MapCalc Cross-Reference of Analysis Operations for *Spatial Analyst*

Organization of MapCalc analytical operations

All GIS software contains procedures to encode, store, control, analyze and output maps. Five fundamental classes organize the map analysis operations in MapCalc to include—

- **Reclassifying maps**—operations CLUMP, CONFIGURE, RENUMBER, SIZE, and SLICE
- **Overlaying maps**—operations COMPOSITE, COMPUTE, CALCULATE, COVER, CROSSTAB and INTERSECT
- **Measuring distance and connectivity**—operations DRAIN, RADIATE, SPAN, SPREAD and STREAM
- **Characterizing neighborhoods**—operations INTERPOLATE, ORIENT, PROFILE, SCAN and SLOPE
- **Statistical relationships**—operations ANALYZE, CLUSTER, COMPARE, CORRELATE, REGRESS and RELATE.

This organizational scheme is based on the user's perspective of map input and output contents—what the map(s) look like going in, and coming out.

RECLASSIFYING operations assign new values to each map category on an existing map layer. Regardless whether you RENUMBER, SLICE, SIZE, CLUMP or CONFIGURE, the resulting map will have the same "boundaries" (spatial arrangement) as the input map. The new values might be ones you directly assigned (RENUMBER), or the ones the computer automatically assigns (SLICE), or ones based on the area of each category (SIZE), or ones indicating the shape of the individual features (CONFIGURE). If the same value is assigned to two adjacent categories, the boundary disappears. In CLUMP, if a feature is composed of several discrete groupings, each will each get a different value and the individual boundaries will be distinct. However, in all RECLASSIFYING operations, the similarities in the spatial arrangement of features on the input and output maps are readily apparent—just a different set numbers.

OVERLAYING operations are radically different as they assign new values based on the independent values on two or more maps. Commands COMPUTE/CALCULATE (with map variables), COVER and INTERSECT overlay maps on a "point-by-point" (cell-by-cell) basis. In each instance, an entirely different looking map is generated as output. "Region-wide" overlay, on the other hand, results in a map with similar spatial arrangement of features as those on the "template" map. The map categories on the template map identify the locations (cells) whose values from the "data map" are summarized. For example, the command "*COMPOSITE Districts_map With Slope_map Average For Avg_Slope*" creates a map of the average slope for each district. The result is a map with the same spatial arrangement of features—just new values. The effect is similar to a RECLASSIFY, but two input maps are required.

DISTANCE MEASUREMENT operations assign values as a function of simple or weighted connections among locations. In each instance, a map of "starter" locations is converted into a map characterizing their connectivity to their surroundings. The connections can be "simple," or "weighted" by intervening conditions. The SPREAD (proximity), and SPAN (narrowness) commands identify the inter- and intra-distance of features. The RADIATE command identifies if locations can be seen from the starter locations. The STREAM and DRAIN commands identify the actual path(s) of the connections from starter locations.

NEIGHBORHOOD operations assign values that summarize conditions within the vicinity of map locations (i.e., "roving window"). In the case of SLOPE, ORIENT and PROFILE commands, the summary implies a characteristic of a surface, or gradient map. In the case of INTERPOLATE or SCAN, the summary is a mathematical or statistical summary of the values within the neighborhood.

STATISTICAL operations assign values as a function of the statistical relationships among maps. In the case of ANALYZE descriptive statistics are reported for a stack of map layers. In the case of CORRELATE and REGRESS the spatial relationship among maps is reported in tabular and equation form. CLUSTER and RELATE generate a new map that shows the similarity among and within maps, respectively. COMPARE produces maps and tabular comparisons between maps.

Cross-reference to Spatial Analyst analytical tools *(by ESRI)*

Spatial Analyst is a raster map analysis toolbox that is part of the ArcGIS system. The following listing is a cross-reference of MapCalc and Spatial Analyst operations organized by the five analytical classes described above. Encoding, storage, control and output operations are excluded from this cross-reference.

RECLASSIFY OPERATIONS: New values are assigned as a function of the initial value, size, shape, or contiguity of each map category on a map.

- **CLUMP** -- MapCalc operation that assigns new values to contiguous groups of cells within each map category. Related Spatial Analyst tools are—
  Generalization Toolset: Contiguity tools: **Region Group (plus Nibble, Majority Filter***)*

- **COMPUTE** (one map) -- MapCalc operation that assigns new values to each map location as the mathematical or statistical function of the existing value. Related GRID commands are
  General Math Toolset, Basic Arithmetic tools: **Plus, Minus, Times, Divide Power**
  General Math Toolset, Power tools: **Square, Square Root**
  General Math Toolset, Exponential and Logarithmic tools: **Exp, Exp2, Exp10, Ln, Log2, Log10**
  Trigonometric Math Toolset: **Cos, Sin, Tan, ACos, ASin, ATan, ATan2, CosH, SinH, TanH, ACosH, ASinH, ATanH**
  Map Algebra Toolset: **Raster Calculator**

- **CONFIGURE** -- MapCalc operation that assigns new values characterizing the shape of the area associated with each category. Related Spatial Analyst tools are—
  None, but shape statistics can be derived from ArcGIS tables through user-defined Python scripts.

- **RENUMBER** -- MapCalc operation that assigns new values to the categories on a map. Related GRID commands are
  Reclass Toolset, Reclassification tools: **Reclass**

- **SIZE** -- MapCalc operation that assigns new values according to the size of the area associated with each map category. Related Spatial Analyst tools are—
  Zonal Toolset, Zonal Geometry tools: **Zonal Geometry** *(Area plus Perimeter, Centroid and Thickness)*

- **SLICE** -- MapCalc operation that assigns new values by dividing the range of values on a map into specified intervals (contouring). Related Spatial Analyst tools are—

Reclass Toolset, Reclassification tools: **Slice** *(Equal Interval, plus Equal Area and natural Breaks)*

OVERLAY OPERATIONS: New values are assigned as a function of the independent values associated with each map location or categories on two or more existing maps.

- **COMPOSITE** -- MapCalc operation that creates a map summarizing values from one map that coincide with the categories of another. Related Spatial Analyst tools are—
  Zonal Toolset, Zonal Statistics tools: **Zonal Statistics** (*Sum*, *Mean*, *STD*, *Median*, *Minimum*, *Maximum*, *Range*, *Majority*, *Minority*, and *Variety*)

- **COMPUTE** (two or more maps) -- MapCalc operation that creates a map as the mathematical or statistical function of two or more maps. Related Spatial Analyst tools are—
  General Math Toolset, Basic Arithmetic tools: **Plus, Minus, Times, Divide Power**
  General Math Toolset, Power tools: **Square, Square Root**
  General Math Toolset, Exponential and Logarithmic tools: **Exp, Exp2, Exp10, Ln, Log2, Log10**
  Trigonometric Math Toolset: **Cos, Sin, Tan, ACos, ASin, ATan, ATan2, CosH, SinH, TanH, ACosH, ASinH, ATanH**
  Map Algebra Toolset: **Raster Calculator**

- **COVER** -- MapCalc operation that creates a new map where non-zero values of the top map replace the values on the previous (bottom) map, or stack of maps. Related Spatial Analyst tools are—
  None, but shape statistics can be derived from ArcGIS tables through user-defined Python scripts.

- **INTERSECT** -- MapCalc operation that creates a map by assigning new values to pair wise combinations of the values on two maps. Related Spatial Analyst tools are—
  Local Toolset, Combinatorial tool: **Combine**

DISTANCE OPERATIONS: New values are assigned as a function of the simple or effective distance, optimal movement, narrowness, or visual connectivity among map locations.

- **DRAIN** -- MapCalc operation that creates a map indicating the number of steepest paths (optimal path density) from a set of locations along a surface. Related Spatial Analyst tools are—
  Hydrology Toolset, Flow Density tools: **Flow Accumulation (plus Flow Length, Flow Direction, Sink, Fill, Watershed, Basin, Focal Flow)**

- **RADIATE** -- MapCalc operation that creates a map indicating areas that are visible from specified locations. Related Spatial Analyst tools are—
  Surface Toolset, Visual Connectivity tools: **Viewshed (plus Observer Points)**

- **SPAN** -- MapCalc operation that creates a map indicating the narrowness within areas associated with each category of a map. Related Spatial Analyst tools are—
  None.

- **SPREAD** -- MapCalc operation that creates a map indicating the shortest effective distance from specified cells to all other locations. Related Spatial Analyst tools are—
  Distance Toolset, Euclidean Distance tools: **Euclidean Distance (plus Euclidean Direction, Euclidean Allocation)**
  Distance Toolset, Effective Distance tools: **Cost Distance (plus Cost Allocation, Cost Back Link)**

- **STREAM** -- MapCalc operation that creates a map identifying the steepest downhill route along a surface (optimal path). Related Spatial Analyst tools are—
    - ***Hydrology Toolset, Surface Configuration tools:*** **Flow Length (plus Flow Direction, Sink, Fill, Watershed, Basin, Focal Flow)**

NEIGHBORHOOD OPERATIONS: New values are assigned as a function of the independent values within a specified distance and direction around each map location.

- **INTERPOLATE** -- MapCalc operation that creates a continuous surface from point data. Related Spatial Analyst tools are—
    - ***Interpolation Toolset:*** **IDW (plus Kriging, Spline, Spline with Barriers, Natural Neighbor, Trend)**

- **ORIENT** -- MapCalc operation that creates a map indicating aspect along a continuous surface. Related Spatial Analyst tools are—
    - ***Surface Toolset, Surface Configuration tools:*** **Aspect (plus Curvature)**

- **PROFILE** -- MapCalc operation that creates a map indicating the cross-sectional profile along a continuous surface. Related Spatial Analyst tools are—
    - **None**.

- **SCAN** -- MapCalc operation that creates a map summarizing the values that occur within the vicinity of each cell. Related Spatial Analyst tools are—
    - ***Neighborhood Toolset, Focal (roving window) tools:*** **Focal Statistics** (*Sum*, *Mean*, *STD*, *Median*, *Minimum*, *Maximum*, *Range*, *Majority*, *Minority*, and *Variety*)

- **SLOPE** -- MapCalc operation that creates a map indicating the slope (1st derivative) along a continuous surface. Related Spatial Analyst tools are—
    - ***Surface Toolset, Surface Configuration tools:*** **Slope**

STATISTICAL OPERATION: New values and statistical summaries are assigned as a function of the numerical relationships among maps.

- **ANALYZE** -- MapCalc operation that creates a map of the simple or weighted average, standard deviation, coefficient of variation and several other descriptive statistics for two or more maps (map stack). Related Spatial Analyst tools are—
    - ***Local Toolset, Cell Statistics tools:*** **Cell Statistics** (*Sum*, *Mean*, *STD*, *Median*, *Minimum*, *Maximum*, *Range*, *Majority*, *Minority*, and *Variety*)

- **CLUSTER** -- MapCalc operation that creates a map that identifies areas with similar data patterns (characteristics) using a stack of input map layers. Related Spatial Analyst tools are—
    - ***Multivariate Toolset, Classification tools:*** **Iso Cluster Unsupervised Classification**

- **COMPARE** -- MapCalc operation that generates a summary table of various comparison statistics between two maps. Related Spatial Analyst tools are—
    - **None**. Comparative statistics can be derived by evaluating index equations using the Raster Calculator or a Python script.

- **CORRELATE** -- MapCalc operation that generates a correlation matrix from a stack of maps. Related Spatial Analyst tools are—
    - **None**. Correlation can be derived using a Python script. Also, the Band Collect tool in the Multivariate toolset provides correlation and covariance summaries.

- **REGRESS** -- MapCalc operation performs a linear regression analysis by using the "least squares" method to fit a line through a set of data points in multiple maps (map stack) and

outputs the regression coefficients of the prediction model. Related Spatial Analyst tools are—
> **None**. Correlation can be derived using a Python script.

- **RELATE** -- MapCalc operation that creates a map that quantifies the similarity of each location on a map to an evaluation data pattern, or set of comparison values. Related Spatial Analyst tools are—
  > **None**.

(updated April 2012)