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Science AMA Series: I'm Dr. Tom Pering, volcanologist at the University of Sheffield, we have recently developed low-cost remote sensing tools for measuring sulphur dioxide at volcanoes using the Raspberry Pi.

TOM_PERING R/SCIENCE

Hello Reddit! My name is Tom Pering and I am currently a Teaching Associate at the University of Sheffield. My research focuses on the gases which volcanoes release. In particular, I am interested in volcanoes which have basaltic magmas. This type of magma allows the constant release of gases at the surface, which can then be measured using remote sensing techniques. As part of this, I am also interested in the modelling of how gas behaves within magmas, which then leads to a range of volcanic activities; such as strombolian eruptions.

The research group in volcano remote sensing at the University of Sheffield has a strong history of developing such techniques. Recently we have developed a low-cost ultraviolet camera approach to remotely sense the volcanic gas sulphur dioxide (SO2), which incorporates the popular Raspberry Pi platform. Happy to answer questions about my research and more broadly about volcanology!

Here are a few example papers from our recent research:

Ultraviolet Imaging with Low Cost Smartphone Sensors: Development and Application of a Raspberry Pi-Based UV Camera - http://www.mdpi.com/1424-8220/16/10/1649

A Low-Cost Smartphone Sensor-Based UV Camera for Volcanic SO2 Emission measurements - http://www.mdpi.com/2072-4292/9/1/27 The dynamics of slug trains in volcanic conduits: evidence for expansion driven slug coalescence – http://www.sciencedirect.com/science/article/pii/S0377027316304267

Hello everyone! I am taking a break for a couple of hours but will keep an eye on this and return to answer questions at about 8 pm GMT (3 pm Eastern Time).

READ REVIEWS

WRITE A REVIEW

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Do gas emissions from a volcano tell you anything about its status? Will sensors like this work congruently with seismographs to better prepare for an eruption?

adenovato

Yes! Here we need to consider the different behaviours at each individual volcano before we think about what gas emissions may tell us. We can broadly think of volcanoes as being "open vent" which constantly release gases from a central vent to the atmosphere, or "closed vent" which have a solidified vent and therefore don't emit gases constantly or only at diminished levels. The key to all of the studies of gas emissions following this is the understanding of what the normal level of gas emissions for a given volcano are. Any departure from these normal levels could tell us something about an individual volcanoes status. A change relative to this normal behaviour could then tell us whether an eruptive episode is ending (e.g., via a decrease in gas emissions) or whether we may have heightened unrest (e.g., via an increase in gas emissions), although these are not hard and fast rules as each volcano can behave differently (in terms of gas emissions) prior to a change in eruptive behaviour. In addition to this we also have to consider the type of gas released. There are three major constituent parts of

volcanoes using the Raspberry Pi., *The Winnower* 4:e151360.01472 , 2017 , DOI: 10.15200/winn.151360.01472

volcanic gas: water vapour, carbon dioxide, and sulphur dioxide. Each of these gases are released from a magma at different depths below a volcano so a higher concentration of one gas compared to another can tell us a little bit about the depth of the magma that is present within the sub-surface plumbing system.

Monitoring seismic signals is another key method for monitoring volcanic activity, and they are already used quite extensively in tandem with gas emissions at certain locations worldwide, for example, Mt. Etna (Sicily, Italy) is a volcano I have done quite a bit of work on and the combination of seismic and gas monitoring has unlocked some really interesting things about the volcano. Our sensors, given their low-cost nature, could certainly open up gas monitoring more widely where it is not done as a matter of course currently.

Thanks for doing this AMA and great to see another use of the Raspberry Pi! How often is this type of low-cost technology used in the field now and what are the drawbacks compared to say the most expensive UV camera?

I know a lot of volcanoes are in remote parts of the world and this feels like a great opportunity to improve access for citizen scientists!

[Buzzmerch1]()

Thanks for the question! Low-cost technologies are now creeping in to science more widely across the board (i.e., not just in volcanology). In my view this is, at least in part, due to platforms such as the Raspberry Pi which are so flexible in their potential uses that they can easily be adapted to unique and individual scientific issues. At the moment, in the field of volcanology, we are just starting to see a more general interest in low-cost technologies in the field, such as our ultraviolet (UV) camera. However, the main drawbacks of these are that you don't get the “finished package” which would generally be provided by a more expensive commercial UV camera. We have spent the past 18-24 months developing our own UV camera (with full research and development costing less than an expensive commercial UV camera) to a stage that we are happy that it could be disseminated to others to enable more widespread use. So I guess here the major drawback is the development time needed. You also touch on another key point here, citizen science. With cheaper technology and more widespread access to the internet and processing devices (smartphones are very powerful these days) the types and range of science that citizens can become involved with should broaden out. This is quite simply good news for scientists as some of the big questions of today just couldn't be answered by scientist's alone.

What's it like to work at volcanoes? Are they lonely? Are there roaming teams of volcanologists around the base?

Are there popular volcanoes to study?

[scienceaccount103040]()

Thanks for the questions. Working on the flanks and at the summits of volcanoes is often an awe-inspiring experience. The volcanoes I travel to and work on are basaltic volcanoes which constantly emit gas and are often producing mild explosive eruptions while I am there (hence the awe-inspiring!). Depending on the volcano, accessing them can be quite hard physically, and whilst you are in and around the area, you always need to be thinking about safety. Hard hats and gas masks are almost always an essential.

Personally, I have never found a volcano lonely, this may be because we most often travel in research groups. There is a lot of comradery among these trips so they are nearly always great fun! Even when the group may split to perform tasks at different locations there is a sense of purpose, silence, and connection with the landscape that I can appreciate and find calming. The only time you get teams of roaming volcanologists around a base would be during a time of volcanic unrest at a specific volcano or during planned workshops where groups of volcanologists with like-minded interested convene to test and discuss methods.

Yes, there are more popular volcanoes to study (these of course depend on what you want to do and your core research interests). The most popular locations (in my experience) tend to be those locations which are easier to access and therefore require less money to get to, and also those with much more reliable activity, so you know that if you travel to that location you will more than likely be able to use your instruments to gather actual data!

How are UV sensors currently used and why does this help?

scienceaccount103040

Volcanologists are particularly interested in using UV sensors as they enable us to remotely sense important gases released by volcanoes. They can be used in pieces of equipment called spectrometers or in the UV cameras that we use. We use UV sensors as one of the major gases released by volcanoes sulphur dioxide (SO2) absorbs UV light at specific wavelengths within the UV. Using this knowledge, we can then take images much as you would at visible wavelengths but instead in the UV at two specific wavelengths, one where SO2 does absorb UV light and one where SO2 doesn't absorb UV light. We can then mathematically compare the two images to get the concentration of SO2 in an image on a pixel-by-pixel basis. The great thing about this technique is that we can take images very rapidly (one every second for example) and we can resolve individual sources (i.e., different craters or fumaroles of a volcano).

Always wondered this.... but what exactly is magma? Is it a solid? A liquid? Something in between?

sciencereader3455

The first thing to point out is that a magma contains a number of different parts: molten rock, gas, and crystals. How a magma behaves or appears is related to the varying quantities of the above components. For example, a magma with more crystals will be stickier, thicker and more resistant to flow than one with fewer crystals. Magma is probably best described as a liquid or partial-liquid. As soon as a magma becomes completely solid (i.e., it cools sufficiently) it is no longer a magma but solid rock.

strombolian eruptions...

Are strombolis a popular food among volcanologists? If not, why not? What is a strombolian eruption and how can gas modeling tell you about them?

sciencereader3455

Unfortunately, I have never had a stromboli! After a quick Google these look tasty so now I wish I have had one…Probably haven't had one because I wouldn't know where to get one in the UK, and my cooking is notoriously average. I have been to the island of Stromboli though where there is lots of yummy pizza.

A strombolian eruption is a very short explosion which is associated with the release of hot and incandescent (glowing red/orange) material mostly a short distance from the eruptive vent. A strombolian eruption is likely driven by a very large gas bubble, which we call gas slugs as they resemble the shape of bullet (they are also called Taylor bubbles). These bubbles can be almost as wide as the conduit (the conduit connects the magma chamber with the vent at the surface) and 10s of metres long. We can then model the behaviour of individual bubbles within a conduit under different conditions, for example: different magma properties such as density and viscosity, different conduit geometries, and different sizes of bubble. We can then try and match up our observations at a given volcano with our models to understand more about an individual volcanic system. A great example of a well studied volcano which exhibits strombolian activity is indeed Stromboli.

Which volcano with the potential to erupt in the next 100 years would cause the most devastation? And how likely is it actually to erupt?

RRobertstein

This is a very difficult question to answer exactly as there are so many different things we need to investigate about an individual volcano to be able to assess devastation and likelihood. These could be aspects such as: how often the volcano erupts, what type of activity is presented, and importantly what hazards are produced. Hazards such as lahars can be much more devastating (to human life) than a lava flow for example. Certainly, the eruptions which could cause the most devastation would be those with larger surrounding populations and which come accompanied with the more dangerous associated hazards.

Are you worried that increasing automation of these detectors will take you out of the field? Also any advice for an aspiring researcher?

RelapsingEmu

Not at the moment, but I do wonder where we will be with the standard of volcano monitoring in decades time. I think with the technology advances we are having in volcanology at the moment (and generally in science) there will continue to be research groups who seek to improve the performance of the current instruments we have and develop new ones which perform their functions better. In short, there will always be a need to update and improve our available equipment. There is also a need to go out into the field and test, monitor, maintain, and replace existing equipment, or even expand beyond existing networks. In the future, we will be able to place many more scientific instruments of a wider variety around a volcano, so I think there will always be a need for fieldwork.

I thoroughly enjoy the research I do as part of my academic position, so if you have a passion and you feel that you would like to pursue this through research, go for it! My first bit of advice is that you need to do very well in your degree(s) obtaining good grades, a Masters is most likely a necessity. Within these you will need to demonstrate a particular aptitude for research. As well as this I have found that a number of things have helped me along the way: hard work, commitment, and asking for advice and help when you need it. I would like to particularly emphasise the latter one. There is a wealth of experience in universities and outside of this fora with experience of getting into research, but also while you are in a research position, the advice of peers and senior academics has really helped me understand the "research world". The last bit of advice, have fun and make sure you enjoy what you research!

Can Climate Change impact the stability of Volcanoes at all?

ChrisNYC70

I am not aware of any significant evidence or study which suggests that climate change will have an impact on the frequency of volcanic activity. The major effects associated with climate change in volcanic regions will likely be secondary, for example, increased rainfall in certain areas leading to an increase in landslides.