Tutorial for Introductory Analysis of Daily Precipitation Data with hydroTSM

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1 Installation

Installing hydroTSM:

```
> install.packages("hydroTSM")
```

2 Setting Up the Environment

1. Loading the *hydroTSM* library, which contains data and functions used in this analysis.

   ```
   > library(hydroTSM)
   ```

2. Loading daily precipitation data at the station San Martino di Castrozza, Trento Province, Italy, with data from 01/Jan/1921 to 31/Dec/1990.

   ```
   > data(SanMartinoPPts)
   ```

3. Selecting only a 6-years time-slice for the analysis

   ```
   > x <- window(SanMartinoPPts, start=as.Date("1985-01-01"))
   ```

4. Monthly values of precipitation

   ```
   > ( m <- daily2monthly(x, FUN=sum) )
   ```

   ```
   1985-01-01 1985-02-01 1985-03-01 1985-04-01 1985-05-01 1985-06-01 1985-07-01
        141.2        7.0      140.6       72.0      175.6      131.4       85.4
   1985-08-01 1985-09-01 1985-10-01 1985-11-01 1985-12-01 1986-01-01 1986-02-01
        159.4       27.2       58.4      101.8       54.8       75.8      131.6
   1986-03-01 1986-04-01 1986-05-01 1986-06-01 1986-07-01 1986-08-01 1986-09-01
         59.6      237.8      108.2      144.8       81.2      141.0       69.8
   1986-10-01 1986-11-01 1986-12-01 1987-01-01 1987-02-01 1987-03-01 1987-04-01
         38.2       44.4       20.4       46.8      111.0       45.6       98.4
   1987-05-01 1987-06-01 1987-07-01 1987-08-01 1987-09-01 1987-10-01 1987-11-01
        212.0      153.8      221.8      175.0       90.6      278.8      164.8
   1987-12-01 1988-01-01 1988-02-01 1988-03-01 1988-04-01 1988-05-01 1988-06-01
         29.8      118.0       49.8       22.4      100.6      187.4      193.0
   ```

```
1988-07-01 1988-08-01 1988-09-01 1988-10-01 1988-11-01 1988-12-01 1989-01-01
     120.4      149.2       61.2      136.4       10.0       59.4        0.0
1989-02-01 1989-03-01 1989-04-01 1989-05-01 1989-06-01 1989-07-01 1989-08-01
     152.6       46.2      365.4       77.4      241.6      302.8      114.4
1989-09-01 1989-10-01 1989-11-01 1989-12-01 1990-01-01 1990-02-01 1990-03-01
      65.4       12.8      145.0      110.6       51.6       12.4       65.8
1990-04-01 1990-05-01 1990-06-01 1990-07-01 1990-08-01 1990-09-01 1990-10-01
     127.0       74.4      175.0      143.8       90.8      106.0      153.0
1990-11-01 1990-12-01
     326.6      106.0
```

5. Dates of the daily values of 'x'

```
> dates <- time(x)
```

6. Amount of years in 'x' (needed for computations)

```
> ( nyears <- yip(from=start(x), to=end(x), out.type="nmbr" ) )

[1] 6
```

3 Basic Exploratory Data Analysis

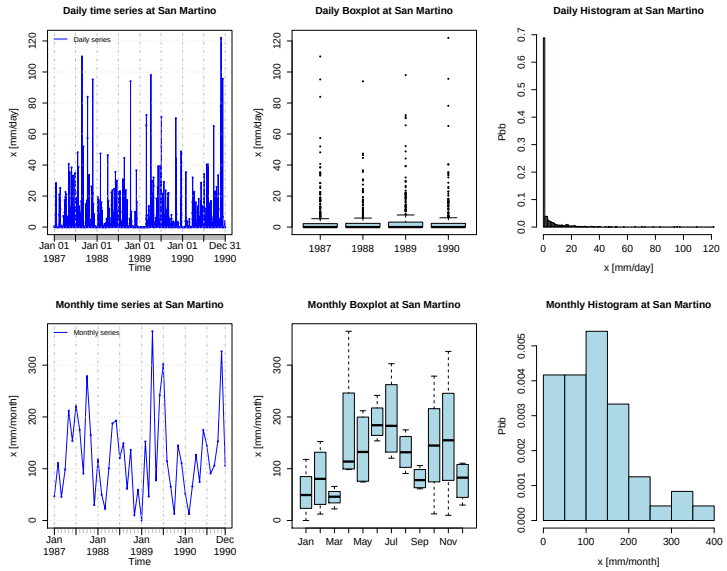
1. Summary statistics

```
> smry(x)
```

```
               Index         x
Min.      1985-01-01    0.0000
1st Qu.   1986-07-02    0.0000
Median    1988-01-01    0.0000
Mean      1988-01-01    3.7470
3rd Qu.   1989-07-01    2.6000
Max.      1990-12-31  122.0000
IQR             <NA>    2.6000
sd              <NA>   10.0428
cv              <NA>    2.6800
Skewness        <NA>    5.3512
Kurtosis        <NA>   39.1619
NA's            <NA>    0.0000
n               <NA> 2191.0000
```

2. Using the *hydroplot* function, which (by default) plots 9 different graphs: 3 ts plots, 3 boxplots and 3 histograms summarizing 'x'. For this example, only daily and monthly plots are produced, and only data starting on 01-Jan-1987 are plotted.

```
> hydroplot(x, var.type="Precipitation", main="at San Martino", pfreq = "dm", from="19
```



3. Amount of days with information (not `NA`) per year

```
> dwi(x)

1985 1986 1987 1988 1989 1990
 365  365  365  366  365  365
```

4. Amount of days with information (not `NA`) per month per year

```
> dwi(x, out.unit="mpy")

     Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
1985  31  28  31  30  31  30  31  31  30  31  30  31
1986  31  28  31  30  31  30  31  31  30  31  30  31
1987  31  28  31  30  31  30  31  31  30  31  30  31
1988  31  29  31  30  31  30  31  31  30  31  30  31
1989  31  28  31  30  31  30  31  31  30  31  30  31
1990  31  28  31  30  31  30  31  31  30  31  30  31
```

5. Plotting the monthly precipitation values for each year, useful for identifying dry/wet months.

```
> # Daily zoo to monthly zoo
> m <- daily2monthly(x, FUN=sum, na.rm=TRUE)
> # Creating a matrix with monthly values per year in each column
> M <- matrix(m, ncol=12, byrow=TRUE)
> colnames(M) <- month.abb
> rownames(M) <- unique(format(time(m), "%Y"))
> # Plotting the monthly precipitation values
> require(lattice)
> matrixplot(M, ColorRamp="Precipitation",
+            main="Monthly precipitation at San Martino st., [mm/month]")
```

4 Annual Analysis

1. Annual values of precipitation

```
> daily2annual(x, FUN=sum, na.rm=TRUE)

  1985   1986   1987   1988   1989   1990
1154.8 1152.8 1628.4 1207.8 1634.2 1432.4
```

2. Average annual precipitation

   Obvious way:

```
> mean( daily2annual(x, FUN=sum, na.rm=TRUE) )

[1] 1368.4
```

   Another way (more useful for streamflows, where `FUN=mean`):

   The function *annualfunction* is applied `FUN` twice over `x`: (i) firstly, over all the elements of `x` belonging to the same year, in order to obtain the corresponding annual values, and (ii) secondly, over all the annual values of `x` previously obtained, in order to obtain a single annual value.

```
> annualfunction(x, FUN=sum, na.rm=TRUE) / nyears

 value
1368.4
```

5 Monthly Analysis

1. Median of the monthly values at station 'x'. Not needed, just for looking at these values in the boxplot.

```
> monthlyfunction(m, FUN=median, na.rm=TRUE)

  Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep   Oct   Nov   Dec
 63.7  80.4  52.9 113.8 141.9 164.4 132.1 145.1  67.6  97.4 123.4  57.1
```

2. Vector with the three-letter abbreviations for the month names

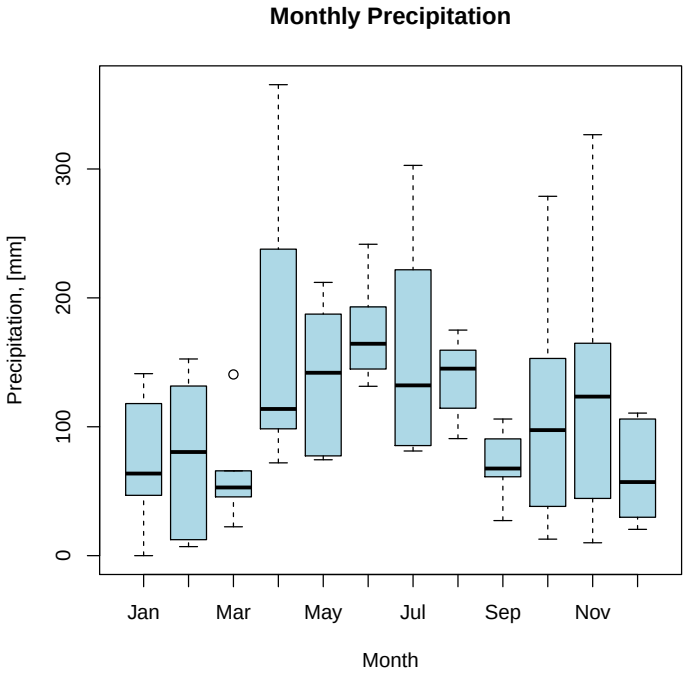
```
> cmonth <- format(time(m), "%b")
```

3. Creating ordered monthly factors

```
> months <- factor(cmonth, levels=unique(cmonth), ordered=TRUE)
```

4. Boxplot of the monthly values

```
> boxplot( coredata(m) ~ months, col="lightblue", main="Monthly Precipitation",
+          ylab="Precipitation, [mm]", xlab="Month")
```



6 Seasonal Analysis

1. Average seasonal values of precipitation

```
> seasonalfunction(x, FUN=sum, na.rm=TRUE) / nyears

     DJF      MAM      JJA      SON
213.1333 369.4000 470.8000 315.0667
```

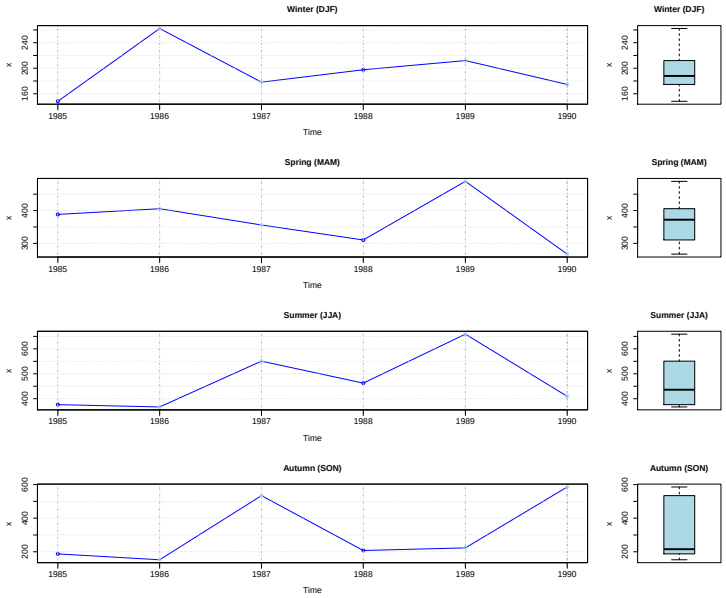
2. Extracting the seasonal values for each year

```
> ( DJF <- dm2seasonal(x, season="DJF", FUN=sum) )

 1985  1986  1987  1988  1989  1990
148.2 262.2 178.2 197.6 212.0 174.6

> ( MAM <- dm2seasonal(m, season="MAM", FUN=sum) )

 1985  1986  1987  1988  1989  1990
388.2 405.6 356.0 310.4 489.0 267.2

> ( JJA <- dm2seasonal(m, season="JJA", FUN=sum) )

 1985  1986  1987  1988  1989  1990
376.2 367.0 550.6 462.6 658.8 409.6

> ( SON <- dm2seasonal(m, season="SON", FUN=sum) )
```

```
 1985  1986  1987  1988  1989  1990
187.4 152.4 534.2 207.6 223.2 585.6
```

3. Plotting the time evolution of the seasonal precipitation values

```
> hydroplot(x, pfreq="seasonal", FUN=sum, stype="default")
```



This tutorial was built under:

```
[1] "x86_64-redhat-linux-gnu (64-bit)"

[1] "R version 2.15.0 (2012-03-30)"

[1] "hydroTSM 0.3-4"
```