



在空间分析中的应用初探

R and Spatial Analysis

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为什么要做空间分析

- 经济学
- 地理学
- 环境科学
- 生物学与生态学
- 流行病学
-



某人于暑假在地球上的轨迹

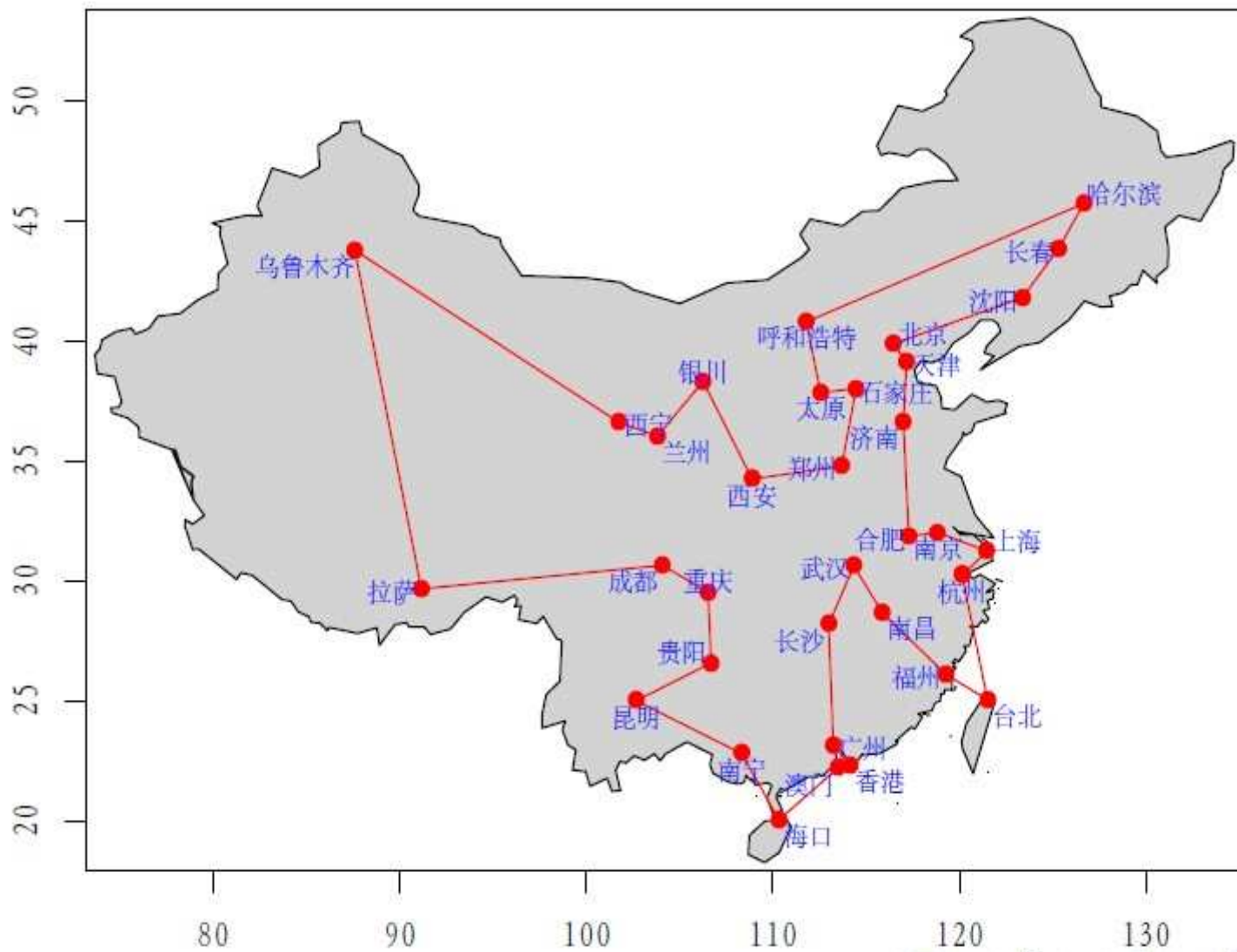
来源: <http://yihui.name/cn/>

H1N1疫情中国分布图



来源网络: http://www.okokok.com.cn/Maps/ZT_H1N1_global.htm





什么是空间分析 what is spatial analysis?

- 分析空间数据 **using spatial data**
- 描述空间格局 **depicting spatial pattern**
- 推断空间过程 **inferring spatial process**

现象（数据） $\xrightarrow{\text{purple arrow}}$ 过程（模型） $\xrightarrow{\text{red arrow}}$ 预测（应用）

空间化或区域化

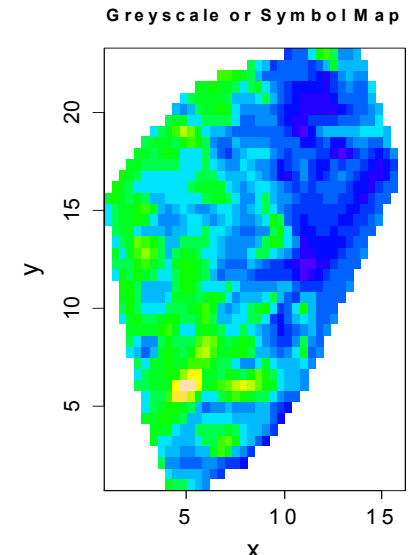
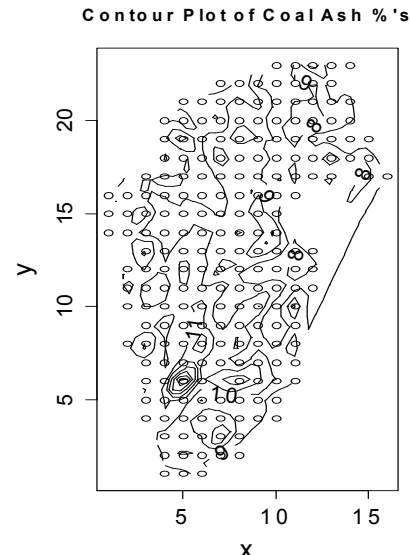
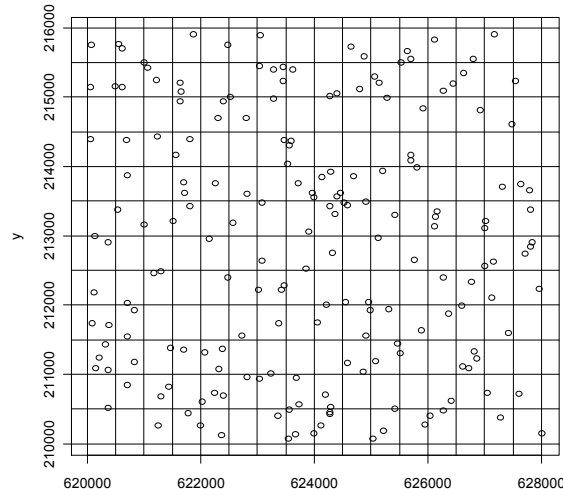
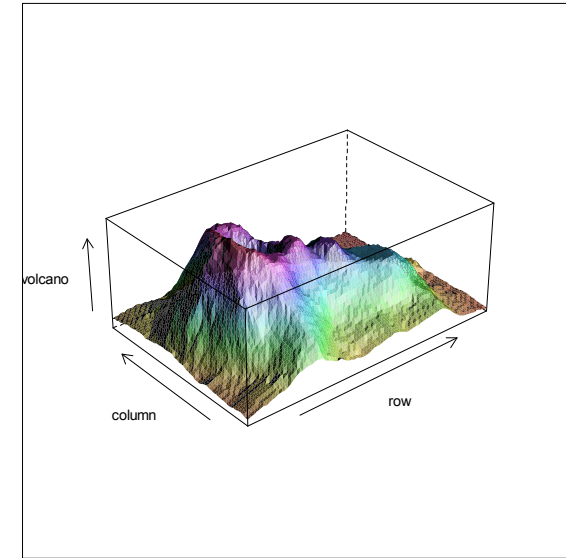
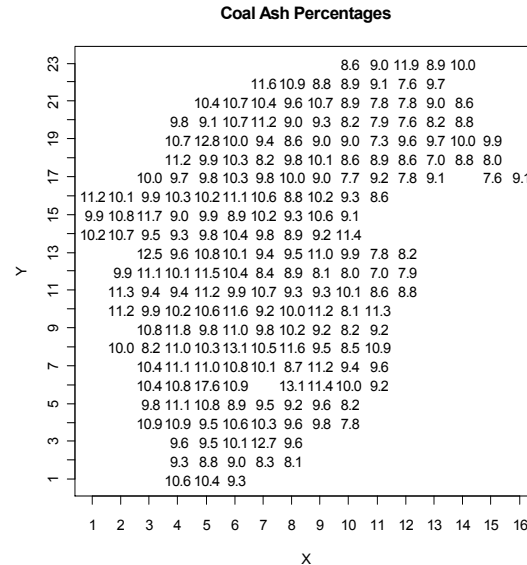


用进行空间分析

- 把空间数据装进R（注意格式）
- 看看数据啥样子（**EDA**）
- 拟合空间模型
- 模拟空间预测
- 多达**70**个**packages**的支持（不完全统计）

空间数据 spatial data

- 矢量 Vector:
- 点 point
- 线 line
- 多边形 polygon
- 栅格 Raster
- Lattice or GRID
- 属性数据

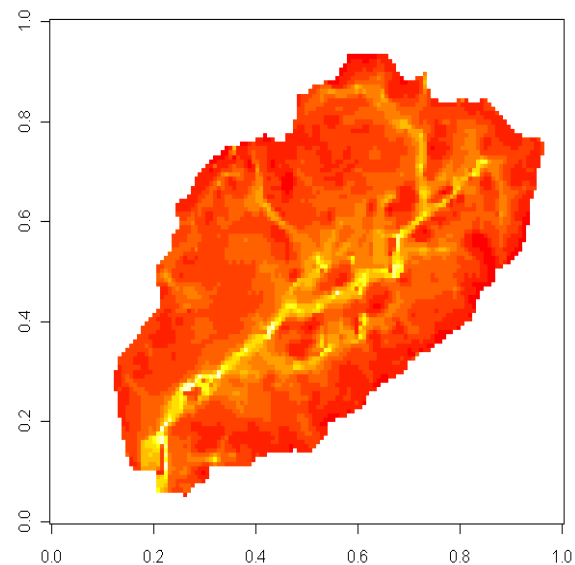


[illegible]

```
dem=read.table("dem.txt",skip=6)#读入DEM数据
```

```
dem=as.matrix(dem)
```

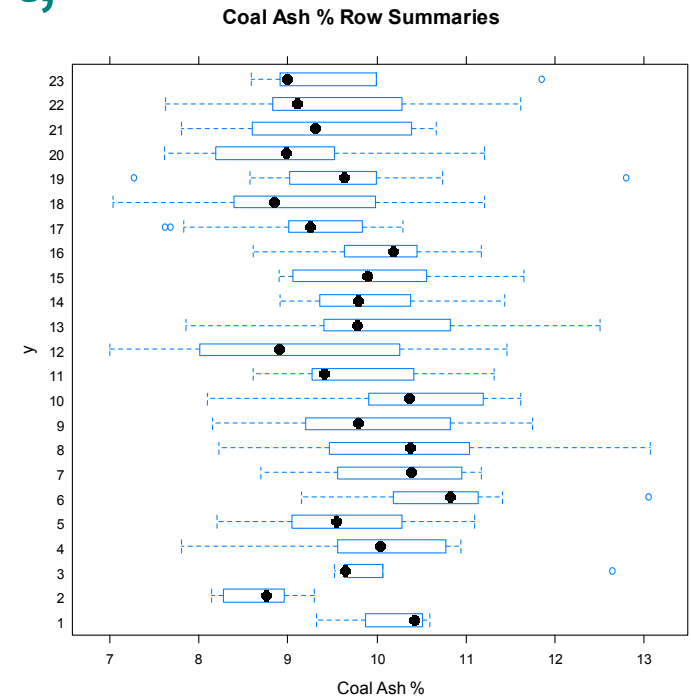
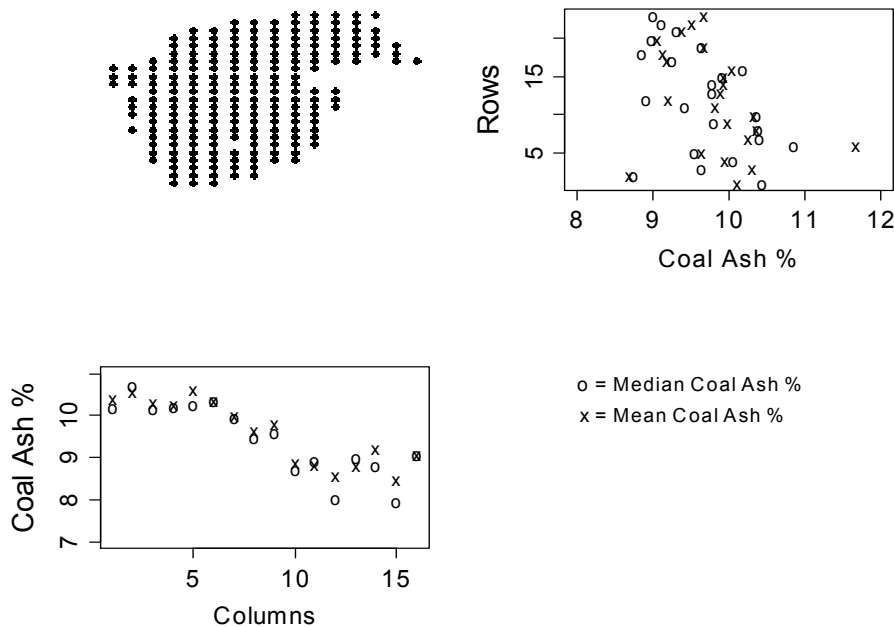
```
dem[dem==-9999]=NA #DEM数据预处理
```



空间数据的表达 Spatial EDA –attribute data

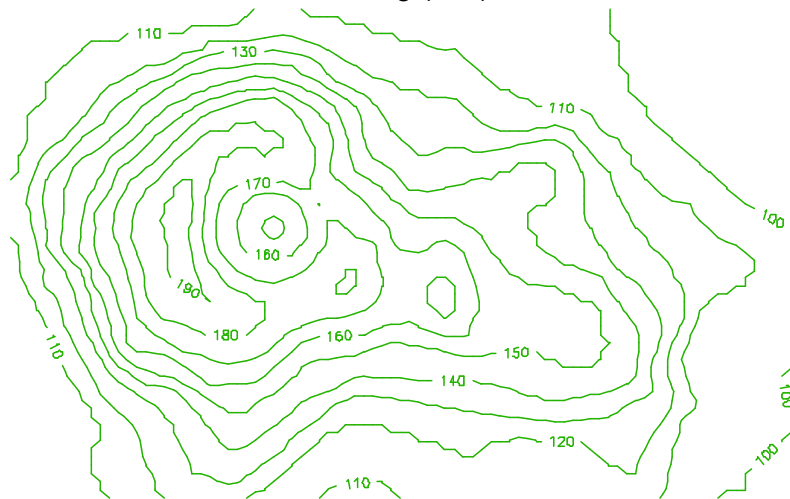
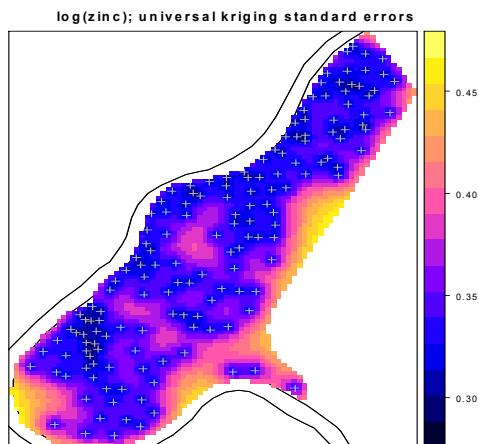
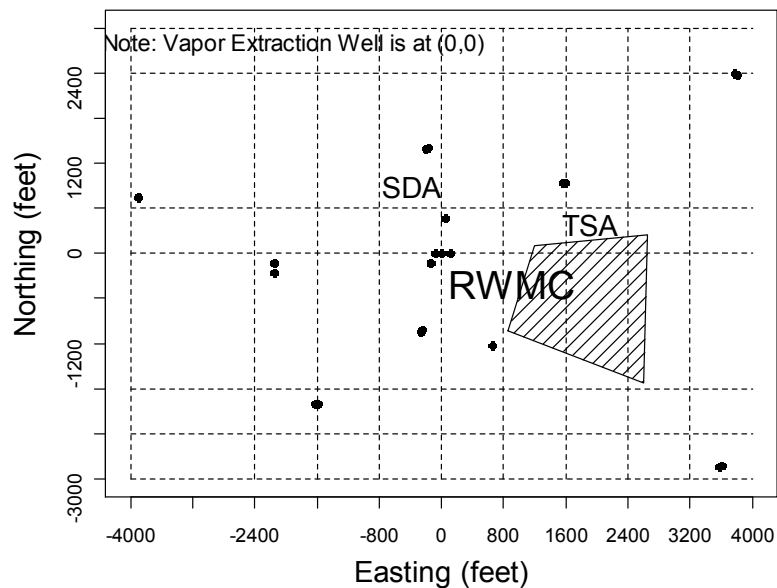
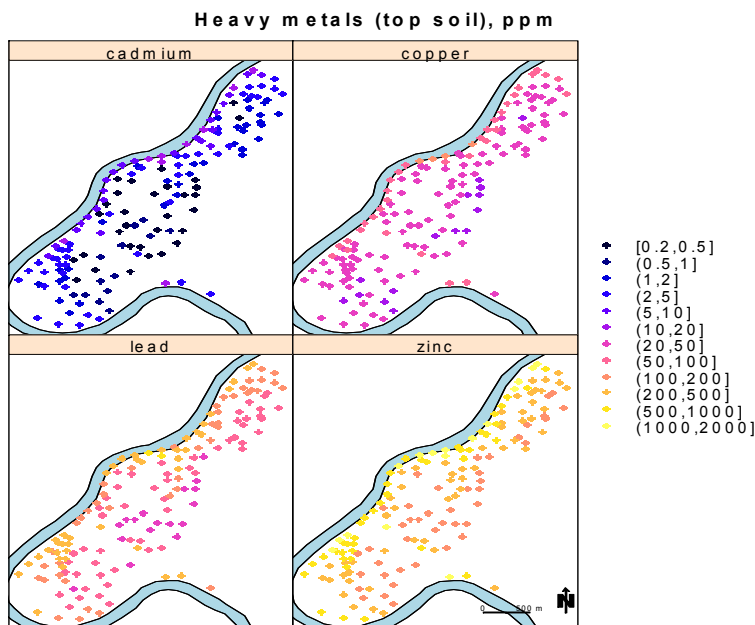
- Histogram, scatterplot, boxplot, stem-leaf plot, QQ plot, etc.

Means and Medians Across Rows and Columns



空间数据的表达 Spatial EDA –coordinates

Monitoring Well East-North Coordinates at the RWMC

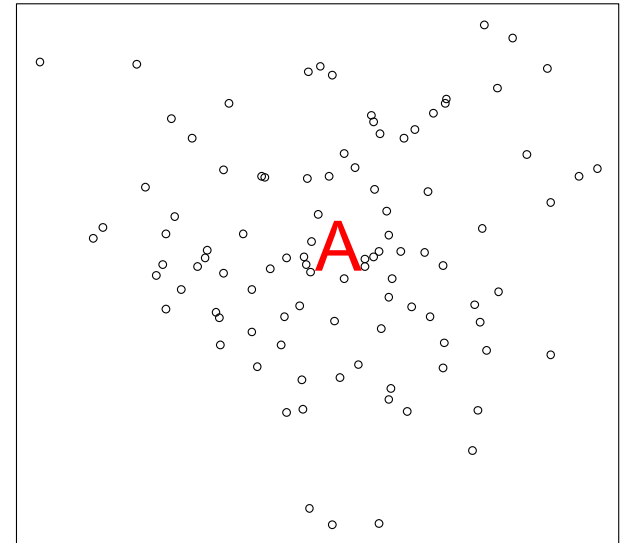
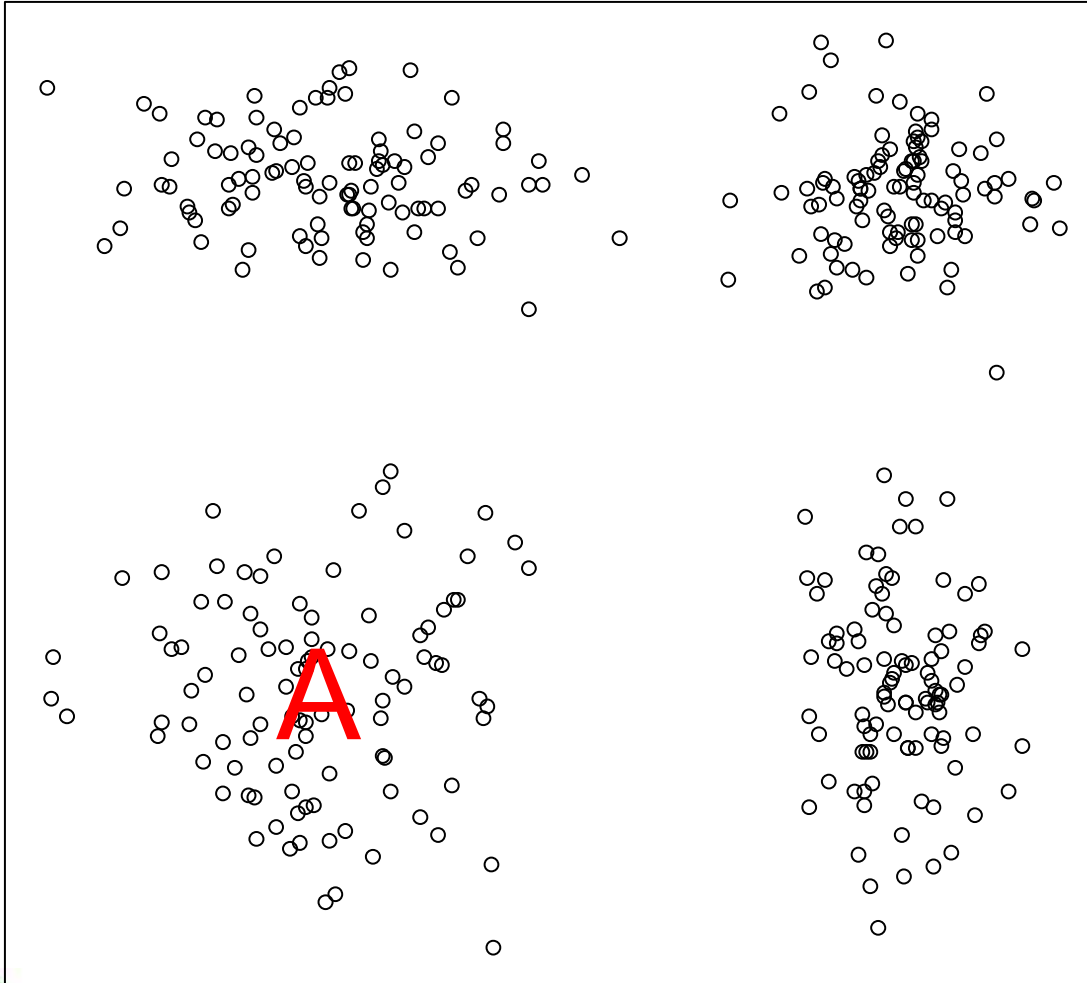


空间分析的方法 **methods for spatial analysis**

- 点格局分析 **point pattern analysis***
- 趋势面分析 **trend surface analysis***
- 空间自相关分析 **spatial autocorrelation***
- 地统计学与空间插值 **geostatistics and kriging***
- 自回归分析 **autoregression**
- 斑块识别与边界描绘 **patch identification and boundary lineation**
- **PCA,CA,PCoA,RDA,PCNM,AEM,etc.**
- 时空交互分析 **spatial temporal interaction**
- 分维、谱和小波分析 **fractal, spectral, wavelet analysis**
- 图论与网络分析 **graph and network analysis**
- 动物移动分析 **animal movement analysis**



空间点格局



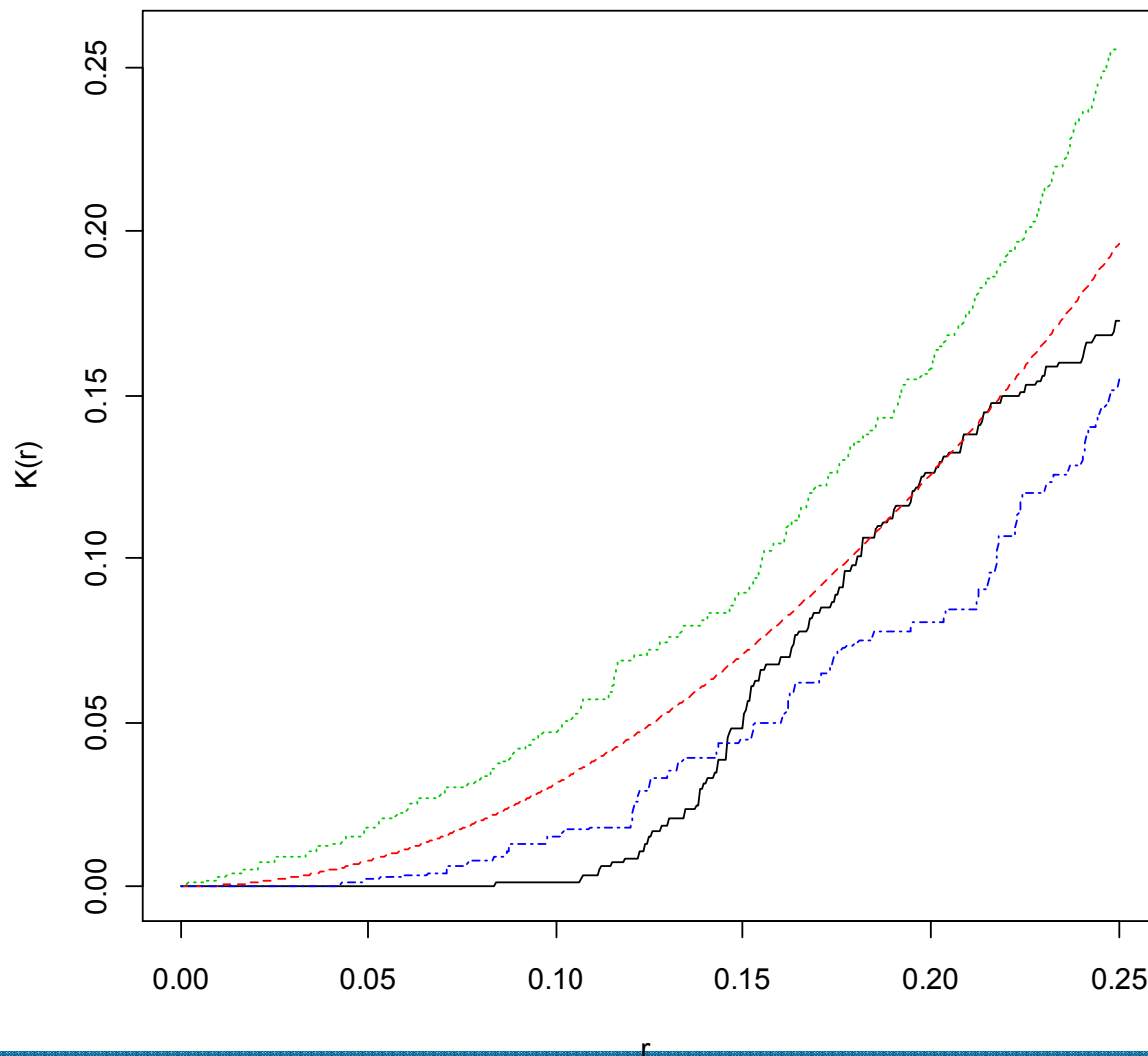
点格局分析 point pattern analysis

- 最近邻体分析 Nearest Neighborhood Analysis，计算distance
- CSR (Complete Spatial Randomness) 计算distance
- MCMC
- 计算函数 (G, F, L, K函数，并进行比较)
- 判断空间格局的特征 (随机，均匀or聚集)
- 估计空间密度函数



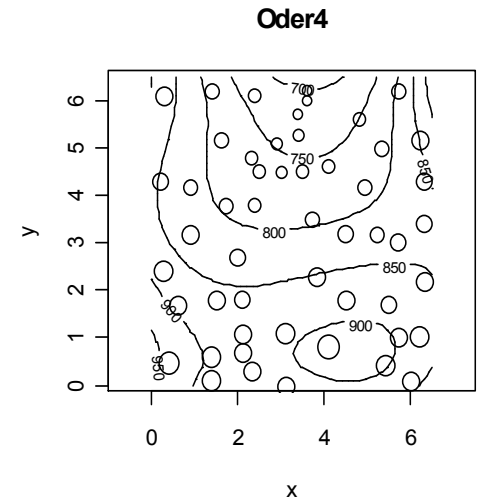
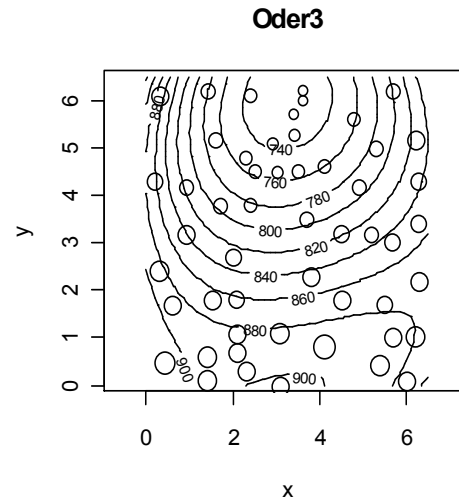
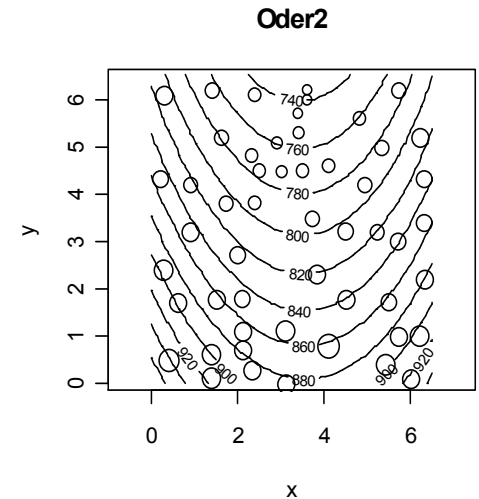
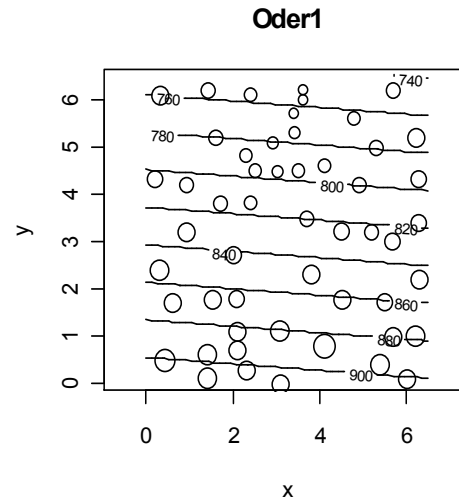
实例 case study

pointwise envelopes



趋势面分析 trend surface analysis

- 趋势面分析是以各个
- 位置的属性值为因变
- 量，以空间位置
- (x, y) 为自变量，
- 拟合一个多项式回
- 归模型。
- AIC判别标准
- Order不宜超过2



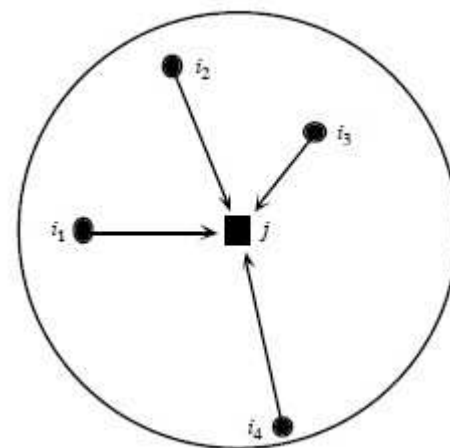
空间自相关 spatial autocorrelation

Moran's I

$$I(h) = \frac{n \sum \sum w_{ij} (z_i - \bar{z})(z_j - \bar{z})}{W \sum (z_i - \bar{z})^2}$$

Geary's c

$$c(h) = \frac{(n-1) \sum \sum w_{ij} (z_i - z_j)^2}{2W \sum (z_i - \bar{z})^2}$$



R中空间自相关的显著性检验: `moran.test()` ; `geary.test()`

地统计学 geostatistics

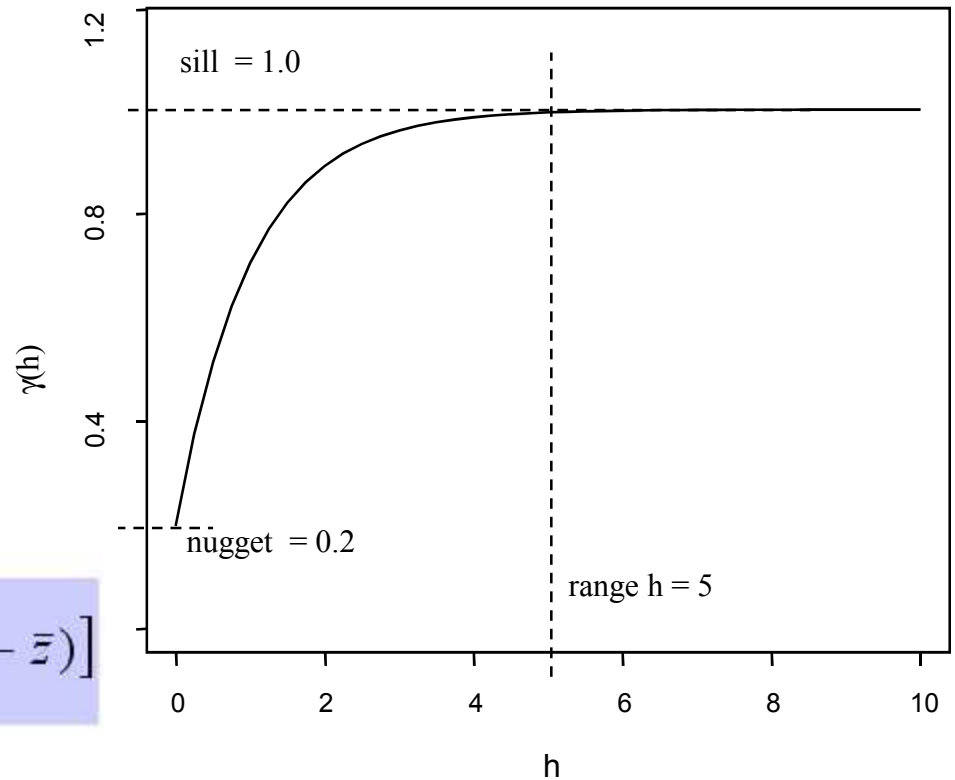
$$\gamma(\mathbf{h}) = \frac{1}{2} \text{var}(Z(\mathbf{s}) - Z(\mathbf{u}))$$

$$\hat{\gamma}(\mathbf{h}) = \frac{1}{2N(\mathbf{h})} \sum_{i=1}^{N(\mathbf{h})} [z(\mathbf{s}_i) - z(\mathbf{s}_i + \mathbf{h})]^2$$

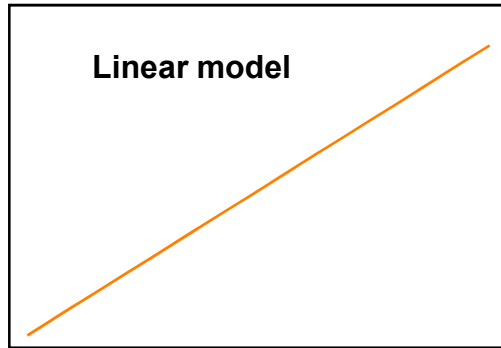
$$C(h) = \text{cov}[z(s_i), z(s_i + h)]$$

$$\hat{C}(h) = \frac{1}{N(h)} \sum_{i=1}^{N(h)} [(z(s_i) - \bar{z})(z(s_i + h) - \bar{z})]$$

$$\rho(h) = \frac{C(h)}{C(0)} = 1 - \frac{\gamma(h)}{C(0)}$$



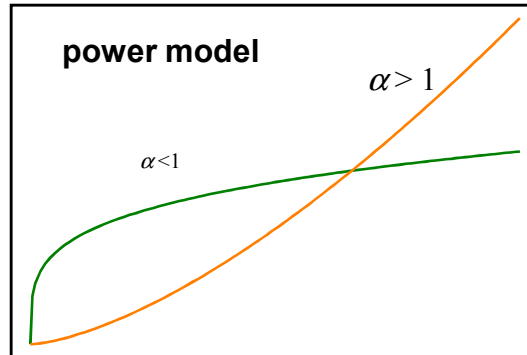
半方差模型 Variogram models



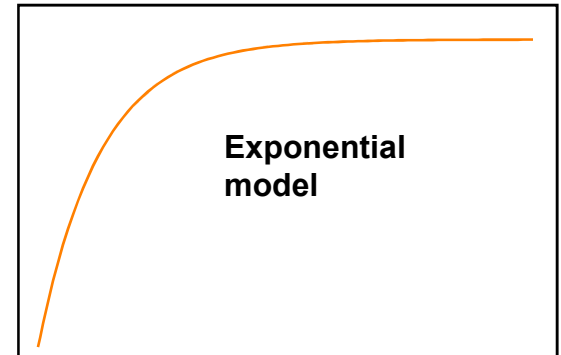
$\gamma(h)$

h

$$\gamma(h) = c_0 + bh$$



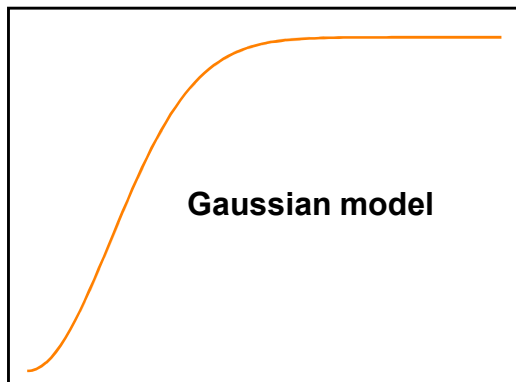
$$\gamma(h) = c_0 + bh^\alpha$$



$\gamma(h)$

h

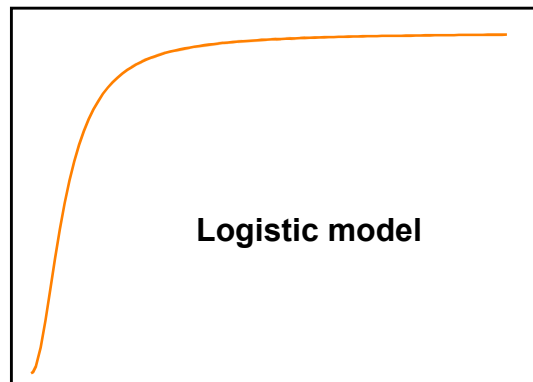
$$\gamma(h) = c_0 + c_1(1 - e^{-h/\alpha})$$



$\gamma(h)$

h

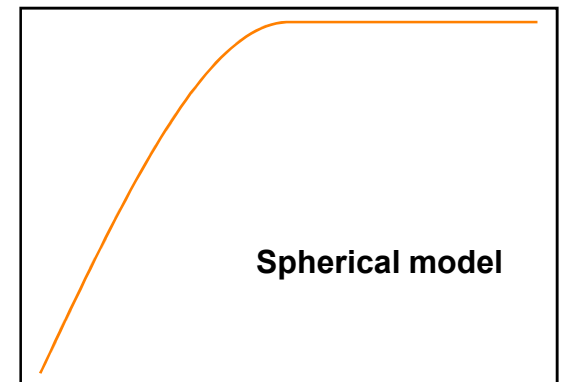
$$\gamma(h) = c_0 + c_1\left(1 - e^{-(h/\alpha)^2}\right)$$



$\gamma(h)$

h

$$\gamma(h) = c_0 + \frac{ah^2}{1 + bh^2}$$



$\gamma(h)$

h

$$\gamma(h) = c_0 + c_1\left(\frac{3}{2}\frac{h}{a} - \frac{1}{2}\left(\frac{h}{a}\right)^3\right) \text{ for } 0 < h \leq a$$

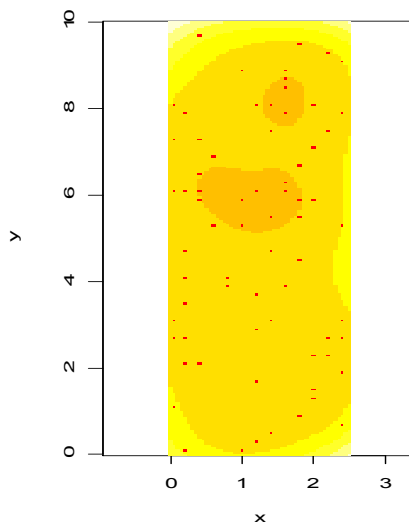
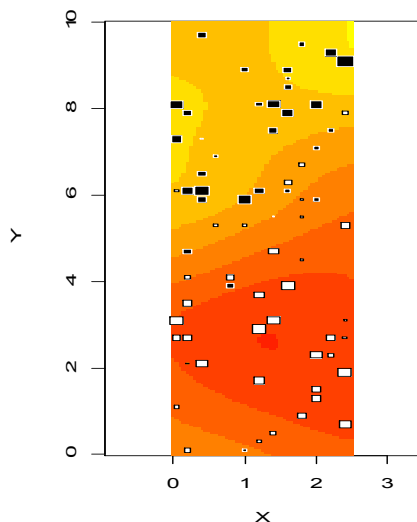
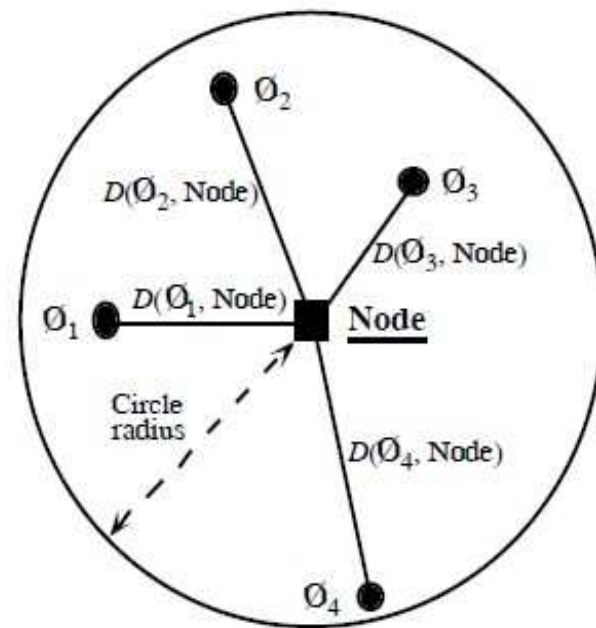
$$\gamma(h) = c_0 + c_1 \text{ for } h \geq a$$

Kriging

- 类比IDW来思考:

$$w_i = \left(\frac{1}{D(\phi_i, \text{Node})^k} \right) / \sum_i \frac{1}{D(\phi_i, \text{Node})^k} \text{ 权重}$$

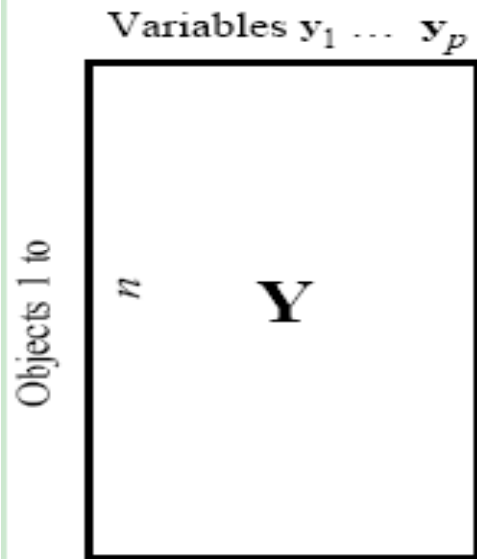
$$\hat{y}_{\text{Node}} = \sum_i w_i y_i \text{ 距离加权平均}$$



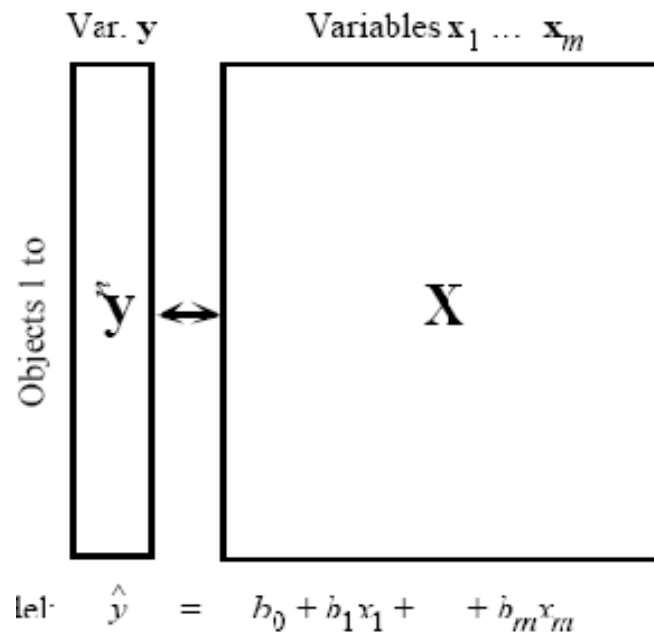
Kriging 步骤

- EDA exploration, removing trend, checking for stationarity and isotropy
- Computing the empirical variogram
- Fitting and selecting a theoretical variogram model to the empirical variogram
- Computing the weight w using the fitted theoretical variogram, i.e., kriging.
- Predicting the values at the locations of interest
- Validation
- Plotting kriging surfaces

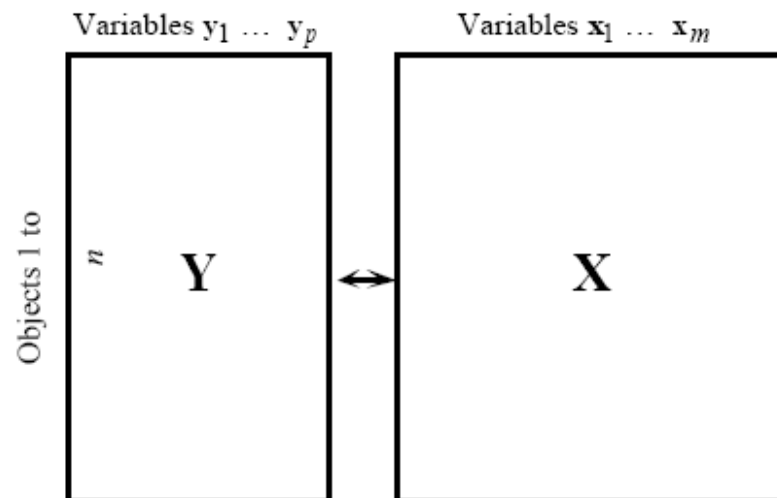
Multivariate methods



Ordination: PCA, CA, PCoA, NMDS



Regression



Canonical Analysis: RDA, CCA

CRAN Task View: Analysis of Spatial Data

Maintainer: Roger Bivand

Contact: Roger.Bivand at nhh.no

Version: 2009-10-28

Base R includes many functions that can be used for reading, visualising, and analysing spatial data. The focus in this view is on "geographical" spatial data, where observations can be identified with geographical locations, and where additional information about these locations may be retrieved if the location is recorded with care.

Base R functions are complemented by contributed packages, some of which are on CRAN, and others are still in development. One active location is [R-Forge](#), which lists "Spatial Data and Statistics" projects in its [project tree](#). Two promising packages on this site are [raster](#) for basic spatial raster (grid) data access and manipulation, and [Rgis](#), which tries to bridge the gap between spatial data handling and good statistical and modeling tools. Some CRAN packages associated with [sp](#) are hosted on Sourceforge in the [R-spatial](#) project, and as yet unreleased source versions may be checked out from CVS there.

The contributed packages address two broad areas: moving spatial data into and out of R, and analysing spatial data in R.

The [R-SIG-Geo](#) mailing-list is a good place to begin for obtaining help and discussing questions about both accessing data, and analysing it. More information about the functions is available from the [Rgeo](#) website. The packages in this view can be roughly structured into the following topics. If you think that some package is missing from the list, please let me know. Please also visit and contribute to the [spatial data handling](#) and [spatial statistics](#) pages on the R Wiki.

- **Classes for spatial data** : Because many of the packages importing and using spatial data have had to include objects of storing data and functions for visualising it, an initiative is in progress to construct shared classes and plotting functions for spatial data. The [sp](#) package has been published on CRAN, and wrapper packages are available from a repository for work in progress at the [R-spatial](#) Sourceforge home page. The [sp](#) package is discussed in a note in [R News](#). Some other packages have become dependent on these classes, including [rgdal](#) and [maptools](#). An alternative approach to some of these issues is implemented in the [PBSmapping](#) package; [PBSmodelling](#) provides modelling support. In addition, [GEOMap](#) provides mapping facilities directed to meet the needs of geologists, and uses the [geomapdata](#) package.

Project Feed

Show: Everything



CHINA STATISTICS

- [Monthly Statistics](#)
- [National Statistics](#)
- [Provincial Statistics](#)
- [City Statistics](#)
- [County Statistics](#)
- [Monthly Industrial Data \(2003-\)](#)
- [Monthly Industrial Data \(99-02\)](#)
- [Yearly Industrial Data \(2003-\)](#)
- [Yearly Industrial Data \(99-02\)](#)
- [Statistics on Map \(I\)](#)
- [Statistics on Map \(II\)](#)

STATISTICAL YEARBOOK

- [Provincial Yearbook\(2002-\)](#)
- [Provincial Yearbook\(-2001\)](#)
- [City Yearbook](#)
- [National Yearbook](#)

CENSUS DATA

- [Economic Census 2004](#)
- [Industrial Census 1995](#)
- [Census 1982](#)
- [Census 1982 \(10%\)](#)
- [Census 1990](#)
- [Census 1995 \(1%\)](#)
- [Province 2000](#)
- [County 2000](#)
- [Census 2005 \(1%\)](#)
- [Census Data Search](#)

CENSUS MAP & REPORT

- [Free Demo](#)
- [DemographicsNowChina](#)
- [DemographicsNowUS](#)



Latest China Statistical News

[more...](#)

- [Gross Foreign Trade Exports Value Attained 110.76 Billion USD in October Monthly...\(2009-11-11\)](#)
- [Main indicators on China's Economy in October\(1\) \(2009-11-10\)](#)
- [The Steady Upturn Trend of National Economy Further Strengthened\(2009-10-22\)](#)
- [Imports and Exports Value all above 100 Billion USD with Sharp Increase in Month...\(2009-10-14\)](#)
- [Industrial Profits Decreased From January to August \(2009-9-27\)](#)
- [Gross Foreign Trade Exports Value Attained 103.7 Billion USD in August, Monthly ... \(2009-9-10\)](#)
- [Main indicators on China's Economy in August\(2009-9-10\)](#)
- [Gross Foreign Trade Value Attained 200 Billion USD in July\(2009-8-11\)](#)
- [Main indicators on China's Economy in July\(2009-8-11\)](#)
- [Producer Price Index \(PPI\) for Manufactured Goods Kept Declining in June\(2009-7-17\)](#)
- [Total Retail Sales of Consumer Goods Shot up in the First Half Year\(2009-7-17\)](#)
- [Producer's Price of Major Agricultural Products Declined in the First Half Year\(2009-7-17\)](#)
- [Total Investment in Fixed Assets Kept Surging in the First Half of this Year\(2009-7-17\)](#)
- [Value-Added of Industry Kept Growth in the First Half of](#)

China Data Center News

[more....](#)

- [Learn more about the 5.12 earthquake of China \(2008-5-28\)](#)
To promote 5.12 Wenchuan earthquake studies, a web site has been established to give an assessment on the current and potential impacts of the recent earthquake in China. You can find details at [\[More...\]](#)
- [Learn more about Tibet\(2008-5-27\)](#)
To promote Tibet studies, China Data Center is pleased to offer the CD version of The Collection of Tibet GIS Maps with Census Data. You can find an online presentation at <http://chinadatacenter.org/p> [\[More...\]](#)
- [The update of China data online service with more statistica...\(2008-1-31\)](#)
The online China database has been expanded to include most statistical yearbooks from the National Bureau of Statistics, which will include provincial statistical yearbooks, city statistical yearbook [\[More...\]](#)
- [New Updates of the Population Census Data Online \(2008-1-31\)](#)
The China Data Online has been updated with some historical population Census and survey data, which include the population Census data in 1982 and 1990 data and the population 1% sample survey data i [\[More...\]](#)
- [New population survey and economic Census data available on...\(2008-1-31\)](#)
The online China Census database has now been expanded with more Census and survey data on population and economy of China. The new data include 2004 Economic Census Data Assembly, 2005 China 1% Popul [\[More...\]](#)
- [The Complete Collection of China Provincial Statistical Year...\(2007-9-15\)](#)
The Complete Collection of China Provincial Statistical Yearbooks (2002-) is now available for orders through China Data Center. China Provincial Statistical Yearbook covers comprehensive statistics o [\[More...\]](#)
- [CDC Announces Unprecedented Access to China 2000 Census Data...\(2007-5-8\)](#)
CDC is proud to announce unprecedented access to China 2000 Census Data provided through www.DemographicsChina.org in a partnership with SRC, LLC, a leading developer and provider of geographic busine [\[More...\]](#)
- [New Release of China Data Explorer Products \(2006-4-24\)](#)
The University of Michigan China Data Center is pleased to release the China Data Explorer products, which blends the

推荐读物 Suggested further reading

- Applied Spatial Data Analysis with R (Use R) by Roger S. Bivand, Edzer J. Pebesma, and Virgilio Gómez-Rubio
- Spatial Analysis: A Guide for Ecologists by Marie-Josée Fortin and Mark R. T. Dale
- Interactive Spatial Data Analysis by Trevor Bailey, Tony Gatrell
- 地统计学及在生态学中的应用 王政权著
- <http://r-spatial.sourceforge.net/>
- <http://geodacenter.asu.edu/r-spatial-projects>
- <http://www.udel.edu/johnmack/frec682/682syll.html>
- <http://rbbs.biosino.org/Rbbs/posts/list/182.page>



谢谢！

