GSA-5859
SISTEMAS DE INFORMAÇÃO GEOGRÁFICA EM SOFTWARE LIVRE

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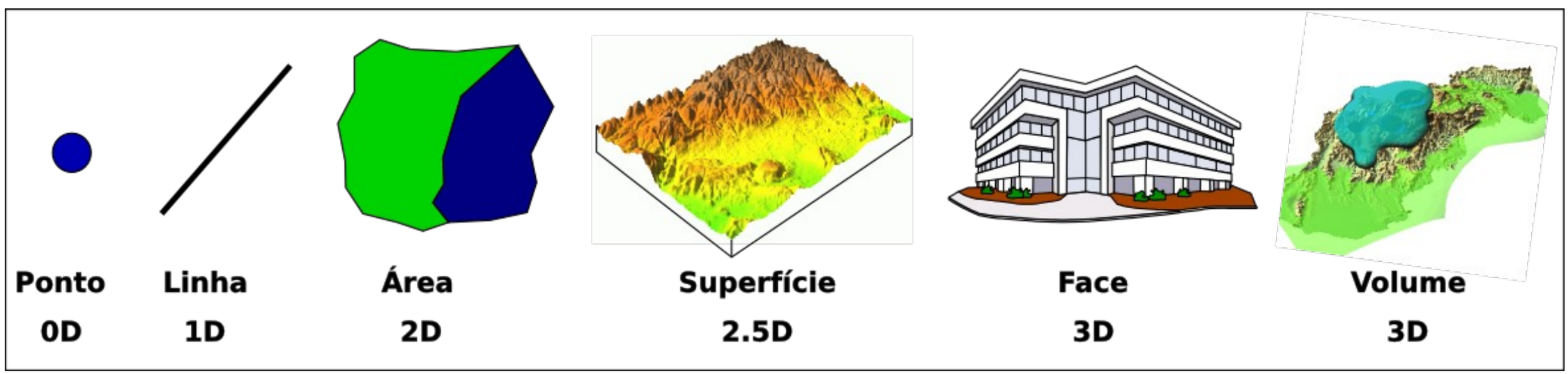
Modelos Digitais de Terreno

MDE/MDT

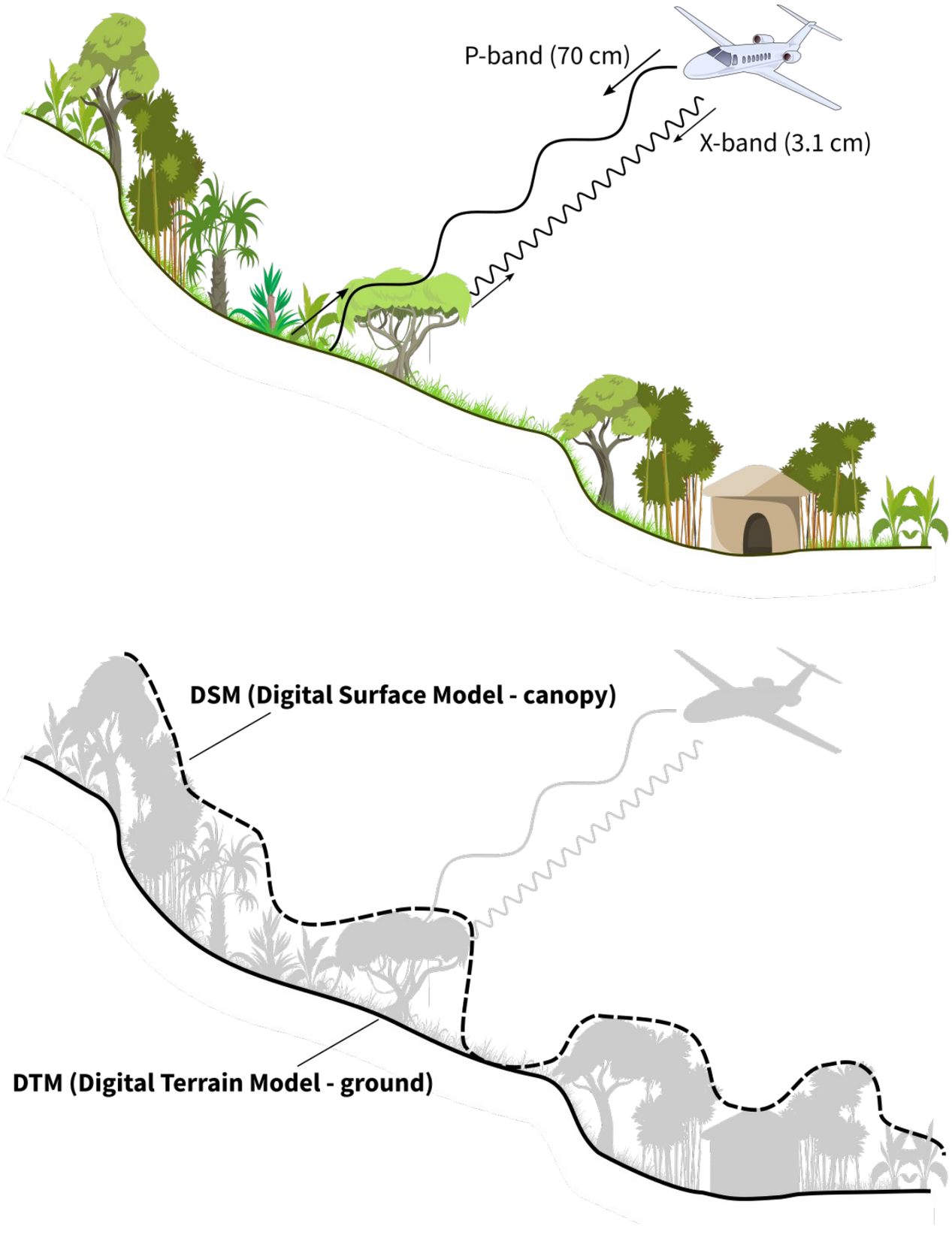
- Representação de uma superfície em SIG
  - Raster
  - Vetor (TIN)
- “2.5D”



MDE/MDT/MDS ??

- MDS – Modelo Digital de **Superfície**
  - termo mais genérico
- MDT, MNT, DTM – Modelo Digital de **Terreno**
  - representa o relevo real
- MDE, DEM – Modelo Digital de **Elevação**
  - não necessariamente representa o relevo real, mas às vezes é usado com esse sentido

MDE/MDT/MDS ??

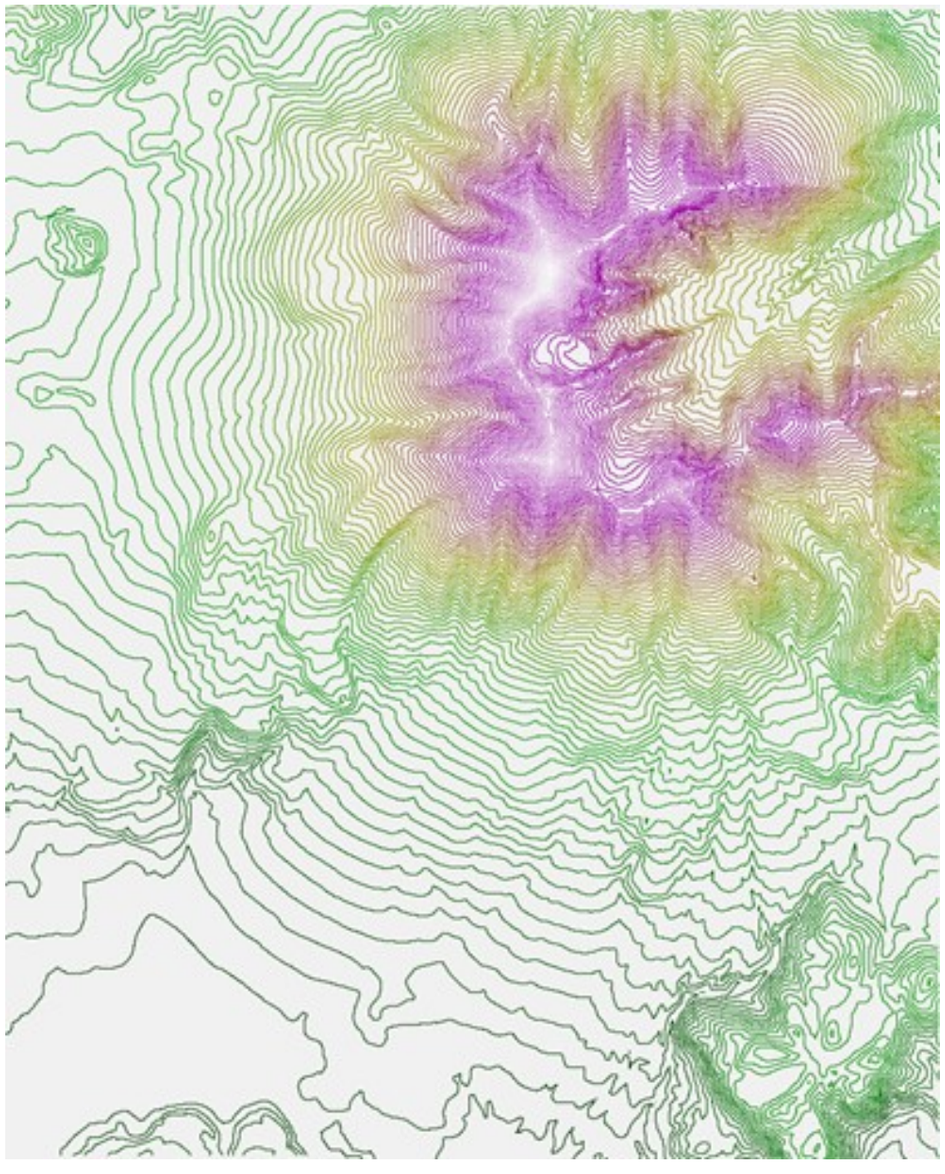

P-band (70 cm)
X-band (3.1 cm)
DSM (Digital Surface Model - canopy)
DTM (Digital Terrain Model - ground)

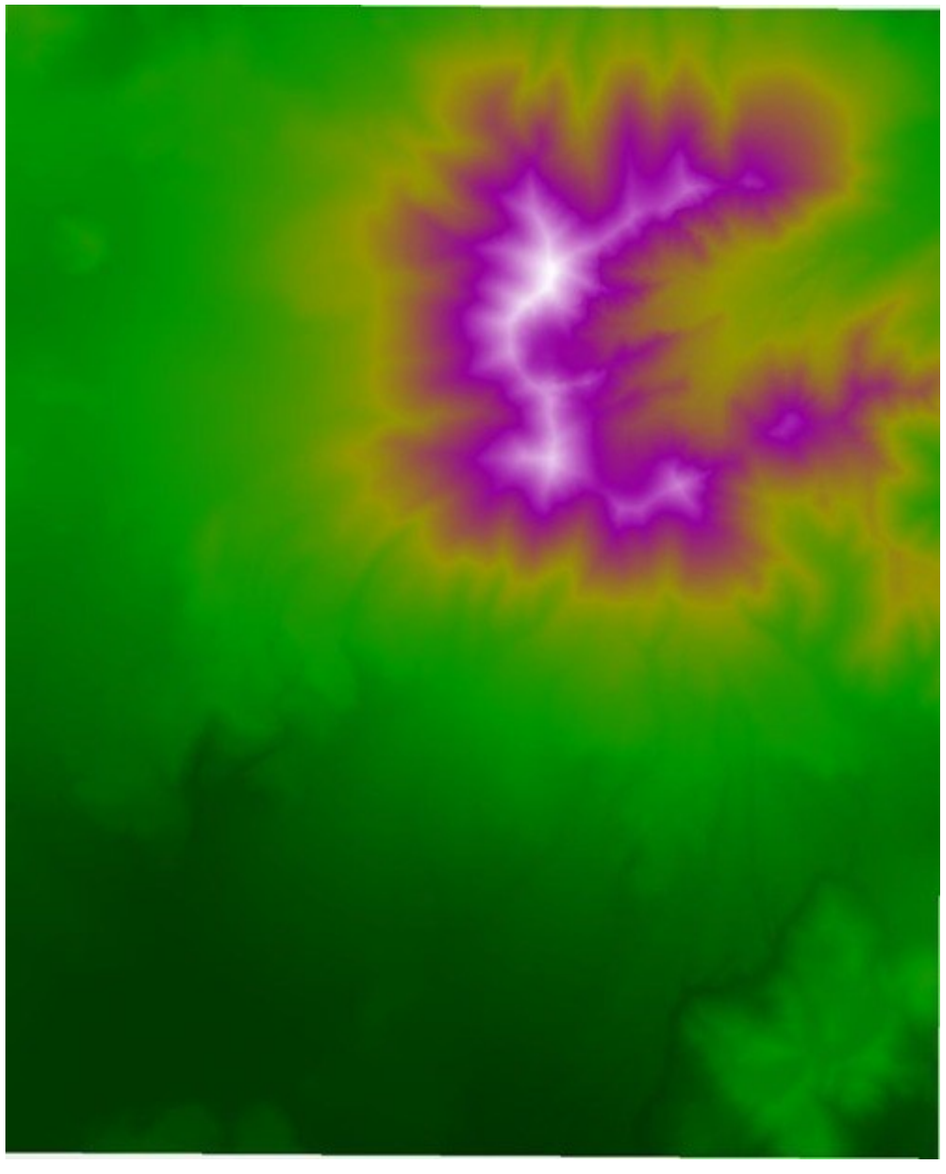
CONSTRUÇÃO DE MDEs

- Interpolação de dados vetoriais
  - curvas de nível
  - pontos cotados
  - curvas + pontos
  - soft breaklines, hard breaklines
- Sensoriamento remoto
  - fotogrametria
  - interferometria de radar
  - LiDAR

CONSTRUÇÃO DE MDEs

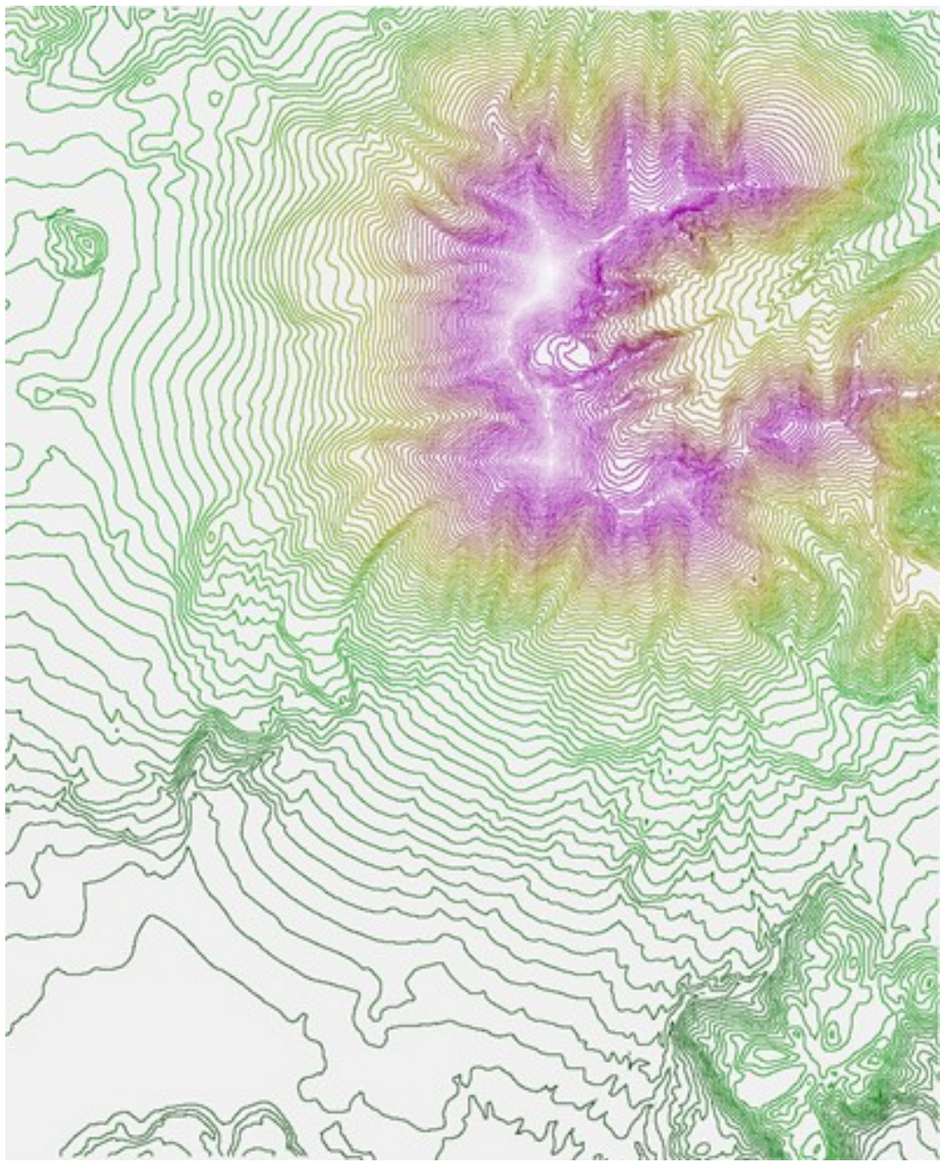
- Interpolação de dados vetoriais

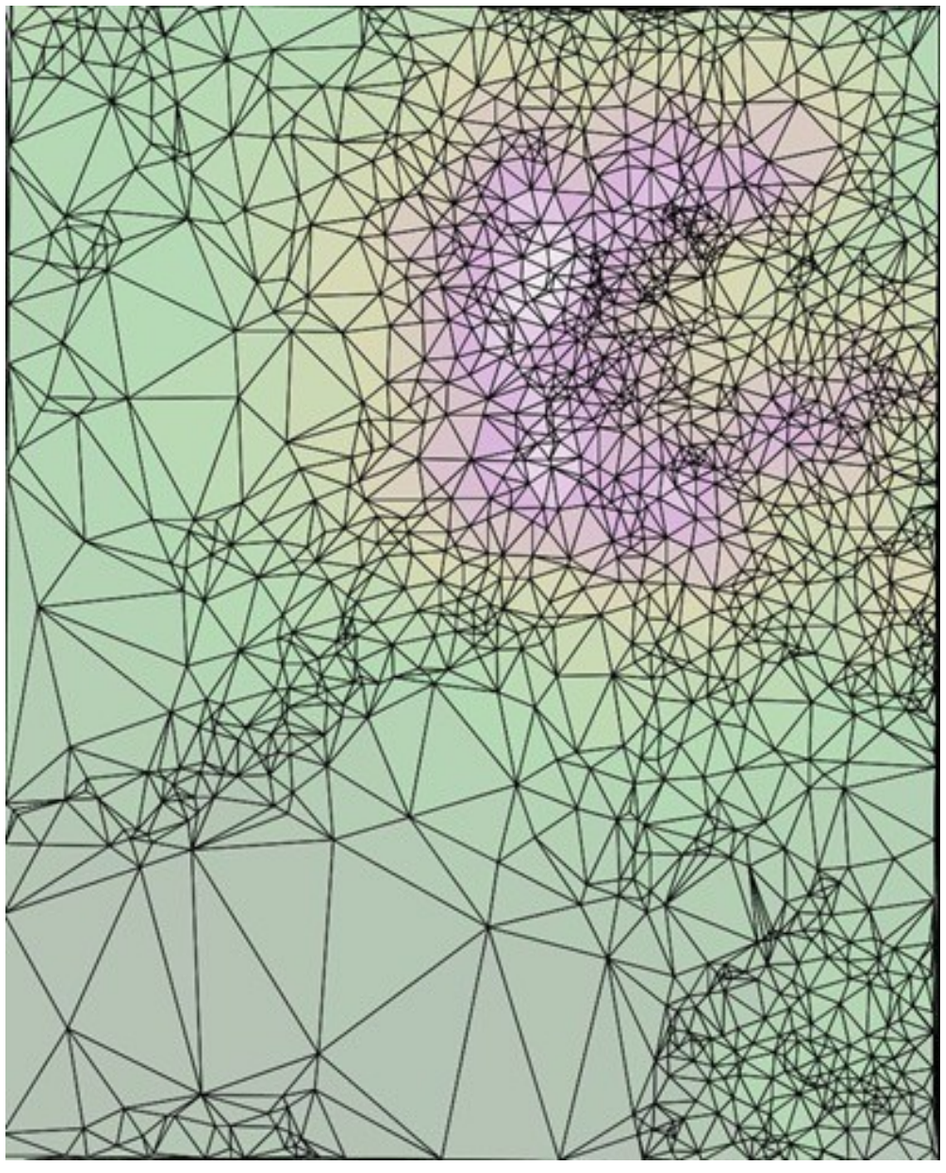




CONSTRUÇÃO DE MDEs

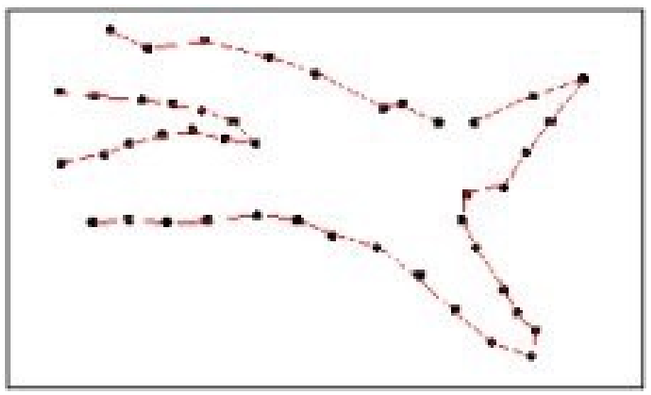
- Interpolação de dados vetoriais



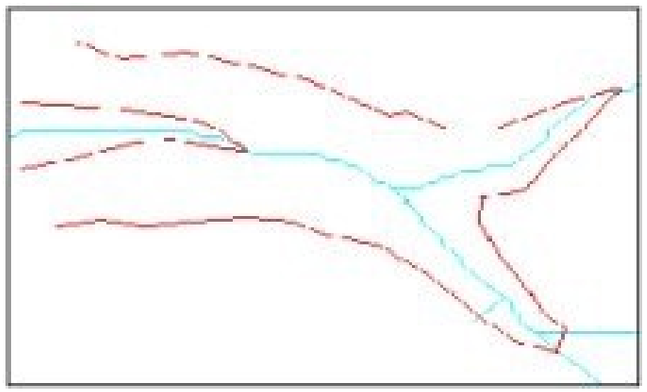


CONSTRUÇÃO DE MDEs

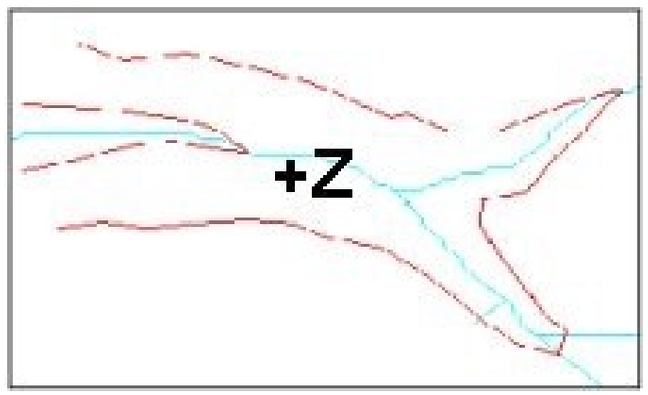
- Breaklines

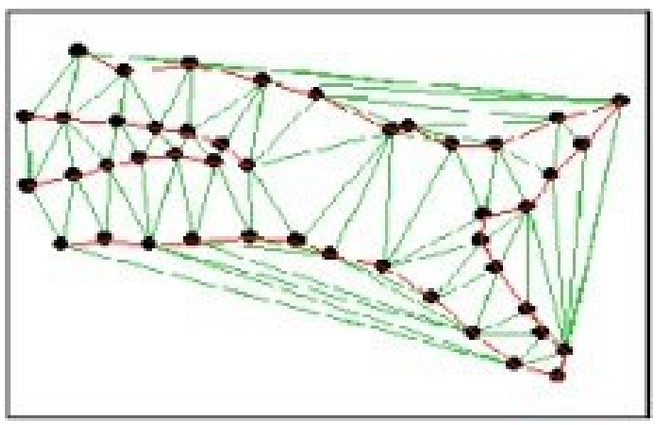


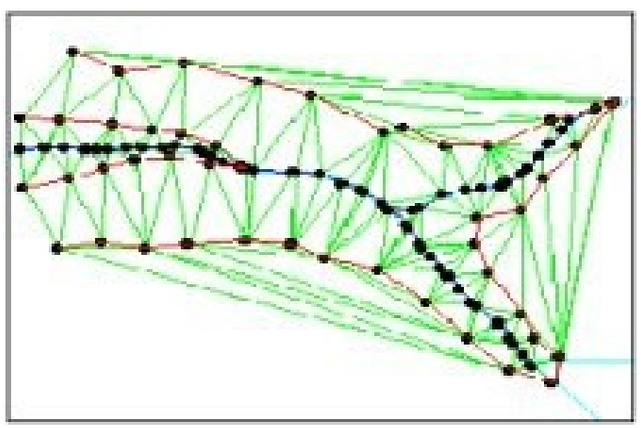
soft breaklines

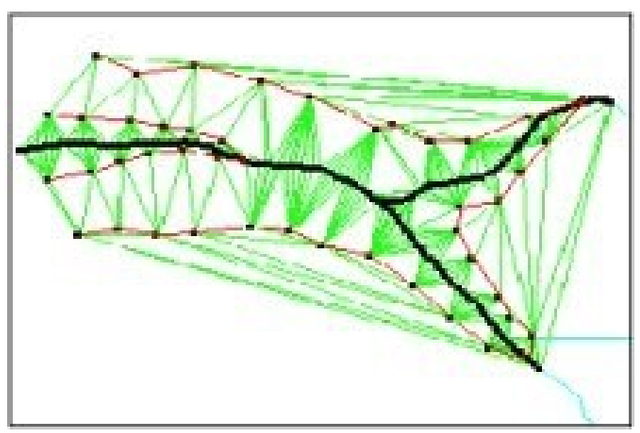


hard breaklines

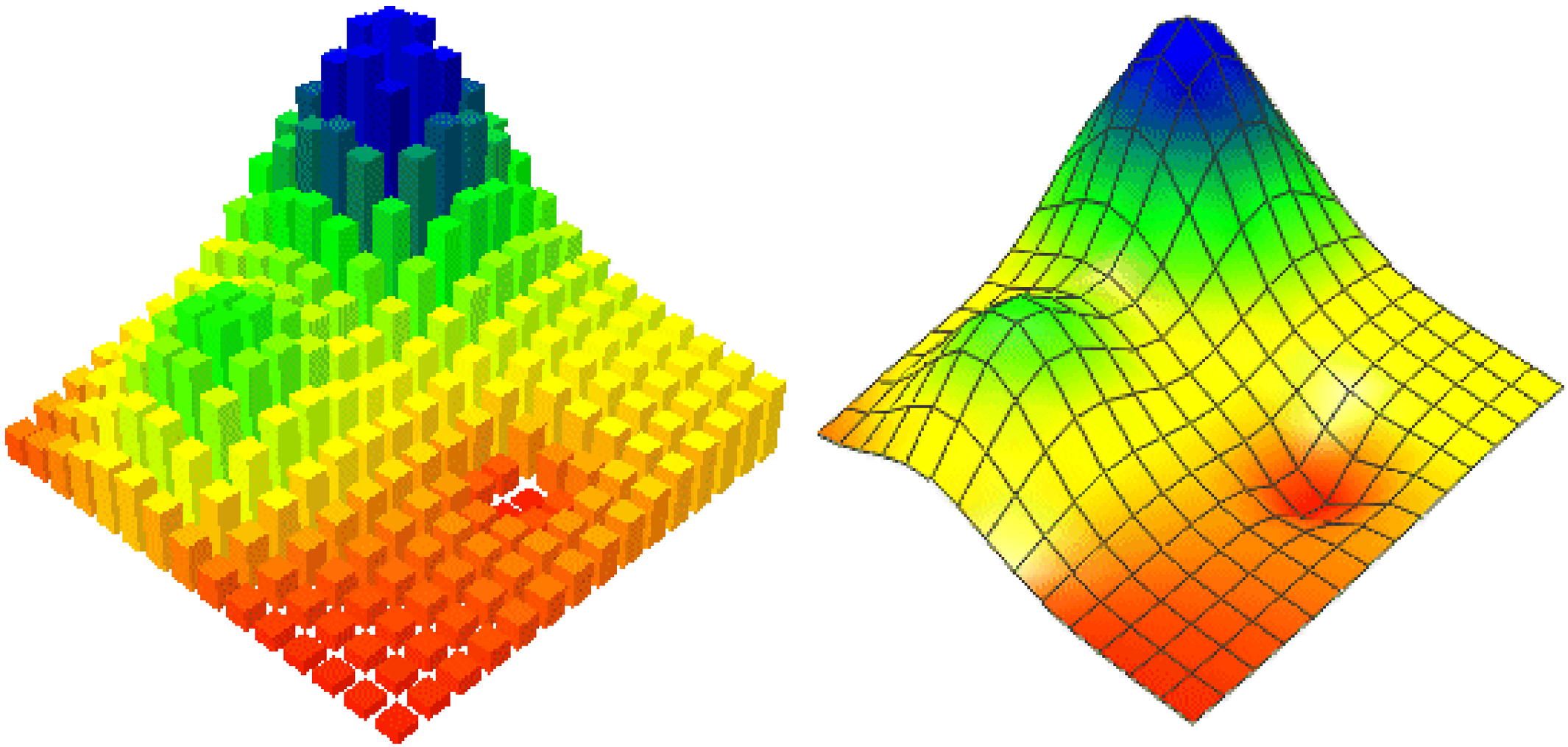






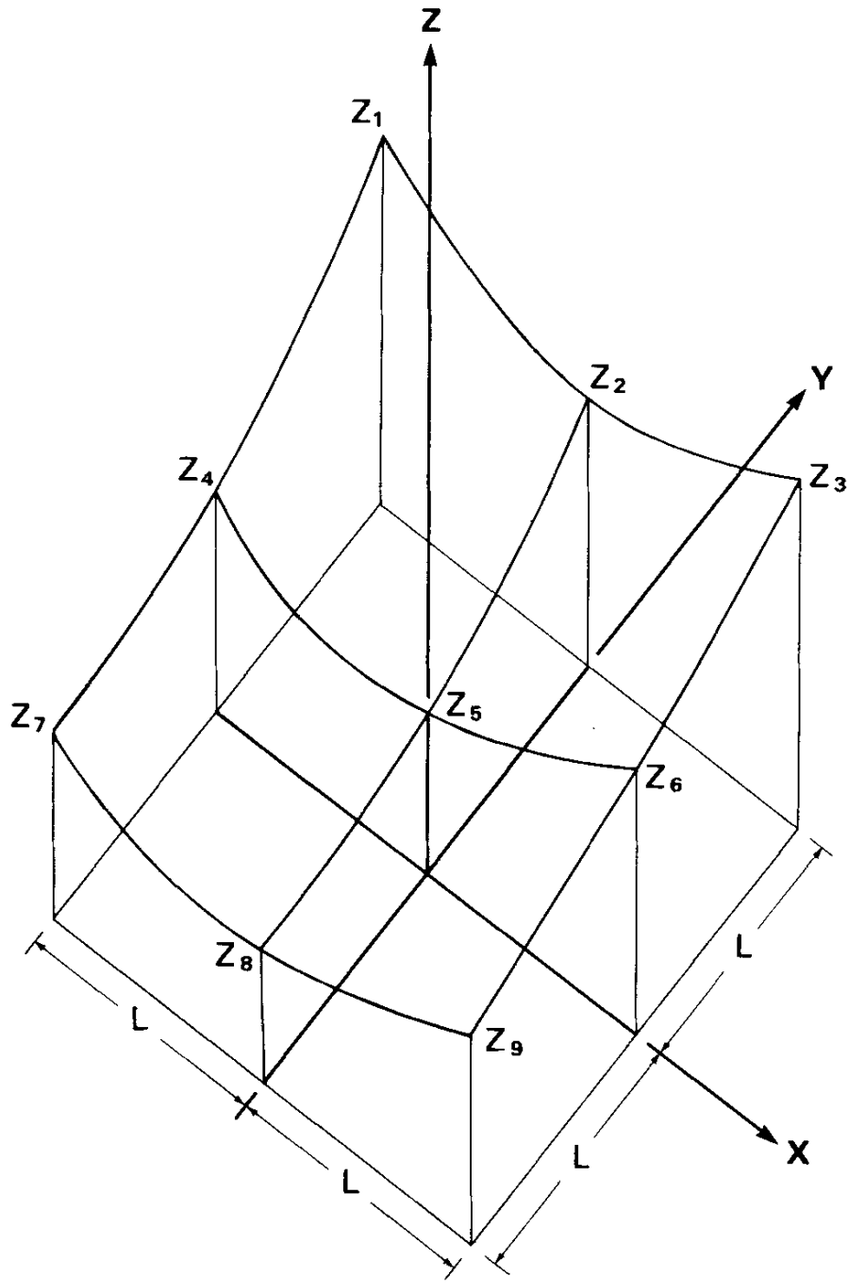


REPRESENTAÇÕES DISCRETAS X CONTÍNUAS

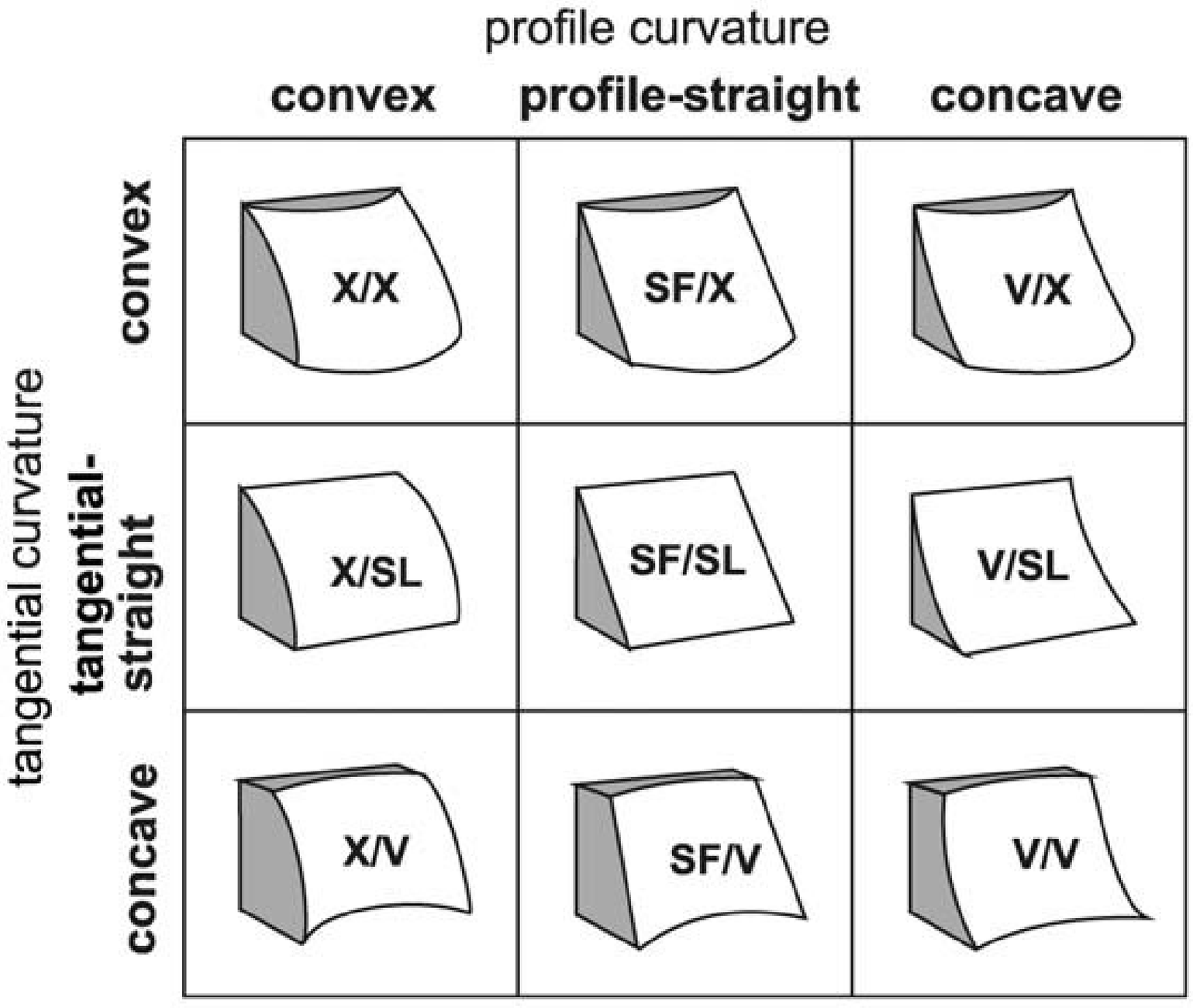


DERIVADAS DA SUPERFÍCIE

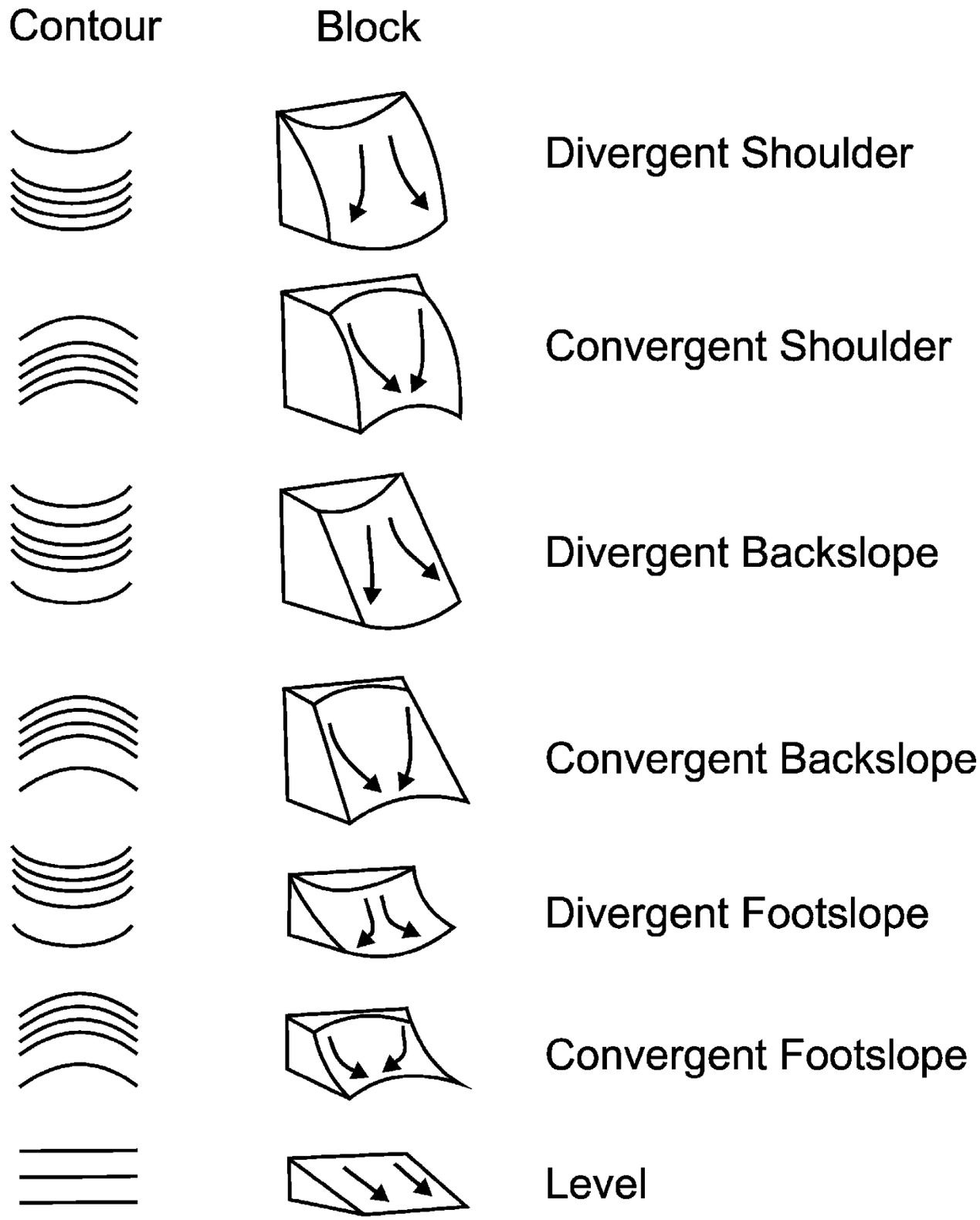
- Declividade (slope)
  - 1a. derivada vertical
- Orient. de vertentes (aspect)
  - 1a. derivada horizontal
- Curvatura de perfil
  - 2a. derivada vertical
- Curvatura tangencial
  - 2a. derivada horizontal



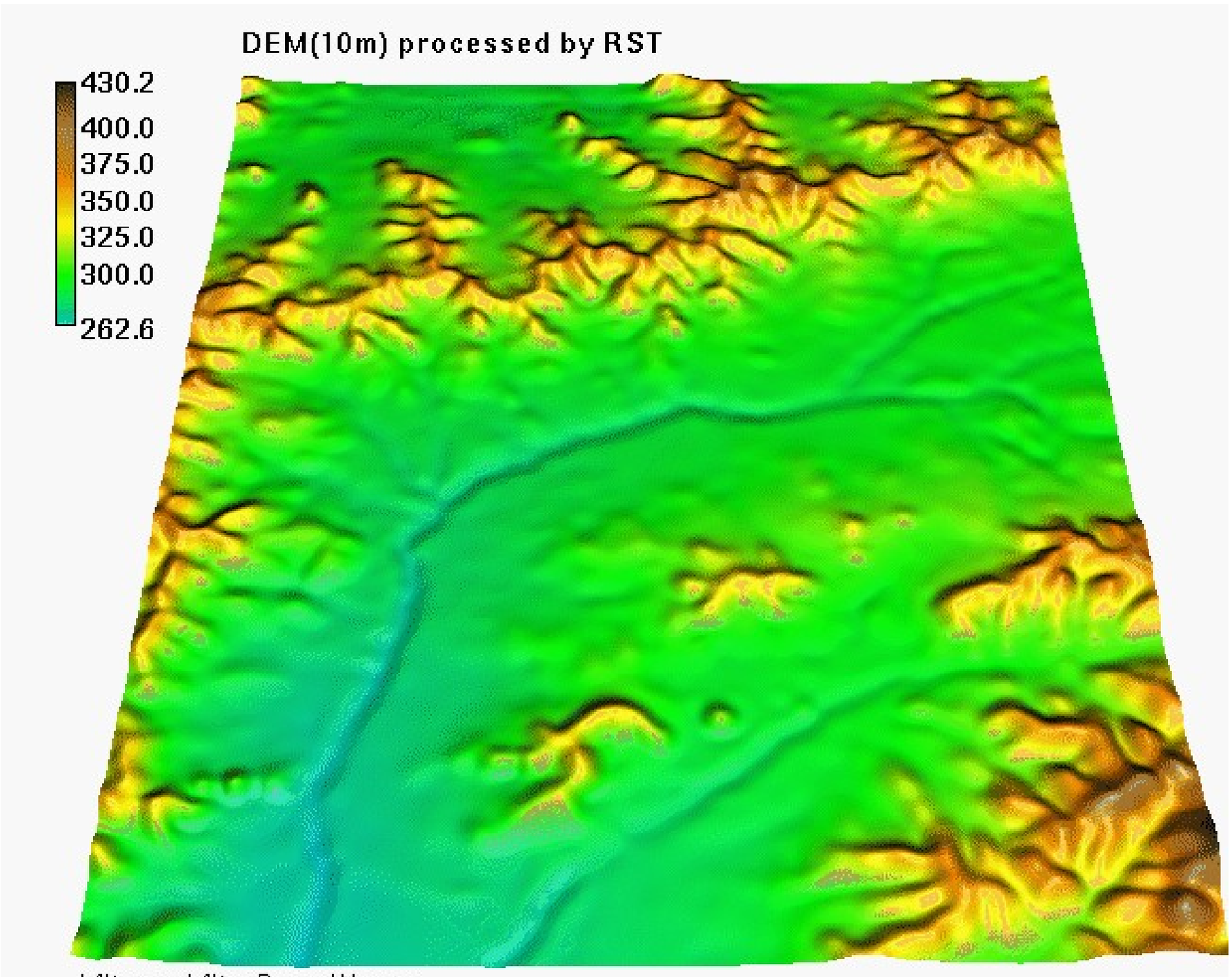
CURVATURAS


profile curvature
convex
profile-straight
concave
tangential curvature
convex
tangential-straight
concave
X/X
SF/X
V/X
X/SL
SF/SL
V/SL
X/V
SF/V
V/V

CURVATURAS

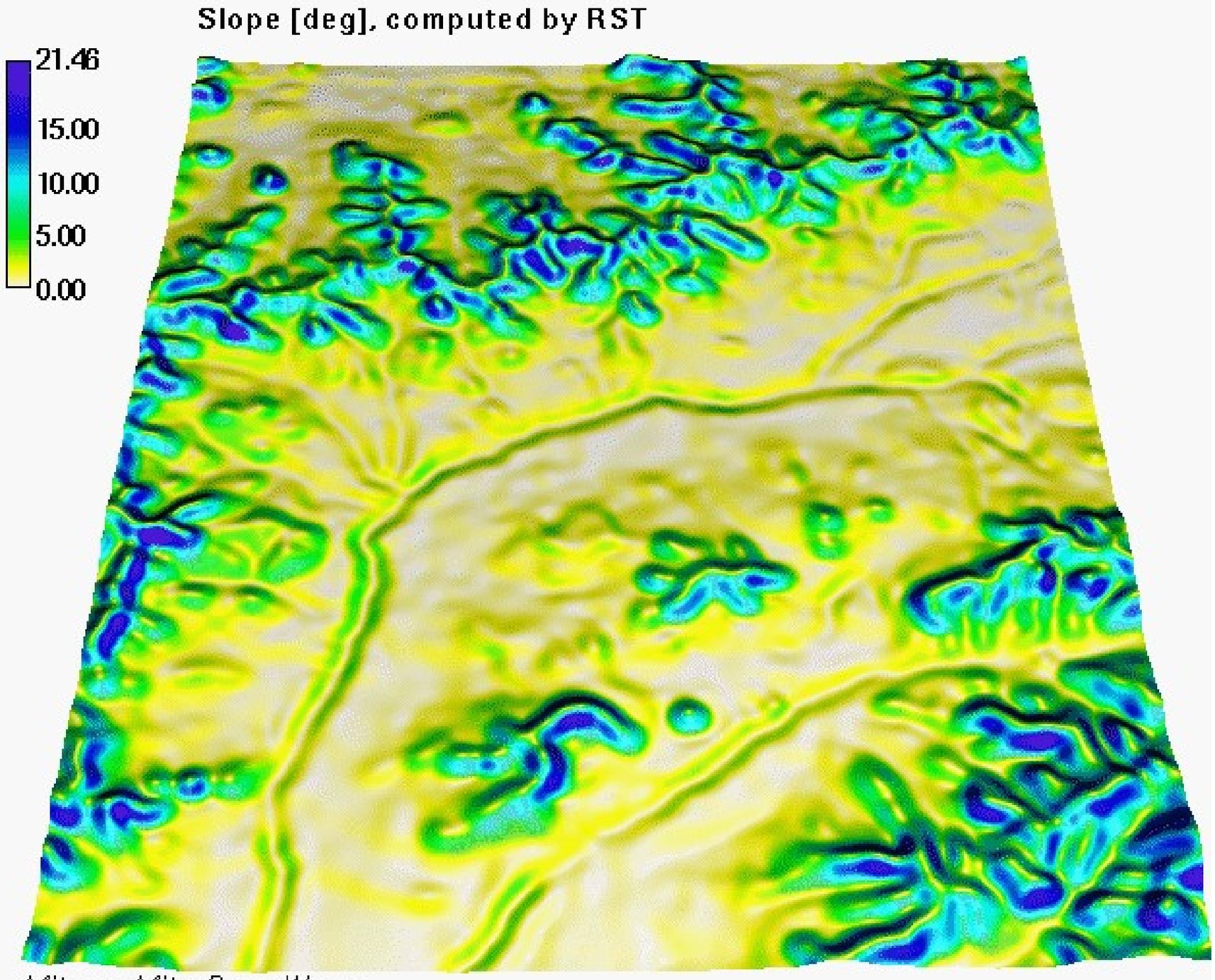

Contour
Block
Divergent Shoulder
Convergent Shoulder
Divergent Backslope
Convergent Backslope
Divergent Footslope
Convergent Footslope
Level

DEM



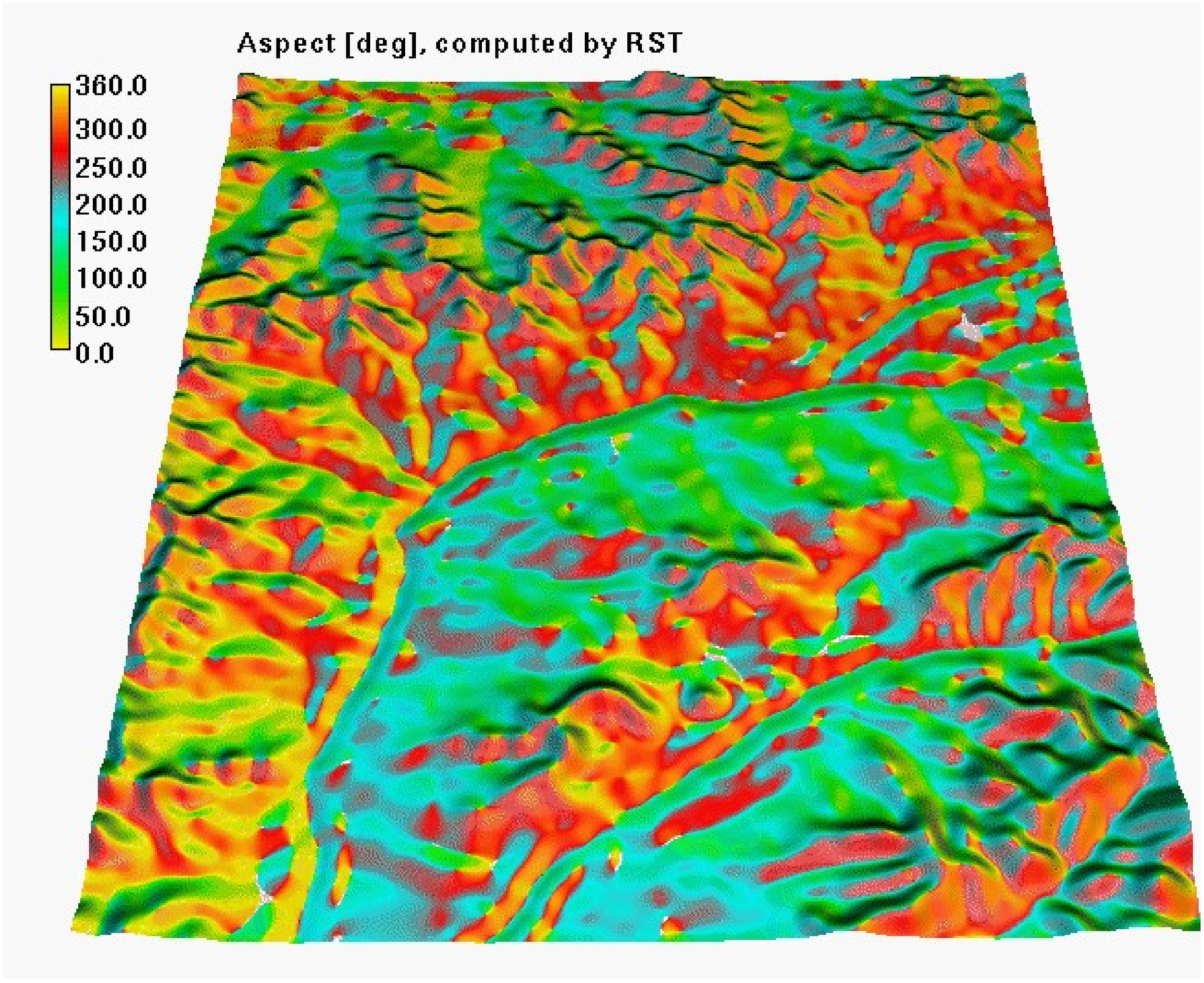
Mitasova,Mitas,Brown,Warren

SLOPE

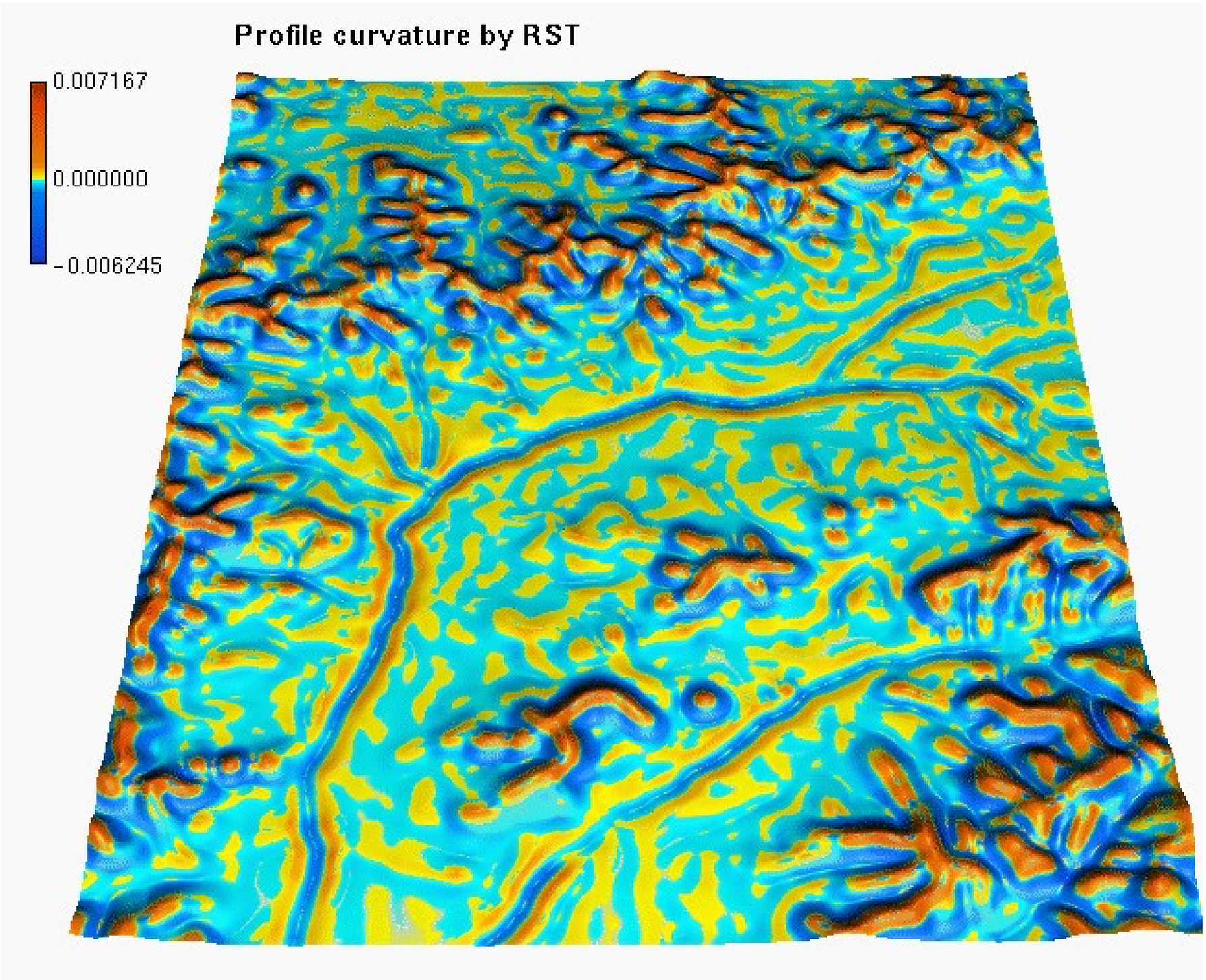


Mitasova,Mitas,Brown,Warren

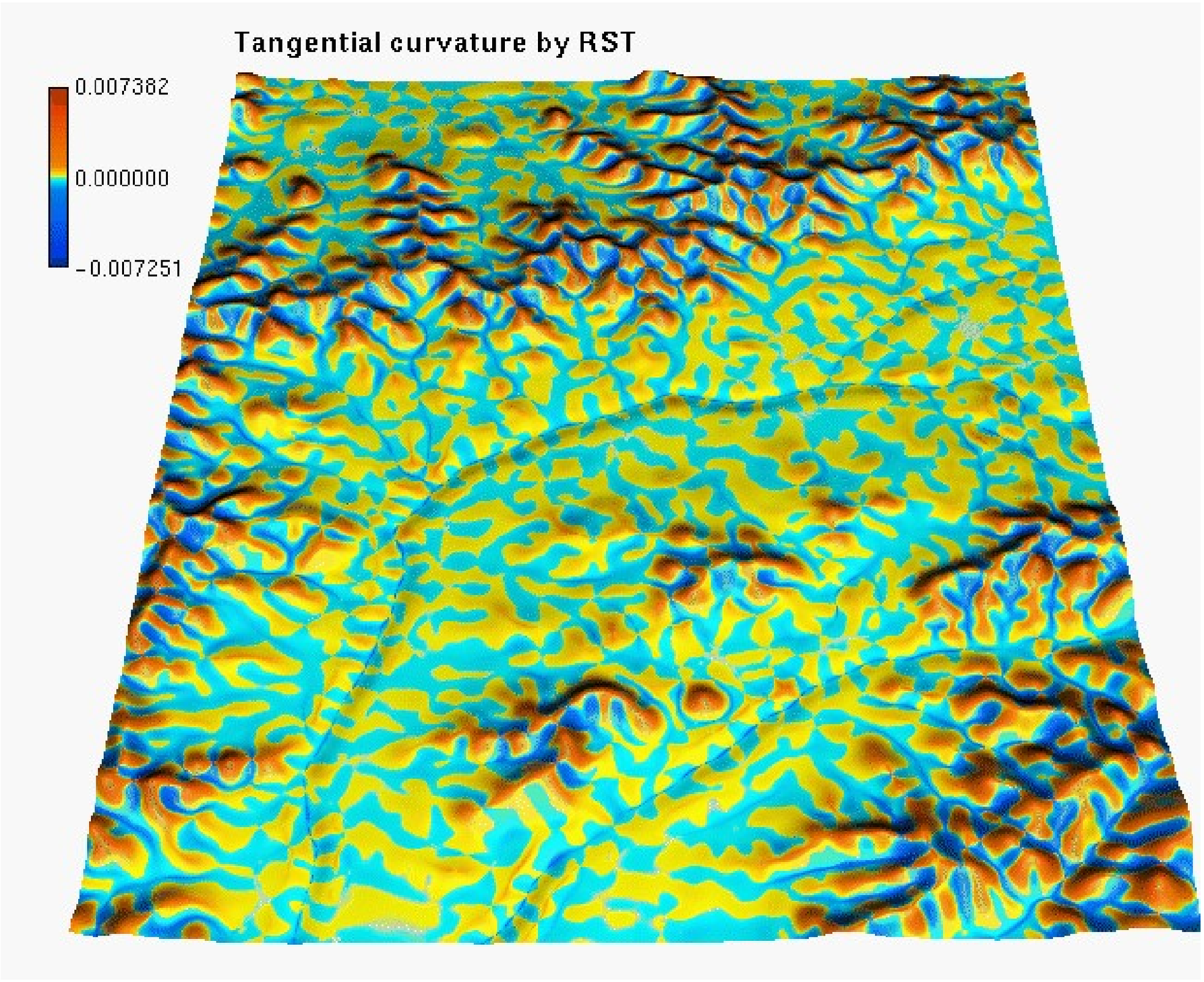
ASPECT


Aspect [deg], computed by RST
360.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0

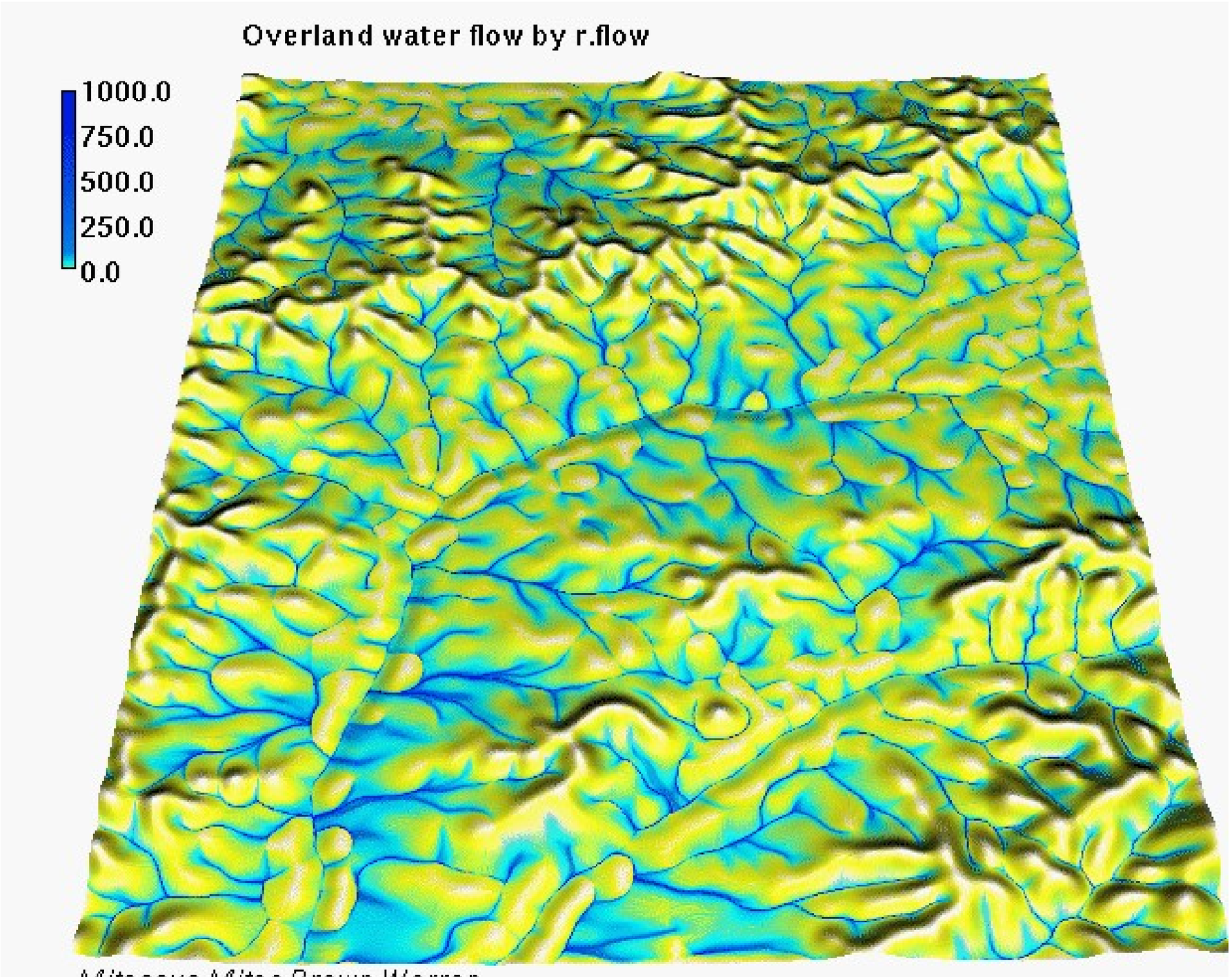
PROFILE CURVATURE



TANG. CURVATURE

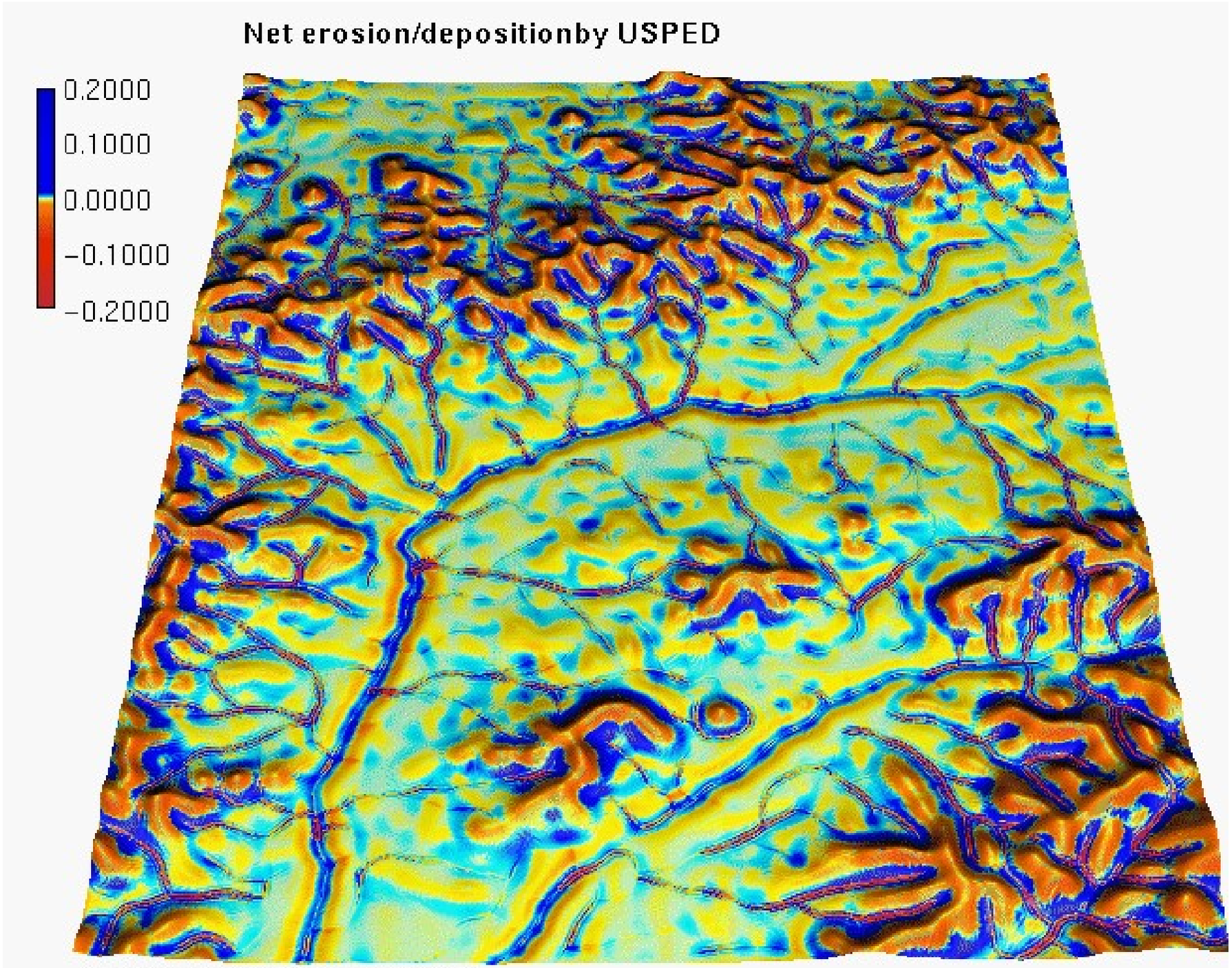


FLOW



Mitasova,Mitas,Brown,Warren

EROSION



Mitasova,Mitas,Brown,Warren

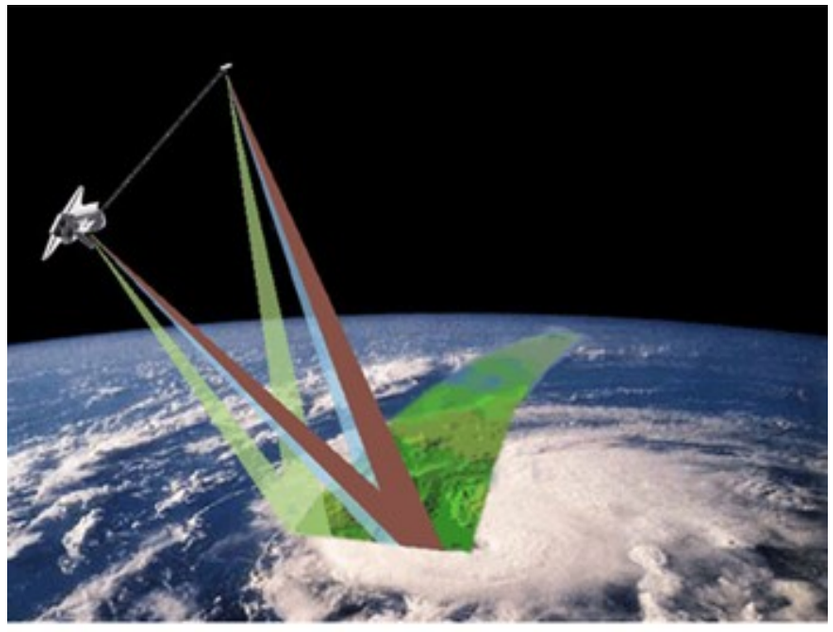
PRINCIPAIS MDEs

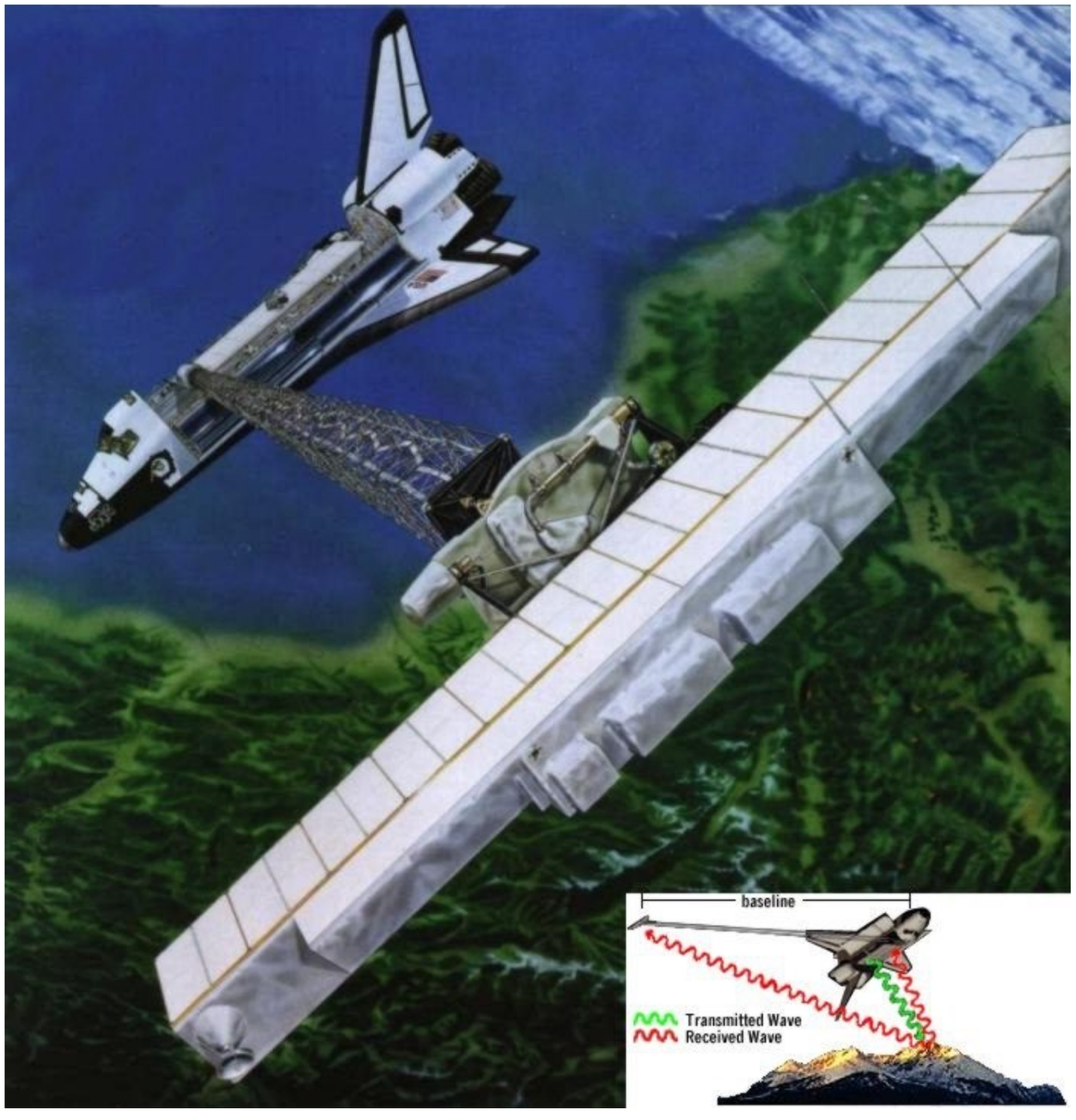
SRTM

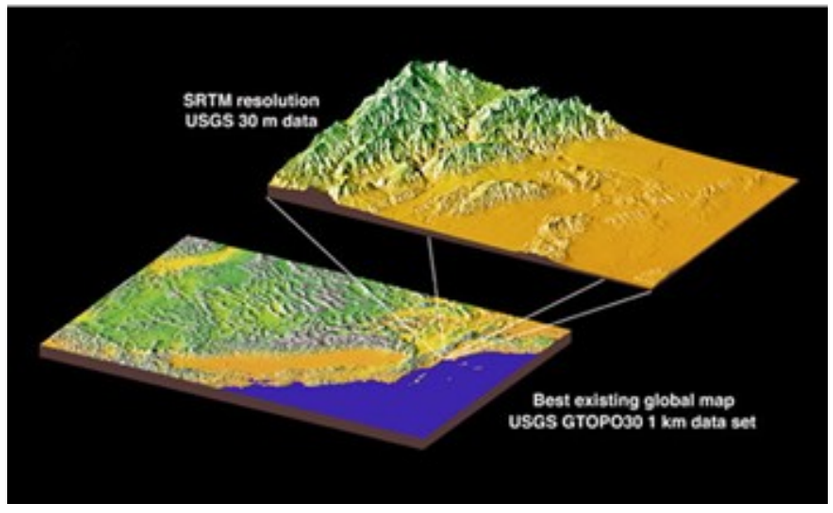
- **Shuttle Radar Topography Mission**
  - MDEs gerados por interferometria de radar, com abrangência de 80% da superfície terrestre
  - Inicialmente:
    - Estados Unidos – resolução de 1'' (aprox. 30m)
    - O resto do Mundo – resolução de 3'' (aprox. 90m)

- Farr, T. G., Rosen, P. A., Caro, E., Crippen, R., Duren, R., Hensley, S., Kobrick, M., Paller, M., Rodriguez, E., Roth, L., Seal, D., Shaffer, S., Shimada, J., Umland, J., Werner, M., Oskin, M., Burbank, D., & Alsdorf, D., 2007. The Shuttle Radar Topography Mission. Review of Geophysics, 45:RG2004.

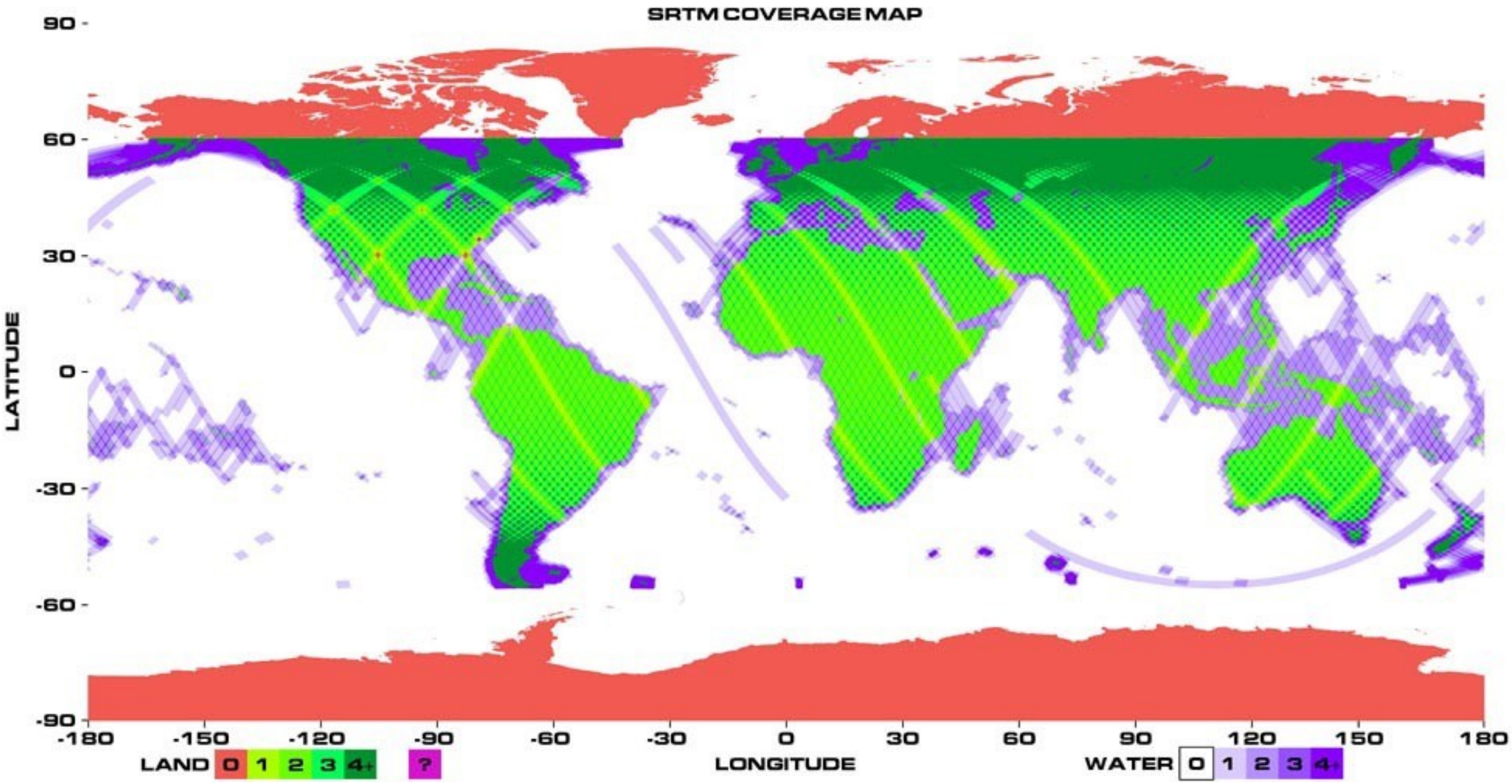
SRTM




baseline
Transmitted Wave
Received Wave


SRTM resolution
USGS 30 m data
Best existing global map
USGS GTOPO30 1 km data set

SRTM

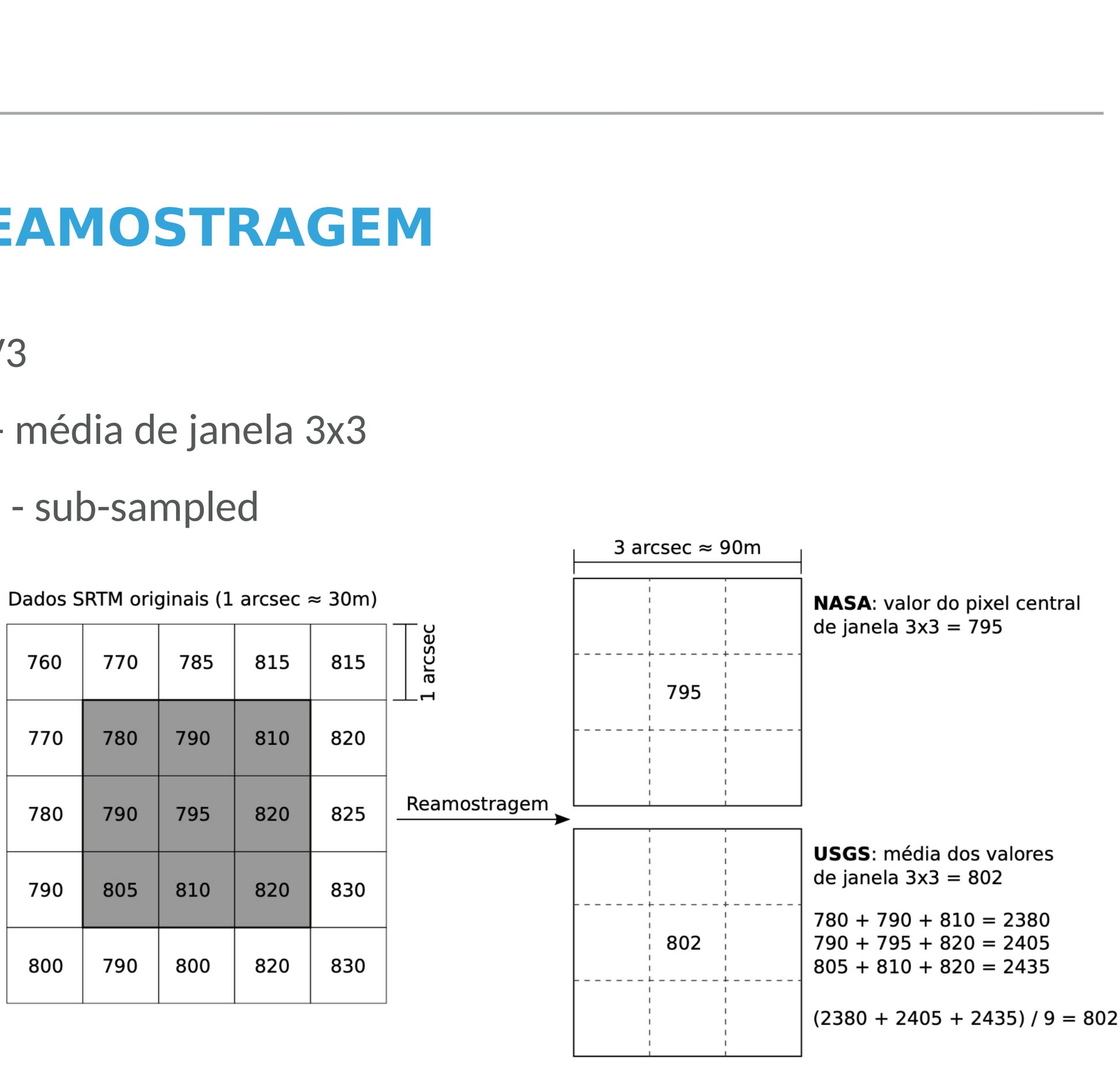

SRTM COVERAGE MAP
90
60
30
0
-30
-60
-90
LATITUDE
-180
-150
-120
-90
-60
-30
0
30
60
90
120
150
180
LONGITUDE
LAND 0 1 2 3 4+ ?
WATER 0 1 2 3 4+

SRTM

- **Versões dos dados SRTM**
  - NASA SRTM V1 - 2003
  - NASA SRTM V2 e V2.1 - "*Finished version*" (2005)
    - SRTM Water Body Data - SWBD
    - Embrapa - Brasil em Relevo (2005)
- NASA SRTM V3 - 2013/2014 (01'' para mundo todo)
- CGIAR-CSI SRTM V4.1 - 2008
- DLR SRTM X-SAR - 30m - 2010

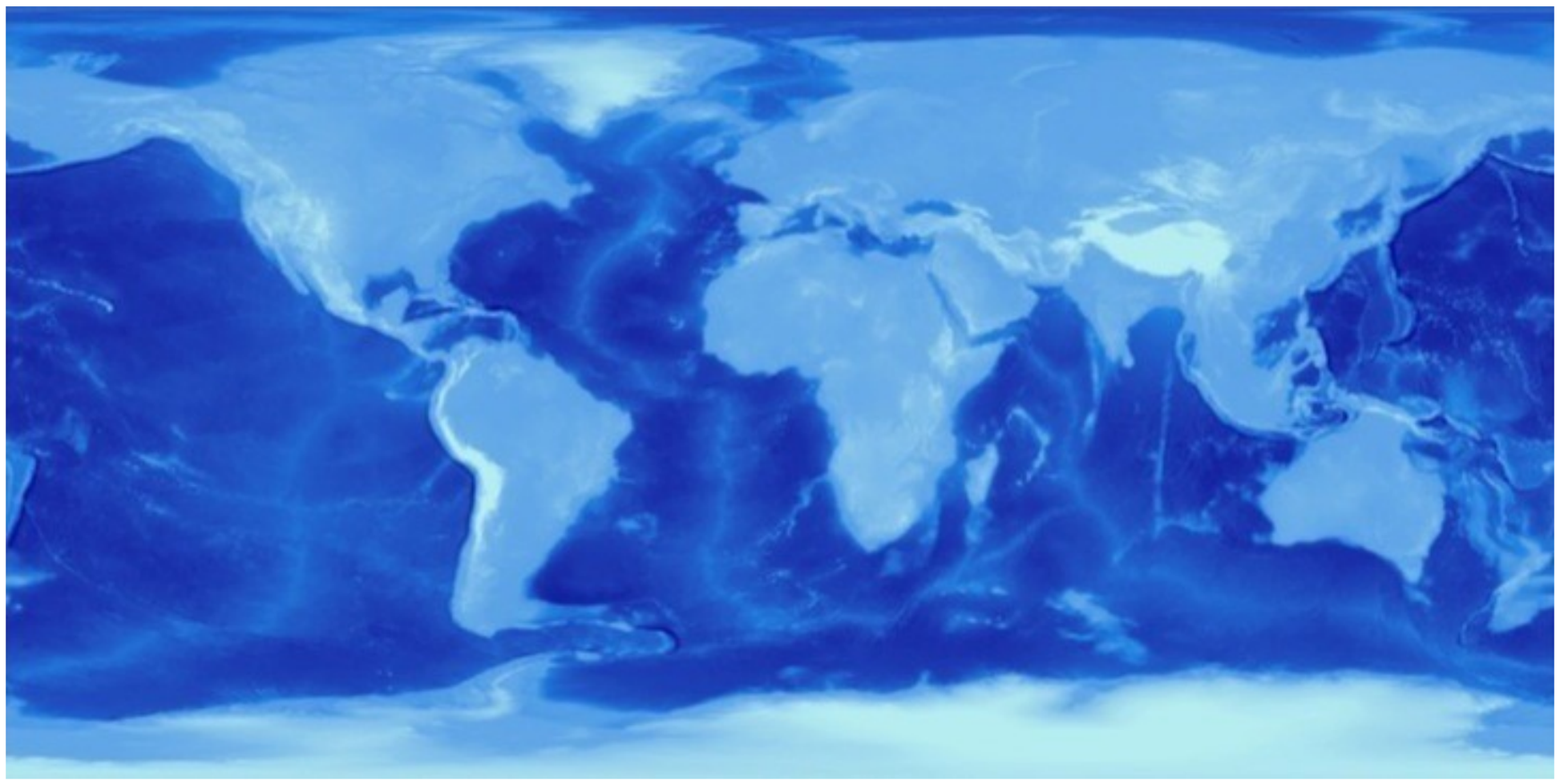
SRTM - REAMOSTRAGEM

- NASA SRTM V3
  - SRTMGL3 - média de janela 3x3
  - SRTMGL3S - sub-sampled



SRTM30_PLUS

- Resolução de 30'' (aprox. 1km)
- SRTM30 (30'') + GLOBE (altas latitudes) + batimetria por satélite + batimetria por navios



DADOS SRTM

- SRTM v1 - http://dds.cr.usgs.gov/srtm/version1/

- SRTM v2.1 - http://dds.cr.usgs.gov/srtm/version2_1/
  - Os diretórios SRTM1, SRTM3 e SRTM30 representam dados com resolução espacial de 1 segundo, 3 segundos e 30 segundos de arco, respectivamente.

- SRTM v3:
  - OpenTopography - http://www.opentopography.org/id/OTSRTM.042013.4326.1
  - NASA Reverb - https://reverb.echo.nasa.gov/reverb
  - USGS LPDAAC Data Pool - https://lpdaac.usgs.gov/data_access/data_pool/

- SRTM V3 01'' - http://e4ftl01.cr.usgs.gov/SRTM/SRTMGL1.003/2000.02.11/

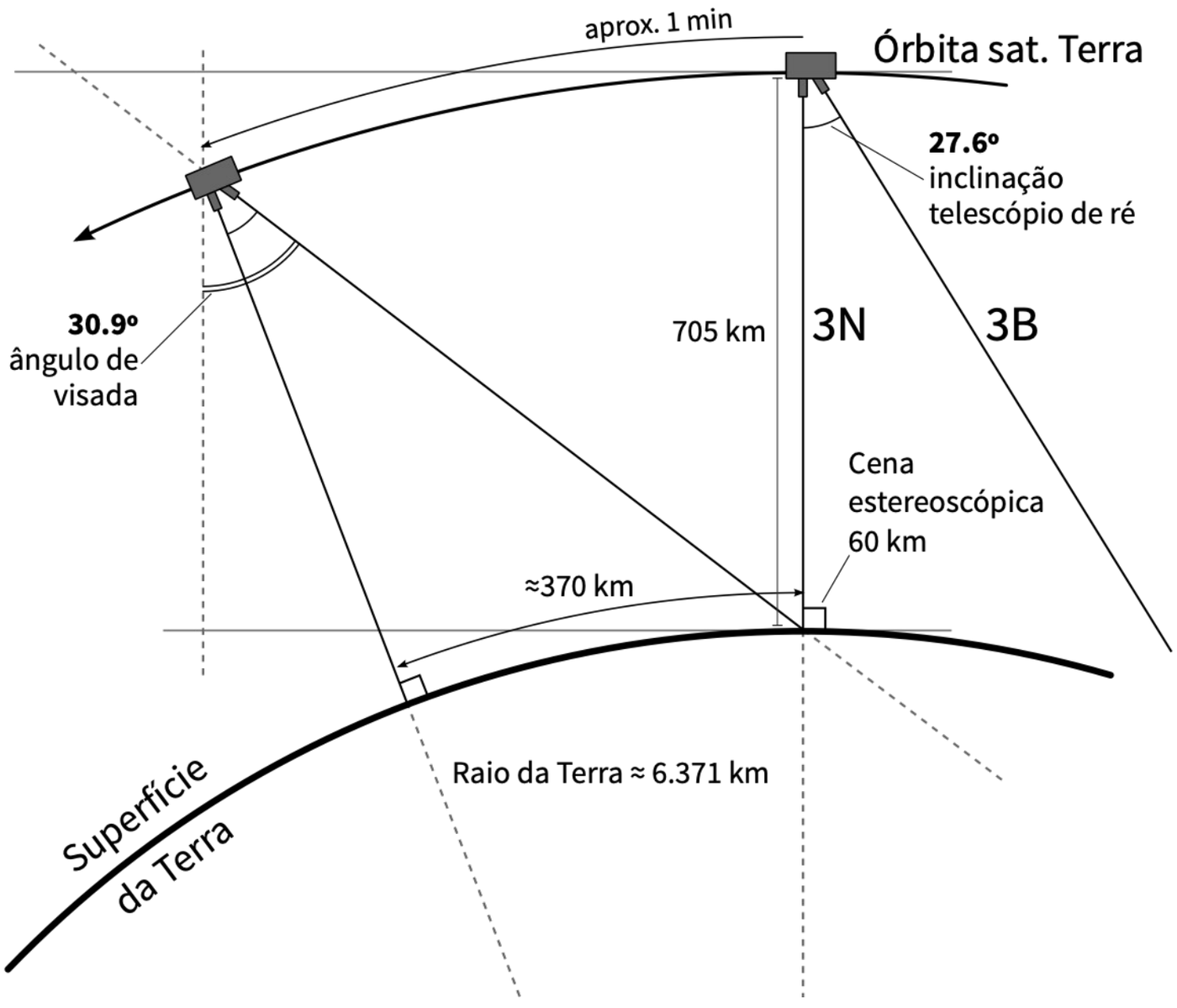
- SRTM v4.1 CGIAR-CSI - http://srtm.csi.cgiar.org/SELECTION/inputCoord.asp

FOTOGRAMETRIA

- Alguns satélites possuem sensores duplicados para formar pares estereoscópicos
  - A partir dos pares, gera-se um MDE
  - Com sensores com capacidade de apontamento, pode-se fazer o mesmo em órbitas diferentes

- Fotogrametria a curta distância
  - Structure-from-Motion (SfM)
  - drones

FOTOGRAMETRIA - ASTER 3N+3B

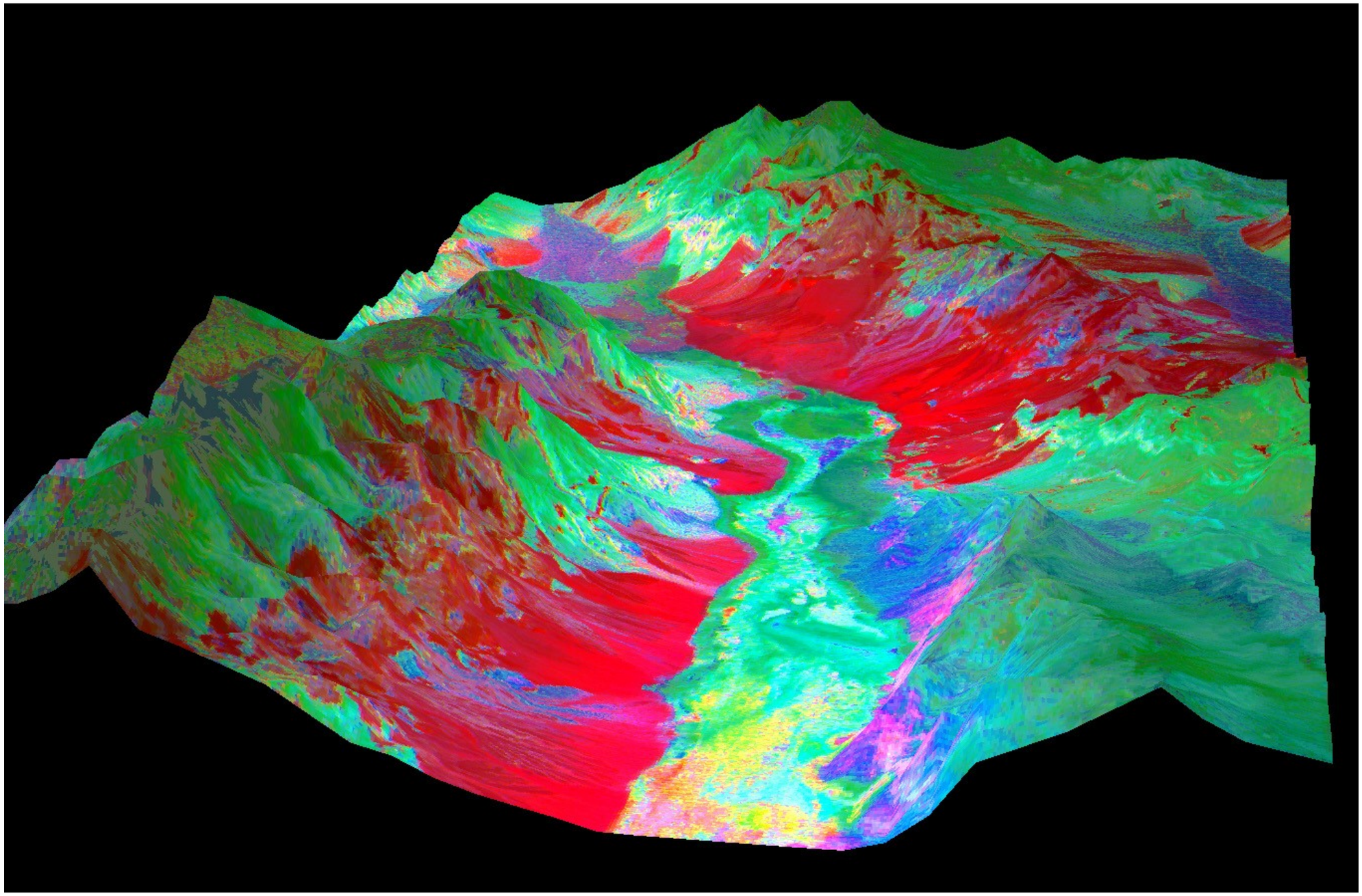


FOTOGRAMETRIA - ASTER GDEM

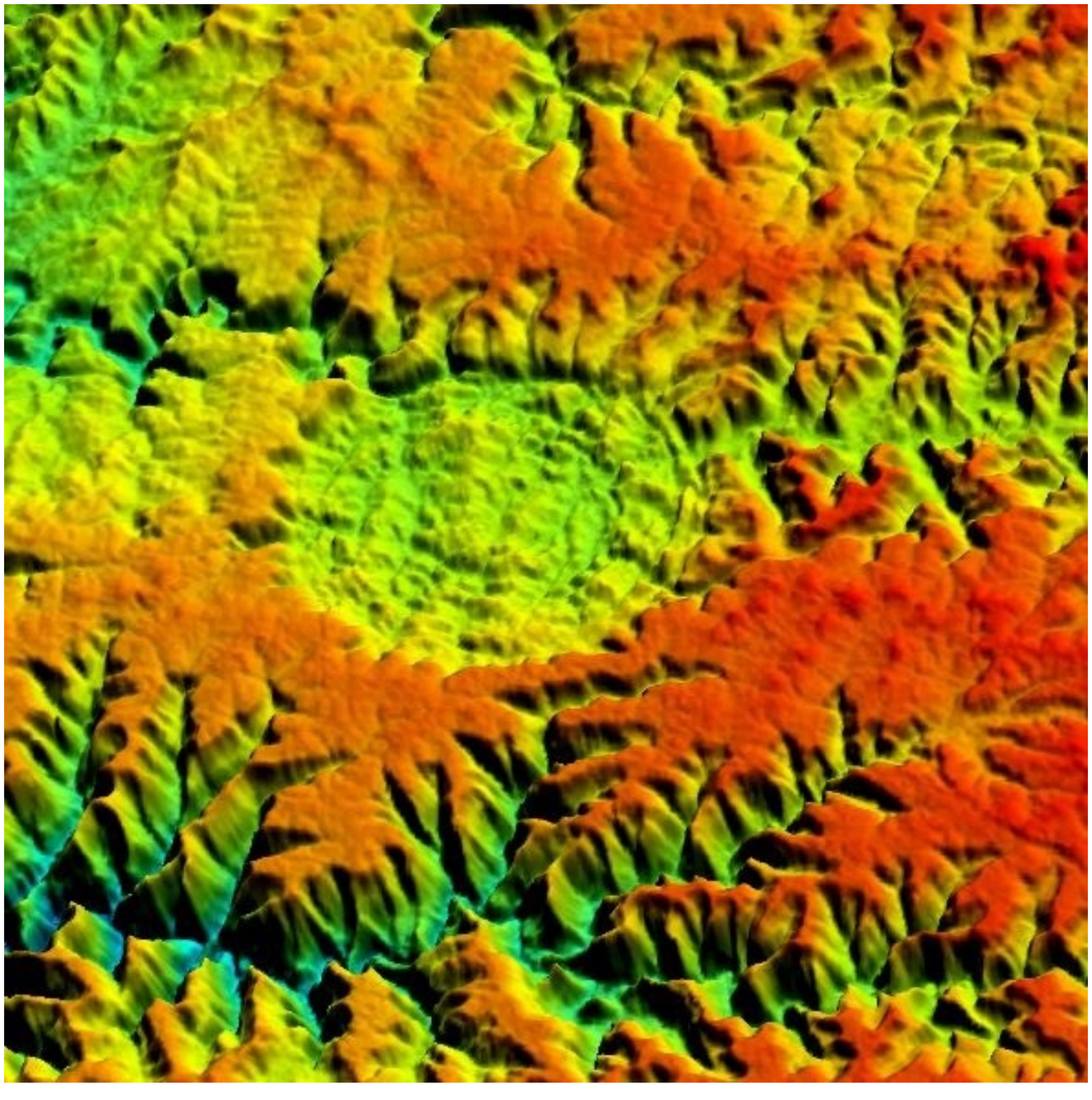
- ASTER GDEM v.1 - 2009
- ASTER GDEM v.2 – 2011
- ASTER GDEM V.3 – 2019

- 30m (teóricos)
- DSM
- Global

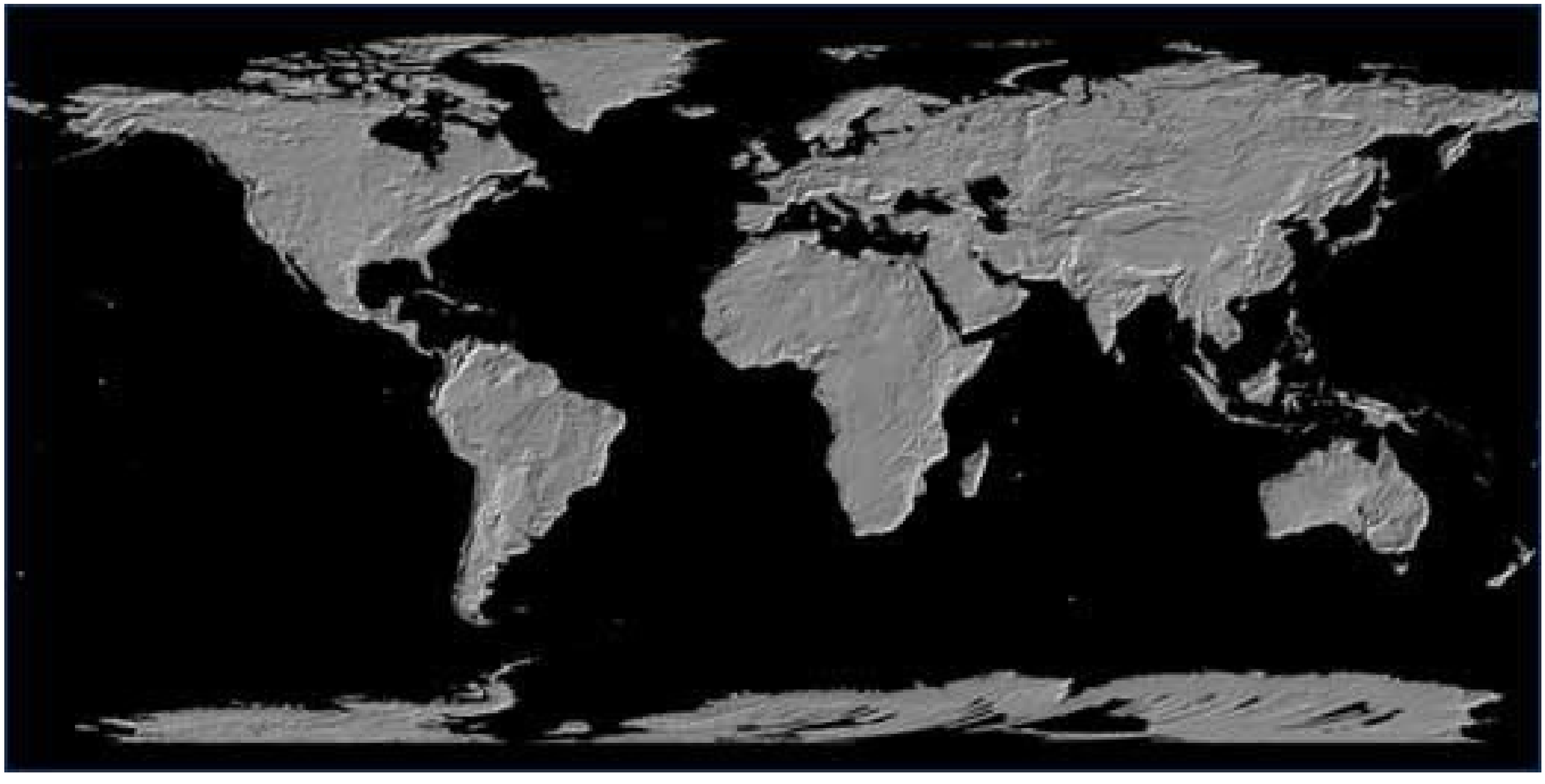
FOTOGRAMETRIA - ASTER 3N+3B



FOTOGRAMETRIA - ASTER 3N+3B



FOTOGRAMETRIA - ASTER GDEM



FOTOGRAMETRIA – ALOS PRISM AW3D30

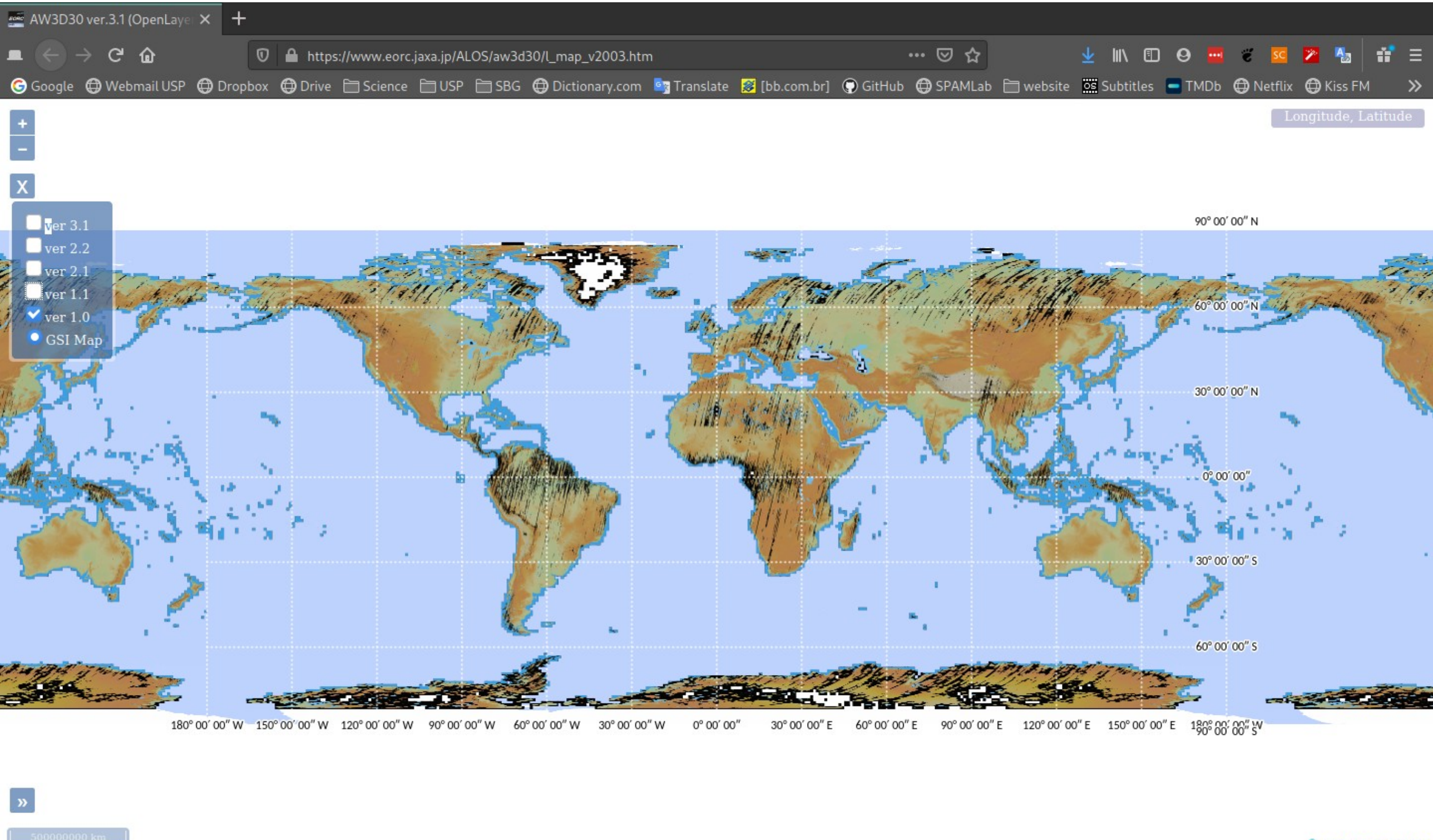
- Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM)
- Modelo comercial com 5m resolução
- Modelo gratutio com 30m resolução

FOTOGRAMETRIA – ALOS PRISM AW3D

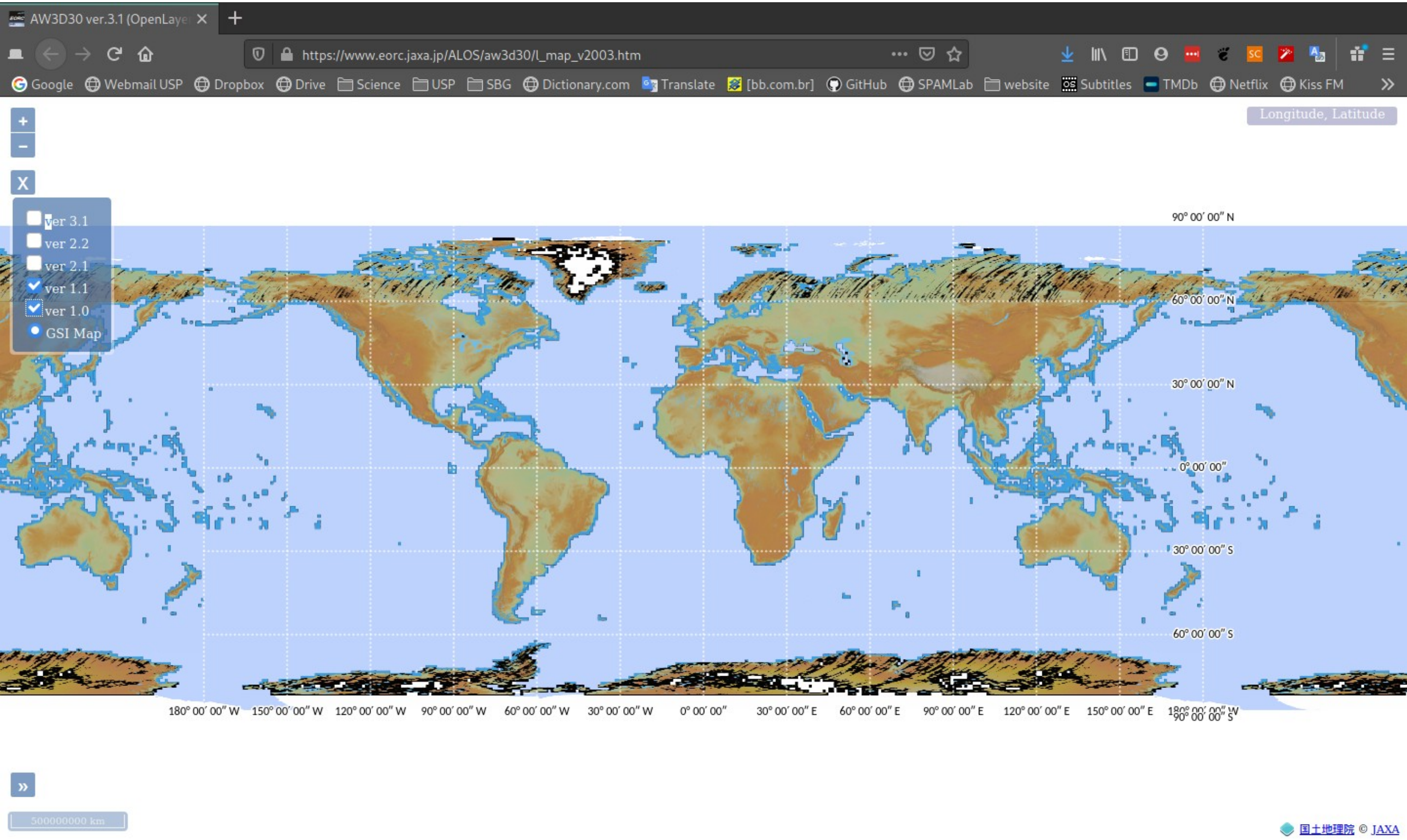
- ALOS AW3D30 v.1.0 – 2016
- ALOS AW3D30 v.1.1 – 2017
- ALOS AW3D30 V.2.1 – 2018
- ALOS AW3D30 V.2.2 – 2019
- ALOS AW3D30 V.3.1 – 2020

  - 30m (teóricos)
  - DSM
  - Global

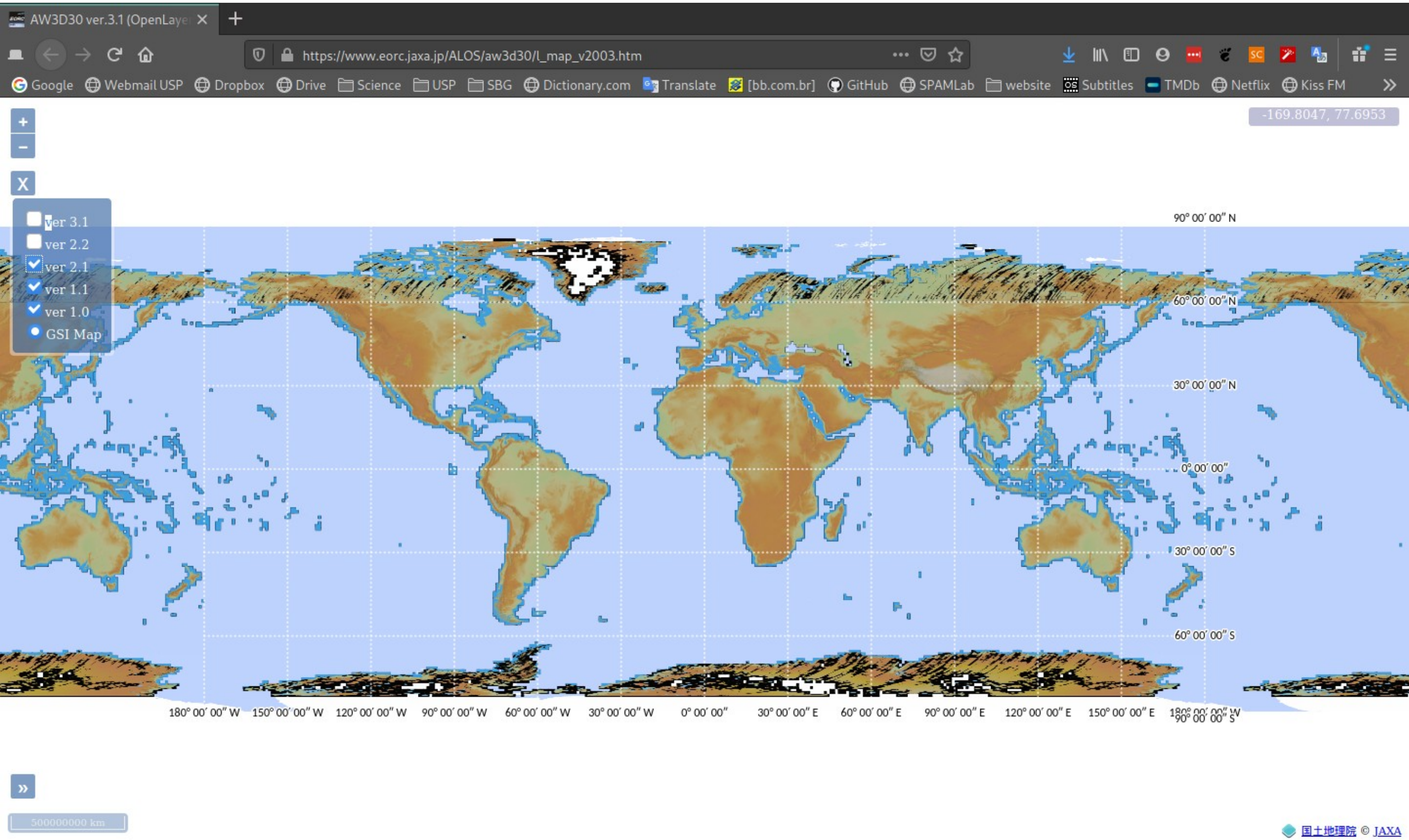
FOTOGRAMETRIA – ALOS PRISM AW3D



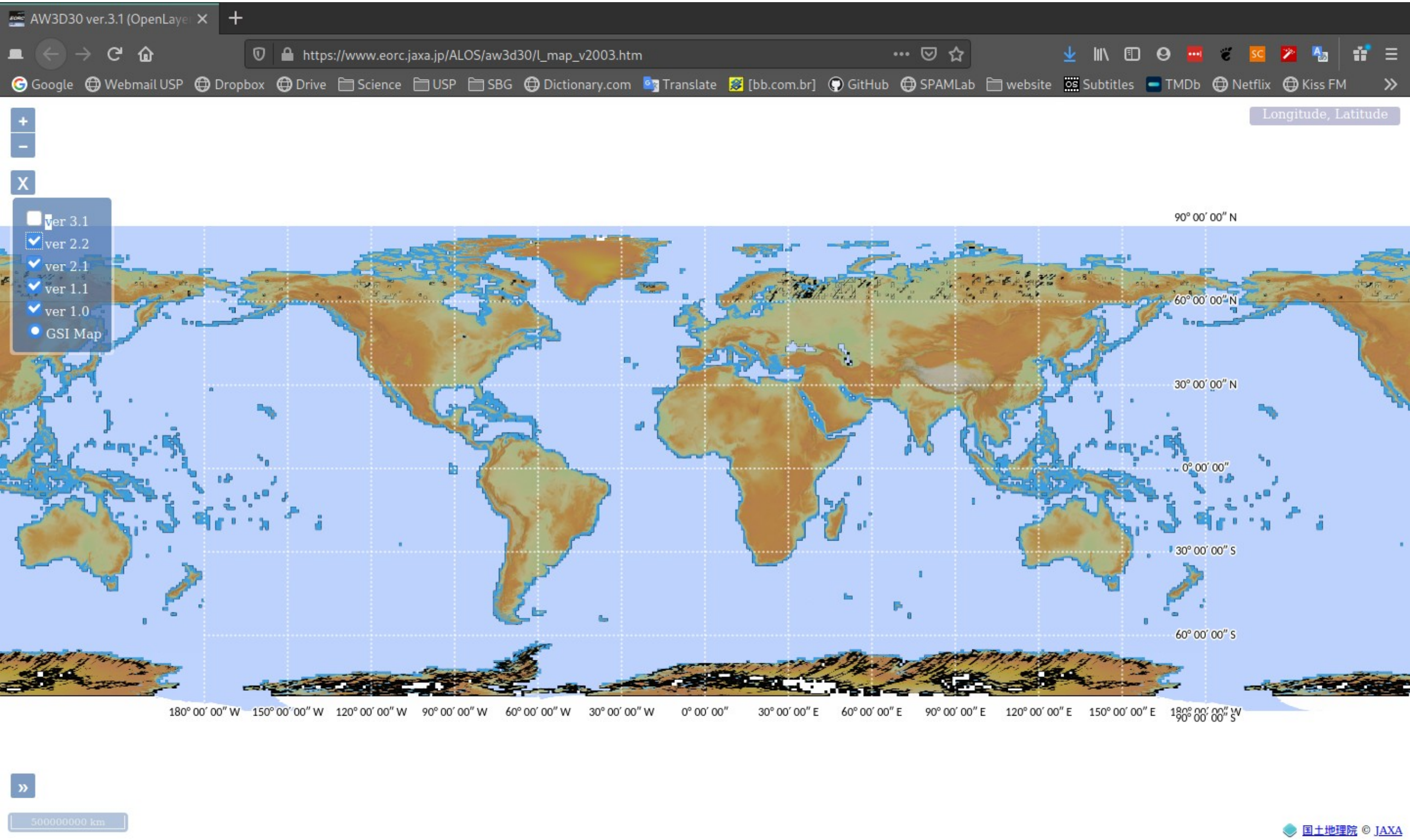
FOTOGRAMETRIA – ALOS PRISM AW3D



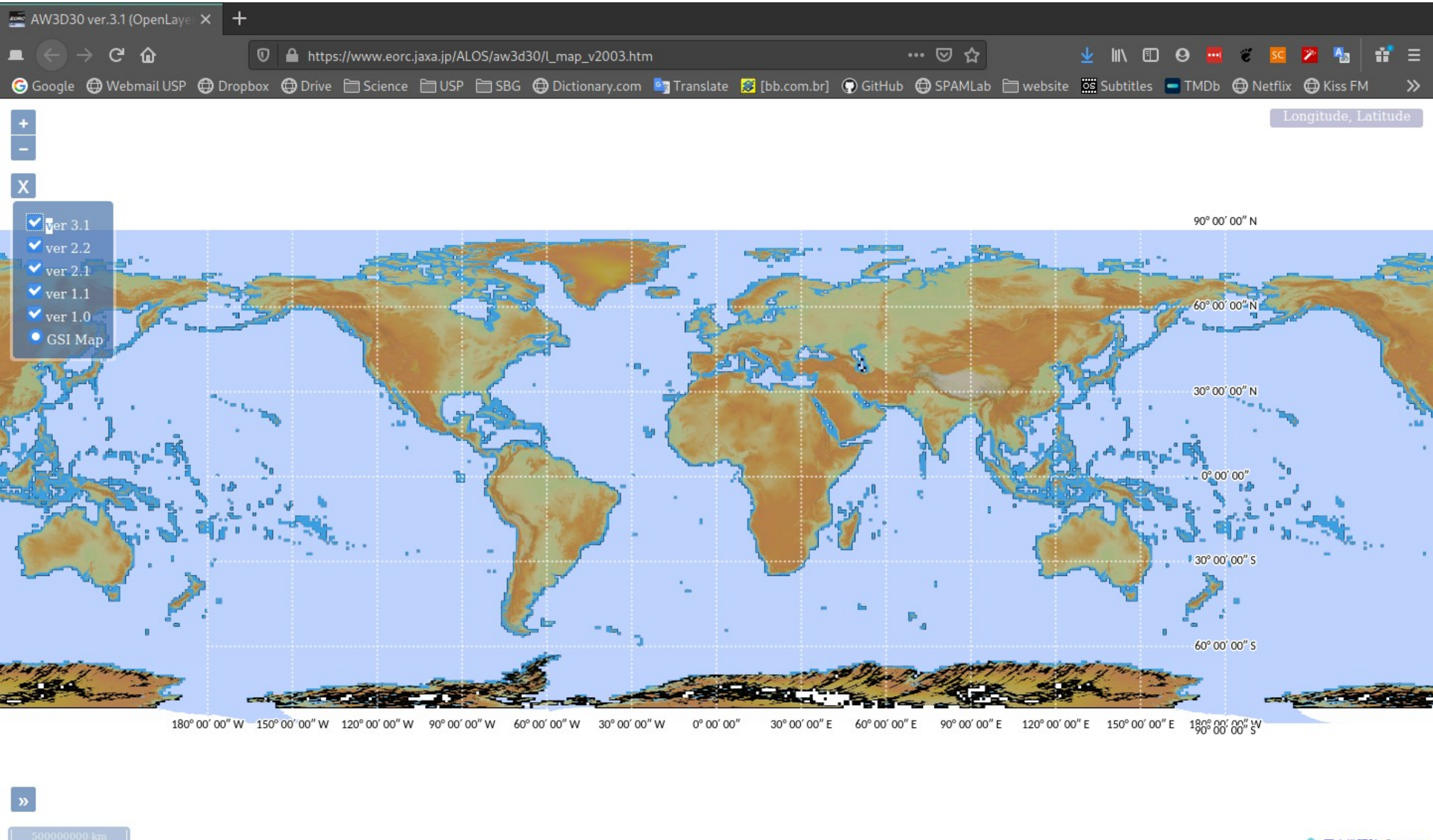
FOTOGRAMETRIA – ALOS PRISM AW3D



FOTOGRAMETRIA – ALOS PRISM AW3D



FOTOGRAMETRIA – ALOS PRISM AW3D

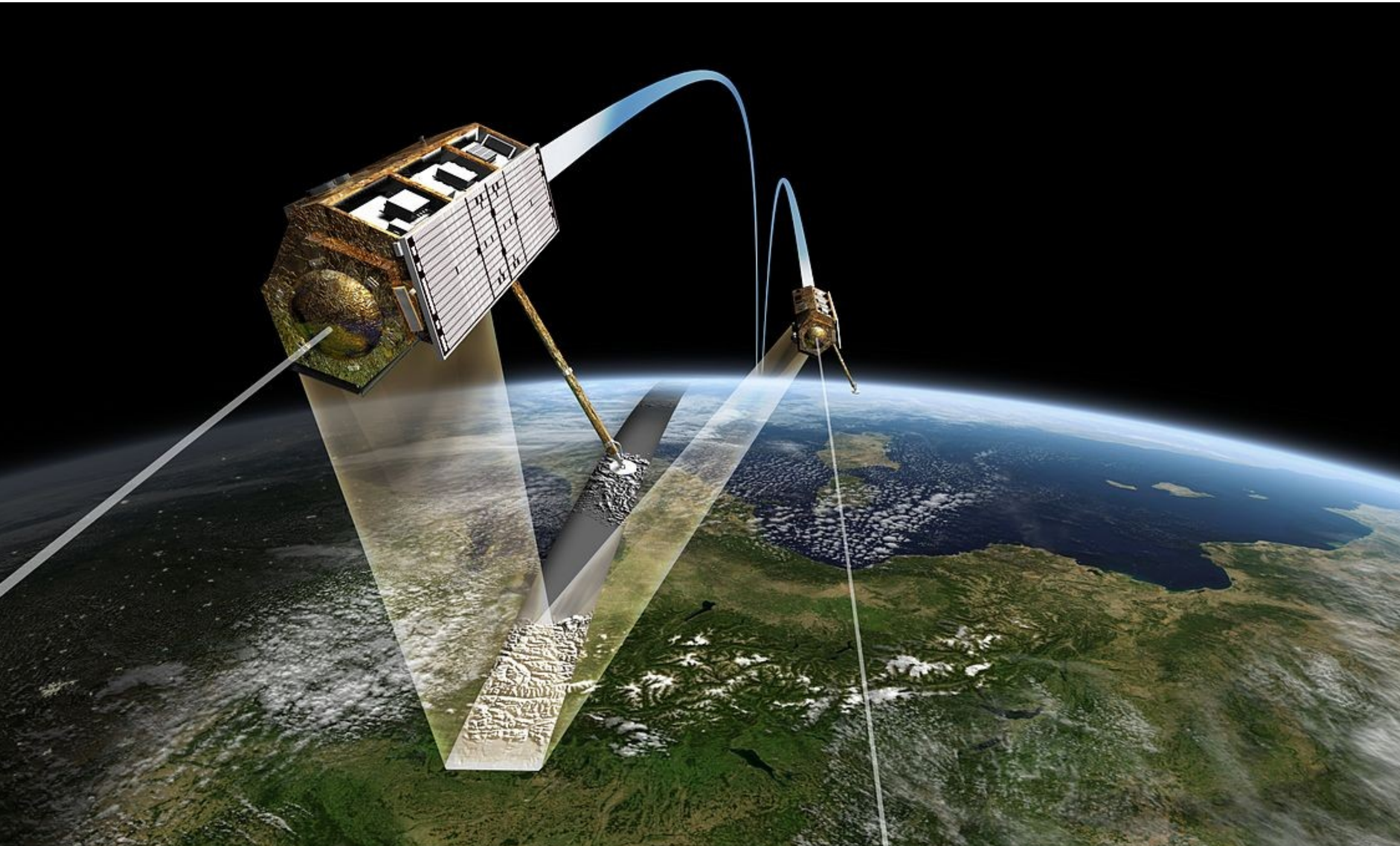


RADAR - TANDEM-X

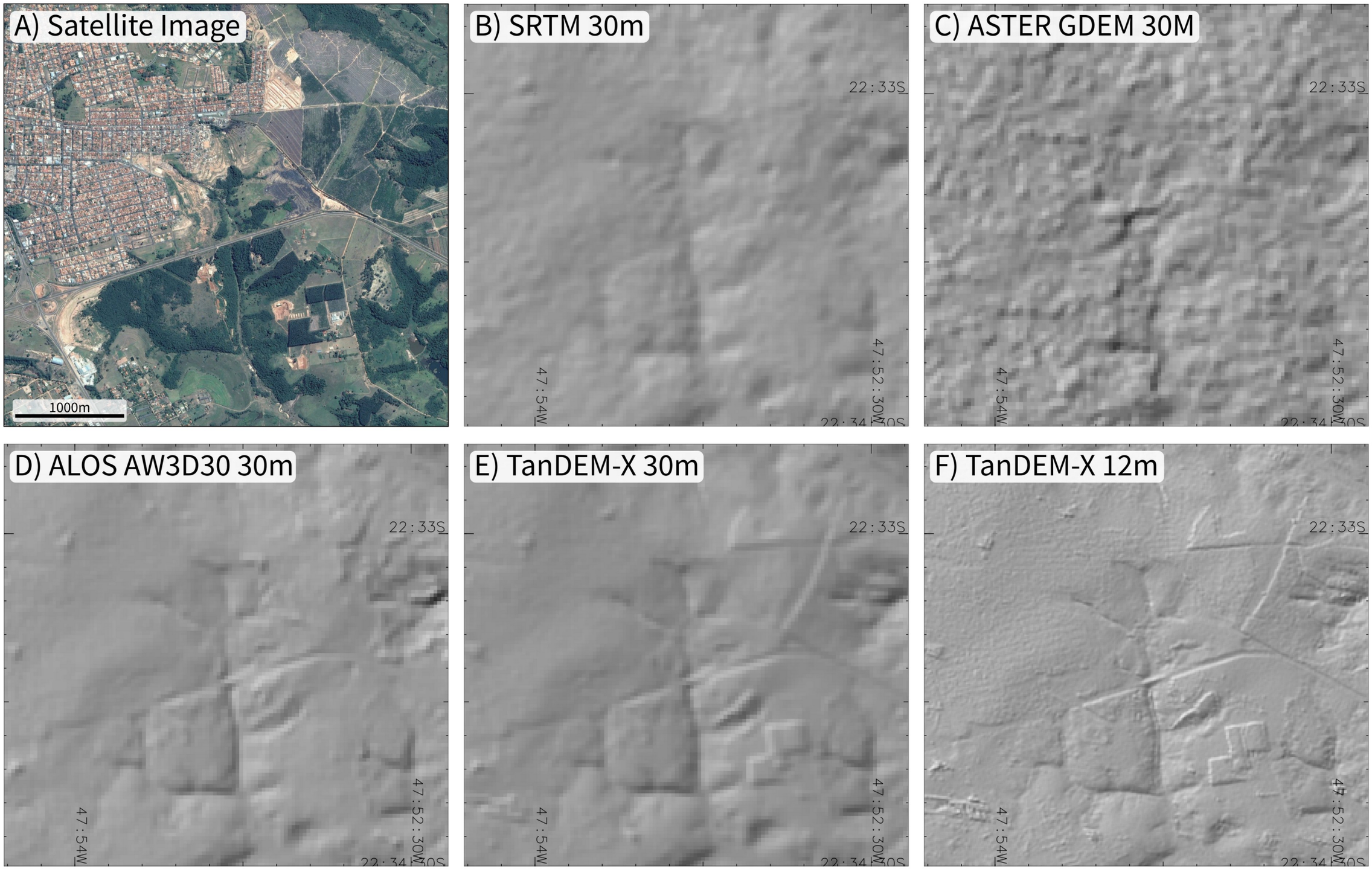
- TerraSAR-X add-on for Digital Elevation Measurement
- Dois satélites com sensores idênticos em formação (tandem)
- Banda X (sem penetração no dossel)
- 12m resolução (WorldDEM - Airbus)
- MDS com 90m gratuito
- https://tandemx-science.dlr.de/

GSA-5859

RADAR - TANDEM-X



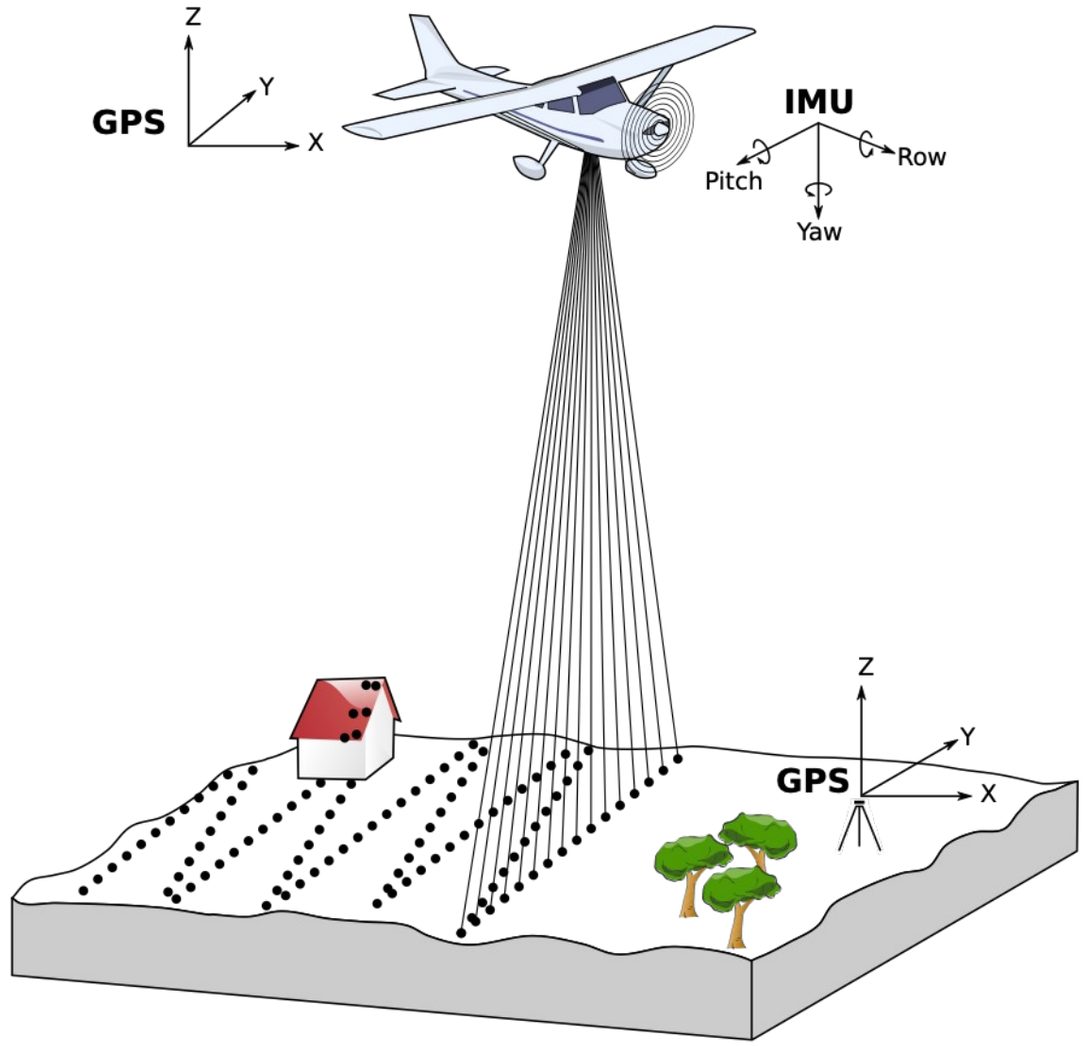
RADAR - TANDEM-X



Grohmann, 2018. RSE. https://doi.org/10.1016/j.rse.2018.04.043

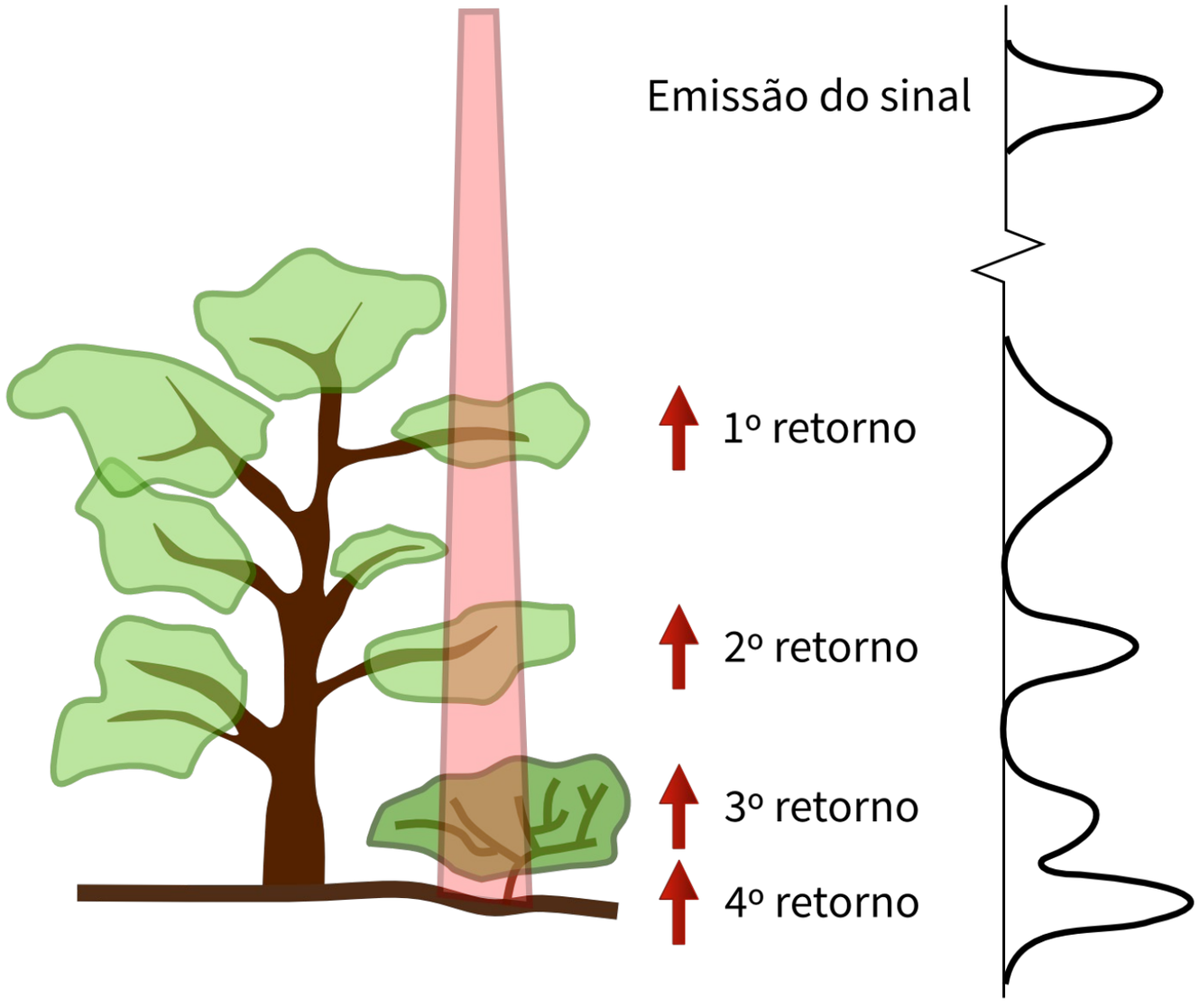
LIDAR

- LiDAR – *Light Detection and Ranging*
- Aeroportado ou Terrestre (TLS)
- Densidade de pontos absurda
- DGPS + IMU + Laser
- Múltiplos retornos
  - múltiplas superfícies

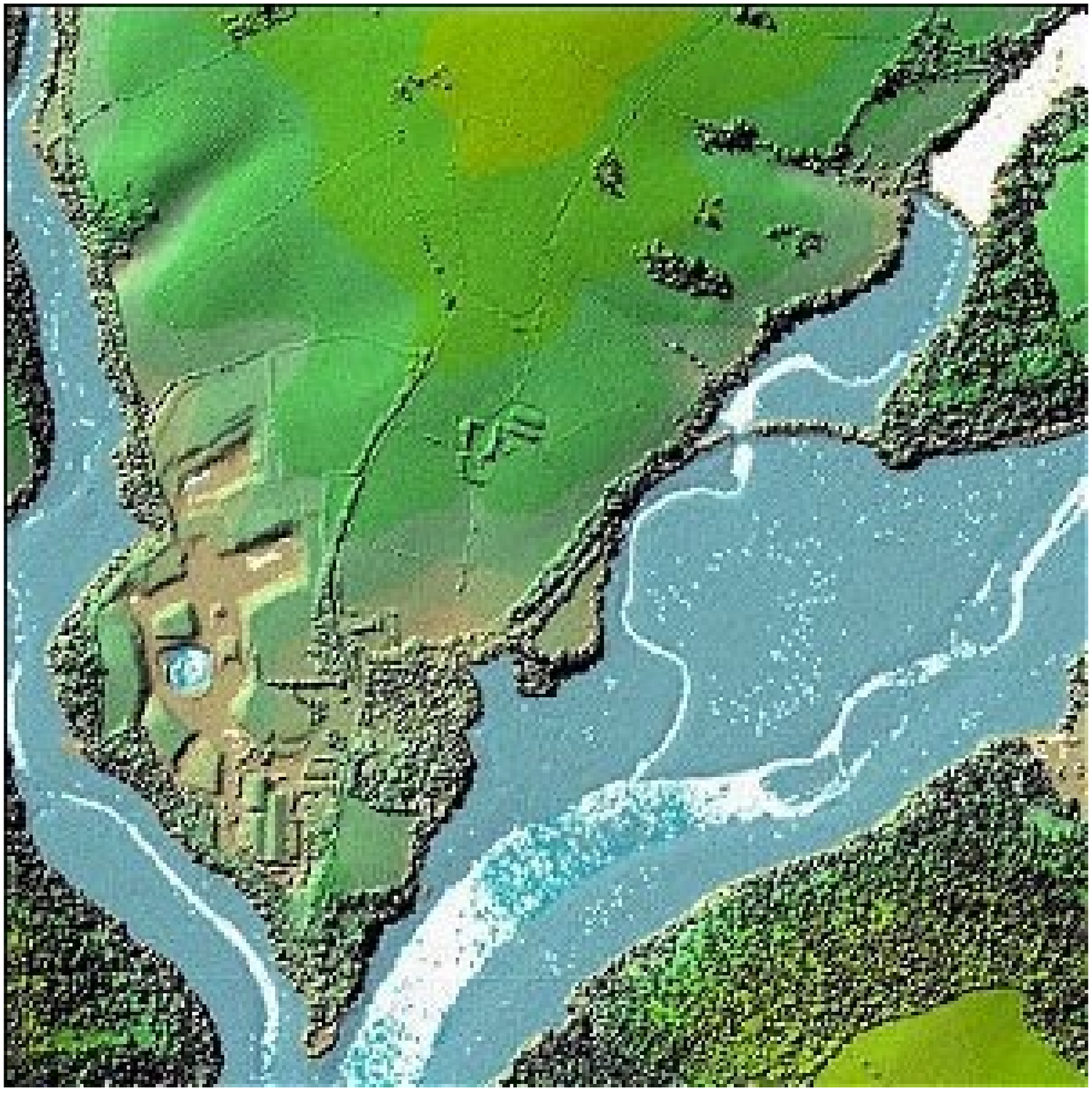


LIDAR

- Múltiplos retornos
  - múltiplas superfícies
  - full waveform



LIDAR



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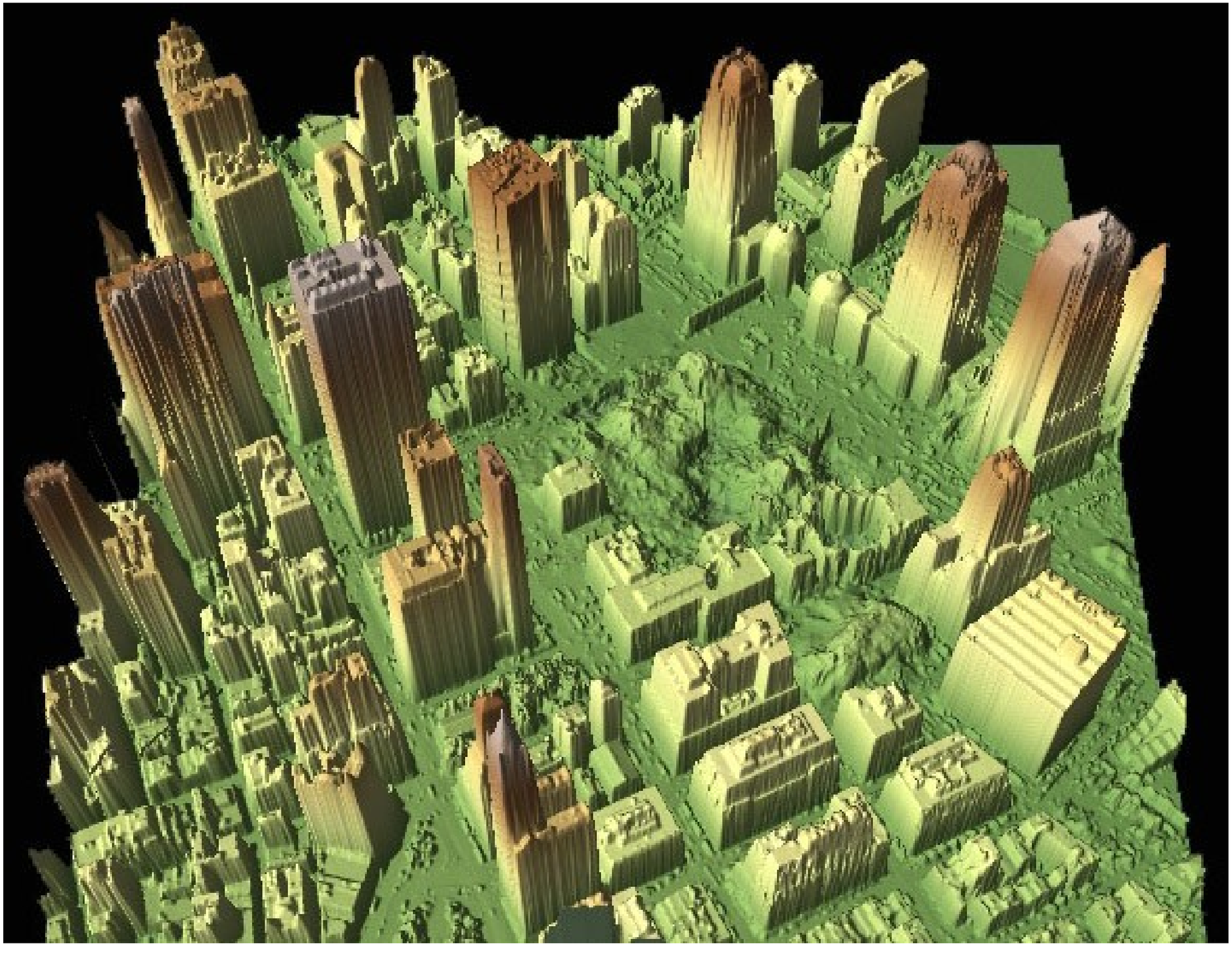

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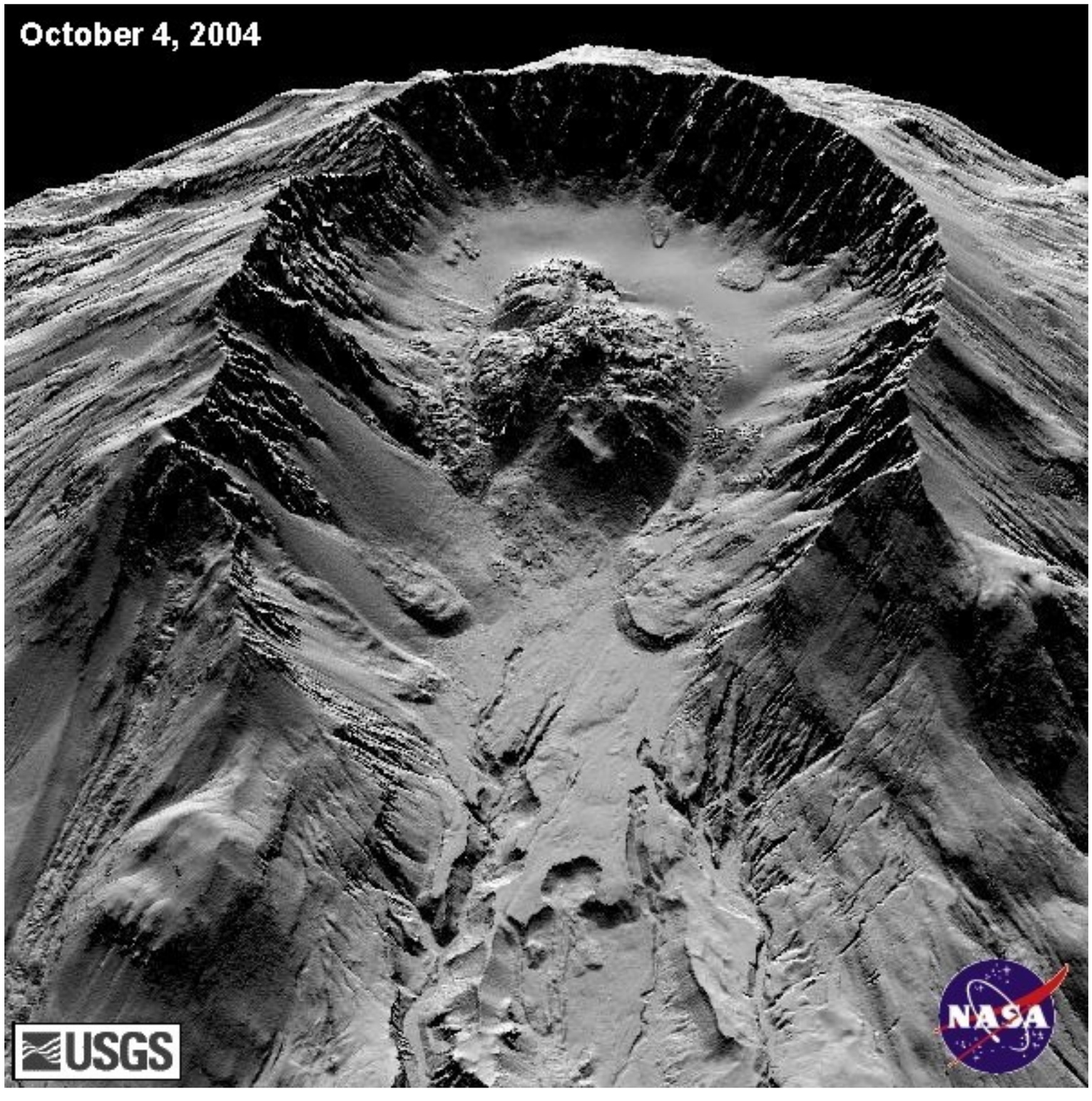

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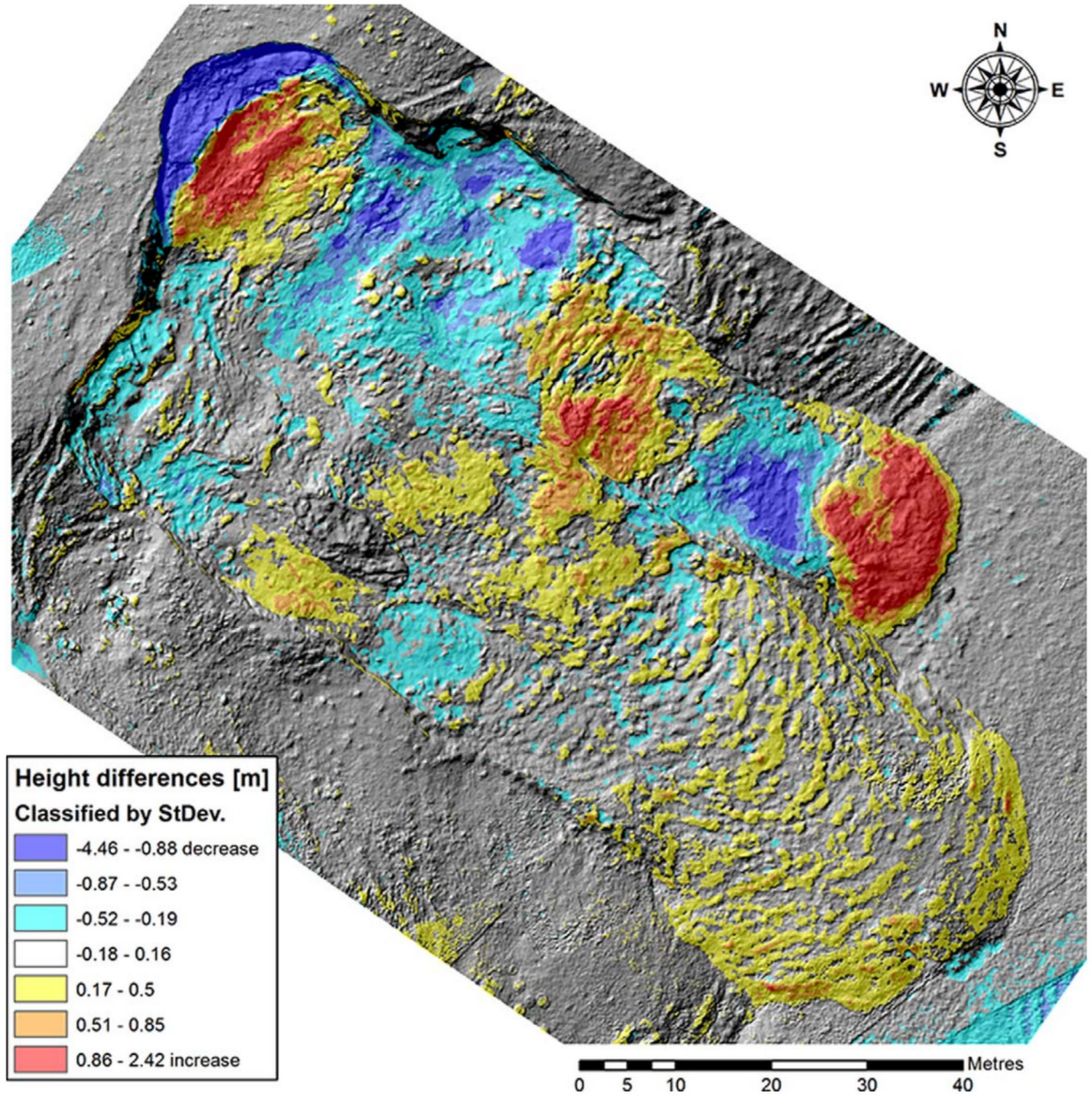
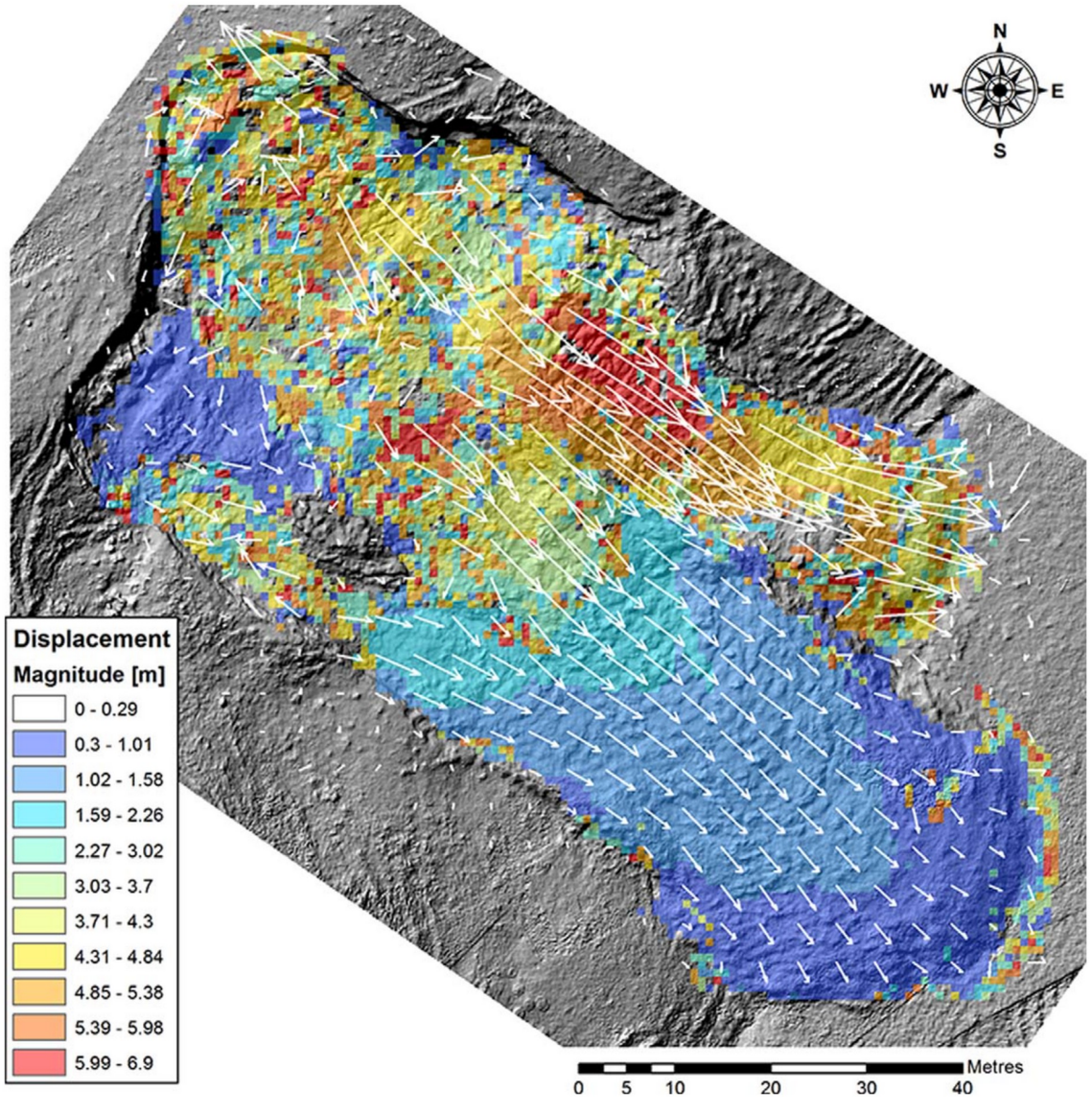
Multi-temporal analysis - displacement





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LIDAR

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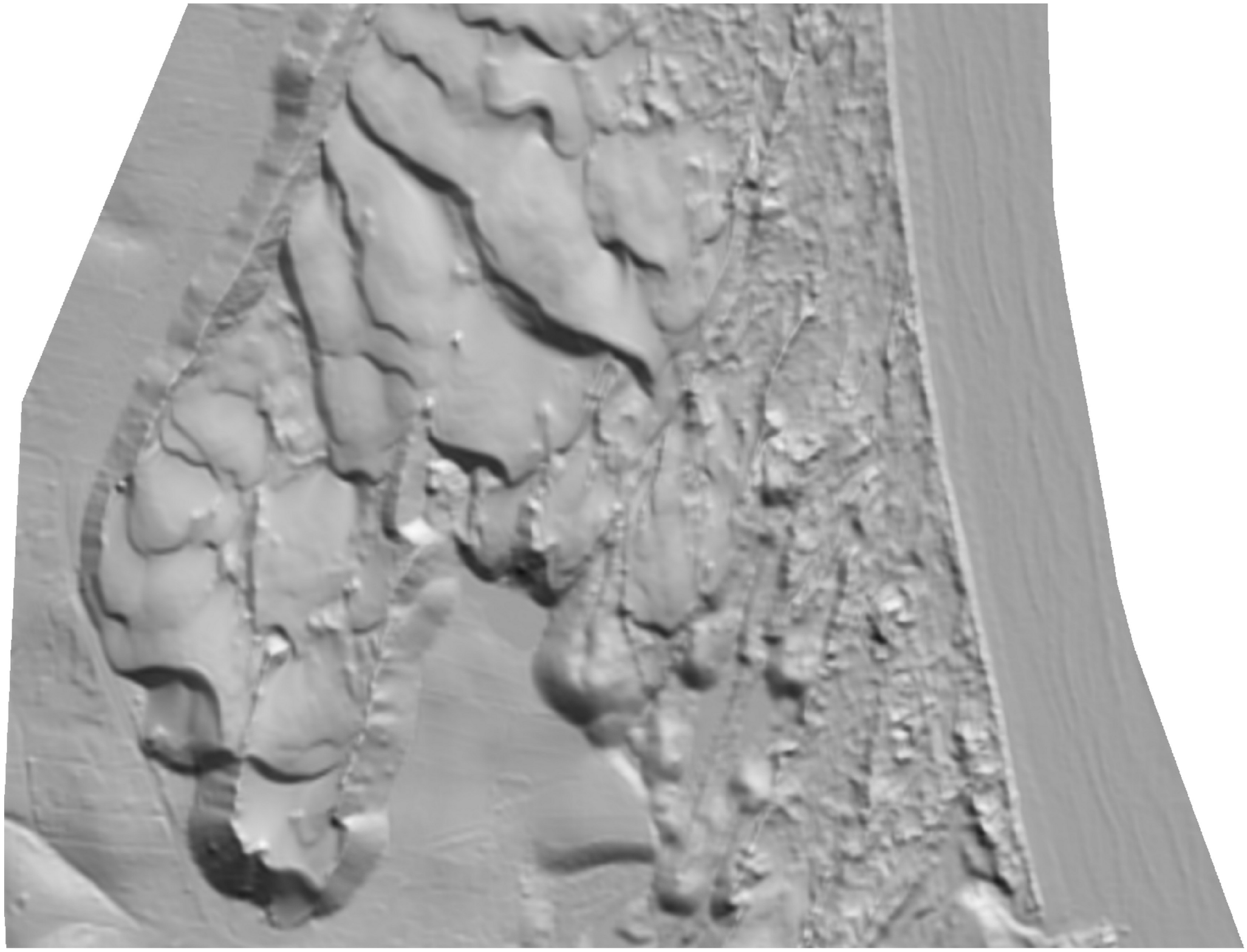

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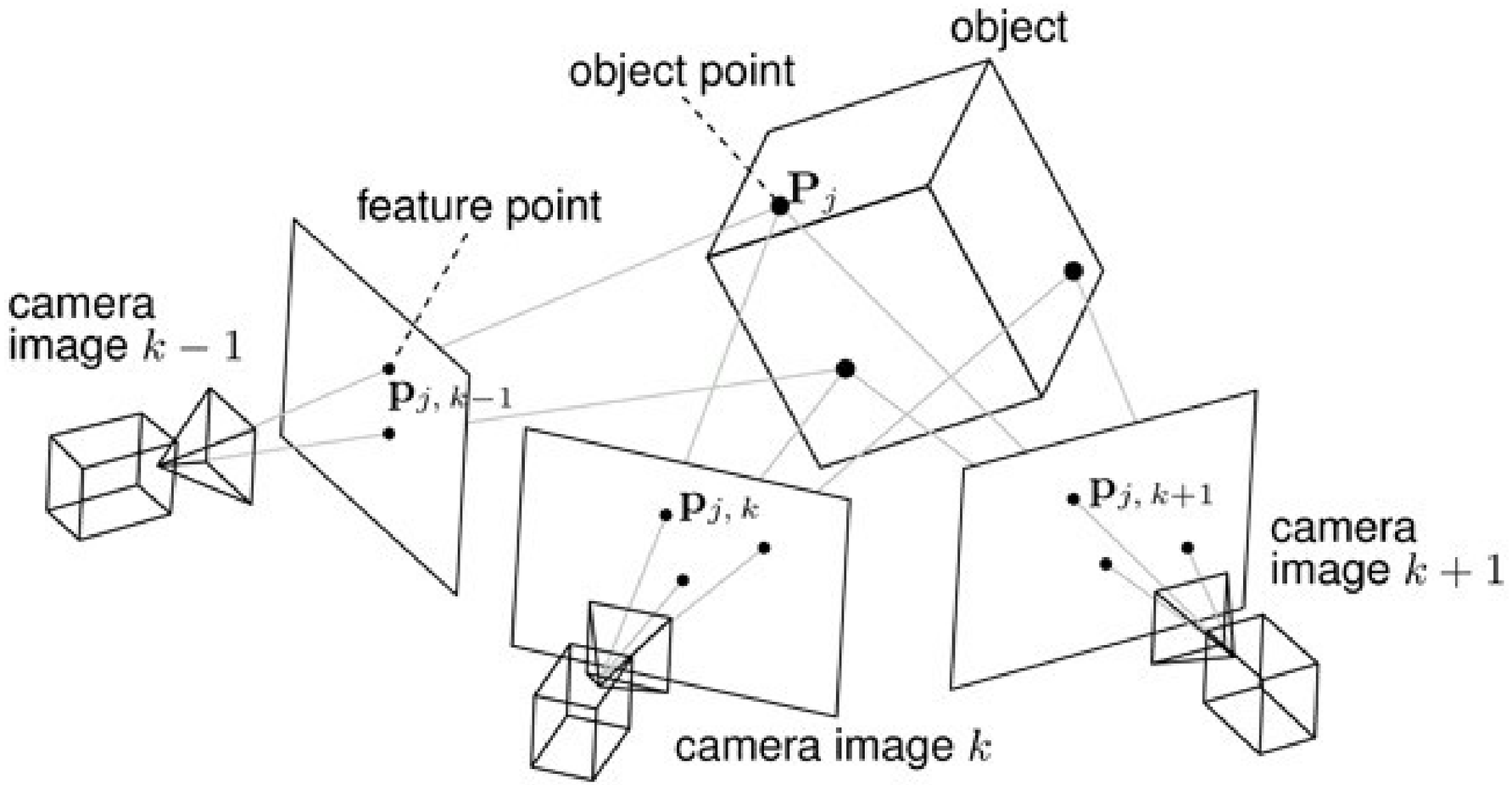
STRUCTURE FROM MOTION - SfM



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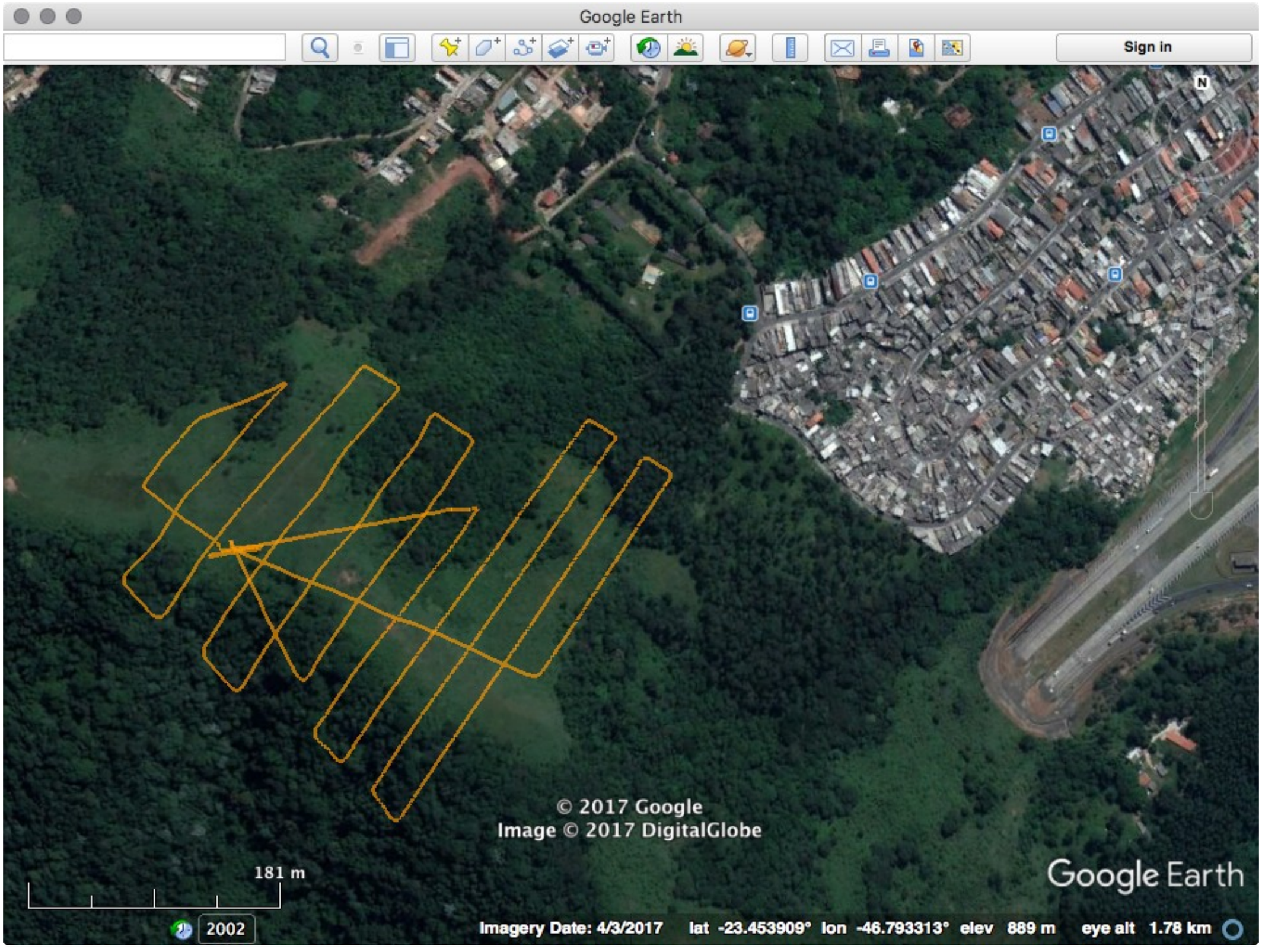

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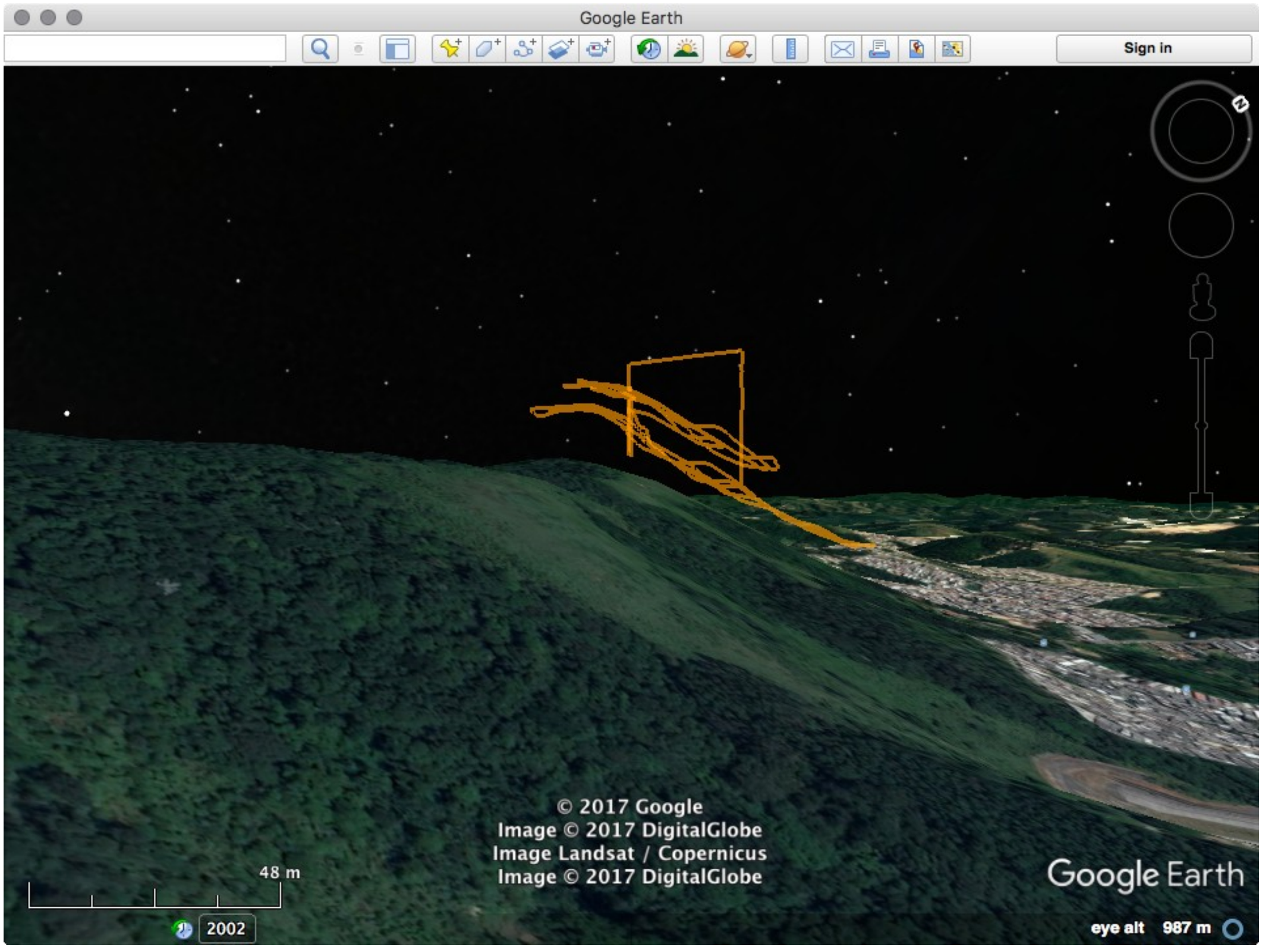

Santos & Grohmann, 2019. Simp.Bras.Sens.Rem.

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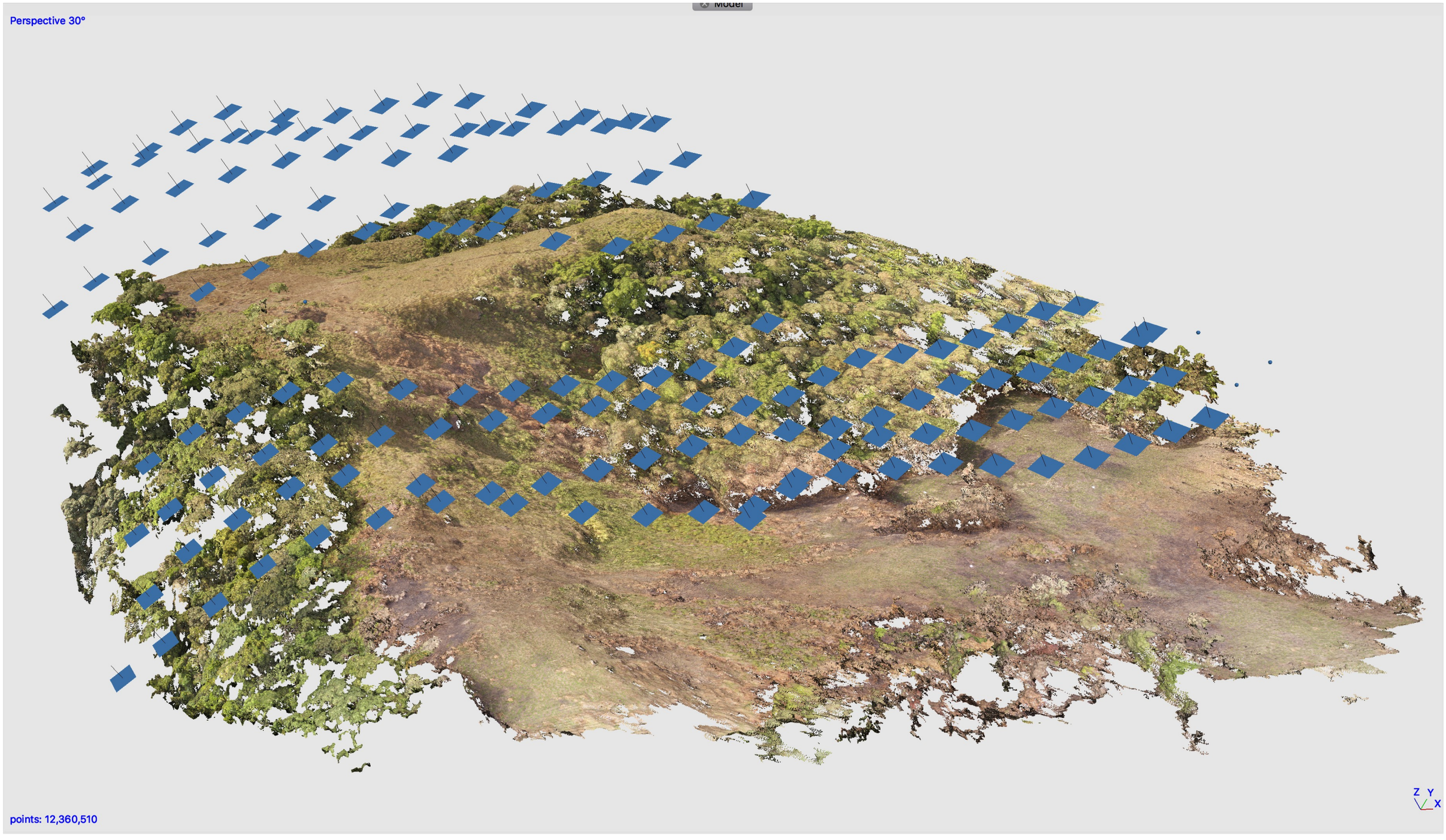

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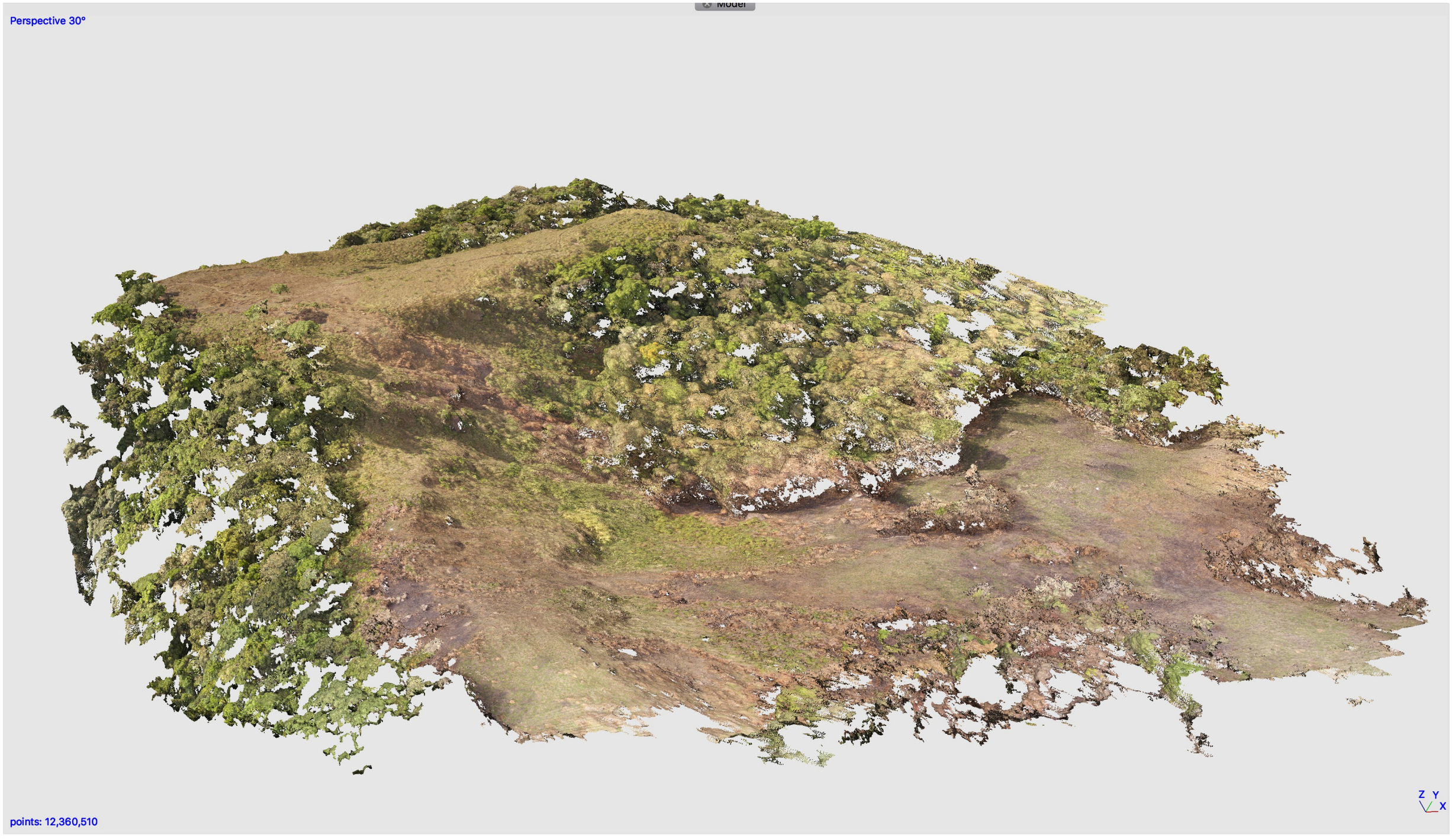

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