Creating Shaded Relief Images and 3D Scenes Using Aerial Photos, DEMs, Arc, and ArcScene

Authors: Barbara and David Tewksbury
Institution: Hamilton College
e-mail: btewksbu@hamilton.edu; dtewksbu@hamilton.edu

Brief Description: Students use ArcGIS (DEMs plus georeferenced orthophotos) to create shaded relief images with correct shadows and to create 3D views of aerial photos in ArcScene to help them visualize landscapes.

Context: This exercise could be part of any course or research project in which it is important to be able to visualize not only the topography in 3D (which could be done simply with a DEM) but also the features visible in an aerial photograph or satellite image of the Earth or Mars.

Prerequisite skills: Students must have basic ArcGIS skills and be able to work with DEMs in ArcMap, and create and manipulate hillshades.

Where situated in the course: Any time after basic GIS skills are taught.

Concept goals: Students will learn a basic GIS technique that can then be used in landscape analysis.

Higher order thinking skills goals: None directly in this activity. This is simply a tutorial that teaches a particular set of techniques.

Other skills goals: Students will practice GIS skills learned in previous assignments.

Description: The first part of this activity teaches students how to make a high quality shaded relief image of an aerial photo using ArcMap, an orthophoto, and a DEM by matching the illumination direction on the hillshade created from the DEM with the illumination direction at the time the photo was taken.

In the second part of this activity, students use a digital orthophoto with an associated DEM, and ArcScene to construct a high resolution 3D visual version of the scene that can be tilted, panned, and zoomed in real time, providing an outstanding way for students to visualize landscape.

Evaluation: Students will be evaluated in a later assignment when they apply this technique to studying a particular landscape.

Creating Shaded Relief Images
Using Aerial Photos, DEMs and ArcMap

Dave and Barb Tewksbury, Hamilton College
dtewksbu@hamilton.edu, btewksbu@hamilton.edu

Shaded relief images can be created in ArcMap using georeferenced aerial photos and matching DEMs. The key to making a good-looking shaded relief image is matching the illumination direction on the hillshade created from the DEM with the illumination in the aerial photo.

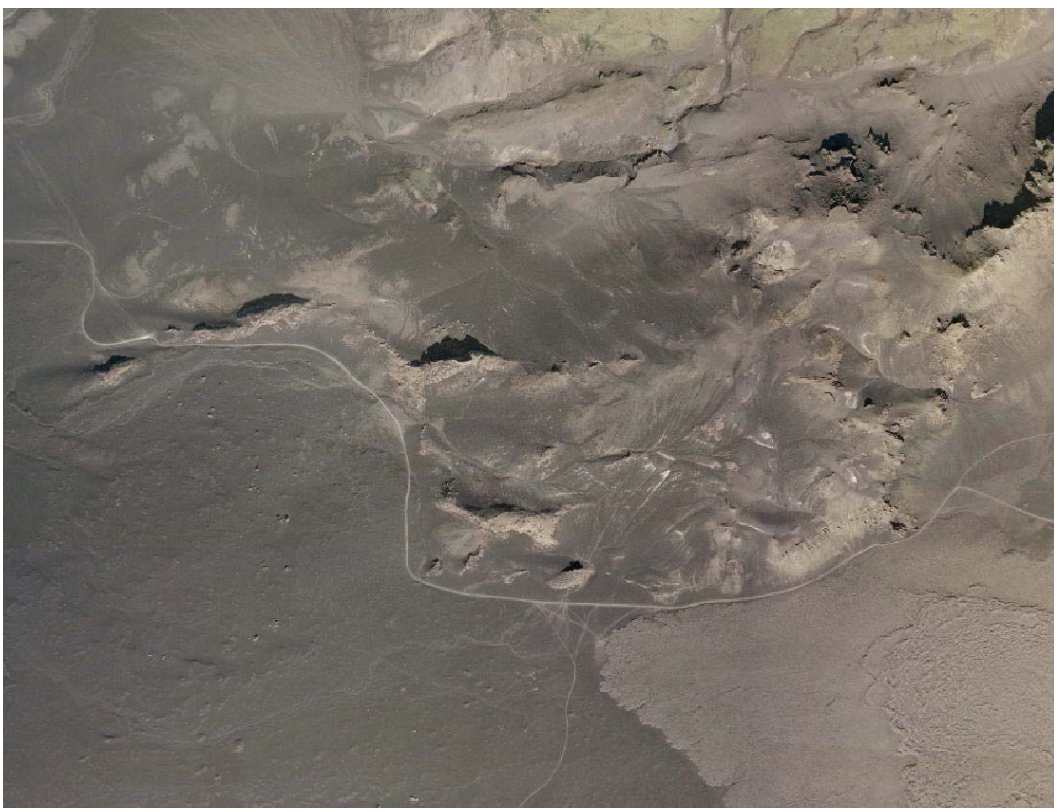
High latitude, an/ord early and late day aerial photos commonly have low sun angle illumination that does not match the default settings used to generate hillshades from DEMs in ArcMap. The following tutorial shows how to create a shaded relief image using a field area in Iceland, but the technique be used with any georeferenced imager and matching DEM.

Software required: ArcMap (any license level) and Spatial Analyst extension.

In ArcMap:

Load both the airphoto and DEM into ArcMap.

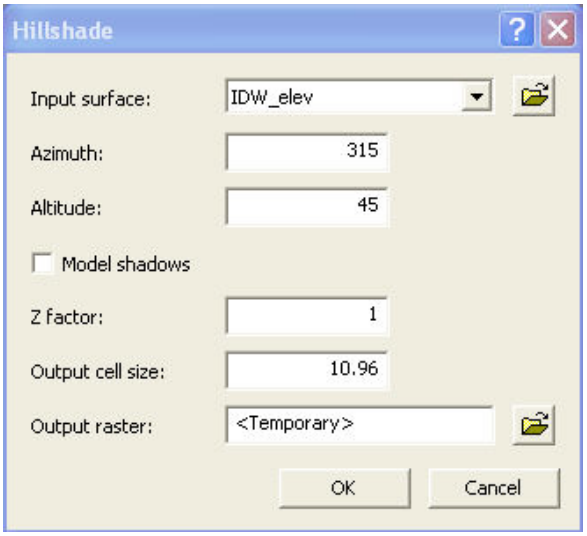
> **Example:** The aerial image below of the Valahnukar area shows palagonite ridges, hills and peaks surrounded by lava flows with an east-west road cutting through the area. *Aerial photography and DEM supplied by Loftmyndir Hf of Reykjavik, Iceland.*



Note the strong shadows on the NNW sides of the peaks and ridges. This lighting will cause issues with a traditionally generated hillshade.

From the **Spatial Analyst** toolbar pull down menu, select **Surface Analysis > Hillshade**

The Hillshade dialog box opens with default settings. For most evenly lit scenes, these settings work fine, but they must be modified for images with strong directional shadows.



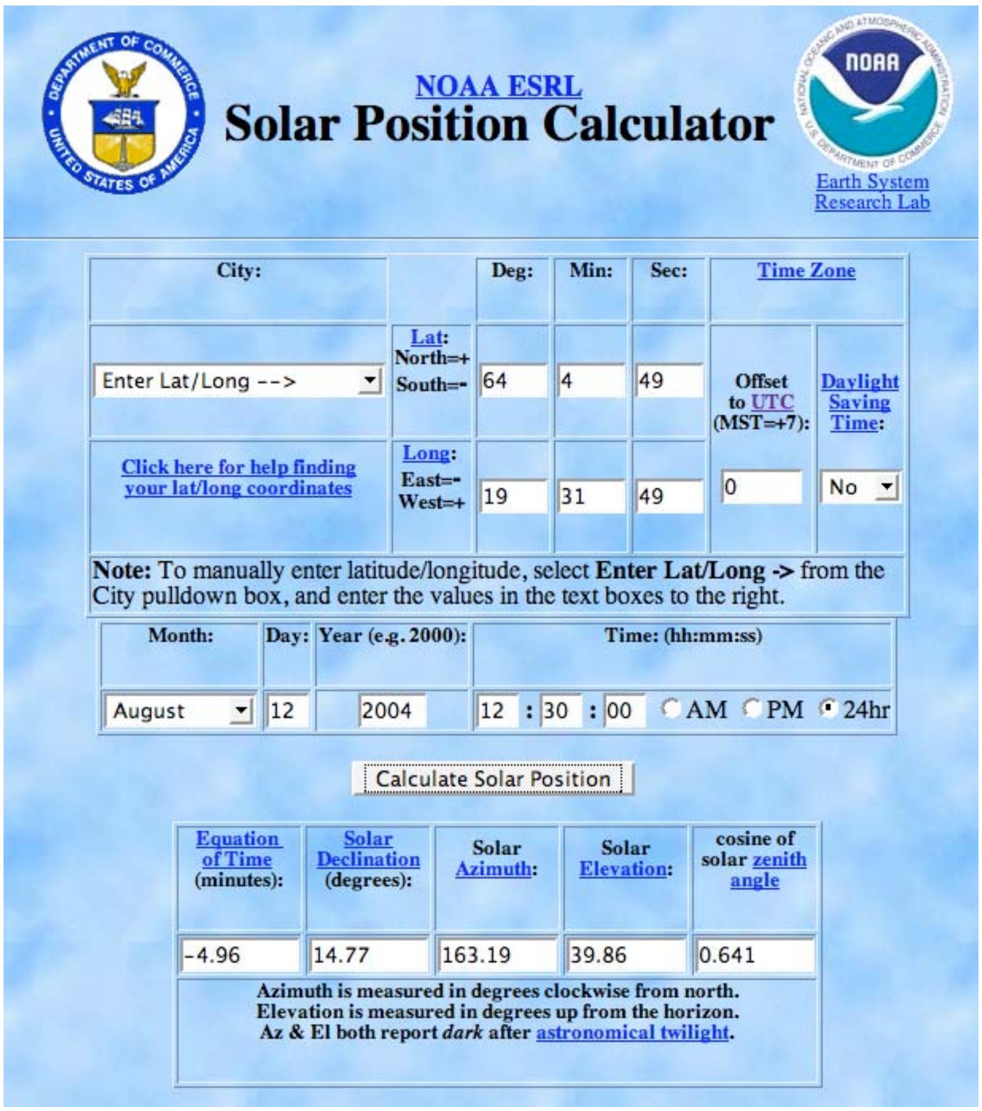
Select the correct **Input surface**
Azimuth is the compass bearing that the light will be coming from (360^0 is due North)
Altitude is the angle above the horizon
Model shadows is unchecked by default. Checking this box colorizes pixels calculated to be in shadow as black.
Z factor > 1 can be used to create vertical exaggeration in the hillshade
Cell size defaults to match the cell size of the DEM in the units of the DEM. Cell size changes must be exact multiples of the DEM cell size (.5, 1.5, 2 etc.). Changing cell size typically creates phantom patterns in the hillshade.
Browse to set the location of the **Output raster**. If you use <Temporary> the hillshade will load into the ArcMap window but will be lost when the map is closed.

The aerial photo in question was taken on 12 August 2004 @ 12:30 UTC

With this information and the Lat/Long of the image, you can go to

http://www.srrb.noaa.gov/highlights/sunrise/azel.html

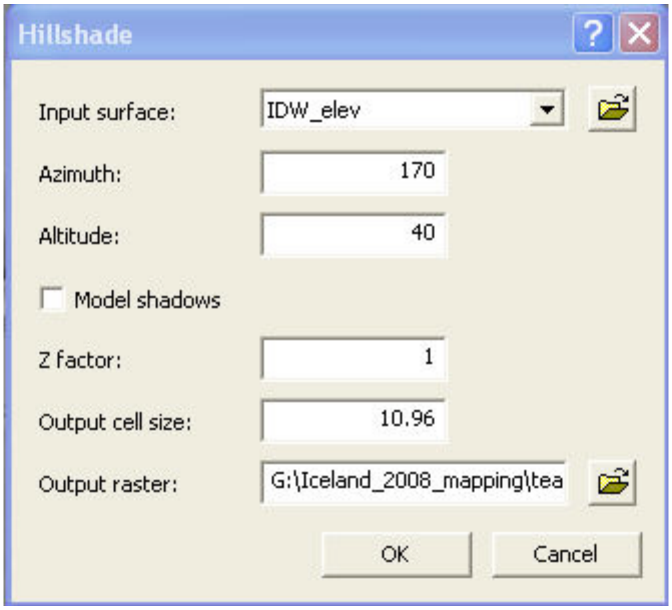
to calculate the position of the sun when the photo was taken.



Or you can simply look at the image and estimate the solar azimuth. In the Iceland image, this is somewhere to the right of clockwise of 180°, with 170^0 as a good guess. The sun also looked a bit lower in the sky, so we reduced 45^0 to 40^0 for the elevation.

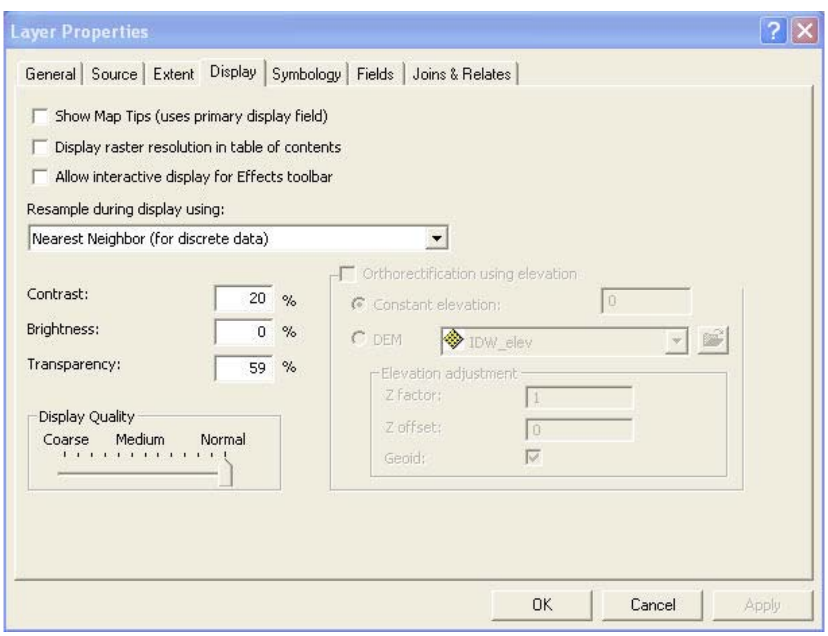
The Solar Calculator shows that the guess was not very far off!

In the Hillshade dialog box, enter the values of 170 and 40 for azimuth and elevation. Browse to the appropriate folder, and name the hillshade file for output and saving.



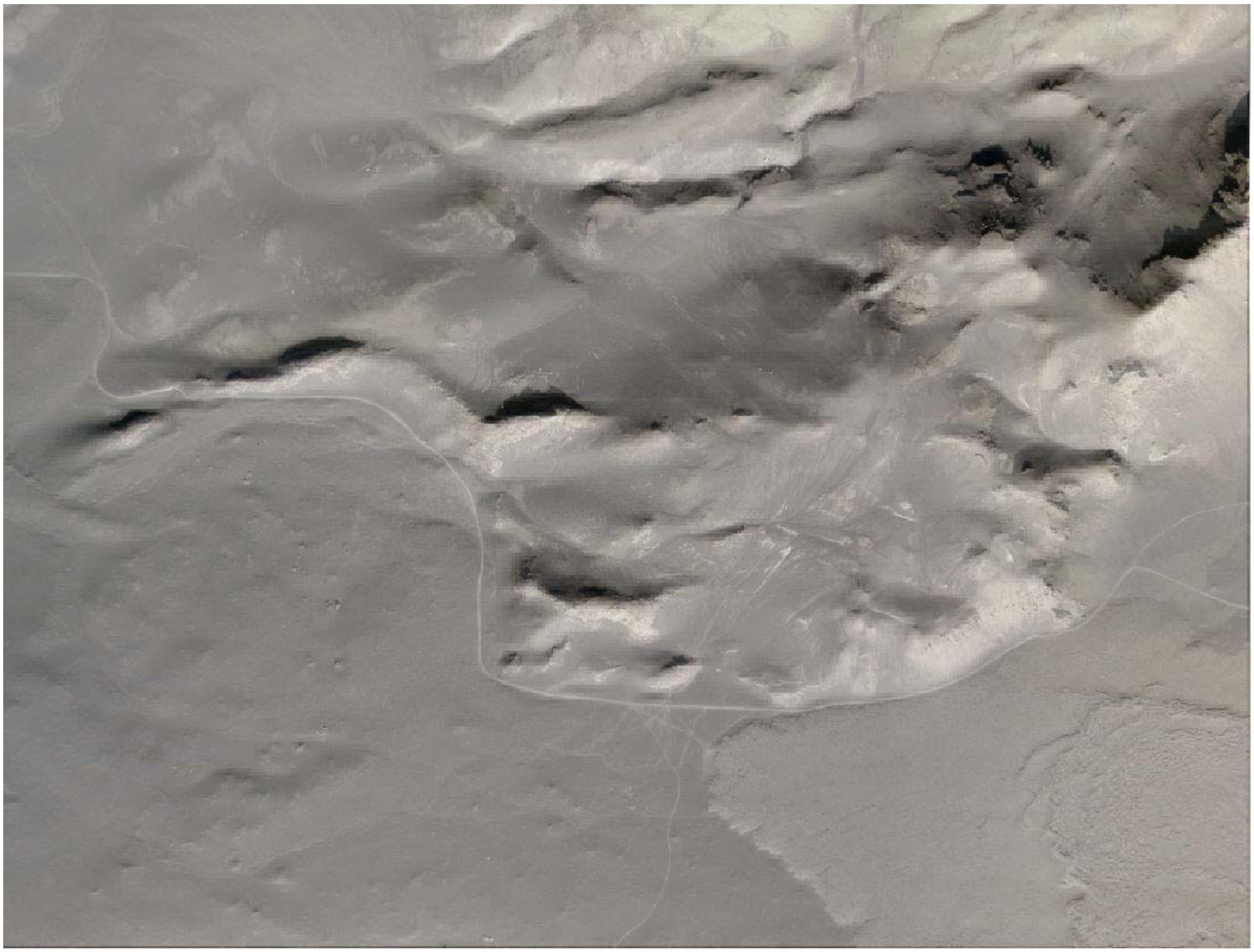
Click OK, and a hillshade will be created from the DEM and added to the map and TOC. If the hillshade does not look good, the first thing to check is that you selected the correct **Input surface**.

To combine the hillshade and aerial photo to create a shaded relief image, move the hillshade above the air photo layer in the TOC. Lower the transparency of the hillshade by right clicking on the hillshade layer in the TOC, scrolling to **Properties** and going to the **Display** tab. Change the Transparency to 55-60 %, and add a little contrast as well. Use the **Apply** button to evaluate changes without closing the dialog box.



If you load the **Effects** toolbar, you can make these changes using the transparency and contrast controls directly from the toolbar. Be sure the correct layer is selected.

The finished shaded relief air photo with partially transparent hillshade overlying aerial image:



Creating 3D Scenes
Using Aerial Photograph, DEM and ArcScene

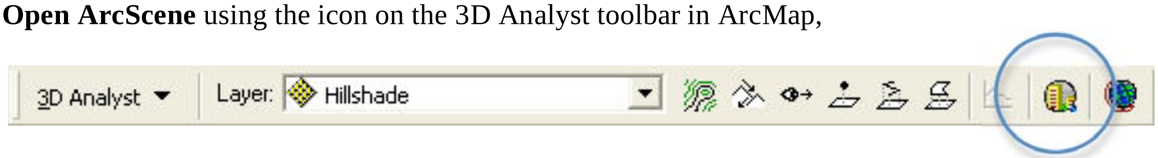
Dave and Barb Tewksbury, Hamilton College
dtewksbu@hamilton.edu, btewksbu@hamilton.edu

Stereo pairs of aerial images, the mainstay of air photo interpretation and mapping, are almost impossible to find and are no longer being produced. Historic collections are very valuable but do not provide recent imagery for current mapping and research projects.

Modern aerial photos are in the form of orthophotos. These are aerial photographs that have been corrected to remove distortion caused by camera optics, tilt and differences in elevation providing uniform scale across the image. Using a digital orthophoto with an associated DEM, ArcScene can construct a 3D visual version of the scene that can be tilted, panned, zoomed in real time providing an outstanding way for students to visualize landscape.

Requirements: orthophoto and matching DEM, ArcScene software (part of 3D Analyst extension)

Open ArcScene using the icon on the 3D Analyst toolbar in ArcMap,

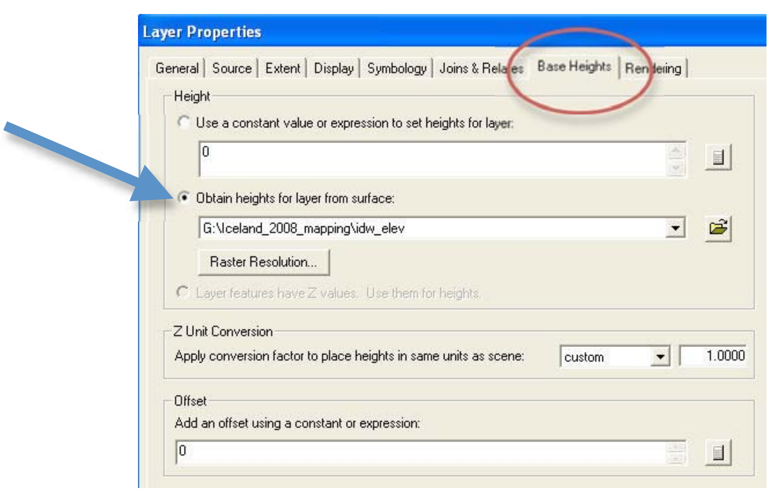


or directly from the Start menu **Start>All Programs>ArcGIS>ArcScene** (path may be different depending on how ArcGIS is installed).

Add the orthophoto to ArcScene The photo will come in at a default position and as a 2D layer.

To create a 3D view, the orthophoto must have base heights related to the matching DEM.

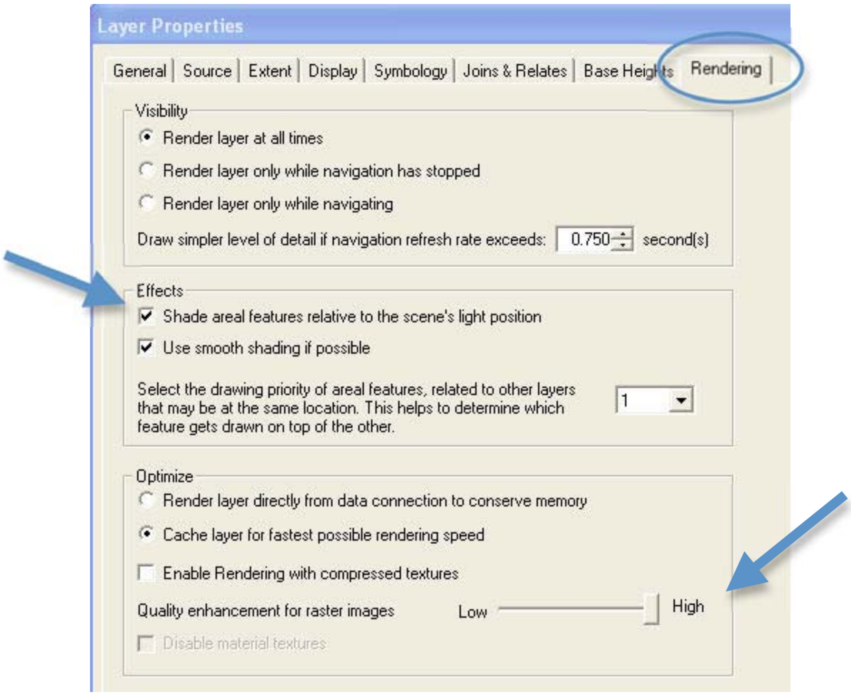
Right click on the orthophoto in the Table of Contents (TOC), scroll to **Properties** and select the **Base Heights** tab.



Click the **Obtain heights for layer from surface** button and browse to select the correct DEM file.

This will “drape” the orthophoto over a 3D surface defined by the DEM.

Right click on the orthophoto layer in the TOC, and scroll to **Properties**. Click the **Rendering** tab.



Check the box next to **Shade areal features relative to scene’s light position.**

Also move the slider to **High** next to **Quality enhancement for raster images.**

ArcScene uses a great deal of video processing and memory to allow movement of imagery in 3D space. Default settings degrade the display quality to allow near real-time movement on systems without robust video cards. For the best 3D visualization, display quality must be changed to high.

If working on a system without a robust videocard with a large amount of dedicated memory this may cause image breakup when moving it in 3D space. High resolution images or large datasets (such as a LiDAR-generated hillshade) may result in image breakup even on high end systems if the display quality is set to high. In these cases you may need to lower the quality.

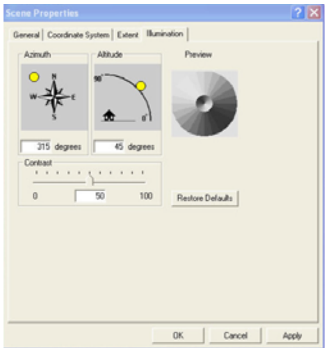
The correct lighting angle of the “scene” light must be established so that shadows in the airphoto match those created in the 3D scene. Conflicting shadows downgrade the quality of the 3D scene and can make visualization and interpretation difficult.

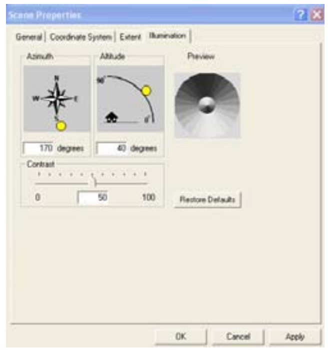
For flatly lit scenes, the default settings are fine, but for scenes with distinct shadows, the **scene light** position must be established to match that of the sun when the airphoto was taken.

Calculating the sun position can be done visually or using the Lat/Long of the photo center and the date and time the airphoto was taken in conjunction with the NOAA Solar Position Calculator, which can be found at

http://www.srrb.noaa.gov/highlights/sunrise/azel.html

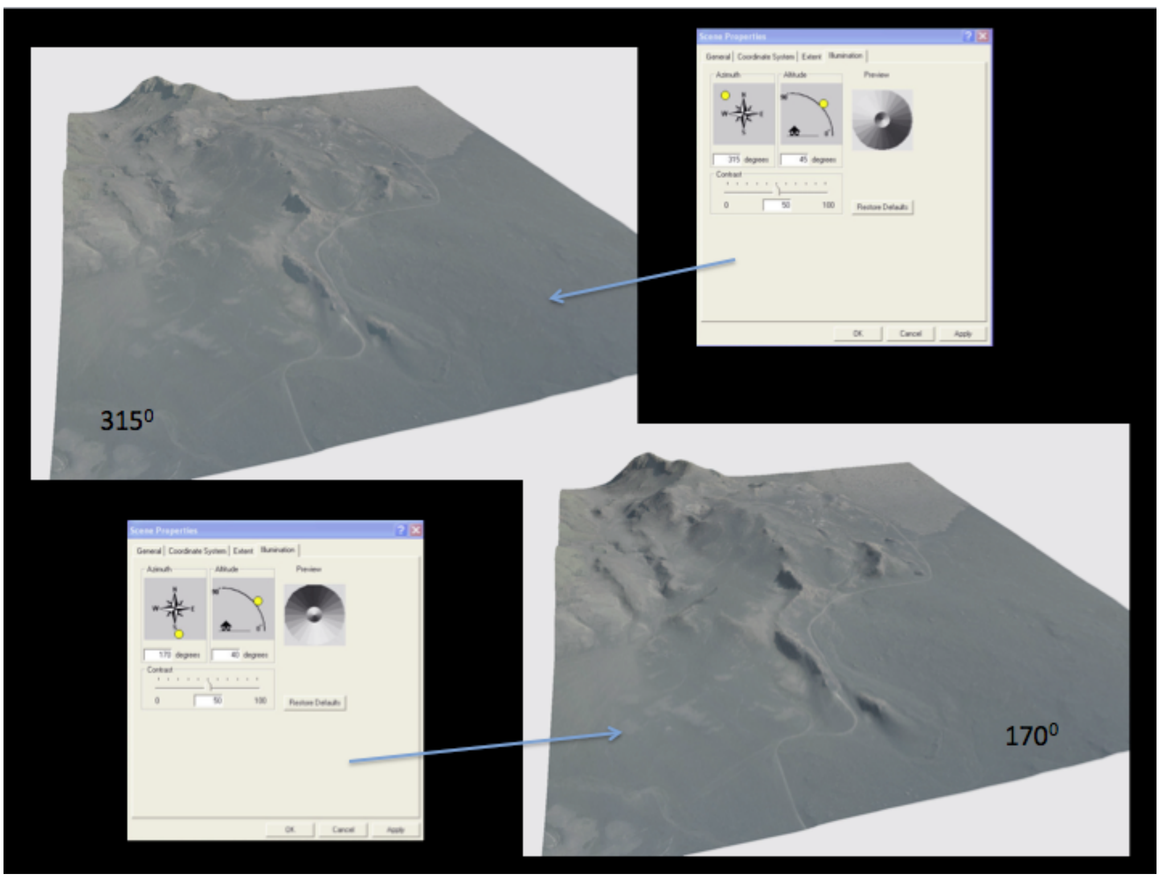
The scene illumination is set by right clicking the **Scene Layers** bar at the top of the TOC scrolling to **Scene Properties** and selecting the **Illumination** tab.



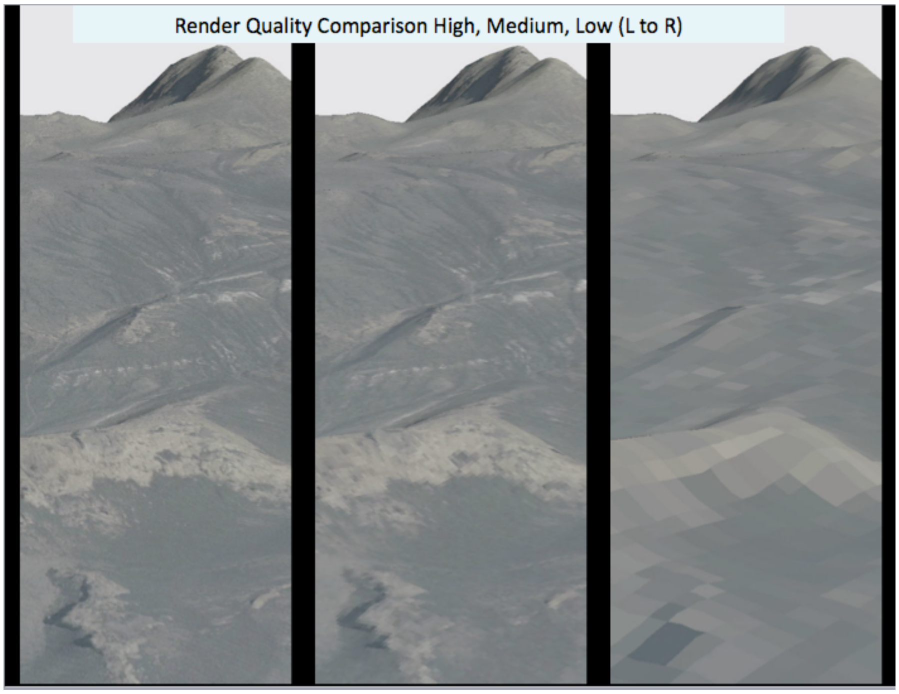


The default light position is an azimuth of 315^0 and an elevation of 45^0. Change these values to the correct values for the orthophoto in use using either estimated values or ones calculated with the Solar Position Calculator.

Click **OK.** The correct scene light position improves the quality of the 3D visualization.



The other factor governing the quality of the visualization is the quality of the display. This comparison below shows why you moved the **Quality enhancement for raster images** slider to **High** in the **Render** section of the airphoto properties.



With correct scene light position and quality rendering, 3D scenes allow examination of airphotos not possible with the stereo pairs using a mirror stereoscope or, for those with the talent, simply focusing at a point past the images themselves.