

Dynamic data visualization with R

Laurent Rouvière

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Overview

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 - visualize data, models and results of a statistical analysis
 - discover (and master) some R visualization packages

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 - visualize data, models and results of a statistical analysis
 - discover (and master) some R visualization packages
- **Teacher:** Laurent Rouvière, laurent.rouviere@univ-rennes2.fr
 - **Research interests:** nonparametric statistics, statistical learning
 - **Teaching:** statistics and probability (University and engineer school)
 - **Responsibilities:** head of the Master **Mathématiques Appliquées, Statistique** of Rennes
 - **Consulting:** energy (ERDF), banks, marketing, sport

Resources

- Slides and tutorials (supplement materials + exercises) available at <https://lrouviere.github.io/VISU/>
- The web

Why data visualization in your Master?

- **Data** are more and more **complex**
- **Models** are more and more **complex**
- **Conclusions** are more and more **complex**.

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 - **calibrate** models
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Consequence

Visualization reveals **crucial** throughout a statistical study.

How to make visualization?

- (at least) 2 ways to understand **visualization**:
 1. **Statistical methods or algorithms**: PCA, LDA, trees. . .
 2. **Computing tools**: R packages.

How to make visualization?

- (at least) 2 ways to understand **visualization**:
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- In this workshop, we will focus on some **R tools**:
 1. **ggplot2**: system for declaratively creating graphics \implies 3-4h.
 2. **Mapping** with **ggmap**, **sf** (static) **leaflet** (dynamic) \implies 3-4h.
 3. **Dynamic or interactive tools**
 - data with **rAmCharts** and **plotly** \implies 1h
 - dashboard with **flexdashboard** \implies 1h
 - web applications with **shiny** \implies 5h

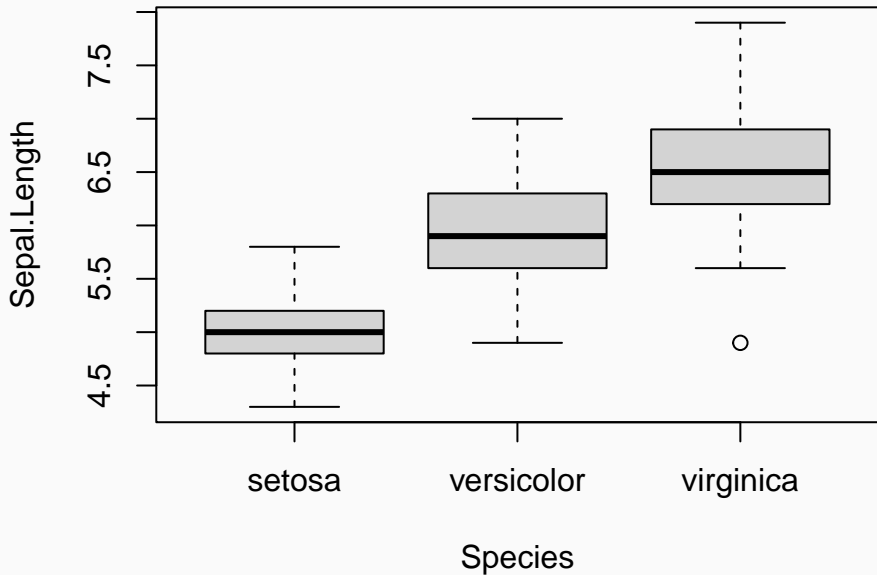
Boxplot for the iris dataset

```
> data(iris)
> summary(iris)
  Sepal.Length   Sepal.Width   Petal.Length   Petal.Width
Min.      :4.300   Min.      :2.000   Min.      :1.000   Min.      :0.100
1st Qu.   :5.100   1st Qu.   :2.800   1st Qu.   :1.600   1st Qu.   :0.300
Median    :5.800   Median    :3.000   Median    :4.350   Median    :1.300
Mean      :5.843   Mean      :3.057   Mean      :3.758   Mean      :1.199
3rd Qu.   :6.400   3rd Qu.   :3.300   3rd Qu.   :5.100   3rd Qu.   :1.800
Max.      :7.900   Max.      :4.400   Max.      :6.900   Max.      :2.500

  Species
setosa      :50
versicolor :50
virginica   :50
```

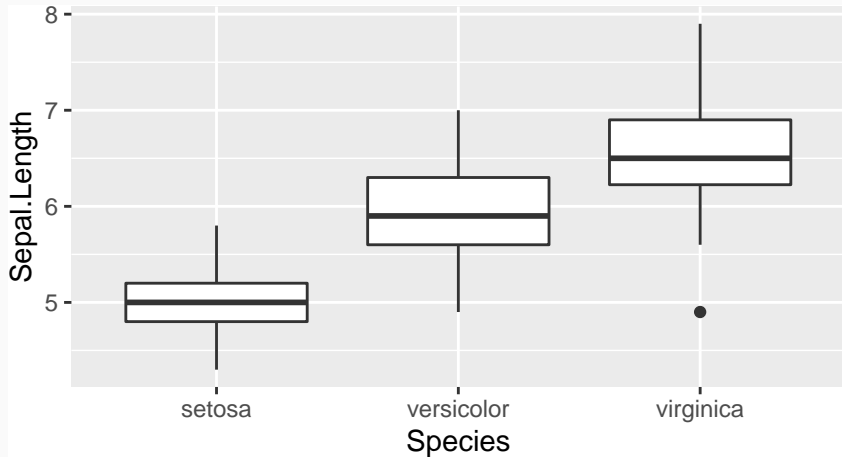
Classical tool

```
> boxplot(Sepal.Length~Species,data=iris)
```

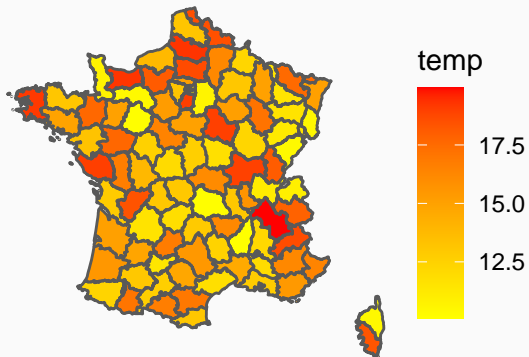


Ggplot tools

```
> library(tidyverse) #ggplot2 in tidyverse  
> ggplot(iris)+aes(x=Species,y=Sepal.Length)+geom_boxplot()
```



A temperature map



Many informations

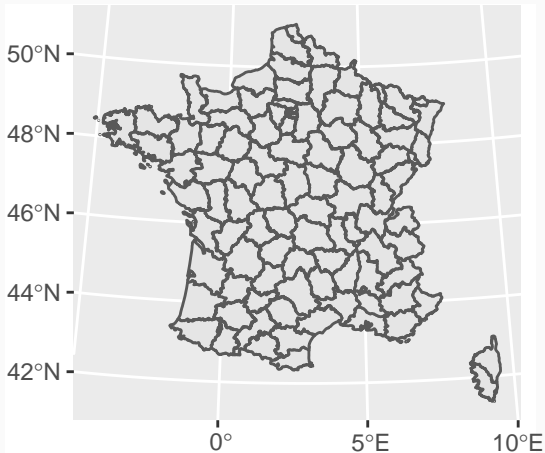
- **Background map** with boundaries of departments;
- **Temperatures** in each departments (meteofrance website).

Mapping with sf

```
> library(sf)
> dpt <- read_sf("./DATA/dpt")
> dpt %>% select(NOM_DEPT,geometry) %>% head()
Simple feature collection with 6 features and 1 field
Geometry type: MULTIPOLYGON
Dimension: XY
Bounding box: xmin: 644570 ymin: 6272482 xmax: 1077507 ymax: 6997000
Projected CRS: RGF93 / Lambert-93
# A tibble: 6 x 2
  NOM_DEPT geometry
  <chr> <MULTIPOLYGON [m]>
1 AIN (((919195 6541470, 918932 6541203, 918628 6~
2 AISNE (((735603 6861428, 735234 6861392, 734504 6~
3 ALLIER (((753769 6537043, 753554 6537318, 752879 6~
4 ALPES-DE-HAUTE-PROVENCE (((992638 6305621, 992263 6305688, 991610 6~
5 HAUTES-ALPES (((1012913 6402904, 1012577 6402759, 101085~
6 ALPES-MARITIMES (((1018256 6272482, 1017888 6272559, 101677~
```

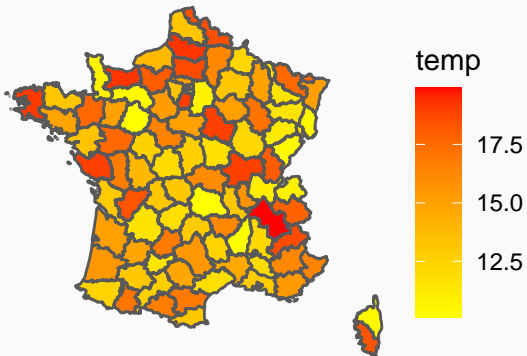
Background map

```
> ggplot(dpt)+geom_sf()
```



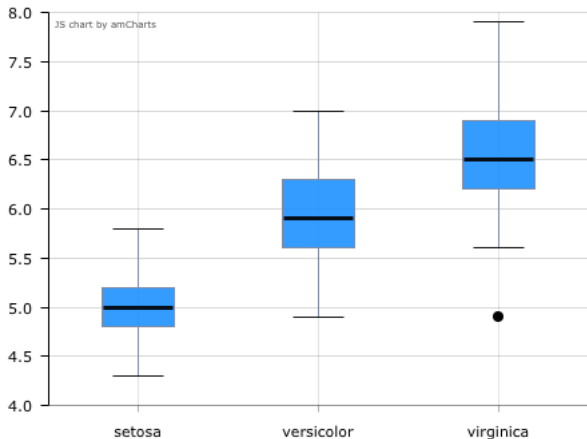
Temperature map

```
> ggplot(dpt) + geom_sf(aes(fill=temp)) +  
+   scale_fill_continuous(low="yellow",high="red")+  
+   theme_void()
```



Interactive charts with rAmCharts

```
> library(rAmCharts)
> amBoxplot(Sepal.Length~Species,data=iris)
```



- Useful to **publish** groups of related **data visualizations** (dataset, classical charts, simple models. . .)
- Package **flexdahboard**:
<https://rmarkdown.rstudio.com/flexdashboard/index.html>

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- Package **flexdahboard**:
<https://rmarkdown.rstudio.com/flexdashboard/index.html>
- Based on **Rmarkdown syntax**
- Example: <https://lrouviere.shinyapps.io/dashboard/>

Interactive web apps with shiny

- **Shiny** is a R package that makes it easy to build interactive web apps straight from R.
- **Examples:**
 - understand overfitting in machine learning: https://lrouviere.shinyapps.io/overfitting_app/
 - bike stations in Rennes: <https://lrouviere.shinyapps.io/velib/>

To summarize

- 15 hours for 3 (or 4) topics.
- 1 topic = slides + tutorial (supplement material + exercises).
- Require **personal efforts**.
- **To Practice**, to make mistakes and to correct these mistakes: **only way** to learn a computer tools.

To summarize

- 15 hours for 3 (or 4) topics.
- 1 topic = slides + tutorial (supplement material + exercises).
- Require **personal efforts**.
- **To Practice**, to make mistakes and to correct these mistakes: **only way** to learn a computer tools.
- You need to **work alone** between the sessions.
- Everyone can develop at its own pace (the goal is to progress), and **ask questions** during the sessions.
- I'm here to (**try**) to answer.

Outline

1. Data visualization with ggplot2

Conventional graphical functions (a reminder)

ggplot2 grammar

2. Mapping

ggmap

Shapefile contours with sf

Interactive maps with leaflet

3. Some Dynamic visualization tools

rAmCharts and plotly

Graphs with visNetwork

Dashboard with flexdashboard

4. Assessment

Data visualization with ggplot2

- **Graphs** are often the **starting point** for statistical analysis.
- One of the main advantages of **R** is how **easy** it is for the user to create many different kinds of graphs.
- We begin by a (short) review on **conventional graphs**,
- followed by an examination of some **more complex representations**, especially with **ggplot2 package**.

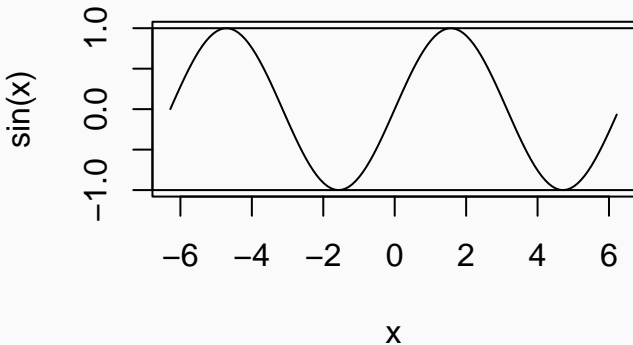
Data visualization with ggplot2

Conventional graphical functions (a reminder)

The plot function

- It is a **generic** function to represent all **kind of data**.
- For a **scatter plot**, we have to specify a vector for the x-axis and a vector for the y-axis.

```
> x <- seq(-2*pi,2*pi,by=0.1)
> plot(x,sin(x),type="l",xlab="x",ylab="sin(x)")
> abline(h=c(-1,1))
```



Graphs for datasets

- Many kind of representations are needed according to the variables we want to visualize.
- Histogram for continuous variables, barplot for categorical variables.
- Scatterplot for 2 continuous variables.
- Boxplot to visualize distributions.

Graphs for datasets

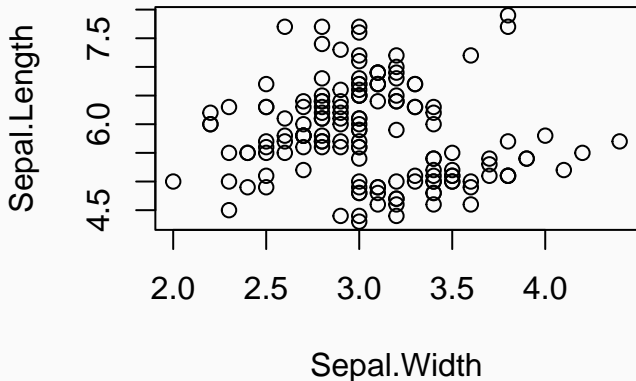
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Fortunately

There is a R function for all representations.

Scatterplot with dataset

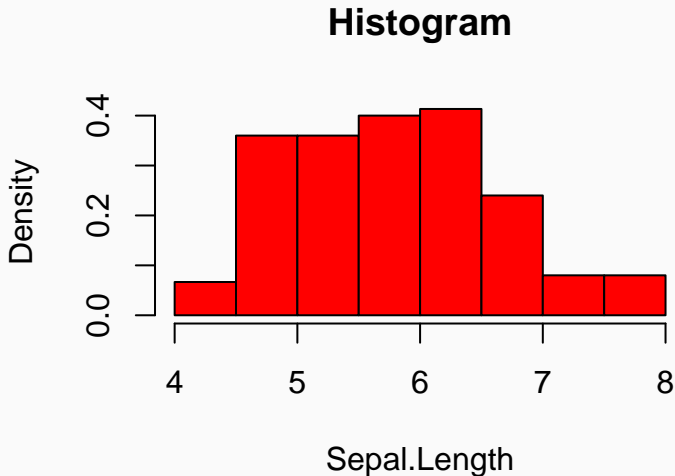
```
> plot(Sepal.Length~Sepal.Width,data=iris)
```



```
> #same as  
> plot(iris$Sepal.Width,iris$Sepal.Length)
```

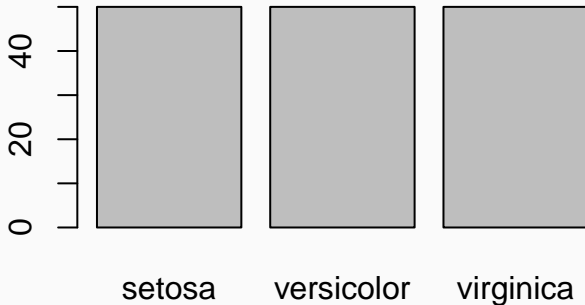
Histogram for continous variable

```
> hist(iris$Sepal.Length,probability=TRUE,  
+      col="red",xlab="Sepal.Length",main="Histogram")
```



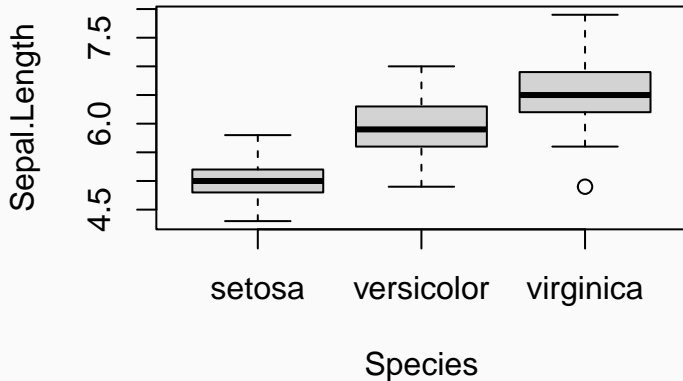
Barplot for categorical variables

```
> barplot(table(iris$Species))
```



Boxplot

```
> boxplot(Sepal.Length~Species, data=iris)
```



Data visualization with ggplot2

ggplot2 grammar

- `ggplot2` is a plotting system for R based on the **grammar of graphics** (as **dplyr** to manipulate data).
- The goal is to provide a **clear syntax** for an **efficient visualization**.
- Ggplot provides **"nice" graphs** (nor always the case for conventional R graphs).
- Documentation: **tutorial**, **book**

For a given dataset, a graph is defined from many **layers**. We have to specify:

- the **data**
- the **variables** we want to plot
- the **type of representation** (scatterplot, boxplot. . .).

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Ggplot graphs are defined from these layers. We indicate

- the data with **ggplot**
- the variables with **aes** (aesthetics)
- the kind of representation with **geom_...**

The grammar

Main elements of the grammar are:

- **Data (ggplot)**: the **dataset**, it should be a dataframe or a tibble.

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The grammar

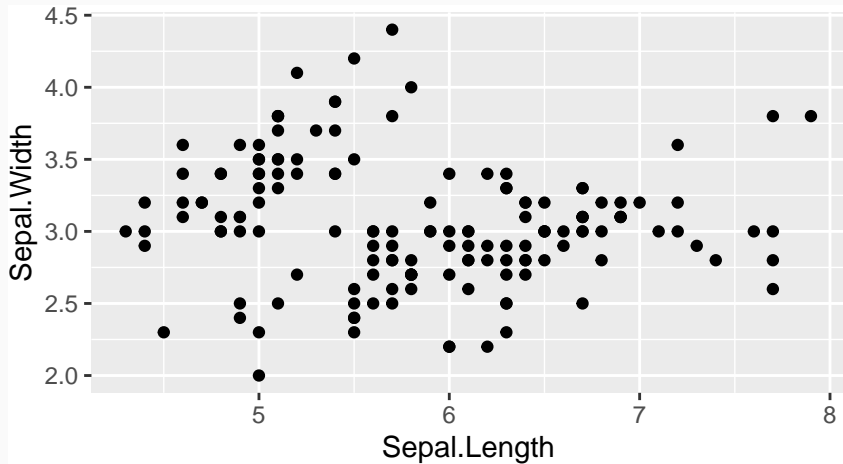
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- **Geometrics (geom_...)**: to control the **type** of plot.
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All these elements are gathered with the operator **+**.

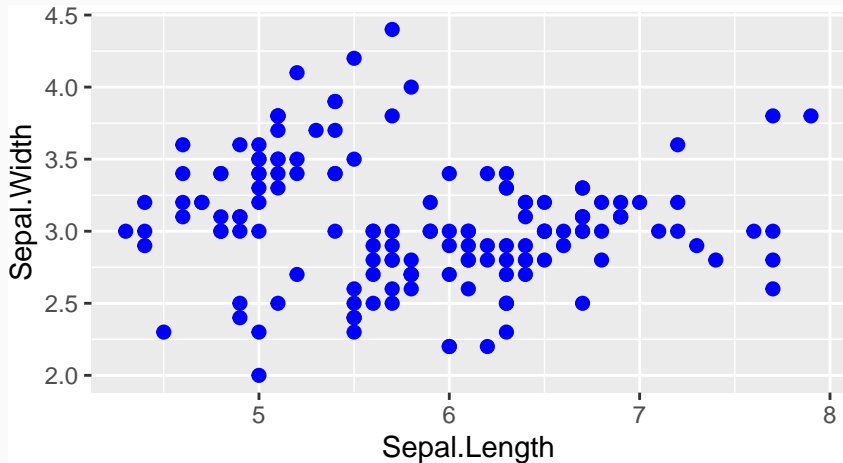
An example

```
> ggplot(iris)+aes(x=Sepal.Length,y=Sepal.Width)+geom_point()
```



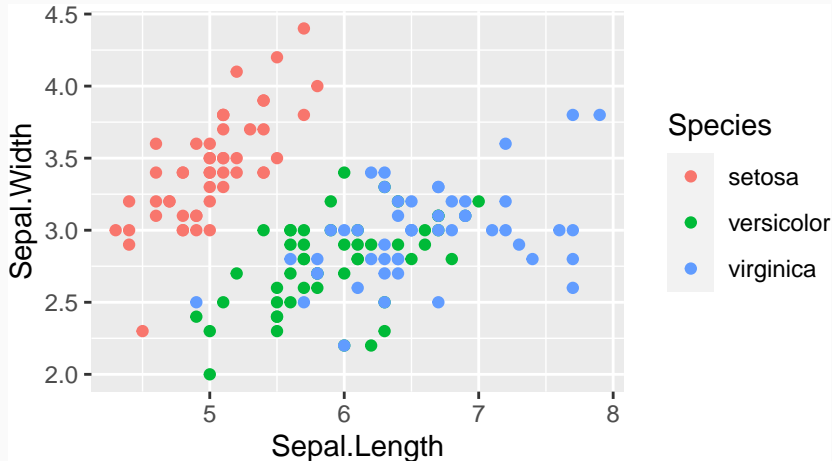
Color and size

```
> ggplot(iris)+aes(x=Sepal.Length,y=Sepal.Width)+  
+   geom_point(color="blue",size=2)
```



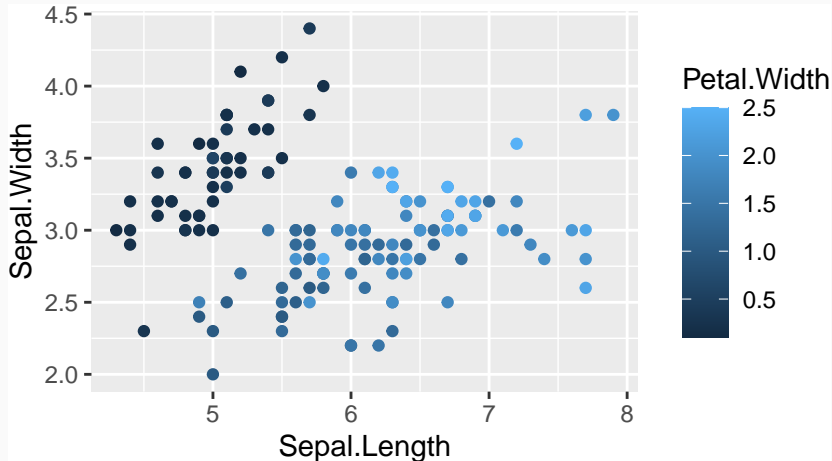
Color by (categorical) variable

```
> ggplot(iris)+aes(x=Sepal.Length,y=Sepal.Width,  
+                 color=Species)+geom_point()
```



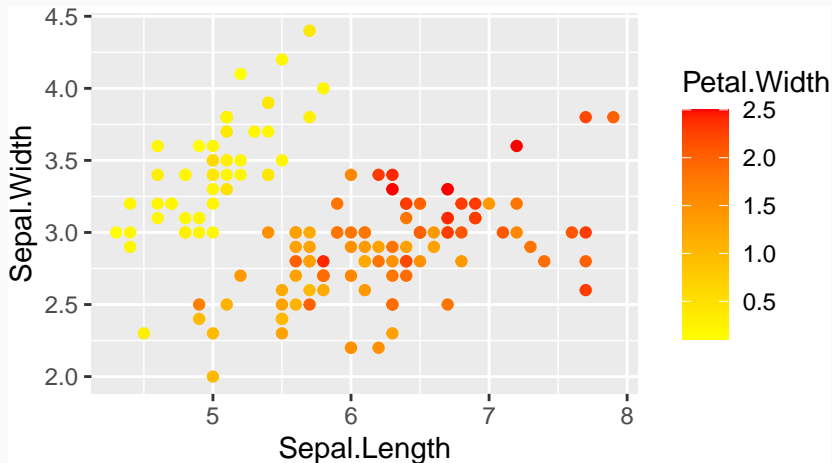
Color by (continuous) variable

```
> ggplot(iris)+aes(x=Sepal.Length,y=Sepal.Width,  
+                 color=Petal.Width)+geom_point()
```



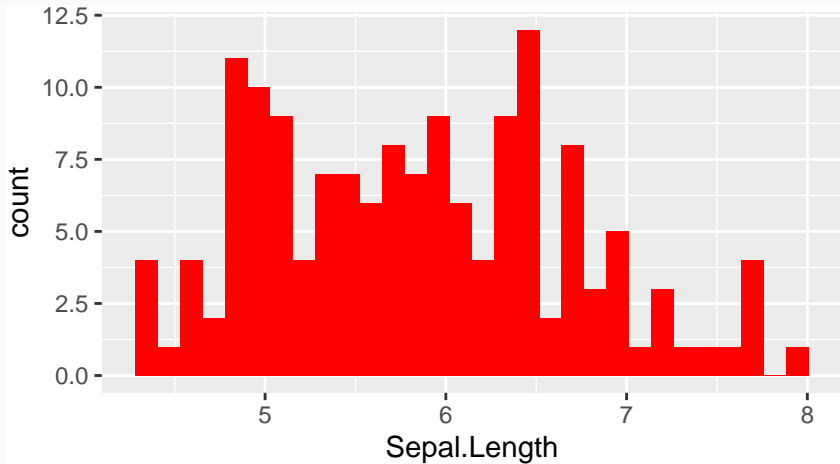
Color by (continuous) variable

```
> ggplot(iris)+aes(x=Sepal.Length,y=Sepal.Width,  
+                 color=Petal.Width)+geom_point()+  
+                 scale_color_continuous(low="yellow",high="red")
```



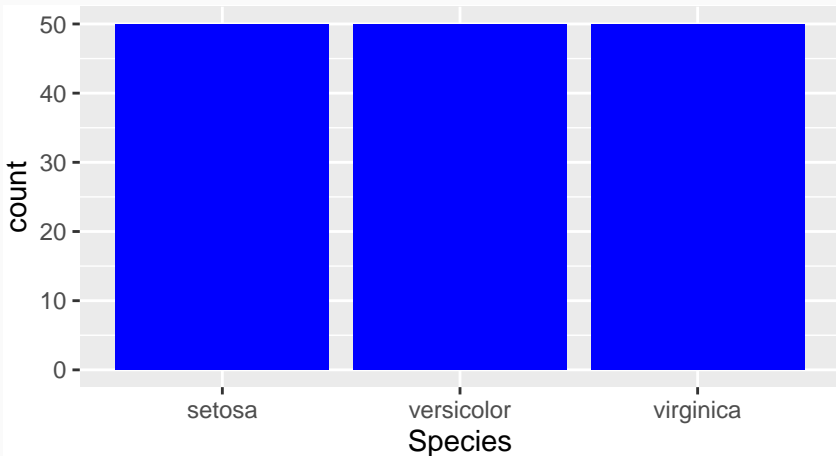
Histogram

```
> ggplot(iris)+aes(x=Sepal.Length)+geom_histogram(fill="red")
```



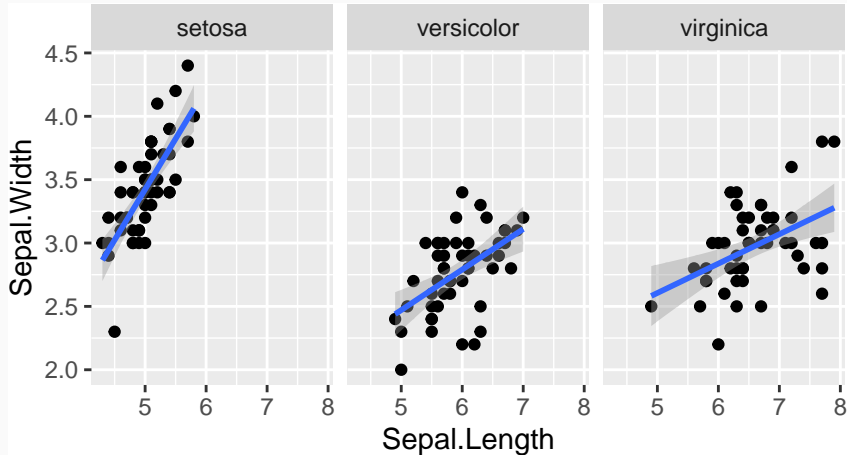
Barplot

```
> ggplot(iris)+aes(x=Species)+geom_bar(fill="blue")
```



Facetting (more “complex”)

```
> ggplot(iris)+aes(x=Sepal.Length,y=Sepal.Width)+geom_point()+  
+   geom_smooth(method="lm")+facet_wrap(~Species)
```

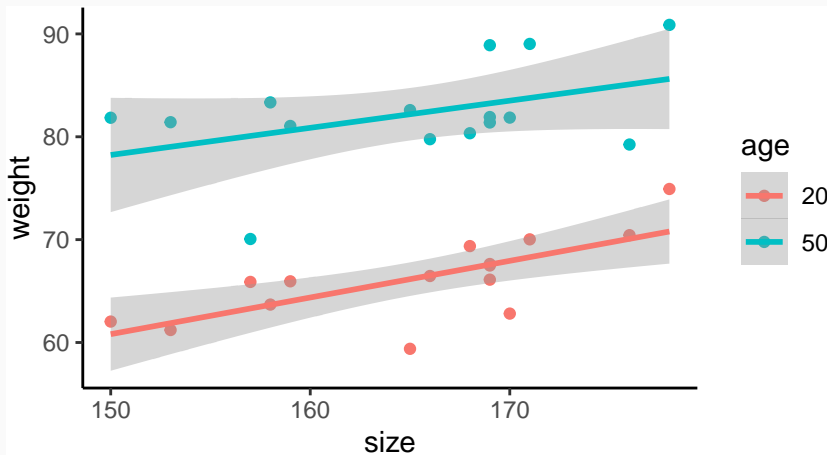


Combining ggplot with dplyr

- We often have to **work on the dataframe** to obtain an **efficient ggplot syntax**.
- For instance

```
> head(df)
# A tibble: 6 x 3
  size weight.20 weight.50
<dbl> <dbl> <dbl>
1 153 61.2 81.4
2 169 67.5 81.4
3 168 69.4 80.3
4 169 66.1 81.9
5 176 70.4 79.2
6 169 67.6 88.9
```

Goal



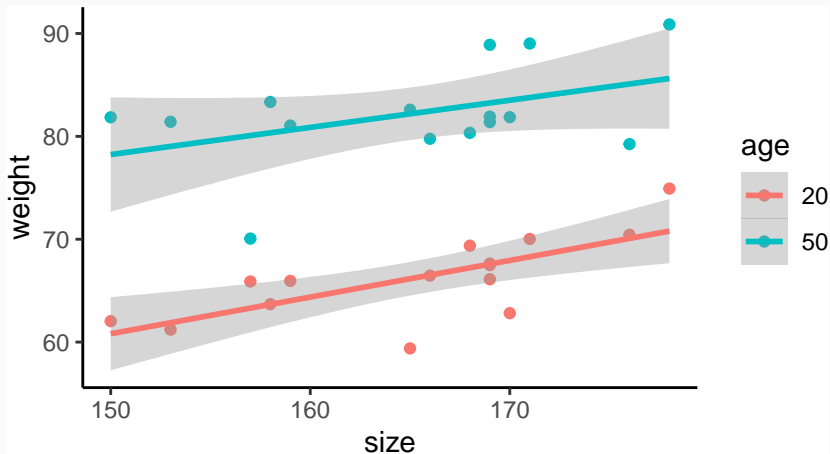
dplyr step

Gather column `weight.M` and `weight.W` into one column `weight` with `pivot_longer`:

```
> df1 <- df %>% pivot_longer(-size, names_to="age", values_to="weight")
> df1 %>% head()
# A tibble: 6 x 3
  size age      weight
<dbl> <chr> <dbl>
1  153 weight.20  61.2
2  153 weight.50  81.4
3  169 weight.20  67.5
4  169 weight.50  81.4
5  168 weight.20  69.4
6  168 weight.50  80.3
> df1 <- df1 %>%
+   mutate(age=recode(age, "weight.20"="20", "weight.50"="50"))
```

ggplot step

```
> ggplot(df1)+aes(x=size,y=weight,color=age)+  
+   geom_point()+geom_smooth(method="lm")+theme_classic()
```



Complement: some demos

```
> demo(image)
> example(contour)
> demo(persp)
> library("lattice");demo(lattice)
> example(wireframe)
> library("rgl");demo(rgl)
> example(persp3d)
> demo(plotmath);demo(Hershey)
```

Complement: some demos

```
> demo(image)
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> library("rgl");demo(rgl)
> example(persp3d)
> demo(plotmath);demo(Hershey)
```

⇒ Work on **this part** of the tutorial.

Mapping

Introduction

- Many applications require **maps** to visualize data or results of a model;
- Many **R packages**: `ggmap`, `RgoogleMaps`, `maps`...
- In this part: `ggmap`, `sf` (**static** mapping) and `leaflet` (**interactive** mapping).

Mapping

ggmap

- Similar to `ggplot...`

- Similar to `ggplot...`

- Instead of

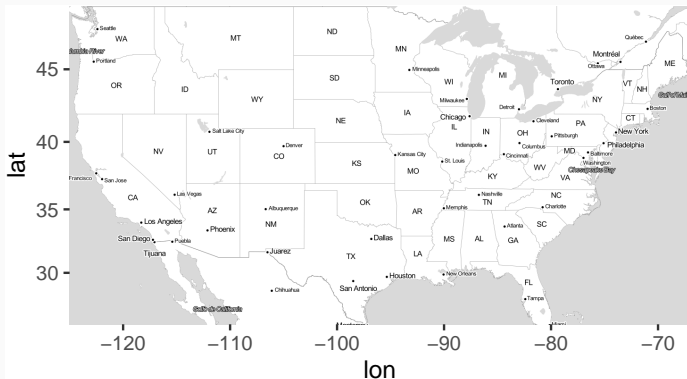
```
> ggplot(data)+...
```

- use

```
> ggmap(backgroundmap)+...
```

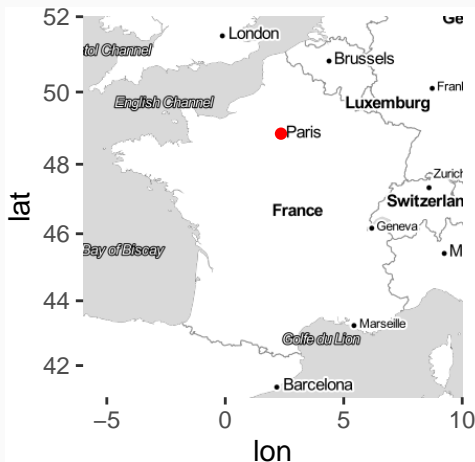
Background map

```
> library(ggmap)
> us <- c(left = -125, bottom = 25.75, right = -67, top = 49)
> map <- get_stamenmap(us, zoom = 5, maptype = "toner-lite")
> ggmap(map)
```



Adding informations with ggplot

```
> fr <- c(left = -6, bottom = 41, right = 10, top = 52)
> fond <- get_stamenmap(fr, zoom = 5, "toner-lite")
> Paris <- data.frame(lon=2.351499, lat=48.85661)
> ggmap(fond)+geom_point(data=Paris, aes(x=lon, y=lat), color="red")
```



Mapping

Shapefile contours with sf

sf package

- **Ggmap**: ok for easy maps (background with some points).
- **Not sufficient** for **more complex representations** (color countries according to variables).

sf package

- **Ggmap**: ok for easy maps (background with some points).
- **Not sufficient** for **more complex representations** (color countries according to variables).
- **sf** allows to manage **specific tools for mapping**: **boundaries** for countries or department, coordinate systems (latitudes-longitudes, World Geodesic System 84. . .)
- Background map with format **shapefile** (**contours** = **polygons**)
- Compatible with **ggplot** (**geom_sf** verb).

sf package

- **Ggmap**: ok for easy maps (background with some points).
- **Not sufficient** for **more complex representations** (color countries according to variables).
- **sf** allows to manage **specific tools for mapping**: **boundaries** for countries or department, coordinate systems (latitudes-longitudes, World Geodesic System 84. . .)
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References

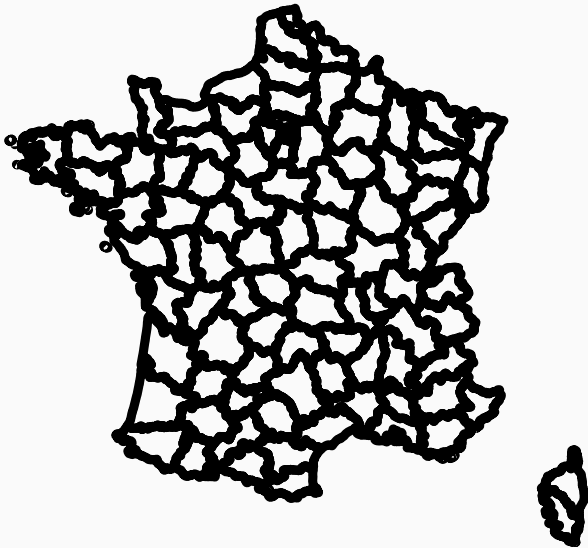
- <https://statnmap.com/fr/2018-07-14-initiation-a-la-cartographie-avec-sf-et-compagnie/>
- **Vignettes** on the cran :
<https://cran.r-project.org/web/packages/sf/index.html>.

Example

```
> library(sf)
> dpt <- read_sf("./DATA/dpt")
> dpt[1:5,3]
Simple feature collection with 5 features and 1 field
Geometry type: MULTIPOLYGON
Dimension:      XY
Bounding box:   xmin: 644570 ymin: 6290136 xmax: 1022851 ymax: 6997000
Projected CRS:  RGF93 / Lambert-93
# A tibble: 5 x 2
  NOM_DEPT                                geometry
  <chr>                                <MULTIPOLYGON [m]>
1 AIN      (((919195 6541470, 918932 6541203, 918628 6~
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3 ALLIER   (((753769 6537043, 753554 6537318, 752879 6~
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```

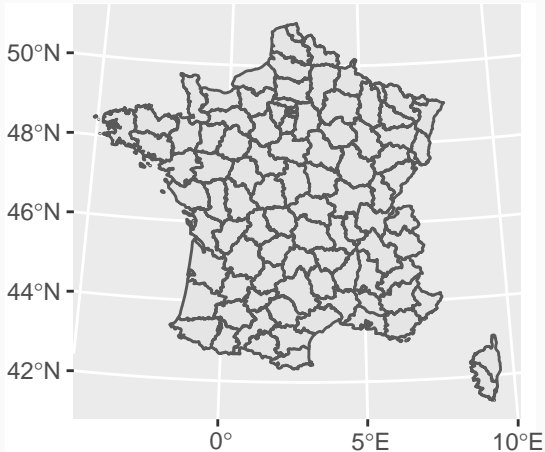
Visualize with plot

```
> plot(st_geometry(dpt))
```



Visualize with ggplot

```
> ggplot(dpt)+geom_sf()
```



Adding points on the map

- Define coordinates with `st_point`

```
> point <- st_sfc(st_point(c(2.351462,48.85670)),  
+               st_point(c(4.832011,45.75781)),  
+               st_point(c(5.369953,43.29617)))
```

Adding points on the map

- Define coordinates with `st_point`

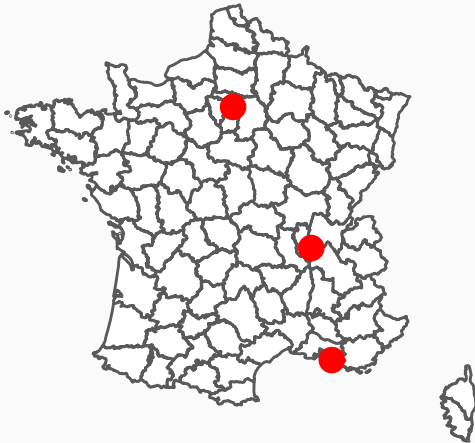
```
> point <- st_sfc(st_point(c(2.351462,48.85670)),  
+               st_point(c(4.832011,45.75781)),  
+               st_point(c(5.369953,43.29617)))
```

- Specify the `coordinate system` (4326 for lat-lon)

```
> st_crs(point) <- 4326 #lat-lon  
> point  
Geometry set for 3 features  
Geometry type: POINT  
Dimension:      XY  
Bounding box:  xmin: 2.351462 ymin: 43.29617 xmax: 5.369953 ymax: 48.85670  
Geodetic CRS:  WGS 84  
POINT (2.351462 48.8567)  
POINT (4.832011 45.75781)  
POINT (5.369953 43.29617)
```

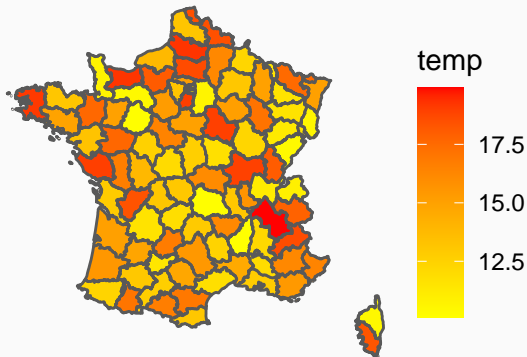
ggplot step

```
> ggplot(dpt) + geom_sf(fill="white")+  
+   geom_sf(data=point,color="red",size=4)+theme_void()
```



Coloring polygons

```
> set.seed(1234)
> dpt1 <- dpt %>% mutate(temp=runif(96,10,20))
> ggplot(dpt1) + geom_sf(aes(fill=temp)) +
+   scale_fill_continuous(low="yellow",high="red")+
+   theme_void()
```



Supplement: geometry class

- One of the main advantage of `sf` is the `geometry` class.
- It allows to conduct the representation with `plot` or `geom_sf`:
 - `point` or `multipoint` \implies points to locate a place;
 - `polygon` or `multipolygon` \implies contours to visualize boundaries.
- Some useful functions:
 - `st_point` and `st_multipoint`: create points or sequence of points
 - `st_sfc`: create a list of `sf objects`
 - `st_crs`: specify coordinate reference system
 - `st_cast`: cast geometry to another type (convert a multipoint object to many point objects)
 - ...

- Creation of a **sf object**

```
> b1 <- st_point(c(3,4))
> b1
POINT (3 4)
> class(b1)
[1] "XY" "POINT" "sfg"
```

- Creation of a **sfc object** (list of **sf objects**)

```
> b2 <- st_sfc(st_point(c(1,2)),st_point(c(3,4)))
> b2
Geometry set for 2 features
Geometry type: POINT
Dimension: XY
Bounding box: xmin: 1 ymin: 2 xmax: 3 ymax: 4
CRS: NA
POINT (1 2)
POINT (3 4)
> class(b2)
[1] "sfc_POINT" "sfc"
```

- Extract **geometry** in a **sf object**

```
> class(dpt)
[1] "sf"          "tbl_df"      "tbl"         "data.frame"
> b3 <- st_geometry(dpt)
> b3
Geometry set for 96 features
Geometry type: MULTIPOLYGON
Dimension: XY
Bounding box: xmin: 99226 ymin: 6049647 xmax: 1242375 ymax: 7110524
Projected CRS: RGF93 / Lambert-93
First 5 geometries:
MULTIPOLYGON (((919195 6541470, 918932 6541203,...
MULTIPOLYGON (((735603 6861428, 735234 6861392,...
MULTIPOLYGON (((753769 6537043, 753554 6537318,...
MULTIPOLYGON (((992638 6305621, 992263 6305688,...
MULTIPOLYGON (((1012913 6402904, 1012577 640275...
> class(b3)
[1] "sfc_MULTIPOLYGON" "sfc"
```

⇒ Work on **this part** of the tutorial.

Mapping

Interactive maps with leaflet

Background map

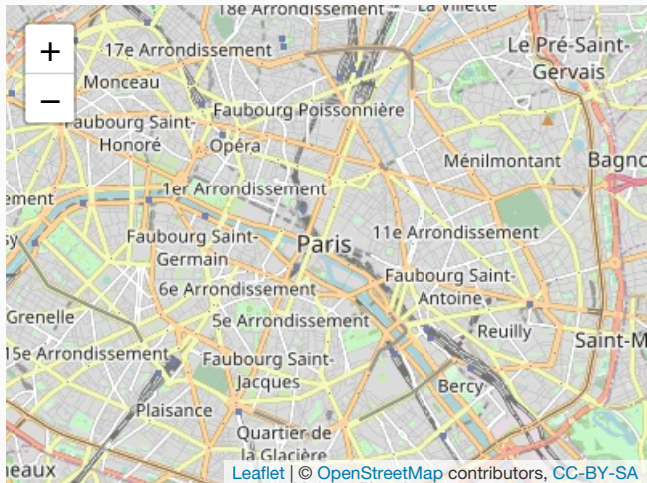
- **Leaflet** is one of the most popular open-source JavaScript libraries for **interactive maps**.
- **Documentation:** [here](#)

```
> library(leaflet)
> leaflet() %>% addTiles()
```



Many background styles

```
> Paris <- c(2.35222,48.856614)
> leaflet() %>% addTiles() %>%
+   setView(lng = Paris[1], lat = Paris[2],zoom=12)
```



```
> leaflet() %>% addProviderTiles("Stamen.Toner") %>%  
+   setView(lng = Paris[1], lat = Paris[2], zoom = 12)
```



Leaflet | Map tiles by [Stamen Design](#), CC BY 3.0 — Map data © [OpenStreetMap](#) contributors

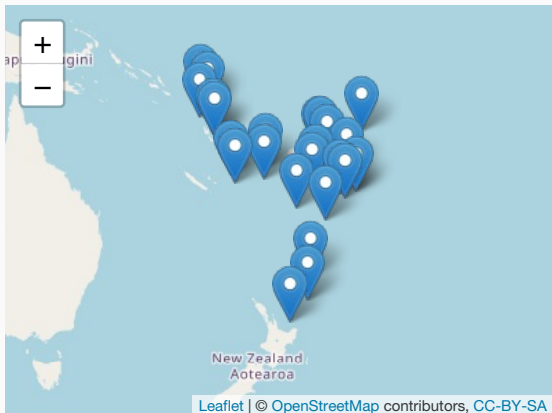
- Location of 1000 seismic events near Fiji

```
> data(quakes)
> head(quakes)
```

	lat	long	depth	mag	stations
1	-20.42	181.62	562	4.8	41
2	-20.62	181.03	650	4.2	15
3	-26.00	184.10	42	5.4	43
4	-17.97	181.66	626	4.1	19
5	-20.42	181.96	649	4.0	11
6	-19.68	184.31	195	4.0	12

Visualize seismicity with magnitude more than 5.5

```
> quakes1 <- quakes %>% filter(mag>5.5)
> leaflet(data = quakes1) %>% addTiles() %>%
+   addMarkers(~long, ~lat, popup = ~as.character(mag))
```

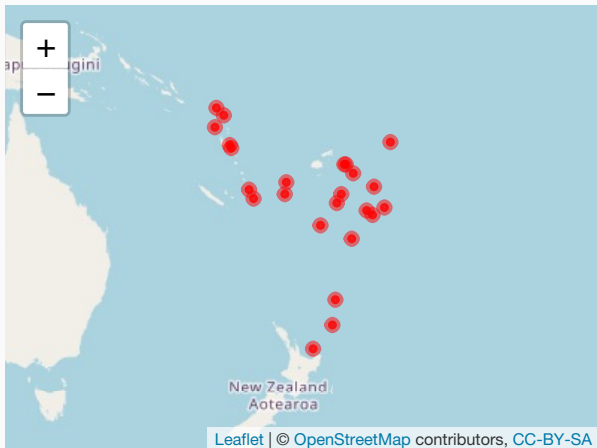


Remark

When you **click** on a marker, the **magnitude** appears.

addCircleMarkers

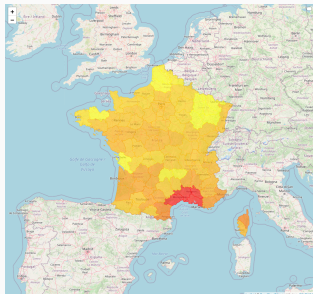
```
> leaflet(data = quakes1) %>% addTiles() %>%  
+   addCircleMarkers(~long, ~lat, popup=~as.character(mag),  
+                   radius=3,fillOpacity = 0.8,color="red")
```



Leaflet | © OpenStreetMap contributors, CC-BY-SA

Color polygon (combining leaflet and sf)

```
> leaflet() %>% addTiles() %>%  
+   addPolygons(data = dpt2,color=~pal1(t_prev),fillOpacity = 0.6,  
+             stroke = TRUE,weight=1,  
+             popup=~paste(as.character(NOM_DEPT),  
+                           as.character(t_prev),sep=" : "))
```



⇒ Work on **this part** of the tutorial.

Some Dynamic visualization tools

Some R tools for dynamic visualization

- Classical charts with `rAmCharts` and `plotly`.
- Graphs with `visNetwork`.
- Dashboard with `flexdashboard`.

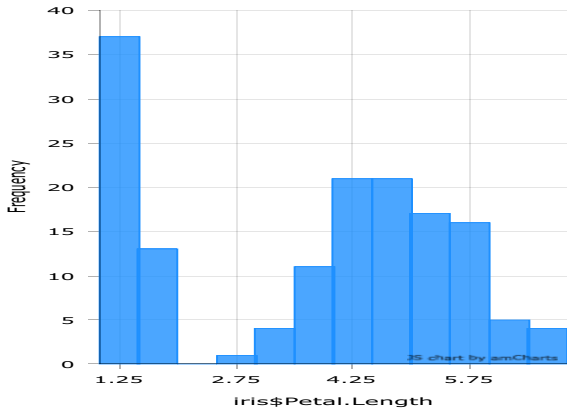
Some Dynamic visualization tools

rAmCharts and plotly

- **user-friendly** for standard graphs (scatterplot, times series, histogram. . .).
- We just have to use classical **R** functions with the **prefix am**.
- **Examples:** **amPlot**, **amHist**, **amBoxplot**.
- **References:** https://datastorm-open.github.io/introduction_ramcharts/

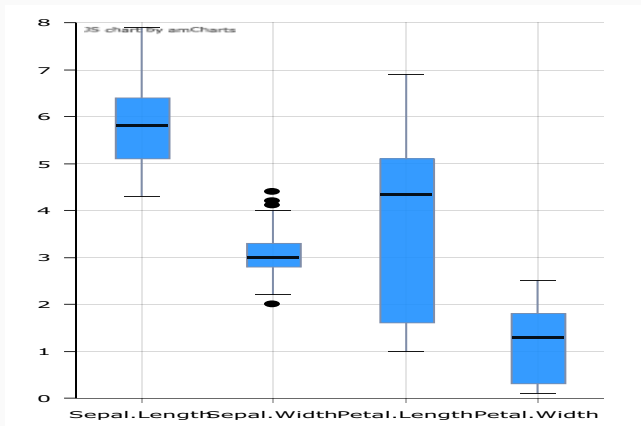
rAmCharts Histogram

```
> library(rAmCharts)
> amHist(iris$Petal.Length)
```



rAmcharts Boxplot

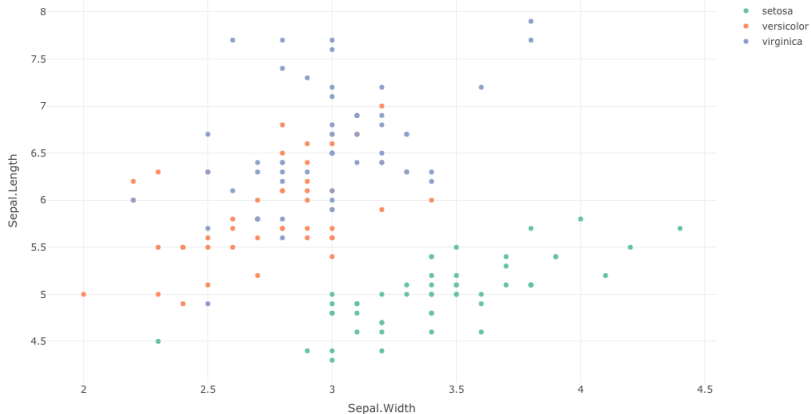
```
> amBoxplot(iris)
```



- R package for creating **interactive web-based graphs** via the open source JavaScript graphing library **plotly.js**.
- Commands are expanded into **3 parts**:
 - dataset and variables (**plot_ly**) ;
 - additional representations (**add_trace**, **add_markers...**) ;
 - options (axis, titles...) (**layout**).
- References: <https://plot.ly/r/reference/>

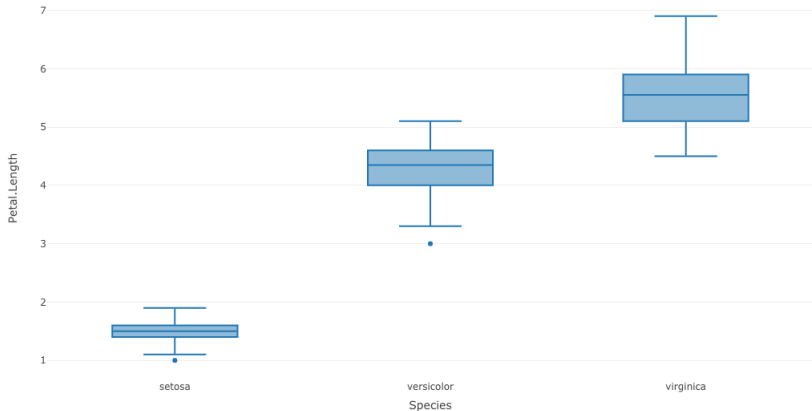
Scatter plot

```
> library(plotly)
> iris %>% plot_ly(x=~Sepal.Width,y=~Sepal.Length,color=~Species) %>%
+   add_markers(type="scatter")
```



Plotly boxplot

```
> iris %>% plot_ly(x=~Species,y=~Petal.Length) %>% add_boxplot()
```



Some Dynamic visualization tools

Graphs with visNetwork

Connections between individuals

- Many datasets can be visualized with **graphs**, especially when one has to study **connections** between individuals (genomic, social network. . .).

Connections between individuals

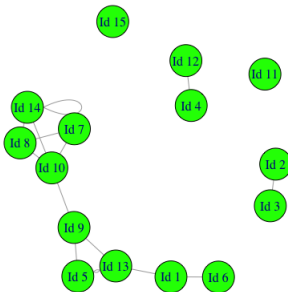
- Many datasets can be visualized with **graphs**, especially when one has to study **connections** between individuals (genomic, social network. . .).
- One individual = **one node** and one connection = **one edge**.

```
> set.seed(123)
> nodes <- data.frame(id = 1:15, label = paste("Id", 1:15))
> edges <- data.frame(from = trunc(runif(15)*(15-1))+1,
+                     to = trunc(runif(15)*(15-1))+1)
> head(edges)
  from to
1     5 13
2    12  4
3     6  1
4    13  5
5    14 14
6     1 13
```


Static graph: igraph package

- **References:** <http://igraph.org/r/>, <http://kateto.net/networks-r-igraph>

```
> library(igraph)
> net <- graph_from_data_frame(d=edges, vertices=nodes, directed=F)
> plot(net, vertex.color="green", vertex.size=25)
```

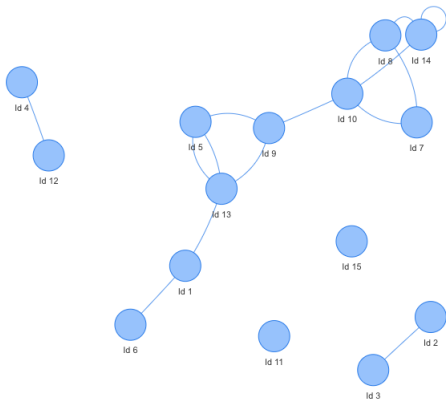


Dynamic graph: visNetwork Package

- Reference:

<https://datastorm-open.github.io/visNetwork/interaction.html>

```
> library(visNetwork)
> visNetwork(nodes,edges)
```



Some Dynamic visualization tools

Dashboard with flexdashboard

- Just a tool... but an **important visualization tool** in datascience
- Allow to **gather important messages** on datasets and/or models

- Just a tool... but an **important visualization tool** in datascience
- Allow to **gather important messages** on datasets and/or models
- **Package:** flexdashboard
- **Syntax:** simple... only **Rmarkdown**
- **Reference:** <https://rmarkdown.rstudio.com/flexdashboard/>

Header

```
---  
title: "My title"  
output:  
  flexdashboard::flex_dashboard:  
    orientation: columns  
    vertical_layout: fill  
    theme: default  
---
```

- Default theme could be replaced by **other themes** (cosmo, bootstrap, cerulean...) (see **here**). You just have to add

```
theme: yeti
```

Descriptive statistics

=====

Column {data-width=650}

Dataset

```{r}

```
DT::datatable(df, options = list(pageLength = 25))
```

```

Column {data-width=350}

Correlation matrix

```{r}

```
cc <- cor(df[,1:11])
```

```
mat.cor <- corrplot::corrplot(cc)
```

```

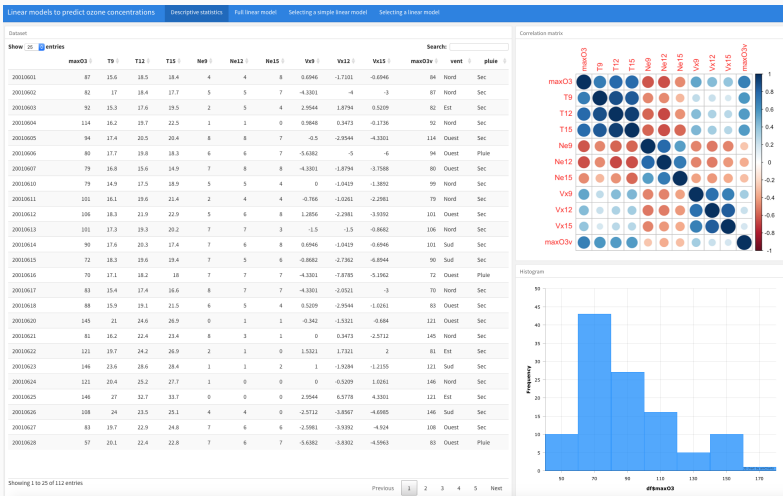
Histogram

```{r}

```
amHist(df$max03)
```

```

Flexdashboard | dashboard



⇒ Work on **this part** of the tutorial.

Assessment

Visualization project

- Group (2 members)
- Find a **visualization problem** (for instance a dataset with a statistical problem: classification, regression. . .)
- Build a shiny web application to visualize important informations on the problem
- Don't hesitate to use tools presented in the lecture (you can also use other tools)
- Deploy the application on the web with **shinyapps**, see <https://docs.rstudio.com/shinyapps.io/index.html>
- Make a markdwon document (4 or 5 pages) which presents your work, use pdf or html output.

You have to submit on moodle:

- Rmarkdown document (html or pdf output) which presents your work and the url of the shiny application
- shiny files (app.R or ui.R and server.R)
- the dataset (or an url where we can download the data)
- all files needed to test your application

before November 15th, 5pm.

Some examples (students of Rennes University, M1 2020)

- <https://kabdallah.shinyapps.io/shinyapp/>
- https://quentincarric.shinyapps.io/FooTool_by_CARRIC_DIALL_O_MAHE/
- <https://pierrelepagnol.shinyapps.io/Reporting/>
- <https://hersantmarc.shinyapps.io/projet/>
- https://euvrardq.shinyapps.io/etude_tendances_youtube/