

Chapter 15. SPATIAL INTERPOLATION

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Key Concepts and Terms

Review Questions

Applications: Spatial Interpolation

Task 1: Use Trend Surface Model for Interpolation

Task 2: Use Kernel Density Estimation Method

Task 3: Use IDW for Interpolation

Task 4: Use Ordinary Kriging for Interpolation

Task 5: Use Universal Kriging for Interpolation

Challenge Question

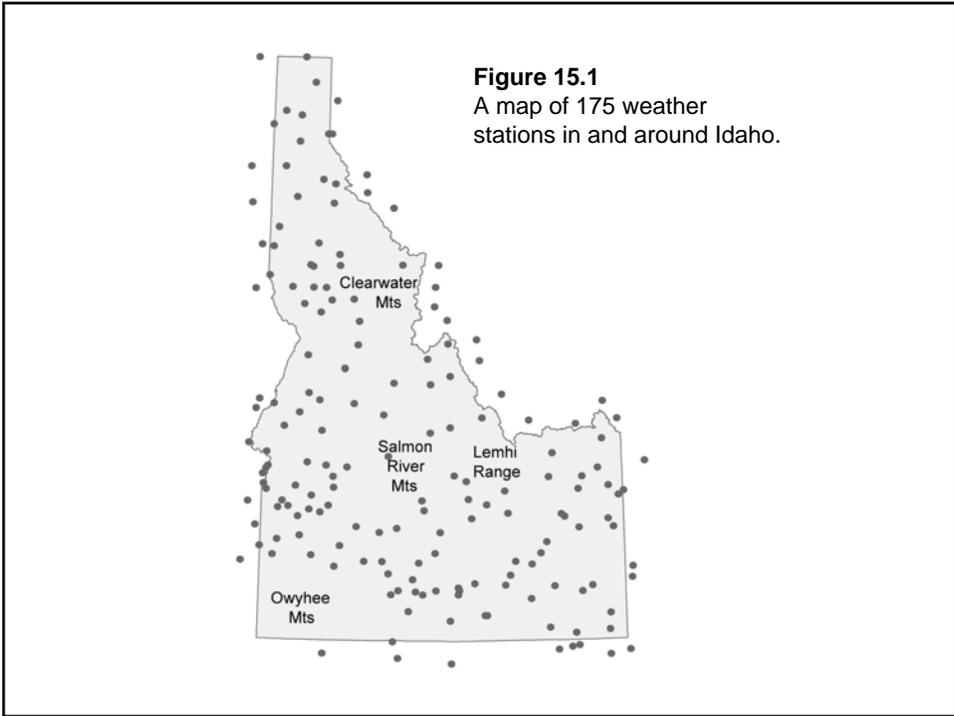
References

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.

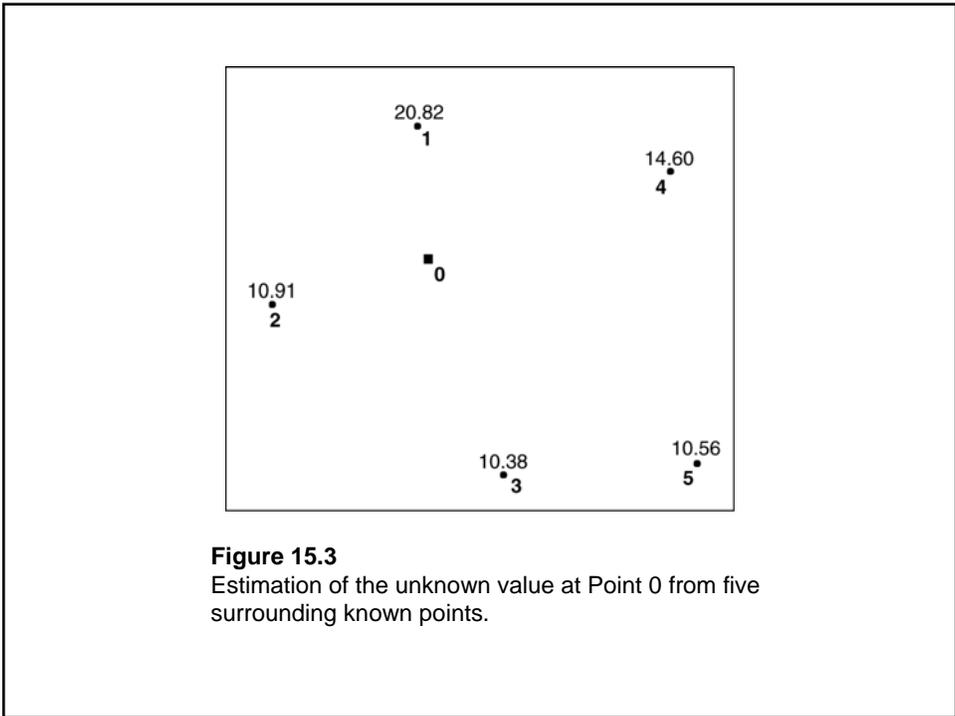
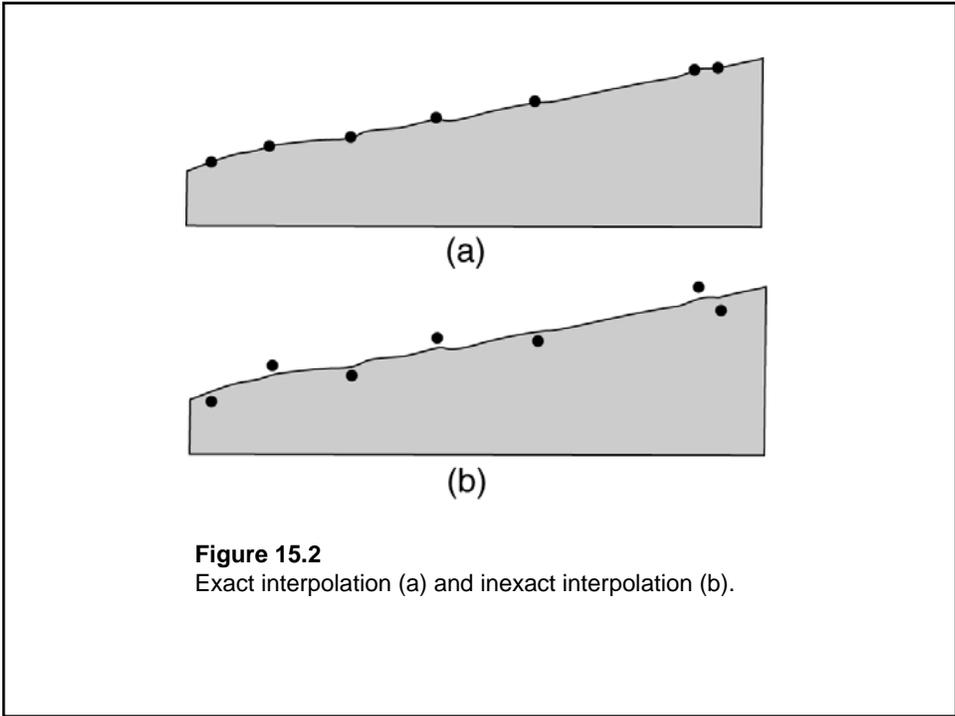
Control Points

- 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

- 1. Spatial interpolation can be global or local.
- 2. Spatial interpolation can be exact or inexact.
- 3. Spatial interpolation can be deterministic or stochastic.



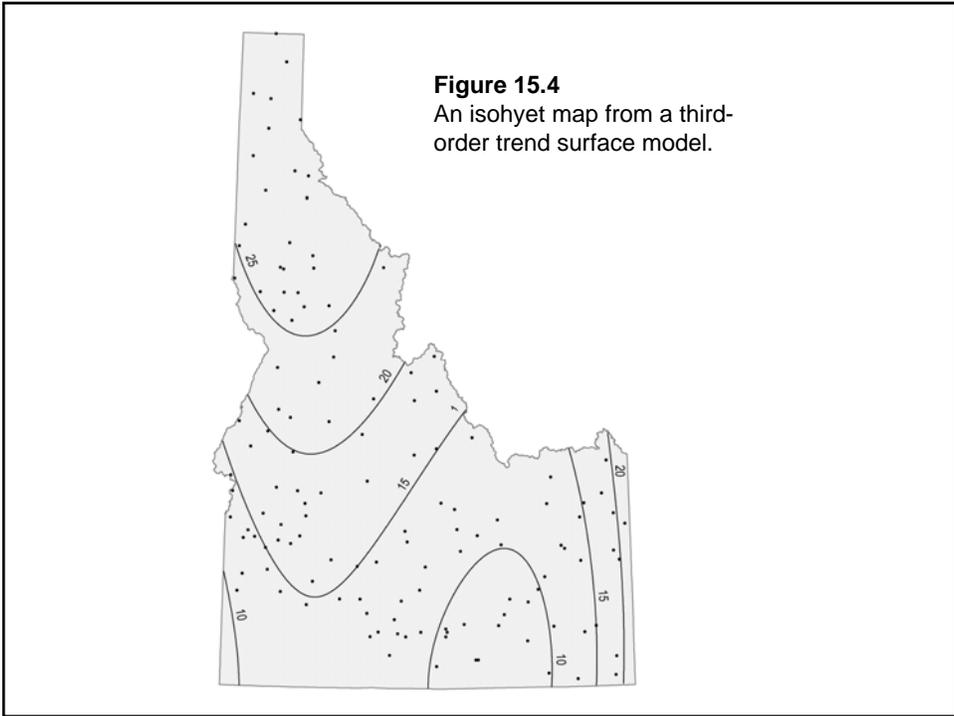
Global		Local	
Deterministic	Stochastic	Deterministic	Stochastic
Trend surface (inexact)*	Regression (inexact)	Thiessen (exact) Density estimation (inexact) Inverse distance weighted (exact) Splines (exact)	Kriging (exact)

*Given some required assumptions, trend surface analysis can be treated as a special case of regression analysis and thus a stochastic method (Griffith and Amrhein 1991).

Table 15.1 A classification of spatial interpolation methods

Global Methods

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

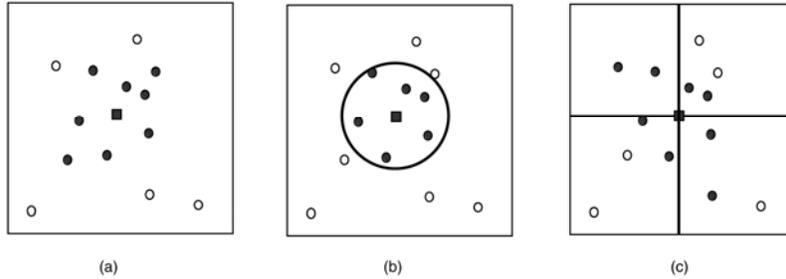


Figure 15.5

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.

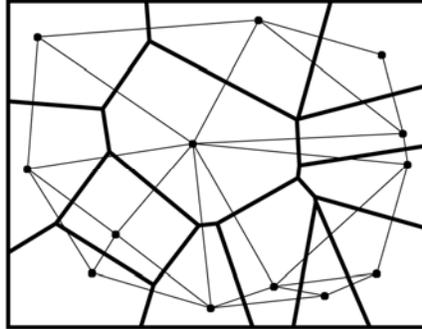


Figure 15.6

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.

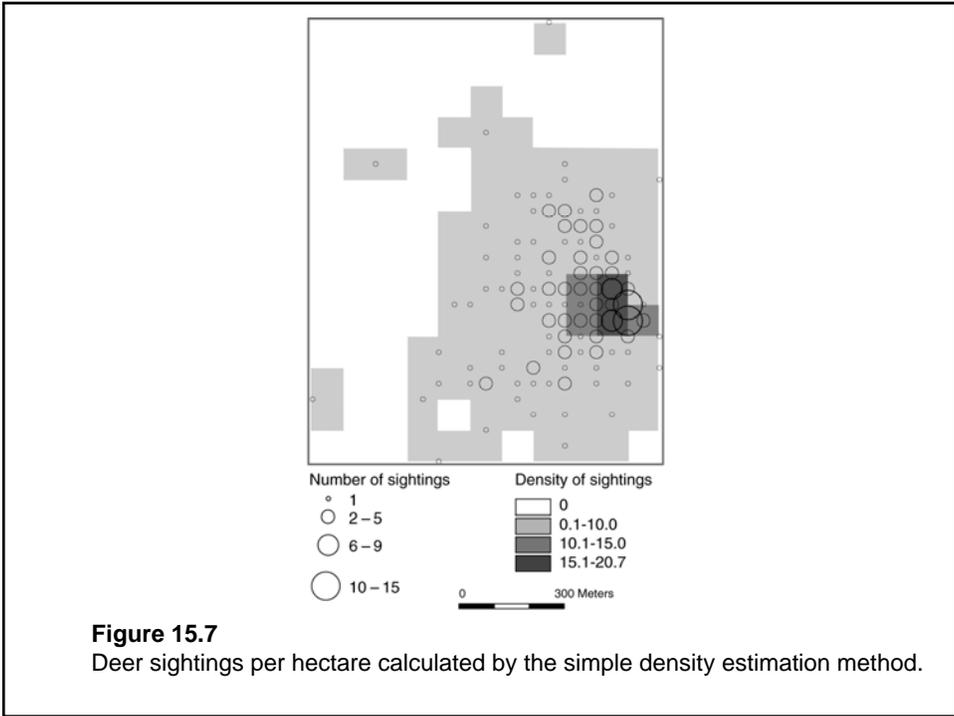


Figure 15.7
Deer sightings per hectare calculated by the simple density estimation method.

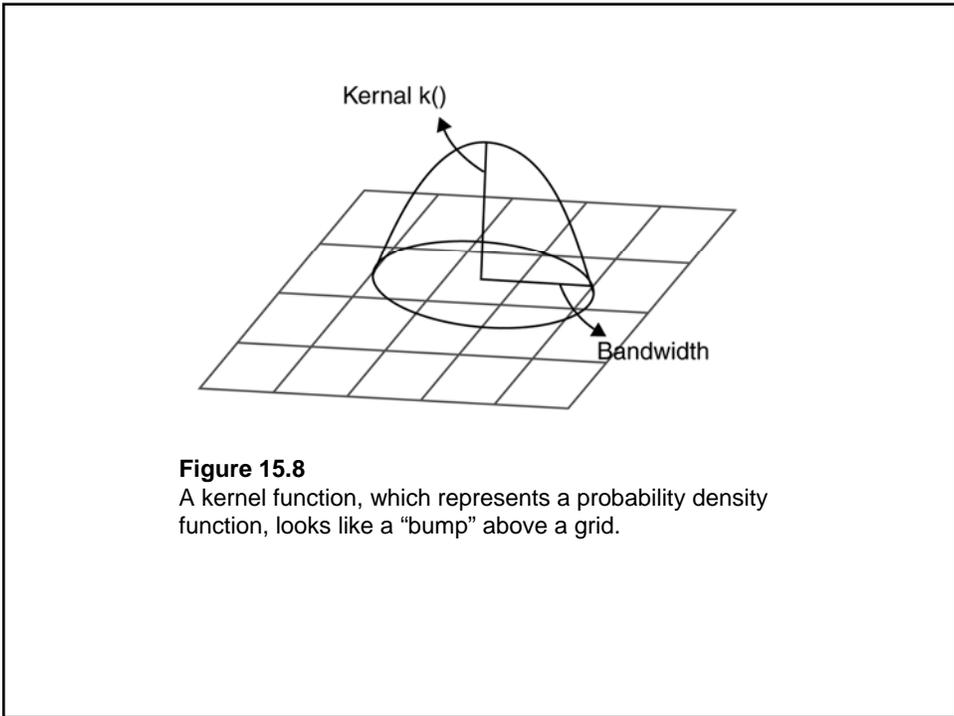
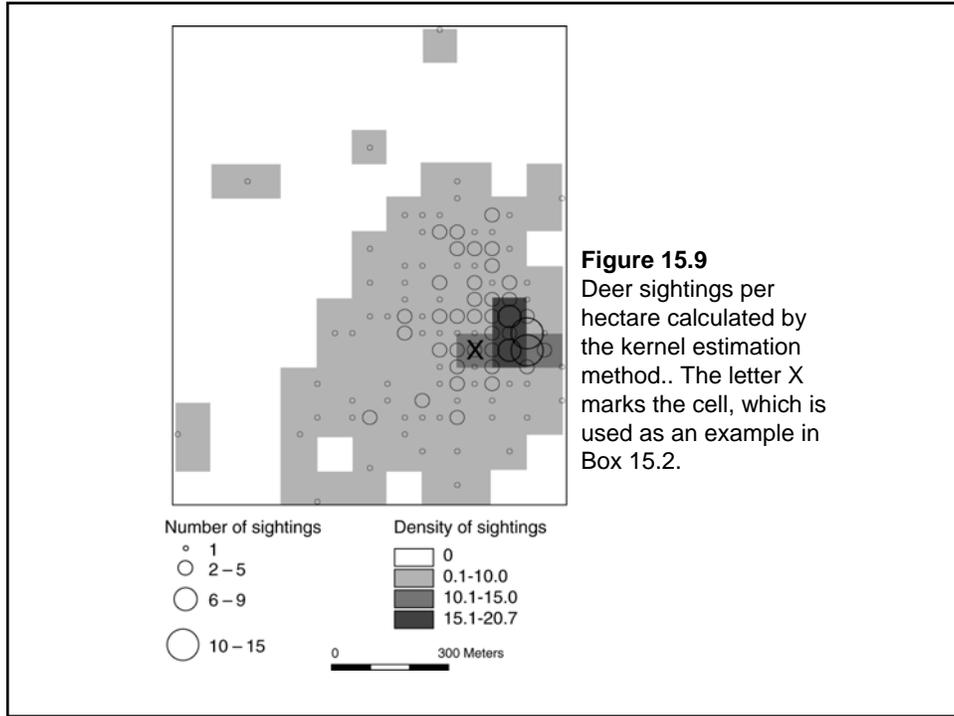


Figure 15.8
A kernel function, which represents a probability density function, looks like a "bump" above a grid.



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.

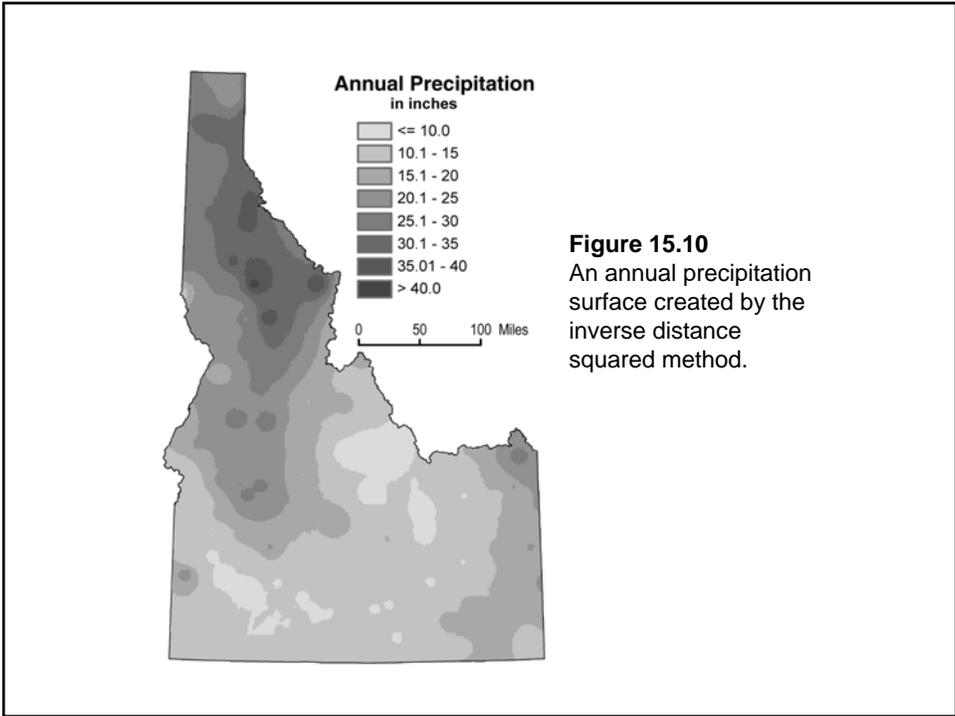


Figure 15.10
An annual precipitation surface created by the inverse distance squared method.

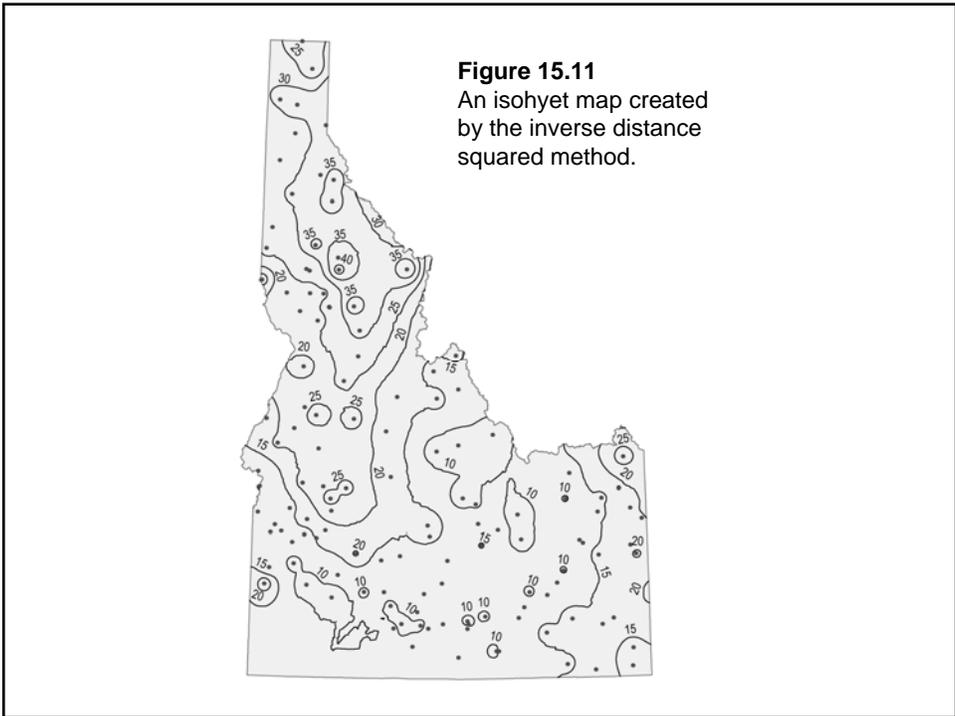


Figure 15.11
An isohyet map created by the inverse distance squared method.

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.

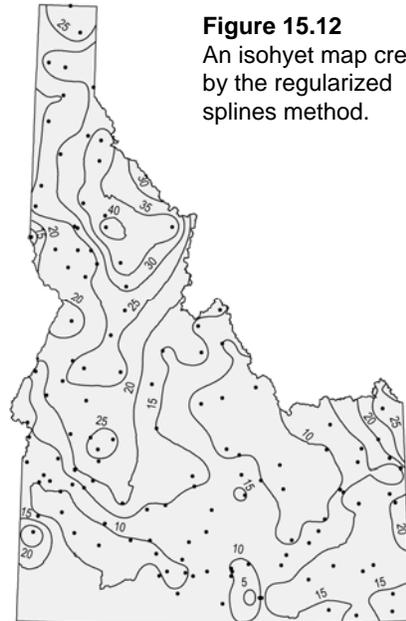
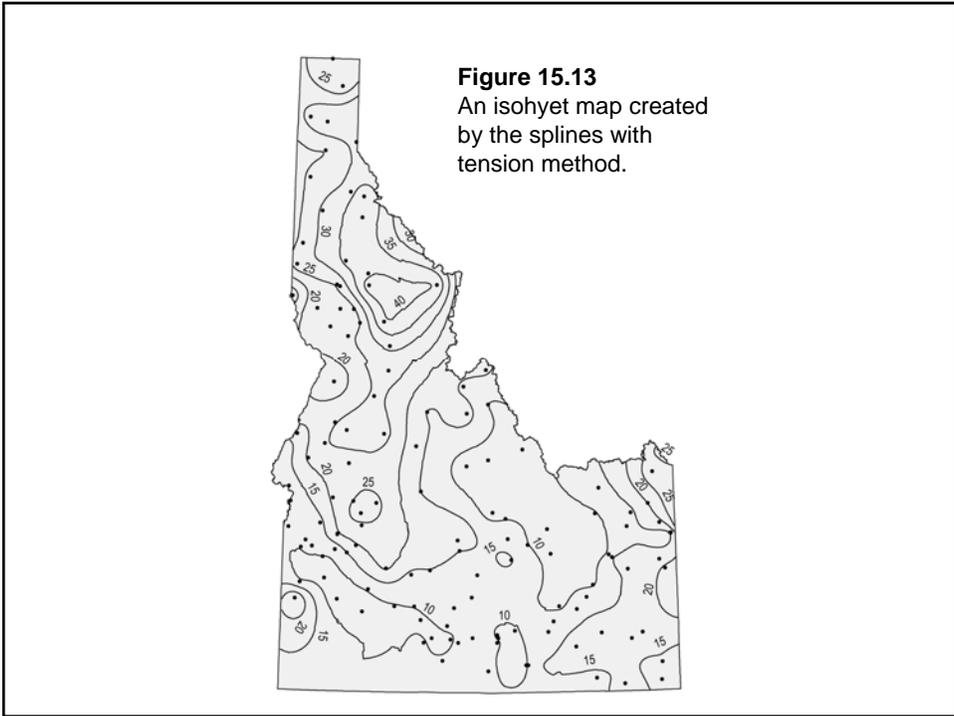


Figure 15.12
An isohyet map created
by the regularized
splines method.



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.

Semivariogram

- Kriging uses the semivariance to measure the spatially correlated component, a component that is also called spatial dependence or spatial autocorrelation.
- A semivariogram cloud plots semivariance against distance for all pairs of known points in a data set. If spatial dependence does exist in a data set, known points that are close to each other are expected to have small semivariances and known points that are farther apart are expected to have larger semivariances.

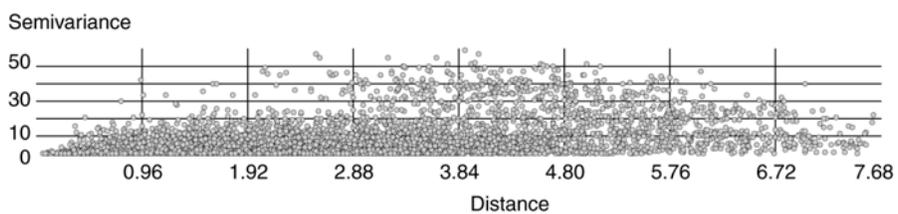


Figure 15.14
A semivariogram cloud.

Binning

With all pairs of known points, a semivariogram cloud is difficult to manage and use. Binning is a process that averages semivariance data by distance and direction.

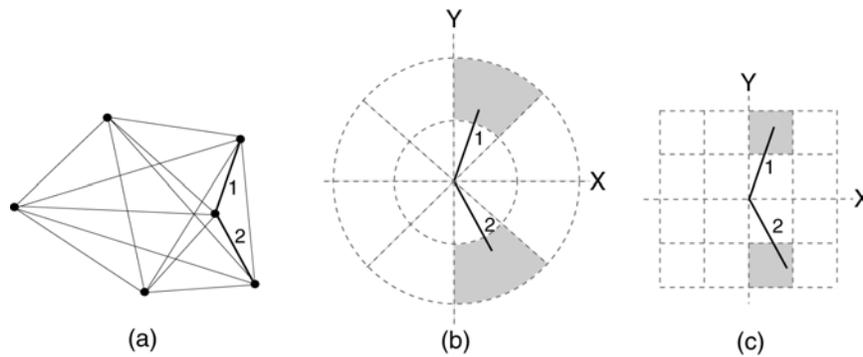


Figure 15.15

A common method for binning pairs of sample points by direction, such as 1 and 2 in (a), is to use the radial sector (b). Geostatistical Analyst to ArcGIS uses grid cells instead (c).

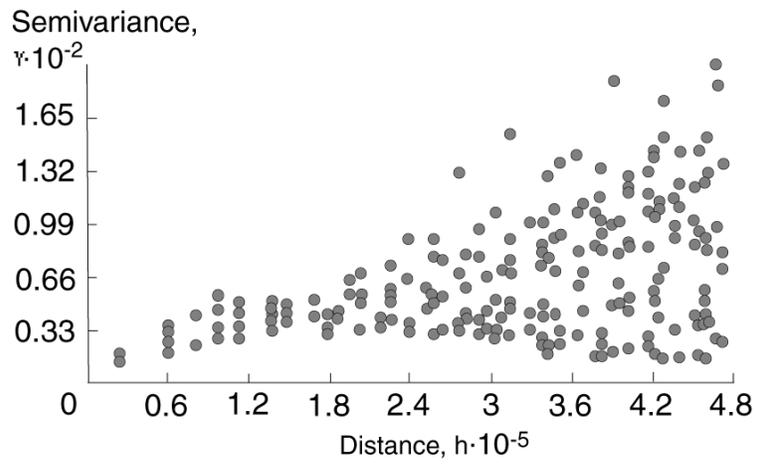


Figure 15.16
A semivariogram after binning by distance.

Model Fitting

A semivariogram must be fitted with a mathematical function or model so that it can be used for estimating the semivariance at any given distance.

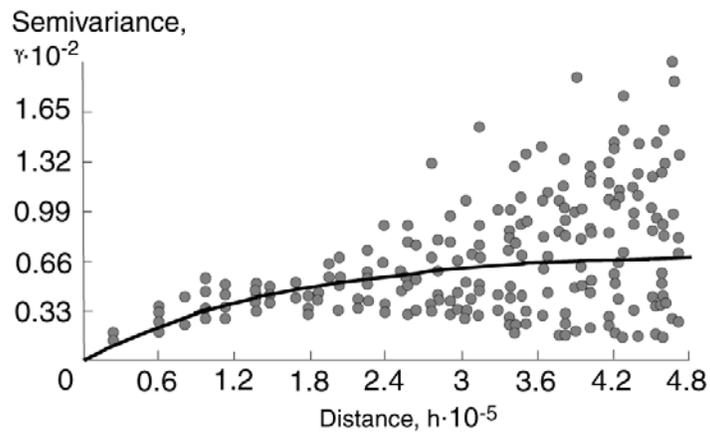


Figure 15.17
Fitting a semivariogram with a mathematical function or a model.

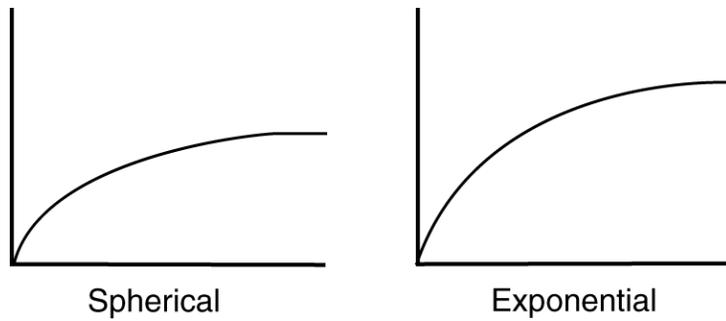


Figure 15.18
Two common models for fitting semivariograms: spherical and exponential.

Nugget, Range, and Sill

- The nugget is the semivariance at the distance of 0, representing measurement error, or microscale variation, or both.
- The range is the distance at which the semivariance starts to level off.
- The sill is the semivariance at which the leveling takes place.

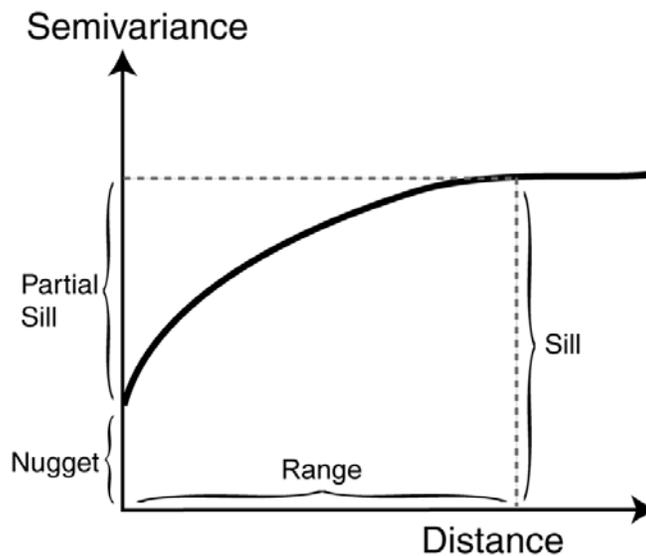


Figure 15.19
Nugget, range, sill, and partial sill.

Ordinary Kriging

Assuming the absence of a drift, ordinary kriging focuses on the spatially correlated component and uses the fitted semivariogram directly for interpolation.

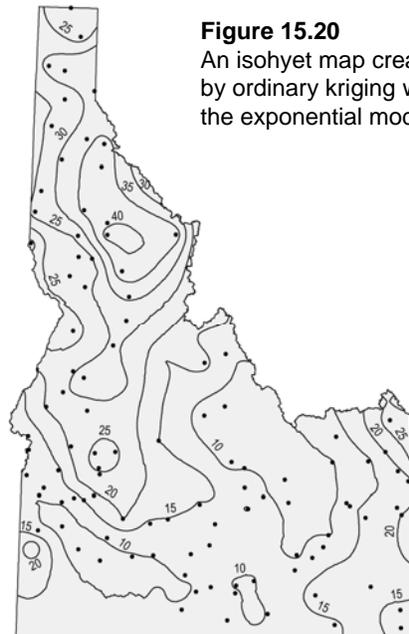
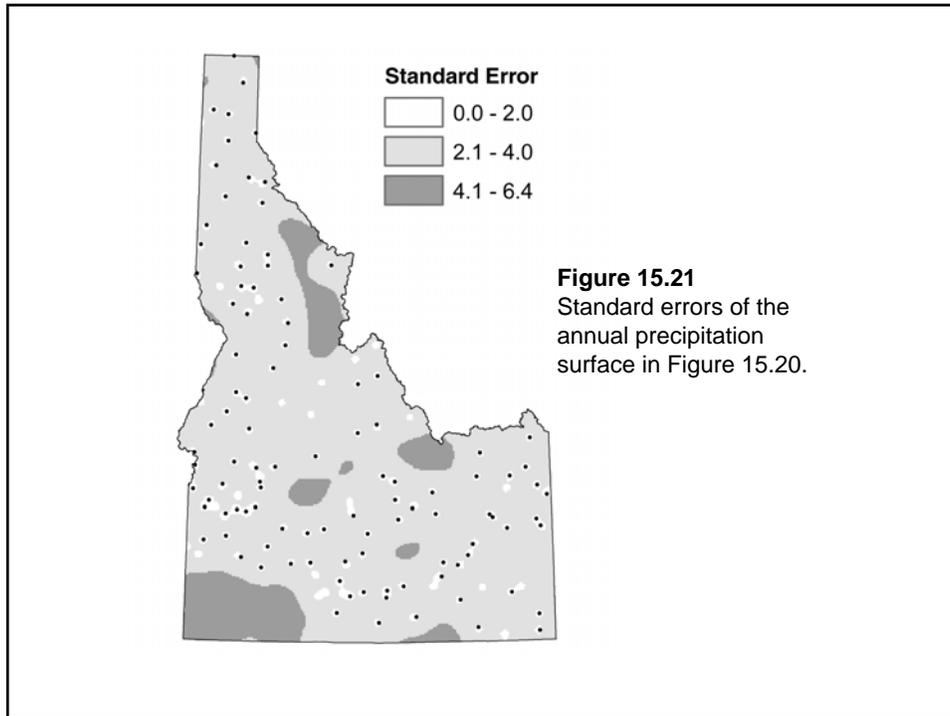
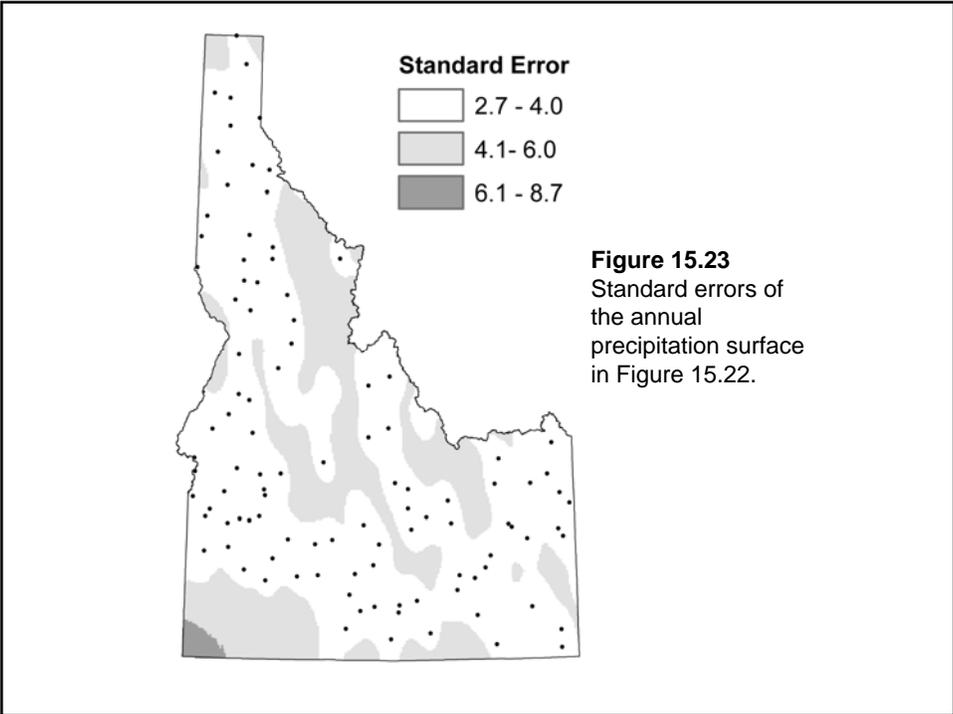
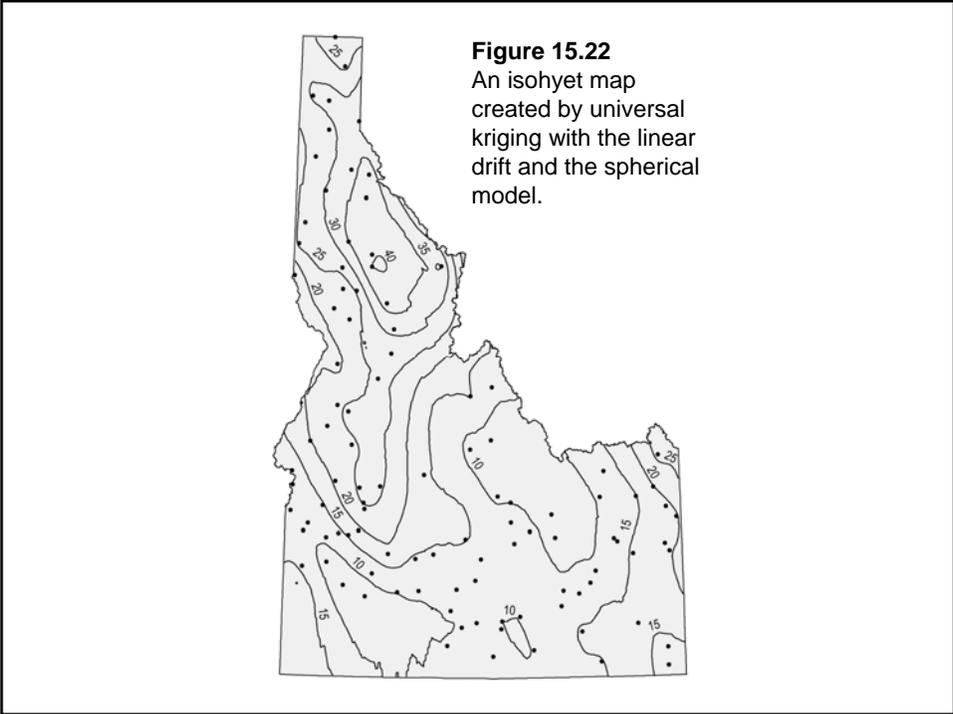


Figure 15.20
An isohyet map created
by ordinary kriging with
the exponential model.



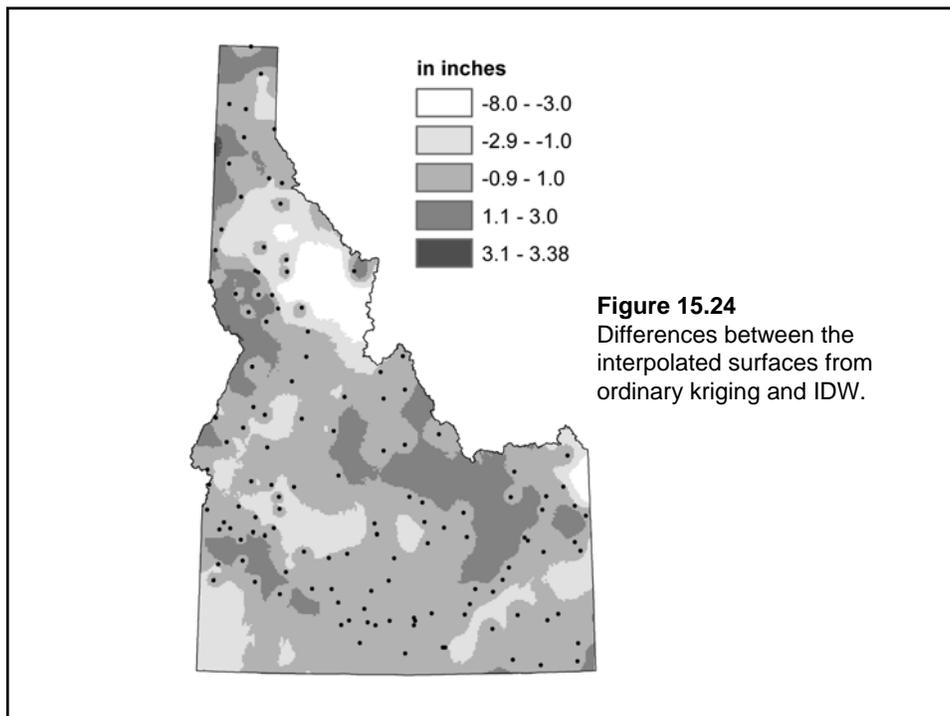
Universal Kriging

Universal kriging assumes that the spatial variation in z values has a drift or a trend in addition to the spatial correlation between the sample points.



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.



PRISM

<http://www.nrcs.usda.gov/technical/maps.html>