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Development of an ultra-deeply anchored GPS station in Tsukuba

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We have installed an ultra-deeply anchored GPS station on the premises of Geographical Survey Institute in Tsukuba. The station, coded as S061, is directly mounted on the top of the inner-tube of the subsidence observation well, which is fixed to 190 m depth. The station is expected to be less affected by anomalous seasonal vertical deformations of the ground in Tsukuba that are known to be caused by groundwater extraction for irrigation of surrounding rice fields. In this paper, we evaluate the stability of the station by comparing the observed vertical deformation differences between S061 and surrounding GPS stations with those independently measured by the subsidence-meter and leveling observations.

First, we prepared two sets of baseline solutions by GPS analysis. One solution, hereafter referred to "short baseline solution", is calculated with "short-baseline strategy" in which L1 and L2 phase observations are used independently with no estimation of tropospheric delays. The other solution, hereafter referred to "long baseline strategy", is calculated with "long-baseline strategy" in which the ionospheric-free combinations of L1 and L2 phase observations are used with estimation of tropospheric delays. We revealed that the vertical deformations of the short baseline solution agree quite well with those obtained by the subsidence-meter and leveling, but that they show episodic scatter in winter. We also found that those of the long baseline solution do not agree with those obtained by the subsidence-meter and leveling at all. We investigated further those disagreements and found that water dew condensated inside a radome is responsible for the former scatter and that the phase multipath, presumably from the roof of the building housing S061, is responsible for the latter.

Next, we evaluate the magnitude of the remaining vertical deformations associated with the deeper layers at the depth of 190 m or larger. We first calculated the coordinate time series of the surrounding GPS stations in the global analysis to obtain absolute vertical deformations. Then the deformations recorded by the subsidence-meter were subtracted from them. What is left would be the deformations due to the layers deeper than 190 m. We compared the time series of the resulting deformations with the water level changes in the nearby well of 300 m-depth, and found that the resulting vertical deformations amount to 4 mm, corresponding to about a quarter of the whole vertical deformations.