PHOTOGRAMMETRY IN ENGINEERING GEOLOGY, THEORY, METHODS AND EXAMPLES

Freddy Yugsi
Engineering Geologist, Sweco Norge

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Freddy Yugsi

Engineering Geologist at Sweco

Trondheim, Sør-Trøndelag, Norway ·

Education

Eidgenössische Technische Hochschule Zürich
PhD, Engineering Geology
2006 – 2010

Experience

Sweco
4 yrs 10 mos

Engineering Geologist
Full-time
Jan 2019 – Present · 1 yr 3 mos
Trondheim Area, Norway

Geotechnical Engineer
Jun 2015 – Present · 4 yrs 10 mos
Trondheim Area, Norway

Researcher
Geological Survey of Norway
Aug 2011 – Jun 2015 · 3 yrs 11 mos
Trondheim Area, Norway

Natural Hazards Division, Landslides Department

Postdoc
Norwegian Geotechnical Institute (NGI)
Jan 2011 – Aug 2011 · 8 mos

Outline

- Introduction
- Image based 3D modelling
- Classic Aerial Photogrammetry
- UAV Photogrammetry
- Necessary equipment
- Rock mass characterization: Automatic registration (Coltop) vs. Semi-automatic registration (Shapemetrix)
- Model comparison and volume calculation

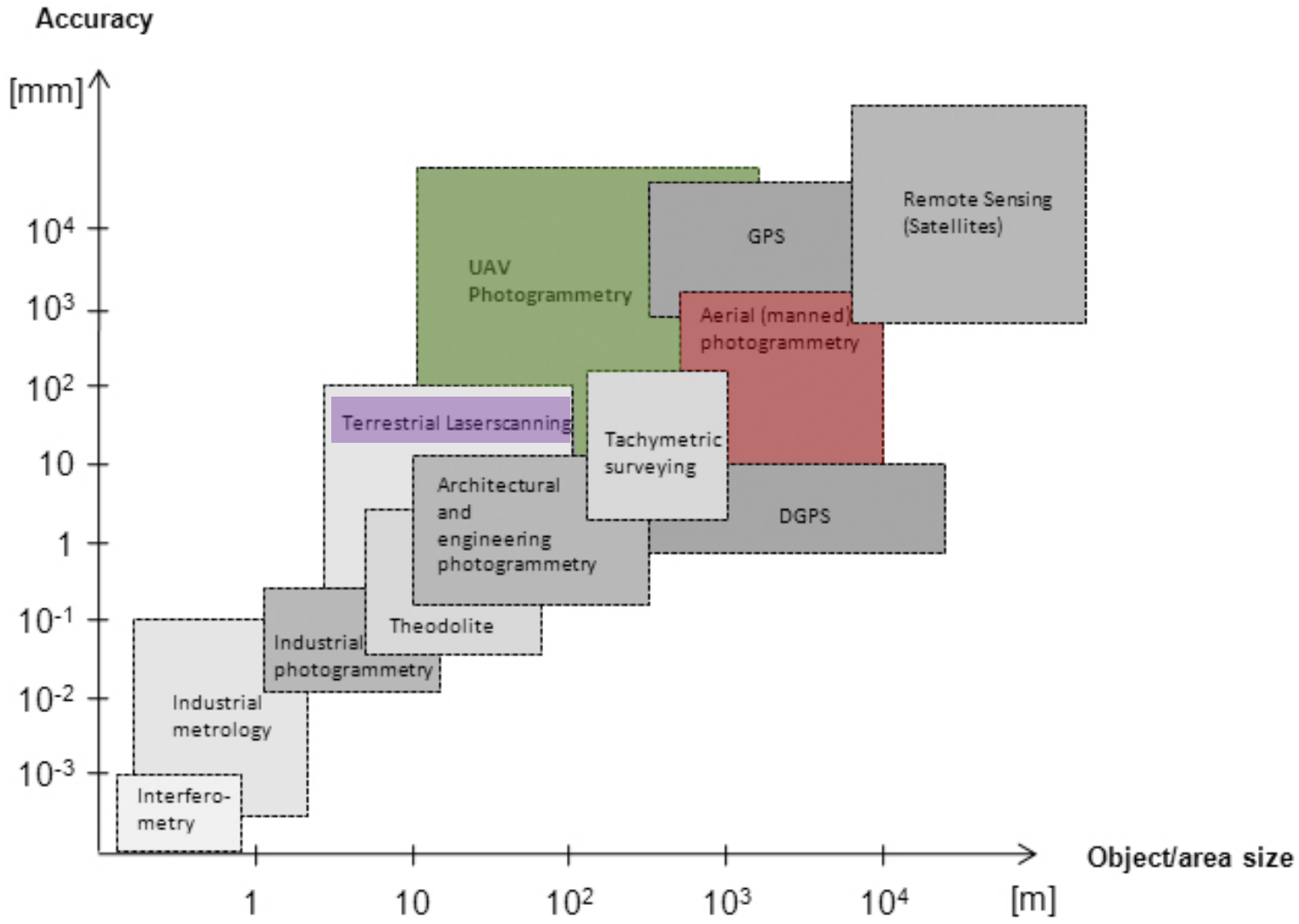
Introduction

- Based on image matching and triangulation
- Produces Digital Elevation Models, Orthophotos, Textured 3D Objects
- Wide use and applications from regional studies (e.g. inventories) to detailed mapping (e.g. rock mass characterization)
- Allows multi-temporal analysis of large areas
- Products are easy to integrate with other datasets using GIS/CAD
- Robust commercial and open source software

Introduction

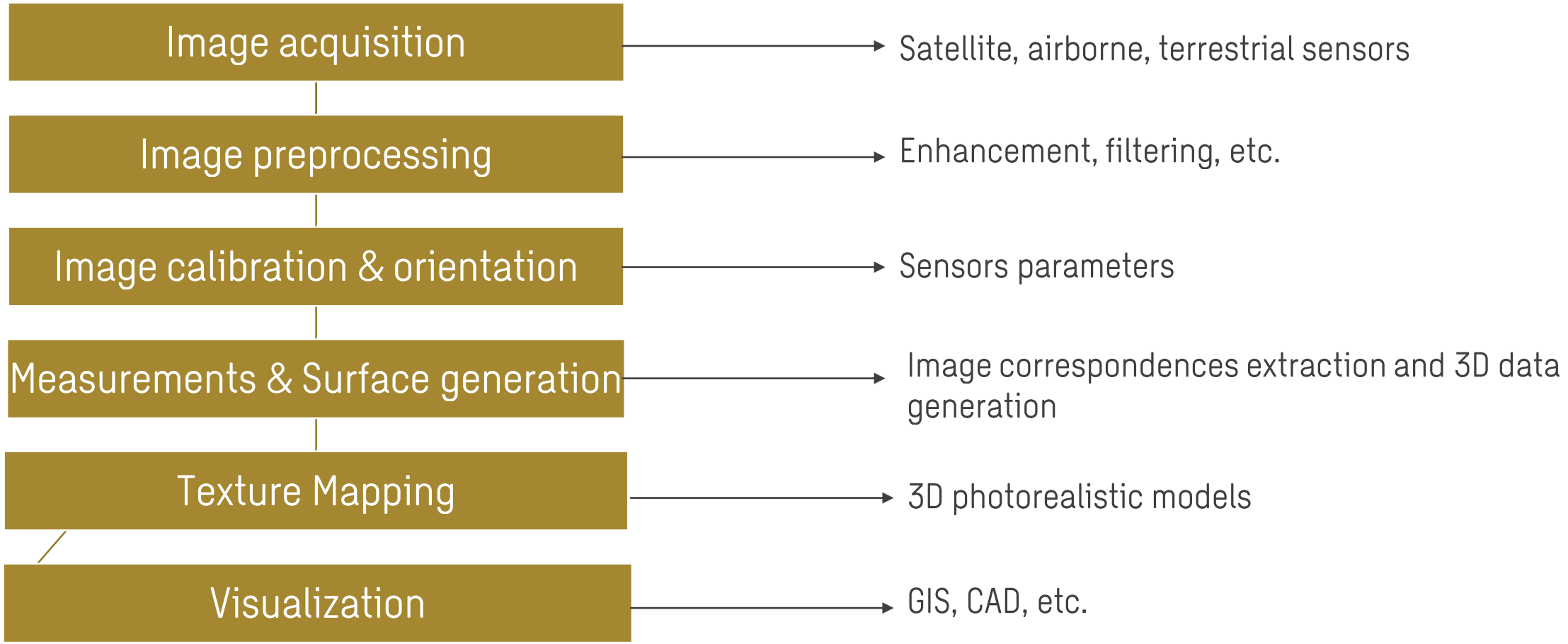
- The use of optical imagery is a standard technique for several applications on detection, characterization and monitoring

- Two scales:
  - Regional analysis (aerial-based)
  - Local analysis (close range)



Eisenbeiss, 2009

Image-based 3D modelling

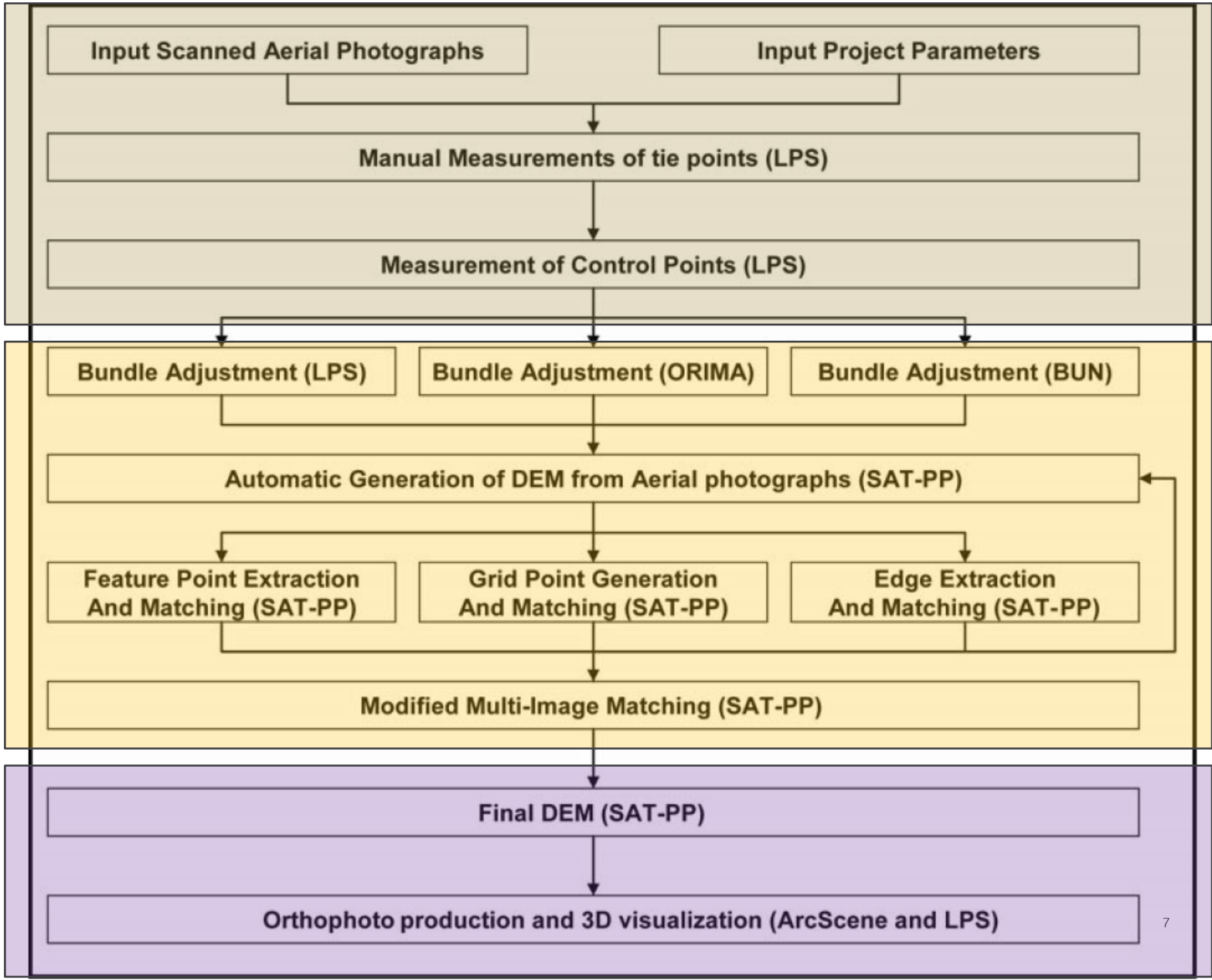


Aerial Photogrammetry

Three software packages used:
- LPS (LeicaPhotogrammetry Suite)
- BUN
- SAT-PP (Satellite Imagery Precision Processing)

Processing includes:
- Project definition
- Interior orientation computation
- Measurement of tie and control points
- Bundle adjustment
- Image triangulation
- Absolute orientation
- DSM generation
- Orthophoto production.

Yugsi et al., 2006



Aerial Photogrammetry

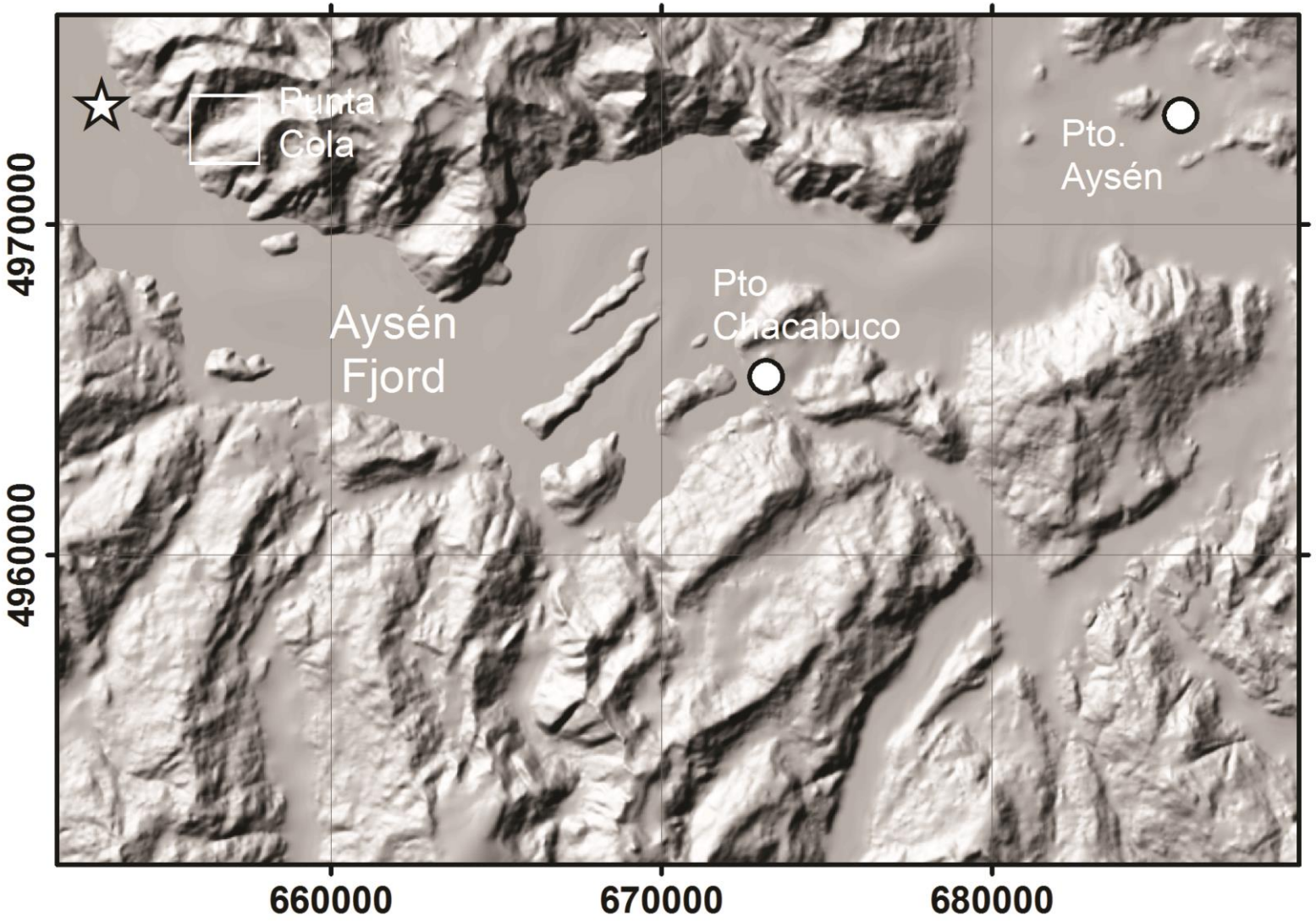
Puerto Aysén, Southern Chile

11 panchromatic aerial photographs (1998).

Georeferencing used 10 dGPS points collected in January 2011.

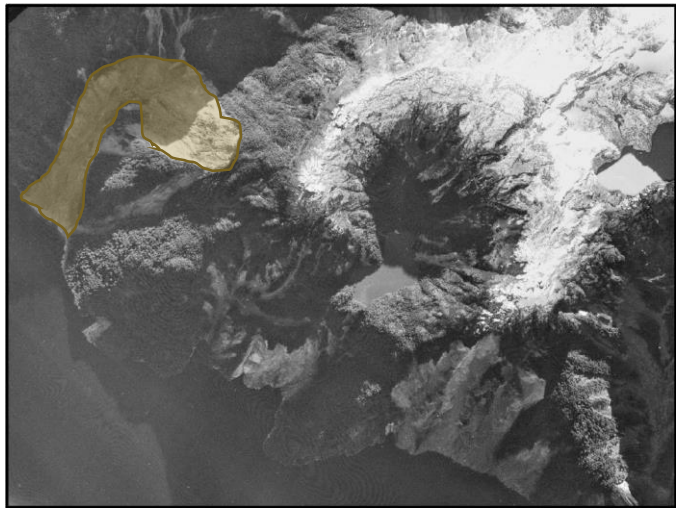
Area: 550 km^2

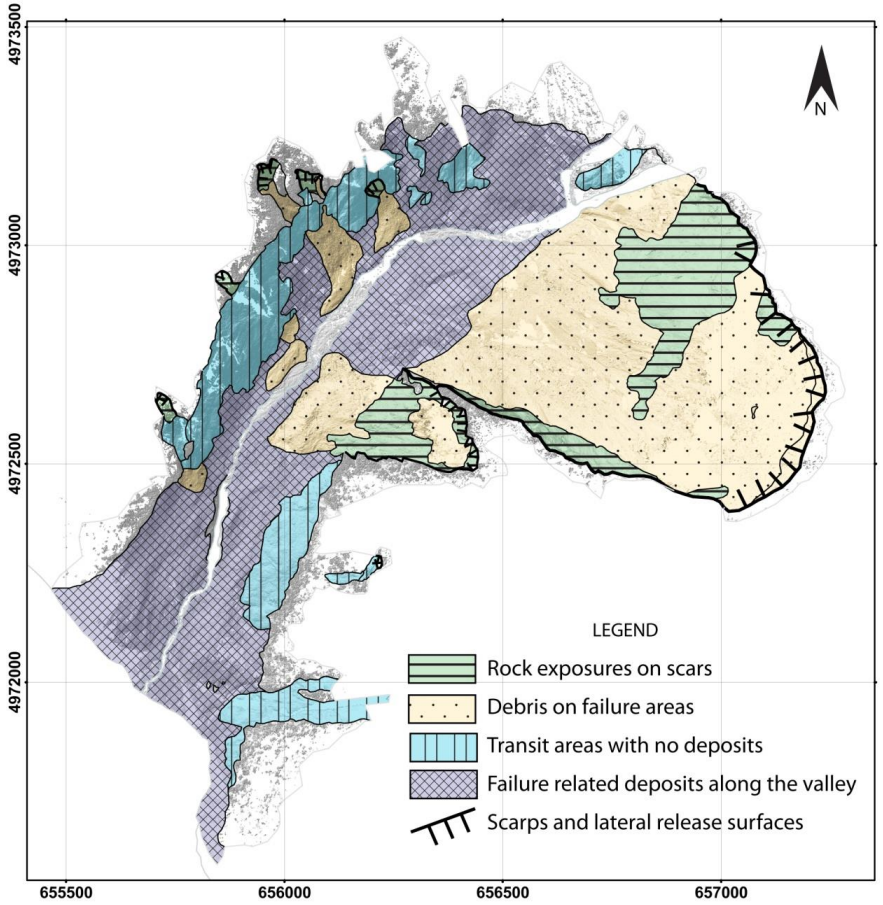
Pixel resolution: 7 m



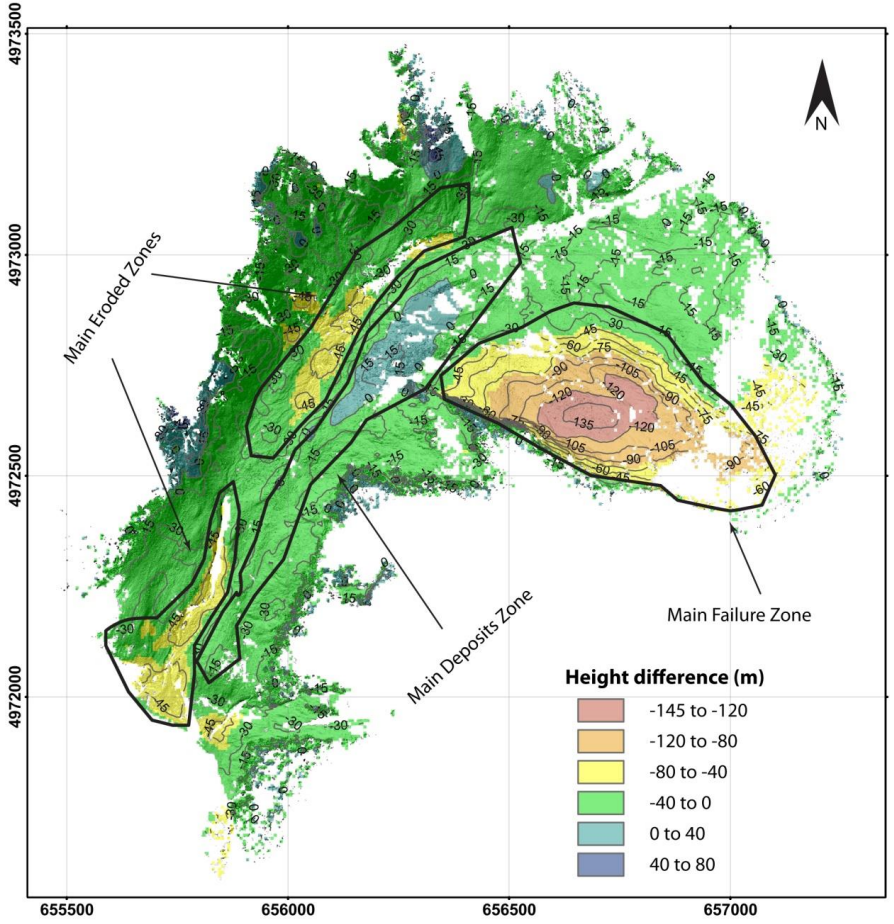
Yugsi et al., 2011

The Punta Cola Rockslide, Chile





Yugsi et al., 2011

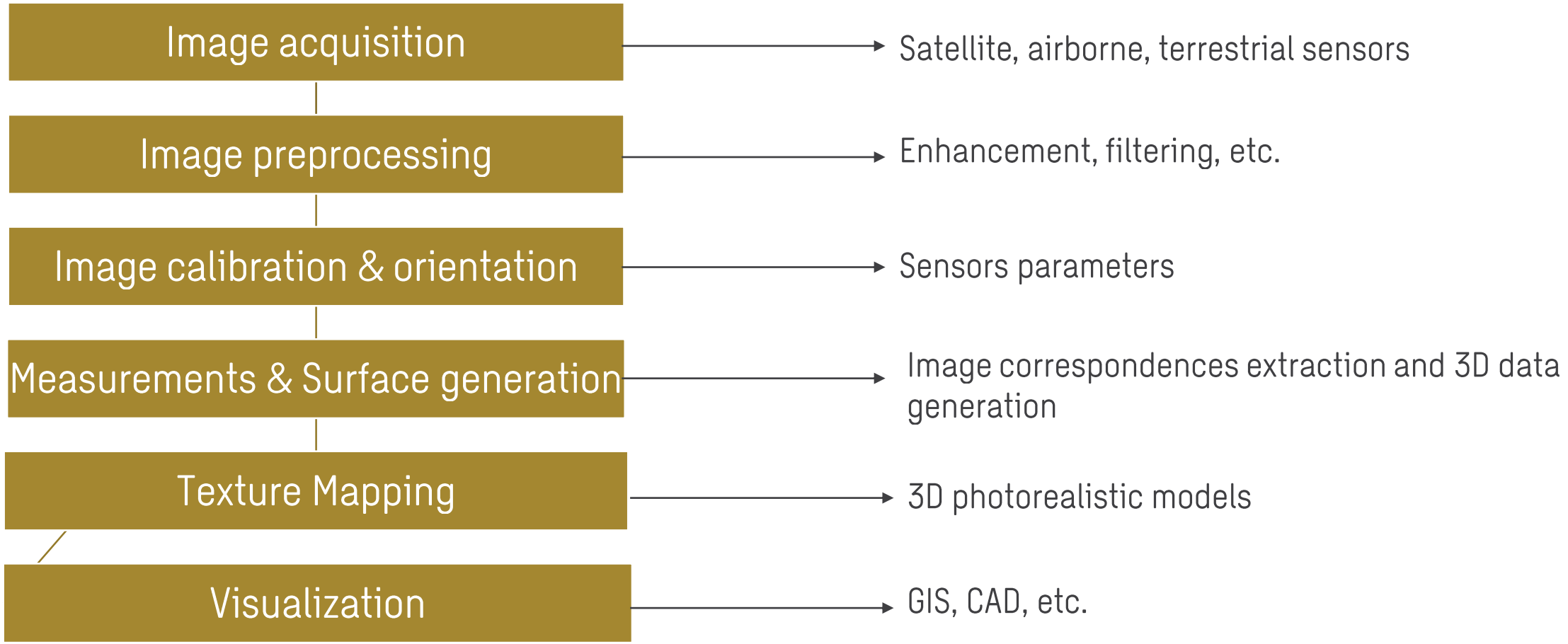


Orthophoto shows a retreat of the shoreline of about 100 m.

Higher erosion on west flank of the valley.

Part of the rock debris deposited close to the source.

Image-based 3D modelling



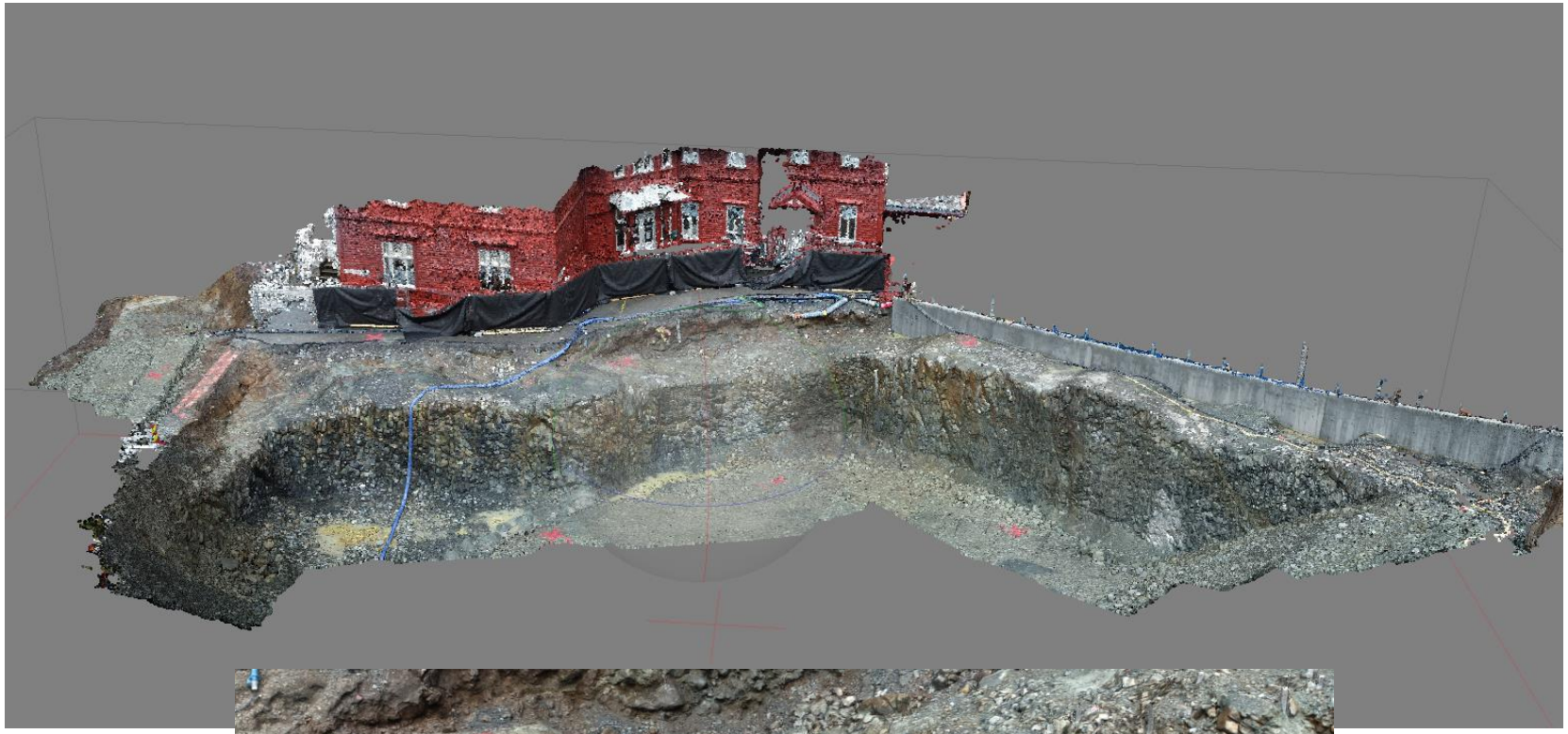
UAV Photogrammetry

One program used:

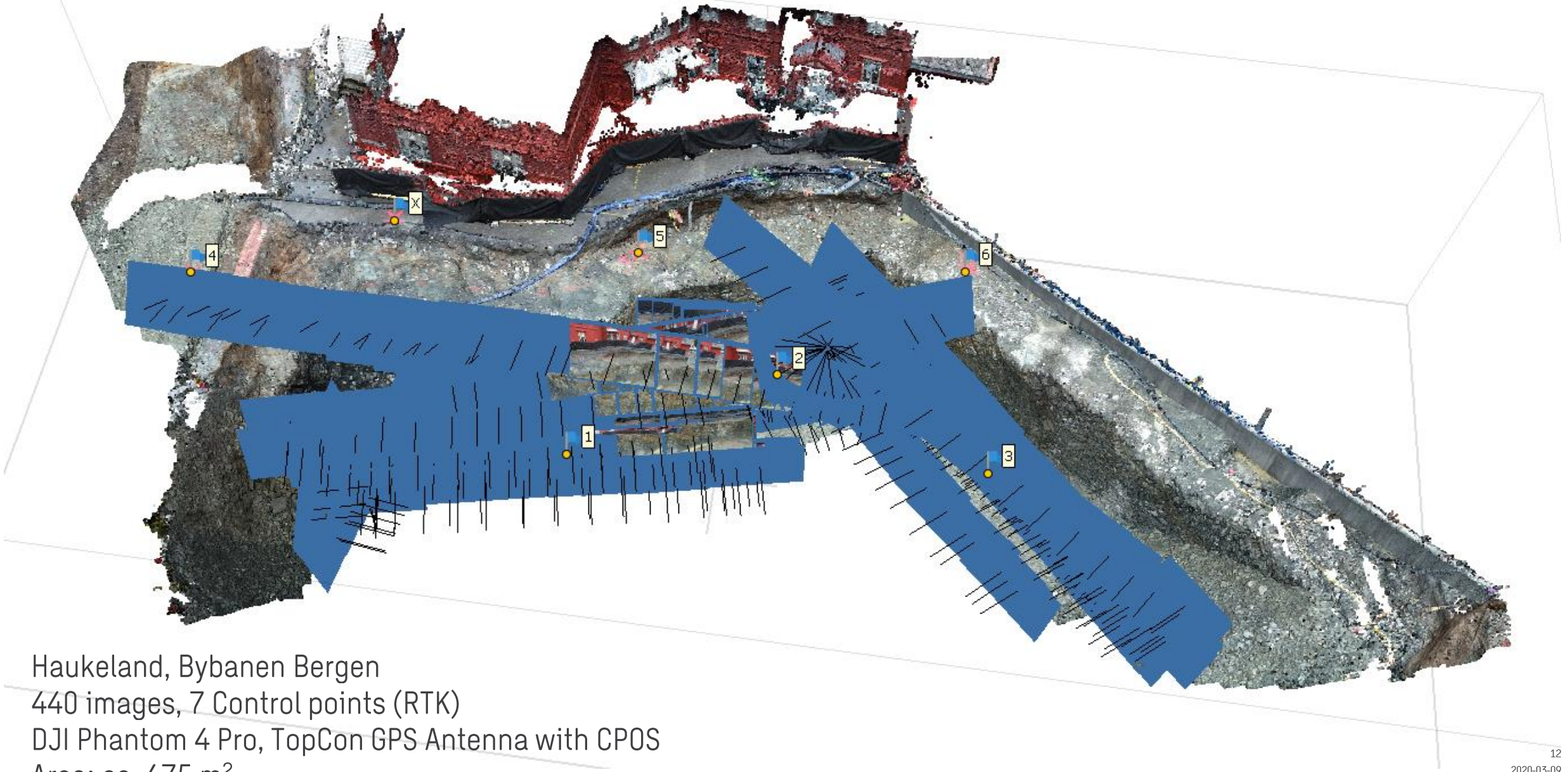
- Agisoft Metashape Professional

Processing includes:

- Project definition (pictures and GPS points)
- Interior orientation computation (Alignment)
- Measurement of tie and control points (Included in project definition. Additional TP if needed)
- Bundle adjustment (Dense Point Cloud generation)
- Image triangulation (Mesh generation)
- DEM generation
- Orthophoto production.



UAV Photogrammetry



Haukeland, Bybanen Bergen
440 images, 7 Control points (RTK)
DJI Phantom 4 Pro, TopCon GPS Antenna with CPOS
Area: ca. 675 m^2

Equipment

- Flexible implementation.
- Setup for image acquisition can be designed based on:
  - Available equipment
  - Access to the surveyed object
  - Expected resolution and accuracy
  - Purpose

- Classic Aerial Photogrammetry: Airborne vehicles, Inertial Measurement Units, Metric cameras (costly)
- Ground Based Photogrammetry: DSLR cameras, prebuild targets and D-GPS antenna(s) (D-POS, C-POS)
- Unmanned Aerial Vehicle photogrammetry (Structure from motion): UAV (drone), D-GPS antenna(s) (D-POS, C-POS), targets

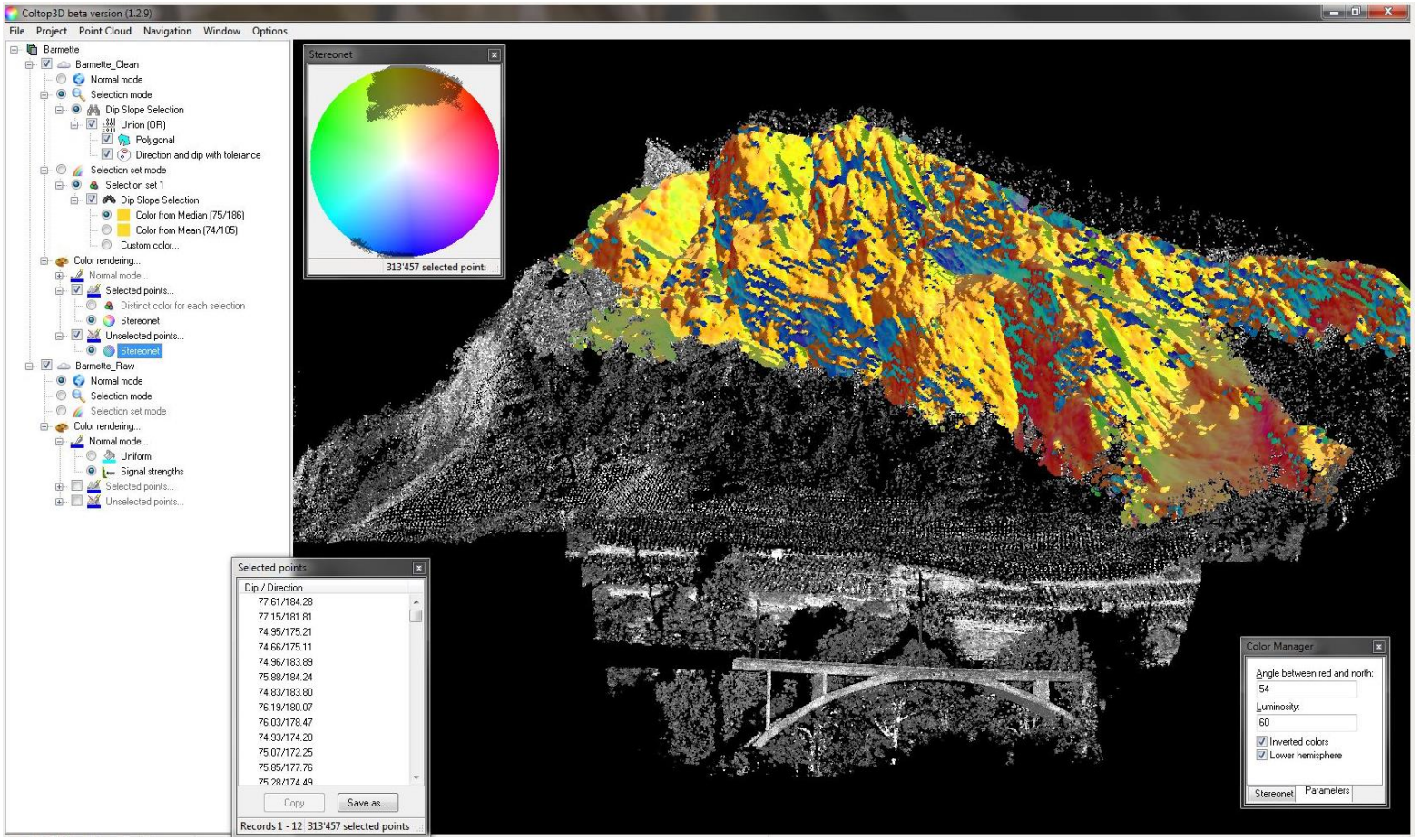
Standard setups can be adjusted if/when other types of equipment are available

Photogrammetry for engineering geology applications

- The main application of photogrammetry in engineering geology is for structural characterization of rock masses.
- Two main types of programs exist.
- Main difference resides on how structural data is registered.
- Other tools available for engineering geology for 3D model comparison

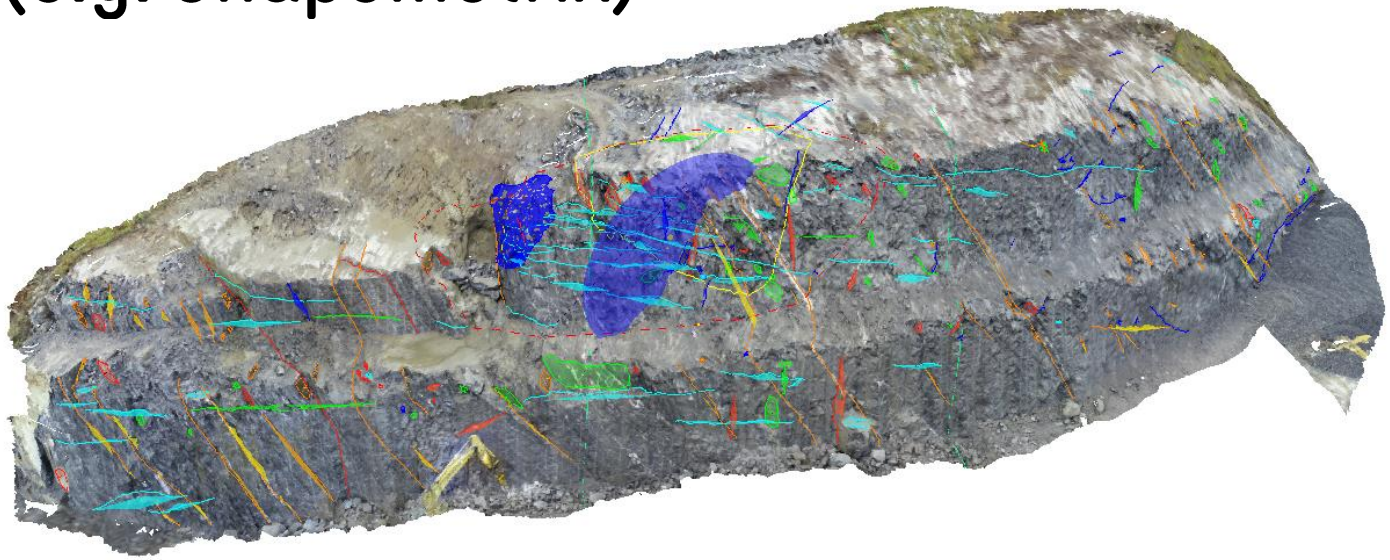
Automatic registration (e.g. COLTOP)

- Developed by the engineering geology group at UNIL, Switzerland
- Imports LiDAR and photogrammetric 3D point clouds
- Software computes automatically for each point an estimation of its orientation
- Orientation data is visualized with individual colors for each dip/direction combinations
- Orientation can be also shown on stereonet plots



Semi-automatic registration (e.g. Shapemetrix)

- Developed by 3GSM a spin off company from Graz University, Austria
- 3D model is generated by the software.
- It can use GPS coordinates for geo-referencing
- User draws over the model to select features (discontinuities). The program automatically fits all vertices of the drawn object in a plane using minimum squares and extract its orientation.
- Orientations can be plotted on a stereonet
- Can compare two 3D models to calculate volume variation
- Data (point cloud and orientations) can be exported to other programs.



Nordmelansfossen, Trøndelag, Norway
56 images, No Control points
DJI Phantom 4 Pro

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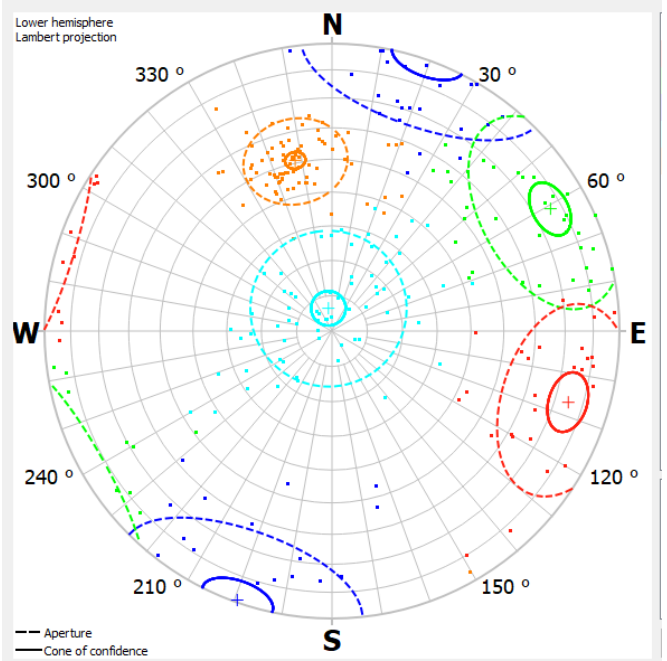

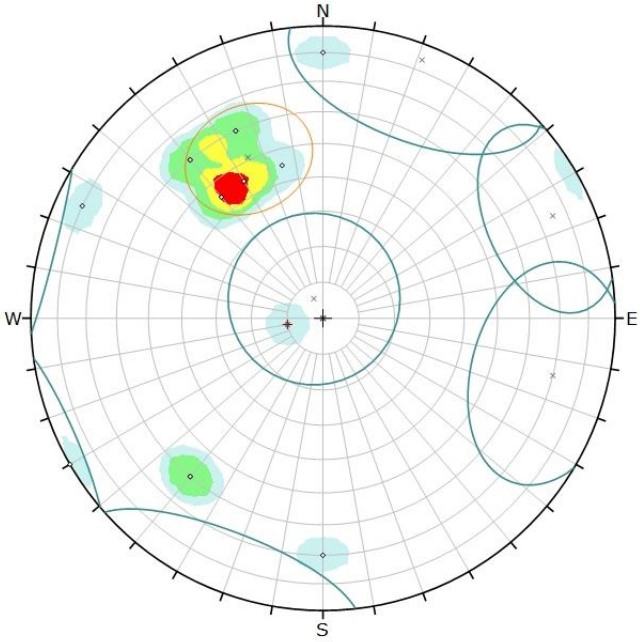

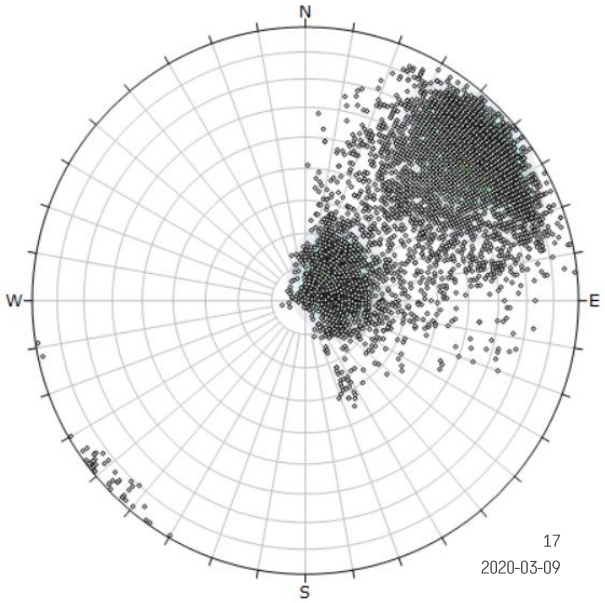

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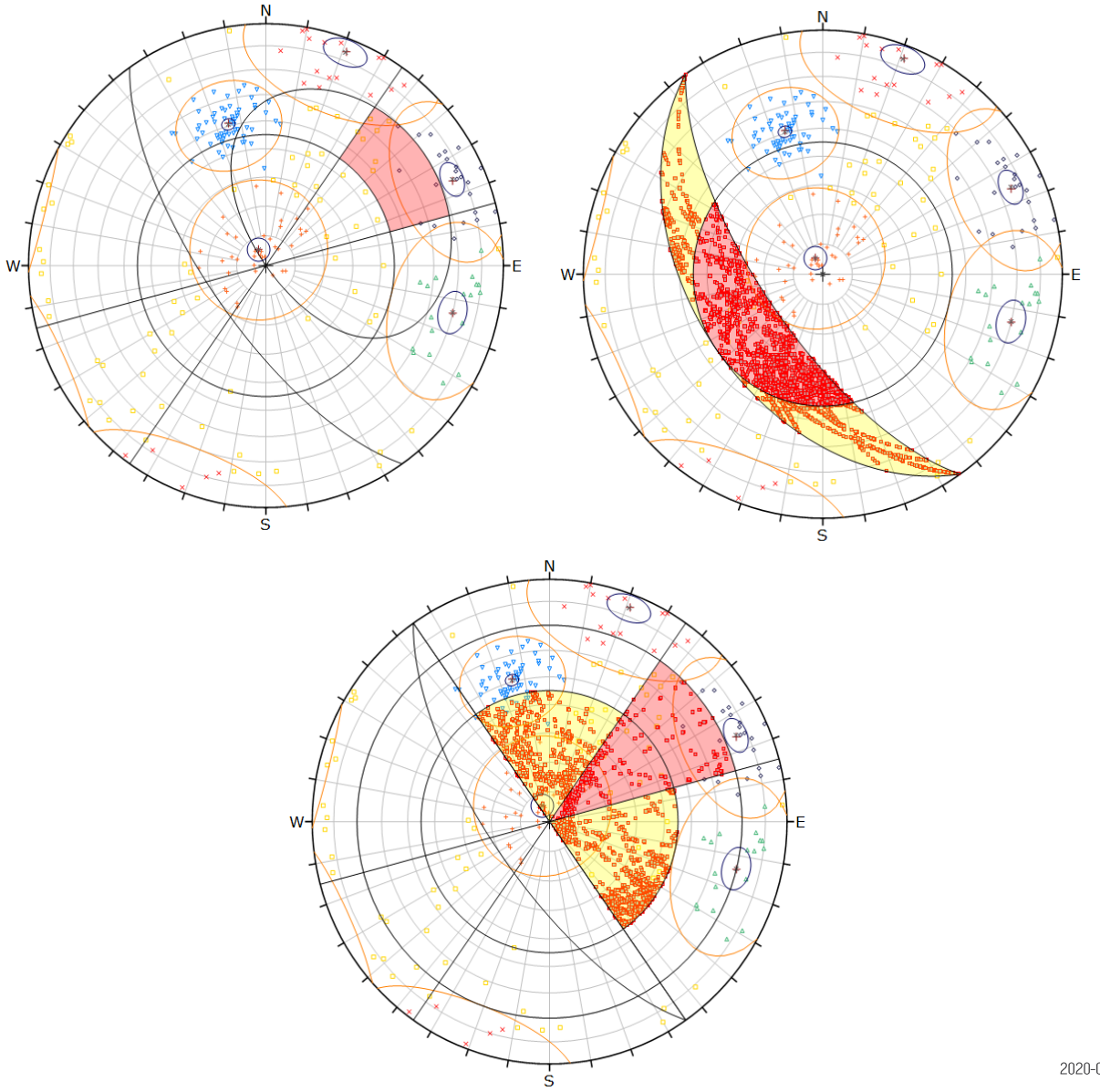
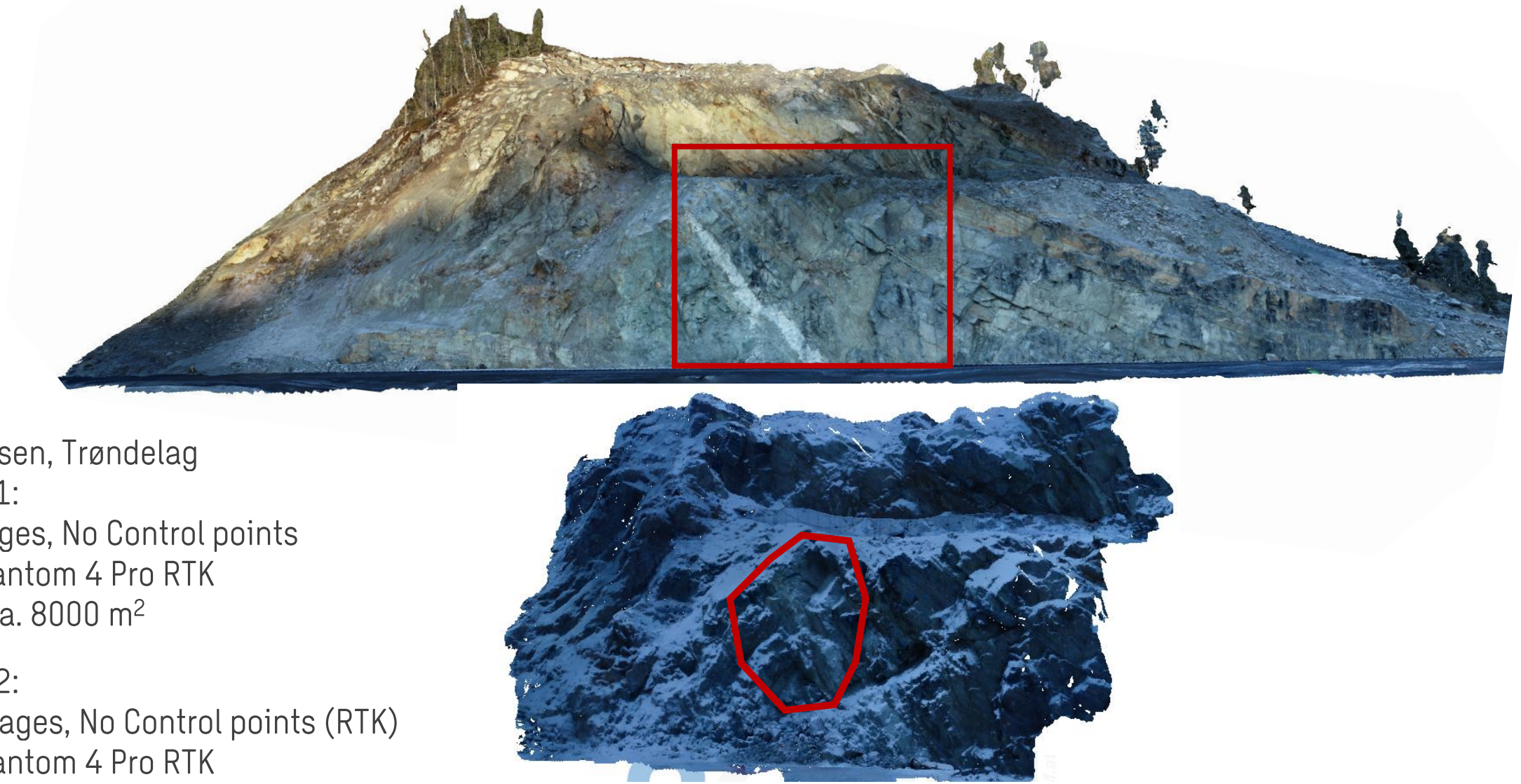


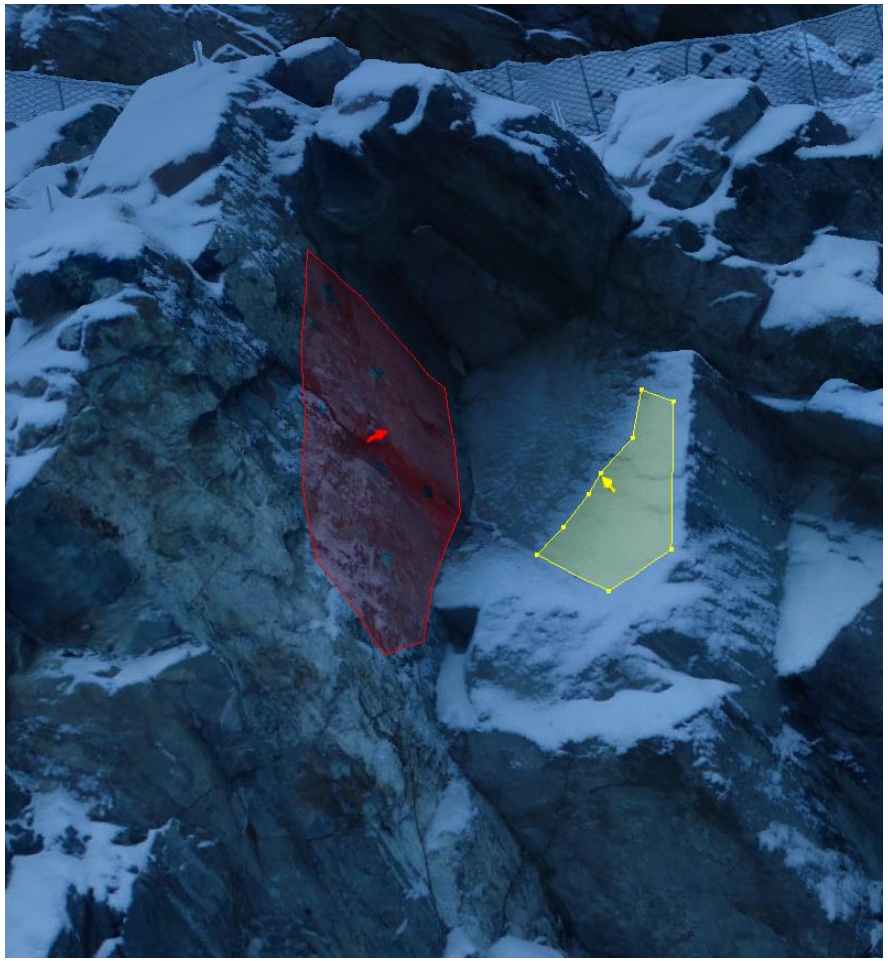
Model comparison – Volume estimation



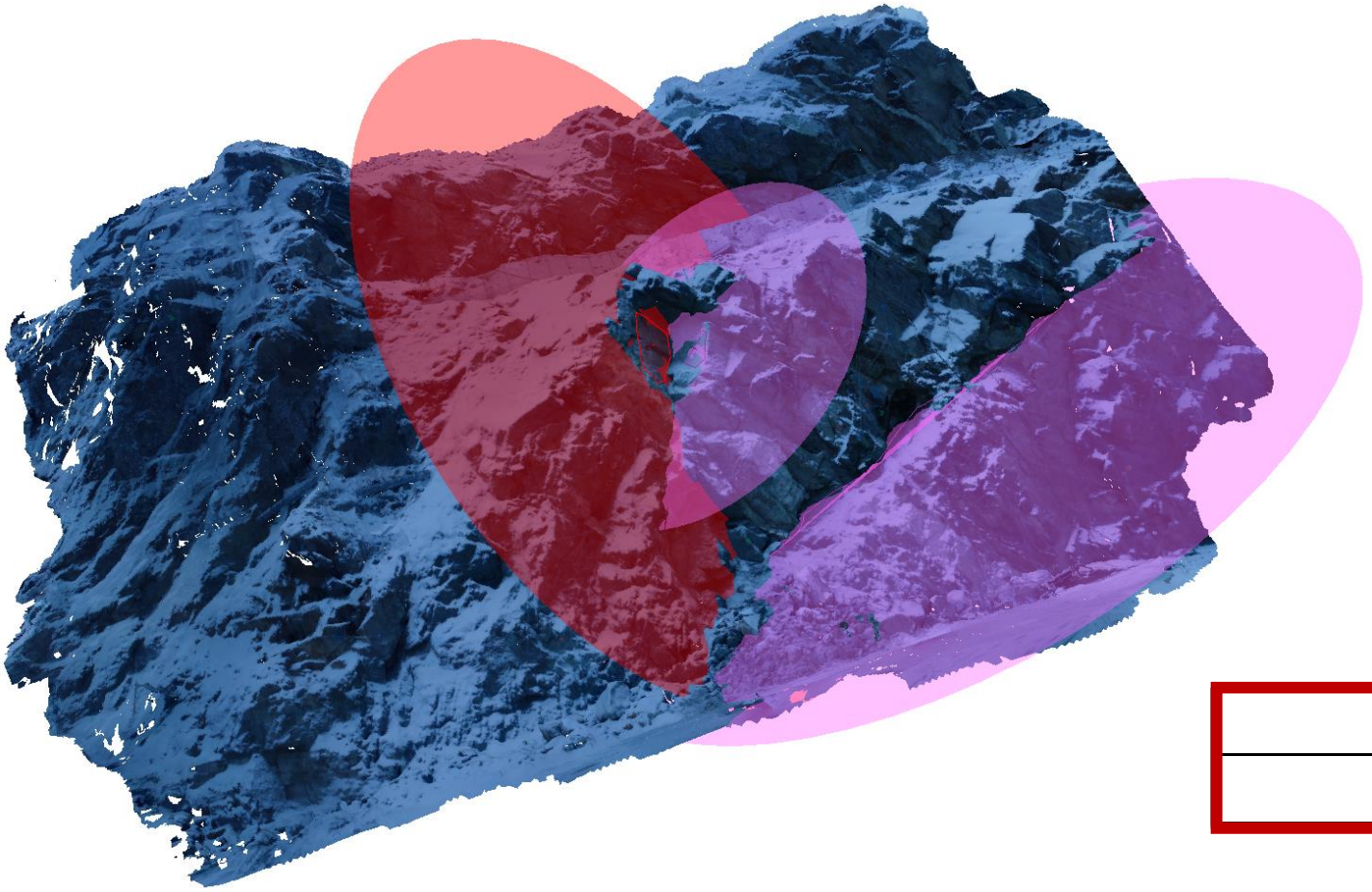
Skarvåsen, Trøndelag
Model 1:
91 images, No Control points
DJI Phantom 4 Pro RTK
Area: ca. 8000 m^2

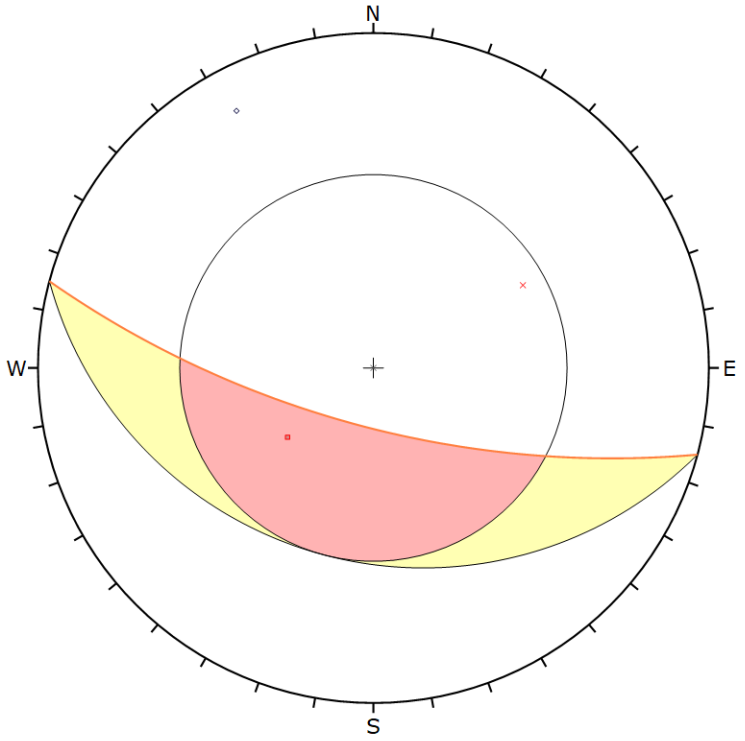
Model 2:
125 images, No Control points (RTK)
DJI Phantom 4 Pro RTK
Area: ca. 2500 m^2

Model comparison – Volume estimation



Model comparison – Volume estimation

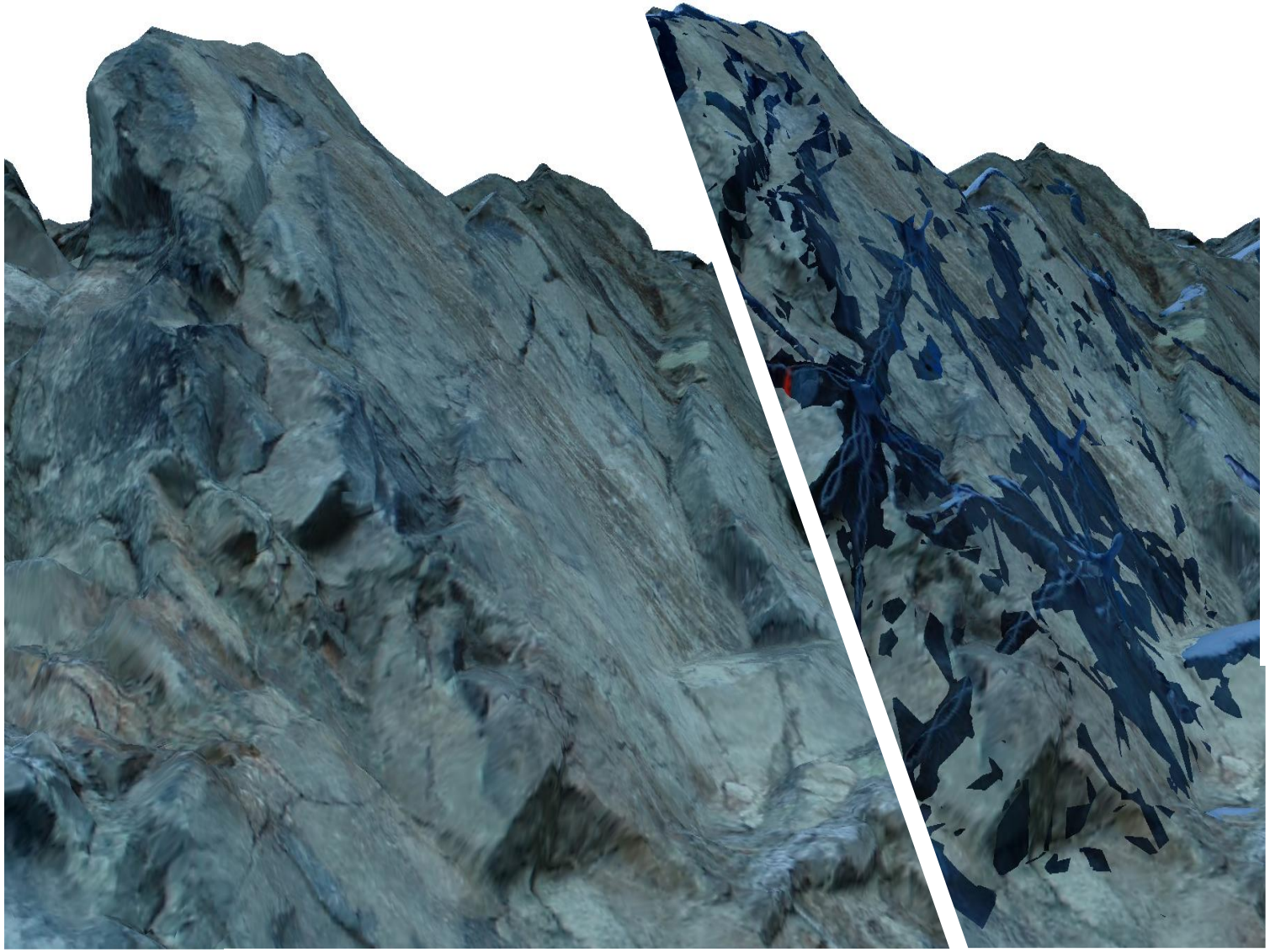




	Critical	Total	%
Wedge Sliding	1	1	100.00%

Model comparison

SWECO



Coarse scene density:	high
Camera parameters optimized:	yes
Started:	2020/02/10 - 10:00:47
Finished:	2020/02/10 - 11:13:09
Computation time:	1h 12m 22s
Cameras added:	125 / 125
World points added:	173 210
Image observations added:	1 172 707
Mean world point observations:	6.77
Ground sample distance mean:	0.004 m

	mean	*std.dev.*	*med*	*max*
EXIF GPS residuals:	0.022 m	0.012 m	0.020 m	0.055 m

SWECO