GEOG 204

LECTURE 17

Course Review

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Final Exam: Wed Nov 30. Cumulative, 45 mins

(Where needed formulae will be provided except for the mean, and standard deviation)

Project Submission: By Fri Dec 7

Room 7-238

(Weldwood Lecture Theatre)

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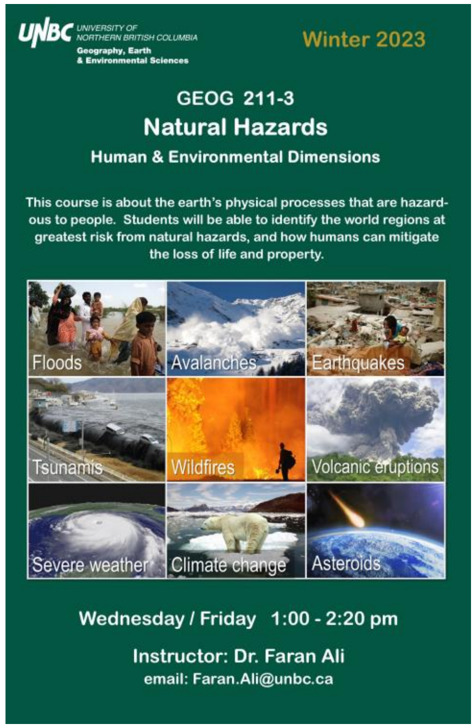

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Definition

- GIS: system used to store, manipulate, analyze, manage, and present geographic data
  - GIScience?
  - Geomatics?
- Importance of GIS
  - Makes it possible to efficiently integrate, manage, and analyze geographical information from maps, remote sensors, data collectors and text.

Presentation Title 4

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Common GIS Operations

- Data Acquisition
- Data Attribute Management
- Data Display
- Data Exploration (exploratory spatial analysis)
- Data analysis and modeling

Geographic phenomena

- Spatial Variation
  - Tobler’s law

  - Homogeneity/Uniform distribution
  - Random distribution
  - Clustering

- Temporal(time) Variation

Representing geographic space

- The two basic forms
  - Objects and Fields
    - Vector and Raster
- The three geometry types
  - Points, lines, polygons
- The different data formats for Raster and Vector
  - e.g. shp, geotiff, GeoJSON, rst,

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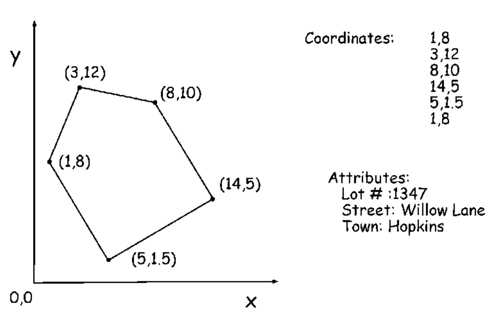
Location and Attributes (Fields)

x (easting), y (northing) [z-elevation] coordinates

e.g. latitude / longitude (degrees, minutes, seconds)



Attributes of latlong_data2

OID	X	Y
0	-79.235444	43.207055
1	-79.261247	43.191196
2	-79.205194	43.149254
3	-79.207431	43.147622
4	-79.215648	43.15465
5	-79.250881	43.164771
6	-79.253802	43.170664
7	-79.267453	43.155617
8	-79.2638	43.16129
9	-79.21237	43.139409
10	-79.244187	43.12796
11	-79.196958	43.134143
12	-79.212195	43.132831
13	-79.279129	43.170963

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Location and Attributes (Fields)

Attribute data: allows us to ask the question … "what is it ?"

> Every layer has an associated table

> These are linked to spatial location by a code number

➢Attributes are stored in columns as *items*

➢Rows display the attributes for each feature = *records*

➢Entries may be text strings, integers, float (decimal) or dates

Item (Description)

Record (place) ->

POLYGON	ESA_1	SPC1	PCT1	SPC2	PCT2	AGE_CL	HT_CL_IN	SITE_IDX	CRNCL_CL	SitePrep	Dist	YearDist	Regen	STTEND
67		HW	40	S	40	2	1	16.6	8	B	R	1985	1999	F
133			0		0	0	0	0	0			0	0	
199		HM	40	HW	30	9	3	7.2	5		L	1980	0	
353		HW	90	BA	10	9	4	11.6	1	B	L	1980	1999	F
229		HW	70	HM	20	9	3	9.5	5	B	L	1980	1999	F
264		HM	50	HW	30	9	3	7.5	5	H	L	1980	1999	F
162			0		0	0	0	0	0			0	0	
393		HW	60	HM	20	9	3	8.5	5	H	L	1980	1999	R
165		HM	80	BL	20	9	3	7	4	H	L	1980	1999	R

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Scale

- Scale: The ratio or relationship between a distance on a map and the corresponding distance the ground.
- Map details depend on the scale of the data
  - The larger the scale, the more the detail
    - Large scale is synonymous with fine scale (fine granularity)
  - The smaller the scale, the less the detail
    - Small scale is synonymous with course scale (course granularity)

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Scale

- Map details depend on the scale of the data
  - With generalisation and simplification one can create a map with a course grained scale from large scale data
- Spatial Scale **could be making reference to**
  - Resolution: the size of your pixel (raster)
  - Extent: the size of your study area
    - "small-scale" operation covers a small area
    - "large-scale" operation covers a large area
- Cartographic Scale
  - 1:1000000 (1 cm = 10 km)
- Scale Bar

Census Data

- Geographic Units
  - Dissemination Block
  - An area bounded on all sides by roads and/or boundaries of standard geographic areas. The dissemination block is the smallest geographic area for which **population and dwelling counts** are disseminated.
  - Dissemination Areas
    - composed of one or more adjacent dissemination blocks with an average population of 400 to 700 persons. It is the smallest standard geographic area for which **all census data** are disseminated.
    - Enumeration Areas: term used for the same geographic unit prior to 2001
  - Census Tracts
    - Larger areas that have a population between 2,500 and 8,000 persons.
    - They are located in centres of 50,000 or more in the previous census.
- Unique aspect about the 2011 Census
- What are boundary files?

Spatial Analysis

- Analysis occurs using either:
  - **Spatial location** e.g. wetlands near a pipeline; houses within 5km
    - Distinguishes GIS from a non-spatial database
  - **Data attributes** e.g. wetlands with black spruce; houses in a price range
    - Distinguishes GIS from 'non-GIS' mapping software
  - **Comparative spatial statistics** e.g. trees are clustered. e.g. wetlands clustered at local scale, uniform at regional scale
    - Statistical Spatial Data Analysis with ArcGIS, QGIS, R (Statistical Software with GIS functionality)

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Spatial Analysis

- Analysis functions
  - Non-topoplogical functions
    - Attribute values of spatial data
  - Topological functions
    - Individual data objects
      - Feature-based
        - individual data objects
      - Layer-based
        - all objects in a layer

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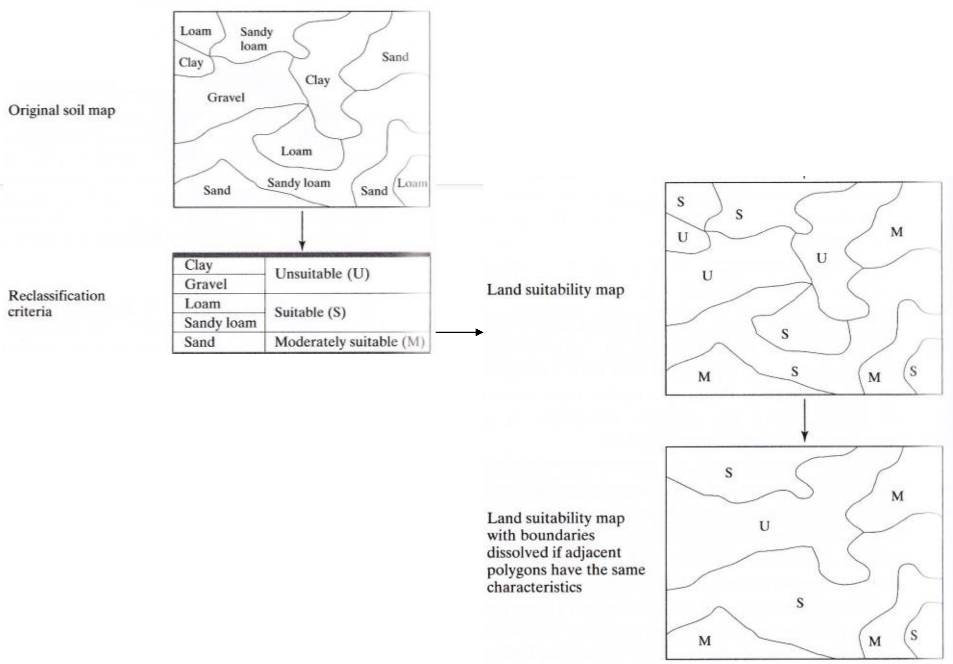
	Nontopological	Topological	
		Featured-based	Layer-based
Logical operations	• Attribute database query		• Reclassification and aggregation
Arithmetic operations	• Change mapping • Summary statistics		
Overlay operations	• Address geocoding	• Overlay analysis	• Overlay analysis
Geometric property operations	• Calculation of areas, perimeters, and distances		• Network analysis
Geometric transformation operations	• Coordinate and geometric transformation • Surface interpolation		
Geometric derivation operations		• Buffering	

Source: C.P. Lo, A.K.W. Yeung (2007) Concepts and Techniques of Geographic Information Systems

Topological Functions

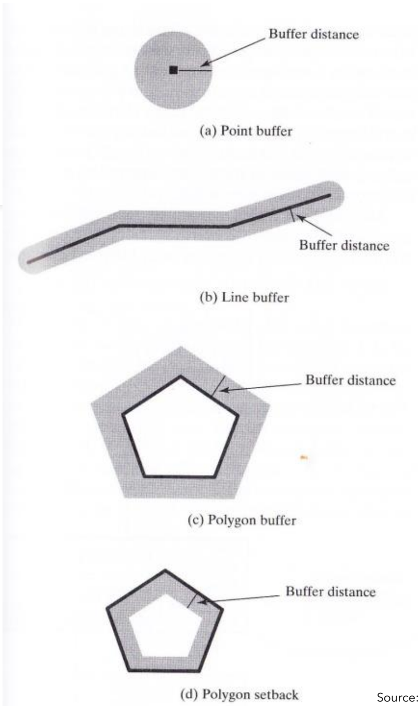
- Reclassification
  - Database simplification process that reduces (modifies) the categories in attribute data
  - Two step process
    - Nontopological: select attribute e.g. a range of values and assign them a new class
    - Topological: dissolve according to new classification scheme



Source: C.P. Lo, A.K.W. Yeung (2007) Concepts and Techniques of Geographic Information Systems

Topological Functions

- Topological Overlay Operators
  - Types:
    - **Point** layer in **polygon** layer
    - **Line** layer in **polygon** layer
    - **Polygon** layer in **Polygon** layer
  - Operators:
    - UNION, INTERSECT, IDENTITY, CLIP, ERASE, SPLIT



Useful when evaluating charactering of an area sounding a feature.

- properties/population with walking distance of a bus stop
- delineation of restricted zones around sensitive sites

Source: C.P. Lo, A.K.W. Yeung (2007) Concepts and Techniques of Geographic Information Systems

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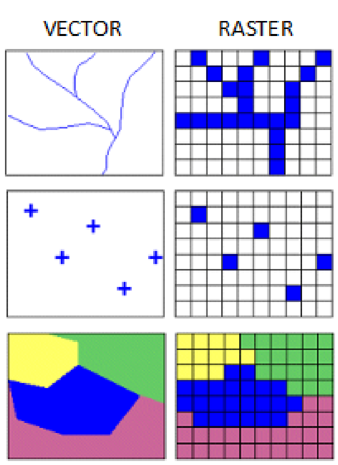
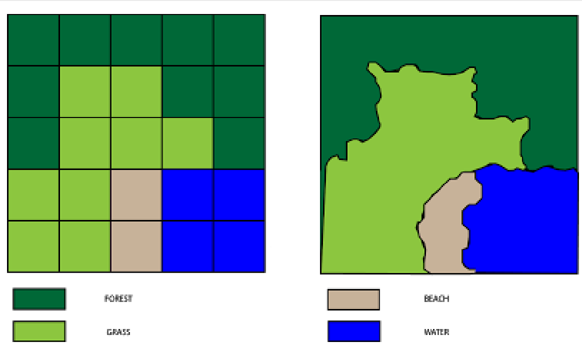
Raster vs. Vector





Source

Raster Data are modeled with a grid of cells. Each cell is described with one value

Source

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Raster Operations

- Raster operations: grouped according to the way raster cells are used in the analysis
  - Local Operations:
    - value of the cell in the output layer is a function of the cell at the same location in the input layer
  - Neighborhood Operations:
    - value of the cell in the output layer is a function of the cells neighboring the cell at the same location in the input layer
  - Extended Neighborhood Operations:
    - value of the cell in the output layer is a function of the cells neighboring and beyond the immediate neighborhood of the cell at the same location in the input layer
  - Regional Operations:
    - the output layer us generated by identifying cells that intersect with or fall within each region on the input layer

Local Operations

- Reclassification
  - Create a new raster layer by applying changes to the attribute values of the cells in the input layer
  - Logical or arithmetic operations

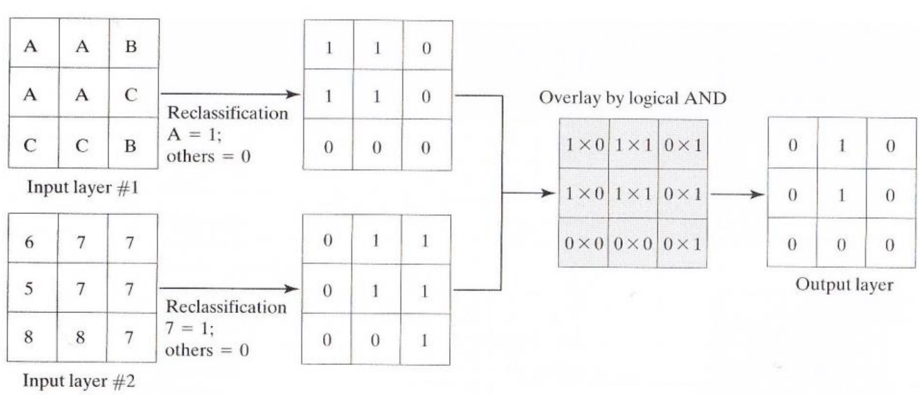
Binary masking; Classification reduction; Classification Ranking; Changing Measurement Scales

- Overlay Analysis
  - Logical or arithmetic operations
    - AND, OR, XOR; addition, subtraction, multiplication, division, assignment
  - Two or more input layers

Raster Operations

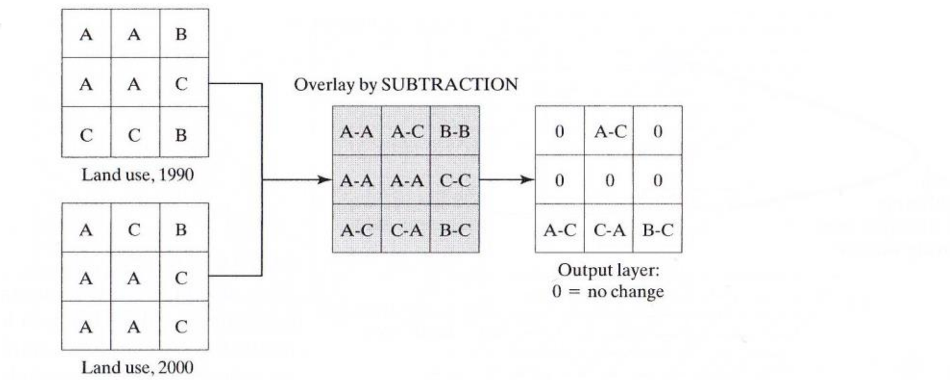
	Local Operations	Neighborhood Operations	Extended Neighborhood Operations	Regional Operations
Logical Operations	• Reclassification			
Arithmetic Operations	• Reclassification	• Aggregation • Filtering	• Statistical analysis	
Overlay Operations	• Logical • Arithmetic			• Category-wide overlay
Geometric Property Operations		• Slope and aspects	• Distance, proximity, and connectivity	• Area • Perimeter • Shape
Geometric Transformation Operations			• Rotation • Translation • Scaling	
Geometric Derivation Operations			• Buffering • Viewshed analysis	• Identification and reclassification

Overlay Analysis



(a) Overlay by logical AND to find "A" and "7" in input raster layer

Overlay Analysis



(a) Overlay by arithmetic SUBTRACTION to detect land-use change

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Spatial Interpolation

- Triangulated Irregular Network (TIN)
  - Consist of z-value nodes that are connected by edges to form contiguous and non-overlapping triangles
  - The edges in TINs can be used to capture the position of linear features that play an important role in the definition of the surface (e.g. ridgelines or stream courses)

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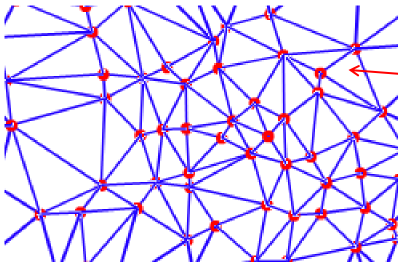
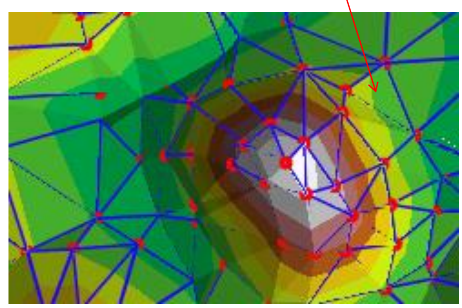
Triangulated Irregular Networks (TIN): vectors



TINs
Each triangle has a consistent slope and aspect



Complexity and scale determine the number of triangles

Method designed by Dr. Tom Poiker (SFU)

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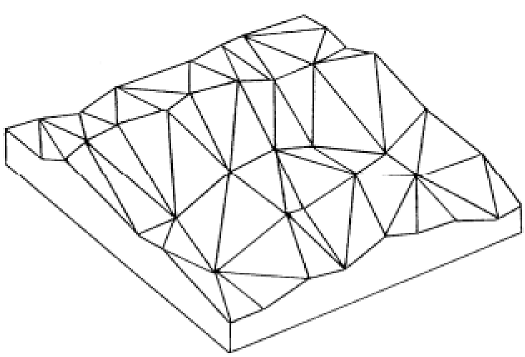
Triangulated Irregular Networks (TIN): vectors



TIN: a series of triangles capturing the topography .. x, y, z at nodes

Each triangle has a uniform slope and direction (aspect)

Advantage: **significant points or lines** can be encoded e.g. peaks, ridges, valleys

Disadvantage: more complex, needs more processing to generate, when a new point is added, the TIN needs to be rebuilt

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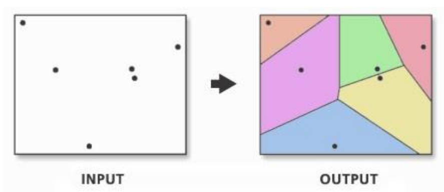
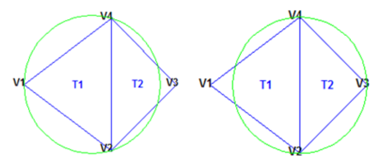
Spatial Interpolation

- Thiessen Polygons



Any location within a Thiessen polygon is closer to its associated point than to any other point input feature

All points are triangulated into a triangulated irregular network (TIN) that meets the Delaunay criterion: the circumcircle of every triangle is empty, that is, there is no other point in its interior.



The perpendicular bisectors for each triangle edge are generated, forming the edges of the Thiessen polygons. The location at which the bisectors intersect determine the locations of the Thiessen polygon vertices.

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Spatial Interpolation

- Contouring
  - Contours are lines that connect locations of equal values for a given continuous phenomenon.
    - as elevation, temperature, precipitation, pollution, or atmospheric pressure.
    - Contour lines are often generally referred to as isolines but can also have specific terms depending on what is being measured (e.g. isobars for pressure, isotherms for temperature, and isohyets for precipitation)

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Spatial Interpolation

- Contouring
  - The distribution of the contour lines shows how values change across a surface.
    - Little change in a value, the lines are spaced farther apart.
    - Great change, the lines are closer together.

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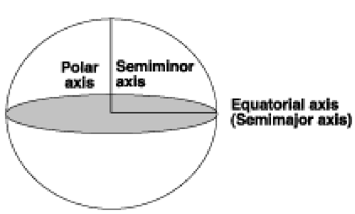
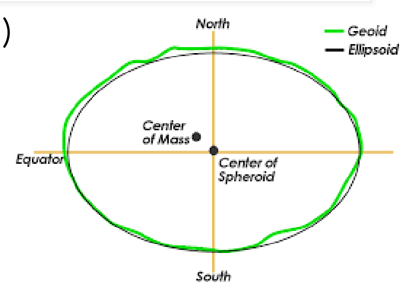
Modeling the Earth's shape

- the Ellipsoid/Spheroid
- the Geoid (approximates earth's gravity)





- the Mean Sea Level
  - Over oceans MSL = geoid; differ on landmass
- the Terrain

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Types of Coordinate Systems

- Geographic coordinate systems
  - Global or spherical coordinate systems such as latitude-longitude.
    - Prime meridian
    - Latitude, Longitude
    - Parallels, meridians
    - Units of measure
- Projected coordinate systems
  - Examples
- Datum
  - Examples

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Map Projections

- Basic Concepts
  - "Project" features on the Earth's curved surface onto a flat surface (e.g. sheet of paper)
  - Therefore "map projection" is about preserving the properties of real-world features when they are depicted on a 2D map.
    - The properties are:
      - Area
      - Shape
      - Distance
      - Direction

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Map Projections Classes

- There are different ways to classify map projections
  - One is based on developable surface on which a network of meridians and parallels is projected
    - Cylindrical
    - Conical
    - Planar/Azimuthal

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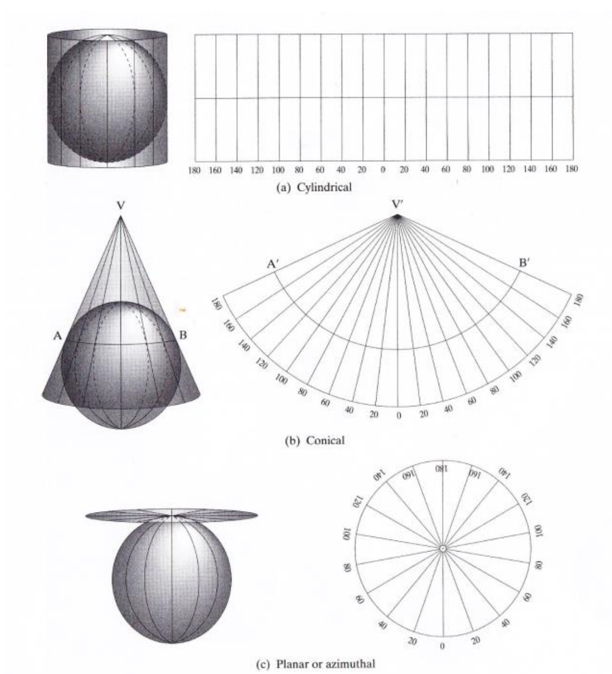

Three basic types of map projections

Source: C.P. Lo and A.K.W Yeung

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Major Projection Classes

- The other is based on the projection properties
  - Conformal
    - Local shapes/angles are correct, areas allowed to vary
  - Equal-area
    - Areas are correct, shapes allowed to vary
  - Equidistant
    - Distance to certain point correct
    - Areas and shapes allowed to vary
  - Azimuthal
    - Directions are accurate

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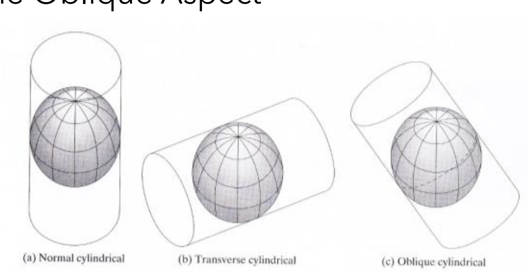
Aspects of Map Projections

- The Normal Aspect
  - Axis of cylinder or cone is coincident to the polar axis
- The Transverse Aspect
- The Oblique Aspect



Different aspects of map projections

Source: C.P. Lo and A.K.W Yeung

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Map Projections

- Coordinate Systems and Map Projections are distinct concepts
  - Coordinate Systems are constructed based on map projections

- The Universal Transverse Mercator Coordinate System??

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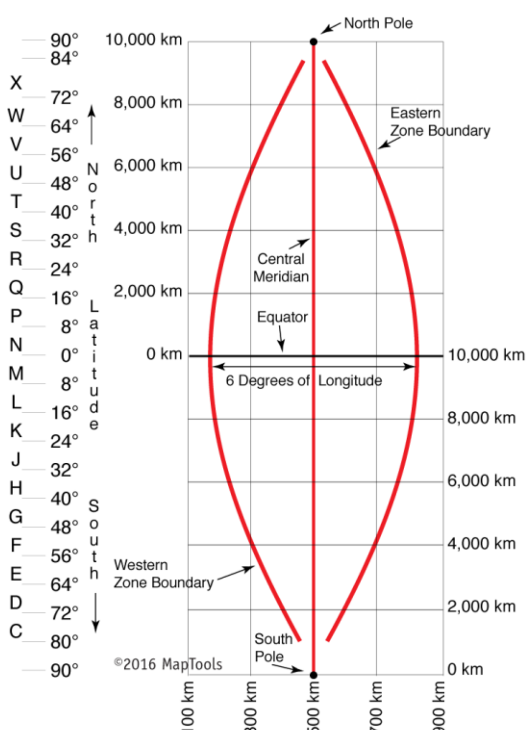

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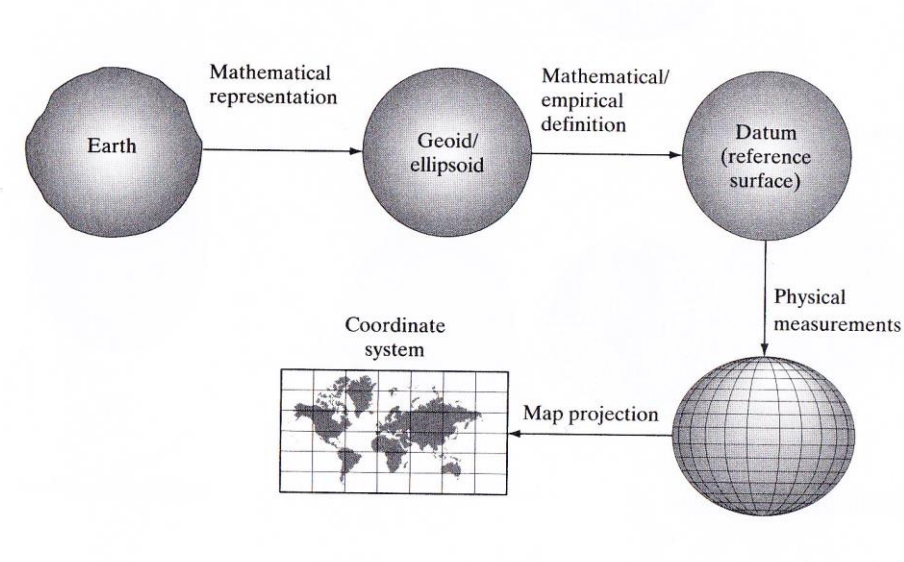

Georeferencing

Source: C.P. Lo and A.K.W Yeung

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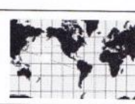
Common Map Projections, Their Properties and Major Uses

Projection/Construction	*Appearance*	*Properties*	*Major Uses*
Albers equal-area/conical	 (a)	Equal area; conformal along standard parallels	Small regional and national maps
Azimuth equidistant/planar	 (b)	Equidistant; true directions from map center	Air and sea navigation charts; equatorial and polar area large-scale maps
Equidistant conic/conical	 (c)	Equidistant along standard parallel and central meridian	Region mapping of midlatitude areas with east–west extent; atlas maps for small countries
Lambert conformal conic/conical	 (d)	Conformal; true local directions	Navigation charts; U.S. State Plane Coordinate System (SPCS) for all east–west State Plane Zones; continental U.S. maps; Canadian maps
Mercator/cylindrical	 (e)	Conformal; true direction	Navigation charts; conformal world maps

Source: C.P. Lo and A.K.W Yeung

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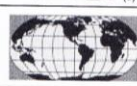
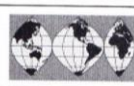
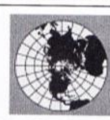
Common Map Projections, Their Properties and Major Uses

Projection/Construction	*Appearance*	*Properties*	*Major Uses*
Polyconic/conical	 (f)	Equidistant along each standard parallel and central meridian	Topographic maps; USGS 7.5- and 15-min quadrangles
Robinson/ pseudocylindrical	 (g)	Compromise between properties	Thematic world maps
Sinusoidal/ pseudocylindrical	 (h)	Equal area; local directions correct along central meridian and equator	World maps and continental maps
Stereographic/planar	 (i)	Conformal; true directions from map center	Navigation charts; polar region maps
Transverse Mercator/cylindrical	 (j)	Conformal; true local directions	Topographic mapping for areas with north–south extent; U.S. State Plan Coordinate System (SPCS) for all north–south State Plane Zones

Source: C.P. Lo and A.K.W Yeung

Geocoding

- Geocoding
  - The process of assigning spatial locations to descriptive data for those locations
    - from location description to spatial locations
- The most common type of geocoding is *address matching*
- Address matching
  - requires two sets of data
    - The first data set contains individual street addresses in a table, one record per address
    - The second is a reference database that consists of a street map and attributes for each street segment such as the street name, address ranges, and postal code
  - Three phases: preprocessing, matching, plotting
    - To plot the location, the system performs linear interpolation

Data Quality: Sources of Errors in Data

- Sources of Errors:
  - **Human errors** include mistakes, such as reading an instrument incorrectly, and faulty judgments (e.g. ambiguous boundaries such as high water mark).
  - **Environmental characteristics**, such as variations in temperature can result in measurement errors
  - **Instrument errors** Measurements are as precise as the instrument's capabilities.
    - The smallest measurement that can be made is the instrument's resolution.

Elements of Data Quality

- Accuracy
  - Positional accuracy
    - closeness of locational information (usually coordinates) to the true position
    - Generally, paper maps are accurate to roughly one line width or 0.5 mm
      - On a 1:10,000 scale, 0.5mm is equivalent to?
      - NTS/NTDB 1:50,000 = $\leq$ 25 metres
      - BC TRIM: 1:20,000 = 10 metres
      - BC/Federal: 1:250,000 = 125 m
  - Thematic/attribute accuracy
    - the closeness of attribute values to their true value

Elements of Data Quality

- Lineage
  - a record of the data sources and of the operations which created the database
    - how were they digitized, from what documents?
    - when were the data collected? By who?
  - is often a useful indicator of accuracy
- Logical consistency
  - refers to the consistency of the data model (particularly the topological consistency)
    - is the database consistent with its definitions?
    - is there exactly one label for each polygon?
    - are there nodes wherever arcs cross, or do arcs sometimes cross without forming nodes?

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Elements of Data Quality

- Completeness
  - degree to which the data exhausts all the possible items
    - are all possible objects included within the database?
  - affected by rules of selection, generalization and scale

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Elements of Data Quality

- Temporal quality
  - The quality of temporal attributes and temporal relationship of features.
- Data usability
  - Suitability to an application and its related functional requirement

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Data Quality - Key Issues

- Key Concepts
  - Accuracy, Precision and Uncertainty

- Accuracy:
  - closeness of the measurements, computations to the true values (or values accepted to be true)
    - spatial data are a generalization of the real world, the "true value" is thus an estimate of the real world
  - ~ absence of errors

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Data Quality - Key Issues

- Precision:
  - the number of decimal places or significant digits in a measurement
    - precision is not the same as accuracy - a large number of significant digits doesn't necessarily indicate that the measurement is accurate
  - a GIS works at high precision, mostly much higher than the accuracy of the data itself

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Data Quality - Key Issues

- Precision and Accuracy
  - If there are systematic variations in either the instruments used, or the phenomenon measured, this affects both accuracy and precision.

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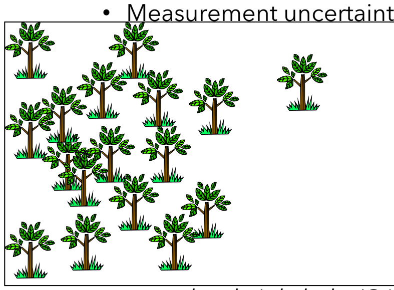
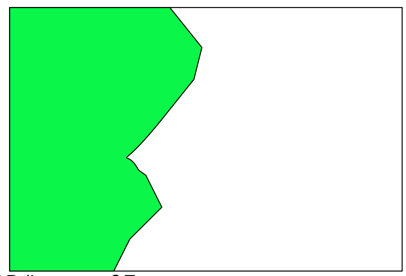
Data Quality - Key Issues

- Uncertainty: our imperfect and inexact knowledge of the world
  - Positional uncertainty
  - Attribute uncertainty
  - Definitional uncertainty
  - Measurement uncertainty





www.geog.ucsb.edu/~kclarke/G176B/Lecture07.ppt

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GIS Trends

- Missing pieces
  - Being explored in academia
    - Uncertainty in GIS
    - Time in GIS
    - 3D GIS
    - …

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GIS: Current Trends

- Mobile GIS
  - Hybrid online/offline access
- Cloud
- Data access and availability
- Augmented Reality & Mixed Reality
- Data capture
  - 3D scanning
  - Photo to point cloud
  - 360 capture

Data For Decision Support

Spatial Data

- Vector data
- Raster data

Information

- A representation of the data
- Processed Data
- E.g. A map, a graph

Knowledge

- Useful information
- Comes from:
  - comprehension of information
  - experience
- Represents understanding and insights
- Learned
- E.g. Wetlands hold sensitive ecosystems

Terms

- Choropleth Map
- Cartogram
- Flow Map
- GIS Functions/Operations vs Analysis Functions/Operations