Spatial Exploratory Data Analysis with R

Applied Spatial Econometrics

Lecture 2 (1.5h)

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Introduction

Mapping

Interactive Analysis

Spatial Interpolation

Purposes of SEDA

One definition of SEDA : "Visualising spatial distributions and local patterns of spatial autocorrelation" (L. Anselin).

- Presenting statistical information on the map.
- Coupling traditionnal tools in Exploratory Data Analysis with a map.
- Use specific tools of Spatial Data Analysis.

Preparation of the data

- Install the following packages:

```
> install.packages(c("classInt", "RColorBrewer",
  "GeoXp", "Guerry", "spatstat"))
```

- Load the necessary packages:

```
> require("rgdal")
> require("maptools")
```

- Load some codes presented in Chapter 1:

```
> source("preambule.R")
```

```
OGR data source with driver: ESRI Shapefile
Source: "Donnees/World WGS84", layer: "Pays_WGS84"
with 251 features
It has 1 fields
```

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Preparation of the data (1)

First, we select the countries of Sub-Saharian Africa :

```
> pays.af<-c("Seychelles","Equatorial Guinea","Gabon","Botswana",
 "Mauritius","South Africa","Namibia","Angola","Swaziland","Congo",
 "Cape Verde","Ghana","Sudan","Djibouti","Nigeria","Sao Tome and Princi
 "Cameroon","Lesotho","Gambia, The","Chad","Senegal","Kenya","Ivory Coa
 "Zambia","Burkina Faso","Tanzania, United Republic of","Benin","Rwanda
 "Uganda","Comoros","Guinea-Bissau","Mali","Mozambique","Guinea","Ethio
 "Madagascar", "Malawi","Togo","Sierra Leone","Niger","Central African
 "Eritrea","Burundi","Somalia","Zimbabwe","Liberia","Zaire")
> africa.sub=world[world@data$NOM%in%pays.af,]
```

Then we create a `data.frame` of the GDP :

```
> africa.df<-data.frame(pib=c(25000,26500,18100,15700,15400,11300,7800,
 5700,4600,4400,3300,2500,2600,2700,2100,2300,2100,1900,2500,2000,1800,
 1700,1400,1600,1600,1400,1400,1300,1200,1100,1200,1100,1300,900,800,11
 1300,800,900,700,600,600,600,700,400),row.names=pays.af)
```

Preparation of the data (2)

We create the `SpatialPolygonsDataFrame` object :

```
> africa.sub<-SpatialPolygonsDataFrame(africa.sub,africa.df)
```

We merge Maghreb and Sub-Saharian Africa :

```
> africa <- spRbind(northAf, africa.sub)
```

We add a variable `region` to the country (`E`, East Af, `C`, Central Af, `N`, North Af, `Au`, Austral Af and `O`, West Af) :

```
> africa@data$region <- factor(c("N","N","N","N","N","N","O",
 "O","C","E","E","O","O","O","E","O","O","C","E","O","O",
 "O","E","O","O","C","O","O","C","O","E", "E","C","C","C",
 "C","E","E","E","E","C","E","E","E","E","E","E","Au","Au",
 "E","Au","Au","Au"))
```

Representing a categorial variable

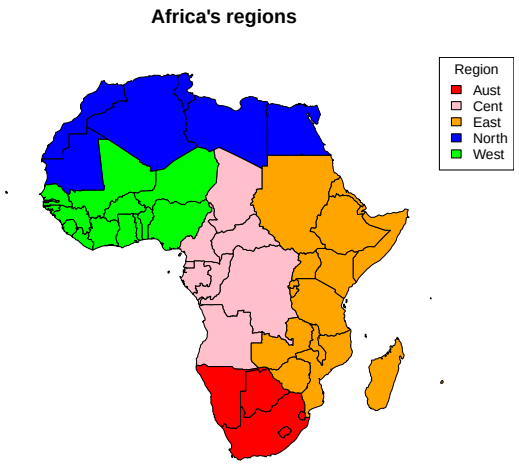
Objective : copy this map `http://fr.wikipedia.org/wiki/Afrique#mediaviewer/File:Zones_Afrique.jpg`

Choice of appropriate colors :

```
> pal.reg <- c("red","pink","orange",
 "blue","green")
```

Plotting the map :

```
> ind=as.numeric(africa@data$region)
> plot(africa, col=pal.reg[ind])
> title("Africa's regions")
> legend("topright",legend=c("Aust","Cent"
 "East","North","West"),cex=0.8,
 title="Region",fill=pal.reg)
```



Representing a numeric variable

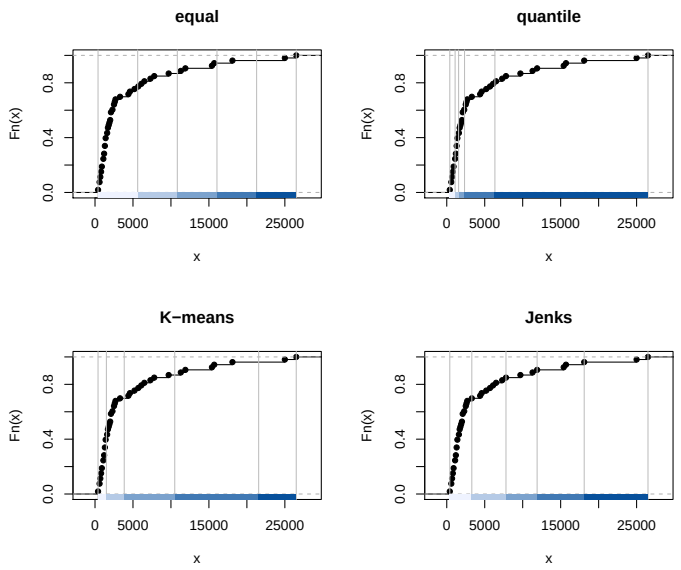
How to cut the GDP variable ? R package **classInt**.

```
> require("classInt")
> pib <- africa@data$pib
```

- The `equal` style divides the range of the variable into *n* parts.
- The `quantile` style provides quantile breaks; arguments to quantile may be passed through ....
- The `kmeans` style uses kmeans to generate the breaks.
- The `jenks` style has been imported from Jenks' Basic code, and has been checked for consistency with ArcView, ArcGIS, and MapInfo.

Application

```
> require("RColorBrewer")
> plotclr <- brewer.pal(5,"Blues")
> pal1 <- plotclr[c(1,5)]
> opar <- par(mfrow=c(2,2))
> plot(classIntervals(pib,5,"equal"),
  pal=pal1, main="equal")
> plot(classIntervals(pib,5,"quantile"),
  pal=pal1, main="quantile")
> plot(classIntervals(pib,5,"kmeans"),
  pal=pal1, main="K-means")
> plot(classIntervals(pib,5,"jenks"),
  pal=pal1, main="Jenks")
> par(opar)
```



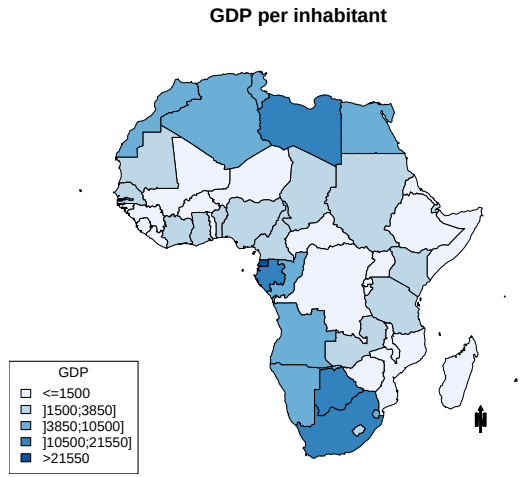
Choropleth map

The breakpoints of the bins :

```
> bk=round(classIntervals(pib, 5,"kmeans")$brks,
 digits=1)
```

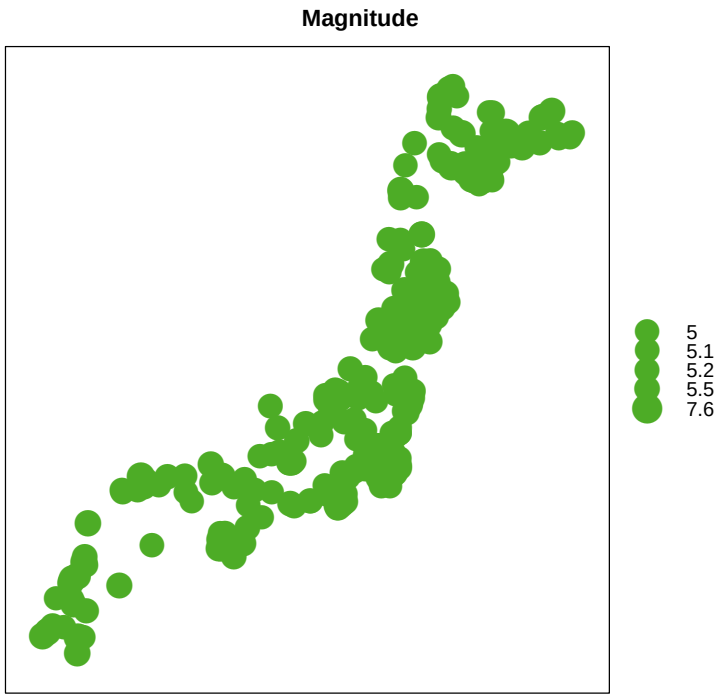
Plotting :

```
> ind=findInterval(pib, bk, all.inside=TRUE
> plot(africa, col=plotclr[ind])
> decoup <- c("<=1500","]1500;3850]",
 "]3850;10500]","]10500;21550]",">21550")
> legend("bottomleft", legend = decoup,
 cex = 0.8,title="GDP", fill=plotclr)
> SpatialPolygonsRescale(layout.north.arrow,
 offset = c(50,-30), scale = 5, plot.grid=F)
> title("GDP per inhabitant")
```

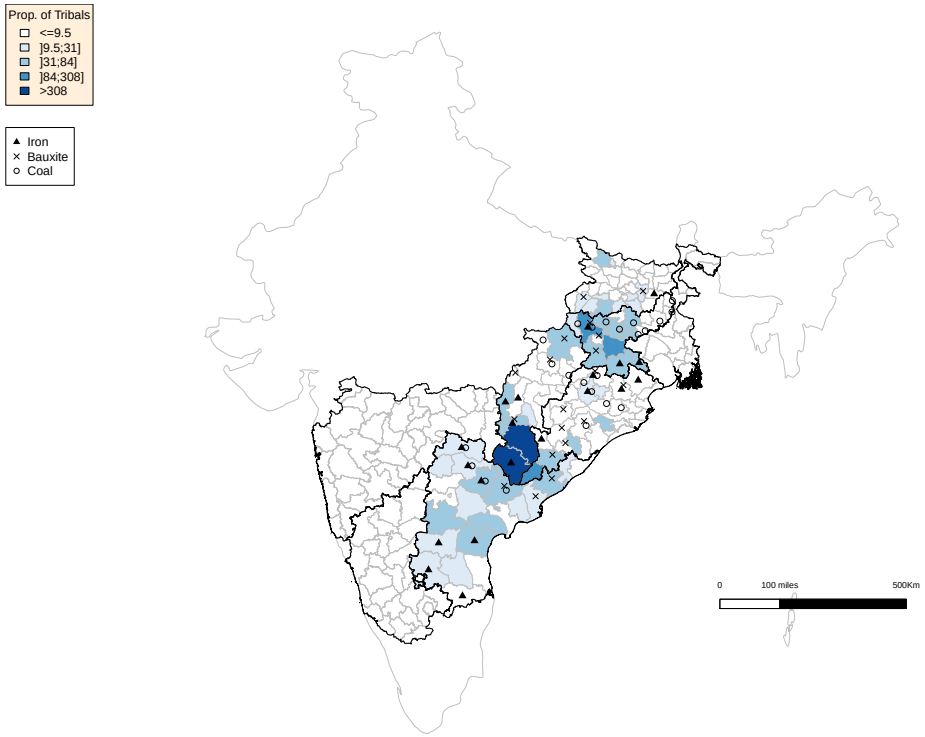


Bubble plot of spatial data

```
> bubble(seisme.jp, "Magnitude")
```



Several variables at the same time



Essays in Political Economy of Maoist Conflict in India (K. Bathia thesis, 2015)

Introduction

Mapping

Interactive Analysis

Spatial Interpolation

GeoXp: Interactive exploratory spatial data analysis

- Can be download on the CRAN: `http://cran.r-project.org`.
- A R vignette: `vignette("presentation_geoxp")`.
- **GeoXp** works with objects of class `SpatialXXXDataFrame`.
- Around 30 functions presented in T. Laurent, A. Ruiz-Gazen and C. Thomas-Agnan, "**GeoXp**: an R package for Exploratory Spatial Data Analysis", *JSS*.

Interactivity principle

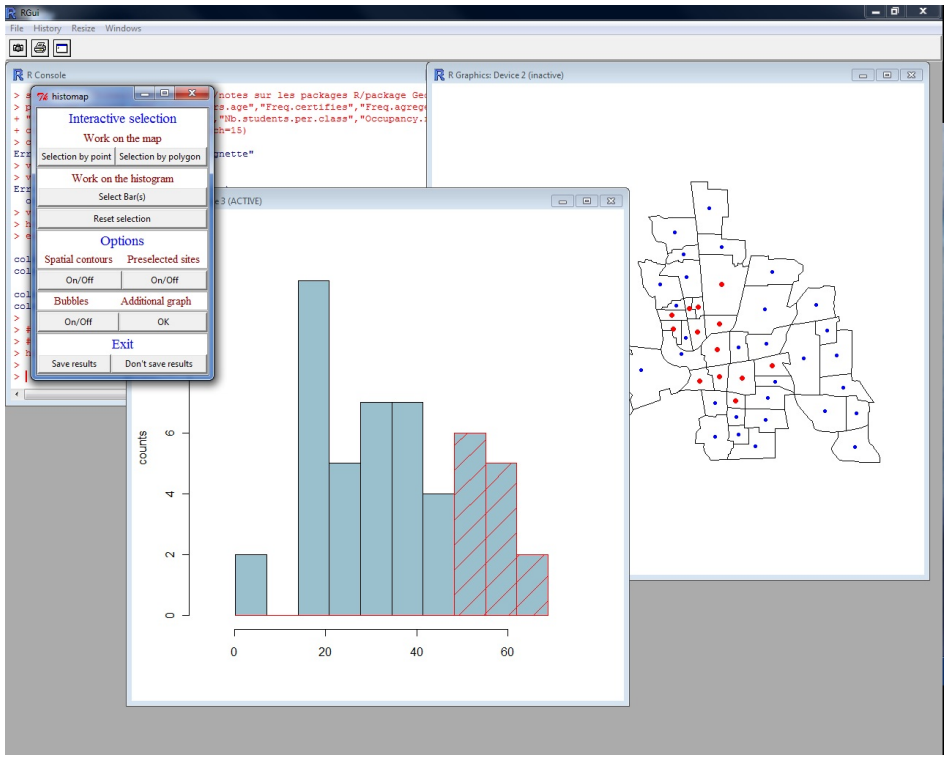
The functions of GeoXp allow an exchange between a map and a statistical graph. This exchange is bilateral :

- the user selects spatial units on the map, whose corresponding elements are then highlighted on the graph
- the user selects elements of the graph, whose corresponding spatial units are then highlighted on the map

The highlighting is done by a change of color or a change of symbol.

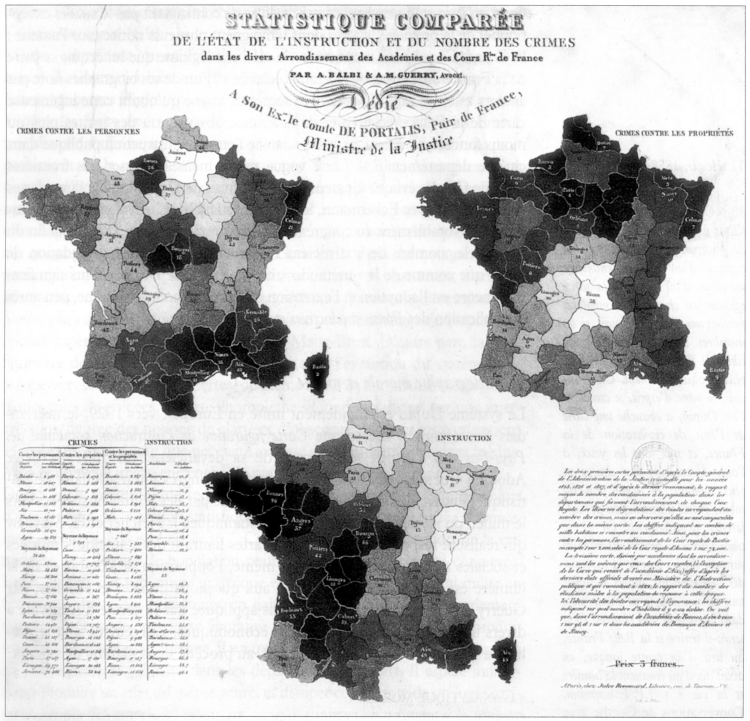
Three windows

A Tcl/Tk window for the menu, a graphical window for the statistical graph and a graphical window for the map



An application with the Guerry's data

- In 1833, André-Michel Guerry wrotes *Essai sur la statistique morale de la France*
- His goal: can we explain the violence in the French department by some social variables (education, clergy, etc.).



Initialisation

- Load the packages:

```
> require("GeoXp")
> require("Guerry")
```

- Two variables of interest : crime against persons (`Crime_pers`) and crime against property `Crime_prop`, for 1000 inhabitants :

```
> gfrance85@data$Crime_pers<-1000/gfrance85@data$Crime_pers
> gfrance85@data$Crime_prop<-1000/gfrance85@data$Crime_prop
```

- Modify the labels of the individuals :

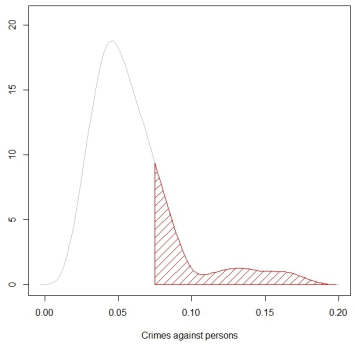
```
> row.names(gfrance85) <- as.character(gfrance85@data$Department)
```

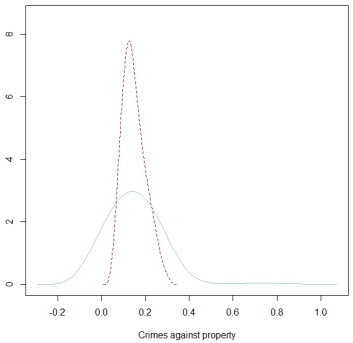
- Explanatory variables: see description in `help(Guerry)`.
- Mapping of the variables `Crime`:

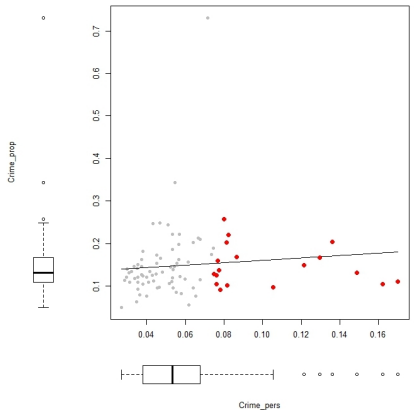
```
> spplot(gfrance85,"Crime_pers",col.regions=rev(heat.colors(16)))
> spplot(gfrance85,"Crime_prop",col.regions=rev(heat.colors(16)))
```

Non parametric estimates of the variables of interest

```
> dbledensitymap(gfrance85, c("Crime_pers", "Crime_prop"),  xlab =
  c("Crimes against persons", "Crimes against property"), identify=T)
```

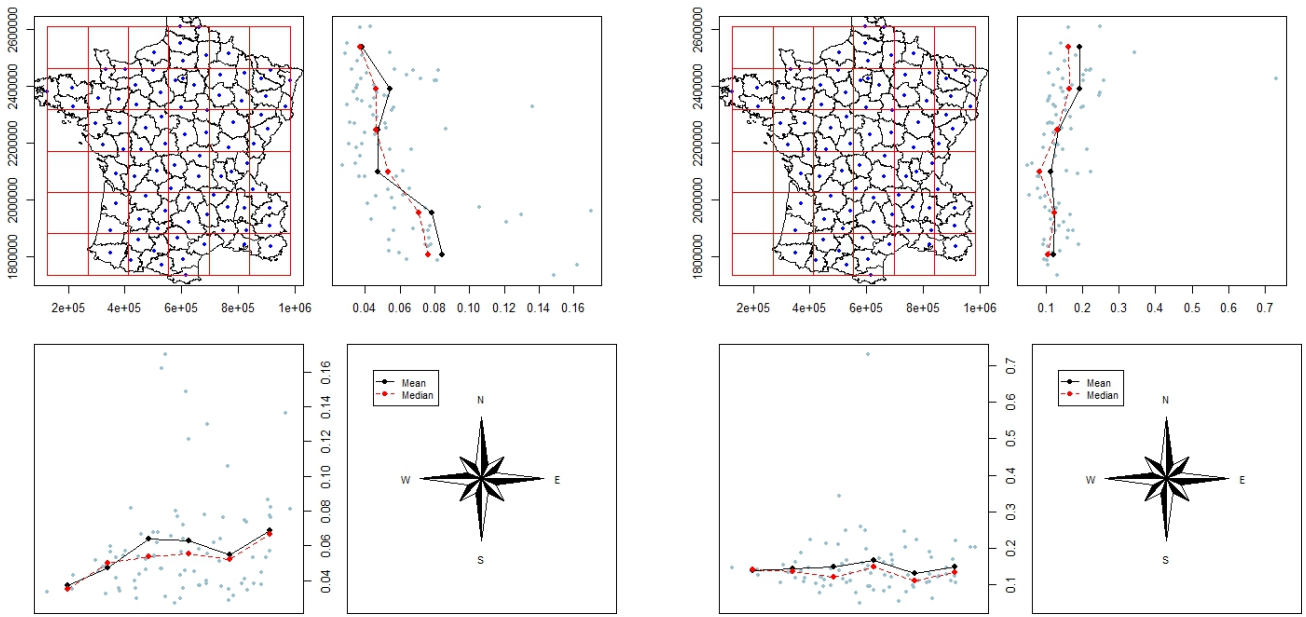






Analysis of a spatial tendency - "Driftmap"

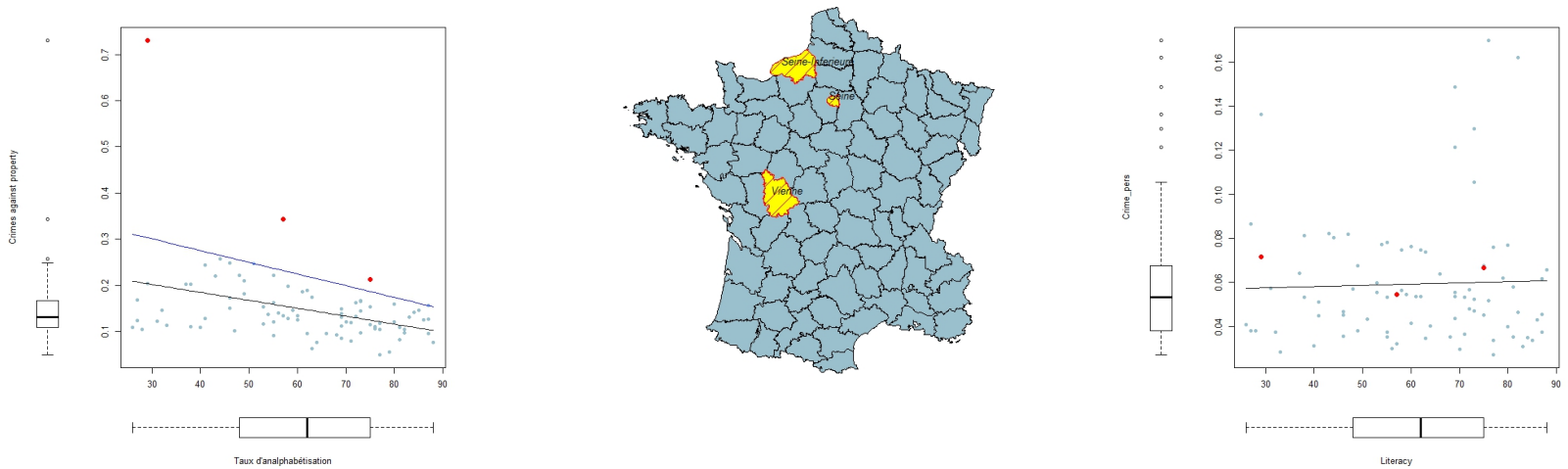
```
> driftmap(gfrance85, "Crime_pers")
> driftmap(gfrance85, "Crime_prop")
```



North/South and West-East tendencies for crimes against persons.
A small South/North tendency for crimes against property.

Relationship between crimes and education

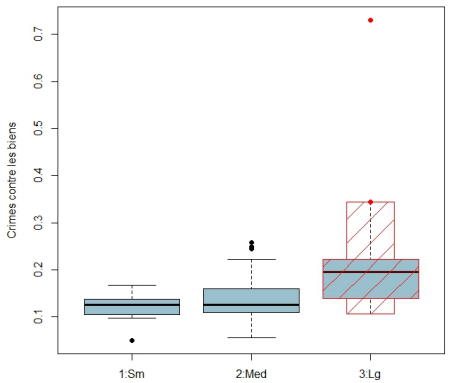
```
> scattermap(gfrance85, c("Literacy", "Crime_prop"),
  xlab="Literacy", ylab="Crimes", identify=TRUE)
```

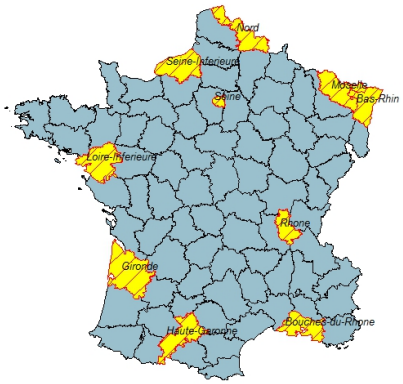


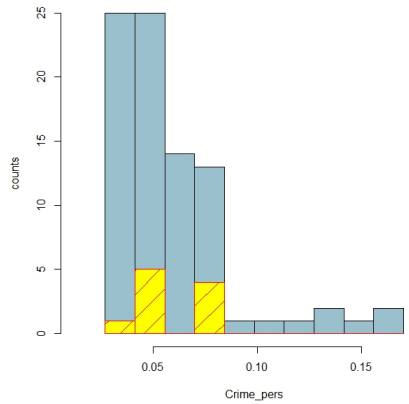
Negative effect of education on the crimes against property. Detection of outliers. No effect of education on the crimes against persons.

Relationship between crimes and presence of a huge city in the department

```
> polyboxplotmap(gfrance85, c("MainCity", "Crime_prop"), identify=TRUE)
```



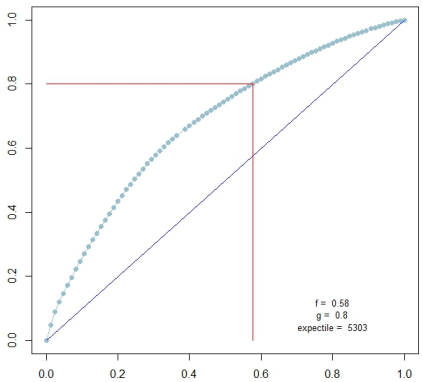


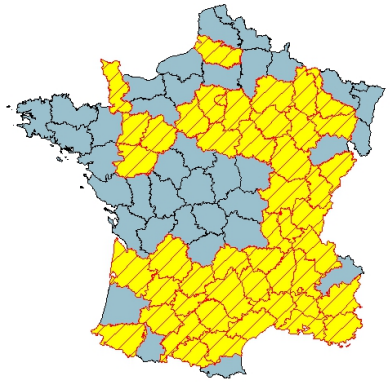


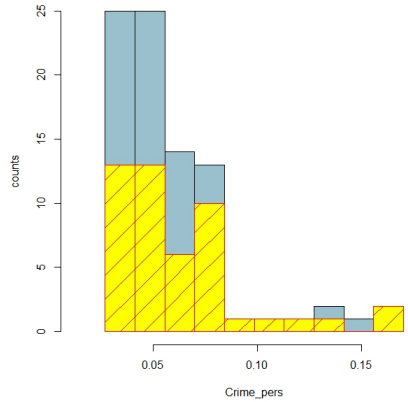
Crimes against property higher in departments with a huge city.

Relationship between crimes and donations to the poor

```
> ginimap(gfrance85, "Donations")
```





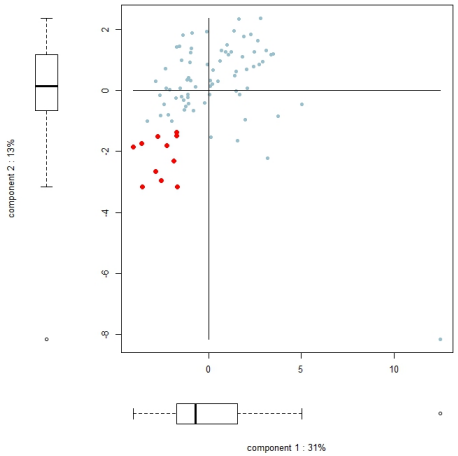


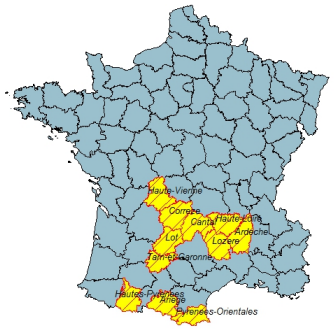
80% of the donations are done by 58% of the departments. Non obvious relationship.

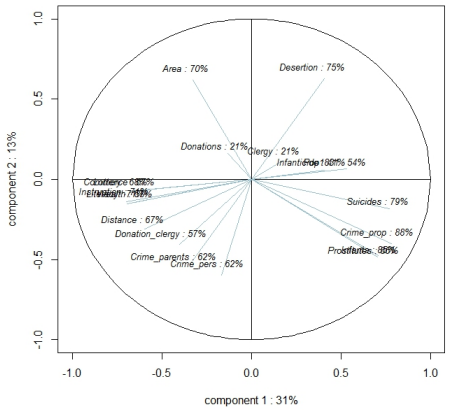
Principal Component Analysis

```
> pcamap(gfrance85, c(7:12, 14:26), identify=TRUE)
```

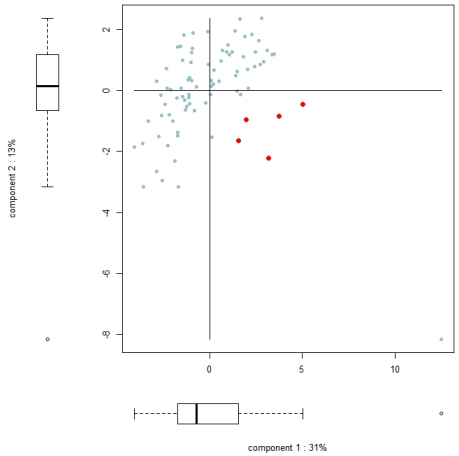
"Crime against person"

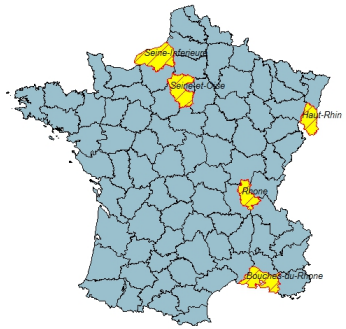






"Crime against property"





Summary

We got the same results that those obtained by A.-M. Guerry :

- The 2 variables `Crimes` are not spatially distributed in the same way. High values of crime against property are not situated in the same departement than high values of crime against person.
- Crime against property are most important in urban areas.
- Crime against person are not related to education.
- Crimes seem to be related to wealth.

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Spatial Interpolation in Spatial Point Pattern analysis

We would like to represent the intensity of the earthquake in Japan. We need to define an observation window :

```
> require("spatstat")
> bb <- bbox(japan2)
> W = owin(bb[1,], bb[2,])
```

we define the spatial point pattern process of the earhtquake located in the window W :

```
> wp.seisme <- ppp(x=seisme.jp2@coords[,1],
 y = seisme.jp2@coords[,2], window=W)
```

We mark the spatial point process

```
> marks(wp.seisme) <- seisme.jp2@data$Magnitude
```

Kernel Smoothed Intensity of Point Pattern

Choice of the bandwidth with `bw.diggle` :

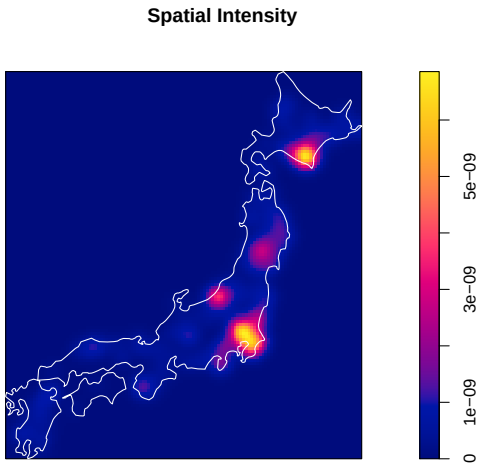
```
> bw.diggle(wp.seisme)
```

Kernel Smoothed Intensity of Point Pattern :

```
> D.seisme<- density(wp.seisme, sigma=3000(
```

Plotting :

```
> plot(D.seisme, main="Spatial Intensity")
> plot(japan2, add=TRUE, border="white")
```



Spatial Interpolation in geostatistic (1)

155 measures of biological concentrations near the river Meuse

```
> data(meuse)
> coordinates(meuse) <- ~x+y
> proj4string(meuse) <- CRS("+init=epsg:28992")
```

We create a Spatial Point pattern process :

```
> require("rgeos")
> test <- gBuffer(meuse, width=250)
> W = as(test, "owin")
> meuse.ppp <- ppp(meuse$x, meuse$y, window=W)
> marks(meuse.ppp) <- meuse$zinc
```

We would like to interpolate the concentration in Zinc. We use the Inverse-distance weighted smoothing of observations at irregular points (see details in `help(idw)`)

```
> dens.zinc <- idw(meuse.ppp, 2)
```

Spatial Interpolation in geostatistic (2)

Other available methods : Mark of nearest neighbour, non parametric spatial smoothing.

```
> op = par(mfrow=c(2,2), mar=c(0,0,3.3,0))
> plot(meuse.ppp,
  main="Concentrations in zinc")
> plot(nnmark(meuse.ppp),
  main="Mark of Nearest Neighbour")
> plot(Smooth(meuse.ppp),
  main="Spatial smoothing")
> plot(dens.zinc,
  main="Inv-dist weighted smoothing")
> par(op)
```