# Development of risk-free observation tools at active volcanoes using unmanned Helicopter

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Observations at active volcanoes using unmanned vehicles are very important from various viewpoints. From a scientific point of view, it is important to conduct observations in the close vicinity of active vent where no scientist can approach without risking his/her life. From a view point of volcano hazard mitigation, reinstalling monitoring sensors is indispensable to maintain observation networks around an active volcano when existing monitoring stations are damaged by the intense activities of the volcano. Installation of volcano monitoring sensors using unmanned vehicle is the only way to recover damaged stations without spending any risk of human lives.

We started a project in which risk-free volcano observation tools are developed. When this project started in 2005, we adopted using unmanned autonomous helicopter RMAX-G1 manufactured by Yamaha-Motor Co., Ltd., but at that time, there was essentially no know-how to use the helicopter for volcano observations. We spent first several years in developing an aeromagnetic survey system using this helicopter with a cesium magnetometer. This system has gradually been improved and has been applied to Izu Oshima, Sakurajima, Kirishima, and Tarumae. These observations have revealed changing magnetization structures of these target volcanoes with high-resolution. We also started developing observation modules that require direct ground contact such as seismic and GPS observation modules. We had to develop a winch that is attached underneath the helicopter and is used to install sensors in the target area near active volcanic vents. Earthquake observation modules and GPS modules were designed so that they satisfy the requirements for helicopter installations. These modules have to be light weight, compact size, and solar powered. We have been maintaining seismic observations at Sakurajima summit area since 2009, and GPS observations at Sakurajima and Kirishima since 2011.

Through these experiences, valuable know-hows necessary to conduct volcano observations using an unmanned helicopter have been gradually but steadily accumulated. For example, the ground coupling of the seismic or GPS modules installed by the helicopter is poor due to the way they are installed on the ground. Albeit the imperfect ground coupling, seismic signals recorded by the modules are as good as well installed sensors if we remove high frequency resonance noise.The location errors of the GPS in horizontal and vertical components are 1cm and 3cm, respectively.These error amplitudes are smaller than the amplitudes of the deformation signals expected for the stations in the close vicinity of the source.

In the presentation, we will start with brief review of the development of this tool. We will then introduce some results obtained by the helicopter observations. Finally, we will briefly mention future perspective of volcano observations using unmanned vehicles.