Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

SGD001-P03 Room: Convention Hall Time: May 27 17:15-18:45

Apparent stability of GPS monumentations on the premise of GSI, Japan from vertical coordinate time series

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On the premises of Geospatial Information Authority of Japan (GSI) in Tsukuba, five continuous GPS stations are installed on the surface (TSKB, TKBA, TSK2, 92110, 960627), and an ultra-deeply anchored GPS station, as well, which is directly connected to the inner tube of a subsidence observation well anchored at a depth of 190m (06S061). The vertical coordinate time series at these stations have a certain feature in common; an annual vertical variation due to the elastic deformation of aquifers associated with groundwater pumping for irrigation. In addition, the site-specific deformations are obvious: those may be linked to the physical instability of monumentation caused by thermal expansion of a pillar or by unstable supporting soils, and to apparent, spurious noises caused, for example, by multipath. Hence, in this study, we will discriminate between the common deformations and the site-specific deformations among those adjacently-located GPS stations, and quantitatively evaluate the apparent monument instability of the sites based on the site-dependent deformation time series by utilizing independent data such as leveling.

First, we analyze the GPS data at these stations for the period of January 2004 to March 2009 using the GIPSY-OASIS II software with the PPP strategy. We employed ECMWF and gridded VMF1 as the apparent zenith hydrostatic delays and mapping functions, respectively. The atmospheric loading deformations are corrected for on observation level by estimation from the global spectral model, a global numerical weather prediction model, published by Japan Meteorological Agency. Moreover, the ocean/hydrological loading deformations are corrected for by using the 10-day averages of time-variable gravity fields modeled from GRACE by CNES/GRGS. Then we stacked the corrected time series of vertical coordinate changes for all stations to obtain common vertical deformations.

The common vertical deformations exhibit a similar seasonal pattern as that of the time-series of the subsidence-meter observation: the meter measures the thickness of the superficial layers down to a depth of 190m and the observed seasonal changes are associated with groundwater pumping for irrigation. What is noteworthy is that the amplitudes of the common deformations are significantly larger than those of the subsidence meter measurements, indicating that the aquifers deeper than 190 m depth also deform seasonally in accordance with the shallower aquifers. The differential deformations have a strong correlation (0.72), with the time-lag of 20 days, with water level changes at the 300 m well at the AIST, 6 km south of GSI. The correlated component have an amplitude of 8 mm, half of that of the common deformations of the shallower aquifers.

Next, we subtract the common vertical deformations from the vertical coordinate changes at each site to yield site-specific vertical deformations. The short-term repeatability of the site-specific vertical deformations is as small as 1.3 mm at minimum at TSKB, and 2.0 mm at maximum at TSK2. The spectra of the site-specific vertical deformations have flicker noise property (index = -1) at TSKB, 92110 and 0627. On the other hand, at TSK2 and TKBA, the spectra have indices as

small as -0.5.

We will further investigate the origins of the apparent monument instabilities of those GPS stations by utilizing independent data such as leveling, and the results obtained will be shown in the presentation.

Keywords: GPS, vertical coordinate changes, apparent stability