Introduction to GIS Theory

Research Computing Services
Sept. 22, 2023
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Please fill out tutorial evaluation: http://rcs.bu.edu/eval

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Housekeeping

- **Video recordings of tutorials found here:**
  https://www.bu.edu/tech/support/research/training-consulting/access-training-materials/
- **Link to Presentation:**
  http://rcs.bu.edu/examples/gis/tutorials/gis_theory/intro_to_gis_theory.pdf
- **We will use breakout rooms for discussion**

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Outline

- What is GIS?
- Common Spatial Data Models
- Spatial Data Storage
- Mechanics of Plotting GIS Data
  1. Datum
  2. Geographic Coordinate System
  3. Projections
- Spatial Operations

What is GIS?

- **Geographic Information System**

  “A **geographic information system** (**GIS**) consists of integrated computer hardware and software that store, manage, analyze, edit, output, and visualize geographic data. Much of this often happens within a spatial database, however, this is not essential to meet the definition of a GIS. In a broader sense, one may consider such a system also to include human users and support staff, procedures and workflows, the body of knowledge of relevant concepts and methods, and institutional organizations.”

https://en.wikipedia.org/wiki/Geographic_information_system

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Examples Research GIS Software used at BU

Software

- QGIS
- ArcGIS Pro
- ENVI
- Matlab – Mapping Toolbox

Cloud Services

- ArcGIS Online
- Google Earth Engine
- Microsoft Planetary Computer
- Pangeo

Programming Languages

- Python - gdal, geopandas, xarray, rioxarray
- R – sf, terra, stars

Libraries/Command Line Tools

- GDAL
- Geos
- Proj

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Examples Research GIS Software used at BU

Getting Access to GIS Software

ArcGIS and ENVI available through CAS IT
http://www.bu.edu/casit/information/purchasing-software/

Access to MatLab - https://www.mathworks.com/academia/tah-portal/boston-university-40523728.html

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Questions:

1. Introduce yourself
2. What do you plan to do with GIS?
3. Is there a particular tool you currently, or plan, to use?

Upcoming GIS Tutorials

- ArcGIS Pro
  - Thu, Sep 28 11:00am - 1:00pm ESRI: Make Things Easier by Automating Maps and Data: Using ModelBuilder in ArcGIS Pro
  - Thu, Oct 12 1:00pm - 3:00pm Introduction to ArcGIS Pro
- ArcGIS Online
  - Thu, Sep 28 2:00pm - 4:00pm Introduction to ArcGIS Online Portal
  - Tue, Oct 3 1:00pm - 3:00pm ArcGIS Online: Map Viewer
  - Thu, Oct 5 10:00am - 12:00pm ESRI: Building and Sharing Mapping Applications: Configurable ArcGIS web tools
- QGIS
  - Tue, Sep 26 1:00pm - 3:00pm Introduction to QGIS

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“Research Software in Action”

- Monday, October 2, 9:30am – 11:30am
- **Teaching an Undergraduate Urban Cultures Course Using GIS Story Maps**
  - Speaker: **Sarah Frederick**, Director of Undergraduate Studies, Associate Professor of Japanese and Comparative Literature, Convener of Japanese Language Program, College of Arts and Sciences
- **Using Data Dashboards to Communicate Environmental Exposures**
  - Speakers: **Muskaan Khemani**, Research Assistance, School of Public Health **and Kevin Lane**, Assistant Professor, School of Public Health
- **Geospatial processing at scale with Google Earth Engine**
  - Speaker: **Paulo Arevalo**, Research Scientist, Department of Earth and Environment, College of Arts and Sciences
- **The Dask Library for Parallel Computing**
  - Speaker: **Brian Gregor**, Lead Research Computing Applications & Data Analyst, Researching Computing Services, IS&T

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GIS Demo

Common GIS Functions

- Read/write spatial data
- Maintain spatial meta data
- Apply transformations for projections
- Apply symbology based on attribute table
- Allow layering of data
- Tools to query/filter data
- Spatial analysis tools
- Exporting tools for printing maps or publish web maps

Find a GIS dataset to evaluate for the tutorial.

https://www.mass.gov/info-details/massgis-data-layers

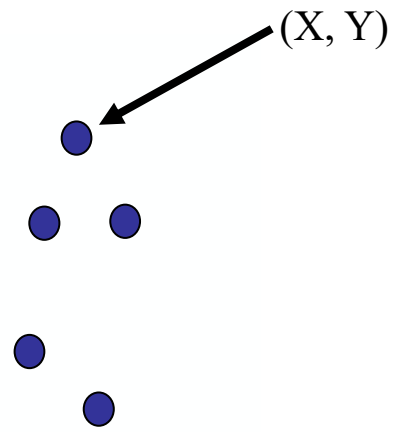
Common Spatial Data Models

Common Spatial Data Models

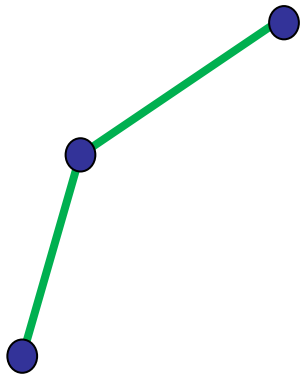
Vector

Raster

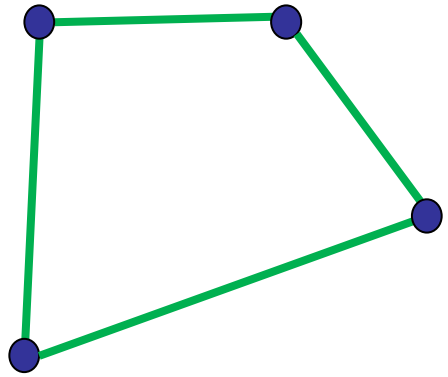
Common Spatial Data Models - Vector



Points



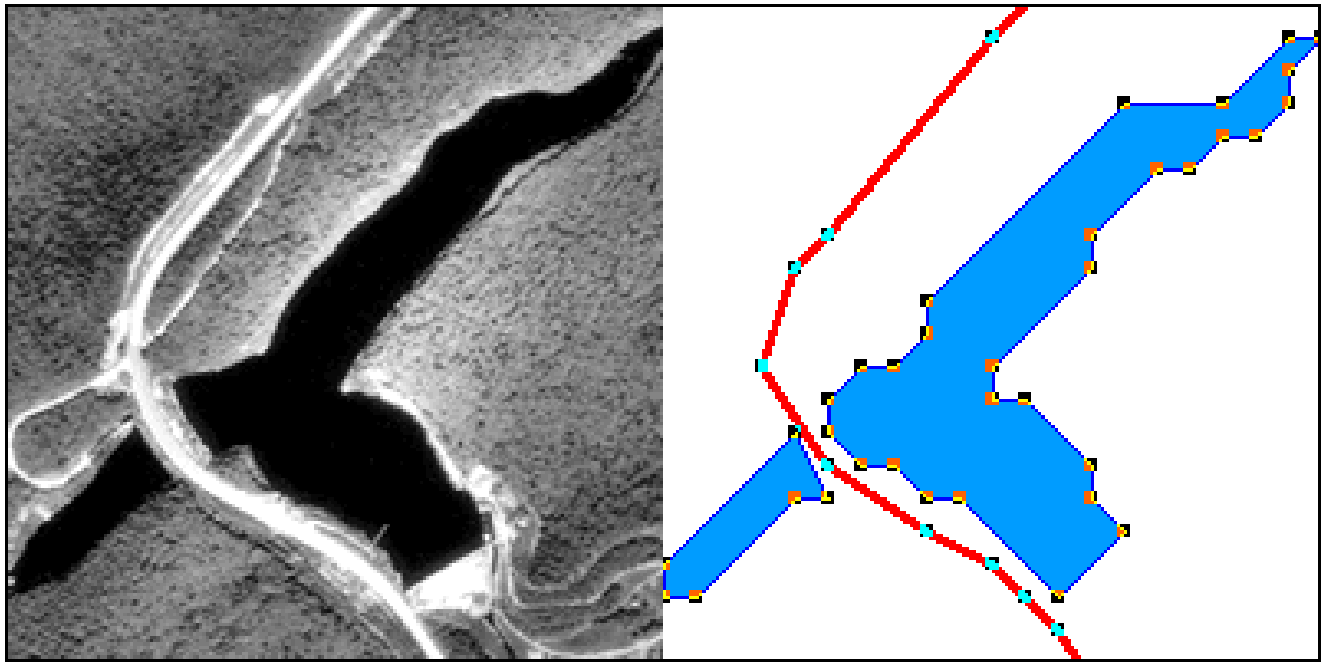
Polylines



Polygon

Note: Each type of vector data is put in its own group, layer, when stored in a data file.

Common Spatial Data Models - Vector



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Source and Additional Reading:
https://www.e-education.psu.edu/natureofgeoinfo/c1_p9.html

Common Spatial Data Models - Vector

ArcGIS Pro Demo

Source and Additional Reading:
https://www.e-education.psu.edu/natureofgeoinfo/c1_p9.html

Common Spatial Data Models

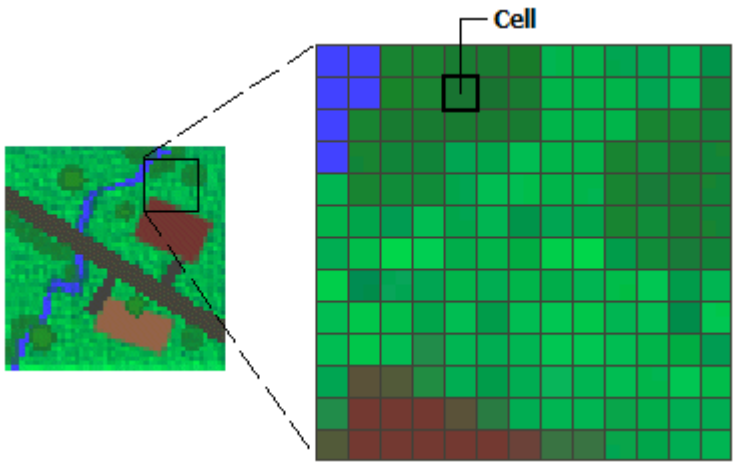
Vector

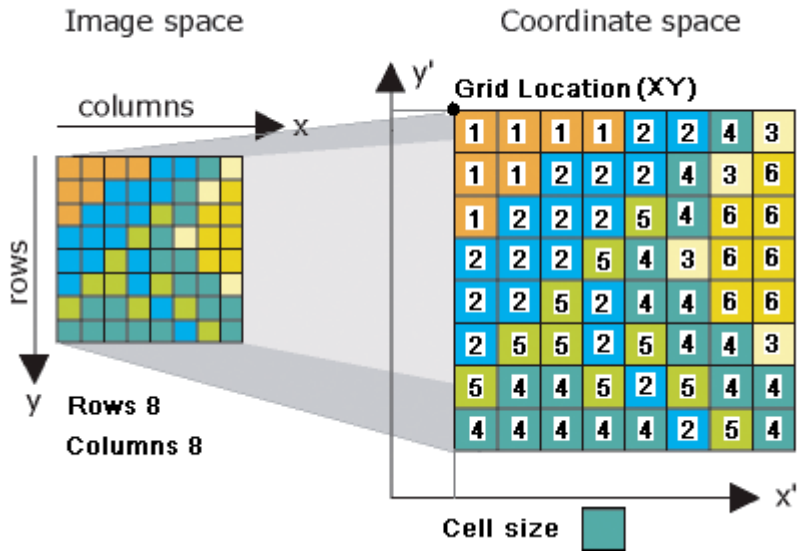
Raster

Common Spatial Data Models - Raster

Raster Data

- continuous data
- uniform gridded data

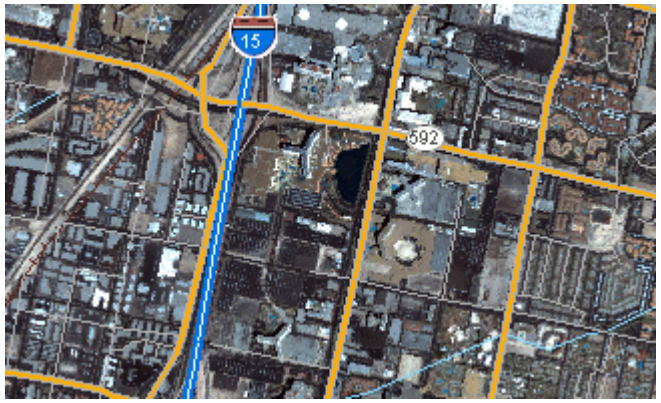


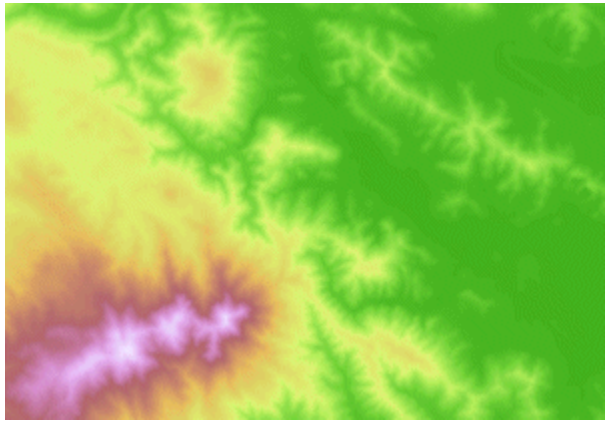


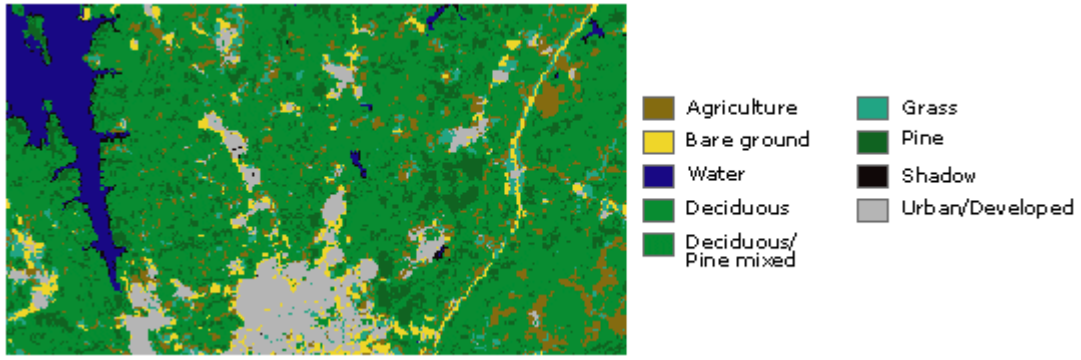
Source: http://desktop.arcgis.com/en/arcmap/latest/manage-data/raster-and-images/what-is-raster-data.htm

Common Spatial Data Models - Raster

Examples of Raster Data

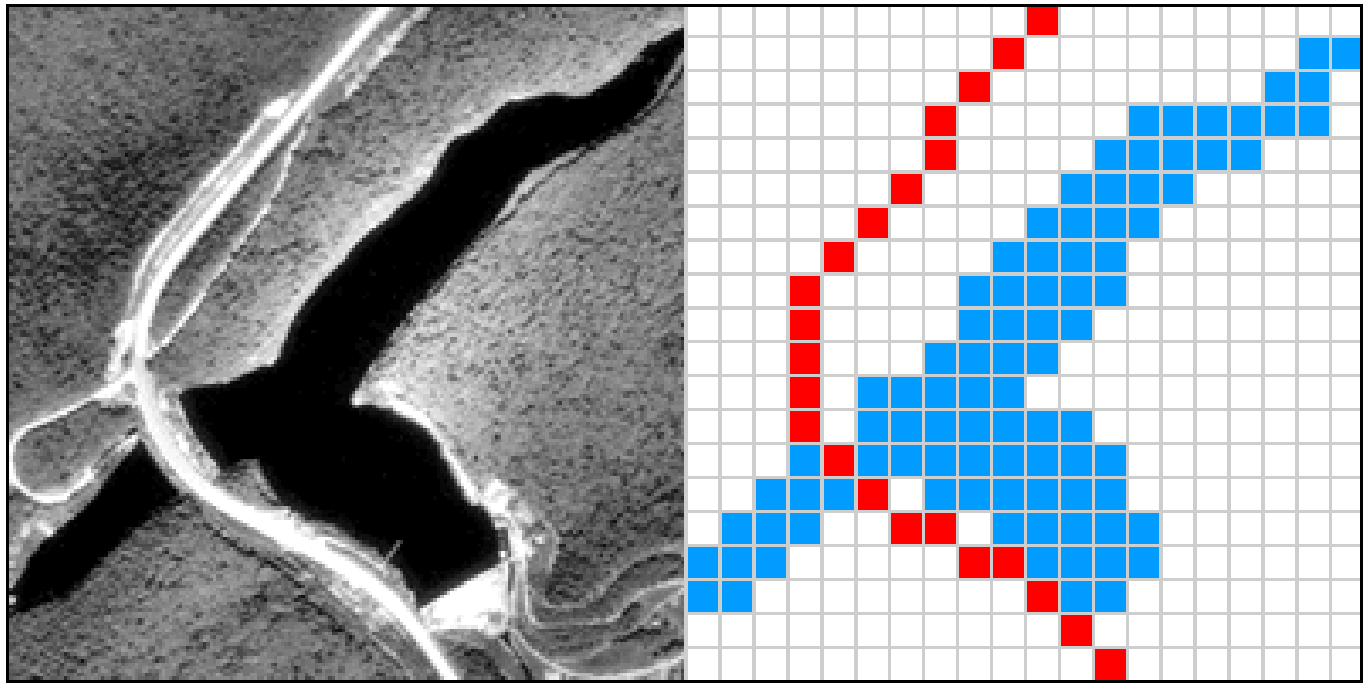






Source: http://desktop.arcgis.com/en/arcmap/latest/manage-data/raster-and-images/what-is-raster-data.htm

Common Spatial Data Models - Raster



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Source and Additional Reading:
https://www.e-education.psu.edu/natureofgeoinfo/c1_p9.html

Common Spatial Data Models - Raster

ArcGIS Pro Demo

https://oceancolor.gsfc.nasa.gov/about/projects/cyan/

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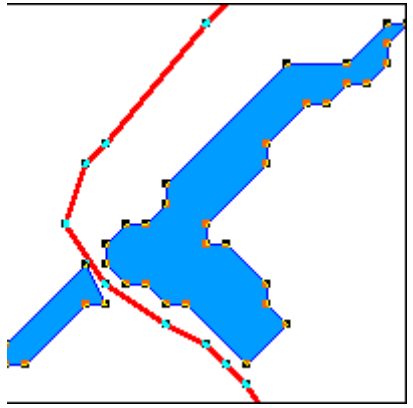
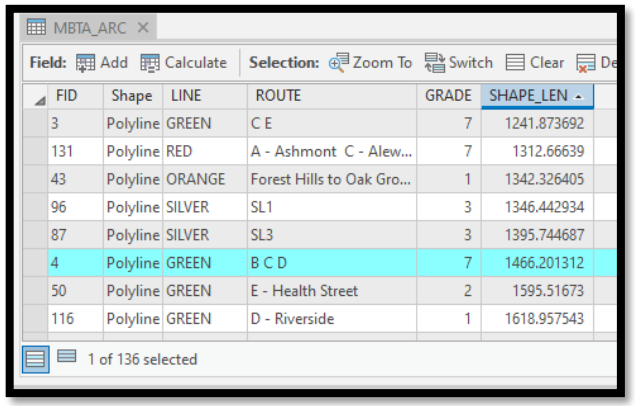
Source and Additional Reading:
https://www.e-education.psu.edu/natureofgeoinfo/c1_p9.html

Common Spatial Data Models - Review

Vector

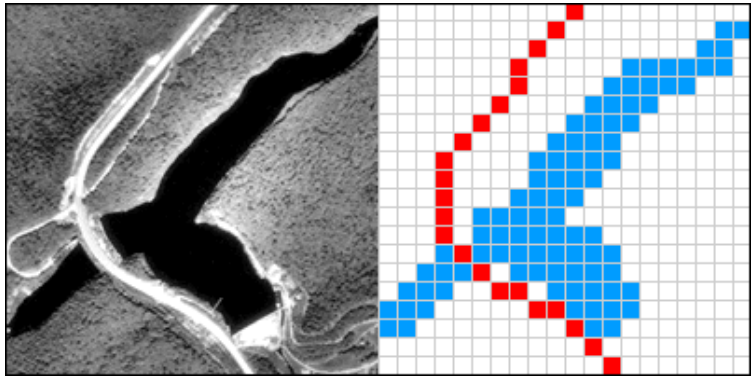




FID	Shape	LINE	ROUTE	GRADE	SHAPE_LEN
3	Polyline	GREEN	C E	7	1241.873692
131	Polyline	RED	A - Ashmont C - Alew...	7	1312.66639
43	Polyline	ORANGE	Forest Hills to Oak Gro...	1	1342.326405
96	Polyline	SILVER	SL1	3	1346.442934
87	Polyline	SILVER	SL3	3	1395.744687
4	Polyline	GREEN	B C D	7	1466.201312
50	Polyline	GREEN	E - Health Street	2	1595.51673
116	Polyline	GREEN	D - Riverside	1	1618.957543

- Attribute Table
  - Labeling
  - Filtering
  - Symbology
  - Grouping

Raster



- Continuous data
- Color coding by cell, by numeric value

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Source and Additional Reading:
https://www.e-education.psu.edu/natureofgeoinfo/c1_p9.html;https://pro.arcgis.com/en/pro-app/tool-reference/spatial-analyst/exploring-digital-elevation-models.htm
;https://desktop.arcgis.com/en/arcmap/latest/extensions/network-analyst/what-is-a-network-dataset.htm ;http://resources.arcgis.com/en/help/main/10.2/01mm/pdf/topology_rules_poster.pdf

Spatial Data Storage

Spatial Data Storage

How is spatial data stored?

AmigoCloud
ESRI ArcObjects
Arc/Info Generate
Arc/Info Binary Coverage
Arc/Info E00 (ASCII) Coverage
Atlas BNA
AutoCAD DWG
Carto
Cloudant
CouchDB/GeoCouch
Comma Separated Value (.csv)
OGC CSW (Catalog Service for the Web)
DB2 Spatial
Microstation DGN
Microstation DGN v8
DODS/OPeNDAP
AutoCAD DWG
AutoCAD DXF
EDIGEO
Google Earth Engine Data API
Elasticsearch: Geographically Encoded Objects for Elasticsearch
ESRIJSON / FeatureService driver
ESRI File Geodatabase (FileGDB)
FlatGeobuf
FMEObjects Gateway
GeoConcept text export
GeoJSON
GeoJSONSeq: sequence of GeoJSON features
Geomedia MDB database
GeoRSS : Geographically Encoded Objects for RSS feeds
Geography Markup Language
Geography Markup Language (GML) driven by application schemas
GMT ASCII Vectors (.gmt)
GeoPackage vector
GPSBabel
GPS Exchange Format
GRASS Vector Format
GPS TrackMaker
Hydrographic Transfer Format
IDB
Idrisi Vector (.VCT)
“INTERLIS 1” and “INTERLIS 2” drivers
“INTERLIS 1” and “INTERLIS 2” drivers
INGRES
JML: OpenJUMP JML format
Keyhole Markup Language
LIBKML Driver (.kml .kmz)
Dutch Kadaster LV BAG 2.0 Extract
MapML
Access MDB databases
Memory
MapInfo TAB and MIF/MID
MongoDB
MongoDBv3
Microsoft SQL Server Spatial Database
MVT: Mapbox Vector Tiles
MySQL
ALKIS
Vector
NextGIS Web
UK .NTF
OGC API - Features
Oracle Spatial
ODBC RDBMS
Open Document Spreadsheet
OGDI Vectors
OpenAir Special Use Airspace Format
ESRI File Geodatabase (OpenFileGDB)
OpenStreetMap XML and PBF
Geospatial PDF
Planetary Data Systems TABLE
PostgreSQL / PostGIS
PostgreSQL SQL Dump
ESRI Personal GeoDatabase
PLScenes (Planet Labs Scenes/Catalog API)
IHO S-57 (ENC)
ESRI ArcSDE
SDTS
SEG-P1 / UKOOA P1/90
SEG-Y / SEGY
Selafin files
ESRI Shapefile / DBF
Norwegian SOSI Standard
SQLite / Spatialite RDBMS
Tim Newport-Peace’s Special Use Airspace Format
Scalable Vector Graphics
SXF
U.S. Census TIGER/Line
TopoJSON driver
VDV-451/VDV-452/INTREST Data Format
Czech Cadastral Exchange Data Format
Virtual Format
Walk Spatial Data
WAsP .map format
OGC WFS service
MS Excel format
MS Office Open XML spreadsheet
X-Plane/Flightgear aeronautical data

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Vector Data

Source: https://gdal.org/drivers/vector/index.html

Spatial Data Storage

How is spatial data stored?

Arc/Info ASCII Grid
ACE2
ADRG/ARC Digitized Raster Graphics (.gen/.thf)
Arc/Info Binary Grid
AIRSAR Polarimetric Format
Azavea Raster Grid
Bathymetry Attributed Grid
Magellan BLX Topo File Format
Microsoft Windows Device Independent Bitmap
Better Portable Graphics
Maptech/NOAA BSB Nautical Chart Format
VTP .bt Binary Terrain Format
Natural Resources Canada's Geoid file format (.byn)
AutoCAD DWG raster layer
CALS Type 1
CEOS Image
DRDC COASP SAR Processor Raster
Cloud Optimized GeoTIFF generator
TerraSAR-X Complex SAR Data Product
Convair PolGASP data
CTable2 Datum Grid Shift
USGS LULC Composite Theme Grid
DAAS (Airbus DS Intelligence Data As A Service driver)
DB2 raster
DirectDraw Surface
Derived subdatasets driver
Spot DIMAP
ELAS DIPEx
OPeNDAP Grid Client
First Generation USGS DOQ
New Labelled USGS DOQ
Military Elevation Data
Arc/Info Export E00 GRID
ECRG Table Of Contents (TOC.xml)
Enhanced Compressed Wavelets (.ecw)
Google Earth Engine Data API Image
ESRI .hdr Labelled
Erdas Imagine Raw
Earth Resources Laboratory Applications Software
ENVI .hdr Labelled Raster
Wavelet compressed images
ERMapper .ERS
Envisat Image Product
Extended Dynamic Range Image File Format
EOSAT FAST Format
FIT
Flexible Image Transport System
Fuji BAS Scanner Image
Generic Binary (.hdr labelled)
Oracle Spatial GeoRaster
Sandia National Laboratories GSAT File Format
Graphics Interchange Format
GMT Compatible netCDF
GeoPackage raster
GRASS Raster Format
GRASS ASCII Grid
WMO General Regularly-distributed Information in Binary form
Golden Software Surfer 7 Binary Grid File Format
Golden Software ASCII Grid File Format
Golden Software Binary Grid File Format
GSC Geogrid
Generic Tagged Arrays
GeoTIFF File Format
Grid eXchange File
Hierarchical Data Format Release 4 (HDF4)
Hierarchical Data Format Release 5 (HDF5)
HF2/HFZ heightfield raster
Erdas Imagine .img
Image Display and Analysis
Idrisi Raster Format
IGN-France height correction ASCII grids
Raster Map
Intergraph Raster Format
Vaisala's weather radar software format
ISCE
International Service for the Geoid
USGS Astrogeology ISIS Cube (Version 2)
USGS Astrogeology ISIS Cube (Version 3)
Japanese DEM (.mem)
ERDAS JPEG2000 (.jp2)
JPEG-2000 (based on Kakadu)
JPEG2000 driver based on Lurawave library
JPEG2000 via MrSID SDK
JPEG2000 driver based on OpenJPEG library
JPEG JFIF File Format
Implementation of the JPEG-2000 part 1
JPEGLS
JPIP Streaming
KEA
KMLSuperoverlay
KOLOR Raw format
NOAA Polar Orbiter Level 1b Data Set (AVHRR)
Erdas 7.x .LAN and .GIS
FARSITE v.4 LCP Format
Daylon Leveller Heightfield
NADCON .los/.las Datum Grid Shift
OziExplorer .MAP
Meta Raster Format
MBTiles
In Memory Raster
Vexcel MFF Raster
Vexcel MFF2 Image
MrSID/MG4 LiDAR Compression / Point Cloud View files
Multi-resolution Seamless Image Database
Meteosat Second Generation
Meteosat Second Generation (MSG) Native Archive Format (.nat)
NLAPS Data Format
NetCDF: Network Common Data Form
NOAA NGS Geoid Height Grids
NextGIS Web
National Imagery Transmission Format
NTv1 Datum Grid Shift
NTv2 Datum Grid Shift
Northwood/Vertical Mapper File Format
Northwood/Vertical Mapper File Format
OZF2/OZFX3 raster
JAXA PALSAR Processed Products
PCI .aux Labelled Raw Format
PCI Geomatics Database File
PCRaster raster file format
Geospatial PDF
Planetary Data System v3
NASA Planetary Data System (Version 4)
PLMosaic (Planet Labs Mosaics API)
Portable Network Graphics
Netpbm (.pgm, .ppm)
PostGIS Raster driver
PHOTOMOD Raster File
R Object Data Store
Rasdaman GDAL driver
Rasters in SQLite DB
Rasters in SQLite DB
RDA (DigitalGlobe Raster Data Access)
RIEGL Database
Swedish Grid Maps
Raster Matrix Format
ROI_PAC
Raster Product Format/RPF (a.toc)
R Raster
RadarSat 2 XML Product
Sentinel-1 SAFE XML Product
CEOS SAR Image
SAGA GIS Binary Grid File Format
ESRI ArcSDE Raster
USGS SDTS DEM
Sentinel-2 Products
SGI Image Format
Scaled Integer Gridded DEM
Snow Data Assimilation System
Standard Product Format (ASRP/USRP) (.gen)
SRTM HGT Format
Terragen™ Terrain File
EarthWatch/DigitalGlobe .TIL
TileDB
TerraSAR-X Product
USGS ASCII DEM (and CDED)
VICAR
GDAL Virtual Format
OGC Web Coverage Service
WEBP
Web Map Services
OGC Web Map Tile Service
X11 Pixmap
ASCII Gridded XYZ
ZMap Plus Grid

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Raster Data

Source: https://gdal.org/drivers/raster/index.html#

Spatial Data Storage

General Categories of Data Storage

Type of Storage	Vector Examples	Raster Example
Individual Files	ESRI Shapefile AutoCAD GeoJSON Excel File	Arc/Info ASCII Grid GeoTIFF JPEG2000 netCDF HDF
Multi-Feature/Raster File	GeoPackage File Geodatabase	GeoPackage raster
Database	SpatialLite PostgresSQL ArcGIS Server MySQL	Oracle Spatial GeoRaster PostGIS Raster SQLite ArcGIS Server
Web Map Services	ArcGIS Online Tiles	Google Maps ArcGIS Online OpenStreetMap Bing Maps

Question:

1. Is your data Raster or Vector (point, polyline, polygon?)?

2. What file type is used to store your data?

3. Does the description mention any quality limitations of your data? (Raster cell size, vector resolution, how it was collected)

Mechanics for Plotting GIS Data

Mechanics for Plotting GIS Data

1. Datum
2. Geographic Coordinate System
3. Coordinates
4. Projection

Mechanics for Plotting GIS Data

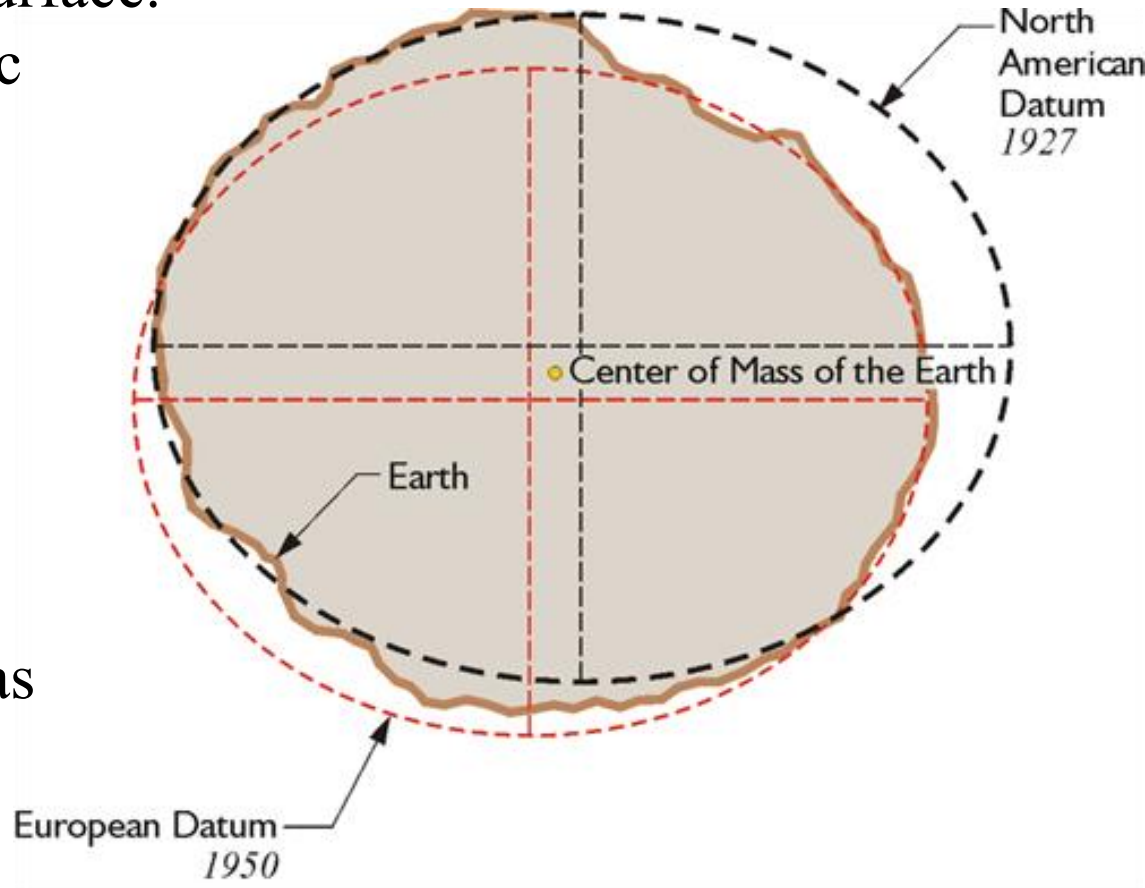
1. **Datum**
2. Geographic Coordinate System
3. Projection

1. Datum

Datums are a models that approximates the earth's surface. Some datums are designed to be accurate for specific areas on the globe.

Examples:
- Australian Geodetic Datum 1984
- North American Datum 1983 (NAD83)
- North American Datum 1927 (NAD27)

Note: There are datums for referencing depth, such as North American Vertical Datum of 1988 (NAVD88)



Source: https://www.e-education.psu.edu/geog862/book/export/html/1669

Mechanics for Plotting GIS Data

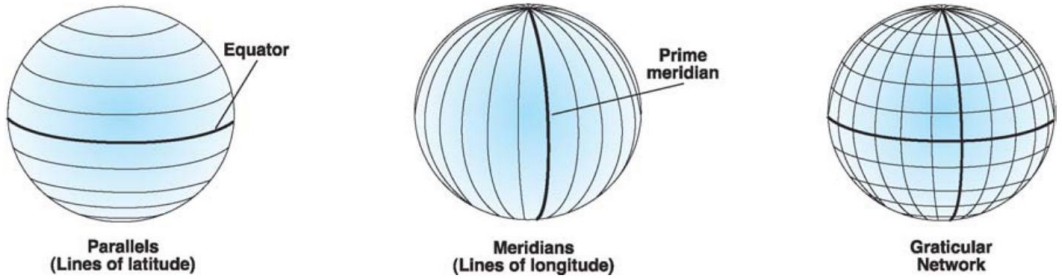
1. Datum
2. **Geographic Coordinate System**
3. Projection

2. Geographic Coordinate System

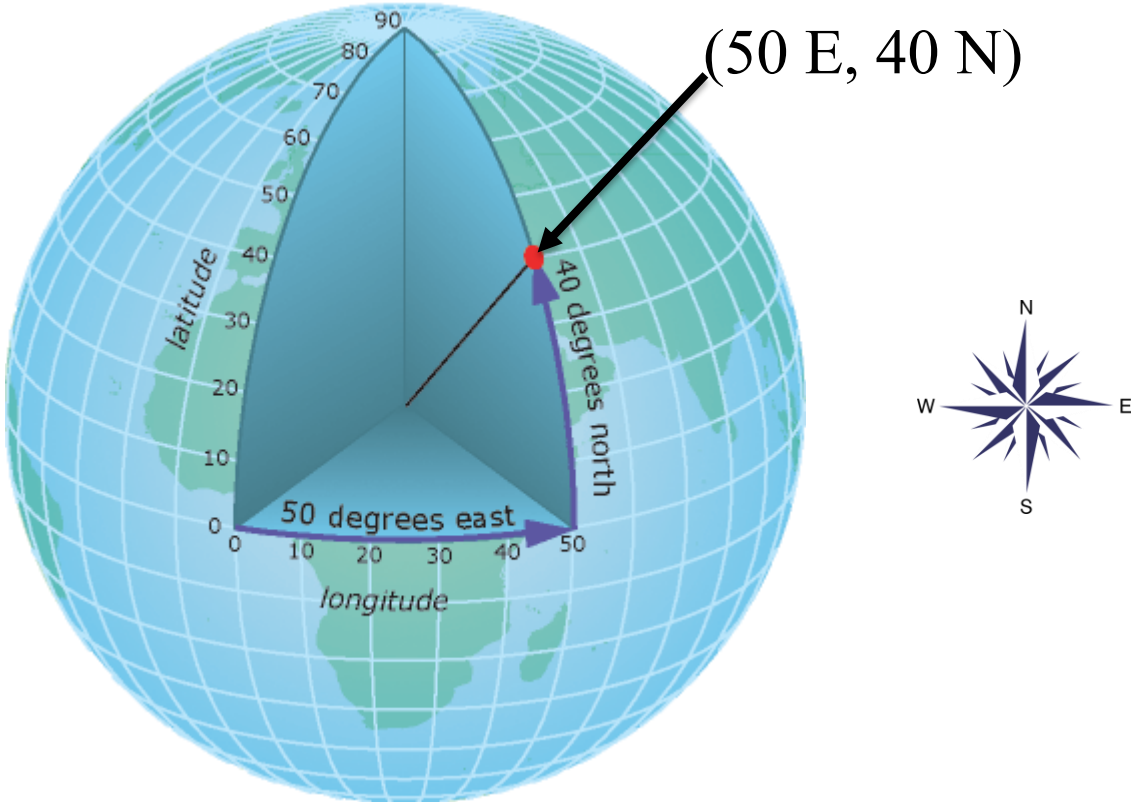
What are Geodetic Datums?

Video Link: https://youtu.be/kXTHaMY3cVk?si=RgyNUfBclTaLJxAC
More information at: https://geodesy.noaa.gov/datums/newdatums/index.shtml

2. Geographic Coordinate System



Source: http://desktop.arcgis.com/en/arcmap/10.3/guide-books/map-projections/about-geographic-coordinate-systems.htm



Source: http://desktop.arcgis.com/en/arcmap/10.3/guide-books/map-projections/geographic-coordinate-system.htm

Defined by a math model.

2. Geographic Coordinate System

Decimal places and accuracy of position.

decimal places	decimal degrees	DMS	Object that can be *unambiguously* recognized at this scale
0	1.0	1° 00′ 0″	country or large region
1	0.1	0° 06′ 0″	large city or district
2	0.01	0° 00′ 36″	town or village
3	0.001	0° 00′ 3.6″	neighborhood, street
4	0.0001	0° 00′ 0.36″	individual street, land parcel
5	0.00001	0° 00′ 0.036″	individual trees, door entrance
6	0.000001	0° 00′ 0.0036″	individual humans
7	0.0000001	0° 00′ 0.00036″	practical limit of commercial surveying
8	0.00000001	0° 00′ 0.000036″	specialized surveying (e.g. tectonic plate mapping)

At 38 degrees North latitude

- One degree of **latitude** equals approximately 69 miles.
- One-degree of **longitude** equals 54.6 miles

Source: https://www.usgs.gov/faqs/how-much-distance-does-a-degree-minute-and-second-cover-your-maps

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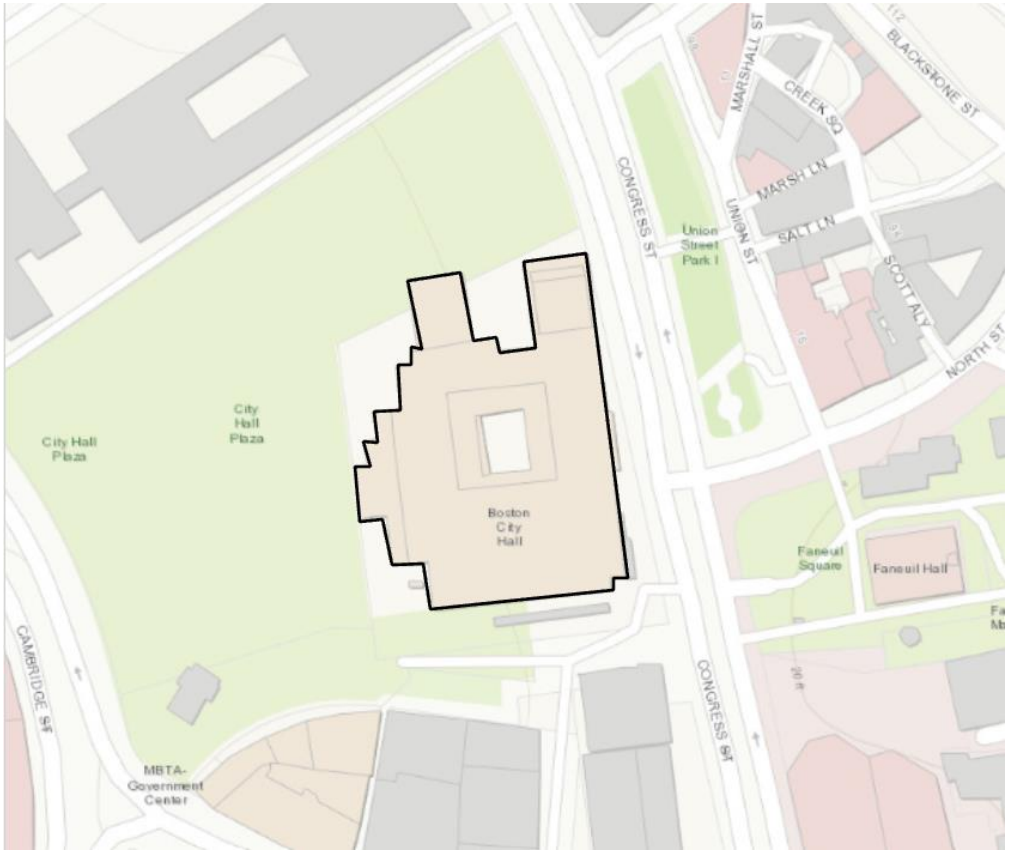
Additional Reading:
https://en.wikipedia.org/wiki/Decimal_degrees

Geographic Coordinate System and Coordinates

NAD 1927



NAD 1983

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Mechanics for Plotting GIS Data

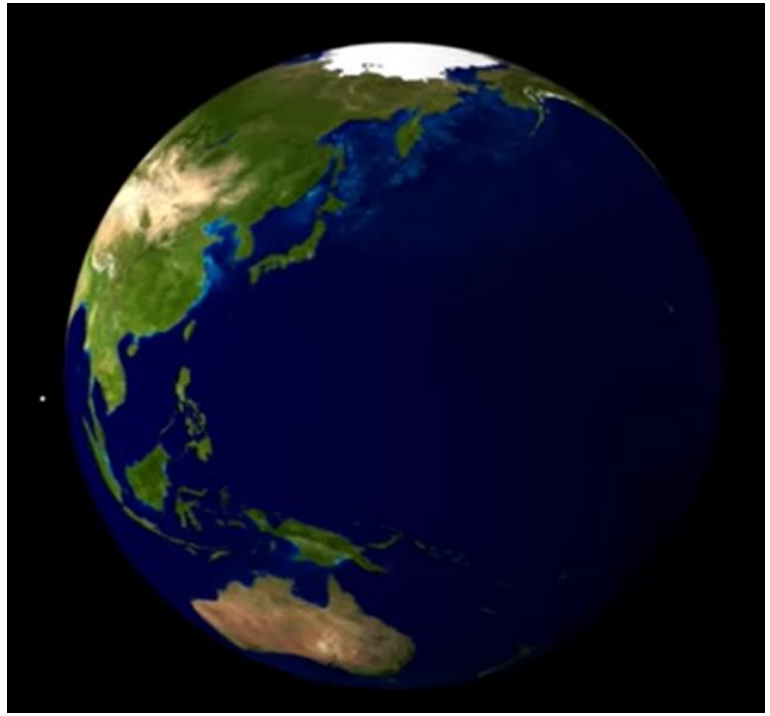
1. Datum
2. Geographic Coordinate System
3. **Projection**

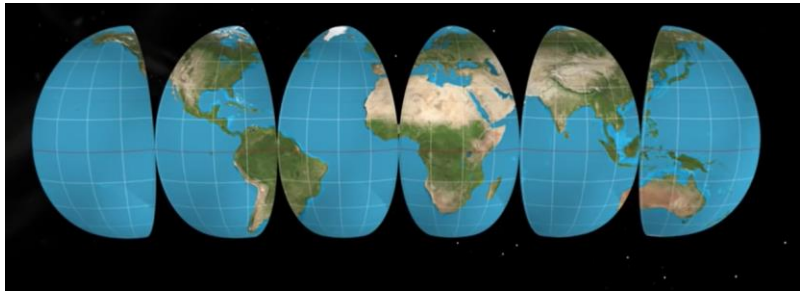
3. Projections

Why all world maps are wrong?

Video Link: https://youtu.be/kIID5FDi2JQ?si=ocnEHGL6IwzvhZJP

3. Projections





Source: https://www.youtube.com/watch?v=CPQZ7NcQ6YQ
Additional Reading:
https://laughingsquid.com/world-mercator-projection-map-country-size/

3. Projections

- Allow creation of flat maps.

- At expense of distorting:
    - Shape
    - Area
    - Direction
    - Distance

* NOTE: Many GIS software require projected data for spatial analysis. The distortions will be incorporated into the result.

- Coordinates are typically in feet, or meters, and positive values
    - e.g (114564 ft, 53746 ft)

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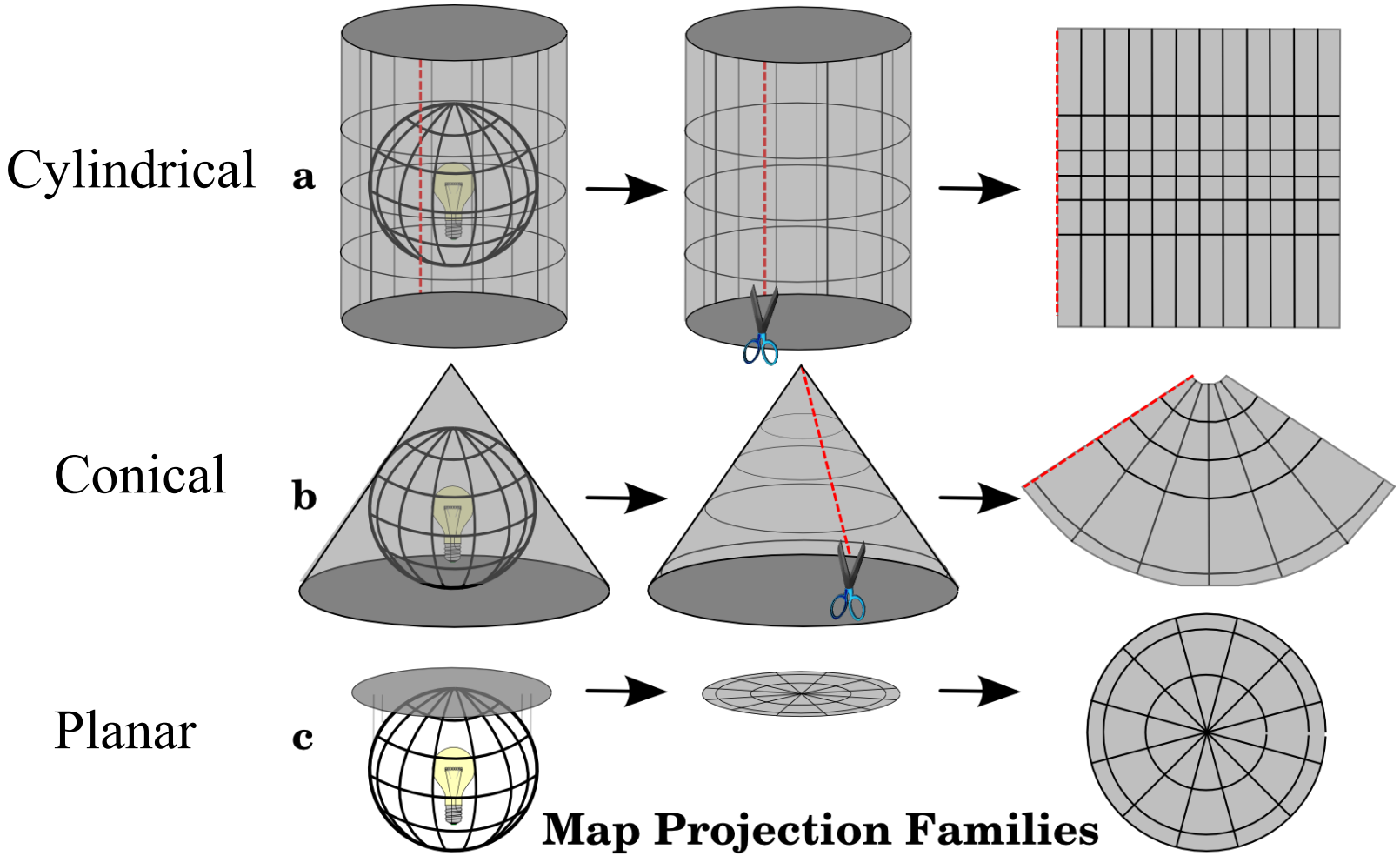
3. Projections

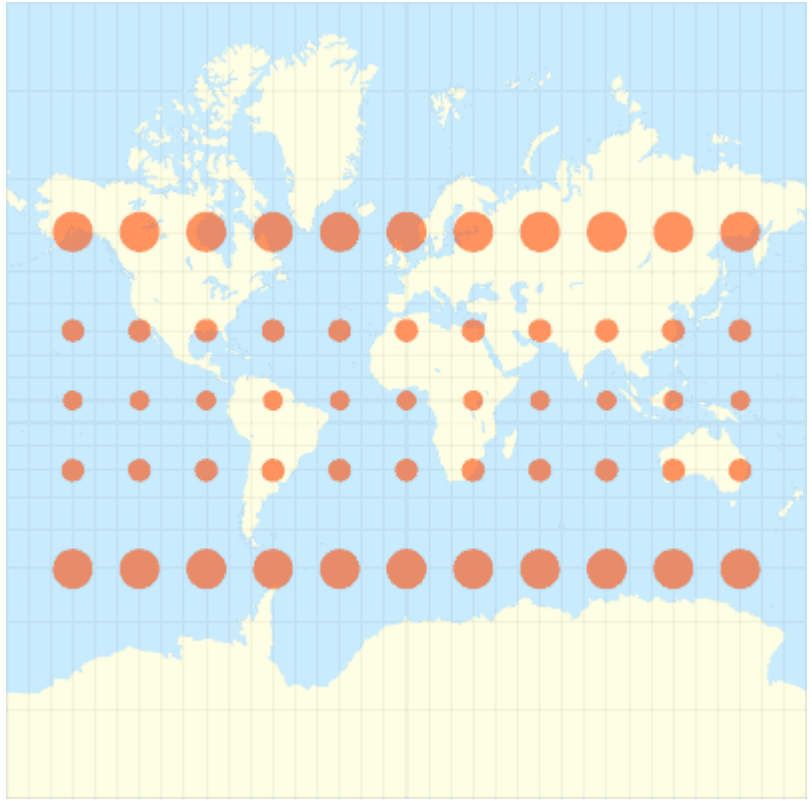


Source: https://docs.qgis.org/3.10/en/docs/gentle_gis_introduction/coordinate_reference_systems.html#id1

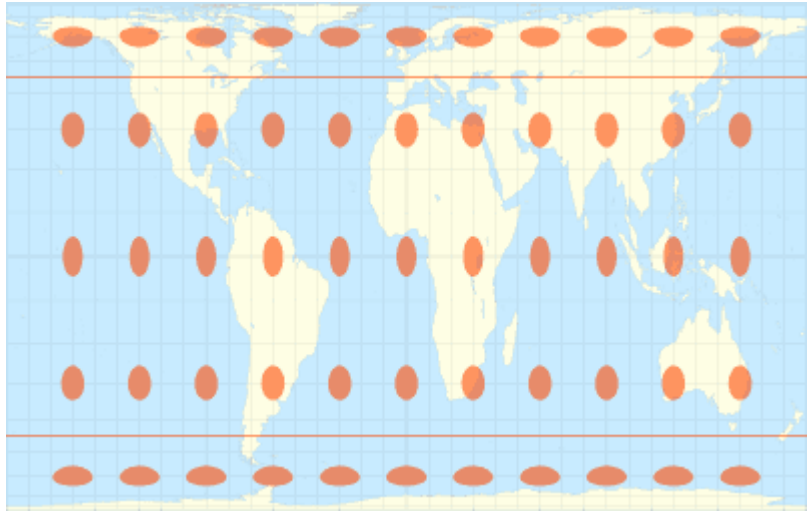
3. Projections

Tissot's Indicatrix

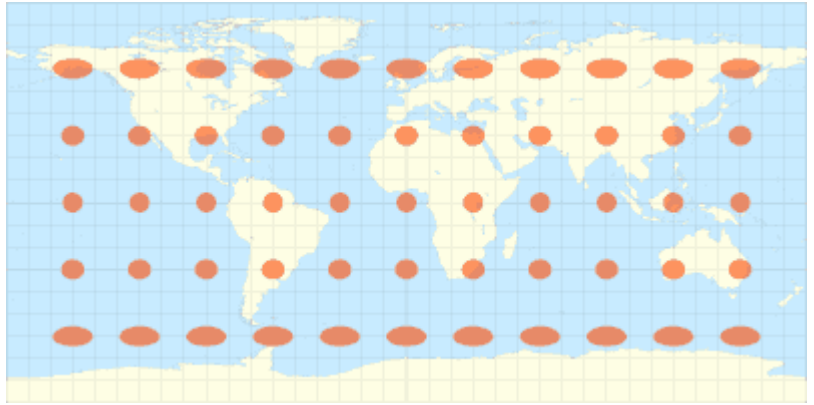
Conformal



Equal Area



Equidistant



Source and Additional Reading:
http://geokov.com/education/map-projection.aspx

3. Projections

Projection Definition Lookup reference starting point

- https://desktop.arcgis.com/en/arcmap/latest/map/projections/pdf/projected_coordinate_systems.pdf

Others Web Sources

- https://spatialreference.org/ref/epsg/
- https://epsg.io/?q=

Question:

1. Which spatial property is important for you to preserve for your project?
    - Shape
    - Area
    - Direction
    - Distance

2. What projection might you use for your area of interest?
https://desktop.arcgis.com/en/arcmap/latest/map/projections/pdf/projected_coordinate_systems.pdf

3. Projections

Types of Projection Definitions

- EPSG
- Well Known Text as HTML
- Human-Readable OGC WKT
- Proj (formerly proj4)
- OGC WKT
- JSON
- GML
- ESRI WKT
- .PRJ File
- USGS
- MapServer Mapfile | Python
- Mapnik XML | Python
- GeoServer
- PostGIS spatial_ref_sys INSERT statement
- Proj4js format

3. Projections

Sample Projection Definitions for **NAD83 / Massachusetts Mainland (ftUS)**

Definition Type	Example
EPSG	2249
Proj4	+proj=lcc +lat_1=42.68333333333333 +lat_2=41.71666666666667 +lat_0=41 +lon_0=-71.5 +x_0=200000.0001016002 +y_0=750000 +ellps=GRS80 +datum=NAD83 +to_meter=0.304800609601219 2 +no_defs
.prj	PROJCS["NAD83 / Massachusetts Mainland (ftUS)",GEOGCS["GCS_North_American_1983",DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137,298.257222101]],PRIMEM["Greenwich",0],UNIT["Degree",0.0174532925199433295]],PROJECTION["Lambert_Conformal_Conic"],PARAMETER["standard_parallel_1",42.68333333333333],PARAMETER["standard_parallel_2",41.71666666666667],PARAMETER["latitude_of_origin",41],PARAMETER["central_meridian",-71.5],PARAMETER["false_easting",656166.667],PARAMETER["false_northing",2460625],UNIT["Foot_US",0.3048006096012192]]

3. Projections

Sample Projection Definitions for **NAD83 / Massachusetts Mainland (ftUS)**

Definition Type	Example
Well Known Text (WKT)	**PROJCS**["NAD83 / Massachusetts Mainland (ftUS)", **GEOGCS**["NAD83", **DATUM**["North_American_Datum_1983", **SPHEROID**["GRS 1980",6378137,298.257222101, AUTHORITY["EPSG","7019"]], AUTHORITY["EPSG","6269"]], **PRIMEM**["Greenwich",0, AUTHORITY["EPSG","8901"]], **UNIT**["degree",0.0174532925199433, AUTHORITY["EPSG","9122"]], AUTHORITY["EPSG","4269"]], **UNIT**["US survey foot",0.304800609601219, AUTHORITY["EPSG","9003"]], **PROJECTION**["Lambert_Conformal_Conic_2SP"], **PARAMETER**["standard_parallel_1",42.6833333333333], **PARAMETER**["standard_parallel_2",41.7166666666667], **PARAMETER**["latitude_of_origin",41], **PARAMETER**["central_meridian",-71.5], **PARAMETER**["false_easting",656166.667], **PARAMETER**["false_northing",2460625], AUTHORITY["EPSG","2249"], **AXIS**["X",EAST], **AXIS**["Y",NORTH]]

3. Projections

Additional Reading

- http://geokov.com/education/map-projection.aspx
- https://www.axismaps.com/guide/general/map-projections/
- https://alastaira.wordpress.com/2011/01/23/the-google-maps-bing-maps-spherical-mercator-projection/
- http://bl.ocks.org/syntagmatic/raw/ba569633d51ebec6ec6e/

Projected Coordinate Systems supported by ArcGIS Pro

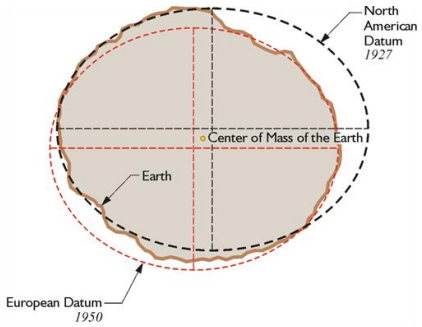
- https://desktop.arcgis.com/en/arcmap/latest/map/projections/pdf/projected_coordinate_systems.pdf

Projection Definition Lookup reference

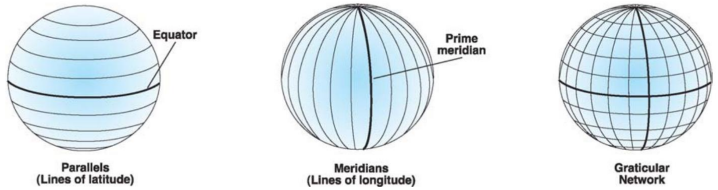
- https://spatialreference.org/ref/epsg/
- https://epsg.io/?q=

Mechanics for Plotting GIS Data (Review)

1. Datum

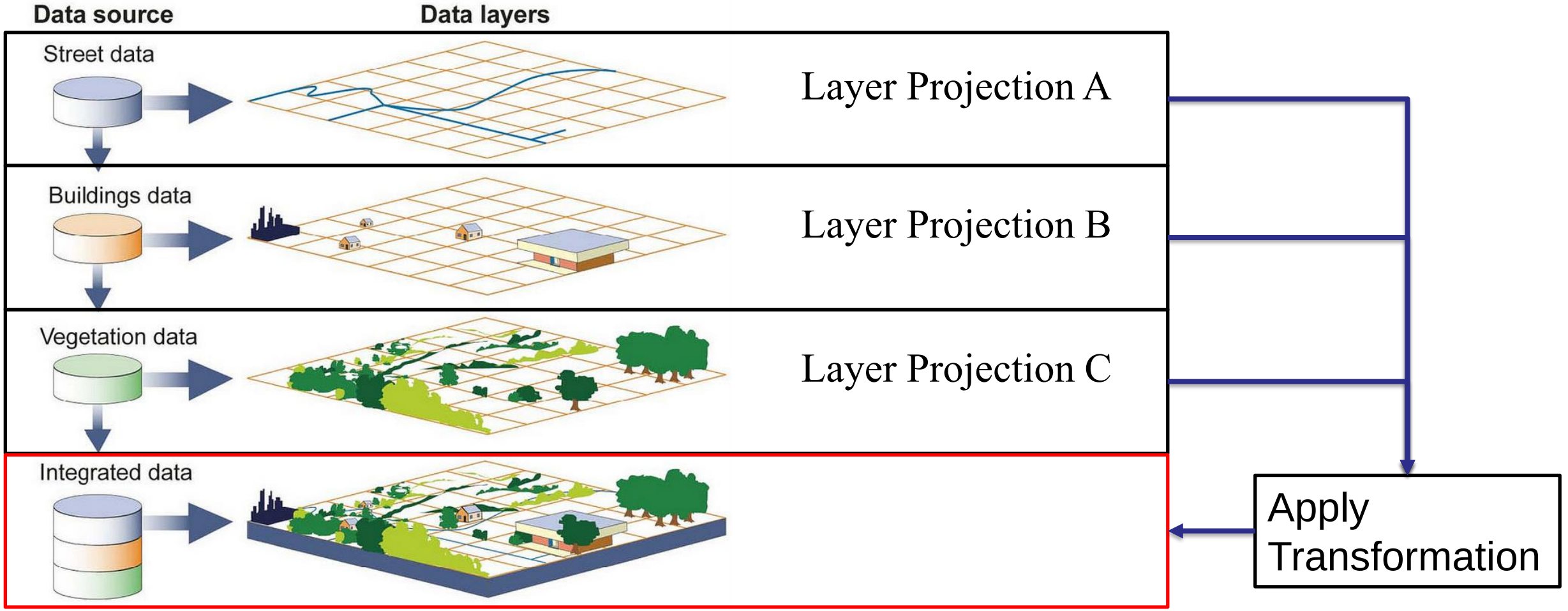


2. Geographic Coordinate System



3. Projection

Mechanics for Plotting GIS Data



Source:
http://www.forestrymaps.alaska.gov/whyGIS.html

Mechanics for Plotting GIS Data

Many GIS packages takes care of the math. Phew!

- What datum/geographic coordinate system/projection do I choose?
  - Institutions or Organization may select a datum/coordinate system.
  - Choose one that minimizes distortion characteristics important for your analysis.

- When to select/change geographic coordinate system or projections in GIS?
  - Importing raw data into GIS
    - Georeferencing images or old maps.
    - Importing CSV files
  - Spatial processing of two layers.
  - Some GIS tools expect projected data.

NAD 1927

NAD 1983

Question:

1. Does your GIS data have a Coordinate Reference System defined? What is it? Is it geographic or projected?

2. What are the units of the coordinates? (e.g. degrees, feet, meters.)

For MassGIS data check out:
https://www.mass.gov/info-details/overview-of-massgis-data

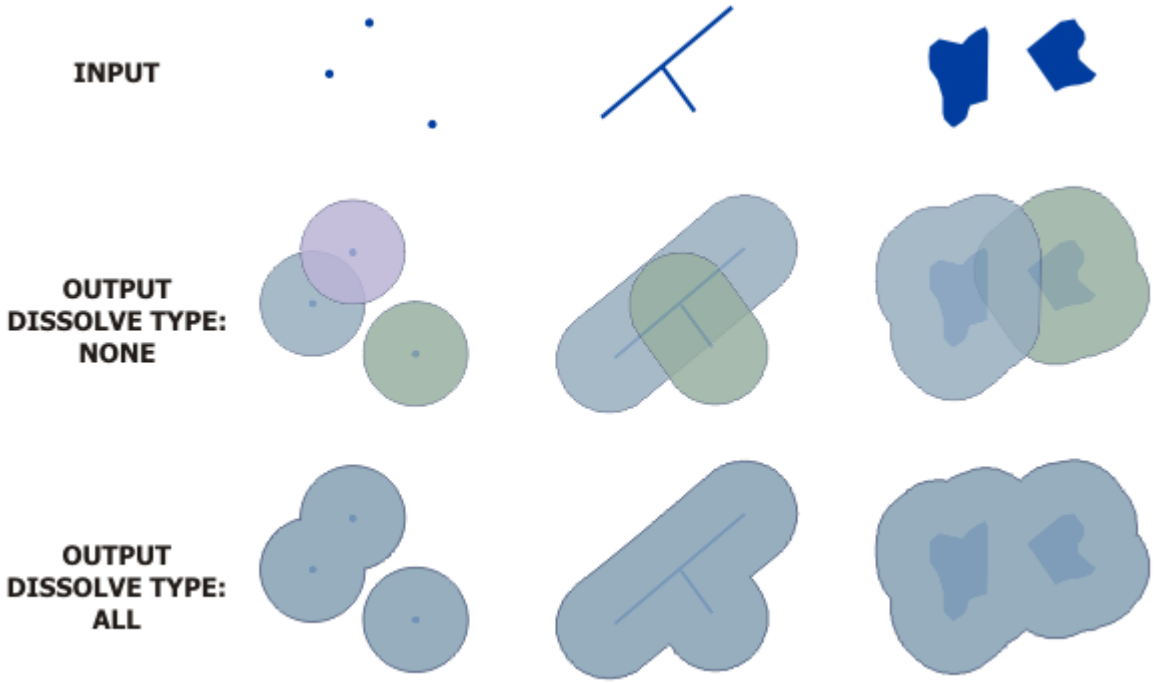
Spatial Operations

Spatial Operations

- Common Spatial Operations with Vector Data
  - Buffer
  - Clip
  - Union
  - Intersect
  - Erase
  - Dissolve
  - Spatial Join
  - Point Distance

Data Layers / Thematic Data

BUFFER

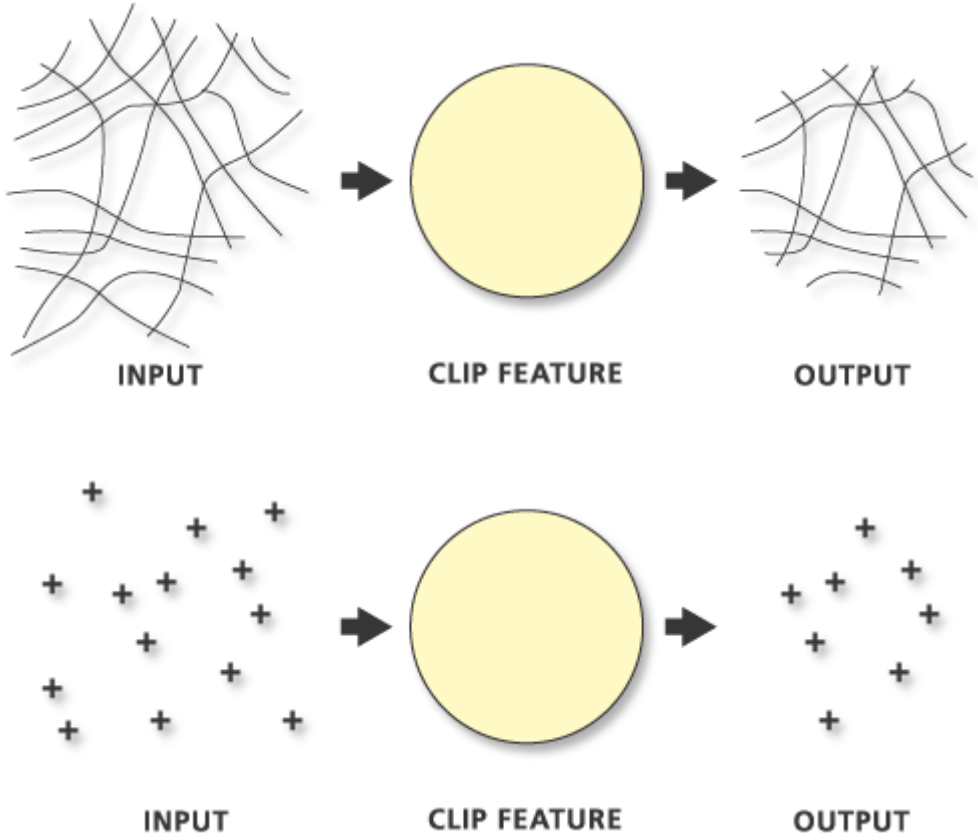


Source: https://desktop.arcgis.com/en/arcmap/latest/tools/analysis-toolbox/buffer.htm

Data Layers / Thematic Data

- Common Vector Overlay Operations

CLIP

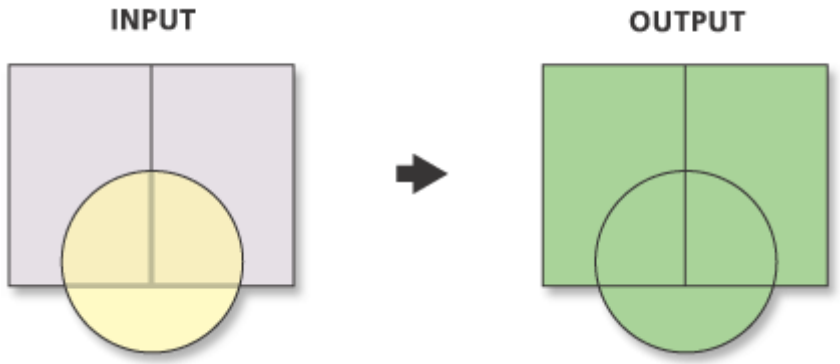


Source: https://desktop.arcgis.com/en/arcmap/latest/tools/analysis-toolbox/clip.htm

Data Layers / Thematic Data

- Common Vector Overlay Operations

UNION

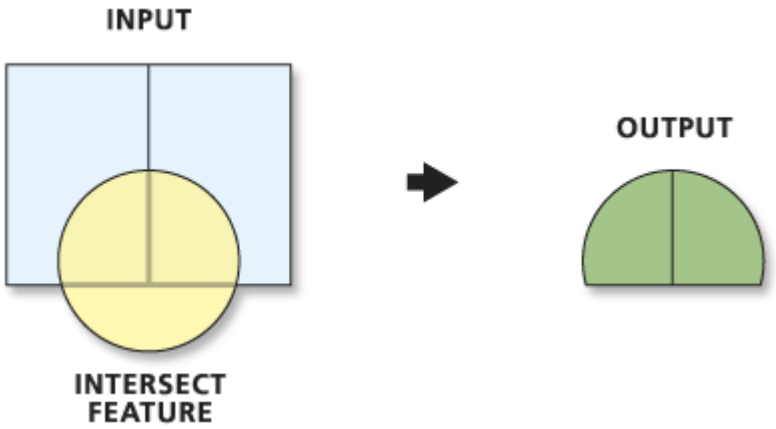


Source: https://desktop.arcgis.com/en/arcmap/latest/tools/analysis-toolbox/union.htm

Data Layers / Thematic Data

- Common Vector Overlay Operations

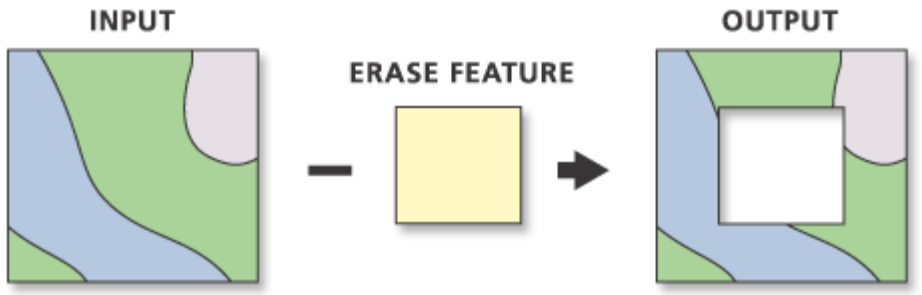
INTERSECT



Source: https://desktop.arcgis.com/en/arcmap/latest/tools/analysis-toolbox/intersect.htm

Data Layers / Thematic Data

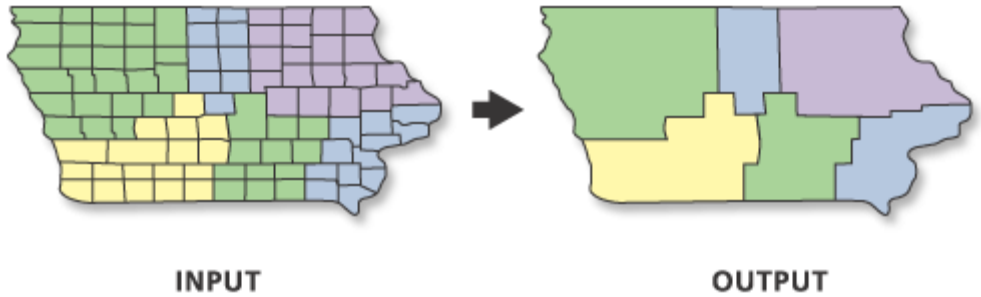
ERASE



Source: https://desktop.arcgis.com/en/arcmap/latest/tools/analysis-toolbox/erase.htm

Data Layers / Thematic Data

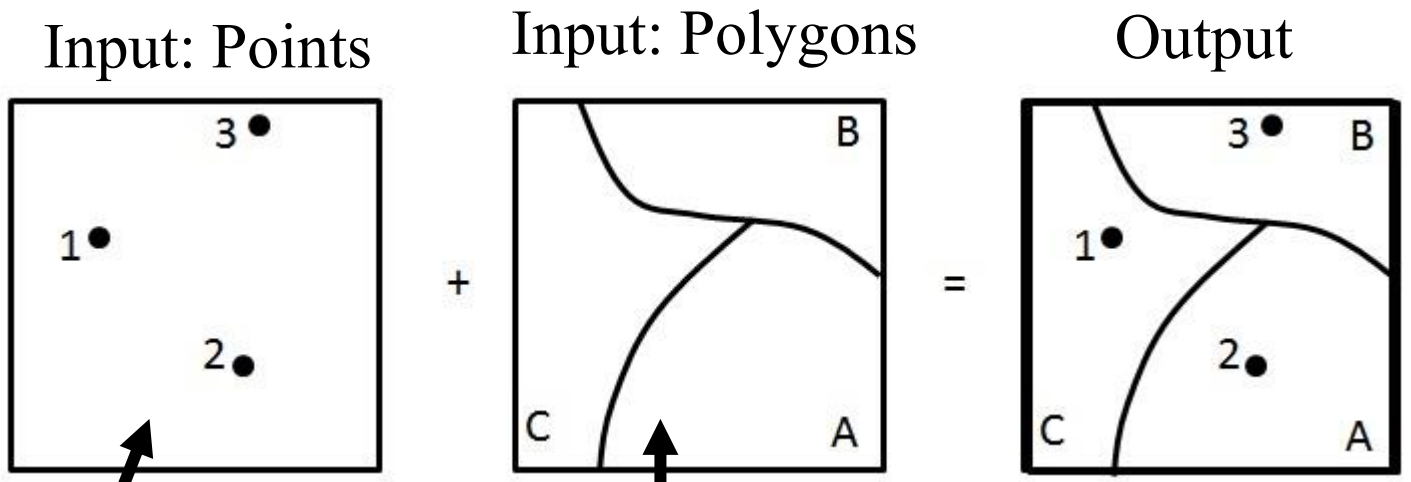
DISSOLVE



Source: https://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?TopicName=Dissolve%20(Data%20Management)

Data Layers / Thematic Data

SPATIAL JOIN



POINT	Tree
1	OAK
2	MAPLE
3	PINE

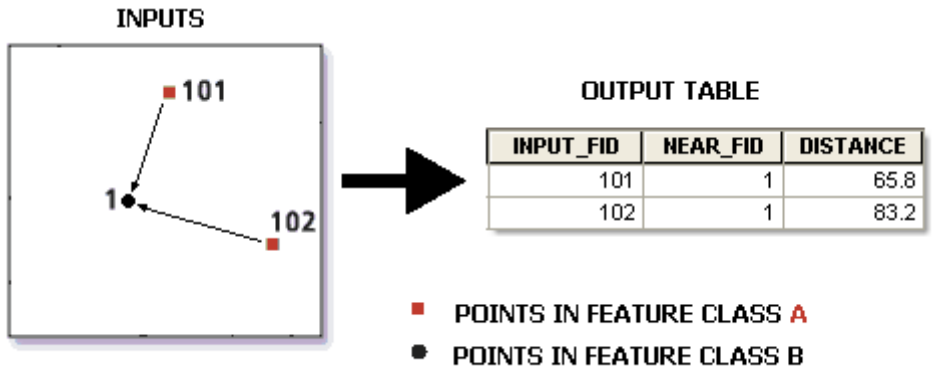
POLY	Town
A	Boston
B	Worcester
C	Springfield

POINT	Tree	POLY	Town
1	OAK	C	Springfield
2	MAPLE	A	Boston
3	PINE	B	Worcester

Source: https://www.polyu.edu.hk/proj/gef/index.php/glossary/point-in-polygon-overlay/

Data Layers / Thematic Data

POINT DISTANCE



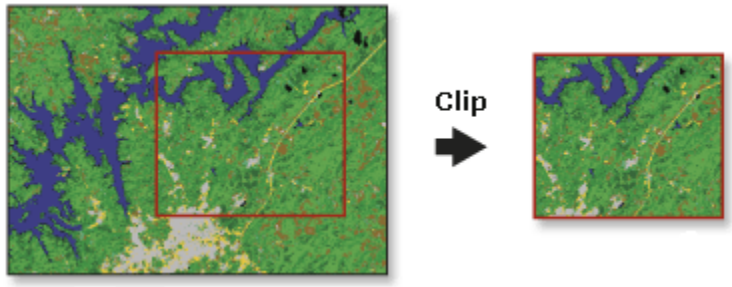
Source: https://desktop.arcgis.com/en/arcmap/latest/tools/analysis-toolbox/point-distance.htm

Spatial Operations

- Common Spatial Operations with Raster Data
  - Clip
  - Mosaic
  - Resample
  - Map Algebra/Raster Math

Data Layers / Thematic Data

CLIP



Source: https://pro.arcgis.com/en/pro-app/latest/tool-reference/data-management/clip.htm#:~:text=Usage,tool%20in%20the%20Analysis%20toolbox.

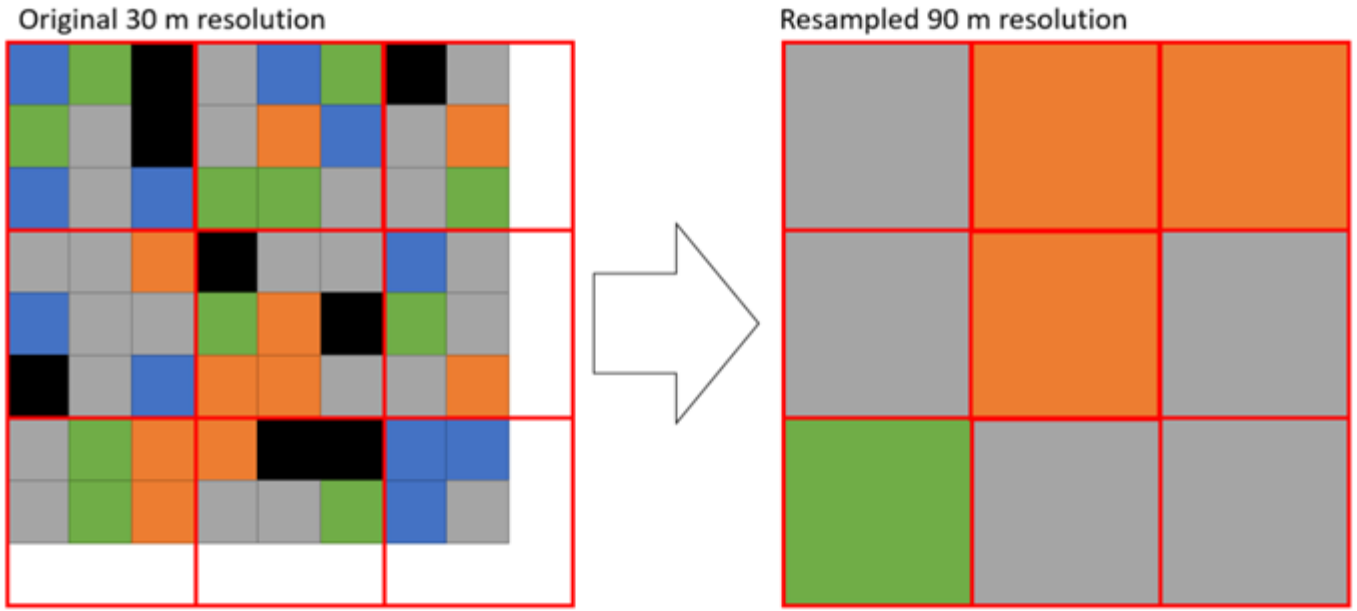
Data Layers / Thematic Data

MOSAIC

Source: https://pro.arcgis.com/en/pro-app/latest/tool-reference/data-management/mosaic.htm

Data Layers / Thematic Data

RESAMPLE



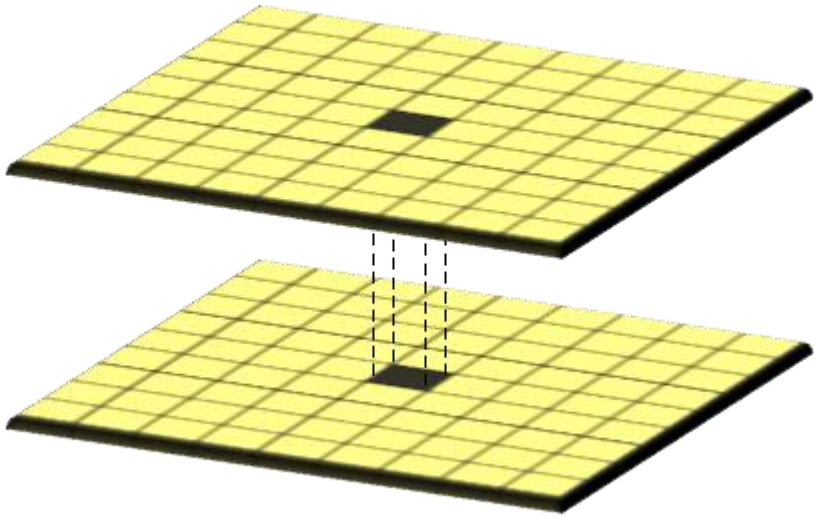
Source: https://iftdss.firenet.gov/firenetHelp/help/pageHelp/content/20-models/resampling.htm?TocPath=Modeling%7C_____6

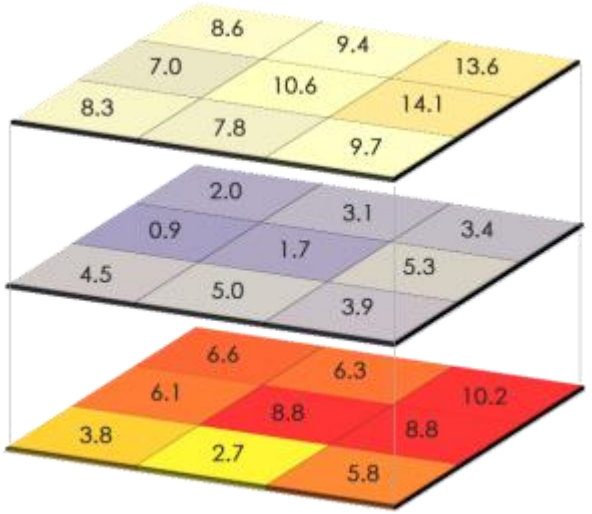
Data Layers / Thematic Data

- Map Algebra/Raster Math

Layer 1

Layer 2





Layer 1

- Layer 2

= Result Layer

Source: https://gisgeography.com/map-algebra-global-zonal-focal-local/

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Question: What spatial operations you think will be useful for you?

Questions

Please fill out tutorial evaluation:
http://rcs.bu.edu/eval

Email me at:
help@scc.bu.edu

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