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Generating High resolution surfaces from images: when photogrammetry and applied geophysics meets

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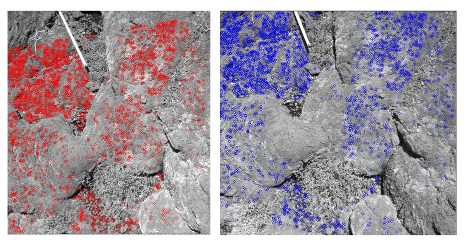
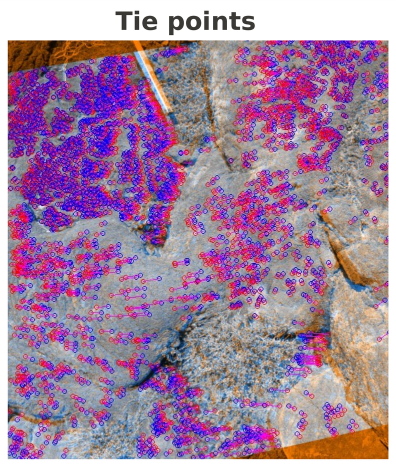
The processing Chain

Computing Tie Points

- Scale-invariant feature transform (SIFT) [**Lowe**, 2004]

SIFT points (img1, img2) on pahoehoe lava flows





Calibration and Pose estimation

- For the entire set of un-oriented images, the pose estimation results from the **photogrammetric model**:

$$\pi(P) = D_{\phi,C_r}(P^p + F * \pi_0(\mathcal{R}(P - \mathcal{C})))$$

Projection of *P* in pixel (2D) — Principal Point — Canonical projection — 3D point — Distorsion model — Focal length — Rotation — Optical center

Dense Matching

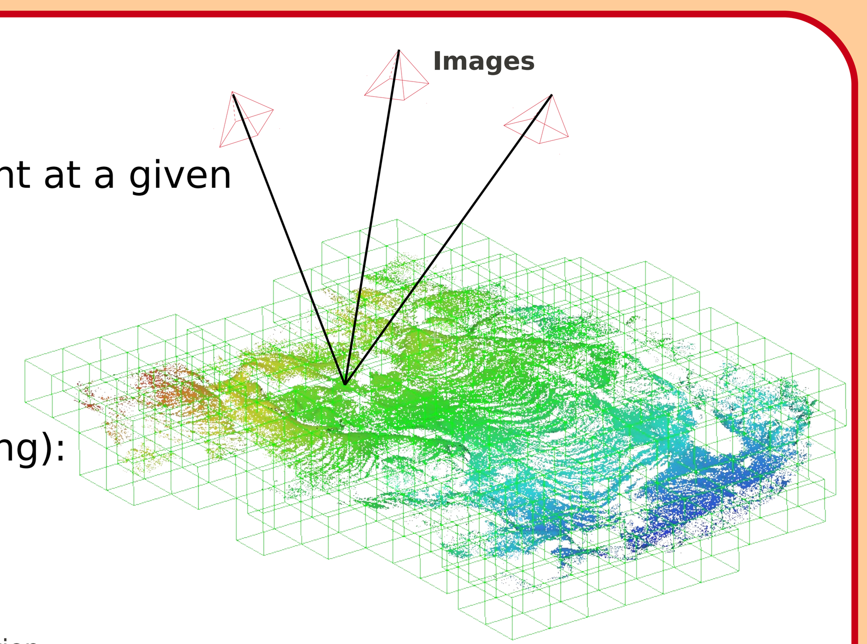
- Computation of the multi correlation coefficient at a given planimetric location (x,y) for different z

$$\rho_{x,y}(z) = \arg\max_{z \in [\![z_{min}, z_{max}]\!]} \rho(z, \underbrace{I_1 \ldots I_n}_{Images})$$

- Global optimization (e.g. dynamic programming):

$$\text{Surface}_{x,y} = \arg\max_z \rho(z, I_1 \ldots I_n) + \lambda E_r(x,y,z)$$

Correlation — Constant — Regularization



The octree topology (green cubes) encapsulates the surface

Multi-scale approach

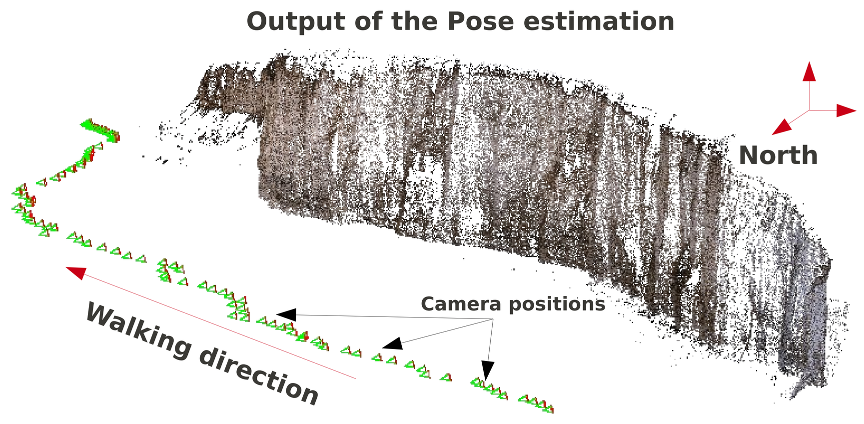
Surveying chalk cliffs

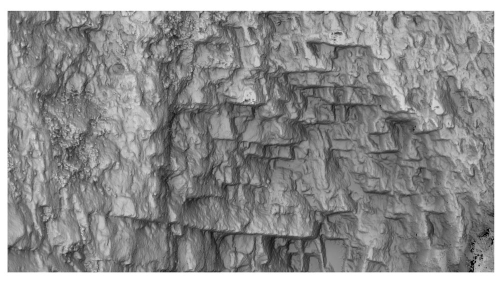
Device

- Canon EOS 5D Mark II
- Focal 35 mm
- Image format CR2 and JPG (21Mpx)

Acquisition protocol

- Take photos walking along the cliffs
- 70% overlap between photos



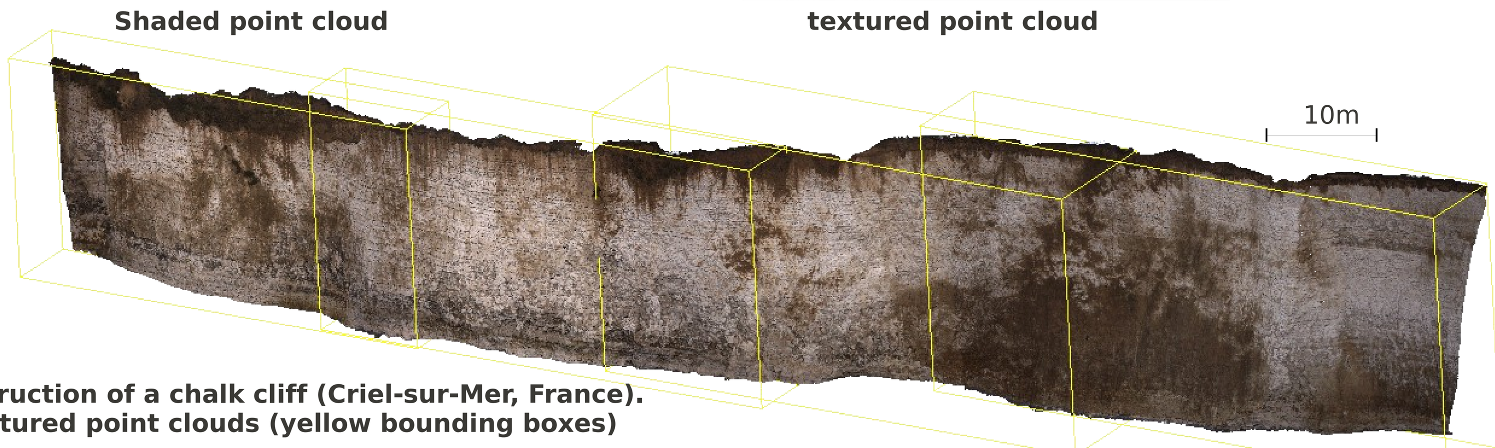


Shaded point cloud

Details of the chalk cliff

1m

textured point cloud



Final reconstruction of a chalk cliff (Criel-sur-Mer, France). 3D RGB textured point clouds (yellow bounding boxes)

Surveying a cliff of dark clays

Device

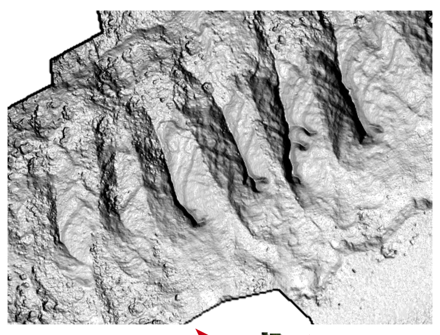
- Canon EOS 5D Mark II
- Focal 70mm
- Image format CR2 and JPG (21Mpx)

Géocube

- Wireless GPS network
- Power Autonomy
- Accuracy: ~2cm

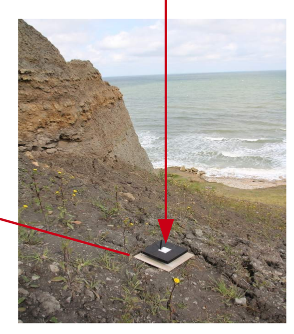
Acquisition protocol

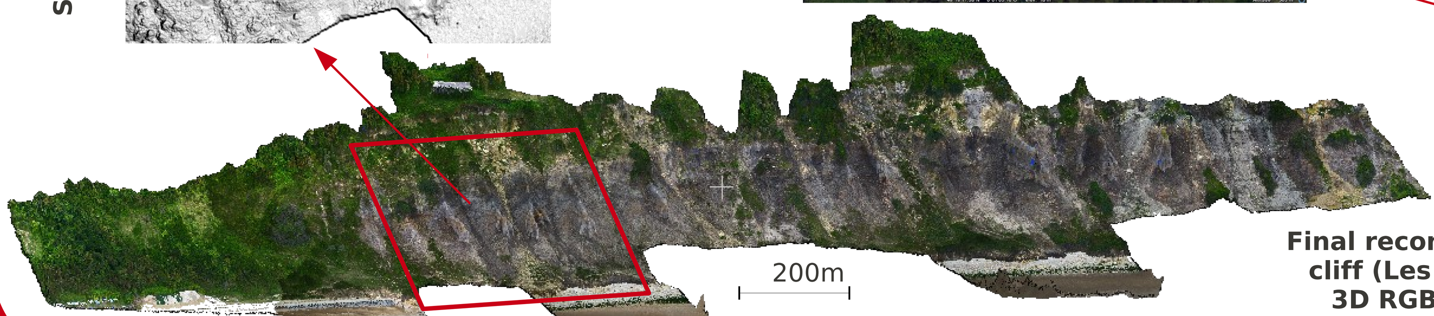
- Camera mounted on an Ultralight power driven aircraft
- Acquisition by parallel and overlapping strips at 400 m asl (ground pixel size of 3cm)
- Georeferencing with 10 Géocubes



Shaded gray-scale DSM

Aerial view of Les Vaches Noires Positions of 10 geocubes





Final reconstruction of a dark clays cliff (Les Vaches Noires, France). 3D RGB textured point clouds

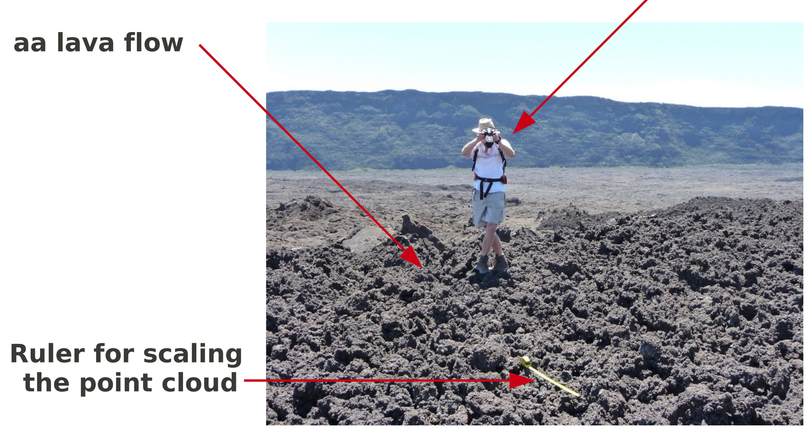
Surface Rougness: Application to Volcanic Terrains in the Piton de la Fournaise, Reunion Island

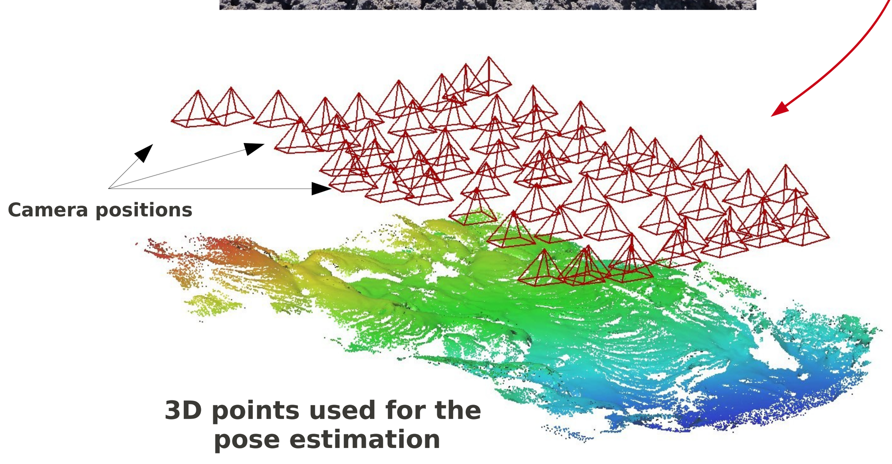
Device

- Canon EOS 60D
- Focal 18 mm
- Image format CR2 and JPG (18Mpx)

Acquisition protocol

- Mimic an aerial survey

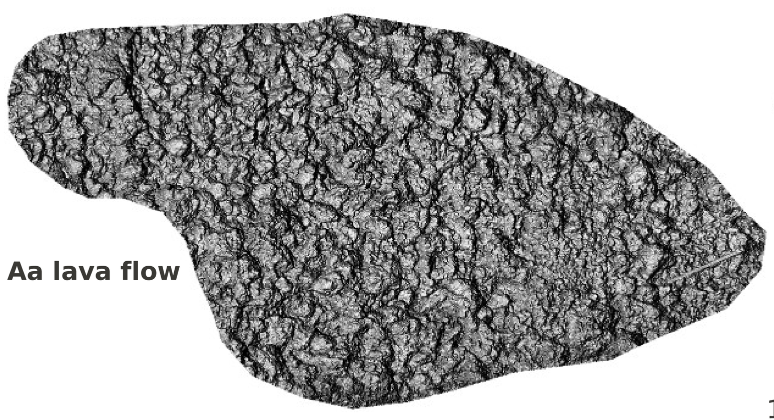




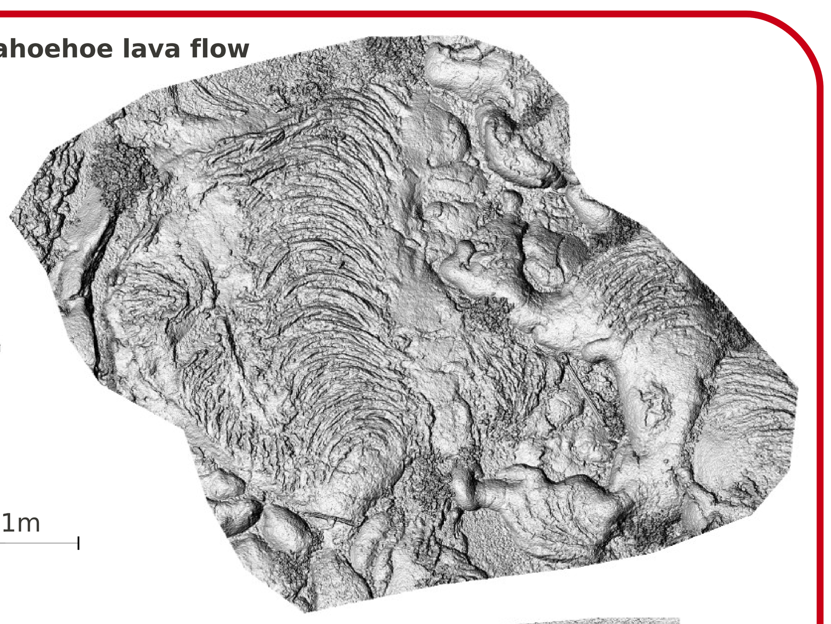
3D points used for the pose estimation

Reconstructed surfaces

Spatial Resolution: 1.2mm/px

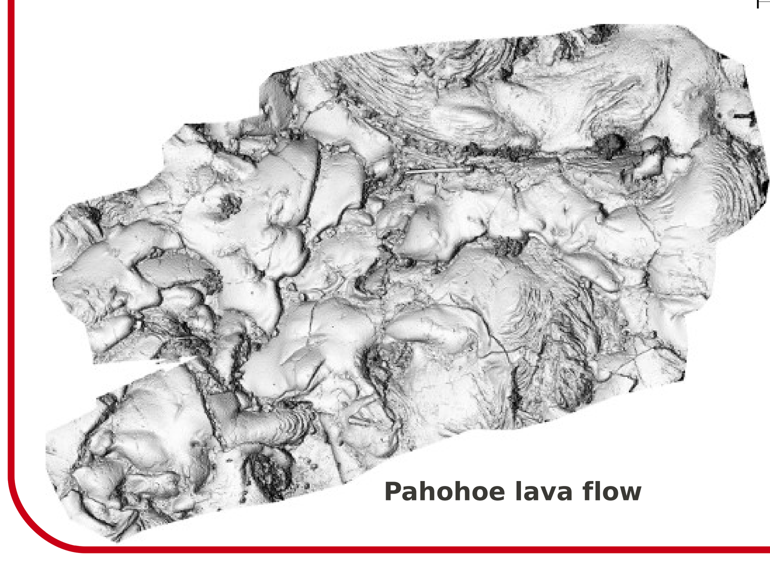


Aa lava flow

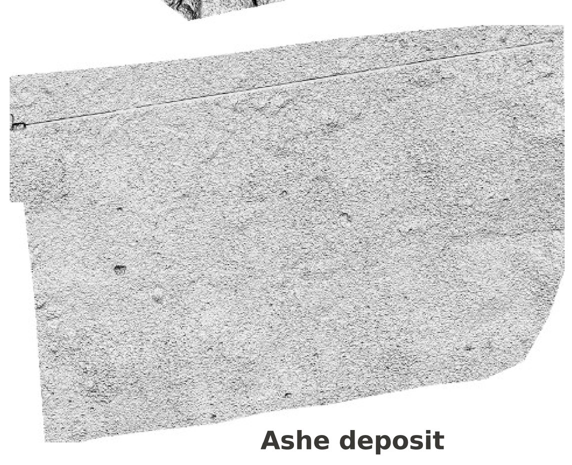


Pahoehoe lava flow

1m



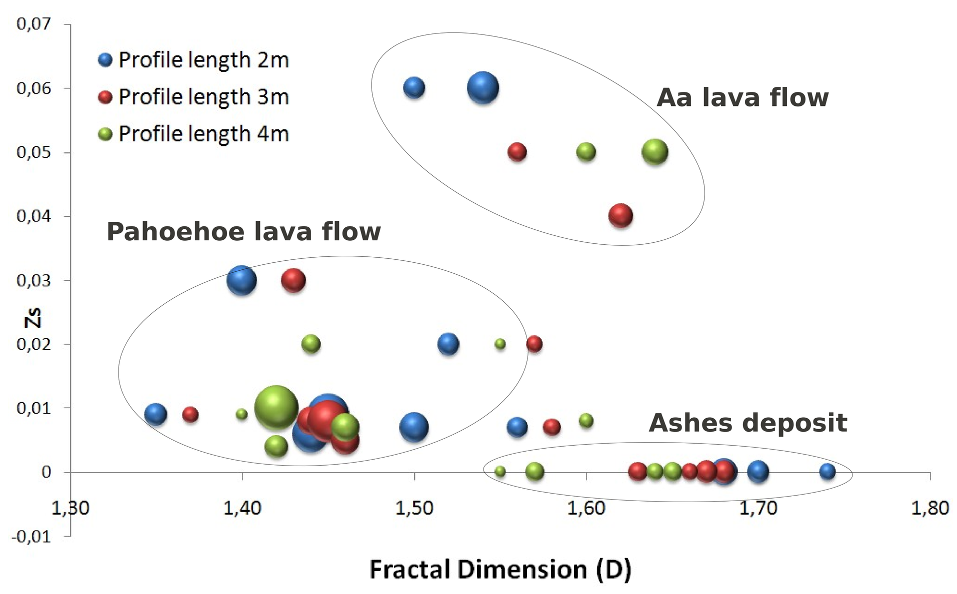
Pahoehoe lava flow



Ashe deposit

Roughness analysis

- 13 areas (5.9 m² to 24.6 m²)
- 100 detrended profiles analyzed of length 2,3,4 m
- Analysis of
  - Standard deviation σ
  - Fractal Dimension D [**Shepard et al.**, 2001]
  - Zs=(correlation lenght)^2/σ [**Zribi&Dechambre**, 2002]



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Conclusions

- Micmac is an open-source software under the CeCCIL-B licence
- Micmac is an efficient tool for generating high resolution surfaces
- Micmac makes photogrammetry affordable for scientists
- The acquisition protocol is simple for e.g. cliff surveillance and detailed terrain analysis
- This tool enables metrology from the reconstructed surfaces

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