EGU General Assembly, 22-27 April, 2012, Vienna, Austria

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

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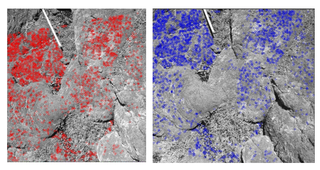
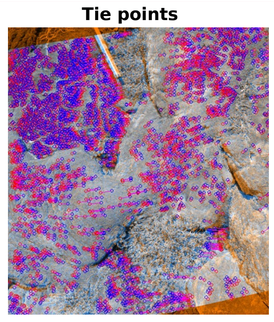
The processing Chain

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

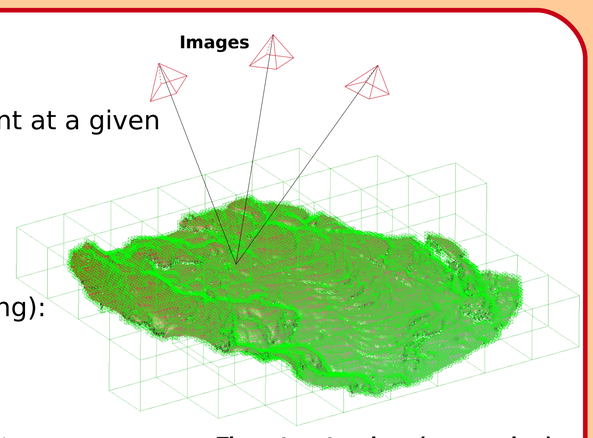
• Computation of the multi correlation coefficient at a given planimetric location (x,y) for different z

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

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

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

Correlation — Constant — Regularization



The octree topology (green cubes) encapsulates the surface

Multi-scale approach

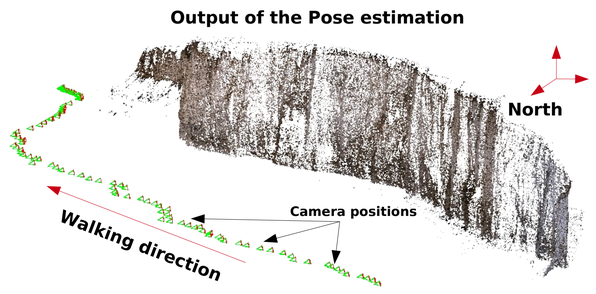
Surveying chalk cliffs

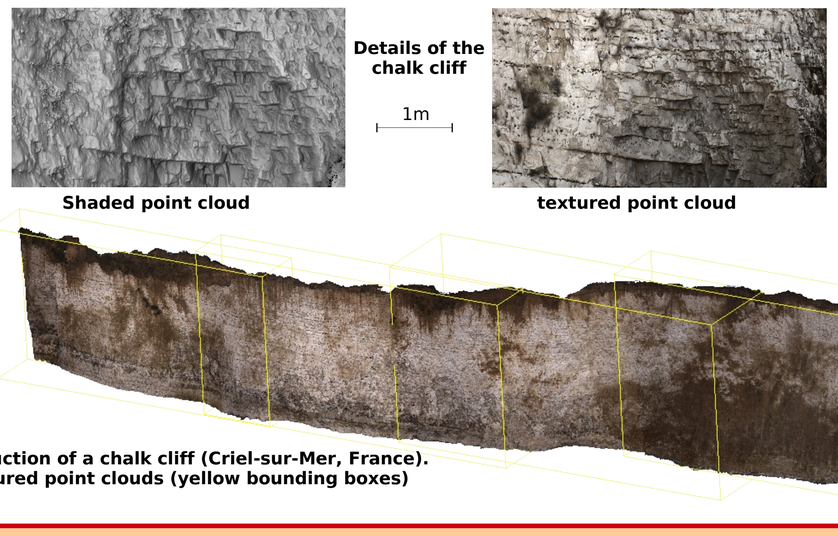
Device

• 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





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

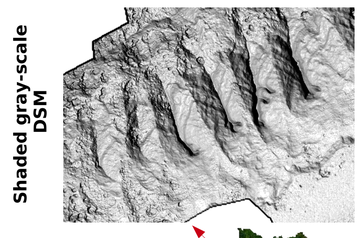
• Canon EOS 5D Mark II
• Focal 70mm
• Image format CR2 and JPG (21Mpx)

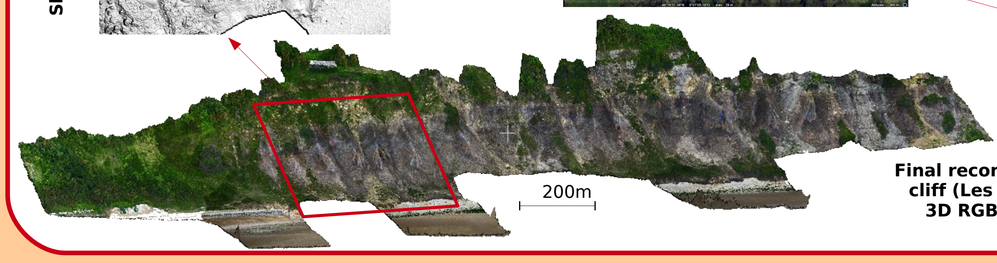
Acquisition protocol

• 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

Géocube

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





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

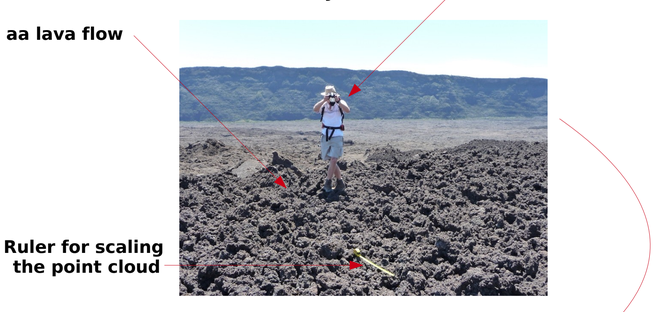
Surface Rougness: Application to Volcanic Terrains in the Piton de la Fournaise, Reunion Island

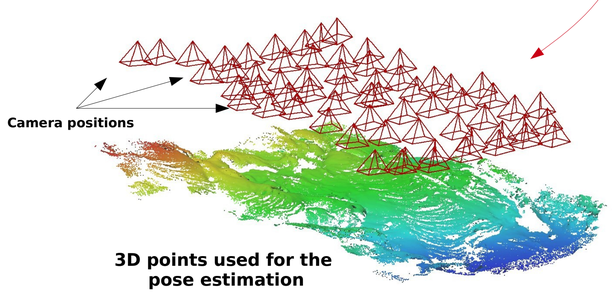
Device

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

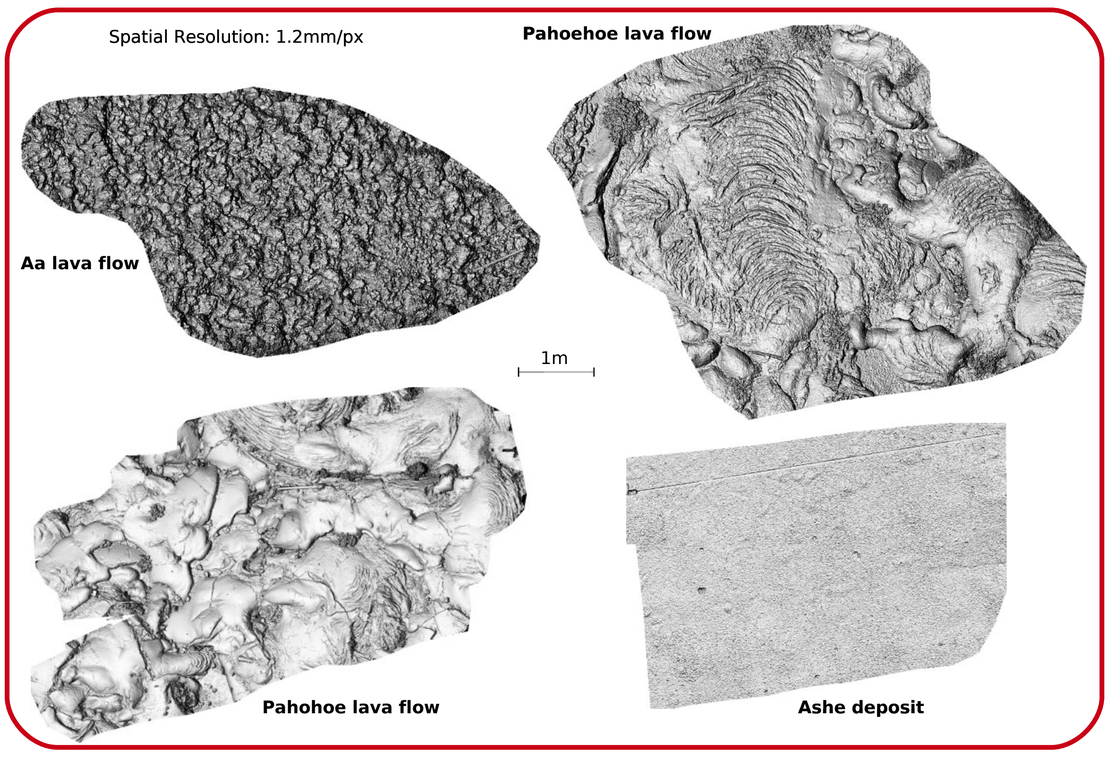
Acquisition protocol

• Mimic an aerial survey





Reconstructed surfaces



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

The authors thank the group Terre Océan Surfaces Continentales Atmosphère (TOSCA/CNES) in the frame of the DEVOIR (*DEformation of active vegetated VOlcanos using Insar and lidaR*) project for funding the field mission in Reunion island.