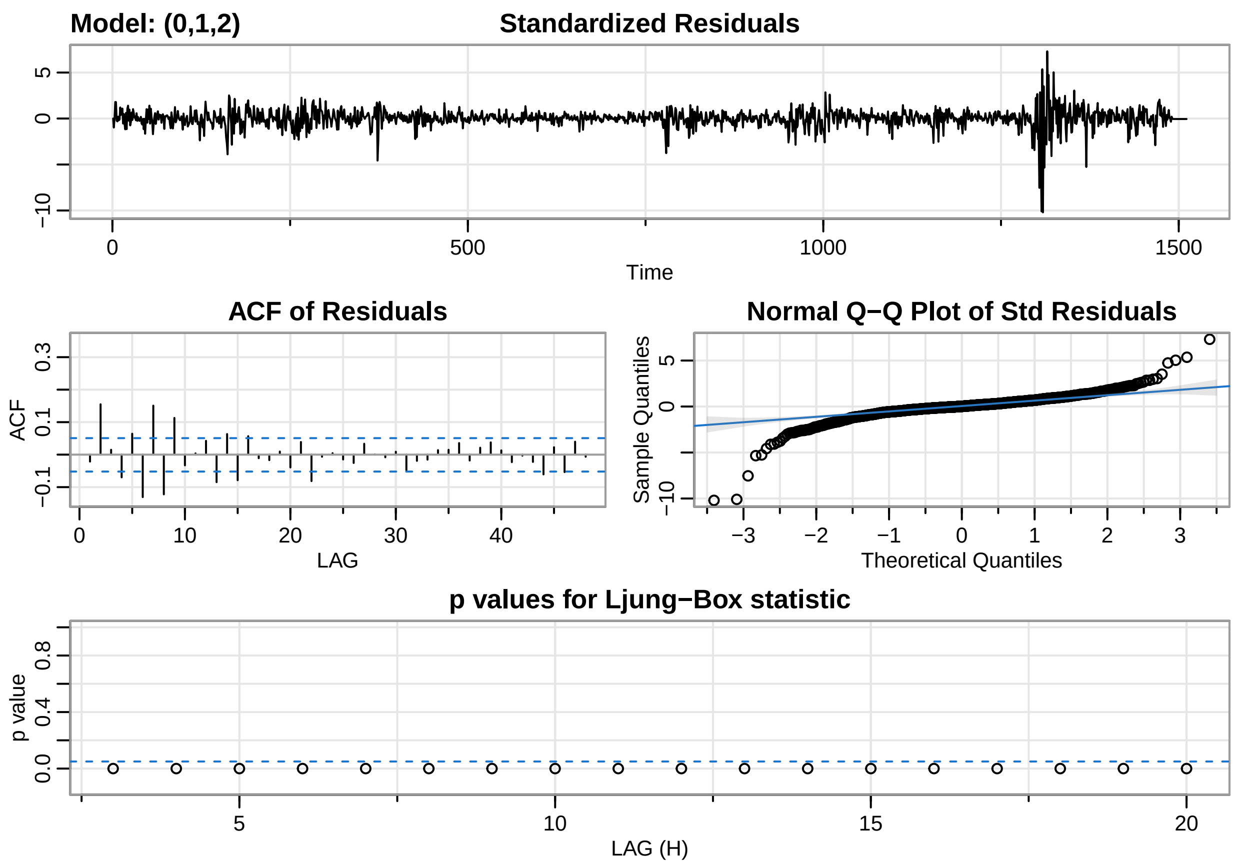

```
csmod3
```

```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1     ma2  constant
##       -1.0913  0.0913         0
## s.e.   0.0226  0.0225         0
##
## sigma^2 estimated as 0.0001304:  log likelihood = 4607.33,  aic = -9206.66
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -1.0913 0.0226 -48.2466  0.0000
## ma2        0.0913 0.0225   4.0590  0.0001
## constant   0.0000 0.0000   0.0105  0.9916
##
## $AIC
```

```
## [1] -6.097125
##
## $AICc
## [1] -6.097114
##
## $BIC
## [1] -6.083033
```

```r
## VT Models
diff_v1 <- diff(log(vt_ts1))
diff_v1 <- diff_v1[!is.na(diff_v1)]
diff_v2 <- diff(log(vt_ts2))
diff_v2 <- diff_v2[!is.na(diff_v2)]
diff_v3 <- diff(log(vt_ts3))
diff_v3 <- diff_v3[!is.na(diff_v3)]

cvmod1 = sarima(diff_v1, 0, 1, 2)
```

```
## initial  value -4.039675
## iter   2 value -4.336020
## iter   3 value -4.381438
## iter   4 value -4.410747
## iter   5 value -4.460310
## iter   6 value -4.471056
## iter   7 value -4.471108
## iter   8 value -4.471188
## iter   9 value -4.471527
## iter  10 value -4.472703
## iter  11 value -4.473519
## iter  12 value -4.474086
## iter  13 value -4.474513
## iter  14 value -4.474996
## iter  15 value -4.475014
## iter  15 value -4.475014
## final  value -4.475014
## converged
## initial  value -4.475252
## iter   2 value -4.475370
## iter   3 value -4.475639
## iter   4 value -4.476048
## iter   5 value -4.476454
## iter   6 value -4.476565
## iter   7 value -4.476580
## iter   8 value -4.476580
## iter   8 value -4.476580
## final  value -4.476580
## converged
```



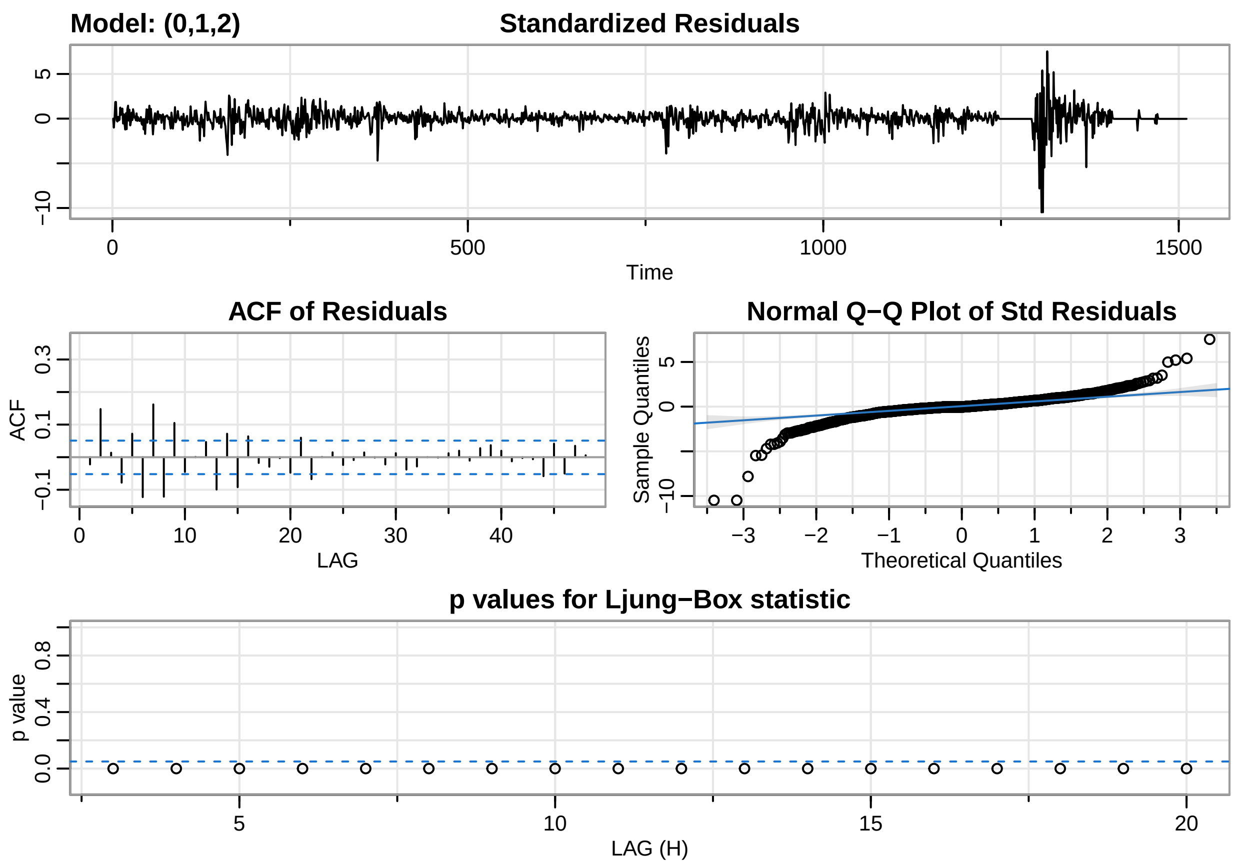

```
cvmod1
```

```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1     ma2  constant
##       -1.1362  0.1362         0
## s.e.   0.0225  0.0223         0
##
## sigma^2 estimated as 0.0001287:  log likelihood = 4617.04,  aic = -9226.08
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -1.1362 0.0225 -50.6082  0.0000
## ma2        0.1362 0.0223   6.0967  0.0000
## constant   0.0000 0.0000   0.0137  0.9891
##
## $AIC
```

```
## [1] -6.109984
##
## $AICc
## [1] -6.109974
##
## $BIC
## [1] -6.095892
```

```r
cvmod2 = sarima(diff_v2, 0, 1, 2)
```

```
## initial  value -4.065202
## iter   2 value -4.365118
## iter   3 value -4.414336
## iter   4 value -4.452044
## iter   5 value -4.489369
## iter   6 value -4.501356
## iter   7 value -4.503955
## iter   8 value -4.504353
## iter   9 value -4.504417
## iter  10 value -4.504584
## iter  11 value -4.508698
## iter  12 value -4.509026
## iter  13 value -4.509027
## iter  14 value -4.509028
## iter  15 value -4.509029
## iter  15 value -4.509029
## final  value -4.509029
## converged
## initial  value -4.509474
## iter   2 value -4.509624
## iter   3 value -4.510026
## iter   4 value -4.510311
## iter   5 value -4.510713
## iter   6 value -4.510860
## iter   7 value -4.510965
## iter   8 value -4.510994
## iter   8 value -4.510994
## final  value -4.510994
## converged
```



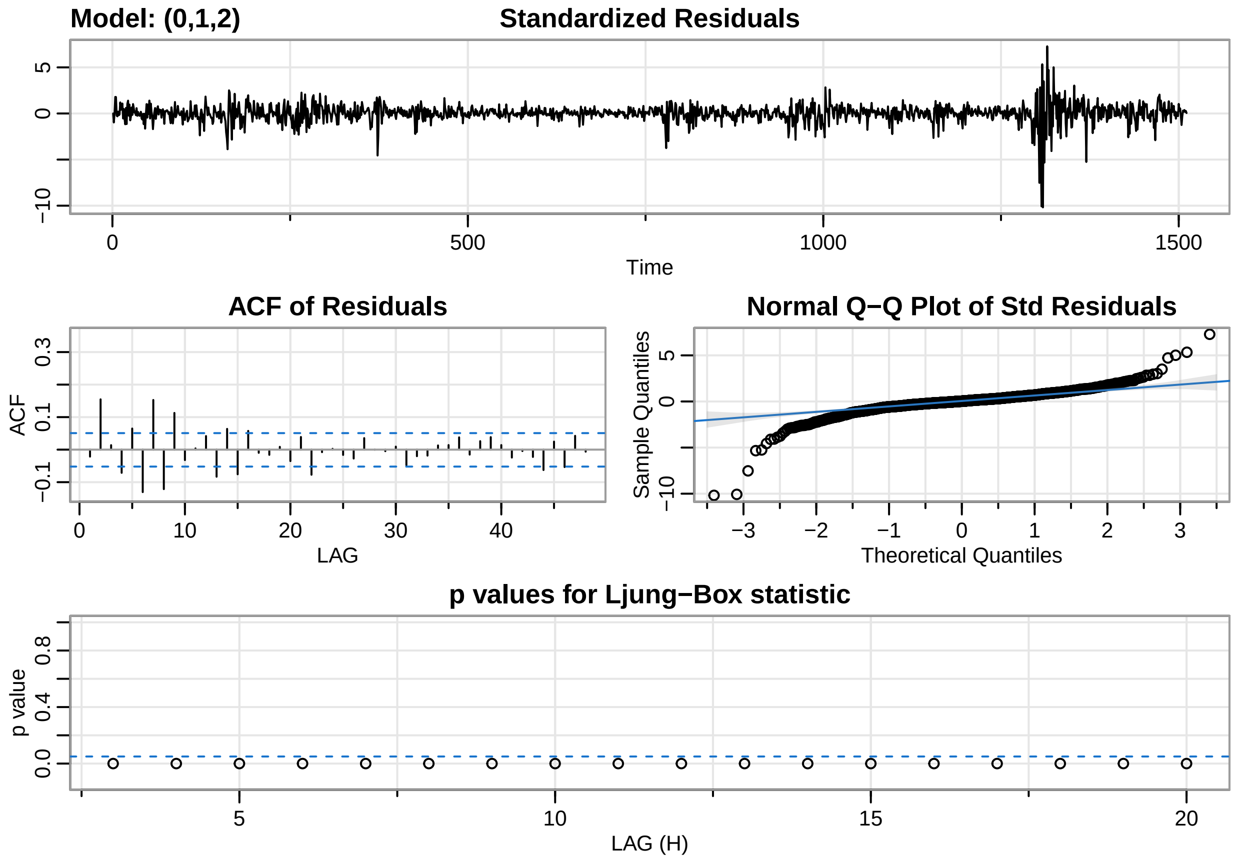

```
cvmod2
```

```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1     ma2  constant
##       -1.1507  0.1507         0
## s.e.   0.0225  0.0224         0
##
## sigma^2 estimated as 0.0001201:  log likelihood = 4669,  aic = -9330.01
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -1.1507 0.0225 -51.0441  0.0000
## ma2        0.1507 0.0224   6.7163  0.0000
## constant   0.0000 0.0000   0.0030  0.9976
##
## $AIC
```

```
## [1] -6.178814
##
## $AICc
## [1] -6.178803
##
## $BIC
## [1] -6.164721
```

```
cvmod3 = sarima(diff_v3, 0, 1, 2)
```

```
## initial  value -4.036952
## iter   2 value -4.333060
## iter   3 value -4.378436
## iter   4 value -4.409178
## iter   5 value -4.462623
## iter   6 value -4.464755
## iter   7 value -4.465657
## iter   8 value -4.466995
## iter   9 value -4.467319
## iter  10 value -4.467725
## iter  11 value -4.469342
## iter  12 value -4.470935
## iter  13 value -4.472006
## iter  14 value -4.472236
## iter  15 value -4.472391
## iter  16 value -4.472408
## iter  17 value -4.472422
## iter  18 value -4.472504
## iter  19 value -4.472513
## iter  20 value -4.472514
## iter  20 value -4.472514
## iter  20 value -4.472514
## final  value -4.472514
## converged
## initial  value -4.472685
## iter   2 value -4.472800
## iter   3 value -4.473127
## iter   4 value -4.473649
## iter   5 value -4.473813
## iter   6 value -4.473924
## iter   7 value -4.473936
## iter   8 value -4.473936
## iter   8 value -4.473936
## final  value -4.473936
## converged
```



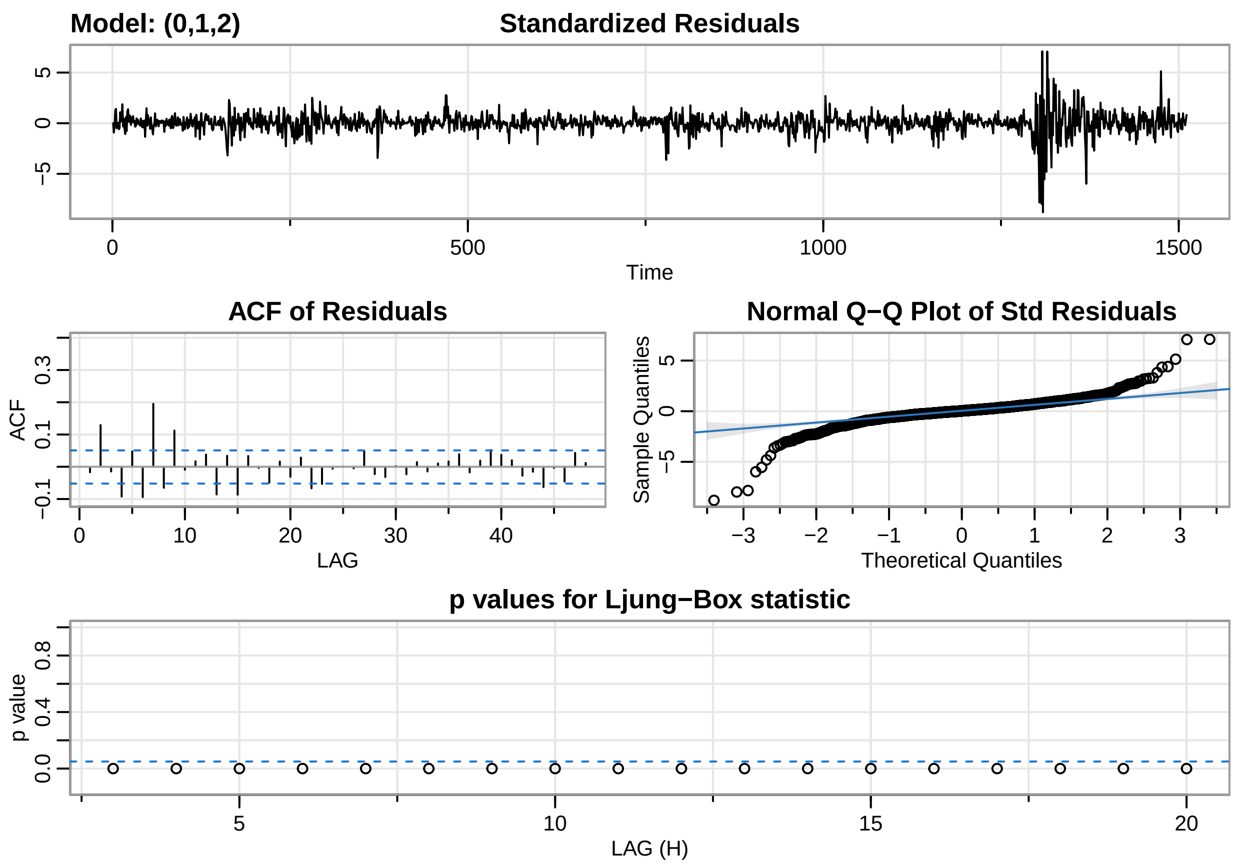

```
cvmod3
```

```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1     ma2  constant
##       -1.1363  0.1363         0
## s.e.   0.0225  0.0224         0
##
## sigma^2 estimated as 0.0001294:  log likelihood = 4613.05,  aic = -9218.09
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1       -1.1363 0.0225 -50.5600   0.000
## ma2        0.1363 0.0224   6.0966   0.000
## constant   0.0000 0.0000   0.0176   0.986
##
## $AIC
```

```
## [1] -6.104697
##
## $AICc
## [1] -6.104686
##
## $BIC
## [1] -6.090604
```

```r
## XLF Models
diff_x1 <- diff(log(xlf_ts1))
diff_x1 <- diff_x1[!is.na(diff_x1)]
diff_x2 <- diff(log(xlf_ts2))
diff_x2 <- diff_x2[!is.na(diff_x2)]
diff_x3 <- diff(log(xlf_ts3))
diff_x3 <- diff_x3[!is.na(diff_x3)]

cxmod1 = sarima(diff_x1, 0, 1, 2)
```

```
## initial  value -3.756573
## iter   2 value -4.035086
## iter   3 value -4.083385
## iter   4 value -4.108818
## iter   5 value -4.133822
## iter   6 value -4.159273
## iter   7 value -4.167111
## iter   8 value -4.177253
## iter   9 value -4.177646
## iter  10 value -4.181190
## iter  11 value -4.181474
## iter  12 value -4.181636
## iter  13 value -4.181647
## iter  14 value -4.187319
## iter  15 value -4.189098
## iter  15 value -4.189098
## iter  15 value -4.189098
## final  value -4.189098
## converged
## initial  value -4.184562
## iter   2 value -4.184727
## iter   3 value -4.184965
## iter   4 value -4.185003
## iter   5 value -4.185006
## iter   6 value -4.185009
## iter   7 value -4.185010
## iter   7 value -4.185010
## iter   7 value -4.185010
## final  value -4.185010
## converged
```




```
cxmod1
```

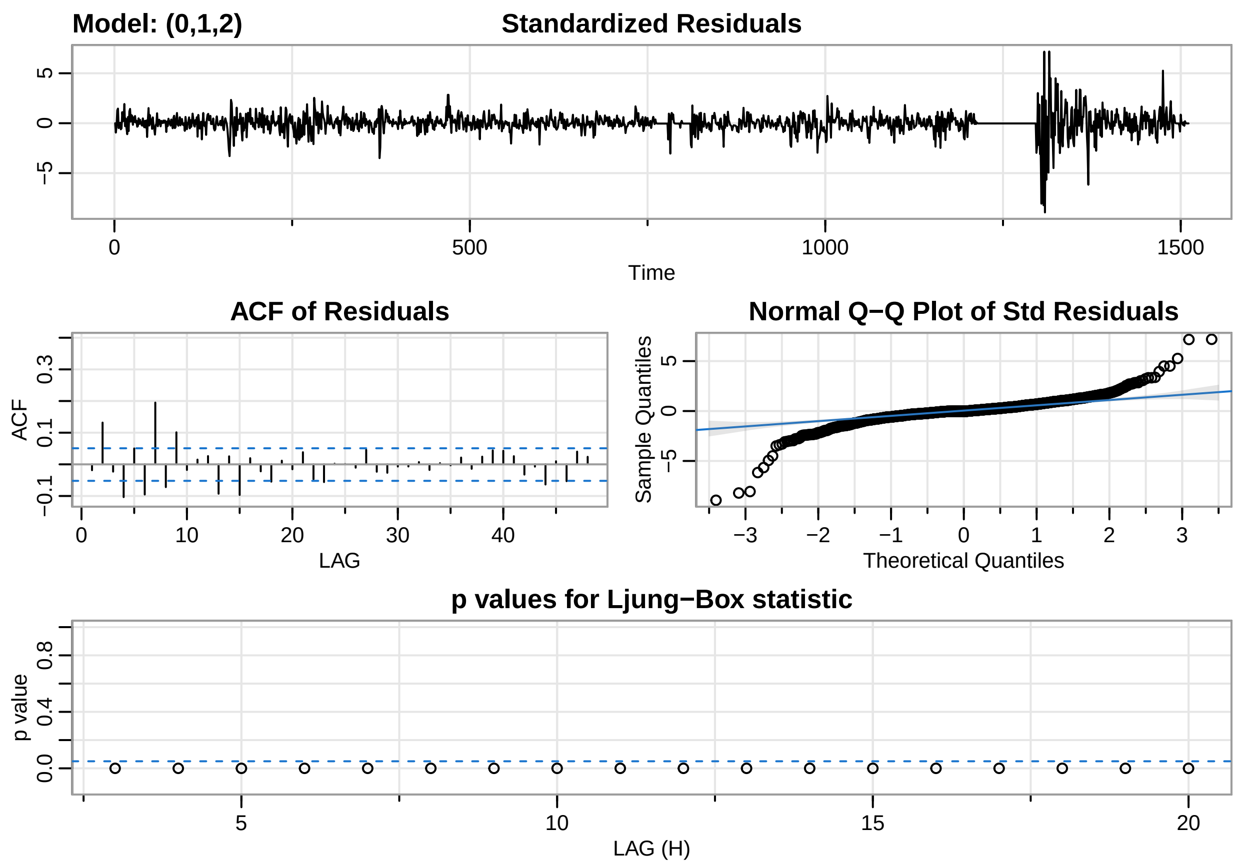
```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1    ma2  constant
##       -1.1290  0.129         0
## s.e.   0.0231  0.023         0
##
## sigma^2 estimated as 0.0002305:  log likelihood = 4176.77,  aic = -8345.53
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1        -1.129 0.0231 -48.9226   0.000
## ma2         0.129 0.0230   5.6202   0.000
## constant    0.000 0.0000   0.0050   0.996
##
## $AIC
```

```
## [1] -5.526844
##
## $AICc
## [1] -5.526834
##
## $BIC
## [1] -5.512752
```

```r
cxmod2 = sarima(diff_x2, 0, 1, 2)
```

```
## initial  value -3.771359
## iter   2 value -4.054931
## iter   3 value -4.102107
## iter   4 value -4.127802
## iter   5 value -4.165501
## iter   6 value -4.178667
## iter   7 value -4.188298
## iter   8 value -4.191824
## iter   9 value -4.193046
## iter  10 value -4.195703
## iter  11 value -4.198088
## iter  12 value -4.209161
## iter  13 value -4.209931
## iter  14 value -4.210167
## iter  15 value -4.210196
## iter  16 value -4.211290
## iter  17 value -4.211299
## iter  18 value -4.211755
## iter  19 value -4.211871
## iter  20 value -4.212113
## iter  21 value -4.212125
## iter  22 value -4.212149
## iter  23 value -4.212166
## iter  24 value -4.212233
## iter  24 value -4.212233
## iter  25 value -4.212260
## iter  25 value -4.212260
## iter  26 value -4.212275
## iter  27 value -4.212305
## iter  28 value -4.212312
## iter  28 value -4.212312
## iter  29 value -4.212325
## iter  29 value -4.212325
## iter  30 value -4.212330
## iter  31 value -4.212331
## iter  32 value -4.212336
## iter  32 value -4.212336
## iter  33 value -4.212337
## iter  33 value -4.212337
## iter  34 value -4.212337
## iter  34 value -4.212337
## iter  35 value -4.212338
## iter  35 value -4.212338
## iter  35 value -4.212338
```

```
## final  value -4.212338
## converged
## initial  value -4.208523
## iter   2 value -4.208539
## iter   3 value -4.208687
## iter   4 value -4.208782
## iter   5 value -4.208818
## iter   6 value -4.208820
## iter   7 value -4.208820
## iter   7 value -4.208820
## iter   7 value -4.208820
## final  value -4.208820
## converged
```




```
cxmod2
```

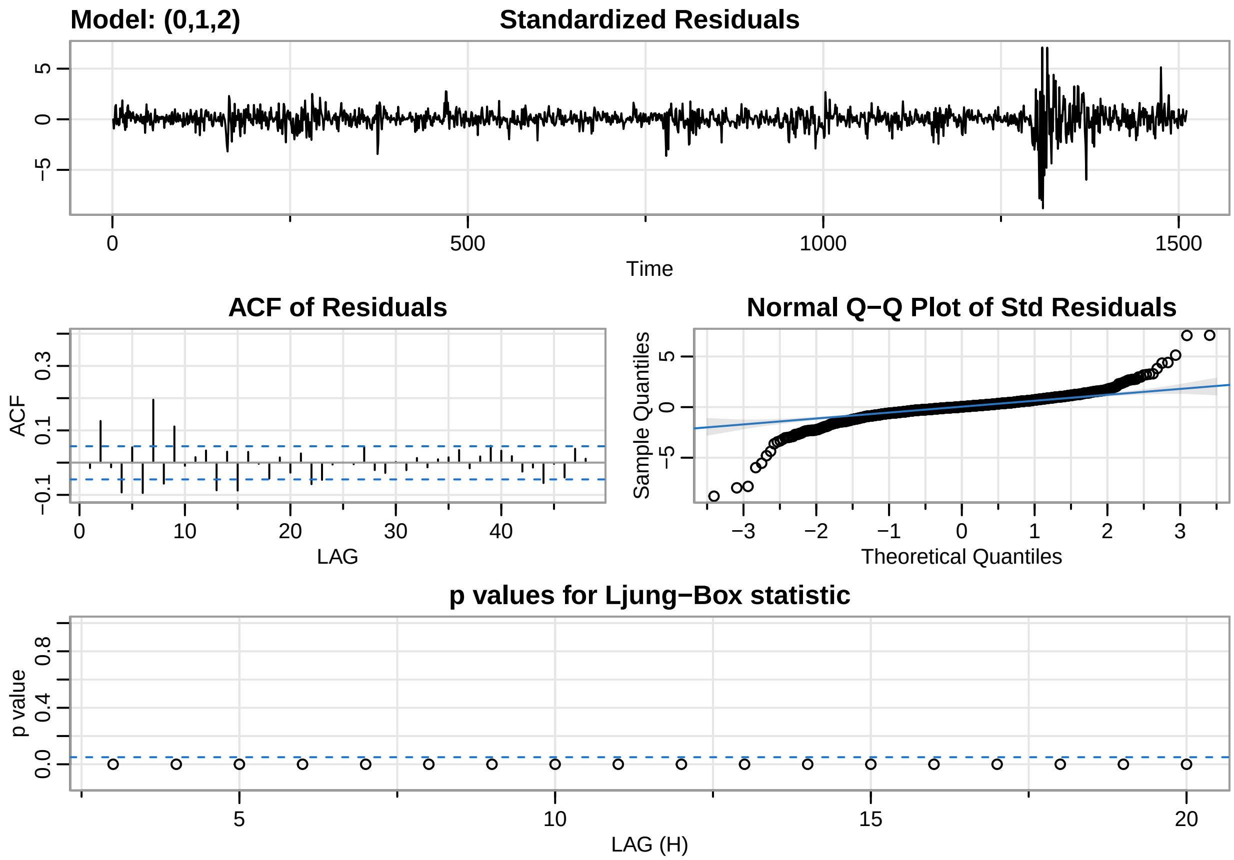
```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1     ma2  constant
```

```
##       -1.1420  0.142         0
## s.e.   0.0231  0.023         0
##
## sigma^2 estimated as 0.0002198:  log likelihood = 4212.72,  aic = -8417.44
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1        -1.142 0.0231 -49.4721  0.0000
## ma2         0.142 0.0230   6.1839  0.0000
## constant    0.000 0.0000   0.0028  0.9978
##
## $AIC
## [1] -5.574465
##
## $AICc
## [1] -5.574455
##
## $BIC
## [1] -5.560373
```

```r
cxmod3 = sarima(diff_x3, 0, 1, 2)
```

```
## initial  value -3.756573
## iter   2 value -4.035086
## iter   3 value -4.083385
## iter   4 value -4.108818
## iter   5 value -4.133822
## iter   6 value -4.159273
## iter   7 value -4.167111
## iter   8 value -4.177253
## iter   9 value -4.177646
## iter  10 value -4.181190
## iter  11 value -4.181474
## iter  12 value -4.181636
## iter  13 value -4.181647
## iter  14 value -4.187319
## iter  15 value -4.189098
## iter  15 value -4.189098
## iter  15 value -4.189098
## final  value -4.189098
## converged
## initial  value -4.184562
## iter   2 value -4.184727
## iter   3 value -4.184965
## iter   4 value -4.185003
## iter   5 value -4.185006
## iter   6 value -4.185009
## iter   7 value -4.185010
## iter   7 value -4.185010
## iter   7 value -4.185010
## final  value -4.185010
```

```
## converged
```




```
cxmod3
```

```
## $fit
##
## Call:
## arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D, Q), period = S),
##     xreg = constant, transform.pars = trans, fixed = fixed, optim.control = list(trace = trc,
##         REPORT = 1, reltol = tol))
##
## Coefficients:
##           ma1    ma2  constant
##       -1.1290  0.129         0
## s.e.   0.0231  0.023         0
##
## sigma^2 estimated as 0.0002305:  log likelihood = 4176.77,  aic = -8345.53
##
## $degrees_of_freedom
## [1] 1507
##
## $ttable
##          Estimate     SE  t.value p.value
## ma1        -1.129 0.0231 -48.9226   0.000
## ma2         0.129 0.0230   5.6202   0.000
```

```
## constant    0.000 0.0000   0.0050   0.996
##
## $AIC
## [1] -5.526844
##
## $AICc
## [1] -5.526834
##
## $BIC
## [1] -5.512752
```

```r
aop <- auto.arima(arkg_ts, ic = "aic")
aop
```

```
## Series: arkg_ts
## ARIMA(5,2,0)
##
## Coefficients:
##           ar1      ar2      ar3      ar4      ar5
##       -0.8012  -0.5525  -0.4417  -0.3548  -0.0984
## s.e.   0.0256   0.0318   0.0330   0.0320   0.0263
##
## sigma^2 estimated as 0.7608:  log likelihood=-1934.13
## AIC=3880.25   AICc=3880.31   BIC=3912.17
```

```r
qop <- auto.arima(qqq_ts, ic = "aic")
qop
```

```
## Series: qqq_ts
## ARIMA(0,1,2) with drift
##
## Coefficients:
##           ma1     ma2   drift
##       -0.1661  0.1079  0.1393
## s.e.   0.0254  0.0264  0.0590
##
## sigma^2 estimated as 5.944:  log likelihood=-3489.13
## AIC=6986.26   AICc=6986.29   BIC=7007.55
```

```r
sop <- auto.arima(schf_ts, ic = "aic")
sop
```

```
## Series: schf_ts
## ARIMA(4,1,2)
##
## Coefficients:
##           ar1      ar2     ar3     ar4     ma1     ma2
##       -1.5783  -0.6268  0.1540  0.0500  1.5272  0.6495
## s.e.   0.1189   0.1211  0.0511  0.0396  0.1157  0.1045
##
## sigma^2 estimated as 0.1012:  log likelihood=-410.68
## AIC=835.36   AICc=835.43   BIC=872.6
```

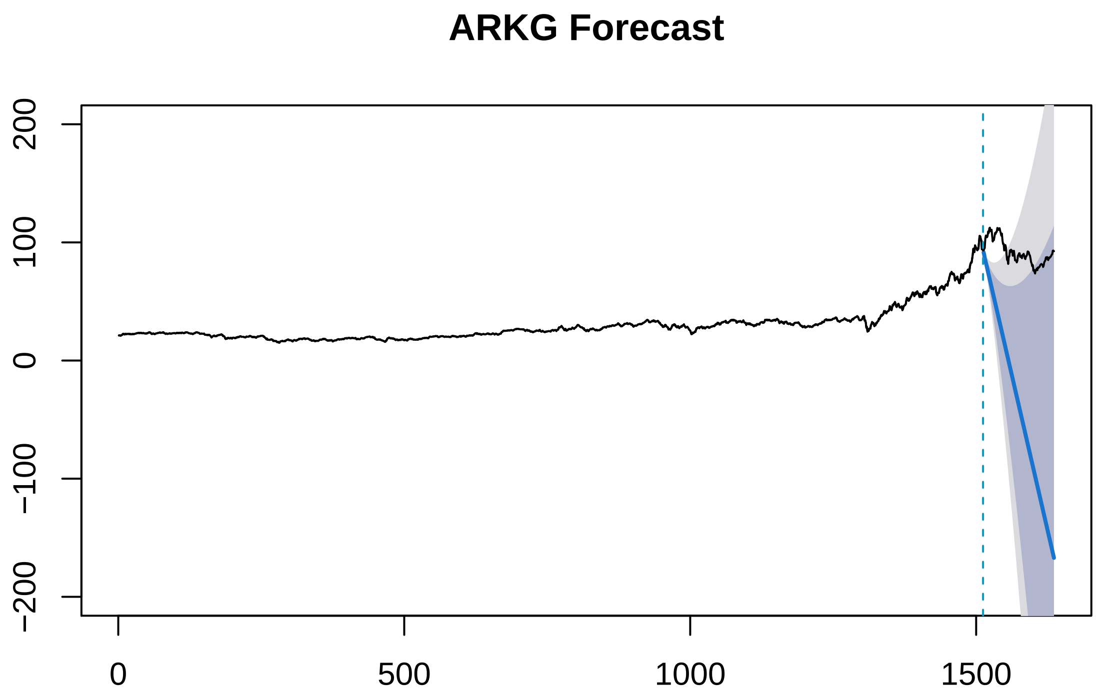
```r
vop <- auto.arima(vt_ts, ic = "aic")
vop
```

```
## Series: vt_ts
## ARIMA(4,1,2) with drift
##
## Coefficients:
##           ar1      ar2     ar3     ar4     ma1     ma2   drift
##       -1.6559  -0.7123  0.1366  0.0525  1.5651  0.6755  0.0214
## s.e.   0.0928   0.1040  0.0521  0.0374  0.0887  0.0827  0.0191
##
## sigma^2 estimated as 0.5335:  log likelihood=-1666.08
## AIC=3348.15   AICc=3348.25   BIC=3390.72
```

```r
xop <- auto.arima(xlf_ts, ic = "aic")
xop
```

```
## Series: xlf_ts
## ARIMA(4,1,2)
##
## Coefficients:
##           ar1      ar2     ar3     ar4     ma1     ma2
##       -1.6061  -0.6942  0.0940  0.0187  1.5232  0.6621
## s.e.   0.0953   0.1088  0.0511  0.0356  0.0916  0.0895
##
## sigma^2 estimated as 0.1173:  log likelihood=-522.42
## AIC=1058.83   AICc=1058.91   BIC=1096.08
```

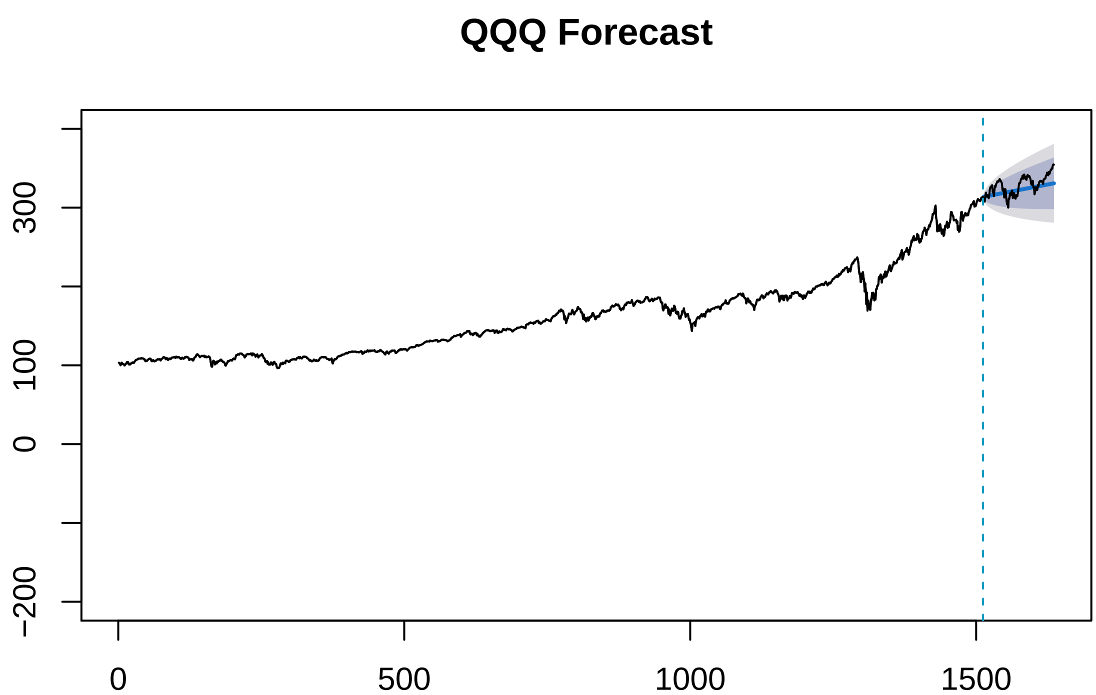
```r
afcast <- forecast(aop, h=124)
plot(afcast, main = "ARKG Forecast", ylim = c(-200, 200))
lines(full_ark$Close)
abline(v=1512, lty=2, col=5)
```




```r
sqrt(mse(arkg2021$Close, afcast$mean))
```

```
## [1] 146.4162
```

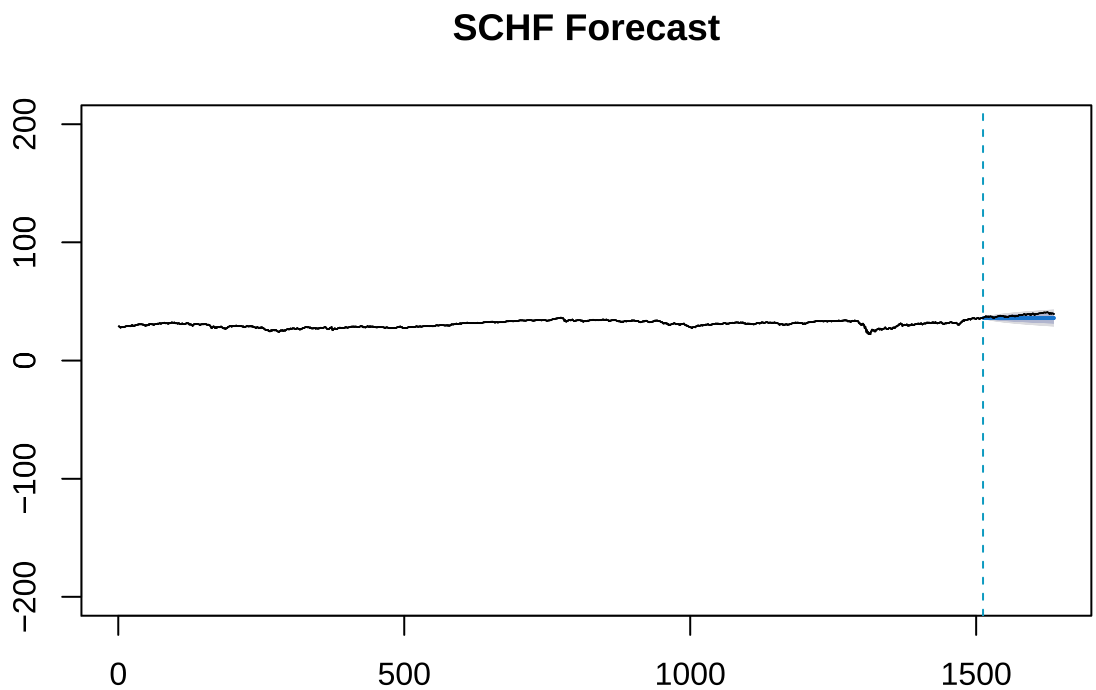
```r
qfcast <- forecast(qop, h=124)
plot(qfcast, main = "QQQ Forecast", ylim = c(-200, 400))
lines(full_qqq$Close)
abline(v=1512, lty=2, col=5)
```




```
sqrt(mse(qqq2021$Close, qfcast$mean))
```

```
## [1] 10.89804
```

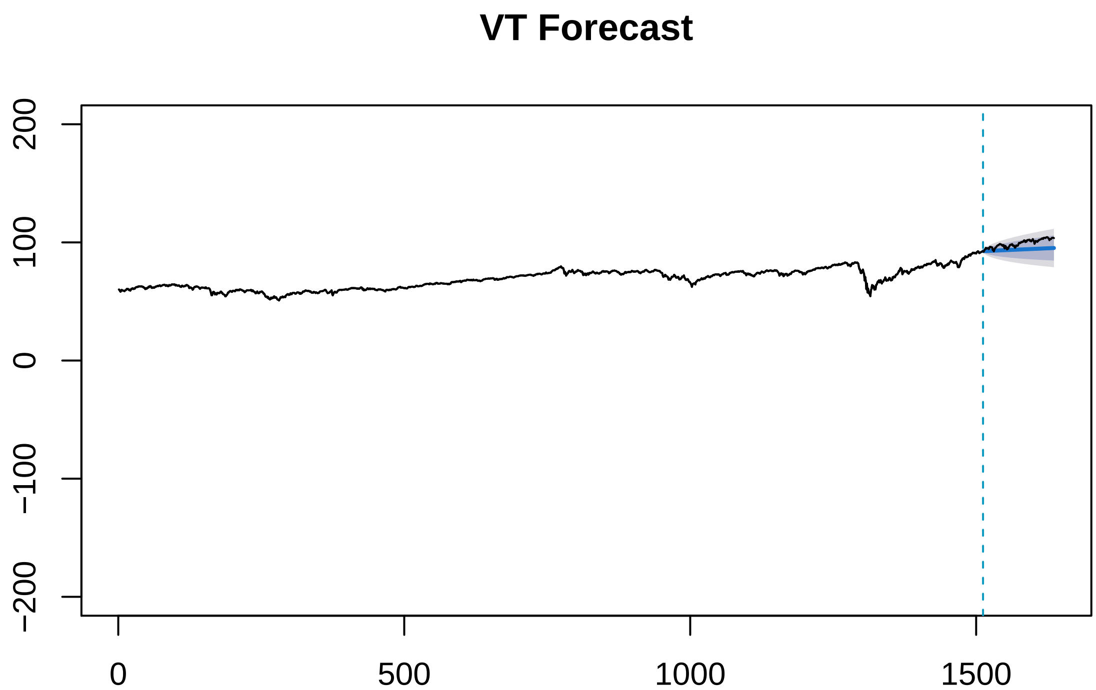
```
sfcast <- forecast(sop, h=124)
plot(sfcast, main = "SCHF Forecast", ylim = c(-200, 200))
lines(full_schf$Close)
abline(v=1512, lty=2, col=5)
```




```r
sqrt(mse(schf2021$Close, sfcast$mean))
```

```
## [1] 2.759467
```

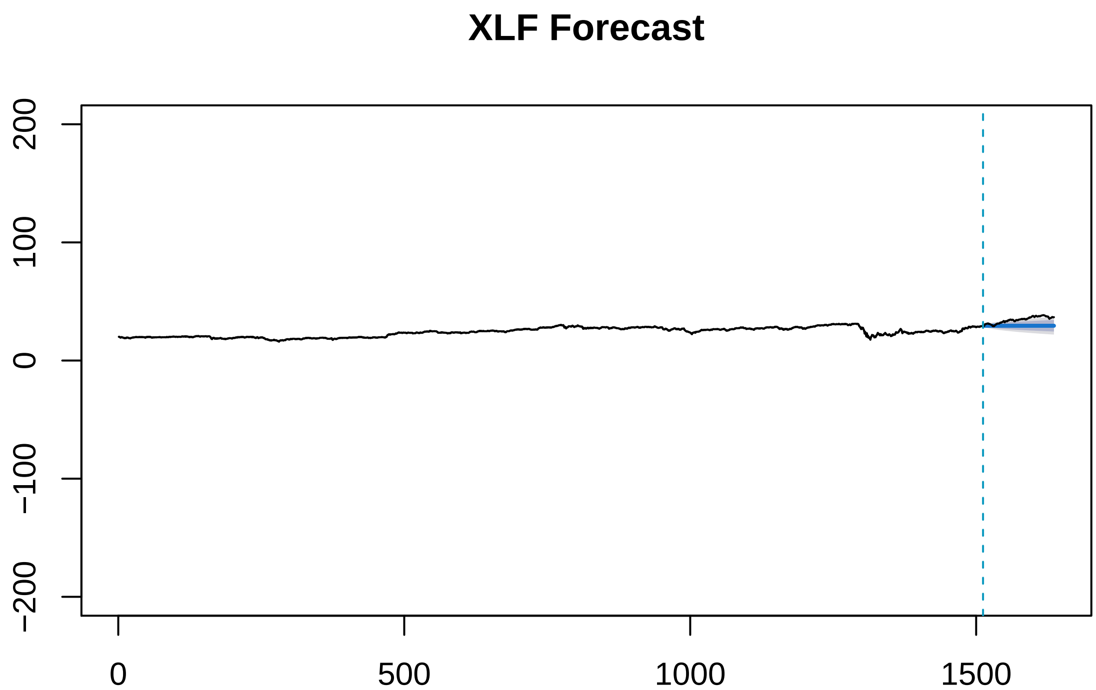
```r
vfcast <- forecast(vop, h=124)
plot(vfcast, main = "VT Forecast", ylim = c(-200, 200))
lines(full_vt$Close)
abline(v=1512, lty=2, col=5)
```




```
sqrt(mse(vt2021$Close, vfcast$mean))
```

```
## [1] 5.791756
```

```
xfcast <- forecast(xop, h=124)
plot(xfcast, main = "XLF Forecast", ylim = c(-200, 200))
lines(full_xlf$Close)
abline(v=1512, lty=2, col=5)
```




```r
sqrt(mse(xlf2021$Close, xfcast$mean))
```

```
## [1] 5.620416
```

```r
aop <- auto.arima(arkg_ts2, ic = "aic")
aop
```

```
## Series: arkg_ts2
## ARIMA(0,1,0)
##
## sigma^2 estimated as 0.2827:  log likelihood=-1189.52
## AIC=2381.04   AICc=2381.04   BIC=2386.36
```

```r
qop <- auto.arima(qqq_ts2, ic = "aic")
qop
```

```
## Series: qqq_ts2
## ARIMA(5,1,3)
##
## Coefficients:
##           ar1      ar2      ar3     ar4     ar5     ma1     ma2     ma3
##       -1.9207  -1.3684  -0.2674  0.1651  0.1405  1.7633  1.1325  0.2672
## s.e.   0.2977   0.6630   0.4226  0.0656  0.0742  0.3217  0.6602  0.3557
##
```

```
## sigma^2 estimated as 3.845:  log likelihood=-3157.75
## AIC=6333.5   AICc=6333.62   BIC=6381.38
```

```r
sop <- auto.arima(schf_ts2, ic = "aic")
sop
```

```
## Series: schf_ts2
## ARIMA(4,1,2)
##
## Coefficients:
##           ar1      ar2     ar3     ar4     ma1     ma2
##       -1.6036  -0.6552  0.1617  0.0581  1.5463  0.6744
## s.e.   0.1089   0.1118  0.0517  0.0394  0.1053  0.0939
##
## sigma^2 estimated as 0.09428:  log likelihood=-357.01
## AIC=728.02   AICc=728.1   BIC=765.27
```

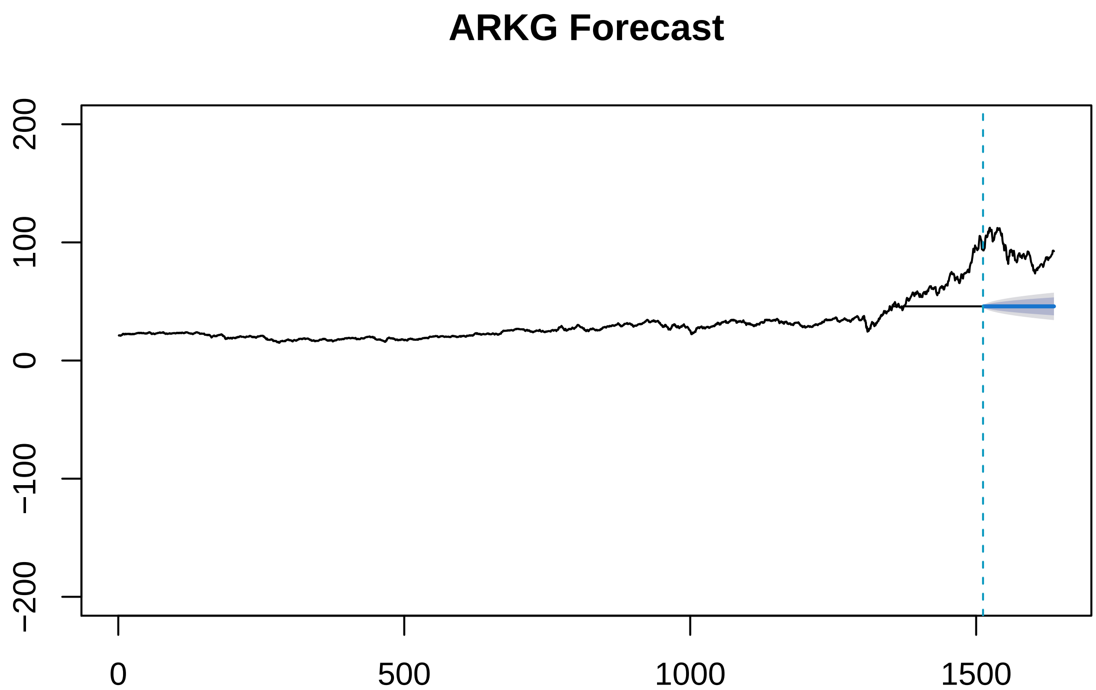
```r
vop <- auto.arima(vt_ts2, ic = "aic")
vop
```

```
## Series: vt_ts2
## ARIMA(4,1,4)
##
## Coefficients:
##           ar1      ar2      ar3      ar4     ma1     ma2     ma3     ma4
##       -1.2825  -1.0554  -1.2139  -0.7981  1.1609  0.9908  1.2231  0.6798
## s.e.   0.0457   0.0506   0.0592   0.0439  0.0510  0.0430  0.0441  0.0450
##
## sigma^2 estimated as 0.4708:  log likelihood=-1571.14
## AIC=3160.28   AICc=3160.4   BIC=3208.17
```

```r
xop <- auto.arima(xlf_ts2, ic = "aic")
xop
```

```
## Series: xlf_ts2
## ARIMA(4,1,2)
##
## Coefficients:
##           ar1      ar2     ar3     ar4     ma1     ma2
##       -1.5742  -0.6552  0.0891  0.0130  1.4720  0.5999
## s.e.   0.1172   0.1312  0.0503  0.0386  0.1142  0.1101
##
## sigma^2 estimated as 0.1082:  log likelihood=-460.84
## AIC=935.69   AICc=935.76   BIC=972.93
```

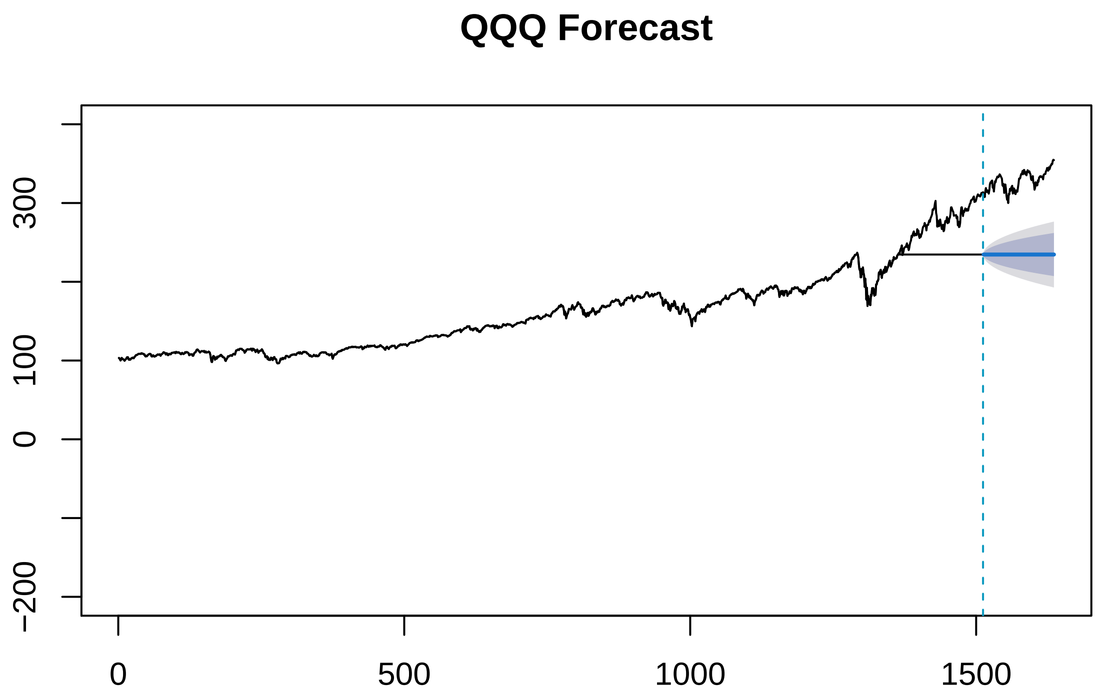
```r
afcast <- forecast(aop, h=124)
plot(afcast, main = "ARKG Forecast", ylim = c(-200, 200))
lines(full_ark$Close)
abline(v=1512, lty=2, col=5)
```




```
sqrt(mse(arkg2021$Close, afcast$mean))
```

```
## [1] 47.29134
```

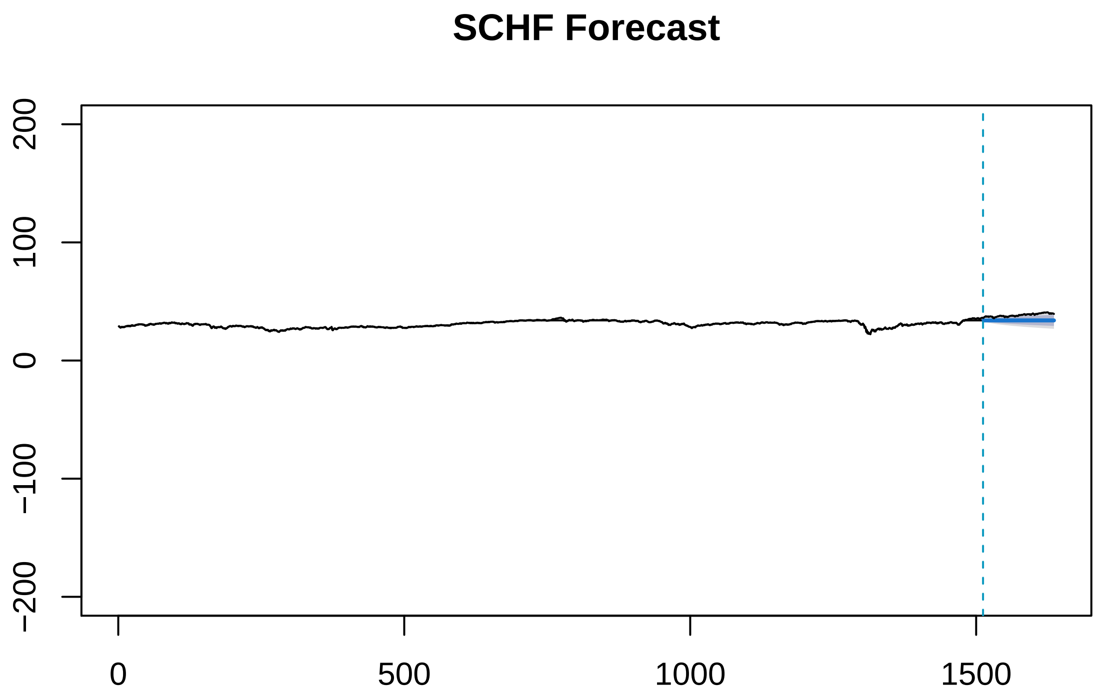
```
qfcast <- forecast(qop, h=124)
plot(qfcast, main = "QQQ Forecast", ylim = c(-200, 400))
lines(full_qqq$Close)
abline(v=1512, lty=2, col=5)
```




```
sqrt(mse(qqq2021$Close, qfcast$mean))
```

```
## [1] 94.26537
```

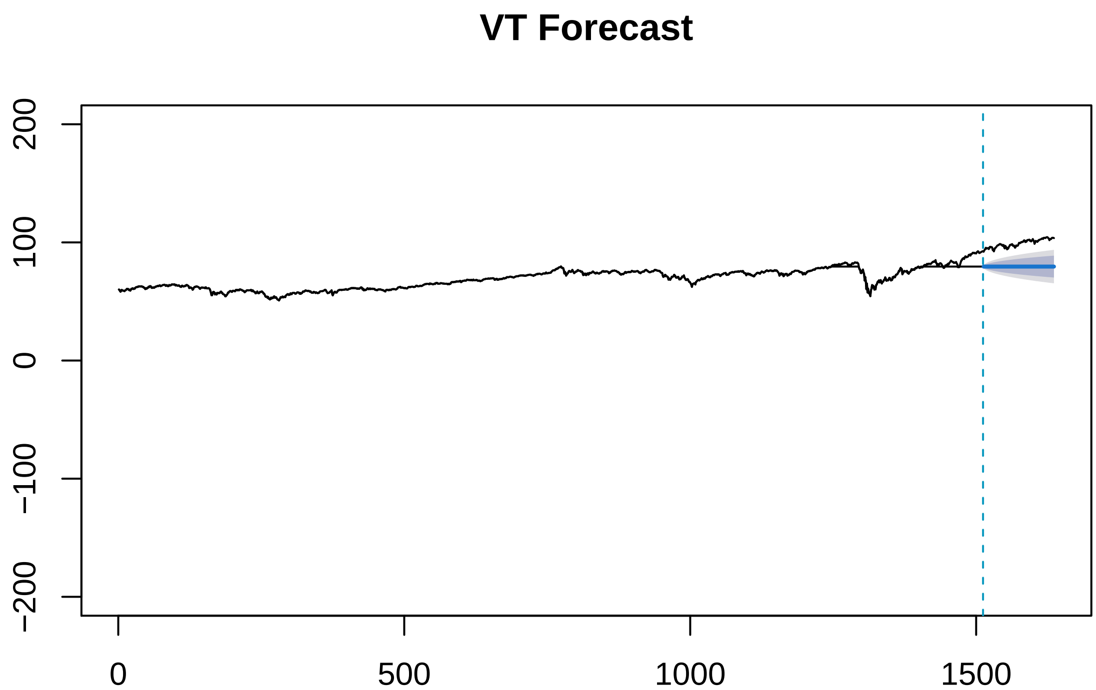
```
sfcast <- forecast(sop, h=124)
plot(sfcast, main = "SCHF Forecast", ylim = c(-200, 200))
lines(full_schf$Close)
abline(v=1512, lty=2, col=5)
```




```r
sqrt(mse(schf2021$Close, sfcast$mean))
```

```
## [1] 4.649884
```

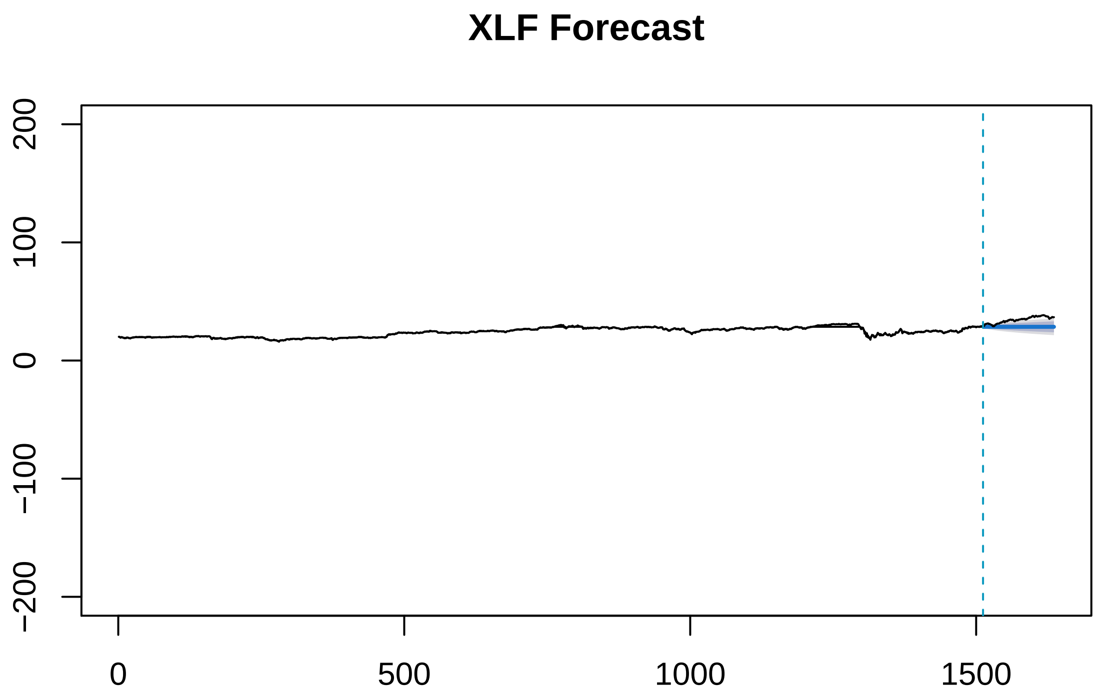
```r
vfcast <- forecast(vop, h=124)
plot(vfcast, main = "VT Forecast", ylim = c(-200, 200))
lines(full_vt$Close)
abline(v=1512, lty=2, col=5)
```




```r
sqrt(mse(vt2021$Close, vfcast$mean))
```

```
## [1] 19.85933
```

```r
xfcast <- forecast(xop, h=124)
plot(xfcast, main = "XLF Forecast", ylim = c(-200, 200))
lines(full_xlf$Close)
abline(v=1512, lty=2, col=5)
```




```
sqrt(mse(xlf2021$Close, xfcast$mean))
```

```
## [1] 6.433126
```