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# Observation at Sakurajima volcano using an unmanned autonomous helicopter

Takao Ohminato[1*], Takayuki Kaneko[1], Takao Koyama[1], Atsushi Yasuda[1], Minoru Takeo[1], Atsushi Watanabe[1], Yoshiaki Honda[2], Masato Iguchi[3], Takatoshi Yanagisawa[4]

[1]Earthquake Research Institute, [2]CEReS, Chiba University, [3]Sakurajima Volcano Research Center, DPRI, [4]JAMSTECH

Observations in the vicinity of summit area of active volcanoes are important in understanding volcanic processes. However, it is challenging to install observation sensors near the active vent because of the danger of sudden eruptions, and thus the summit area of active volcanoes are often left blank from the observational point of view. We are developing a risk-free observation system based on an unmanned autonomous helicopter (UAV) combined with various types of observation devices. The UAV has been already used for the aeromagnetic surveys in Izu-Oshima, and succeeded in detecting fine scale geomagnetic anomalies. In addition to the aeromagnetic survey, we aim at developing various types of volcano-observation tools based on the UAV such as installing seismometers and GPS modules, sampling volcanic ash in the vicinity of active vents, and obtaining both infrared and visible images from onboard cameras. In this presentation, we will present an outlines of the installation of seismic modules at Sakurajima volcano, Japan conducted in fall of 2009 and 2010.

We used the UAV, model RMAX-G1 developed by Yamaha-Motor Co., Ltd. The payload of the helicopter is approximately 10kg, including the fuel and attached equipments. The autonomous aviation is available within 5km from the base station with meter accuracy using kinematic-differential GPS. This high positional accuracy makes it possible to conduct repeated observation at exactly the same place. Real-time images taken from the onboard cameras are transmitted to the base station. This facility is a great advantage in remote installation of sensors.

We developed an earthquake observation module (EOM) and a winch system both are designed exclusively for the UAV. Since the payload of the helicopter includes not only the weight of the EOM but also the weight of the onboard winch, onboard camera, and fuel, we had to limit the EOM's weight around 5kg. In order to realize such light weight, we had to newly develop light-weight solar panels. The EOM is carried by the helicopter to just above the target point for installation, being hanged at the tip of the wire of the onboard winch. Then, by sending out the wire gradually from the winch, the EOM is dropped slowly and is installed on the ground without strong shock. The EOM is solar powered, and is equipped with GPS for timing. Data are transmitted over the cellular-phone network. Since it is also difficult to level the sensors, a triaxial accelerometer is adopted as a seismic sensor.

Sakurajima is one of the most active volcanoes in Japan. Since the reopening of the Showa crater at the eastern flank in 2006, eruptions continue at the Showa crater, and the recent annual number of explosive eruptions is record-breaking. Entering the area within 2 km from the summit craters is prohibited, and thus there is no observation station in the restricted area. Seismic sensors in this area will significantly improve the data quality. From November 2nd to 12th in 2009 and 2010, we installed the EOMs in the summit area of Sakurajima within 2km from the active vent. We carefully investigated geographical maps and high resolution aerial photographs beforehand in order to decide potential target positions for installation of EOMs. In the experiment in 2009, we could successfully install three modules at the planned positions. In the experiment in 2010, we not only could install EOMs at 4 places, but also could retrieve three EOMs installed in the previous year. Although the EOMs installed in 2009 could not work properly due to trouble of the EOMs main board, the EOMs installed in 2010 are still arrive and are sending seismic signals at the time of this abstract submission. Although the recorded waveforms of the explosive eruptions are contaminated by the modules mechanical resonance noise above 30 Hz or more, waveforms in general are good in the frequency band lower than that frequency.

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