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Effect of underground water on gravity at Matsushiro, Japan

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Hydrological corrections are essential for precise gravimetry. The superconducting gravimeter (SG) station at Matsushiro, Japan is housed inside a tunnel, and therefore subject to the effects of underground water both below and above the gravimeter horizon. Indeed, gravity decreases after rainfall, indicating that the Newtonian attraction by the water mass on the hill is the dominant effect. Imanishi et al. (2006) developed a simple numerical model to predict gravity changes from rainfall amount, which works well at least for the short term effects. However, there are some cases where this model fails, especially when the amount of rainfall is relatively large. A physical model based on the spatial distribution and temporal movement of underground water must be developed.

To address this problem, we installed two Scintrex gravimeters (CG-3M) in the tunnel of Matsushiro to make continuous gravity monitoring with a total of three sensors. The distances from the entrance at the three sensors are 0m (Scintrex #1), 25m (SG) and 45m (Scintrex #2), respectively. The depths at these locations are 0m, 20m and 40m, respectively. It is expected that the three gravimeters indicate different responses to rainfall because they sense attraction by underground water in different parts of the hill.

After the installation of the Scintrex gravimeters, there have been two of rainfall events, which took place on October 7 and 26, 2009. The amount of rainfall was 71 mm and 35 mm, respectively. In these events, the superconducting gravimeter indicated gravity decrease as large as 2 and 1 microgals, respectively, which is in agreement with predictions from the model of Imanishi et al. (2006). No significant gravity changes were recorded by the Scintrex gravimeter # 1 located near the entrance of the tunnel, probably because the downward attraction by the water below the gravimeter horizon cancel the upward attraction. The Scintrex gravimeter #2 at 40m depth indicated gravity decrease of 10 and 5 microgals, respectively, roughly five times as large as that for the superconducting gravimeter. The water mass on the hill surface supplied by the rainfall solely is not sufficient to produce such a large amount of gravity changes. It was also observed that the tilt of the Scintrex gravimeter #2 indicated a slight change in these rainfall events. These observations may provide important information on the dynamics of underground water at Matsushiro.

In our poster, we will present a model on the dynamics of underground water based on the data of the three gravimeters, as well as the data of the moisture meter temporarily installed at Matsushiro.

Keywords: superconducting gravimeter, Scintrex gravimeter, underground water