Online Young Scientist School MEGAPOLIS-2021

Multi-Scales and -Processes Integrated Modelling, Observations and Assessment for Environmental Applications

GIS technologies in environmental sciences (urban climate)

FACULTY OF GEOGRAPHY
Lomonosov MSU Moscow

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A short introduction

Education

2007 – MSc in Cartography (Lomonosov MSU)

2010 – PhD in Cartography (Lomonosov MSU)

Courses taught

- Geographical Information Science
- Visualization and Analysis of Geographic Data Using R Language
- Programming and Data Science
- Spatial Statistics
- Visualization of Spatial Data
- Generalization of Spatial Data

Working experience

2006–2008 – «Mercator Group» (mapping for TV news)

2008-2011 – Esri CIS (server GIS expert)

Since 2011 г – **Lomonosov MSU Faculty of Geography, Leading research scientist**

Scientific Interests

Theoretical and applied GIScience, automated cartography

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tsamsonov

Presentation is based on

1. Samsonov, T. E., and Varentsov, M. I. **Computation of city-descriptive parameters for high-resolution numerical weather prediction in moscow megacity in the framework of the COSMO model**. *Russian Meteorology and Hydrology 45*, 7 (2020), 515–521.

2. Varentsov M., Samsonov T., Demuzere M. **Impact of urban canopy parameters on a megacity's modelled thermal environment** // *Atmosphere*. — 2020. — Vol. 11, no. 12. — P. 1349.

3. *Samsonov T. E., Konstantinov P. I., Varentsov M. I.* **Object-oriented approach to urban canyon analysis and its applications in meteorological modeling** // *Urban Climate*. — 2015. — Vol. 13. — P. 122–139.

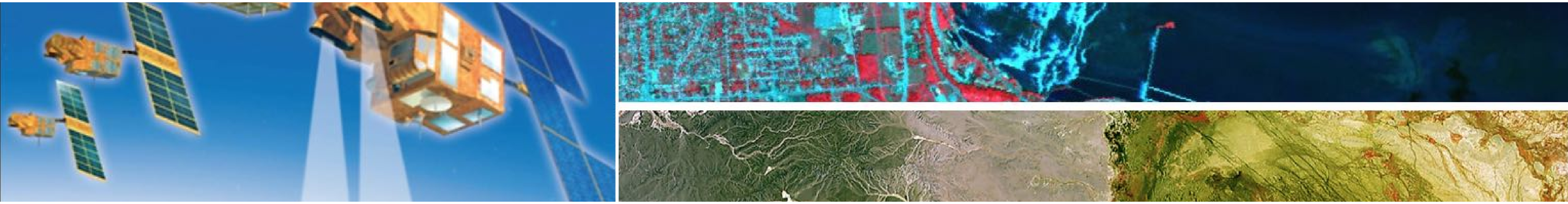
4. *Samsonov T., Trigub K.* **Towards computation of urban local climate zones (lcz) from OpenStreetMap data** // Proceedings of the 14th International Conference on GeoComputation, 4th-7th September 2017. — Leeds, UK, 2017. — P. 1–9.

5. *Samsonov T. E., Konstantinov P. I.* **Openstreetmap data assessment for extraction of urban land cover and geometry parameters required by urban climate modeling** // Extended Abstract Proceedings of the GIScience 2014, September 23-26, Vienna, Austria. — Vol. 40 of *GeoInfo Series*. — Hochschülerschaft, TU Vienna Vienna, Austria, 2014. — P. 395–399.

Cartography

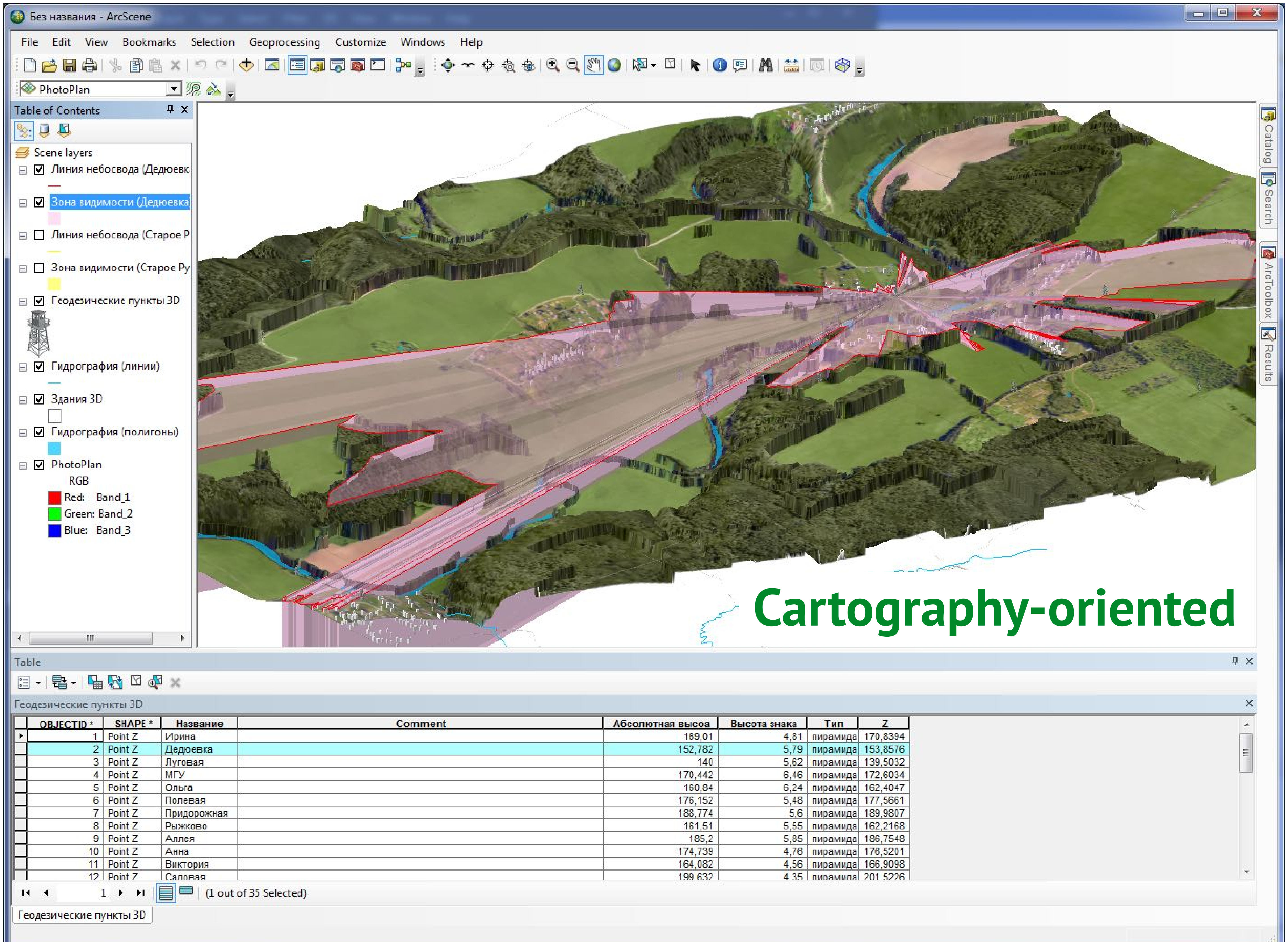
Geographical Information Science

Remote sensing & Photogrammetry



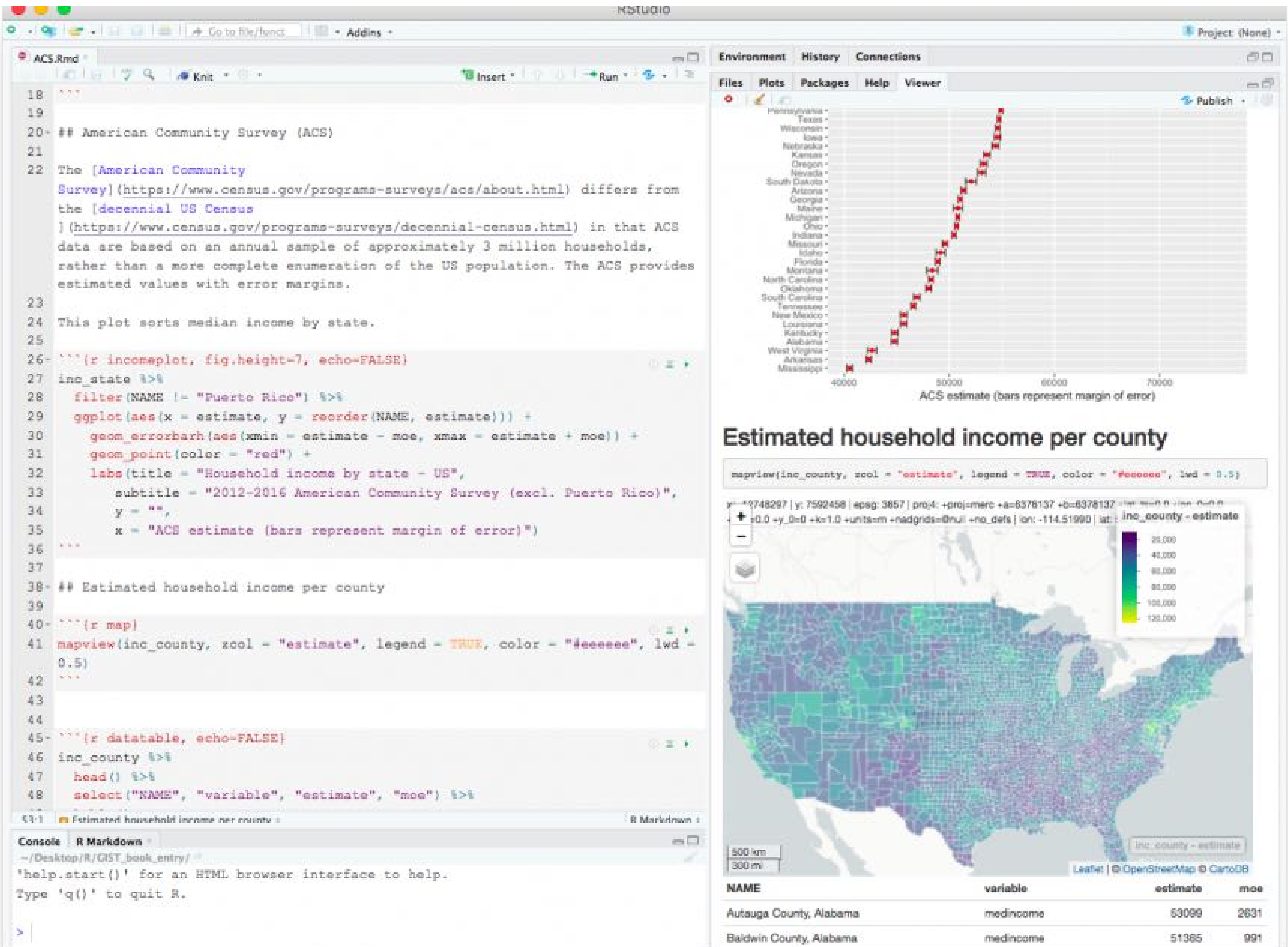
Geodesy

Geographical Information Systems



OBJECTID *	SHAPE *	Название	Comment	Абсолютная высоа	Высота знака	Тип	Z
1	Point Z	Ирина		169,01	4,81	пирамида	170,8394
2	Point Z	Дедюевка		152,782	5,79	пирамида	153,8576
3	Point Z	Луговая		140	5,62	пирамида	139,5032
4	Point Z	МГУ		170,442	6,46	пирамида	172,6034
5	Point Z	Ольга		160,84	6,24	пирамида	162,4047
6	Point Z	Полевая		176,152	5,48	пирамида	177,5661
7	Point Z	Придорожная		188,774	5,6	пирамида	189,9807
8	Point Z	Рыжково		161,51	5,55	пирамида	162,2168
9	Point Z	Аллея		185,2	5,85	пирамида	186,7548
10	Point Z	Анна		174,739	4,76	пирамида	176,5201
11	Point Z	Виктория		164,082	4,56	пирамида	166,9098
12	Point Z	Садовая		199,632	4,35	пирамида	201,5226

Geographical Information Systems

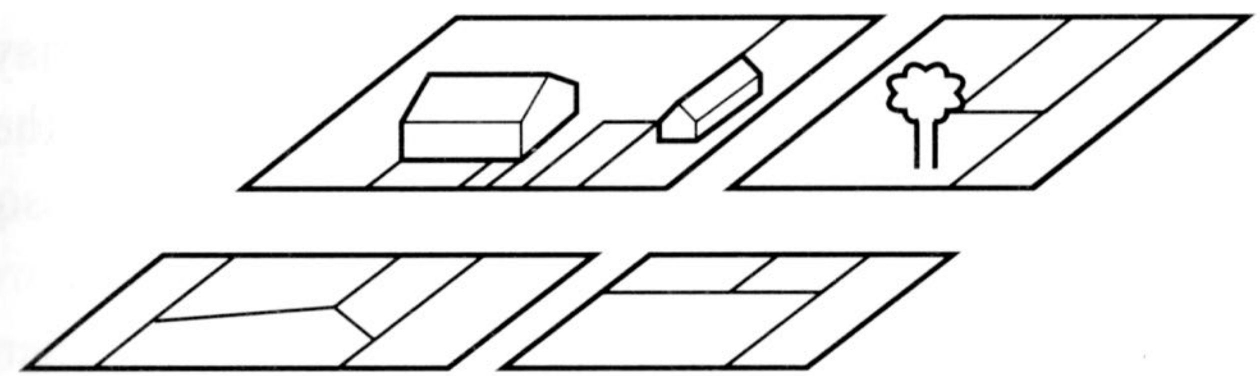


Computation-oriented

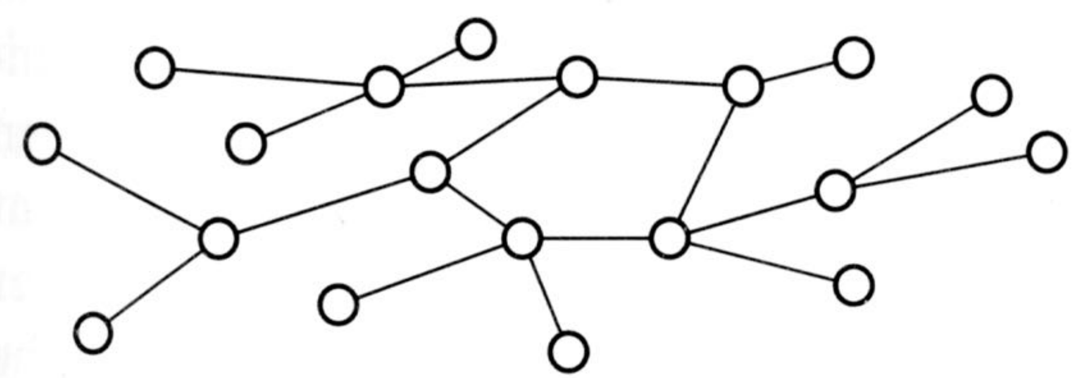
GIScience vocabulary

Conceptual models of geographic space

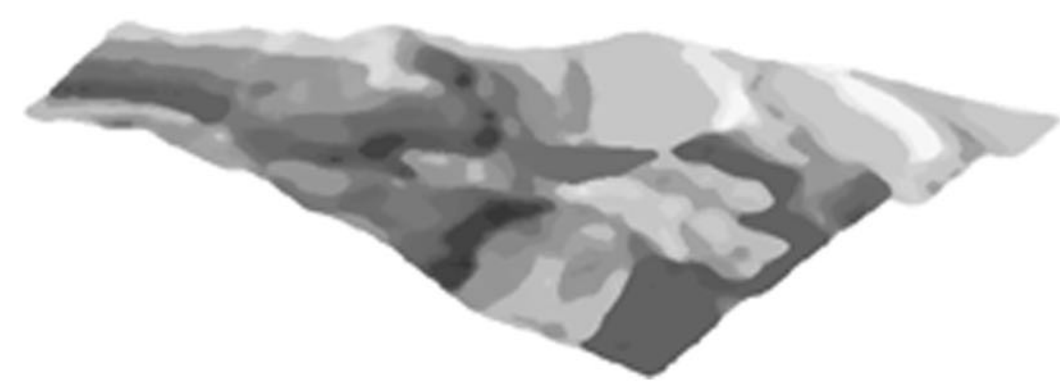
Object-oriented models



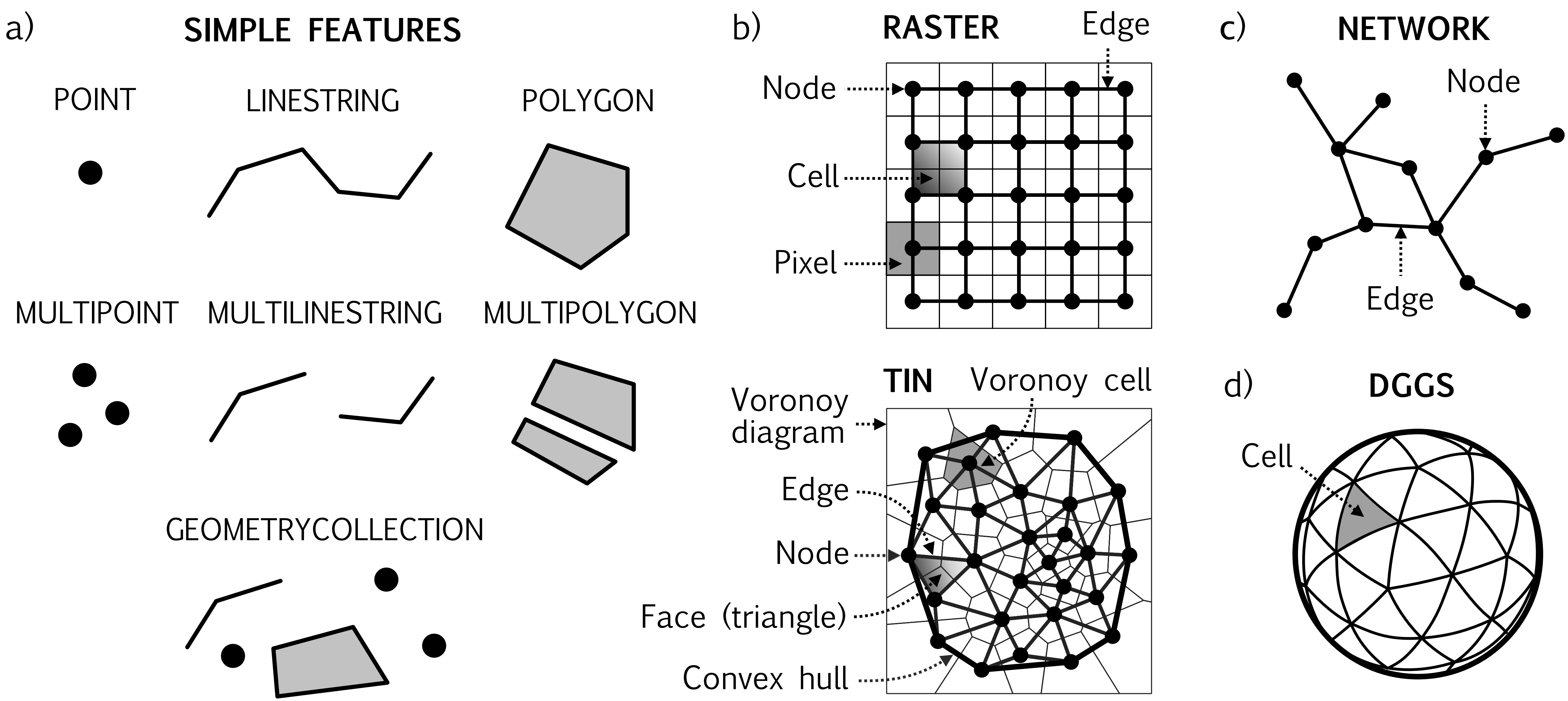
Network models



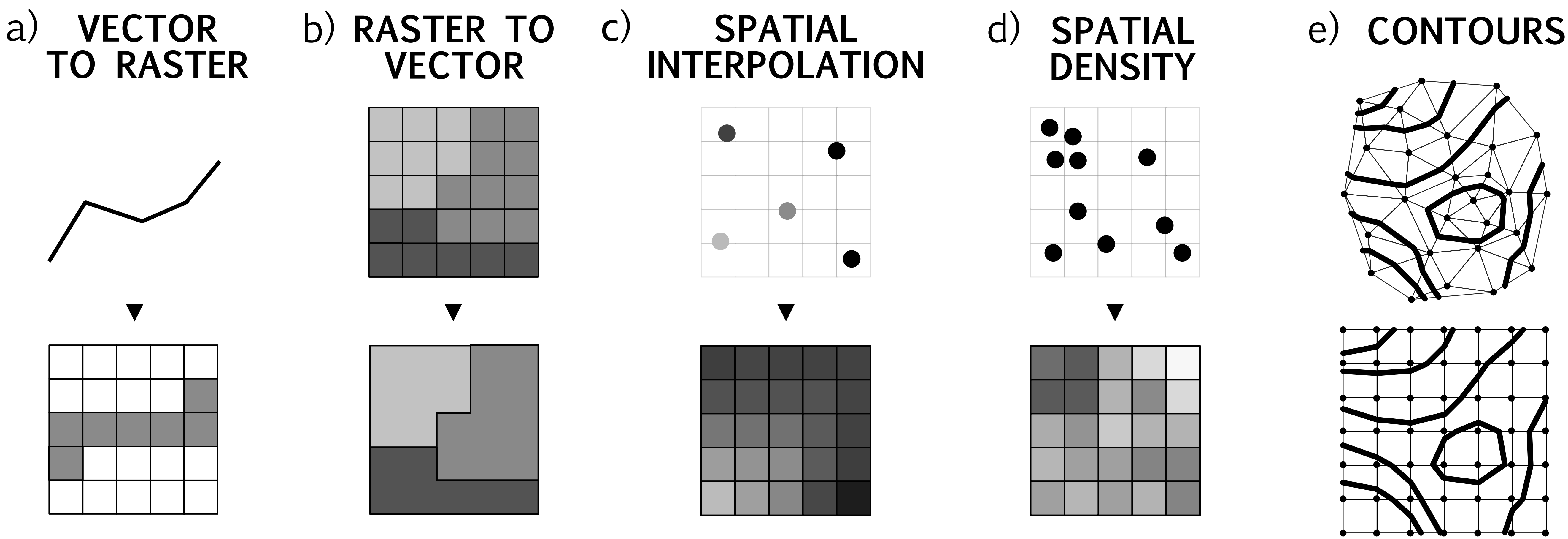
Geographical field models



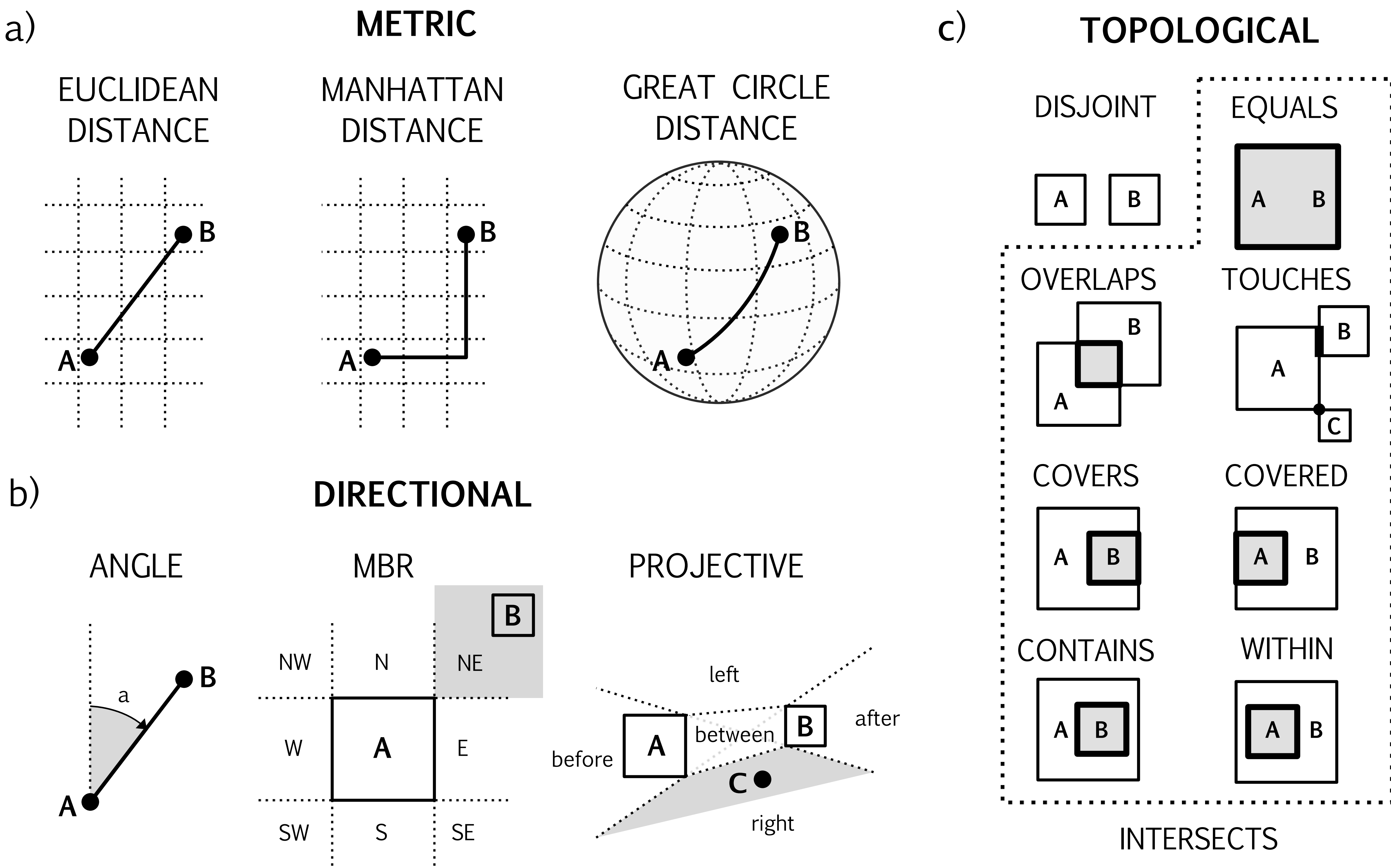
Spatial data models



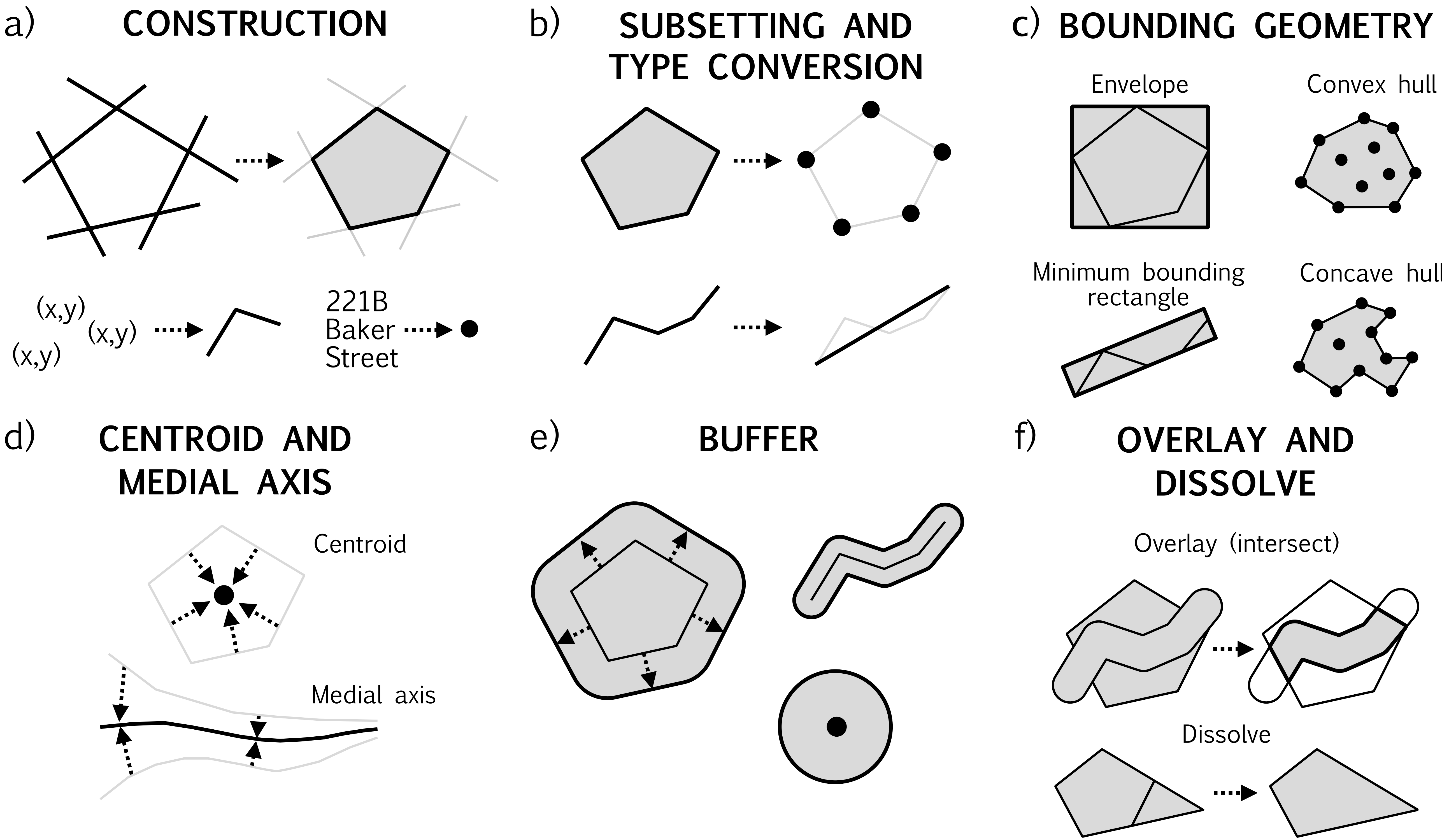
Spatial data model transformations



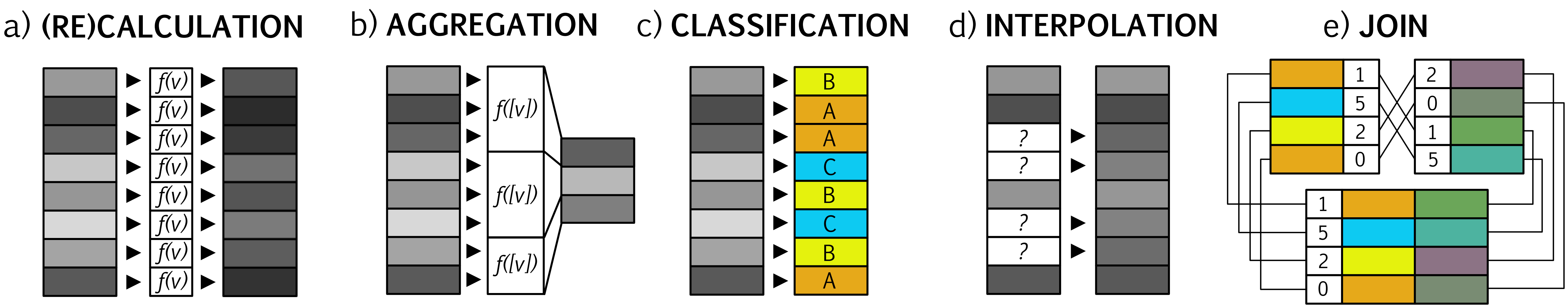
Spatial relations



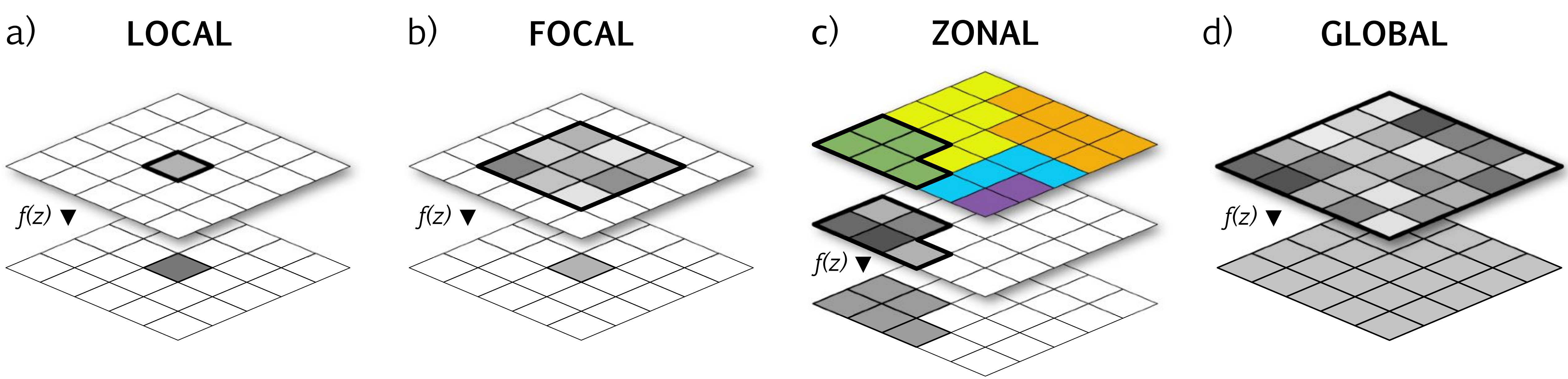
Geometric transformations



Attribute transformations



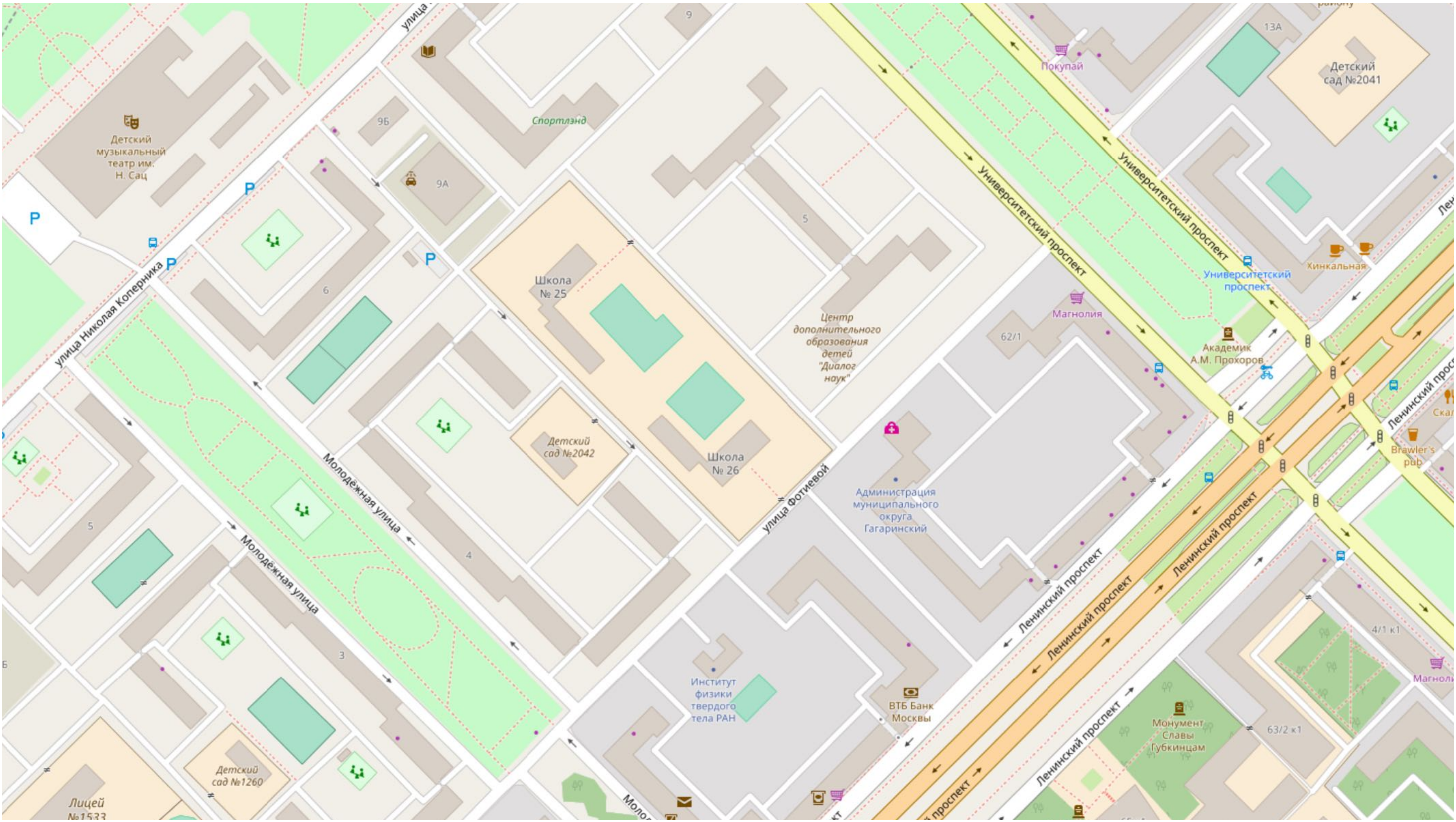
Raster algebra



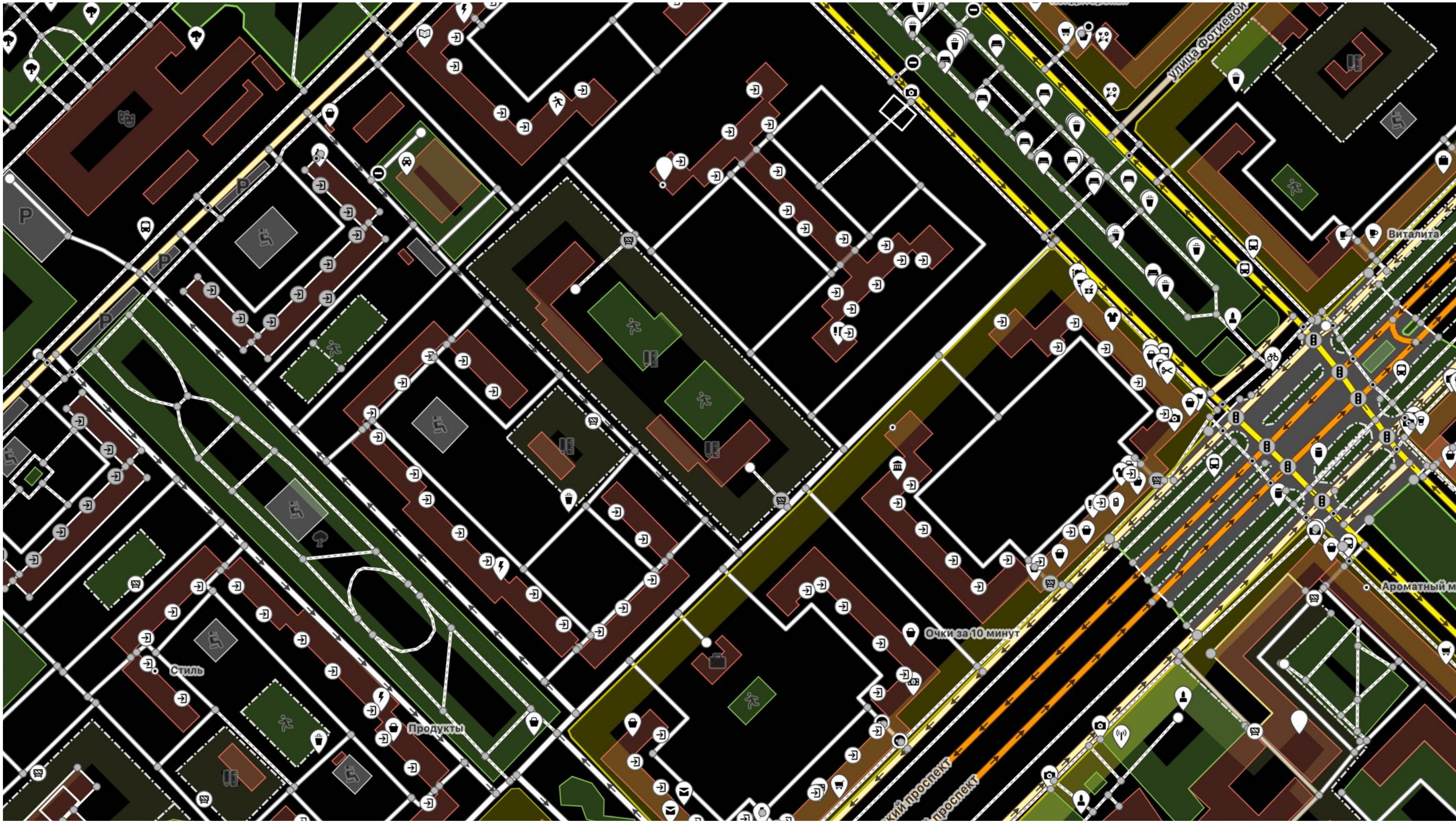
Use case: urban land cover from OpenStreetMap data

A map

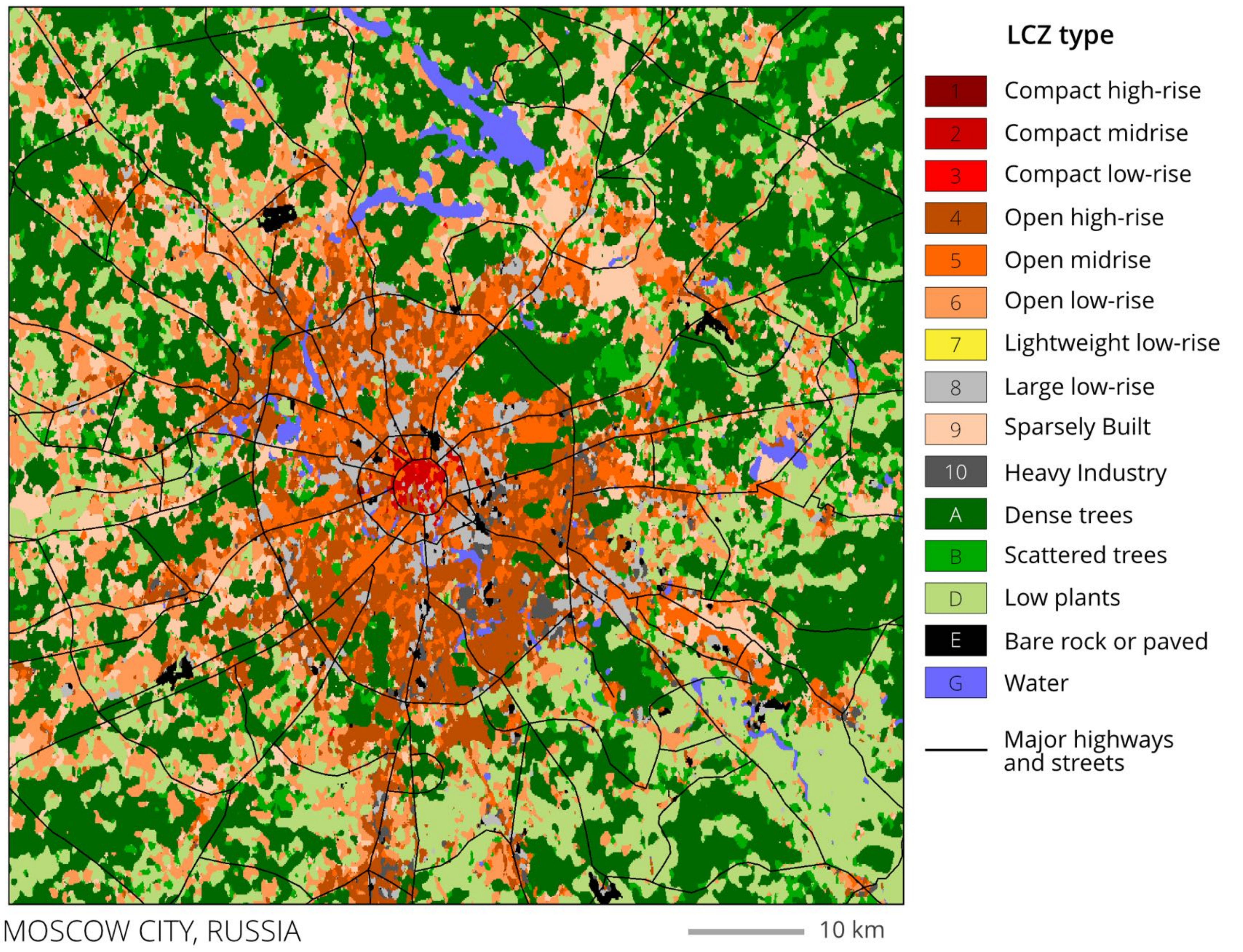
https://www.openstreetmap.org/



Vector data behind the map



Moscow LCZs



LCZ type
1 Compact high-rise
2 Compact midrise
3 Compact low-rise
4 Open high-rise
5 Open midrise
6 Open low-rise
7 Lightweight low-rise
8 Large low-rise
9 Sparsely Built
10 Heavy Industry
A Dense trees
B Scattered trees
D Low plants
E Bare rock or paved
G Water
Major highways and streets
MOSCOW CITY, RUSSIA
10 km

OSM application:
Evaluation of LCZs inner structure

OSM XML

▼

Topographic layers

▼

Dissolve-Erase-Merge
(Topological Integration)

▼

Reclassify

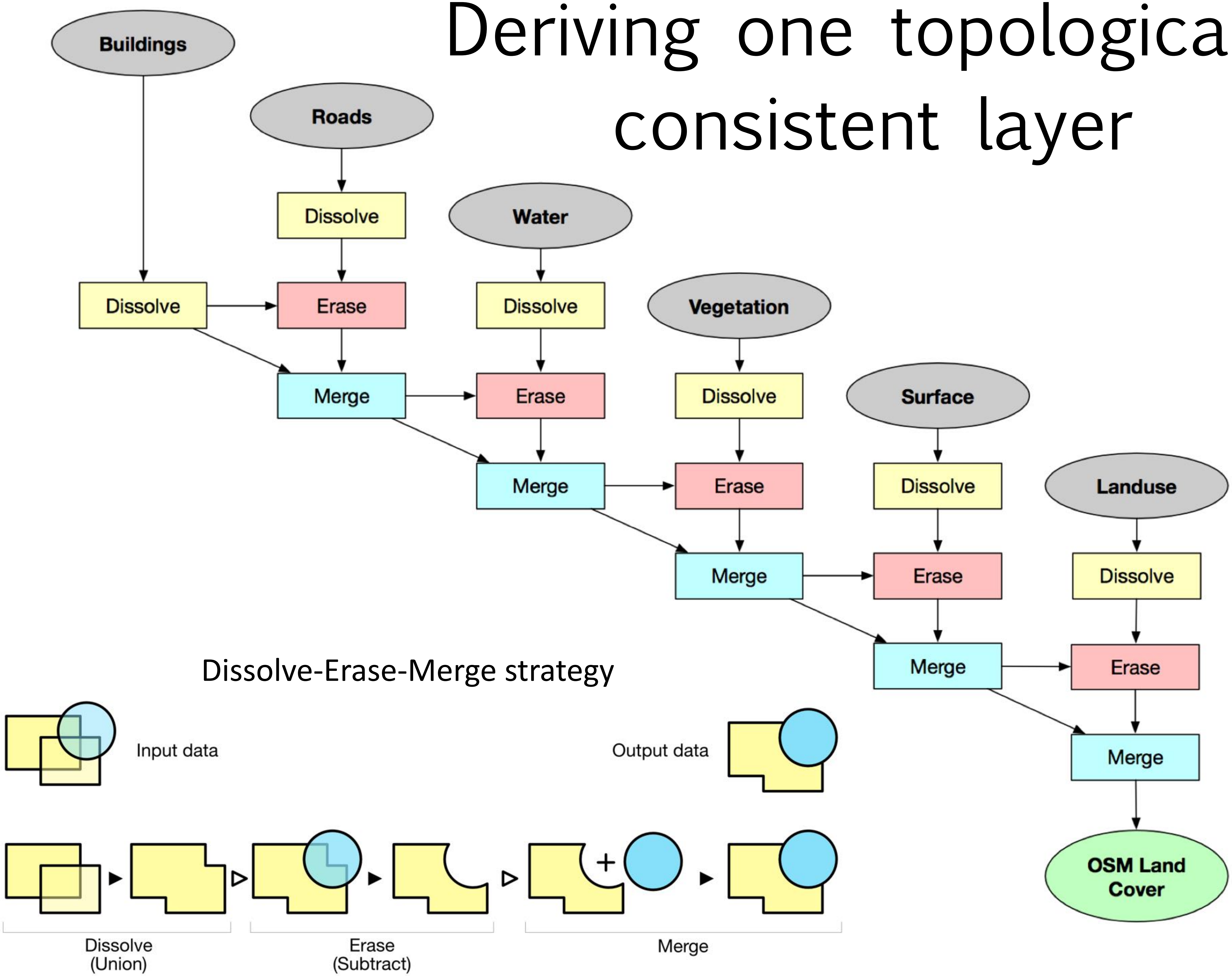
▼

Tabulate within LCZ classes

Deriving layers from OSM

№	Name	Query	Fields
1	**Landuse**	<landuse> IS NOT NULL AND NOT <landuse> IN ('forest')	NAME, LANDUSE, RSDNTL
2	**Vegetation**	<natural> IN ('wood', 'scrub', 'heath') OR <landuse> IN ('forest')	NATURAL, LANDUSE, WOOD, NAME
3	**Buildings**	<building> IS NOT NULL AND NOT <building> IN ('no', 'entrance')	BUILDING, A_STRT, A_SBRB, A_HSNMBR, B_LEVELS, NAME
4	**Surface**	<natural> IN ('beach', 'sand', 'fell', 'grassland', 'heath', 'scree', 'scrub')	NATURAL
5	**Water**	<natural> IN ('water', 'wetland') OR <waterway> = 'riverbank'	NAME, NATURAL, WATERWAY, WETLAND
6	**Roads**	<highway> IN ('motorway', 'motorway_link', 'trunk', 'trunk_link', 'primary', 'primary_link', 'secondary', 'secondary_link', 'tertiary', 'tertiary_link', 'residential', 'unclassified', 'road', 'living_street', 'service', 'track', 'pedestrian', 'footway', 'path', 'steps', 'bridleway', 'construction', 'cycleway', 'proposed', 'raceway')	NAME, REF, HIGHWAY, ONEWAY, BRIDGE, TUNNEL, MAXSPEED, LANES, WIDTH, SURFACE

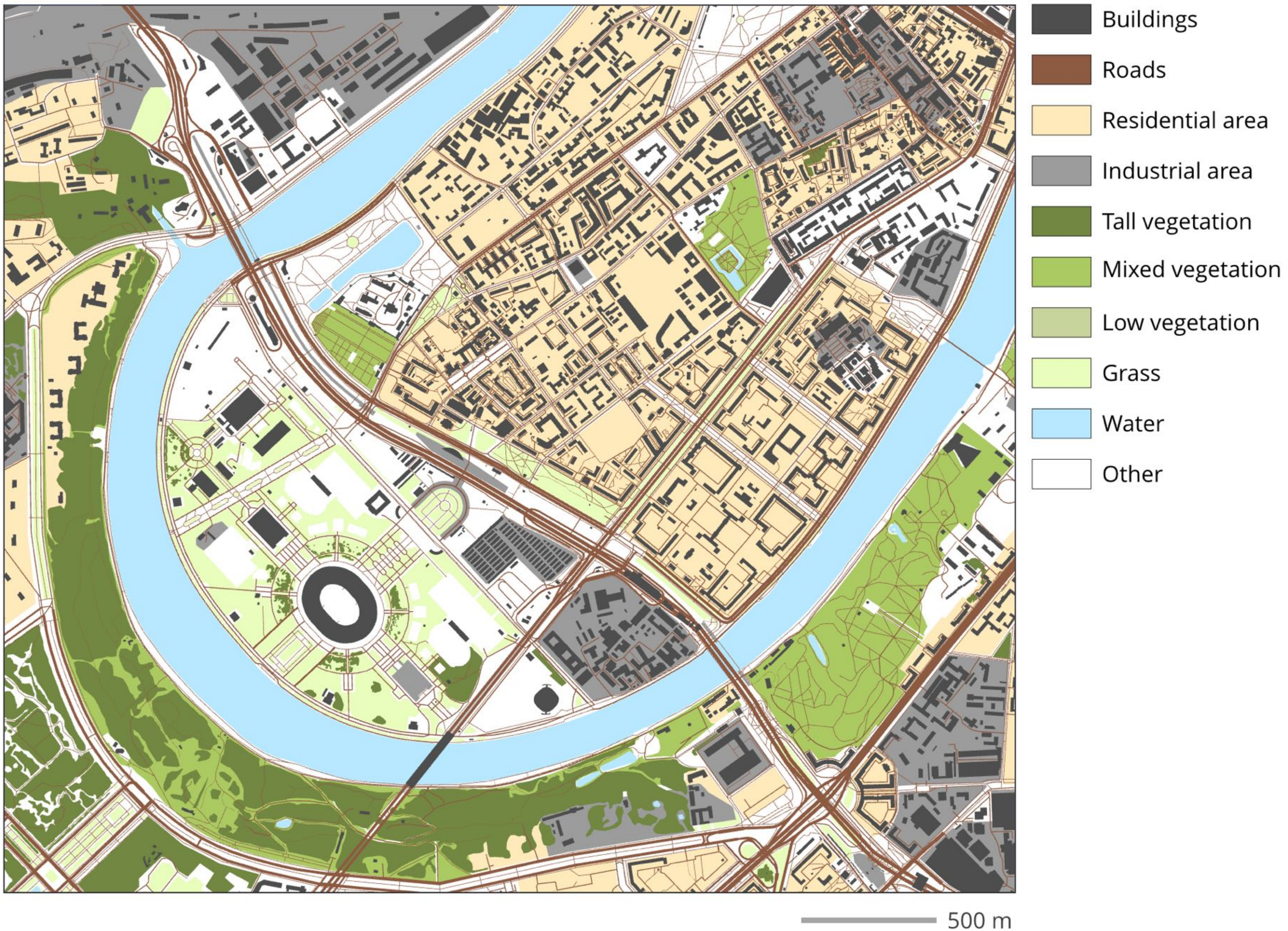
Deriving one topologically consistent layer



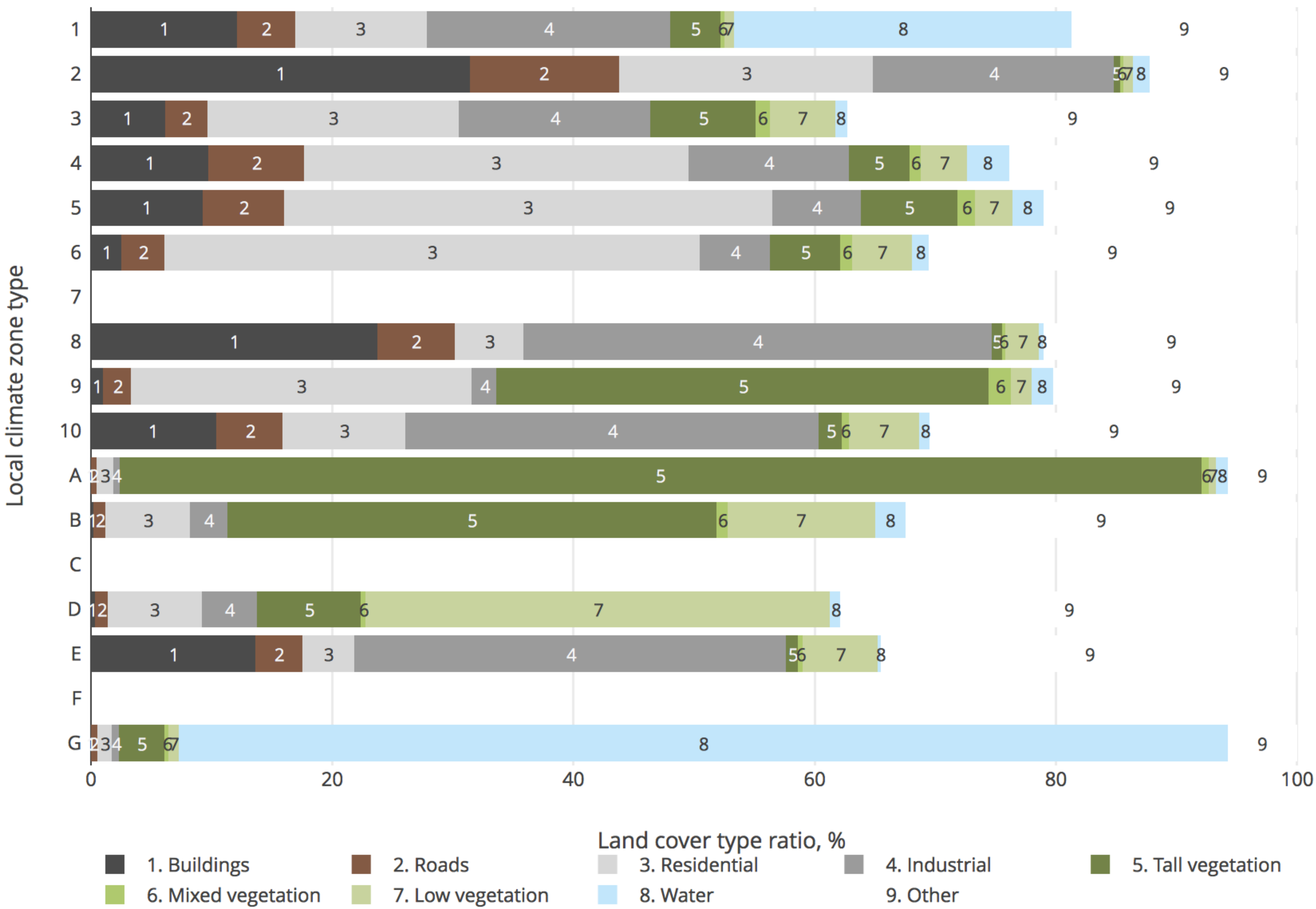
Classifying the features in layer

Land cover type	Query
Buildings	"BUILDING" is not NULL
Roads	"HIGHWAY" is not NULL
Grass	”LANDUSE" in ('grass', 'grassland', 'meadow') or "SURFACE" = 'grass' OR "NATURAL" = 'grassland'
High vegetation	"LANDUSE" in ('forest','logging') OR "NATURAL" in ('tree', 'tree_row', 'wood') OR "WOOD" IS NOT NULL
Low vegetation	"LANDUSE" in ('orchard', 'vineyard', 'scrub', 'farm', 'farmland', 'greenfield') or "NATURAL" = 'scrub'
Mixed vegetation	"LANDUSE" in ('cemetery', 'garden', 'park' , 'natural_reserve')
Surface (impervious)	"LANDUSE" = 'parking' or ("SURFACE" in ('asphalt' , 'asphalt;compacted' , 'asphalt;concrete' , 'asphalt;gravel' , 'brick' , 'cobblestone' , 'concrete' , 'concrete:lanes' , 'concrete:plates' , 'granite' , 'paved' , 'paving_stones' , 'pebblestone' , 'stone') AND "HIGHWAY" IS NULL)
Water	"NATURAL" in ('water', 'waterway', 'wetland') OR "WATERWAY" IS NOT NULL OR "LANDUSE" = 'reservoir'
Industrial	"LANDUSE" in ('construction' , 'garage' , 'garages', 'industrial', 'military' , 'railway' , 'retail' , 'depot', 'commercial')
Residential	"LANDUSE" in ('residential', 'allotments')

OSM Landcover

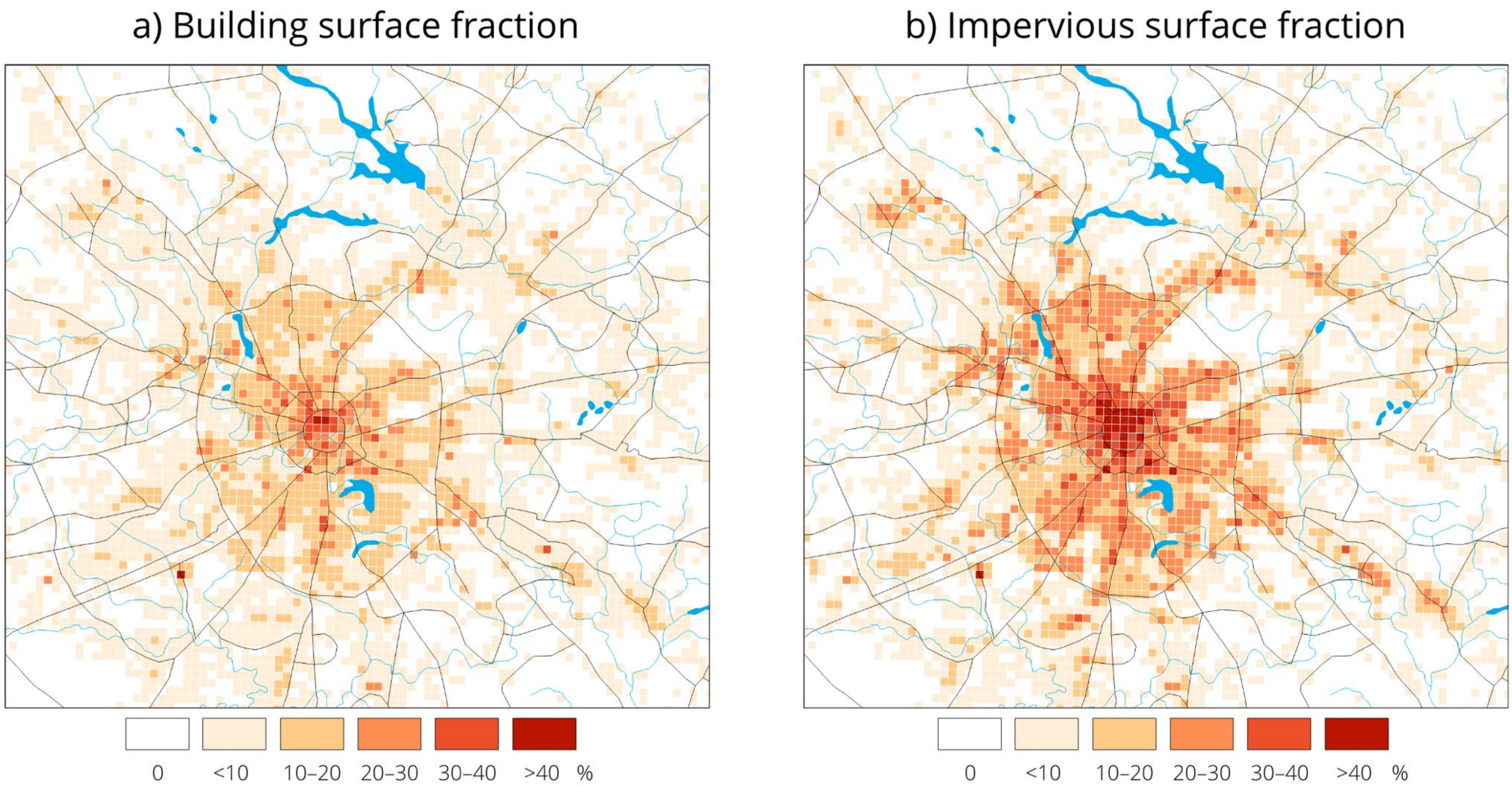


LCZ vs OSM Landcover tabulation



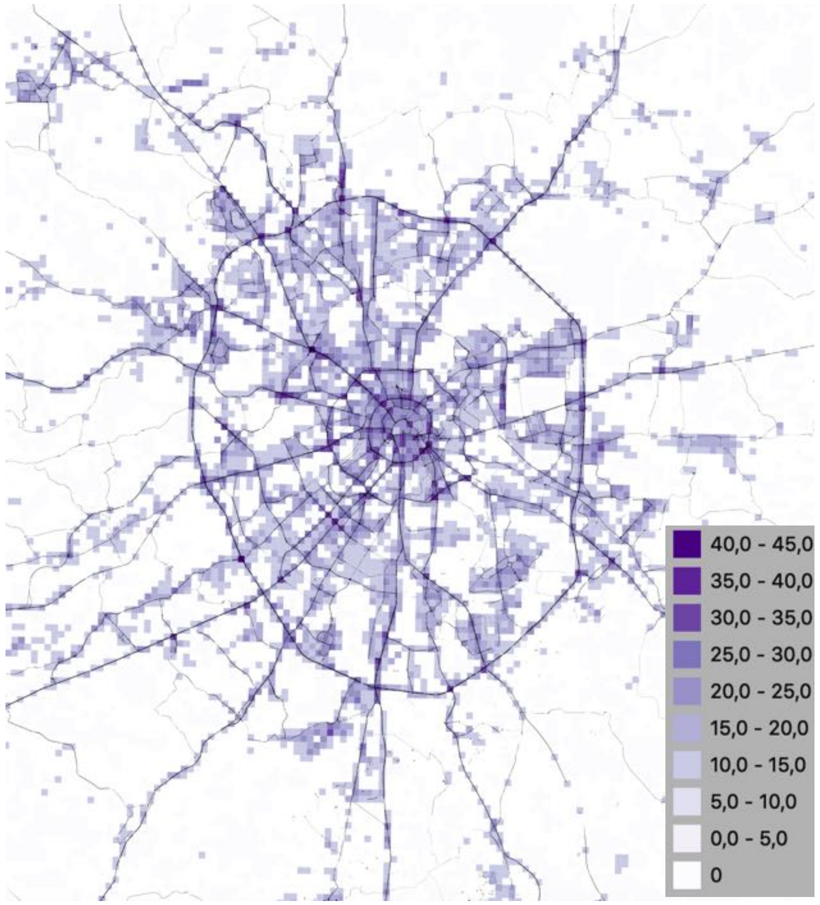
OSM application:

Deriving LCZ parameters from OSM

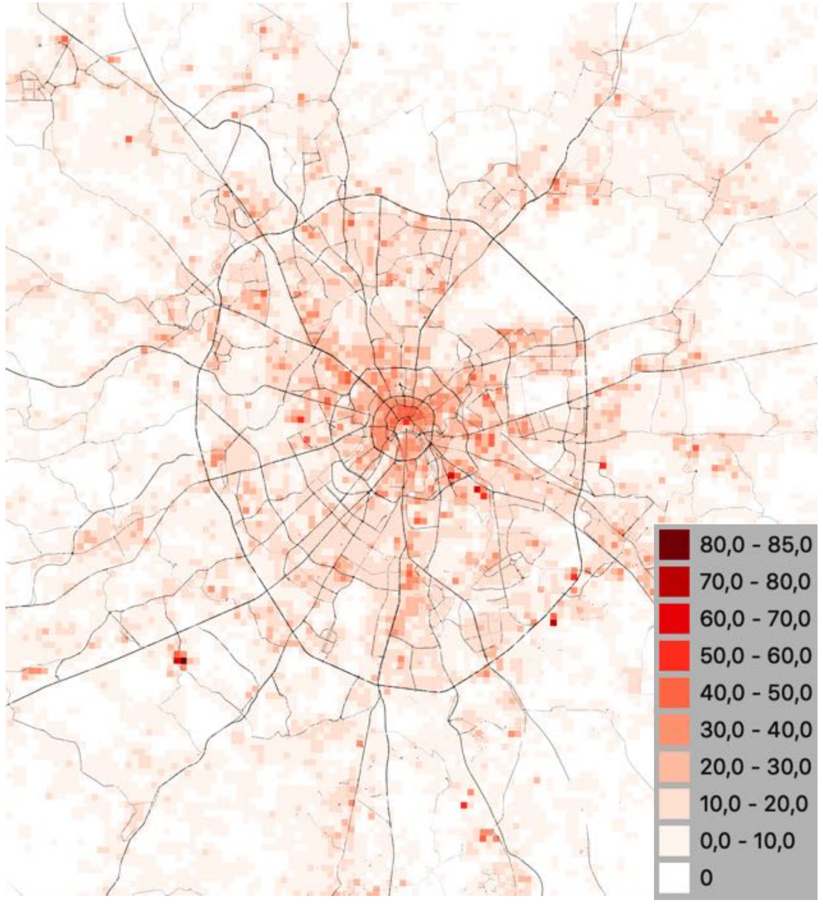


Built-up landcover data from OSM

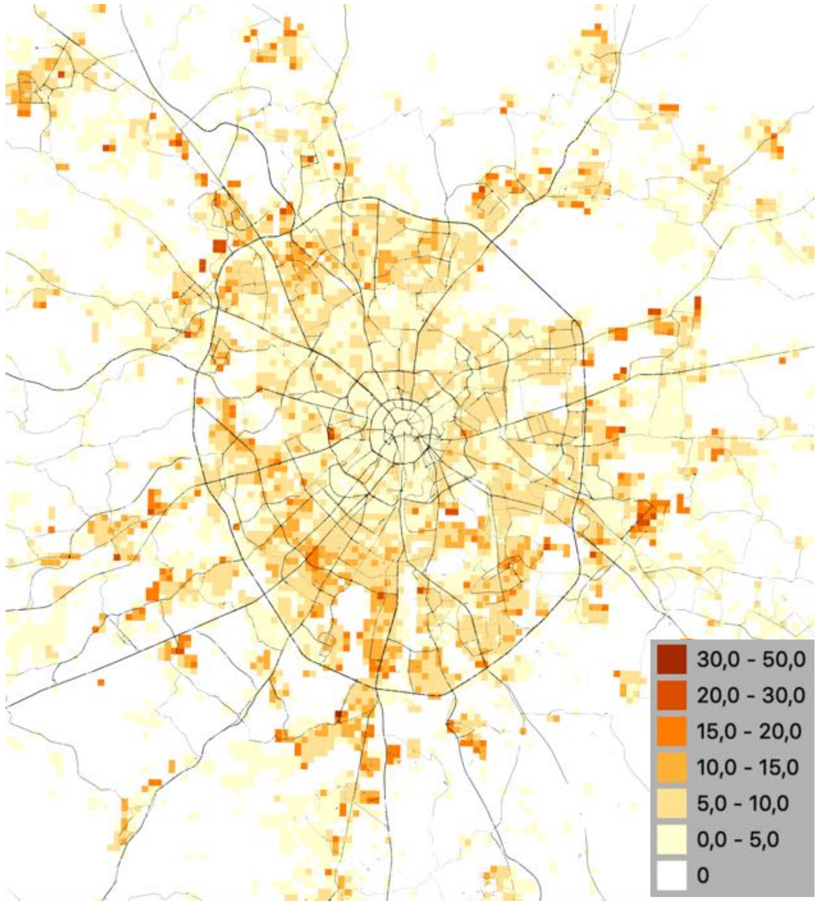
Road ratio, %

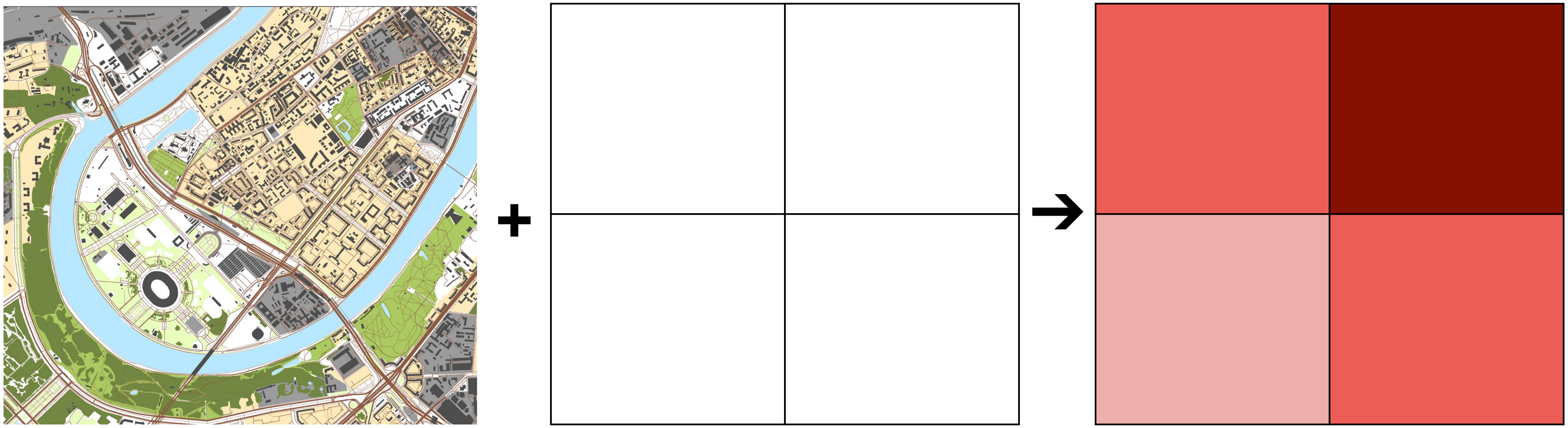


Building ratio, %



Mean building levels

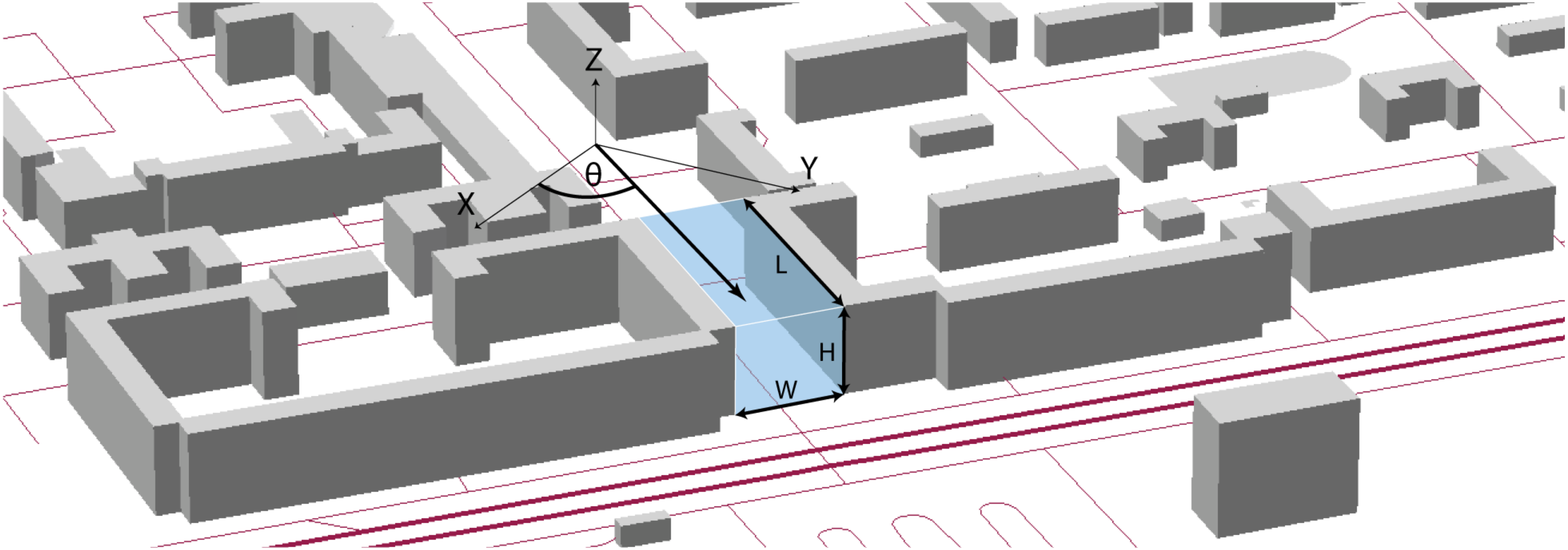




Use case: urban geometry from OpenStreetMap data

Urban canyon geometry from OSM

Urban canyon — a space between buildings



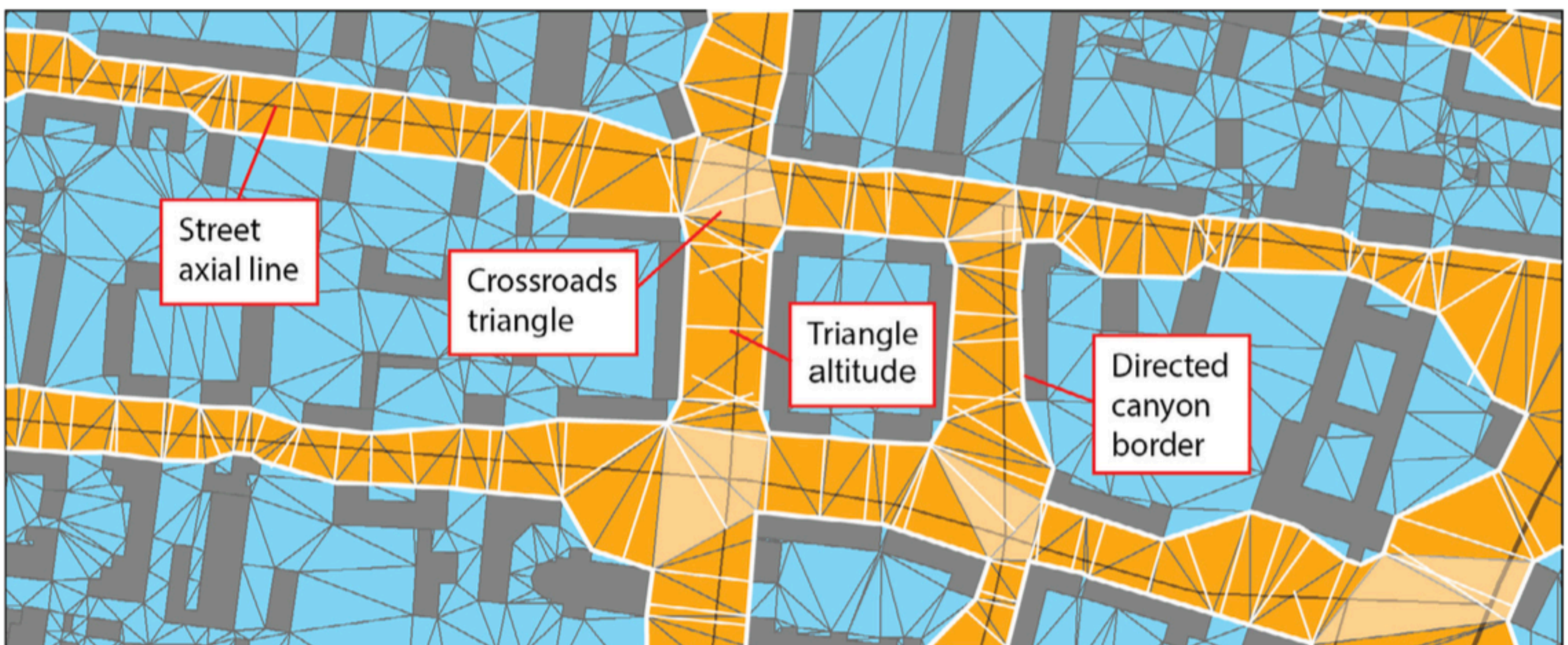
Urban canyon width estimation

Local canyon width w_i is calculated for every triangle as altitude to the side, which is not intersected by street network:

Average canyon width is calculated for n triangles as a weighted average of their altitudes with triangle areas S_i as weights:

$$w_i = \frac{2S_i}{a_i}$$

For undirected canyons and crossroads an average triangle side length is used instead of a_i

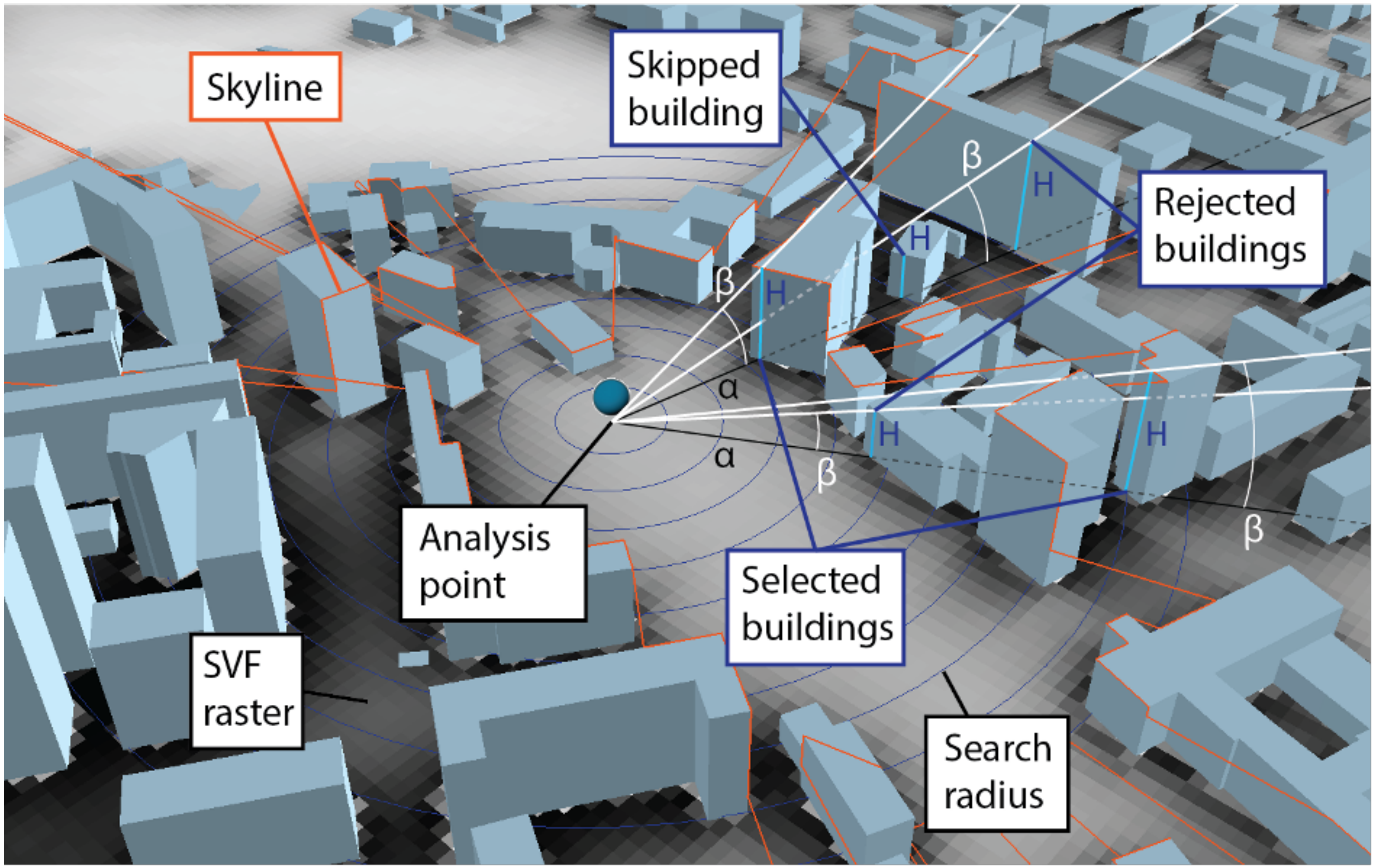


Canyon Width

Can be derived in GIS using triangulation of buildings

Sky View Factor

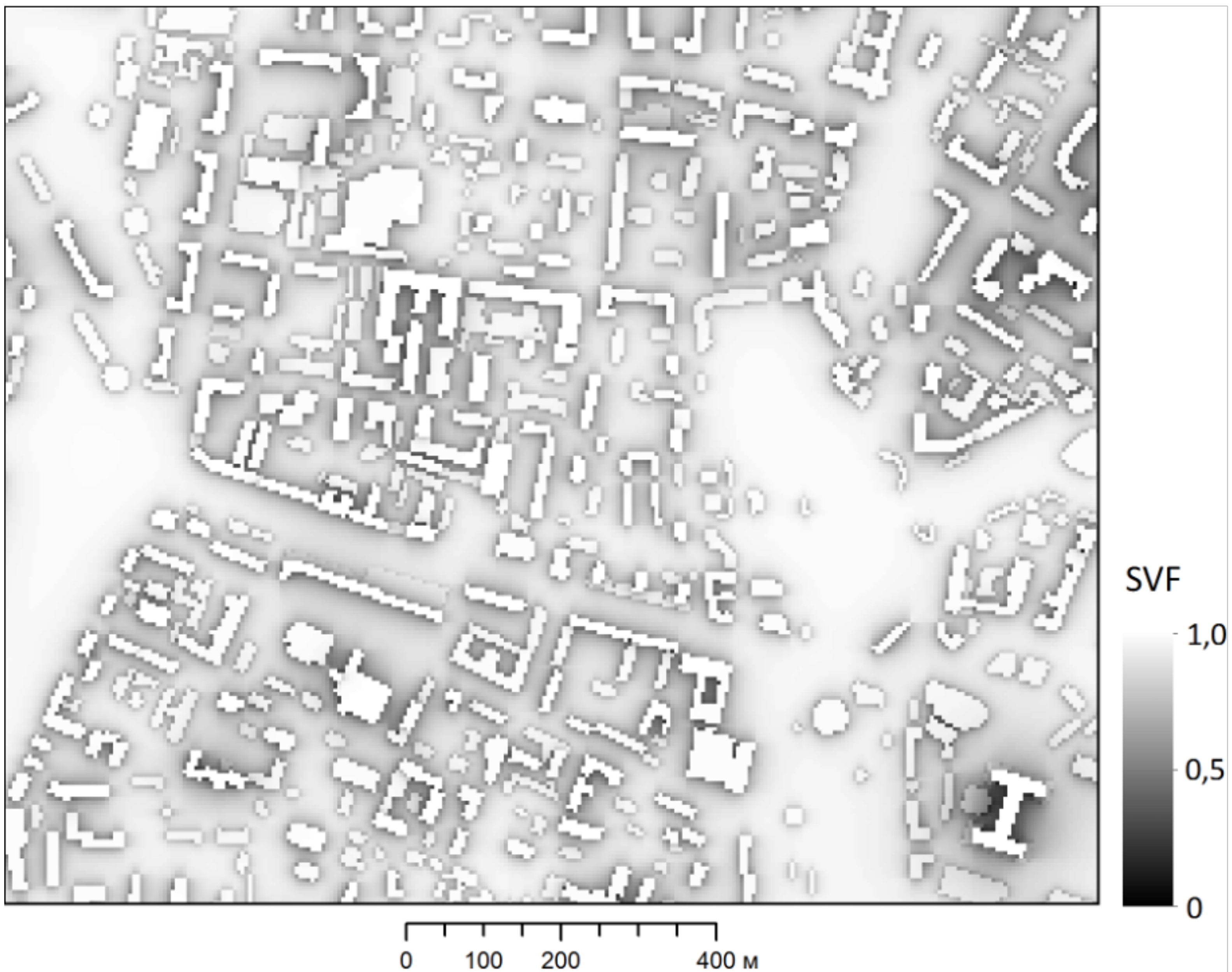
A portion of the sky hemisphere visible at point



Can be derived in GIS using focal raster analysis with extended neighborhood

Sky View Factor

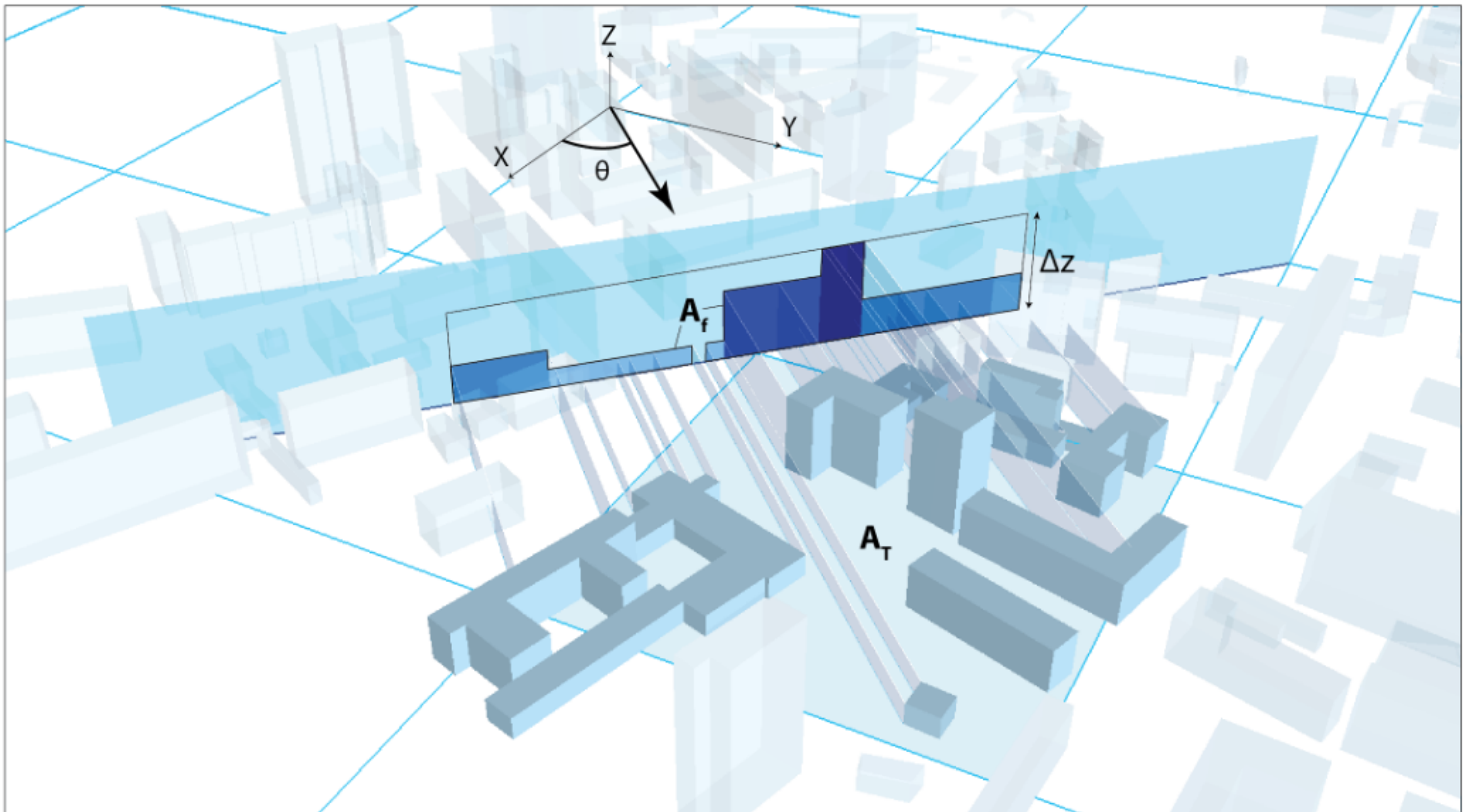
A portion of the sky hemisphere visible at point



Can be derived in GIS using focal raster analysis with extended neighborhood

Frontal area index

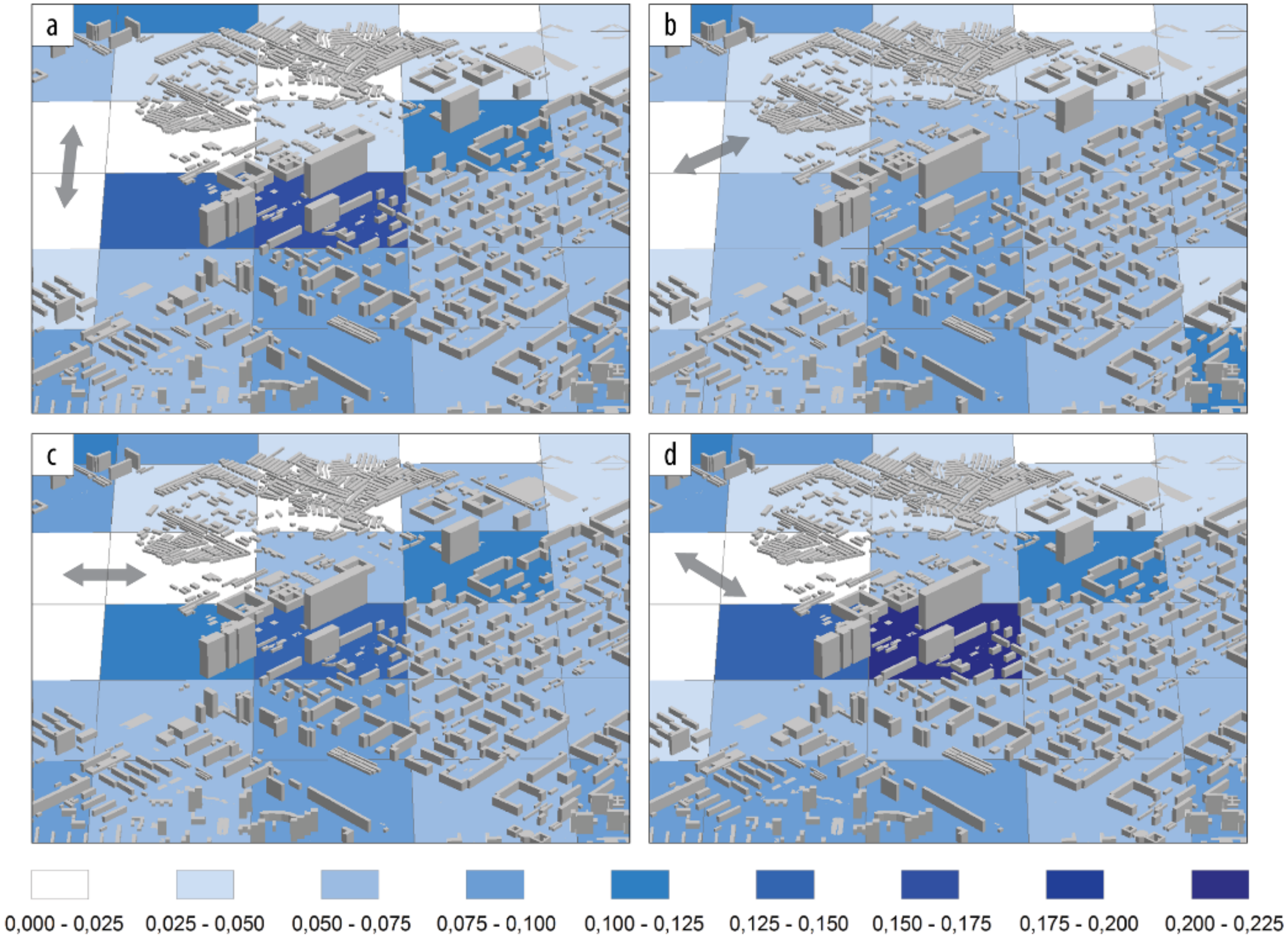
The **frontal area index** determines the "vertical roughness" of the surface.
It is calculated as the ratio of the projection of the area of the walls of buildings A_f, visible from a given direction θ and the area of the cell A_T on which these buildings are located



Can be derived in GIS using geometric intersections

Frontal area index

The **frontal area index** determines the "vertical roughness" of the surface.
It is calculated as the ratio of the projection of the area of the walls of buildings A_f, visible from a given direction θ and the area of the cell A_T on which these buildings are located



Changes with **θ**

Frontal area index

Changes with **θ**

Frontal area index

Changes with **θ**

Frontal area index

Changes with $\boldsymbol{\theta}$

Frontal area index

Changes with **θ**

Frontal area index

Changes with **θ**

Resume

1. Geographical Information Science (GIScience) provides technical tools for analyzing spatial data
2. The main GIScience idiom shifted from cartographic to computational during recent years.
3. Numerous parameters of urban environment can be derived from OpenStreetMap data.
4. These parameters are useful for verification of external classifications (land cover) and for describing urban geometry

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