

Geographic Information System (GIS)

IS 454

Lecture 3: The Nature of Geographical Data

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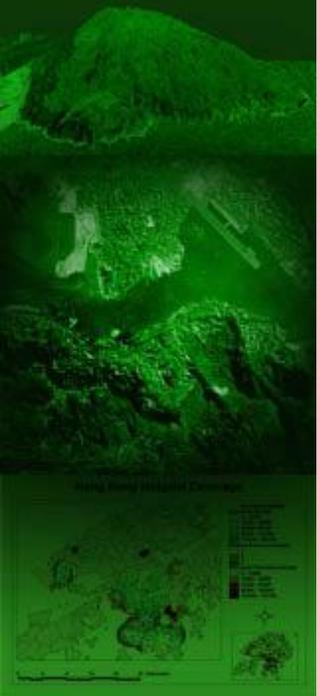
The Nature of Geographical Data

- ☞ Geographical phenomena
- ☞ Spatial autocorrelation and scale
- ☞ Spatial sampling
- ☞ Spatial interpolation
- ☞ Uncertainty of geographical data



Geographical phenomena

- ☐ Our behaviour in space often reflects past patterns of behaviour.
- ☐ Some geographical phenomena vary smoothly across space, while others may not.
- ☐ The first law of geography: everything is related to everything else, but near things are more related than distant things.
 - ☐ This property is known as **spatial autocorrelation**.



Spatial autocorrelation and scale

☞ Spatial autocorrelation:

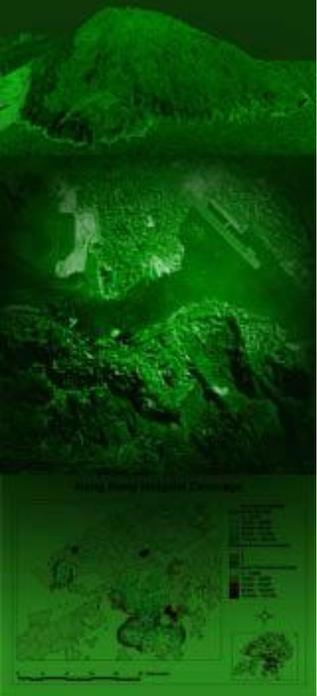
- ☐ Measurements on how near and distant things are interrelated.

☞ Temporal autocorrelation:

- ☐ The relationship between consecutive events in time.

☞ Examining spatio-temporal processes:

- ☐ explanation in time need only look to the past, but
- ☐ explanation in space must look in all directions simultaneously.



Spatial autocorrelation and spatial objects

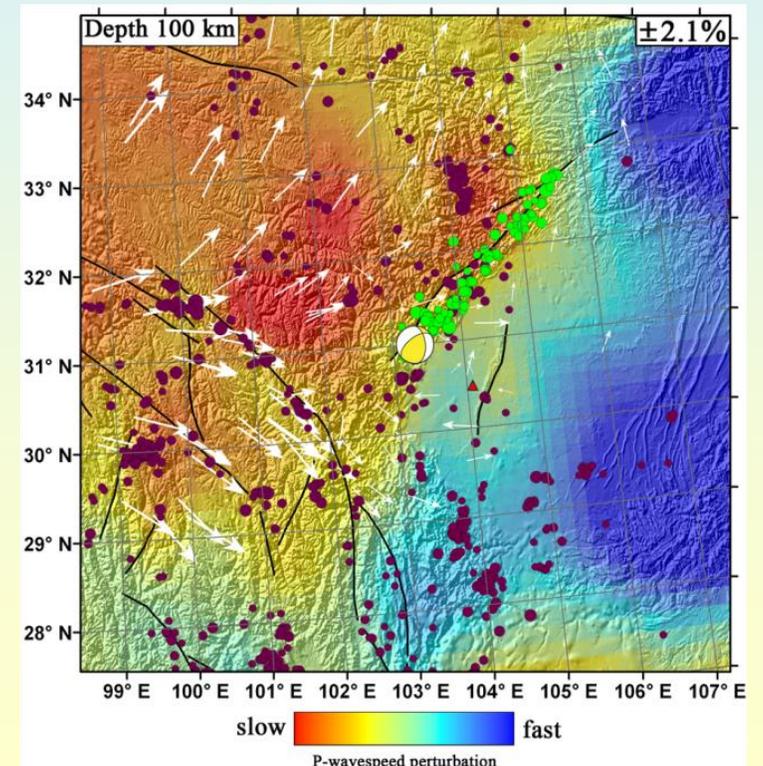
- ❏ Spatial autocorrelation deal simultaneously with similarities in the location of **spatial objects**.
- ❏ It is determined both by similarities in **position**, and by similarities in **attributes**
- ❏ Indices are used to measure spatial autocorrelation of objects.
 - ❑ Moran's I
 - ❑ Geary's C
 - ❑ Ripley's K

Types of spatial objects

- ☐ Spatial objects are classified according to their topological dimension, which provides a measure of the way they fill space.
- ☐ Point – dimension 0
- ☐ Line – dimension 1
- ☐ Area – dimension 2
- ☐ Volume – dimension 3
- ☐ Time – usually considered to be the fourth dimension of spatial objects, although GIS is currently incapable of dealing with it properly.

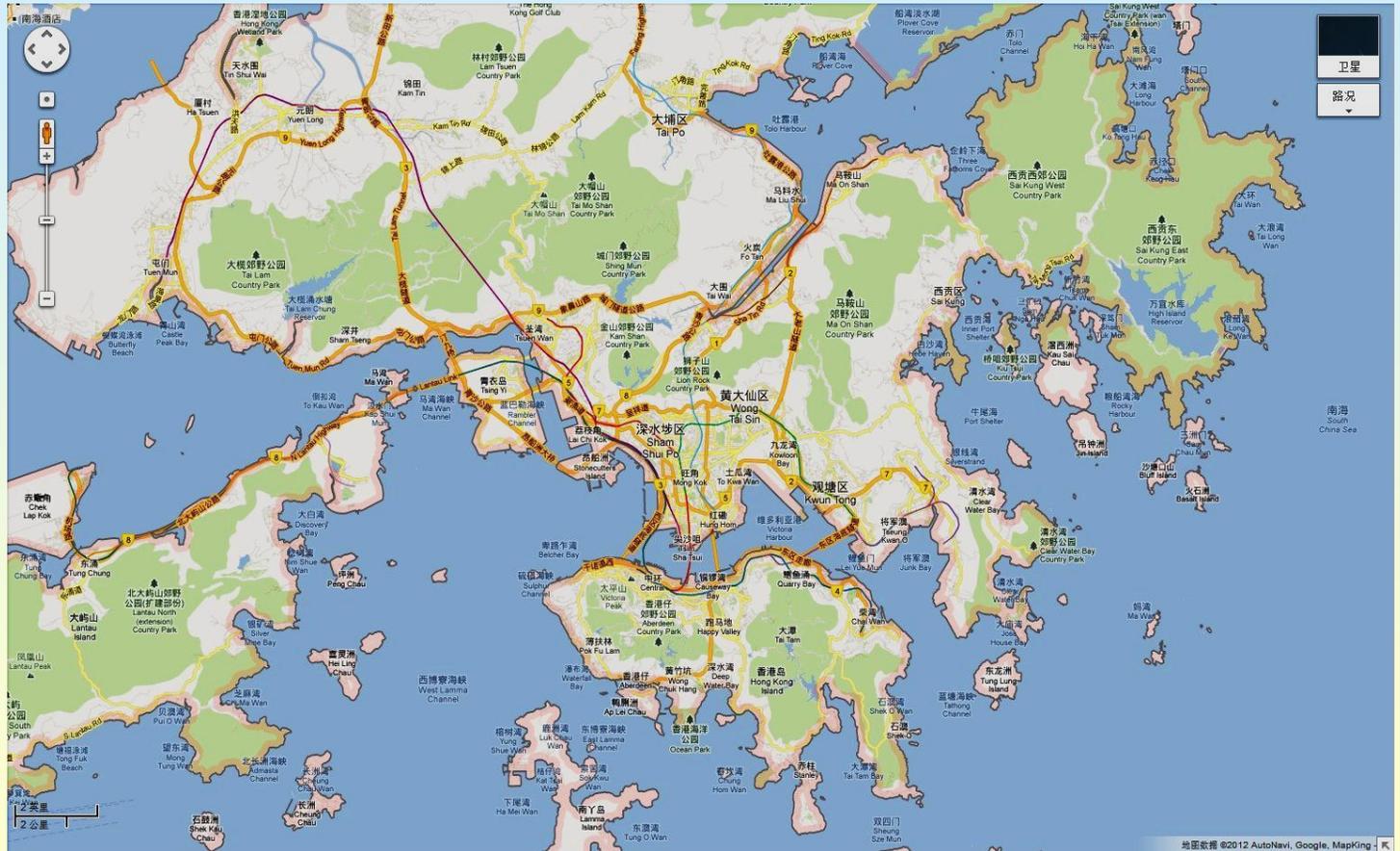
Point

- ☞ A point object has neither length nor breadth nor depth.
- ☞ May be used to indicate spatial occurrences or events, and their spatial pattern.



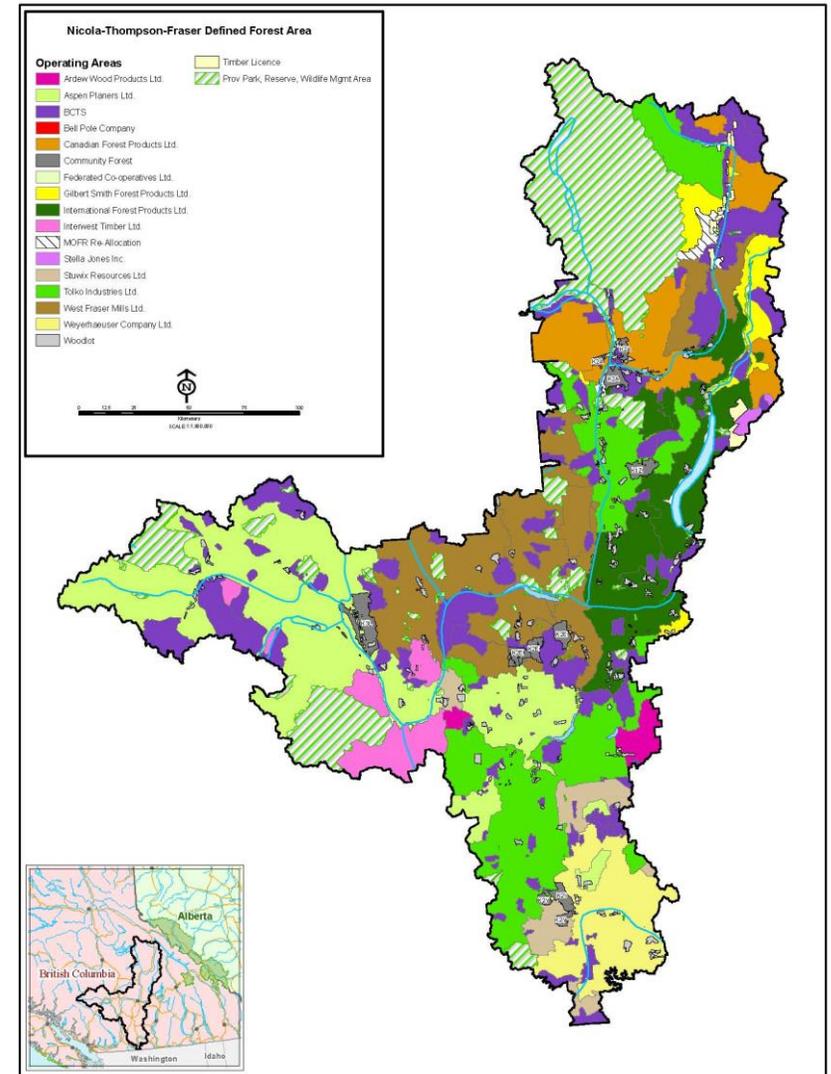
Line

- ☞ A line object has length, but not breadth or depth.
- ☞ Used to represent linear entities that are frequently built together into networks.
- ☞ Also used to measure distances between spatial objects.



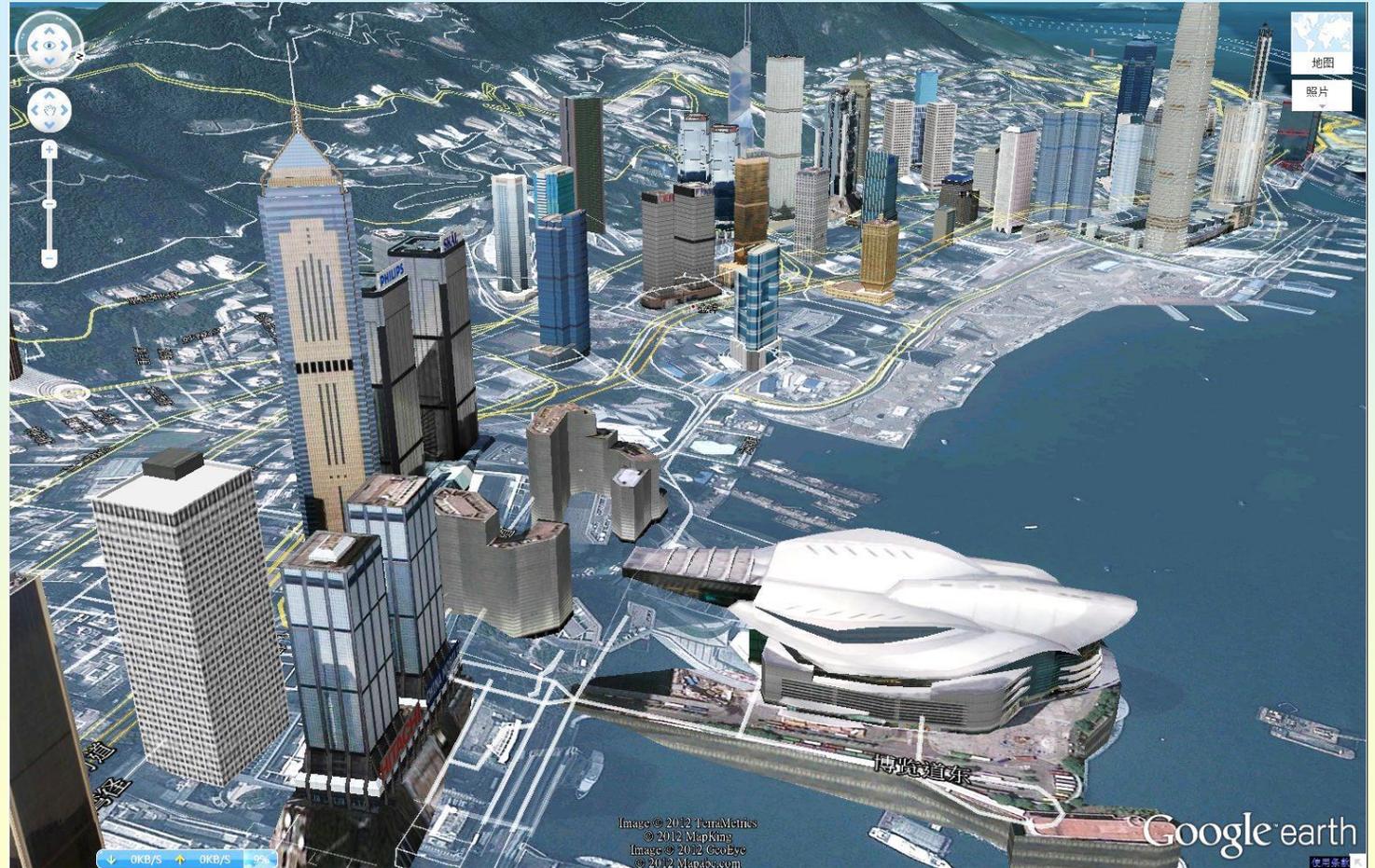
Area

- ❏ An area object has two dimension, length and breadth, but not depth.
- ❏ Represents enclosed areas of natural or artificial objects.



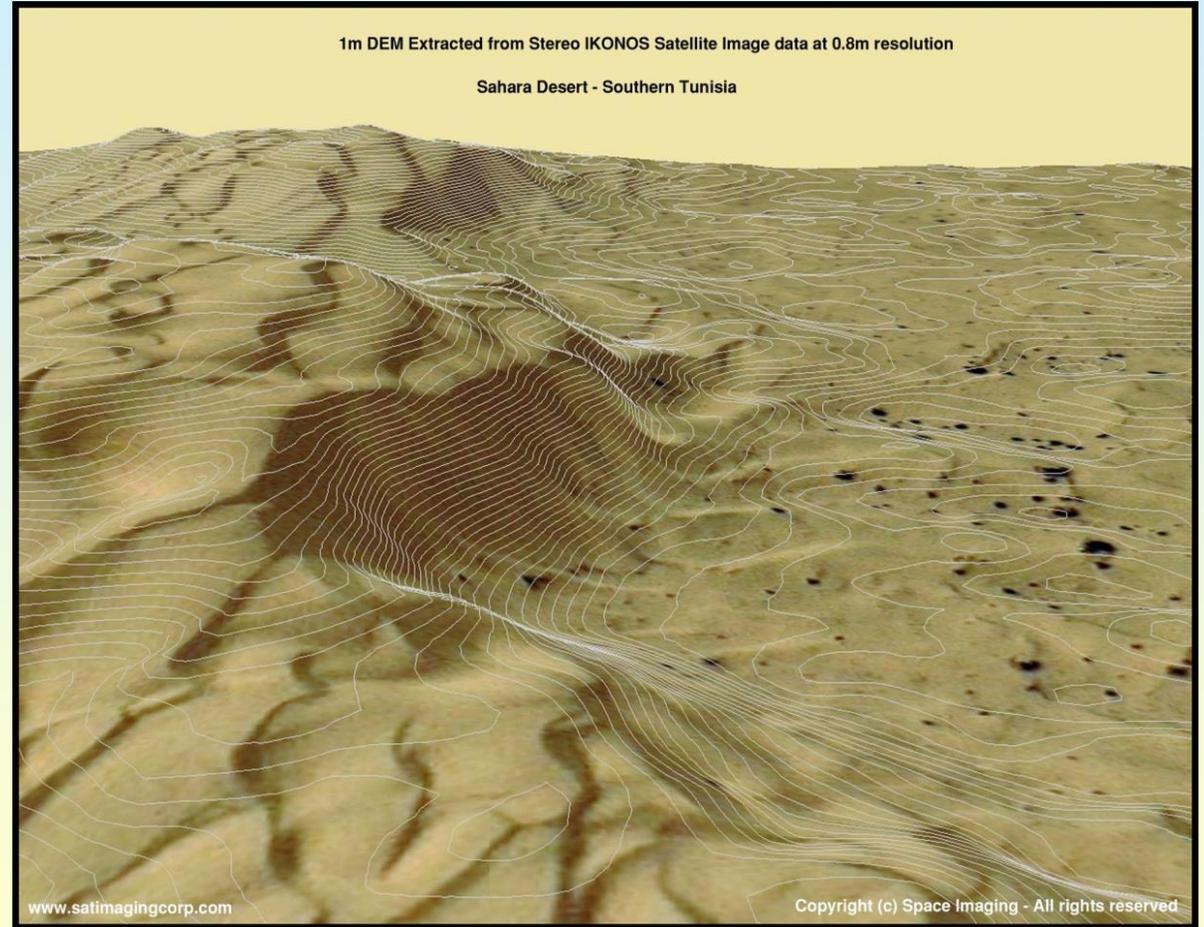
Volume

- ☐ A volume object have length, breadth and depth.
- ☐ Used to present natural (e.g. mine bodies and buildings) or artificial objects.



Surface

- ❏ A surface is a kind of volume object but its depth is actually the spot height of the surface.
- ❏ Used to present natural or statistical surface objects.



Types of attributes

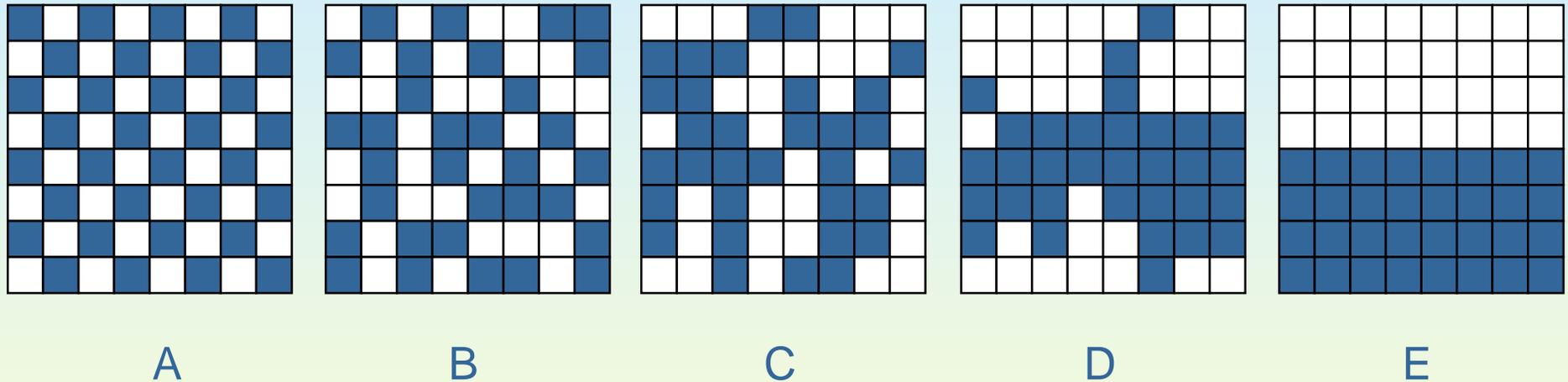
- ☞ Normal attribute types
 - ☐ Nominal
 - ☐ Ordinal
 - ☐ Interval
 - ☐ Ratio
- ☞ Categories beyond the normal types
 - ☐ E.g. cyclic (0 – 360°)
 - ☐ Average of 1° and 359° = ?

Positive, negative and zero spatial autocorrelation

- ☐ **Positive**: features are similar in location are also similar in attributes.
- ☐ **Negative**: features that are close together in space tend to be more dissimilar in attributes than features that are further apart.
- ☐ **Zero**: attributes are independent of location.



Spatial autocorrelation

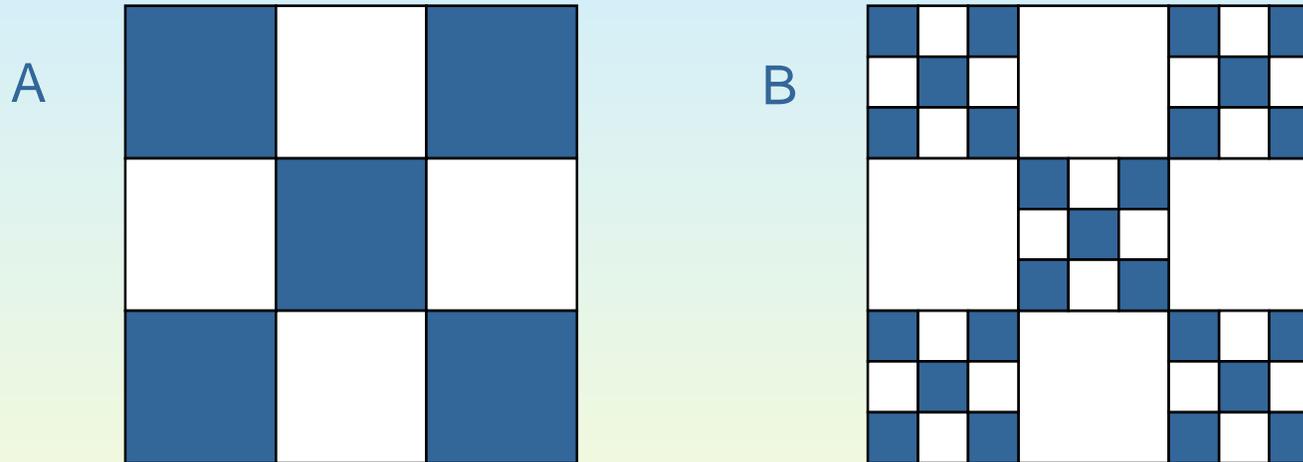


(A) Extreme negative spatial autocorrelation; (B) a dispersed arrangement; (C) spatial independence; (D) spatial clustering; and (E) extreme positive spatial autocorrelation.

The meaning of scale

- ☞ Level of spatial detail in data
- ☞ Geographical extent or scope of a project
 - ☐ e.g. a large-scale project covers a large area.
 - ☐ A small-scale project covers a small area.
- ☞ Scale of a map: representative fraction (RF)
- ☞ Scale is often integral to the trade off between the level of spatial resolution and the degree of attribute detail that can be handled for a given application.

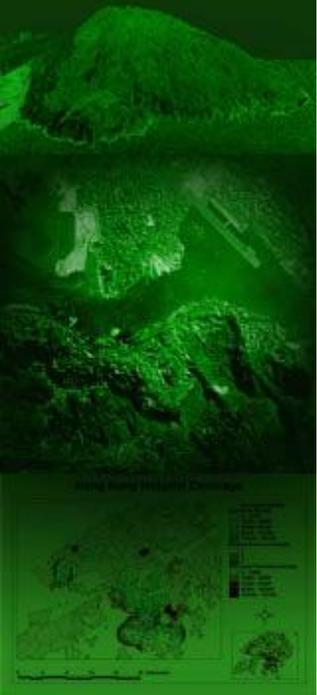
Level of resolution



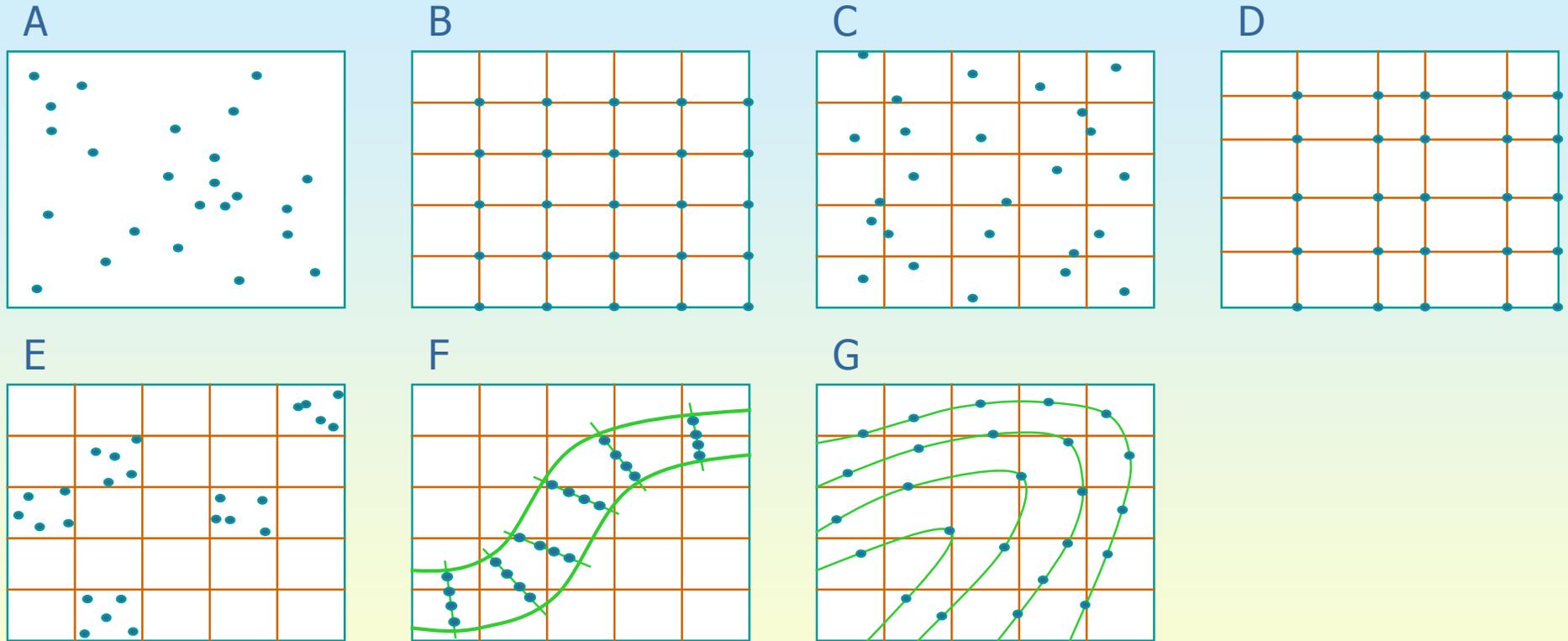
(A) A coarse-scale representation of attributes in a pattern of negative spatial autocorrelation. (B) The pattern of spatial autocorrelation at the coarser scale is replicated at the finer scale. The overall pattern is said to exhibit the property of **self-similarity**.

Spatial sampling

- ❏ Self-similar structure is characteristic of natural as well as social systems.
 - ❑ A rock may resemble the physical form of the mountain.
 - ❑ A small group 'typical' people's opinion may resemble that of the society.
- ❏ Sampling is therefore the typical way to gain geographical data.
- ❏ Geographical data are only as good as the sampling scheme used to create them.



Spatial sampling schema



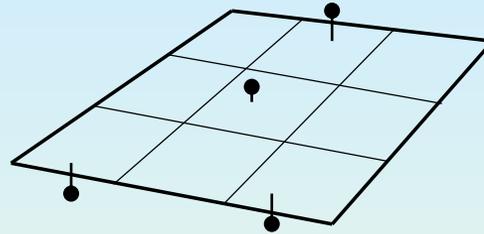
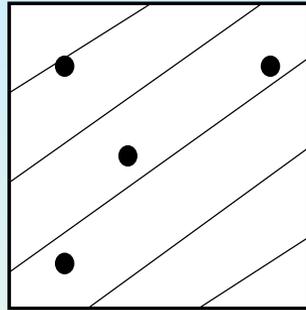
Spatial sample designs: (A) simple random sampling; (B) systematic sampling; (C) systematic sampling with local random allocation; (D) systematic sampling with random variation in grid spacing; (E) clustered sampling; (F) transect sampling; and (G) contour sampling.

Spatial interpolation

- ☐ In sampling, part of reality to hold within our representation.
- ☐ Judgement is required to fill in the gaps between the observations.
- ☐ This requires understanding of the likely attenuating effect of distance between samples.
- ☐ The function that fills the gaps is known as **interpolation** function.

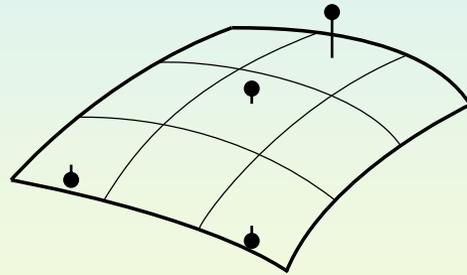
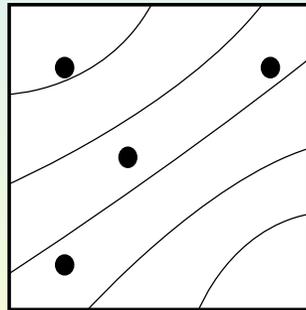
Interpolation function

Linear



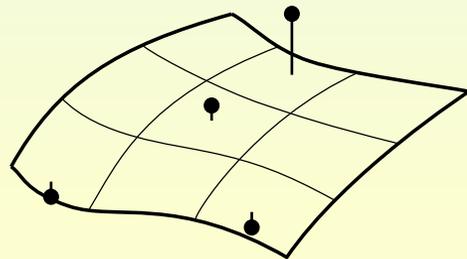
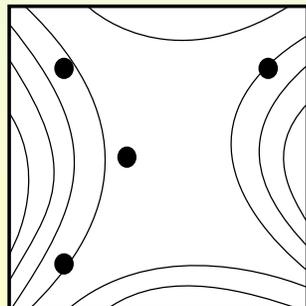
$$f(X, Y) = b_0 + b_1X + b_2Y$$

Quadratic



$$f(X, Y) = b_0 + b_1X + b_2Y + b_3X^2 + b_4XY + b_5Y^2$$

Cubic



Generic form:

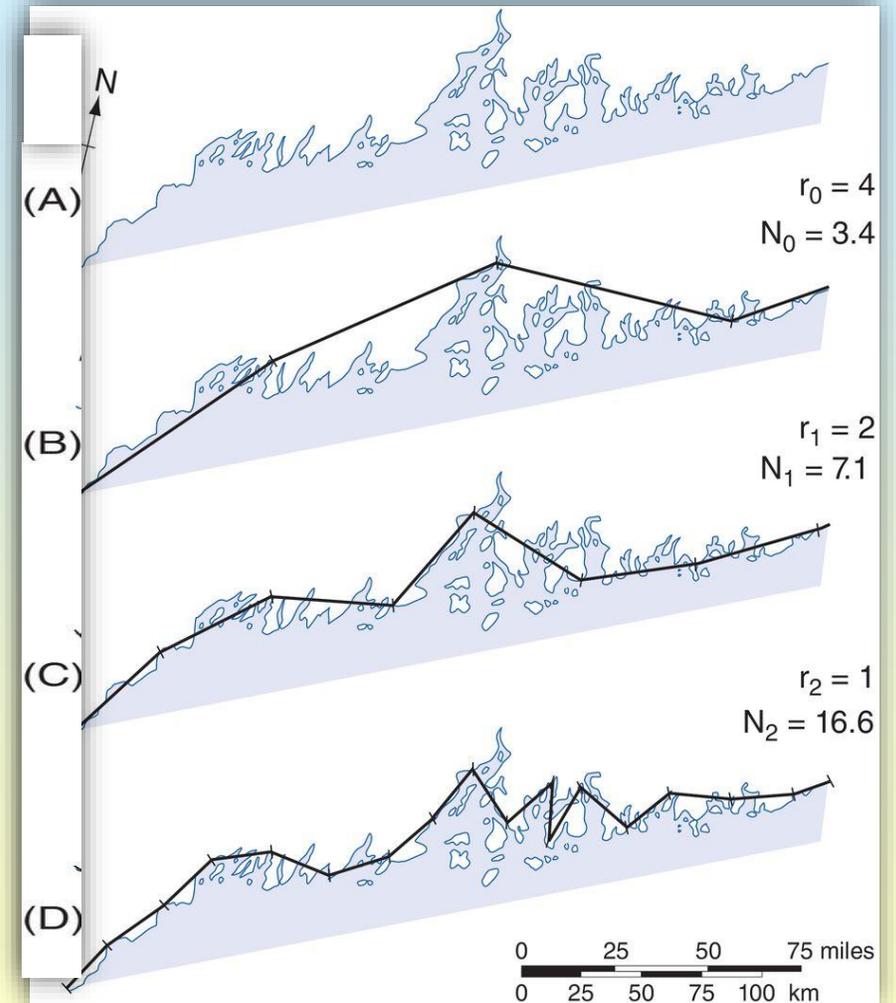
$$f(X, Y) = \sum_{r+s \leq p} b_{rs} X^r Y^s$$

The length of coast line problem

- How long is a coast line?
 - Indeterminate
 - Scale-dependent

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.

(Source: Longley et al. 2016, pp52)



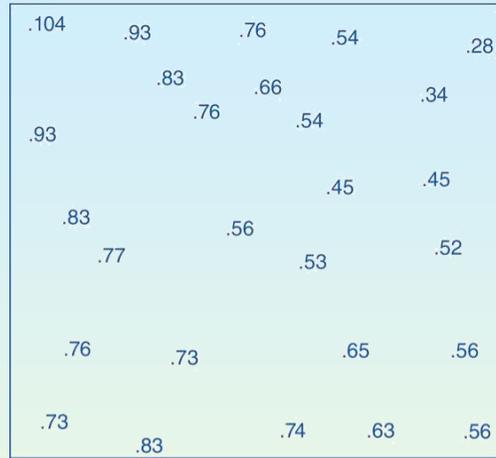
Example of Coast line



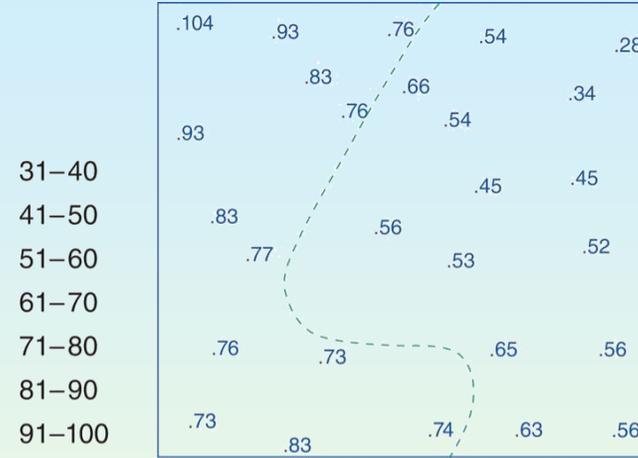
Coast line of a city: The length of the coastline increases with the increasing level of details and scale. The precise length of the coast line is indeterminate.



H.W: Write a report to explain how the temperature is visualized ?

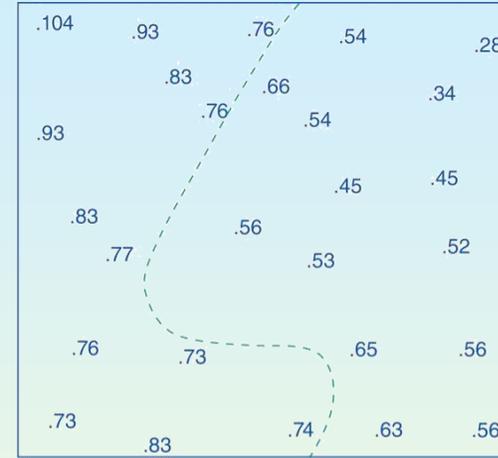


(A)

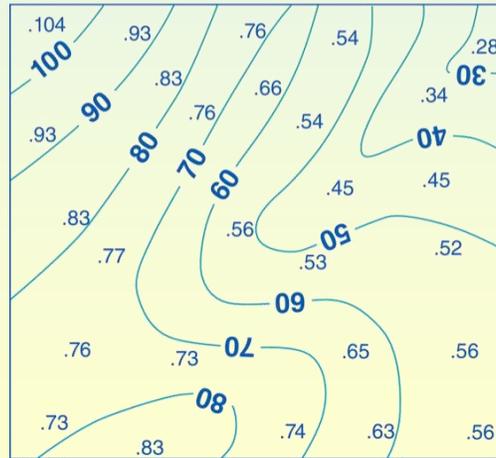


31-40
41-50
51-60
61-70
71-80
81-90
91-100

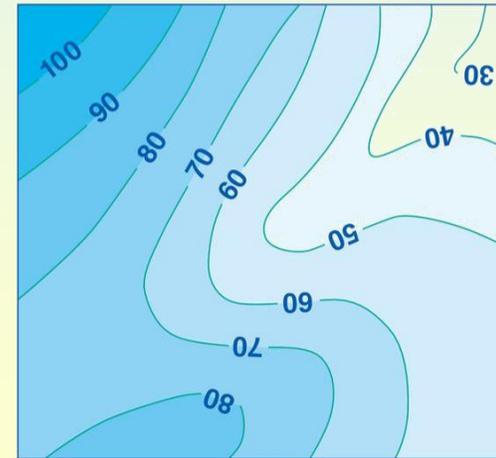
(B)



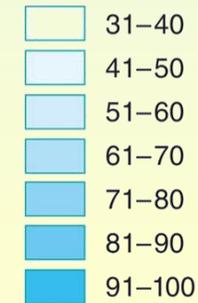
(C)



(D)



(E)



Summary

- ❏ The law of geography states the property of spatial autocorrelation.
- ❏ Spatial autocorrelation is the measurements on how near and distant things are interrelated.
- ❏ Spatial objects are classified according to their topological dimension, which provides a measure of the way they fill space.
- ❏ Geographical data are only as good as the sampling scheme used to create them.
- ❏ Interpolation is the function that fills the gaps in samples.