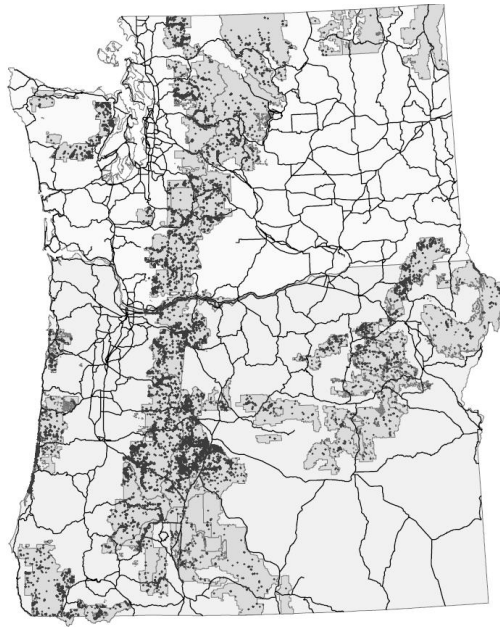


- Zhang, C. et al. 2008. Use of local Moran's I and GIS to identify pollution hotspots of Pb in urban soils of Galway, Ireland. The Science of the total environment, 398 (1-3), p. 212.

– Brownfield development



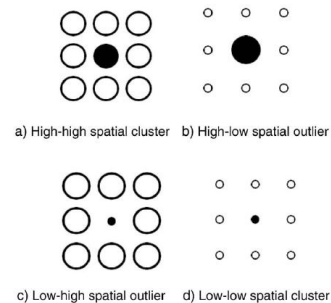
Crime Pattern in National Forest (Map source: Michael Wing, OSU)

Galway, Ireland



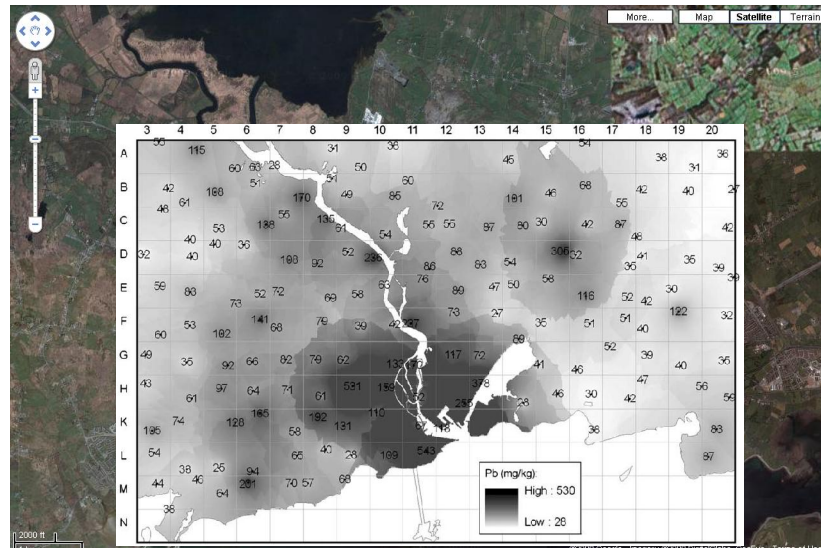
Spatial Patterns of Pb Hotspots

- Sources of Pb:
 - Traffic (lead additive in gas)
 - Burning of peat & coal for home heating
 - Solid waste
- Spatial cluster (regional hotspots) – sites with high Pb concentration surrounded by high concentration sites.
- Spatial outlier (individual hotspots) – sites with high Pb concentration surrounded by low concentration sites.
- Cool spots



Data

- 166 surface soil samples (0-10 cm depth)
- Stratified random sampling (1 sample per 0.25 km²)



One-point Descriptor

Table 1 – Comparison between Pb concentrations in soils of Galway City and Ireland (in mg/kg)

	N	Min.	5%	10%	25%	Median	75%	90%	95%	Max.
Galway City soils ^a	166	25	30	35	42	58	86	132	187	543
Soils of Ireland ^b	1310	1.1	11.7	13.6	18.2	24.8	33.5	48.0	61.9	2634.7
Mineral soils of Ireland ^b	977	4.8	12.4	14.3	18.8	24.8	33.3	47.8	61.0	550.9

^aZhang (2006); ^bFay et al. (2007).

Moran's I (Two-point Descriptor)

$$I = \left(\frac{n}{\sum_i \sum_j w_{ij}} \right) \left(\frac{\sum_i \sum_j w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - \bar{x})^2} \right)$$

x_i and x_j : values observed at locations i and j

$\bar{x}$: average of all x_i

w_{ij} : weight between locations i and j

Examples of w_{ij}

$w_{ij} = 1 / d_{ij}$

$w_{ij} = 1$ if i touches j , else 0 (local Moran's I)

+1: clustering (positive spatial autocorrelation)

0: random

-1: dispersion (negative spatial autocorrelation)

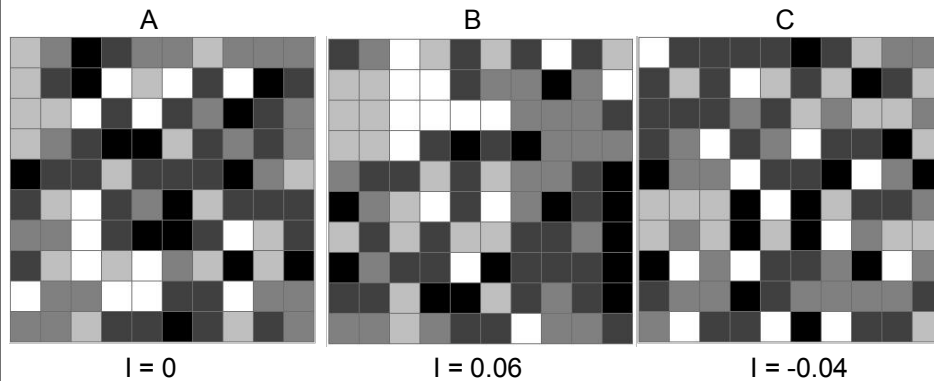
Conceptualization of Spatial Relationships

Specifies how spatial relationships between features are conceptualized.

- Inverse Distance—The impact of one feature on another feature decreases with distance.
- Inverse Distance Squared—Same as Inverse Distance, but the impact decreases more sharply over distance.
- Fixed Distance Band—Everything within a specified critical distance is included in the analysis; everything outside the critical distance is excluded.
- Zone of Indifference—A combination of Inverse Distance and Fixed Distance Band. Anything up to a critical distance has an impact on your analysis. Once that critical distance is exceeded, the level of impact quickly drops off.
- Polygon Contiguity (First Order)—The neighbors of each feature are only those with which the feature shares a boundary. All other features have no influence.
- Get Spatial Weights From File—Spatial relationships are defined in a spatial weights file. The pathname to the spatial weights file is specified in the Weights Matrix File parameter.

Value of Distance Band: > sampling interval
< half of the smaller dimension of the study area

What can you tell about the difference in these patterns?



Test for Statistical Significance

- T-test (observed data have a normal distribution)
 - Z score, p value (α)
- (Conditional) permutation
 - Rearrangement of existent elements
 - Check for pseudo significance
 - $PS = (M+1) / (R+1) \times 100\%$
 - M : number of instances that meet certain criteria
 - R : total number of permutation instances

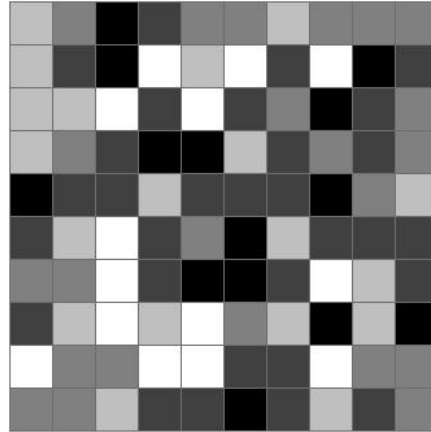
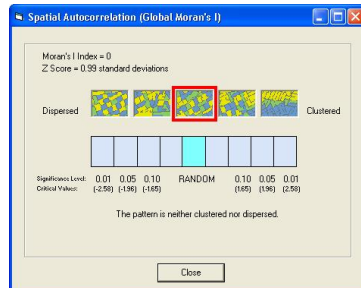
A. Random Pattern

Global Moran's I Summary

Moran's Index: 0.000019

Z Score: 0.987484

p-value: 0.323405



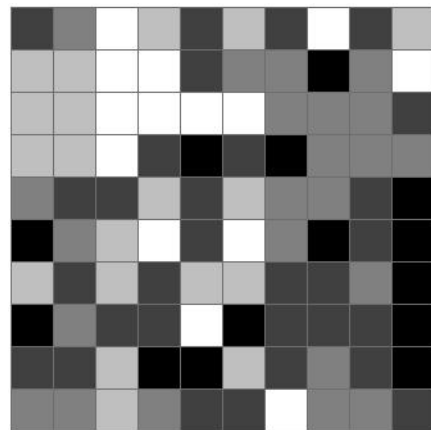
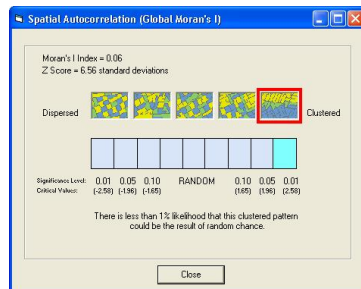
B. Positive Spatial Autocorrelation

Global Moran's I Summary

Moran's Index: 0.057173

Z Score: 6.564235

p-value: 0.000000



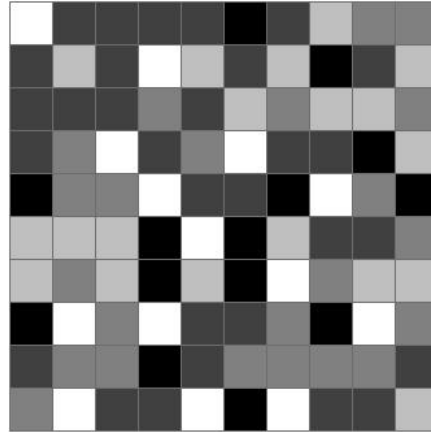
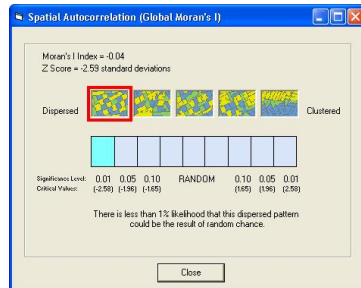
C. Negative Spatial Autocorrelation

Global Moran's I Summary

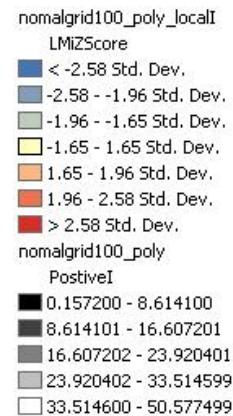
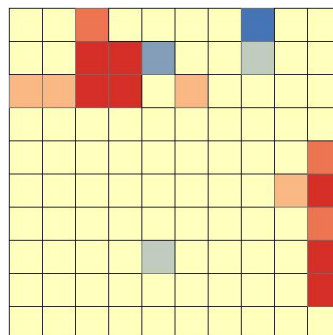
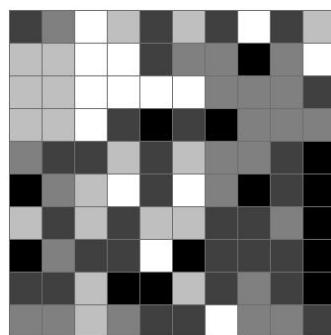
Moran's Index: -0.036682

Z Score: -2.593673

p-value: 0.009496

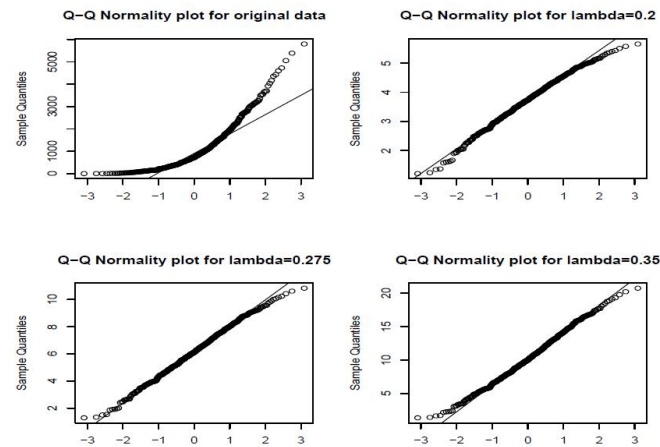


Local Moran's I: Local Indicators of Spatial Association (LISA)

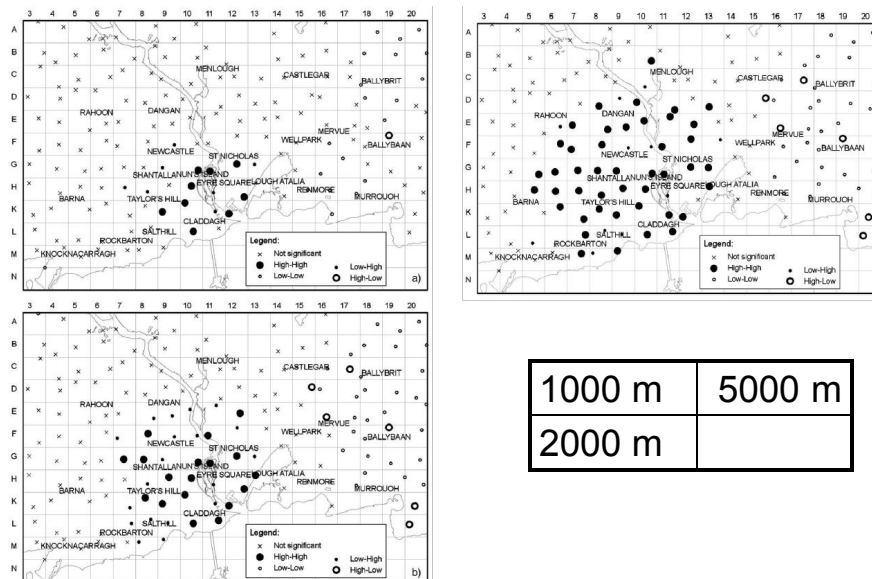


Transform Data to Normal Distribution

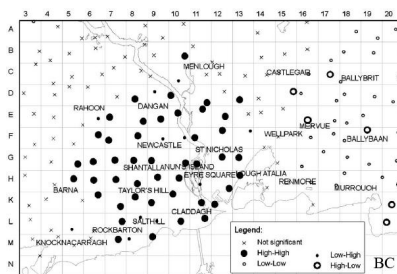
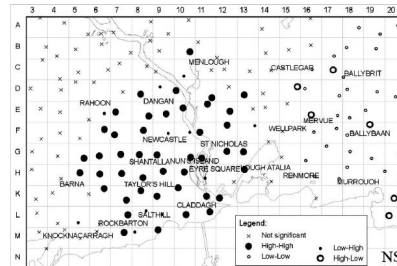
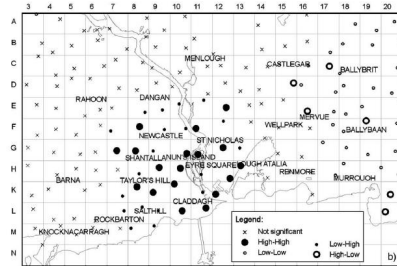
- Box-Cox (Power/Log) Transformation (see eq. 2)
- Normal score transformations (see page 214)



Results – Distance Bands



Results – Data Transformation



Original	Normal Score
Box-Cox	

Results – Outliers

- Not recommended to remove outliers
- Instead, replace their values with the upper bound of the Box-and-Whiskers plot.

Conclusions

- Conceptualization of spatial relationship and the distribution (i.e., histogram) of data affect the results of LISA
- Provide information for spatial interpolation

Moran's scatterplot (available in Geoda)

- X axis: variable value at a location
- Y axis: spatial weighted average variable values of the neighbors of that location.

