

Geocomputation

Spatial Queries and Geometric Operations



Module outline

- W1 Reproducible Spatial Analysis
- W2 Spatial Queries and Geometric Operations
- W3 Point Pattern Analysis
- W4 Spatial Autocorrelation
- W5 Spatial Models
- W6 Raster Data Analysis
- W7 Geodemographic Classification
- W8 Accessibility Analysis
- W9 Beyond the Choropleth
- W10 Complex Visualisations



Core Spatial Analysis

Applied Spatial Analysis

Data Visualisation

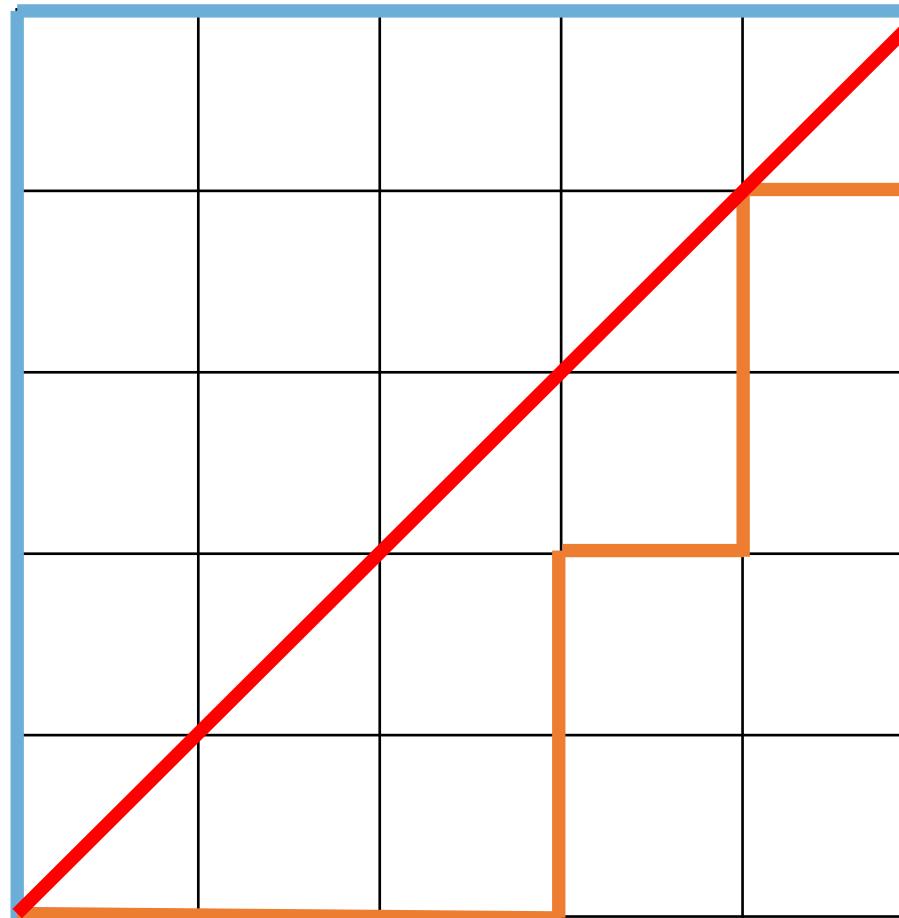
This week

- Spatial properties.
- Attribute joins.
- Spatial operations.

Spatial properties

- Spatial involves performing mathematical operations on spatial properties.
- Key properties include areas of and distances between spatial objects.
- There are diverse ways to conceptualise and work with these properties depending on the analytical context and available data.

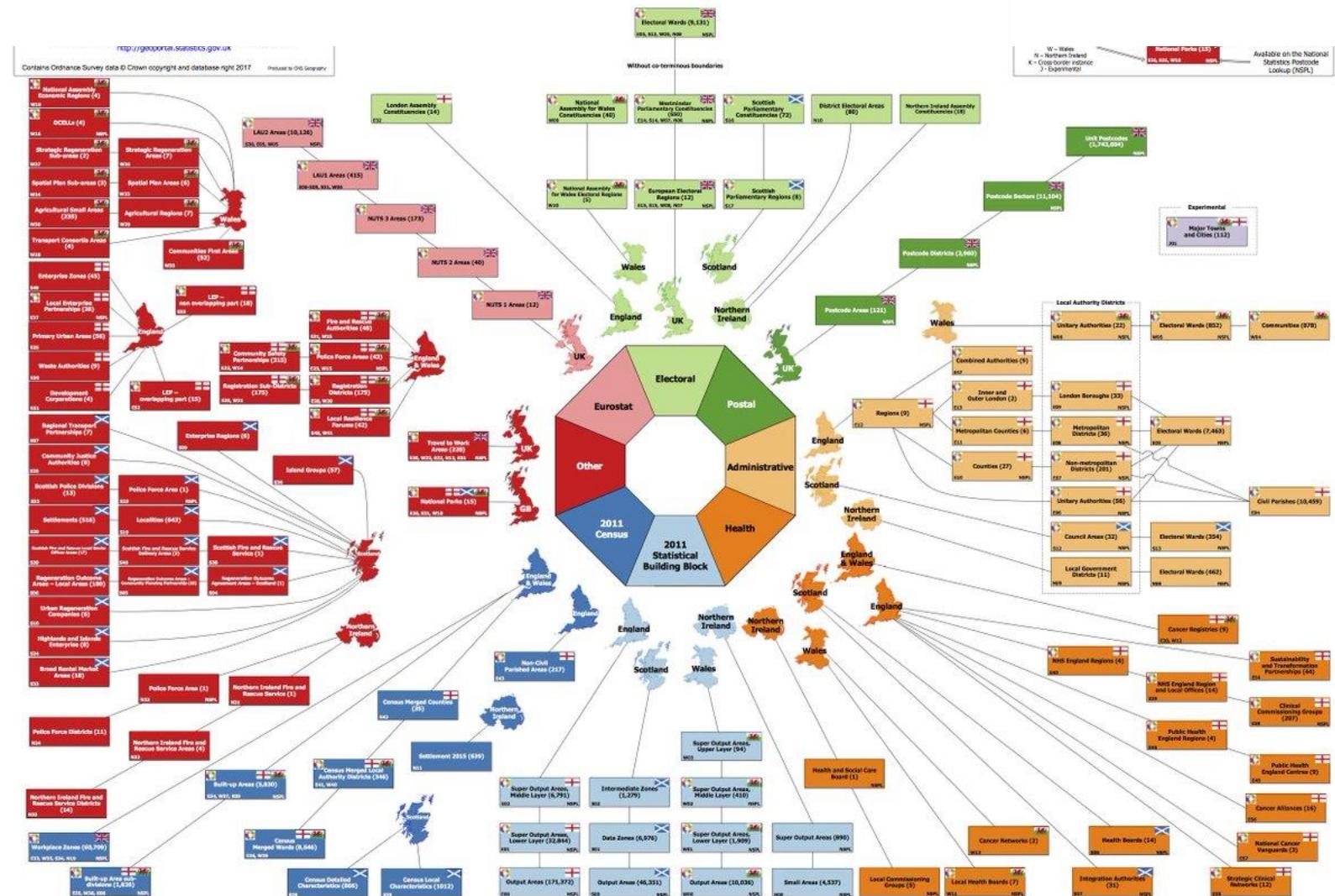
Distance



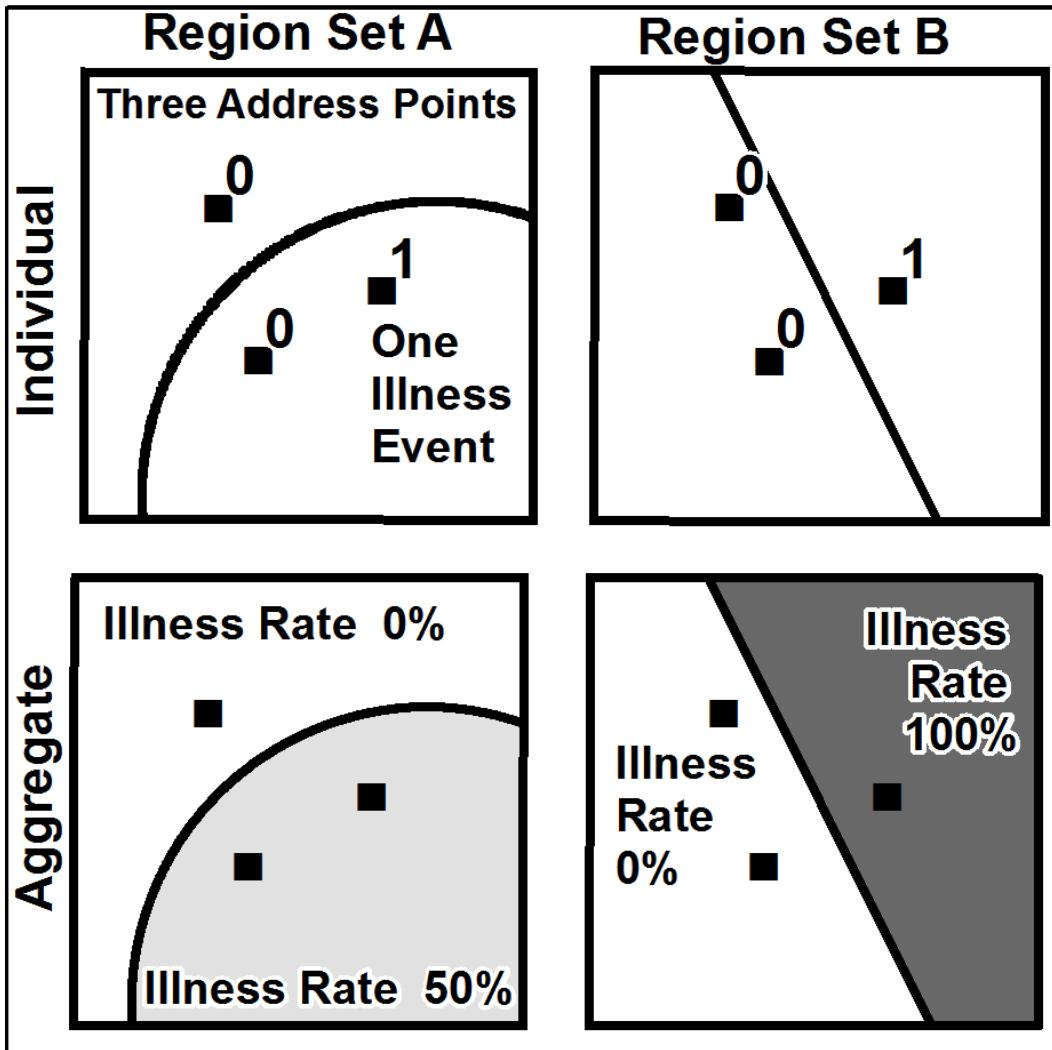
Area



Area



Area



Spatial features

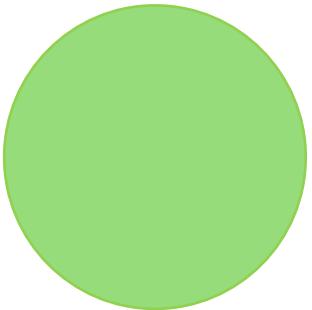
- Features: Objects created in a spatial dataset, representing geographic entities such as points, lines, or polygons.
- Attributes: Characteristics or properties of features, often stored as data in GIS, describing specific details about the feature.

Point vector

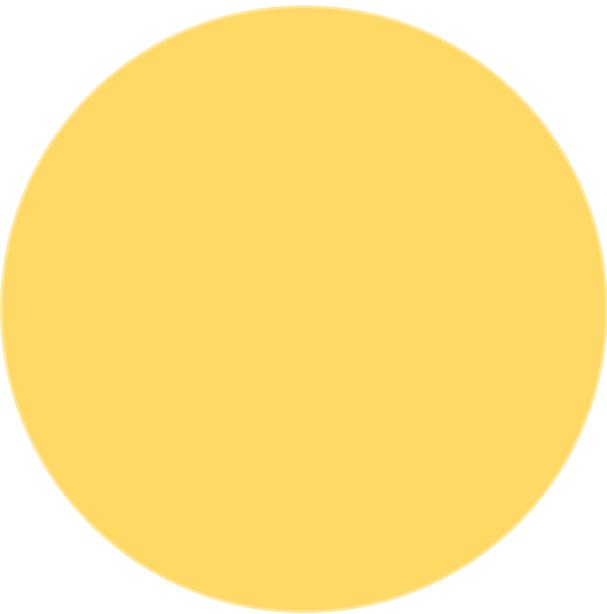
Characteristics of a point vector in a GIS data model:

- Single XY location (coordinate).
- Has no area.
- Has no length.
- Geometry consists of a single node or vertex.
- Used for: discrete features or events.

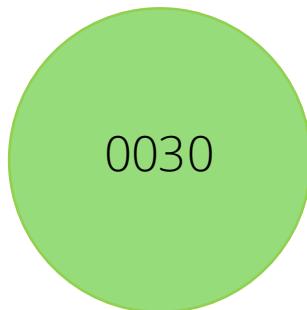
Point vector



Point vector



Point vector



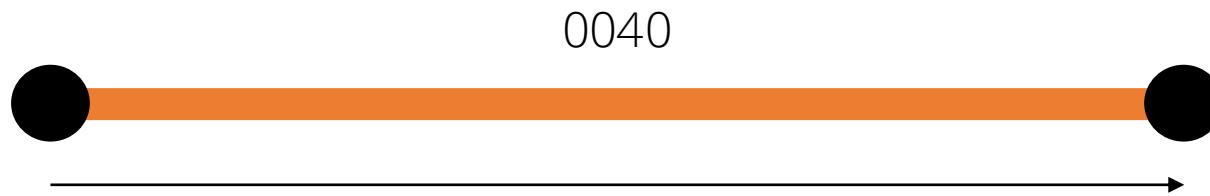
FeatureID	Type	Height
0030	Ent	500

Polyline vector

Characteristics of a polyline vector in a GIS data model:

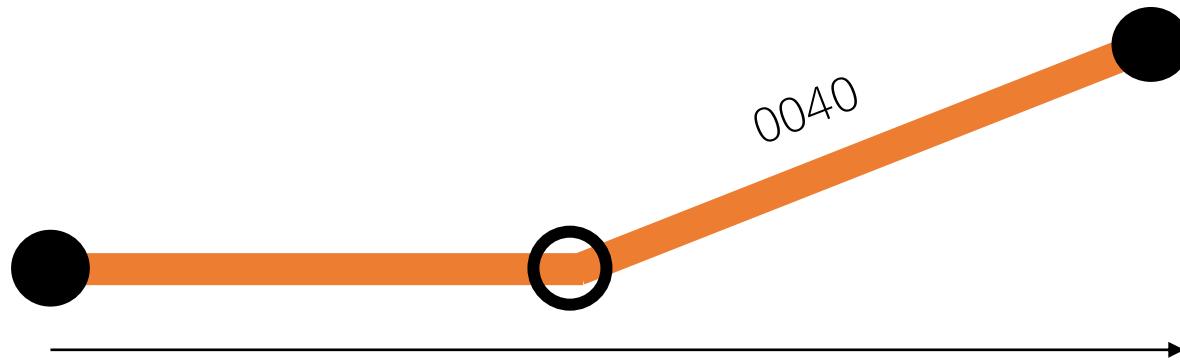
- Series of XY locations (coordinates) that form a line.
- Has no area.
- Has a length.
- Has a direction (importance when it comes to roads, rivers, etc.).
- Can be connected to other polyline vectors to form a network.
- Geometry consists of two **nodes** (start node and end node) and can have one or more **vertices**.
- Used for: features without an area but with a length.

Polyline vector



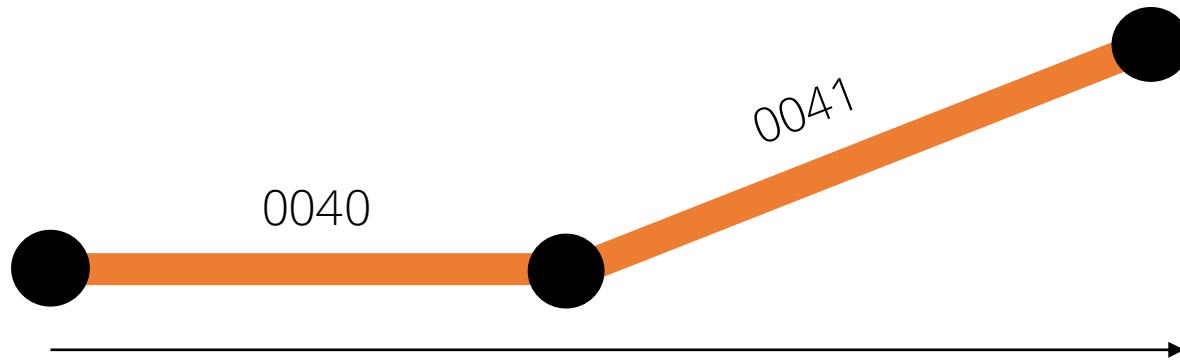
FeatureID	Type	Length
0040	Bicycle lane	1,500

Polyline vector



FeatureID	Type	Length
0040	Bicycle lane	1,650

Polyline vector



FeatureID	Type	Length
0040	Bicycle lane	600
0041	Bicycle lane	1,050

Polygon vector

Characteristics of a polyline vector in a GIS data model:

- Series of XY locations (coordinates) to form an enclosed region.
- Has an area.
- Has no length.
- Geometry consists of at least three nodes or vertices whereby the first node or vertex connects with the last one.
- Used for: features with enclosed regions such as buildings and administrative areas.

Polygon vector



FeatureID	Type	Area
0050	University building	2000

Representation

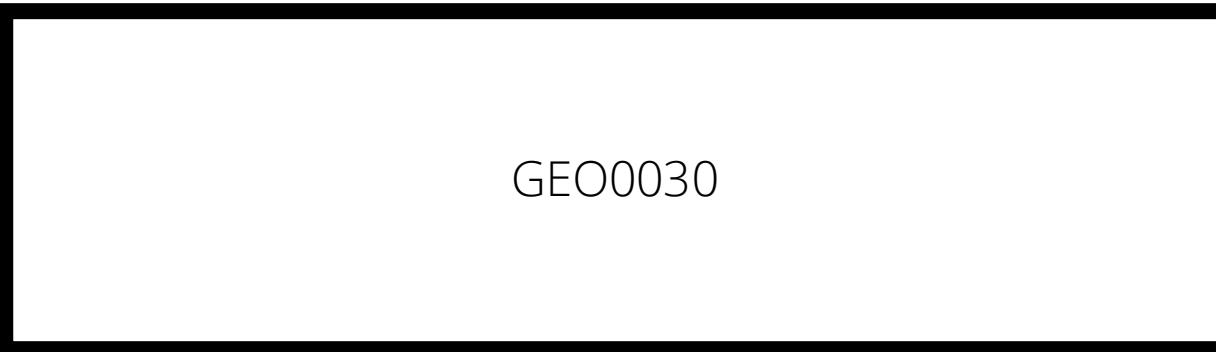
Representing the North-West Wing Building



Attribute joins

GeOID	Population
GEO0030	540
GEO0031	320

Attribute joins



GEO0030

FeatureID	Geoid
0050	GEO0030

Attribute joins



FeatureID	Geoid	Geoid	Population
0050	GEO0030	GEO0030	540
		GEO0031	320

Attribute joins



FeatureID	GeOID	GeOID	Population
0050	GEO0030	GEO0030	540
		GEO0031	320

Attribute joins

GEO0030

FeatureID	Geoid	Population
0050	GEO0030	540

Left joins

Table 1



1		
2		

Table 2



1		
3		
4		

Left Join



1			
2			

Inner joins

Table 1



1		
2		

Table 2



1		
3		
4		

Inner Join



1			
---	--	--	--

Outer joins

Table 1



1		
2		

Table 2



1		
3		
4		

Outer Join



1				
2				
3				
4				

Spatial data formats

```
## Simple feature collection with 100 features and 6 fields
## geometry type: MULTIPOLYGON
## dimension: XY
## bbox: xmin: -84.32385 ymin: 33.88199 xmax: -75.45698 ymax: 36.58965
## epsg (SRID): 4267
## proj4string: +proj=longlat +datum=NAD27 +no_defs
## precision: double (default; no precision model)
## First 3 features:
##   BIR74 SID74 NWBIR74 BIR79 SID79 NWBIR79
## 1 1091 1 10 1364 0 19 MULTIPOLYGON((( -81.47275543...
## 2 487 0 10 542 3 12 MULTIPOLYGON((( -81.23989105...
## 3 3188 5 208 3616 6 260 MULTIPOLYGON((( -80.45634460...
```

Simple feature

Simple feature geometry list-column (sfc)

Simple feature geometry (sfg)

Spatial data formats

- Several commonly used file formats that store spatial data exist.
- Different file formats for vector data and raster data.
- Common vector formats: shapefile, GeoJSON, GeoPackage
- Common raster formats: GeoTIFF, GeoPackage

Shapefiles

- Perhaps the most (in)famous file format.
- Widely used, despite being outdated, especially limitations of .dbf format.
- A shapefile is not a single file, but a collection of files of which at least three are needed for the data to be displayed in GIS software.

Shapefiles

- `.shp` contains the feature geometry. *Mandatory*.
- `.shx` index file which stores the position of the feature's ID in the `.shp` file.
Mandatory.
- `.dbf` stores all attribute information associated with the records. *Mandatory*.
- `.prj` contains the coordinate system information and projection. *Optional but not really*.
- `.xml` general metadata. *Optional*.
- `.cpg` encoding information. *Optional*.
- `.sbn` optimisation file for spatial queries. *Optional*.

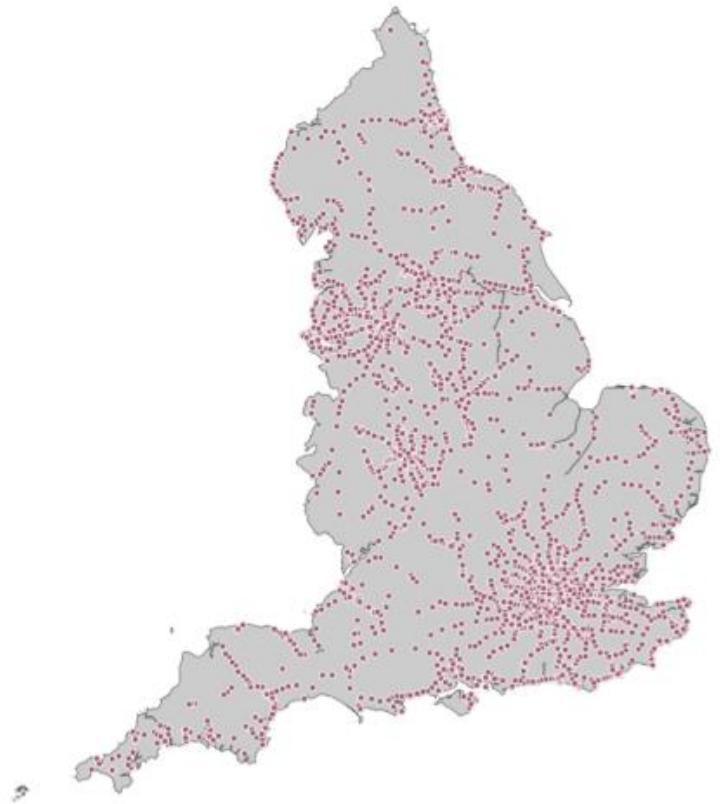
Shapefiles



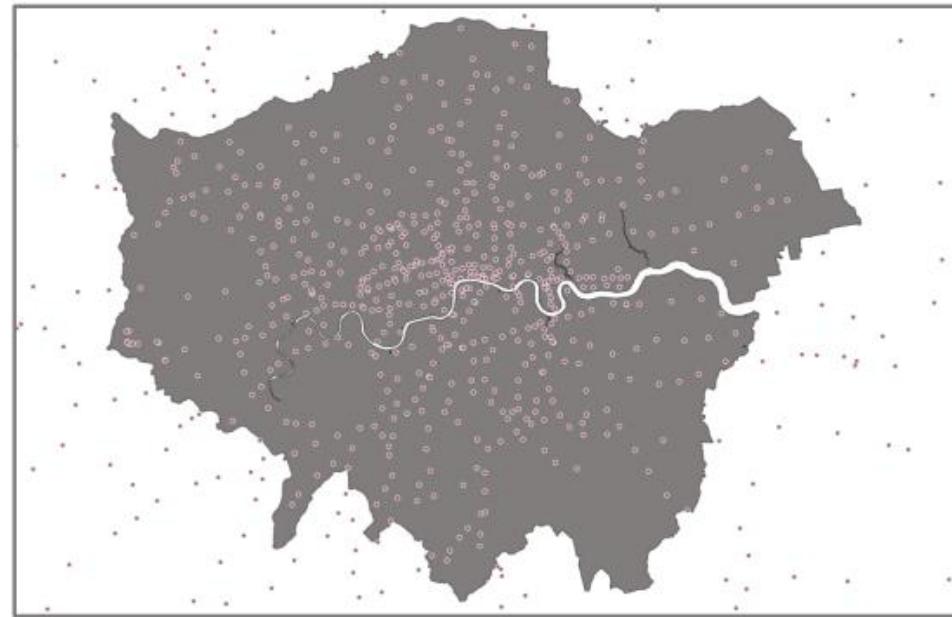
GeoPackage

- A GeoPackage is an open, standards-based, platform-independent, portable, self-describing, compact format for transferring geospatial data.
- It stores spatial data layer as a single file, based upon an SQLite database.
- How to spot in the wild: `.gpkg`

Spatial operations



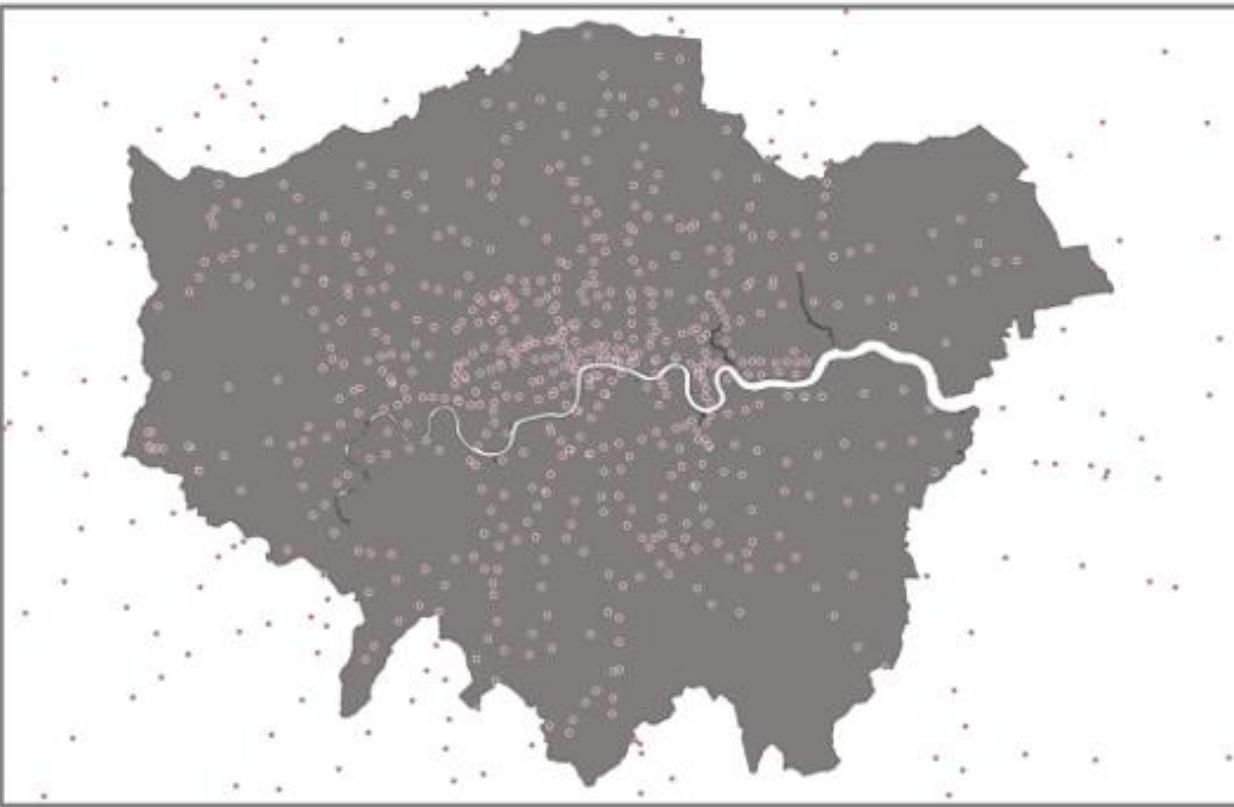
?



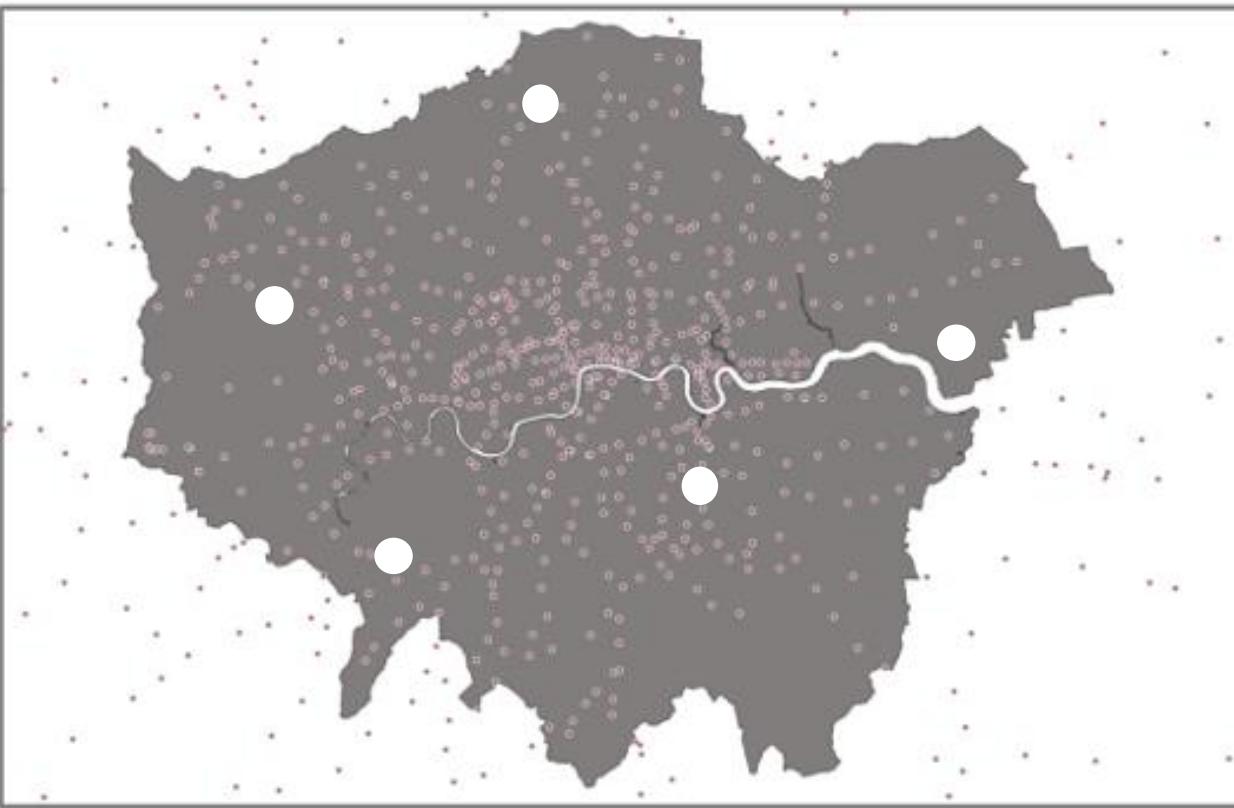
Spatial operations

- Spatial relationships describe how the exteriors, interiors, and boundaries of different geometries interact, often referred to as topological relationships.
- Spatial operations make use of these spatial relationships between spatial objects to combine, identify, extract information.
- Difference between spatial queries and geometric operations.

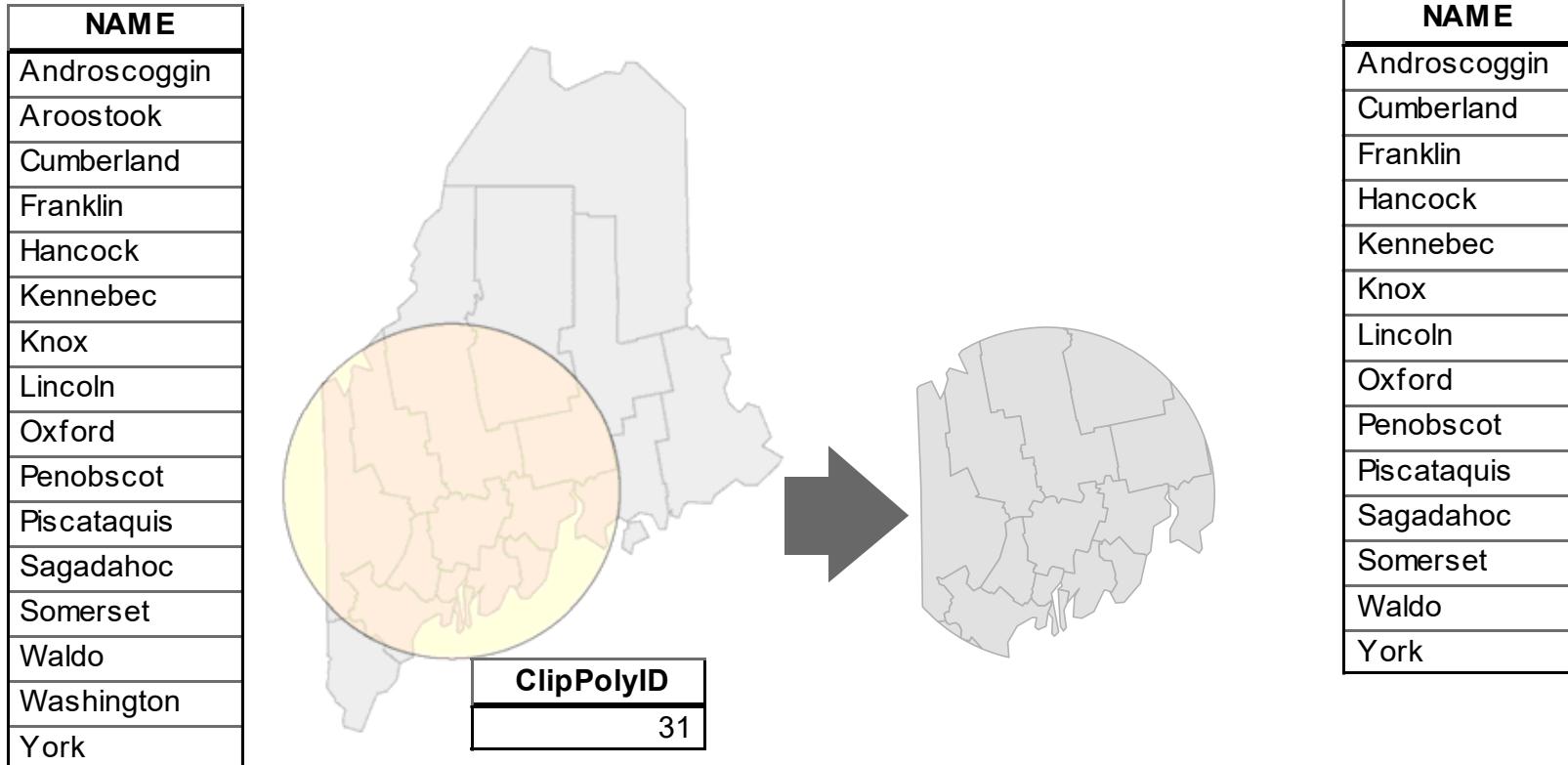
Spatial query



Attribute query



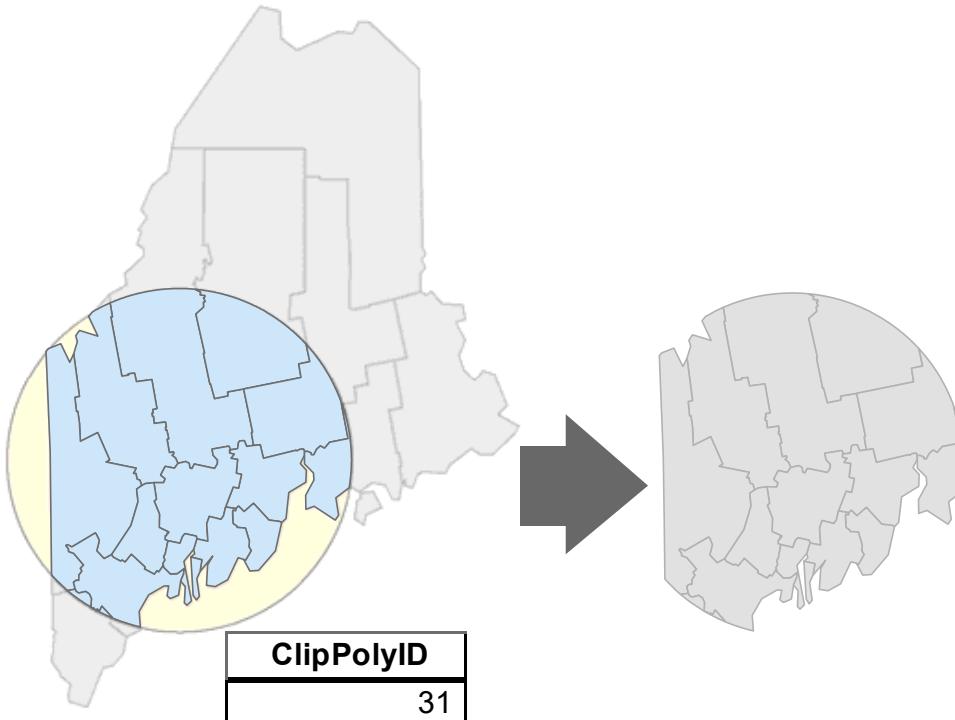
Geometric operations



Gimdond, M. 2025. Intro to GIS and Spatial Analysis. [online]
<https://mgimond.github.io/Spatial/introGIS.html>

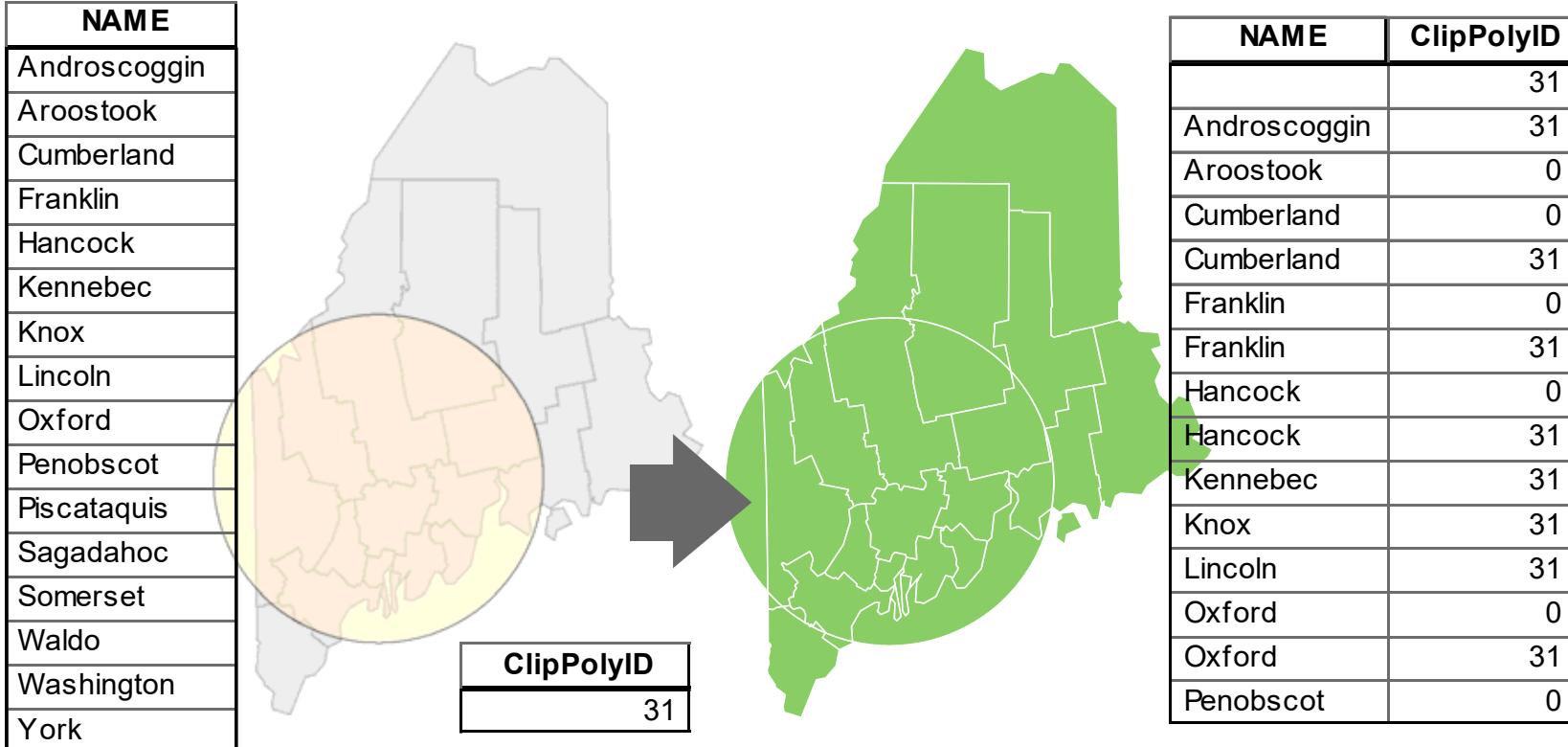
Geometric operations

NAME
Androscoggin
Aroostook
Cumberland
Franklin
Hancock
Kennebec
Knox
Lincoln
Oxford
Penobscot
Piscataquis
Sagadahoc
Somerset
Waldo
Washington
York



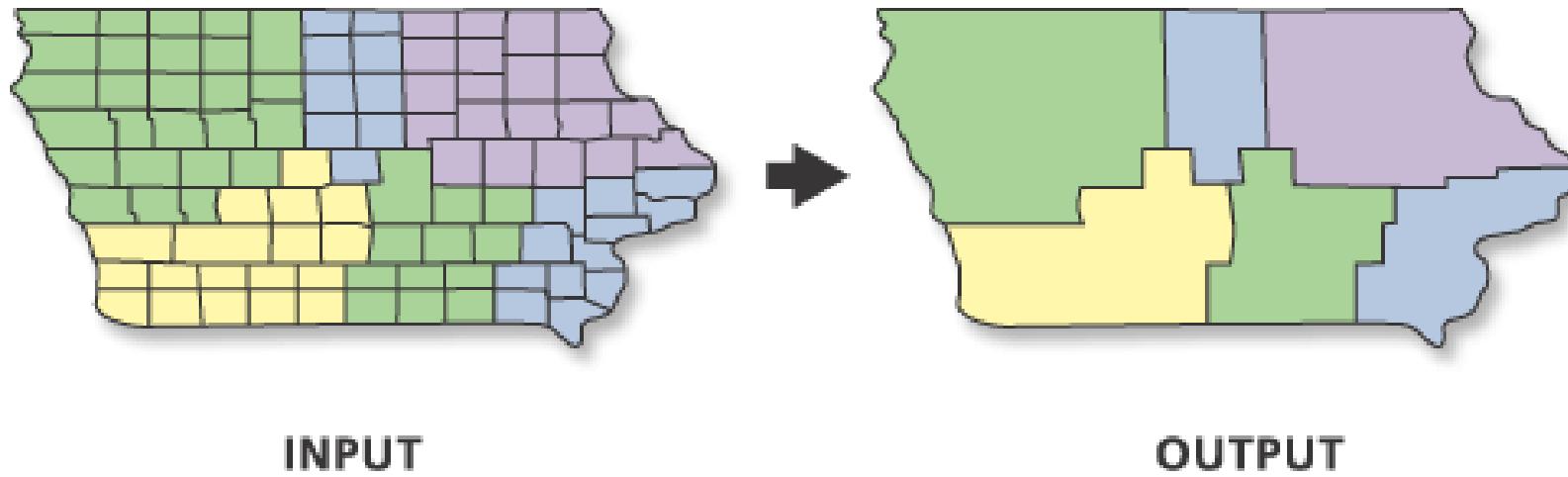
NAME	ClipPolyID
Androscoggin	31
Cumberland	31
Franklin	31
Hancock	31
Kennebec	31
Knox	31
Lincoln	31
Oxford	31
Penobscot	31
Piscataquis	31
Sagadahoc	31
Somerset	31
Waldo	31
York	31

Geometric operations



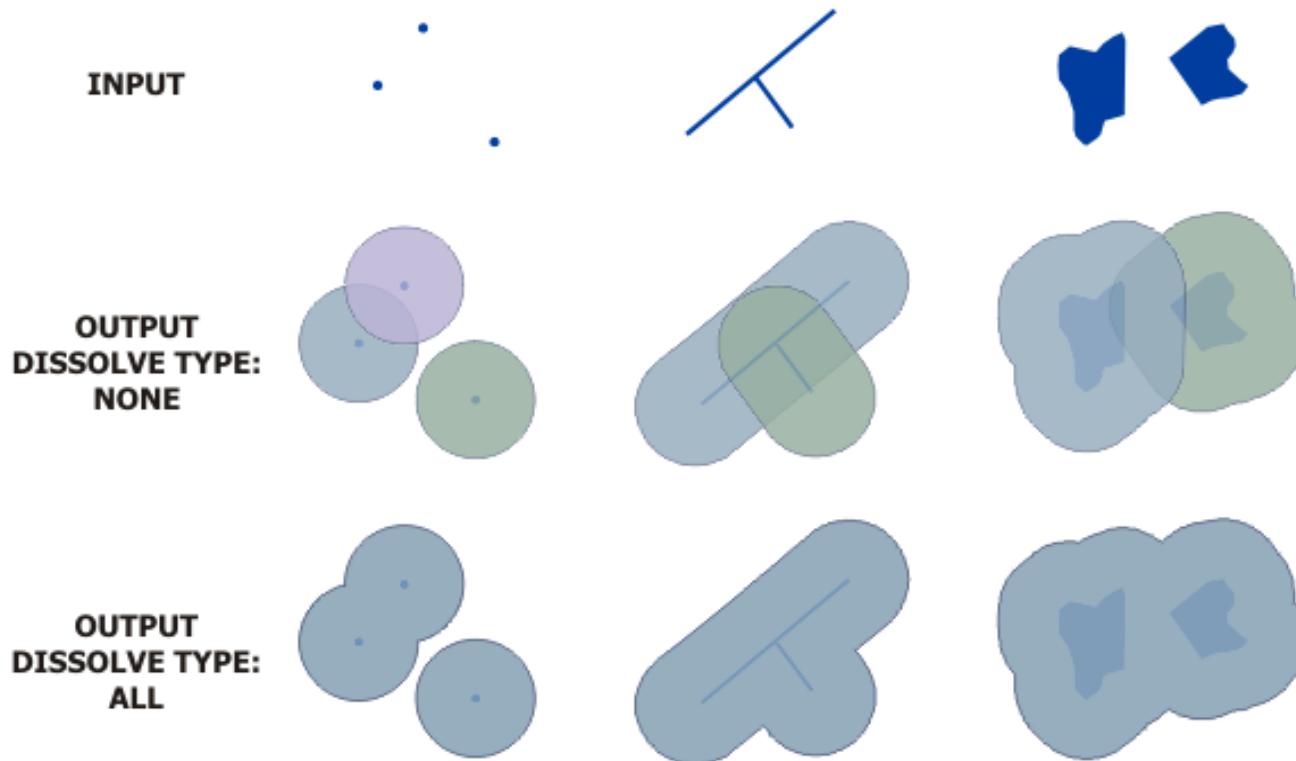
Gimdond, M. 2025. Intro to GIS and Spatial Analysis. [online]
<https://mgimond.github.io/Spatial/introGIS.html>

Geometric operations



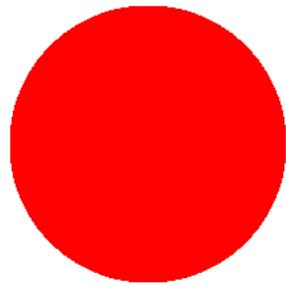
ESRI. 2025. Dissolve. [online]
<https://pro.arcgis.com/en/pro-app/latest/tool-reference/data-management/dissolve.htm>

Geometric operations



ESRI. 2025. Buffer (Analysis). [online]
<https://pro.arcgis.com/en/pro-app/latest/tool-reference/analysis/buffer.htm>

RStudio



LIVE

Conclusion

- The core of spatial analysis comes down to conducting spatial queries and executing geometric operations.
- Spatial analysis relies therewith on the spatial properties of an object as well as on the spatial relationships both *within* and *between* spatial objects.

Questions

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