FIRE - Fogo Island volcano: multi disciplinary Research on 2014 Eruption

WP.8 - Eruption Timeline and Lava Modelling

Team

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Objectives

- Reconstruct the detailed succession of events from the start of the 2014 eruption until its demise, characterising variations in eruptive style and emitted products, changes in vent geometry, eruptive/effusive rates and lava flow advancement.

- Develop a 3D Very High Resolution (VHR) morphological model of the 2014 eruptive vent and lava flows.

- Accurately characterise the 2014 eruption in terms of volume magnitude and volcanic explosivity index (VEI).

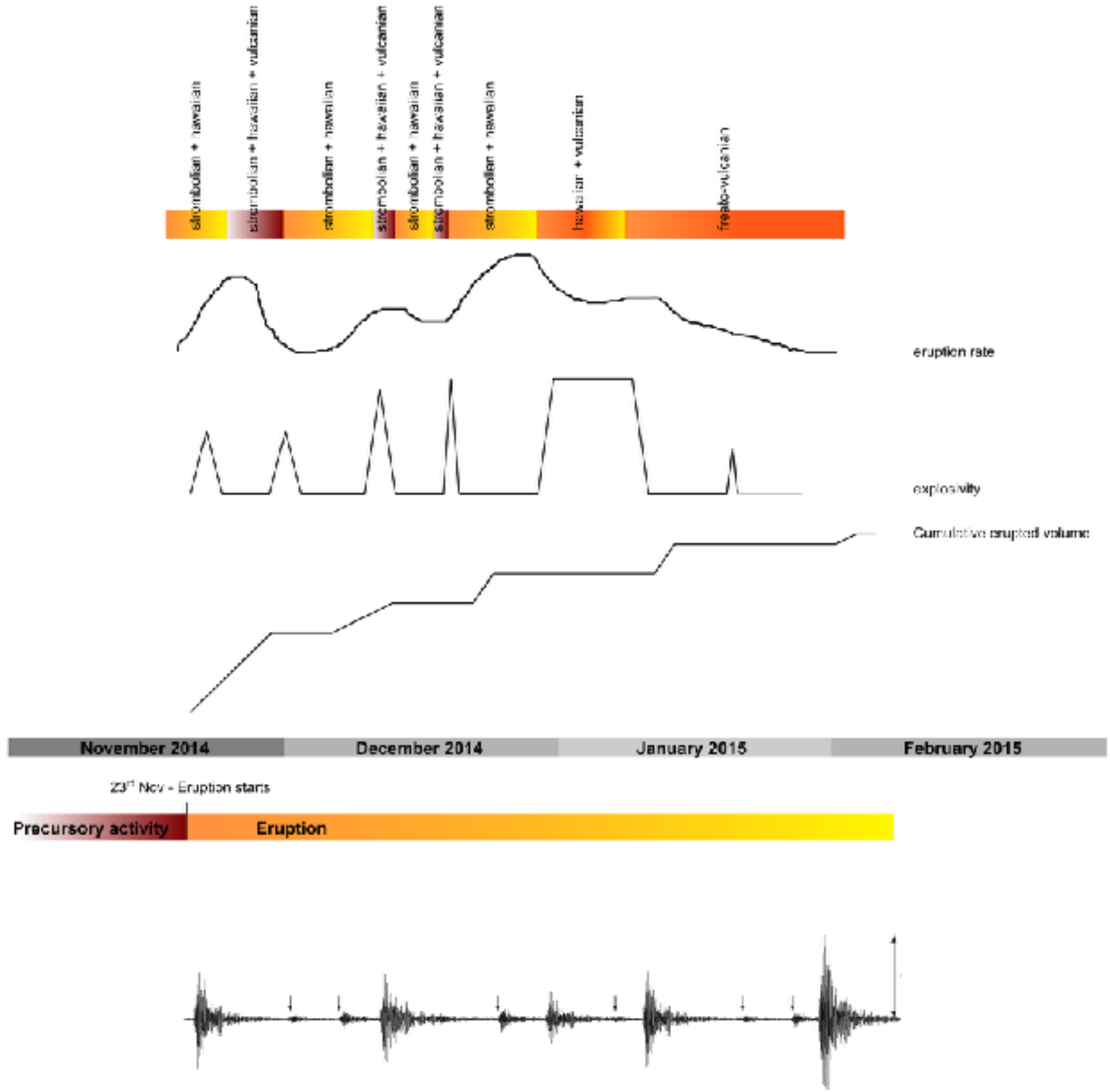
- Validate computational tools to timely and reliably forecast lava flow paths and flow front velocities, suitable to Fogo's terrain and eruptive style.

- Build a probability distribution map of future lava flow paths, in order to identify areas within Chã das Caldeiras that are less vulnerable to future lava cover.

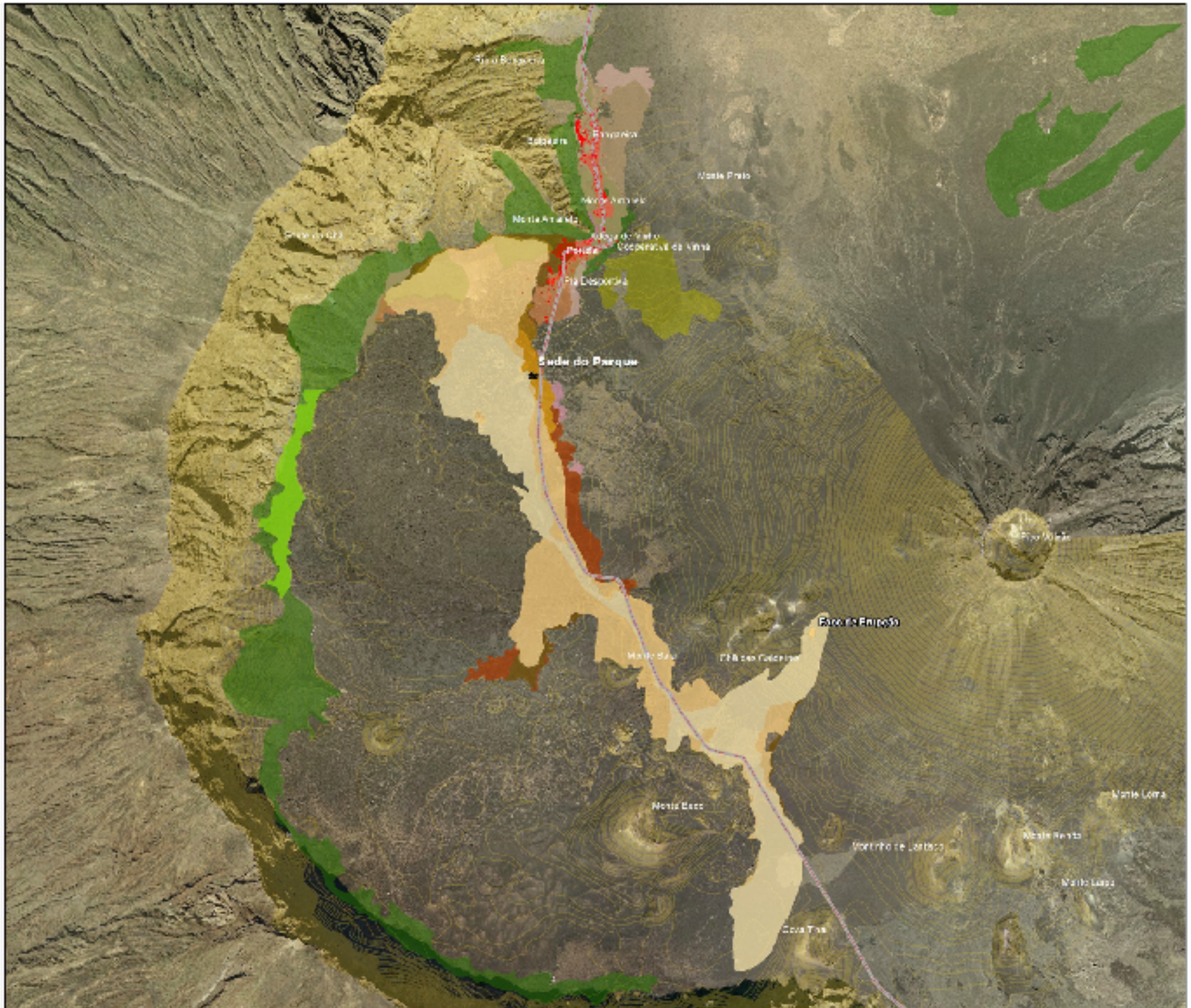
Activities

- T8.1. **Compilation and analysis of in loco eruption observations**, including ample imagery, GPS positioning in differential mode (using the new permanent station at Monte Beco as reference), Differential GPS lava flow mapping and laser-measured lava flow instant speeds.
- T8.2. Analysis of the available **remote sensing imagery** in collaboration with Tasks 2 and T3.
- T8.3. Detailed **field analysis and characterisation of volcanic successions**, including fine scale tephrostratigraphy of proximal and distal deposits, and **lava flow morphological distribution**.
- T8.4. Detailed **reconstruction of the eruption timeline** using the data described above (T8.1., T8.3., T8.3.).
- T8.5. **Correlation of the events** identified in T8.4. with their **seismic** and **geodetic signatures** (T5, 6 and 7).
- T8.6. Acquisition of stereo aerial photos over the 2014 lava field to generate a **Very High Resolution Digital Surface Model (VHR DSM)** with 30 cm of minimum resolution. Operation of a drone Sensefly ebee UAV, equipped with RGB or NIR cameras (which permits a maximum resolution of 5 cm), over the 2014 lava field in order to obtain stereo aerial photos and generate a VHR digital elevation model (30 cm is the minimum resolution, the equipment allows a maximum resolution of 5 cm).
- T8.7. Integration of the VHR DSM obtained in T8.6. with either the TerraSARX pre-eruption DSM (12m - resolution) or with other available pre-eruption DSTM of higher resolution **to produce a full 3D VHR model of the 2014 lava flows**. This model will validate lava flow observations (e.g. channel width and depth, levees height, flow direction) and volumes of erupted products. It will also enable the accurate modelling of future lava flows.
- T8.8. **Calibration and validation of lava flow simulation tools** (e.g. VORIS, FLOWGO, QLavHA), using both Fogo's 2014 eruption imagery and the lava flow 3D model produced in T4.7. The adaptation of the computer software STAV to lava flows will be attempted by incorporating a thermodynamic module.

Eruption Timeline



Levantamento da Cobertutura das Lavas



Legenda

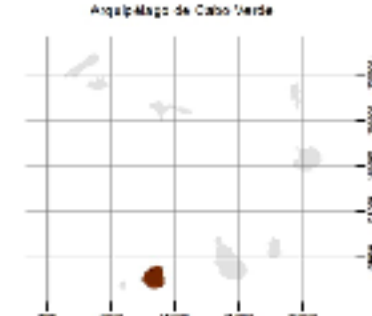
- Sede_Parque
- Estrada Cha das Caldeira
- Curvas de nivel
- Construcao
- Agrofloresta
- Areas Florestais
- Areas Cultivadas

Fluxo de Lava Monitorizacao

Designacao

- 25-11-2014
- 26-11-2014
- 27-11-2014
- 28 11 2014
- 30-11-2014
- 01 -12-2014
- 02-12-2014
- 04-12-2014
- 05 -12-2014
- 06 -12-2014
- 07 -12-2014
- 08-12-2014
- 12 12 2014
- 14 12 2014

Arquipélago de Cabo Verde



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Natural Hazards and Earth System Sciences
Discussions
EGU

Lava flow hazard at Fogo Volcano, Cape Verde, before and after the 2014-2015 eruption

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...tions help to better understand volcanic hazards and may assist emergency preparedness at active ... Fogo Volcano, Cape Verde, such simulations can explain the 2014-2015 lava flow crisis and ... base to better prepare for the inevitable next eruption. In a rapid disaster response effort, we ...pping in the field and a satellite based remote sensing analysis. We produced the first ... ...va flows from combined Terrestrial Laser Scanning ...

AGU PUBLICATIONS

Journal of Geophysical Research: Solid Earth

JGR

RESEARCH ARTICLE
10.1002/2015JB012666

Key Points:
- Complementary information provided by SEVIRI, MODIS, OLI, and ALI is exploited
- Lava flow hazard scenarios during the ongoing eruption at Fogo are produced
- Simulations driven by satellite-derived effusion rates well fit real lava flows

Supporting Information:
- Supporting Information S1
- Data Set S1

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Citation:
Cappello, A., G. Ganci, S. Calvari, N. M. Pérez, P. A. Hernández, S. V. Silva, J. Cabral, and C. Del Negro (2016), Lava flow hazard modeling during the 2014-2015 Fogo eruption, Cape Verde, *J. Geophys. Res. Solid Earth*, 121, doi:10.1002/2015JB012666.

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Lava flow hazard modeling during the 2014–2015 Fogo eruption, Cape Verde

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Abstract Satellite remote sensing techniqu... enable a rapid response during effusive crises a... satellite thermal monitoring system and the MA... hazards during the 2014–2015 Fogo eruption. In ... of recent years, since the lava flows actually invade... allowed mapping of the probable evolution of lav... gaining as much relevant information as possible. HO... to output hot spot location, lava thermal flux, and eff... MAGFLOW simulations of lava flow paths and to conti... Landsat 8 OLI and EO-1 ALI images complement the fi... through time and adding considerable data on lava flo... simulations. The integration of satellite data and modeli... efficient system for global assessment and real time respo... of the effusive activity, (ii) the probable evolution of the la...

1. Introduction

When an effusive eruption is in progress, the hazard posed... assessed by modeling the probability of lava flow inundati... assessment is the timely forecasting of flow paths, flow adv... tion to topography, the behavior of lava flows is controlled b... rheology, heat loss, viscosity, velocity, and flow morphology... *Harris and Rowland*, 2009]. Each of these parameters does n... way; the magnitude of their effect varies with the distance from... vations [*Calvari and Pinkerton*, 1998]. This means that it is necess... the resulting flow extent. As such, lava flow models using a sou... process and rheology of lava, including the way in which effusio... this affects lava spreading, are of paramount ...

AGU PUBLICATIONS

Geophysical Research Letters

RESEARCH LETTER
10.1002/2016GL069457

Key Points:
- Tri-stereo photogrammetry at Fogo increases point cloud density by a factor of 6.5 and reduces area with no height measurements by 43%
- Estimated accuracy of heights in generated tri-stereo Pleiades-1 DEM is <0.51 m
- Lava flow volume and mean output rate of 2014-2015 Fogo eruption are $45.83 \pm 0.02 \times 10^6\ m^3$ and $6.8\ m^3\ s^{-1}$

Supporting Information:
- Supporting Information S1

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Citation:
Bagnardi, M., P. J. González, and A. Hooper (2016), High-resolution digital ...

High-resolution digital elevation model from tri-stereo Pleiades-1 satellite imagery for lava flow volume estimates at Fogo Volcano

Marco Bagnardi[1], Pablo J. González[1,2], and Andrew Hooper[1]

[1]COMET, School of Earth and Environment, University of Leeds, Leeds, UK, [2]Now at School of Environmental Sciences, University of Liverpool, Liverpool, UK

Abstract Resolving changes in topography through time using accurate high-resolution digital elevation models (DEMs) is key to understanding active volcanic processes. For the first time in a volcanic environment, we utilize very high-resolution tri-stereo optical imagery acquired by the Pleiades-1 satellite constellation and generate a 1 m resolution DEM of Fogo Volcano, Cape Verde—the most active volcano in the Eastern Atlantic region. Point cloud density is increased by a factor of 6.5 compared to conventional stereo imagery, and the number of 1 m^2 pixels with no height measurements is reduced by 43%. We use the DEM to quantify topographic changes associated with the 2014–2015 eruption at Fogo. Height differences between the posteruptive Pleiades-1 DEM and the preeruptive topography from TanDEM-X give a lava flow volume of $45.83 \pm 0.02 \times 10^6\ m^3$, emplaced over an area of 4.8 km^2 at a mean rate of $6.8\ m^3\ s^{-1}$.

1. Introduction

Volcanic activity is among the fastest processes causing changes to the Earth's surface, whether new volumes ... or catastrophically removed by explosive events and triggered land... associated with volcanic eruptions provide ...

Deliverables

- D8.1. Detailed reconstruction of the **eruption timeline** specifying eruptive products, events and their geophysical signature (M24).
- D8.2. **Very high resolution DEM** of Chã das Caldeiras, including the vent and lava flows of the 2014 eruption. (M12).
- D8.3. **Numerical 3D lava flow model** completed, calibrated using the 2014 observations. **Maps of lava flow paths** predicted for hypothetical eruptive scenarios (M36).

Missions/Fieldwork

- 1st Fieldwork mission - December 2016
- 2nd Fieldwork mission - December–June 2017/2018

Objectives

- Characterise in detail the 2014 eruption, its products and resulting landscape, in order to gain insight into the volcanic system and its dynamics.

- Develop lava flow forecasting tools adapted to the local conditions, calibrated with observations of the 2014 eruption.