Introduction to Spatial Analyst 9.1

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Outline

- What is Spatial Analyst?
- Raster Data Review
- Setting the Analysis Environment
- Interpolation
- Surface Analysis
- Distance and Density
- Statistics (Cell, Zone, Neighborhood)
- Map Algebra
- Re-vegetation example

What is it ???

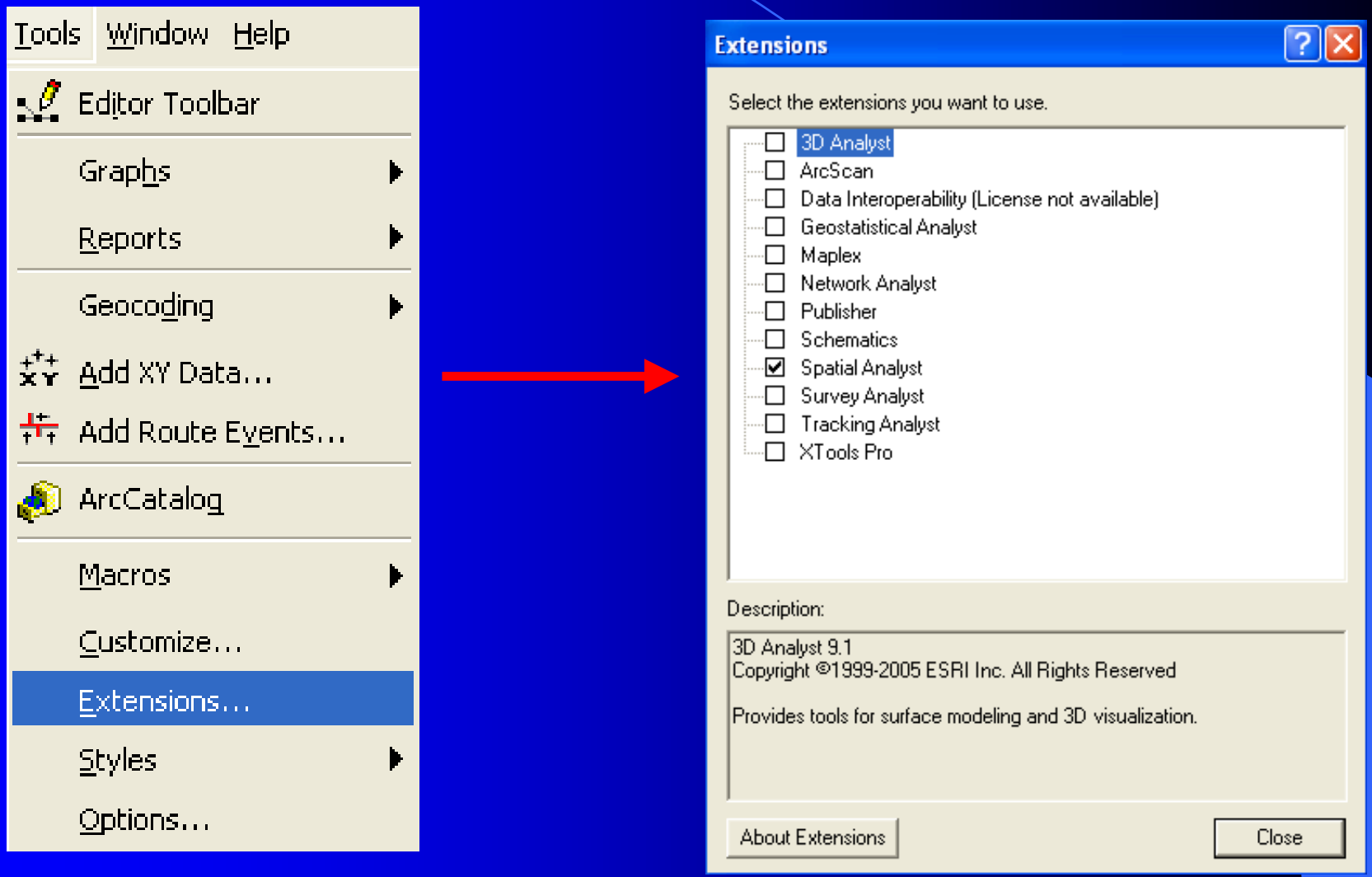
- Spatial Analyst is a collection of tools for analyzing and modeling cell-based data

  (1) Built-in Tools for analysis

  (2) Map Algebra language for modeling

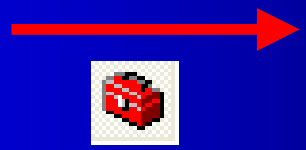
  (3) Tools for pre-processing raster data into desired format for analysis

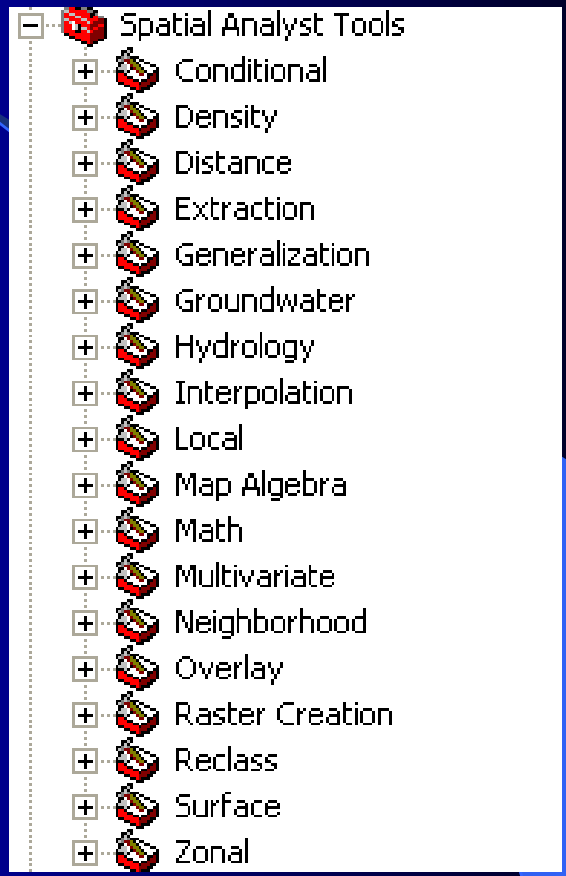
Enabling Spatial Analyst



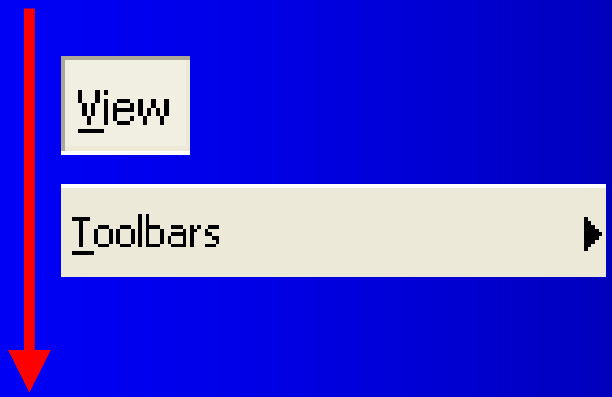
Accessing Spatial Analyst Tools

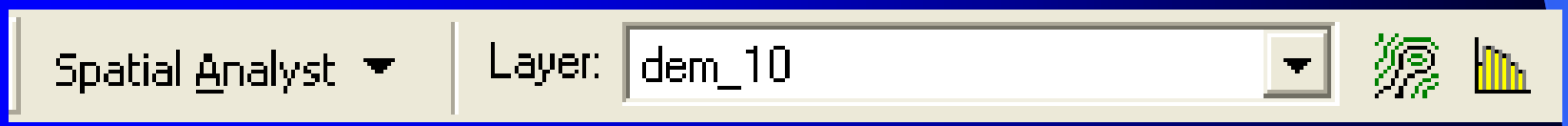
(a) ArcToolbox



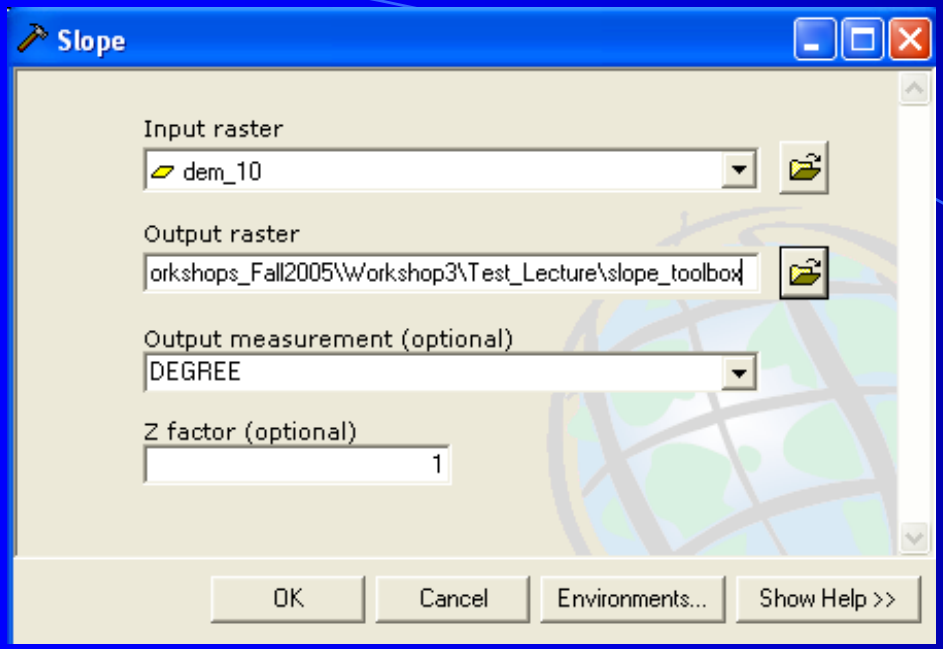


(b) Spatial Analyst Toolbar



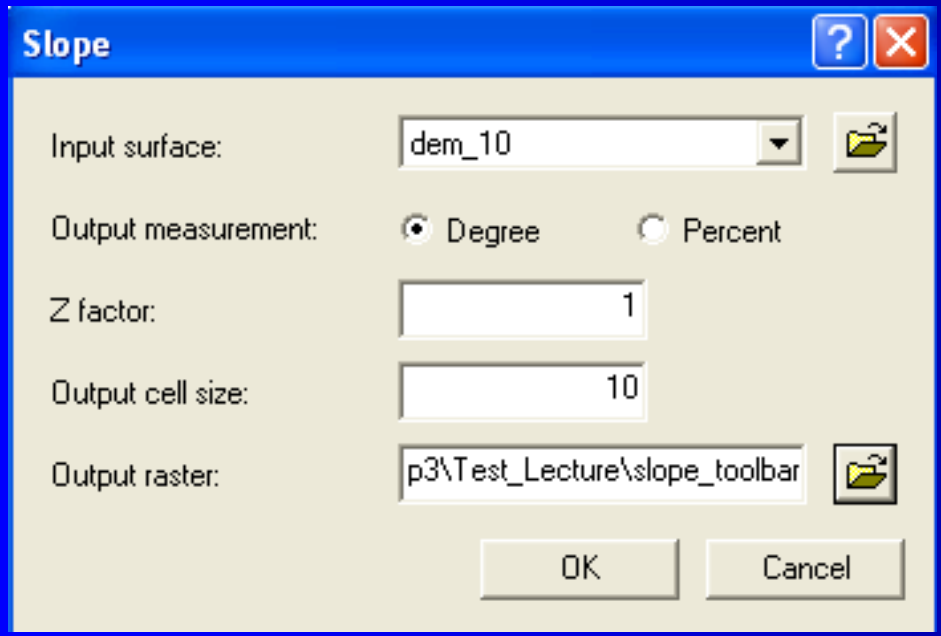


Comparison



(a) Toolbox Interface

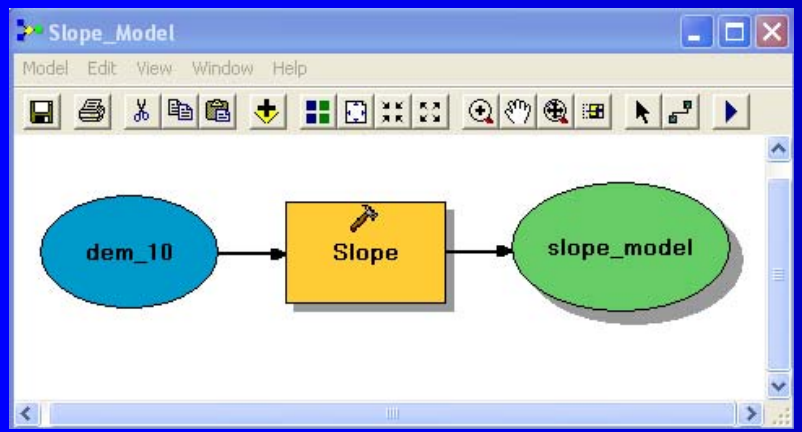
Show Help >> button is useful



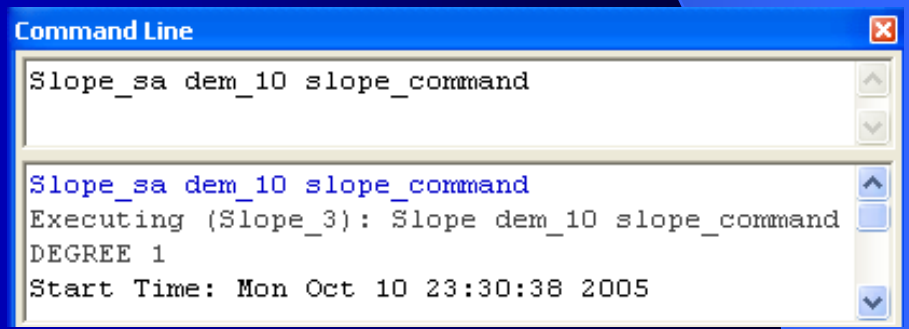
(b) Toolbar Interface

Other Ways to Access Spatial Analyst Tools

(c) Model Builder



(d) Command Line



Raster Data Revisited

- Represent world as a grid of equal-sized cells
- Every cell has a value that represents information about that cell
- Regular structure is well-suited for math and statistics
- Can store thematic data or image data
- Data can be continuous or discrete
- Attribute table is a histogram

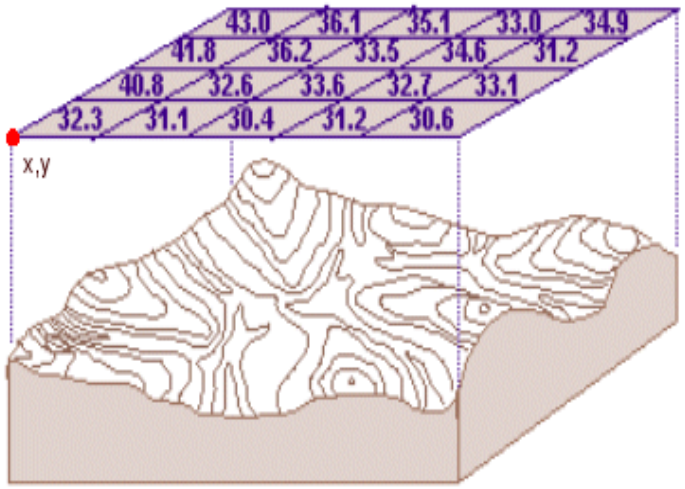
Rainfall values

1.85	1.62	1.59	1.47	1.33	1.09
1.51	1.60	1.47	1.22	1.10	0.65
1.41	1.26	1.04	0.88	0.69	0.49
1.21	0.90	0.72	0.53	0.17	0.29
0.94	0.71	0.45	0.13	0.00	0.00
0.49	0.37	0.15	0.00	0.00	0.00

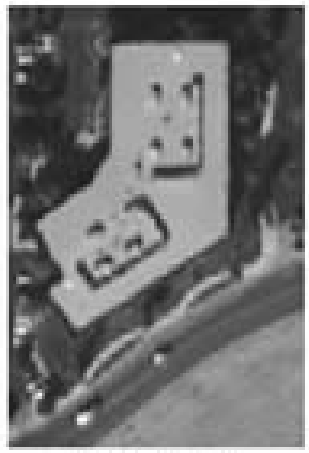
Source: http://campus.esri.com

ObjectID	Value	Count
0	0	54837
1	1	394
2	2	539
3	3	899
4	4	622
5	5	863

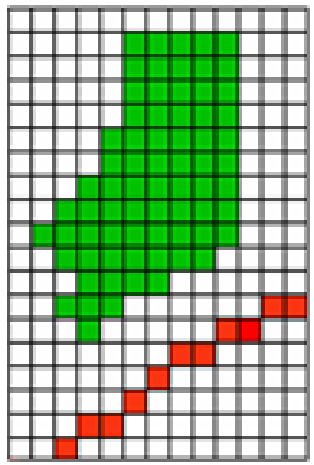
Examples of Raster Data



The raster data model represents geographic data, here elevation, as rows and columns of equally sized cells. One corner of the raster must be defined by an x,y coordinate pair.



Real World



Raster

<u>Continuous data</u>:
Changes gradually over space

⟷

<u>Discrete data</u>:
Has well-defined boundaries

Source: http://campus.esri.com

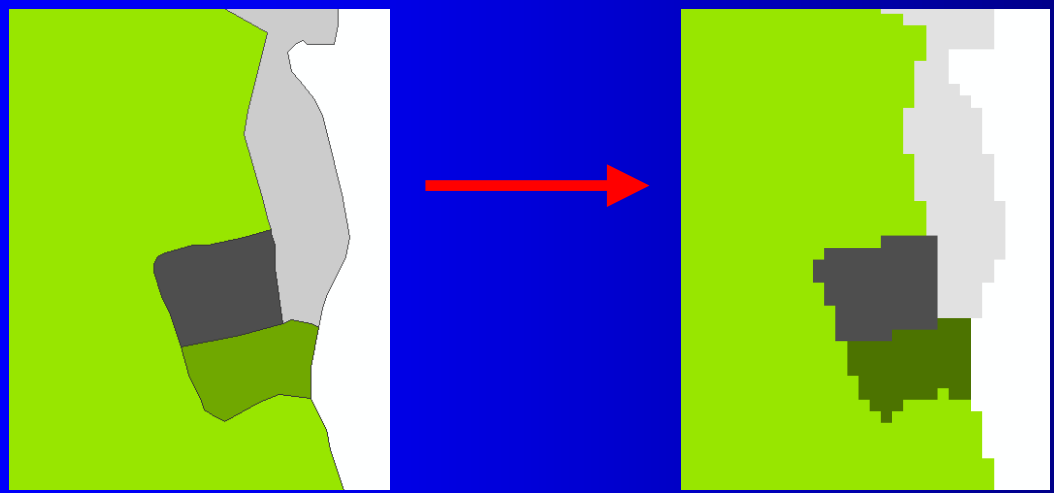
Processing Raster Data in Spatial Analyst

- Conversion from vector (x,y coordinates)
- Extraction by shape, attribute, or mask
- Reclassification of cell values
- Generalization (e.g., aggregating cells)
- Creation of new grids (constant, normal, or random values)

Conversion from Vector to Raster

- Toolbar

- Conversion from (x,y) coordinates to a grid
- Choose output cell size and field

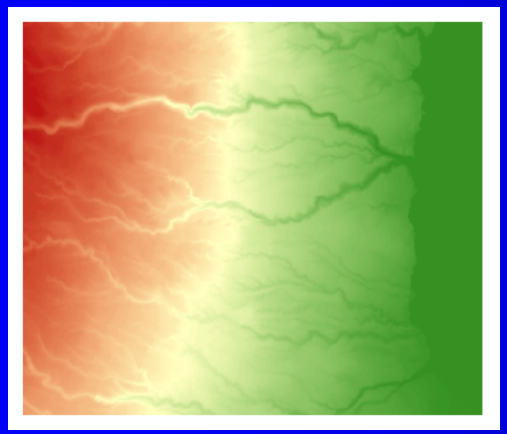


Vector

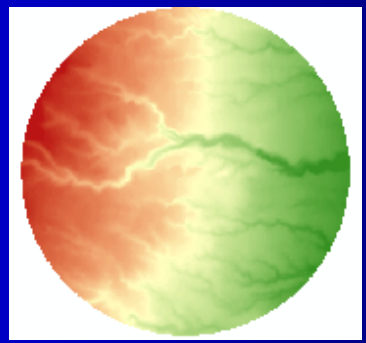
Raster

Extracting Subsets of Raster Data

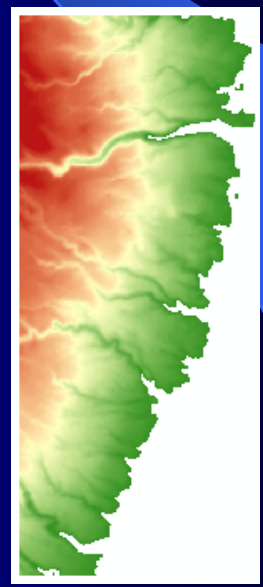
- By shape (circle, rectangle, etc.)
- By attribute (using SQL statements)
- By mask (using another raster or feature data set)



Original Elevation Grid



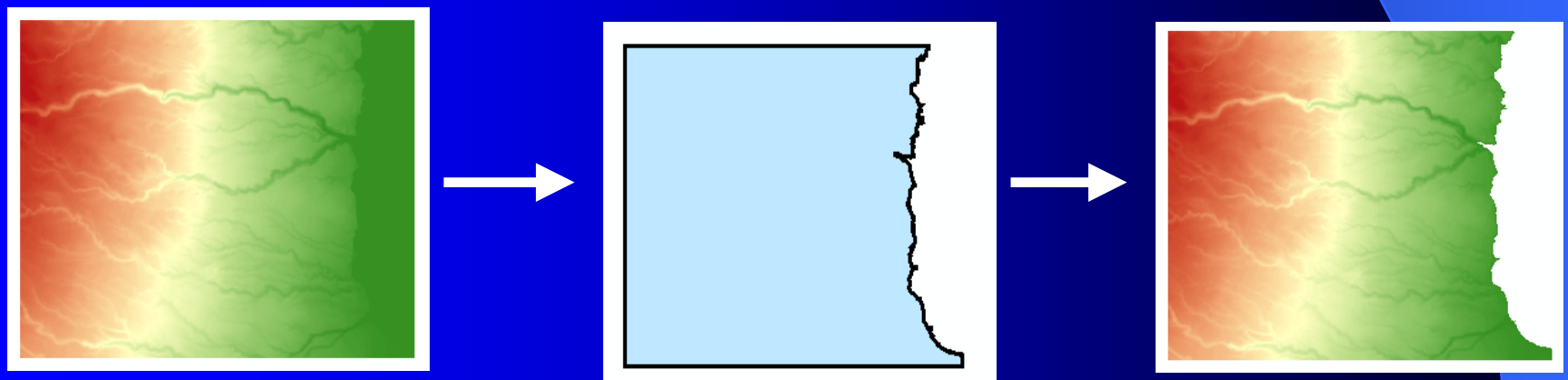
Extracted Circle



Extracted by attribute where value > 300

Extract by Mask (continued)

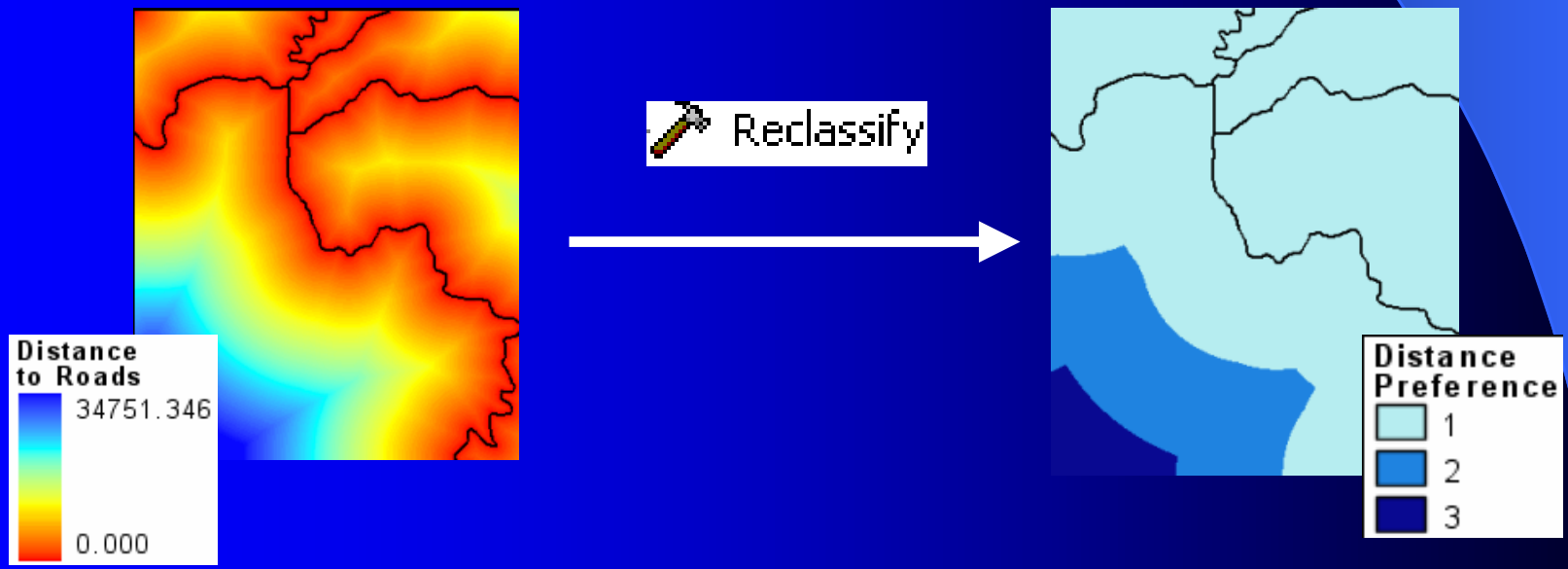
- Mask has data inside the polygon, but not outside
- Masks can be applied to other Spatial Analyst tools to limit the analysis area



Original Elevation Grid | Mask | Extracted Elevation Grid

Reclassification of Cell Values

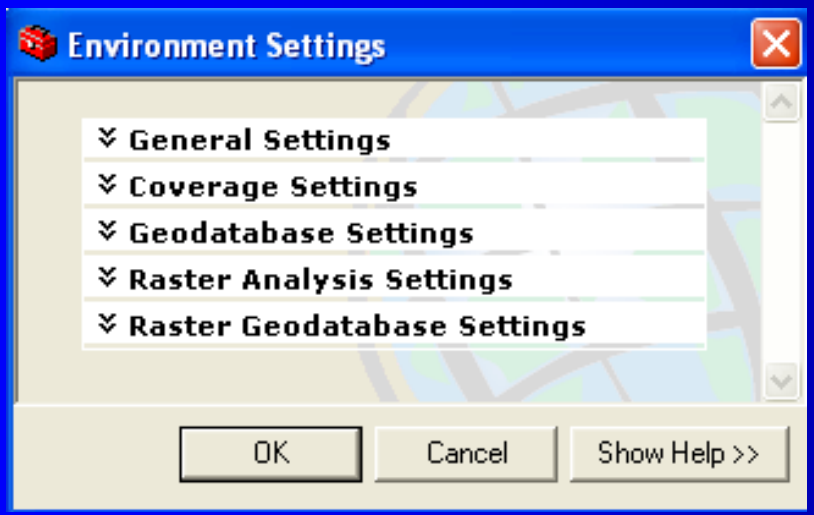
- Reassign new values to grid cells
- Purpose: simplify data; convert to a common scale; replace incorrect, old or missing data



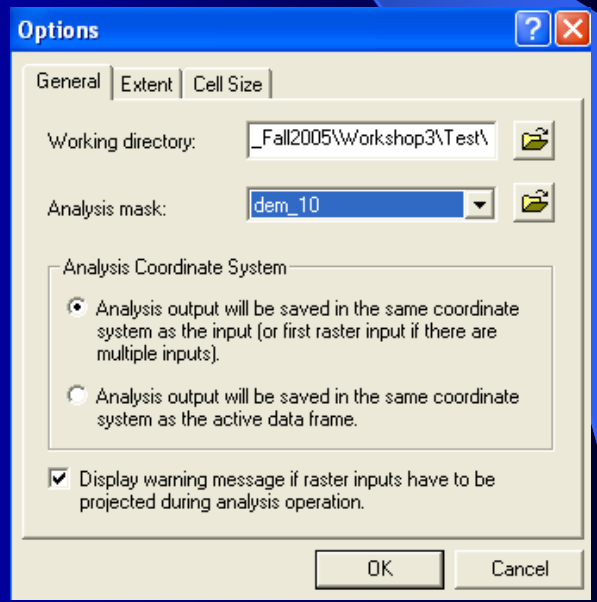
Source: http://campus.esri.com

Setting the Analysis Environment

- Set default parameters and framework for analysis
- The Toolbox and toolbar have separate environmental settings windows



Toolbox Settings



Toolbar Settings

Key Environmental Settings

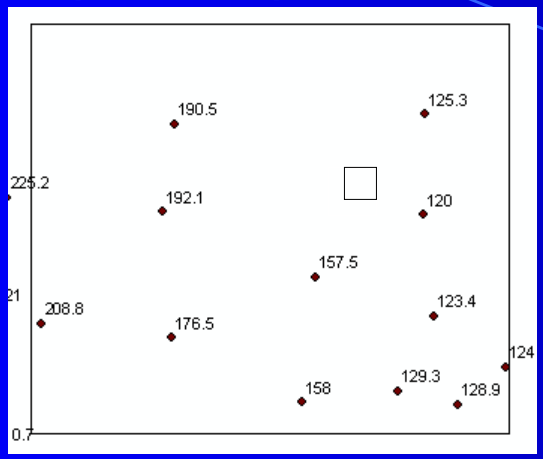
Current Workspace	Input workspace
Scratch Workspace / Working Directory	Output folder
Output Extent	Extent of study area
Output Coordinate System	Coordinate system of output raster data sets
Snap Raster	Align cells to this raster
Cell Size:	Size of cells in output rasters
Mask:	Restricts processing to mask cells with data

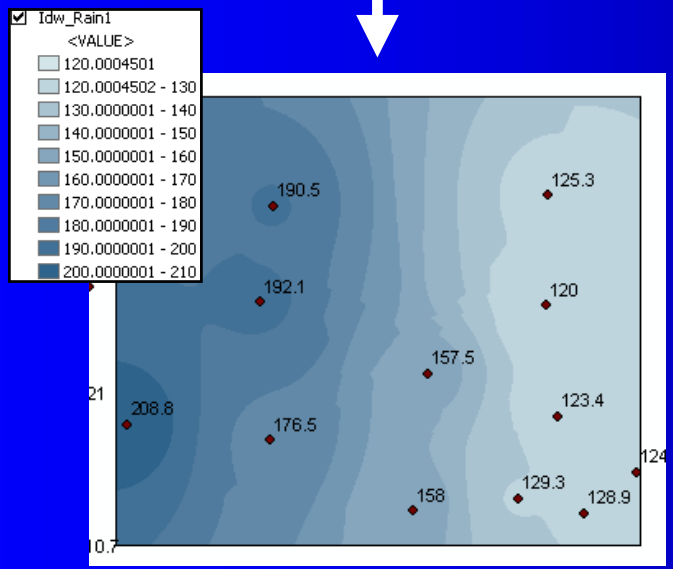
Interpolation

- Process of estimating unknown values from known values
- Relies on spatial autocorrelation (the degree to which near and distant things are related)
- In theory, near points are more alike than distant ones
- Four different techniques in ArcGIS with multiple parameters each

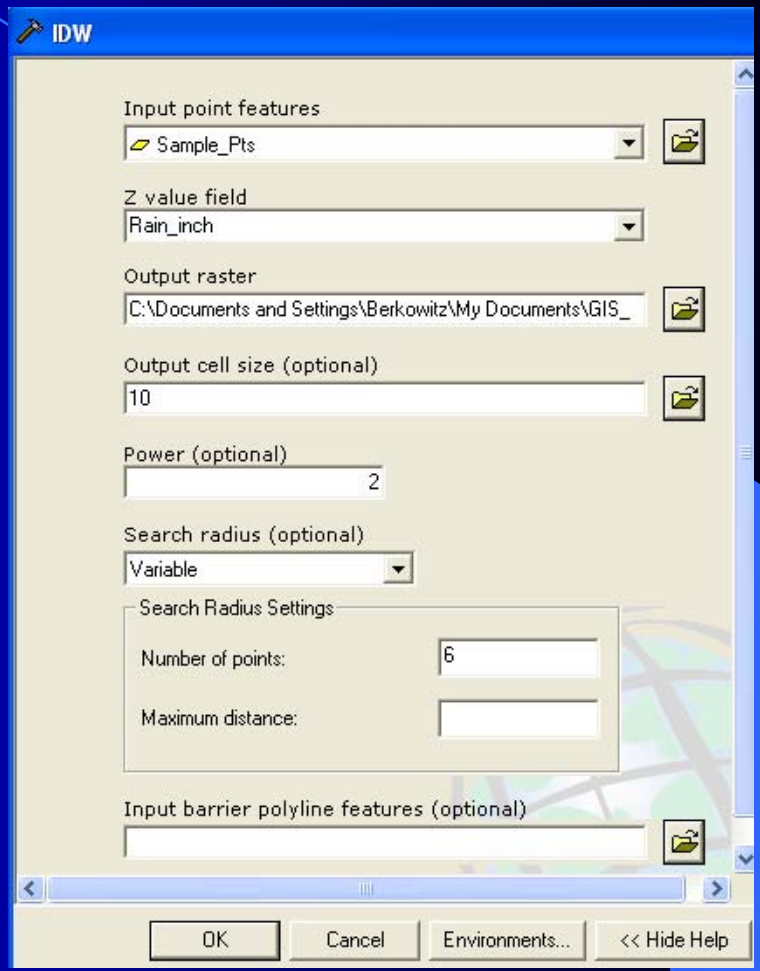
IDW Interpolation

Input Sample Points

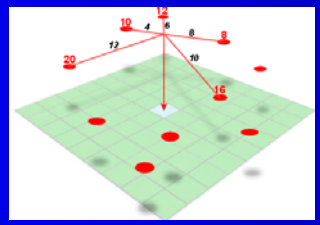
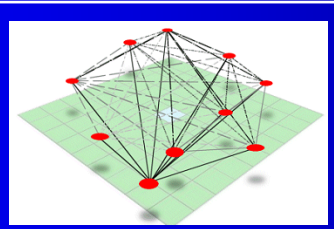
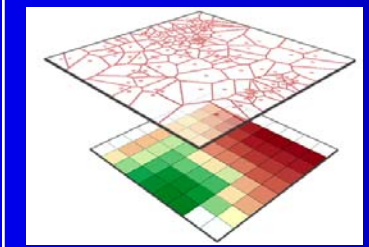
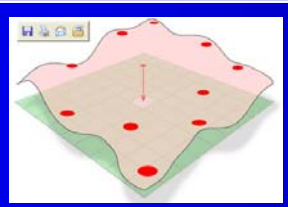




Interpolated Surface



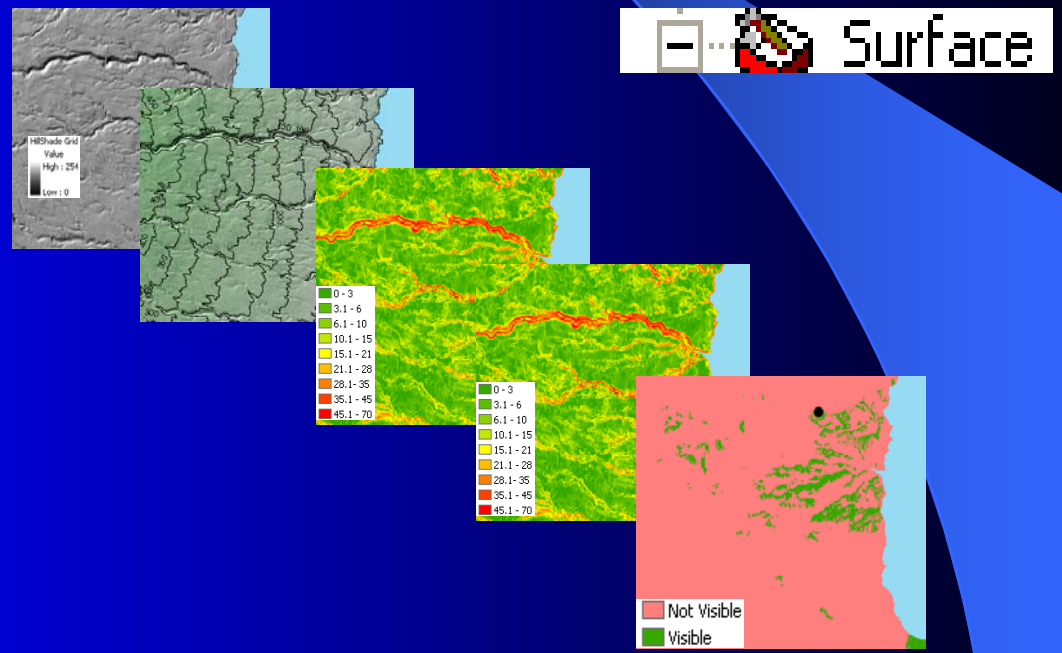
4 ArcGIS Interpolation Methods

Inverse Distance Weighted		Weighted average. Weights proportional to $1/d^{(exp)}$.
Kriging		Weighted average. Weights based on spatial autocorrelations.
Natural Neighbor		Weighted average. Weights based on Voronoi polygons.
Spline		Curve Fitting Technique.

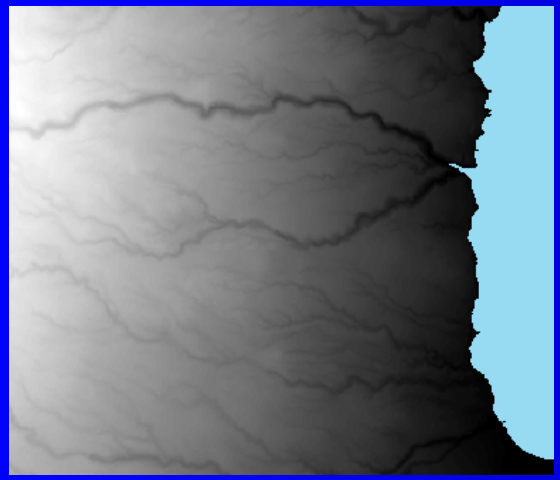
Figures: http://campus.esri.com

Surface Analysis

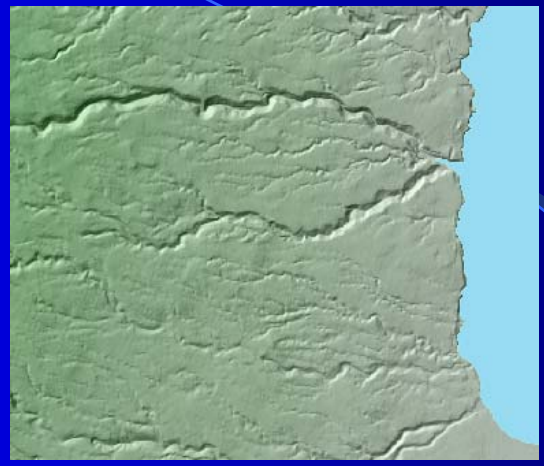
- Collection of tools for visualizing and analyzing surfaces
  - Hillshade
  - Contour
  - Slope
  - Aspect
  - Viewshed



Common Surface Analysis Outputs

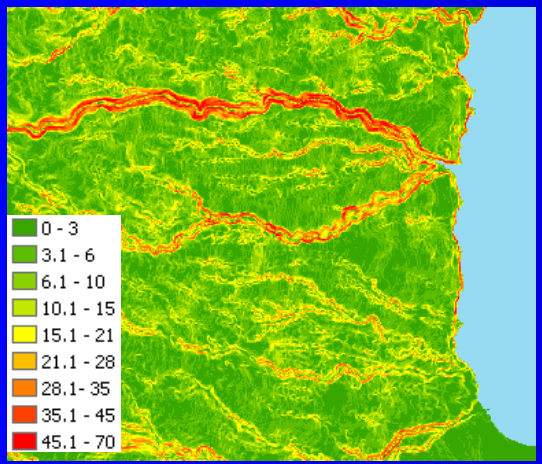


Input Elevation Grid

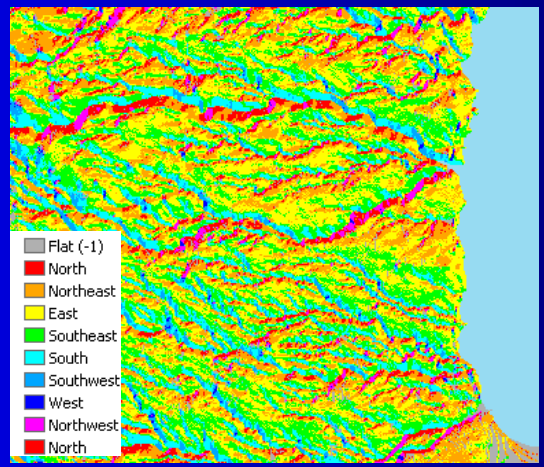


Hillshade

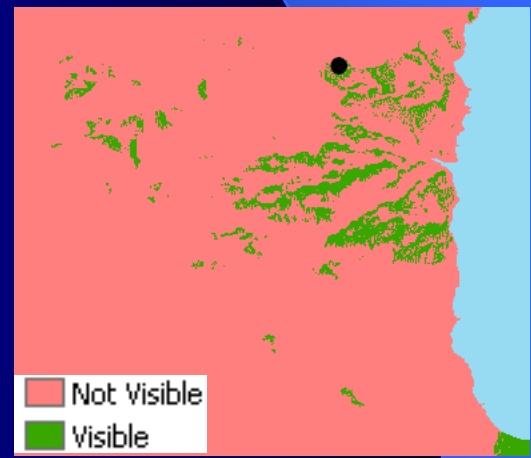
Contours



Slope



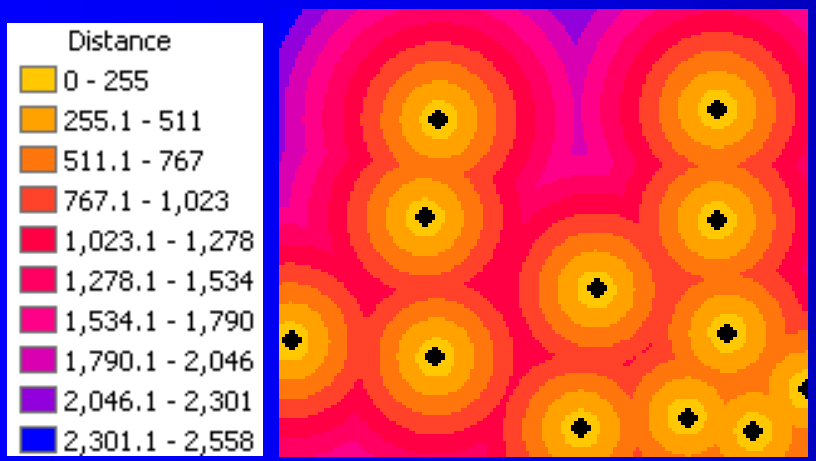
Aspect



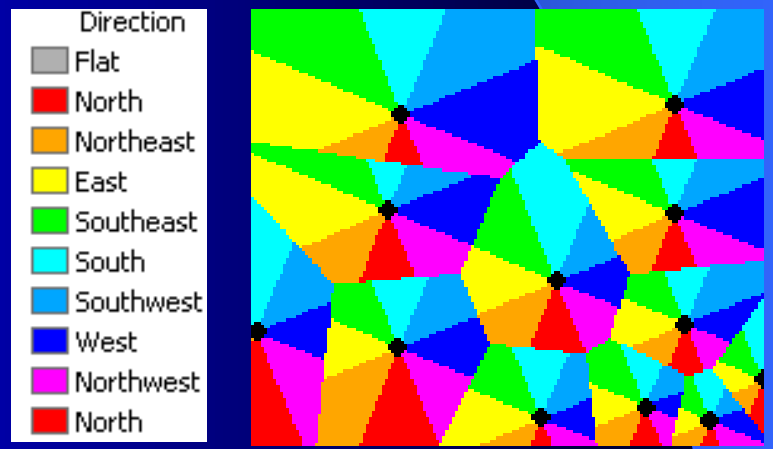
Viewshed

Distance and Direction Surfaces

- Euclidean distance to the closest source
- Euclidean direction to closest source
- Cost-weighted distances and directions
- Least cost paths



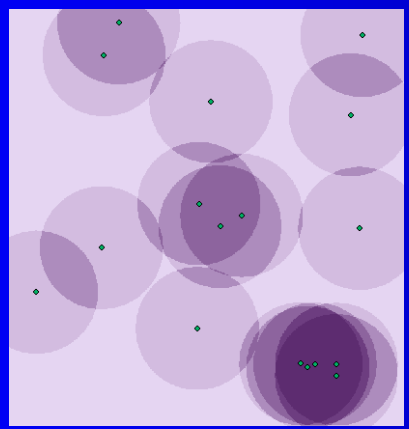
Distance to nearest rain gauge



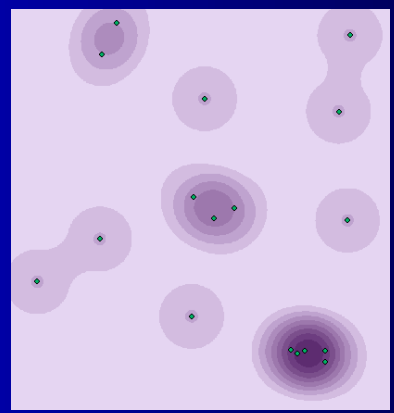
Direction to nearest rain gauge

Density Surfaces

- Density = number of features per unit area
- Density of attributes per unit area
- Based on a circular neighborhood
- Simple vs. kernel methods



Simple density
(points / km2)



Kernel density
(points / km2)

Statistics: by neighborhood, zone, & cell

- Neighborhood statistics: based on a focal area (e.g., circle, rectangle) around each cell
- Zonal statistics: based on zones
- Cell statistics: based on a particular cell across multiple raster data sets

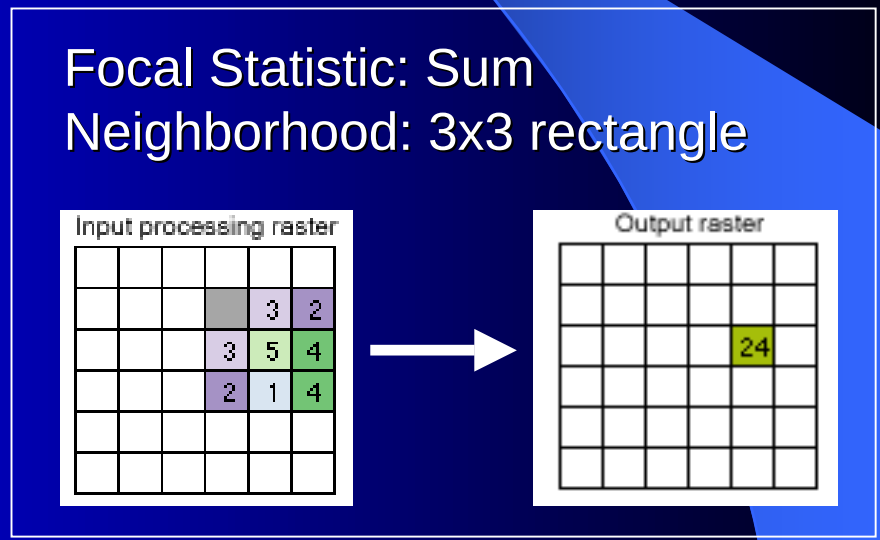
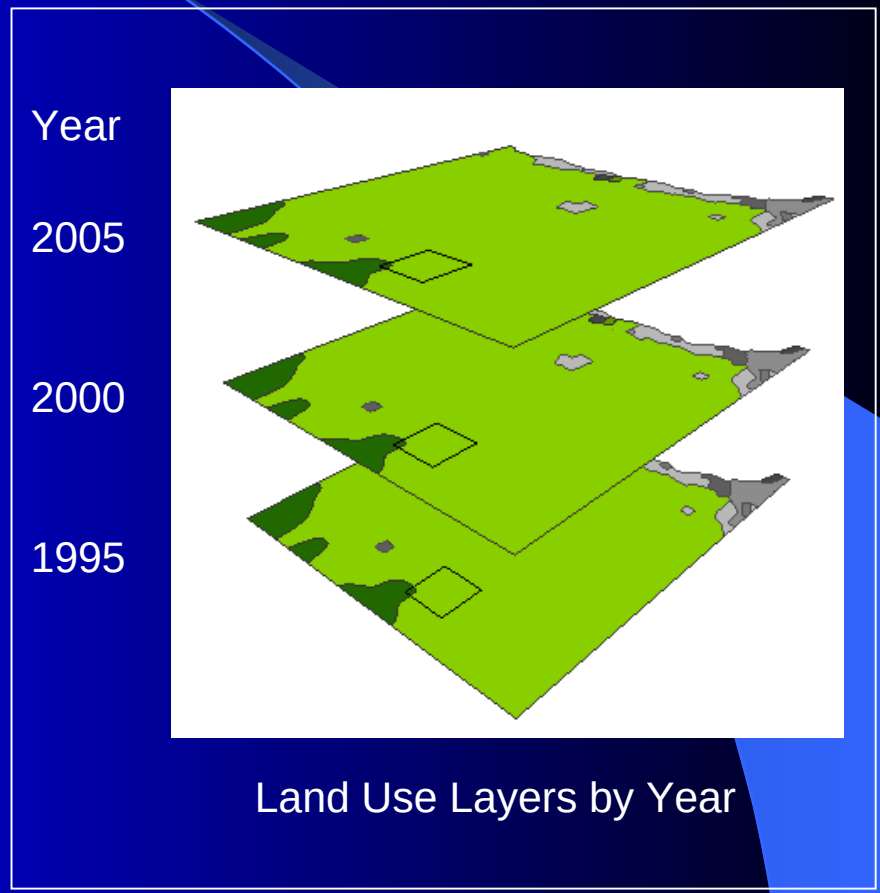


Diagram of Cell Statistics

- Cell Statistics Tool: uses the same cell across 3 data sets (land use time-series)
- Types of descriptive statistics available: min, max, mean, median, standard deviation, range, sum, etc.



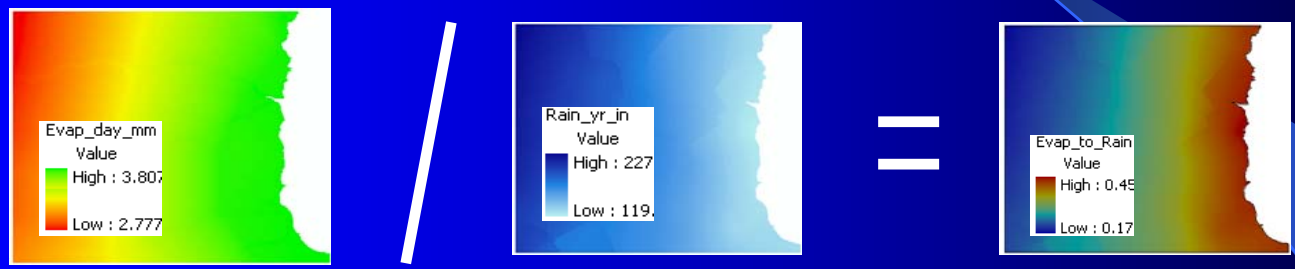
Land Use Layers by Year

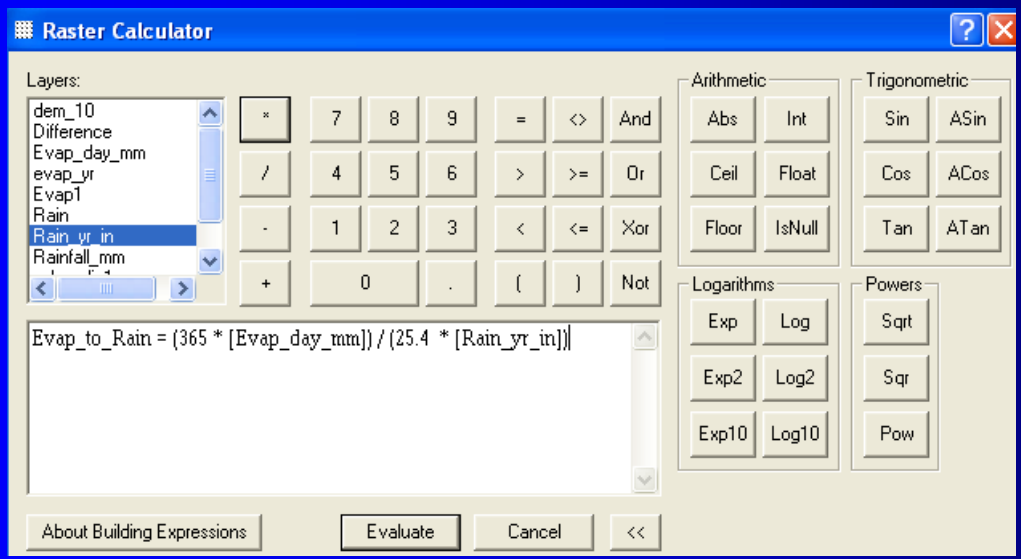
Map Algebra

- Mathematical language for grids
- Basic mathematical operations
- Arithmetic functions
- Trigonometric functions
- Logarithms, square roots, powers
- Conditional expressions (if-then)
- Neighborhood functions and statistics
- Geographic functions

Map Algebra example

- Potential Evaporation / Rainfall

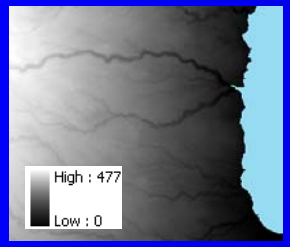




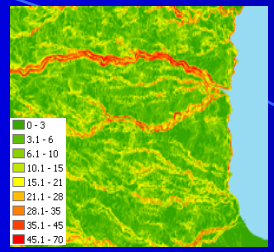
Applied example of Spatial Analyst

- Objective: find suitable sites for a re-vegetation project
- Sites must meet 5 criteria:
  - ✓ 1. Slope < 25 degrees
  - ✓ 2. Aspect is southern (135-225 degrees)
  - ✓ 3. Rainfall < 180 inches/yr
  - ✓ 4. Solar radiation >= 350 Calories/cm2
  - ✓ 5. Land use is not urban
- Input data: DEM, rainfall points, solar radiation grid, land use polygons
- Output: a grid showing suitable sites

(1)



Input DEM

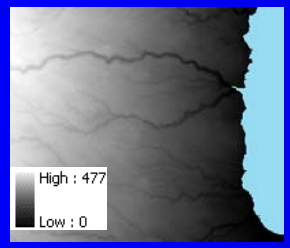


Slope

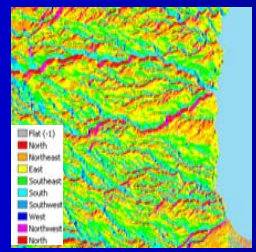
Mean Slope

Mean Slope < 25

(2)



Input DEM

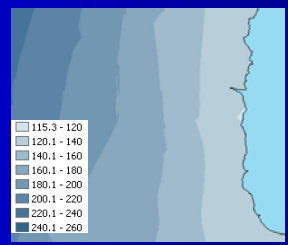


Aspect

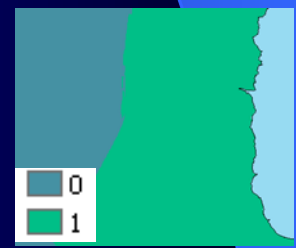
135 < Aspect < 225

(3)

Input Rainfall Points

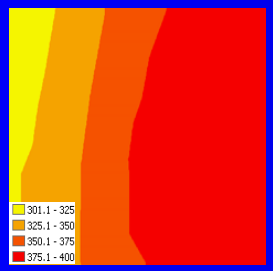


Interpolated Rainfall

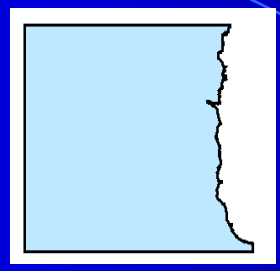


Rainfall <180

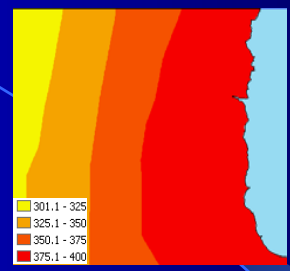
(4)



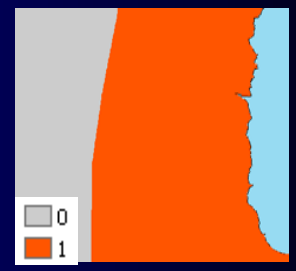
Solar Radiation



Mask



Extracted S.R.



S.R. >=350

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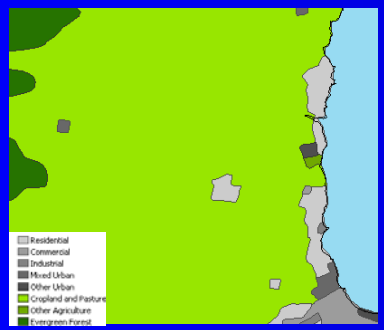
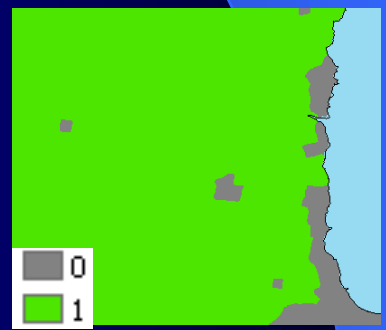
(5)



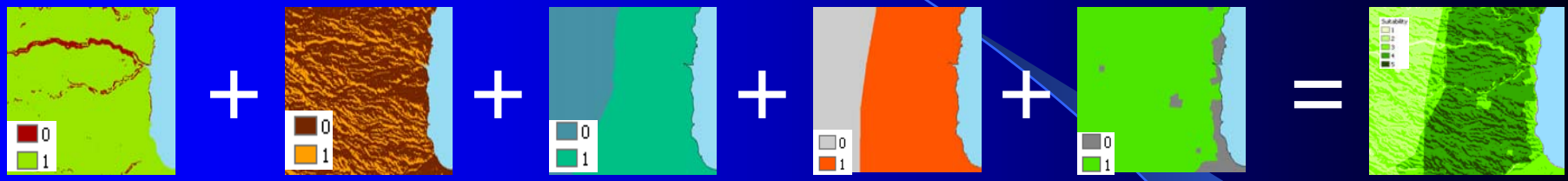
Land Use Shapefile

Land Use raster



Not_Urban

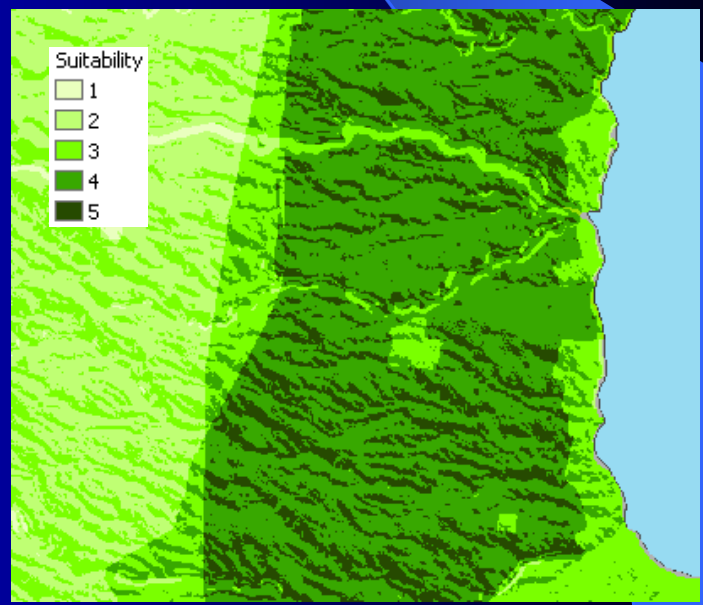
Aggregating the Binary (1/0) Grids



Slope + Aspect + Rainfall + Solar + Not_Urban = Suitability

Raster Calculator Expression

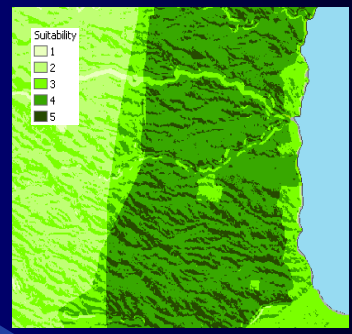
```
Suitability = [Slope_LT25] + [Aspect_South] + [Rain_LT180] +
[Solar_GE350] + [Not_Urban]
```

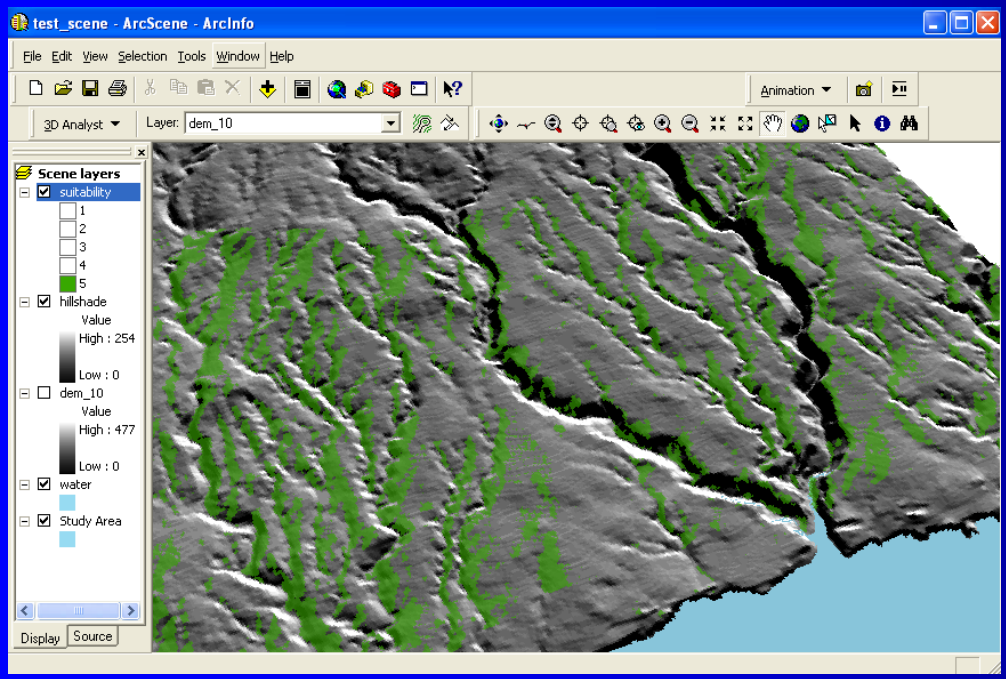


Suitability Grid

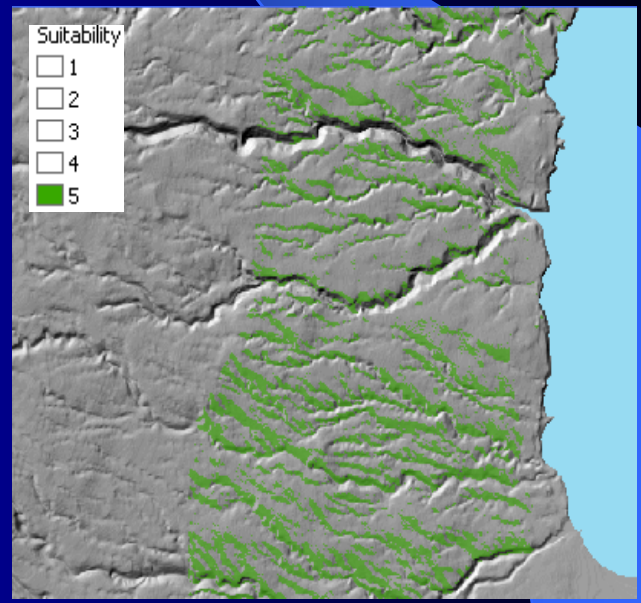
Viewing Suitable Areas (grid cell value = 5)

Suitability Raster





3D overlay with Hillshade



2D overlay with Hillshade

Concluding Remarks

- In ArcGIS, users need to choose appropriate data formats and analytical tools to meet their goals
- Spatial Analyst contains most of the tools for cell-based analysis, modeling, and statistics
- Many of these tools are unique
- Most of them require raster data