Using R as a Geographical Information System

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CRA-W

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1 - Shapefiles

2 - Manipulating data

3 - Rasters

4 - Artistic maps

1 - Shapefiles

- a - Definition
- b - Load & Objects
- c - Data
- d - Mapping

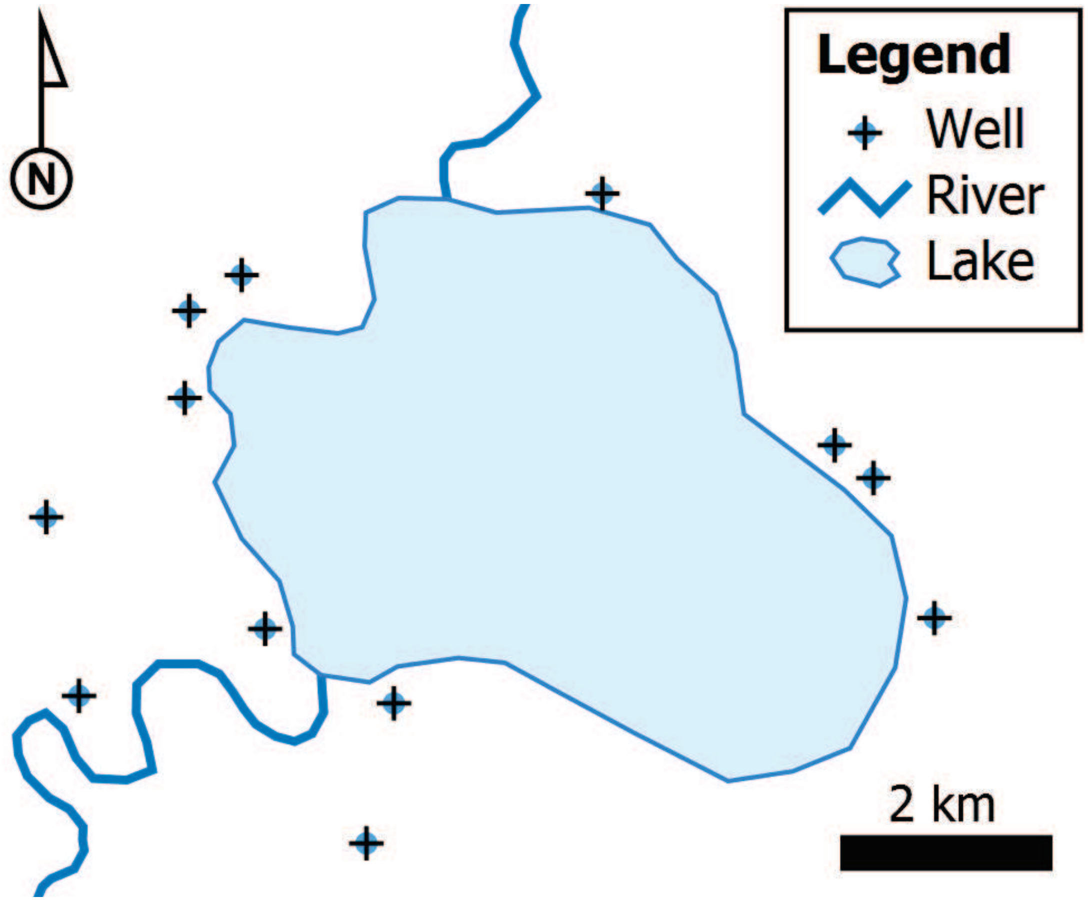
2 - Manipulating data

3 - Rasters

4 - Artistic maps

- **geospatial vector** data format (ESRI, 90′s)
- now, **open standard** for spatial data interoperability
- vector features: **points, lines, and polygons**.

source : wikipedia



source : wikipedia

Packages

```
library(sp) # vector data
library(rgdal) # important gis library, input/ouput, projection
```

Functions

```
readOGR(dsn="FOLER",
        layer="FILE",
        input_field_name_encoding="latin1"
        )
```

ex. : Polygons

```r
provinces <- readOGR(dsn="./data/AdminVector_2011_L72_shp",layer="AD_4_Province",input_field_name_encoding="latin1")

summary(provinces)
```

ex. : Points and lines

```r
city <- readOGR(dsn="./data/City",layer="city")

roads <- readOGR(dsn="./data/Roads",layer="RoadMap")
```

Attribute data

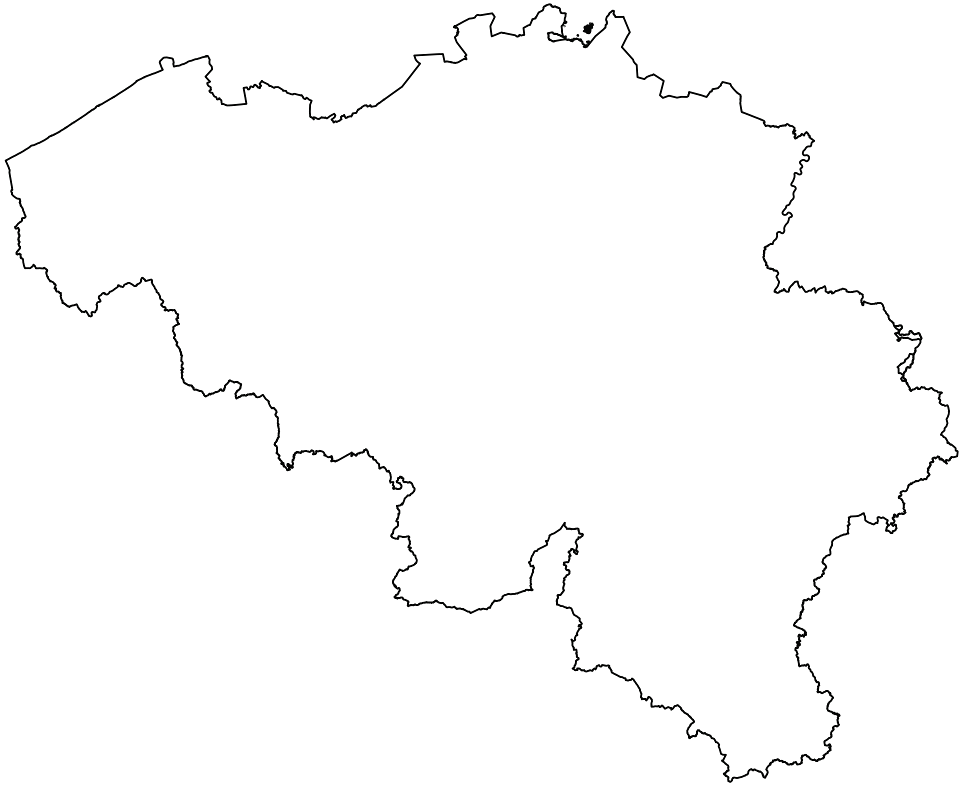
```
names(provinces) # names of variables

provinces@data # data frame of the attrubute data

dim(provinces@data) # dimension of the data frame
head(provinces@data) # dimension of the data frame
```

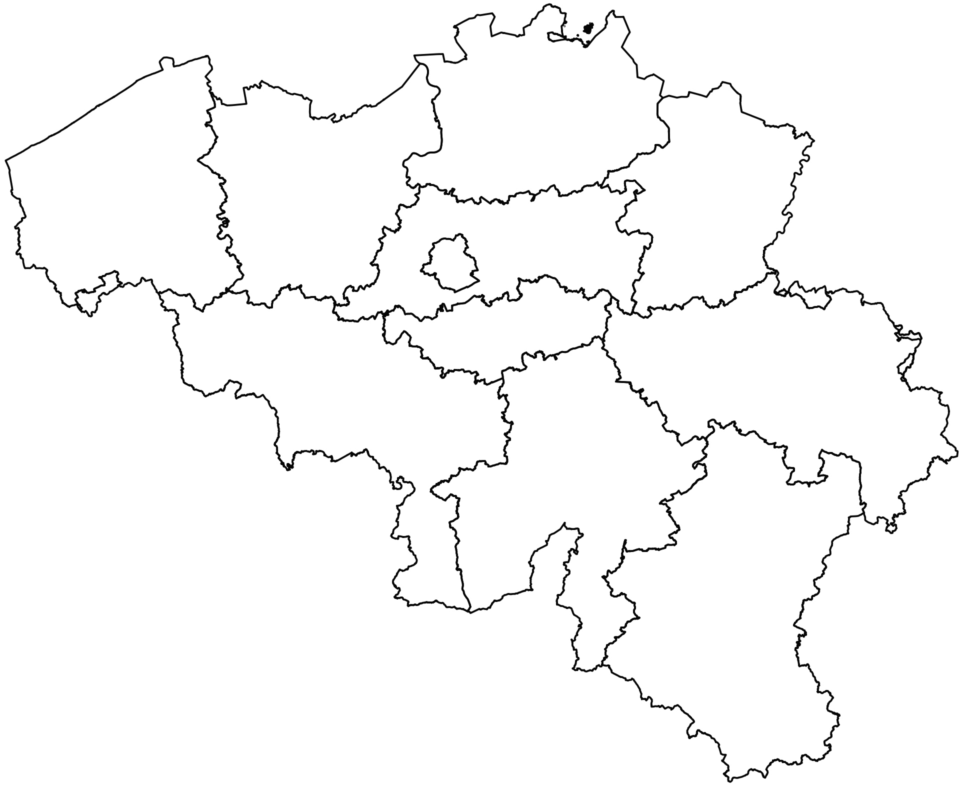
Basic maps : Belgium

```r
plot(belgium)
```



Basic maps : provinces

```
plot(provinces)
```



Shapes attributes based on data : color, cex, lwd, . . .

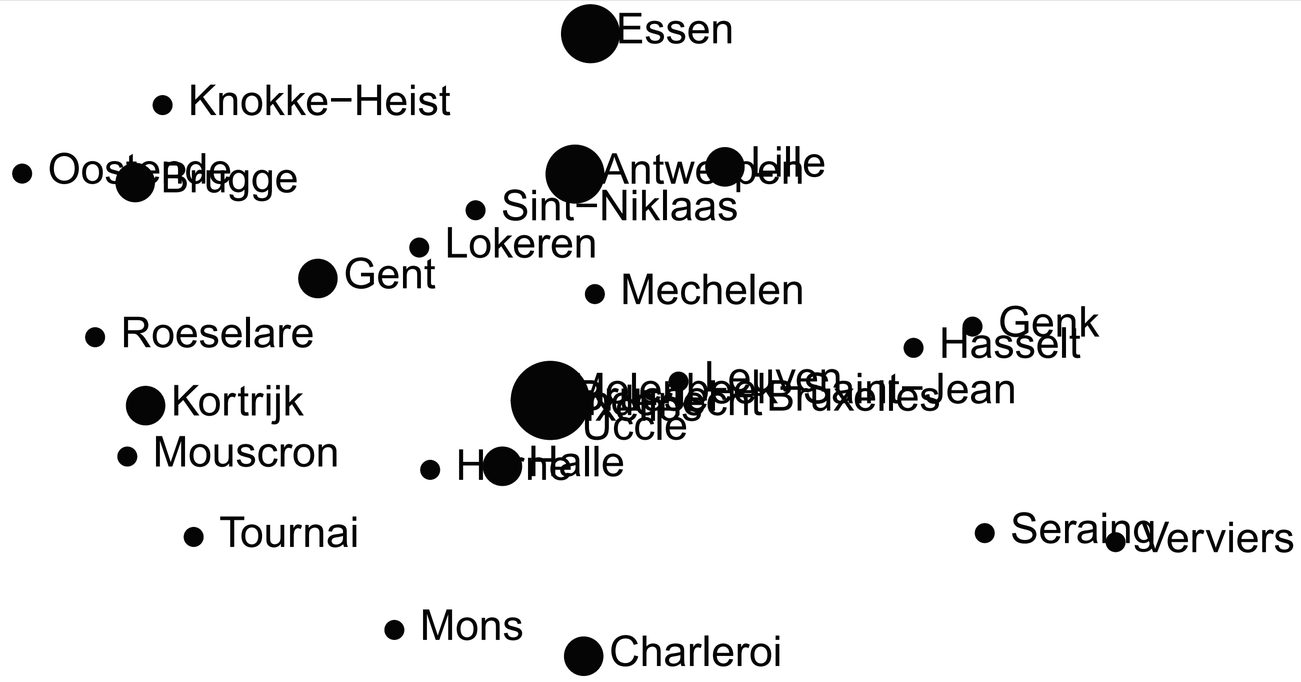
```
# one color for each province
plot(provinces,col=provinces$NISCODE)

# one color for each type of roads
plot(roads,
     lwd=roads@data$FUNCRDCL,
     col=roads@data$FUNCRDCL)

# size of the point varying according to the level of the city
plot(city,cex=(14-(city$LEVEL)),pch=19)
```

Labelling using "text"

```
plot(city,cex=(14-(city$LEVEL)),pch=19)
text(city[!is.na(city$LEVEL),],labels=city$NAME[!is.na
    (city$LEVEL)],pos=’4’)
```



Combining different shapes using "add=TRUE"

```r
# only one polygon in green
plot(provinces) # plot all provinces
plot(provinces[provinces$NISCODE==90000,],col="green",
    add=TRUE)
```

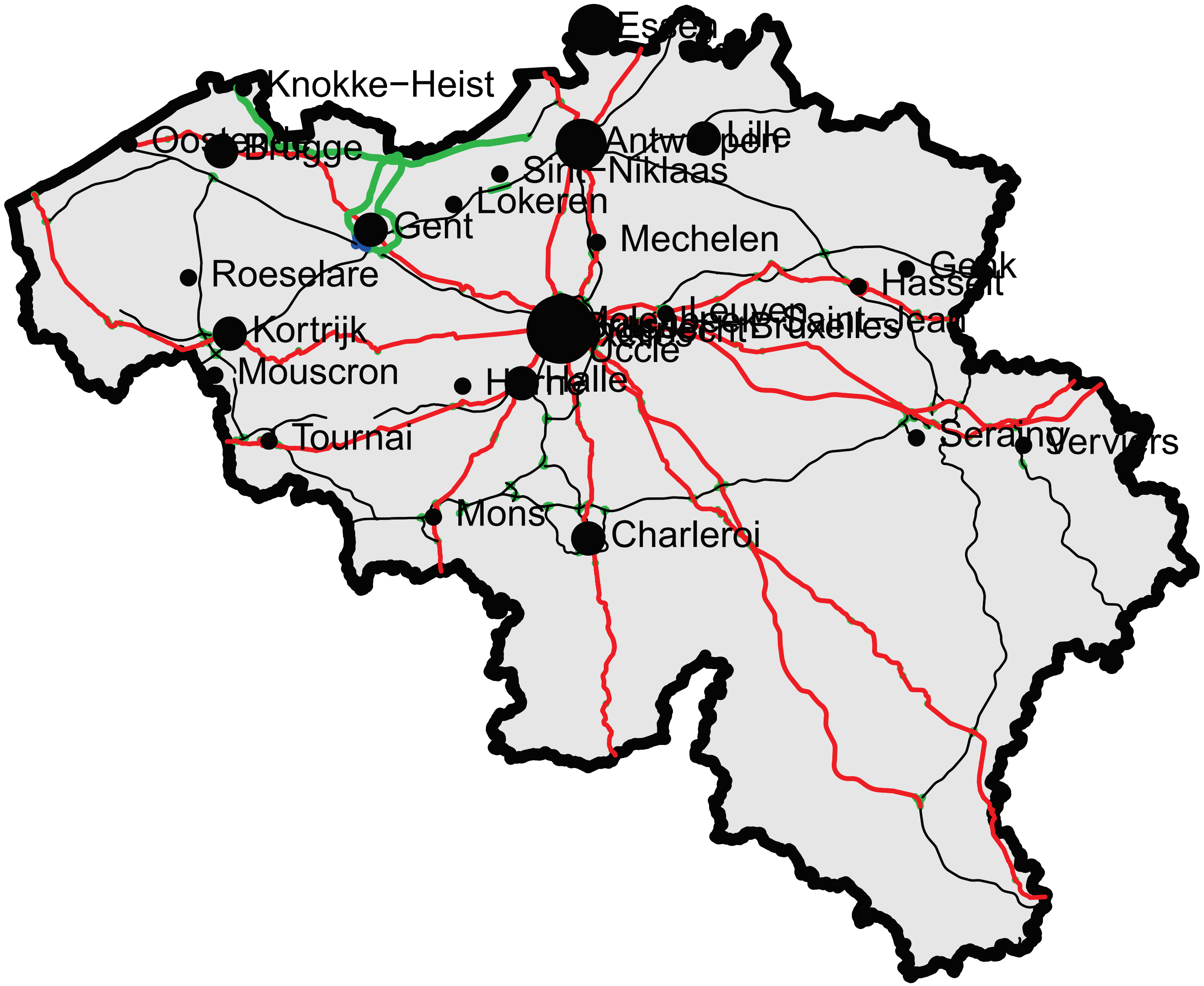
Building a first whole map

```
plot(belgium,lwd=5,col=grey(0.9))

plot(roads,lwd=roads@data$FUNCRDCL,col=roads@data$FUNCRDCL,add=TRUE)

plot(city,cex=(14-(city$LEVEL)),pch=19,add=TRUE)
text(city[!is.na(city$LEVEL),],city$NAME[!is.na(city$LEVEL)],pos=’4’)
title("Major cities and roads of Belgium")
```

Major cities and roads of Belgium



Mapping with ggplot2

Packages

```r
library(ggplot2) # vizualisation
library(plyr) # for join, better than merge
library(grid) # for function unit in theme of ggplot
```

- ggplot2 does not deal with spatial objects ’out-of-the-box’
- but it deals with data frames

Mapping with ggplot2

Functions for formatting data

```
# create an ’id’ if not present
SHAPEFILE@data$id <- ID

# get the coordinates of all spatial objects of the shapefile
DATA.FRAME <- fortify(SHAPEFILE)

# link the attribute data to the new data frame
DATA.FRAME.2 <- join(DATA.FRAME,SHAPEFILE@data,by="id")
```

Most important variables of the new data frame

- `long` – x coodinates
- `lat` – y coordinates
- `group` – *identifies the groups of coordinates that pertain to individual polygons*

Basic functions for visualising data

```
MAP <- (ggplot(DATA.FRAME, aes(long,lat)))

MAP.2 <- (MAP
          + geom_polygon(aes(group=group),fill='COLOR')
          )

print(MAP.2)
```

Basic geom and options

- `+ geom_path(...)` – lines, borders of polygons
- `+ geom_point(...)` – points
- `+ coord_equal()` – fix the ratio between x and y coordinates
- `+ labs` – labelling the maps

1 - Shapefiles

2 - Manipulating data

a - Loading and formatting data

b - Mapping – with extra

c - Projection

d - Geostatistics

3 - Rasters

4 - Artistic maps

Get the data on the web

- `http://www.atlas-belgique.be/cms2/#`
- select a criteria > see the map
- Near the scale > 'i' > Export values

Excel → .csv/.txt/...

- check, remove lines (?), ...
- NA for "not available" data
- 'save as' > .txt (sep. tabulation) | .csv (sep ";")

Loading the data

```
DATA.FRAME <-
   read.delim2("./FOLDER/FILE.txt",  # your file
               dec=",",         # decimal character
               stringsAsFactors=FALSE)  # explicit
```

Formatting the data

```
names(DATA.FRAME)[1] <- AN.ID
# duplicate the major shapefile
NEW.SP.OBJ <- SHAPEFILE
# add the attribute from
NEW.SP.OBJ@data <- join(SHAPEFILE@data,
                        DATA.FRAME,
                        by='AN.ID') # use names() <-
```

Example

- ‘Part des exploitations avec des légumes en plein air’
- Basic map colored according these values

Plotting the data using ggplot2

```r
# pre-treatment
fortify(...)
join(...)

# mapping
map <- (ggplot(DATA.FRAME, aes(long,lat))
  + geom_polygon(aes(group=group,fill=valeur))
  + coord_equal()
)
print(map)
```

Defining a new theme : theme.map.white

```r
theme.map.white <- theme(
    plot.title=element_text(size=rel(1.5),hjust=0),
    # panel.grid.minor = element_blank(),
    # panel.grid.major = element_blank(),
    panel.background=element_blank(),
    plot.background = element_blank(),# element_rect(
       fill="#e6e8ed"),
    panel.border = element_blank(),
    axis.line = element_blank(),
    axis.text.x = element_blank(),
    axis.text.y = element_blank(),
    axis.ticks = element_blank(),
    axis.title.x = element_blank(),
    axis.title.y = element_blank(),
    legend.position="bottom",
    legend.direction="horizontal",
    legend.key.width=unit(0.1,'npc')
    )
```

Creating `map.admin` – a list of spatial layers

```
map.admin <- list(
    geom_polygon(data=belgium,
                 aes(x=long, y=lat, group=group),
                 fill=NA,color="grey50", size=1),
    geom_polygon(data=provinces,
                 aes(x=long, y=lat, group=group),
                 fill=NA,color="grey50",size=0.5)
    )
```

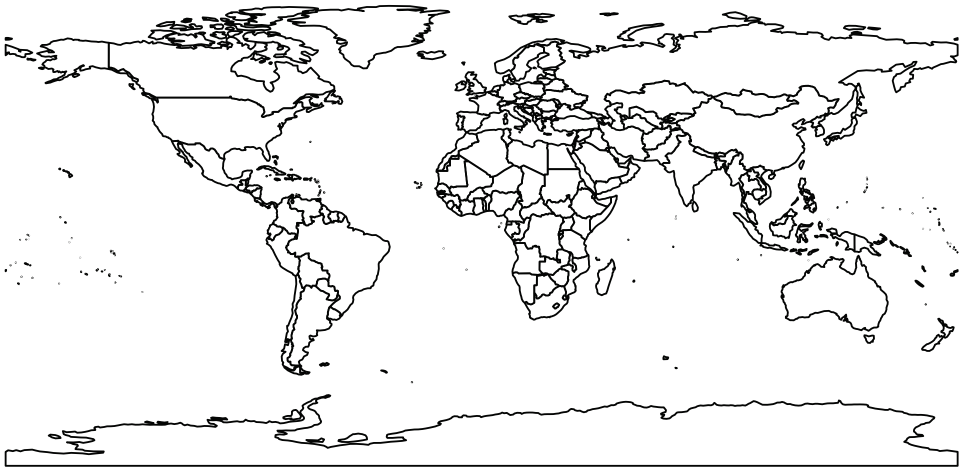
‘belgium’ and ‘provinces’ are **spatial objects**
no need to fortify these layers ! (why???)

see also : `map.info`

a personal scale bar and a north arrow for Lambert Belge 72

Ex. Worl Map

```r
library(rworldmap)
w <- getMap()
plot(w)
```



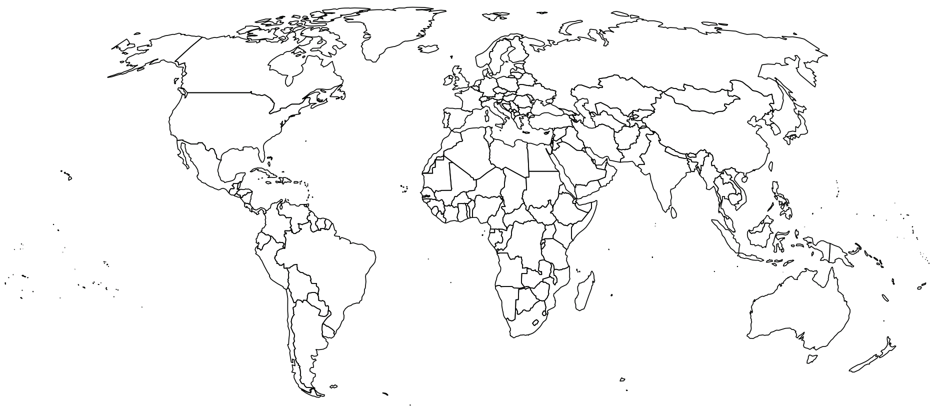
Get the projection - proj4string

```
summary(w)
```

```
Object of class SpatialPolygonsDataFrame
Coordinates:
   min       max
x -180 180.00000
y  -90  83.64513
Is projected: FALSE
proj4string :
[+proj=longlat +ellps=WGS84 +datum=WGS84 +no_defs]
Data attributes: [...]
---
# get the proj4string string :
proj4string(w)
```

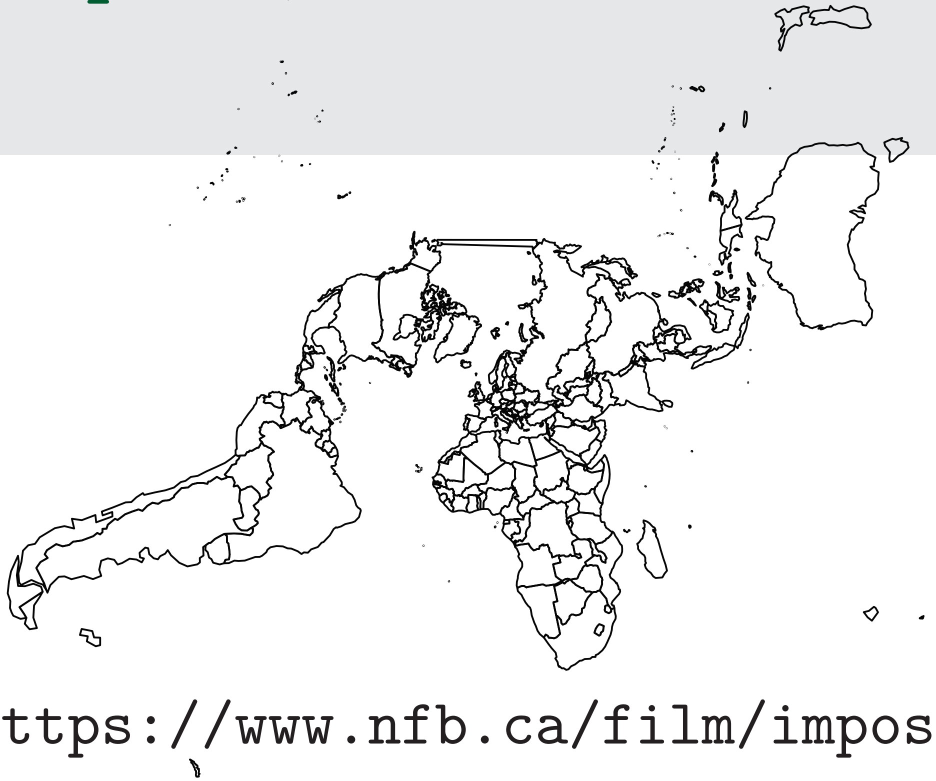
Change the projection : Robin

```
w.robin <-
    spTransform(w,CRS("+proj=robin +ellps=WGS84"))
plot(w.robin)
```



Change the projection : Lambert belge 72

```
w.lb72 <- spTransform(w,"+proj=lcc +lat_
    1=51.16666723333333 +lat_2=49.8333339 +lat_0=90 +
    lon_0=4.367486666666666 +x_0=150000.013 +y_
    0=5400088.438 +ellps=intl +towgs84
    =106.869,-52.2978,103.724,-0.33657,0.456955,-1.84218,1
     +units=m +no_defs")
plot(w.lb72)
```



lien détente : https://www.nfb.ca/film/impossible_map

Formatting data

```
DATE.FRAME <- read.table(...)

# transform to a spatial object
coordinates(DATA.FRAME) <- ~long+lat

# attribute a projection
proj4string(SP) <- CRS("+init=epsg:4326")
## ie "+proj=longlat +ellps=WGS84 +datum=WGS84 +no_defs"

# change the projection
SP.2 <- spTransform(SP,crs(ANOTHER_SP))
```

Spatial analysis

```
# select only some points
selection <- over(SP.POINTS,SP.POLYGONS)
SP.POINTS.2 <- SP_POINTS[!is.na(selection[,1]),]

# analysis, e.g. count the points per polygon
SP.POINT.POLYGONS <- aggregate(x=SP.POINTS.2,by=SP.
    POLYGONS,FUN=length)
```

Mapping

...

1 - Shapefiles

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- a - Definition
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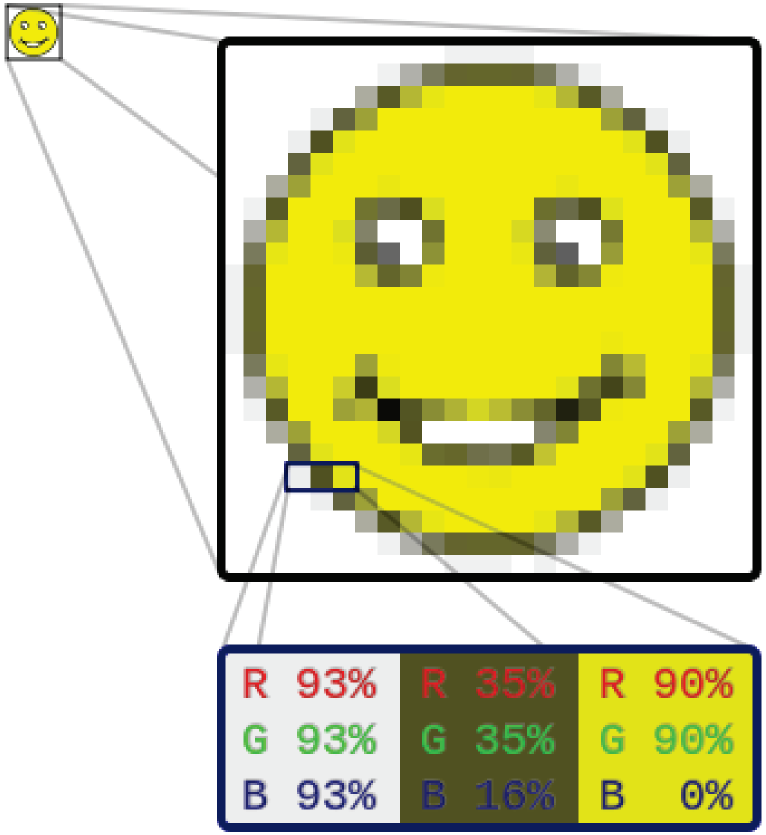
- c - Mapping
- d - Analysis

4 - Artistic maps

dot matrix data structure representing a generally rectangular grid of pixels, or points of color
(e.g. remote sensing data)

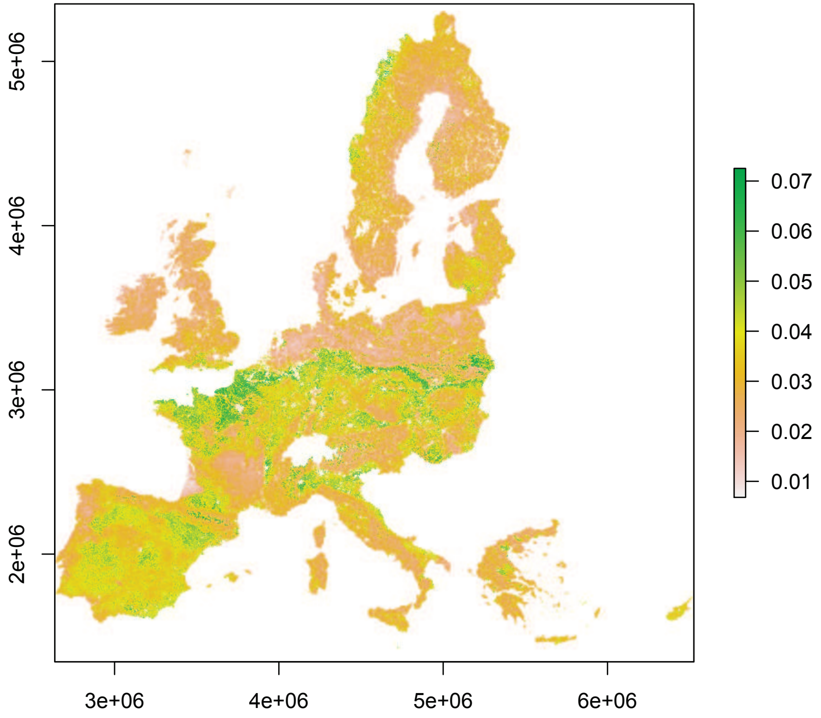


R 93%	R 35%	R 90%
G 93%	G 35%	G 90%
B 93%	B 16%	B 0%

source : wikipedia

Package & basic loading function

```
library(raster) # raster data
MAP <- raster(‘‘./FOLDER/FILE.tif’’)
```



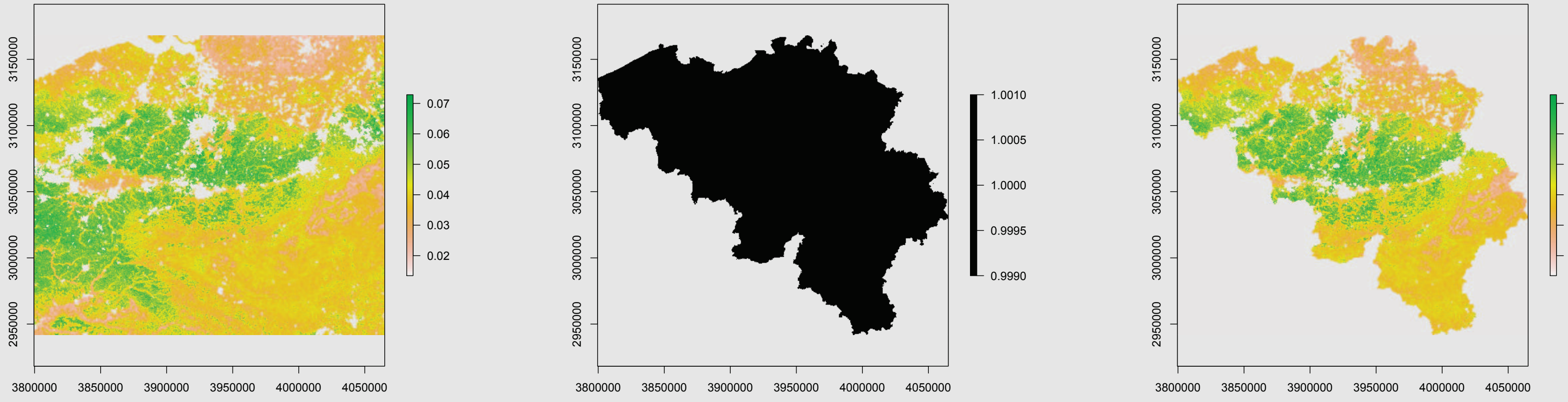
Crop – Frame – Clip

```r
# cropping according to the bounding box
CROPPED.RASTER.MAP <- crop(RASTER.MAP,OTHER_MAP)

# framing : rasterizing an SP object according to the tiles of a raster
FRAME.RASTER.LAP <-
    rasterize(SP.POLYGONS,CROPPED.RASTER.MAP)

# clipping
CLIPPED.RASTER.MAP <-
    mask(x=CROPPED.RASTER.MAP,mask=FRAME.RASTER.MAP)
```

Crop – Frame – Clip



Function for changing projection, resolution, . . .

```
projectRaster(from=..., to=...,res=...,crs=...)
```

Tip : defining a `raster.base`

```
raster.base <-
    projectRaster(A.GOOD.RASTER,res=YOUR_RESOLUTION,
        crs=crs(belgium))
```

This will be useful for defining the same structure (exent, resolution, projection,. . .) for all your rasters

```
NEW.RASTER <- projectRaster(RASTER,raster.base,crs=crs
    (belgium))
```

Saving your data

```
writeRaster(YOUR.RASTER,
            filename="./FOLDER/FILE.tif",
            format="GTiff",
            overwrite=TRUE)

## can be read by raster("./FOLDER/FILE.tif")
```

basic plot

```
plot(RASTER)
```

with ggplot2

```
DATA.FRAME <- as.data.frame(RASTER,xy=TRUE,na.rm=TRUE)

map <- (ggplot(aes(x = x, y = y),data=DATA.FRAME)
               + geom_tile(aes(fill=CRITERIA))
               + labs(title="TITRE")
               + scale_fill_gradientn()
               + coord_equal()
               ## + map.info
               ## + map.admin
               ## + theme.map.white
               )
```

Some functions (package raster)

```r
alt.be <- getData('alt', country='BEL',path='./data/getdata/')

slope.be <- terrain(alt.be, opt='slope')

aspect.be <- terrain(alt.be, opt='aspect')

hill.be <- hillShade(slope.be, aspect.be, 40, 270)
```

ex. Establishing vineyards in Belgium

- 'Nul'
- (Slope > 2%) & (W < Aspect < E) → 'Acceptable'
- (Slope > 2%) & (SW < Aspect < SE) → 'Bon'
- (Slope > 4%) & (SW < Aspect < SE) → 'Supérieur'

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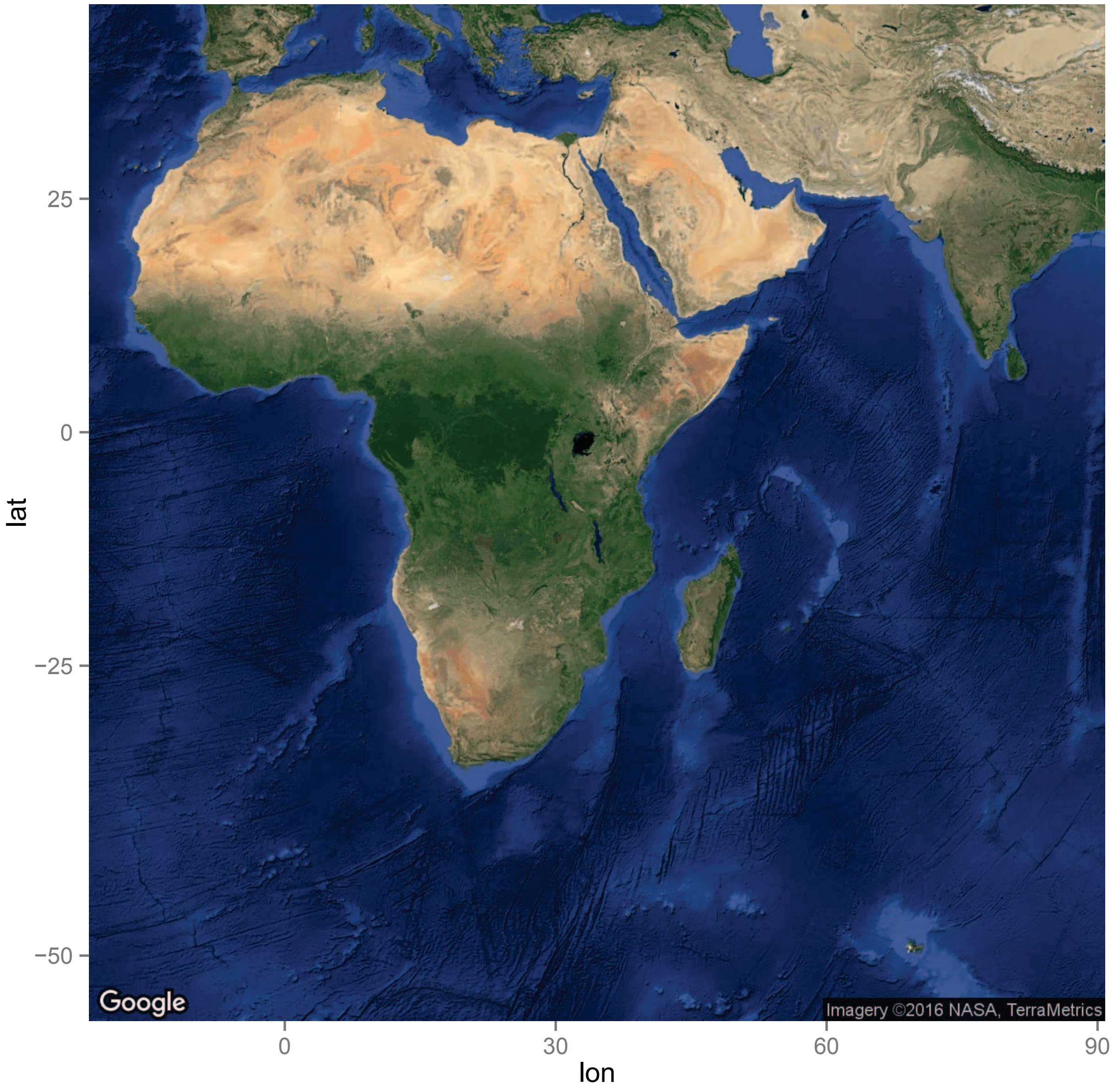
a - ggmap

b - gpx


25
0
−25
−50
lat
0
30
60
90
lon
Google
Imagery ©2016 NASA, TerraMetrics

Packages

```
## library(maps)
## library(mapdata)
library(ggmap)
```

Functions

```
## getting coordinates of a location
COORD <- geocode(’YOUR.LOCATION’) # x, y coordinates

## building the map
MAP <- get_map(location=...,source=...,maptype=...)
# all the map

# location can be a string or a bounding box
# source = c("google", "osm", "stamen", "cloudmade")
# maptype = c("terrain", "terrain-background", "satellite","roadmap", ...)

# plotting the map
ggmap(MAP)
```

Packages

```
library(XML)
```

source : http://www.r-bloggers.com/stay-on-track-plotting-gps-tracks-with-r/

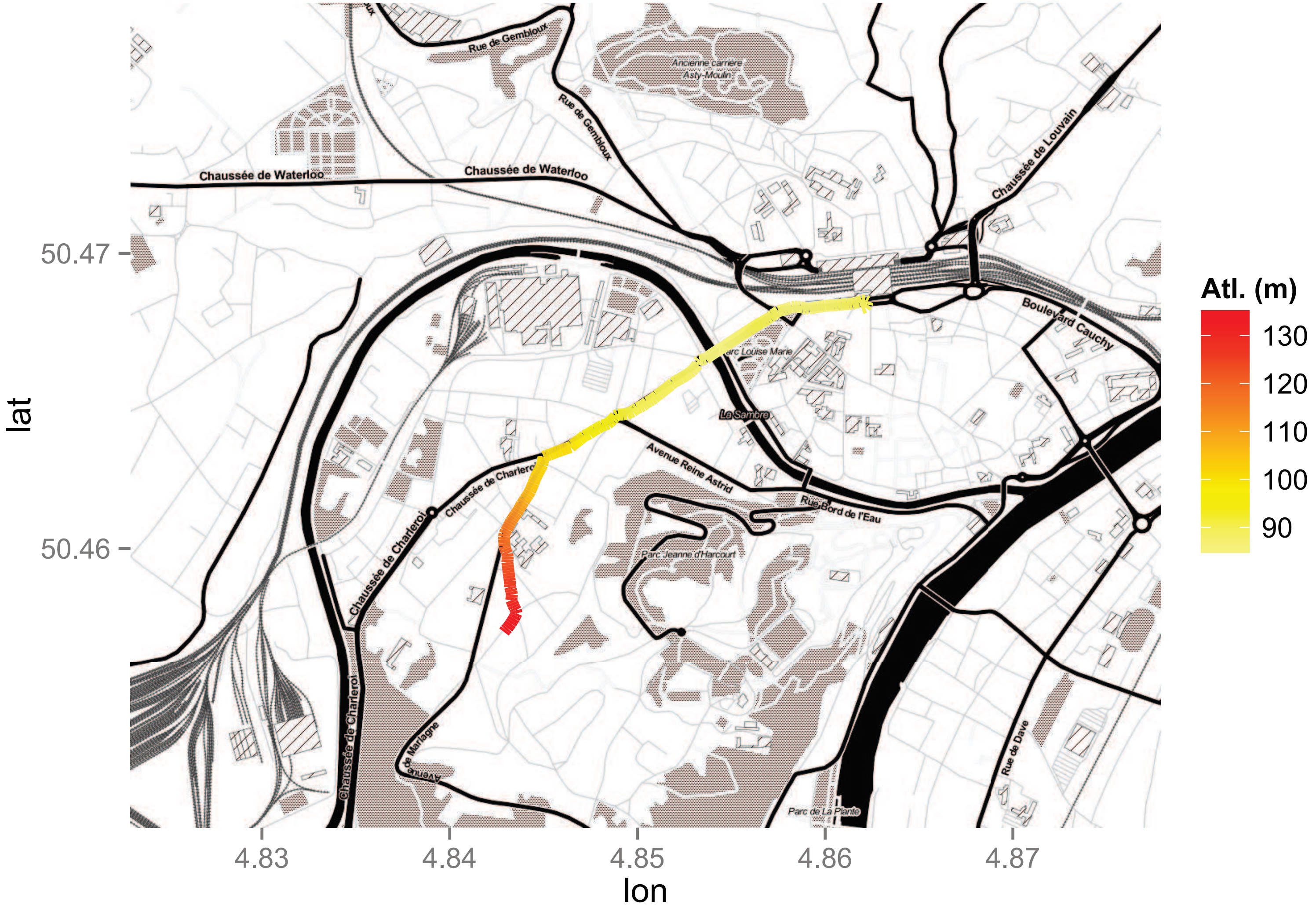
Procedure .gpx → data.frame (black box)

```r
gpx.gare <- htmlTreeParse("./FOLDER/FILE.gpx",error = function (...) {}, useInternalNodes = T)

## Get all elevations, times and coordinates via the respective xpath
elevations <- as.numeric(xpathSApply(gpx.gare, path = "//trkpt/ele", xmlValue))
times <- xpathSApply(gpx.gare, path = "//trkpt/time", xmlValue)
coords <- xpathSApply(gpx.gare, path = "//trkpt", xmlAttrs)

## Extract latitude and longitude from the coordinates
lats <- as.numeric(coords["lat",])
lons <- as.numeric(coords["lon",])

## Put everything in a dataframe and get rid of old variables
df.gare.retour <- data.frame(lat = lats, long = lons, ele = elevations, time = times)
```


Atl. (m)
130
120
110
100
90
lat
50.47
50.46
lon
4.83
4.84
4.85
4.86
4.87
Rue de Gembloux
Ancienne carrière Asty-Moulin
Rue de Gembloux
Chaussée de Waterloo
Chaussée de Waterloo
Chaussée de Louvain
Boulevard Cauchy
Parc Louise Marie
La Sambre
Avenue Reine Astrid
Chaussée de Charleroi
Rue Bord de l'Eau
Chaussée de Charleroi
Parc Jeanne d'Harcourt
Chaussée de Charleroi
Avenue de Mariagne
Rue de Dave
Parc de La Plante

Références

Tutorial

Lovelace, R. and Cheshire, J. (2014). Introduction to visualising spatial data in R. National Centre for Research Methods Working Paper.

Unknown. Overview of Coordinate Reference Systems (CRS) in R.

Rowlingson, B., 2012. R Reference Card – Geospatial data. (`http://www.maths.lancs.ac.uk/rowlings/Teaching/UseR2012/cheatsheet.html`)

Frazier, M., –. ggmap quickstart. `https://www.nceas.ucsb.edu/~frazier/RSpatialGuides/ggmap/ggmapCheatsheet.pdf`

Ressources web

R in general

http://www.cookbook-r.com/
http://docs.ggplot2.org/current/#
http://is-r.tumblr.com/

Geographical

http://www.atlas-belgique.be/cms2/#
http://spatialreference.org/
http://spatial.ly/

GIS and R

http://r-gis.net/
http://rgeomatic.hypotheses.org/
http://www.r-bloggers.com/plot-maps-like-a-boss/
http:
//www.r-bloggers.com/creating-an-analysis-as-a-package-and-vignette/
http://www.r-bloggers.com/stay-on-track-plotting-gps-tracks-with-r/
http://www.56n.dk/create-your-own-hexamaps/

List of packages (check)

```
# install.packages("rgeos")
# install.packages("maps")
# install.packages("mapdata")
# install.packages("maptools")
# install.packages("mapproj")
# install.packages("raster")
# install.packages("gpclib")
# install.packages("mapproj")
# install.packages("gpclib")
# install.packages("rgdal")
# install.packages("dismo")
# install.packages("GISTools")
# install.packages("ggmap")
# install.packages("scales")
# install.packages("rworldmap")
# install.packages("rasterVis")
```

List of packages (check)

```
# install.packages("RColorBrewer")
# install.packages("gdata") ## pour read.xls
# install.packages("foreign")
# install.packages("dplyr")
# install.packages("magrittr")
# install.packages("tidyr")
# install.packages("gridExtra")
```