

Spatial Interpolation & Ecotoxicological Risk Assessment with R

GIS Application, Winter Semester 2018

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March 15, 2018



A little bit about my research

Geoinformatics I Spatial Ecotoxicology and Environmental Health Chemical Pollution Boundary Spatial Risk Assessment



CHEMICAL POLLUTION

A dangerous chemical romance

How ongoing use of banned chemicals and extensive deforestation now haunts northern Pakistan, leaving population prone to serious health issues

Story highlights

- Due to lack of regulations many internationally banned chemicals are still used in developing countries.
- Research has discovered alarming levels of exposure to banned persistent organic pollutants (POPs) including DDT and PCBs in northern Pakistan, posing a carcinogenic threat to humans.
- The POP pollution is further exacerbated by extensive deforestation in the north of Pakistan during the last decade.

Request publication

Use of internationally banned chemicals

Polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCs) are the most dangerous forms of POPs. DDT is the most commonly known POP and has been banned in the US and Europe since 1972.

Alarming, Bhowmik and his colleagues measured widespread and recent application of two dangerous PCBs and OCs, including DDT in northern mountainous regions of Pakistan. The main source of these notorious chemicals are unregulated use of agricultural pesticides and insecticides for malaria control.

These chemicals pose high risk of exposure to human health. The researchers identified high carcinogenic risk for DDT when compared the concentration of PCBs in dust particles with international human health safety standard.

Related info

Sohail, M., Ziai, S.A.M.A., Pergola, J., Bhawmik, A.K., Mahmood, A., Ali, N., Salim-Alizadeh, T., Bhowmik, A.K. (2017). The role of the Hindu Kush-Himalayan mountain range as a sink for persistent Pollutant emitters via dust fallout throughout the region and their implication for human health risks. *Science of The Total Environment* in press. <https://doi.org/10.1016/j.scitotenv.2017.05.164>

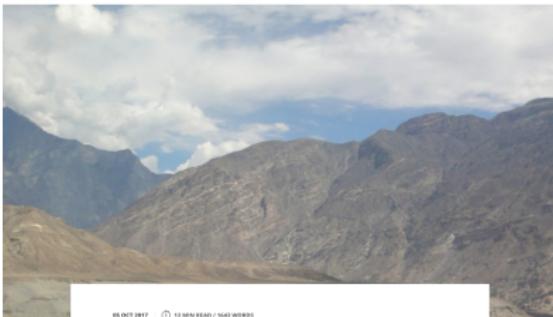
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Commentary/Pollution lessons from the Himalayan foothills

Rivers like Pakistan, already naturally prone to heavy-metal contamination, also experience high levels of added pollution from human activities. How can understanding chemical risk in Pakistan help us to address chemical pollution, in order to protect our future – and our children?

WRITTEN BY AVIT K. BHOWMIK



Avit Bhowmik

Spatial Interpolation. GIS Application '18

Future Earth

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**

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- **Spatial (Geospatial)**

Anselin, 1989. What is special
about spatial data?

- **Spatiotemporal**

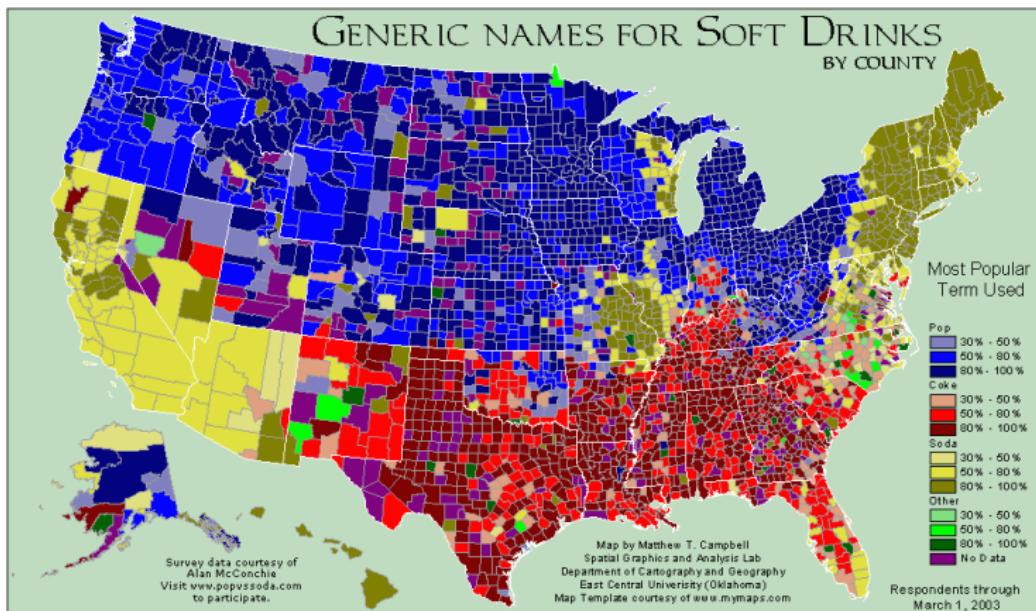
Burrough and Frank, 1995. Int J
GIS

- **System**

- **Science**

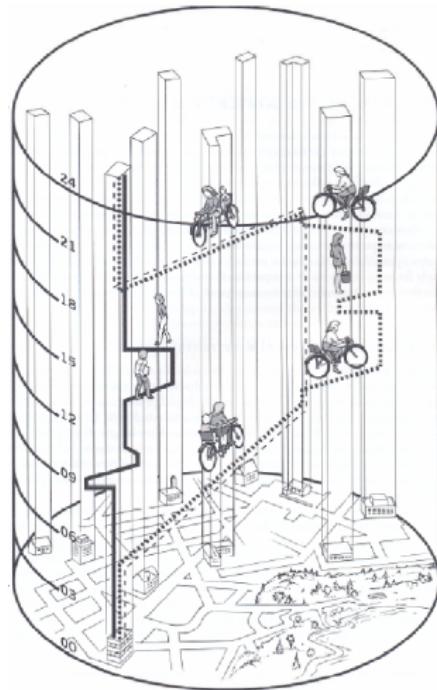
Goodchild, 1992. Int J GIS

80% of data are Spatiotemporal



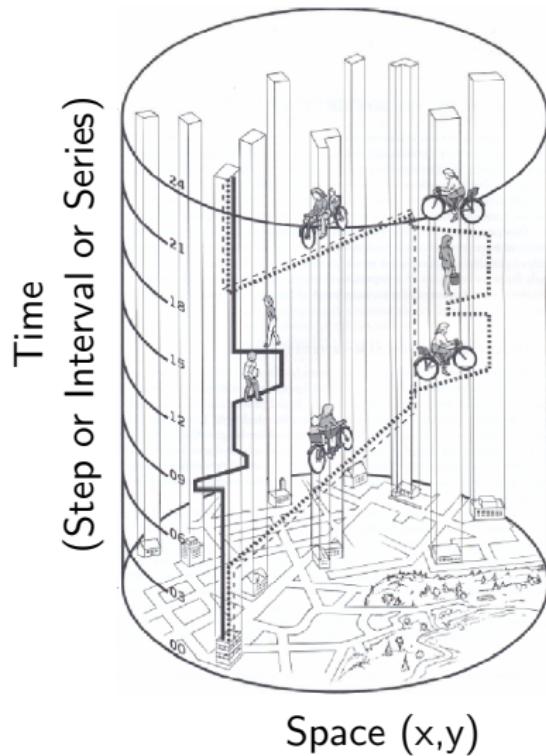
Bossler, 2002. Manual of Geospatial Science and Technology

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?



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

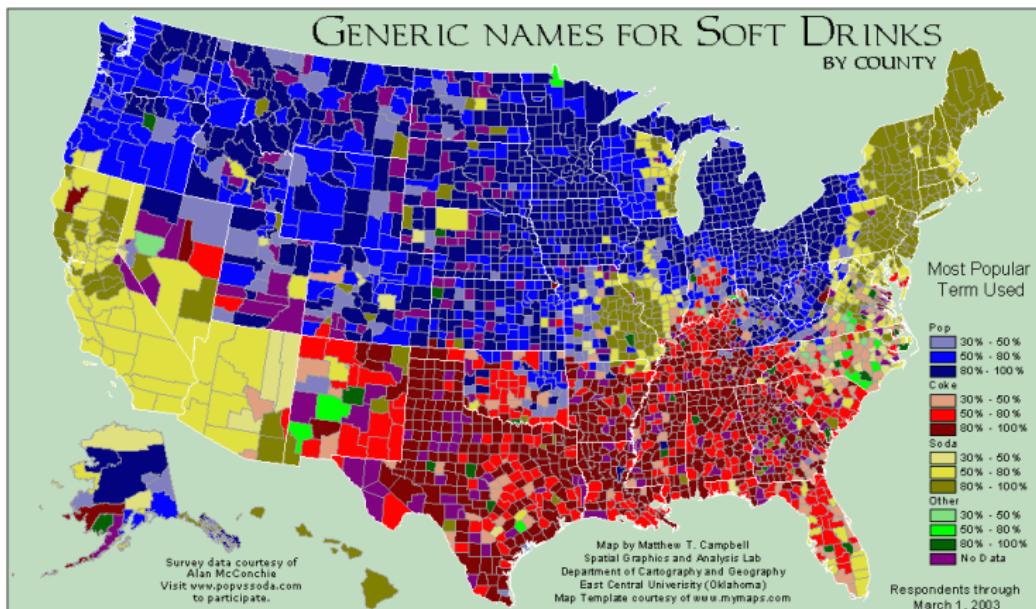
First law of geography

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



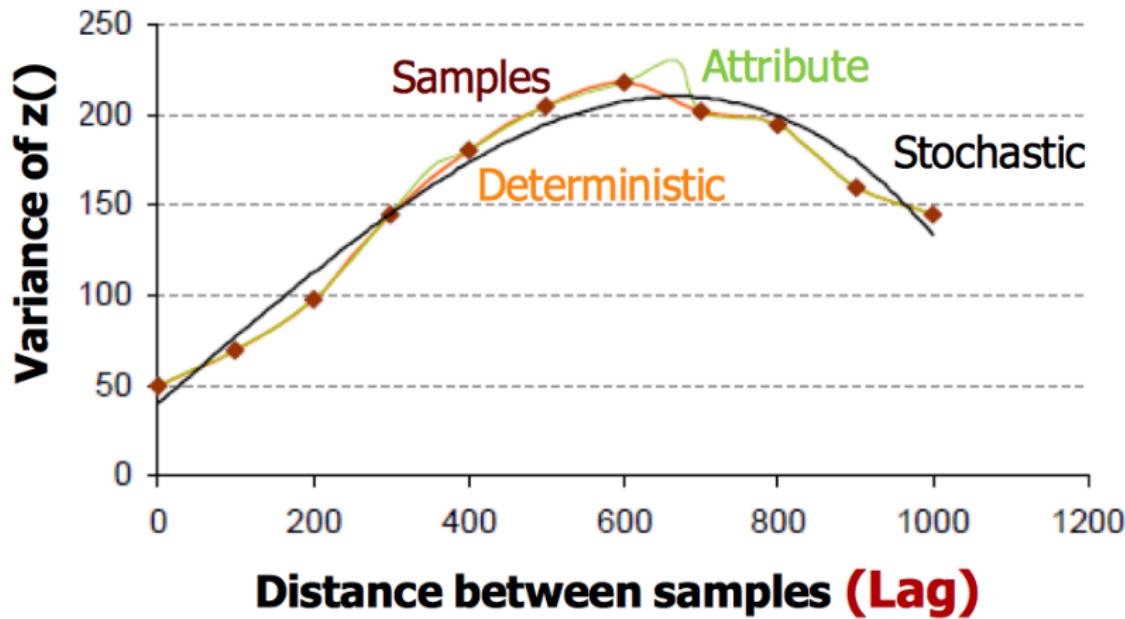
Photo: Professor Dr. Waldo Tobler, 2007

Spatial(-temporal) Autocorrelation

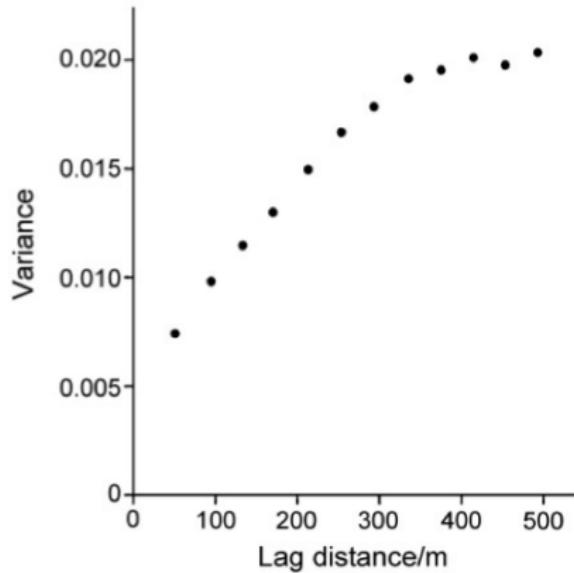
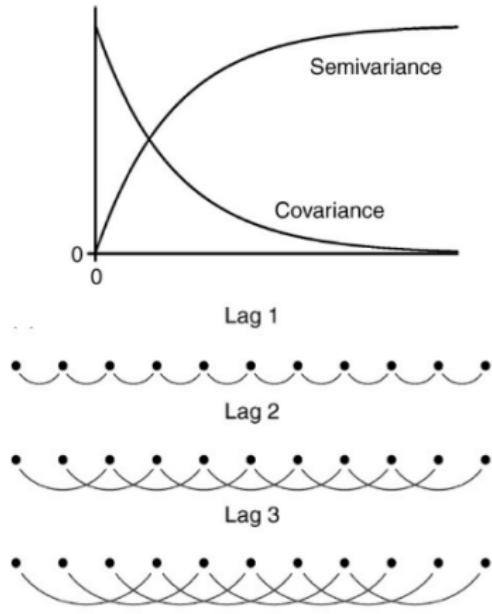


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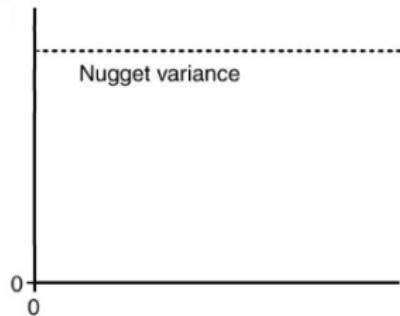
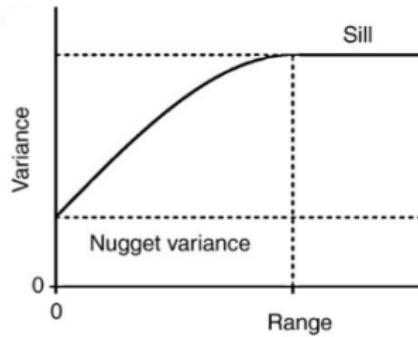
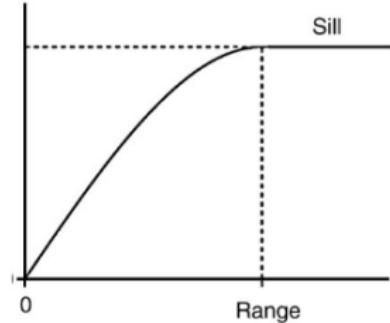
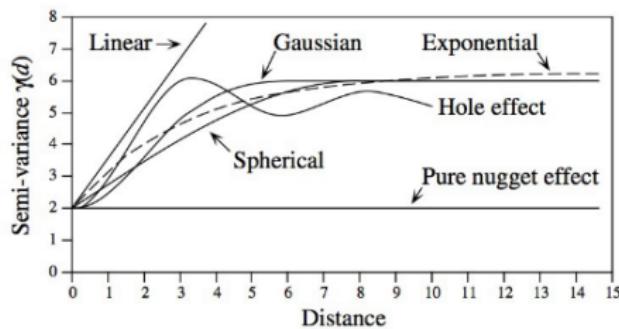
Spatial(-temporal) Variability



Spatial(-temporal) Variability



Spatial(-temporal) Variogram



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

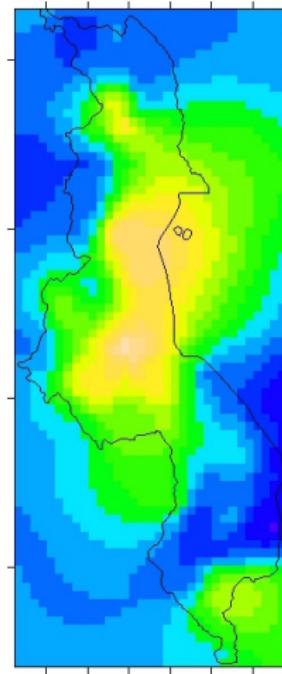
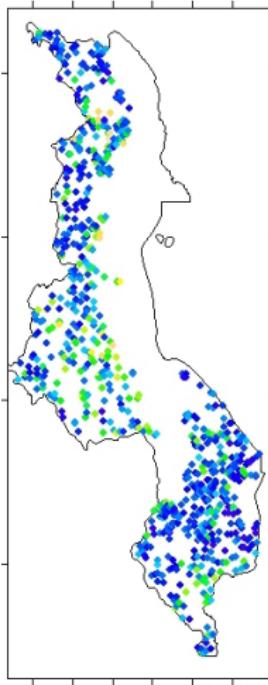
Input

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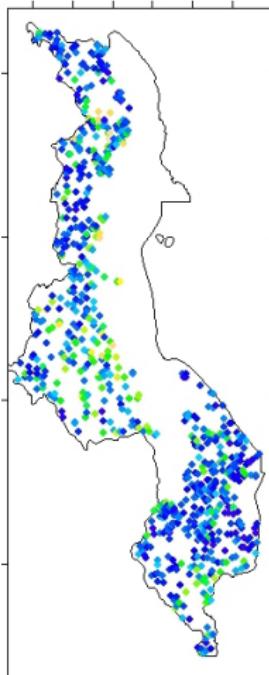
Output

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

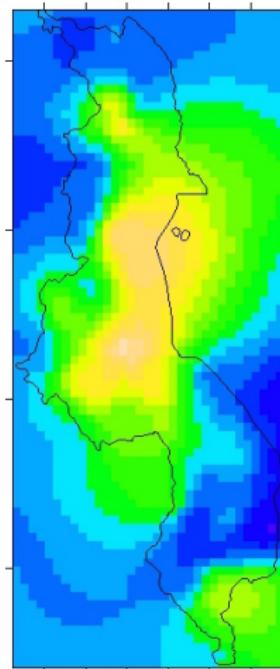
Spatial(-temporal) Interpolation



Spatial(-temporal) Interpolation



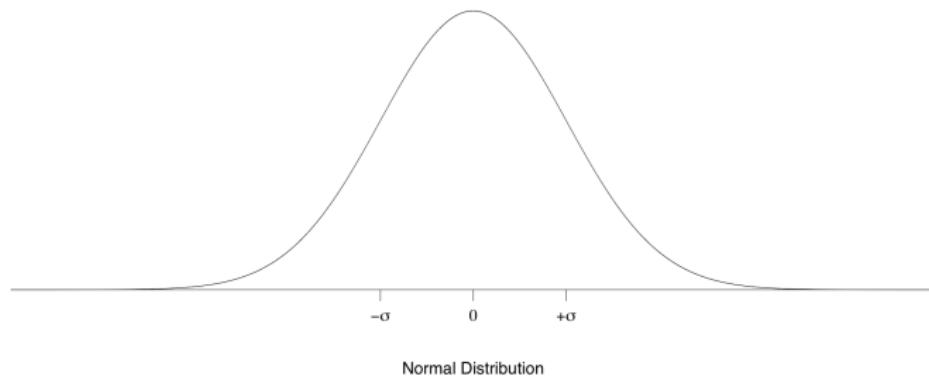
Z



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

Stochastic or Geostatistical Interpolation

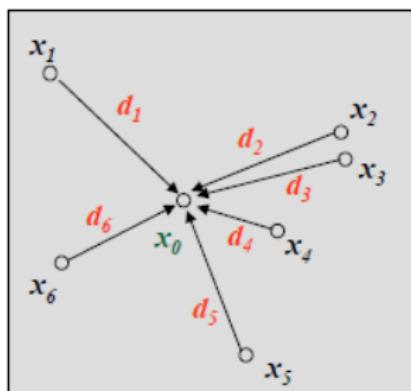
- A probability distribution function is associated to its probable values
- Uncertainties can be associated to its estimation
- e.g. Kriging
- Minimization of estimation variance (error)



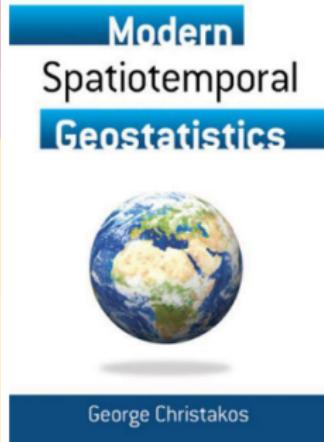
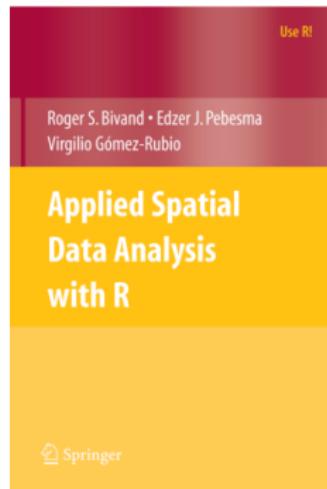
Deterministic Interpolation

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

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



Learn more about Spatial(-temporal) Statistics



Spatio-temporal geostatistics using `gstat`



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 `variogam` 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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Vol. 54, Issue 10, Sep 2012				
Submitted 2011-05-15, Accepted 2013-05-05				

The slides, scripts, materials and data are available from:
<https://github.com/AvitBhowmik/gisapp18>

Learning by doing!



Thank You!

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