

Import Data - ACF - PACF

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1/28/2021

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 your 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 where 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. Note that if `header=TRUE`, you should not skip the row with the header. The default 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/lmm89/Desktop/ENV790_30_TSA_S2021/Data/inflowtimeseries.txt"

#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
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)
```

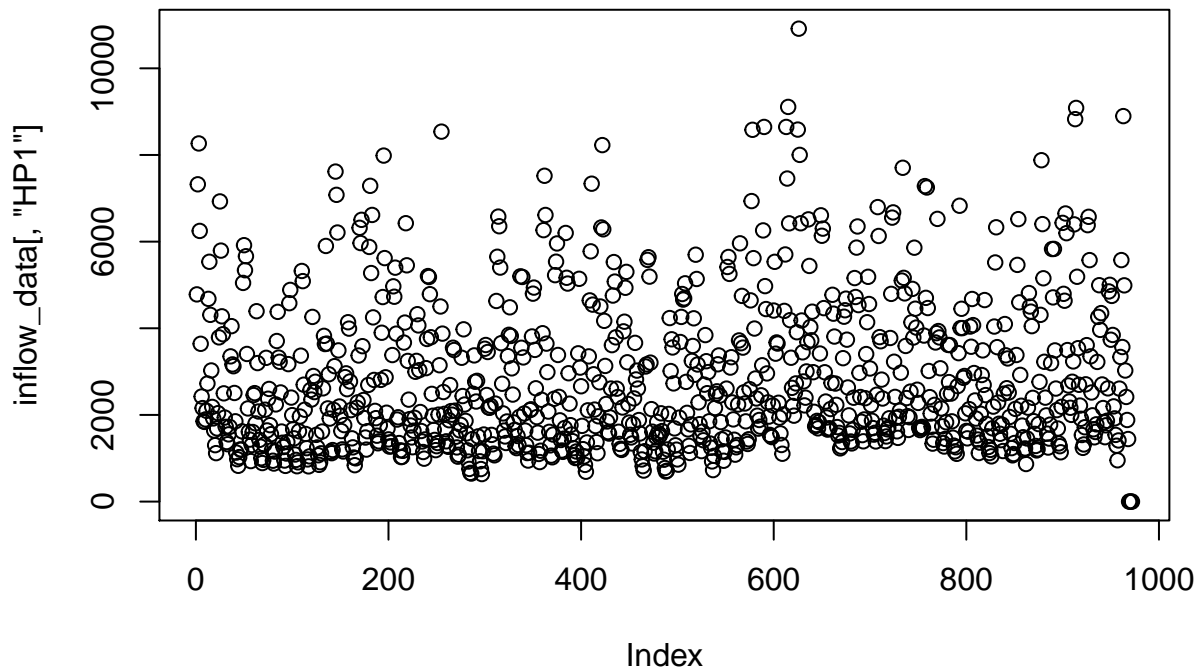
```
##      my_date  HP1  HP2  HP3
## 1 1931-01-01 4782 4076 2518
## 2 1931-02-01 7323 7681 4188
## 3 1931-03-01 8266 5921 3253
## 4 1931-04-01 6247 4600 2449
## 5 1931-05-01 3642 2789 1651
## 6 1931-06-01 2425 2062 1270
```

Initial plots

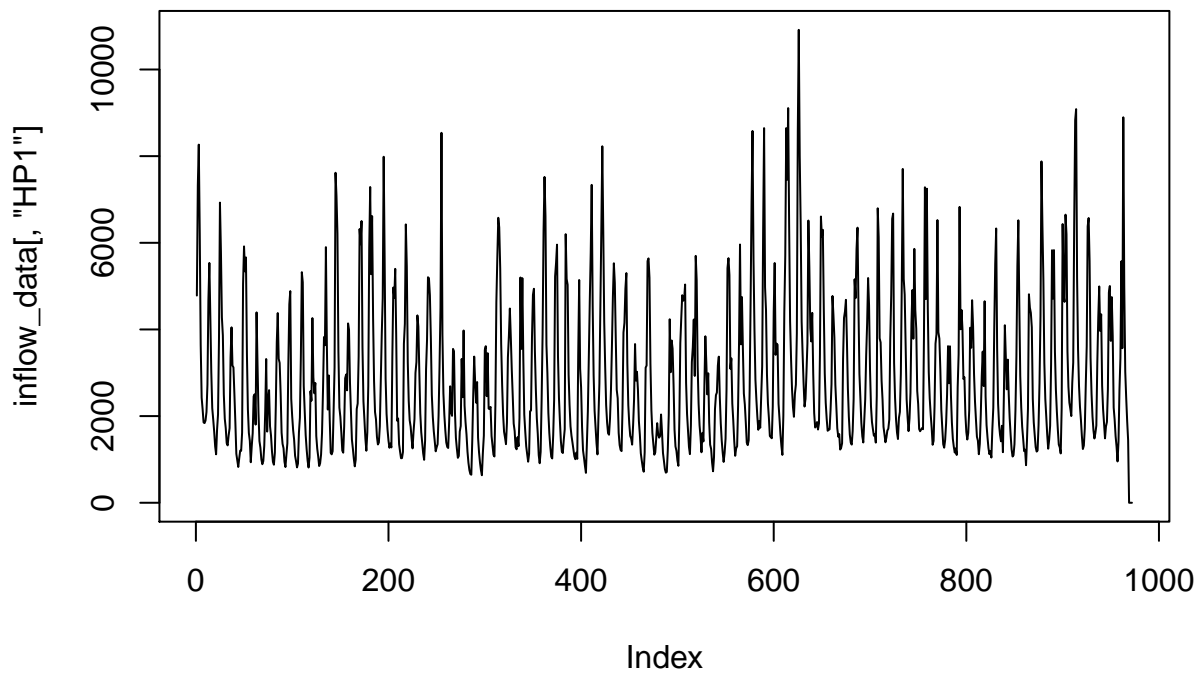
A plot of observed values over time is the first you do to start understanding the data set. The default packages on R offer the function `plot()`.

```
#Graph 1: Plot the series for HP1
```

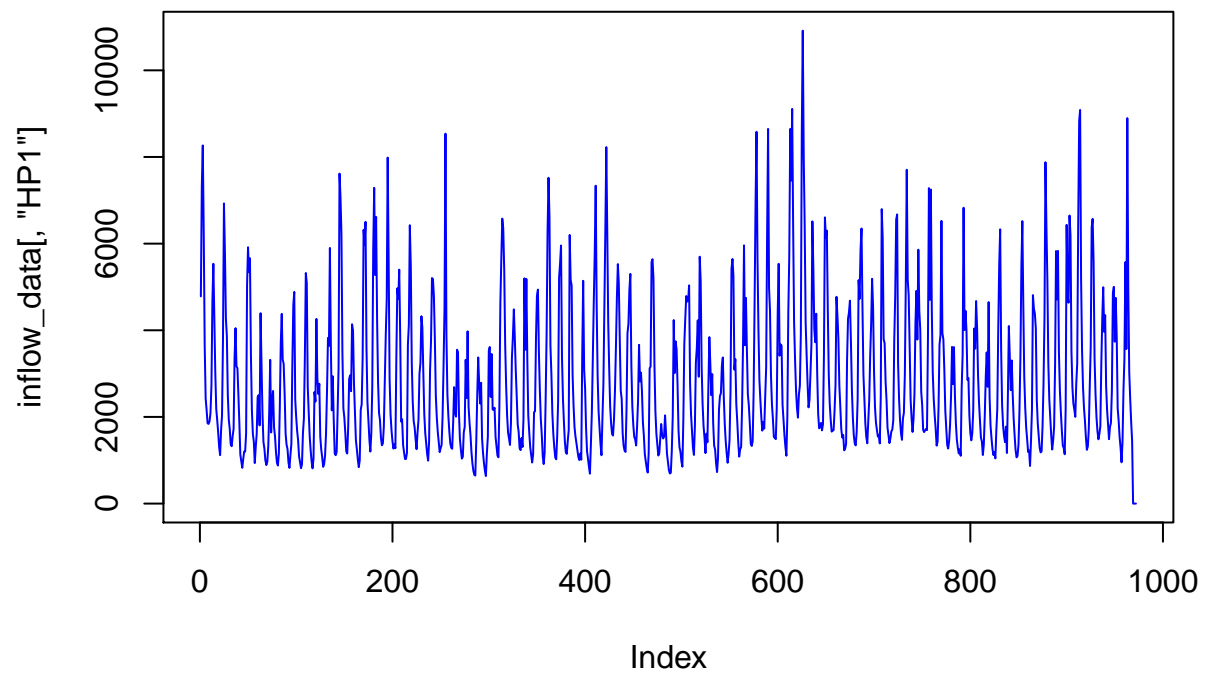
```
plot(inflow_data[, "HP1"]) # note that this do not generate a nice plot
```



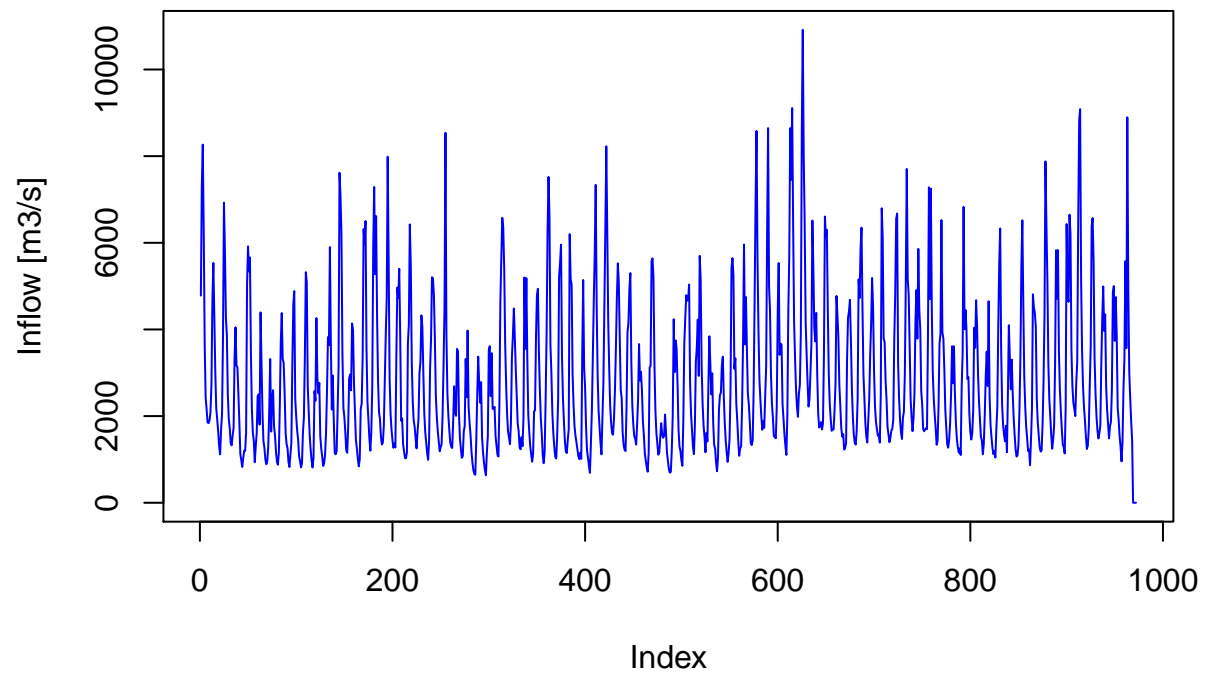
```
plot(inflow_data[, "HP1"], type="l") #The type "l" tells you want a line plot check help(plot)
```



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



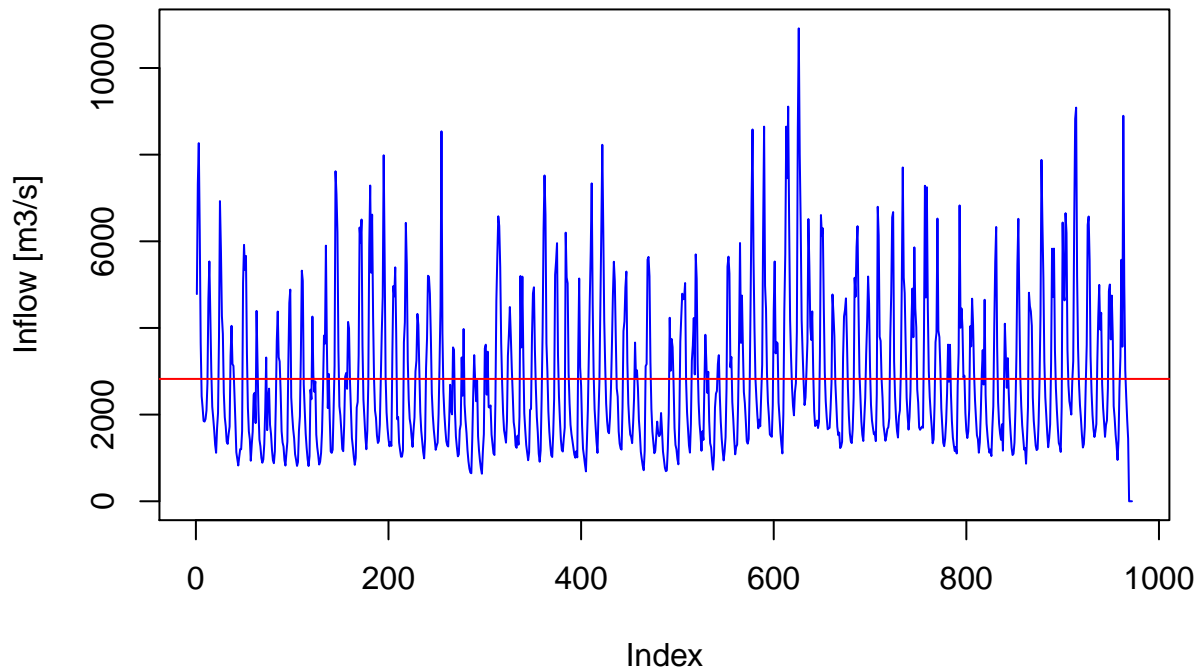
```
plot(inflow_data[, "HP1"], type="l", col="blue", ylab="Inflow [m3/s]")
```



```
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")
```

Historical Inflow Data for HP1

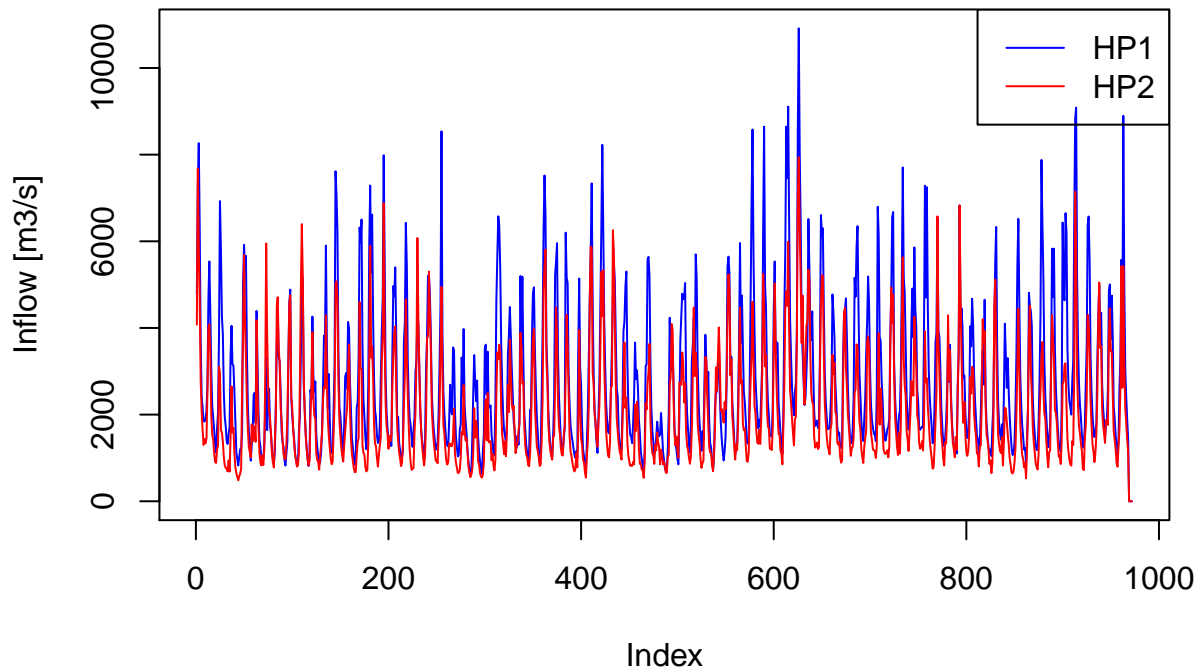


Suppose you want to plot HP1 and HP2 on the same graph.

```
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="Inflow 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"))
```

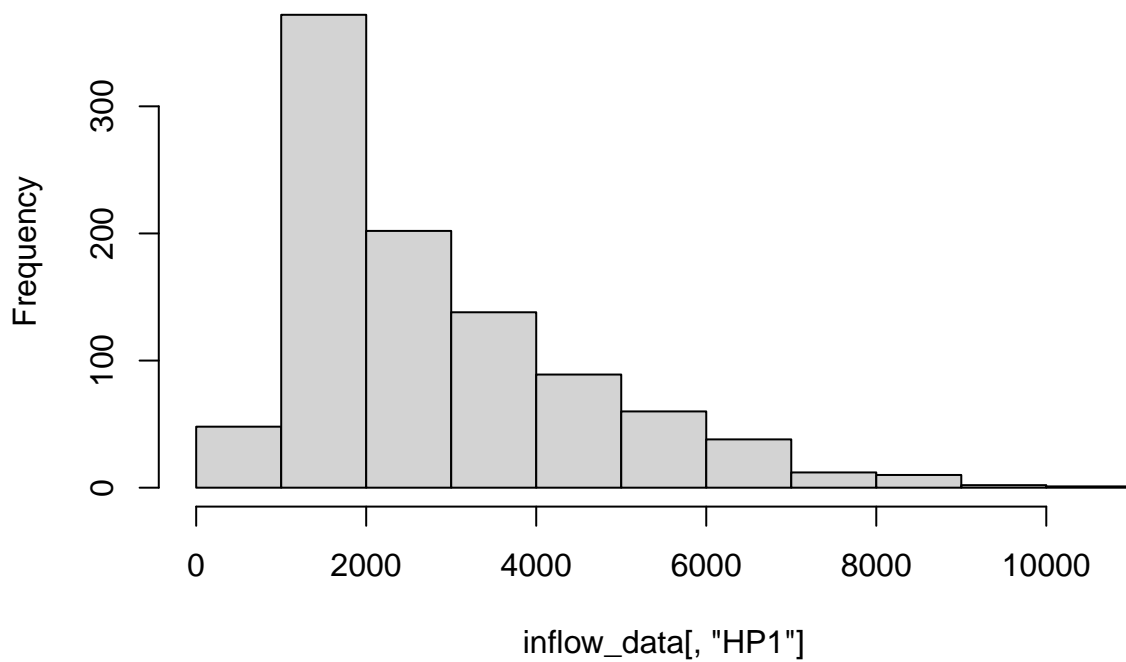
Inflow Series for HP1 and HP2



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

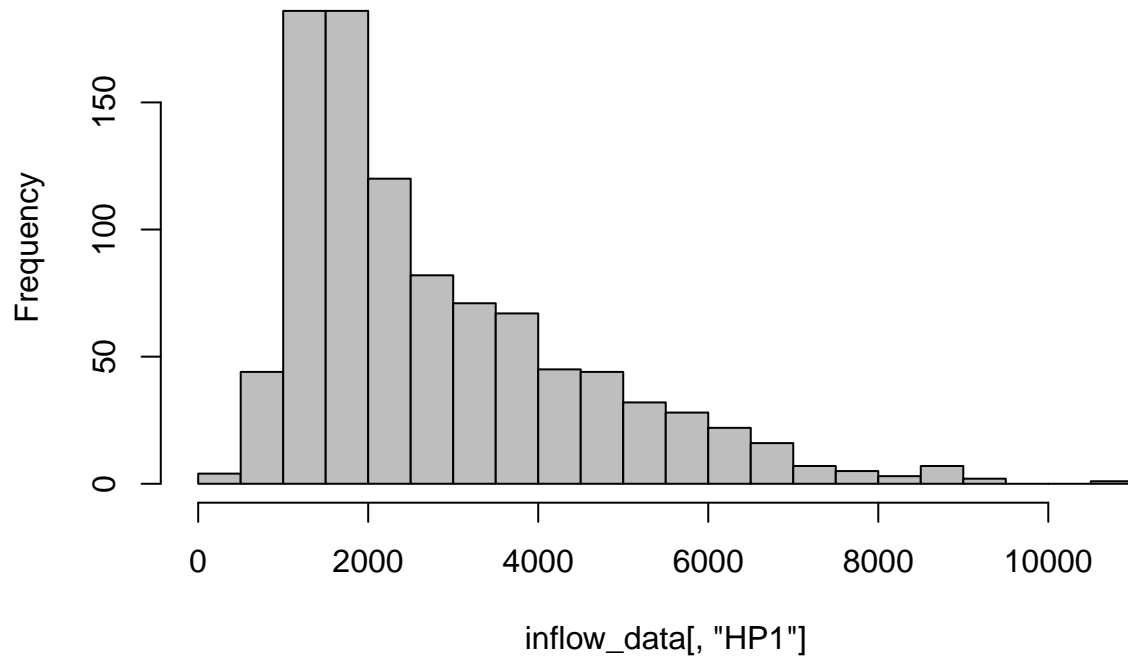
```
#Graph 3: Simple Histogram  
hist(inflow_data[, "HP1"])
```

Histogram of inflow_data[, "HP1"]



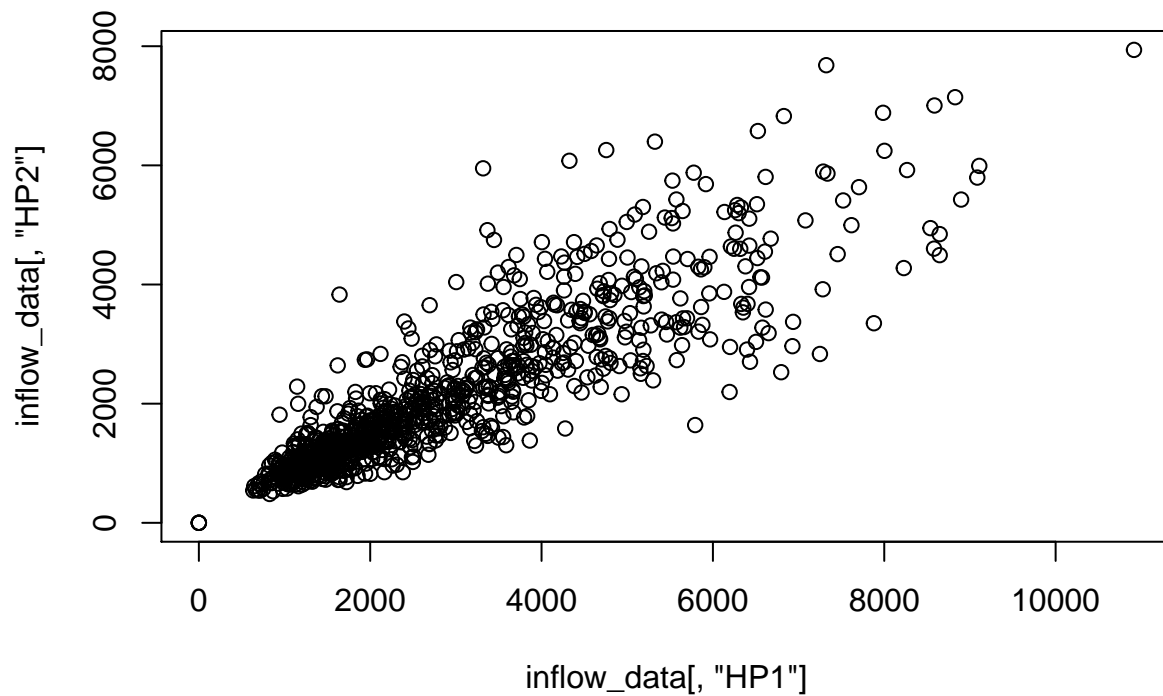
```
hist(inflow_data[, "HP1"], breaks=30, col="gray") #increase number of bars with breaks input
```

Histogram of inflow_data[, "HP1"]



#Graph 4: Scatter Plot of HP1 and HP2

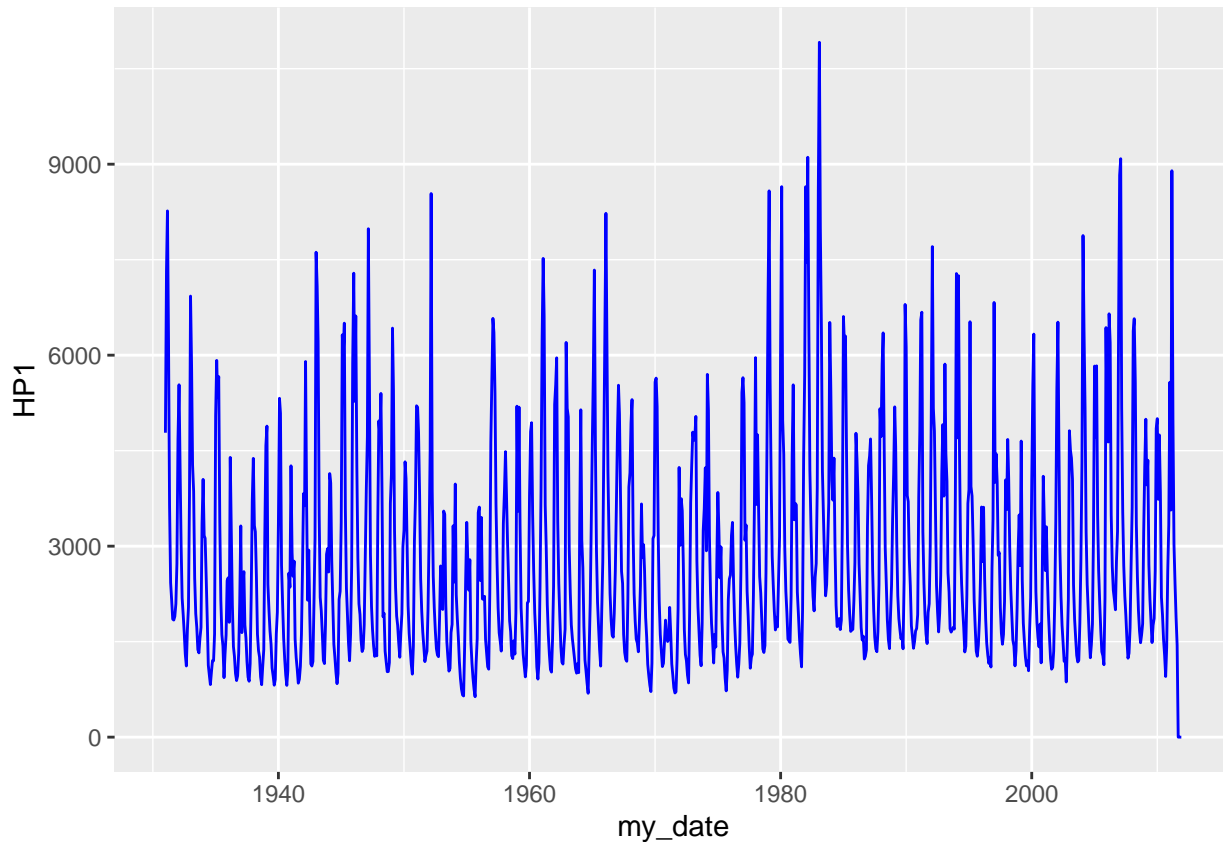
```
plot(inflow_data[, "HP1"], inflow_data[, "HP2"])
```



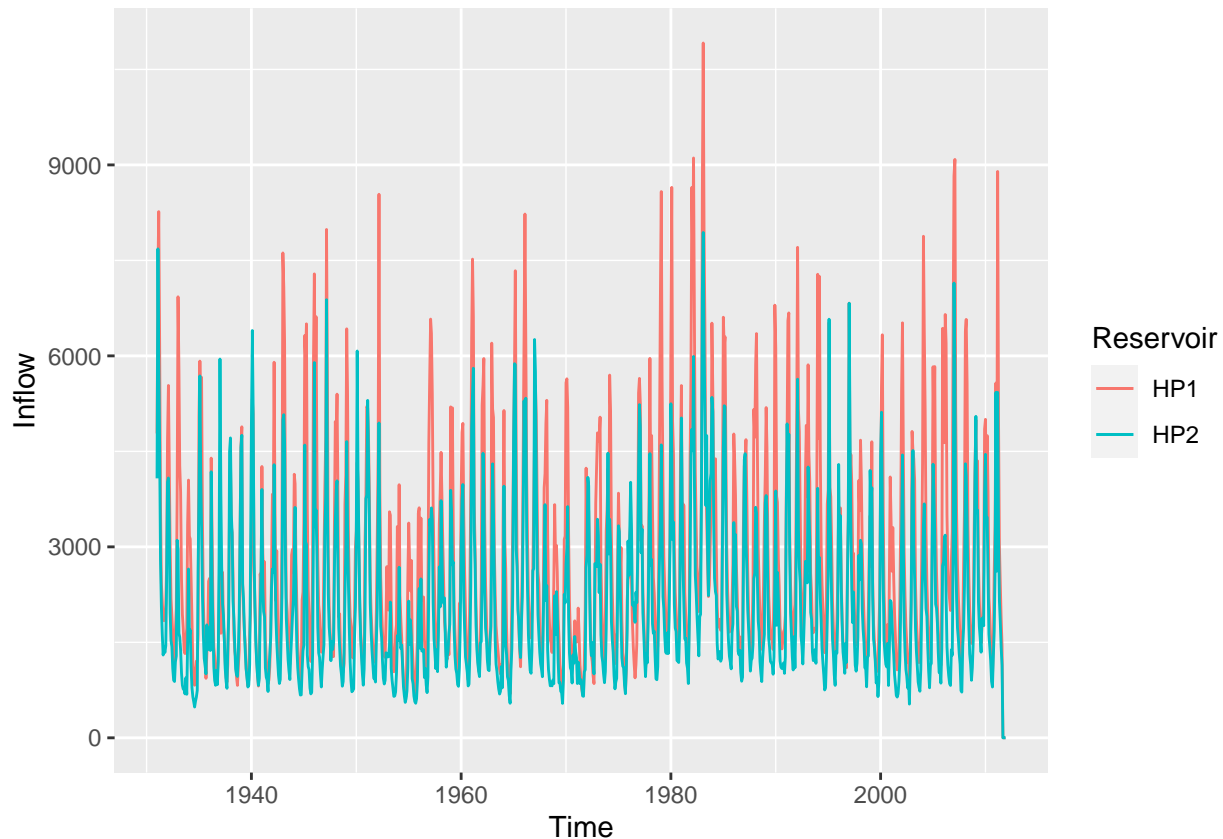
Improving plots with time period information

We could improve the plots generated in the previous sections using another package *ggplot2*. Package *ggplot2* offers better looking plots, additional functionalities, 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.

```
ts_inflow_data <- ts(inflow_data[,2:(2+nhydro-1)]) #note that we are only transforming columns with inf
ts_inflow_data
```

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
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##	359	2350	1354	1176
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##	361	6265	4870	3378
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##	364	3646	3248	2351
##	365	2988	2727	1843
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##	367	1610	1394	913
##	368	1297	1183	902
##	369	1061	1044	984
##	370	1022	962	936
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##	374	5537	4469	2343
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##	378	1875	1551	1171
##	379	1421	1227	1142
##	380	1179	1069	1070
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##	382	1453	1527	1393
##	383	1698	1755	1263
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##	427	1849	1293	962
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##	436	3791	2714	1848
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##	441	1220	1071	793
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##	459	2609	2002	1194
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##	477	1161	1303	996
##	478	1490	1173	970
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562 1305 1178 1387
563 2241 1826 1995
564 3720 3307 3426
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##	620	2207	1578	1411
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##	735	5164	3274	2490
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##	737	3592	2431	1943
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##	789	1254	1486	1662
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##	795	4450	3351	2394
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##	797	2856	1810	1918
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##	823	1260	1192	1412
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853 5463 3161 3248
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874 1206 732 1271
875 1789 1075 1455
876 2763 1965 2000
877 4310 2572 1945
878 7879 3350 2474

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##	919	1911	1328	1431
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```

## 933 1483 904 974
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## 940 4350 3576 1864
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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.