Remote Sensing for landslide studies

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28/09/2023

Data used

Data type	Sensor	Spatial resolution	Other parameters
Elevation (DEM)	LiDAR	0.5m	Data validity: 2019 Source: https://www.swisstopo.admin.ch/en/geodata/height/alti3d.html
Sentinel-2 data	Passive RS	10-60m	Spectral resolution:12 bands
ICEYE	Active RS	Not worse than1m	Spotlight (Fine and High) modes

Various goals of this tutorial

Radar Remote Sensing

Task 1: Checking the stability of the rockslide after main event

Task 2: checking wether any rockslide motion was visible in high resolution ICEYE SAR data before main event

Spectral Remote Sensing

Task 3: Object based supervised classification for landslide mapping (2023/06/25)

Task 4: Object based supervised classification for landslide mapping (2023/04/25)

Geomophological analysis of DEM

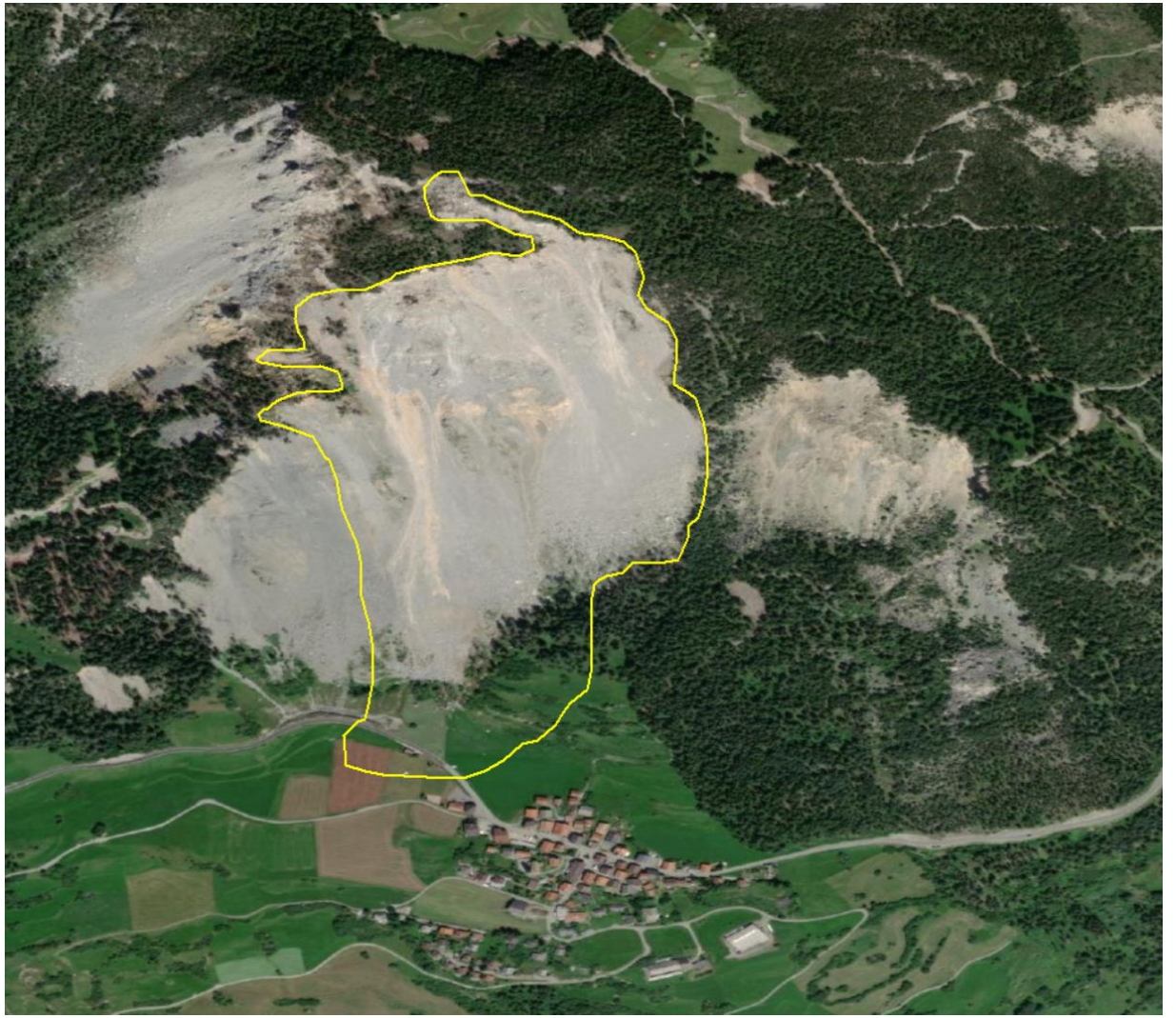
Task 5 : DEM analysis (slope, aspect) and characterization of the slopes and visualisation of all products in 3D

Area of Interest

- Brienz, Switzerland was evacuated in May 2023 due to growing evidence of an imminent rockslide
- On June 15, 2023, the rockslide occurred releasing debris and narrowly missing the village

https://www.youtube.com/watch?v=cvVA5-gHW5o&ab_channel=BBCNews

https://www.youtube.com/watch?v=7pFb2rqj8lU&ab_channel=DWNews



SAR data characterization

Product ID	Date	Product Mode	Incidence angle [°]	Satellite	Orbit type	Ground Resolution (approximately) [m]
SLH2190765	22 May ’23	SpotlightHigh	29.39-29.90	X13	ascending	1
SLH2180750	28 May ’23	SpotlightHigh	29.58-30.09	X13	ascending	1
SLF2391199	22 Jul ’23	SpotlightFine	32.90-33.40	X15	ascending	0.5
SLF2390303	26 Jul ’23	SpotlightFine	32.75-33.25	X15	ascending	0.5

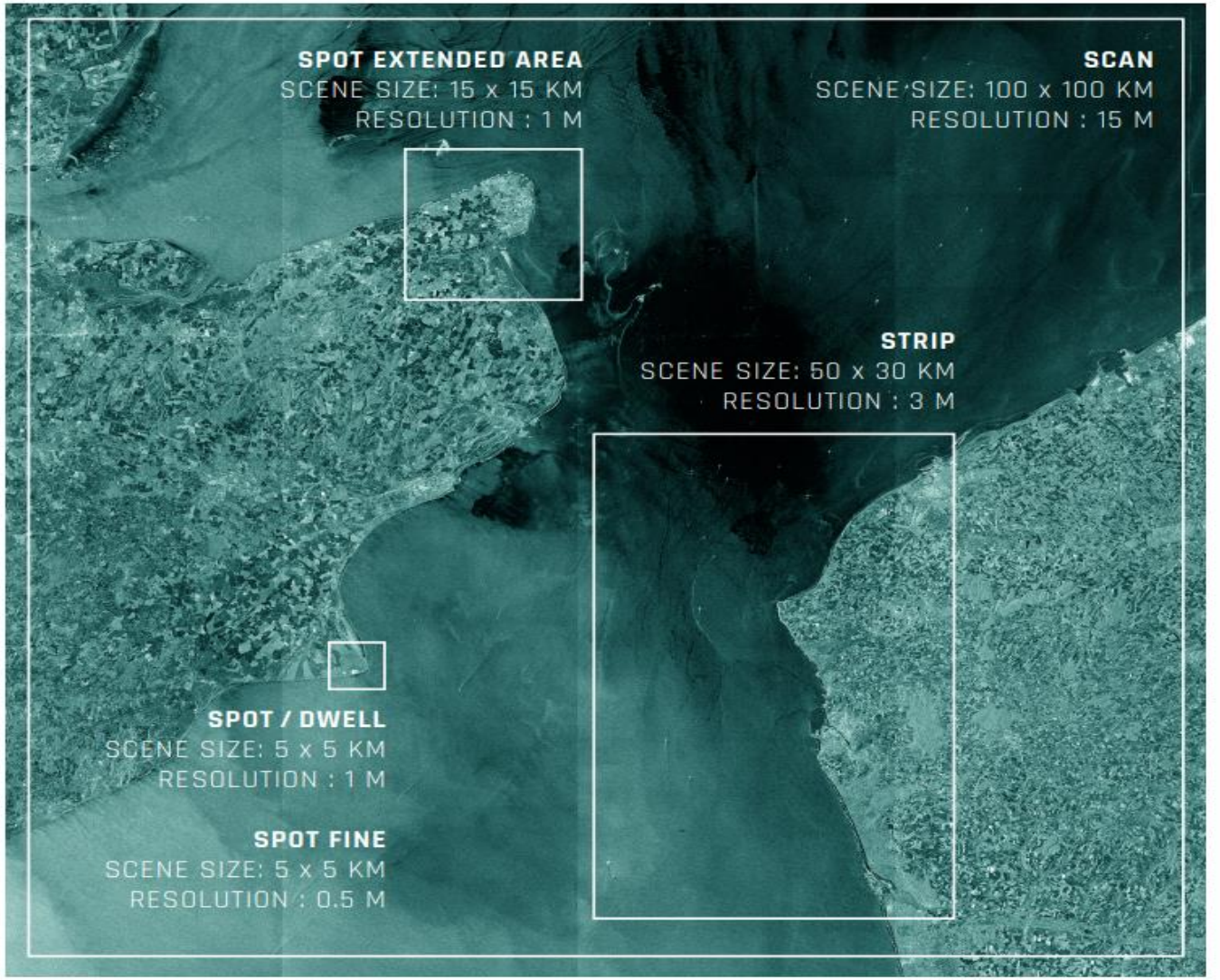
ICEYE product types

ICEYE'S UNIQUE ANTENNA IS AN ELECTRONICALLY-STEERED PHASED ARRAY THAT CAN BE CONTROLLED TO ENABLE A RANGE OF IMAGING MODES FOR DEMANDING OPERATIONAL NEEDS.

ICEYE SAR IMAGING MODES:

UP TO 50 CM RESOLUTION.

UP TO 50.000 KM² SCENE SIZE.

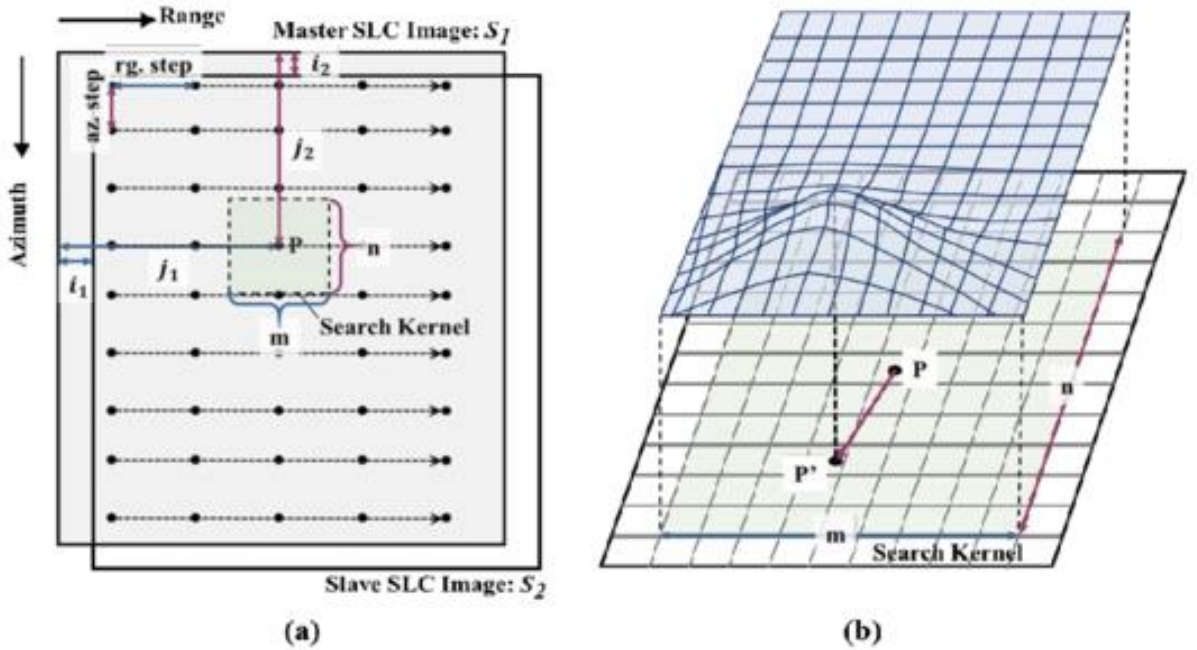


Source: https://sar.iceye.com/5.2.0/

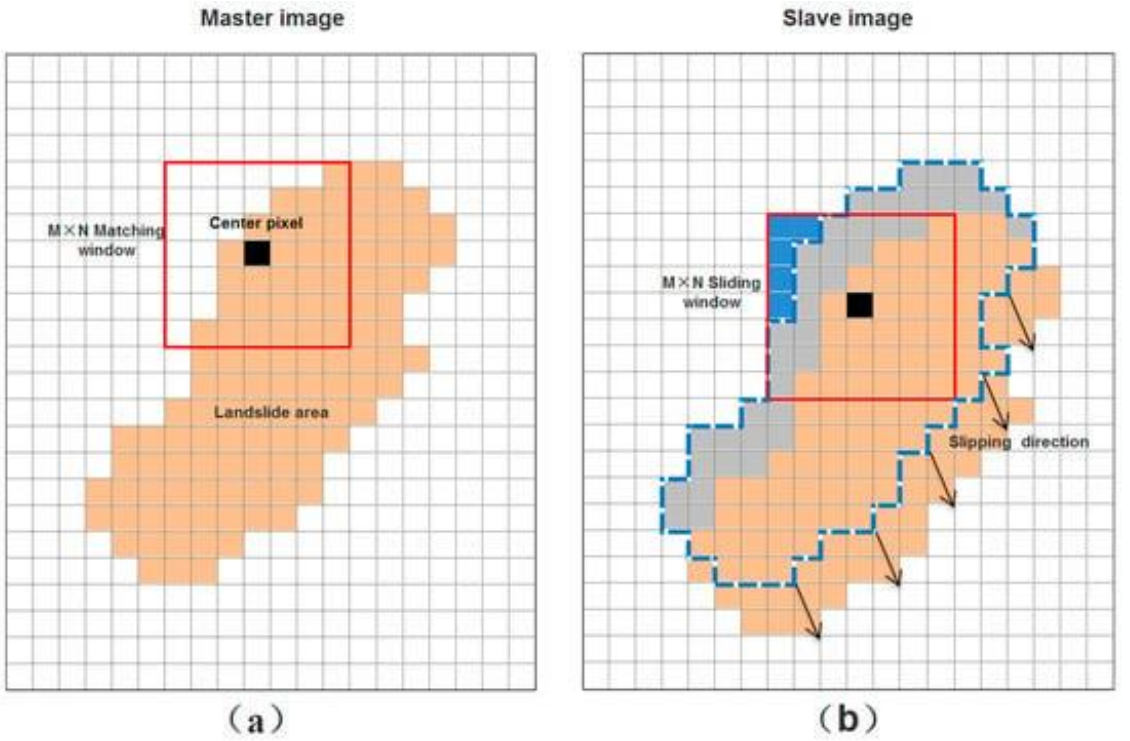
Iceye processing steps in SNAP

1. Radiometric calibration
2. Coregistration **time consuming proces*
3. Offset tracking **time consuming process*
4. Speckle filtering
5. Multilooking
6. Geocoding/Range Doppler Terrain Correction

Schematic diagram of the SAR offset tracking

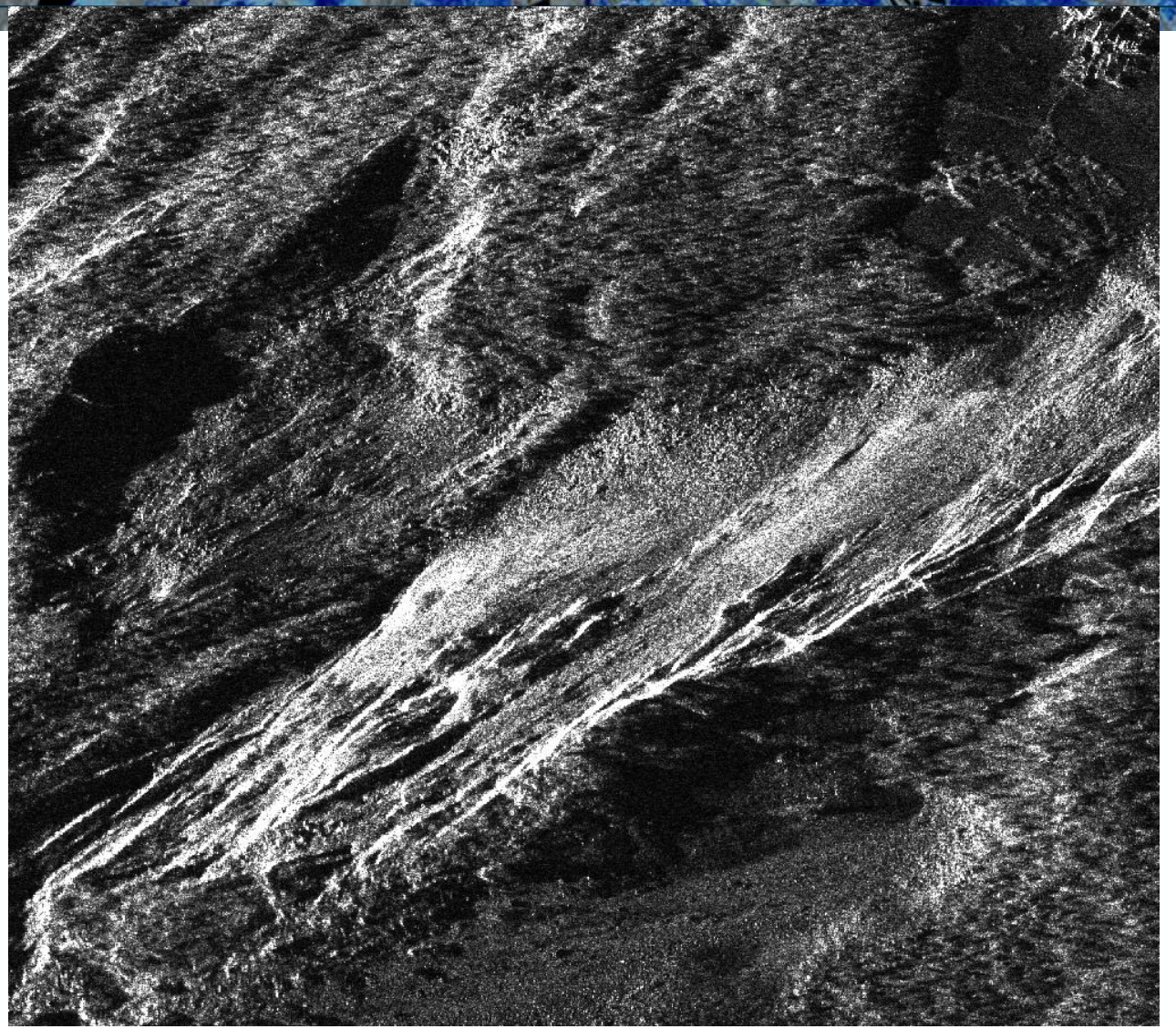


source: Chae, et al., 2019



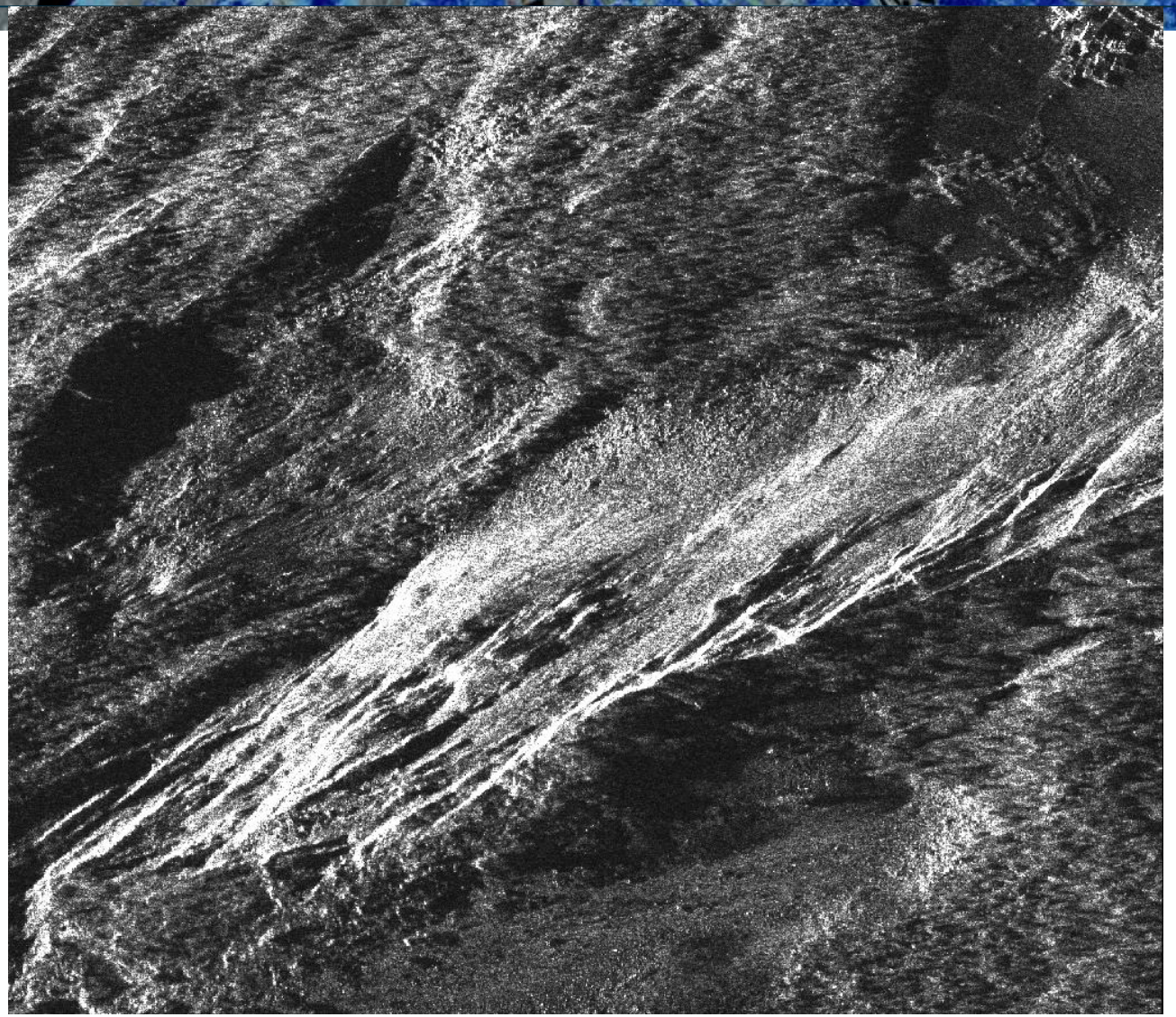
source: Cai et al., (2017)

ICEYE 2023/05/22



1. The movement of the rocks could be observed even a month before the rockslide occurred

ICEYE 2023/05/28



1. The movement of the rocks could be observed even a month before the rockslide occurred

ICEYE 2023/07/22

2. Significant debris release continues, more than a month after the initial rockslide

ICEYE 2023/07/26

2. Significant debris release continues, more than a month after the initial rockslide

Sentinel-2 data specification

Band	Central wavelenght (µm)	Resolution (m)
B1- Coastal Aerosol	0.443	60
B2-Blue	0.490	10
B3-Green	0.560	10
B4- Red	0.665	10
B5- Red Edge1	0.705	20
B6- Red Edge 2	0.740	20
B7-Red Edge 3	0.783	20
B8-NIR	0.842	10
B8A-Narrow NIR	0.865	20
B9-Water Vapor	0.945	60
B10-SWIR Cirrus	1.375	60
B11-SWIR1	1.610	20
B12-SWIR2	2.190	20

Mapping rockslides using spectral RS in ArcMap

1. Calculation of the spectra indices

BSI = ((B11 + B04) - (B08 + B02)) / ((B11 + B04) + (B08 + B02))

NDVI = (B04-B08) / (B04+B8)

*Resample
*Raster Calculator

*check the values extent between the bands which are planned to be merged (/1000

2. Merging spectral indices into one raster (ndvi, bsi, band8)
3. Segmentation
4. Training samples preparation
5. Training Random Trees classifier
6. Classify composite raster
7. Reclassify raster
8. Raster to shapefile conversion
9. Manual editing

*Composite bands

*Mean Shift segmentation

*Train Ranom Trees classifier

*Classify raster

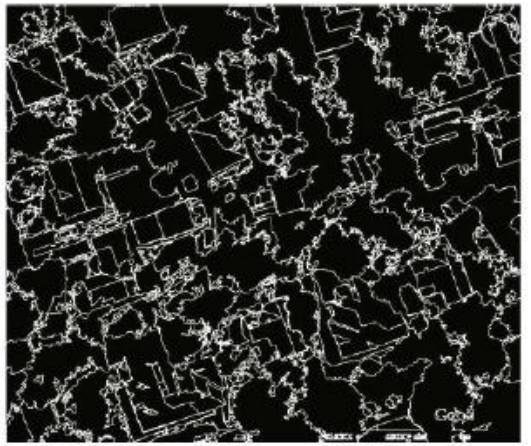
*Reclassify

Mean Shift segmentation

Original Satellite Imagery

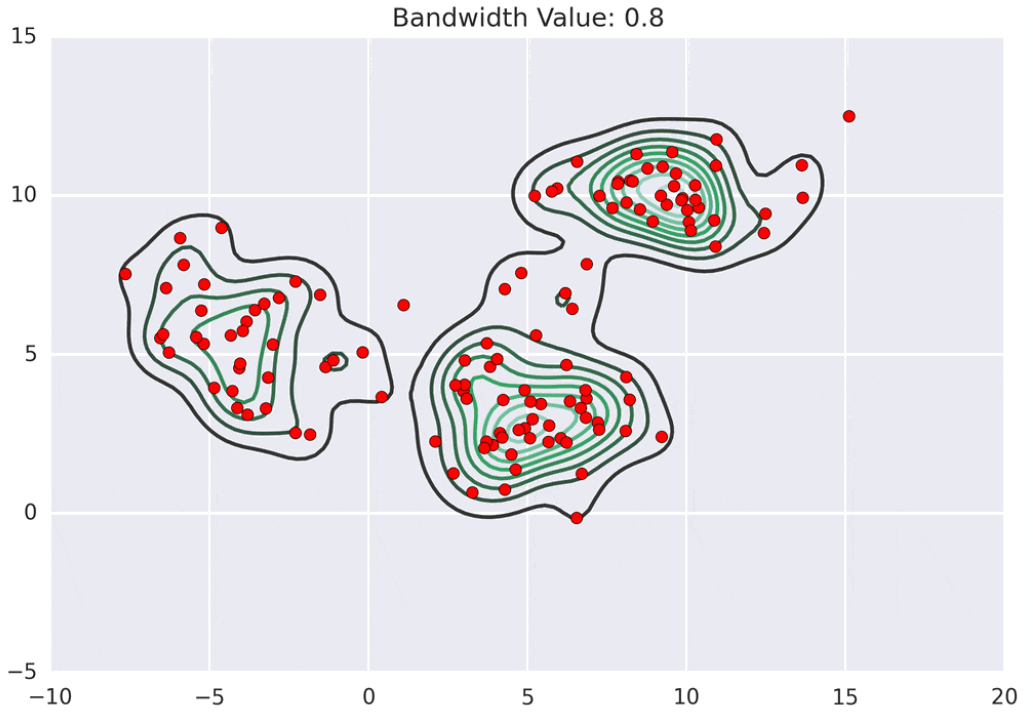
Mean Shift Clustered Imagery

Mean Shift Labelled Imagery



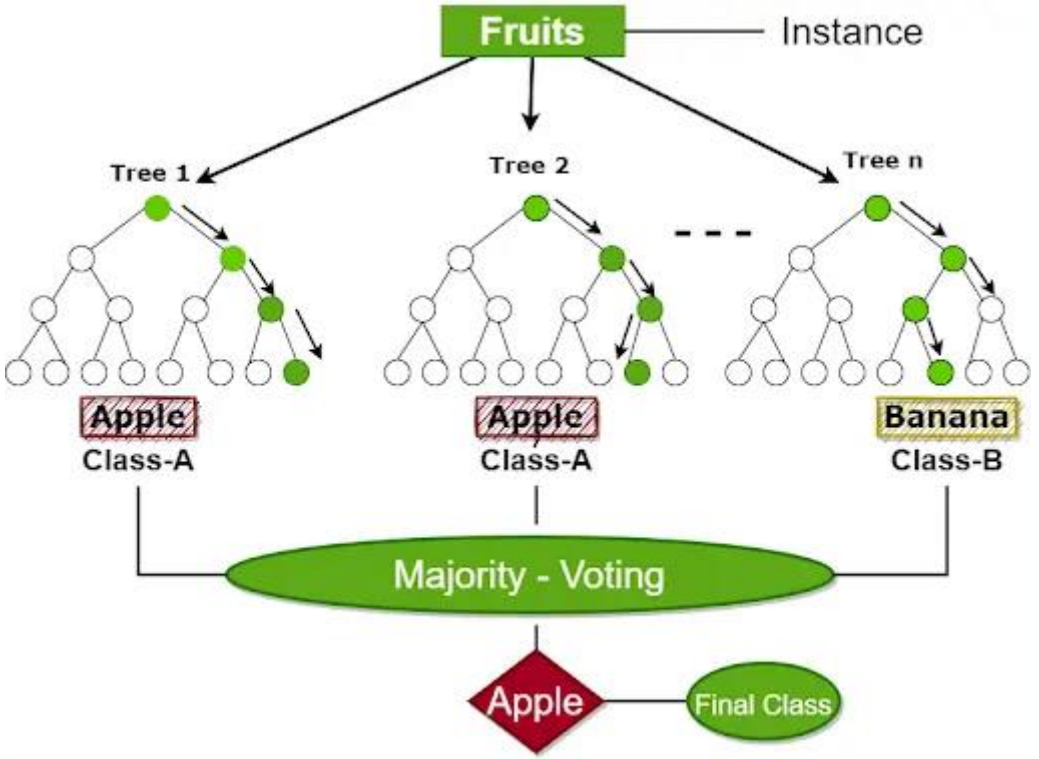
Mean Shift Segmentation Boundaries

Source: Zou and Lin, 2013



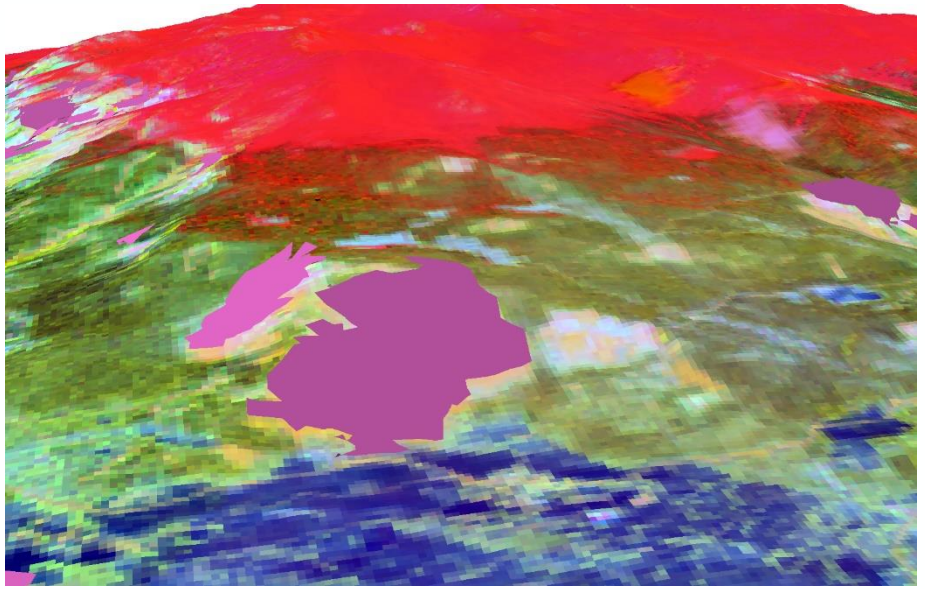
Source: https://analyticsindiamag.com/hands-on-tutorial-on-mean-shift-clustering-algorithm/

Random Trees classifier

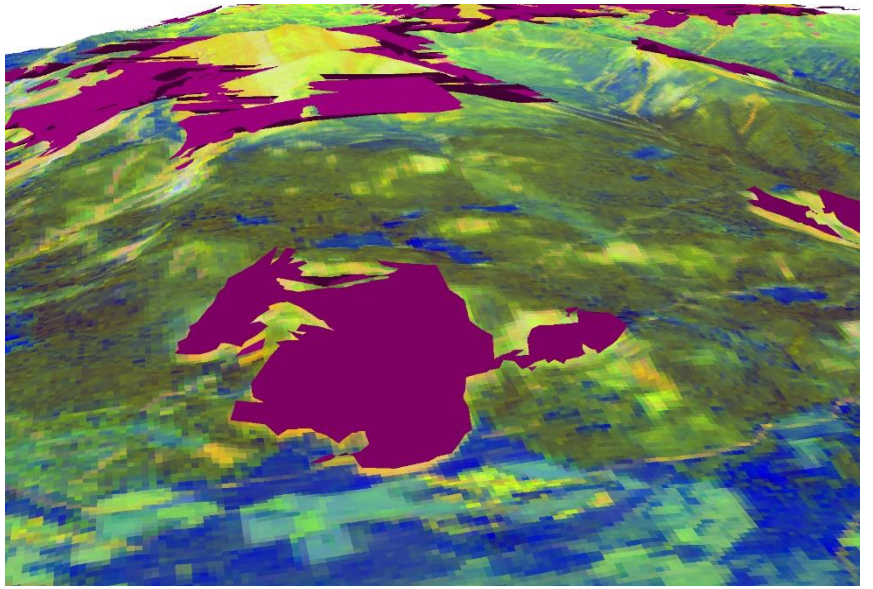


Source: https://www.turing.com/kb/random-forest-algorithm

Rockslides mapped automatically



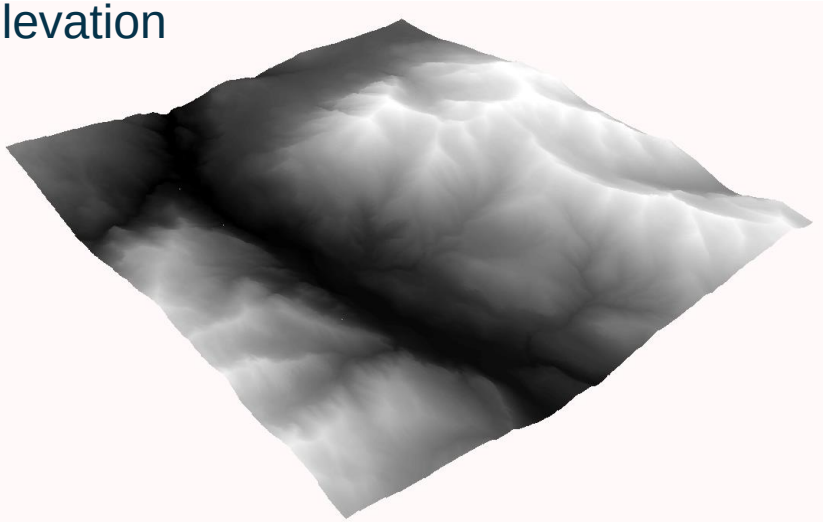
Landslide automatically mapped for the time 2023/04/25



Landslide automatically mapped for the time 2023/06/25

Goal 3: Slope characterization based on topography

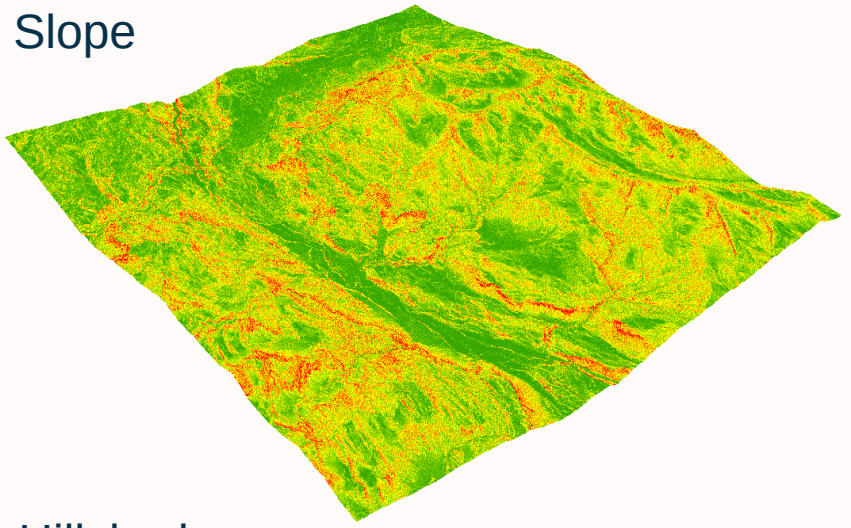
Elevation



High : 2979,76

Low : 822,485

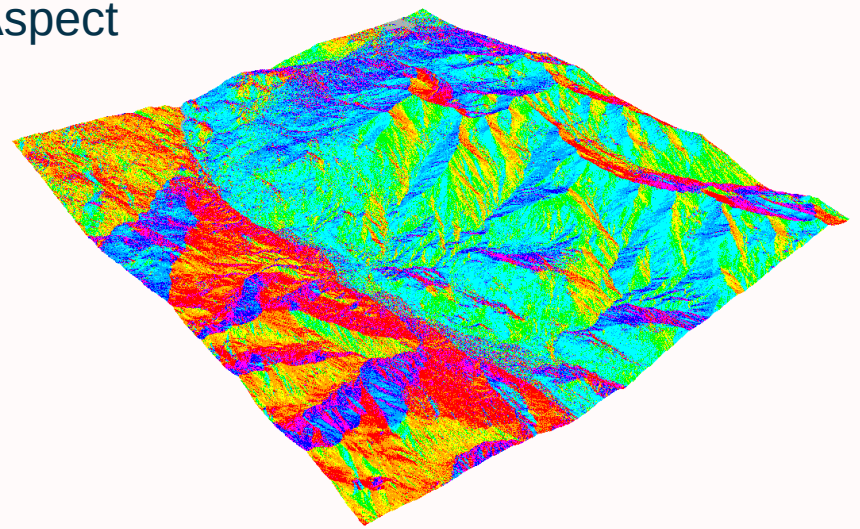
Slope



High : 88,4354

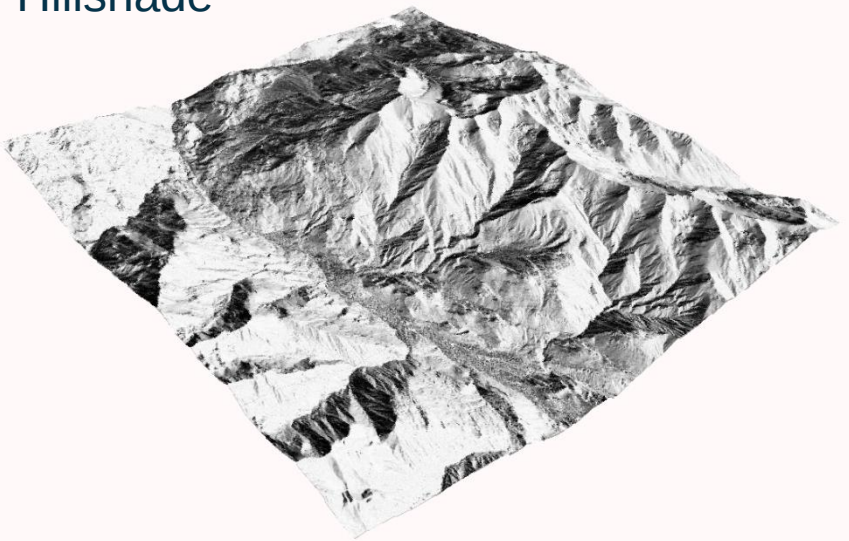
Low : 0

Aspect



Flat (-1)
North (0-22.5)
Northeast (22.5-67.5)
East (67.5-112.5)
Southeast (112.5-157.5)
South (157.5-202.5)
Southwest (202.5-247.5)
West (247.5-292.5)
Northwest (292.5-337.5)
North (337.5-360)

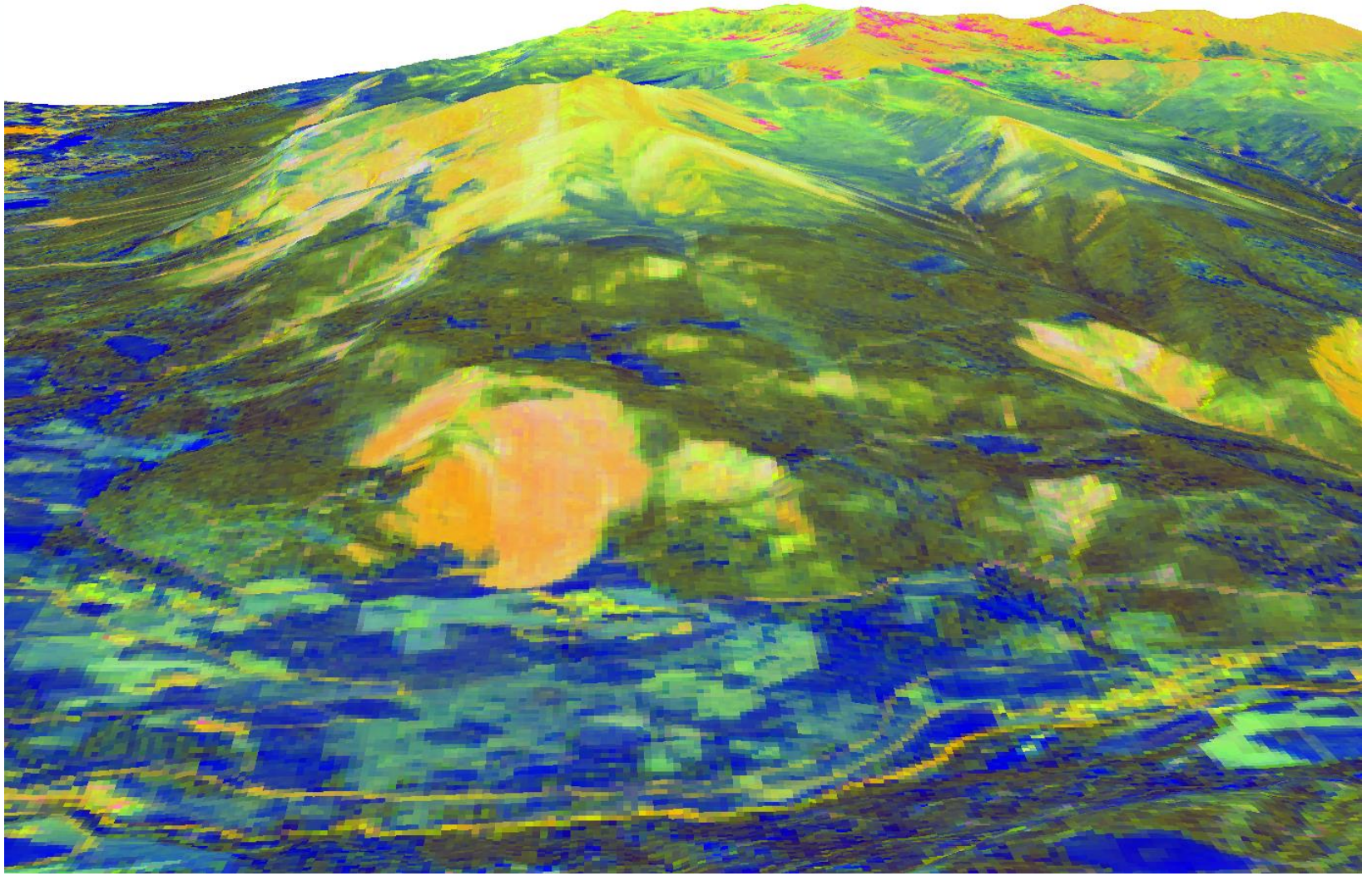
Hillshade



High : 764

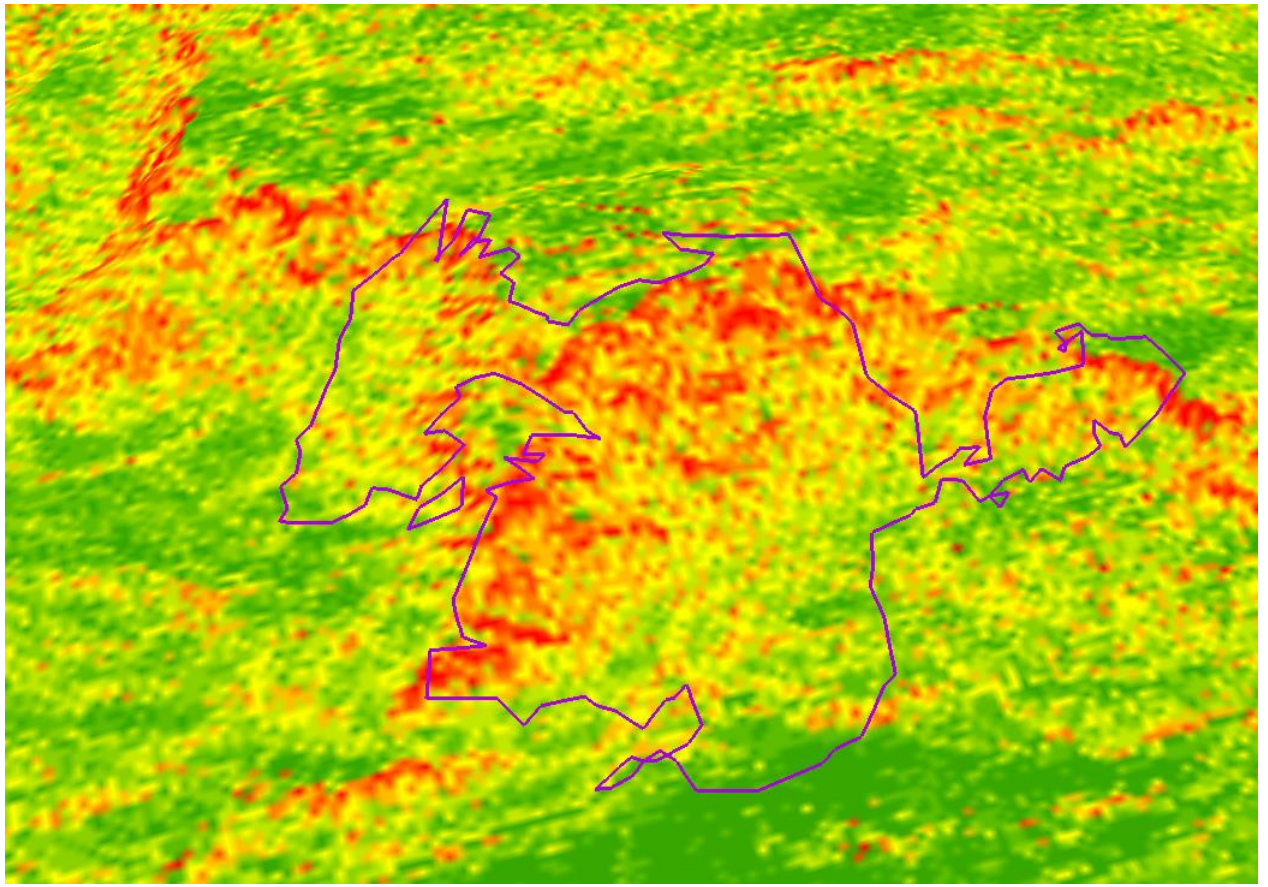
Low : 155

Goal 4: Products visulisatino in 3D- valuable for interpretation



RGB Composition
of
R: NDVI
G: BSI
B: B08/10000

Visualisation of all products in 3D in ArcScene



Cai, J., Wang, C., Mao, X., & Wang, Q. (2017). An adaptive offset tracking method with SAR images for landslide displacement monitoring. *Remote Sensing*, *9*(8), 830.

Chae, S. H., Lee, W. J., Baek, W. K., & Jung, H. S. (2019). An improvement of the performance of SAR offset tracking approach to measure optimal surface displacements. *IEEE Access*, *7*, 131627-131637.

Iceye Product Documentation: https://sar.iceye.com/5.2.0/

Zou, Z., & Lin, X. (2013). Geoinformatics production for urban disasters risk reduction: A zero cost solution. In *Geo-Informatics in Resource Management and Sustainable Ecosystem: International Symposium, GRMSE 2013, Wuhan, China, November 8-10, 2013, Proceedings, Part I* (pp. 313-324). Berlin, Heidelberg: Springer Berlin Heidelberg.

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