

Volcanic gas measurements using UAVs

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Volcanic gas is a mixture of volatile contents separated from magma and its composition may reflect the temperature and pressure conditions at a degassing depth, and the processes of phase change, interaction with rocks, and so on. In addition, since the ascent speed of volcanic gas is much larger than that of magma itself, it provides the earliest signals of subsurface processes such as the magma supply rate and/or the depth of the magma head. For this reason, volcanic gas composition is an important quantity to infer the current state of volcanic activity and to predict its transition in the future. In volcanic gas measurements, one of the conventional methods is the direct sampling and post-analyses in laboratory. However, such a direct sampling is often dangerous, especially when the volcano is erupting. In such a situation, measurements using UAVs are quite useful (Hashimoto et al., 2018). In this study, we review the recent progress in this research field, focusing on the case studies that we have been working on in these years.

Regarding the chemical composition, the Multi-GAS system is widely used, in which the sensors of some chemical species with a recording system are integrated into an apparatus and gas composition is directly measured on site. Recently, we made the apparatus smaller and lighter to mount on an unmanned aircraft. An electric-motor-type multi-rotor drone was used in the survey that was conducted two months after Mt. Ontake eruption in 2014 (Mori et al., 2016). This type of measurement can be done more easily in a field where we can use an engine-type compact unmanned helicopter that has much larger payload than small drones. In our experiment conducted in Noboribetsu, Hokkaido, we used the concentration meters of three gas species, which are relatively inexpensively available, and a thermo-hygrometer. We put them together in a net, hung it on an unmanned helicopter, and suspend it in the plume. The concentration ratios between CO₂, H₂S, SO₂, and H₂O were measured. At Kusatsu Shirane volcano, it has been proven that a trained researcher can perform similar operations with a drone.

With regard to gas emission rate, remote sensing of sulfur dioxide by an ultraviolet spectrometer is often used for volcano monitoring. The operation is normally performed on ground by driving a vehicle that mounts a measuring apparatus, looking the UV light in the sky. After the considerable miniaturization and weight reduction of the instruments in recent years, even an operation using a hobby-use drone has become possible (Tanaka and Mori, 2017).

In summary, volcanic gas measurements using UAVs are technically reaching a practical level. Further development in the research field is expected when the researchers acquire the operation skills of UAVs. We are also engaged in training and educational activities for improving such skills with the aid of the Next-generation Volcano Research and Human Resource Development Project by the MEXT.

Keywords: volcanic gas, chemical composition, drone, unmanned helicopter