



Center for Spatially Integrated Social Science

GIS and Spatial Analysis

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Outline

- GIS and Spatial Analysis
- Spatial Data
- Spatial Data Analysis:
Some Examples

GIS and Spatial Analysis

Geographic Information Systems

➤ GIS as a Set of Tools

- **Burrough**: “set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes”
- a GIS, GISes (= systems)

➤ GIS as Science (the “new” geography)

- **Goodchild**: Geographic Information Science
 - generic scientific questions pertaining to geographic data
 - central role of **spatial analysis**
- **GIScience**

GIS Functions

- Many Different Taxonomies
- Anselin-Getis 92 (and others)
 - four broad sets of functions
 - Input
 - Storage
 - Analysis
 - Output

What is Spatial Analysis

➤ From Data to Information

- **beyond mapping**: added value
- transformations, manipulations and application of analytical methods to spatial (geographic) data

➤ Lack of Locational Invariance

- analyses where the outcome changes when the locations of the objects under study changes
 - median center, clusters, spatial autocorrelation
- **where matters**



spatial analysis avant la lettre Dr. Snow's map of cholera deaths in London

Categories of Spatial Analysis

➤ Different Taxonomies

- six categories (Longley et al 2001)
 - queries and reasoning
 - measurements
 - transformations
 - descriptive summaries
 - optimization
 - hypothesis testing
- others
 - analytical cartography (Tobler)
 - cartographic modeling (Tomlin)

Components of Spatial Analysis

- Exploratory Spatial Data Analysis
 - Finding interesting patterns
- Visualization
 - Showing interesting patterns
- Spatial Modeling, Regression
 - Explaining interesting patterns

Implementation of Spatial Analysis

- Beyond GIS
- Analytical functionality not part of typical commercial GIS
- Exploration requires **interactive** approach
- Spatial modeling requires **specialized** statistical methods
 - Explicit treatment of spatial autocorrelation
 - Space-time is not space + time

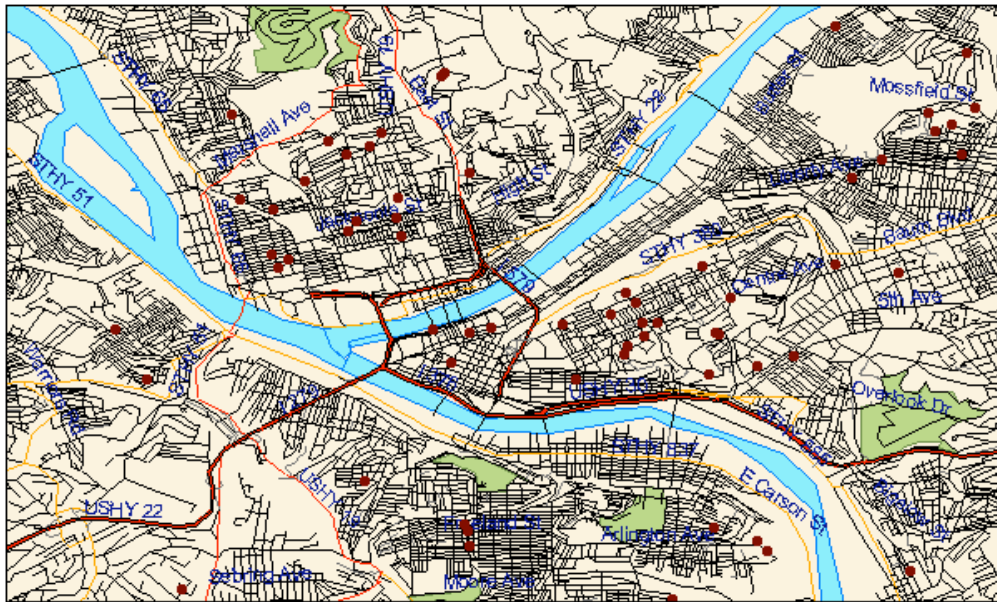
Spatial Data

What Is Special About Spatial Data

- Location, Location, Location
 - “where” matters
- Dependence Is Rule
 - spatial interaction, contagion, externalities, spillovers, copy-cattin
- First Law of Geography (**Tobler**)
 - everything depends on everything else, but closer things more so

Nature of Spatial Data

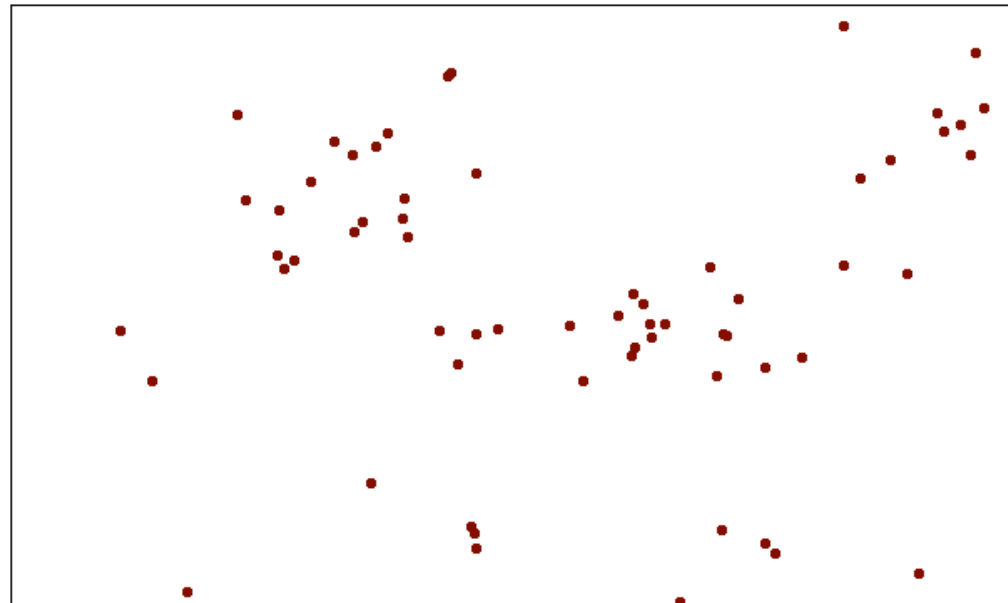
- Spatially Referenced Data
“georeferenced”
 - “attribute” data associated with location
 - where matters
- Example: Spatial Objects
 - points: *x, y* coordinates
 - cities, stores, crimes, accidents
 - lines: arcs, *from node, to node*
 - road network, transmission lines
 - polygons: series of connected arcs
 - states, counties, census tracts

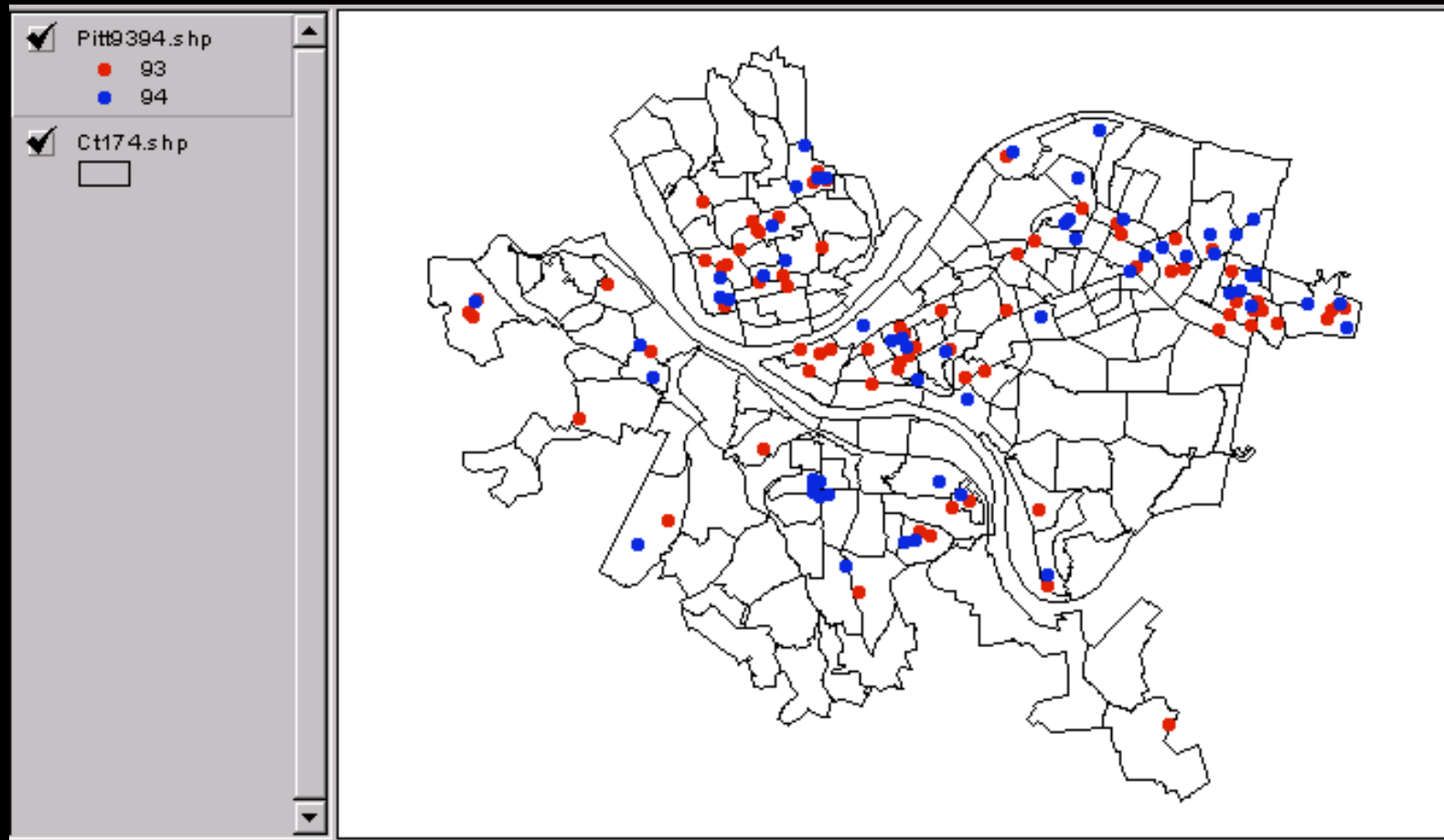


points in geographic context

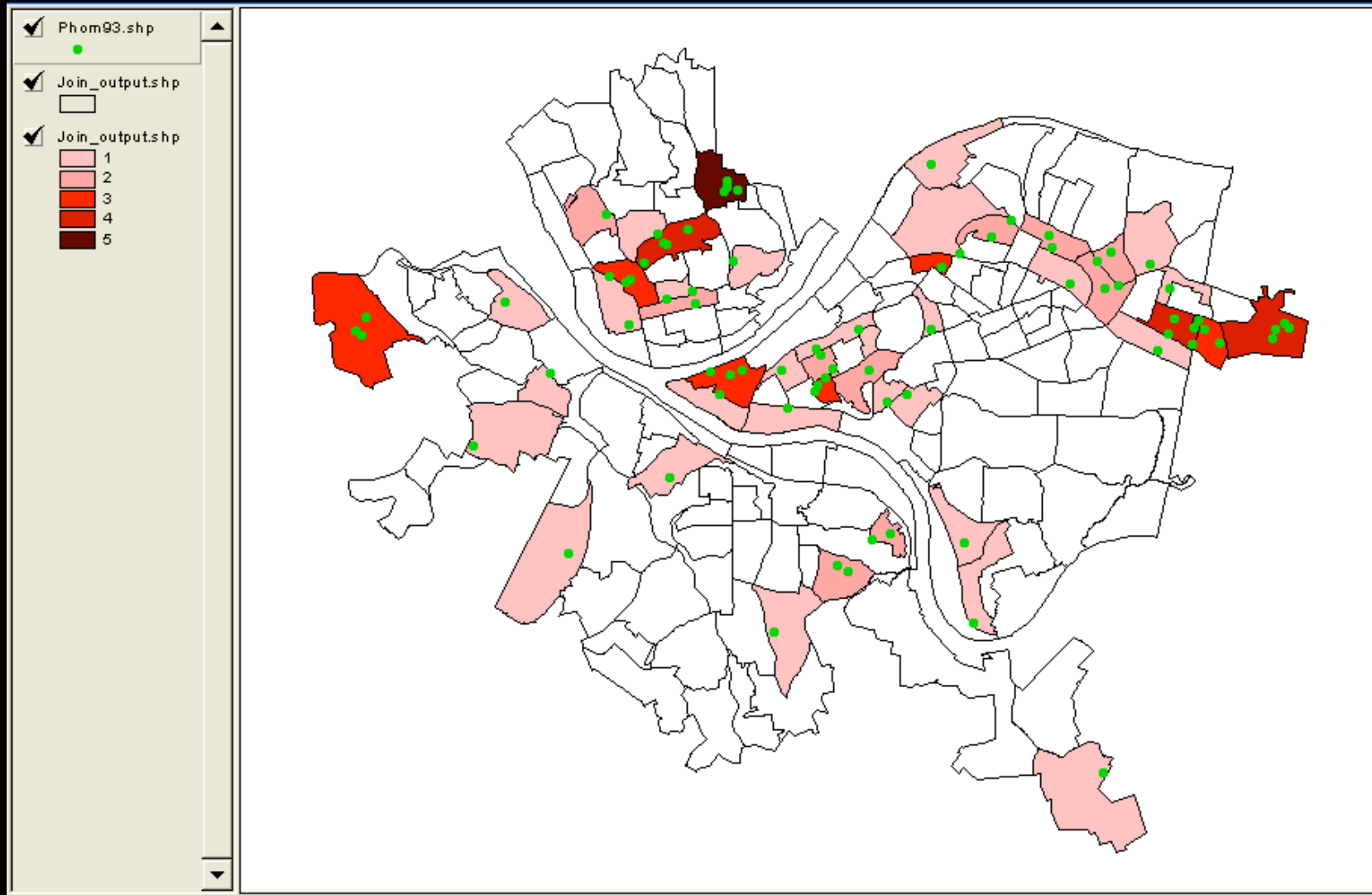
pattern of points in
uniform plane

Spatial Objects



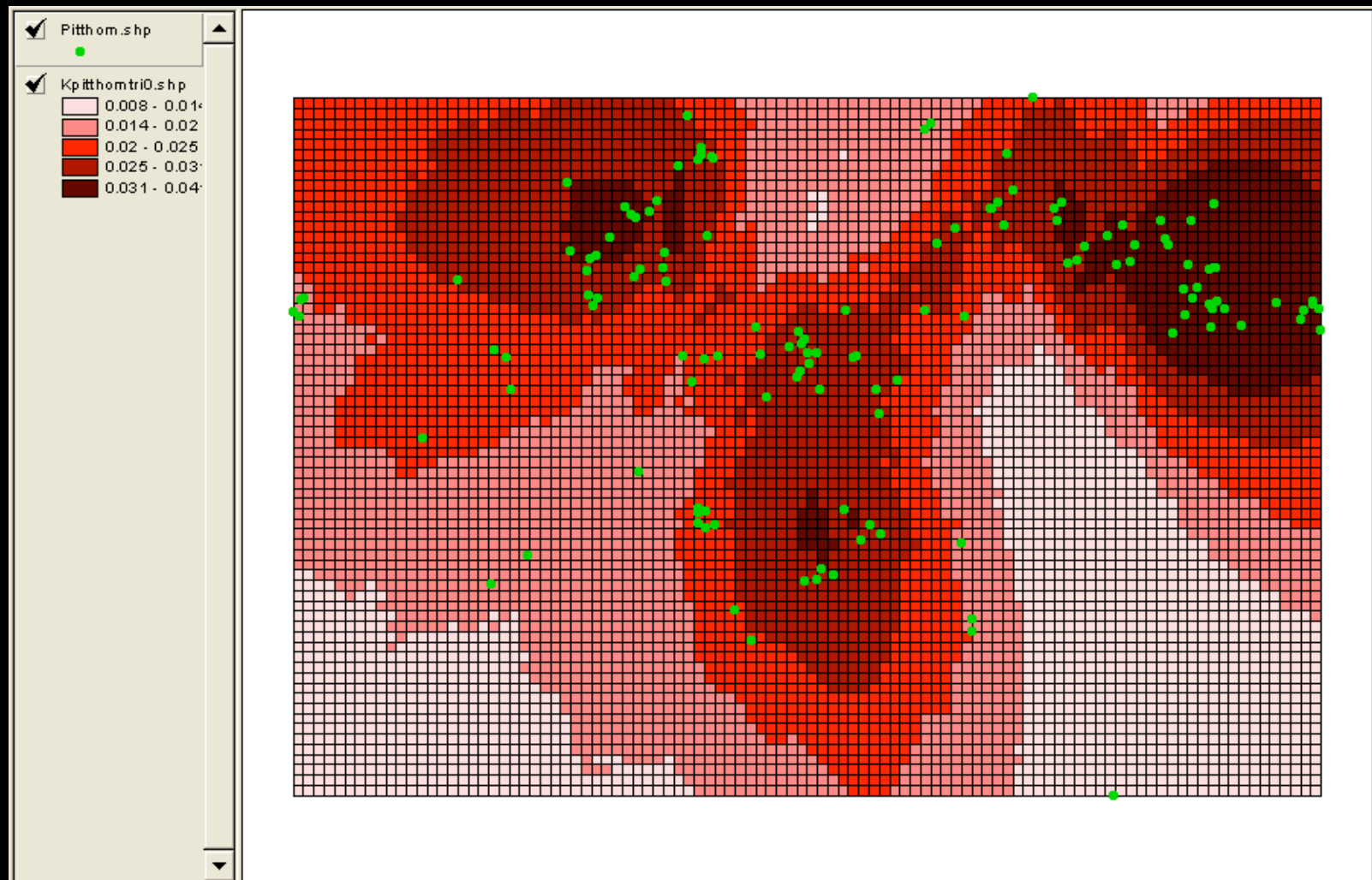


Pittsburgh 93-94 homicide locations as points in census tracts event counts



Homicide Counts in Areal Units

Continuous or Discrete Representation

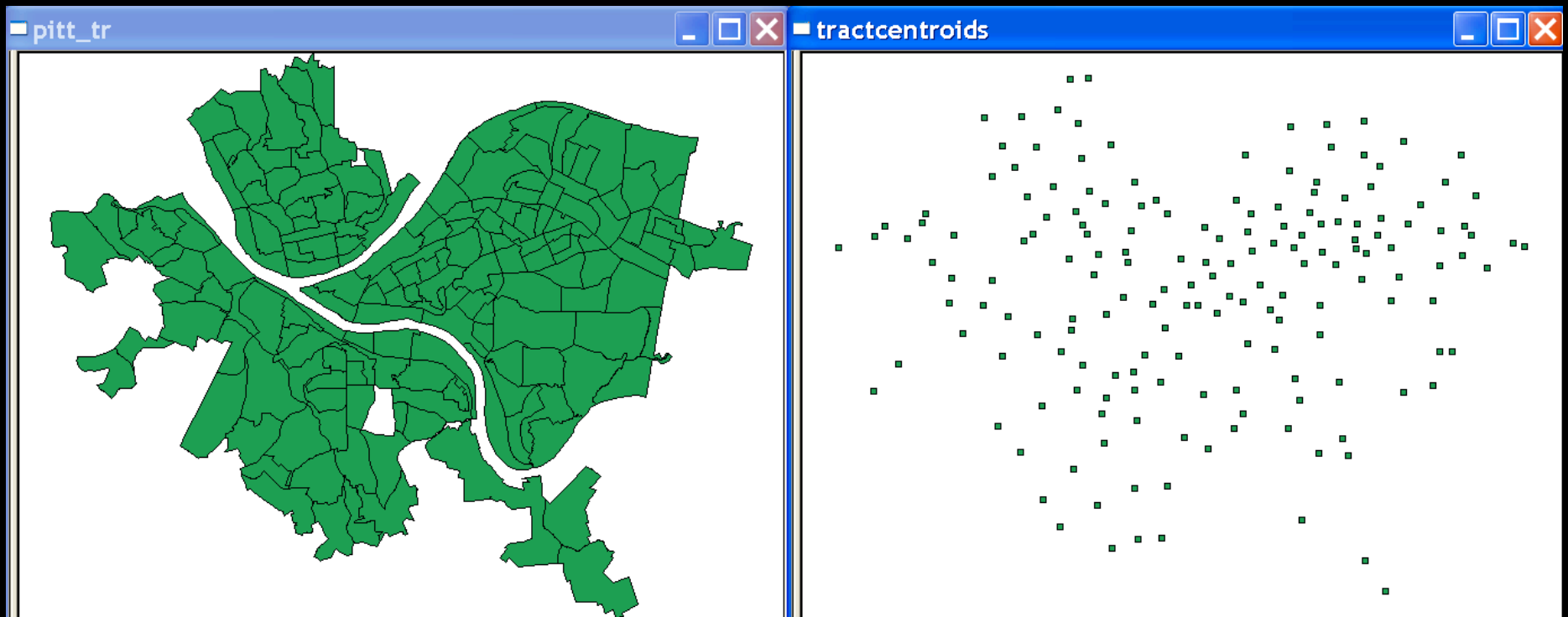


Kernel Density Surface for Homicide Points as a Grid

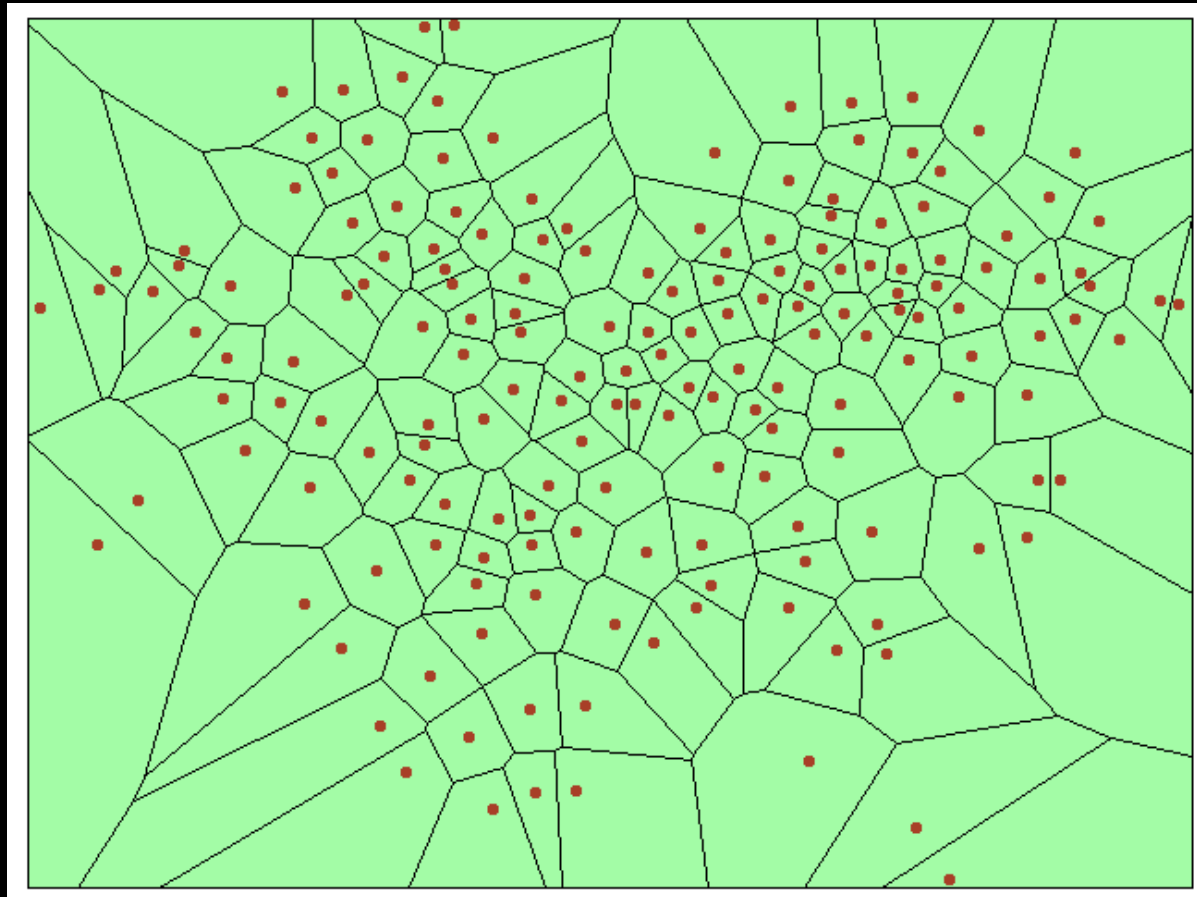
Spatial Object Representation

- Objects are Discrete
- Polygons
 - areal units represented by boundary
 - polygon to point: centroid
- Points
 - locations represented by coordinates
 - point to polygon: tessellation

Tract Polygon to Tract Centroid



Tract Centroid to Thiessen Polygons



Types of Spatial Data - Points

➤ Points

- Points as Events
 - crimes (addresses), accidents (locations)
 - Point Pattern Analysis
- Points as Samples from a Surface
 - air quality monitors, house sales
 - Geostatistics
- Points as Objects
 - county centroids
 - Lattice Data Analysis

Types of Spatial Data - Areas

➤ Areas (Areal Units)

▪ Aggregates of Events

- crimes per census tract
- spatially extensive variables

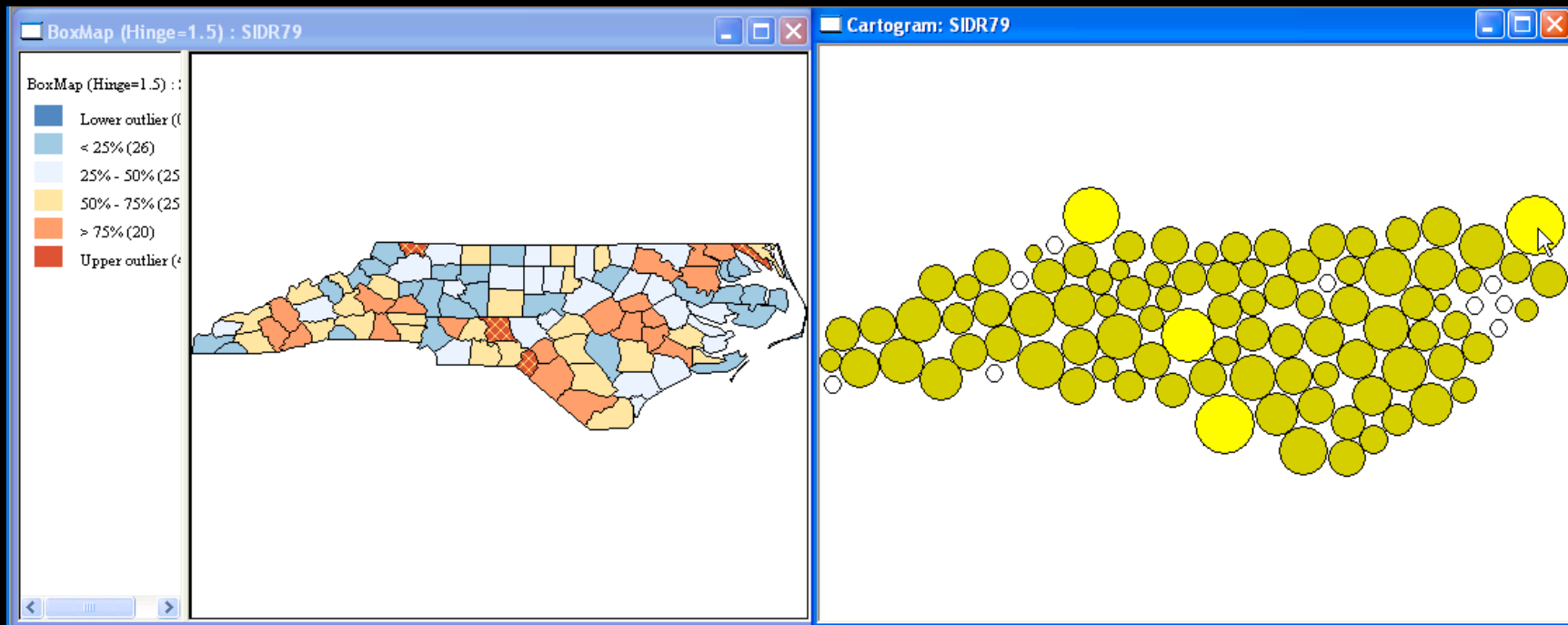
▪ Summaries

- median house value, density
- underlying **heterogeneity** = ecological fallacy
- spatially intensive variables

Spatial Data Analysis

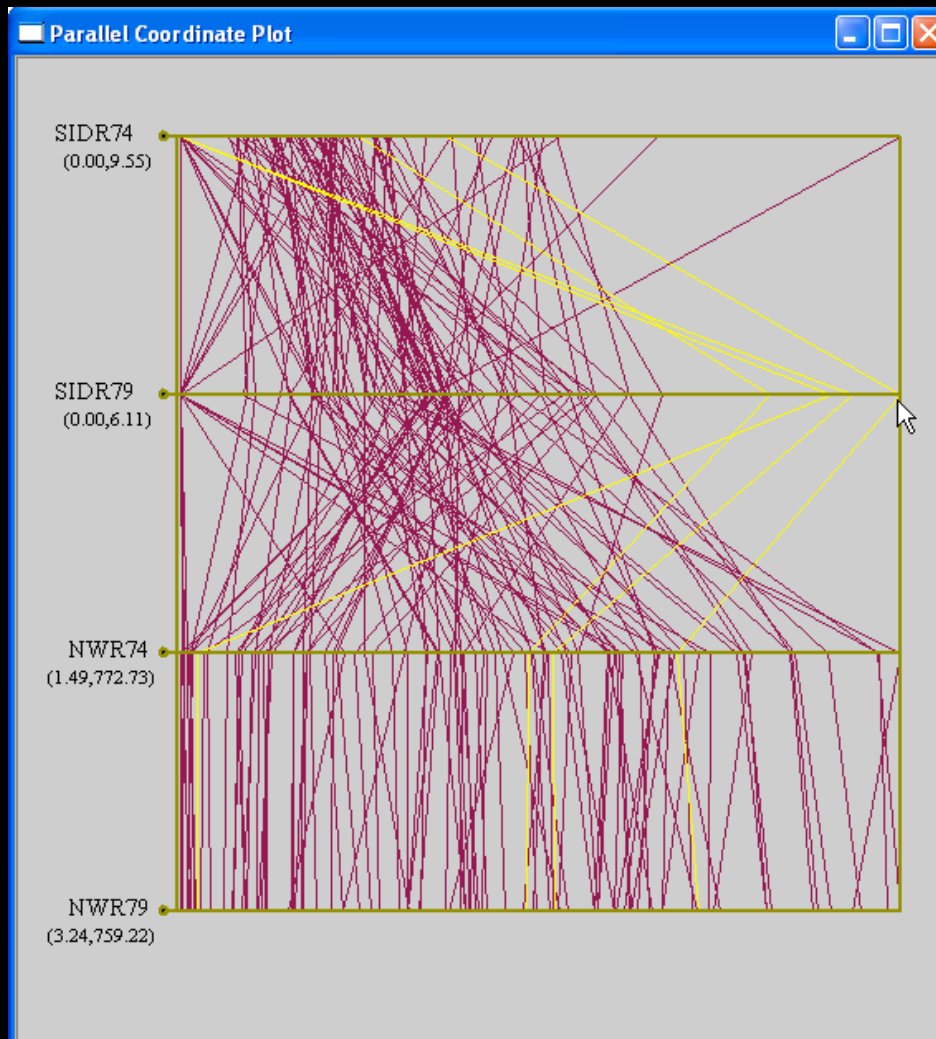
Some Examples

Cartogram in GeoDa



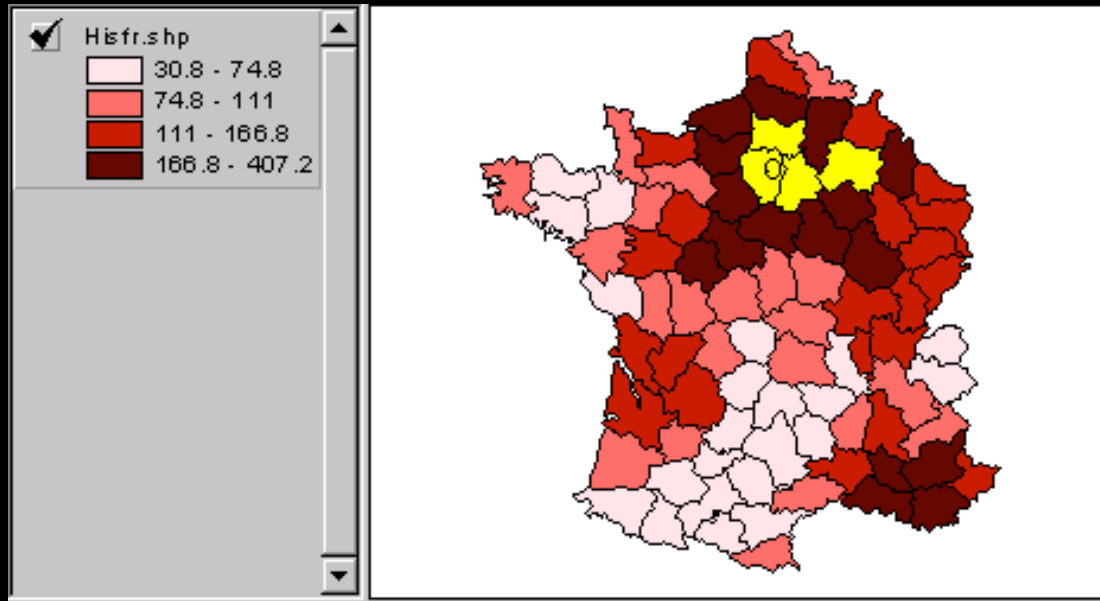
SIDS Rates (79) NC Counties

Parallel Coordinate Plot

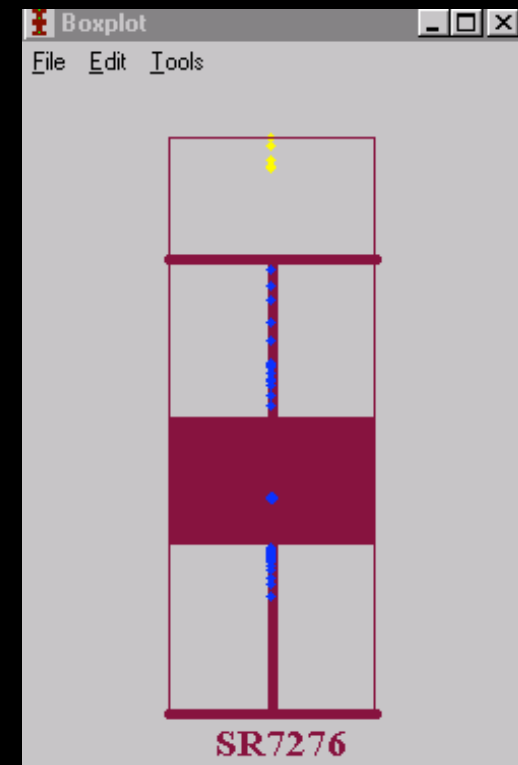


Box Map

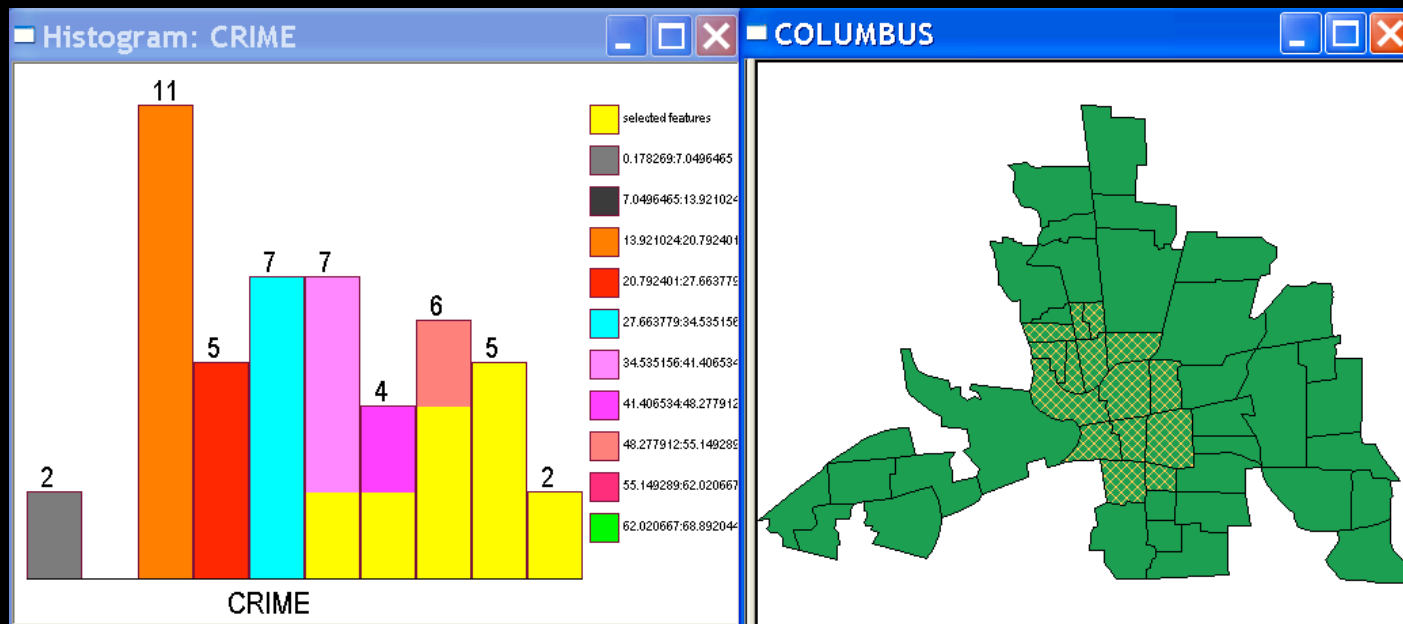
- quartile map with outliers highlighted



suicide rates in France (Durkheim 1897)

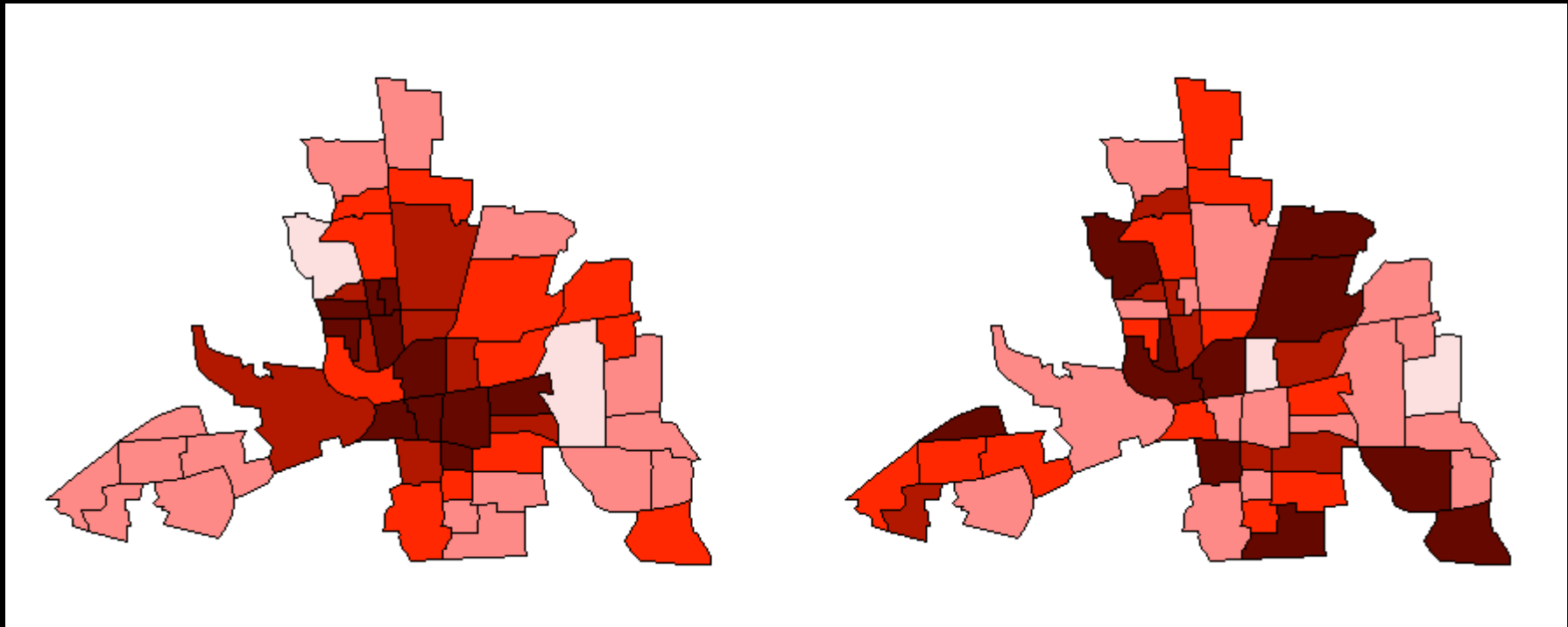


Regional Histogram

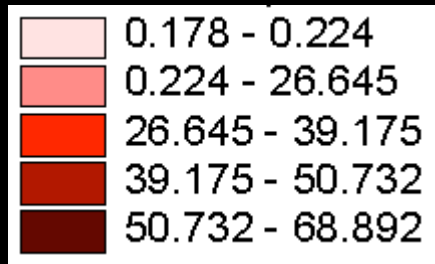


Spatial Autocorrelation

Observed (left) and randomized (right)
distribution for Columbus Crime

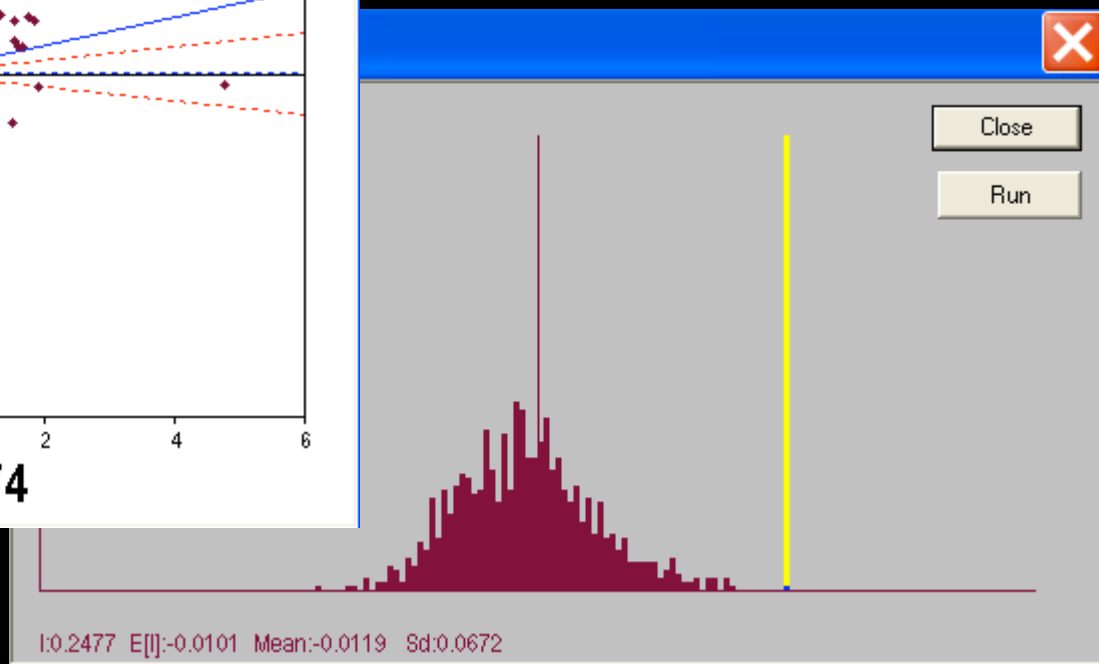
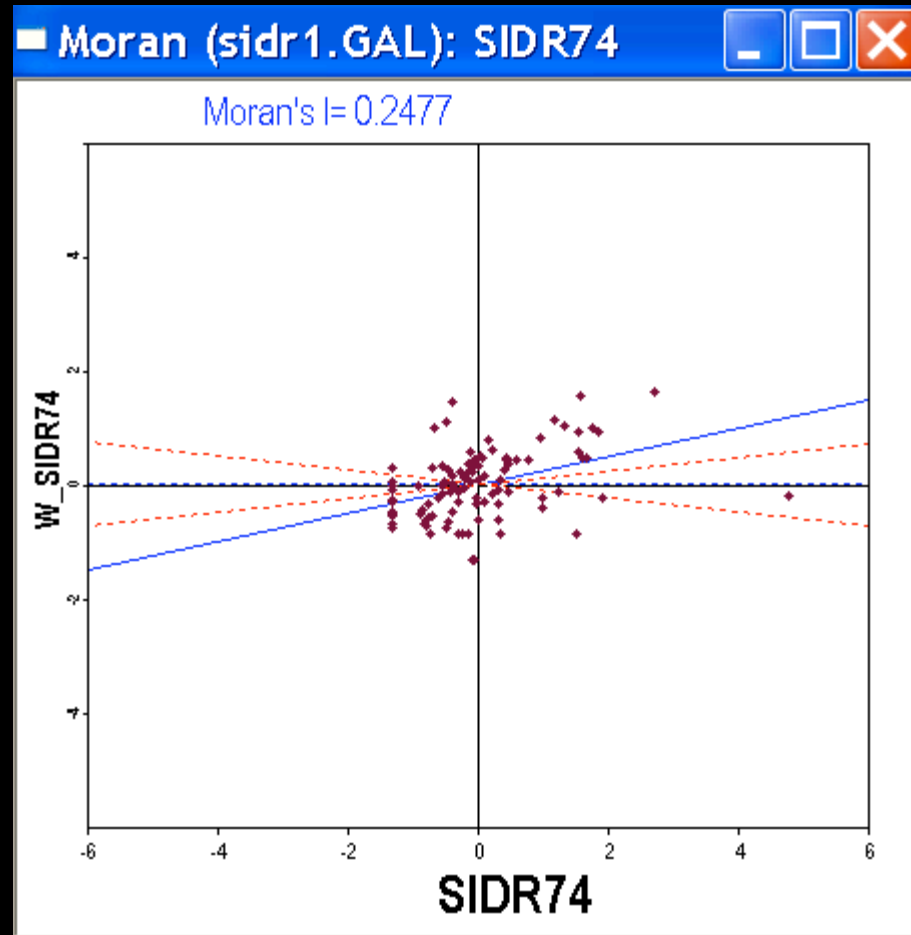


Moran's I = 0.486

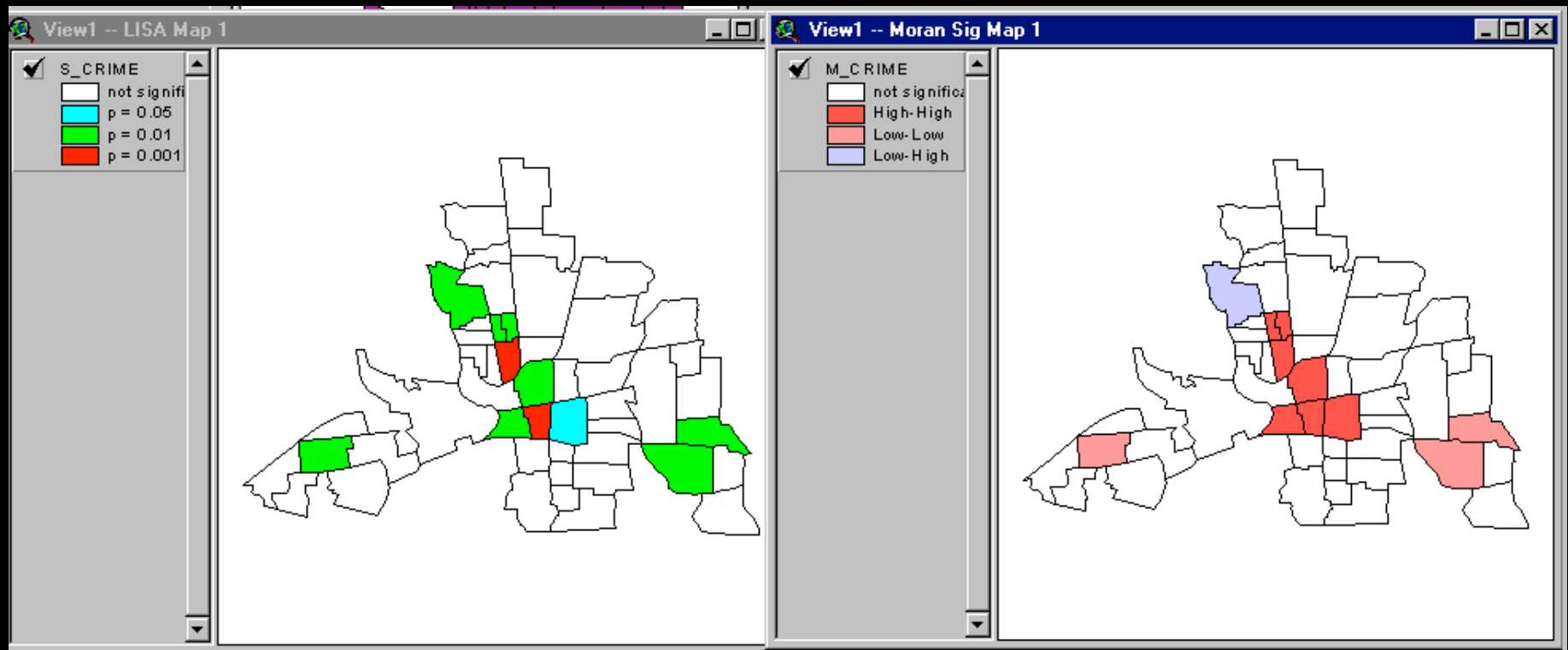


Moran's I = -0.003

Moran Scatterplot and Randomization

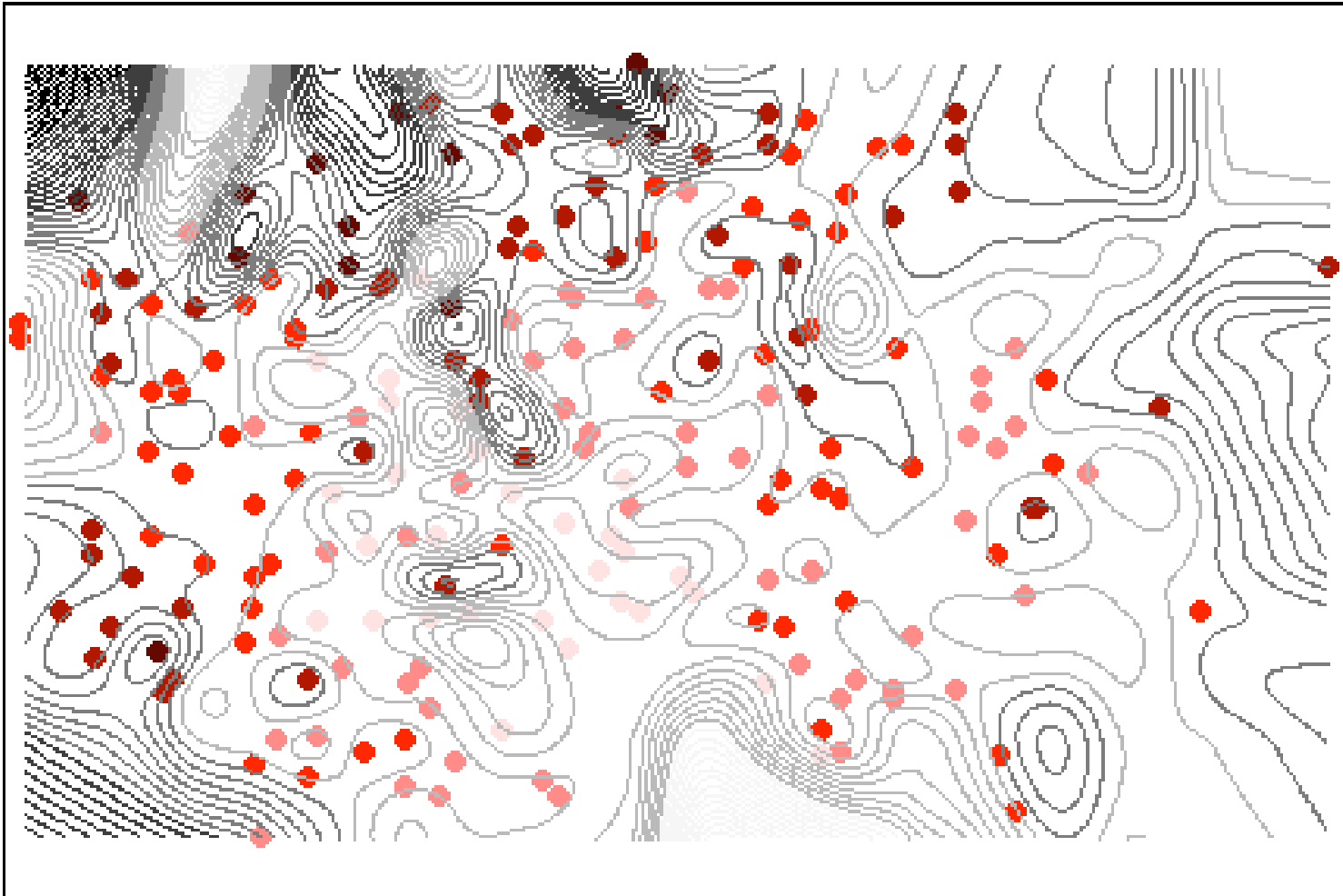


LISA Cluster Maps

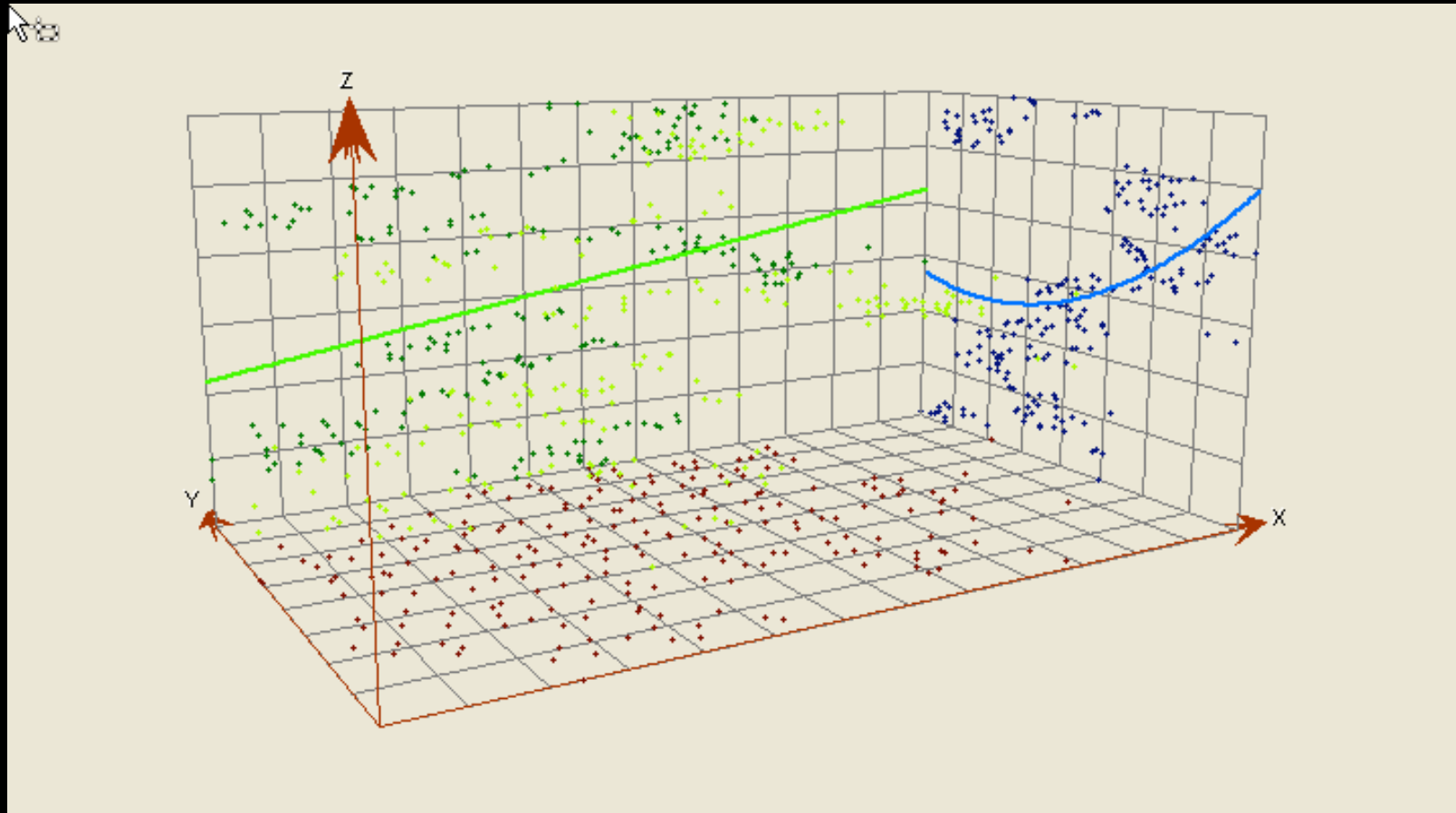


locations with significant
Local Moran Statistic

significant LISA classified by
type of local association



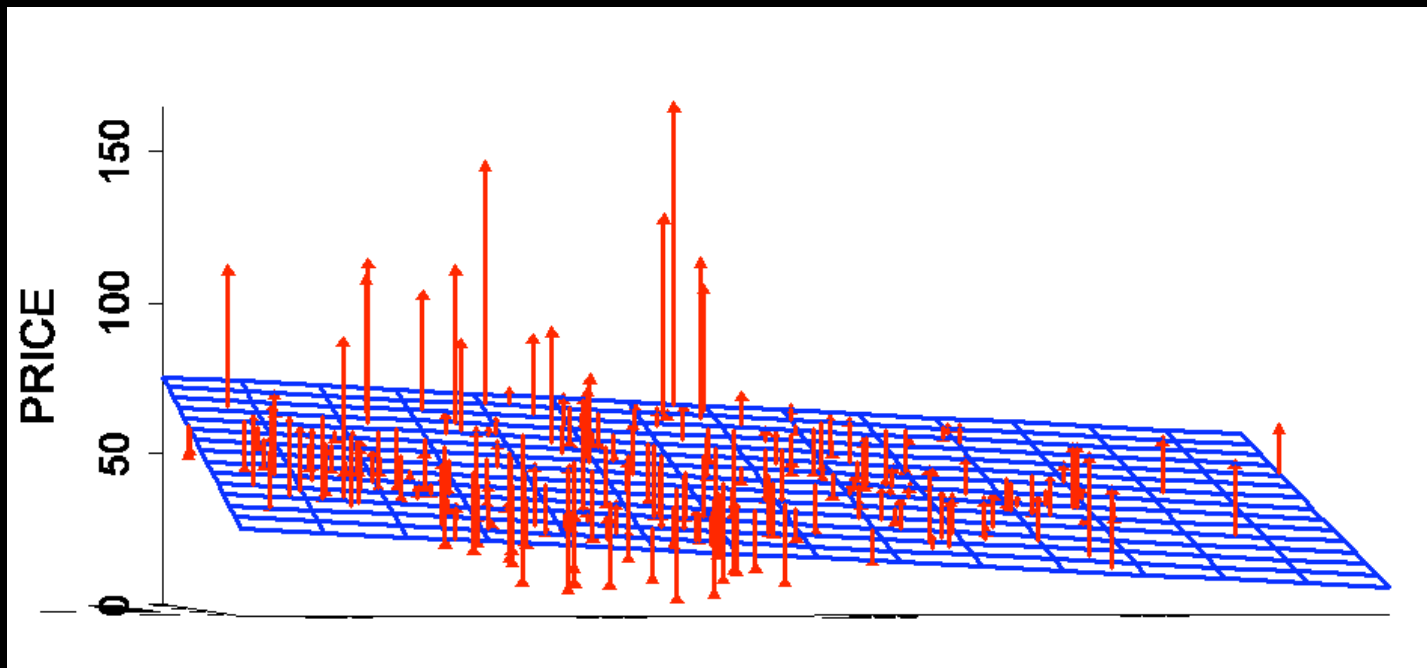
Residential Sales Price, Baltimore MD (1980)
sample points (darker is higher) and contours



Baltimore House Sales Prices
Spatial Trend Analysis

Linear Spatial Trend

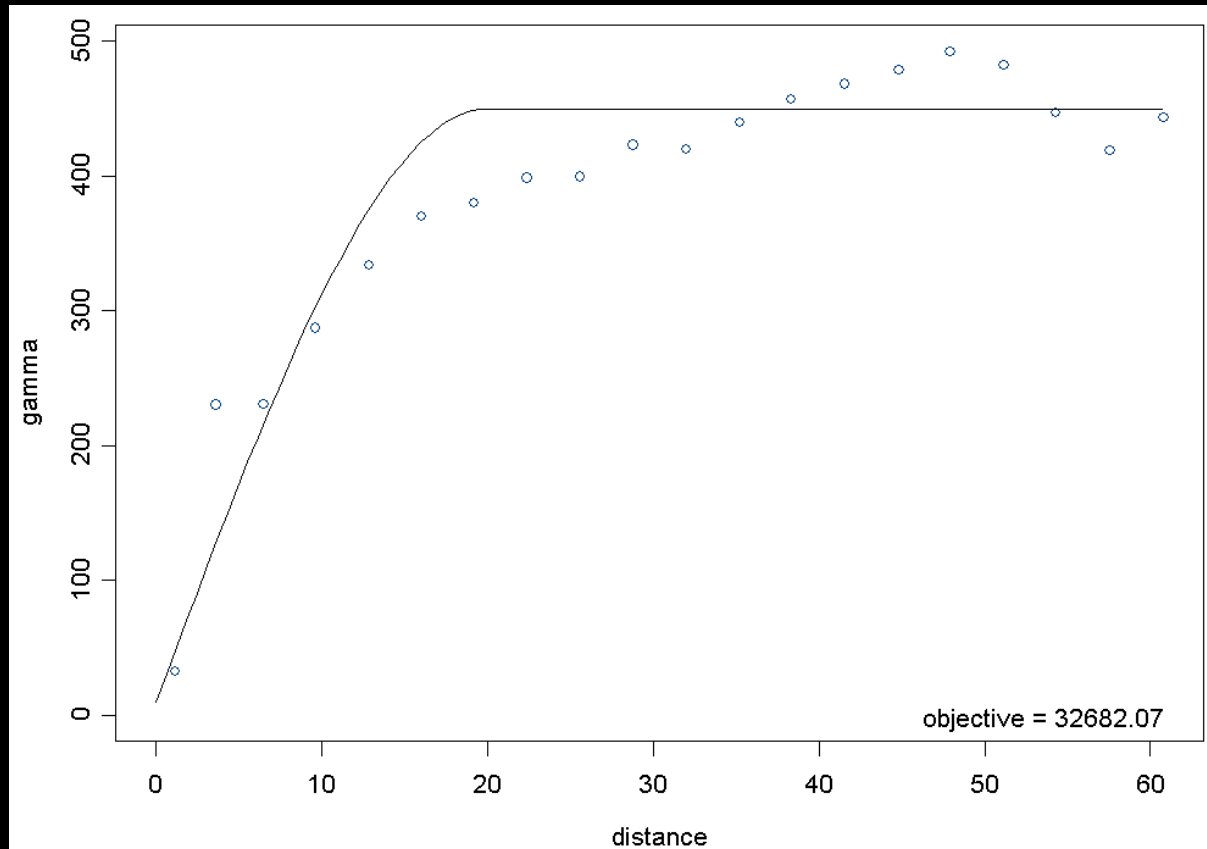
Baltimore House Prices



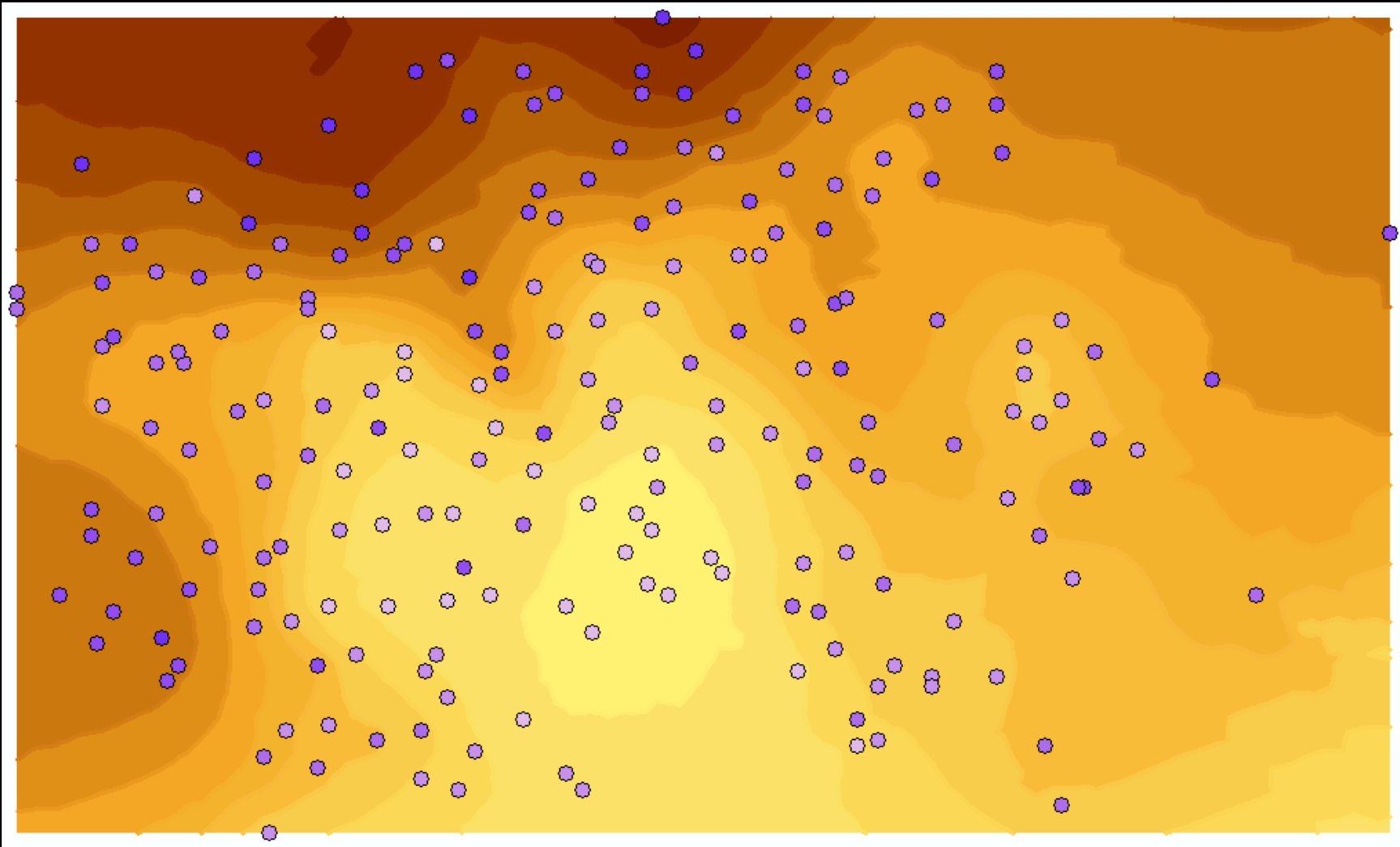
$$P = -166.02 - 0.148 X + 0.634 Y \quad R^2 = 0.27$$

Fitted Spherical Variogram

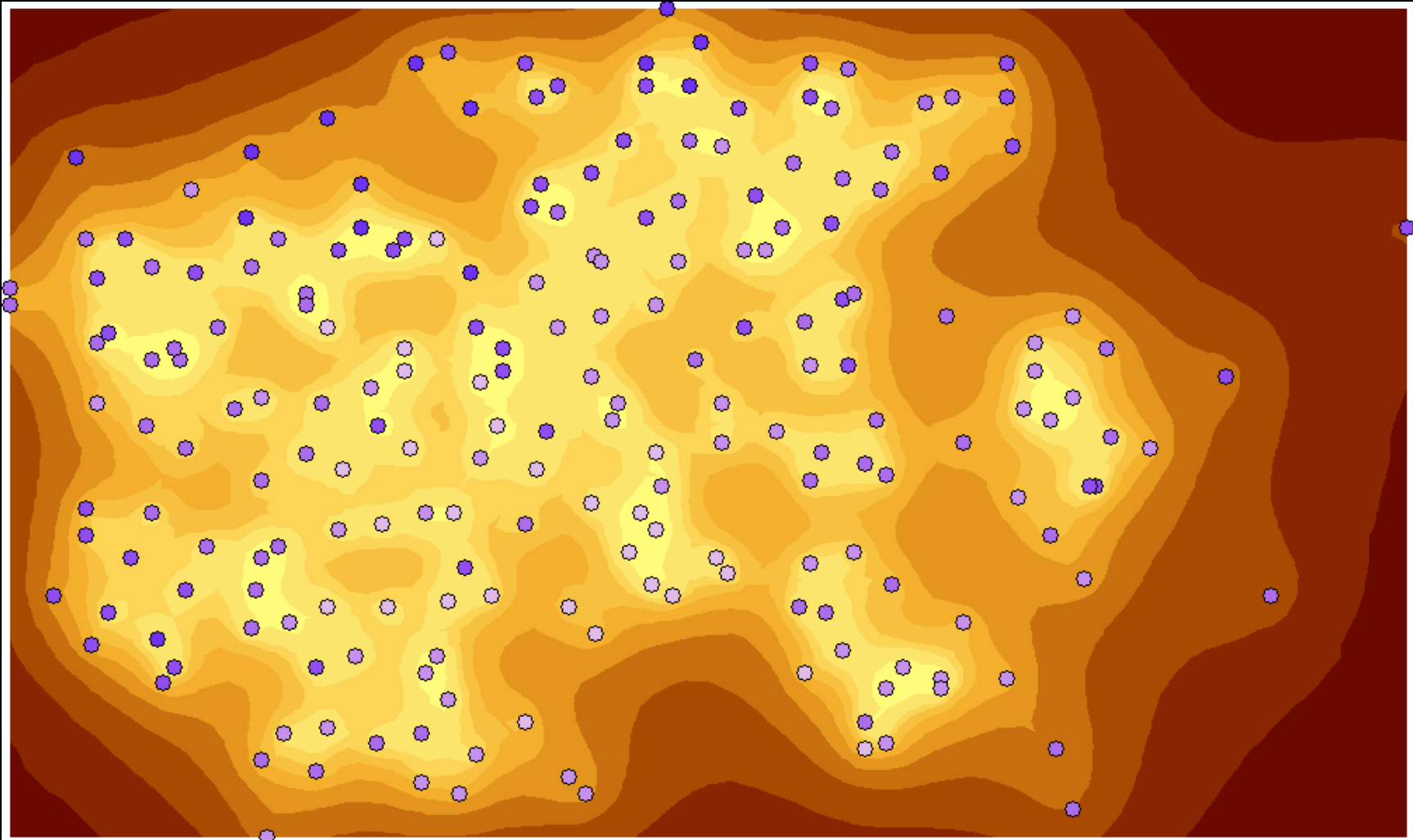
Baltimore Trend Surface Residuals



range = 20, sill = 440, nugget = 10



Predicted Value Map



Standard Errors of Spatial Interpolation

