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Volcano Observations Using an Unmanned Autonomous Helicopter : seismic observations near the active summit vents of Sakurajima volcano, Japan

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Observations in the vicinity of summit area of active volcanoes are important not only for understanding physical processes in the volcanic conduit but also for eruption prediction and volcanic hazards mitigation. It is, however, challenging to install observation sensors near active vents because of the danger of sudden eruptions. We have been developing a volcano observation system based on an unmanned autonomous vehicle (UAV) for safe observations near active volcano. We deployed an unmanned autonomous helicopter manufactured by Yamaha-Motor Co., Ltd. The UAV is 3.6m long and weighs 84kg with maximum payload of 10kg. The UAV can aviate autonomously along a previously programmed path within a meter accuracy using real-time kinematics differential GPS equipment. The maximum flight time and distance from the operator are 90 minutes and 5km, respectively. We have also developed an earthquake observation module (EOM), which is exclusively designed for the UAV installation in the vicinity of active volcanic vent. In order to meet the various requirements for UAV installation, the EOM is very compact, light-weight (5-6kg), and is solar-powered. It is equipped with GPS for timing, a communication device using cellular-phone network, and triaxial accelerometers.
Our first application of the EOM installation using the UAV is one of the most active volcanoes in Japan, Sakurajima volcano. Since 2006, explosive eruptions have been continuing at the reopened Showa crater at the eastern flank near the summit of Sakurajima. Entering the area within 2 km from the active craters is prohibited, and thus there were no observation station in the vicinity of active vents at the summit area. From November 2nd to 12th, 2009, and From November 2nd to 12th, 2010, we could successfully install four EOMs in the summit area within 2km from the active craters by using the UAV. The EOMs installed in the 2009 experiment worked up to three weeks and then ceased operation due to trouble of the data logger. In the 2010 experiment, UAV succeeded in removing four EOMs that were installed in the 2009 experiment. We installed four EOMs with bug fixed data logger. These EOMs are satisfactory working at the time of writing this abstract. We succeeded in retrieving seismic waveform data accompanying more than 100 moderate eruptions at Showa crater. Except for contamination by the mechanical resonance of the frame of EOM around 35 Hz, the recorded waveforms of the explosive eruptions are as good as the best permanent stations in Sakurajima. Preliminary results of the analyses show that the dominant frequency of these seismic signals is around 1 - 5 Hz and no clear very-long-period component.