Using multiple datasets to characterise the recent eruptive history of Volcán de Fuego, Guatemala

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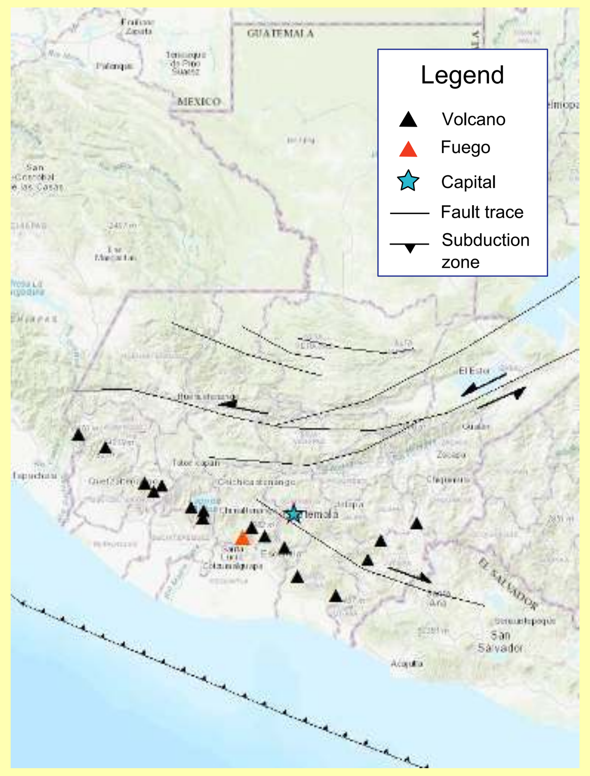
Background



The interpretation of volcanic activity by analysis of geophysical signals is inherently uncertain. Studying signals across various timescales may reveal changes that are otherwise obscured.

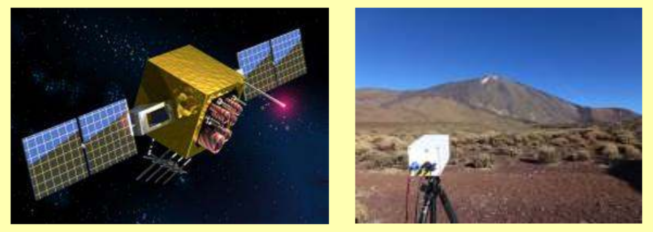
Volcán de Fuego is a volcano in Guatemala. Fuego displays persistent Strombolian activity punctuated by paroxysms of extraordinary violence [1]. Eruptive activity in 2016 followed a distinctive repeated cycle. Sporadic fire fountaining and summit explosions gradually increased in frequency and intensity. Lava flows preceded a violent paroxysm that produced pyroclastic flows.

Here we present preliminary results from multiple datasets to compare long- and short-term patterns, and discuss future opportunities for multi-parameter monitoring.

Above: view of Fuego from La Reunion golf resort, located 7km to the south-east. Images in the *Climax* section are from this camera. **Left:** map of Fuego and Guatemala.

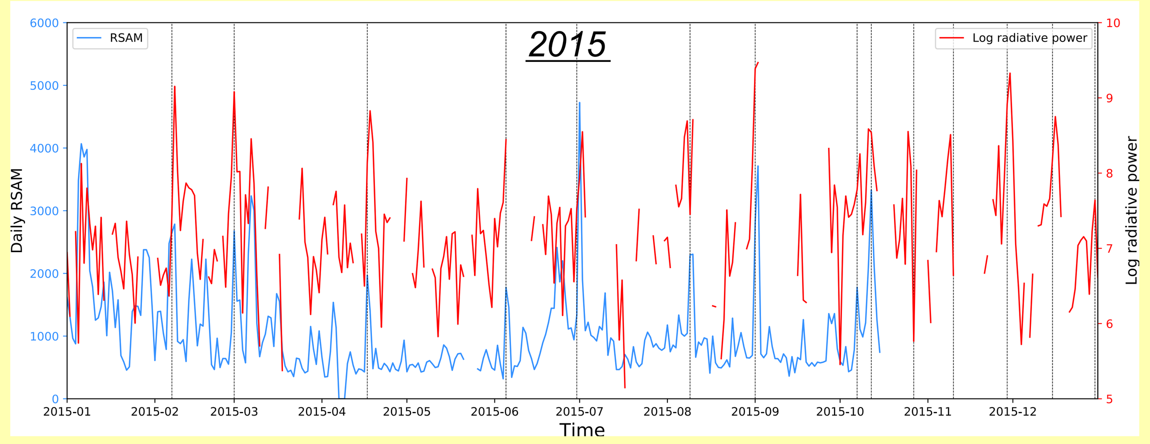
Data types and methods of investigation

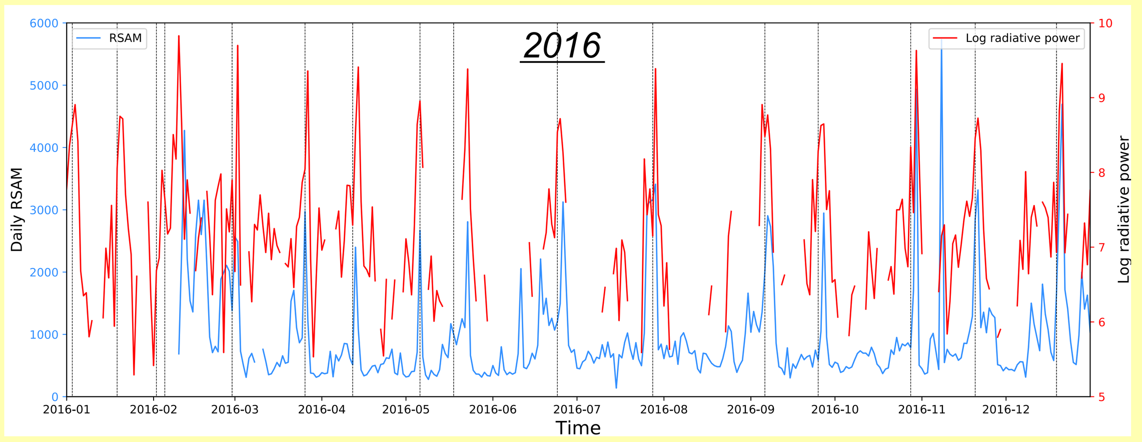
Our primary data source is infrared images captured by a multispectral NicAIR camera between March and October 2016. This camera is located 7km SE from Fuego's summit; its field of view captures Fuego's eastern flank, and the Las Lajas and El Jute ravines. Additional datasets include radiative power values from the MODIS satellite; RSAM values provided by INSIVUMEH; and visual imagery and derivative products produced by members of the University of Bristol´s School of Engineering.

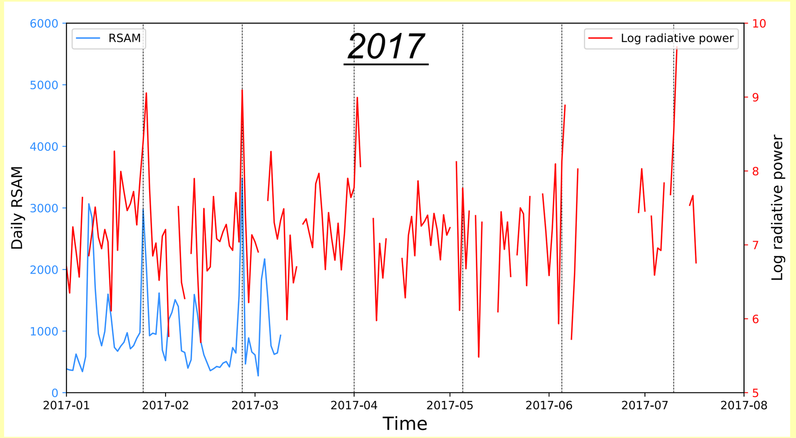


Above: examples of various methods used to capture remote sensing data associated with volcanic eruptive activity.

Overview of activity: 2015 to 2017







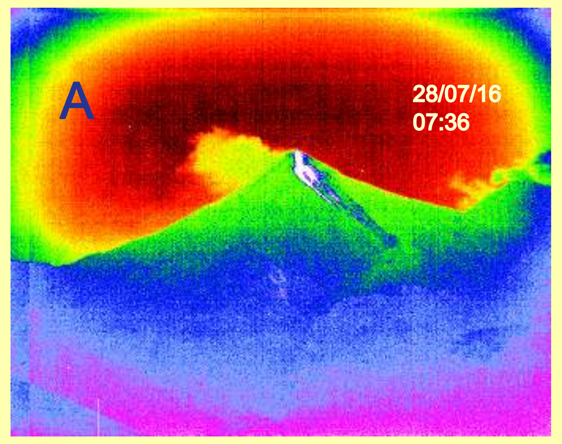
From top: Activity of Fuego between 2015 and 2017 described by timeseries of daily real-time seismic amplitude measurements (RSAM) (in blue) and by radiative power in logarithmic scale (in red). Paroxysms are indicated with a vertical dashed line. **Credit:** MIROVA data from Dr. Diego Coppola.

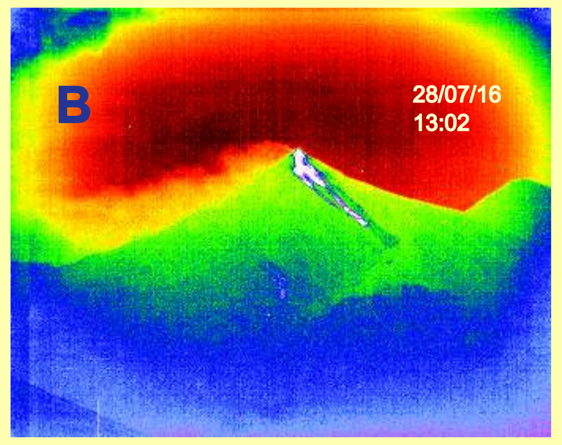
These figures show Fuego's activity between January 2015 and July 2017. The data describe several repeated patterns of behaviour.

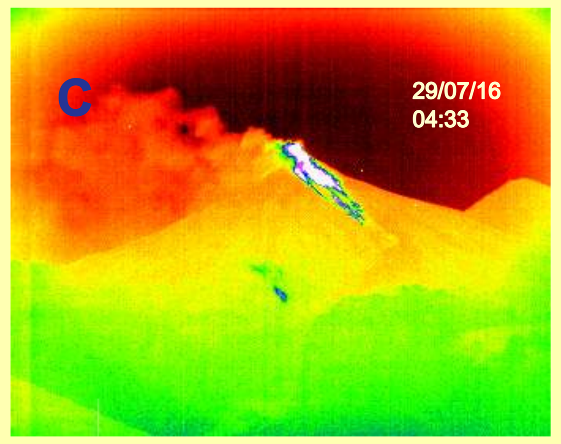
There is a consistent increase in seismic activity prior to paroxysm. The largest RSAM value is on 9th November 2016, a day not associated with significant seismic or volcanic activity. The computer INSIVUMEH used to process seismic data failed in October 2015, and a new machine was installed in February 2016. This accounts for the lack of RSAM values between these dates.

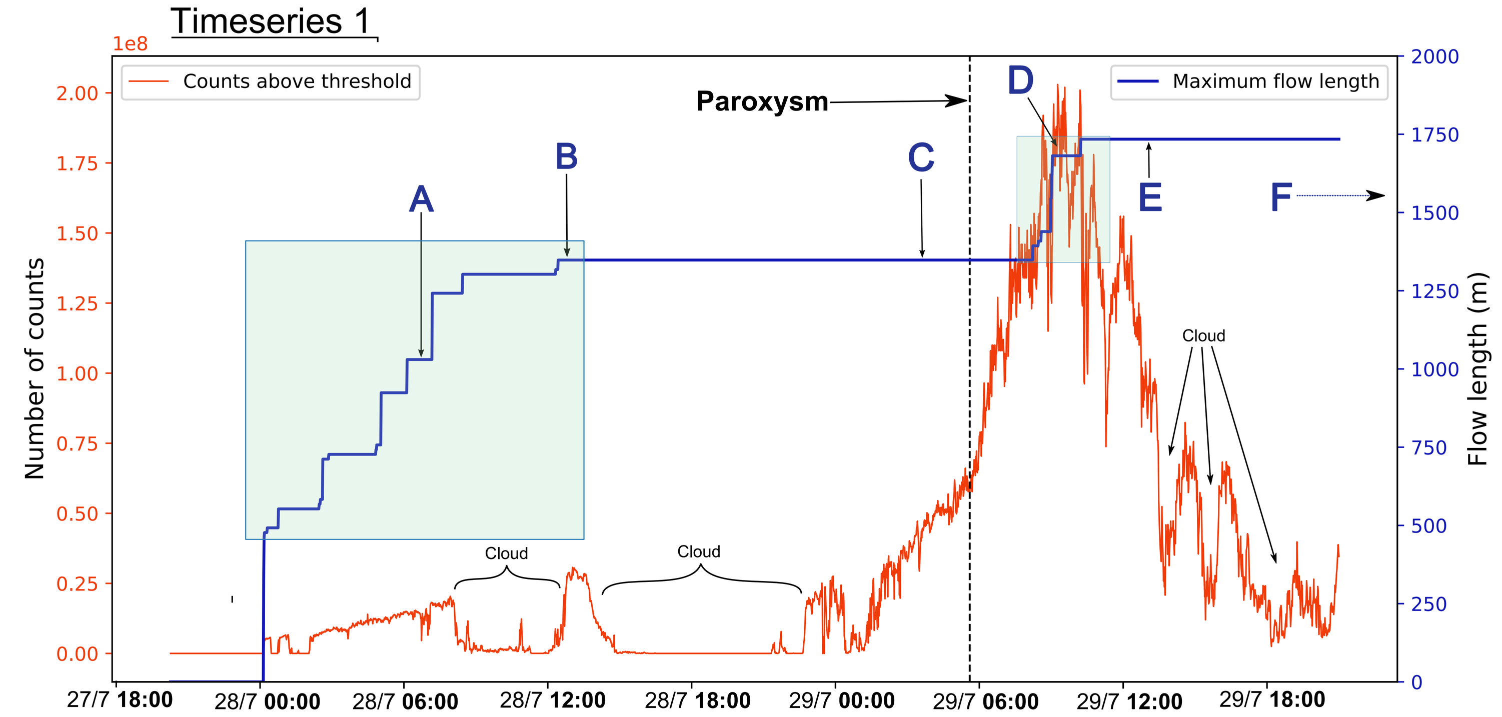
Radiative power values correlate strongly with both seismic values and paroxysmal activity. Previous work has suggested that Fuego exhibits least activity directly after a paroxysm. However, Fuego appears to exhibits least radiative power midway between two paroxysms.
It is possible that explosive activity after paroxysm is invisible to observers at lower elevations, due to loss of summit elevation by excavation of crater material during paroxysm.

Climax: eruptive cycle 28th - 30th July 2016

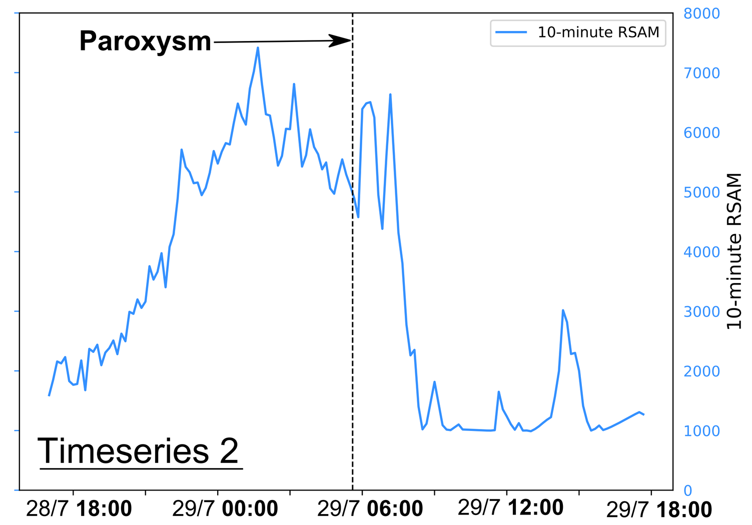


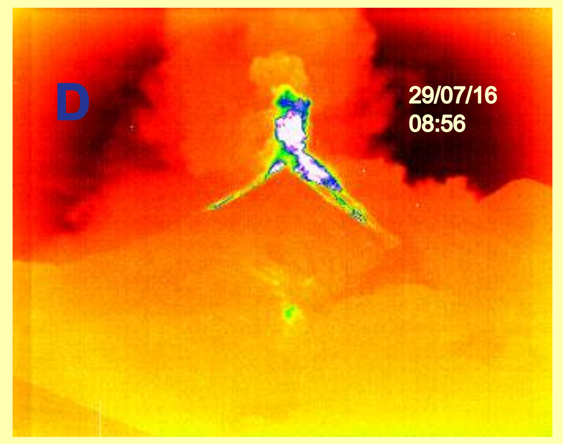


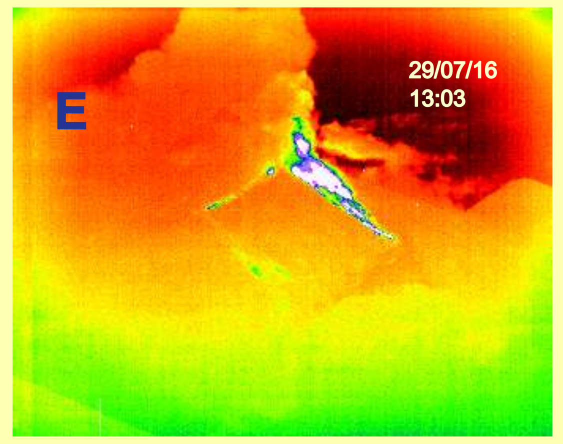


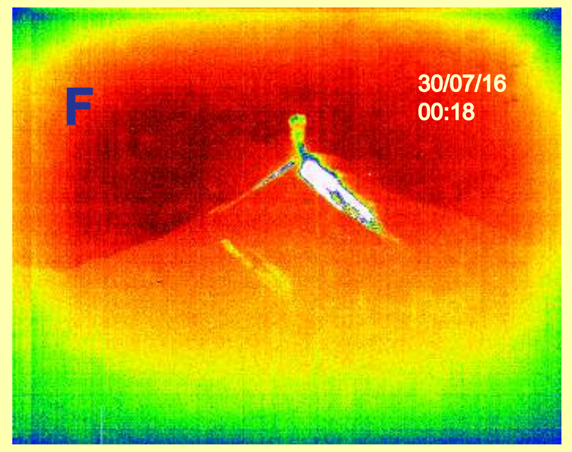


Scan the QR code to see the paroxysm!









Images, A - F: Infrared images of Fuego taken between 28th and 30th July 2016. Local time and date of each image is recorded in white text on the right side of the image, and the position of each image is indicated in **Timeseries 1**. Timeseries 1 describes increase in length of lava flows in the Las Lajas ravine (in **dark blue**), and number of counts above a threshold value corresponding to hot pixels (in **burnt orange**). **Timeseries 2** describes 10-minute RSAM values during the most intense phase of paroxysm (in **blue**). All times and dates are in local time, and onset of paroxysm is indicated.

Above: Incandescence at Fuego. Photo from INSIVUMEH.

The eleventh paroxysm of Fuego in 2016 began at 05:36 local time (12:36 UTC) on 29th July [2]. It was preceded by hours of summit explosions and elevated seismicity. The eruption lasted approximately 44 hours. During its development, we observed the emplacement of lava flows and the creation, intensification, and eventual decay of an eruptive column.
Lava effusion occured in two distinct periods (see shaded blue boxes in Timeseries 1). The second period of effusion coincides with paroxysm onset. The maximum calculated flow length was 1734.26 m. We estimate a total extruded volume of 182,097 m^3 of lava, giving an average effusion rate of 1.0376 $m^3 s^{-1}$. The first effusive period generated 141,543 m^3 of lava, representing 77% of the entire volume extruded in Las Lajas during this paroxysm.
A maximum value of 7,418.6 was observed at 01:40 on 29th July, followed by a decrease to 4,576.8 at 05:50. This minimum preceded a second maximum of 6,505.3 observed at 06:20, tallying with paroxysm onset. RSAM decreased sharply after 07:30.

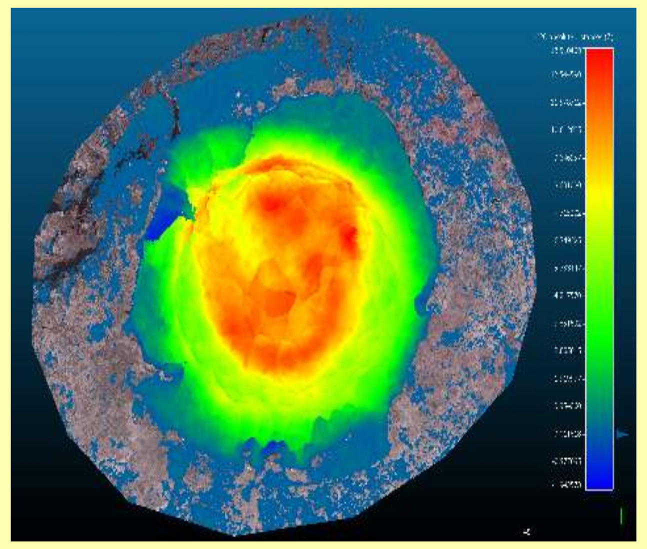
Discussion

The July 2016 paroxysm of Fuego displays some features in common with the 2002-03 effusive eruptions of Stromboli, in the apparent triggering of a paroxysmal event by sustained effusive activity. The predictable cycle of Fuego's recent activity may be explained as the start of a paroxysm provoked by the extrusion of a threshold cumulative volume of lava [3]. In this way, a violent paroxysm at Fuego could be seen as the ultimate consequence of continuous effusion dynamics [4].

The integration of multiple datasets to effectively describe eruptive activity at Fuego has been shown [5]. We believe that juxtaposing information from infrared, visual, and satellite imagery, together with seismic data, may clarify the more mysterious aspects of Fuego's behaviour.

Future efforts

Future work will focus on better understanding the precise mechanisms that trigger paroxysm at Fuego. In November 2017 we will unite existing data with data obtained from unmanned aerial vehicles (UAVs).



Left: a composite image taken of Fuego's summit crater between 19th and 23rd February 2017. The image was created by calculating elevation differences between two DEMs taken by sequential UAV flights. The image highlights elevation increase prior to a paroxysm on 25th February, and illustrates growth of a transient cone of ballistic material. **Photo credit:** Dr. Kieran Wood.

References

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