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VLBI-GPS Co-location Results in Japan

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Abstract

We present the results of our co-location surveys at two of our network VLBI sites and a preliminary comparison of VLBI and GPS solutions on a baseline between Tsukuba and Shintotsukawa. The comparison shows no systematic differences exceeding 10ppb between the two techniques. In addition we introduce a local hydrological effect on the vertical component of space geodetic measurements.

1. Introduction

Geographical Survey Institute (GSI) now operates and maintains 4 VLBI stations in Japan as well as 1,200 nationwide permanent GPS tracking array (GEONET: GPS Earth Observation NETwork), see Figure 1. Accurate tie information is indispensable for the maintenance of the high-precision terrestrial reference frame and it is true for our new geodetic system (JGD2000) as it is based on the fundamental network consisting of VLBI and GPS [2]. Co-location surveys at Tsukuba and Shintotsukawa VLBI sites show local ties are established at the mm-level between VLBI and GPS reference points and the comparison of baseline solutions indicates that there will not be relative systematic differences exceeding 10ppb between the two. As the precision of space geodetic measurement improves, we have to consider formerly negligible global/local effects that may contribute to the variation of solutions. We will show an example of local hydrological effect on the vertical component of positions and discuss its significance.

2. Local Tie and Transformation to Global Reference Frame

Local tie was established at each site between a GEONET point and the VLBI antenna by the method described in [5]. The standard error (north, east, up) in mm, of the determination was (0.5, 0.5, 1.0) for Tsukuba and (0.7, 0.8, 1.0) for Shintotsukawa. To transform the local relative vector to the ITRF system, we made GPS observations between the network and a direction maker 7-13km away from the site to determine the network's horizontal orientation and used the deflection of the vertical at the site. For the deflection of the vertical, we used the value obtained by astronomical observations at Tsukuba (1980-1983) and interpolated one from Japan's Geoid model (GSIGEO2000, [3]) at Shintotsukawa. The interpolation was compared with several sites with observed values and considered good enough for the transformation [4]. The relative vectors between GPS and VLBI are shown in Table 1.

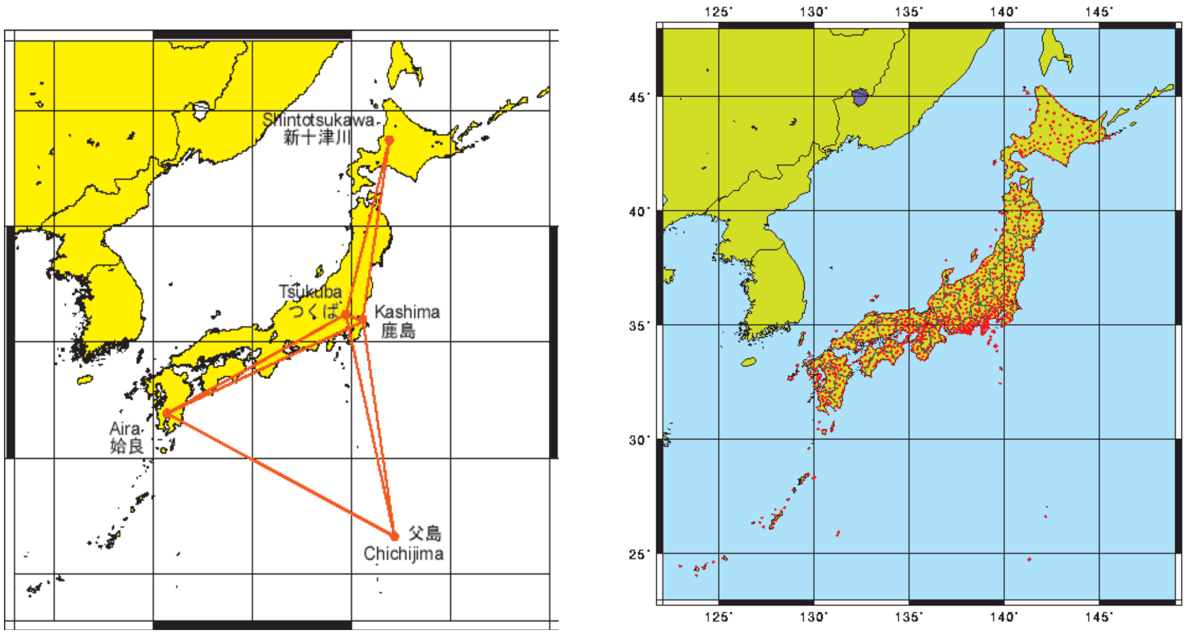

Figure 1. GSI's space geodetic networks, VLBI(left) and GEONET(right).

Table 1. Vectors from GPS to VLBI (ITRF2000, unit: m)

Vector	X	Y	Z	L
TSKB to 32m	-209.5453	29.7219	-216.8837	303.0366
942004 to 3.8m	6.5162	14.3860	-3.9314	16.2749

3. Comparison of VLBI and GPS Tme Series Solutions

Two sets of time series solutions were compared on one baseline. VLBI solutions were converted to the GPS baseline with simple vector additions as depicted in Figure 2. Analysis software was Calc/Solve for VLBI and Bernese for nationwide GPS network [1]. Figure 3 shows the two sets of solutions from 1995 to 2003 measurements for each component of the vector. No artificial offset between the two series was added. In horizontal components no systematic differences exceeding a few cm are seen. In contrast the vertical series differ by a few cm or more and we need to investigate what causes this discrepancy. Possible causes are, simple error of calculation, snow on GPS antenna, local effects such as by groundwater described in the next section, etc.

4. Local Effect on Vertical Position

For some time, an IGS site at GSI Tsukuba, TSKB has been known to show anomalous seasonal variation in height component. Recently the cause and mechanism of variation were revealed by Tobita et al.[7] and Munekane et al.[6]. We briefly introduce their results here. Time series (a) in

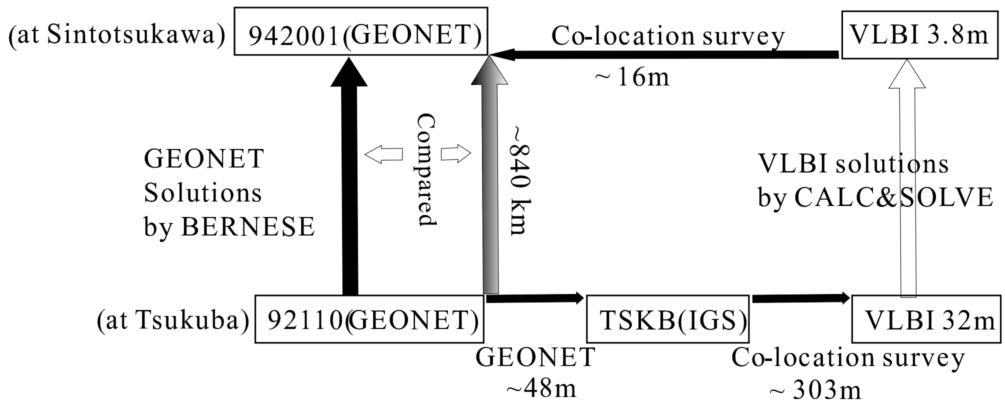

Figure 2. Comparison of VLBI and GPS, GEONET and VLBI+Local-tie solutions compared on the baseline (942001-92110).

Figure 4 shows the height variation for the past 8 years of TSKB. There is a strong correlation between the height change and groundwater level monitored at several deep wells at the site, see (b) and (c) in Figure 4. It was explained by the elastic deformation of water-contained layers and the cause of the water-level change was also investigated. The bottom graph in Figure 4 shows the relation of groundwater level and the amount of its extraction in a year. In the 4 months of summer, groundwater is used to irrigate the rice field in Tsukuba and corresponding to this, the level of water goes down and begins to come back in September.

5. Conclusion

An accurate local tie was established at 3 of 4 GSI VLBI sites in Japan. Co-location survey will be completed in 2004-5 if the remaining Chichijima site is co-located. Now that our domestic VLBI experiment has tripled its frequency (once per month in 2003) and time series solutions will be a reference for Japan's geodetic network by comparing and combining with daily GPS solutions. Investigation on smaller geophysical, meteorological and environmental effect on site positions becomes more important than ever as we further pursue the improvement of space geodetic observation. We will have to look into antenna thermal deformation, various loading effects and site specific environmental effect such as we introduced here.

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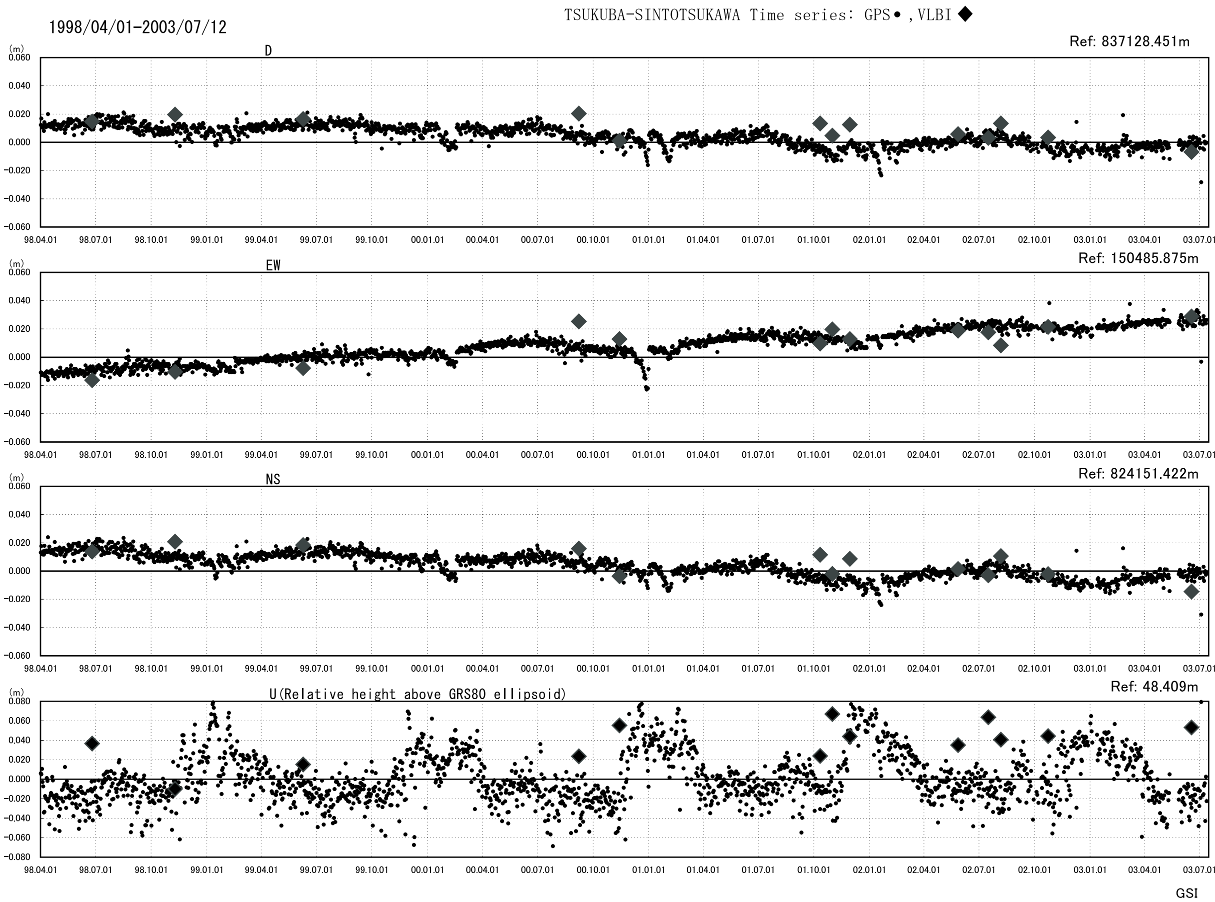

Figure 3. Time series solutions of baseline compoments, dot for GPS, diamond for VLBI.

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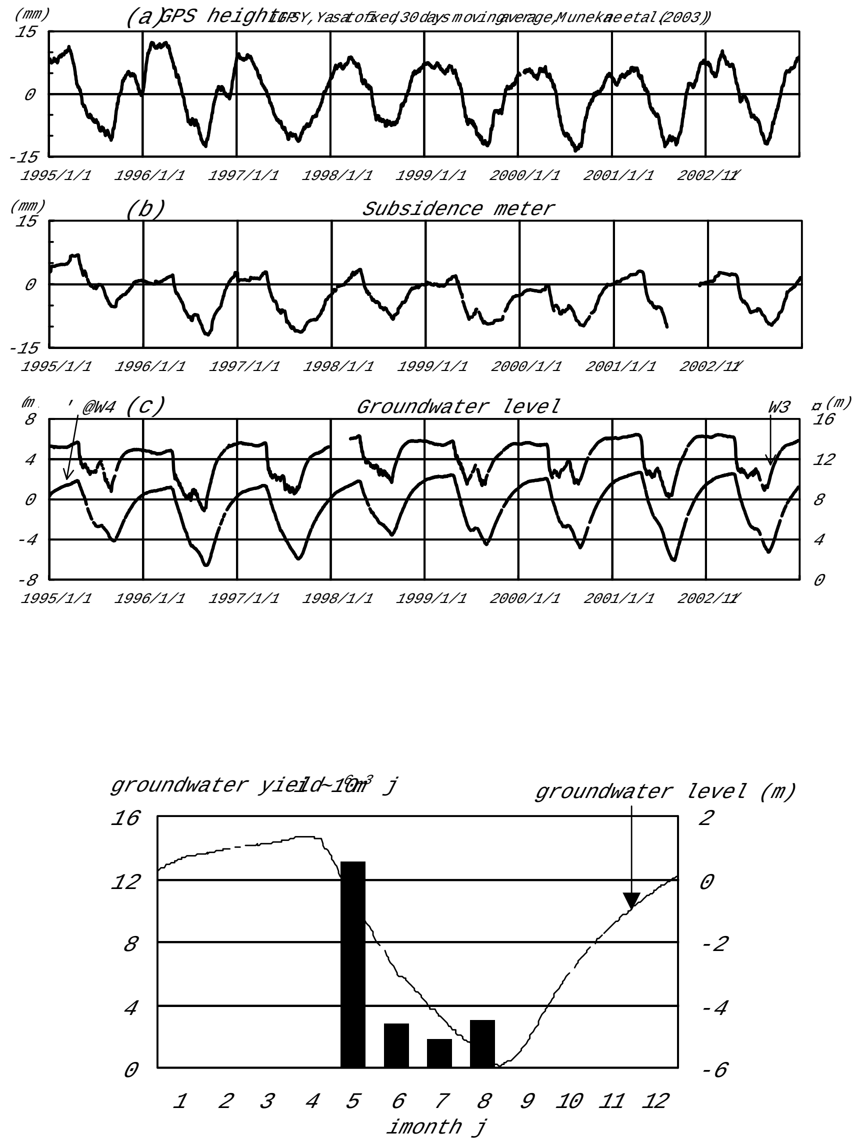

Figure 4. GPS height variation and relevant quantities, (a)GPS height, (b)Subsidence meter, (c)Groundwater level, bottom: Groundwater level vs. extracted amount, [6], [7].