

GEOG 432/832: Programming, Scripting, and Automation for GIS

Unit 12.01: ESDA and spatial autocorrelation

Dr. Bitterman

Today's schedule

- Open discussion
- Slides, discussion, and exercises
- For next class

Open discussion

Building spatial weights matrices

Today's prep:

```
%matplotlib inline  
  
import seaborn as sns  
import pandas as pd  
from libpysal import weights  
from libpysal.io import open as psopen  
import geopandas as gpd  
import numpy as np  
import matplotlib.pyplot as plt
```

Verify all packages are in your environment

What's ESDA again?

Exploratory

Spatial

Data

Analaysis

Exploratory

- Focus on *discovery*
- No assumptions (or limited assumptions)
- Learn something about your data

Spatial

- Investigate patterns/processes with an emphasis on *geography* and *spatial relations*

Data analysis

- Descriptive analysis
- Statistical techniques
- Visualization

Questions that ESDA helps answer:

- Is the variable I'm looking at concentrated over space? Do similar values tend to locate closeby?
- Can I identify any particular areas where certain values are clustered?

Deeper:

- What is the causal process that generate this pattern?
- Why do we observe spatial clusters?
- Do any spatial outliers exist?

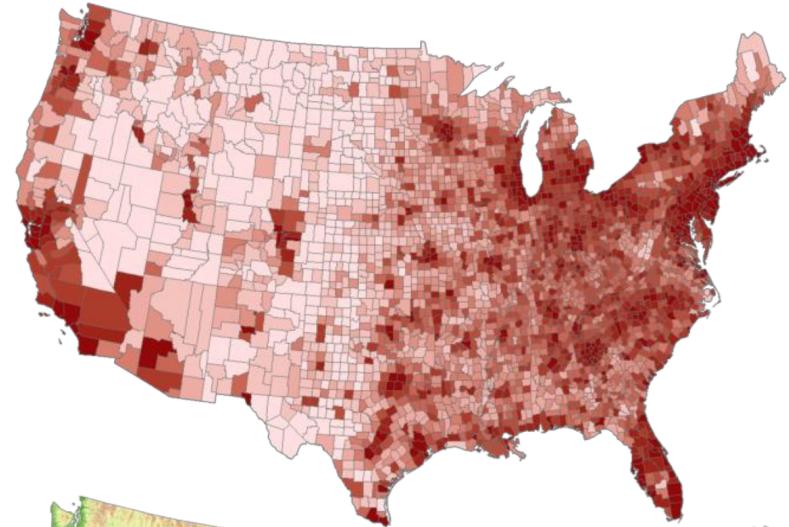
Spatial autocorrelation

- Statistical representation of Tobler's 1st law
- It's like traditional correlation... but spatial! ...and self-referenced

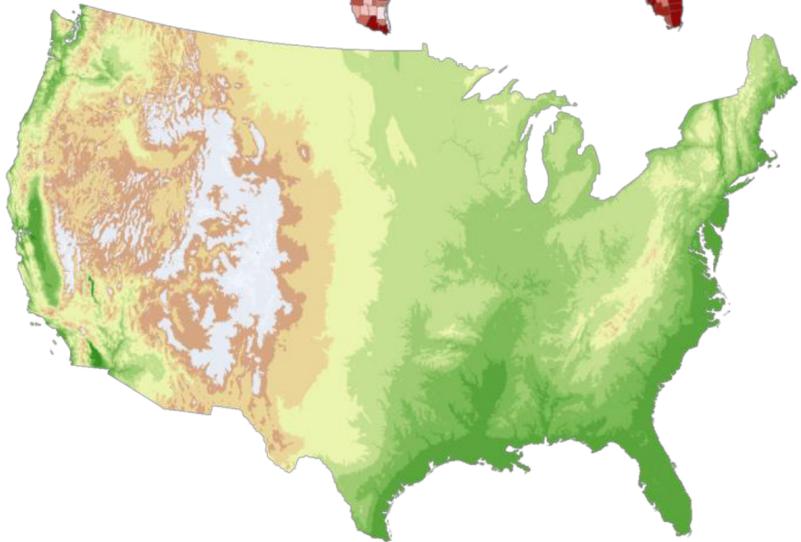
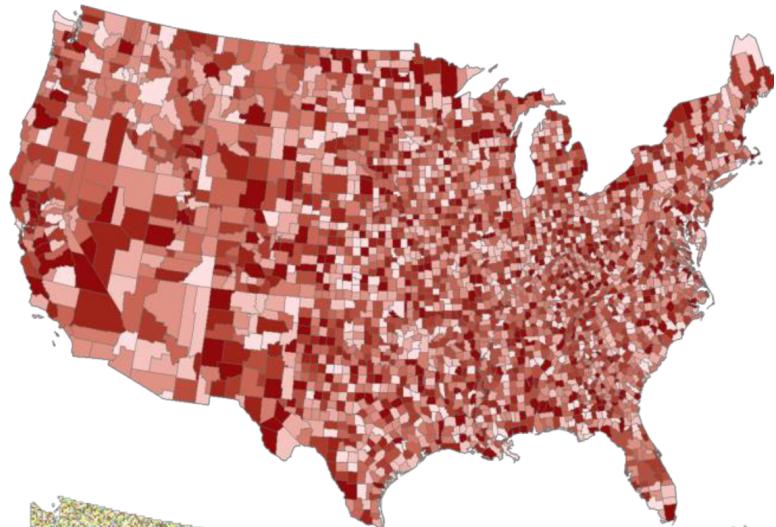
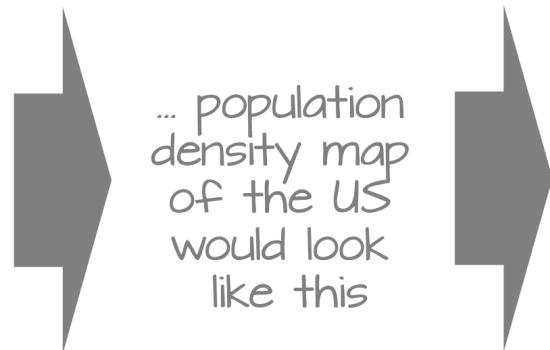
Degree to which similar values are located in similar regions

Two types:

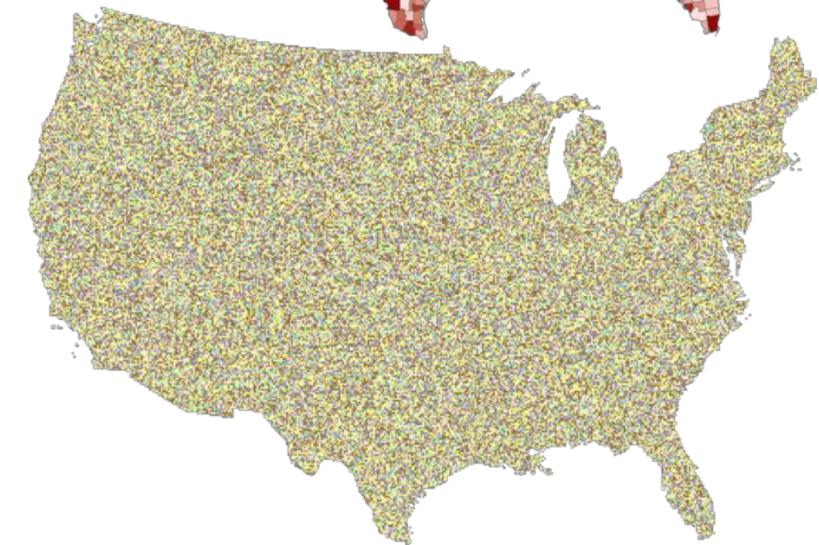
- Positive: similar values in a similar location (*closeby*)
- Negative: similar values in dissimilar locations (*farther apart*)



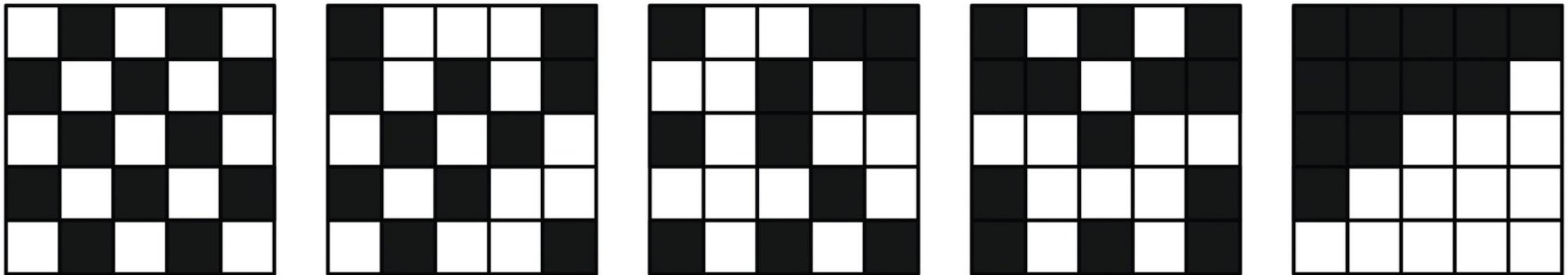
If features were
randomly distributed ...



... elevation map
of the US
would look
like this



Moran's I



$\text{Moran's } I < E(I)$
indicates tend
to dispersion

Random
 $\text{Moran's } I = E(I)$

$\text{Moran's } I > E(I)$
indicates tend
to clustering

Examples?

Positive?

Negative?

Examples?

Positive?

- income
- vegetation
- elevation
- temperature

Negative?

- Fire stations
- Hospitals
- Supermarkets

Scales of spatial autocorrelations

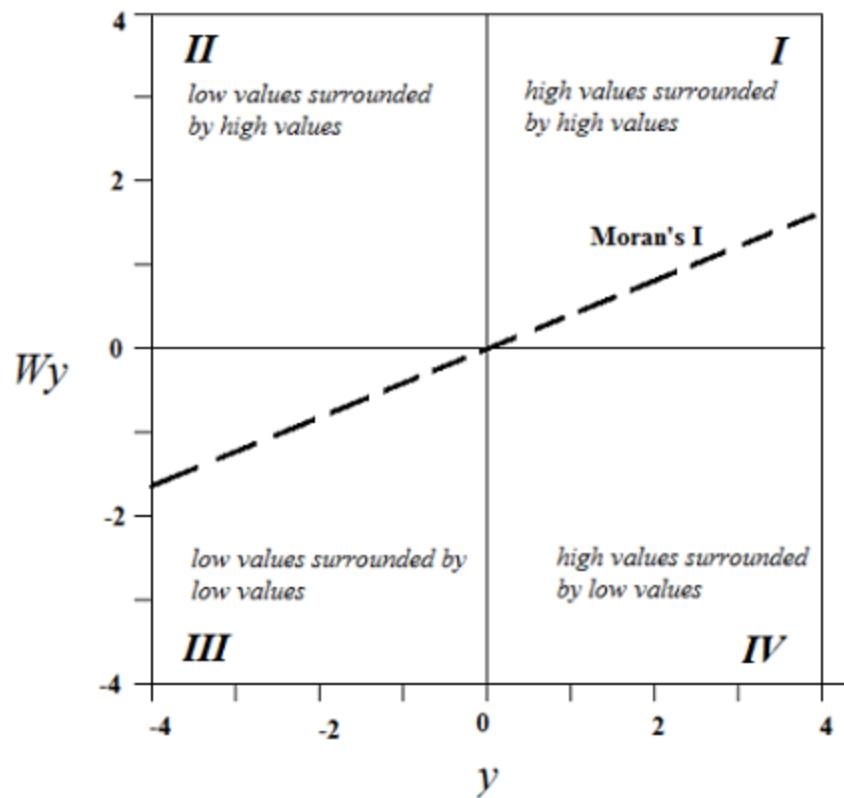
- "Global":
 - *Clustering* -> do values tend to be close to other (dis)similar values?
 - Describes the whole study area
- "Local":
 - *Clusters* -> are there any specific parts of a map with an extraordinary concentration of (dis)similar values?
 - Hotspots, coldspots, spatial outliers

Global spatial autocorrelation

Remember the Moran plot?

And what's "spatial lag" again?

Moran plot



Moran's I

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

where N is the number of spatial units indexed by i and j

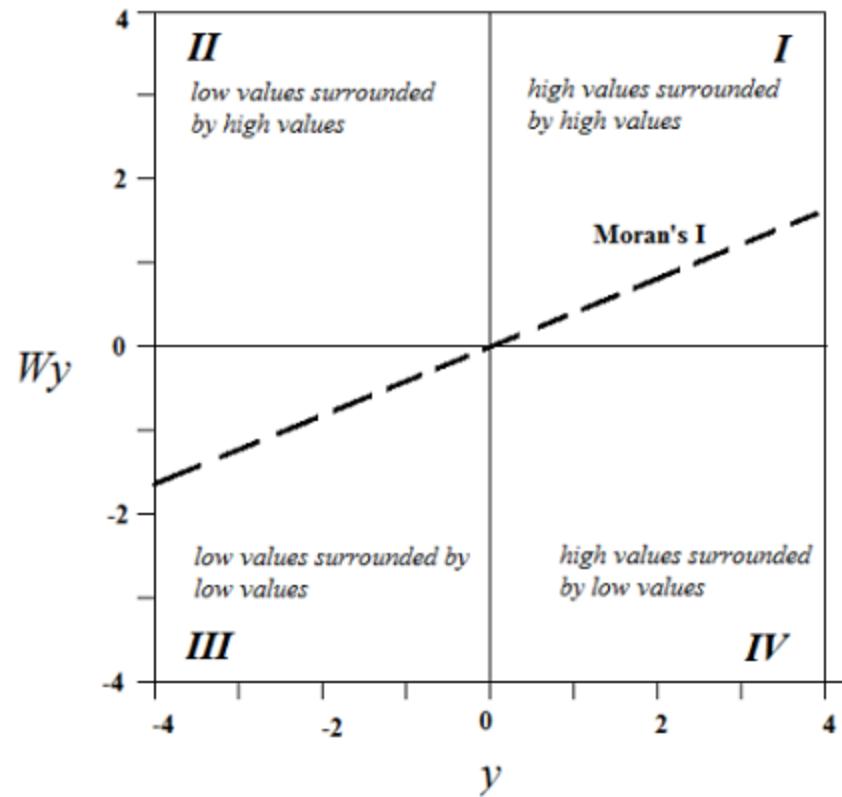
x is the variable of interest

\bar{x} is the mean of x

w_{ij} is a matrix of spatial weights with zeroes on the diagonal

W is the sum of all w_{ij}

Perhaps more simply (conceptually, at least)



The slope of the best fit line in the Moran plot

Local spatial autocorrelation

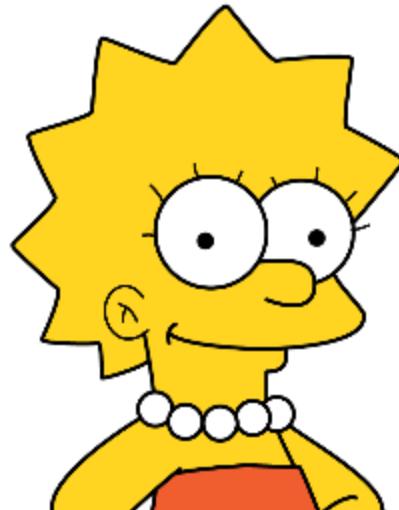
"Clusters", or *pockets of spatial instability*

Portions of a map where values are correlated in a particularly strong and specific way

- High-High + SA of *high* values (*hotspots*)
- Low-Low + SA of *low* values (*coldspots*)
- High-Low - SA (*spatial outliers*)
- Low-High - SA (*spatial outliers*)

LISAs

- Local Indicators of Spatial Association
- Statistical tests for spatial cluster detection → Statistical significance
- Compares the observed map with many randomly generated ones to see how likely it is to obtain the observed associations for each location



Let's try something in the time we have left

- download *unit12inclass.zip* from GitHub repository
- What does it contain?

How we got here

- Started with the *Counties* geodatabase from:
<https://www.census.gov/geographies/mapping-files/2010/geo/tiger-data.html>
- FAR too many columns to fit in a shapefile
- So I trimmed it down for the purposes of this class

Your job(s)... as a group?:

- Read the file
- Choose a reasonable index column
- Find the Median Income attribute (column)... HOW???
- Visualize it
- Create a weights matrix based on a *reasonable* conceptualization of a neighborhood.
How do you know what's *reasonable*?

We'll fiinish the spatial autocorrelation work next class

For next class

- Lab 6 due this week
- Lab 7 starts Friday
- Readings are linked/posted on Canvas...