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Airborne surveillance using an unmanned autonomous helicopter at Tarumae volcano

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1. Introduction

Volcanic eruptions generally prohibit humans from approaching active craters. Meanwhile, it is important during an eruption to perform visual surveillance, geophysical measurements, material sampling in the vicinity of the craters. Besides scientific purposes, these are also useful in deciding emergency actions such as evacuation or recovery plans considering the ongoing volcanic activity and possible subsequences. We started airborne volcano surveillance using an unmanned helicopter on a trial basis in cooperation with the Hokkaido Regional Development Bureau since 2011. We performed the experiments at Mt.Tarumae (1,041m) in 2011 and 2012. As of 2012, the volcano was not erupting but showed persistent fumarolic activity around the summit lava dome. In this study, we report the results of the repeated aeromagnetic survey and an operation test of a material sampler.

2. Aeromagnetic surveys

We performed the first airborne magnetic survey in Sep. 2011. The vehicle flew on the programmed route in the autonomous flight mode with the aid of GPS navigation. The same route was intended to be flown in the second survey in Sep. 2012 aiming for detecting temporal changes. Although we partly failed to fly due to an unfavorable weather in the second survey, we recovered the data from important part across the lava dome. We compared the actual flight paths between the two surveys and found that the deviation was mostly within 10m. Meanwhile, the field gradient along the flight paths was generally within +/-1nT/m. Then we considered that +/-10nT was an error range in a direct comparison of the magnetic field between the nearest points from the separate datasets. Through this procedure, we obtained a systematic pattern of temporal changes with a p-p amplitude of approximately 30nT. The spatial pattern implying the cooling remagnetization beneath the dome was consistent with the recent result from the repeated magnetic surveys on the ground by Hokkaido University and Sapporo District Meteorological Observatory, JMA. However, the observed amplitude was almost five times larger than the estimation from the ground-based remagnetization rate. Further careful investigations are necessary to identify the cause of this difference.

3. Material sampling

In the experiment in 2012, we also performed an operation test of a material sampling attachment in the vicinity of the base station. The gadget is reeled down from a winch on the fuselage. At a touchdown, the lock is released and the grab-bucket is shut. Because this system is originally designed for sampling solid pieces or muddy materials, we attached some double-stick tapes on the grab-bucket to collect ash grains, too. In our experiment, several pieces of pumice and lithic with a diameter of some centimeters were picked up as well as ash particles of some grams. Although we found some issues to improve such as the triggering sensitivity at a touchdown, the first test was generally satisfactory. When applied to a future eruption, the amount collected will be sufficient for analyzing the contribution of a fresh magma at an initial eruption stage.

4. Summary and conclusions

Through our two-year experiments, the unmanned helicopter was proved to be practically useful for volcano surveillance at Mt.Tarumae. In particular, autonomous flight proved a performance of positioning control within an accuracy of approximately 10m. This is an advantage in detecting volcano-magnetic changes from a direct comparison procedure. In application of this vehicle to a future volcanic unrest, it is practically important to find beforehand some candidate sites for a base station from which we control the helicopter, and to perform some preliminary operations to overview an undisturbed condition when a volcano is calm.

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Keywords: Tarumae volcano, unmanned helicopter, airborne surveillance, geomagnetic field, temporal change, material sampling