3D Displacement Retrieval on Glacial Areas by Airborne Multi-View Photogrammetry

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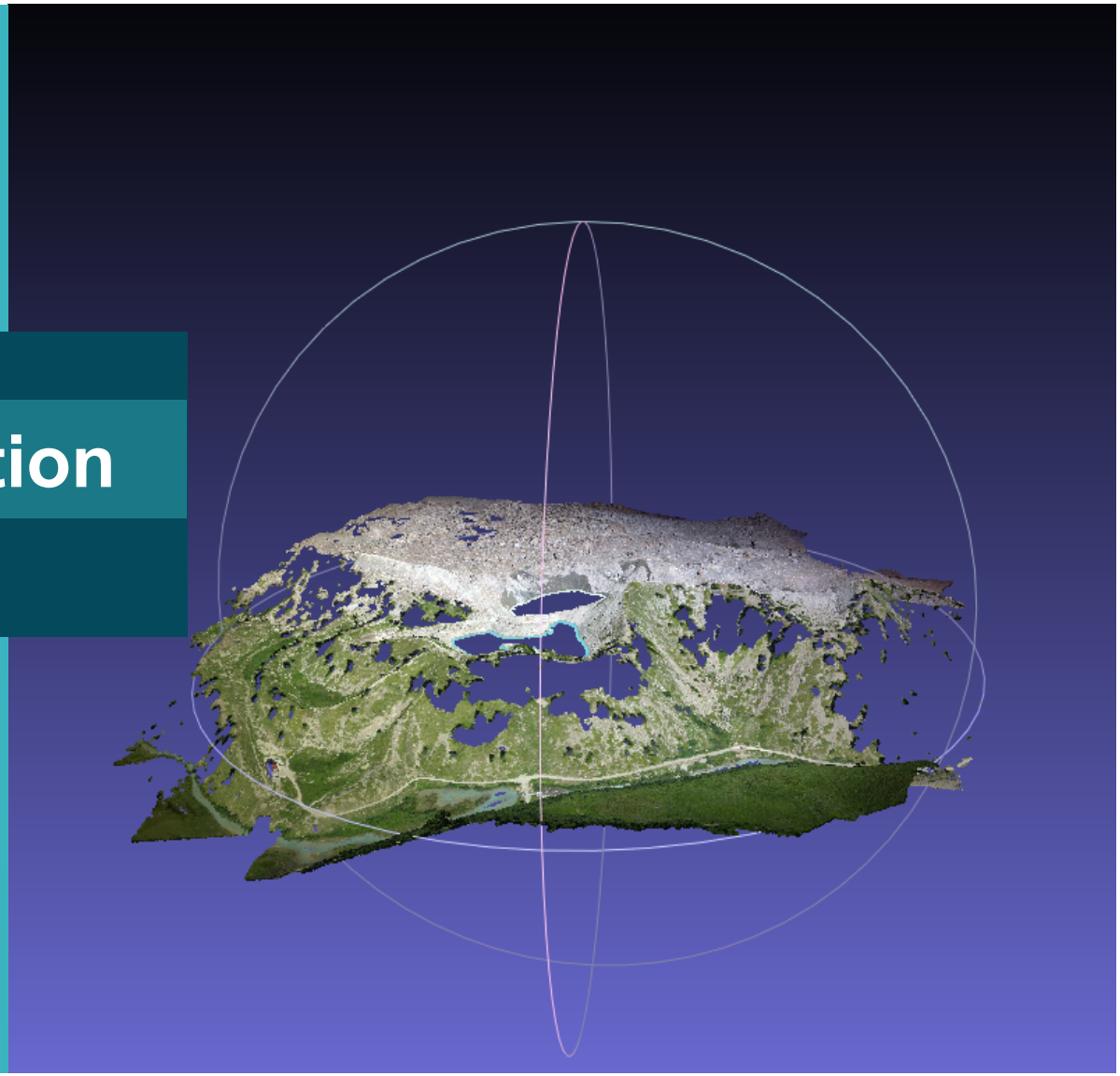
Introduction



Background

Importance

Variations in glaciers → Regional climate change

Glaciers → Regulation of water balance

Global warming

River bed blockage

Natual dam formation

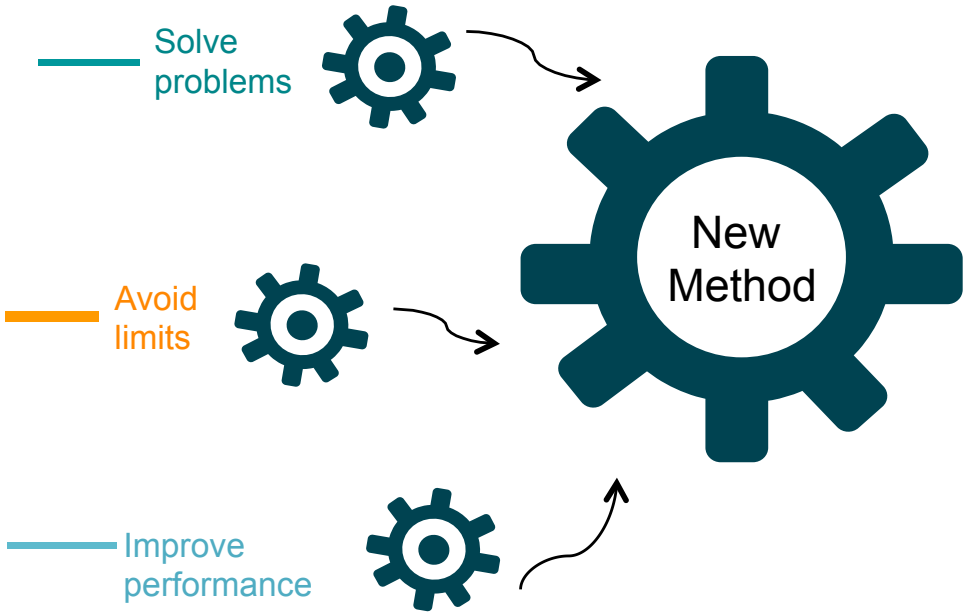
Terrestrial Photogrammetry

- Tool: Digital Camera
- Methods:
  1. Stereo
  2. Multi-view
- Limits:
  1. Light movement of camera
  2. Accessibility

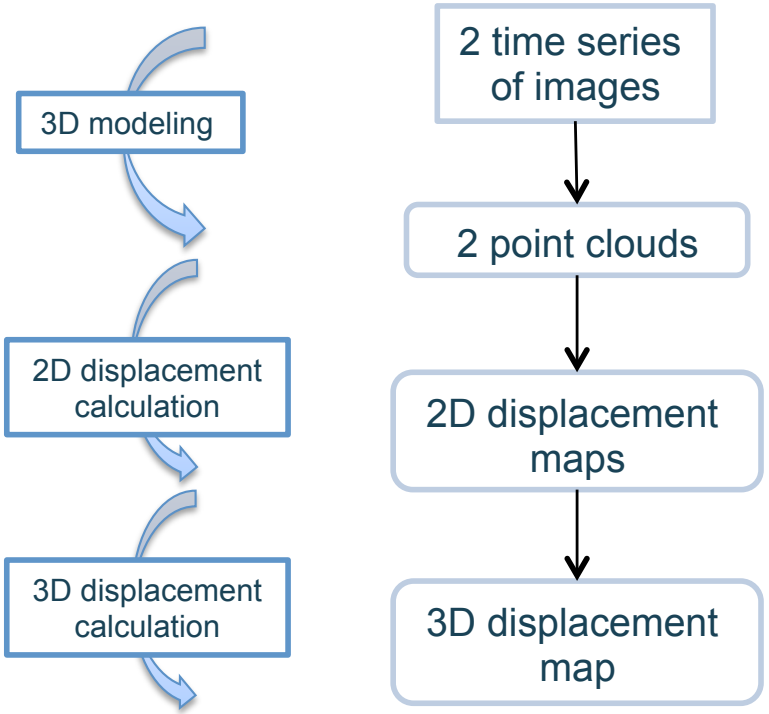
Aerial Photogrammetry

- Tools: Satellite, Plane, UAV
- Methods: Stereo, Multi-view
- Limits:
  1. Weather (cloud, wind)
  2. Error on Z axe

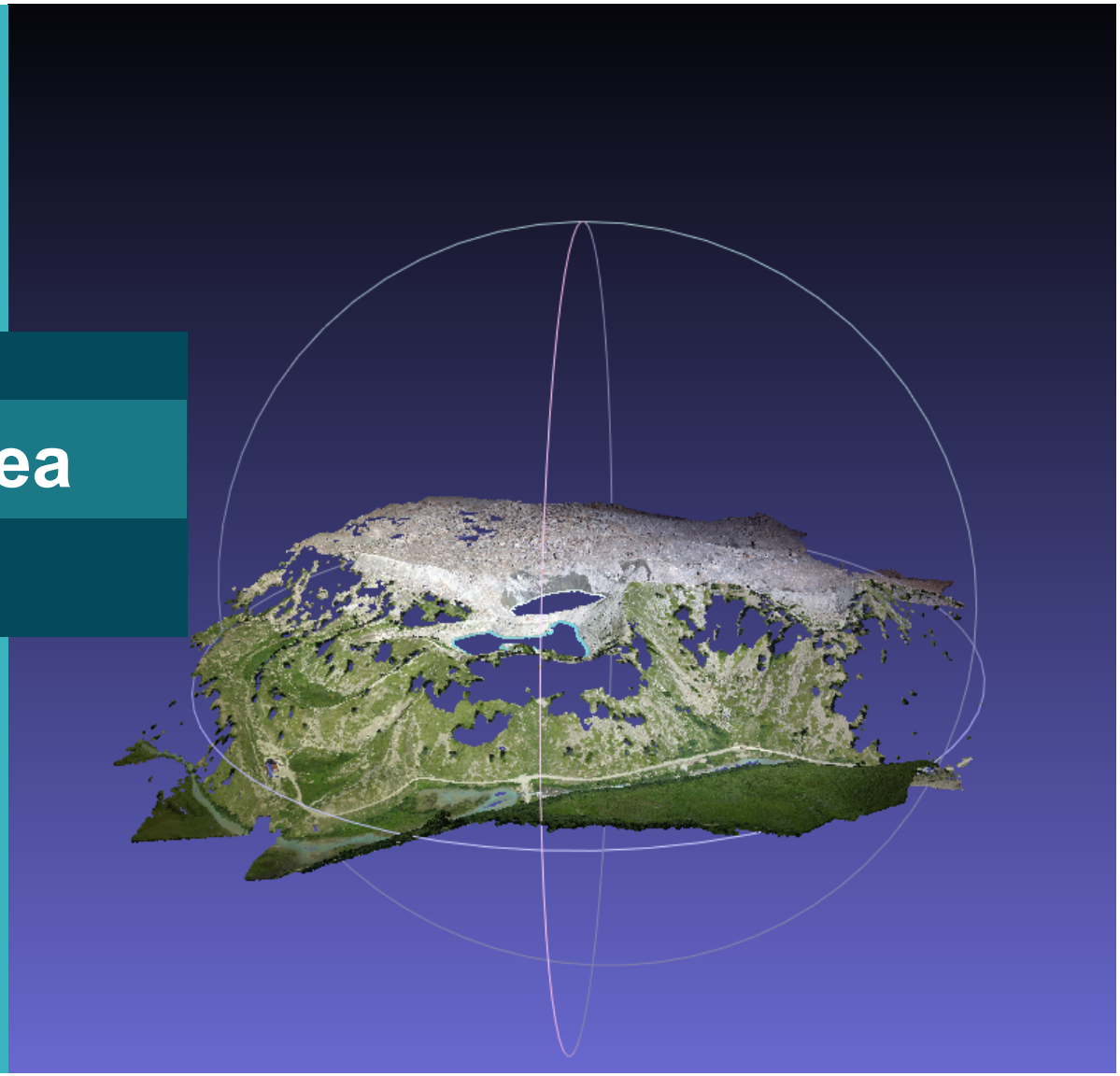
New method porposition



A new method for calculating 3D displacement by using airborne multi-view photogrammetry



Study Area



Study Area - Miage Glacier

Miage Glacier

- The third largest Italian glacier.
- Flows on the SE side of the Mont Blanc massif

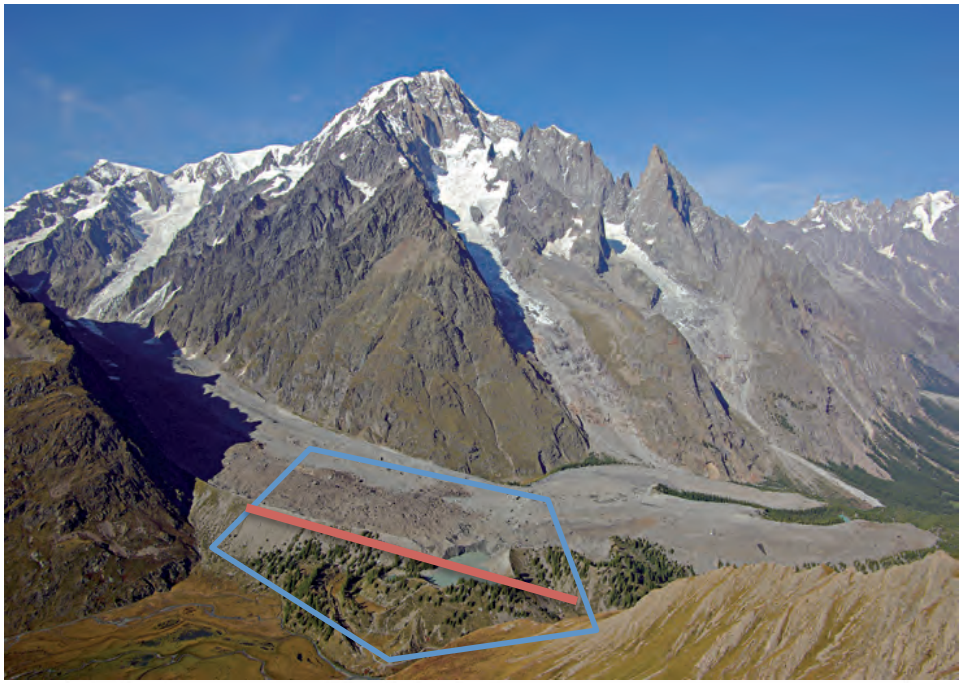
Location

Miage Lake

- Area: 36 000 m2
- Height: 2017 m a.s.l.

Study Area

Miage Morainic Amphitheatre



Miage morainic amphitheatre

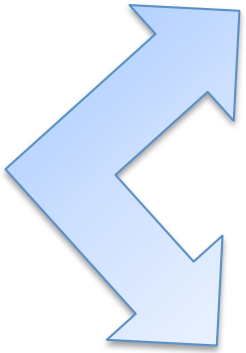
Location

Acquisition

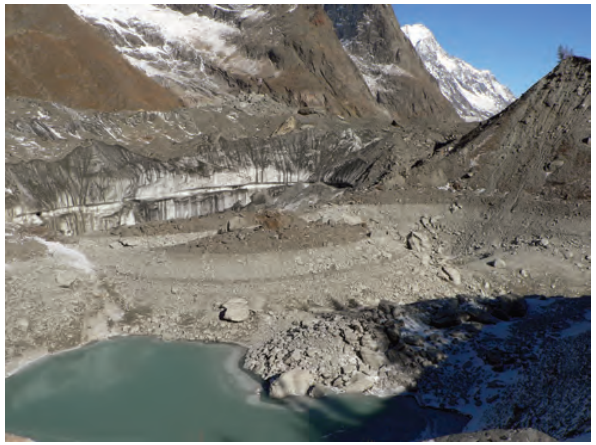
Acquisition Twice

↓

Two series of images



Before drainage



After drainage

Tool

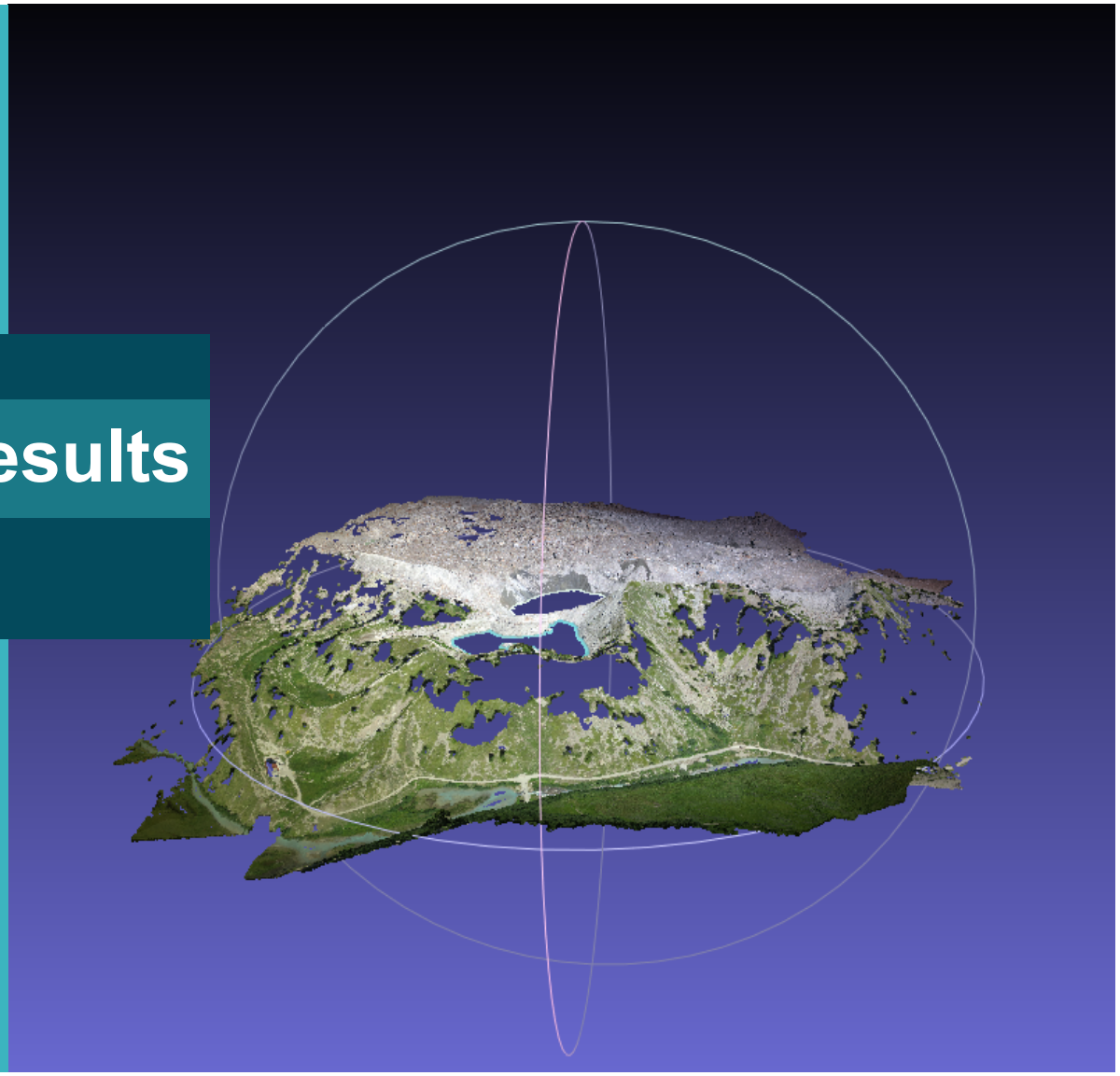
UAV: SenseFly Swinglet CAM
Camera: Canon IXUS 125HS
Onboard GPS

Strategy

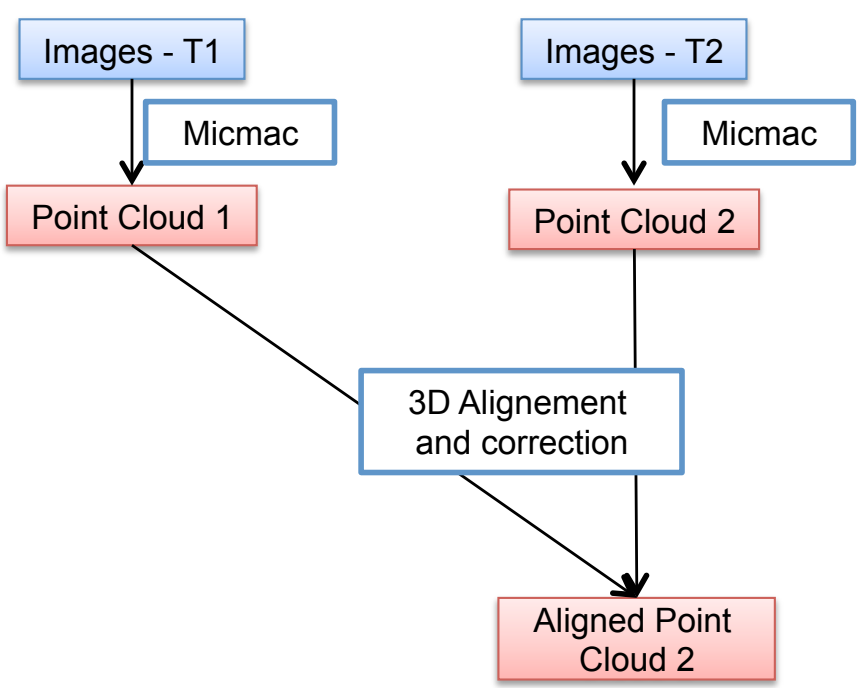
	First Flight	Second Flight
Start time	10h47 am	8h22 am
Duration	18 mins	24 mins
Area coverd	0.36 km^2	0.36 km^2
Distance	14.0 km	14.1 km
Altitude	170 m	170 m
Resolution	5 cm/px	5 cm/px
Image Number	143	250

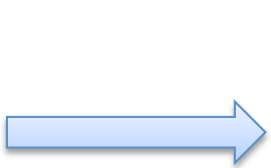
Forward overlap: 85%
Side overlap: 80%

Method & Results

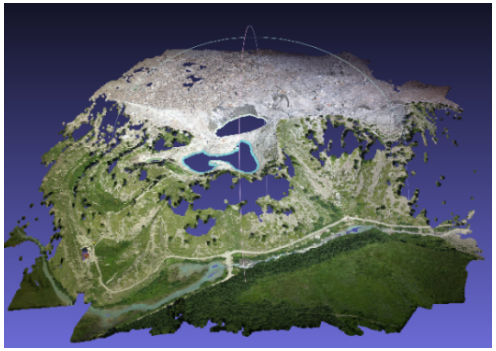


Method: 3D Modeling

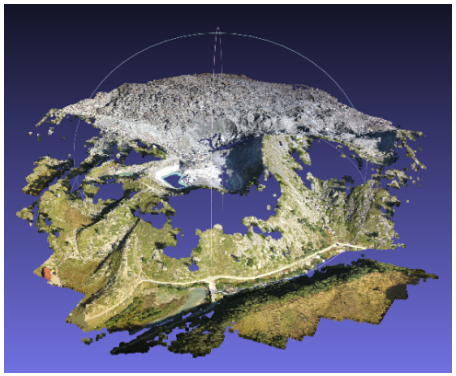




3D modeling



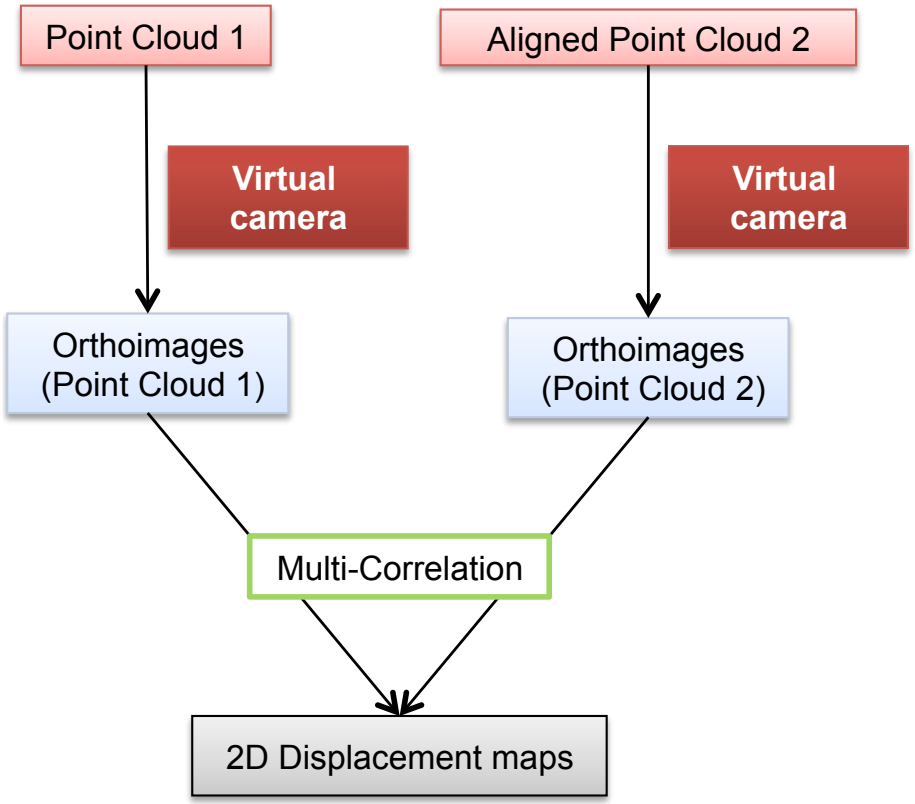
Point Cloud 1
1300 p/m^2

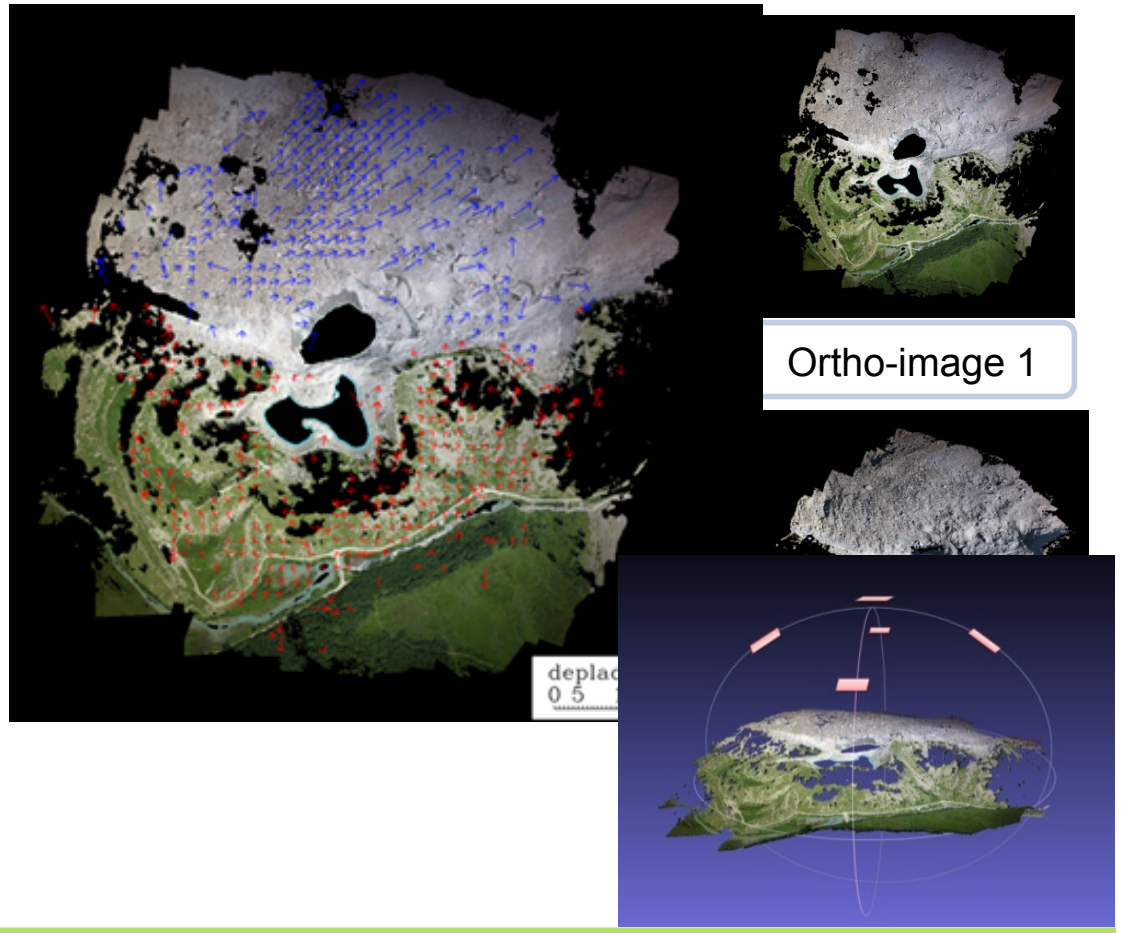


Aligned Point Cloud 2
1700 p/m^2

After Alignement:
Error Fixed Area: 0~0.5m
Error Mobile Area:0~0.5m in X and Y, 0.5~5m in Z

Method: 2D displacement calculation



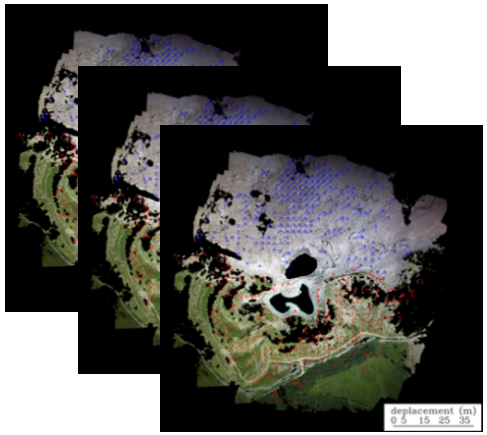


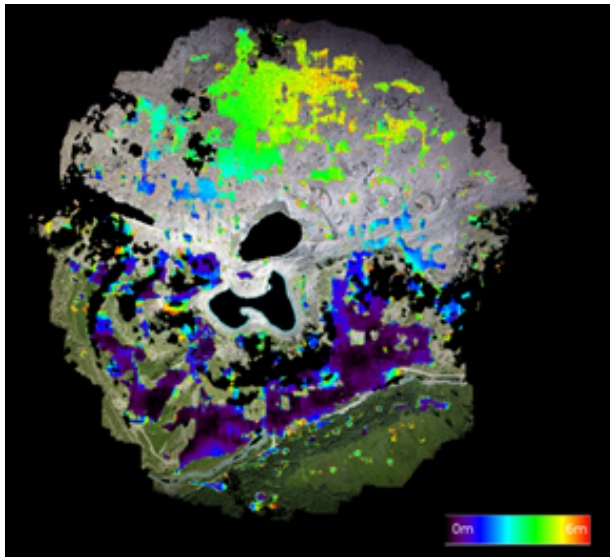
Method: 3D displacement calculation

2D Displacement maps

Inversion

3D Displacement map

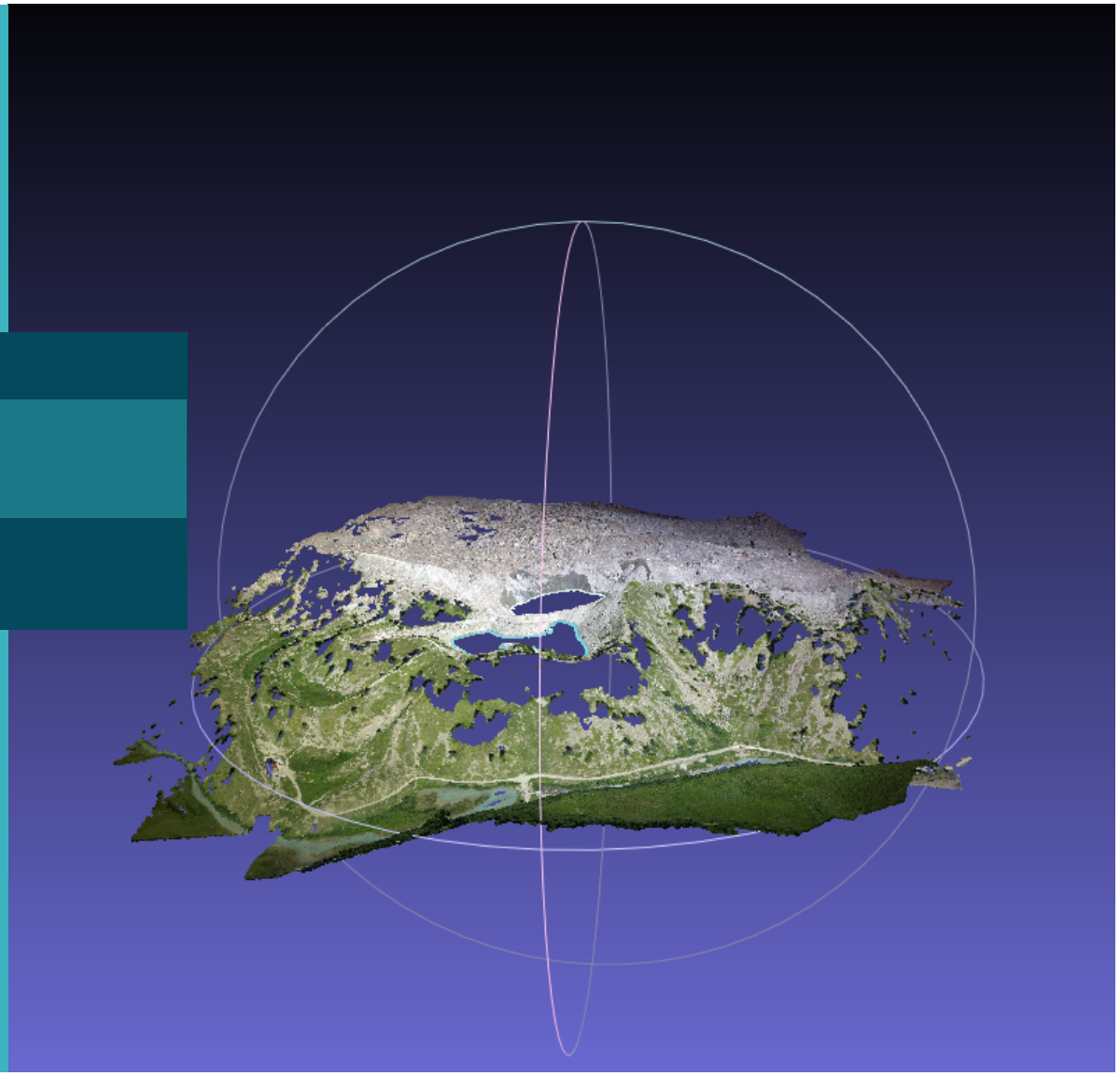




Inversion: $R=PU$ $\Rightarrow$ $U=(P^TP)^{-1}P^TR$

P: projection matrices
U: vector of 3D displacement
P^T: transposed matrix of P
R: vector of 2D displacement

Conclusion



Advantage

Light

- Light Equipements
- No GCPs

Complete

3D displacement of “each” pixel

Cost effective

Open source Software

Widly applicable

Method can be used for all types of photogrammetry

Ground Control Points

Set ground control points on land

Existing 3D model

Extract GCPs from an existing 3D model

High precision UAV GPS

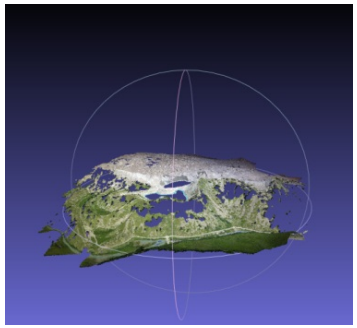
Increase the precision of embedded GPS on UAV

Improve the precision

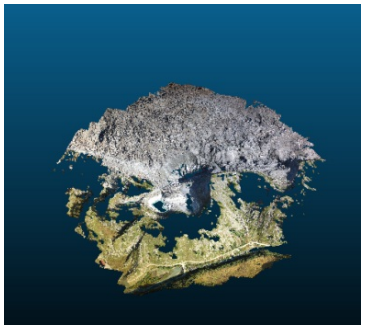
Questions?

Thank you for your attention!

Results

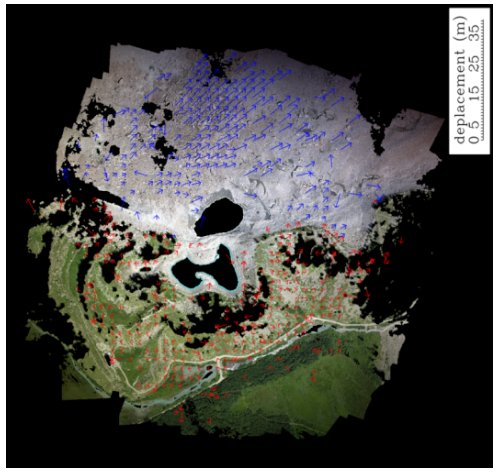


Point Cloud 1



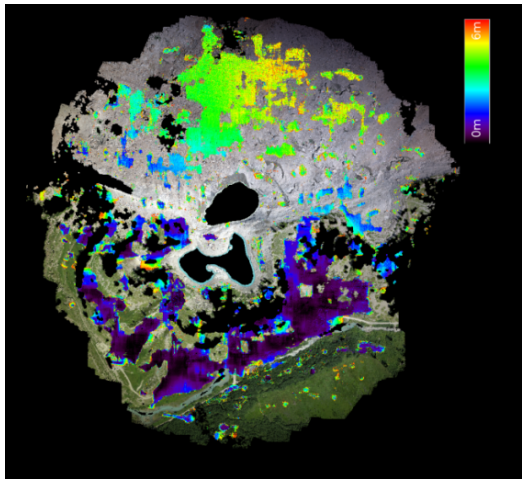
Corrected Point Cloud 2

	Point Cloud 1	Point Cloud 2
Density	1300 p/m^2	1700 p/m^2
Error Fixed Area	Before Alignement: 0~1m After Alignement: 0~0.5m	
Error Mobile Area	Before Alignement: 0~3m in X and Y, 6~10m in Z. After Alignement: 0~0.5m in X and Y, 0.5~5m in Z.	



Red arrows: Fixed area, less than 0.5m

Blue arrows: Mobile area, homogeneous, meet the direction of the movement



Fixed Area: blue, 3D displacements are closed to 0

Mobile Area: green~blue, between 3~5m