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Ground deformation of Guntur, Sinabung and Merapi volcanoes, in Indonesia by continuous GPS observation

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Indonesia is the greatest volcano-country in the world, with 129 active volcanoes. Prediction of volcanic eruption and mitigation of volcanic hazards are urgently required. However, many active volcanoes are equipped with only one seismic station. For the mid- and long- term prediction and evaluation of post-eruptive activity, continuous observations of ground deformations are necessary. Therefore, we have recently installed GPS stations in Guntur , Sinabung and Merapi volcanoes.

Guntur volcano complex is located 35 km SE of Bandung city, West Java, Indonesia. Although Guntur volcano has been dormant in eruptive activity since 1847, seismicity of volcanic earthquakes is active and mid- and long-term prediction of volcanic eruption is required for reduction of volcanic hazards. On the other hand, ground deformation monitoring is important to evaluate post-deformation of eruption and/or transition of eruptive style.

Sinabung volcano in North Sumatra erupted on August 2010 after >400 years dormancy. The eruptive activity began with phreatic eruption and declined in September, however seismicity on and around the volcano was still high even after the eruptions. An explosive eruption occurred on October 26, 2010 at Merapi volcano in Central Java and the eruptive activity was followed by continuous occurrence of pyroclastic flow from the summit crater during the period from November 3- 5.

In October 2009, 3 stations were installed in the area surrounding Masigit-Parukuyan-Kabuyutan-Guntur craters of the Gntur volcano. Each station is equipped with a dual-frequency GPS receiver (Leica GRX1200+GNSS). A battery and a solar panel were used for power supply for the receiver. Similar observation systems were installed at Merapi volcano in December 2010 and at Sinabung volcano in February 2011. Receivers (Leica GR10) are installed at the flanks of these volcanoes. Continuous observation with a sampling rate of 1second is performed at all stations and GPS data are saved as RINEX file. At the Guntur volcano, observed data is retrieved via the WLAN installed between each station and the Guntur Volcano observatory (POST). We applied a PPP (precise point positioning) using GPS analysis software, GIPSY-OASIS II Ver.5.0. In the analysis, JPL precise ephemeris is used, and dairy coordinates are calculated in the frame of ITRF2005. From the obtained coordinates, we can calculate baseline among stations.

We compare the result in the Guntur volcano with a past leveling result. By precise leveling surveys during the period from August 1996 to November 1997, the uplift around the summit area was detected (Hendrasto et al., 1998). Using grid search assuming a Mogi source as the deformation source, location of the source and volume change were determined. The obtained source is located at a depth of 5 km beneath Mt. Masigit (Sadikin, 2008). With this position fixed, volume change between each leveling survey was calculated. Total volume of the pressure source increased by $1.5*10^6$ m^3 during the period from August 1996 to December 2002 and volume increase rate is estimated to be $2.5*10^5$ m^3/year(Sadikin, 2008). If we apply this average rate to the GPS observation period, we expect a inflation with a volume change of $2.75*10^5$ m^3 which cases 0.5cm baselines change among GPS sites. Any significant changes can not be recognized in our GPS measurement. This means deformation rate at the Mogi source beneath Mt. Masigit was smaller than the average rate obtained by leveling data during the period from August 1996 to December 2002 when the seismicity of volcanic earthquakes of Guntur volcano was high.

Keywords: volcano monitoring, GPS, indonesia