

WORKING WITH NRVIS DIGITAL ELEVATION MODELS (DEM)

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
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Step 1: Finding the DEM Tiles You Need

NRVIS DEMs are distributed and packaged in small tiles, so as to keep file sizes and processing times manageable. You will need to determine which tile(s) you need before continuing.

From the folder “[Drive of GIS Data]:\ont_mnr\DEMs\DEM_Tile_Bnds” add all four Shapefiles to ArcMap. If you need to, add other reference data, such as streets or municipal boundaries, to ArcMap to orientate yourself.

Use the ‘Identify’ tool  to determine which tile(s) cover your area of interest – the Tile Number is contained in the “NUMBER” field in the Identify window:




In this example, the Study Area encompasses four tiles: 86 (shown above), 81, 82, and 85.

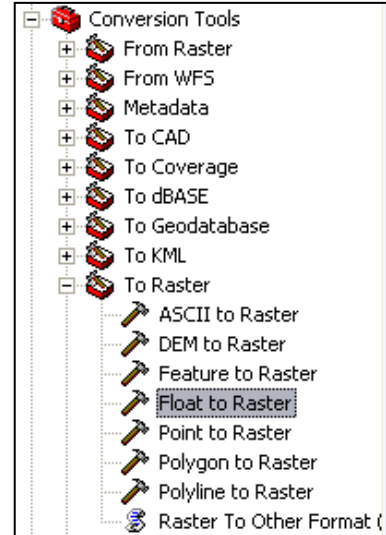
Make a note of the Tile Number(s) you need, *as well* as the Zone Number – this latter number can be determined from the name of the Shapefile which contains the tiles you need.

Step 2: Importing the DEM Tiles into ArcMap


The NRVIS DEMs are stored as FLT (float) files. ArcMap cannot display FLT files directly: instead, you must convert the FLT files to a different format.

In ArcMap or ArcCatalog, open ArcToolbox by clicking . Alternatively, click the 'Window' menu, then click on 'ArcToolbox.'

Within ArcToolbox, expand the 'Conversion Tools' toolbox, then expand the 'To Raster' toolset, either by double-clicking or by using the [+] symbols (Shown at right).



Double-click on 'Float to Raster.'

In the dialogue box that pops up, click  beside the 'Input floating raster point file' textbox to browse to the tiles you require. Browse to "[Drive of GIS Data]:\ont_mnr\DEMs\" and then to the folder of the appropriate Zone (determined in the previous step). Select the correct Tile number, and then 'Open' the FLT file for that Tile.

In the 'Output raster' textbox, change the folder to an easily accessible one, and give the new raster an appropriate name. Enter an appropriate extension (refer to the table below for acceptable extension types), or include no extension to save the new raster as a GRID.

<i>Extension</i>	<i>Result</i>
[No extension]	ArcGIS GRID file
.img	ERDAS IMAGINE Image
.tif	TIFF Image

For most purposes, a GRID file will be sufficient. If you intend to use the DEM in other programs, you may find ERDAS IMAGINE or TIFF to be more appropriate.

After entering a location for the 'Output raster,' click 'OK.' The converted DEM will automatically be added to the ArcMap display.

If you only needed one tile, move on to the next step now.

If your study area spans more than one tile, repeat this step as many times as necessary to convert all of the FLT files appropriately, then move on to the next step.

Step 3: Defining the Projection of the Newly Converted DEMs


Once you have imported the DEM(s) of your choice into ArcMap, you will want to define their projection(s). Until you do this, the DEMs will have no spatial reference, and ArcMap may not be able to display the DEMs along with other raster or vector data.

Ensure your newly converted DEMs are loaded into ArcMap. Open ArcToolbox, expand the 'Data Management' toolbox, then the 'Projections and Transformations' toolset.

If you only converted one tile, complete the following instructions, then move on to Step 5.

Double-click on the 'Define Projection' tool.

Drag the Tile Name from the Table of Contents onto the 'Input Dataset or Feature Class' drop-down box. Alternatively, simply select the Tile Name from the drop-down box.

Beside the 'Coordinate System' textbox, click the Choose Coordinate System button ()

In the dialogue that pops up, click 'Select. . .'

Since the original FLT files were projected using UTM zones, open the 'Projected Coordinate Systems' folder, then 'UTM,' then 'NAD 1983.'

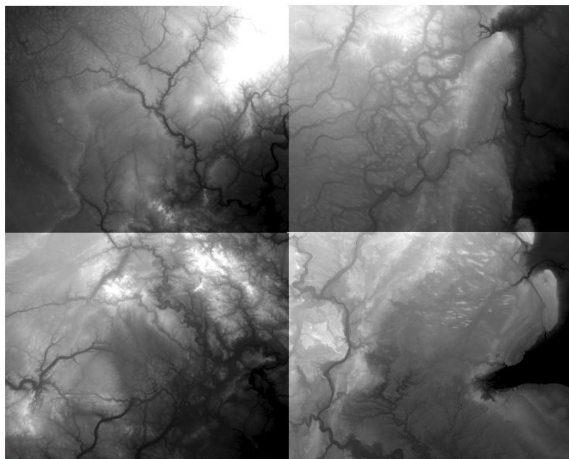
Choose the appropriate UTM Zone – 15N, 16N, 17N, or 18N – as you determined in Step 1. Click 'Add,' then click 'OK' and 'OK' again.

If you converted more than one tile, simply complete the above instructions as many times as you need to, until all of your tiles have the correct projection information, **then move on to the next step.**

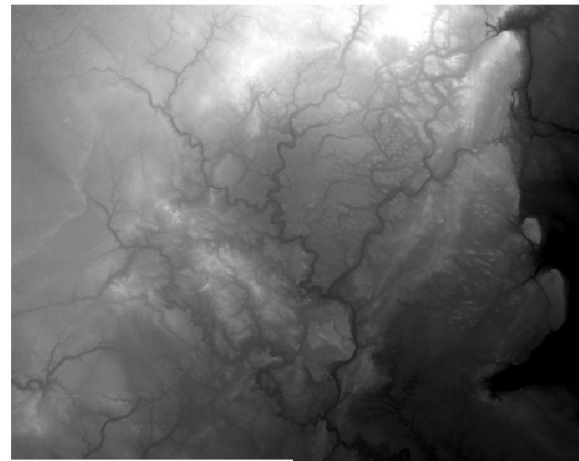
Step 4: Mosaicking Two or More DEM Tiles Together

NOTE: Mosaicking images that span large areas, or cross UTM Zone Boundaries, is **not recommended** and may distort, stretch, or skew the resulting image significantly, thus negatively impacting the reliability of your analysis!

When working with adjacent DEM tiles in ArcMap, it is highly advisable that you mosaic, or merge, the tiles into a single DEM. Doing so is beneficial for a number of reasons: A single DEM will draw significantly faster in ArcMap than will several, even if they cover the same area; edges of individual tiles may unduly influence geoprocessing and analysis tasks, to the detriment of your research; and, of course, a mosaicked DEM looks far more appealing than several tiles. Compare the following two images: the first shows four unmosaicked DEMs; the second shows those DEMs mosaicked together.



Unmosaicked DEMs



Mosaicked DEMs

Mosaicking DEMs in ArcMap is very simple, and requires just one tool in ArcToolbox.

To start, ensure all the tiles you need have been loaded into ArcMap, as described in Step 2, above.

In ArcToolbox, expand the *'Data Management'* toolbox, then expand the *'Raster'* toolset. Expand the *'Raster Dataset'* toolset, and open the *'Mosaic to New Raster'* tool.

To load your tiled DEMs into the *'Input Rasters'* field, simply select all of them in the Table of Contents, and drag them onto that field. Alternatively, use the drop-down box to select your tiles individually.

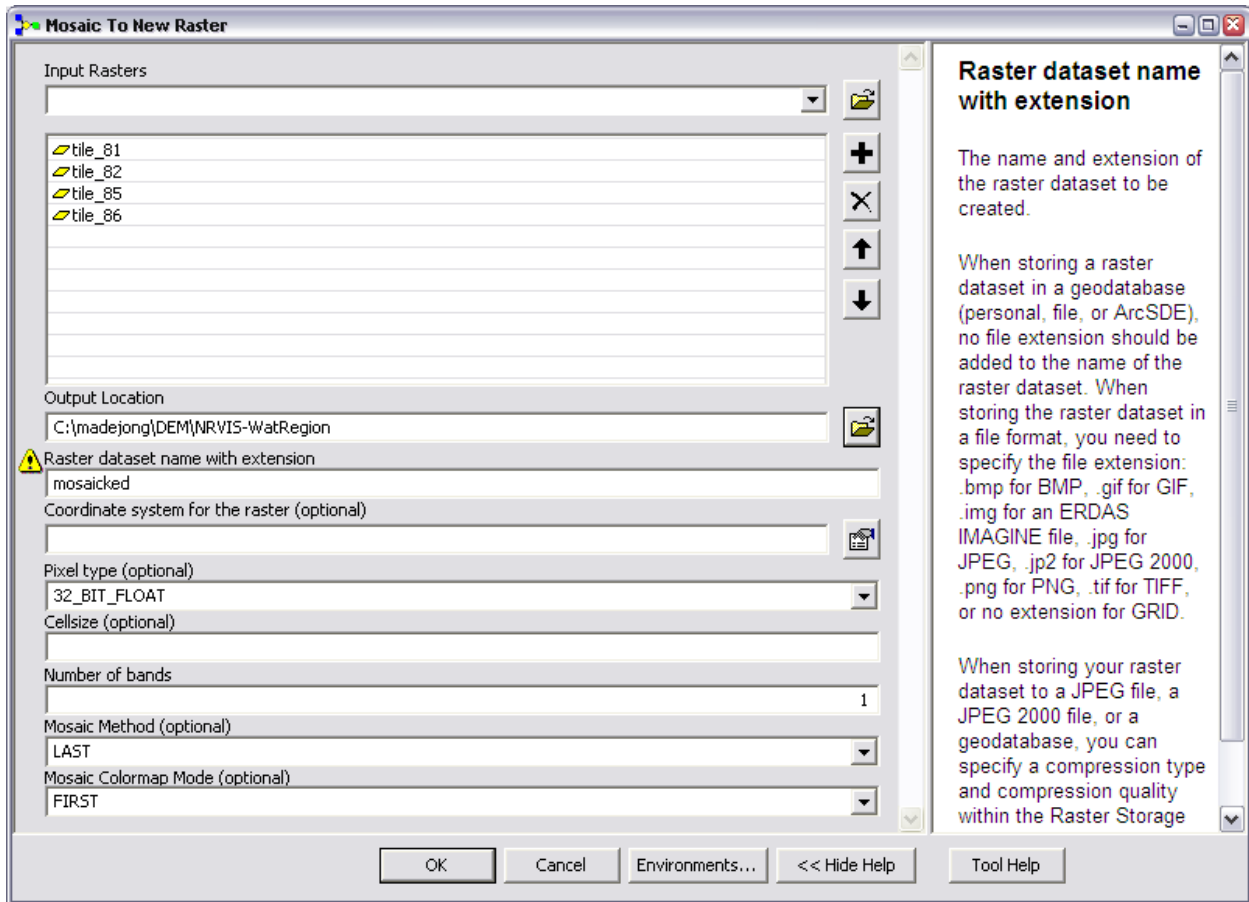
Enter an appropriate location and name for your mosaicked DEM. Add an appropriate file extension, if necessary, as described in the table at right.

Extension	Result
[No extension]	ArcGIS GRID file
<i>.img</i>	ERDAS IMAGINE Image
<i>.bmp</i>	BMP Image
<i>.gif</i>	GIF Image
<i>.jpg</i>	JPEG Image
<i>.jp2</i>	JPEG-2000 Image
<i>.png</i>	PNG Image
<i>.tif</i>	TIFF Image

Change the 'Pixel Type' to '32_BIT_FLOAT' – this is the Pixel Depth and Type of the tiled DEMs. To double-check this, right-click on one of the tile names in the Table of Contents and click Properties, then navigate to the 'Source' tab. The Pixel Type should be 'floating point,' and the Pixel Depth should be '32 Bit.'

Leave the remaining settings blank or with their default values.

Your Mosaic to New Raster dialogue box should look similar to the following:



Click 'OK' and wait for processing to complete. The mosaicked DEM will be added to your display automatically.

Step 5: Clipping your DEM to a Smaller Area

Occasionally, users of NRVIS DEMs may need the DEM for only a small portion of a tile. In these cases, these users may wish to clip the DEM to a smaller area for any number of reasons – to save disk space, to reduce geoprocessing time, or to make analysis results more manageable, for instance.

While clipping DEMs may be advantageous to the user in certain circumstances, care should be taken: clipping a DEM too closely to a study area *could* have negative implications on your analyses. Do try to capture the study area, as well as a ‘buffer’ around the study area to ensure ArcMap – and the eventual recipient of the analysis – has some context in which to perform and interpret the analyses.

There are two routes you may choose to take in clipping a DEM. You may either (a) permanently clip the DEM, or (b) only clip derivative products. Both routes are outlined below.

Route A: Clipping the DEM Permanently

To clip the converted or mosaicked DEM permanently to a specific area, in ArcMap ensure the DEM and some polygonal clip feature are both in the table of contents. In the example presented below, a mosaicked DEM will be clipped to the municipal boundary of the Region of Waterloo, as shown below.

This route is most appropriate if you want the DEM clipped permanently, of course, but also if you intend to do your analysis over a long period of time, on different computers, or just in different ArcMap sessions or instances. This route is also most appropriate if you prefer to work with ArcCatalog or ArcToolbox.

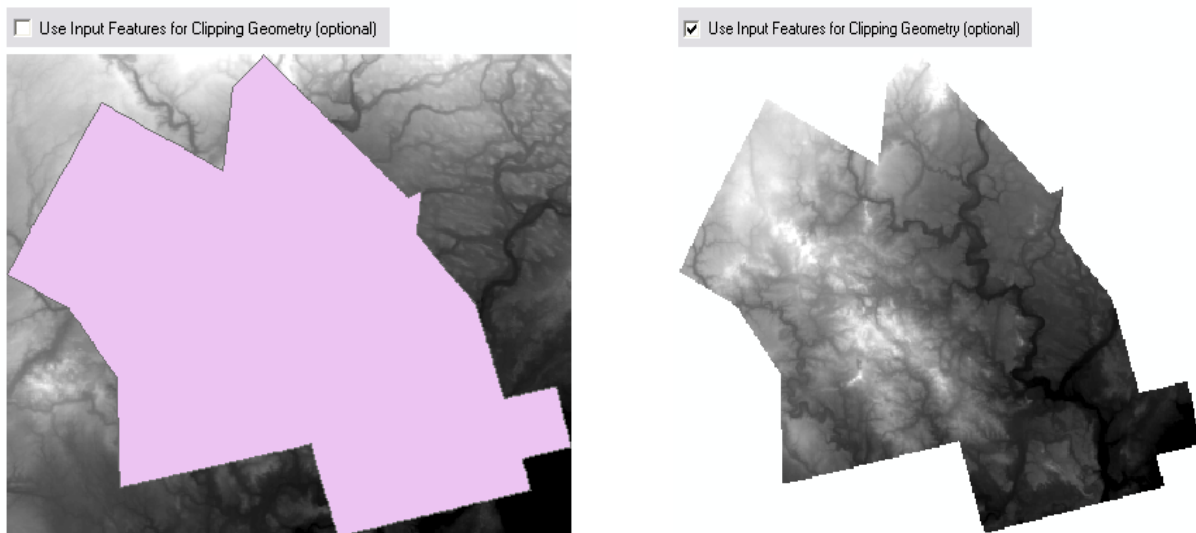


In ArcMap, open ArcToolbox, then expand the 'Data Management' toolbox. Open the 'Raster' toolset, then expand the 'Raster Processing' toolset. Open the 'Clip' tool.

In the 'Clip' dialogue box, set the 'Input Raster' to your converted or mosaicked DEM.

Set the 'Output Extent' to your polygonal clip features, OR enter four bounding co-ordinates, in metres, and in the appropriate UTM zone. If you're using a polygon feature class as the Output Extent, the bounding co-ordinates will automatically be filled in for you.

If you are using a polygon feature class as the Output Extent, you will be presented with the option to 'Use Input Features for Clipping Geometry.' The following images illustrate the effect of this option:



If you leave the checkbox unchecked, the DEM will be clipped to the rectangular extent of the polygon feature class. If you check the checkbox, the DEM will be clipped to the extent of the polygon(s).

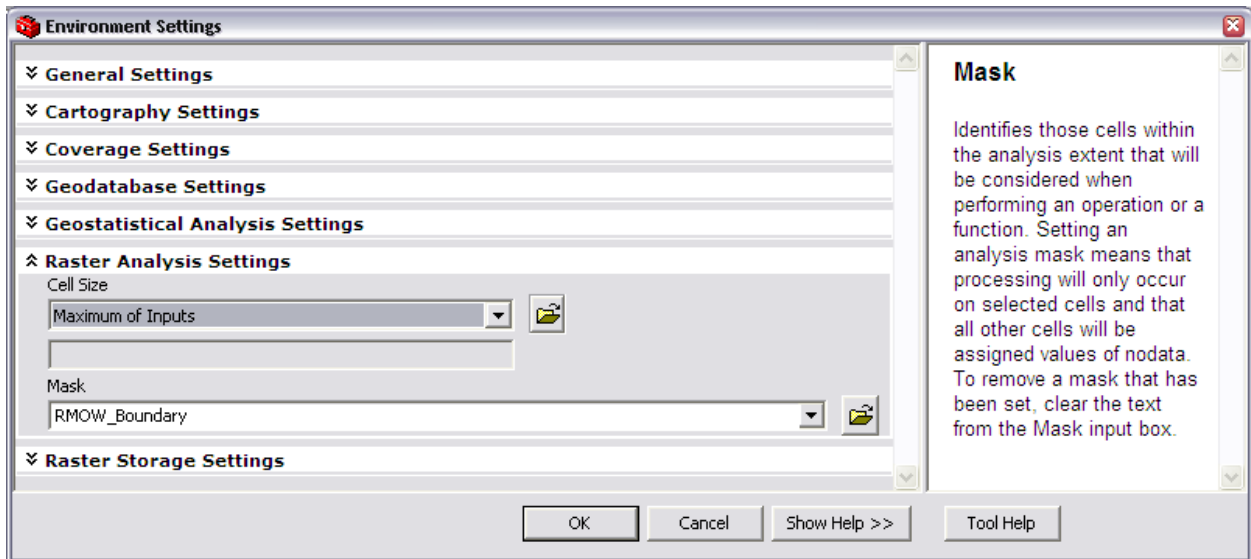
Assign an appropriate output location, file name, and extension, as described earlier, then click 'OK.' The clipped DEM will be added to your map automatically.

Route B: Clipping Only Derivative Products

Through this route, the input DEM is not clipped at all, but derivative products – for instance, slope or curvature rasters – will be clipped to the area you specify. This route is *not permanent* but session-based, and can only be used in ArcMap: meaning every time you open ArcMap to work with this DEM, you will have to run through this process again.

In ArcMap, open the 'Tools' menu, and click 'Options.' Navigate to the 'Geoprocessing' tab, and click the 'Environments' button.

In the Environments dialogue box, expand the 'Raster Analysis Settings' option. In the 'Mask' drop-down menu, select the polygon feature class you wish to use as your analysis mask, as shown below:



Keep in mind that by setting these Environments, you affect every ArcToolbox tool: any analysis performed on any raster will be clipped to this Mask. You must remove this setting, either by going back in to the Environment Settings or by exiting and re-opening ArcMap, if you no longer wish to apply this Mask.

Deriving a Slope Raster from a DEM

Recall that a DEM is a raster dataset containing an elevation value for each of its cells. The first derivative of a DEM, then, is the change in elevation: slope. Slope rasters can be calculated in ArcGIS using either ArcToolbox or the Spatial Analyst toolbar. This tutorial explains only how to calculate a slope raster using ArcToolbox. The resultant raster contains a slope value for each cell, either as Percent Rise or Degrees.

In ArcToolbox, expand the '*Spatial Analyst Tools*' toolbox, then expand the '*Surface*' toolset. Open the '*Slope*' tool.

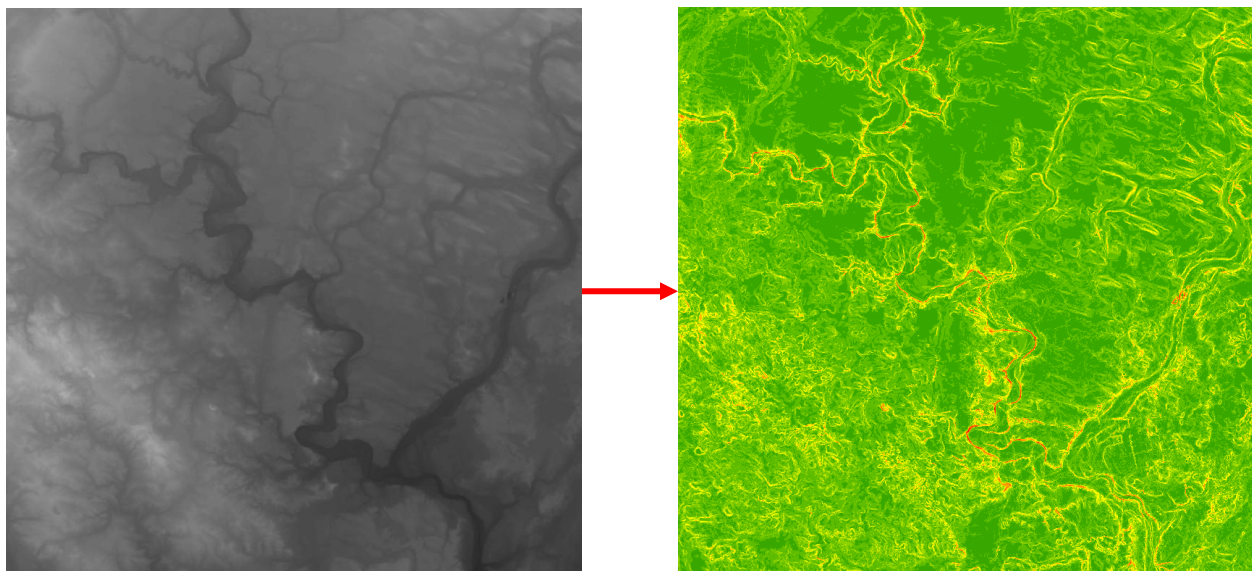
Set the '*Input Raster*' to your mosaicked/clipped/otherwise-prepared DEM.

In the '*Output Raster*' textbox, enter an appropriate location, name, and file extension for your Slope raster. Acceptable file extensions are *.img* for ERDAS IMAGINE images, or *.tif* for GeoTiffs, or no extension for GRIDs.

Select your desired '*Output measurement*' – either Degrees or Percent Rise. Degrees is the default. Percent Rise is calculated as $Rise/Run$; Degrees is calculated as $\Theta(Tan) * Rise/Run$.

Leave the Z-Factor as 1. This Z-Factor is intended to compensate for differences in units of measurement between the ground and the elevation. Since our linear units are Meters, and our elevations are also in Meters, there is no compensation necessary. If our elevation was measured in feet, and our linear units in meters, for example, we would need to enter a Z-Factor of 0.3048 – because 1 foot = 0.3048 meters.

Click '*OK*' to begin calculating the slope raster. The resultant slope raster will automatically be added to ArcMap's display.

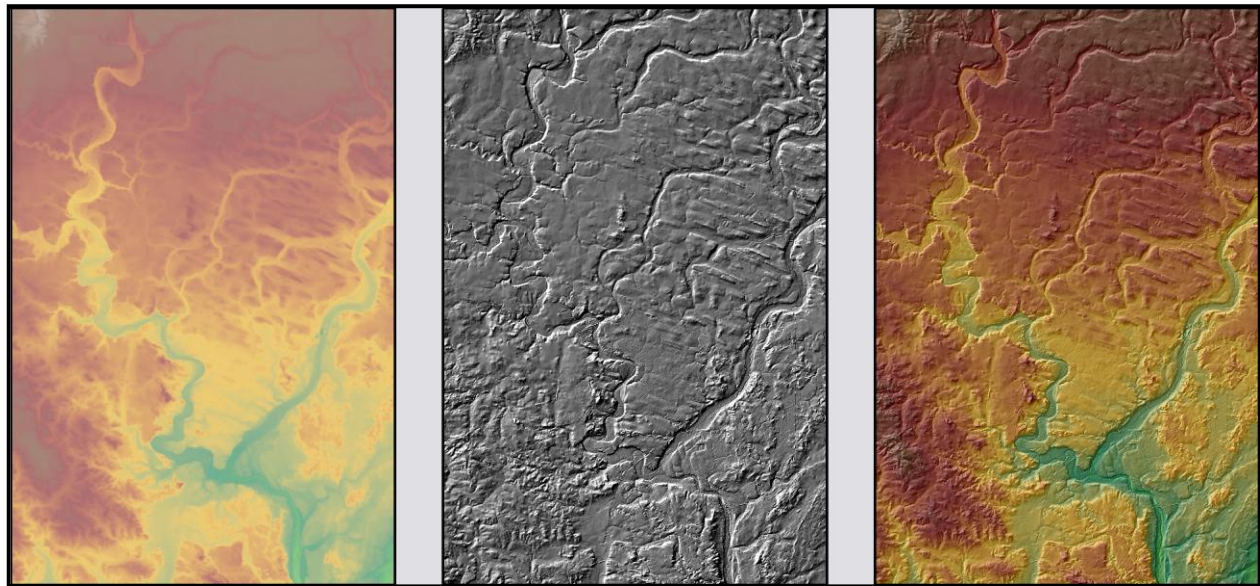


DEM

Slope

Deriving a Hillshade Raster from a DEM

A Hillshade Raster is a hypothetical illumination of a surface which can be used to enhance the visualisation of a surface for analysis or graphical display. To produce a hillshade raster, a hypothetical 'sun' or light source is used to calculate the illumination and shadow values of each raster cell in the DEM, in relation to neighbouring cells.

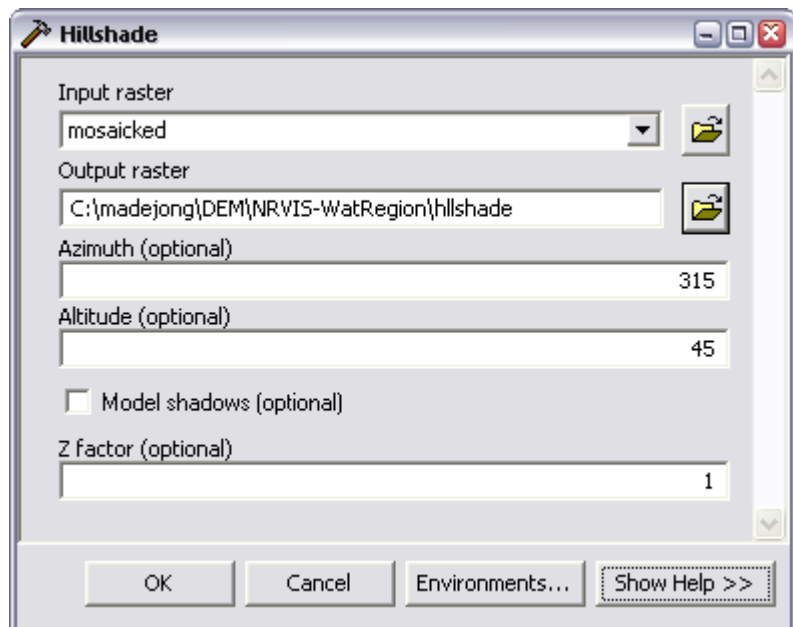
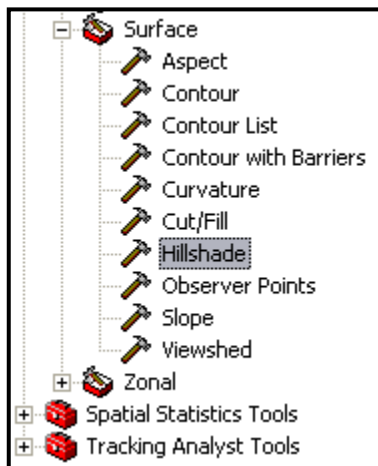


DEM – 50% Transparent

Hillshade – Symbolised by
Standard Deviations

DEM – 50% Transparent –
Overlaid on Hillshade

In ArcMap, ensure the Spatial Analyst extension is turned on. Open ArcToolbox, and expand the *Spatial Analyst* toolbox, then open the *Surface* toolset. Double-click on the *Hillshade* tool.



Set the 'Input Raster' to your mosaicked and/or clipped DEM, and specify an appropriate path, name, and extension for the 'Output Raster.' Acceptable file extensions are *.img* for ERDAS IMAGINE images, or *.tif* for GeoTiffs, or no extension for GRIDs.

The Azimuth refers to the horizontal angle of the light source – that is, the direction from which the artificial 'sun' is coming. Generally, the default 315° produces an adequate hillshade, but you may want to experiment with different values.

The Altitude refers to the vertical angle of the light source – when this angle is 0°, the light source will be at ground level; when it is 90°, the light source will be directly overhead. Again, the default 45° is usually adequate, but you may want to try different values.

The 'Model Shadows' checkbox allows you to specify whether or not the effects of shadows will be shown on the hillshade. If this box is left unchecked, the output hillshade will show light and dark areas, without any consideration of shadowing. If checked, shadows will be modelled. In some cases, modelling shadows produces a hillshade that is too dark to be of much use – in these cases, unchecking the box can help. However, checking the 'Model Shadows' box usually produces a more appealing hillshade.

When working with NRVIS DEMs, leave the 'Z factor' set to 1, because X, Y, and Z measurements are all in meters (see the section on 'Deriving a Slope Raster' for more information on Z factors).

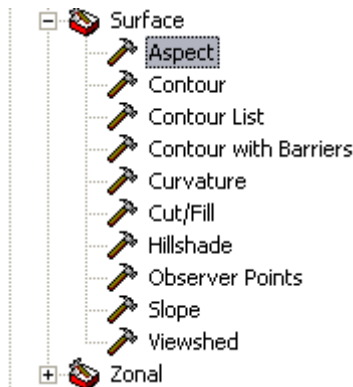
Click OK. The hillshade will be produced (this may take some time) and will be added to the map upon completion.

To display your new hillshade raster beneath other data, don't forget to increase the transparency of any polygon layer above the hillshade! To do so, simply double-click on the name of the layer to open the 'Properties' dialogue box. Navigate to the 'Display' tab, and enter a number (between 30% and 60% is usually adequate, but experiment!) in the textbox beside 'Transparency.'

Deriving an Aspect Raster from a DEM

An Aspect raster identifies ‘the downslope direction of the maximum rate of change in value from each cell to its neighbours’ (ESRI). In simpler terms, aspect can be thought of as the ‘slope direction’ – the values of the output raster will be the compass direction which a particular slope faces.

Deriving an Aspect Raster from a DEM couldn’t be simpler. In ArcMap or ArcCatalog, open ArcToolbox and expand the ‘*Spatial Analyst Tools*’ toolbox, then expand the ‘*Surface*’ toolset.

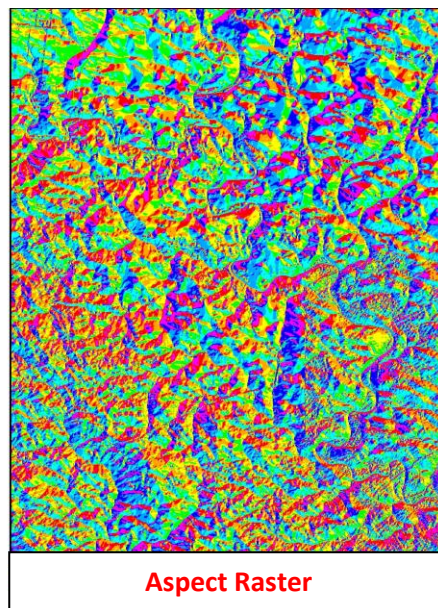
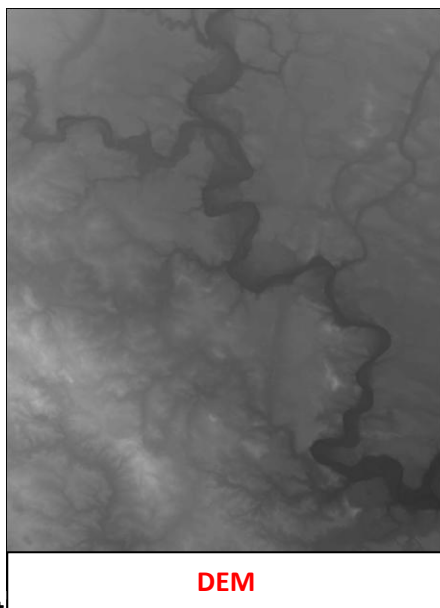


Open the ‘*Aspect*’ tool.

Set the ‘*Input Raster*’ to your mosaicked/clipped/otherwise-prepared DEM. (**NOT** a slope raster!)

In the ‘*Output Raster*’ textbox, enter an appropriate location, name, and file extension for your Aspect raster. Acceptable file extensions are *.img* for ERDAS IMAGINE images, or *.tif* for GeoTiffs, or no extension for GRIDs.

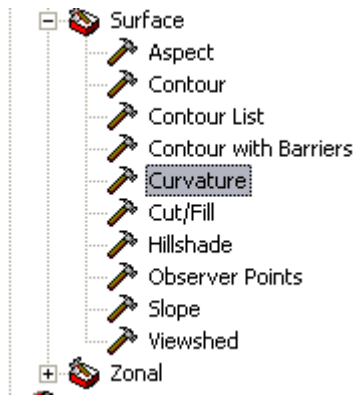
Click ‘OK’ to create the Aspect raster. Once processing is complete, the raster will be added to your map.



Deriving a Curvature Raster from a DEM

Curvature rasters can be used to describe the physical characteristics of a drainage basin in an effort to understand erosion and runoff processes. The slope affects the overall rate of movement downslope. Aspect defines the direction of flow. The profile curvature affects the acceleration and deceleration of flow and, therefore, influences erosion and deposition. The planform curvature influences convergence and divergence of flow.

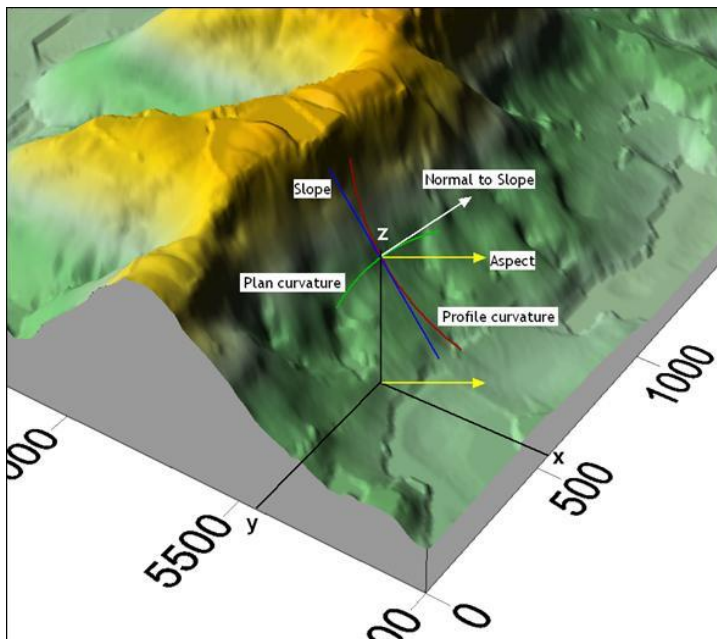
To derive curvature rasters in ArcMap or ArcCatalog, open ArcToolbox and expand the 'Spatial Analyst Tools' toolbox, then expand the 'Surface' toolset.



Open the 'Curvature' tool.

Set the 'Input Raster' to your mosaicked/clipped/otherwise-prepared DEM. (**NOT** a slope raster!)

Before proceeding any further, look at the other fields in the Curvature tool. Three outputs are possible from the Curvature tool. The first, the 'Output Curvature Raster,' is simply curvature calculated on a cell-by-cell basis. *Profile* curvature is the curvature in the direction of the slope; *Plan* curvature is the curvature perpendicular to the slope. See the diagram below to aid in understanding this:

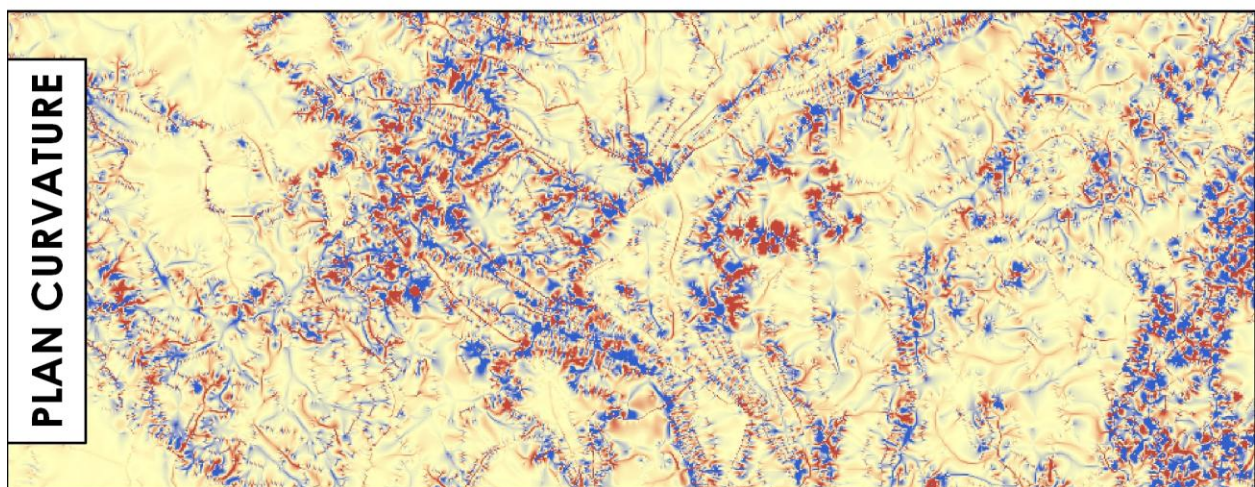
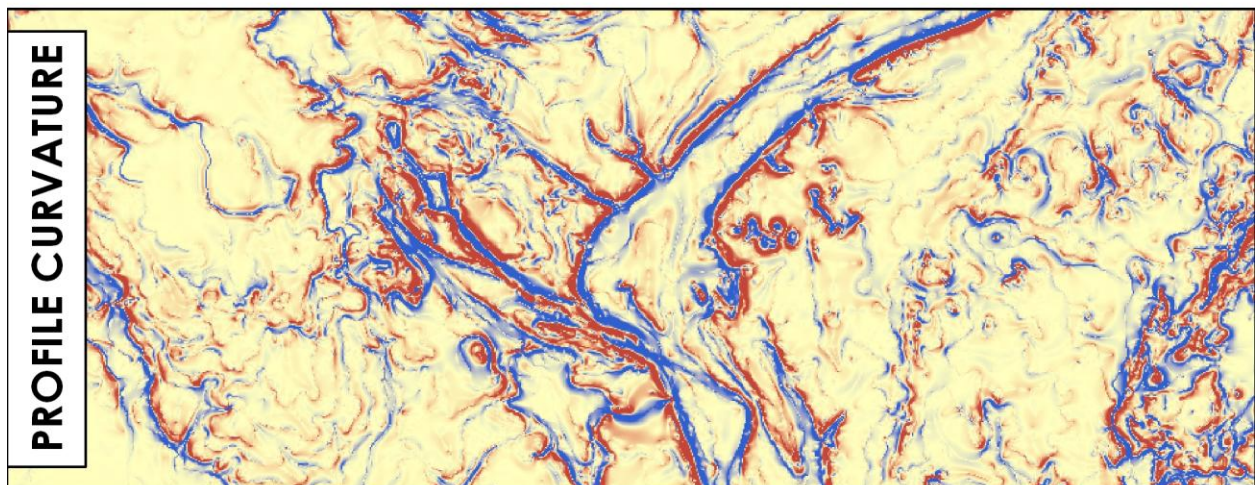
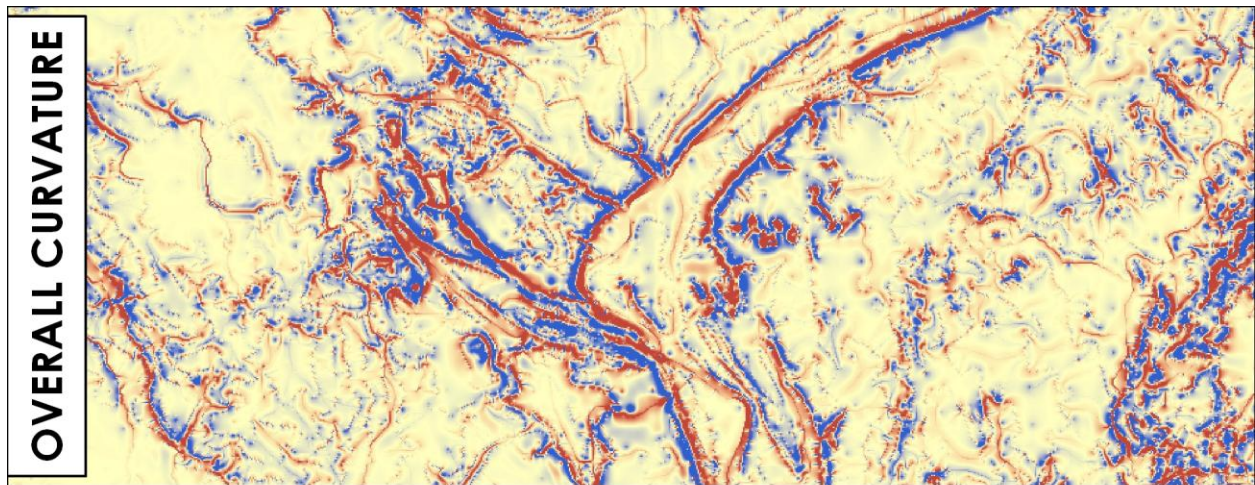


In the 'Output Curvature Raster' textbox, enter an appropriate location, name, and file extension for your Curvature raster. Acceptable file extensions are *.img* for ERDAS IMAGINE images, or *.tif* for GeoTiffs, or no extension for GRIDS.

If desired, also fill in the *Output profile curve raster* and *Output plan curve raster* fields now.

For NRVIS DEMs, leave the Z factor as 1.

Click 'OK.' The curvature raster(s) will be automatically added to your map. Sample curvature outputs are shown below:

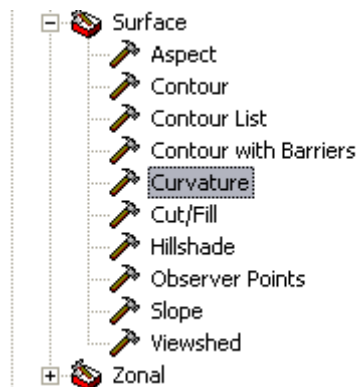


Deriving Custom Contours from a DEM

Custom contours can easily be derived from a DEM in ArcMap or ArcCatalog. While convenient, these contours should generally not be relied upon if a better alternative is available. Nevertheless, for visualisation and rudimentary analysis, the contours derived from DEMs can be quite useful.

NOTE: Generally, deriving contours from DEMs larger than one NRVIS tile will produce an error. The contours are generated in a computer's virtual memory – not on the hard-drive – and most computers will run out of memory well before the contours have finished generating. Instead, clip the DEM to a smaller area before generating contours.

To derive contours from a DEM in ArcMap or ArcCatalog, open ArcToolbox. Expand the '*Spatial Analyst Tools*' toolbox, then expand the '*Surface*' toolset.



Open the '*Contour*' tool.

Set the '*Input Raster*' to your mosaicked/clipped/otherwise-prepared DEM.

In the '*Output polyline features*' textbox, set an appropriate path and name for the output polyline Shapefile.

In the '*Contour Interval*' box, enter an interval in meters. NRVIS DEMs contain elevation in meters; as such, the contour intervals must also be in meters. Use decimals if deriving contours with intervals less than 1m.

If desired, enter a value for the '*Base Contours*.' This base contour value will be the starting point for all other contours – for instance, if you have entered a contour interval of 5m and a base contour of 28m, then contour lines will be generated at 18m, 23m, 28m, 33m, 38m, etc.

Leave the Z Factor as 1 if using a NRVIS DEM as an input.

Click 'OK.' Depending on the extent of the DEM and the contour interval, processing could take quite some time. Once the contours have been generated, they will automatically be added to your map.

The image below shows a portion of a DEM in Waterloo Region and 10m contours derived therefrom:

