Groundwater-Driven Vertical Movement in Tsukuba (Part 2)

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We have been conducting leveling surveys among the VLBI, the continuous GPS sites and the subsidencemeter, which is anchored to the base at the depth of 190m under the ground surface, in the campus of Geographical Survey Institute (GSI) to investigate the mechanism of seasonal vertical motion of the VLBI and GPS sites.

The survey results clearly show the annual up-down motions of the VLBI and GPS sites relative to the subsidencemeter. The amplitude of the annual motion of the VLBI site, whose base is at the depth of 45m, is slightly smaller than that of the GPS sites. This result confirms the similar results obtained by GPS observation (Munekane et al., 2004). The temporal variation of this small difference is correlated with that of the ground water levels of shallow wells, suggesting an effect of variation of water pressure in the aquifers shallower than 45m. On the other hand, large annual signals observed at deeper wells support the hypothesis of an annual variation of water pressure of the aquifers deeper than 45 m as a cause of a large part of the annual signals common to the VLBI and GPS sites.

Another leveling survey from GSI's campus to the location of a pumping well for irrigation at about 1.3km far from GSI has been also carried out every 4 months since April, 2006. The relative height changes along the levering path are at 1 mm level during the past two years. It is inferred that the annual vertical motion of the area of at least the 1 km range from GSI is uniform.

To evaluate the stability of the base at the 190-m depth and to monitor the vertical motion of the VLBI and GPS sites continuously, a GPS antenna was equipped directly on the top of the subsidencemeter and the continuous observation was started in April, 2007. The time series of height of the GPS antenna obtained show the annual changes relative to the other GPS sites in GSI campus similar to the results by leveling survey. It turned out, however, that the height solution of this site has a bias that is changing with time. This bias is significant especially if analyzed with ionosphere-free linear combination of the dual frequency signals and with estimation for troposphere delay. This bias change is associated with the change in the effect of the radome and multipath. Countermeasures to this effect are under consideration.