GIST 4302/5302: Spatial Analysis and Modeling

Lecture 2: Review of Map Projections and Intro to Spatial Analysis

Guofeng Cao

http://www.spatial.ttu.edu

Department of Geosciences
Texas Tech University

guofeng.cao@ttu.edu

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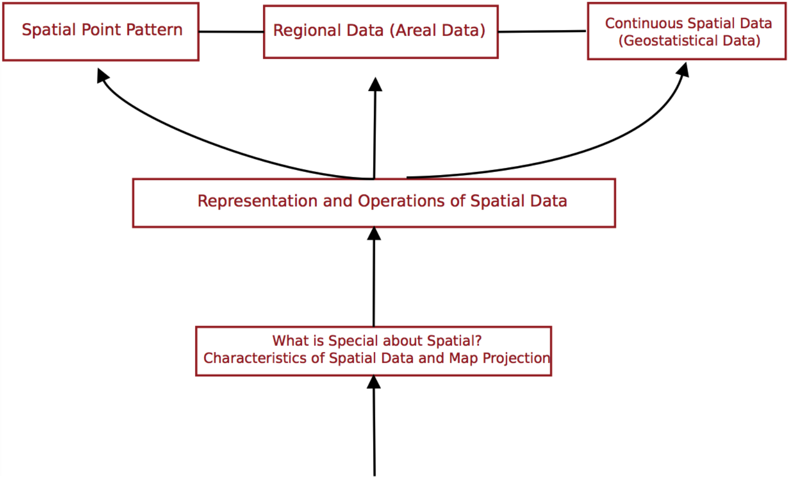
Course Outline



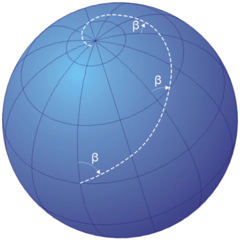
Map projections

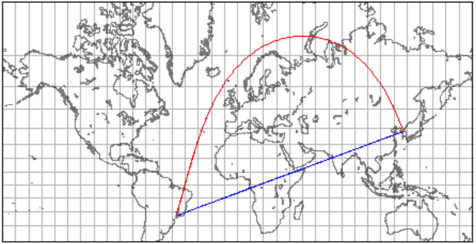
- Elements in map projections
  - Datum (e.g., WGS84$\sim$NAD 83, NAD 27)
  - Developable surfaces
  - Projection
- Distortions
  - shape (comformal), distance, area (equivalent), direction
  - distortions magnitude varies across a map
  - be careful of what you want to preserve

- A handy guide to a varieties of projections and their use: http://www.radicalcartography.net/index.html?projectionref, made by Bill Rankin

Mercator Projection

- One of the most commonly used map projections in wall maps
- Which of the following operations is/are suitable in Mercator projection?
  1. navigation
  2. distance measuring
  3. nearest neighbors
- Why the air flight traces are not straight lines on a map?
- What would it really look like if drawing a line on a map with Mercator projection?





Distortions of Mercator Projection

- It usually leads to distortions in terms of shape and area
- Online map websites (e.g., Google Maps, ArcGIS online) use Web Mercator, a variant of Mercator projection
- Mercator puzzle: `http://hive.sewanee.edu/pridepj0/286/mercatorMap.html`

Mercator Projection

- Africa in Mercator projection

Mercator Projection

- In fact, area of Africa is about 14 times of Greenland

Mercator Projection

- In fact, Africa is as big as the United States, China, India, Japan and all of Europe combined

Figure: Image courtesy: Kai Krause

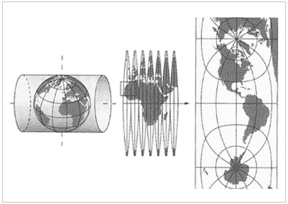
- Scene in TV show *West Wing*:
  https://www.youtube.com/watch?v=n8zBC2dvERM

Gall-Peters Projection

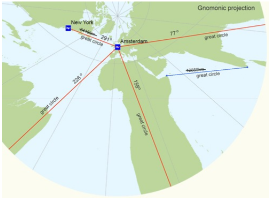
- Peters projection mentioned in the video
- Equal-area

Other Commonly Used Projections

- UTM (Universal Traverse Mercator)



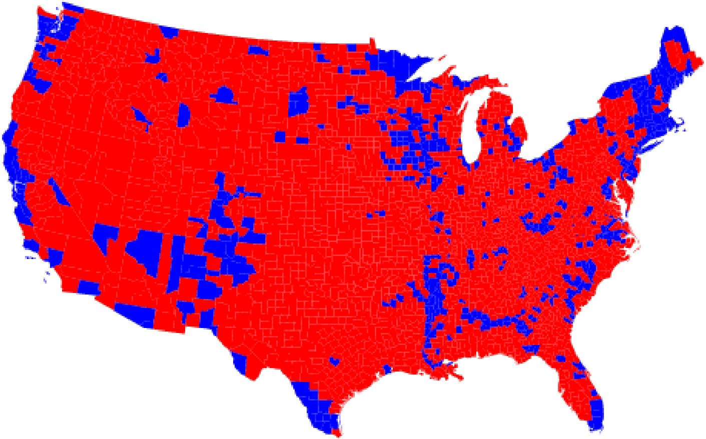
- Gnomonic (great circles as straight lines)



- Equal-area (e.g.,Lambert, Albers)

Cartogram

- County map of 2004 US presidential election result



Cartogram

- *Equal-density* cartogram of 2004 US presidential election result

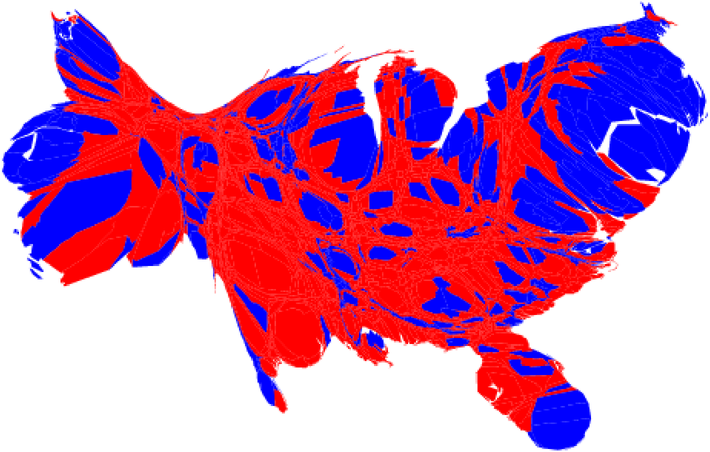


Figure: Image courtesy: Gastner, Shalizi,and Newman

Cartogram

- *Equal-density:* cartogram of world population in the year of 2000

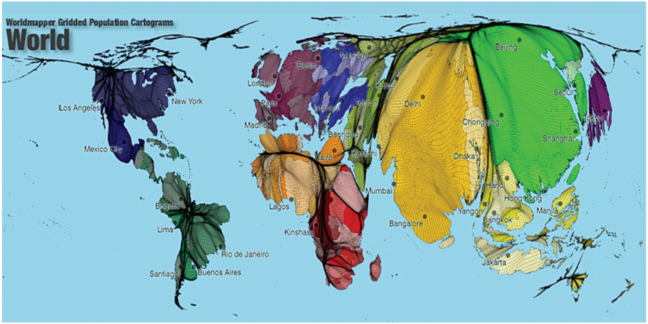


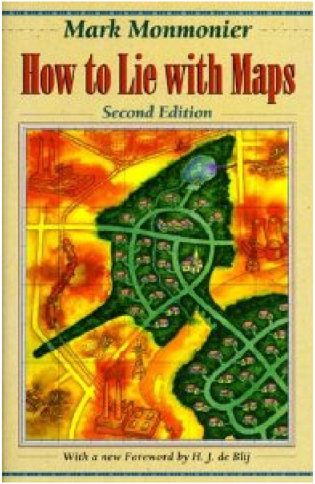
Figure: Image courtesy: ESRI

Measures and Map Projections

- Comparing results of volume measures (e.g., length and area) in different map projections http://servicesbeta.esri.com/demos/compareMeasurements.html

Maps Lie

Maps could lie, be citical when reading them!!



Introduction to Spatial Analysis and Modeling

Components of Spatial Analysis and Modeling

- Data do not equal information
- Components of spatial analysis (geospatial data in particular)
  - Visualization: Showing interesting patterns (mapping, geovisualization)
  - Exploratory spatial data analysis: Finding interesting patterns
  - Spatial modeling, regression: Explaining interesting patterns

Scope of Spatial Analysis and Modeling

- Type of spatial data analysis
  - Spatial data manipulation (in GIS)
    - Spatial query, measurements, transformation, network analysis, location analysis (spatial optimization) ...
  - Spatial data analysis
    - Exploratory spatial analysis
    - Visual analytics
    - Data-driven, let data speak themselves
  - Spatial statistics
    - An extension of traditional statistics into a spatial settings to determine whether or not data are typical or unexpected
    - Geostatistics: Quantify the spatial relationships between observations of different locations for estimation of unknown locations
  - Spatial modeling
    - Involves constructing models to predict spatial outcomes
    - Only focus on spatial statistical modeling

Topics

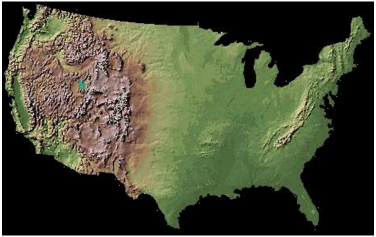
- Spatial data representation and manipulation
  - Buffer, spatial query, overlay analysis (lab 2-3)
  - Surface analysis and map algebra (lab 4)
  - Model builder (lab 5)
  - Geocoding (lab 6)
- Point pattern analysis (lab 7)
- Spatial statistics
  - Spatial autocorrelation (lab 8)
  - Spatial regression (lab 9)
- Spatial interpolation
  - Deterministic interpolation (lab 10)
  - Kriging (lab 10)
- Spatial uncertainty

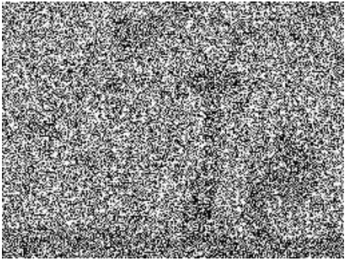
Characteristics of (Geographic) Spatial Data

1. Spatial (and temporal) Context: "Everything is related to everything else, but near things are more related than distant things"
    - Waldo Toblers First Law (TFL) of geography
    - nearby things are more similar than distant things
    - phenomena vary slowly over the Earth's surface
    - Compare time series

Characteristics of (Geographic) Spatial Data

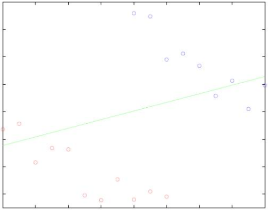
- Implication of Tobler's First Law (TFL)
    - We can do samplings and fill the gap using estimation procedures (e.g. weather stations)
    - Spatial patterns
    - Image a world without TFL:
        - White noise
        - No lines, polygons or geometry (how to draw a polygon on a white noise map?)



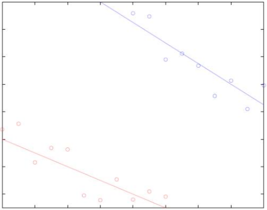


Characteristics of (Geographic) Spatial Data

2. Spatial heterogeneity
    - "Second law of geography" (Goodchild, UCGIS 2003)
    - Earths surface is non-stationary
    - Laws of physical sciences remain constant, virtually everything else changes
        - Elevation,
        - Climate, temperatures
        - Social conditions
    - Implications
        - Global model might be inconsistent with regional models
        - Spatial Simpsons Paradox (a special case of modifiable areal unit problem, which we will discuss more in the later of this class)



(a) Global Model



(b) Regional Models

Side note: example of Simpson's paradox

- Simpson's paradox usually fools us on tests of performance in real life
- The following is a real life example. Comparison of recovery rates between a new treatment and a traditional treatment for kidney stones.

	New Treatment	Traditional Treatment
Small Stones	93%(81/87)	87%(234/270)
Large Stones	73%(192/263)	69%(55/80)
All	78%(273/350)	83%(289/350)

- Comparison of batting average of two baseball players:

	1996	1997	Combined
Derek Jeter	25.0%(12/48)	31.4%(183/582)	31.0%(195/630)
David Justice	25.3%(104/411)	32.1%(45/140)	27.0%(149/551)

Characteristics of (Geographic) Spatial Data

- In a spatial settings, it is related to modifiable areal unit problem (MAUP) or omitted variable problem, which will discuss more in the later of this class

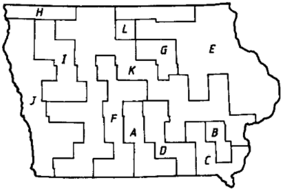


Figure 2a. Zoning system that minimises the regression slope coefficient (-24, r = -.25)

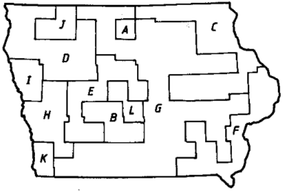


Figure 2b. Zoning system that maximises the regression slope coefficient (12, r = .87)

Figure: Image Courtesy of OpenShaw

Characteristics of (Geographic) Spatial Data

3. Fractal behavior
    - What happens as scale of map changes?
    - Coast of Maine
- Implications
    - Scale is critical for the problem of study
    - Volume of geographic features tends to be underestimated
        - length of lines
        - area of polygons
    - Think of the difference of distances that an ant and elephant needed to travel from where I stand to the center of memorial circle

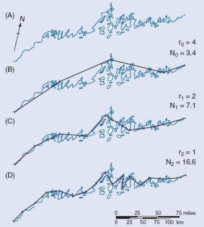


Figure 4.18 The coastline of Maine, at three levels of recursion: (A) the base curve of the coastline; (B) approximation using 100 km steps; (C) 50 km step approximation; and (D) 25 km step approximation

Microscale or Macroscale

Please try to tell whether the following maps are micro- or macro-scale:

- https://weather.com/science/news/macro-or-micro-can-you-tell-these-images-apart-20131107

Summary: three interrelated characteristics of spatial data

- Spatial context/spatial pattern/spatial structure/spatial dependence/spatial texture..
- Spatial heterogeneity/locality
- Fractal behaviors/scaling effects