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GEO SPATIAL ANALYSIS

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AGENDA

1 Learning Objectives

2 Geospatial Analysis

3 Applications

4 Data Types

5 Coordinate Reference Systems

6 Basic Operations

7 Why Python?

LEARNING OBJECTIVES

1. Understand the basics of geospatial analysis
2. Gain knowledge of data formats and structures
3. Understand the importance of coordinate reference systems (CRS)
4. Some basic operations using python

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GEOSPATIAL ANALYSIS

- Study and practice of methods used to collect, store, manage, visualize, analyze and present geographic data [4]
- Analysis of data with geographical or spatial information
- Geospatial data: includes geographic components such as coordinates or spatial attributes

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APPLICATIONS OF GEOSPATIAL ANALYSIS

- Urban Planning and Infrastructure
  - Zoning and Land Use
  - Public Transport Optimization
  - Infrastructure Management
- Disaster Management
  - Risk Assessment
  - Evacuation Planning
  - Damage Assessment
- Environment and Conservation
  - Climate Change Analysis
  - Pollution Monitoring

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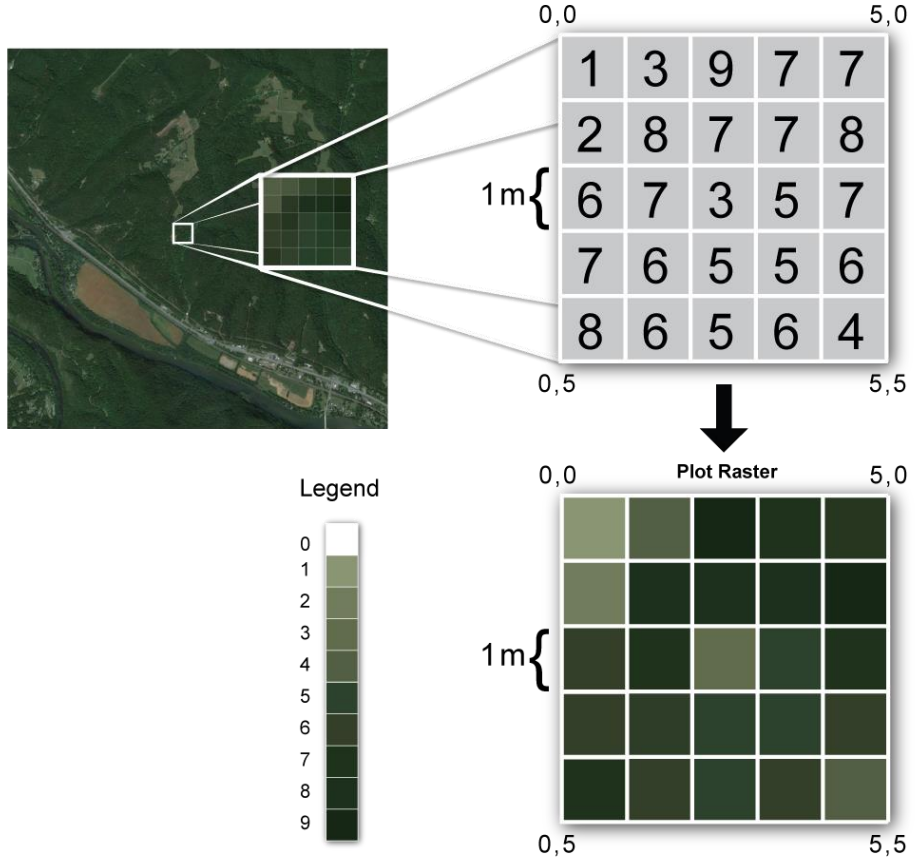
RASTER DATA

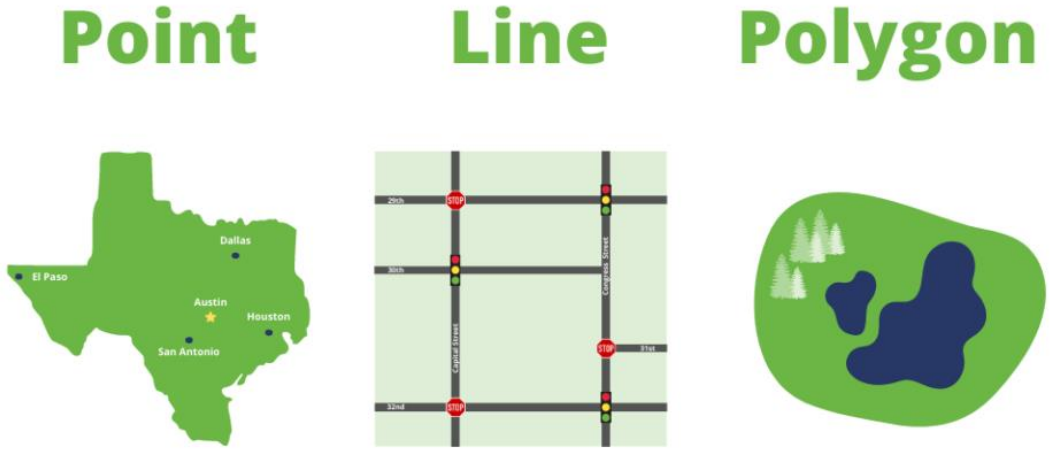
- Raster data = data represented in a grid format, often used for continuous data like elevation models
- Basic element: pixel
- Based on pixels arranged in a grid
- Geospatial raster differs from digital photo in that it contains spatial information that connects the data to a particular location [1]
- Available in different resolutions – area on the ground that each pixel of raster covers
- Data types: *.jpeg, *.geotiff, *.grid



Raster Concept (Source: National Ecological Observatory Network (NEON))

VECTOR DATA

- Represent specific features on the Earth‘s surface and assigns attributes to those features [2]
- Shows spatial objects as a point, line or polygon
  - Point – defined by a single x,y coordinate, e.g. sampling locations, location of trees, temperature measuring station
  - Lines – composed of at least two points that are connected, e.g. road, stream
  - Polygons – consists of 3 or more vertices that connected, e.g. lakes, nation borders
- Common data types: *.shp, *.dwg, *.dxf



https://cdn.prod.website-files.com/63c95e5d2e1ac67354777789/6410cf39c99cf4105eb17862_raster-vs-vector-11-copy-1024x515.png

RASTER VS. VECTOR DATA

Raster Data

- Large volume of data -> longer computing times
- Representation of continuous surfaces
- Potentially very high level of detail (depends on resolution)
- Data is unweighted
- Carries only one attribute [1]

Vector Data

- Geometry contains information
- Each geometry feature can carry multiple attributes
- Data storage can be more efficient
- Potential loss of detail
- Calculations on multiple vector layers can be slower than raster data [2]

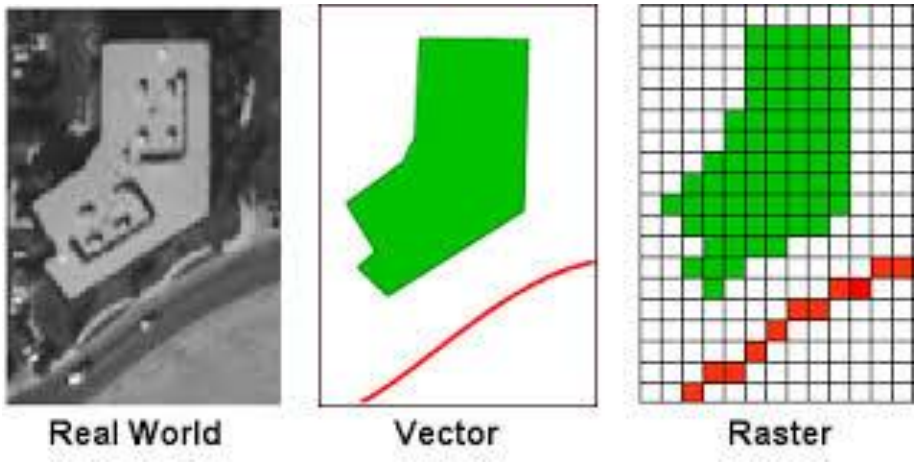


Image: https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcTiLYbxke07A7FdLWYzQjevIv-VKcywGbcm4Q&s

COORDINATE REFERENCE SYSTEMS

- Data structure can only be interprated by geospatial applications when accompanied by coordinate reference system (CRS)
- CRS connect data to the Earth‘s surface using a mathematical model
- Connects the data in the software environment with the location
- Different CRS use different methods to project the raster in geographical space
- Considers different ways to project the round earth onto a flat surface
- Important: data with different projections are not compatible for further analysis

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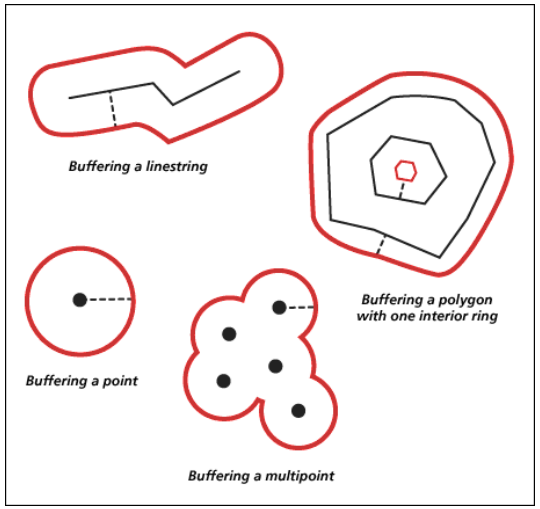
COORDINATE REFERENCE SYSTEMS

Source: opennews.or

BASIC OPERATIONS

- Buffering
  - Creates a zone around a feature at a specified distance
  - Commonly used for proximity analysis, such as identifying areas within 500 meters of a road
- Clipping
  - Extracts parts of a spatial dataset that intersect with another layer
  - Cropping geospatial data



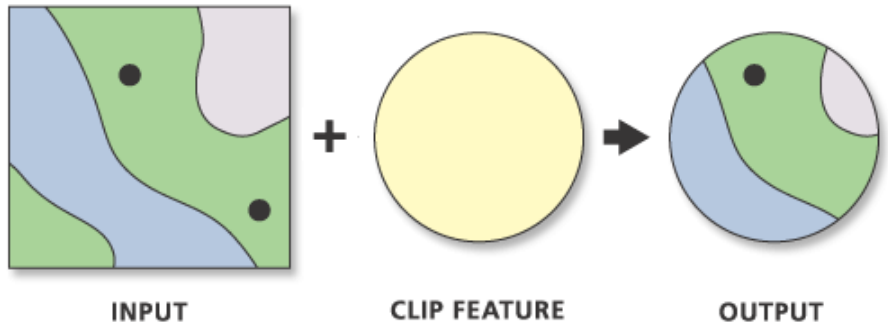


Image source: [1] https://desktop.arcgis.com/en/arcmap/latest/manage-data/using-sql-with-gdbs/GUID-0D42E244-367F-41BD-B089-9BBFC6115CB7-web.gif
[2] https://pro.arcgis.com/en/pro-app/latest/tool-reference/analysis/clip.htm

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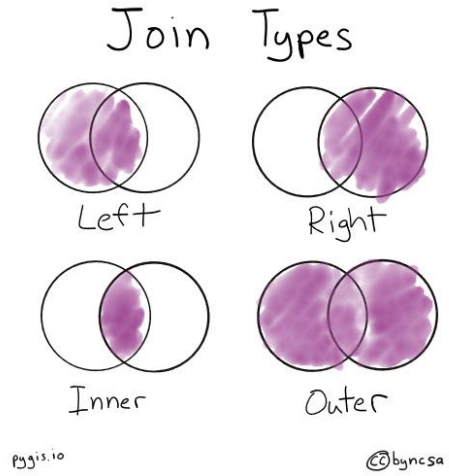
BASIC OPERATIONS

- Spatial Joins
  - Combine attributes of two spatial layers based on their relative locations
- Raster Calculations
  - Apply mathematical operations across raster layers to derive new insights
  - E.g. calculating the slope or aspect of a DEM



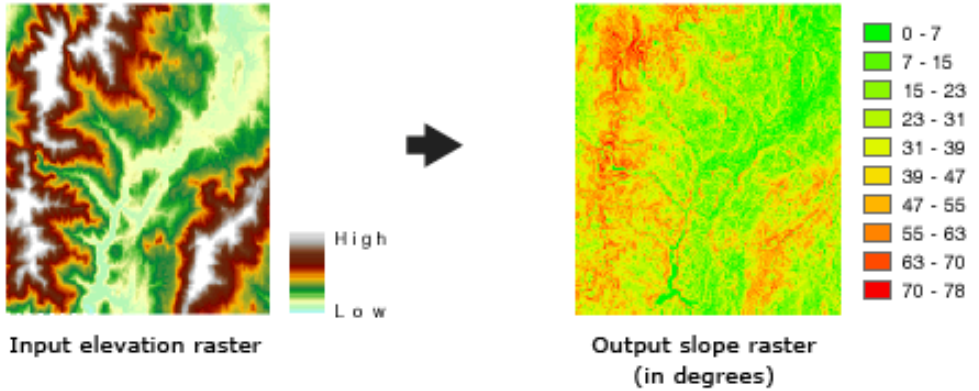


Image source: [1] https://pygis.io/docs/e_spatial_joins.html
[2] https://desktop.arcgis.com/en/arcmap/latest/tools/spatial-analyst-toolbox/how-slope-works.htm

WHY PYTHON?

- Many different stand-alone software available for spatial analysis
  - Open-source: QGIS
  - Commercial software: ESRI (ArcGIS)
- Some downsides:
  - Low reproducibility – actions cannot be recorded and replayed
  - Limited ability to customized functions
  - Intimidating interface for new users
- Using code can mitigate the lack of reproducibility
- Python is easier to learn than other general-purpose programming languages
- Workflow recorded in one document, can be re-run any time [3]

TOOLS & LIBRARIES IN PYTHON

- GeoPandas: simplified spatial operations (vector data)
- Shapely: Geometric operations
- Matplolib/Plotly: Visualization
- Rasterio: Handling raster data
- Rioxarray: handling raster data
- GDAL: reading, writing and processing geospatial data

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LET‘S LOOK AT AN EXAMPLE!

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REFERENCES

[1] *Introduction to Geospatial Raster and Vector Data with Python: Introduction to Raster Data*. (2023, 14. August). https://carpentries-incubator.github.io/geospatial-python/01-intro-raster-data.html

[2] *Introduction to Geospatial Raster and Vector Data with Python: Introduction to Vector Data*. (2023, 14. August). https://carpentries-incubator.github.io/geospatial-python/02-intro-vector-data.html

[3] *Introduction to Geospatial Raster and Vector Data with Python: The Geospatial Landscape*. (2023, 14. August). https://carpentries-incubator.github.io/geospatial-python/04-geo-landscape.html

[4] *What is Geospatial Analysis? - Geospatial Analysis*. (2025, 7. Januar). College Of Arts And Sciences | Geospatial Analysis. https://cas.umw.edu/gis/