



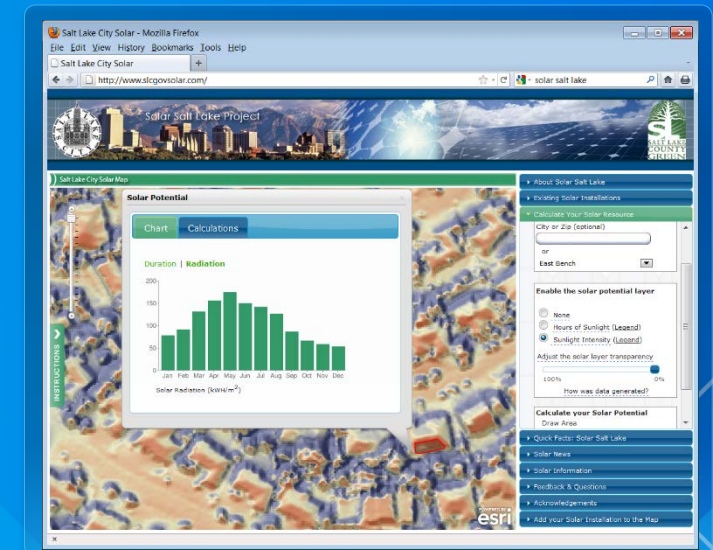
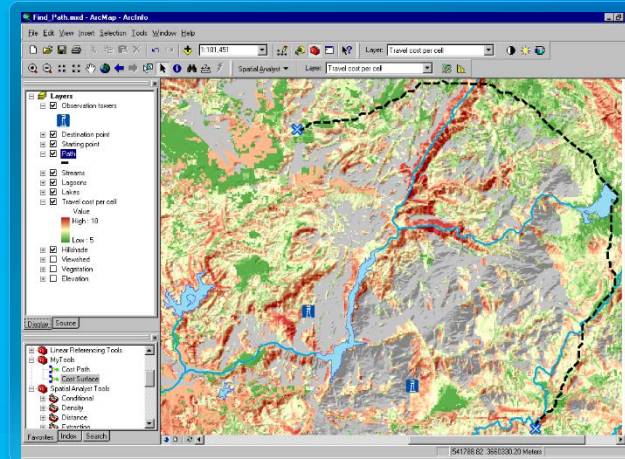
Spatial Analyst: Getting Started

Steve Kopp

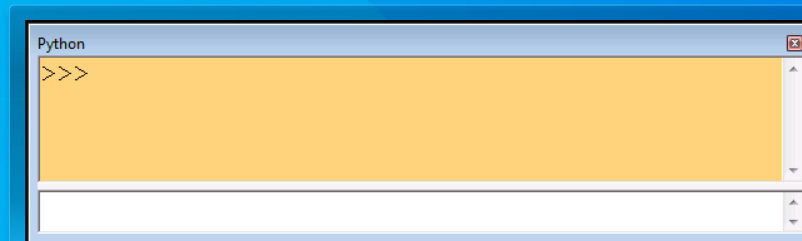
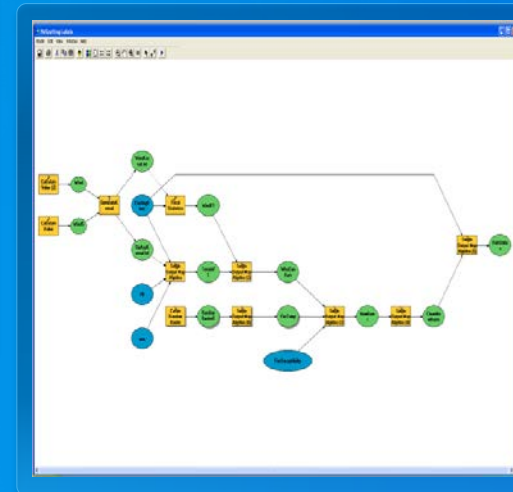
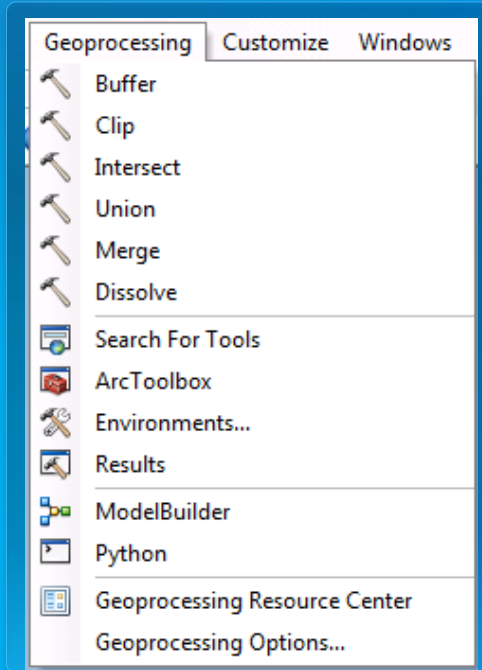
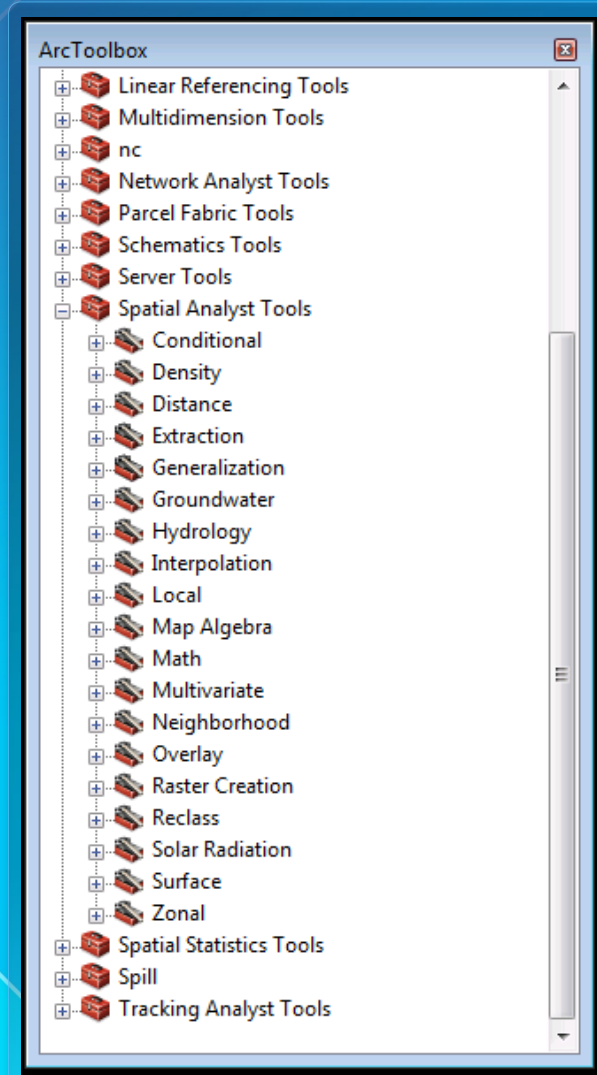
Elizabeth Graham

ArcGIS Spatial Analyst

- Integrated raster and vector spatial analysis tools
 - Over 170 geoprocessing tools and raster functions
- Extension product that adds functionality to ArcGIS Desktop, Engine, Server, Online

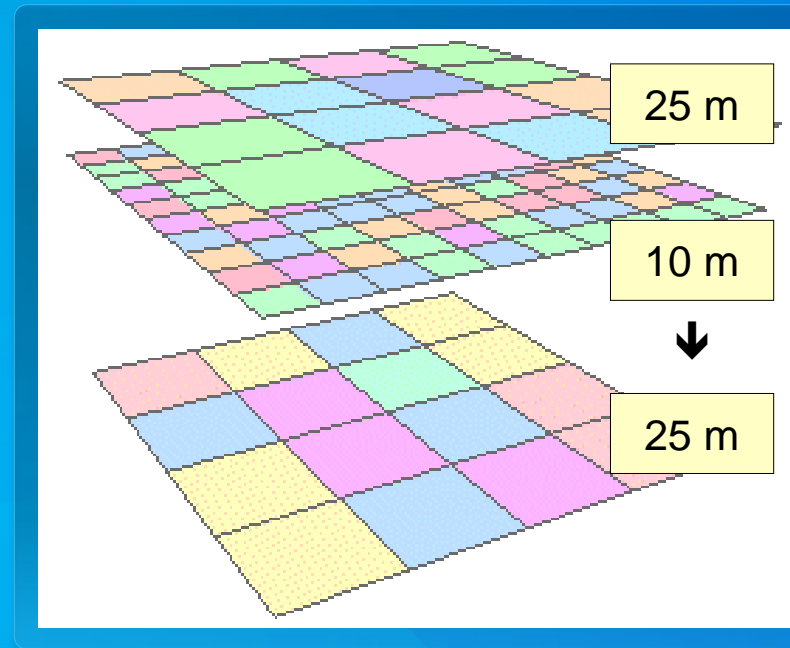


Spatial Analyst Overview



Geoprocessing Environment

- **Cellsize**
- **Extent**
 - Snap Raster
- **Mask**
- **Map Projection**



Getting Started with Spatial Analyst

Finding and Using Tools

- Spatial Analyst Tools
- Conditional
- Density
- Distance
- Extraction
- Generalization

- Groundwater
- Hydrology
- Interpolation
- Local
- Map Algebra
- Math
- Multivariate

- Neighborhood
- Overlay
- Raster Creation
- Reclass
- Solar Radiation
- Surface
- Zonal



Analysis Tools

- **Mathematical Operators and Functions**
- **Distance and Proximity Analysis**
- **Density Mapping**
- **Neighborhood and Block Statistics**
- **Zonal Overlay**
- **Interpolation and Contouring**
- **Surface Analysis**
- **Hydrologic and Groundwater Analysis**
- **Reclassification**
- **Geometric Transformation**
- **Morphological Analysis**
- **Multivariate Statistical Analysis**

Mathematical Operators

- **Arithmetic** (+, -, *, /)
- **Boolean** (AND, OR, XOR, NOT)
- **Logical** (<, >, =, <>, etc.)
- **Bitwise** (shift, compliment)

The diagram illustrates the addition of two 2x2 grids. The first grid has values 4 (red), 2 (green), 1 (yellow), and 3 (blue). The second grid has values 3 (red), 4 (green), 1 (yellow), and 1 (blue). The result grid has values 7 (red), 6 (green), 2 (yellow), and 4 (blue). The addition is shown as: $\begin{bmatrix} 4 & 2 \\ 1 & 3 \end{bmatrix} + \begin{bmatrix} 3 & 4 \\ 1 & 1 \end{bmatrix} = \begin{bmatrix} 7 & 6 \\ 2 & 4 \end{bmatrix}$

Map Query

- Boolean (AND, OR, XOR, NOT)
- Logical (>, >=, =, <>, <, <=)



Mathematical Functions

- Arithmetic—Abs, Int, Float, etc.
- Trigonometric—Sin, Cos, Tan, etc.
- Exponential—Exp, Exp2, Exp10
- Logarithmic—Log, Log2, Log10
- Powers—Sqr, Sqrt

The Int function

1.3	1.2	0.1	0.8
NoData	1.8	2.5	2.7
4.4	-1.9	-0.5	2.9
4.6	0	1.7	1.5

Input raster

=

1	1	0	0
NoData	1	2	2
4	-1	0	2
4	0	1	1

Output raster

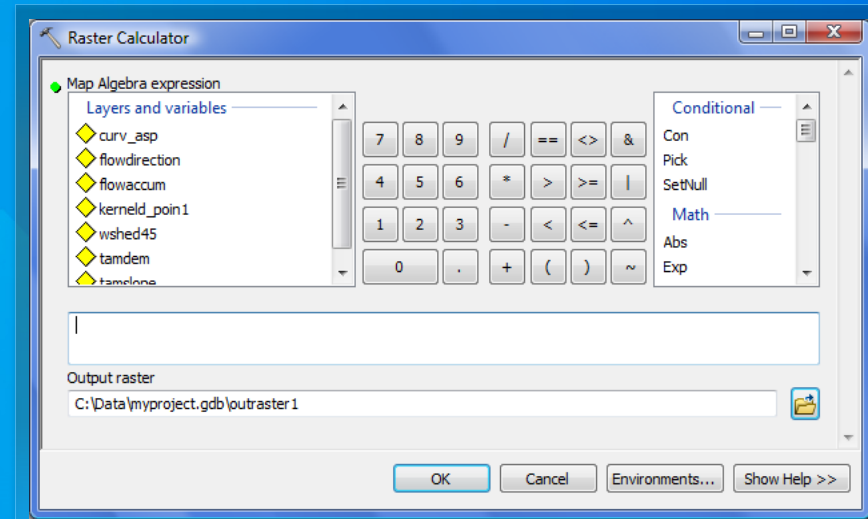
 = NoData

Map Algebra and the Raster Calculator tool

- An analysis language for raster data
 - Uses math-like expressions with operators and functions
 - Tight integration between Map Algebra and Python
 - All Geoprocessing tools
 - Import and use functions from other Python libraries
 - Process chain optimization to improve performance

```
SmoothHill = Hillshade(FocalStatistics(Elevation * 0.3048))
```

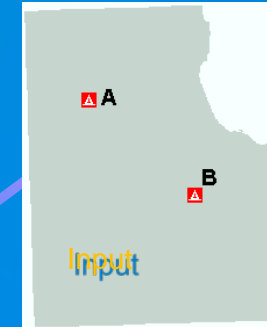
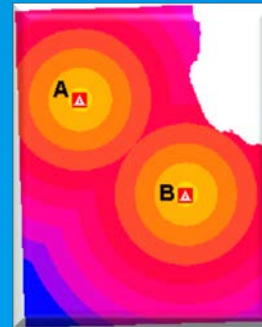
- Raster Calculator Geoprocessing tool provides easy construction of Map Algebra expressions



Distance and Proximity Analysis

- **Straight line distance and allocation**
 - Create distance buffers from features
 - Allocate resources to distribution centers
- **Cost weighted distance and allocation**
 - Include a weight or impedance surface to constrain movement
- **Shortest path**
 - Find least cost path between two points
 - Identify corridors of predicted travel

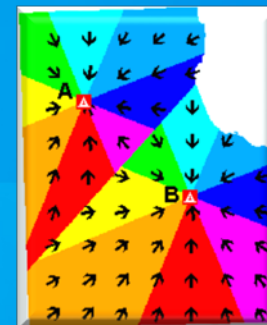
Straight Line Distance



Shortest Path



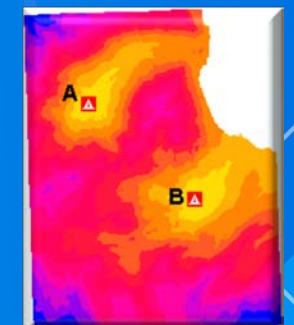
Direction



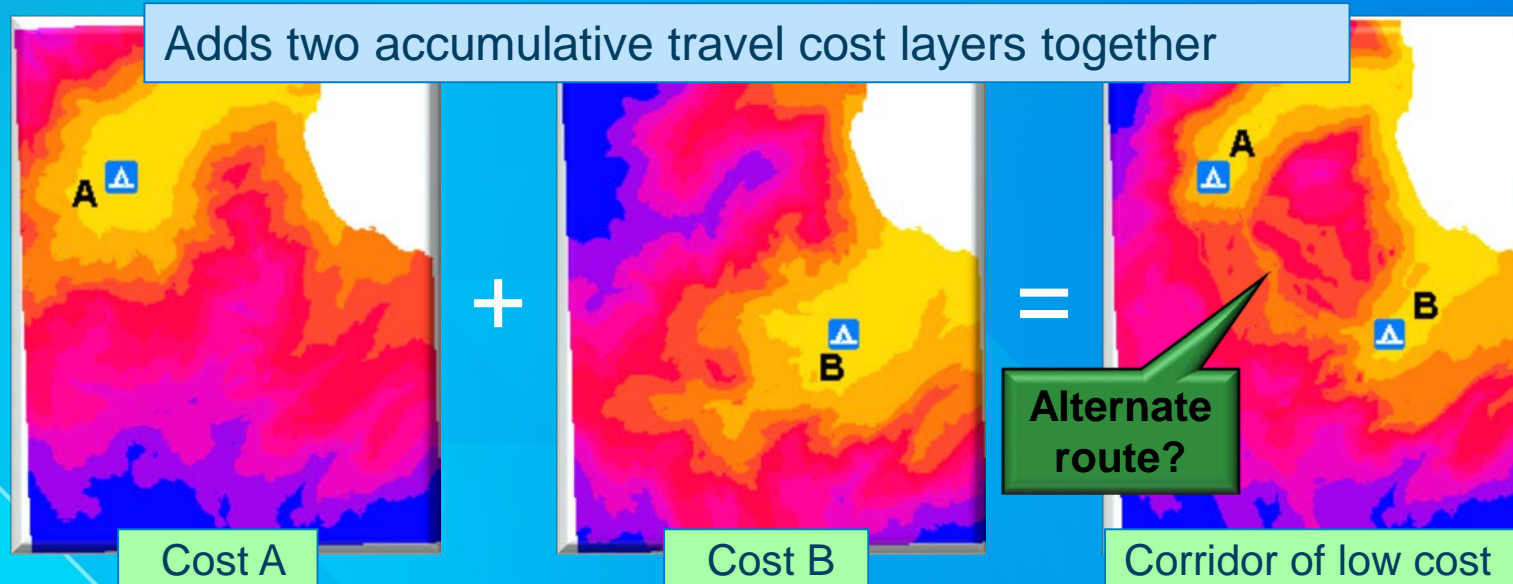
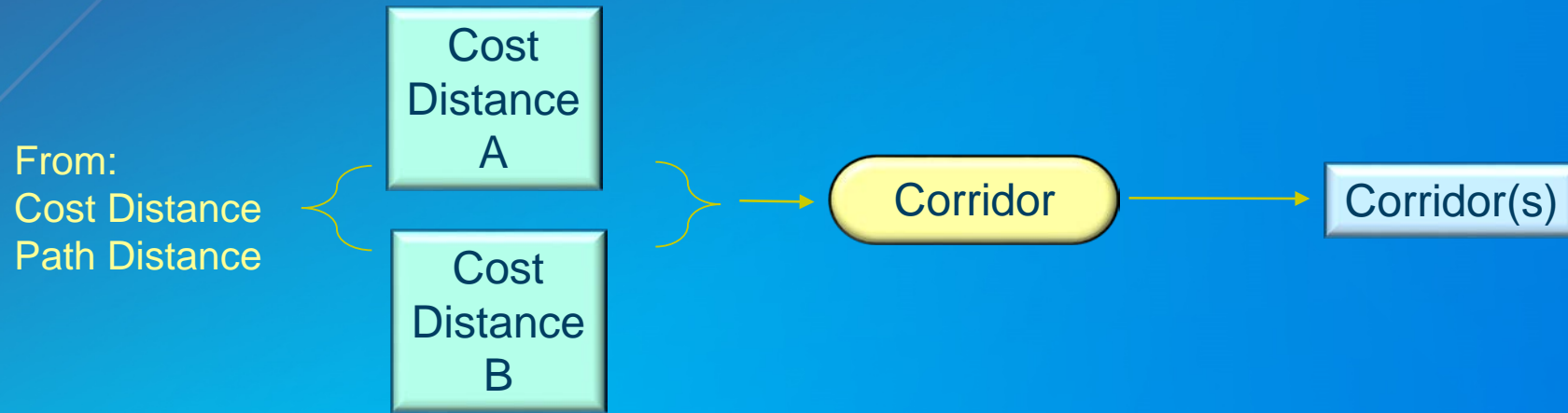
Allocation



Cost Weighted Distance

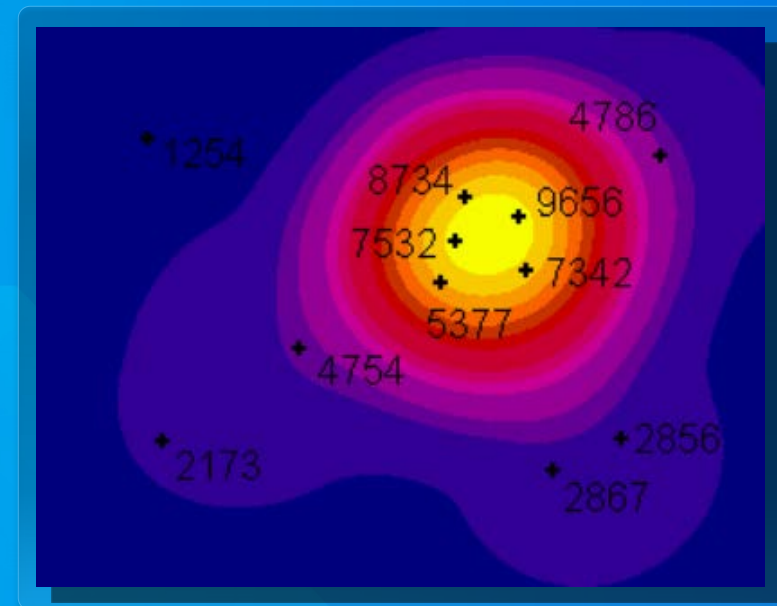


Corridor Analysis



Density Mapping

- Simple Density and Kernel Density
- Count occurrences of a phenomenon within an area
“Magnitude per unit area”
- Use points or lines as input
 - Population per Km2
 - Road density per Mi2

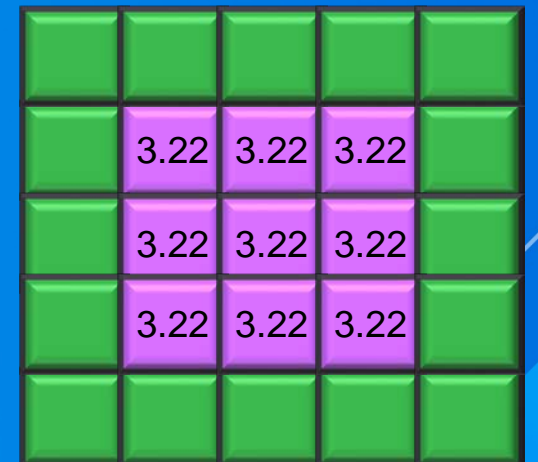
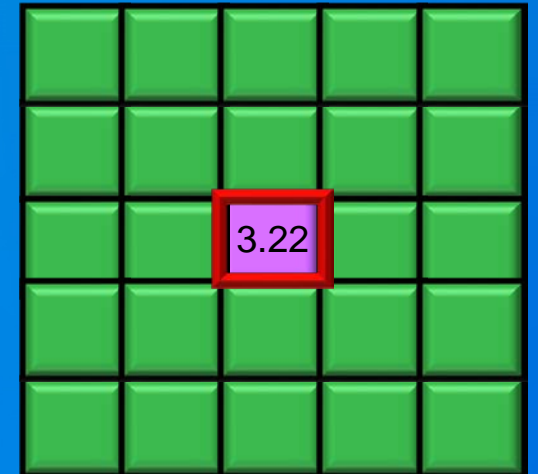


Neighborhood and Block Statistics

- Used for filtering, data smoothing, and data aggregation

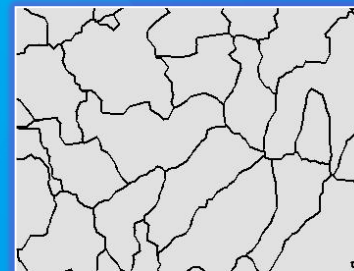
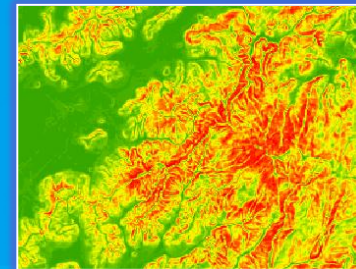
Statistics for neighborhoods

Majority
Maximum
Mean
Median
Minimum
Minority
Range
Sum
Standard Deviation
Variety

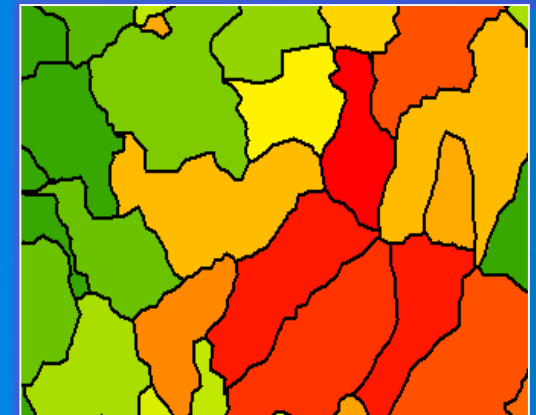


Zonal Overlay

- A **zone** is all the areas/cells with the same value
- Calculate a statistic within the zones for each cell in a raster
- Input zones can be feature or raster
- Output as a raster, summary table, or graph
 - Max flow length in each watershed
 - Median income in each ZIP CODE
 - Mean elevation per vegetation zone

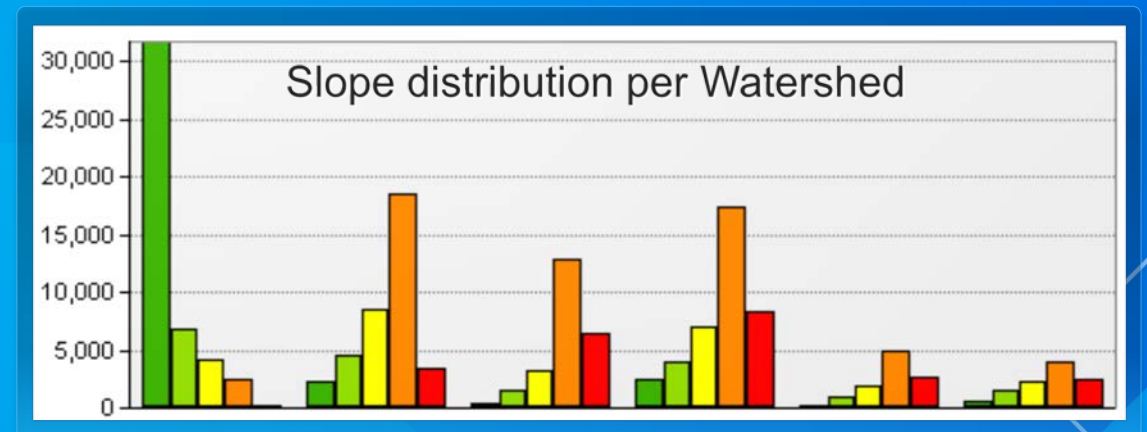


Mean Slope per Watershed



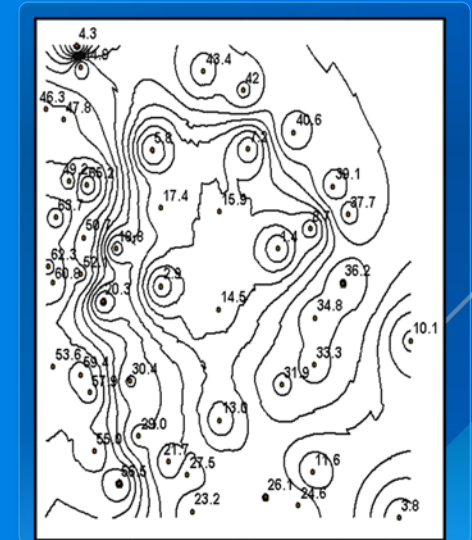
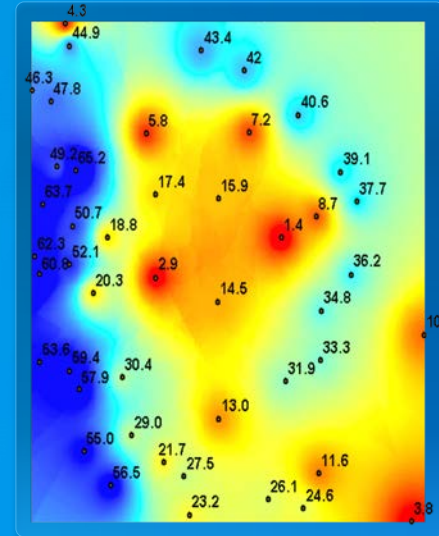
Zonal Histogram

- Create histograms of cell counts within Zones
 - Same zone definitions as Zonal Statistics
 - Zones can also be classes defined in the renderer
- Investigate frequency/distribution of one dataset within classes of another dataset
 - Slope distribution within Land use classes
 - Rainfall distribution within Elevation classes
 - Crime distribution by beat



Interpolation and Contouring

- **Generate surfaces from point measurements**
 - Natural Neighbors
 - Minimum Curvature Spline
 - Spline with Barriers
 - TopoToRaster
 - Kriging
 - Polynomial Trend Surface
 - Inverse Distance Weighted
- **Create contours from surfaces**
 - Batch GP tools
 - Interactive contour button

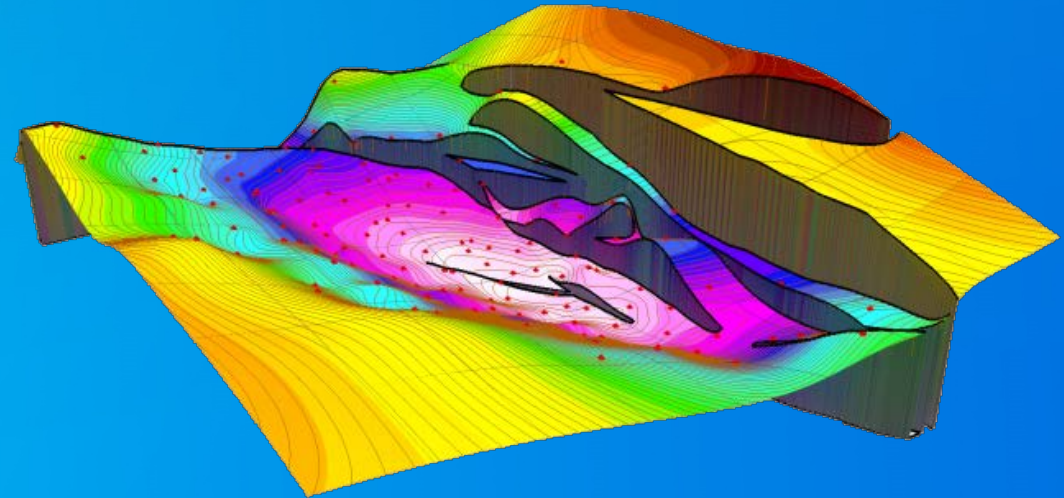
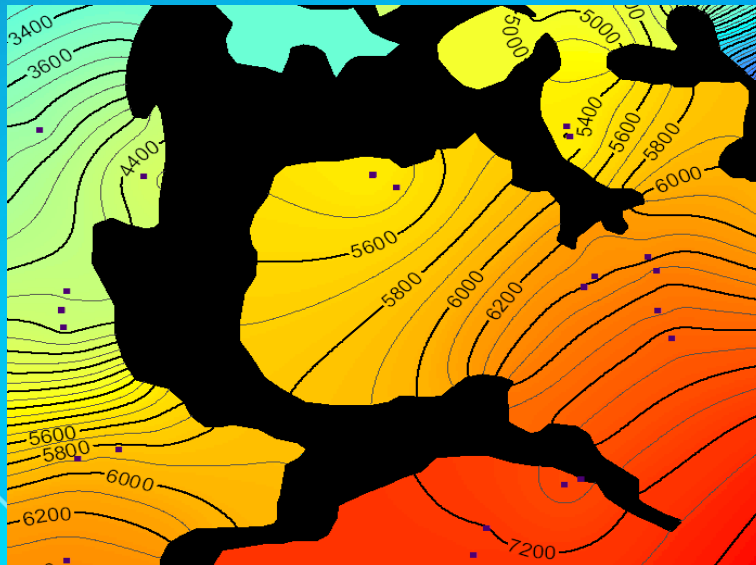


Choosing an interpolation method

- **You know nothing about your data...**
 - Use Natural Neighbors. It is the most conservative. Assumes all highs and lows are sampled, will not create artifacts.
- **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 know the highs and lows are not sampled...**
 - Use Spline. Be careful of points that are near in space but very different in value creating unnatural artifacts.
 - Use Geostatistical Analyst Kernel Smoothing Interpolation
- **Your surface is not continuous...**
 - Use Spline with Barriers if you know there are faults or other discontinuities in the surface.
- **You want or need a geostatistical technique**
 - Use Geostatistical Analyst Empirical Bayesian Kriging

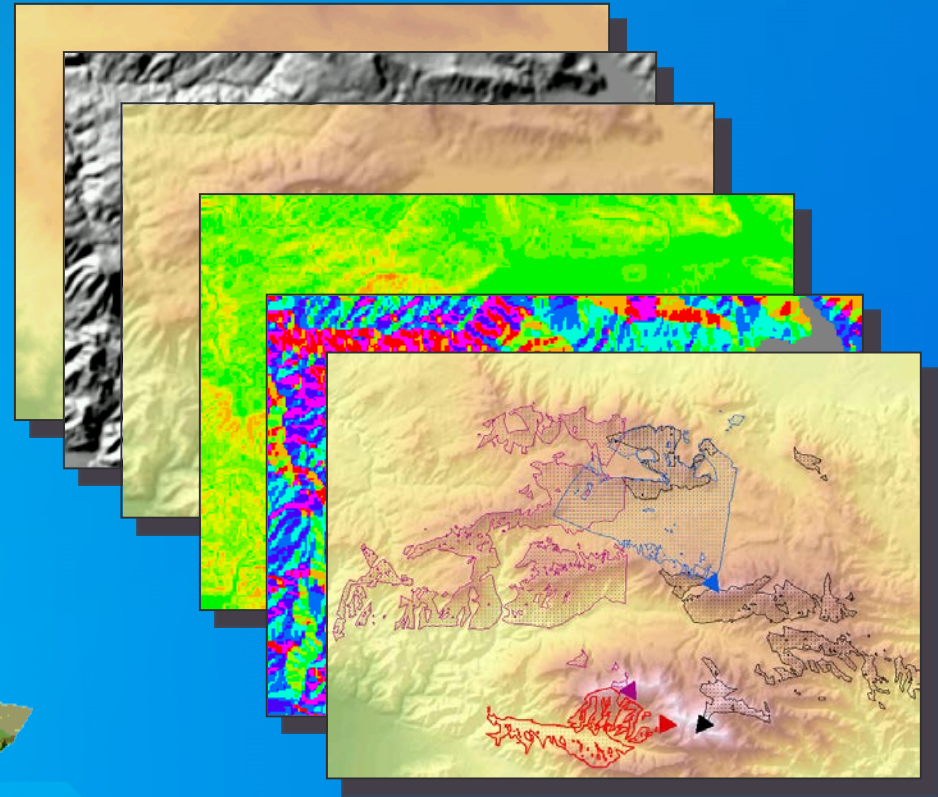
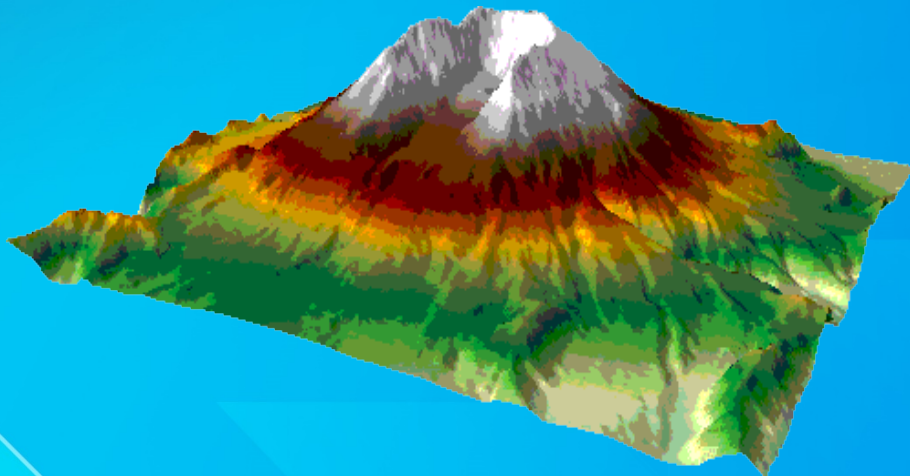
Interpolation and Contouring with Barriers

- **Spline with Barriers tool** – a Minimum Curvature Spline that honors barriers, faults, and void areas.
- **Contour with Barriers**



Surface Analysis

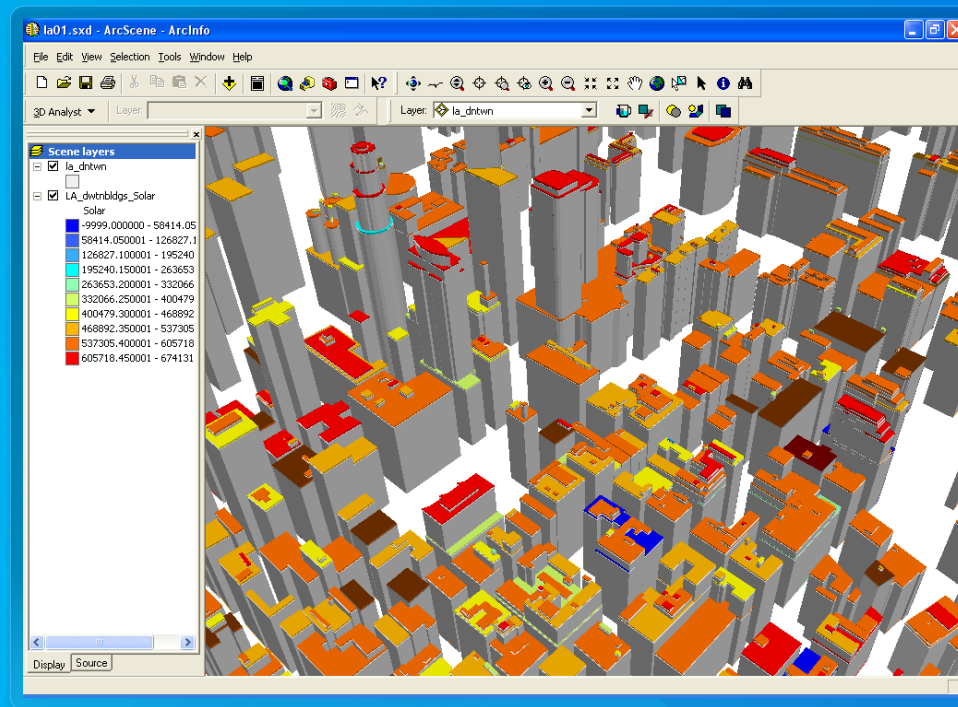
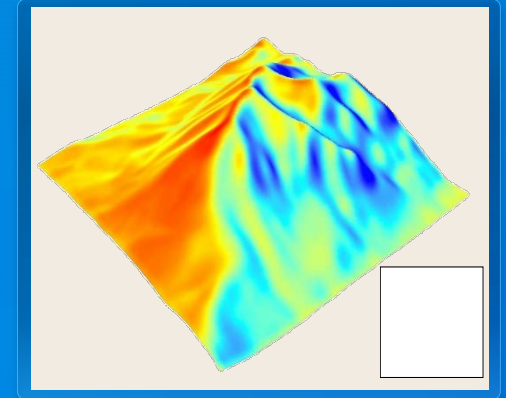
- Hillshade
- Slope
- Aspect
- Viewshed
- Cut/Fill
- Curvature



Also available in ArcGIS Online

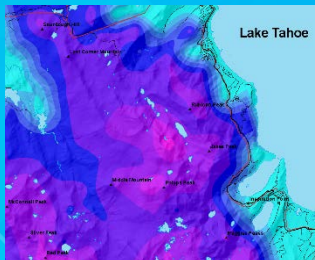
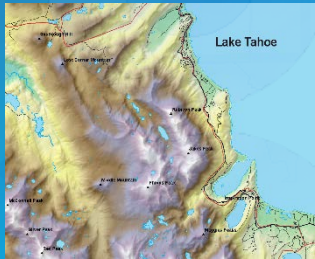
Solar Radiation Tools

- Calculate amount of direct and indirect solar radiation on the earth's surface.
- Applications in agriculture, hydrology, snow science, fire modeling, energy, etc.
- Two methods
 - Area
 - Point Locations
- 3 geoprocessing tools
 - Area Solar Radiation
 - Point Solar Radiation
 - Solar Radiation Graphics



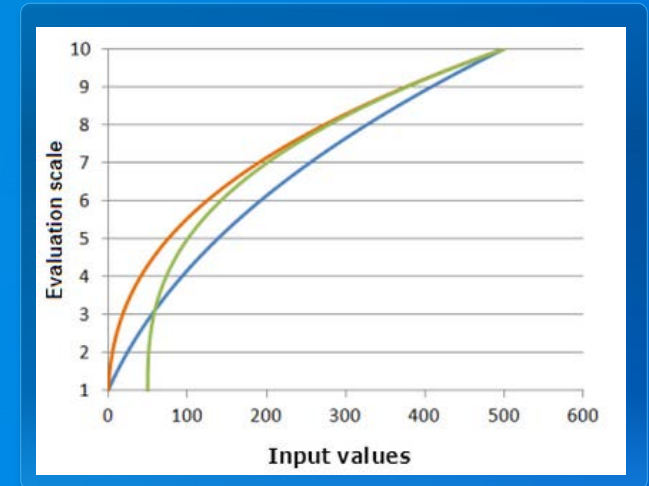
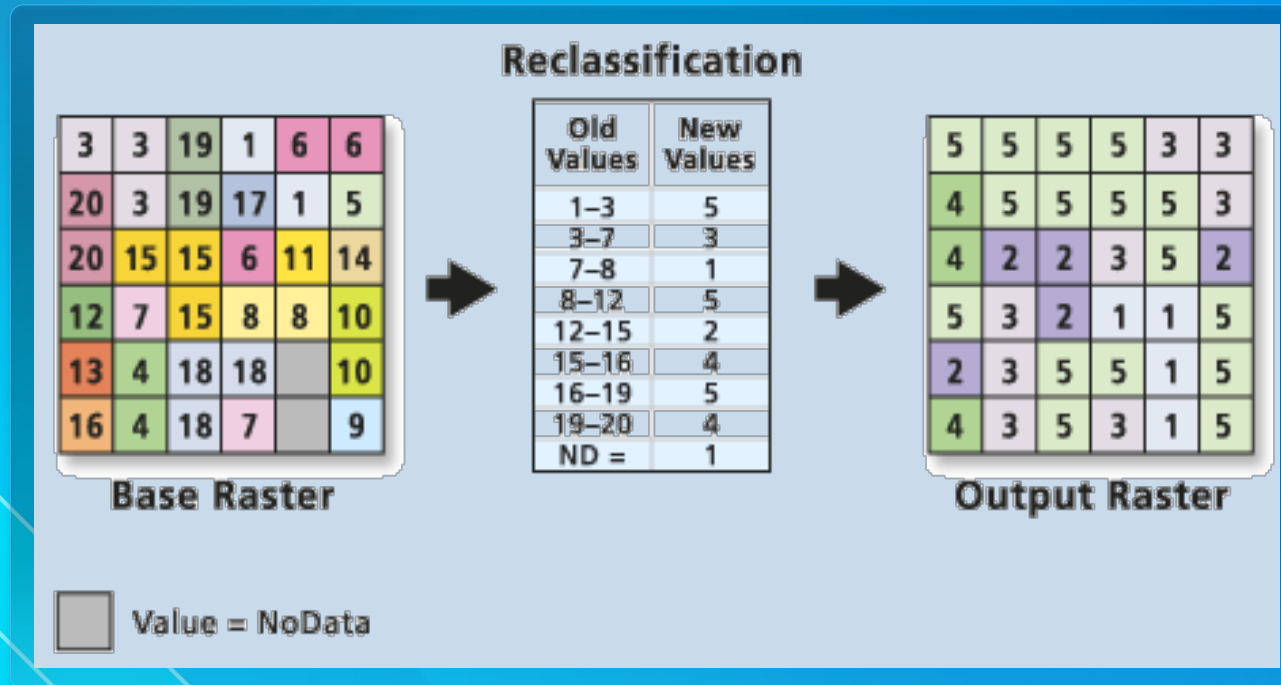
Building Blocks of Ski Suitability

Euclidian Distance
Natural Neighbors
Slope



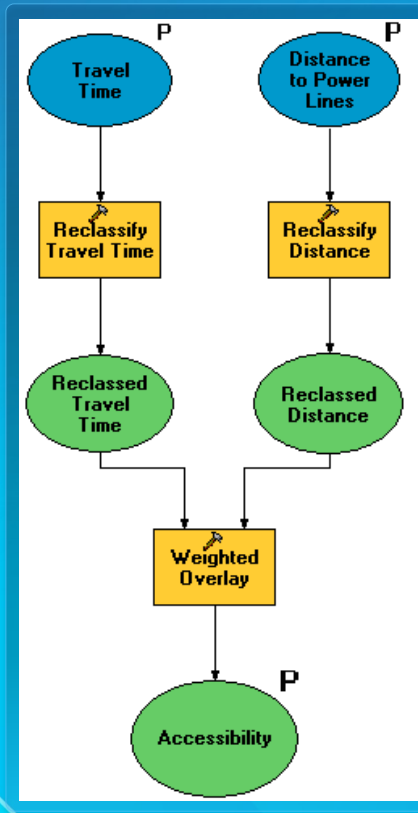
Reclassification and Transformation

- Reclassify individual values or ranges of values.
- Load and save reclass tables.
- Transform continuous values



The Weighted Overlay tool

- Assign weights and combine multiple inputs



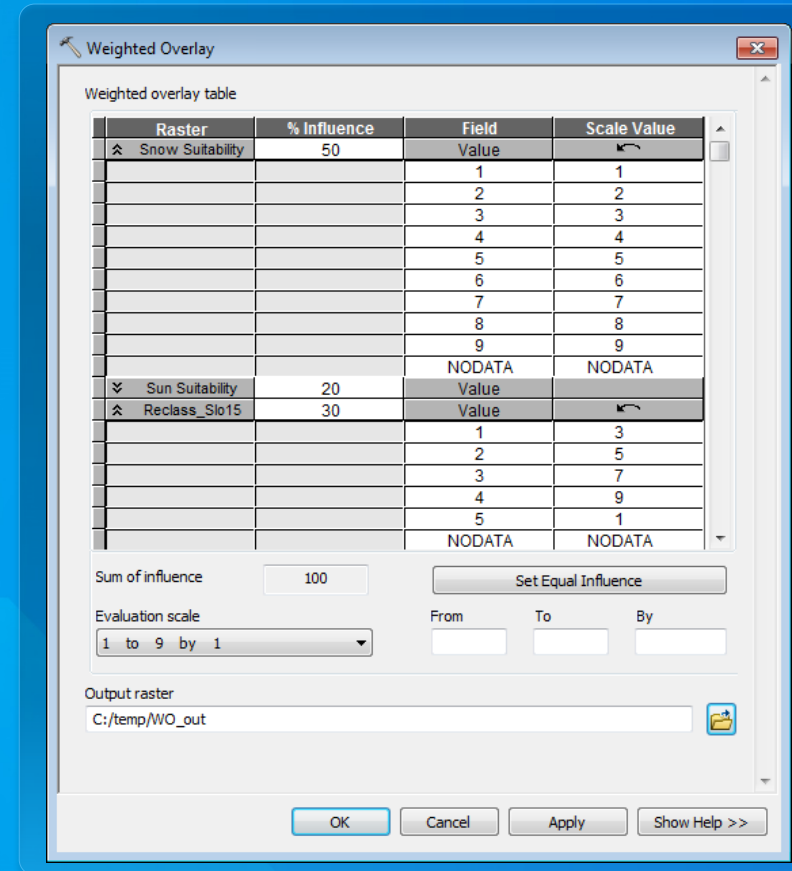
The screenshot shows the 'Weighted Overlay' dialog box in a GIS software. It features a 'Weighted overlay table' with the following data:

Raster	% Influence	Field	Scale Value
stravel	70	Value	↩
		1	1
		2	2
		3	3
		4	4
		5	5
		6	6
		7	7
		8	8
		9	9
		NODATA	NODATA
spower	30	Value	↩
		1	1
		2	2
		3	3

Below the table, the 'Sum of influence' is set to 100, and the 'Evaluation scale' is set to '1 to 9 by 1'. The 'Output raster' path is 'C:\Student\SPAG\Exercise10\SkiModel\maccess'. Buttons for 'OK', 'Cancel', 'Apply', and 'Show Help >>' are at the bottom.

Weighted Overlay

- Perform Weighted Overlay analysis for suitability modeling *“where is the best place”*
 - Weight layers
 - Weight classes
 - Supports NoData and restricted values
 - *Easy to modify weights and try multiple scenarios*





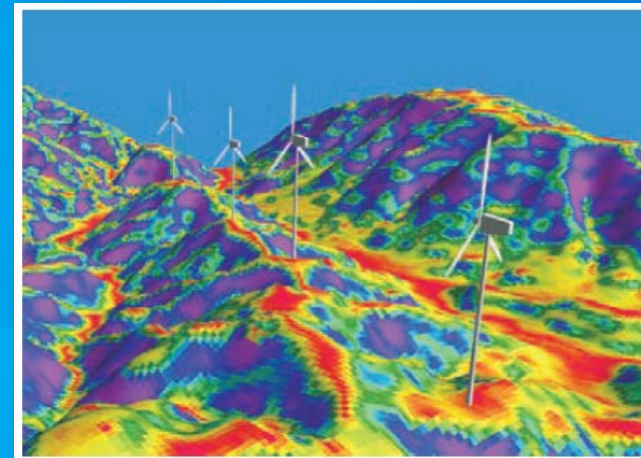
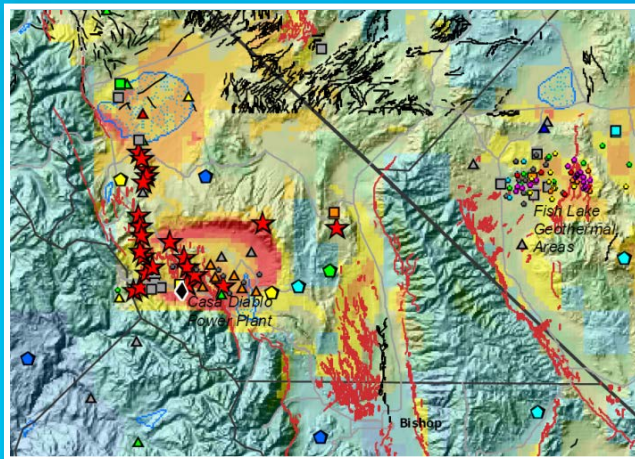
Building the Suitability Model

Reclassify
Weighted Overlay

Fuzzy Overlay

- 2 Geoprocessing tools - Fuzzy Reclassify, Fuzzy Overlay
- Useful in site selection and suitability modeling
- Similar to existing Weighted Overlay, but adds...
 - Continuous weighting
 - Fuzzy AND, OR, Gamma combinations (not just Plus)

Great Basin Geothermal Potential



New Zealand Wind Energy Siting

Hydrologic Analysis

- Create watersheds and stream networks from DEMs
 - Flow Direction
 - Flow Accumulation
 - Watershed Delineation
 - Flow Length
 - Sink Filling
 - Stream Ordering

...also available in ArcGIS Online



Multivariate Statistics

- Class Signatures, Edit Signatures, Dendrogram
- Principal Component, Iso Cluster, MLClassify
- Class Probability, Band Collection Statistics

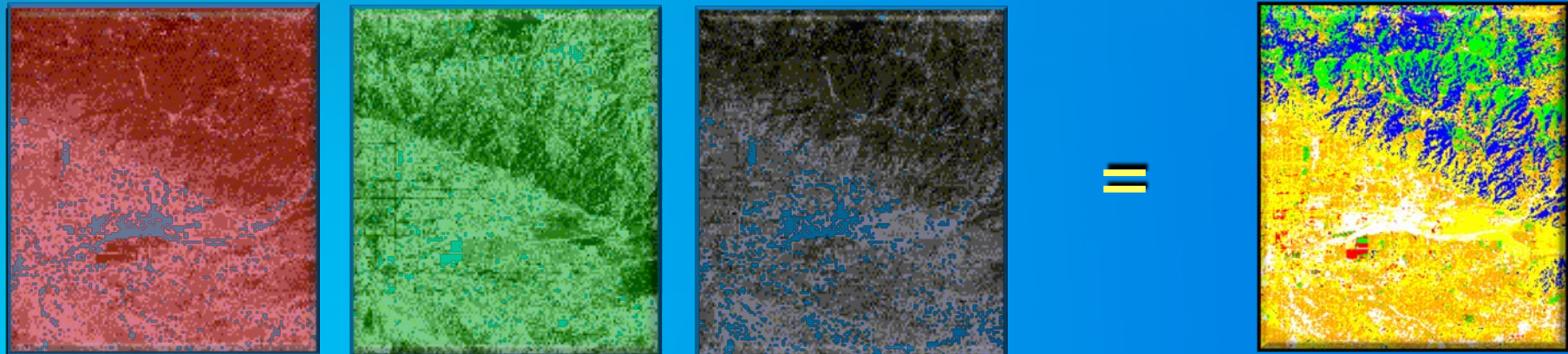


Image Classification Toolbar

- Exposes image classification capabilities in interactive workflow interface
- Includes capabilities for easy collecting and evaluating training samples

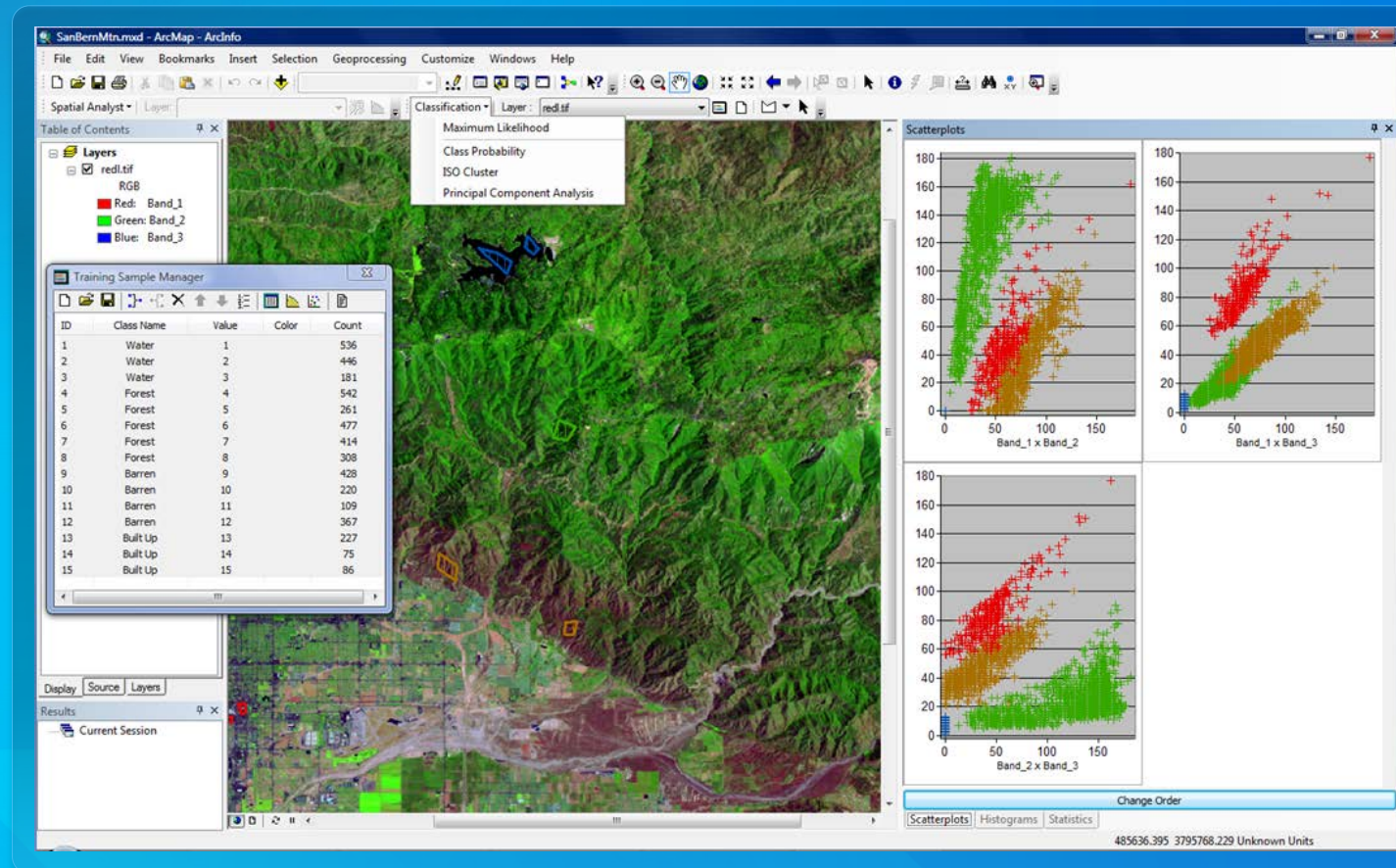
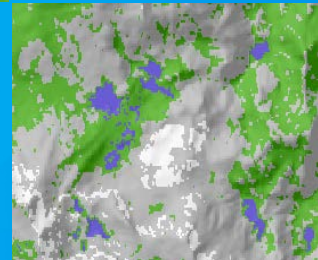
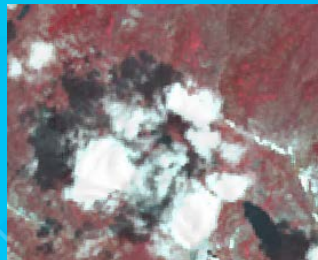
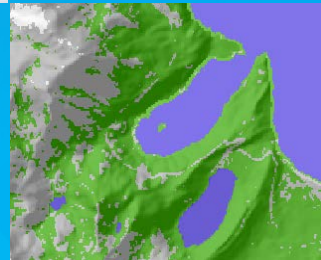
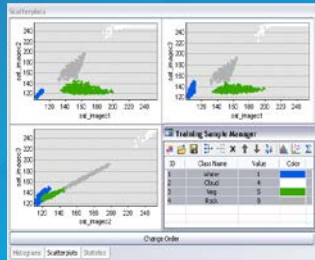


Image Classification Toolbar

Supervised Classification



New Improved Image Segmentation and Classification in 10.3 and 10.3.1

Improving classification accuracy for higher resolution imagery

- **Segmentation Geoprocessing Tools & Raster Functions**
- **Classification GP Tools and Raster Functions**
 - Support Vector Machine
 - Maximum Likelihood
 - IsoCluster
 - *Random Trees (coming in 10.4)*
- **Accuracy Assessment GP Tools**
- **These tools and capabilities support Object-Based Image Analysis (OBIA)**
feature extraction methods
- **Incorporates spatial and spectral image information, and other GIS information**



Generalization and Data Cleanup

- Smooth boundaries between zones
- Value replacement, nibbling
- Majority filtering
- Expand, shrink
- Group regions
- Raster thinning

