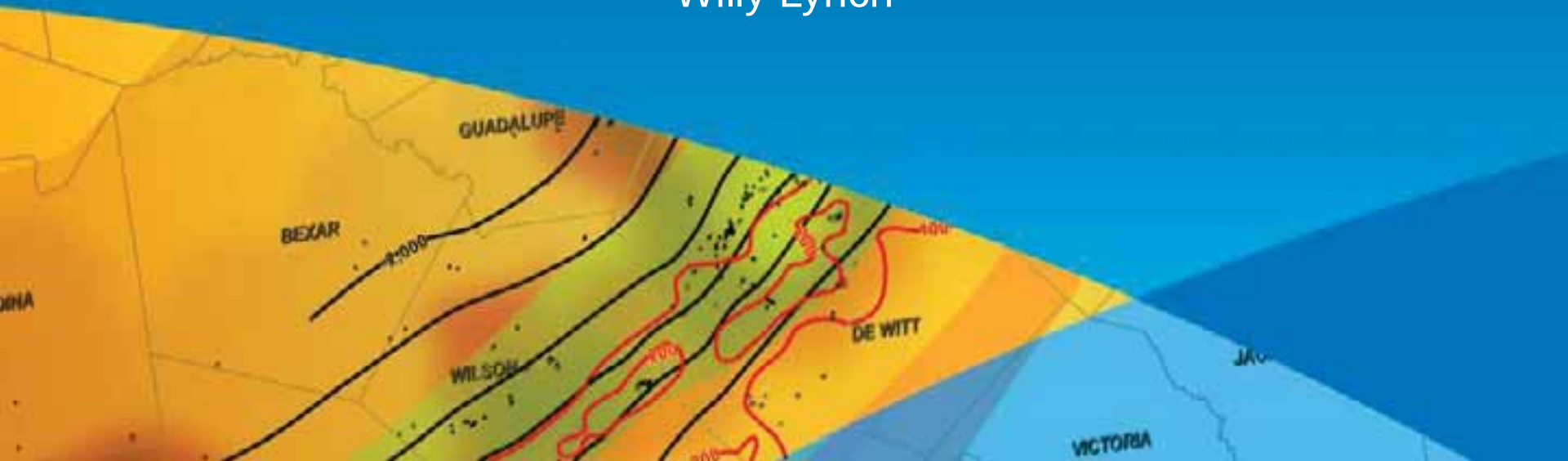
Esri Petroleum GIS Conference
March 7–9, 2013 | Houston, Texas

Performing Analysis with ArcGIS Extensions:
Spatial Analyst, Geostatistical Analyst, and 3D Analyst

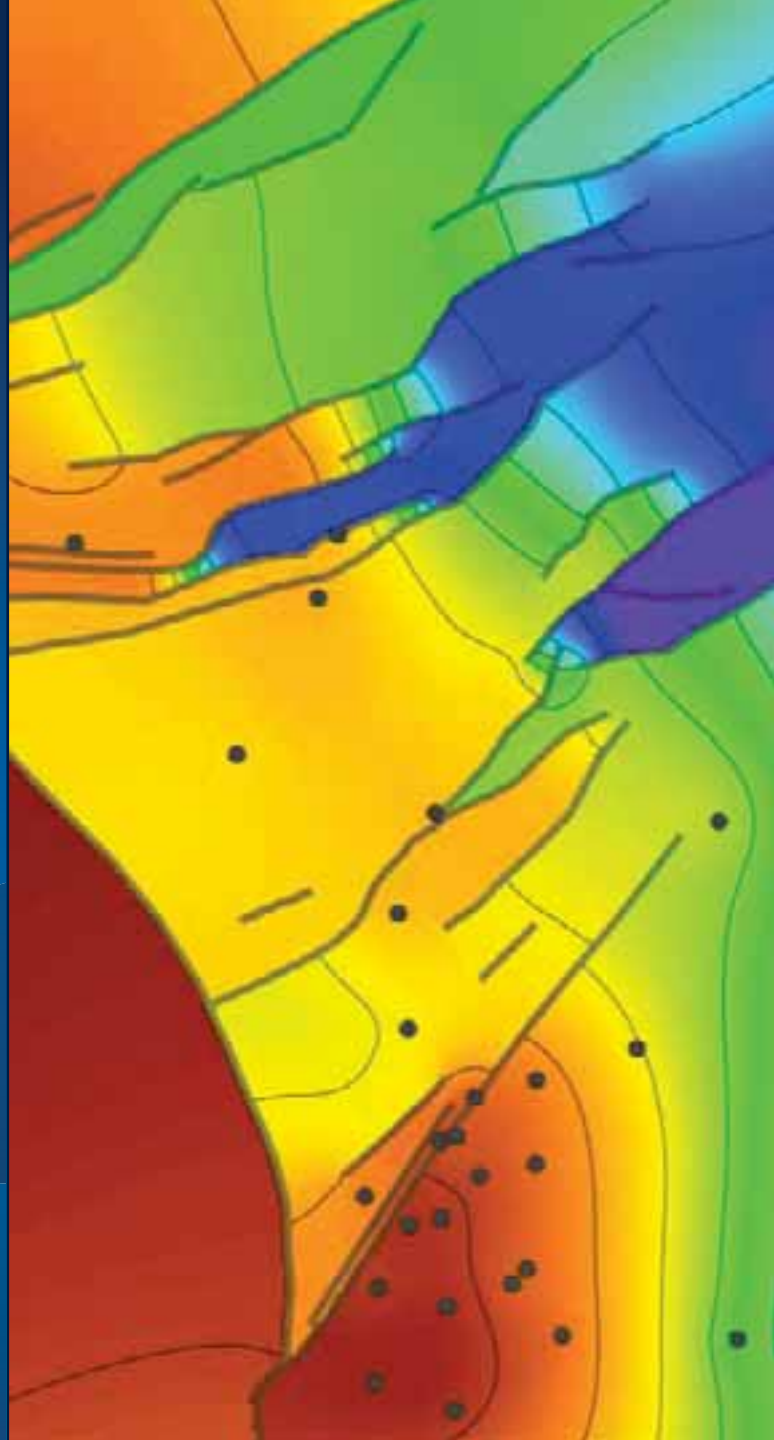
Steve Kopp
Willy Lynch



Key Themes

- Gridding and Contouring
- 3D Analysis and Visualization
- Finding the best place

Gridding and Contouring



Types of Surfaces

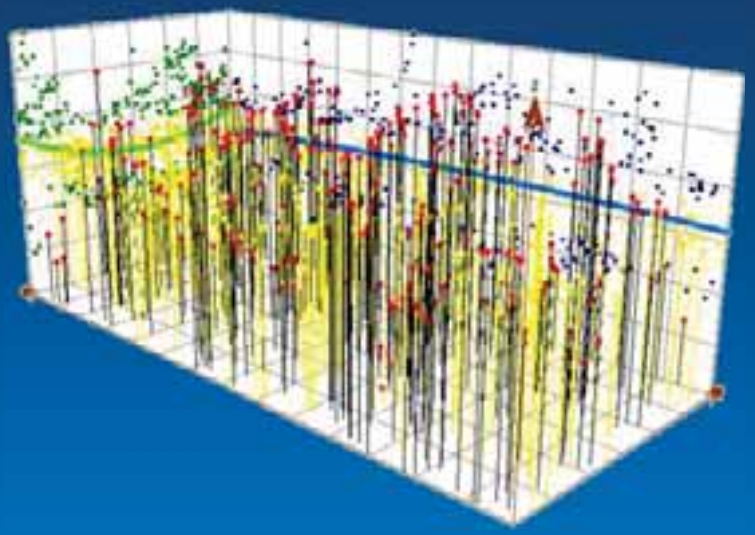
- Top and bottom of formations
- Formation characteristics
  - Porosity
  - Permeability
- Elevation
- Soil characteristics
- Air quality
- Water quality

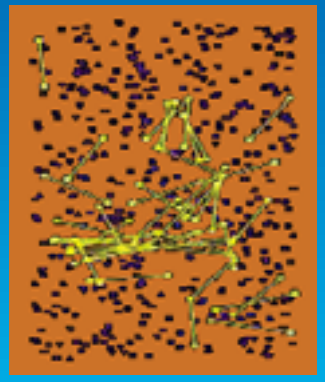
Interpolation Steps

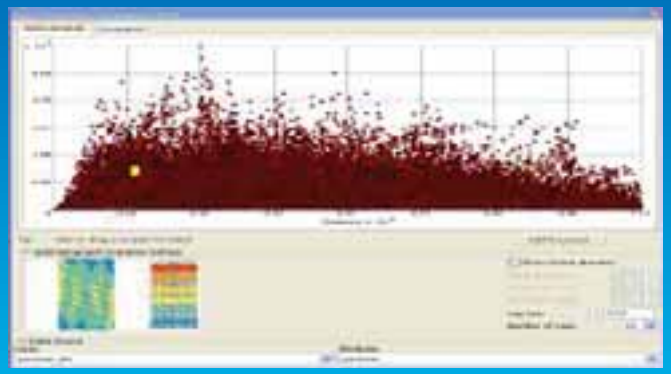
1) Understand your data
2) Experiment with techniques and parameters
3) Create surfaces
4) Evaluate your surfaces

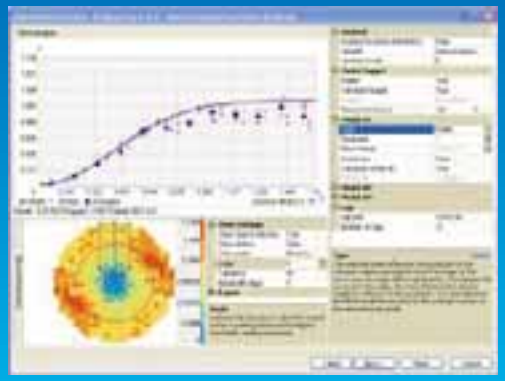
Explore your Data

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







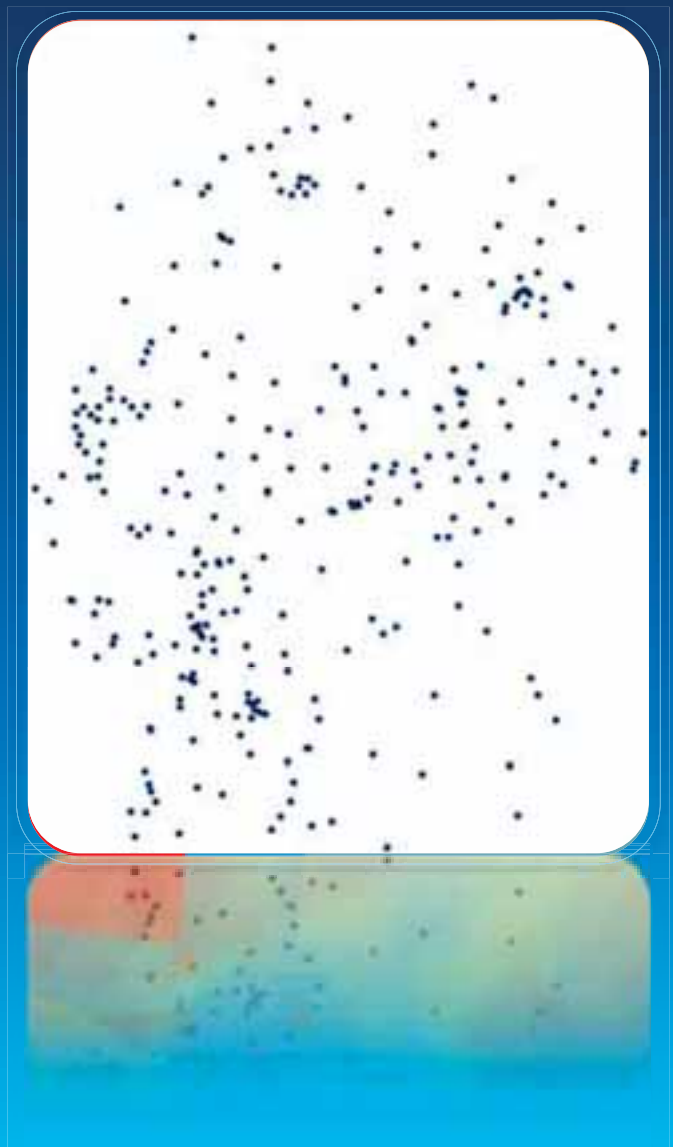


Questions to ask about your data

- 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

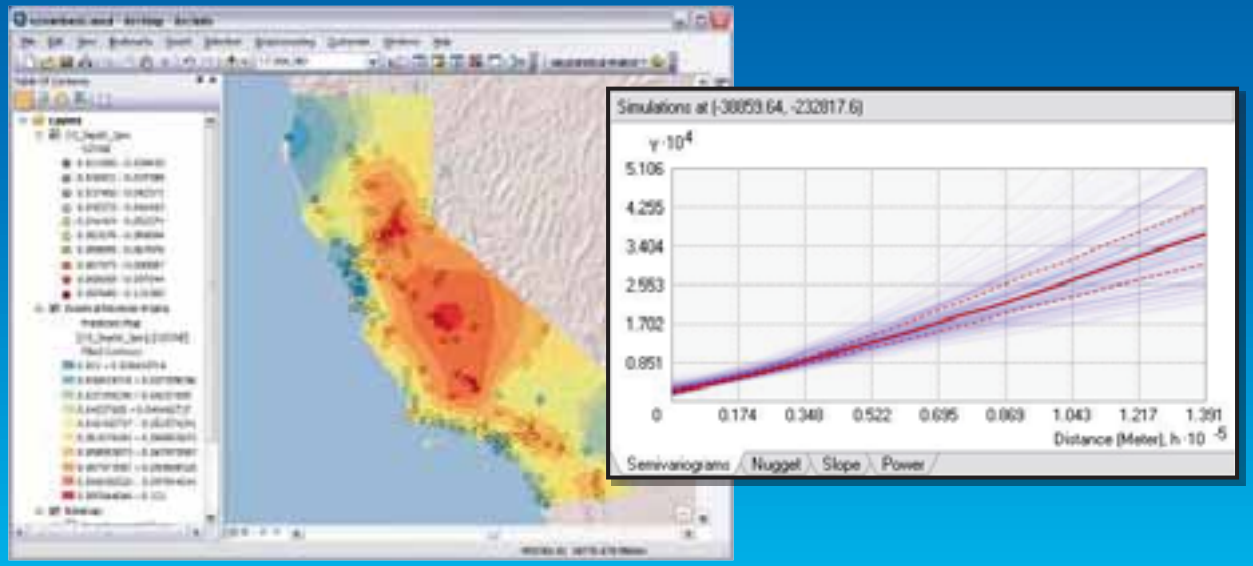
- You know nothing about your data…
  - Use Natural Neighbors. Its is the most conservative, honors the points. Assumes all highs and lows are sampled, will not create artifacts.
- Going the next step in complexity…
  - Use Kernel Interpolation
- Your surface is not continuous…
  - Use Kernel Interpolation 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

Interpolation Improvements in 10.1

- Empirical Bayesian Kriging
- Areal Interpolation
- TopoToRaster updated to ANUDEM 5.3
- Filled Contour sample tool

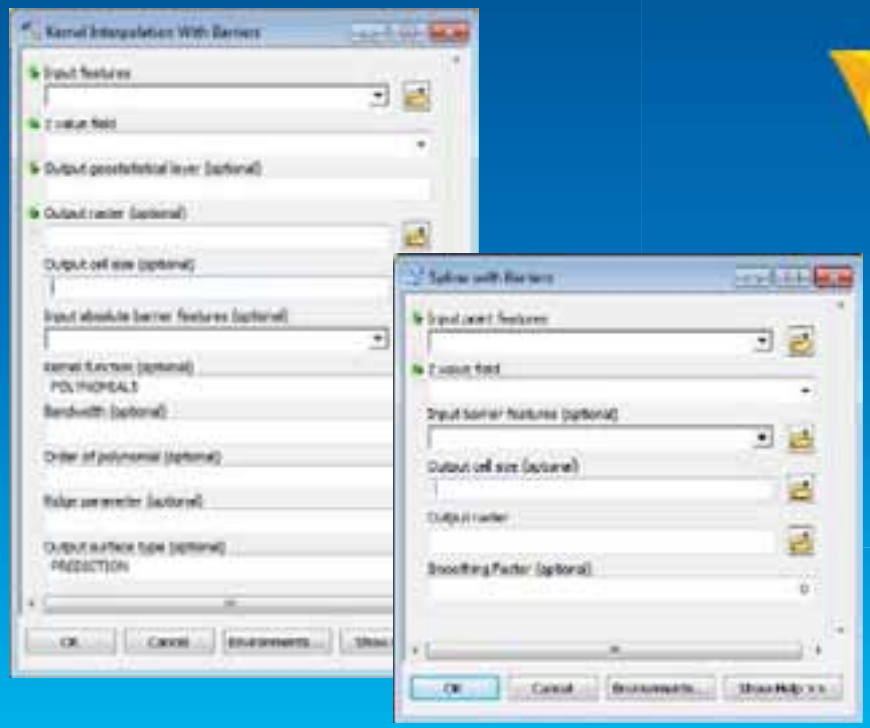
Empirical Bayesian Kriging

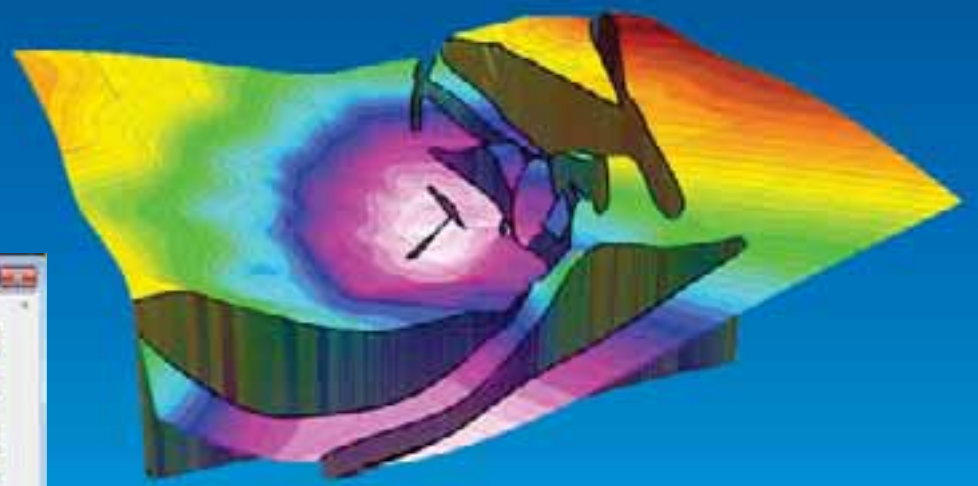
- Spatial relationships are modeled automatically
  - Very easy to use (few parameters)
  - Available as a GP tool
- Results often better than traditional kriging
- Uses local models to capture small scale effects
  - Doesn’t assume one model fits the entire dataset



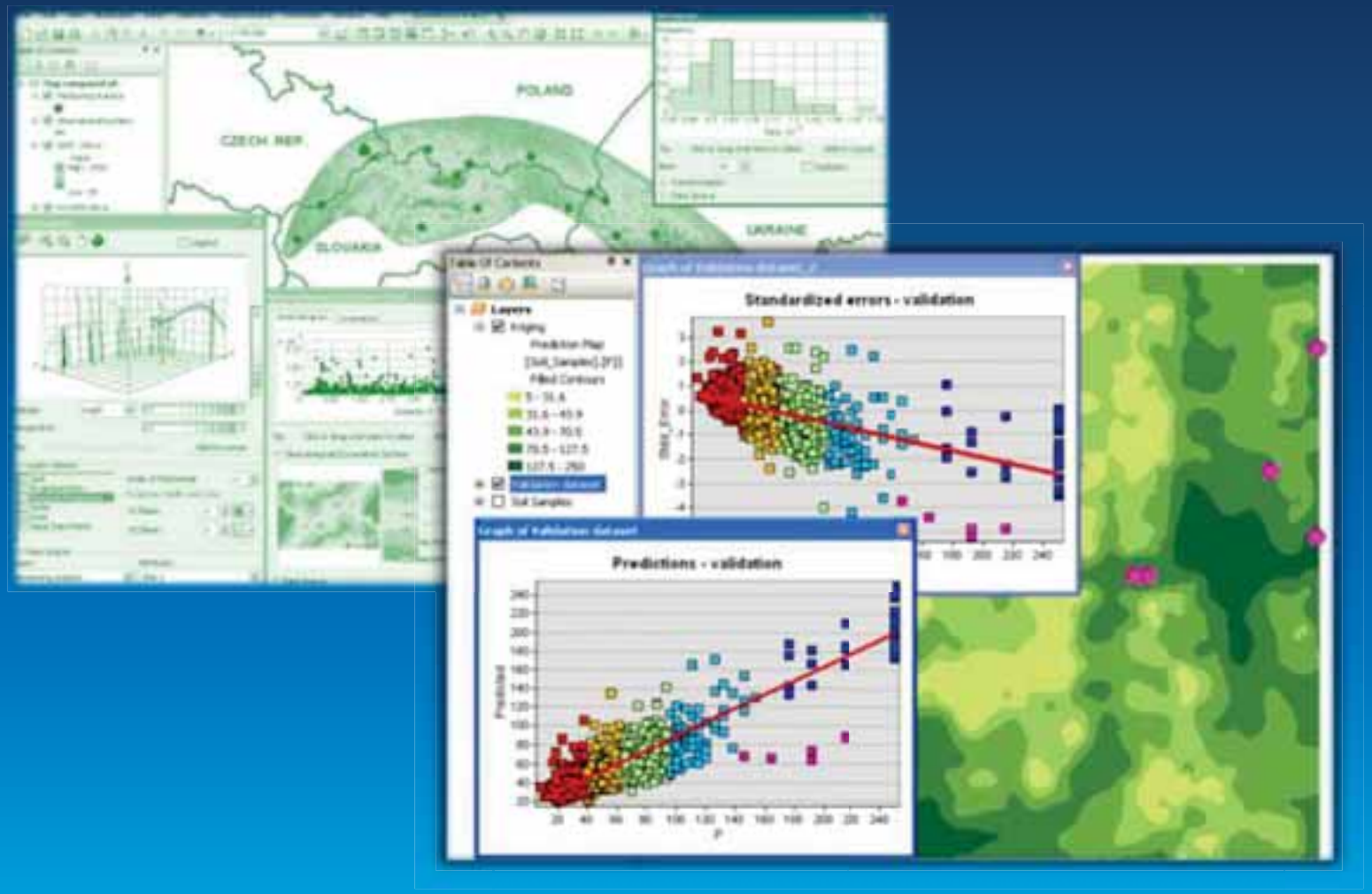
Interpolation with Barriers

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





Evaluate the surface

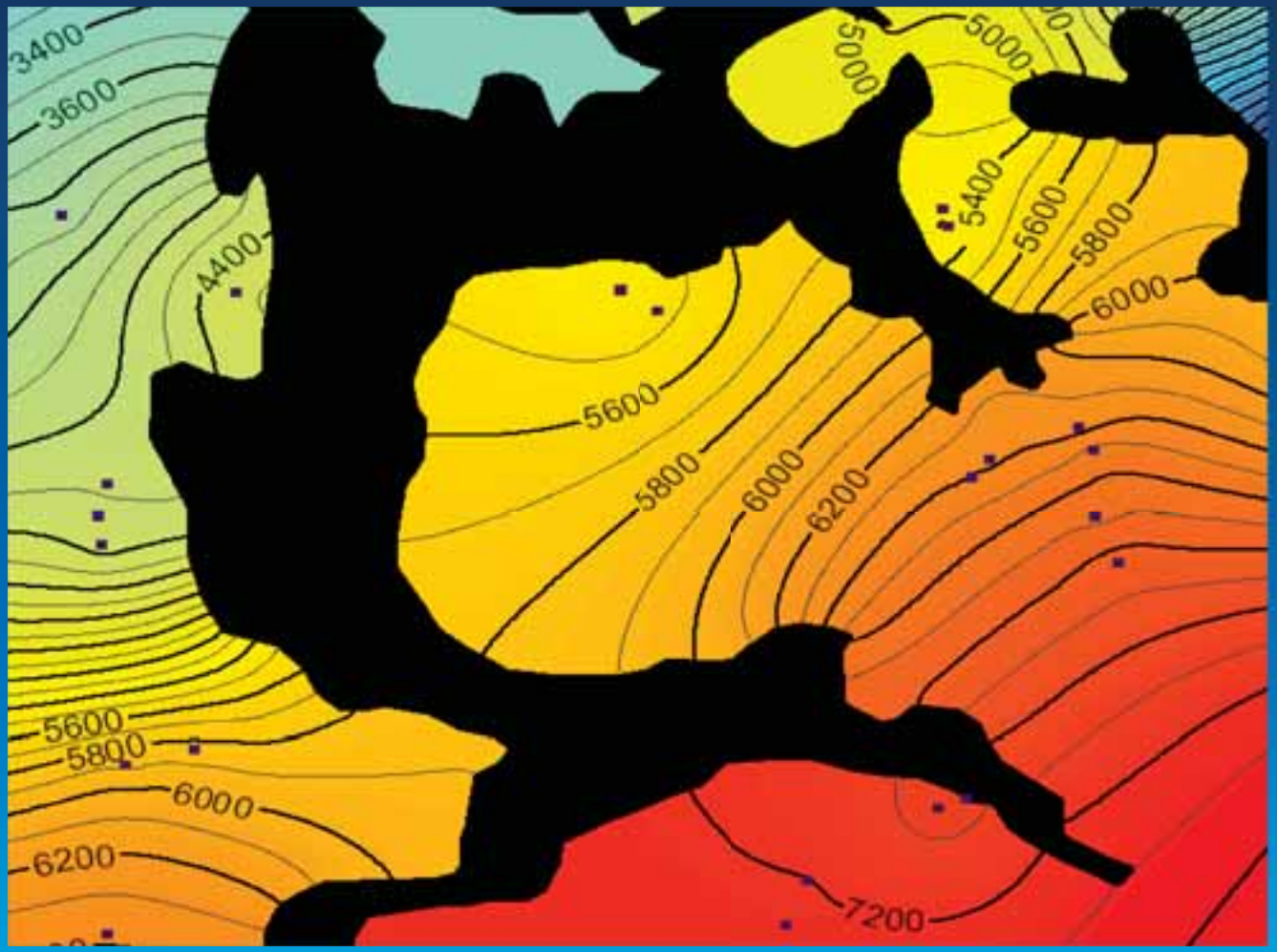


4 Contouring tools

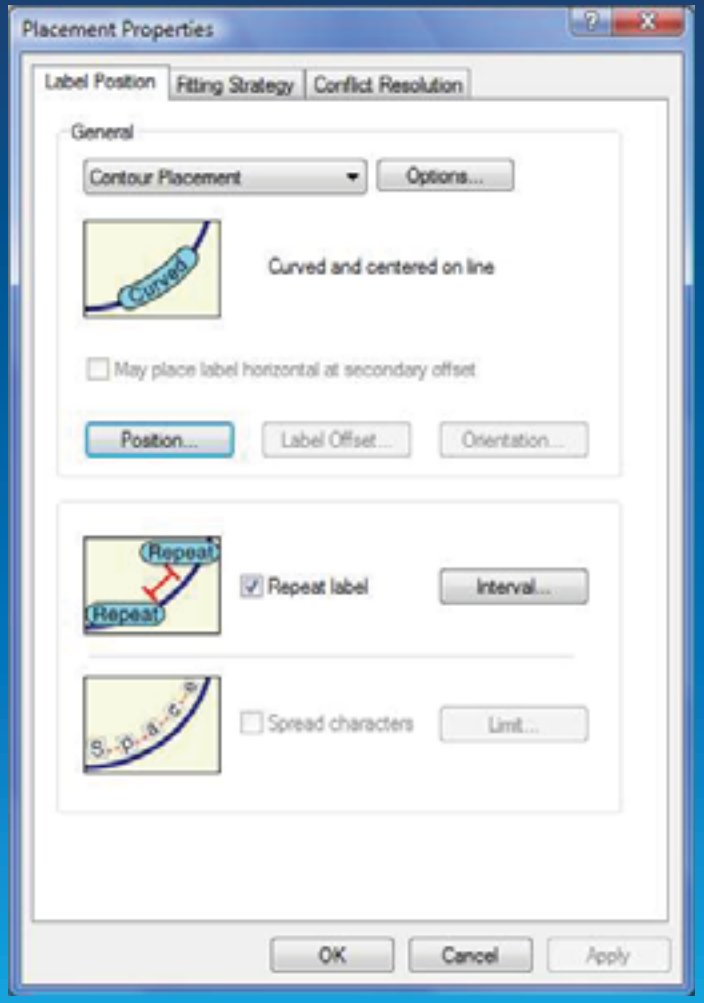
- Contour
  - If you aren't sure what to use, use this one
- Contour with Barriers
  - Supports input of line and polygon barrier features
  - Includes specific logic for attributing index contours
  - Slower than the other contouring tools
- Contour List
  - Primarily used in scripting when you want a specific set of contours
- Filled Contours (polygons)
  - Sample tool to created closed polygon contours. Available in the ArcGIS Online Resource Center as a geoprocessing package.

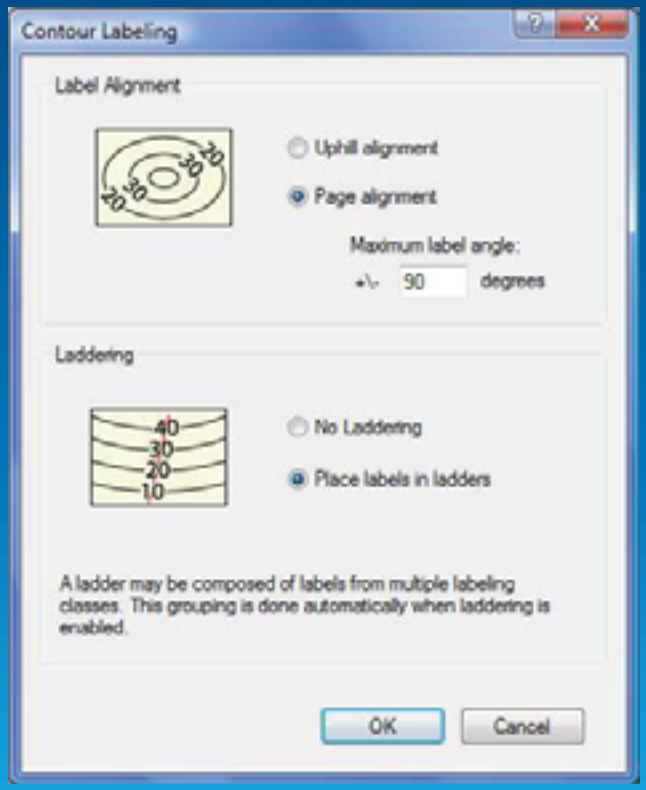
All create nearly identical geometry

Contour with Barriers

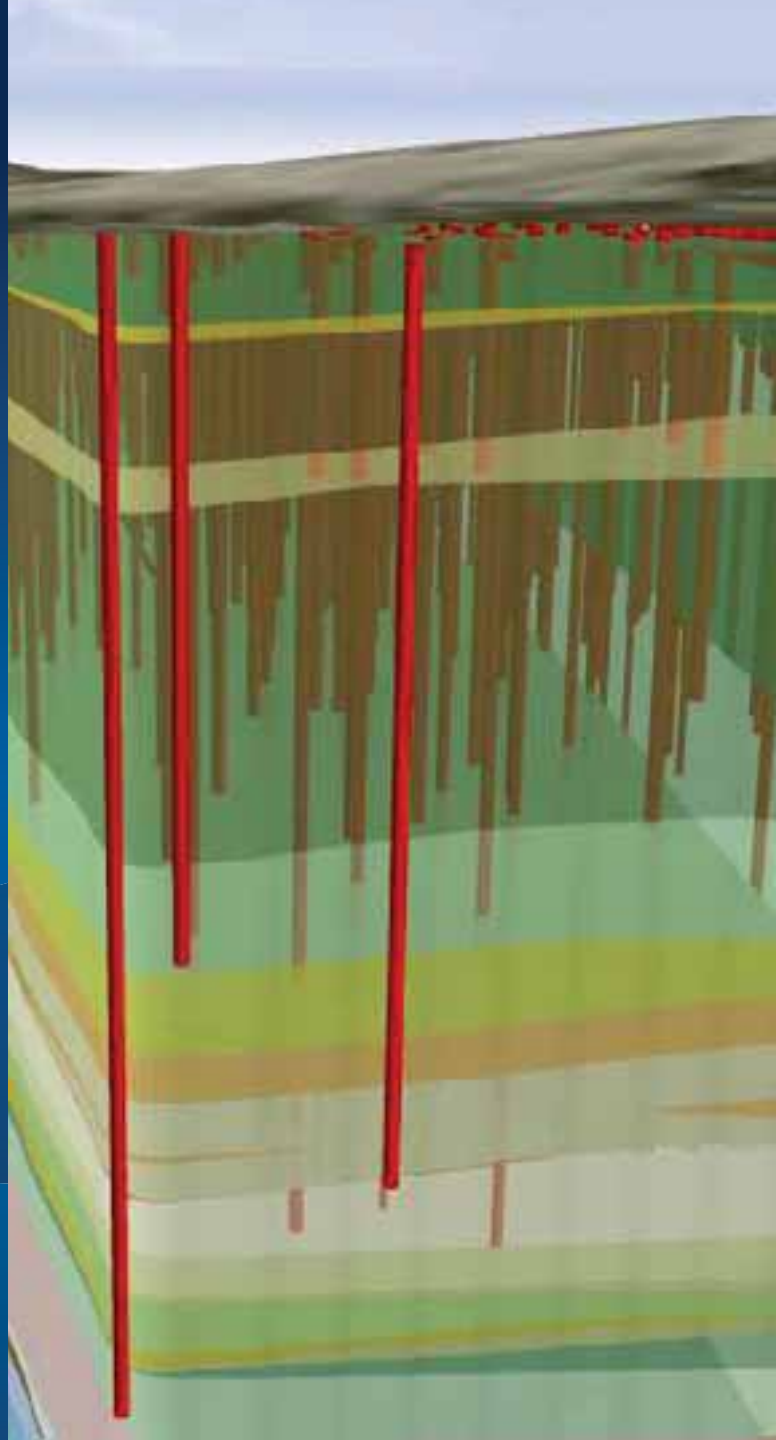


Contour Labeling



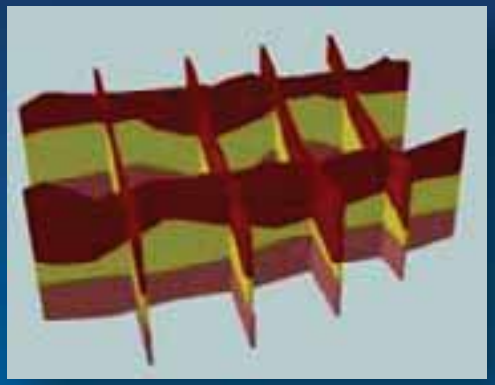


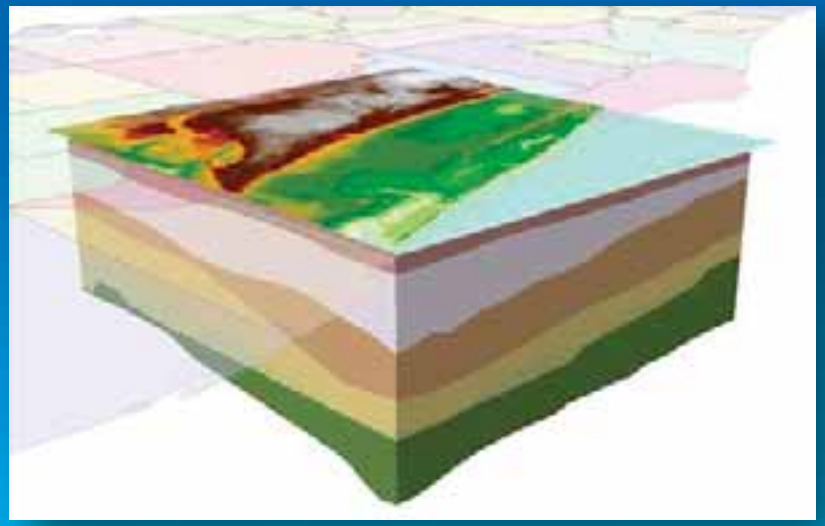
3D Analysis

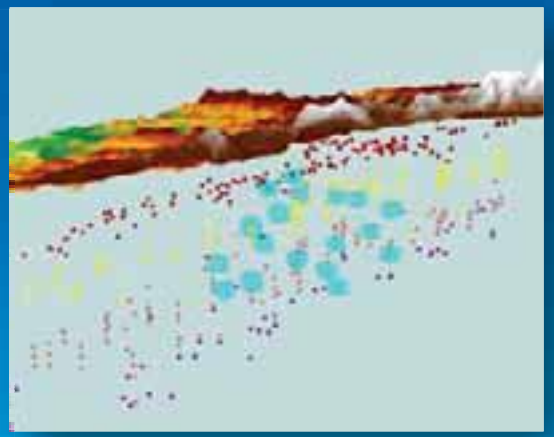


Analysis with 3-Dimensional Data

- 3D Selection now honored
- New analytic capabilities to answer spatial questions in 3 dimensions
  - What is close to what?
  - What is connected to what?
  - What is on top of (intersects) what?



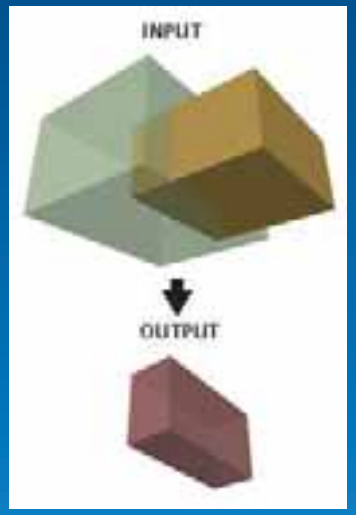




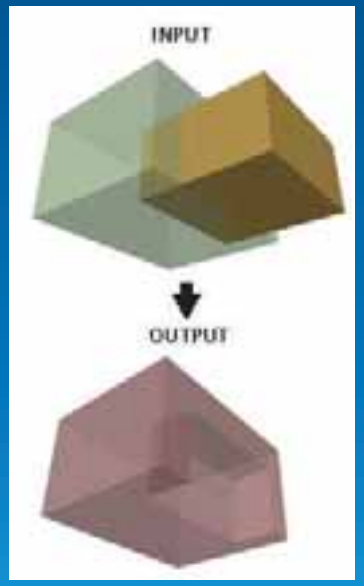
New and Improved 3D Analysis Tools

- For 3D Points, 3D Lines, and Multipatch geometries
  - Intersect *
  - Union
  - Difference *
  - Near
  - 3D Buffer *
  - Inside
  - Is Closed
  - Close Multipatch *

Intersect



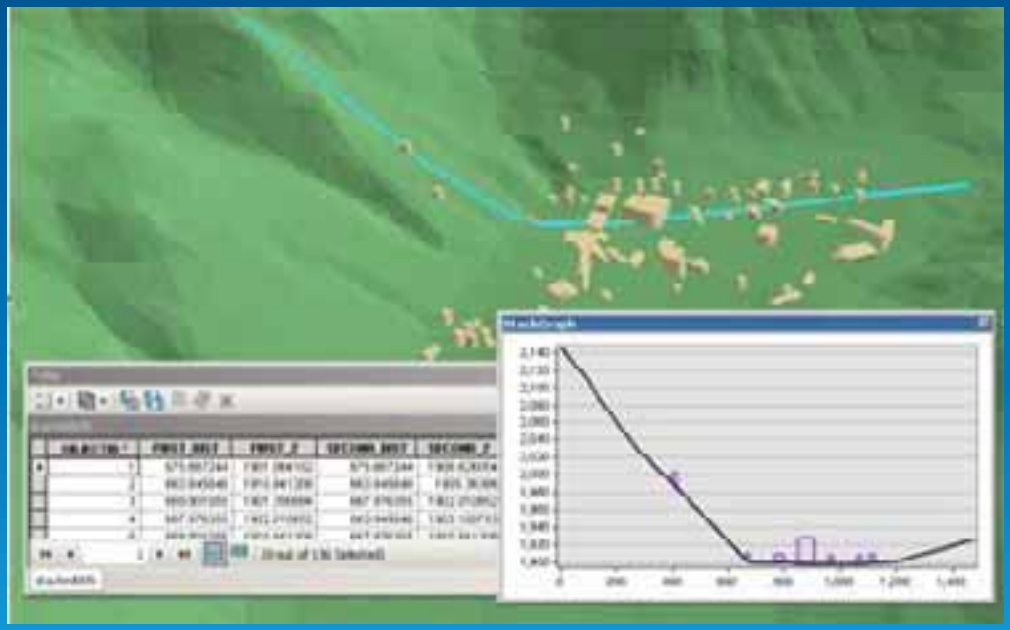
Difference



* New or improved tools in 10.1

Stacked Profiles

- **Requires multipatch features**
- **Creates Graphs**



http://resources.arcgis.com/en/help/main/10.1/index.html#//00q9000000mm000000

3D Web Maps from City Engine

- **Author in City Engine**
- **View in Web GL enabled browser and hardware**

http://www.arcgis.com/home/item.html?id=640a410464fc4654ab8812d80e397a90

Optimal Site Selection

Finding the “best place”

Finding the best place

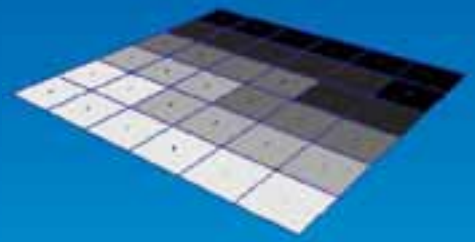
- **Basin and play analysis**
- **Evaluating drilling sites**
- **Analyzing pipeline corridors**

  - Where to site a new gas station?
  - Where is economic growth most likely to occur?
  - Which sites are better for sasquatch habitat?

Reality

GIS layers

Suitability for oil



Model criteria:
- High organic source rock
- Under heat and pressure
- Favorable basin characteristics

Discrete and Continuous Phenomena

- **Discrete phenomena**
  - **Geology**
  - **Landuse**
  - **Ownership**
- **Continuous phenomena**
  - **Porosity**
  - **Permeability**
  - **Elevation**
  - **Distance**

Discrete

0	1	1	2
No Data	1	1	1
No Data	1	2	2
1	1	2	2

Landuse

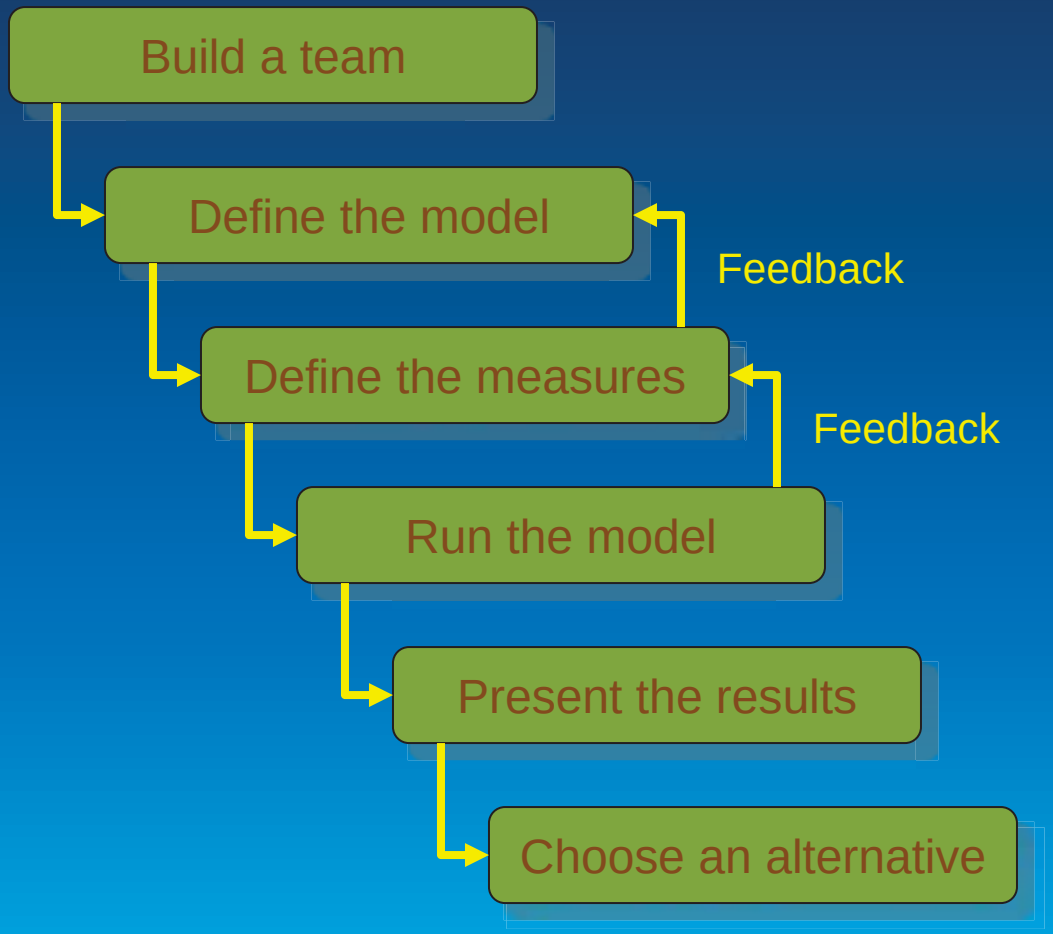
0 = Urban
1 = Forest
2 = Water

Continuous

70	75	72	65
43	63	57	49
19	25	39	42
11	18	No Data	No Data

Porosity

A common pattern to follow



Define the model

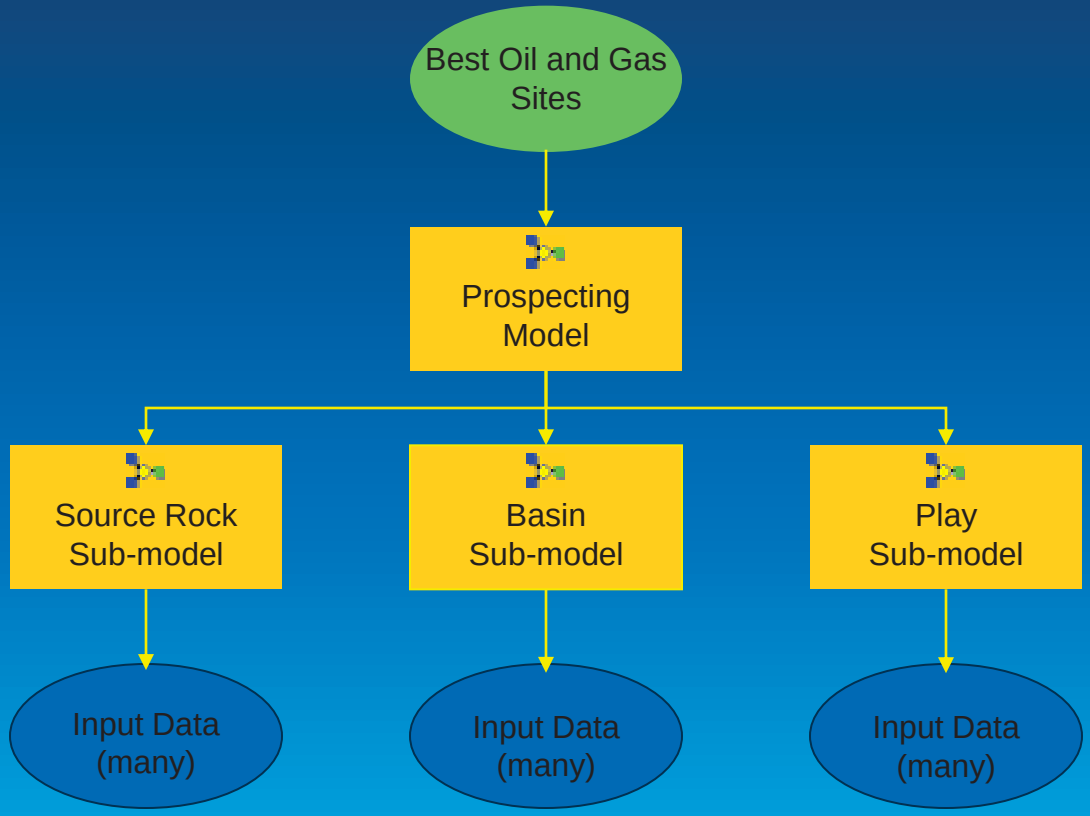
- This is normally a team activity
  - Domain experts, decision makers
- Define the problem
  - Identify likely locations for oil and gas
- Determine how to measure
  - Need high organic source rock
  - Need heat and pressure
  - Need good porosity and permeability, plus a cap rock
- Obtain GIS data

Define the Measures

- **Determine significant** layers to the phenomenon being modeled
- **Reclassify** the values of each layer into a relative scale
  - Use relevant class breaks
- **Weight** the importance of each layer
- **Add** the layers together
- **Run and Revise** the model

Break big models into sub-models

- **Helps clarify relationships, simplifies problems**

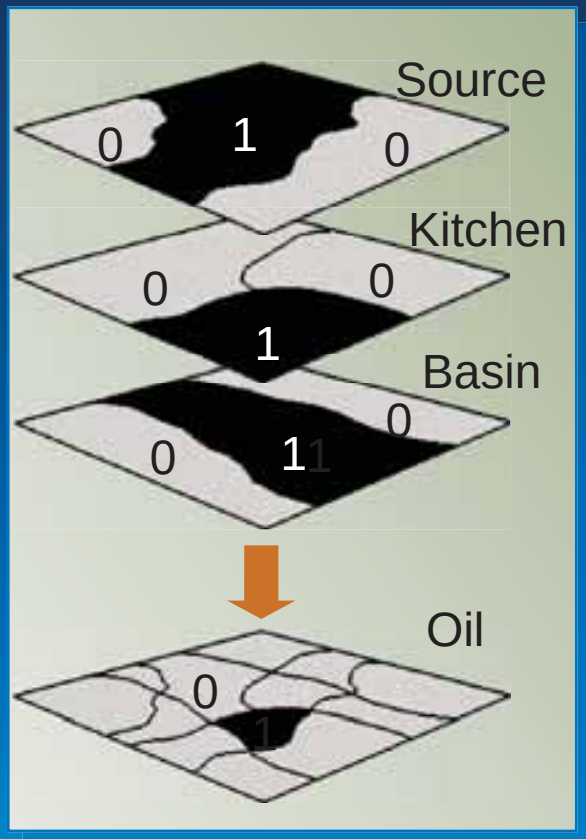


Binary suitability models

- Use for simple problems
  - Like a query
- Classify layers as good (1) or bad (0)
  - Combine:

```
[Oil] = [Source] & [Kitchen] & [Basin]
```

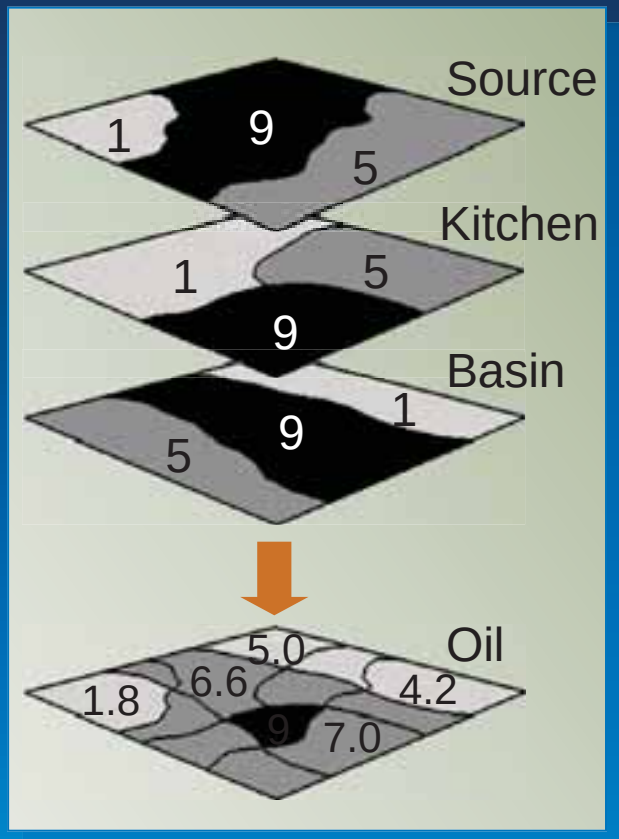
- Advantages:
  - Easy
- Disadvantages:
  - No “next-best” sites
  - All layers have same importance
  - All good values have same importance



Weighted suitability models

- Use for complex problems
- Classify layers into suitability 1–9
  - Weight and add together:

```
Oil = ([Source]* 0.5)
    + ([Kitchen] * 0.3)
    + ([Basin]  * 0.2)
```



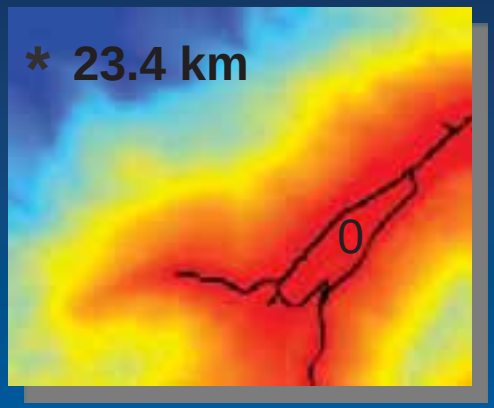
- Advantages:
  - All values have relative importance
  - All layers have relative importance
  - Returns suitability on a scale (e.g. 1–9)
- Disadvantages:
  - Assigning weights requires deeper problem understanding

Define a scale of suitability

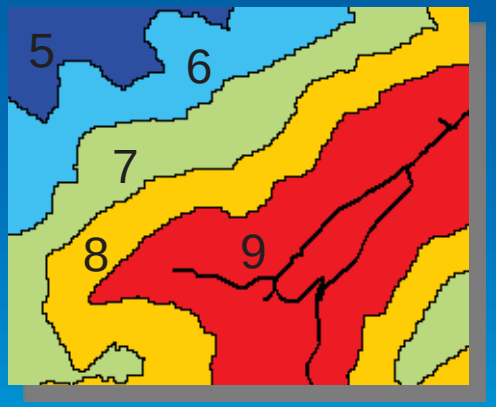
- **Define a scale for suitability**
  - Many possible; typically 1 to 9 (worst to best)
  - Reclassify layer values into relevant classes
  - Assign suitability value to each class
  - Use the same scale for all layers in the model

	Source rock suitability
Best	9 – Barnett Shale
	8
	7
	6
	5
	4
	3
	2
Worst	1 – Granite

	Porosity suitability
Best	9 – 20
	8
	7
	6
	5
	4
	3
	2
Worst	1 – 0



Distance to existing pipe



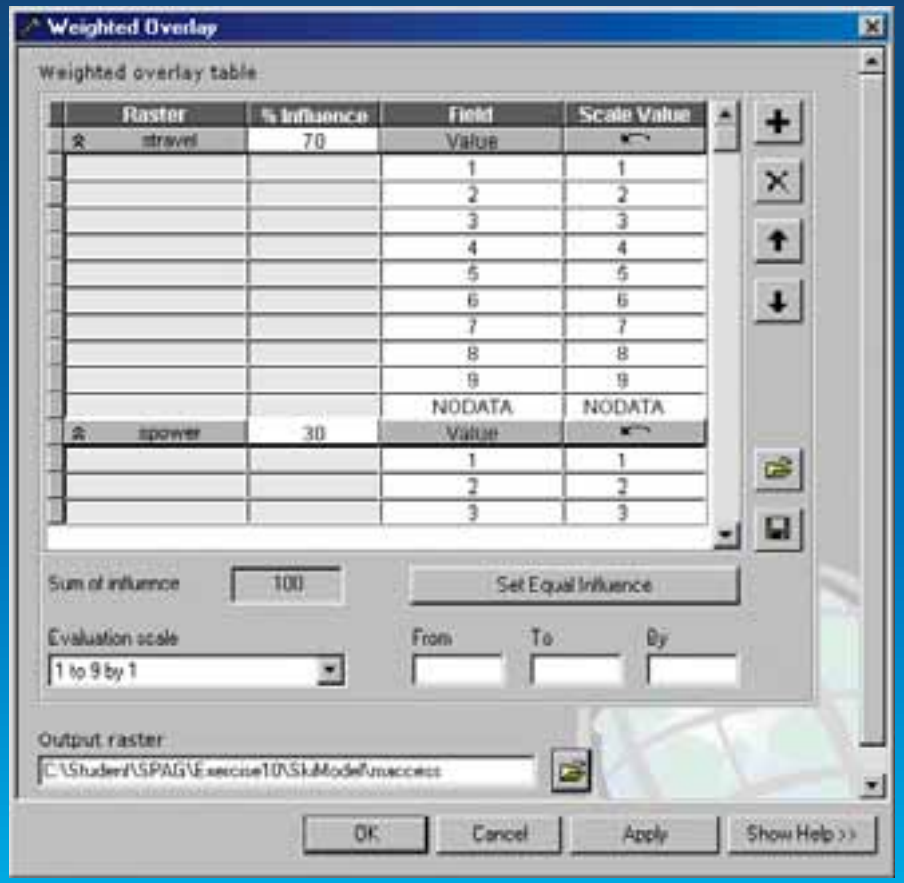
Pipeline Suitability

Within and between layers

The Weighted Overlay tool

- Weights and combines multiple inputs

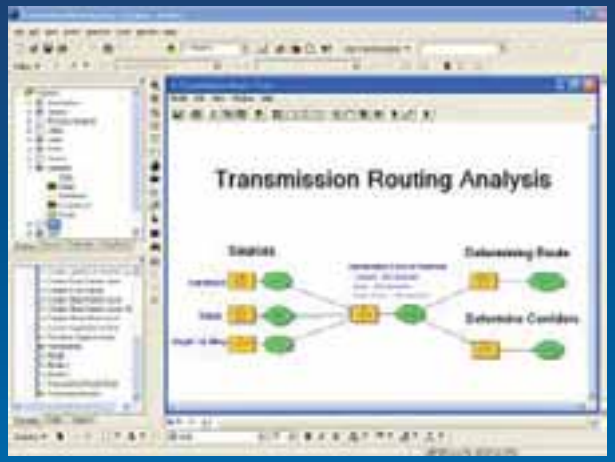
- Easy to change see and change all weights of layers and classes in one place

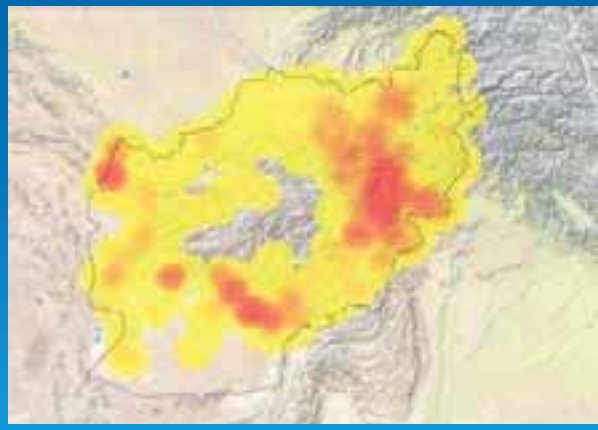


Pipeline Routing

Weighted Overlay Model – Typical Factors

- Availability of data
- Topography
  - Slope / Curvature
- Land
  - Land use
  - Property ownership
  - Transportation facilities
  - Animal migration corridors
- Environment
  - Land cover
  - Environmentally sensitive areas

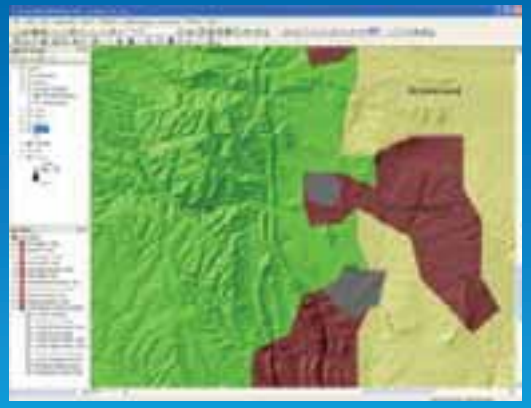




Pipeline Routing

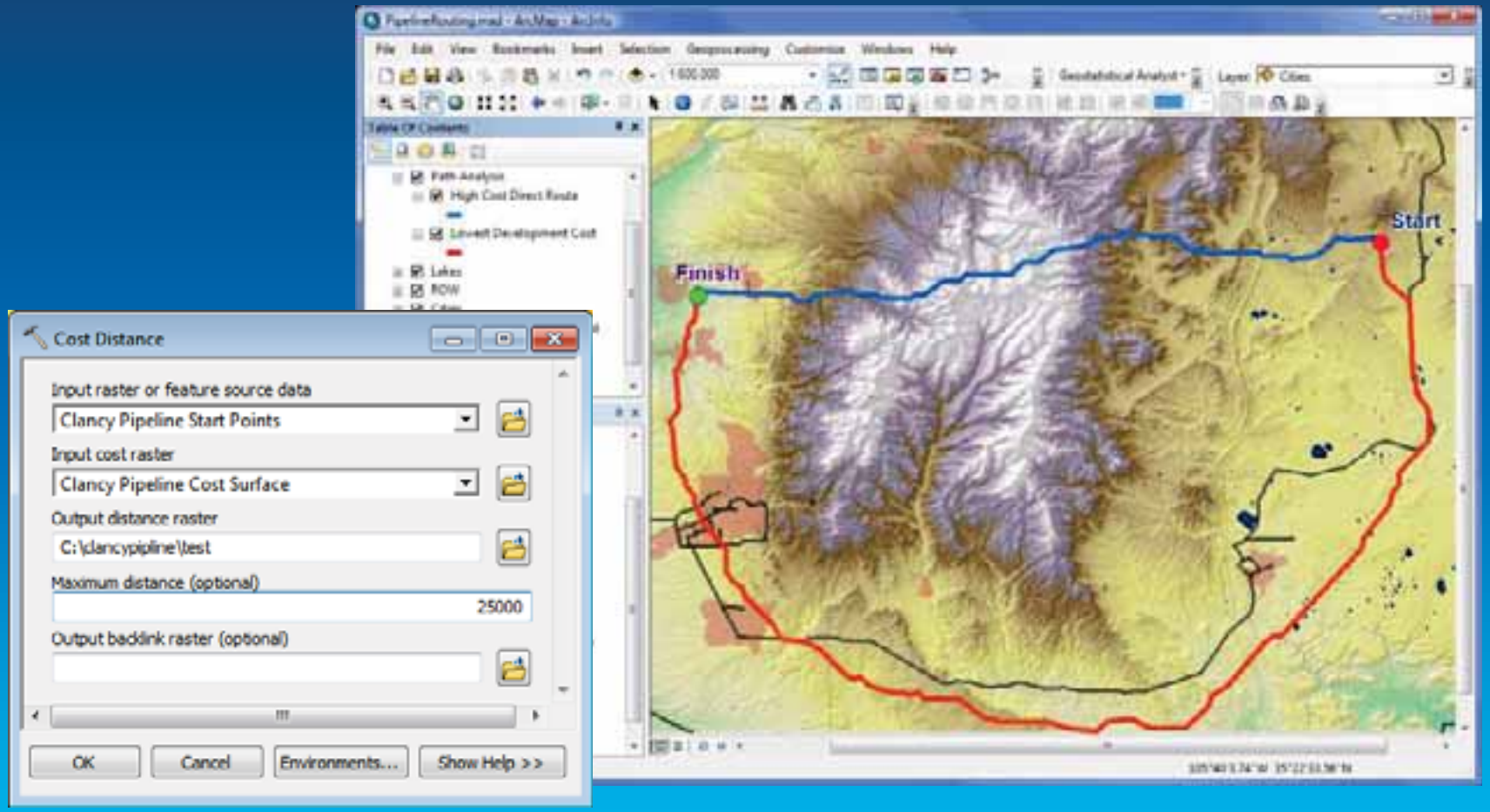
Weighted Overlay Model – Typical Factors

- Water bodies
  - Lakes, rivers and wetlands
- Population
  - Proximity to housing
  - Large urban centers
- Geology
  - Surface geology, faults and outcrops
- Soils
  - Soil classification
  - Critical factors - acidity, conductivity
- Costs
  - Total length and distance from roadway
  - Road, railway, utility and infrastructure crossings



Pipeline Routing with *CostDistance* tool

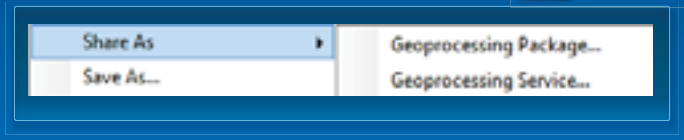
- Shortest route
- Least expensive route

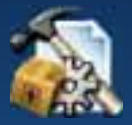


Sharing Analysis

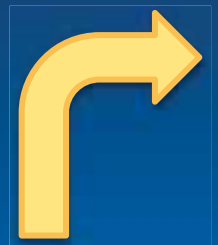
Analysis

Share as…



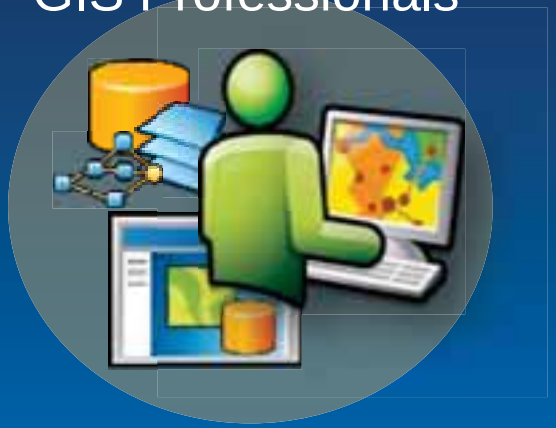


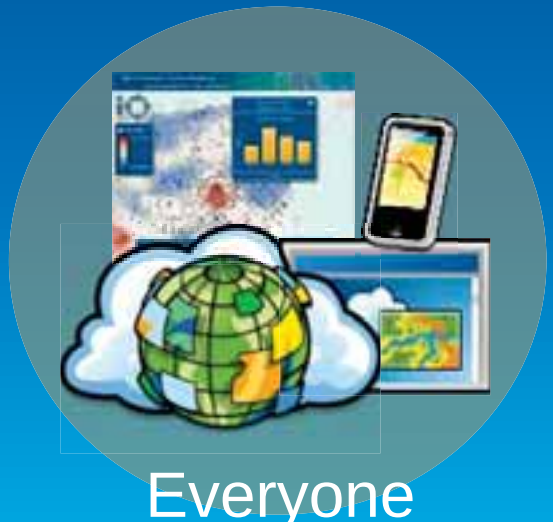
Package



Service

GIS Professionals





Everyone

Sharing Analysis and Workflows in 10.1

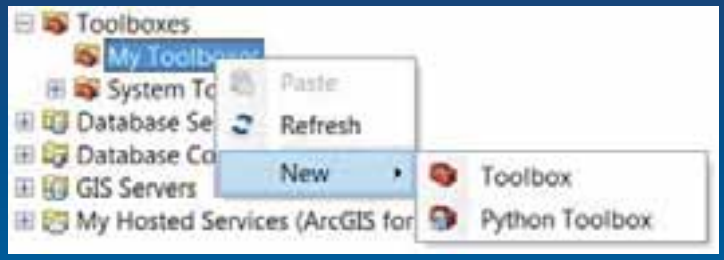
- **Sharing a Package**
  - **GIS Professional to GIS Professional**
  - **Sharing corporate workflows and analytic methods**
- **Sharing a Service**
  - **GIS Professional to everyone**
    - **Use in Desktop**
    - **Use in web application**
    - **Use in mobile application**

10.1 Publishing Geoprocessing Services

- Make publishing services easier
  - Analyze tools being published
  - Determine data needed for the service
    - Copy data that is not registered in the data store
    - Fix paths to data registered in the data store
  - Copy model and script tools and all dependent model and script tools
  - Modify intermediate and output paths to write to the scratch workspace so that the tool will work well as a service
  - Can publish selected tools from a toolbox instead of publishing an entire toolbox
  - Share the service with ArcGIS Online

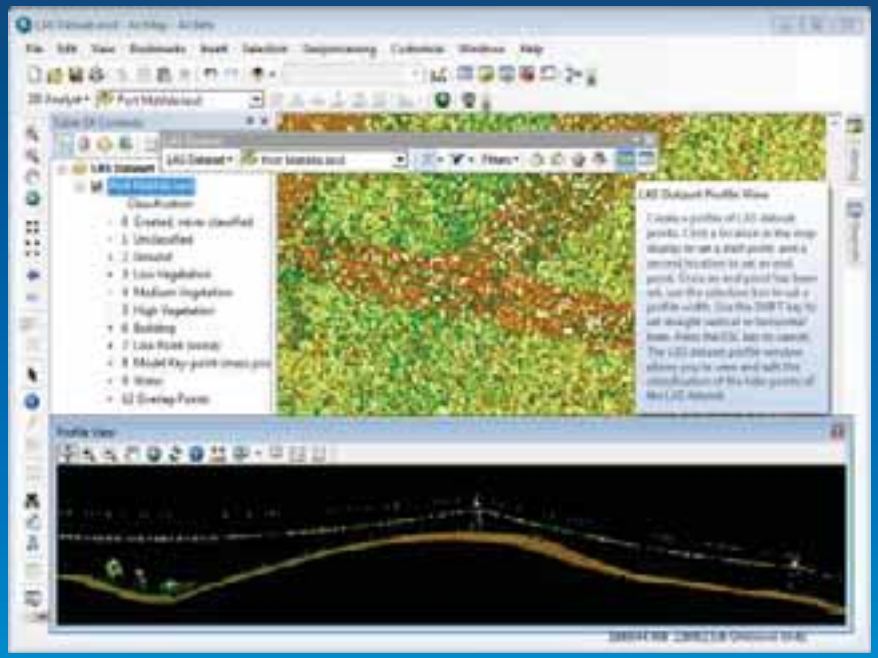
Geoprocessing Developer Improvements

- Python Toolboxes
- Python Add Ins
- ArcPy Data Access Module
- ArcPy Network Module
- Geometry Class improvements
  - Topological operators
    - Buffer, Clip, Union, Intersect, etc.
  - Geodesic methods
    - getLength, getArea



What's new for LiDAR in ArcGIS 10.1 ?

- Direct read, use, and editing of LAS files in ArcGIS
- LAS Dataset
- Use in Terrains
- Use in Mosaics
- Interactive 3D editing



Understanding our world.