CHARACTERIZATION OF LANDSLIDE-PRONE TERRAIN USING GEOGRAPHICAL INFORMATION SYSTEMS

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Department of Geological Engineering

Digital Elevation Models Useful for Landslide Inventory

1991 West Lost Trail Creek Sturzstrom Landslide Dam
Rio Grande National Forest San Juan Mountains, Colorado

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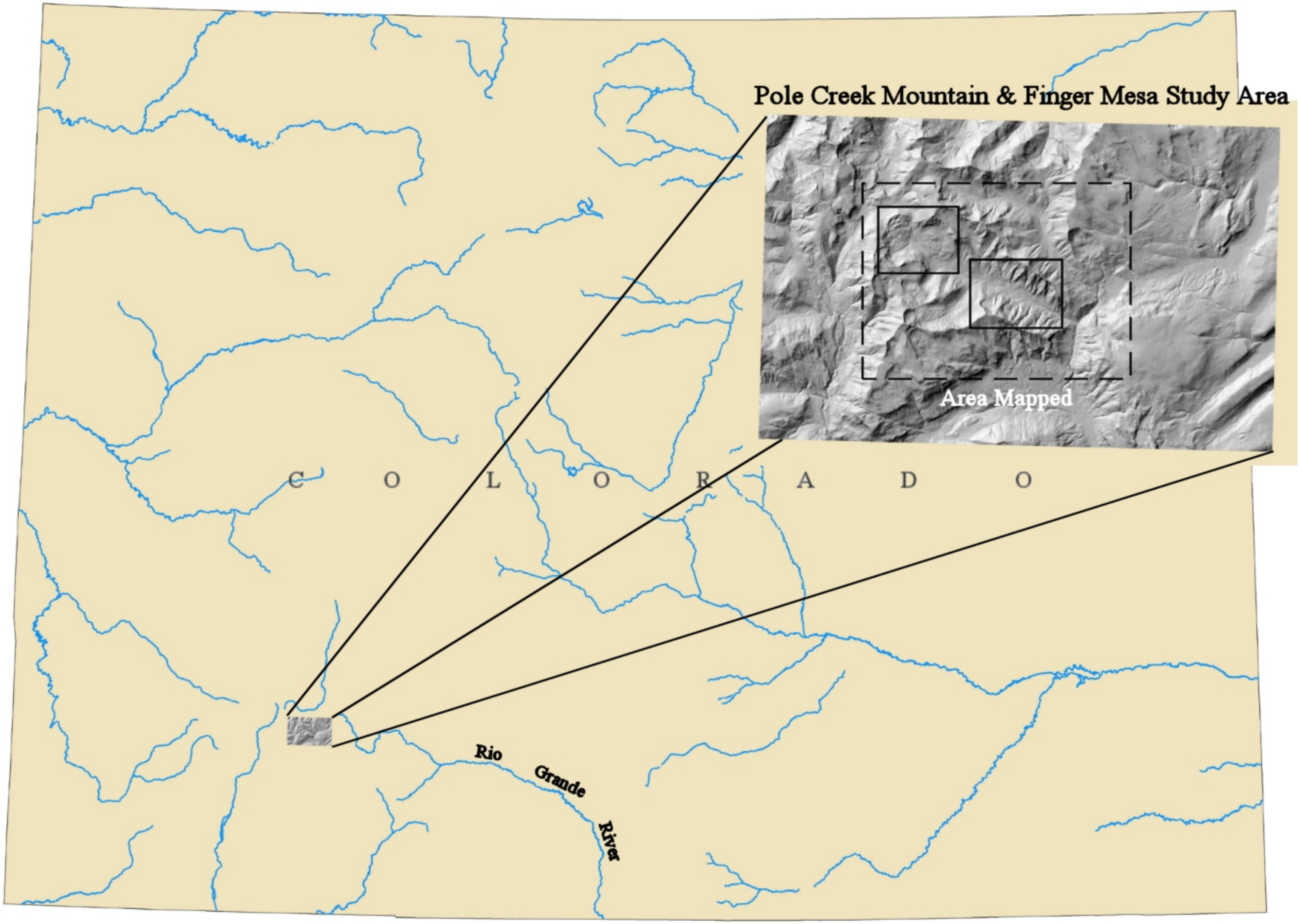
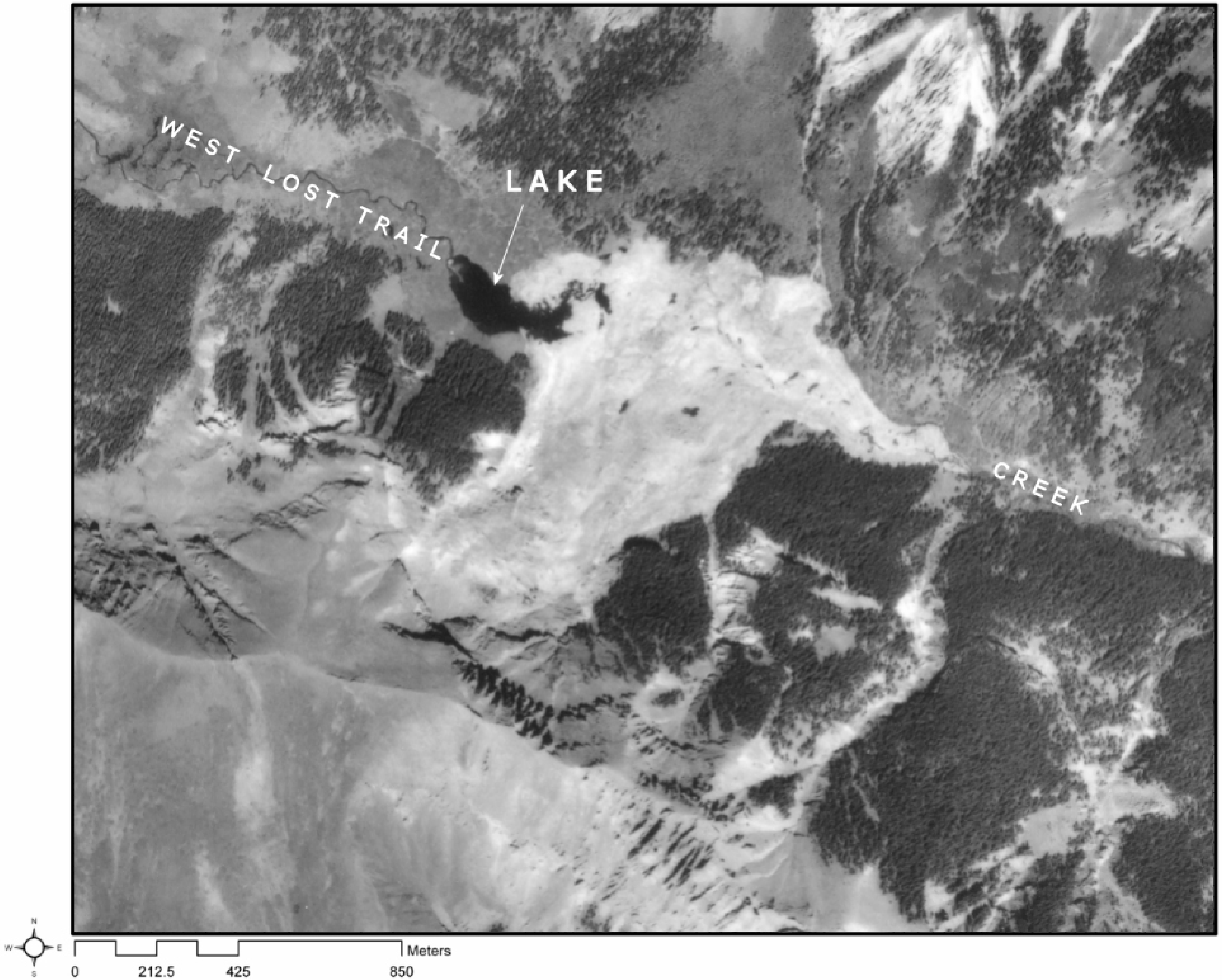
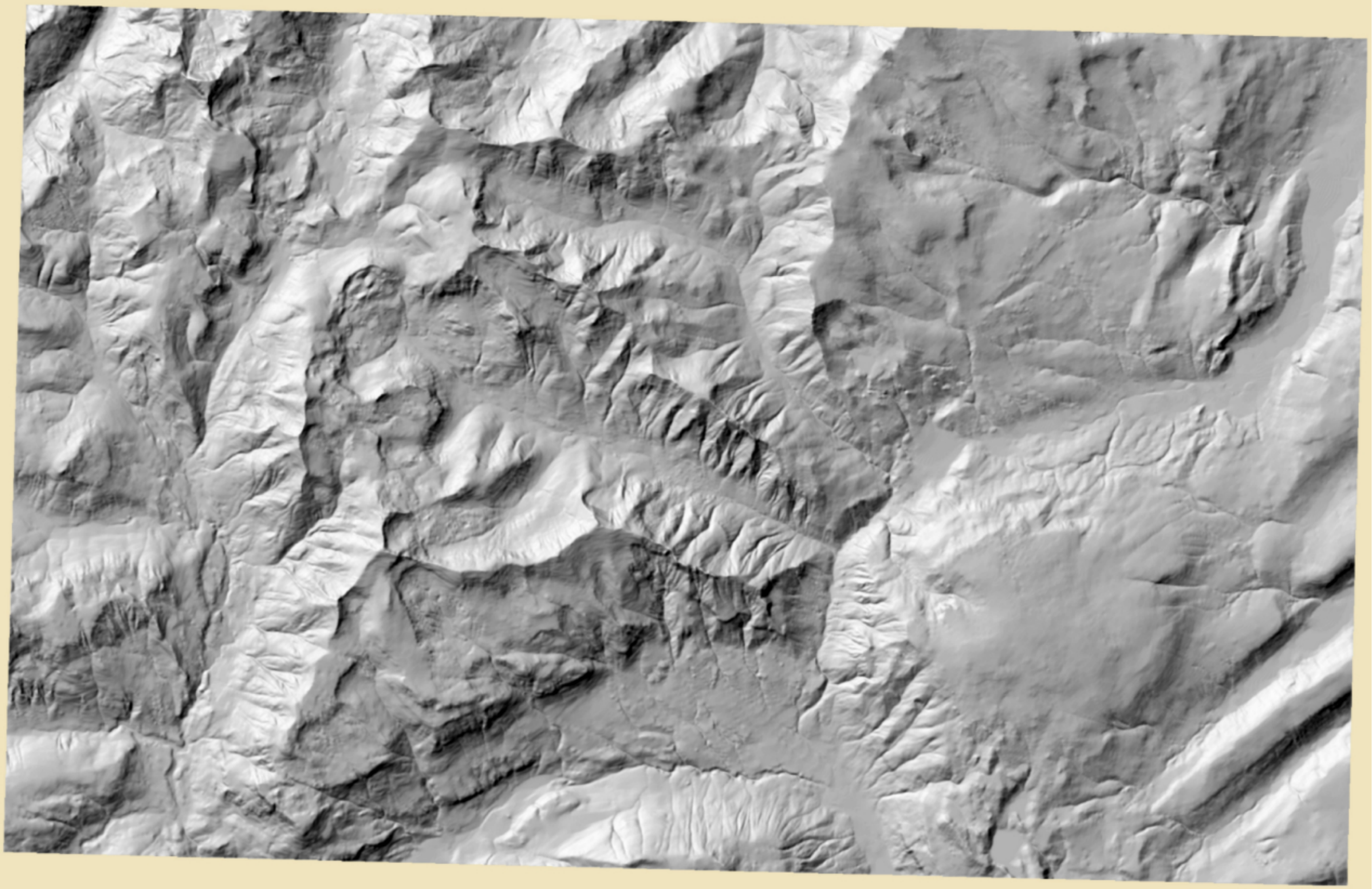


- **The 1991 West Lost Trail Creek Landslide occurred on the boundary of the Pole Creek Mountain and Finger Mesa 7.5-min quadrangles in the upper Rio Grande watershed.**

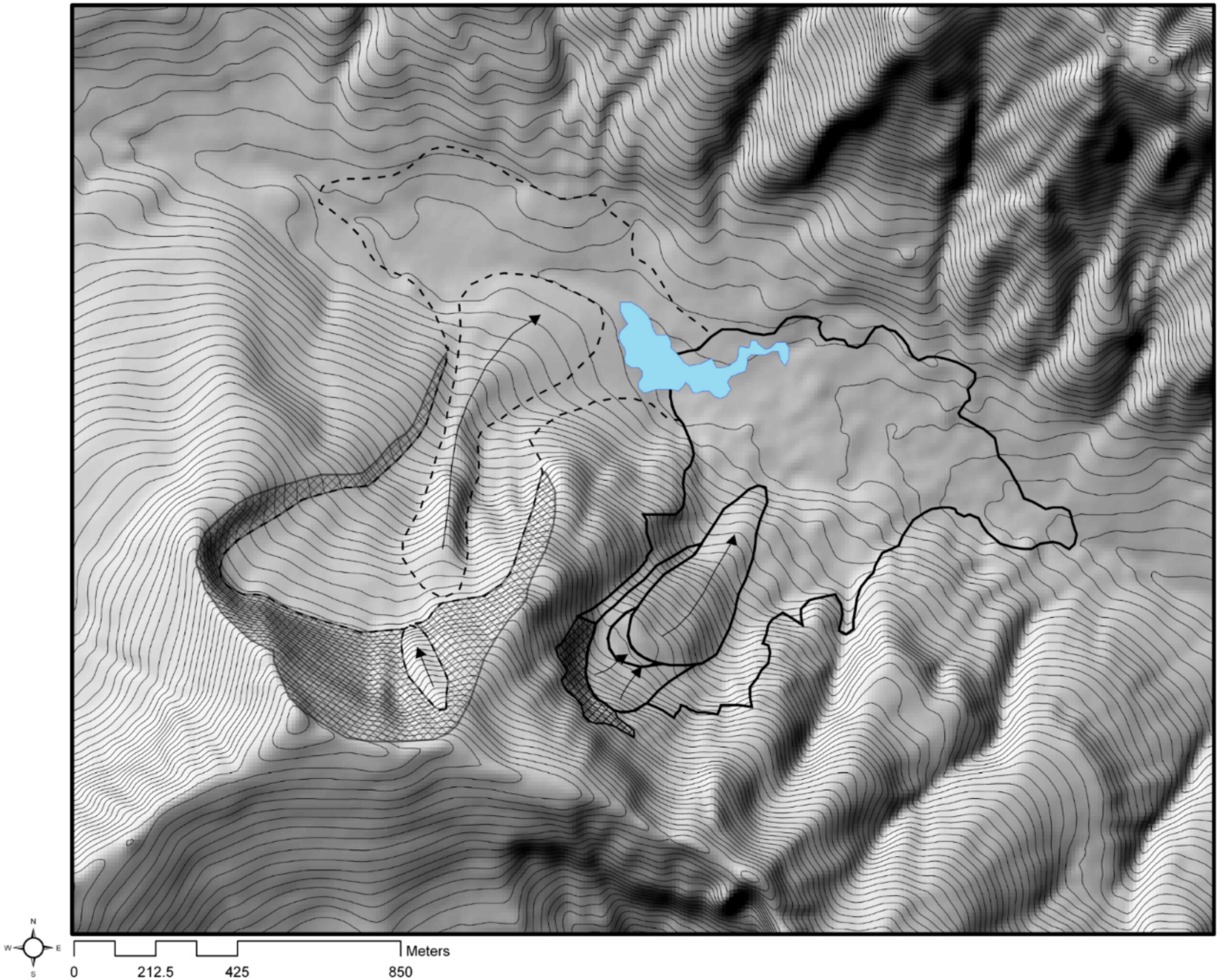


- Digital Orthophoto Quarter Quadrangle (DOQQ) from September 1998 showing the lake formed along West Lost Trail Creek and the isolated ponds throughout the debris field

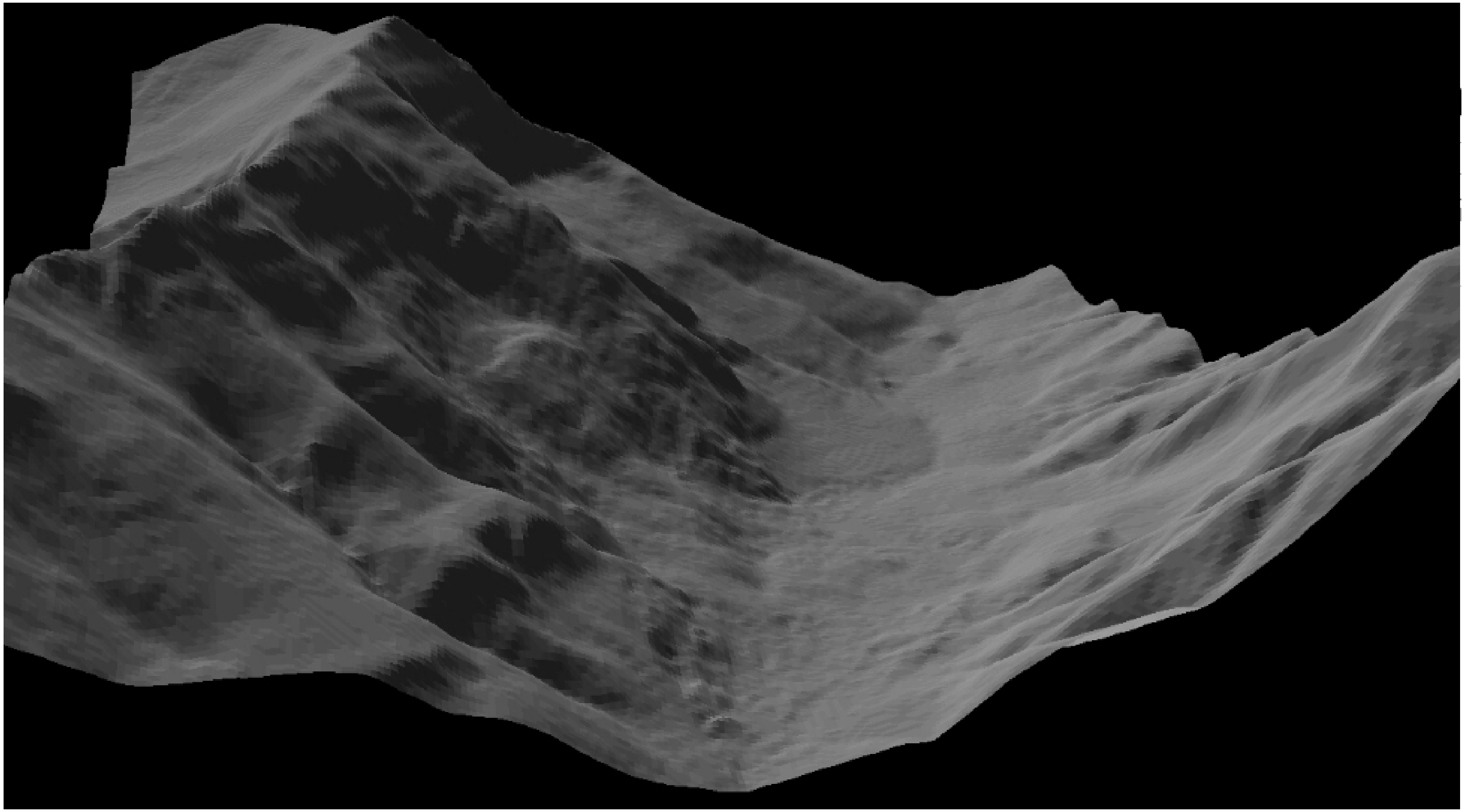


- 10 m Digital Elevation Models for the Pole Creek Mountain and Finger Mesa 7.5’ quadrangles, made from Sept 1998 photos

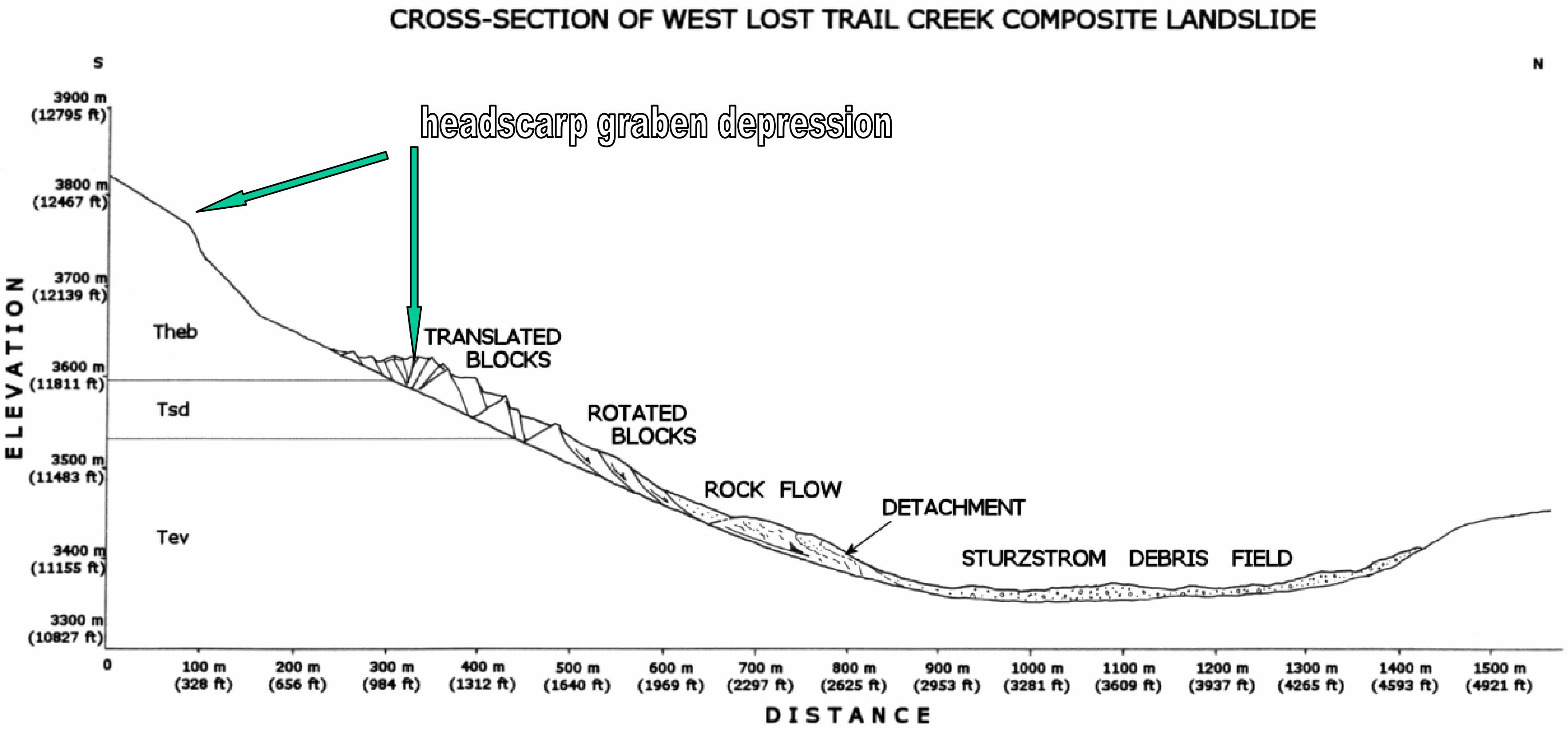
- **Landslide inventory map created on a shaded relief DEM covering 65 km² area surrounding the subject landslide (arrow)**



- These 10 m contours were rendered by using 3D Analyst subroutine of ArcGIS 8.2 The blue area is the lake formed by landslide dam
- The 1991 slide is shown by the black outline and a larger prehistoric event immediately upstream is shown by the dashed outline



- DEMs are quickly replacing aerial photos as a useful visual tool for recognition of landslide-prone terrain
- This is an oblique view of the 1991 West Lost Trail Creek landslide on the10 m DEM using MicroDEM/Terrabase II



- **Cross section through 1991 composite landslide, showing the various components. The sturzstrom occurred on the lower slope.**

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Using Topographic Expression to Identify Earthflows

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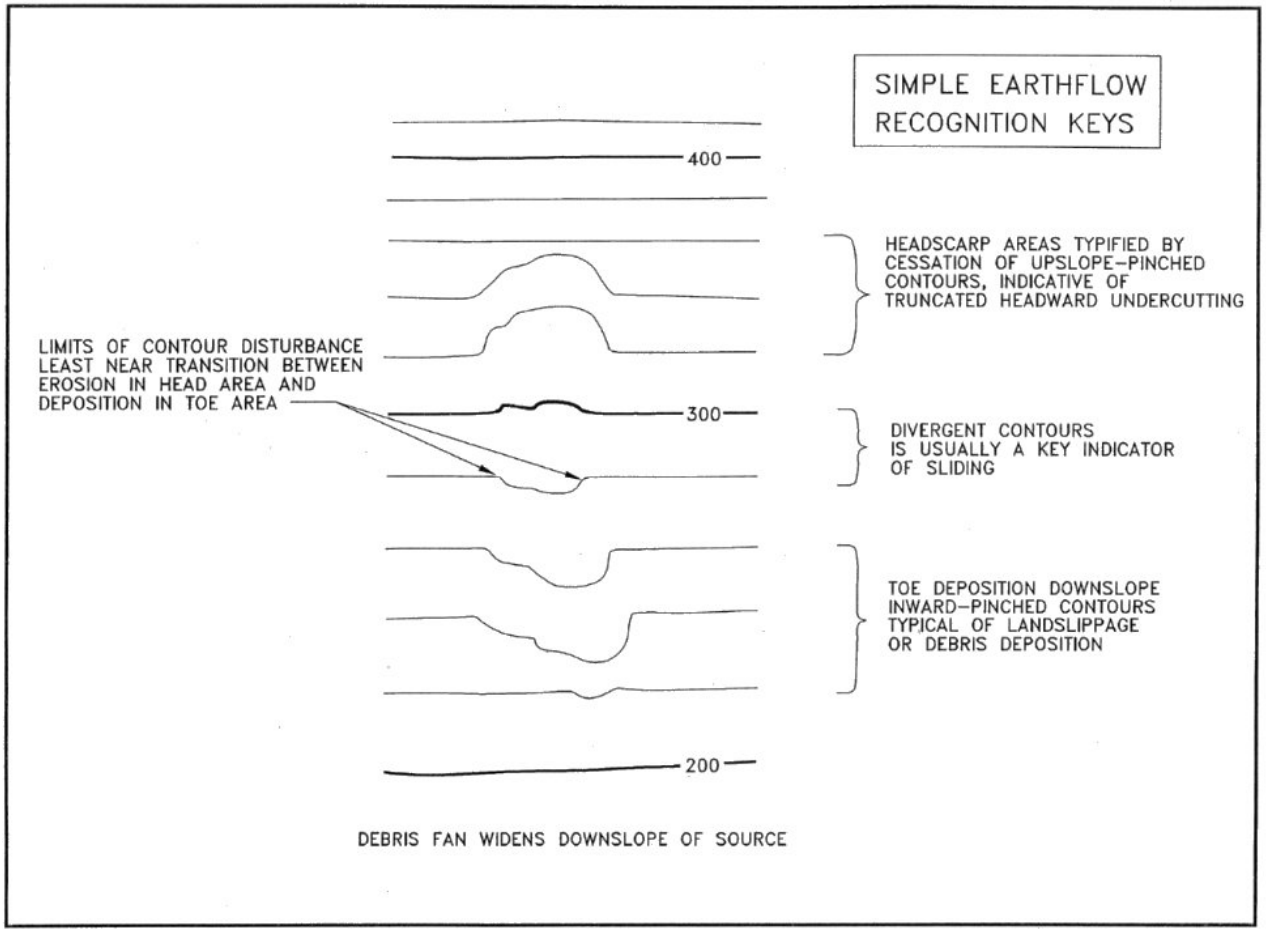
Topographic Keys for Earthflows

- Opposing contours
- Headscarp evacuation areas
- Necking down at transition between deflation/ inflation zones



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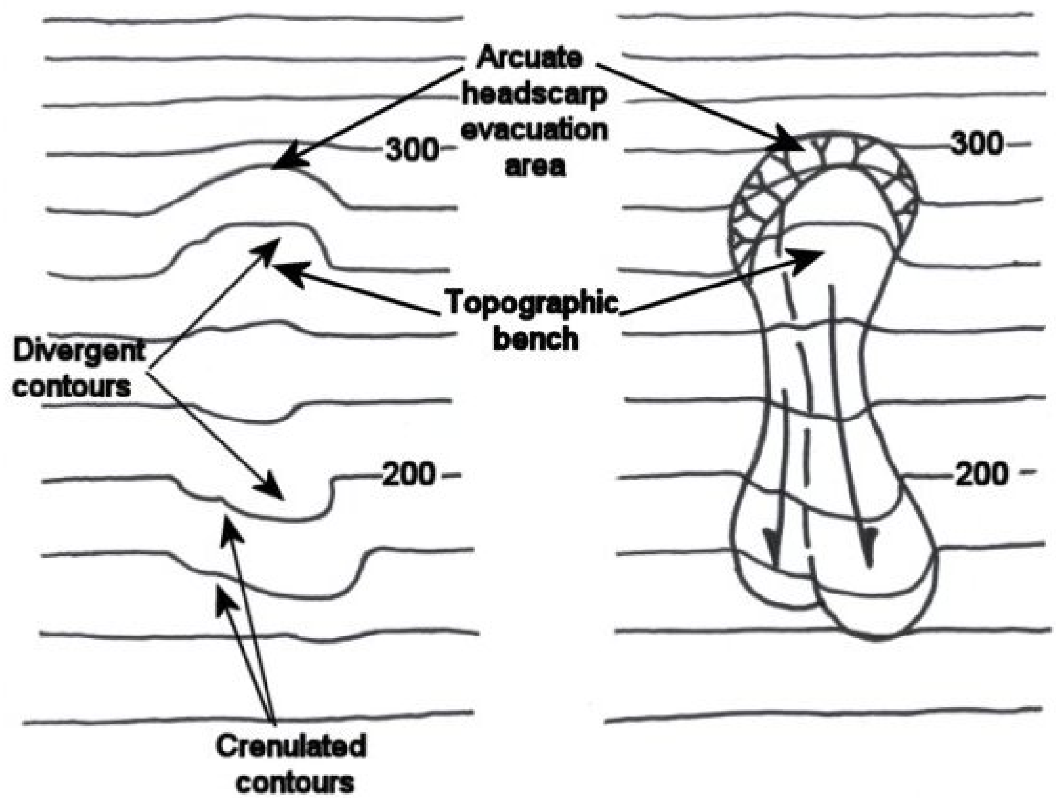
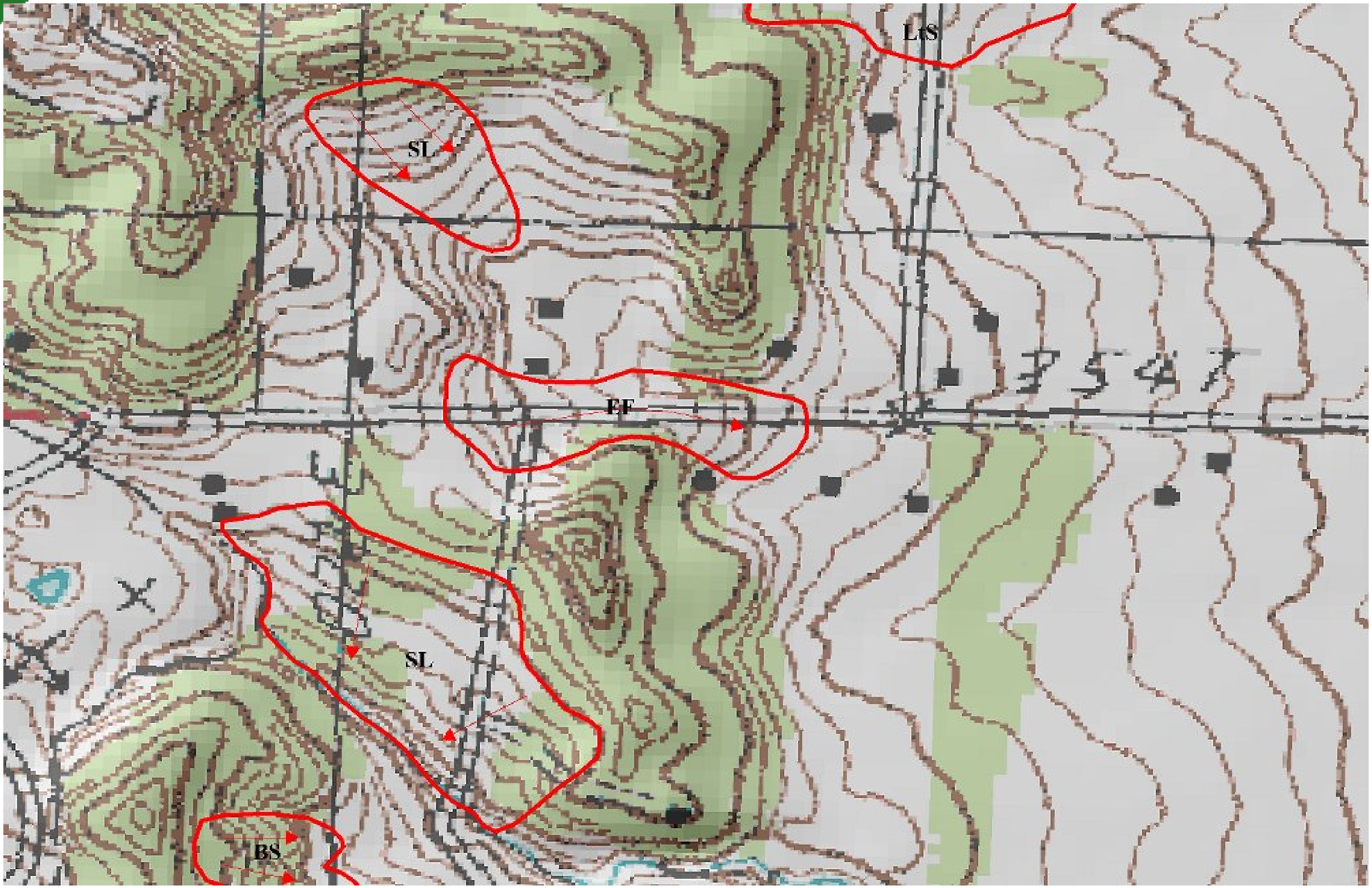
Programming a GIS to Recognize Diagnostic Topographic Patterns

- Use drainage and topographic keys to recognize anomalous site characteristics typical of landslides
  - Divergent contours
  - Crenulated contours
  - Arcuate headscarp evacuation areas
  - Isolated topographic benches





- Earthflow features mapped in the Valley Ridge area of Crowley's Ridge near Campbell, MO

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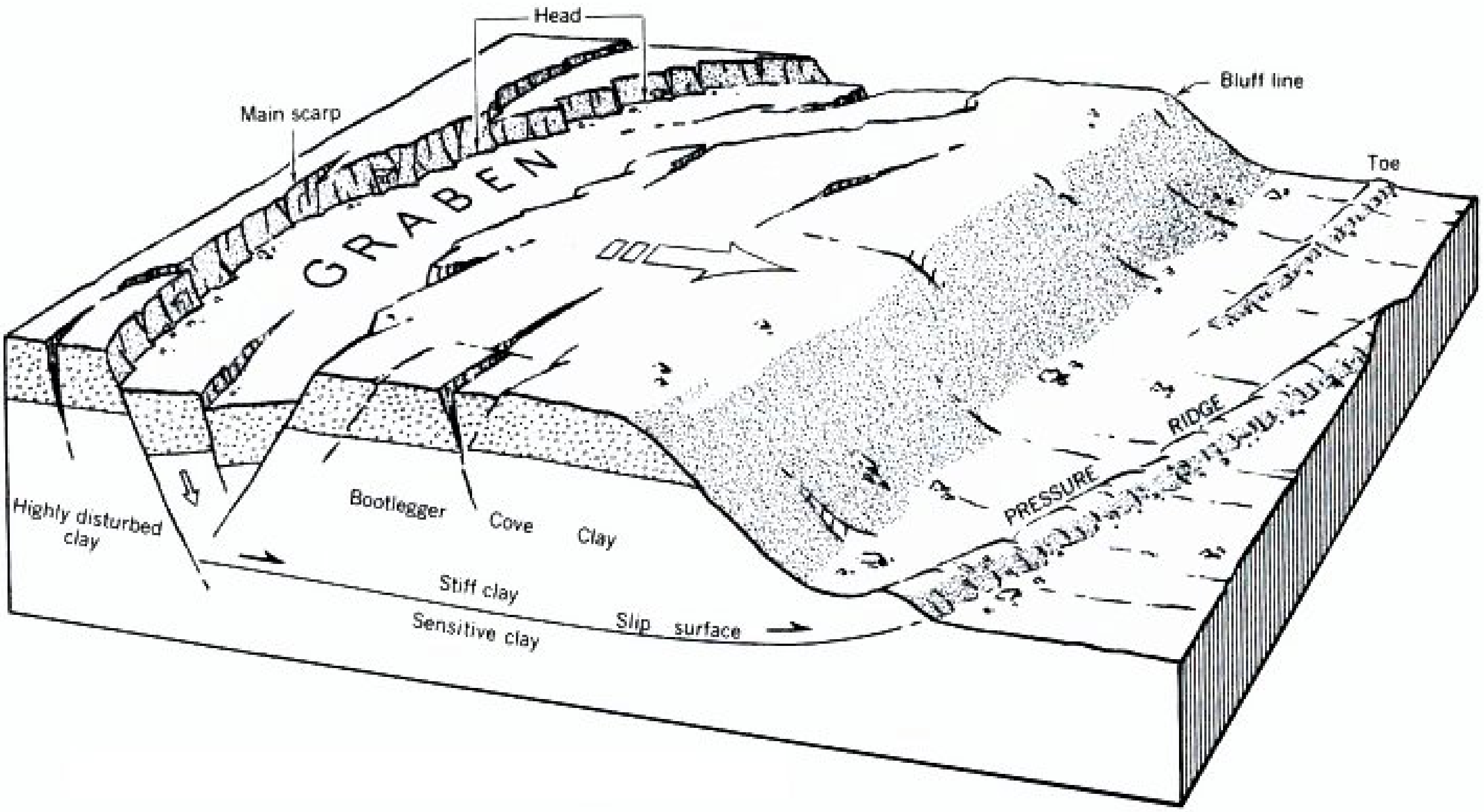
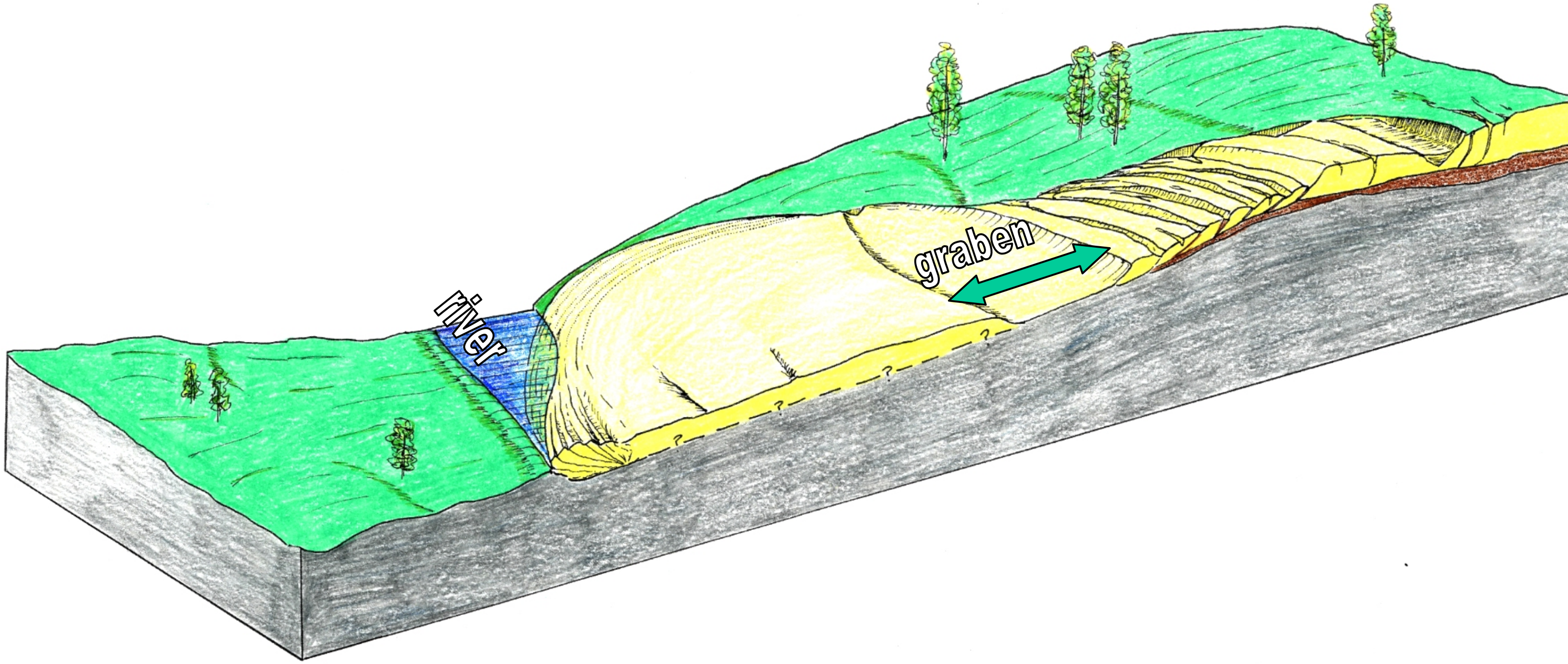
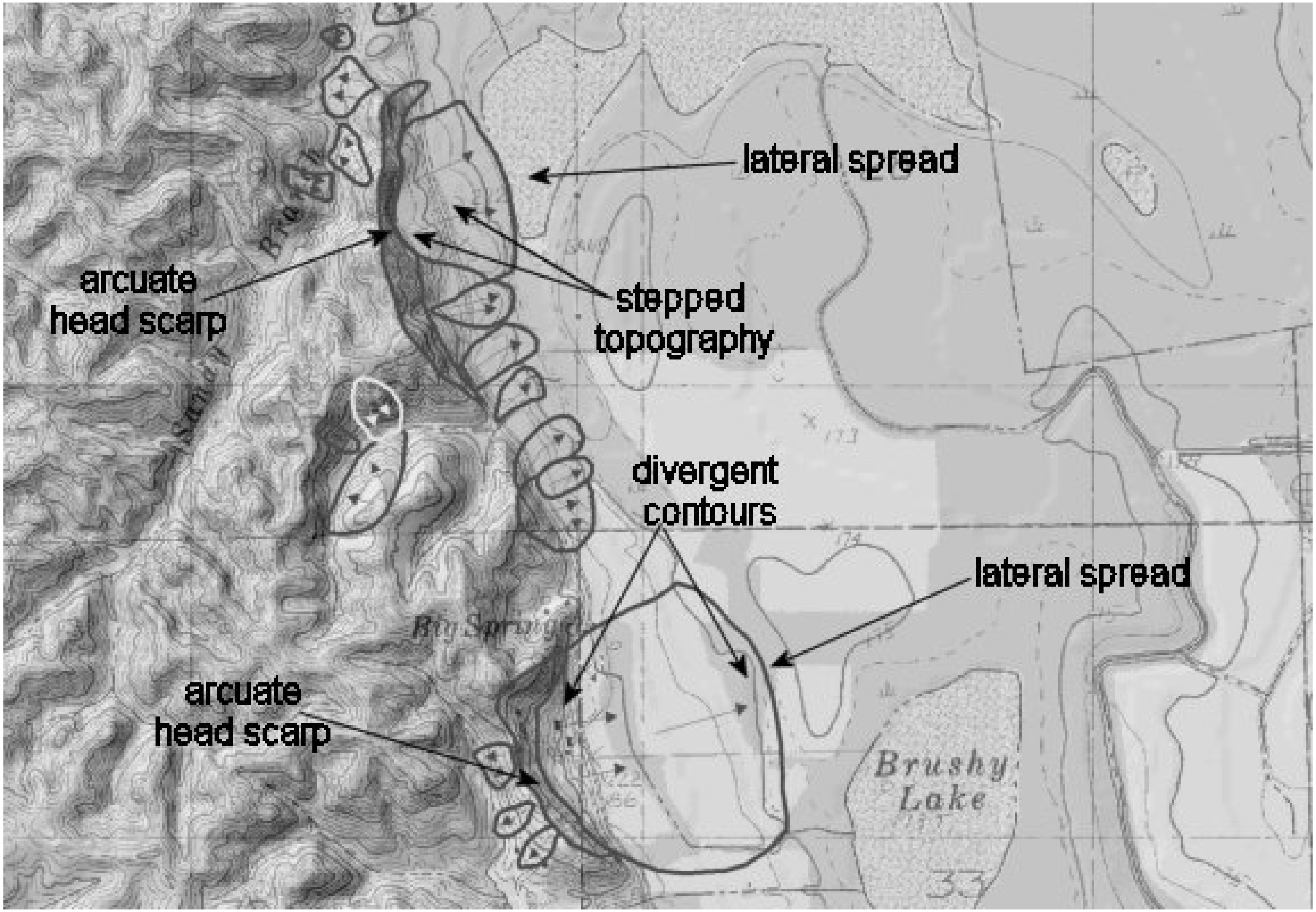
Using shaded DRGs overlain on DEMs to Search for Seismically-Induced Lateral Spreads



What causes lateral spreads?

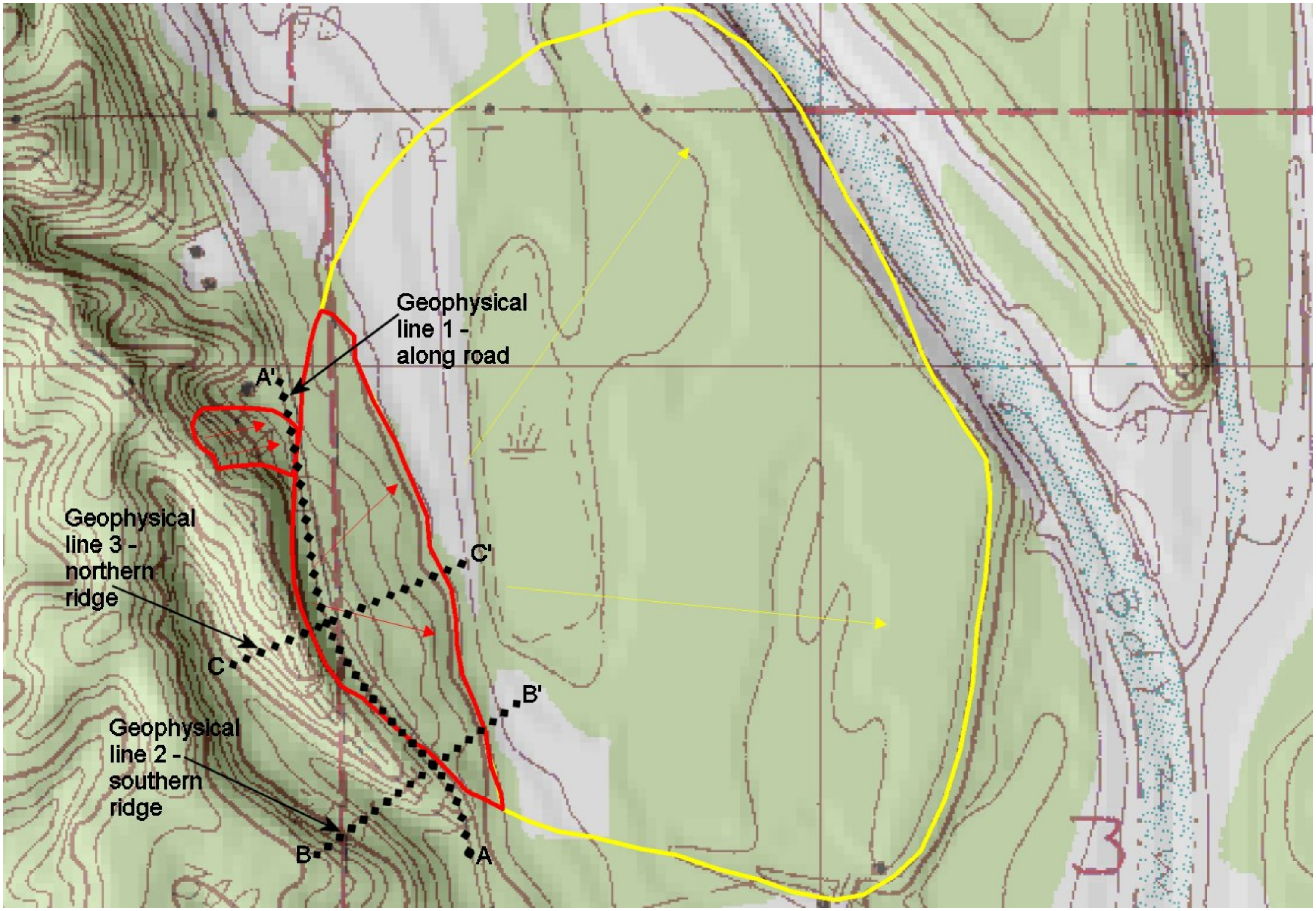


Lateral spreads are caused by liquefaction of discrete buried horizons, which allow overlying materials to "raft" towards an adjacent topographic depression, usually a body of water, such as a river, inlet or bay



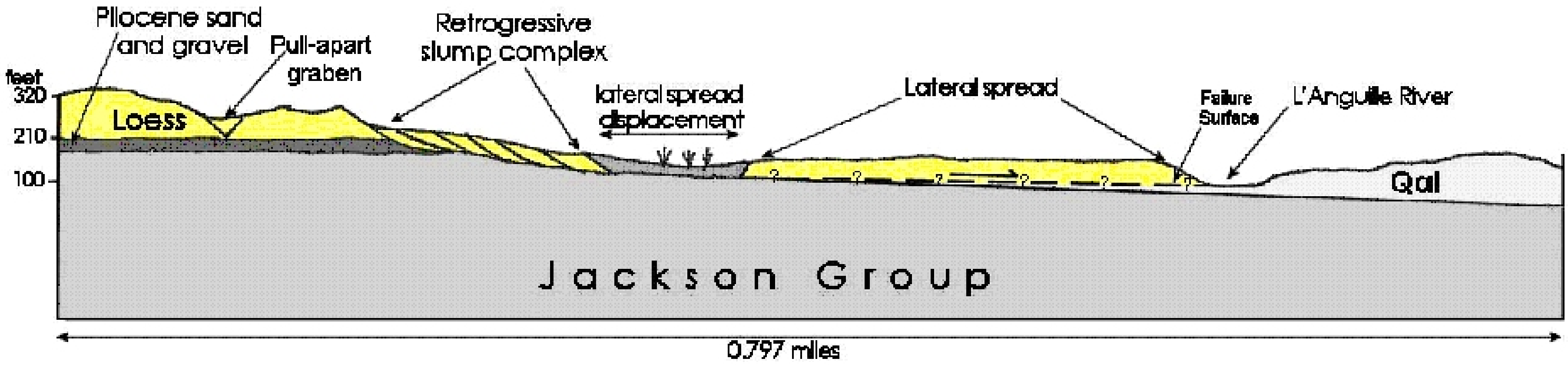
- Lateral spread features and smaller coherent translational block slides along eastern escarpment of Crowley's Ridge near Helena, Arkansas

Lateral Spread Feature near Jefferson, AR



Red outlines retrogressive slump blocks in headscarp area; black dots denote geophysical survey lines; yellow outlines the spread feature

Jefferson Lateral Spread Feature, 25 km north of Helena, Arkansas



- The Jefferson lateral spread feature is about 1.3 km long, 1.3 km wide and up to 30 m deep
- It appears to have slid in to the L'Angulle River near it's mouth with the St. Francis River.

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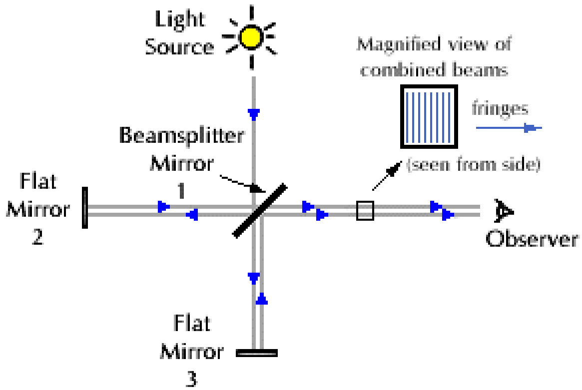
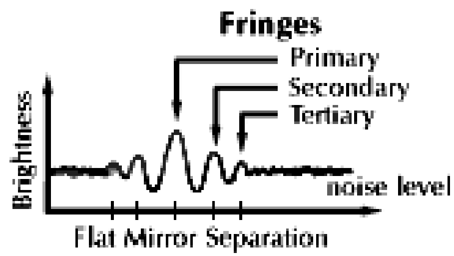
Interferrometric Synthetic Aperture Radar (INSAR)



Michelson Interferometer



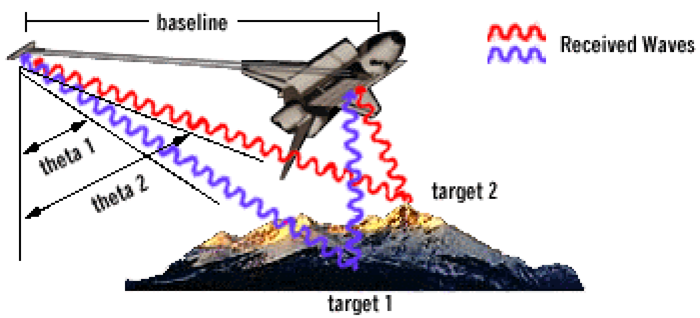
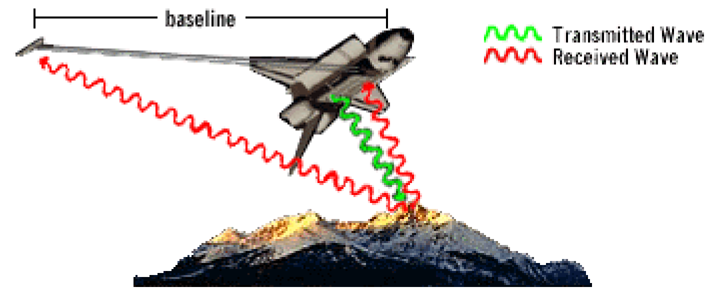


Figure 4: Differential Distance Gives Topography



Radar signals being transmitted and recieved in the SRTM mission (image not to scale).

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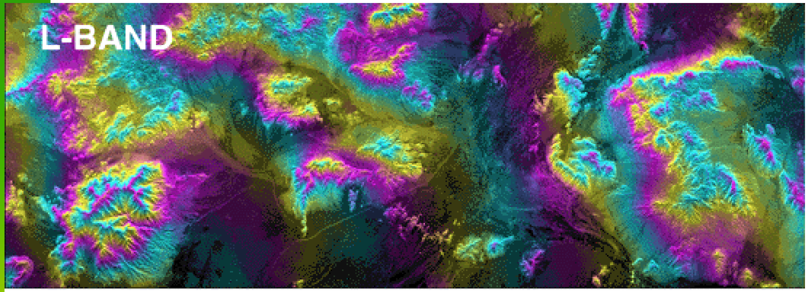
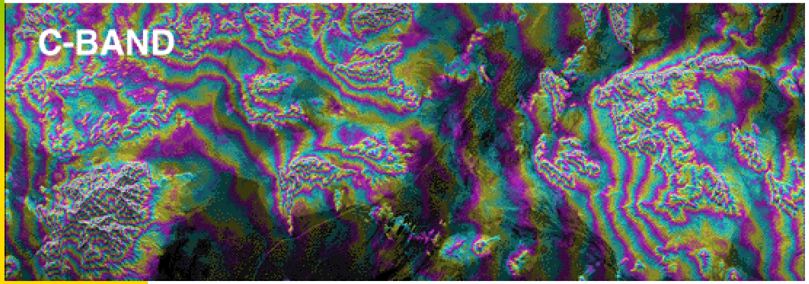
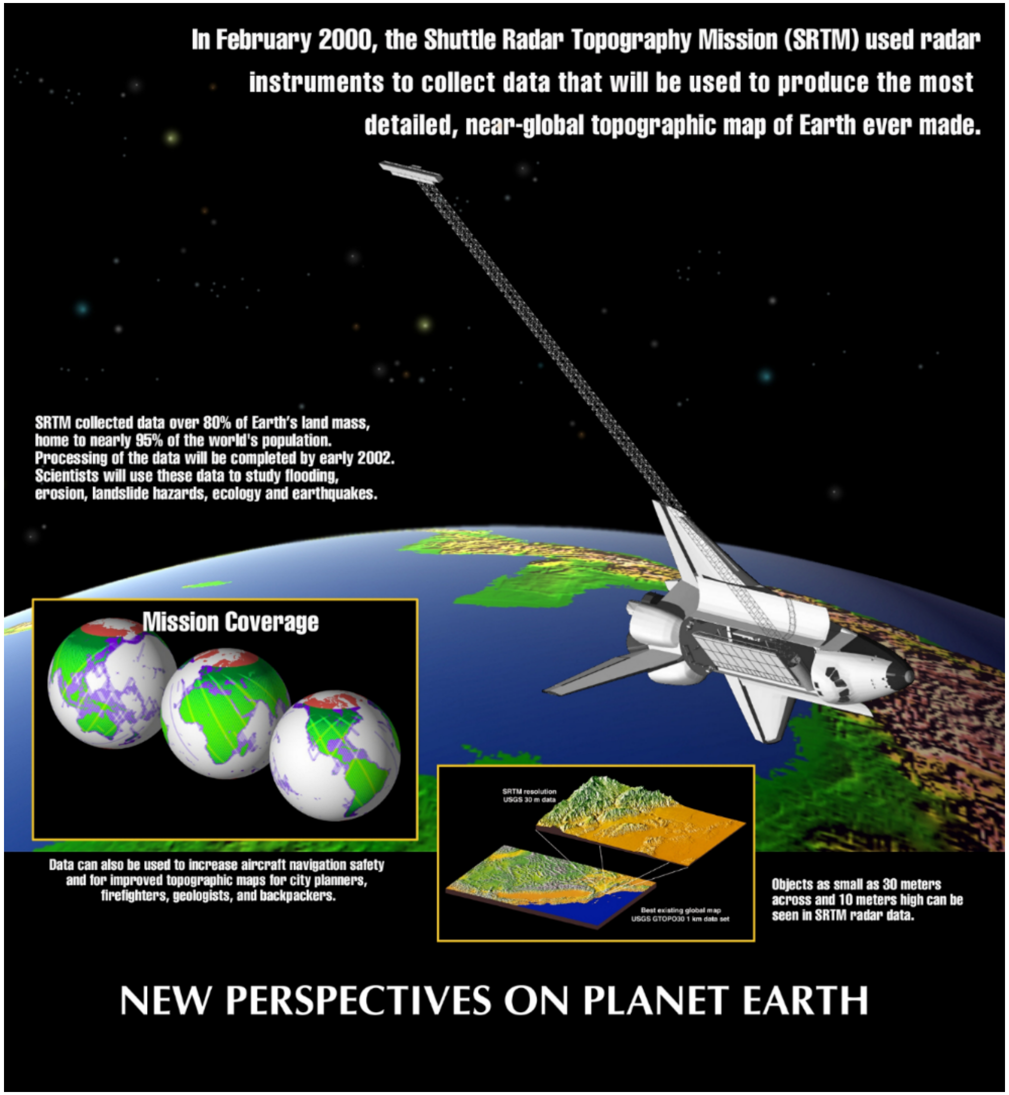
Shuttle Radar Topography Mission (SRTM) Data







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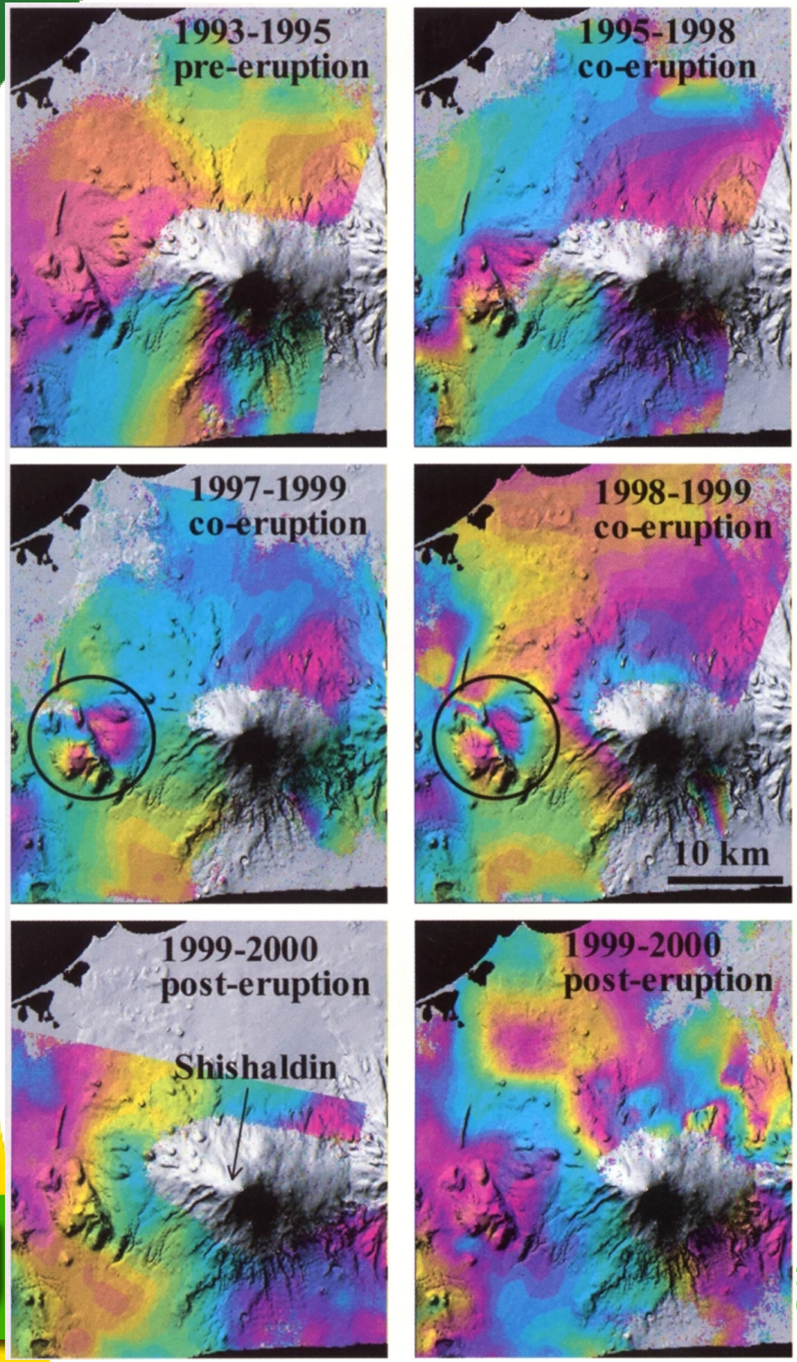

- Repeated INSAR passes allow slight variations in elevation and spatial distribution to be monitored with amazing accuracy
- Topo-removed interferograms draped over shaded DEMs of Shishaldin volcano from 1993 to 2000
- Circles indicate areas of marked elevation change

Topographic Surface Imaging Using Light Detection and Ranging (LiDAR)

2m LiDAR DEMs

Thurston County, Washington

and

1m LiDAR DEM

Salmon Creek Landslide near Twin Falls, Idaho

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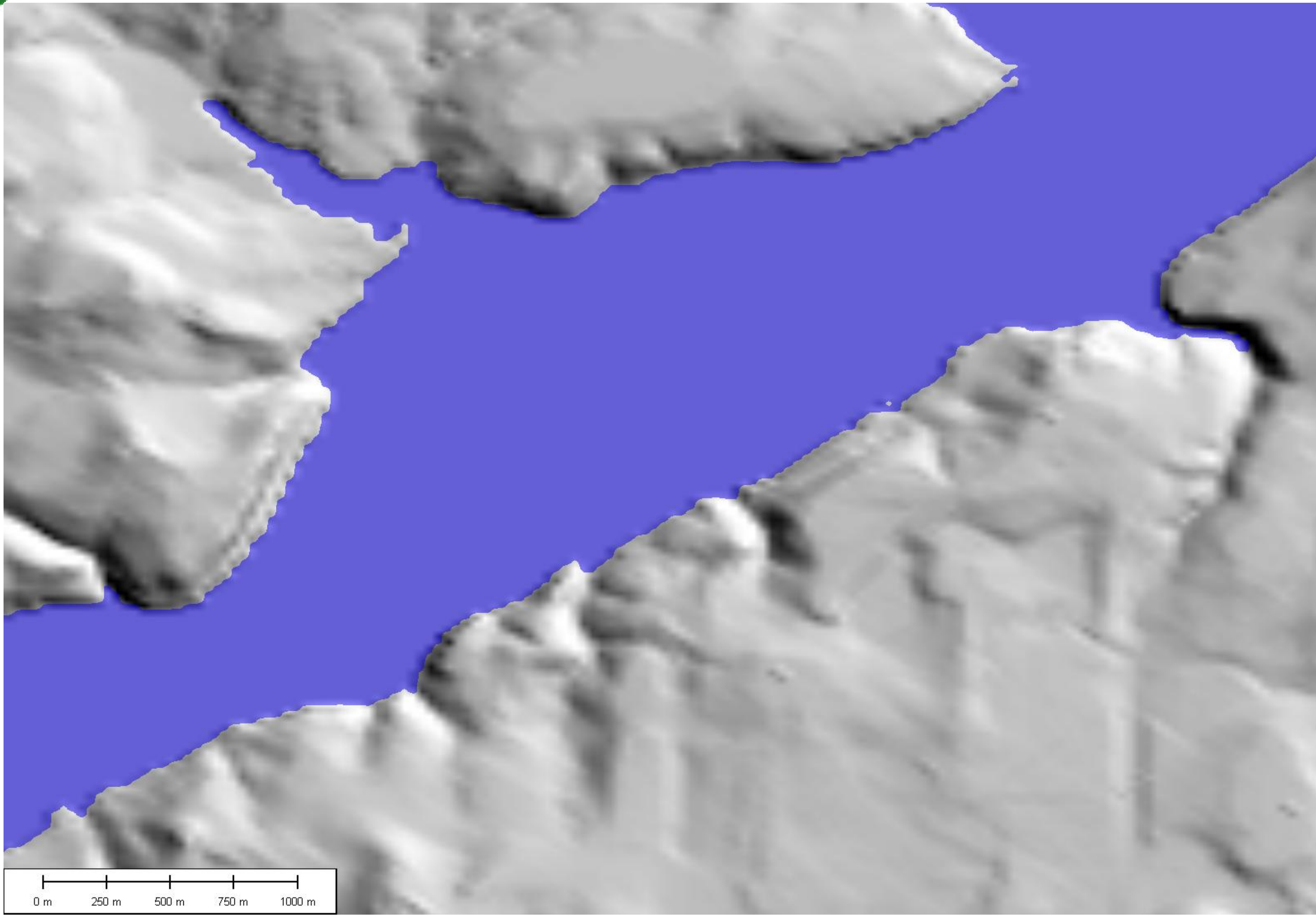

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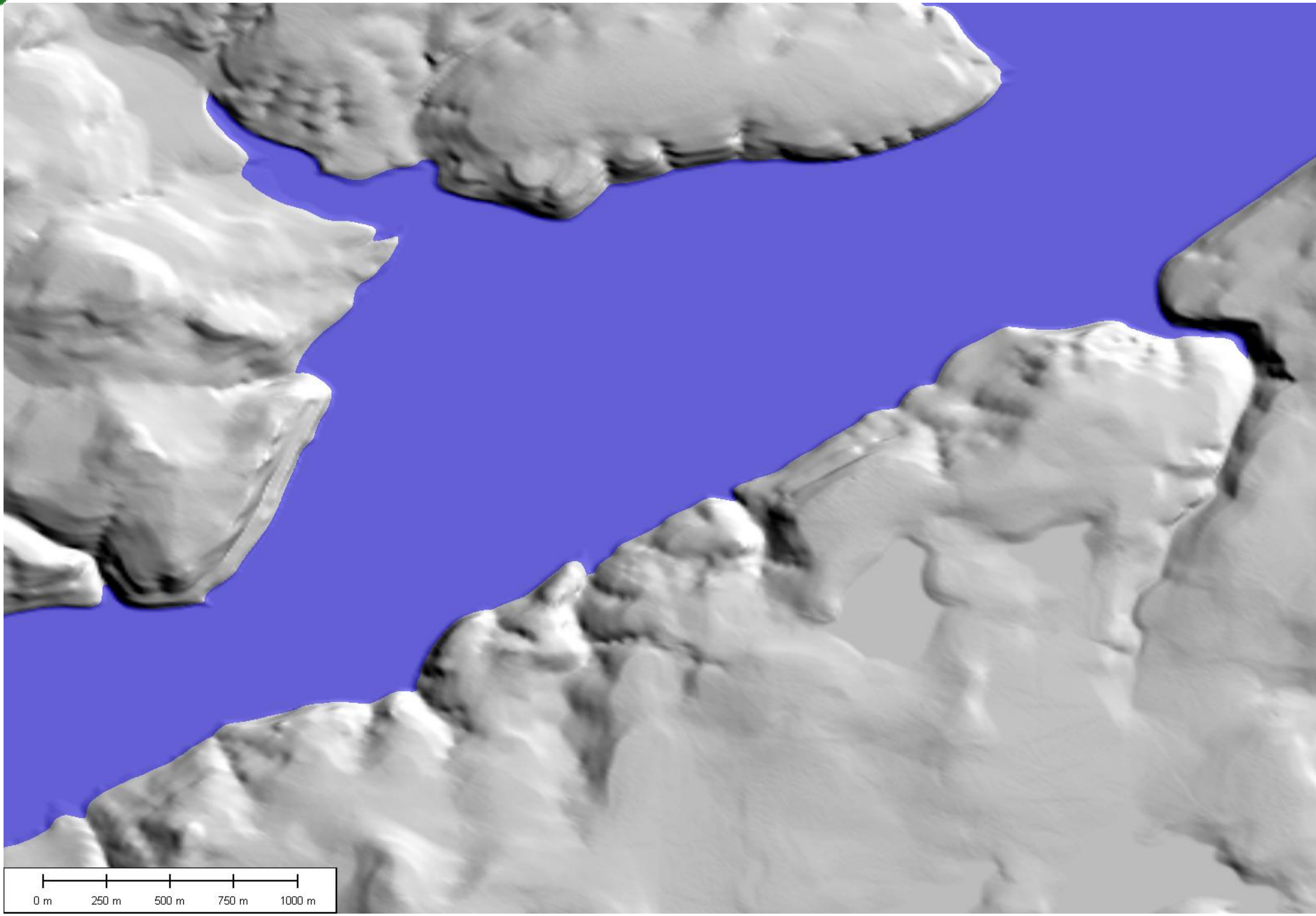
USGS 30m DEM



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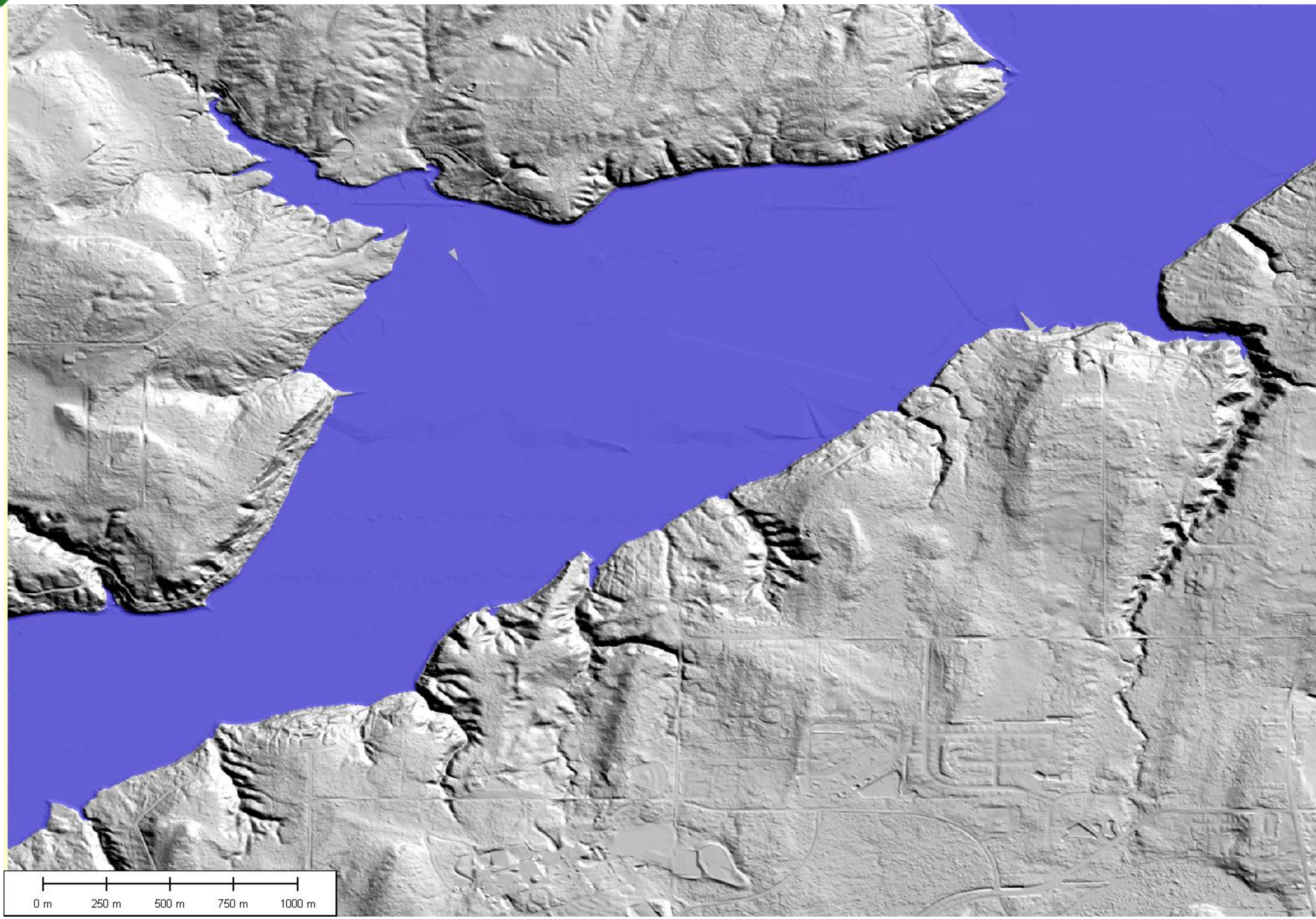
USGS 10m DEM

9X resolution of a 30m DEM



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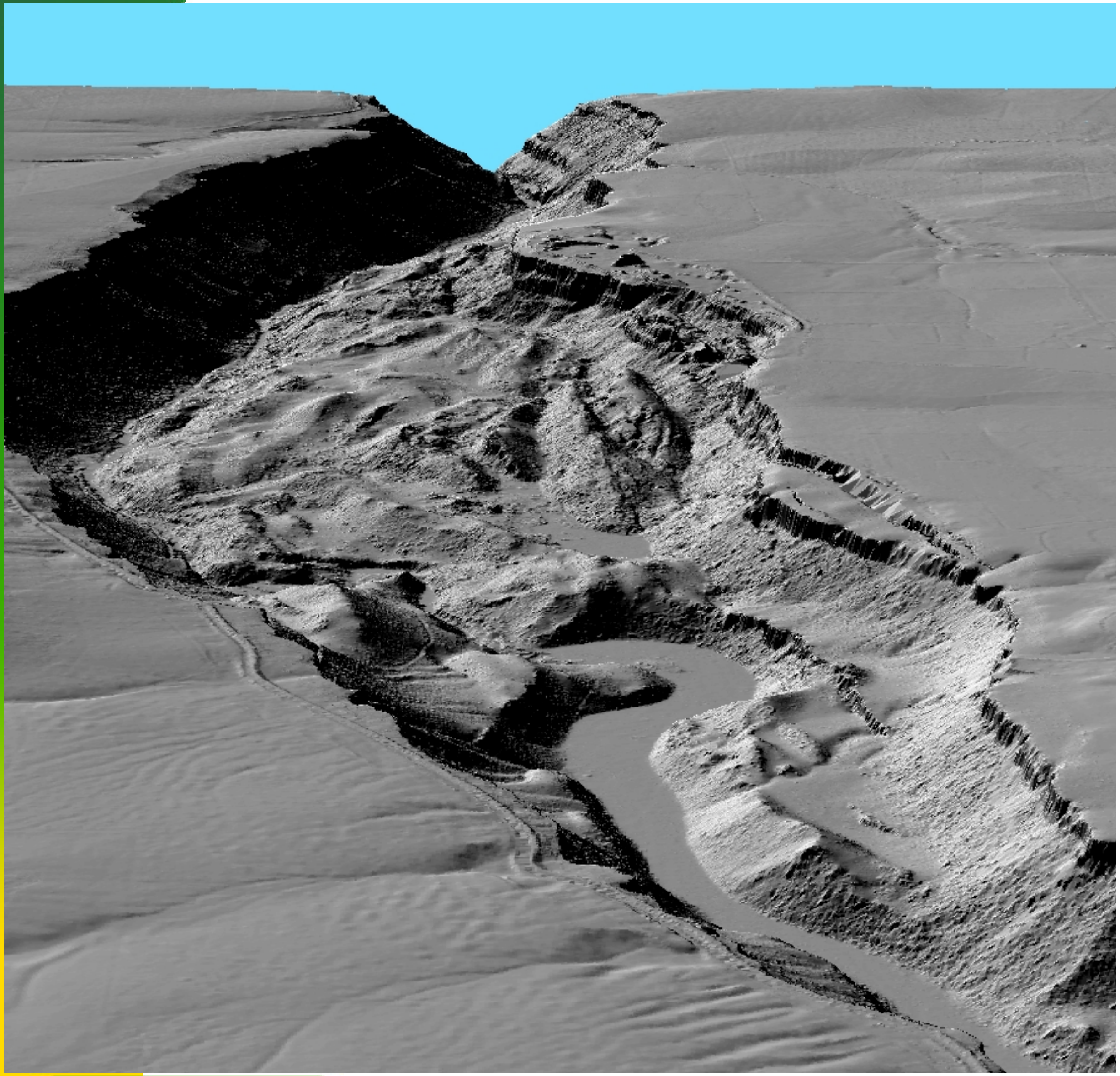
LiDAR 2m DEM;
25X resolution of 10m DEM



- **1 m LiDAR posting image** of the **Salmon Falls Landslide** southwest of Twin Falls, ID
- Area of 0.2 km^2
- 13 million data points
- vertical resolution of 15 cm
- 100X resolution of a 10m DEM

Image courtesy of Nancy Glenn at Idaho State University

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Comparison of High-Altitude LiDAR-Derived DEMs with Conventional Photo-Derived DEMs

Kaintuck Hollow area
Newburg, Missouri

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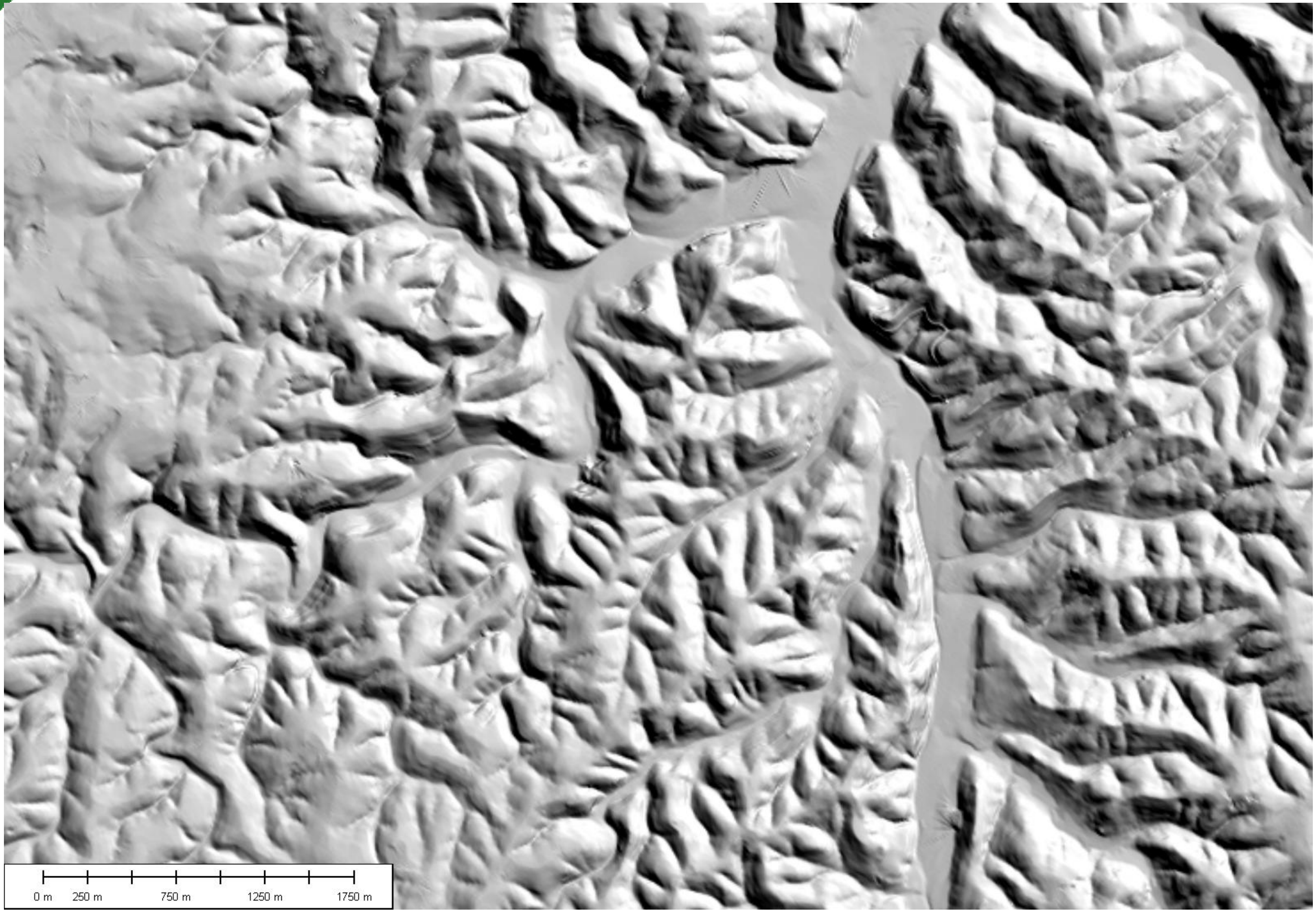

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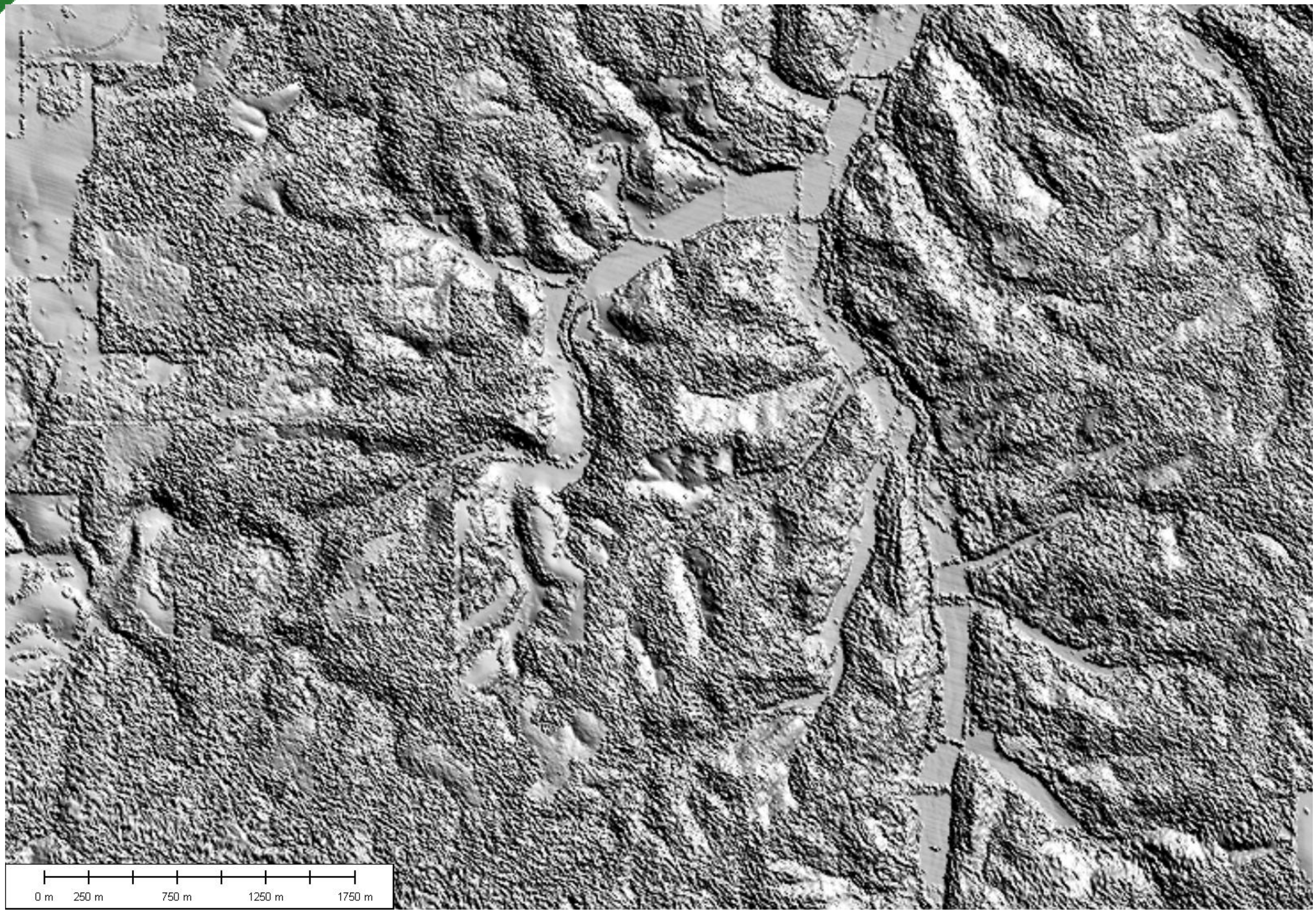
Standard USGS 10m DEM



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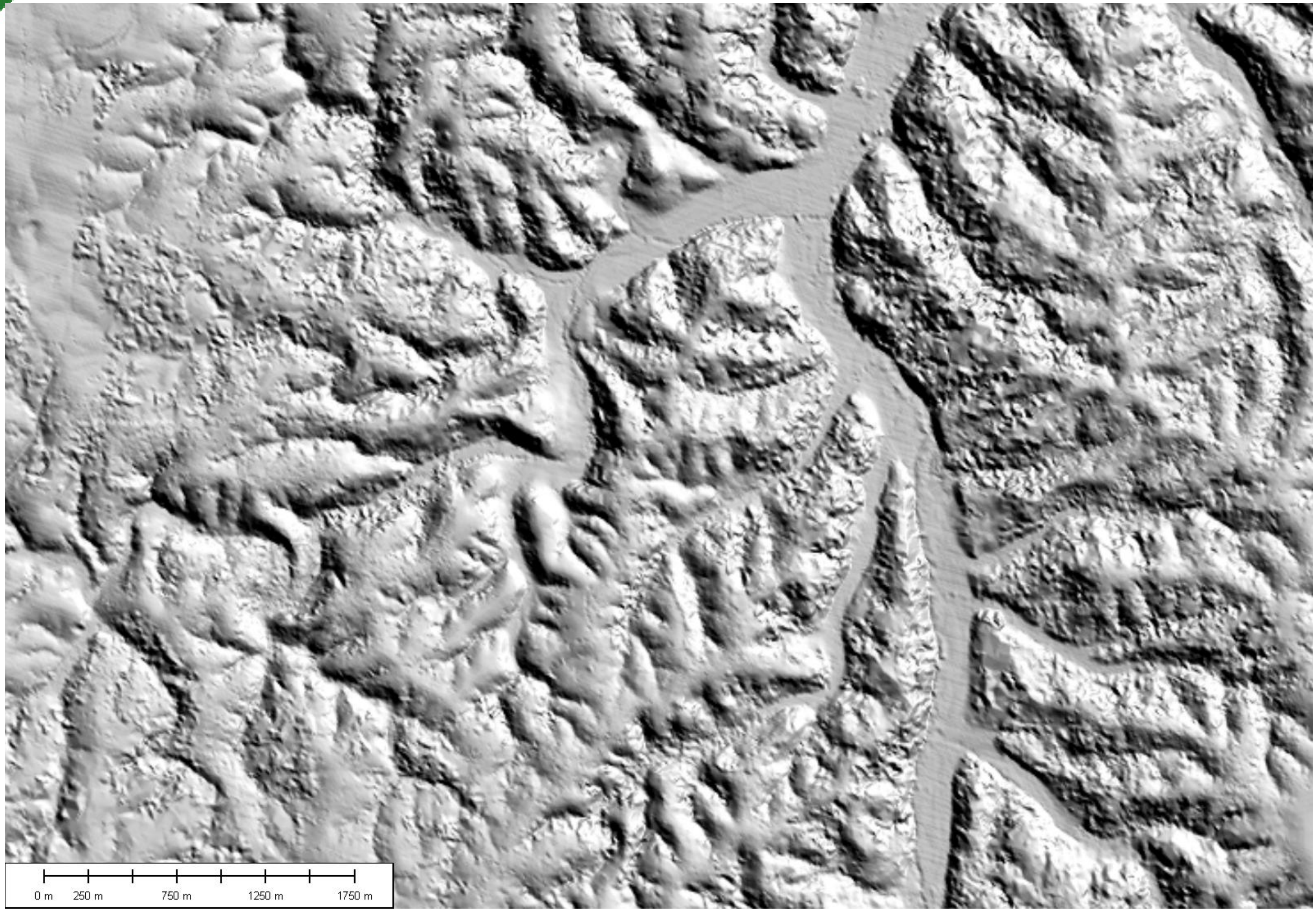
LiDAR 10m Leaf On DEM (Raw)



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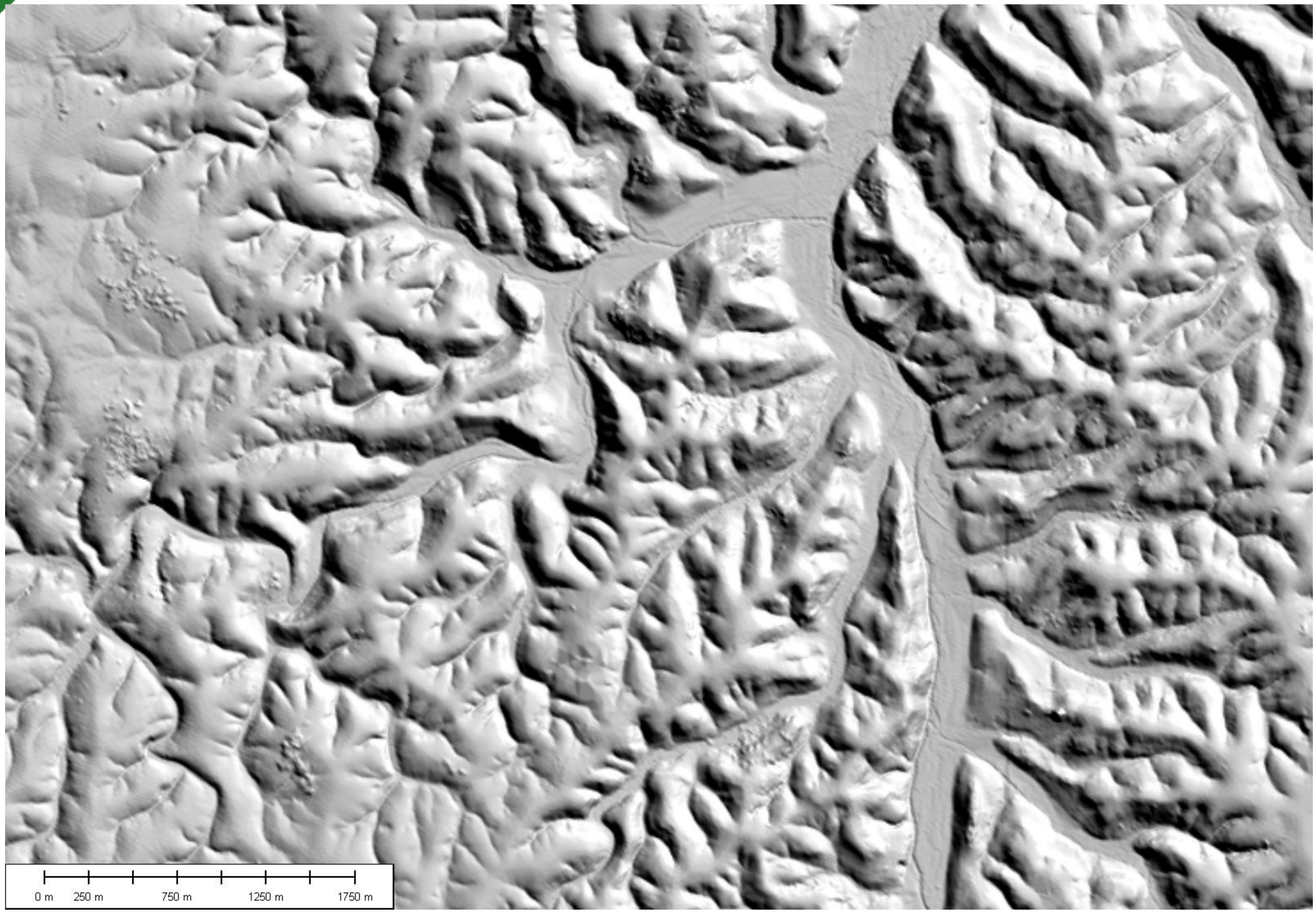
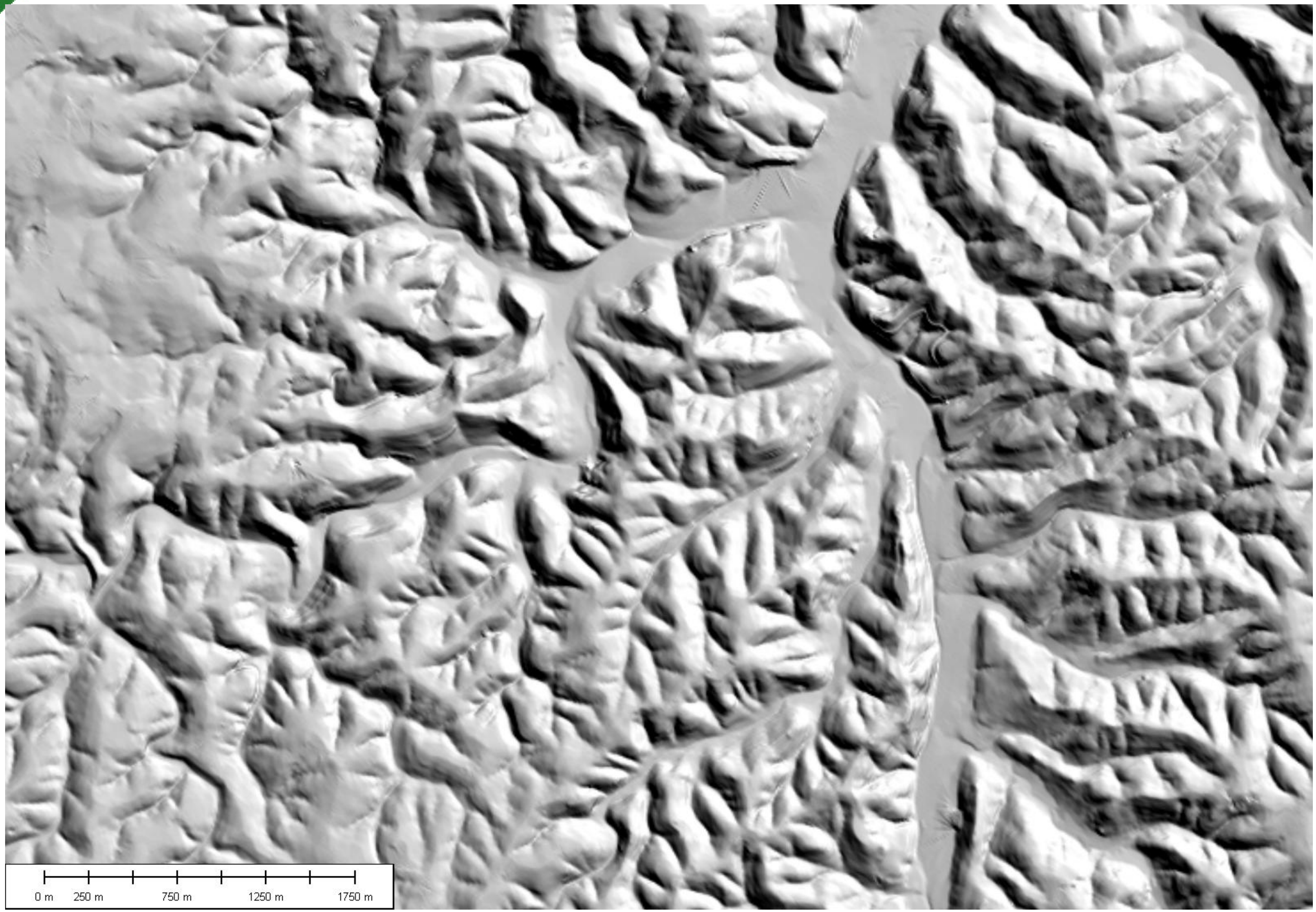
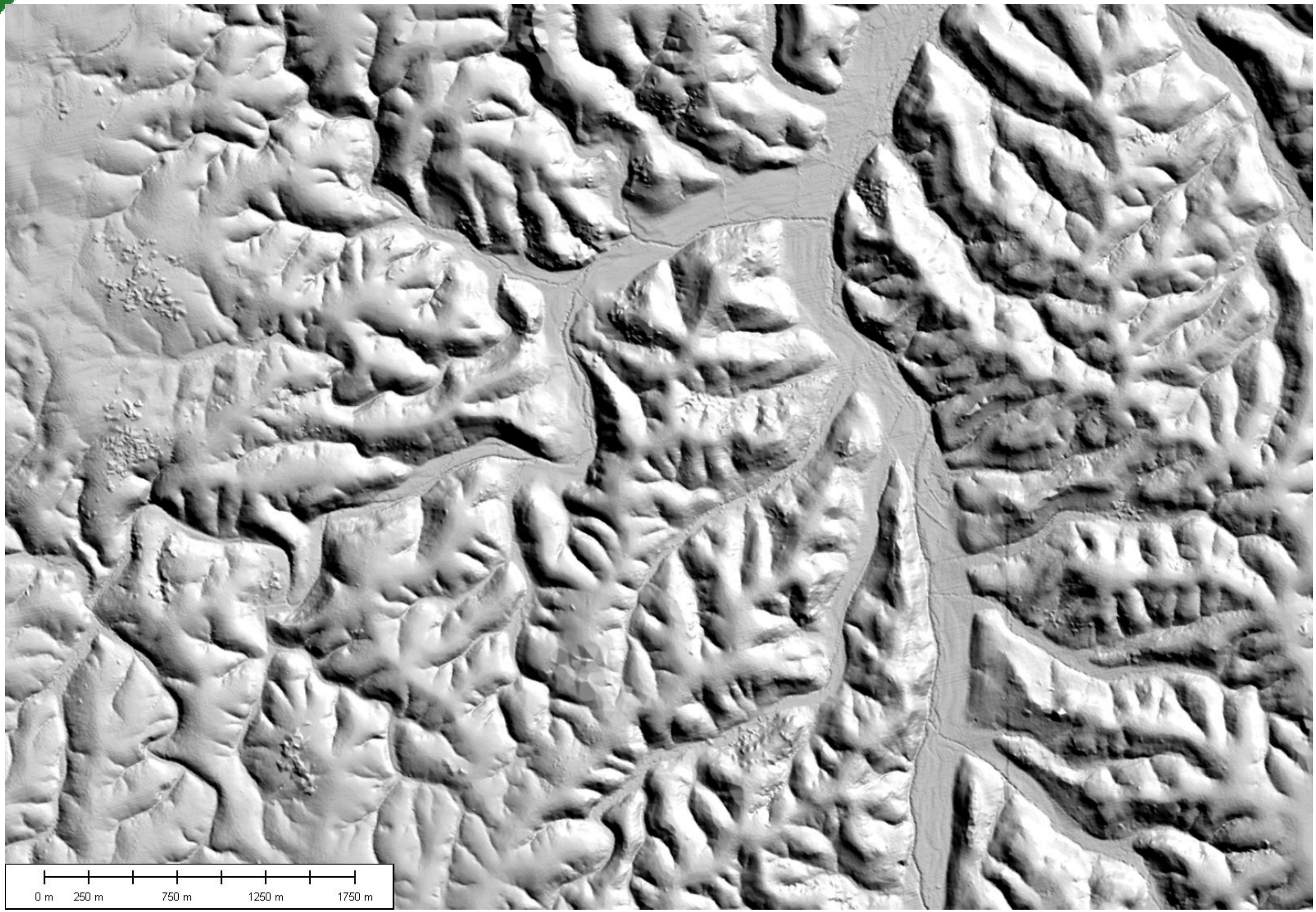
LiDAR 10m Leaf-On DEM
(Processed or “clean”)



LiDAR 10m from 5m Leaf-Off DEM (bumps are cedars)



Standard USGS 10m DEM



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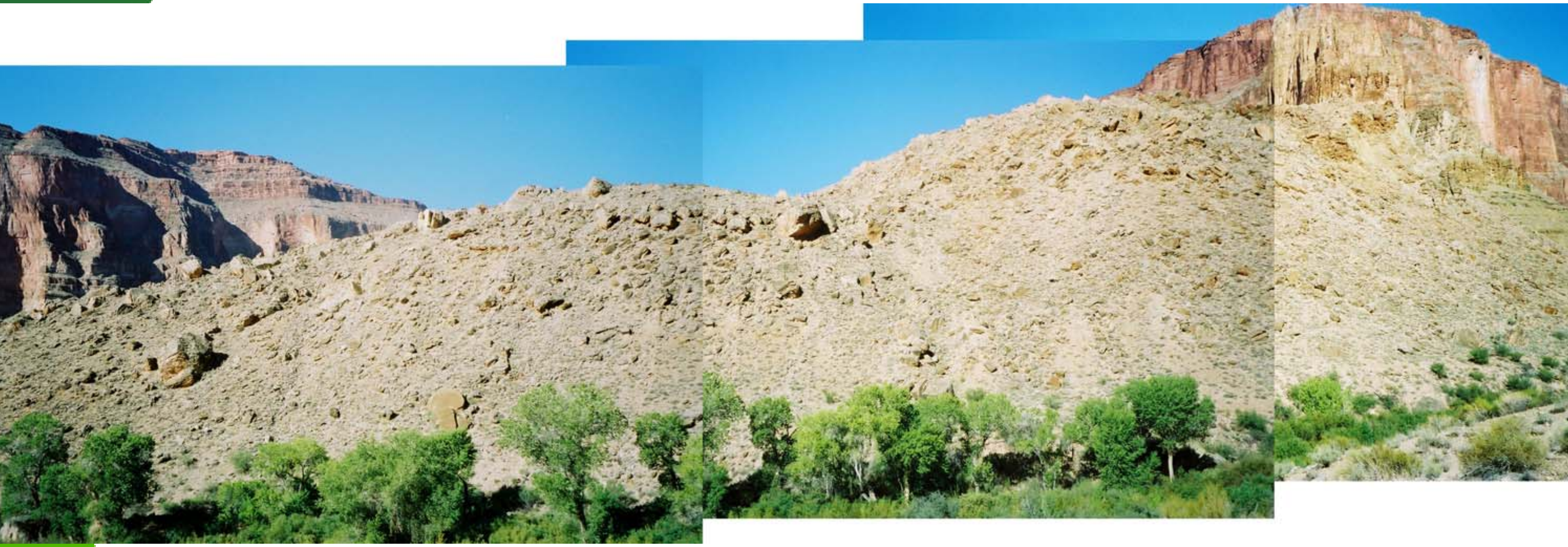
LiDAR 5m Leaf-Off DEM



3D Terrain Visualization Using DEMs

Deer Creek Landslide

Grand Canyon, AZ

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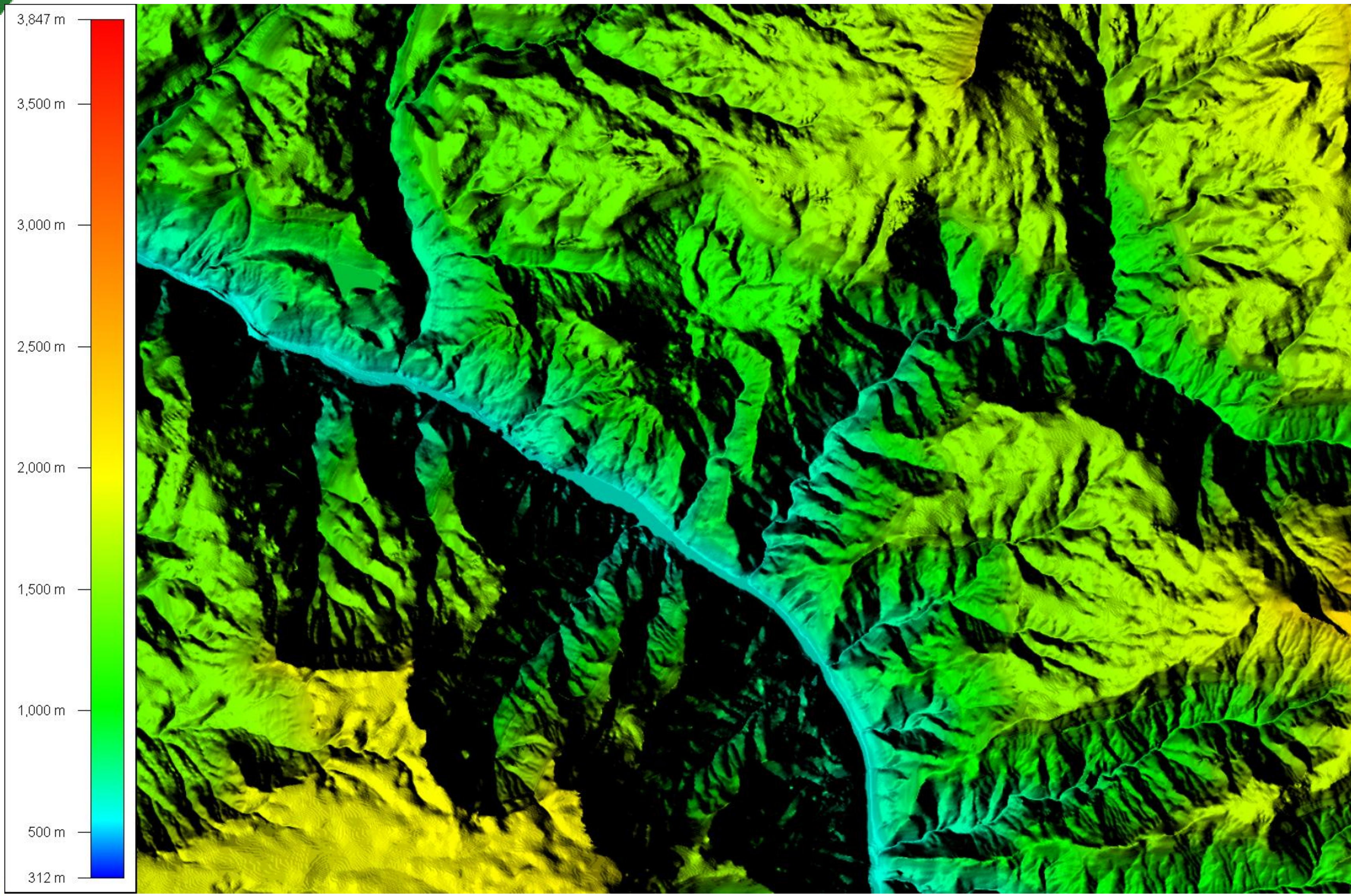

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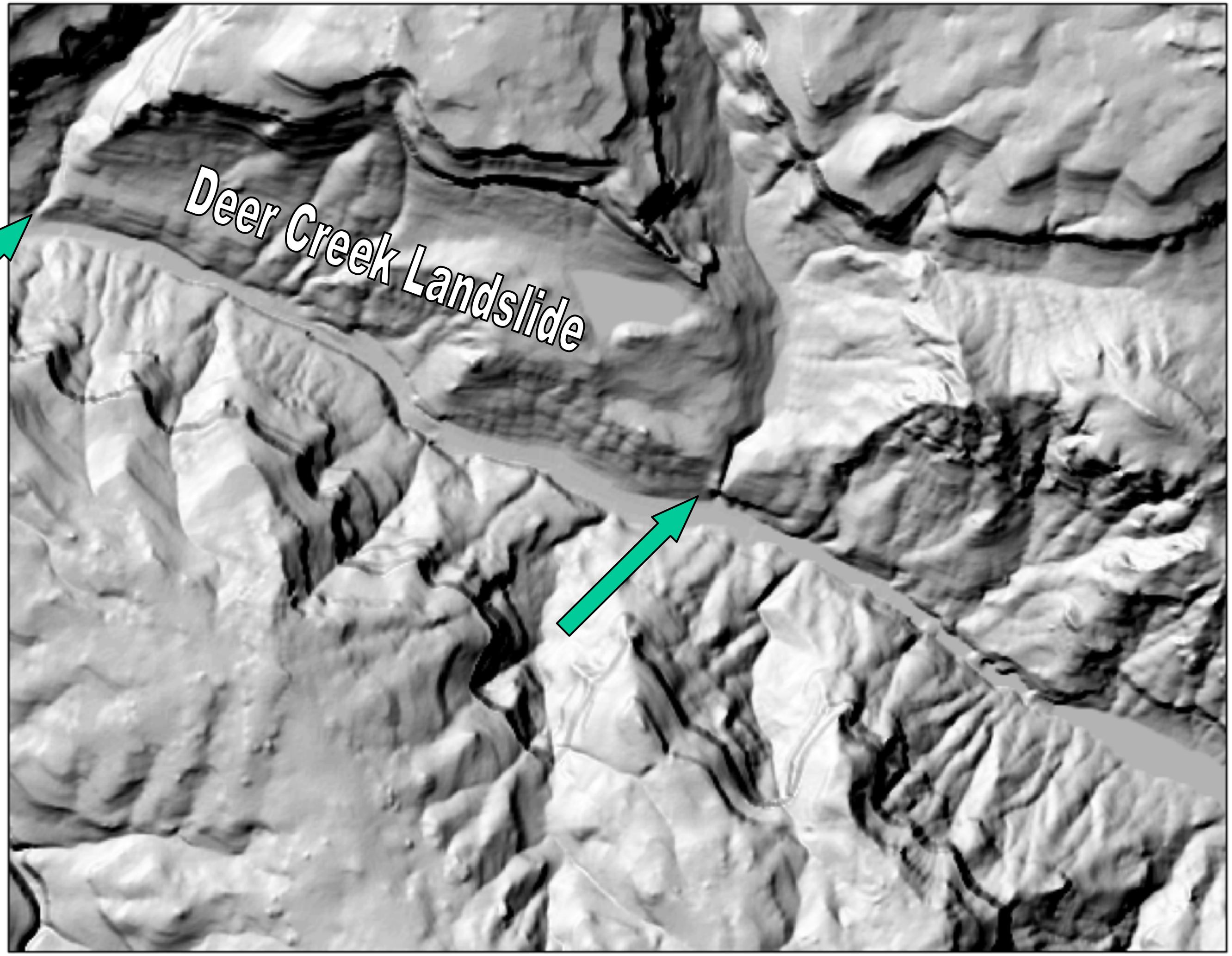
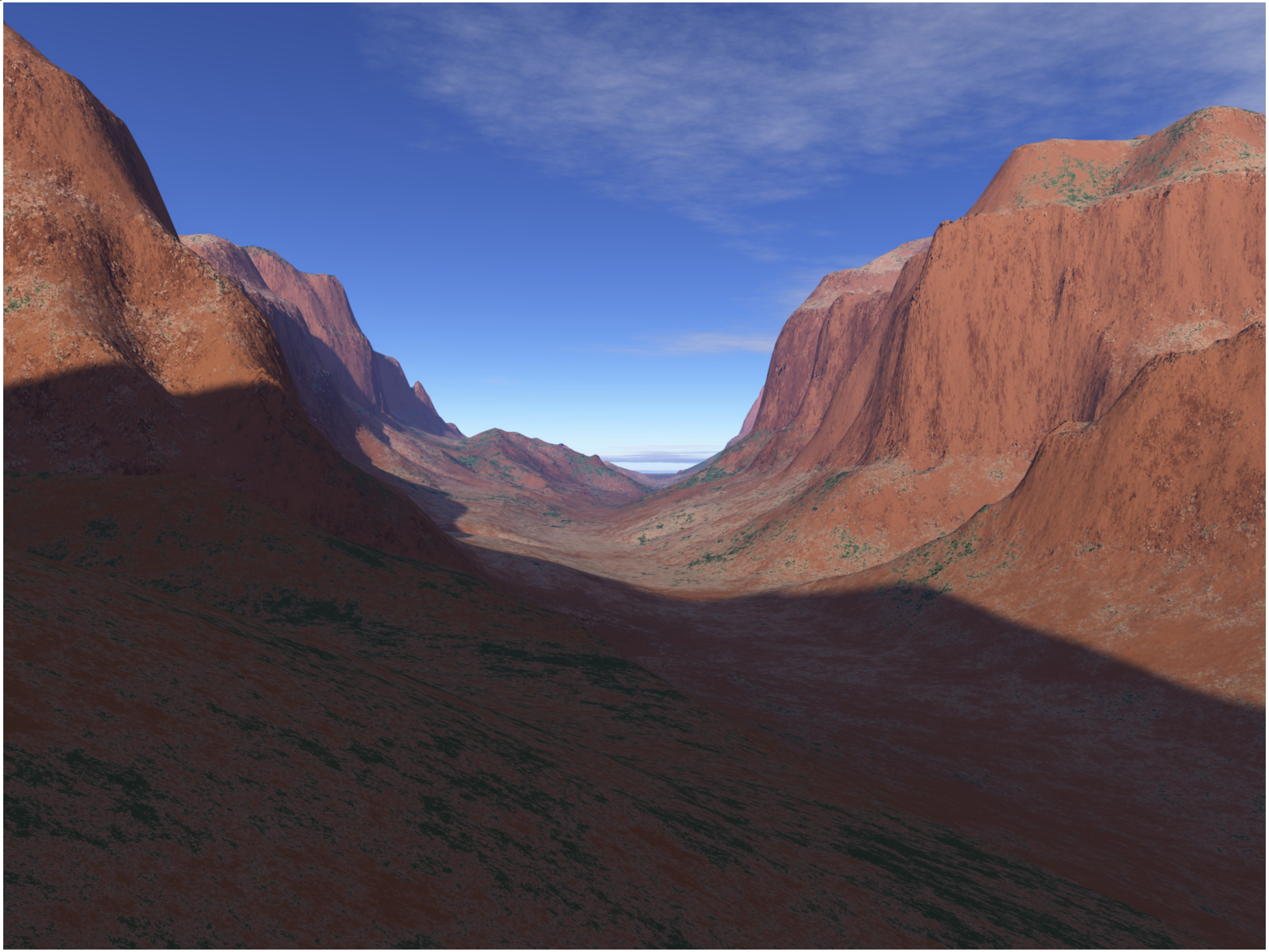
USGS 10 m DEM
using Global Mapper



10 m DEM using ArcGIS. Deer Creek Landslide, between Mile 136 and 138.5 in the Grand Canyon



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Rendering of Deer Creek Landslide derived from 10 m DEM using Terragen software

CONCLUSIONS

- Digital map products prepared using GIS are readily obtainable. These data can be manipulated by a multitude of GIS software to extract needed information
- The ability to map the “bare earth” surface of the ground is now technologically feasible
- Some “data voids” can be expected if INSAR or LiDAR platforms are limited to a single axis
- Post spacing and platform altitude control data density and image resolution; small scale features may remain elusive