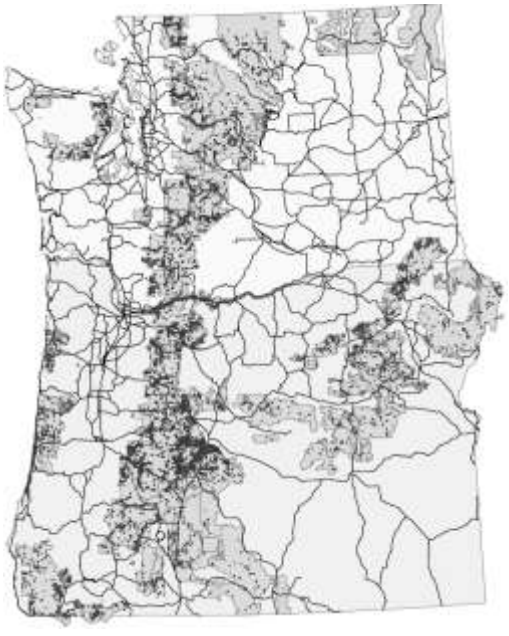
- Zhang, C. et al. 2008. Use of local Moran's I and GIS to identify pollution hotspots of Pb in urban soils of Galway, Ireland. The Science of the total environment, 398 (1-3), p. 212.

  – Brownfield development

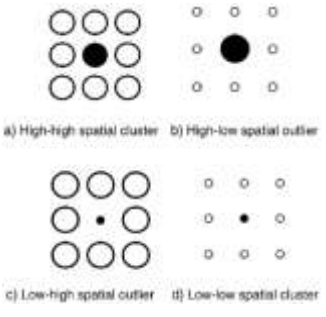


Crime Pattern in National Forest (Map source: Michael Wing, OSU)

Galway, Ireland

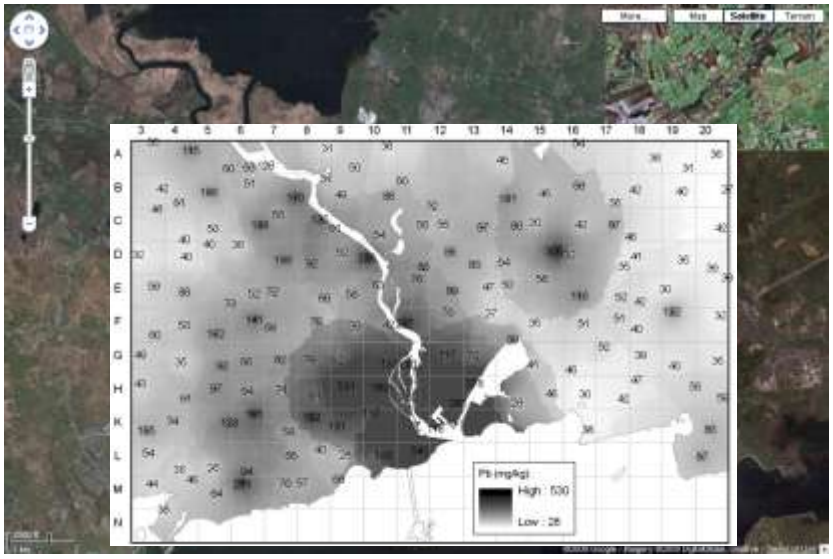
Spatial Patterns of Pb Hotspots

- 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 km^2)



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

[a]Zhang (2006); [b]Fay 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)

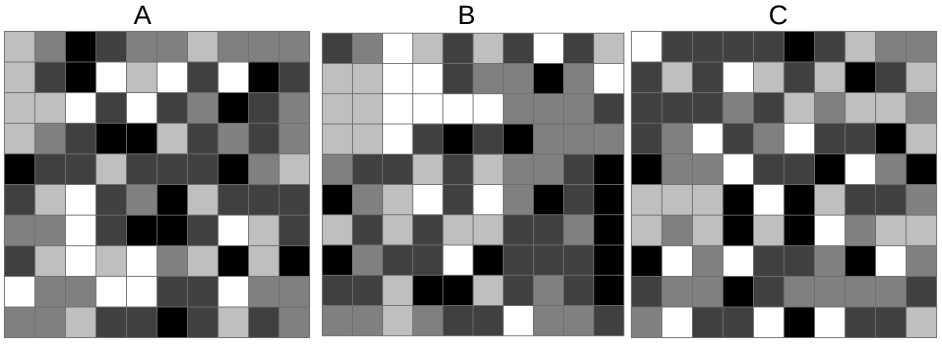
Conceptualization of Spatial Relationships

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

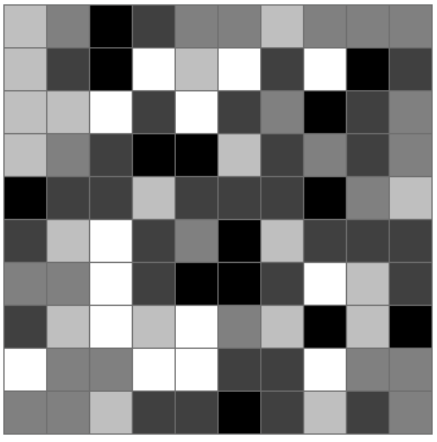
    PS = (M+1) / (R+1) x 100%

    M: number of instances that meet certain criteria

    R: total number of permutation instances

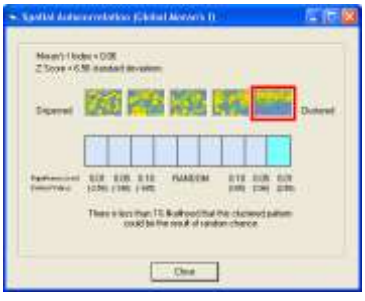
A. Random Pattern

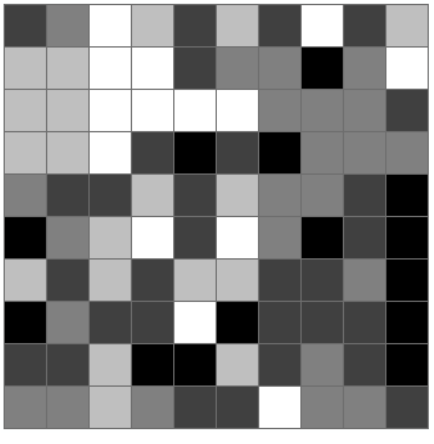
Global Moran's I Summary
Moran's Index: 0.000019
Z Score: 0.987484
p-value: 0.323405



B. Positive Spatial Autocorrelation

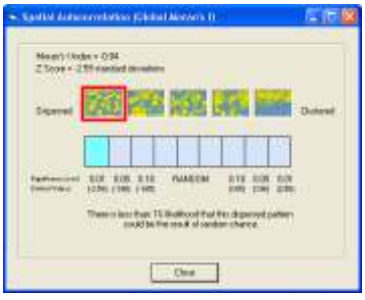
Global Moran's I Summary
Moran's Index: 0.057173
Z Score: 6.564235
p-value: 0.000000

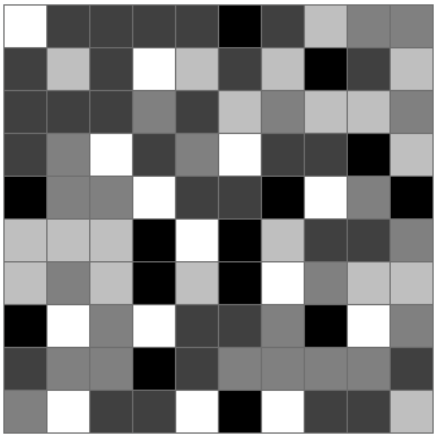




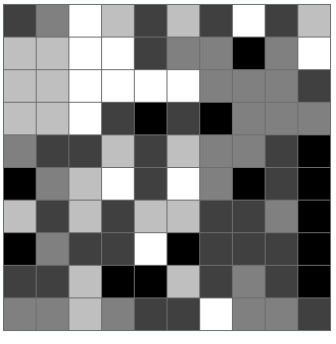
C. Negative Spatial Autocorrelation

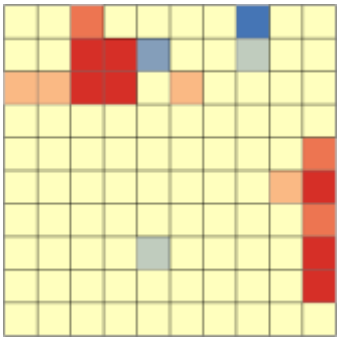
Global Moran's I Summary
Moran's Index: -0.036682
Z Score: -2.593673
p-value: 0.009496

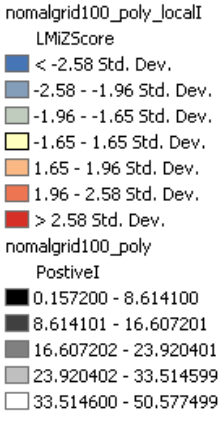




Local Moran's I: Local Indicators of Spatial Association (LISA)

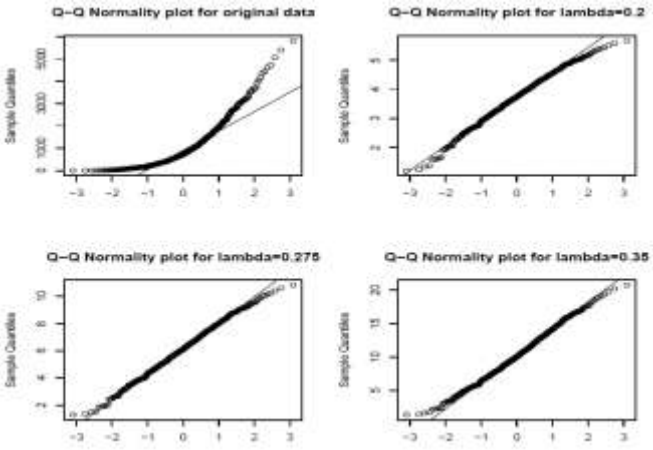




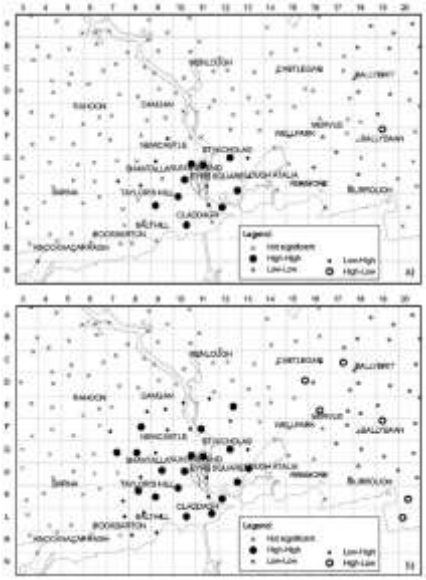


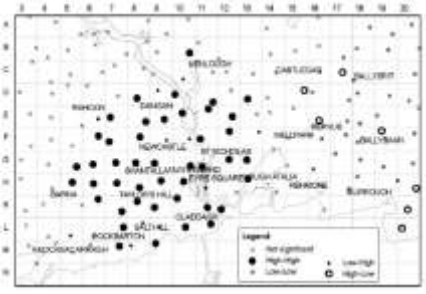
Transform Data to Normal Distribution

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



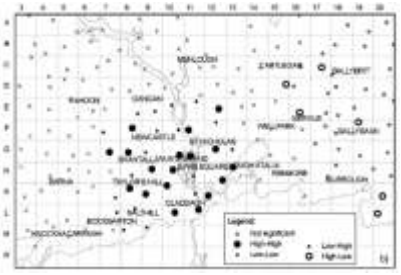
Results – Distance Bands

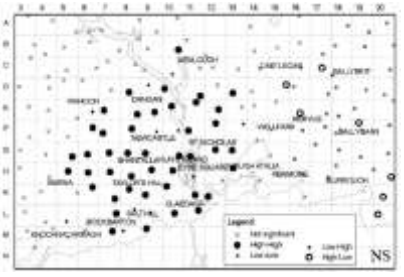


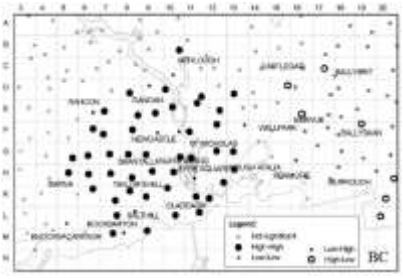


1000 m	5000 m
2000 m	

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.

Moran's scatterplot (available in Geoda)

- X axis: variable value at a location (e.g., Pb level)
- Y axis: spatial weighted average variable values of the neighbors of that location.