Using highly accurate satellite topographic mapping to accelerate oil and gas projects in Kurdistan

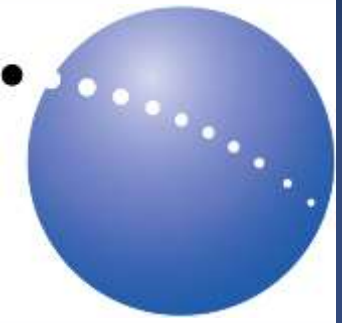
Over 15 PhotoSat Kurdistan stereo satellite topographic mapping projects

Gerry Mitchell
PhotoSat President

Using highly accurate satellite topographic mapping to accelerate oil and gas projects in Kurdistan

Over 400 global PhotoSat stereo satellite topographic mapping projects

30cm elevation mapping accuracy



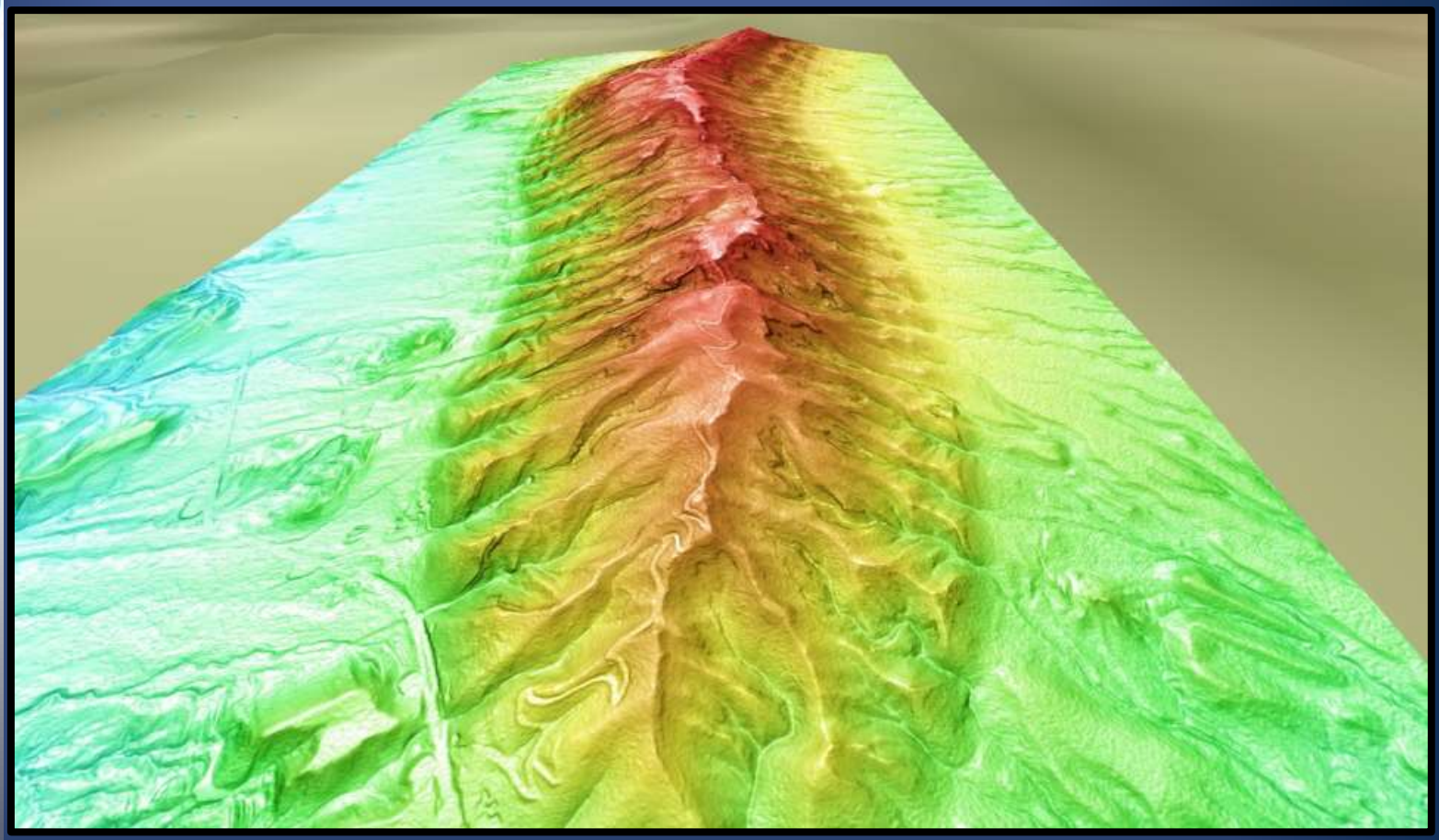
***Engineering quality satellite topographic mapping accelerates work programs and prevents delays in all phases of oil and gas projects*.**

30cm elevation mapping accuracy accelerates and avoids delays for:

- Geological targeting
- Seismic surveys
- Well sites
- Access roads
- Oil and Gas Facilities
- Pipelines

Satellite Mapping for Geological Targeting

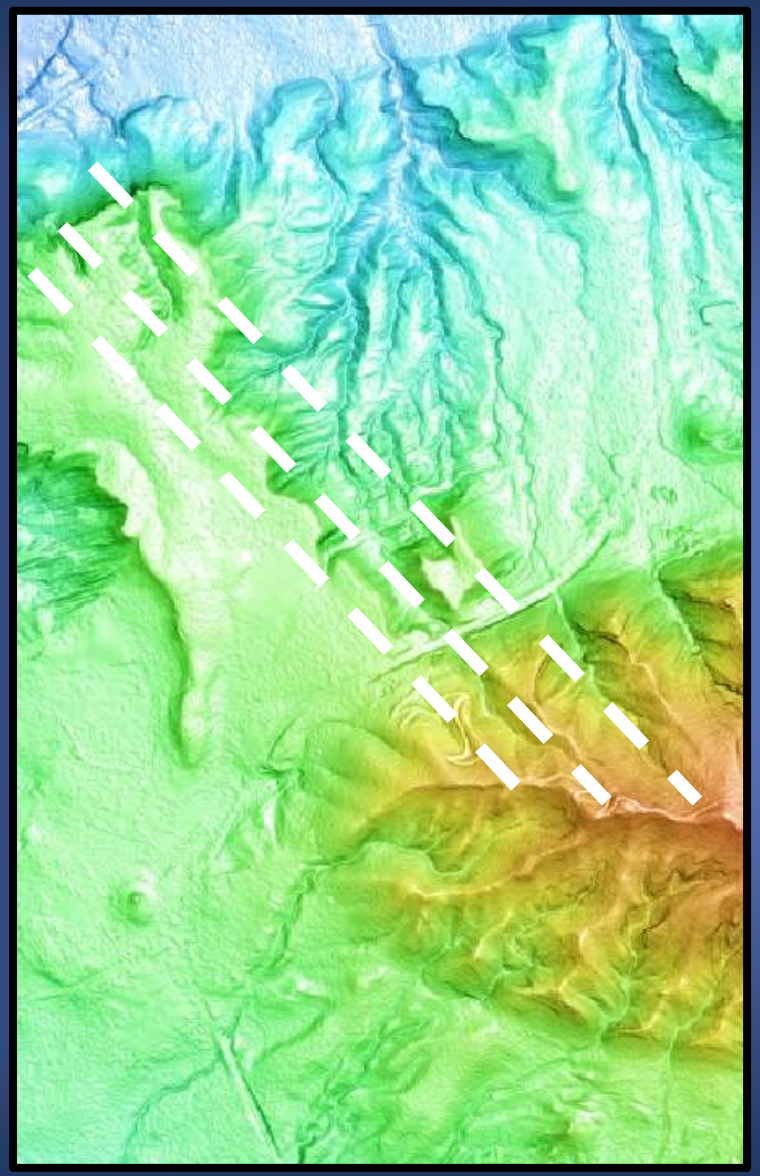
Major structures



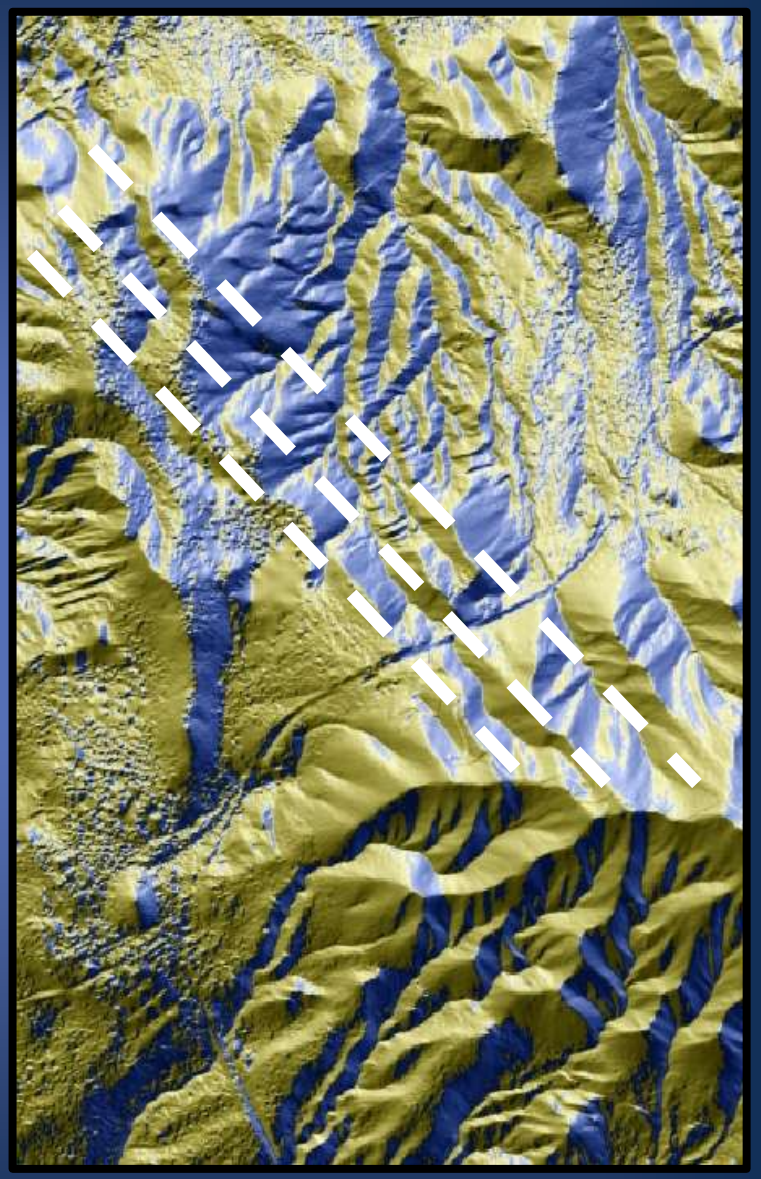
West Tawke Anticline satellite topography 3D view looking east

www.photosat.ca

Satellite Mapping for Geological Targeting

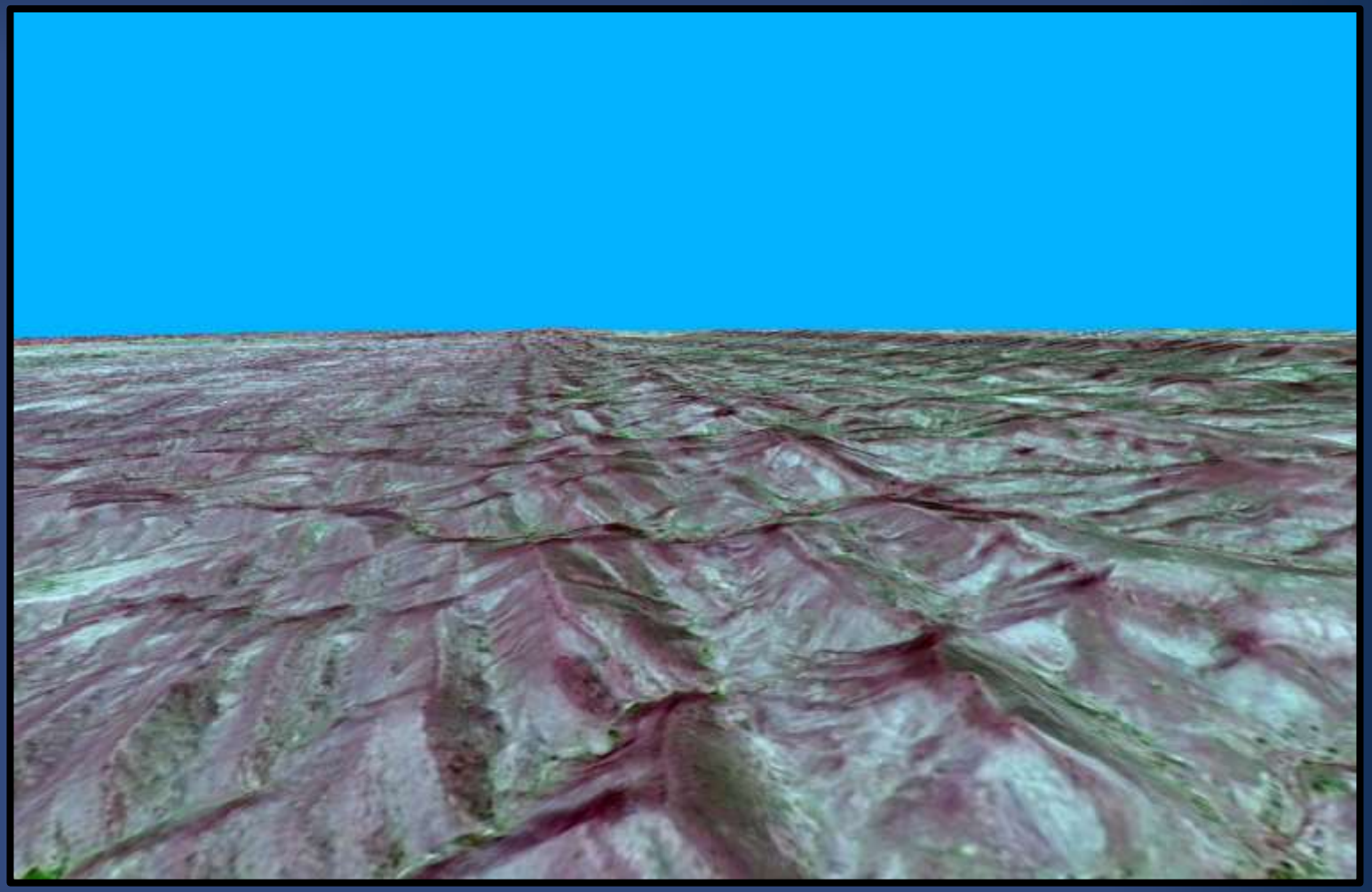


NW striking faults



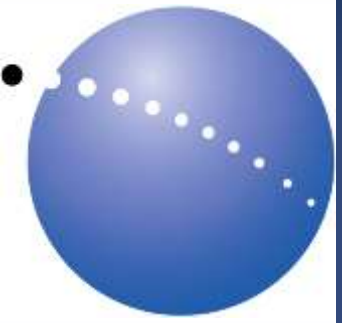
Slope direction

Satellite Mapping for Geological Targeting



Kirkuk thrust fault surface trace

Satellite mapping for seismic surveys

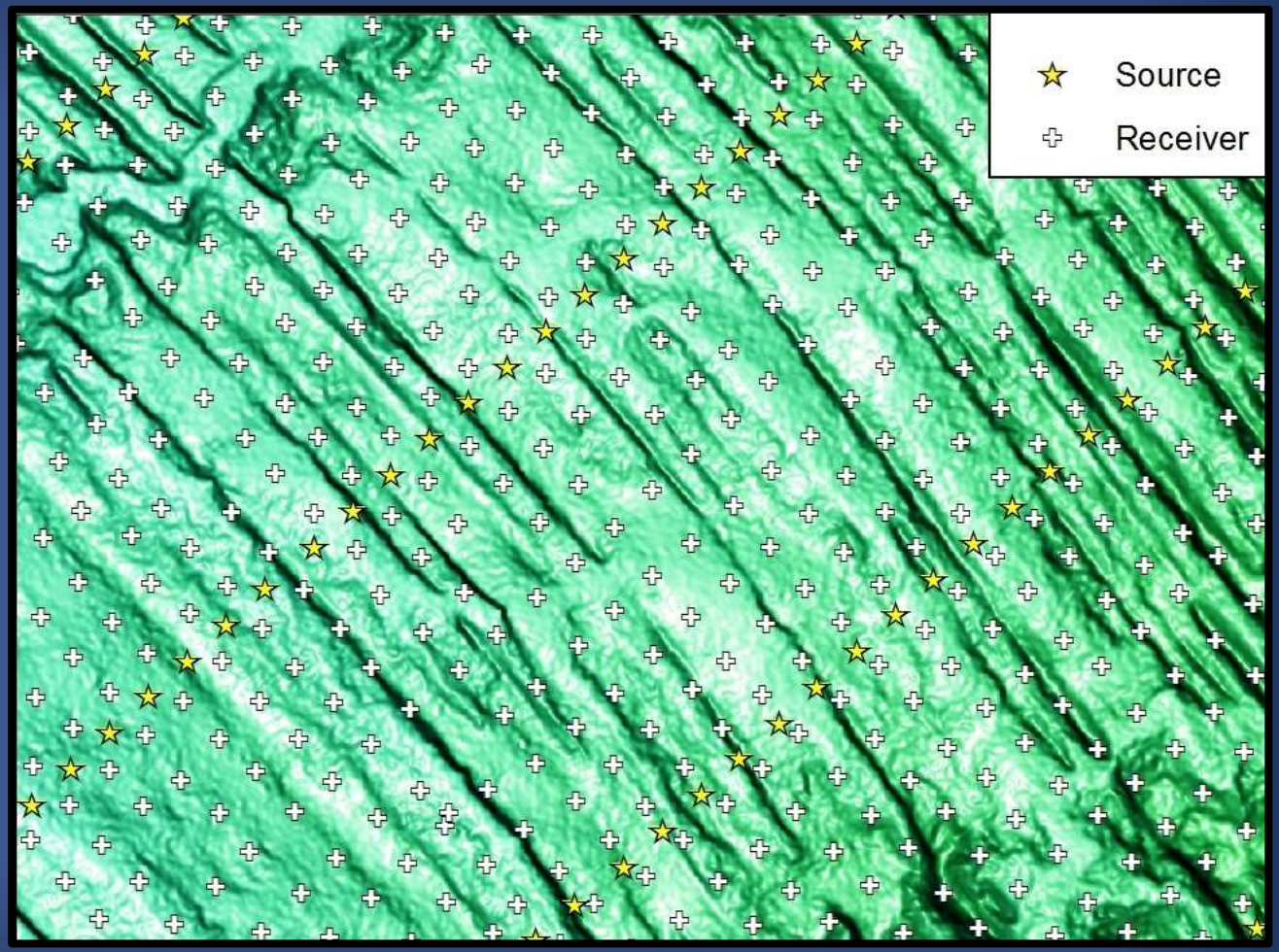


- Improves seismic survey planning
- Reduces source point scouting
- Improves seismic safety
- Improves seismic quality

Satellite mapping for seismic surveys

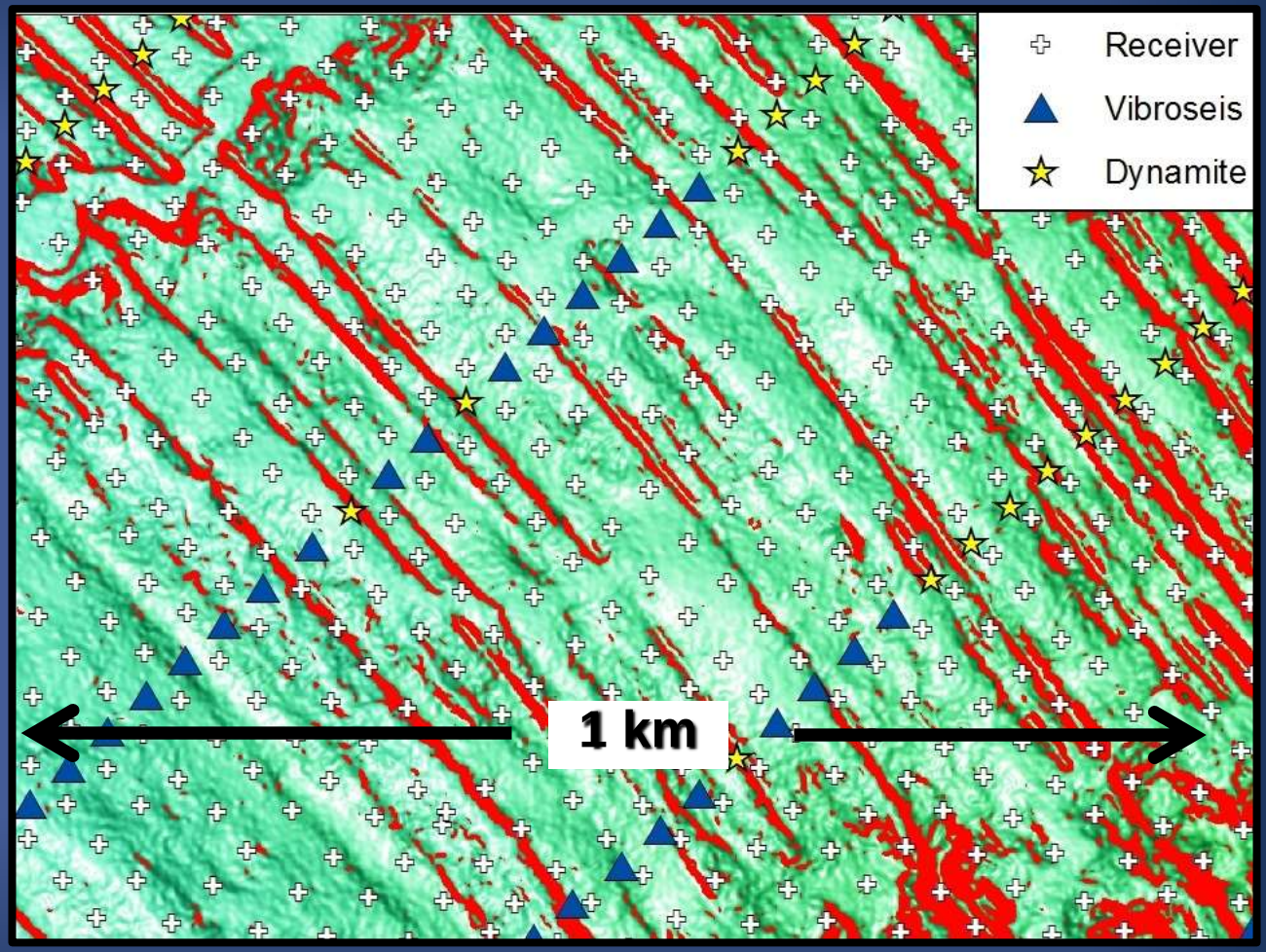
Seismic survey access route scouting

Satellite mapping for seismic surveys



Proposed 3D seismic survey plotted over a satellite topographic image

Satellite mapping for seismic surveys



Proposed 3D survey seismic source types

Red areas: slopes > 15% grade

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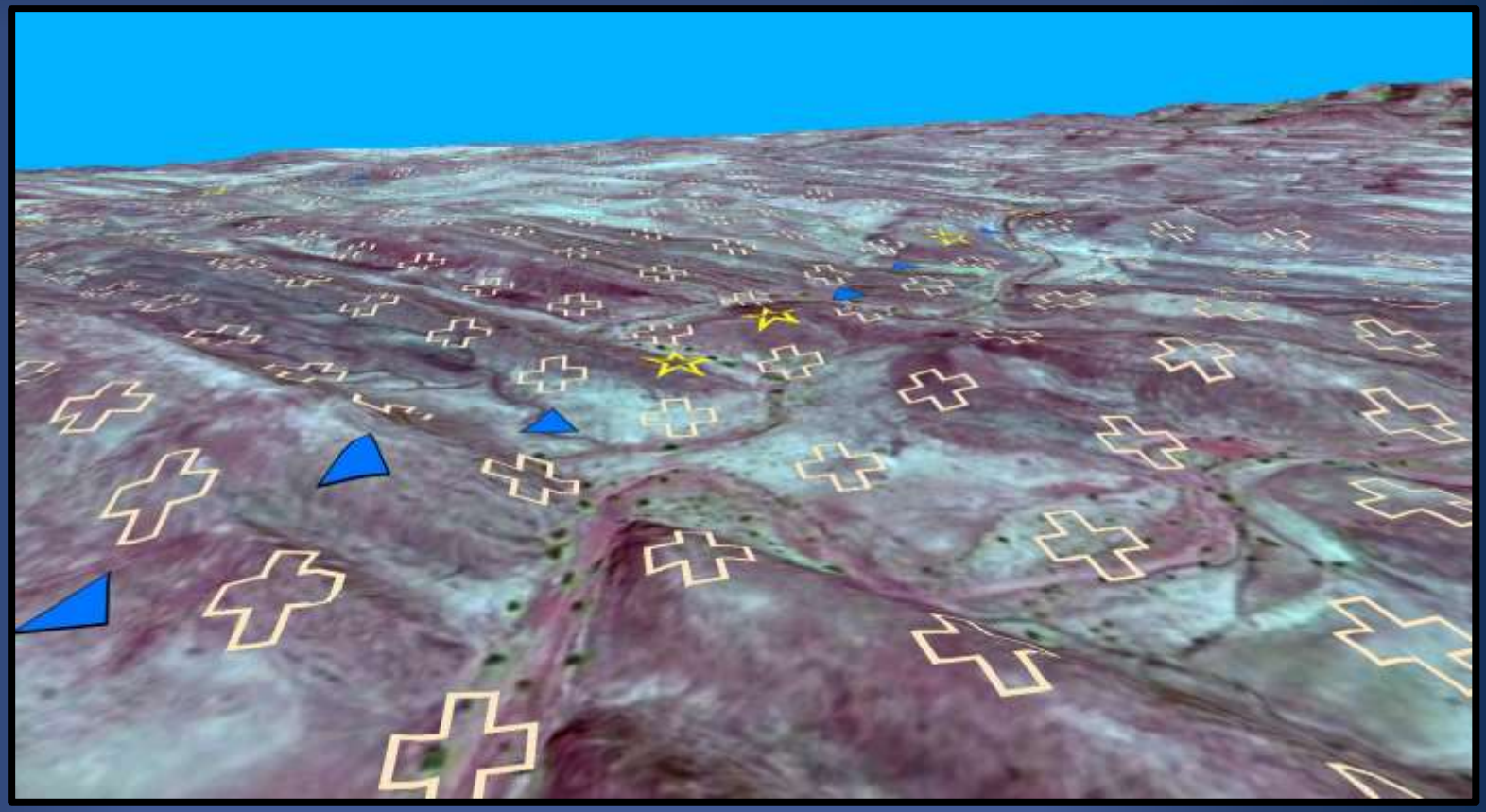
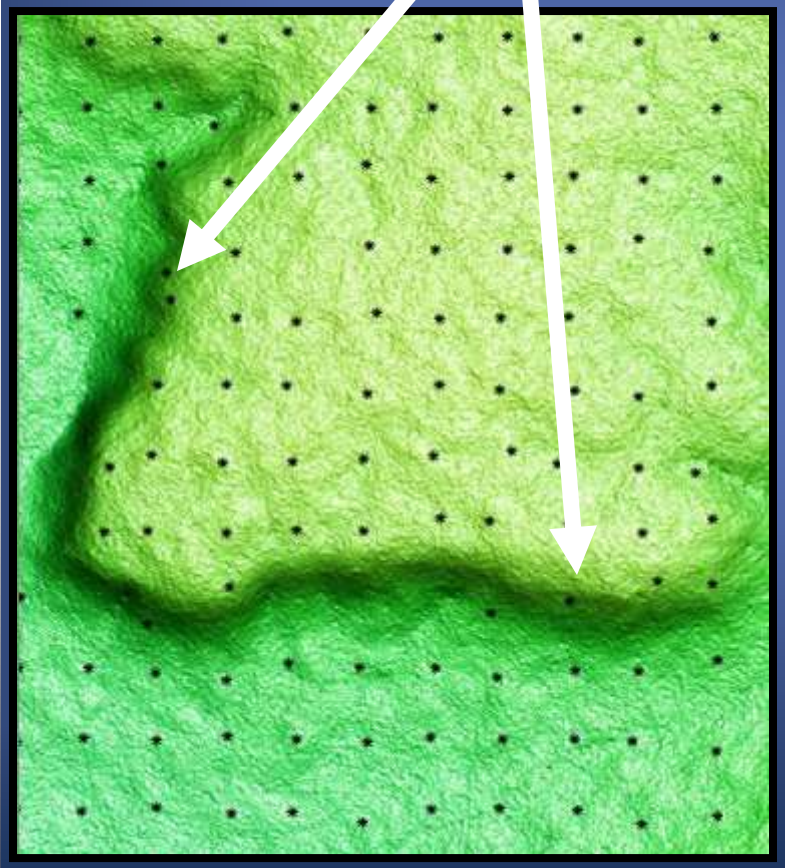
Satellite mapping for seismic surveys

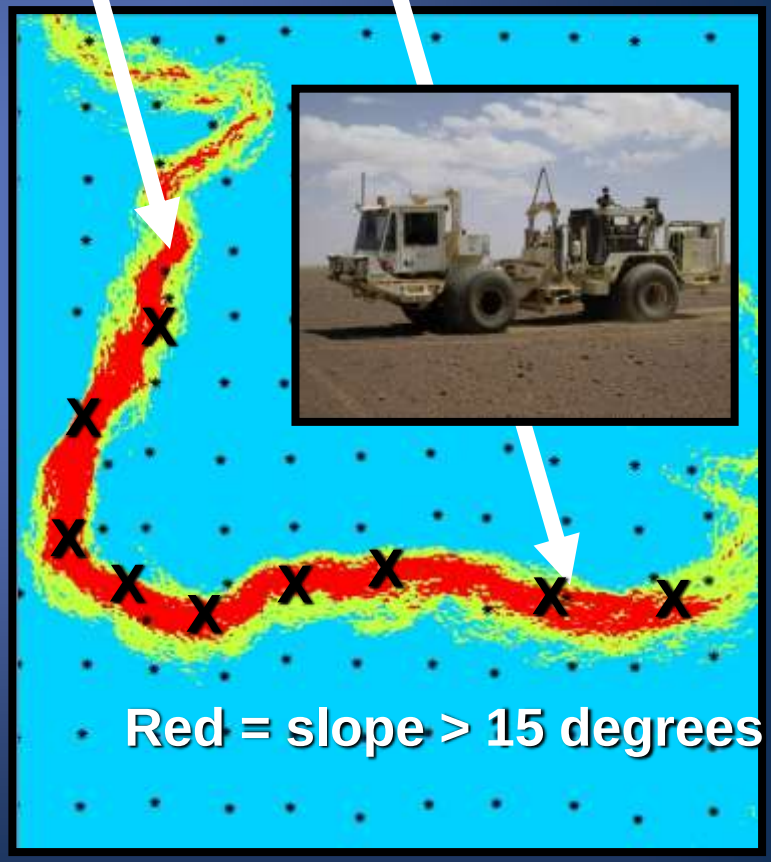


Proposed 3D survey seismic source types

Satellite mapping improves seismic survey safety

Avoid vibroseis source points on steep slopes

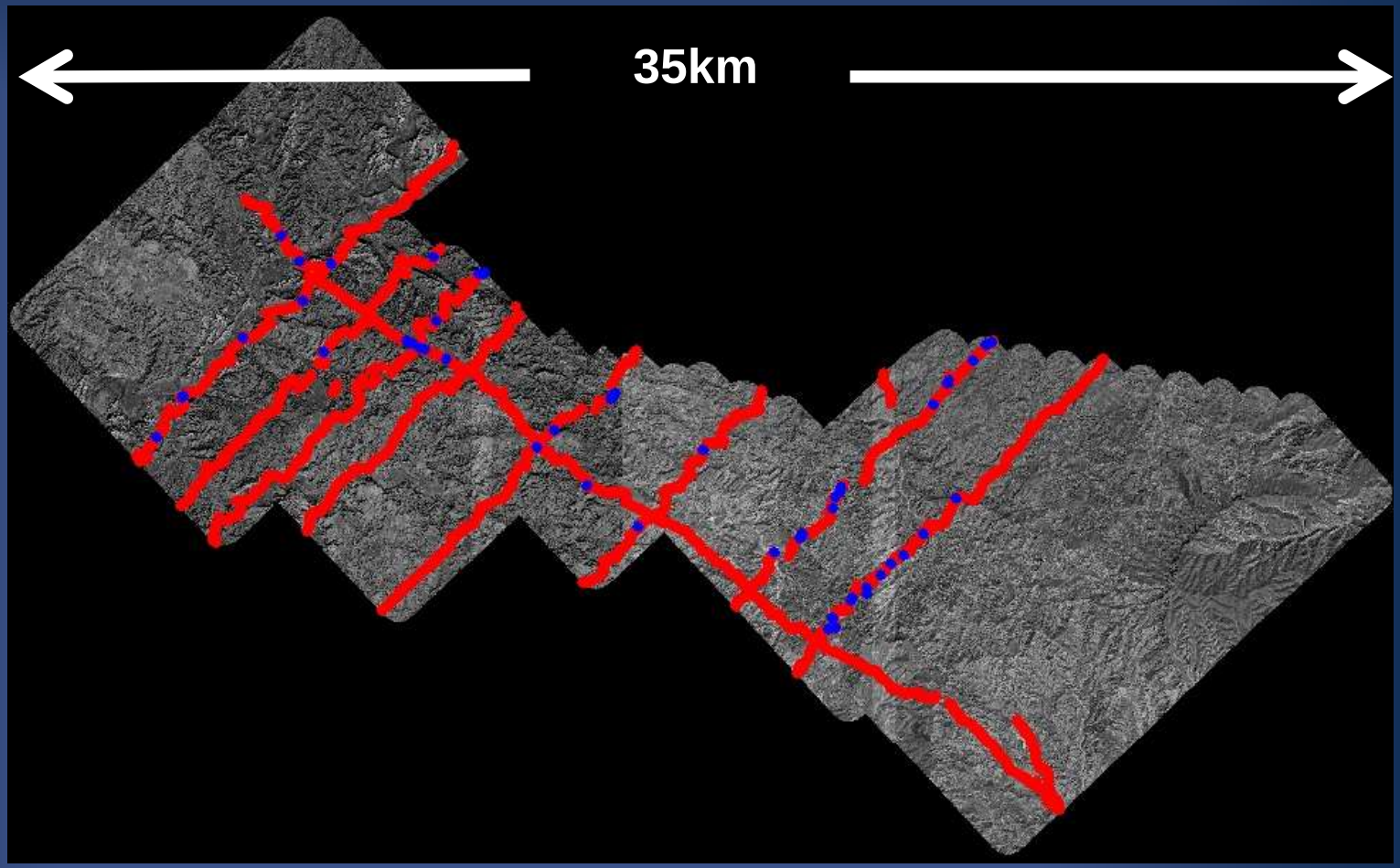




Satellite mapping for seismic surveys

Seismic survey xyz source and receiver point location QC

Satellite mapping for seismic surveys



Seismic source points in blue in error by > 1m in elevation

Confirmed Seismic Safety Improvements

Feedback from BP Libya

Advance scouting reduced by ~ 80%

The stereo satellite topography and imagery gives an accurate enough picture so that only a few areas require field visits in advance, to identify inaccessible source-points and to plan for efficient disposition of the vibrator trucks, reducing the number of project personnel days.

Safer Vibroseis operations

Accurate maps of the ground slope enable mapping of no-go zones for the vibrator trucks, lessening the risk of overturning the trucks on steep inclines.

Fewer surveyor field days

Combined with Seismic Recorders with built in GPS receivers, the stereo satellite elevation mapping can eliminate surveying of the seismic receiver elevations.

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Improved Seismic Quality

Feedback from BP Libya

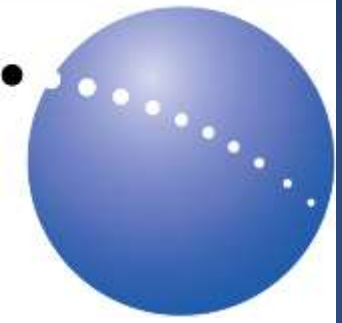
The stereo satellite topography provides the necessary source and receiver location elevation accuracy for seismic processing.

The stereo satellite topography can be used to quality control the source and receiver elevations and eliminate the need for additional surveying.

Source-points are surveyed using GPS systems mounted on the vibrator trucks. Elevation accuracy can be poor during GPS start up and during times of low GPS satellite visibility.

For seismic receivers with GPS antennas the stereo satellite topography eliminates the need for any surveying of the receiver elevations.

Satellite mapping for well sites



- Well site surface location identification and selection
- Well site mapping
- Well pad construction design and cost estimates (cut and fill volumes)

Conventional well site mapping

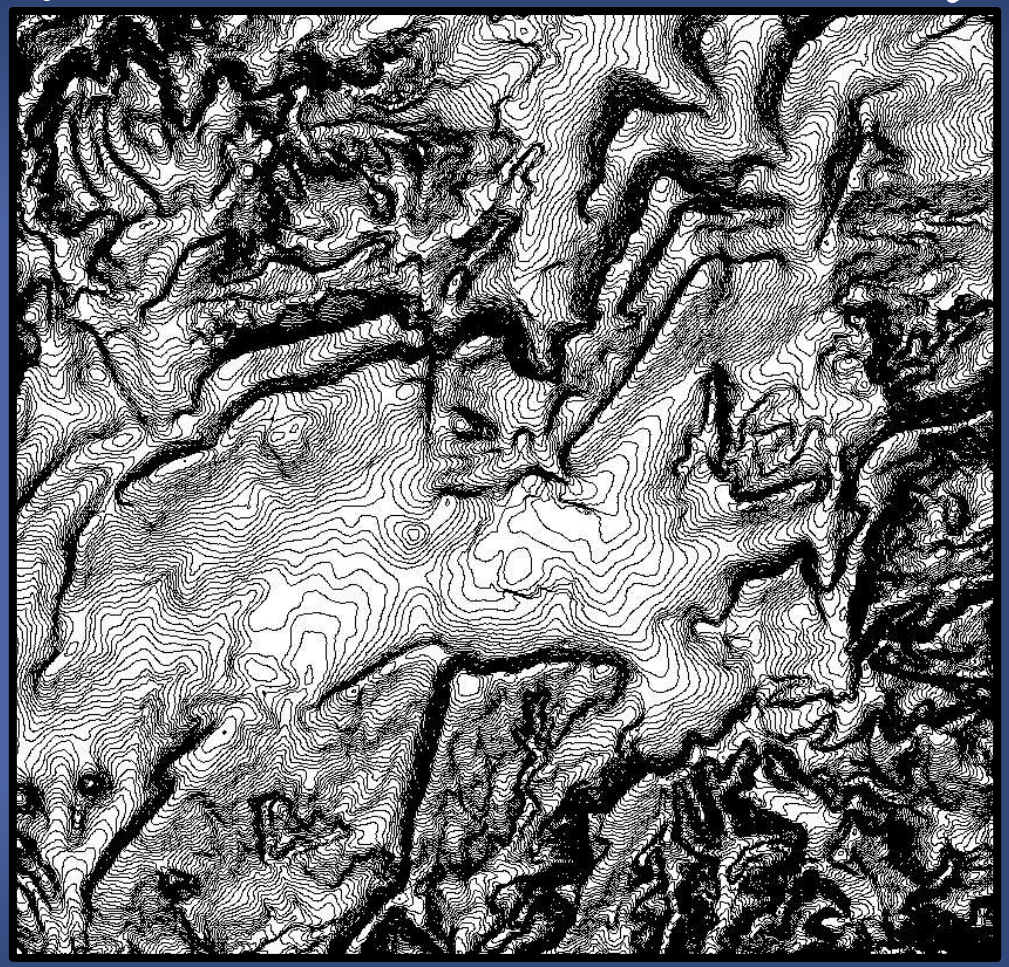
Conventional well site mapping

Satellite well site mapping

Well site identification and selection

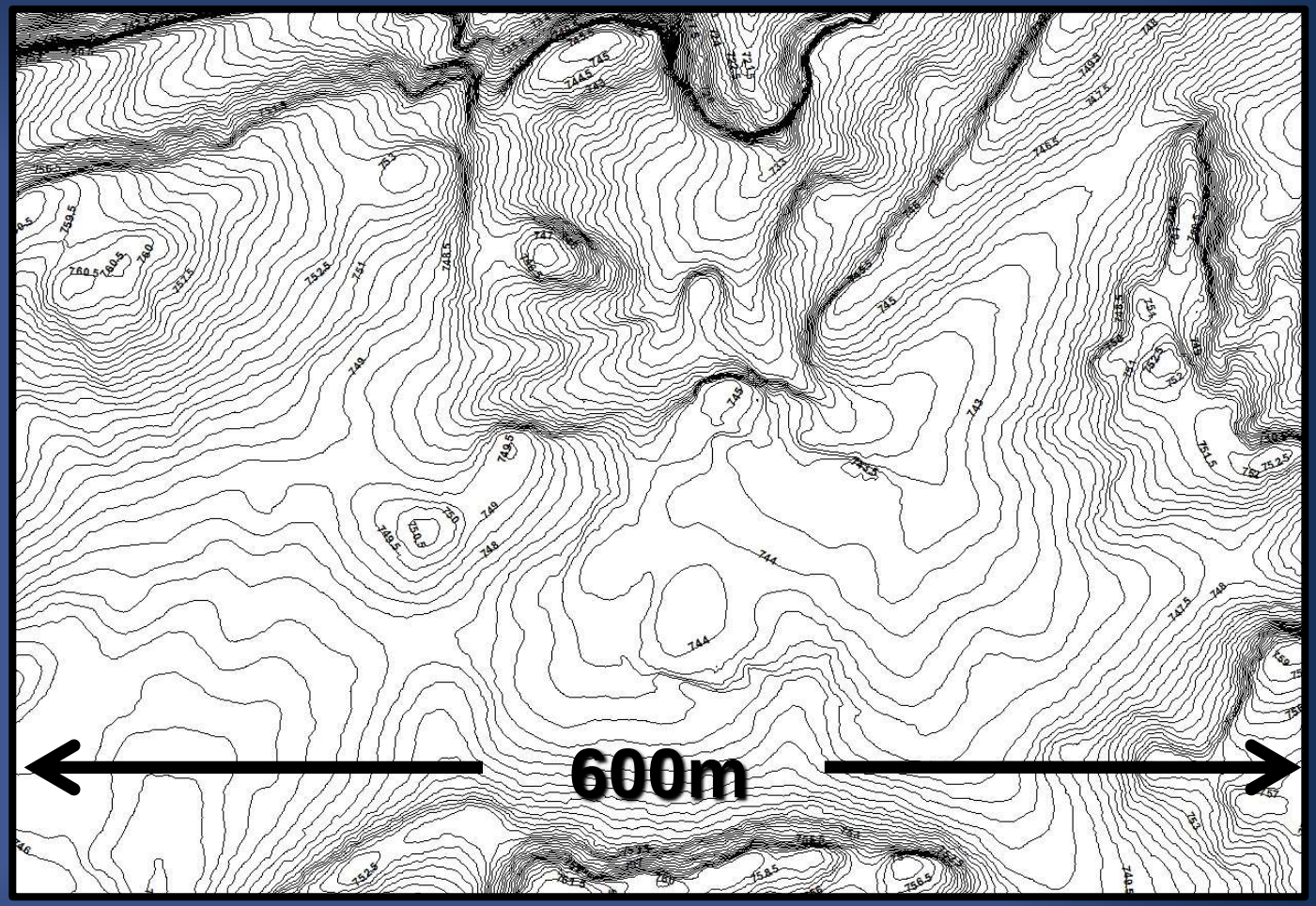
Satellite well site mapping

2km



Well site mapping
50cm contours

Satellite well site mapping



Well pad construction design and cost estimate (cut and fill volumes)

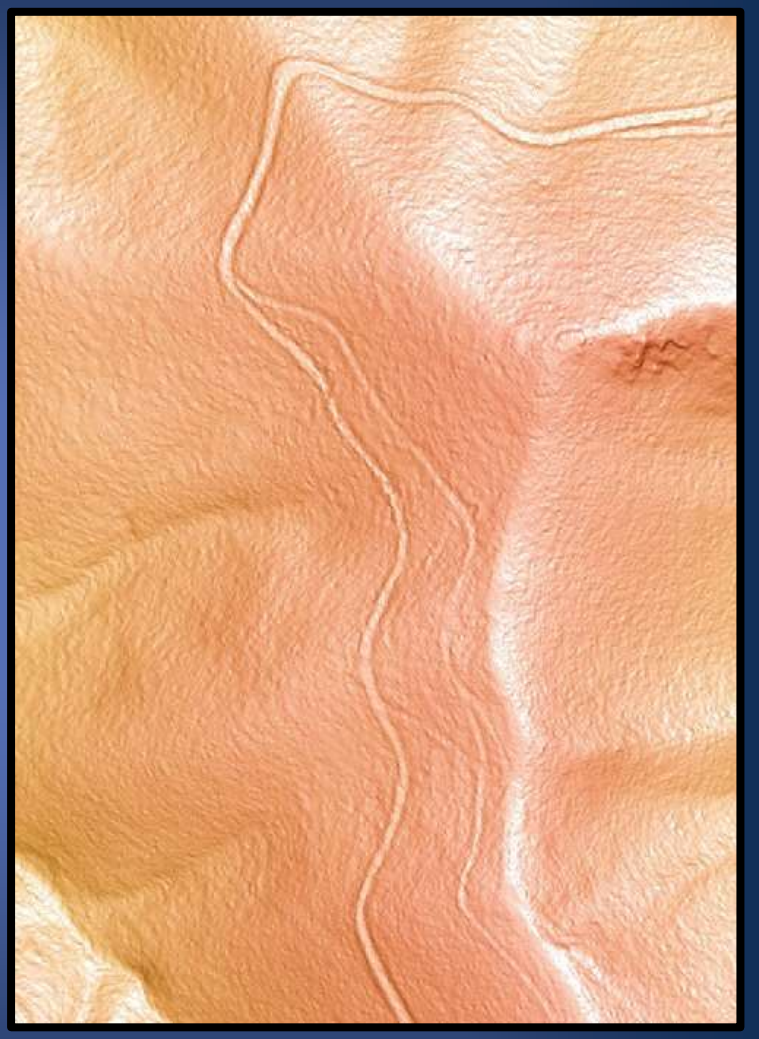
50cm contours

Access road mapping

Access road planning and construction requires cut and fill volume estimates.

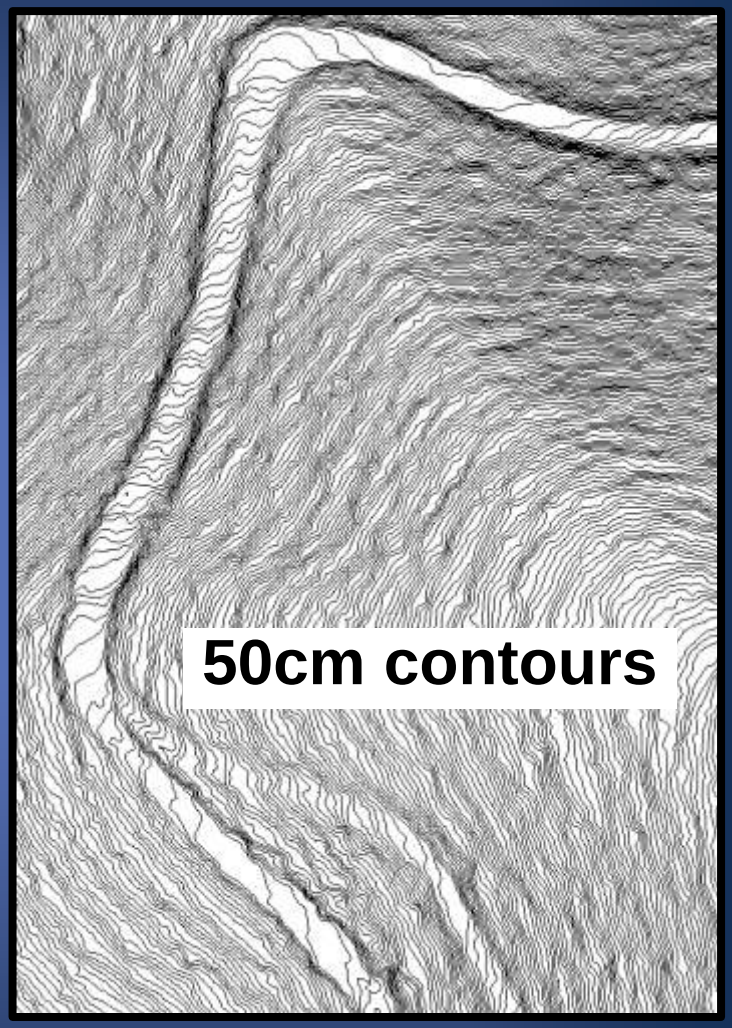
Conventional access road mapping

Satellite access road mapping



Access road identification and permitting

Satellite access road mapping



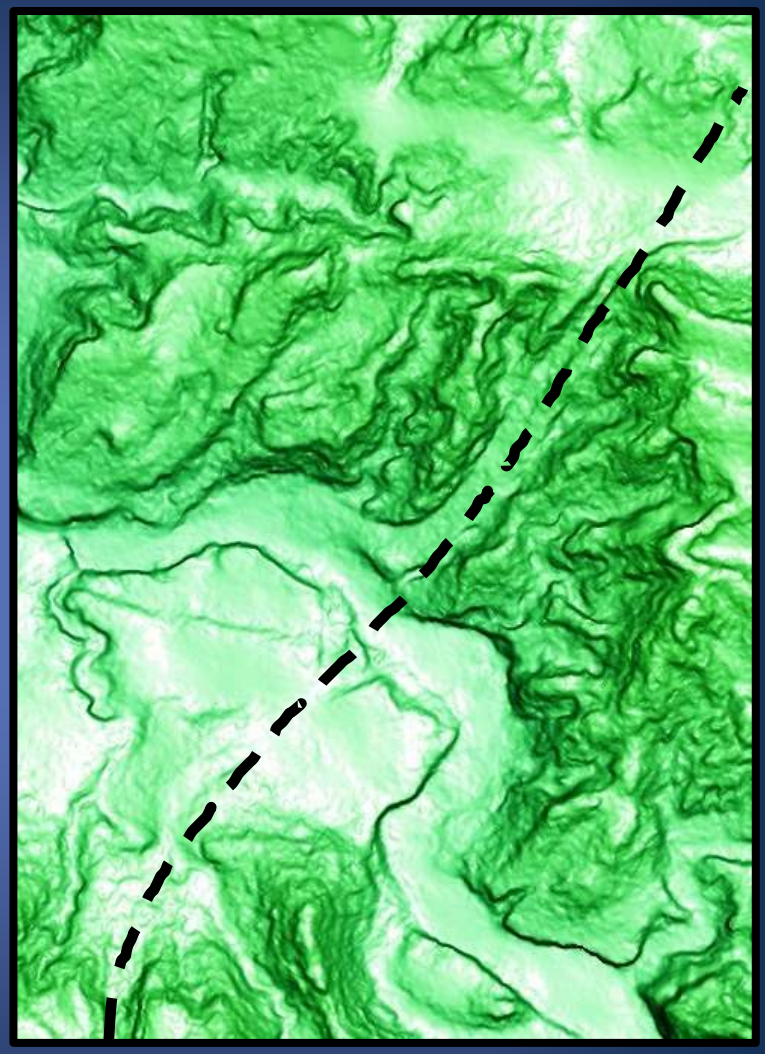
Access road identification and permitting

Cut and fill volumes

Satellite pipeline mapping

Pipeline construction planning

Satellite pipeline mapping



Pipeline right of way identification

Satellite pipeline mapping

Pipeline right of way identification

Cut and fill volumes

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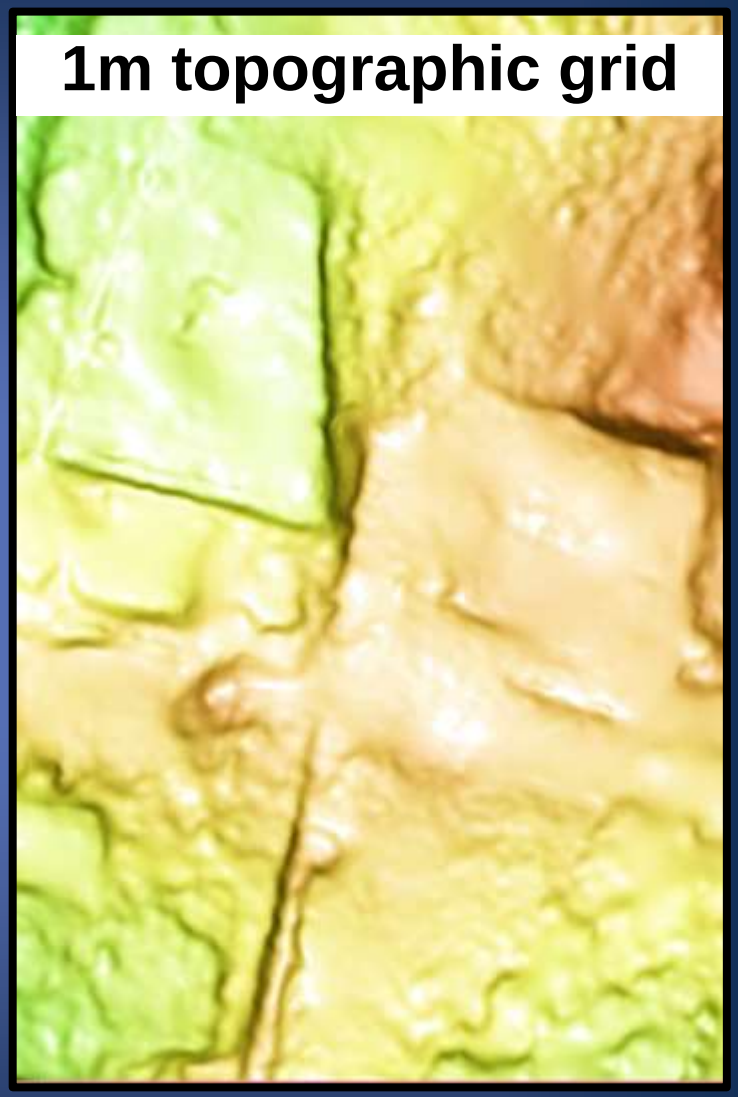
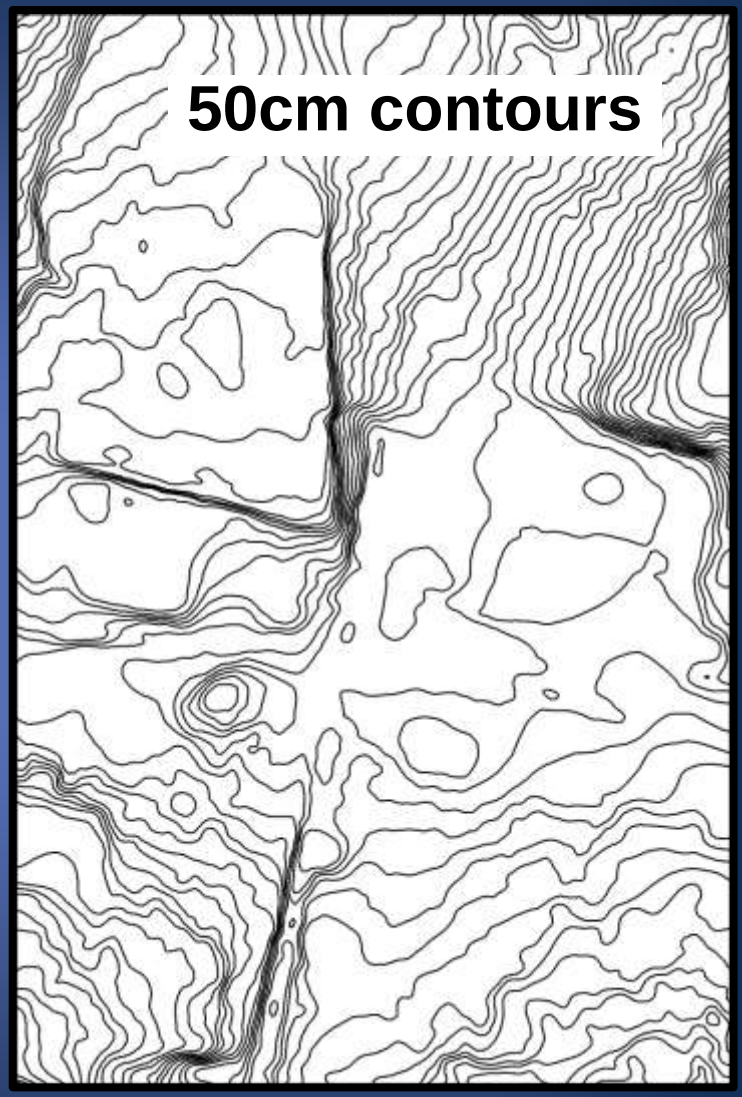
Satellite oil field facilities mapping



Fishkhabour production & transport facilities

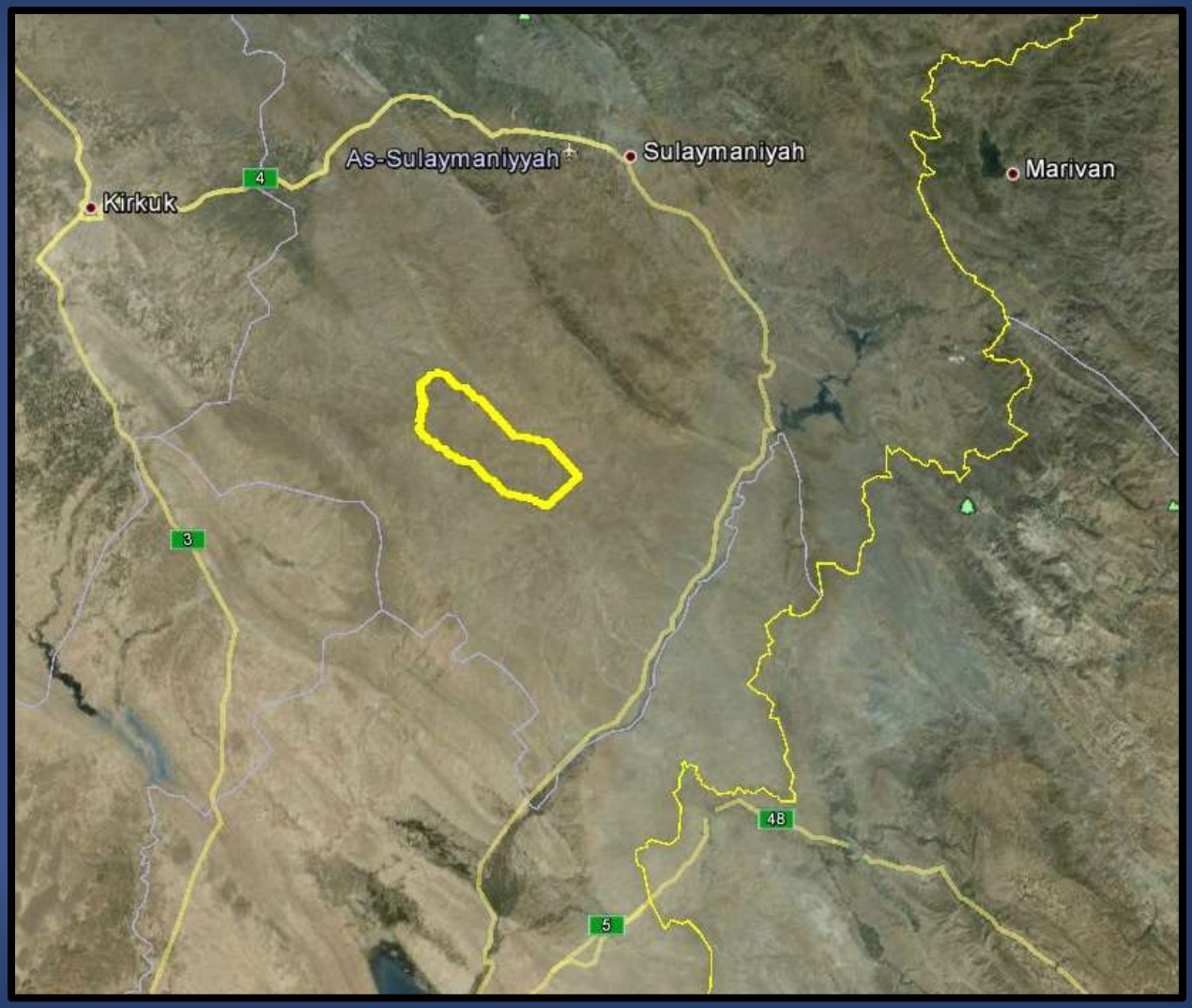
Satellite oil field facilities mapping



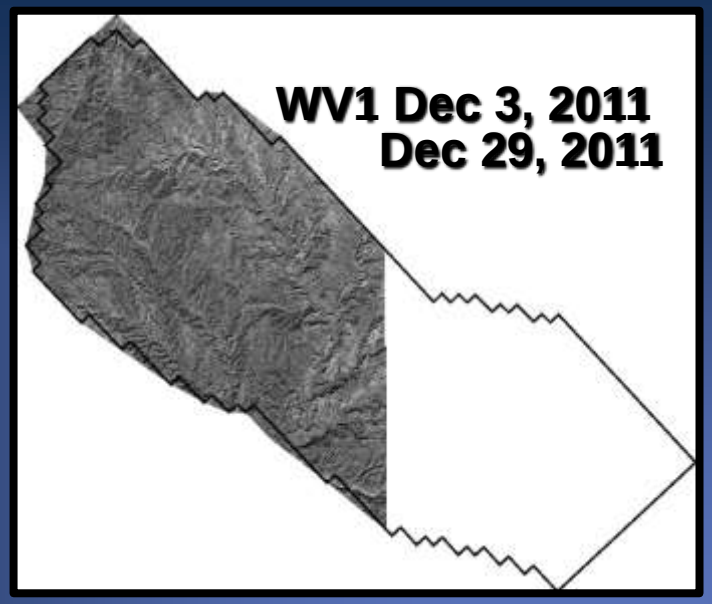
Fishkhabour production & transport facilities

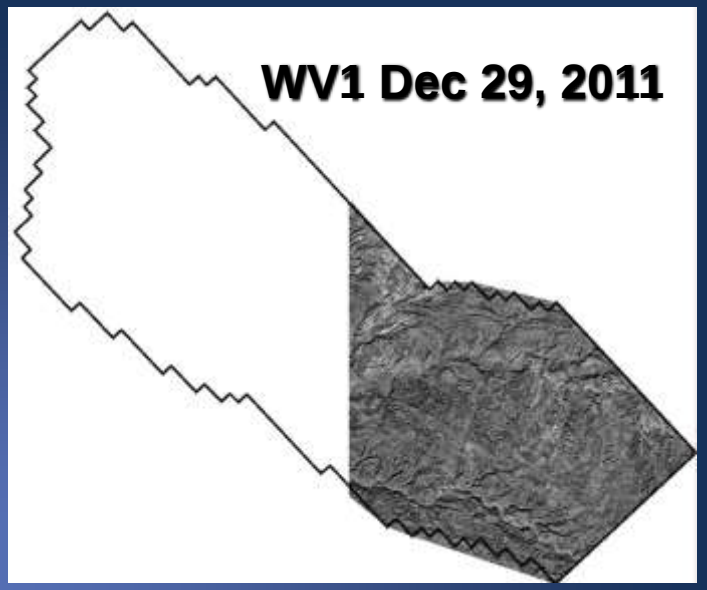
Kurdistan satellite topographic mapping examples

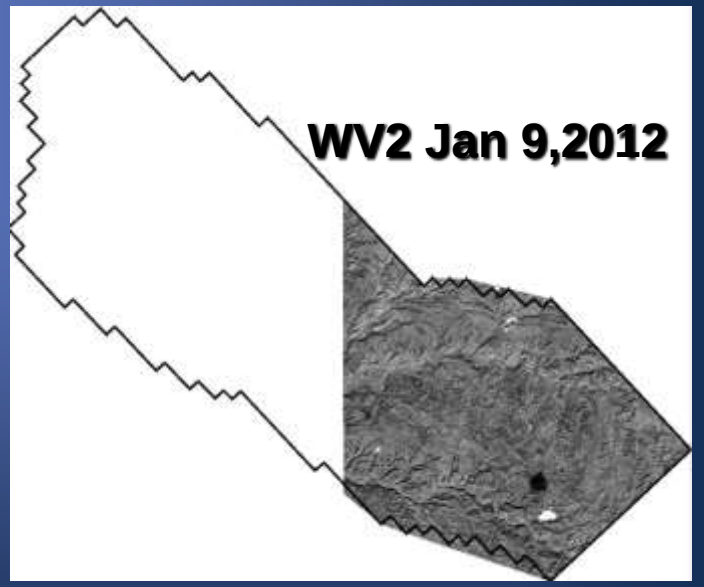
Stereo Satellite Topographic Mapping
Tobkhana & Kurdamir Blocks



Talisman, WesternZagros

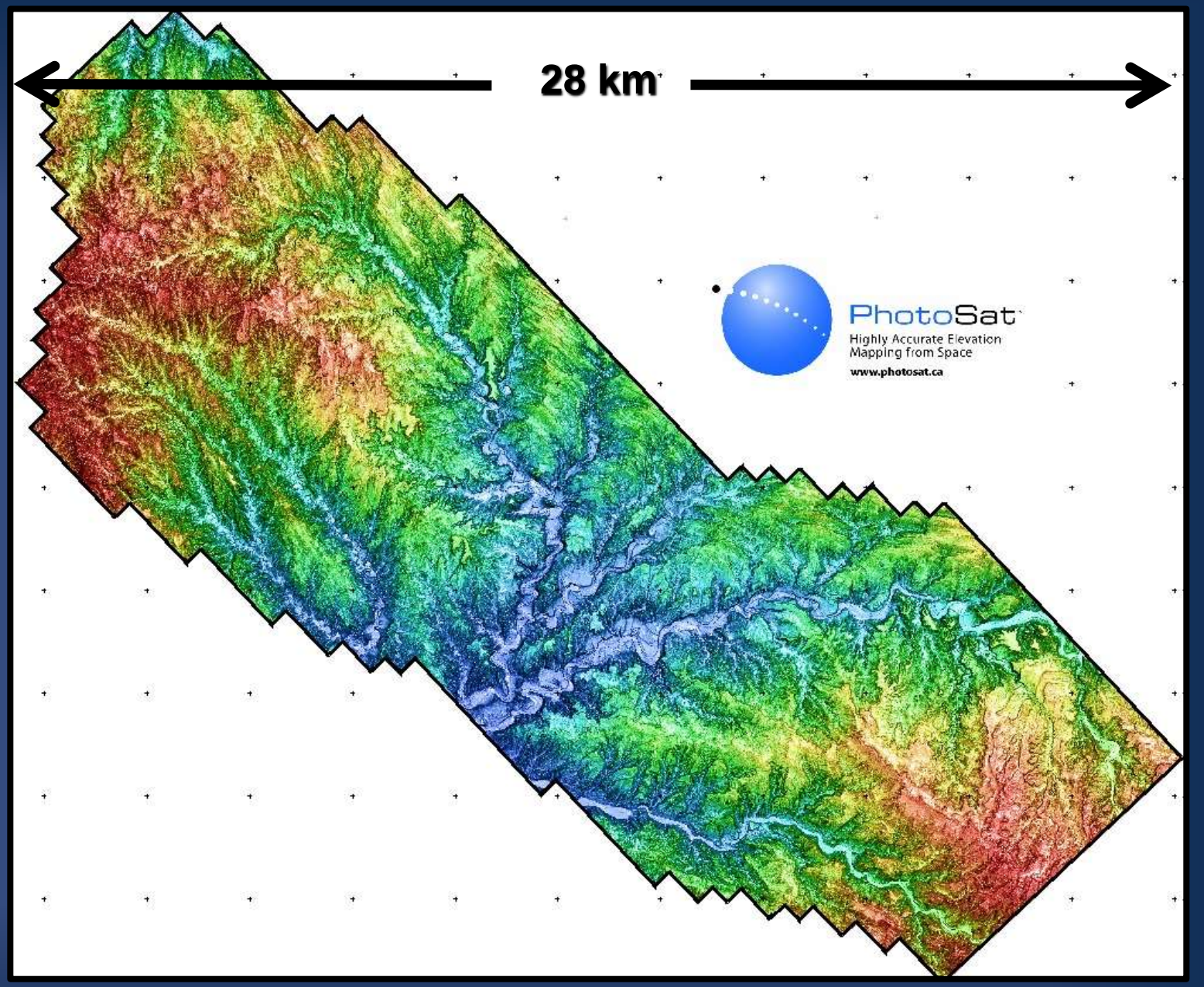




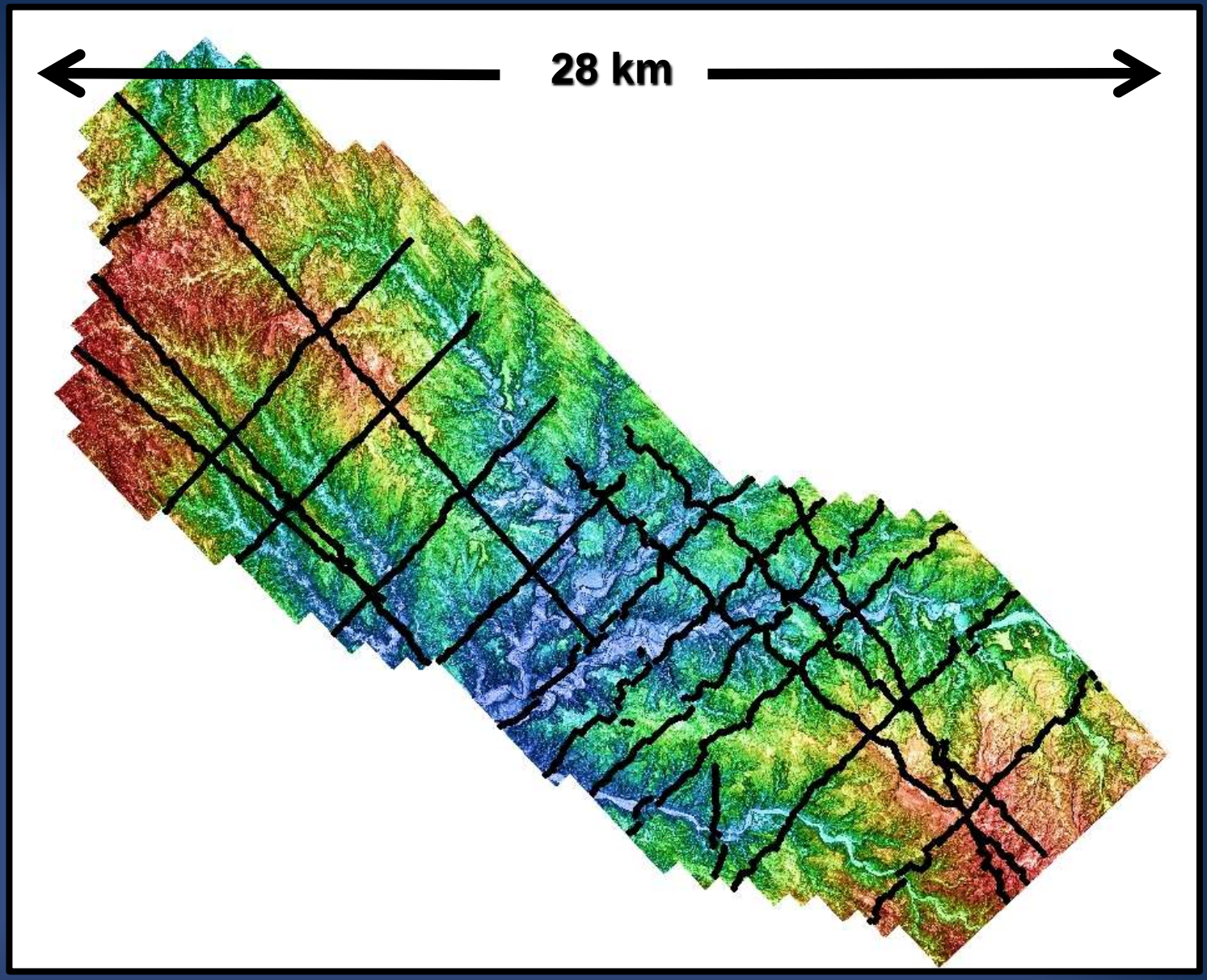


Stereo satellite photos

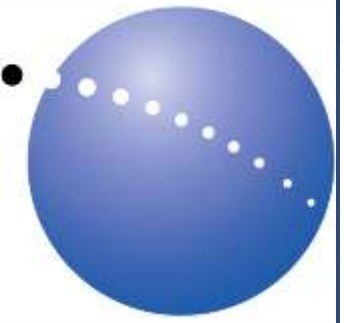
www.photosat.ca

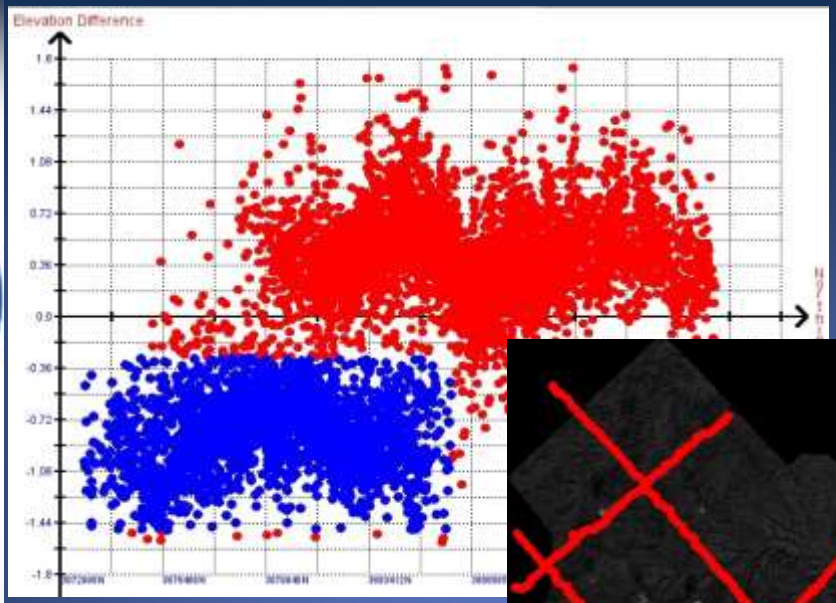


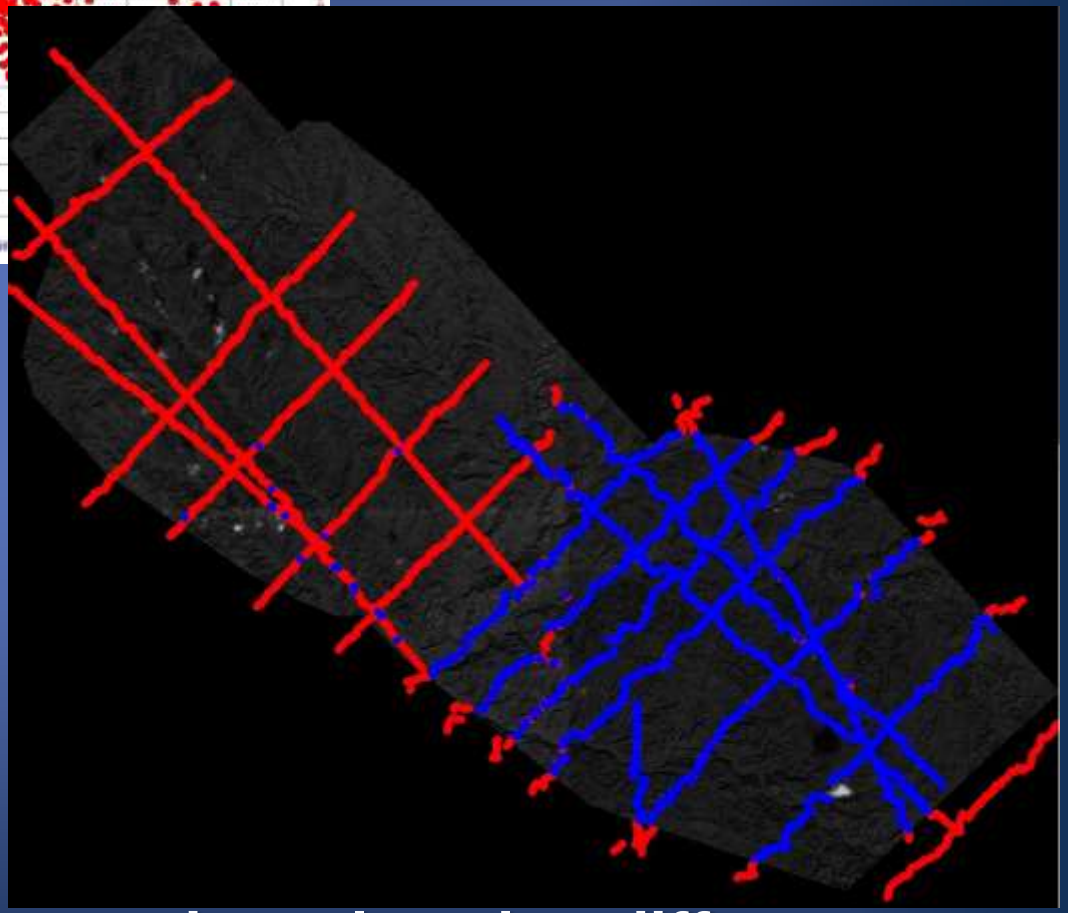
satellite topographic grid



2D seismic source points







Seismic source points elevation differences to satellite elevations

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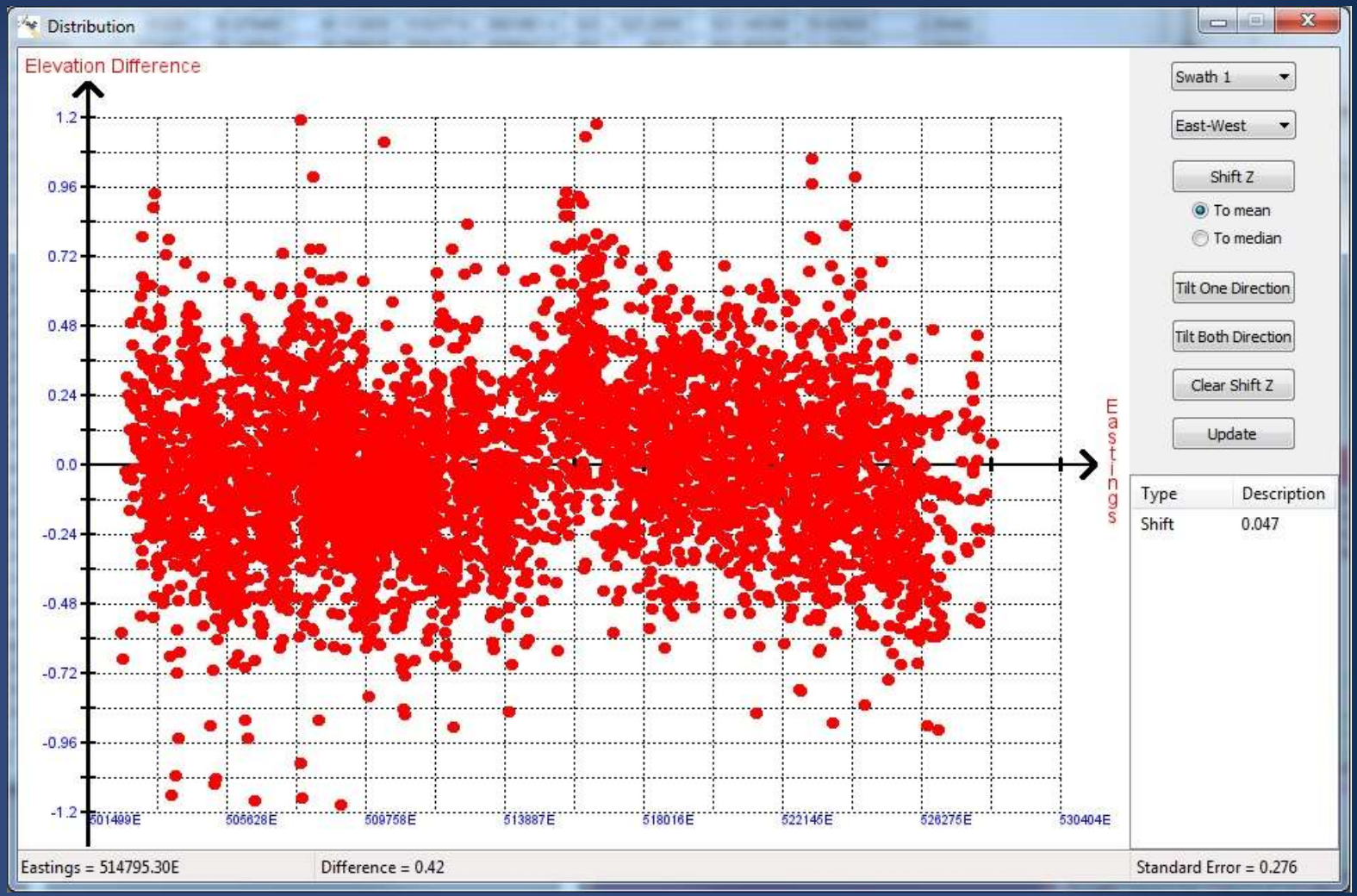
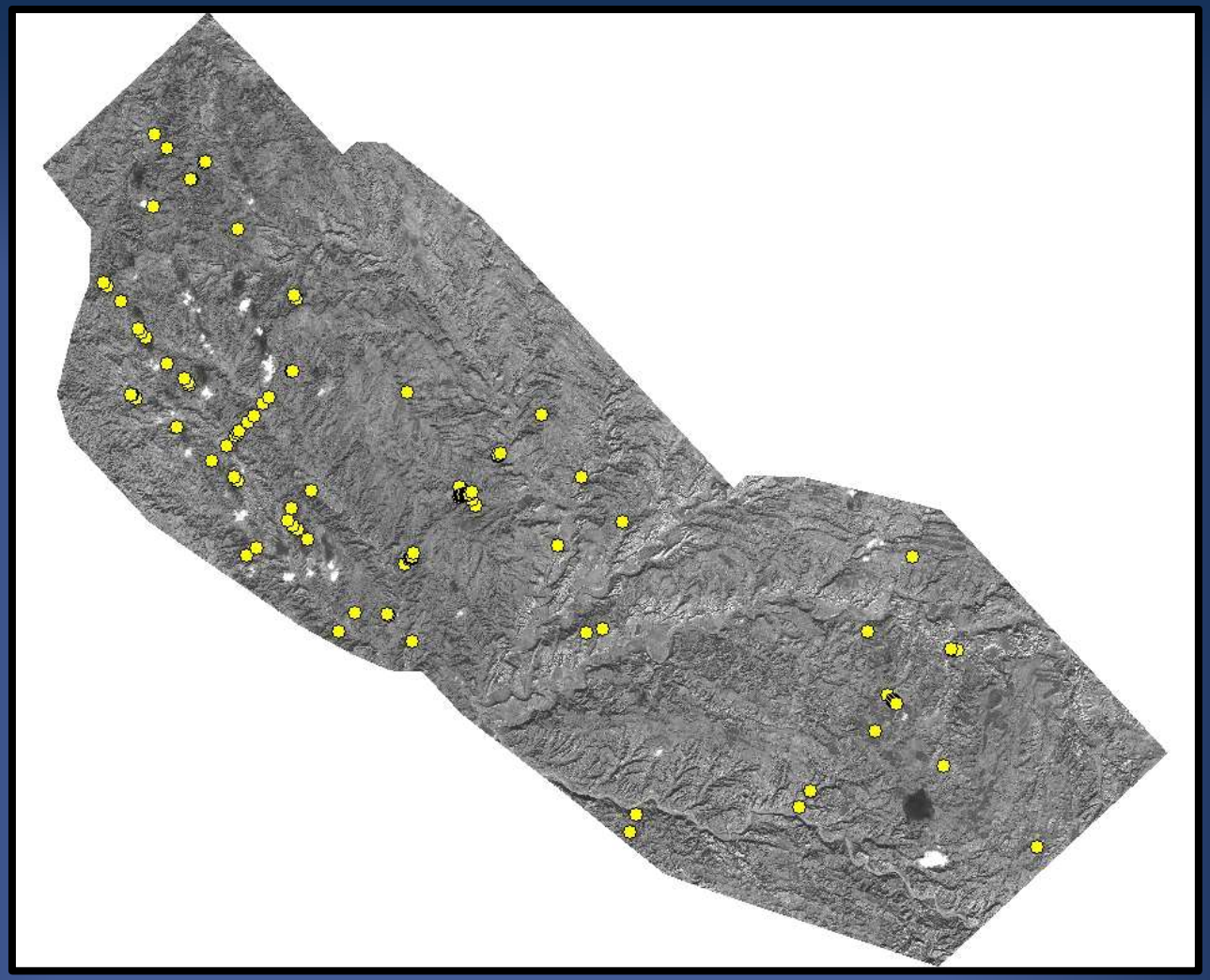


Kurdistan seismic source points differences to satellite elevations, SE points raised 1.3m Standard deviation 28cm.

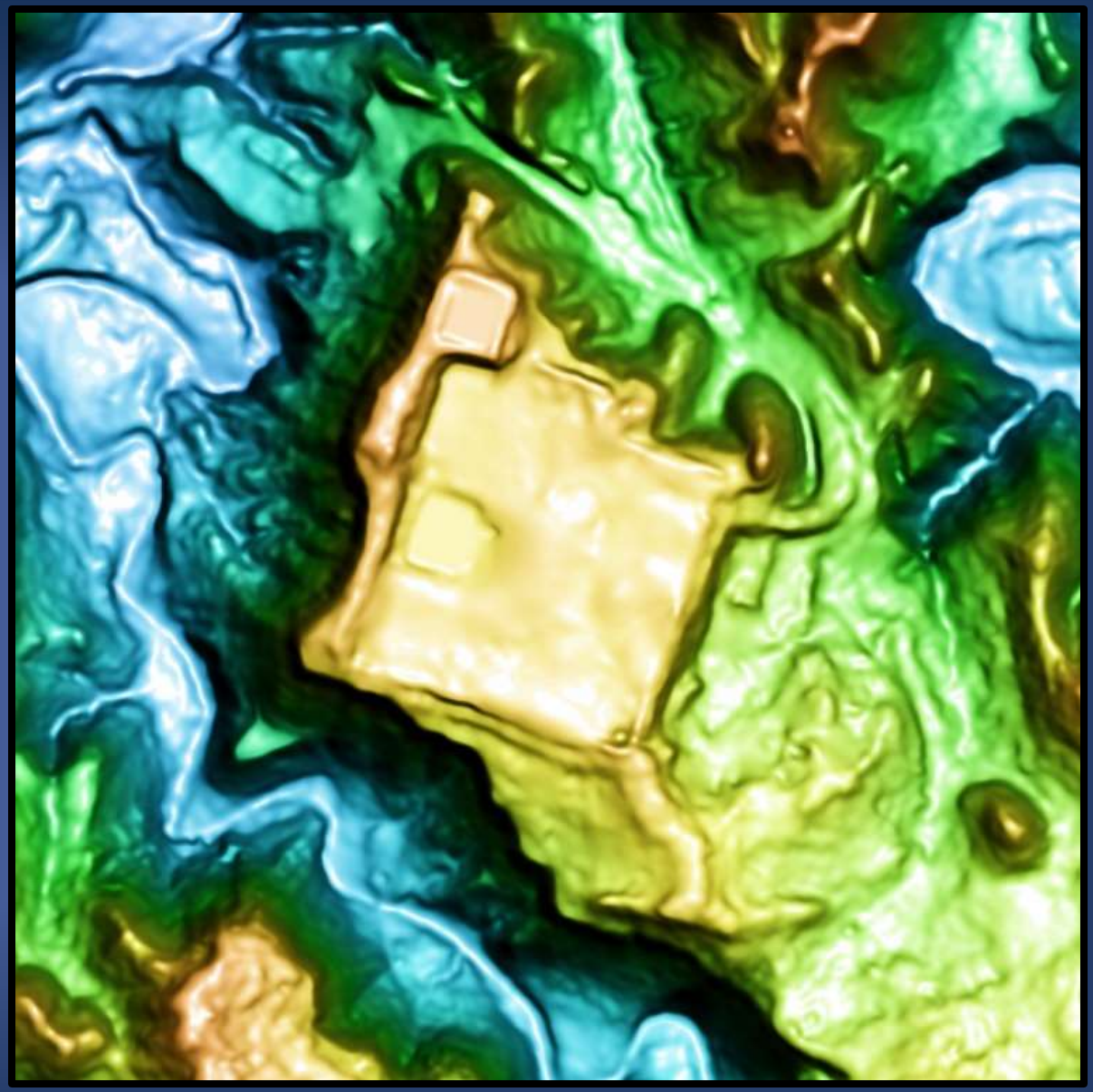
www.photosat.ca



107 seismic source points greater than 1m elevation difference to satellite elevations. These are probably survey errors due to too few GPS satellites in range. These source point elevations should be replaced by the stereo satellite elevations.

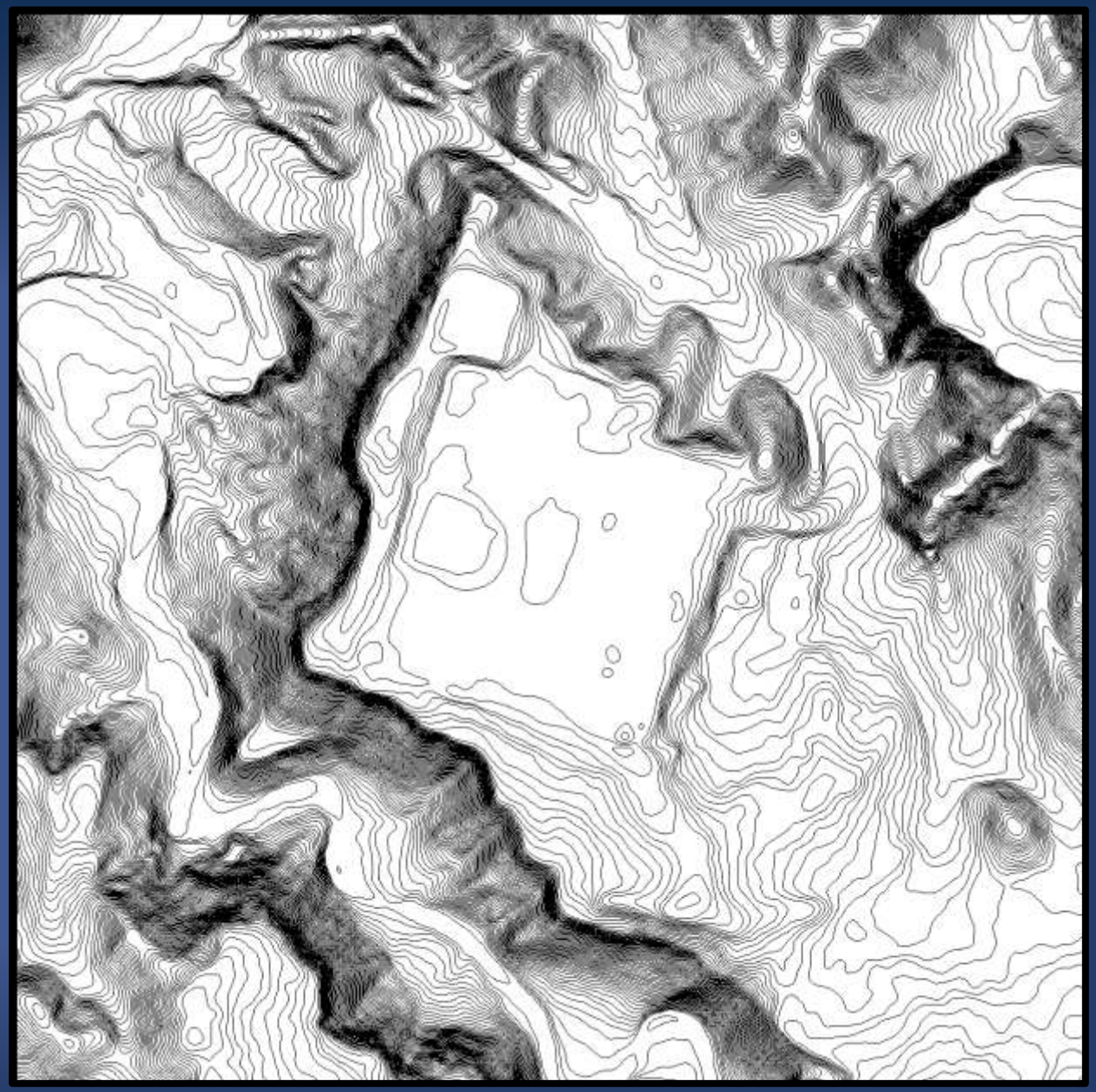
Talisman well site

www.photosat.ca



Talisman well site 1m satellite topographic grid

www.photosat.ca



Talisman well site 50cm satellite elevation contours

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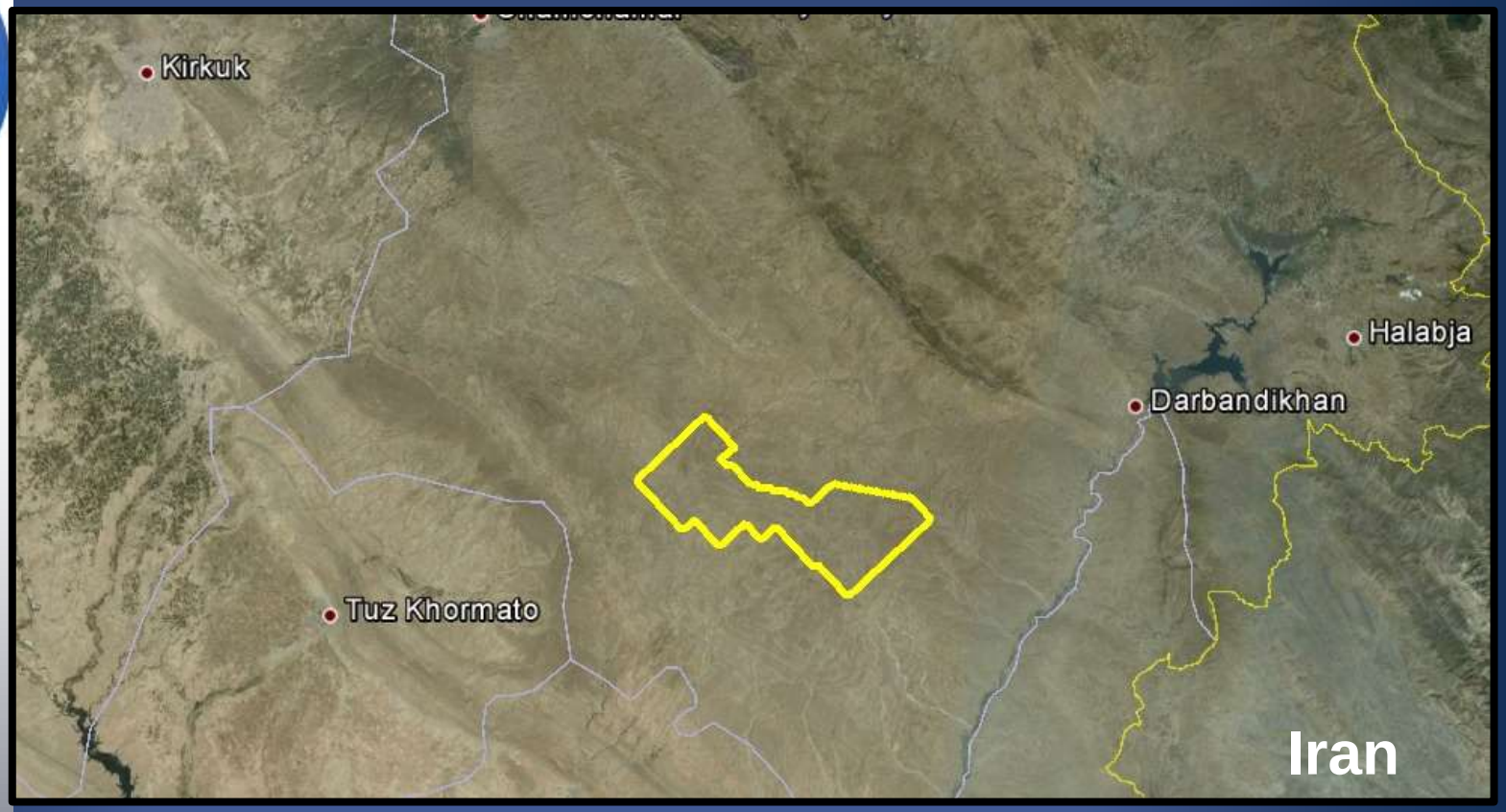
Garmian Block Kurdistan

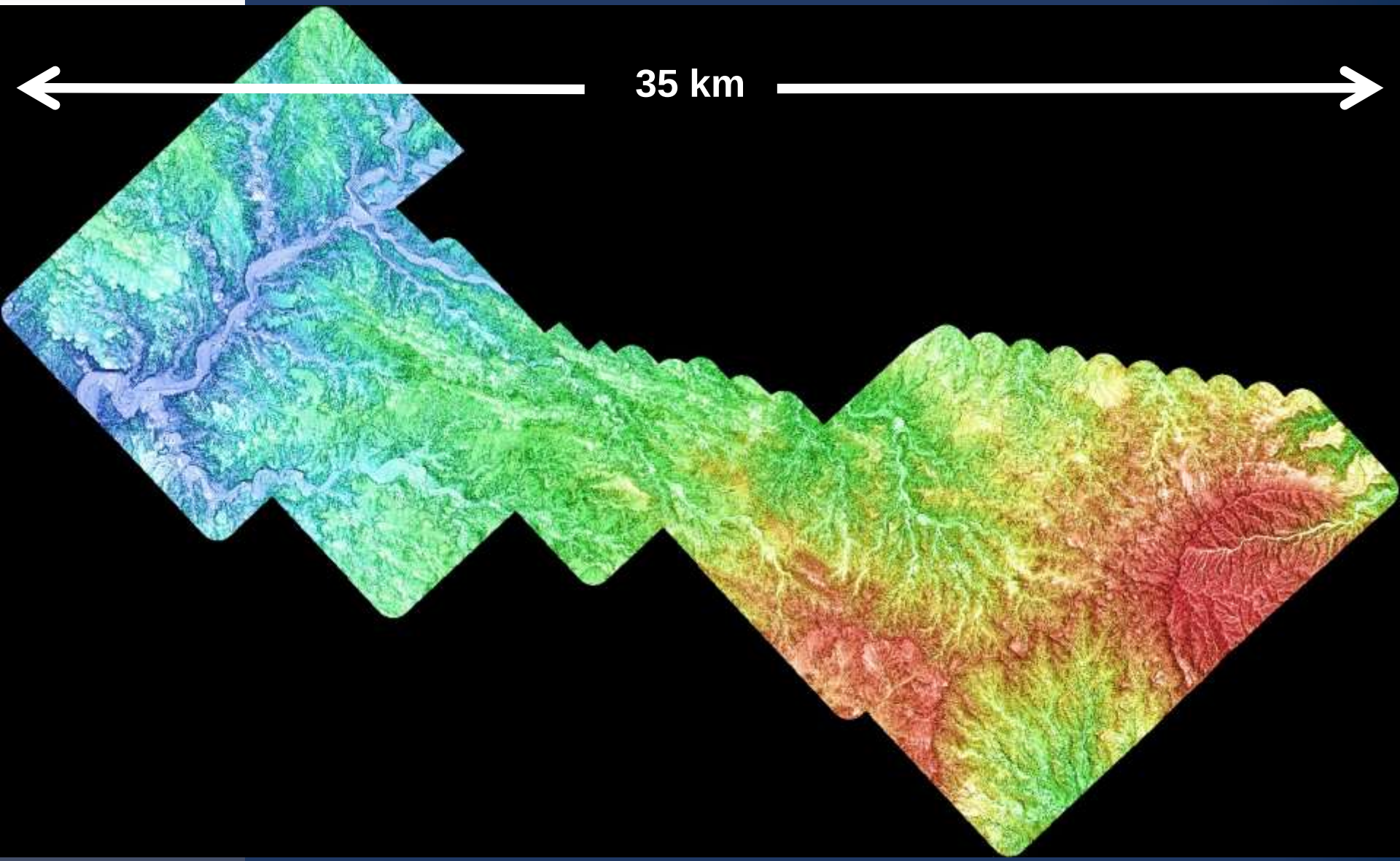
WesternZagros

Garmian Block Kurdistan



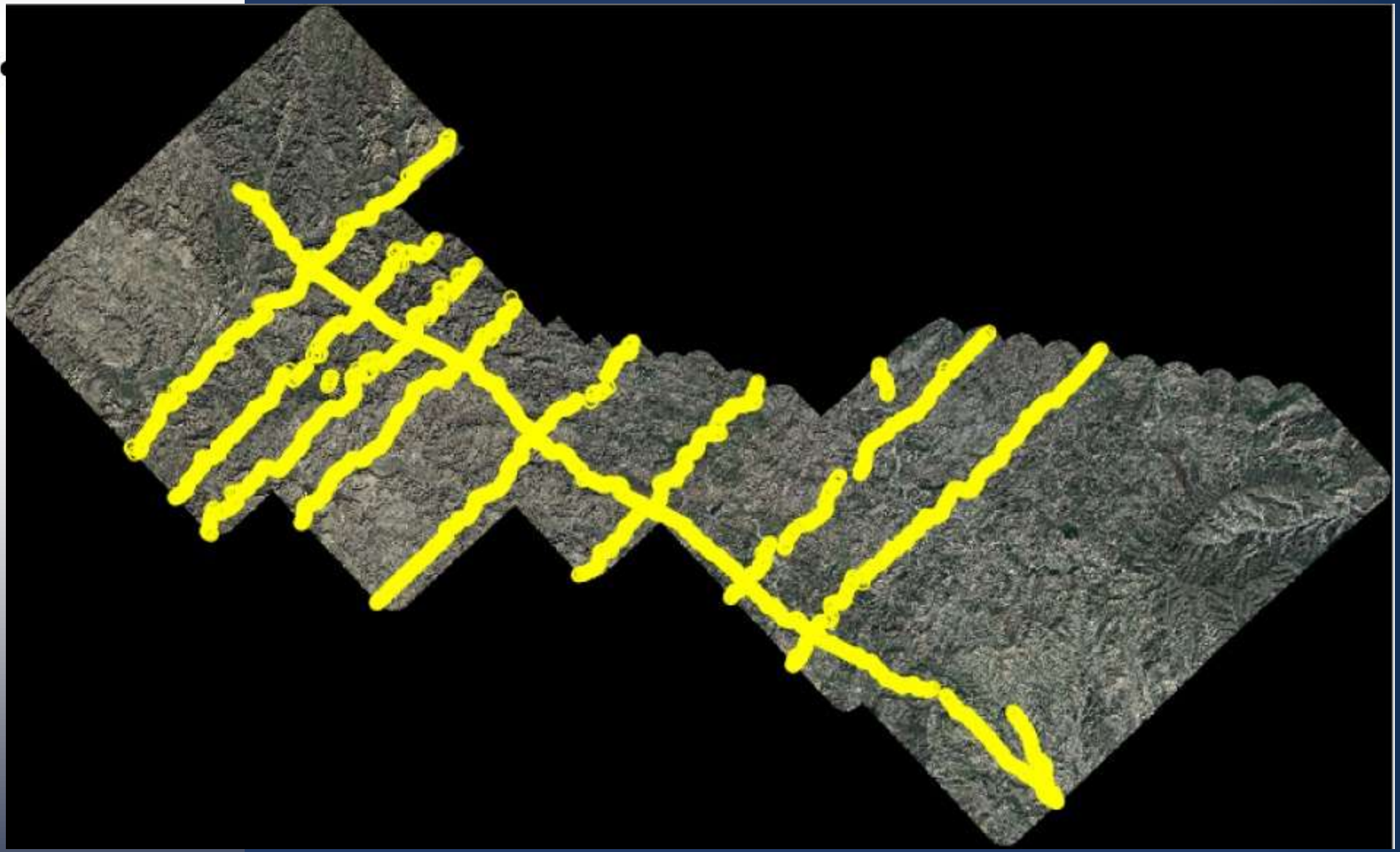
Western Zagros

Stereo Satellite Topographic Mapping



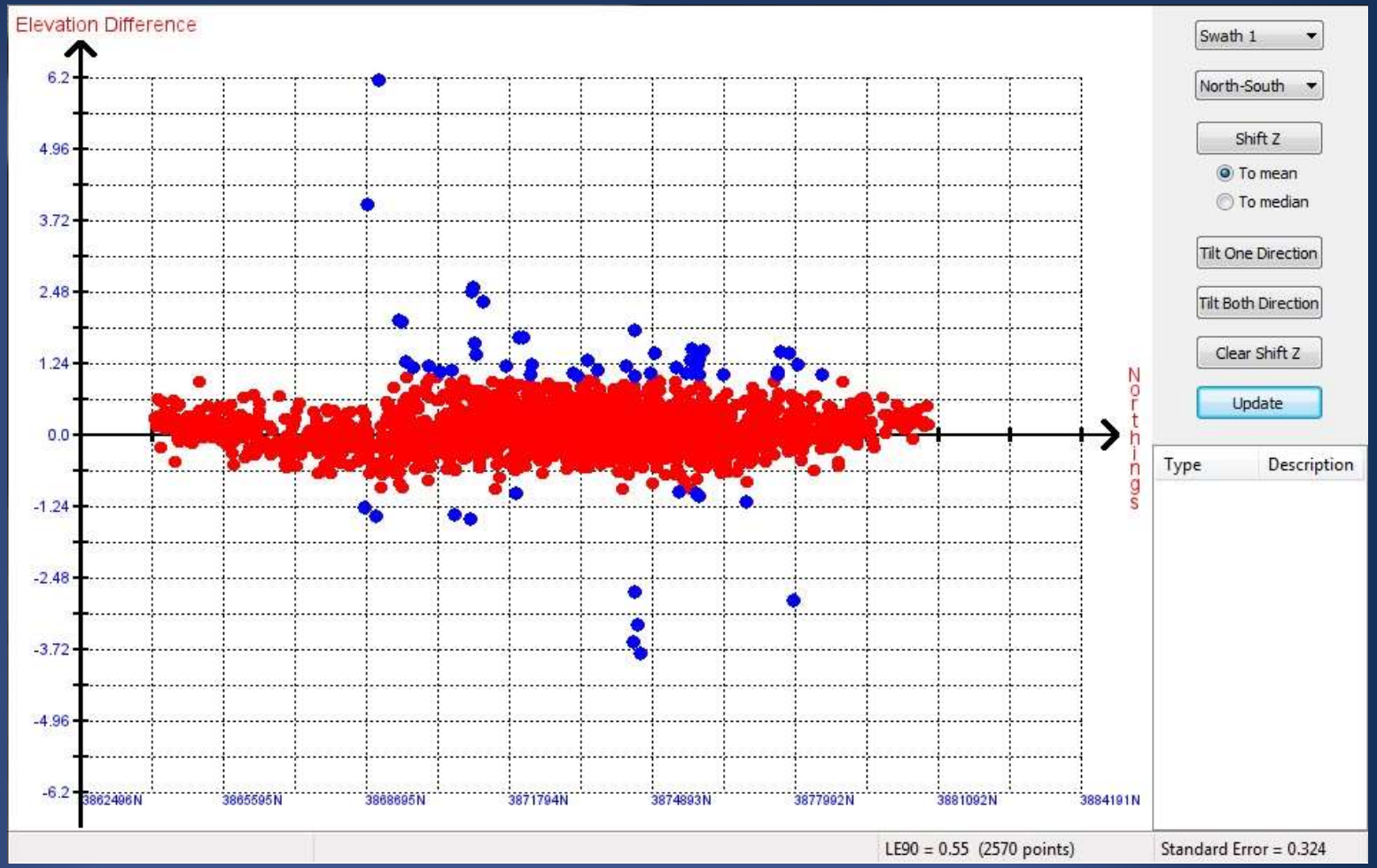
North Garmian Project topographic image

Stereo Satellite Topographic Mapping



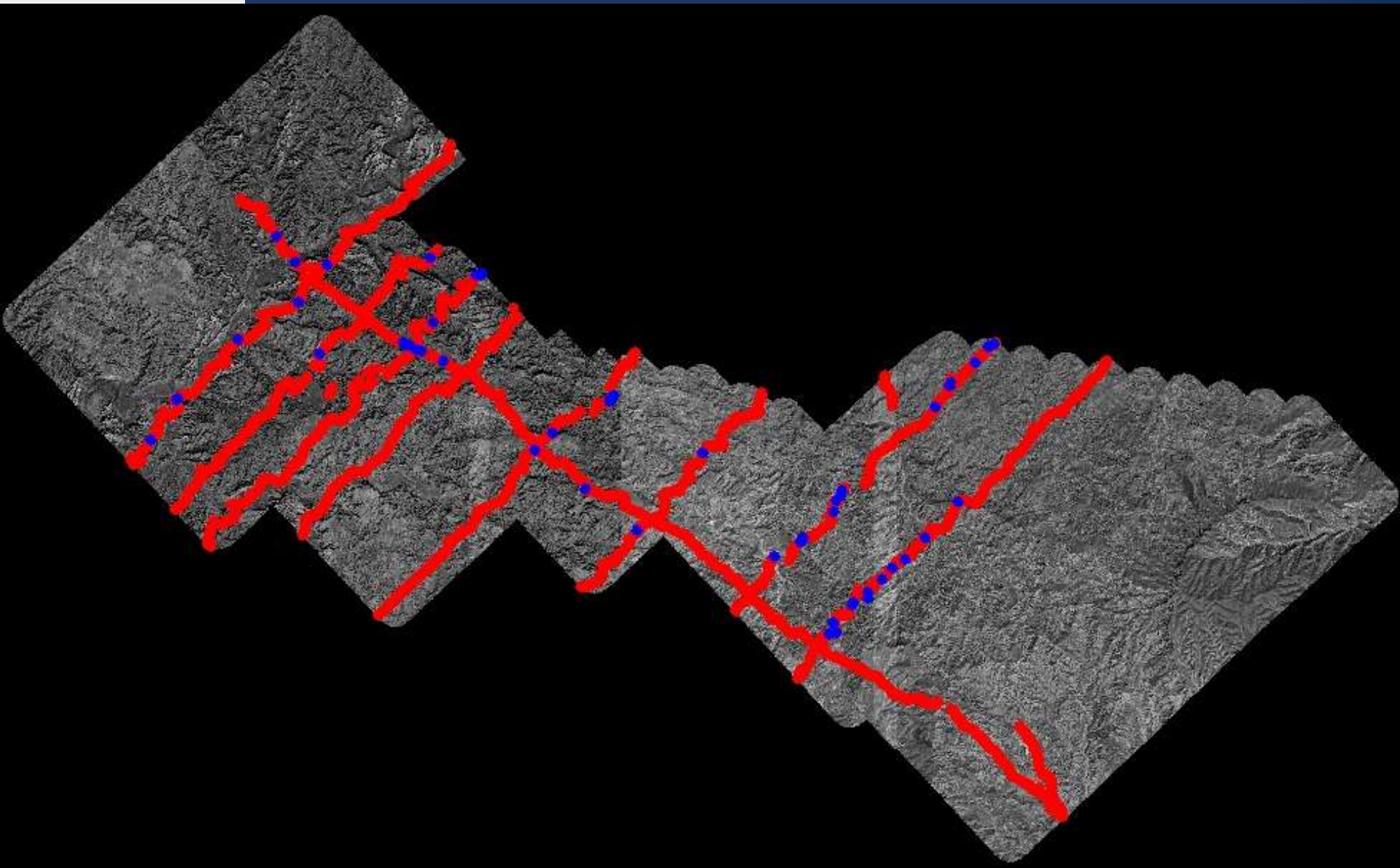
2D seismic source points

Stereo Satellite Topographic Mapping



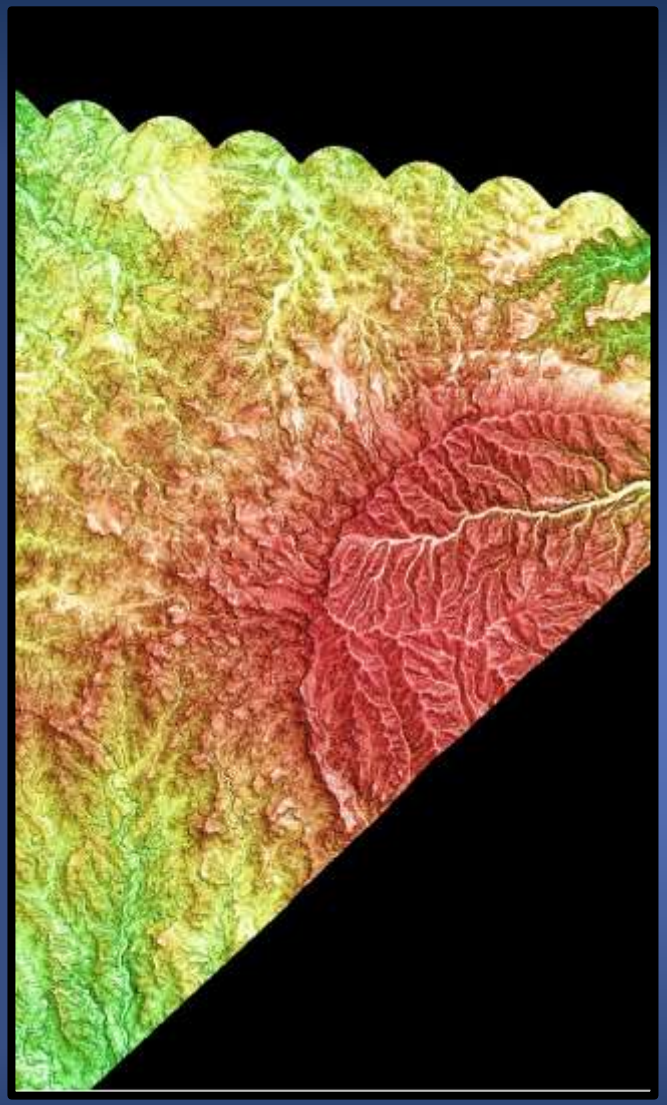
North Garmian Project scatter plot of elevation differences between seismic source points elevations and satellite topography. Standard deviation 34cm.

Stereo Satellite Topographic Mapping

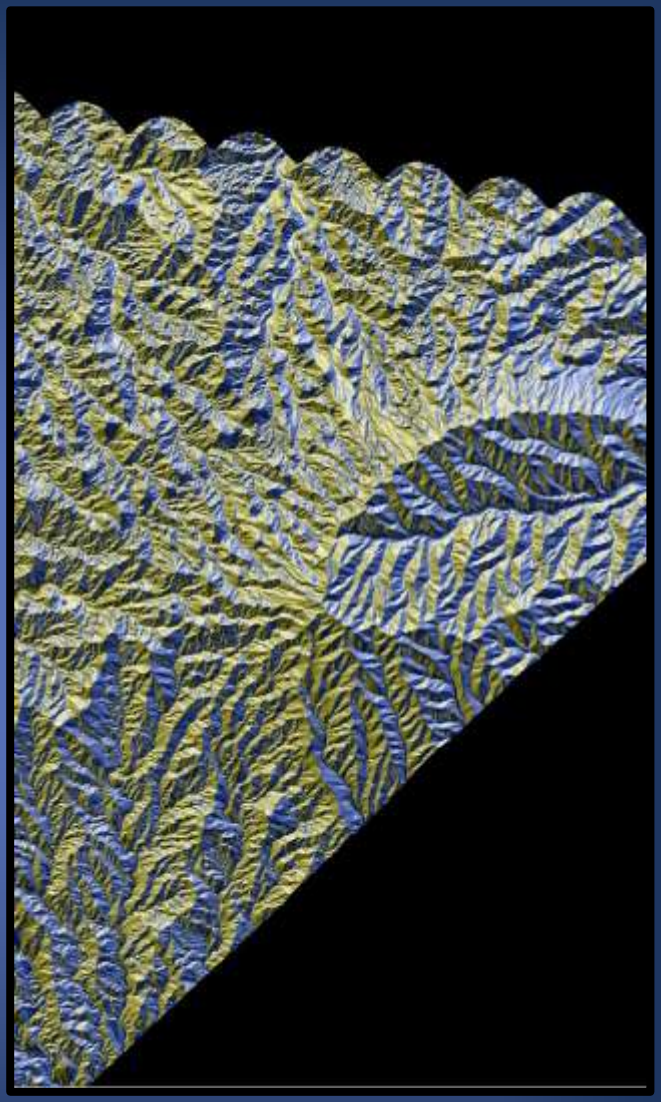


Seismic source points > 1m elevation difference

Stereo Satellite Topographic Mapping

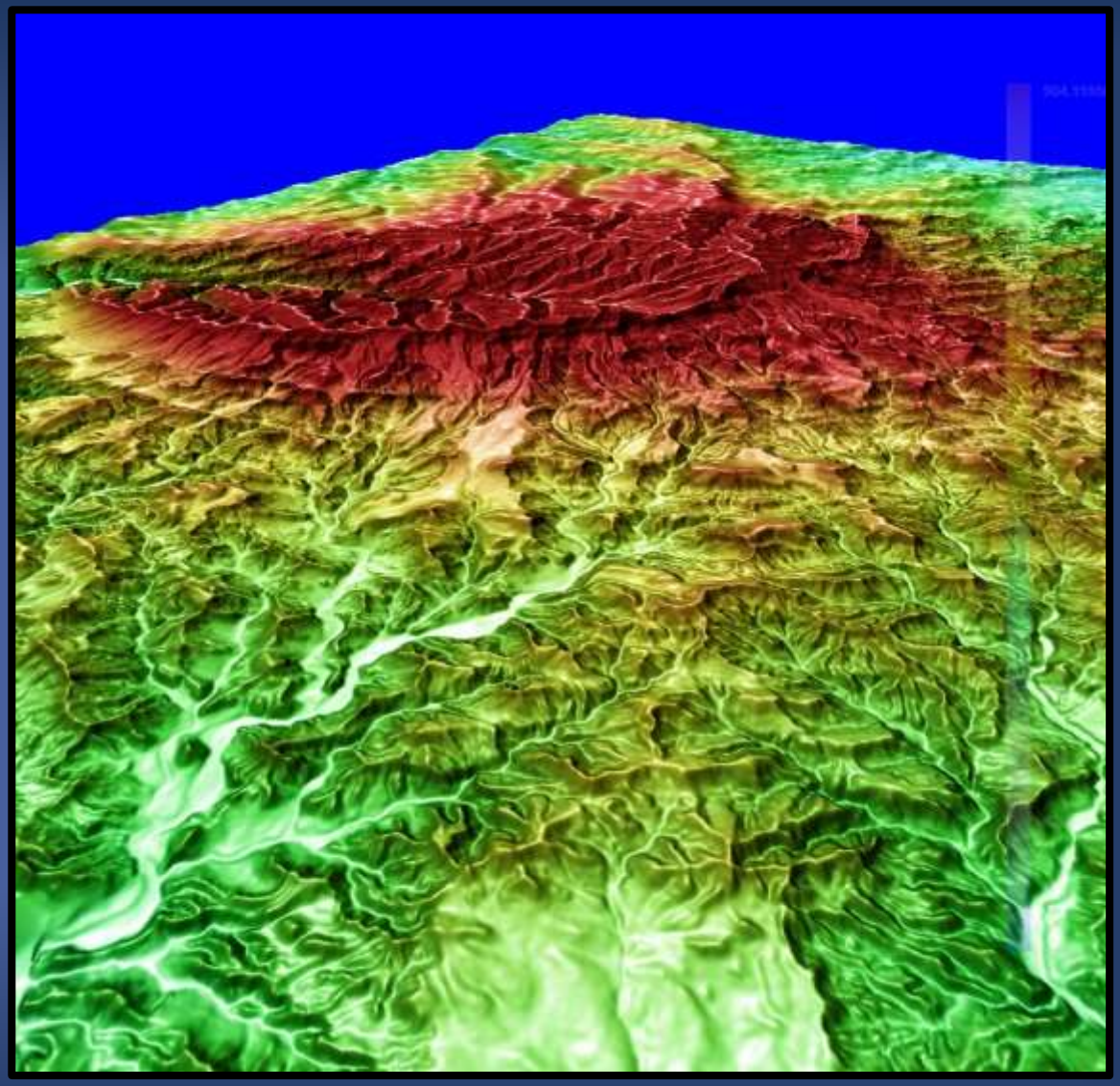


Satellite topography

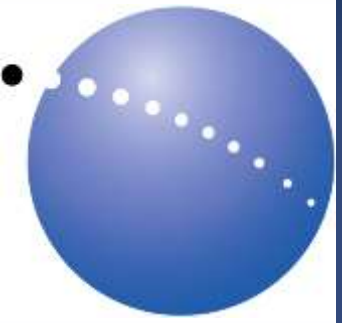


Slope direction

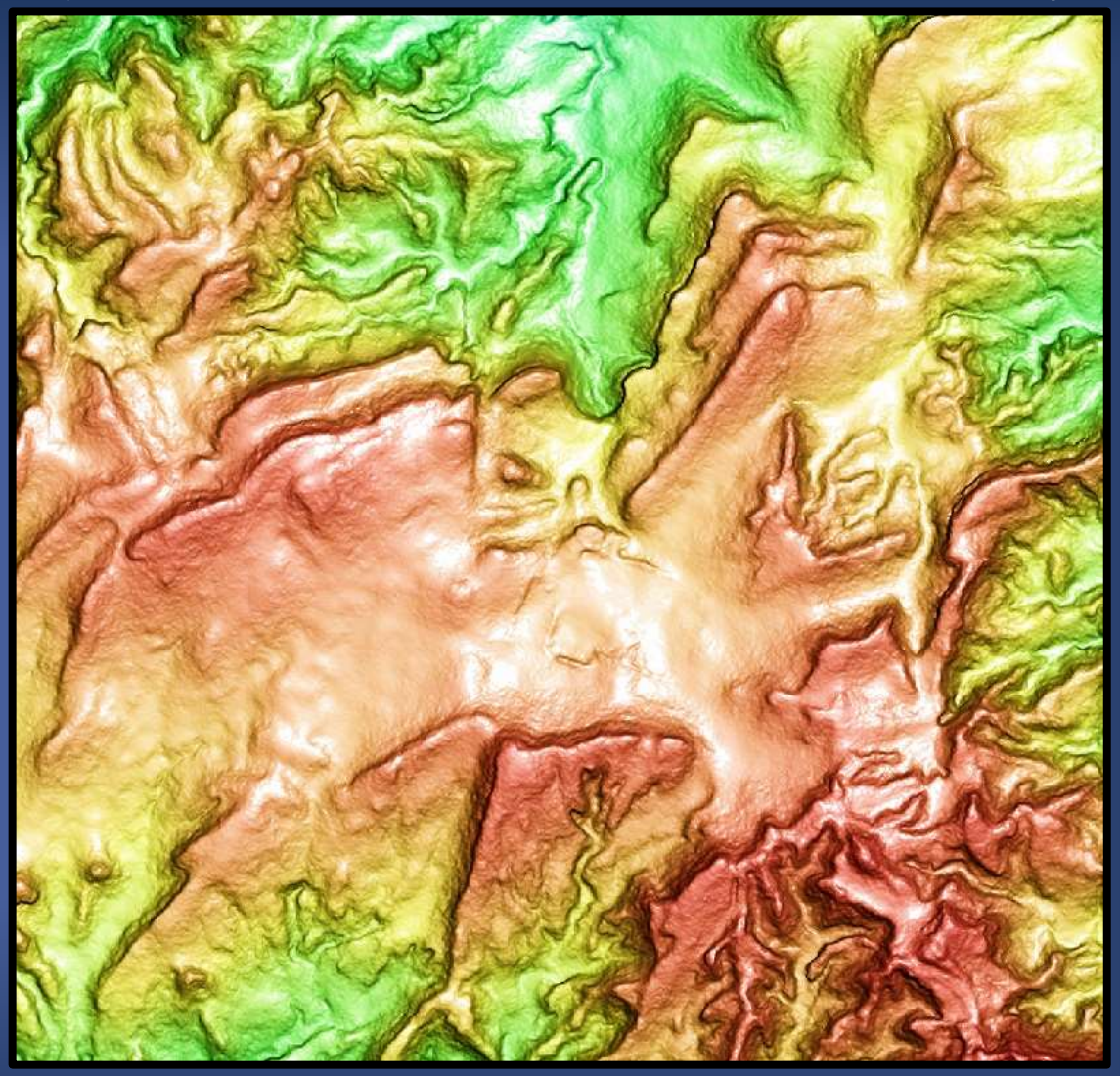
Stereo Satellite Topographic Mapping



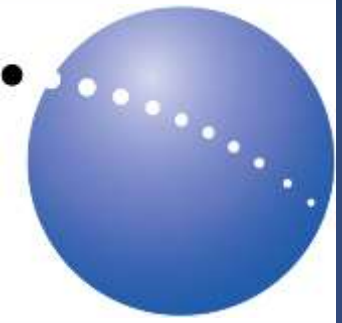
3D view of satellite topography.



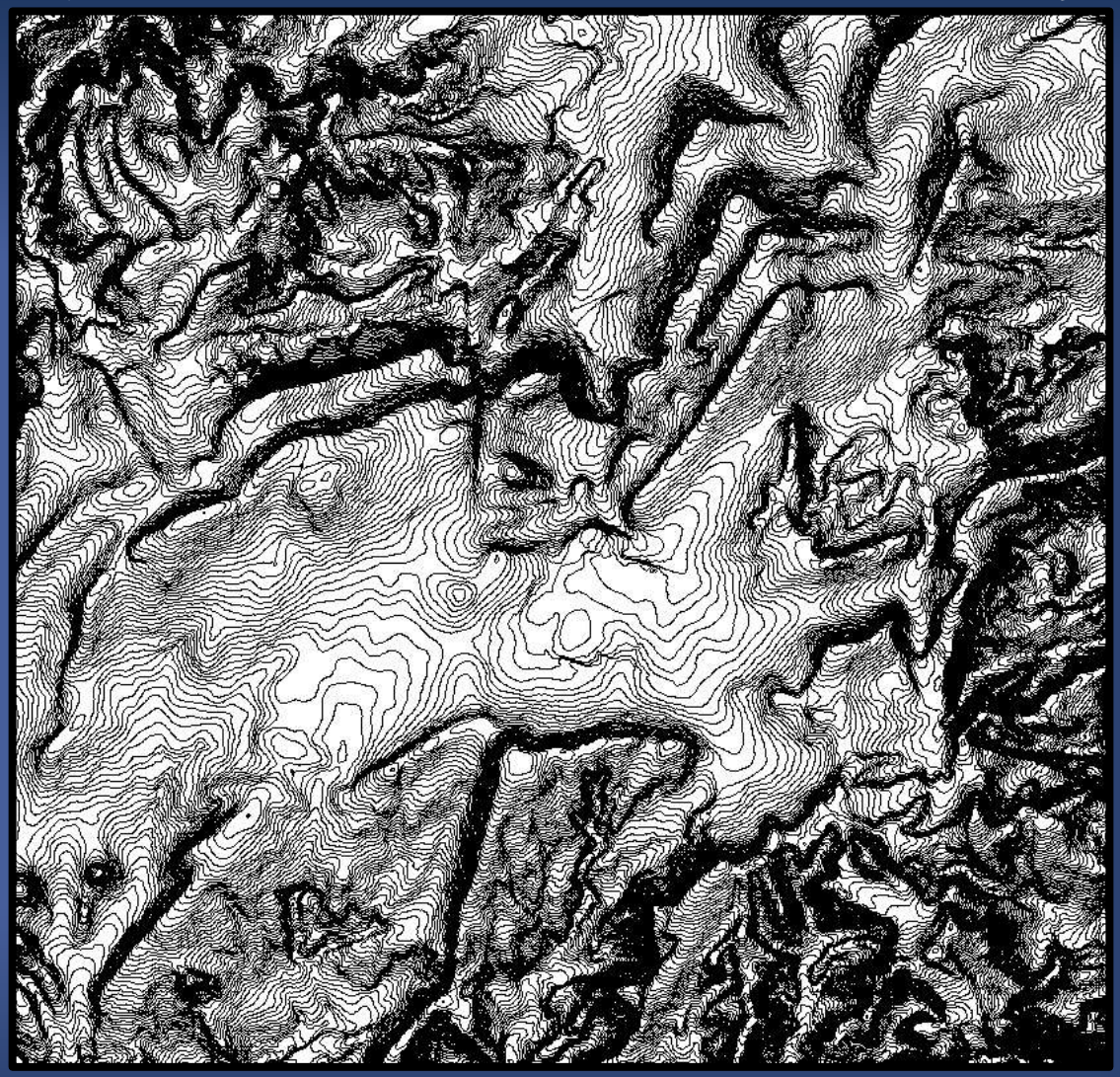
2km



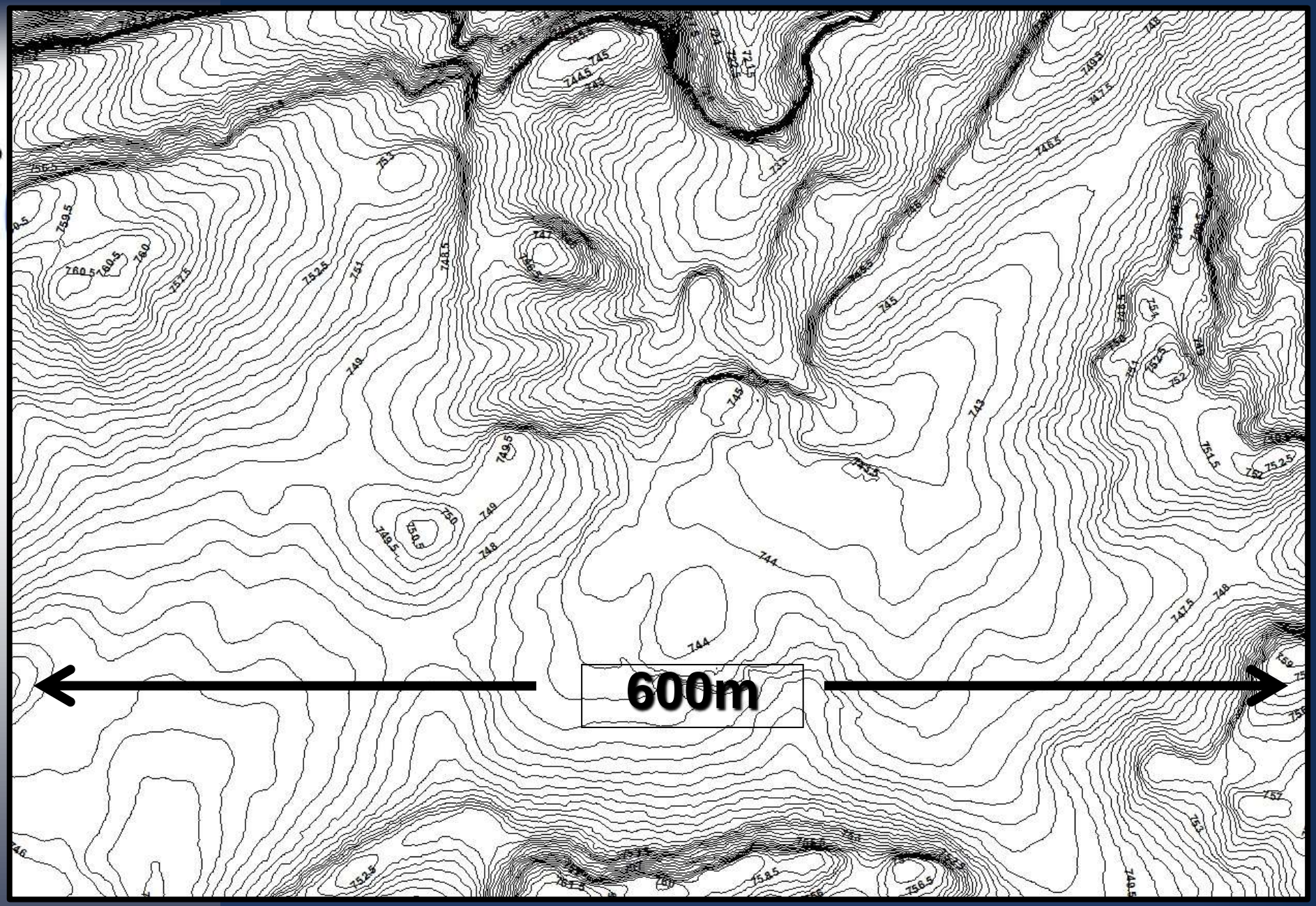
1m topographic grid



2km



50cm contours



50cm contours

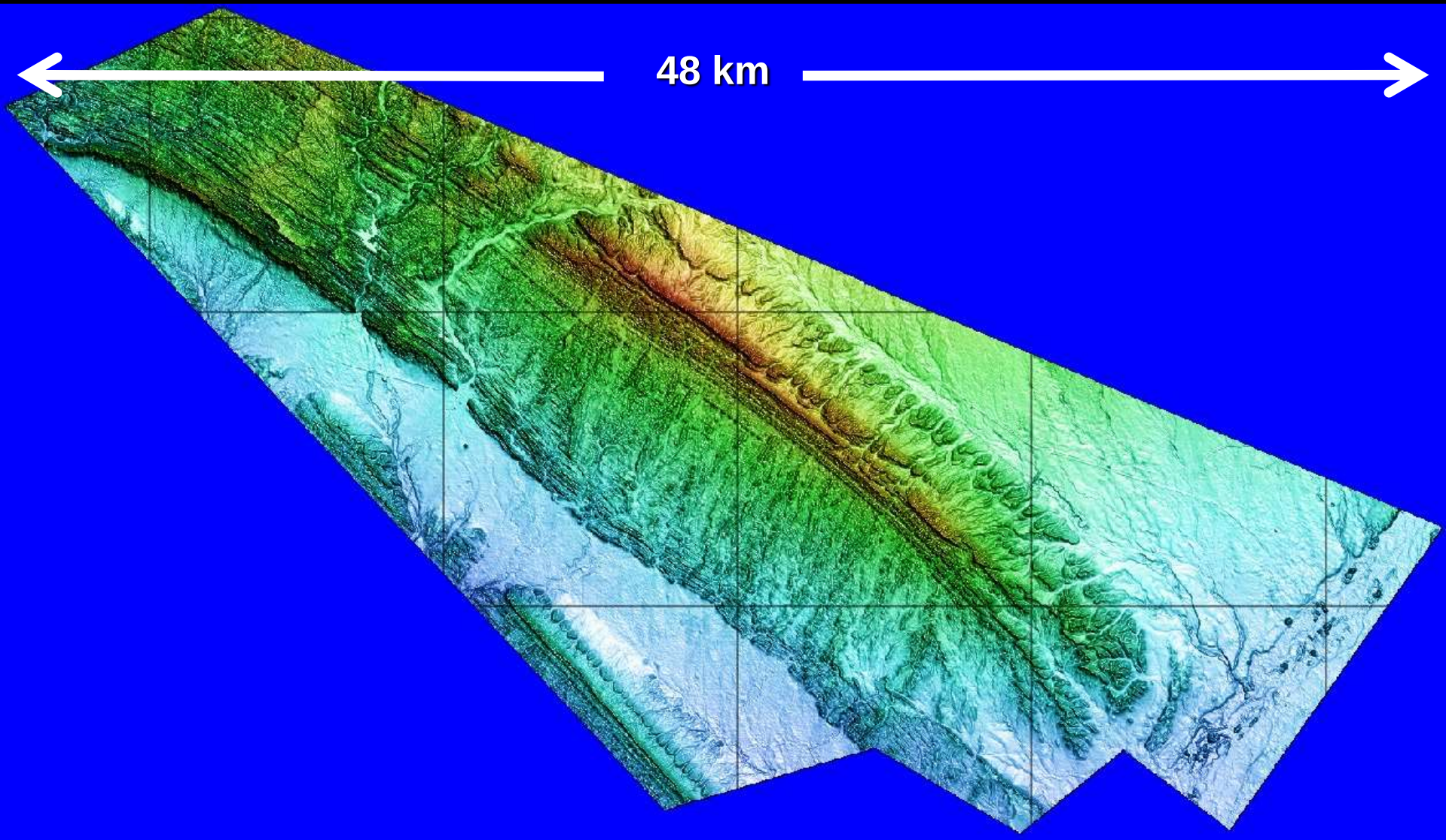
Shakal Block Kurdistan

Gazprom Neft Middle East B.V.

Shakal Block Kurdistan

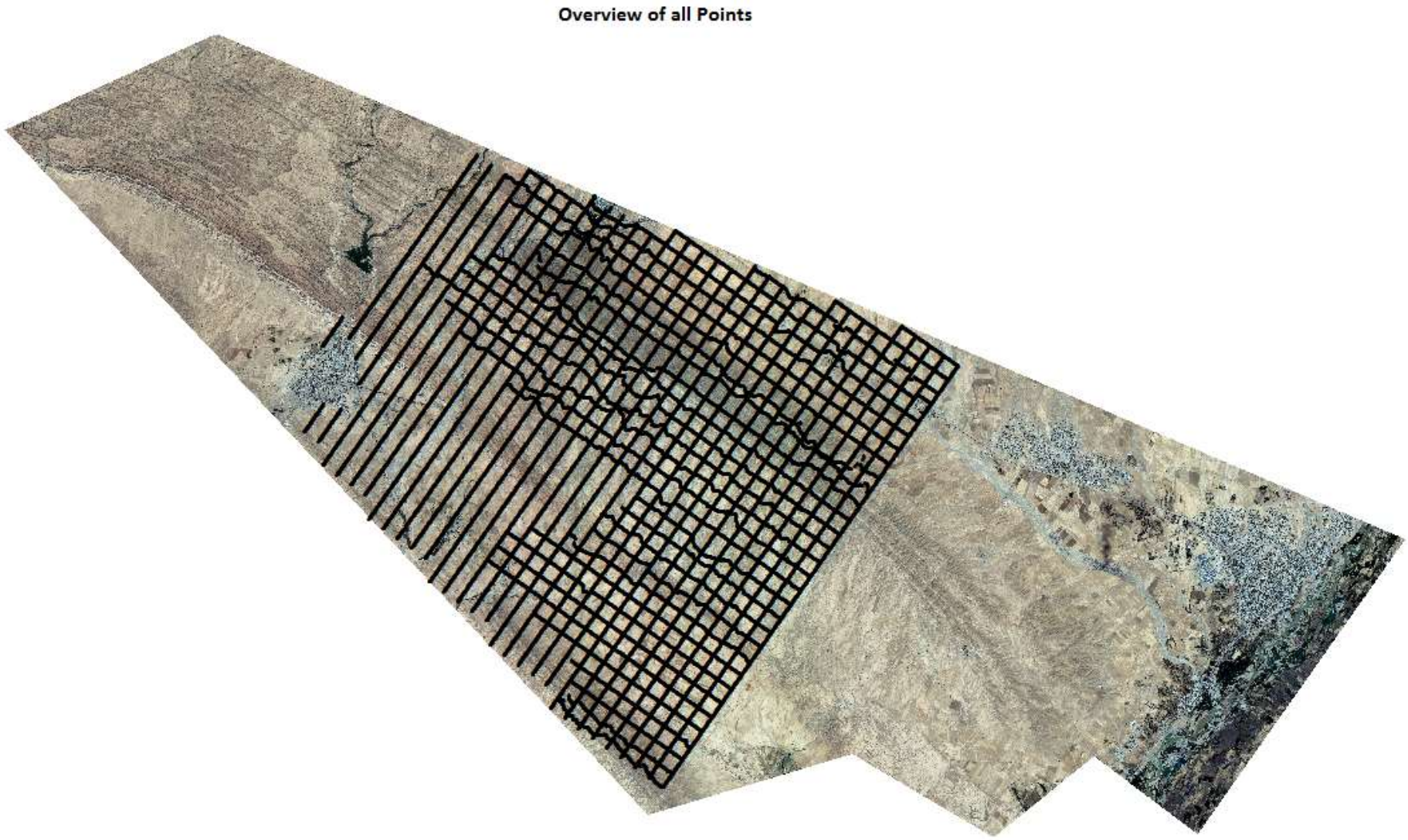
Gazprom Neft Middle East B.V.

Shakal Block Kurdistan



Pleiades satellite topography

Shakal Block Kurdistan



Pleiades satellite ortho photo with seismic source point overlay

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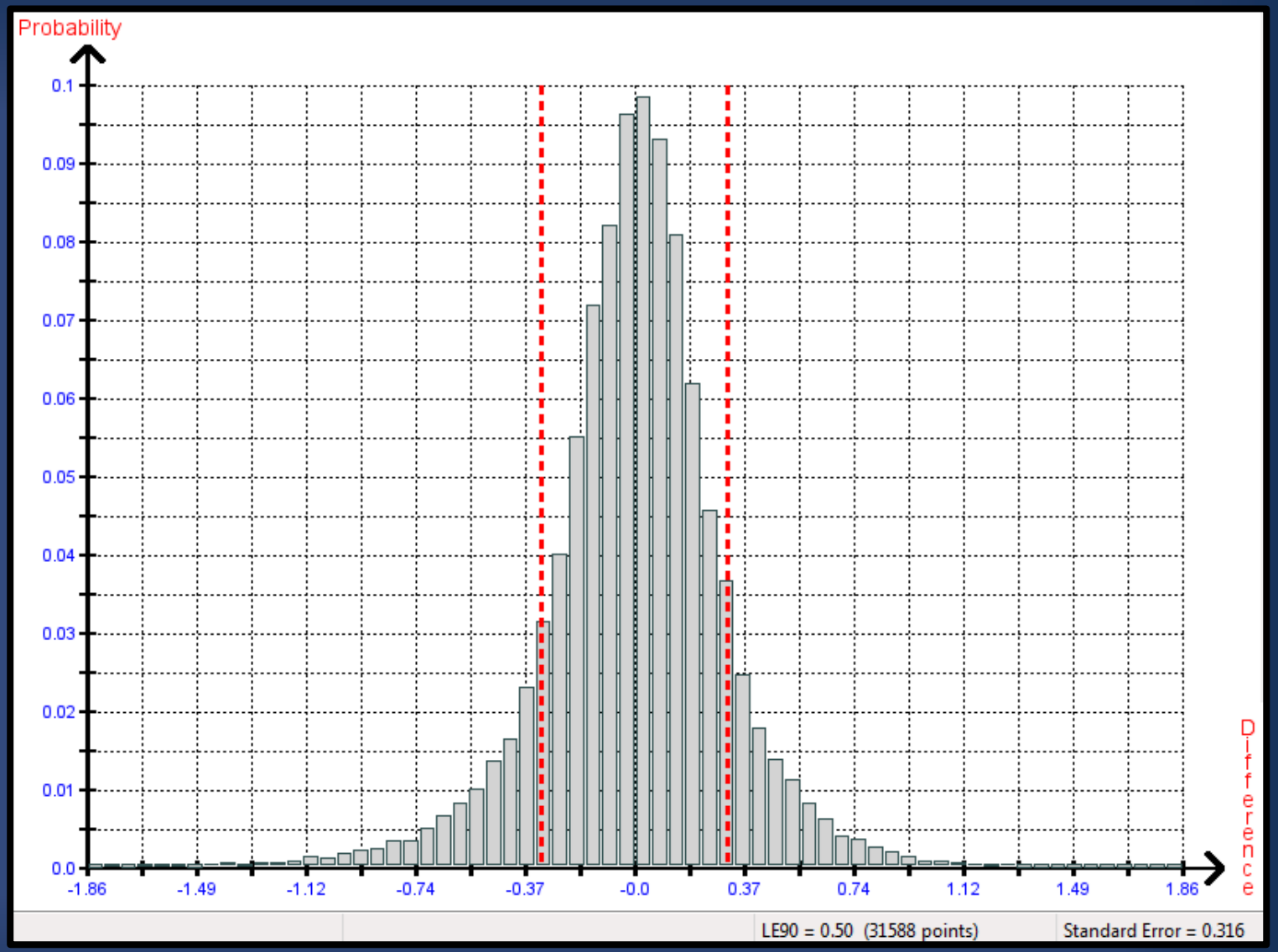
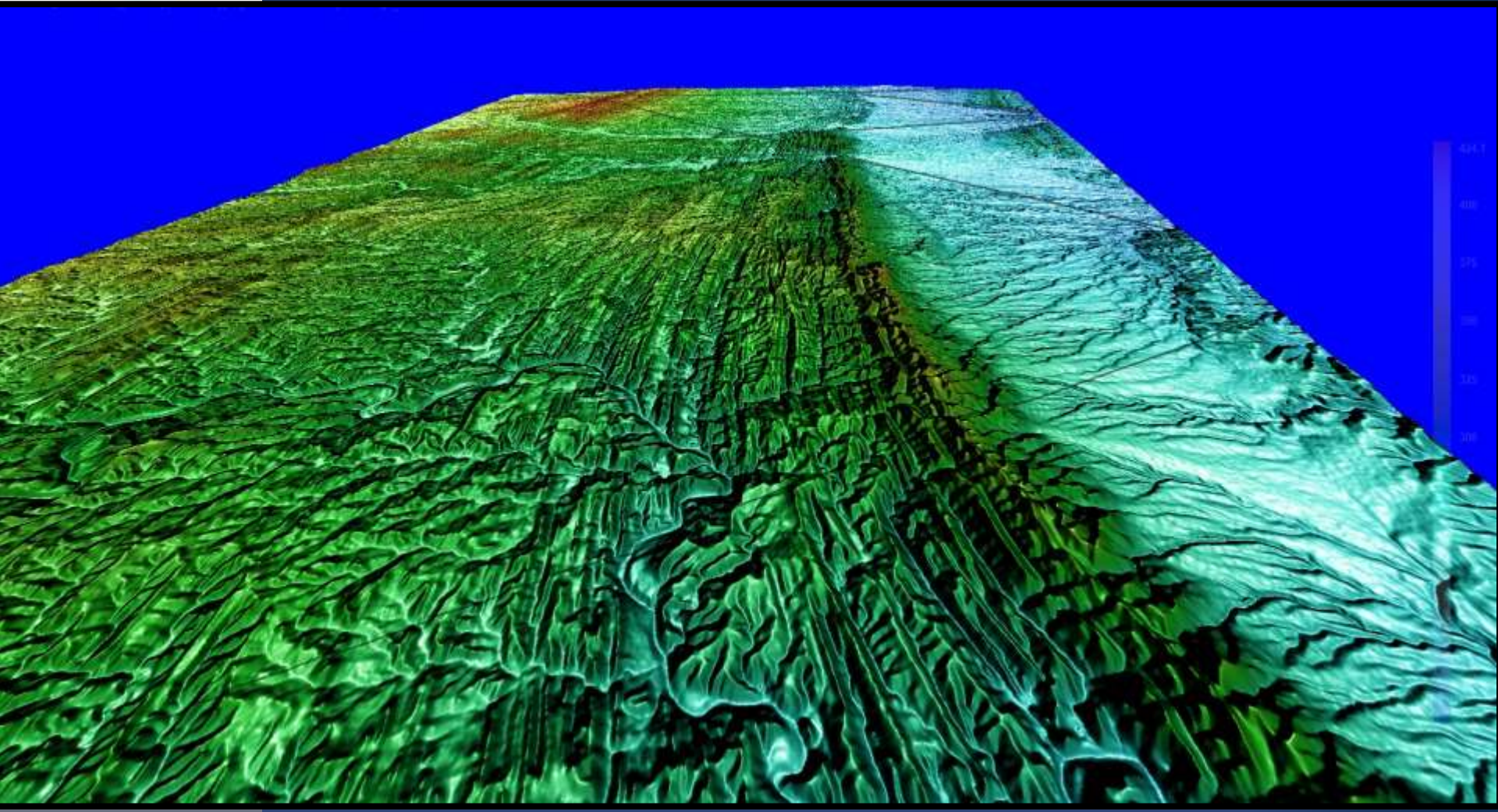
Shakal Block Kurdistan



Satellite topography match to 31,588 seismic source point elevations, standard error 32cm.

www.photosat.ca

Shakal Block Kurdistan



3D view of satellite topographic grid looking SE

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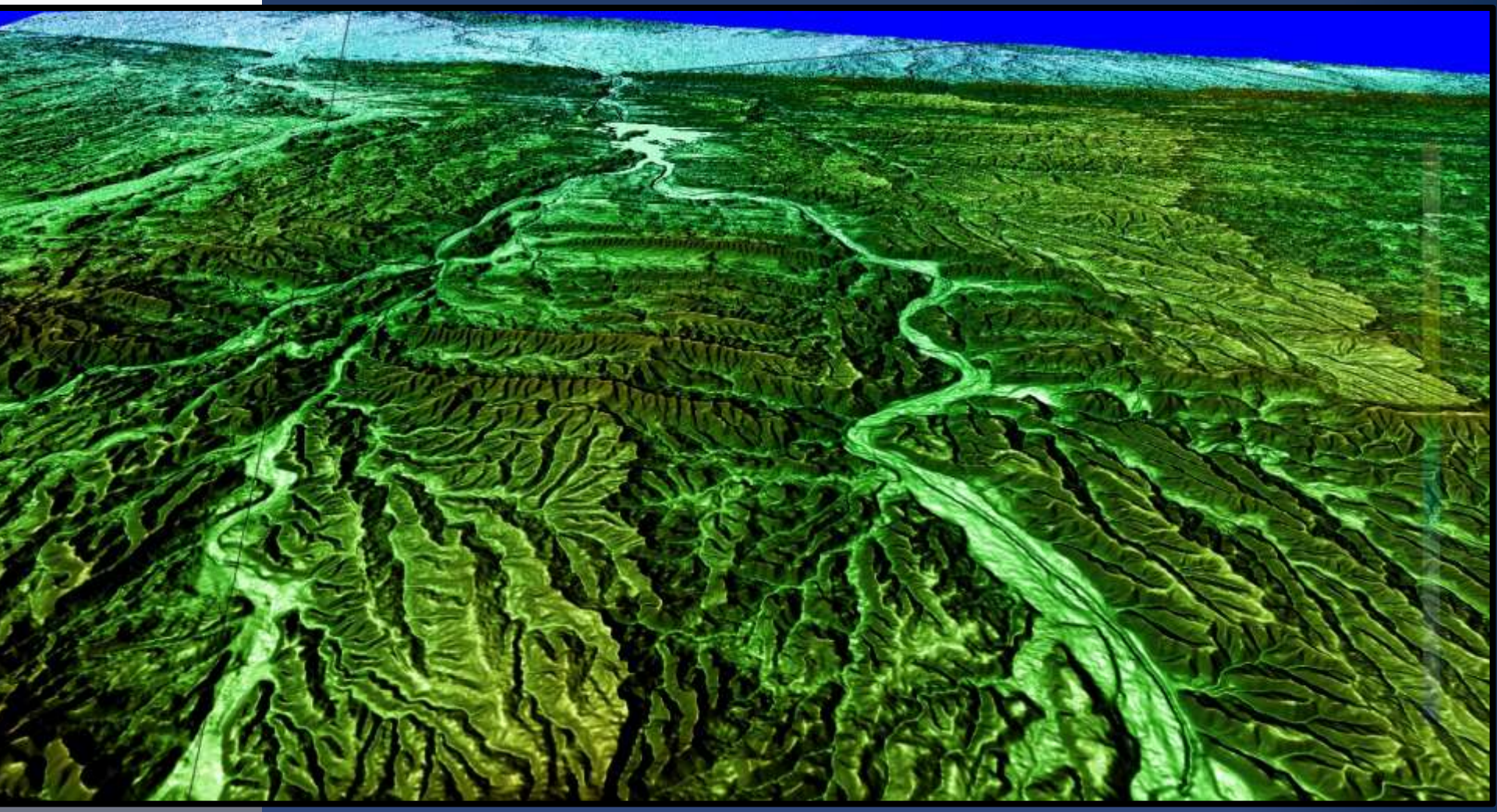
Shakal Block Kurdistan



3D view of satellite topographic grid looking SW

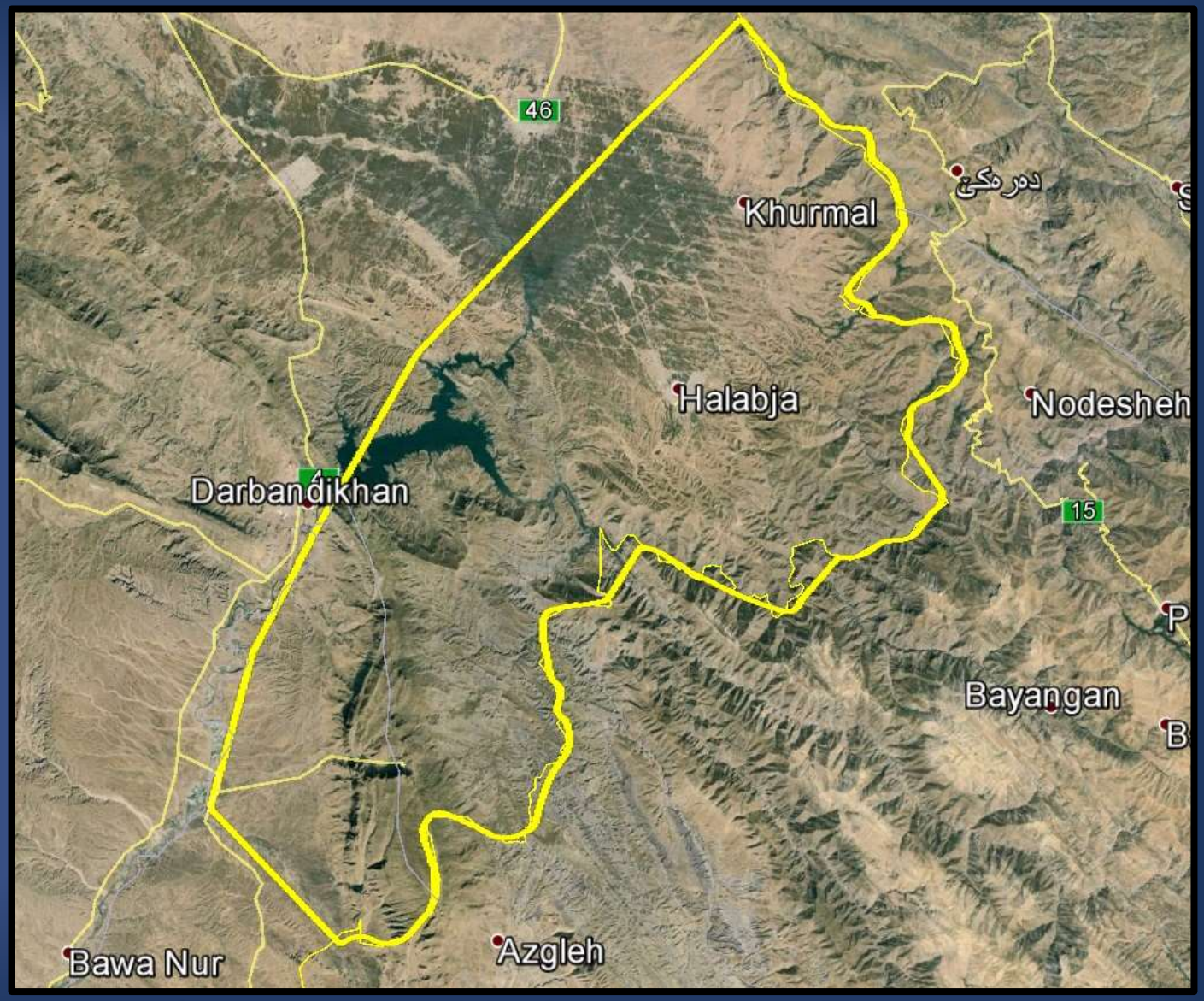
Shakal Block Kurdistan

3D view of satellite ortho photo
looking SE

Halabja Block Kurdistan

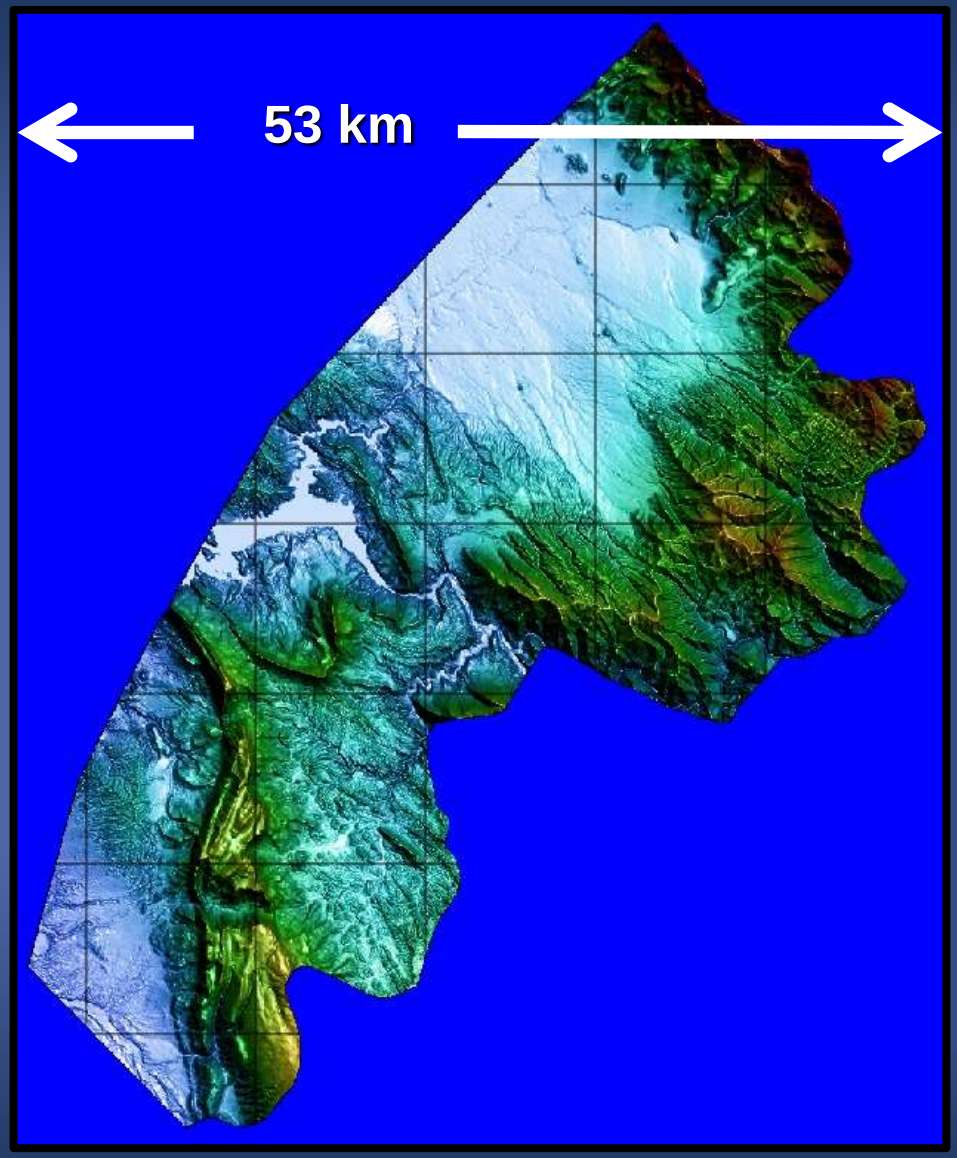
Gazprom Neft Middle East B.V.

Halabja Block Kurdistan



Gazprom Neft Middle East B.V.

Halabja Block Kurdistan

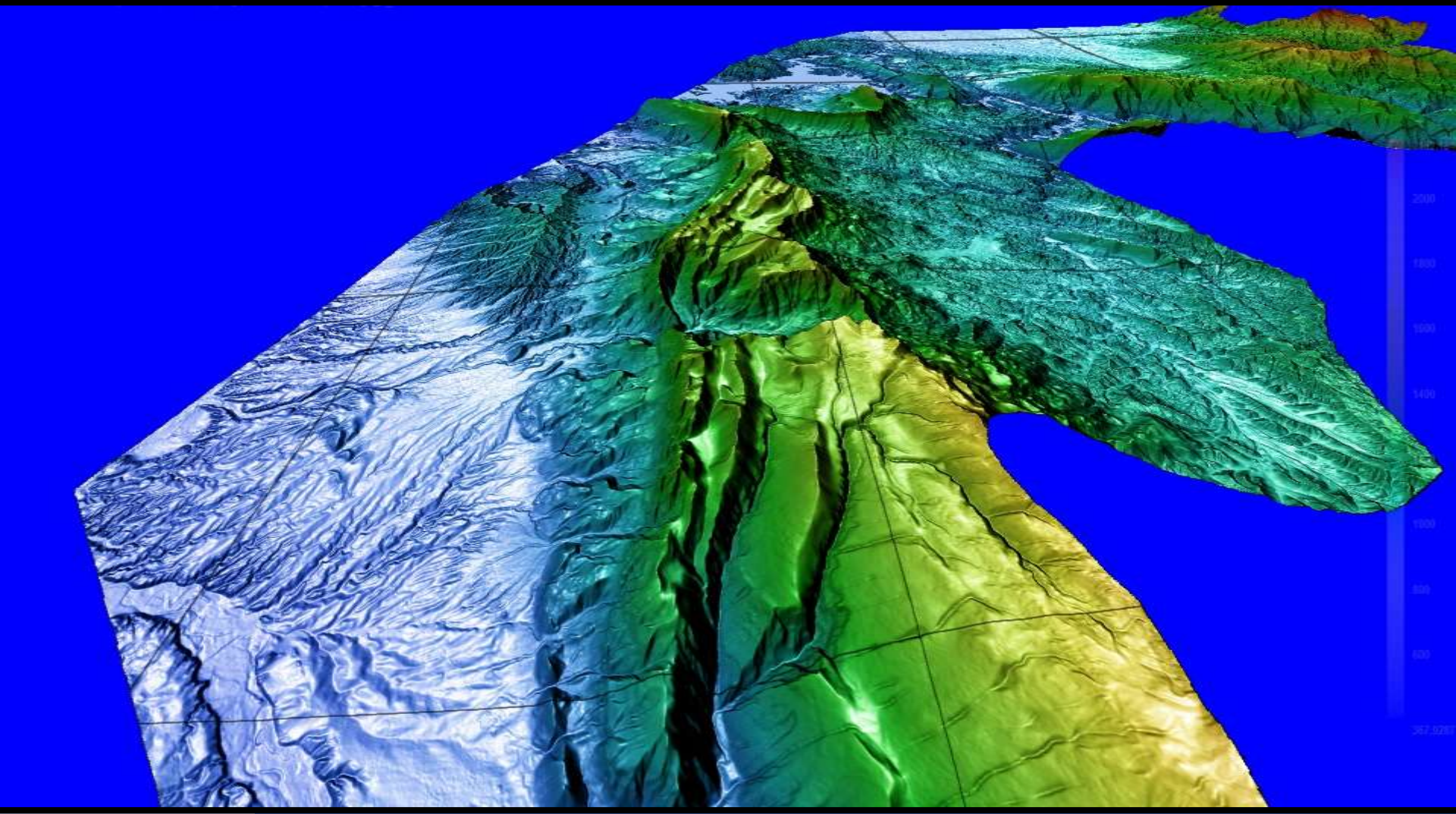


Pleiades satellite topography

Halabja Block Kurdistan

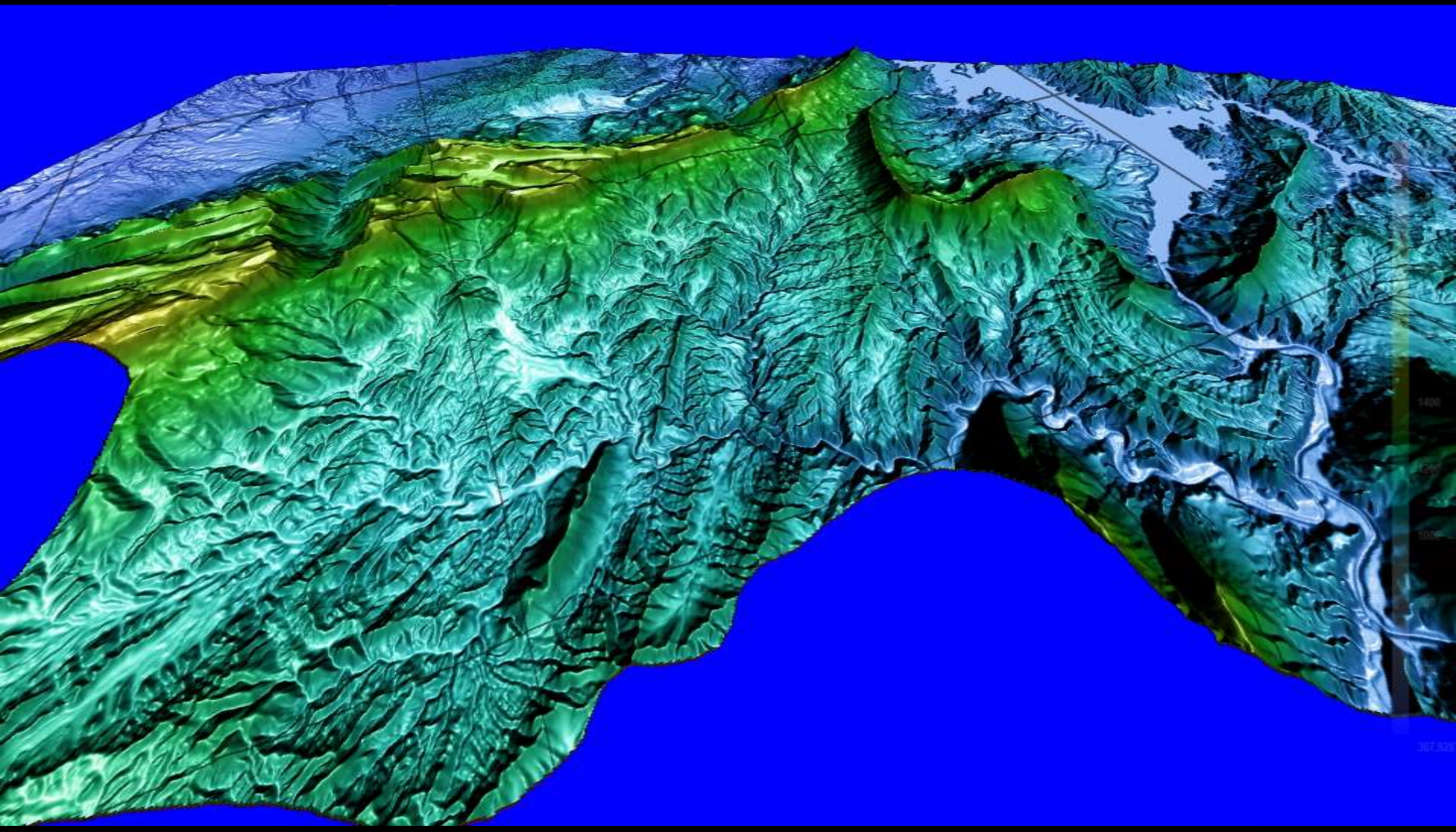
Pleiades satellite topography

Halabja Block Kurdistan



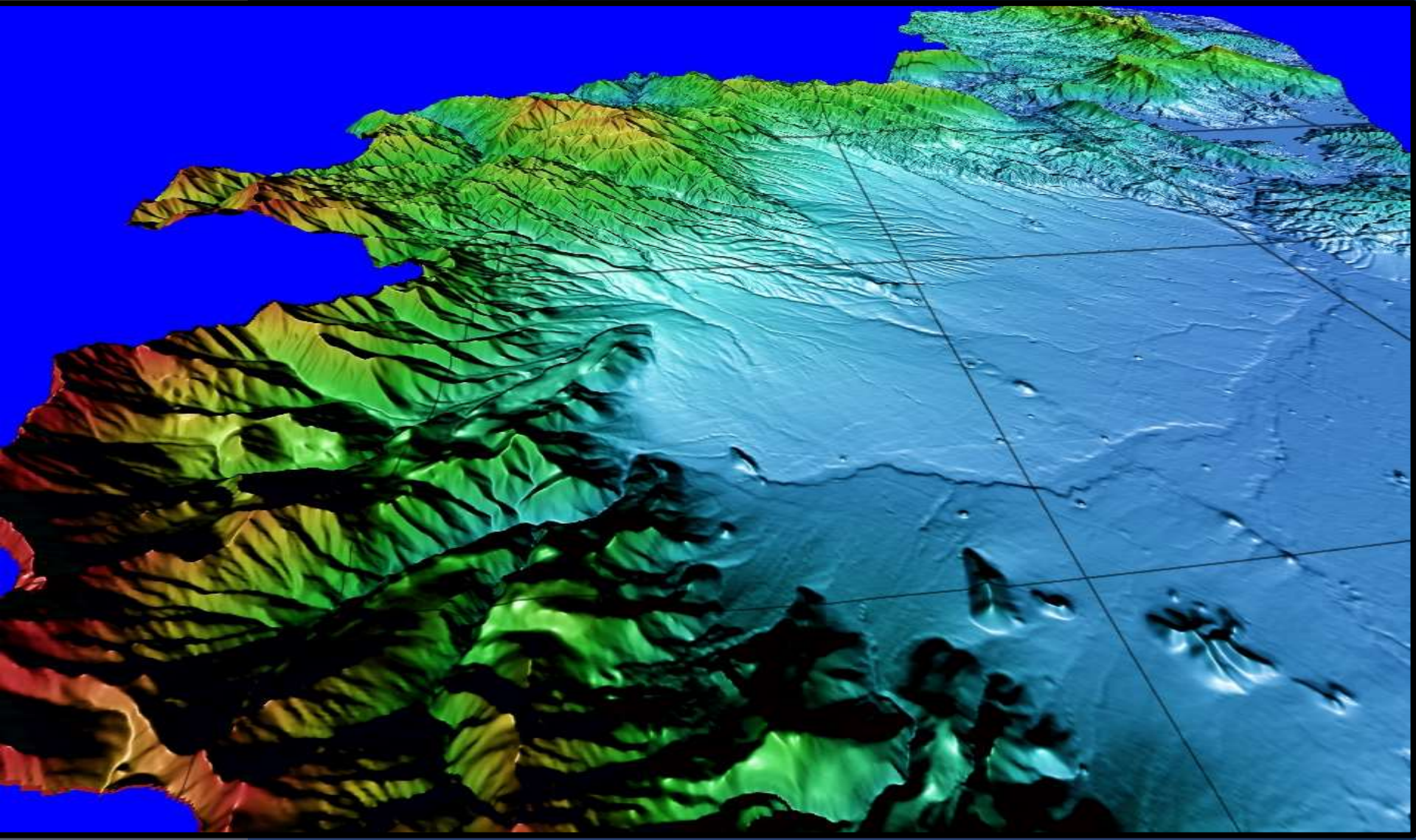
3D satellite topography looking north

Halabja Block Kurdistan



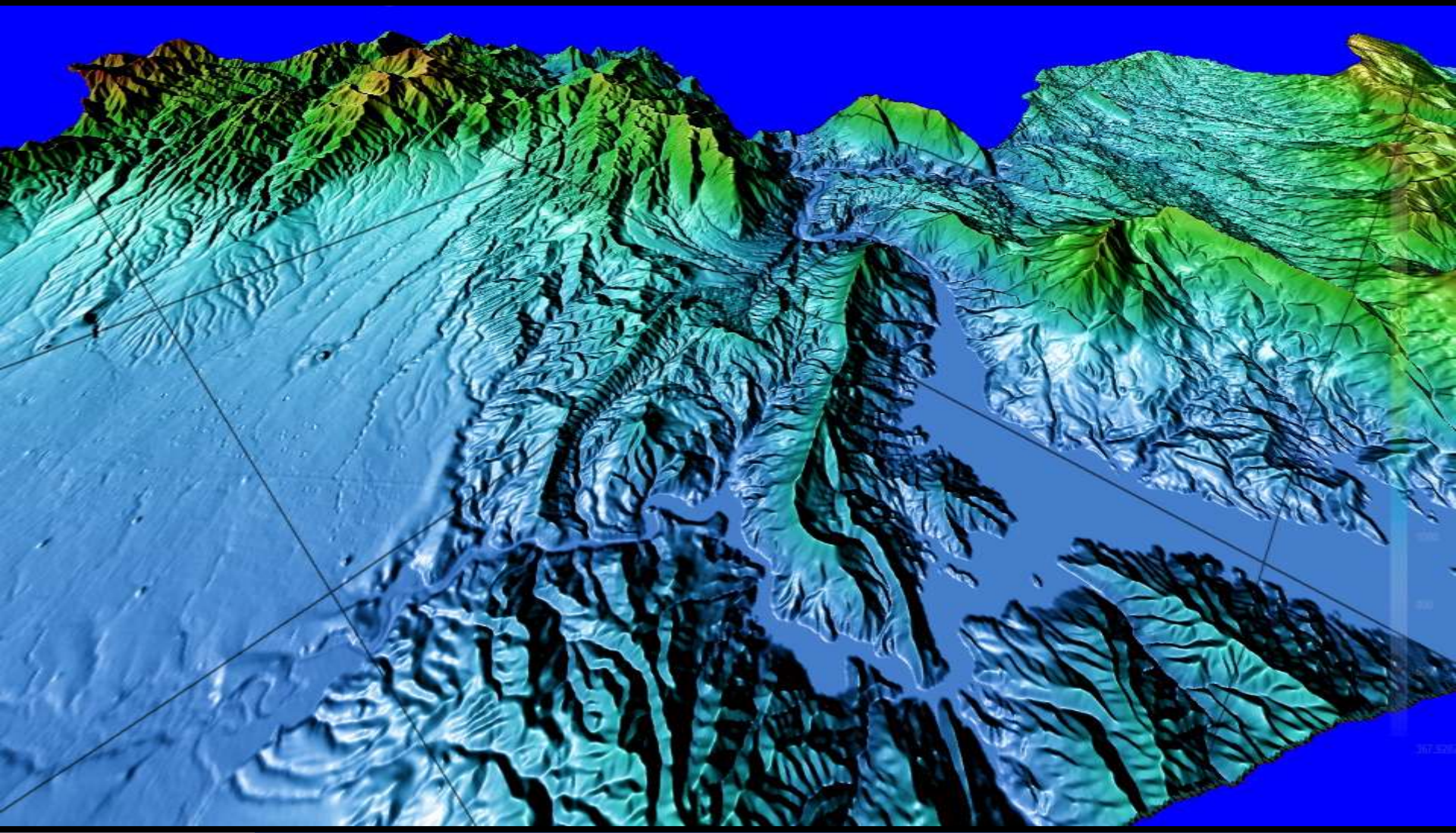
3D satellite topography looking west

Halabja Block Kurdistan



3D satellite topography
looking south

Halabja Block Kurdistan



3D satellite topography
looking east

Halabja Block Kurdistan

3D satellite photo

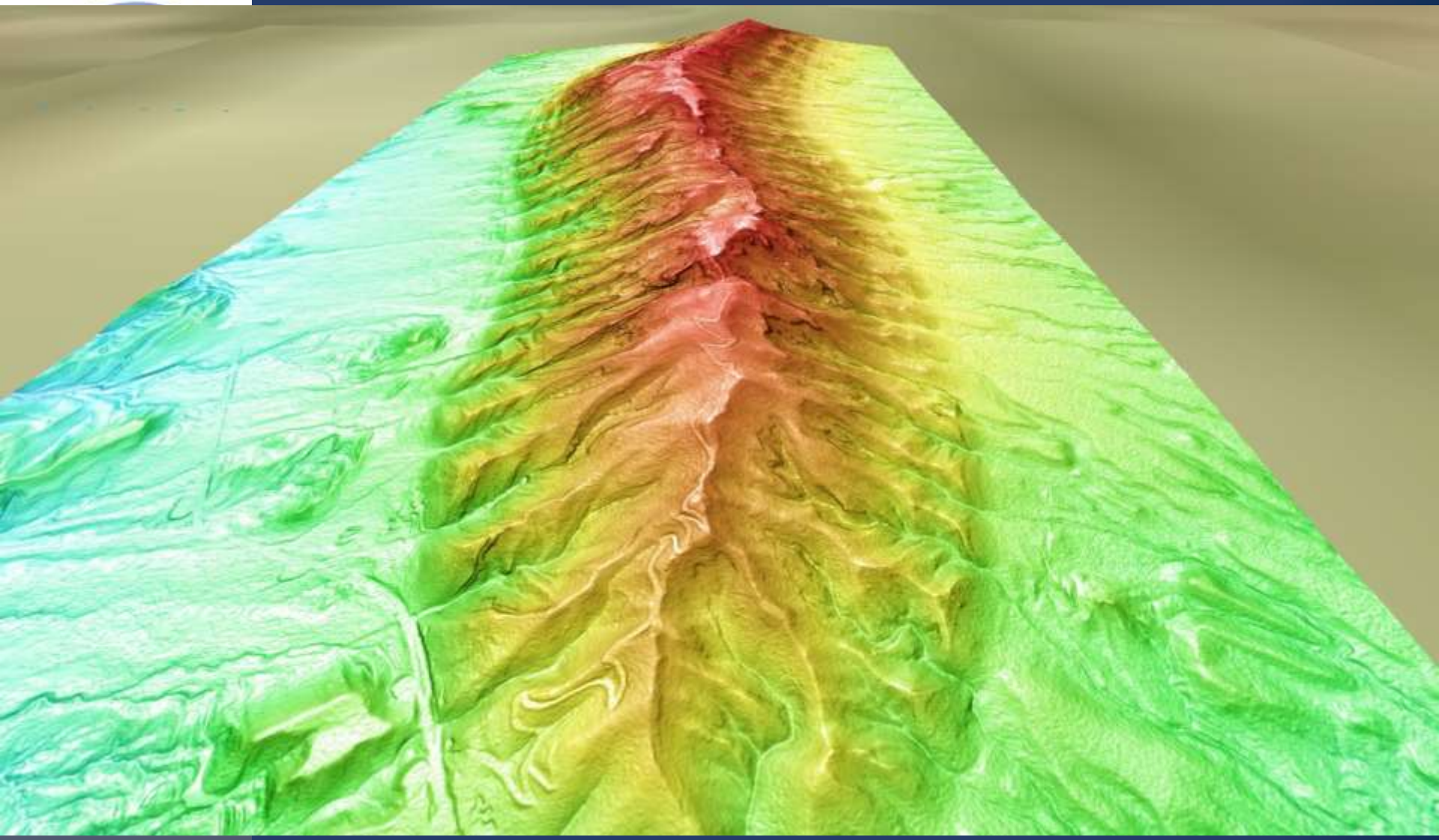
Tawke Kurdistan

Tawke Kurdistan

Pleiades satellite photo 3D view looking east

www.photosat.ca

Tawke Kurdistan



Pleiades satellite topography 3D view looking east

www.photosat.ca

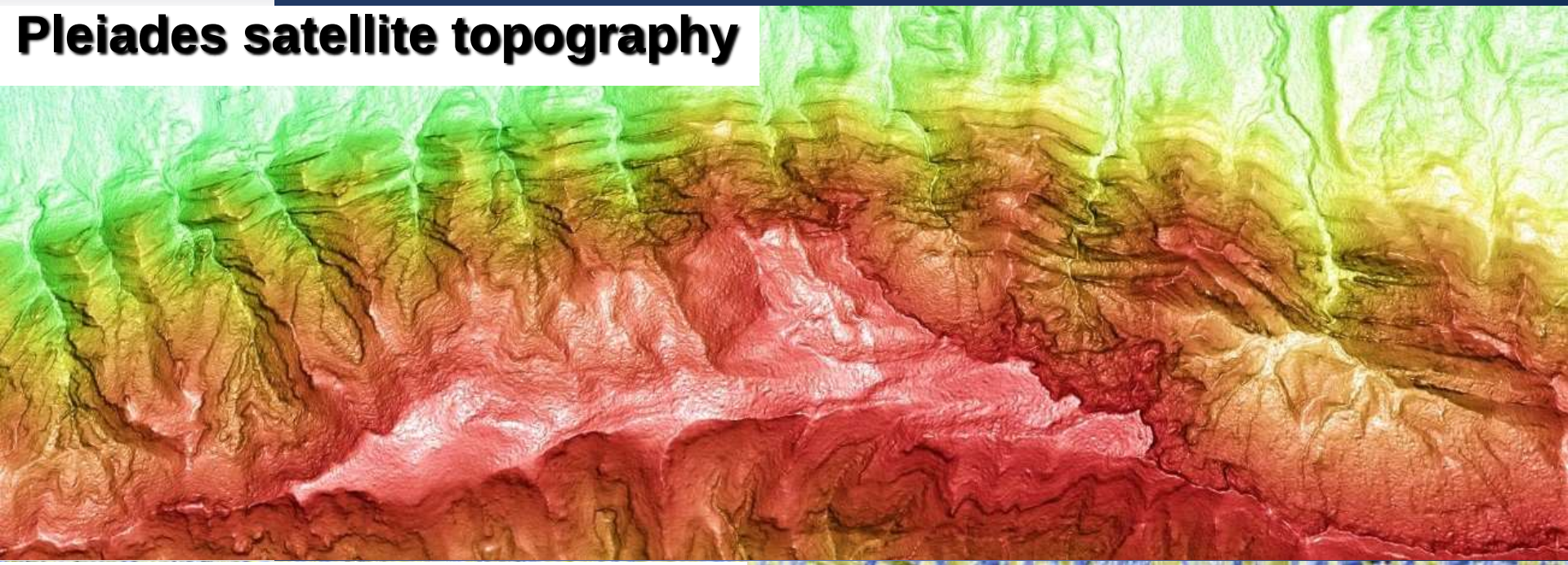
Tawke Kurdistan

Pleiades satellite topography

Pleiades satellite photo

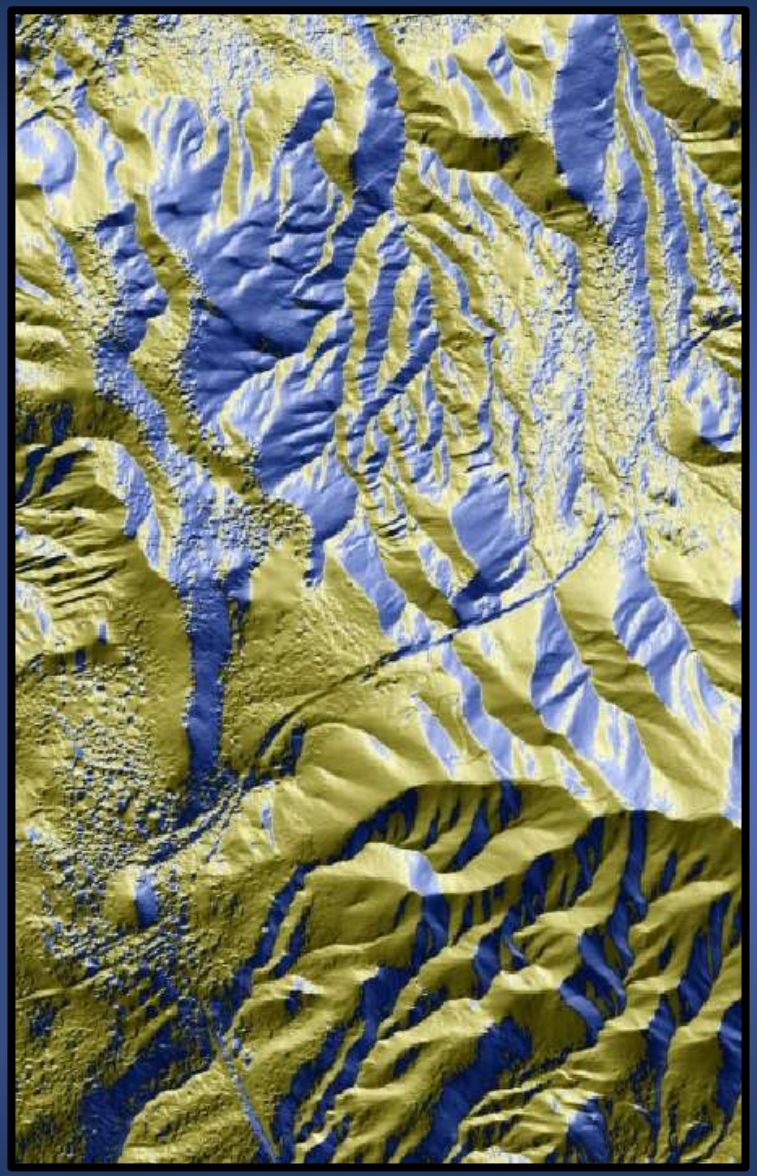
Tawke Kurdistan

Pleiades satellite topography

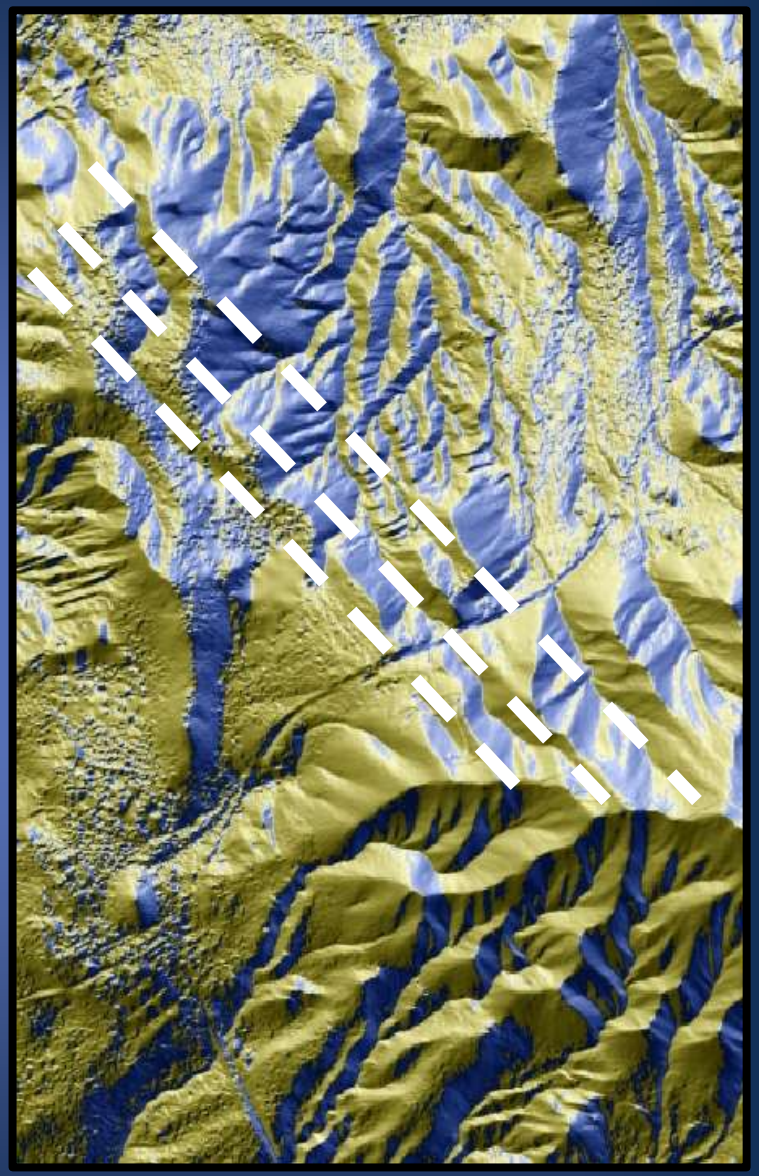


Topographic slope direction

Tawke Kurdistan



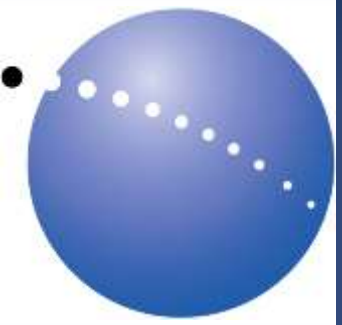
NW striking structures clearly visible



Slope direction

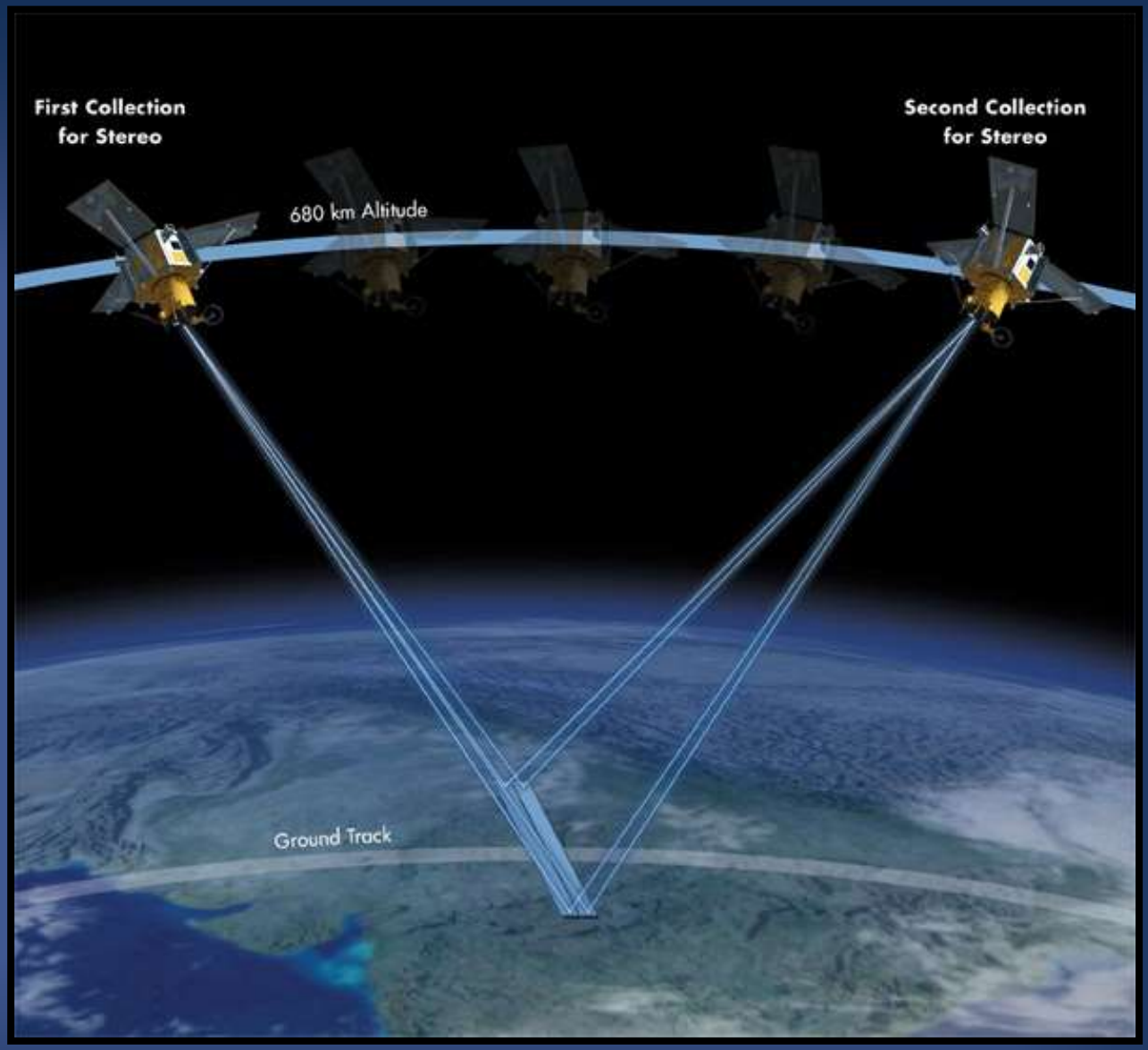
Stereo satellite elevation mapping

PhotoSat technology



PhotoSat stereo satellite topographic mapping technology:

PhotoSat satellite topography generally has over four times the elevation mapping accuracy and resolution of conventional mapping technology using the same satellite photos. In areas of steep rugged terrain PhotoSat's method has an even greater advantage.



Stereo satellite photos used to map topography

High resolution stereo satellites

GeoEye Stereo Satellites

IKONOS 1m colour
2004

High resolution stereo satellites

GeoEye Stereo Satellites

IKONOS 1m colour
2004

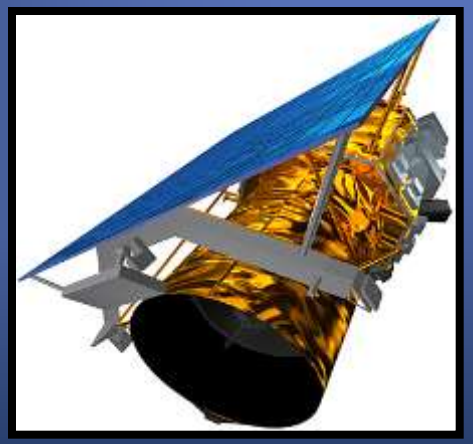
DigitalGlobe Stereo Satellites

WorldView-1 50cm greyscale
2008

High resolution stereo satellites

GeoEye Stereo Satellites

IKONOS 1m colour
2004



GeoEye-1 50cm colour
2009

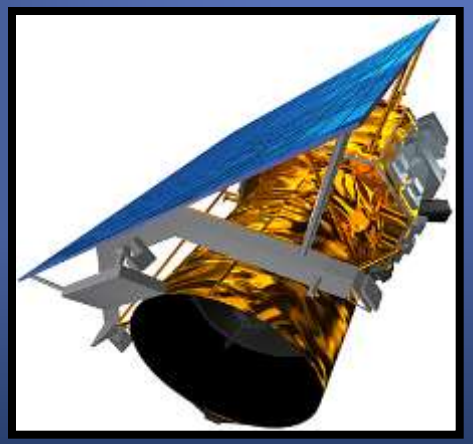
DigitalGlobe Stereo Satellites

WorldView-1 50cm greyscale
2008

High resolution stereo satellites

GeoEye Stereo Satellites

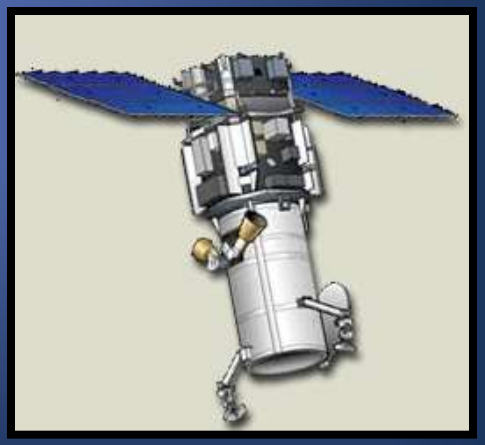
IKONOS 1m colour
2004



GeoEye-1 50cm colour
2009

DigitalGlobe Stereo Satellites

WorldView-1 50cm greyscale
2008



WorldView-2 50cm colour
2010

High resolution stereo satellites

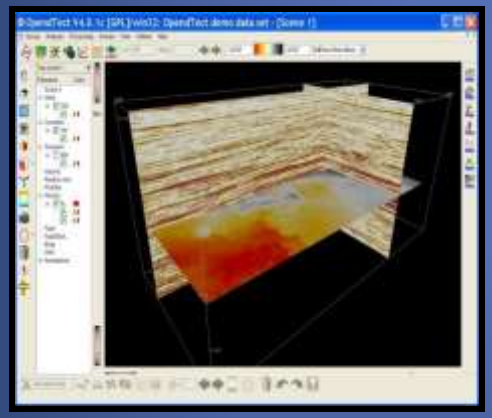
ASTRIUM Pleiades 1A
June 2012

ASTRIUM Pleiades 1B
February 2013

Three key technical components enabling geophysical elevation mapping from space

High resolution stereo satellite photos

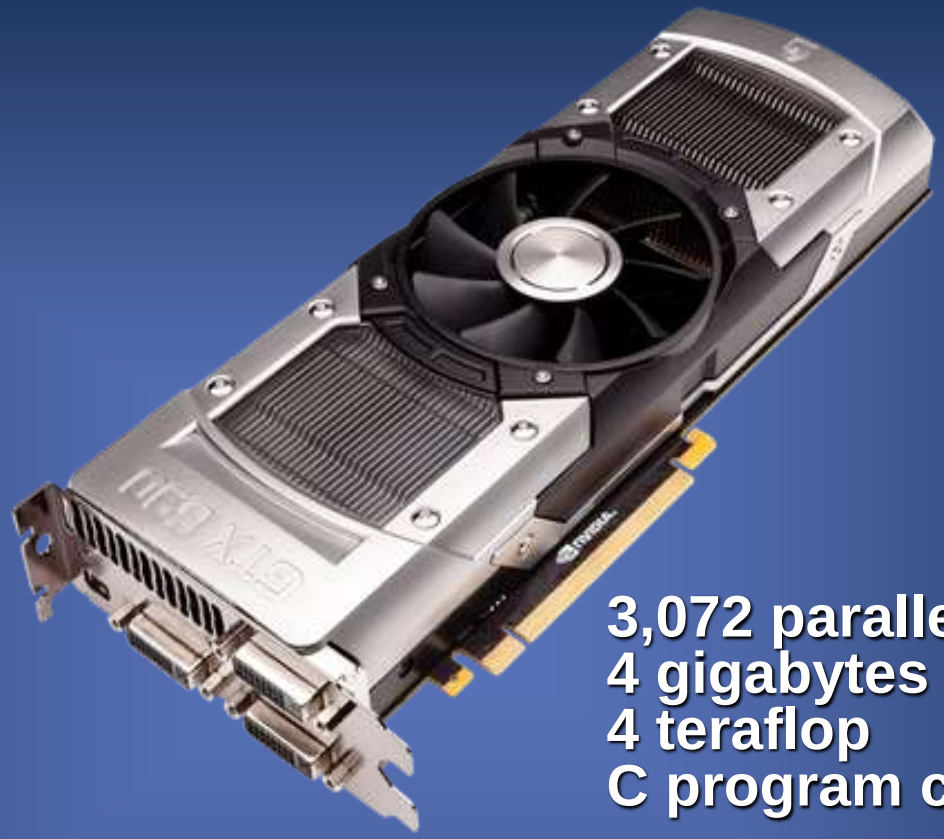
Adaptation of seismic processing systems



Graphics Processing Units (GPUs)

www.photosat.ca

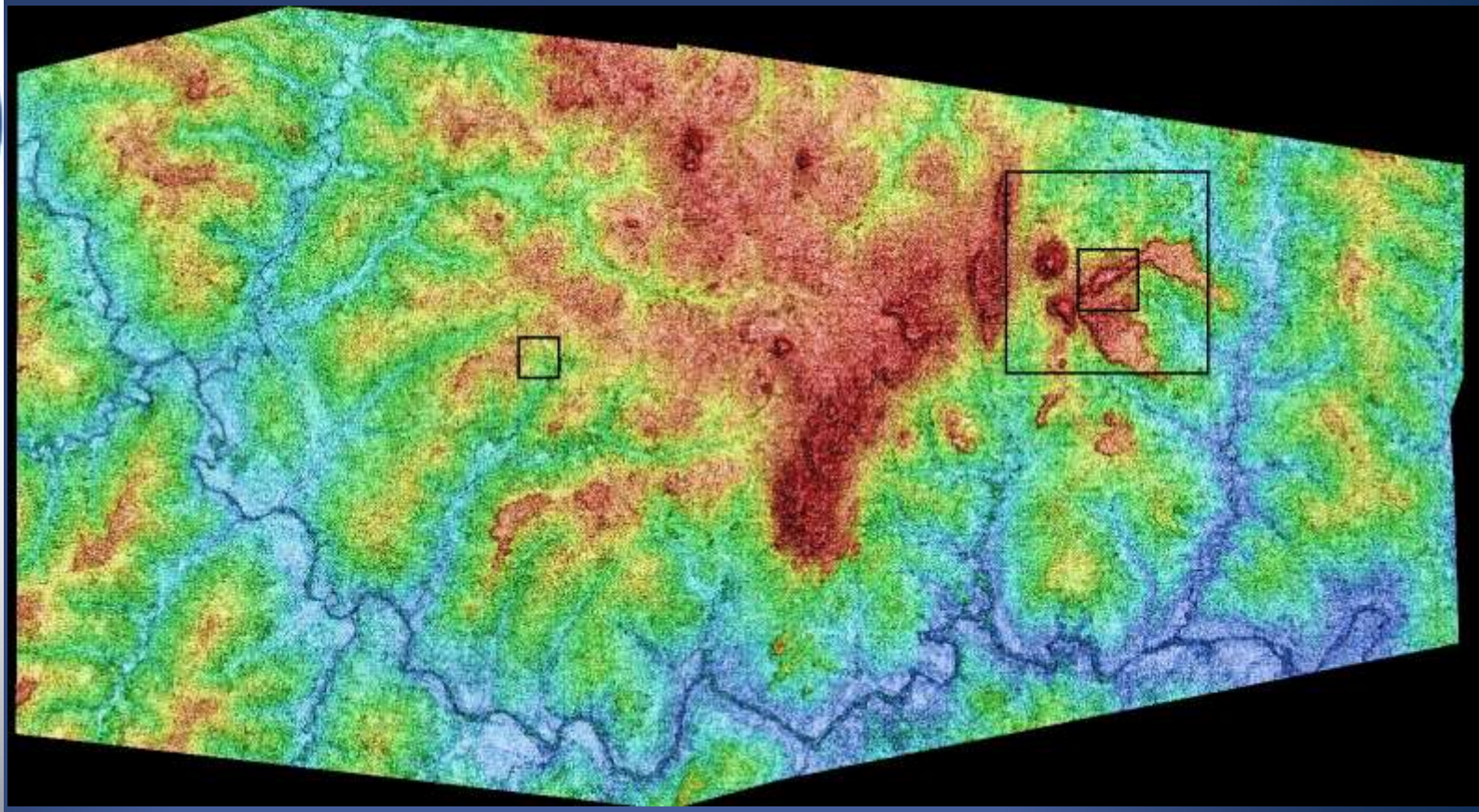
Graphic Processing Units (GPUs)



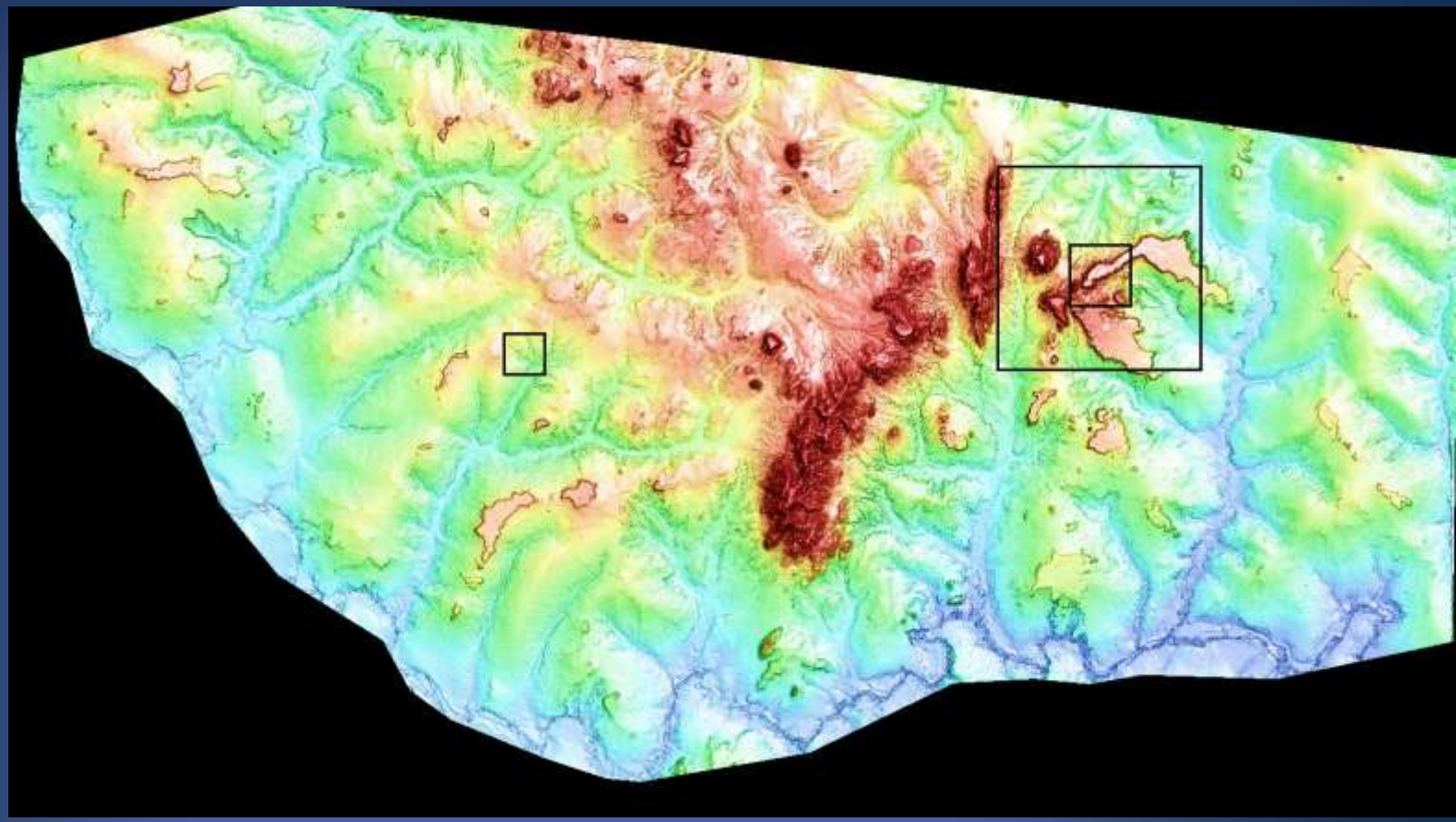
3,072 parallel processors
4 gigabytes RAM
4 teraflop
C program compiler

GPUs perform numerical processing up to 1000 times faster than CPUs. This enables us to do the hundreds of millions of 2D Fourier transforms necessary to automatically produce 1m Digital Surface Models from stereo satellite photos in reasonable times.

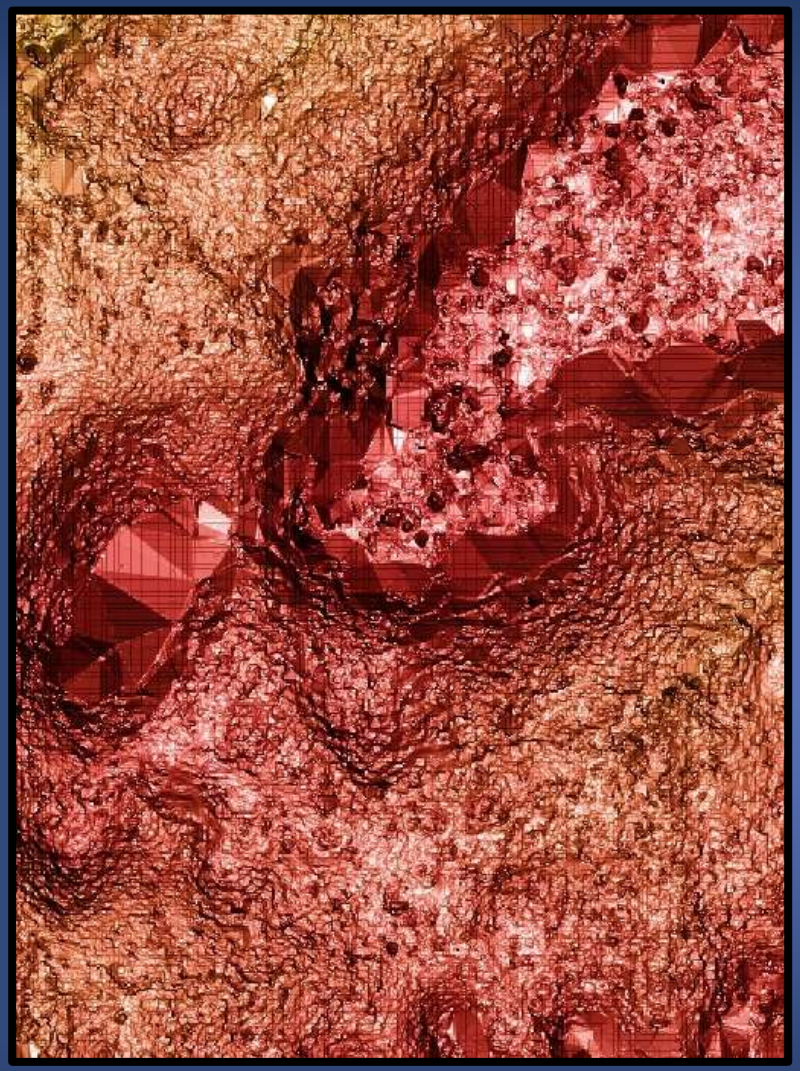
Comparisons between PhotoSat satellite topography and other stereo satellite topographic mapping products



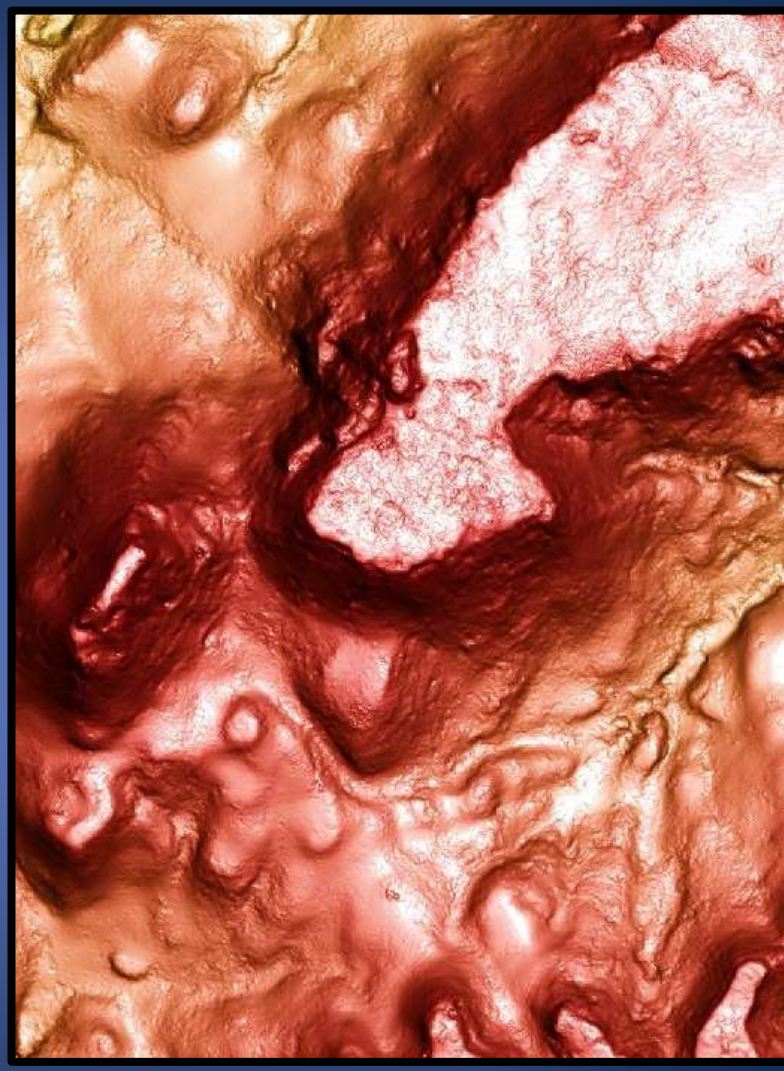
Burkina Faso WV2 Geoimage mapping Socket Set



Burkina Faso WV2 PhotoSat mapping

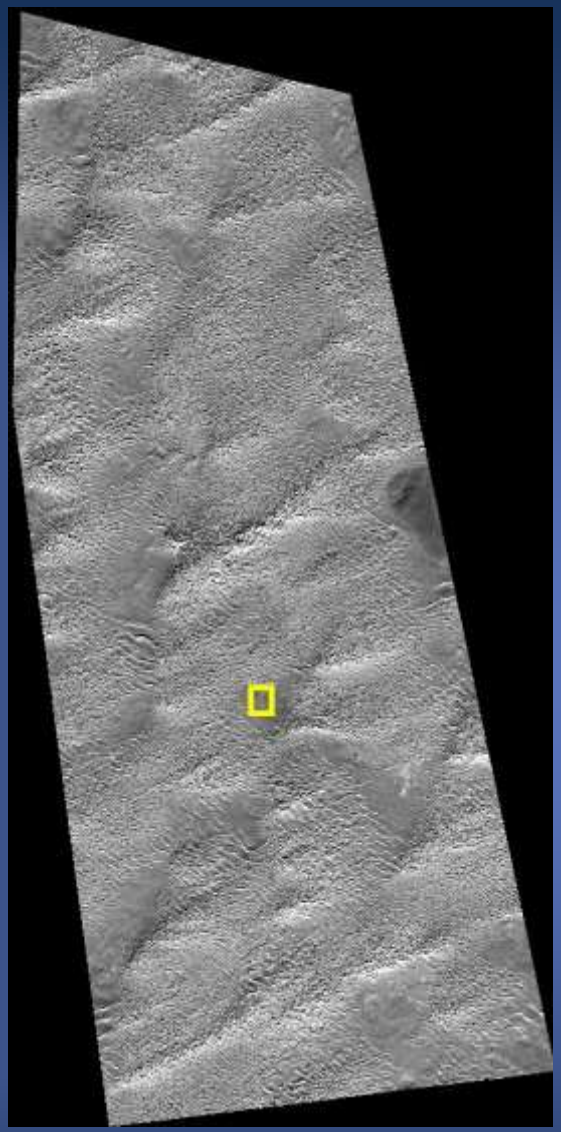


GeoImage mapping

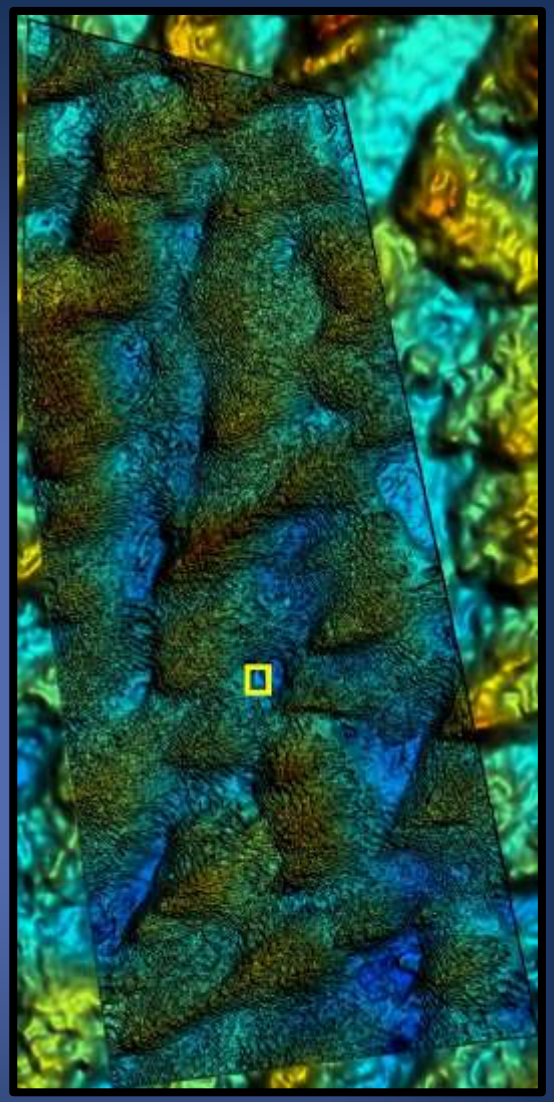


PhotoSat mapping

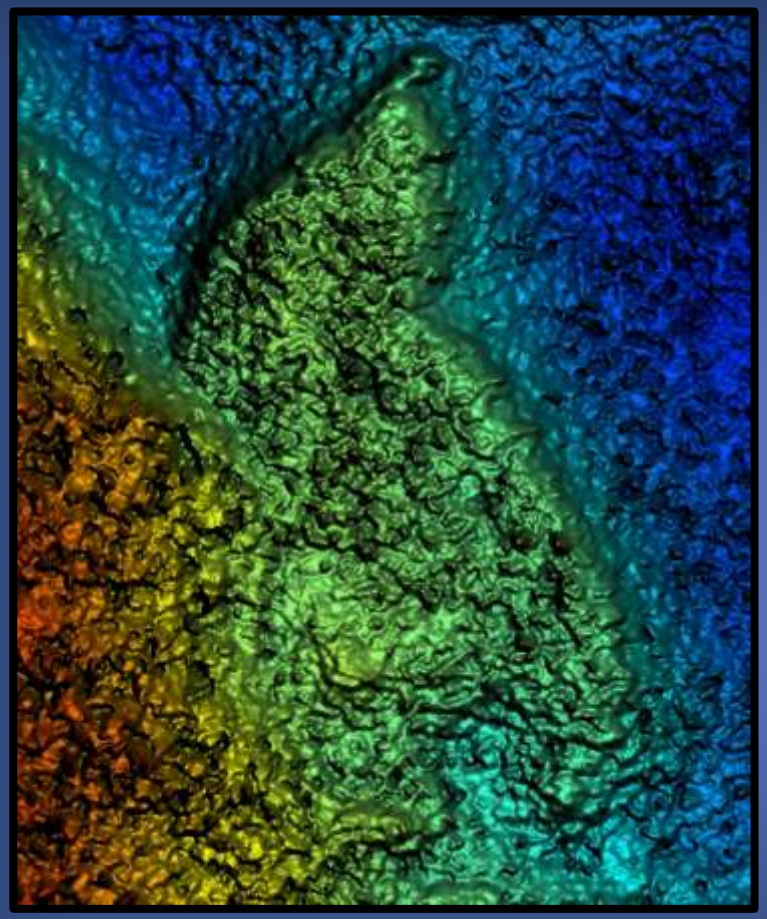
www.photosat.ca



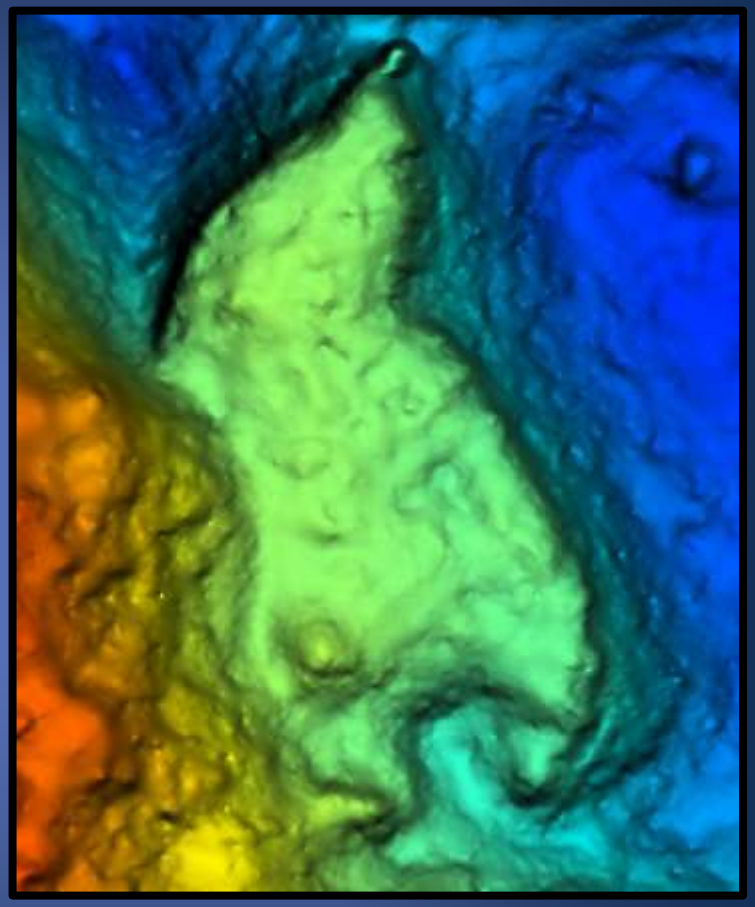
Algeria WV2



PhotoSat mapping

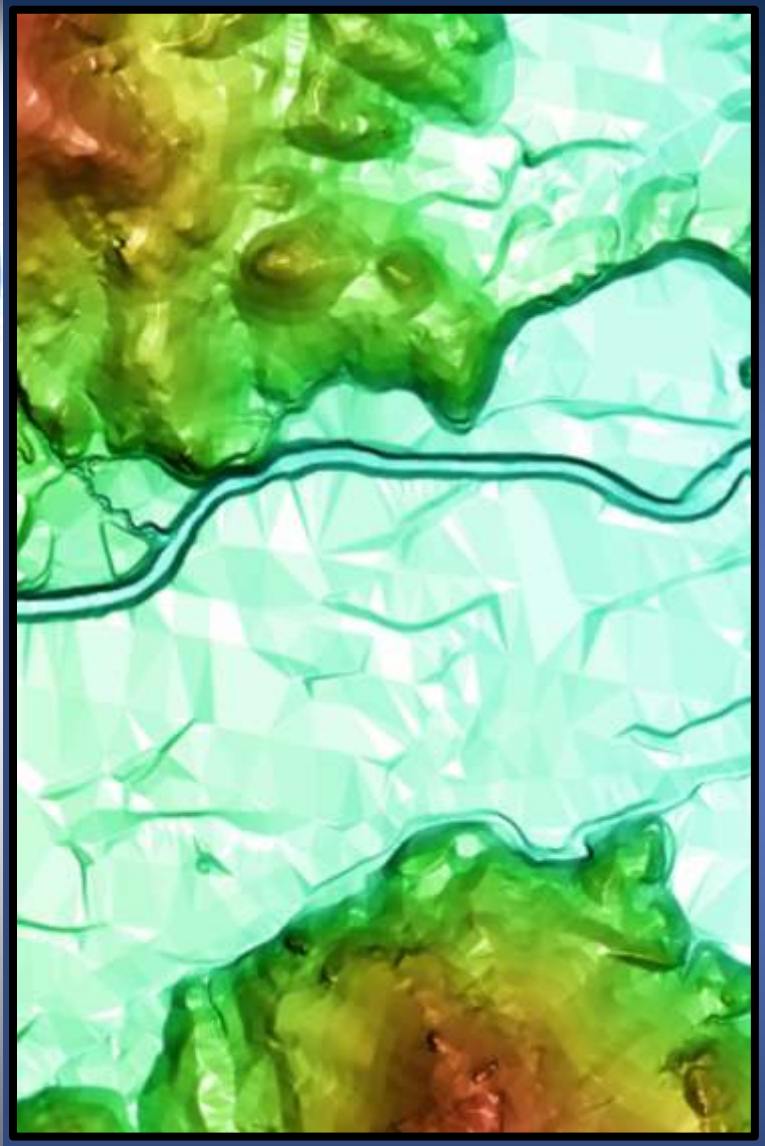


ASTRIUM WV2 mapping

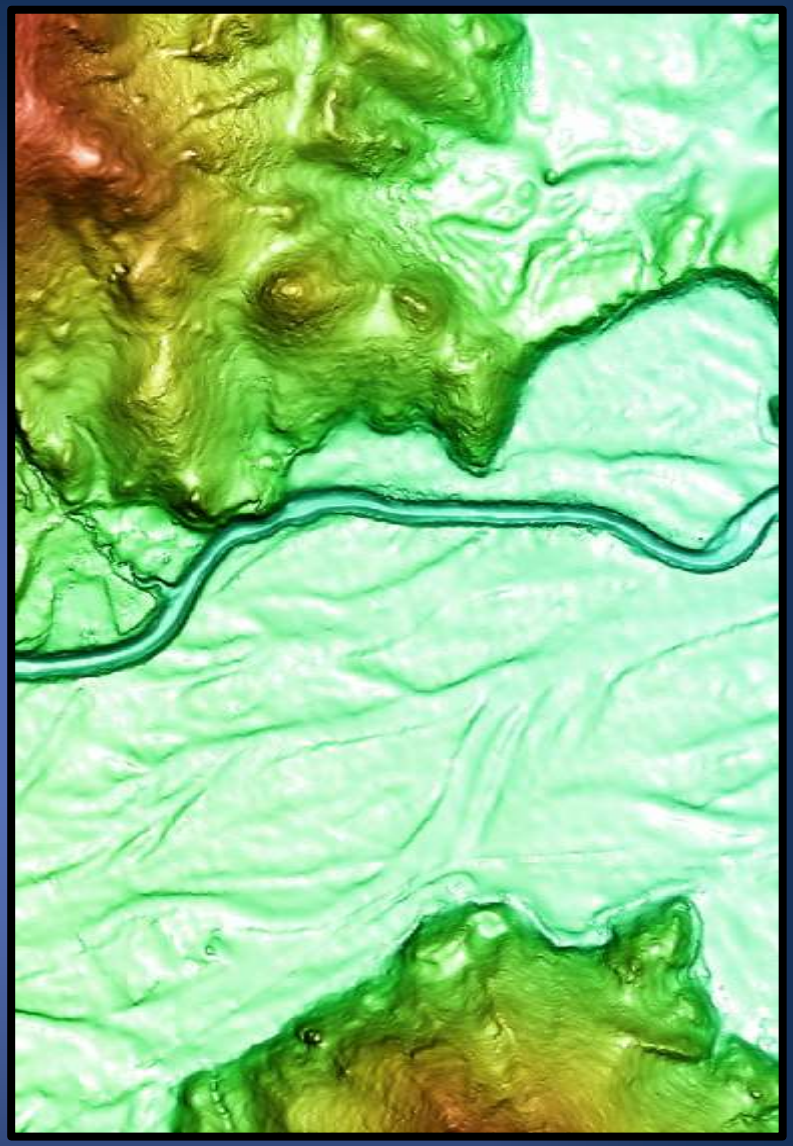


PhotoSat WV2 mapping

PhotoSat continuous processing improvements



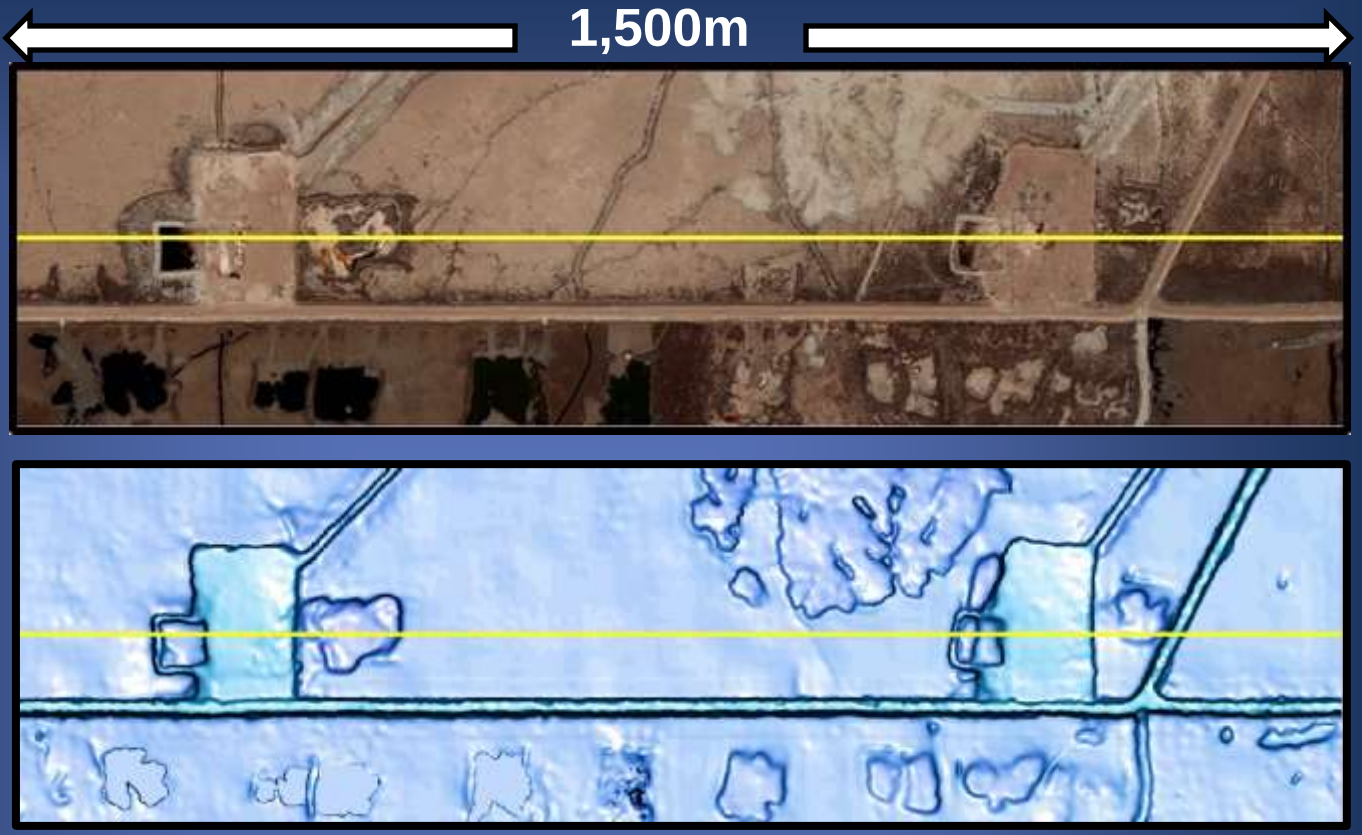
PhotoSat satellite Topographic mapping 2004



PhotoSat satellite Topographic mapping 2012

www.photosat.ca

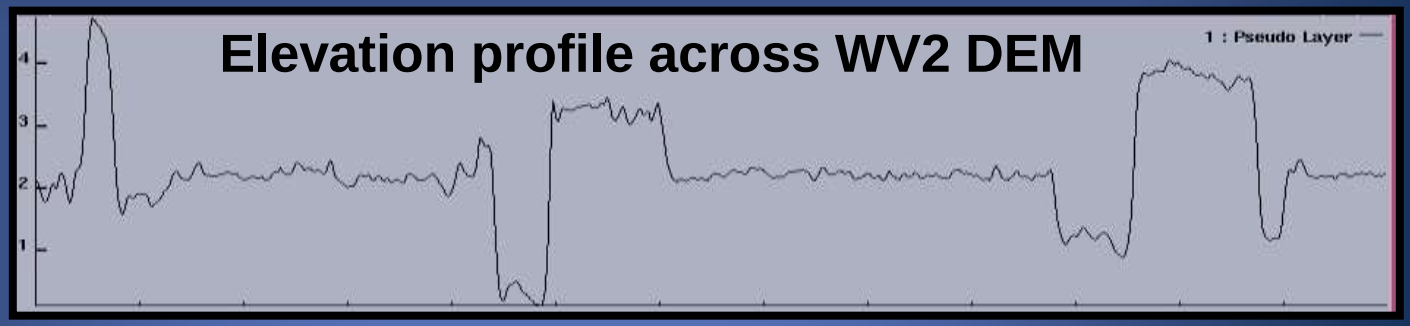
Stereo Satellite Elevation Profile



2011

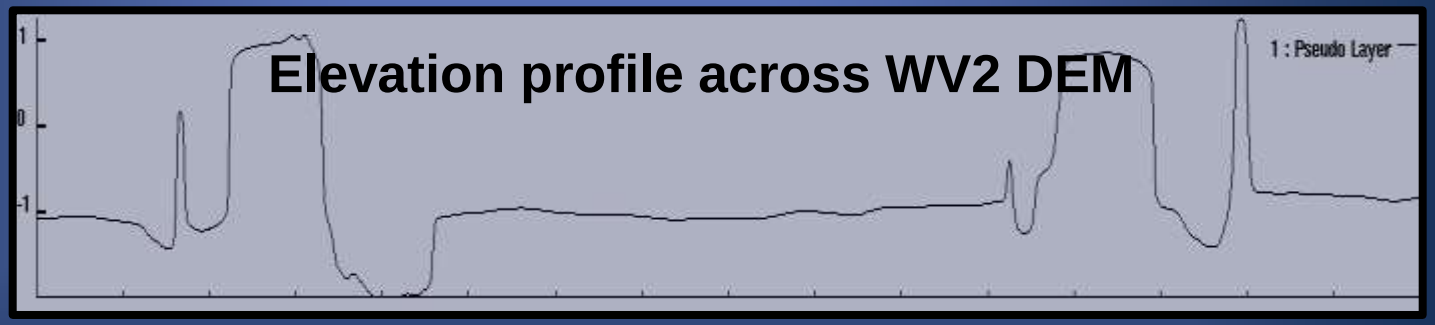
Stereo Satellite Elevation Noise Reduction

1,200m



2010 processing 20 cm of noise

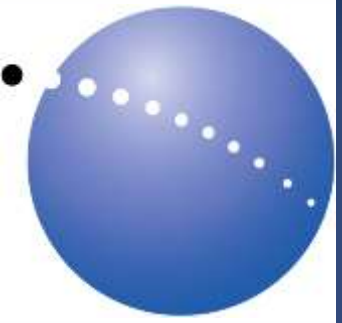
1,500m



2011 processing < 10 cm of noise

PhotoSat Development Team

PhotoSat Production Team



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