

# Raster Arithmetic and Indices

The Raster Arithmetic and Indices process (Image / Combine / Arithmetic and Indices) in TNTmips performs mathematical operations using the cell values in one or more input raster objects to produce an output raster with the same row and column dimensions as the input. Calculations are performed independently for each cell position. Many of the operations perform calculations using values from two or more input rasters, in which case all inputs must have the same row and column dimensions. Other operations (such as Scale/Offset and Auto-Scale) are applied independently to one or more input rasters, in which case the input raster dimensions do not have to match.

Raster calculations are organized into four groups: Algebraic, Logical, General Indices, and Broadband Vegetation Indices. The Algebraic group provides mathematical combinations of values from grayscale rasters, several options for rescaling, and an operation to replace values in a specified value range. The operations in the Logical group produce a binary raster object and include methods to convert grayscale and RGB color sets to a binary raster as well as logical combinations of multiple input binary rasters.

The General Indices group includes two methods to compute normalized ratio indices from a pair of input rasters. These and the previous group operations are described below. The Broadband Vegetation Indices group includes a variety of vegetation index computations, which are described in the Technical Guide entitled *Image Processing: Broadband Vegetation Indices*.

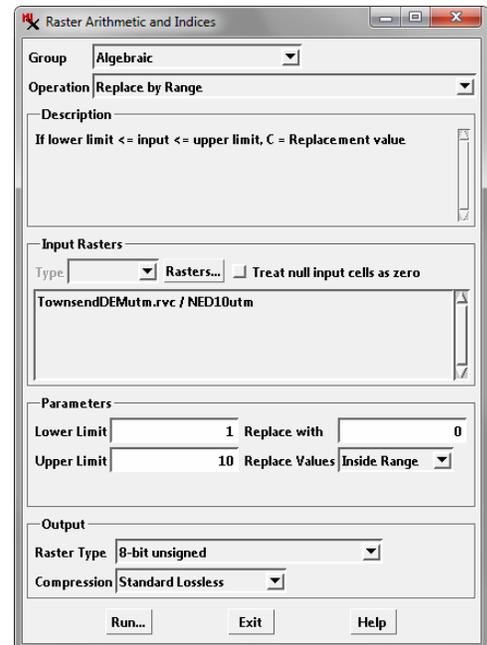
## Raster Arithmetic and Indices Interface

Choose the desired group from the Group menu, then select from the Operation menu for that group. The description pane shows the mathematical formula used in the operation. Use the Rasters button to choose the input raster or rasters, which are then listed in the pane below. Some operations that combine values from multiple inputs can use either separate rasters or color components from a color-composite raster. For these operations the Type menu is active, allowing you to choose either Composite or Separate before pressing the Rasters button; the Type setting establishes the filter that is applied in the selection dialog for the input.

If the *Treat null input cells as zero* toggle is turned on, null input cells are included in the selected computation using a zero value, and the output cell value is the result of the computation. If this toggle is off, null input cells are ignored and the corresponding cells in the output are set as null.

The Parameters box may include calculation parameters that can be set by the user for the chosen operation.

Use the menus in the Output box to choose the Raster Type and a Compression option for the output raster or rasters. The Raster Type selection is restricted to Binary for the operations in the Logical group. Some of the operations allow setting a Scale, a multiplier that is applied to the result to allow you to scale the output values to a range suitable for the input data and the selected output raster type. The default Scale Factor value is 1. You should take special care to set an appropriate scale when you choose an integer raster type for the results from an algebraic operation.



## Algebraic Operations

The Algebraic group provides a set of operations that let you perform individual mathematical calculations using multiple input rasters. The Add and Multiply operations can use values from two or more input rasters, which can be selected in any order. The Subtract and Divide operations are restricted to a pair of input rasters, with values in the second raster (B) subtracted from or divided into the values in the first raster (A). The only additional parameter for these operations is the Scale Factor. These operations can be used to perform custom spatial modeling in a raster-based GIS context in which each raster represents a different spatial parameter in the model.

The remaining operations in the Algebraic group [Scale/Offset, Logarithmic (base 10), Replace by Range, and Auto-Scale] apply a mathematical transformation separately to the values in each individual input raster.

**Add:** sum values from 2 or more rasters:

$$C = R_1 + R_2 + \dots + R_n$$

**Subtract:** subtract values in raster B from those in Raster A:

$$C = A - B$$

**Multiply:** multiply values from 2 or more rasters:

$$C = R_1 * R_2 * \dots * R_n$$

**Divide:** divide values in raster A by those in raster B:

$$C = A / B$$

**Scale/Offset:** apply a scale factor, pre-scale offset, and post-scale offset:

$$C = (A + \text{offset1}) * \text{Scale} + \text{offset2}$$

(continued)

The Parameters panel provides fields for entering the scale factor, pre-scale offset, and post-scale offset.

Parameters	
Scale Factor	3.5
Pre-Scale Offset	22
Post-Scale Offset	1

**Logarithmic (base 10):** take the log to base 10 of the values in the input rasters:

$$C = \text{Log}_{10}(\text{input})$$

**Replace by Range:** replace values inside (or outside) of the specified range:

*Inside range:*

if lower limit  $\leq$  Input  $\leq$  upper limit, C = replacement value  
otherwise C = Input

*Outside range:*

if Input < lower limit or Input > upper limit, C = replacement value  
otherwise C = Input

The Parameters panel provides fields for entering the replacement value, lower limit, and upper limit. Use the Replace Value to choose whether to replace values inside or outside of the specified range.

Parameters	
Replace with	0
Lower Limit	1
Upper Limit	25
Replace Values	Inside Range

**Auto-Scale:** auto-scale the input values to the range of the specified output raster type. This operation has no additional parameter settings.

### Logical Operations

The operations in the Logical group includes methods to produce a binary raster from other raster data types as well as logical (boolean) combinations of input binary rasters.

**Threshold:** compute binary raster C from a grayscale raster using a specified threshold value:

$$\text{If Input} < \text{threshold, } C = 1 \text{ else } C = 0$$

The Parameters panel provides a Threshold Value field for entering the desired value. You can also use the Output White

Parameters	
Threshold Value	100
Output White	Less Than

menu to select the comparison operator: *Less Than*, *Greater Than*, *Less Than Or Equal To*, or *Greater Than Or Equal To*.

**Threshold Gray:** compute a binary raster D from an RGB composite or separate R, G, and B rasters using a threshold distance from the average gray level:

$$\text{avg} = (R + G + B) / 3$$

$$\text{distance} = \sqrt{(R - \text{avg})^2 + (G - \text{avg})^2 + (B - \text{avg})^2}$$

$$\text{If distance} < \text{threshold then } D = 1, \text{ else } D = 0$$

The Parameters panel provides a Threshold Value field for setting the threshold distance. The Output White menu lets you choose the comparison operator, providing the same choices as for the Threshold operation.

**Extract Color:** compute a binary raster D from an RGB composite or separate R, G, and B rasters by extracting a color using color thresholds. The choice of color to extract (black, red, green, blue, cyan, magenta, yellow, or white) sets the operator (*greater than* or *less than*) for each color channel. Example for the color cyan:

$$\text{if } R < \text{red threshold and } G > \text{green threshold and } B > \text{blue threshold then } D = 1, \text{ else } D = 0$$

On the Parameters panel, choose the color from the Color to Extract menu and use the provided fields to enter threshold values for Red, Green, and Blue color channels.

Parameters	
Color to Extract	Cyan
Threshold for Red	50
Threshold for Green	200
Threshold for Blue	200

**Range:** compute a binary raster C, setting 1 for input values inside (or outside) of the specified range:

*Inside range:*

if lower limit  $\leq$  Input  $\leq$  upper limit, C = 1, else C = 0

*Outside range:*

if Input < lower limit or Input > upper limit, C = 1, else C = 0

The Parameters panel provides fields for entering the lower limit and upper limit and an Output White menu to choose whether to assign 1 to input values inside or outside of the range.

Parameters	
Lower Limit	50
Upper Limit	100
Output White	Outside Range

**Complement:** compute the complement of a binary input raster, replacing 1 with 0 and 0 with 1:

$$\text{if Input} = 0, C = 1; \text{ if Input} = 1, C = 0$$

The following operations produce an output binary raster that is a logical (boolean) combination of two or more input binary rasters. These operations have no user-defined parameters.

**OR:** set value 1 in binary output raster C if any binary input has value 1:

$$C = R_1 \text{ or } R_2 \text{ or } \dots \text{ or } R_n$$

**AND:** set value 1 in binary output raster C if all binary inputs have value 1:

$$C = R_1 \text{ and } R_2 \text{ and } \dots \text{ and } R_n$$

**Exclusive Union:** set value 1 in binary output for each cell where a pair of input rasters differ in value. For more than 2 inputs, set 1 where an odd number of inputs have value 1:

$$C = R_1 \text{ xor } R_2 \text{ xor } \dots \text{ xor } R_n$$

### General Indices

Compute an index from a pair of grayscale input rasters (A and B) or from the red and green components of an RGB composite raster. When you select Composite from the Type

Input Rasters	
Type	Composite Rasters... Treat null input cells as zero
A:	Composite Red
B:	Composite Green

menu and select the composite raster, the red and green components are automatically assigned to inputs A and B, respectively. You can apply a scale factor to the result of the index calculation.

**Normalized Difference:** compute a normalized difference ratio index raster (ND):

$$ND = (A - B) / (A + B)$$

**Transformed Normalized Difference:** compute a transformed normalized difference ratio index raster (TND):

$$TND = \sqrt{[(A - B) / (A + B) + 0.5]}$$