Measuring soil moisture with GPS multipath: Application to Asama volcano

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The existence of groundwater often causes a significant disturbance to geodetic data, and geodesists have studied how to correct the disturbance. Kazama and Okubo (2008), for example, estimated groundwater disturbance to gravity with hydrological backgrounds, and showed an excellent agreement between the estimated disturbance and observed gravity change at Asama volcano, central Japan. In order to understand more detailed mechanism of the groundwater disturbance, we need more densely sampled hydrological observables (such as water head and soil moisture) around the gravity stations. However, hydrological equipments are too expensive to develop a hydrological observation network.

GPS network may offer a substitute for the hydrological equipments. Larson et al. (2007) analyzed signal-noise ratio (SNR) of GPS radio wave, and found that SNR values oscillated because of the interference between direct waves and multipath waves from the ground. They also indicated that the oscillation amplitudes were positively correlated with the soil moisture values, because multipath waves reflect more strongly at wetter ground.

We then applied the multipath method to a GPS network around Asama volcano, in order to realize highly-dense hydrological observations at Asama. We first extracted SNR (S2) data series from GPS raw data, observed at Asama Volcanic Observatory on November 16, 2007 (UTC). We found that the SNR oscillate by about 5 volts/volts every 3-4 minutes, most probably due to the multipath effect from the soil near the GPS antenna. We also found that the observed oscillation period is consistent with the one expected from optical path difference between direct and multipath waves.

In our poster presentation, we will analyze all raw data from November 2007, and compare the SNR fluctuation with soil moisture near the GPS antenna.

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[Reference 1] Kristine M. Larson, Eric E. Small, Ethan Gutmann, Andria Bilich, Penina Axelrad and John Braun, Using GPS multipath to measure soil moisture fluctuations: initial results, GPS Solut., doi: 10.1007/s10291-007-0076-6, 2007.

[Reference 2] Takahito Kazama and Shuhei Okubo, Hydrological modeling of groundwater disturbance to gravity: Theory and application to Asama volcano, central Japan, Geophys. Res. Lett., submitted, 2008.