SA-TIED Geospatial Analysis Workshop

Overview

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Objectives

We will explore the following topics:

- Fundamentals of using R for data analysis.
- Creating thematic maps using R.
- Quantifying the degree of spatial dependence in a dataset.
- Incorporating space into statistical models.

Schedule

Day 1 – Morning	R for Data Analysis
Day 1 – Afternoon	R for Spatial Analysis
Day 2 – Morning	Spatial Autocorrelation
Day 2 – Afternoon	Spatial Models

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S04 – Spatial Models

This session

- Spatial models.
- Geographically weighted statistics.
- Geographically weighted associations.
- More spatial analysis.

Linear models

- Used to determine the relationship or association between a dependent with one or more independent variables.
- Important assumptions: homoscedasticity and independence of residuals.
- Violating this assumption can lead to inefficient estimates and unreliable hypothesis tests.

Linear models

When building a model based on spatial data:

- Plot the residuals of the linear model to visually inspect for spatial patterns.
- Calculate Moran’s I statistic on the residuals to assess spatial autocorrelation.
- If spatial autocorrelation is present, fit a spatial linear model to account for it.
- Recalculate Moran’s I statistic on the residuals of the spatial model to confirm that the autocorrelation has been addressed.

Spatial models

A spatial error model adjusts for spatial autocorrelation by adding a spatially lagged error term to the regression equation:

$$y = X\beta + v, v = \lambda W v + \epsilon$$

where $X\beta$ represents the standard regression components, λ is a spatial autoregressive parameter, W represents the spatially weights matrix, and u is a vector of spatially autocorrelated errors.

Spatial models

A spatial lag model incorporates a spatially lagged dependent variable, which is the weighted sum of the dependent variable values in neighboring locations, into the regression equation:

$$y = \rho W y + X\beta + \epsilon$$

where ρ is the spatial autoregressive coefficient, Wy represents the spatially lagged dependent variable, and $X\beta$ represents the standard regression components.

Spatial models

- Both the spatial error and spatial lag models assume that the relationships between variables are the same across the study area, with adjustments made only for spatial dependencies.
- A Lagrange Multiplier Test can be used to make a decision as to which of these two models is most appropriate.
- What about non-stationarity?

Geographically weighted statistics

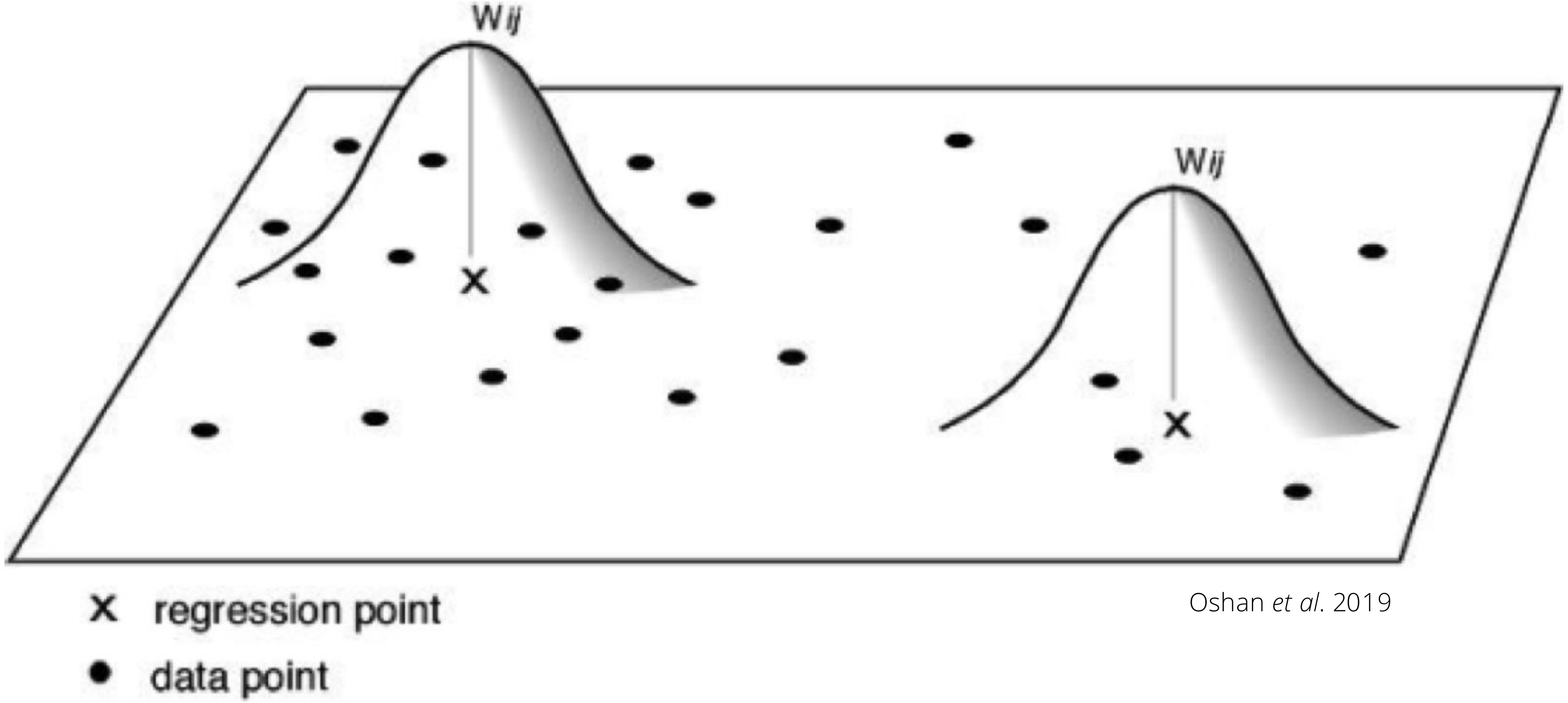
- Unlike traditional global models, which estimate a single set of parameters for the entire study area, geographically weighted statistics allow for parameter estimates that vary across different locations.
- Local means, local standard deviations, local variances.
- Typically uses some kernel function to weigh observations based on their distance from the location of interest.

Geographically weighted statistics

"Everything is related to everything else, but near things are more related than distant things."

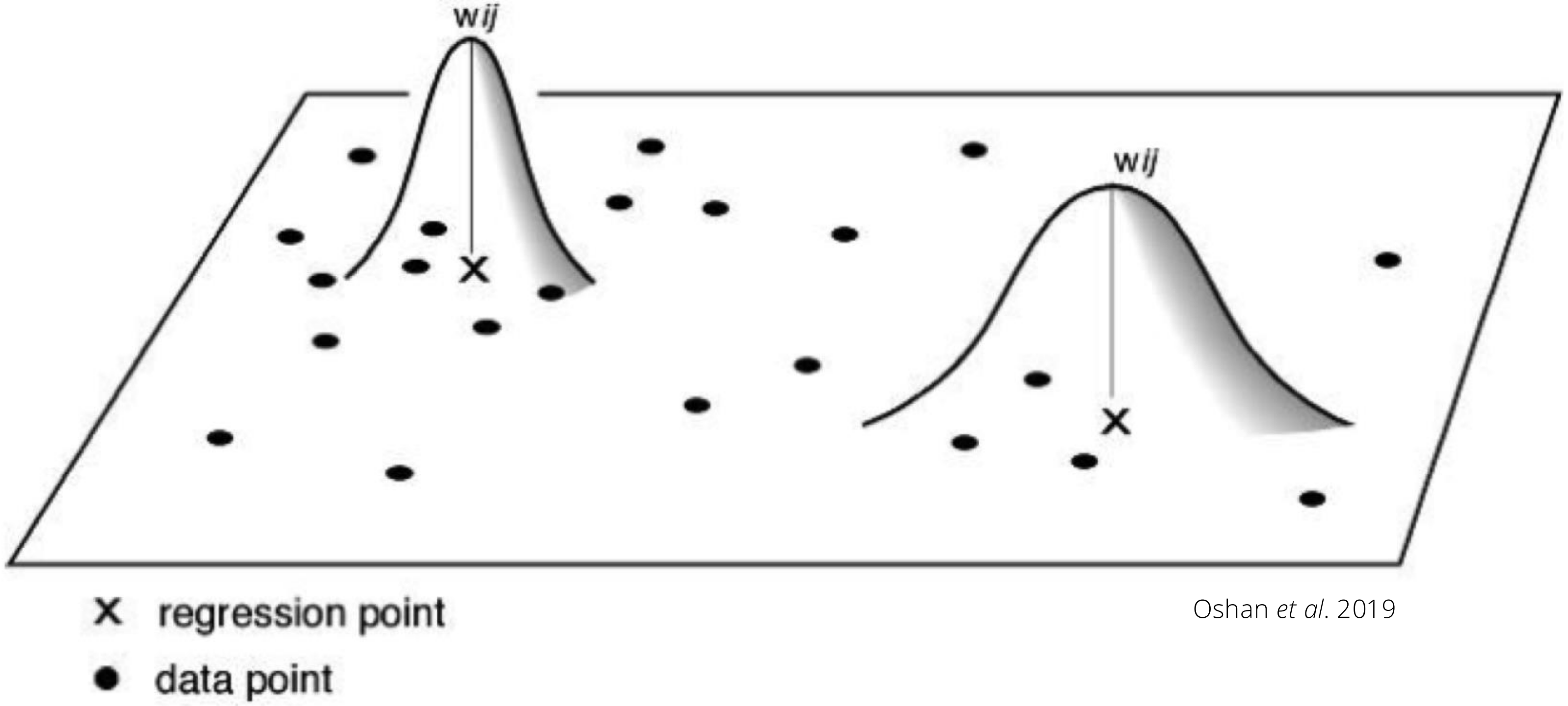
Walter Tobler 1970

Geographically weighted statistics



Oshan *et al*. 2019

Geographically weighted statistics



Oshan *et al*. 2019

Geographically weighted associations

- These ideas can be extended to correlation and regression:
  - Geographically weighted correlation (GWC)
  - Geographically weighted regression (GWR)
- The basic GWR equation is:

$$y_i = \beta_0(v_i, v_i) + \sum_{k=1}^{p} \beta_k(v_i, v_i) x_{ik} + \epsilon_i$$

where (v_i, v_i) are the coordinates of location i and $\beta k(v_i, v_i)$ are the location-specific coefficients.

Geographically weighted associations

- Each area has its own set of regression coefficients.
- Each location has its own R^2 value.
- Each area has its own standard errors for the coefficient.
- More recently: bandwidths can vary between different variables.

Questions

Justin van Dijk

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SA-TIED Geospatial Analysis Workshop

More spatial analysis

More spatial analysis

- File formats.
- Map projections.
- Digitisation and geocoding.
- Spatial operations.
- Accessibility analysis.
- Geodemographic classification.
- Raster data.

File formats: Geopackage

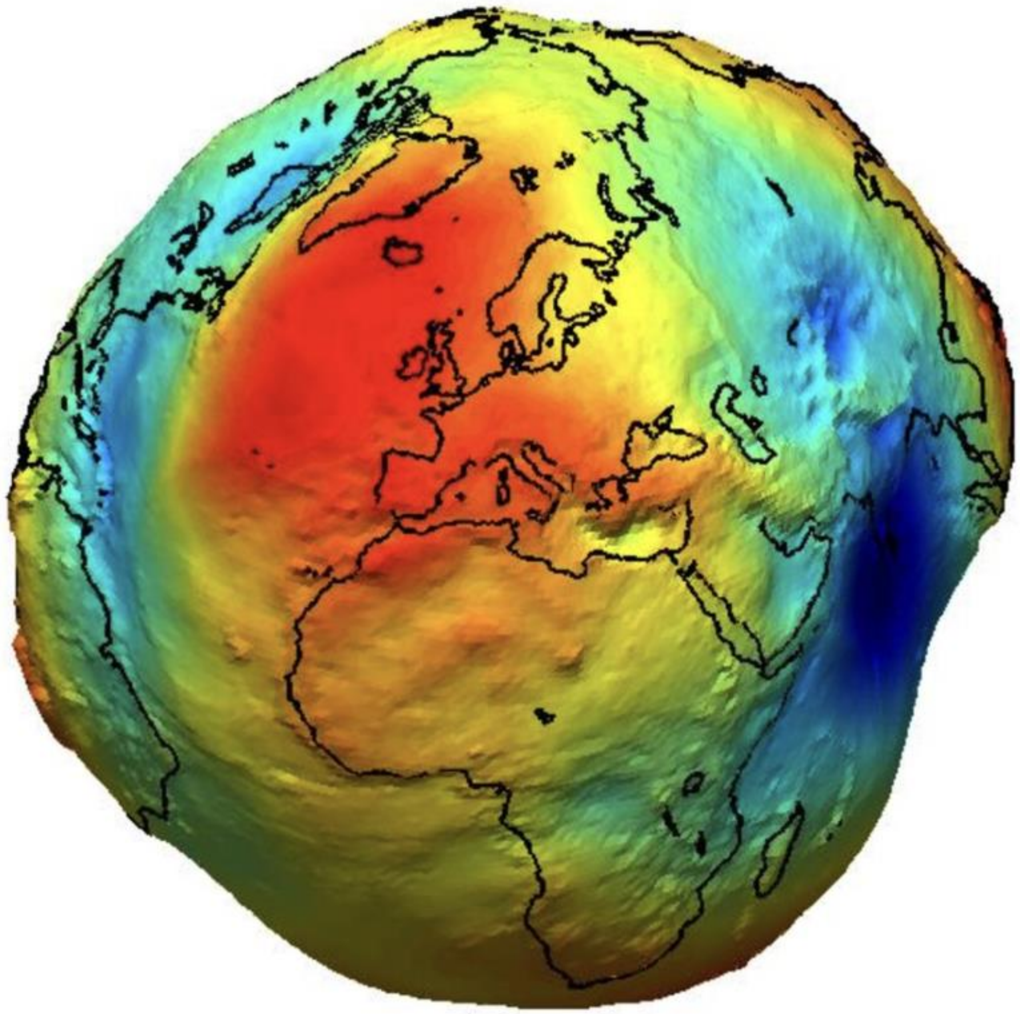
- A GeoPackage is an open, standards-based, platform-independent, portable, self-describing, compact format for transferring geospatial data.
- It stores spatial data layer as a single file, based upon an SQLite database.
- How to spot in the wild: .gpkg

File formats: Shapefile

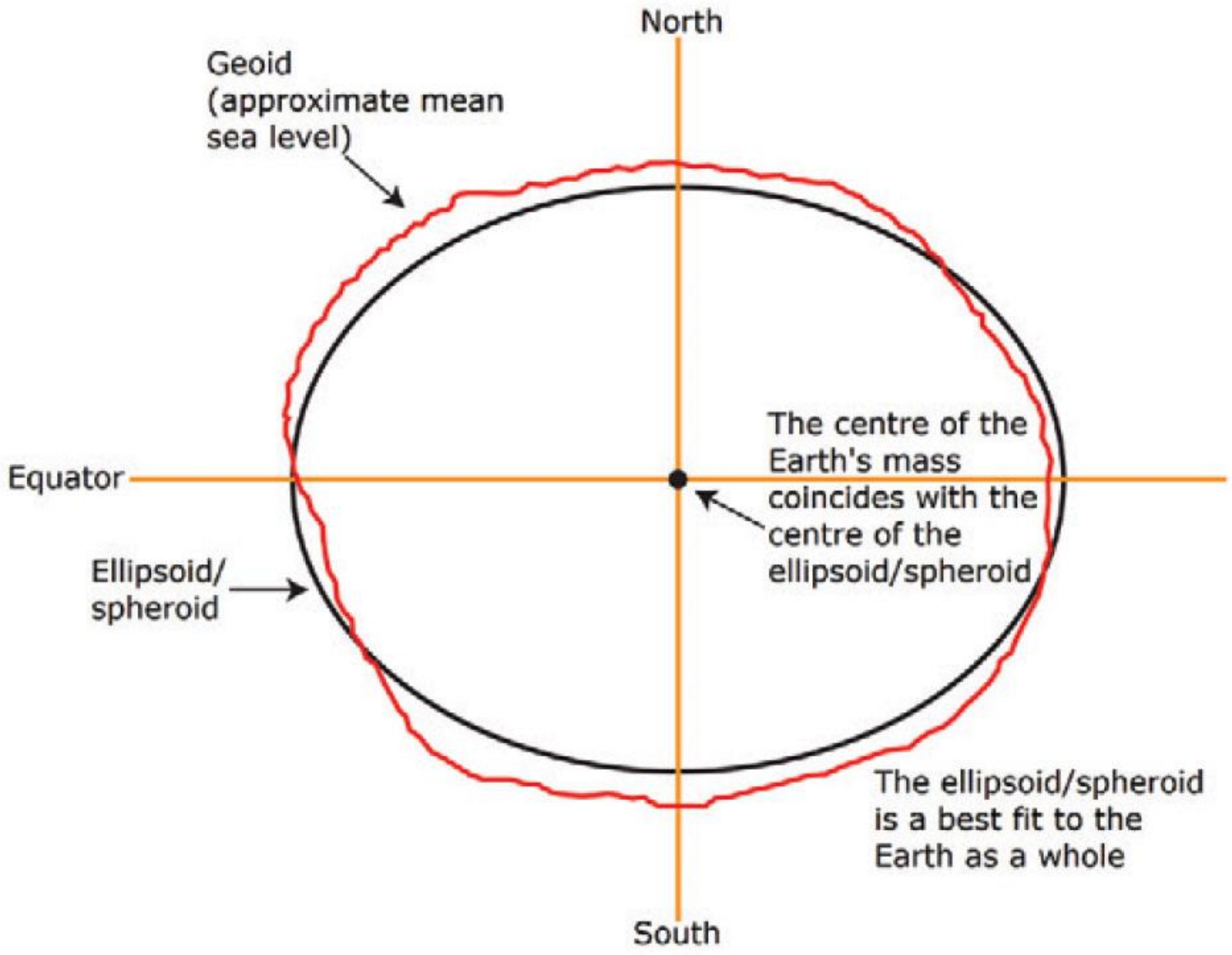
- `.shp` contains the feature geometry. *Mandatory.*
- `.shx` index file which stores the position of the feature's ID in the `.shp` file. *Mandatory.*
- `.dbf` stores alle attribute information associated with the records. *Mandatory.*
- `.prj` contains the coordinate system information and projection.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

File formats: Shapefile

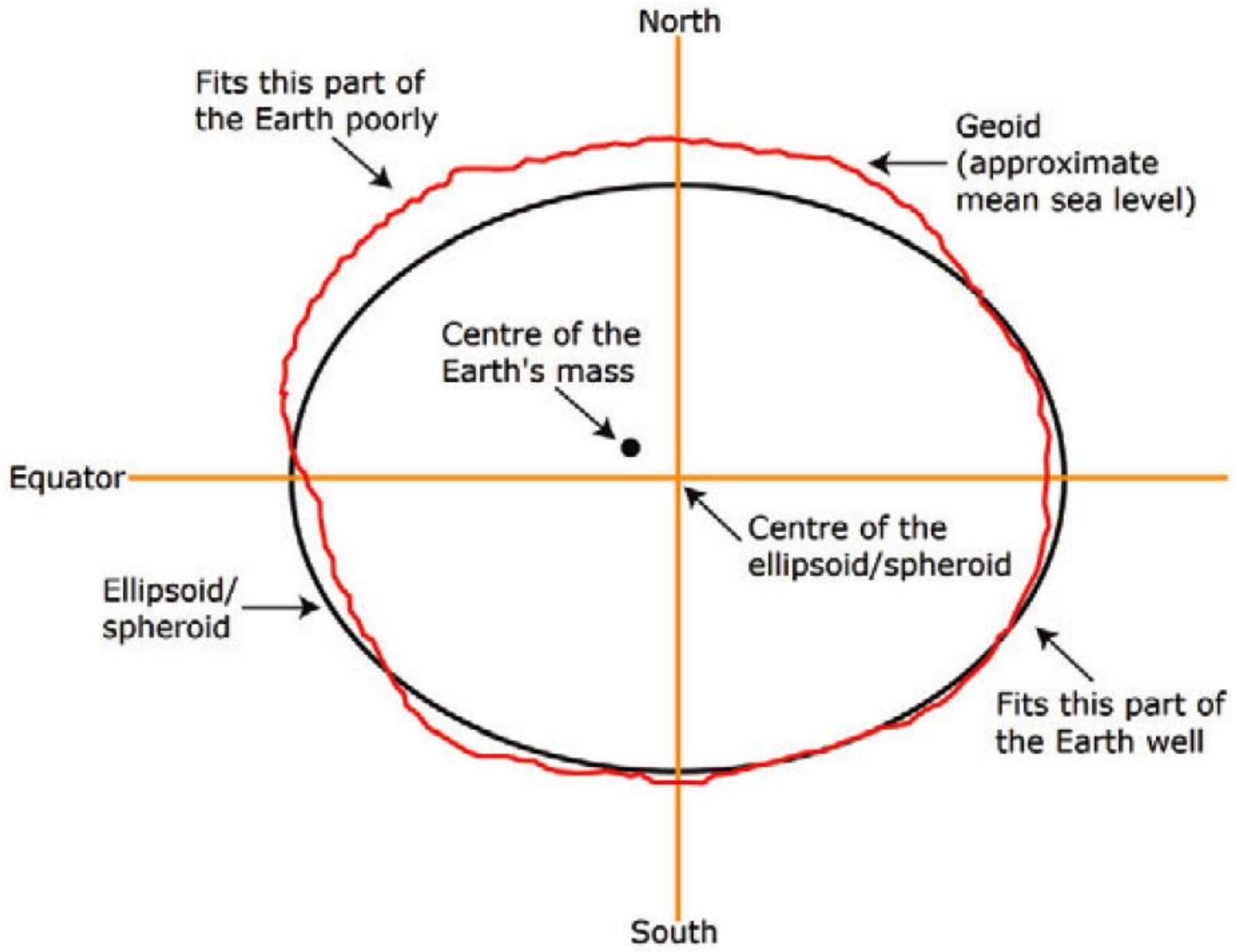
Map projections



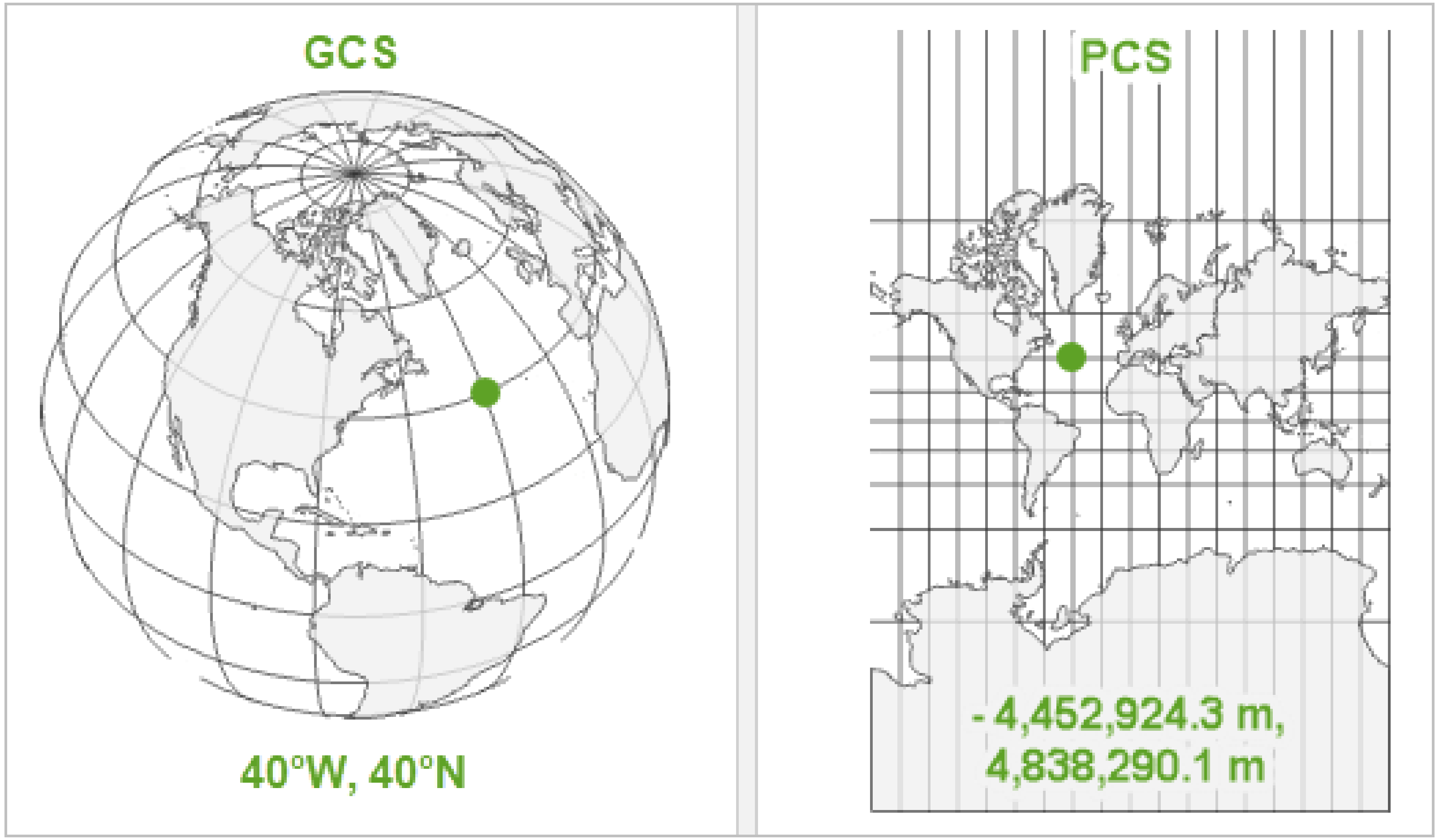
Map projections



Map projections



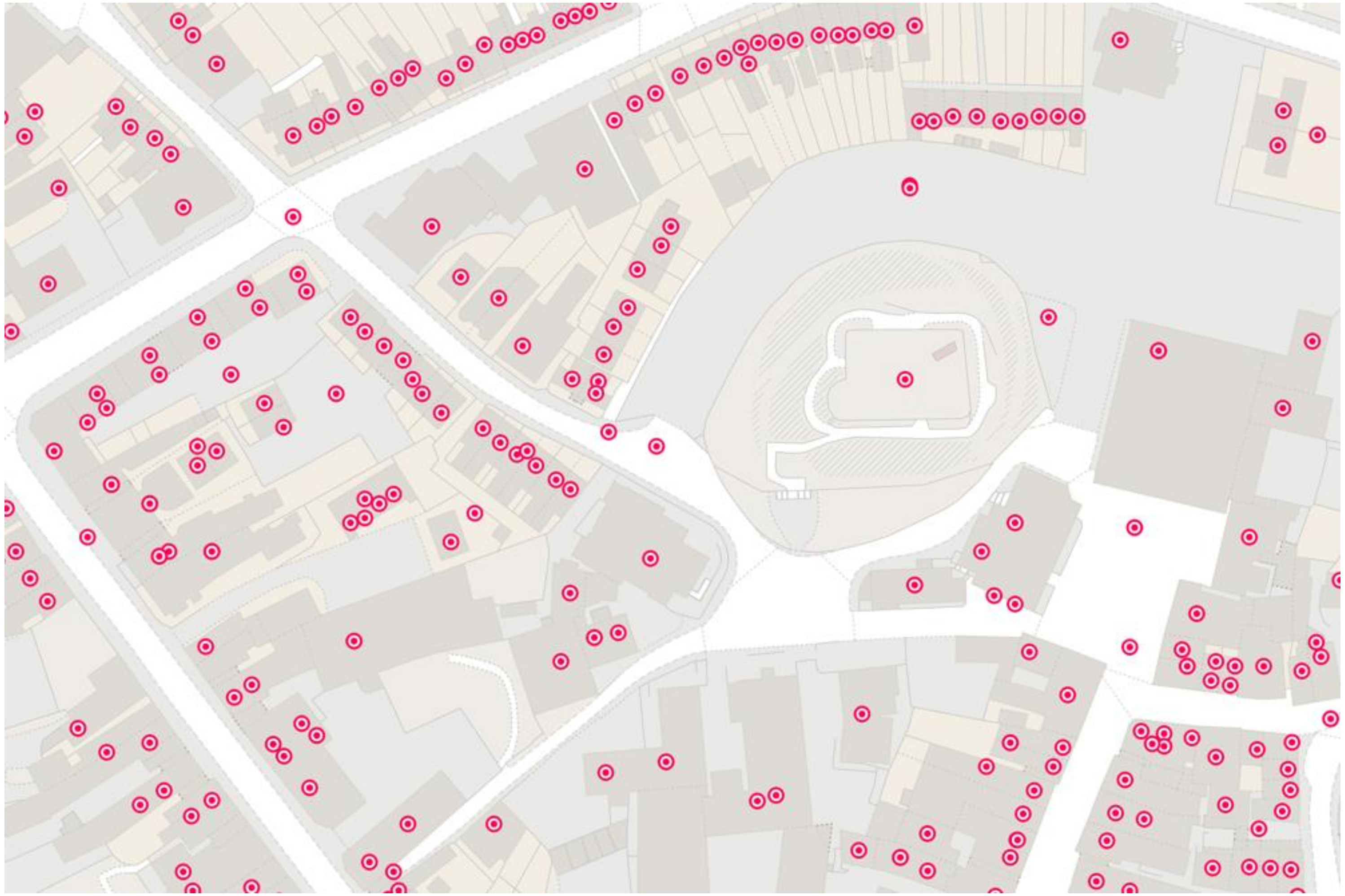
Map projections



Geocoding

Forename	**Surname**	**Address**
Justin	van Dijk	Flat 18 Terry House SW22NT London

Geocoding



Spatial operations

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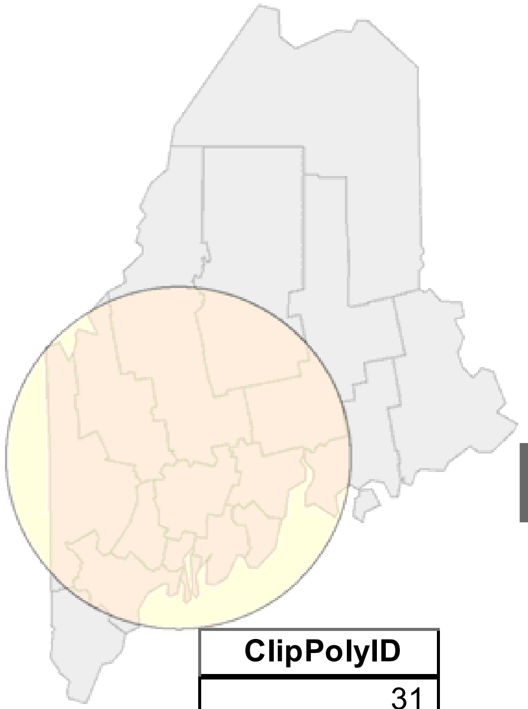
Oxford
Penobscot
Piscataquis
Sagadahoc
Somerset
Waldo
Washington
York



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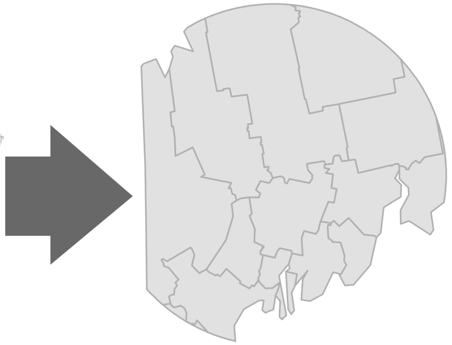

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Gimdond, M. 2021. Intro to GIS and Spatial Analysis. [online]
https://mgimond.github.io/Spatial/introGIS.html

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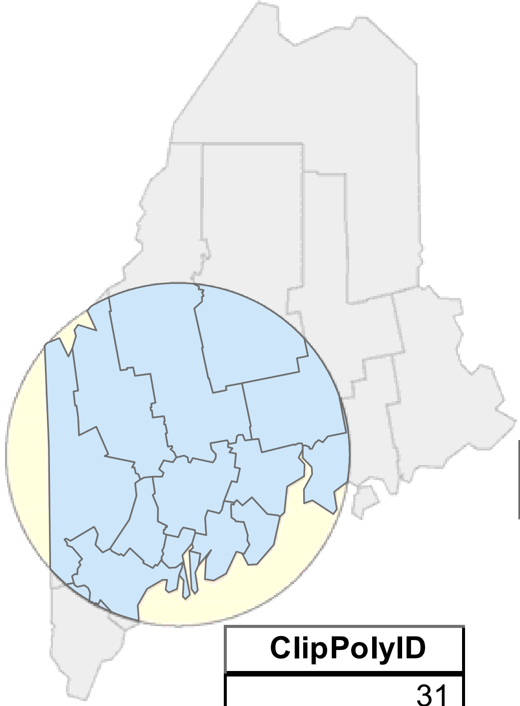

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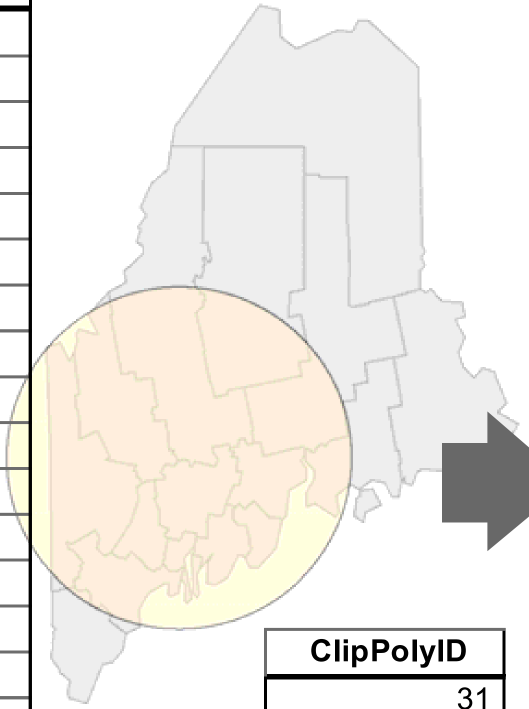

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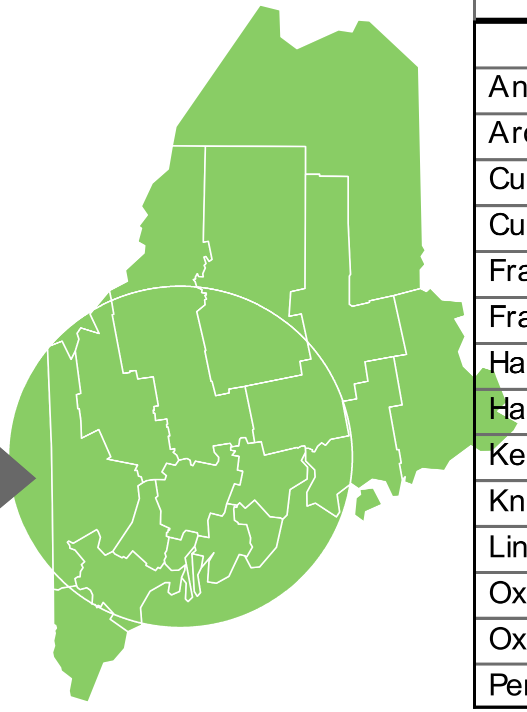

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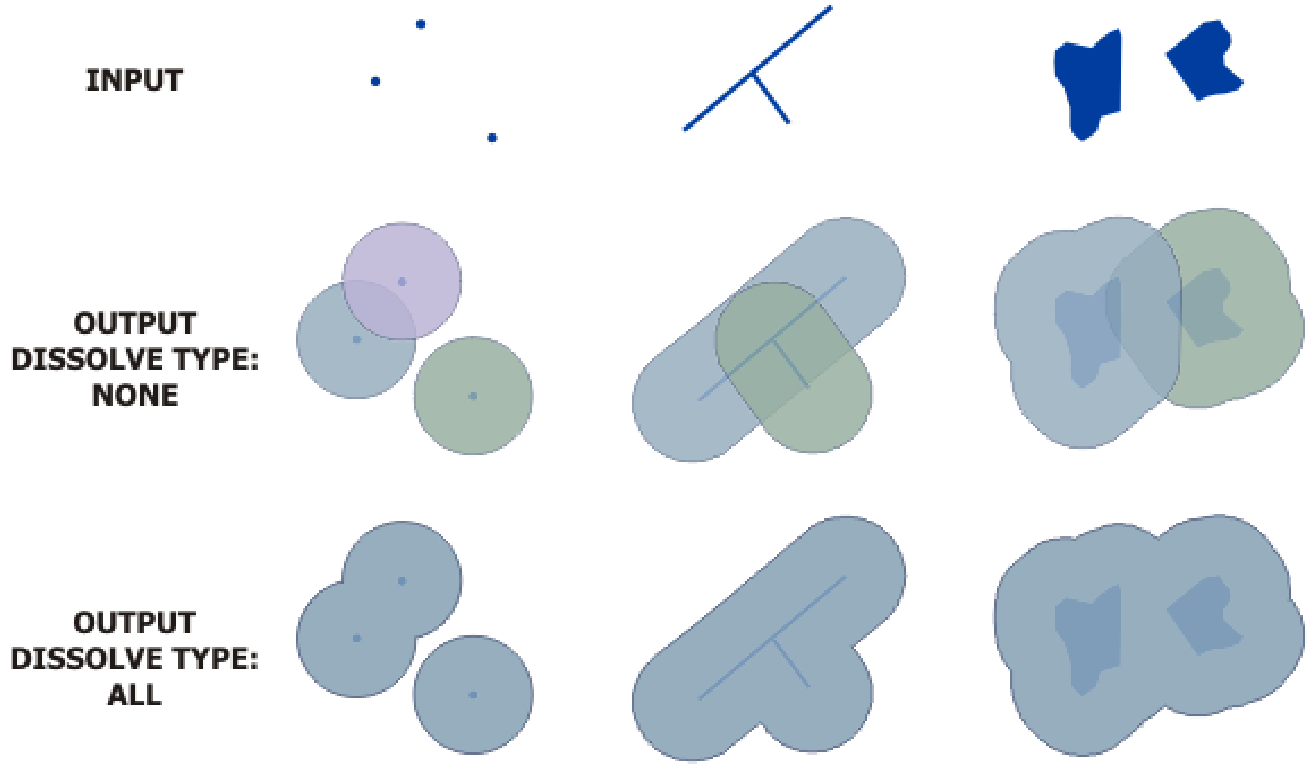
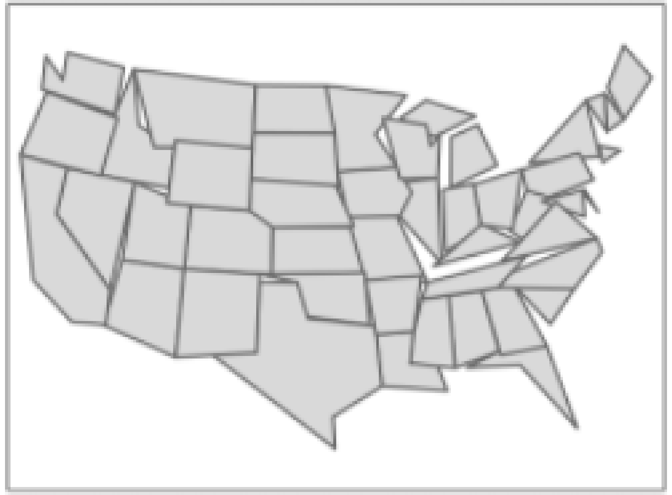
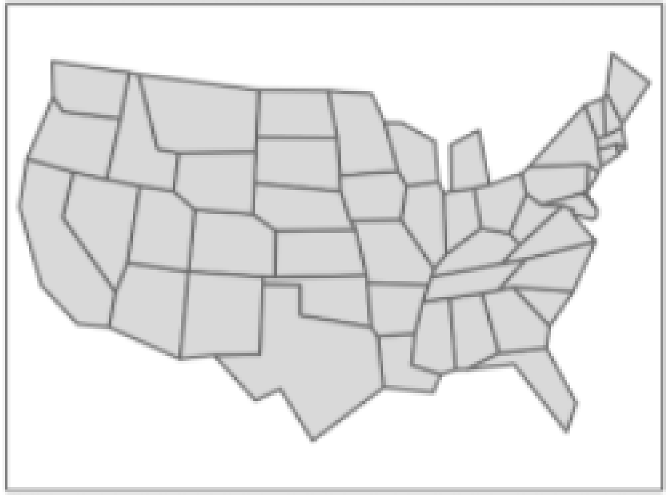
Spatial operations



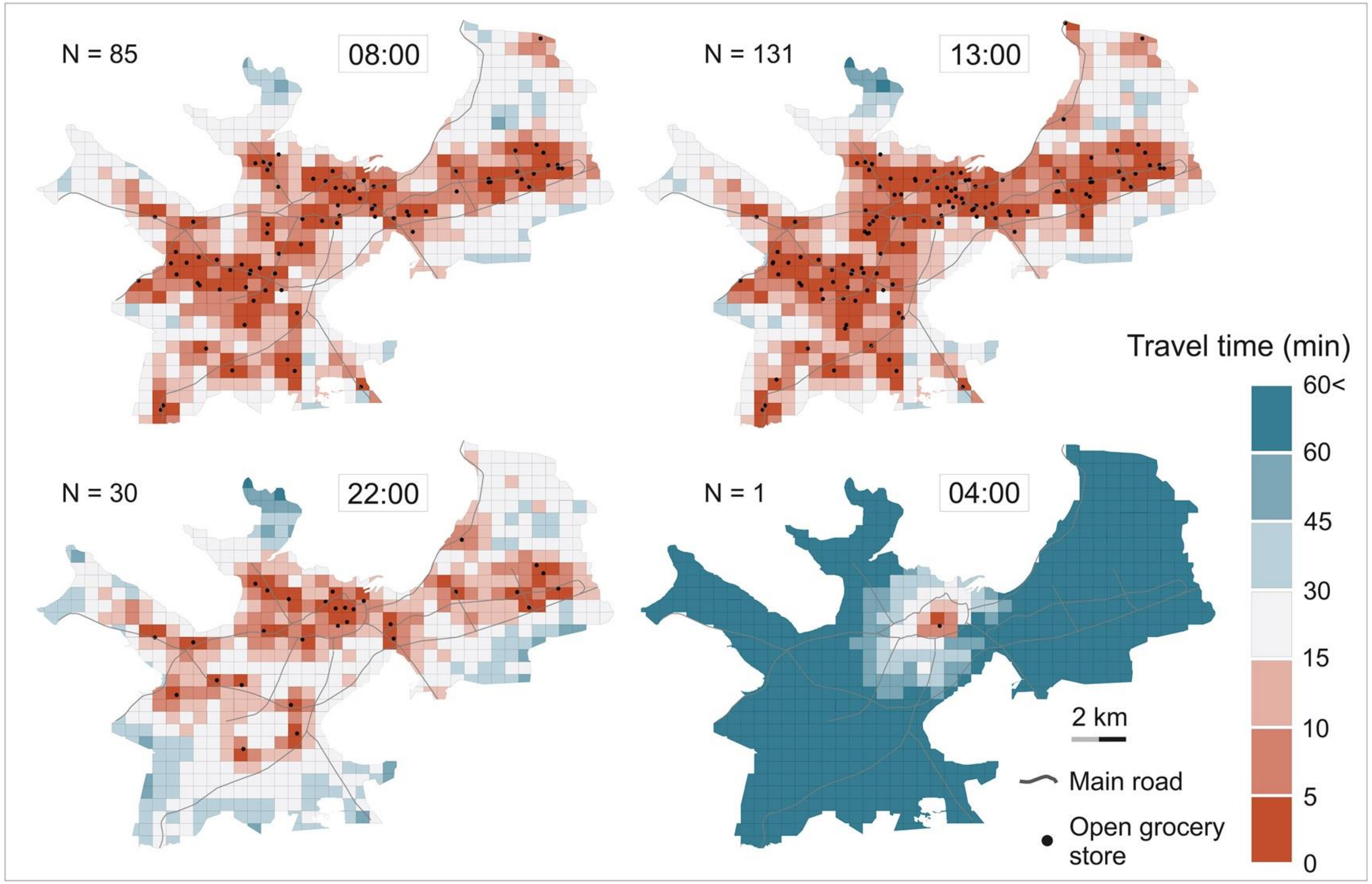
ESRI. 2021. Buffer. [online]
https://pro.arcgis.com/en/pro-app/latest/tool-reference/analysis/buffer.htm

Spatial operations





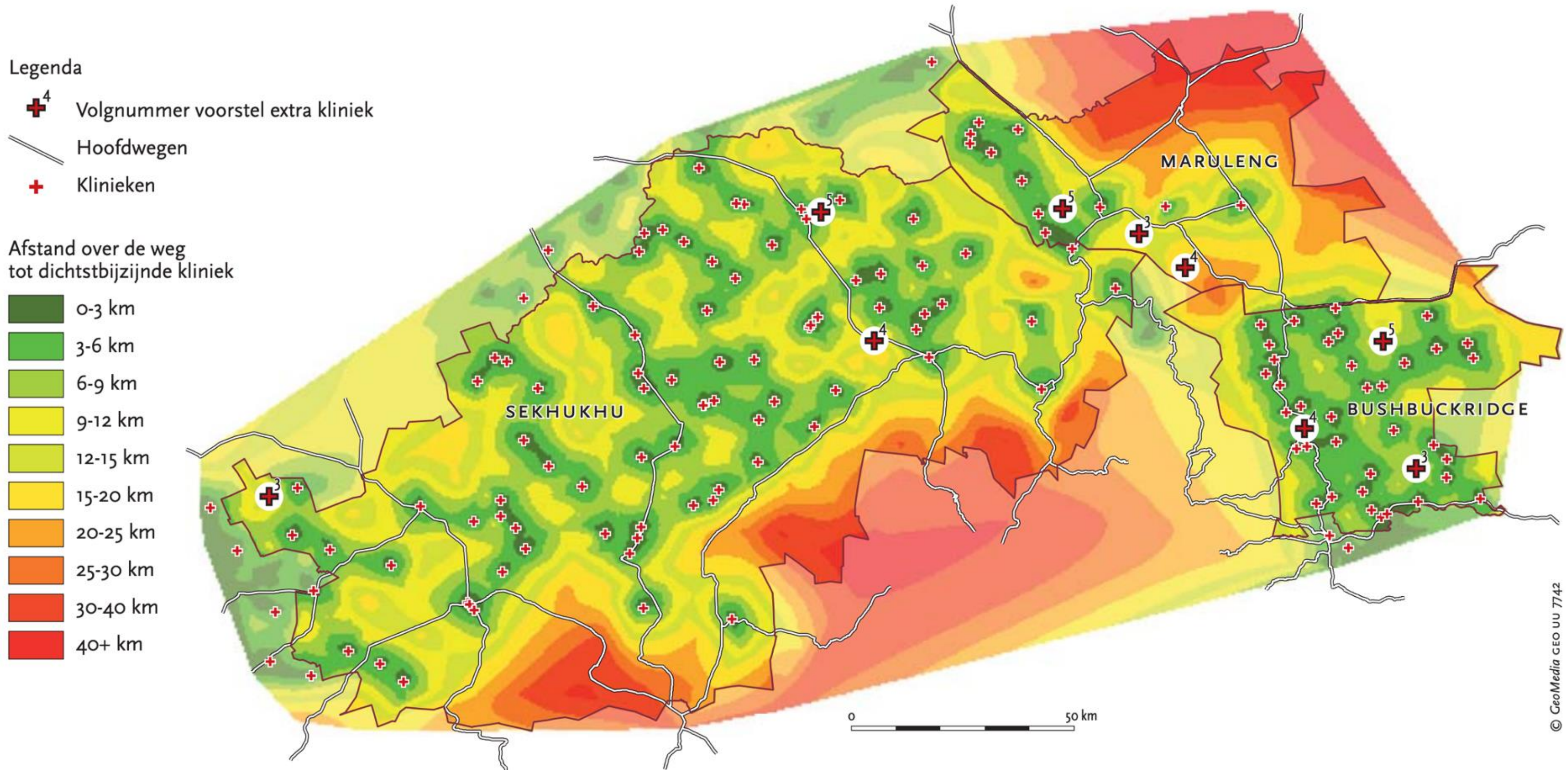
Accessibility analysis



Järv *et al.* 2018

Accessibility analysis

Accessibility analysis



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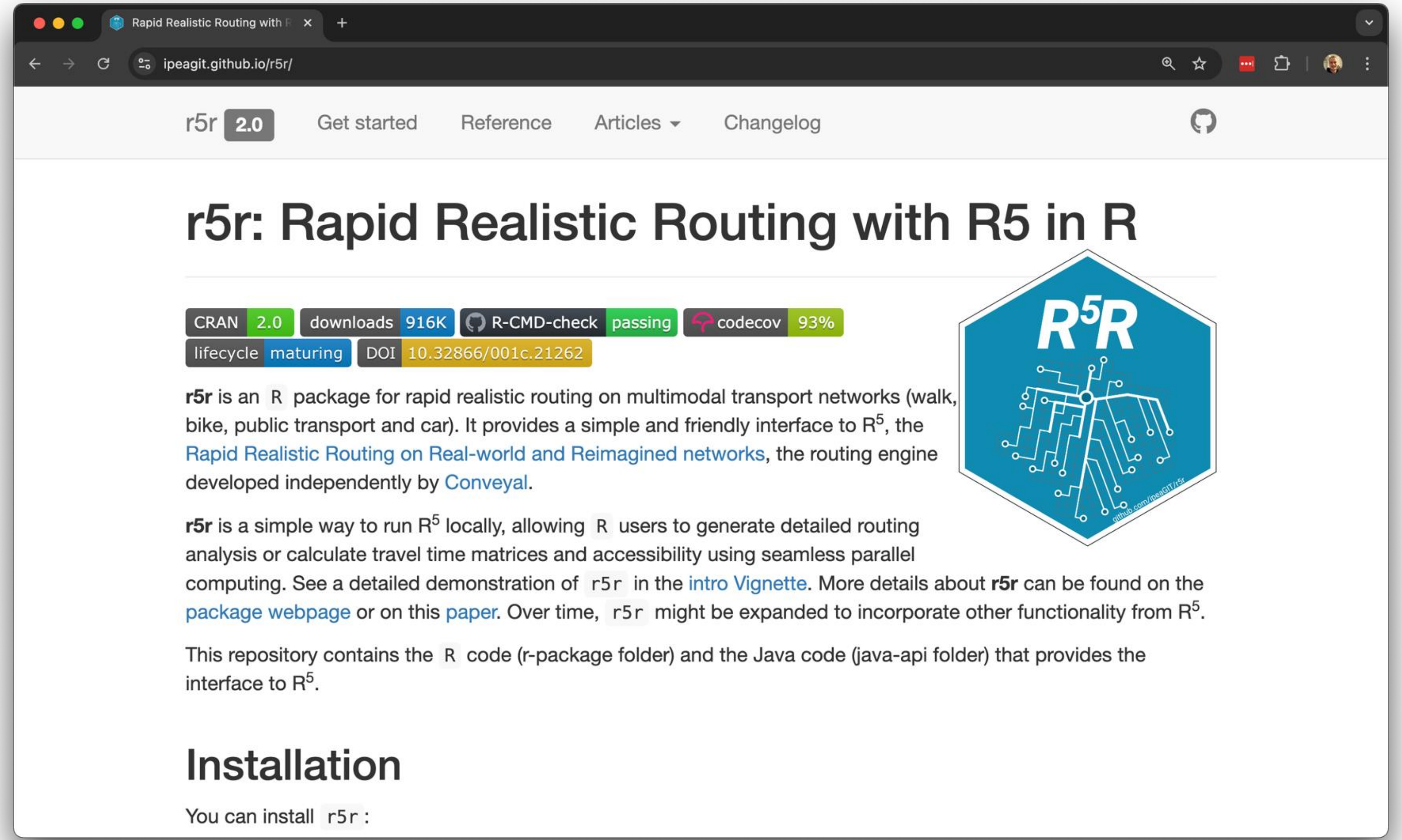
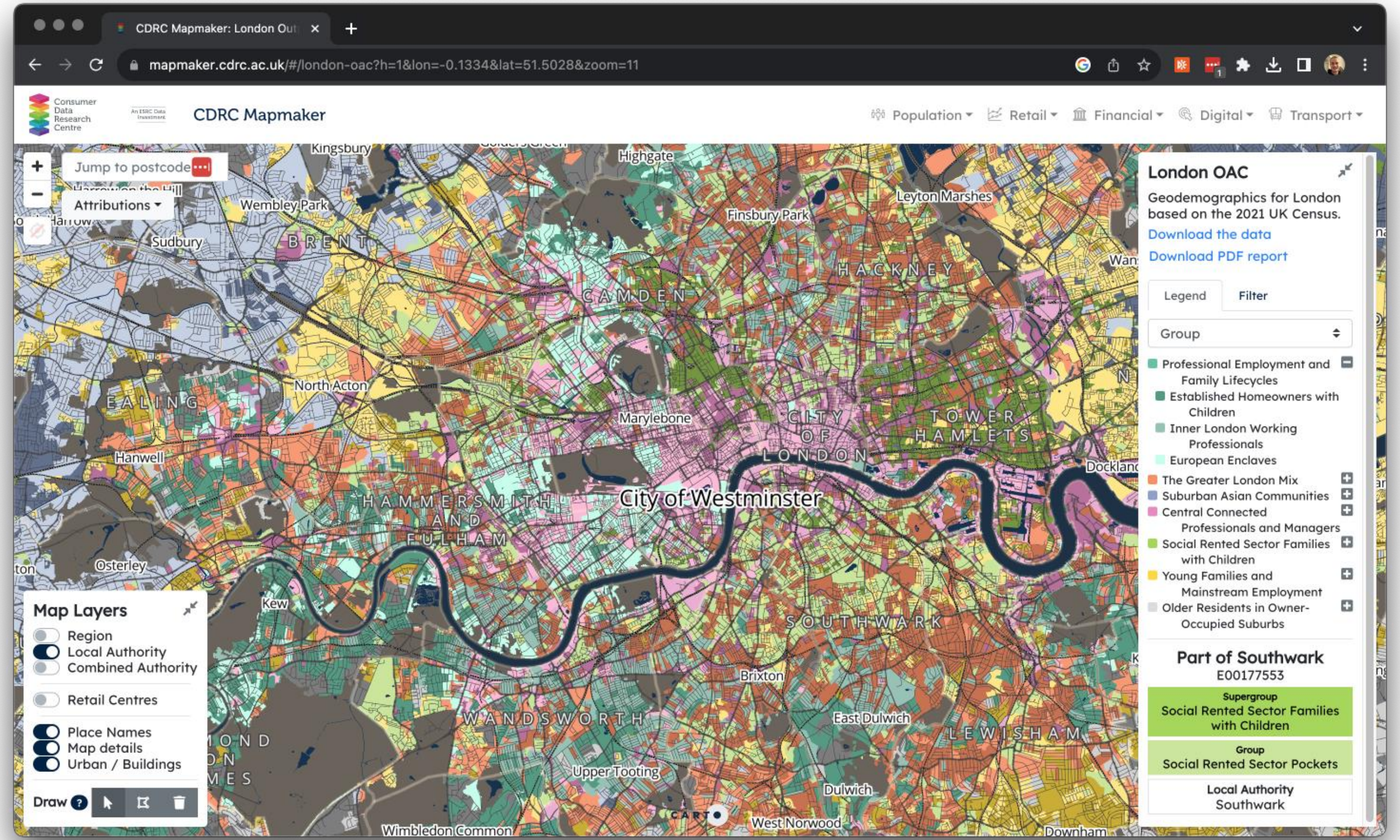
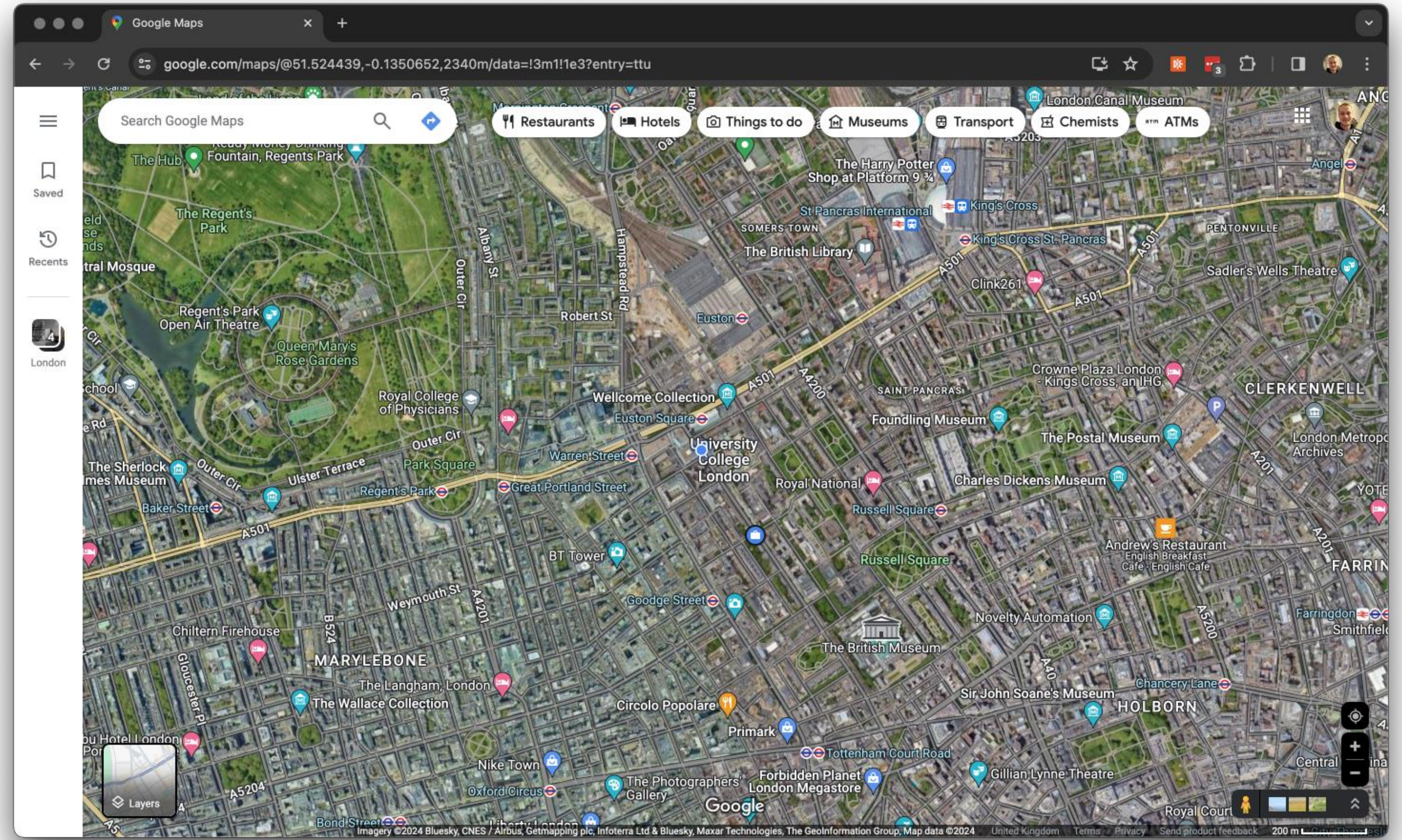


Geodemographic classification



2021 London Output Area Classification on mapmapker.cdrc.ac.uk

GIScience



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The Regent's Park
Regent's Park Open Air Theatre
Queen Mary's Rose Gardens
Royal College of Physicians
The Sherlock Holmes Museum
Baker Street
Regent's Park
Great Portland Street
Warren Street
Euston Square
Wellcome Collection
Euston
The British Library
St Pancras International
King's Cross
King's Cross St. Pancras
The Harry Potter Shop at Platform 9 ¾
London Canal Museum
SOMERS TOWN
PENTONVILLE
Angel
Sadler's Wells Theatre
Clink261
SAINT PANCRAS
Crowne Plaza London - Kings Cross, an IHG
CLERKENWELL
Foundling Museum
The Postal Museum
London Metropolitan Archives
University College London
Royal National
Charles Dickens Museum
Russell Square
BT Tower
Goodge Street
Andrew's Restaurant
Novelty Automation
The British Museum
MARYLEBONE
Chiltern Firehouse
The Langham, London
The Wallace Collection
Circolo Popolare
Primark
Tottenham Court Road
Sir John Soane's Museum
Chancery Lane
HOLBORN
Nike Town
Oxford Circus
The Photographers' Gallery
Forbidden Planet London Megastore
Gillian Lynne Theatre
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Royal Court
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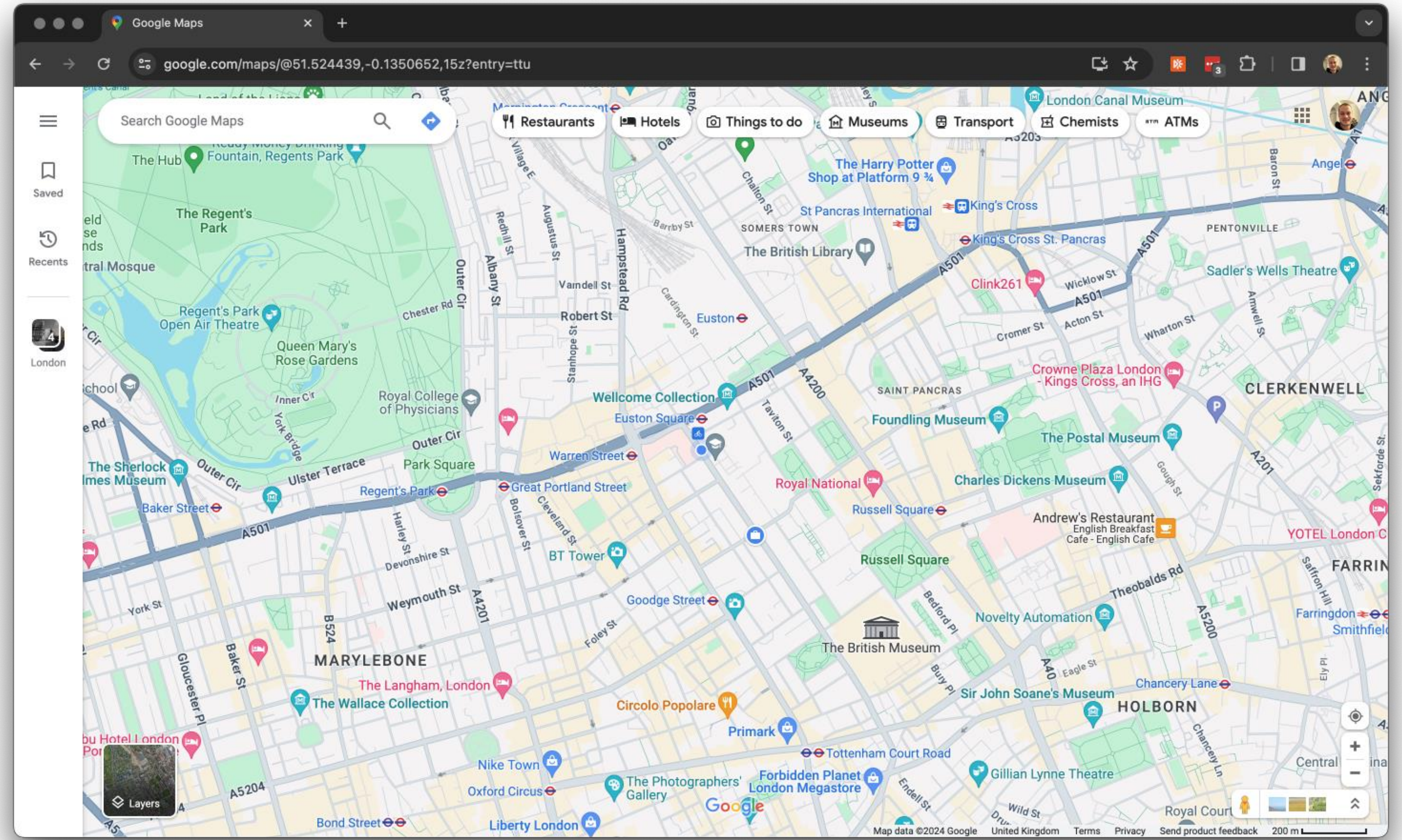
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GIScience

- GIScience relies on representing spatial information in a digital format. Traditionally, geographic information is conveyed in two primary ways:.
  Vector This method uses a finite set of discrete geometric objects, such as points, lines, and polygons, to represent spatial features.
  Raster This approach employs images or grids to represent surfaces, with each cell or pixel holding a value, often indicating attributes like colors or measurements.

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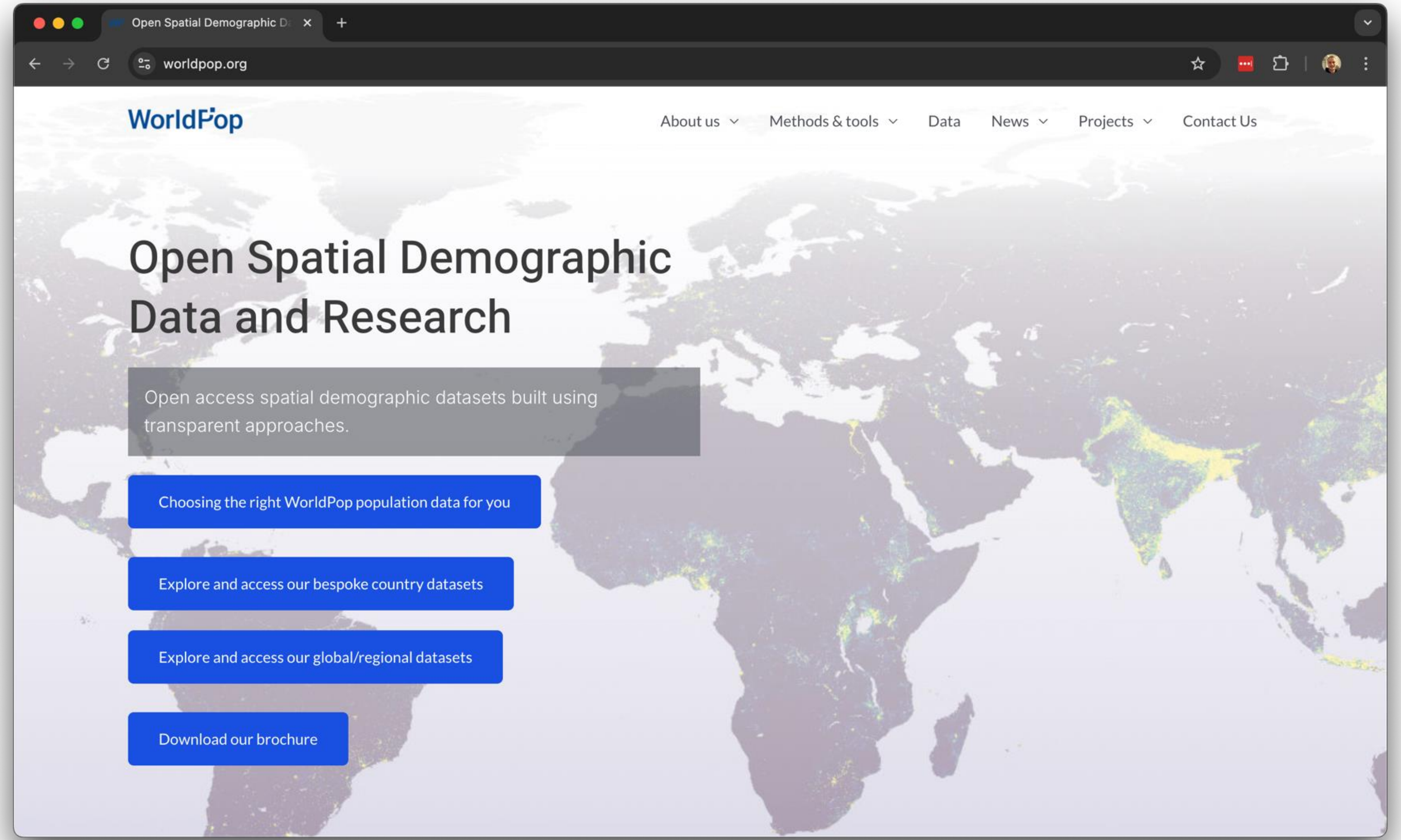
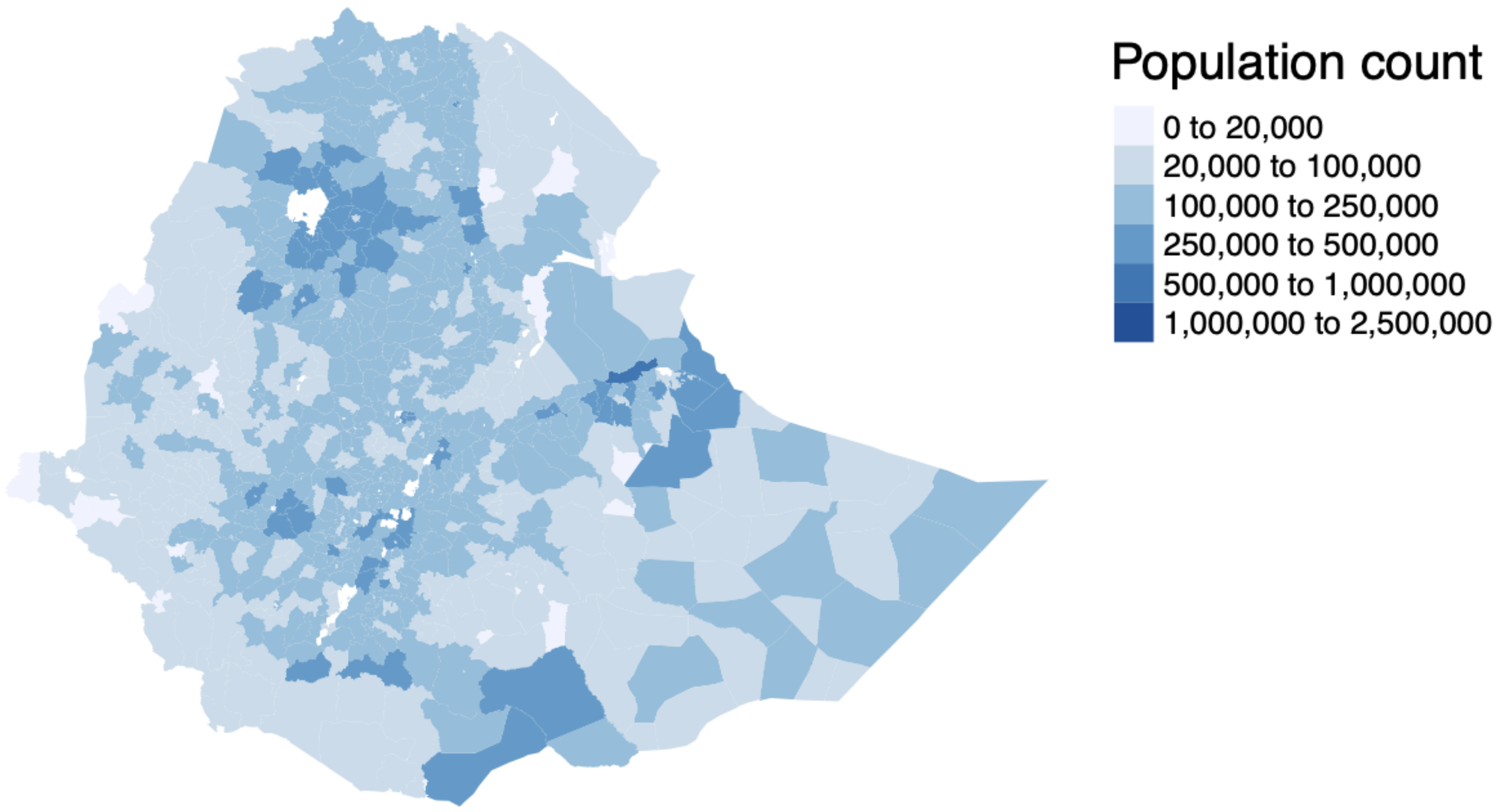
Dasymetric mapping



Raster data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100,000 to 250,000
250,000 to 500,000
500,000 to 1,000,000
1,000,000 to 2,500,000

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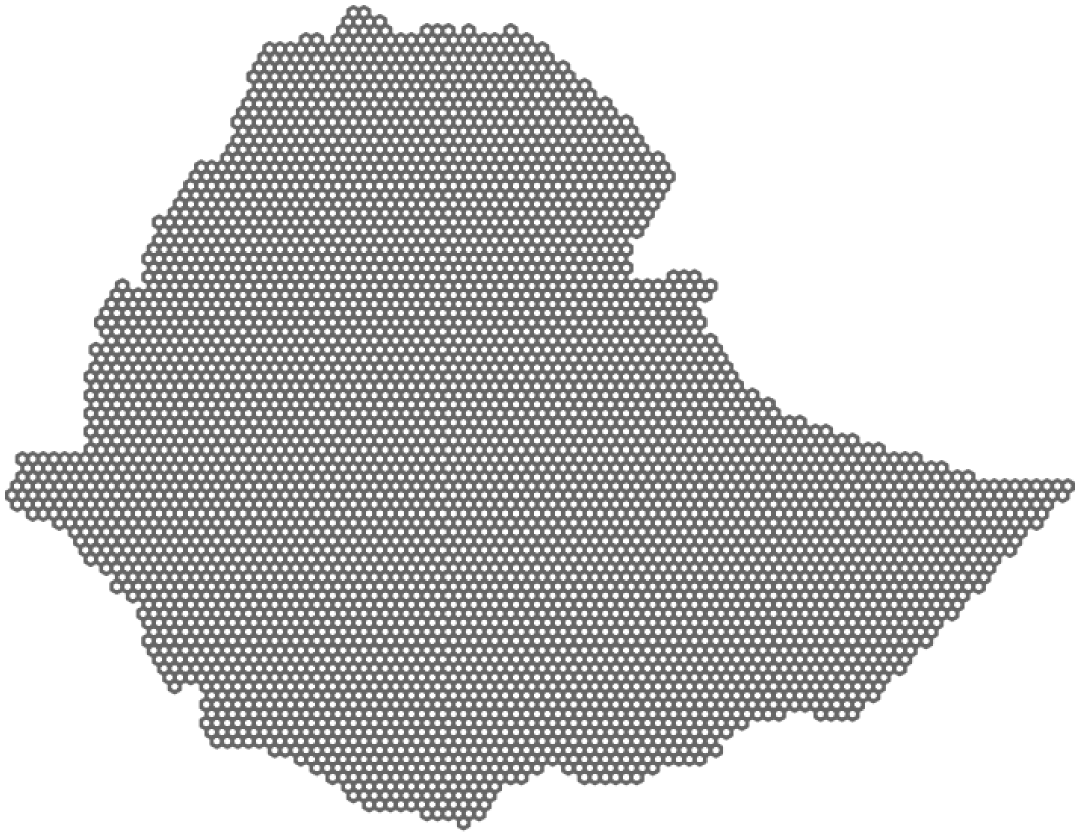

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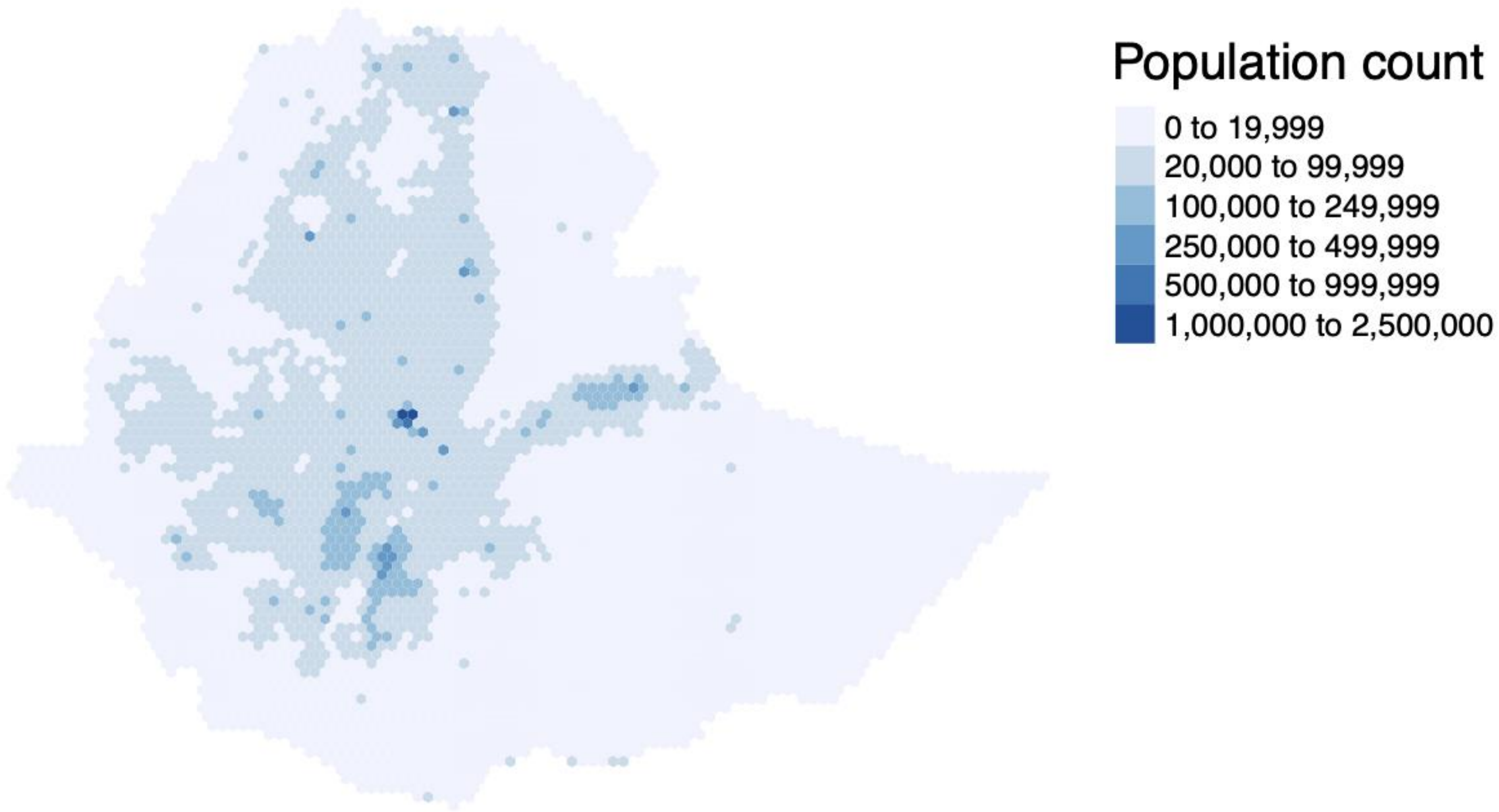
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20,000 to 99,999
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500,000 to 999,999
1,000,000 to 2,500,000

Questions

Justin van Dijk

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