2013 Esri International User Conference
July 8–12, 2013 | San Diego, California

Technical Workshop

Concepts and Applications of Kriging

Eric Krause

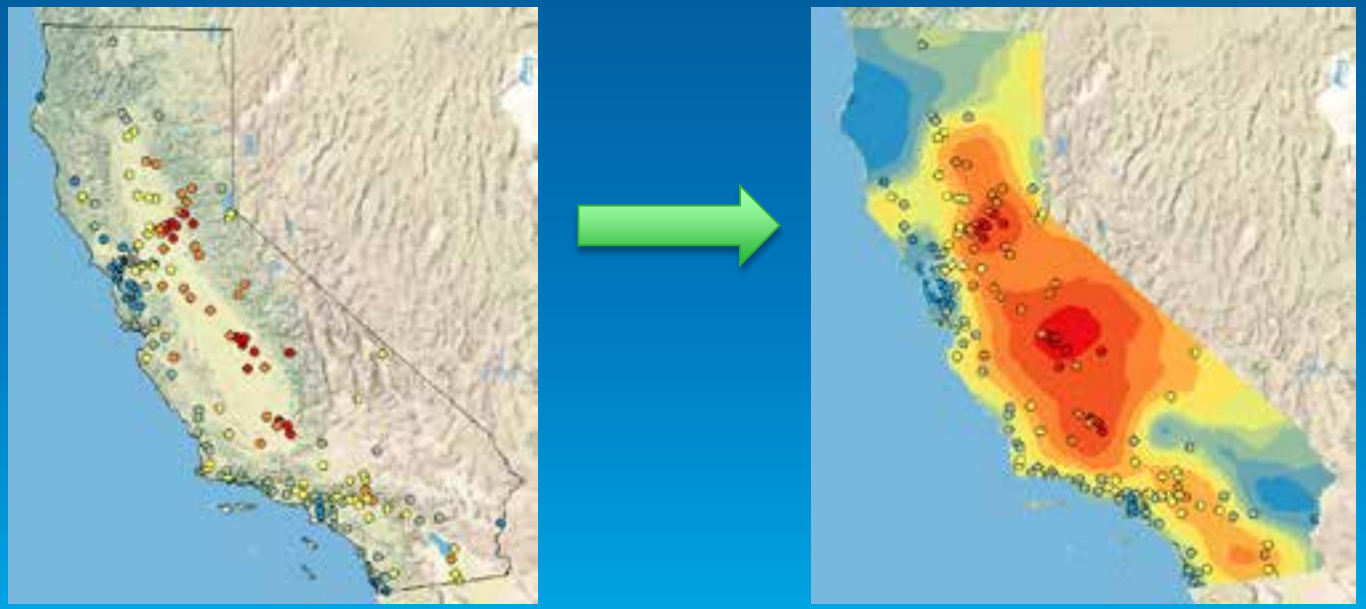
Konstantin Krivoruchko

Outline

- Intro to interpolation
- Exploratory spatial data analysis (ESDA)
- Using the Geostatistical Wizard
- Validating interpolation results
- Empirical Bayesian Kriging
- Areal Interpolation
- Questions

What is interpolation?

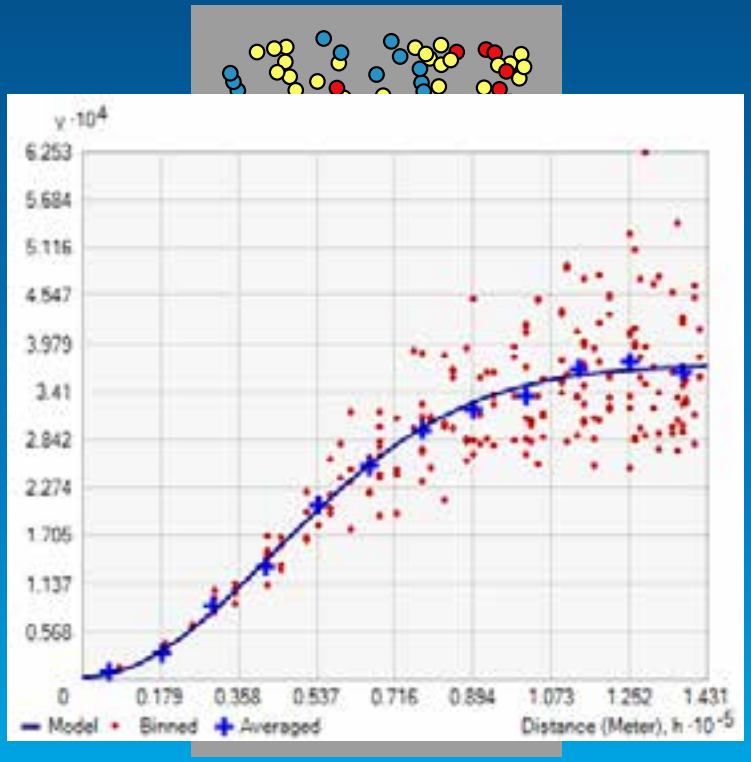
- Predict values at unknown locations using values at measured locations
- Many interpolation methods: kriging, IDW, LPI, etc

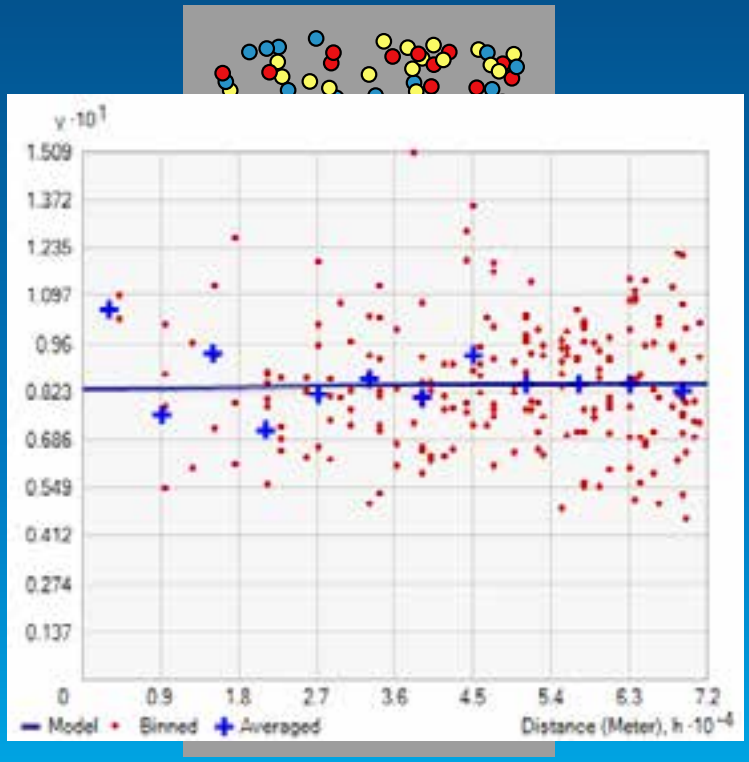


What is autocorrelation?

Tobler’s first law of geography:

"Everything is related to everything else,
but near things are more related than distant things."





Demo

Geostatistical Wizard

Eric Krause

What is kriging?

- Kriging is the optimal interpolation method if the data meets certain conditions.
- What are these conditions?
  - Normally distributed
  - Stationary
  - No trends
- How do I check these conditions?
  - Exploratory Spatial Data Analysis (ESDA)

What is an “optimal” interpolator?

- Estimates the true value, on average
- Lowest expected prediction error
- Able to use extra information, such as covariates
- Filters measurement error
- Can be generalized to polygons (Areal interpolation, Geostatistical simulations)
- Estimates probability of exceeding a critical threshold

Geostatistical workflow

1. Explore the data
2. Choose an interpolation method
3. Fit the interpolation model
4. Validate the results
5. Repeat steps 2-4 as necessary
6. Map the data for decision-making

Exploratory Spatial Data Analysis

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

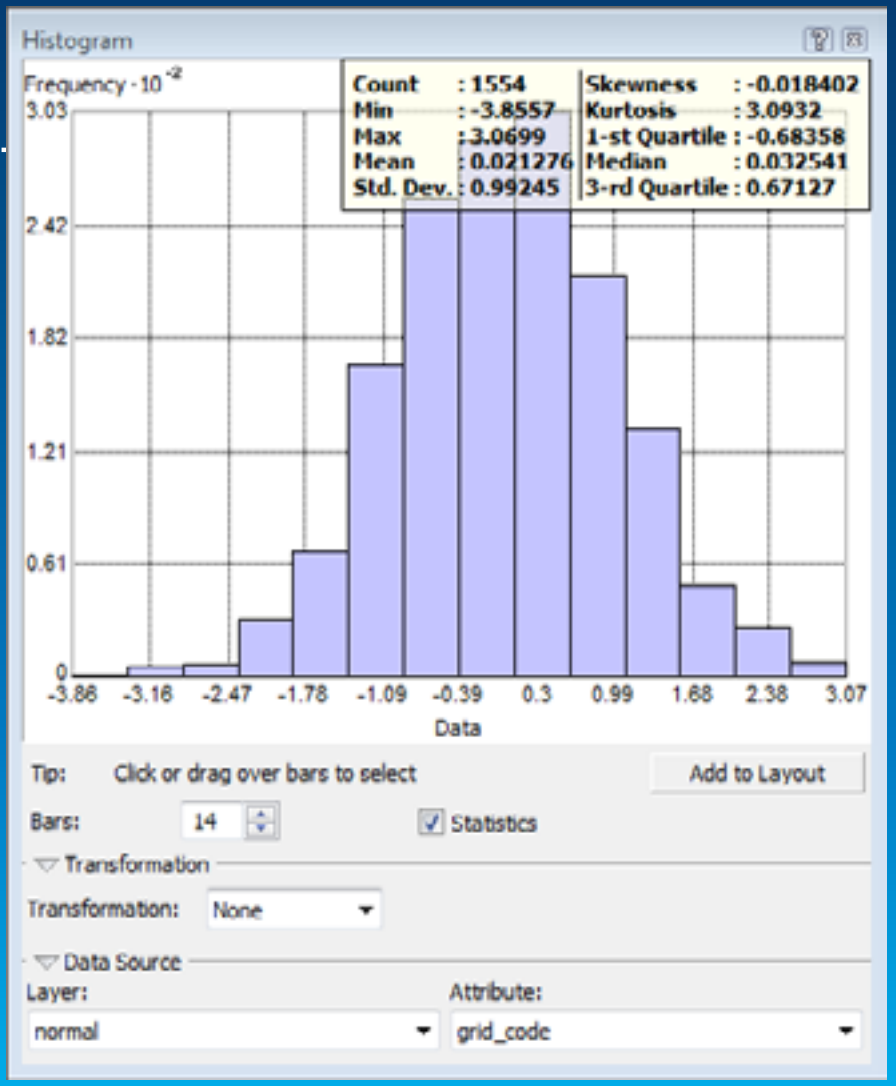
Does my data follow a normal distribution?

- How do I check?
  1. Histogram
     - Check for bell-shaped distribution
     - Look for outliers
  2. Normal QQPlot
     - Check if data follows 1:1 line

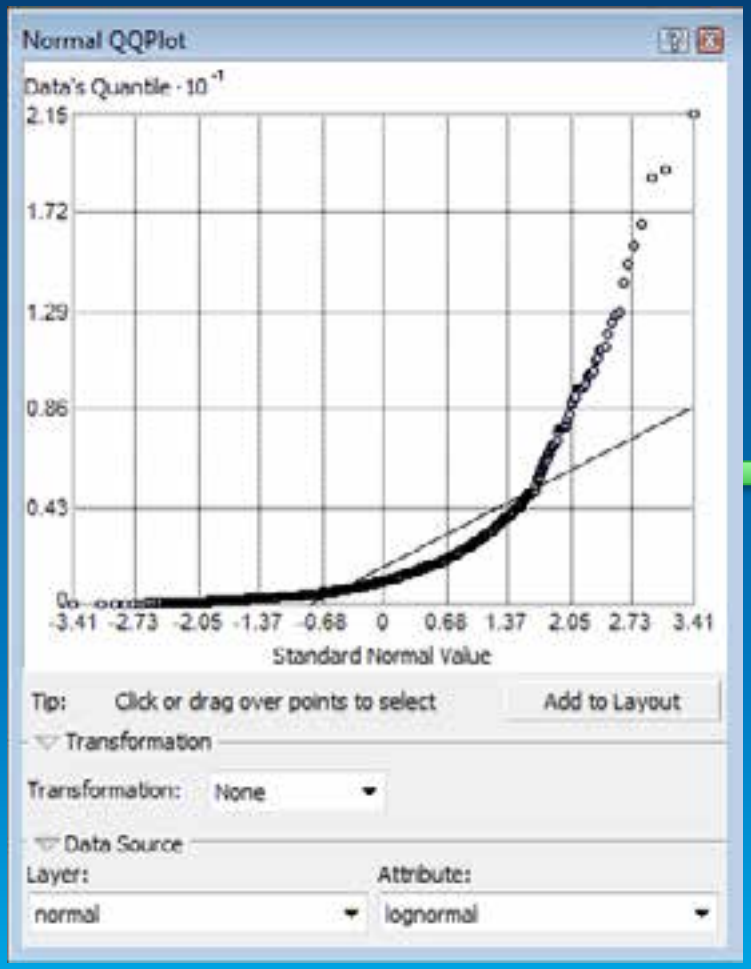
- What can I do if my data is not normally distributed?
  - Apply a transformation
    - **Log, Box Cox, Arcsin, Normal Score Transformation**

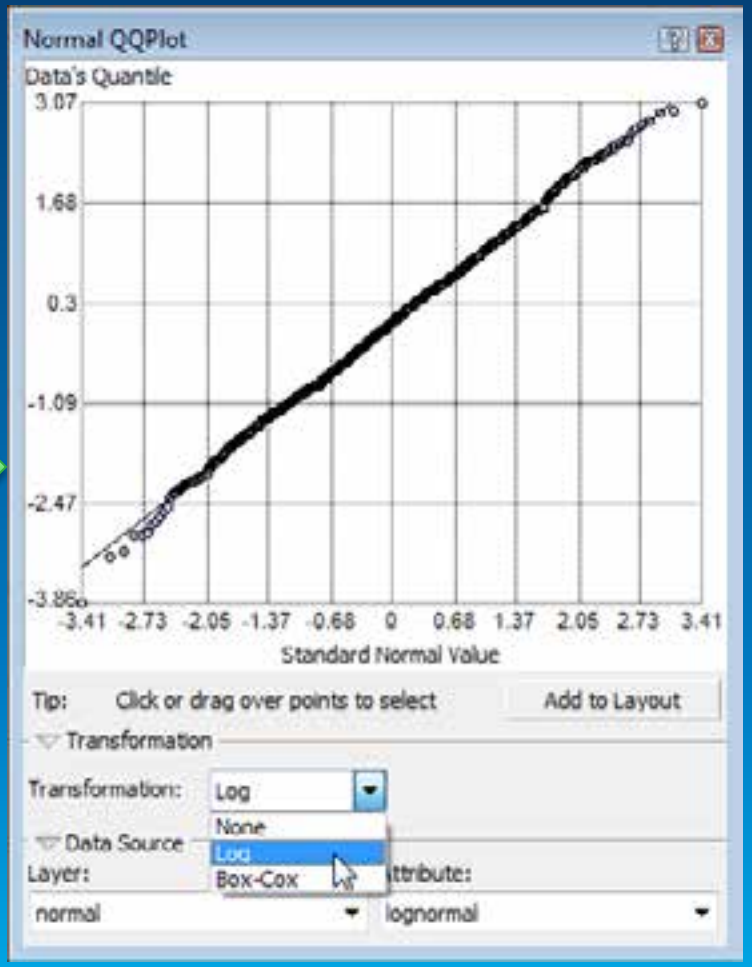
Does my data follow a normal distribution?

- What should I look f
  - Bell-shaped
  - No outliers
  - Mean ≈ Median
  - Skewness ≈ 0
  - Kurtosis ≈ 3



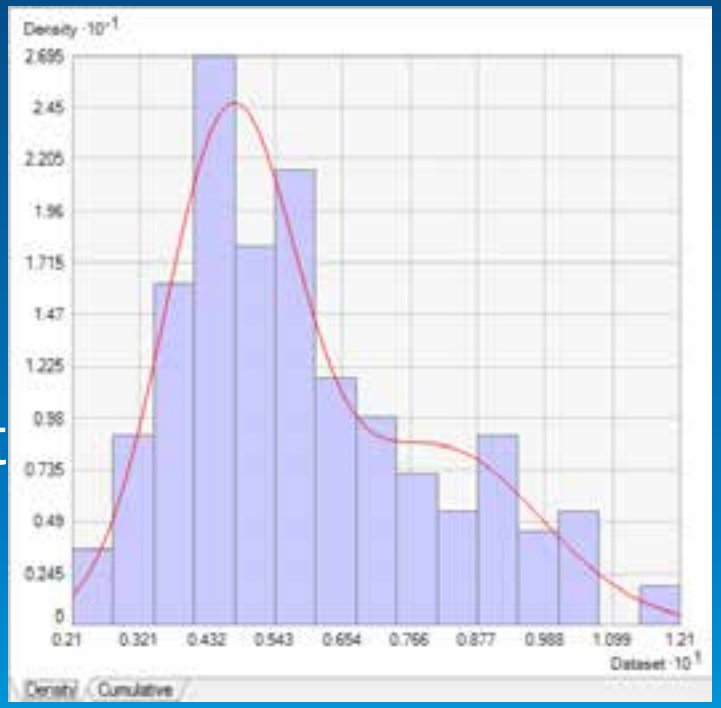
Does my data follow a normal distribution?





Normal Score Transformation

- Fits a smooth curve to the data
- Performs a quantile transformation to the normal distribution
- Performs calculations with transformed data, then transforms back at the end
- Simple kriging with normal score transformation is default in ArcGIS 10.1

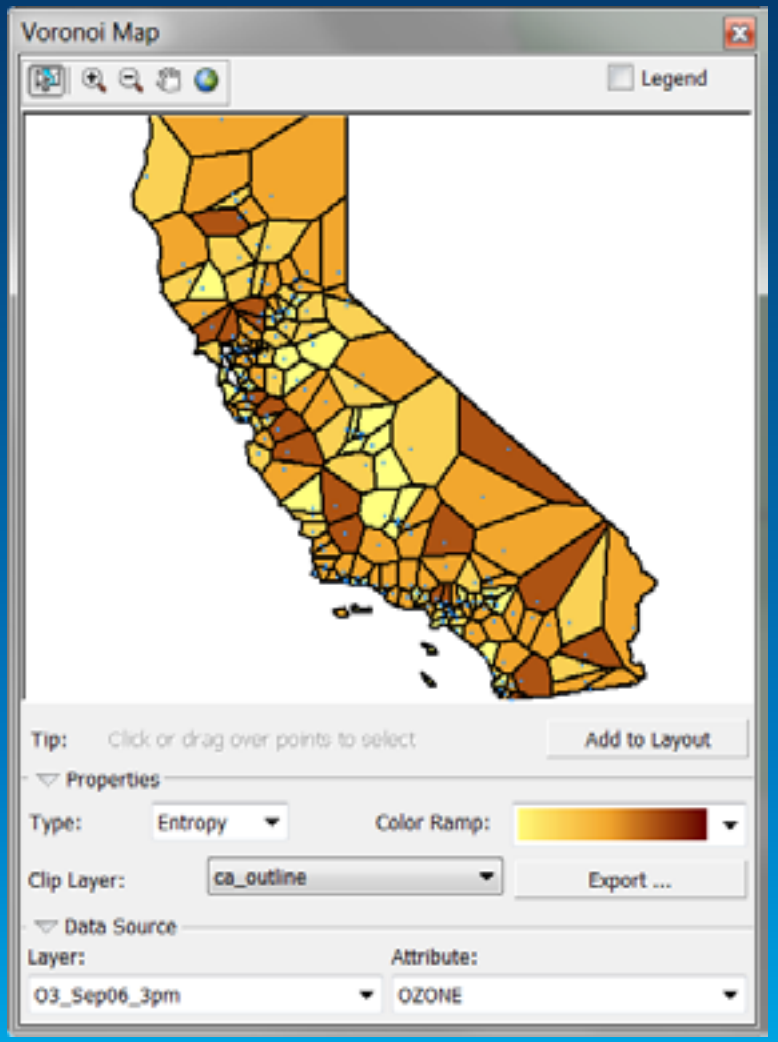


Is my data stationary?

- What is stationarity?
  - The statistical relationship between two points depends only on the distance between them.
  - The variance of the data is constant (after trends have been removed)
- How do I check for stationarity?
  - Voronoi Map symbolized by Entropy or Standard Deviation
- What can I do if my data is nonstationary?
  - Transformations can stabilize variances
  - Empirical Bayesian Kriging – ArcGIS 10.1

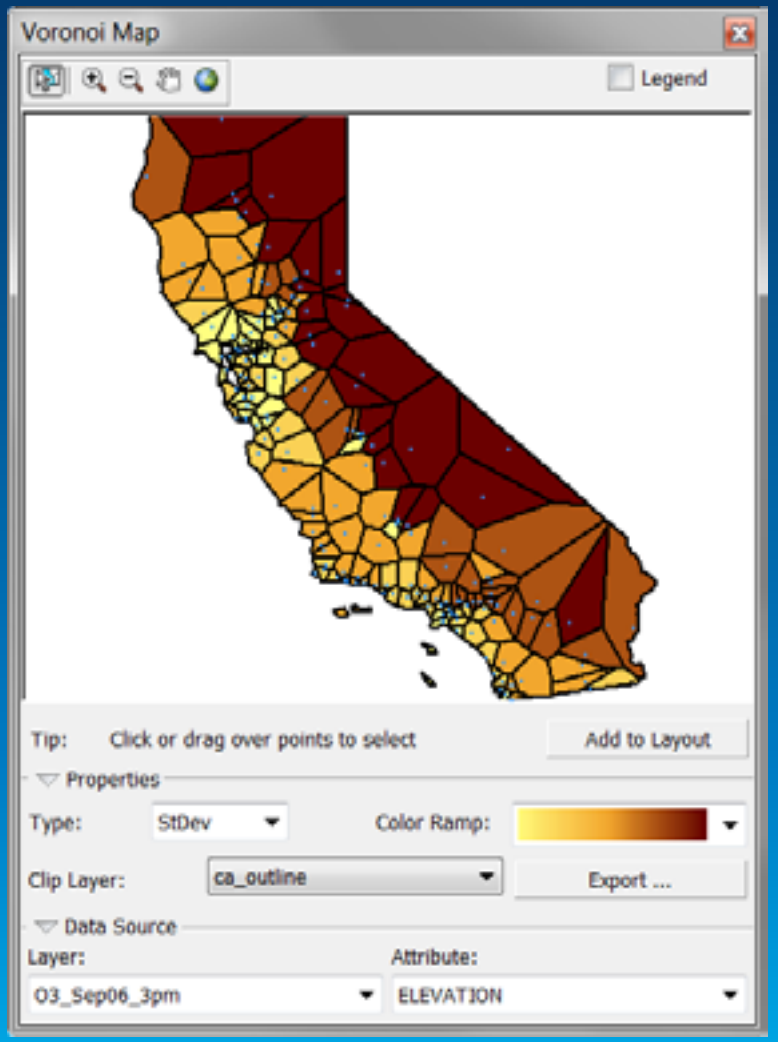
Is my data stationary?

- When symbolized by Entropy or StDev, look for randomness in the symbolized Thiessen Polygons.



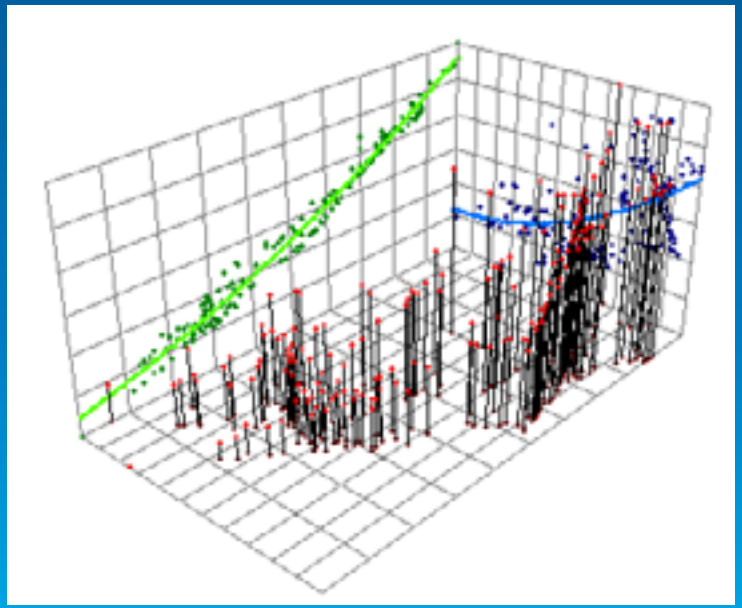
Is my data stationary?

- When symbolized by Entropy or StDev, look for randomness in the symbolized Thiessen Polygons.



Does my data have trends?

- What are trends?
  - Trends are systematic changes in the values of the data across the study area.
- How do I check for trends?
  - Trend Analysis ESDA tool
- **What can I do if my data has trends?**
  - **Use trend removal options**
  - **Potential problem – Trends are often indistinguishable from autocorrelation and anisotropy**

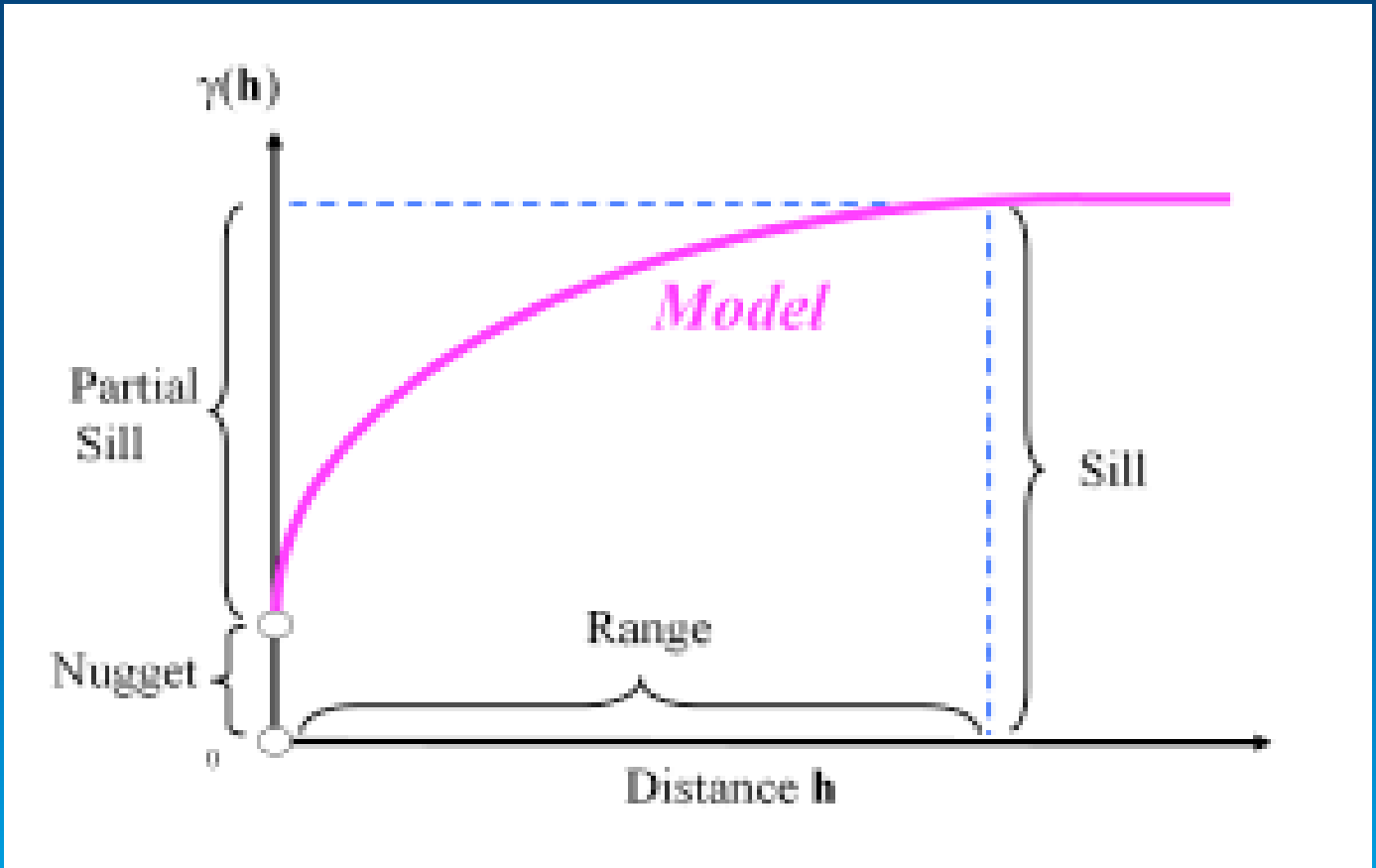


Demo

ESDA

Eric Krause

Semivariogram/Covariance Modeling



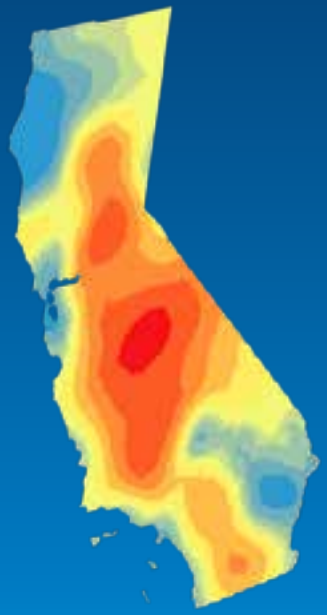
Cross-validation

- Used to determine the quality of the model
  - Iteratively discard each sample
  - Use remaining points to estimate value at measured location
  - Compare predicted versus measured value

Prediction Errors	
Samples	75049 of 75049
Mean	-3.308263e-7
Root-Mean-Square	0.002382183
Mean Standardized	-0.0001263315
Root-Mean-Square Standardized	0.8544209
Average Standard Error	0.002788466
Export Result Table	

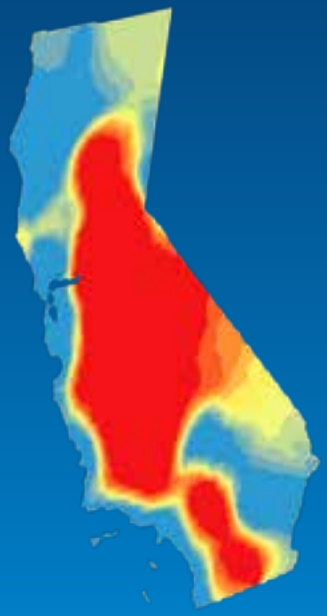
Kriging output surface types

Prediction

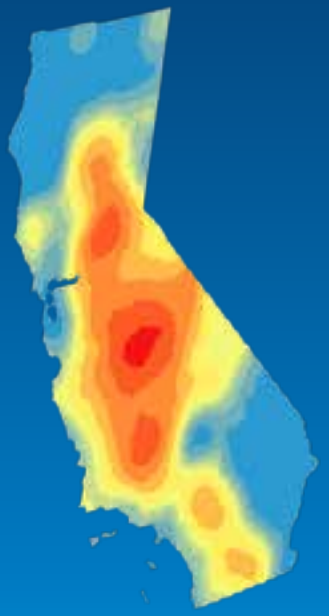


Error of Predictions

Probability



Quantile



Demo

Kriging

Eric Krause

Empirical Bayesian Kriging (EBK)

- Spatial relationships are modeled automatically
- Results often better than interactive modeling
- Uses local models to capture small scale effects
  - Doesn’t assume one model fits the entire data

How does EBK work?

1. Divide the data into subsets of a given size
   - Controlled by “Subset Size” parameter
   - Subsets can overlap, controlled by “Overlap Factor”
2. For each subset, estimate the semivariogram
3. Simulate data at input point locations and estimate new semivariogram
4. Repeat step 3 many times. This results in a distribution of semivariograms
   - Controlled by “Number of Simulations”
5. Mix the local surfaces together to get the final surface.

Empirical Bayesian Kriging

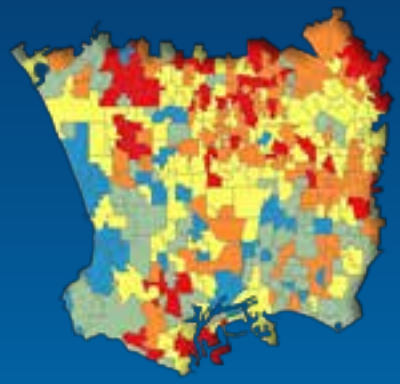
- Advantages
  - Requires minimal interactive modeling
  - Standard errors of prediction are more accurate than other kriging methods
  - More accurate than other kriging methods for small or nonstationary datasets
- Disadvantages
  - Processing is slower than other kriging methods
  - Limited customization

Demo

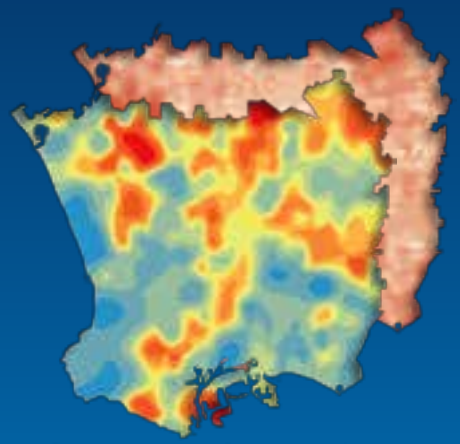
Empirical Bayesian Kriging

Eric Krause

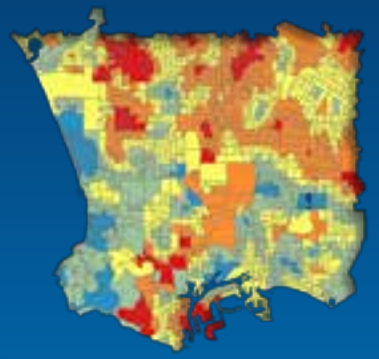
Areal Interpolation



Obesity by school zone



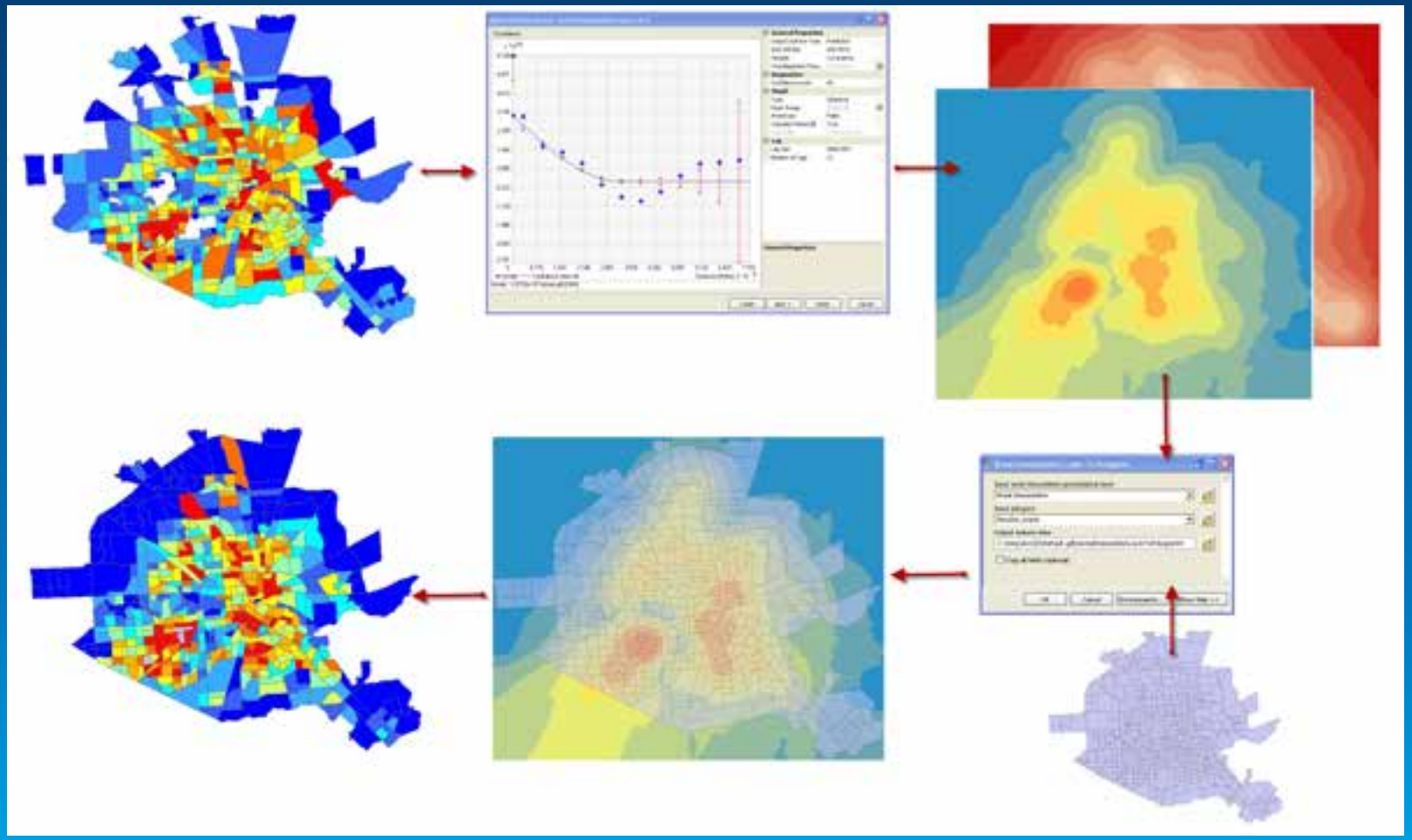
Obesity surface and error surface



Obesity by census block

- Predict data in a different geometry
  - School zones to census tracts
- Model and fill-in missing data

Polygon to Polygon Workflow

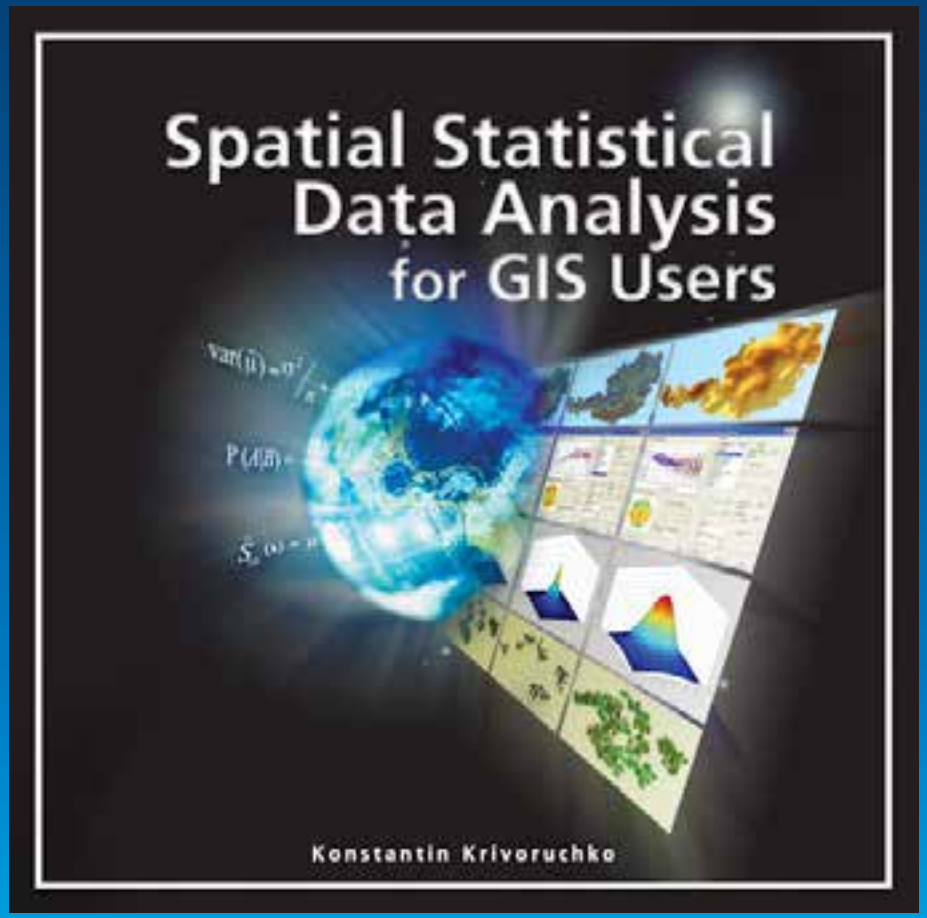


Demo

Areal Interpolation

Eric Krause

Available in the bookstore and from Esri Press



resources.arcgis.com

ArcGIS Resource Center
Communities
Help
Blogs
Forums
Videos
Forums
Forum
What's New?
Today's Posts
FAQ
Forum Actions
Forum ▸ ArcGIS ▸ Extensions ▸ Geostatistical Analyst
Did you post and someone replied with a good answer? Help the community to find these great posts with answers by
that it has been answered for you.
+ Post New Thread
Threads 1 to 50
Forum: Geostatistical Analyst
Title / Thread Starter
Replies / Views
Semivariogram interpretation after detrending
Started by bekkiee, 06-29-2012 12:07 PM
Replies: 1
Views: 41
Binary and Ordinal Data for Kirging or other Interpolation techniques?
Started by jathank, 06-11-2012 09:16 AM
Replies: 5
Views: 98
Learning how to use the Geostatistical Analyst extension
Started by yppmark, 06-14-2012 06:36 AM
Replies: 2
Views: 77
Advice to a newbie. How do I bring xy data into my shapefile?
Started by janiew, 06-12-2012 02:53 AM
Replies: 4
Views: 72
Data Preparation For Kriging
Started by Traeumer, 06-07-2012 10:35 AM
Replies: 4
Views: 81
ESDA, Kriging
Started by maya3m, 06-05-2012 10:09 PM
Replies: 1
Views: 73
Densify Sampling Network
Started by harpssi, 05-31-2012 03:52 PM
Replies: 4
Views: 85
(Beginner) Geostastical Analyst - Memory Error
Replies: 5

Presentations of interest…

- EBK – Robust kriging as a GP tool
  - Wednesday 10:00 – 10:30, Demo Theater
- Geostatistical Simulations
  - Thursday 11:00 – 11:30, Demo Theater
- Creating Surfaces
  - Wednesday 8:30 – 9:45, Tech Workshop, Room 03
- Surface Interpolation in ArcGIS
  - Wednesday 4:30 – 5:30 Demo Theater
- Geostatistical Analyst - An Introduction
  - Wednesday 1:30 – 2:45pm, Tech Workshop, Room 05 A
- Areal Interpolation – Performing polygon-to-polygon predictions
  - Wednesday 5:30 – 6:00 Demo Theater
- Designing and Updating a Monitoring Network
  - Thursday 11:30 – 12:00 Demo Theater

Thank you…

Please fill out the session evaluation

First Offering ID: 1180

Second Offering ID: 1301

Online – www.esri.com/ucsessionsurveys

Paper – pick up and put in drop box

Understanding our world.