



Geographic Phenomena - Concepts and Examples

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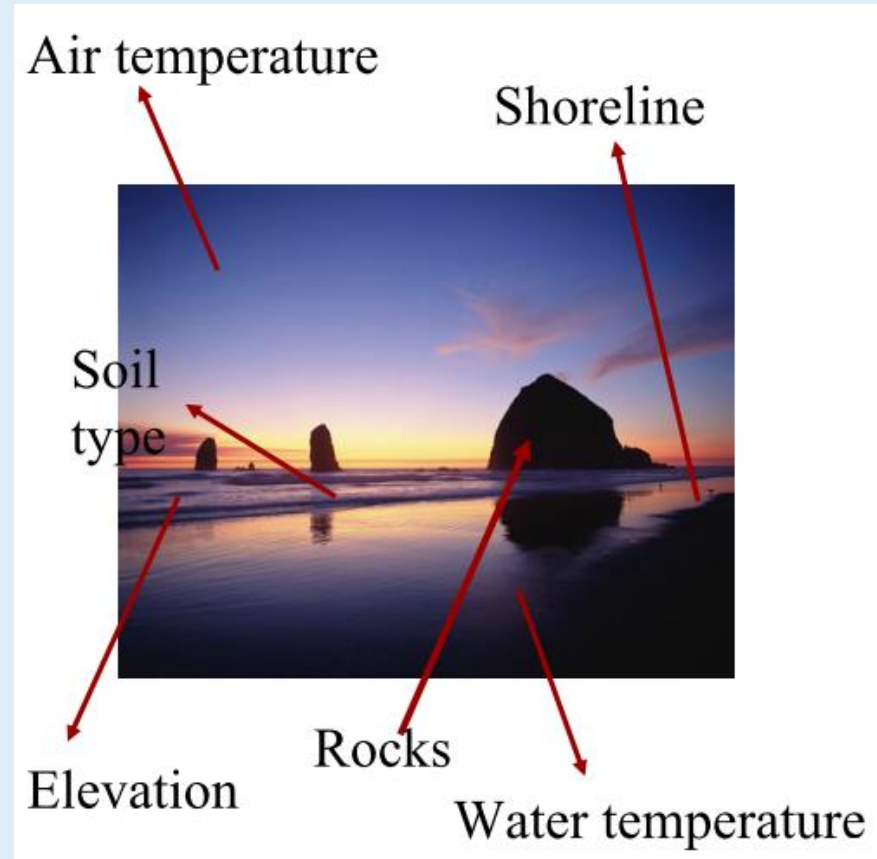
*Online Certificate Course on “Remote Sensing & GIS Technology and Applications”
for University Teachers & Government Officials (June 13 -July 01, 2020)
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Introduction

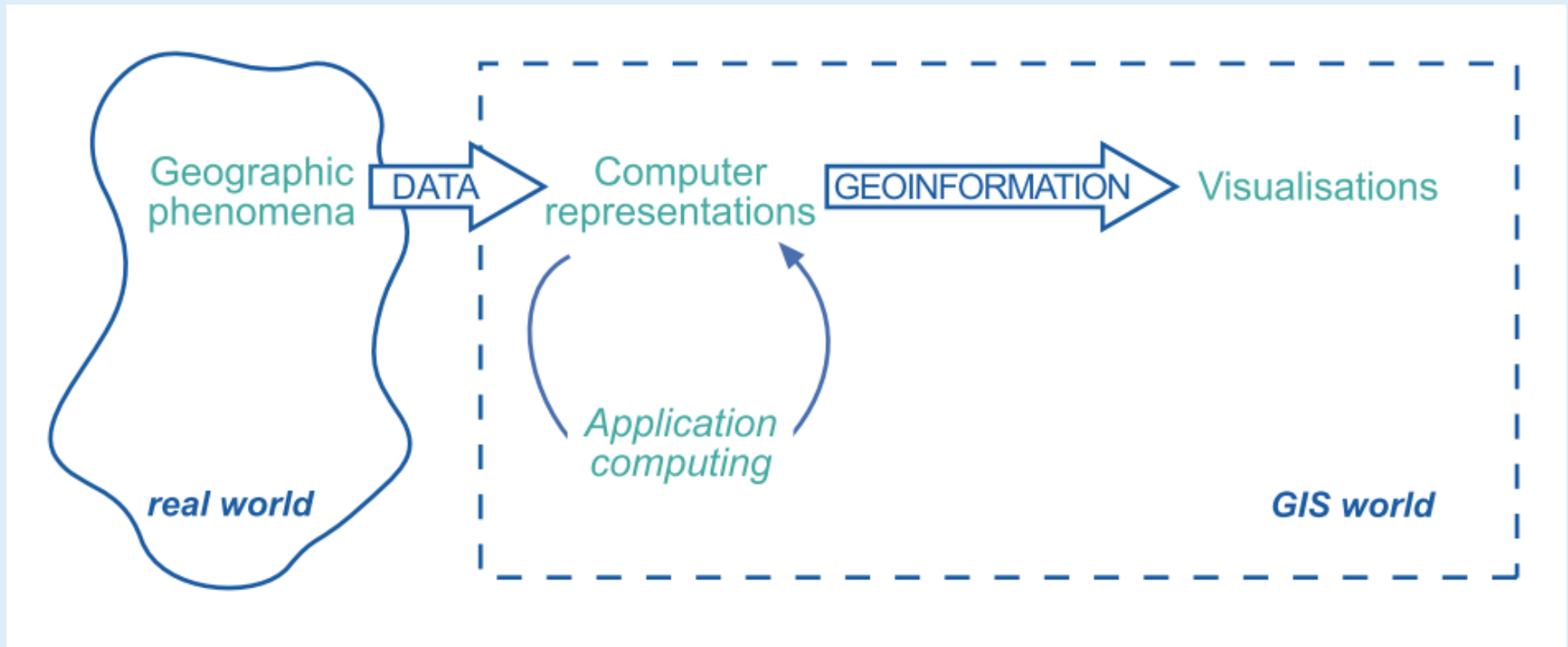
Geographic phenomena are the study objects of a GIS.

Geographic phenomena exist in the real world, everything you see outside is a Geographic phenomenon.

Some of the things you do not see are also Geographic phenomena like temperature.



Real world → Spatial data



Data model represents the linkages between **the real world domain of geographic data** and the computer or GIS representation of these features (*Marble et al, 1982*).

Geographic phenomena

A geographic phenomenon is a manifestation of an entity or process of interest that:

- Can be **named** or described
- Can be **geo-referenced**
- Can be assigned a **time** interval at which it is/was present

Description: IIRS Main Building

Location: 30°20'27.1"N 78°02'39.0"E

Established in: 1966

Courses: M.Tech., M.Sc. etc.



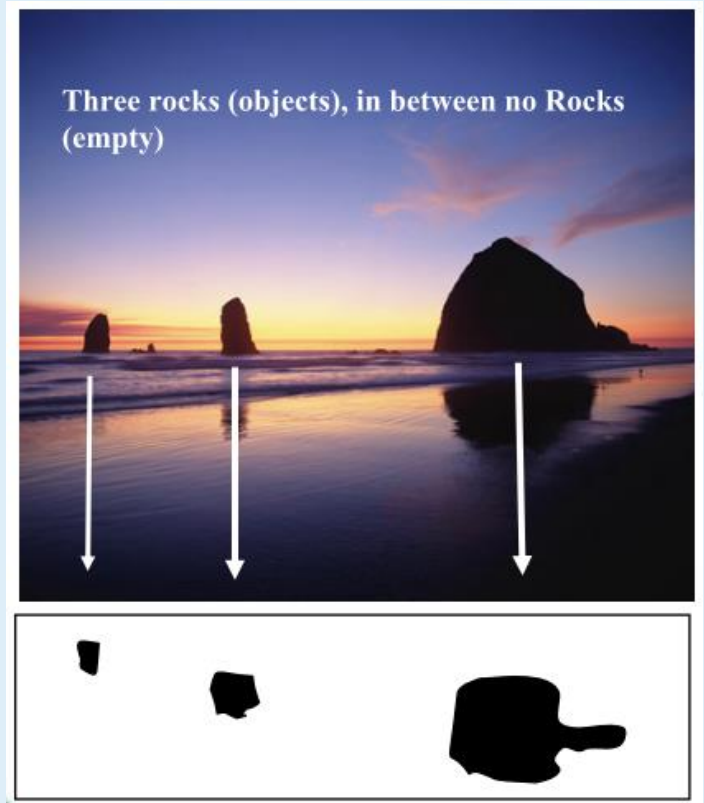
Types of Geographic Phenomena

- A (geographic) **field** is a geographic phenomenon for which, for every point in the study area, a value can be determined. (temperature, pressure and elevation)
- A (geographic) **object** is a geographic phenomenon that does not cover the total study area, the space in between objects is potentially empty or undetermined. (buildings, rivers)

Objects



- Example: Building
- Characteristics:
 - Crisp boundaries
 - Inside the boundary only one value



Field



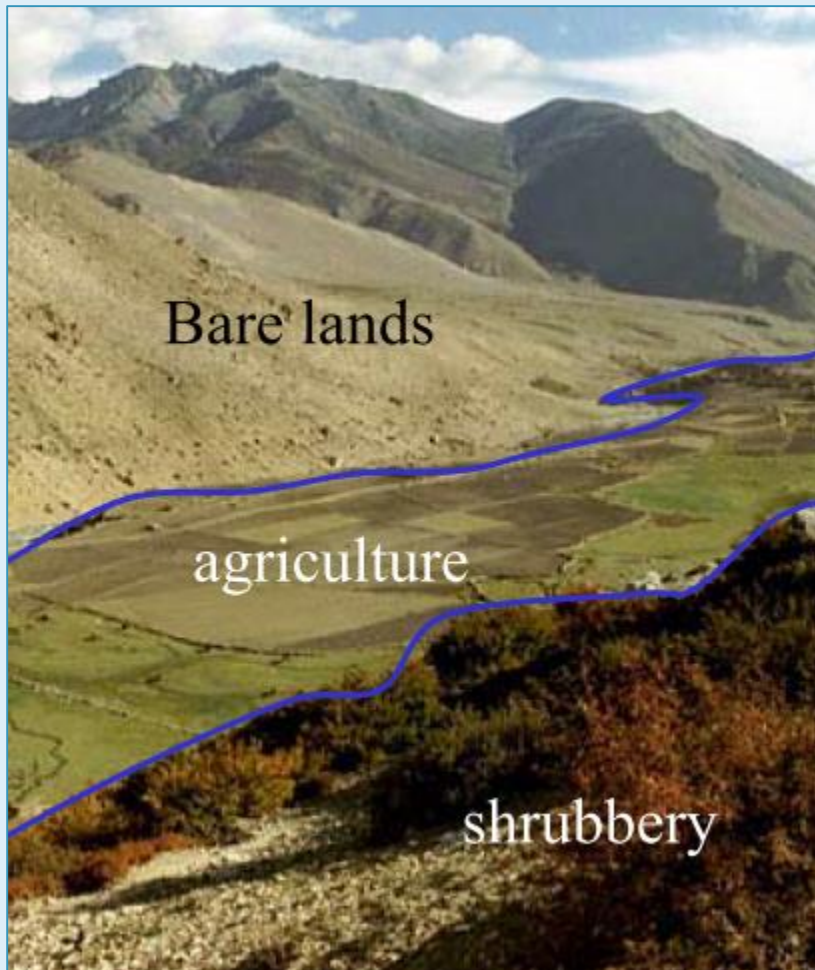
- Examples:
 - Temperature
 - Barometric Pressure
 - Elevation
- Characteristics:
 - On the image on the left you can measure elevation (height) everywhere

Field (Continuous)



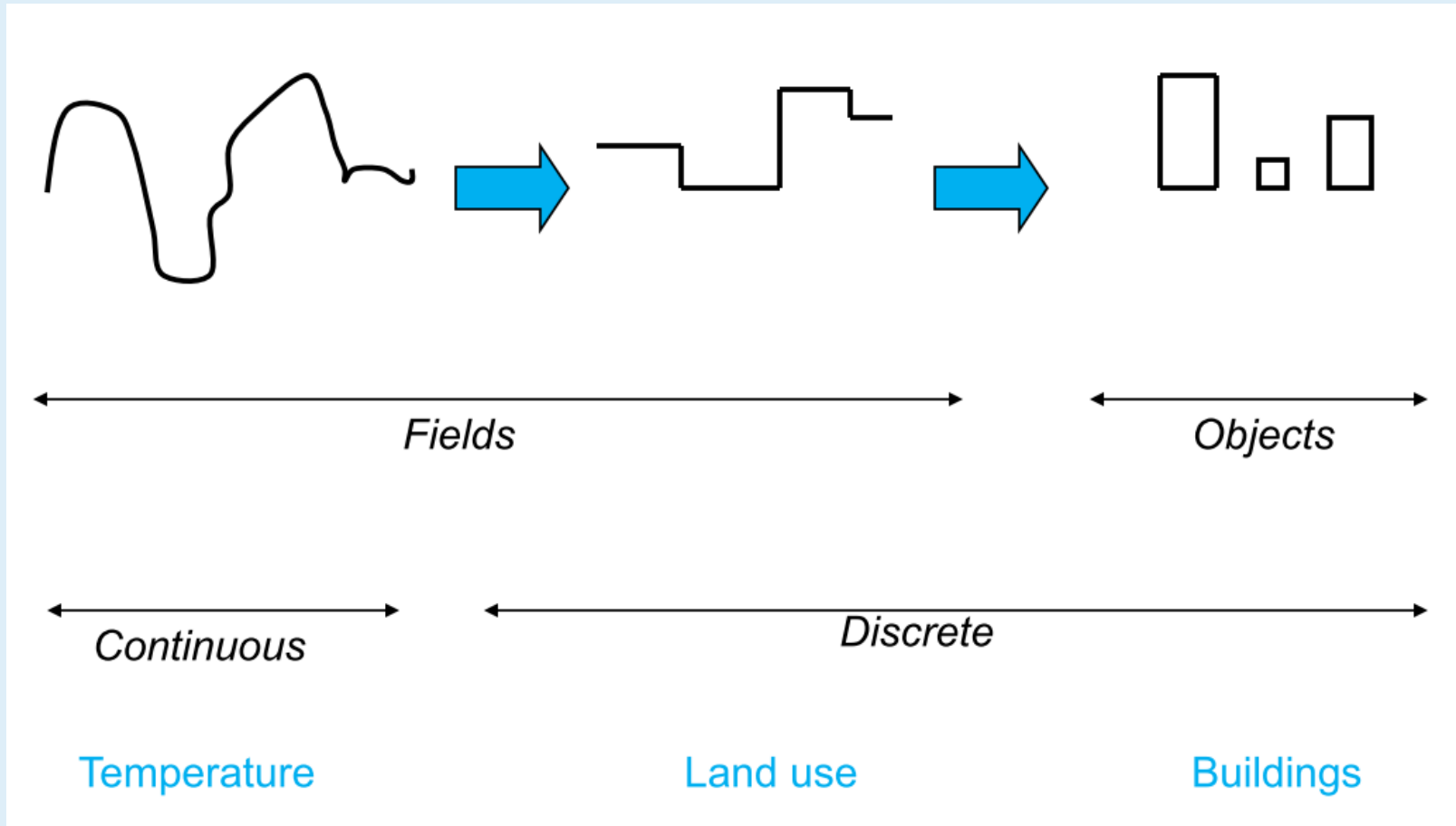
- Continuous means that all changes in field values are gradual
- In a differentiable field we can measure the change.
- In the example on the left, we can measure the gradient (slope) as the change of elevation.

Field (Discrete)

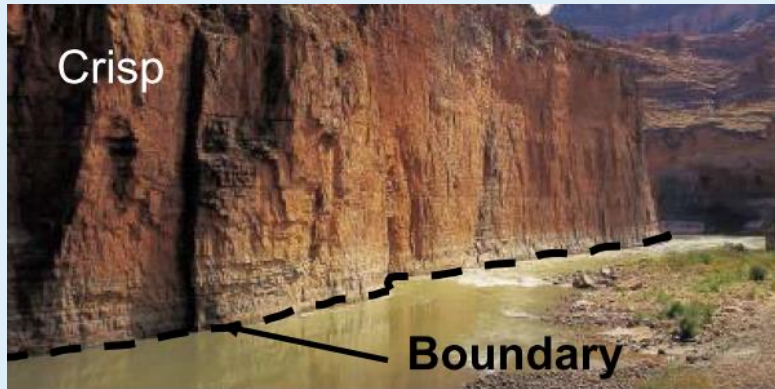


- Discrete fields cut up the study space in subparts with a clear boundary, with all locations in one part having the same value
- Typical examples are land classifications, geological classes, soil types, landuse types, crop types or natural vegetation types

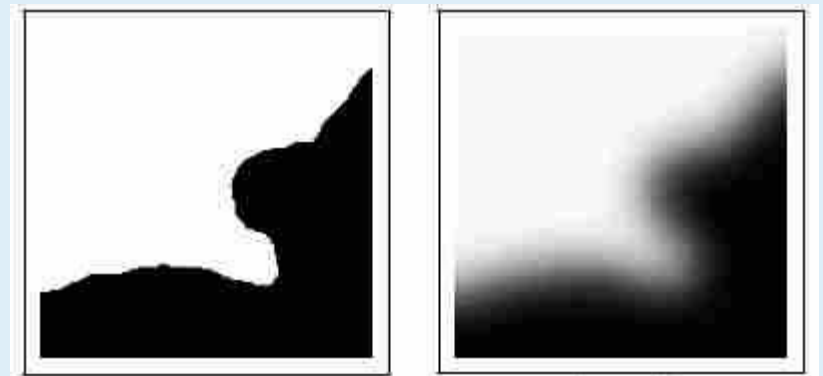
Types of Geographic Phenomena



Boundaries



- Both objects and discrete fields have boundaries
- Two different types of boundaries
 - **Crisp** boundaries
 - **Fuzzy** boundaries



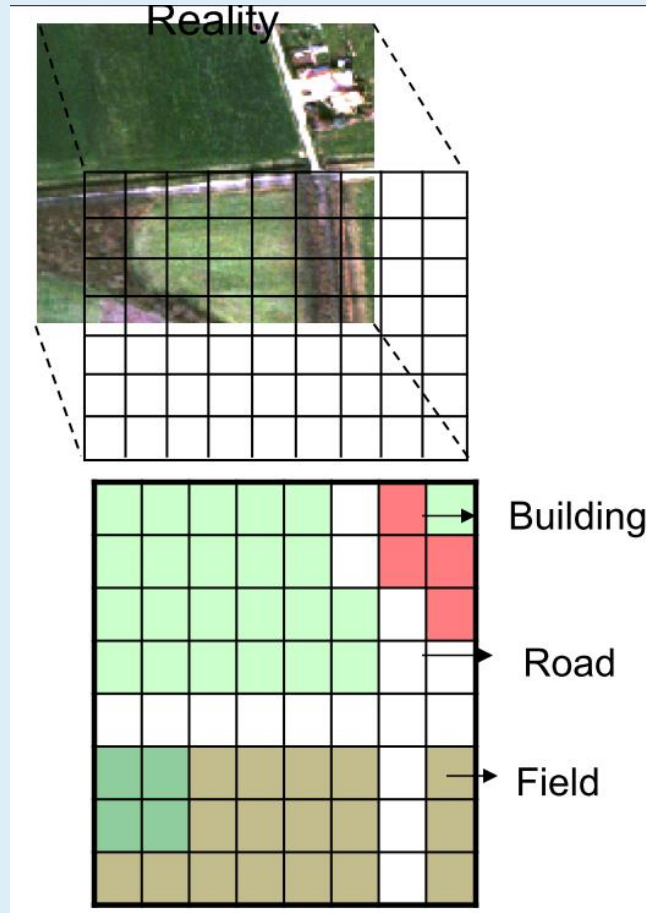
Summary geographic phenomena

	Coverage	Boundaries	Type of boundaries	Characteristics
Continuous field	Cover the total space	Have <u>no</u> boundaries		
Discrete field	Cover total space	Have boundaries	Crisp or fuzzy	
Collection of Objects	Have gaps in between	Have boundaries	Crisp or fuzzy	Have a location, size, orientation, shape

Computer representation

- So far we only discussed geographic phenomena, in the following slides we discuss computer representation.
- Computer representation can be divided in two groups:
 - Tessellations
 - Vector based representation
- Now we will see how computer representations can be applied to represent geographic fields and objects.

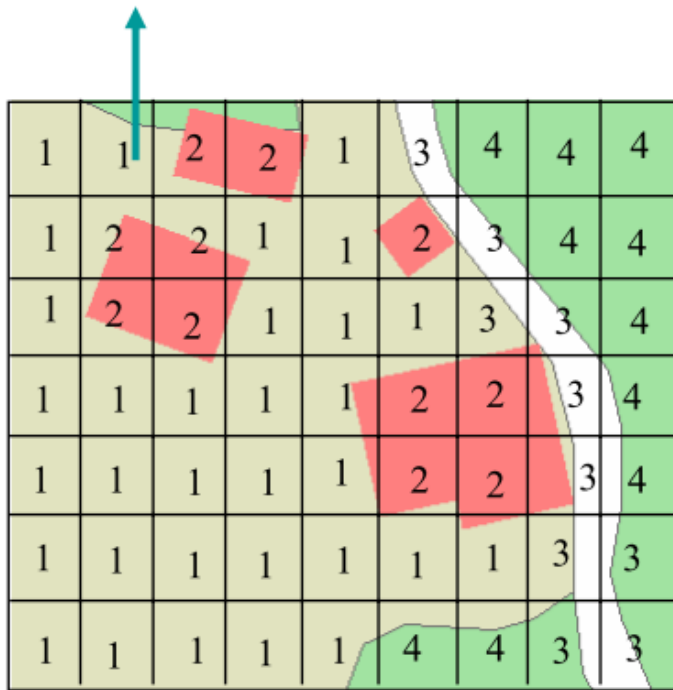
Tessellation (Regular)



- A tessellation is a partitioning of space into mutually exclusive cells that together make up the complete study area.
- The cells are of the same shape and size, and the field attribute value assigned to a cell is associated with the entire area occupied by the cell.

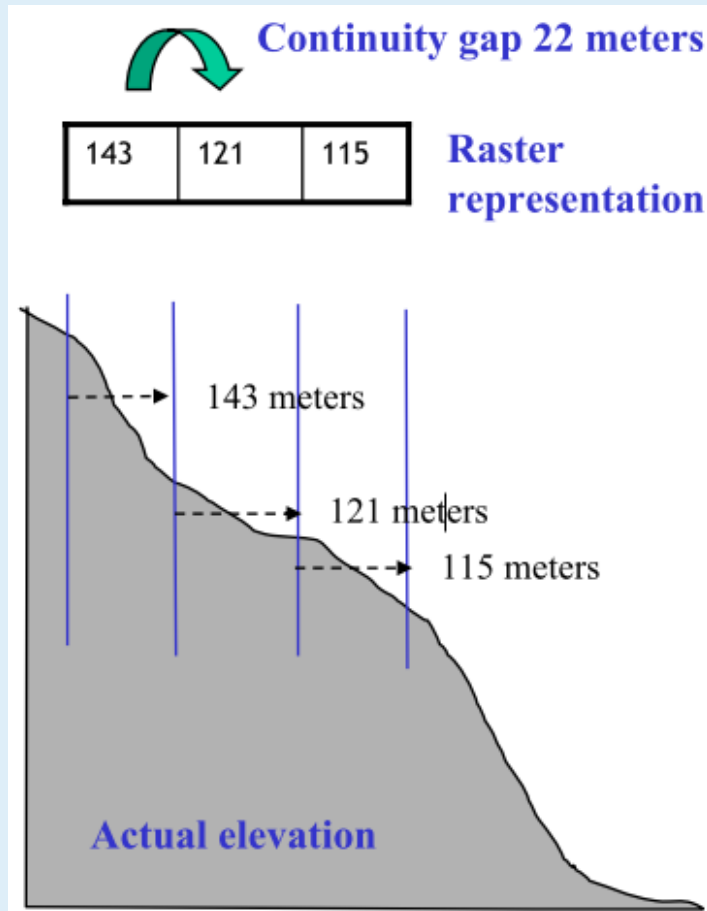
Tessellation (Regular)

Each cell represents an area of 10 by 10 meters, the resolution is 10x10 meter sq.



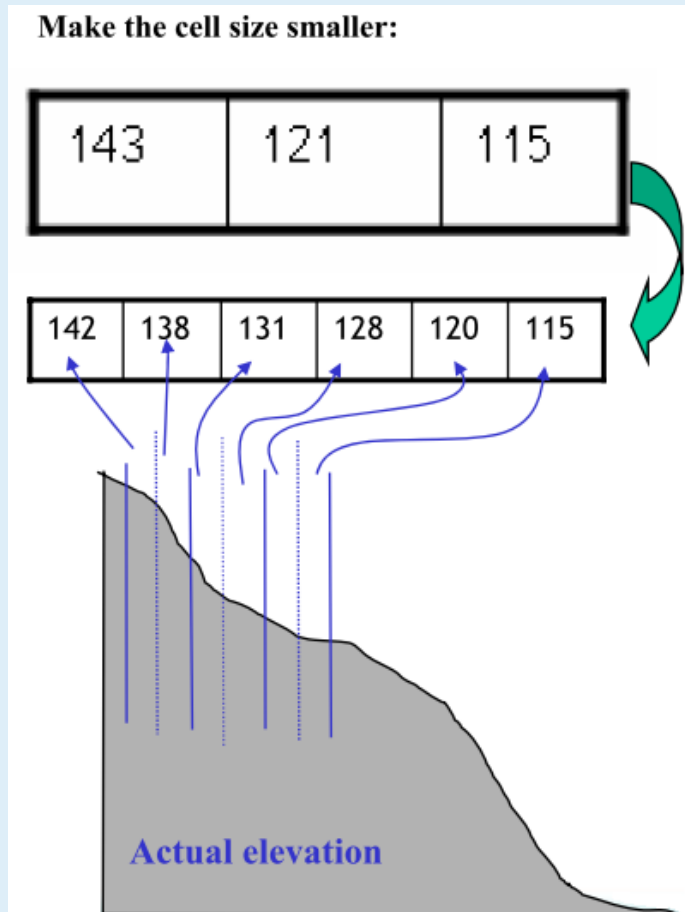
- The size of the area that a single raster cell represents is called the raster's *resolution*.

Tessellation (Regular)



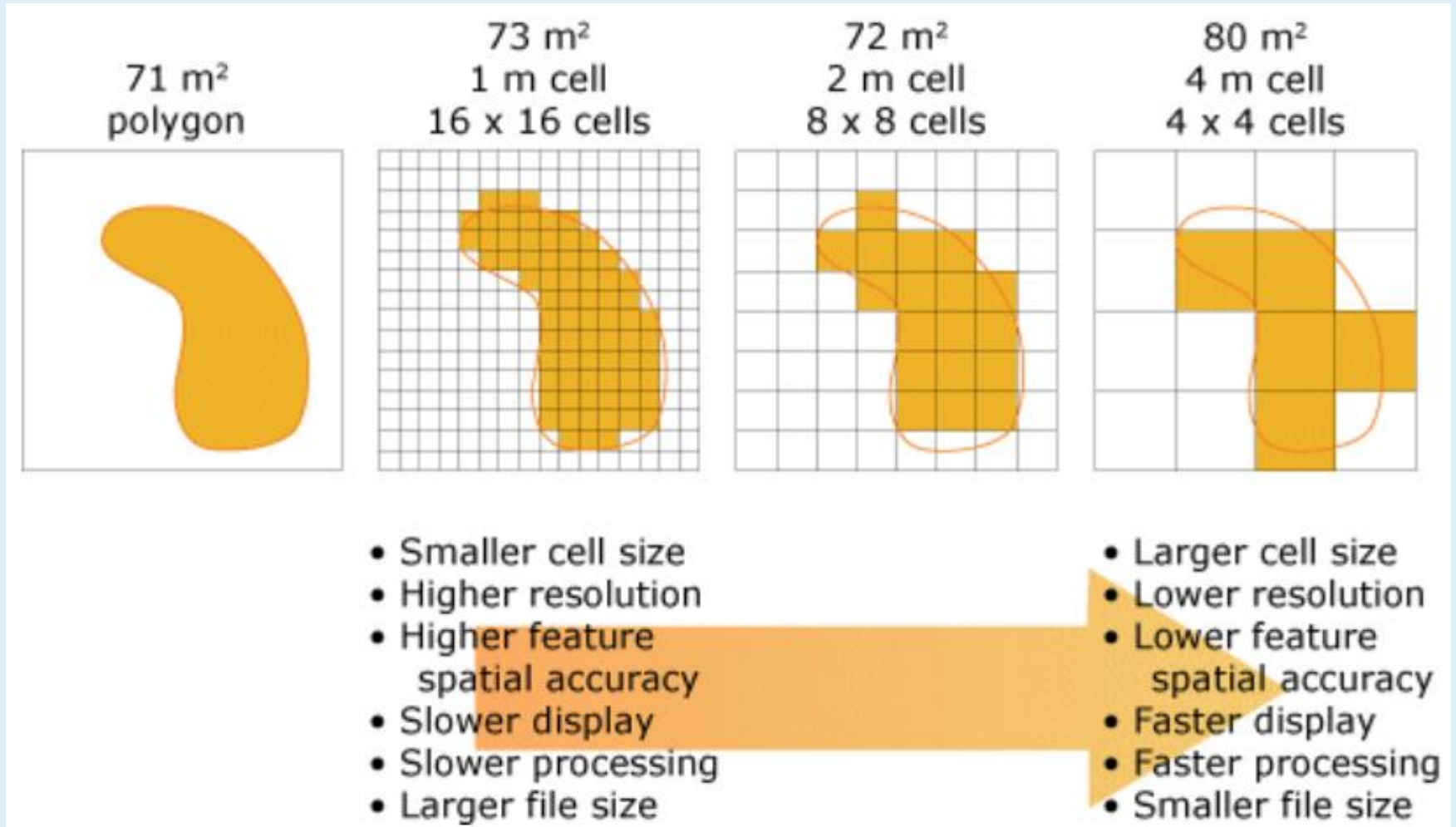
- When we represent a continuous field, values are changing constantly
- In a regular tessellation each cell has only one value, that represents the total area of a cell (average elevation)
- There will be a continuity gap between adjacent cells

Tessellation (Regular)

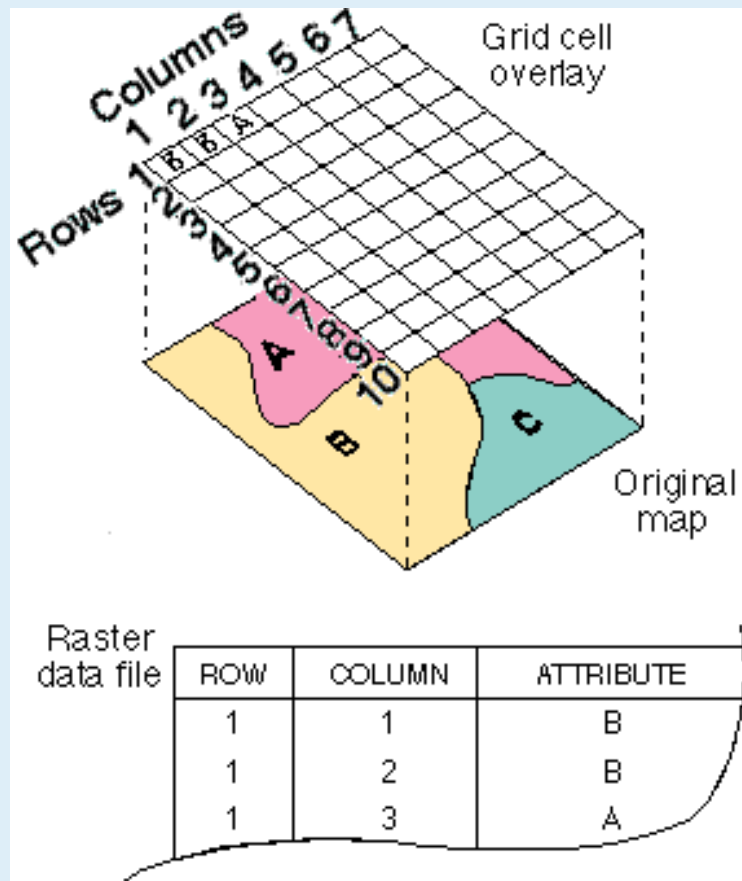


- Two ways to improve on this continuity issue:
 1. Make the cell size smaller
 2. Assume that the cell value only represents one specific location and provide a good interpolation function for all other locations

Cell size



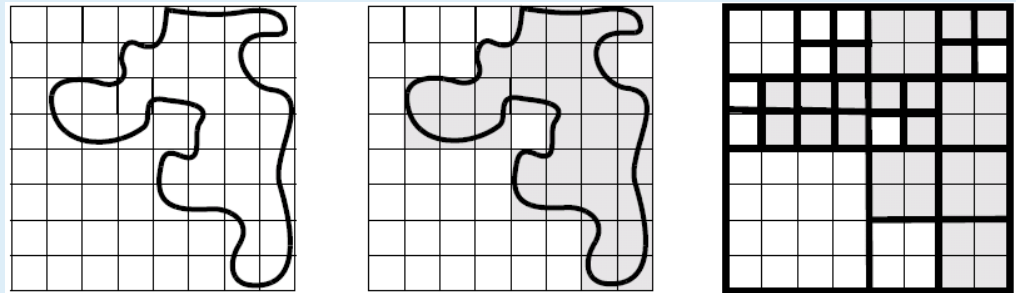
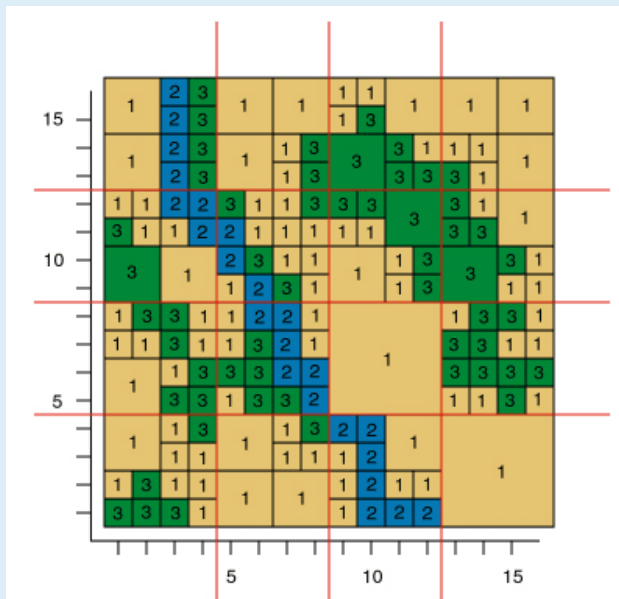
Raster



- A raster is a set of regularly spaced (and contiguous) cells with associated (field) values.
- The associated values represent cell values, not point values.
- This means that the value for a cell is assumed to be valid for all locations within the cell.

Tessellation (Irregular)

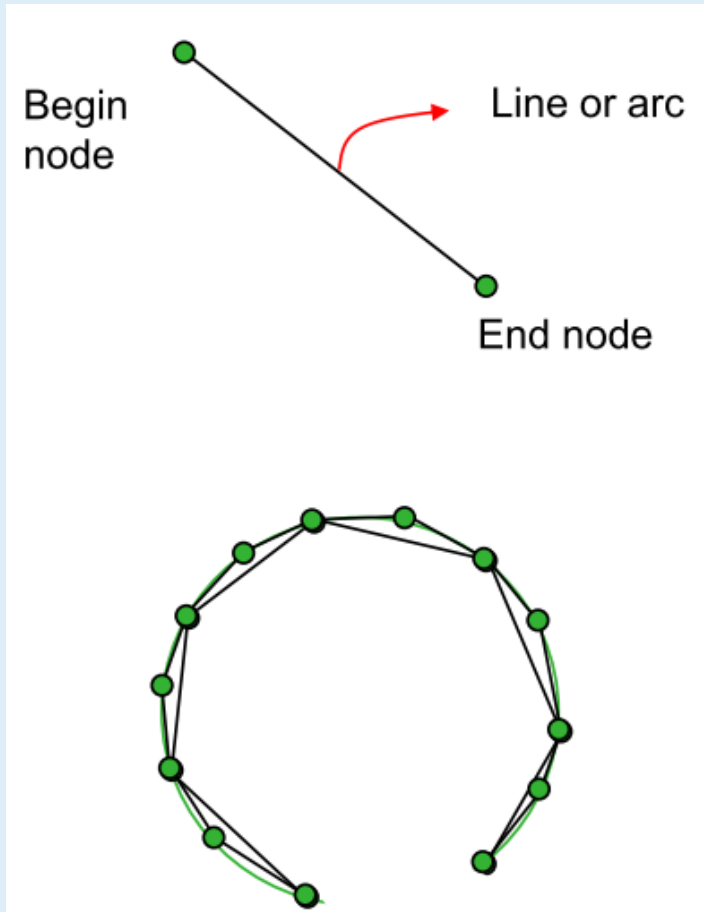
- Irregular tessellations are again partitions of space into mutually exclusive cells, but now the cells vary in size and shape, allowing them to adapt to the spatial phenomena they represent.
- Example: Quadtrees, Run length encoding



Vector based - Point (0-D)

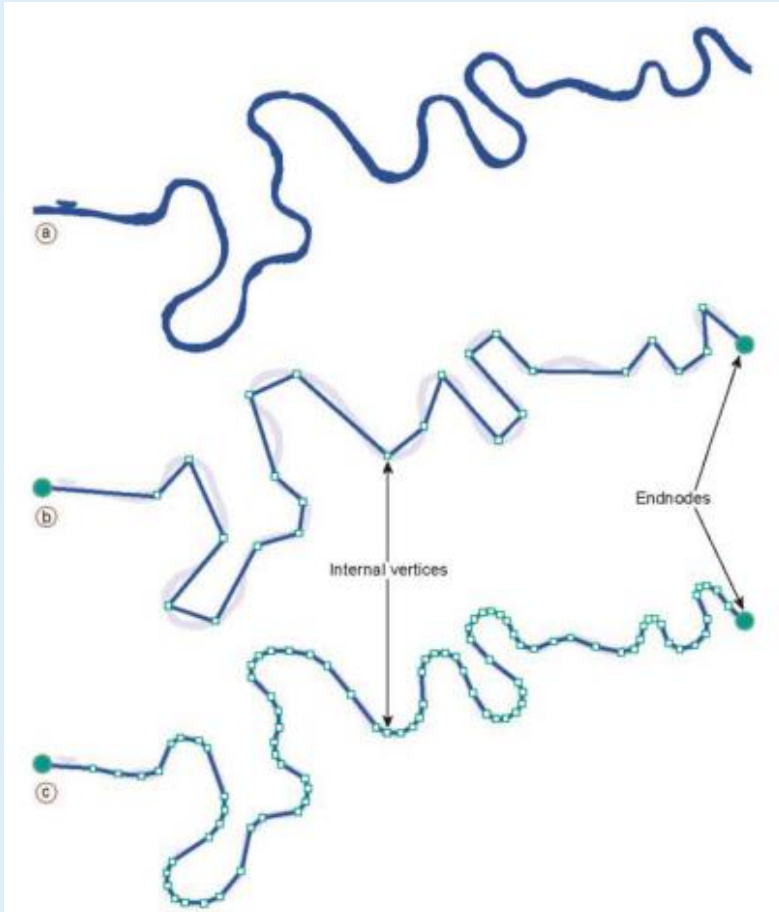
- Points are defined as single coordinate pairs (x, y) when we work in 2D or coordinate triplets (x, y, z) when we work in 3D
- Points are used to represent objects, that are shape- and size less (zero-dimensional)
- Examples:
 - Cities on India Map
 - Schools on Chandigarh Map

Vector - Line (1-D)



- Used to represent one-dimensional objects (roads, railroads, canals, rivers...)
- Line is defined by 2 end nodes and 0-n internal nodes.
- An internal node or vertex is like a point that only serves to define the line
- Many GISs store a line as a sequence of coordinates of its end nodes and vertices, assuming that all its line segments are straight.

Line (2)



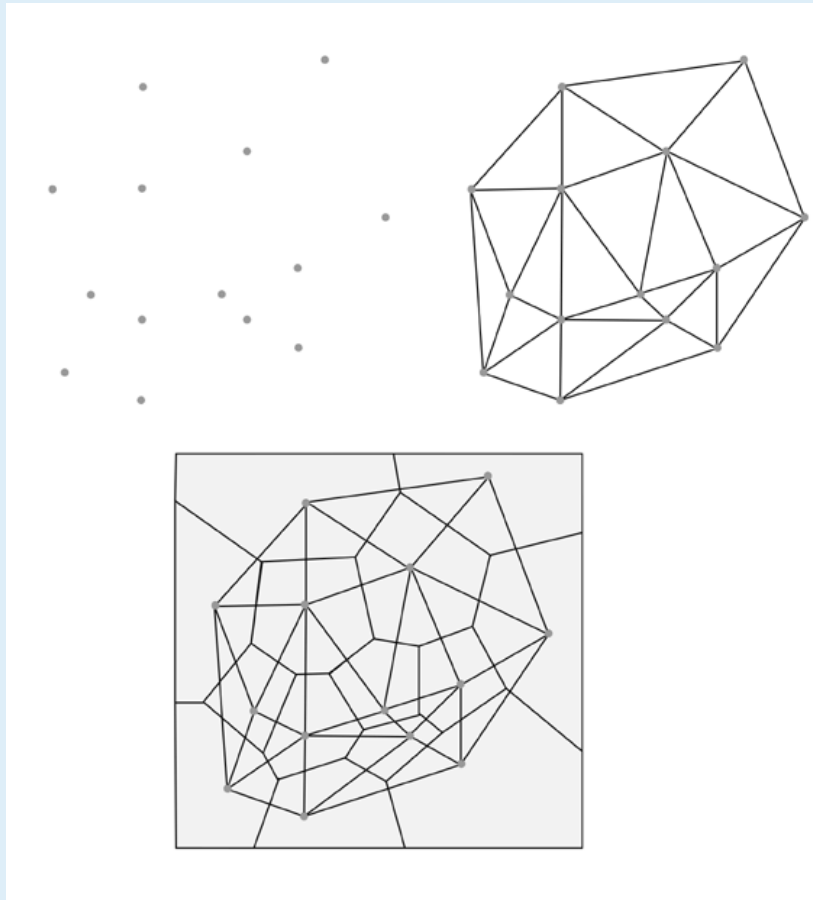
- By increasing the number of internal vertices, we can improve the shape
- Number of vertices determines the precision.
- Scale is related to the spatial accuracy - lower number of internal vertices - coarse scale - generalization.

Vector - Area (Polygon) (2-D)



- When area objects are stored using a vector approach, the usual technique is to apply a boundary model.
- This means that each area feature is represented by some arc/node structure that determines a polygon as the area's boundary.
- Area features of the same type are stored in a single data layer, represented by mutually non-overlapping polygons.

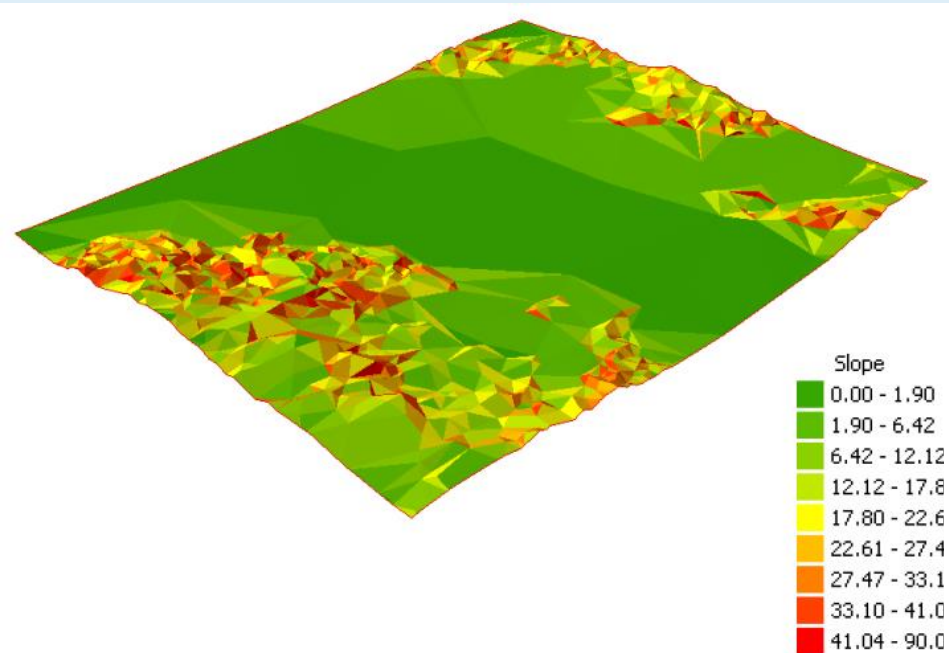
Triangulated Irregular Networks



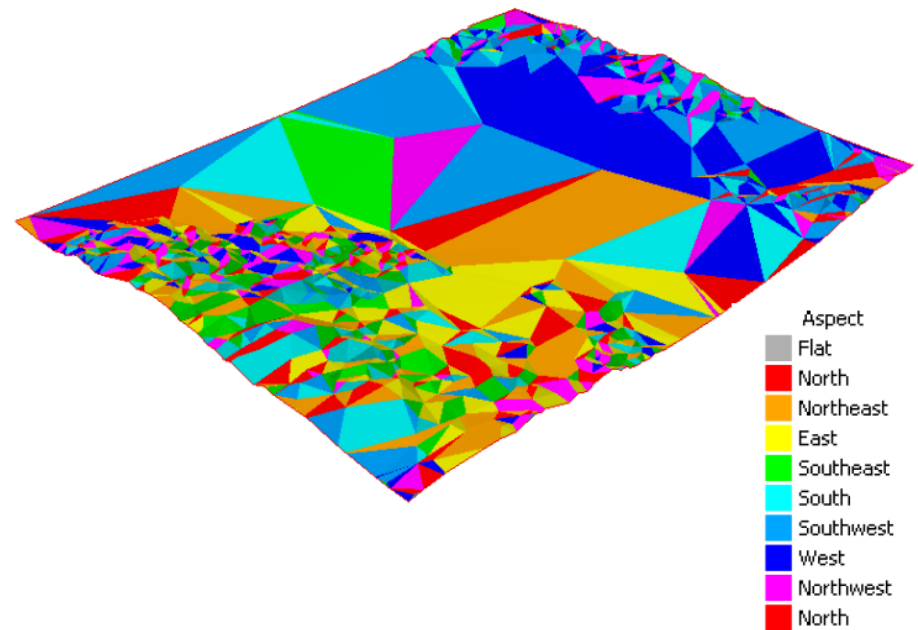
- A **vector-based** representation of a surface
- Commonly used in applications that involve **terrain**
- Composed of a series of contiguous, non-overlapping **triangles** that are known as faces
- Built from a series of points using a technique called **Delaunay** triangulation
- Advantages: More **efficient** at storing data
- Also used to construct **Thiessen** polygons, which form the basis for **interpolating** to areas.

TIN (Examples)

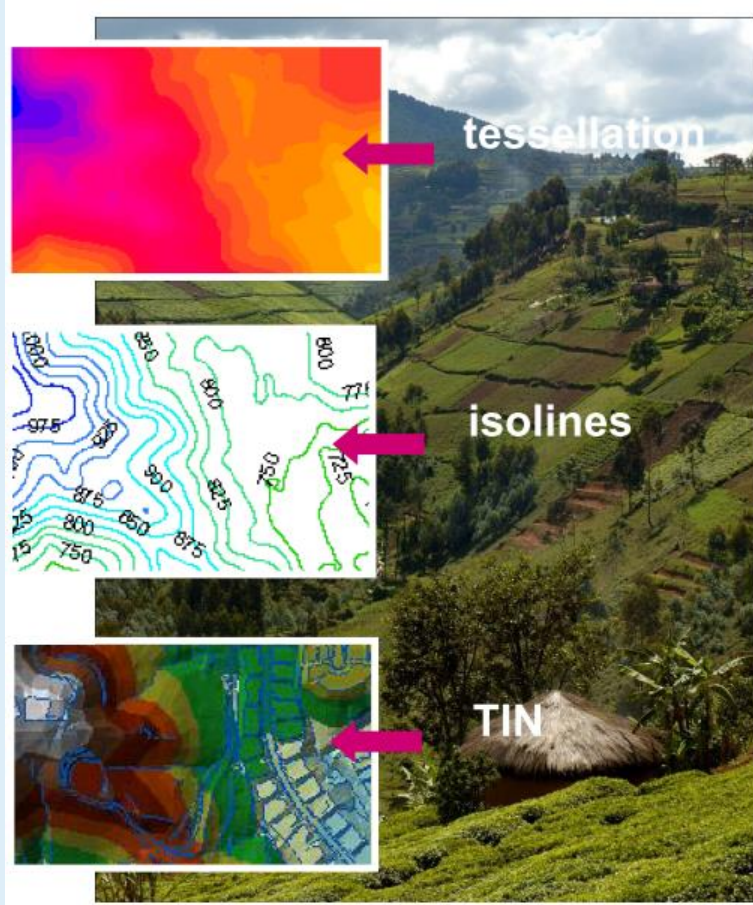
SLOPE



ASPECT

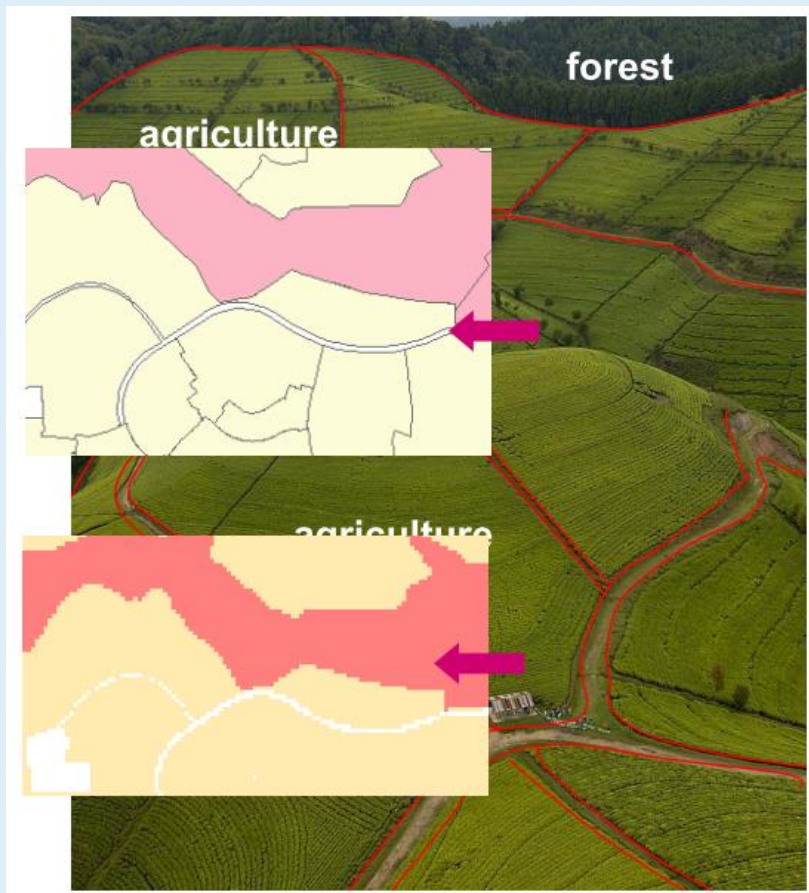


REPRESENTATIONS OF GEOGRAPHIC FIELDS (CONTINUOUS)



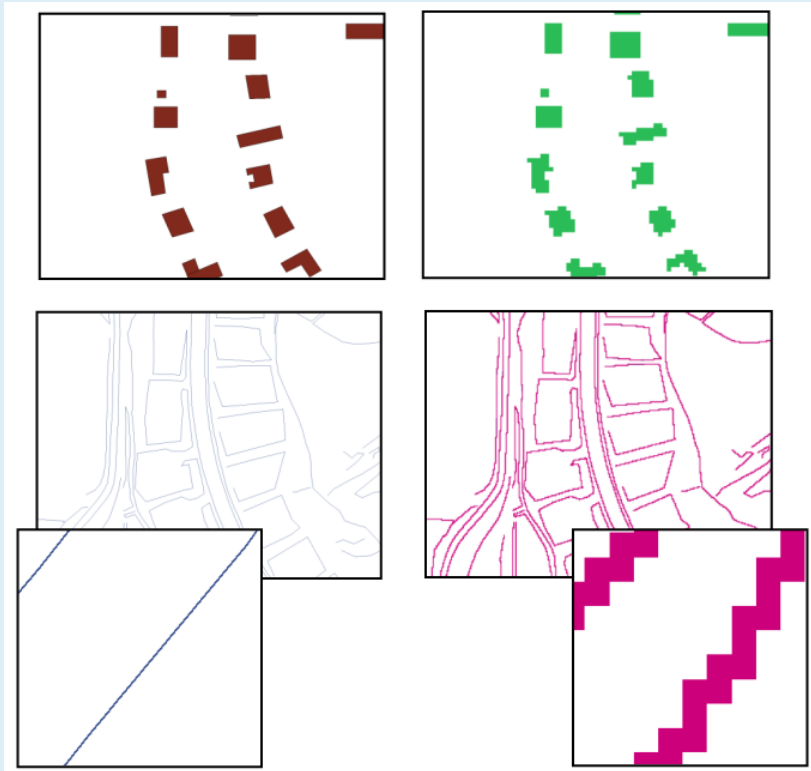
- Continuous fields (like elevation) can be represented as:
 - Tessellation
 - Isolines
 - TIN
- Continuous fields when represented as a tessellation will lead to floating point cell values
- Both tessellation and TIN can be regarded as surfaces

REPRESENTATIONS OF GEOGRAPHIC FIELDS (DISCRETE)



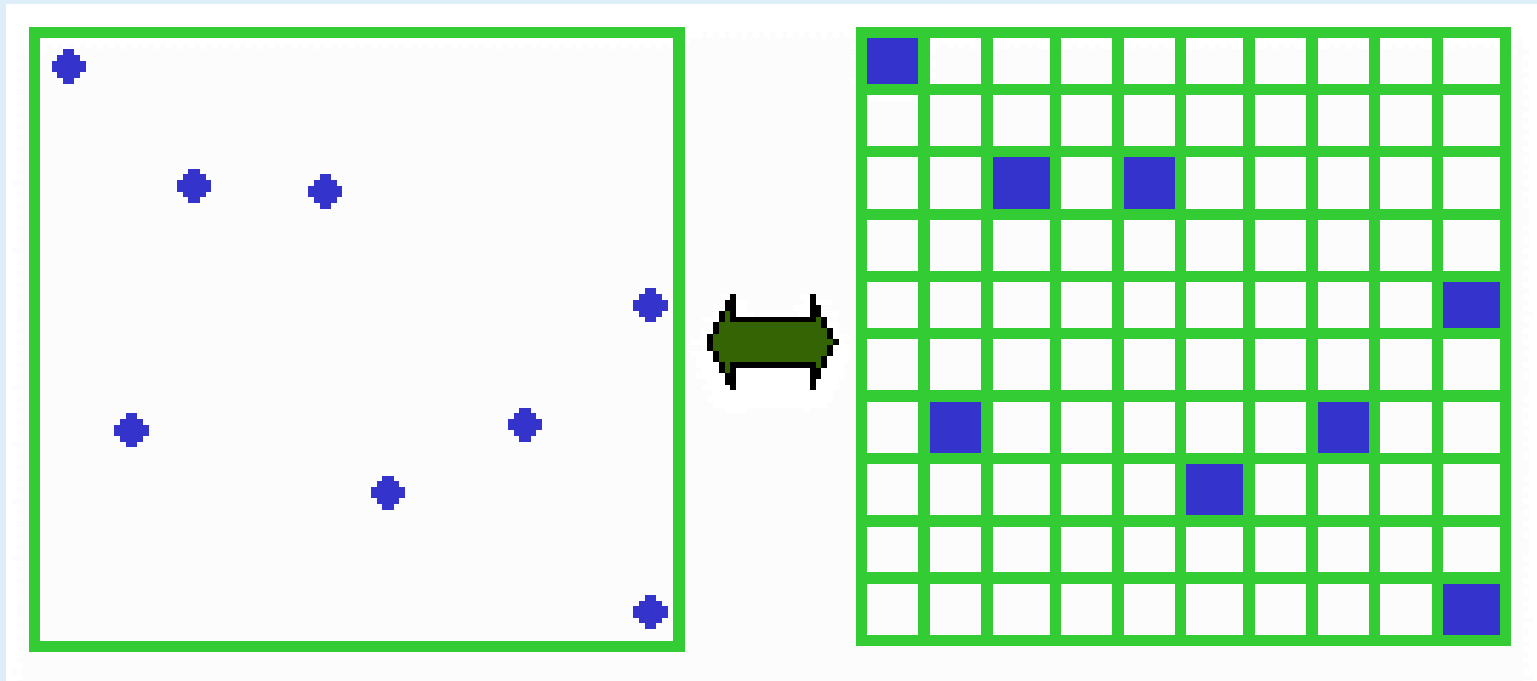
- Discrete fields (like landuse or soil type) can be represented as:
 - Tessellation
 - Polygons
- Discrete raster representations will lead to integer cell values

Representation of Objects

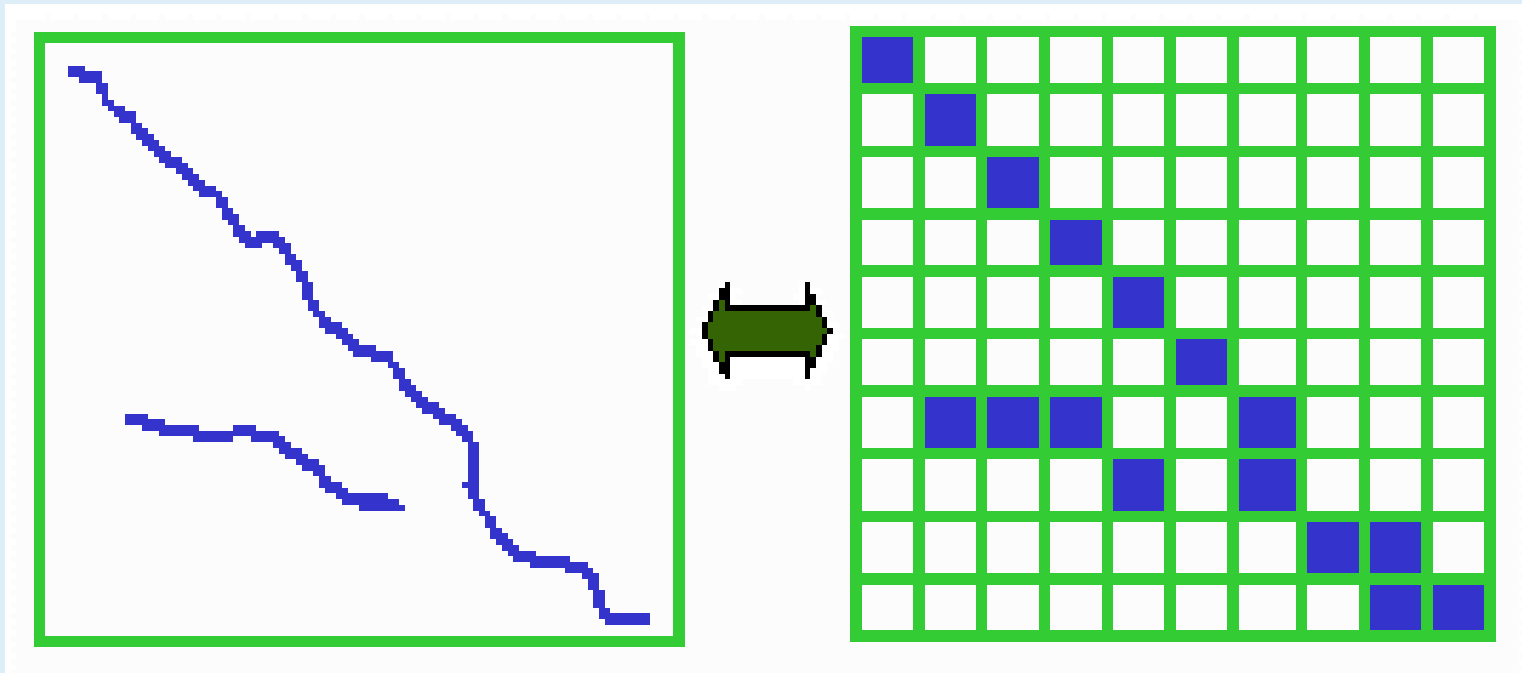


- Line and point objects are more awkward to represent using rasters, as rasters are area-based
- Objects are more naturally represented in vector

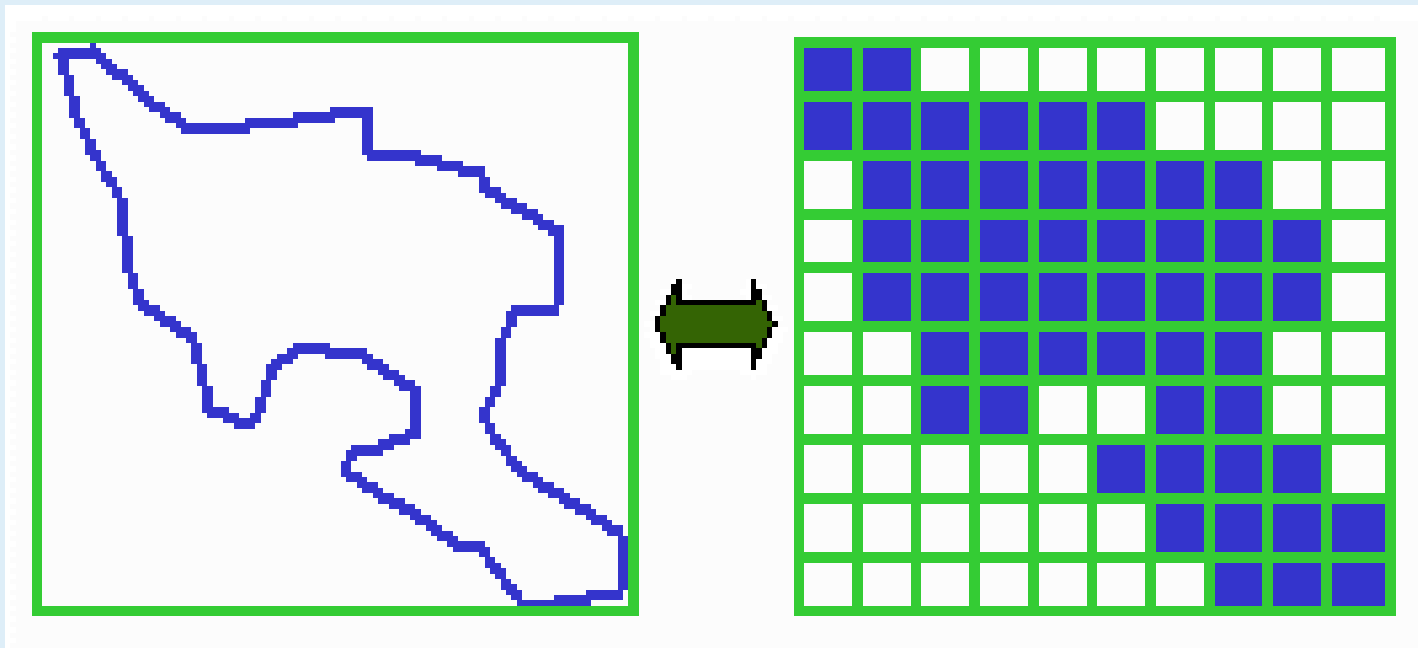
Representation of Objects - Points as Cells



Representation of Objects - Line as a Sequence of Cells



Representation of Objects - Polygon as a Zone of Cells



Comparison

Property	Raster Data Model	Vector Data Model
Data Structure	Simple	Complex
Overlaying	Easy and Efficient	Difficult to perform
Compatible to RS imagery	Yes	No
Spatial Variability	Efficient	Insufficient
Programmability	Simple	Difficult
Storage	Inefficient	Compact
Geometric Properties	Erroneous	Correct
Network Analysis	Difficult	Easy
Map Visual Appeal	Less	High
Information Variation	Based on resolution	Based on scale
Topology	Not implemented	Efficient encoding

Choice of representation

- From the suitable digital representations the choice is generally based on two issues:
 - What original raw data is available?
 - What sort of data manipulation does the application want to perform?

Scale of a map - Example of representation of cities



- Small scale map
- 1:50million
- Preferably - Point



- Large scale map
- 1:5000
- Preferably - Polygon

Quiz time!

- Fill a option in the correct box

	Field (Continuous or Discrete)	Object (Point, Line or Polygon)
Elevation Points		
Canal (1:50,000)		
River (1:5000)		
Satellite Image (LISS3 - 24m)		
Digital Elevation Model (DEM)		
Soil Map (1:250K)		
Ward boundary		

Quiz time! - Answers

- Fill a option in the correct box

	Field (Continuous or Discrete)	Object (Point, Line or Polygon)
Elevation Points		✓ Point
Canal (1:50,000)		✓ Line
Large River (1:5000)		✓ Polygon
Satellite Image (LISS3 - 24m)	✓ Continuous	
Digital Elevation Model (DEM)	✓ Continuous	
Soil Map (1:250K)	✓ Discrete	
Ward boundary		✓ Polygon



Thank you

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