Working with the Raster Calculator

The Raster Calculator provides you a powerful tool for performing multiple tasks. You can perform mathematical calculations using operators and functions, set up selection queries, or type in Map Algebra syntax. Inputs can be raster datasets or raster layers, coverages, shapefiles, tables, constants, and numbers.

What is Map Algebra?
Map Algebra provides one method to run Spatial Analyst tools. Tools can also be run using dialog boxes or a command line. In the Spatial Analyst functional reference, you can access tool syntax and examples using each of the methods available to run tools.

Accessing the Raster Calculator
To access the Raster Calculator, select it from the Spatial Analyst toolbar menu. In the dialog, you can enter Map Algebra into the expression box.

An example of the Raster Calculator dialog with a Map Algebra expression already entered is picture to the right.

Notes on the Raster Calculator dialog:

- The available rasters will be displayed in the Layers list.
- If you have entered a (valid) function name, you can right-click on it and select the Usage... option to see the command usage.
- Use the context help button for more information on each of the elements of the Raster Calculator interface.
- For more information on constructing Map Algebra expressions, click on the About Building Expressions button.
- Values and certain functions can be entered by their respective buttons. Additional functions (Arithmetic, Trigonometric, Logarithmic and Power) are revealed by clicking on the expand button.

We will examine just a few of the myriad usages of the Raster Calculator.

Performing simple functions - Masking

1. Open a new blank ArcMap Document and load data elements “chenry_etm99.img” and “Chenry_20mdem”. The latter is a DEM interpolated from surveyed elevation points (spot_elev.shp). This DEM contains “nonsense” data around the outside of the model. This is because the survey points were concentrated in the center of the model.
2. Let’s use the raster calculator to create a DEM with only the “good” elevation data.

Load the raster element “chenry_aoi”. This is a raster file (converted from a polygon) that approximates the boundary of the “good” elevation data.

3. Open the Raster Calculator from the Spatial Analyst tool bar dropdown menu. We see your three data layers are listed. But how do we use these to produce the desired data?

ArcGIS Desktop Help contains instructions on the proper raster calculator syntax for most operations. From the ArcMap main menu, click “Help”.

4. On the ‘Search’ tab, type “raster calculator”. A description of the calculator appears in the display window. Click on the link entitled “Access the Spatial Analyst Functional Reference”. This will help you find the tool that you require.

We need to extract the “good” data from out DEM, so click on the “Extraction” link. Scrolling down, we can see that the tool extract by mask extracts the cells of a raster that correspond with the areas defined by a mask. Click on the link for this tool.

Listed are several different ways to use this tool. Since the raster calculator uses map algebra, click on the ‘SelectMask” link under “Map Algebra syntax” for the correct text.

5. Beneath the illustration on the SelectMask reference page is the appropriate raster calculator syntax. Right-click on this syntax and select ‘Copy’.
6. In the Raster Calculator window, right-click and select “Paste”. In the expression, replace InRas1 with “chenry_20mdem” and InRas2 with “chenry_aoi”. The best way to do this is to highlight InRas1 and then double-click on “chenry_20mdem”. This will replace the InRas1 text with the DEM layer. Do this for the AOI layer as well. Your expression should appear as shown.

7. Click on ‘Evaluate’ to execute the calculation. A new DEM with the erroneous data excluded, conforming to the boundary of the AOI layer is now created. The symbology of the DEM may also be changed for better visualization (as shown).

This exercise demonstrates that proper raster calculator syntax for nearly any processing function can be found in the ArcGIS Desktop help. The time it takes you to perform these calculations will quickly diminish as you learn and remember the syntax for the functions which you perform most frequently.

Now let’s create a slope surface for your newly created DEM.
8. ArcGIS help reveals that the proper raster calculator syntax for creating a slope surface is: “OutRas = Slope(InRas1)”.

Enter this text in the Raster Calculator. The name “OutRas” is the same as your new DEM (which is saved as a temp file on your computer). To avoid conflicts, change “OutRas” to “DemSlope” and replace “InRas1” with “OutRas” (your temporary DEM).

9. Click “Evaluate” and the Raster Calculator produces a slope surface based upon your DEM (recolored as shown below).

Simple Math in the Calculator

1. Mathematical operations may be performed on the values in raster cells. Let’s perform a quick calculation on the “chenry_20mdem” to see how this works.

The values in the cell of this DEM are recorded in feet above mean sea level. Assume
that we are working on a project that requires all data to be in metric units.

**Conversion factor:** 1 foot = .3048 meters

2. Open the Raster Calculat°. Double-click the chenry_20mdem layer to add it to the dialogue box.

3. We want to multiply the raster values by .3048, so your expression should read: `[chenry_20mdem] * .3048`

4. Click ‘Evaluate’ and a new DEM is created that appears visually identical to the other. However, examination of the table of contents shows that the range of cell values now corresponds to meters rather than feet. (I have renamed the ‘Calculation’ to ‘DEM_meters’ to help illustrate)

**Math with multiple rasters – Addition**

1. Open the ArcMap document entitled “Raster_Calculator.mxd”. In this exercise, we will use the raster Calculator to help us find ideal areas in which to build a new home. Each of the raster layers in the view represents one of our criteria. These rasters are classified so that lower numbers represent the more desirable areas. The criteria are:

   **Distance to “flat” water:** locations nearest to flat water bodies such as slow rivers and lakes are most desirable

   **Distance to major roads:** locations proximal to major arteries are preferred to reduce cross-town travel times

   **Average family size:** larger family sizes are preferred to increase playmates for children

   **Percent Owner Occupied:** prefer to build away from rental properties

   **Population Density:** less dense area are more desirable, but not mandatory

Take a few minutes to examine these layers.

2. Open the Raster Calculator. We will mathematically add the pixel values in these layers by constructing the simple query shown in the dialogue box below.

Double-click each layer to add it to the scene and type a plus “+” symbol between each entry.
Click ‘Evaluate’ to create a new raster layer that ranks areas within the image.

The initial output will may have a ‘unique values’ color scheme. Change this to a “stretched” color scheme using green to red hues for better visual ranking. Remember: lower numbers are the best areas.

![Image of color scheme]

**Math with multiple rasters – Multiplication**

1. Instead of ranking our results, let’s assume that we have divided each of our criteria into ranges that are “acceptable” and “unacceptable”.

2. Add the layers “binary_pop”, “binary_owner”, “binary_fam”, “binary_roads”, and “binary_h2o” to ArcMap. These display each criteria with all pixels rated 0 (unacceptable) or 1 (acceptable).

3. Open the Raster Calculator. Instead of adding each of these layers, construct a dialogue that multiplies them.

\[ \text{[binary_fam]} \times \text{[Binary_h2o]} \times \text{[binary_owner]} \times \text{[binary_pop]} \times \text{[binary_roads]} \]

4. Click ‘Evaluate’ to produce a layer that highlights the only acceptable areas for your home. Consider that if any of overlapping cells contains a “0” values, the result of the entire analysis will equal 0.

In this image green areas = 1 and red = 0.

**Weighted Analysis in the Raster Calculator**

1. You’ve decided that you value some of your criteria more highly than others and that the binary analysis is too restrictive. If all criteria add up to 100%, you determine that the following weights should be assigned to the various selection criteria: Percent Owner Occupied = 30%, Average Family size = 25%, Distance to Roads = 20%, Distance to flat water = 15%, and Population Density = 10%.
2. Using the Raster Calculator, construct the following query:

\[
[\text{Percent Owner Occupied}] \times .5 + [\text{Average Family Size}] \times .25 + [\text{Distance to Roads}] \times .2 \\
+ [\text{Distance to flat water}] \times .15 + [\text{Population Density}] \times .1
\]

3. Click ‘Evaluate’ and a new weighted and ranked layer (left) is created. Compare this with your purely additive layer (right) and note the differences.