

# Introduction to open source Spatial Analysis Tools and R

International Summer Academy on Spatial Ecotoxicology and Ecotoxicological Risk Assessment  
Using an Open Community Approach

Dr. Avit Kumar Bhowmik

*avit.bhowmik@su.se*

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**Stockholm Resilience Centre**  
Sustainability Science for Biosphere Stewardship



**Stockholm**  
University



...and Maximillian Bakenhus

# Why Open Source?



# Why Open Source?

## Closed Source vs. Open Source



©HarsimranSinghCS100W

# Why Open Source?

## Advantages

- No costs (!!!)

European Commission 2012: c.a. 450 billion euro savings p.a.

<https://joinup.ec.europa.eu/news/contribution-open-source-europes-economy-450-billion-year>

- Coherent standard with proprietary software

- Freedom to adjust and distribute program

- Transparency and Reproducibility

Rocchini and Neteler (2012) TREE, Barnes (2010) Nature

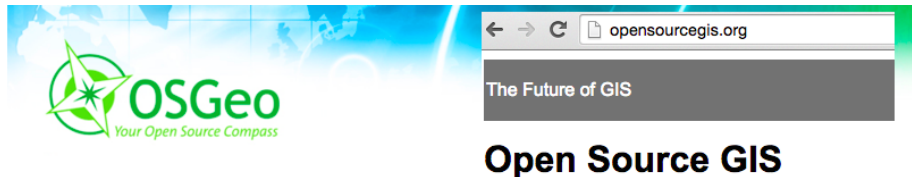
- Platform-independent

# Why Open Source?

## (Dis)advantages

- Comes without guarantee regarding bugs and features (but mailing lists and internet community)
- Sometimes smaller user communities (especially in companies and administration)
- In most cases less user-friendly/steeper learning curve

# Big communities of “Free Open Source Software (FOSS)”



*[Last update: 12/8/2013 - About 350 projects listed.]*





# Learn about “Free Open Source Software (FOSS)”



## OSGeo Foundation

- Home
- About the Foundation
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- Sponsors
- Sponsor OSGeo
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- Swag Store
- Contact

## OSGeo Community

- Welcome
- Member Area
- News
- Events
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- Mailing Lists
- Education
- Blogs
- Books
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- Service Providers
- Journal
- Sol Katz Award
- Local Chapters
- Spotlights
- Gallery

## Language

- English
- Ελληνισμός
- 繁體中文
- Deutsch
- Français
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- 한국어
- Nederlands
- Polski
- Portuguese (Brazilian)
- Pycon08
- Español
- Türkçe

Home

## OSGeo Educational Content Inventory

Search the listing by entering filter criteria.  
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Title	Software	Language
<input type="text"/>	<input type="text"/>	<input type="button" value="All"/> <input type="button" value="Abkhazian"/> <input type="button" value="Afar"/> <input type="button" value="Afrikaans"/> <input type="button" value="Akan"/> <input type="button" value="Albanian"/> <input type="button" value="Amharic"/> <input type="button" value="Arabic"/>

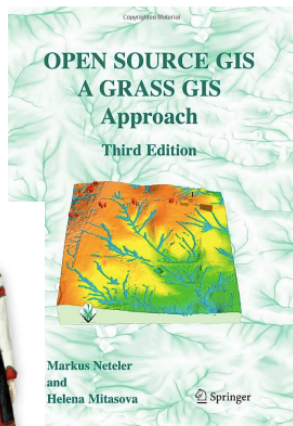
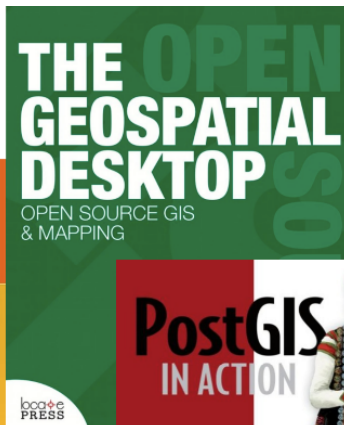
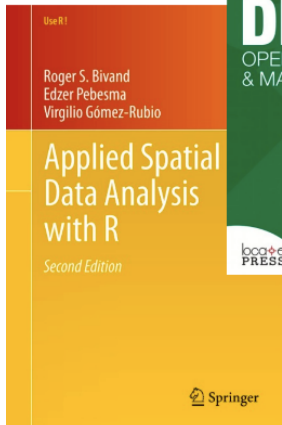


# GEOSTAT

Summer School for PhD students  
**geostat-course.org**

Title	Author(s)	Date added
Using the CORINE2000 land cover/ land use data base with GRASS-GIS under Ubuntu-linux 8.04	Nikos Alexandris	2012-10-10 17:36
Georeferenciación de Imagen con Qgis	Arnold Fernández Rivas	2012-09-24 17:37
Instalación de Sextante en Qgis	Arnold Fernández Rivas	2012-09-24 17:36
Elaboración de Polígonos de Thiessen Con Qgis	Arnold Fernández Rivas	2012-09-24 17:34
Taller de Routing	Breve Introducción Teórica Cálculo de rutas en entornos reales pgRouting Shooting Star OSRM ¿Qué es OpenLS? Cómo implementar OpenLS GoFleetLS Conclusiones	María Arias de Reyna 2012-09-18 09:09
Introducción a PostGIS	Qué es PostGIS El tipo Geometría Funciones Básicas Configuración	María Arias de Reyna 2012-09-18 09:06
Introducción a OpenLayers	Taller introductorio a OpenLayers: Qué es OpenLayers Visualización Mapa Básico Visualizar Capas Controles Creación de Nuevos Controles	María Arias de Reyna, Alejandro Díaz 2012-09-18 09:04
Introducción a GeoServer	Taller introductorio a GeoServer: Qué es Geoserver Instalación Gestionar Capas GeoWebCache Seguridad Configuración	María Arias de Reyna 2012-09-18 09:01

# Learn about “Free Open Source Software (FOSS)”



# Learn about “Free Open Source Software (FOSS)”

*International Journal of Geographical Information Science*  
Vol. 23, No. 10, October 2009, 1345–1370



Taylor & Francis  
Taylor & Francis Group

Welcome to Germany - Building Bridges

## Review Article

### An overview on current free and open source desktop GIS developments



STEFAN STEINIGER\*† and ERWAN BOCHER‡

†Department of Geography, University of Calgary, Calgary, AB, Canada

‡Ecole Central de Nantes, IRSTV, Nantes Cedex, France

(Received 23 April 2008; final version received 19 October 2008)

Over the past few years the world of free and open source geospatial software has experienced some major changes. For instance, the website FreeGIS.org currently lists 330 GIS-related projects. Besides the advent of new software projects and the growth of established projects, a Foundation has been established to of an overview on existing free and open understanding of the open source explanation of associated terms and in license types: the General Public License (GPL). After laying out the different desktop GIS software projects main tables summarise information currently available software versions. Free open source software, with an emphasis



#### Research Policy

Volume 32, Issue 7, July 2003, Pages 1243–1258

Open Source Software Development



#### Why Open Source software can succeed \*

Andrea Bonaccorsi<sup>1</sup>, Cristina Rossi<sup>1,2</sup>

Ecological Informatics 4 (2009) 183–195



Contents lists available at ScienceDirect

#### Ecological Informatics

journal homepage: [www.elsevier.com/locate/ecolinf](http://www.elsevier.com/locate/ecolinf)



**Keywords:** free software; open source;

### Free and open source geographic information tools for landscape ecology

Stefan Steiniger\*, Geoffrey J. Hay

Department of Geography, University of Calgary, Calgary, Alberta, Canada T2N1N4

# Open source (coherent) spatial analyses tools

GIS Sector	Examples proprietary Software	Examples Free Open Source Software
Desktop GIS	ArcGIS, GeoMedia, Map-Info, Idrisi	GRASS GIS, ILWIS, QGIS, SAGA GIS, <b>R</b>
Spatial Statistics	ArcGIS Extensions, Idrisi, ERDAS Imagine	OpenGeoDa, GeoMS, <b>R &amp; packages</b>
Spatial Databases	Oracle Spatial, ArcGIS SDE	PostGIS, SpatiaLite, <b>R &amp; packages</b>
Remote Sensing & Image Processing	ERDAS Imagine, ENVI, Ecognition, IDL	OTB, ILWIS, Opticks, GRASS GIS, <b>R</b>





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- Originally available in command line interface, popular editor: **RStudio**



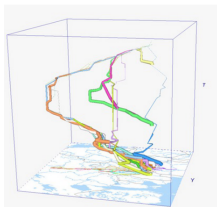
- R is a software (**much more!**) for statistical (**much much more!**) analyses
- Syntax : C++ family
- Object-oriented using classes
- Originally available in command line interface, popular editor: **RStudio**
- Also available in graphical user interface (GUI), e.g. “Duducer” and “R Commander”. **But forget about them!**

## Why R?

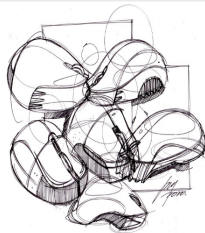
You cannot do it with anything else!

## Why R?

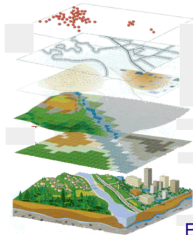
You cannot do it with anything else!



Analyses of Space-time data



Co-interfacing with other software



Efficient big raster data analysis



# R and moRe: Functions

gDistance (rgeos)	R Documentation
Distance between geometries	Function {package}
Description	General description
Calculates the distance between the given geometries	
Usage	Command and it's argument
<pre>gDistance(spgeom1, spgeom2=NULL, byid=FALSE, hausdorff=FALSE, densifyFrac = NULL) gWithinDistance(spgeom1, spgeom2=NULL, dist, byid=FALSE,   hausdorff=FALSE, densifyFrac=NULL)</pre>	Detailed description of arguments
Arguments	
<pre>spgeom1, spgeom2</pre> sp objects as defined in package sp. If spgeom2 is NULL then spgeom1 is compared to itself. <pre>byid</pre> Logical vector determining if the function should be applied across ids (TRUE) or the entire object (FALSE) for spgeom1 and spgeom2 <pre>hausdorff</pre> Logical determining if the discrete Hausdorff distance should be calculated <pre>densifyFrac</pre> Numerical value between 0 and 1 that determines the fraction by which to densify each segment of the line <pre>dist</pre> Numerical value that determines cutoff distance	Description of how function actually works
Details	
Discrete Hausdorff distance is essentially a measure of the similarity or dissimilarity of the two geometries, see references below for more detailed explanations / descriptions.	

# R and moRe: Functions

What function  
returns

Value

`gDistance` by default returns the cartesian minimum distance between the two geometries in the units of the current projection. If `hausdorff` is TRUE then the Hausdorff distance is returned for the two geometries.

`gWithinDistance` returns TRUE if returned distance is less than or equal to the specified `dist`.

Author(s)

Roger Bivand & Colin Rundel

References

Hausdorff Differences: [http://en.wikipedia.org/wiki/Hausdorff\\_distance](http://en.wikipedia.org/wiki/Hausdorff_distance) <http://lin-ear-th-inking.blogspot.com/2009/01/computing-geometric-similarity.html>

See Also

Related functions

[`gWithinDistance`](#)

Examples

Examples, can be  
run from R by  
`gDistance()`

```
pt1 = readWKT("POINT(0.5 0.5)")
pt2 = readWKT("POINT(2 2)")
```

```
p1 = readWKT("POLYGON((0 0,1 0,1 1,0 1,0 0))")
p2 = readWKT("POLYGON((2 0,3 1,4 0,2 0))")
```

```
gDistance(pt1,pt2)
gDistance(p1,pt1)
```

# R and moRe: Objects

## Vector

- An array (collection) of numbers, strings or factors
- e.g. 1 2 3 4 5 or "a" "b" "c" "d" "e"

# R and moRe: Objects

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- An array (collection) of numbers, strings or factors
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## Factor

- An array (collection) of level (grouping variables), can be numbers or strings
- e.g. a b c d e



# R and moRe: Objects

## Matrix

- A table where rows and columns contain vectors
- Vector types of columns and rows should be the same, e.g. either numeric or string, these can not be combined

	col 1	col 2
row 1	"a"	"c"
row 2	"b"	"d"

# R and moRe: Objects

## Matrix

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	col 1	col 2
row 1	"a"	"c"
row 2	"b"	"d"

## Data Frame

- A table where columns contain vectors
- Vector types of columns can be different, e.g. numeric and string, and can be combined

	vector 1	vector 2
row 1	"a"	1
row 2	"b"	2

# R and moRe: Objects

## List

- A collection of elements, vectors or other objects

```
List[["Vector"]] "a" "b" "c" "d" "e"
```

```
List[["Matrix"]]
```

	col 1	col 2
row 1	"a"	"c"
row 2	"b"	"d"

```
List[["Data Frame"]]
```

	vector 1	vector 2
row 1	"a"	1
row 2	"b"	2

## Spatial Packages

```
library(spacetime)
library(sp)
library(rgdal)
library(maptools)
library(mapdata)
library(raster)
library(rgeos)
library(spgrass)
library(tseries)
```

## Integration with other spatial tools

- GRASS GIS ('spgrass6' package)
- SAGA GIS ('RSAGA' package)
- QGIS ('manageR' package)
- PostGIS (different solutions)
- ArcGIS ('RpyGeo' package) and many more...

## Spatial objects: class()

```
SpatialPointsDataFrame  
SpatialLinesDataFrame  
SpatialPolygonsDataFrame  
SpatialGridDataFrame  
stfddf  
sp  
raster  
Extent  
Date  
xts, ts
```

# Let's do it together!



## Brain warming!

A piece of white lined paper with blue horizontal lines is centered on a light orange background. The paper has a torn right edge and a piece of grey tape at the top center. The word "Homework" is written in a dark purple, cursive-like font across the middle of the paper.

Homework



## Swirl

<http://swirlstats.com/students.html>

## Online Course

<http://tryr.codeschool.com/levels/1/challenges/1>

<https://www.r-project.org/>



Project ▾

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## Software Map

[Tag cloud](#) | [Project Tree](#) | [Project List](#)

## Project tree

 [Topic](#) > **Spatial Data & Statistics**

E

- [Classes for Spatial Data](#) (9 projects)
- [Disease Mapping and Areal Data Analysis](#) (3 projects)
- [Ecological Analysis](#) (43 projects)
- [Geostatistics](#) (9 projects)
- [Point Pattern Analysis](#) (7 projects)
- [Reading and Writing Spatial Data](#) (13 projects)

## CRAN Task View: Analysis of Spatial Data

**Maintainer:** Roger Bivand

**Contact:** Roger.Bivand at nhh.no

**Version:** 2015-08-09

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](#). Information on R-spatial packages, especially [sp](#) will be posted on the R-Forge rsatial project [website](#), including a visualisation gallery.

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. The mailing list is a good place to search for information about relevant courses.

There are a number of contributed tutorials and introductions; a recent one is [Introduction to visualising spatial data in R](#) by Robin Lovelace and James Cheshire.

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.

- **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 is discussed in a note in [R News](#). Many other packages have become dependent on these classes, including [rddal](#) and [maptools](#). The [rgeos](#) package provides an interface to topology functions for [sp](#) objects using [GEOS](#). The [raster](#) package is a major extension of spatial data classes to virtualise access to large rasters, permitting large objects to be analysed, and extending the analytical tools available for both raster and vector data. Used with [rasterVis](#), it can also provide enhanced visualisation and interaction. The [spatial.tools](#) package contains spatial functions meant to enhance the core functionality of the [raster](#) package, including a parallel processing engine for use with rasters. The [micromap](#) package provides linked micromaps using [ggplot2](#). The [spacetime](#) package extends the shared classes defined in [sp](#) for spatio-temporal data (see [Spatio-Temporal Data in R](#)). The [Grid2Polygons](#) converts a spatial object from class SpatialGridDataFrame to SpatialPolygonsDataFrame.

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.

<https://cran.r-project.org/web/views/Spatial.html>

## Cookbook for R

Welcome to the Cookbook for R. The goal of the cookbook is to provide solutions to common tasks and problems in analyzing data.

Most of the code in these pages can be copied and pasted into the R command window if you want to see them in action.

1. [Basics](#)
2. [Numbers](#)
3. [Strings](#)
4. [Formulas](#)
5. [Data input and output](#)
6. [Manipulating data](#)
7. [Statistical analysis](#)
8. [Graphs](#)
9. [Scripts and functions](#)
10. [Tools for experiments](#)



My book about data visualization in R is available! The book covers many of the same topics as the Graphs and Data Manipulation sections of this website, but it goes into more depth and covers a broader range of techniques. You can preview it at [Google Books](#).

Purchase it from [Amazon](#), or direct from [O'Reilly](#).

This site is created by Winston Chang. It is not related to Paul Teetor's excellent [R Cookbook](#) ([Amazonlink](#)).

<http://www.cookbook-r.com/>

The slides, scripts, materials and data are available from:  
<https://github.com/AvitBhowmik/SA16>

# See you on Tomorrow!