ΠΜΣ «Διαχείριση Υδρομετεωρολογικών Καταστροφών»

ΡΟΕΣ ΥΠΟΛΕΙΜΜΑΤΩΝ ΚΑΙ ΠΑΡΑΚΤΙΕΣ ΠΛΗΜΜΥΡΕΣ: ΕΝΝΟΙΕΣ ΚΙΝΔΥΝΟΥ ΕΥΠΑΘΕΙΑΣ ΚΑΙ ΕΛΑΣΤΙΚΟΤΗΤΑΣ

Διάλεξη 3

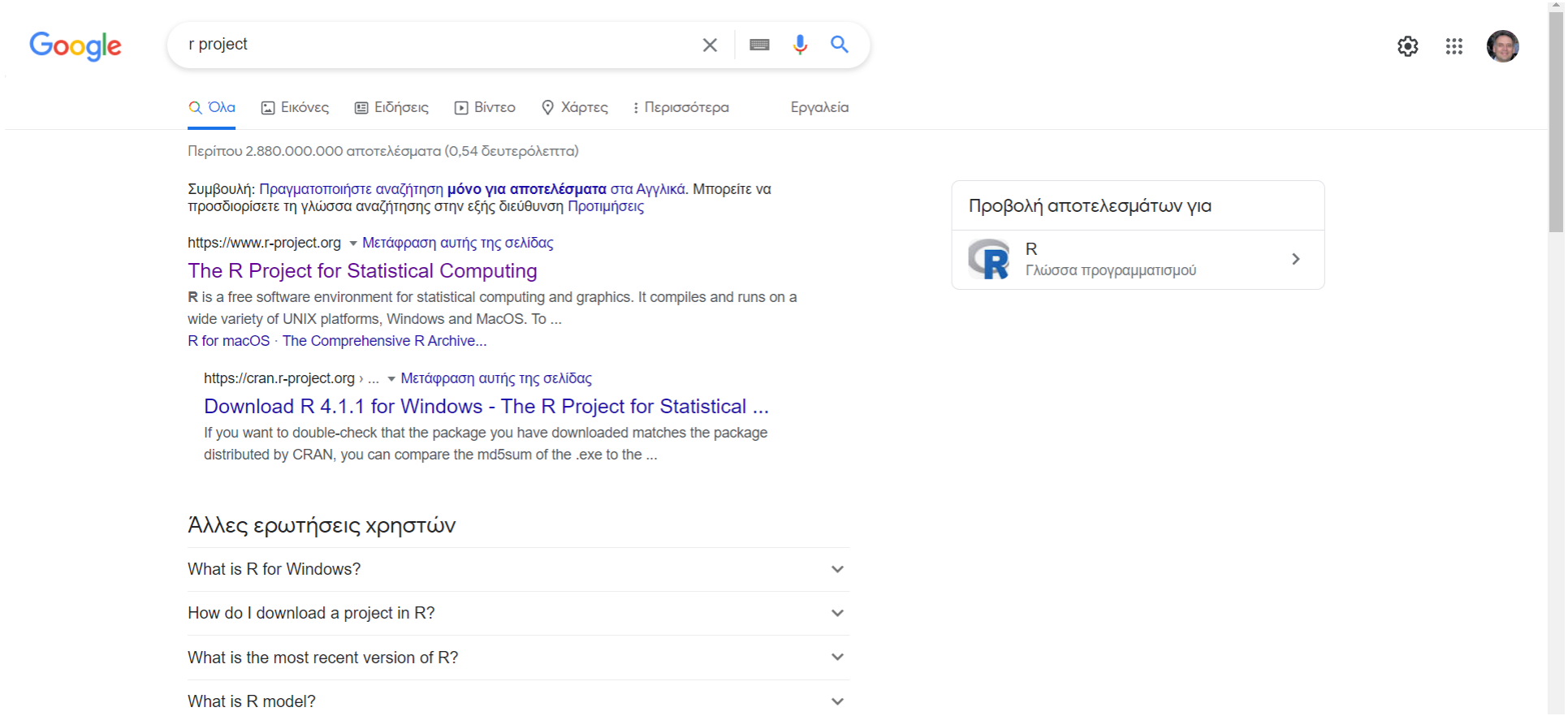
Ανάλυση Βροχομετρικών Δεδομένων με την Χρήση της Γλώσσας Προγραμματισμού R

Καθηγητής ΔΠΘ Γεώργιος Συλαίος

Τηλέφωνο 25410 79398, Mail: gsylaios@env.duth.gr ή skype: gsylaios

ΑΝΑΛΥΣΗ ΔΕΔΟΜΕΝΩΝ ΒΡΟΧΟΠΤΩΣΗΣ ΜΕ ΤΗΝ ΧΡΗΣΗ ΤΗΣ ΓΛΩΣΣΑΣ ΠΡΟΓΡΑΜΜΑΤΙΣΜΟΥ R

Πως εγκαθιστώ την R στον Η/Υ μου?



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The R Project for Statistical Computing

Getting Started

R is a free software environment for statistical computing and graphics. It compiles and runs on a wide variety of UNIX platforms, Windows and MacOS. To **download R**, please choose your preferred CRAN mirror.

If you have questions about R like how to download and install the software, or what the license terms are, please read our answers to frequently asked questions before you send an email.

News

- **R version 4.1.2 (Bird Hippie) prerelease versions** will appear starting Friday 2021-10-22. Final release is scheduled for Monday 2021-11-01.
- **R version 4.1.1 (Kick Things)** has been released on 2021-08-10.
- **R version 4.0.5 (Shake and Throw)** was released on 2021-03-31.
- Thanks to the organisers of useR! 2020 for a successful online conference. Recorded tutorials and talks from the conference are available on the R Consortium YouTube channel.
- You can support the R Foundation with a renewable subscription as a supporting member

News via Twitter

The R Foundation Retweeted

Henrik Bengtsson
@henrikbengtsson
Analogously to the win-builder, there's now an 'R MAC Builder' with "the same setup and available packages as the CRAN M1 build machine"mac.r-project.org/macbuilder/sub…#RStats macOS M1

Sep 24, 2021

El Salvador	
http://cran.salud.gob.sv/	Ministry of Health (Ministerio de Salud)
Estonia	
https://ftp.eenet.ee/pub/cran/	EENet
France	
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Germany	
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Iceland	
https://cran.hafro.is/	Marine Research Institute
India	
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Indonesia	
https://repo.bppt.go.id/cran/	Agency for The Application and Assessment of Technology
Iran	
https://cran.um.ac.ir/	Ferdowsi University of Mashhad
Italy	
https://cran.mirror.garr.it/CRAN/	Garr Mirror, Milano
https://cran.stat.unipd.it/	University of Padua
Japan	
https://cran.ism.ac.jp/	The Institute of Statistical Mathematics, Tokyo

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The Comprehensive R Archive Network

Download and Install R

Precompiled binary distributions of the base system and contributed packages, **Windows and Mac** users most likely want one of these versions of R:

- Download R for Linux
- Download R for (Mac) OS X
- Download R for Windows

R is part of many Linux distributions, you should check with your Linux package management system in addition to the link above.

Source Code for all Platforms

Windows and Mac users most likely want to download the precompiled binaries listed in the upper box, not the source code. The sources have to be compiled before you can use them. If you do not know what this means, you probably do not want to do it!

- The latest release (2018-07-02, Feather Spray) R-3.5.1.tar.gz, read what's new in the latest version.
- Sources of R alpha and beta releases (daily snapshots, created only in time periods before a planned release).
- Daily snapshots of current patched and development versions are available here. Please read about new features and bug fixes before filing corresponding feature requests or bug reports.
- Source code of older versions of R is available here.
- Contributed extension packages

Questions About R

- If you have questions about R like how to download and install the software, or what the license terms are, please read our answers to frequently asked questions before you send an email.

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R for Windows

Subdirectories:

base	Binaries for base distribution. This is what you want to **install R for the first time**.
contrib	Binaries of contributed CRAN packages (for R >= 2.13.x; managed by Uwe Ligges). There is also information on third party software available for CRAN Windows services and corresponding environment and make variables.
old contrib	Binaries of contributed CRAN packages for outdated versions of R (for R < 2.13.x; managed by Uwe Ligges).
Rtools	Tools to build R and R packages. This is what you want to build your own packages on Windows, or to build R itself.

Please do not submit binaries to CRAN. Package developers might want to contact Uwe Ligges directly in case of questions / suggestions related to Windows binaries.

You may also want to read the R FAQ and R for Windows FAQ.

Note: CRAN does some checks on these binaries for viruses, but cannot give guarantees. Use the normal precautions with downloaded executables.

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R-4.1.1 for Windows (32/64 bit)

Download R 4.1.1 for Windows (86 megabytes, 32/64 bit)
Installation and other instructions
New features in this version

If you want to double-check that the package you have downloaded matches the package distributed by CRAN, you can compare the md5sum of the .exe to the fingerprint on the master server. You will need a version of md5sum for windows: both graphical and command line versions are available.

Frequently asked questions

- Does R run under my version of Windows?
- How do I update packages in my previous version of R?
- Should I run 32-bit or 64-bit R?

Please see the R FAQ for general information about R and the R Windows FAQ for Windows-specific information.

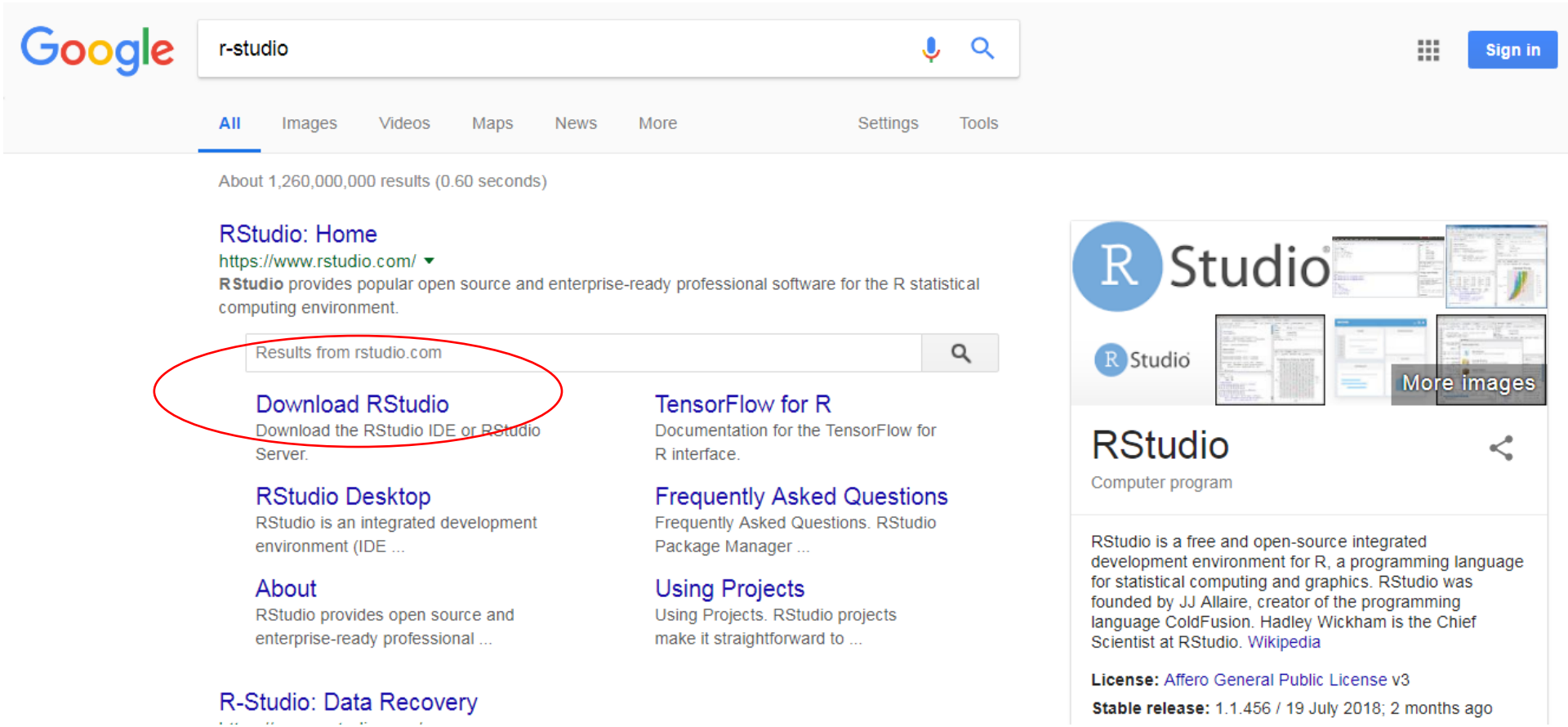
Other builds

- Patches to this release are incorporated in the r-patched snapshot build.
- A build of the development version (which will eventually become the next major release of R) is available in the r-devel snapshot build.
- Previous releases

Note to webmasters: A stable link which will redirect to the current Windows binary release is <CRAN MIRROR>/bin/windows/base/release.html.

Last change: 2021-08-10

Πως εγκαθιστώ το R-studio στον Η/Υ μου?



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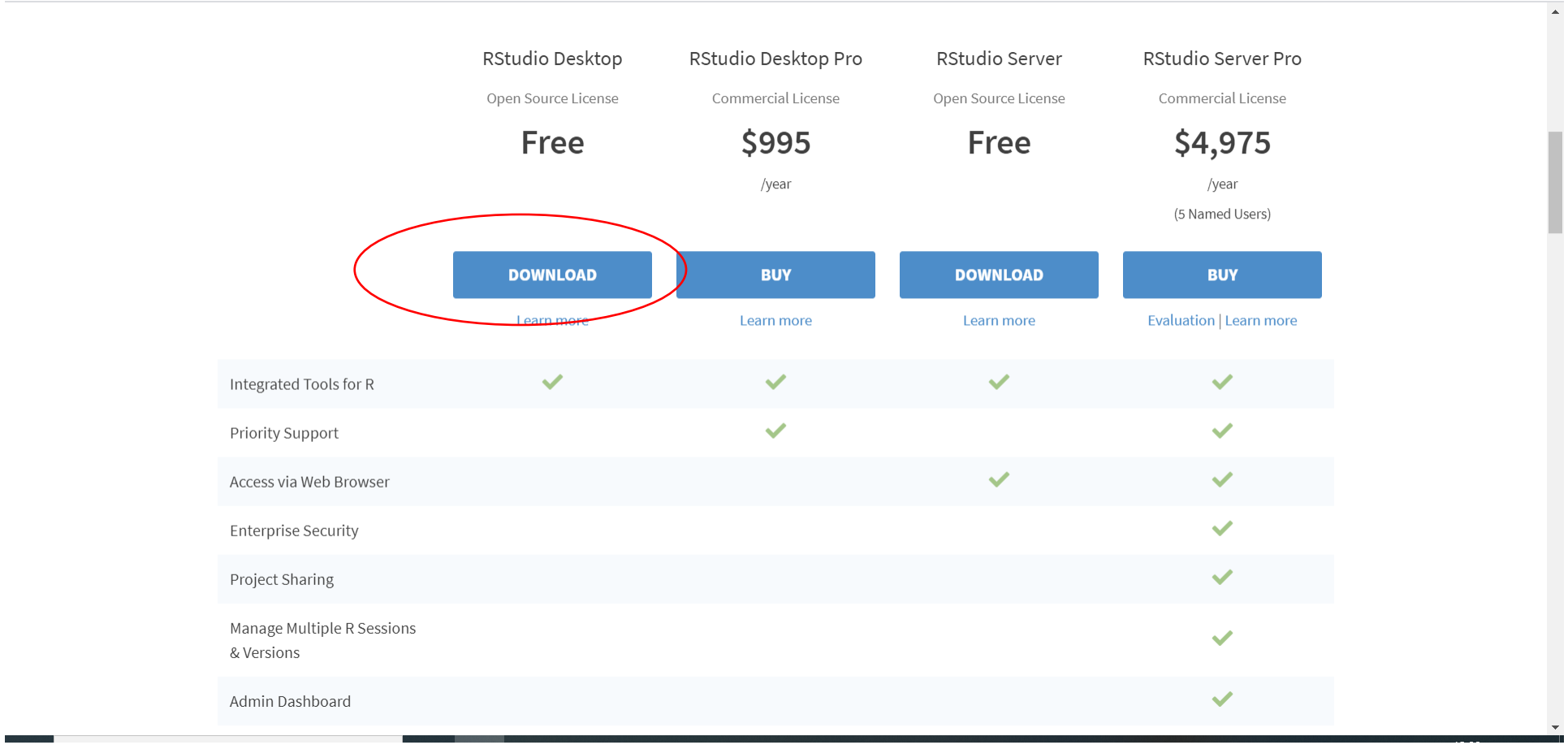
RStudio is a set of integrated tools designed to help you be more productive with R. It includes a console, syntax-highlighting editor that supports direct code execution, and a variety of robust tools for plotting, viewing history, debugging and managing your workspace.

RStudio's new solution for every professional data science team. RStudio Team includes RStudio Server Pro, RStudio Connect and RStudio Package Manager.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Evaluation | Learn more
Integrated Tools for R
Priority Support
Access via Web Browser
Enterprise Security
Project Sharing
Manage Multiple R Sessions & Versions
Admin Dashboard

RStudio Desktop 2021.09.0+351 - Release Notes

1. Install R. RStudio requires R 3.0.1+.

2. Download RStudio Desktop. Recommended for your system:

DOWNLOAD RSTUDIO FOR WINDOWS
2021.09.0+351 | 156.88MB

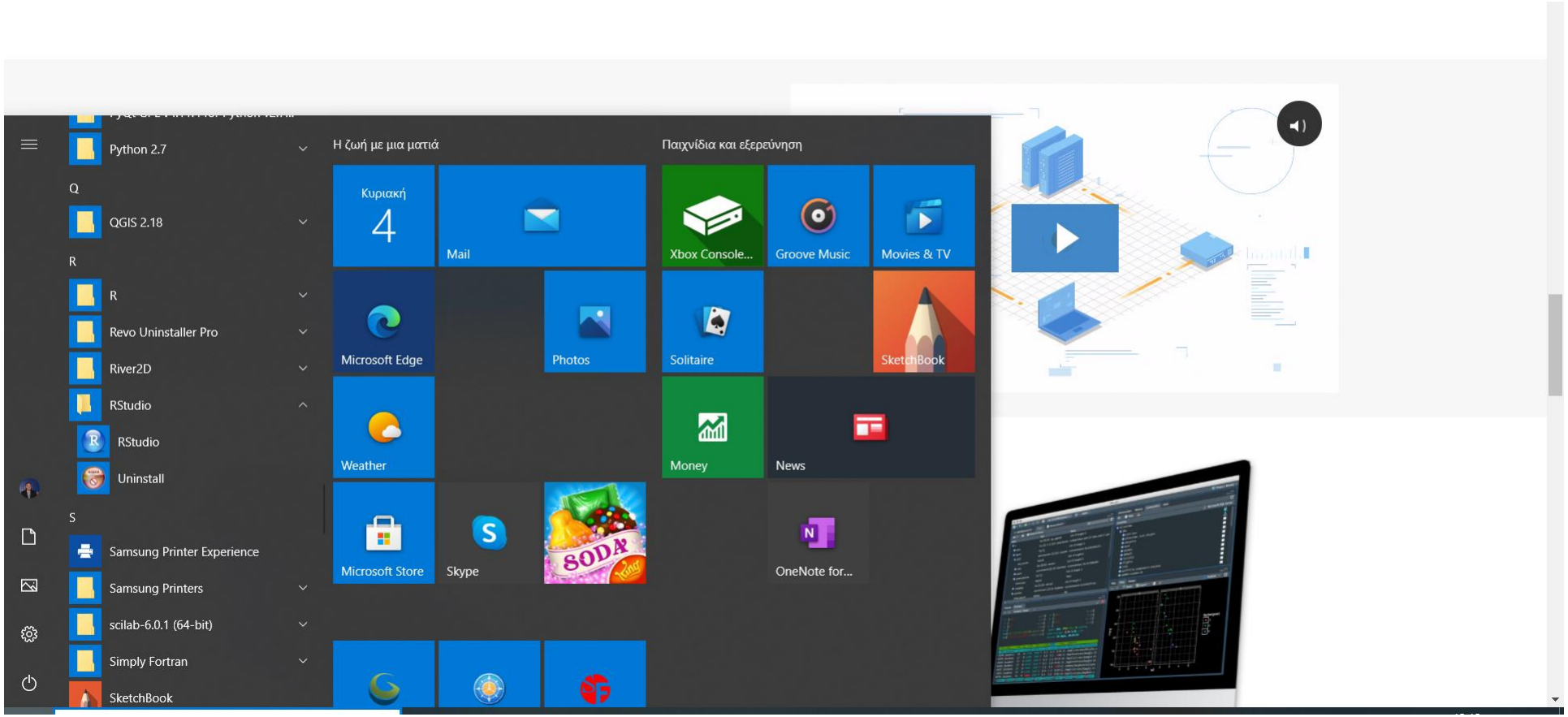
Requires Windows 10 (64-bit)

All Installers

Linux users may need to import RStudio's public code-signing key prior to installation, depending on the operating system's security policy.

RStudio requires a 64-bit operating system. If you are on a 32 bit system, you can use an older version of RStudio.

OS	Download	Size	SHA-256
Windows 10	RStudio-2021.09.0-351.exe	156.88 MB	f698d4a2


Python 2.7
Q
QGIS 2.18
R
R
Revo Uninstaller Pro
River2D
RStudio
RStudio
Uninstall
S
Samsung Printer Experience
Samsung Printers
scilab-6.0.1 (64-bit)
Simply Fortran
SketchBook
Η ζωή με μια ματιά
Κυριακή
4
Mail
Microsoft Edge
Photos
Weather
Microsoft Store
Skype
Παιχνίδια και εξερεύνηση
Xbox Console...
Groove Music
Movies & TV
Solitaire
SketchBook
Money
News
OneNote for...

Προσδιορισμός αριθμητικού μέσου και διαμέσου διανύσματος με την R

```
> x = c(1,2,3,4,5)
> mean(x)
[1] 3
```

Προσδιορίζω το μήκος του διανύσματος, δηλαδή τον αριθμό των στοιχείων του διανύσματος (n) με την συνάρτηση length:

```
> length(x)
[1] 5
```

Προσδιορίζω τον τετριμμένο αριθμητικό μέσο του διανύσματος με τη χρήση της συνάρτησης mean και την επιλογή trim:

```
> y = c(1,5,9,12,15,28)
> mean(y)
[1] 11.66667
> mean(y,0.33)
[1] 10.25
```

Στατιστική Ανάλυση Δείγματος με την Γλώσσα R

Έστω ότι κάνουμε δειγματοληψία σε μία σειρά θέσεων κατά μήκος ενός ποταμού, και μετά την εργαστηριακή ανάλυση προσδιορίσαμε τις παρακάτω συγκεντρώσεις διαλυμένου οξυγόνου (σε mg/l):

8.47, 6.08, 9.57, 12.18, 7.60, 9.67, 9.39, 10.83, 10.46, 10.55, 8.37, 10.58, 9.42, 7.95, 11.86

Για να δημιουργήσουμε διάνυσμα με τα δεδομένα στην R γράφουμε την εντολή:
> DO = c(8.47, 6.08, 9.57, 12.18, 7.60, 9.67, 9.39, 10.83, 10.46, 10.55, 8.37, 10.58, 9.42, 7.95, 11.86)

Για την ελάχιστη τιμή

> min(DO)

[1] 6.08

και την μέγιστη τιμή

> max(DO)

[1] 12.18

Η συνάρτηση range() επιστρέφει δύο τιμές – την ελάχιστη και την μέγιστη
> range(DO)

[1] 6.08 12.18

Οπότε γράφουμε
>range.DO = max(DO)-min(DO)

Στατιστική Ανάλυση Δείγματος με την Γλώσσα R

Έστω ότι κάνουμε δειγματοληψία σε μία σειρά θέσεων κατά μήκος ενός ποταμού, και μετά την εργαστηριακή ανάλυση προσδιορίσαμε τις παρακάτω συγκεντρώσεις διαλυμένου οξυγόνου (σε mg/l):

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> range(DO)

[1] 6.08 12.18

Οπότε γράφουμε
>range.DO = max(DO)-min(DO)

Υπολογισμός Τυπικής Απόκλισης

```
> DO = c(8.47, 6.08, 9.57, 12.18, 7.60, 9.67, 9.39, 10.83, 10.46, 10.55, 8.37, 10.58, 9.42, 7.95, 11.86)
> mean(DO)
[1] 9.532
> DO-mean(DO)
 [1] -1.062 -3.452  0.038  2.648 -1.932  0.138 -0.142  1.298
 [9]  0.928  1.018 -1.162  1.048 -0.112 -1.582  2.328
> (DO-mean(DO))^2
 [1]  1.127844 11.916304  0.001444  7.011904  3.732624  0.019044
 [7]  0.020164  1.684804  0.861184  1.036324  1.350244  1.098304
[13]  0.012544  2.502724  5.419584
> sum((DO-mean(DO))^2)
[1] 37.79504
> (sum((DO-mean(DO))^2))/(length(DO)-1)
[1] 2.699646
> sqrt((sum((DO-mean(DO))^2))/(length(DO)-1))
[1] 1.64306
```

Υπολογισμός Τυπικής Απόκλισης

```
> DO = c(8.47, 6.08, 9.57, 12.18, 7.60, 9.67, 9.39, 10.83, 10.46, 10.55, 8.37, 10.58, 9.42, 7.95, 11.86)
> mean.DO = mean(DO)
[1] 9.532
> term1 = DO-mean(DO)
 [1] -1.062 -3.452  0.038  2.648 -1.932  0.138 -0.142  1.298
 [9]  0.928  1.018 -1.162  1.048 -0.112 -1.582  2.328
> term2 = term1^2
 [1]  1.127844 11.916304  0.001444  7.011904  3.732624  0.019044
 [7]  0.020164  1.684804  0.861184  1.036324  1.350244  1.098304
[13]  0.012544  2.502724  5.419584
> term3 = sum(term2)
[1] 37.79504
> term4 = term3/(length(DO)-1)
[1] 2.699646
> term5 = sqrt(term4)
[1] 1.64306
```

Υπολογισμός Τυπικής Απόκλισης

```
DO = c(8.47, 6.08, 9.57, 12.18, 7.60, 9.67, 9.39, 10.83, 10.46, 10.55, 8.37, 10.58, 9.42, 7.95, 11.86)
mean.DO = mean(DO)  #
term1 = DO-mean.DO
term2 = term1^2
term3 = sum(term2)
term4 = term3/(length(DO)-1)
term5 = sqrt(term4)
sd = term5
```

Συναρτήσεις Ανάλυσης Δεδομένων

mean(x) – αριθμητικός μέσος
mean(x,0.10) – τετριμμένος μέσος
median(x) – διάμεσος
mlv(x) – συχνότερα εμφανιζόμενη τιμή – απαιτεί εγκατάσταση του πακέτου modeest
min(x) – ελάχιστη τιμή
max(x) – μέγιστη τιμή
range(x) – ελάχιστη και μέγιστη τιμή
sd(x) – τυπική απόκλιση
var(x) – διακύμανση
IQR(x) – ενδοτεταρτομοριακό εύρος
sum(x) – άθροισμα όρων διανύσματος
length(x) – μέγεθος διανύσματος
sqrt(x) – τετραγωνική ρίζα
summary(x) – περίληψη στατιστικών χαρακτηριστικών δεδομένων

Το πακέτο hydroTSM της R

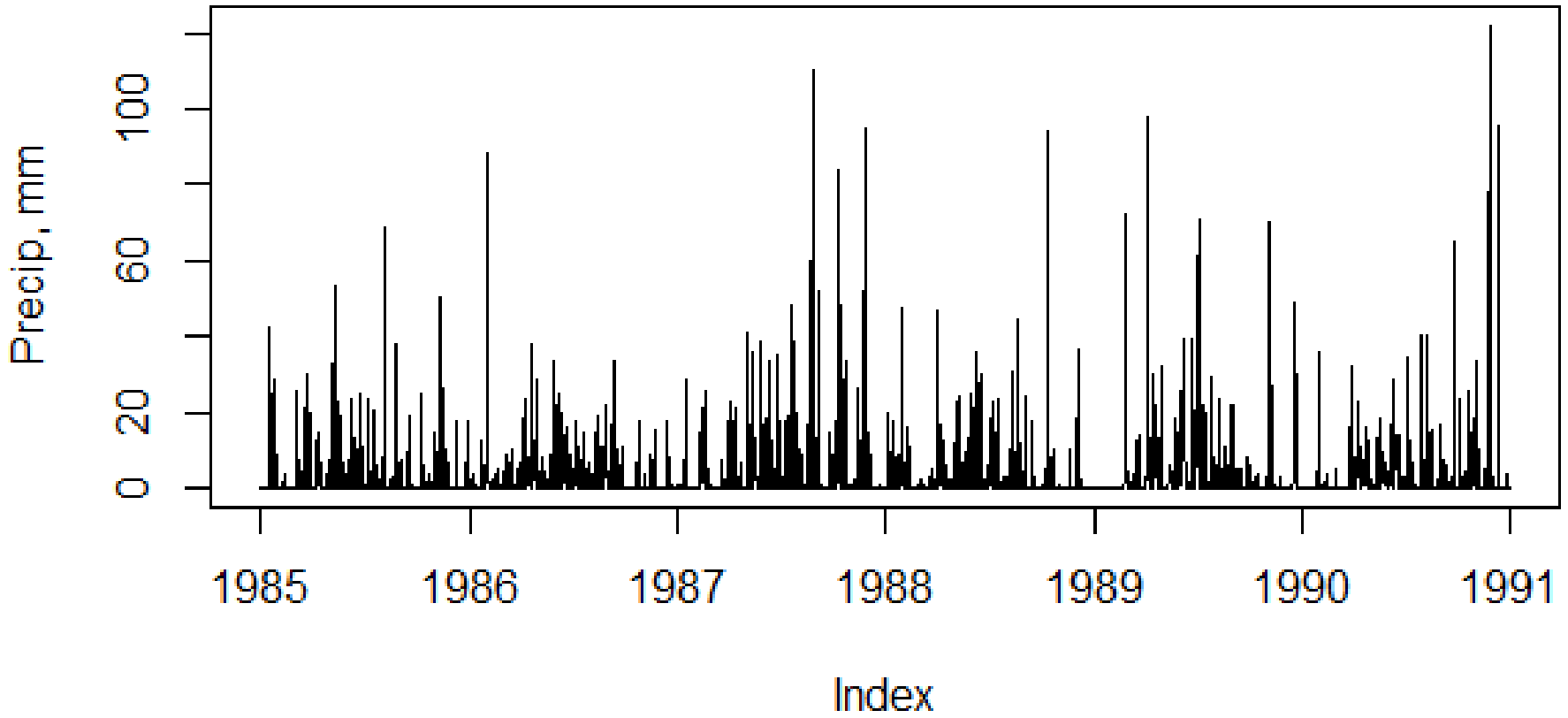
Το πακέτο hydroTSM είναι ένα βασικό εργαλείο ανάλυσης υδρολογικών δεδομένων στην R.

Κυρίως χρησιμοποιείται για την ανάλυση δεδομένων:
α) βροχόπτωσης
β) παροχής ποταμών

Όπως τα περισσότερα πακέτα της R το hydroTSM διαθέτει έτοιμα ενσωματωμένα δεδομένα ώστε ο χρήστης να αναλύσει και να εκπαιδευτεί στην χρήση του πακέτου.

Σήμερα θα αναλύσουμε το ενσωματωμένο σετ δεδομένων ημερήσιας βροχόπτωσης από έναν μετεωρολογικό σταθμό που ονομάζεται SanMartinoPPts

Άλλα ενσωματωμένα σετ δεδομένων είναι: EbroPPtsMonthly (μηνιαία δεδομένα βροχόπτωσης από την λεκάνη απορροής του ποταμού Ebro στην Ισπανία), OcaEnOnaQts (ημερήσια δεδομένα ποτάμιας παροχής από την λεκάνη του ποταμού Ebro).


Precip, mm
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20
60
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1985
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1987
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1989
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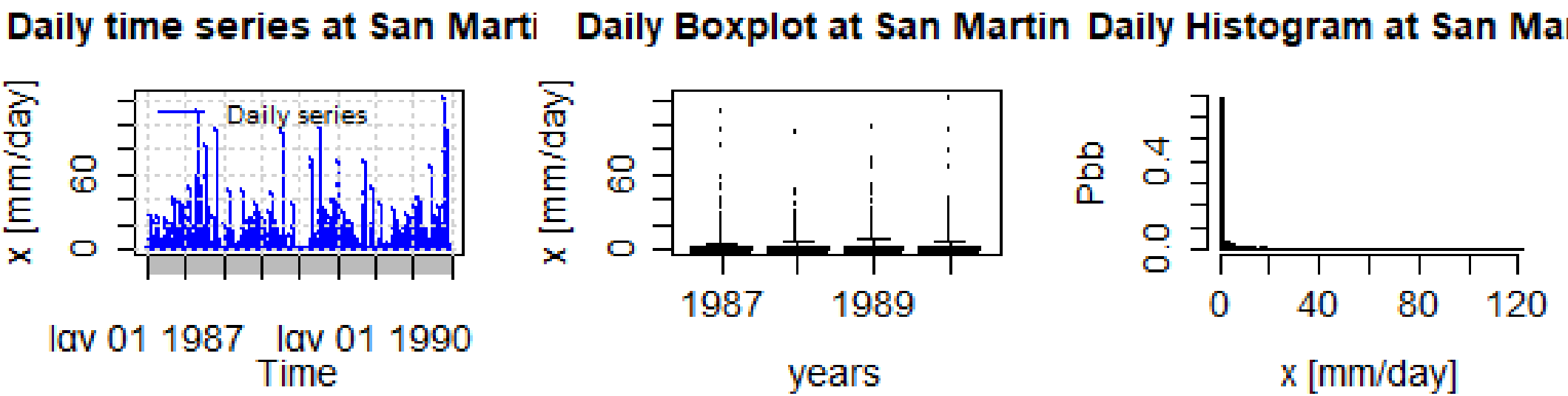
1991
Index


Daily time series at San Marti
Daily Boxplot at San Martin
Daily Histogram at San Marti
Daily series
x [mm/day]
0
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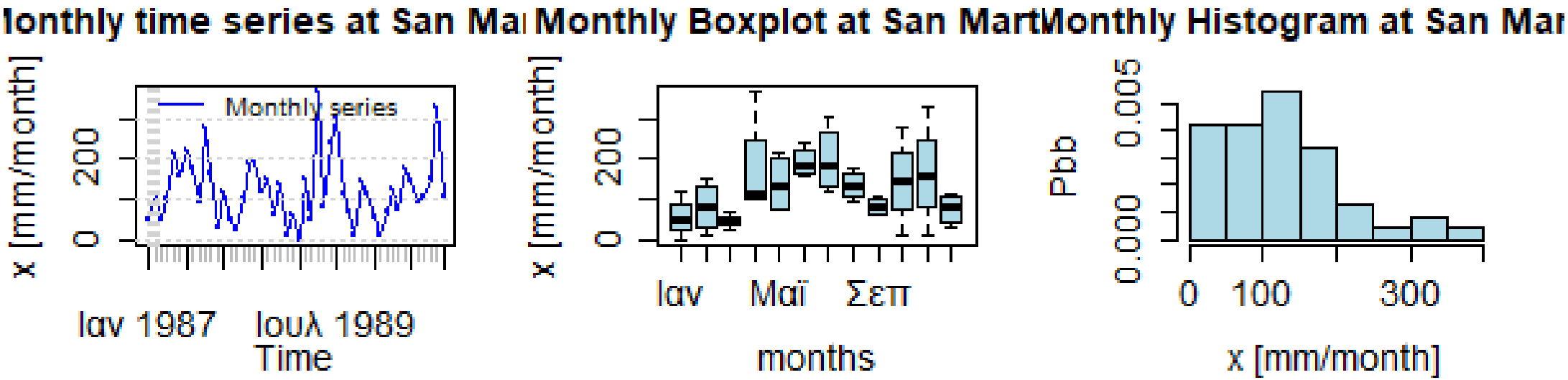
lonthly time series at San Ma
Monthly Boxplot at San Mart
Monthly Histogram at San Mar
Monthly series
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Ιουλ 1989
Time
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months
Pbb
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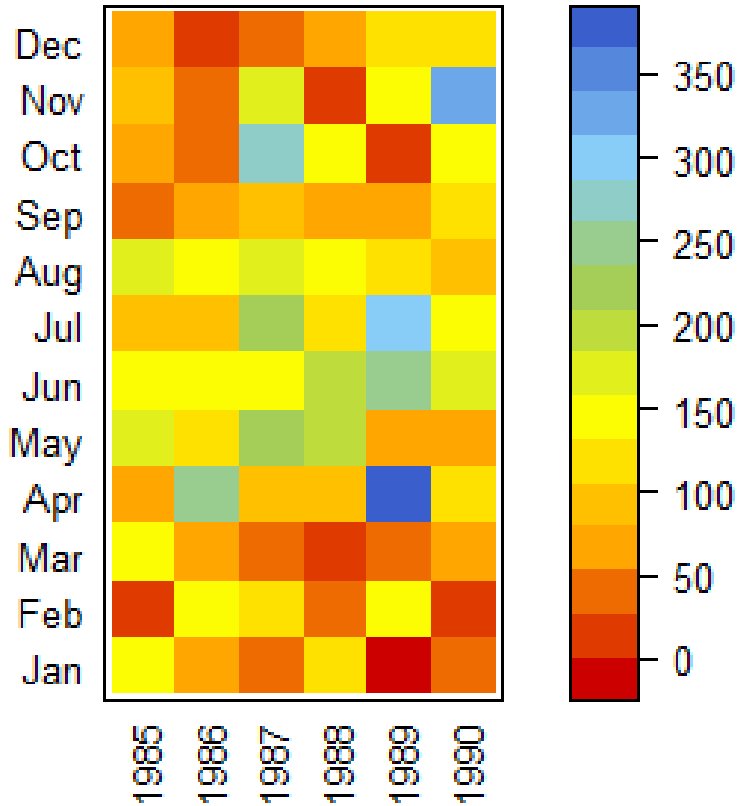
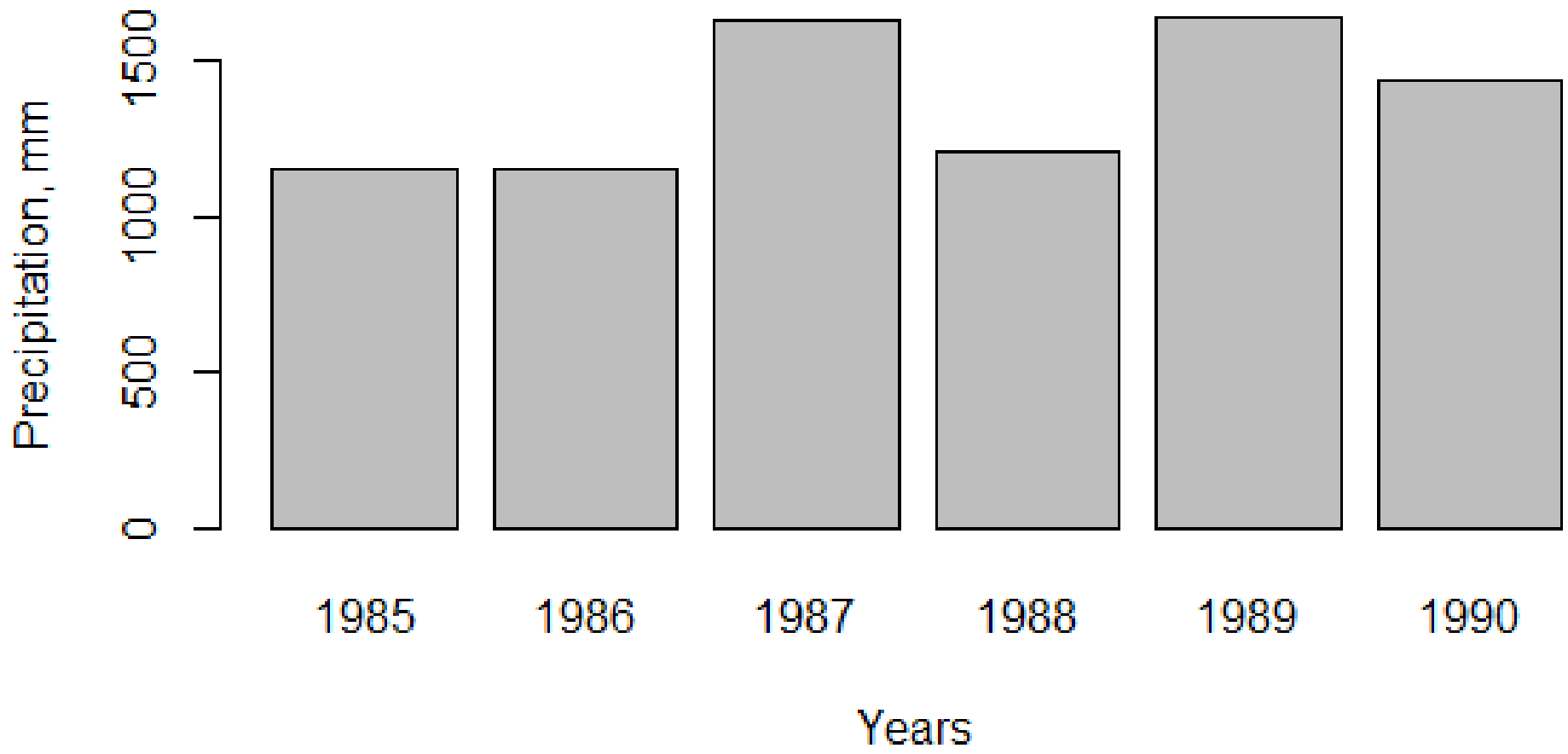
0.005
0
100
300
x [mm/month]

Monthly precipitation at San Martino st., [mm/month]




Precipitation, mm
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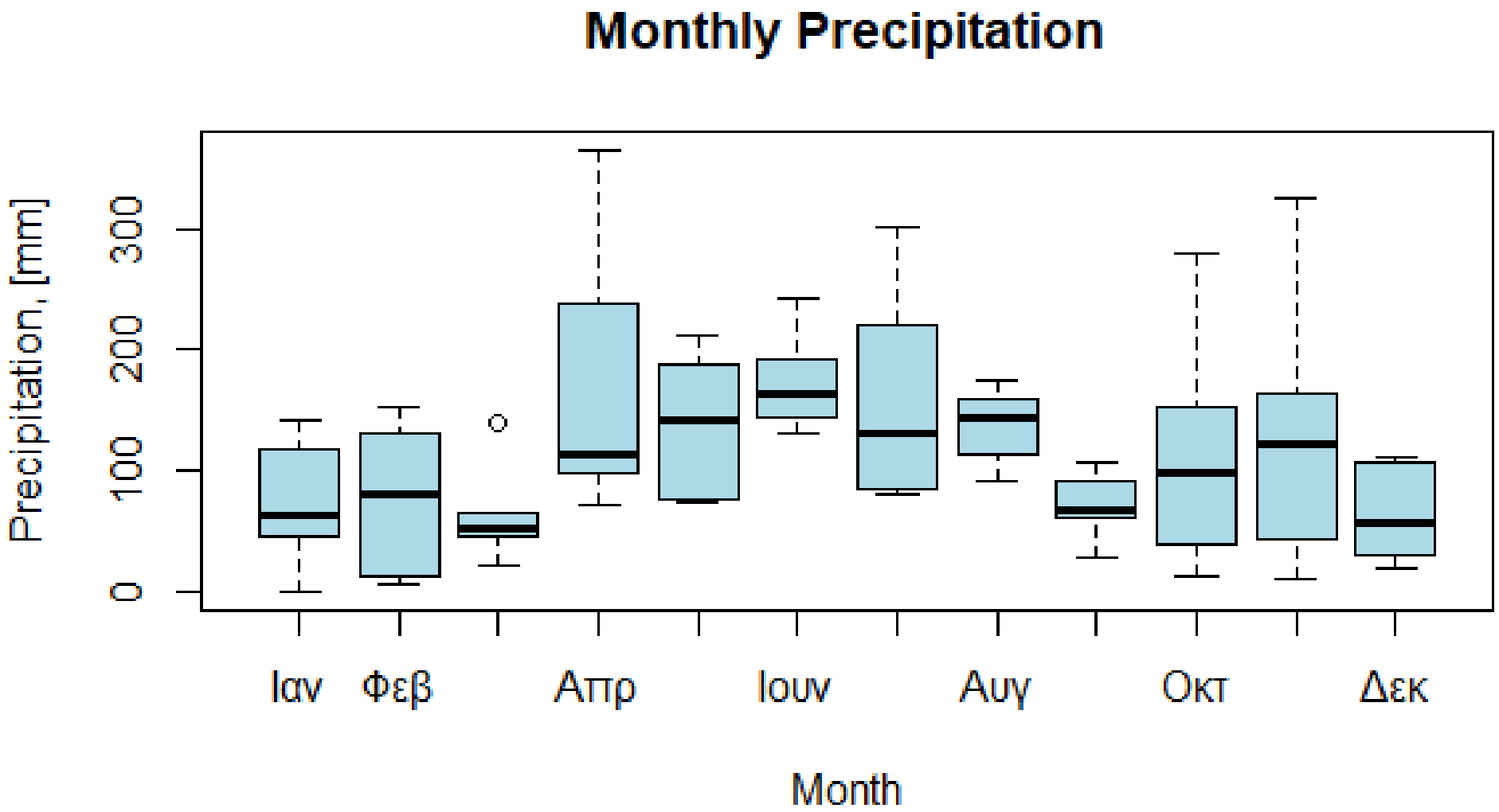
500
1000
1500
1985
1986
1987
1988
1989
1990
Years


Monthly Precipitation
Precipitation, [mm]
0
100
200
300
Ιαν
Φεβ
Απρ
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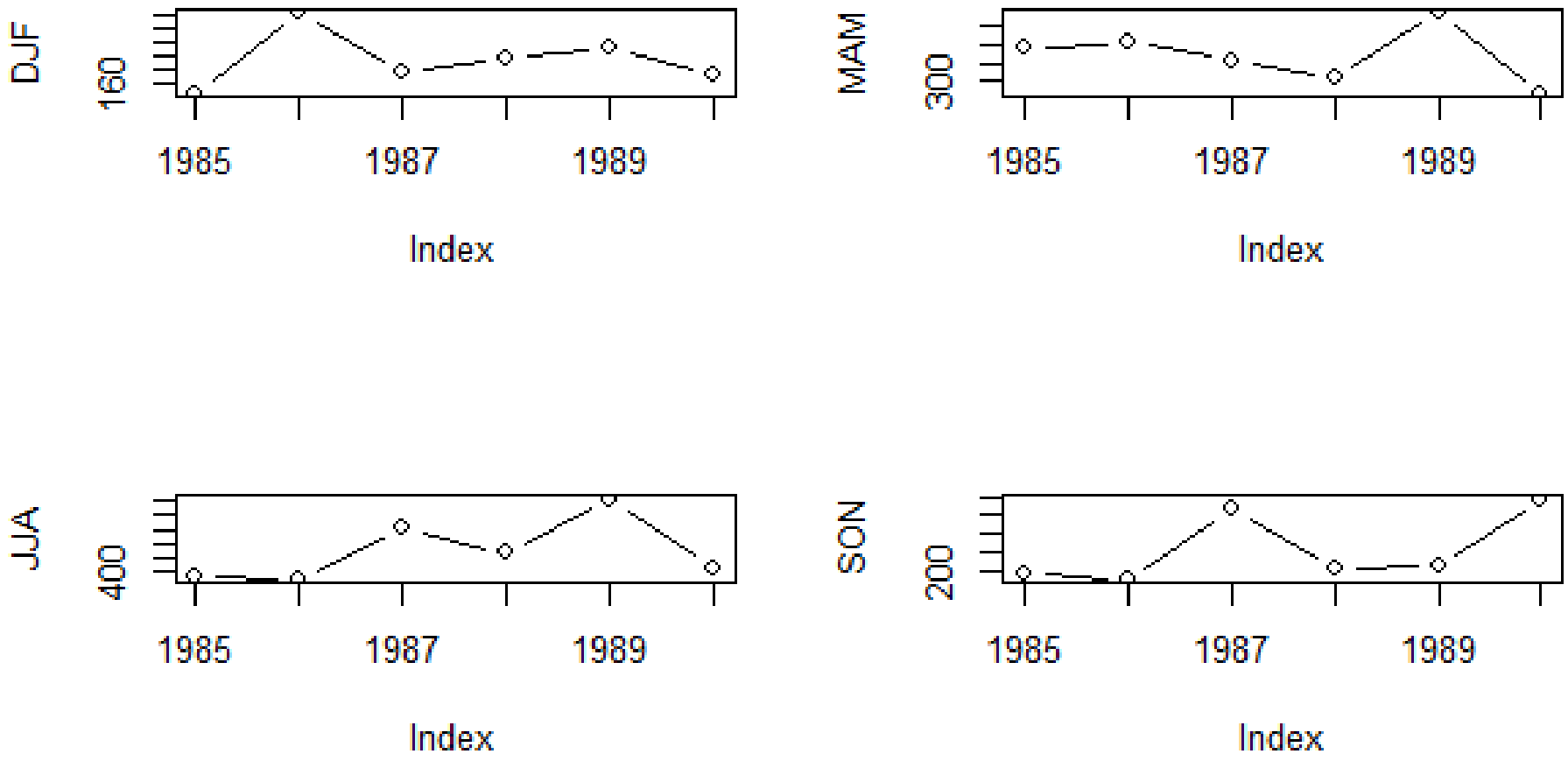
Δεκ
Month


DJF
160
1985
1987
1989
Index
MAM
300
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1989
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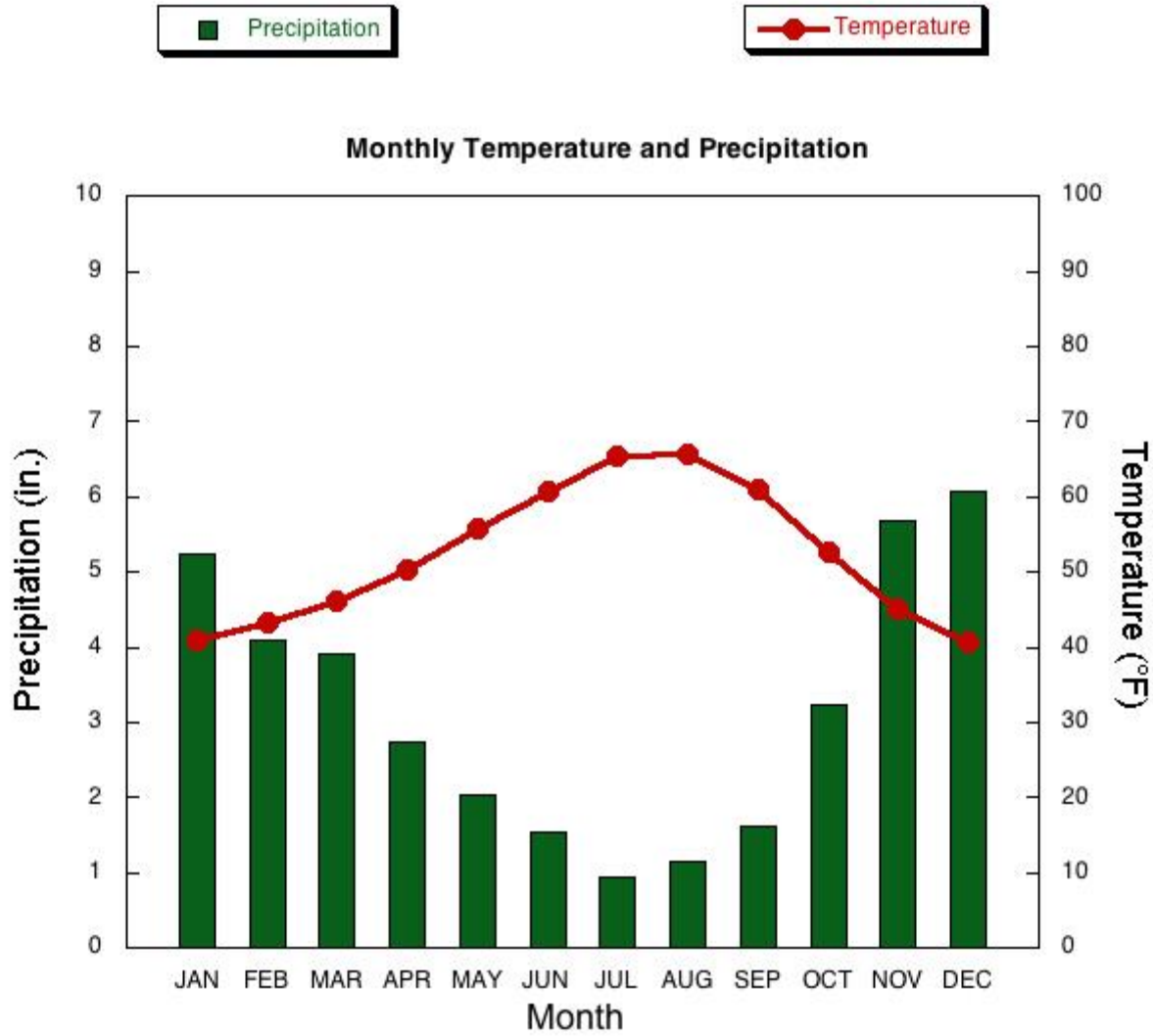
Precipitation
Temperature
Monthly Temperature and Precipitation
Precipitation (in.)
Temperature (°F)
0
1
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4
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8
9
10
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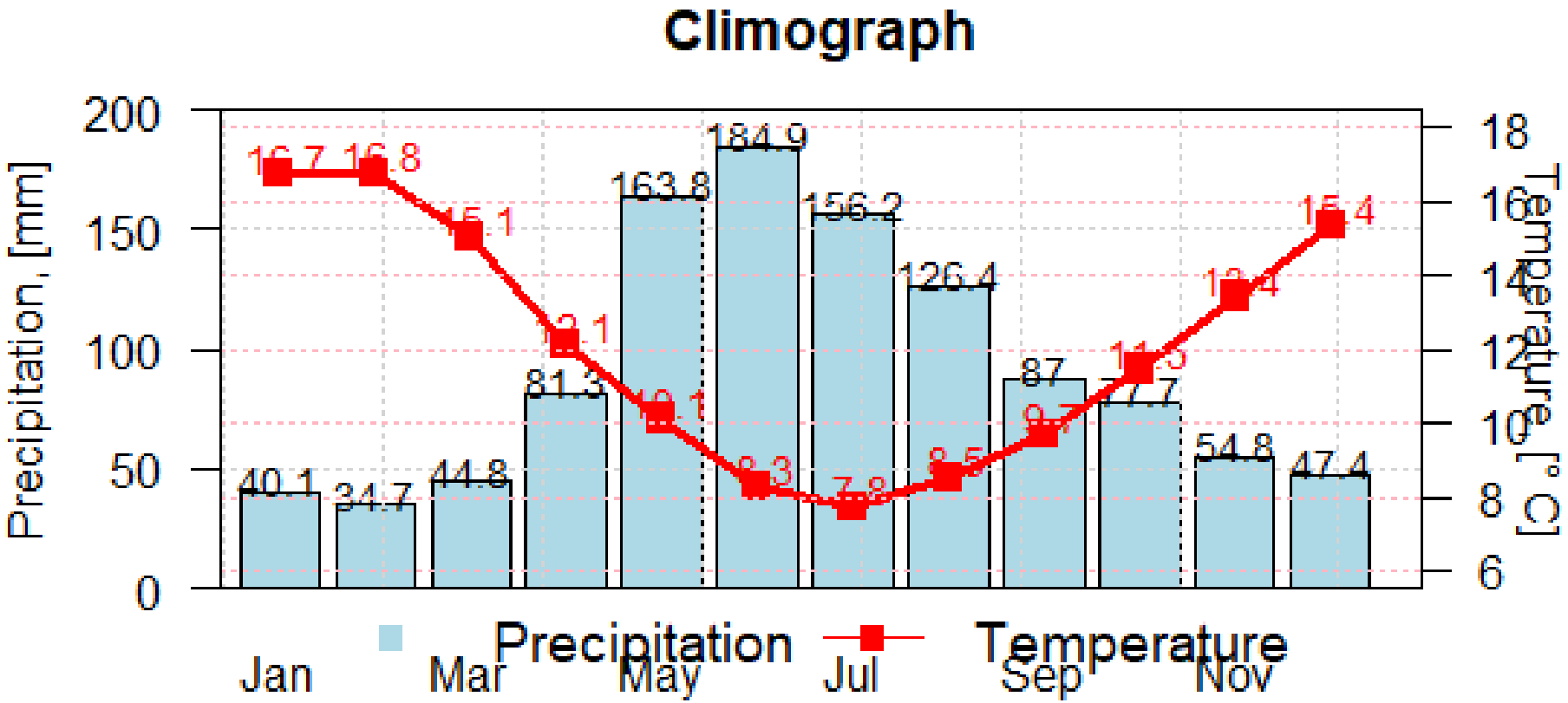
60
70
80
90
100
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month

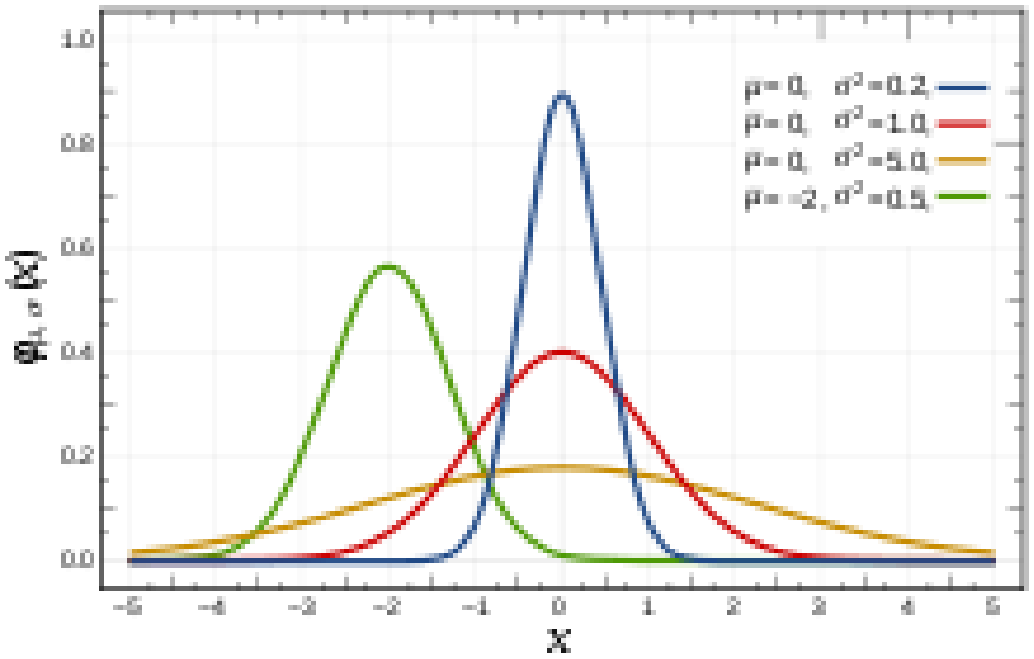

Climograph
Precipitation, [mm]
Temperature [°C]
200
150
100
50
0
18
16
14
12
10
8
6
40.1
34.7
44.8
81.3
163.8
184.9
156.2
126.4
87
77.7
54.8
47.4
16.7
16.8
15.1
12.1
9.3
7.8
8.5
9.7
14.3
12.4
15.4
Jan
Mar
May
Jul
Sep
Nov
Precipitation
Temperature

Προσαρμογή της βέλτιστης συνάρτησης πυκνότητας πιθανότητας πάνω στα δεδομένα

1. Κανονική συνάρτηση πυκνότητας πιθανότητας

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$$

Μέσα από την προσαρμογή αναζητούμε δύο παράγοντες:
α) την μέση τιμή (μ),
β) την τυπική απόκλιση (σ)



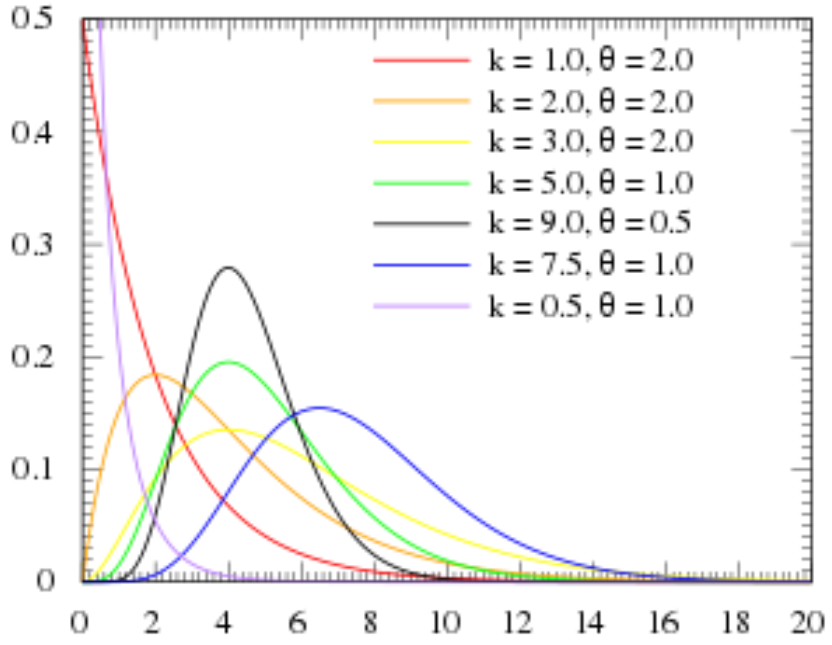
Προσαρμογή της βέλτιστης συνάρτησης πυκνότητας πιθανότητας πάνω στα δεδομένα

2. Gamma συνάρτηση πυκνότητας πιθανότητας

$$f(x;k,\theta)=\frac{x^{k-1}e^{-\frac{x}{\theta}}}{\theta^{k}\Gamma\left(k\right)}$$

$$\Gamma\left(k\right)=(k-1)!$$

Μέσα από την προσαρμογή αναζητούμε δύο παράγοντες:
α) την παράμετρο μορφής (shape, k),
β) την παράμετρο κλίμακας (scale, θ)
Το αντίστροφο της κλίμακας λέγεται rate β = 1/θ

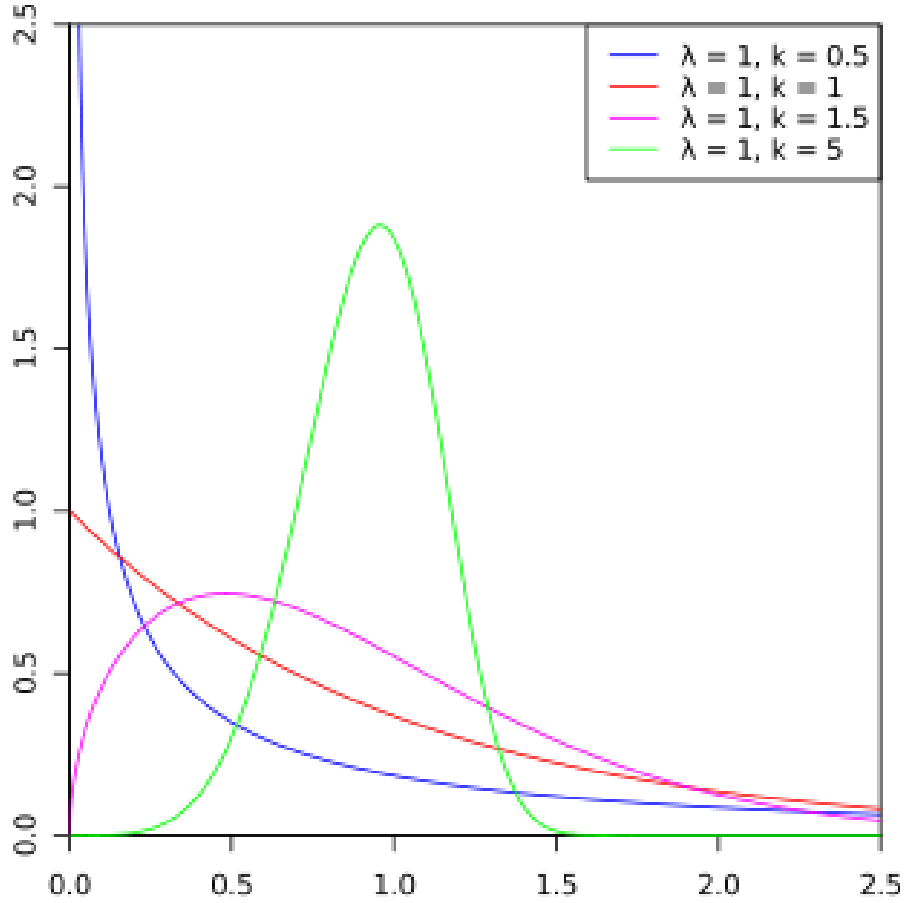


Προσαρμογή της βέλτιστης συνάρτησης πυκνότητας πιθανότητας πάνω στα δεδομένα

3. Weibull συνάρτηση πυκνότητας πιθανότητας

$$f(x;\lambda,k)=\begin{cases}\dfrac{k}{\lambda}\left(\dfrac{x}{\lambda}\right)^{k-1} e^{-(x/\lambda)^k}, & x\geq 0\\ 0, & x<0\end{cases}$$

Μέσα από την προσαρμογή αναζητούμε δύο παράγοντες:
α) την παράμετρο μορφής (shape, k),
β) την παράμετρο κλίμακας (scale, λ)



```
install.packages("hydroTSM")
install.packages("plyr")
install.packages("devtools")
install.packages("lattice")
install.packages("fitdistplus")


library(hydroTSM)
library(plyr)
library(devtools)
library(lattice)
library(fitdistrplus)

#Import data from hydroTSM package
#Daily precipitation data
data(SanMartinoPPts)

#Select only the data from 1985
x <- window(SanMartinoPPts, start=as.Date("1985-01-01"))
```

```
#Check the starting date
start(x)

#Check the ending date
end(x)

#Check if the time-series is regular or not
is.regular(x)

#Strict check on time-series
is.regular(x,strict=TRUE)

#Omit the third value and check regularity again
is.regular(x[-3],strict=TRUE)
```

```
#move the time-series one step forward
lag(x, k =-1 )
merge(x, lag1 = lag(x, k=1))

#move the time-series one step forward
merge(x, lag1 = lag(x, k=1))

#Get data summary
summary(x)
smry(x)

#Create a simple plot of data-set
plot(x, ylab = "Precip, mm")


#Plot data with the hydroplot function
hydroplot(x,
        var.type="Precipitation",
        main="at San Martino",
        pfreq = "dm",
        from="1987-01-01")
```

```
#Transform daily into monthly values
m <- daily2monthly(x, FUN=sum)
smry(m)

# 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
# with a heat plot
print(matrixplot(M, ColorRamp="Precipitation",
            main="Monthly precipitation at San Martino st., [mm/month]"))

#Transform daily into yearly values
z = daily2annual(x, FUN=sum, na.rm=TRUE)
smry(z)
```

```
#Plot annual time-series
barplot(z,
        xlab = "Years",
        ylab = "Precipitation, mm")

#Get Years from time-series
yr = as.numeric(format(index(z),"%Y"))

#plot again with year-values in x-axis
barplot(z,
        yr,
        xlab = "Years",
        ylab = "Precipitation, mm")

#Compute annual mean value
z.mean = sum(z)/length(z)

#Monthly data analysis
#Median of the monthly values of dataset x
monthlyfunction(m, FUN=median, na.rm=TRUE)
cmonth <- format(time(m), "%b")
months <- factor(cmonth,
                 levels=unique(cmonth),
                 ordered=TRUE)
```

```
#Create boxplot of monthly values
boxplot(coredata(m) ~ months,
        col="lightblue",
        main="Monthly Precipitation",
        ylab="Precipitation, [mm]",
        xlab="Month")

#Seasonal Analysis
#Compute the mean-seasonal values of precipitation
seasonalfunction(x, FUN=sum) / length(z)

#Extracting the seasonal values for each year
DJF <- dm2seasonal(x, season="DJF", FUN=sum)
MAM <- dm2seasonal(m, season="MAM", FUN=sum)
JJA <- dm2seasonal(m, season="JJA", FUN=sum)
SON <- dm2seasonal(m, season="SON", FUN=sum)

#Plot Seasonal Precipitation plots
par(mfrow = c(1,1))
plot(DJF,type="b")
plot(MAM,type="b")
plot(JJA,type="b")
plot(SON,type="b")
```

```
#Extreme value analysis
hydroplot(x,
        ptype="ts",
        pfreq="o",
        var.unit="mm")

#Counting and plotting the number of days
#in the period where precipitation is > 10 [mm]
R10mm <- length( x[x>10] )

#Identifying the wet days
#daily precipitation >= 10 mm
wet.index <- which(x >= 10)
smry(wet.index)

#Computing the 95th percentile
#of precipitation on wet days
quantile(wet.index)
PRwn95 <- quantile(wet.index,
                probs=0.95,
                na.rm=TRUE)
```

```
#Identifying the very wet days
#daily precipitation >= PRwn95
very.wet.index <- which(x >= PRwn95)

#Computing the total precipitation on the very wet days
R95p <- sum(x[very.wet.index])

#Create Climograph
data(MaquehueTemuco)

# extracting individual ts of precipitation, maximum and minimum temperature
pcp <- MaquehueTemuco[, 1]
tmx <- MaquehueTemuco[, 2]
tmn <- MaquehueTemuco[, 3]
```

```
# Plotting the climograph
par(mfrow=c(1,1))
m <- climograph(pcp=pcp,
                tmx=tmx,
                tmn=tmn,
                pcp.label="Precipitation, [mm]",
                tmean.label="Temperature, [\U00B0 C]",
                na.rm=TRUE)


#Transform daily to monthly precipitation values
#Transform daily into yearly values
mon = daily2monthly(x, FUN=sum, na.rm=TRUE)

#Compute monthly precipitation descriptive statistics
mean.mon.prec = mean(mon)
median.mon.prec = median(mon)
range = range(mon)
range.mon.prec = range[2]-range[1]
sd.mon.prec = sd(mon)
var.mon.prec = var(mon)
IQR.mon.prec = IQR(mon)
summary(mon)
```

```
#Plot the location of monthly precipitation
#in relation to other theoretical probability density distributions
mon1 = data.frame(mon)
descdist(mon1$mon)

#Fit the normal probability density distribution
#to the monthly precipitation data
fn <- fitdist(mon1$mon,
        "norm",
        method = "mle")
#Get summary of normal model output
summary(fn)
#Make a plot of data and normal distribution curve
plot(fn)
```

```
#Fit the gamma probability density distribution
#to the monthly precipitation data
fg = fitdist(replace(mon1$mon,
          which(mon1$mon==0),0.1),
    "gamma",
    method = "mle")

summary(fg)
plot(fg)

#Fit the most appropriate Weibull probability density
#distribution model to the monthly precipitation data
fw <- fitdist(replace(mon1$mon,
          which(mon1$mon==0),0.1),
          "weibull",
          method = "mle")
#Get summary of Weibull model output
summary(fw)
plot(fw)
```

```
#Get the probability of an event
#with precipitation from 50 to 400 mm/month with step 50 m^3/s
dweibull(seq(50,400,by=50),
      shape=1.440047, scale = 124.590789,
      log = FALSE)

#Get the cumulative probability of an event
#with discharge higher than 300 mm/month
pweibull(300,
      shape=1.440047, scale = 124.590789,
      log = FALSE,
      lower.tail=TRUE)
```