

SATELLITE LASER RANGING OBSERVATIONS IN1997

Summary - Satellite laser ranging observations have been continued by a fixed type satellite laser ranging station at the Simosato Hydrographic Observatory (JHDLRS-1) and by a transportable one (HTLRS) .

Key words: satellite laser ranging(SLR) - global geodesy - JHDLRS-1 - HTLRS

This is a report of the satellite laser ranging (SLR) observations made at the Simosato Hydrographic Observatory by a fixed type satellite laser ranging station called JHDLRS-1 (Sasaki et al., 1983) and by a transportable one called HTLRS (Sasaki, 1988). This report contains the lists of data obtained at these stations in 1997.

Previous data obtained by the JHDLRS-1 appear in the Series of Astronomy and Geodesy, Data Report of Hydrographic Observations for the period from 1982 to 1985, and in the Series of Satellite Geodesy from 1986 to 1996; those obtained by the HTLRS appear in the Data Report of Hydrographic Observation, Series of Satellite Geodesy, No. 3 - 11.

1. Observation

The routine ranging observation for Lageos-I, Starlette, and Beacon (BE)-C started in April 1982 by the JHDLRS-1 under the mutual cooperation between the Hydrographic Department of Japan (JHD) and the National Aeronautics and Space Administration (NASA) of the United States of America. In August 1986, the Japanese first Geodetic Satellite "Ajisai" was launched and its tracking observation by the JHDLRS-1 started. Thereafter, 14 satellites were added in the routine observation : "ERS-1" in July 1991, "TOPEX/POSEIDON" in August 1992, "Lageos-II" in October 1992, "Stella" in September 1993, "Meteor-3" in January 1994, "Etalon-1","Etalon-2" in November 1994 ,"ERS-2" in May 1995, "GFZ-1" in June 1995, "GPS-35","GPS-36" in August 1995, and "ADEOS" in October 1996, "DIADEM1C", "DIADEM1D" in May 1997.

The range observation for Lageos-I, Starlette and Ajisai, by the HTLRS started in December 1987 in a campaign style. Lageos-II, ERS-1, TOPEX/POSEIDON and Stella have been also observed by the HTLRS . The range observations by the HTLRS at off-lying islands and at some coastal areas have been carried out as follows.

Jan. 1988 - Mar. 1988	: Titi Sima
Jul. 1988 - Sep. 1988	: Isigaki Sima
Jan. 1989 - Mar. 1989	: Minamitori Sima
Jul. 1989 - Sep. 1989	: Okinawa Sima
Oct. 1989 - Nov. 1989	: Tusima
Sep. 1990 - Oct. 1990	: Oki Shoto
Dec. 1990 - Feb. 1991	: Minami-Daito Sima
Aug. 1991 - Nov. 1991	: Tokati
Jan. 1992 - Mar. 1992	: Iwo Sima
Aug. 1992 - Oct. 1992	: Wakkanai
Jan. 1993 - Mar. 1993	: Hatizyo Sima
Jan. 1994 - Mar. 1994	: Makurasaki
Jul. 1994 - Oct. 1994	: Oga
Feb. 1995 - Mar. 1995	: Bisei

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Jul. 1995 - Aug. 1995	: Bisei
Jan. 1996 - Mar. 1996	: Tyosi
Sep. 1996 - Dec. 1996	: Titi Sima
Jul. 1997 - Nov. 1997	: Isigaki Sima

The major specifications of the JHDLS-1 and the HTLRS are listed in Table 1 and Table 2 (Sasaki et al., 1983, Sasaki, 1988). The locations of the systems and fiducial stone markers set up near the systems are shown in Table 3 (Takemura, 1983) and Table 4.

The observation schedule of the JHDLS-1 was made by selecting passes whose maximum elevation were over 30 degrees for Starlette, Ajisai, ERS-1, ERS-2, TOPEX/POSEIDON, Stella, Etalon-1, Etalon-2 and GFZ-1, ADEOS, GPS-35, GPS-36, and over 30 degrees in the nighttime and 35 degrees in the daytime for Lageos-I and Lageos-II. The observation schedule of the HTLRS was made by selecting passes whose maximum elevations were over 20 degrees only in the nighttime. When the HTLRS was in operation, the same criterion was applied to the JHDLS-1. Routine observation was not carried out on Saturday and Sunday. The priority of the selection for simultaneous transits was in the order of Ajisai, Lageos, ERS, TOPEX/POSEIDON, Starlette, Stella, GFZ-1, Etalon, and GPS.

IRV orbital elements of the satellites obtained from the Goddard Space Flight Center(GSFC) of NASA via ftp were used for scheduling and tracking. The tracking was carried out when the elevation of satellites was above 20 degrees. The temperature, atmospheric pressure and relative humidity were measured once in a pass. Before and after ranging satellites, the ranging calibrations were made by using a ground target.

In order to improve ranging precision, the JHDLS-1 has been upgraded several times. A Micro-Channel-Plate photomultiplier was introduced in the JHDLS-1 in January 1985. A GPS clock was introduced into the JHDLS-1 in December 1988 to monitor and correct the atomic clock used in the system, and it has been in operation since April 1989. A GPS clock has been also used in the HTLRS. A laser subsystem of the JHDLS-1 was upgraded to a Quantel YAG 460-5 at the beginning of June 1990. Receiving electronics was also upgraded and RMS was improved in December 1993.

The total numbers of returns and passes obtained by the JHDLS-1 at Simosato and by the HTLRS at Isigaki Sima in 1997 are listed in Table 5 and Table 6.

2. Polynomial fitting and preliminary analysis of range data

False range data were removed by a visual rejection system. The system works on CRT screens by applying a filter of polynomial fitting to measured range itself by use of the on-site computer. Preliminary values of standard deviation for each pass were estimated in this process.

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A part of obtained data, named quick-look (QL) data, were sent to the GSFC from Simosato within one day through INTERNET. QL data of TOPEX/POSEIDON was sent to the GSFC from Simosato within 8 hours through INTERNET. QL data of ERS-1, ERS-2, and GFZ-1 were also sent to the Deutsches Geodatisches Forschungsinstitut (DGFI) within one day through INTERNET. All the range data, after application of the correction of the internal time delay of the SLR systems obtained by the ground target ranging, named full-rate (FR) data, were recorded on a hard disk in MERIT-II Format (CSTG, 1987) together with the satellite ID, the station ID, the transmitted time corrected into UTC (USNO MC), the meteorological data, the preliminary measurement standard deviation and some preprocessing indications. All the FR data were sent to the GSFC.

The weighted mean range precisions estimated by using the polynomial fitting for all the data obtained by the JHD LRS-1 in 1997 are 6.1cm for Lageos-I, 4.7cm for Lageos-II, 3.6cm for Starlette, 4.4cm for Ajisai, 3.5cm for ERS-2, 3.8cm for TOPEX/POSEIDON, 3.9cm for Stella, 10.4cm for Etalon-1, 9.3cm for Etalon-2, and 2.8cm for GFZ-1, 3.3cm for ADEOS, 4.6cm for DIADIME1C, 4.4cm for DIADIME1D, respectively, as shown in Table 5. The same for the HTLRS at Isigaki Sima are 6.1cm for Ajisai, 5.5 cm for Lageos-I, 4.2cm for Lageos-II, 17.2cm for ERS-2, 10.1cm for Starlette, 3.6cm for Stella, 7.2cm for TOPEX/POSEIDON, respectively, as shown in Table 6.

The QL data sent to the GSFC were used to update orbital elements. These data were transferred from the GSFC to the Center for Space Research(CSR) of the University of Texas at Austin and were used for the estimation of the polar motion and the variation of the angular velocity of the earth rotation by processing with the SLR data from other sites in the world. All the FR data were also analyzed in the CSR and other SLR analysis centers, and more precise values for the earth rotation parameters have been estimated. The FR data sent to the GSFC were used to detect crustal movements and global plate motions.

The JHD has been processing FR data obtained at Simosato and other SLR sites by using an original orbital processor (Sasaki, 1984) and GEODYN-II/SOLVE made by NASA(Eddy et al., 1990). A result of the geodetic coordinates for the cross point of azimuth and elevation axes of the JHD LRS-1, obtained as the Marine Geodetic Result (Tatsuno and Fujita, 1994), is $33^{\circ} 34' 39.700\text{N}$, $135^{\circ} 56' 13.337\text{E}$, 101.62 m for latitude, longitude and height above the reference ellipsoid of 6378137m semi-major axis and $1/298.257223563$ flattening, respectively.

The observations of satellite laser ranging were made by K. Muneda, H. Daimon, Y. Takanashi, Y. Narita, N. Koshin, M. Takahashi, E. Kurihara and S. Kobayashi of the Simosato Hydrographic Observatory and K. Matsumoto, K.Koyama, K. Terai, N. Ikeda, K. Sawada, H. Fukura and H. Watanabe of the JHD Headquarters.

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Table 1. Principal Specifications of Satellite Laser Ranging Station of the Simosato Hydrographic Observatory (JHDLRS-1)

Subsystem	Specification
Mount configuration	Elevation over azimuth/Coude path
Angular resolution	20bits (1.2 arcsec)
Transmitter diameter	17 cm
Receiver diameter	60 cm
Laser wave length	532 nm
Output energy	125 mJ
Laser pulse width	100 ps
Repetition rate	4 pps
Receiver detector	Micro-Channel-Plate PMT
Flight time counter	20 ps resolution
Frequency standard	Rubidium oscillator
Time comparison	GPS (TrueTime, XL-DC602)
Computer	32-bits personal computer with hard disks, 3.5inch floppy disk drive, printer, CRTs and a TA

Table 2. Principal Specifications of the Hydrographic Department Transportable Satellite Laser Ranging Station (HTLRS)

Subsystem	Specification
Mount configuration	Elevation over azimuth/Coude path
Angular resolution	20bits (1.2 arcsec)
Transmitter diameter	10 cm
Receiver diameter	35 cm
Laser wave length	532 nm
Output energy	50 mJ
Laser pulse width	50 - 100 ps
Repetition rate	5 pps
Receiver detector	Micro-Channel-Plate PMT
Flight time counter	20 ps resolution
Frequency standard	Cesium oscillator
Time comparison	GPS (MAGNAVOX, MX4200)
Computer	16 - bits personal computers with hard disks 3.5 inch floppy disk drive, printer, CRTs and a modem

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Table 3. Geodetic coordinates of JHDLRS-1

Location	Site ID	Coordinates (Tokyo Datum)			
		°			
Cross point of Az. and El. axes of JHDLRS-1	International	33	34	27.496N	
	7838	135	56	23.537E	
	Domestic SHO-L			62.44m	
		°			
The fiducial stone marker at the Simosato Hydrographic Observatory	Domestic	33	34	28.078N	
	SHO-H0	135	56	23.236E	58.36m

Table 4. Geodetic coordinates of HTLRS

Location	Site ID	Coordinates (Tokyo Datum)			
		°			
Cross point of Az. and El. axes of HTLRS at Isigaki Sima	International	24	21	5.312N	
	7307	124	10	36.118E	55.32m
		°			
The fiducial stone marker at the Isigaki Sima	Domestic	24	21	54.086N	
	Isigaki-H1	124	12	54.317E	73.50m

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Table 5. Data acquisition at the Simosato Hydrographic Observatory in 1997

Satellite	No. of ranges	No. of passes	RMS
Lageos-I	60,121	61	6.1 cm
Lageos-II	40,605	41	4.7
Starlette	29,571	57	3.6
Ajisai	123,475	143	4.4
ERS-2	22,190	50	3.5
TOPEX/POSEIDON	47,820	60	3.8
Stella	10,600	32	3.9
Etalon-1	1,646	4	10.4
Etalon-2	2,816	5	9.3
GFZ-1	812	3	2.8
ADEOS	10,706	30	3.3
DIADIME1C	24,289	39	4.6
DIADIME1D	9,745	20	4.4

Observers : K. Muneda, H. Daimon, Y. Takanashi, Y. Narita, N. Koshin, M. Takahashi,
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Table 6. Data acquisition at Isigaki in 1997

Satellite	No. of ranges	No. of passes	RMS
Ajisai	20,611	34	6.1 cm
Lageos-I	5,175	22	5.5
Lageos-II	60	2	4.2
ERS-2	304	3	17.2
Starlette	55	1	10.1
Stella	374	4	3.5
TOPEX/POSEIDON	4541	9	7.2

Observers : K. Matsumoto, K. Koyama, K. Terai, N. Ikeda, K. Sawada, H. Fukura, Y. Sumiya,
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