

# Spatial Interpolation with R

GIS Application, Winter Semester 2016

Dr. Avit Kumar Bhowmik

Stockholm Resilience Centre, Stockholm University

*avit.bhowmik@su.se*

March 28, 2016

What do we know?

# What is GIS?



# GIS

# GIS

## ? Information ?

# GIS

## ? Information ?

- **Geographic**

Parent and Church, 1987. Conf. GIS

- **Spatial (Geospatial)**

Anselin, 1989. What is special about spatial data?

- **Spatiotemporal**

Burrough and Frank, 1995. Int J GIS

# GIS

## ? Information ?

- **Geographic**

Parent and Church, 1987. Conf. GIS

- **Spatial (Geospatial)**

Anselin, 1989. What is special about spatial data?

- **Spatiotemporal**

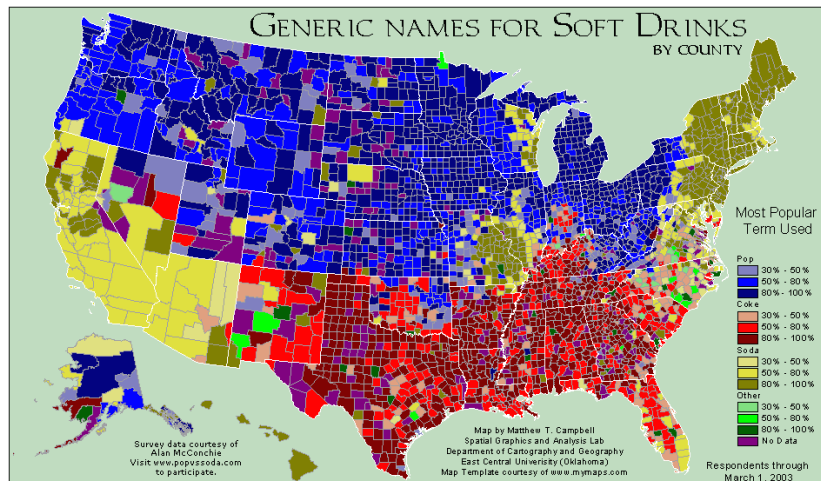
Burrough and Frank, 1995. Int J GIS

- **System**

- **Science**

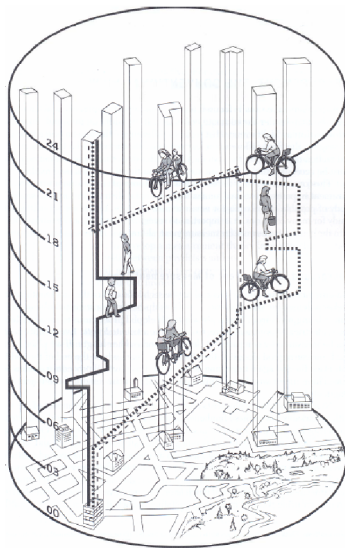
Goodchild, 1992. Int J GIS

# 80% of data are Spatiotemporal



Bossler, 2002. Manual of Geospatial Science and Technology

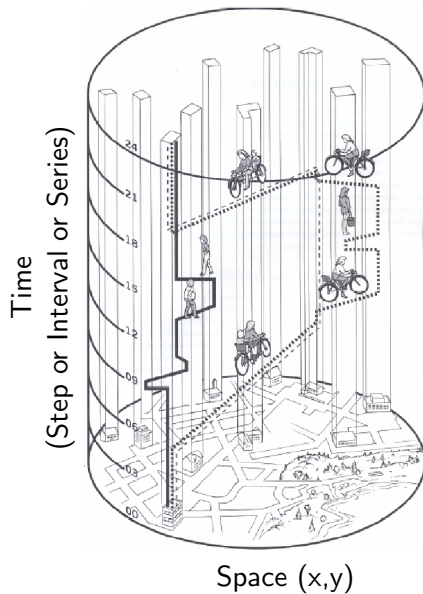
# Representation of Spatiotemporal Data



Chrisman, 1997. Exploring GIS

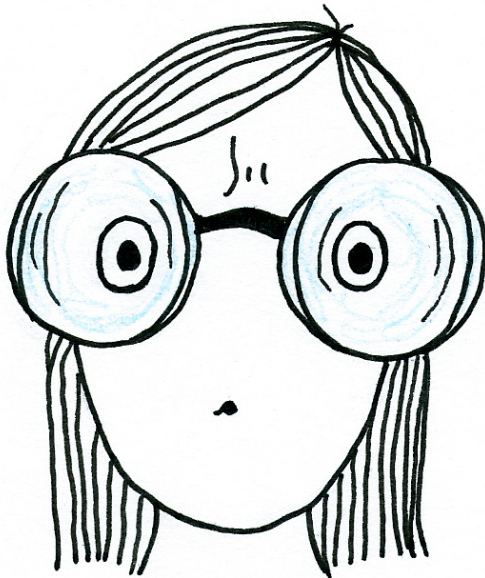


# Representation of Spatiotemporal Data



Chrisman, 1997. Exploring GIS

# Wear the GI Glasses



What do we know?

# What is Spatial Statistics?



## Experts Thoughts

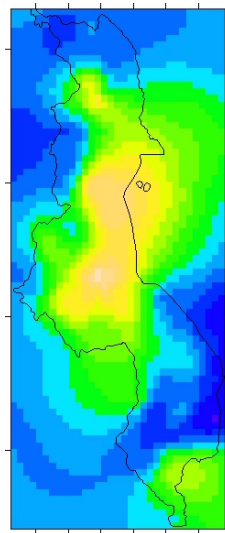
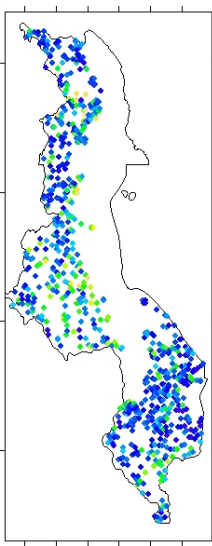
- Spatial statistics offers a way of describing the spatial continuity that is an essential feature of many natural phenomena and provides adaptations of classical regression techniques to take the advantage of this continuity

Isaaks and Srivastava, 1989. *An Introduction to Applied Geostatistics*

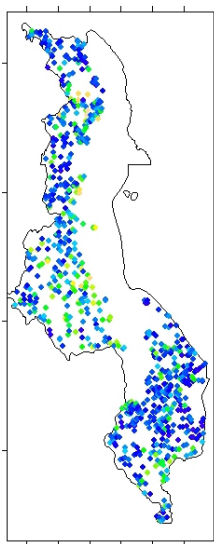
- Spatial statistics provides a set of statistical tools for incorporating the spatial coordinates of observations in data processing

Goovaerts, 2007. *Geostatistics for Natural Resources Evaluation*

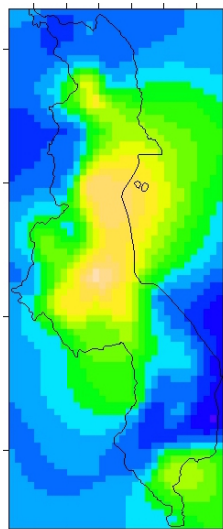
# Spatial Interpolation



# Spatial Interpolation



**Z**



$z$  is a random process with unique mean and variance  
 $z(\text{sampled locations}) \approx z(\text{unsampled location})$

# Spatial Interpolation

## Input

- Set of Points sampled, sparsely distributed in space and time
- Each point represents a measurement of a variable (spatiotemporal attribute) that occurs in that space and time location

# Spatial Interpolation

## Input

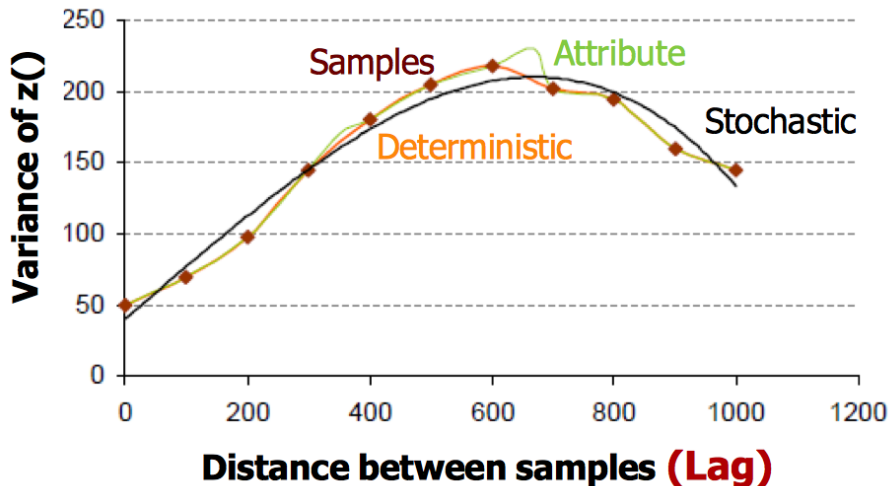
- Set of Points sampled, sparsely distributed in space and time
- Each point represents a measurement of a variable (spatiotemporal attribute) that occurs in that space and time location

## Output

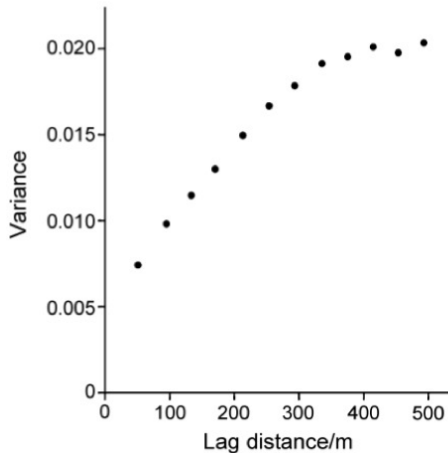
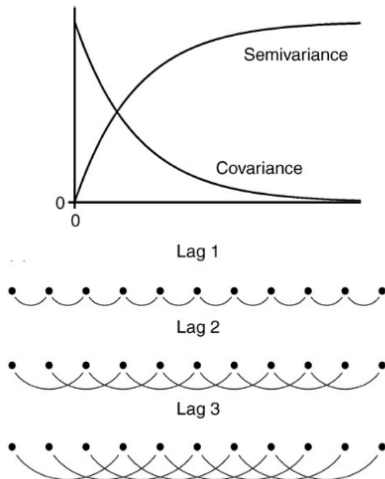
- **Spatial Data Model**
- Computer/mathematical representation that allows one to perform estimations and/or simulations for attribute values at spatial/temporal locations not sampled



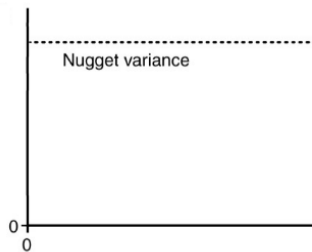
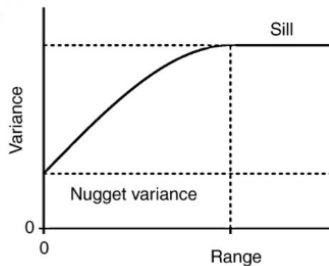
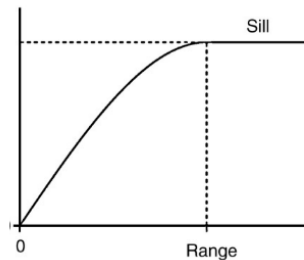
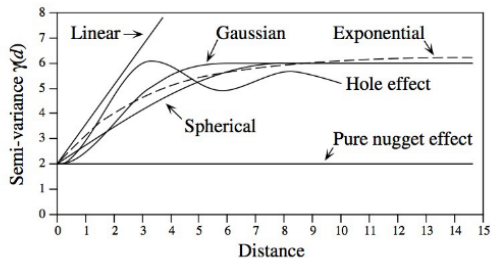
# Spatial Variability



# Spatial Variability



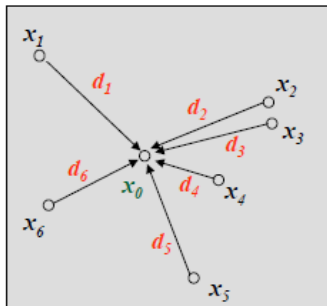
# Spatial Variogram



# Deterministic Interpolation

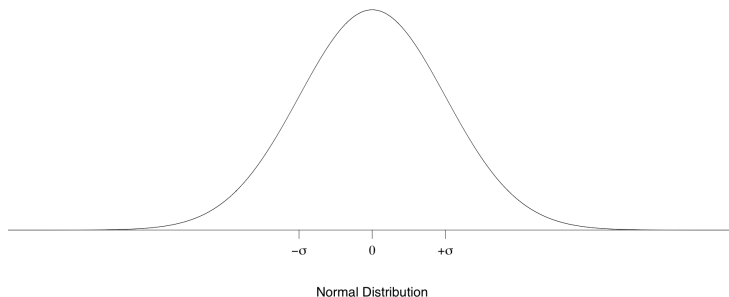
- An unique value is associated to its spatial location
- No uncertainty is associated to its estimation
- e.g. Inverse Distance Weighting (IDW)

$$Z^*(x_0) = \frac{\sum_{i=1}^n \frac{1}{d_i^2} z(x_i)}{\sum_{i=1}^n \frac{1}{d_i^2}}$$

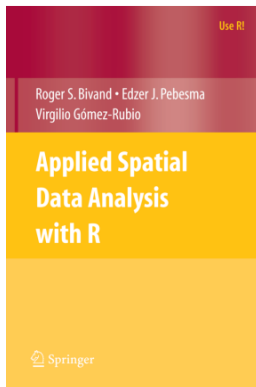


# Stochastic or Geostatistical Interpolation

- A probability distribution function is associated to its probable values
- Uncertainties can be associated to its estimation
- e.g. Kriging
- Minimization of estimation variance (error)



# Learn more about Spatial(-temporal) Statistics



## Modern Spatiotemporal Geostatistics



George Christakos

Spatio-temporal geostatistics using **gstat**



Ifgi  
Institute for Geoinformatics  
University of Münster

Edzer Pebesma

February 15, 2013

## 1 Introduction

Since **gstat** package version 1.0-0, a dependency of **gstat** on the R package **spacetime** was introduced, allowing the code in **gstat** to exploit spatio-temporal data structures from that package. This vignette describes the possibilities and limitations of the package for spatio-temporal geostatistics.

To understand some of the possibilities and limitations, some knowledge of the history of the software is needed. The original **gstat** software (Pebesma and Wesseling, 1998) was a standalone computer *program* written in around 25,000 lines of C code, and would do geostatistical modelling, prediction and simulation. The **gstat** R package (Pebesma, 2004) consisted mostly of an R interface to this C code, together with convenience functions to use R's modelling interface (formula's, see `?lm`) and graphic capabilities (trellis graphics in package **lattice** to show cross variogram as matrix plots; interaction with variogram clouds using base plots).

Starting 2003, a group of programmers developed a set of classes and methods for dealing with spatial data in R (points, lines, polygons, grids), which was supported by the publications of the well-known ASDAR book (Bivand et al.

# Learn more about Spatial(-temporal) Statistics

ELSEVIER

Type here to search on Elsevier.com



Advance

Journals & books

Online tools

Authors, editors & reviewers



Sample Issue

## Spatial Statistics

*Spatial Statistics* publishes articles on the theory and application of spatial and spatio-temporal statistics. It favours manuscripts that present the results of new applications, or in which new...

[View full aims and scope](#)

Editor in Chief: A. Stein

[View full editorial board](#)



Taylor & Francis

Publication History

Sample copy

Alert me

International Journal of Geographical Information Science



AAG members may now opt to access IJGIS free of charge!

ISSN

1365-8816 (Print), 1362-3087 (Online)

[Purchase issue](#)

Publication Frequency  
12 issues per year



Add to shortlist

Recommend to: A friend A librarian

☐ To select/unselect all items click here

[Choose an action](#)

Articles

☐ Visualizing and quantifying the movement of vegetative drought using remote-sensing data and GIS

Coco M. Rulinda, Alfred Stein & Ulan D. Tundukulov  
pages 1481-1496

DOI: 10.1080/13658816.2012.723712

Published online: 06 Nov 2012

Citations: 0

Article Views: 1051

Further Information

[Access options](#)

Published by the American Statistical Association

Editors in Chief: Jay D. Lomax, Barbara Glabe & Arthur Delmonico ISSN 1544-1940, CODEN JSST

*Journal of Statistical Software*

[Home](#) [Instructions for Authors](#) [JSS Style Guide](#) [Editorial Board](#)

[Current Volume](#) [Browse](#) [Search](#)

Established in 1996, the Journal of Statistical Software publishes articles, book reviews, code snippets, and software reviews on the subject of statistical software and algorithms. The contents are freely available online. For both articles and code snippets the source code is published along with the paper.

Statistical software is the key link between statistical methods and their application in practice. Software that makes this link is the province of the journal, and may be realized as, for instance, tools for large scale computing, database technology, desktop computing, distributed systems, the World Wide Web, reproducible research, archiving and documentation, and embedded systems.

We attempt to present research that demonstrates the joint evolution of computational and statistical methods and techniques. Implementations can use languages such as C, C++, S, Fortran, Java, PHP, Python and Ruby or environments such as Mathematica, MATLAB, R, S-PLUS, SAS, Stata, and XLISP-STAT.



## Recent Publications

Article	Code Snippets	Book Reviews	Software Reviews	Special Issues
GLIMMIX: Online Power Computation for Linear Models with and without a Random Covariate Vol. 54, Issue 10, Sep 2013 Submitted 2011-05-19, Accepted 2013-03-05			Sarah M. Kreidler, Keith E. Muller, Gary Grams, Brandon M. Ringham, Zachary T. Colan-Duvalov, Ulmar P. Sakasidis, Anna E. Barin, Deborah H. Glueck	

The slides, scripts, materials and data are available from:  
[https://github.com/AvitBhowmik/summer\\_academy\\_15](https://github.com/AvitBhowmik/summer_academy_15)

Learning by doing!





Thank You!

