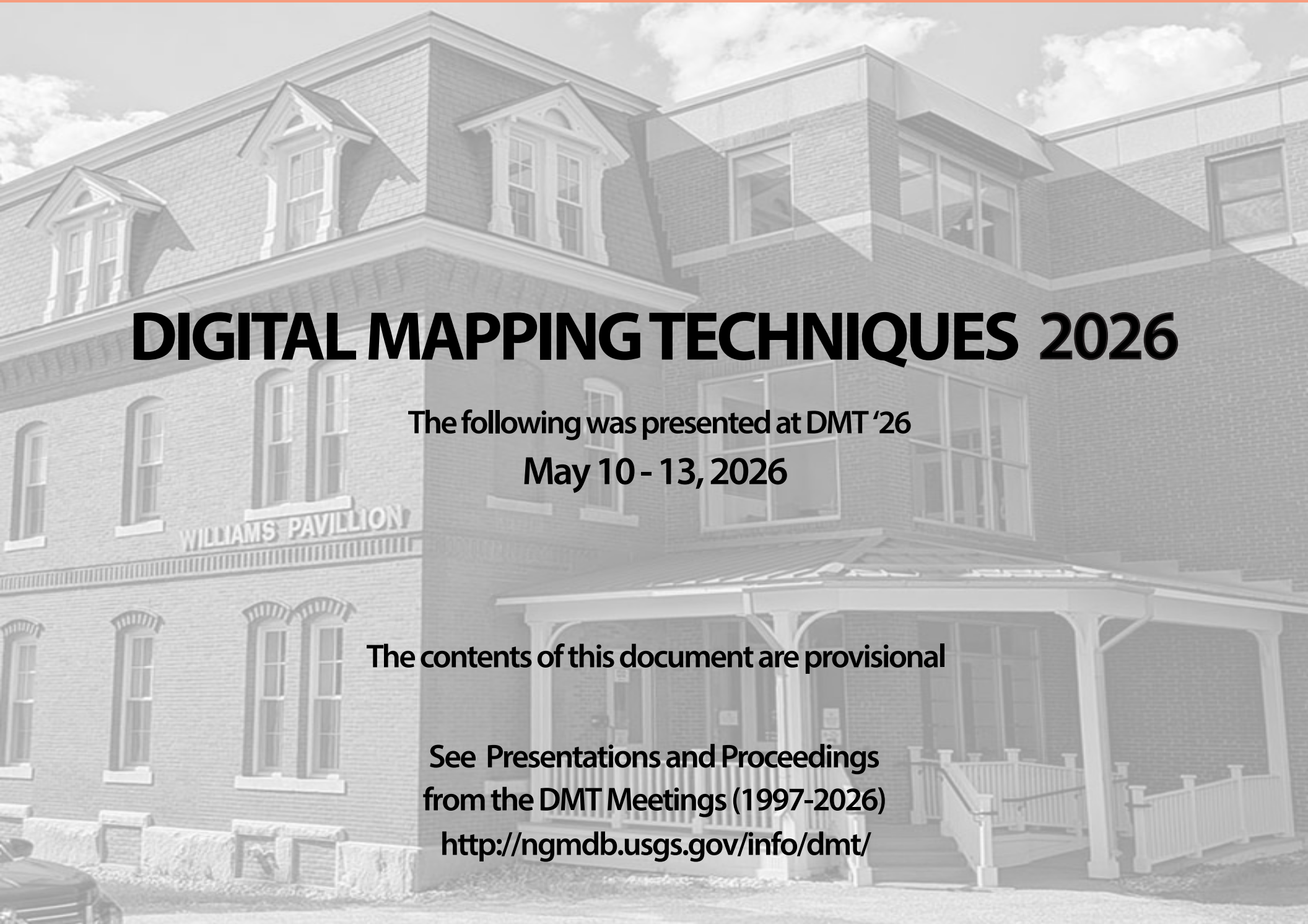

DIGITAL MAPPING TECHNIQUES 2026

The following was presented at DMT '26

May 10 - 13, 2026

The contents of this document are provisional

See Presentations and Proceedings
from the DMT Meetings (1997-2026)
http://ngmdb.usgs.gov/info/dmt/

Automating and Using Red Relief Image Maps for Desktop Mapping Presentation Slide Guide

By Blair Stuhlmuller at the Washington Geological Survey

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SLIDE 1: This presentation is on Red Relief Image Maps (RRIM) and how the process of making them can be streamlined. Red Relief Image Maps are powerful visualization tools for investigating topographical features but can be time consuming or confusing to produce and there can be a technical barrier for people to use them in their workflows. Automating the creation of red relief maps given a specific quadrangle or spatial extent allows mappers to quickly access and use this visualization method for various desktop mapping projects, especially surficial features, pre-field season reconnaissance and more. The WGS landslide hazard team in particular is looking forward to using this tool!

SLIDE 2: RRIM can visualize the topographic slope, concavities and convexities at the same time effectively representing both large-scale land features as well as fine structure at the same time in wide variety of topographic situations.

SLIDE 3: Example of smaller scale RRIM. Image is from ESRI User Conference.

SLIDE 4: No additional notes. All information on slide.

SLIDE 5: What makes RRIM so unique is the new parameter calculated from two openness parameters. This parameter efficiently eliminates light direction dependency like in shaded relief image and expresses convexity and concavity at the same time. The Ridge and Valley index is expressed by gray-scale image layer and topographic slope is a red color layer.

This concept is not new. Positive and negative openness were defined by Yokoyama et al. (2002) and there's several papers and even an ESRI presentation on this. There are also existing python script toolboxes for these topographic openness ratsers. SAGA (System for Automated Geoscientific Analyses) already has a very extensive open-source toolbox. In their Terran Analysis Visibility and Lighting toolset they have a Topographic Openness script that does the meat of the processing and creates two rasters– a positive and negative openness raster.

In general, negative openness represents concavity of surface and positive openness represents convexity of surface. Negative openness shows higher value such as valley, inside of crater and gully. While positive openness shows higher value such as crest, ridge and razor back. Figure 6 is conceptual diagram of positive and negative openness from Yokoyama et al., 2002. Those are shown schematically for values less than 90 degrees.

Edge line of brown and white is topographic surface. L is radial limit of calculation for chosen points (P1 and P2) on a DEM.

SLIDE 6: In the automated, custom arcpy toolbox I created, a RRIM is created by making three derivatives from an elevation DEM and then blending them together. Two of these are topographic openness and are not native to ArcGIS Pro. But there is a collection of .pyt tools created by SAGA that does this and those can be run in ArcGIS Pro just fine. So, it's totally possible to create these in ArcGIS Pro, but it requires people to download and load up the SAGA tools, then clip their elevation data, then run the tool and figure out how to do some raster math. It's not hard, but in the past this tech barrier discouraged people from creating and using them. All these steps are scriptable and that's what I did.

When the tool is launched, there is the option to use the current view extent and extract a temporary dem from the network lidar; or choose their own raster The tool creates a simple slope raster from the input. The tool accesses the SAGA tools and runs the topographic openness tool creating two separate rasters. The Raster Calculator tool subtracts the 'negative openness' from the 'positive openness' raster to create the differential openness raster. It deletes the positive and negative versions when done combining.

The tool provides a default symbolization to the two layers: slope on top, 30% transparency, and a white to red color ramp; and differential openness on bottom, white to black color ramp.

SLIDE 7: The Topographic Openness tool can be slow. It's not unusual for a full quad to take 30+ minutes of processing time. When testing the code, it would take nearly 50 minutes to run a whole quad. So I added a down sampling option which greatly reduces processing time. It recasts the lidar into 6 or 9 ft cells instead of 3 if you don't need that level of resolution.

SLIDE 8: Example inputs and output image.

SIDE 9: Since it can be easier to add tiffs to maps or take them in the field, there's the option to export all the layers as a blended tiff image.

If given some more time, I'd like to add a buffer option around the quad boundaries, so the red relief extends beyond the map boundary a little but overall, this tool works exactly as I'd hoped.

WASHINGTON STATE DEPT OF
NATURAL RESOURCES
WASHINGTON
GEOLOGICAL SURVEY

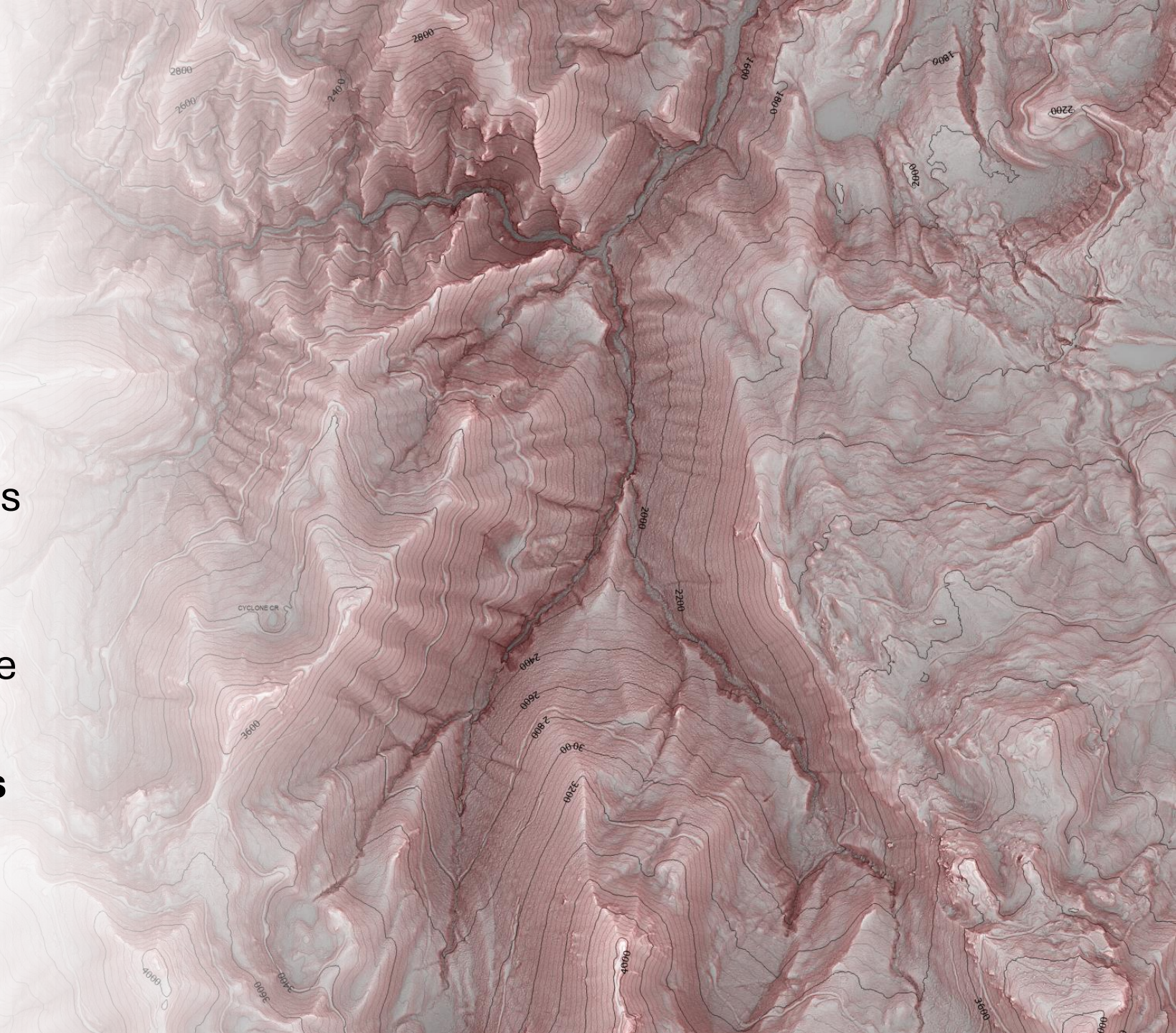
Automating and Using Red Relief Image Maps for Desktop Mapping

Blair Stuhlmuller

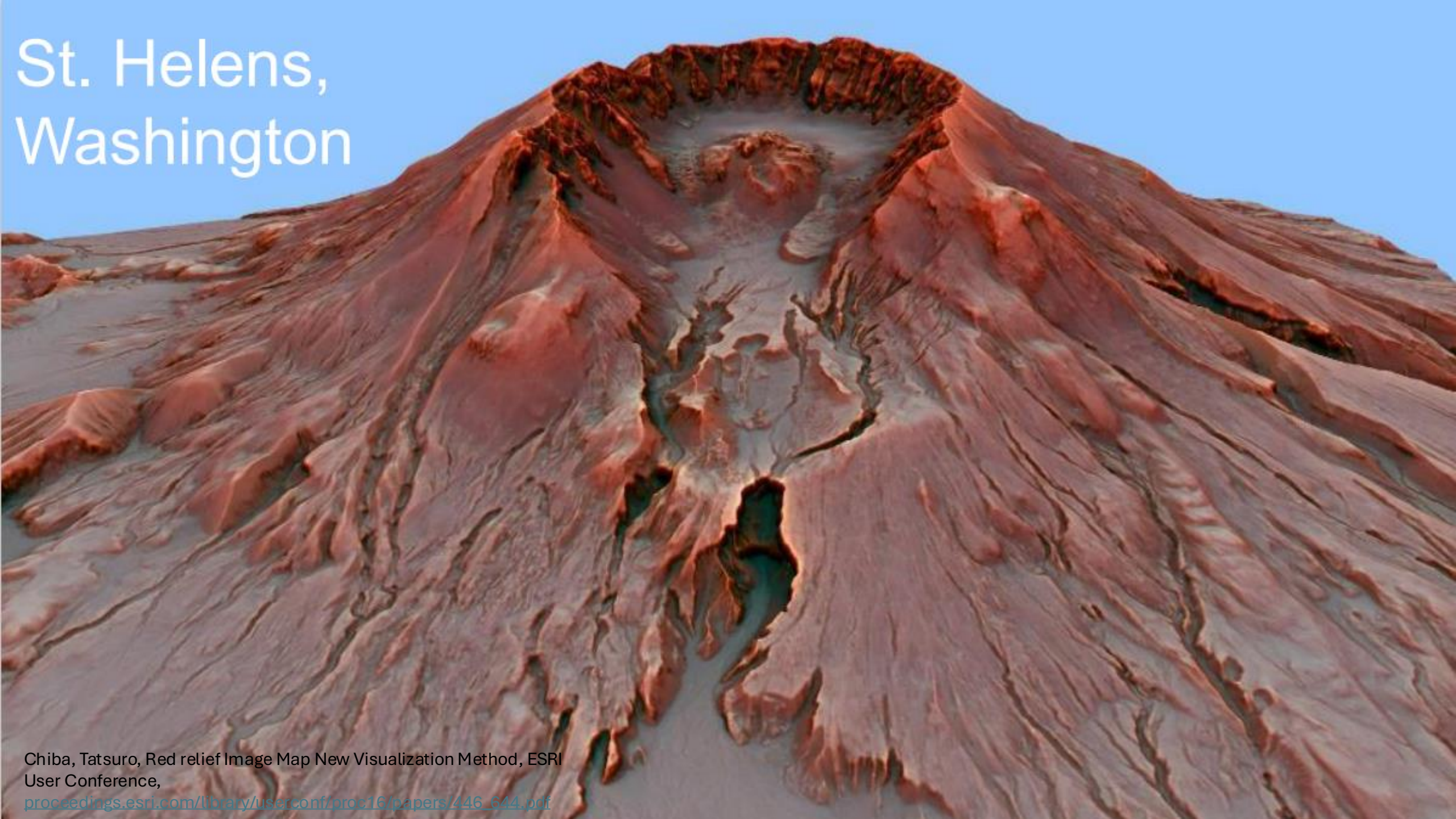
Presented at DMT'26 in Freeport, ME

What are Red Relief Image Maps?

- Helps visualize the topographic slope, concavities and convexities at the same time.
  - **Slope gradient** value is assigned a red color. The steeper, the redder.
  - **Topographic Openness** exaggerates the relief giving a 3D appearance.



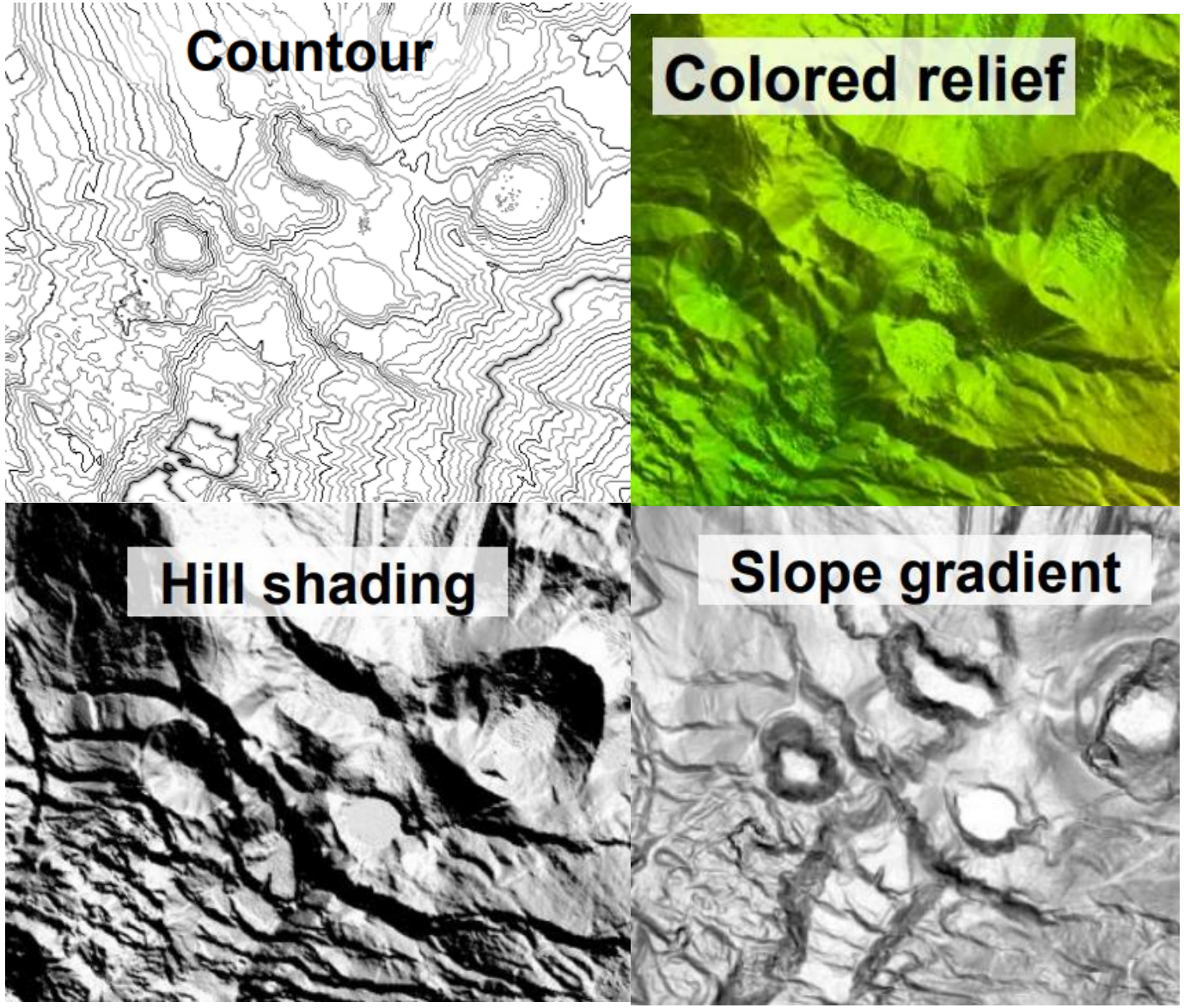
St. Helens, Washington



Chiba, Tatsuro, Red relief Image Map New Visualization Method, ESRI User Conference, proceedings.esri.com/library/userconf/proc16/papers/446_644.pdf

Limitations of Other Visualization Methods

- **Contour**→ Poor representation of smaller features on flat and very steep
- **Hill-Shade**→ Dependent on light source
- **Colored Relief**→ limited number of colors, shade can obscure smaller features
- **Slope Gradient**→ cannot always distinguish between convex and concave



How do Red Relief Image Maps Work?

- **Slope**= steeper slopes are redder
- **Positive openness (O_p)** = convexity of surface, lighter
- **Negative openness (O_n)** = concavity of surface, darker

New Parameter:

Ridge and Valley Index (I)

$$I = (O_p - O_n)/2$$

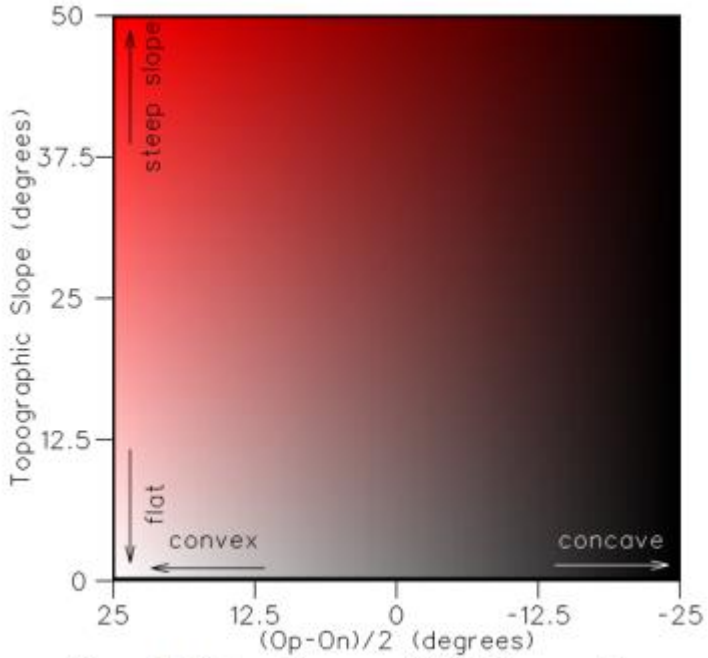


Figure 7. Colour diagram of RRIM (example).

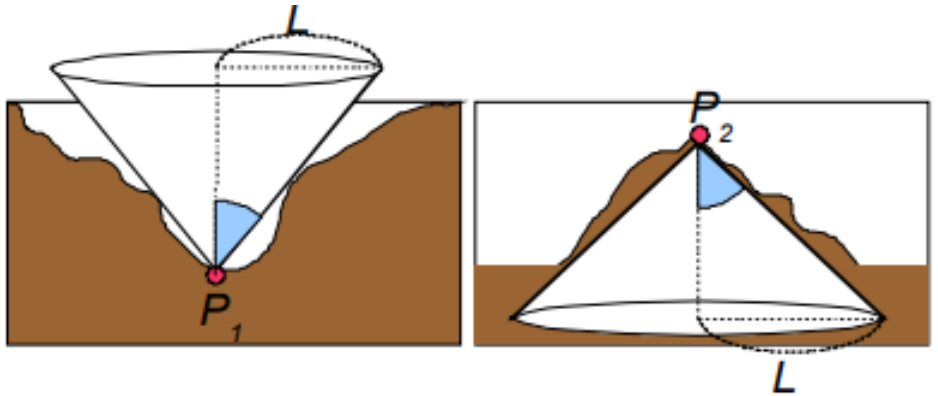
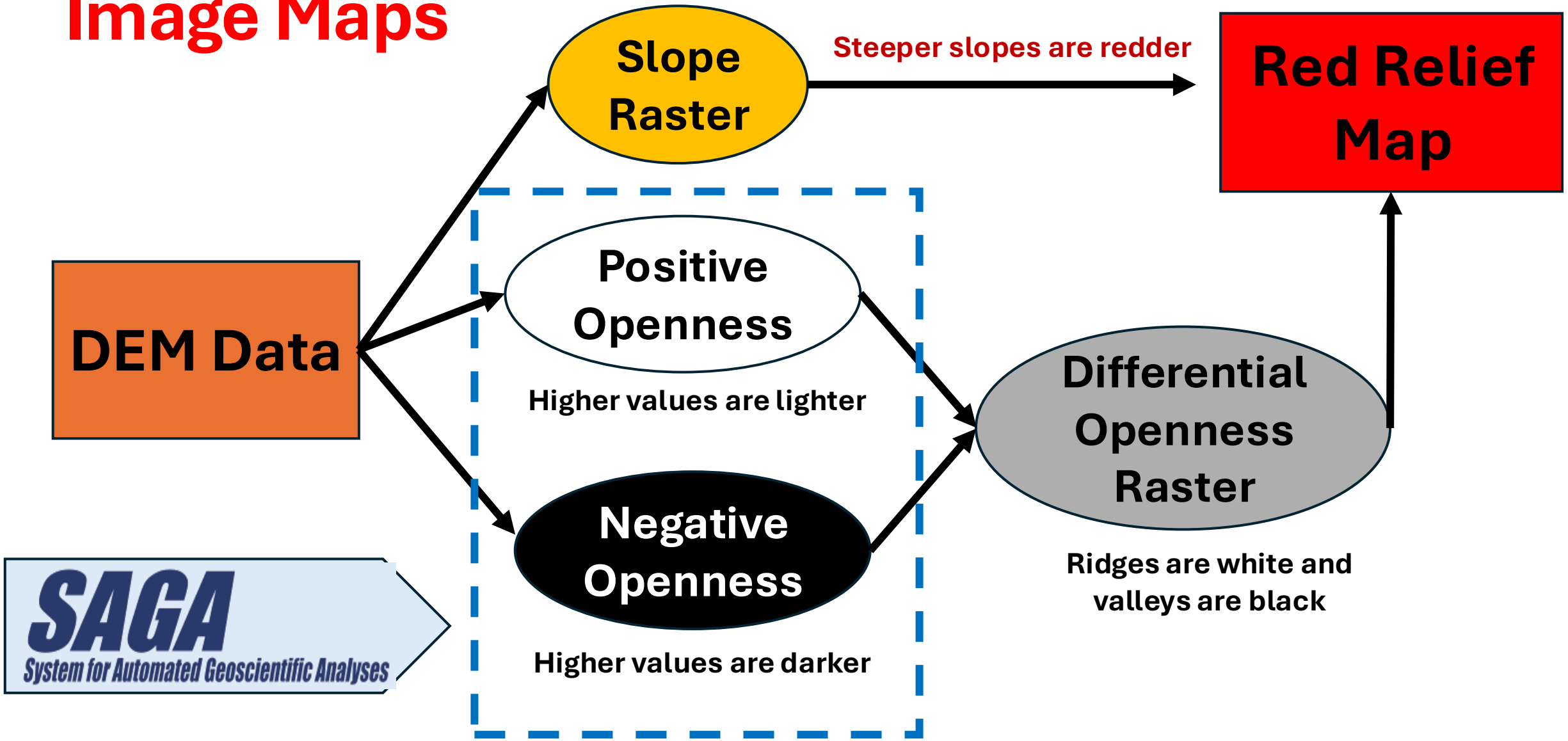


Figure 6. Conceptual diagram of positive openness (left side) and negative openness (right side).

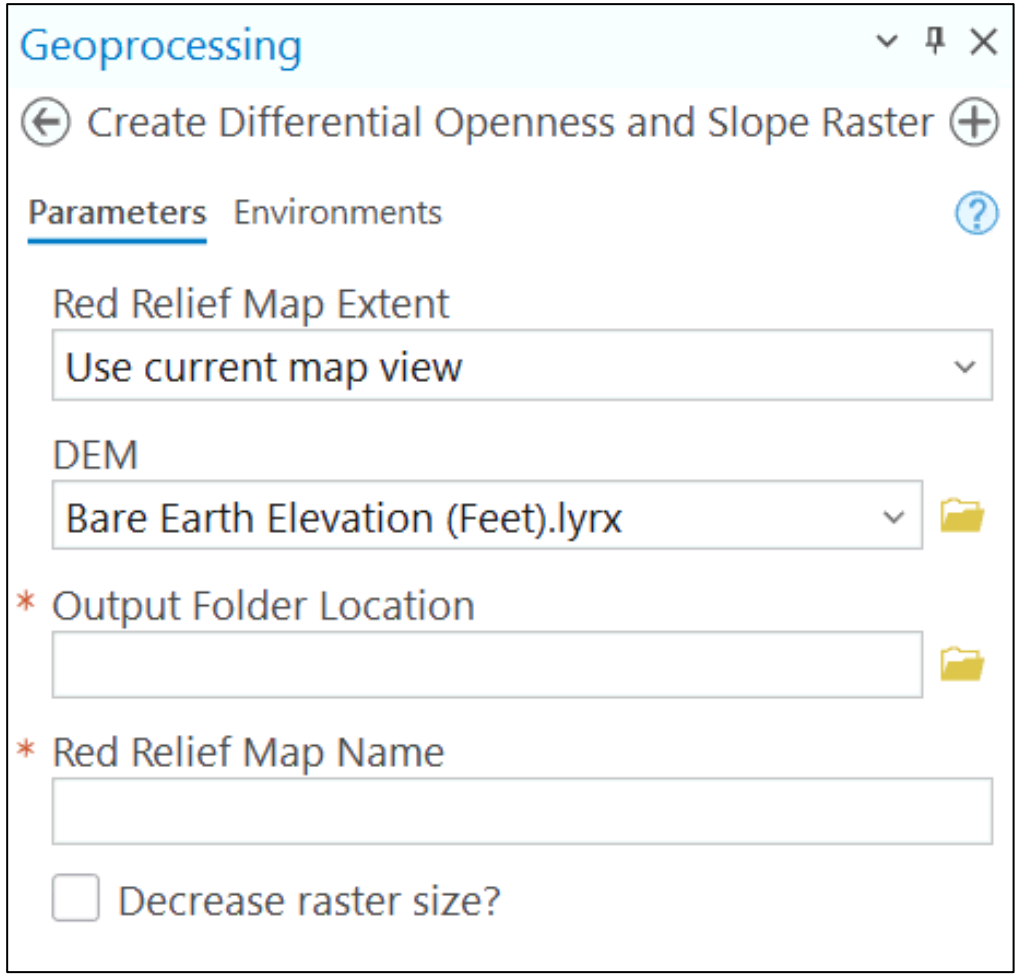
Basic Workflow for Automating Red Relief Image Maps

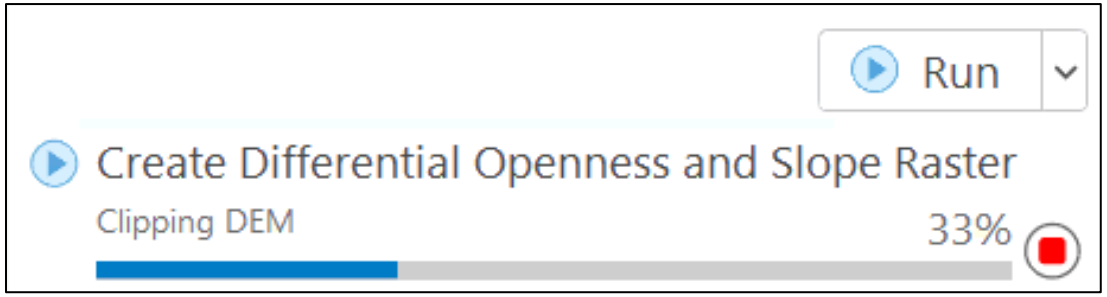


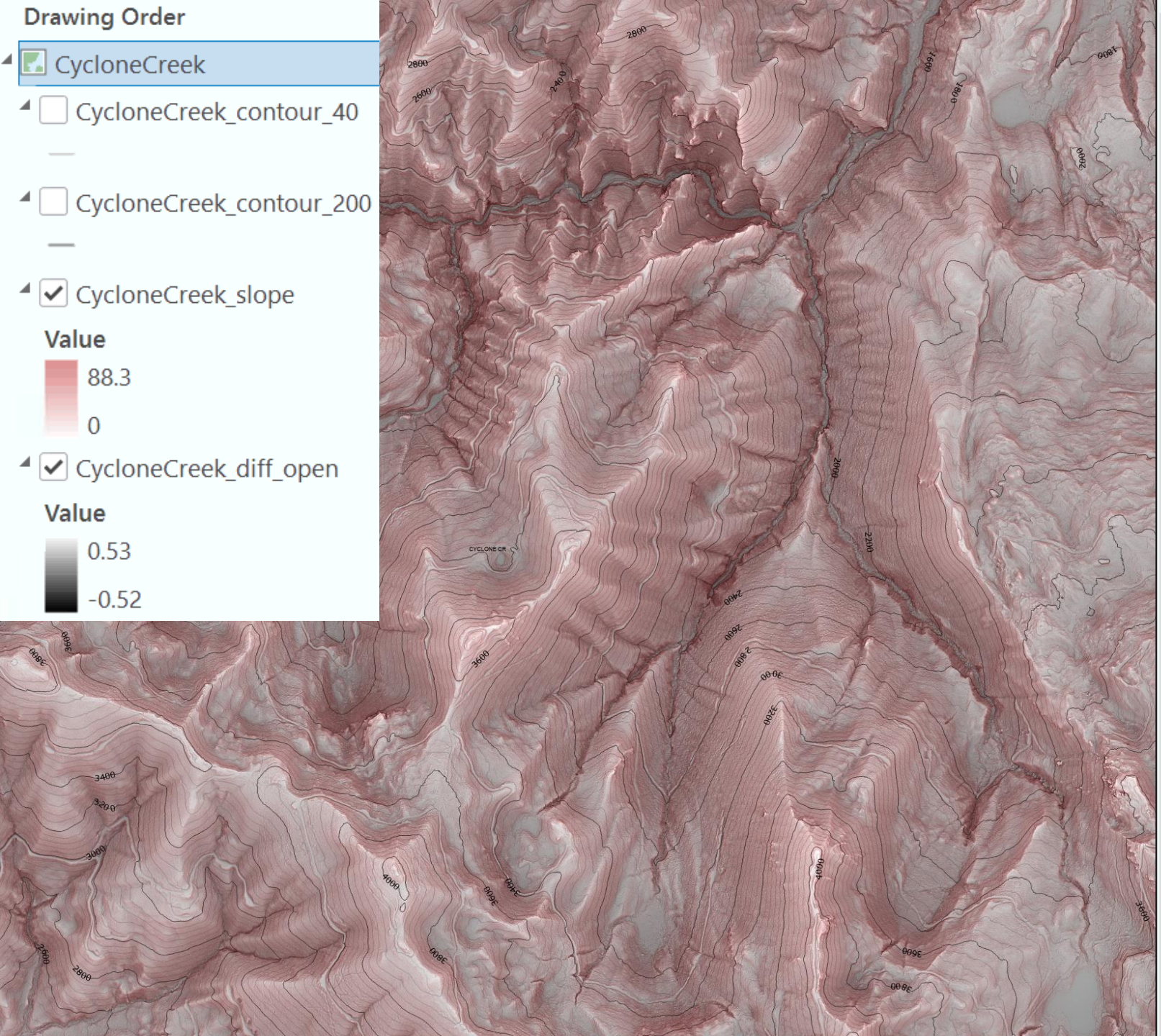
Tool 1: Creating Differential Openness and Slope Raster

The first tool creates **40ft and 200ft contour intervals**, a **Slope Raster** and a **Differential Openness Raster** from a lidar DEM clipped to the desired map extent (either current map view or a set extent feature class like a quad boundary).

It adds the created rasters to the open map view and orders and symbolizes them correctly.







Geoprocessing

Create Differential Openness and Slope Raster

Parameters Environments

Red Relief Map Extent

Use other map extent feature class

Extent Feature Class

USGS - 7.5-Min. Quad Boundaries

Use the selected records: 1

DEM

Bare Earth Elevation (Feet).lyrx

Output Folder Location

Tool Practice

Red Relief Map Name

CycloneCreek

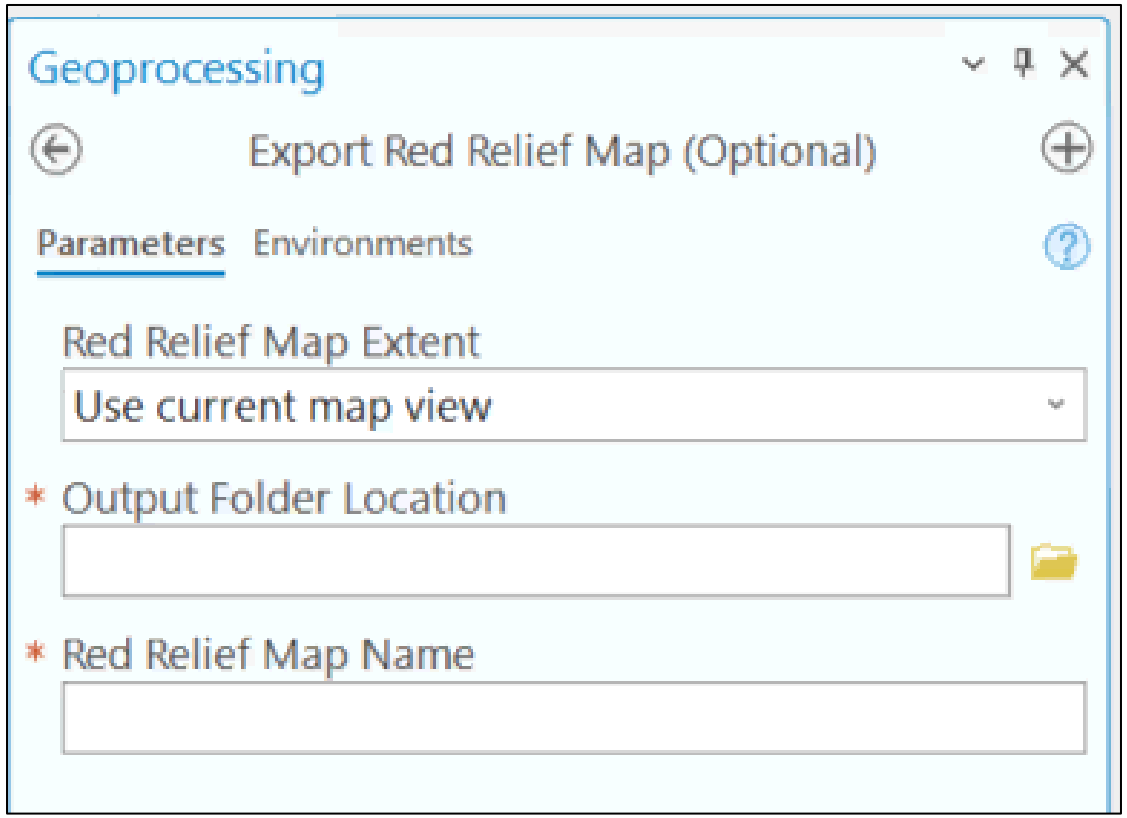
Decrease raster size?

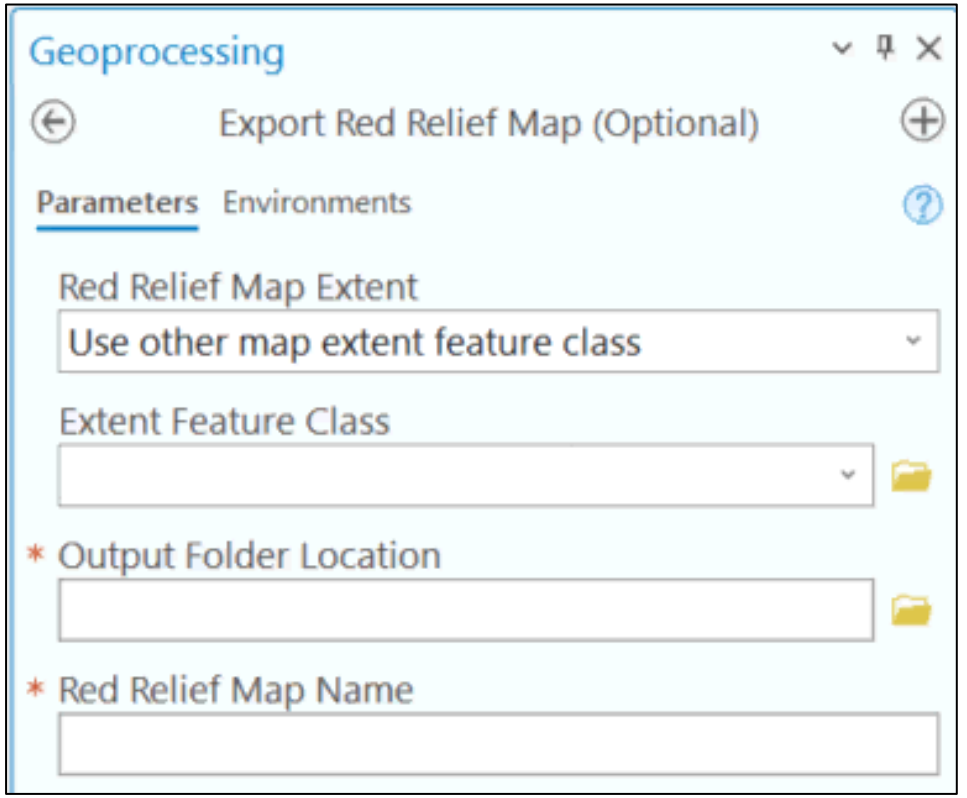
Cell Size

6

TOOL 2: Export Red Relief Map as TIFF (Optional)

This tool will combine all the **visible layers** on the screen into a single raster with the same view extent as the current map or set extent from a feature class. The final TIFF will be added to the map after the tool runs.





Resources

Chiba, Tatsuro, Red relief Image Map New Visualization Method, ESRI User Conference, proceedings.esri.com/library/userconf/proc16/papers/446_644.pdf

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Any questions?

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