

# Spatial Interpolation with R

GIS Application, Winter Semester 2017

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



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

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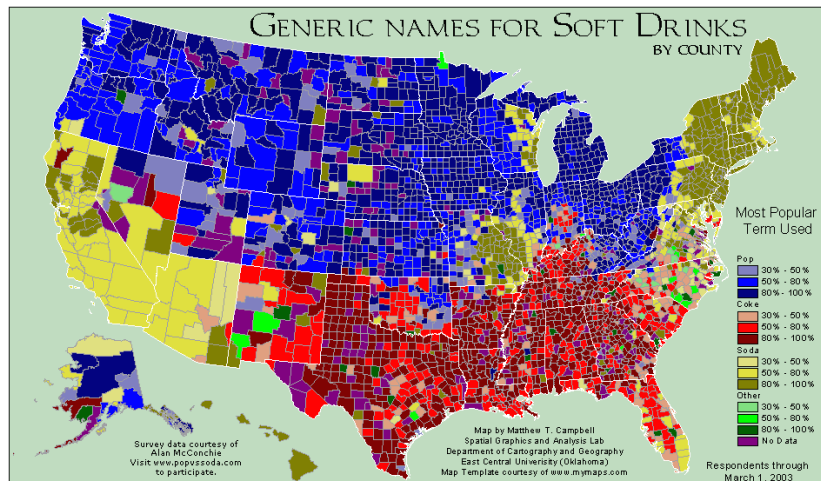
Burrough and Frank, 1995. Int J GIS

- **System**

- **Science**

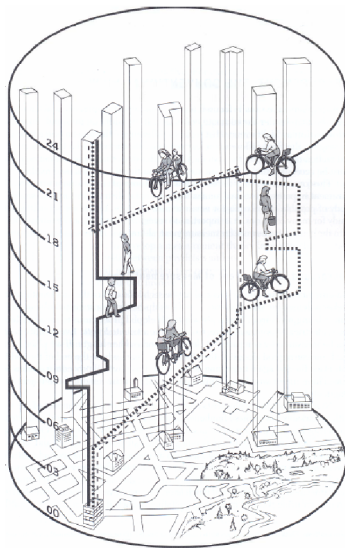
Goodchild, 1992. Int J GIS

# 80% of data are Spatiotemporal



Bossler, 2002. Manual of Geospatial Science and Technology

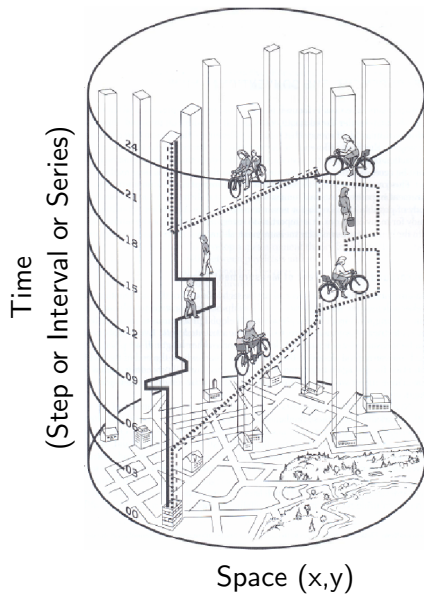
# Representation of Spatiotemporal Data



Chrisman, 1997. Exploring GIS

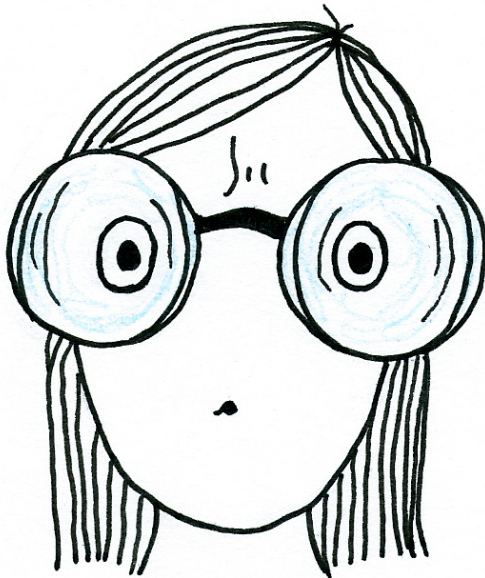


# Representation of Spatiotemporal Data



Chrisman, 1997. Exploring GIS

# Wear the GI Glasses



What do we know?

# What is Spatial Statistics?



# Spatial(-temporal) 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(-temporal) Autocorrelation

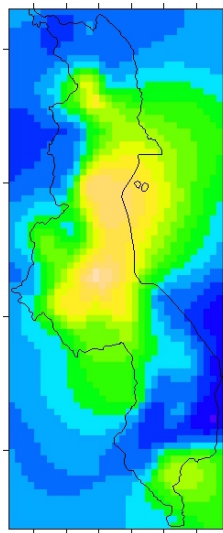
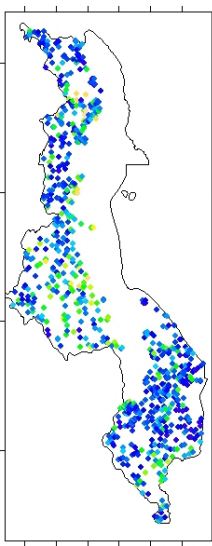
## First law of geography

“Everything is related to everything else, but near things are more related to each other”

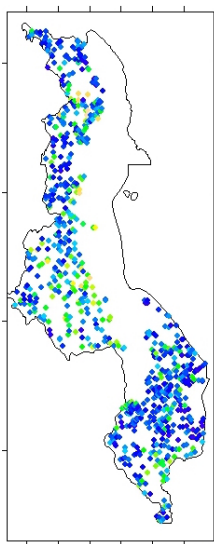


Photo: Professor Dr. Waldo Tobler, 2007

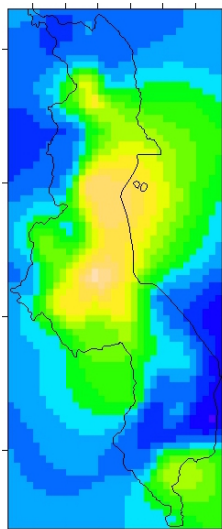
# Spatial(-temporal) Interpolation



# Spatial(-temporal) Interpolation



**Z**



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

# Spatial(-temporal) 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(-temporal) Interpolation

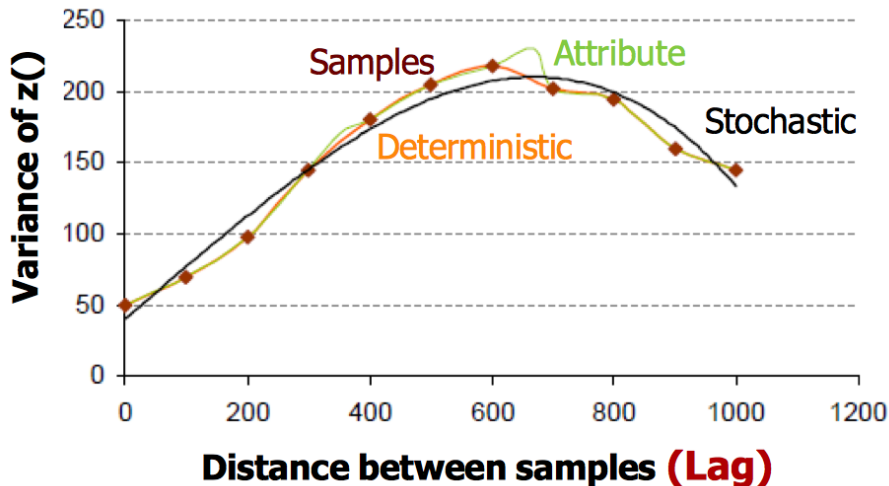
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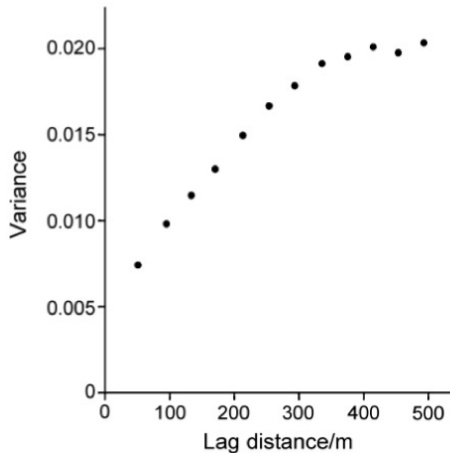
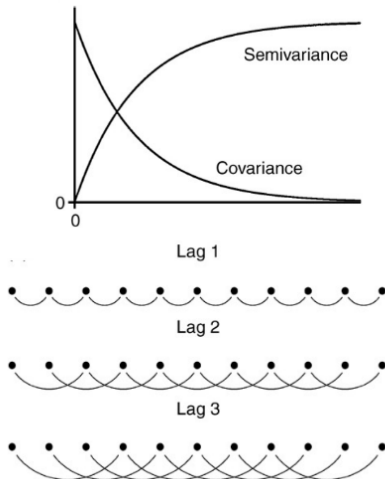
## Output

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

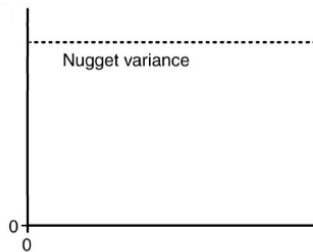
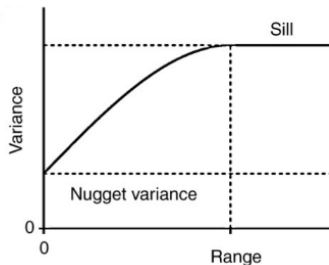
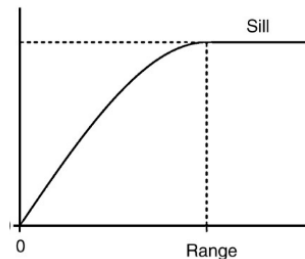
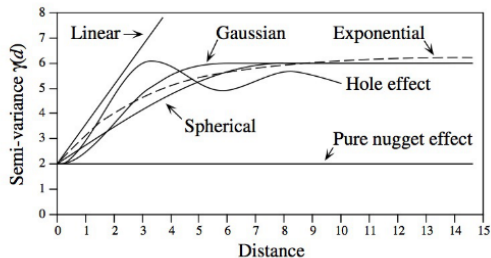
# Spatial(-temporal) Variability



# Spatial(-temporal) Variability

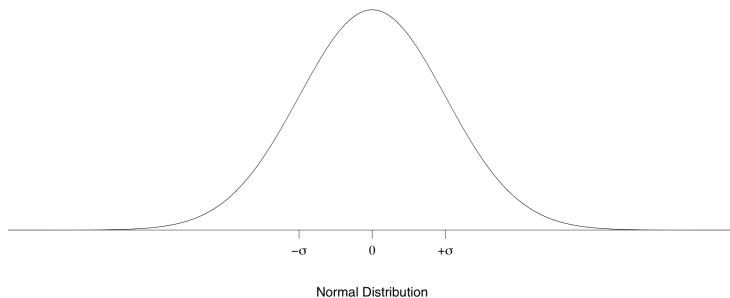


# Spatial(-temporal) Variogram



# Stochastic or Geostatistical Interpolation

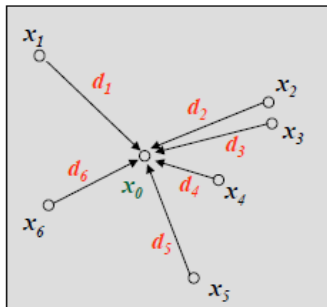
- A probability distribution function is associated to its probable values
- Uncertainties can be associated to its estimation
- e.g. Kriging
- Minimization of estimation variance (error)



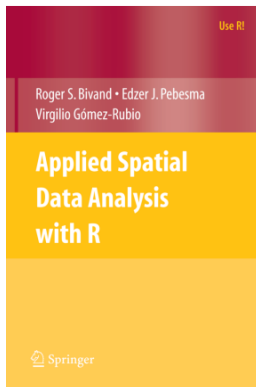
# Deterministic Interpolation

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

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



# 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

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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, 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
<a href="#">GLIM4SPM: Online Program Computation for Linear Models with and without a Random Component</a> Vol. 54, Issue 10, Sep 2013 Submitted 2011-05-19, Accepted 2013-03-05			<a href="#">Sarah M. Kreidler, Keith E. Muller, Gary Grimes, Brandon M. Ringham, Zachary T. Colan-Duvalov, Ulmar P. Sakasidis, Anna E. Barin, Deborah H. Gluck</a>	



The slides, scripts, materials and data are available from:

<https://github.com/AvitBhowmik/gisapp17>

Learning by doing!



Thank You!

