

UCLA Department of Statistics
Statistical Consulting Center

R Graphics II: Graphics for Exploratory Data Analysis

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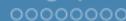
Outline

- 1 Summary Plots
- 2 Time Series Plots
- 3 Geographical Plots
- 4 3D Plots
- 5 Simulation Plots
- 6 Solutions to the Exercises
- 7 Useful Links for R

Disclaimer

The author assumes you are familiar with R and are comfortable subsetting.





1 Summary Plots

- Basic Plots
- Looking at Distributions
- Identifying Observations
- Exercise I

2 Time Series Plots

3 Geographical Plots

4 3D Plots

5 Simulation Plots

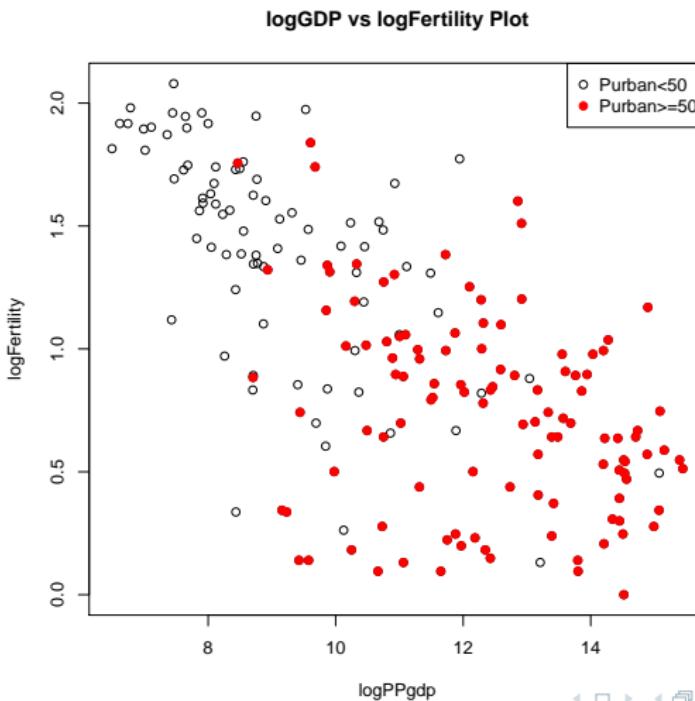
6 Solutions to the Exercises

7 Useful Links for R

Basic Plot I

```
1 # Step 1: Load the Data
2 library(alr3)
3 data(UN2)
4 attach(UN2)
5 # Step 2: Subset appropriately
6 ind<-which(Purban>50)
7 # Step 3: Plot
8 plot(logFertility~logPPgdp, xlab="logPPgdp",
      ylab="logFertility", main="logGDP vs
      logFertility Plot")
9 points(logFertility[ind]~logPPgdp[ind], col="red",
          pch=19)
10 legend("topright", pch=c(1,19), col=1:2, c("
            Purban<50", "Purban>=50"))
```

Basic Plot II



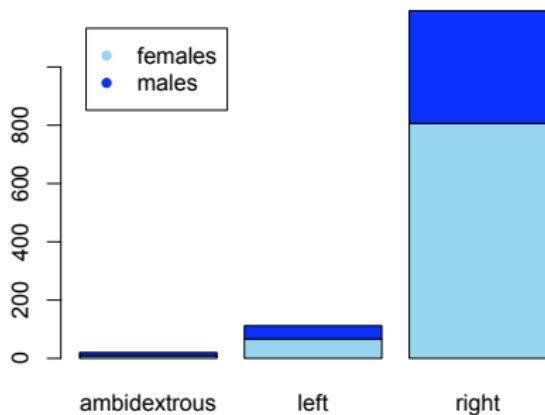
Segmented bar charts I

Displays two categorical variables at a time:¹

```
1 survey = read.table("http://www.stat.ucla.edu  
/~mine/students_survey_2008.txt", header =  
TRUE, sep = "\t")  
2 attach(survey)  
3 barplot(table(gender, hand), col = c("skyblue"  
, "blue"), main = "Segmented Bar Plot \n  
of Gender")  
4 legend("topleft", c("females", "males"), col =  
c("skyblue", "blue"), pch = 16, inset =  
0.05)
```

Segmented bar charts II

**Segmented Bar Plot
of Gender**



	ambidextrous	left	right
female	9	67	806
male	11	45	387

¹These two slides are modified from the SCC Mini-Course "Introductory Statistics with R" by Mine Çetinkaya-Rundquist, Consulting UCLA

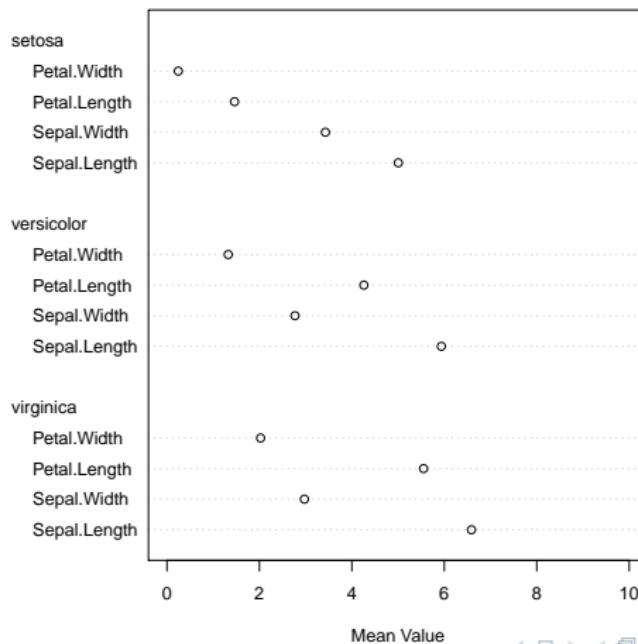
Dot charts I

To compare values for variables in each category:

```
1 # Step 1: Load the data
2 data(iris)
3 attach(iris)
4 # Step 2: Calculate means for each species:
5 aggregate(iris[, -5], list(Species = Species),
6   mean)->a
7 # Step 3: Assign row names
8 row.names(a)<-a[, 1]
9 # Step 4: Plot
10 dotchart(t(a[, -1]), xlim = c(0,10), main =
11   "Plots of Means for Iris Data Set", xlab =
12   "Mean Value")
```

Dot charts II

Plots of Means for Iris Data Set

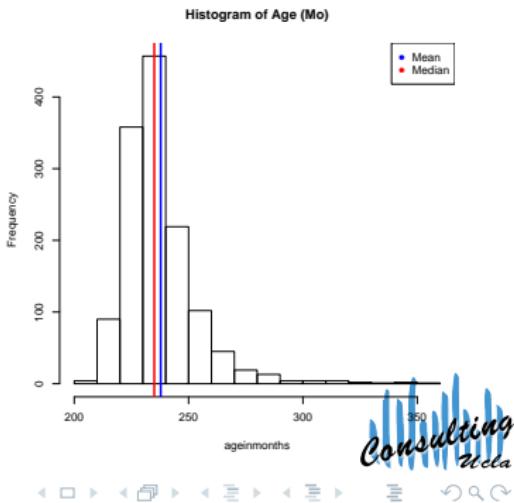


Histograms

Adding Summary Statistics to Plots

Add the mean and median to a histogram:

```
1 hist(ageinmonths , main="Histogram of Age (Mo)")  
2 abline(v=mean(ageinmonths) ,  
         col = "blue" , lwd=3)  
3 abline(v=median(ageinmonths  
           ) , col = "red" , lwd=3)  
4 legend("topright" , c("Mean"  
           , "Median") , pch = 16,  
           col = c("blue" , "red"))
```



Histograms I

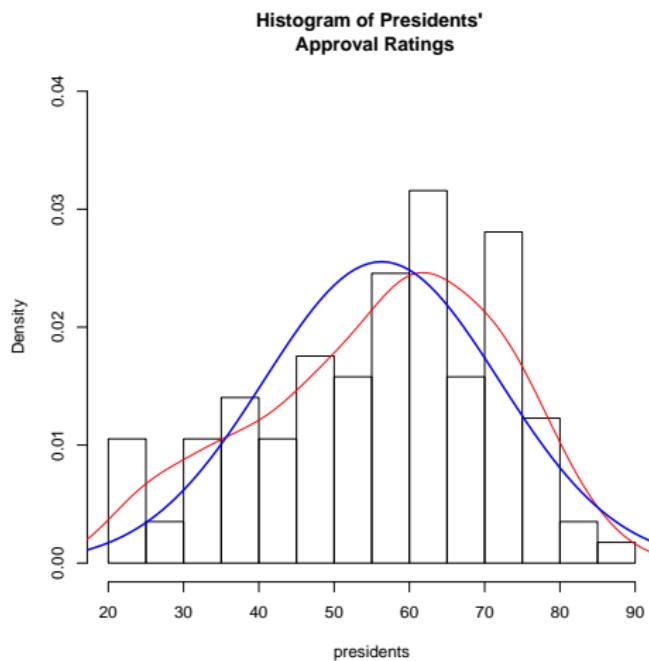
Checking Normality

One of the methods to test for normality of a variable is to look at the histogram (the sample density is in red, the theoretical normal density in blue):

```
1 data(presidents)
2 hist(presidents, prob=T, ylim=c(0, 0.04),
      breaks=20)
3 lines(density(presidents, na.rm=TRUE), col="
      red")
4 mu<-mean(presidents, na.rm=TRUE)
5 sigma<-sd(presidents, na.rm=TRUE)
6 x<-seq(10,100, length=100)
7 y<-dnorm(x,mu,sigma)
8 lines(x,y, lwd=2, col="blue")
```

Histograms II

Checking Normality



Box and Whisker Plot I

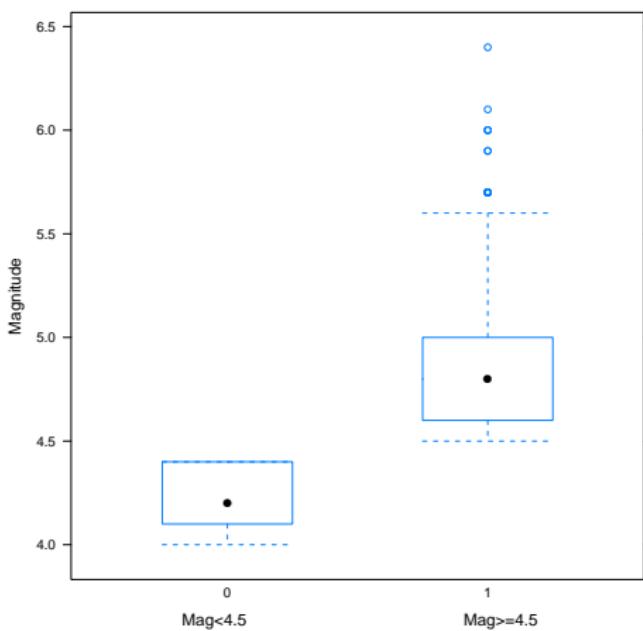
Another method of looking at the distribution of the data is via boxplot:

```
1 data(quakes)
2 # Subset the magnitude:
3 ind<-ifelse(quakes[, 4]<4.5, 0, 1)
4 ind<-as.factor(ind)
5 library(lattice)
6 bwplot(quakes[, 4]~ind, xlab=c("Mag<4.5", "Mag
>=4.5"), ylab="Magnitude")
```



Box and Whisker Plot II

Fiji EQ since 1964

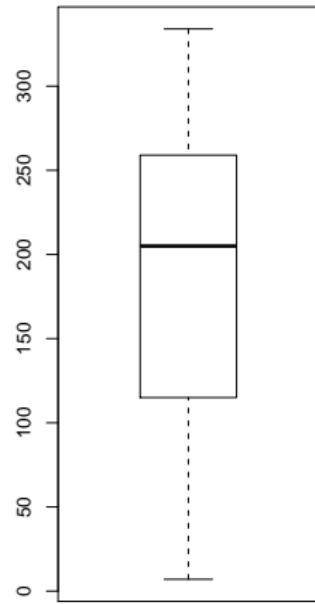
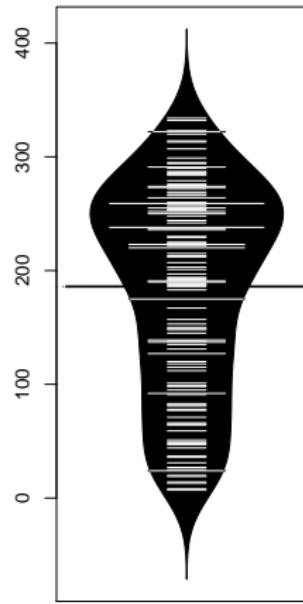


Beanplot I

An alternative to the boxplot is the beanplot():

```
1 library(beanplot)
2 par(mfrow=c(1,2))
3 data(airquality)
4 boxplot(airquality[, 2], main="Boxplot", xlab=
  "Solar")
5 beanplot(airquality[, 2], main="Beanplot",
  xlab="Solar")
```

Beanplot II

Boxplot**Beanplot**

Scatterplots I

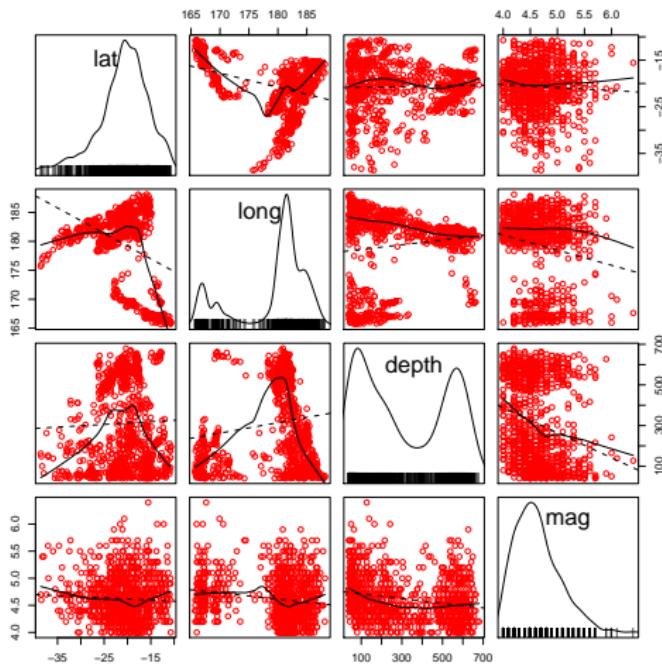
A method of looking at the distribution and correlation of the data is via `scatterplot.matrix()`:

```
1 data(quakes)
2 library(car)
3 scatterplot.matrix(quakes[, 1:4])
```



Looking at Distributions

Scatterplots II



Checking Equality of Distributions I

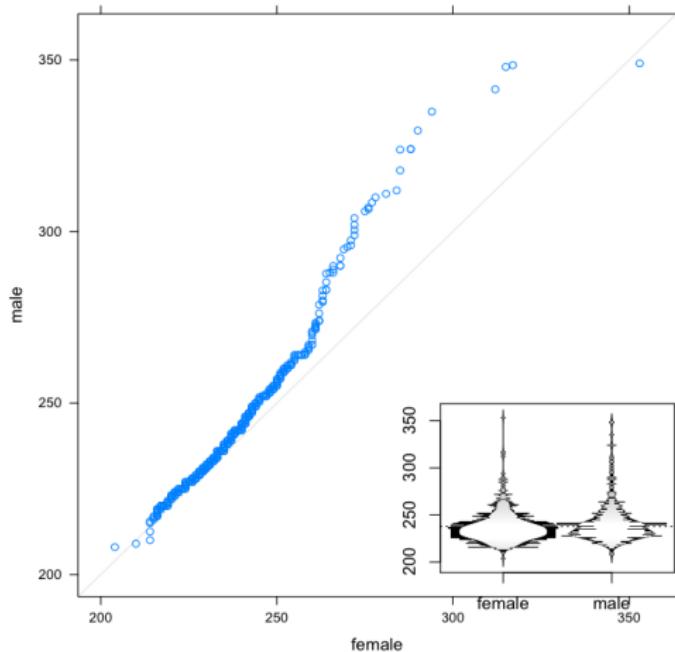
Approach 1

A method of checking equality of distributions is via `qq()`:

```
1 library(lattice)
2 survey = read.table("http://www.stat.ucla.edu
  /~mine/students_survey_2008.txt", header =
  TRUE, sep = "\t")
3 attach(survey)
4 qq(gender~ageinmonths)
```

Checking Equality of Distributions II

Approach 1



Checking Equality of Distributions I

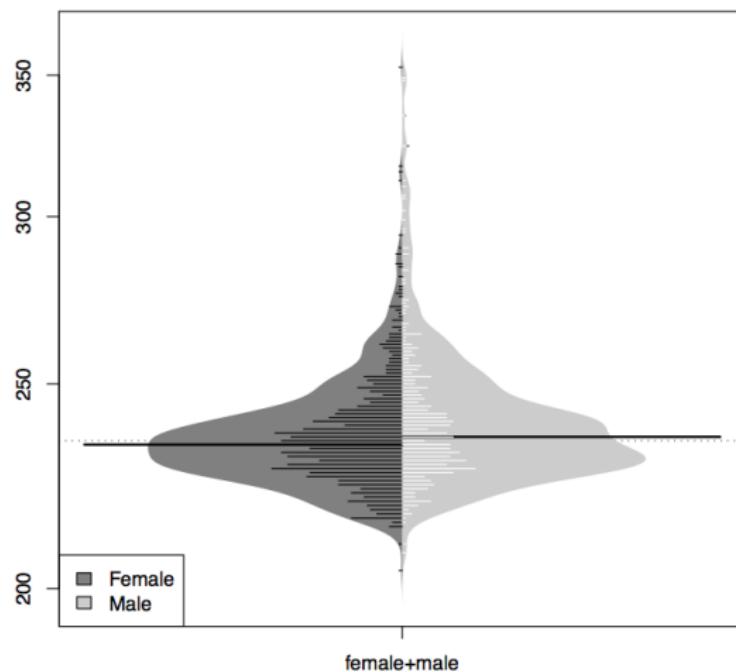
Approach 2

Another method for checking equality of distributions is via `beanplot()`:

```
1 survey = read.table("http://www.stat.ucla.edu  
/~mine/students_survey_2008.txt", header =  
    TRUE, sep = "\t")  
2 attach(survey)  
3 beanplot(ageinmonths ~ gender, data=survey,  
    col=list(grey(0.5),c(grey(0.8),"white")),  
    border = NA, overallline = "median", l1  
    =0.01, side="both")  
4 legend("bottomleft",fill=c(grey(0.5),grey(0.8))  
    ), legend=c("Female","Male"))
```

Checking Equality of Distributions II

Approach 2



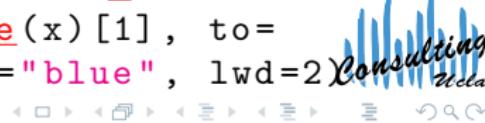
Identify-ing Observations I

Preliminaries

```
1 # Generate data and fit a regression curve:  
2 set.seed(3012008)  
3 x=rnorm(100); y=-x+I(x^2) +rnorm(100)  
4 fit<-lm(y~x+I(x^2)); fit
```

Intercept	x	x^2
0.1307	-0.9701	0.9549

```
1 # Plot the resulting regression curve:  
2 plot(y~x, pch=19)  
3 curve(expr=fit[[1]][1]+fit[[1]][2]*x+fit  
[[1]][3]*I(x^2), from=range(x)[1], to=  
range(x)[2], add=TRUE, col="blue", lwd=2)
```

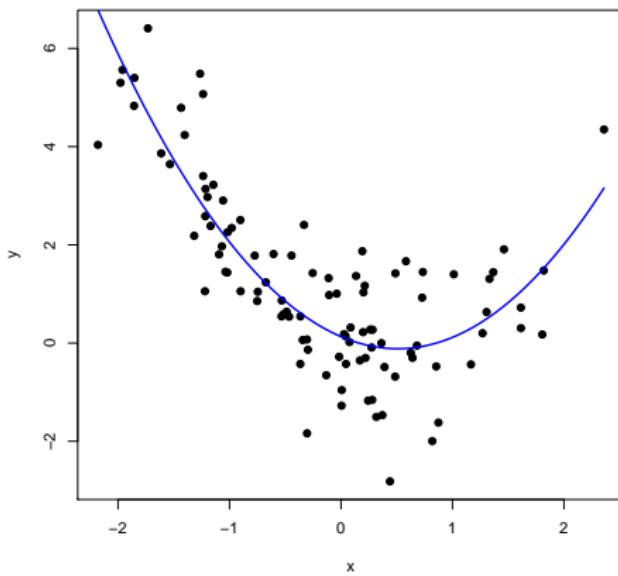




Identify-ing Observations

Identify-ing Observations II

Preliminaries



Identify-ing Observations I

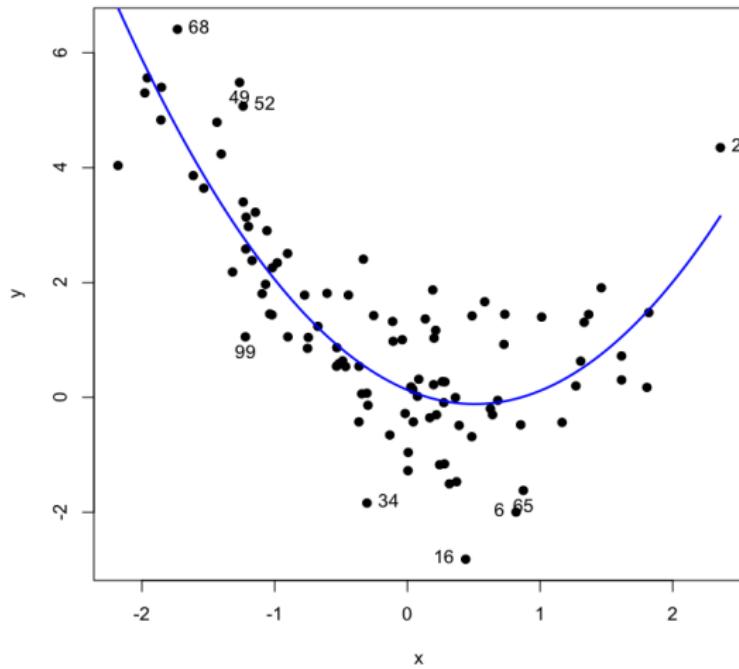
Left-click on the observations in the graphics window to see the row number.

Right-click on the observation to exit the function.

```
1 # Plot the data and fit the regression curve:  
2 plot(y~x, pch=19)  
3 curve(expr=fit[[1]][1]+fit[[1]][2]*x+fit  
        [[1]][3]*I(x^2), from=range(x)[1], to=  
        range(x)[2], add=TRUE, col="blue", lwd=2)  
4 # Identify the "outlying" observations:  
5 index<-identify(y~x); index
```

Identify-ing Observations

Identify-ing Observations II



Exercise I

Compare the distributions of the sepal widths for the three species of irises (using the `iris` data set).

1 Summary Plots

2 Time Series Plots

- Multivariate Plots
- Exercise II

3 Geographical Plots

4 3D Plots

5 Simulation Plots

6 Solutions to the Exercises

7 Useful Links for R

Multivariate Time Series Plots I

Approach 1

To plot more than variables one at a time, use `plot()`:

```
1 # Convert data to a time series via ts() or
  # zoo():
2 data(airquality)
3 a<-airquality[, 1:3]
4 time<-ts(1:nrow(a), start=c(1973, 5),
  frequency=365)
5 # If your data is stored as a data frame,
6 # coerce it to be a matrix via as.matrix()
7 class(a)
8 a.mat<-as.matrix(a)
9
10
```

Multivariate Time Series Plots II

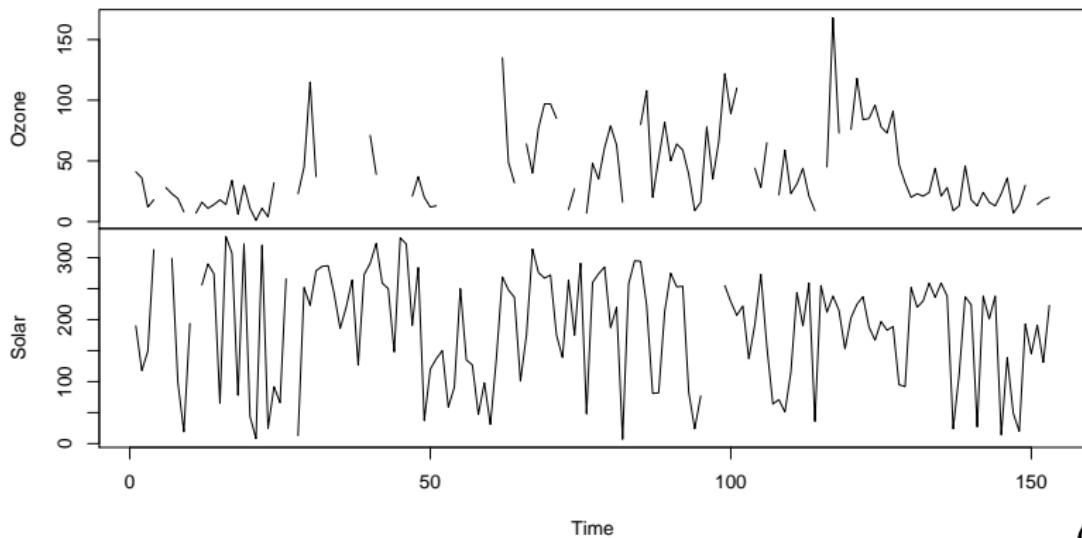
Approach 1

```
11 # Make a time series of the two (or more  
#      variables)  
12 library(zoo)  
13 name.zoo<-zoo(cbind(a.mat[, 1], a.mat[, 2]))  
14 colnames(name.zoo)<-c("Ozone", "Solar")  
15 ##### Plot the variables  
16 plot(name.zoo)
```

Multivariate Time Series Plots III

Approach 1

Plots of Ozone and Solar



Multivariate Time Series Plots

Approach 2

To plot more than variables one at a time, use `mvtspplot()`:²

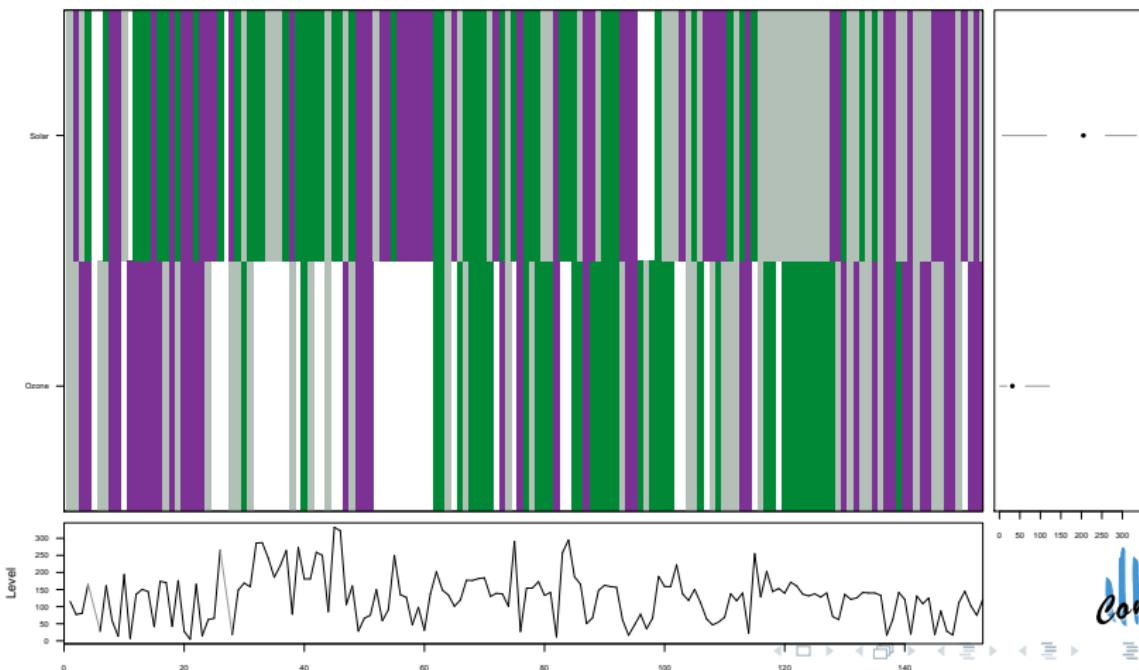
```
1 # Load the R Code for the function
2 source("http://www.biostat.jhsph.edu/~rpeng/RR
      /mvtspplot/mvtspplot.R")
3 # After processing data as in Approach 1
4 # Plot the variables
5 mvtspplot(name.zoo)
6 # Purple=low, grey=medium, green=high, white=
  missing values
```



²For documentation, go to: www.jstatsoft.org/v25/c01/paper

Multivariate Time Series Plots

Approach 2



Multivariate Time Series Plots I

Approach 3

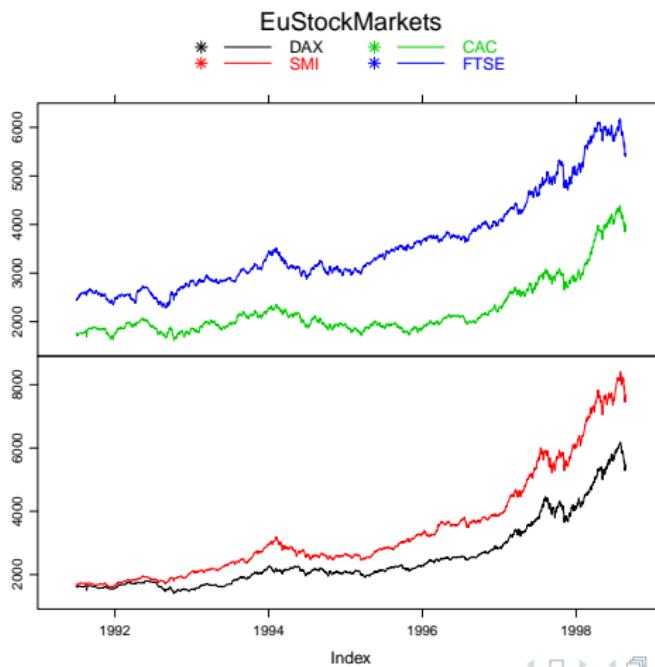
To plot more than variables one at a time, use `xyplot()`:

```
1 # After processing data as in Approach 1
2 # load both libraries:
3 library(lattice)
4 library(zoo)
5 data(EuStockMarkets)
6 z<-EuStockMarkets
7 xyplot(z, screen = c(1,1,2,2), col = 1:4,
       strip = FALSE, key = list(title =
         "EuStockMarkets", columns=2, points=FALSE,
         lines=TRUE, col=1:4, text=list(colnames(z))
       )))
```



Multivariate Time Series Plots II

Approach 3



Exercise II

Analyze the `EuStockMarkets` data using the function `mtvspplot()`. What stands out and why?

1 Summary Plots

2 Time Series Plots

3 Geographical Plots

- Maps
- Projection Maps
- Exercise III

4 3D Plots

5 Simulation Plots

6 Solutions to the Exercises

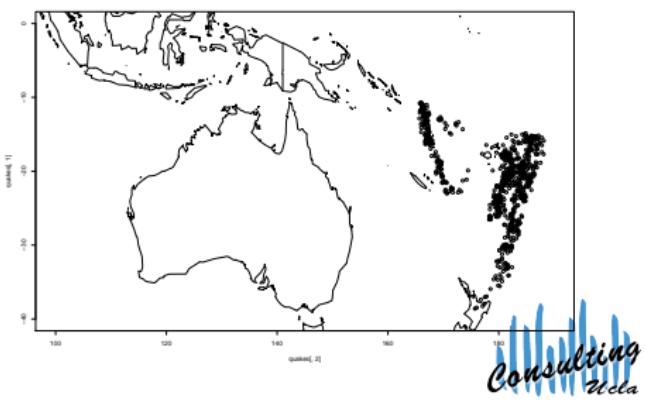
7 Useful Links for R

Geographic Maps

Map of Fiji Earthquakes Since 1964

To overlay a map to a plot containing latitude and longitude, load the package `maps`:

```
1 data(quakes)
2 library(maps)
3 plot(quakes[, 2],
      quakes[, 1], xlim=
c(100, 190), ylim=
c(-40, 0))
4 map("world", add=T)
```



Geographic Maps I

Map of Fiji Earthquakes Since 1964

To include information on magnitude of earthquake, use cex argument of the plot() function:

```
1 # Step 1: Recode magnitude to have 3
  categories only
2 ind<-which(mag<5)
3 ind2<-which(mag<6 & mag >=5)
4 ind3<-which(mag >=6)
5 color<-rep(NA, length(mag))
6 color[ind]<-1; color[ind2]<-2; color[ind3]<-3
7
8
9
10
```

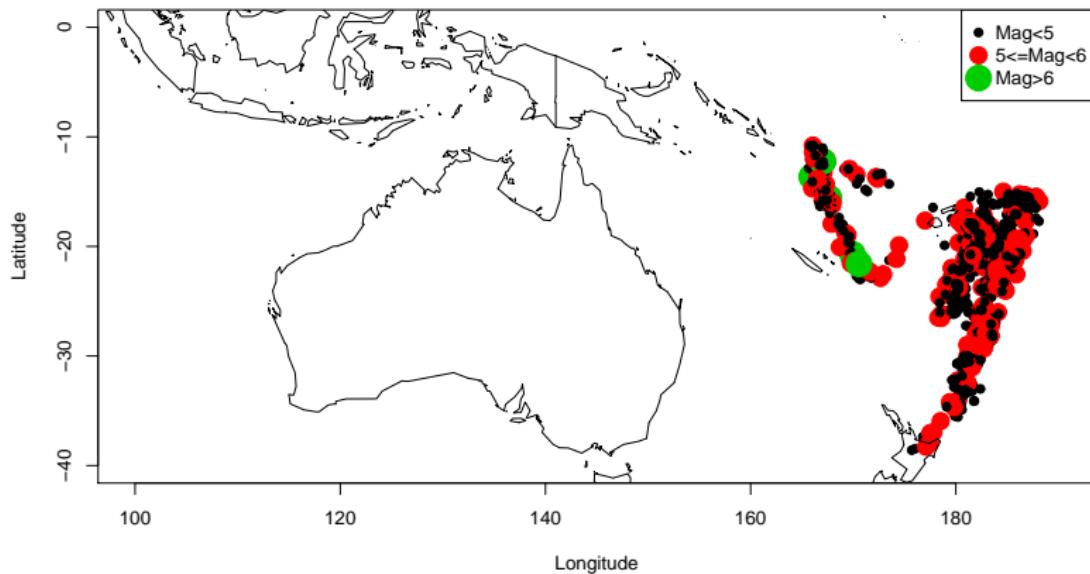
Geographic Maps II

Map of Fiji Earthquakes Since 1964

```
11  # Step 2: Plot
12  plot(quakes[, 2], quakes[, 1], cex=color, pch
13    =19, col=color, xlim=c(100, 190), ylim=
14      c(-40,0), xlab="Longitude", ylab="Latitude
15    ")
16  legend("topright", pch=19, col=1:3, c("Mag<5",
17    "5<=Mag<6", "Mag>6"), pt.cex=1:3)
18  map("world", add=T)
```

Geographic Maps III

Map of Fiji Earthquakes Since 1964



Projection Maps I

Map of Fiji Earthquakes Since 1964

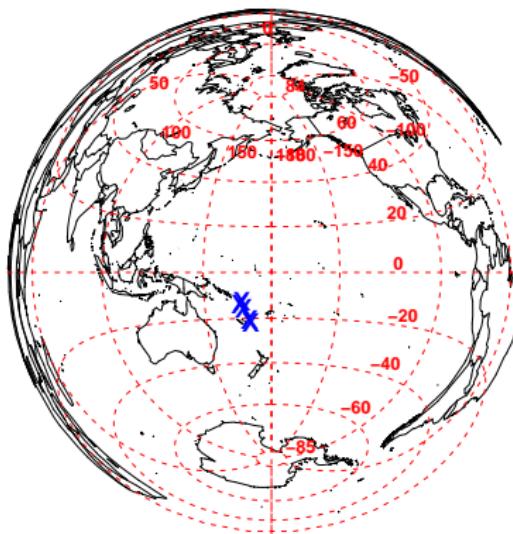
For a different perspective of a map, use `mapproject()`:

```
1 library(mapproj)
2 library(maps)
3 m <- map('world',plot=FALSE)
4 # Projection is Azimuthal with equal-area
5 map('world',proj='azequalarea',orient=c(
       longitude=0,latitude=180,rotation=0))
6 map.grid(m,col=2)
7 points(mapproject(list(y=quakes[which(quakes[,4]>=6),
                           1],x=quakes[which(quakes[, 4]>=6),
                           2])),col="blue",pch="x",cex=2)
```



Projection Maps II

Map of Fiji Earthquakes Since 1964



Bonus Feature of the `maps` package:

To determine in which part of the world the observations are (based on latitude and longitude), use `map.where()`:

```
1 in.what.country <- map.where(database="world",
  quakes[, 2], quakes[, 1])
```

To determine which observations are in the ocean:

```
1 # Number of points in ocean after filtering:
2 ind <- sum(is.na(in.what.country)); ind
3 # Number of observations: 1000
4 # Number in Ocean: 993
```

Exercise III

For the ozone data set³, determine the region of the world that the observations correspond to and overlay the appropriate map.

³<http://www.ats.ucla.edu/stat/R/faq/ozone.csv>



1 Summary Plots

2 Time Series Plots

3 Geographical Plots

4 3D Plots

- lattice library
- ggplot2 library
- rgl library
- Saving Plots as a PDF
- Exercise IV

5 Simulation Plots

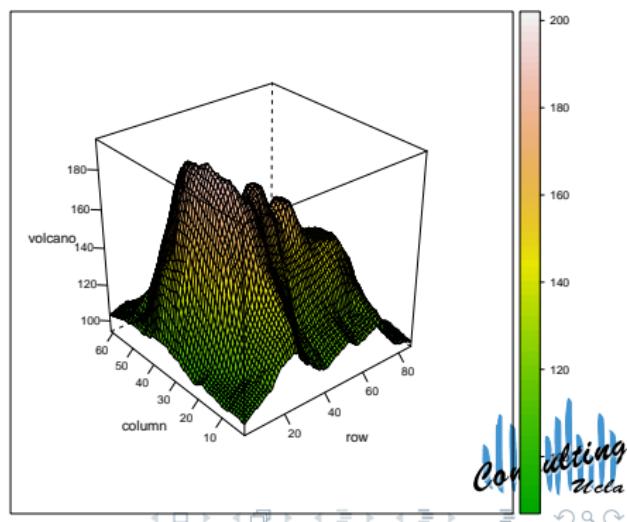
6 Solutions to the Exercises

7 Useful Links for R

3D Images with Package lattice

Method 1: Using `wireframe()`:

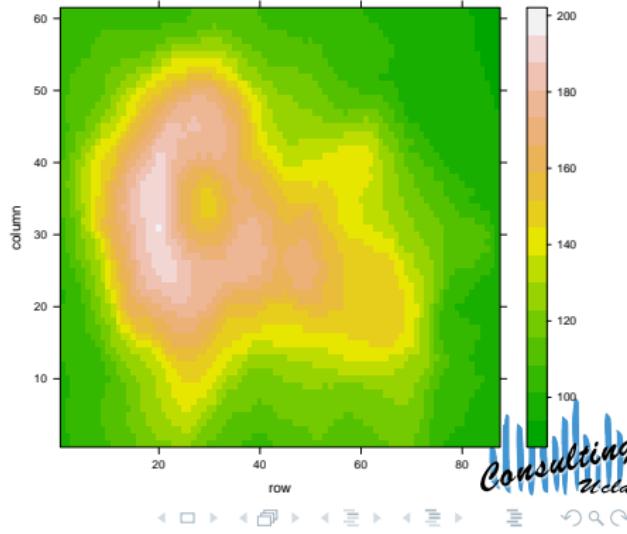
```
1 library(lattice)
2 wireframe(volcano ,
            col.regions =
terrain .
colors(100), asp =
1, color.key=TRUE
, drape=TRUE,
scales = list(
arrows = FALSE))
```



3D Images with Package lattice

Method 2: Same image with the `levelplot()` function:

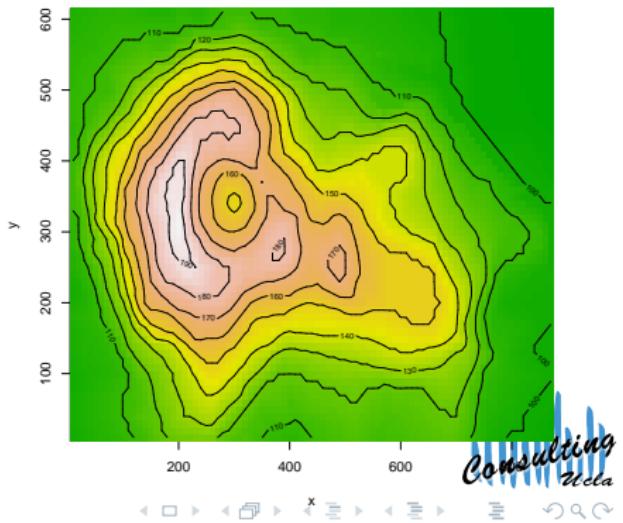
```
1 library(lattice)  
2 levelplot(volcano,  
           asp=1, col.regions  
           =terrain.colors)
```



3D Images with Package lattice

Method 3: Same image with the `image()` function:

```
1 x<-10*(1:nrow(volcano))
   )
2 y<-10*(1:ncol(volcano))
   )
3 image(x, y, volcano,
       col = terrain.
       colors(100), axes =
       TRUE)
4 contour(x, y, volcano,
       add = TRUE, col =
       1)
```



3D Images with Package ggplot2 |

Another way to create 3D images is with the package `ggplot2`:

```
1 # Step 1: Load the data
2 data(quakes)
3 attach(quakes)
4 # Step 2: Create a categorical variable for
      earthquake magnitude
5 ind<-which(mag<5)
6 ind2<-which(mag<6 & mag >=5)
7 ind3<-which(mag >=6)
8 color<-rep(NA, length(mag))
9 color[ind]<-1; color[ind2]<-2; color[ind3]<-3
10 color<-as.factor(color)
11
12
```



3D Images with Package ggplot2 II

```
13 # Step 3: Plot
14 library(ggplot2)
15 ggplot(data=quakes, aes(long, lat))+
16 geom_point(aes(long, lat))+
17 borders("world")+
18 coord_cartesian(xlim=c(100,190), ylim=c(-40,0)
)
```

3D Images with Package ggplot2 III



Consulting
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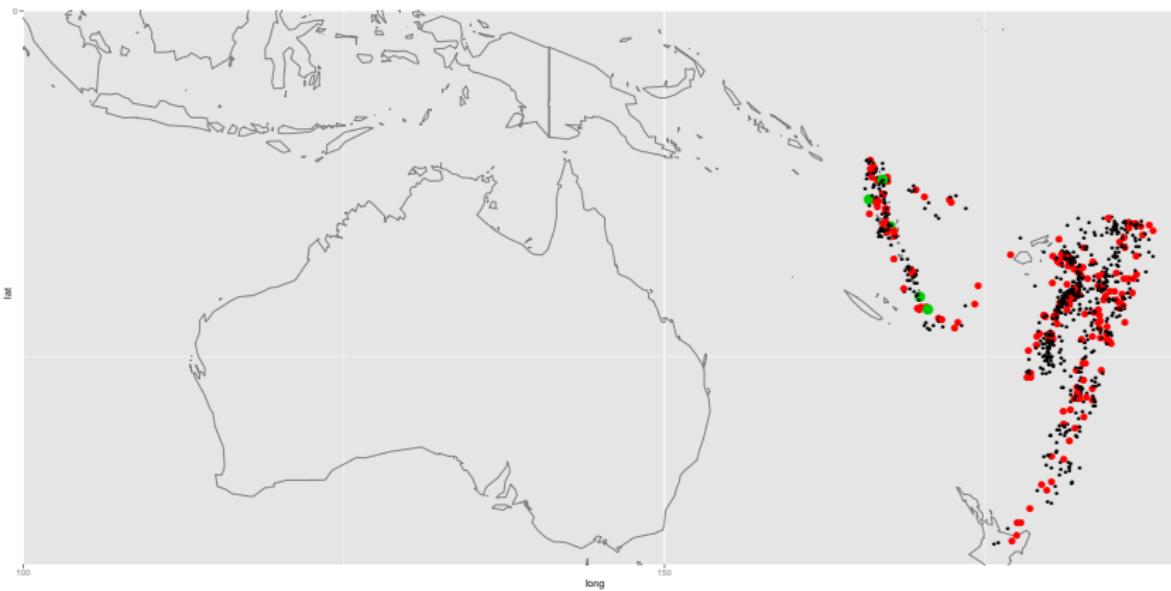
3D Images with Package ggplot2 |

To include information on magnitude of earthquake, use `geom_point()`:

```
1 ggplot(data=quakes, aes(long, lat))+
2 borders("world")+
3 coord_cartesian(xlim=c(100,190), ylim=c(-40,0)
)+  
4 geom_point(data=quakes, colour=as.numeric(  
color), size=2*as.numeric(color))
```



3D Images with Package ggplot2 II



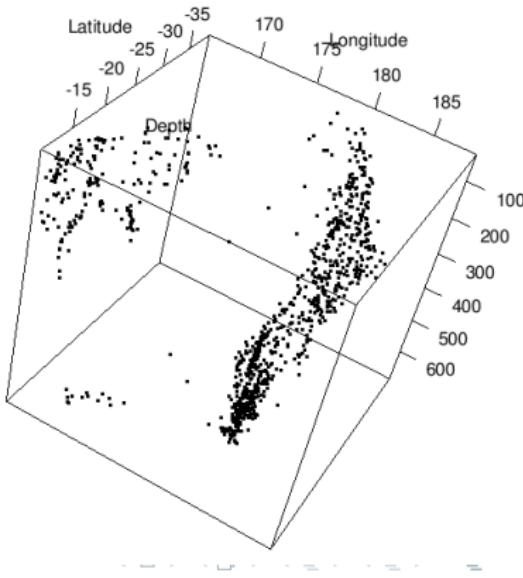
Consulting
ucla

rgl library

3D Images with Package rgl

A way to create 3D interactive images is with the package `rgl`:

```
1 library(rgl)
2 data(quakes)
3 plot3d(x=quakes[, 2],
          y=quakes[, 1], z=
          quakes[, 3], xlab=
          "Longitude", ylab=
          "Latitude", zlab="Depth")
```



Saving Plots as a PDF

For Static Plots

Note: The files will be saved in the folder specified with `setwd()`.
To save a static plot in R as a PDF, use function `pdf()`:

```
1 # To save the image to the desktop:  
2 setwd("~/Desktop")  
3 wireframe(volcano, col.regions = terrain.  
           colors(100), asp = 1, color.key=TRUE,  
           drape=TRUE, scales = list(arrows = FALSE))  
4 dev.off()
```

Saving Plots as a PDF

For Dynamic Plots

Note: The files will be saved in the folder specified with `setwd()`.

To save a dynamic plot in R as a PDF, use function

`rgl.snapshot()`:

```
1 # To save the image to the desktop:  
2 setwd("~/Desktop")  
3 # Step 1: Produce the 3D image:  
4 plot3d(x=quakes[, 2], y=quakes[, 1], z=quakes  
        [, 3], xlab="Longitude", ylab="Latitude",  
        zlab="Depth")  
5 # Step 2: Can rotate before taking a snapshot:  
6 rgl.snapshot("quakes.png")
```

Exercise IV

Use the `rgl` library to create a 3D plot of the `ozone` data set ⁴.



⁴<http://www.ats.ucla.edu/stat/R/faq/ozone.csv>

1 Summary Plots

2 Time Series Plots

3 Geographical Plots

4 3D Plots

5 Simulation Plots

- Preliminaries
- Performing the Simulation and Visualizing the Results
- Exercise V

6 Solutions to the Exercises

7 Useful Links for R

Simulations

Preliminaries: The function `outer()`

```
1 x=5:6; y=1:3  
2 outer(x,y)
```

	[,1]	[,2]	[,3]
[1,]	5	10	15
[2,]	6	12	18

```
1 fcn<-function(x,y){z=x+y}  
2 outer(x,y,fcn)
```

	[,1]	[,2]	[,3]
[1,]	6	7	8
[2,]	7	8	9

Simulations I

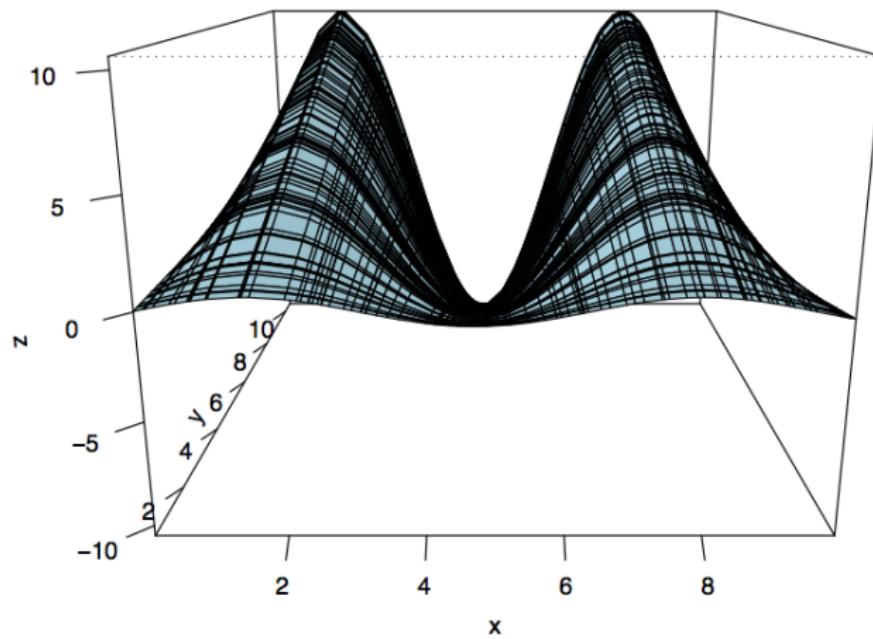
Visualize with `persp()`

Suppose we want to know what the function $y \times \sin(x)$ looks like:

```
1 # Sample from the random uniform:
2 x <- sort(runif(100, min=0, max=10))
3 y <- x+runif(1)
4 f <- function(x,y) { r <- y*sin(x)}
5 z <- outer(x,y,f)
6 persp(x, y, z, col = "lightblue", shade = 0.1,
       ticktype = "detailed", expand=0.7)
```

Simulations II

Visualize with `persp()`



Simulations I

Visualize with `image()`

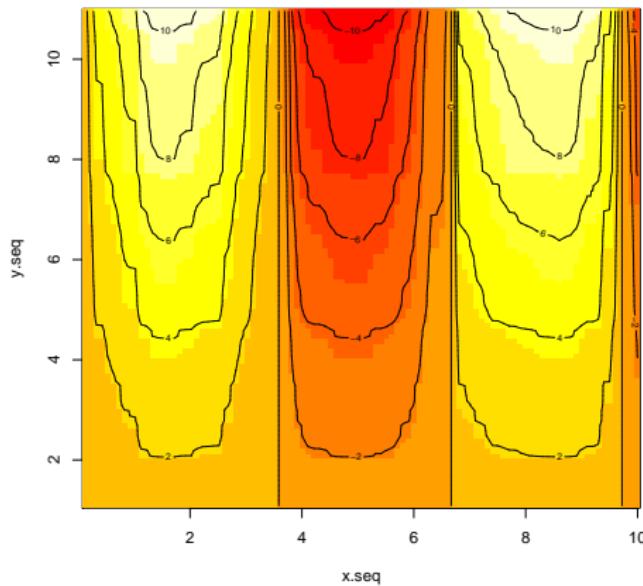
To visually see its maximum and minimum values, look at the contours of the function:

```
1 # Format the data appropriate for the image()
  function:
2 x.seq<-seq(from=range(x)[1], to=range(x)[2],
  length=100)
3 y.seq<-seq(from=range(y)[1], to=range(y)[2],
  length=100)
4 n1<-length(x.seq)
5 n2<-length(y.seq)
6 mat1<-matrix(z, nrow=n1, ncol=n2, byrow=FALSE)
7 image(x.seq, y.seq, mat1)
8 contour(x.seq, y.seq, mat1, add=TRUE)
```



Simulations II

Visualize with `image()`



Simulations I

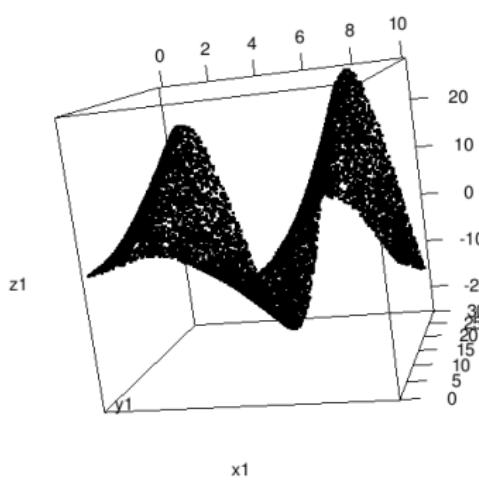
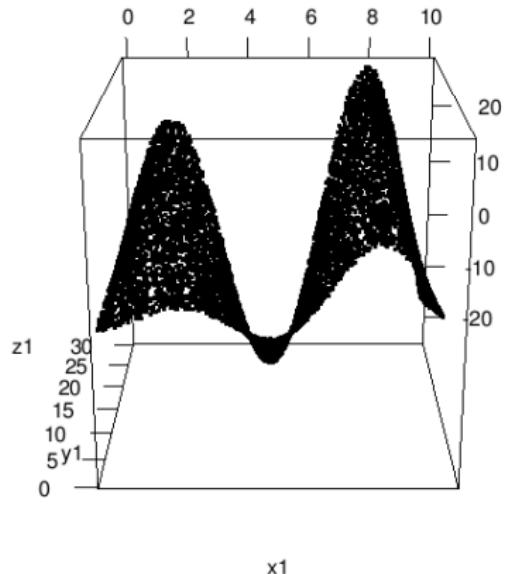
Visualize with `plot3d()`

Suppose we want to know what the function $y \times \sin(x)$ looks like with a dynamic plot:

```
1 # Sample from the random uniform:  
2 x1 <- sort(runif(10000, min=0, max=10))  
3 y1 <- x1+runif(1000, min=0, max=20)  
4 z1<-y1*sin(x1)  
5 library(rgl)  
6 plot3d(x1, y1, z1)
```

Simulations II

Visualize with `plot3d()`



Exercise V

Visualize the following function:

$$z = \frac{\sin(\frac{3}{2}x)}{y} \quad (1)$$



1 Summary Plots

2 Time Series Plots

3 Geographical Plots

4 3D Plots

5 Simulation Plots

6 Solutions to the Exercises

- Solution to Exercise I
- Solution to Exercise II
- Solution to Exercise III
- Solution to Exercise IV
- Solution to Exercise V

7 Useful Links for R

Solution to Exercise I

```
1 beanplot(Sepal.Width ~ Species, data=iris,  
           col=list(grey(0.5),c(grey(0.8),"white")),  
           border = NA, overallline = "median", ll  
           =0.01, side="both")
```

Solution to Exercise II

Solution to Exercise II

```
1 source("http://www.biostat.jhsph.edu/~rpeng/RR  
/mvtsplot/mvtsplot.R")  
2 mvtsplot(EuStockMarkets)
```



Solution to Exercise III

```
1 ozone<-read.table("http://www.ats.ucla.edu  
    /stat/R/faq/ozone.csv", sep=",", header=T)  
2 attach(ozone)  
3 plot(Lat~Lon, xlim=c(-125, -113), ylim=  
    c(31,42))  
4 map("state", "california", add=TRUE)
```



Solution to Exercise IV

```
1 ozone<-read.table("http://www.ats.ucla.edu  
/stat/R/faq/ozone.csv", sep=",", header=T)  
2 attach(ozone)  
3 library(rgl)  
4 plot3d(z=Av8top, x=long, y=lat)
```

Solution to Exercise V

```
1 # Sample from the random uniform:
2 x <- sort(runif(100, min=0, max=10))
3 y <- x+runif(1)
4 f <- function(x,y) { r <- sin(1.5*x)/y}
5 z <- outer(x,y,f)
6 persp(x, y, z, col = terrain.colors(length(z)
  /4), shade = 0.1, ticktype = "detailed",
  expand=0.7)
```

1 Summary Plots

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6 Solutions to the Exercises

7 Useful Links for R

Online Resources for R

Download R: <http://cran.stat.ucla.edu/>

Search Engine for R: <http://rseek.org>

R Reference Card:

<http://cran.r-project.org/doc/contrib/Short-refcard.pdf>

R Graphics Gallery:

<http://research.stowers-institute.org/efg/R/>

R Graph Gallery: <http://addictedtor.free.fr/graphiques/>

UCLA Statistics Information Portal: <http://info.stat.ucla.edu/grad/>

UCLA Statistical Consulting Center: <http://scc.stat.ucla.edu>



Thank you.
Any questions?