

#### Esri International User Conference | San Diego, CA Technical Workshops | July 2011

## **Geostatistical Analyst - An Introduction**

Steve Lynch and Eric Krause

#### **Presentations of interest...**

#### Geostatistical Simulations

- Tuesday 5:00pm – 6:00pm Demo Theater

#### Surface Interpolation in ArcGIS

Wednesday 9:00am – 10:00am Demo Theater

#### Creating Surfaces

- Wednesday 1:30pm 2:45pm 1A/B
- Concepts and Applications of Kriging
  - Thursday 10:15am 11:30am 14A

### Outline

- What is
  - geostatistics?
  - Geostatistical Analyst?
- Interpolation workflow
- Demonstrations
- Supplementary information
- Post 10
- Questions / Answers

# Please fill out the questionnaire

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What is geostatistics ?

# The statistics of spatially correlated data



What is geostatistics ?

# The statistics of spatially correlated data





#### **Geostatistical Analyst - Overview**

#### Interactive

- Exploratory Spatial Data Analysis tools
- Variography
- Kriging
- Other interpolation methods
- Cross validation
- Geoprocessing toolbox
  - Interpolation
  - Sampling Network Design
  - Simulation
  - Utilities
  - Conversion

#### Where is Geostatistical Analyst used?



### Where is Geostatistical Analyst used?



#### Experiment conducted by the US EPA 20 years ago

- 12 independent reputable geostatisticians
- Given the same data
- Asked to perform the same straightforward estimation
- Results were widely different
- Different
  - data analysis conclusions
  - variogram models and choice of kriging type
  - searching neighborhoods.

Isaaks & Srivastava, 1989. An Introduction to Applied Geostatistics.

#### **Geostatistical Analyst – Toolbar and Toolbox**



El General Example Strends (Milladoo Pater Serie-program ĸ. Emberine could D Hadel Negati 1----Callshire Mapping 1 mar Heatquerert Strot 100 -E model at the state is Electronic de las 10 a Heir Farse Aniashrooy Paint Cataloge Fatal M. true. 15 Mudel #7 E Pladel #3 140 589 12413.04 Mumbrid of Large 12 Channel 7 The releated model influences the president of the attroom values, particularly when the shape of the surveness the origin differs significanly. The denses the curve near the origin, the more effuence the closest neighbors will have on the production. It is dealerable that the fitted north inche he close to the armingt stresses on the sent-alcorpt argin.

Prat.

Carval

# **Wizard demonstration**

Demonstration

#### What's new in 10 – Geoprocessing tools

- Global Polynomial Interpolation
- Local Polynomial Interpolation
- IDW
- Radial Basis Functions
- Cross Validation
- Subset Features

### What's new in 10 - functionality

- Interpolation with barriers
  - Diffusion Interpolation
  - Kernel Interpolation
- Sampling network design
  - From scratch
  - Existing network

#### What's new in 10 – Optimize buttons

- Local Polynomial Interpolation
- Kriging
  - Nugget, partial sill and other(s), are optimized using cross validation with focus on the estimation of the range parameter.



#### Interpolation workflow

- Exploratory Spatial Data Analysis (ESDA)
- Interpolation
- Goodness of fit

#### **Exploratory Spatial Data Analysis**

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



#### **Exploratory Spatial Data Analysis (ESDA)**





### **Exploratory Spatial Data Analysis (ESDA)**





Mean	~
Simple	
Mean	
Mode	
Cluster	
Entropy	
Median	
StDev	$\mathbb{N}$
IQR	ふ

### **Exploratory Spatial Data Analysis (ESDA)**





#### Crosscovariance



# Kriging

- Concepts and Applications of Kriging
- Thursday 10:15am 11:30am 14A

#### Outline

- Introduction to kriging
- Best practices
- Fitting a proper model
- Variography, transformations, isotropy, stationarity
- Comparing models using cross validation
- Interpreting results

#### What is kriging?

- It is a geostatistical interpolation technique
- that models the spatial correlation of point measurements
- to estimate values at unmeasured locations.
- Associates uncertainty with the predictions





### Kriging as a geoprocessing tool!

- Requires interactive variography
- Spatial Analyst
- Empirical Bayesian Kriging

#### **Interpolation with Barriers**

- Kernel interpolation
- Diffusion interpolation







### **Kernel Interpolation with Barriers**

Demonstration

#### **Goodness of fit / Model acceptance**

- Subset Features
- Cross Validation

Subset Features	. 🗆 🐹
· Input features	
	1 12
<ul> <li>Output training feature class</li> </ul>	and the second second
	6
Output test feature class (optional)	
N.	B
Size of training feature subset (optional)	
Contraction (Contraction)	50
Subset size units (optional) PERCENTAGE_OP_INPUT	
OK Cancel Environments	Show Help >>

Source ID	Measured	Predicted	Error	*	Predicted 10 <sup>1</sup>
1	0.045	0.0560	0.01109		191
2	0.106	0.1136	0.00762		
3	0.04	0.0416	0.00162		1095
4	0.041	0.0454	0.00442		· · · · · · · · · · · · · · · · · · ·
5	0.09	0.0986	0.00861	-	0.96
6	0.053	0.0473	-0.0056	-	11 Jack
7	0.031	0.0320	0.00107		0.835
8	0.074	0.0654	-0.0085		
9	0.056	0.0509	-0.0050		071 + + +
10	0.066	0.0705	0.00457		a a state of the s
11	0.071	0:0699	-0.0010		0.505
12	0.034	0:0453	0.01137		a sale since the
13	0.100	0.1034	0.00044		0.45
14	0.079	0:0914	0.01247		
15	0.049	0.0706	0.02969		0.335
16	0.065	0.0725	0.00750		
17	0.041	0.0429	0.00192		0.21 0.225 0.46 0.505 0.21 0.025 0.96 1.005 1.21
10	0.069	0.0565	-0.0124		Sal 5000 970 8360 871 6600 830 1000 121
19	0.064	0.0623	-0.0016		Measured 10 *
20	0.067	0.0678	0.00085		Predicted (Enor
21	0.061	0.0572	-0.0037		
22	0.04	0.0431	0.00311		Regression function 0.54216/739478018 * ± 0.00970228093599739
23	0.032	0.0334	0.00142		Prediction Errors
24	0.046	0.0440	-0.0019		Samples 167 of 167
25	0.101	0.0885	-0.0124		Mean 0.0009436512
26	0.044	0.0447	0.00071		Boot Mean Server 0.005e40107
27	0.041	0.0400	-0.0009		NOW TOOL AND UNIVERSITY
20	0.055	0.0456	-0.0093	×	Export Result Table

#### **Subset Features**



ELEVATION	Predicted	Error	~
99	196.216111	97.216111	
-32	47.910613	79.910613	B
194	256.709823	62.709823	
545	605.799907	60.799907	
91	149.811753	58.811753	
65	116.717815	51.717815	
98	148.111075	50.111075	~

### **Cross validation – Modelbuilder + Python**

Demonstration



#### Cressie, 1990

- Cross validation does not prove that the model is correct,
- merely that it is not grossly incorrect.

#### **Geostatistical layer**

- Method and parameters
- Pointer to the data
- Dynamic

#### Input datasets Dataset C:\\ozone Feature Class Type. Data field 1 OZONE Records 167 Method Kriging Type. Ordinary Prediction Output type Dataset # 1 Trend type. None Searching neighborhood Standard Neighbors to include. 5 Include at least 2 Sector type Four and 45 degree 184,205.54207886063 Major semiaxis Minor semiaxis 184,205.54207886063 Angle. 0 Variogram Semivariogram Number of lags 12 Lag size 22.735.88177094771 Nugget 3.568854444304942e-005 Measurement error % 100 Stable E Model type. 1.9771484375 Parameter

Range.

Anisotropy

Partial sill

0.000554848233

No

184,205.54207886063

# **Geostatistical layer**

Demonstration

**Output =** Prediction, Prediction SE, Probability, Quantile, Condition number



### **Gaussian Geostatistical Simulations**

- Geostatistical Simulations
- Tuesday 5:00pm 6:00pm Demo Theater

### Simple kriging

the real state





#### **Create Spatially Balanced Points**

- Monitor road pollution
- Convert roads to raster
- High value = busy road
- Low value = quite road



### **Create Spatially Balanced Points (cont.)**

input inclusion probability raster	
Create Spatially Balanced Points weights_roads	- 6
Number of output points	
	250
Output point Feature class	
'ronitor_sites	0

Sampling Network Design



### **Densify Sampling Network**

- Used kriging to create:
  - Prediction surface
  - Standard error of prediction
- Want to add 2 new sites





**Sampling Network Design** 

### **Densify Sampling Network (Cont.)**



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#### Post 10

# **Areal Interpolation**



# **Empirical Bayesian Kriging**



# resources.arcgis.com



#### http://esripress.esri.com



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