Creating Surfaces

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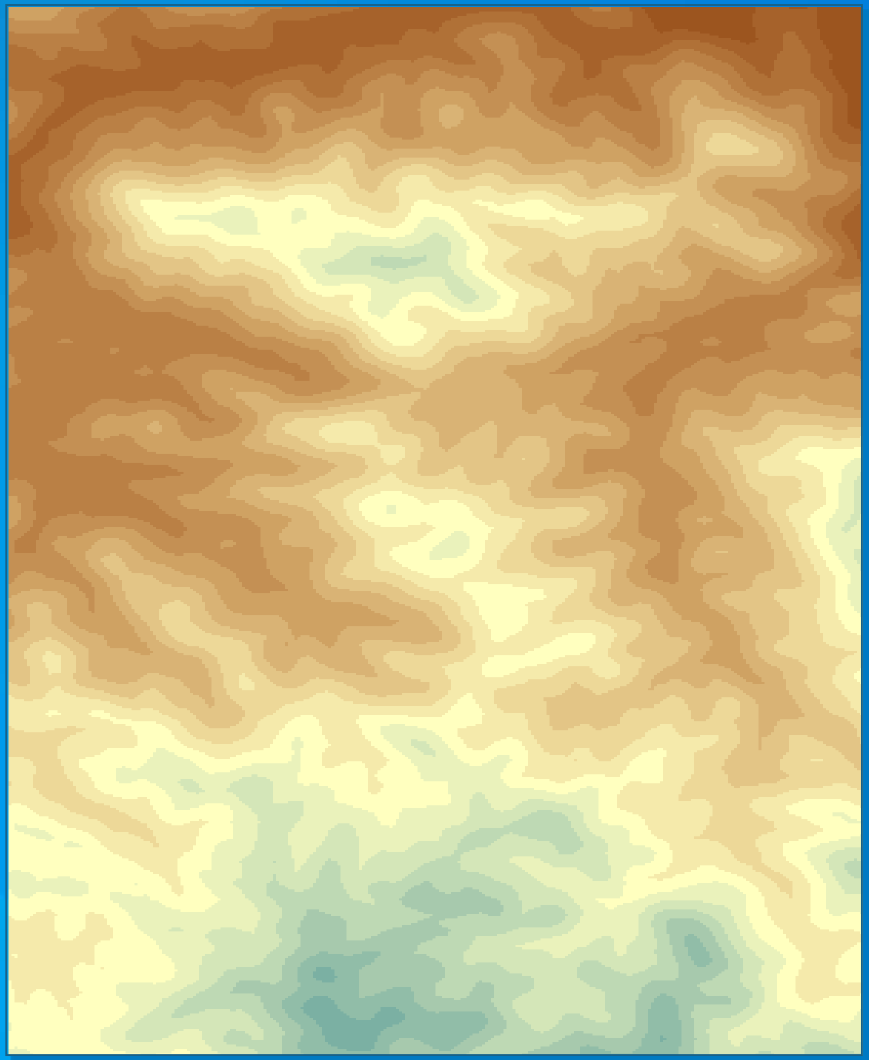
Overview

- Learn the types of surfaces and the data structures used to store them

- Emphasis on surface interpolation
  - Learn the interpolation workflow
  - Understand how interpolators work
  - Understand how to choose an appropriate interpolation technique and its parameters

Types of Surfaces

- Elevation
- Soil chemistry
- Water quality
- Population
- Income
- Disease occurrence



What kind of surfaces do you create?

- What is the source data?
  - Points, lines, polygons, raster
  - Is quality a concern

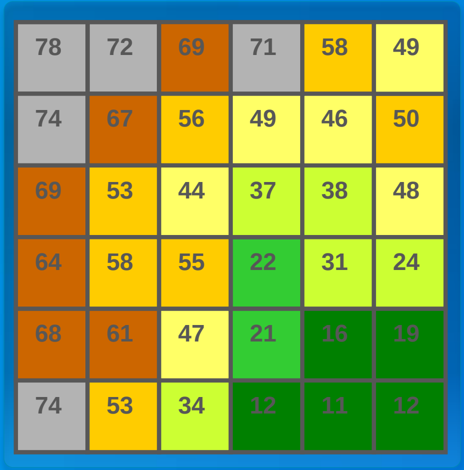
- What is the phenomenon?
  - Measurements, *counts*, something else

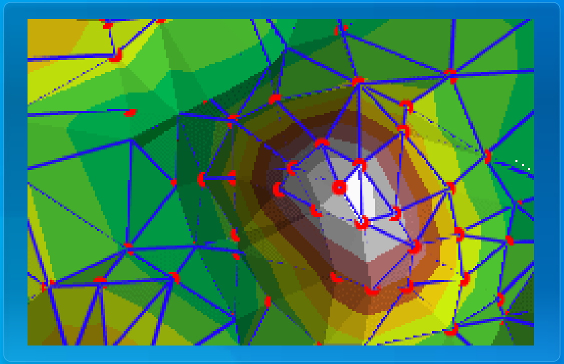
- Anything special or odd about it?
  - Discontinuous
  - Highs and lows sampled or not

- What do you want/expect for a result?
  - Raster, TIN, contour lines or polygons, estimates at points, estimate of surface quality

Storing surfaces in ArcGIS

- Raster
- TIN / Terrain
- Points
  - LiDAR, LAS
- Isolines / Contours
- Geostatistical Layer





TIN and Terrain

- Maintain accuracy of measured locations

- Discontinuities are handled with breaklines
  - Hard breaklines (cliff, fault)
  - Soft breaklines (road, stream)

Where do I find these capabilities?

- Spatial Analyst – raster, contour
- 3D Analyst – raster, contour, TIN, terrain
- Geostatistical Analyst – raster, contour line, filled contour polygon, point, geostatistical layer
- ArcGIS Online – filled contour polygon

2 common types of surfaces

- **Density surfaces = counts of things over an area**

- **Interpolated surfaces of measured quantities**

  This session is about interpolation

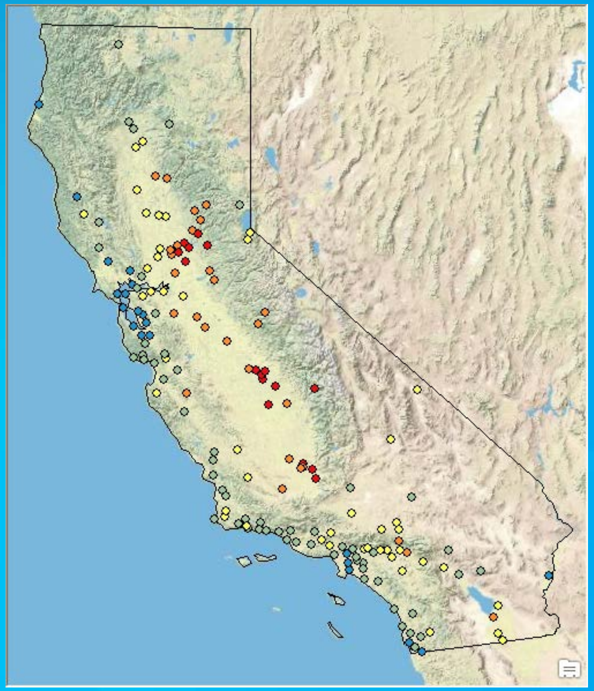
Density

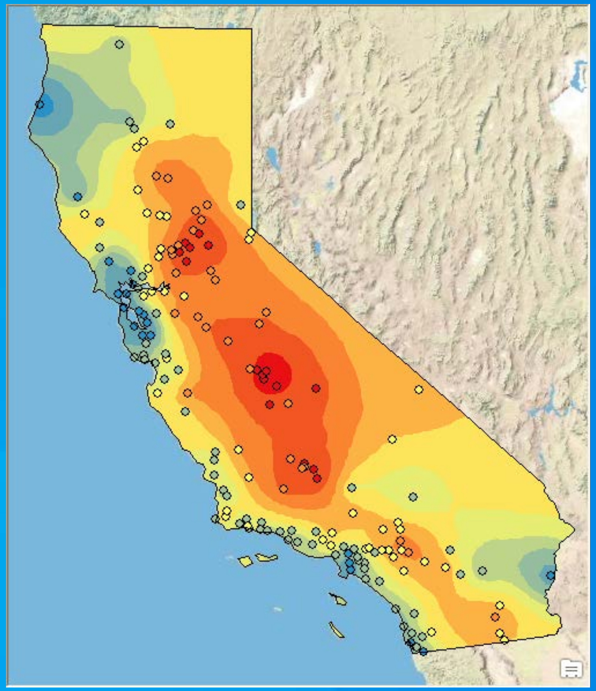
- Density surfaces are maps of *magnitude per unit area*
- Count occurrences of a phenomenon within an area and distribute it through the area.
- Simple Density and Kernel Density
- Use points or lines as input.
  - Population per Km2
  - Road density per Mi2

Interpolation

- Interpolation is the process of transforming measurements of a continuous phenomenon into a continuous surface representation

Estimating new values at unsampled locations





Types of input for Interpolation

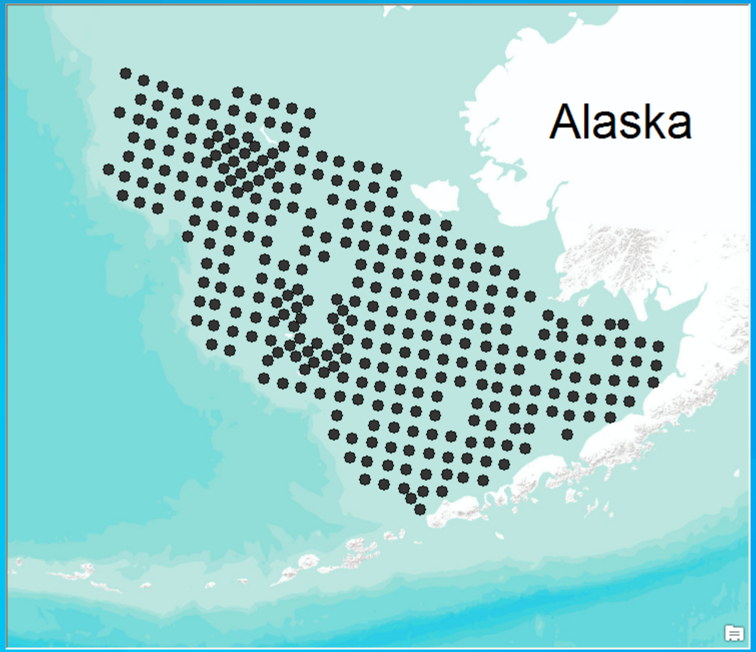
- Points
  - Continuous values
    - LAS
- Polylines
  - Contours
- Polygon
  - Centriod
  - Areal Interpolation
  - Dasymetric mapping
- Raster
  - Fill in missing values
  - Change resolution through Resampling or Interpolation
  - Modify surface with supplemental data

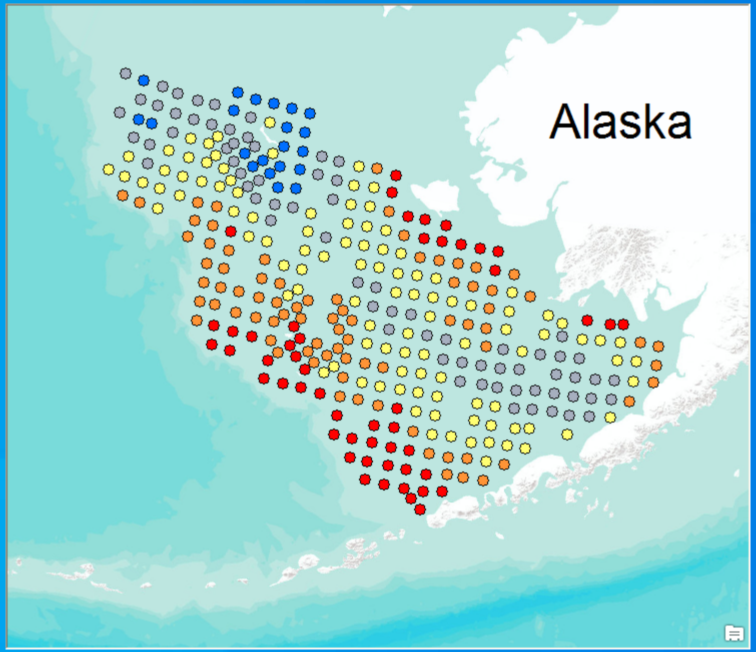
Interpolation Steps

1) Understand your data
2) Experiment with techniques and parameters
3) Create surfaces
4) Evaluate your surfaces
5) Repeat…

Exploratory Spatial Data Analysis

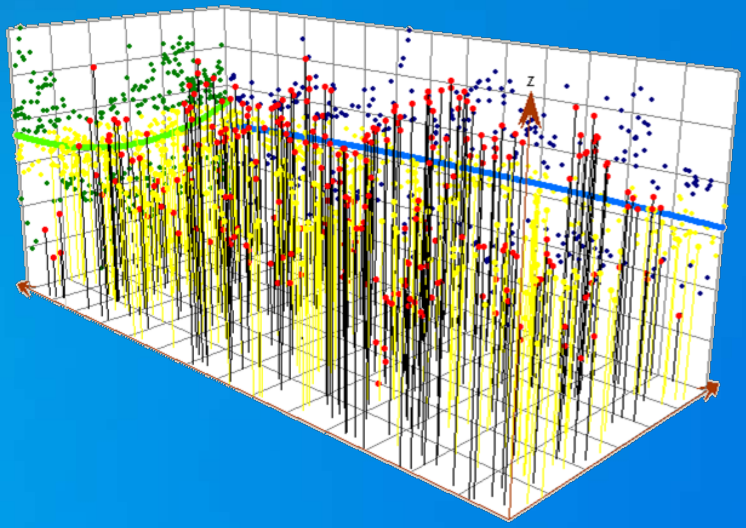
- Where is the data located?
- What are the values of the data points?
- How does the location of a point relate to its value?

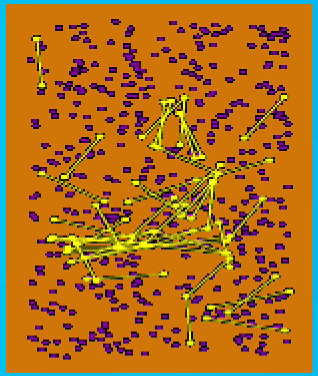


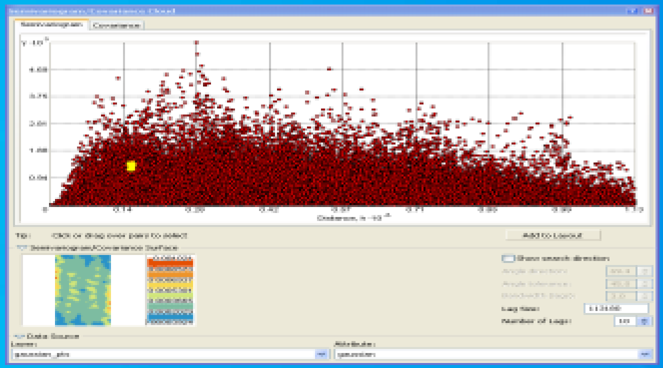


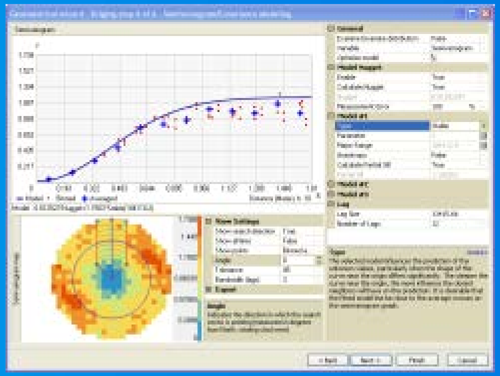
Explore your Data

- Outliers
- Trends
- Spatial Dependency
- Distribution
  - Statistical distribution of values
  - Spatial distribution of points
- Stationarity









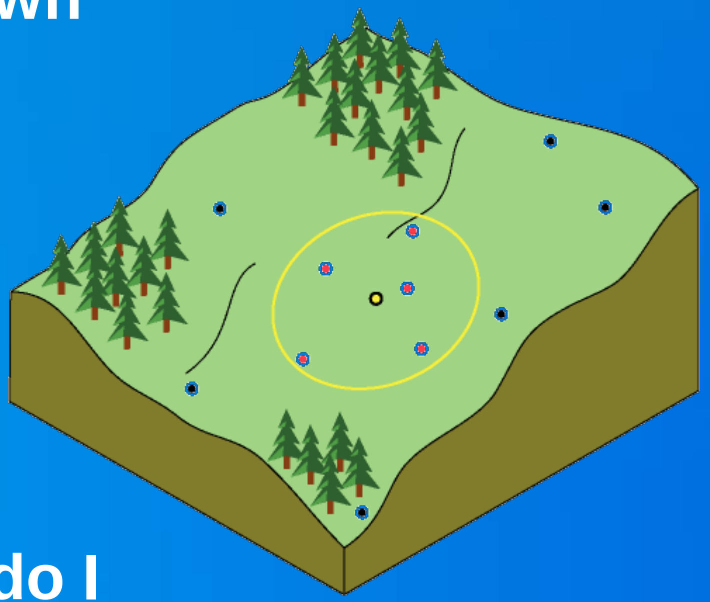
Creating Surfaces

Exploring your Data

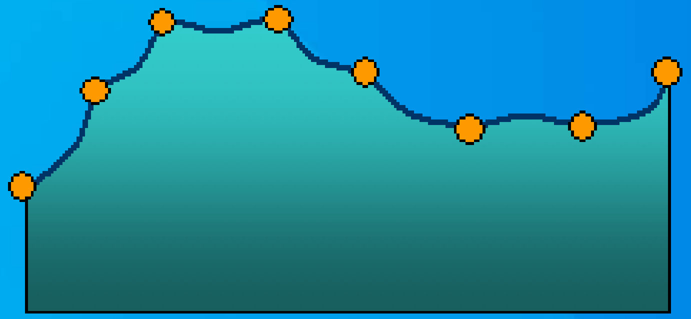
Demonstration

Two parts of all interpolators

1) **Neighborhood definition – where do I find known points to estimate a new value**



2) **Estimation function – from those points, how do I calculate a new value**



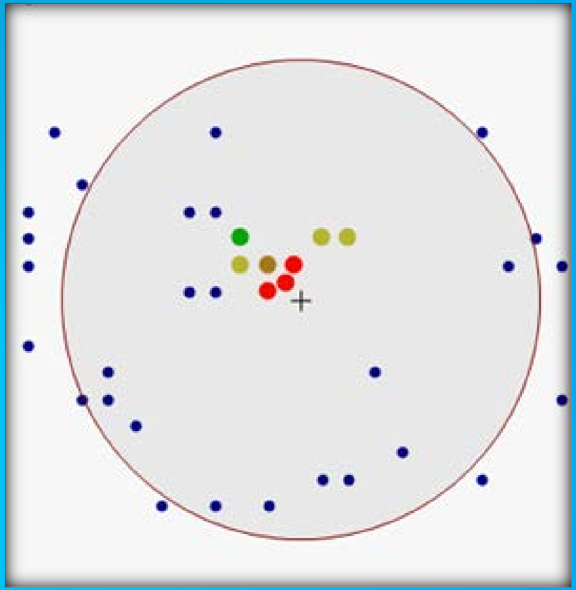
Searching neighborhood

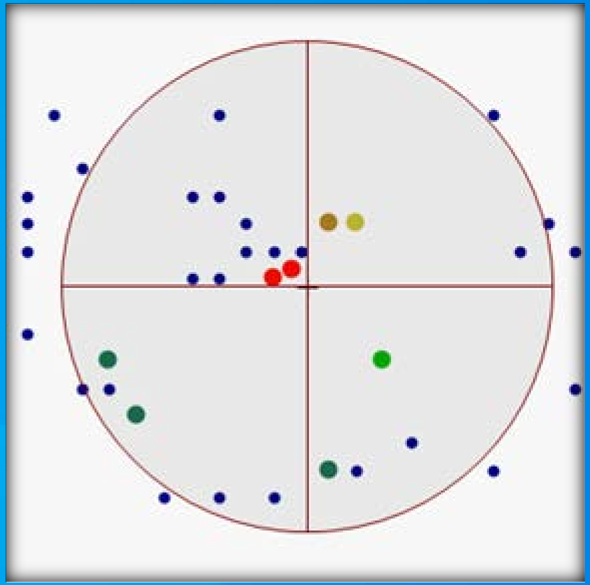
- **Variable number of points**
  - Specify a maximum search distance and number of points, a smaller number of points may be used.
  - Can result in NoData cells
- **Fixed number of points**
  - Specify a minimum number of points, and the search distance is increased until that number of points is found.

Tobler's first law of geography applies
"Everything is related to everything else, but near things are more related than distant things."

Searching Neighborhoods with Multiple sectors

- **Multi-sector neighborhoods are very useful for data with an irregular spatial distribution or clustering**





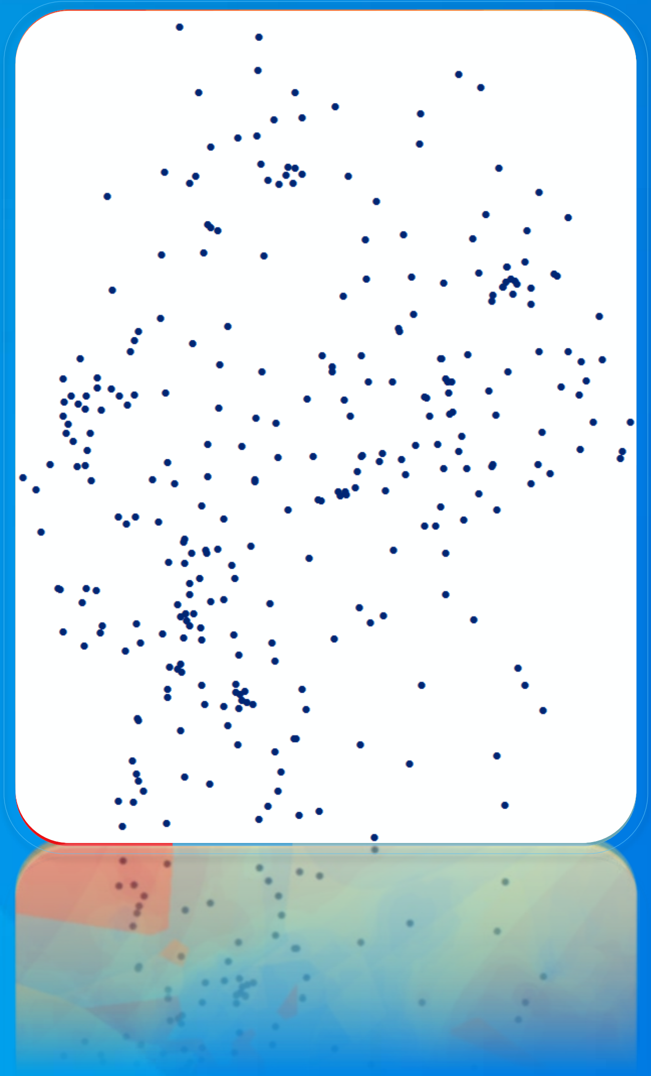
Available in Geostatistical Analyst

Questions to ask about your data

- Characteristics of phenomena?
- Sample spacing
  - Oversampled or needs extrapolation?
- Honor the input points?
- Barriers or discontinuities?
- Specialized needs
  - Topo To Raster (hydro applications)
- Suspected spatial patterns, trends, error?

Interpolation algorithms in ArcGIS

- Natural Neighbors
- Minimum Curvature Spline
- Spline with Barriers
- Radial Basis Functions
- TopoToRaster
- Local Polynomial
- Global Polynomial
- Diffusion Interpolation with Barriers
- Kernel Interpolation with Barriers
- Inverse Distance Weighted
- Kriging
- Cokriging
- Moving Window Kriging
- Geostatistical Simulation

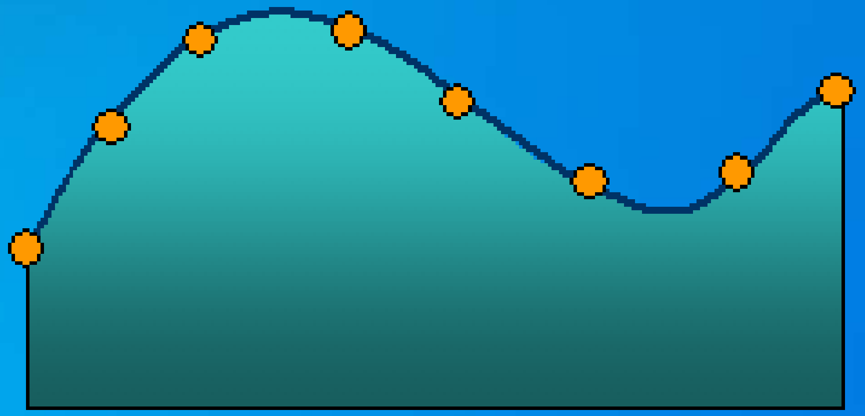


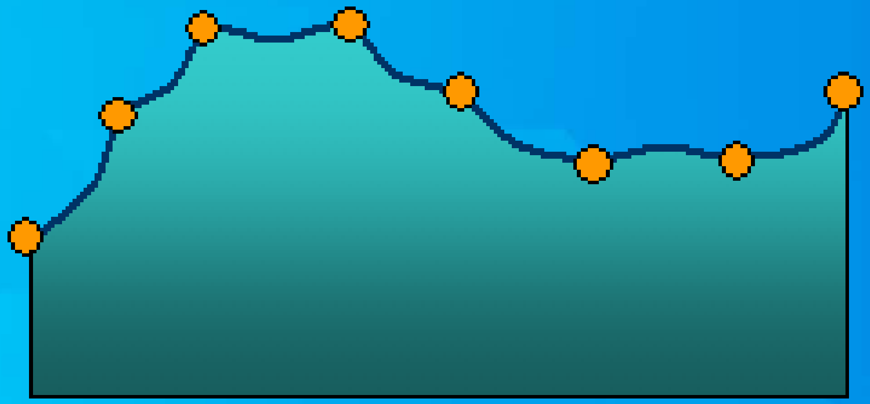
Choosing an interpolation method

- You know nothing about your data…
  - Use Natural Neighbors. Its is the most conservative, honors the points. Assumes all highs and lows are sampled, will not create artifacts.
- Going the next step in complexity…
  - Use Kernel Interpolation or Empirical Bayesian Kriging
- Your surface is not continuous…
  - Use Kernel Interpolation or Spline with Barriers if you know there are faults or other discontinuities in the surface.
- Your input data is contours…
  - Use TopoToRaster. It is optimized for contour input. If not creating a DEM, turn off the drainage enforcement option.
- You want a geostatistical method
  - Use Empirical Bayesian Kriging

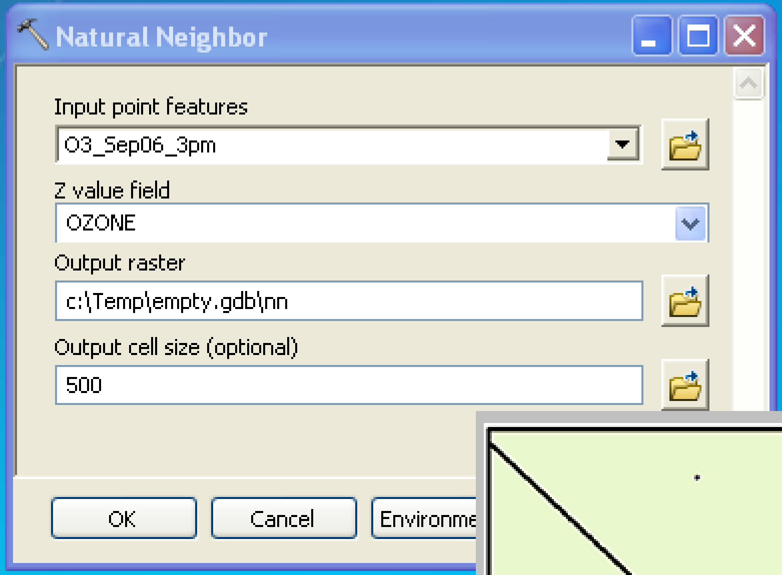
Considerations in choosing an interpolator

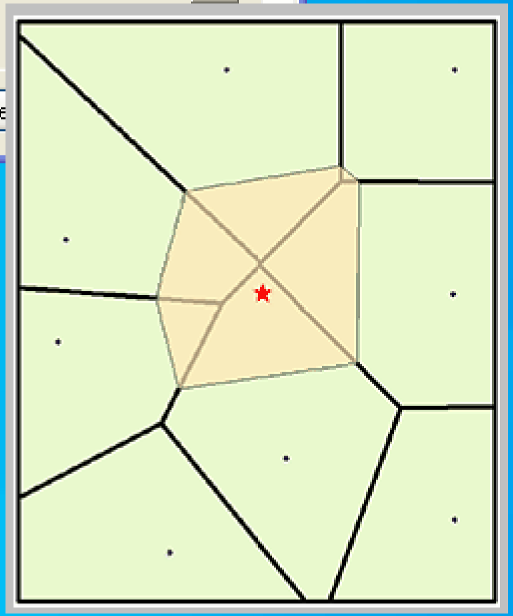
- Standard error of prediction
- Stationarity
- Normally distributed
- Exact interpolator
- Support barriers
- Speed

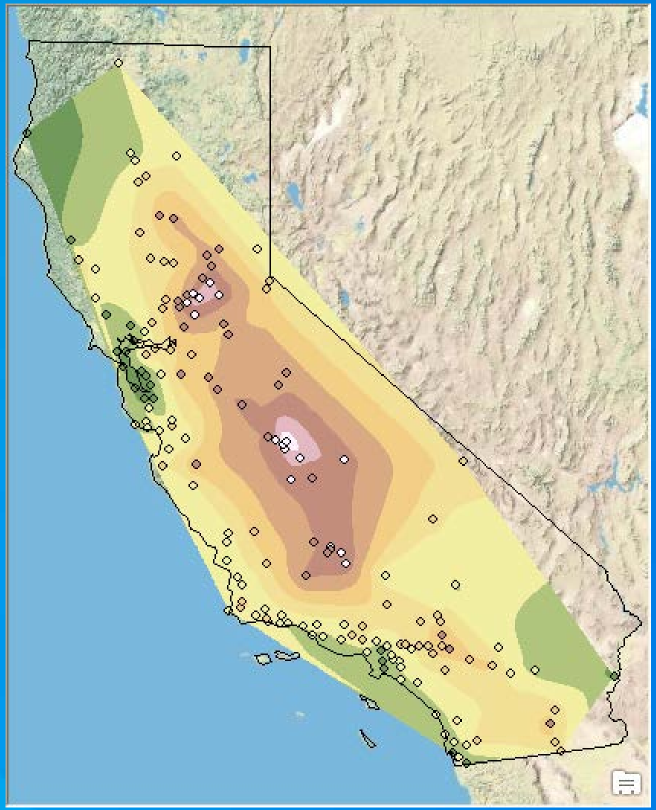




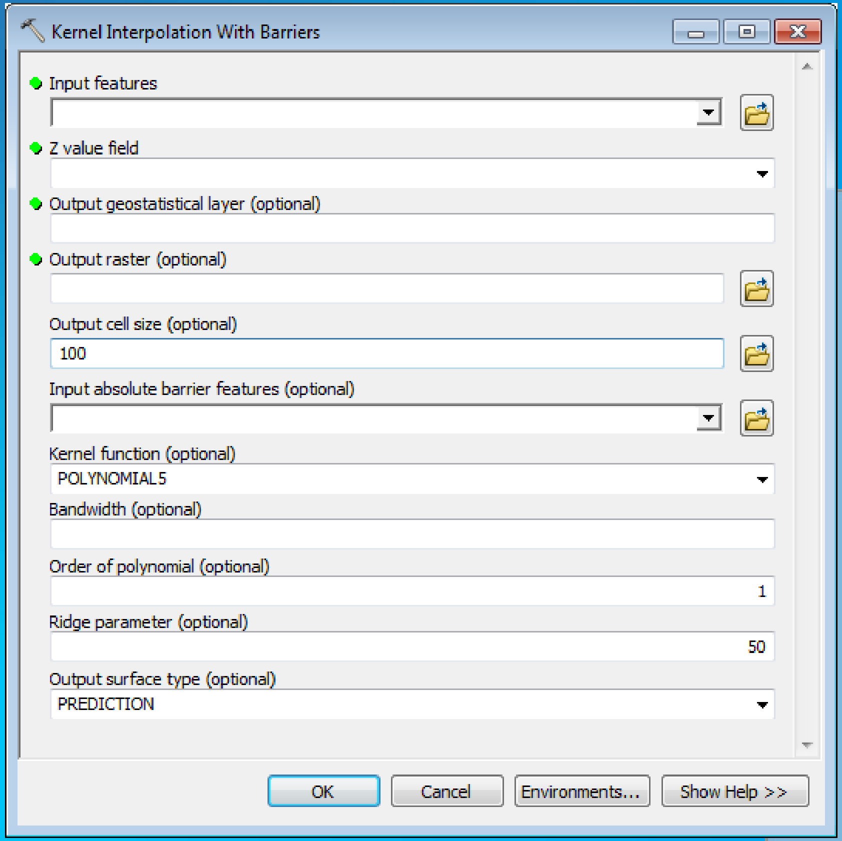
The simplest, safest interpolator…
Natural Neighbor

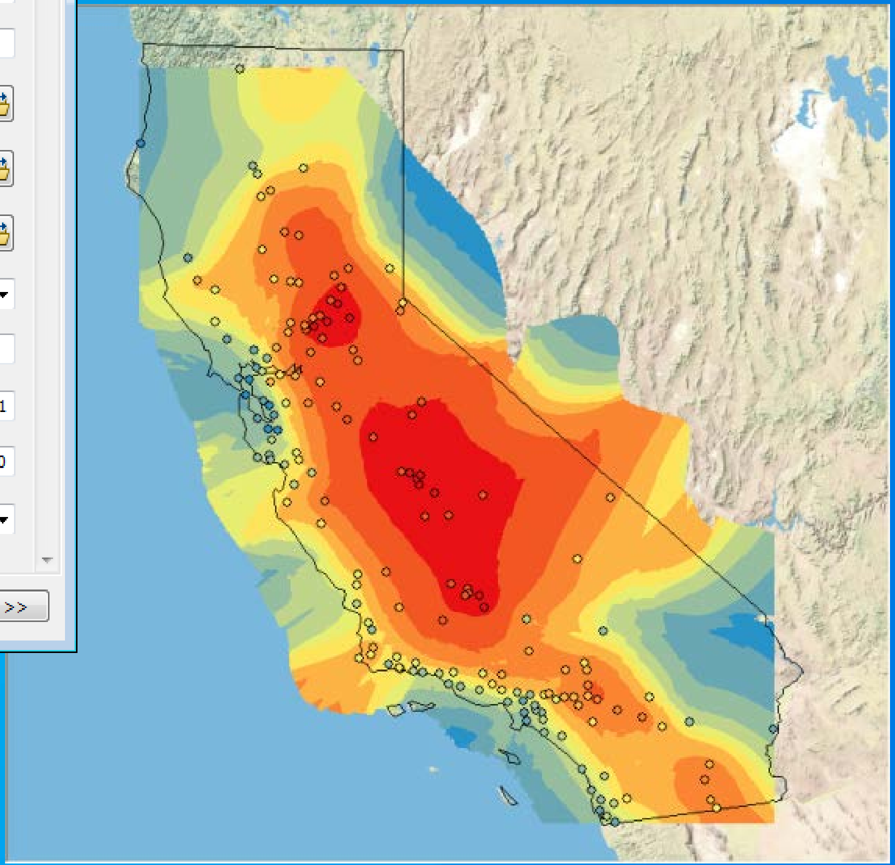






Kernel Interpolation





Easy Interpolations of Ozone Concentration

Demonstration

You want a prediction standard error map

- Choose from:
  - Kernel Interpolation
  - Local Polynomial Interpolation
  - Kriging

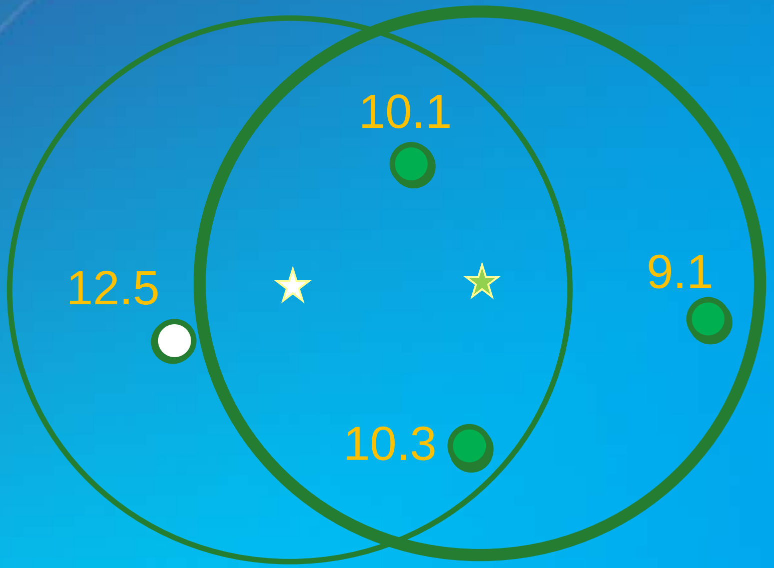
You want an exact interpolator that honors the points

- Choose from:
  - Natural Neighbors
  - Spline
  - Radial Basis Function
  - IDW

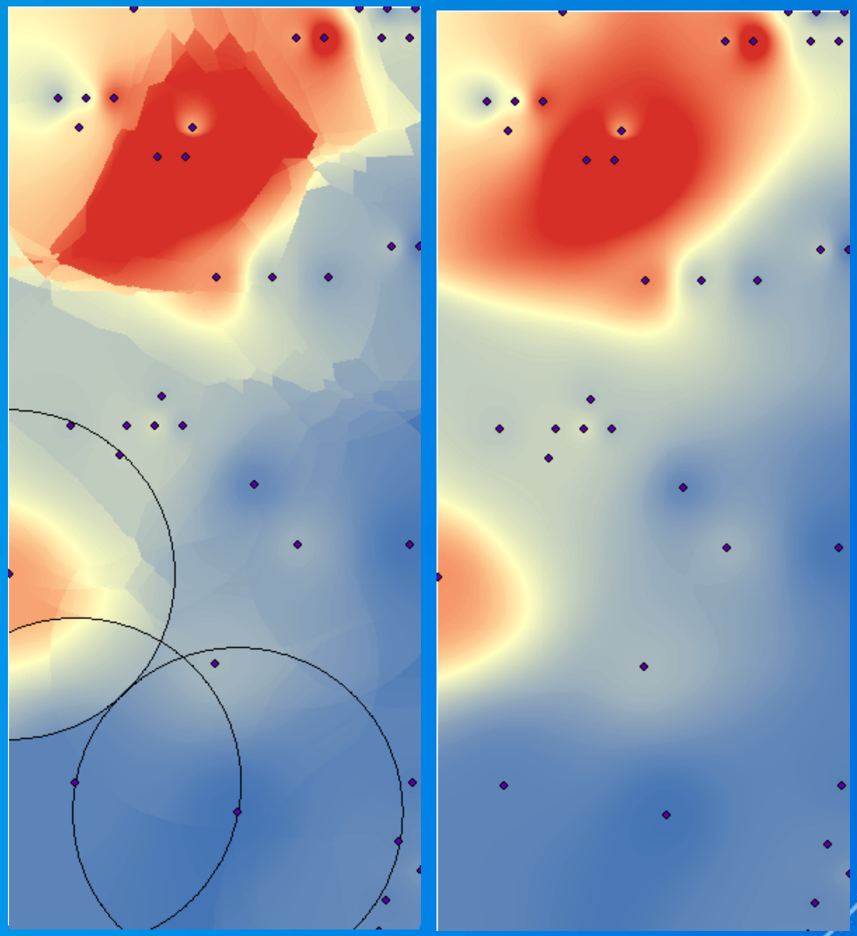
The high and low values have not been sampled…
and are important

- Do *not* use
  - Natural Neighbors
  - IDW

You want smooth interpolation



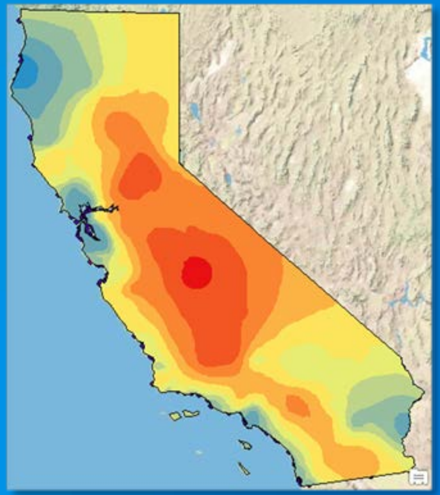
Unlike smoothing the output,
this method modifies the weights

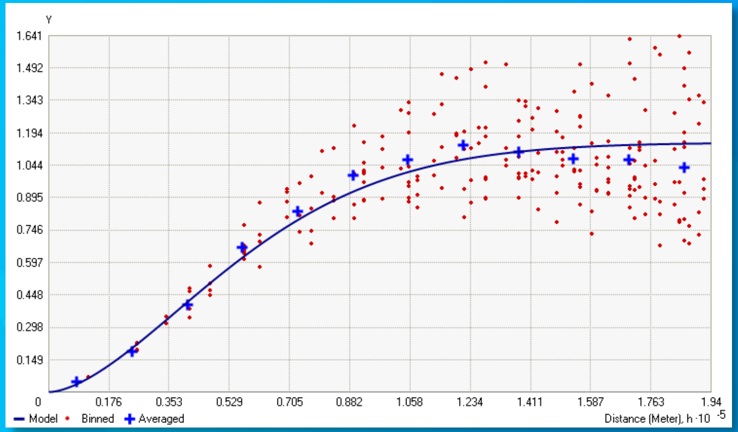


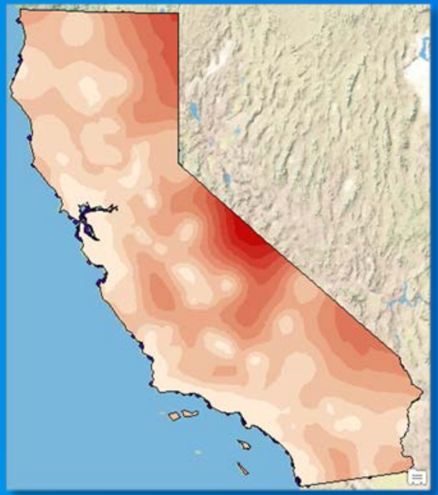
Smooth interpolation is an option in the Geostatistical Analyst interpolators

When to use Kriging

- Assumptions:
  - Spatially correlated
  - Stationary *
  - Normally distributed
    - or transformed to normal
- Want prediction and prediction standard error







If you know the phenomenon is correlated with something measured more

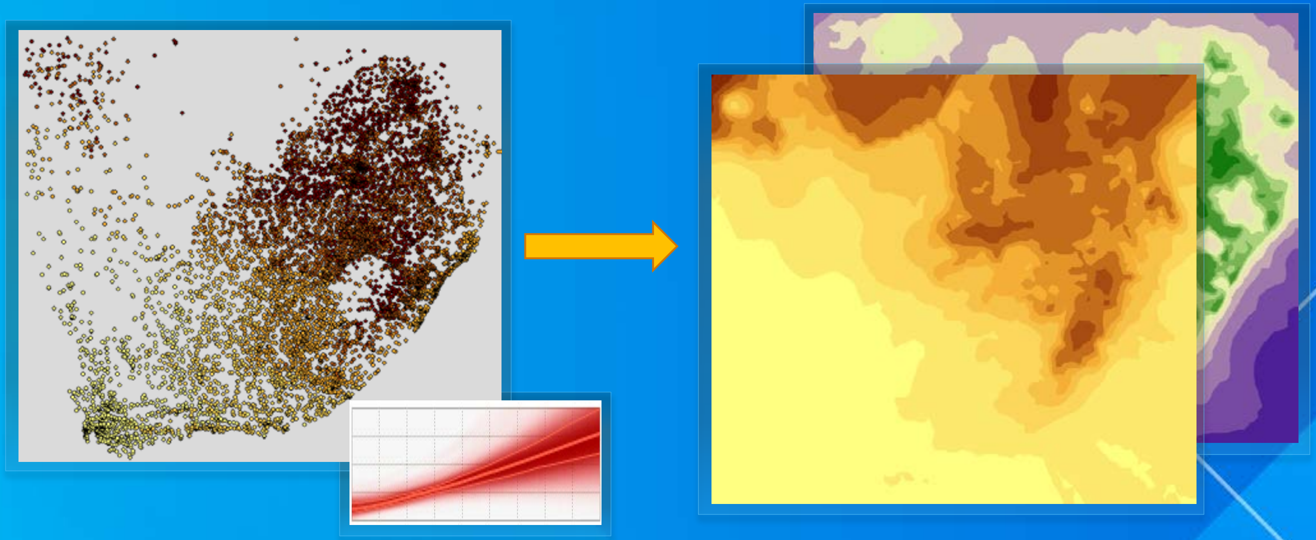
- If you have a sparsely measured variable such as temperature, which is correlated with another variable such as elevation that has much more sampling…

Use CoKriging

New tool coming in 10.4 for multivariate prediction

Empirical Bayesian Kriging

- Advantages
  - Requires minimal interactive modeling
  - Allows accurate predictions of non-stationary data
  - More accurate than other kriging methods for small datasets
  - Geoprocessing tool
- Disadvantages
  - Processing is slower than other kriging methods.
  - Cokriging and anisotropy are unavailable.
- Also available in ArcGIS Online

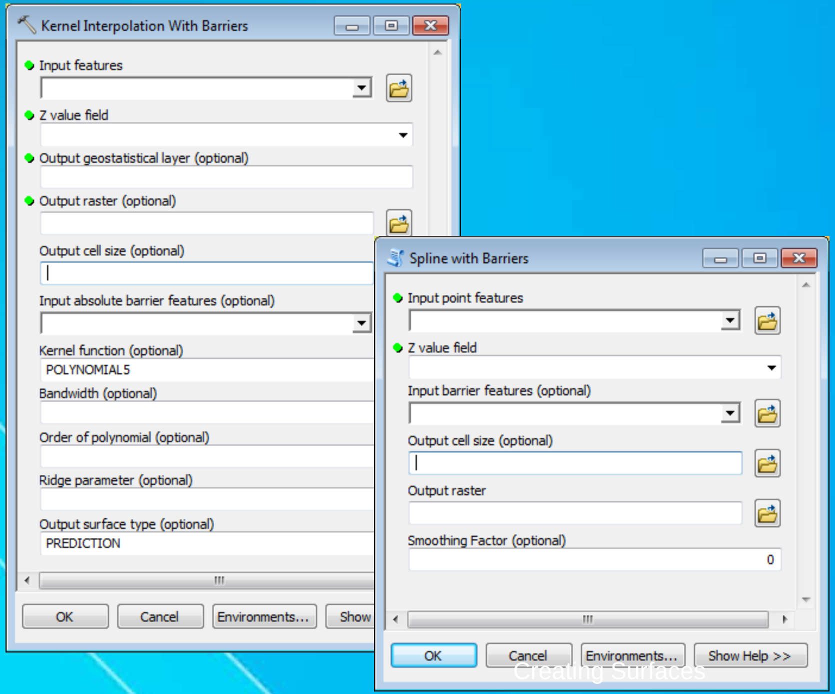


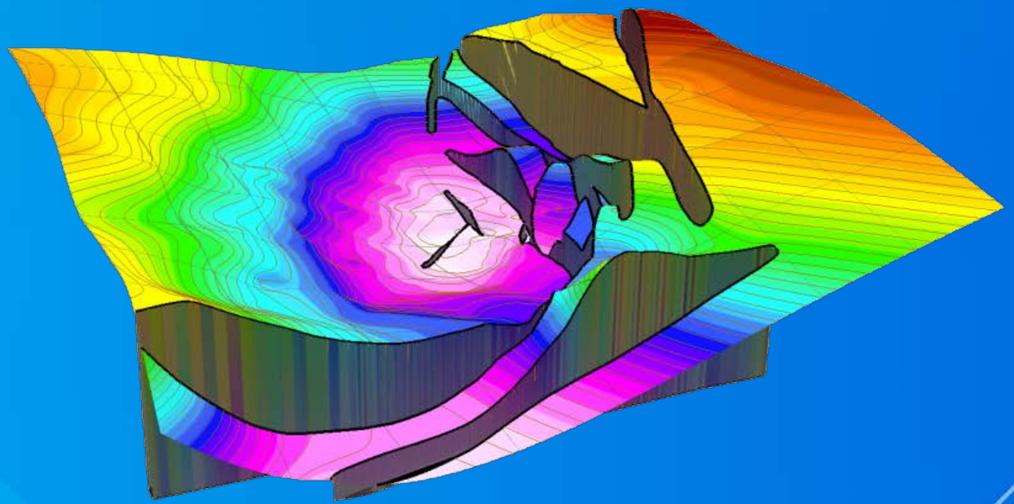
Kriging Rainfall

Demonstration

Cliffs, faults, or barriers in your study area

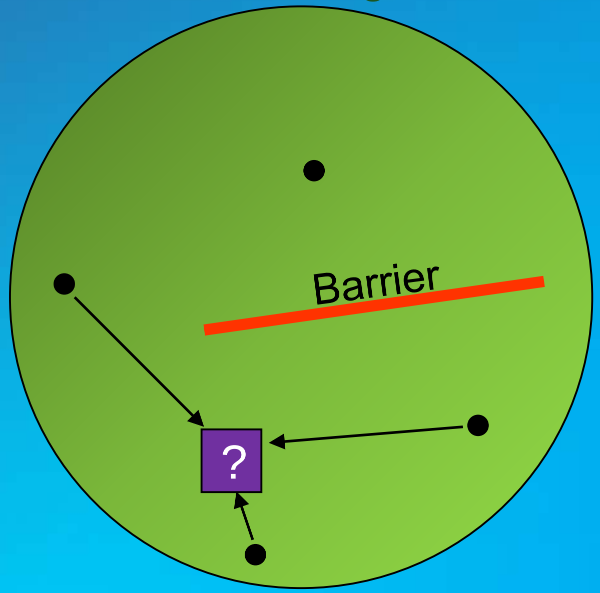
- Kernel Interpolation with Barriers
- Diffusion Interpolation with Barriers
- Spline with Barriers tool
  - Uses Zoraster algorithm, similar result to ZMap
  - Straight line barrier exclusion





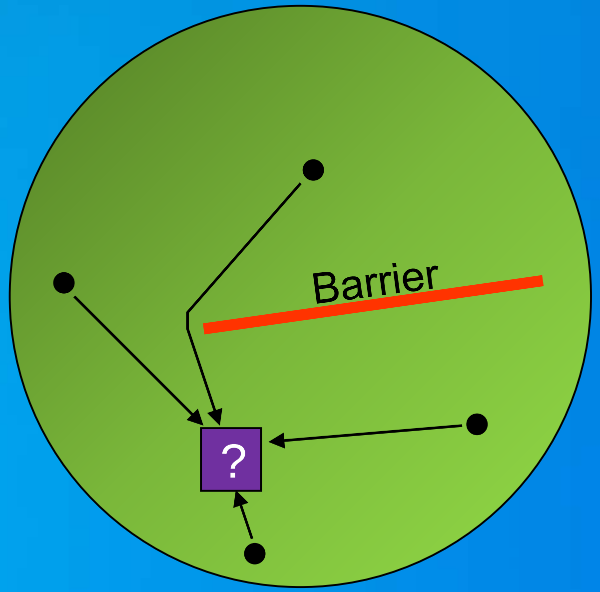
Interpolation with Barriers

Line of sight



- IDW

Non Euclidean distance



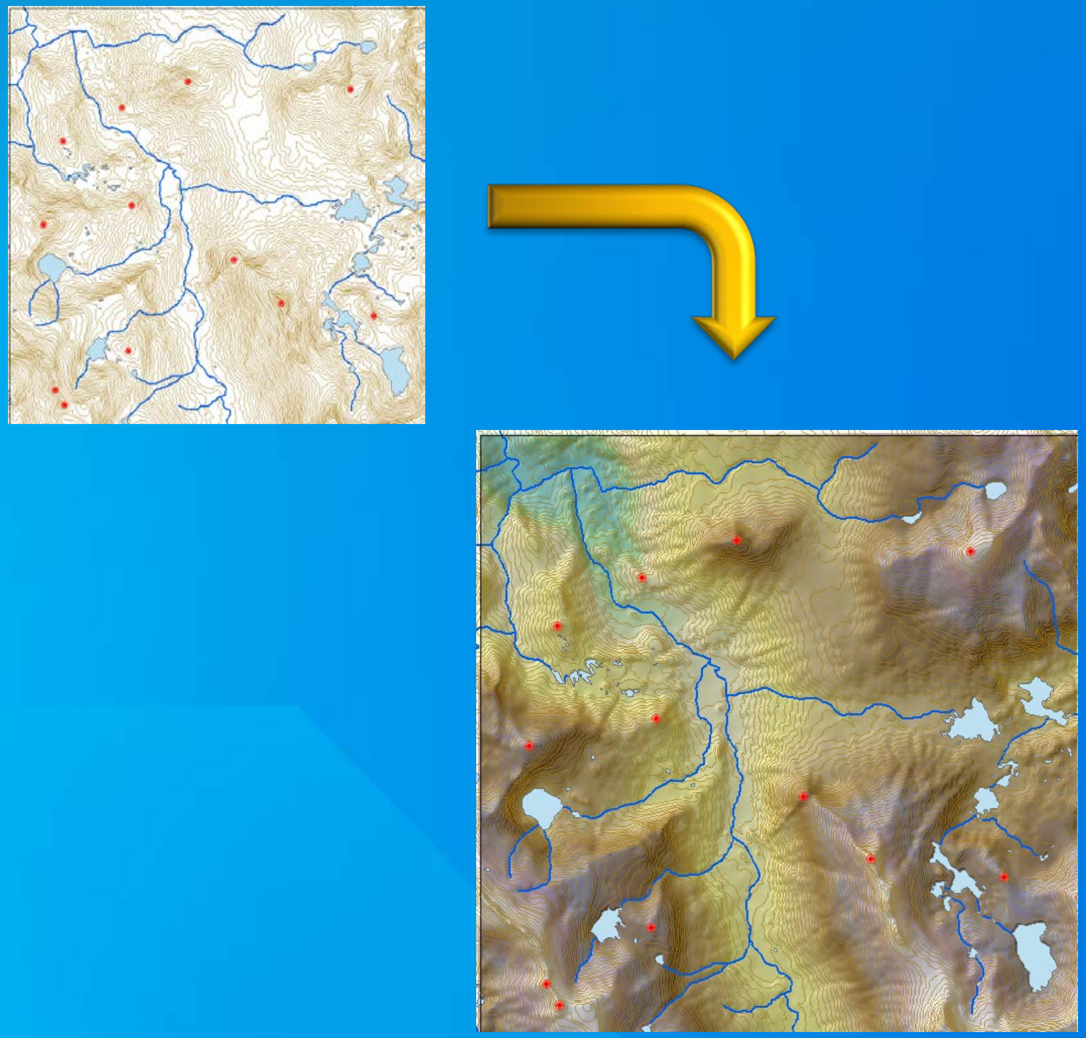
- Kernel Interpolation with Barriers
- Diffusion Interpolation with Barriers
- Spline with Barriers

Geologic Interpolation with barriers

Demonstration

For contour input, and creating hydrologic DEMs

- Topo To Raster
  - ANUDEM
- Inputs
  - Spot heights
  - Contours
  - Streams
  - Sinks
  - Lakes
- Optional drainage enforcement

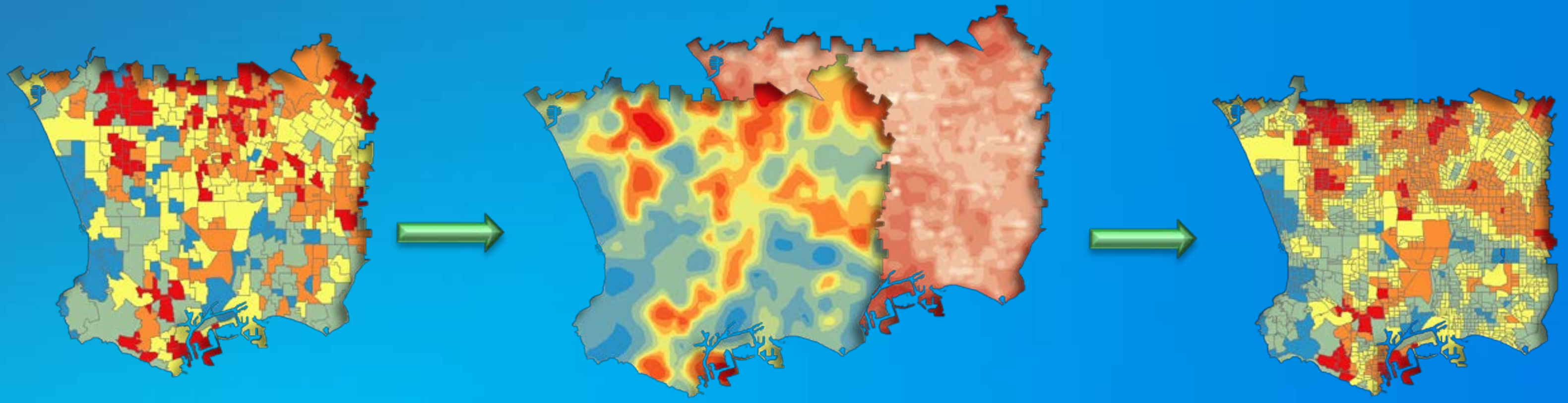


TopoToRaster for DEM Creation

Demonstration

Your input is polygons

Use Areal Interpolation



Obesity by school zone

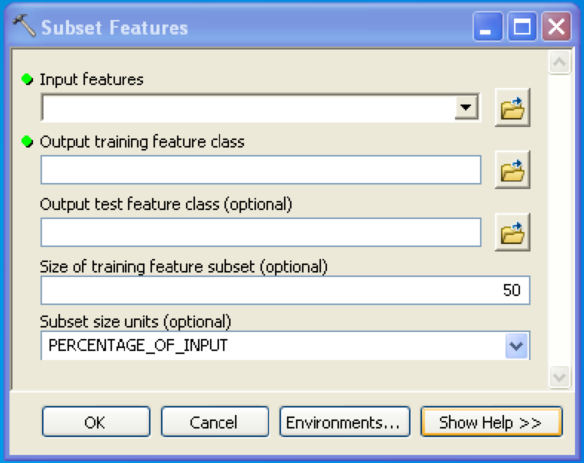
Obesity surface and error surface

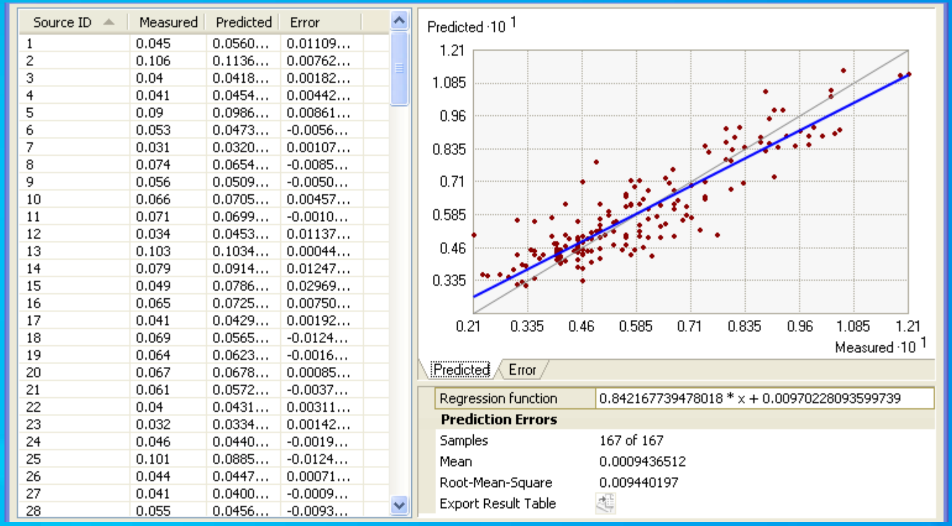
Obesity by census block

- Statistically robust method for creating surfaces from aggregated polygon data
- And aggregating back to other polygons

How good is your surface?

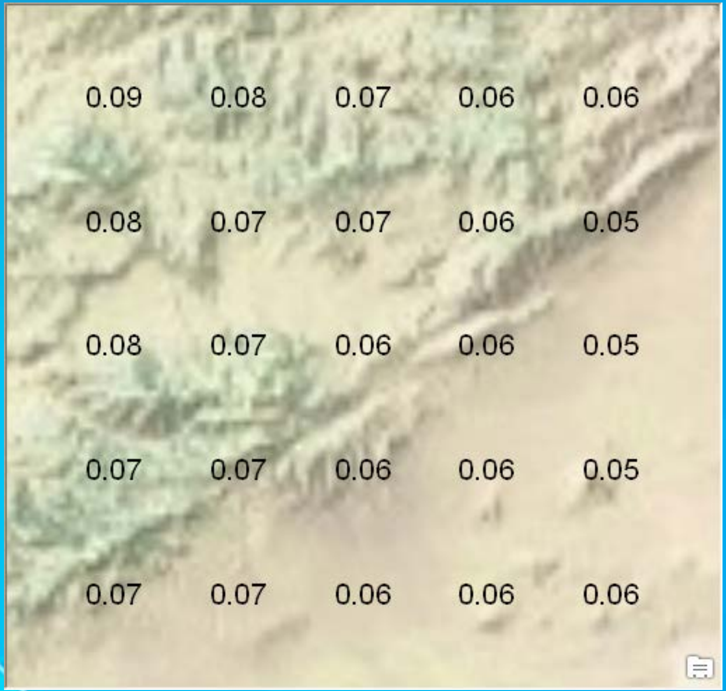
- Standard Error surface
- Cross Validation
- Subset Features





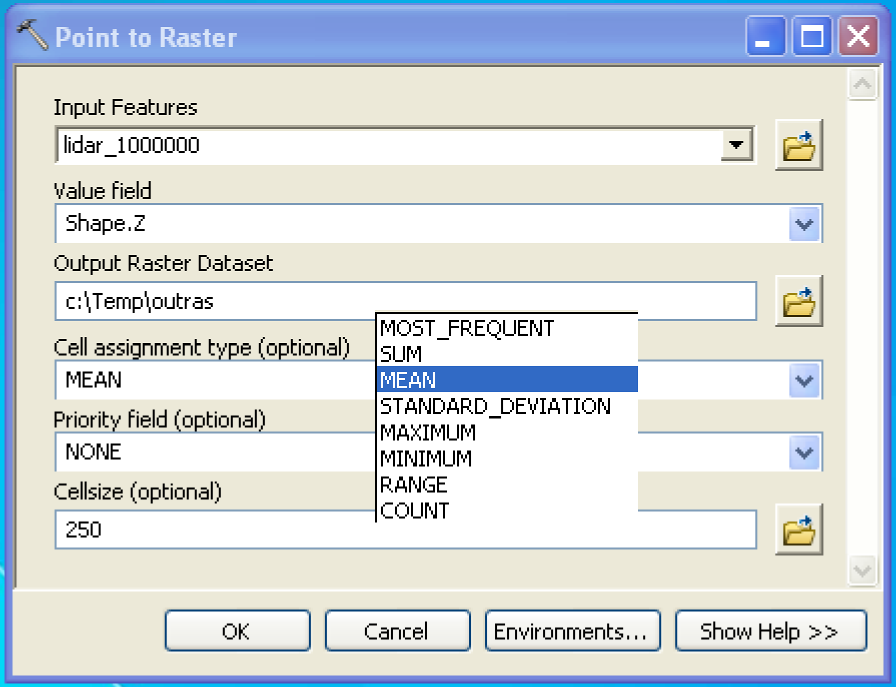
Your input is equally spaced points

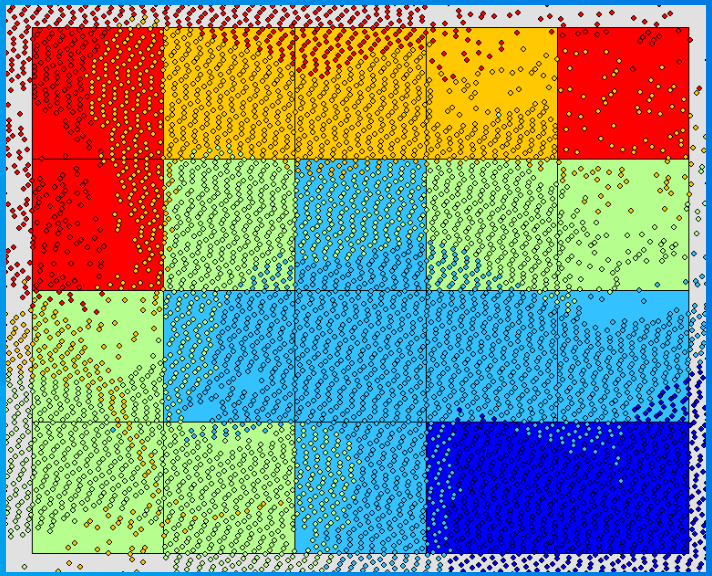
- If input points are already equally spaced on a regular grid, you probably don’t need to interpolate, just use **PointToRaster**



You have many input points per output cell

- **If your data is highly oversampled, you probably do not need to interpolate, you can just use the PointToRaster tool, and select the statistic of interest.**





Working with VERY large input point data

- Point To Raster
  - Most frequent
  - Sum, mean std. deviation
  - Minimum, maximum, range, count
- Smaller input extent
- Subset Features

The slide to remember…

1) Understand your data
2) Experiment with techniques and parameters
3) Create surfaces
4) Evaluate your surfaces
5) Refine parameters and ***repeat…***

Thank you…

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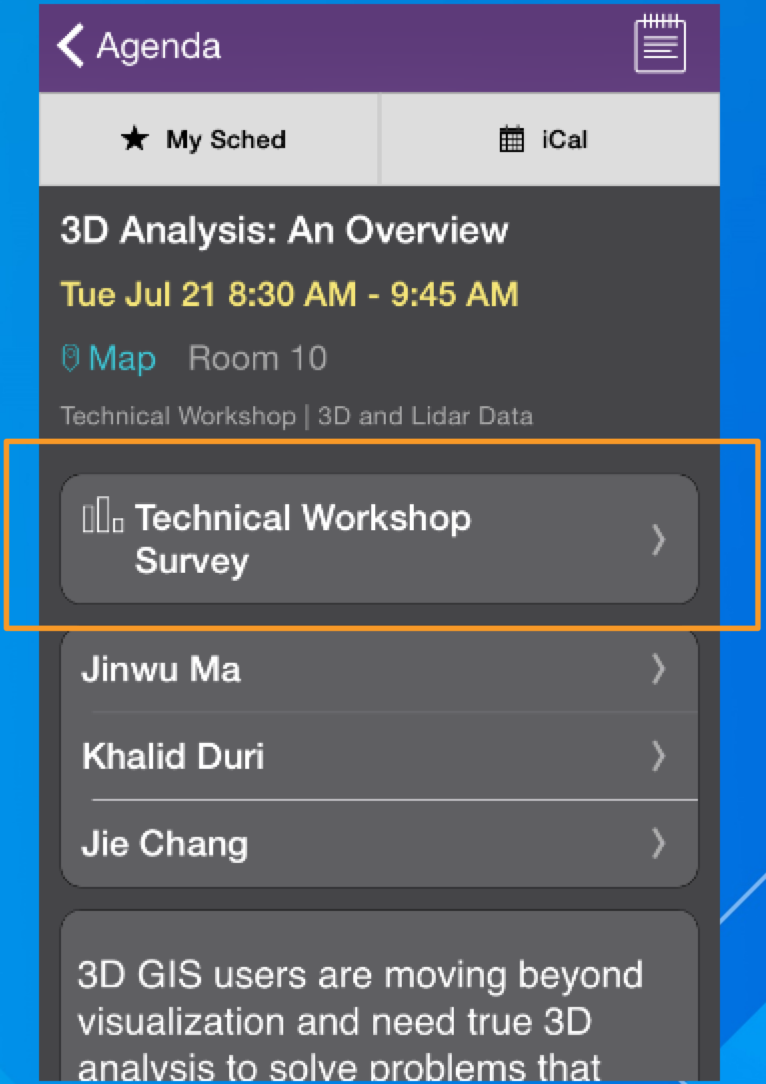
- Select [Creating Surfaces] in the Mobile App
  - Use the Search Feature to quickly find this title
- Click “Technical Workshop Survey”
- Answer a few short questions and enter any comments



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Understanding our world.