Affordable Technology for Monitoring Degassing Volcanoes

Lara Smale (1), Reni Magbagbeola (2), Stephen Hailes (2), **Christopher Kilburn** (1),
Erouscilla Joseph (3), and Carlisle Williams (4)

(1) University College London Hazard Centre, Earth Sciences, London, U.K, (2) University College London, Computer Sciences, London, United Kingdom ,
(3) Seismic Research Centre, University of the West Indies, St Augustine, Trinidad & Tobago, (4) Disaster Management Coordination Agency, Montserrat

UCL

We are seeking partners to develop and deploy integrated low-cost geochemical and geophysical monitoring networks. For more information, please see the contact details below.

1. Introduction

Monitoring of actively degassing volcanoes is essential for the timely detection of signals of unrest and understanding the environmental-health hazard posed by volcanic gases. However, the high costs of conventional methods of surveillance often leads to poor spatial and temporal sampling or prohibits monitoring activities entirely.

Following pilot tests at Campi Flegrei, Italy [1], EVANeSCE, a joint initiative between UCL and the University of the West Indies Seismic Research Centre (UWI SRC), has been established to develop low-cost sensors capable of real-time acquisition of data using Commercial Off The Shelf (COTS) components.

Here we present on-going work testing prototype designs for sensing CO_2 at Sulphur Springs, Saint Lucia in the West Indies.

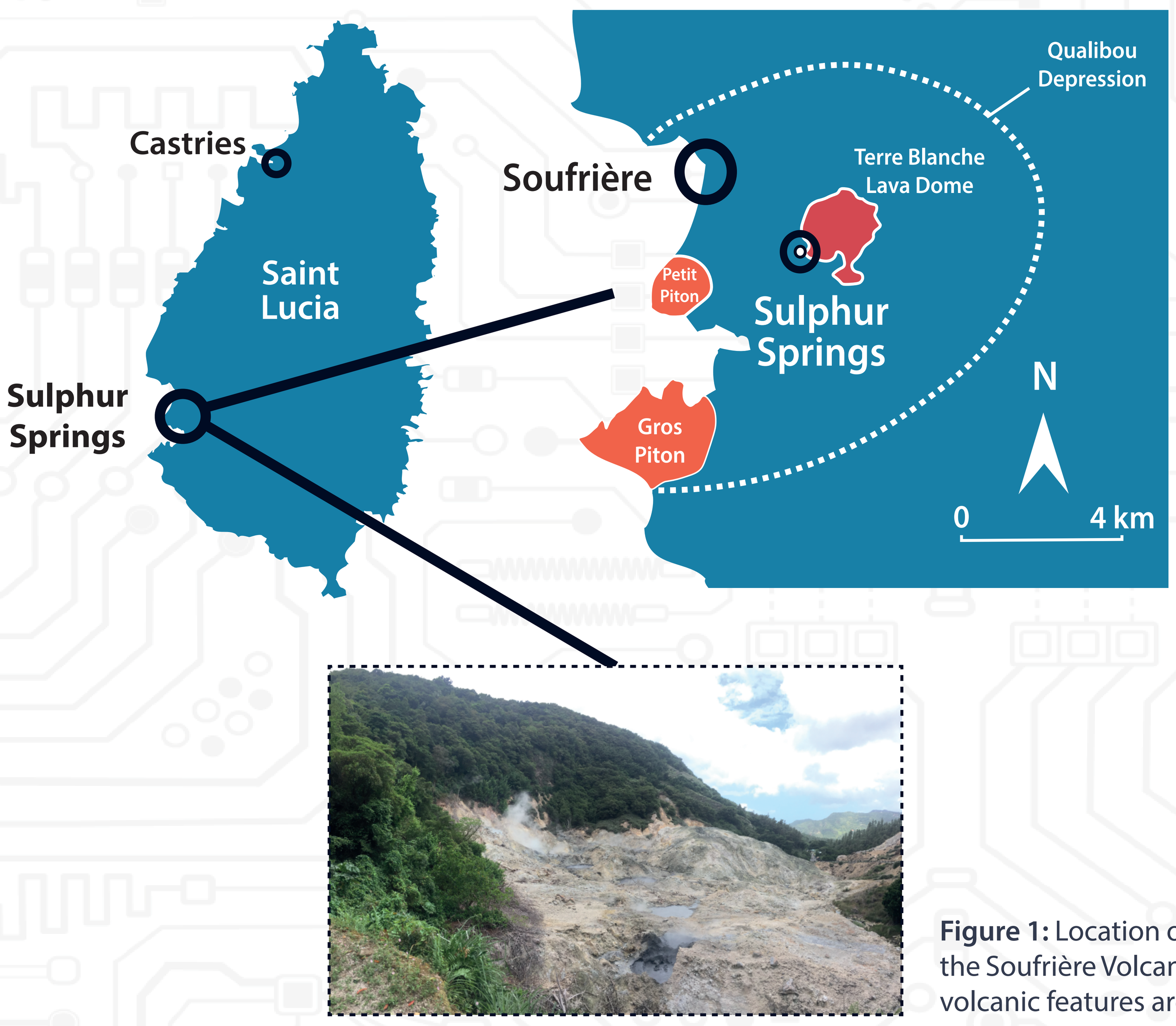


Figure 1: Location of Sulphur Springs within the Qualibou Depression, part of the Soufrière Volcanic Centre and overview of the degassing area. Positions of volcanic features are adapted from [2].

2. Test Site

Sulphur Springs is an active hydrothermal area located in the Soufrière Volcanic Centre (SVC) (Fig. 1). It is characterised by a high degree of hydrothermal alteration, diffuse fumarolic activity and bubbling pools [2]. The dry fraction of fumarole gases is dominated by CO_2, followed by H_2S. The area is considered to be the most likely location of future volcanic activity on the island and is a major tourist attraction that attracts an average of 200 000 visitors a year [2].

It presents an ideal test location due to the variable degassing conditions across the site and the presence of an established geochemical monitoring programme run by the UWI SRC since 2001.

3. The Sensors

The sensors have been designed to be adaptable to both the environmental context and user requirements. Currently under development are methods for monitoring CO_2 concentrations in the atmosphere and soil CO_2 flux.

Each unit contains a COTS Non-Dispersive Infra-Red (NDIR) CO_2 sensor with a maximum detection limit of 10 000 or 50 000 ppm, which is connected to a Lo-Py micro-controller (fig. 2A). The electronics are housed in adapted household storage containers or ABS electronics enclosures and we are currently experimenting with custom 3D printed components, e.g. sampling chambers (fig. 2B). Data is wirelessly transmitted from each unit to a base station containing a Raspberry Pi computer (fig. 2C) and uploaded to the internet. Additional SD memory cards ensure continuous data logging in case of radio connectivity or internet connection failure. A sustainable power supply is achieved through the use of solar panels and rechargeable lead-acid batteries (fig. 2D).

The accompanying code contains a series of user definable options such as sampling rate, sleep-modes for power conservation and an alarm function if an assigned value is exceeded. In the case of an error the sensors can automatically reboot or be triggered remotely.

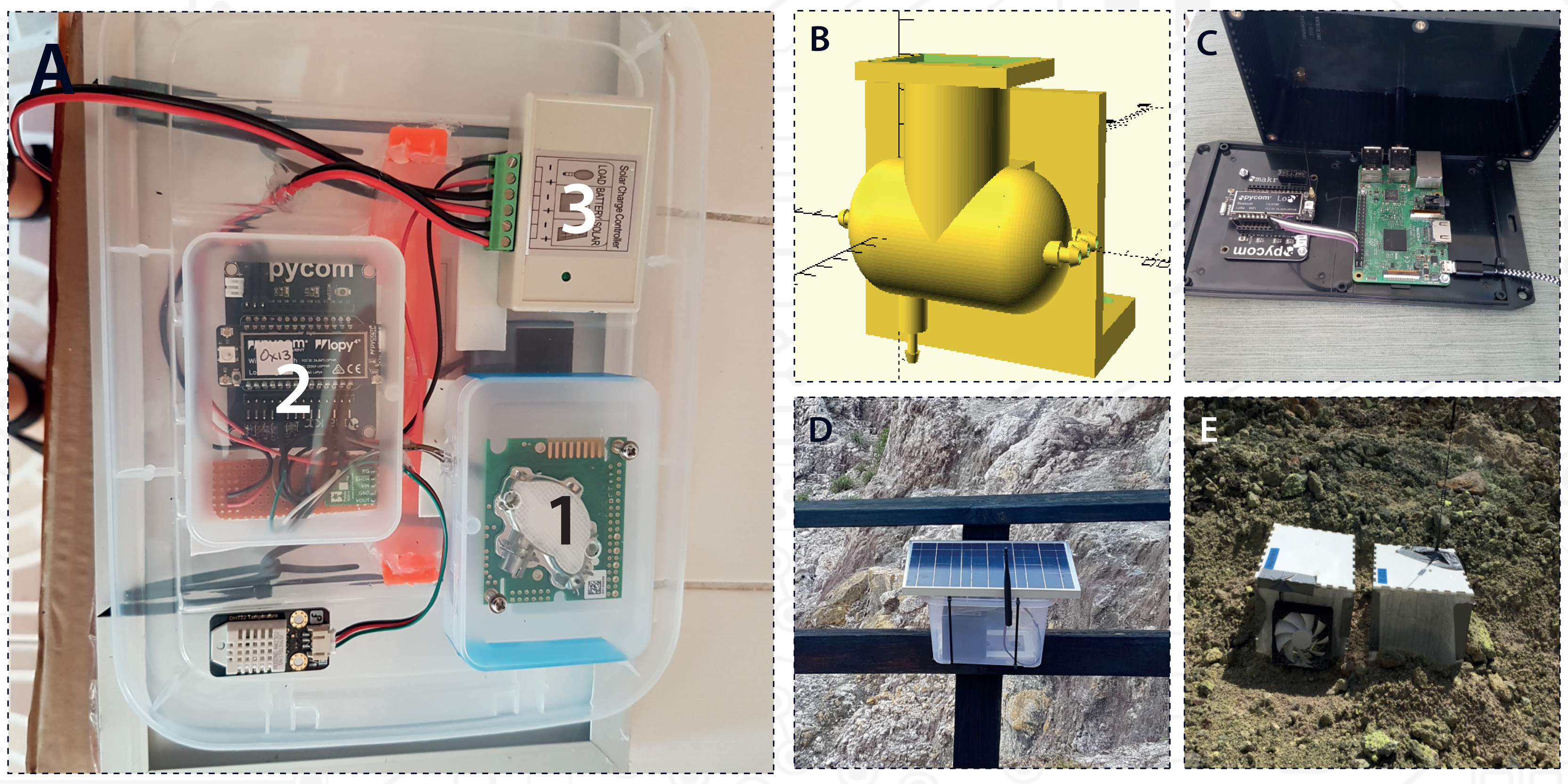
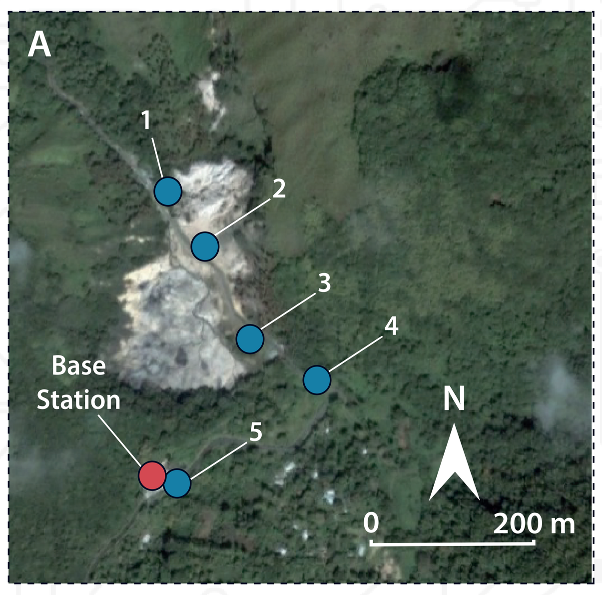


Figure 2: A. The essential components of each sensor. 1 is a NDIR CO_2 sensor, 2 is the Lo-Py micro-controller and 3 is the power supply from the solar panel. B. Example of a 3D printed sample chamber to which pumps may be attached. C. Raspberry Pi computer in the base station. D. Atmospheric CO_2 sensor set up with solar panel and radio antenna. E. Measuring soil CO_2 flux. Photos A-D: Steve Hailes.



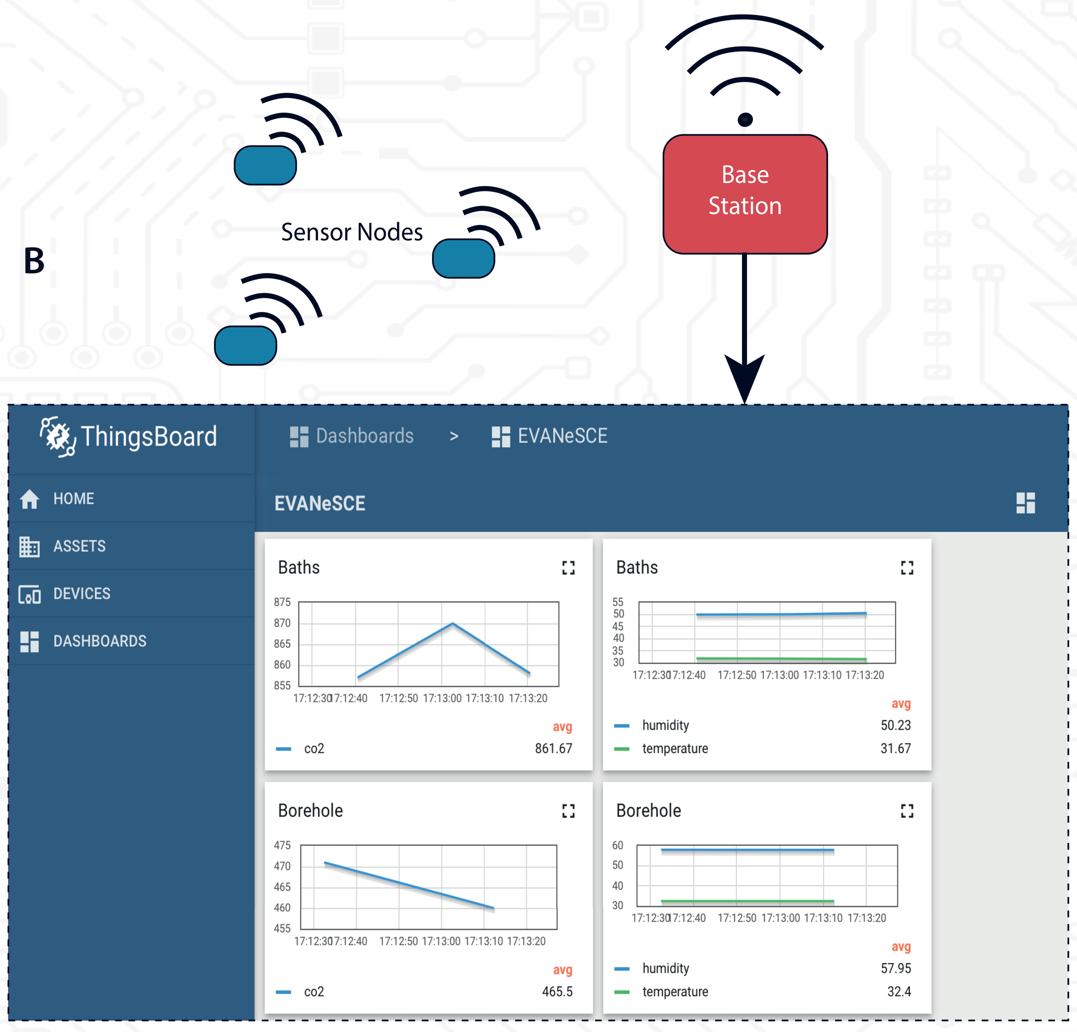


Figure 3: A. shows the locations of sensor nodes monitoring atmospheric CO_2. B. Schematic of the network and screenshot of the data from each sensor as it appears on the ThingsBoard platform.

4. Example Application

In March, 2018 five atmospheric CO_2 sensors were installed at Sulphur Springs (fig. 3A) to assess how they function in-situ over time and to monitor fluctuations in the gas concentration across the site. They are located in the areas of highest foot traffic, sampling locations in the path of the prevailing plume direction and surrounding the main degassing field. Each sensor measures the CO_2 concentration every twenty seconds and is connected to a radio aerial, which has a range of 2 km (provided a clear line of sight) that transmits the data to the base station for internet upload.

Data collection and visualisation occurs in real-time using ThingsBoard, an open-source Internet of Things (IoT) platform (fig. 3B) and can be accessed anywhere with an internet connection.

Early results show the sensors to be performing well and indicate that they are well suited for the rapid detection of spatial and temporal changes in atmospheric CO_2 concentration.

5. Lessons Learned

Previous work has shown that the sensors for atmospheric CO_2 concentration yielded comparable values to those obtained using conventional methods [1], whilst testing at Sulphur Springs confirms that the sensors can provide meaningful information at a fraction of the cost (c. one-tenth). As yet the initial designs for measuring CO_2 flux have been unable to withstand the acidic conditions in areas of visible degassing for periods of more than five hours but it is expected that this issue can be resolved by improved isolation of the electronics. Direct Connection?

The intended primary function of the sensors is for monitoring degassing over extended areas, but early testing suggests they have significant potential for other applications such as site characterisation for optimal siting of conventional instruments, providing data for hazard communication products and gas monitoring for non-volcanological purposes (e.g. geothermal exploration and carbon capture and sequestration).

6. Future Work

Scope for future work at Sulphur Springs includes:

- 3D plume mapping using sensors mounted on drones
- Development of a smart phone application showing maps of high and low concentrations
- Integration of sensors into a live monitoring system
- Open-Source publication of tested designs and accompanying code

Figure 4: Testing the sensor connection.

7. References

[1] Kilburn, CRJ et al. (2016), Cities on Volcanoes 9, Poster
[2] Joseph et al. (2013) J. Volcanol. Geotherm. Res., 254, 23-36

More Information?

Email: **Lara Smale** (lara.smale.13@ucl.ac.uk) or **Christopher Kilburn** (c.kilburn@ucl.ac.uk)

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UCL Hazard Centre, Department of Earth Sciences, University College London, Gower Street, London, WC1E 6BT, UK

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