GeoXp : an R package for interactive exploratory spatial data analysis. Illustration with a data set of schools in Midi-Pyrénées.

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Introduction

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Main objective : **exploratory spatial data analysis** and **coupling** between a **map** and a **statistical graph**.

Principle

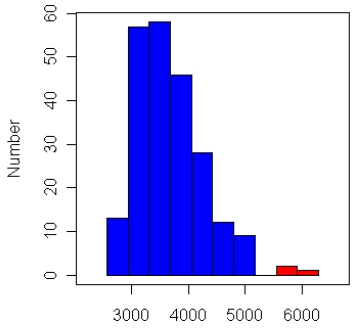
GeoXp links dynamically **statistical plots** like boxplot, histogram, scatterplot,... with a **map**.

Selection of a zone on the **map** results in the automatic highlighting of the **corresponding points** on the **statistical graph**.

Selection of a portion of the graph results in the automatic highlighting of the **corresponding sites** on the **map**.

Principle

Example : sites selected by mouse clicking on bars of histogram are represented in red on the map.



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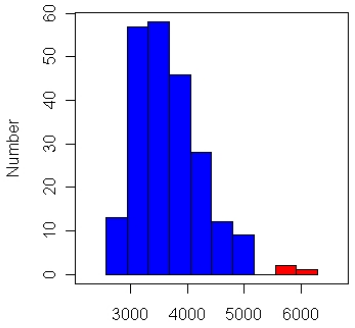

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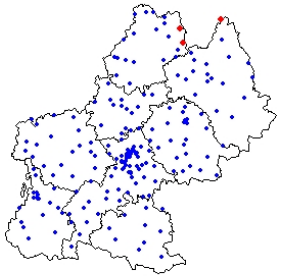

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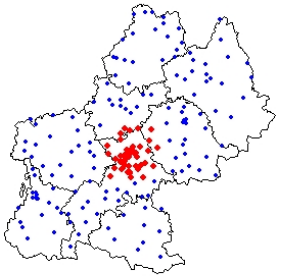
Example : sites selected by points or polygon on the map are represented in red on the histogram.



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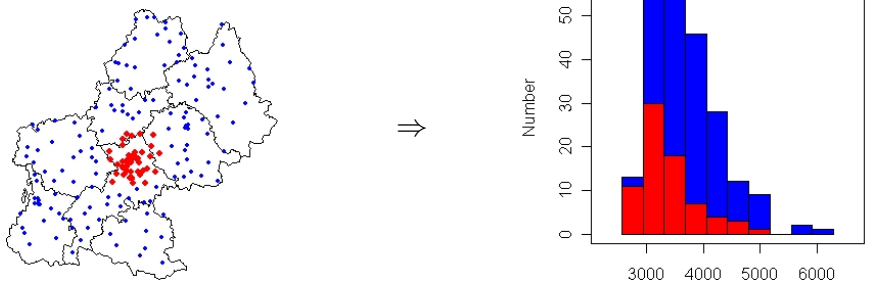

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Geostatistic functions : angle plot, drift plot,...

Econometric functions : Moran plot, neighbour plot,...

Multivariate functions : principal component analysis, cluster analysis....

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Point pattern analysis : a site is represented on the map by a point. Coordinates are included into **two vectors** of **numeric values**.

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Remark : **no lattice/area data analysis** and **no use of Spatial Classes** such as in spdep library (Roger Bivand).

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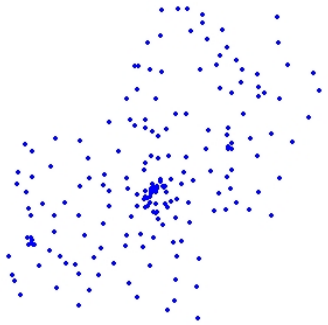
Example 4 (spatial econometric analysis) :
moranplotmap(*latitude*, *longitude*, *var*, *W*, *opt*1, *opt*2*d*)

Common options



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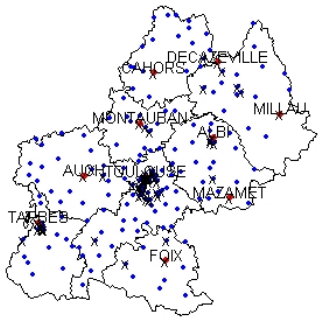

Possibility to improve the map :

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- Possibility to print labels.

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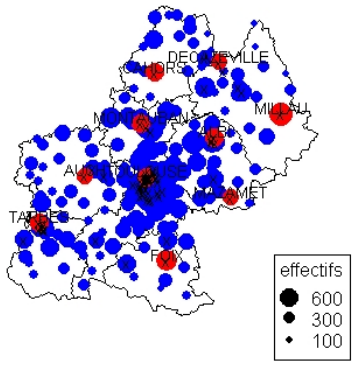
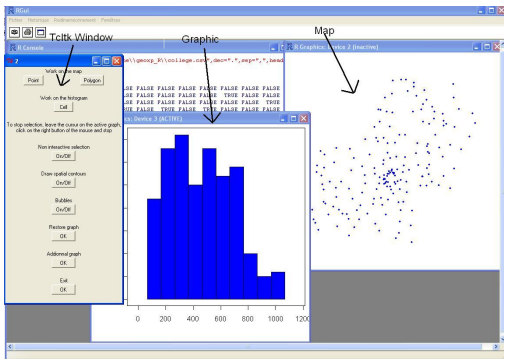


Possibility to improve the map :

- Possibility to draw **spatial contours**.
- Possibility to cross out specific sites.
- Possibility to print labels.
- Possibility to draw bubbles.

Interface

Call of a function ⇒ drawing of a graph, a map and creation of a **tcltk Window** (library `tcltk`), tool for **selecting** a zone on the map (or on the graph) and **using options**.



Use of GeoXp : data set considered

Spatial units s_j $(j = 1, ...226)$: **public schools** in French Midi-Pyrénées region. Spatial position of a school is represented by the **centroid of the "commune"** where the school is located.

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Observed variables : number of students, age of staff, different fields of study, status of teacher,... during the 2003-2004 school year.

Presentation of GeoXp
Descriptive analysis
Geostatistic functions
Spatial Econometrics
Multivariate analysis
Principle
Use of GeoXp
Options
Interface
Description of Data

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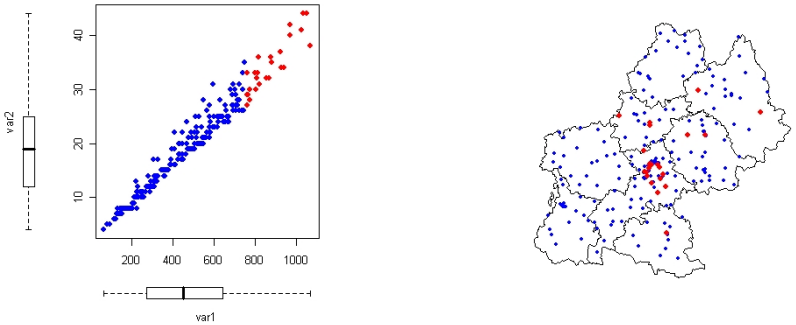
Aim : determine characteristic of schools according to their localization in rural, periurban and urban area (Insee classification).

Scatter plot

scattermap(X,Y,var1,var2,carte=coord,listvar=dataset)



Number of classroom $\sim$ number of students

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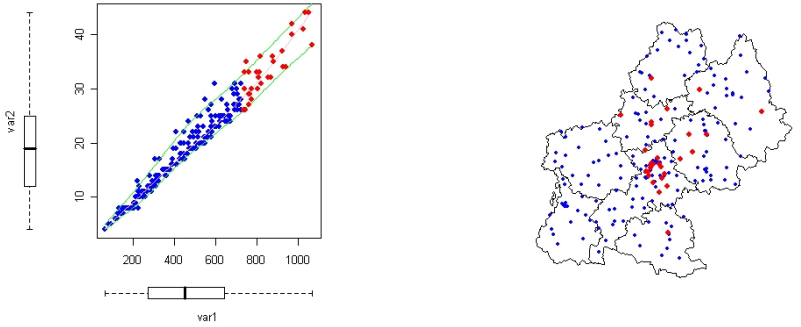
Gini Map
Kernel Density Function estimate

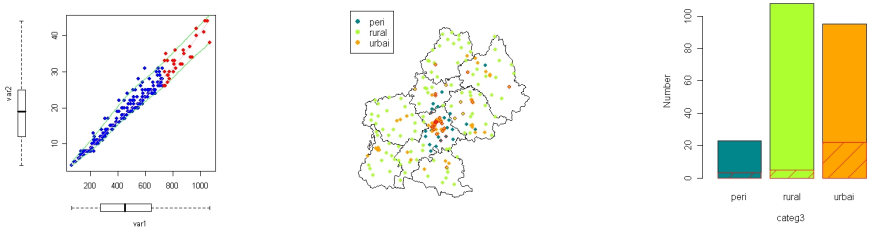
Scatter plot

Possibility to draw conditionnal quantile regression for a given list of quantiles orders (*ex : quantiles=c(0.05,0.5,0.95)*).



Scatter plot

Possibility to **add a graph** among **histogram**, **scatterplot** and **barplot**, by selecting variable(s) (given in *listvar*) on `tcltk` window .

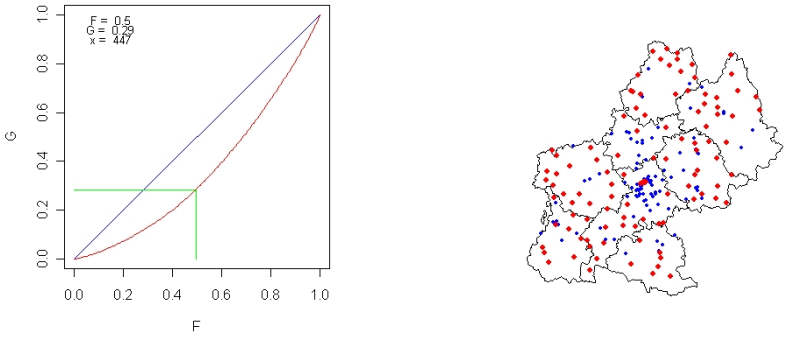


The schools selected are mainly included in urban area.

Gini Map

ginimap(lat,long,var,carte=coord,listvar=dataset)

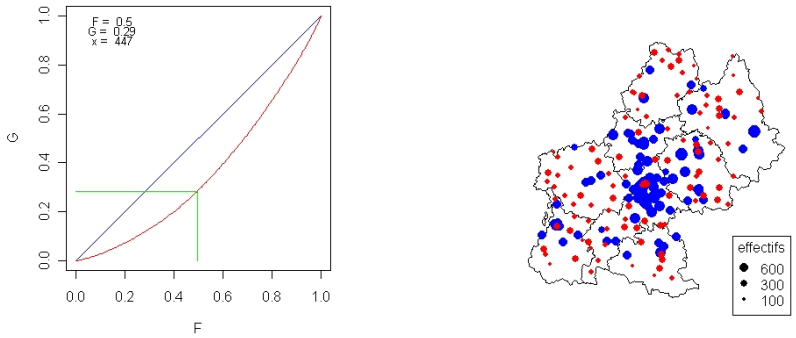
Computes a **Lorentz curve** from 'var' and calculates the **Gini Index** associate.



Gini Index = 0.28 ; the 50% schools with lowest number of students contain only 29% of the student population.

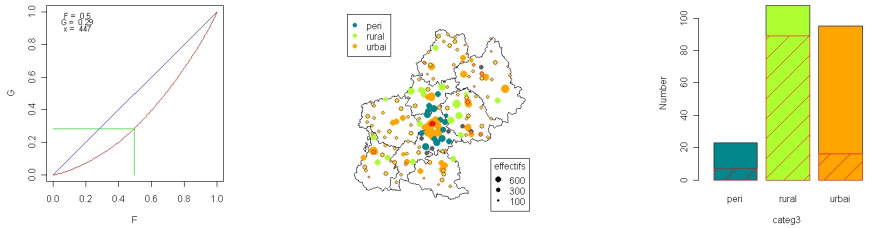
Gini Map

Possibility to draw bubbles by selecting on `tcltk` window a numerical variable among *listvar*.



Gini Map

The schools selected are mainly included in rural area.

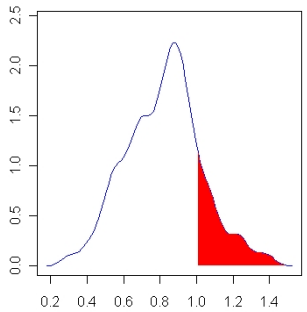


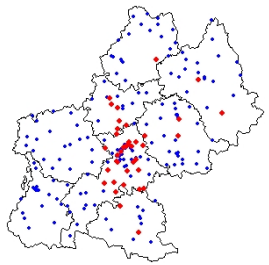
Kernel Density function estimate

densitymap(lat,long,var,carte=coord,listvar=dataset)

Use of function `bkde.R` (library `Kernsmooth`) with option *kernel=triweight*.

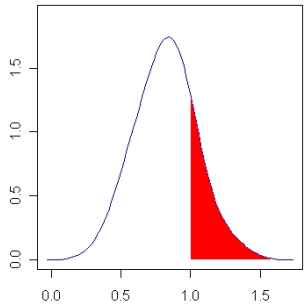
Possibility to choose an interval by **mouse clicking** on the graph on the **extremities** of interval or by **directly specifying values**.

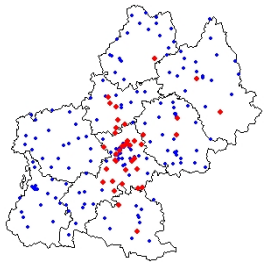




Kernel Density function estimate

Possibility to change **smoothing parameter** α with a **cursor** on `tcltk` window.



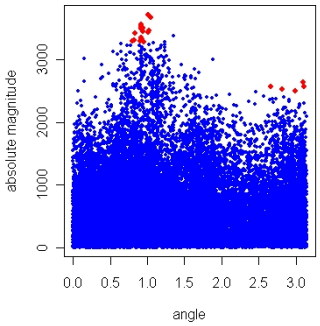


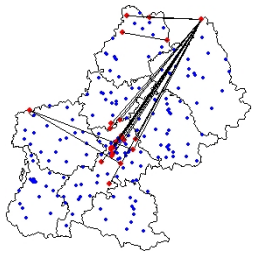
Urban schools with a high coefficient are close to Toulouse.

Angle plot

angleplotmap(lat,long,var,carte=coord,listvar=dataset)

Represents the **absolute difference** between the value of *var* at **two sites** as a function of the **angle** between **vector** $\overrightarrow{s_i s_j}$ and **the x-axis**.

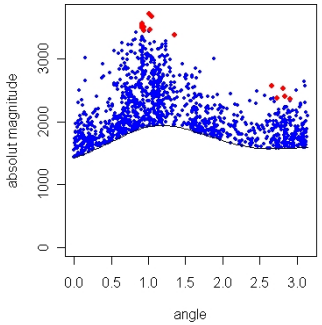


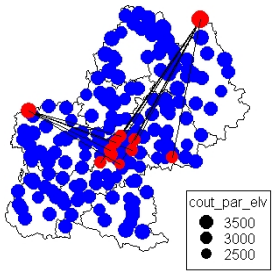


Variable average cost per student.

Angle plot

Possibility to draw only couple of sites whose absolute difference is **larger** than the 95% **regression quantile smooth spline**.

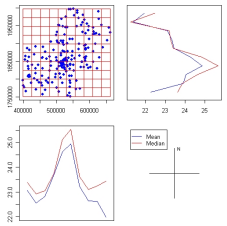




2 schools in the North and in the west with high average cost per student.

Drift map function

Creates a **grid** on the map and calculates **the mean and median for each cell**. The right plot (resp. left plot) represents row (resp. column) means and median.



Average number of student per class reaches a maximum in the center of the region which corresponds to the surroundings of Toulouse.

Spatial weight matrix

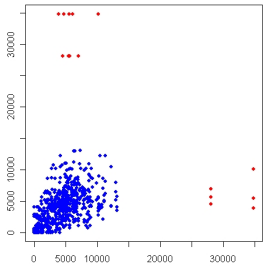
Possibility to create spatial weight matrix based on a **threshold distance** or based on a given number of **nearest neighbors**.

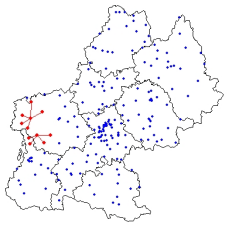
ex :

$$W = \begin{pmatrix} 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 \end{pmatrix}$$

Neighbour plot

Scatterplot of the values of a variable at **neighbouring sites** for a **neighbourhood structure** given by a **spatial weight matrix**.



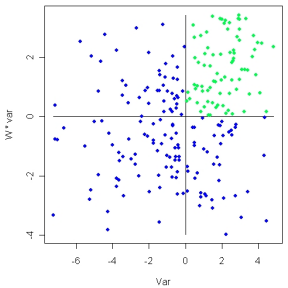


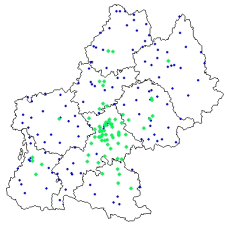
2 schools with a **high difference** with its neighbours for variable *average distance between school and home*. W built with 3 nearest neighbors.

Moran plot

On x-axis, is represented $(Var - \bar{Var})$ and on y-axis, is represented $W(Var - \bar{Var})$.

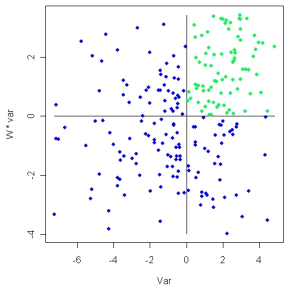
It also calcultes **Moran's I statistic** (see nonnormoran.r) and gives a **p-value** associated to the **gaussian test** or to the **permutation test**.

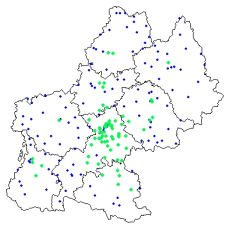


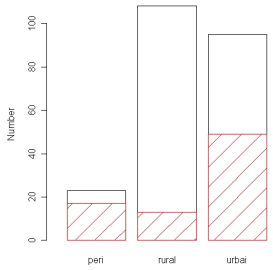


Moran plot

High spatial autocorrelation for *average number of student by class* : Moran'I statistic = 0.19 with $p - value < 0.0001$.





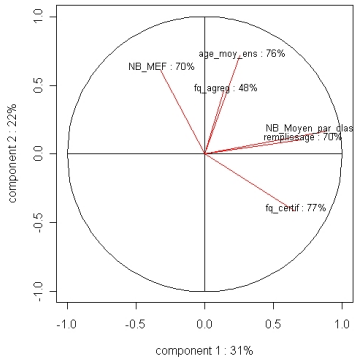


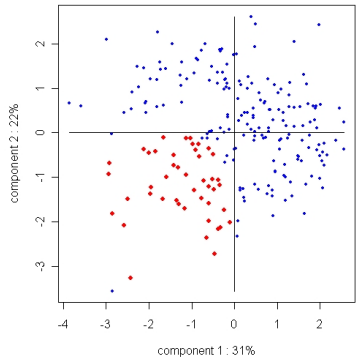
Schools with high values and whose neighbours have also high values are mainly included in urbain area.)

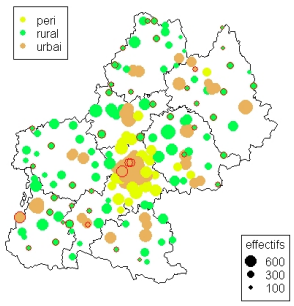
PCA

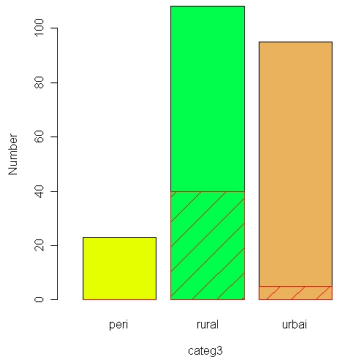
pcamap(lat,long,dataset)

Draws the plots summarizing a **generalized Principal Component Analysis** (PCA).







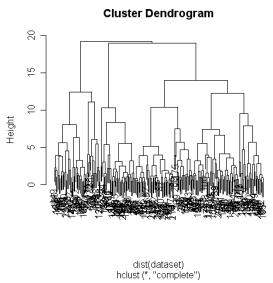


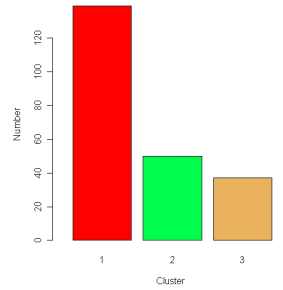
Cluster Analysis

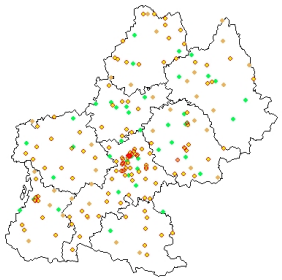
clustermap(lat,long,dataset,number.of.class)

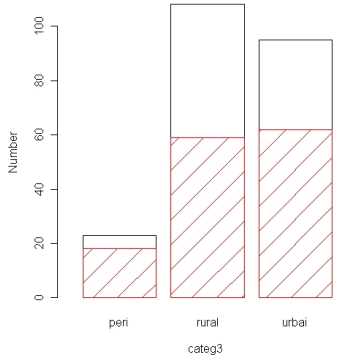
Performs a **classification** of the sites from the variables included in 'dataset' and **computes a bar plot** of the **clusters calculated**.

Two methods : *Hierarchical Cluster Analysis* (see hclust.R) or *k-means clustering* (see kmeans.R)









There seem to exist no link between calculated clusters and geographical area.

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Multivariate analysis
Principal component analysis
Cluster analysis

Perspective

Writing of a GeoXp user manual.

Presentation of GeoXp
Descriptive analysis
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To include others functions as scatterplot 3D, sliced inverse regression, projection pursuit, spatial autoregressive models (SAR, SEM,...).

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Integration of `Micromaps` software (Carr and Symanzik).

Conclusion

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Merci de votre attention ! !