

# Geocomputation

## Raster Data Analysis



# Module outline

- W1 Reproducible Spatial Analysis
- W2 Spatial Queries and Geometric Operations
- W3 Point Data 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

- Raster GIS data model.
- Raster-specific functions and operations.
- Spatial data interpolation.

# Before we start

- Go to [www.menti.com](https://www.menti.com)
- Use code: XXXX XXXX











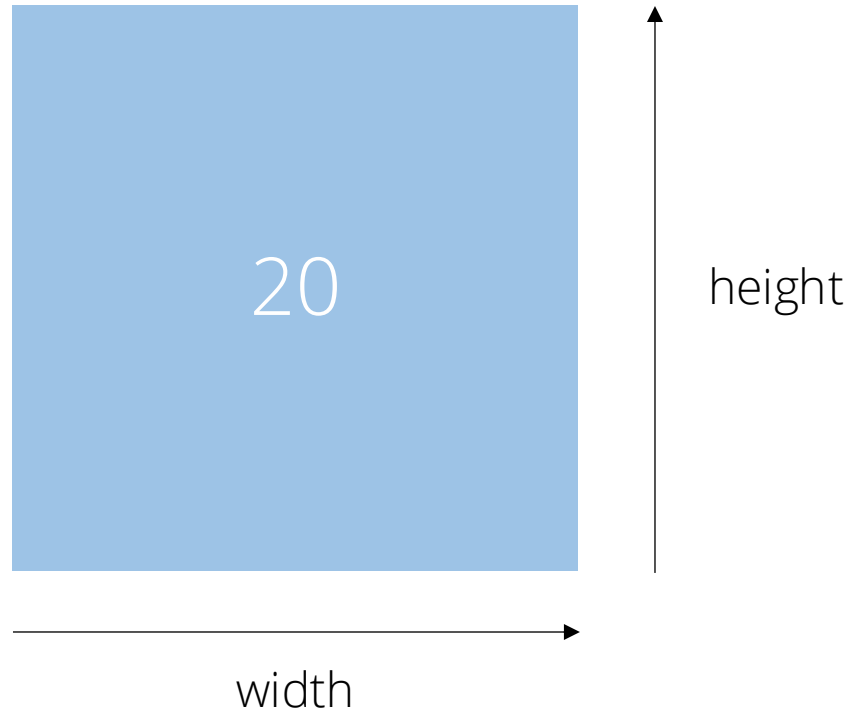


# Raster data

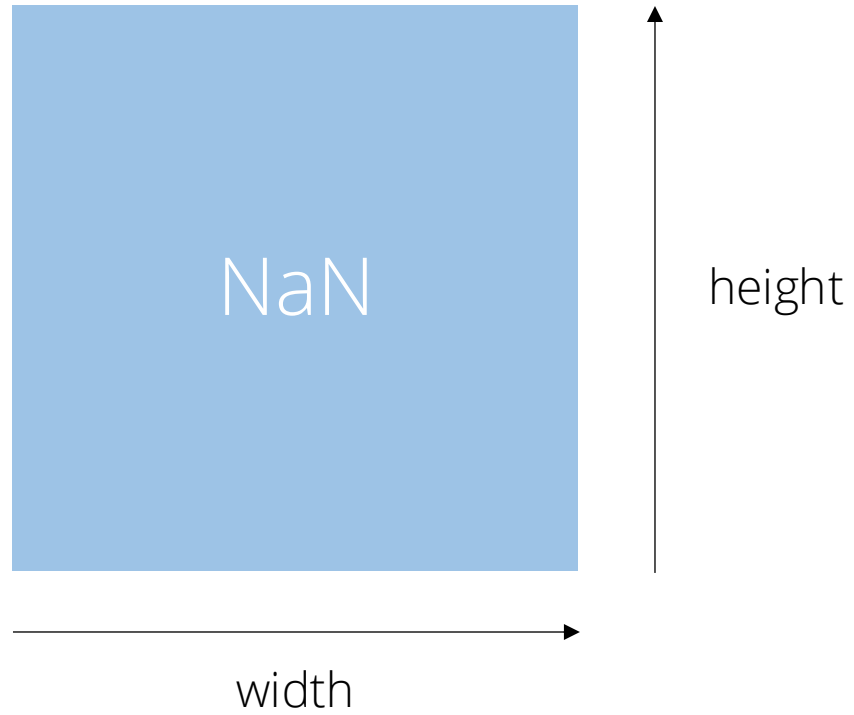
- Unlike vector data, raster data represents features as continuous surfaces, showing gradients of change rather than discrete measurements.
- Raster data is organised as a matrix of pixels or grid cells, each containing a numeric or textual value representing a feature.
- It consists of rows and columns, with each pixel or grid cell defined by its resolution (height and width).



# Raster data



# Raster data





# Vector versus raster

- Why not vectorise everything? After all, we can add as many attributes as needed?
- "Raster is faster, but vector is corrector" highlights the trade-offs between these data models.
- The choice between raster and vector data depends on your specific application and the type of analysis you intend to perform.

# Raster data

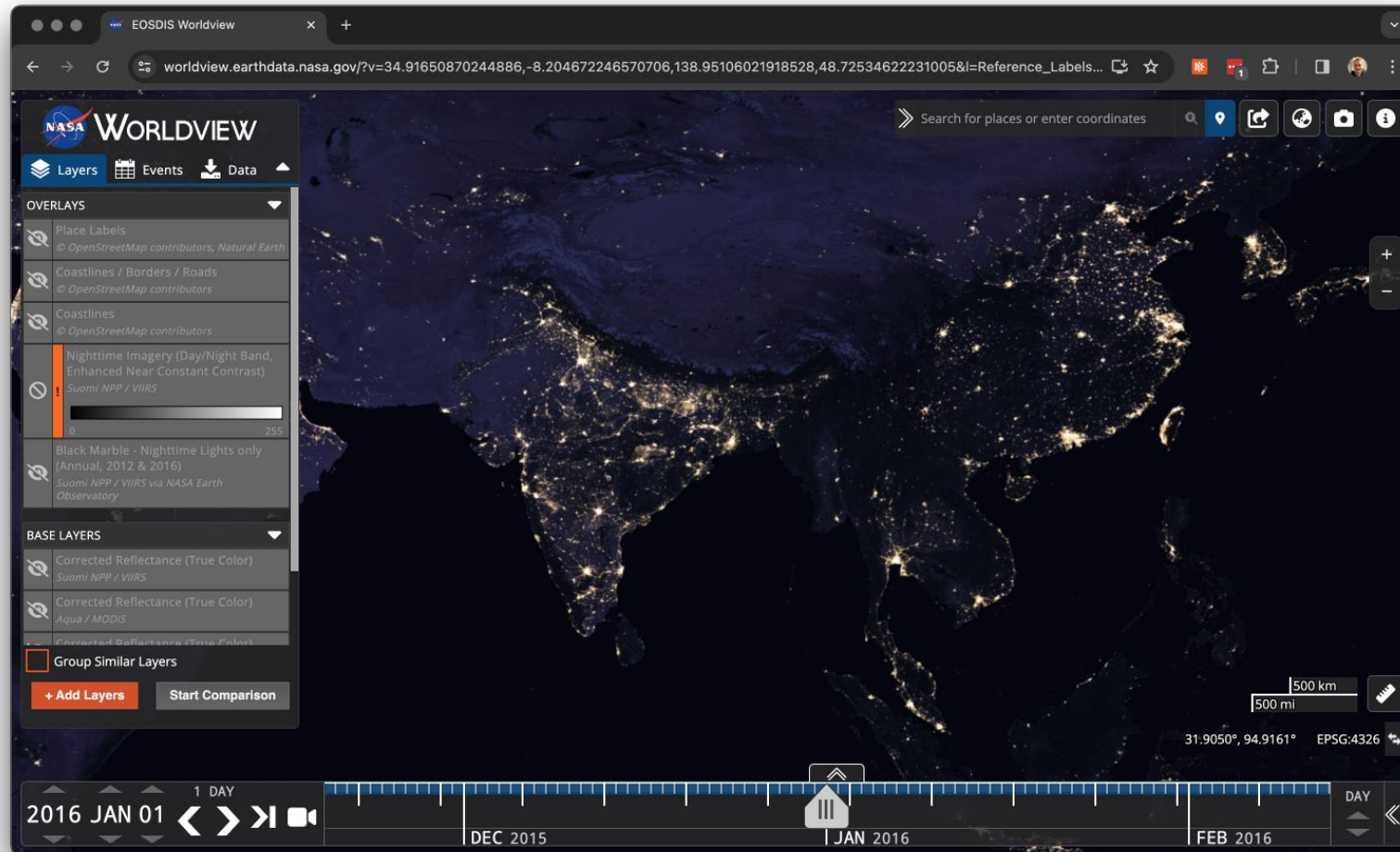
- Raster data are commonly found in applications where every location has one value.
- Variable can be continuous (temperature, elevation, air pollution), categorical (land use), or imagery (reflectance values).
- Cell size is constant across the raster surface.
- When do we encounter raster data:
  - Remote sensing
  - Outcome of spatial analysis



# Raster versus vector

	Advantages	Disadvantages
Raster	Map Algebra with raster data is usually quick and easy to perform	Linear features and paths are difficult to display
	Some specific use cases can only be achieved with raster data (e.g. modeling water flow over the land surface)	Subject to a pixelated look and feel  Datasets can become very large because they record values for each cell
Vector	Graphical output is generally more aesthetically-pleasing	Continuous data is poorly stored and displayed
	Higher geographic accuracy because data isn't dependent on grid size	Needs a lot of work and maintenance to ensure that it is accurate and reliable

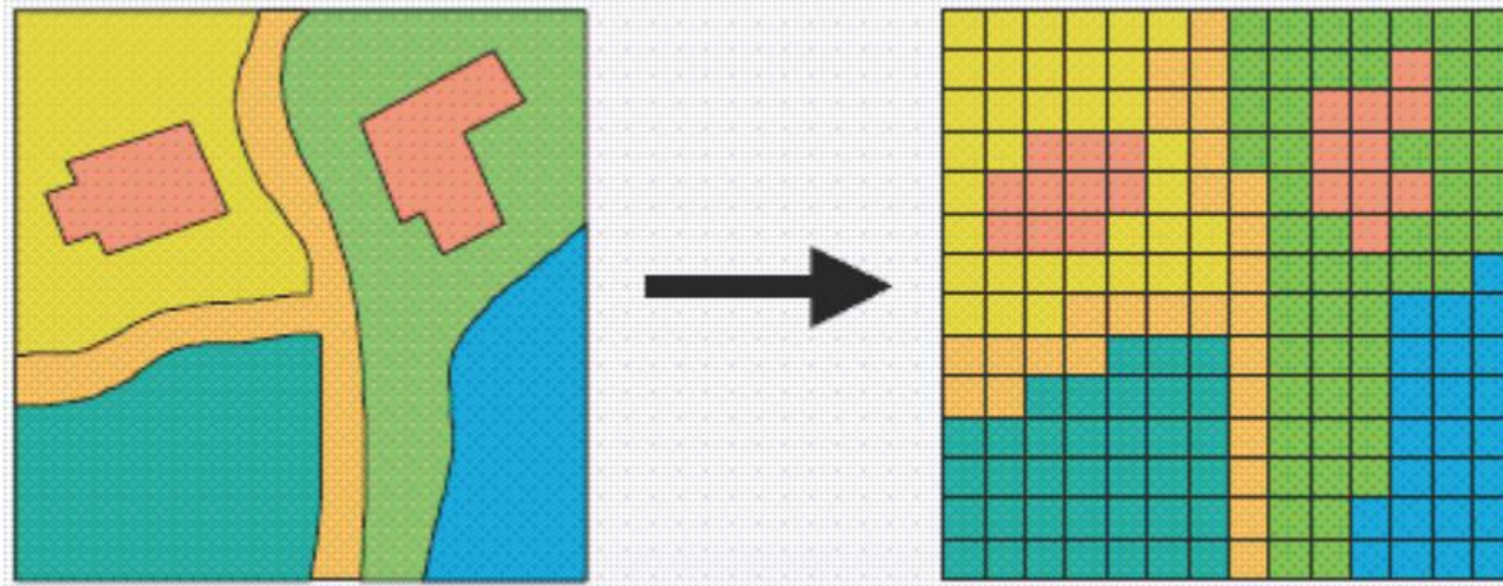
# Raster data



Continuous (numerical value of data)

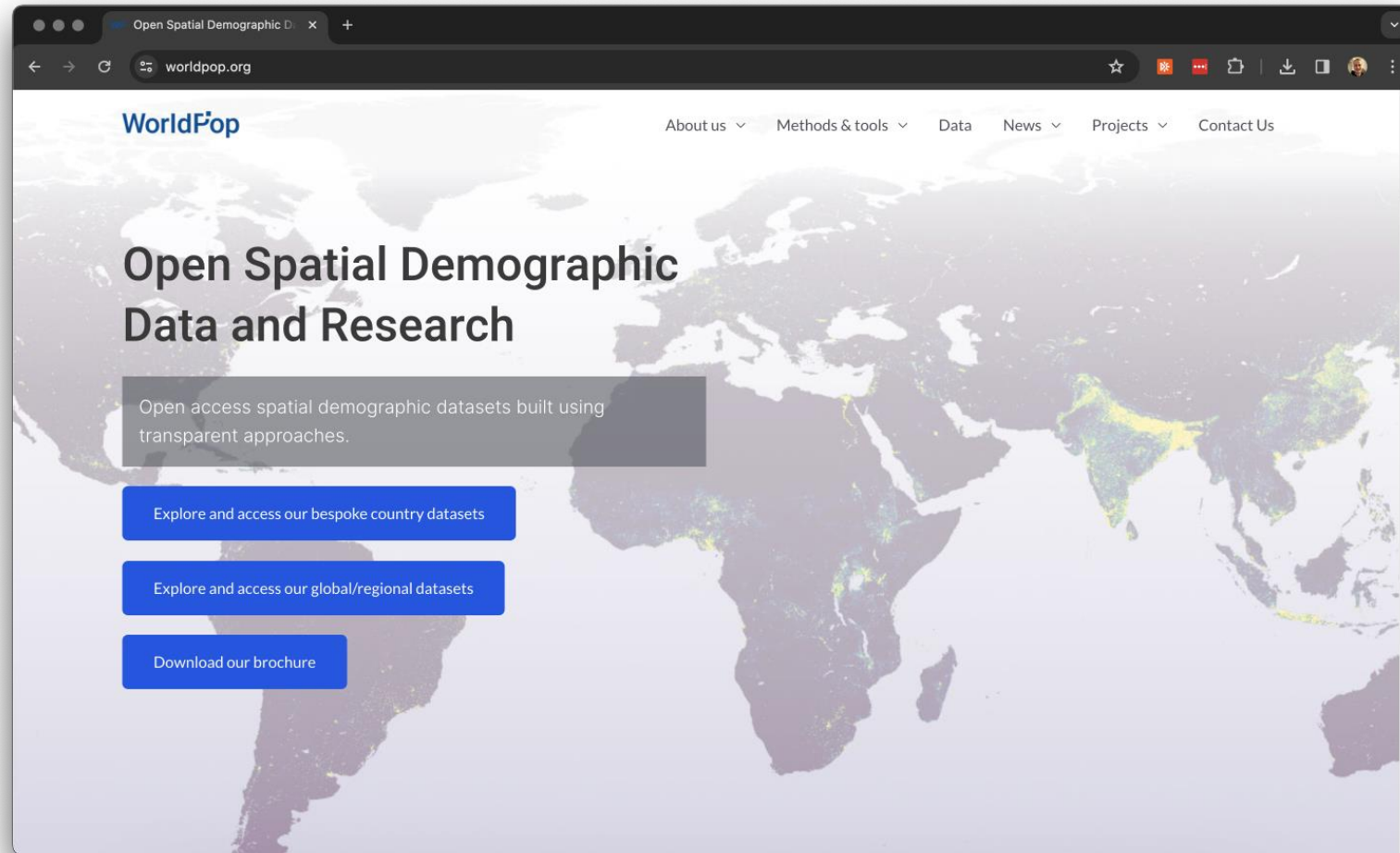


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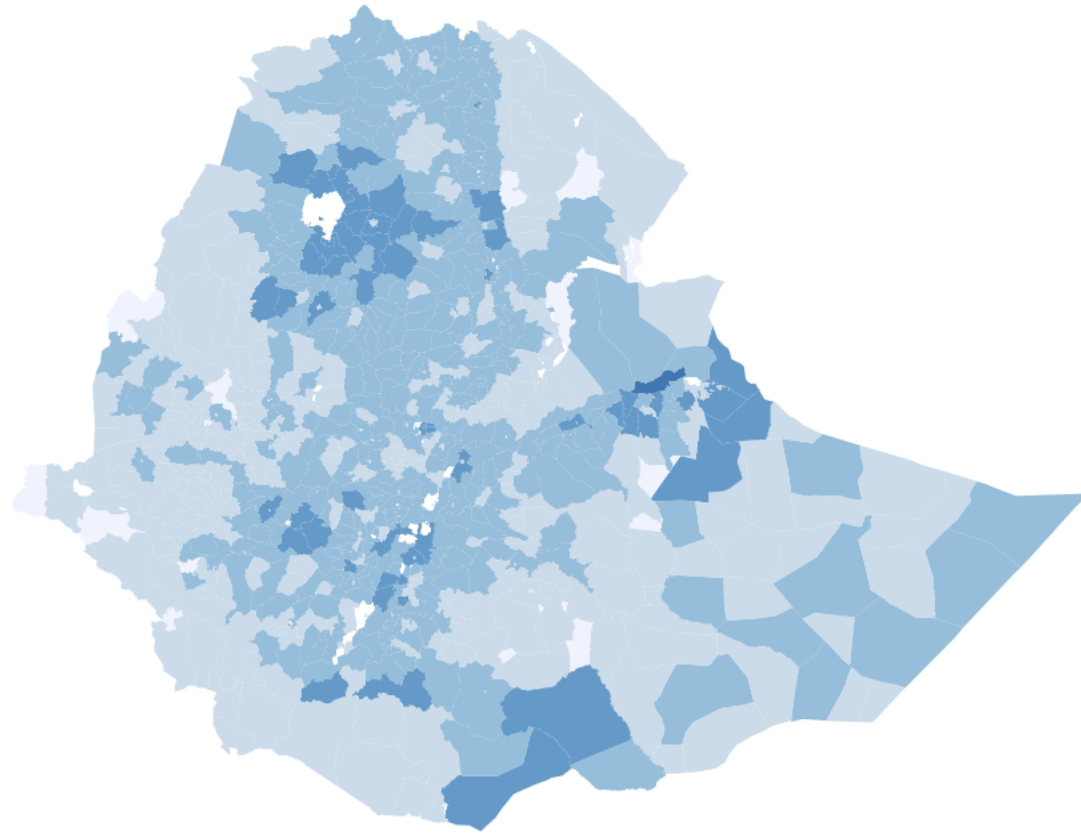


Categorical (number represent category)

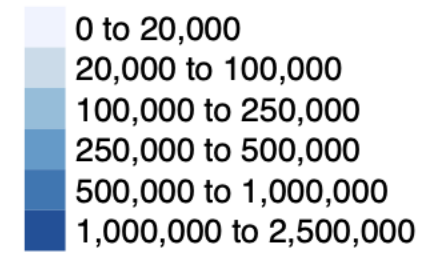
# Raster data



# Raster data

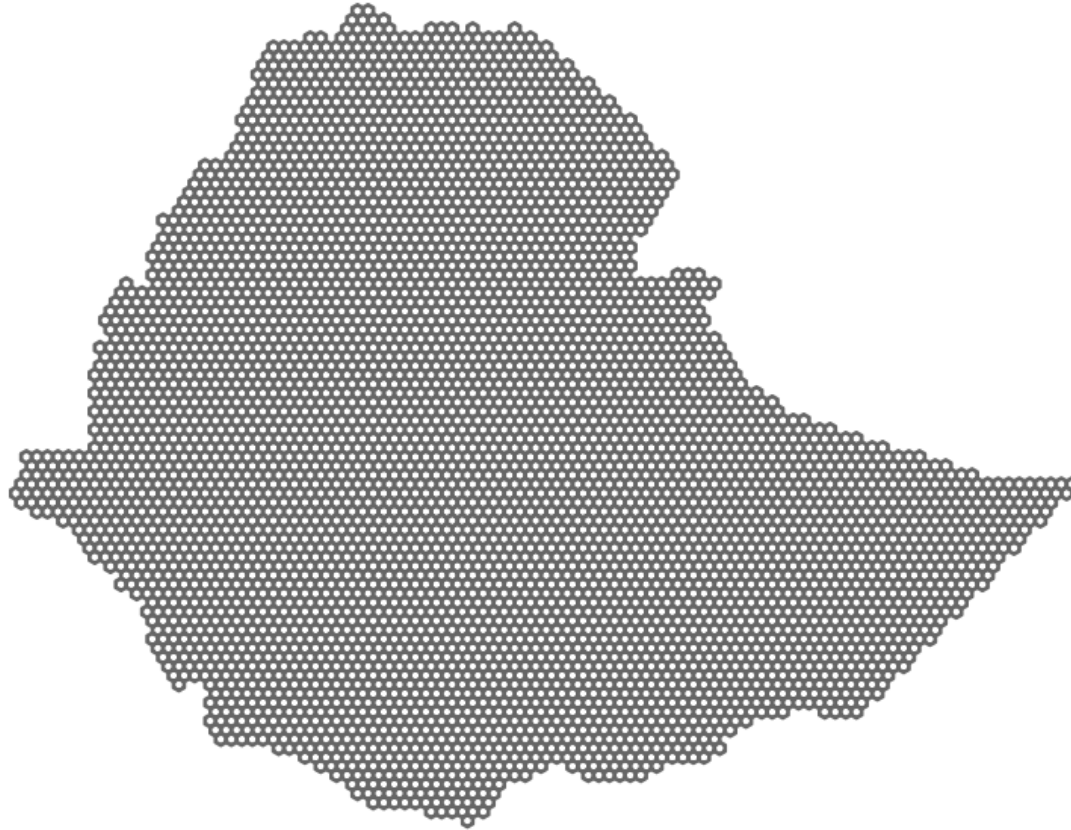


## Population count

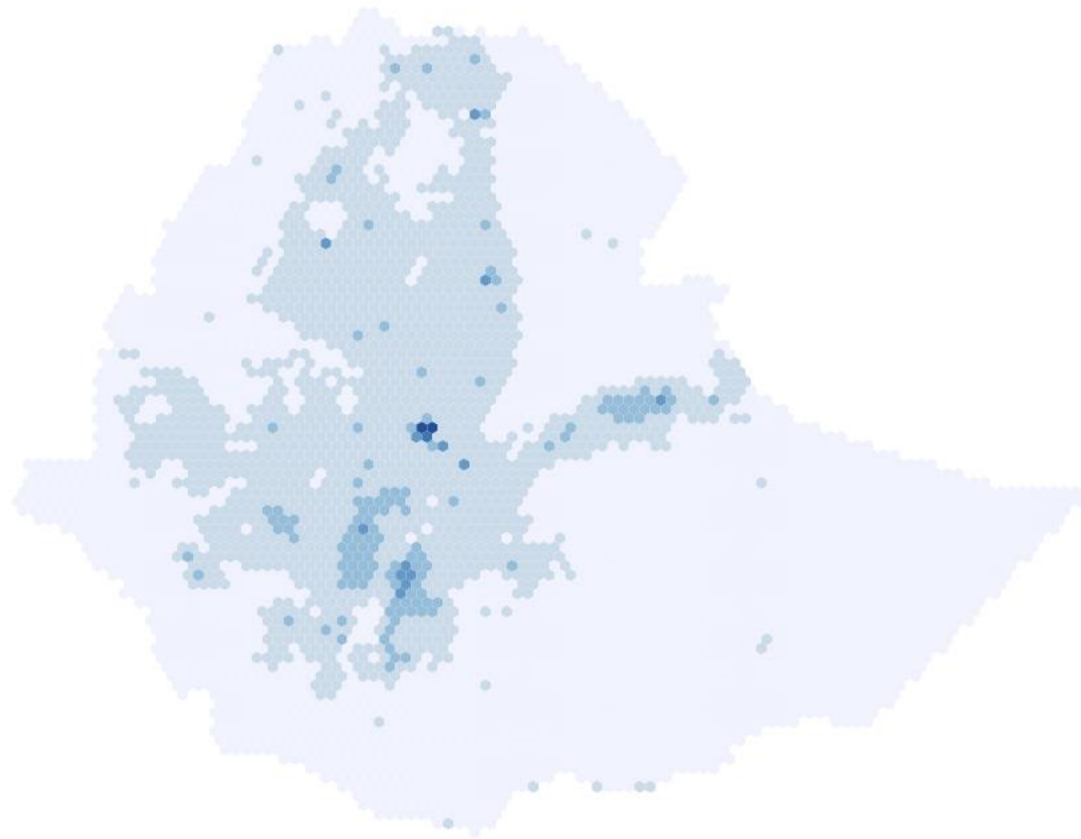




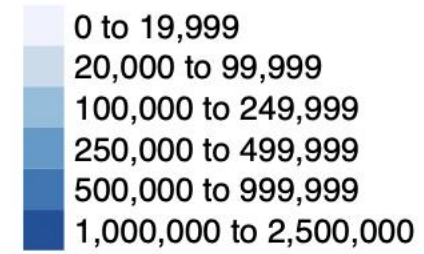
# Raster data



# Raster data



## Population count



# Raster data

- Multiple data formats, including GeoTIFF, ASCII Grid, Esri Grid and GIF.
- Must be **georeferenced** (i.e. have a CRS) to plot properly.
- Using raster data also means we should use raster-specific functions and operations.



# Raster data

- Local operations applied to each individual cell and only involve those cells sharing the same location
- Focal operations assign to the output cells some summary value of the neighbouring cells
- Zonal operations computes a new summary value from aggregated cells
- Global operations make use of some or all input cells when computing an output cell

# Raster data

1	0	0	0	0	0
1	1	0	0	0	0
1	1	1	1	0	1
0	1	1	0	0	0
0	0	0	0	1	0

basic raster

# Local operations and functions



1	0	0	0	0	0
1	1	0	0	0	0
1	1	1	1	0	1
0	1	1	0	0	0
0	0	0	0	1	0

multiplication \* 2

2	0	0	0	0	0
2	2	0	0	0	0
2	2	2	2	0	2
0	2	2	0	0	0
0	0	0	0	2	0

1	0	0	0	0	0
1	1	0	0	0	0
1	1	1	1	0	1
0	1	1	0	0	0
0	0	0	0	1	0

1	0	0	0	0	0
1	2	0	0	0	0
1	2	1	1	0	1
0	2	1	0	0	0
0	0	0	0	1	0

addition

2	0	0	0	0	0
2	3	0	0	0	0
2	3	2	2	0	2
0	3	2	0	0	0
0	0	0	0	2	0

1	0	0	0	0	0
1	2	0	0	0	0
1	2	1	1	0	1
0	2	1	0	0	0
0	0	0	0	1	0

logical

0	0	0	0	0	0
0	2	0	0	0	0
0	2	0	0	0	0
0	2	0	0	0	0
0	0	0	0	0	0



1	0	0	0	0	0
1	1	0	0	0	0
1	1	1	1	0	1
0	1	1	0	0	0
0	0	0	0	1	0

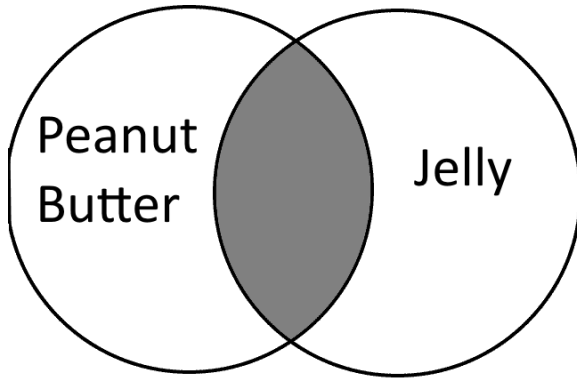
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1	2	0	0	0	0
1	2	1	1	0	1
0	2	1	0	0	0
0	0	0	0	1	0

Boolean AND

1	1	1	1	1	1
1	0	1	1	1	1
1	0	1	1	1	1
1	0	1	1	1	1
1	1	1	1	1	1

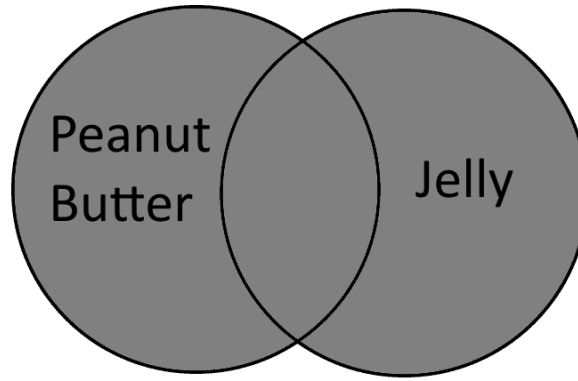
# Boolean operators

Truth evaluation using Boolean operators



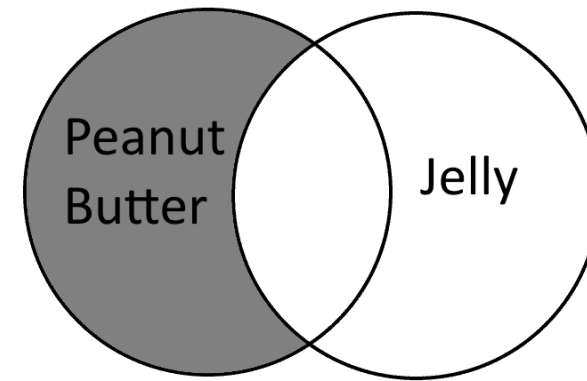
## AND

Using AND, this search would only retrieve results with Peanut Butter and Jelly.



## OR

Using OR, this search would retrieve results with peanut butter, with jelly, and with both.



## NOT

Using NOT, this search would retrieve results with peanut butter, and exclude those with jelly or PB with jelly.

# Focal operations and functions

1	0	0	0	0	0
1	2	0	0	0	0
1	2	1	1	0	1
0	2	1	0	0	0
0	0	0	0	1	0

focal (sum)

3	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

1	0	0	0	0	0
1	2	0	0	0	0
1	2	1	1	0	1
0	2	1	0	0	0
0	0	0	0	1	0

focal (sum)

3	0	0	0	0	0
6	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0



1	0	0	0	0	0
1	2	0	0	0	0
1	2	1	1	0	1
0	2	1	0	0	0
0	0	0	0	1	0

focal (sum)

3	0	0	0	0	0
6	0	0	0	0	0
0	0	8	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

# Zonal operations and functions

1	0	0	0	0	0
1	2	0	0	0	0
1	2	1	1	0	1
0	2	1	0	0	0
0	0	0	0	1	0

1	0	0	0	0	0
1	2	0	0	0	0
1	2	1	1	0	1
0	2	1	0	0	0
0	0	0	0	1	0

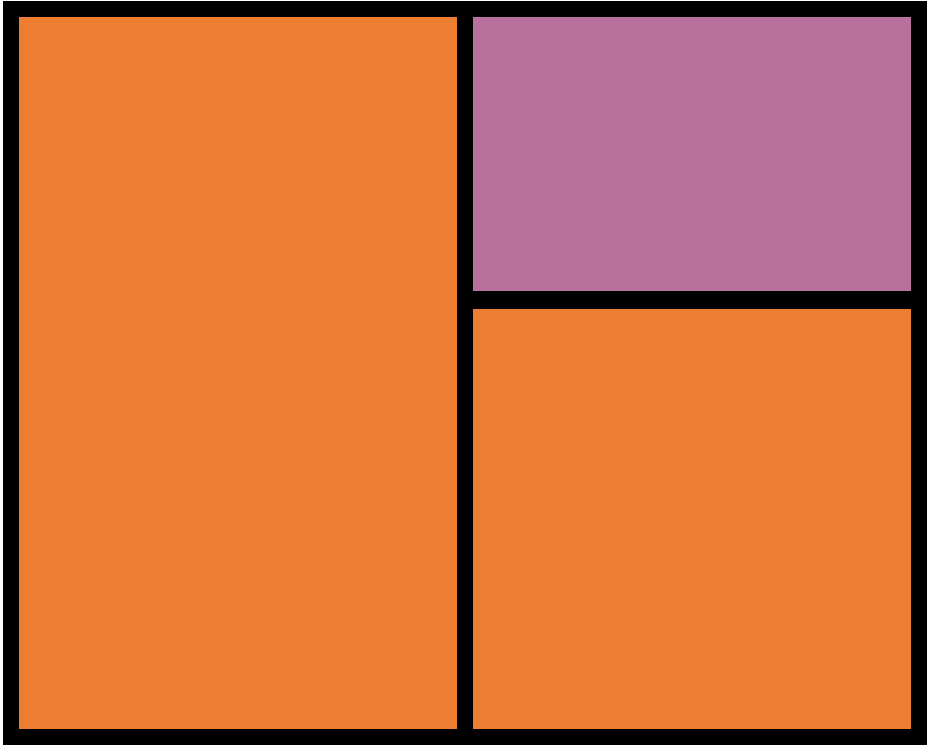
zonal

11	11	11	0	0	0
11	11	11	0	0	0
11	11	11	3	3	3
11	11	11	3	3	3
11	11	11	3	3	3

1	0	0	0	0	0
1	2	0	0	0	0
1	2	1	1	0	1
0	2	1	0	0	0
0	0	0	0	1	0

1	0	0	0	0	0
1	2	0	0	0	0
1	2	1	1	0	1
0	2	1	0	0	0
0	0	0	0	1	0

zonal




# Global operations and functions



Multi-criteria decision support

pdf.sciencedirectassets.com/282793/1-s2.0-S2213138815X00051/1-s2.0-S2213138815000788/main.pdf?X-Amz-Security-Token=IQoJb3JpZ2luX2VjEFEaCX...

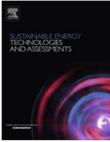
Multi-criteria decision support system for wind farm site selection using GIS1 / 13150%



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Original Research Article

Multi-criteria decision support system for wind farm site selection using GIS

 CrossMark

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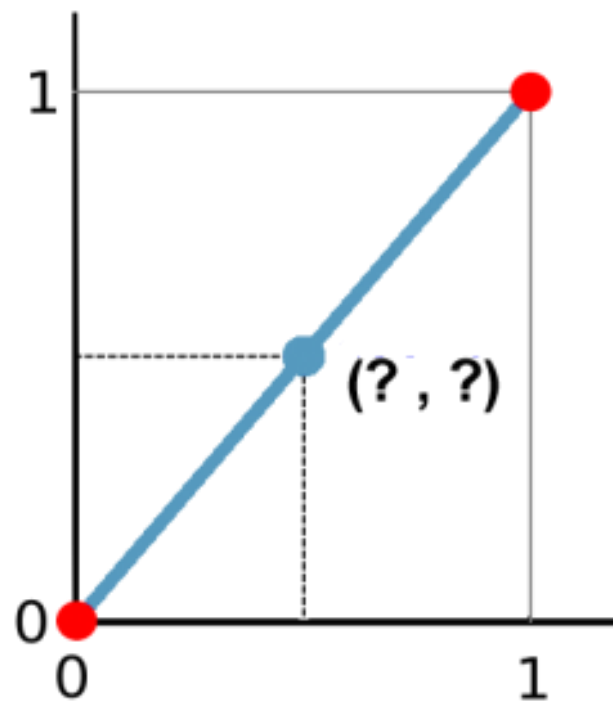
ABSTRACT

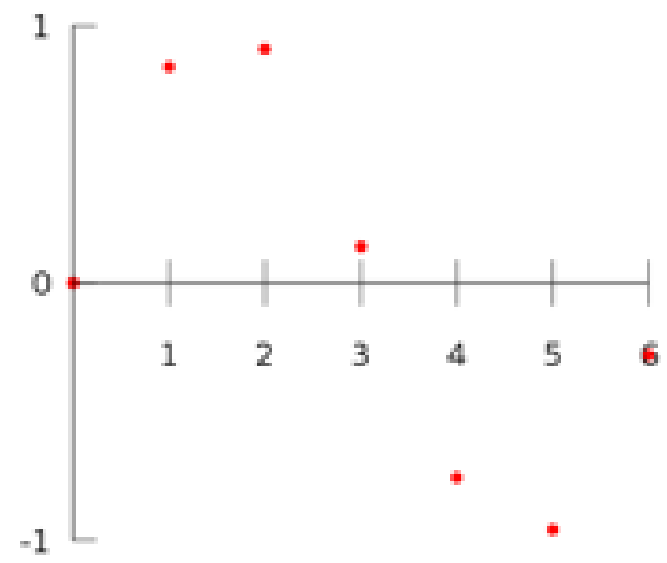
The present study analyzed a multi-criteria decision support system to define wind energy resources in western Iran. Clean domestic renewable energy can be the best option in consideration of intense economic development and its accompanying increase in energy consumption. The most important barrier to wider deployment of renewable resources in Iran is the price of fossil fuels, which is the lowest in the world. The government has recently decided to remove subsidies for fossil fuel, meaning that its price will increase and will make the cost of green energies more attractive.

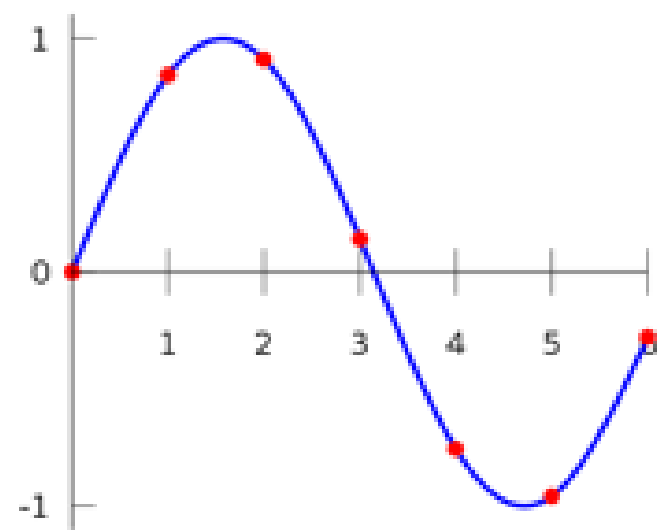
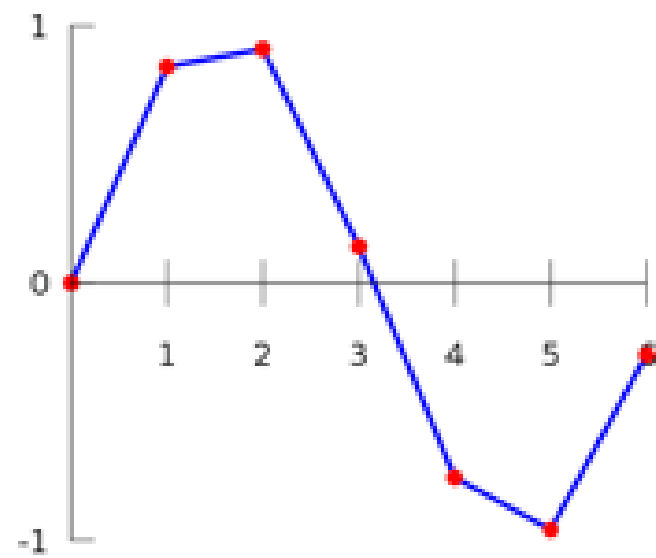
Wind power is an option for improved economic conditions in the region and low environmental impacts. This study applied geographic information system to determine the potential of wind energy in Markazi province in western Iran. The multiple criteria decision making method and site selection criterion for wind resources assessment is explained and developed for the study area. Criteria of equal importance were investigated, including technical, environmental, economic and geographic standards. The results were favorable for electricity production in accordance with international standards from wind in western Iran. The results show that 28% of the study area has capacity for installing large wind farms.

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# Data interpolation





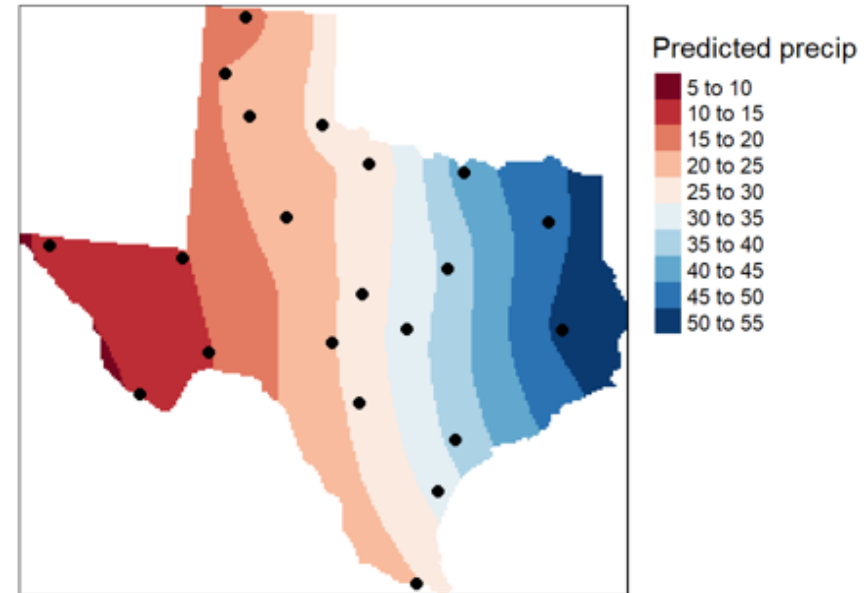
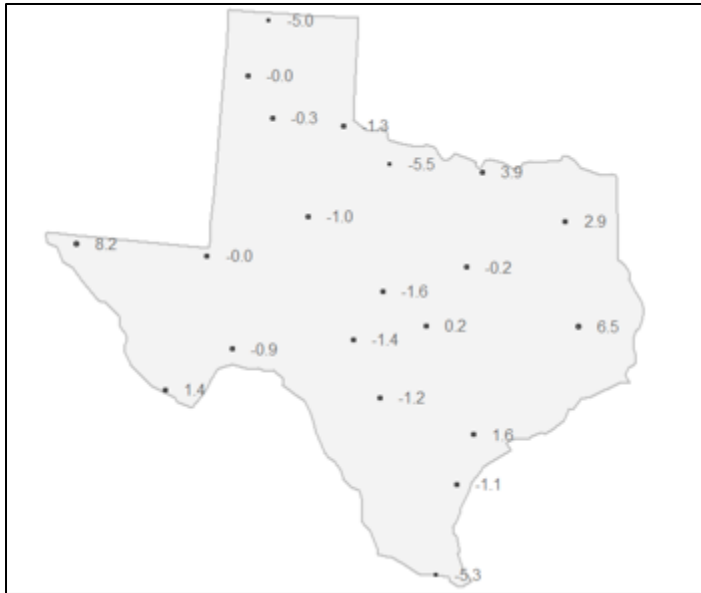




# Spatial data interpolation

- Similar to 'regular' data interpolation, but in two dimensions, accounting for spatial relationships.
- Commonly used for phenomena that are difficult to measure directly, such as spatial concentrations.
- Utilises regularly distributed or sampled points to create a continuous (predictive) surface from these sampled point values.
- There are various methods available to derive interpolated values, depending on the data and application.

# Spatial data interpolation



Gimond, M. 2020. *Geodesic geometry*. [online] <https://mgimond.github.io/>

# Spatial data interpolation

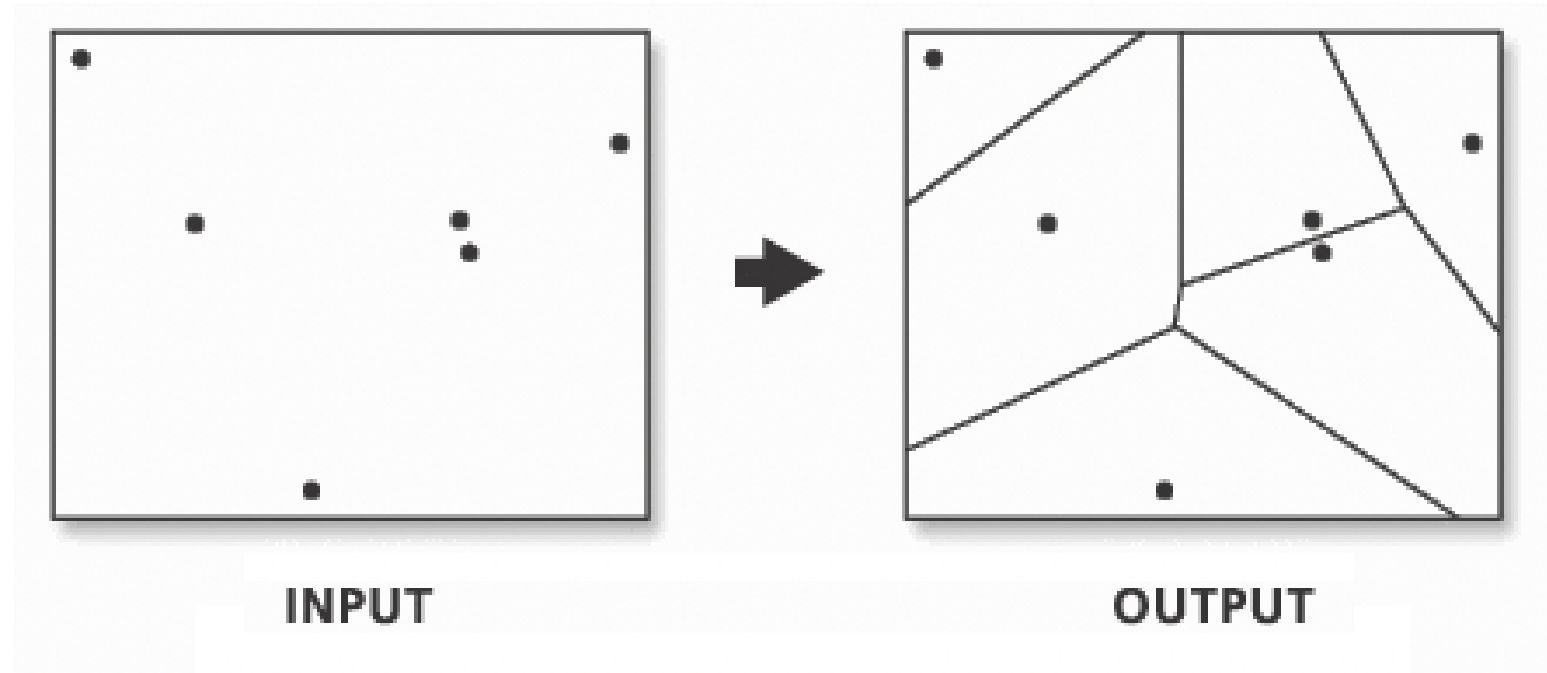
## Deterministic methods

- These type of models have parameter values that are typically arbitrarily defined.

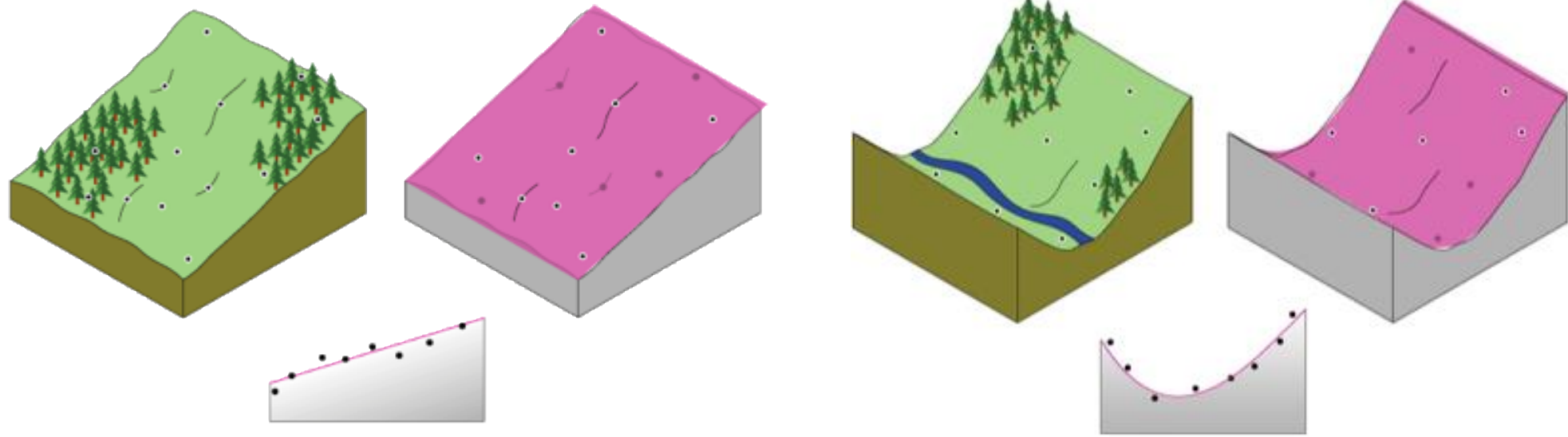
## Geostatistical methods

- The parameter values for these models have to be estimated.

# Spatial data interpolation: Nearest neighbour



# Spatial data interpolation: Trend

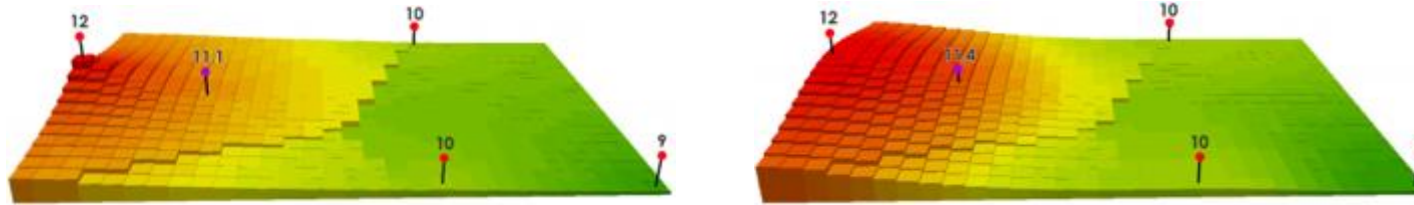




# Spatial data interpolation: IDW

- IDW: Inverse Distance Weighting (“Tobler’s Law”).
- Assumes near points are more alike than far points (distance decay).
- Spatial autocorrelation is the underlying assumption of IDW.

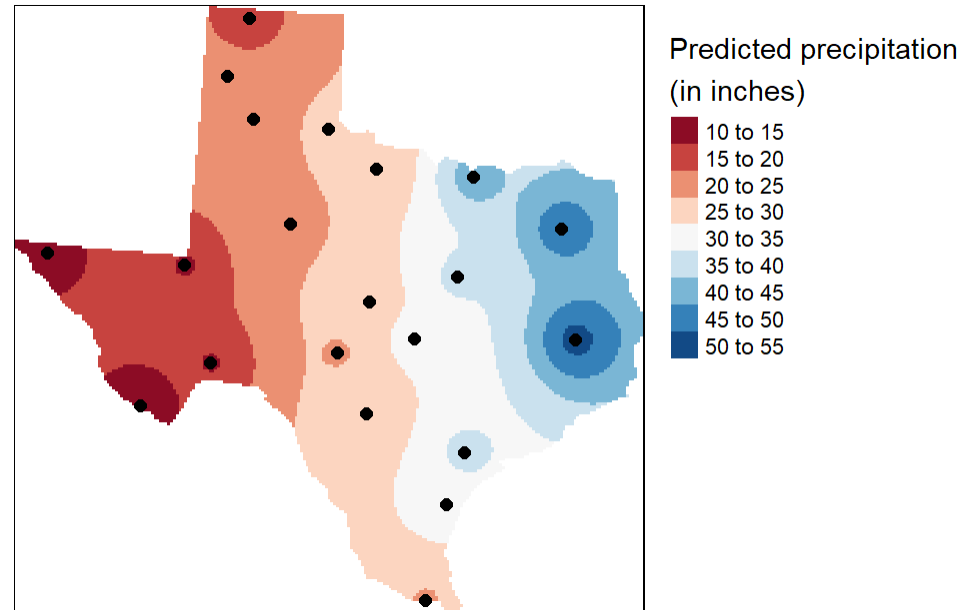
# Spatial data interpolation: IDW



IDW with different power settings

$$z_p = \frac{\sum_{i=1}^n \left( \frac{z_i}{d_i^p} \right)}{\sum_{i=1}^n \left( \frac{1}{d_i^p} \right)}$$

# Spatial data interpolation: IDW

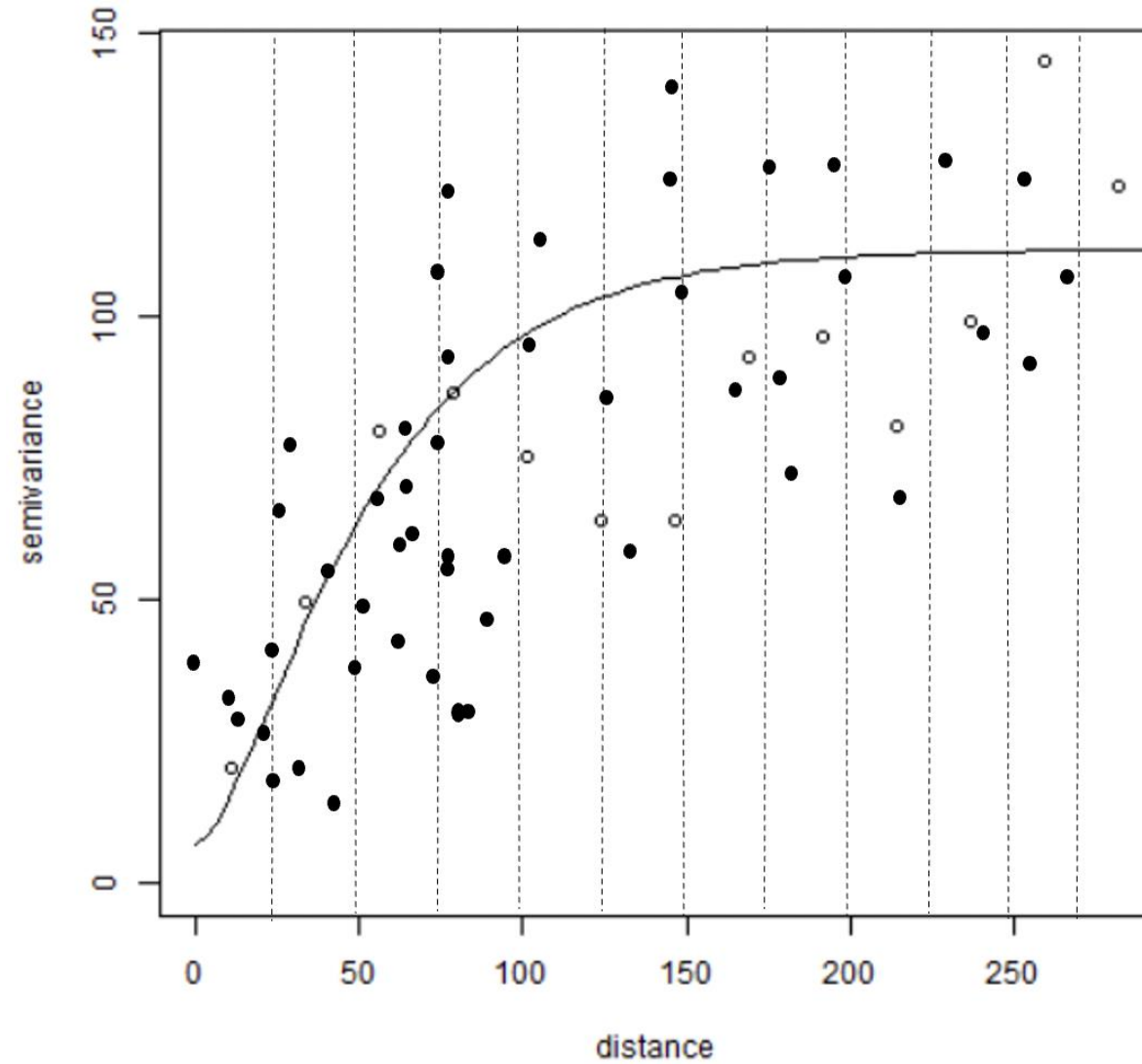


Gimond, M. 2020. *Geodesic geometry*. [online] <https://mgimond.github.io/>

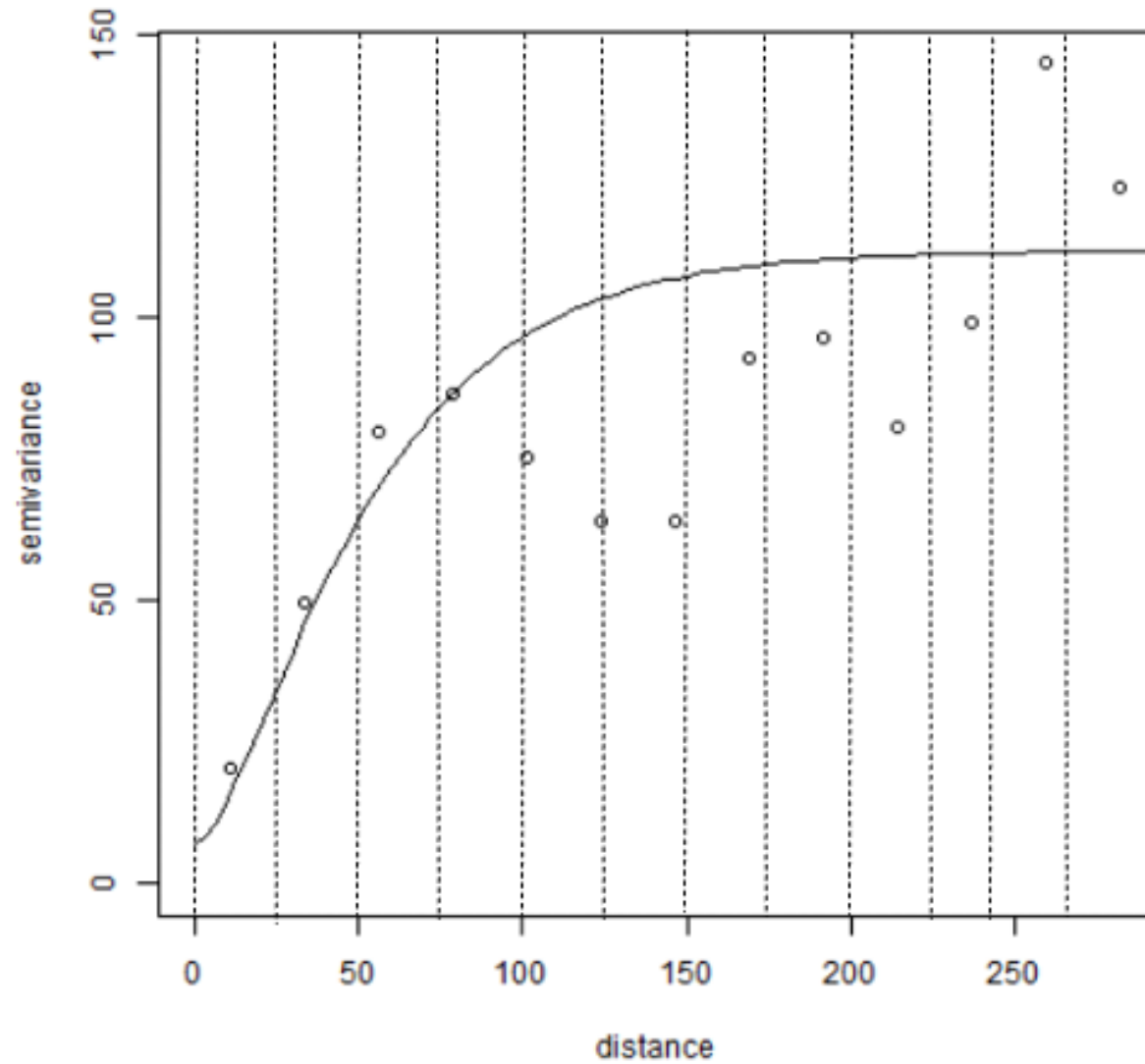
# Spatial data interpolation: Kriging

- Considers both distance and degree of variation between known data points when estimating values in unknown areas.
- Kriging is a complex, multistep process starting with a semi-variogram.

# Spatial data interpolation: Kriging



# Spatial data interpolation: Kriging



# Spatial data interpolation: IDW versus Kriging

- IDW (Inverse Distance Weighting) assumes that spatial autocorrelation between neighbouring points is inversely proportional to the distance between them, and this relationship can be defined by a distance-based function.
- Kriging assumes that both distance and directionality between sample points influence spatial autocorrelation. It fits functions to describe the correlation between points and explains the variation across the surface.



# Conclusion

- Raster data model is essential for representing categorical and continuous data.  
Raster data come with their own set of functions and operations.
- Spatial data interpolation is the idea to estimate **unknown values** of a phenomenon.  
Spatial data interpolation creates a continuous surface, requiring the use of the raster data model.
- Multiple methods for interpolation (e.g., IDW, Kriging) that vary in assumptions.

# Questions

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