5

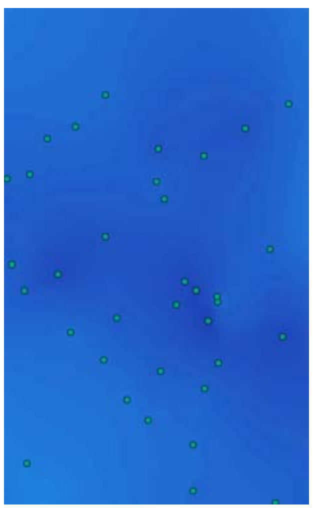
Interpolation Tools

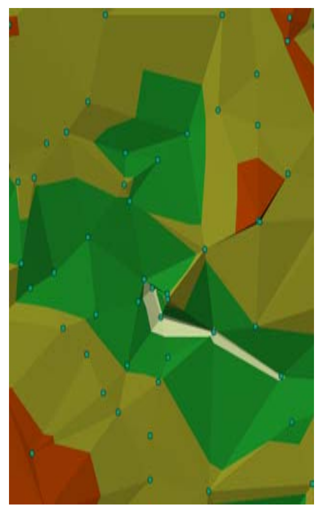
Lesson 5 overview

- Concepts
  - Sampling methods
  - Creating continuous surfaces
  - Interpolation
  - Density surfaces in GIS
- Interpolators
  - IDW, Spline,Trend, Kriging,Natural neighbors
  - TopoToRaster
- Assessing accuracy
- Exercise 5

Creating surfaces

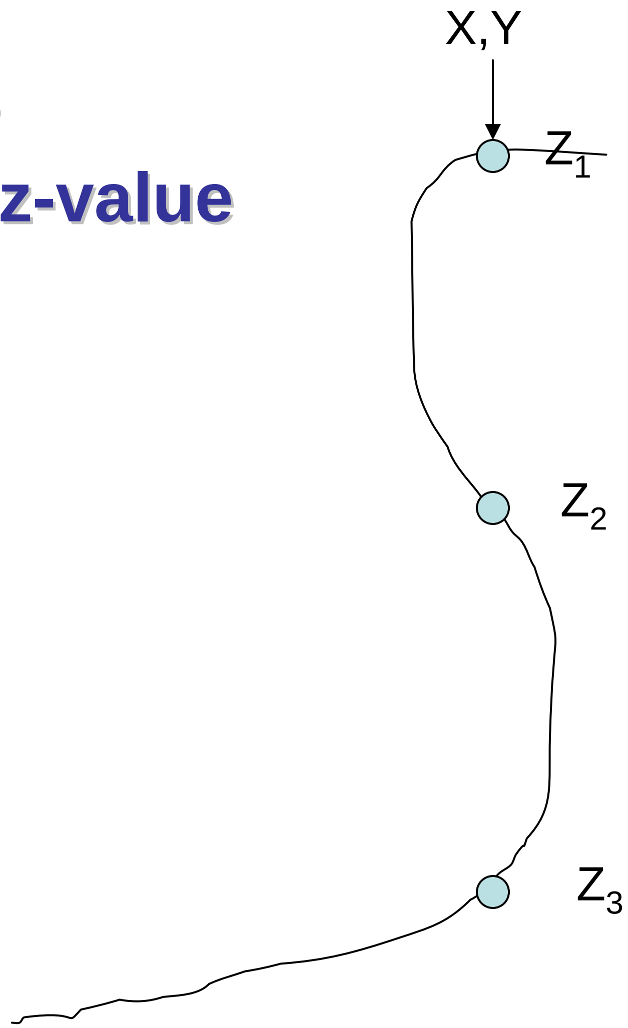
- Interpolate from sample points
- Example: Terrain, pH value, water quality
- Convert from another format
- Example: USGS Digital Elevation Model (DEM)
- Four ways to represent surfaces:





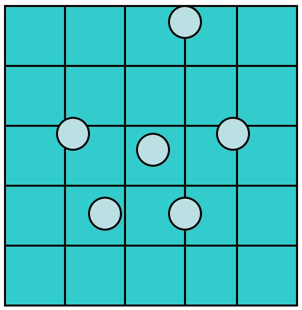

Functional surface

- Considered to be continuous
- For an x,y location, only one z-value
- NOT a true 3D model: 2 ½ dimensional
- Can be used to represent:
  - Terrestrial surfaces
  - Statistical surfaces
  - Mathematical surfaces



What is Interpolation?

- Procedure to predict value at unsampled locations within sampled region
- Based on the principle of spatial autocorrelation or spatial dependence
  - Spatial autocorrelation — measures degree of relationship/dependence between near and distant objects



- Implements Tobler's First law of Geography:

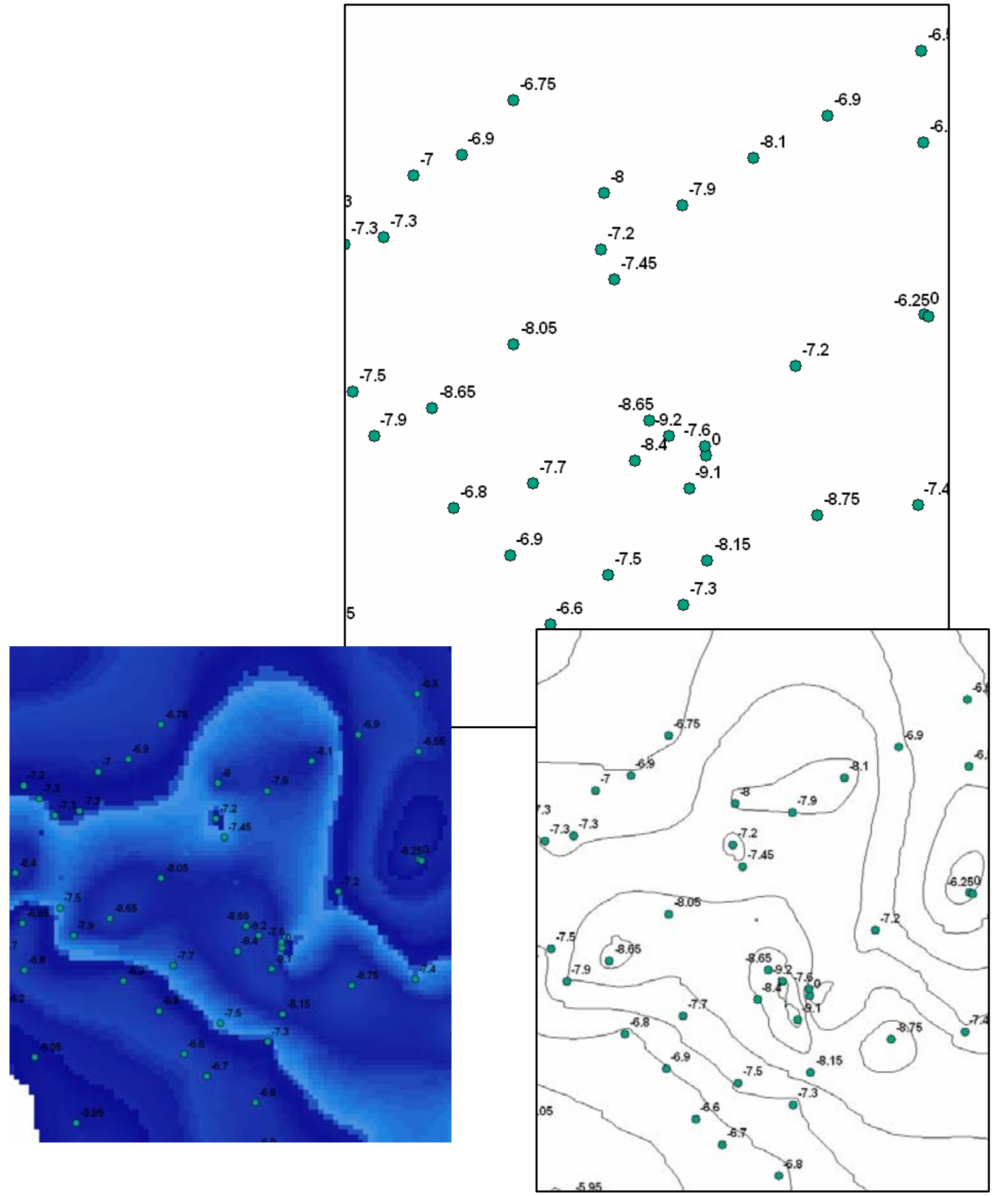
"everything is related to everything else, but close things are closely related"

Elements of interpolation

- The known points (samples)
  - Sample factors - size, limits, location ,outliers
- The unknown points (interpolated values)
  - Interpolation models:
    - Deterministic - create surfaces from measured points, based on either the extent of similarity (IDW) or degree of smoothing (Trend).
    - Geostatistical - based on statistics (Kriging) with advanced prediction modeling, includes measure of certainty or accuracy of predictions.
- Different interpolation methods will (almost always) produce different results.

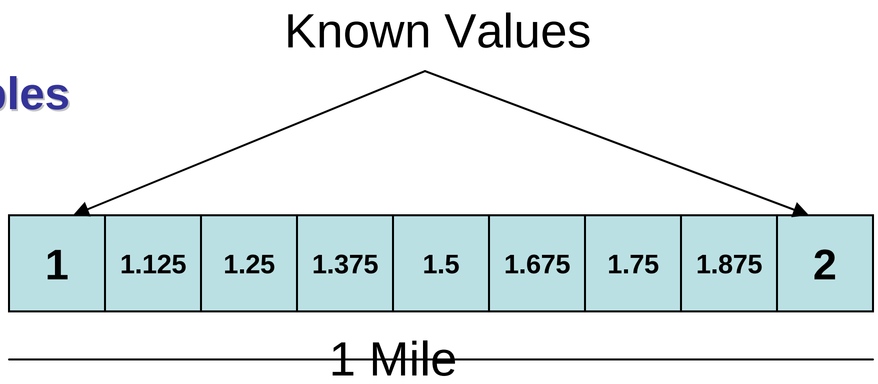
Sampling a surface

- Perfect surface requires infinite number of measurements
- Therefore samples need to be significant and random, if possible
- Error increases away from sample points



Linear interpolation

- Interpolation of cell values
  - A best estimate between samples
- May consider:
  - Distance
  - Weight
- Used for:
  - Predicting
  - Forecasting
  - Describing
  - Understanding
  - Calculating
  - Estimating
  - Analyzing
  - Explaining



Controlling sample points for interpolation

- IDW, Spline & Kriging support control of sample numbers
- Sample methods:
  - Nearest neighbors — you choose how many
  - Search radius — variable or max distance
- Returns *NoData* if insufficient samples

Barriers to interpolation

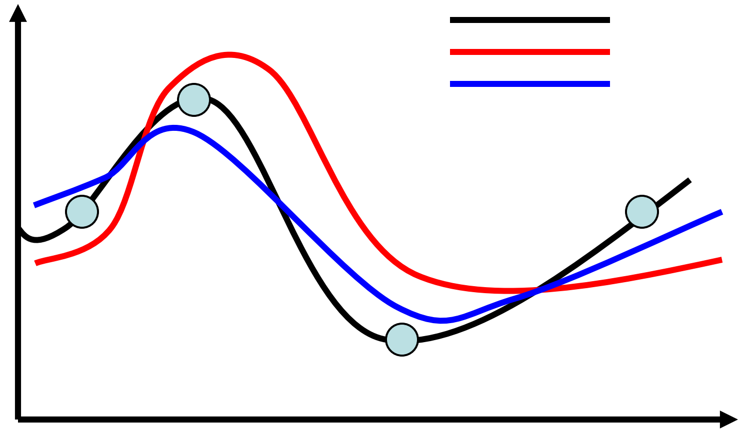
- Barriers represented by line feature classes
  - Examples: Faults, cliffs, levees, depth to ground water
- Restricts samples to same side of line as cell
- IDW, KRIGING ()support barriers

Interpolating unknown values

- Input
  - Point dataset
  - x,y coordinates in a text file
- Output
  - Floating-point raster
- Tools

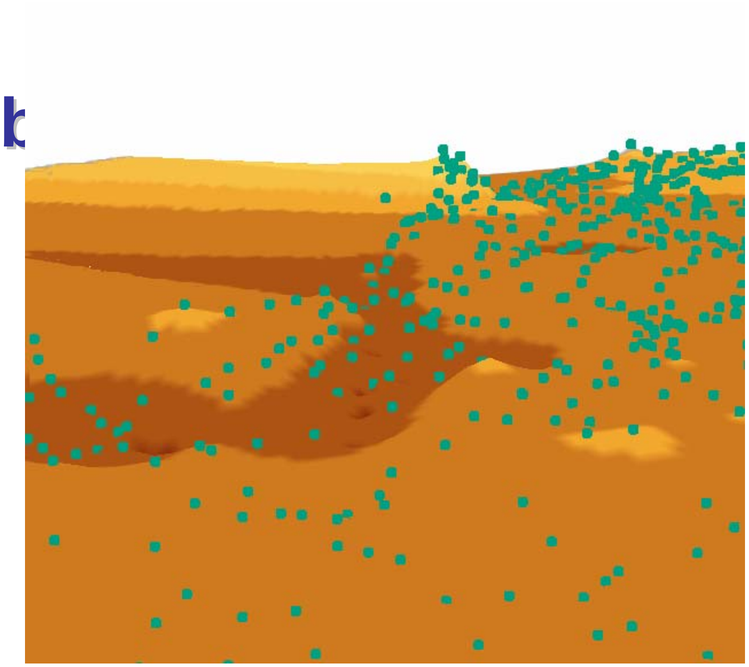
Interpolation types

- ❑ **Deterministic or Geostatistical**
- ❑ **Deterministic:**
  - **Surface created from samples based on extent of similarity or degree of smoothing.**
    - **E.g., IDW, Spline,Trend**
- ❑ **Geostatistical**
  - **Spatial variation modeled by random process with spatial autocorrelation**
  - **Creates error surface — indication of prediction validity**
  - **E.g., Kriging**



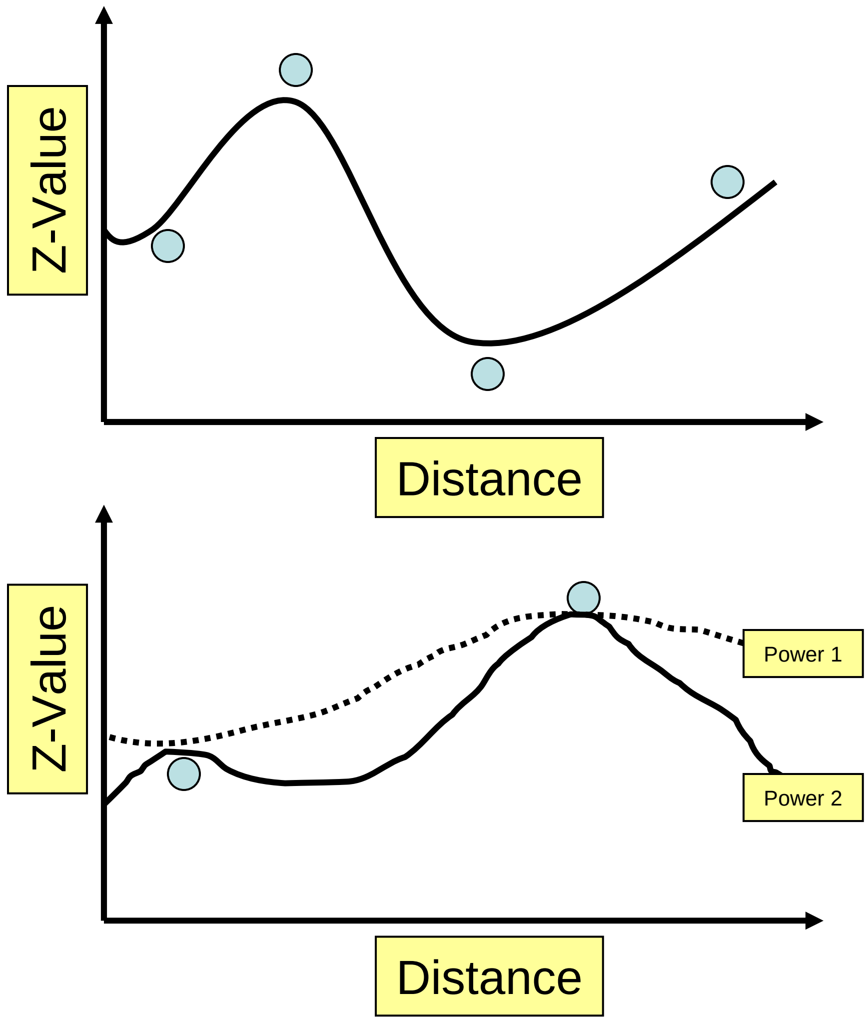
IDW

- Deterministic Interpolation technique
- Influence of known values diminishes with distance
- Surface will not pass through samples (averaging)
- Power value and barrier can b
- Sample subset defined by
  - Nearest neighbor
  - Fixed radius



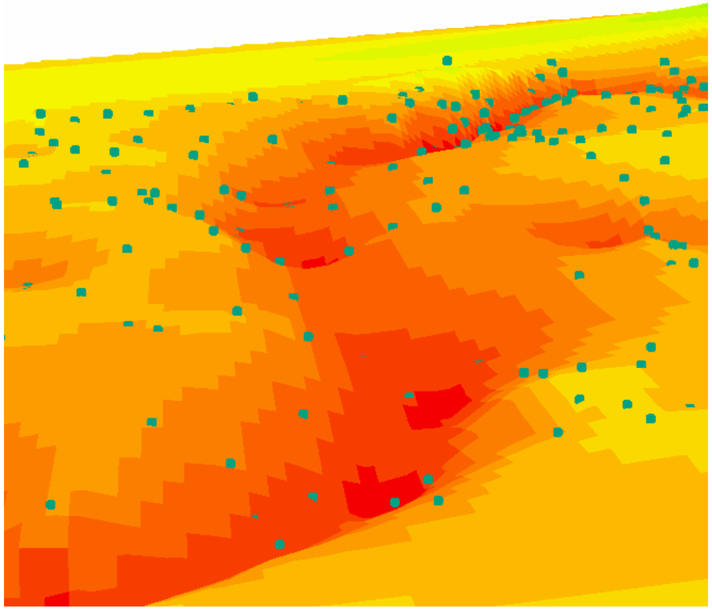
IDW parameters

- Best for dense evenly spaced samples
- No estimates above max or below mm sample value
- Can adjust relative influence or power of samples



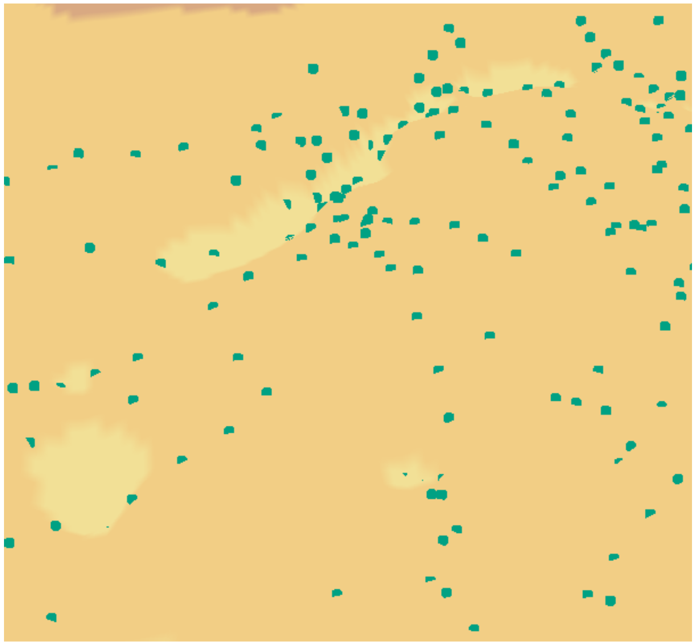
Natural Neighbor Interpolation

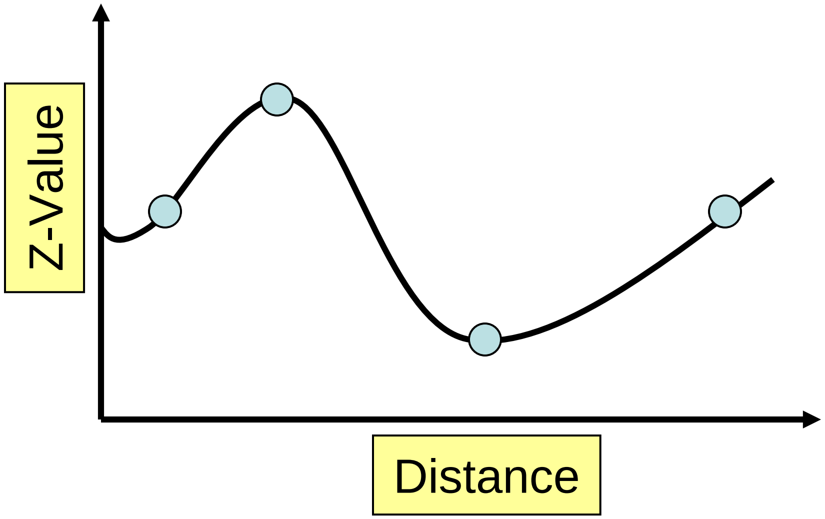
- Uses Thiessen polygon network of scatter points.
- Interpolation by weighted average of surrounding or neighboring data points
  - Area-based weights
- Cell value is "natural neighbor" of interpolation subset
- Resulting surface analogous to a taut rubber sheet stretched to meet all the data.
- Works well with clustered scatter points
- Efficiently handles large numbers of input points



Spline

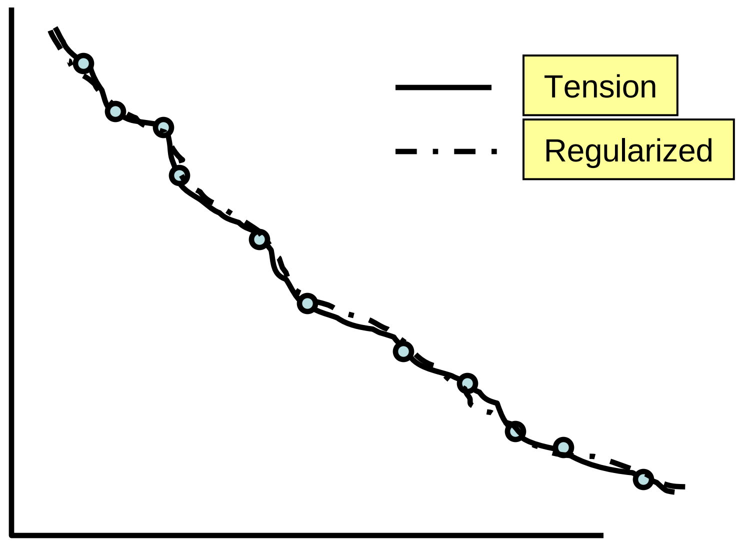
- The surface passes exactly through the sample points
  - Fits a minimum-curvature surface through the input points
  - Like a rubber sheet that is bent around the samples
  - Best for smoothly varying surfaces (e.g., temperature)
  - Can predict ridges and valleys





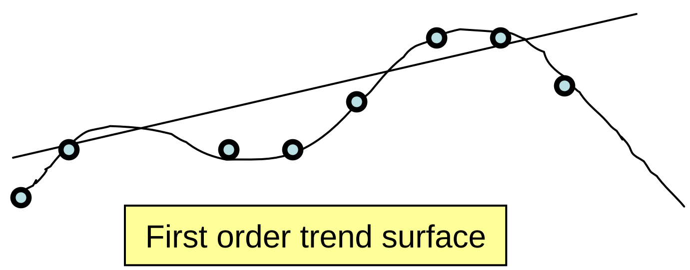
Choosing a spline type

- **Regularized**
  - A looser fit, but may have overshoots and undershoots
  - Generally makes a smoother surface
  - Higher values of {weight} smooth more
- **Tension**
  - Forces the curve
  - Generally makes a coarser surface
  - Higher values of {weight} coarsen more than lower values



Trend

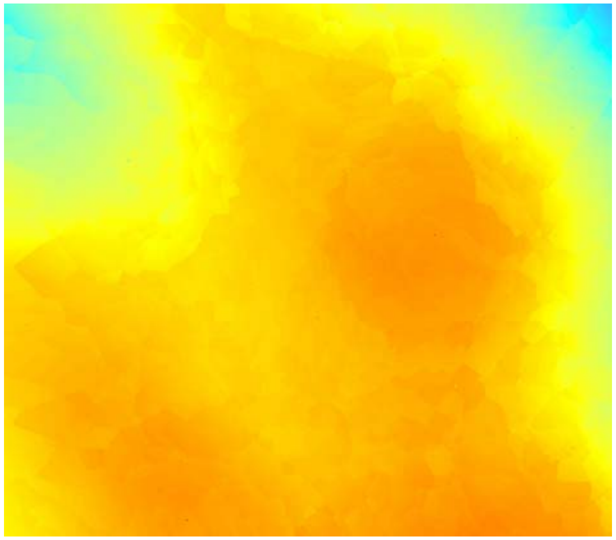
- Inexact interpolator:
  - Surface usually not through sample points
- Detects trends in the sample data
  - Similar to natural phenomena, which usually vary smoothly.
- Statistical approach:
  - Allows statistical significance of the surface and uncertainty of the predicted values to be calculated
  - Fits one polynomial equation to entire surface



Order 1: No curve (flat tilted surface)
2: One curve
3: Two curves
4: Three curves, etc.

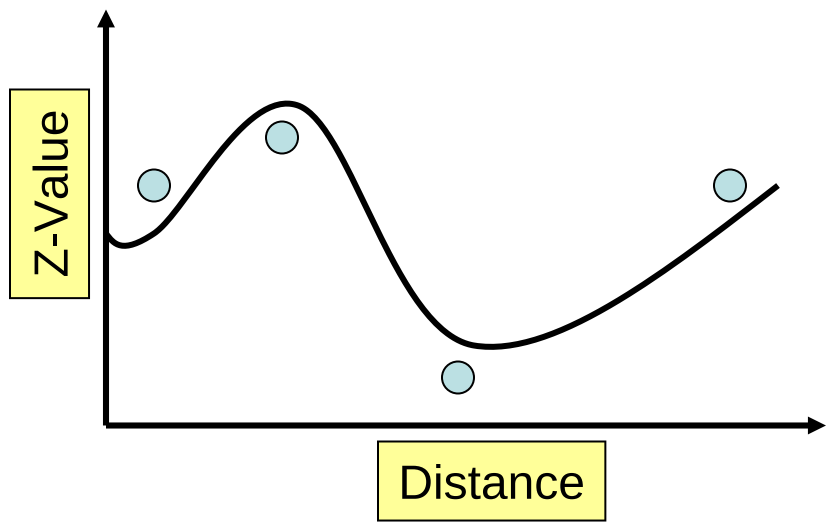
Kriging

- A powerful statistical technique
  - Predicted values derived from measure of relationship in samples
  - Employs sophisticated weighted average technique
- Cell value can exceed sample value range
  - Surface does not pass through samples
- Various types of kriging
- Uses a search radius
  - Fixed
  - Variable



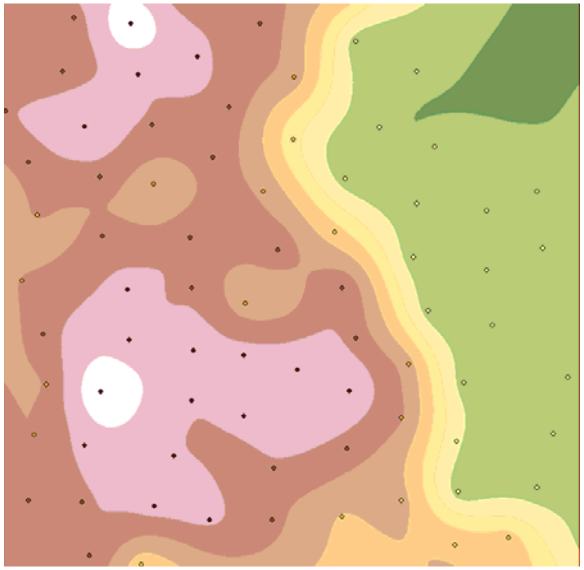
Kriging methods

- Several methods — spatial analyst supports:
  - Ordinary — assumes overall area mean; no trend.
  - Universal — assumes unknown trend in area mean.
- Geostatistical analyst extension — supports more

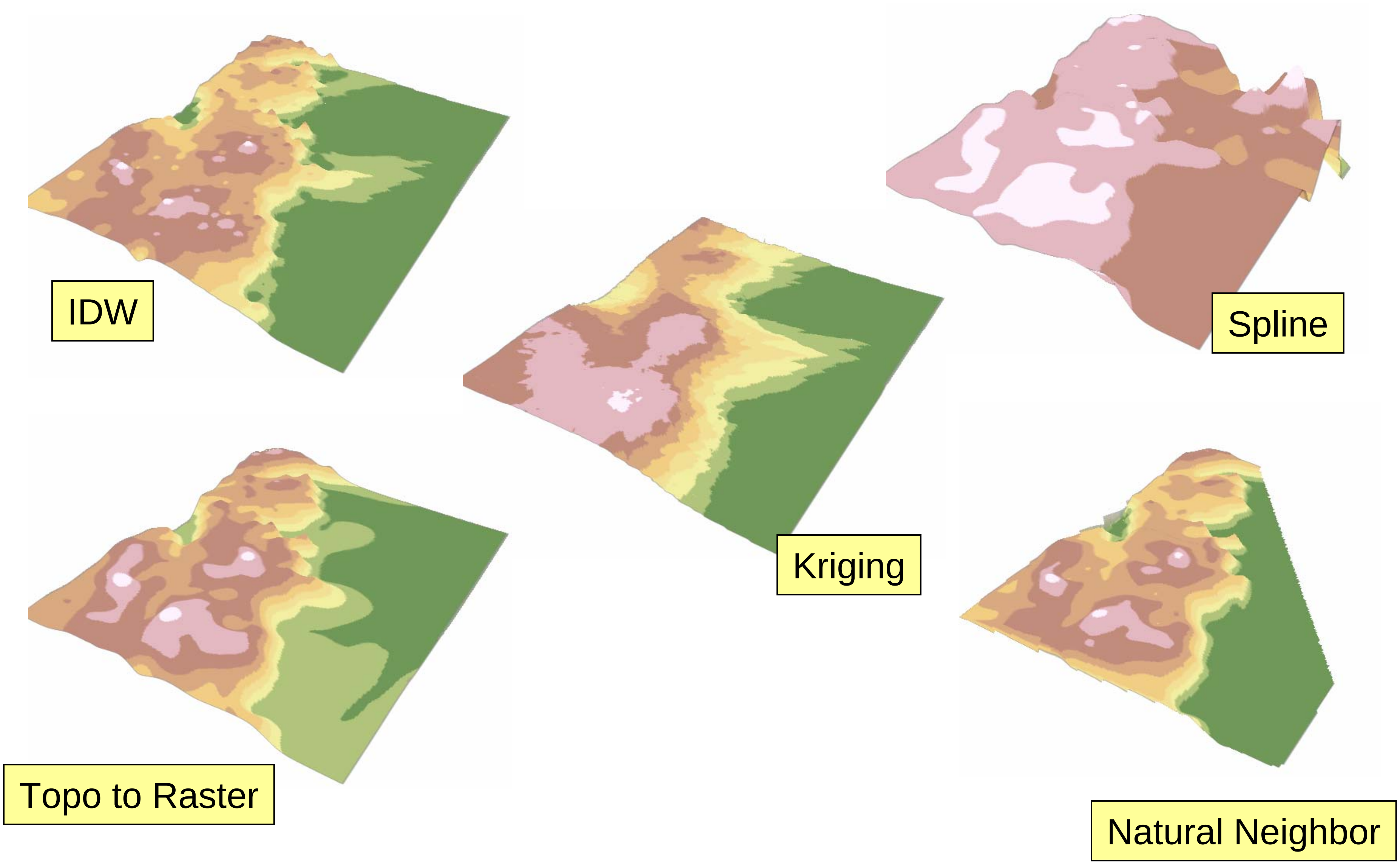


Topo to Raster

- Interpolates elevation imposing constraints to ensure:
  - Connected drainage structure.
  - Correct representation of ridges and streams from input data.
- Deploys iterative finite difference interpolation technique.
  - Optimized to computational efficiency of 'local' interpolation without losing the surface continuity of global interpolation
- Designed to work intelligently with contour inputs.



Visual comparisons of Interpolators



Feature density estimation

- Count occurrences of a phenomena within an area and distribute it through the area
  - Similar to focal functions
  - Performs statistics on features
  - Population field influences density
- Use points or lines as input
- Examples
  - Population per square kilometer
  - Road density per square mile
  - The number of customers per square mile

Testing your surface

- Different interpolators will produce different results with same input data.
- No single method is more accurate than others for all situations.
- Accuracy — may be determined by comparison with a second set of “withheld” samples for accuracy checking.
  - Remove random test sample points
  - Create surface
  - Interpolate
  - Did interpolator predict missing samples?
  - Repeat
  - Try with each interpolator
- Select the method based on knowledge of the the study area, phenomena of interest, and available resources.