Affordable technology for monitoring remote volcanoes

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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.

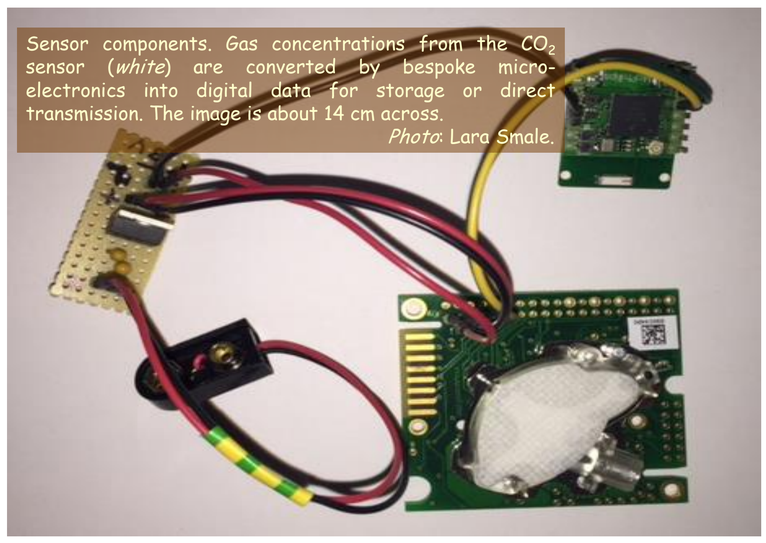
Summary. *Pilot low-cost gas sensors have been field tested for CO_2 emissions across the Campi Flegrei volcano, west of Naples in southern Italy. The results agree well with contemporaneous measurements from conventional instruments. The pilot sensors will next be adapted for global deployment as part of affordable networks for the long-term monitoring of volcanoes in remote locations.*


Degassing at Solfatara Crater, Campi Flegrei. *Photo:* Christopher Kilburn.

1. Monitoring remote volcanoes

Most active volcanoes are not regularly monitored or not monitored at all. The majority also occur in nations that have limited economic resources for the long-term monitoring of volcanoes.

Project Volcalarm is a new Anglo-Italian initiative for developing low-cost sensors for the real-time acquisition of geochemical and geophysical signals of volcanic unrest. Here we present preliminary results for CO_2 sensors tested against conventional methods for monitoring degassing at the Campi Flegrei volcano in southern Italy.

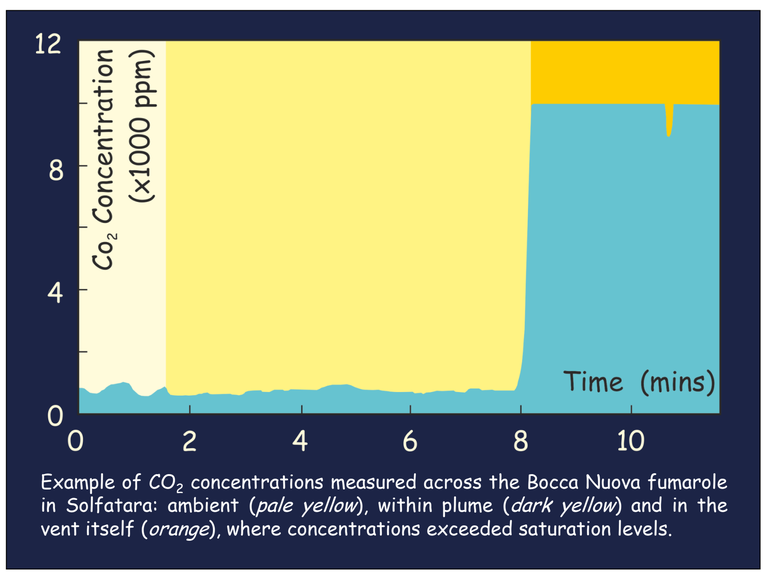

Sensor components. Gas concentrations from the CO_2 sensor (*white*) are converted by bespoke micro-electronics into digital data for storage or direct transmission. The image is about 14 cm across. *Photo*: Lara Smale.

2. Affordable gas sensors

The miniaturized sensors consist of a commercial detector that measures CO_2 concentrations by non-dispersive infrared spectroscopy (www.CO2Meter.com). Bespoke components designed at UCL convert gas concentrations into digital data. For the feasibility study, the data were stored locally on a micro-SD card, but this can be substituted with a wireless transmission system for relaying signals to remote locations. The detector has a total detection range from 0 to 10,000 ppm and notional lifetime of at least 15 years.

3. Why Campi Flegrei?

The active volcanic district of Campi Flegrei covers 100 km^2 by the western suburbs of Naples. Surface degassing has been recorded since at least Roman times and is today regularly monitored from Solfatara, near the eastern coast of the volcano. Gas emissions are monitored using a MultiGAS sensor and GasFinder 2.0 tunable diode laser absorption spectroscopy [1,2]. The data provide an ideal as reference for testing the accuracy and reliability of low-cost gas sensors.



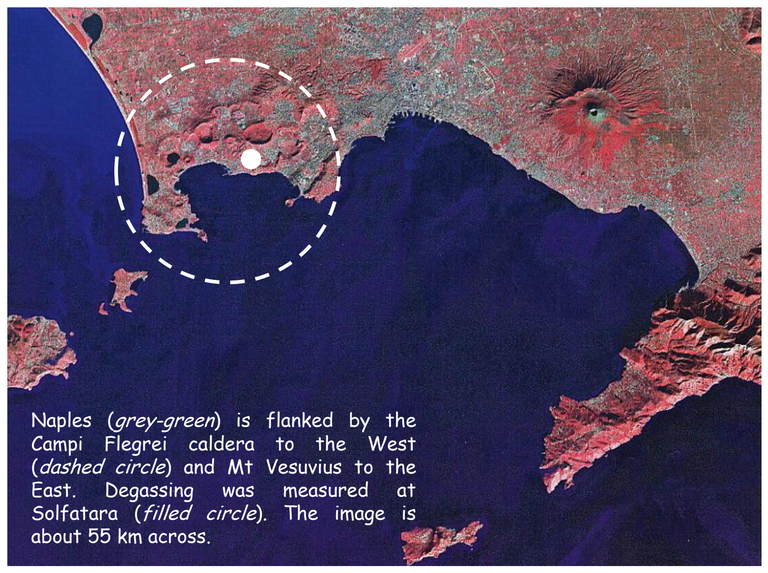
Example of CO_2 concentrations measured across the Bocca Nuova fumarole in Solfatara: ambient (*pale yellow*), within plume (*dark yellow*) and in the vent itself (*orange*), where concentrations exceeded saturation levels.

4. Results

The Bocca Nuova fumarole is degassing at vent temperatures of 160^{0}C. Conventional monitoring yields typical CO_2 concentrations of c. 400 ppm for the ambient atmosphere and 600-1,200 ppm in the plume, becoming larger closer to the vent [1,2]. The corresponding values from repeated measurements with the low-cost sensors yielded c. 800 ppm in the ambient atmosphere and plume.

The plume values are consistent with conventional measurements. The ambient values were higher than expected, possibly due to contamination from the plume. Within the vent itself, CO_2 concentrations exceeded the saturation values for the sensors.


The Bocca Nuova sampling area (*dashed circle*) in Solfatara. *Photo*: Christopher Kilburn.


Naples (*grey-green*) is flanked by the Campi Flegrei caldera to the West (*dashed circle*) and Mt Vesuvius to the East. Degassing was measured at Solfatara (*filled circle*). The image is about 55 km across.

4. Future development

Our preliminary studies show that low-cost CO_2 sensors yield gas concentrations comparable to values obtained from conventional, high-cost instruments.

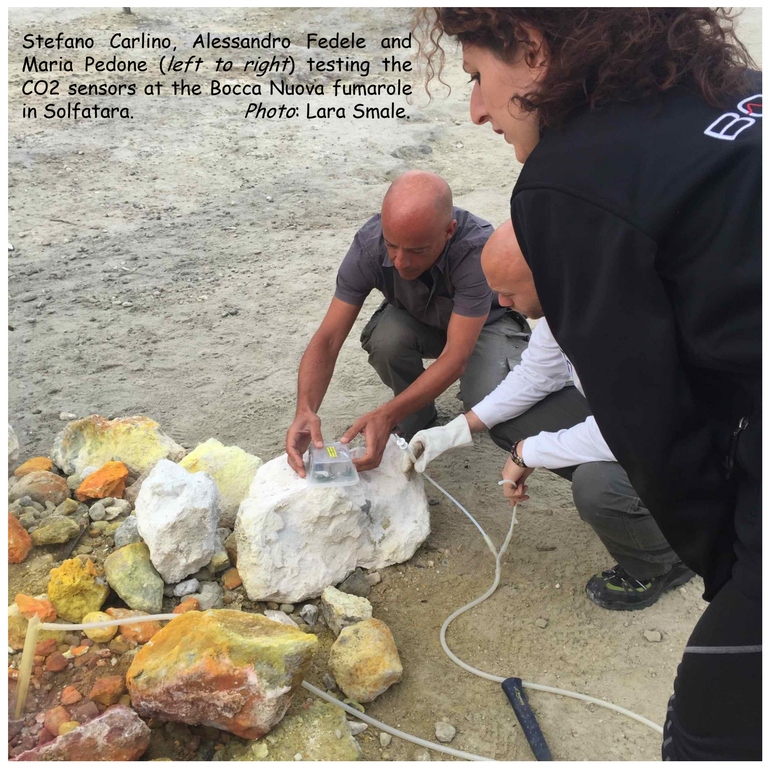
They are not suitable for measurements at high-temperatures *within* fumarolic vents. However, such locations do not predominate gas monitoring networks, so that the low-cost sensors remain attractive for long-term and continuous, real-time monitoring.

Unit costs are expected to be one-tenth of those for conventional instruments. Future developments include incorporating:

- robust housings for extreme environments;
- low-maintenance, long-duration power supplies (e.g., solar-powered batteries);
- transmission systems for relaying data directly to monitoring observatories.
- thermal switches to protect sensors against surges in gas temperature.

References

1. Aiuppa, A et al. (2013) *G-Cubed*, *14 (10)*, 4153–4169.
2. Pedone, M et al. (2014) *Bull. Volcanol.*, *76*, 812-825.


Stefano Carlino, Alessandro Fedele and Maria Pedone (*left to right*) testing the CO2 sensors at the Bocca Nuova fumarole in Solfatara. *Photo*: Lara Smale.

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