SHADED RELIEF IN BLENDER

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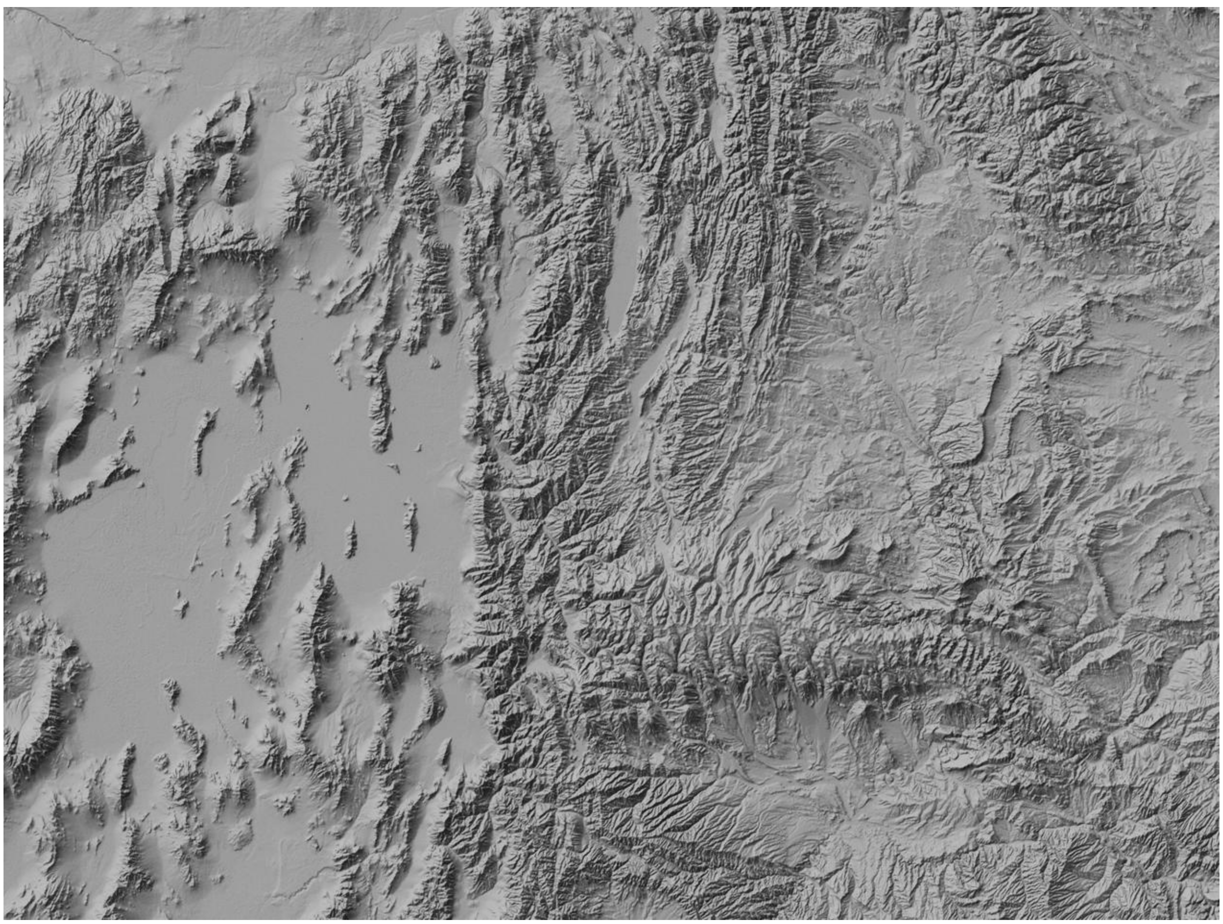
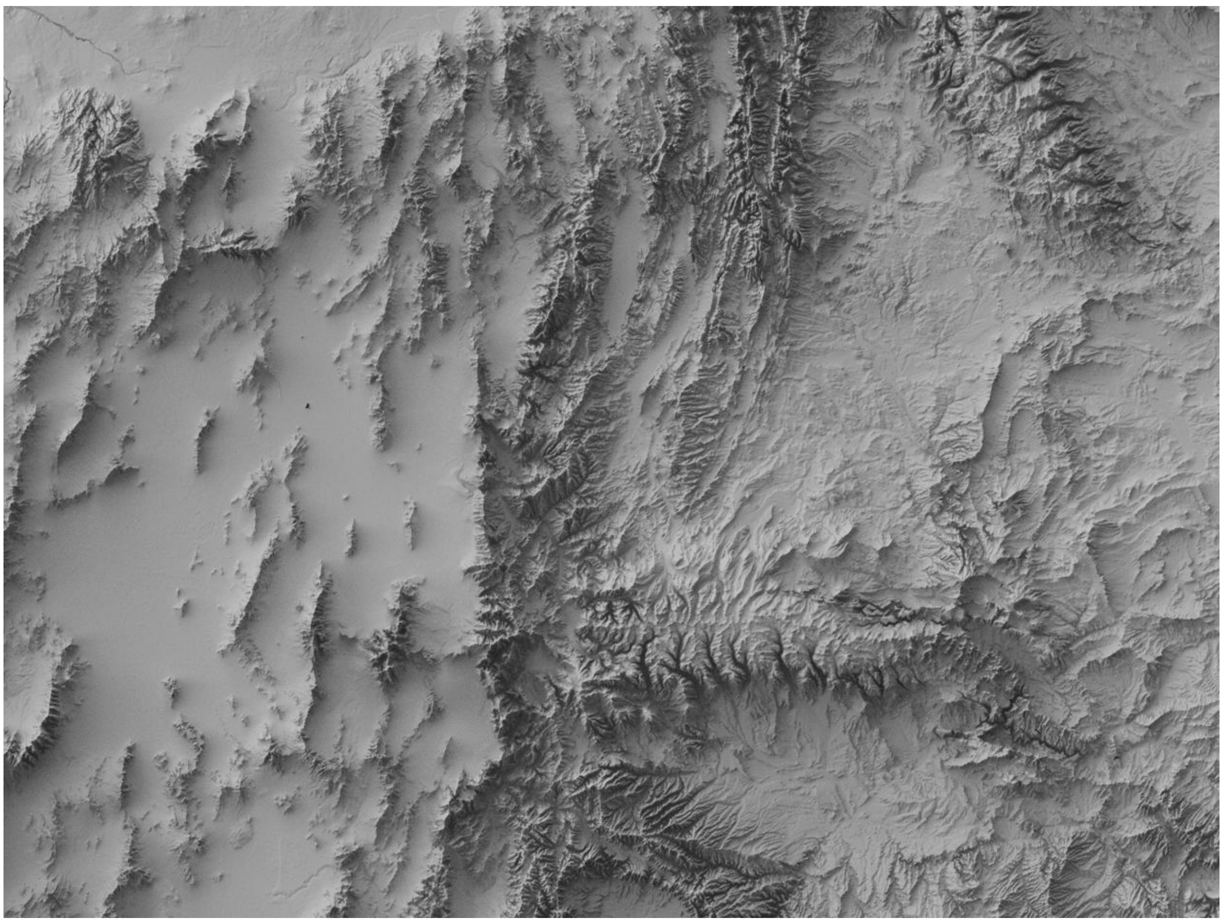
Blender is a free, open-source 3D modeling program which can be turned toward cartographic purposes. My recent efforts with the software have focused on using it to generate shaded relief images which I believe to be superior to those produced by a standard analytical hillshade algorithm.

Below, in Figure 1, is a standard analytical hillshade of a portion of the western United States. In this case, the simulated lighting is coming from the upper left corner of the image, and shining downward at a 45º angle. The analytical hillshade algorithm determines, for each pixel, its slope and aspect, and compares those to the angle of the imagined light source to determine how brightly-lit that pixel should be (ESRI Developer Network 2014).

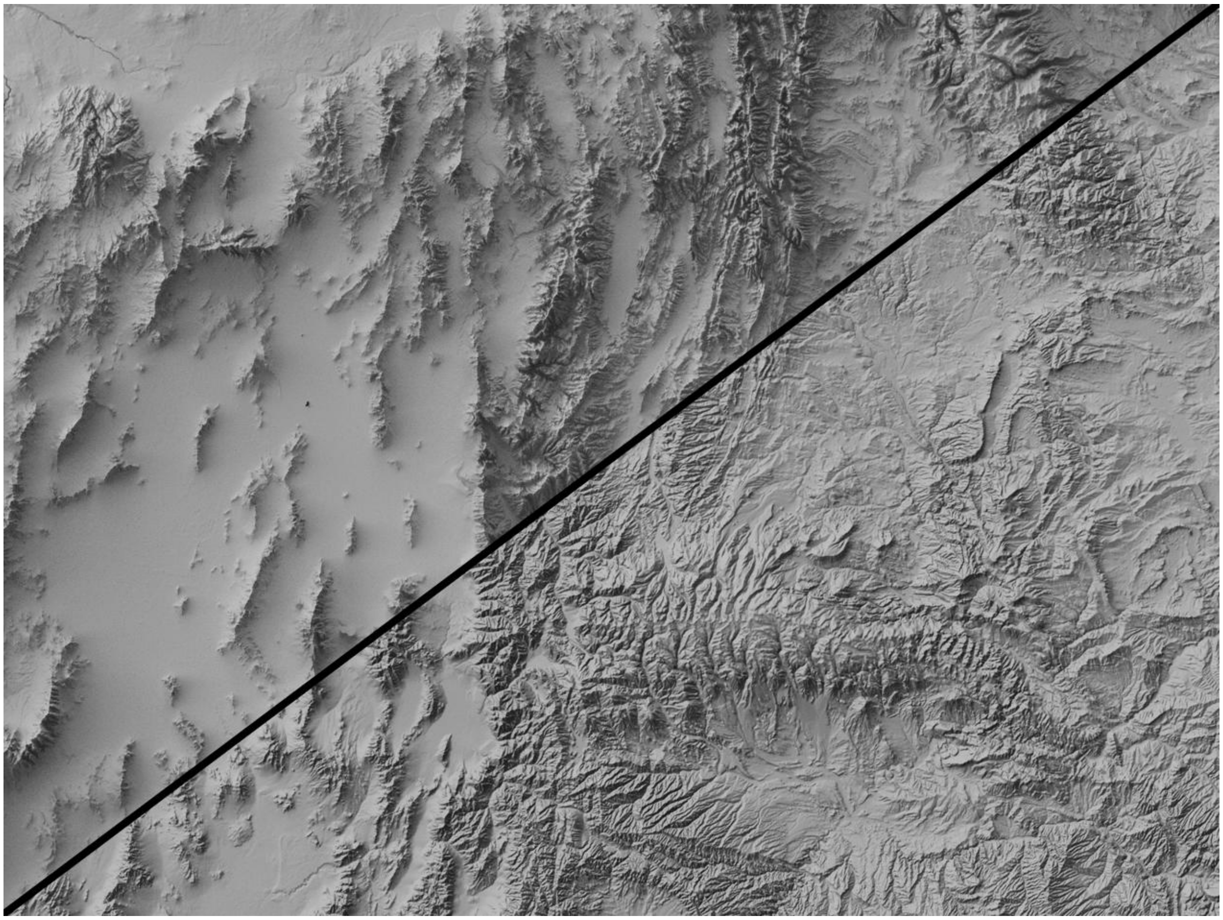

(Figure 1)

While this simple algorithm produces a fairly effective representation of the terrain, it is somewhat uncanny and artificial in appearance. The hillshade algorithm lights each pixel of the terrain with little regard to its context. Since it is run on each pixel individually, a slope may be brightly lit, despite being in the shadow of a great mountain nearby—a mountain that the algorithm does not consider. Or, likewise, the back side of a mountain may be shown much darker than we would expect in reality, as the algorithm does not account for the notion that light may bounce off of nearby terrain and illuminate areas that do not receive direct sunlight.

Blender is designed for complex, high-end 3D graphics, and as such has a sophisticated rendering engine. The Cycles Render Engine, built in to Blender, is based on the principle of ray tracing (Blender Wiki 2014). For each pixel in the final raster shaded relief image (and therefore each pixel of the terrain), the algorithm determines its color based on what light rays would have reached it, both from the light source directly and from light reflected around the scene (Rademacher 2014). This approach provides from a much more natural appearance because it is based on spatial context. Unlike an analytical hillshade, ray tracing accounts for shadows and reflected light, and produce a superior result, as seen in Figure 2.

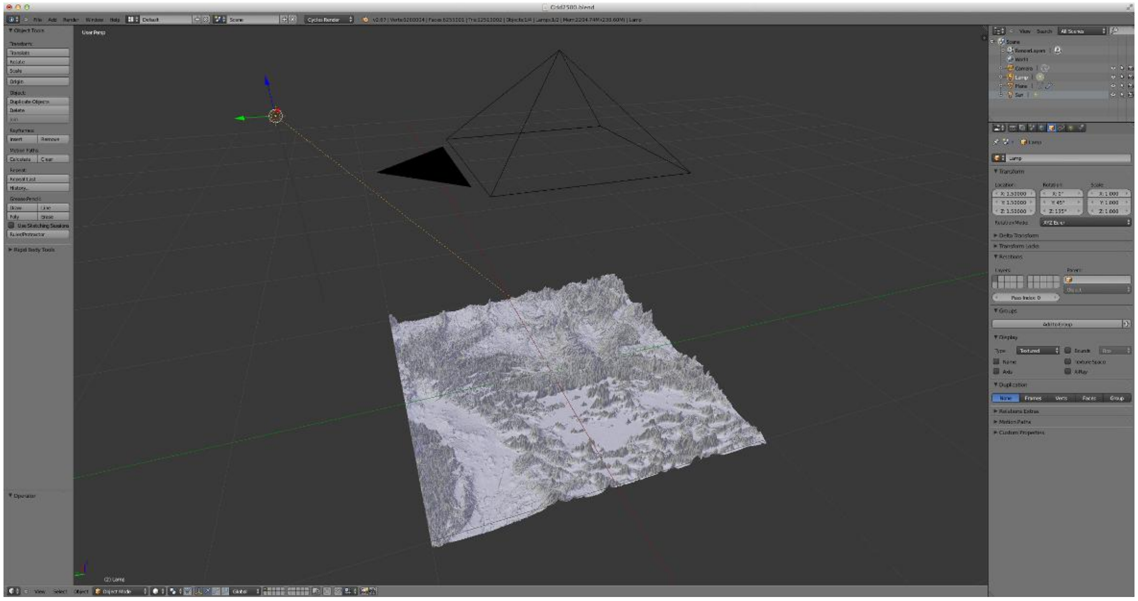

(Figure 2)

The results are more attractive than an analytical hillshade, but also I believe them to be more intelligible. The goal of hillshades/shaded relief is to allow a reader to visually interpret landforms, and I would argue that the more natural lighting permits a clearer understanding of the shape of the terrain. Shadowed valleys, for example, become more distinct from the mountains that obscure them, while scattered light proves enough illumination to keep them from being totally dark. The final result is easier to interpret while also being more pleasant to look at.



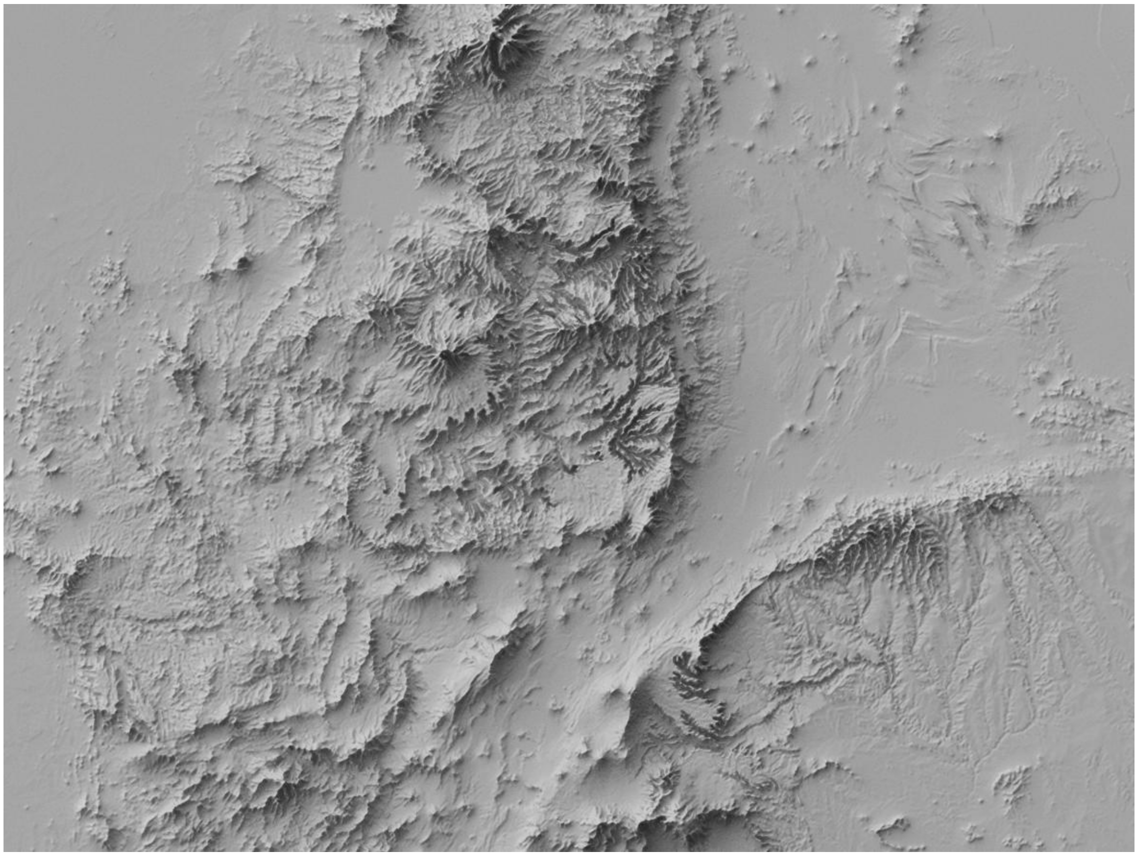
(Figure 3)

A tutorial on using Blender to produce shaded relief is outside the scope of this paper, but detailed instructions can be found at bit.ly/1mpEvTM. The process is somewhat similar to Wenschow's method, though done virtually. Karl Wenschow, working in the early 20th century, produced shaded relief images by constructing physical plaster terrain models, and then photographing them from overhead (Relief Shading 2006). Likewise, in Blender, we can set up a virtual model of our terrain, applying a simulated light source, and then calculating what the final image would look like if seen from above with an orthographic camera.

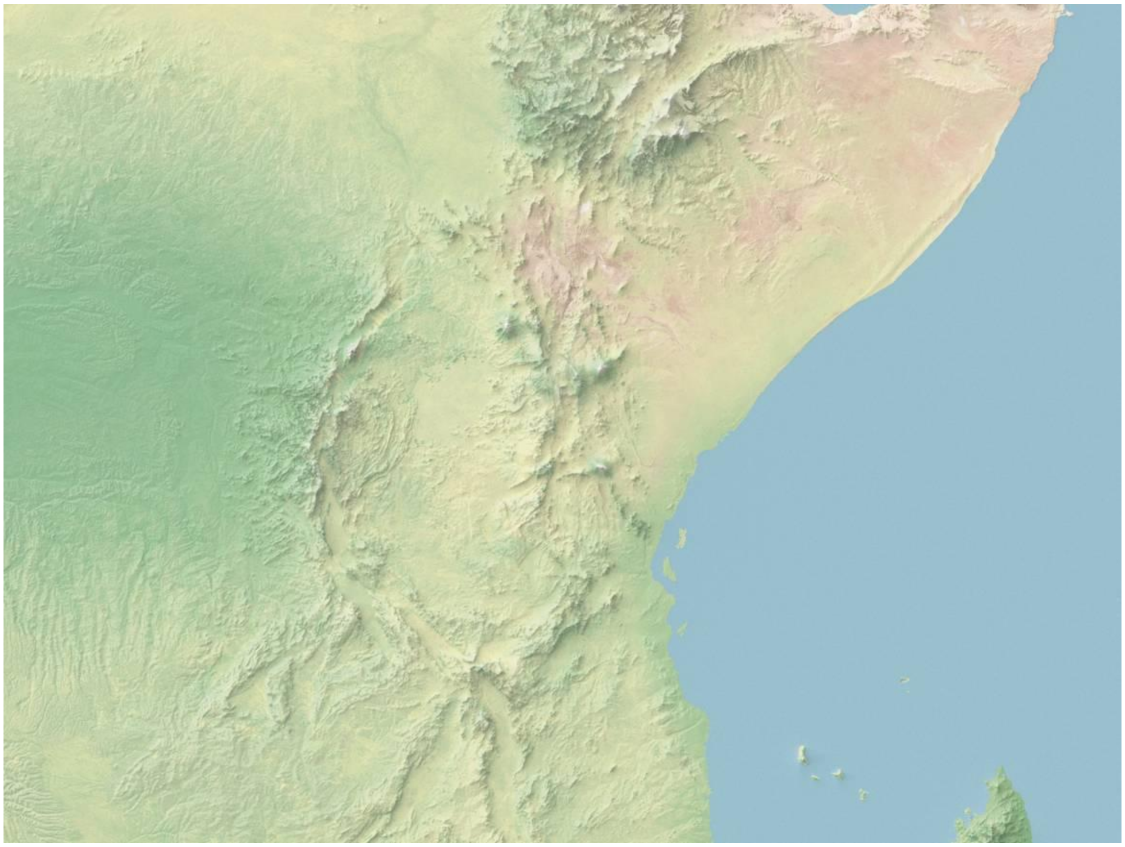


(Figure 4)

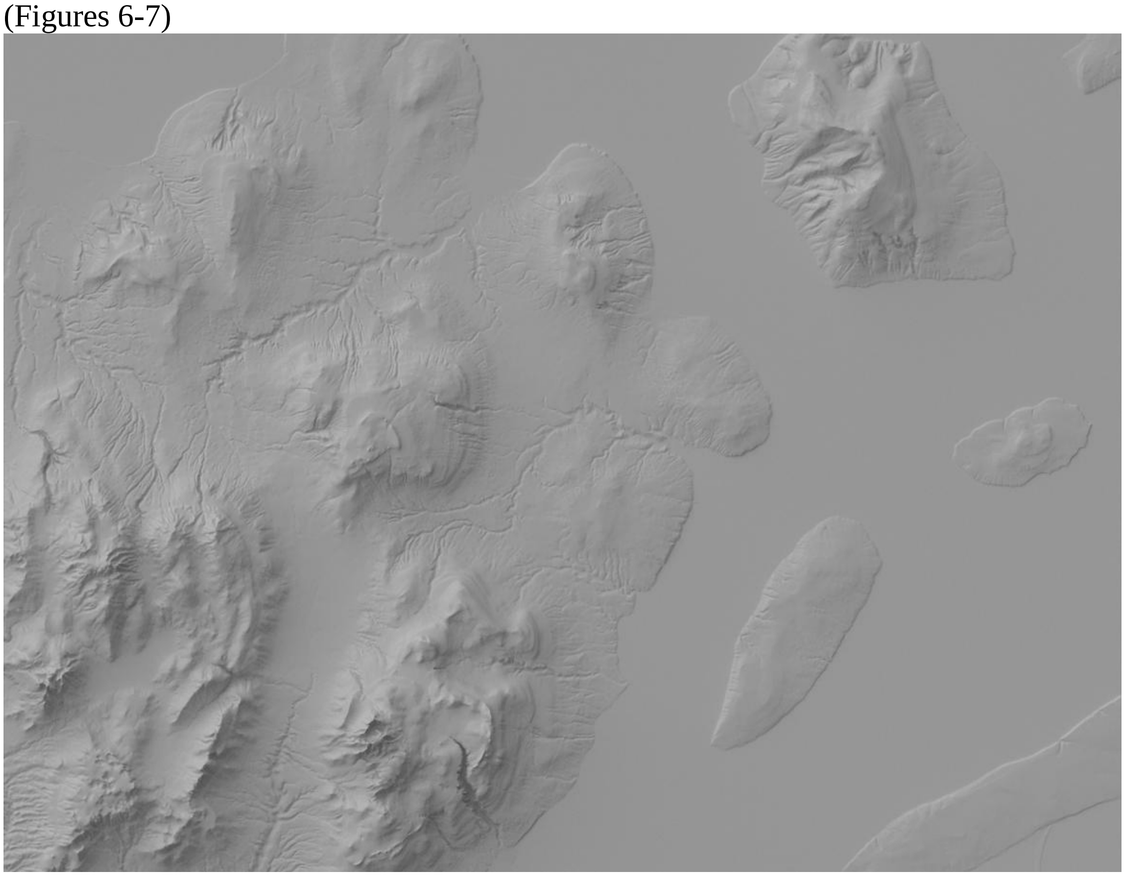
Figures 5–7 show some further Blender-produced images. Like a traditional analytical hillshade, they combine well with hypsometric or land-cover tints. Figure 6 shows a Blender relief paired with Tom Patterson's Natural Earth II (naturalearthdata.com).



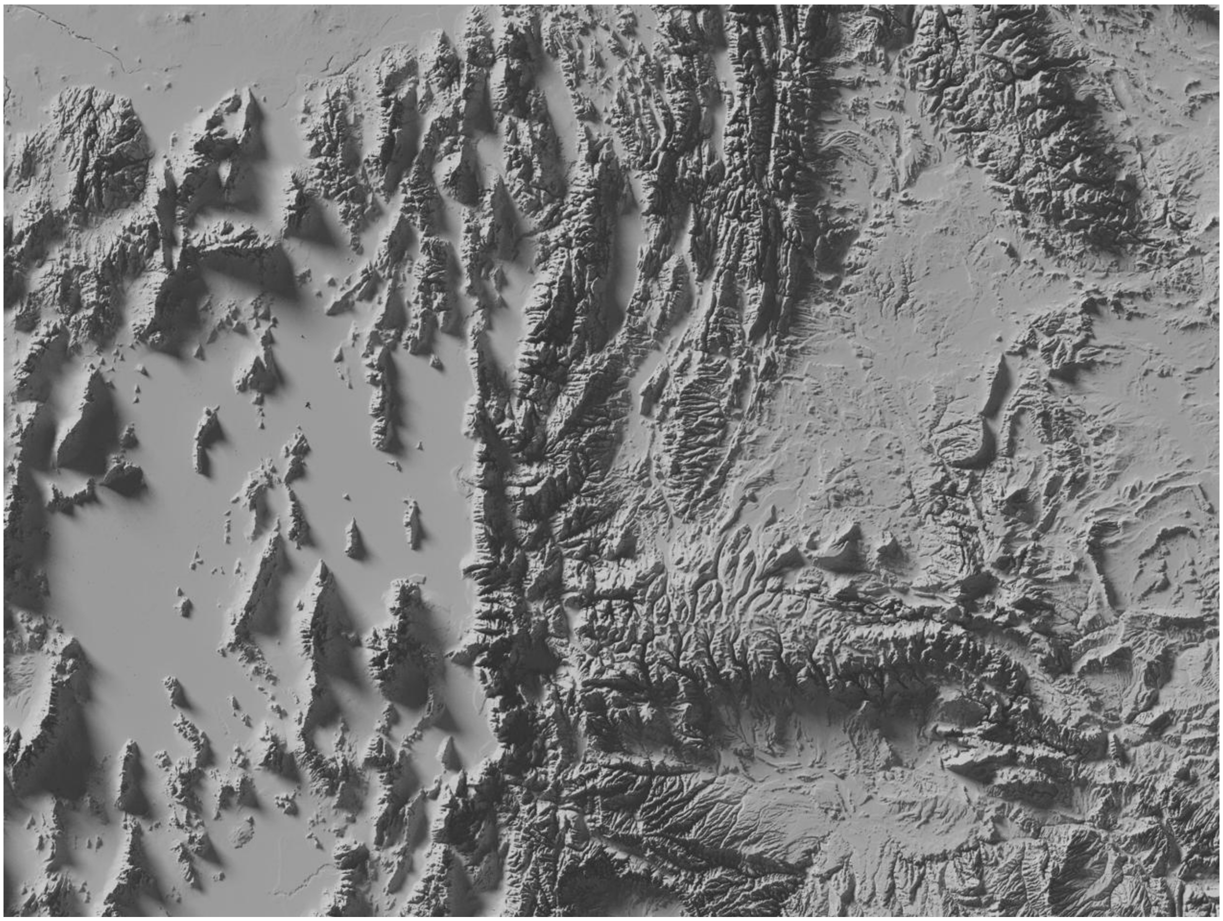
(Figure 5)



(Figures 6-7)



The software offers a great deal more flexibility than an analytical hillshade, as it is intended for complex work. Multiple light sources can be used, for example, to better highlight certain significant features. I commonly place one light source in the traditional upper-left 45º position, and another directly overhead at 90º, shining straight down, so as to ensure that some light reaches into the deepest canyons. Light sources can be adjusted in color or in softness. Figure 8 shows an adjustment to the light source to cause sharper shadows, giving an appearance that our terrain is on the Moon, or some other low-atmosphere location.



(Figure 8)

The method comes with some limitations. Blender is not spatially-aware, and so the user must take care to ensure that all image exported from Blender align with other map layers in the workflow. Third-party plug-ins, such as BlenderGIS (github.com/domlysz/BlenderGIS), give Blender some limited spatial capabilities to ease this process. Due to the complexity of the lighting calculations, producing reliefs in excess of 3–4 megapixels requires top-end computer hardware, or splitting the DEM into tiles and reassembling the relief out of multiple pieces. The process is also more time-consuming than an analytical hillshade, which can usually be done in minutes. Blender relief may take, for a single image, 15–20 minutes of preparation and render time.

While the process is somewhat more complex, the results, I feel, are worth the effort. Blender relief is more visually interesting and naturalistic than that produced via an analytical hillshade. This is very much the tip of the iceberg, I believe, in terms of the cartographic uses of this program, both for shaded relief and other applications (such as oblique views). I look forward to seeing what my colleagues can get Blender to do.

References

Blender Wiki, 2014, *Cycles Render Engine*, Web site: wiki.blender.org/index.php/Doc:2.6/Manual/Render/Cycles (accessed September 28, 2014).

ESRI Developer Network, 2014, *How Hillshade Works*, Web site: edndoc.esri.com/arcobjects/9.2/net/shared/geoprocessing/spatial_analyst_tools/how_hillshade_works.htm (accessed September 28, 2014).

Rademacher P, 2014, *Ray Tracing: Graphics for the Masses*, Web site: www.cs.unc.edu/~rademach/xroads-RT/RTarticle.html (accessed September 28, 2014).

Relief Shading, 2006, *Wenschow*, Web site: www.reliefshading.com/techniques/wenschow.html (accessed September 28, 2014).