

Multi-sensor system with air blowers for airborne volcanic gas survey using drones: an improvement of a sensor response time

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Drones (Unoccupied aircraft systems, UAS) are essential tools for understanding and monitoring volcanoes. They can also make measurements for geochemical analysis from hazardous area such as toxic volcanic gas near active vents during initial stages of volcano unrest as well as throughout eruptions. Gas measurements using drones equipped with a multi-gas sensor system have been performed at many volcanoes (Mori et al., 2016; Stix et al., 2018; Liu et al., 2019). Molar ratios in the volcanic gas are evaluated by a slope of regression lines between the one gas concentration and other gas concentration, therefore, a consistency of response time of sensors is critical. Using commercial gas sensors, we have developed a multi-sensor system which includes electrochemical sensors for sulfur species (SO₂ and H₂S, RAE System ToxiREA), a non-dispersive infrared (NDIR, TandD TR-76Ui) sensor for CO₂. Concentration of H₂O is calculated using the relative humidity measured by a capacitive humidity sensor and temperature measured by a thermistor (SENECOM SE-TRH-FS15-SS). Response times of a NDIR CO₂ sensor and a thermistor show marked changes in response to ambient wind speed, probably due to forced convection. In order to adjust response time of all of sensors, we attached small air blowers to a NDIR and thermistor sensors. Our laboratory experiments indicate that sensor response times can be set to around 10 seconds under the condition of ambient wind speed of more than 1.5 m/s. Assuming a linear response, an uncertainty of molar ratios in the volcanic gas is estimated to be less than 30 % in maximum if an exposure time to the volcanic time is 10 seconds, while an uncertainty is estimated to be 120 % in maximum without using air blowers. Exposure time of multi-sensor system to fumarolic gas is limited because of capability of drones. Therefore, air blowers are useful to improve accuracy of evaluations of molar ratios in the volcanic gas, especially in small plume.

Keywords: Volcanic gas, MultiGAS, Drone, Unoccupied aircraft system