Geographic Information Systems 2018/19
Week 11, Topic 1

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In this session...

Interpolation

Multi-criteria Evaluation

Modeling

Spatial Interpolation

Spatial interpolation is the process of using points with known values to estimate values at other points.

In GIS applications, spatial interpolation is typically applied to a raster with estimates made for all cells. Spatial interpolation is therefore a means of creating surface data from sample points.

Control Points are points with known values. They provide the data necessary for the development of an interpolator for spatial interpolation.

The number and distribution of control points can greatly influence the accuracy of spatial interpolation.

Type of Spatial Interpolation

Spatial interpolation can be global or local.

Spatial interpolation can be exact or inexact.

Spatial interpolation can be deterministic or stochastic.

Global

- Uses every known point available to estimate a value
- Designed to capture the general trend

Local

- Uses a sample of known points
- Designed to capture short range variation

Exact

- Predicts a value at a point location that is the same as its known value

Inexact

- Predicts a value at a point that differs from its known value

Deterministic

- Provides no assessment of errors

Stochastic

- Considers the presence of randomness and offers assessment of prediction errors

A classification of spatial interpolation methods

Global		Local	
Deterministic	**Stochastic**	**Deterministic**	**Stochastic**
Trend surface (inexact)*	Regression (inexact)	Thiessen (exact) Density estimation (inexact) Inverse distance weighted (exact) Splines (exact)	Kriging (exact)

* Given some required assumptions, trend surface analysis can be treated as a special case of regression analysis and thus a stochastic method

Global Methods

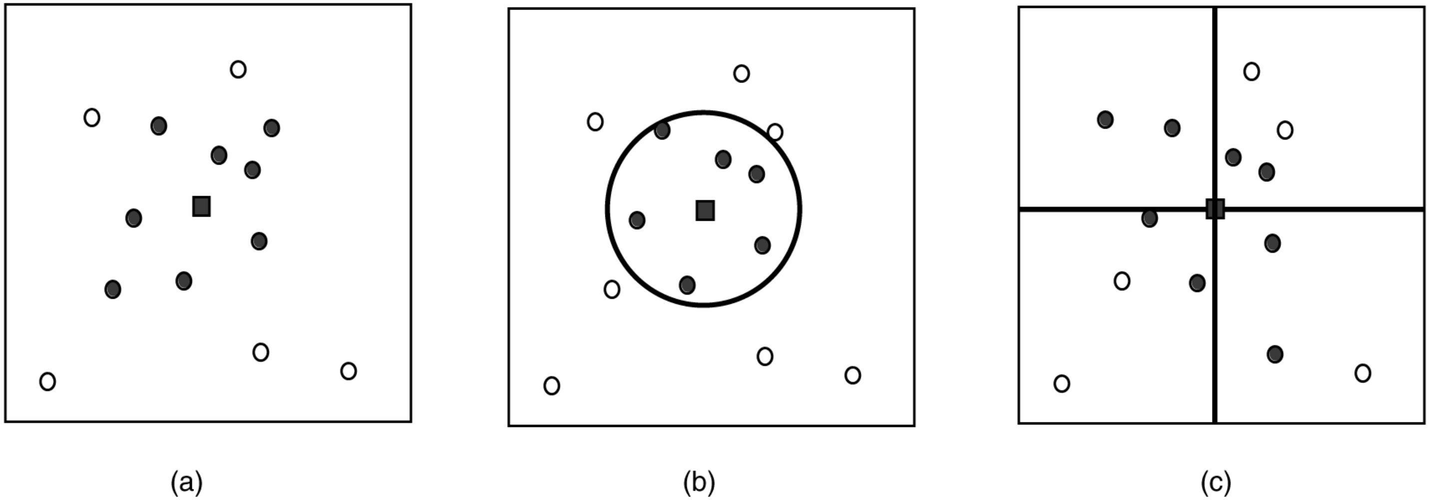
Trend surface analysis, an inexact interpolation method, approximates points with known values with a polynomial equation.

“Goodness of fit” can be measured and tested.

A **regression model** relates a dependent variable to a number of independent variables in a linear equation (an interpolator), which can then be used for prediction or estimation.

Local Methods

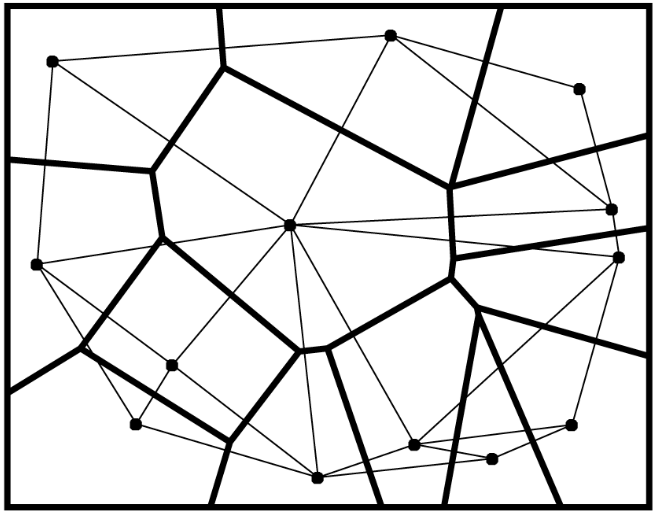
Because local interpolation uses a sample of known points, it is important to know how many known points to use, and how to search for those known points.



Three search methods for sample points: (a) find the closest points to the point to be estimated, (b) find points within a radius, and (c) find points within each quadrant.

Thiessen Polygons

Thiessen polygons assume that any point within a polygon is closer to the polygon’s known point than any other known points.

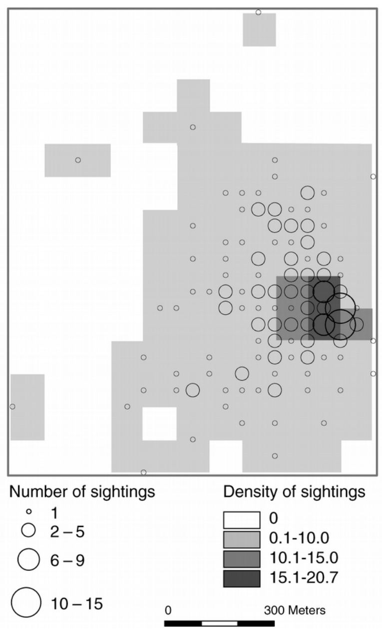


Thiessen polygons (in thicker lines) are interpolated from the known points and the Delaunay triangulation (in thinner lines).

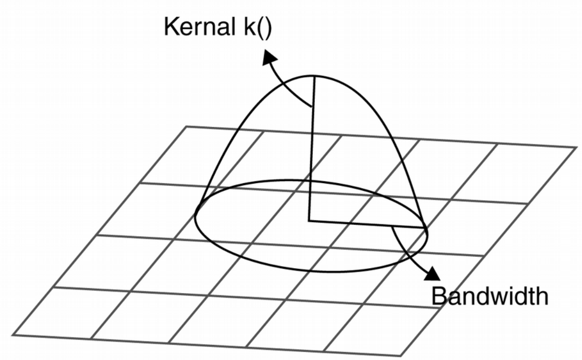
Density Estimation

Density estimation measures cell densities in a raster by using a sample of known points.

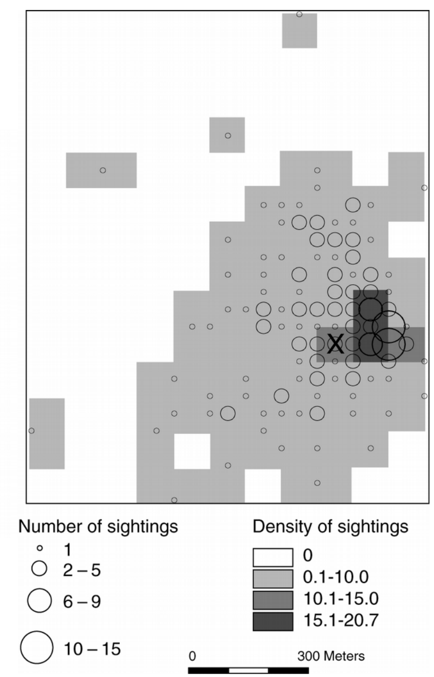
There are simple and kernel density estimation methods.



Deer sightings per hectare calculated by the simple density estimation method.



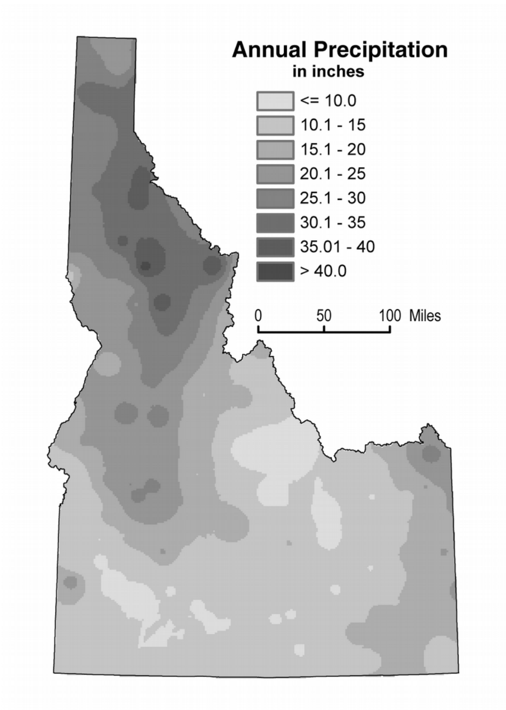
A kernel function, which represents a probability density function, looks like a “bump” above a grid.



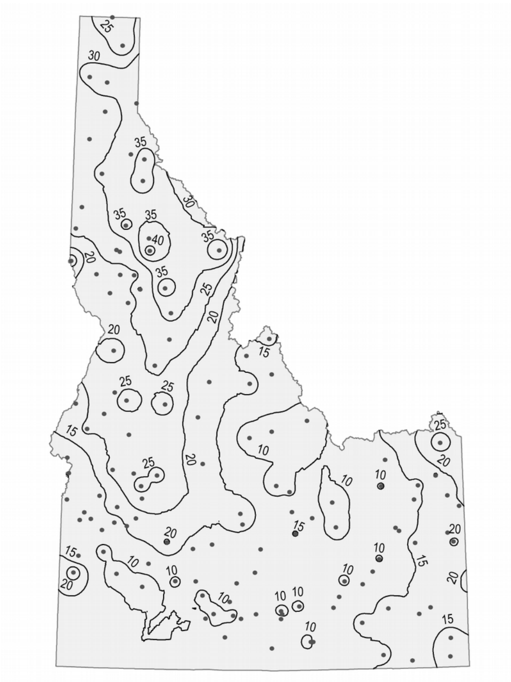
Deer sightings per hectare calculated by the kernel estimation method.. The letter X marks the cell

Inverse Distance Weighted Interpolation

Inverse distance weighted (**IDW**) interpolation is an exact method that enforces that the estimated value of a point is influenced more by nearby known points than those farther away.

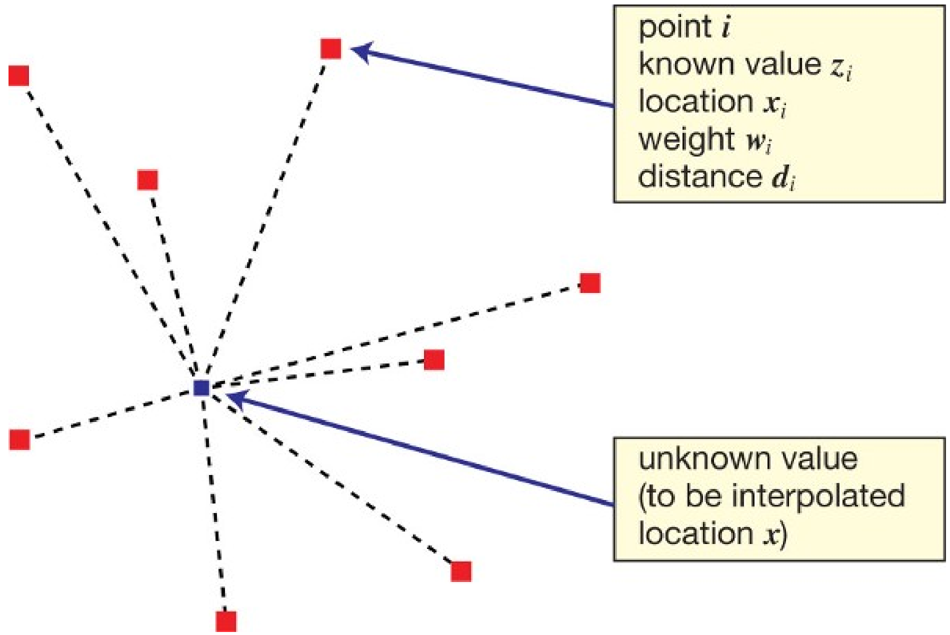


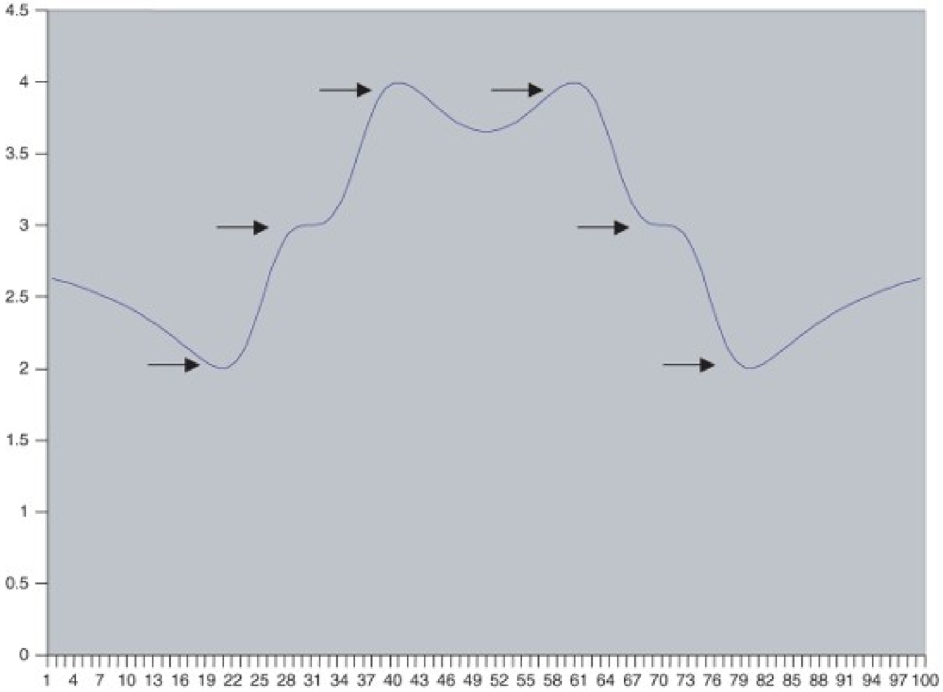
An annual precipitation surface created by the inverse distance squared method.



An isohyet map created by the inverse distance squared method.

Inverse Distance Weighted





Issues with IDW

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

Thin-Plate Splines

Thin-plate splines create a surface that passes through the control points and has the least possible change in slope at all points. In other words, thin-plate splines fit the control points with a minimum curvature surface.

Kriging

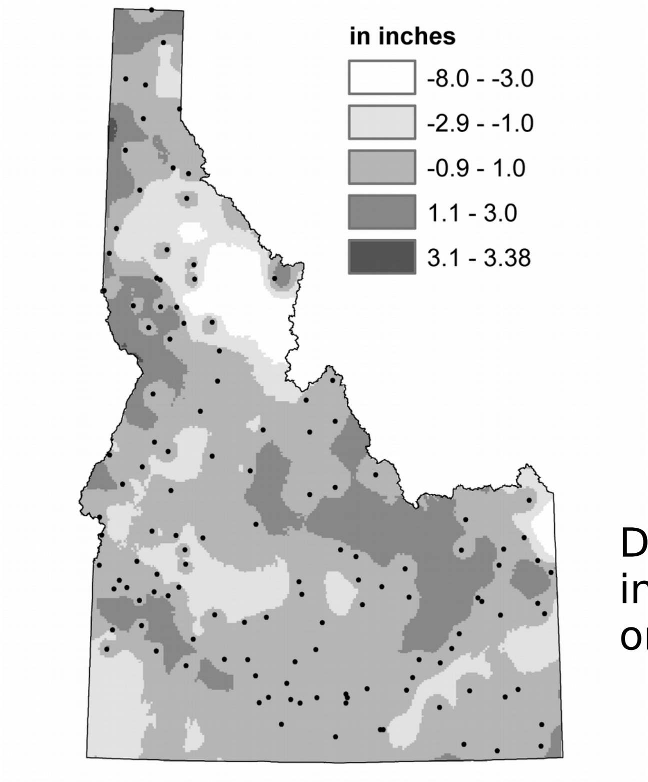
Kriging is a geostatistical method for spatial interpolation. Kriging can assess the quality of prediction with estimated prediction errors.

Kriging assumes that the spatial variation of an attribute is neither totally random (stochastic) nor deterministic. Instead, the spatial variation may consist of three components: a spatially correlated component, representing the variation of the regionalized variable; a “drift” or structure, representing a trend; and a random error term.

The interpretation of these components has led to development of different kriging methods for spatial interpolation.

Comparison of Spatial Interpolation Methods

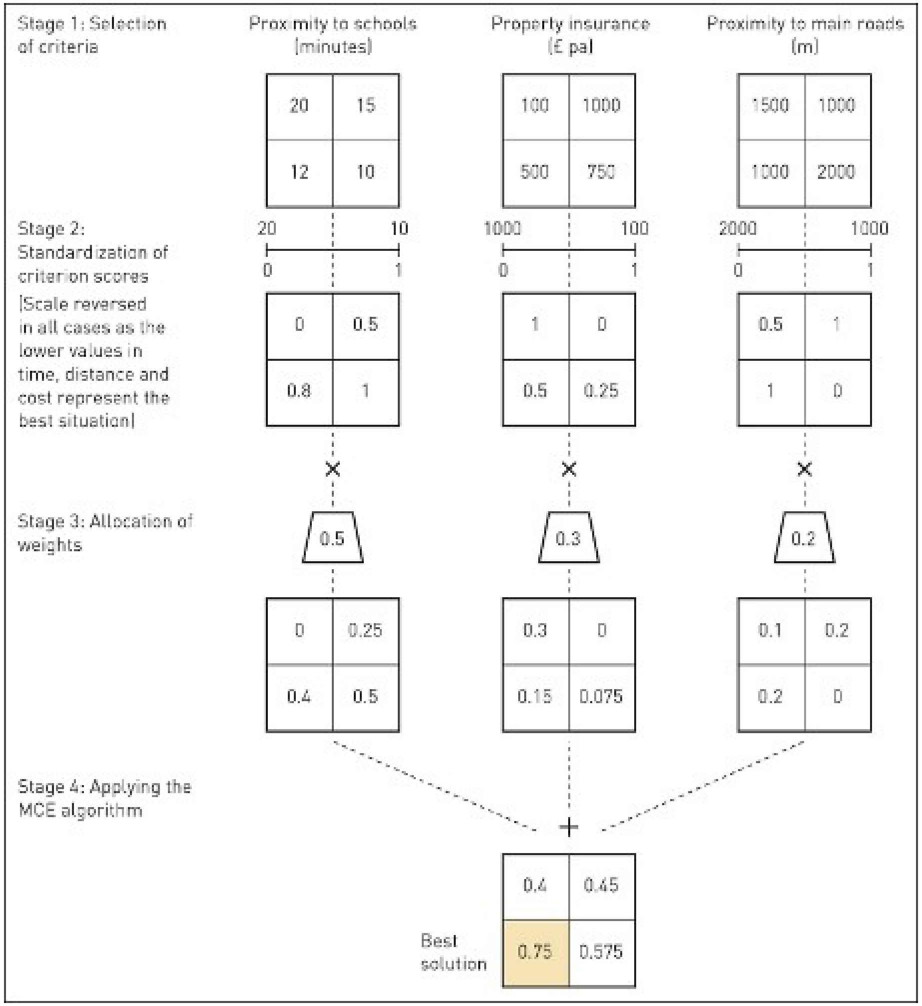
Using the same data but different methods, we can expect to find different interpolation results. Likewise, different predicted values can occur by using the same method but different parameter values.



Differences between the interpolated surfaces from ordinary kriging and IDW.

Multi-criteria Evaluation

- Simplified MCE algorithm
  - Weighted linear summation technique
- Steps
  - Define problem
  - Selection of criteria
  - Standardisation of criterion scores
  - Allocation of weights
  - Application of algorithm
- Problems
  - Choice of algorithm
  - Specification of weights



Modeling

Spatial form and spatial process

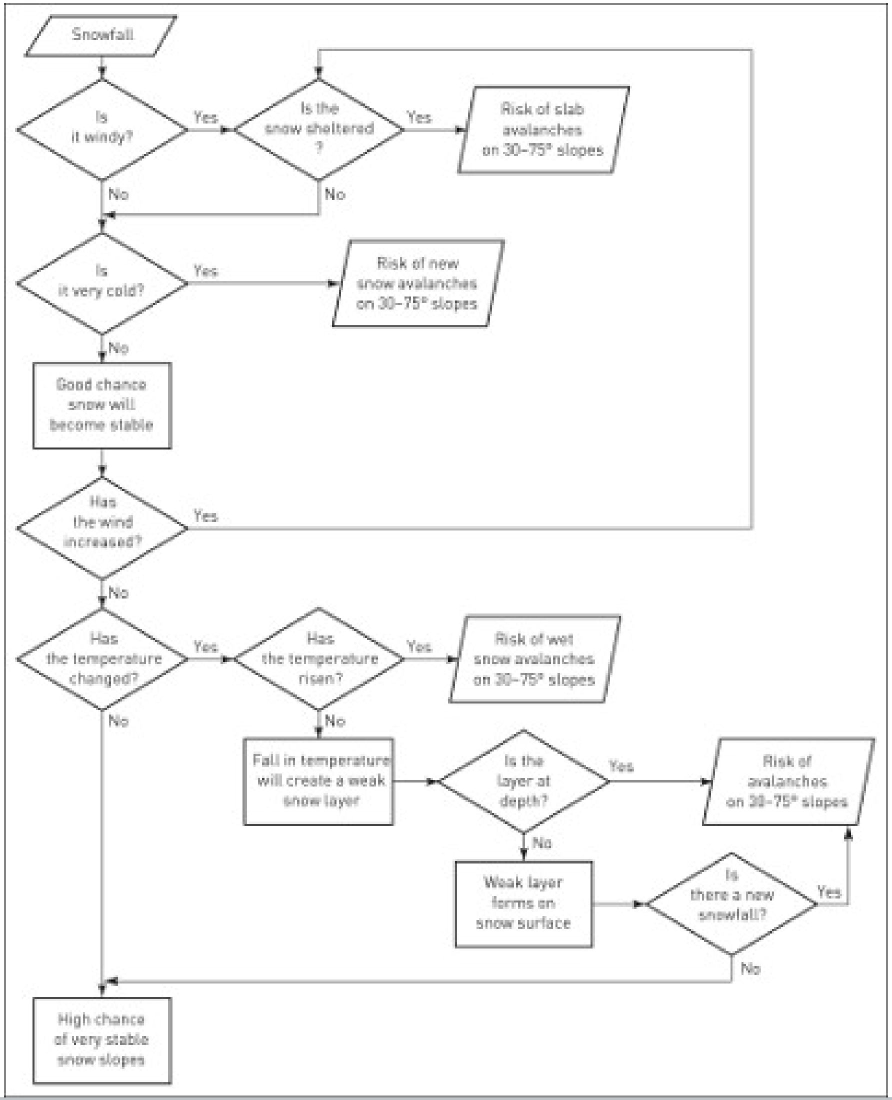
- Form
  - How the world looks
- Process
  - How the world works
- What factors (processes) act to change form?
- Examples
  - Population change
  - Consumer spending patterns
  - Soil erosion
  - Climate change

Examples of types of process models

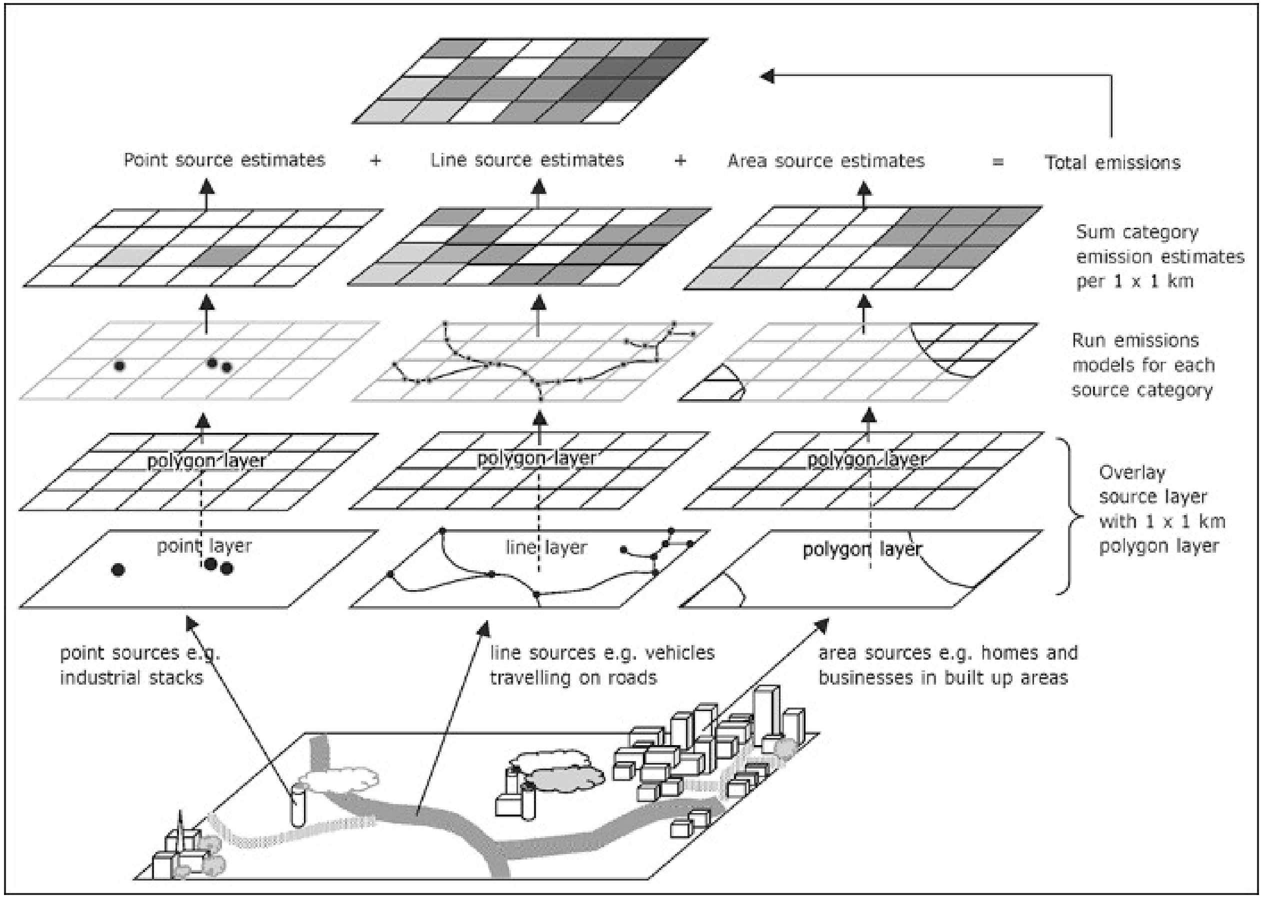
- Physical process models
- Human process models
- Decision-making models
- Any model simulates real world processes
- Aids understanding of real world processes
- Cheaper (and safer) to simulate rather than do the real thing
- A priori models
  - Used where a body of theory is yet to be established
- Investigate whether a phenomenon is actually happening
  - Example: Global Warming

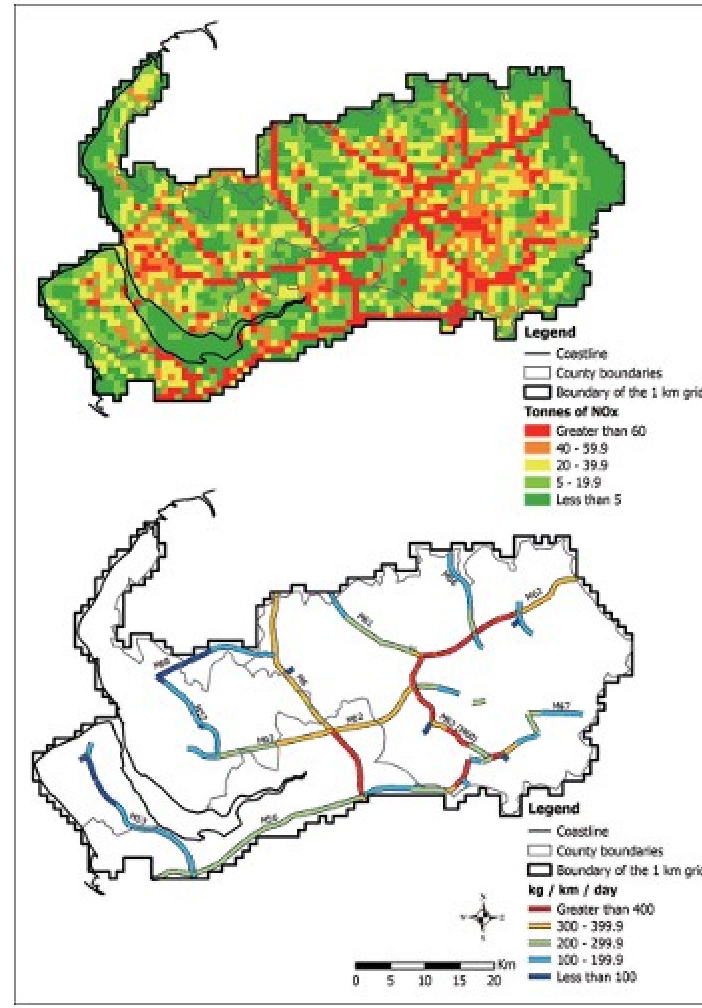
- A posteriori models
  - Designed to explore an established theory
- Natural and scale analogue models
  - Uses actual events or real-world objects as a basis
  - Scale models
    - Maps
    - Images
- Conceptual models
  - Usually expressed in verbal or graphical form
- Mathematical models
  - Statistical techniques
  - Stochastic or deterministic

Modeling Example
(Natural analogue model for predicting avalanche hazard)

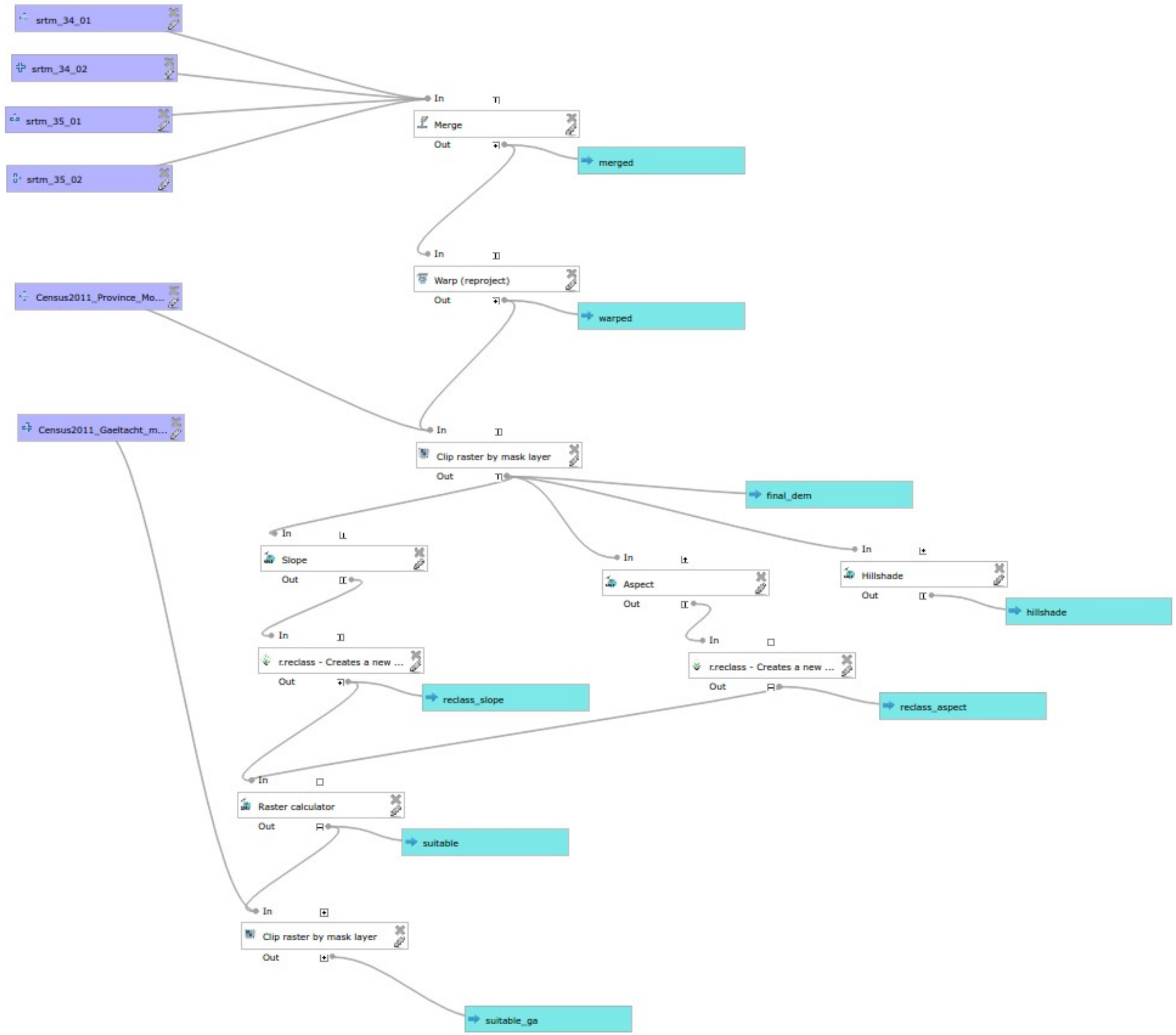


Modeling Example
(Modelling physical and environmental processes)





Modeling Example from QGIS



Coming next...

Bringing it all together – a worked example

Review and wrap up

And finally…

- … the exam