Tutorial for Introductory Analysis of Daily Precipitation Data with hydroTSM

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1 Installation

Installing hydroTSM, along with the required and suggested packages:

```
> install.packages("hydroTSM", dependencies = c("Depends", "Suggests"))
```

2 Setting Up the Environment

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

   ```
   > library(hydroTSM)
   ```

2. Loading daily streamflows 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 3-years time-slice for the analysis

   ```
   > x <- window(SanMartinoPPts, start = as.Date("1988-01-01"))
   ```

4. Monthly values of precipitation

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

   1988-01-01 1988-02-01 1988-03-01 1988-04-01 1988-05-01 1988-06-01 1988-07-01
        118.0       49.8       22.4      100.6      187.4      193.0      120.4
   1988-08-01 1988-09-01 1988-10-01 1988-11-01 1988-12-01 1989-01-01 1989-02-01
        149.2       61.2      136.4       10.0       59.4        0.0      152.6
   1989-03-01 1989-04-01 1989-05-01 1989-06-01 1989-07-01 1989-08-01 1989-09-01
         46.2      365.4       77.4      241.6      302.8      114.4       65.4
   1989-10-01 1989-11-01 1989-12-01 1990-01-01 1990-02-01 1990-03-01 1990-04-01
         12.8      145.0      110.6       51.6       12.4       65.8      127.0
   1990-05-01 1990-06-01 1990-07-01 1990-08-01 1990-09-01 1990-10-01 1990-11-01
         74.4      175.0      143.8       90.8      106.0      153.0      326.6
   1990-12-01
        106.0
   ```

5. Dates of the daily values of 'x'

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

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

```
> (nyears <- length(seq(from = dates[1], to = dates[length(dates)],
+     by = "years")))

[1] 3
```

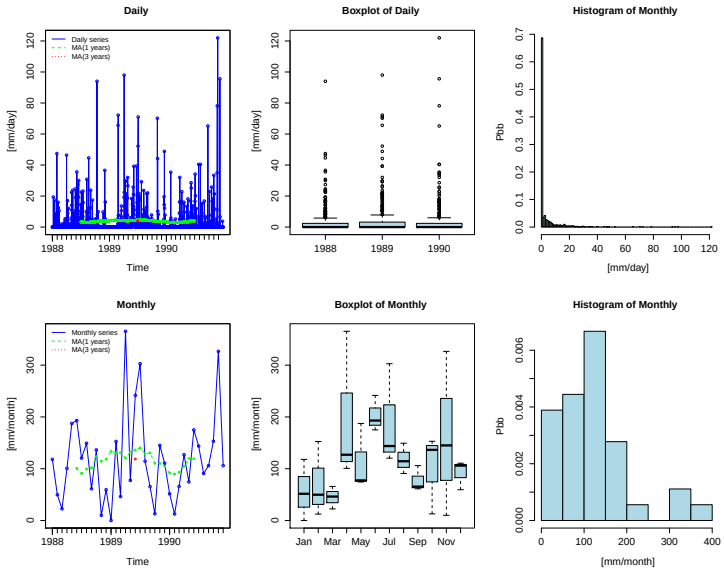
3 Basic Exploratory Data Analysis

1. Summary statistics

```
> smry(x)

              [,1]
Min.        0.0000
1st Qu.     0.0000
Median      0.0000
Mean        3.9000
3rd Qu.     2.6000
Max.      122.0000
IQR         2.6000
sd         10.6220
cv          2.7236
Skewness    5.3426
Kurtosis   38.0635
NA's        0.0000
n        1096.0000
```

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)

```
> hydroplot(x, var.type = "Precipitation", sname = "San Martino",
+     pfreq = "dm")
```



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

```
> dwi(x)

1988 1989 1990
 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
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.

```
> m <- daily2monthly(x, FUN = sum, na.rm = TRUE)
> M <- matrix(m, ncol = 12, byrow = TRUE)
> colnames(M) <- month.abb
> rownames(M) <- unique(format(time(m), "%Y"))
> require(lattice)
> matrixplot(M, ColorRamp = "Precipitation", main = "Monthly precipitation at San Mar
```

4 Annual Analysis

1. Annual Values

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

```
  1988   1989   1990
1207.8 1634.2 1432.4
```

2. Average Annual Precipitation

   Obvious way:

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

   [1] 1424.8
   ```

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

   The function *annualfunction* applies `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
   1424.8
   ```

5 Monthly Analysis

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

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

     Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep   Oct   Nov   Dec
    51.6  49.8  46.2 127.0  77.4 193.0 143.8 114.4  65.4 136.4 145.0 106.0
   ```

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

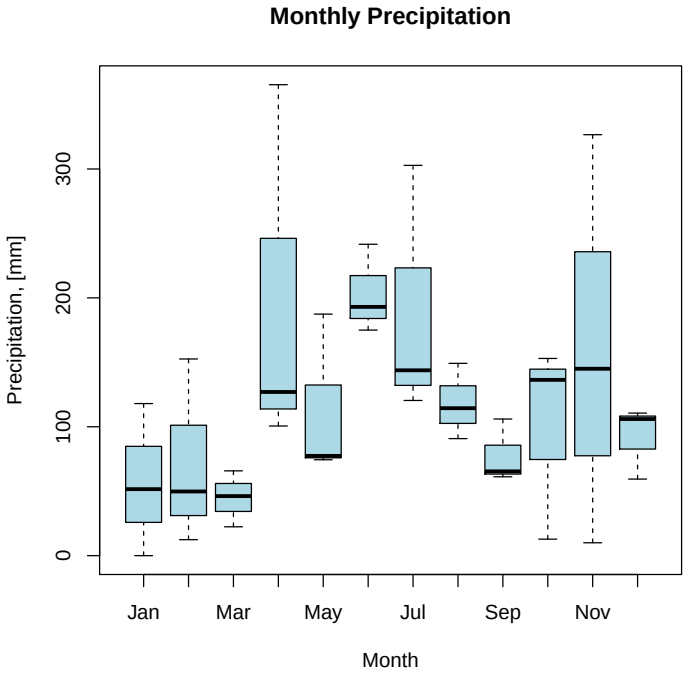
   ```
   > cmonth <- format(time(m), "%b")
   ```

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
184.8000 355.5333 510.3333 338.8000
```

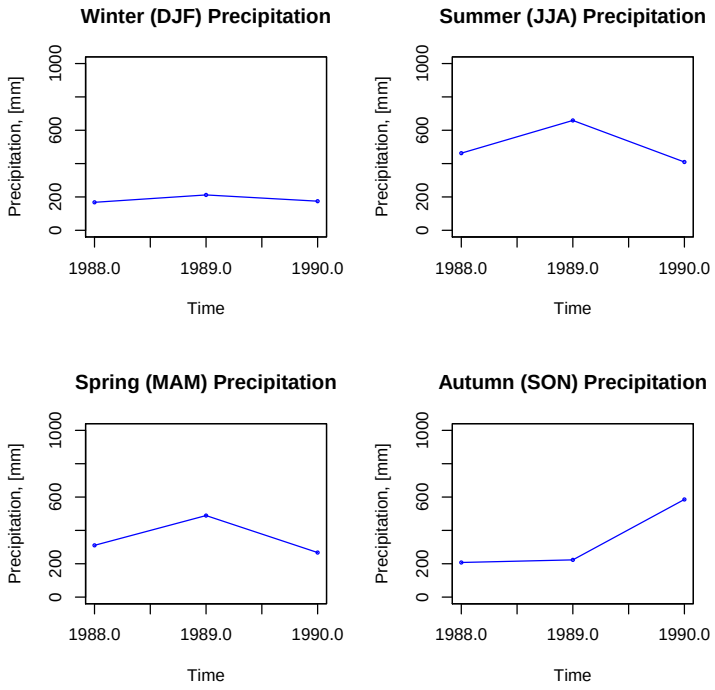
2. Extracting the seasonal values for each year

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

 1988  1989  1990
167.8 212.0 174.6

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

 1988  1989  1990
310.4 489.0 267.2

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

 1988  1989  1990
462.6 658.8 409.6

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

```
 1988  1989  1990
207.6 223.2 585.6
```

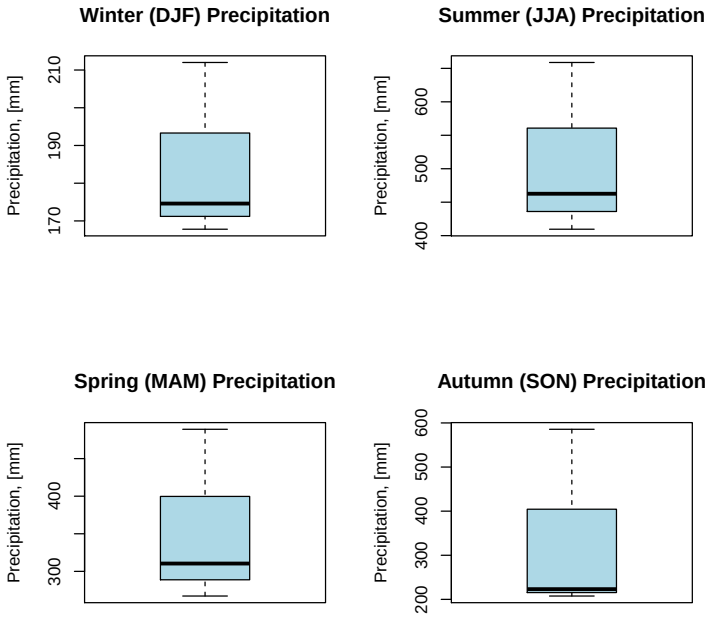
3. Plotting the time evolution of the seasonal precipitation values

```
> par(mfcol = c(2, 2))
> plot(DJF, type = "o", cex = 0.4, col = "blue", xlab = "Time",
+     ylab = "Precipitation, [mm]", ylim = c(0, 1000), main = "Winter (DJF) Precipitat
> plot(MAM, type = "o", cex = 0.4, col = "blue", xlab = "Time",
+     ylab = "Precipitation, [mm]", ylim = c(0, 1000), main = "Spring (MAM) Precipitat
> plot(JJA, type = "o", cex = 0.4, col = "blue", xlab = "Time",
+     ylab = "Precipitation, [mm]", ylim = c(0, 1000), main = "Summer (JJA) Precipitat
> plot(SON, type = "o", cex = 0.4, col = "blue", xlab = "Time",
+     ylab = "Precipitation, [mm]", ylim = c(0, 1000), main = "Autumn (SON) Precipitat
```



4. Boxplots of the seasonal precipitation values of each year

```
> par(mfcol = c(2, 2))
> boxplot(coredata(DJF), col = "lightblue", ylab = "Precipitation, [mm]",
+     main = "Winter (DJF) Precipitation")
> boxplot(coredata(MAM), col = "lightblue", ylab = "Precipitation, [mm]",
+     main = "Spring (MAM) Precipitation")
> boxplot(coredata(JJA), col = "lightblue", ylab = "Precipitation, [mm]",
+     main = "Summer (JJA) Precipitation")
> boxplot(coredata(SON), col = "lightblue", ylab = "Precipitation, [mm]",
+     main = "Autumn (SON) Precipitation")
```


Winter (DJF) Precipitation
Precipitation, [mm]
170
190
210
Summer (JJA) Precipitation
Precipitation, [mm]
400
500
600
Spring (MAM) Precipitation
Precipitation, [mm]
300
400
Autumn (SON) Precipitation
Precipitation, [mm]
200
300
400
500
600