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Local Ties between Co-located Space Geodetic Instruments at QUASAR Network Observatories

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Abstract. Local tie parameters between reference points of space geodetic instruments at the QUASAR VLBI network observatories have been derived from classical geodetic measurements. The results were compared with the eccentricity vectors obtained from VLBI and GPS observations.

1. Introduction

32-m radio telescopes (RT-32) and dual frequency GPS receivers with Choke Ring antennas are co-located space geodetic instruments at the QUASAR VLBI network observatories. At all observatories of the network GPS antennas are installed on concrete pillars constructed on the roofs of administrative buildings. The eccentricity vectors between reference points of co-located instruments were determined independently from different types of measurements: classical geodetic and space geodetic (VLBI and GPS). The obtained results are presented in this paper.

2. Local Tie Parameters from Geodetic Measurements

The local tie parameters between the RT-32 reference points and GPS markers at the observatories were derived from classical geodetic measurements carried out in 2005–2006. The geodetic measurements of different types within the local networks have been adjusted by using COLUMBUS software (3.6 DEMO version). Formal errors obtained in the course of these adjustments are in the range of 2–4 mm for horizontal components (N, E) and 5-8 mm for up-components (U). The main reason for this is the fact that the reference point of the radio telescope antenna is not accessible. It is supposed that the antenna reference point is located on the azimuthal axis of the telescope at the level of its elevation axis (the antenna offset is determined at this level). The horizontal coordinates of the reference point are presumed to coincide with a point where the azimuthal axis intersects the horizontal platform of the telescope. Obviously, these coordinates could be determined more accurately than the up-component of the elevation axis.

Obtained local tie parameters are presented in Tabl. 1.

Table 1. Local ties between reference points from classical geodetic measurements

Observatory	Eccentricity vectors RT-32–GPS	
	Components	Values, m
Svetloe	N	−57.594
	E	58.483
	U	9.323
Zelenchukskaya	N	−64.746
	E	7.954
	U	8.755
Badary	N	61.882
	E	−73.496
	U	10.204

3. Geocentric Coordinates of Reference Points

The coordinates of reference points at all observatories have been determined in the ITRF2005 (epoch 2000.0) within the framework of IAA and EPN analysis centers activities. The results of these determinations are summarized in Tabl. 2–4.

Table 2. ITRF2005 coordinates of reference points at the Svetloe observatory

	RT-32	GPS
DOMES number	12350S001	12350M001
Observations used	VLBI (2003–2007)	GPS (1996–2006)
AC (software)	IAA (OCCAM/GROSS)	EPN (Bernese)
X, m	2730173.900 ± 0.004	2730155.439 ± 0.001
Y, m	1562442.612 ± 0.002	1562364.664 ± 0.001
Z, m	5529969.033 ± 0.007	5529989.227 ± 0.001

Table 3. ITRF2005 coordinates of reference points at the Zelenchukskaya observatory

	RT-32	GPS
DOMES number	12351S001	12351M001
Observations used	VLBI (2005–2007)	GPS (1996–2006)
AC (software)	IAA (OCCAM/GROSS)	EPN (Bernese)
X, m	3451207.790 ± 0.013	3451174.813 ± 0.001
Y, m	3060375.220 ± 0.010	3060335.365 ± 0.001
Z, m	4391914.907 ± 0.014	4391955.600 ± 0.001

Table 4. ITRF2005 coordinates of reference points at the Badary observatory

	RT-32	GPS
DOMES number	12338S003	12338M002
Observations used	VLBI (2006–2007)	GPS (2005–2007)
AC (software)	IAA (OCCAM/GROSS)	IAA (GRAPE)
X, m	-838200.729 ± 0.009	-838281.524 ± 0.002
Y, m	3865751.572 ± 0.021	3865777.318 ± 0.003
Z, m	4987670.962 ± 0.027	4987624.653 ± 0.002

The presented data show that the coordinates of GPS markers have significantly smaller formal errors when compared with the RT-32 coordinates. A greater number of GPS observations at much longer time intervals explains this effect. But the real accuracy of these coordinates may be at the same level. It is partly shown in the case of coordinate determinations at the Badary observatory.

The ITRF2005 coordinates at the Badary observatory have been obtained at the IAA Analysis Center by processing VLBI and GPS observations.

To derive the RT-32 coordinates, VLBI-observations of the QUASAR network under the Ru-E program have been processed with the OCCAM/GROSS software [1]. The series of coordinates obtained from 15 daily sessions of observations between Aug. 2006 and May 2007 are presented in Fig. 1. Weighted averages of coordinates are given in Tabl. 4.

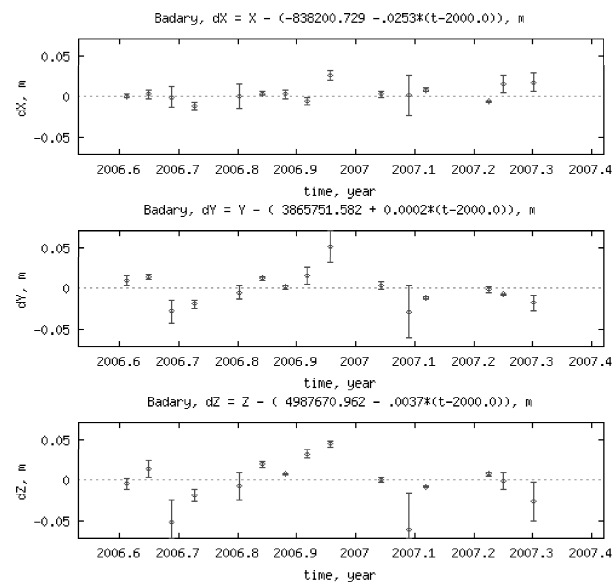

Figure 1. Coordinates of RT-32 at the Badary observatory

The coordinates of GPS-station BADG at the Badary observatory have been determined from GPS observations over a period from April 2005 to March 2007. Data processing was performed by using the software package GRAPE [2] in the mode of triple differences of phase observations. The daily series of observations from 30–40 IGS stations were processed under the condition that coordinates of all stations were fixed in the ITRF2005 except for BADG.

At the BADG station antenna LEIAT504 (Leica) with radome LEIS is used on a permanent basis. For experimental purposes, however, the radome was temporarily removed for the period between November 2005 and August 2006. While processing the observations, the displacements of the antenna phase centers according to IGS data were taken into account. The coordinates of the BADG station obtained from the daily series of GPS observations over a 2 year period are presented in Fig. 2. Some irregularities in coordinates

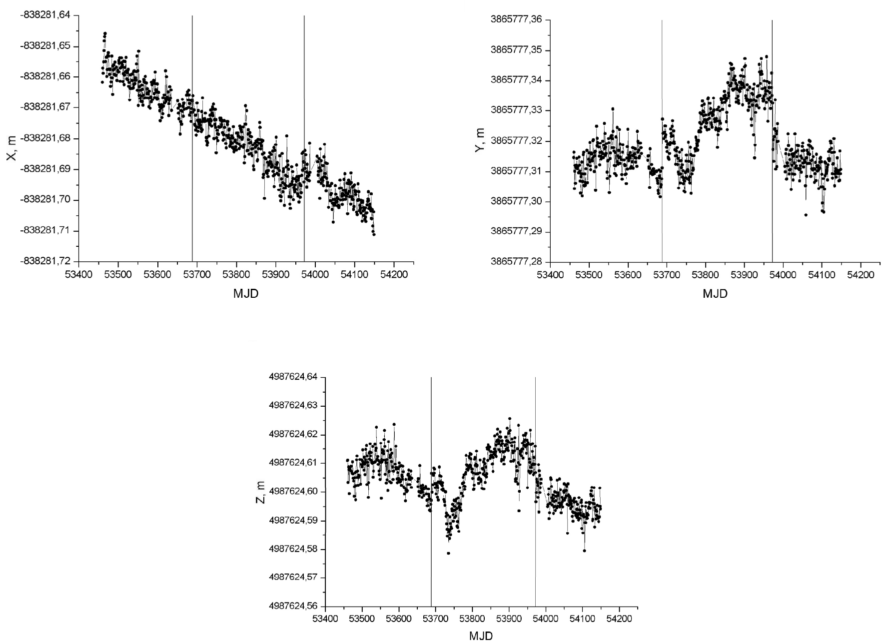

Figure 2. Coordinates of BADG station

are probably caused by seasonal effects. There is also an effect of inexact modelling of the phase center displacements. The vertical lines in the graphics show the days when the radome was removed and reinstalled. These days show noticeable jumps in coordinates and it is not possible to consider the series of obtained coordinates as homogeneous. Therefore, the series of coordinates were divided into three sections and data in the central section was extracted from the analysis in order to determine velocities and coordinates of the station for epoch 2000.0.

4. Consistency of VLBI, GPS and LGN Results

Consistency of the ITRF2005 coordinates with local tie results were also examined. The following differences

$$\Delta X = X_{RT-32} - X_{GPS}, \quad \Delta Y = Y_{RT-32} - Y_{GPS}, \quad \Delta Z = Z_{RT-32} - Z_{GPS}$$

have been formed using the ITRF2005 coordinates from Tabl. 2–4. When transformed to local NEU systems these eccentricity vectors can be compared with local tie parameters given in Tabl. 1. The results of such comparisons for each observatory of the QUASAR network are presented in Tabl. 5. They show that differences are at level of 1 cm except for the up-component of the Svetloe observatory and this should be investigated further.

Table 5. Differences between eccentricity vectors obtained by various methods

Components	Svetloe	Zelenchukskaya	Badary
N, mm	2.8	− 1.2	10.5
E, mm	0.9	−11.5	7.2
U, mm	23.4	− 9.1	−6.6

In general, the differences are comparable with error budget of the results obtained from VLBI, GPS and LGN data. The most likely reasons for these deviations are: a) the inconsistency of VLBI and GPS subsystems in ITRF2005 realization; b) using a limited subset of stations when determining the coordinates; c) errors in data processing algorithms; d) errors associated with local geodetic surveying. Seasonal variations can also be slightly different for VLBI and GPS antennas. For a detailed analysis of these effects the accumulation of observational data over more extended periods and regular monitoring of local geodetic networks are needed.

Acknowledgements

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References

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