The Use of Micro Drones in Geologic Field Work

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Abstract

Drones are remotely-operated aerial vehicles that can be fixed-wing planes or helicopters. Micro drone helicopters are usually in the form of small (~ 40 cm x 40 cm x 25 cm) aerial platforms that have four or more rotating blades. This configuration gives them great maneuverability, stability, and control. In the field, micro drones provide a light-weight tool platform that are quick to setup and easy to launch, control, and transport to even the most remote areas. They require very little launch and recovery space. The cost of a basic micro drone is such that even the total loss of a vehicle is not significant. The low cost also means that multiple drones can be used, providing for redundancy if one is lost or damaged. A basic, off-the-shelf micro drone system can be set up for visual/camera surveys almost immediately.

Drone aerial surveys, field mapping, and monitoring can be done in real-time, depending on the system. Most importantly, drones can provide access to areas that are hard to reach and/or dangerous, such as vertical or overhanging rock outcrops or gas-rich and unstable volcanic areas. They can be used to survey disaster areas during and after events. Some examples of their uses are that they can quickly provide an overview of an area affected by flooding or mass wasting; give archaeological geologists an aerial perspective of a site; be used in coastal and reef surveys; and can even be flown inside caves for karst research. Micro drones can be potentially modified to collect other types of data as well, such as weather data, thermal imaging, sample collection, etc. High winds (>40 kph), for instance, can severely limit control or flight time, due to rapidly drained battery power as the drone uses energy to maintain its position. Instrumentation weight is also limited. Current, off-the-shelf drones with a basic camera package can stay airborne for between 20 and 30 minutes. Micro drones are also not water-resistant which limits their use in wet conditions.

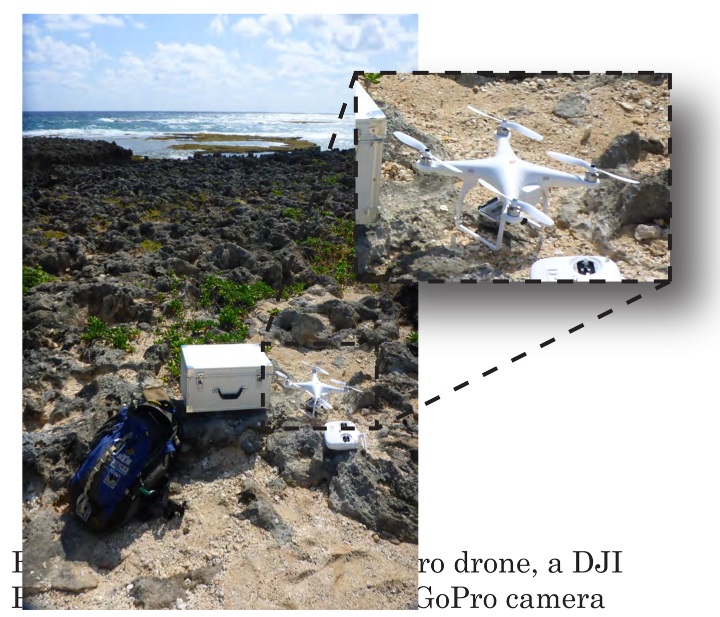
Ready availability of micro drones has led to them being used, intentionally or otherwise, by some individuals to aggravate wildlife and/or other people. Because of this, laws and regulations are being proposed and put into place to curtail their use. It is important for researchers who use them to do so responsibly.

Introduction

The last few years have seen the rapid development and availability of both commercial and private aerial drones, which are remotely-operated vehicles that can be fixed-wing planes or helicopters (e.g. Lowy, 2014; Fox News, 2014; KSL, 2014; NBC, 2014; Van Houtryve, 2014). Drones are being developed for use in everything from pizza and other product delivery (e.g. Albright, 2014; Ribeiro, 2014) to farming and movie making (e.g. BBC, 2014; KJTV/CNN, 2014; Mogg, 2014a), and from poaching and looting prevention (e.g. Howard, 2014; Salopek, 2014) to wildlife surveys (e.g. Bangen et al., 2011; WHT, 2014). In fact, the use of drones is becoming so widespread that the National Aeronautics and Space Administration (NASA) is currently in the process of developing a traffic control system to manage drone flights (Mogg, 2014b).

Especially popular are micro drone helicopters or "quadcopters," which are usually in the form of small (~ 50 cm x 50 cm x 25 cm) aerial platforms that have four or more propellers (Figure 1). This configuration gives them great maneuverability, stability, and control. Newer drones have built-in GPS systems that provide even greater control and make it easy for even the most inexperienced person to quickly learn the basics of flying. In the field, micro drones provide a light-weight tool platform that is quick to set-up, launch, and control. Their size makes them easy and convenient to transport to even the most remote areas (Figure 2). A basic, off-the-shelf micro drone system can be set up for visual/camera surveys almost immediately.

They require very little launch and recovery space and the cost of a basic unit is such that even the total loss of a vehicle is not financially catastrophic (Carrivick et al., 2013). Their low cost also means that multiple drones can be used, providing for redundancy if one is lost or damaged.



…ro drone, a DJI …GoPro camera mounted between the landing gear. This photo was taken at a remote location on the North Shore of Oahu, Hawaii, USA.

Field Uses

Large drones are already being used for geologic research. For example, Johnson et al. (2012) have used drones to collect data that allows them to model flood events in Afghanistan (see also Goldade et al., 2013). Funaki et al. (2006) tested the use of drones to collect magnetic field data at Chokai Volcano, Japan. Eck and Stoll (2011) collected similar measurements at a slide in a coal mine in Turkey. In addition, other aerial tools are available to researchers in the field, such as kites and blimps (Carrivick et al., 2013).

Although smaller, and limited in their instrumentation compared to larger drones, kites, or blimps, the potential use of micro drones in geologic research is great. Micro drone aerial surveys, field mapping, and monitoring can be done in real-time, depending on the system. Most importantly, drones can provide access to areas that are hard to reach and/or dangerous, such as vertical or overhanging rock outcrops or gas-rich and unstable volcanic areas (Figure 2a) (Curtis, 2012). They can be used to survey or map disaster areas during and after events, such as during flooding or mass wasting (Delacourt et al., 2007). They have already been used for such things as bathymetric and topographic mapping Example of river channels (Lejot et al., 2007), as well as post-earthquake land changes (Gong et el., 2012). They can be used in geoarchaeological surveys to give a broad, aerial perspective of a site (Figure 2b) (e.g. Gannon, 2014), can also be used in coastal and reef surveys (Figure 2c), and can even be flown inside caves for karst research (McFarlane et al, 2013).

One specific example of the benefits of using a micro drone in the field was done during the 2014 field season while collecting field samples and data at Mt. Yasur Volcano on Tanna Island, Vanuatu. Mt. Yasur lies on a remote island in the South Pacific. Access to the volcano is usually limited to riding for two and a half hours in the back of a local pick-up truck on mostly undeveloped dirt roads from the island's one small airport. In order to conserve space, the micro drone (a DJI Phantom 2) was simply packed into a backpack with its propellers and landing gear removed – no protective case was used.

On arrival at the volcano, the propellers and landing gear were reattached and the drone was launched. It was night and the drone was flown using just the built-in lights as visual guides for the location of the drone, although newer models can be set up to send real-time video to a tablet or smart phone. The drone was flown directly over the active vents and within the gas plume of the volcano for five minutes. The flight time was short due to reduced battery storage caused by the drone having to maintain its position and path in the winds around the edge of the crater.

This survey resulted in observations that were not apparent without using the drone. On arrival at the top of the volcano, followed by a hike along the rim of the main crater, it was observed that there were three active vents emitting lava (Figure 3). However, an analysis of the video and photographs collected from the drone indicated that, in fact, there were actually six active vents (Figure 4) – three large vents and three smaller ones. In addition, it was clear that the most active vent was partially obstructed.

Figure 2: Some examples of micro drone use. A. Volcanology - drones are able to collect data in dangerous environments, such as active volcanic centers (Inset: micro drone image of lava explosion from vent 2 - see figures 3 and 4). B. Geoarchaeology/Sedimentalogy - drone footage of the remains of a 1890s boat pier (Inset: water level view of the same pier). C. Coastal geology - drone footage of the nearshore, reef environment (Inset: ground level view of the same area).

Finally, the drone performed in a way that allowed for the collection, in real-time, of these observations during the active explosion and ejection of lava bombs – an extremely hazardous environment (see also O'Callaghan, 2014). Twice, due to wind or loss of battery-power, the drone crash-landed at high speed. In neither case did the drone sustain any damage other than a few minor scratches to the propeller blades. However, a set of spare blades is recommended.

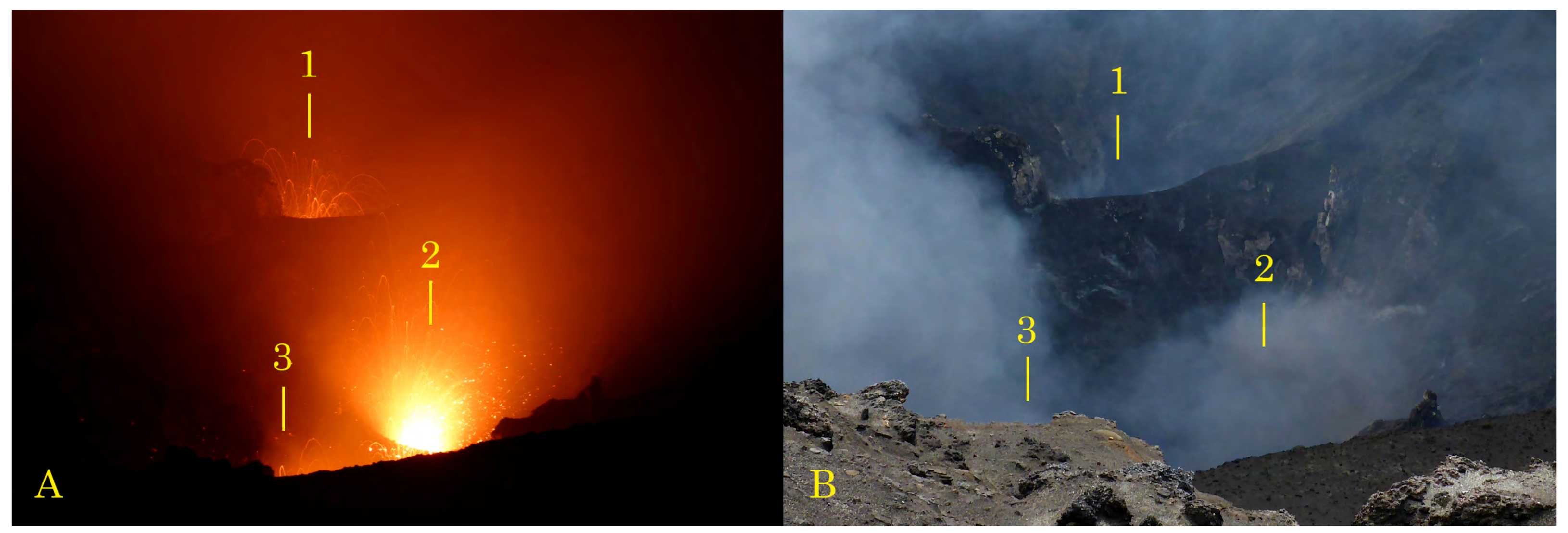


Figure 3: View of from crater edge of Mt. Yasur. In both night (A) and day (B) only three (1-3) lava vents are visible.

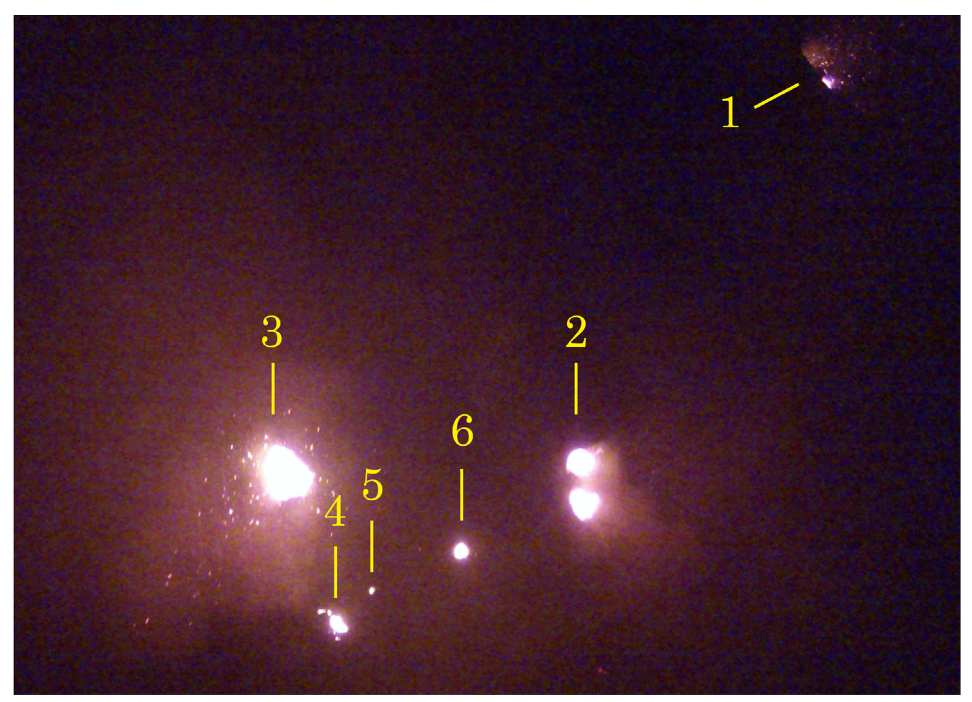


Figure 4: Micro drone image taken directly over crater of Mt. Yasur. From this view, six vents (1-6) are apparent (vents 1-3 correlate with the same numbered vents in figure 3). It is also possible to see that vent 2 is ob-

Challenges in Using Micro Drones

The challenges or difficulties in using micro drones can be dividing into three categories:

1. Natural
2. Technological
3. Legal

In the first case, the biggest challenge to the use of micro drones concerns the weather. High winds (>30 km/h), for instance, can severely limit control or flight time, due to rapidly drained battery power as the drone uses energy to maintain its position. In addition, strong winds or wind gusts can blow the drone off course, into obstacles, and/or beyond areas of recovery. They also can reduce the fine control of the drone. Current micro drones are also not water-proof, which limits their use in rainy conditions or over water, should the drone fall into the water. That being said, I have used my micro drone extensively over water – it is just important to monitor the charge of the battery to prevent loss of power to the drone in such circumstances.

Technologically, drone flight times are limited by their power source. Depending on the atmospheric conditions and/or weight of instrumentation attached to the drone, I have observed flight times to vary between 4 and 20 minutes. Another issue is determining the scale of view from the drone images. The simplest way to solve this is to have a ground-based scale (e.g. measuring tape or an object of known size), but it is also possible to install laser pointers to provide a reference scale no matter what the height of the drone (Figure 5). However, these work best in areas that provide a strong color-contrast to the laser light and/or during dusk, night, or early morning.

Finally, the ready availability and proliferation of micro drones has led to a sort of legal gray area, in which governments are scrambling to try and regulate their use (Figure 6) (e.g. KSL, 2014; Lowy, 2014). Users of drones have been found, intentionally or otherwise, to aggravate wildlife (Robison, 2014), crash into hot springs in Yellowstone National Park (Forgione, 2014), almost collide with planes (Botelho, 2014), and/or cause privacy concerns or annoyance to other people (Flacy, 2014). Because of these and other examples, the laws and regulations that are being proposed and put into place aim to curtail the use of micro drones. It is important for researchers who use them to do so responsibly, so that their use as research platforms will remain open.

The Future

Micro drone use in geologic field work has enormous potential. Most of the work discussed here relates only to the collection of visual data. However, micro drones can be potentially modified to collect many other forms of data, such as ambient weather data, thermal imaging, gas measurements, mapping and surveying (e.g. Micklethwaite et al., 2012), long term aerial monitoring, sample collection, and countless other possibilities that have not been thought of yet.

Earth scientists should embrace the use of drones or at least be open to their potential benefits, BUT they should do so wisely, and in consideration of the legal and private issues that are beginning to present themselves.

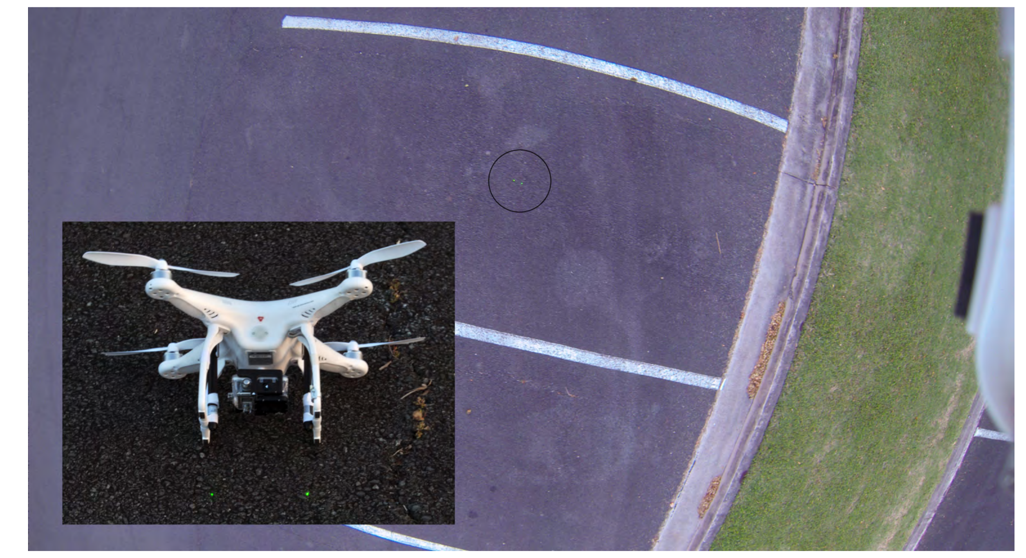


Figure 5: One way to scale images or video taken by micro drones - use bright laser pointers.

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