

ISA

Geographic Information Systems 2026/2027

Lesson 06 - Basic functions for vector data processing

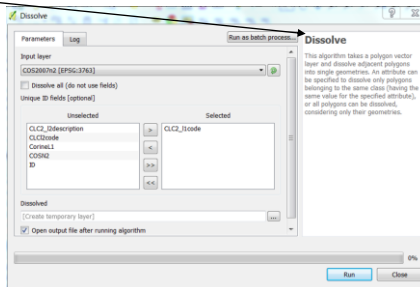


Topics

- SELECT
- Basic functions – vector data
- Vector layer spatial operations

QGIS documentation

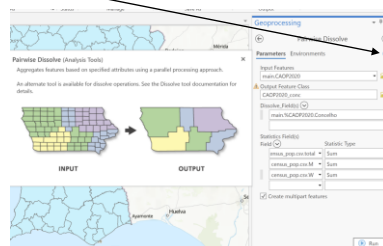
- https://docs.qgis.org/3.28/en/docs/user_manual/index.html
- https://docs.qgis.org/3.28/en/docs/gentle_gis_introduction
- menu HELP → Help Contents
- some menu functions - example



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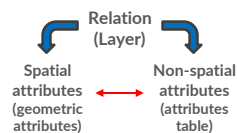
ArcGIS Pro documentation

- <https://pro.arcgis.com/en/pro-app/latest/get-started/get-started.htm>
- <https://pro.arcgis.com/en/pro-app/latest/help/main/welcome-to-the-arcgis-pro-app-help.htm>
- context HELP → Help Contents
- detailed help, e.g.: <https://pro.arcgis.com/en/pro-app/latest/tool-reference/analysis/pairwise-dissolve.htm>



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Basic functions – vector data

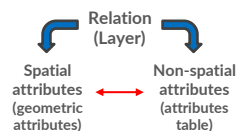


Spatial operations are based on Euclidean geometry

- Mathematical system to study shapes, sizes and positions of figures in space
- based on axioms & postulates describing the properties of space in 2D & 3D
- Characterised by:
 - **Flat space**: geometry assumes that space is flat, not curved
 - **Parallel lines**: 2 parallel lines never intersect, no matter how far they extend
 - **Sum of Angles**: The sum of angles in a triangle is always 180 degrees
 - **Pythagorean Theorem**: The square of the hypotenuse equals the sum of squares of the other 2 sides in a right-angled triangle
- Euclidean geometry deals with:
 - Points
 - Lines
 - Planes
 - Angles
 - Polygons
 - Circles
 - Three-dimensional shapes (e.g., cubes, spheres)

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Basic functions – vector data



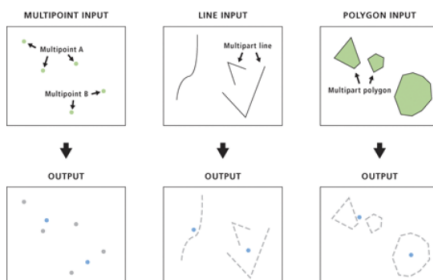
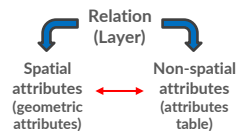
SELECT:

- by ATTRIBUTE values
 - logical operators: AND, OR, NOT
 - relational operators: =, <>, <, >, >=, <=
 - other operators: LIKE, ILIKE, IN
 - and also
 - arithmetic operators: +, -, *, /, %, ^
 - other operators/functions, such as: ||, concat(), ...
- by LOCATION
 - spatial operators such as
 - CONTAINS
 - INTERSECTS
 - WITHIN A DISTANCE
 - WITHIN
 - ARE IDENTICAL TO
 - BOUNDARY TOUCHES
 - SHARE A LINE SEGMENT WITH
 - CROSSED BY THE OUTLINE
 - HAVE THEIR CENTER IN

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Basic functions – vector data

- Operation with only one input layer
 - Feature to point ([ArcGIS](#)), Centroids ([QGIS](#))

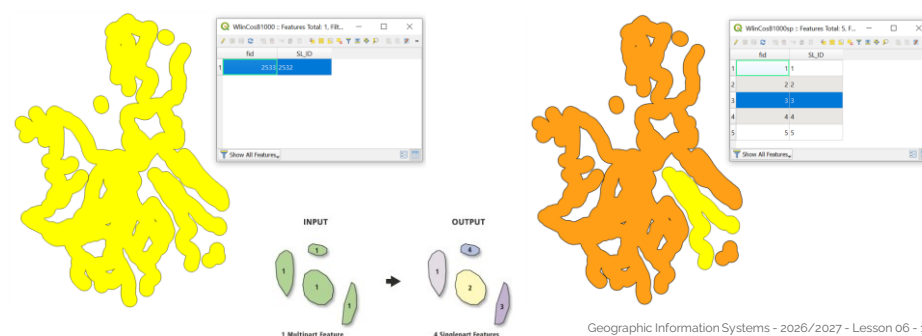
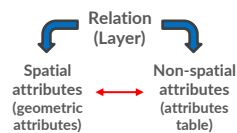


attributes of the input features will be maintained in the output feature class

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Basic functions – vector data

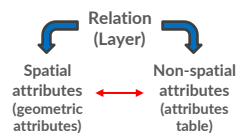
- Operation with only one input layer
 - Multipart to Singlepart ([ArcGIS/QGIS](#))



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Basic functions – vector data

- Operation with **only one input layer**
 - Add ([QGIS](#))/Calculate ([ArcGIS](#)) geometry attributes



Computes geometric properties of the feature into a new layer

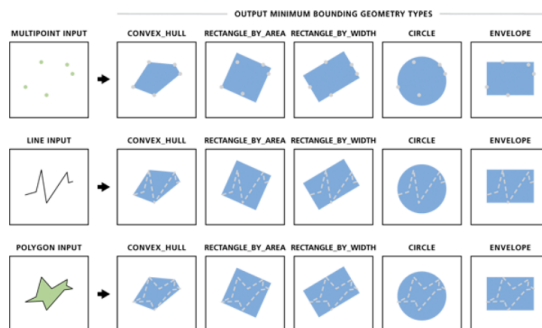
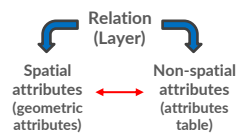
/

Adds information to a feature's attribute fields representing the spatial or geometric characteristics and location of each feature (**modifies the input data**)

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Basic functions – vector data

- Operation with **only one input layer**
 - Minimum bounding geometry ([ArcGIS](#) / [QGIS](#))



Impact on attributes relates to the choices made in the grouping options

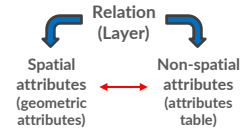
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Basic functions – vector data

- Operation with **only one input layer**

- Delete

- Delete ([ArcGIS](#))
 - Delete Identical ([ArcGIS](#))/Delete duplicate geometries/by attributes ([QGIS](#), [QGIS](#))
 - Delete Multiple ([ArcGIS](#))



Permanently deletes data. Certain options allow establishing criteria based on spatial and non-spatial attributes

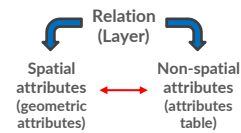
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Basic functions – vector data

- Operation with **only one input layer**

- Buffer

- Fixed distance buffer ([ArcGIS/QGIS](#))
 - Variable distance buffer (based on a numerical attribute)



Owner



Buffer



Buffer with dissolve



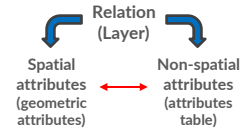
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Basic functions – vector data

- Operation with only one input layer

- Buffer

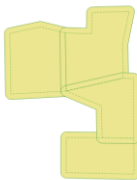
- Fixed distance buffer ([ArcGIS/QGIS](#))
 - Variable distance buffer (based on a numerical attribute)



Owner



Buffer



Buffer with dissolve



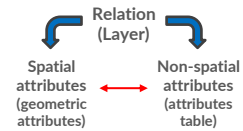
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Basic functions – vector data

- Operation with only one input layer

- Buffer

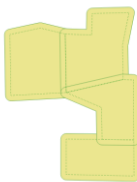
- Fixed distance buffer ([ArcGIS/QGIS](#))
 - Variable distance buffer (based on a numerical attribute)



Owner



Buffer



buffer — Features Total: 4, Filtered: 4, 1

fid	Name	Owner
1	A	Jorge Sousa
2	B	Manuel Silva
3	C	Jorge Sousa
4	D	Ricardo Costa

Show All Features

Buffer with dissolve



buffer_diss — Features Total: 1, Filtered: 1, 5

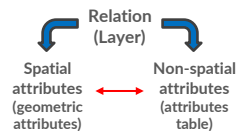
fid	Name	Owner
1	A	Jorge Sousa

Show All Features

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Basic functions – vector data

- Operation with **only one input layer**
 - Dissolve
 - Dissolve ([ArcGIS/QGIS](#)) (all or by attribute)
 - Dissolve by Field (attribute), with statistics



Owner



Dissolve



fid	Name	Owner
1	A	Jorge Sousa

Dissolve with field (Owner)

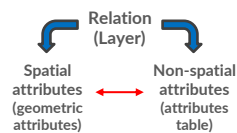


fid	Name	Owner
1	A	Jorge Sousa
2	B	Manuel Silva
4	D	Ricardo Costa

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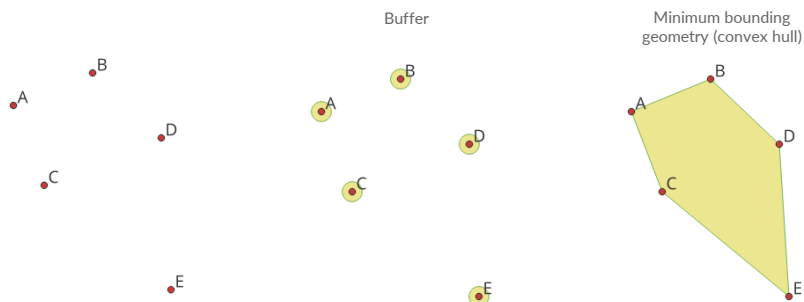
Basic functions – vector data

- Operation with **only one input layer**
 - Feature to point ([ArcGIS](#)) , Centroids ([QGIS](#))
 - Multipart to Singlepart ([ArcGIS/QGIS](#))
 - Add geometry attributes ([QGIS](#))
 - Minimum bounding geometry ([ArcGIS](#) / [QGIS](#))
 - Delete
 - Delete ([ArcGIS](#))
 - Delete Identical ([ArcGIS](#))/Delete duplicate geometries/by attributes ([QGIS](#))
 - Delete Multiple ([ArcGIS](#))
 - Buffer
 - Fixed distance buffer ([ArcGIS/QGIS](#))
 - Variable distance buffer (based on a numerical attribute)
 - Dissolve
 - Dissolve ([ArcGIS/QGIS](#)) (all or by attribute)
 - Dissolve by Field (attribute), with statistics



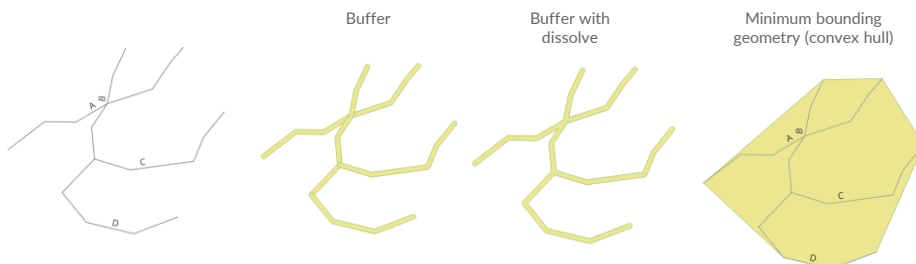
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Example for point data



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Example for line data



linha — Features Total: 4, Filter:

	fid	name
1	1	A
2	2	B
3	3	C
4	4	D

Show All Features

linha_buffer — Features Total: 4, Filter:

	fid	name
1	1	A
2	2	B
3	3	C
4	4	D

Show All Features

linha_buffer_diss — Features Total: 1, Filter:

	fid	name
1	1	A

Show All Features

linha_convex_hull — Features Total: 1, Filter:

	fid	id	area	perimeter
1	1	0	8651841.38...	11227.7232...

Show All Features

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Basic functions – vector data

Input data examples

Owner



owners — Features Total: 4, Filtered: 4

fid	Name	Owner
1	A	Jorge Sousa
2	B	Manuel Silva
3	C	Jorge Sousa
4	D	Ricardo Costa

Show All Features

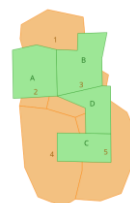
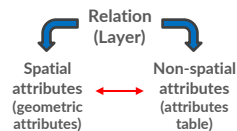
Soil_type



soil_type — Features Total: 5, Filtered: 5, Selected: 0

fid	Name	Soil_type
1	1	Blanket bog peat soils
2	2	Blanket bog peat soils
3	3	Very acid loamy upland soils with a wet peaty surface
4	4	Slowly permeable wet very acid upland soils with a peaty surface
5	5	Freely draining very acid sandy and loamy soils

Show All Features



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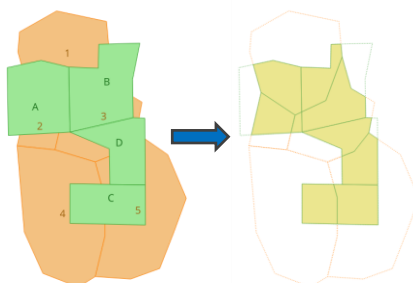
Basic functions – vector data

- Vector layers **OVERLAY** (theoretically, 2 or more layers required)
 - Intersect ([ArcGIS](#) / [QGIS](#))

Owner



Soil_type



Intersections — Features Total: 9, Filtered: 9, Selected: 0

fid	Name	Owner	fid_2	Name_2	Soil_type
1	1 A	Jorge Sousa	1 1	Blanket bog peat soils	Blanket bog peat soils
2	2 A	Jorge Sousa	2 2	Blanket bog peat soils	Blanket bog peat soils
3	3 A	Jorge Sousa	3 3	Very acid loamy upland soils with a wet peaty surface	Very acid loamy upland soils with a wet peaty surface
4	4 B	Manuel Silva	1 1	Blanket bog peat soils	Blanket bog peat soils
5	5 B	Manuel Silva	3 3	Very acid loamy upland soils with a wet peaty surface	Very acid loamy upland soils with a wet peaty surface
6	6 C	Jorge Sousa	4 4	Slowly permeable wet very acid upland soils with a peaty surface	Slowly permeable wet very acid upland soils with a peaty surface
7	7 C	Jorge Sousa	5 5	Freely draining very acid sandy and loamy soils	Freely draining very acid sandy and loamy soils
8	8 D	Ricardo Costa	3 3	Very acid loamy upland soils with a wet peaty surface	Very acid loamy upland soils with a wet peaty surface
9	9 D	Ricardo Costa	5 5	Freely draining very acid sandy and loamy soils	Freely draining very acid sandy and loamy soils

Show All Features

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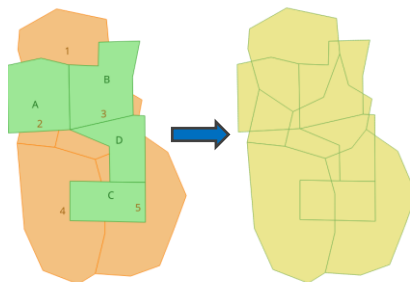
Basic functions – vector data

- Vector layers **OVERLAY** (theoretically, 2 or more layers required)
 - Union ([ArcGIS](#) / [QGIS](#))

Owner



Soil_type



union — Features Total: 17, Filtered: 0

fId	Name	Id_1	Name_1	Id_2	Name_2
1	A	1 1	Jorge Sousa	Blanket bo...	
2	2 A	2 2	Jorge Sousa	Very acid lo...	
3	3 A	3 3	Jorge Sousa	Very acid lo...	
4	4 B	1 1	Manuel Silva	Blanket bo...	
5	5 B	3 3	Manuel Silva	Very acid lo...	
6	6 C	4 4	Jorge Sousa	Slowly per...	
7	7 C	5 5	Jorge Sousa	Freely drai...	
8	8 D	3 3	Ricardo Costa	Very acid lo...	
9	9 D	5 5	Ricardo Costa	Freely drai...	
10	10 A	NUL	NUL	Jorge Sousa	NUL
11	11 B	NUL	NUL	Manuel Silva	NUL
12	12 D	NUL	NUL	Ricardo Costa	NUL
13	13	NUL	NUL	1 1	Blanket bo...
14	14	NUL	NUL	2 2	Blanket bo...
15	15	NUL	NUL	3 3	Very acid lo...
16	16	NUL	NUL	4 4	Slowly per...
17	17	NUL	NUL	5 5	Freely drai...

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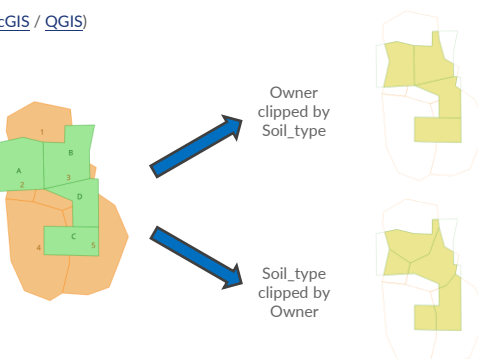
Basic functions – vector data

- Vector layers **OVERLAY** (theoretically, 2 or more layers required)
 - Clip ([ArcGIS](#) / [QGIS](#))

Owner



Soil_type



a_clip_b — Features Total: 4, Filtered: 4

fId	Name	Owner
1	A	Jorge Sousa
2	2 B	Manuel Silva
3	3 C	Jorge Sousa
4	4 D	Ricardo Costa

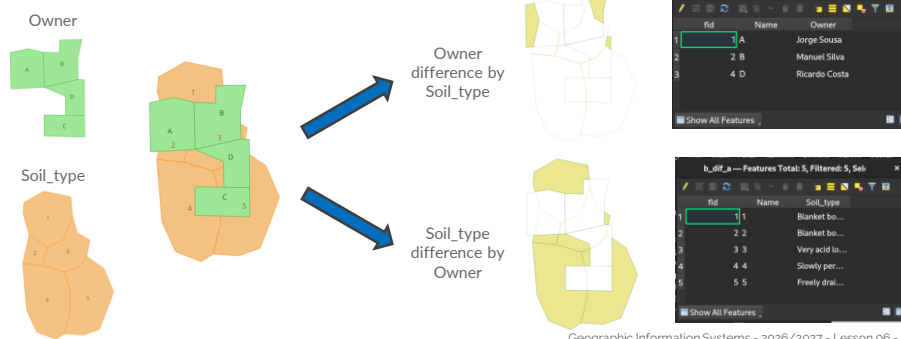
b_clip_a — Features Total: 5, Filtered: 5

fId	Name	Soil_type
1	Blanket bo...	Blanket bo...
2	2 2	Blanket bo...
3	3 3	Very acid lo...
4	4 4	Slowly per...
5	5 5	Freely drai...

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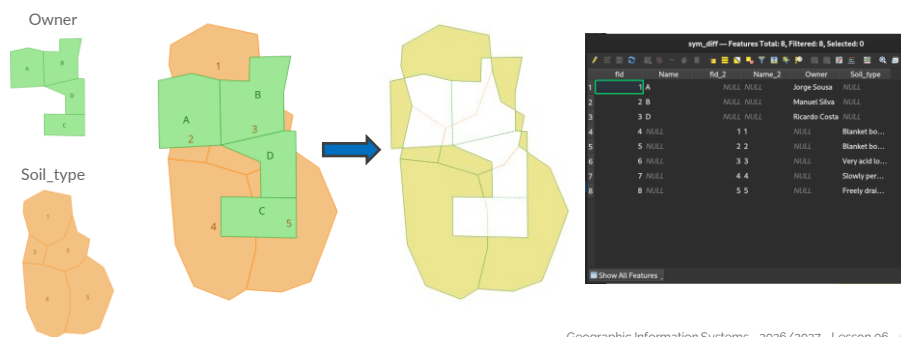
Basic functions – vector data

- Vector layers **OVERLAY** (theoretically, 2 or more layers required)
 - Erase / Difference ([ArcGIS](#) / [QGIS](#))



Basic functions – vector data

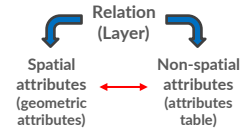
- Vector layers **OVERLAY** (theoretically, 2 or more layers required)
 - Symmetrical difference ([ArcGIS](#) / [QGIS](#))



Basic functions – vector data

- Vector layers **OVERLAY** (theoretically, 2 or more layers required)

- Intersect ([ArcGIS](#) / [QGIS](#))
- Union ([ArcGIS](#) / [QGIS](#))
- Clip ([ArcGIS](#) / [QGIS](#))
- Erase / Difference ([ArcGIS](#) / [QGIS](#))
- Symmetrical difference ([ArcGIS](#) / [QGIS](#))

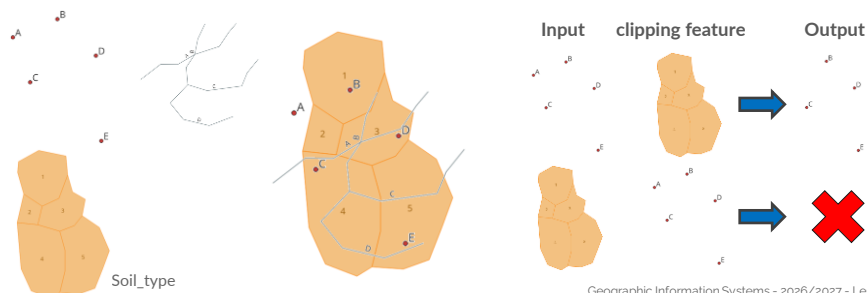


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Basic functions – vector data

- Spatial operations involving multiple layers are:
 - dependent on their typology

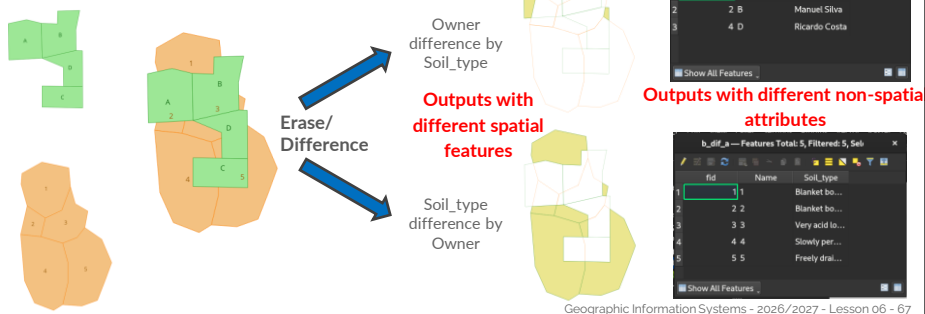
Can I do spatial operation (intersect, clip, union) between these features and a polygon? What will be the result?



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Basic functions – vector data

- Spatial operations involving multiple layers are:
 - dependent on their typology
 - dependent in some cases on the order



Basic functions – vector data

- Spatial operations involving multiple layers are:
 - dependent on their typology
 - dependent in some cases on the order
 - commutative vs. non-commutative spatial operations

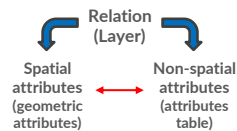
Intersect →

Union →

Clip →

Erase/Difference →

Symmetrical difference →



$$3 + 5 = 5 + 3$$

$$a + b = b + a$$

Commutative

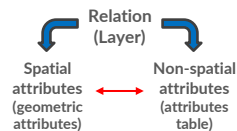
$$3 - 5 \neq 5 - 3$$

$$a - b \neq b - a$$

Non-commutative

Basic functions – vector data

- Spatial operations involving multiple layers are:
 - dependent on their typology
 - dependent in some cases on the order
 - commutative vs. non-commutative spatial operations



$$3 + 5 = 5 + 3$$

$$a + b = b + a$$

Commutative

Intersect	→	Commutative
Union	→	Commutative
Clip	→	Non-commutative
Erase/Difference	→	Non-commutative
Symmetrical difference	→	Commutative

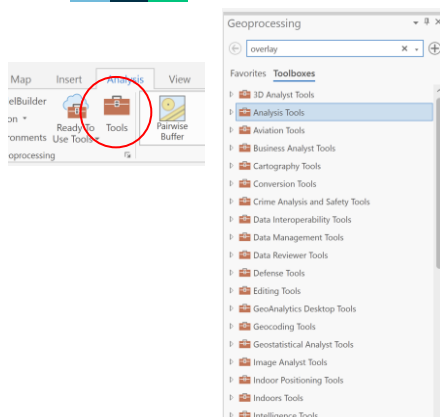
$$3 - 5 \neq 5 - 3$$

$$a - b \neq b - a$$

Non-commutative

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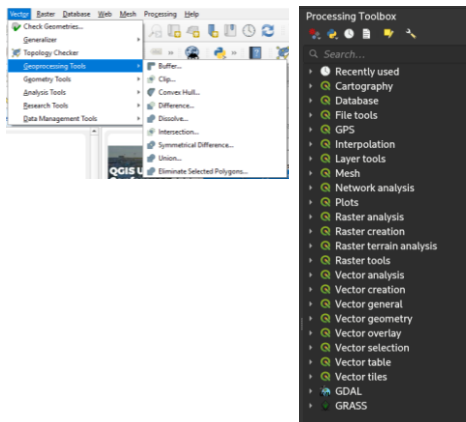
ArcGIS Pro Geoprocessing



- Generic toolboxes
- Business specific toolboxes
- Not all toolboxes are available - licensing
- Custom or user created toolboxes
- Documentation includes detailed description
 - illustration
 - parameters
 - python syntax / example

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QGIS Processing



- Plugin (install if not available)
- In continuous expansion by the community
- Documentation includes detailed description
 - illustration
 - parameters
 - python syntax / example

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Credits

The structure and content of the course, including most of the slides and exercises was developed by Professor Graça Abrantes (SIG 2021_2022) and Professor Rui Figueira (SIG 2023_2024)

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