High-resolution topographic reconstruction from archival photographs in the Mont-Blanc massif estimating historical rockwall erosion rates and glacial volume changes

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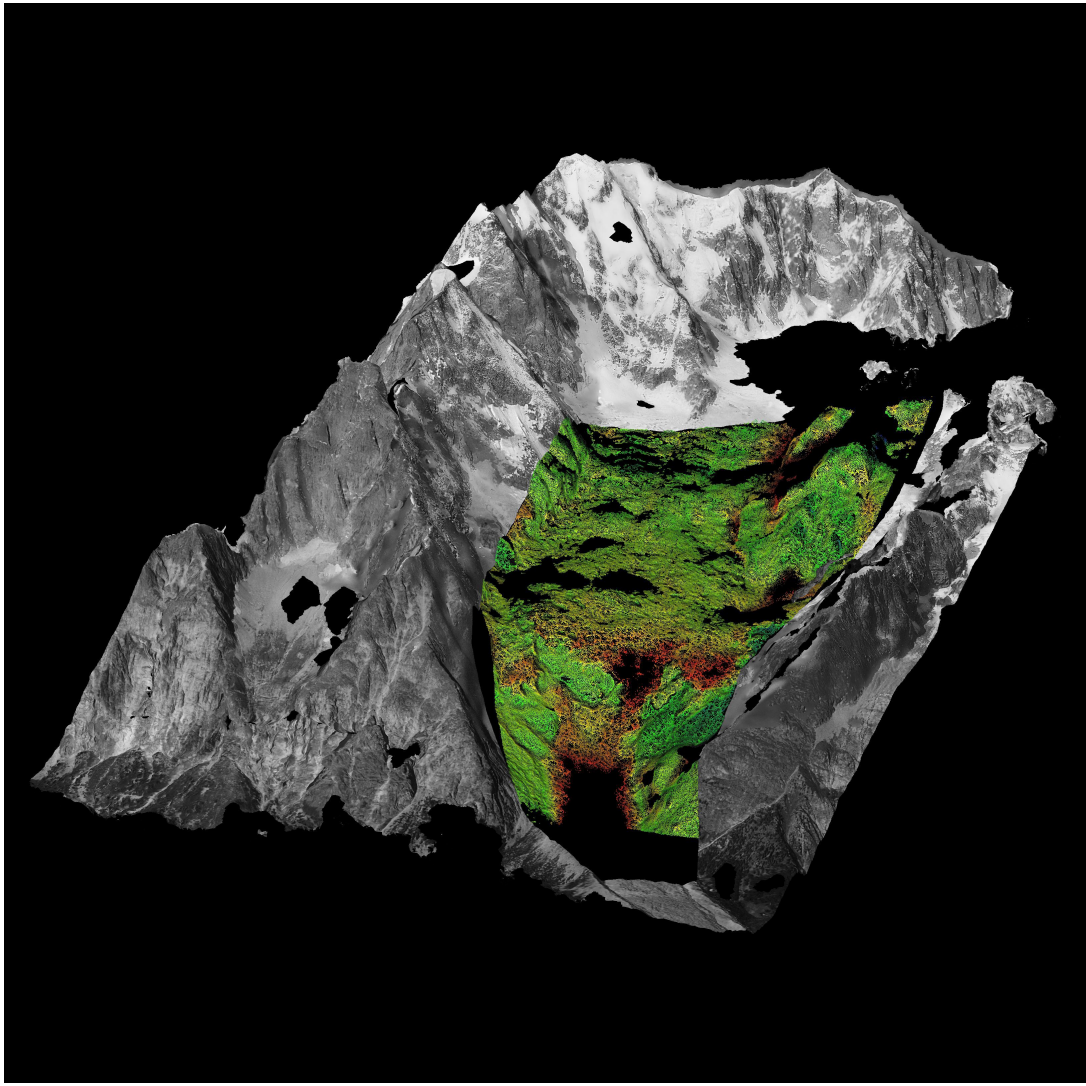


Volume change of Brenva Glacier, 1952-2021

Context

Grand Pilier d'Angle and Mont-Blanc (4,810 m)

l'Aiguille du Midi, (3,842 m)

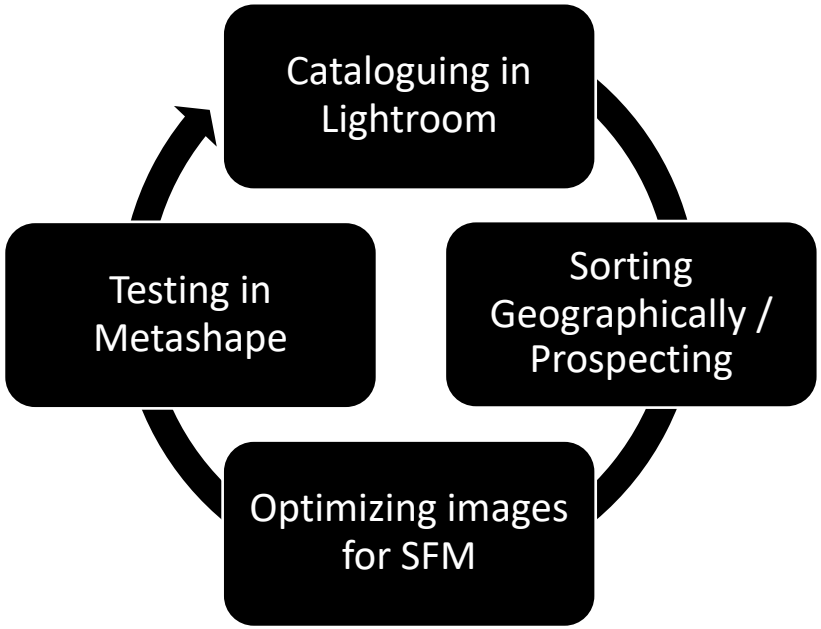
- Mont-Blanc massif is the highest mountain range in western Europe
- Contains large, steep, and vertical rock walls, up to 1200 m in height, which are largely within the cryosphere, and subject to permafrost degradation
- Rockfall and erosion rate studies have been largely limited to the modern era of LIDAR and other remote-sensing based reconstructions
- The project aims to enlarge the timescale of measurements for erosion rate on the great rock walls of the MBM
- The project also seeks to qualify and quantify the volumetric change of suspended glaciers

Image Acquisition

- Online Archives
- Local Government archives
- Private
- Regional Museums
- Libraries
- Film archives
- Youtube
- Public calls







- >5000 photographs
- 1890 - 1990
- 35mm – 8x10inch glass plates
- Scanned negatives and prints
- Largely missing metadata
  - Precise date
  - Equipment used
- No fiduciary marks
- Often unknown reproduction parameters
- Lack of access to original materials

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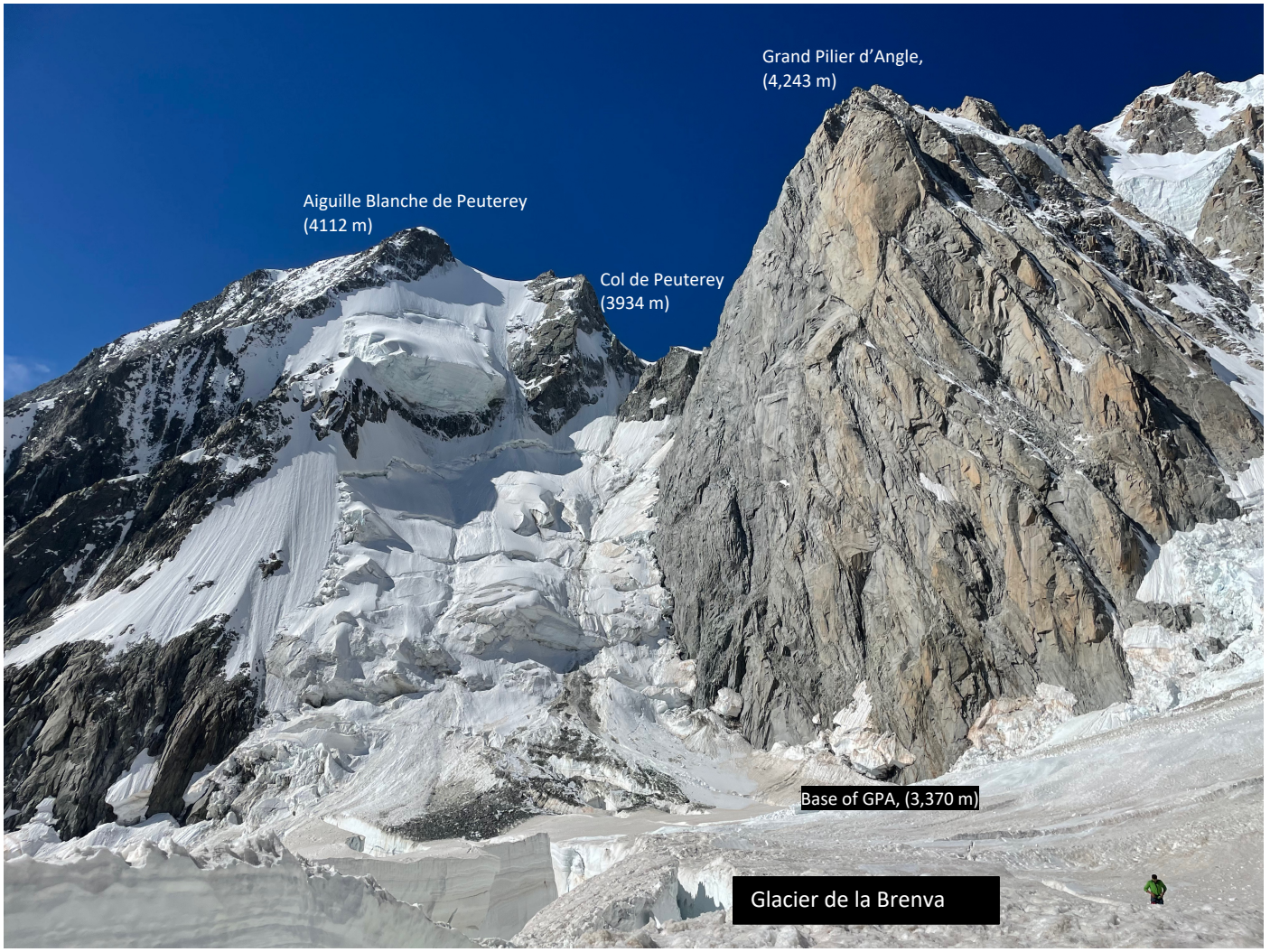
Geographic Context

Grand Pilier d'Angle (4,243 a.s.l.)

45.828160° N, 6.878423° E

Mario Fantin, 1952, courtesy of the Club Alpin Italiano

Grand Pilier d'Angle (4,243 m)



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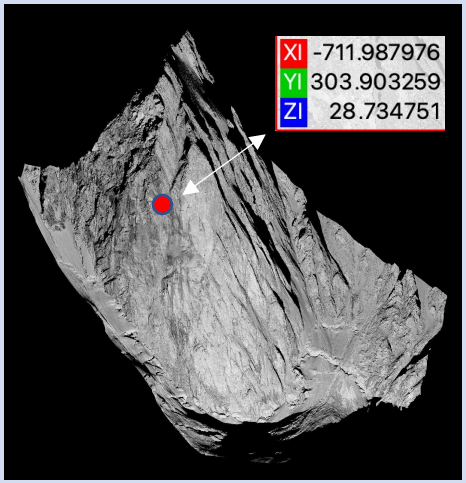
Daniel Uhlmann, August 2021

Metashape Workflow: GPA

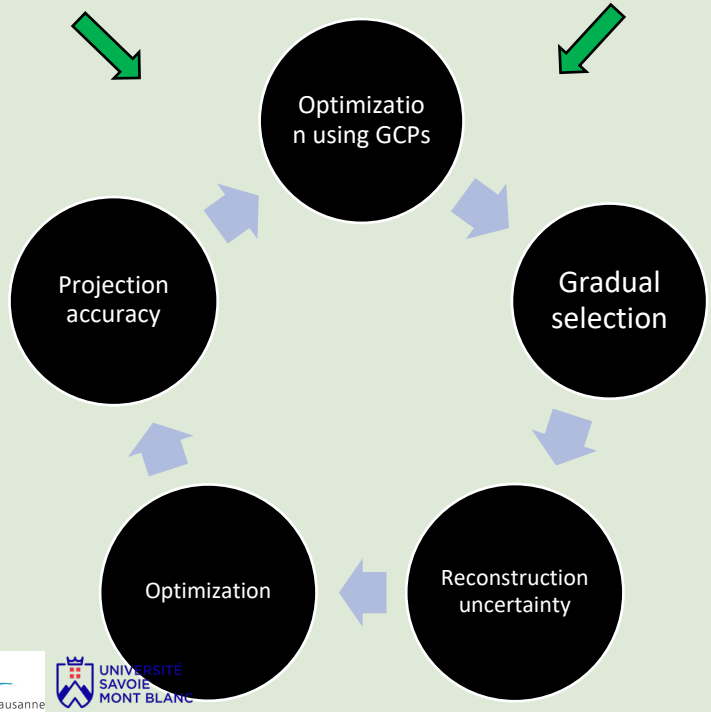
Import developed photos in TIFF

Control Point selection from LIDAR point cloud

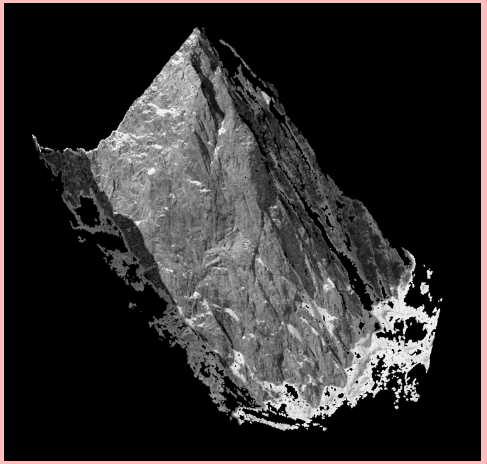


LIDAR-generated point cloud, August 2021

Alignment using LIDAR-derived control points (Sparse cloud)



Dense cloud output, 4 million points



SFM-generated point cloud, images from 1952

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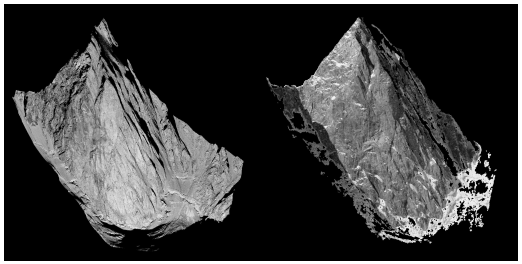
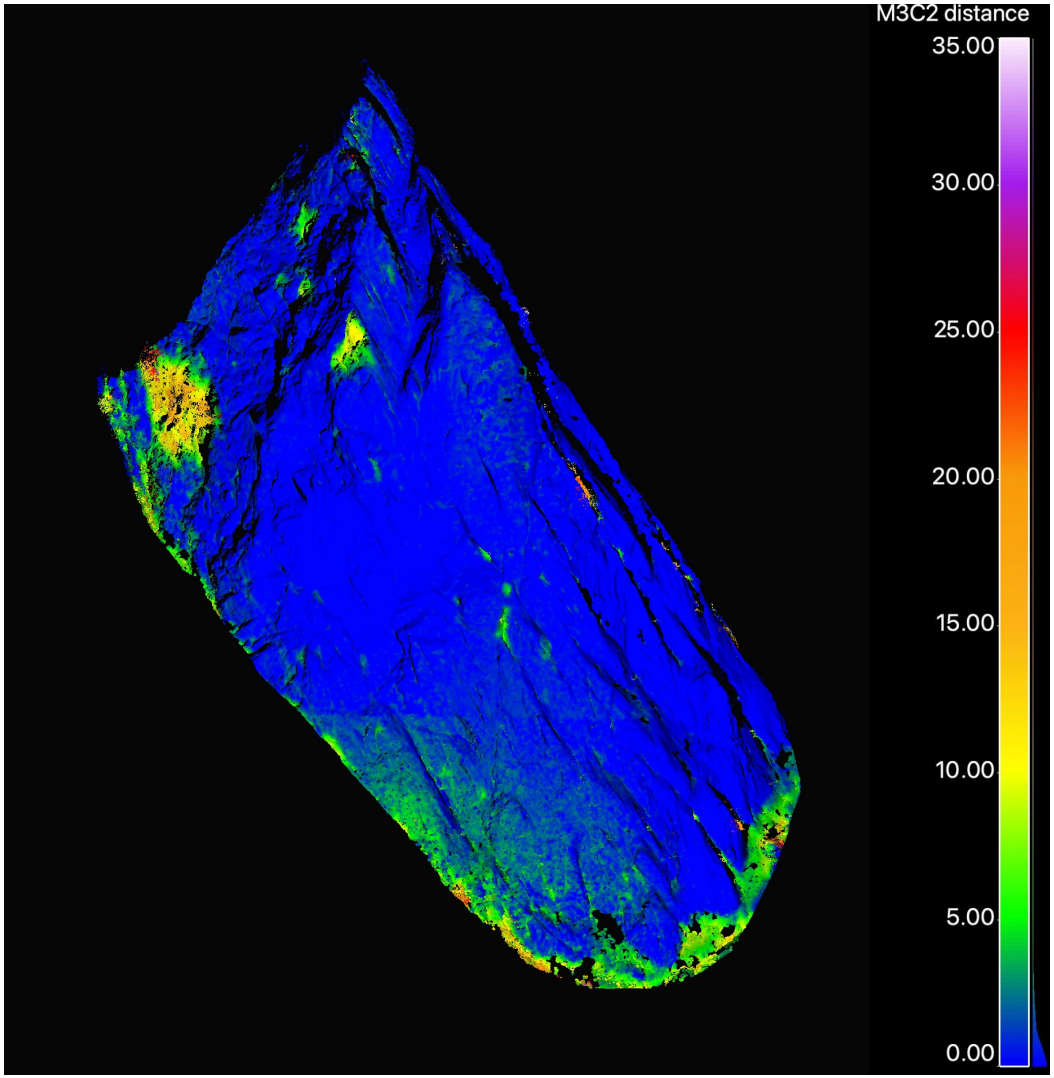
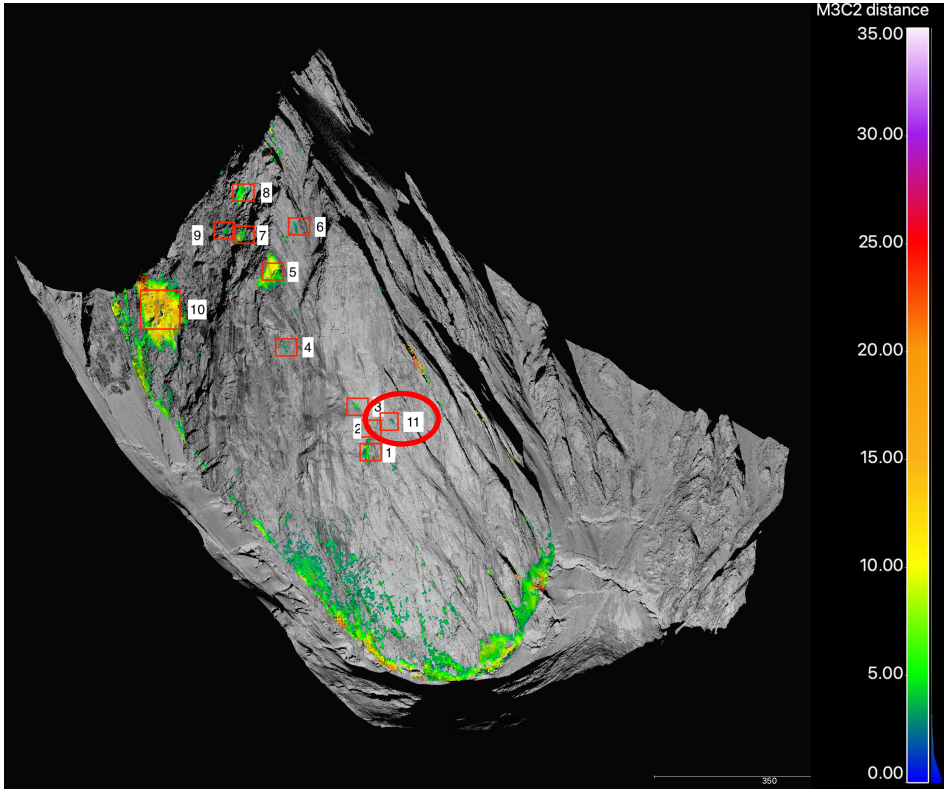
Cloud Compare Workflow



1) Registration via point picking (max 1 m error at each point)
2) Iterative fine registration until RMS error is less than 1 (ideally 0.3 – 0.5)
3) M3C2 Algorithm.
4) Error estimation and model quality estimation with M3C2 model

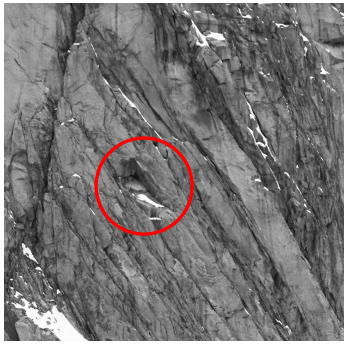


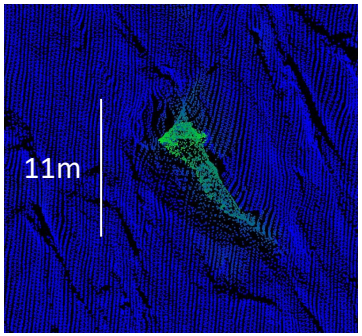
Rockfall identification and volume estimation

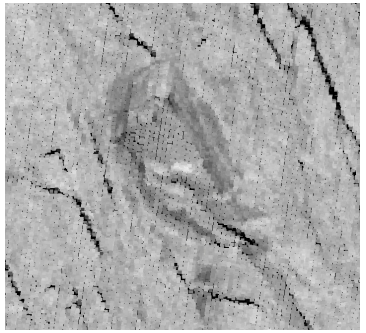


1952

2021







Annual erosion rate of Grand Pilier d'Angle, 1952-2021: 3.39 mm/a

Discussion

- Error sources difficult to quantify
  - Source images
  - Reproduction
  - SFM modeling
- Erosion rates are a result of large time-spans
- SFM-derived point clouds will contain inherent error, warping, and other defects which limit base threshold of rockfall or landslide size identification.
- Standardization of SFM-based methods is needed
- Treatment of base images can greatly affect output data and resolution
- With a minimum of 4 high-quality archival photographs, erosion rate can be estimated

The next steps…