The Developing Techniques of The Helwan SLR-Station (2000)

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Abstract: A new modifications applied at the Helwan Satellite Laser Ranging Station are discussed. The analysis procedure used to analyze and remove the noise from the Helwan satellite laser ranging (SLR) data as well as the normal points computations are explained. The results of the SLR data taken at 2000 for some of those satellites and a comparison with the results of the data obtained before that modification are discussed.

1 Introduction

It is known that when a fast rise time and short width pulses are available, it makes the time interval measurements at nanosecond resolution possible on the basis of the single observation. The laser observation technique is one of the most accurate satellite tracking stations available when accurate timing and appropriate corrections for range bias caused by the atmosphere are incorporated [4]. In Helwan station a passive mode locked (ND: YAG) semi-train pulses laser [2,3] that produce sharply defined pulses of nearly monochromatic high energy in a beam with a very low angle of divergence is used.

In this research, we investigate the new modifications of the Helwan Station related to the time interval counter as well as the modification discussed in [3]. The procedure used to analyze and remove the noise from the data [3], is outlined. The results of the data obtained at 2000 as well as the data obtained at 1995 (for comparison purposes) are discussed.

2 The modifications

In paper [2], we explained the developing techniques of the Helwan laser tracking station. We concerned mainly with the different kinds of laser transmitters that used in the station. We explained in details the laser transmitters, which generate either a single pulse or semi-train of pulses. The output energy for a single pulse at 0.53 μm is 30 mJ, but for the semi train of pulses is 80 mJ.

In the previous paper [3], We explained and discussed the results of the data taken at 1999, in which the modifications of the system, which related to the PMT RCA 31034A that was replaced by the PMT Hamamatsu H6533 box with PMT tube R4998. Due to the long operating time of the PMT RCA 31034A, (used since 1997), its sensitivity decreased by approximately three times [1]. Also, a high precision meteorological station (MET-3) was installed to improve temperature, humidity and atmospheric pressure's.

In this paper, a new modification occurred by installing the SR620 counter with Rubidium Oscillator of 4 ps resolution instead of the counter HB5370B (of 1 ns resolution).

3 The analysis of the Helwan SLR-data

The analysis of the data is based on calculating the difference between the observed and the predicted ranges. The analysis procedure had used by the help of the faculty of nuclear physics at Prague [6]. The principal phases of the analysis process are: -

1) On-line evaluation of the ranging to prediction residuals,
2) Off-line procedures,
3) Polynomial fitting of the residuals data.

To analyze and remove the noise of the Helwan satellite laser ranging (SLR) data, the analysis procedure are carried out for the satellite laser ranging data as mentioned in [3, 6]. Generally, during the satellite ranging, the epoch, propagation time, the number of laser shot and the observed predicted range in

ms values (1 ms > 150 km) are stored in a computer ranging data file as shown in Table 1. For more details see the reference no. [3].

00 06 10 92052010									
288 37 999 79.70 0. 0 0 1									
					O-C				
no.Las.	h	m	s	range(ms)	on line	off line	poly. fit		
8	19	16	8.0002810	15.84076620	-0.111	-0.43	-1.40	0	0
10	19	16	8.4002839	15.83152337	-0.110	0.95	0.02	0	1
11	19	16	8.6002841	15.82690615	-0.104	1.50	0.59	1	0
33	19	16	13.0002797	15.72604572	-0.107	-0.11	-0.67	0	0
40	19	16	14.4002819	15.69425012	-0.102	-0.58	-1.03	1	0
67	19	16	19.8002823	15.57297712	-0.086	0.81	0.70	3	0
69	19	16	20.2002827	15.56408021	-0.092	0.08	-0.01	2	1
74	19	16	21.2002800	15.54189452	-0.084	1.63	1.60	3	0
107	19	16	27.8002792	15.39738260	-0.087	-0.57	-0.29	2	0
156	19	16	37.6002808	15.18914556	-0.083	1.22	1.82	1	0
157	19	16	37.8002846	15.18497499	-0.089	-0.31	0.30	0	0
163	19	16	39.0002814	15.16002989	-0.078	-0.68	-0.05	2	1
164	19	16	39.2002810	15.15588488	-0.083	0.24	0.88	1	0
169	19	16	40.2002792	15.13520574	-0.086	1.19	1.85	0	0
173	19	16	41.0002800	15.11871923	-0.088	-0.87	-0.19	0	0
193	19	16	45.0002812	15.03709913	-0.084	-0.83	-0.08	0	1
201	19	16	46.6002823	15.00482937	-0.078	-0.28	0.49	1	0
310	19	17	8.4002824	14.58749986	-0.061	-0.62	0.24	1	0
311	19	17	8.6002818	14.58387012	-0.061	-0.79	0.07	1	1
313	19	17	9.0002802	14.57662235	-0.066	-0.62	0.23	0	0
315	19	17	9.4002821	14.56939105	-0.049	1.15	2.00	3	0
322	19	17	10.8002805	14.54419159	-0.060	-0.70	0.15	1	1
324	19	17	11.2002797	14.53702667	-0.048	-0.12	0.73	3	0
327	19	17	11.8002802	14.52630615	-0.064	-0.61	0.23	0	0
328	19	17	12.0002813	14.52274012	-0.064	-0.83	0.01	0	1

Table 1. Part of the SLR data obtained for the satellite Topex.

4 Normal points computations

The primary output of the satellite laser ranging stations is the normal points data. The algorithm of the normal points computation is explained [5]. The values of the bins are agreed to be 15 s, for the satellites Becon-C Topex, GFO-

1, ERS-2 and Champ. For the satellites Ajisai, Starlette and Stella, the value of the bin i is 30 s. and 120 s for the satellites Lageos-1 and Lageos-2.

The output values of the normal points are computed for each observed satellite. The normal points are computed for the satellite Topex (as an example) and the results are shown in table 2.

5 Results and discussion

The laser ranging has been carried out for many satellites. Lageos 1, lageos 2, AJISAI, ERS2, Starllite, Stella, Topex, GFO-1, champ and others are samples of those satellites. The principal phases of the analysis are carried out for each satellite. The range residuals in ns of the observed satellites are plotted in y-axis versus the no. of laser shots in x-axis. As an example, the range residuals are shown in Fig. 1 and Fig. 2. for the satellites Topex and ERS-2 respectively.

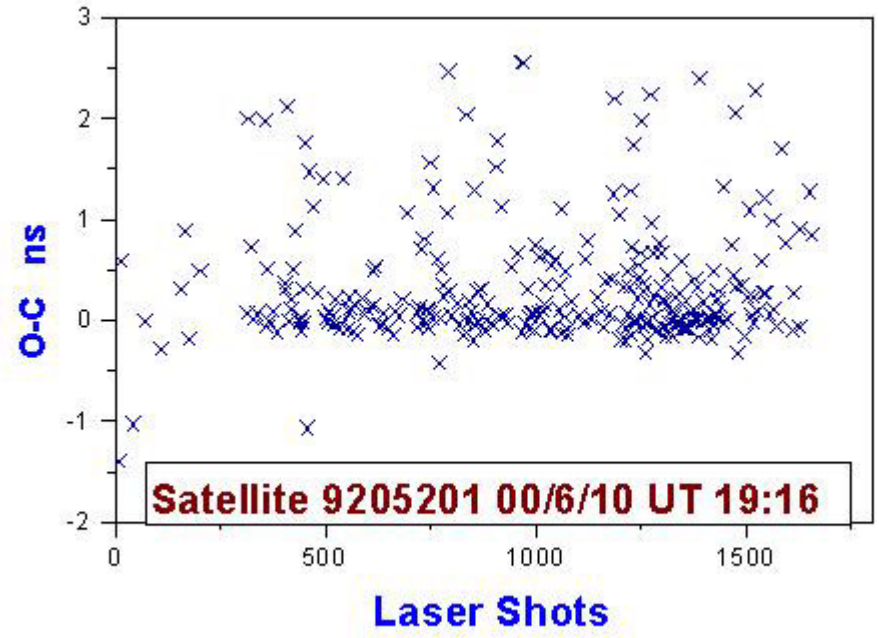


Fig. 1. Range residual in ns v.s No. of laser shots
as plotted for the satellite Topex.

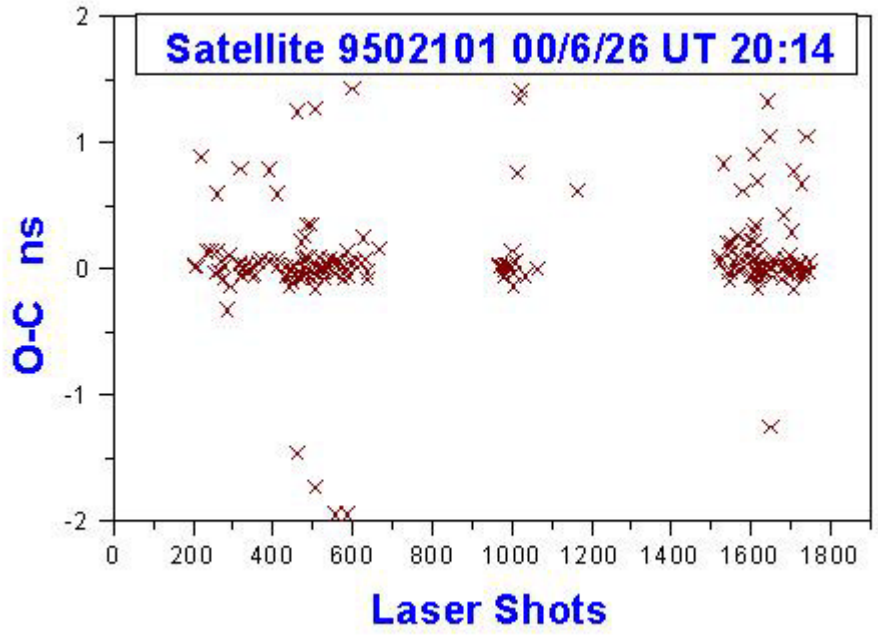
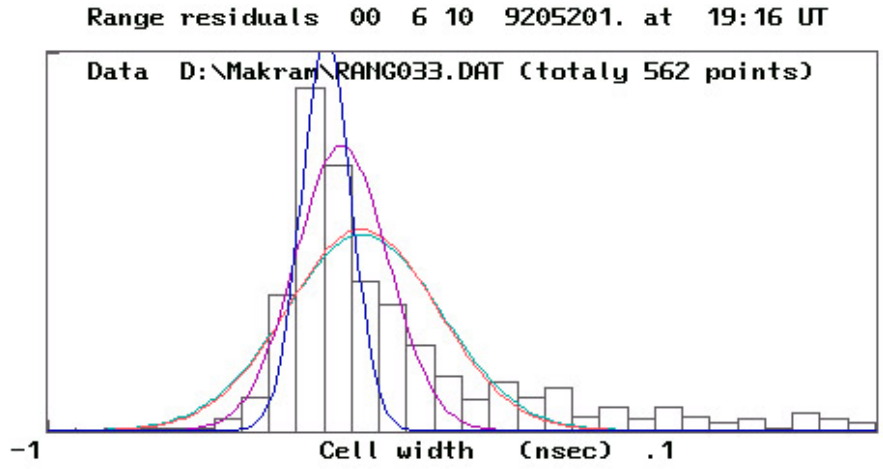


Fig. 2. Range residual in ns v.s No. of laser shots
as plotted for the satellite ERS-2.

Histograms of the range residuals of the polynomials are plotted in Fig. 3 and Fig. 4., for the same satellites in Figs 1 and 2 respectively. It is clear that, the accuracy of the measurements of those satellites is nearly 0.09 ns for the satellite Topex and 0.048 ns for ERS-2.



	Criter.		MEAN	SIGMA	PT
Limits	-1.000 /	1.000	0.139593	0.281807	491
	3 * SIGMA		0.136181	0.272244	487
	2.5*SIGMA		0.061459	0.167517	425
	2.0*SIGMA		0.005541	0.090102	314

Fig. 3. A histogram of the range residual as computed for the satellite Topex.

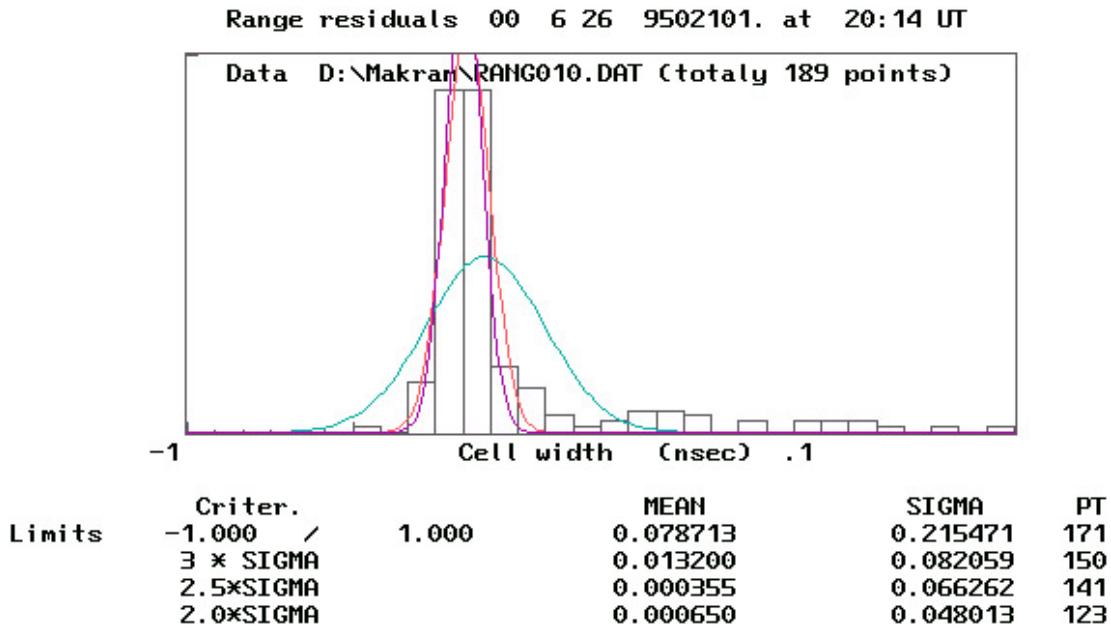


Fig. 4. A histogram of the range residual as computed for the satellite ERS-2.

#	h	m	s	Range (ms)	psec	PT/NPT
1	19	16	8.4002839	5.83152337	86.0	1
2	19	16	20.2002827	15.56408021	86.0	1
3	19	16	39.0002814	15.16002989	86.0	1
4	19	16	45.0002812	15.03709913	86.0	1
5	19	17	12.0002813	14.52274017	61.9	6
6	19	17	27.8002831	14.25322289	81.3	11
7	19	17	36.0002799	14.12311718	75.9	10
8	19	17	52.4002844	13.88390465	81.1	17
9	19	18	7.8002811	13.68589302	89.6	14
10	19	18	29.6002828	13.45200150	91.6	7
11	19	18	36.0002815	13.39405154	87.1	23
12	19	18	54.2002831	13.25673078	96.1	19
13	19	19	7.4002797	13.18313193	83.4	12
14	19	19	24.0002869	13.12227556	69.9	22
15	19	19	37.8002838	13.09891576	92.5	20
16	19	19	52.8002849	13.10175425	83.9	13
17	19	20	11.2002810	13.14536517	74.8	24
18	19	20	21.6002839	13.18943371	106.9	30
19	19	20	37.6002831	13.28423532	95.6	32
20	19	20	51.8002823	13.39528279	69.8	21
21	19	21	7.6002834	13.54779045	99.8	11
22	19	21	26.2002852	13.76503104	98.7	6
23	19	21	37.0002844	13.90916860	55.7	3

Table 2. The normal point as computed for the satellite Topex observed at 10/6/00.

The normal points computed for the satellite Topex as an example is shown in table 2. The normal point interval (bin i) is 30 seconds as explained before [3].

For the comparison purposes we analyzed the data obtain at 9/6/95 for the satellite Topex (as an example). The range residuals are plotted in relation to the number of laser shots and the result is shown in Fig. 5. The histogram of the range residuals are computed and plotted in Fig. 6. The accuracy of the measurements is nearly equal to 0.236 ns. It is worse than the results for the same satellite (Topex) observed at 2000. This means that, the precision of the measurements became much better than the previous (before the new modification and the upgrading of the station).

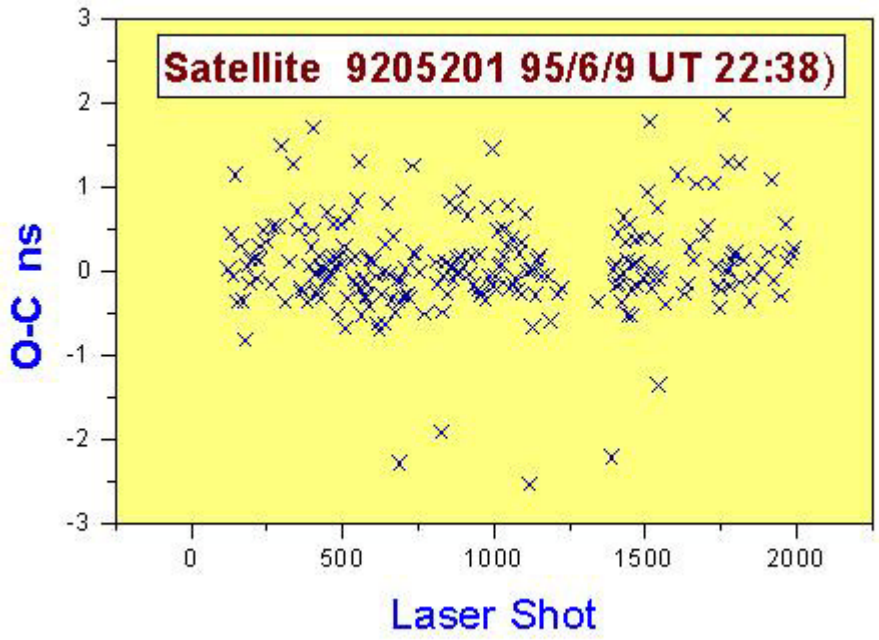
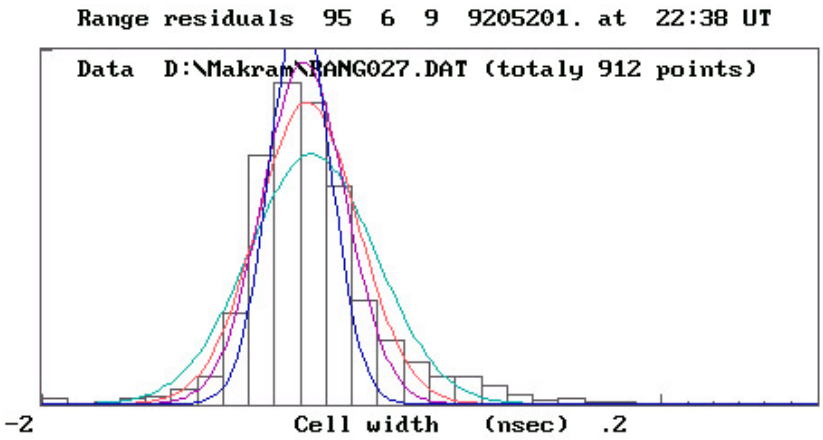


Fig. 7. Range residual in ns v.s the No. of laser shots
as plotted for the satellite Topex observed at 9/6/1995.



	Criter.		MEAN	SIGMA	PT
Limits	-2.000 /	2.000	0.087869	0.491121	901
	3 * SIGMA		0.049593	0.387776	859
	2.5*SIGMA		0.022956	0.323268	812
	2.0*SIGMA		-0.006464	0.235607	690

Fig. 4. A histogram of the range residual as computed for the satellite Topex observed at 9/6/1995.

6 Conclusion

In 2000, the Helwan station the laser observations are carried out for many satellites. The satellites under observations are Beco-C, ERS-1 ERS-2, Ajisai, Starlette, Topex, Gfo-1, Sunsat, Champ and Westpack as well as the height orbiting satellites Lageos1 and Lageos2. The principal phases of the analysis process are carried out for each satellite pass. As a result of the new modification as well as for comparison purposes, the laser ranging data are computed for the satellite Topex obtained at 9/6/1995 (as an example) with the same satellite data obtained at 10/6/2000. The precision of the observation obtained at 2000 is more accurate than that one obtained at 95 (before the new upgrading of the station). It is also clear that the accuracy of the measurements of the satellite ERS-2 is nearly equal to 7.5 mm. This means that the precessions of the satellite's observation below 10 mm are available.

References

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