Import Data - ACF - PACF

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Setting R code chunk options

The first R code chunk is named **setup**. Here we are setting the options for R code chunks. The choice echo=TRUE means both code and output will appear on report. If for a specific chunk you want different options, you can always change that on the first line as we did in the following chunk. We chose include=FALSE which means that nothing related to this chunk (code and output) will appear on the knitted file.

Loading packages and initializing

It's useful to designate one code chunk to load packages on the beginning of the file. You can always add to this chunk as needed. But concentrate the packages needed on only one chunk.

Importing data

For this first example we will import water inflow data for reservoirs in Brazil. We have data for 15 different reservoirs spread all over the country. To import a .txt, .csv or .xlsx file you can use the function *read.table()*. This function will store the data as a data frame and has useful inputs such as

- *file =* : use this input to point to yoru data file. If it's on the same folder as your .Rmd then you only need to write the file name. But if it's on another folder you need to point to the path were file is located;
- *header =* : if your file has a header you should set this to TRUE, o.w. FALSE;
- *skip =* : if your file has rows explaining the data or any other rows on the top that need to be skipped you should just set skip to be equal to the number of row that should be skipped before reading the data. Mote that if header=TRUE, you should not skip the row with the header. The defaul is *skip=0*;
- *dec =* : define *dec="."* or *dec=","* depending on how it's defined on your set. The default is ".".

```
#Importing time series data from text file
#I am calling it raw for now because it's data as it is in the file
raw_inflow_data <- read.table(file="/Users/nickvalby/TSA 2021/ENV790_30_TSA_S2021/Data/inflowtimeseries

#Show alternative way of doing it with relative path
#raw_inflow_data <- read.table(file="../Data/inflowtimeseries.txt",header=FALSE,skip=0)

#If you want specific columns just trim the table
raw_inflow_data <- raw_inflow_data[,1:5] #the space before the comma means you want all rows
                                #and 1:5 means all columns from 1 to 5
nhydro <- ncol(raw_inflow_data)-2 #remove date info
nobs <- nrow(raw_inflow_data)

#If your file does not have header like this one you can add column names after creating the data frame
colnames(raw_inflow_data)=c("Month","Year", "HP1", "HP2","HP3")
```

```
#Checking data
head(raw_inflow_data)
```

```
##   Month Year  HP1  HP2  HP3
## 1   Jan 1931 4782 4076 2518
## 2   Feb 1931 7323 7681 4188
## 3   Mar 1931 8266 5921 3253
## 4   Apr 1931 6247 4600 2449
## 5   May 1931 3642 2789 1651
## 6   Jun 1931 2425 2062 1270
```

```
str(raw_inflow_data)
```

```
## 'data.frame':    972 obs. of  5 variables:
##  $ Month: chr  "Jan" "Feb" "Mar" "Apr" ...
##  $ Year : int  1931 1931 1931 1931 1931 1931 1931 1931 1931 1931 ...
##  $ HP1  : int  4782 7323 8266 6247 3642 2425 2158 1854 1839 1896 ...
##  $ HP2  : int  4076 7681 5921 4600 2789 2062 1644 1301 1439 1340 ...
##  $ HP3  : int  2518 4188 3253 2449 1651 1270 1204 1152 1297 1259 ...
```

Date or time period

The data sets we will work with will be index by time, remember we are doing TIME series analysis. After importing your data set make sure that you have your dates right. For this specific inflow file our date is spread in two different columns. The first one is the month and the second the year. The best package to handle date conversion in R is lubridate. Let's see how we can use lubridate functions to combine those two columns into one date object. Note that this is only one example for our particular data set, for more info on lubridate function refer to tho this file file also available on our Sakai lessons page for M3.

```
#using package lubridate
my_date <- paste(raw_inflow_data[,1],raw_inflow_data[,2],sep="-")
my_date <- my(my_date)  #function my from package lubridate
head(my_date)
```

```
## [1] "1931-01-01" "1931-02-01" "1931-03-01" "1931-04-01" "1931-05-01"
## [6] "1931-06-01"
```

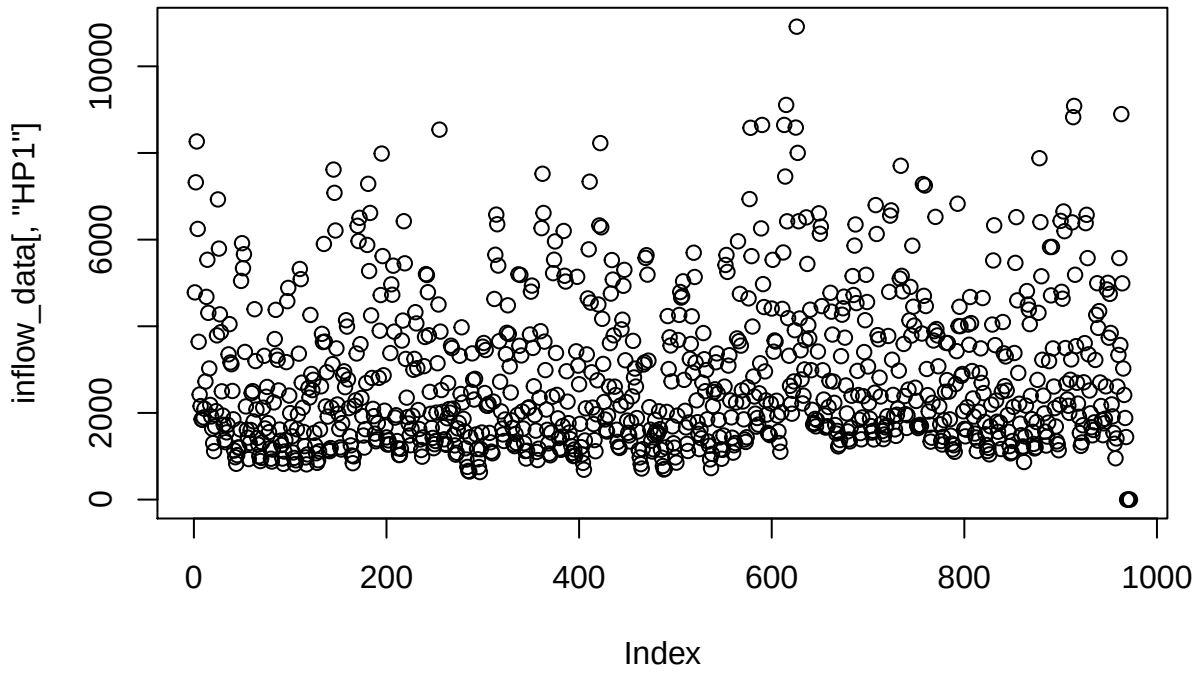
```
#add that to inflow_data
inflow_data <- cbind(my_date,raw_inflow_data[,3:5])
head(inflow_data)
```

```
##      my_date  HP1  HP2  HP3
## 1 1931-01-01 4782 4076 2518
## 2 1931-02-01 7323 7681 4188
## 3 1931-03-01 8266 5921 3253
## 4 1931-04-01 6247 4600 2449
## 5 1931-05-01 3642 2789 1651
## 6 1931-06-01 2425 2062 1270
```

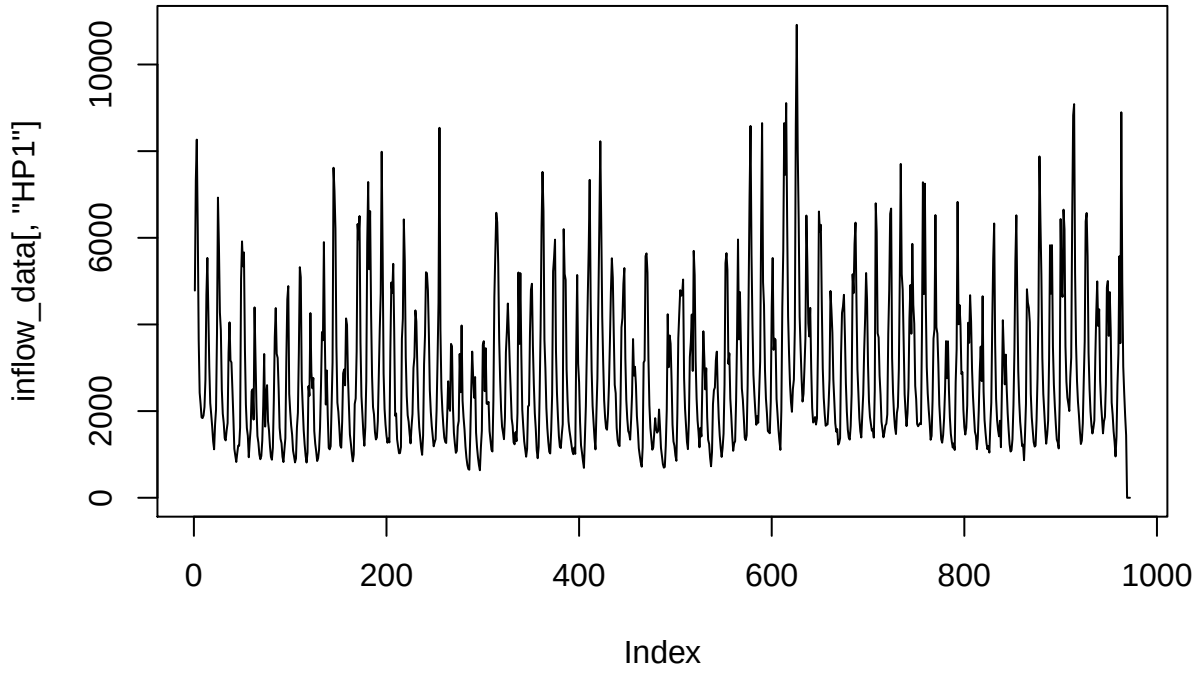
Initial plots with plot() function

A plot of observed values over time is the first you do to start understanding the data set. The default packages on R offer the function *plot()*.

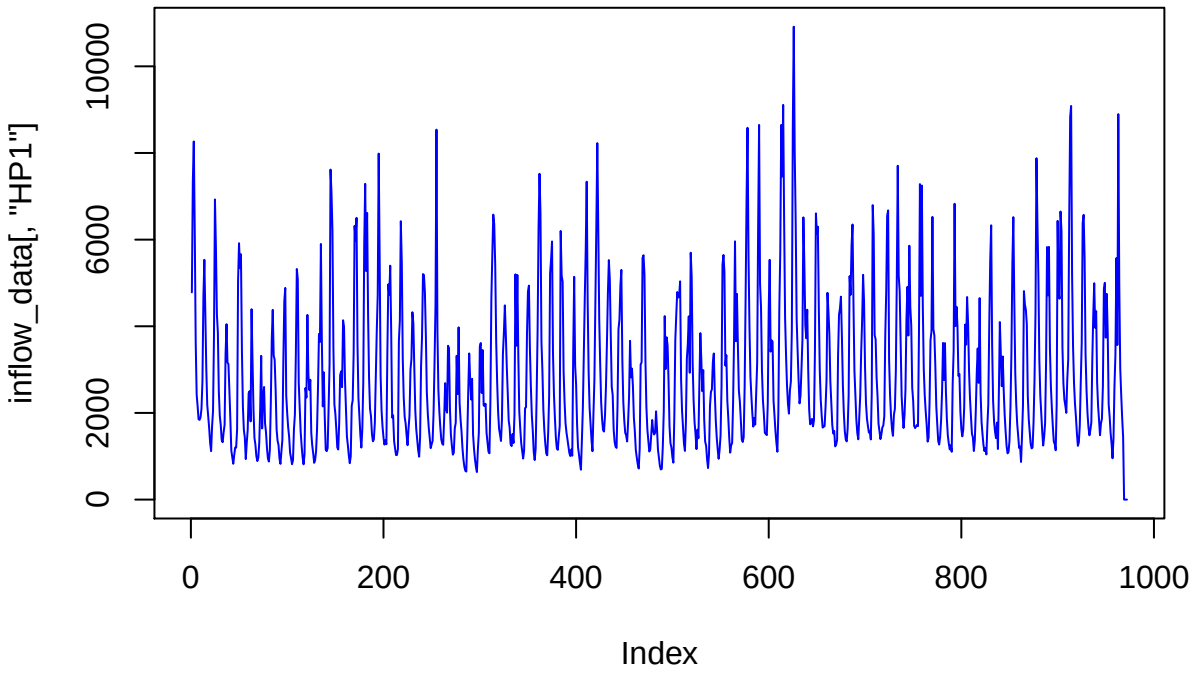
```
#Graph 1: Plot the series for HP1
plot(inflow_data[,"HP1"]) # note that this do not generate a nice plot
```



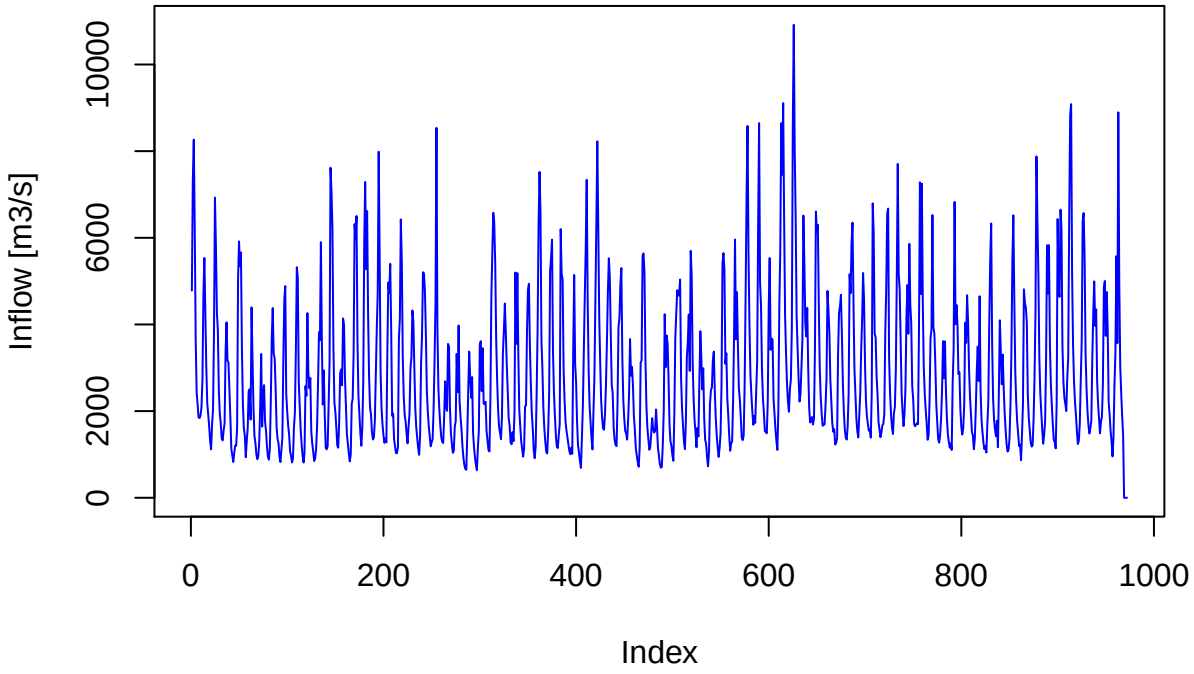

```
plot(inflow_data[,"HP1"],type="l") #The type "l" tells you want a line plot check help(plot)
```



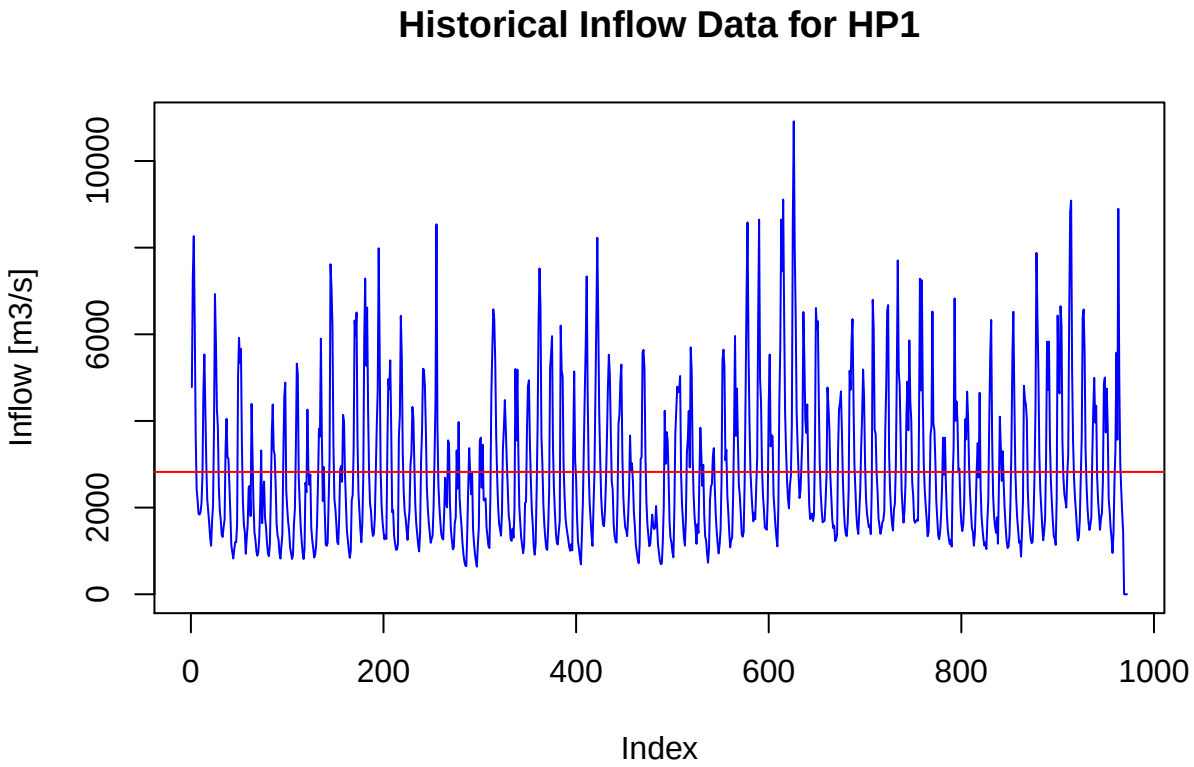

```
#for other types of plots

plot(inflow_data[,"HP1"],type="l",col="blue") #Change the color of the series
```




```
plot(inflow_data[,"HP1"],type="l",col="blue",ylab="Inflow [m3/s]")
```

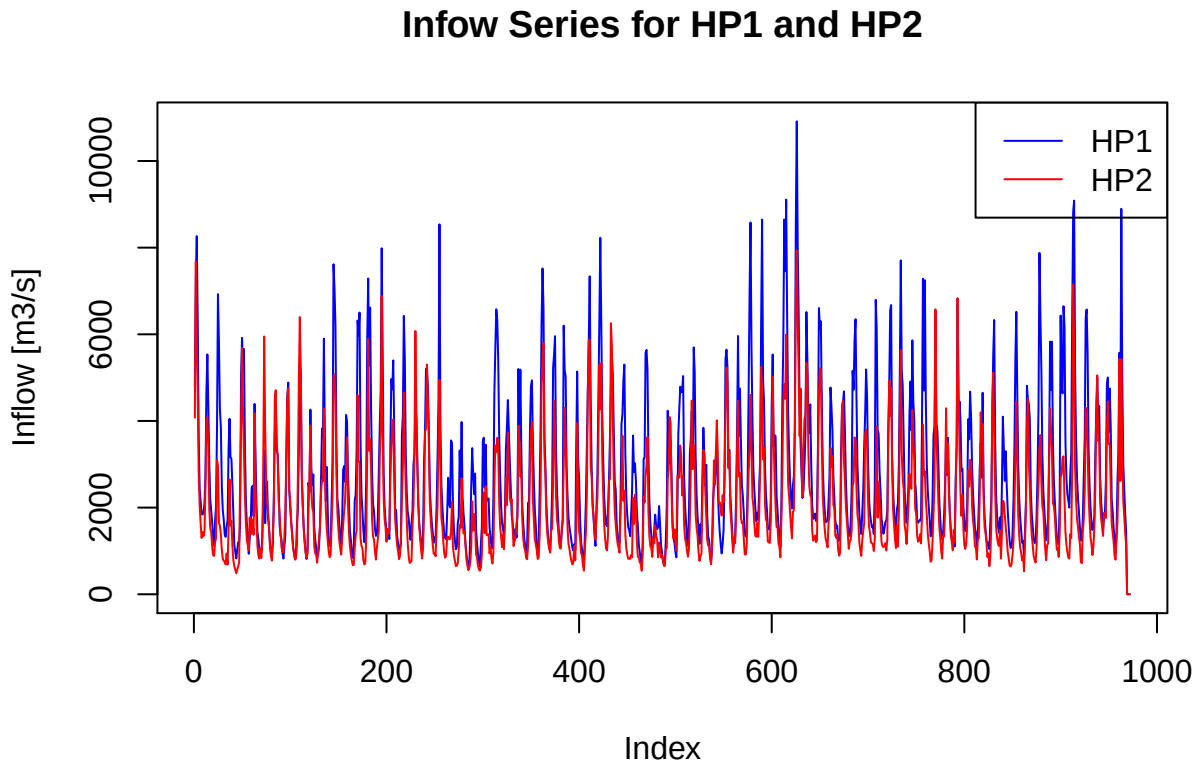



```
plot(inflow_data[,"HP1"],type="l",col="blue",ylab="Inflow [m3/s]",main="Historical Inflow Data for HP1")

#Additional - Suppose you want to add a line with the mean
abline(h=mean(inflow_data[,"HP1"]),col="red")
```



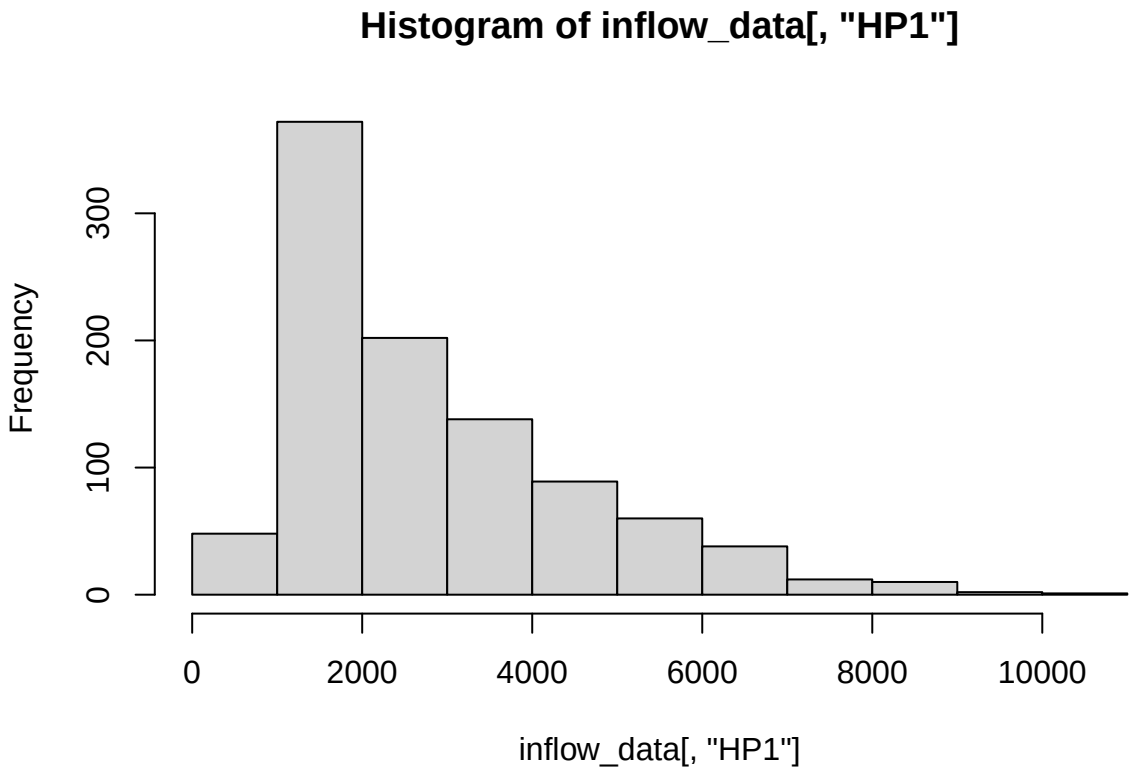
Suppose you want to plot HP1 and HP2 on the same graph.

```
plot(inflow_data[,"HP1"],type="l",col="blue",ylab="Inflow [m3/s]")
lines(inflow_data[,"HP2"],col="red") #Note if you use plot you generate a new graph
                    #no need to specify type in lines() function
title(main="Infow Series for HP1 and HP2")

#If you want to add legend
legend("topright",legend=c("HP1","HP2"), lty=c("solid","solid"),col=c("blue","red"))
```

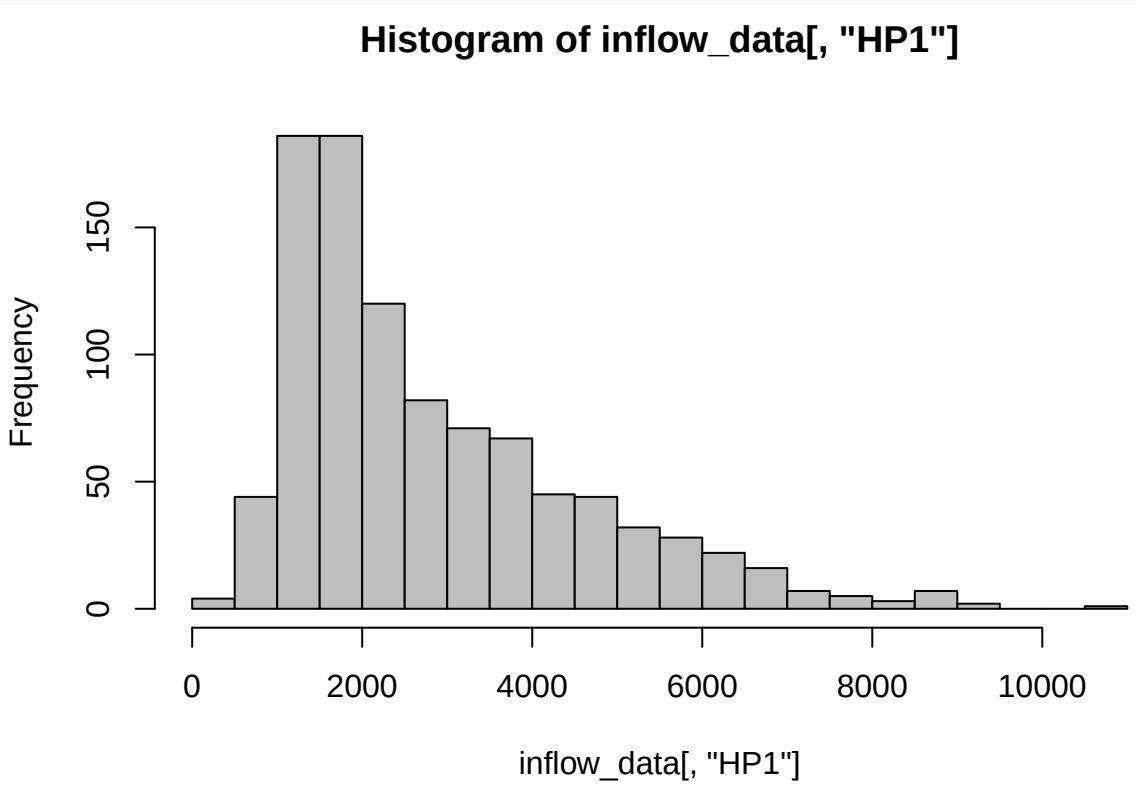


There are other useful plots available for data visualization like histograms and scatter plots. Here are a couple examples.

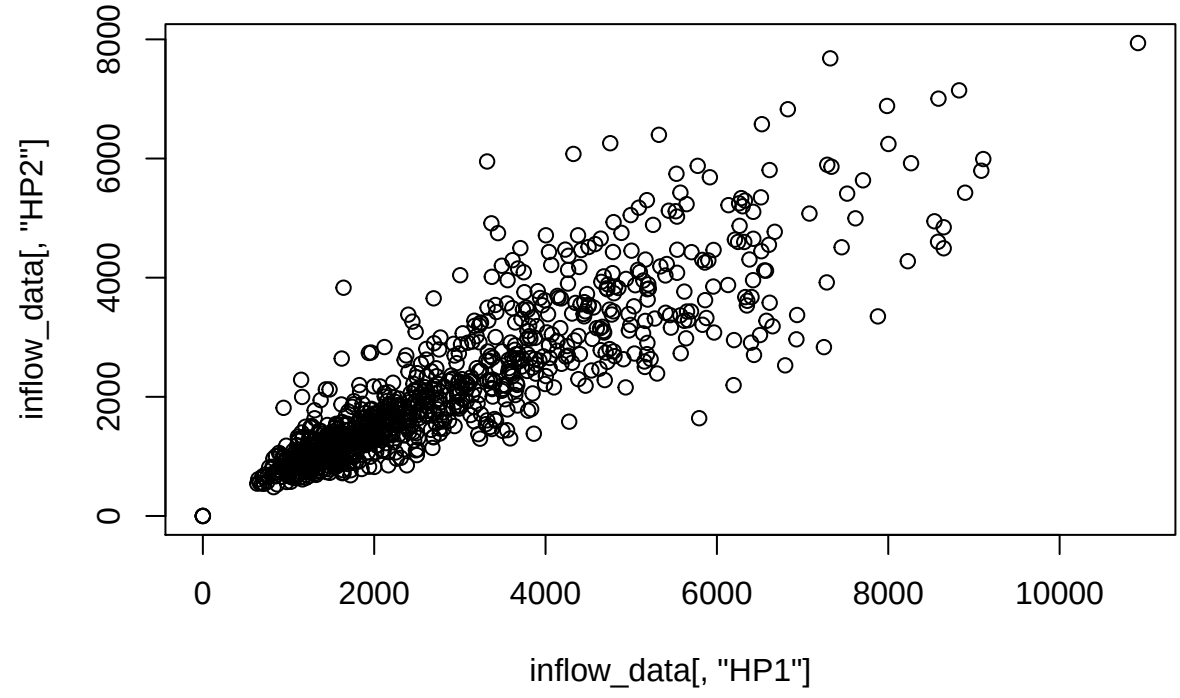
```
#Graph 3: Simple Histogram
hist(inflow_data[,"HP1"])
```



```r
hist(inflow_data[,"HP1"],breaks=30,col="gray")  #increase number of bars with breaks input
```



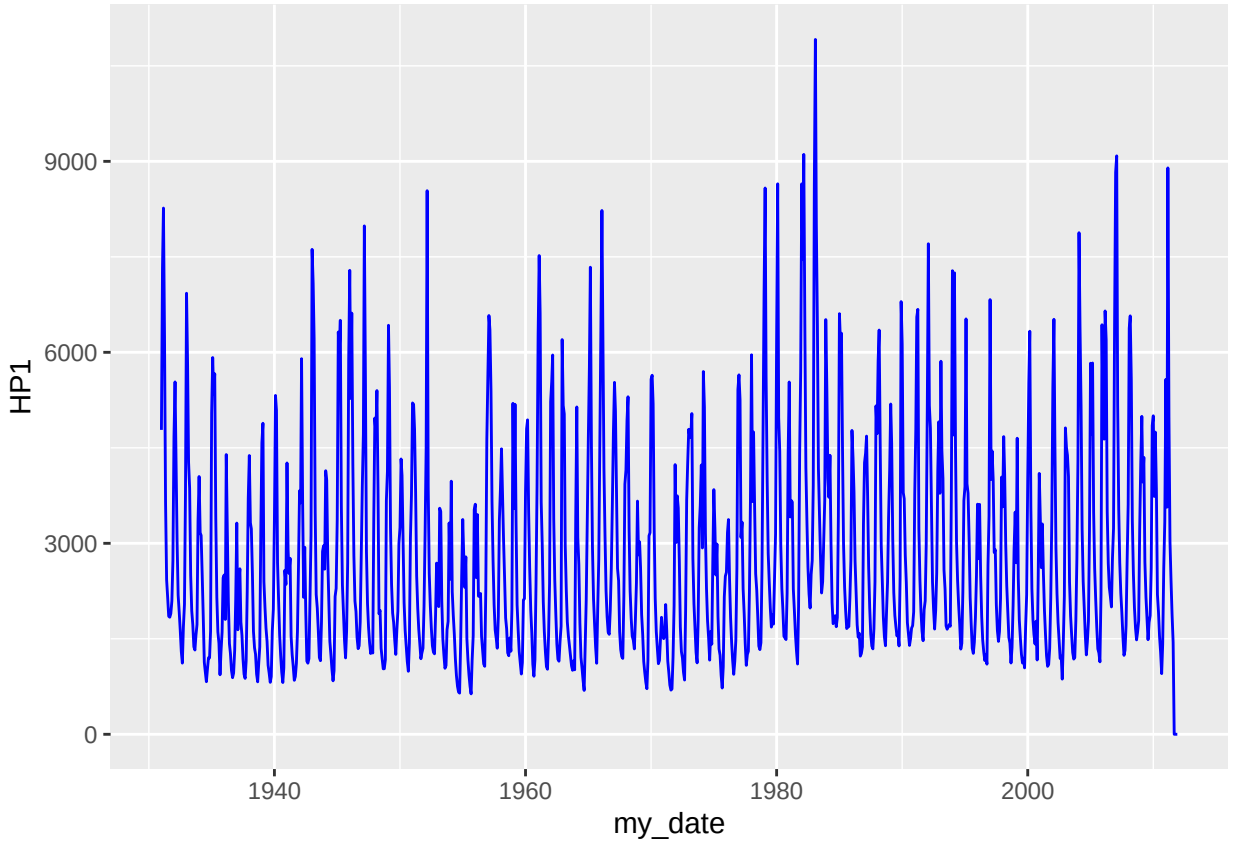

```r
#Graph 4: Scatter Plot of HP1 and HP2
plot(inflow_data[,"HP1"],inflow_data[,"HP2"])
```



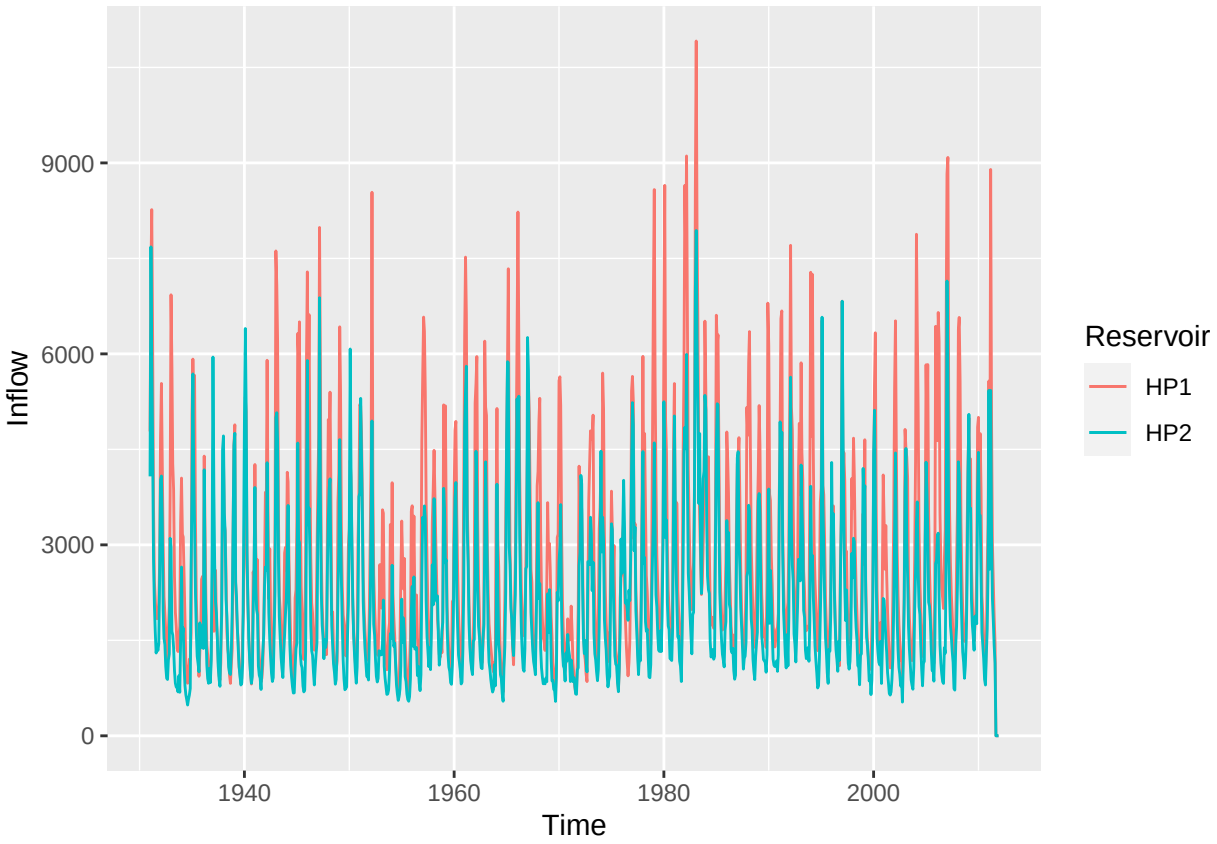
Improving plots with time period information and ggplot

We could improve the plots generated in the previous sections using another package *ggplot2*. Package ggplot2 offers better looking plots, additional fucntionalities, easy incorporation of the date labels, legends, etc. Let's see how we would reproduce the plots from the previous section with ggplot2.

```
#using package ggplot2
ggplot(inflow_data, aes(x=my_date, y=HP1)) +
            geom_line(color="blue")
```




```
#adding two time series to the same plot
ggplot(inflow_data, aes(x=my_date, y=Inflow)) +
            geom_line(aes(y=HP1,col="HP1")) +
            geom_line(aes(y=HP2,col="HP2")) +
            xlab("Time") +
            labs(color="Reservoir")
```



Transforming data into time series object

Many of the functions we will use require a time series object. You can transform your data in a time series using the function *ts()*. Only the columns with reservoir inflow data should be transformed, not the ones with month and year. Your ts object is not a data frame, but like I said we will need it as a ts for some function we will explore in future scripts.

```
## Time Series:
## Start = 1
## End = 972
## Frequency = 1
##       HP1  HP2  HP3
##   1  4782 4076 2518
##   2  7323 7681 4188
##   3  8266 5921 3253
##   4  6247 4600 2449
##   5  3642 2789 1651
##   6  2425 2062 1270
##   7  2158 1644 1204
##   8  1854 1301 1152
##   9  1839 1439 1297
##  10  1896 1340 1259
##  11  2095 1447 1218
##  12  2725 2479 2013
##  13  4679 4021 2435
##  14  5535 4082 2262
##  15  4310 3398 2065
##  16  3026 1965 1574
##  17  2185 1528 1341
```

```
##  18  1919 1431 1387
##  19  1640 1092 1146
##  20  1302  905 1095
##  21  1118  885  895
##  22  1688 1193  968
##  23  2040 1286 1049
##  24  3790 3104 2104
##  25  6928 2965 2513
##  26  5793 1641 2239
##  27  4276 1583 1634
##  28  3863 1381 1439
##  29  2498 1022 1354
##  30  1940  827 1178
##  31  1725  767 1109
##  32  1375  757  965
##  33  1324  690  925
##  34  1551  943  956
##  35  1724  684 1003
##  36  3352 1494 1341
##  37  4049 2652 1692
##  38  3166 1589 1541
##  39  3124 1694 1421
##  40  2507 1115 1183
##  41  1853  788 1065
##  42  1131  646  904
##  43   978  570  846
##  44   826  484  805
##  45  1026  574  764
##  46  1203  639  912
##  47  1199  743  714
##  48  1621 2642 2101
##  49  5047 3873 1744
##  50  5918 5685 2339
##  51  5340 4189 1952
##  52  5663 3286 1748
##  53  3407 2247 1260
##  54  2150 1628 1103
##  55  1610 1250  966
##  56  1430 1133  950
##  57   935 1006 1066
##  58  1305 1774 1824
##  59  1606 1383 1047
##  60  2458 1726 1224
##  61  2503 1691 1758
##  62  1804 1372 1299
##  63  4394 4179 2212
##  64  3197 2481 1399
##  65  2079 1681 1054
##  66  1424 1114  911
##  67  1269  900  920
##  68  1001  825  936
##  69   889 1059 1134
##  70   963  836  901
##  71  1317 1191  868
```

```
##  72  2120 2835 1714
##  73  3318 5950 2331
##  74  1642 3831 1741
##  75  2374 2695 1648
##  76  2600 2104 1767
##  77  1764 1927 1405
##  78  1556 1547 1322
##  79  1186 1098  995
##  80   943  889  926
##  81   878  778  830
##  82  1153 1401 1184
##  83  2243 1916 1428
##  84  3706 4496 1443
##  85  4379 4711 1520
##  86  3323 3497 1303
##  87  3227 3199 1312
##  88  2519 2144 1146
##  89  1617 1872  926
##  90  1359 1428  889
##  91  1259 1083  876
##  92   947  986  888
##  93   824  964  908
##  94  1109 1330 1141
##  95  1375 1945 1056
##  96  3173 3192 1601
##  97  4579 4563 2107
##  98  4886 4752 1716
##  99  2400 2422 1291
## 100  1995 2175 1092
## 101  1671 1682 1066
## 102  1459 1346  983
## 103  1086 1083  877
## 104   961  928  805
## 105   816  798  777
## 106   906  828  751
## 107  1623 1151 1020
## 108  1963 2743 1261
## 109  3368 4912 2119
## 110  5323 6398 3155
## 111  5088 5174 1885
## 112  2698 2899 1203
## 113  2120 2064 1048
## 114  1560 1523  938
## 115  1233 1201  857
## 116   973  968  790
## 117   813  825  770
## 118  1043  934  766
## 119  2576 1962 1017
## 120  2355 2617  987
## 121  4262 3901 1415
## 122  2899 2357  944
## 123  2527 1983  935
## 124  2765 1901 1115
## 125  1540 1100  789
```

```
## 126  1250  952  777
## 127  1069  908  815
## 128   848  728  723
## 129   908 1033  899
## 130  1114 1294 1037
## 131  1617 1569 1154
## 132  2614 2343 1570
## 133  3825 2651 1616
## 134  3636 2606 1925
## 135  5900 4290 2084
## 136  3646 2865 1431
## 137  2151 1930 1011
## 138  2938 1509 1394
## 139  1916 1236 1261
## 140  1150  982  868
## 141  1117  854  824
## 142  1189  914  815
## 143  2117 1588  777
## 144  3126 2266 1387
## 145  7617 4996 2160
## 146  7080 5076 2028
## 147  6210 4638 2041
## 148  3490 2763 1304
## 149  2195 1873  957
## 150  1983 1525 1012
## 151  1628 1231  895
## 152  1205 1049  810
## 153  1156  916  821
## 154  1765 1294 1030
## 155  2873 1598 1274
## 156  2960 1911 1134
## 157  2594 2161 1306
## 158  4140 2932 1492
## 159  3992 3619 1881
## 160  2772 2088 1192
## 161  2111 1437  974
## 162  1460 1105  859
## 163  1252  923  832
## 164  1017  769  758
## 165   840  672  726
## 166   998  675  644
## 167  2165 1071 1012
## 168  2291 1368  911
## 169  3372 1459 1220
## 170  6319 4599 2241
## 171  5967 3079 1855
## 172  6503 3037 1814
## 173  3587 1302 1347
## 174  2344 1118 1318
## 175  1926 1070 1381
## 176  1478  783  970
## 177  1200  690  882
## 178  1625  719  806
## 179  2692 1321 1208
```

```
## 180  5877 3323 1771
## 181  7288 5895 2318
## 182  5275 3314 2450
## 183  6616 3579 2796
## 184  4252 2852 1620
## 185  2808 1739 1277
## 186  2094 1334 1213
## 187  1926 1265 1148
## 188  1521 1007  940
## 189  1345  799  893
## 190  1390 1066  956
## 191  1764 1286  943
## 192  2809 1465 1146
## 193  3897 3186 1944
## 194  4721 3805 2380
## 195  7986 6882 3258
## 196  5620 3766 1870
## 197  2869 2264 1406
## 198  2051 1740 1165
## 199  1687 1547 1102
## 200  1436 1212 1053
## 201  1269 1509 1017
## 202  1366 1387 1075
## 203  1277 1501  825
## 204  3382 2655 1617
## 205  4968 3388 2177
## 206  4728 3886 2414
## 207  5399 4037 2409
## 208  3876 2633 1834
## 209  1893 1727 1222
## 210  1946 1409 1196
## 211  1351 1129 1031
## 212  1183  997 1037
## 213  1028  811  903
## 214  1030  884  904
## 215  1171 1326  928
## 216  3670 2200 1274
## 217  4132 2937 1551
## 218  6425 4653 1959
## 219  5453 3371 1752
## 220  3246 2441 1510
## 221  2353 1745 1169
## 222  1903 1190 1086
## 223  1756  893  946
## 224  1480  724  873
## 225  1255  744  580
## 226  1636  768  656
## 227  1934 1587  689
## 228  2996 2053 1383
## 229  3247 3246 1715
## 230  4325 6077 3716
## 231  4066 4213 3644
## 232  3033 3066 2129
## 233  2067 2175 1183
```

```
## 234  1629 1575 1011
## 235  1387 1281  888
## 236  1144 1008  775
## 237   990  827  695
## 238  1435 1079 1025
## 239  3080 1931  958
## 240  3753 3756 1286
## 241  5205 3816 2626
## 242  5183 5301 4184
## 243  4787 4430 3701
## 244  3793 3461 1932
## 245  2486 2116 1110
## 246  1981 1670 1123
## 247  1655 1378  896
## 248  1423 1156  824
## 249  1187  935  731
## 250  1279  937  811
## 251  1352  877  849
## 252  2007 1527 1164
## 253  3147 2033 1234
## 254  4503 3546 2339
## 255  8539 4946 1901
## 256  3877 2989 1789
## 257  2528 1751  841
## 258  2025 1574  925
## 259  1670 1208  910
## 260  1391  936  684
## 261  1289  846  649
## 262  1264  902 1023
## 263  1878 1336 1226
## 264  2689 1327  812
## 265  2089 1270 1359
## 266  2006 1277 1313
## 267  3551 1440 1017
## 268  3498 2133 1385
## 269  2098 1094  975
## 270  1496  903  782
## 271  1250  778  781
## 272  1037  651  774
## 273  1080  657  766
## 274  1643  722  943
## 275  1772 1014 1067
## 276  3319 1605  912
## 277  2436 1533 1138
## 278  3976 2679 1797
## 279  2240 1661 1311
## 280  1863 1404 1101
## 281  1573 1459 1101
## 282  1183 1134 1286
## 283   924  811  890
## 284   754  664  817
## 285   663  557  717
## 286   647  616  750
## 287  1443  736  638
```

```
## 288  2487 1102  701
## 289  3374 2148 1245
## 290  2765 1468  787
## 291  2309 1851 1099
## 292  2787 1583  858
## 293  1504  928  776
## 294  1167  850  771
## 295   930  657  687
## 296   751  570  693
## 297   635  543  809
## 298  1162  614  567
## 299  1548  899  833
## 300  3528 1959  868
## 301  3614 2347 1098
## 302  2460 1408  842
## 303  3452 2497 1042
## 304  2171 1363 1060
## 305  2164 1366 1561
## 306  2212 1386 2175
## 307  1539  947 1299
## 308  1321 1090 1493
## 309  1106  829 1096
## 310  1068  710  926
## 311  2262  961  718
## 312  4630 2472  741
## 313  5651 3432 1523
## 314  6578 3276 2107
## 315  6355 3612 2279
## 316  5401 3411 2730
## 317  3656 2119 1124
## 318  2720 1551  907
## 319  2035 1338 1287
## 320  1639 1087 1157
## 321  1503 1382 1502
## 322  1352 1040 1205
## 323  1849 1652 1249
## 324  3357 2686 1516
## 325  3849 2057 1726
## 326  4484 3726 4135
## 327  3823 2978 3054
## 328  3075 2233 2604
## 329  2470 2114 2037
## 330  1827 2197 2117
## 331  1656 1540 1568
## 332  1279 1110 1302
## 333  1234 1277 1181
## 334  1514 1357  973
## 335  1305 1640 1399
## 336  1955 1783 1498
## 337  5199 3888 2056
## 338  3550 3568 2528
## 339  5184 2716 2902
## 340  3327 2761 2252
## 341  2033 1723 1429
```

```
## 342  1639 1284 1345
## 343  1301 1080 1145
## 344  1120 1013 1124
## 345   947  835  973
## 346  1127  809  923
## 347  2111 1107  881
## 348  2130 1730 1603
## 349  3811 3019 2515
## 350  4799 3739 2828
## 351  4939 3979 3045
## 352  3501 2196 1983
## 353  2615 1713 1396
## 354  1950 1269  908
## 355  1591 1160 1016
## 356  1099 1029 1070
## 357   912  815  922
## 358  1174  844  948
## 359  2350 1354 1176
## 360  3886 2389 1727
## 361  6265 4870 3378
## 362  7520 5411 2615
## 363  6615 5806 3975
## 364  3646 3248 2351
## 365  2988 2727 1843
## 366  2078 1778 1175
## 367  1610 1394  913
## 368  1297 1183  902
## 369  1061 1044  984
## 370  1022  962  936
## 371  1547 1489 1252
## 372  2373 1510 1072
## 373  5226 2633 1561
## 374  5537 4469 2343
## 375  5958 3851 3168
## 376  3384 2289 1665
## 377  2416 1723 1171
## 378  1875 1551 1171
## 379  1421 1227 1142
## 380  1179 1069 1070
## 381  1148 1055 1063
## 382  1453 1527 1393
## 383  1698 1755 1263
## 384  6200 2952 1186
## 385  5166 4304 4031
## 386  5032 3519 3473
## 387  2962 2565 2230
## 388  2260 1519 1216
## 389  1764 1158  844
## 390  1548 1042  917
## 391  1395  884  699
## 392  1234  768  685
## 393  1075  688  697
## 394  1005  730  682
## 395  1156 1118 1094
```

```
## 396  1013  784  823
## 397  3422 1595  584
## 398  5142 3953 1921
## 399  3092 2213 1496
## 400  2662 1446  925
## 401  1748 1306  887
## 402  1210  959  712
## 403  1041  900  826
## 404   847  666  838
## 405   689  543  717
## 406  1365 1066  898
## 407  2106 1399  878
## 408  3351 2262 1467
## 409  4644 4655 2908
## 410  5776 5877 3605
## 411  7337 5862 4323
## 412  4546 2972 2252
## 413  2938 2693 1628
## 414  2123 2004 1153
## 415  1743 1832 1007
## 416  1373 1429  799
## 417  1116 1261  715
## 418  1968 1798 1261
## 419  2753 2212 1203
## 420  4503 3523 2067
## 421  6327 5294 1890
## 422  8228 4276 1817
## 423  6284 5335 2658
## 424  4172 3153 1933
## 425  3131 2328 1611
## 426  2253 1618 1222
## 427  1849 1293  962
## 428  1604 1056  820
## 429  1570 1014  758
## 430  1943 1368  891
## 431  2609 2625 1328
## 432  3611 2658 1758
## 433  4755 6257 2547
## 434  5528 5744 3681
## 435  5078 4131 3085
## 436  3791 2714 1848
## 437  2606 1927 1203
## 438  2413 1613 1032
## 439  1612 1342  856
## 440  1331 1165  665
## 441  1220 1071  793
## 442  1192  960  861
## 443  2171 1880 1182
## 444  3929 2609 1802
## 445  4152 3663 2968
## 446  4935 2158 1635
## 447  5302 2391 2067
## 448  3215 1373 1088
## 449  2252 1067  925
```

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## 450  1824  917  802
## 451  1541  817  718
## 452  1480  836  726
## 453  1341  816  699
## 454  1789  907  708
## 455  2381  850  560
## 456  3663 2231  839
## 457  2819 1621 1282
## 458  3023 2297 1429
## 459  2609 2002 1194
## 460  1882 1211 1057
## 461  1571  863  717
## 462  1142  868  690
## 463   972  731  561
## 464   818  711  515
## 465   716  541  493
## 466  1163  921  667
## 467  3118 2254 1421
## 468  3167 2121  923
## 469  5578 2731 1516
## 470  5640 2982 2387
## 471  5192 3632 2748
## 472  3207 1890 1560
## 473  2134 1330 1104
## 474  1613 1099 1123
## 475  1358 1061 1059
## 476  1109  861  796
## 477  1161 1303  996
## 478  1490 1173  970
## 479  1838 1592  773
## 480  1585 1354 1095
## 481  1502 1259 1302
## 482  1538  853 1172
## 483  2038 1191 1501
## 484  1627 1048 1070
## 485  1150  851  962
## 486   966  915 1043
## 487   774  816  997
## 488   694  659  748
## 489   711  652  727
## 490  1204 1037  870
## 491  2023 1070  700
## 492  4236 2675 1144
## 493  3013 2879 1901
## 494  3746 4091 3104
## 495  3557 3958 2153
## 496  2727 2345 1610
## 497  1689 1537 1327
## 498  1300 1292 1202
## 499  1198 1497 1283
## 500   973 1179 1125
## 501   852 1005 1113
## 502  1938 2736 1810
## 503  3683 2722 1433
```

```
## 504  4262 2691 1100
## 505  4791 3434 1874
## 506  4662 3175 2000
## 507  4691 2281 1330
## 508  5038 2727 2059
## 509  2763 1617 1611
## 510  2048 1287 1387
## 511  1666 1191 1155
## 512  1286 1005 1066
## 513  1122  866 1181
## 514  1781 1040 1468
## 515  3247 1708 1409
## 516  3592 2912 1769
## 517  4230 4471 2875
## 518  2927 2889 2433
## 519  5698 3433 3076
## 520  5138 3065 2309
## 521  3164 1829 1582
## 522  2290 1536 1686
## 523  1786 1346 1337
## 524  1517  977 1327
## 525  1165  769 1162
## 526  1614  878 1347
## 527  1415  935 1281
## 528  2699 2183 2189
## 529  3843 3331 2661
## 530  3240 3239 2445
## 531  2502 2397 2009
## 532  2989 1802 1771
## 533  1853 1255 1397
## 534  1340 1125 1082
## 535  1242 1105 1145
## 536   927  829 1076
## 537   727  693  950
## 538  1056 1096 1255
## 539  2160 1684 1479
## 540  2484 3091 2050
## 541  2545 2553 2514
## 542  3169 3277 3481
## 543  3373 4014 2474
## 544  2446 3262 1870
## 545  1835 2085 1830
## 546  1436 2125 2149
## 547  1159 1998 1872
## 548   942 1815 1871
## 549  1147 2286 2057
## 550  1479 2124 2242
## 551  2608 2804 1856
## 552  5415 4229 1691
## 553  5646 5234 3376
## 554  5255 4886 2380
## 555  3093 2908 1647
## 556  3332 3279 2037
## 557  2288 1969 1551
```

```
## 558  1897 1649 1643
## 559  1428 1255 1308
## 560  1083  961 1021
## 561  1253 1320 1514
## 562  1305 1178 1387
## 563  2241 1826 1995
## 564  3720 3307 3426
## 565  5961 4465 3741
## 566  3655 2715 2074
## 567  4748 2801 2847
## 568  3554 1788 1504
## 569  2521 1642 1611
## 570  2264 1674 1693
## 571  1851 1270 1534
## 572  1386  925 1361
## 573  1330  913 1384
## 574  1438 1118 1051
## 575  2595 2088 1760
## 576  4644 2783 2221
## 577  6936 3373 3037
## 578  8581 4602 2290
## 579  5619 3276 1792
## 580  3994 2215 1339
## 581  2841 2025 1519
## 582  2380 1611 1251
## 583  1983 1347 1239
## 584  1684 1326 1159
## 585  1883 1650 1511
## 586  1730 1324 1897
## 587  2453 1877 1437
## 588  3146 2927 2516
## 589  6259 5248 3127
## 590  8647 4493 3534
## 591  4973 3113 2482
## 592  4444 3390 2220
## 593  2958 2098 1607
## 594  2290 1726 1469
## 595  1962 1670 1402
## 596  1540 1213 1138
## 597  1513 1203 1279
## 598  1488 1183 1236
## 599  2219 1696 1201
## 600  4409 3552 2177
## 601  5534 5025 2996
## 602  3414 3541 1739
## 603  3673 2646 1724
## 604  3647 2029 1486
## 605  2281 1552 1235
## 606  1937 1565 1422
## 607  1574 1175  991
## 608  1306 1094 1082
## 609  1104  853  970
## 610  2011 1718 1300
## 611  4401 2715 2087
```

```
## 612  5704 4428 2336
## 613  8647 4846 2808
## 614  7456 4510 3000
## 615  9109 5991 4339
## 616  6422 3958 2557
## 617  4187 2554 1859
## 618  3320 2271 2072
## 619  2625 1899 1844
## 620  2207 1578 1411
## 621  1983 1288 1339
## 622  2511 1902 2039
## 623  2727 1941 2087
## 624  3909 3774 3311
## 625  8586 7005 4782
## 626 10915 7938 5078
## 627  8002 6244 4089
## 628  6424 5105 2986
## 629  4180 3651 2537
## 630  3445 4748 4328
## 631  2773 2995 2224
## 632  2220 2236 1573
## 633  2398 3379 2241
## 634  3004 4041 2324
## 635  3679 4154 2059
## 636  6514 5348 2407
## 637  5439 5124 2903
## 638  4029 3387 2352
## 639  3723 2508 1914
## 640  4383 2296 1941
## 641  2986 2236 1848
## 642  2072 1484 1341
## 643  1737 1238 1222
## 644  1768 1270 1379
## 645  1863 1357 1462
## 646  1690 1203 1295
## 647  1834 1247 1228
## 648  3417 3003 1970
## 649  6607 4552 2122
## 650  6135 5217 2323
## 651  6300 5198 3063
## 652  4465 3435 2314
## 653  2985 2262 1629
## 654  2309 1840 1342
## 655  1941 1509 1377
## 656  1661 1282 1198
## 657  1683 1191 1037
## 658  1692 1083  937
## 659  2136 1657 1124
## 660  2740 1791 1097
## 661  4773 3381 1557
## 662  4337 2947 2156
## 663  3809 3194 2420
## 664  2724 2064 1586
## 665  2233 1991 1372
```

```
## 666  1720 1357 1100
## 667  1525 1304 1041
## 668  1586 1375 1312
## 669  1228 1026 1126
## 670  1268  889 1042
## 671  1374  952 1167
## 672  3310 2605 2100
## 673  4267 4367 2567
## 674  4416 4464 3928
## 675  4684 3079 2603
## 676  3737 2630 1864
## 677  2634 2014 2070
## 678  1990 1716 2096
## 679  1573 1382 1414
## 680  1387 1048 1169
## 681  1342 1217 1264
## 682  1657 1252 1377
## 683  2397 1471 1520
## 684  5159 2501 1743
## 685  4722 2587 2316
## 686  5862 3622 2835
## 687  6350 3533 3284
## 688  4535 2442 2485
## 689  2970 1834 1916
## 690  2413 1663 1994
## 691  1842 1199 1382
## 692  1534 1014 1265
## 693  1391  884 1105
## 694  1896 1249 1213
## 695  2386 1465 1444
## 696  3405 1627 1743
## 697  4140 3694 3811
## 698  5188 3806 4297
## 699  4560 3500 3015
## 700  3072 2191 2277
## 701  2227 1569 1837
## 702  1865 1416 1671
## 703  1697 1199 1442
## 704  1546 1178 1835
## 705  1587 1155 1469
## 706  1388  999 1178
## 707  2467 1269 1616
## 708  6797 2528 2203
## 709  6130 3877 4398
## 710  3796 1768 1966
## 711  3700 2599 2316
## 712  2815 2176 1835
## 713  2379 1659 1762
## 714  1752 1206 1293
## 715  1581 1111 1378
## 716  1396 1089 1335
## 717  1503 1111 1460
## 718  1667 1177 1552
## 719  1707 1013 1538
```

```
## 720  1923 1270 1596
## 721  3776 3497 2284
## 722  4794 4932 4050
## 723  6554 4121 3366
## 724  6675 4770 3360
## 725  3228 2915 2193
## 726  2416 1960 1773
## 727  1932 1616 1562
## 728  1621 1265 1315
## 729  1470 1066 1115
## 730  1958 1590 1734
## 731  2096 1099 1121
## 732  2975 1850 1849
## 733  5101 4094 2235
## 734  7705 5634 2462
## 735  5164 3274 2490
## 736  4805 2683 2322
## 737  3592 2431 1943
## 738  2389 1598 1167
## 739  1972 1433 1212
## 740  1653 1160 1256
## 741  1946 1577 1733
## 742  2539 2050 1962
## 743  4136 2773 2233
## 744  4909 2631 2261
## 745  3786 2434 2362
## 746  5860 4254 3812
## 747  4452 3589 2677
## 748  4016 3081 2311
## 749  2582 1969 1543
## 750  2277 1860 1807
## 751  1703 1349 1303
## 752  1650 1213 1440
## 753  1687 1243 1731
## 754  1724 1385 1727
## 755  1697 1171 1133
## 756  3832 1793 1713
## 757  7282 3920 2805
## 758  4702 2743 2519
## 759  7249 2834 2150
## 760  4467 2187 1982
## 761  3014 1839 1487
## 762  2411 1409 1392
## 763  2032 1179 1349
## 764  1726  989 1190
## 765  1338  752 1097
## 766  1428  786 1154
## 767  2232 1237 1243
## 768  3672 1854 1723
## 769  3888 2548 2412
## 770  6525 6576 5801
## 771  3936 3659 3044
## 772  3788 2978 2937
## 773  3077 2137 1915
```

```
## 774  2149 1544 1521
## 775  1737 1316 1576
## 776  1351  986 1333
## 777  1271  824 1186
## 778  1447 1360 1587
## 779  1831 1331 1473
## 780  2487 1930 1561
## 781  3615 4294 3192
## 782  2758 2795 2320
## 783  3612 3488 3619
## 784  2492 2330 2050
## 785  1852 1790 1750
## 786  1474 1350 1440
## 787  1292 1203 1339
## 788  1158 1014 1331
## 789  1254 1486 1662
## 790  1102 1188 1596
## 791  2665 2429 1727
## 792  3426 3424 2014
## 793  6828 6827 4028
## 794  4004 4711 4138
## 795  4450 3351 2394
## 796  4004 2348 2033
## 797  2856 1810 1918
## 798  2899 2291 2666
## 799  2037 1519 1563
## 800  1631 1140 1335
## 801  1459 1047 1357
## 802  1613 1171 1472
## 803  2133 1585 2228
## 804  4040 2863 2995
## 805  3574 2482 2120
## 806  4676 3104 3158
## 807  4073 3047 3580
## 808  2967 2030 2658
## 809  2334 1707 2154
## 810  1916 1500 1686
## 811  1523 1101 1353
## 812  1432 1087 1557
## 813  1120  802 1646
## 814  1361 1275 2092
## 815  2026 1284 1505
## 816  2921 2309 2662
## 817  3490 4200 5066
## 818  2694 3653 3948
## 819  4651 3929 3698
## 820  2458 2219 2243
## 821  1793 1548 1760
## 822  1506 1414 1663
## 823  1260 1192 1412
## 824  1120  861 1234
## 825  1194  944 1358
## 826  1043  648 1132
## 827  1691  873 1304
```

```
## 828  2192 1625 1746
## 829  4040 4431 2571
## 830  5519 5115 3361
## 831  6331 3674 3173
## 832  3565 2422 2118
## 833  2286 1531 1589
## 834  1797 1313 1491
## 835  1565 1155 1356
## 836  1418 1114 1412
## 837  1777 1483 1806
## 838  1167  823 1191
## 839  2491 1389 1564
## 840  4098 2158 2398
## 841  3376 2130 2304
## 842  2617 1836 2834
## 843  3304 1540 2230
## 844  2517 1311 1750
## 845  1952  994 1496
## 846  1566  837 1337
## 847  1234  667 1236
## 848  1067  640 1092
## 849  1097  691 1131
## 850  1352  890 1577
## 851  2139 1223 1627
## 852  3383 2004 2264
## 853  5463 3161 3248
## 854  6519 4444 4197
## 855  4598 3153 2956
## 856  2924 1809 1873
## 857  2212 1357 1685
## 858  1754 1073 1353
## 859  1485  967 1394
## 860  1191  782 1338
## 861  1227  894 1346
## 862   867  530 1058
## 863  1457 1196 1468
## 864  2168 2076 1760
## 865  4813 3851 3129
## 866  4502 4514 3333
## 867  4384 3021 2578
## 868  4049 2475 2380
## 869  2394 1714 1572
## 870  1856 1360 1585
## 871  1563 1134 1322
## 872  1284  877 1156
## 873  1181  793 1160
## 874  1206  732 1271
## 875  1789 1075 1455
## 876  2763 1965 2000
## 877  4310 2572 1945
## 878  7879 3350 2474
## 879  6404 3675 2299
## 880  5154 2593 1878
## 881  3227 2029 1755
```

```
## 882  2399 1906 1784
## 883  1989 1425 1438
## 884  1568 1045 1121
## 885  1247  786  935
## 886  1454 1139 1385
## 887  1776 1170 1640
## 888  3195 3018 1932
## 889  5829 4298 4184
## 890  4713 3821 3047
## 891  5832 3209 2433
## 892  3489 2101 1876
## 893  2609 2036 1746
## 894  2111 1802 1756
## 895  1686 1354 1441
## 896  1342 1026 1201
## 897  1278 1057 1224
## 898  1138  859 1402
## 899  2188 1394 1325
## 900  6433 2703 2648
## 901  4795 2762 2493
## 902  4636 3149 3498
## 903  6650 3184 2970
## 904  6195 2196 2371
## 905  3497 1430 1341
## 906  2679 1142 1080
## 907  2310  975 1207
## 908  2165  850 1115
## 909  2001  823  953
## 910  2766 1384 1230
## 911  3235 1297 1071
## 912  6398 2908 2327
## 913  8827 7144 5205
## 914  9086 5795 4742
## 915  5189 2905 2563
## 916  3540 2184 1434
## 917  2696 1732 1626
## 918  2216 1557 1395
## 919  1911 1328 1431
## 920  1536 1155 1278
## 921  1240  742  703
## 922  1319  718  848
## 923  1716 1446 1550
## 924  2707 1726 1546
## 925  3611 2390 2323
## 926  6380 4305 3220
## 927  6573 4117 2995
## 928  5573 3367 2333
## 929  3352 2282 1970
## 930  2518 1754 1797
## 931  1991 1316 1384
## 932  1669 1156 1244
## 933  1483  904  974
## 934  1606 1104 1323
## 935  1783 1531 1265
```

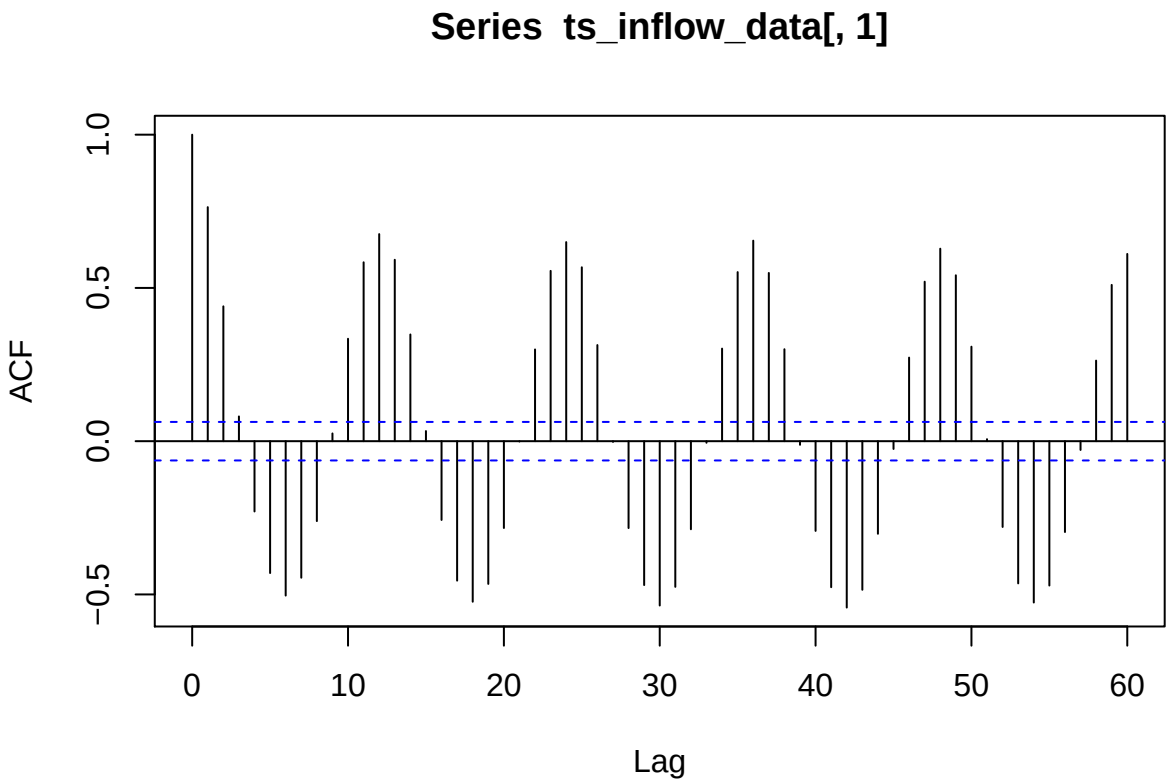
```
## 936  3223 2429 1146
## 937  4263 4130 1927
## 938  4994 5050 3127
## 939  3963 3537 2415
## 940  4350 3576 1864
## 941  2703 2132 1217
## 942  2159 1746 1273
## 943  1831 1570 1384
## 944  1486 1345 1631
## 945  1760 1875 2167
## 946  1865 1882 1970
## 947  2613 1761 2086
## 948  4850 3826 4130
## 949  5003 4453 5110
## 950  3736 3463 4173
## 951  4747 3464 3186
## 952  3846 2488 2907
## 953  2197 1628 1889
## 954  1920 1423 1666
## 955  1539 1214 1481
## 956  1289  886 1173
## 957   953  798 1189
## 958  1411 1265 1580
## 959  2608 1681 1255
## 960  3338 2608 1921
## 961  5574 5427 4117
## 962  3567 2619 3061
## 963  8897 5426 5805
## 964  4991 3207 3323
## 965  3025 2156 2274
## 966  2415 1813 1936
## 967  1883 1426 1560
## 968  1444 1139 1441
## 969     0    0    0
## 970     0    0    0
## 971     0    0    0
## 972     0    0    0
```

Note that ts_inflow_data has information on start, end and frequency. We will discuss frequency in future lectures, for now let's just keep the default value for frequency which is 1.

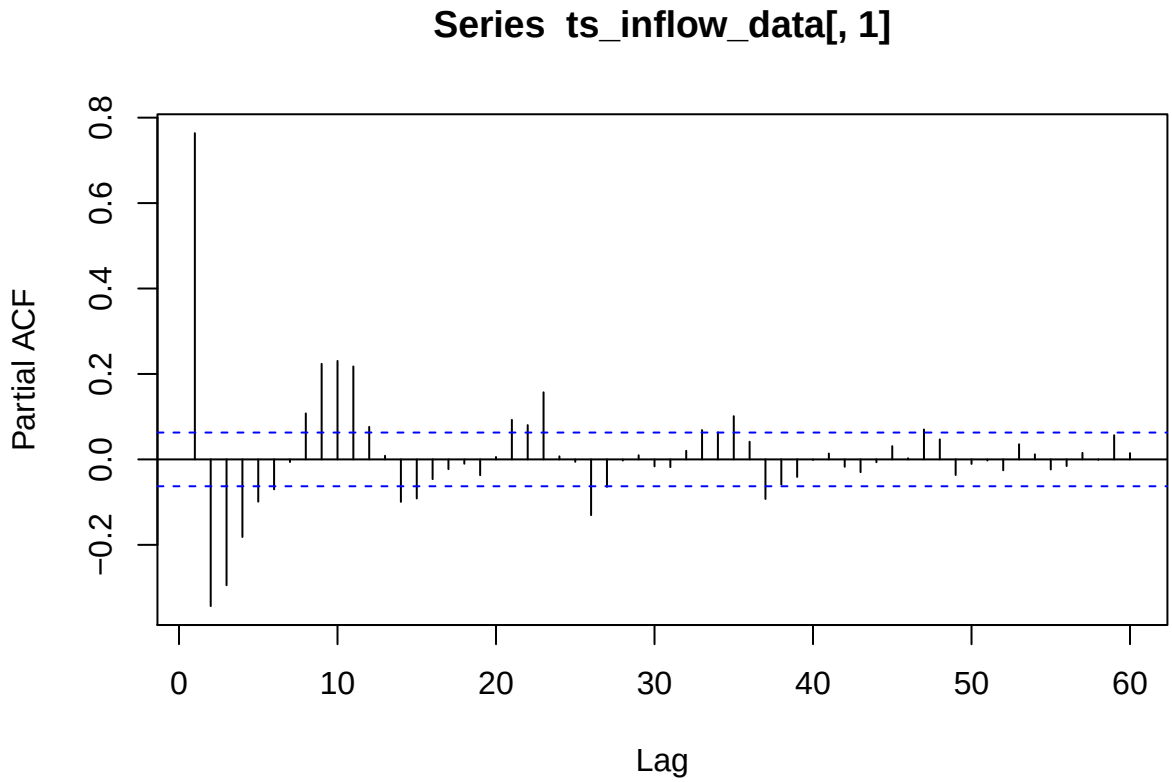
Plotting ACF and PACF

There are multiple ways to get acf and pacf plots in R. The default package "stats" have the functions acf() and pacf(). Another option is with the functions Acf() and Pacf() from package "forecast". Package forecast is not a default package. So you need to install and load it on the beginning of your scripts.

```
# The function acf() and pacf() is from package "stats"
HP1_acf=acf(ts_inflow_data[,1],lag.max=60, type="correlation", plot=TRUE)
```

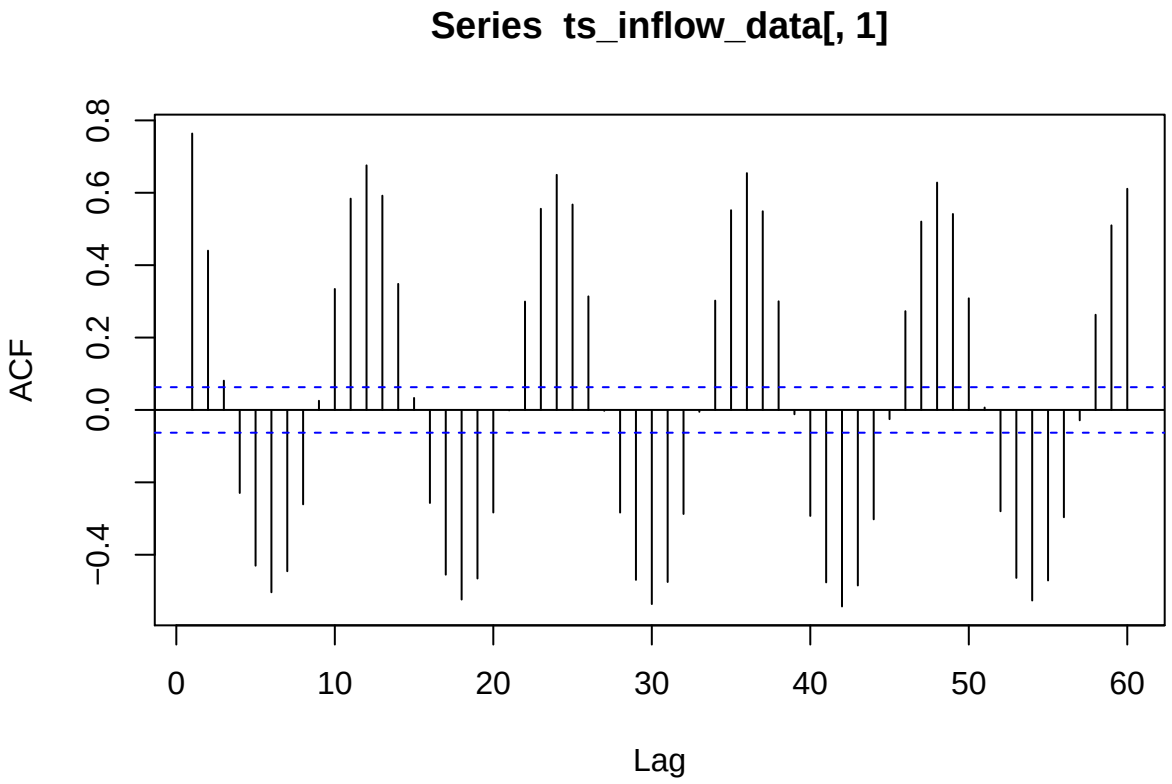



```
HP1_pacf=pacf(ts_inflow_data[,1],lag.max=60, plot=TRUE)
```




```
#Computing ACF and PACF with package forecast (better plots)
```

```
#The next line will output a plot since we have plot=TRUE and also store the acf values in the object
HP1_acf=Acf(ts_inflow_data[,1],lag.max=60, type="correlation", plot=TRUE)
```




```
HP1_pacf=Pacf(ts_inflow_data[,1],lag.max=60, plot=TRUE)
```