

When Time-of-Day Matters; Visualizing DEMs

The acronym, DEM, which stands for Digital Elevation Model, can have different meanings to different users. Some users interpret a DEM to be any digital representation of the elevation, including digital contours (vectors) and triangular irregular networks (TINs). Others, myself included, use DEM to refer to raster-based representations of elevation where the values of each raster cell are derived from elevations (adjusted to some datum) of some surface. The surface referenced in the DEM may be the bare-earth terrain, devoid of any above-surface features, man-made or natural, often referred to as a Digital Terrain Model (DTM) or some other surface, such as the tree canopy or building rooftop surface, often referred to as a Digital Surface Model (DSM). DEM enhancement, such as hydro-flattening and/or hydro-enforcing, is the topic of a future column. Now, using lidar (IfSAR, sonar and/or phodar/photogrammetry) as the source data, the ground (or submerged ground) returns are processed into a bare earth DTM, and the first returns are processed into a specific DSM.

This month's tips focus on visualizing DEMs, specifically IfSAR (Interferometric Synthetic Aperture Radar) and/or lidar-derived DTMs. The illustrations were constructed using ArcGIS Pro 3.0 and an IfSAR DTM, but the workflow to produce the end products are identical in both the previous Pro versions (2.X) and the Esri Desktop products (10.X and earlier). Similar workflows can be used for making these visualizations in QGIS and GlobalMapper. NOTE: The DTM used in the illustrations was obtained from the US National Map (TNM Download v2 [nationalmap.gov]); a topic for a future Tips & Tricks column.

TIP #1 — BUILDING RASTER PYRAMIDS

When a raster layer is first added to the Contents Pane, the user is asked to build pyramids and calculate statistics. This is a one-time calculation and by doing so will add a metadata file (.aux) and an overlay (.ovr) file to the directory with the raster DTM (Figure 1). The raster pyramids and statistics decrease the rendering time of the raster, and I recommend building the pyramids/statistics as a routine when working with rasters. Deleting these file will not alter the raster, but will increase the rendering time.

By checking the “Always use this choice” box (Figure 1), Pyramids and Statistics for all future rasters newly added to your map will be calculated and this prompt will not reappear. (NOTE: To re-activate the prompt, or change the settings, use Project | Options | Raster and Imagery.)

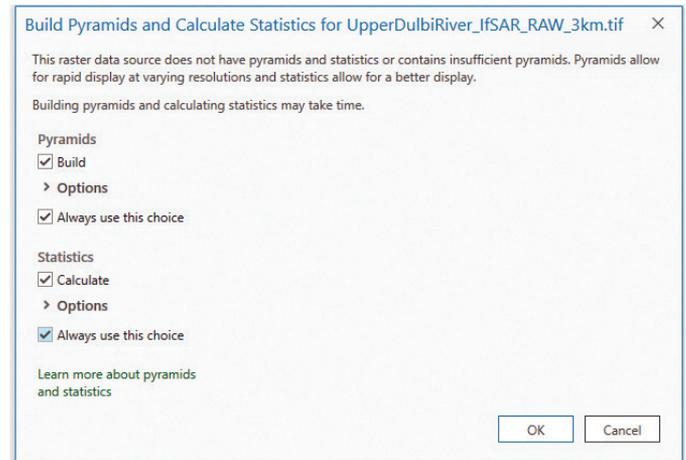


Figure 1. Building Pyramids and Statistics when first adding a raster to ArcGIS Pro3.0. Check the “Always use this choice” to affect all future rasters added to the Contents Pane.

TIP #2 — ADJUST THE DEFAULT COLOR SCHEME (RAMP)

The default color scheme ramp for a DTM, or any DEM for that matter, is a the black (low elevation) to-white (higher elevation) color ramp as in Figure 2 below. This default ramp, while representative of the elevation, is neither very informative nor visually pleasing (looks like an X-ray image to me.)

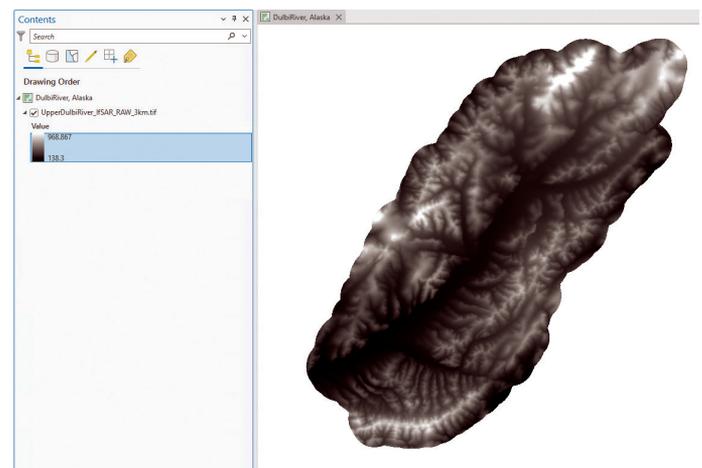


Figure 2. The default color scheme for a DTM newly added to the map. The elevation range is seen in the Contents pane.

Of course, it is easy to alter the color scheme and most GIS software programs provide multiple color scheme choices. As the elevation is expressed as a continuous value, choose a continuous, rather than discrete, color scheme. In the ArcGIS Pro, you can either right-click on the color scheme ramp (highlighted in Figure 2) in the Contents Pane, and use the drop-down arrow to reveal the choices, or you can select the DTM in the Contents Pane and open the Symbology Tab (Figure 3) to alter the color scheme.

Choosing a continuous color scheme ramp (I chose the Elevation #1 color ramp, fifth color scheme from the top) results in the DTM being rendered as in Figure 4. This U.S. Geological Survey (USGS) standard elevation color scheme runs from Blues (low elevations) to Greens to Red/Browns, and finally to Whites (high elevations) and provides the viewer with additional visual information. Now the user can clearly visualize the river draining from the northeast (higher elevations) to the southwest (lower elevations), as well as the highest elevation (white) mountain peaks. While this rendering is more visually appealing than the standard black-to-white shading, but, at least to me, it looks a little primitive.

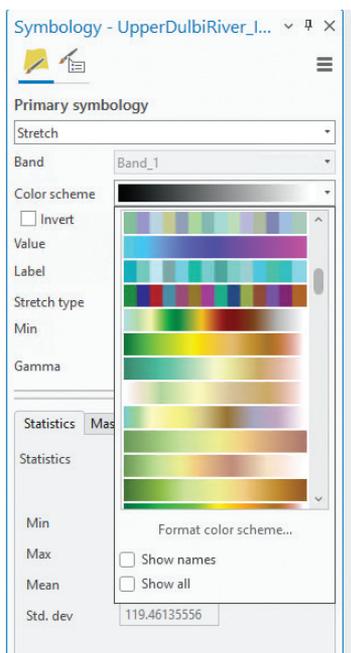


Figure 3. The Symbology Tab in ArcGIS Pro 3.0 shows the Primary Symbology (as Stretch) and the default color scheme. Using the arrow to the right of the Color Scheme reveals user-defined choices for color schemes.

TIP #3 — CHANGING THE PRIMARY SYMBOLOGY OF THE DTM

To further enhance the rendering of the DTM, notice that the default on the Primary Symbology tab is set to “Stretch” and that there is a dropdown arrow (to the right) on that same line. Using the dropdown (Figure 5) reveals several additional choices for rendering. The choice that I prefer is the “Shaded Relief”. This is frequently referred to as a “Hill-shade” in Esri and other GIS software packages, including QGIS and the WhiteBox Toolset (discussed in a previous Tips & Tricks column).

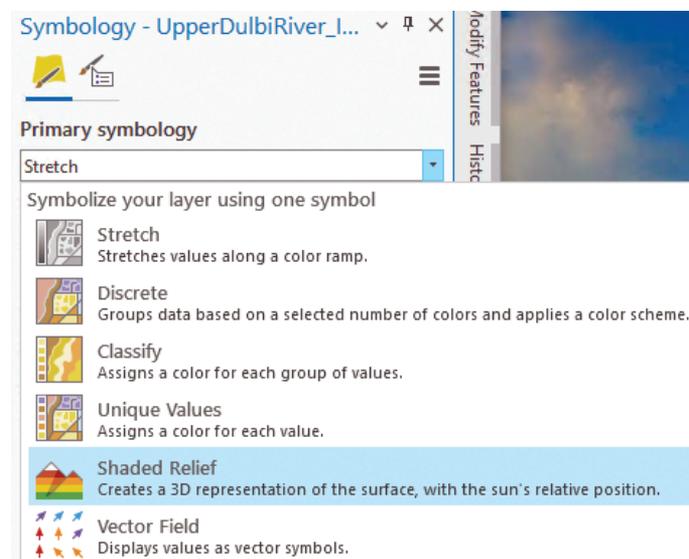


Figure 5. Options for the Primary symbology raster rendering. A simple choice to enhance the rendering is to choose “Shaded Relief”.

Deploying the Shaded Relief renderer (Figure 5) opens a new tab (Figure 6) with additional options. The default is to have the sun at 45 degrees (relative to the horizon) and at an Azimuth of 315 degrees (northwestern portion of the sky as in mid-afternoon) and no vertical exaggeration (Z Factor = 1). These parameters result in the rendering of the DTM as in Figure 6.

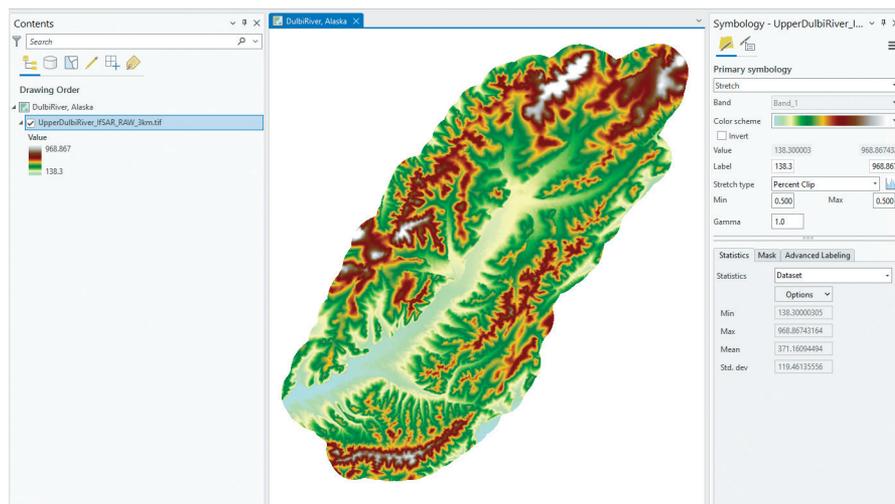


Figure 4. The DTM rendered with the USGS Standard Elevation #1 color scheme. Note that the Primary Symbology is set to “Stretch”.

Setting the Z Scale factor to a 5X exaggeration results in a more dramatic and easily interpretable rendition of the DTM as in Figure 7.

With the 5X Z Factor exaggeration, the river is even better defined as are the mountain valleys, ridges and peaks.

Adjusting the sun angle to a position lower in the sky (Altitude = 15 degrees) exaggerates the shadows as in Figure 8 tends to increase shadow lengths, while increasing the sun altitude reduces shadows.

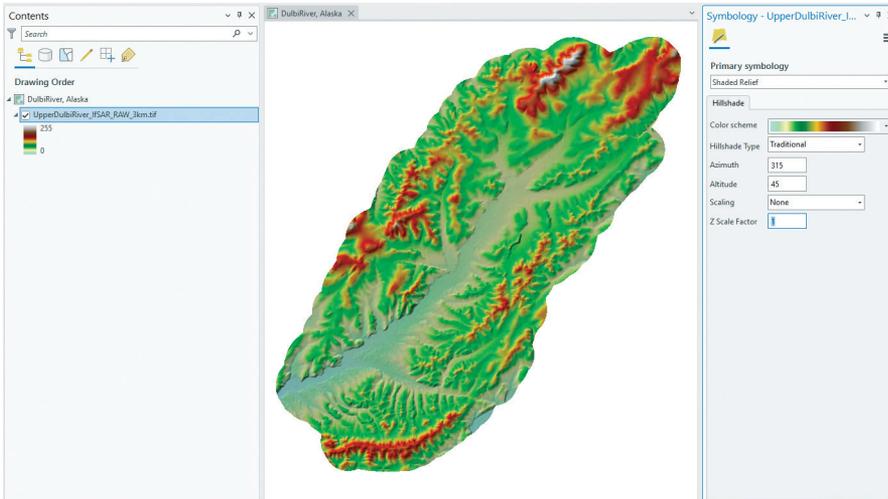


Figure 6. The Shaded Relief options tab. The user can specify the compass bearing (Azimuth) and height on the meridian (Altitude) for solar illumination, and an exaggeration (Z Scale) factor. The default solar parameters simulate a mid-afternoon illumination and shadows.

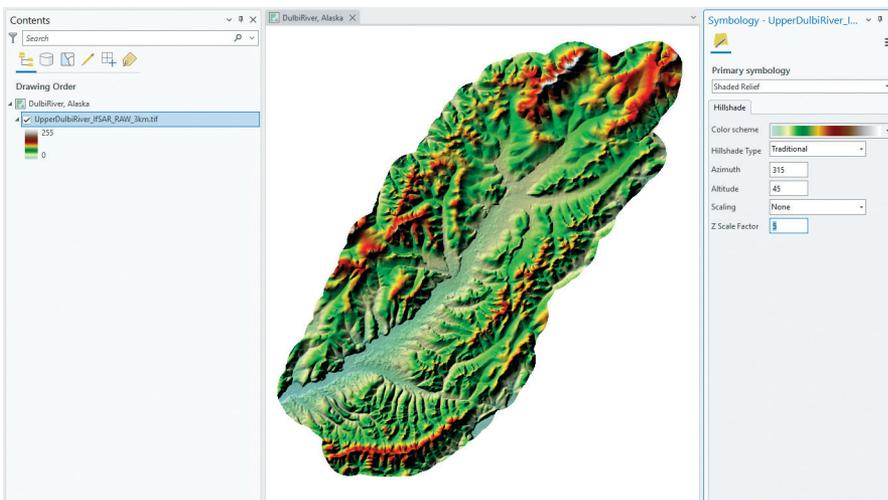


Figure 7. Shaded Relief rendering of the DTM with the default sun Azimuth and Altitude, but with a 5X Z Scale Factor exaggeration.

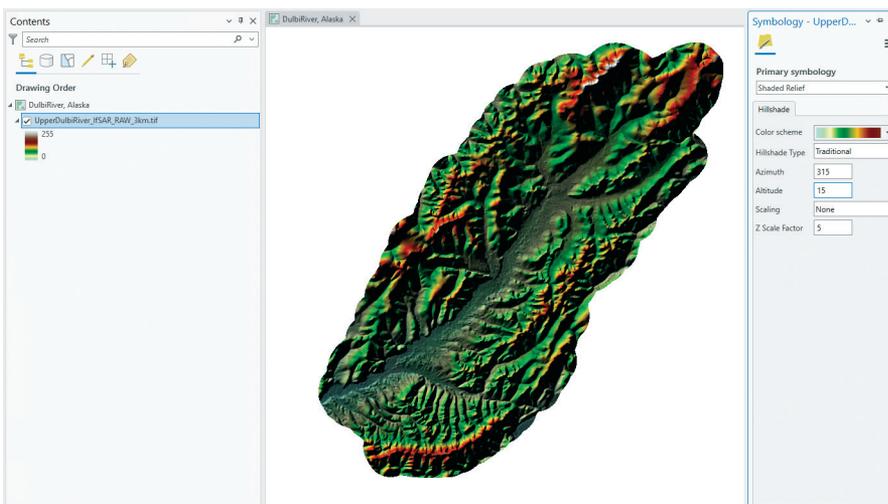


Figure 8. DTM rendered with sun illumination at 15 degrees Altitude showing more shadows than in Figure 7.

Similarly, the direction of the shadows, simulating time of day, can be changed by altering the Azimuth to have the sun in the east (~45 – 115 degrees) simulating a morning view, rather than the west (315 degrees) simulating an afternoon view.

I prefer to maintain the late afternoon sun angle and shadows (Azimuth = 315 and Altitude = 45) but adjust the Z-factor for flatter terrains (Z Factor = 8), normal terrains (Z Factor = 5), and mountainous terrains (Z Factor = 3).

TIP #4 — CREATE YOUR OWN HILLSHADE DTM AND CUSTOMIZE THE LOOK

To achieve an even more customized look, in ArcGIS Pro open the Geoprocessing Tab and either search for or navigate to the “Hillshade” Geoprocessing Tool (Spatial Analyst | Surface | Hillshade or 3D Analyst Tools | Raster | Surface | Hillshade). You can build this raster in Esri (Hillshade), QGIS (in Raster | Terrain Analysis), in WhiteBox (Geomorphometric Analysis | Hillshade), SAGA (Terrain Analysis- Lighting, Visibility | Analytical Hillshading), and several other GIS programs. In general, you will see the same, or similar, parameters as previously, Sun Azimuth, Sun Altitude and Z Factor (vertical exaggeration) to construct the Hillshade raster.

In the example in Figure 9 (next page), I built the Hillshade raster using the Geoprocessing Tool in Spatial Analyst selected the DTM as input, set the afternoon sun azimuth and altitude (315 degrees and 45 degrees, respectively) and specified a 5X vertical exaggeration (Z Factor).

Then, I placed the Hillshade5X.tif raster below the DTM raster in the Drawing Order on the Contents Pane. Selecting the Original DTM, I returned the Primary Symbology to “Stretch” but retained the USGS Elevation #1 color scheme and made the DTM raster 35% transparent (Figure 10).

This workflow results in a visually appealing rendition (Figure 11) of the DTM similar to the Shaded Relief option in Tip 3, and permits additional customization of the DTM rendering independent of the “Shaded Relief” option.

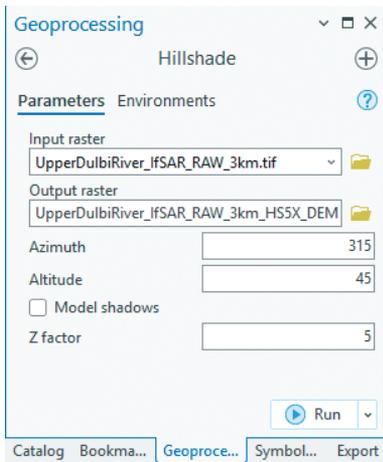


Figure 9. The Spatial Analyst Hillshade Geoprocessing Tool dialog used to construct a 5X exaggerated hillshaded raster.

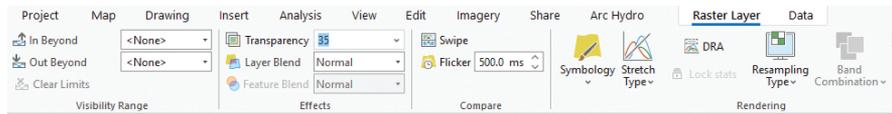


Figure 10. Selecting the original DTM in the Contents Pane, then selecting Raster Layer on the Ribbon and adjusting the Transparency to 35%.

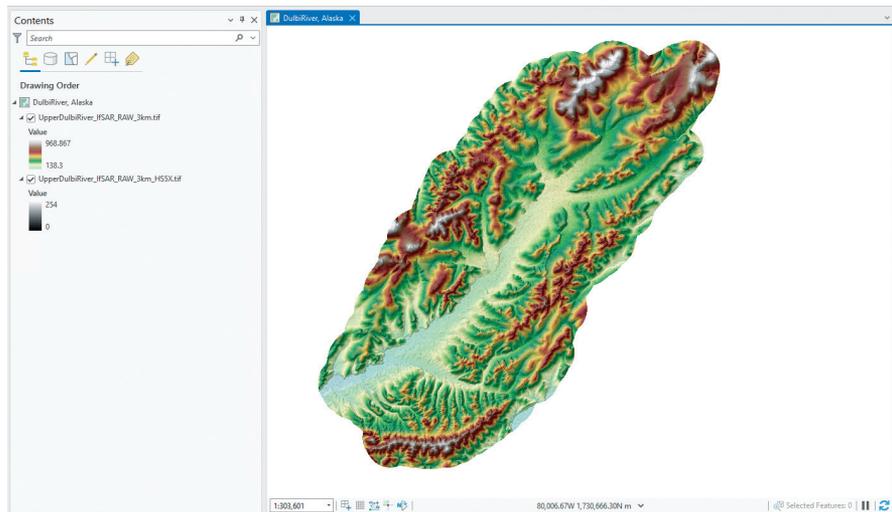


Figure 11. DTM rendered with 35% Transparency and an independent 5X exaggeration Hillshade raster showing through from beneath.

You can experiment with different color scheme ramps, different lighting conditions and different transparency levels to achieve the precise rendering you desire for your map.

Send your questions, comments, and tips to GISSTT@ASPRS.org.

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But not too young to be curious
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