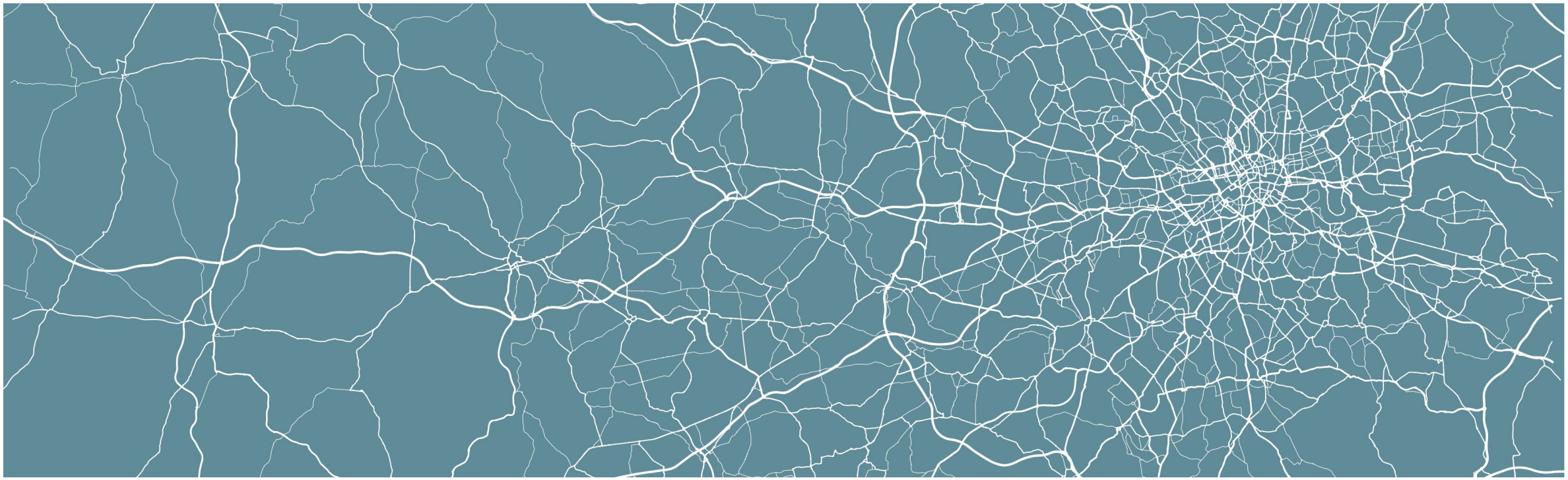
Geocomputation

Rasters, Zonal Statistics and Interpolation



UCL

Where are we at?

Part I: Foundational Concepts

W1	Geocomputation: An Introduction	
W2	GIScience and GIS software	QGIS
W3	Cartography and Visualisation	
W4	Programming for Data Analysis	R
W5	Programming for Spatial Analysis	

Where are we at?

Part II: Core Spatial Analysis

W6 Geometric Operations and Spatial Queries
W7 Spatial Autocorrelation
W8 Point pattern analysis

] R

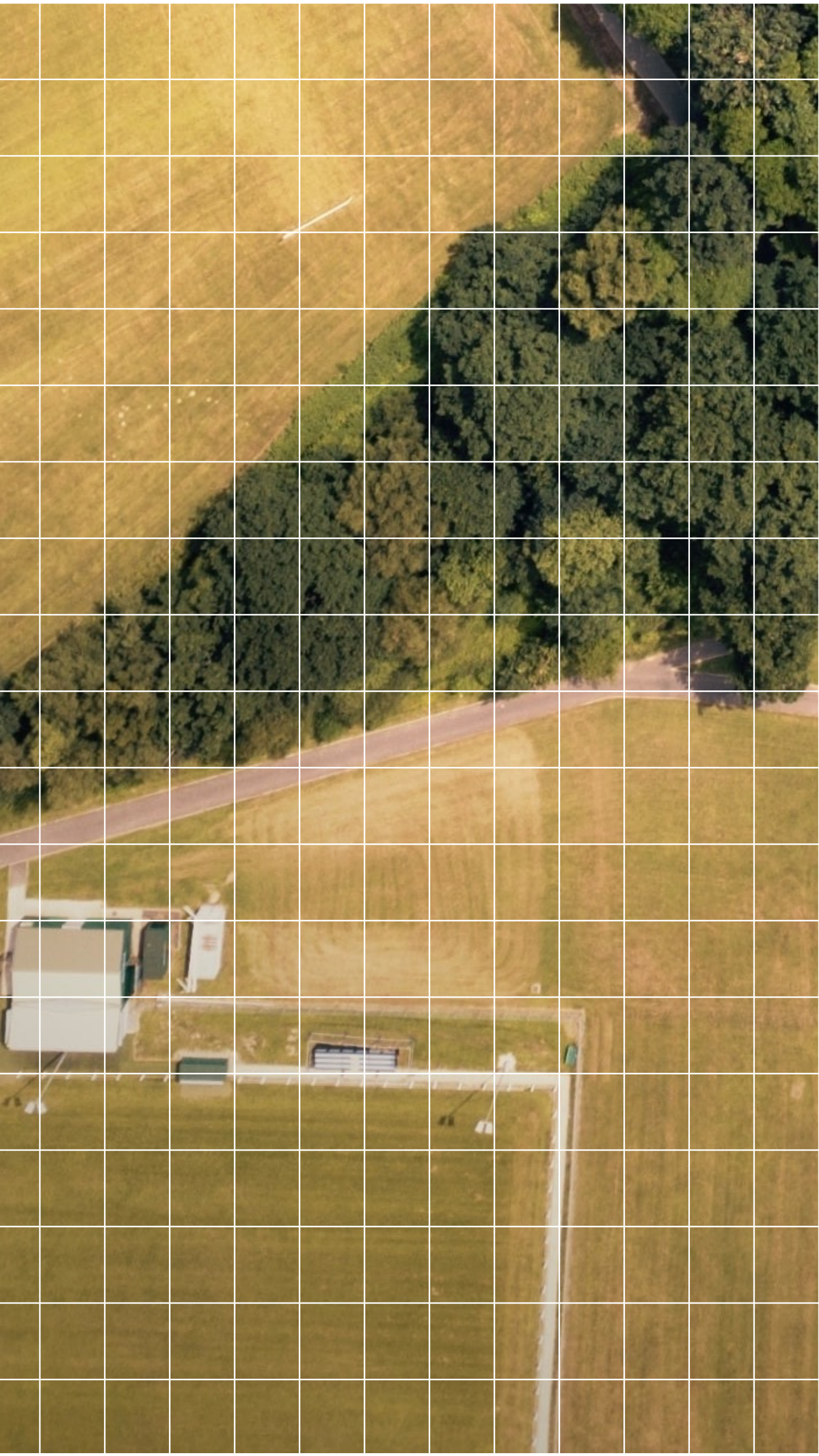
Part III: Advanced Spatial Analysis

W9 **Rasters, Zonal Statistics and Interpolation**
W10 Transport Network Analysis

] R

This week

- Raster GIS data model
- Raster-specific functions and operations
- Data interpolation and spatial data interpolation
- Some general pointers for the exam

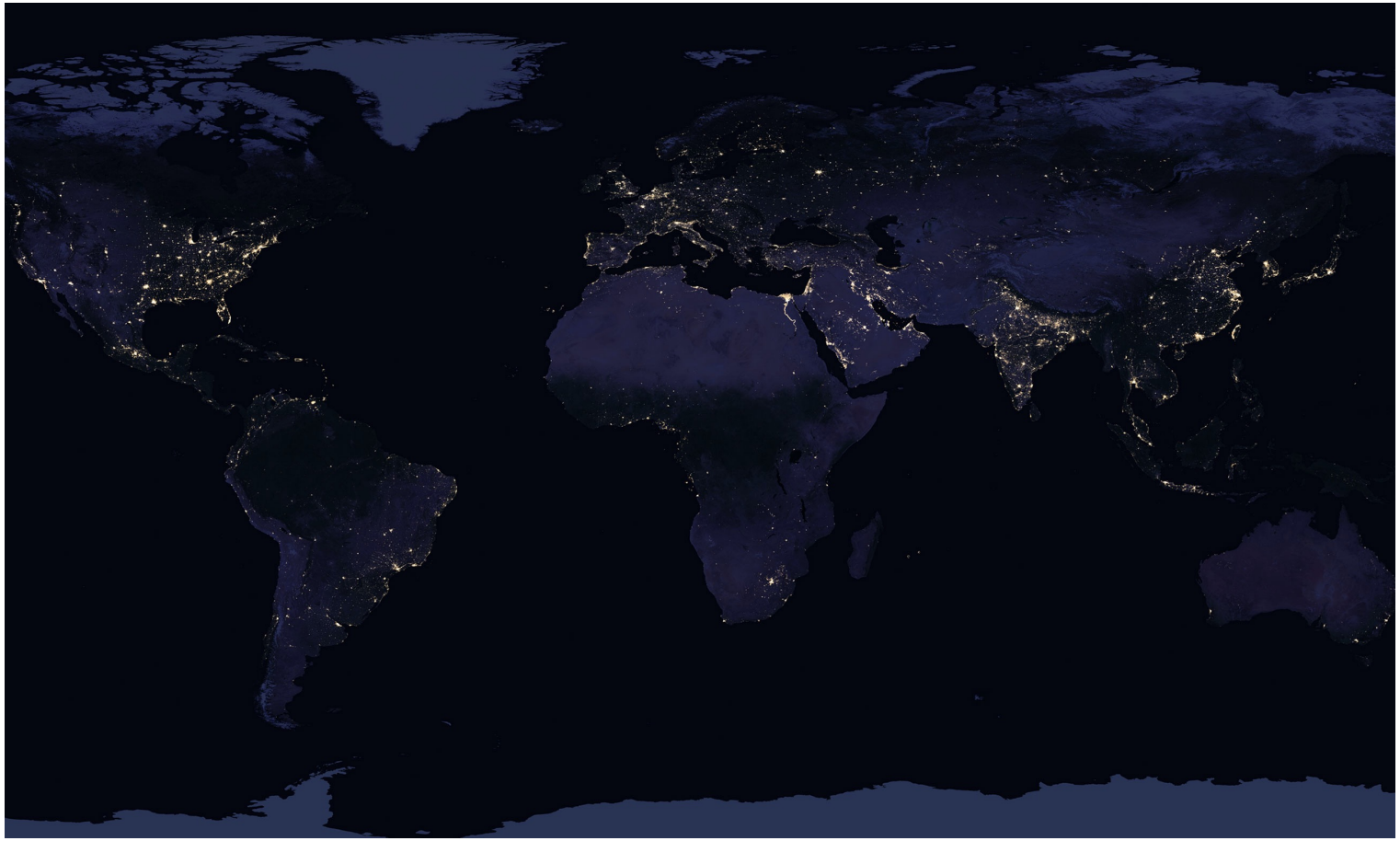


8	9	9	10	0	10	10	10	0	0	0	7	5	3	0	0	0	0	1
8	9	9	10	10	0	10	9	9	0	0	5	3	0	0	0	0	0	0
8	8	9	9	10	0	0	9	8	7	5	0	0	0	1	0	0	0	0
5	8	8	9	10	10	0	9	7	5	0	0	5	5	5	0	0	0	1
3	5	8	9	9	10	0	0	3	0	0	0	5	0	0	1	0	0	2
2	5	8	8	9	9	10	0	0	0	1	5	0	0	0	0	0	0	1
2	4	6	8	8	9	0	0	0	1	5	0	0	5	5	5	0	0	1
0	3	6	8	8	0	0	0	0	5	0	5	5	5	5	5	0	0	0
2	2	5	8	0	0	0	0	0	0	5	5	5	5	5	5	3	0	0
0	2	5	0	0	1	2	3	4	4	4	4	4	4	4	5	0	0	0
0	0	0	0	1	1	1	1	4	4	4	4	4	4	4	5	0	0	0
0	0	1	1	2	2	2	2	3	3	3	3	3	3	3	4	0	3	0
1	1	1	1	2	2	3	3	3	3	1	1	1	1	1	2	3	4	3

Raster properties

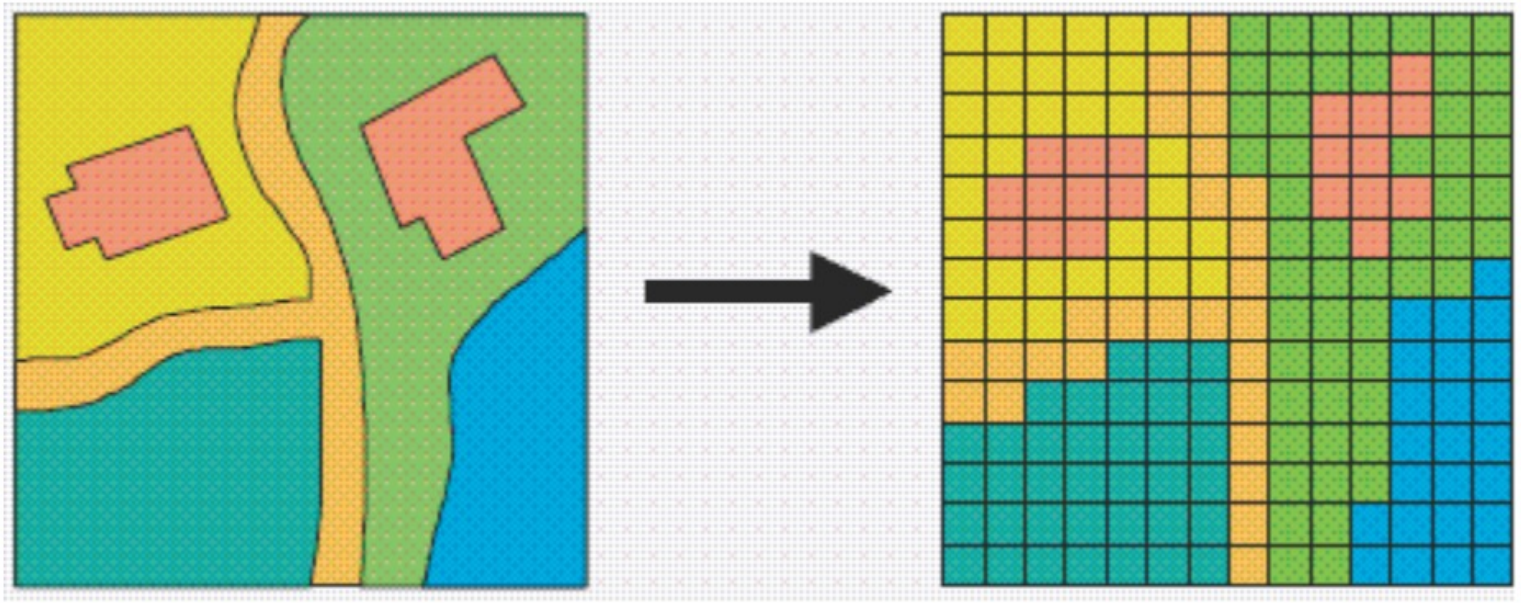
- Raster data are commonly found in applications where every location has one value.
- Variable can be continuous (temperature, elevation, air pollution), categorical (land use), or imagery (reflectance values).
- Cell size is constant across the raster surface.
- When do we encounter raster data:
 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

Raster data



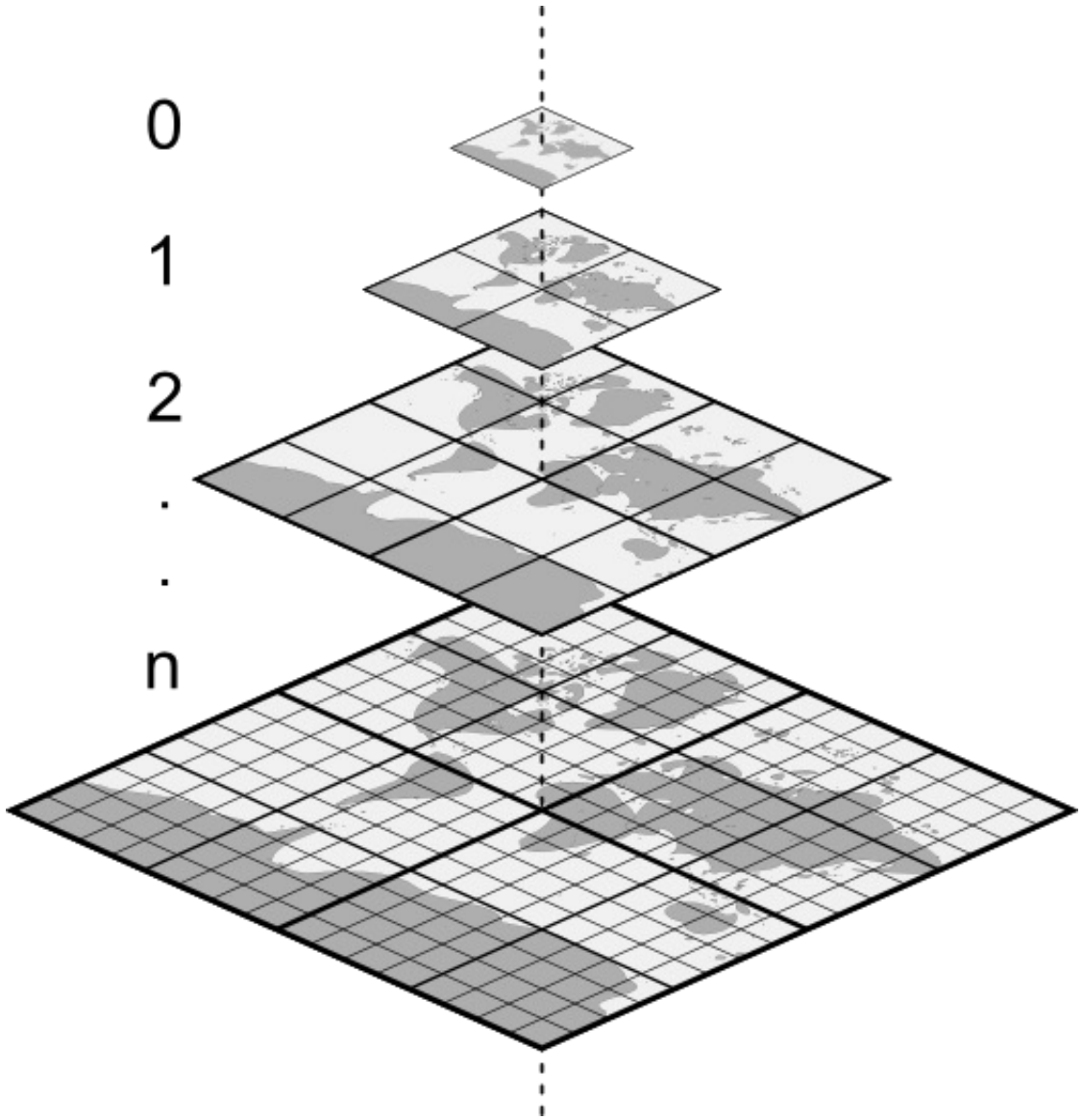
Continuous (numerical value of data)

Raster data

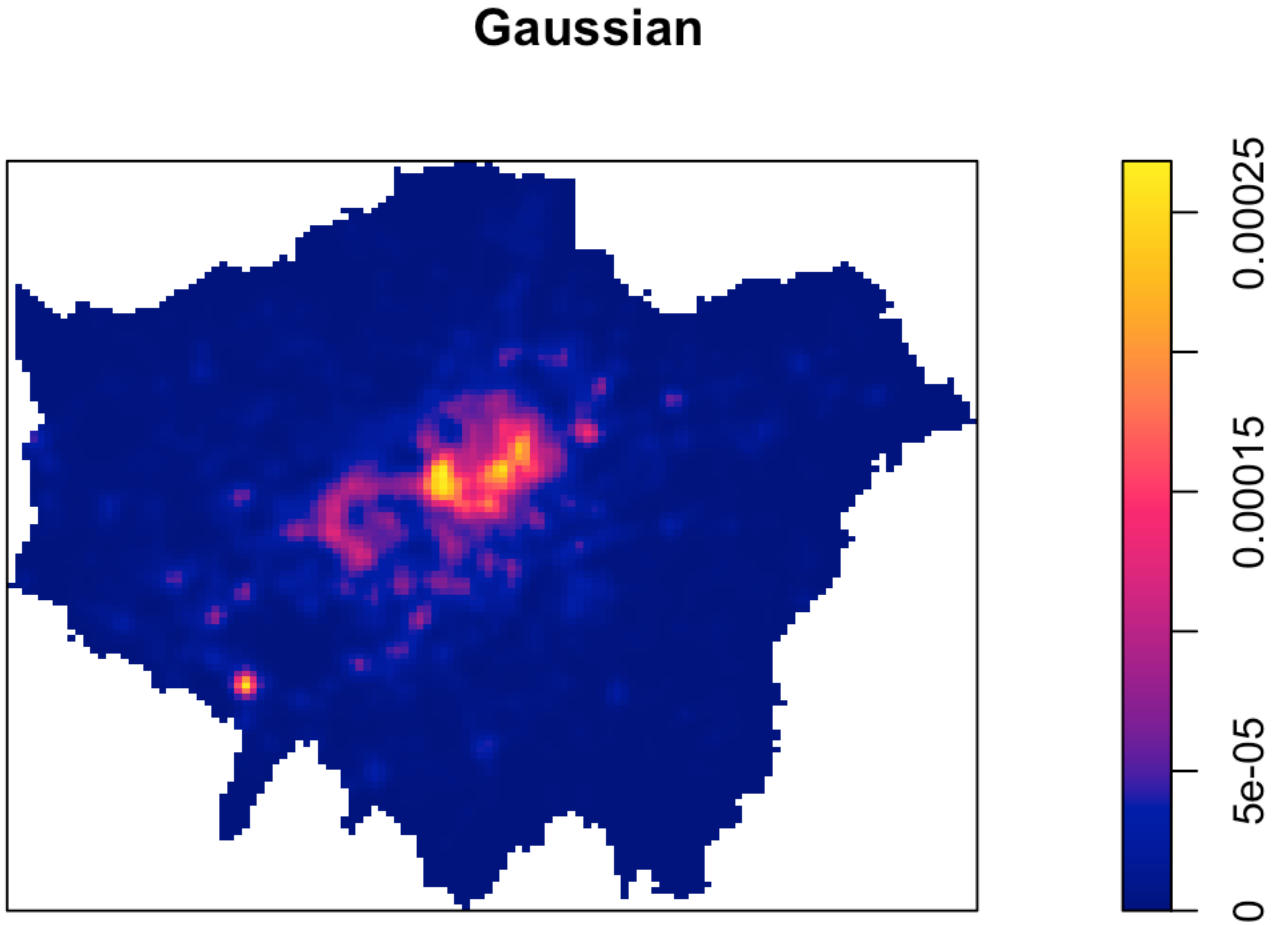


Categorical (number represent category)

Raster data



Raster data



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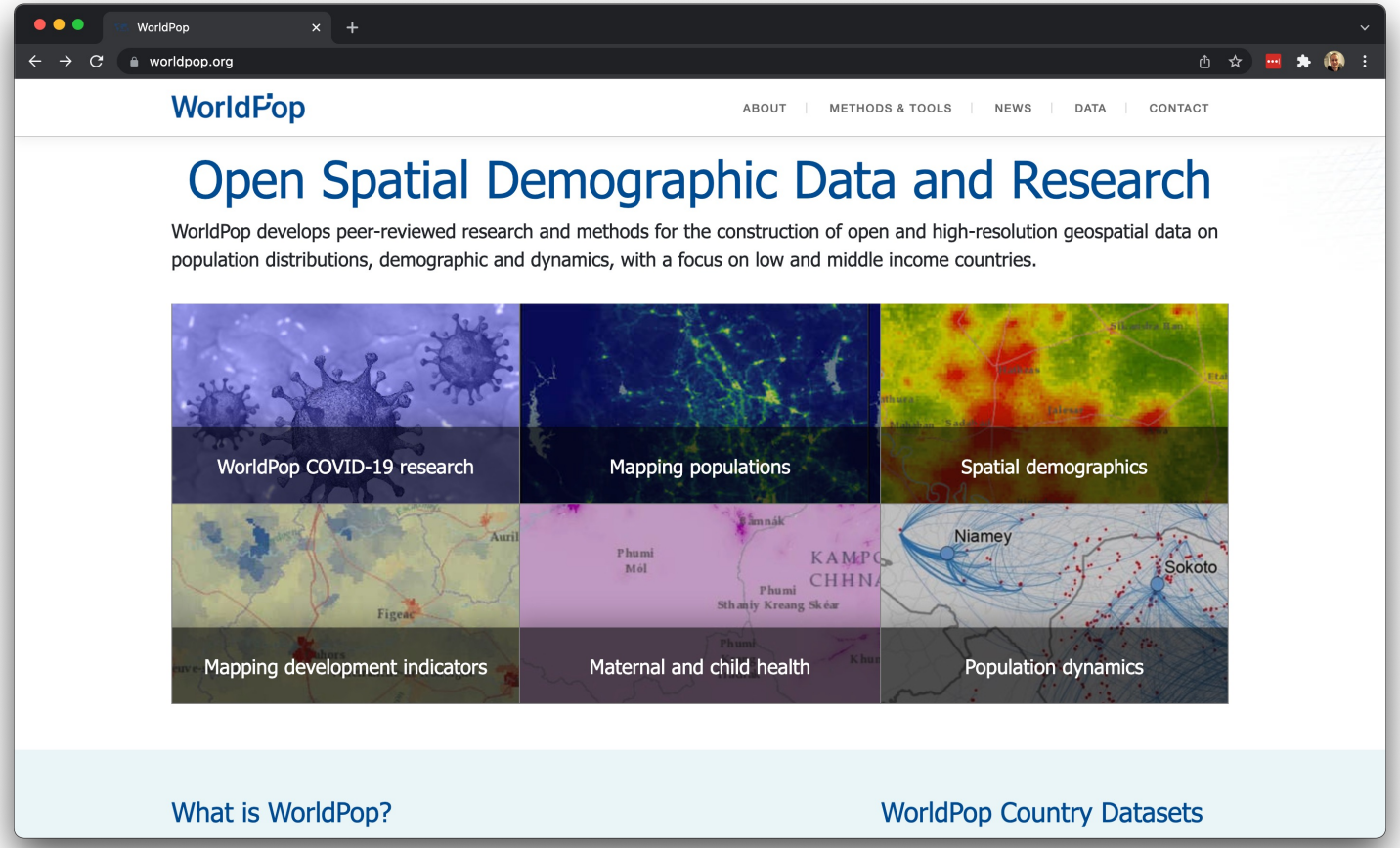
WorldPop
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NEWS
DATA
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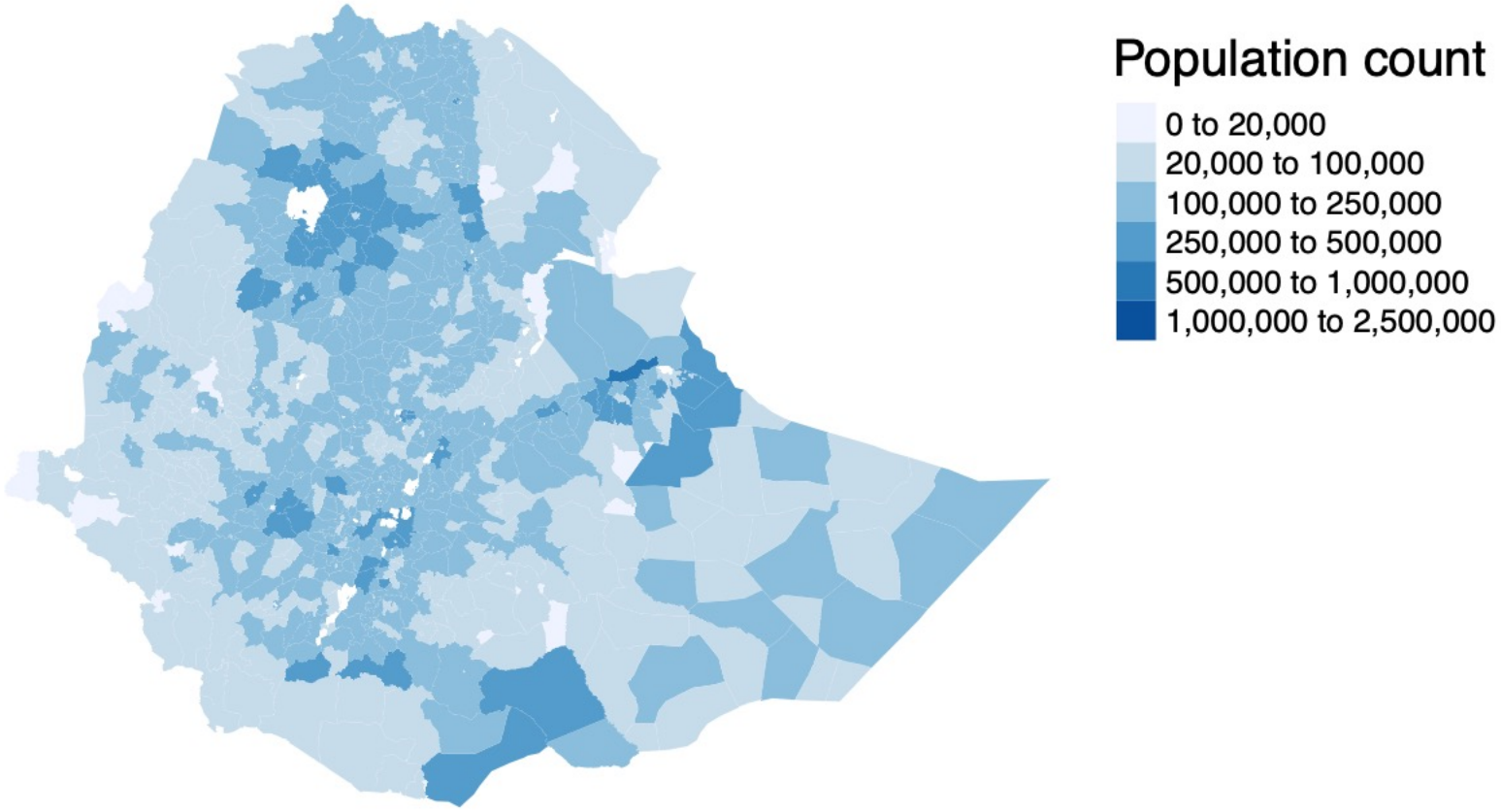
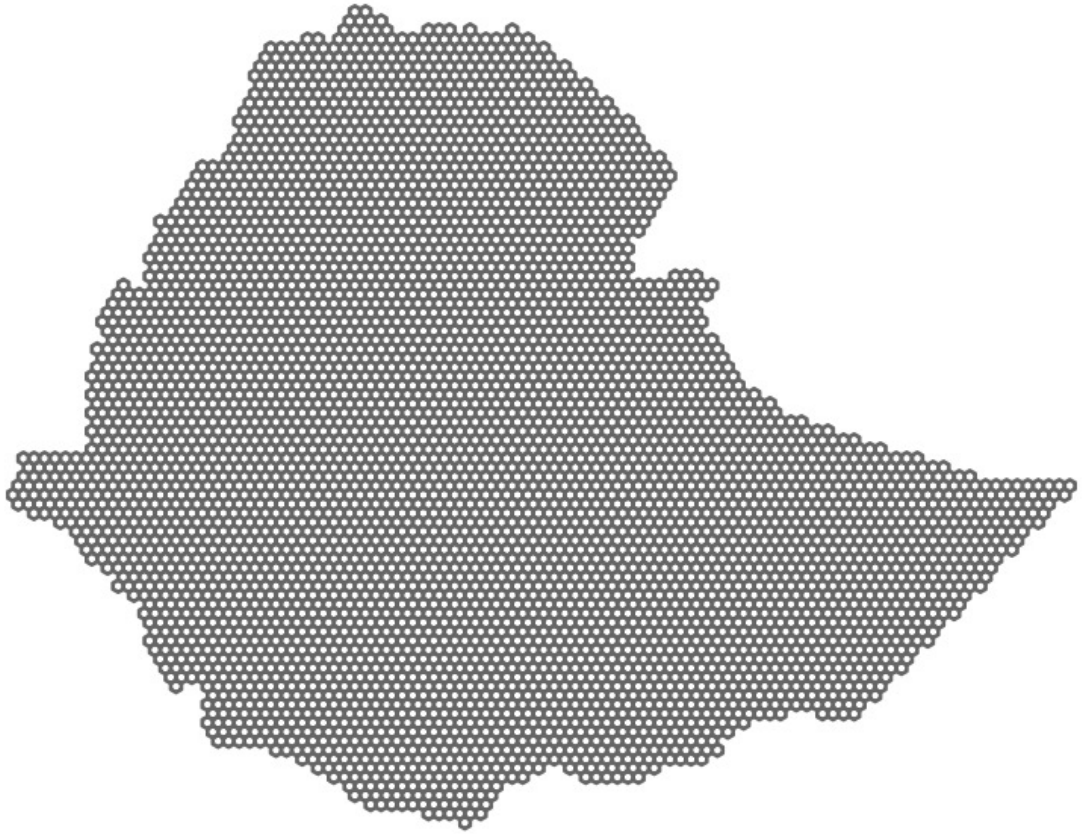
Open Spatial Demographic Data and Research
WorldPop develops peer-reviewed research and methods for the construction of open and high-resolution geospatial data on population distributions, demographic and dynamics, with a focus on low and middle income countries.
WorldPop COVID-19 research
Mapping populations
Spatial demographics
Mapping development indicators
Maternal and child health
Population dynamics
Niamey
Sokoto
What is WorldPop?
WorldPop Country Datasets

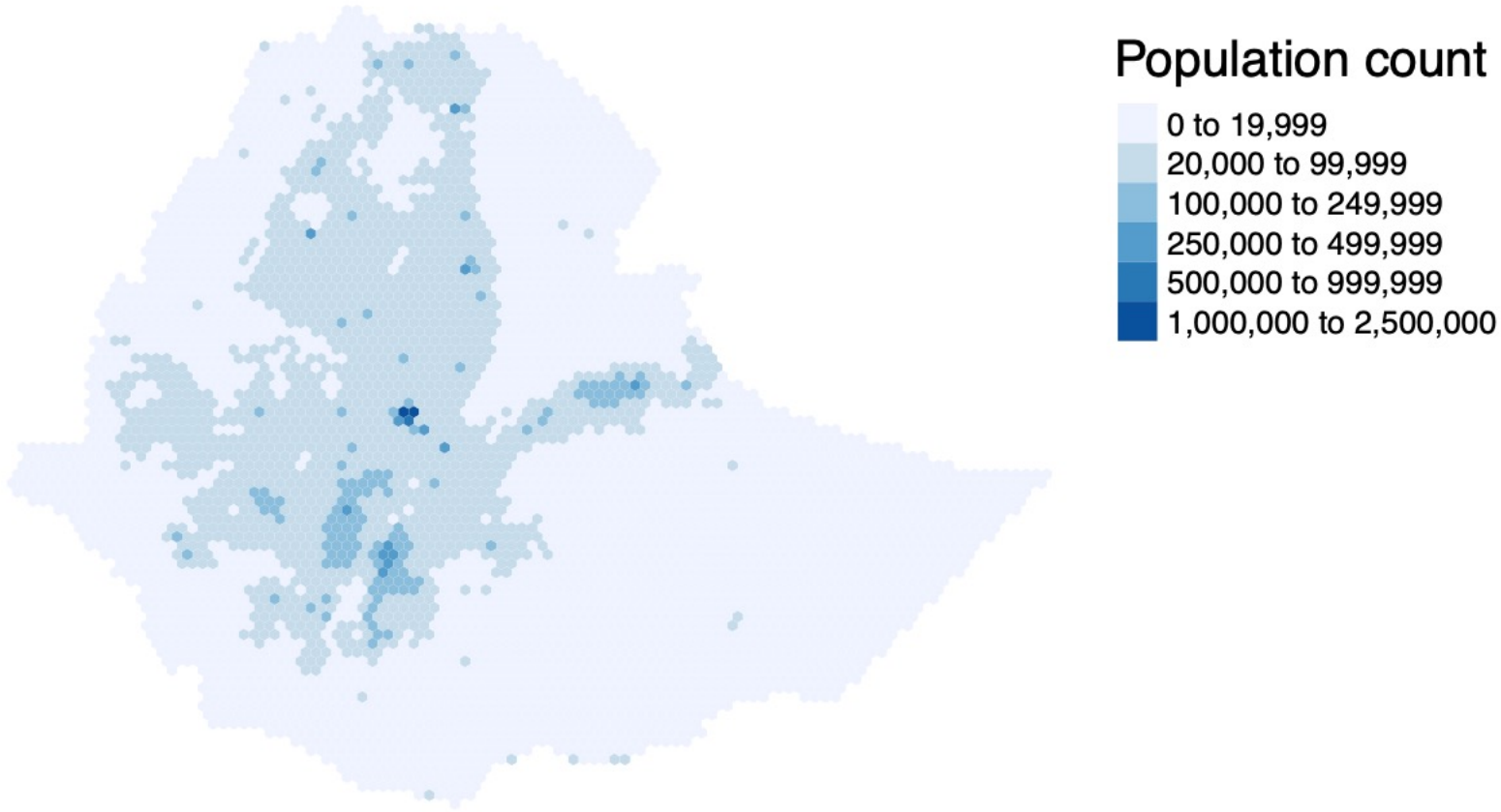
Raster data


Population count
0 to 20,000
20,000 to 100,000
100,000 to 250,000
250,000 to 500,000
500,000 to 1,000,000
1,000,000 to 2,500,000

Raster data



Raster data


Population count
0 to 19,999
20,000 to 99,999
100,000 to 249,999
250,000 to 499,999
500,000 to 999,999
1,000,000 to 2,500,000

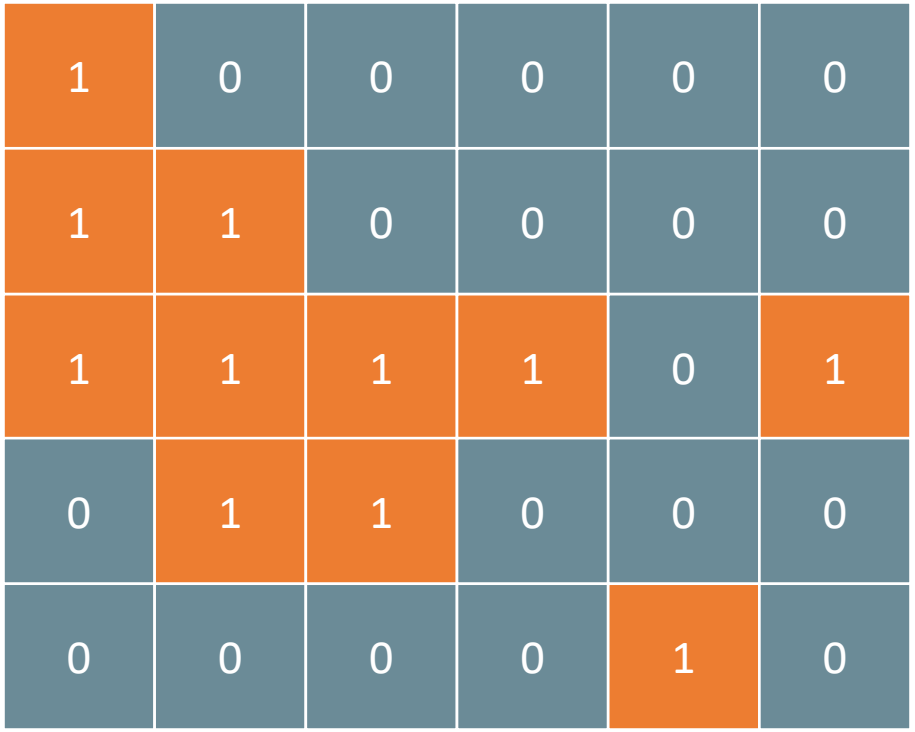
Raster data

- 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



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

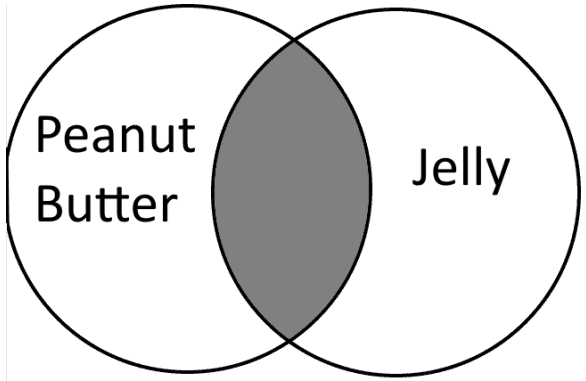
1	0	0	0	0	0
1	2	0	0	0	0
1	2	1	1	0	1
0	2	1	0	0	0
0	0	0	0	1	0

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

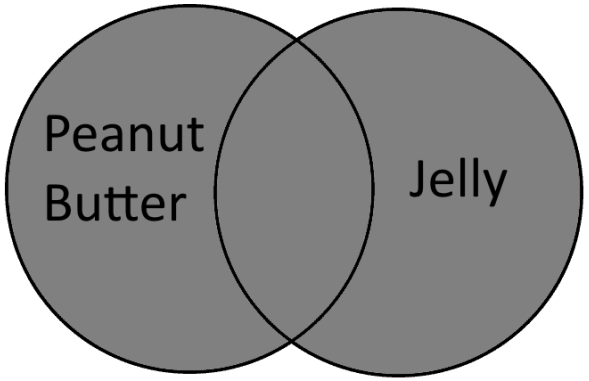
Boolean operators

Truth evaluation using Boolean operators



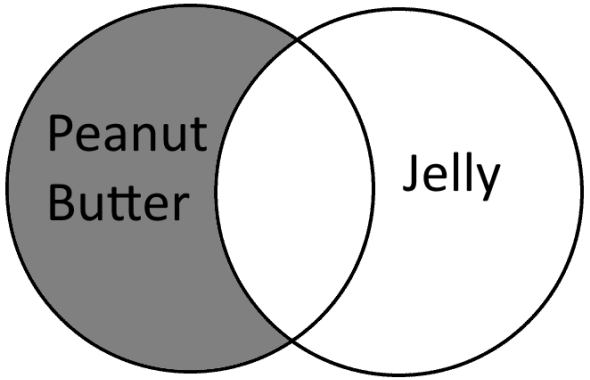
AND

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	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

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	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

zonal

Global operations and functions

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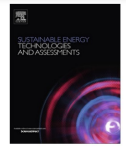

Original Research Article

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

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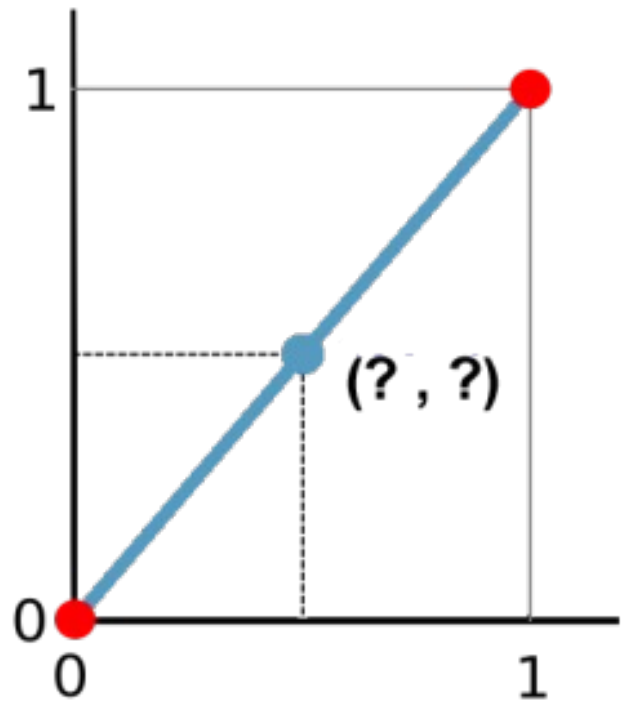
Wind farm
Iran

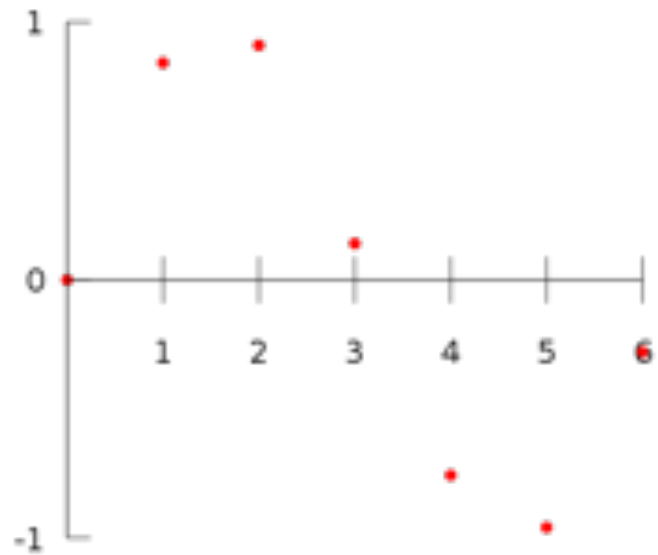
ABSTRACT

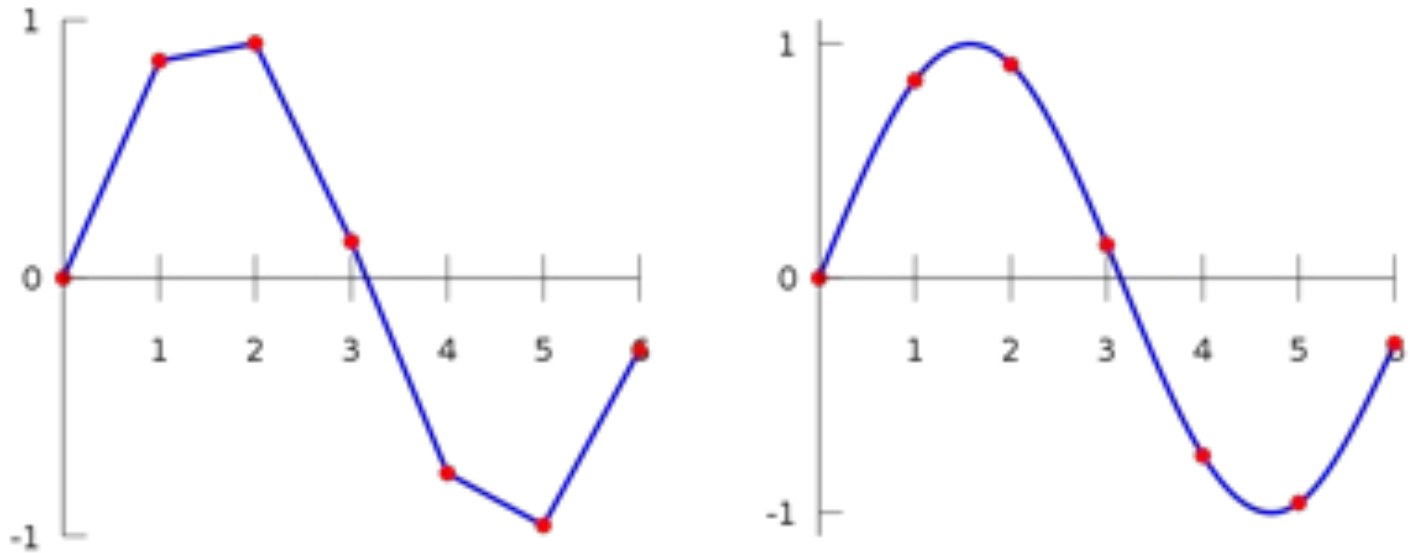
The present study analyzed a multi-criteria decision support system to define wind energy resources in western Iran. Clean domestic renewable energy can be the best option in consideration of intense economic development and its accompanying increase in energy consumption. The most important barrier 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.

Data interpolation


1
(? , ?)
0
0
1

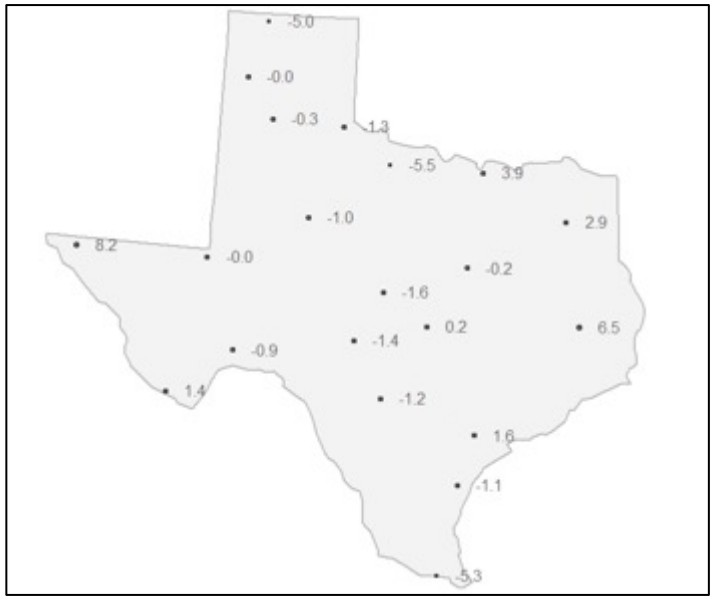

1
0
-1
1
2
3
4
5
6

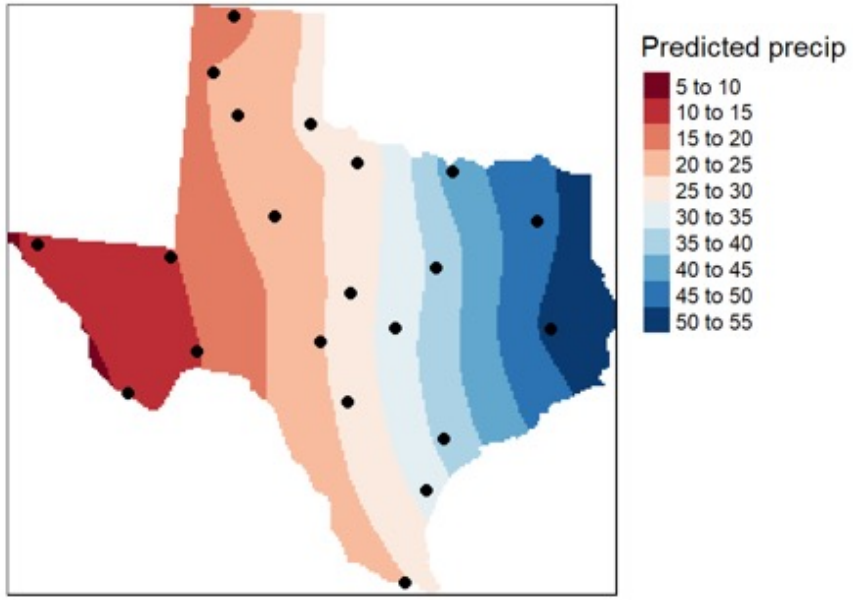

1
0
-1
1
2
3
4
5
1
0
-1
1
2
3
4
5

Spatial data interpolation

- Same idea but we need to account for the importance of space.
- Creation of a continuous (or prediction) surface from sampled point values.
- Common for difficult to measure phenomena (e.g. concentrations over space).
- Using regularly distributed or sampled points.
- Multiple approaches to derive a prediction.

Spatial data interpolation





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

Spatial data interpolation

- Difficult to take measures for everything – instead measure the phenomenon at strategically dispersed sample locations and predicted values can be assigned to all other locations.
- Points can be randomly or regularly spaced or even based on a sampling scheme.
- Multiple approaches to derive a prediction: each method is a type of model, as a result, different assumptions made of the data.

Spatial data interpolation

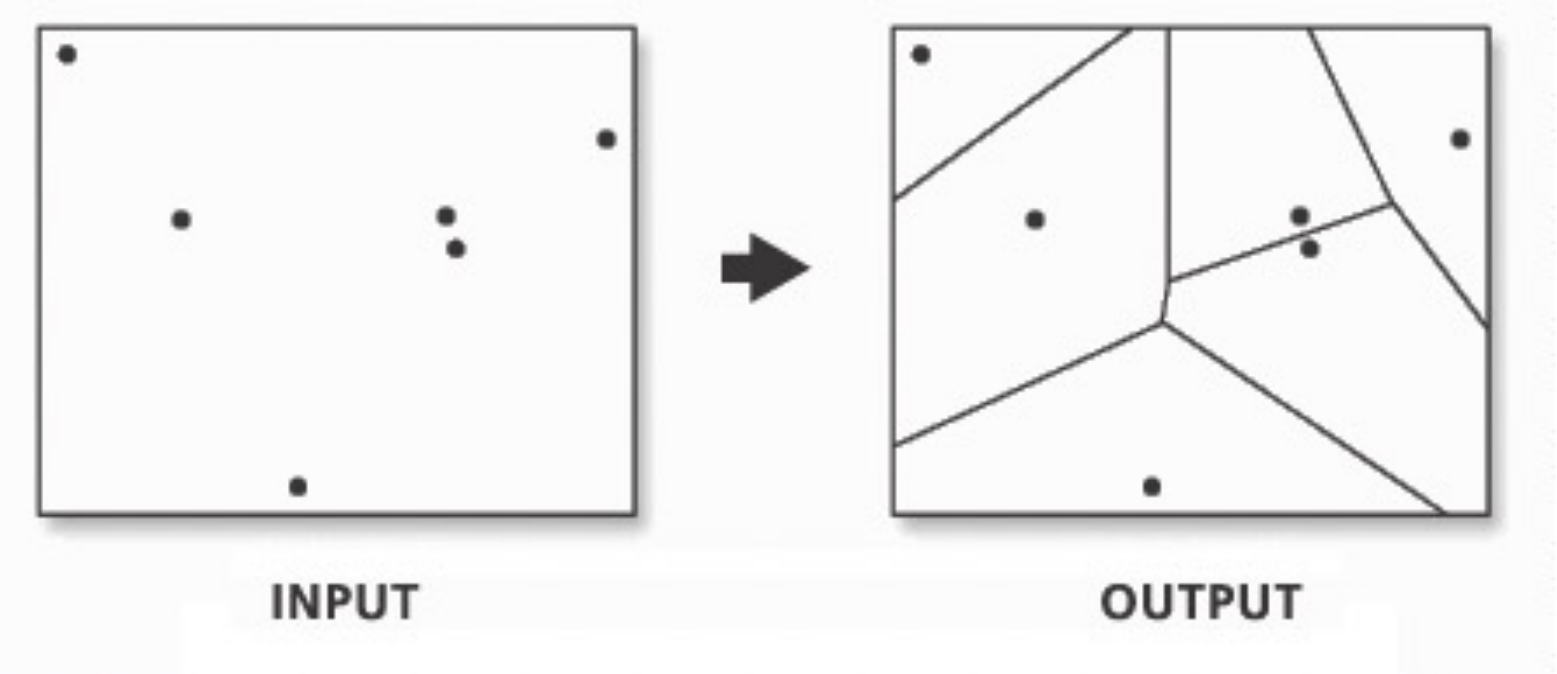
Deterministic methods

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

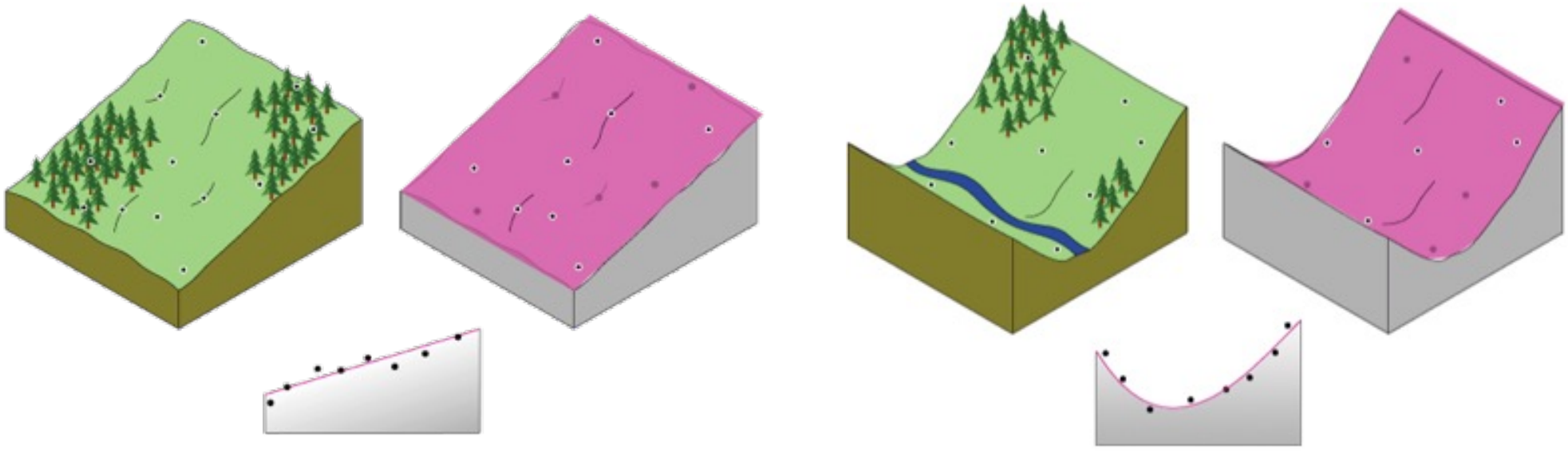
Geostatistical methods

The parameter values for the these set of models have to be estimated.

Spatial data interpolation: nearest neighbour



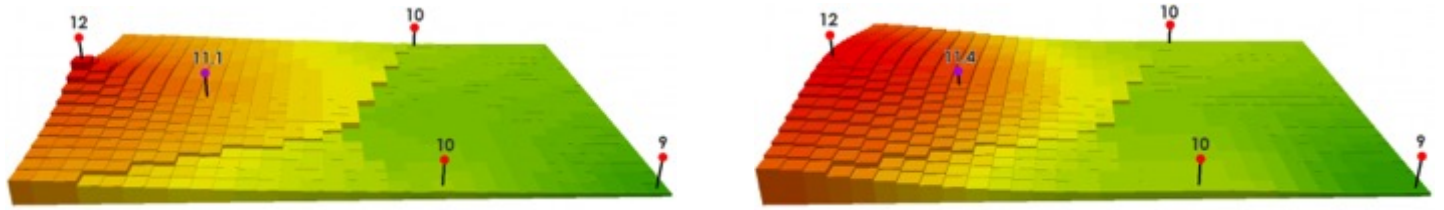
Spatial data interpolation: trend



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.

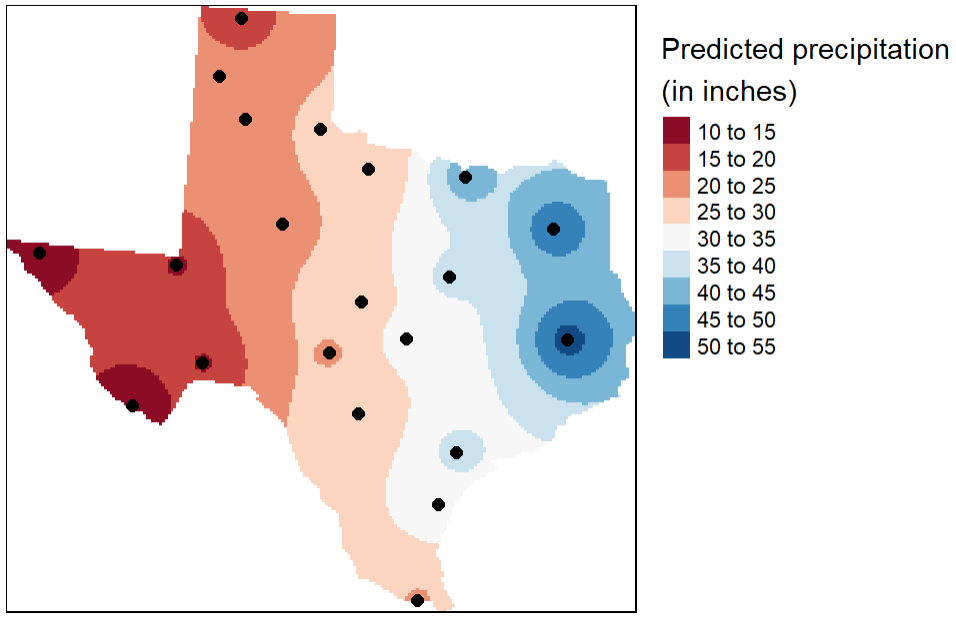
Spatial data interpolation: IDW



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

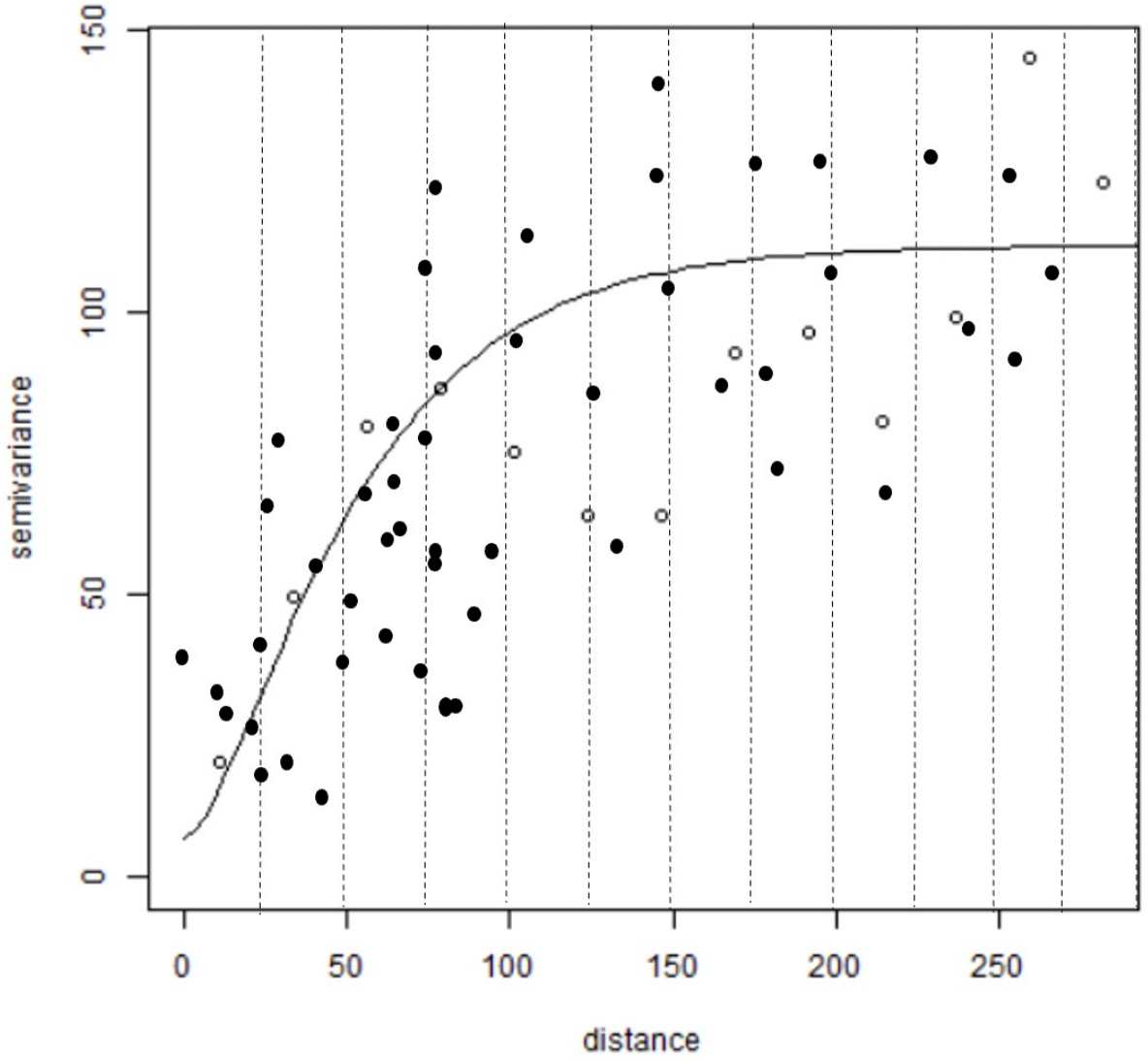


Gimond, M. 2020. *Geodesic geometry*. [online] https://mgimond.github.io/

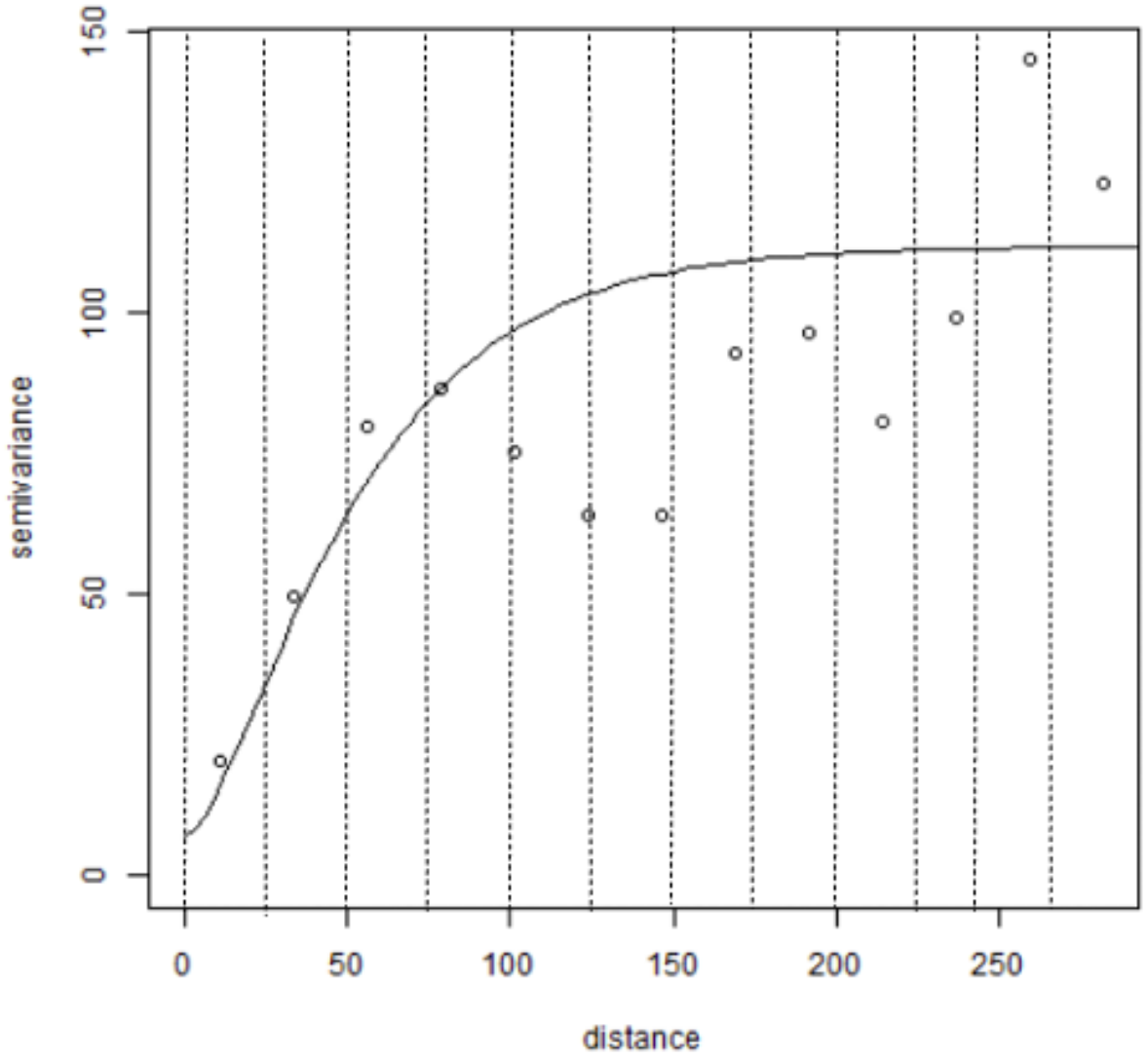
Spatial data interpolation: Kriging

- Considers both distance and degree of variation between known data points when estimating values in unknown areas.
- Assumption also here: closer things are more predictable and have less variability, while distant things are less predictable and less related.
- Kriging is a complex, multistep process starting with a semi-variogram.

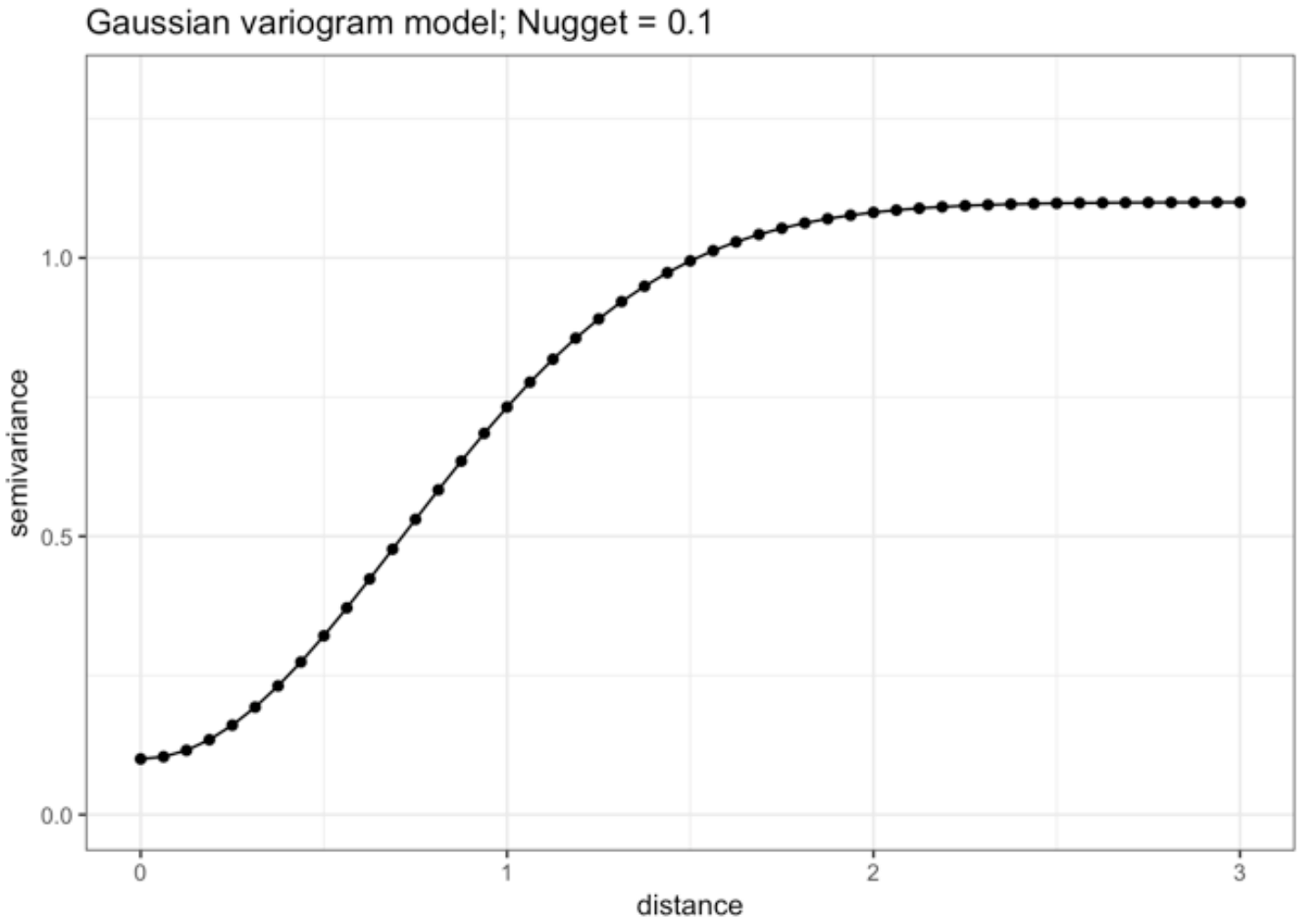
Spatial data interpolation: Kriging



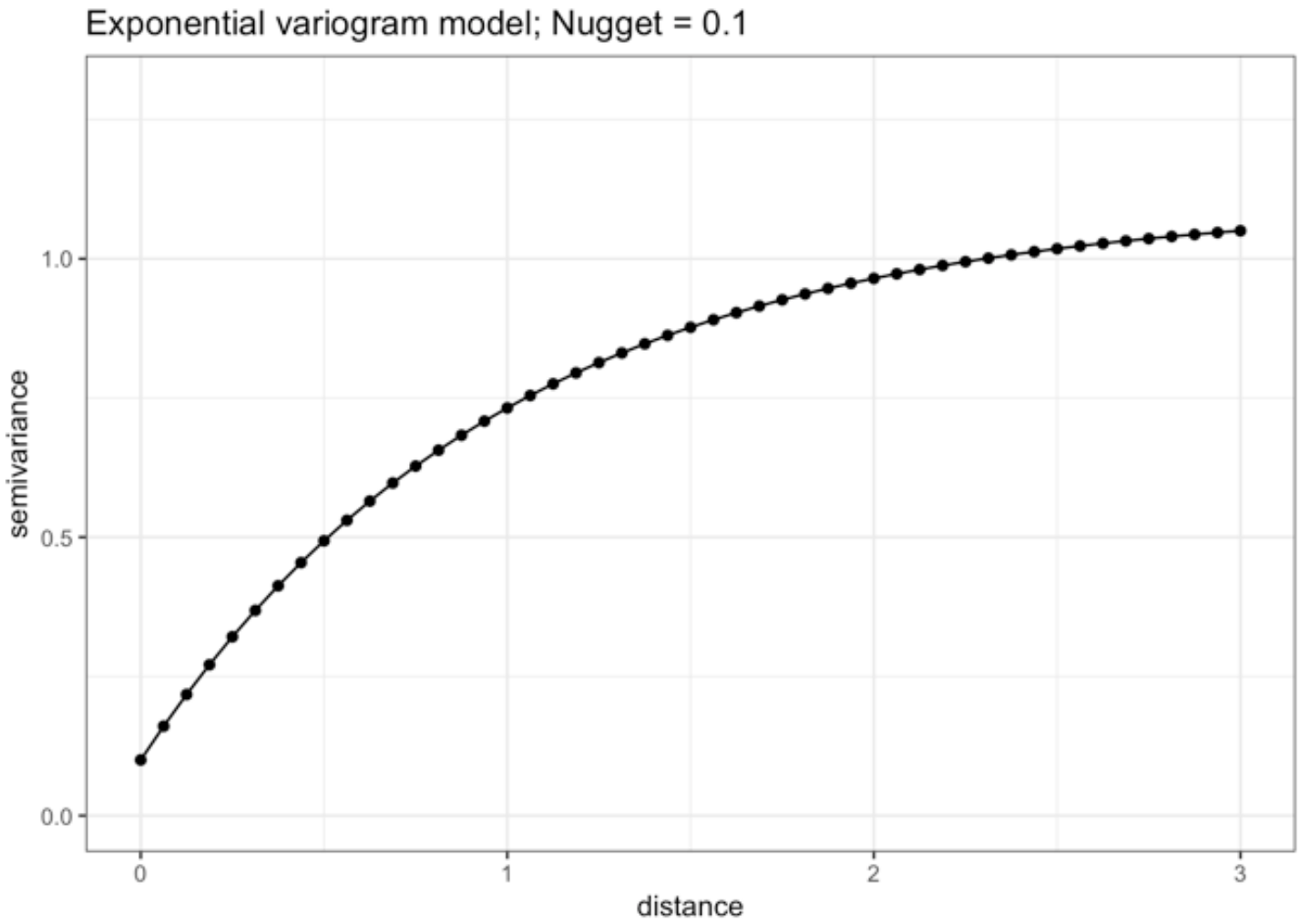
Spatial data interpolation: Kriging



Spatial data interpolation: Kriging



Spatial data interpolation: Kriging



IDW versus Kriging

- IDW assumes that spatial autocorrelation between neighboring points is proportional to the distance (and that it can be defined by distance reverse function).
- Kriging assumes that distance (mainly) or directionality between sampling points reflects the spatial autocorrelation, and functions can be fitted to describe the correlation between points (and explain the variation on the surface).

Conclusion

- Raster data comes with raster specific functions and operations.
- Raster data become important in the context of certain types of categorical data as well as continuous data.
- Spatial data interpolation is the idea to estimate unknown values of a phenomenon – spatial autocorrelation is the underlying process.
- Because spatial data interpolation tries to create a continuous surface we need to us the raster data model.

Some pointers for the exam

Exam format

- 2-hour timed exam
- 2 essays (1,000 word limit per question), aim to spend one hour on each
- 6 questions to choose from a range of topics covered by the lectures across the term
- No questions on coding or programming: focus on theory, underlying principles and laws, methods and applications
- Some in text citations are expected, but do not go overboard (no reference list)

Exam general guidance

General

Any essay-based answer should demonstrate the ability to construct a clear argument, and build a coherent answer providing evidence to make each point, drawing on readings and case studies as appropriate.

Strategy

First 10 minutes planning your response. Then you would likely spend the next 40 minutes writing out that response. Then you might spend the final 10 minutes reading through your piece to check for clarity.

Exam general guidance

- Demonstrate the ability to construct a clear argument: make sure you have an Introduction, Analysis/Discussion and Conclusion.
- Build a coherent answer: think about the logic of your answer, ‘build’ the argument from point to point.
- Provide evidence drawing on readings and case studies: use the book chapters and articles in the reading list to substantiate your points; you might use books as your “technical reference” whilst articles for case studies can be used to illustrate your points.

Exam essay structure

- Introduction
- Prioritise your analysis points (2 – 4)
  - Make your point as clear as possible, use a single sentence
  - Example with some in-text citations
- Conclusion to summarise your argument

Exam marking criteria

Marking Criteria for Exams[3]

	Inadequate	Adequate	Fair	Good	Excellent	Outstanding	Exceptional
	1-19: 5 inadequate 1-5 20-29: 4 inadequate 1-5 30-39: 3 inadequate 1-5	40-49: Majority of 1-5 Adequate or higher	50-59: Majority 1-5 Fair or higher	60-69: Majority 1-5 Good or higher	70-79: Majority 1-5 Excellent or higher	80-89: Majority 1-5 Outstanding or higher	90+: Majority 1-5 Exceptional
1. Response to the task set	Either no argument or argument is inept & irrelevant. Conclusions absent or irrelevant.	An indirect response to the task set, with gesture towards a relevant argument & conclusions.	A reasonable response with a limited sense of argument & partial conclusions.	A sound response with a reasonable argument & straightforward, logical conclusions.	A distinctive response with a clear argument & sensible conclusions; evidence of nuance.	Impressive response with nuanced argument, presenting significant & nuanced insights.	Exceptional response with very sophisticated argument ending in subtle conclusions.
2. Grasp of relevant issues	General misunderstanding of issues discussed.	Rudimentary, inter-mittent grasp of issues with confusions.	Reasonable grasp of issues & their broader implications.	Sound understanding, with insights into broader implications.	Thorough grasp w/ some sophisticated insights.	Striking grasp of complexities & significance of issues.	Exceptional grasp of complexities & issues' significance.
3. Reflection, thought, & conceptual framework	Erroneous or un-conceptual analysis. Poor understanding of basics of the taught materials.	Analysis relies on partial reproduction of taught materials. Some concepts absent or wrongly used.	Reasonable reproduction of taught materials. Rudimentary use of concepts.	Evidence of student's own analysis. Concepts effectively defined & used systematically.	Innovative analysis. Concepts deftly defined & used with some theoretical context.	Impressive thought, insights & analysis. Concepts deftly defined & used w/ strong context.	Engaged / cutting edge work. Sophisticated conceptual framework used in context.
4. Knowledge of literature & empirical topic	No evidence of, or largely inaccurate use of, conceptual literature & empirical material.	Rudimentary knowledge of required reading & empirical aspects of topic, with inaccuracies.	Limited knowledge of required reading & empirical aspects of the topic, with inaccuracies.	Sound knowledge of required reading & empirical aspects, with occasional inaccuracies.	Thorough knowledge of relevant reading & empirical aspects of the topic.	Impressive knowledge of relevant literature & empirical aspects of the topic.	Comprehensive knowledge of relevant literature & empirical aspects of the topic.
5. Evidence to support claims	No effective use of evidence to support any claims made.	Evidence rarely or ineffectively used to support claims.	A few claims warranted by evidence.	The essay's most crucial claims are supported by relevant evidence.	The essay's claims are mostly supported by appropriate evidence.	The essay's claims are warranted by apt, accurate evidence.	Claims are warranted by accurate, up-to-date & detailed evidence.
6. Structure & planning	Structure not discernible; minimal progression. (-3)	Structure discernible, but frequently absent. (-2)	Structure is apparent; frequent digression. (-1)	Conventional structure w/ rare digressions. (0)	Logical, coherent structure. (1)	Outstanding structure adds to overall effect. (2)	Exceptional structure crucial to argument. (3)
7.Writing style[4]	Style is consistently unclear. Inappropriate word choices. (-3)	Style & word choice lacks fluency & argument is only clear in parts. (-2)	Style generally clear but errors in use of jargon, grammar & spelling. (-1)	Style largely clear & fluent. Use of jargon is generally accurate. (0)	Style consistently clear & fluent with accurate use of terms. (1)	Style is elegant & precise with accurate use of jargon. (2)	Sophisticated style w/ impeccable spelling, grammar & jargon. (3)

[3] For an incomplete answer, apply the criteria for which any evidence has been provided (e.g., an essay plan as evidence of structure). An incomplete answer will not necessarily constitute a fail.

[4] The clarity of handwriting is not a marking criteria, however where handwriting is illegible work may have to be transcribed at student expense.

Exam further help

- Geography Exam Preparation Session:

  Tuesday March 14 from 13h00-14h30 online (joining details on Moodle).
- Geocomputation Exam Q&A Session:

  Friday April 28 from 11h00-12h00 in Bentham House LG17 Lecture Theatre B.
- Past Exam Papers (e.g. 2020, 2021) to get an idea of the type of questions to expect.

Geocomputation Extra Help Session

- Friday March 24 from 14h00-16h00 in North-West Wing 304.
- Bring your own laptop.
- Not mandatory.

Geocomputation Extra Help Session

- Monday April 3 from 12h00-14h00 in North-West Wing 1.16.
- Bring your own laptop.
- Not mandatory.

Questions

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