Short Introduction to R

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Notes

- The following materials are borrowed and modified based on slides and examples from
- 1. Dr. Hung Chen http://www.math.ntu.edu.tw/~hchen/Prediction/notes/R-programming.ppt
- 2. Dr. Henry Horng-Shing Lu
- http://www.stat.nctu.edu.tw/~misg/hslu/course/statistics/An_Introduction_of_R.pdf
- 3. Oscar Torres-Reyna

  *http://dss.princeton.edu/training/**RStudio**101.pdf*

R and S-Plus

- S: an interactive environment for data analysis developed at Bell Laboratories since 1976
  - 1988 - S2: RA Becker, JM Chambers, A Wilks
  - 1992 - S3: JM Chambers, TJ Hastie
  - 1998 - S4: JM Chambers
- Exclusively licensed by *AT&T/Lucent* to *Insightful Corporation*, Seattle WA. Product name: “S-plus”.
- Implementation languages C, Fortran.
- See: http://cm.bell-labs.com/cm/ms/departments/sia/S/history.html
- R: initially written by Ross Ihaka and Robert Gentleman at Dep. of Statistics of U of Auckland, New Zealand during 1990s.
- Since 1997: international “R-core” team of ca. 15 people with access to common CVS archive.

R

- R is “GNU S” — A language and environment for data manipula-tion, calculation and graphical display.
  - R is similar to the award-winning S system, which was developed at Bell Laboratories by John Chambers et al.
  - a suite of operators for calculations on arrays, in particular matrices,
  - a large, coherent, integrated collection of intermediate tools for interactive data analysis,
  - graphical facilities for data analysis and display either directly at the computer or on hardcopy
  - a well developed programming language which includes conditionals, loops, user defined recursive functions and input and output facilities.

What R Does and Does Not

- data handling and storage: numeric, textual
- matrix algebra
- hash tables and regular expressions
- high-level data analytic and statistical functions
- classes (“OO”)
- graphics
- programming language: loops, branching, subroutines

- is not a database, but connects to DBMSs
- has no graphical user interfaces, but connects to Java, TclTk
- language interpreter can be very slow, but allows to call own C/C++ code
- no spreadsheet view of data, but connects to Excel/MsOffice
- no professional / commercial support

R and Statistics

- Packaging: a crucial infrastructure to efficiently produce, load and keep consistent software libraries from (many) different sources / authors
- Statistics: most packages deal with statistics and data analysis
- State of the art: many statistical researchers provide their methods as R packages

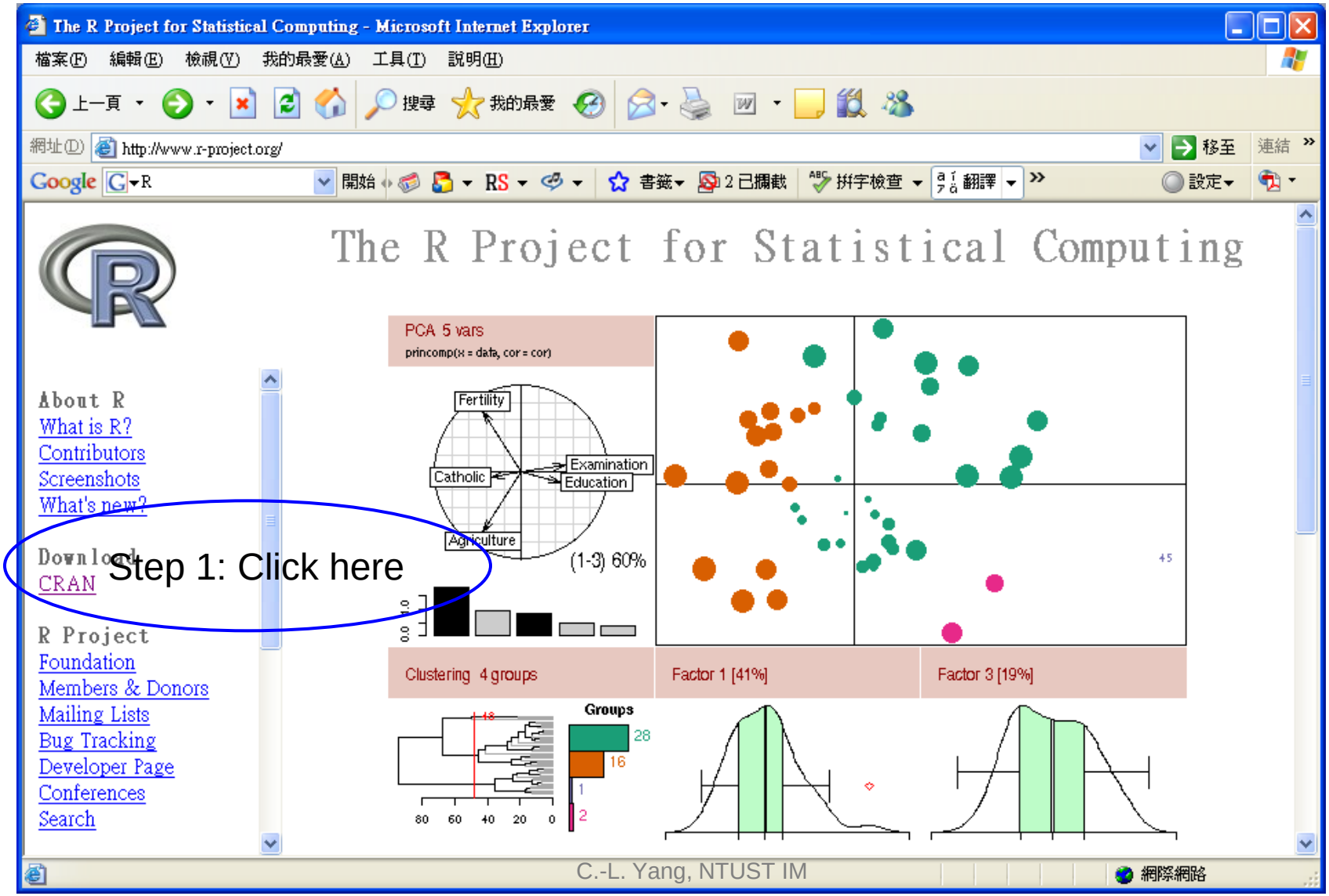
Data Analysis and Presentation

- The R distribution contains functionality for large number of statistical procedures.
  - linear and generalized linear models
  - nonlinear regression models
  - time series analysis
  - classical parametric and nonparametric tests
  - clustering
  - smoothing
- R also has a large set of functions which provide a flexible graphical environment for creating various kinds of data presentations.

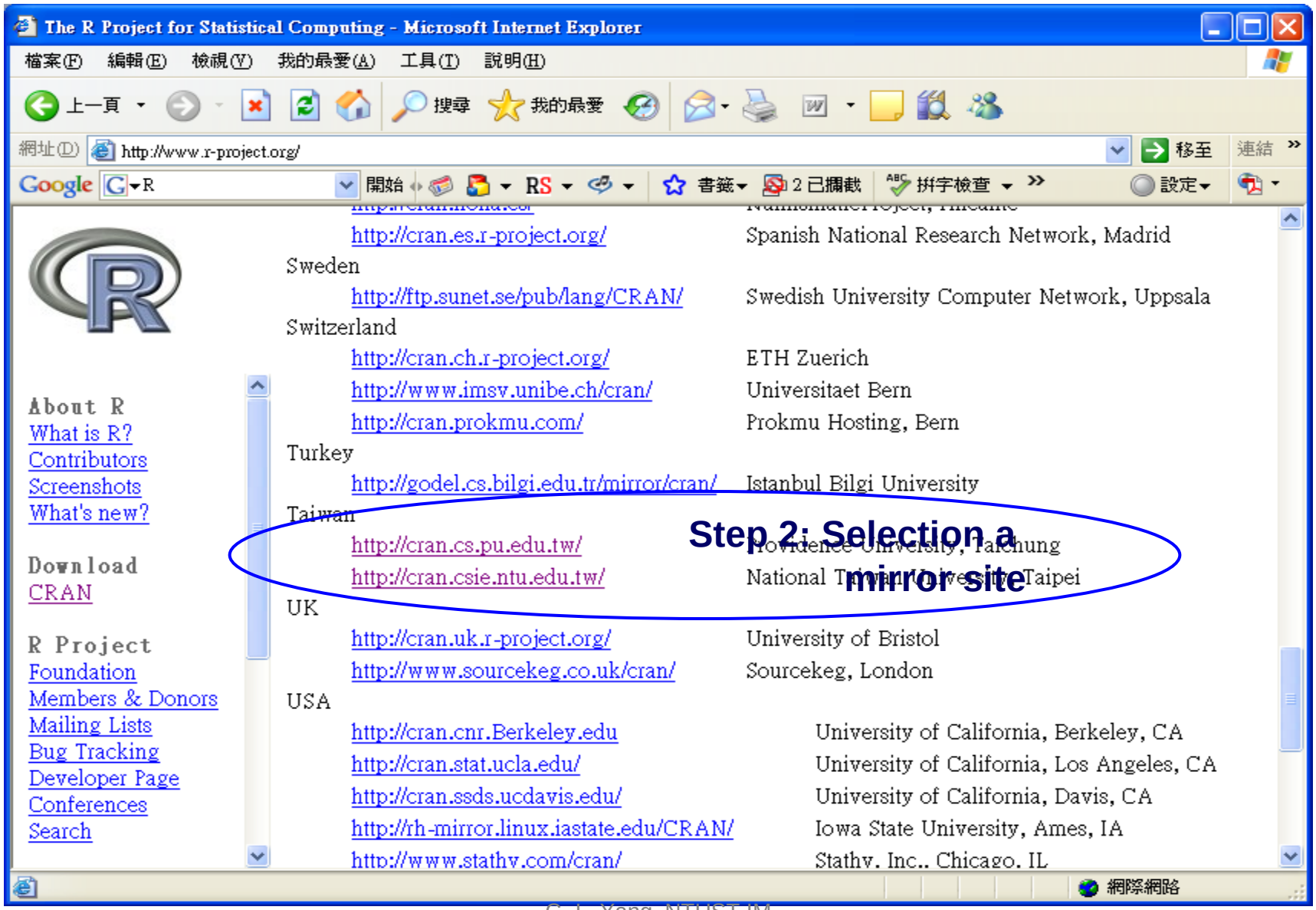
Installation of R

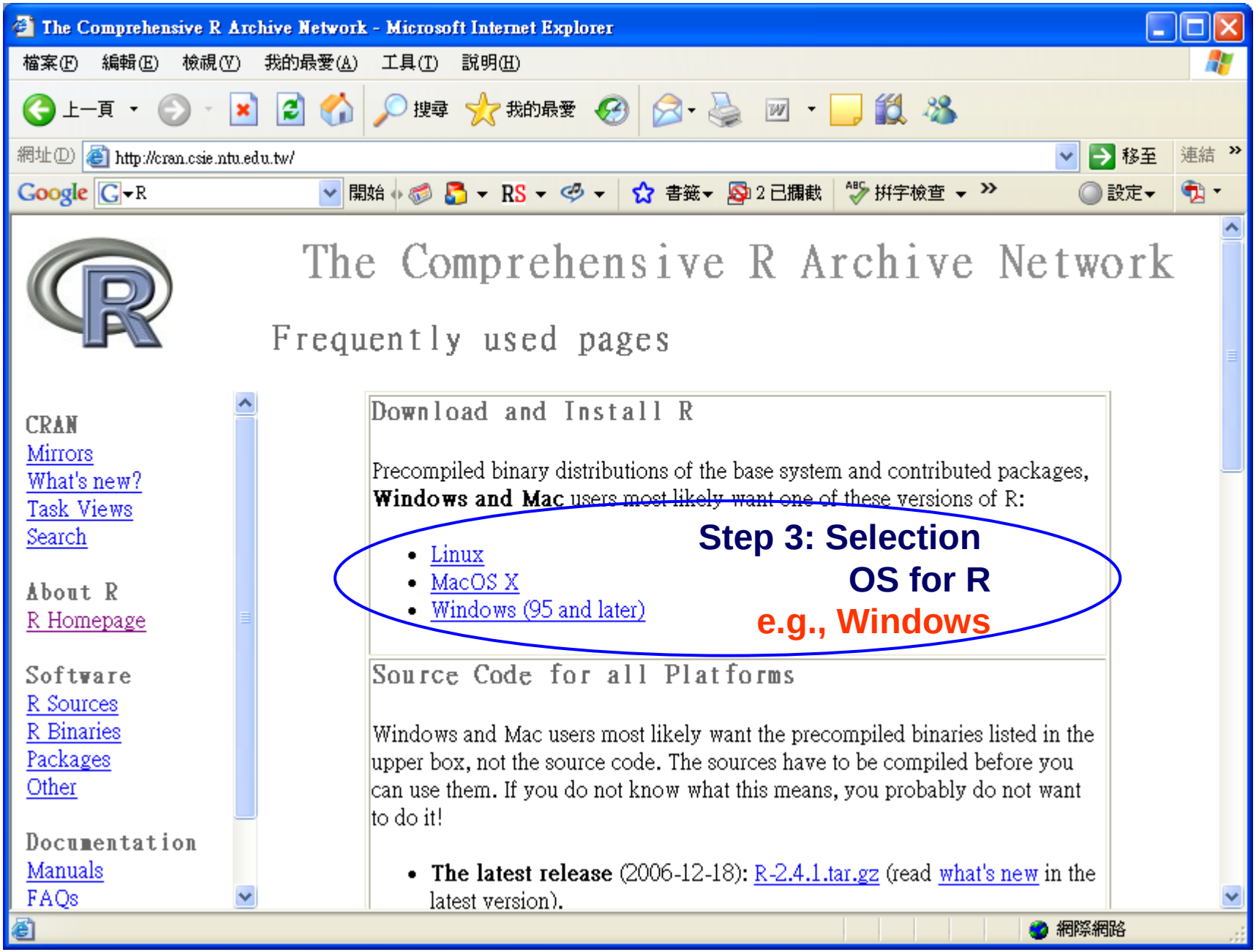
Installation of R

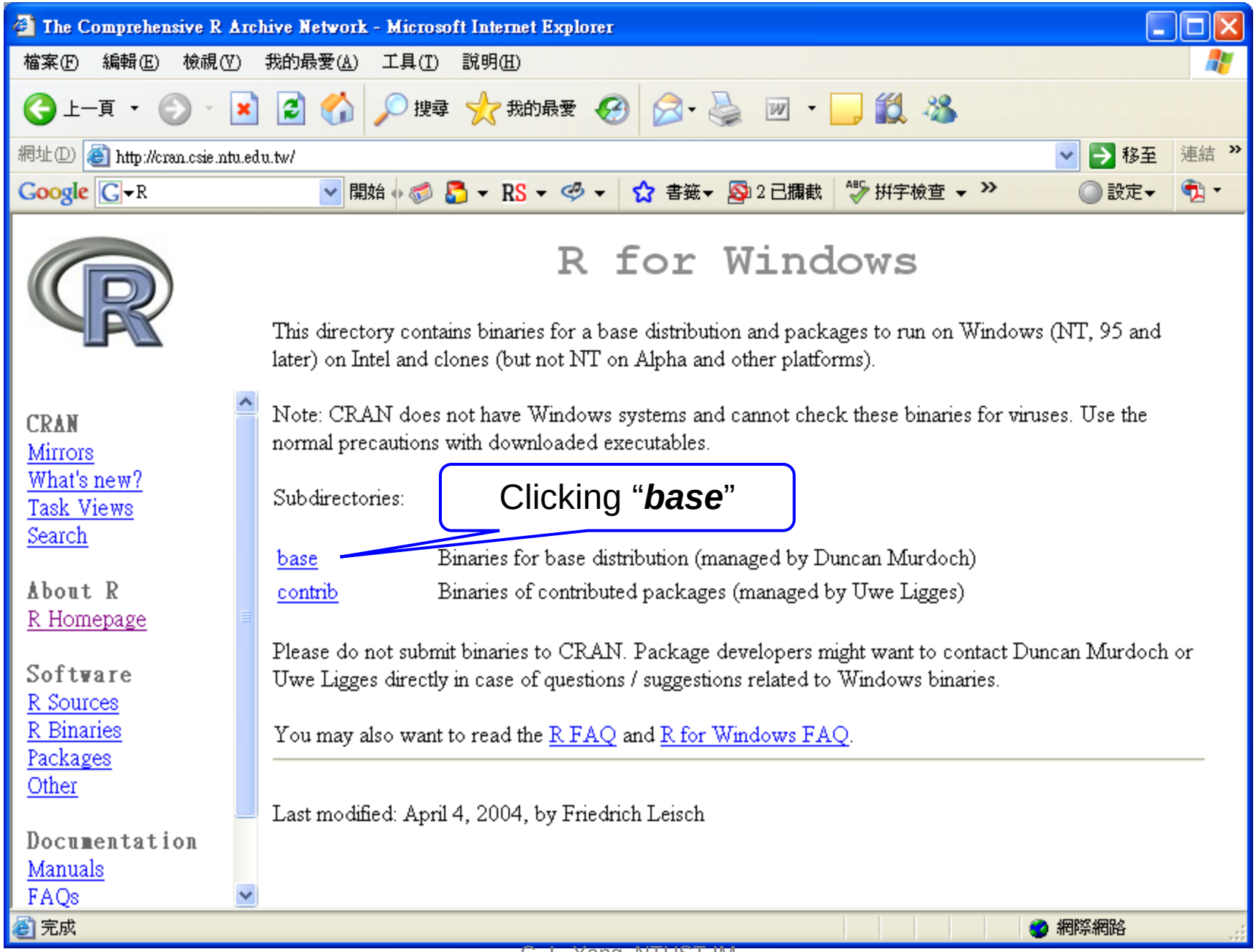
http://www.r-project.org/

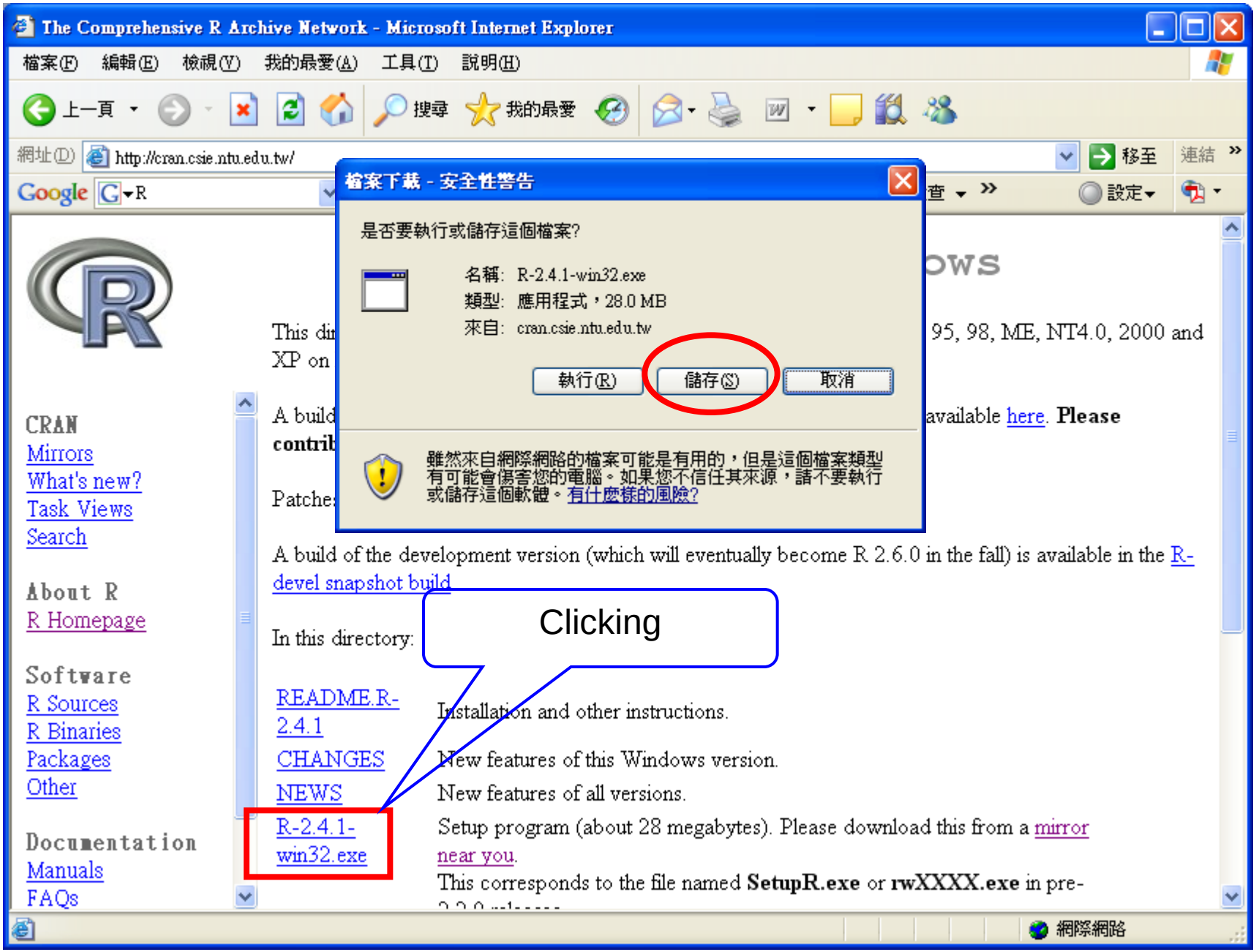


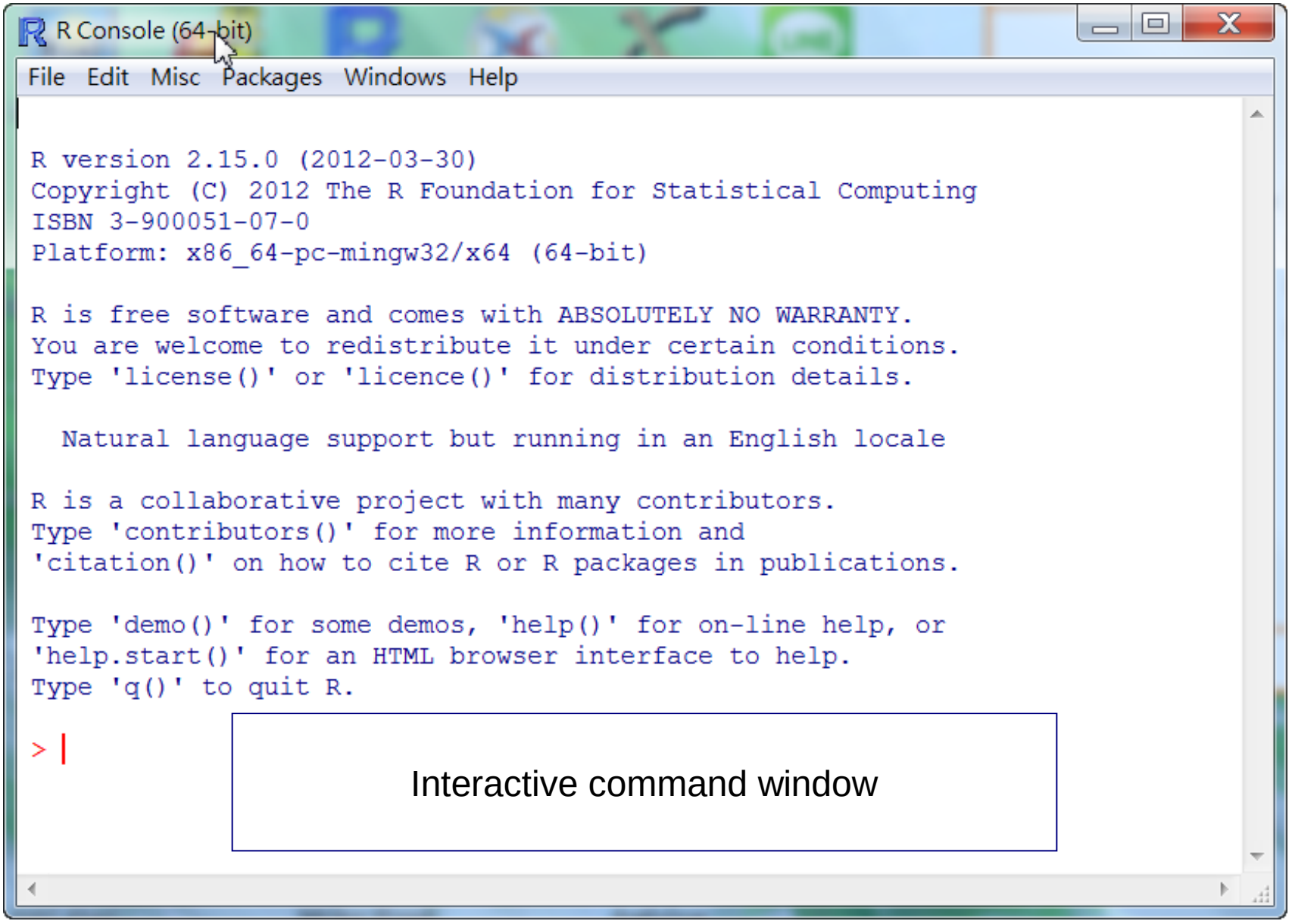
Selection a Mirror Site




The Comprehensive R Archive Network - Microsoft Internet Explorer
http://cran.csie.ntu.edu.tw/
The Comprehensive R Archive Network
Frequently used pages
CRAN
Mirrors
What's new?
Task Views
Search
About R
R Homepage
Software
R Sources
R Binaries
Packages
Other
Documentation
Manuals
FAQs
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:
Linux
MacOS X
Windows (95 and later)
Step 3: Selection
OS for R
e.g., Windows
Source Code for all Platforms
Windows and Mac users most likely want 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 (2006-12-18): R-2.4.1.tar.gz (read what's new in the latest version).


The Comprehensive R Archive Network - Microsoft Internet Explorer
檔案(F) 編輯(E) 檢視(V) 我的最愛(A) 工具(T) 說明(H)
上一頁 搜尋 我的最愛
網址(D) http://cran.csie.ntu.edu.tw/
移至 連結
Google R 開始 書籤 2 已攔截 拼字檢查 設定
R for Windows
This directory contains binaries for a base distribution and packages to run on Windows (NT, 95 and later) on Intel and clones (but not NT on Alpha and other platforms).
CRAN
Mirrors
What's new?
Task Views
Search
About R
R Homepage
Software
R Sources
R Binaries
Packages
Other
Documentation
Manuals
FAQs
Note: CRAN does not have Windows systems and cannot check these binaries for viruses. Use the normal precautions with downloaded executables.
Subdirectories:
Clicking "base"
base Binaries for base distribution (managed by Duncan Murdoch)
contrib Binaries of contributed packages (managed by Uwe Ligges)
Please do not submit binaries to CRAN. Package developers might want to contact Duncan Murdoch or 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.
Last modified: April 4, 2004, by Friedrich Leisch
完成
網際網路

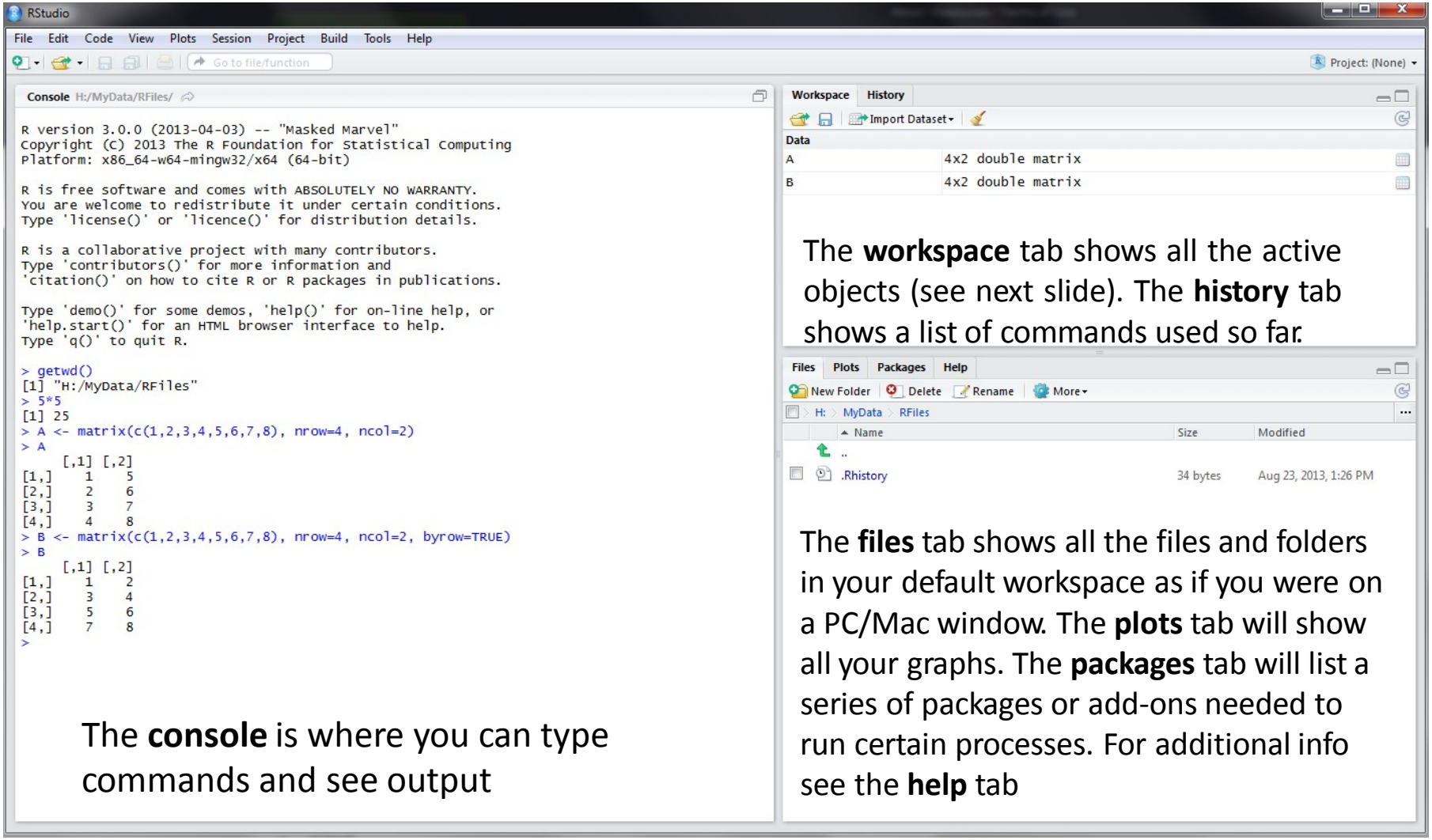

The Comprehensive R Archive Network - Microsoft Internet Explorer
檔案(F) 編輯(E) 檢視(V) 我的最愛(A) 工具(T) 說明(H)
上一頁 搜尋 我的最愛
網址(D) http://cran.csie.ntu.edu.tw/
移至 連結
Google R
設定
檔案下載 - 安全性警告
是否要執行或儲存這個檔案?
名稱: R-2.4.1-win32.exe
類型: 應用程式，28.0 MB
來自: cran.csie.ntu.edu.tw
執行(R) 儲存(S) 取消
雖然來自網際網路的檔案可能是有用的，但是這個檔案類型有可能會傷害您的電腦。如果您不信任其來源，請不要執行或儲存這個軟體。有什麼樣的風險?
CRAN
Mirrors
What's new?
Task Views
Search
About R
R Homepage
Software
R Sources
R Binaries
Packages
Other
Documentation
Manuals
FAQs
95, 98, ME, NT4.0, 2000 and
available here. Please
A build of the development version (which will eventually become R 2.6.0 in the fall) is available in the R-devel snapshot build
In this directory:
README.R-2.4.1 Installation and other instructions.
CHANGES New features of this Windows version.
NEWS New features of all versions.
R-2.4.1-win32.exe Setup program (about 28 megabytes). Please download this from a mirror near you.
This corresponds to the file named SetupR.exe or rwXXXX.exe in pre-
Clicking
網際網路


R Console (64-bit)
File Edit Misc Packages Windows Help
R version 2.15.0 (2012-03-30)
Copyright (C) 2012 The R Foundation for Statistical Computing
ISBN 3-900051-07-0
Platform: x86_64-pc-mingw32/x64 (64-bit)
R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.
Natural language support but running in an English locale
R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.
Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.
>
Interactive command window

RStudio

- RStudio allows the user to run R in a more user-friendly environment. It is open-source (i.e. free) and available at http://www.rstudio.com/

RStudio screen



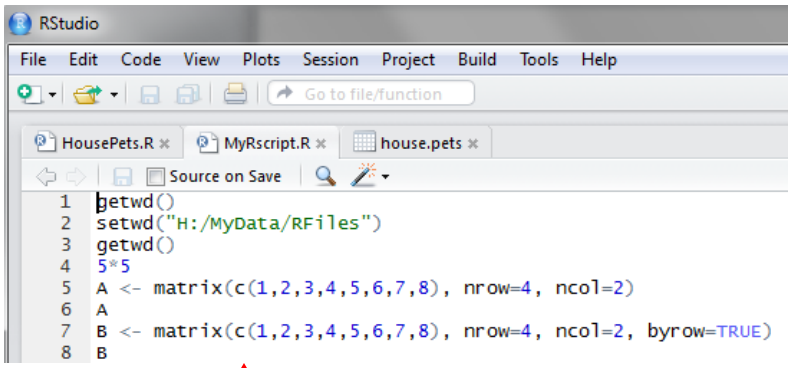
The **workspace** tab shows all the active objects (see next slide). The **history** tab shows a list of commands used so far.

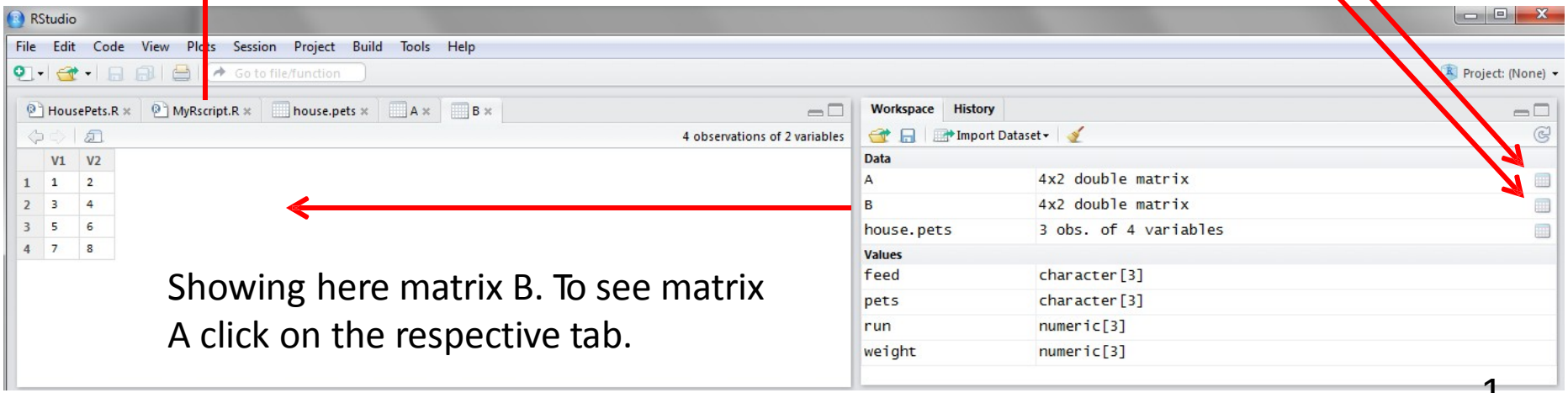
The **files** tab shows all the files and folders in your default workspace as if you were on a PC/Mac window. The **plots** tab will show all your graphs. The **packages** tab will list a series of packages or add-ons needed to run certain processes. For additional info see the **help** tab

The **console** is where you can type commands and see output

Workspace tab (1)

The workspace tab stores any object, value, function or anything you create during your R session. In the example below, if you click on the dotted squares you can see the data on a screen to the left.

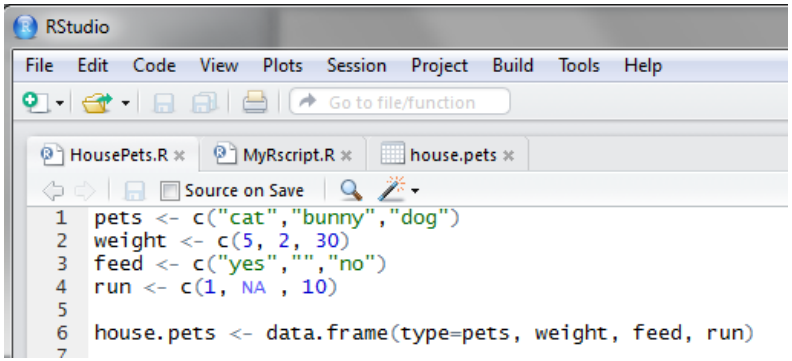




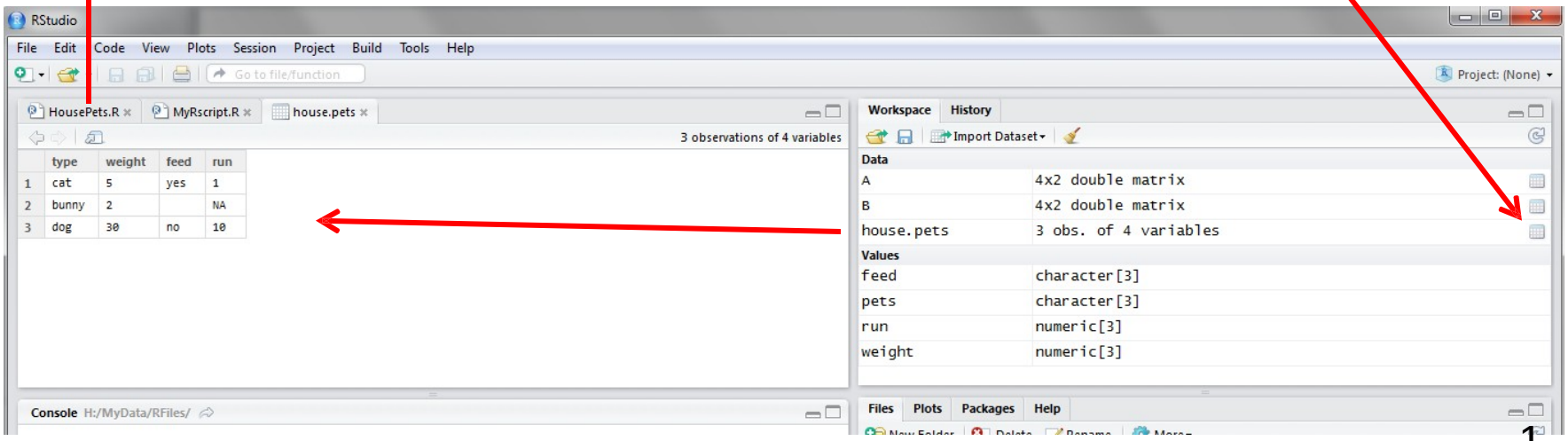
Showing here matrix B. To see matrix A click on the respective tab.

Workspace tab (2)

Here is another example on how the workspace looks like when more objects are added. Notice that the data frame `house.pets` is formed from different individual values or vectors.

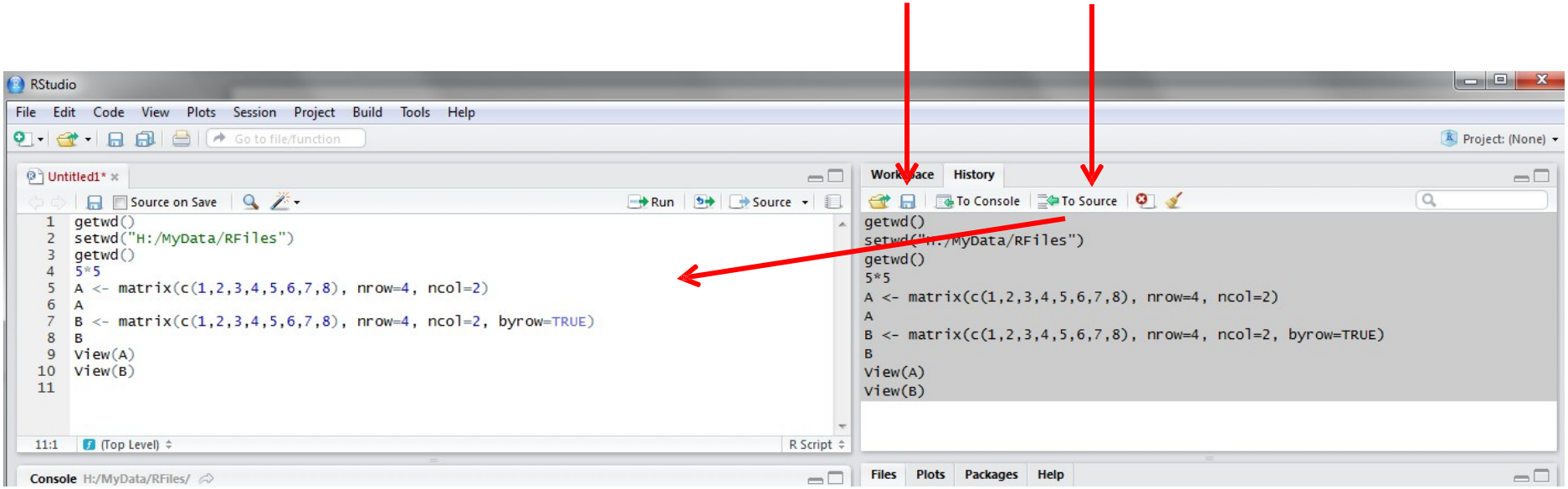


Click on the dotted square to look at the dataset in a spreadsheet form.

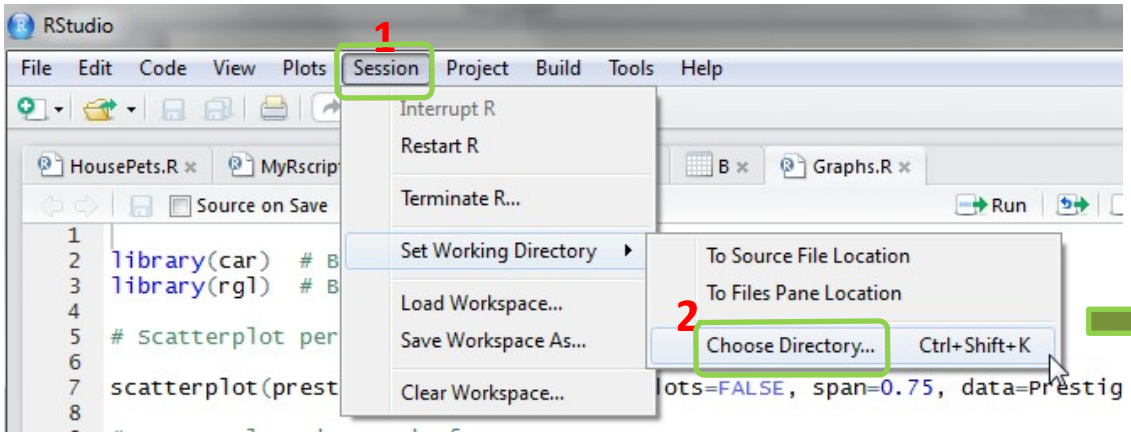


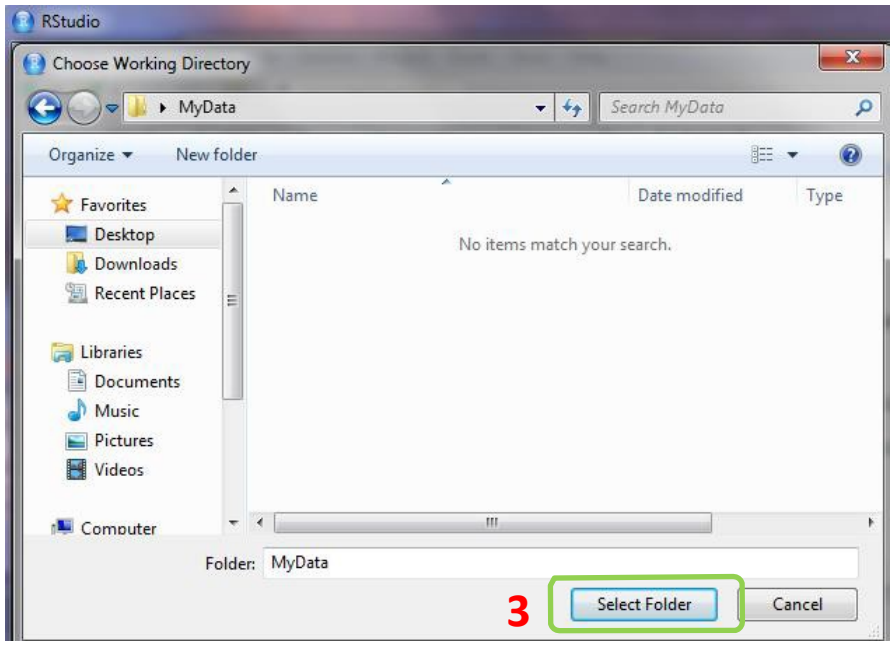
History tab

The history tab keeps a record of all previous commands. It helps when testing and running processes. Here you can either **save** the whole list or you can **select** the commands you want and send them to an R script to keep track of your work.
In this example, we select all and click on the "To Source" icon, a window on the left will open with the list of commands. Make sure to save the 'untitled1' file as an *.R script.



Changing the working directory



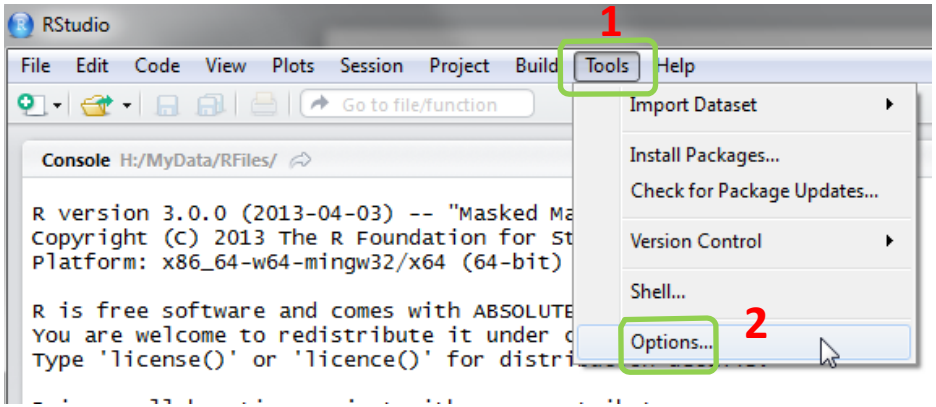


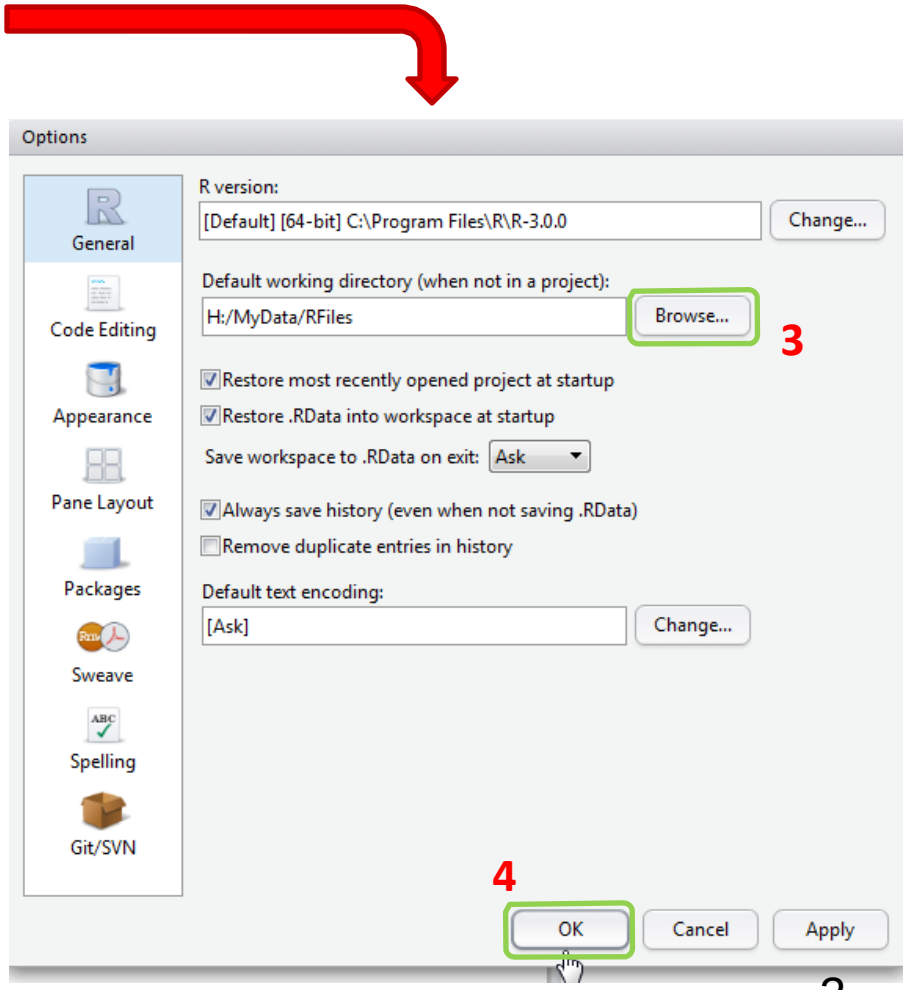
If you have different projects you can change the working directory for that session, see above. Or you can type:

```
# Shows the working directory (wd)

getwd()

# Changes the wd

setwd("C:/myfolder/data")
```

More info see the following document:
http://dss.princeton.edu/training/RStata.pdf

Setting a default working directory





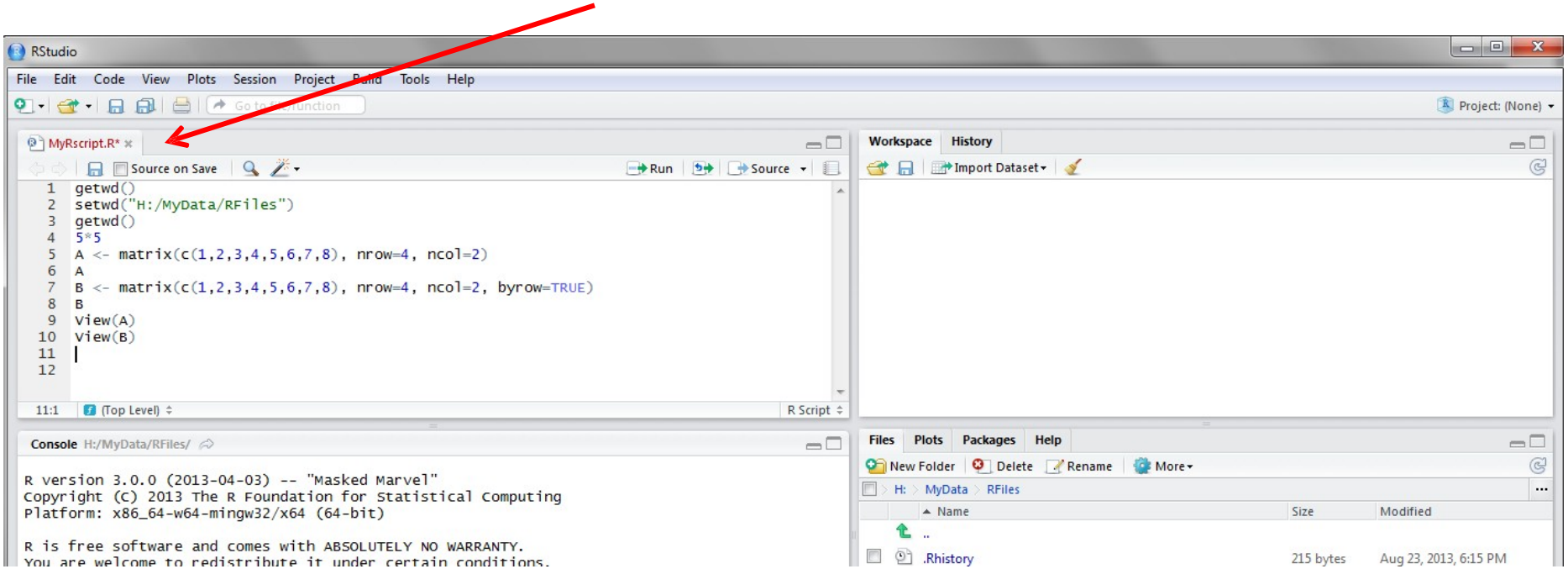
Every time you open RStudio, it goes to a default directory. You can change the default to a folder where you have your datafiles so you do not have to do it every time. In the menu go to Tools->Options

R script (1)

The usual Rstudio screen has four windows:

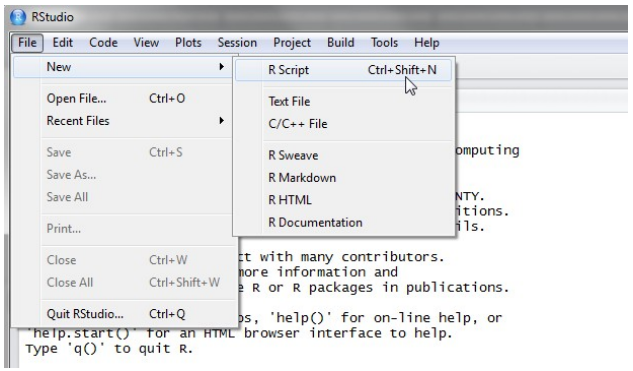
1. Console.
2. Workspace and history.
3. Files, plots, packages and help.
4. The R script(s) and data view.

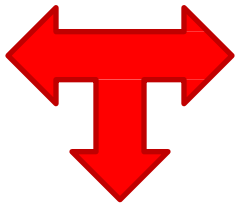
The R script is where you keep a record of your work. For Stata users this would be like the do-file, for SPSS users is like the syntax and for SAS users the SAS program.

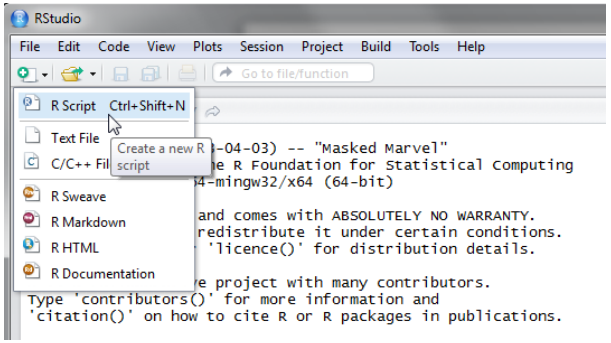


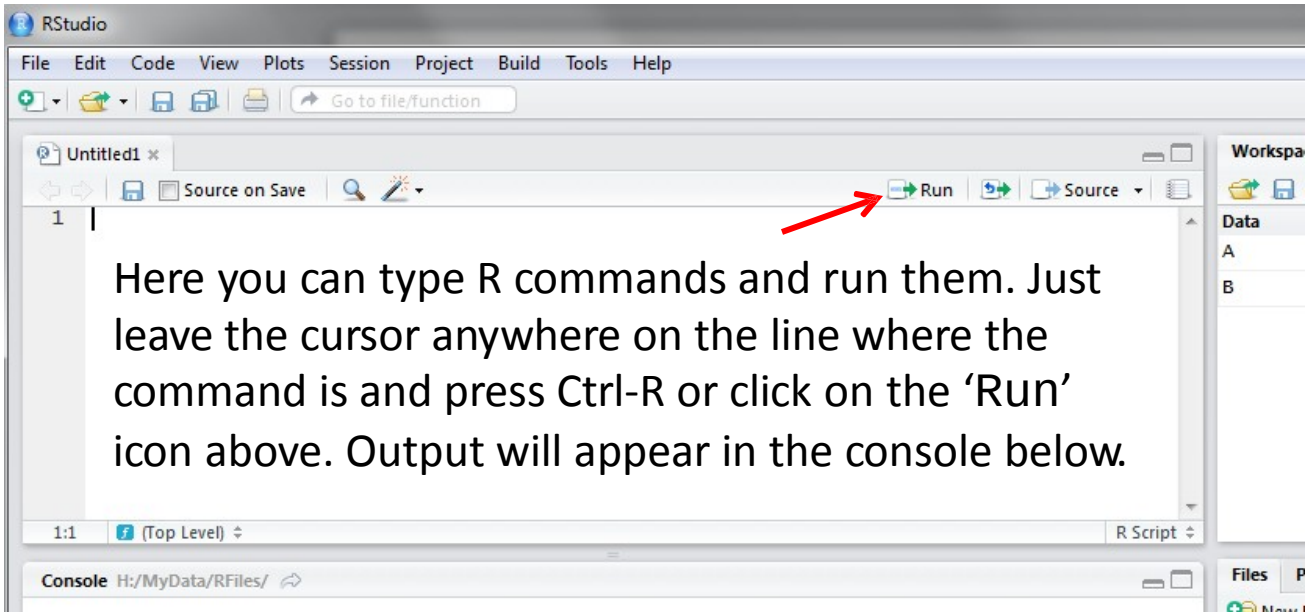
R script (2)

To create a new R script you can either go to `File -> New -> R Script`, or click on the icon with the “+” sign and select “R Script”, or simply press Ctrl+Shift+N. Make sure to save the script.



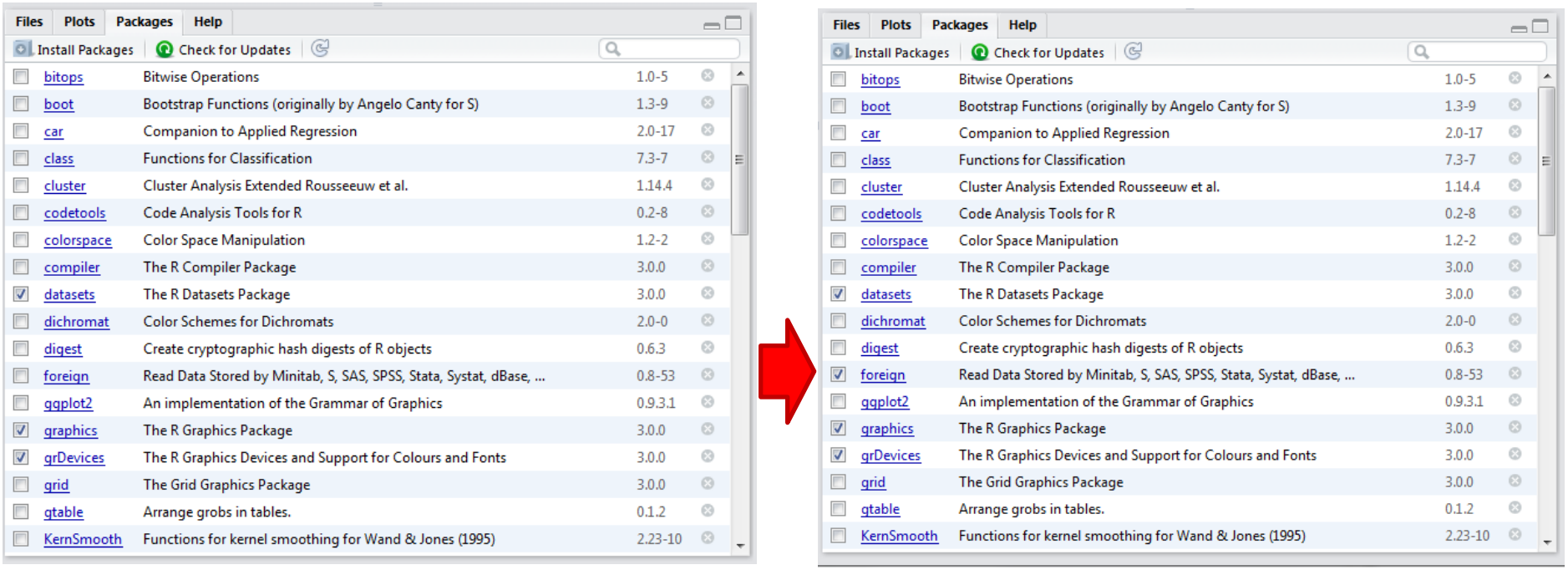




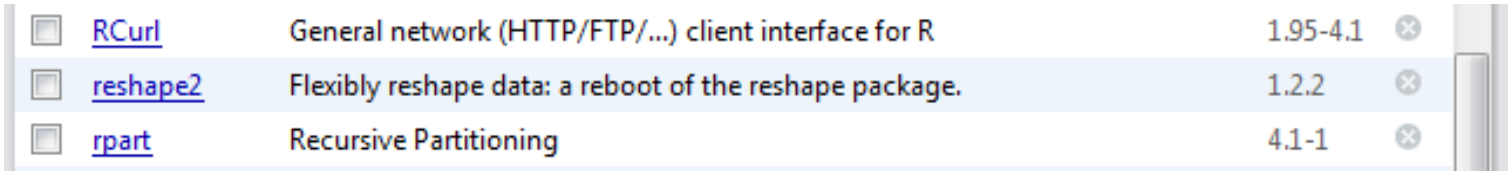


Packages tab

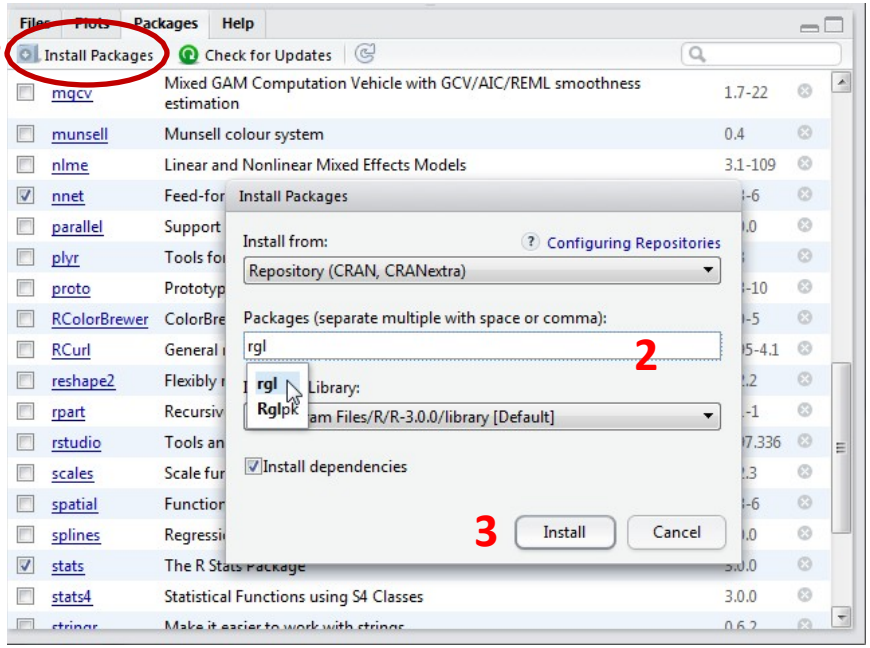
The package tab shows the list of add-ons included in the installation of RStudio. If checked, the package is loaded into R, if not, any command related to that package won't work, you will need select it. You can also install other add-ons by clicking on the 'Install Packages' icon. Another way to activate a package is by typing, for example, `library(foreign)`. This will automatically check the `--foreign` package (it helps bring data from proprietary formats like Stata, SAS or SPSS).



Installing a package

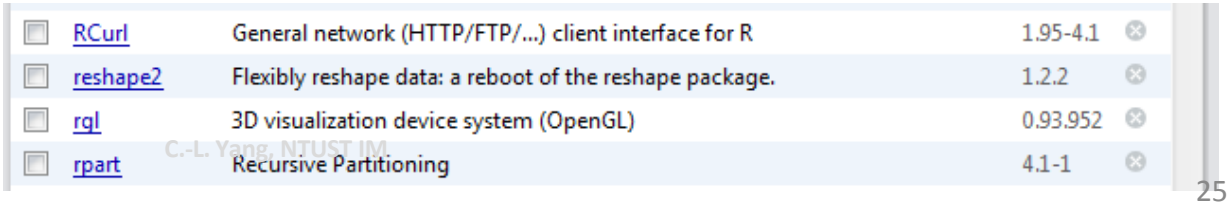


Before



We are going to install the package – `rgl` (useful to plot 3D images). It does not come with the original R install.
Click on "`Install Packages`", write the name in the pop-up window and click on "`Install`".

After



Plots tab (1)

RStudio

File Edit Code View Plots Session Project Build Tools Help

HousePets.R | MyRscript.R | house.pets | A | B | Graphs.R*

Source on Save | Run | Source

```
1
2  library(car)  # By John Fox and Sanford Weisberg
3  library(rgl)  # By Daniel Adler and Duncan Murdoch
4
5  # Scatterplot per group
6
7  scatterplot(prestige ~ income|type, boxplots=FALSE, span=0.75, data=Prestige)
8
9  # Scatterplots in matrix form
10
11 scatterplotMatrix(~ prestige + income + education, span=0.7,data=Prestige)
12
13 # 3D graph, scatter3d is from the --car package. It will open in a separate window.
14
15 scatter3d(prestige ~ income + education, id.n=3, data=Duncan)
```

11:7 (Top Level) R Script

Console H:/MyData/RFiles/

```
> scatterplot(prestige~income|type, boxplots=FALSE, span=0.75, data=Prestige)
>
```

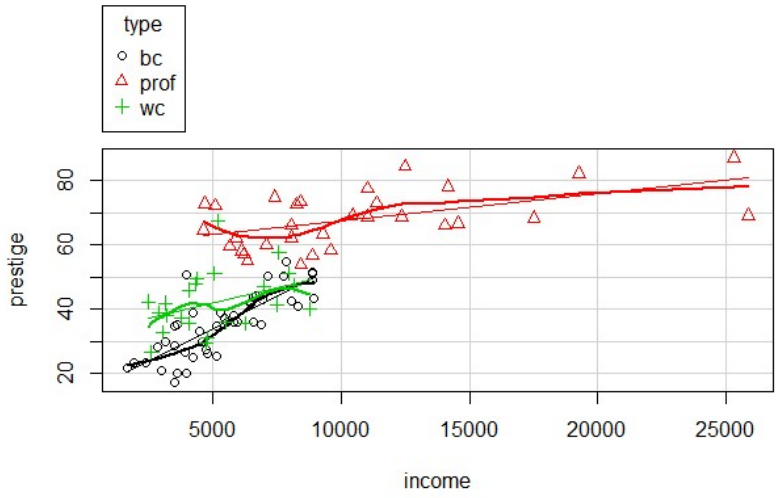
Workspace | History

Import Dataset

Data	
A	4x2 double matrix
B	4x2 double matrix
house.pets	3 obs. of 4 variables
Values	
feed	character[3]
pets	character[3]
run	numeric[3]
weight	numeric[3]

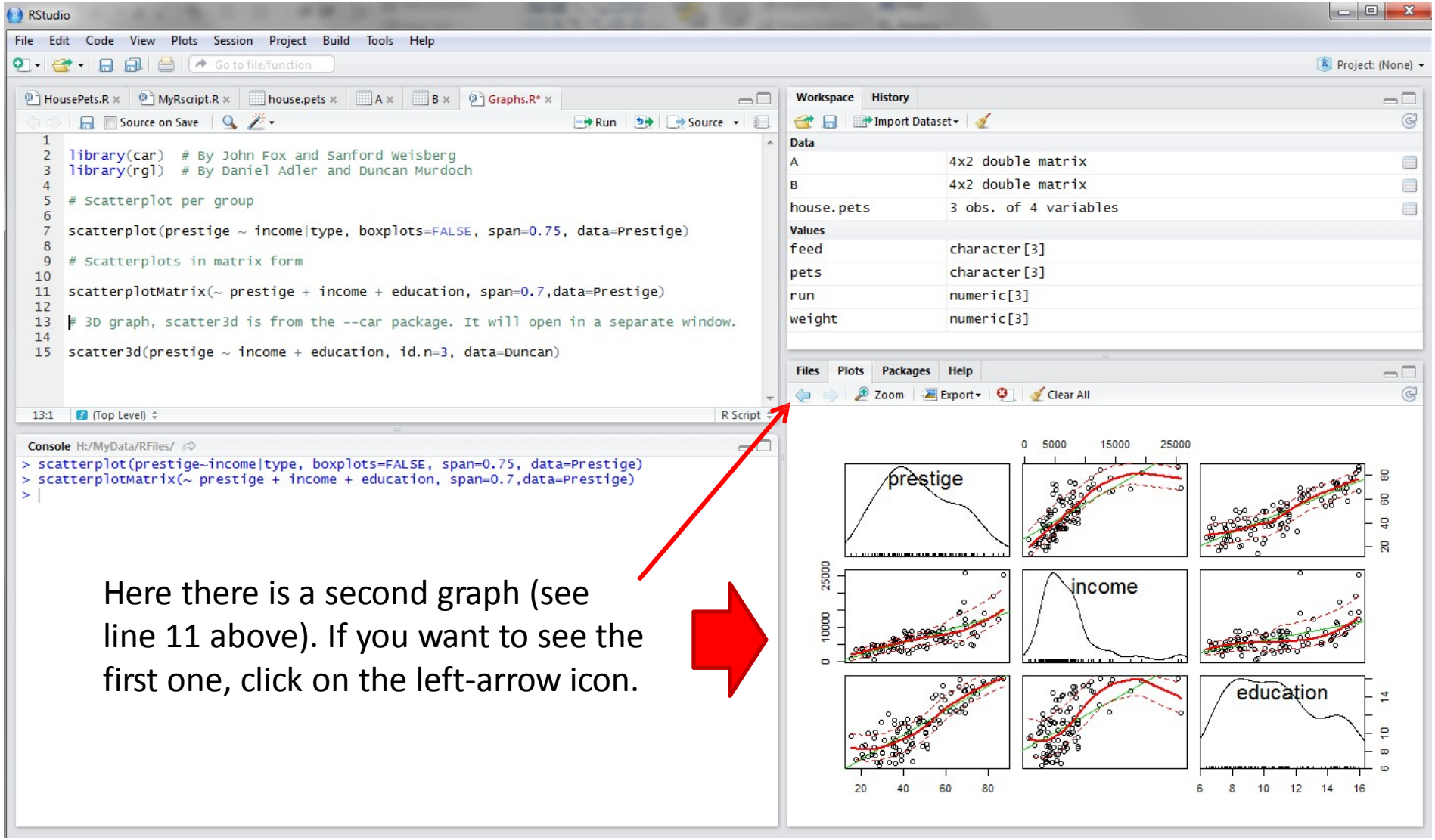
Files | Plots | Packages | Help

Zoom | Export | Clear All



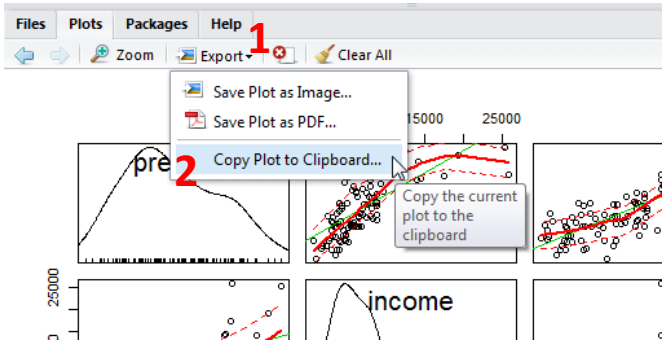
The **plots** tab will display the graphs.
The one shown here is created by the command on line 7 in the script above.
See next slide to see what happens when you have more than one graph

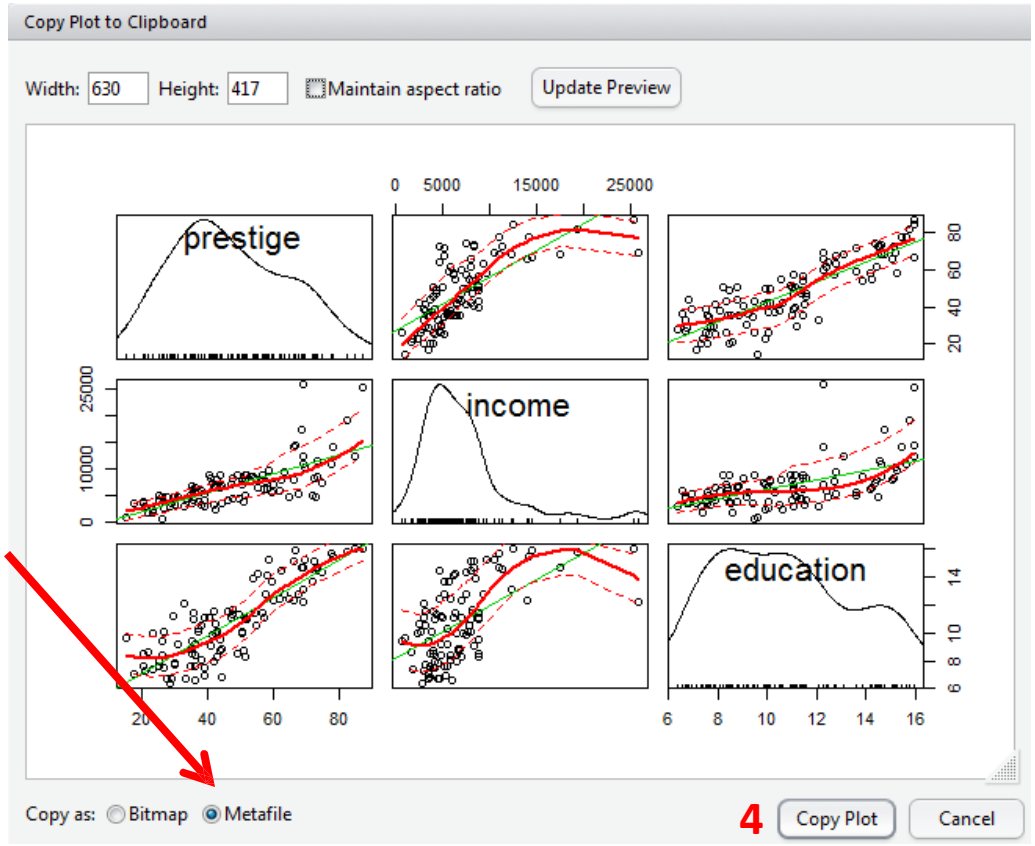
Plots tab (2)


RStudio
File Edit Code View Plots Session Project Build Tools Help
HousePets.R
MyRscript.R
house.pets
A
B
Graphs.R*
Source on Save
Run
Source
1 library(car) # By John Fox and Sanford Weisberg
2 library(rgl) # By Daniel Adler and Duncan Murdoch
3
4 # Scatterplot per group
5
6 scatterplot(prestige ~ income|type, boxplots=FALSE, span=0.75, data=Prestige)
7
8 # Scatterplots in matrix form
9
10 scatterplotMatrix(~ prestige + income + education, span=0.7,data=Prestige)
11
12 # 3D graph, scatter3d is from the --car package. It will open in a separate window.
13
14 scatter3d(prestige ~ income + education, id.n=3, data=Duncan)
13:1 (Top Level) R Script
Console H:/MyData/RFiles/
> scatterplot(prestige~income|type, boxplots=FALSE, span=0.75, data=Prestige)
> scatterplotMatrix(~ prestige + income + education, span=0.7,data=Prestige)
Workspace History
Import Dataset
Data
A 4x2 double matrix
B 4x2 double matrix
house.pets 3 obs. of 4 variables
Values
feed character[3]
pets character[3]
run numeric[3]
weight numeric[3]
Files Plots Packages Help
Zoom Export Clear All
prestige
income
education
Here there is a second graph (see line 11 above). If you want to see the first one, click on the left-arrow icon.

Plots tab (3) – Graphs export

To extract the graph, click on "Export" where you can save the file as an image (PNG, JPG, etc.) or as PDF, these options are useful when you only want to share the graph or use it in a LaTeX document. Probably, the easiest way to export a graph is by copying it to the clipboard and then paste it directly into your Word document.





3 Make sure to select 'Metafile'

5 Paste it into your Word document

3D graphs

RStudio

File Edit Code View Plots Session Project Build Tools Help

HousePets.R | MyRscript.R | house.pets | A | B | Graphs.R

Source on Save | Run | Source

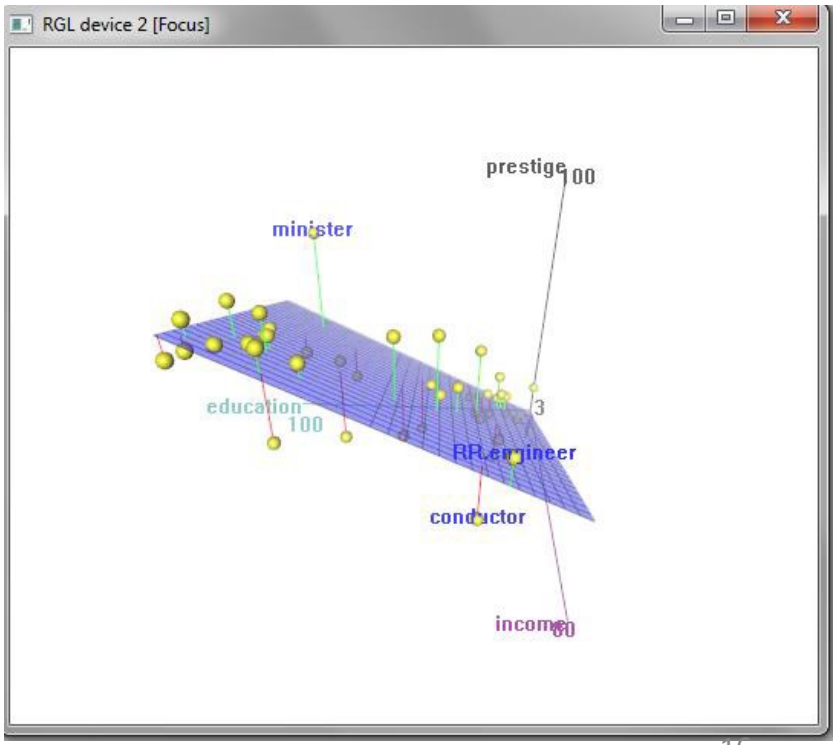
```
1
2  library(car)  # By John Fox and Sanford Weisberg
3  library(rgl)  # By Daniel Adler and Duncan Murdoch
4
5  # Scatterplot per group
6
7  scatterplot(prestige ~ income|type, boxplots=FALSE, span=0.75, data=Prestige)
8
9  # Scatterplots in matrix form
10
11 scatterplotMatrix(~ prestige + income + education, span=0.7,data=Prestige)
12
13 # 3D graph, scatter3d is from the --car package. It will open in a separate window.
14
15 scatter3d(prestige ~ income + education, id.n=3, data=Duncan)
```

15:1 (Top Level)

Console H:/MyData/RFiles/

```
> scatterplot(prestige~income|type, boxplots=FALSE, span=0.75, data=Prestige)
> scatterplotMatrix(~ prestige + income + education, span=0.7,data=Prestige)
> scatter3d(prestige ~ income + education, id.n=3, data=Duncan)
>
```

3D graphs will display on a separate screen (see line 15 above). You won't be able to save it, but after moving it around, once you find the angle you want, you can screenshot it and paste it to you Word document.



Basic of R Programming

Environment Commands

```
> search() # loaded packages
[1] ".GlobalEnv"        "package:stats"     "package:graphics"
[4] "package:grDevices" "package:utils"     "package:datasets"
[7] "package:methods"   "Autoloads"         "package:base"

> ls() # Used objects
 [1] "bb"              "col"             "colorlut"        "EdgeList"
 [5] "Edges"           "EXP"             "f“

> rm(bb) # remove object “bb”

> ?lm  # ? Function name = look function

> args(lm) # look arguments in “lm”

> help(lm) #See detail of function (lm)
```

Operators

- Mathematic operators: + - * / ^
  - Mod: %%
  - sqrt, exp, log, log10, sin, cos, tan, …..
- Other operators:
  - $ component selection HIGH
  - [, [[subscripts, elements
  - : sequence operator
  - %*% matrix algebra
  - <, >, <=, >= inequality
  - ==, != comparison
  - ! not
  - &, |, &&, || and, or
  - ~ formulas
  - <- assignment (or = 1.9.1 later)

Arithmetic Operators

Operator	Description
+	addition
-	subtraction
*	multiplication
/	division
^ or **	exponentiation
x %% y	modulus (x mod y) 5%%2 is 1
x %/% y	integer division 5%/%2 is 2

Logical Operators

Operator	Description
<	less than
<=	less than or equal to
>	greater than
>=	greater than or equal to
==	exactly equal to
!=	not equal to
!x	Not x
x | y	x OR y
x & y	x AND y
isTRUE(x)	test if x is TRUE

Demo Algebra, Operators and Functions

```
> 1+2
[1] 3
> 1 > 2
[1] FALSE
> 1 > 2 | 2 > 1
[1] TRUE
> 1:3
[1] 1 2 3
> A = 1:3
> A
[1] 1 2 3
> A*6
[1]  6 12 18
> A/10
[1] 0.1 0.2 0.3
> A %% 2
[1] 1 0 1
```

```
> B=4:6
> A*B
[1]  4 10 18
> A%*%B
     [,1]
[1,]   32
> A %*% t(B)
     [,1] [,2] [,3]
[1,]    4    5    6
[2,]    8   10   12
[3,]   12   15   18
> A / B
[1] 0.25 0.40 0.50
> sqrt(A)
[1] 1.000000 1.414214 1.732051
> log(A)
[1] 0.0000000 0.6931472 1.0986123
```

```
> round(sqrt(A),2)
[1] 1.00 1.41 1.73
> ceiling(sqrt(A))
[1] 1 2 2
> floor(sqrt(A))
[1] 1 1 1
> eigen( A%*% t(B))
$values
[1] 3.200000e+01 5.835176e-16 2.480655e-16

$vectors
          [,1]      [,2]       [,3]
[1,] 0.2672612  0.3273463 -0.8890009
[2,] 0.5345225 -0.8217055  0.2540003
[3,] 0.8017837  0.4665237  0.3810004
> eigen( A%*% t(B))$values
[1] 3.200000e+01 5.835176e-16 2.480655e-16
```

Variables

```
> a = 49
> sqrt(a)
[1] 7
```

numeric

```
> a = "The dog ate my homework"
> sub("dog","cat",a)
[1] "The cat ate my homework“
```

character string

```
> a = (1+1==3)
> a
[1] FALSE
```

logical

Vectors, Matrices, and Arrays

- vector: an ordered collection of data of the same type
- > a = c(1,2,3)
- > a*2
- [1] 2 4 6

- In R, a single number is the special case of a vector with 1 element.
- Other vector types: character strings, logical

Vectors, Matrices, and Arrays

- matrix: a rectangular table of data of the same type

```
> A = matrix(1:12,3,4)
> A
     [,1] [,2] [,3] [,4]
[1,]    1    4    7   10
[2,]    2    5    8   11
[3,]    3    6    9   12
>
```

- array: 3-,4-,..dimensional matrix

```
> A[1,]
[1]  1  4  7 10
>
```

Lists

- vector: an ordered collection of data of the same type.

```
> a = c(7,5,1)
> a[2]
[1] 5
```

- list: an ordered collection of data of arbitrary types.

```
> doe = list(name="john",age=28,married=F)
> doe$name
[1] "john"
> doe$age
[1] 28
```

- Typically, vector elements are accessed by their index (an integer), list elements by their name (a character string). But both types support both access methods.

Data Frame

- data frame: is supposed to represent the typical data table that researchers come up with – like a spreadsheet.

- It is a rectangular table with rows and columns; data within each column has the same type (e.g. number, text, logical), but different columns may have different types.

Branching

```
if (logical expression) {
  statements
} else {
  alternative statements
}
```

else branch is optional

Loops

- When the same or similar tasks need to be performed multiple times; for all elements of a list; for all columns of an array; etc.
  - Monte Carlo Simulation
  - Cross-Validation (delete one and etc)

```
> for(i in 1:10) {
+     print(i*i)
+ }
[1] 1
[1] 4
[1] 9
[1] 16
[1] 25
[1] 36
[1] 49
[1] 64
[1] 81
[1] 100
```

```
> i=1
> while(i<=10) {
+     print(i*i)
+     i=i+sqrt(i)
+ }
[1] 1
[1] 4
[1] 11.65685
[1] 27.68836
[1] 57.0912
```

lapply, sapply, apply

- When the same or similar tasks need to be performed multiple times for all elements of a list or for all columns of an array.
  - May be easier and faster than “for” loops
- lapply(li, *function*)
  - To each element of the list li, the function *function* is applied.
  - The result is a list whose elements are the individual *function* results.

```
> li = list("klaus","martin","georg")
> lapply(li, toupper)
[[1]]
[1] "KLAUS"

[[2]]
[1] "MARTIN"

[[3]]
[1] "GEORG"
```

lapply, sapply, apply

- sapply(li, fct)
- Like apply, but tries to simplify the result, by converting it into a vector or array of appropriate size

```
> li = list("klaus","martin","georg")
> sapply(li, toupper)
[1] "KLAUS"  "MARTIN" "GEORG"
```

```
> fct = function(x) { return(c(x, x*x, x*x*x)) }
> sapply(1:5, fct)
     [,1] [,2] [,3] [,4] [,5]
[1,]    1    2    3    4    5
[2,]    1    4    9   16   25
[3,]    1    8   27   64  125
```

apply

apply(arr, margin, fct)
Apply the function fct along some dimensions of the array arr, according to margin, and return a vector or array of the appropriate size.

```
> A
     [,1] [,2] [,3] [,4]
[1,]    1    4    7   10
[2,]    2    5    8   11
[3,]    3    6    9   12
> apply(A, 1, sum)
[1] 22 26 30
> apply(A, 2, sum)
[1]  6 15 24 33
```

Functions and Operators

Functions do things with data
“Input”: function arguments (0,1,2,…)
“Output”: function result (exactly one)

Example:

```
add = function(a,b)
{ result = a+b
  return(result) }
```

Operators:
Short-cut writing for frequently used functions of one or two arguments.
Examples: + - * / ! & | %%

Functions and Operators

- Functions do things with data
  - “Input”: function arguments (0,1,2,…)
  - “Output”: function result (exactly one)

Exceptions to the rule:

- Functions may also use data that sits around in other places, not just in their argument list: “scoping rules”*
- Functions may also do other things than returning a result. E.g., plot something on the screen: “side effects”

Numeric Functions

Function	Description
abs(*x***)**	absolute value
sqrt(*x***)**	square root
ceiling(*x***)**	ceiling(3.475) is 4
floor(*x***)**	floor(3.475) is 3
trunc(*x***)**	trunc(5.99) is 5
round(*x***, digits=***n***)**	round(3.475, digits=2) is 3.48
signif(*x***, digits=***n***)**	signif(3.475, digits=2) is 3.5
cos(*x***), sin(***x***), tan(***x***)**	also acos(*x*), cosh(*x*), acosh(*x*), etc.
log(*x***)**	natural logarithm
log10(*x***)**	common logarithm
exp(*x***)**	e^*x*

Character Functions

Function	Description
substr(*x***, start=***n1***, stop=***n2***)**	Extract or replace substrings in a character vector. x <- "abcdef" substr(x, 2, 4) is "bcd" substr(x, 2, 4) <- "22222" is "a222ef"
grep(*pattern***,** *x* **,** **ignore.case**=FALSE**,** **fixed**=FALSE**)**	Search for *pattern* in *x*. If fixed =FALSE then *pattern* is a regular expression. If fixed=TRUE then *pattern* is a text string. Returns matching indices. grep("A", c("b","A","c"), fixed=TRUE) returns 2
sub(*pattern***,** *replacement***,** *x***,** **ignore.case** =FALSE**,** **fixed**=FALSE**)**	Find *pattern* in *x* and replace with *replacement* text. If fixed=FALSE then *pattern* is a regular expression. If fixed = T then *pattern* is a text string. sub("\\s",".","Hello There") returns "Hello.There"
strsplit(*x***,** *split***)**	Split the elements of character vector *x* at *split*. strsplit("abc", "") returns 3 element vector "a","b","c"
paste(..., sep="")	Concatenate strings after using *sep* string to seperate them. paste("x",1:3,sep="") returns c("x1","x2" "x3") paste("x",1:3,sep="M") returns c("xM1","xM2" "xM3") paste("Today is", date())
toupper(*x***)**	Uppercase
tolower(*x***)**	Lowercase

Date Values

Dates are represented as the number of days since 1970-01-01, with negative values for earlier dates.

```
> # use as.Date( ) to convert strings to dates
> mydates <- as.Date(c("2007-06-22", "2004-02-13"))
> # number of days between 6/22/07 and 2/13/04 days <- mydates[1] - mydates[2]
> mydates
[1] "2007-06-22" "2004-02-13"
```

Sys.Date( ) returns today's date.

Date() returns the current date and time.

Date Values

The following symbols can be used with the format( ) function to print dates.

Symbol	Meaning	Example
%d	day as a number (0-31)	01-31
%a	abbreviated weekday	Mon
%A	unabbreviated weekday	Monday
%m	month (00-12)	00-12
%b	abbreviated month	Jan
%B	unabbreviated month	January
%y	2-digit year	07
%Y	4-digit year	2007

Date Values

```
# print today's date
today <- Sys.Date()
format(today, format="%B %d %Y")
    "June 20 2007"
```