THE "SIMEIZ-KATZIVELY" CO-LOCATION SITE OF SPACE GEODESY TECHNIQUES: CURRENT STATE AND FUTURE ACTIVITY

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ABSTRACT. Two Satellite Laser Ranging (SLR) stations, two Global Navigation Satellite System (GNSS) stations and Very Long Base Interferometry (VLBI) station are placed on the "Simeiz-Katzively" co-location site. The activity of these space geodesy techniques in 2010-2012 is presented. Special attention is paid on results of new local tie surveys at this co-location site.

1. CURRENT STATE OF ACTIVITY

Space geodetic techniques, such as SLR, VLBI, GNSS and traditional geodetic techniques observe the Earth system parameters at the "Simeiz-Katzively" co-location site (Crimea, Ukraine) since many years (see Figure **??**). In 80-ies of the XX century the second generation SLR systems named "KRYM" were used in the former USSR (see, e. g., Abalakin V. K. at al. 1985, Basov N. G. and Kokurin Yu. L., 1986). Two of these stations were placed at the Crimea, namely the Crimean scientific station of the Physical Institute of the USSR Academy of Sciences (at present the Crimean Laser Observatory of the Main Astronomical Observatory of the NAS of Ukraine, CLRO) and the Simeiz station of the Astronomical Council of the USSR Academy of Sciences (at present the Crimean Astrophysical Observatory of the Kyiv National University, CRAO). These stations participate in the ILRS under the names: Katzively (№1893) and Simeiz (№1873) since 1984 and 1998 respectively. The information of their activities in 2010-2012 is presented in Table 1.

Year	Location	Number of passes			Number of NP		
		LEO	Lageos	HEO	LEO	Lageos	HEO
2010	Katzively	1287	203	146	18183	1563	1079
2010	Simeiz	1105	332	8	14354	2688	44
2011	Katzively	1413	240	210	20156	1961	1455
2011	Simeiz	1108	296	10	14898	2309	75
2012	Katzively	1865	260	339	41194	3336	3946
2012	Simeiz	1007	244	80	11828	1740	488

Table 1: Operational compliance issues of the Katzively and the Simeiz SLR stations.

Based on the ILRS analysis one can state that these stations are less active as compared with operational activity of modern ILRS stations. Therefore as a first step we plane to improve a measurement precision (up to 10 mm) by using new guiding and recording systems. As a next step a new type of the SLR system will be installed at this co-located site.

In 1995 the VLBI observations were started by CRAO in cooperation with Goddard Space Flight Center (GSFC). At present the Simeiz VLBI station (IERS Number 123375008) is based on radiotelescope RT-22, recording system Mark-5A and Mark-5B+ and H-maser (time and frequency). RT-22 has steering parabolic mirror with diameter 22 m and focal length 9525 mm. Root mean square accuracy of surface is 0.25 mm and effective area 210 m^2 which does not depend on elevation angle at frequencies 2.3 and 8.4 GHz. The antenna has an azimuth-elevation mounting with axis offset -1.8±0.2 mm. Working range

Figure 1: The "Simeiz-Katzively" co-location site

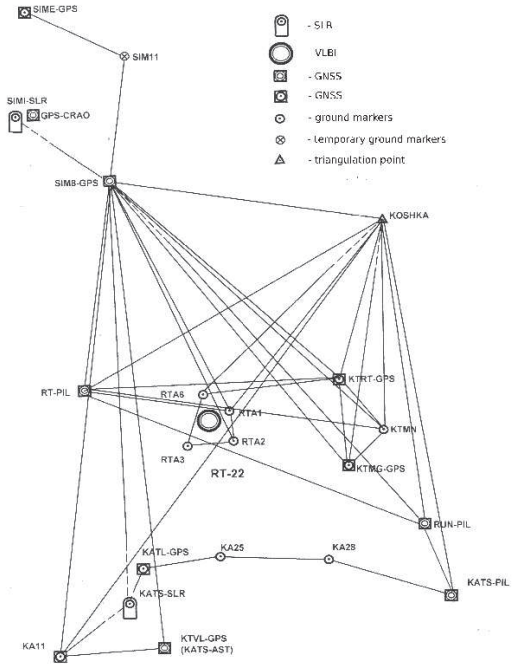

Figure 2: Set-up of the local survey at the "Simeiz-Katzively" co-location site

in azimuth is [-210°, 210°] (zero is to the south) and in elevation [-1°, 85°]. Maximum slewing rate is 1°.5/sec. The control system of the telescope provides an accuracy of pointing at the level of about 10″. The information on activity of the Simeiz VLBI station in 2010 – 2012 is given in Table 2.

Year	Number of sessions
2010	16
2011	17
2012	16

Table 2: Operational activity of the Simeiz VLBI station.

There are two GNSS station at this co-location site. The GNSS station CRAO was installed in 2004, the GNSS station KTLV was installed in2009. These stations receive the GPS signals (KTVL station observes the GLONASS also) with observation interval of 1 second.

2. NEW PRECISE LOCAL SURVEY TIES AT THE "SIMEIZ-KATZIVELY" CO-LOCATION SITE.

Study of the inter-technique discrepancies for ITRF and ERP realizations is one of new challenges for IERS. These discrepancies could be eliminated by careful combination of SLR, VLBI and GNSS data, along with precise local survey ties. Local survey at the "Simeiz-Katzively" co-location site was started in 1993 and several campaigns were undertaken in 1994, 2004, 2008 and 2011 (Samoylenko O. M., Odynets P. S. and Yatskiv Ya. S., in press).

As the result the coordinates of reference points of space-geodesy techniques and ground-based markers were derived with respect of the ITRF-2000 for the epoch 2004.6 and corresponding local ties for these reference points with respect to position of the RT-22 (see Appendix) were estimated.

Horizontal deformations δS, α and ν (in vectorial form) based on the data of local surveys were derived for different time intervals (see Table 3).

There are three zones of deformations at the "Simeiz-Katzively" co-location site, namely zone of intensive deformations (KATS Zone), zone of small deformations (SIMIRT Zone) and the SLR CRAO site which is relatively stable zone (see Figure 2).

Reference points	Time intervals								
	1994 – 2004			2004 – 2008			2008 – 2011		
	δS mm	α degree	ν mm/year	δS mm	α degree	ν mm/year	δS mm	α degree	ν mm/year
RT22G	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KATS-SLR	33.8	185	3.4	38.2	168	9.6	11.2	236	3.7
KAVL-GPS	29.1	177	2.9	32.0	166	8.0	15.8	197	5.3
KATS-PIL	77.0	166	7.7	32.9	139	8.2	27.6	197	9.2
KAT-GRAV	-	-	-	184.0	132	46.0	33.0	125	11.0
KTMR-GPS	-	-	-	-	-	-	18.2	187	1.1
RUN-PIL	147.3	162	14.7	31.2	121	7.8	13.7	160	4.6
KTHI-GPS	52.3	114	5.2	31.3	132	7.8	-	-	-
KTRT-GPS	4.3	234	0.4	4.1	101	1.0	3.8	748	1.3
RT-PIL	2.6	157	0.3	4.1	101	1.0	4.5	80	1.5
KOSHKAC	12.7	333	1.3	12.7	90	3.2	27.8	300	9.3
SIMI-SLR	18.6	130	1.9	3.3	255	0.8	3.9	19	1.3
GPS-CRA	-	-	-	11.7	240	2.9	8.7	37	2.9
SIM8-GPS	-	-	-	3.1	322	0.8	4.7	298	1.6
SIMI-AST	0.0	0	0.0	3.4	2	0.9	4.4	55	1.5
SIME-GPS	24.8	188	2.5	6.8	126	1.7	25.1	96	8.4

Table 3: Horizontal deformations at the "Simeiz-Katzively" co-location site (credit: O. M. Samoylenko).

Velocities of horizontal displacements of markers in KATS Zone are from 3 mm/year to 15 mm/year (average value 8 mm/year). In SIMIRT Zone there are horizontal displacements of about 3 mm/year. Vertical displacements in these zones are three times less as compared with horizontal ones. Based on these results one can conclude that local deformations are very complicated at the "Simeiz-Katzively" co-location site. They have to be taken into account when combining the results of space geodesy observations and when new generation space geodesy techniques will be installed at this site.

3. FOLLOW-ON THE "SIMEIZ-KATZIVELY" OBSERVATION TECHNIQUES.

For consistent participation of the "Simeiz-Katzively" co-location site in International Space Geodesy Services (ILRS, IVS, IGS, etc.) it is necessary to undertake the following actions:

- modernizing the existing space geodesy techniques,
- improving the systematic of space geodesy observations and identifying their errors for excluding inter-techniques discrepancies,
- conducting the new local tie surveys,
- installing the new generation space geodesy techniques for SLR and VLBI observations.

We have started an implementation of the actions mentioned above.

4. REFERENCES

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APPENDIX.

RESULTS OF LOCAL TIE SURVEYS AT THE "SIMEIZ-KATZIVELY" CO-LOCATION SITE CURRIEDOUT IN 1994, 1999, 2008 and 2011.

Table 4: Excenters with respect to position of RT-22G at the epoch 2004.6 (local survey of 1994).

Station number	Station name	ΔX, m	$\sigma\Delta X$, mm	ΔY, m	$\sigma\Delta Y$, mm	ΔZ, m	$\sigma\Delta Z$, mm
1	2	3	4	5	6	7	8
12337S008	RT22G	0,0000	1,0	0,0000	2,0	0,0000	0,9
12337S006	KATS-SLR	713,4922	2,3	- 426,8797	1,5	- 335,0690	2,2
12337S003	SIMI-SLR	- 1328,631	0,2	197,4942	2,6	1461,0637	2,4
12337M001	SIME-GPS	- 1484,5990	5,2	155,2269	4,3	1648,7410	6,5
	KTRT-GPS	- 70,1277	-	54,7318	-	- 6,6172	-
	RT-PIL	- 10,7951	-	- 128,3651	-	191,5581	-
	KATS-PIL	650,2011	4,8	-259,1464	17,0	- 407,7329	1,0
	KTMR-GPS	389,2674	1,5	- 41,1734	8,9	- 334,2626	1,9

Note. 1) SIMI-SLR is point of mobile SLR station on which GPS receiver are centered;
2) Root mean square error of points does not include errors of GPS ground markers.

Table 5: Excenters with respect to position of RT-22G at the some epoch.

Excenters with respect to position of RT-22G at the epoch 2004.6 (local survey of 2004).

Station number	Method Method	Station name	ΔX, m	$\sigma\Delta X$, mm	ΔY, m	$\sigma\Delta Y$, mm	ΔZ, m	$\sigma\Delta Z$, mm
1	2	3	4	5	6	7	8	9
12337S008	VLBI	RT22G	0,0000	1,4	0,0000	1,2	0,0000	1,2
12337S006	SLR	KATS-SLR	713,5046	1,4	- 426,8749	5,5	- 335,1034	8,9
12337S003	SLR	SIMI-SLR	- 1328,6341	2,9	197,5098	3,1	1461,0536	5,8
12337M001	SLR GPS	SIME-GPS	- 1484,5782	3,7	155,2366	5,2	1648,7289	9,5
12337M002	GPS	GPS-CRAO	- 1333,7703	2,3	196,8987	3,7	1467,8380	6,5
	GPS	KTRT-GPS	- 70,1254	-	54,7290	-	- 6,6204	-
	GPS	RT-PIL	- 10,7927	-	- 128,3647	-	191,5636	-
	GPS	KATS-PIL	650,2201	1,1	- 259,1105	5,6	- 407,8023	7,1
	GPS	SIM8-GPS	- 1275,1947	2,4	261,8975	2,6	1392,7492	1,3
	GPS	KTMG-GPS	41,6859	2,3	68,1443	2,2	-106,0268	4,1

Excenters with respect to position of RT-22G at the epoch 2004.6 (local survey of 2008).

Station number	Method Method	Station name	ΔX, m	$\sigma\Delta X$, mm	ΔY, m	$\sigma\Delta Y$, mm	ΔZ, m	$\sigma\Delta Z$, mm
12337S008	VLBI	RT22G	0,0000	1,5	0,0000	1,7	0,0000	1,4
12337S006	SLR	KATS-SLR	713,5319	1,0	- 426,8470	6,8	- 335,1183	7,6
12337S003	SLR	SIMI-SLR	- 1328,6336	3,8	197,5062	4,9	1461,0508	6,5
12337M001	SLR GPS	SIME-GPS	- 1484,5820	5,5	155,2406	5,3	1648,7337	6,3
12337M002	GPS	GPS-CRAO	- 1333,7625	4,2	196,8918	4,5	1467,8324	5,2
	GPS	KTRT-GPS	- 70,1272	-	54,7326	-	- 6,6210	-
	GPS	RT-PIL	- 10,7946	-	- 128,3611	-	191,5630	-
	GPS	KATS-PIL	650,2372	1,2	- 259,0728	6,3	- 407,8022	6,4
	GPS	SIM8-GPS	- 1275,1951	4,6	261,8949	3,4	1392,7509	1,7
	GPS	KTMG-GPS	41,6765	1,7	68,1482	1,7	- 106,0303	2,5

Excenters with respect to position of RT-22G at the epoch 2004.6 (local survey of 2011).

Station number	Method Method	Station name	ΔX, m	$\sigma\Delta X$, mm	ΔY, m	$\sigma\Delta Y$, mm	ΔZ, m	$\sigma\Delta Z$, mm
12337S008	VLBI	RT22G	0,0000	1,5	0,0000	1,7	0,0000	1,4
12337S006	SLR	KATS-SLR	713,5449	1,0	- 426,8494	6,8	- 335,1179	7,6
12337S003	SLR	SIMI-SLR	- 1328,6322	3,8	197,5087	4,9	1461,0585	6,5
12337M001	SLR GPS	SIME-GPS	- 1484,5976	5,5	155,2603	5,3	1648,7281	6,3
12337M002	GPS	GPS-CRAO	- 1333,7676	4,2	196,8946	4,5	1467,8396	5,2
	GPS	KTRT-GPS	- 70,1191	-	54,7338	-	- 6,6158	-
	GPS	RT-PIL	- 10,7875	2,4	- 128,3510	2,4	191,5754	3,0
	GPS	KATS-PIL	650,2556	1,2	- 259,0703	6,3	- 407,8229	6,4
	GPS	SIM8-GPS	- 1275,1947	4,6	261,8902	3,4	1392,7517	1,7
	GPS	KTMG-GPS	41,6921	1,7	68,1430	1,7	- 106,0198	2,5
12337M003	GPS	KTVL-GPS	760,9140	4,0	- 458,5208	5,0	- 358,2345	6,7