# Near-automatic generation of lava dome DEMs from photos

Mike R. James[1] and Nick Varley[2]

[1]Lancaster Environment Centre, Lancaster University, LA1 4YQ, UK, (*m.james@lancs.ac.uk) [2]Facultad de Ciencias, Universidad de Colima, Bernal Díaz del Castillo # 340, Colima, Col. México

## 1. Introduction

Digital elevation models (DEMs) and 3D surfaces have been generated from aerial images for many years, but traditional techniques based on conventional photogrammetry usually require specialist software, expertise, and extensive measurement of control points or features .

Using a computer vision approach which combines structure-from-motion[1] and multi-view stereo[2] (**SfM-MVS**), 3D models can be automatically constructed using images from consumer cameras with the following advantages[3]:

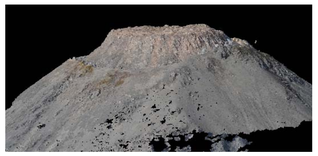
- flexible image capture and free software
- significantly reduced control-point requirements

In volcanology, SfM-MVS has been previously used with ground-based images of lava[4]; here, we explore its use to derive DEMs of the Volcán de Colima lava dome from images taken by different people during light aircraft over flights.

## 2. SfM-MVS method

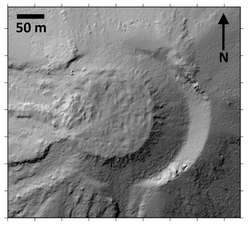
image collection using a consumer camera from different positions

*run the automatic reconstruction*[a]



3D coloured point cloud (without scale or orientation)

*define scale and georeference*[b]




interpolate point cloud into DEM surface

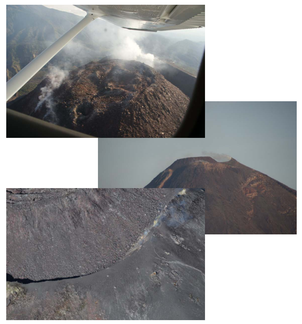
## 3. Colima datasets

- over flights with light aircraft (~30 -200 photos per flight)
- images taken using Nikon D90 with 18-105 mm lens or a Sony DSLR-A200 18-210 mm (110930)

| Date | Camera | Num. of images | Suitability for 3D reconstruction |
|---|---|---|---|
| 26th Dec. 2010 | Nikon | 28 | excellent |
| 27th May, 2011 | Nikon | 114 | excellent |
| 30th Sept., 2011 | Sony | 160 | - |
| 15th Nov., 2011 | Nikon | 122 | poor |
| 26th Dec., 2011 | Nikon | 192 | OK |

### Good image sets

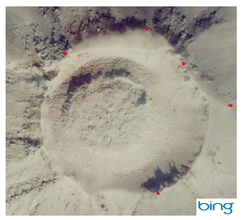
- scene at similar scale in all images
- highly textured scene
- no blurring and few deep shadows
- object of interest dominates most images and is viewed from a number of different positions (e.g. 20 or more)



### Difficult/poor image sets

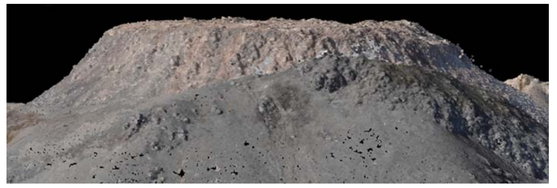
- object of interest small within scene
- obscuration by cloud or plume
- blurring and deep shadows

## 4. Georeferencing




- no ground control targets used
- natural control features identified in 0.5-m-resolution web-sourced aerial imagery
- RMS error to control features ≈1-2 m
- point cloud alignment refined by iterative closest point adjustment of static areas

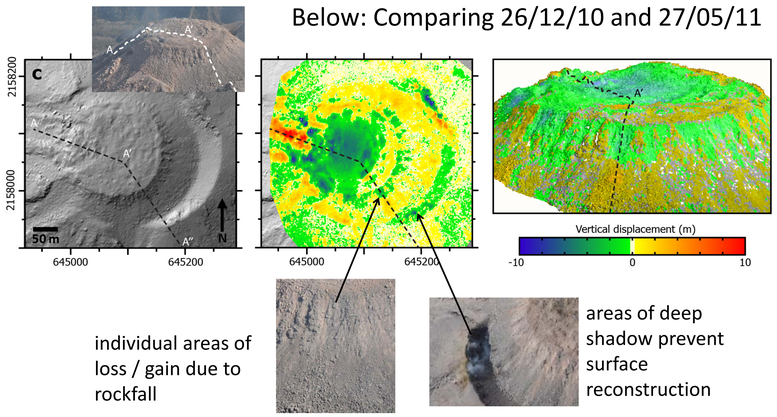
## 5. Results and Conclusions



Example 3D point cloud model (26th Dec. 2010)

Point clouds are converted to DEMs to facilitate comparison

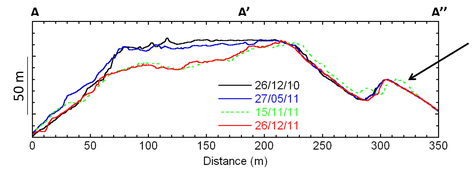
Below: Comparing 26/12/10 and 27/05/11




individual areas of loss / gain due to rockfall

areas of deep shadow prevent surface reconstruction

Cross section (A-A'') through all reconstructions




low quality reconstruction (15/11/11) identified by poor fit on crater edge

- SfM-MVS allows detailed DEM generation from photos
- good quality images will allow structural changes and processes such as rockfall and talus generation to be quantified

## Software and References

[a] **Reconstruction pipeline:** http://blog.neonascent.net/archives/bundler-photogrammetry-package
[b] **Georeferencing:** http://www.lancs.ac.uk/staff/jamesm/software/sfm_georef.htm

[1] Snavely et al (2006), Photo tourism: Exploring photo collections in 3D, *ACM Trans. Graphics*, 25, 835-846, doi: 10.1145/1141911.1141964.
[2] Furukawa & Ponce (2010), Accurate, dense, and robust multiview stereopsis, *IEEE Trans. Pattern Anal. Mach. Intell.*, 32, 1362-1376, doi: 10.1109/TPAMI.2009.161.
[3] James & Robson (submitted to *J.Geophys. Res.*) Straightforward reconstruction of 3D surfaces and topography with a camera: Accuracy and geoscience applications
[4] James et al (2011), Lava channel roofing, overflows, breaches and switching: insights from the 2008-2009 eruption of Mt. Etna, *Bull. Volcanol.*, doi: 10.1007/s00445-011-0513-9.

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