Applying MapCalc Map Analysis Software

Cross-Reference of MapCalc Analysis Operations: MapCalc contains a comprehensive set of grid-based map analysis operations. Many of the capabilities are represented in other educational and commercial software packages. The following cross-reference listings will help in translating the concepts and procedures developed in MapCalc to other grid-based systems.

Overview and Organization of Map Analysis Operations

Grid Module for ArcInfo by ESRI, Inc.
ERDAS Imagine by ERDAS, Inc.
GRASS a public domain package
IDRISI by Clark University

Overview and Organization of Map Analysis Operations

All GIS packages contain 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. For example, a **RECLASSIFYING** operation assigns a new value to each map category. 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.

This organizational scheme is based on the pMAP software system (Spatial Information Systems,
1986) and used in the books **BEYOND MAPPING** and **SPATIAL REASONING** by Joseph K.
Berry (1993 and 1995, John Wiley & Sons). An alternative classification scheme is used in the
book **GEOGRAPHICAL INFORMATION SYSTEMS AND CARTOGRAPHIC MODELING** by C.
Dana Tomlin (1990, Prentice Hall Publishers). Tomlin’s classification is based on how the
computer algorithm obtains data for processing. It identifies three fundamental classes that
include

- **Local** functions (single or multiple values associated with individual locations)
- **Focal and Incremental** functions (values of immediate or extended neighborhoods), and
- **Zonal** (values of entire or partial zones).

The following cross-reference is provided for individuals familiar with this alternative
classification scheme.
The following sections cross-reference individual operations in MapCalc to selected GIS packages. The five MapCalc analytical classes (Berry classification scheme) are used to organize the cross-references.

Grid Module for ArcInfo by ESRI, Inc. (www.esri.com)

GRID is a raster geo-processing toolbox that is integrated with the ARC/INFO vector GIS system (Environmental Systems Research Institute (ESRI), 380 New York Street, Redlands, California 92373). Spatial Analyst is a derivative of GRID and is distributed as an extension to the ArcView system. The following listing is a cross-reference of MapCalc and GRID/SA operations organized by the five analytical classes. The analytical operations in GRID are grouped into 24 functional classes that are indicated in the body of the listing (e.g., Shape Analysis function, Hydrologic function, etc.). The organizational structure closely adheres to the Tomlin classification scheme. Encoding, storage, control and output operations are excluded from the 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 GRID commands are
  - Shape Analysis function REGIONGROUP
  - Hydrologic functions STREAMLINK, STREAMORDER

- **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
  - Arithmetic operator UNARY-
  - Boolean operator ^
  - Bitwise operators <<,>>,^^
  - Assignment operator =

Note: the Tomlin classification scheme doesn't identify statistical operators.
Trigonometric operators ACOS, ACOSH, ASIN, ASINH, ATAN, ATAN2, ATANH, COS, COSH, SIN, SINH, TAN, TANH
Exponential and Logarithmic operators EXP, EXP10, EXP2, LN, LOG10, LOG2, POW, SQR, SQRT
Selection functions SELECT, TEST
Statistical functions EQUALTO, GREATERTHAN, LESSTHAN, LPOS, UPOS
Other functions ABS, CEIL, CON, FLOAT, FLOOR, INT, INSUL, MERGE, PICK, NORMAL, RAND, SCALAR, SETNULL

- **CONFIGURE** -- MapCalc operation that assigns new values characterizing the shape of the area associated with each category. Related GRID commands are None, but shape statistics can be derived from ARC/INFO tables through user defined scripts

- **RENUMBER** -- MapCalc operation that assigns new values to the categories on a map. Related GRID commands are Reclassification function RECLASS

- **SIZE** -- MapCalc operation that assigns new values according to the size of the area associated with each map category. Related GRID commands are Zonal functions ZONALAREA, ZONALPERIMETER, ZONALTHICKNESS

- **SLICE** -- MapCalc operation that assigns new values by dividing the range of values on a map into specified intervals (contouring). Related GRID commands are Reclassification function SLICE

**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 GRID commands are Zonal functions ZONALFILL, ZONALMAX, ZONALMEAN, ZONALMIN, ZONALRANGE, ZONALSTD, ZONALSUM, ZONALVARIETY

- **COMPUTE** (two or more maps) -- MapCalc operation that creates a map as the mathematical or statistical function of two or more maps. Related GRID commands are Arithmetic operators *, +, -, DIV, MOD
  Boolean operators !, &, |
  Relational operators <, <=, ==, >, >=, ^=
  Bitwise operators !!, &&, ||
  Combinatorial operators CAND, COR, CXOR
  Logical operators DIFF, IN, OVER
  Statistical functions MAJORITY, MAX, MED, MIN, MINORITY, RANK, REGRESSION, VARIETY
  Other function FMOD

- **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 GRID commands are
Selection functions SELECTBOX, SELECTCIRCLE, SELECTMASK, SELECTPOINT, SELECTPOLYGON

- **INTERSECT** -- MapCalc operation that creates a map by assigning new values to pair wise combinations of the values on two maps. Related GRID commands are Combinatorial function 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 GRID commands are Hydrologic function FLOWACCUMULATION

- **RADIATE** -- MapCalc operation that creates a map indicating areas that are visible from specified locations. Related GRID commands are Visibility tools VISENCODE, VISIBILITY

- **SPAN** -- MapCalc operation that creates a map indicating the narrowness within areas associated with each category of a map. Related GRID commands are None

- **SPREAD** -- MapCalc operation that creates a map indicating the shortest effective distance from specified cells to all other locations. Related GRID commands are Distance functions CORRIDOR (compute sum), COSTALLOCATION (slice), COSTDISTANCE, EUCALLOCATION, EUDIRECTION (orient), EUCDISTANCE Shape Analysis functions EXPAND, SHRINK Hydrologic function WATERSHED, BASIN

- **STREAM** -- MapCalc operation that creates a map identifying the steepest downhill route along a surface (optimal path). Related GRID commands are Distance functions COSTBACKLINK, COSTPATH, PATHDISTANCE Hydrologic function FLOWDIRECTION (orient)

**NEIGHBORHOOD OPERATIONS**: New values are assigned as a function of the 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 GRID commands are Surface functions IDW, KRIGING, SPLINE, TREND

- **ORIENT** -- MapCalc operation that creates a map indicating aspect along a continuous surface. Related GRID commands are Surface function ASPECT Distance function EUCDIRECTION

- **PROFILE** -- MapCalc operation that creates a map indicating the cross-sectional profile along a continuous surface. Related GRID commands are Surface functions SAI, SHADE
• **SCAN** -- MapCalc operation that creates a map summarizing the values that occur within the vicinity of each cell. Related GRID commands are
  
  Conditional statement IF, WHILE, DOCELL summaries within a DOCELL block using Accumulative operators *=, +, -, -=, /=, {=, }= and/or Assignment operator :=
  
  Statistical operation POPULARITY
  
  Focal functions FOCALFLOW, FOCALMAX, FOCALMEAN, FOCALMIN, FOCALRANGE, FOCALSTD, FOCALSUM, FOCALVARIETY
  
  Data Clean-up functions BOUNDARYCLEAN, MAJORITYFILTER, NIBBLE, THIN
  
  Hydrologic functions FILL, SINK

• **SLOPE** -- MapCalc operation that creates a map indicating the slope (1st derivative) along a continuous surface. Related GRID commands are
  
  Surface function SLOPE

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

<cross-reference in preparation, see www.innovativegis.com/basis for update>

*ERDAS Imagine by ERDAS, Inc.* *(www.erdas.com)*

*Imagine* is a powerful image mapping and visualization package with a robust set of grid-based map analysis tools (ERDAS, 2801 Buford Highway, N.E. Atlanta, GA 30329).

**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 ERDAS commands are
  
  CLUMP
  
  SIEVE- deletes clumps smaller than user specified
  
  ELIMINATE- similar to Sieve but dissolves smaller clumps into neighbors.

• **COMPUTE** (one map) -- MapCalc operation that assigns new values to each map location as the mathematical or statistical function of the existing value. Related ERDAS commands are
  
  RECODE
  
  Trigometric operators: ACOS, ASIN, ATAN, COS, SIN, TAN
  
  Expodential and Logarithmic operators: LOG, LN, SQRT
  
  Other functions: Row, pi, modabs, int, even, odd, max, min, convert units, format string/number, lowercase, uppercase
  
  SINGLE INPUT ‘FUNCTIONS’
  
  Trigometric operators: ACOS, ACOSH, ASIN, ASINH, ATAN, COS, COSH, SIN, SINC, SINH, TAN, TANH
  
  Expodential and Logarithmic operators: EXP, LOG, LOG10, SQRT
  
  Other functions: ABS, ANGLE, BINARY, CEIL, CONJ, DELTA, EVEN, GAMMA, IMAG, INV, ODD, REAL, RECT, ROUND, SIGN, STEP, TRI, TRUNC, WHOLE
• **CONFIGURE** -- MapCalc operation that assigns new values characterizing the shape of the area associated with each category. Related ERDAS commands are

  PERIMETER

• **RENUMBER** -- MapCalc operation that assigns new values to the categories on a map. Related ERDAS commands are

  RECODE

  **Trigometric operators:** ACOS, ASIN, ATAN, COS, SIN, TAN
  **Exponential and Logarithmic operators:** LOG, LN, SQRT
  **Other functions:** Row, pi, modabs, int, even, odd, max, min, convert units, format string/number, lowercase, uppercase

  **SINGLE INPUT ‘FUNCTIONS’**
  **Trigometric operators:** ACOS, ACOSH, ASIN, ASINH, ATAN, COS, COSH, SIN, SINC, SINH, TAN, TANH
  **Exponential and Logarithmic operators:** EXP, LOG, LOG10, SQRT
  **Other functions:** ABS, ANGLE, BINARY, CEIL, CONJ, DELTA, EVEN, GAMMA, IMAG, INV, ODD, REAL, RECT, ROUND, SIGN, STEP, TRI, TRUNC, WHOLE

• **SIZE** -- MapCalc operation that assigns new values according to the size of the area associated with each map category. Related ERDAS commands are

  Size of each value is always present in ‘Histogram’ column of every image (mandatory)
  **CLUMP** (reports clump pixel size)

• **SLICE** -- MapCalc operation that assigns new values by dividing the range of values on a map into specified intervals (contouring). Related ERDAS commands are

  **TOPOGRAPHIC LEVEL SLICE** (refers to DEM, but any raster is fine)

**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 ERDAS commands are

  **ZONAL ATTRIBUTES** (Raster summary of Vector regions, must have template in Vector)

• **COMPUTE** (two or more maps) -- MapCalc operation that creates a map as the mathematical or statistical function of two or more maps. Related ERDAS commands are

  **TWO INPUT ‘OPERATORS’**
  Add, subtract, Multiplication, Division, Power and MOD

  **INDEX**

• **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 ERDAS commands are

  **OVERLAY** (you specify if min or max value of each cell in the two layers takes priority)
  Combined with Recode command allows same functionality with several steps i.e. masking data
• **INTERSECT** -- MapCalc operation that creates a map by assigning new values to pair wise combinations of the values on two maps. Related ERDAS commands are MATRIX

**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 ERDAS commands are None

• **RADIATE** -- MapCalc operation that creates a map indicating areas that are visible from specified locations. Related ERDAS commands are VIEWSHED ANALYSIS

• **SPAN** -- MapCalc operation that creates a map indicating the narrowness within areas associated with each category of a map. Related ERDAS commands are None

• **SPREAD** -- MapCalc operation that creates a map indicating the shortest effective distance from specified cells to all other locations. Related ERDAS commands are SEARCH (Euclidean distance only)

• **STREAM** -- MapCalc operation that creates a map identifying the steepest downhill route along a surface (optimal path). Related ERDAS commands are None

**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 ERDAS commands are 3-D Surfacing

• **ORIENT** -- MapCalc operation that creates a map indicating aspect along a continuous surface. Related ERDAS commands are ASPECT

• **PROFILE** -- MapCalc operation that creates a map indicating the cross-sectional profile along a continuous surface. Related ERDAS commands are None but might be possible using Spatial Modeler

• **SCAN** -- MapCalc operation that creates a map summarizing the values that occur within the vicinity of each cell. Related ERDAS commands are NEIGHBORHOOD: Sum, Diversity, Density, Majority, Minority, Max, Min, Rank

• **SLOPE** -- MapCalc operation that creates a map indicating the slope (1st derivative) along a continuous surface. Related ERDAS commands are SLOPE
STATISTICAL OPERATIONS: New values and statistical summaries are assigned as a function of the statistical relationships among maps.

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