Sunspot Analysis

Daniel Byrne

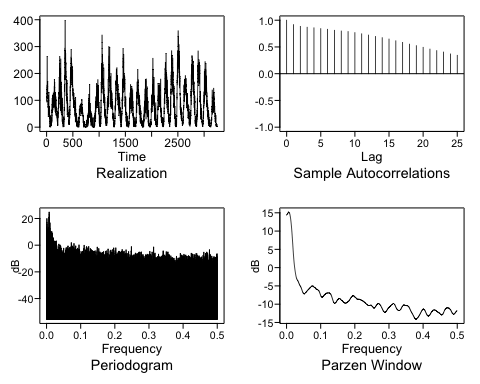
11/5/2019

## Monthly Mean Total Sunspot Number

Monthly mean total sunspot number obtained by taking a simple arithmetic mean of the daily total sunspot number over all days of each calendar month. Monthly means are available only since 1749 because the original observations compiled by Rudolph Wolf were too sparse before that year. (Only yearly means are available back to 1700)

* Column 1-2: Gregorian calendar date
  + Year
  + Month
* Column 3: Date in fraction of year.
* Column 4: Monthly mean total sunspot number.
* Column 5: Monthly mean standard deviation of the input sunspot numbers.
* Column 6: Number of observations used to compute the monthly mean total sunspot number.
* Column 7: Definitive/provisional marker. ‘1’ indicates that the value is definitive. ‘0’ indicates that the value is still provisional.

par(mfrow=c(1, 3))  
x = z$V4  
plotts.sample.wge(x)



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## [8] 0.8116275 0.7980604 0.7883408 0.7682251 0.7458649 0.7221870 0.6964056  
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## [866] -9.92684233 -9.90624596 -9.88835145 -9.87318438 -9.86076028  
## [871] -9.85108542 -9.84415759 -9.83996682 -9.83849606 -9.83972185  
## [876] -9.84361494 -9.85014086 -9.85926052 -9.87093075 -9.88510483  
## [881] -9.90173301 -9.92076300 -9.94214046 -9.96580942 -9.99171272  
## [886] -10.01979238 -10.04998997 -10.08224689 -10.11650459 -10.15270481  
## [891] -10.19078960 -10.23070143 -10.27238306 -10.31577743 -10.36082741  
## [896] -10.40747542 -10.45566299 -10.50533025 -10.55641522 -10.60885314  
## [901] -10.66257558 -10.71750966 -10.77357703 -10.83069294 -10.88876527  
## [906] -10.94769355 -11.00736804 -11.06766887 -11.12846527 -11.18961495  
## [911] -11.25096361 -11.31234469 -11.37357928 -11.43447640 -11.49483338  
## [916] -11.55443676 -11.61306332 -11.67048158 -11.72645352 -11.78073670  
## [921] -11.83308662 -11.88325936 -11.93101444 -11.97611780 -12.01834490  
## [926] -12.05748385 -12.09333836 -12.12573064 -12.15450398 -12.17952505  
## [931] -12.20068571 -12.21790447 -12.23112738 -12.24032842 -12.24550935  
## [936] -12.24669908 -12.24395260 -12.23734939 -12.22699165 -12.21300212  
## [941] -12.19552182 -12.17470763 -12.15072988 -12.12377002 -12.09401829  
## [946] -12.06167173 -12.02693222 -11.99000486 -11.95109651 -11.91041456  
## [951] -11.86816595 -11.82455635 -11.77978947 -11.73406654 -11.68758582  
## [956] -11.64054221 -11.59312682 -11.54552652 -11.49792350 -11.45049467  
## [961] -11.40341100 -11.35683677 -11.31092871 -11.26583497 -11.22169410  
## [966] -11.17863384 -11.13676990 -11.09620467 -11.05702591 -11.01930551  
## [971] -10.98309817 -10.94844032 -10.91534903 -10.88382119 -10.85383282  
## [976] -10.82533865 -10.79827202 -10.77254511 -10.74804951 -10.72465722  
## [981] -10.70222210 -10.68058179 -10.65956008 -10.63896976 -10.61861593  
## [986] -10.59829975 -10.57782253 -10.55699014 -10.53561765 -10.51353397  
## [991] -10.49058660 -10.46664608 -10.44161019 -10.41540771 -10.38800155  
## [996] -10.35939118 -10.32961427 -10.29874747 -10.26690622 -10.23424376  
## [1001] -10.20094921 -10.16724480 -10.13338253 -10.09964008 -10.06631641  
## [1006] -10.03372690 -10.00219837 -9.97206406 -9.94365858 -9.91731309  
## [1011] -9.89335069 -9.87208206 -9.85380154 -9.83878350 -9.82727906  
## [1016] -9.81951332 -9.81568284 -9.81595348 -9.82045867 -9.82929789  
## [1021] -9.84253553 -9.86019996 -9.88228295 -9.90873929 -9.93948679  
## [1026] -9.97440644 -10.01334300 -10.05610588 -10.10247034 -10.15217916  
## [1031] -10.20494471 -10.26045150 -10.31835917 -10.37830605 -10.43991319  
## [1036] -10.50278889 -10.56653366 -10.63074559 -10.69502598 -10.75898522  
## [1041] -10.82224860 -10.88446205 -10.94529756 -11.00445808 -11.06168174  
## [1046] -11.11674522 -11.16946611 -11.21970421 -11.26736155 -11.31238136  
## [1051] -11.35474577 -11.39447252 -11.43161065 -11.46623552 -11.49844311  
## [1056] -11.52834406 -11.55605742 -11.58170456 -11.60540316 -11.62726175  
## [1061] -11.64737464 -11.66581770 -11.68264475 -11.69788492 -11.71154082  
## [1066] -11.72358774 -11.73397369 -11.74262046 -11.74942549 -11.75426468  
## [1071] -11.75699597 -11.75746358 -11.75550295 -11.75094605 -11.74362710  
## [1076] -11.73338847 -11.72008657 -11.70359753 -11.68382256 -11.66069278  
## [1081] -11.63417334 -11.60426668 -11.57101486 -11.53450086 -11.49484886  
## [1086] -11.45222344 -11.40682775 -11.35890090 -11.30871444 -11.25656823  
## [1091] -11.20278585 -11.14770965 -11.09169561 -11.03510820 -10.97831529  
## [1096] -10.92168332 -10.86557271 -10.81033363 -10.75630223 -10.70379715  
## [1101] -10.65311660 -10.60453579 -10.55830471 -10.51464637 -10.47375537  
## [1106] -10.43579673 -10.40090505 -10.36918397 -10.34070581 -10.31551147  
## [1111] -10.29361057 -10.27498178 -10.25957337 -10.24730404 -10.23806393  
## [1116] -10.23171595 -10.22809735 -10.22702161 -10.22828066 -10.23164746  
## [1121] -10.23687885 -10.24371883 -10.25190215 -10.26115819 -10.27121516  
## [1126] -10.28180447 -10.29266527 -10.30354906 -10.31422424 -10.32448044  
## [1131] -10.33413269 -10.34302508 -10.35103393 -10.35807032 -10.36408194  
## [1136] -10.36905410 -10.37300995 -10.37600987 -10.37815002 -10.37956014  
## [1141] -10.38040069 -10.38085935 -10.38114709 -10.38149386 -10.38214401  
## [1146] -10.38335172 -10.38537628 -10.38847756 -10.39291168 -10.39892691  
## [1151] -10.40675984 -10.41663202 -10.42874686 -10.44328702 -10.46041206  
## [1156] -10.48025663 -10.50292895 -10.52850965 -10.55705099 -10.58857643  
## [1161] -10.62308050 -10.66052899 -10.70085952 -10.74398231 -10.78978140  
## [1166] -10.83811609 -10.88882272 -10.94171680 -10.99659547 -11.05324018  
## [1171] -11.11141977 -11.17089379 -11.23141604 -11.29273833 -11.35461438  
## [1176] -11.41680376 -11.47907587 -11.54121379 -11.60301790 -11.66430928  
## [1181] -11.72493269 -11.78475897 -11.84368704 -11.90164513 -11.95859135  
## [1186] -12.01451362 -12.06942880 -12.12338120 -12.17644038 -12.22869843  
## [1191] -12.28026667 -12.33127205 -12.38185313 -12.43215591 -12.48232956  
## [1196] -12.53252215 -12.58287644 -12.63352582 -12.68459060 -12.73617445  
## [1201] -12.78836129 -12.84121255 -12.89476479 -12.94902785 -13.00398343  
## [1206] -13.05958409 -13.11575286 -13.17238327 -13.22933989 -13.28645943  
## [1211] -13.34355232 -13.40040485 -13.45678177 -13.51242935 -13.56707897  
## [1216] -13.62045108 -13.67225944 -13.72221577 -13.77003443 -13.81543730  
## [1221] -13.85815853 -13.89794918 -13.93458157 -13.96785311 -13.99758973  
## [1226] -14.02364860 -14.04592007 -14.06432895 -14.07883490 -14.08943204  
## [1231] -14.09614779 -14.09904102 -14.09819960 -14.09373738 -14.08579086  
## [1236] -14.07451553 -14.06008213 -14.04267281 -14.02247745 -13.99969009  
## [1241] -13.97450565 -13.94711693 -13.91771194 -13.88647162 -13.85356790  
## [1246] -13.81916213 -13.78340389 -13.74643006 -13.70836426 -13.66931648  
## [1251] -13.62938304 -13.58864667 -13.54717684 -13.50503024 -13.46225134  
## [1256] -13.41887316 -13.37491811 -13.33039891 -13.28531968 -13.23967705  
## [1261] -13.19346138 -13.14665807 -13.09924898 -13.05121386 -13.00253192  
## [1266] -12.95318336 -12.90315105 -12.85242216 -12.80098977 -12.74885450  
## [1271] -12.69602611 -12.64252486 -12.58838295 -12.53364563 -12.47837225  
## [1276] -12.42263700 -12.36652948 -12.31015497 -12.25363446 -12.19710437  
## [1281] -12.14071603 -12.08463490 -12.02903946 -11.97411999 -11.92007706  
## [1286] -11.86711987 -11.81546443 -11.76533172 -11.71694566 -11.67053110  
## [1291] -11.62631182 -11.58450852 -11.54533688 -11.50900563 -11.47571481  
## [1296] -11.44565402 -11.41900082 -11.39591927 -11.37655856 -11.36105170  
## [1301] -11.34951447 -11.34204431 -11.33871948 -11.33959818 -11.34471791  
## [1306] -11.35409484 -11.36772333 -11.38557554 -11.40760115 -11.43372721  
## [1311] -11.46385809 -11.49787558 -11.53563910 -11.57698612 -11.62173270  
## [1316] -11.66967422 -11.72058632 -11.77422603 -11.83033309 -11.88863156  
## [1321] -11.94883153 -12.01063118 -12.07371890 -12.13777570 -12.20247770  
## [1326] -12.26749875 -12.33251312 -12.39719824 -12.46123732 -12.52432194  
## [1331] -12.58615446 -12.64645017 -12.70493926 -12.76136834 -12.81550174  
## [1336] -12.86712235 -12.91603208 -12.96205206 -13.00502236 -13.04480150  
## [1341] -13.08126576 -13.11430817 -13.14383760 -13.16977766 -13.19206575  
## [1346] -13.21065216 -13.22549940 -13.23658173 -13.24388488 -13.24740611  
## [1351] -13.24715445 -13.24315122 -13.23543063 -13.22404064 -13.20904380  
## [1356] -13.19051809 -13.16855770 -13.14327367 -13.11479427 -13.08326517  
## [1361] -13.04884926 -13.01172613 -12.97209122 -12.93015461 -12.88613946  
## [1366] -12.84028020 -12.79282046 -12.74401072 -12.69410597 -12.64336314  
## [1371] -12.59203862 -12.54038576 -12.48865250 -12.43707914 -12.38589623  
## [1376] -12.33532279 -12.28556466 -12.23681317 -12.18924402 -12.14301651  
## [1381] -12.09827293 -12.05513832 -12.01372036 -11.97410959 -11.93637981  
## [1386] -11.90058865 -11.86677840 -11.83497688 -11.80519857 -11.77744574  
## [1391] -11.75170981 -11.72797259 -11.70620774 -11.68638216 -11.66845735  
## [1396] -11.65239083 -11.63813737 -11.62565031 -11.61488258 -11.60578779  
## [1401] -11.59832102 -11.59243955 -11.58810338 -11.58527556 -11.58392239  
## [1406] -11.58401337 -11.58552102 -11.58842048 -11.59268903 -11.59830535  
## [1411] -11.60524880 -11.61349851 -11.62303242 -11.63382631 -11.64585280  
## [1416] -11.65908043 -11.67347269 -11.68898728 -11.70557541 -11.72318128  
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## [1426] -11.84614068 -11.86870381 -11.89159254 -11.91470029 -11.93792058  
## [1431] -11.96114882 -11.98428439 -12.00723261 -12.02990681 -12.05223032  
## [1436] -12.07413829 -12.09557938 -12.11651719 -12.13693134 -12.15681825  
## [1441] -12.17619149 -12.19508177 -12.21353640 -12.23161839 -12.24940509  
## [1446] -12.26698644 -12.28446281 -12.30194257 -12.31953931 -12.33736888  
## [1451] -12.35554628 -12.37418238 -12.39338064 -12.41323385 -12.43382091  
## [1456] -12.45520371 -12.47742427 -12.50050196 -12.52443111 -12.54917885  
## [1461] -12.57468332 -12.60085229 -12.62756222 -12.65465777 -12.68195190  
## [1466] -12.70922656 -12.73623390 -12.76269836 -12.78831925 -12.81277420  
## [1471] -12.83572329 -12.85681394 -12.87568640 -12.89197991 -12.90533933  
## [1476] -12.91542211 -12.92190547 -12.92449354 -12.92292419 -12.91697553  
## [1481] -12.90647149 -12.89128667 -12.87134988 -12.84664656 -12.81721975  
## [1486] -12.78316965 -12.74465193 -12.70187462 -12.65509395 -12.60460921  
## [1491] -12.55075688 -12.49390427 -12.43444278 -12.37278124 -12.30933924  
## [1496] -12.24454083 -12.17880862 -12.11255839 -12.04619430 -11.98010470  
## [1501] -11.91465855 -11.85020249 -11.78705845 -11.72552175 -11.66585980  
## [1506] -11.60831109 -11.55308467 -11.50035987 -11.45028641 -11.40298466  
## [1511] -11.35854619 -11.31703446 -11.27848574 -11.24291016 -11.21029295  
## [1516] -11.18059581 -11.15375845 -11.12970029 -11.10832234 -11.08950927  
## [1521] -11.07313154 -11.05904786 -11.04710766 -11.03715380 -11.02902535  
## [1526] -11.02256050 -11.01759946 -11.01398747 -11.01157764 -11.01023384  
## [1531] -11.00983329 -11.01026899 -11.01145188 -11.01331259 -11.01580287  
## [1536] -11.01889646 -11.02258964 -11.02690111 -11.03187151 -11.03756236  
## [1541] -11.04405456 -11.05144644 -11.05985147 -11.06939557 -11.08021422  
## [1546] -11.09244930 -11.10624589 -11.12174890 -11.13909981 -11.15843336  
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## [1556] -11.32201729 -11.35782682 -11.39612074 -11.43685812 -11.47997077  
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## [1566] -11.78126000 -11.83681762 -11.89325804 -11.95029580 -12.00763097  
## [1571] -12.06495222 -12.12194009 -12.17827039 -12.23361773 -12.28765899  
## [1576] -12.34007680 -12.39056284 -12.43882092 -12.48456988 -12.52754607  
## [1581] -12.56750552 -12.60422578 -12.63750734 -12.66717470 -12.69307713  
## [1586] -12.71508916 -12.73311088 -12.74706797 -12.75691180 -12.76261934  
## [1591] -12.76419314 -12.76166135 -12.75507775 -12.74452182 -12.73009885  
## [1596] -12.71194001 -12.69020235 -12.66506865 -12.63674714 -12.60547088  
## [1601] -12.57149687 -12.53510488 -12.49659583 -12.45628979 -12.41452370  
## [1606] -12.37164868 -12.32802705 -12.28402910 -12.24002971 -12.19640483  
## [1611] -12.15352793 -12.11176641 -12.07147819 -12.03300835 -11.99668598  
## [1616] -11.96282126 -11.93170276 -11.90359502 -11.87873637 -11.85733707  
## [1621] -11.83957770 -11.82560776 -11.81554467 -11.80947288 -11.80744327

* The mean appears as if it will vary depending on when the signal is sampled.
* The ACF also indicates a slow decay indicating the presence of a unit root.
* The variance of the signal appears also to change across the realization.

Considering this time series violates the condition 1 that the mean is not dependent on time and condition 2 that the variance depends on time then this time series is NOT stationary.

## AIC Analysis

aic5.wge(x)

## ---------WORKING... PLEASE WAIT...   
##   
##   
## Five Smallest Values of aic

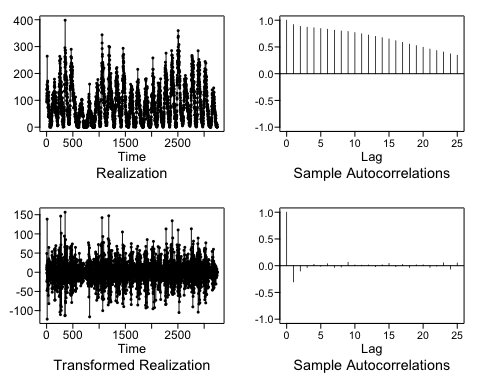
## p q aic  
## 14 4 1 6.449453  
## 17 5 1 6.450036  
## 15 4 2 6.450105  
## 11 3 1 6.450293  
## 6 1 2 6.450380

aic5.wge(x, type = "bic")

## ---------WORKING... PLEASE WAIT...   
##   
##   
## Five Smallest Values of bic

## p q bic  
## 6 1 2 6.457871  
## 8 2 1 6.459227  
## 11 3 1 6.459656  
## 9 2 2 6.460359  
## 14 4 1 6.460690

d = artrans.wge(x,phi.tr = 1)



aic5.wge(d)

## ---------WORKING... PLEASE WAIT...   
##   
##   
## Five Smallest Values of aic

## p q aic  
## 9 2 2 6.452957  
## 16 5 0 6.457524  
## 11 3 1 6.457539  
## 14 4 1 6.458139  
## 3 0 2 6.458164

AIC5 reccommends a 4,1. BIC reccomends a 1,2

## Model Fit

m41 = est.arma.wge(x,p=4,q=1)

##   
## Coefficients of Original polynomial:   
## 1.0269 -0.1459 0.0401 0.0586   
##   
## Factor Roots Abs Recip System Freq   
## 1-0.9817B 1.0186 0.9817 0.0000  
## 1-0.3403B+0.2020B^2 0.8422+-2.0592i 0.4495 0.1882  
## 1+0.2952B -3.3877 0.2952 0.5000  
##   
##

m12 = est.arma.wge(x,p=1,q=2)

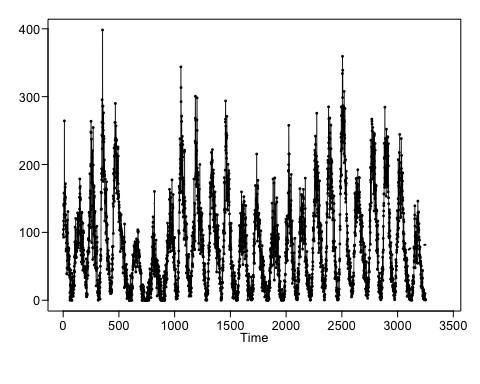
##   
## Coefficients of Original polynomial:   
## 0.9826   
##   
## Factor Roots Abs Recip System Freq   
## 1-0.9826B 1.0177 0.9826 0.0000  
##   
##

m212 = est.arma.wge(d,p=2,q=2)

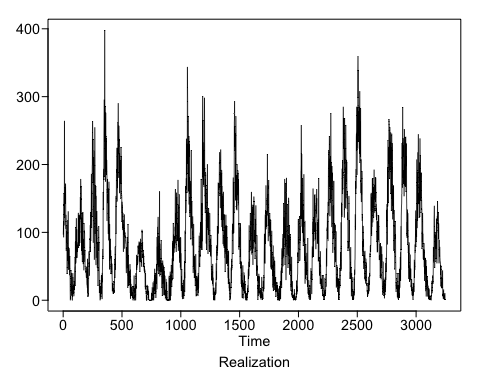
##   
## Coefficients of Original polynomial:   
## 1.3250 -0.3771   
##   
## Factor Roots Abs Recip System Freq   
## 1-0.9111B 1.0976 0.9111 0.0000  
## 1-0.4139B 2.4162 0.4139 0.0000  
##   
##

# ASE for 4,1 model

f = fore.aruma.wge(x,phi=m41$phi,theta=m41$theta,n.ahead=15\*12, lastn = TRUE, limits= FALSE)



plotts.wge(x)

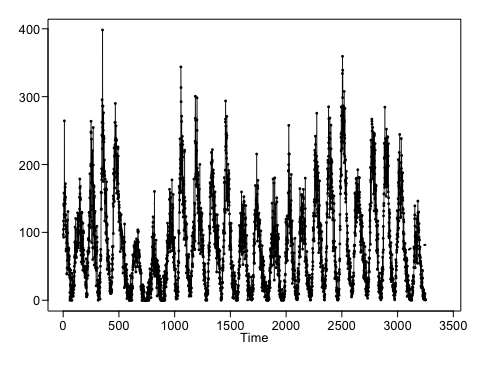


ase(f$f,x)

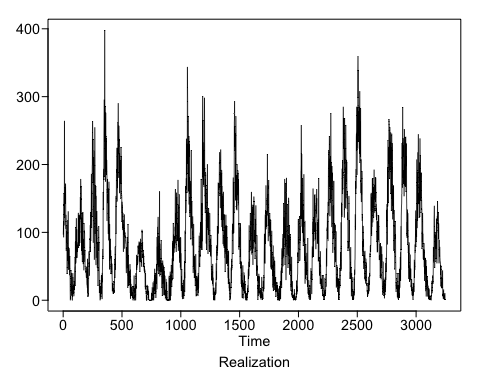
## [1] 2711.115

# ASE for 1,2 model

f21 = fore.aruma.wge(x,phi=m12$phi,theta=m12$theta,n.ahead=15\*12, lastn = TRUE, limits= FALSE)



par(mfrow=c(1, 2))  
plotts.wge(x)

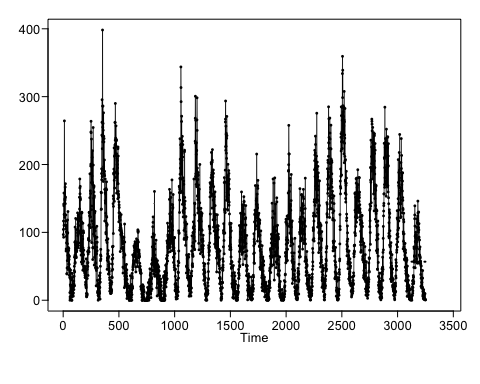


ase(f21$f,x)

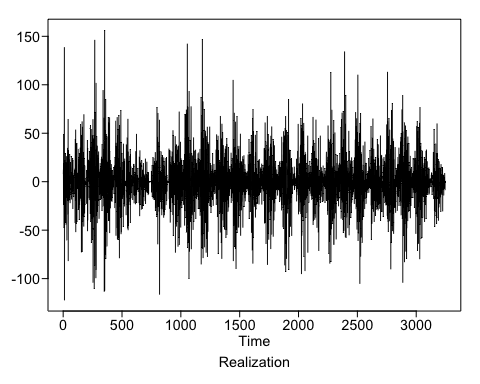
## [1] 2696.64

# ASE for 2,1,2 model

f21 = fore.aruma.wge(x,phi=m212$phi,theta=m212$theta,d=1,n.ahead=15\*12, lastn = TRUE, limits= FALSE)



par(mfrow=c(1, 2))  
plotts.wge(d)



ase(f21$f,x)

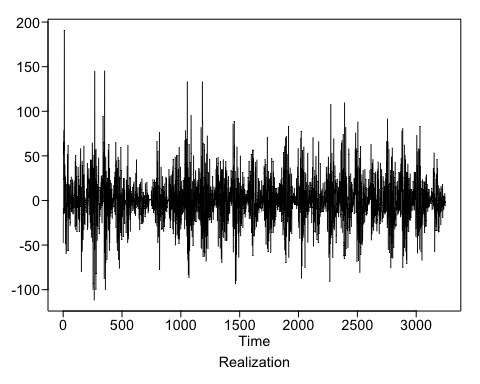
## [1] 1685.226

ljung.wge(m212$res)

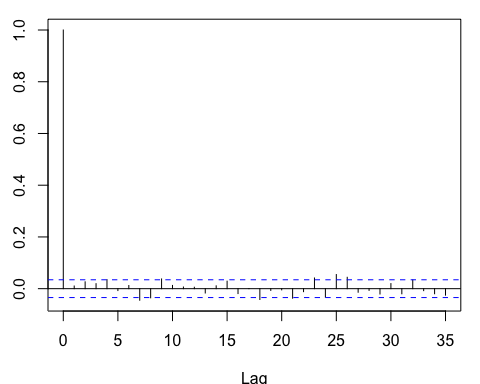
## Obs 0.01023261 0.02650152 0.01932884 0.034989 -0.007305343 0.01211574 -0.04468853 -0.0353967 0.03763788 0.01255345 0.006391068 0.005612741 -0.01668853 0.01092545 0.02900778 -0.01895316 0.0004895282 -0.04186458 -0.006721559 -0.004628401 -0.03690256 -0.01151097 0.04131391 -0.03284021

## $test  
## [1] "Ljung-Box test"  
##   
## $K  
## [1] 24  
##   
## $chi.square  
## [1] 49.61484  
##   
## $df  
## [1] 24  
##   
## $pval  
## [1] 0.001584632

plotts.wge(m212$res)

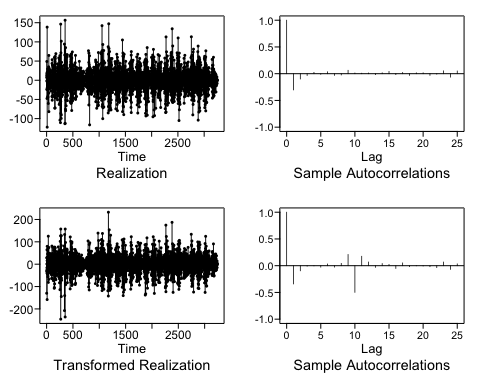


acf(m212$res)



## Seasonal Model

d10 = artrans.wge(d,phi.tr = c(0,0,0,0,0,0,0,0,0,1))



aic5.wge(d10)

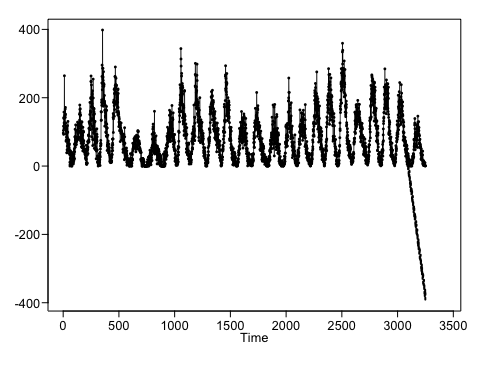
## ---------WORKING... PLEASE WAIT...   
##   
##   
## Five Smallest Values of aic

## p q aic  
## 6 1 2 7.059843  
## 14 4 1 7.060623  
## 11 3 1 7.061746  
## 5 1 1 7.063731  
## 8 2 1 7.063794

md10 = est.arma.wge(d10,p=1,q=2)

##   
## Coefficients of Original polynomial:   
## 0.5460   
##   
## Factor Roots Abs Recip System Freq   
## 1-0.5460B 1.8315 0.5460 0.0000  
##   
##

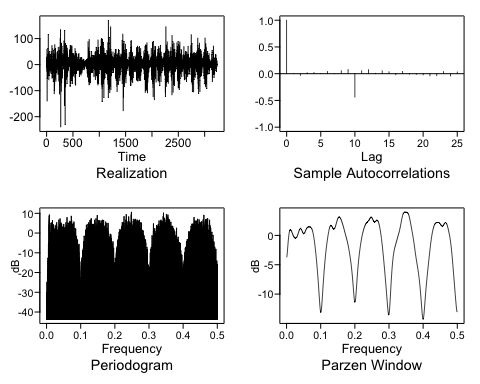
fd10 = fore.aruma.wge(x,phi=md10$phi,theta=md10$theta,d=1,s=10,n.ahead=15\*12, lastn = TRUE, limits= FALSE)



ase(fd10$f,x)

## [1] 60824.75

plotts.sample.wge(md10$res)



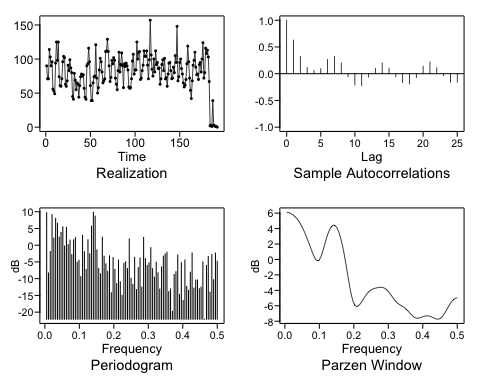
## $autplt  
## [1] 1.000000000 0.003948283 -0.031828910 0.018475017 0.021557835  
## [6] 0.003694154 0.041015272 0.004241089 0.056647214 0.079000157  
## [11] -0.439508016 0.056176742 0.075605264 0.008343112 0.054330728  
## [16] 0.036748152 -0.021799541 0.042890603 -0.009065264 -0.012332792  
## [21] -0.023405057 -0.040143651 -0.038103680 0.039620688 -0.043458402  
## [26] 0.032817070  
##   
## $freq  
## [1] 0.0003087373 0.0006174745 0.0009262118 0.0012349491 0.0015436863  
## [6] 0.0018524236 0.0021611609 0.0024698981 0.0027786354 0.0030873726  
## [11] 0.0033961099 0.0037048472 0.0040135844 0.0043223217 0.0046310590  
## [16] 0.0049397962 0.0052485335 0.0055572708 0.0058660080 0.0061747453  
## [21] 0.0064834826 0.0067922198 0.0071009571 0.0074096944 0.0077184316  
## [26] 0.0080271689 0.0083359061 0.0086446434 0.0089533807 0.0092621179  
## [31] 0.0095708552 0.0098795925 0.0101883297 0.0104970670 0.0108058043  
## [36] 0.0111145415 0.0114232788 0.0117320161 0.0120407533 0.0123494906  
## [41] 0.0126582278 0.0129669651 0.0132757024 0.0135844396 0.0138931769  
## [46] 0.0142019142 0.0145106514 0.0148193887 0.0151281260 0.0154368632  
## [51] 0.0157456005 0.0160543378 0.0163630750 0.0166718123 0.0169805496  
## [56] 0.0172892868 0.0175980241 0.0179067613 0.0182154986 0.0185242359  
## [61] 0.0188329731 0.0191417104 0.0194504477 0.0197591849 0.0200679222  
## [66] 0.0203766595 0.0206853967 0.0209941340 0.0213028713 0.0216116085  
## [71] 0.0219203458 0.0222290831 0.0225378203 0.0228465576 0.0231552948  
## [76] 0.0234640321 0.0237727694 0.0240815066 0.0243902439 0.0246989812  
## [81] 0.0250077184 0.0253164557 0.0256251930 0.0259339302 0.0262426675  
## [86] 0.0265514048 0.0268601420 0.0271688793 0.0274776165 0.0277863538  
## [91] 0.0280950911 0.0284038283 0.0287125656 0.0290213029 0.0293300401  
## [96] 0.0296387774 0.0299475147 0.0302562519 0.0305649892 0.0308737265  
## [101] 0.0311824637 0.0314912010 0.0317999383 0.0321086755 0.0324174128  
## [106] 0.0327261500 0.0330348873 0.0333436246 0.0336523618 0.0339610991  
## [111] 0.0342698364 0.0345785736 0.0348873109 0.0351960482 0.0355047854  
## [116] 0.0358135227 0.0361222600 0.0364309972 0.0367397345 0.0370484718  
## [121] 0.0373572090 0.0376659463 0.0379746835 0.0382834208 0.0385921581  
## [126] 0.0389008953 0.0392096326 0.0395183699 0.0398271071 0.0401358444  
## [131] 0.0404445817 0.0407533189 0.0410620562 0.0413707935 0.0416795307  
## [136] 0.0419882680 0.0422970052 0.0426057425 0.0429144798 0.0432232170  
## [141] 0.0435319543 0.0438406916 0.0441494288 0.0444581661 0.0447669034  
## [146] 0.0450756406 0.0453843779 0.0456931152 0.0460018524 0.0463105897  
## [151] 0.0466193270 0.0469280642 0.0472368015 0.0475455387 0.0478542760  
## [156] 0.0481630133 0.0484717505 0.0487804878 0.0490892251 0.0493979623  
## [161] 0.0497066996 0.0500154369 0.0503241741 0.0506329114 0.0509416487  
## [166] 0.0512503859 0.0515591232 0.0518678605 0.0521765977 0.0524853350  
## [171] 0.0527940722 0.0531028095 0.0534115468 0.0537202840 0.0540290213  
## [176] 0.0543377586 0.0546464958 0.0549552331 0.0552639704 0.0555727076  
## [181] 0.0558814449 0.0561901822 0.0564989194 0.0568076567 0.0571163939  
## [186] 0.0574251312 0.0577338685 0.0580426057 0.0583513430 0.0586600803  
## [191] 0.0589688175 0.0592775548 0.0595862921 0.0598950293 0.0602037666  
## [196] 0.0605125039 0.0608212411 0.0611299784 0.0614387157 0.0617474529  
## [201] 0.0620561902 0.0623649274 0.0626736647 0.0629824020 0.0632911392  
## [206] 0.0635998765 0.0639086138 0.0642173510 0.0645260883 0.0648348256  
## [211] 0.0651435628 0.0654523001 0.0657610374 0.0660697746 0.0663785119  
## [216] 0.0666872492 0.0669959864 0.0673047237 0.0676134609 0.0679221982  
## [221] 0.0682309355 0.0685396727 0.0688484100 0.0691571473 0.0694658845  
## [226] 0.0697746218 0.0700833591 0.0703920963 0.0707008336 0.0710095709  
## [231] 0.0713183081 0.0716270454 0.0719357826 0.0722445199 0.0725532572  
## [236] 0.0728619944 0.0731707317 0.0734794690 0.0737882062 0.0740969435  
## [241] 0.0744056808 0.0747144180 0.0750231553 0.0753318926 0.0756406298  
## [246] 0.0759493671 0.0762581044 0.0765668416 0.0768755789 0.0771843161  
## [251] 0.0774930534 0.0778017907 0.0781105279 0.0784192652 0.0787280025  
## [256] 0.0790367397 0.0793454770 0.0796542143 0.0799629515 0.0802716888  
## [261] 0.0805804261 0.0808891633 0.0811979006 0.0815066379 0.0818153751  
## [266] 0.0821241124 0.0824328496 0.0827415869 0.0830503242 0.0833590614  
## [271] 0.0836677987 0.0839765360 0.0842852732 0.0845940105 0.0849027478  
## [276] 0.0852114850 0.0855202223 0.0858289596 0.0861376968 0.0864464341  
## [281] 0.0867551713 0.0870639086 0.0873726459 0.0876813831 0.0879901204  
## [286] 0.0882988577 0.0886075949 0.0889163322 0.0892250695 0.0895338067  
## [291] 0.0898425440 0.0901512813 0.0904600185 0.0907687558 0.0910774931  
## [296] 0.0913862303 0.0916949676 0.0920037048 0.0923124421 0.0926211794  
## [301] 0.0929299166 0.0932386539 0.0935473912 0.0938561284 0.0941648657  
## [306] 0.0944736030 0.0947823402 0.0950910775 0.0953998148 0.0957085520  
## [311] 0.0960172893 0.0963260266 0.0966347638 0.0969435011 0.0972522383  
## [316] 0.0975609756 0.0978697129 0.0981784501 0.0984871874 0.0987959247  
## [321] 0.0991046619 0.0994133992 0.0997221365 0.1000308737 0.1003396110  
## [326] 0.1006483483 0.1009570855 0.1012658228 0.1015745600 0.1018832973  
## [331] 0.1021920346 0.1025007718 0.1028095091 0.1031182464 0.1034269836  
## [336] 0.1037357209 0.1040444582 0.1043531954 0.1046619327 0.1049706700  
## [341] 0.1052794072 0.1055881445 0.1058968818 0.1062056190 0.1065143563  
## [346] 0.1068230935 0.1071318308 0.1074405681 0.1077493053 0.1080580426  
## [351] 0.1083667799 0.1086755171 0.1089842544 0.1092929917 0.1096017289  
## [356] 0.1099104662 0.1102192035 0.1105279407 0.1108366780 0.1111454153  
## [361] 0.1114541525 0.1117628898 0.1120716270 0.1123803643 0.1126891016  
## [366] 0.1129978388 0.1133065761 0.1136153134 0.1139240506 0.1142327879  
## [371] 0.1145415252 0.1148502624 0.1151589997 0.1154677370 0.1157764742  
## [376] 0.1160852115 0.1163939487 0.1167026860 0.1170114233 0.1173201605  
## [381] 0.1176288978 0.1179376351 0.1182463723 0.1185551096 0.1188638469  
## [386] 0.1191725841 0.1194813214 0.1197900587 0.1200987959 0.1204075332  
## [391] 0.1207162705 0.1210250077 0.1213337450 0.1216424822 0.1219512195  
## [396] 0.1222599568 0.1225686940 0.1228774313 0.1231861686 0.1234949058  
## [401] 0.1238036431 0.1241123804 0.1244211176 0.1247298549 0.1250385922  
## [406] 0.1253473294 0.1256560667 0.1259648040 0.1262735412 0.1265822785  
## [411] 0.1268910157 0.1271997530 0.1275084903 0.1278172275 0.1281259648  
## [416] 0.1284347021 0.1287434393 0.1290521766 0.1293609139 0.1296696511  
## [421] 0.1299783884 0.1302871257 0.1305958629 0.1309046002 0.1312133374  
## [426] 0.1315220747 0.1318308120 0.1321395492 0.1324482865 0.1327570238  
## [431] 0.1330657610 0.1333744983 0.1336832356 0.1339919728 0.1343007101  
## [436] 0.1346094474 0.1349181846 0.1352269219 0.1355356592 0.1358443964  
## [441] 0.1361531337 0.1364618709 0.1367706082 0.1370793455 0.1373880827  
## [446] 0.1376968200 0.1380055573 0.1383142945 0.1386230318 0.1389317691  
## [451] 0.1392405063 0.1395492436 0.1398579809 0.1401667181 0.1404754554  
## [456] 0.1407841927 0.1410929299 0.1414016672 0.1417104044 0.1420191417  
## [461] 0.1423278790 0.1426366162 0.1429453535 0.1432540908 0.1435628280  
## [466] 0.1438715653 0.1441803026 0.1444890398 0.1447977771 0.1451065144  
## [471] 0.1454152516 0.1457239889 0.1460327262 0.1463414634 0.1466502007  
## [476] 0.1469589379 0.1472676752 0.1475764125 0.1478851497 0.1481938870  
## [481] 0.1485026243 0.1488113615 0.1491200988 0.1494288361 0.1497375733  
## [486] 0.1500463106 0.1503550479 0.1506637851 0.1509725224 0.1512812596  
## [491] 0.1515899969 0.1518987342 0.1522074714 0.1525162087 0.1528249460  
## [496] 0.1531336832 0.1534424205 0.1537511578 0.1540598950 0.1543686323  
## [501] 0.1546773696 0.1549861068 0.1552948441 0.1556035814 0.1559123186  
## [506] 0.1562210559 0.1565297931 0.1568385304 0.1571472677 0.1574560049  
## [511] 0.1577647422 0.1580734795 0.1583822167 0.1586909540 0.1589996913  
## [516] 0.1593084285 0.1596171658 0.1599259031 0.1602346403 0.1605433776  
## [521] 0.1608521149 0.1611608521 0.1614695894 0.1617783266 0.1620870639  
## [526] 0.1623958012 0.1627045384 0.1630132757 0.1633220130 0.1636307502  
## [531] 0.1639394875 0.1642482248 0.1645569620 0.1648656993 0.1651744366  
## [536] 0.1654831738 0.1657919111 0.1661006483 0.1664093856 0.1667181229  
## [541] 0.1670268601 0.1673355974 0.1676443347 0.1679530719 0.1682618092  
## [546] 0.1685705465 0.1688792837 0.1691880210 0.1694967583 0.1698054955  
## [551] 0.1701142328 0.1704229701 0.1707317073 0.1710404446 0.1713491818  
## [556] 0.1716579191 0.1719666564 0.1722753936 0.1725841309 0.1728928682  
## [561] 0.1732016054 0.1735103427 0.1738190800 0.1741278172 0.1744365545  
## [566] 0.1747452918 0.1750540290 0.1753627663 0.1756715036 0.1759802408  
## [571] 0.1762889781 0.1765977153 0.1769064526 0.1772151899 0.1775239271  
## [576] 0.1778326644 0.1781414017 0.1784501389 0.1787588762 0.1790676135  
## [581] 0.1793763507 0.1796850880 0.1799938253 0.1803025625 0.1806112998  
## [586] 0.1809200370 0.1812287743 0.1815375116 0.1818462488 0.1821549861  
## [591] 0.1824637234 0.1827724606 0.1830811979 0.1833899352 0.1836986724  
## [596] 0.1840074097 0.1843161470 0.1846248842 0.1849336215 0.1852423588  
## [601] 0.1855510960 0.1858598333 0.1861685705 0.1864773078 0.1867860451  
## [606] 0.1870947823 0.1874035196 0.1877122569 0.1880209941 0.1883297314  
## [611] 0.1886384687 0.1889472059 0.1892559432 0.1895646805 0.1898734177  
## [616] 0.1901821550 0.1904908923 0.1907996295 0.1911083668 0.1914171040  
## [621] 0.1917258413 0.1920345786 0.1923433158 0.1926520531 0.1929607904  
## [626] 0.1932695276 0.1935782649 0.1938870022 0.1941957394 0.1945044767  
## [631] 0.1948132140 0.1951219512 0.1954306885 0.1957394257 0.1960481630  
## [636] 0.1963569003 0.1966656375 0.1969743748 0.1972831121 0.1975918493  
## [641] 0.1979005866 0.1982093239 0.1985180611 0.1988267984 0.1991355357  
## [646] 0.1994442729 0.1997530102 0.2000617475 0.2003704847 0.2006792220  
## [651] 0.2009879592 0.2012966965 0.2016054338 0.2019141710 0.2022229083  
## [656] 0.2025316456 0.2028403828 0.2031491201 0.2034578574 0.2037665946  
## [661] 0.2040753319 0.2043840692 0.2046928064 0.2050015437 0.2053102810  
## [666] 0.2056190182 0.2059277555 0.2062364927 0.2065452300 0.2068539673  
## [671] 0.2071627045 0.2074714418 0.2077801791 0.2080889163 0.2083976536  
## [676] 0.2087063909 0.2090151281 0.2093238654 0.2096326027 0.2099413399  
## [681] 0.2102500772 0.2105588144 0.2108675517 0.2111762890 0.2114850262  
## [686] 0.2117937635 0.2121025008 0.2124112380 0.2127199753 0.2130287126  
## [691] 0.2133374498 0.2136461871 0.2139549244 0.2142636616 0.2145723989  
## [696] 0.2148811362 0.2151898734 0.2154986107 0.2158073479 0.2161160852  
## [701] 0.2164248225 0.2167335597 0.2170422970 0.2173510343 0.2176597715  
## [706] 0.2179685088 0.2182772461 0.2185859833 0.2188947206 0.2192034579  
## [711] 0.2195121951 0.2198209324 0.2201296697 0.2204384069 0.2207471442  
## [716] 0.2210558814 0.2213646187 0.2216733560 0.2219820932 0.2222908305  
## [721] 0.2225995678 0.2229083050 0.2232170423 0.2235257796 0.2238345168  
## [726] 0.2241432541 0.2244519914 0.2247607286 0.2250694659 0.2253782031  
## [731] 0.2256869404 0.2259956777 0.2263044149 0.2266131522 0.2269218895  
## [736] 0.2272306267 0.2275393640 0.2278481013 0.2281568385 0.2284655758  
## [741] 0.2287743131 0.2290830503 0.2293917876 0.2297005249 0.2300092621  
## [746] 0.2303179994 0.2306267366 0.2309354739 0.2312442112 0.2315529484  
## [751] 0.2318616857 0.2321704230 0.2324791602 0.2327878975 0.2330966348  
## [756] 0.2334053720 0.2337141093 0.2340228466 0.2343315838 0.2346403211  
## [761] 0.2349490584 0.2352577956 0.2355665329 0.2358752701 0.2361840074  
## [766] 0.2364927447 0.2368014819 0.2371102192 0.2374189565 0.2377276937  
## [771] 0.2380364310 0.2383451683 0.2386539055 0.2389626428 0.2392713801  
## [776] 0.2395801173 0.2398888546 0.2401975918 0.2405063291 0.2408150664  
## [781] 0.2411238036 0.2414325409 0.2417412782 0.2420500154 0.2423587527  
## [786] 0.2426674900 0.2429762272 0.2432849645 0.2435937018 0.2439024390  
## [791] 0.2442111763 0.2445199136 0.2448286508 0.2451373881 0.2454461253  
## [796] 0.2457548626 0.2460635999 0.2463723371 0.2466810744 0.2469898117  
## [801] 0.2472985489 0.2476072862 0.2479160235 0.2482247607 0.2485334980  
## [806] 0.2488422353 0.2491509725 0.2494597098 0.2497684471 0.2500771843  
## [811] 0.2503859216 0.2506946588 0.2510033961 0.2513121334 0.2516208706  
## [816] 0.2519296079 0.2522383452 0.2525470824 0.2528558197 0.2531645570  
## [821] 0.2534732942 0.2537820315 0.2540907688 0.2543995060 0.2547082433  
## [826] 0.2550169805 0.2553257178 0.2556344551 0.2559431923 0.2562519296  
## [831] 0.2565606669 0.2568694041 0.2571781414 0.2574868787 0.2577956159  
## [836] 0.2581043532 0.2584130905 0.2587218277 0.2590305650 0.2593393023  
## [841] 0.2596480395 0.2599567768 0.2602655140 0.2605742513 0.2608829886  
## [846] 0.2611917258 0.2615004631 0.2618092004 0.2621179376 0.2624266749  
## [851] 0.2627354122 0.2630441494 0.2633528867 0.2636616240 0.2639703612  
## [856] 0.2642790985 0.2645878358 0.2648965730 0.2652053103 0.2655140475  
## [861] 0.2658227848 0.2661315221 0.2664402593 0.2667489966 0.2670577339  
## [866] 0.2673664711 0.2676752084 0.2679839457 0.2682926829 0.2686014202  
## [871] 0.2689101575 0.2692188947 0.2695276320 0.2698363692 0.2701451065  
## [876] 0.2704538438 0.2707625810 0.2710713183 0.2713800556 0.2716887928  
## [881] 0.2719975301 0.2723062674 0.2726150046 0.2729237419 0.2732324792  
## [886] 0.2735412164 0.2738499537 0.2741586910 0.2744674282 0.2747761655  
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## [517] 2.690976e+00 2.645917e+00 2.599535e+00 2.551922e+00  
## [521] 2.503155e+00 2.453307e+00 2.402438e+00 2.350602e+00  
## [525] 2.297843e+00 2.244197e+00 2.189695e+00 2.134358e+00  
## [529] 2.078206e+00 2.021250e+00 1.963502e+00 1.904970e+00  
## [533] 1.845663e+00 1.785588e+00 1.724757e+00 1.663181e+00  
## [537] 1.600877e+00 1.537868e+00 1.474177e+00 1.409837e+00  
## [541] 1.344886e+00 1.279365e+00 1.213324e+00 1.146815e+00  
## [545] 1.079898e+00 1.012634e+00 9.450875e-01 8.773249e-01  
## [549] 8.094128e-01 7.414165e-01 6.733988e-01 6.054183e-01  
## [553] 5.375278e-01 4.697731e-01 4.021912e-01 3.348094e-01  
## [557] 2.676438e-01 2.006989e-01 1.339662e-01 6.742446e-02  
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## [621] -6.362614e+00 -6.550200e+00 -6.742644e+00 -6.939917e+00  
## [625] -7.141938e+00 -7.348571e+00 -7.559612e+00 -7.774785e+00  
## [629] -7.993727e+00 -8.215980e+00 -8.440976e+00 -8.668024e+00  
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## [717] -3.105006e-02 5.517560e-02 1.391365e-01 2.208596e-01  
## [721] 3.003811e-01 3.777453e-01 4.530045e-01 5.262180e-01  
## [725] 5.974513e-01 6.667747e-01 7.342622e-01 7.999900e-01  
## [729] 8.640353e-01 9.264742e-01 9.873806e-01 1.046825e+00  
## [733] 1.104872e+00 1.161579e+00 1.216999e+00 1.271172e+00  
## [737] 1.324132e+00 1.375900e+00 1.426489e+00 1.475902e+00  
## [741] 1.524129e+00 1.571154e+00 1.616951e+00 1.661487e+00  
## [745] 1.704722e+00 1.746612e+00 1.787110e+00 1.826170e+00  
## [749] 1.863745e+00 1.899793e+00 1.934275e+00 1.967163e+00  
## [753] 1.998435e+00 2.028084e+00 2.056113e+00 2.082543e+00  
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## [765] 2.260339e+00 2.275720e+00 2.290856e+00 2.305953e+00  
## [769] 2.321217e+00 2.336852e+00 2.353059e+00 2.370027e+00  
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## [777] 2.471687e+00 2.496109e+00 2.521991e+00 2.549302e+00  
## [781] 2.577975e+00 2.607904e+00 2.638948e+00 2.670930e+00  
## [785] 2.703642e+00 2.736848e+00 2.770287e+00 2.803677e+00  
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## [793] 2.959222e+00 2.985873e+00 3.010335e+00 3.032334e+00  
## [797] 3.051616e+00 3.067947e+00 3.081123e+00 3.090963e+00  
## [801] 3.097322e+00 3.100083e+00 3.099166e+00 3.094524e+00  
## [805] 3.086148e+00 3.074065e+00 3.058340e+00 3.039076e+00  
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## [821] 2.577341e+00 2.537966e+00 2.500108e+00 2.464167e+00  
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## [873] 2.171525e+00 2.115424e+00 2.055642e+00 1.992196e+00  
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## [881] 1.620872e+00 1.536010e+00 1.447703e+00 1.355991e+00  
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## [889] 8.478694e-01 7.366343e-01 6.222934e-01 5.048858e-01  
## [893] 3.844487e-01 2.610173e-01 1.346243e-01 5.299990e-03  
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## [925] -4.893020e+00 -5.093442e+00 -5.295090e+00 -5.497882e+00  
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## [1317] -1.034472e+01 -1.011752e+01 -9.893118e+00 -9.671699e+00  
## [1321] -9.453400e+00 -9.238305e+00 -9.026458e+00 -8.817863e+00  
## [1325] -8.612492e+00 -8.410287e+00 -8.211165e+00 -8.015018e+00  
## [1329] -7.821720e+00 -7.631127e+00 -7.443080e+00 -7.257407e+00  
## [1333] -7.073929e+00 -6.892459e+00 -6.712807e+00 -6.534782e+00  
## [1337] -6.358195e+00 -6.182863e+00 -6.008611e+00 -5.835273e+00  
## [1341] -5.662701e+00 -5.490758e+00 -5.319329e+00 -5.148317e+00  
## [1345] -4.977648e+00 -4.807270e+00 -4.637155e+00 -4.467298e+00  
## [1349] -4.297717e+00 -4.128455e+00 -3.959575e+00 -3.791160e+00  
## [1353] -3.623312e+00 -3.456150e+00 -3.289807e+00 -3.124426e+00  
## [1357] -2.960162e+00 -2.797174e+00 -2.635627e+00 -2.475686e+00  
## [1361] -2.317518e+00 -2.161286e+00 -2.007146e+00 -1.855252e+00  
## [1365] -1.705746e+00 -1.558764e+00 -1.414429e+00 -1.272855e+00  
## [1369] -1.134143e+00 -9.983815e-01 -8.656485e-01 -7.360080e-01  
## [1373] -6.095122e-01 -4.862014e-01 -3.661044e-01 -2.492392e-01  
## [1377] -1.356132e-01 -2.522452e-02 8.193743e-02 1.858912e-01  
## [1381] 2.866621e-01 3.842817e-01 4.787863e-01 5.702164e-01  
## [1385] 6.586157e-01 7.440301e-01 8.265068e-01 9.060937e-01  
## [1389] 9.828386e-01 1.056788e+00 1.127989e+00 1.196483e+00  
## [1393] 1.262314e+00 1.325520e+00 1.386138e+00 1.444203e+00  
## [1397] 1.499747e+00 1.552799e+00 1.603388e+00 1.651541e+00  
## [1401] 1.697283e+00 1.740641e+00 1.781640e+00 1.820307e+00  
## [1405] 1.856673e+00 1.890769e+00 1.922629e+00 1.952294e+00  
## [1409] 1.979807e+00 2.005217e+00 2.028579e+00 2.049955e+00  
## [1413] 2.069412e+00 2.087024e+00 2.102872e+00 2.117041e+00  
## [1417] 2.129626e+00 2.140722e+00 2.150433e+00 2.158864e+00  
## [1421] 2.166122e+00 2.172316e+00 2.177556e+00 2.181946e+00  
## [1425] 2.185590e+00 2.188585e+00 2.191021e+00 2.192980e+00  
## [1429] 2.194533e+00 2.195739e+00 2.196644e+00 2.197281e+00  
## [1433] 2.197667e+00 2.197803e+00 2.197677e+00 2.197257e+00  
## [1437] 2.196501e+00 2.195349e+00 2.193729e+00 2.191560e+00  
## [1441] 2.188747e+00 2.185191e+00 2.180785e+00 2.175421e+00  
## [1445] 2.168991e+00 2.161388e+00 2.152510e+00 2.142266e+00  
## [1449] 2.130572e+00 2.117360e+00 2.102578e+00 2.086191e+00  
## [1453] 2.068186e+00 2.048572e+00 2.027383e+00 2.004678e+00  
## [1457] 1.980544e+00 1.955095e+00 1.928474e+00 1.900850e+00  
## [1461] 1.872422e+00 1.843413e+00 1.814072e+00 1.784669e+00  
## [1465] 1.755493e+00 1.726851e+00 1.699060e+00 1.672444e+00  
## [1469] 1.647329e+00 1.624036e+00 1.602879e+00 1.584153e+00  
## [1473] 1.568133e+00 1.555064e+00 1.545160e+00 1.538593e+00  
## [1477] 1.535494e+00 1.535948e+00 1.539990e+00 1.547605e+00  
## [1481] 1.558727e+00 1.573243e+00 1.590991e+00 1.611765e+00  
## [1485] 1.635320e+00 1.661375e+00 1.689619e+00 1.719716e+00  
## [1489] 1.751313e+00 1.784042e+00 1.817527e+00 1.851392e+00  
## [1493] 1.885260e+00 1.918763e+00 1.951543e+00 1.983256e+00  
## [1497] 2.013572e+00 2.042183e+00 2.068799e+00 2.093155e+00  
## [1501] 2.115004e+00 2.134126e+00 2.150323e+00 2.163423e+00  
## [1505] 2.173273e+00 2.179746e+00 2.182739e+00 2.182168e+00  
## [1509] 2.177971e+00 2.170108e+00 2.158557e+00 2.143316e+00  
## [1513] 2.124400e+00 2.101842e+00 2.075689e+00 2.046004e+00  
## [1517] 2.012863e+00 1.976354e+00 1.936577e+00 1.893640e+00  
## [1521] 1.847659e+00 1.798758e+00 1.747062e+00 1.692704e+00  
## [1525] 1.635812e+00 1.576516e+00 1.514944e+00 1.451216e+00  
## [1529] 1.385446e+00 1.317739e+00 1.248188e+00 1.176874e+00  
## [1533] 1.103862e+00 1.029202e+00 9.529250e-01 8.750443e-01  
## [1537] 7.955537e-01 7.144270e-01 6.316183e-01 5.470617e-01  
## [1541] 4.606724e-01 3.723473e-01 2.819661e-01 1.893931e-01  
## [1545] 9.447892e-02 -2.937719e-03 -1.030276e-01 -2.059687e-01  
## [1549] -3.119438e-01 -4.211376e-01 -5.337348e-01 -6.499169e-01  
## [1553] -7.698597e-01 -8.937311e-01 -1.021688e+00 -1.153876e+00  
## [1557] -1.290424e+00 -1.431445e+00 -1.577031e+00 -1.727255e+00  
## [1561] -1.882168e+00 -2.041795e+00 -2.206138e+00 -2.375174e+00  
## [1565] -2.548849e+00 -2.727087e+00 -2.909781e+00 -3.096800e+00  
## [1569] -3.287985e+00 -3.483152e+00 -3.682093e+00 -3.884578e+00  
## [1573] -4.090358e+00 -4.299165e+00 -4.510721e+00 -4.724735e+00  
## [1577] -4.940913e+00 -5.158958e+00 -5.378579e+00 -5.599493e+00  
## [1581] -5.821429e+00 -6.044138e+00 -6.267391e+00 -6.490986e+00  
## [1585] -6.714753e+00 -6.938552e+00 -7.162276e+00 -7.385852e+00  
## [1589] -7.609238e+00 -7.832420e+00 -8.055409e+00 -8.278234e+00  
## [1593] -8.500934e+00 -8.723552e+00 -8.946124e+00 -9.168665e+00  
## [1597] -9.391164e+00 -9.613564e+00 -9.835750e+00 -1.005754e+01  
## [1601] -1.027866e+01 -1.049873e+01 -1.071728e+01 -1.093367e+01  
## [1605] -1.114715e+01 -1.135679e+01 -1.156153e+01 -1.176011e+01  
## [1609] -1.195112e+01 -1.213301e+01 -1.230410e+01 -1.246258e+01  
## [1613] -1.260663e+01 -1.273439e+01 -1.284410e+01 -1.293410e+01  
## [1617] -1.300297e+01 -1.304955e+01 -1.307305e+01

## Best Model

The best model appars to be the 212 model. It has the lowest ASE, and the forecasts seem to track the actual data.

## Accuspike data

spike = read.csv("accuspike.csv")  
plotts.sample.wge(spike$Active.Users)



## $autplt  
## [1] 1.00000000 0.62988010 0.32605516 0.11724172 0.05853230  
## [6] 0.09502224 0.26720075 0.32572460 0.20160161 -0.05589477  
## [11] -0.20965996 -0.22547446 -0.06329814 0.09792376 0.19963264  
## [16] 0.10497351 -0.05600133 -0.16683179 -0.19080221 -0.07439083  
## [21] 0.13842523 0.21987990 0.11138830 -0.03782526 -0.16355361  
## [26] -0.15822851  
##   
## $freq  
## [1] 0.005208333 0.010416667 0.015625000 0.020833333 0.026041667  
## [6] 0.031250000 0.036458333 0.041666667 0.046875000 0.052083333  
## [11] 0.057291667 0.062500000 0.067708333 0.072916667 0.078125000  
## [16] 0.083333333 0.088541667 0.093750000 0.098958333 0.104166667  
## [21] 0.109375000 0.114583333 0.119791667 0.125000000 0.130208333  
## [26] 0.135416667 0.140625000 0.145833333 0.151041667 0.156250000  
## [31] 0.161458333 0.166666667 0.171875000 0.177083333 0.182291667  
## [36] 0.187500000 0.192708333 0.197916667 0.203125000 0.208333333  
## [41] 0.213541667 0.218750000 0.223958333 0.229166667 0.234375000  
## [46] 0.239583333 0.244791667 0.250000000 0.255208333 0.260416667  
## [51] 0.265625000 0.270833333 0.276041667 0.281250000 0.286458333  
## [56] 0.291666667 0.296875000 0.302083333 0.307291667 0.312500000  
## [61] 0.317708333 0.322916667 0.328125000 0.333333333 0.338541667  
## [66] 0.343750000 0.348958333 0.354166667 0.359375000 0.364583333  
## [71] 0.369791667 0.375000000 0.380208333 0.385416667 0.390625000  
## [76] 0.395833333 0.401041667 0.406250000 0.411458333 0.416666667  
## [81] 0.421875000 0.427083333 0.432291667 0.437500000 0.442708333  
## [86] 0.447916667 0.453125000 0.458333333 0.463541667 0.468750000  
## [91] 0.473958333 0.479166667 0.484375000 0.489583333 0.494791667  
## [96] 0.500000000  
##   
## $db  
## [1] 9.7125013 -8.2901601 -1.9027817 9.1597083 2.1242776  
## [6] 8.0361675 6.5611026 2.4266679 3.8098512 5.4996716  
## [11] -0.2386696 5.3518919 0.1751288 1.5203398 -2.8131904  
## [16] 1.6063926 2.2702643 -5.0597089 -4.4950068 -9.4023847  
## [21] 2.9510867 -1.9692244 -7.2386190 1.6298642 -2.6120875  
## [26] 5.6863585 9.8631290 8.7040828 -1.3850615 -6.9853967  
## [31] -8.5542331 2.3976711 -3.3000940 -5.5873976 -7.7990567  
## [36] -3.1684640 -14.2249051 -3.6804092 -7.2406967 -11.4643390  
## [41] -4.4521206 -10.9215764 -14.9849255 -5.4468605 -4.9309040  
## [46] -6.9952894 1.8796557 -9.8770830 -11.7399969 -3.6387029  
## [51] -13.2524801 -6.6931188 -3.8283512 -12.5481549 2.3208150  
## [56] -4.0117239 -6.0428133 -5.2938877 -0.7221650 -7.0275737  
## [61] -9.5462419 -5.0769525 -8.2391783 -13.0960683 -6.4700303  
## [66] -3.2632472 -2.6347648 -2.0804722 -13.8844508 -13.0915534  
## [71] -19.7400776 -8.7445985 -7.9198822 -2.9083918 -14.7090887  
## [76] -5.2362806 -16.5397723 -4.4323766 -12.2573115 -13.5021199  
## [81] -8.0775849 -2.3429494 -12.8199333 -10.4579626 -10.3791220  
## [86] -13.0109108 -12.5036575 -4.9969825 -22.1032416 -6.0409170  
## [91] -3.3915084 -14.0340040 -2.7949945 -10.3137926 -2.3418252  
## [96] -4.7929936  
##   
## $dbz  
## [1] 6.12076226 6.07080618 5.98511460 5.86015772 5.69130845  
## [6] 5.47329586 5.20088985 4.86977434 4.47749461 4.02430968  
## [11] 3.51377761 2.95302261 2.35299670 1.72973557 1.10839279  
## [16] 0.53165344 0.07038178 -0.17591721 -0.11067735 0.29715040  
## [21] 0.97706979 1.79380733 2.61292466 3.33599883 3.90203725  
## [26] 4.27638688 4.44007372 4.38277252 4.09897516 3.58647634  
## [31] 2.84674252 1.88733715 0.72719601 -0.59408763 -2.00296944  
## [36] -3.38066425 -4.57271140 -5.44047377 -5.93004521 -6.08531241  
## [41] -5.99493254 -5.74365425 -5.40114543 -5.02644344 -4.66829619  
## [46] -4.36093332 -4.12095078 -3.94803901 -3.82939185 -3.74674768  
## [51] -3.68446225 -3.63610293 -3.60693833 -3.61143414 -3.66738021  
## [56] -3.78939147 -3.98373438 -4.24513302 -4.55573461 -4.88687917  
## [61] -5.20477445 -5.48012633 -5.69861958 -5.86641276 -6.00672446  
## [66] -6.14952595 -6.32011197 -6.53088413 -6.77746637 -7.03891986  
## [71] -7.28235303 -7.47237649 -7.58357313 -7.61040192 -7.56857099  
## [76] -7.48747920 -7.39937856 -7.33116049 -7.30065807 -7.31609656  
## [81] -7.37657623 -7.47220969 -7.58368753 -7.68226217 -7.73219567  
## [86] -7.69772874 -7.55417007 -7.29820167 -6.95057361 -6.54911483  
## [91] -6.13709130 -5.75362227 -5.42907021 -5.18449679 -5.03307944  
## [96] -4.98187304

aic5.wge(spike$Active.Users)

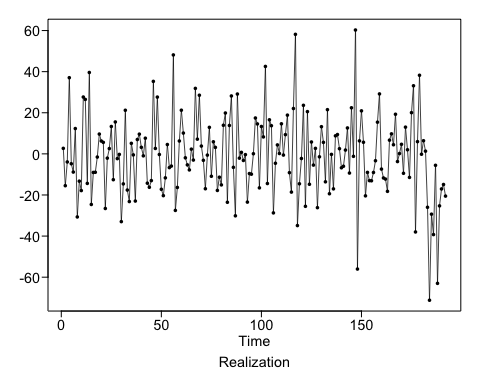
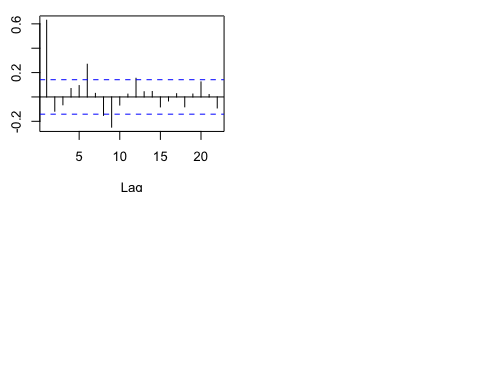
## ---------WORKING... PLEASE WAIT...   
##   
##   
## Five Smallest Values of aic

## p q aic  
## 17 5 1 6.009981  
## 14 4 1 6.019087  
## 7 2 0 6.039300  
## 4 1 0 6.040475  
## 5 1 1 6.041323

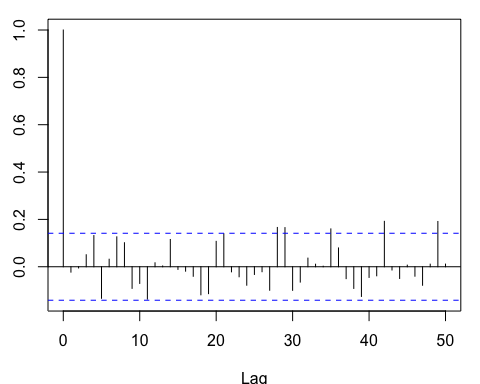
pacf(spike$Active.Users)  
model = est.arma.wge(spike$Active.Users,p=5,q=1)

##   
## Coefficients of Original polynomial:   
## 1.2086 -0.3977 -0.0670 0.0240 0.1627   
##   
## Factor Roots Abs Recip System Freq   
## 1-0.9451B 1.0581 0.9451 0.0000  
## 1-1.0136B+0.6400B^2 0.7919+-0.9672i 0.8000 0.1408  
## 1+0.7501B+0.2689B^2 -1.3946+-1.3318i 0.5186 0.3787  
##   
##

plotts.wge(model$res)



acf(model$res,lag.max = 50)

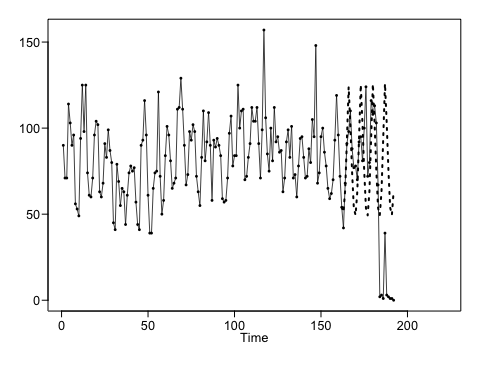


ljung.wge(model$res)

## Obs -0.02273884 -0.005086344 0.05066221 0.1317686 -0.133232 0.03180593 0.1263324 0.1014284 -0.09128505 -0.07043315 -0.1367051 0.01670384 0.003312508 0.1151697 -0.01113439 -0.01870592 -0.04025088 -0.1185883 -0.1136132 0.1072787 0.1394619 -0.02149607 -0.04236373 -0.07795571

## $test  
## [1] "Ljung-Box test"  
##   
## $K  
## [1] 24  
##   
## $chi.square  
## [1] 37.2867  
##   
## $df  
## [1] 24  
##   
## $pval  
## [1] 0.04096048

fore.aruma.wge(spike$Active.Users,phi = model$phi,theta = model$theta,s=7,lastn = TRUE,n.ahead=30, limits = FALSE)



## $f  
## [1] 51.18201 64.24432 93.77643 123.97063 101.01155 74.13056 53.33145  
## [8] 49.43651 63.18656 94.10322 125.23367 102.32835 74.88858 53.47510  
## [15] 49.30392 63.15543 94.34106 125.66913 102.78233 75.22584 53.67364  
## [22] 49.42847 63.28613 94.51813 125.88243 102.99624 75.41107 53.82367  
## [29] 49.55572 63.40767  
##   
## $ll  
## [1] 1.482693 4.132311 30.067614 59.666534 36.698315  
## [6] 9.597624 -12.204248 -42.835651 -41.195910 -15.277784  
## [11] 14.556648 -8.606391 -36.689452 -59.716597 -85.480618  
## [16] -83.085011 -57.196341 -27.594358 -51.029758 -79.541387  
## [21] -102.979164 -125.702774 -122.374860 -96.344328 -66.894823  
## [26] -90.515854 -119.219297 -142.775137 -163.333041 -159.136181  
##   
## $ul  
## [1] 100.8813 124.3563 157.4852 188.2747 165.3248 138.6635 118.8671  
## [8] 141.7087 167.5690 203.4842 235.9107 213.2631 186.4666 166.6668  
## [15] 184.0885 209.3959 245.8785 278.9326 256.5944 229.9931 210.3265  
## [22] 224.5597 248.9471 285.3806 318.6597 296.5083 270.0414 250.4225  
## [29] 262.4445 285.9515  
##   
## $resid  
## [1] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [6] 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000  
## [11] 0.0000000 0.0000000 -22.0542828 18.5468095 1.4602436  
## [16] 1.8110937 7.6181727 -29.8799986 -17.2235369 20.4219065  
## [21] -34.1027757 -2.0097916 6.9244111 11.5244980 14.8595874  
## [26] -22.2035319 9.2863427 -7.9114250 26.3102119 -30.8905158  
## [31] -17.1972768 7.8944576 -5.0366749 -38.7262688 7.4384368  
## [36] -0.2381643 10.0118896 21.5948997 -11.6170765 20.7794987  
## [41] 22.2388388 2.5023900 -13.7582179 6.6936070 -19.9901724  
## [46] 25.6701757 -0.5400717 28.5852434 -7.9370677 -2.9763762  
## [51] -4.0667018 1.3353997 -30.7225031 -9.3297315 -33.5716147  
## [56] 48.4503936 -10.2758833 3.9957873 17.9383690 16.6929417  
## [61] 16.8166163 4.0262225 -53.4885149 19.7043208 18.6294434  
## [66] -9.2724635 10.6229965 -2.9712285 30.4513182 9.1443855  
## [71] 4.6708149 -19.2625012 2.4049773 -18.9571281 -18.0523190  
## [76] -22.6506015 -0.6441821 -14.6522304 5.6070875 -14.4951155  
## [81] 1.0054234 30.7798428 -29.4349446 10.6708341 45.9626470  
## [86] 4.7997156 -15.0461032 15.2019685 -21.9657598 24.2900643  
## [91] -17.0268674 -28.5408249 -16.9085642 20.5633144 -38.9989028  
## [96] 2.1519435 16.7150638 17.7672723 -16.1720651 36.7955003  
## [101] 17.8292948 52.4303276 -14.4911634 -0.8737424 -0.8668409  
## [106] -12.1780395 -17.8958127 -3.8919711 -42.3656705 29.0540177  
## [111] -17.1558465 -4.3393322 47.5633788 -4.5804010 -22.9568436  
## [116] 21.8898195 43.5257437 -34.3054474 -23.9089085 -21.0962531  
## [121] 32.7726626 -6.9210305 -1.5104413 -72.9524288 40.6668009  
## [126] 9.0926094 4.9280948 -49.7954987 24.0913357 -7.3341445  
## [131] 20.3926953 -19.3769457 26.9704984 -22.0801987 25.9215220  
## [136] -15.6032491 -4.4496453 3.8088384 16.1133686 -28.2808751  
## [141] 13.3786920 2.1092176 29.6427994 -18.1011457 13.0177030  
## [146] -3.7238370 67.0329608 -50.0169020 4.4668944 8.3132901  
## [151] 14.9672592 -42.8492896 -7.8075511 -73.2875692 42.9509266  
## [156] -15.3797208 -24.2605602 9.7801166 49.5968327 1.6073533  
## [161] 1.3003294 0.8294825 -9.1820071 10.0029813 -5.6834020  
## [166] -24.7384589 26.6768170 7.9864376 12.4153926 22.8895929  
## [171] -16.1202987 3.2641962 -2.4318840 -30.7313050 23.7868814  
## [176] 32.9782394 -42.6453043 15.4039722 25.2417483 -2.1769401  
## [181] 17.8513832 -18.7322214 -59.1256629 -33.2200953 -35.2943706  
## [186] -77.5135872 -5.3865848 -69.3933693 -26.6191170 8.9225992  
## [191] 56.3068487 8.7992563  
##   
## $wnv  
## [1] 642.9669  
##   
## $se  
## [1] 25.35679 30.66939 32.50450 32.80821 32.81288 32.92497 33.43658  
## [8] 47.07763 53.25636 55.80663 56.46787 56.59936 56.92757 57.75087  
## [15] 68.76762 74.61247 77.31500 78.19566 78.47556 78.96287 79.92490  
## [22] 89.35268 94.72500 97.37881 98.35574 98.73066 99.30121 100.30551  
## [29] 108.61671 113.54278  
##   
## $psi  
## [1] 0.68038496 0.42462446 0.17564538 0.02182089 0.10705244 0.22979206  
## [7] 1.30697091 0.98192730 0.65771459 0.33980051 0.15206252 0.24072917  
## [13] 0.38320025 1.47234473 1.14165978 0.79911491 0.46151851 0.26115719  
## [19] 0.34543360 0.48757991 1.57546951 1.24018697 0.89044771 0.54534675  
## [25] 0.33900158 0.41919789 0.55837502 1.64334929 1.30463322 0.95103133  
##   
## $ptot  
## [1] 12  
##   
## $phitot  
## [1] 1.20859469 -0.39768520 -0.06697446 0.02397209 0.16266014  
## [6] 0.00000000 1.00000000 -1.20859469 0.39768520 0.06697446  
## [11] -0.02397209 -0.16266014