

Sales Forecast

Ivy(Ruxin) Tong

```
## Warning: package 'astsa' was built under R version 3.6.2
```

```
## Warning: package 'TSA' was built under R version 3.6.2
```

```
##
```

```
## Attaching package: 'TSA'
```

```
## The following objects are masked from 'package:stats':
```

```
##
```

```
##      acf, arima
```

```
## The following object is masked from 'package:utils':
```

```
##
```

```
##      tar
```

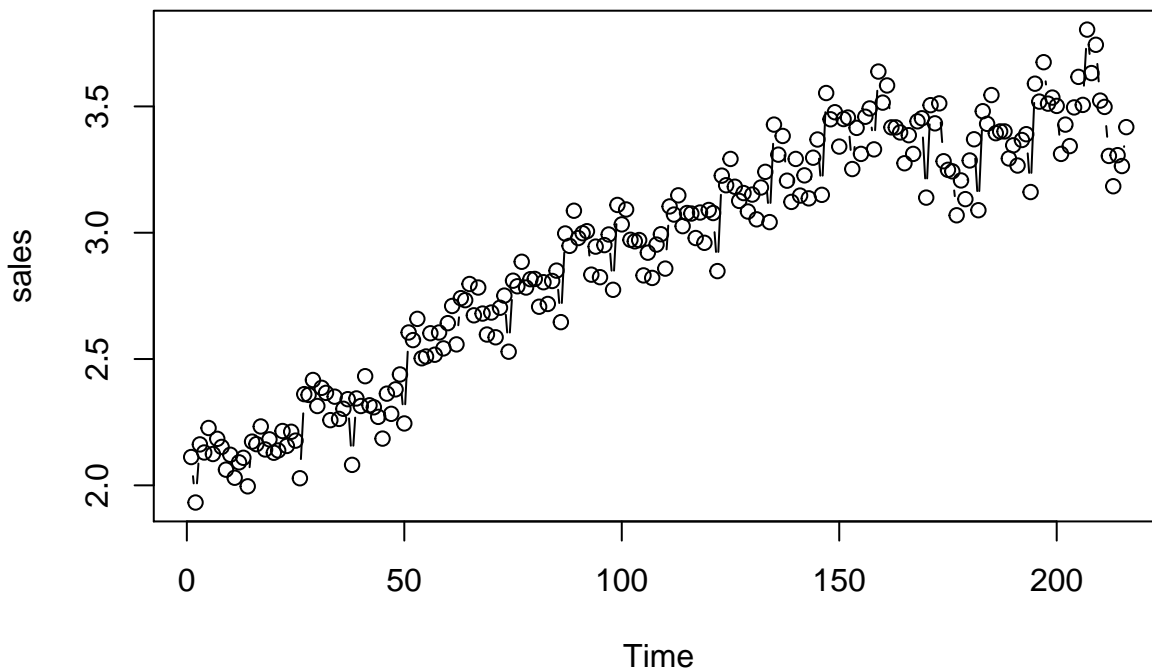
```
# read data and univariate time series data analysis
```

```
salesdata=read.table("SalesData.csv",sep = ",", header=TRUE)
```

```
salesdata=ts(salesdata) #this makes sure R knows that x is a time series #time series plot of x with po
```

```
sales=salesdata[,3]
```

```
plot(sales, type="b")
```

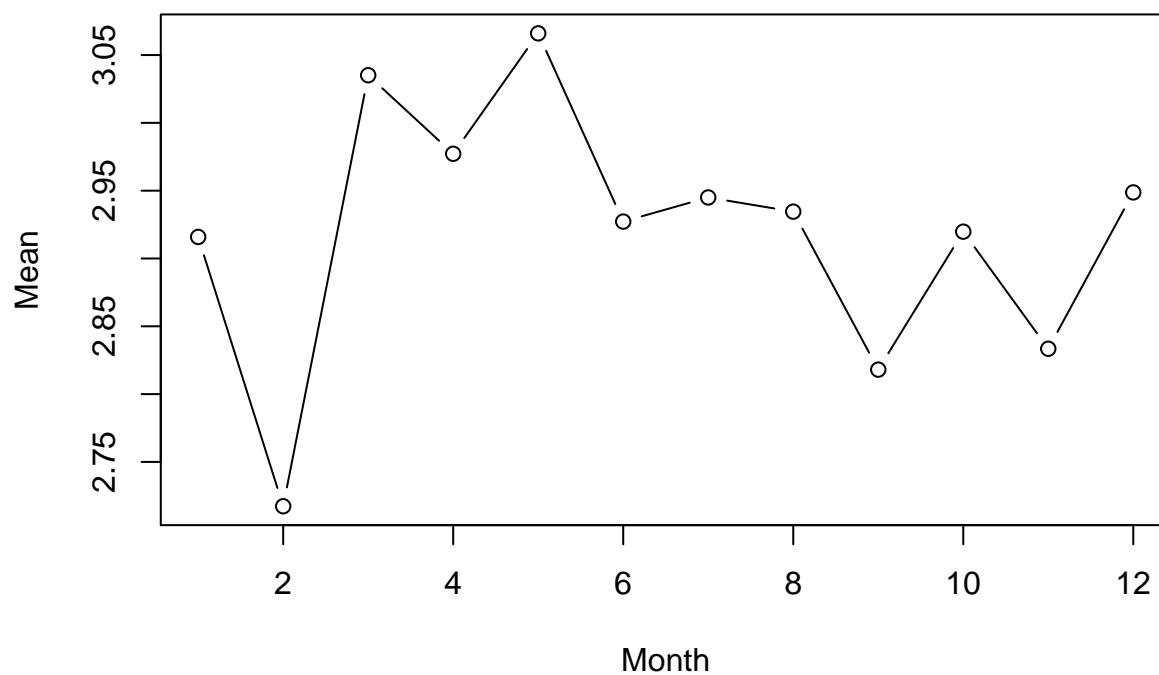


```
salesm = matrix(sales, ncol=12,byrow=TRUE)
```

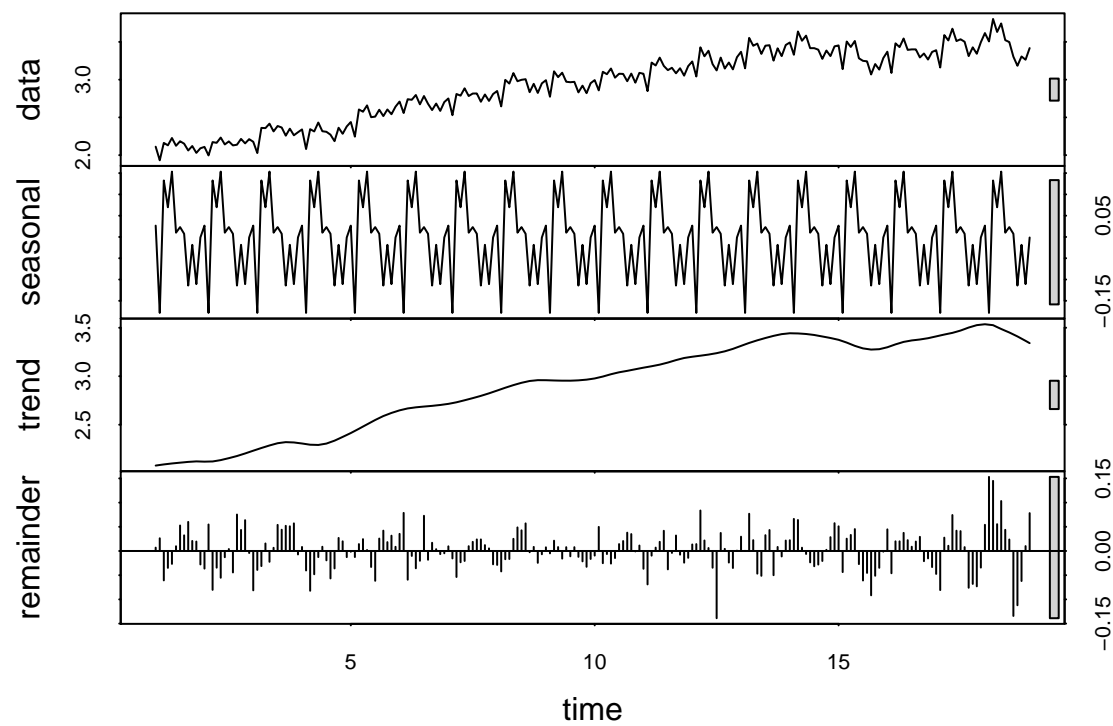
```
col.means=apply(salesm,2,mean)
```

```
plot(col.means,type="b", main="Monthly Means Plot for sales", xlab="Month", ylab="Mean")
```

Monthly Means Plot for sales



```
sales=ts(sales, freq =12)
stl.sales=stl(sales, "periodic")
plot(stl(sales, "periodic"))
```



```
stl.sales
```

```
## Call:
```

```

## stl(x = sales, s.window = "periodic")
##
## Components
##          seasonal      trend      remainder
## Jan  1  0.026597548 2.078414  0.0069887783
## Feb  1 -0.178516189 2.084233  0.0262827907
## Mar  1  0.132703441 2.090053 -0.0607565644
## Apr  1  0.069823277 2.095044 -0.0348675588
## May  1  0.153609760 2.100035 -0.0266451998
## Jun  1  0.010078603 2.104116  0.0098052590
## Jul  1  0.023102982 2.108197  0.0527001810
## Aug  1  0.007476214 2.112169  0.0323546374
## Sep  1 -0.114206180 2.116141  0.0600647188
## Oct  1 -0.018514685 2.118755  0.0207601365
## Nov  1 -0.110878765 2.121368  0.0195111307
## Dec  1 -0.001276026 2.120089 -0.0278126762
## Jan  2  0.026597548 2.118810 -0.0364073178
## Feb  2 -0.178516189 2.119719  0.0547970892
## Mar  2  0.132703441 2.120628 -0.0803318713
## Apr  2  0.069823277 2.127670 -0.0344928297
## May  2  0.153609760 2.134711 -0.0553204346
## Jun  2  0.010078603 2.144782 -0.0128604805
## Jul  2  0.023102982 2.154853  0.0040439367
## Aug  2  0.007476214 2.165869 -0.0443454211
## Sep  2 -0.114206180 2.176885  0.0753208462
## Oct  2 -0.018514685 2.190035  0.0434796794
## Nov  2 -0.110878765 2.203185  0.0636940892
## Dec  2 -0.001276026 2.217450 -0.0041736081
## Jan  3  0.026597548 2.231715 -0.0813121401
## Feb  3 -0.178516189 2.245596 -0.0390801630
## Mar  3  0.132703441 2.259478 -0.0311815534
## Apr  3  0.069823277 2.272602  0.0155747406
## May  3  0.153609760 2.285726 -0.0223356120
## Jun  3  0.010078603 2.297315  0.0066060120
## Jul  3  0.023102982 2.308905  0.0539920992
## Aug  3  0.007476214 2.314543  0.0439811086
## Sep  3 -0.114206180 2.320180  0.0520257431
## Oct  3 -0.018514685 2.318486  0.0510289227
## Nov  3 -0.110878765 2.316791  0.0570876787
## Dec  3 -0.001276026 2.311422 -0.0071459850
## Jan  4  0.026597548 2.306053  0.0083495167
## Feb  4 -0.178516189 2.299780 -0.0402642021
## Mar  4  0.132703441 2.293508 -0.0822112885
## Apr  4  0.069823277 2.292258 -0.0480810072
## May  4  0.153609760 2.291008 -0.0126173725
## Jun  4  0.010078603 2.298121  0.0088005541
## Jul  4  0.023102982 2.305234 -0.0193370561
## Aug  4  0.007476214 2.320226 -0.0567022211
## Sep  4 -0.114206180 2.335218 -0.0360117609
## Oct  4 -0.018514685 2.354546  0.0269682065
## Nov  4 -0.110878765 2.373875  0.0200037503
## Dec  4 -0.001276026 2.393937 -0.0126607999
## Jan  5  0.026597548 2.413999 -0.0015961848
## Feb  5 -0.178516189 2.436003 -0.0124868428

```

##	Mar	5	0.132703441	2.458007	0.0142891316
##	Apr	5	0.069823277	2.480707	0.0244701762
##	May	5	0.153609760	2.503406	0.0019845742
##	Jun	5	0.010078603	2.525946	-0.0330248450
##	Jul	5	0.023102982	2.548487	-0.0615898010
##	Aug	5	0.007476214	2.568814	0.0257098234
##	Sep	5	-0.114206180	2.589141	0.0420650730
##	Oct	5	-0.018514685	2.605182	0.0183331055
##	Nov	5	-0.110878765	2.621222	0.0316567145
##	Dec	5	-0.001276026	2.634613	0.0086625937
##	Jan	6	0.026597548	2.648005	0.0353976382
##	Feb	6	-0.178516189	2.657820	0.0786965281
##	Mar	6	0.132703441	2.667635	-0.0593379495
##	Apr	6	0.069823277	2.673388	-0.0102116775
##	May	6	0.153609760	2.679142	-0.0357520521
##	Jun	6	0.010078603	2.683130	-0.0202090188
##	Jul	6	0.023102982	2.687119	0.0727784778
##	Aug	6	0.007476214	2.690655	-0.0181313687
##	Sep	6	-0.114206180	2.694192	0.0170144099
##	Oct	6	-0.018514685	2.698745	0.0037696516
##	Nov	6	-0.110878765	2.703298	-0.0064195301
##	Dec	6	-0.001276026	2.709020	-0.0047435221
##	Jan	7	0.026597548	2.714741	0.0096616513
##	Feb	7	-0.178516189	2.722872	-0.0153557870
##	Mar	7	0.132703441	2.731003	-0.0537065929
##	Apr	7	0.069823277	2.741488	-0.0233114296
##	May	7	0.153609760	2.751973	-0.0205829128
##	Jun	7	0.010078603	2.762968	0.0099530430
##	Jul	7	0.023102982	2.773964	0.0189334620
##	Aug	7	0.007476214	2.785605	0.0239192068
##	Sep	7	-0.114206180	2.797246	0.0239605768
##	Oct	7	-0.018514685	2.810358	0.0121564929
##	Nov	7	-0.110878765	2.823471	0.0054079854
##	Dec	7	-0.001276026	2.837803	-0.0275265354
##	Jan	8	0.026597548	2.852134	-0.0287318909
##	Feb	8	-0.178516189	2.866719	-0.0422027072
##	Mar	8	0.132703441	2.881303	-0.0170068910
##	Apr	8	0.069823277	2.894763	-0.0165859373
##	May	8	0.153609760	2.908222	0.0251683697
##	Jun	8	0.010078603	2.920198	0.0487236222
##	Jul	8	0.023102982	2.932174	0.0427233378
##	Aug	8	0.007476214	2.941477	0.0570467039
##	Sep	8	-0.114206180	2.950780	-0.0025743047
##	Oct	8	-0.018514685	2.955048	0.0084669170
##	Nov	8	-0.110878765	2.959315	-0.0244362848
##	Dec	8	-0.001276026	2.959048	-0.0067716456
##	Jan	9	0.026597548	2.958780	0.0076221589
##	Feb	9	-0.178516189	2.957380	-0.0048638191
##	Mar	9	0.132703441	2.955980	0.0213168354
##	Apr	9	0.069823277	2.955047	0.0081294339
##	May	9	0.153609760	2.954115	-0.0157246142
##	Jun	9	0.010078603	2.954013	0.0079088958
##	Jul	9	0.023102982	2.953910	-0.0110131311
##	Aug	9	0.007476214	2.955606	0.0079178045

```

## Sep  9 -0.114206180 2.957302 -0.0120956348
## Oct  9 -0.018514685 2.960905 -0.0213906079
## Nov  9 -0.110878765 2.964509 -0.0326300046
## Dec  9 -0.001276026 2.970710 -0.0164340705
## Jan 10  0.026597548 2.976911 -0.0095089711
## Feb 10 -0.178516189 2.986715  0.0498009128
## Mar 10  0.132703441 2.996519 -0.0252225708
## Apr 10  0.069823277 3.008487 -0.0063098180
## May 10  0.153609760 3.020454 -0.0260637117
## Jun 10  0.010078603 3.030521 -0.0145994800
## Jul 10  0.023102982 3.040588  0.0143092148
## Aug 10  0.007476214 3.047961  0.0205624157
## Sep 10 -0.114206180 3.055335  0.0378712418
## Oct 10 -0.018514685 3.063553  0.0349614898
## Nov 10 -0.110878765 3.071771 -0.0008926856
## Dec 10 -0.001276026 3.079968  0.0113081239
## Jan 11  0.026597548 3.088164 -0.0367619014
## Feb 11 -0.178516189 3.095531 -0.0690152292
## Mar 11  0.132703441 3.102898 -0.0096019245
## Apr 11  0.069823277 3.111143  0.0070336562
## May 11  0.153609760 3.119388  0.0190025902
## Jun 11  0.010078603 3.130120  0.0418014399
## Jul 11  0.023102982 3.140852 -0.0379552473
## Aug 11  0.007476214 3.153539 -0.0040151651
## Sep 11 -0.114206180 3.166226  0.0319805423
## Oct 11 -0.018514685 3.177102 -0.0075875276
## Nov 11 -0.110878765 3.187979 -0.0241000210
## Dec 11 -0.001276026 3.194442 -0.0141655642
## Jan 12  0.026597548 3.200904  0.0134980579
## Feb 12 -0.178516189 3.206265  0.0142515730
## Mar 12  0.132703441 3.211625  0.0836717206
## Apr 12  0.069823277 3.217435  0.0217412337
## May 12  0.153609760 3.223246  0.0061441002
## Jun 12  0.010078603 3.230511 -0.0345891317
## Jul 12  0.023102982 3.237775 -0.1388779004
## Aug 12  0.007476214 3.247280  0.0372441079
## Sep 12 -0.114206180 3.256784  0.0044217413
## Oct 12 -0.018514685 3.269408 -0.0238934108
## Nov 12 -0.110878765 3.282032 -0.0351529865
## Dec 12 -0.001276026 3.297441  0.0008348890
## Jan 13  0.026597548 3.312851  0.0295519298
## Feb 13 -0.178516189 3.328114  0.0004022444
## Mar 13  0.132703441 3.343377  0.0769191914
## Apr 13  0.069823277 3.356784  0.0223928489
## May 13  0.153609760 3.370190 -0.0468001402
## Jun 13  0.010078603 3.382206 -0.0512844584
## Jul 13  0.023102982 3.394221  0.0326756865
## Aug 13  0.007476214 3.405209  0.0433146701
## Sep 13 -0.114206180 3.416197 -0.0499907211
## Oct 13 -0.018514685 3.425175  0.0083396748
## Nov 13 -0.110878765 3.434153 -0.0112743528
## Dec 13 -0.001276026 3.438637  0.0216391466
## Jan 14  0.026597548 3.443121  0.0222818114
## Feb 14 -0.178516189 3.442183  0.0663336137

```

```

## Mar 14 0.132703441 3.441245 0.0640520485
## Apr 14 0.069823277 3.438390 0.0067871632
## May 14 0.153609760 3.435535 -0.0061443687
## Jun 14 0.010078603 3.430458 -0.0235367634
## Jul 14 0.023102982 3.425382 -0.0314846949
## Aug 14 0.007476214 3.417630 -0.0281057558
## Sep 14 -0.114206180 3.409877 -0.0206711915
## Oct 14 -0.018514685 3.402090 0.0024243959
## Nov 14 -0.110878765 3.394303 0.0285755598
## Dec 14 -0.001276026 3.384847 0.0574290093
## Jan 15 0.026597548 3.375391 0.0510116242
## Feb 15 -0.178516189 3.361110 -0.0435935016
## Mar 15 0.132703441 3.346829 0.0254680051
## Apr 15 0.069823277 3.329986 0.0331902454
## May 15 0.153609760 3.313144 0.0452458389
## Jun 15 0.010078603 3.300000 -0.0270788366
## Jul 15 0.023102982 3.286856 -0.0609590489
## Aug 15 0.007476214 3.280824 -0.0453003108
## Sep 15 -0.114206180 3.274792 -0.0915859476
## Oct 15 -0.018514685 3.276702 -0.0511871364
## Nov 15 -0.110878765 3.278612 -0.0347327487
## Dec 15 -0.001276026 3.288647 -0.0013711969
## Jan 16 0.026597548 3.298683 0.0447195202
## Feb 16 -0.178516189 3.313518 -0.0460019525
## Mar 16 0.132703441 3.328353 0.0199432073
## Apr 16 0.069823277 3.341154 0.0200229149
## May 16 0.153609760 3.353954 0.0374359759
## Jun 16 0.010078603 3.361504 0.0224172488
## Jul 16 0.023102982 3.369054 0.0088429850
## Aug 16 0.007476214 3.373988 0.0195358977
## Sep 16 -0.114206180 3.378922 0.0292844355
## Oct 16 -0.018514685 3.385540 -0.0210254748
## Nov 16 -0.110878765 3.392159 -0.0152798086
## Dec 16 -0.001276026 3.401473 -0.0331970825
## Jan 17 0.026597548 3.410788 -0.0473851910
## Feb 17 -0.178516189 3.420257 -0.0807409205
## Mar 17 0.132703441 3.429727 0.0275699825
## Apr 17 0.069823277 3.438417 0.0107601805
## May 17 0.153609760 3.447107 0.0742837319
## Jun 17 0.010078603 3.458972 0.0419492509
## Jul 17 0.023102982 3.470838 0.0410592331
## Aug 17 0.007476214 3.486507 0.0080168247
## Sep 17 -0.114206180 3.502176 -0.0759699587
## Oct 17 -0.018514685 3.514546 -0.0680313603
## Nov 17 -0.110878765 3.526916 -0.0730371853
## Dec 17 -0.001276026 3.531591 -0.0343152911
## Jan 18 0.026597548 3.536267 0.0541357684
## Feb 18 -0.178516189 3.531337 0.1531787191
## Mar 18 0.132703441 3.526408 0.1448883023
## Apr 18 0.069823277 3.506774 0.0554026881
## May 18 0.153609760 3.487140 0.1032504272
## Jun 18 0.010078603 3.469125 0.0437963066
## Jul 18 0.023102982 3.451110 0.0237866492
## Aug 18 0.007476214 3.430723 -0.1341989848

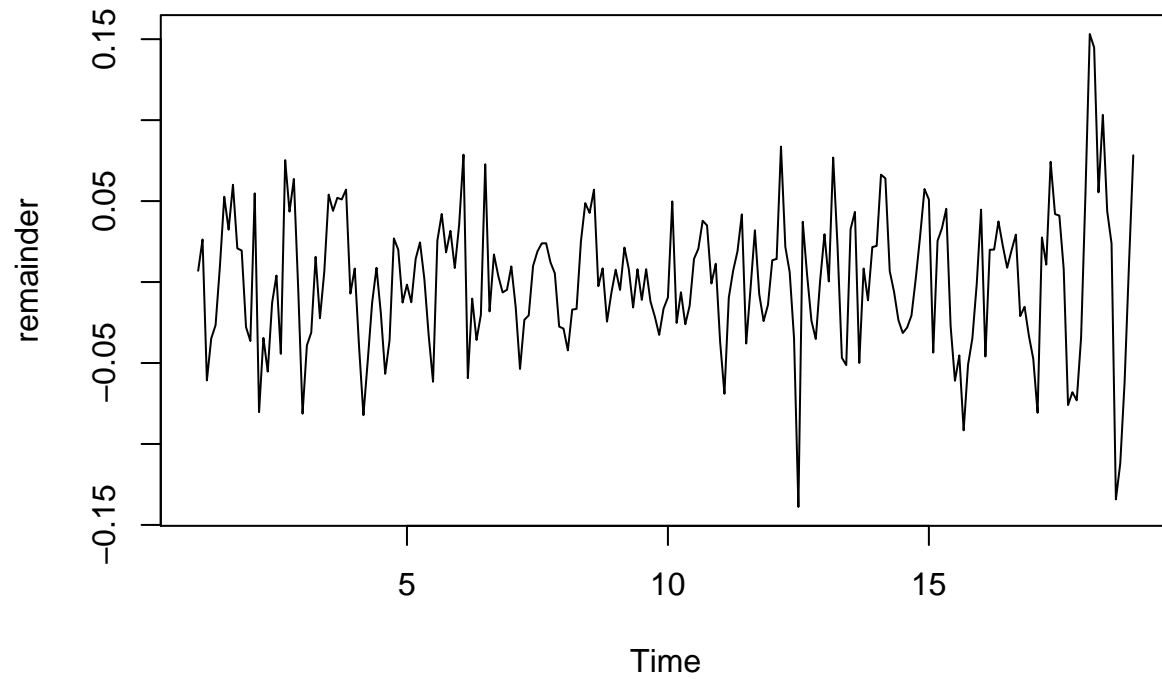
```

```
## Sep 18 -0.114206180 3.410335 -0.1121289937
## Oct 18 -0.018514685 3.387555 -0.0620398484
## Nov 18 -0.110878765 3.364774 0.0101048733
## Dec 18 -0.001276026 3.341001 0.0782749883
```

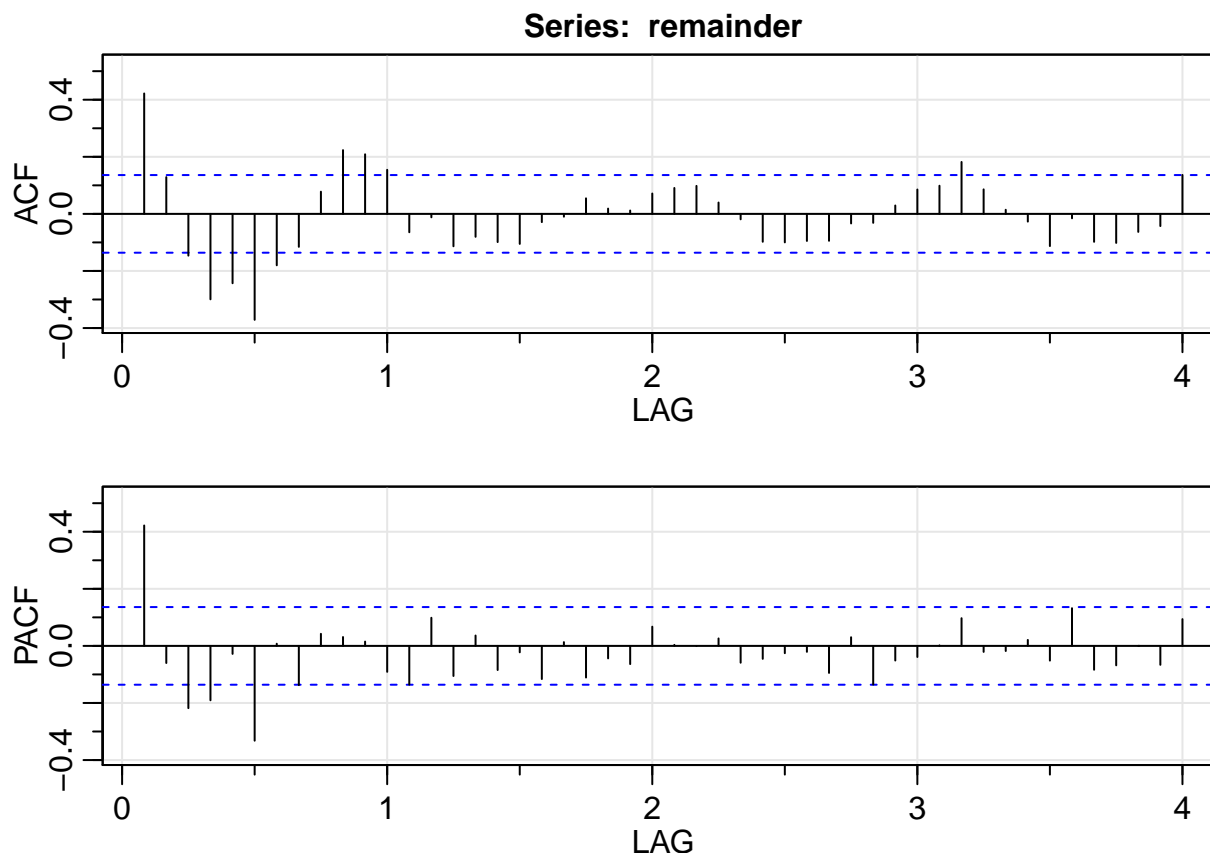
```
results=stl(sales,"periodic")
remainder=results$time.series[,3]
mean(remainder)
```

```
## [1] 0.0008288457
```

```
plot(remainder)
```



```
acf2(remainder)
```



```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
## ACF  0.42  0.13 -0.15 -0.30 -0.24 -0.37 -0.18 -0.12  0.08  0.22  0.21  0.15
## PACF  0.42 -0.06 -0.22 -0.19 -0.03 -0.33  0.01 -0.14  0.04  0.03  0.02 -0.09
##      [,13] [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23]
## ACF  -0.06 -0.01 -0.11 -0.08 -0.10 -0.11 -0.03 -0.01  0.05  0.02  0.01
## PACF -0.14  0.10 -0.11  0.04 -0.08 -0.02 -0.12  0.01 -0.11 -0.04 -0.06
##      [,24] [,25] [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34]
## ACF   0.07  0.09  0.1  0.04 -0.02 -0.10 -0.10 -0.09 -0.09 -0.03 -0.03
## PACF  0.07  0.00  0.0  0.03 -0.06 -0.05 -0.03 -0.02 -0.09  0.03 -0.14
##      [,35] [,36] [,37] [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45]
## ACF   0.03  0.09  0.1  0.18  0.09  0.01 -0.03 -0.11 -0.02 -0.10 -0.10
## PACF -0.05 -0.04  0.0  0.10 -0.02 -0.02  0.02 -0.05  0.13 -0.08 -0.07
##      [,46] [,47] [,48]
## ACF  -0.06 -0.04  0.14
## PACF  0.00 -0.07  0.09
```

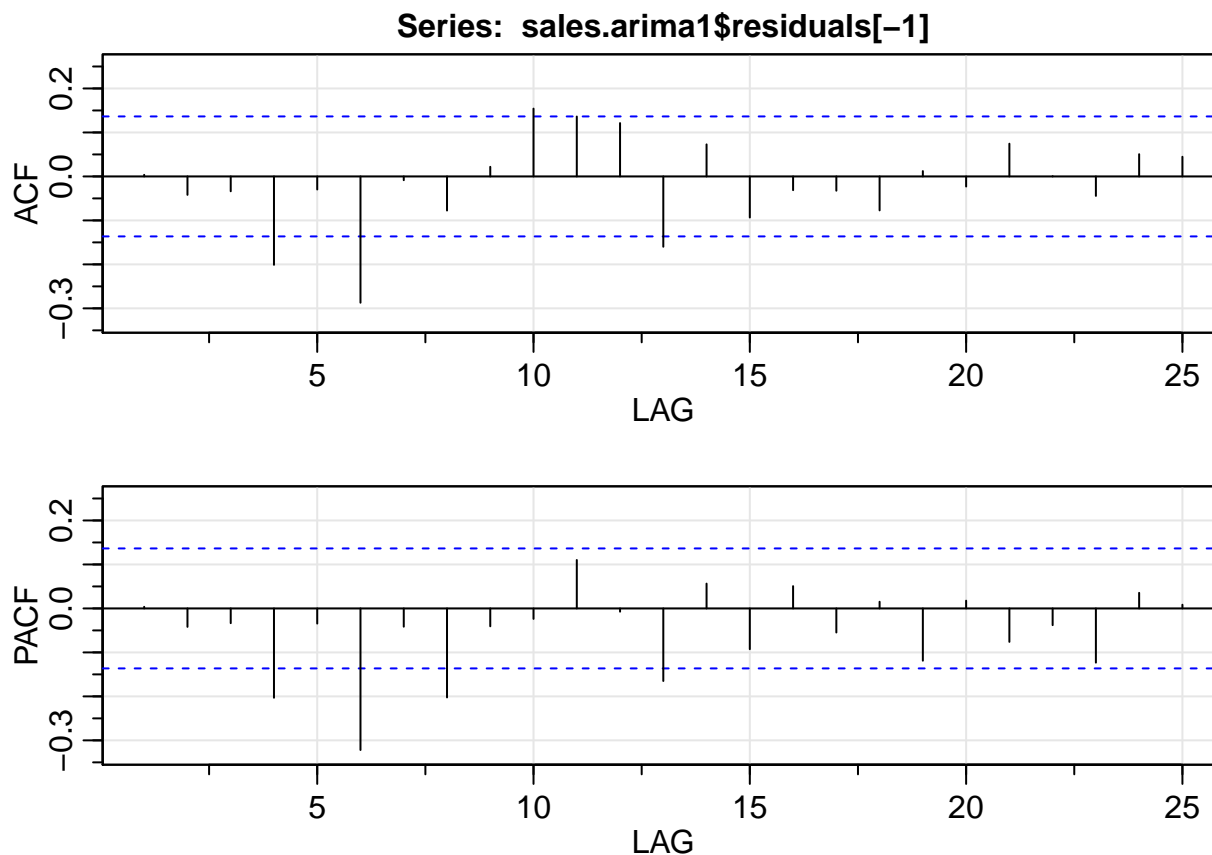
Model Fitting

```
sales.arima1=arima(remainder,order=c(0,0,2), include.mean=F)
sales.arima1
```

```
##
## Call:
## arima(x = remainder, order = c(0, 0, 2), include.mean = F)
##
## Coefficients:
##          ma1      ma2
##      0.4381  0.3007
## s.e.  0.0635  0.0754
```



```
##
## sigma^2 estimated as 0.001462: log likelihood = 398.35, aic = -792.7
acf2(sales.arima1$residuals[-1],col="MA2 - sales ARIMA model residuals", is.df=F)
```

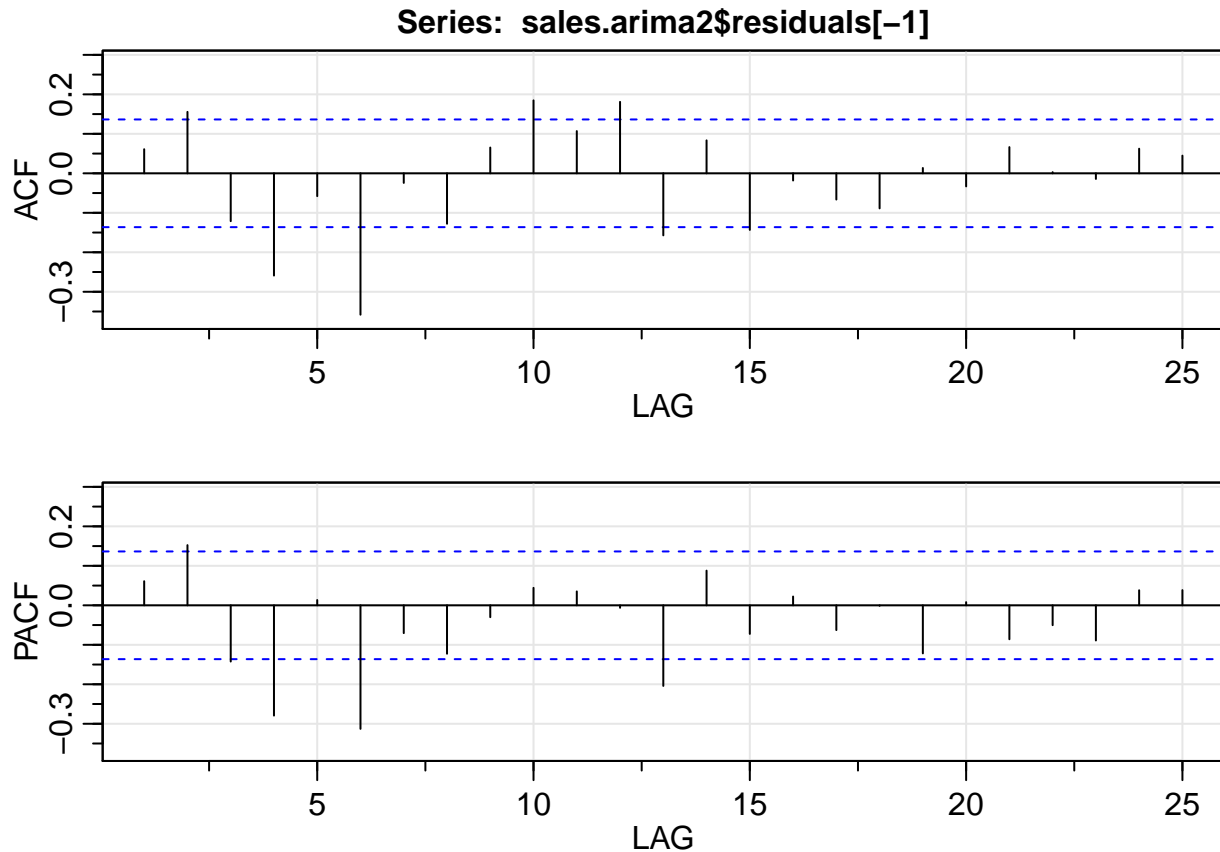


```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
## ACF    0 -0.04 -0.03 -0.2 -0.03 -0.29 -0.01 -0.08 0.02 0.15 0.14 0.12
## PACF    0 -0.04 -0.03 -0.2 -0.03 -0.32 -0.04 -0.20 -0.04 -0.02 0.11 -0.01
##      [,13] [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23]
## ACF -0.16 0.07 -0.09 -0.03 -0.03 -0.08 0.01 -0.02 0.07 0.00 -0.04
## PACF -0.16 0.06 -0.09 0.05 -0.05 0.02 -0.12 0.02 -0.08 -0.04 -0.12
##      [,24] [,25]
## ACF 0.05 0.04
## PACF 0.04 0.01
```

```
sales.arima2=arima(remainder,order=c(0,0,1), include.mean=F)
sales.arima2
```

```
##
## Call:
## arima(x = remainder, order = c(0, 0, 1), include.mean = F)
##
## Coefficients:
##          ma1
##          0.3787
## s.e. 0.0580
##
## sigma^2 estimated as 0.001546: log likelihood = 392.4, aic = -782.81
```

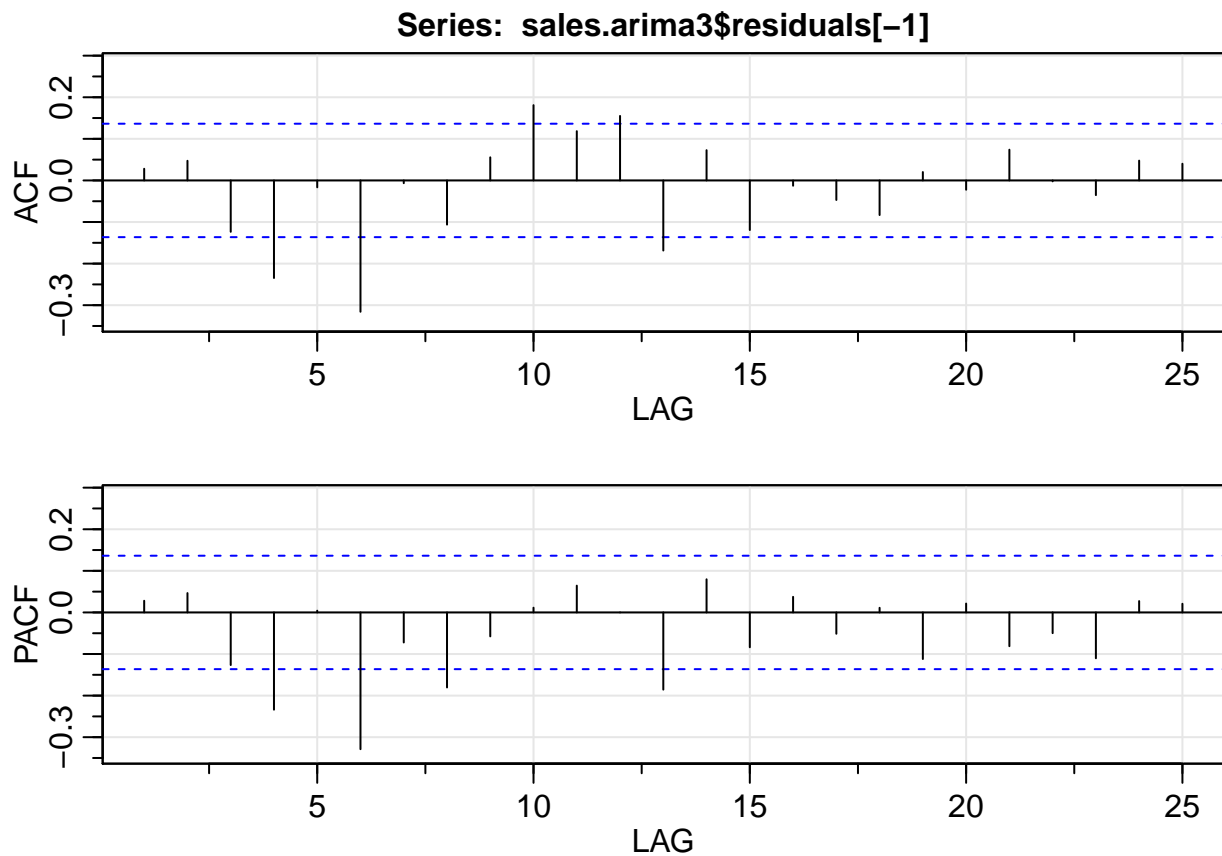
```
acf2(sales.arima2$residuals[-1],col="MA1 - sales ARIMA model residuals", is.df=F)
```



```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
## ACF  0.06 0.16 -0.12 -0.26 -0.06 -0.36 -0.02 -0.13  0.07  0.18  0.11  0.18
## PACF 0.06 0.15 -0.14 -0.28  0.01 -0.31 -0.07 -0.12 -0.03  0.04  0.04 -0.01
##      [,13] [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23]
## ACF  -0.16  0.08 -0.14 -0.02 -0.07 -0.09  0.01 -0.03  0.07  0.00 -0.01
## PACF -0.20  0.09 -0.07  0.02 -0.06  0.00 -0.12  0.01 -0.09 -0.05 -0.09
##      [,24] [,25]
## ACF   0.06  0.04
## PACF  0.04  0.04
```

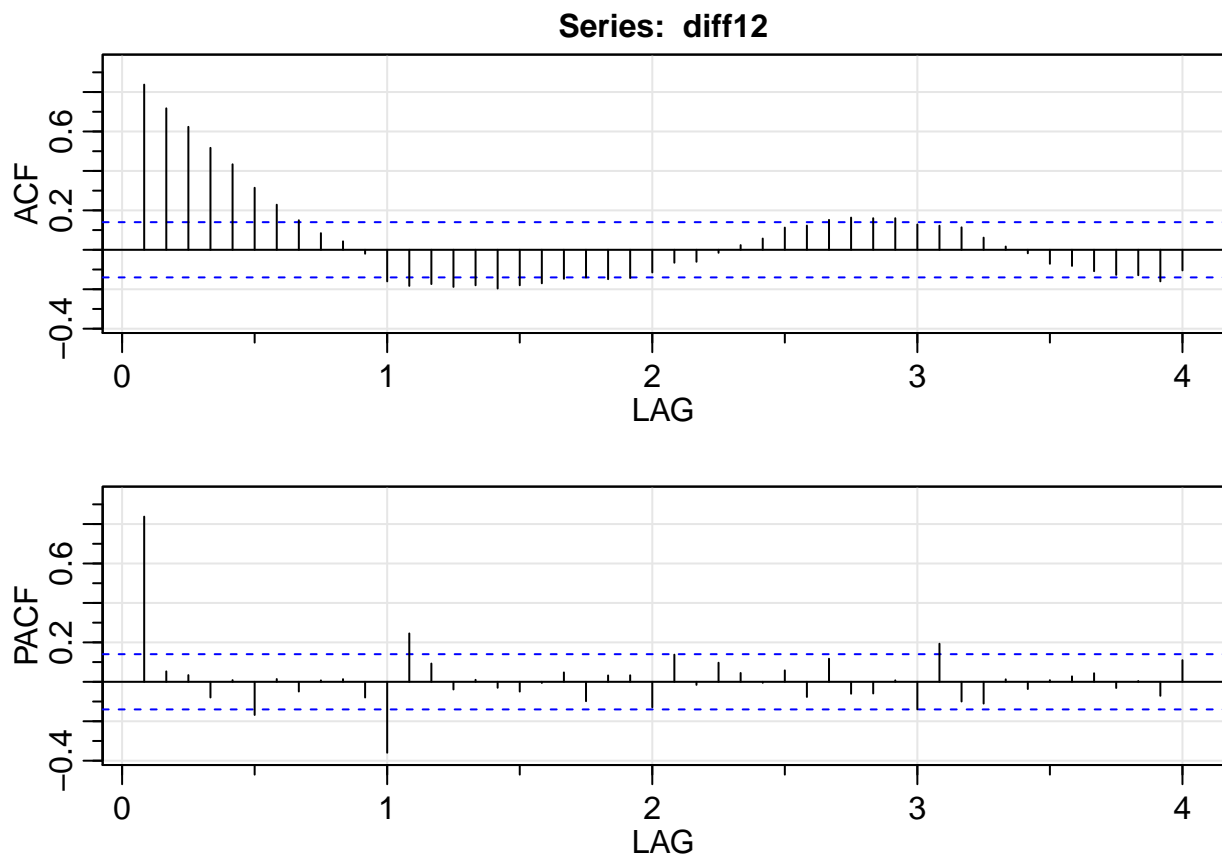
```
sales.arima3=arima(remainder,order=c(1,0,0), include.mean=F)
sales.arima3
```

```
##
## Call:
## arima(x = remainder, order = c(1, 0, 0), include.mean = F)
##
## Coefficients:
##          ar1
##         0.4267
## s.e.    0.0618
##
## sigma^2 estimated as 0.001505:  log likelihood = 395.33,  aic = -788.65
acf2(sales.arima3$residuals[-1],col="AR1 - sales ARIMA model residuals", is.df=F)
```



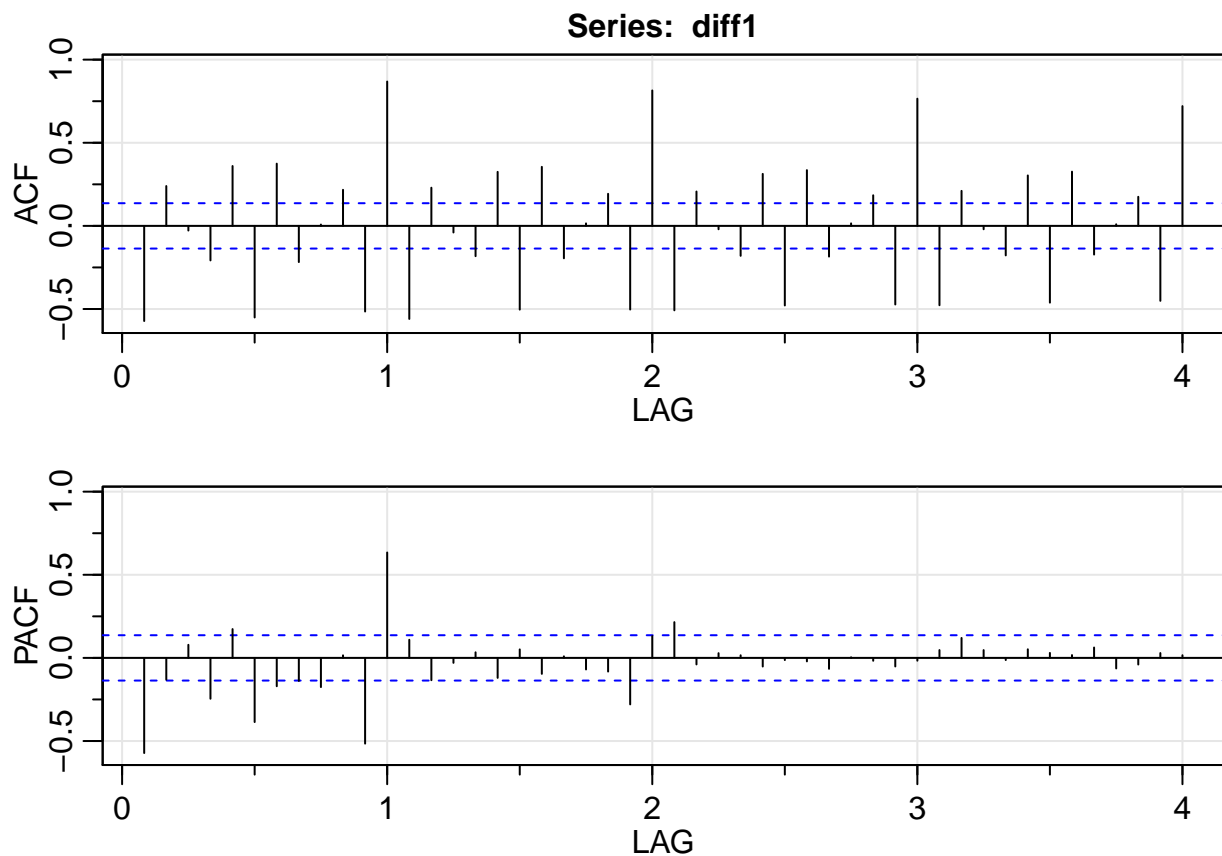
```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
## ACF  0.03 0.05 -0.12 -0.23 -0.02 -0.32 -0.01 -0.11  0.06  0.18  0.12  0.16
## PACF 0.03 0.05 -0.13 -0.23  0.00 -0.33 -0.07 -0.18 -0.06  0.01  0.06  0.00
##      [,13] [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23]
## ACF  -0.17  0.07 -0.12 -0.01 -0.05 -0.08  0.02 -0.02  0.07  0.00 -0.04
## PACF -0.19  0.08 -0.08  0.04 -0.05  0.01 -0.11  0.02 -0.08 -0.05 -0.11
##      [,24] [,25]
## ACF   0.05  0.04
## PACF   0.03  0.02
```

```
diff12=diff(sales,12)
acf2(diff12)
```



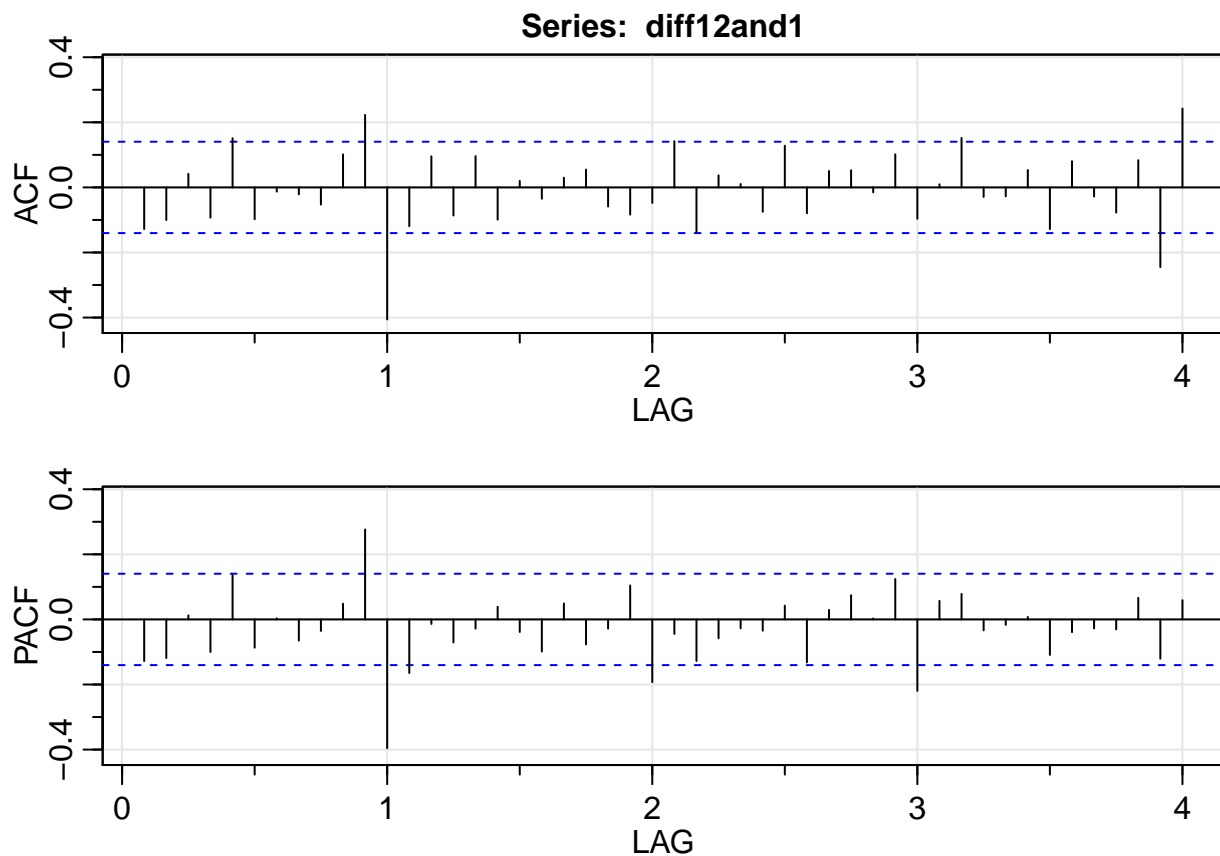
```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
## ACF  0.84 0.72 0.62 0.52 0.43 0.31 0.23 0.15 0.08 0.04 -0.02 -0.16
## PACF 0.84 0.05 0.03 -0.08 0.01 -0.17 0.01 -0.05 0.01 0.01 -0.08 -0.36
##      [,13] [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23]
## ACF -0.18 -0.17 -0.19 -0.18 -0.20 -0.18 -0.17 -0.15 -0.14 -0.15 -0.14
## PACF 0.25 0.09 -0.04 0.01 -0.03 -0.05 -0.01 0.05 -0.10 0.03 0.03
##      [,24] [,25] [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34]
## ACF -0.11 -0.07 -0.06 -0.02 0.02 0.06 0.11 0.12 0.15 0.16 0.16
## PACF -0.13 0.14 -0.02 0.10 0.04 0.00 0.06 -0.08 0.12 -0.06 -0.06
##      [,35] [,36] [,37] [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45]
## ACF 0.16 0.13 0.12 0.11 0.06 0.02 -0.02 -0.07 -0.08 -0.11 -0.13
## PACF 0.01 -0.14 0.19 -0.10 -0.11 0.01 -0.04 0.01 0.03 0.04 -0.03
##      [,46] [,47] [,48]
## ACF -0.13 -0.16 -0.10
## PACF 0.00 -0.07 0.11
```

```
diff1=diff(sales,1)
acf2(diff1)
```



```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11]
## ACF  -0.57  0.24 -0.03 -0.21  0.36 -0.55  0.37 -0.22  0.01  0.22 -0.52
## PACF -0.57 -0.13  0.08 -0.25  0.17 -0.39 -0.17 -0.14 -0.18  0.02 -0.52
##      [,12] [,13] [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22]
## ACF   0.87 -0.56  0.23 -0.04 -0.18  0.33 -0.50  0.36 -0.20  0.02  0.19
## PACF  0.63  0.11 -0.13 -0.03  0.03 -0.12  0.05 -0.10  0.01 -0.07 -0.08
##      [,23] [,24] [,25] [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33]
## ACF  -0.50  0.81 -0.51  0.21 -0.02 -0.18  0.31 -0.48  0.34 -0.18  0.02
## PACF -0.28  0.13  0.22 -0.04  0.03  0.02 -0.05 -0.01 -0.02 -0.07  0.00
##      [,34] [,35] [,36] [,37] [,38] [,39] [,40] [,41] [,42] [,43] [,44]
## ACF   0.18 -0.47  0.77 -0.48  0.21 -0.02 -0.18  0.30 -0.46  0.33 -0.17
## PACF -0.02 -0.05 -0.02  0.05  0.12  0.05 -0.01  0.05  0.03  0.02  0.06
##      [,45] [,46] [,47] [,48]
## ACF   0.01  0.17 -0.45  0.72
## PACF -0.06 -0.04  0.03  0.02
```

```
diff12and1=diff(diff12,1)
acf2(diff12and1)
```



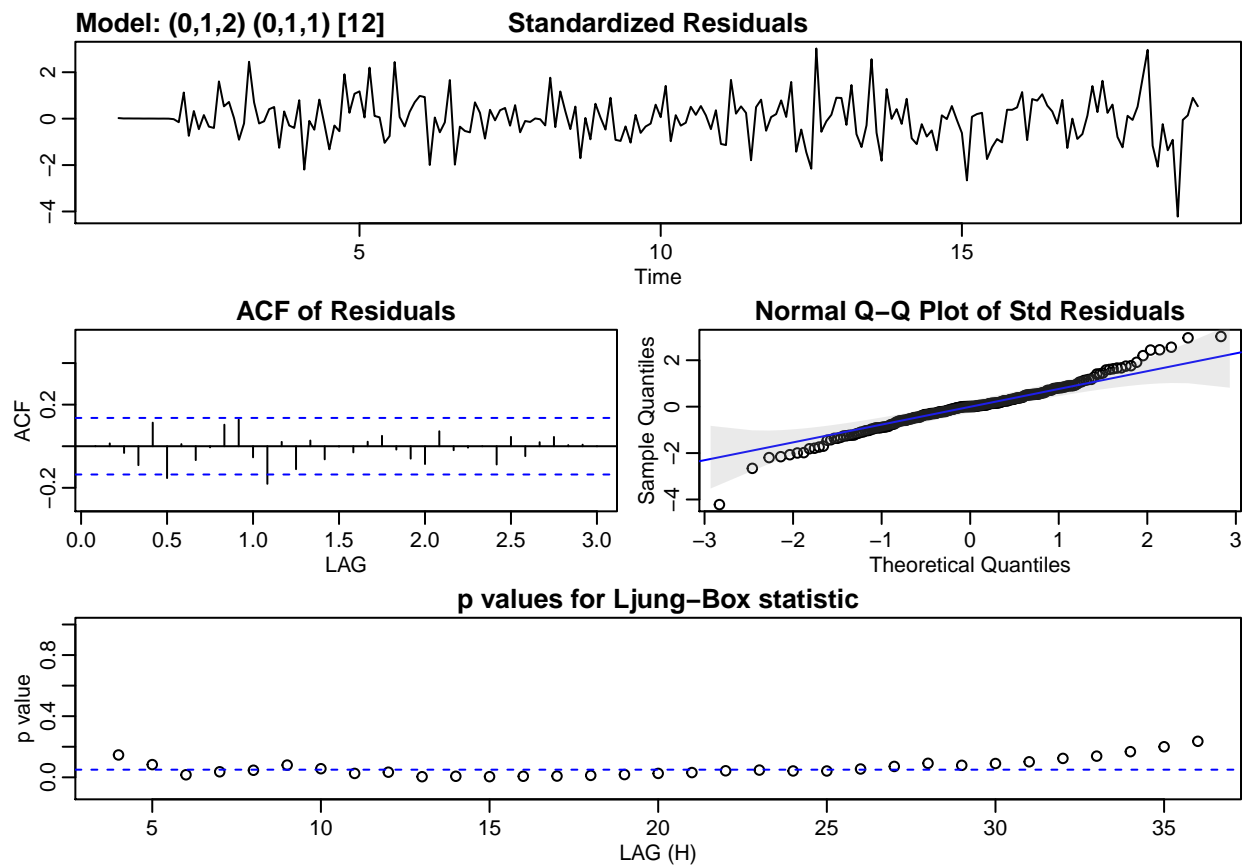
```
##      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
## ACF  -0.13 -0.10 0.04 -0.09 0.15 -0.10 -0.01 -0.02 -0.05 0.10 0.22 -0.41
## PACF  -0.13 -0.12 0.01 -0.10 0.14 -0.09 0.00 -0.07 -0.04 0.05 0.28 -0.40
##      [,13] [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23]
## ACF  -0.12 0.10 -0.09 0.10 -0.10 0.02 -0.03 0.03 0.05 -0.06 -0.08
## PACF  -0.16 -0.01 -0.07 -0.03 0.04 -0.04 -0.10 0.05 -0.08 -0.03 0.10
##      [,24] [,25] [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34]
## ACF  -0.05 0.14 -0.14 0.04 0.01 -0.08 0.13 -0.08 0.05 0.05 -0.02
## PACF  -0.19 -0.04 -0.13 -0.06 -0.03 -0.03 0.04 -0.13 0.03 0.07 0.00
##      [,35] [,36] [,37] [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45]
## ACF   0.10 -0.10 0.01 0.15 -0.03 -0.03 0.05 -0.13 0.08 -0.03 -0.08
## PACF   0.12 -0.22 0.06 0.08 -0.03 -0.02 0.01 -0.11 -0.04 -0.03 -0.03
##      [,46] [,47] [,48]
## ACF   0.08 -0.24 0.24
## PACF   0.07 -0.12 0.06
```

Evaluation

```
sarima(sales,0,1,2,0,1,1,12)
```

```
## initial value -2.822082
## iter 2 value -2.973322
## iter 3 value -3.013732
## iter 4 value -3.026593
## iter 5 value -3.028533
## iter 6 value -3.031839
## iter 7 value -3.032106
## iter 8 value -3.032121
## iter 9 value -3.032121
```

```
## iter    9 value -3.032121
## iter    9 value -3.032121
## final   value -3.032121
## converged
## initial value -3.017868
## iter    2 value -3.018035
## iter    3 value -3.018163
## iter    4 value -3.018164
## iter    4 value -3.018164
## iter    4 value -3.018164
## final   value -3.018164
## converged
```

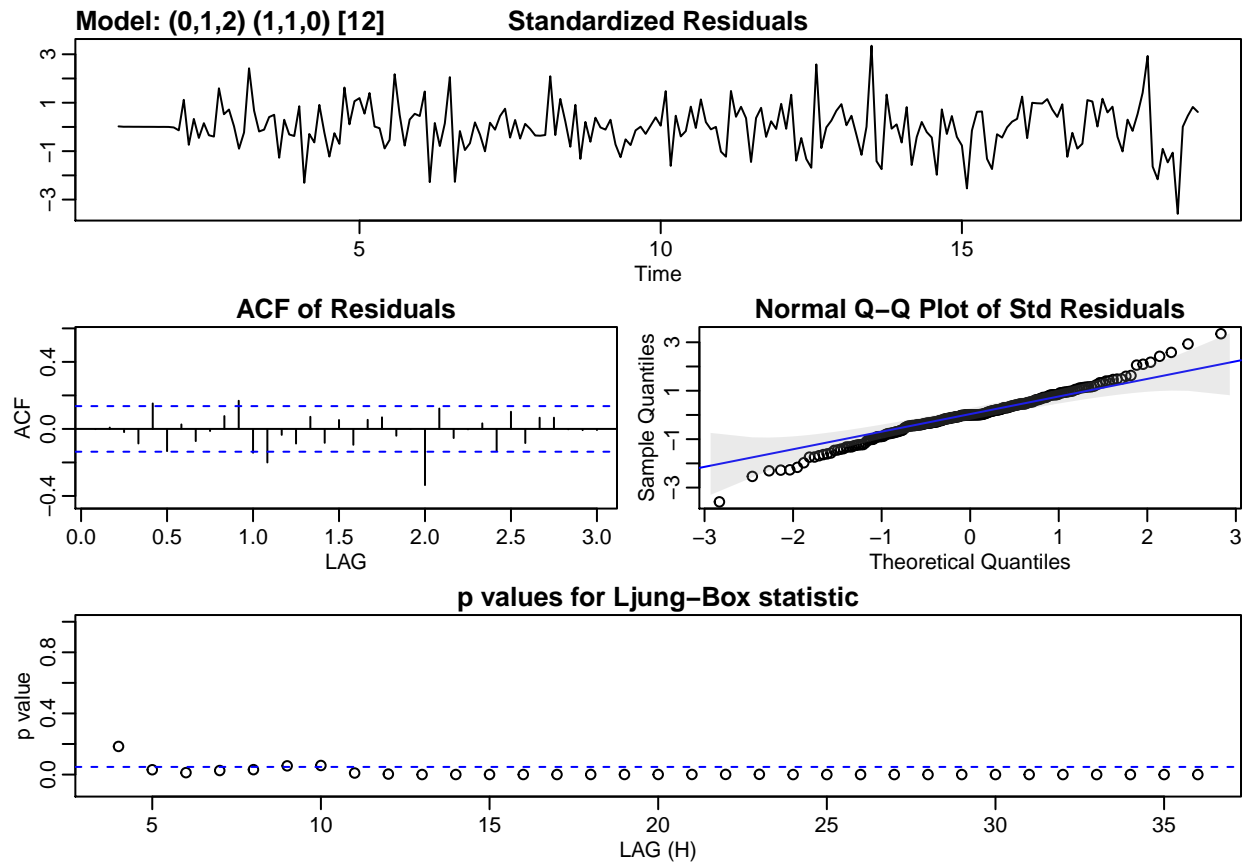


```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), include.mean = !no.constant, transform.pars = trans, fixed = fixed,
##     optim.control = list(trace = trc, REPORT = 1, reltol = tol))
##
## Coefficients:
##          ma1          ma2          sma1
##       -0.1535   -0.0592   -0.7101
## s.e.    0.0703    0.0769    0.0543
##
## sigma^2 estimated as 0.002293:  log likelihood = 324.64,  aic = -641.29
##
```

```
## $degrees_of_freedom
## [1] 200
##
## $ttable
##      Estimate      SE  t.value p.value
## ma1   -0.1535 0.0703  -2.1844 0.0301
## ma2   -0.0592 0.0769  -0.7703 0.4420
## sma1  -0.7101 0.0543 -13.0798 0.0000
##
## $AIC
## [1] -2.996661
##
## $AICc
## [1] -2.996127
##
## $BIC
## [1] -2.934732
```

```
sarima(sales,0,1,2,1,1,0,12)
```

```
## initial  value -2.808234
## iter    2 value -2.926397
## iter    3 value -2.928318
## iter    4 value -2.928418
## iter    5 value -2.928419
## iter    5 value -2.928419
## iter    5 value -2.928419
## final   value -2.928419
## converged
## initial  value -2.936121
## iter    2 value -2.936294
## iter    3 value -2.936312
## iter    3 value -2.936312
## iter    3 value -2.936312
## final   value -2.936312
## converged
```

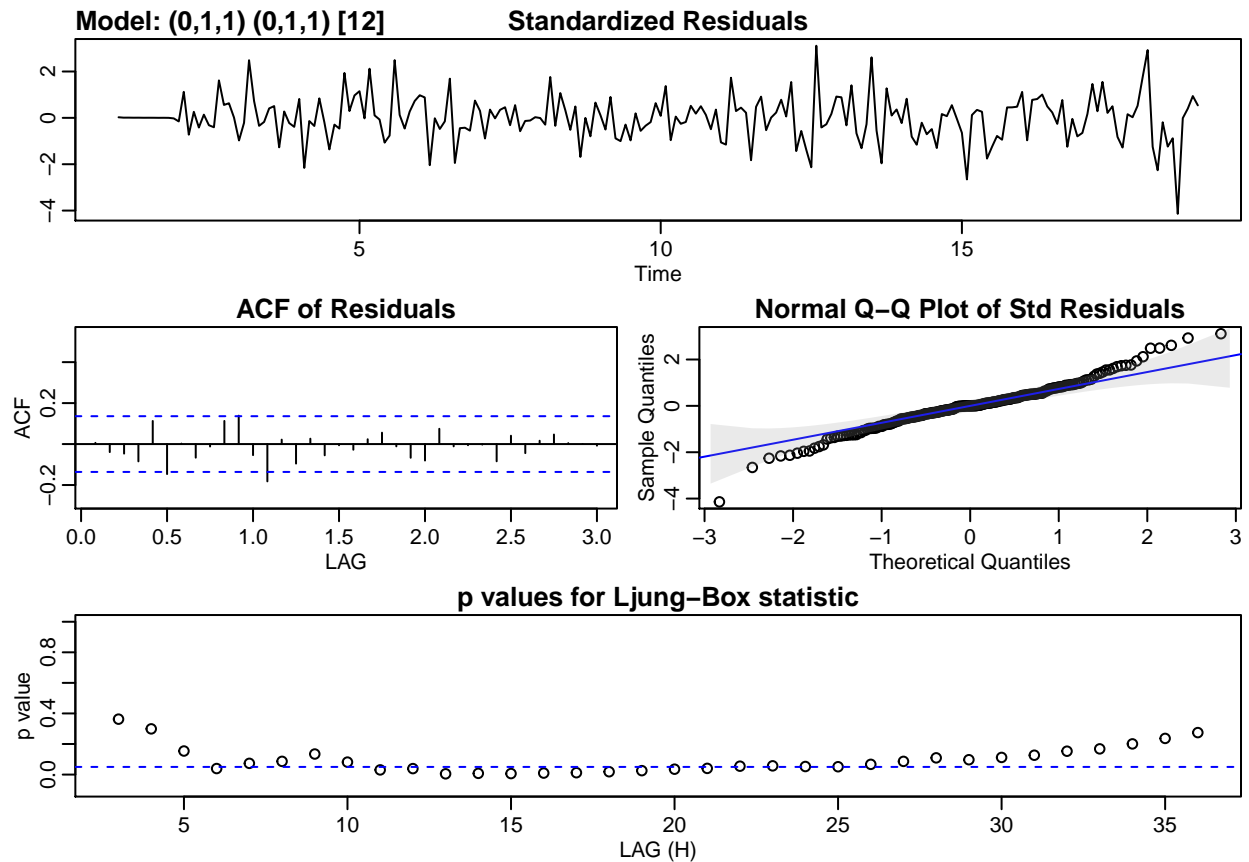
```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), include.mean = !no.constant, transform.pars = trans, fixed = fixed,
##     optim.control = list(trace = trc, REPORT = 1, reltol = tol))
##
## Coefficients:
##          ma1          ma2          sar1
##        -0.1518   -0.0618   -0.4506
## s.e.    0.0704    0.0751    0.0664
##
## sigma^2 estimated as 0.002777:  log likelihood = 308.03,  aic = -608.05
##
## $degrees_of_freedom
## [1] 200
##
## $ttable
##      Estimate      SE t.value p.value
## ma1   -0.1518  0.0704  -2.1563  0.0323
## ma2   -0.0618  0.0751  -0.8220  0.4121
## sar1  -0.4506  0.0664  -6.7900  0.0000
##
## $AIC
## [1] -2.841372
##
```

```

## $AICc
## [1] -2.840838
##
## $BIC
## [1] -2.779443
sarima(sales,0,1,1,0,1,1,12)

## initial  value -2.822082
## iter    2 value -2.969883
## iter    3 value -3.013888
## iter    4 value -3.026731
## iter    5 value -3.027685
## iter    6 value -3.030852
## iter    7 value -3.031024
## iter    8 value -3.031112
## iter    9 value -3.031113
## iter    9 value -3.031113
## iter    9 value -3.031113
## final   value -3.031113
## converged
## initial  value -3.016424
## iter    2 value -3.016550
## iter    3 value -3.016683
## iter    4 value -3.016684
## iter    4 value -3.016684
## iter    4 value -3.016684
## final   value -3.016684
## converged

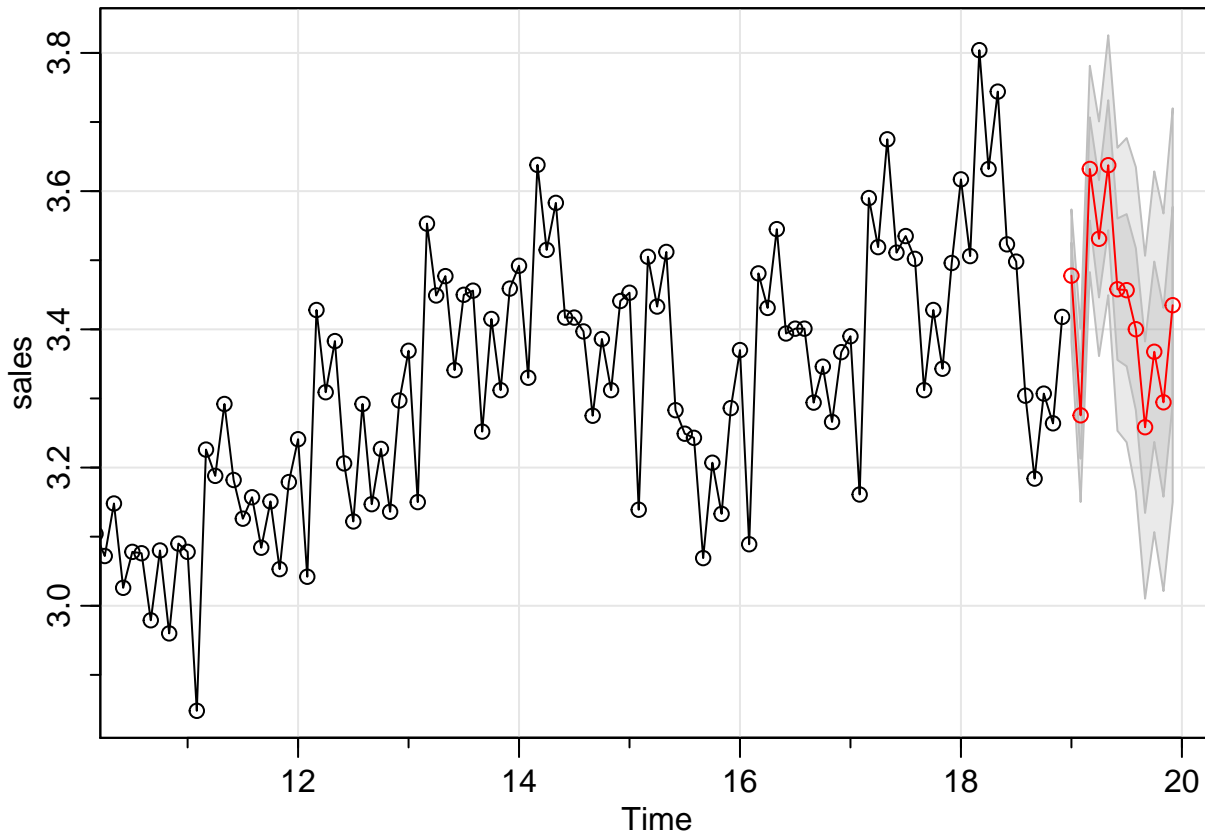
```



```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), include.mean = !no.constant, transform.pars = trans, fixed = fixed,
##     optim.control = list(trace = trc, REPORT = 1, reltol = tol))
##
## Coefficients:
##          ma1      sma1
##       -0.1560  -0.7165
## s.e.   0.0739   0.0538
##
## sigma^2 estimated as 0.002297:  log likelihood = 324.34,  aic = -642.68
##
## $degrees_of_freedom
## [1] 201
##
## $ttable
##      Estimate      SE  t.value p.value
## ma1  -0.1560  0.0739  -2.1113  0.036
## sma1  -0.7165  0.0538 -13.3260  0.000
##
## $AIC
## [1] -3.003198
##
## $AICc
```

```
## [1] -3.002933
##
## $BIC
## [1] -2.956752
```

```
# Forecast
sarima.for(sales,12,0,1,1,0,1,1,12)
```



```
## $pred
##      Jan      Feb      Mar      Apr      May      Jun      Jul      Aug
## 19 3.477666 3.275568 3.632091 3.531044 3.637497 3.458033 3.456673 3.400179
##      Sep      Oct      Nov      Dec
## 19 3.258374 3.367593 3.294429 3.434967
##
## $se
##      Jan      Feb      Mar      Apr      May      Jun
## 19 0.04792906 0.06271868 0.07463291 0.08489117 0.09403695 0.10236888
##      Jul      Aug      Sep      Oct      Nov      Dec
## 19 0.11007191 0.11727004 0.12405121 0.13048042 0.13660739 0.14247111
```