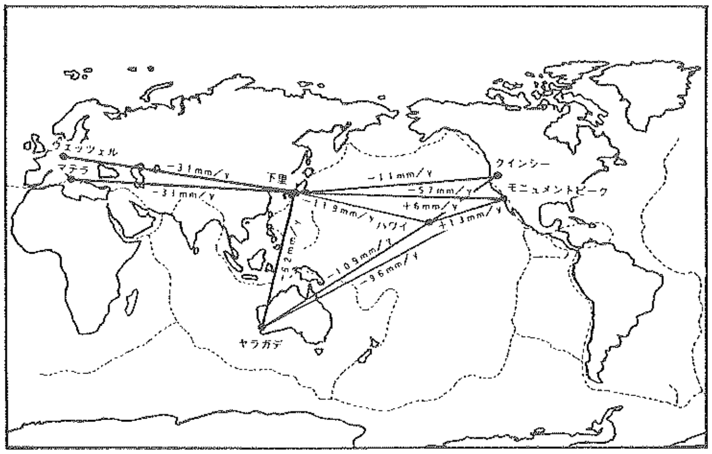
ISSN 0914-5753

水 路 部 観 測 報 告

衛星測地編

第 3 号

平 成 2 年 3 月



海 上 保 安 庁

DATA REPORT
OF
HYDROGRAPHIC OBSERVATIONS

SERIES OF SATELLITE GEODESY

No. 3, March 1990

MARITIME SAFETY AGENCY
TOKYO, JAPAN

Compiled by the Hydrographic Department of Japan (JHD).
Inquiries as to this publication should be addressed to:
Hydrographic Department
Tsukiji-5, Chuo-ku, Tokyo,
104 Japan.

DATA REPORT

OF

HYDROGRAPHIC OBSERVATIONS

SERIES OF SATELLITE GEODESY

No. 3, March 1990

SATELLITE LASER RANGING OBSERVATIONS IN 1988

Summary – Satellite laser ranging observations have been continued by a fixed type satellite laser ranging system at the Simosato Hydrographic Observatory (SHOLAS) and by a transportable one (HTLRS) at off-lying islands. The total numbers of returns obtained by SHOLAS in 1988 are 41,113 from 102 passes of Lageos, 14,852 from 78 passes of Starlette and 143,444 from 271 passes of Ajisai, respectively. Those obtained by HTLRS at Titi sima and Isigaki sima in 1988 are 21,128 from 32 passes of Lageos, 1,111 from 6 passes of Starlette and 37,177 from 66 passes of Ajisai, respectively. The range precisions of SHOLAS are 10.2 cm for Lageos, 12.4 cm for Starlette and 9.6 cm for Ajisai, respectively. Those of HTLRS are 3.7 cm for Lageos, 4.0 cm for Starlette and 3.9 cm for Ajisai, respectively.

Key words: satellite laser ranging – global geodesy

This is a report of satellite laser ranging (SLR) observations obtained by a fixed type satellite laser ranging system at the Simosato Hydrographic Observatory called SHOLAS and a transportable one called HTLRS (Sasaki 1988) at off-lying islands. This report contains the list of data obtained by these two systems in 1988. Previous data obtained by SHOLAS appear in Series of Astronomy and Geodesy, Data Report of Hydrographic Observations for the period from 1982 to 1985, and in Series of Satellite Geodesy from 1986 to 1987. Routine observation by HTLRS started in December 1987, and this is the first report of data obtained by HTLRS at off-lying islands.

1. Observation

The routine ranging observation for Lageos, Starlette, and Beacon (BE)-C started in April 1982 by using a fixed type SLR system at the Simosato Hydrographic Observatory (SHOLAS) under the mutual cooperation between the Hydrographic Department (JHD) and the National Aeronautics and Space Administration (NASA) of the United States of America.

According to the launch of Japanese first Geodetic Satellite "Ajisai" in August 1986, observations for BE-C were terminated in July 1986. Lageos, Starlette and Ajisai have been observed routinely since August 1986. The range observation for Lageos, Starlette and Ajisai by HTLRS started in December 1987. The first observation of HTLRS at off-lying islands was made at Titi sima from January to March in 1988. The second was at Isigaki sima from July to September in 1988.

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

The observation schedule was made by selecting passes whose maximum elevation over 30 degrees for Ajisai, nighttime passes of Lageos and Starlette, over 35 degrees for daytime passes of Lageos, except both Saturday afternoon and Sunday. The priority of the selection for simultaneous transits was in the order of Ajisai, Lageos and Starlette.

The SAO-formatted orbital elements of the satellites for the use of scheduling and tracking were sent from the Goddard Space Flight Center (GSFC) of NASA through GE Mark III network. The orbital elements of Ajisai were also calculated in the Headquarter of JHD by using quick-look data sent from GSFC via GE Mark III network since the launch of the satellite. For the satellite tracking, an analytical tracking program using the elements were used. The tracking was carried out when the elevation of satellites were above 20 degrees. The temperature, atmospheric pressure and relative humidity are measured once in a pass. Before and after ranging satellites, the ranging calibrations were made by using ground targets.

The total numbers of returns and passes obtained by SHOLAS and by HTLRS at Titi sima and Isigaki sima in 1988 are listed in Tables 4, 5 and 6. A GPS clock was introduced in SHOLAS in December 1988, and it has been available since April 1989. A GPS clock was also used in HTLRS in order to check the Loran C clock.

2. Polynomial fitting and preliminary analysis of range data

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

A part of range obtained data, named quick-look (QL) data, were sent to GSFC within two days through GE Mark III network. All the range data, after applied 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 magnetic tape 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, the clock precision and some preprocessing indications. The FR data on magnetic tapes for the above three satellites were sent to GSFC, the Center for Space Research (CSR) of the University of Texas and Centre d'Etudes et de Recherches Geodynamicet Astronomiques (CERGA) of France.

The weighted mean range precisions estimated by using the polynomial fitting for all the data obtained by SHOLAS in 1988 are 10.2 cm for Lageos, 12.4 cm for Starlette and 9.6 cm for Ajisai as shown in Table 4. The same for HTLRS are 3.7 cm for Lageos, 4.0 cm for Starlette and 3.9 cm for Ajisai.

The QL data sent to GSFC were used to update orbital elements. These data were transferred from GSFC to CSR and were used for the estimation of the polar motion and variation of angular velocity of the earth rotation by processing with laser range data from other sites in the world. All the FR data were also analyzed in CSR and more precise values for the earth rotation parameters have been estimated. The FR data sent to the Crustal Dynamics Project were used to detect crustal movements and international plate motions.

JHD has been processing a part of SLR data obtained at Simosato and other SLR sites by using an orbital processor (Sasaki, 1984a). A preliminary result of the geodetic coordinates for the cross point of azimuth and elevation axes of SHOLAS, which is based on the longitude determined by the lunar laser ranging (LLR) observations at the McDonald Observatory, the University of Texas, is 33° 34′ 39.″68N, 135° 56′ 13.″35E, 100.9 m for latitude, longitude and height above the reference ellipsoid of 6 378 137 m semi-major axis and 1/298.257 flattening, respectively (Sasaki, 1989).

The observations of satellite laser ranging were made by H. Nakagawa, E. Nisimura, K. Koyama, K. Onodera, H. Sasaki, A. Masuyama, H, Ito, H. Mori and T. Kurokawa of Simosato Hydrographic Observatory and T. Kanazawa, T. Utiyama, E. Nisimura, K. Fuchida, M. Nagaoka, K. Asai, K. Kawai, T. Kawai, T. Fujii and K. Tomii of JHD Headquarter.

Calculations and compilation for this report have been made by A. Sengoku, M. Nagaoka, K. Fuchida, S. Masai and T. Fujii of JHD Headquarter and H. Nakagawa of the Simosato Hydrographic Observatory.

References

Abshire, J. B., 1980: *NASA Report*, "Plan for Investigating Atmospheric Errors in Satellite Laser Ranging Systems".

CSTG, 1987: *Satellite Laser Ranging Newsletter* SLR subcommission of the CSTG (International Coordination of Space Techniques for Geodesy and Geodynamics) vol. 2, No. 1, p.5.

Marini, J. W., Murray, Jr., C. W.,1973: *NASA report*, X-591-73-351, GSFC, Maryland.

Sasaki, M., Ganeko, Y., Harada, Y., 1983: *Data Report of Hydrogr. Obs., Series of Astronomy and Geodesy*, No. 17, 49.

Sasaki, M., 1984a: *Report of Hydrogr. Researches*, No. 19, p.107.

Sasaki, M., 1984b: *Jour. Geod. Soc. Japan*, vol. 30, p.29.

Sasaki, M., 1988: *Data Report of Hydrogr. Obs., Series of Satellite Geodesy*, No. 1, p.59.

Sasaki, M., 1989: private communication.

Kanazawa, T., Sengoku, A., Nagaoka, M., Nisimura, E., 1987: *ibid.*, No. 21, p.63 (for 1985).

Schutz, B. E., 1983: *Data Report of Hydrogr. Obs., Series of Astronomy and Geodesy*, No. 17, p.44.

USNO, 1987, 1988: *Daily Time Differences and Relative Phase Values, Series 4*, No. 1040 – 1091.

The reports of the SLR observations for the preceding years were presented in the following numbers of the Data Report of Hydrographic Observations.

Sasaki, M., Nagaoka, M., 1984: *Data Report of Hydrogr. Obs., Series of Astronomy and Geodesy*, No. 18, p.55 (for 1982).

Sasaki, M., Sengoku, A., Nisimura, E., Nagaoka, M., 1985: *ibid.*, No. 19, p.50 (for 1983).

Sasaki, M., Sengoku, A., Nagaoka, M., Nisimura, E., 1986: *ibid.*, No. 20, p.44 (for 1984).

Kanazawa, T., Sengoku, A., Nagaoka, M., Nisimura, E., 1988: *Data Report of Hydrogr. Obs. Series of Satellite Geodesy*, No. 1, p.19 (for 1986).

Kanazawa, T., Sengoku, A., Nagaoka, M., Nakagawa, H., 1989: *ibid.*, No. 2, p.1 (for 1987).

Table 1. Principal specifications of Satellite Laser Ranging System (SHOLAS) at the Simosato Hydrographic Observatory

Subsystem	Specification
Mount configuration	elevation over azimuth
Angular resolution	20 bits (1.2 arcsec)
Transmitter diameter	17 cm
Receiver diameter	60 cm
Laser wave length	532 nm
Output energy	150 mJ (normal)
Laser pulse width	200 ps
Repetition rate	4 pps
Receiver detector	PMT (9%Q.E. and 300 ps rise time)
Flight time counter	20 ps resolution
Frequency standard	Rubidium oscillator
Time comparison	multi-Loran C wave (NW pacific Chain)
Computer	PDP 11/60 (64 kw) with two disks and an MT drives

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	20 bits (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 with 300 ps rise time
Flight time counter	20 ps resolution
Frequency standard	Rubidium oscillator (rate: 2×10^{-11})
Time comparison	multi-Loran C wave
Computer	two 16-bits micro computers with a hard disk, a 5 inch- and two 3.5 inch-floppy disks, printer/recorder, two CRTs and a modem

Table 3. Geodetic coordinates

Location	Site ID	Coordinates (Tōkyō Datum)
Cross point of AZ. and EL. axes of SHOLAS	International 7838 Domestic SHO-L	33° 34′ 27″.4962 N* 135 56 23.5369 E 62.445 m
Cross line, the fiducial stone marker at Simosato Hydrogr. Obs.	Domestic SHO-HO	33° 34′ 28″.0775 N** 135 56 23.2356 E 58.358 m

* Surveyed in November 1988.
** Surveyed in January 1982.

Location	Site ID	Coordinates (Local Datum)
Cross point of AZ. and EL. axes of HTLRS at Titi sima	International 7844	27° 5′ 19″.1038 N 142 12 49.0991 E 212.811 m
Cross point of AZ. and EL. axes of HTLRS at Isigaki sima	International 7307	24° 21′ 0″.9661 N 124 10 27.0484 E 57.047 m

Table 4. Data acquisition at Simosato Hydrographic Observatory in 1988

Satellite	Ranges	Passes	r.m.s.
Lageos	41,113	102	10.2 cm
Starlette	14,852	78	12.4
Ajisai	143,444	271	9.6

Observers H. Nakagawa, E. Nisimura, K. Koyama, K. Onodera, H. Sasaki, A. Masuyama, H. Ito, H. Mori, T. Kurokawa, K. Asai* and K. Tomii*

*JHD headquarter

Table 5. Data acquisition at Titi sima in 1988

Satellite	Ranges	Passes	r.m.s.
Lageos	5,482	11	3.7 cm
Starlette	595	4	2.7
Ajisai	19,741	38	3.7

Observers T. Kanazawa, T. Utiyama, K. Fuchida and M. Nagaoka

Table 6. Data acquisition at Isigaki sima in 1988

Satellite	Ranges	Passes	r.m.s.
Lageos	15,646	21	3.7 cm
Starlette	516	2	5.5
Ajisai	17,436	28	4.2

Observers T. Utiyama, E. Nisimura, K. Fuchida, M. Nagaoka, T. Kawai, K. Kawai, T. Fujii, H. Ito* and H. Mori*

*Simosato Hydrographic Observatory

Table 7. Observations and data fitting

Explanation

Column	
1, 8	Serial number of passes ranged successfully for each satellite.
2	Observation time (UTC) of the first return and the last return observed in the satellite pass.
3	Satellite identification (ID), LG: Lageos, ST: Starlette, AJ: Ajisai.
4	Azimuth when the tracking of the satellite started at 20° of elevation.
5	Elevations at the maximum, at the first return obtained and at the last return obtained in the satellite path. U means through the maximum elevation.
6	Number of successful returns from the satellite in the pass.
7	Order of the polynomials applied and the root mean square deviation of the curve fitting to measured range minus predicted range. Before the fitting applied an atmospheric correction (Marini and Murray, 1973) is added.

The range correction added to the measured range is

$$dR = -\frac{g(\lambda)}{f(\varphi, H)} \cdot \frac{A + B}{\sin E + \dfrac{B/(A+B)}{\sin E + 0.01}},$$

where

$$g(\lambda) = 0.9650 + \frac{0.0164}{\lambda^2} + \frac{0.000228}{\lambda^4},$$

$$f(\varphi, H) = 1 - 0.0026 \cos 2\varphi - 0.00031\, H,$$

$$A = 0.002357\, P + 0.000141\, e,$$

$$B = (1.084 \times 10^{-8})\, PTK + (4.734 \times 10^{-8})\, \frac{P^2}{T} \cdot \frac{2}{(3 - 1/K)},$$

$$K = 1.163 - 0.00968 \cos 2\varphi - 0.00104\, T + 0.00001435\, P,$$

$$e = 6.11 \cdot \frac{Rh}{100} \cdot 10^{7.5(T-273.15)/\{237.3+(T-273.15)\}}$$

Here

- dR : Range correction (meters),
- E : True elevation of satellite,
- P : Atmospheric pressure at the site (millibars),
- T : Atmospheric temperature at the site (degrees Kelvin),
- Rh : Relative humidity at the site (%),
- λ : Wavelength of the laser (microns),
- φ : Latitude of the site,
- H : Altitude of the site (kilometers).

This term is not corrected for the measured range in the final MT file.

Column	
9	Station ID, 7838: Simosato Hydrographic Observatory. 7844: Titi Sima 7307: Isigaki Sima
10	Atmospheric temperature (degrees Centigrade).
11	Atmospheric pressure (millibars).
12	Relative humidity (%).
13	Calibrated internal delay time of the SLR system obtained by the ground target ranging. The light velocity change in the air (Abshire, 1980) is used for the atmospheric correction. This term is corrected for the range data in the final MT file.

The group velocity of light in the air is given by

$$v = c \cdot (1 + 10^{-6} N)^{-1},$$

where

$$N = 80.343\ (0.9650 + \frac{0.0164}{\lambda^2} + \frac{0.00028}{\lambda^4})\frac{P}{T} - 11.3\frac{e}{T},$$

$$e = 6.11 \cdot \frac{Rh}{100} \cdot 10^{7.5(T-273.15)/\{237.3+(T-273.15)\}}.$$

Here

- c : The vacuum speed of light,
- P : Atmospheric pressure (millibars),
- T : Atmospheric temperature (degrees Kelvin),
- Rh : Relative humidity (%),
- λ : Wavelength of the light (microns).

14	Time correction: Transmitting time of the Loran C North West Pacific (997) Chain minus time of the clock used in the SLR system. This term is corrected for the transmitted time in the final MT file.
15	Time correction: UTC (USNO MC) minus transmitting time of the Loran C North West Pacific (997) Chain (USNO, 1987, 1988). This term is corrected for the transmitted time in the final MT file.
16	Comments.

Table 4. Observations and data fitting

(1) No.	(2) Obs.Time(UTC) date	caught	lost	(3) SAT.	(4)Az. ST	(5)Elev. MX	CT	LT	(6) RTN	(7)Fitting N	RMS
	Y M D	h m s	h m s		°	°	°	°			cm
1	88 01 08	10 00 07	10 16 44	LG	-210R	85	23	69	133	14	10.9
2	88 01 10	10 48 54	11 33 20	LG	-190R	65	22U	22	476	22	10.3
3	88 01 11	09 42 26	10 09 54	LG	140L	85	67U	26	54	14	8.5
4	88 01 13	10 17 54	10 58 25	LG	-200R	75	31U	25	141	16	8.1
5	88 01 14	09 07 49	09 37 30	LG	130L	75	61U	22	40	10	7.5
6	88 01 16	09 56 43	10 18 18	LG	-210R	85	69U	40	28	11	13.5
7	88 01 17	08 50 08	09 02 23	LG	125L	65	52	23	35	8	8.9
8	88 01 17	11 57 08	12 26 22	LG	-155R	35	21U	28	112	16	8.6
9	88 01 17	20 57 41	21 20 56	LG	50R	35	29U	25	27	11	18.9
10	88 01 18	10 33 42	10 56 13	LG	-190R	65	32	59	227	13	11.0
11	88 01 20	11 22 03	11 56 46	LG	-170R	45	24U	26	111	16	10.0
12	88 01 23	10 49 58	11 18 01	LG	-180R	55	33U	38	100	12	9.8
13	88 01 25	20 39 40	21 03 41	LG	50R	35	30U	22	24	9	8.5
14	88 01 26	10 17 37	10 21 53	LG	-190R	65	41	51	10	6	20.3
15	88 01 27	09 03 10	09 17 38	LG	140L	85	69U	59	11	6	10.4
16	88 02 02	11 29 17	11 51 00	LG	-155R	35	33U	22	62	11	7.1
17	88 02 02	20 18 01	20 45 18	LG	50R	35	29U	20	205	17	11.8
18	88 02 03	10 25 23	10 34 14	LG	-190R	65	39	20	17	10	11.9
19	88 02 06	09 25 08	10 00 12	LG	-200R	75	49U	21	284	15	9.4
20	88 02 07	20 38 21	21 01 55	LG	45R	45	42U	21	26	9	11.4
21	88 02 08	10 11 43	10 43 22	LG	-180R	55	36U	28	29	15	10.4
22	88 02 10	19 50 49	20 24 47	LG	50R	35	21U	21	90	17	12.0
23	88 02 12	20 37 07	21 06 59	LG	40R	55	25U	43	91	13	11.2
24	88 02 13	10 29 49	10 49 49	LG	-170R	45	36U	36	14	10	3.4
25	88 02 15	20 07 59	20 36 47	LG	45R	45	30U	30	35	14	10.1
26	88 02 16	09 50 30	10 16 52	LG	-180R	55	33U	40	54	14	11.9
27	88 02 17	20 48 55	21 14 15	LG	35R	65	22U	61	75	11	10.9
28	88 02 18	10 45 11	11 05 41	LG	-155R	35	30U	28	43	8	8.7
29	88 02 18	19 30 16	19 59 25	LG	50R	35	20U	27	59	13	10.1
30	88 02 19	09 16 41	09 50 25	LG	-190R	65	39U	28	56	12	10.7
31	88 02 20	20 27 28	20 43 47	LG	40R	55	44U	48	53	10	11.7
32	88 02 21	10 01 27	10 39 48	LG	-165R	45	23U	21	150	20	11.5
33	88 02 28	20 08 40	20 34 55	LG	40R	55	46U	28	25	9	6.9
34	88 03 05	18 55 25	19 19 07	LG	50R	35	27U	28	88	15	11.2
35	88 03 07	19 41 09	20 14 59	LG	40R	55	32U	28	205	17	10.5
36	88 03 23	18 56 35	19 37 18	LG	40R	55	24U	24	286	21	12.9
37	88 04 13	18 28 40	19 12 59	LG	35R	65	22U	24	34	10	10.4
38	88 04 14	17 11 14	17 46 20	LG	50R	35	22U	20	206	19	10.2
39	88 04 15	19 15 56	19 55 05	LG	25R	85	21U	41	153	14	9.8
40	88 04 18	18 45 20	19 29 41	LG	30R	75	28U	20	767	23	11.4
41	88 04 19	17 33 30	17 57 25	LG	45R	45	38U	30	49	16	9.1
42	88 04 24	17 35 13	18 14 27	LG	35R	55	21U	30	427	16	11.2
43	88 05 23	16 54 29	17 34 18	LG	30R	65	34U	22	190	21	9.4
44	88 05 26	16 15 00	16 42 10	LG	35R	55	21U	53	217	11	8.8
45	88 05 28	17 02 36	17 46 47	LG	30R	75	22U	27	1047	20	11.2
46	88 05 29	15 50 16	16 15 16	LG	40R	45	34U	35	56	16	10.4
47	88 06 05	16 43 25	17 07 18	LG	30R	80	23	76	231	11	9.9
48	88 06 06	15 24 29	15 49 16	LG	40R	45	25U	43	15	12	12.0
49	88 06 10	16 58 23	17 16 15	LG	25R	85	26	77	527	10	9.1
50	88 06 13	16 27 09	17 09 52	LG	30R	75	32U	21	542	18	9.0
51	88 06 30	14 22 21	14 54 35	LG	40R	45	21U	37	426	22	10.5
52	88 07 07	18 57 32	19 28 12	LG	15L	37	21U	23	444	10	7.2
53	88 07 08	14 12 42	14 37 17	LG	40R	45	38U	32	399	12	10.2
54	88 07 11	13 31 02	13 59 50	LG	50R	38	22U	31	483	14	8.3
55	88 07 11	17 01 09	17 38 31	LG	20L	60	25U	31	686	15	13.0
56	88 07 19	16 39 08	16 54 38	LG	20L	60	21	55	41	8	11.6
57	88 07 31	14 32 35	15 10 29	LG	30R	80	45U	20	481	20	10.8
58	88 07 31	18 02 30	18 19 55	LG	20L	35	28U	33	93	13	9.5
59	88 08 05	14 42 23	15 20 09	LG	25R	85	35U	30	280	19	9.1
60	88 08 07	15 26 06	15 43 54	LG	20L	70	23	66	226	11	10.3

Table 4. Observations and data fitting

(8) No.	(9) STN	(10) TMP	(11) PRESS	(12) HUM	(13) IDT	(14) DTS	(15) DTL	(16) COMMENTS
		°C	mb	%	ns	µs	µs	
1	7838	9.8	1006.2	59	7.5	-0.7	-0.4	
2	7838	2.5	1015.8	69	7.6	-0.2	-0.4	
3	7838	5.2	1018.4	58	7.2	-0.2	-0.5	
4	7838	7.3	1018.6	85	7.6	-0.2	-0.6	
5	7838	11.7	1016.9	70	7.6	-0.2	-0.8	
6	7838	10.1	1007.7	69	7.5	-0.4	-1.0	
7	7838	7.9	1007.5	52	7.4	-0.2	-1.1	
8	7838	6.2	1007.5	60	7.5	-0.1	-1.1	
9	7838	6.0	1006.6	57	7.6	-0.2	-1.1	
10	7838	5.3	1015.2	47	7.6	-0.4	-1.2	
11	7838	7.7	1016.5	90	7.5	-0.5	-1.4	
12	7838	3.4	995.7	40	7.4	-0.2	-1.7	
13	7838	4.7	1007.3	57	7.5	-0.3	-1.9	
14	7838	5.7	1008.8	47	7.1	-0.1	-2.0	
15	7838	7.0	1009.0	41	7.5	-0.2	-2.0	
16	7838	7.4	996.2	46	7.8	-0.6	-2.5	
17	7838	-0.3	999.4	51	7.8	-0.7	-2.5	
18	7838	-0.3	1005.9	49	7.7	-0.7	-2.6	
19	7838	8.1	994.6	34	7.6	-0.2	-2.7	
20	7838	-1.0	1009.3	84	7.6	-0.2	-2.8	
21	7838	3.1	1010.1	58	7.5	-0.1	-2.9	
22	7838	1.1	1016.9	56	7.5	-0.4	-3.1	
23	7838	3.7	1013.2	58	7.6	-0.5	-3.2	
24	7838	7.3	1013.4	43	7.6	-0.3	-3.1	
25	7838	3.5	1012.3	45	7.5	-0.4	-3.1	
26	7838	4.4	1014.3	53	6.3	-0.8	-3.1	
27	7838	2.8	1008.8	60	7.8	-1.4	-3.0	
28	7838	3.2	1013.2	53	7.8	-1.2	-2.9	
29	7838	0.3	1017.6	66	7.8	-1.2	-2.9	
30	7838	5.1	1020.8	58	7.9	-1.1	-2.9	
31	7838	3.8	1018.2	57	7.5	-0.7	-2.8	
32	7838	4.1	1021.5	41	7.5	-0.4	-2.7	
33	7838	4.0	1014.9	63	7.6	-0.5	-2.2	
34	7838	1.4	1012.2	82	7.8	-0.4	-1.8	
35	7838	-0.2	1013.2	60	7.5	-0.4	-1.6	
36	7838	5.1	1013.4	69	7.4	-0.8	-0.7	
37	7838	13.7	1002.9	45	7.2	-0.7	-0.3	
38	7838	10.8	1007.1	37	7.3	-0.7	-0.4	
39	7838	10.0	1014.7	60	7.4	-0.5	-0.4	
40	7838	13.8	993.3	84	7.3	-0.4	-0.5	
41	7838	14.0	1000.1	83	7.4	-0.5	-0.5	
42	7838	8.1	1006.4	76	7.5	-0.5	-0.6	
43	7838	12.8	1001.4	62	7.8	-0.5	-0.4	
44	7838	14.5	1006.2	89	7.4	0.0	-0.5	
45	7838	14.1	1006.9	95	7.3	0.2	-0.6	
46	7838	16.7	1005.3	86	7.6	-0.5	-0.6	
47	7838	16.3	1006.3	70	7.7	-0.3	-0.9	
48	7838	19.6	1007.7	92	7.7	-0.4	-1.0	
49	7838	17.2	996.2	88	7.4	-0.5	-1.1	
50	7838	18.8	996.0	94	7.5	-0.3	-1.2	
51	7838	21.6	992.3	78	7.0	-0.5	-2.1	
52	7838	23.8	997.3	86	7.3	-0.4	-2.7	
53	7838	26.1	999.0	86	7.5	0.2	-2.7	
54	7838	24.3	1002.3	91	7.4	-0.5	-2.9	
55	7838	23.5	1001.4	93	7.2	-0.4	-2.9	
56	7838	21.3	1001.4	95	7.4	-0.2	-2.9	
57	7838	21.6	1001.4	85	7.3	0.6	-2.6	
58	7838	20.3	1001.4	89	6.8	0.5	-2.6	
59	7838	24.8	1008.6	93	6.6	0.0	-2.5	
60	7838	25.2	1007.3	80	7.3	-0.2	-2.4	

Table 4. Observations and data fitting (continued)

(1) No.	(2) Obs.Time(UTC) date	caught	lost	(3) SAT.	(4)Az. ST	(5)Elev. MX	CT	LT	(6) RTN	(7)Fitting N	RMS
	Y M D	h m s	h m s		°	°	°	°			cm
61	88 08 17	12 26 09	12 40 41	LG	40R	50	28	47	109	8	12.3
62	88 08 22	16 08 51	16 47 25	LG	20L	45	22U	21	514	16	12.5
63	88 08 25	15 37 15	15 55 34	LG	20L	55	27U	54	206	9	8.7
64	88 08 26	14 13 27	14 30 40	LG	25L	80	27	74	391	10	11.5
65	88 08 29	17 27 40	17 39 35	LG	20L	32	32	21	147	8	10.8
66	88 08 31	11 05 02	11 29 09	LG	55R	30	27U	21	318	16	11.2
67	88 08 31	14 26 33	15 08 49	LG	20L	70	24U	25	218	17	10.4
68	88 09 07	15 28 26	16 04 05	LG	20L	45	21U	27	478	14	10.8
69	88 09 08	14 06 48	14 46 06	LG	20L	70	24U	31	1162	20	10.5
70	88 09 12	12 12 55	12 56 02	LG	30R	70	30U	20	791	23	10.6
71	88 09 12	15 51 02	16 13 38	LG	20L	40	33U	29	141	14	11.4
72	88 09 13	10 57 06	11 27 13	LG	45R	40	31U	22	472	16	10.6
73	88 10 09	11 01 30	11 12 26	LG	35R	60	58	38	156	12	12.3
74	88 10 10	12 50 16	13 30 51	LG	20L	70	32U	21	1544	18	10.6
75	88 10 13	00 04 27	00 25 16	LG	-135R	50	47U	24	102	12	9.4
76	88 10 13	12 11 23	12 58 31	LG	25L	80	22U	20	1553	24	10.5
77	88 10 14	10 49 06	11 36 36	LG	30R	70	21U	20	1247	24	10.7
78	88 10 16	11 37 07	12 24 33	LG	25R	85	22U	21	1340	22	9.4
79	88 10 19	11 02 40	11 50 09	LG	30R	80	21U	22	1676	24	9.6
80	88 10 23	09 09 22	09 48 44	LG	45R	40	20U	21	777	19	8.6
81	88 10 31	12 20 06	13 04 01	LG	20L	60	21U	20	909	19	10.5
82	88 11 01	11 00 38	11 28 31	LG	25R	85	30U	64	481	12	10.3
83	88 11 02	09 38 28	10 21 18	LG	35R	60	27U	21	1569	20	8.6
84	88 11 03	11 45 40	12 22 04	LG	20L	70	21U	41	158	16	10.8
85	88 11 06	11 12 31	11 58 25	LG	25L	80	24U	20	725	19	9.8
86	88 11 07	09 52 17	10 36 41	LG	30R	70	28U	20	1577	22	9.4
87	88 11 10	09 18 41	09 57 38	LG	35R	60	27U	28	987	23	9.3
88	88 11 13	08 42 40	09 25 54	LG	40R	50	22U	20	1335	24	9.9
89	88 11 13	12 14 26	12 47 24	LG	20L	50	21U	37	1019	14	9.1
90	88 11 18	12 29 05	13 07 41	LG	20L	45	21U	20	946	13	10.8
91	88 11 20	13 40 18	13 48 18	LG	20L	35	32	23	86	9	9.7
92	88 11 22	10 39 25	11 14 00	LG	25L	75	40U	30	852	17	11.8
93	88 11 24	11 23 08	11 57 27	LG	20L	60	27U	34	68	9	8.8
94	88 12 18	17 12 00	17 25 46	LG	100L	50	39U	47	48	10	11.0
95	88 12 20	07 51 23	08 21 20	LG	35R	60	53U	21	690	15	8.9
96	88 12 20	11 09 12	11 41 06	LG	20L	45	21U	32	277	11	11.1
97	88 12 21	19 59 02	20 41 09	LG	-190R	65	29U	21	429	18	9.1
98	88 12 22	08 23 28	09 11 34	LG	30R	80	22U	20	2197	19	8.9
99	88 12 22	12 01 25	12 29 56	LG	15L	35	26U	20	494	12	8.9
100	88 12 23	10 34 56	10 44 31	LG	20L	50	21	40	113	10	12.1
101	88 12 25	11 25 31	11 59 10	LG	20L	40	24U	20	300	13	10.4
102	88 12 26	09 59 57	10 41 42	LG	20L	60	20U	25	1020	22	10.4

Table 4. Observations and data fitting (continued)

(8) No.	(9) STN	(10) TMP	(11) PRESS	(12) HUM	(13) IDT	(14) DTS	(15) DTL	(16) COMMENTS
		˚C	mb	%	ns	μs	μs	
61	7838	23.9	1001.0	94	9.0	-0.5	-2.1	
62	7838	26.5	994.2	89	7.2	-0.3	-1.9	
63	7838	24.3	998.6	92	7.5	0.0	-1.9	
64	7838	24.3	998.6	84	7.0	-0.3	-1.9	
65	7838	23.1	997.5	66	7.1	-0.4	-1.9	
66	7838	23.5	998.8	65	7.5	-0.5	-1.8	
67	7838	21.6	998.6	72	7.3	-0.4	-1.8	
68	7838	23.0	1000.5	94	7.1	-0.5	-1.8	
69	7838	22.3	1005.1	94	7.2	-0.1	-1.9	
70	7838	23.5	996.4	67	7.0	-0.6	-2.1	
71	7838	22.7	997.3	69	6.8	-0.6	-2.1	
72	7838	25.2	1002.5	79	6.7	-0.5	-2.1	
73	7838	19.7	1008.6	72	7.3	-0.5	-1.9	
74	7838	16.3	1012.8	76	7.6	-0.2	-1.9	
75	7838	17.0	999.9	43	7.4	-0.3	-2.0	DAYTIME
76	7838	11.6	1006.2	62	7.1	-0.5	-2.0	
77	7838	13.9	1008.2	68	6.7	-0.5	-2.0	
78	7838	16.8	1011.0	72	7.3	-0.4	-2.0	
79	7838	15.9	1013.8	65	6.7	-0.8	-2.1	
80	7838	16.1	1011.4	68	6.6	-0.5	-2.1	
81	7838	11.2	1016.0	62	7.0	-0.8	-2.4	
82	7838	12.1	1014.1	84	7.0	-0.9	-2.4	
83	7838	14.6	1004.0	44	6.9	-0.5	-2.4	
84	7838	12.2	1009.5	59	6.9	-0.7	-2.4	
85	7838	11.6	1009.9	67	7.1	-0.9	-2.6	
86	7838	14.9	1011.9	49	7.6	-0.8	-2.6	
87	7838	12.8	1004.2	45	8.0	-0.4	-2.6	
88	7838	15.1	1001.2	62	6.7	-0.9	-2.5	
89	7838	13.3	1001.2	72	6.9	-0.4	-2.5	
90	7838	9.9	1003.4	60	6.8	-0.5	-2.4	
91	7838	8.2	1013.6	64	7.3	-1.7	-2.3	
92	7838	8.6	1014.3	82	6.5	-0.9	-2.3	
93	7838	7.1	1000.3	49	6.4	-0.5	-2.2	
94	7838	4.9	1016.5	66	7.1	-0.5	-1.6	
95	7838	12.9	1008.8	64	7.6	-1.0	-1.6	DAYTIME
96	7838	9.3	1009.7	58	7.4	-1.0	-1.6	
97	7838	4.3	1012.5	70	7.5	-1.0	-1.6	
98	7838	7.2	1016.5	46	7.6	-0.7	-1.6	
99	7838	5.2	1018.0	55	7.4	-0.9	-1.6	
100	7838	7.6	1015.2	83	7.5	-1.0	-1.6	
101	7838	3.1	1009.9	60	7.4	-1.4	-1.5	
102	7838	4.2	1011.7	62	7.5	-0.4	-1.5	

Table 4. Observations and data fitting (continued)

(1) No.	(2) Obs.Time(UTC) date	caught	lost	(3) SAT.	(4)Az. ST	(5)Elev. MX	CT	LT	(6) RTN	(7)Fitting N	RMS
	Y M D	h m s	h m s		°	°	°	°			cm
1	88 01 06	14 50 57	14 55 04	ST	200L	55	52U	22	80	11	10.7
2	88 01 14	11 55 59	12 01 51	ST	195L	40	24U	33	275	13	8.1
3	88 01 16	12 34 43	12 42 56	ST	-120R	65	28U	21	312	21	7.9
4	88 01 17	11 04 57	11 12 46	ST	200L	50	24U	23	329	16	8.8
5	88 01 17	12 55 11	13 00 13	ST	-100R	45	28U	34	95	11	6.4
6	88 01 18	11 24 59	11 31 23	ST	220L	80	34	34	146	18	9.4
7	88 01 18	13 15 46	13 21 06	ST	-75R	30	25	21	51	12	11.9
8	88 01 20	10 13 34	10 22 39	ST	205L	55	22U	20	324	22	9.2
9	88 01 22	10 56 06	10 57 06	ST	-110R	60	54	59	23	5	8.1
10	88 01 26	08 31 51	08 40 09	ST	215L	65	23U	30	30	13	8.6
11	88 01 27	14 26 33	14 30 55	ST	-30R	30	27U	22	22	9	12.4
12	88 01 28	09 12 10	09 20 00	ST	-105R	50	29U	22	145	18	8.7
13	88 01 29	07 41 33	07 47 12	ST	220L	75	28U	56	26	11	7.6
14	88 02 03	05 46 43	05 49 25	ST	205L	55	42	21	27	7	8.6
15	88 02 03	07 32 42	07 38 40	ST	-95R	45	40U	20	107	12	9.0
16	88 02 04	13 22 18	13 30 47	ST	-50R	80	24U	20	272	21	14.1
17	88 02 06	12 14 07	12 20 10	ST	-40R	60	42U	23	236	17	9.5
18	88 02 07	12 32 07	12 39 09	ST	-50L	80	29U	29	293	21	11.8
19	88 02 08	05 30 09	05 36 11	ST	-110R	55	37U	32	101	14	9.1
20	88 02 08	11 02 00	11 09 49	ST	-35R	45	24U	20	113	16	11.8
21	88 02 08	12 52 33	12 57 59	ST	-65L	50	33U	28	32	12	12.2
22	88 02 09	05 52 19	05 55 42	ST	-85R	40	39U	27	62	9	8.2
23	88 02 12	03 13 08	03 16 58	ST	215L	75	63	22	52	8	11.3
24	88 02 12	10 31 09	10 38 55	ST	-45R	70	30U	24	332	20	8.6
25	88 02 15	09 39 57	09 48 21	ST	-45R	80	28U	23	241	21	10.2
26	88 02 16	02 36 23	02 45 57	ST	-120R	65	24U	20	125	18	8.3
27	88 02 18	01 26 14	01 34 10	ST	225L	80	26U	32	73	19	10.3
28	88 02 18	08 49 13	08 57 42	ST	-50R	85	28U	23	223	21	9.2
29	88 02 19	01 45 49	01 54 12	ST	-110R	60	25U	26	142	20	10.4
30	88 02 22	00 55 45	01 02 36	ST	-110R	55	28U	31	169	16	10.2
31	88 02 25	05 40 14	05 44 30	ST	-35R	50	43U	32	39	12	8.9
32	88 03 03	04 15 51	04 24 06	ST	-50R	85	31U	26	24	11	16.9
33	88 03 07	01 55 15	02 01 59	ST	-35R	45	26U	29	140	12	10.7
34	88 03 08	02 14 43	02 20 42	ST	-40R	65	29U	46	284	15	9.4
35	88 03 23	13 11 14	13 16 49	ST	185L	35	23U	21	250	17	10.1
36	88 03 27	12 39 36	12 45 48	ST	220L	70	29U	25	48	12	69.8
37	88 04 08	09 17 57	09 23 49	ST	-120R	70	39	21	93	13	13.0
38	88 04 11	08 29 21	08 32 02	ST	-115R	65	62	31	51	10	6.7
39	88 04 11	15 50 53	15 51 38	ST	-60L	65	59	48	34	6	29.3
40	88 04 14	14 55 49	15 03 33	ST	-60L	55	21U	20	319	22	9.8
41	88 04 15	06 07 05	06 12 53	ST	205L	50	34U	22	191	17	9.6
42	88 04 15	07 58 02	08 01 39	ST	-85R	35	34U	20	86	11	8.6
43	88 04 15	13 26 33	13 33 55	ST	-35R	55	22U	20	563	21	9.6
44	88 04 25	11 15 20	11 21 27	ST	-60L	60	34U	20	423	20	8.9
45	88 04 26	09 45 30	09 51 40	ST	-35R	45	28U	20	410	18	10.4
46	88 05 23	00 19 24	00 26 32	ST	-30R	35	22U	20	88	13	9.1
47	88 06 06	14 34 32	14 39 30	ST	-100R	45	39U	30	136	12	9.9
48	88 06 10	17 47 04	17 51 52	ST	-25R	30	30	20	164	12	10.4
49	88 06 30	13 24 24	13 28 02	ST	-55L	80	59	21	130	8	7.7
50	88 07 30	03 04 44	03 06 41	ST	-45R	70	44	69	155	8	7.1
51	88 08 05	01 23 39	01 24 58	ST	-50R	80	48	79	220	9	11.2
52	88 08 05	16 35 04	16 37 59	ST	180L	30	30U	20	105	8	7.9
53	88 08 26	12 28 36	12 32 54	ST	-80R	35	33U	21	87	11	10.1
54	88 08 28	11 16 13	11 22 17	ST	-100R	45	32U	27	261	15	11.1
55	88 09 07	14 34 43	14 43 06	ST	-55L	80	23U	20	293	21	13.0
56	88 09 08	07 36 13	07 40 07	ST	-105R	55	52	26	271	9	8.9
57	88 09 12	07 03 20	07 09 28	ST	-80R	35	30U	20	167	16	11.6
58	88 09 13	12 53 24	13 01 41	ST	-55L	60	25	20	350	22	9.9
59	88 09 14	05 52 39	05 58 36	ST	-100R	45	37U	25	140	12	10.2
60	88 09 26	00 42 39	00 45 23	ST	220L	75	69	33	293	9	7.5

Table 4. Observations and data fitting (continued)

(8) No.	(9) STN	(10) TMP	(11) PRESS	(12) HUM	(13) IDT	(14) DTS	(15) DTL	(16) COMMENTS
		°C	mb	%	ns	μs	μs	
1	7838	2.2	1017.2	75	7.7	-0.5	-0.4	
2	7838	10.0	1016.5	74	7.6	-0.2	-0.8	
3	7838	10.3	1008.0	65	7.7	-0.3	-1.0	
4	7838	5.8	1007.3	64	7.5	-0.1	-1.1	
5	7838	6.6	1007.2	58	7.5	-0.1	-1.1	
6	7838	4.9	1015.9	49	7.3	-0.5	-1.2	
7	7838	3.3	1016.6	52	7.5	-0.4	-1.2	
8	7838	8.9	1015.9	87	7.5	-0.7	-1.4	
9	7838	12.3	993.6	86	7.4	-0.3	-1.6	
10	7838	7.6	1007.5	40	7.3	-0.3	-2.0	
11	7838	2.4	1009.9	66	7.4	-0.3	-2.0	
12	7838	8.1	1011.4	55	7.4	-0.5	-2.1	
13	7838	12.9	1004.0	77	9.8	-0.2	-2.1	DAYTIME
14	7838	3.0	1001.2	39	7.6	-0.6	-2.6	DAYTIME
15	7838	1.8	1002.5	39	7.6	-0.5	-2.6	DAYTIME
16	7838	4.5	1008.8	68	7.7	-0.6	-2.6	
17	7838	6.1	996.8	43	7.7	-0.4	-2.7	
18	7838	1.0	1007.1	60	7.8	-0.3	-2.8	
19	7838	7.5	1006.7	47	7.8	-0.4	-2.9	DAYTIME
20	7838	2.5	1010.6	60	7.6	-0.1	-2.9	
21	7838	1.0	1010.8	69	7.5	-0.2	-2.9	
22	7838	9.9	1009.4	41	7.5	-0.3	-3.0	DAYTIME
23	7838	10.2	1009.7	66	7.7	-0.5	-3.2	DAYTIME
24	7838	6.5	1012.6	50	7.5	-0.4	-3.2	
25	7838	4.4	1010.8	46	7.4	-0.5	-3.1	
26	7838	9.9	1012.5	30	6.6	-0.8	-3.1	DAYTIME
27	7838	9.0	1009.7	37	7.9	-1.4	-2.9	DAYTIME
28	7838	3.5	1011.9	52	7.6	-1.1	-2.9	
29	7838	8.5	1021.5	42	7.7	-1.8	-2.9	DAYTIME
30	7838	8.4	1024.5	49	6.8	-0.8	-2.6	DAYTIME
31	7838	13.5	1014.9	59	7.7	-0.8	-2.4	DAYTIME
32	7838	12.4	1001.8	35	7.5	-0.6	-1.9	DAYTIME
33	7838	10.6	1007.5	41	7.6	-0.8	-1.6	DAYTIME
34	7838	8.6	1012.5	36	7.6	-0.8	-1.6	DAYTIME
35	7838	9.6	1010.9	51	7.6	-0.6	-0.7	
36	7838	6.6	1010.4	58	7.5	-0.3	-0.6	
37	7838	11.2	1004.4	49	7.0	-0.8	-0.2	DAYTIME
38	7838	16.0	1022.6	55	7.4	-0.7	-0.2	DAYTIME
39	7838	11.7	1022.6	78	7.5	-0.9	-0.2	
40	7838	12.9	1005.8	52	7.4	-0.6	-0.4	
41	7838	21.0	1009.0	21	7.5	-0.7	-0.4	DAYTIME
42	7838	19.5	1009.5	28	7.4	-0.7	-0.4	DAYTIME
43	7838	11.5	1014.1	61	7.4	-0.8	-0.4	
44	7838	13.8	1011.4	72	7.6	-0.9	-0.6	
45	7838	17.4	1011.8	57	7.6	-1.4	-0.5	
46	7838	21.2	988.3	65	7.8	-0.8	-0.4	DAYTIME
47	7838	20.4	1008.0	85	7.7	-0.7	-1.0	
48	7838	17.2	996.2	88	7.5	-0.4	-1.1	
49	7838	21.9	991.8	78	7.3	-0.4	-2.1	
50	7838	26.2	999.9	78	7.5	-0.2	-2.7	DAYTIME
51	7838	29.1	1007.5	80	7.2	-0.1	-2.5	DAYTIME
52	7838	24.1	1008.0	95	6.6	0.1	-2.5	
53	7838	25.3	999.0	84	7.0	-0.5	-1.9	
54	7838	27.0	995.3	82	7.2	-0.4	-1.9	
55	7838	23.3	1000.5	98	7.3	-0.5	-1.8	
56	7838	27.0	1004.0	76	7.5	-0.3	-1.9	DAYTIME
57	7838	28.1	992.7	69	6.7	-0.9	-2.1	DAYTIME
58	7838	25.1	1002.7	74	7.1	-0.7	-2.1	
59	7838	27.7	1000.5	62	7.2	-0.6	-2.0	DAYTIME
60	7838	25.8	993.3	68	6.5	-0.6	-2.0	DAYTIME

Table 4. Observations and data fitting (continued)

(1) No.	(2) Obs.Time(UTC) date	caught	lost	(3) SAT.	(4)Az. ST	(5)Elev. MX	CT	LT	(6) RTN	(7)Fitting N	RMS
	Y M D	h m s	h m s		°	°	°	°			cm
61	88 10 01	00 26 42	00 34 23	ST	-90R	40	23U	23	77	19	9.7
62	88 10 13	02 36 04	02 45 32	ST	-45R	80	28U	20	409	22	9.5
63	88 10 14	01 06 09	01 14 31	ST	-35R	40	22U	20	367	16	8.2
64	88 10 15	03 16 02	03 23 08	ST	-70L	35	26U	20	53	12	8.7
65	88 10 19	00 53 45	00 57 08	ST	-50L	80	22U	60	36	12	13.5
66	88 11 02	11 32 00	11 37 39	ST	185L	33	22U	20	318	16	10.2
67	88 11 06	10 59 40	11 07 15	ST	220L	70	22U	20	681	23	10.2
68	88 11 09	10 10 25	10 16 29	ST	225L	80	37U	21	123	18	9.7
69	88 11 10	10 28 49	10 35 20	ST	-110R	55	23U	25	249	21	12.7
70	88 11 11	10 48 51	10 54 56	ST	-90R	35	21U	20	311	15	10.3
71	88 11 13	09 37 57	09 45 16	ST	-110R	50	21U	20	819	23	10.6
72	88 11 18	07 38 12	07 44 43	ST	-125R	70	34U	21	261	21	8.9
73	88 11 22	07 06 23	07 13 02	ST	-90R	40	21U	21	94	19	10.6
74	88 11 24	05 57 49	06 03 24	ST	-115R	55	43U	21	230	17	9.4
75	88 12 19	05 03 32	05 09 29	ST	-55L	65	38U	22	270	21	11.4
76	88 12 20	03 37 55	03 39 53	ST	-35R	50	37	20	73	7	8.0
77	88 12 21	03 57 58	03 59 46	ST	-45R	75	39	21	54	8	9.0
78	88 12 23	02 41 52	02 47 50	ST	-35R	55	25U	34	152	16	11.1

Table 4. Observations and data fitting (continued)

(8) No.	(9) STN	(10) TMP	(11) PRESS	(12) HUM	(13) IDT	(14) DTS	(15) DTL	(16) COMMENTS
		°C	mb	%	ns	μs	μs	
61	7838	23.2	1007.5	66	7.7	-0.8	-2.0	DAYTIME
62	7838	17.9	1000.1	40	7.5	-0.2	-2.0	DAYTIME
63	7838	17.9	1008.2	44	6.7	-0.6	-2.0	DAYTIME
64	7838	22.3	1008.4	52	6.7	-0.8	-2.0	DAYTIME
65	7838	21.4	1011.4	35	6.6	0.2	-2.1	DAYTIME
66	7838	12.1	1004.9	65	7.0	-0.6	-2.4	
67	7838	12.1	1009.9	62	7.0	-0.8	-2.6	
68	7838	14.2	1010.4	95	8.1	-0.3	-2.6	
69	7838	12.4	1004.7	48	8.1	-0.3	-2.6	
70	7838	7.9	1008.2	65	6.8	-0.8	-2.6	
71	7838	14.7	1001.4	64	6.7	-1.0	-2.5	
72	7838	13.6	1001.3	69	6.9	-0.3	-2.4	DAYTIME
73	7838	14.3	1013.2	56	7.1	-0.7	-2.3	DAYTIME
74	7838	12.0	996.2	45	6.5	-0.6	-2.2	DAYTIME
75	7838	15.5	1011.9	46	7.3	-0.7	-1.6	DAYTIME
76	7838	15.5	1009.3	54	7.6	-1.0	-1.6	DAYTIME
77	7838	16.2	1005.3	34	7.5	-0.8	-1.6	DAYTIME
78	7838	11.5	1016.5	58	7.6	-1.0	-1.6	DAYTIME

Table 4. Observations and data fitting (continued)

(1) No.	(2) Obs.Time(UTC) date	caught	lost	(3) SAT.	(4)Az. ST	(5)Elev. MX	CT	LT	(6) RTN	(7)Fitting N	RMS
	Y M D	h m s	h m s		°	°	°	°			cm
1	88 01 08	01 59 26	02 07 12	AJ	-60L	55	22U	50	561	12	8.8
2	88 01 08	23 04 04	23 14 42	AJ	-35R	40	23U	20	328	14	8.8
3	88 01 09	01 05 14	01 13 25	AJ	-50L	80	22U	62	700	13	8.5
4	88 01 10	23 18 41	23 29 35	AJ	-40R	55	29U	21	505	18	9.1
5	88 01 11	01 19 02	01 26 58	AJ	-60L	50	21U	45	456	18	9.5
6	88 01 11	16 13 44	16 24 58	AJ	215L	70	34U	20	671	23	9.0
7	88 01 11	18 18 04	18 26 27	AJ	-90R	45	37U	20	316	13	8.6
8	88 01 13	16 25 17	16 38 37	AJ	-125R	80	22U	20	646	23	8.3
9	88 01 13	18 30 17	18 39 56	AJ	-70R	33	22U	20	273	15	9.3
10	88 01 14	00 39 19	00 49 10	AJ	-65L	45	23U	28	596	15	8.8
11	88 01 16	13 45 44	13 55 05	AJ	180L	32	21U	20	244	13	8.8
12	88 01 16	15 45 26	15 58 05	AJ	-120R	70	24U	21	615	21	8.9
13	88 01 16	17 50 19	17 59 37	AJ	-65R	32	22U	20	192	13	9.0
14	88 01 18	13 57 29	14 09 49	AJ	205L	55	22U	21	223	19	10.7
15	88 01 18	15 59 20	16 11 29	AJ	-100R	50	21U	22	661	21	9.7
16	88 01 19	23 18 33	23 28 10	AJ	-70L	40	21U	26	189	15	8.7
17	88 01 20	14 10 25	14 23 49	AJ	225L	85	21U	21	1108	24	8.9
18	88 01 20	16 16 05	16 20 21	AJ	-80R	37	28	37	159	8	8.3
19	88 01 22	12 25 22	12 34 50	AJ	185L	40	27U	21	323	14	8.9
20	88 01 22	14 25 24	14 37 27	AJ	-115R	65	27U	21	508	22	9.4
21	88 01 22	16 31 05	16 38 18	AJ	-60R	30	25U	22	160	10	7.9
22	88 01 22	20 37 27	20 48 45	AJ	-45R	70	32U	21	786	19	8.6
23	88 01 23	13 29 59	13 43 39	AJ	-130R	85	21U	20	844	23	9.4
24	88 01 23	15 36 01	15 44 36	AJ	-80R	35	27U	21	362	12	9.0
25	88 01 23	19 42 27	19 53 59	AJ	-40R	50	25U	21	952	17	8.4
26	88 01 23	21 43 38	21 56 09	AJ	-60L	55	21U	20	513	18	9.0
27	88 01 24	12 40 12	12 45 02	AJ	210L	65	49U	51	134	8	8.9
28	88 01 24	14 39 49	14 50 48	AJ	-95R	45	24U	21	625	19	9.4
29	88 01 24	18 48 08	18 58 56	AJ	-35R	40	22U	20	448	16	8.9
30	88 01 24	20 49 11	21 02 32	AJ	-50L	80	21U	21	707	23	8.8
31	88 01 25	11 43 51	11 54 42	AJ	190L	45	24U	21	266	21	9.6
32	88 01 25	13 44 04	13 57 08	AJ	-110R	60	21U	20	640	23	9.3
33	88 01 25	19 55 22	20 08 01	AJ	-45R	75	22U	23	760	23	9.4
34	88 01 26	12 50 28	13 01 50	AJ	-130R	80	26U	28	25	9	66.9
35	88 01 26	19 01 28	19 13 29	AJ	-40R	55	22U	22	792	23	9.7
36	88 01 26	21 08 17	21 15 25	AJ	-65L	50	48U	21	121	12	9.8
37	88 01 27	11 55 49	12 08 59	AJ	215L	70	21U	21	449	20	8.6
38	88 01 27	13 58 57	14 10 42	AJ	-90R	45	21U	20	334	18	9.2
39	88 01 27	18 07 30	18 18 56	AJ	-40R	40	21U	20	409	22	9.7
40	88 01 27	20 08 54	20 22 06	AJ	-55L	75	21U	21	904	23	8.6
41	88 01 28	11 02 38	11 14 22	AJ	195L	45	21U	21	796	19	9.5
42	88 01 28	13 04 22	13 16 22	AJ	-105R	55	23U	22	676	19	9.5
43	88 01 28	17 14 13	17 22 04	AJ	-40R	33	23U	25	69	15	8.7
44	88 01 29	12 12 00	12 21 52	AJ	-125R	75	38U	26	374	14	10.0
45	88 01 29	14 17 04	14 24 10	AJ	-70R	33	30U	20	232	11	9.5
46	88 01 29	18 22 21	18 33 47	AJ	-40R	55	29U	20	434	20	10.0
47	88 01 29	20 24 41	20 34 48	AJ	-65L	45	29U	21	198	19	9.9
48	88 01 31	16 33 34	16 43 31	AJ	-35R	35	22U	20	461	16	9.9
49	88 01 31	18 34 32	18 47 47	AJ	-45R	85	21U	21	745	23	10.0
50	88 02 01	13 37 17	13 43 11	AJ	-65R	32	30U	22	50	8	9.8
51	88 02 01	17 43 06	17 46 08	AJ	-40R	60	37	58	69	7	12.2
52	88 02 02	10 35 02	10 48 20	AJ	220L	80	22U	21	880	23	8.7
53	88 02 02	16 46 50	16 58 12	AJ	-35R	45	22U	22	519	16	10.2
54	88 02 02	18 48 26	19 01 14	AJ	-55L	65	22U	21	489	22	9.7
55	88 02 03	09 41 24	09 52 17	AJ	200L	55	21U	30	727	21	9.2
56	88 02 03	11 43 48	11 55 16	AJ	-100R	50	22U	24	561	18	9.5
57	88 02 03	15 53 24	16 03 18	AJ	-35R	35	23U	20	285	13	9.7
58	88 02 03	17 54 02	18 07 28	AJ	-50R	85	21U	21	341	22	10.5
59	88 02 04	12 55 17	13 03 20	AJ	-65R	30	25U	21	126	12	11.6
60	88 02 04	14 59 01	15 07 40	AJ	-40R	30	22U	21	250	17	9.5

Table 4. Observations and data fitting (continued)

(8) No.	(9) STN	(10) TMP	(11) PRESS	(12) HUM	(13) IDT	(14) DTS	(15) DTL	(16) COMMENTS
		°C	mb	%	ns	µs	µs	
1	7838	13.0	1003.8	53	7.6	-0.8	-0.4	DAYTIME
2	7838	9.9	1006.2	44	7.6	-1.0	-0.4	DAYTIME
3	7838	11.6	1006.9	47	7.7	-1.0	-0.4	DAYTIME
4	7838	4.1	1017.5	51	7.7	-0.3	-0.4	DAYTIME
5	7838	6.9	1018.4	43	7.6	-0.2	-0.5	DAYTIME
6	7838	2.8	1018.4	65	7.7	-0.1	-0.5	
7	7838	2.6	1018.2	72	7.7	-0.2	-0.5	
8	7838	5.3	1019.2	83	6.7	-0.4	-0.6	
9	7838	4.6	1018.6	87	6.8	-0.2	-0.6	
10	7838	12.8	1019.7	60	7.8	-0.2	-0.8	DAYTIME
11	7838	9.8	1008.2	70	7.6	-0.3	-1.0	
12	7838	9.4	1007.7	74	7.5	-0.2	-1.0	
13	7838	8.2	1008.1	70	7.6	-0.4	-1.0	
14	7838	3.2	1016.5	50	7.4	-0.3	-1.2	
15	7838	2.3	1016.5	61	7.6	-0.6	-1.2	
16	7838	6.6	1016.5	84	7.5	-0.7	-1.3	DAYTIME
17	7838	6.4	1015.6	87	7.5	-0.7	-1.4	
18	7838	5.8	1015.4	84	7.6	-0.8	-1.4	
19	7838	12.6	993.6	86	7.5	-0.4	-1.6	
20	7838	15.2	992.3	66	7.4	-0.5	-1.6	
21	7838	14.9	991.1	66	7.5	-0.2	-1.6	
22	7838	13.8	989.2	58	7.6	-0.3	-1.6	
23	7838	1.3	997.2	73	7.5	-0.4	-1.7	
24	7838	0.8	998.4	72	7.5	-0.3	-1.7	
25	7838	-0.1	1001.4	54	7.6	-0.3	-1.7	
26	7838	-0.1	1003.2	56	7.5	-0.4	-1.7	
27	7838	0.8	1007.5	62	7.5	-0.4	-1.8	
28	7838	1.9	1007.5	58	7.6	-0.6	-1.8	
29	7838	1.9	1007.5	61	7.5	-0.4	-1.8	
30	7838	2.4	1007.7	61	6.6	-0.5	-1.8	
31	7838	4.6	1007.1	59	7.3	-0.2	-1.9	
32	7838	4.0	1007.1	62	7.5	-0.2	-1.9	
33	7838	5.1	1007.1	55	7.4	-0.4	-1.9	
34	7838	5.4	1008.8	51	7.4	-0.3	-2.0	
35	7838	4.7	1007.7	54	7.4	-0.5	-2.0	
36	7838	3.6	1008.0	56	7.3	-0.2	-2.0	
37	7838	3.4	1009.6	59	7.6	-0.3	-2.0	
38	7838	2.5	1009.9	65	7.5	-0.2	-2.0	
39	7838	4.5	1010.6	45	7.4	-0.3	-2.0	
40	7838	3.7	1010.6	57	7.5	-0.1	-2.0	
41	7838	5.5	1012.1	58	0.0	-0.1	-2.1	
42	7838	5.0	1012.1	55	9.7	-0.2	-2.1	
43	7838	4.9	1010.2	64	9.9	-0.2	-2.1	
44	7838	8.5	1007.5	61	9.8	-0.2	-2.1	
45	7838	8.3	1008.0	48	9.5	-0.1	-2.1	
46	7838	7.1	1008.8	54	9.6	-0.4	-2.1	
47	7838	7.0	1009.5	53	9.6	0.0	-2.1	
48	7838	4.0	1008.5	49	9.4	-0.5	-2.3	
49	7838	2.9	1009.6	52	9.5	-0.2	-2.3	
50	7838	4.8	1008.6	56	7.0	-0.3	-2.4	
51	7838	4.0	1005.8	66	7.2	-0.5	-2.4	
52	7838	7.8	996.1	44	7.9	-0.5	-2.5	
53	7838	1.6	998.8	40	7.8	-0.6	-2.5	
54	7838	0.2	999.2	43	7.7	-0.5	-2.5	
55	7838	-0.5	1005.6	48	7.7	-0.5	-2.6	
56	7838	-0.6	1006.6	50	7.7	-0.5	-2.6	
57	7838	-1.3	1007.7	59	7.6	-0.6	-2.6	
58	7838	-0.8	1008.4	60	7.6	-0.7	-2.6	
59	7838	4.1	1008.8	67	7.6	-0.5	-2.6	
60	7838	3.7	1008.2	70	7.6	-0.9	-2.6	

Table 4. Observations and data fitting (continued)

(1) No.	(2) Obs.Time(UTC) date	caught	lost	(3) SAT.	(4)Az. ST	(5)Elev. MX	CT	LT	(6) RTN	(7)Fitting N	RMS
	Y M D	h m s	h m s		°	°	°	°			cm
61	88 02 04	17 00 30	17 13 05	AJ	-45R	65	23U	21	946	21	9.3
62	88 02 04	19 06 31	19 08 46	AJ	-70L	38	36	38	13	8	3.5
63	88 02 05	16 06 57	16 18 36	AJ	-40R	50	24U	20	865	17	8.9
64	88 02 05	18 10 13	18 20 51	AJ	-60L	60	34U	20	752	19	8.9
65	88 02 06	09 01 22	09 13 46	AJ	205L	60	23U	21	693	23	8.9
66	88 02 06	11 03 31	11 15 35	AJ	-100R	45	21U	20	569	23	10.1
67	88 02 06	15 12 21	15 23 17	AJ	-40R	37	21U	20	421	22	10.2
68	88 02 06	17 14 33	17 27 15	AJ	-50L	80	26U	20	490	22	9.6
69	88 02 07	10 10 13	10 21 47	AJ	-115R	65	31U	20	639	21	9.6
70	88 02 07	12 14 21	12 23 10	AJ	-60R	30	22U	20	234	11	8.0
71	88 02 07	14 18 30	14 27 50	AJ	-40R	30	21U	20	119	16	9.1
72	88 02 07	16 19 42	16 33 04	AJ	-45R	70	21U	20	806	23	9.7
73	88 02 07	18 24 44	18 32 53	AJ	-75L	35	29U	20	204	17	10.3
74	88 02 08	09 14 28	09 27 51	AJ	-130R	85	22U	20	484	22	10.0
75	88 02 08	11 18 54	11 29 11	AJ	-80R	35	22U	20	173	20	9.8
76	88 02 08	15 26 18	15 38 21	AJ	-40R	50	23U	20	679	23	10.1
77	88 02 08	17 27 59	17 39 39	AJ	-60L	55	22U	24	304	19	9.6
78	88 02 09	08 20 40	08 33 38	AJ	210L	65	22U	20	58	15	9.3
79	88 02 09	14 32 45	14 42 48	AJ	-35R	40	24U	22	240	17	10.0
80	88 02 10	07 27 55	07 37 51	AJ	190L	45	23U	26	205	15	9.7
81	88 02 10	09 28 42	09 41 25	AJ	-110R	60	23U	20	497	22	8.9
82	88 02 10	13 40 25	13 47 40	AJ	-35R	32	28U	21	20	9	6.1
83	88 02 10	15 41 07	15 50 35	AJ	-45R	75	31U	34	705	17	8.7
84	88 02 10	17 42 59	17 51 46	AJ	-80L	32	22U	21	106	12	8.4
85	88 02 12	07 41 55	07 51 37	AJ	215L	70	33U	30	262	19	10.7
86	88 02 12	09 45 23	09 54 04	AJ	-90R	45	31U	24	79	13	9.1
87	88 02 12	13 54 45	14 03 09	AJ	-35R	40	35U	20	188	13	10.5
88	88 02 12	15 53 38	16 06 31	AJ	-55L	75	24U	20	515	22	9.6
89	88 02 13	12 58 40	13 07 19	AJ	-35R	33	24U	22	152	12	8.2
90	88 02 13	14 59 58	15 10 12	AJ	-45R	80	26U	35	388	20	10.6
91	88 02 14	14 05 47	14 17 35	AJ	-40R	55	25U	22	492	18	10.3
92	88 02 14	16 09 04	16 19 06	AJ	-65L	45	29U	20	221	17	10.2
93	88 02 15	07 07 03	07 12 11	AJ	220L	75	72	25	293	15	10.1
94	88 02 15	09 04 51	09 14 26	AJ	-85R	40	29U	20	352	14	9.8
95	88 02 15	13 11 22	13 23 01	AJ	-40R	45	21U	20	437	22	9.9
96	88 02 15	15 12 49	15 26 01	AJ	-55L	70	21U	20	250	21	9.5
97	88 02 16	06 07 31	06 17 34	AJ	200L	50	28U	26	193	17	9.5
98	88 02 16	08 11 06	08 20 40	AJ	-105R	55	39U	20	324	18	10.7
99	88 02 16	12 18 17	12 27 30	AJ	-35R	35	24U	21	164	14	10.4
100	88 02 18	06 27 07	06 28 20	AJ	220L	80	69	54	116	8	8.0
101	88 02 18	08 24 16	08 34 02	AJ	-80R	38	26U	20	158	16	10.7
102	88 02 18	12 31 04	12 42 53	AJ	-40R	45	22U	20	245	21	10.3
103	88 02 18	14 32 36	14 45 27	AJ	-55L	65	21U	21	286	21	10.4
104	88 02 19	05 30 33	05 38 29	AJ	200L	55	52U	20	312	17	10.2
105	88 02 19	07 29 55	07 40 08	AJ	-100R	50	32U	21	406	16	9.9
106	88 02 19	11 37 38	11 47 41	AJ	-35R	35	23U	20	394	14	9.0
107	88 02 19	13 39 14	13 51 42	AJ	-50R	90	26U	21	275	21	9.3
108	88 02 21	11 50 38	12 02 42	AJ	-35R	50	22U	20	582	19	10.0
109	88 02 21	13 52 33	14 04 12	AJ	-60L	60	23U	25	202	21	9.6
110	88 02 22	10 57 16	11 02 48	AJ	-35R	38	24U	37	250	9	8.8
111	88 02 22	13 00 19	13 10 07	AJ	-50L	85	36U	28	223	15	8.6
112	88 02 24	11 11 32	11 20 30	AJ	-40R	50	29U	31	419	14	7.9
113	88 02 24	13 13 07	13 24 14	AJ	-60L	55	27U	22	123	18	10.6
114	88 02 25	04 11 58	04 16 15	AJ	210L	65	64	29	167	8	8.3
115	88 02 25	06 11 45	06 18 54	AJ	-90R	45	41U	23	160	16	9.6
116	88 02 25	10 19 10	10 25 09	AJ	-40R	40	34U	30	19	7	11.1
117	88 03 03	03 56 32	04 04 10	AJ	-105R	50	46U	23	153	12	10.0
118	88 03 03	10 03 45	10 16 26	AJ	-50R	80	26U	20	762	23	9.3
119	88 03 03	12 09 05	12 13 49	AJ	-91L	25	24	21	16	6	8.7
120	88 03 07	02 17 49	02 29 43	AJ	-115R	65	25U	24	727	23	9.4

Table 4. Observations and data fitting (continued)

(8) No.	(9) STN	(10) TMP	(11) PRESS	(12) HUM	(13) IDT	(14) DTS	(15) DTL	(16) COMMENTS
		°C	mb	%	ns	μs	μs	
61	7838	4.7	1007.1	71	7.6	-0.9	-2.6	
62	7838	6.0	1006.2	71	7.5	-0.6	-2.6	
63	7838	16.0	994.4	92	6.8	-0.4	-2.7	
64	7838	14.7	993.6	86	7.6	-0.4	-2.7	
65	7838	8.6	994.0	36	7.6	-0.2	-2.7	
66	7838	6.8	995.5	40	7.5	-0.3	-2.7	
67	7838	3.8	998.1	40	7.6	-0.3	-2.7	
68	7838	2.9	998.8	43	7.6	-0.4	-2.7	
69	7838	1.3	1006.3	50	7.4	-0.3	-2.8	
70	7838	1.5	1007.1	55	7.7	-0.3	-2.8	
71	7838	0.0	1007.7	49	7.7	-0.2	-2.8	
72	7838	0.3	1008.0	47	7.6	-0.1	-2.8	
73	7838	-0.2	1008.5	64	7.7	-0.4	-2.8	
74	7838	4.1	1009.1	60	7.5	-0.1	-2.9	
75	7838	2.3	1010.7	62	7.5	0.0	-2.9	
76	7838	-1.0	1010.8	79	7.5	-0.1	-2.9	
77	7838	0.3	1010.8	71	7.6	0.0	-2.9	
78	7838	6.3	1010.1	47	7.6	-0.2	-3.0	DAYTIME
79	7838	3.2	1011.2	59	7.8	-0.4	-3.0	
80	7838	6.8	1013.0	51	7.6	-0.4	-3.1	DAYTIME
81	7838	3.5	1014.4	63	7.5	-0.1	-3.1	
82	7838	0.4	1017.2	75	7.5	-0.5	-3.1	
83	7838	-0.3	1017.2	78	7.5	-0.3	-3.1	
84	7838	-1.5	1017.1	80	7.5	-0.4	-3.1	
85	7838	9.7	1010.4	38	7.6	-0.3	-3.2	DAYTIME
86	7838	7.2	1012.3	46	7.4	-0.3	-3.2	
87	7838	4.2	1013.0	62	7.5	-0.4	-3.2	
88	7838	3.0	1012.5	70	7.6	-0.2	-3.2	
89	7838	3.1	1013.5	61	7.5	-0.7	-3.1	
90	7838	3.2	1014.2	64	7.5	-0.4	-3.1	
91	7838	5.8	1006.9	50	7.6	-0.5	-3.1	
92	7838	2.8	1006.4	65	7.6	-0.5	-3.1	
93	7838	7.9	1009.5	44	7.4	-0.5	-3.1	DAYTIME
94	7838	5.2	1010.4	47	7.4	-0.6	-3.1	
95	7838	1.9	1012.5	56	7.5	-0.6	-3.1	
96	7838	3.2	1011.9	58	7.5	-0.4	-3.1	
97	7838	11.2	1010.8	34	6.2	-0.9	-3.1	DAYTIME
98	7838	7.0	1012.3	41	6.6	-1.2	-3.1	DAYTIME
99	7838	4.0	1014.2	54	6.4	-1.1	-3.1	
100	7838	7.9	1009.7	43	7.4	-0.9	-2.9	DAYTIME
101	7838	4.3	1011.7	57	7.6	-0.9	-2.9	
102	7838	2.6	1014.7	60	7.8	-1.0	-2.9	
103	7838	2.0	1015.6	62	7.7	-1.3	-2.9	
104	7838	8.3	1019.3	52	8.2	-1.2	-2.9	DAYTIME
105	7838	8.0	1019.5	53	8.0	-1.2	-2.9	DAYTIME
106	7838	3.3	1021.9	59	7.9	-1.2	-2.9	
107	7838	1.9	1021.3	61	7.8	-1.3	-2.9	
108	7838	2.9	1022.3	43	7.5	-0.7	-2.7	
109	7838	1.7	1022.6	48	7.7	-0.4	-2.7	
110	7838	7.5	1022.3	81	7.6	-1.1	-2.6	
111	7838	5.4	1022.1	87	7.5	-0.9	-2.6	
112	7838	8.3	1015.2	65	7.7	-0.5	-2.5	
113	7838	7.4	1015.8	54	7.7	-0.9	-2.5	
114	7838	14.9	1016.2	52	7.6	-0.5	-2.4	DAYTIME
115	7838	14.0	1015.3	58	7.5	-0.8	-2.4	DAYTIME
116	7838	10.0	1016.9	62	7.5	-0.6	-2.4	
117	7838	11.5	1001.8	34	7.5	-0.6	-1.9	DAYTIME
118	7838	5.2	1006.2	42	7.6	-0.8	-1.9	
119	7838	3.8	1008.8	43	7.6	-0.9	-1.9	
120	7838	10.5	1007.3	40	7.5	-0.7	-1.6	DAYTIME

Table 4. Observations and data fitting (continued)

(1) No.	(2) Obs.Time(UTC) date	caught	lost	(3) SAT.	(4)Az. ST	(5)Elev. MX	CT	LT	(6) RTN	(7)Fitting N	RMS
	Y M D	h m s	h m s		°	°	°	°			cm
121	88 03 07	04 24 45	04 32 02	AJ	-65R	30	28U	20	122	14	11.2
122	88 03 07	06 28 38	06 36 07	AJ	-35R	30	26U	21	105	10	9.0
123	88 03 07	08 30 54	08 41 44	AJ	-40R	65	36U	20	684	19	9.8
124	88 03 07	10 32 38	10 41 12	AJ	-70L	37	27U	23	135	20	10.9
125	88 03 08	01 25 46	01 36 33	AJ	-135R	85	41U	20	454	22	10.1
126	88 03 08	03 27 01	03 33 47	AJ	-80R	37	21U	35	75	13	9.3
127	88 03 24	03 18 46	03 29 49	AJ	-40R	50	21U	27	541	20	9.7
128	88 03 28	01 44 47	01 54 42	AJ	-35R	40	22U	25	202	17	10.4
129	88 03 28	03 46 12	03 51 06	AJ	-50L	75	22	64	337	10	8.3
130	88 04 05	23 45 07	23 51 34	AJ	-40R	45	30	41	42	10	11.5
131	88 04 10	23 19 43	23 23 53	AJ	-45R	70	44	68	37	8	14.4
132	88 04 11	16 19 54	16 24 17	AJ	-130R	80	57	21	82	11	9.9
133	88 04 13	14 24 12	14 35 43	AJ	195L	45	22U	20	1334	18	9.8
134	88 04 13	16 25 30	16 37 58	AJ	-110R	55	23U	21	681	23	10.0
135	88 04 14	15 30 34	15 44 15	AJ	-125R	80	21U	20	1259	24	9.7
136	88 04 14	23 44 27	23 55 39	AJ	-60L	50	22U	24	374	22	9.8
137	88 04 15	14 36 35	14 49 59	AJ	215L	75	21U	20	1131	24	10.2
138	88 04 15	16 39 58	16 51 36	AJ	-85R	40	21U	20	749	19	9.6
139	88 04 17	12 51 05	13 00 28	AJ	175L	32	21U	20	161	12	11.2
140	88 04 19	13 07 02	13 13 58	AJ	200L	55	47U	27	99	11	9.5
141	88 04 19	15 07 34	15 15 15	AJ	-100R	50	36U	31	350	14	9.5
142	88 04 20	14 17 16	14 22 31	AJ	-120R	70	67	25	345	20	9.8
143	88 04 24	12 36 30	12 48 58	AJ	-130R	90	27U	20	1243	22	9.5
144	88 04 24	14 39 39	14 50 24	AJ	-75R	35	20U	20	481	16	9.5
145	88 04 25	11 41 47	11 54 52	AJ	210L	65	21U	20	963	23	9.6
146	88 04 25	13 45 26	13 56 32	AJ	-90R	45	26U	20	793	15	8.9
147	88 05 09	11 21 11	11 26 43	AJ	-65R	30	26U	26	381	10	7.3
148	88 05 09	13 25 27	13 32 53	AJ	-35R	30	26U	21	237	9	8.5
149	88 05 12	06 42 14	06 43 58	AJ	190L	40	30	22	40	6	8.7
150	88 05 12	08 42 03	08 46 33	AJ	-110R	60	51	21	292	9	8.9
151	88 05 12	14 47 08	14 58 14	AJ	-45R	70	36U	20	737	17	8.3
152	88 05 12	16 54 57	16 57 37	AJ	-75L	32	29U	20	34	6	10.2
153	88 05 17	12 18 55	12 28 33	AJ	-35R	45	32U	20	486	16	9.7
154	88 05 17	14 18 13	14 31 36	AJ	-55L	70	21U	20	839	23	9.4
155	88 05 18	07 20 29	07 25 38	AJ	-100R	55	51	22	311	9	10.4
156	88 05 18	11 24 49	11 32 34	AJ	-35R	35	28U	22	395	14	10.2
157	88 05 18	13 27 09	13 34 56	AJ	-45R	80	43U	38	741	15	8.1
158	88 05 23	10 55 48	11 08 12	AJ	-40R	50	21U	20	516	20	9.8
159	88 05 23	12 57 45	13 10 21	AJ	-60L	60	22U	21	893	23	10.0
160	88 05 26	04 13 27	04 16 30	AJ	-130R	80	50	25	88	13	8.7
161	88 05 26	10 19 06	10 24 52	AJ	-40R	50	41U	37	42	16	10.3
162	88 05 26	12 17 20	12 29 53	AJ	-60L	55	21U	20	1168	24	9.0
163	88 05 28	10 29 23	10 42 27	AJ	-45R	75	23U	20	1095	24	9.1
164	88 05 28	12 32 17	12 41 20	AJ	-75L	32	21U	21	577	19	9.0
165	88 05 29	11 39 03	11 45 09	AJ	-60L	50	31U	44	87	13	10.5
166	88 05 30	04 40 52	04 44 18	AJ	-90R	40	37	21	43	14	8.9
167	88 05 30	10 45 23	10 53 43	AJ	-55L	75	39U	35	425	18	9.4
168	88 06 04	04 08 12	04 17 45	AJ	-65R	32	21U	20	249	13	10.2
169	88 06 04	08 19 33	08 22 32	AJ	-40R	60	57U	53	76	7	9.6
170	88 06 06	02 24 05	02 27 02	AJ	-100R	50	49	35	236	9	8.6
171	88 06 06	06 32 39	06 34 28	AJ	-35R	35	35	31	45	10	9.8
172	88 06 06	08 33 58	08 38 53	AJ	-50R	85	80U	37	390	10	8.0
173	88 06 13	06 18 17	06 19 45	AJ	-45R	75	63	74	107	8	9.5
174	88 06 14	05 22 55	05 25 49	AJ	-40R	55	43U	54	170	8	9.1
175	88 07 01	17 04 38	17 12 12	AJ	195L	50	21	45	177	16	10.8
176	88 07 01	19 06 25	19 18 58	AJ	-105R	55	22U	20	871	21	10.2
177	88 07 02	01 18 29	01 22 34	AJ	-45R	80	30	70	521	16	9.1
178	88 07 07	00 55 34	00 57 57	AJ	-60L	60	57U	59	213	9	9.5
179	88 07 07	17 47 25	17 58 03	AJ	-100R	50	29U	21	97	15	10.3
180	88 07 08	14 51 15	14 59 55	AJ	185L	38	23U	27	161	12	8.7

Table 4. Observations and data fitting (continued)

(8) No.	(9) STN	(10) TMP	(11) PRESS	(12) HUM	(13) IDT	(14) DTS	(15) DTL	(16) COMMENTS
		°C	mb	%	ns	μs	μs	
121	7838	10.7	1006.2	40	7.6	-0.9	-1.6	DAYTIME
122	7838	9.8	1007.1	38	7.6	-0.7	-1.6	DAYTIME
123	7838	7.2	1008.6	38	7.6	-0.7	-1.6	DAYTIME
124	7838	4.4	1011.0	42	7.4	-0.5	-1.6	
125	7838	8.0	1013.2	38	7.5	-0.7	-1.6	DAYTIME
126	7838	10.0	1011.4	35	7.5	-0.9	-1.6	DAYTIME
127	7838	13.1	1014.9	51	7.4	-0.8	-0.7	DAYTIME
128	7838	13.5	1011.2	40	7.3	-0.5	-0.6	DAYTIME
129	7838	14.6	1010.1	36	7.3	-0.7	-0.6	DAYTIME
130	7838	17.4	1009.0	47	7.4	-0.9	-0.3	DAYTIME
131	7838	15.4	1024.3	51	7.0	-1.1	-0.2	DAYTIME
132	7838	12.2	1022.3	77	7.4	-0.9	-0.2	
133	7838	12.6	1004.5	76	7.2	-0.5	-0.3	
134	7838	12.7	1003.6	70	7.3	-0.7	-0.3	
135	7838	12.5	1006.2	48	7.2	-0.6	-0.4	
136	7838	15.8	1011.0	36	7.3	-1.0	-0.4	DAYTIME
137	7838	10.2	1014.3	67	7.4	-0.8	-0.4	
138	7838	9.6	1014.1	67	7.5	-0.9	-0.4	
139	7838	16.4	1015.2	74	7.2	-1.1	-0.5	
140	7838	15.2	1000.1	66	7.1	-0.5	-0.5	
141	7838	14.9	1000.3	73	7.7	-0.5	-0.5	
142	7838	16.9	1002.3	86	7.6	-0.6	-0.5	
143	7838	11.0	1005.6	58	7.6	-0.8	-0.6	
144	7838	8.6	1005.8	72	7.6	-0.8	-0.6	
145	7838	13.1	1011.7	72	7.6	-0.8	-0.6	
146	7838	12.2	1011.7	72	6.9	-1.0	-0.6	
147	7838	14.2	1011.7	69	7.8	-0.5	-0.5	
148	7838	16.3	1012.0	71	7.8	-0.8	-0.5	
149	7838	22.5	991.6	42	7.9	0.0	-0.5	DAYTIME
150	7838	20.6	993.3	43	7.8	0.0	-0.5	DAYTIME
151	7838	14.4	997.9	44	7.6	0.1	-0.5	
152	7838	14.1	997.3	45	7.7	0.1	-0.5	
153	7838	16.7	1004.0	98	7.6	-0.1	-0.4	
154	7838	15.7	1003.6	90	7.6	-0.4	-0.4	
155	7838	23.1	1002.7	69	7.7	-0.6	-0.4	DAYTIME
156	7838	21.4	1004.7	50	7.6	-0.4	-0.4	
157	7838	21.2	1005.3	48	7.7	-0.3	-0.4	
158	7838	15.8	998.1	53	7.5	-0.4	-0.4	
159	7838	14.8	1000.6	56	7.6	-0.5	-0.4	
160	7838	20.6	1006.0	76	7.7	-0.2	-0.5	DAYTIME
161	7838	17.5	1005.6	92	7.6	0.0	-0.5	
162	7838	16.1	1005.8	94	7.7	0.0	-0.5	
163	7838	18.3	1007.1	88	7.6	-0.1	-0.6	
164	7838	17.7	1008.2	81	7.5	-0.3	-0.6	
165	7838	18.2	1005.6	97	7.3	-0.7	-0.6	
166	7838	22.1	1007.7	64	7.5	-0.4	-0.6	DAYTIME
167	7838	19.0	1009.0	77	7.6	-0.3	-0.6	
168	7838	24.2	993.8	67	7.3	-0.6	-0.8	DAYTIME
169	7838	24.0	995.6	56	7.7	-0.3	-0.8	DAYTIME
170	7838	22.7	1009.0	79	7.6	-0.7	-1.0	DAYTIME
171	7838	23.1	1008.4	83	7.6	-0.6	-1.0	DAYTIME
172	7838	22.9	1007.5	76	7.7	-0.6	-1.0	DAYTIME
173	7838	23.7	996.0	83	7.7	0.0	-1.2	DAYTIME
174	7838	23.9	998.4	83	7.6	-0.2	-1.3	DAYTIME
175	7838	21.5	998.0	76	7.5	-0.2	-2.2	
176	7838	21.7	998.0	76	7.2	0.0	-2.2	
177	7838	25.1	999.2	80	7.2	0.0	-2.3	DAYTIME
178	7838	25.1	1000.5	77	7.4	-0.5	-2.7	DAYTIME
179	7838	23.8	997.4	88	7.4	-0.2	-2.7	
180	7838	25.1	998.8	84	7.4	0.2	-2.7	

Table 4. Observations and data fitting (continued)

(1) No.	(2) Obs.Time(UTC) date	caught	lost	(3) SAT.	(4)Az. ST	(5)Elev. MX	CT	LT	(6) RTN	(7)Fitting N	RMS
	Y M D	h m s	h m s		°	°	°	°			cm
181	88 07 11	14 10 23	14 21 01	AJ	190L	40	22U	22	915	21	9.7
182	88 07 11	18 18 53	18 25 11	AJ	-60R	30	28U	21	245	9	8.9
183	88 07 19	15 05 12	15 16 30	AJ	-85R	40	21U	21	930	15	8.8
184	88 07 31	10 24 19	10 32 52	AJ	-125R	80	53U	25	625	15	11.1
185	88 07 31	12 25 01	12 35 11	AJ	-70R	35	21U	20	1049	14	8.6
186	88 07 31	16 32 16	16 44 42	AJ	-40R	55	24U	20	780	21	11.3
187	88 07 31	18 34 27	18 44 34	AJ	-65L	50	23U	27	218	17	9.7
188	88 08 04	10 49 58	10 56 52	AJ	-85R	40	23U	36	57	15	8.7
189	88 08 05	09 55 24	10 02 39	AJ	-100R	50	27U	44	280	13	10.0
190	88 08 05	14 03 39	14 13 50	AJ	-40R	35	21U	22	292	15	10.0
191	88 08 07	10 09 21	10 12 38	AJ	-80R	38	21	34	214	9	8.4
192	88 08 14	12 02 26	12 10 47	AJ	-40R	40	21U	34	230	17	9.1
193	88 08 17	11 22 33	11 33 48	AJ	-40R	45	23U	20	603	17	10.6
194	88 08 17	13 23 30	13 35 58	AJ	-55L	70	21U	25	308	21	10.3
195	88 08 23	10 03 58	10 09 08	AJ	-40R	50	35U	43	399	10	11.7
196	88 08 25	10 14 44	10 27 47	AJ	-45R	70	21U	22	1133	22	10.6
197	88 08 25	12 17 42	12 25 26	AJ	-75L	35	21U	30	851	13	9.8
198	88 08 26	09 20 43	09 33 25	AJ	-40R	50	21U	20	1701	20	10.0
199	88 08 26	11 23 03	11 35 24	AJ	-60L	55	23U	20	1295	24	10.6
200	88 08 28	09 36 52	09 45 33	AJ	-45R	75	38U	34	437	14	9.0
201	88 08 29	02 35 25	02 41 50	AJ	-130R	85	83U	23	522	16	10.6
202	88 08 29	04 39 24	04 41 42	AJ	-75R	35	34U	28	42	6	12.2
203	88 08 29	08 40 20	08 53 13	AJ	-40R	55	21U	20	1654	24	10.8
204	88 08 29	10 42 30	10 54 43	AJ	-65L	50	21U	21	119	16	11.1
205	88 08 30	07 46 32	07 50 28	AJ	-35R	40	21	38	210	11	9.0
206	88 08 30	09 48 46	10 01 14	AJ	-55L	75	25U	22	928	23	9.5
207	88 08 31	02 47 46	02 55 48	AJ	-105R	55	51U	21	487	14	10.4
208	88 08 31	06 56 48	07 02 34	AJ	-40R	33	33U	20	491	10	8.4
209	88 08 31	08 54 30	09 07 36	AJ	-45R	75	24U	20	1690	24	9.5
210	88 09 02	02 58 17	03 09 23	AJ	-85R	40	22U	20	888	17	10.2
211	88 09 02	07 08 12	07 10 47	AJ	-40R	45	31U	41	79	9	13.8
212	88 09 07	00 27 54	00 41 11	AJ	-115R	65	21U	20	909	23	8.9
213	88 09 07	08 44 37	08 51 54	AJ	-70L	40	33U	24	649	11	9.4
214	88 09 08	01 38 10	01 48 44	AJ	-80R	37	22U	20	941	17	10.8
215	88 09 08	05 46 41	05 57 01	AJ	-40R	50	28U	23	692	17	10.0
216	88 09 12	06 12 39	06 16 55	AJ	-50L	80	22	56	66	7	8.5
217	88 09 12	21 07 04	21 14 07	AJ	190L	45	23U	39	268	11	10.1
218	88 09 12	23 08 21	23 15 02	AJ	-110R	60	26U	56	614	11	10.8
219	88 09 13	07 29 52	07 31 19	AJ	-75L	32	25	20	43	6	12.2
220	88 09 14	06 34 18	06 39 01	AJ	-65L	50	46	20	214	9	10.6
221	88 09 16	02 36 56	02 42 13	AJ	-35R	33	21	33	148	8	10.0
222	88 09 16	04 38 24	04 48 34	AJ	-45R	80	23U	41	326	20	10.5
223	88 09 26	01 44 27	01 53 04	AJ	-45R	70	29U	42	425	14	10.2
224	88 10 01	01 16 56	01 23 05	AJ	-55L	75	24	74	102	10	8.6
225	88 10 10	14 09 41	14 20 57	AJ	205L	60	28U	22	887	19	8.9
226	88 10 13	13 27 58	13 40 58	AJ	210L	65	21U	21	651	23	10.2
227	88 10 14	12 34 55	12 46 19	AJ	190L	45	21U	21	1073	18	10.4
228	88 10 14	14 35 49	14 48 40	AJ	-110R	60	21U	21	1774	22	9.3
229	88 10 16	12 47 23	12 59 38	AJ	215L	75	21U	26	1404	22	10.0
230	88 10 19	12 07 02	12 20 16	AJ	220L	75	21U	21	1950	25	9.0
231	88 10 23	10 32 59	10 45 49	AJ	205L	55	21U	20	2050	21	8.2
232	88 10 26	09 52 47	10 05 23	AJ	205L	65	22U	21	1887	19	8.9
233	88 11 01	08 32 06	08 44 10	AJ	215L	75	24U	24	1388	20	8.4
234	88 11 01	10 35 44	10 46 25	AJ	-90R	40	25U	20	1093	16	9.6
235	88 11 02	07 38 29	07 50 24	AJ	200L	50	22U	21	1067	22	9.2
236	88 11 03	10 50 11	11 00 02	AJ	-70R	32	21U	20	585	13	9.0
237	88 11 06	10 10 12	10 19 39	AJ	-65R	30	21U	20	789	13	7.2
238	88 11 07	09 15 01	09 25 34	AJ	-80R	38	22U	20	816	19	9.7
239	88 11 07	13 22 33	13 32 21	AJ	-35R	45	22U	31	719	15	10.6
240	88 11 08	12 30 32	12 37 08	AJ	-40R	37	29U	29	91	11	11.6

Table 4. Observations and data fitting (continued)

(8) No.	(9) STN	(10) TMP	(11) PRESS	(12) HUM	(13) IDT	(14) DTS	(15) DTL	(16) COMMENTS
		˚C	mb	%	ns	μs	μs	
181	7838	24.2	1002.1	92	7.5	-0.4	-2.9	
182	7838	23.6	1001.6	92	7.4	-0.4	-2.9	
183	7838	21.1	1002.3	96	7.3	0.0	-2.9	
184	7838	24.6	1000.1	87	7.1	0.5	-2.6	
185	7838	22.3	1001.4	86	6.9	0.4	-2.6	
186	7838	21.2	1001.6	89	6.9	0.7	-2.6	
187	7838	20.5	1001.4	87	6.9	0.6	-2.6	
188	7838	25.1	1003.8	92	6.8	-0.5	-2.5	
189	7838	26.6	1008.0	87	6.7	0.0	-2.5	
190	7838	24.5	1008.8	94	6.7	0.0	-2.5	
191	7838	25.8	1007.1	87	7.0	-0.3	-2.4	
192	7838	25.0	1000.8	95	7.5	-0.4	-2.2	
193	7838	24.1	1001.0	95	9.0	-0.5	-2.1	
194	7838	24.7	1001.2	94	8.7	-0.5	-2.1	
195	7838	27.9	996.0	88	7.0	-0.1	-1.9	
196	7838	27.0	998.4	88	7.0	-0.1	-1.9	
197	7838	25.7	998.6	90	7.0	0.1	-1.9	
198	7838	26.8	998.1	85	7.5	-0.5	-1.9	DAYTIME
199	7838	25.6	998.8	88	7.2	-0.4	-1.9	
200	7838	27.6	994.4	79	7.1	-0.3	-1.9	
201	7838	30.0	995.7	66	7.2	-0.3	-1.9	DAYTIME
202	7838	30.1	994.9	65	7.2	-0.2	-1.9	DAYTIME
203	7838	28.0	995.5	70	7.1	-0.4	-1.9	DAYTIME
204	7838	25.2	996.4	82	7.3	-0.4	-1.9	
205	7838	29.4	997.7	51	7.5	-0.5	-1.8	DAYTIME
206	7838	25.7	998.4	72	7.4	-0.5	-1.8	
207	7838	29.7	994.4	62	7.4	-0.5	-1.8	DAYTIME
208	7838	30.2	997.3	47	7.3	-0.4	-1.8	DAYTIME
209	7838	26.7	997.7	51	7.4	-0.5	-1.8	DAYTIME
210	7838	27.9	997.9	60	7.3	-0.4	-1.7	DAYTIME
211	7838	27.5	997.3	65	7.1	-0.4	-1.7	DAYTIME
212	7838	27.7	998.1	79	7.1	-0.2	-1.8	DAYTIME
213	7838	26.5	997.9	84	7.3	-0.4	-1.8	DAYTIME
214	7838	27.4	1004.2	76	7.5	-0.2	-1.9	DAYTIME
215	7838	28.7	1003.8	70	7.1	-0.3	-1.9	DAYTIME
216	7838	28.2	992.5	72	6.7	-0.6	-2.1	DAYTIME
217	7838	21.9	999.4	72	6.5	-0.6	-2.1	DAYTIME
218	7838	24.9	1000.3	69	6.5	-0.6	-2.1	DAYTIME
219	7838	27.0	1000.5	68	7.0	-0.6	-2.1	DAYTIME
220	7838	27.4	1000.3	65	7.4	-0.6	-2.0	DAYTIME
221	7838	30.7	993.3	57	6.3	-0.8	-2.0	DAYTIME
222	7838	30.7	992.7	64	6.8	-0.7	-2.0	DAYTIME
223	7838	25.5	993.3	75	6.6	-0.4	-2.0	DAYTIME
224	7838	23.6	1007.1	63	7.6	-0.7	-2.0	DAYTIME
225	7838	15.5	1012.8	80	7.4	-0.3	-1.9	
226	7838	9.4	1006.2	79	7.2	-0.4	-2.0	
227	7838	12.1	1008.6	79	6.6	-0.8	-2.0	
228	7838	11.0	1008.4	83	6.7	-0.7	-2.0	
229	7838	17.2	1011.0	71	7.3	-0.5	-2.0	
230	7838	14.9	1014.7	69	6.7	-0.8	-2.1	
231	7838	14.9	1011.4	73	6.7	-0.8	-2.1	
232	7838	15.2	1011.0	82	6.7	-0.9	-2.2	
233	7838	15.2	1014.7	68	6.9	-0.8	-2.4	
234	7838	12.3	1014.1	85	7.0	-0.8	-2.4	
235	7838	17.5	1003.6	36	7.1	-0.6	-2.4	DAYTIME
236	7838	11.4	1008.8	69	6.9	-0.7	-2.4	
237	7838	12.0	1009.9	59	7.0	-0.8	-2.6	
238	7838	15.6	1011.0	50	7.4	-0.8	-2.6	
239	7838	12.1	1013.0	49	7.6	-0.6	-2.6	
240	7838	13.8	1015.2	82	7.9	-0.3	-2.6	

Table 4. Observations and data fitting (continued)

(1) No.	(2) Obs.Time(UTC) date	caught	lost	(3) SAT.	(4)Az. ST	(5)Elev. MX	CT	LT	(6) RTN	(7)Fitting N	RMS
	Y M D	h m s	h m s		°	°	°	°			cm
241	88 11 08	14 30 02	14 43 16	AJ	-50L	85	22U	21	1354	24	8.9
242	88 11 09	05 24 40	05 35 14	AJ	185L	38	22U	20	535	18	10.3
243	88 11 09	07 26 49	07 37 54	AJ	-115R	65	34U	20	447	22	10.0
244	88 11 09	09 30 16	09 39 18	AJ	-60R	30	21U	20	714	11	7.3
245	88 11 09	11 40 35	11 43 54	AJ	-40R	30	29	20	60	7	10.2
246	88 11 10	06 33 54	06 43 48	AJ	-135R	90	48U	21	690	23	11.2
247	88 11 10	08 34 40	08 45 19	AJ	-75R	35	21U	20	951	17	9.9
248	88 11 10	12 41 59	12 54 19	AJ	-40R	50	21U	20	1192	22	9.4
249	88 11 10	14 43 47	14 56 30	AJ	-60L	55	21U	20	1408	20	9.3
250	88 11 11	11 48 04	11 59 11	AJ	-35R	38	21U	20	1047	16	10.6
251	88 11 11	13 49 18	14 03 01	AJ	-50L	80	20U	20	1581	24	9.7
252	88 11 13	14 03 29	14 16 00	AJ	-60L	50	20U	20	1165	20	9.7
253	88 11 14	11 11 47	11 19 11	AJ	-35R	40	38U	20	784	11	8.7
254	88 11 14	13 09 22	13 22 27	AJ	-50L	75	22U	21	1375	24	9.5
255	88 11 15	12 17 13	12 26 21	AJ	-45R	75	34U	34	544	18	10.9
256	88 11 18	05 23 56	05 36 41	AJ	-105R	55	21U	20	965	21	9.5
257	88 11 18	09 34 00	09 43 36	AJ	-40R	35	23U	20	633	17	9.2
258	88 11 18	11 34 48	11 48 16	AJ	-45R	80	21U	20	1249	24	9.8
259	88 11 20	09 46 57	09 58 51	AJ	-40R	45	21U	20	1123	18	9.4
260	88 11 20	11 48 36	12 01 43	AJ	-55L	65	21U	20	1111	24	10.7
261	88 11 22	10 00 22	10 13 11	AJ	-40R	65	21U	22	1455	20	8.2
262	88 11 24	10 14 02	10 27 23	AJ	-50L	85	21U	21	666	23	10.2
263	88 12 17	01 46 28	01 51 45	AJ	-35R	33	33U	21	101	10	12.6
264	88 12 19	01 56 08	02 06 46	AJ	-35R	45	24U	23	514	16	11.4
265	88 12 19	03 58 07	04 09 58	AJ	-55L	70	27U	23	600	13	13.3
266	88 12 20	01 01 34	01 12 08	AJ	-35R	35	21U	20	715	15	9.7
267	88 12 21	02 10 41	02 22 00	AJ	-40R	60	30U	21	824	23	11.0
268	88 12 22	01 15 08	01 27 15	AJ	-40R	45	21U	20	758	21	9.6
269	88 12 23	02 23 00	02 35 57	AJ	-50R	85	23U	22	857	21	8.1
270	88 12 26	01 42 21	01 50 11	AJ	-50L	85	22U	71	105	14	9.3
271	88 12 27	00 48 16	01 01 13	AJ	-45R	70	21U	22	803	19	8.5

Table 4. Observations and data fitting (continued)

(8) No.	(9) STN	(10) TMP	(11) PRESS	(12) HUM	(13) IDT	(14) DTS	(15) DTL	(16) COMMENTS
		°C	mb	%	ns	μs	μs	
241	7838	12.7	1014.9	82	7.7	-0.3	-2.6	
242	7838	18.8	1010.8	75	8.4	-0.6	-2.6	DAYTIME
243	7838	17.5	1010.6	82	7.8	-0.3	-2.6	DAYTIME
244	7838	14.3	1010.4	95	8.0	-0.5	-2.6	
245	7838	13.1	1009.9	95	8.0	-0.3	-2.6	
246	7838	17.2	1002.3	35	6.9	-0.4	-2.6	DAYTIME
247	7838	13.8	1003.4	40	7.9	-0.5	-2.6	
248	7838	9.6	1005.8	45	7.9	-0.6	-2.6	
249	7838	8.9	1006.9	42	8.0	-0.4	-2.6	
250	7838	7.6	1008.2	64	6.8	-0.8	-2.6	
251	7838	6.5	1008.4	69	6.8	-0.9	-2.6	
252	7838	14.1	1000.8	68	6.9	-0.5	-2.5	
253	7838	12.8	1006.6	65	6.4	-1.0	-2.5	
254	7838	11.5	1007.1	71	6.4	-1.0	-2.5	
255	7838	12.3	1013.8	53	7.0	-1.0	-2.4	
256	7838	14.4	1001.3	69	7.0	-0.5	-2.4	DAYTIME
257	7838	11.5	1002.7	61	6.9	-0.5	-2.4	
258	7838	10.4	1003.4	62	7.0	-0.5	-2.4	
259	7838	10.8	1012.8	53	7.0	-1.6	-2.3	
260	7838	9.2	1013.6	59	7.1	-1.6	-2.3	
261	7838	9.1	1014.3	79	6.8	-0.7	-2.3	
262	7838	7.1	999.4	57	6.4	-0.4	-2.2	
263	7838	8.8	1013.8	42	8.3	-0.7	-1.6	DAYTIME
264	7838	13.6	1015.6	60	7.4	-0.7	-1.6	DAYTIME
265	7838	16.2	1012.5	45	7.0	-0.8	-1.6	DAYTIME
266	7838	13.3	1011.9	54	7.4	-0.8	-1.6	DAYTIME
267	7838	15.0	1007.5	41	7.6	-0.7	-1.6	DAYTIME
268	7838	11.3	1015.6	48	7.7	-1.1	-1.6	DAYTIME
269	7838	12.0	1016.9	57	7.6	-0.9	-1.6	DAYTIME
270	7838	9.3	1012.3	42	7.5	-0.5	-1.5	DAYTIME
271	7838	9.9	1012.3	42	7.6	-0.8	-1.5	DAYTIME

Table 4. Observations and data fitting (continued)

(1) No.	(2) Obs.Time(UTC) date Y	M	D	caught h	m	s	lost h	m	s	(3) SAT.	(4)Az. ST °	(5)Elev. MX °	CT °	LT °	(6) RTN	(7)Fitting N	RMS cm
1	88	2	1	9	13	39	9	16	32	LG	160R	80	73U	80	44	9	2.5
2	88	2	3	10	1	55	10	3	48	LG	170R	60	56	58	28	5	2.4
3	88	2	5	10	56	39	11	12	43	LG	200R	38	38	21	644	15	3.7
4	88	2	5	19	51	55	20	4	59	LG	50R	35	34U	32	200	9	4.1
5	88	2	12	8	42	9	8	47	33	LG	150L	85	33	20	160	9	3.3
6	88	2	12	20	39	45	20	59	59	LG	30R	70	28U	67	115	15	4.9
7	88	2	14	9	11	20	9	35	38	LG	170R	70	70U	20	578	9	4.8
8	88	2	22	8	45	28	9	8	46	LG	170R	70	60U	35	1115	15	4.0
9	88	2	26	19	19	39	19	51	11	LG	50R	45	36U	21	752	15	3.7
10	88	2	27	8	58	18	9	28	28	LG	180R	60	50U	21	1458	15	3.8
11	88	2	29	18	52	18	19	13	49	LG	50R	35	35U	22	388	9	3.6
12	88	7	27	16	46	53	17	5	29	LG	20L	65	65	35	1032	25	3.3
13	88	7	31	14	47	44	15	12	8	LG	30R	65	60U	32	1510	25	3.9
14	88	7	31	18	11	36	18	20	16	LG	0L	35	28U	34	182	20	3.4
15	88	8	1	13	32	3	13	35	30	LG	60R	40	37U	36	57	5	3.2
16	88	8	1	17	1	31	17	13	30	LG	10L	60	57U	43	278	15	2.9
17	88	8	2	15	30	26	15	54	47	LG	30L	90	52U	48	719	15	3.6
18	88	8	4	16	9	50	16	29	22	LG	20L	70	27U	67	404	30	3.5
19	88	8	5	14	50	40	15	19	18	LG	30R	80	36	52	664	15	4.1
20	88	8	10	15	1	58	15	28	0	LG	20L	90	29U	69	720	21	4.3
21	88	8	17	12	49	41	13	7	34	LG	50R	37	37	24	207	9	4.1
22	88	8	19	16	53	19	17	9	7	LG	10L	40	24U	40	388	15	3.4
23	88	8	22	16	22	45	16	47	43	LG	10L	45	33U	36	474	13	3.4
24	88	8	23	15	20	1	15	32	53	LG	20L	75	70U	35	154	9	4.9
25	88	8	25	15	45	23	16	22	38	LG	10L	55	29U	24	280	15	3.7
26	88	9	2	15	25	33	16	2	30	LG	10L	55	29	24	2212	31	3.4
27	88	9	8	14	17	44	14	55	20	LG	20L	75	33U	30	2558	31	3.7
28	88	9	9	13	14	50	13	33	30	LG	30R	70	69	30	1250	15	3.8
29	88	9	11	14	14	33	14	20	36	LG	20L	85	49U	33	105	5	4.0
30	88	9	12	12	24	35	12	54	7	LG	40R	60	35U	38	673	19	5.2
31	88	9	12	15	56	48	16	22	38	LG	10L	40	29U	27	24	11	2.3
32	88	9	13	14	28	0	14	49	35	LG	20L	65	23	65	1755	25	3.4

Table 4. Observations and data fitting (continued)

(8) No.	(9) STN	(10) TMP	(11) PRESS	(12) HUM	(13) IDT	(14) DTS	(15) DTL	(16) COMMENTS
		°C	mb	%	ns	µs	µs	
1	7844	15.4	990.6	65	50.8	-58.6	-2.4	
2	7844	15.2	987.5	53	50.8	-58.6	-2.6	
3	7844	9.5	993.2	94	50.6	-58.6	-2.7	
4	7844	13.8	989.1	81	50.5	-58.6	-2.7	
5	7844	11.9	992.3	91	50.8	-58.6	-3.2	
6	7844	15.4	993.3	84	50.9	-58.6	-3.2	
7	7844	15.5	989.8	73	50.9	-58.6	-3.1	
8	7844	14.3	1001.5	57	50.7	-58.6	-2.6	
9	7844	14.2	992.6	98	50.8	-58.6	-2.4	
10	7844	18.9	990.7	91	50.8	-58.6	-2.3	
11	7844	17.1	995.0	78	50.8	-58.6	-2.1	
12	7307	26.0	995.8	93	50.5	- 1.0	-2.8	
13	7307	27.0	999.9	92	50.8	- 1.0	-2.6	
14	7307	27.0	998.8	92	50.5	- 1.0	-2.6	
15	7307	28.1	1001.9	82	50.6	- 1.0	-2.6	
16	7307	27.2	1001.6	88	50.6	- 1.0	-2.6	
17	7307	28.2	1002.6	86	50.8	- 1.0	-2.6	
18	7307	26.7	998.6	97	50.5	- 1.0	-2.5	
19	7307	25.8	998.9	97	50.6	- 1.0	-2.5	
20	7307	26.5	1000.6	88	50.8	- 1.0	-2.3	
21	7307	28.2	1003.3	91	50.5	- 1.0	-2.1	
22	7307	27.8	1002.5	86	50.6	- 1.0	-1.9	
23	7307	28.0	1001.9	85	50.7	- 1.0	-1.9	
24	7307	28.4	1003.4	85	50.6	- 1.0	-1.9	
25	7307	27.2	1006.7	86	50.8	- 1.0	-1.9	
26	7307	26.5	999.9	90	50.7	- 1.0	-1.7	
27	7307	27.0	1006.0	84	50.5	- 1.0	-1.9	
28	7307	27.1	1006.1	85	50.6	- 1.0	-1.9	
29	7307	27.1	1003.9	85	50.3	- 1.0	-2.0	
30	7307	26.9	1003.0	82	50.7	- 1.0	-2.1	
31	7307	25.8	1003.1	83	50.6	- 1.0	-2.1	
32	7307	25.1	1003.7	77	50.7	- 1.0	-2.1	

Table 4. Observations and data fitting (continued)

(1) No.	(2) Obs.Time(UTC) date			caught			lost			(3) SAT.	(4)Az. ST	(5)Elev. MX	CT	LT	(6) RTN	(7)Fitting N	RMS
	Y	M	D	h	m	s	h	m	s		°	°	°	°			cm
1	88	2	3	13	5	48	13	9	27	ST	330R	45	24U	44	169	11	2.8
2	88	2	5	11	56	46	12	2	18	ST	350R	30	25U	19	115	11	2.5
3	88	2	12	10	33	16	10	41	21	ST	330R	65	25U	23	209	15	3.0
4	88	2	14	11	12	40	11	17	16	ST	290L	38	23U	36	102	11	2.6
5	88	8	24	11	43	18	11	49	58	ST	230R	80	44U	25	137	25	7.3
6	88	9	13	12	54	7	13	0	15	ST	350R	33	25U	21	379	15	3.7

Table 4. Observations and data fitting (continued)

(8) No.	(9) STN	(10) TMP	(11) PRESS	(12) HUM	(13) IDT	(14) DTS	(15) DTL	(16) COMMENTS
		°C	mb	%	ns	µs	µs	
1	7844	14.5	989.0	51	51.0	-58.6	-2.6	
2	7844	9.4	993.1	94	51.1	-58.6	-2.7	
3	7844	10.8	993.2	93	51.1	-58.6	-3.2	
4	7844	15.8	989.5	74	51.0	-58.6	-3.1	
5	7307	28.2	1005.0	83	50.5	- 1.0	-1.9	
6	7307	25.6	1003.5	74	50.9	- 1.0	-2.1	

Table 4. Observations and data fitting (continued)

(1) No.	(2) Obs.Time(UTC) date	caught	lost	(3) SAT.	(4)Az. ST	(5)Elev. MX	CT	LT	(6) RTN	(7)Fitting N	RMS
	Y M D	h m s	h m s		°	°	°	°			cm
1	88 1 23	19 48 20	19 56 16	AJ	340R	40	36U	21	136	13	4.7
2	88 1 24	18 51 30	19 0 49	AJ	340R	30	20U	20	507	20	3.0
3	88 1 24	20 54 27	21 5 46	AJ	310L	85	37U	19	389	15	5.2
4	88 1 25	11 44 25	11 55 9	AJ	210L	75	38U	21	802	25	3.4
5	88 1 25	13 50 4	13 55 49	AJ	280R	32	32U	20	268	17	3.8
6	88 1 25	18 2 23	18 3 49	AJ	360R	22	22	20	25	9	4.6
7	88 1 25	19 58 17	20 10 25	AJ	320R	65	22U	25	895	25	3.9
8	88 1 26	12 51 47	13 2 49	AJ	260R	45	27U	19	1395	25	4.3
9	88 1 26	19 11 18	19 13 15	AJ	330R	45	44	36	222	15	3.8
10	88 1 27	9 57 15	10 5 20	AJ	170L	30	23U	20	773	31	4.8
11	88 1 30	9 17 1	9 24 41	AJ	170L	33	26U	23	555	25	3.5
12	88 1 30	11 15 50	11 28 20	AJ	240R	60	23U	21	1453	25	3.5
13	88 1 30	13 25 47	13 27 20	AJ	320R	25	22	20	32	7	4.2
14	88 1 30	17 32 37	17 40 49	AJ	340R	35	28U	20	814	25	3.0
15	88 1 30	19 31 54	19 39 52	AJ	310L	70	24U	57	1197	25	3.2
16	88 2 1	9 29 31	9 37 30	AJ	200L	60	34U	37	914	31	3.6
17	88 2 1	11 33 48	11 34 38	AJ	270R	40	35	38	123	5	3.8
18	88 2 3	9 41 39	9 54 18	AJ	230R	80	27U	20	1087	25	4.8
19	88 2 4	8 48 12	8 52 27	AJ	210L	65	29	63	67	9	3.4
20	88 2 4	10 54 1	10 54 37	AJ	270R	40	34	36	79	9	2.8
21	88 2 4	17 4 11	17 14 6	AJ	330R	55	26U	30	1158	31	3.5
22	88 2 4	19 7 34	19 16 1	AJ	290L	35	28U	21	597	15	3.7
23	88 2 5	9 56 3	10 7 47	AJ	250R	50	26U	19	1299	25	3.4
24	88 2 5	16 10 57	16 11 35	AJ	340R	40	27	29	61	5	3.4
25	88 2 5	18 11 18	18 22 44	AJ	300L	60	23U	25	1120	25	3.3
26	88 2 6	15 18 27	15 22 45	AJ	350R	28	26U	26	77	9	3.2
27	88 2 11	16 51 30	16 58 5	AJ	300L	50	26U	44	724	15	3.5
28	88 2 12	9 49 16	9 52 19	AJ	310R	27	23U	20	87	15	3.1
29	88 2 12	14 0 23	14 4 53	AJ	340R	32	32	21	279	15	3.0
30	88 2 12	15 57 9	16 8 18	AJ	310L	75	28U	26	575	25	3.8
31	88 2 14	14 8 38	14 20 21	AJ	330R	50	23U	21	1004	25	3.5
32	88 2 14	16 15 42	16 16 53	AJ	290L	45	44U	43	17	5	2.4
33	88 2 22	11 5 6	11 6 52	AJ	350R	33	29	26	75	7	3.4
34	88 2 22	13 3 19	13 13 8	AJ	320L	90	38U	27	187	19	3.7
35	88 2 26	11 31 33	11 38 54	AJ	320R	65	59U	25	414	15	3.4
36	88 2 26	13 32 56	13 37 56	AJ	280L	30	28U	23	167	15	4.9
37	88 2 27	10 35 1	10 42 14	AJ	330R	45	32U	34	132	9	3.7
38	88 2 27	12 36 15	12 40 25	AJ	300L	50	29	48	35	15	4.7
39	88 7 27	18 9 47	18 15 22	AJ	360R	25	25	20	71	15	4.0
40	88 7 29	12 7 7	12 16 4	AJ	270R	35	28	21	629	15	4.4
41	88 7 31	12 22 22	12 28 6	AJ	300R	23	21U	21	350	25	3.9
42	88 7 31	18 34 54	18 46 29	AJ	330R	65	31	21	1764	25	3.1
43	88 8 1	19 43 13	19 43 55	AJ	300L	45	30U	34	38	10	3.7
44	88 8 2	18 55 56	19 0 10	AJ	310L	75	53U	21	659	25	6.0
45	88 8 4	10 53 34	10 54 53	AJ	280R	30	25U	21	51	15	3.8
46	88 8 5	16 6 43	16 13 36	AJ	350R	33	24	28	535	31	3.9
47	88 8 5	18 7 13	18 16 26	AJ	310L	70	25U	43	548	28	3.4
48	88 8 10	15 40 44	15 51 5	AJ	330R	55	35U	21	689	25	4.5
49	88 8 10	17 43 56	17 45 24	AJ	280L	35	31	34	49	7	4.5
50	88 8 16	14 19 12	14 30 50	AJ	330R	70	32U	20	757	25	9.2
51	88 8 16	16 22 4	16 29 9	AJ	280L	27	23U	21	160	17	4.5
52	88 8 17	13 32 22	13 35 2	AJ	340R	45	37U	24	339	15	3.2
53	88 8 17	15 26 27	15 36 42	AJ	300L	45	25	24	673	17	3.4
54	88 8 18	12 34 1	12 39 48	AJ	350R	30	30	21	158	15	6.5
55	88 8 18	14 31 19	14 44 17	AJ	310L	75	23U	21	985	22	3.8
56	88 8 19	13 40 49	13 50 19	AJ	320R	75	49U	21	1249	19	3.6
57	88 8 21	14 0 37	14 1 10	AJ	310L	65	42U	38	44	5	3.9
58	88 8 22	10 58 8	11 3 13	AJ	0R	23	22U	20	71	9	5.2
59	88 8 22	12 57 39	13 7 37	AJ	320R	80	27	36	1437	25	3.0
60	88 8 23	12 3 31	12 12 42	AJ	330R	55	24U	36	650	15	3.8

Table 4. Observations and data fitting (continued)

(8) No.	(9) STN	(10) TMP	(11) PRESS	(12) HUM	(13) IDT	(14) DTS	(15) DTL	(16) COMMENTS
		˚C	mb	%	ns	μs	μs	
1	7844	17.9	985.6	71	51.1	-58.6	-1.7	
2	7844	15.1	992.2	69	51.4	-58.6	-1.8	
3	7844	13.4	992.7	81	51.3	-58.6	-1.8	
4	7844	16.1	994.7	62	51.3	-58.6	-1.9	
5	7844	13.2	994.4	83	51.1	-58.6	-1.9	
6	7844	16.4	992.8	67	51.4	-58.6	-1.9	
7	7844	16.5	993.0	67	51.3	-58.6	-1.9	
8	7844	18.8	992.5	78	51.3	-58.6	-2.0	
9	7844	19.0	990.6	79	51.4	-58.6	-2.0	
10	7844	19.7	990.5	87	51.3	-58.6	-2.0	
11	7844	17.5	992.9	75	51.2	-58.6	-2.2	
12	7844	16.8	993.0	82	51.1	-58.6	-2.2	
13	7844	15.8	992.6	82	51.1	-58.6	-2.2	
14	7844	15.0	990.9	95	51.1	-58.6	-2.2	
15	7844	16.5	990.6	92	51.0	-58.6	-2.2	
16	7844	14.0	990.6	72	51.2	-58.6	-2.4	
17	7844	15.4	992.0	66	51.1	-58.6	-2.4	
18	7844	15.3	987.2	54	50.8	-58.6	-2.6	
19	7844	12.3	993.5	73	51.2	-58.6	-2.6	
20	7844	12.4	994.8	78	50.9	-58.6	-2.6	
21	7844	10.0	994.3	87	51.0	-58.6	-2.6	
22	7844	7.7	993.9	92	50.9	-58.6	-2.6	
23	7844	9.9	993.2	93	51.0	-58.6	-2.7	
24	7844	13.6	991.3	82	51.0	-58.6	-2.7	
25	7844	14.2	989.8	75	51.1	-58.6	-2.7	
26	7844	19.3	984.1	76	51.0	-58.6	-2.7	
27	7844	12.1	993.6	72	51.1	-58.6	-3.1	
28	7844	10.8	992.9	94	51.2	-58.6	-3.2	
29	7844	15.5	993.8	77	51.1	-58.6	-3.2	
30	7844	16.1	992.9	78	51.1	-58.6	-3.2	
31	7844	16.4	987.3	80	51.0	-58.6	-3.1	
32	7844	17.2	984.9	83	51.1	-58.6	-3.1	
33	7844	12.8	1002.8	67	51.0	-58.6	-2.6	
34	7844	13.8	1003.0	63	51.0	-58.6	-2.6	
35	7844	16.5	995.5	92	51.0	-58.6	-2.4	
36	7844	13.5	994.9	99	50.9	-58.6	-2.4	
37	7844	18.7	991.0	95	51.1	-58.6	-2.3	
38	7844	18.8	991.1	97	51.1	-58.6	-2.3	
39	7307	26.0	995.4	90	50.9	- 1.0	-2.8	
40	7307	27.6	995.8	82	51.0	- 1.0	-2.7	
41	7307	27.8	999.3	86	51.1	- 1.0	-2.6	
42	7307	27.0	998.8	91	51.1	- 1.0	-2.6	
43	7307	27.7	1001.7	88	50.9	- 1.0	-2.6	
44	7307	27.8	1001.5	88	51.0	- 1.0	-2.6	
45	7307	28.1	998.4	88	51.3	- 1.0	-2.5	
46	7307	26.1	998.4	95	51.0	- 1.0	-2.5	
47	7307	26.5	997.9	90	51.0	- 1.0	-2.5	
48	7307	26.2	1000.3	88	51.2	- 1.0	-2.3	
49	7307	26.4	999.5	87	51.0	- 1.0	-2.3	
50	7307	28.2	1002.0	87	51.1	- 1.0	-2.1	
51	7307	28.2	1001.9	85	50.8	- 1.0	-2.1	
52	7307	28.2	1003.3	88	51.3	- 1.0	-2.1	
53	7307	28.2	1003.3	87	51.0	- 1.0	-2.1	
54	7307	28.2	1003.4	85	51.1	- 1.0	-2.0	
55	7307	27.8	1003.6	85	51.1	- 1.0	-2.0	
56	7307	28.0	1003.3	85	51.0	- 1.0	-1.9	
57	7307	28.4	1003.2	87	51.0	- 1.0	-1.9	
58	7307	28.6	1001.8	84	51.2	- 1.0	-1.9	
59	7307	28.4	1003.0	82	51.1	- 1.0	-1.9	
60	7307	28.7	1003.0	85	50.9	- 1.0	-1.9	

Table 4. Observations and data fitting (continued)

(1) No.	(2) Obs.Time(UTC) date			caught			lost			(3) SAT.	(4)Az. ST	(5)Elev. MX	CT	LT	(6) RTN	(7)Fitting N	RMS
	Y	M	D	h	m	s	h	m	s		°	°	°	°			cm
61	88	8	24	11	9	42	11	17	24	AJ	340R	35	22U	31	474	15	4.3
62	88	8	24	13	17	34	13	23	8	AJ	310L	60	60U	22	412	15	3.6
63	88	8	25	12	17	16	12	29	35	AJ	320R	85	27U	21	1465	21	3.9
64	88	8	26	13	25	49	13	35	15	AJ	280L	33	23U	20	1321	25	3.7
65	88	8	28	11	37	42	11	49	20	AJ	320L	85	33U	21	635	21	3.9
66	88	9	2	11	10	7	11	21	34	AJ	300L	45	23U	21	1223	25	3.7

Table 4. Observations and data fitting (continued)

(8) No.	(9) STN	(10) TMP	(11) PRESS	(12) HUM	(13) IDT	(14) DTS	(15) DTL	(16) COMMENTS
		°C	mb	%	ns	μs	μs	
61	7307	28.4	1004.7	82	51.1	- 1.0	-1.9	
62	7307	28.5	1005.8	83	51.0	- 1.0	-1.9	
63	7307	27.1	1006.9	83	51.0	- 1.0	-1.9	
64	7307	27.8	1006.2	82	51.0	- 1.0	-1.9	
65	7307	27.9	1003.3	86	51.1	- 1.0	-1.9	
66	7307	26.8	999.2	86	50.9	- 1.0	-1.7	

PHOTOGRAPHIC DIRECTION OBSERVATION
OF
AJISAI AT TITI SIMA AND SIMOSATO HYDROGRAPHIC OBSERVATORY

Summary – Photographic direction observations of AJISAI by satellite cameras at Titi sima and Simosato Hydrographic Observatory (SHO) had been made in January through March 1988. 14 photographs were taken by the fixed satellite camera at SHO while 6 by the transportable one at Titi sima. Among these, the satellite direction data on 15 plates could be collated with flashing time data.

Key words: satellite camera – Ajisai – photographic direction observation

1. Observation

Photographic direction observations of AJISAI by satellite cameras at Titi sima and Simosato Hydrographic Observatory (SHO) were made in January through March 1988. The fixed satellite camera at the Simosato Hydrographic Observatory is an astronomical telescope with a plate holder controlled by a personal computer (Kanazawa, 1989). The transportable one is an astronomical telescope with a plate holder worked by hand.

The observation schedule was determined by considering the status of flashing, the elevation of the satellite, its distance from the Moon and the possibility of common view. Each plate was exposed 10 seconds and about 30 flashes of the satellite were taken as well as the image of the stars.

The timing data of flashes were obtained by the SHO Laser Ranging System as well as the Transportable Laser Ranging Station (HTLRS). These observations were performed at the same time.

2. Collation of direction data with the flash timing

The positions of images on the developed photographic plates were measured with a comparater by a contractor. The positional data of flash and star images were converted into right-ascension and declination by the Satellite Data Analysis Computer System (Nagamori, 1989). While the predictions of directions were made by means of the SAO elements provided by NASA. With the aid of these predictions, the obtained directional data were collated to the obtained timing data (Kubo, 1989). The collated data are listed in Table 1.

The data analysis was made by K. Asai and K. Kawai of Satellite Geodesy Office. This report was written by K. Kawai.

Reference

Kanazawa, T., 1989: *Data Report of Hydrographic Observations Series of Satellite Geodesy*, No. 2, p.50.

Kubo, Y., 1989: *Data Report of Hydrographic Observations Series of Satellite Geodesy*, No. 2, p.72.

Nagamori, K., 1989: *Data Report of Hydrographic Observations Series of Satellite Geodesy*, No. 2, p.59.

Table 1. Directional data of Ajisai's flash

Explanation

Column 1	Serial number		
2	Observation date		
3	Observation time (UTC)		
4	R.A. (Right-Ascension) of satellite flash		
5	Decl. (Declination) of satellite flash		
6	Station ID, 7838: Simosato Hydrographic Observatory		
	7844: Titi sima		
7	Meteorological data,	TMP	Atmospheric temperature (degree centigrade)
		HUM	Relative humidity (%)
		PRESS	Atmospheric pressure (millibars)

Table 1. Directional data of Ajisai's flash

(1) No.	(2) date			(3) time			(4) R.A.			(5) Decl.			(6) STN	(7) TMP	HUM	PRESS
	Y	M	D	h	m	s	h	m	s	d	m	s	ID	°C	%	mb
1	88	1	30	11	19	54.5005	2	37	7.854	+23	4	50.546	7844	16.8	82	993
2	88	1	30	11	19	55.6294	2	37	32.622	+23	15	12.964	7844	16.8	82	993
3	88	1	30	11	19	56.3432	2	37	49.174	+23	23	7.898	7844	16.8	82	993
4	88	1	30	11	19	56.6435	2	37	56.097	+23	26	26.603	7844	16.8	82	993
5	88	1	30	11	19	57.1495	2	38	8.156	+23	32	2.670	7844	16.8	82	993
6	88	1	30	11	19	57.8634	2	38	24.767	+23	39	57.494	7844	16.8	82	993
7	88	1	30	11	19	58.1638	2	38	31.861	+23	43	11.530	7844	16.8	82	993
8	88	1	30	11	19	58.6697	2	38	44.019	+23	48	51.123	7844	16.8	82	993
9	88	1	30	11	19	59.3835	2	39	0.814	+23	56	52.828	7844	16.8	82	993
10	88	1	30	11	19	59.6840	2	39	7.544	+24	0	12.487	7844	16.8	82	993
11	88	1	30	11	20	0.1899	2	39	19.860	+24	5	51.433	7844	16.8	82	993
12	88	1	30	11	20	0.9036	2	39	36.906	+24	13	47.872	7844	16.8	82	993
13	88	1	30	11	20	1.2041	2	39	44.015	+24	17	14.958	7844	16.8	82	993
14	88	1	30	11	20	1.7100	2	39	56.281	+24	22	52.971	7844	16.8	82	993
15	88	1	30	11	20	2.4237	2	40	13.375	+24	30	49.310	7844	16.8	82	993
16	88	1	30	11	20	2.7242	2	40	20.523	+24	34	15.212	7844	16.8	82	993
17	88	1	30	11	20	3.2300	2	40	32.638	+24	39	51.815	7844	16.8	82	993
18	88	1	30	11	20	3.9438	2	40	49.860	+24	47	53.612	7844	16.8	82	993
19	88	1	30	11	20	4.2443	2	40	57.226	+24	51	16.206	7844	16.8	82	993
20	88	1	30	11	20	4.7502	2	41	9.400	+24	57	1.151	7844	16.8	82	993
21	88	1	30	11	20	5.4640	2	41	26.919	+25	5	3.838	7844	16.8	82	993
22	88	1	30	19	37	55.5946	12	43	52.748	+14	35	21.358	7844	16.5	92	991
23	88	1	30	19	37	56.7680	12	45	1.696	+14	19	27.765	7844	16.5	92	991
24	88	1	30	19	37	57.1145	12	45	55.082	+14	7	6.812	7844	16.5	92	991
25	88	1	30	19	37	58.2880	12	46	48.168	+13	54	46.441	7844	16.5	92	991
26	88	1	30	19	37	58.6346	12	47	4.215	+13	51	6.394	7844	16.5	92	991
27	88	1	30	19	37	59.8080	12	47	57.624	+13	38	38.399	7844	16.5	92	991
28	88	1	30	19	38	0.1545	12	48	13.149	+13	35	2.814	7844	16.5	92	991
29	88	1	30	19	38	1.3280	12	48	55.914	+13	24	28.234	7844	16.5	92	991
30	88	1	30	19	38	1.6744	12	49	5.554	+13	22	38.149	7844	16.5	92	991
31	88	1	30	19	38	2.5034	12	49	37.108	+13	15	17.768	7844	16.5	92	991
32	88	1	30	19	38	2.8480	12	49	54.628	+13	11	12.275	7844	16.5	92	991
33	88	1	30	19	38	3.1944	12	50	14.446	+13	6	33.372	7844	16.5	92	991
34	88	1	30	19	38	3.5849	12	50	19.590	+13	5	22.852	7844	16.5	92	991
35	88	1	30	19	38	4.0234	12	50	29.841	+13	2	55.758	7844	16.5	92	991
36	88	1	30	19	38	4.5981	12	50	40.220	+13	0	29.544	7844	16.5	92	991
37	88	1	30	19	38	4.7144	12	50	45.615	+12	59	12.402	7844	16.5	92	991
38	88	1	30	19	38	5.1050	12	51	2.976	+12	55	9.549	7844	16.5	92	991
39	88	1	31	18	43	55.3086	14	39	27.660	+ 8	29	3.321	7838	8.9	52	1010
40	88	1	31	18	43	55.6552	14	39	37.032	+ 8	25	50.261	7838	8.9	52	1010
41	88	1	31	18	43	56.0455	14	39	47.176	+ 8	22	14.319	7838	8.9	52	1010
42	88	1	31	18	43	56.4844	14	39	58.757	+ 8	18	15.598	7838	8.9	52	1010
43	88	1	31	18	43	56.5999	14	40	1.974	+ 8	17	13.258	7838	8.9	52	1010
44	88	1	31	18	43	56.8289	14	40	7.970	+ 8	15	4.748	7838	8.9	52	1010
45	88	1	31	18	43	57.0591	14	40	14.092	+ 8	12	57.985	7838	8.9	52	1010
46	88	1	31	18	43	57.1754	14	40	17.154	+ 8	11	58.448	7838	8.9	52	1010
47	88	1	31	18	43	58.1201	14	40	42.012	+ 8	3	24.129	7838	8.9	52	1010
48	88	1	31	18	43	59.0865	14	41	7.205	+ 7	54	33.930	7838	8.9	52	1010
49	88	1	31	18	43	59.6404	14	41	21.864	+ 7	49	33.949	7838	8.9	52	1010
50	88	1	31	18	44	0.6067	14	41	46.979	+ 7	40	48.873	7838	8.9	52	1010
51	88	1	31	18	44	1.1608	14	42	1.453	+ 7	35	51.997	7838	8.9	52	1010
52	88	1	31	18	44	2.1271	14	42	26.433	+ 7	27	9.502	7838	8.9	52	1010
53	88	1	31	18	44	2.6813	14	42	40.757	+ 7	22	8.035	7838	8.9	52	1010
54	88	1	31	18	44	3.6477	14	43	6.009	+ 7	13	31.727	7838	8.9	52	1010
55	88	1	31	18	44	4.6606	14	43	31.907	+ 7	4	28.526	7838	8.9	52	1010
56	88	1	31	18	44	5.1677	14	43	44.584	+ 7	0	0.431	7838	8.9	52	1010
57	88	2	1	9	33	55.7095	5	23	49.395	+ 8	11	29.752	7844	14.0	72	991
58	88	2	1	9	33	56.0322	5	24	2.751	+ 8	14	34.797	7844	14.0	72	991
59	88	2	1	9	33	56.4473	5	24	20.000	+ 8	18	30.464	7844	14.0	72	991
60	88	2	1	9	33	57.2298	5	24	52.322	+ 8	26	5.403	7844	14.0	72	991

Table 1. Directional data of Ajisai's flash (continued)

(1) No.	(2) date			(3) time	(4) R.A.	(5) Decl.	(6) STN	(7) TMP	HUM	PRESS
	Y	M	D	h m s	h m s	d m s	ID	°C	%	mb
61	88	2	1	9 33 57.5524	5 25 5.878	+ 8 29 11.603	7844	14.0	72	991
62	88	2	1	9 33 57.9675	5 25 23.149	+ 8 33 10.378	7844	14.0	72	991
63	88	2	1	9 33 58.7501	5 25 55.650	+ 8 40 39.806	7844	14.0	72	991
64	88	2	1	9 33 59.0727	5 26 9.250	+ 8 43 47.696	7844	14.0	72	991
65	88	2	1	9 33 59.4878	5 26 26.345	+ 8 47 47.762	7844	14.0	72	991
66	88	2	1	9 34 0.2702	5 26 59.176	+ 8 55 17.957	7844	14.0	72	991
67	88	2	1	9 34 0.5929	5 27 12.729	+ 8 58 26.066	7844	14.0	72	991
68	88	2	1	9 34 1.0081	5 27 29.953	+ 9 2 23.503	7844	14.0	72	991
69	88	2	1	9 34 1.7906	5 28 2.701	+ 9 9 49.162	7844	14.0	72	991
70	88	2	1	9 34 2.1131	5 28 16.068	+ 9 12 54.099	7844	14.0	72	991
71	88	2	1	9 34 2.5284	5 28 33.609	+ 9 16 54.302	7844	14.0	72	991
72	88	2	1	9 34 3.3108	5 29 6.403	+ 9 24 20.235	7844	14.0	72	991
73	88	2	2	10 39 55.4131	3 41 9.859	+ 9 52 32.501	7838	7.8	44	996
74	88	2	2	10 39 55.8515	3 41 26.350	+ 9 56 53.815	7838	7.8	44	996
75	88	2	2	10 39 56.1962	3 41 39.094	+10 0 20.614	7838	7.8	44	996
76	88	2	2	10 39 56.4276	3 41 47.904	+10 2 36.013	7838	7.8	44	996
77	88	2	2	10 39 56.5427	3 41 52.131	+10 3 48.287	7838	7.8	44	996
78	88	2	2	10 39 57.7164	3 42 36.645	+10 15 28.184	7838	7.8	44	996
79	88	2	2	10 39 58.0629	3 42 49.637	+10 18 55.211	7838	7.8	44	996
80	88	2	2	10 39 59.2369	3 43 34.319	+10 30 39.083	7838	7.8	44	996
81	88	2	2	10 39 59.5834	3 43 47.480	+10 34 7.006	7838	7.8	44	996
82	88	2	2	10 40 1.1038	3 44 45.525	+10 49 20.864	7838	7.8	44	996
83	88	2	2	10 40 2.2773	3 45 30.713	+11 1 8.043	7838	7.8	44	996
84	88	2	2	10 40 2.6241	3 45 44.054	+11 4 37.885	7838	7.8	44	996
85	88	2	2	10 40 3.7977	3 46 29.275	+11 16 26.599	7838	7.8	44	996
86	88	2	2	10 40 4.9735	3 47 14.859	+11 28 20.341	7838	7.8	44	996
87	88	2	3	9 45 55.2411	4 12 18.910	- 6 38 55.113	7838	-0.5	48	1006
88	88	2	3	9 45 55.8687	2 45 31.690	+14 54 8.885	7844	15.3	54	987
89	88	2	3	9 45 56.0579	4 12 48.373	- 6 32 19.175	7838	-0.5	48	1006
90	88	2	3	9 45 56.1439	2 45 41.198	+14 57 17.025	7844	15.3	54	987
91	88	2	3	9 45 57.0753	4 13 25.133	- 6 24 10.082	7838	-0.5	48	1006
92	88	2	3	9 45 57.3892	2 46 24.544	+15 11 30.670	7844	15.3	54	987
93	88	2	3	9 45 57.6649	2 46 33.591	+15 14 28.989	7844	15.3	54	987
94	88	2	3	9 45 58.2821	4 14 9.192	- 6 14 23.391	7838	-0.5	48	1006
95	88	2	3	9 45 58.3322	2 46 57.744	+15 22 11.948	7844	15.3	54	987
96	88	2	3	9 45 58.5959	4 14 20.445	- 6 11 49.428	7838	-0.5	48	1006
97	88	2	3	9 45 58.9092	2 47 17.859	+15 28 48.858	7844	15.3	54	987
98	88	2	3	9 45 59.1845	2 47 27.576	+15 31 56.243	7844	15.3	54	987
99	88	2	3	9 45 59.8025	4 15 4.571	- 6 2 0.847	7838	-0.5	48	1006
100	88	2	3	9 46 0.1163	4 15 16.002	- 5 59 29.316	7838	-0.5	48	1006
101	88	2	3	9 46 0.4296	2 48 11.211	+15 46 10.711	7844	15.3	54	987
102	88	2	3	9 46 0.7045	2 48 20.892	+15 49 19.643	7844	15.3	54	987
103	88	2	3	9 46 1.3230	4 16 0.283	- 5 49 38.518	7838	-0.5	48	1006
104	88	2	3	9 46 1.9500	2 49 4.997	+16 3 36.303	7844	15.3	54	987
105	88	2	3	9 46 2.1399	4 16 30.208	- 5 42 57.903	7838	-0.5	48	1006
106	88	2	3	9 46 2.2251	2 49 14.766	+16 6 43.935	7844	15.3	54	987
107	88	2	3	9 46 2.8930	2 49 38.728	+16 14 24.002	7844	15.3	54	987
108	88	2	3	9 46 3.6604	4 17 25.883	- 5 30 35.990	7838	-0.5	48	1006
109	88	2	3	9 46 4.0218	2 50 18.843	+16 27 25.105	7844	15.3	54	987
110	88	2	3	9 46 4.2974	2 50 28.795	+16 30 34.628	7844	15.3	54	987
111	88	2	3	9 46 4.6777	4 18 3.387	- 5 22 14.009	7838	-0.5	48	1006
112	88	2	3	9 46 4.7134	2 50 43.797	+16 35 24.635	7844	15.3	54	987
113	88	2	3	11 47 55.1436	1 55 2.934	+41 48 19.558	7838	-0.6	50	1007
114	88	2	3	11 47 55.4683	1 55 9.106	+41 51 58.248	7838	-0.6	50	1007
115	88	2	3	11 47 56.6634	1 55 31.939	+42 5 3.689	7838	-0.6	50	1007
116	88	2	3	11 47 56.9883	1 55 37.948	+42 8 37.133	7838	-0.6	50	1007
117	88	2	3	11 47 57.4436	1 55 47.086	+42 13 41.663	7838	-0.6	50	1007
118	88	2	3	11 47 58.1840	1 56 1.177	+42 21 43.214	7838	-0.6	50	1007
119	88	2	3	11 47 58.5082	1 56 7.406	+42 25 16.917	7838	-0.6	50	1007
120	88	2	3	11 47 59.7038	1 56 30.701	+42 38 31.885	7838	-0.6	50	1007

Table 1. Directional data of Ajisai's flash (continued)

(1) No.	(2) date			(3) time			(4) R.A.			(5) Decl.			(6) STN	(7) TMP	HUM	PRESS
	Y	M	D	h	m	s	h	m	s	d	m	s	ID	°C	%	mb
121	88	2	3	11	48	0.4843	1	56	45.554	+42	47	2.930	7838	-0.6	50	1007
122	88	2	3	11	48	1.2241	1	56	59.992	+42	55	16.511	7838	-0.6	50	1007
123	88	2	3	11	48	1.5488	1	57	6.558	+42	58	52.195	7838	-0.6	50	1007
124	88	2	3	11	48	2.0044	1	57	15.468	+43	3	49.021	7838	-0.6	50	1007
125	88	2	3	11	48	2.7439	1	57	30.009	+43	12	2.771	7838	-0.6	50	1007
126	88	2	3	11	48	3.5244	1	57	45.586	+43	20	39.842	7838	-0.6	50	1007
127	88	2	3	11	48	4.2642	1	58	0.181	+43	28	53.067	7838	-0.6	50	1007
128	88	2	3	11	48	4.5889	1	58	6.982	+43	32	29.650	7838	-0.6	50	1007
129	88	2	3	11	48	5.0441	1	58	15.895	+43	37	33.977	7838	-0.6	50	1007
130	88	2	4	19	11	56.7723	11	20	5.357	-15	35	10.519	7844	7.7	92	994
131	88	2	4	19	11	57.6387	11	20	31.765	-15	42	3.020	7844	7.7	92	994
132	88	2	4	19	11	58.2929	11	20	51.771	-15	47	3.689	7844	7.7	92	994
133	88	2	4	19	11	59.1590	11	21	17.759	-15	53	49.404	7844	7.7	92	994
134	88	2	4	19	12	0.6793	11	22	4.002	-16	5	41.501	7844	7.7	92	994
135	88	2	4	19	12	1.3339	11	22	23.766	-16	10	49.189	7844	7.7	92	994
136	88	2	4	19	12	3.7209	11	23	36.068	-16	29	30.542	7844	7.7	92	994
137	88	2	4	19	12	4.6023	11	24	2.914	-16	36	19.123	7844	7.7	92	994
138	88	2	4	19	12	4.9576	11	24	13.692	-16	38	53.981	7844	7.7	92	994
139	88	2	4	19	12	5.2417	11	24	22.282	-16	41	13.424	7844	7.7	92	994
140	88	2	4	19	12	5.3953	11	24	26.863	-16	42	25.016	7844	7.7	92	994
141	88	2	4	19	12	5.6932	11	24	36.052	-16	44	40.145	7844	7.7	92	994
142	88	2	5	10	1	56.5321	2	28	23.876	+59	34	41.054	7844	9.9	93	993
143	88	2	5	10	1	58.0520	2	29	44.008	+59	51	18.481	7844	9.9	93	993
144	88	2	5	10	1	59.5718	2	31	5.024	+60	7	48.644	7844	9.9	93	993
145	88	2	5	10	2	1.0919	2	32	27.921	+60	24	19.871	7844	9.9	93	993
146	88	2	5	10	2	2.6118	2	33	51.636	+60	40	41.283	7844	9.9	93	993
147	88	2	5	10	2	4.1317	2	35	17.123	+60	57	3.831	7844	9.9	93	993
148	88	2	5	10	2	5.6517	2	36	43.298	+61	13	19.253	7844	9.9	93	993
149	88	2	6	11	9	55.7581	2	25	24.094	+69	50	49.507	7838	6.8	40	996
150	88	2	6	11	9	56.0918	2	25	45.374	+69	54	24.973	7838	6.8	40	996
151	88	2	6	11	9	56.4951	2	26	12.128	+69	58	44.414	7838	6.8	40	996
152	88	2	6	11	9	57.2910	2	27	4.127	+70	7	24.298	7838	6.8	40	996
153	88	2	6	11	9	57.6118	2	27	25.767	+70	10	54.282	7838	6.8	40	996
154	88	2	6	11	9	58.0149	2	27	52.655	+70	15	18.526	7838	6.8	40	996
155	88	2	6	11	9	58.8112	2	28	45.800	+70	23	50.223	7838	6.8	40	996
156	88	2	6	11	9	59.1314	2	29	8.684	+70	27	21.590	7838	6.8	40	996
157	88	2	6	11	9	59.5341	2	29	35.629	+70	31	40.030	7838	6.8	40	996
158	88	2	6	11	10	0.3311	2	30	30.584	+70	40	12.479	7838	6.8	40	996
159	88	2	6	11	10	0.6511	2	30	52.873	+70	43	42.891	7838	6.8	40	996
160	88	2	6	11	10	2.5750	2	33	9.580	+71	4	13.564	7838	6.8	40	996
161	88	2	6	11	10	4.0948	2	35	0.629	+71	20	24.407	7838	6.8	40	996
162	88	2	7 ~~6~~	10	15	55.4753	3	44	58.352	+61	49	32.180	7838	1.3	50	1006
163	88	2	7 ~~6~~	10	15	56.9952	3	47	13.664	+62	3	18.187	7838	1.3	50	1006
164	88	2	7 ~~6~~	10	15	57.6899	3	48	16.591	+62	9	32.707	7838	1.3	50	1006
165	88	2	7 ~~6~~	10	15	58.5153	3	49	31.171	+62	16	57.491	7838	1.3	50	1006
166	88	2	7 ~~6~~	10	15	59.2102	3	50	34.143	+62	23	8.327	7838	1.3	50	1006
167	88	2	7 ~~6~~	10	16	0.0353	3	51	49.193	+62	30	28.031	7838	1.3	50	1006
168	88	2	7 ~~6~~	10	16	0.7303	3	52	54.301	+62	36	29.002	7838	1.3	50	1006
169	88	2	7 ~~6~~	10	16	1.5552	3	54	10.877	+62	43	39.169	7838	1.3	50	1006
170	88	2	7 ~~6~~	10	16	2.2499	3	55	15.882	+62	49	44.674	7838	1.3	50	1006
171	88	2	7 ~~6~~	10	16	3.0756	3	56	33.592	+62	56	46.669	7838	1.3	50	1006
172	88	2	7 ~~6~~	10	16	3.7702	3	57	39.324	+63	2	41.573	7838	1.3	50	1006
173	88	2	7 ~~6~~	10	16	4.5958	3	58	58.203	+63	9	42.132	7838	1.3	50	1006
174	88	2	12	9	49	55.5684	1	22	33.830	+78	38	1.536	7838	7.2	46	1012
175	88	2	12	9	49	55.8290	1	23	0.732	+78	40	35.260	7838	7.2	46	1012
176	88	2	12	9	49	56.0782	1	23	28.209	+78	43	6.817	7838	7.2	46	1012
177	88	2	12	9	49	56.6848	1	24	33.090	+78	49	9.359	7838	7.2	46	1012
178	88	2	12	9	49	57.0907	1	25	17.030	+78	53	11.437	7838	7.2	46	1012
179	88	2	12	9	49	58.6116	1	28	6.572	+79	8	15.503	7838	7.2	46	1012
180	88	2	12	9	49	59.1189	1	29	4.920	+79	13	12.351	7838	7.2	46	1012

Table 1. Directional data of Ajisai's flash (continued)

(1) No.	(2) date Y M D	(3) time h m s	(4) R.A. h m s	(5) Decl. d m s	(6) STN ID	(7) TMP °C	HUM %	PRESS mb
181	88 2 12	9 49 59.7258	1 30 16.891	+79 19 11.241	7838	7.2	46	1012
182	88 2 12	9 50 0.1326	1 31 3.850	+79 23 8.355	7838	7.2	46	1012
183	88 2 12	9 50 0.6393	1 32 5.868	+79 28 6.551	7838	7.2	46	1012
184	88 2 12	9 50 1.2484	1 33 20.247	+79 34 0.943	7838	7.2	46	1012
185	88 2 12	9 50 1.6531	1 34 10.290	+79 37 58.671	7838	7.2	46	1012
186	88 2 12	9 50 2.1603	1 35 12.950	+79 42 52.659	7838	7.2	46	1012
187	88 2 12	9 50 2.7673	1 36 31.282	+79 48 44.544	7838	7.2	46	1012
188	88 2 12	9 50 3.1718	1 37 23.241	+79 52 38.457	7838	7.2	46	1012
189	88 2 12	9 50 3.6812	1 38 31.120	+79 57 31.676	7838	7.2	46	1012
190	88 2 12	9 50 4.2877	1 39 51.823	+80 3 17.789	7838	7.2	46	1012
191	88 2 22	11 1 56.1219	10 53 40.108	+72 1 44.671	7838	7.5	81	1022
192	88 2 22	11 1 56.7113	10 53 50.338	+71 55 21.499	7838	7.5	81	1022
193	88 2 22	11 1 57.3184	10 53 59.712	+71 48 48.925	7838	7.5	81	1022
194	88 2 22	11 1 57.6433	10 54 5.234	+71 45 17.498	7838	7.5	81	1022
195	88 2 22	11 1 59.1653	10 54 29.331	+71 28 50.505	7838	7.5	81	1022
196	88 2 22	11 1 59.7558	10 54 38.794	+71 22 31.049	7838	7.5	81	1022
197	88 2 22	11 2 0.3619	10 54 48.147	+71 15 55.374	7838	7.5	81	1022
198	88 2 22	11 2 0.4962	10 54 50.422	+71 14 29.840	7838	7.5	81	1022
199	88 2 22	11 2 0.6864	10 54 53.558	+71 12 22.276	7838	7.5	81	1022
200	88 2 22	11 2 1.1013	10 55 0.036	+71 7 58.580	7838	7.5	81	1022
201	88 2 22	11 2 1.2772	10 55 2.465	+71 6 4.657	7838	7.5	81	1022
202	88 2 22	11 2 1.6081	10 55 7.715	+71 2 31.606	7838	7.5	81	1022
203	88 2 22	11 2 2.0192	10 55 13.917	+70 58 0.113	7838	7.5	81	1022
204	88 2 22	11 2 2.6234	10 55 23.193	+70 51 31.442	7838	7.5	81	1022
205	88 2 22	11 2 3.1298	10 55 30.661	+70 45 59.059	7838	7.5	81	1022
206	88 2 22	11 2 3.5413	10 55 37.062	+70 41 34.908	7838	7.5	81	1022
207	88 2 22	11 2 4.1435	10 55 46.164	+70 35 1.886	7838	7.5	81	1022
208	88 2 22	11 2 4.6519	10 55 53.596	+70 29 32.097	7838	7.5	81	1022
209	88 2 22	11 2 5.0623	10 55 59.846	+70 25 11.225	7838	7.5	81	1022
210	88 2 24	11 15 55.5799	9 5 21.054	+65 16 53.635	7838	8.3	65	1015
211	88 2 24	11 15 57.1017	9 6 53.835	+64 59 55.994	7838	8.3	65	1015
212	88 2 24	11 15 58.6239	9 8 25.165	+64 42 58.324	7838	8.3	65	1015
213	88 2 24	11 15 59.3745	9 9 10.090	+64 34 34.632	7838	8.3	65	1015
214	88 2 24	11 16 0.1456	9 9 55.996	+64 25 53.035	7838	8.3	65	1015
215	88 2 24	11 16 1.6674	9 11 23.142	+64 8 50.323	7838	8.3	65	1015
216	88 2 24	11 16 2.9718	9 12 36.920	+63 54 10.997	7838	8.3	65	1015
217	88 2 24	11 16 3.1889	9 12 49.548	+63 51 37.542	7838	8.3	65	1015
218	88 2 24	11 16 3.9398	9 13 31.580	+63 43 6.919	7838	8.3	65	1015
219	88 2 24	11 16 4.4926	9 14 2.623	+63 36 47.508	7838	8.3	65	1015
220	88 2 24	11 16 4.7118	9 14 14.050	+63 34 26.488	7838	8.3	65	1015
221	88 2 24	11 16 5.0509	9 14 32.433	+63 30 37.698	7838	8.3	65	1015

COLLOCATION OBSERVATION BETWEEN TWO SLR STATIONS AT THE SIMOSATO HYDROGRAPHIC OBSERVATORY IN 1988

Summary – The collocation observations of a fixed type (SHOLAS) and a transportable (HTLRS) satellite laser ranging systems were made at the Simosato Hydrographic Observatory in May and November 1988. 20 Ajisai passes and 6 Lageos passes were obtained. Analyzing these data, it is shown that the range data obtained by SHOLAS were shorter than those by HTLRS by 0.7 cm in May 1988 and were longer by 2.3 cm in November 1988.

Key words: SHOLAS – HTLRS – collocation observation

1. Observation

The Simosato Hydrographic Observatory (SHO) has observed geodetic satellites with a fixed type satellite laser ranging system named SHOLAS (Simosato Hydrographic Observatory Laser Ranging Station) since 1982 (Sasaki et al., 1983). SHO has played an important roll in the worldwide network of SLR since Simosato is the only one station in Asia constantly releasing SLR observation data.

A transportable laser ranging system named HTLRS (Hydrographic Department Transportable Laser Ranging Station) was completed in 1987 (Sasaki, 1988). This system has been used for the precise determination of the position of Japanese off-lying islands since 1988.

These two systems are collocated at SHO twice a year in order to check their systematic errors. The first collocation observation was made in December, 1987. It was shown from the analysis of this observation (Sengoku, 1988) that the systematic difference of range data of two systems was 1.1 cm. The range data obtained by SHOLAS was longer than those by HTLRS.

In 1988, the collocation observations were made SHO twice. The one was from May 23rd to May 30th when 7 Ajisai passes and 1 Lageos pass were observed. The other was from November 8th to November 20th when 13 Ajisai passes and 5 Lageos passes were obtained. Observed passes are shown in Tables 1 and 2. The sky coverage maps are shown in Figures 1 and 2.

Table 1. Observed passes observation in May 1988

No.	Time (UTC)	SHOLAS (return)	HTLRS (return)	Satellite
	h m h m			
1	1988 May 23 10 55 – 11 08	516	1294	Ajisai
2	23 12 57 – 13 10	893	566	Ajisai
3	26 12 17 – 12 30	1168	640	Ajisai
4	28 10 28 – 10 42	1095	1377	Ajisai
5	28 12 32 – 12 41	577	549	Ajisai
6	28 17 01 – 17 50	1047	775	Lageos
7	29 11 37 – 11 49	87	645	Ajisai
8	30 10 42 – 10 56	425	87	Ajisai
total		5808	5933	
		11741		

Table 2. Observed passes in November 1988

No.	Time (UTC)	SHOLAS (return)	HTLRS (return)	Satellite
	h m h m			
1	1988 Nov. 8 12 28 – 12 39	91	831	Ajisai
2	8 14 29 – 14 43	1354	450	Ajisai
3	9 9 29 – 10 01	714	932	Ajisai
4	10 9 15 – 9 54	987	1208	Lageos
5	10 12 41 – 12 54	1192	952	Ajisai
6	10 14 43 – 14 56	1408	1293	Ajisai
7	11 11 48 – 11 59	1047	1102	Ajisai
8	11 13 49 – 14 03	1581	1020	Ajisai
9	13 8 41 – 9 26	1335	1337	Lageos
10	13 12 14 – 12 56	1019	425	Lageos
11	13 14 03 – 14 16	1165	1111	Ajisai
12	14 11 07 – 11 19	784	301	Ajisai
13	14 13 09 – 13 22	1375	550	Ajisai
14	15 12 15 – 12 28	544	592	Ajisai
15	18 12 28 – 13 07	946	1815	Lageos
16	20 9 46 – 9 58	1123	1411	Ajisai
17	20 11 48 – 12 01	1111	1047	Ajisai
18	20 13 17 – 13 50	86	971	Lageos
total		18495	18373	
		36868		

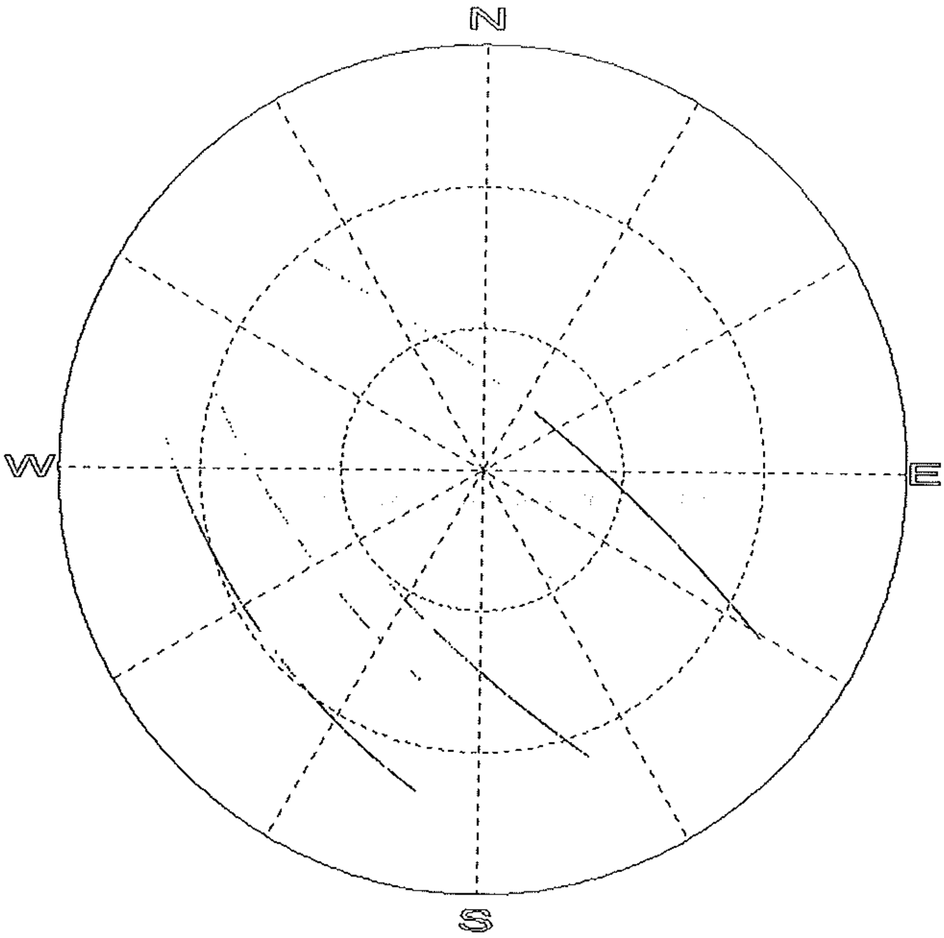


Figure 1. Sky coverage (May, 1988).

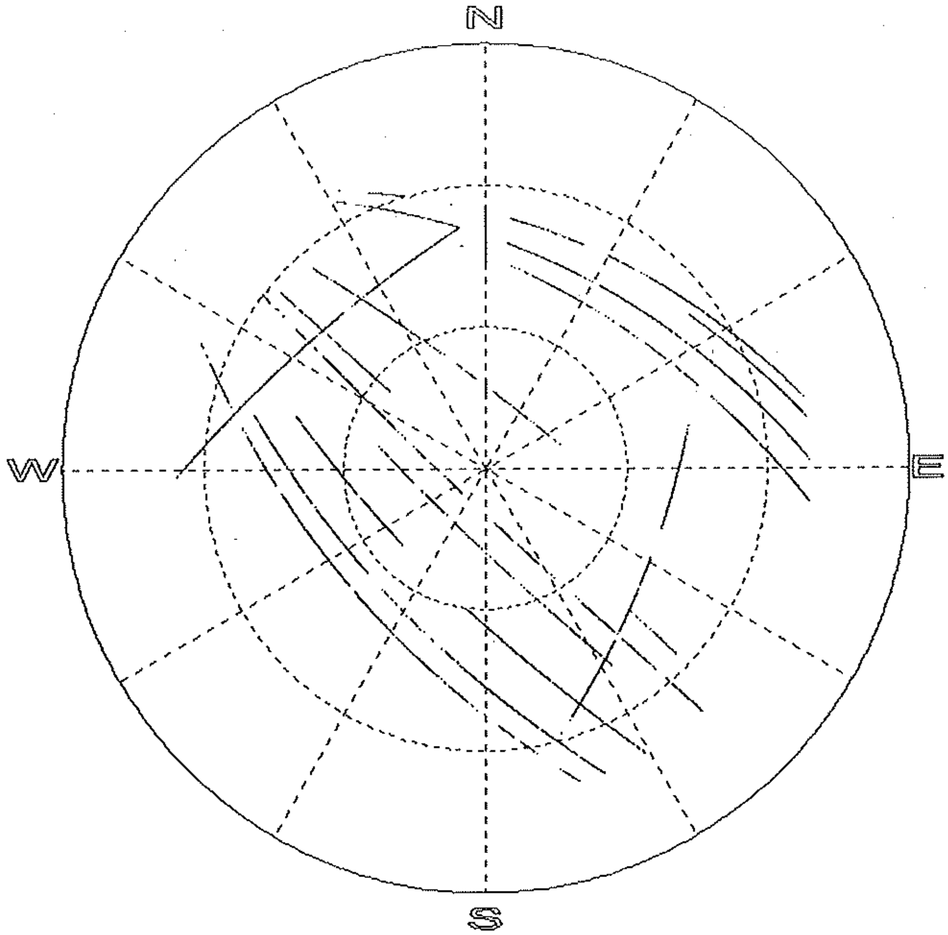


Figure 2. Sky coverage (November, 1988).

2. Survey

HTLRS was put on the concrete base. In May, 1988, the relative position of the center of rotation of HTLRS (TL02: May, 1988) to the reference plate (TL) on the concrete base was measured optically. The relative position between two centers of rotation of SHOLAS and HTLRS were calculated using the results of T. Takemura (1983) and A. Sengoku et al. (1988).

In November, 1988, reference points SHO were surveyed by A. Sengoku, M. Nagaoka and K. Kawai (Figure 3). Their geodetic positions are shown in Table 3. The relative position of the center of rotation of HTLRS (TL03: November, 1988) to the center of rotation of SHOLAS (L) was surveyed at the same time. Survey chart is shown in Figure 3.

The relative rectangular coordinates of the center of rotation of HTLRS to that of SHOLAS were determined in the equator and Greenwich based system as follows.

$$dx = -13.915\ (m)$$
$$dy = 11.707\ (m) \qquad \text{(May, 1988)}$$
$$dz = -32.603\ (m)$$

$$dx = -13.911\ (m)$$
$$dy = 11.711\ (m) \qquad \text{(November, 1988)}$$
$$dz = -32.603\ (m)$$

The distance between two centers of rotation is 37.331 (m) in May and is 37.331 (m) in November.

In the local horizontal coordinates, the relative position of HTLRS to SHOLAS was obtained as follows.

$$dX = 1.264\ (m)\ \text{eastward}$$
$$dY = -37.200\ (m)\ \text{northward} \qquad \text{(May, 1988)}$$
$$dZ = -2.917\ (m)\ \text{upward}$$

$$dX = 1.259\ (m)\ \text{eastward}$$
$$dY = -37.200\ (m)\ \text{northward} \qquad \text{(November, 1988)}$$
$$dZ = -2.916\ (m)\ \text{upward}$$

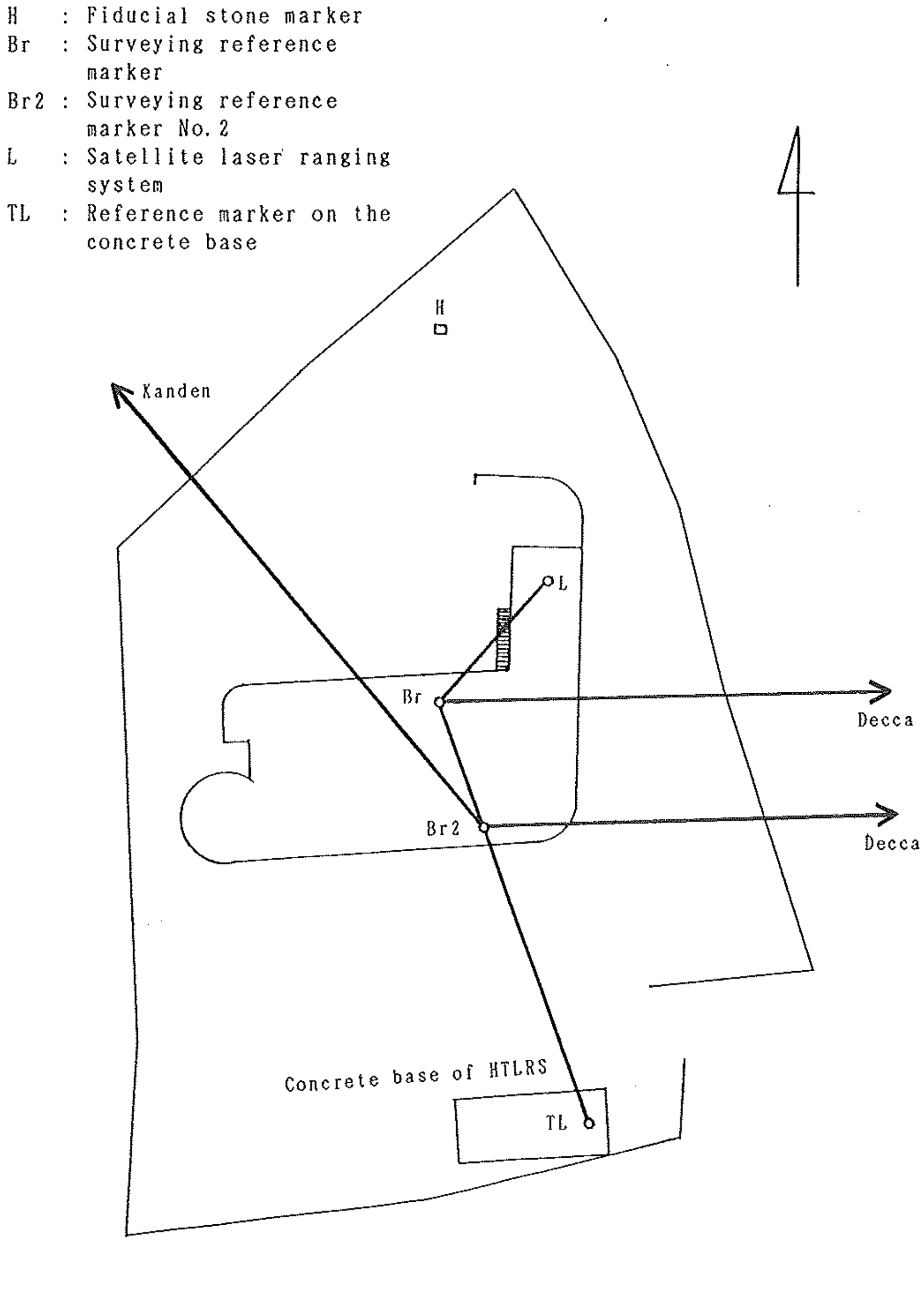


Figure 3. Survey chart of Simosato Hydrographic Observatory.

3. Geometrical analysis

3.1 Principle of geometrical analysis of collocation observation

The difference of two sets of range data obtained by SHOLAS and HTLRS respectively should be equal to the geometrical path difference if the range observations are made by two systems simultaneously. The difference (D) between the geometrical path difference (dr) and the raw range difference ($|r_1| - |r_2|$), which stands for systematic error of range observation data, is expressed as follows (Sengoku, 1989).

$$D = dr - (|\vec{r}_1| - |\vec{r}_2|)$$

$$= \vec{r}_2 \cdot \vec{d}/|\vec{r}_2| - (|\vec{r}_1| - |\vec{r}_2|) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where $\vec{d} = \vec{r}_1 - \vec{r}_2$. If D is positive, a range observed by system 2 is longer than that by system 1.

First, raw range data obtained by the one system were smoothed by a polinomial fitting. Next by using the fitted polinomial, smoothed data were produced to make pairs with the corresponding observation obtained by the other in equation (1). For a precise estimation of the geometrical path difference, it is necessary to determine orbits of satellites by a certain dynamical procedure. Detailed description of the geometrical analysis is seen in the previous report (Sengoku, 1989).

3.2 Determination of orbits

The precise orbits of satellites were determined dynamically by a reduction program developed at Hydrographic Department (Sasaki, 1984) using the range data obtained by SHOLAS and HTLRS. Observation of two passes were used to determine the orbits. GEM-T1 (degree and order up to 36) was used for Earth's gravity model. The polar motion determined by IRIS (IERS bulletin A) was also used. Since the orbit was determined using data obtained by only SHOLAS and HTLRS, which were placed about 40 m apart, the determined orbit was not accurate so globally. But it was sufficient for our analysis. In order to determine D at precision of 1 mm, the accuracy of satellite position is required to be less than 40 m through the observation. It is possible to achieve such accuracy in orbits by the local analysis we did here. Tables 4 and 5 show the obtained residuals for each pass. Several passes were omitted since their orbits were not precise enough. Typical noise level of raw range is about 10 cm for SHOLAS and 4 cm for HTLRS, respectively. Therefore, residuals are expected to be 4 ~ 10 cm. In most cases, residuals were within this range.

Thus, the topocentric positions of satellites were calculated with enough accuracy at each observation epoch.

Table 3. Relative positions among reference points (Tōkyō Datum)

Symbol	Latitude	Longitude	Height
Br2 – Br	−0″.2723	+0″.1899	+0.036 m
L – Br	+0.2572	+0.2971	+1.114
TL – Br	−0.9434	+0.4154	−3.740
TL02 – Br	−0.9501	+0.3460	−1.804
TL03 – Br	−0.9502	+0.3459	−1.802
K – Br	+32.0635	−39.2401	+43.696
D – Br	+8.5170	+55.3550	−3.252

Table 4. Dynamical determination of the orbits in May 1988

No.	Used pass No.*	Satellite	Number of data	Residual
a	1, 2	Ajisai	3269	5.5 cm
b	5, 4	Ajisai	3598	5.1
c	5, 7	Ajisai	1858	4.8

*see Table 1

Table 5. Dynamical determination of the orbits in November 1988

No.	Used pass No.*	Satellite	Number of data	Residual
a	1, 2	Ajisai	2726	5.9 cm
b	5, 6	Ajisai	4845	5.8
c	7, 8	Ajisai	4750	6.3
d	12, 13	Ajisai	3010	6.7
e	16, 17	Ajisai	4692	5.8
f	9, 10	Lageos	4116	5.8
g	11, 12	Ajisai	3361	6.0
h	13, 14	Ajisai	3061	6.3
i	15, 18	Lageos	3818	4.7

*see Table 2

3.3 Estimation of D

First, smoothed data for SHOLAS were paired with the corresponding one for HTLRS by means of polynomial fitting. Then, D was estimated by equation (1). The applied orders of polynomials, the mean of D ($\bar{D}$) and the other results are shown for each pass in Tables 6 and 7. Data residuals larger than 15 cm were omitted.

The average of $\bar{D}$ was 0.7 cm in May and –2.3 cm in November, respectively. Roughly speaking, this means that range data obtained by SHOLAS were 0.7 cm shorter than those obtained by HTLRS in May and 2.3 cm longer in November. We cannot conclude whichever SHOLAS and/or HTLRS caused this difference. The average of $\bar{D}$ is 0.7 cm for Ajisai in May, –2.1 cm for Ajisai and –3.3 cm for Lageos in November. The average of $\bar{D}$ for Ajisai does not differ from that for Lageos significantly.

The relations among D, and the elevation and azimuth of satellites are plotted in Figures 4 through 7. It is clear that $\bar{D}$ was not dependent on the elevation in 1988. But $\bar{D}$ seems to have varied slightly as the azimuth change.

Collocation observations were made by T. Kanazawa, A. Sengoku, K. Fuchida, M. Nagaoka, K. Kawai and T. Fujii. The reduction of survey was made by K. Kawai and was checked by T. Takemura. The analysis of collocation observation was made by T. Fujii and A. Sengoku. This report was written by A. Sengoku and T. Fujii.

References

Sasaki, M., Ganeko, Y., Harada, Y. 1983: *Data Report of Hydrogr. Obs., Series of Astronomy and Geodesy*, No. 17, p.49.

Sasaki, M. 1984: *Report of Hydrogr. Researches*, No. 19, p.107.

Sasaki, M. 1987: *Data Report of Hydrogr. Obs., Series of Satellite Geodesy*, No. 1, p.59.

Sengoku, A. 1989: *Data Report of Hydrogr. Obs., Series of Satellite Geodesy*, No. 2, p.28.

Table 6. Results of the geometrical analysis of collocation observation in May 1988

No.	Time (UTC)	SHOLAS (returns)	HTLRS (returns)	Satellite	Polynomial order	$\bar{D}$	r.m.s.	Used orbit*
	h m h m					cm	cm	
1	1988 May 23 13 04 – 13 10	526	540	Ajisai	12	−1.7	3.8	a
2	28 10 31 – 10 42	975	1,277	Ajisai	20	1.4	3.7	b
3	28 12 32 – 12 41	517	549	Ajisai	18	1.7	4.1	b
4	28 12 32 – 12 41	513	531	Ajisai	14	1.9	4.0	c
5	29 11 37 – 11 48	643	72	Ajisai	18	0.1	7.4	c
					average	0.7	4.6	

*see Table 5

Table 7. Results of the geometrical analysis of collocation observation in November 1988

No.	Time (UTC)	SHOLAS (returns)	HTLRS (returns)	Satellite	Polynomial order	$\bar{D}$	r.m.s.	Used orbit*
	h m h m					cm	cm	
1A	1988 Nov. 8 14 32 – 14 35	493	250	Ajisai	8	−2.0	4.9	a
1B	8 14 40 – 14 41	129	97	Ajisai	5	−2.1	4.7	a
2	10 12 42 – 12 54	1,031	952	Ajisai	20	−2.6	4.1	b
3	10 14 44 – 14 56	1,223	1,293	Ajisai	22	−4.0	3.6	b
4	11 11 48 – 11 59	863	1,102	Ajisai	17	−3.1	3.8	c
5	11 13 49 – 13 03	1,374	1,018	Ajisai	27	−3.8	4.3	c
6	13 08 57 – 09 26	852	1,314	Lageos	12	−1.9	3.8	f
7	13 14 04 – 14 16	1,020	1,111	Ajisai	23	−1.6	4.2	g
8	14 11 15 – 11 19	333	301	Ajisai	8	−4.7	4.2	d
9	14 13 15 – 13 20	687	521	Ajisai	12	−0.1	3.7	d
10	14 13 14 – 13 20	697	534	Ajisai	13	−0.1	3.7	h
11	15 12 17 – 12 22	371	497	Ajisai	13	−2.9	4.8	h
12	18 12 37 – 13 08	759	1,525	Lageos	13	−4.6	3.7	i
13	20 09 47 – 09 59	993	1,411	Ajisai	18	0.8	3.8	e
14	20 11 56 – 12 02	387	654	Ajisai	10	−0.8	3.6	e
					average	−2.3	4.1	

*see Table 6

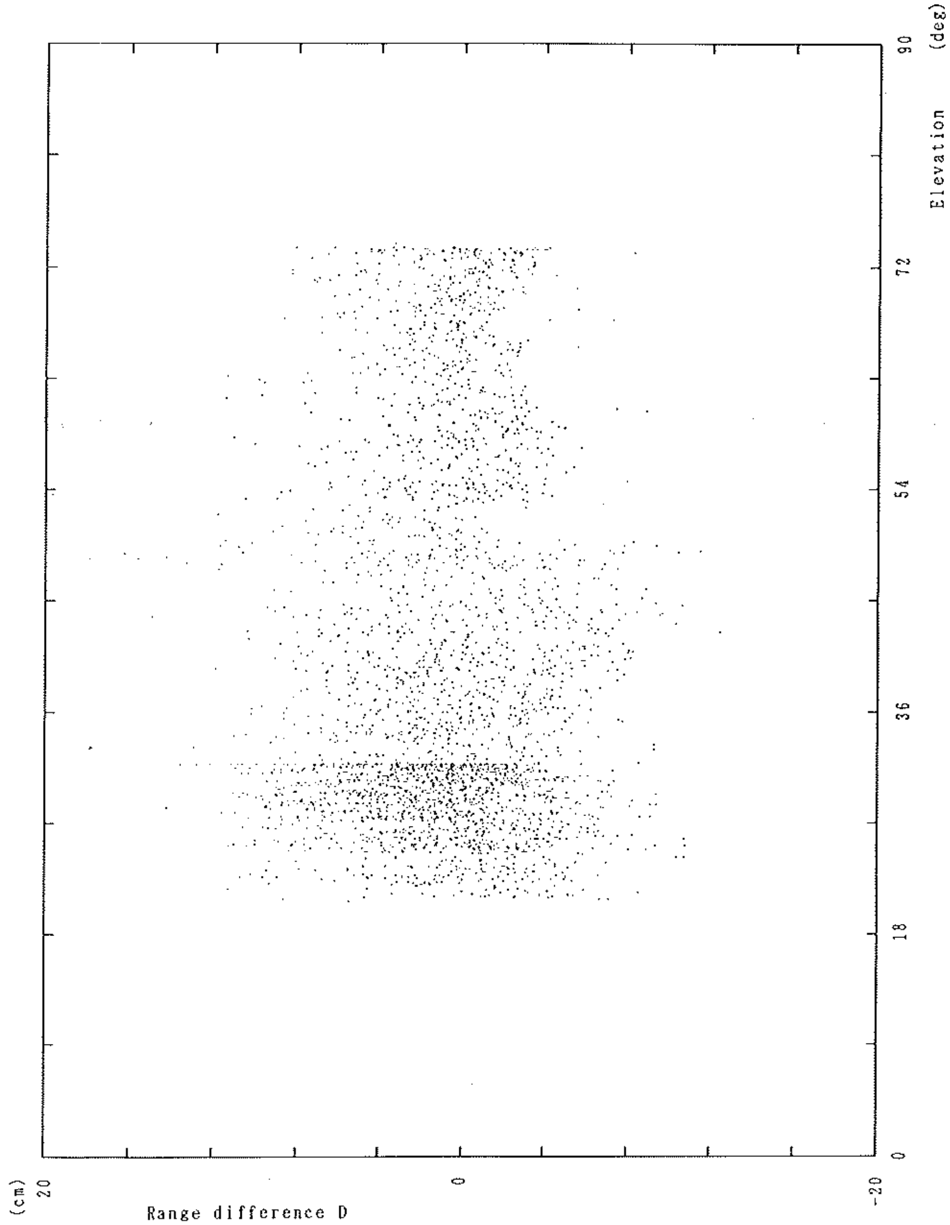


Figure 4. Elevation dependence of D (May, 1988).

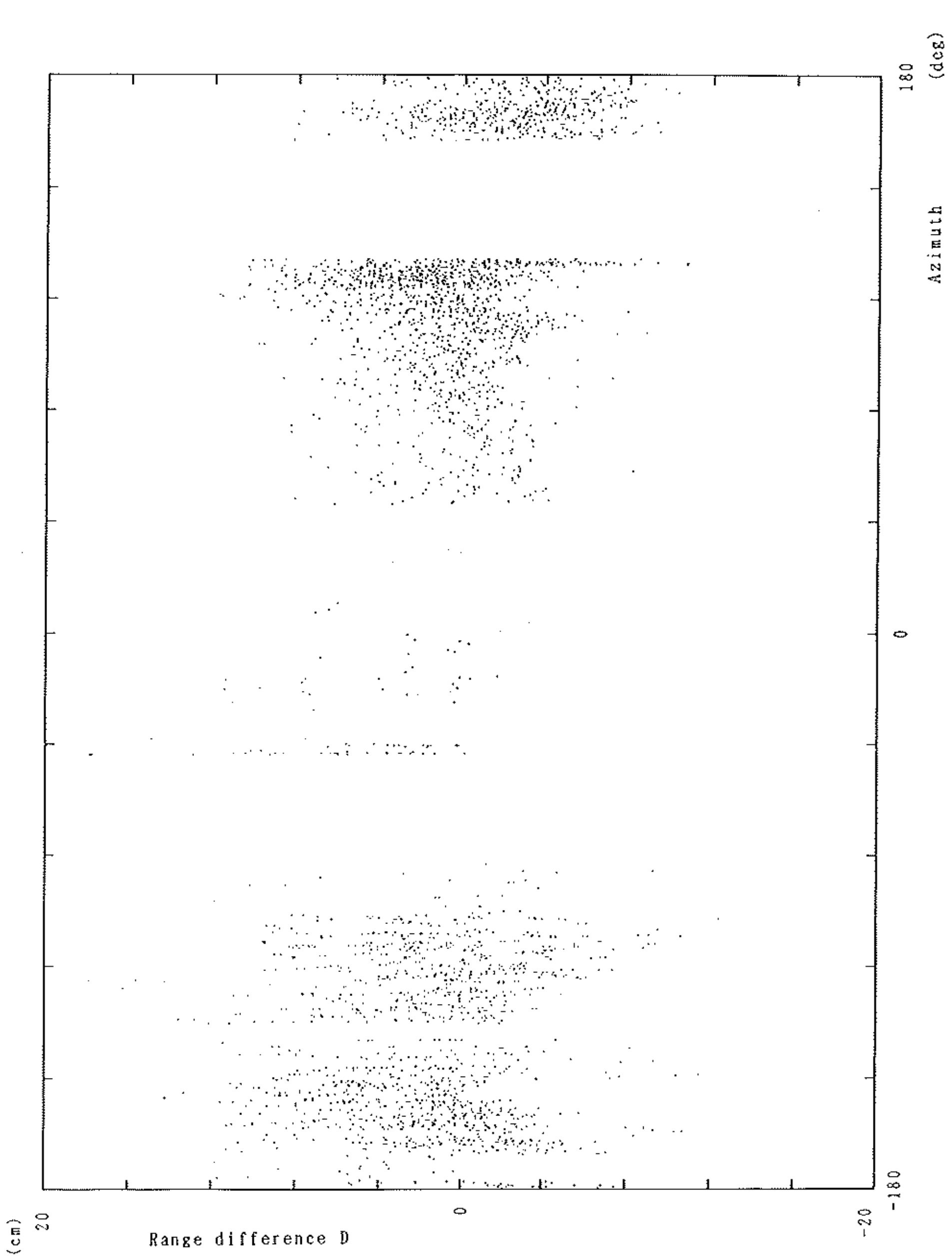


Figure 5. Azimuth dependence of D (May, 1988).

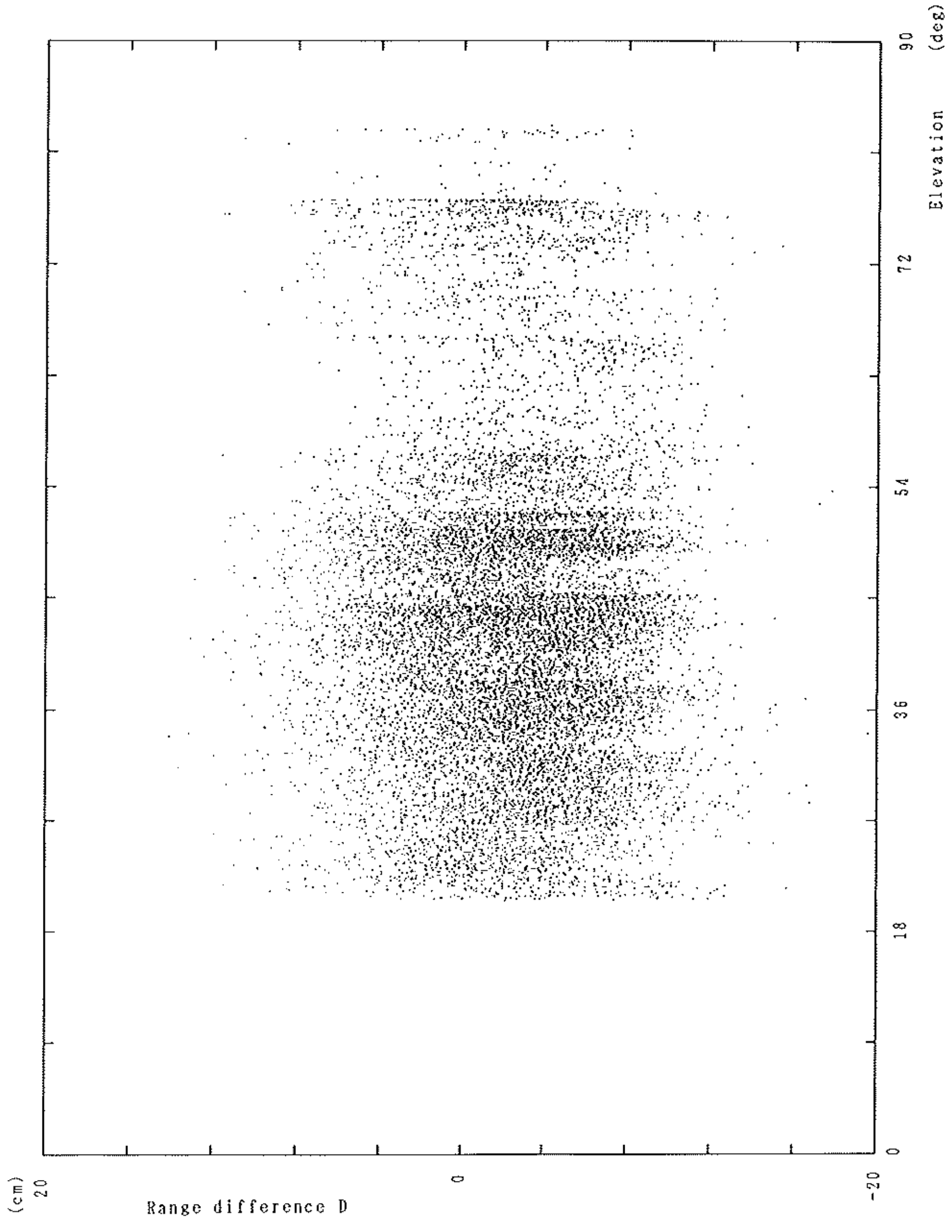


Figure 6. Elevation dependence of D (November, 1988).

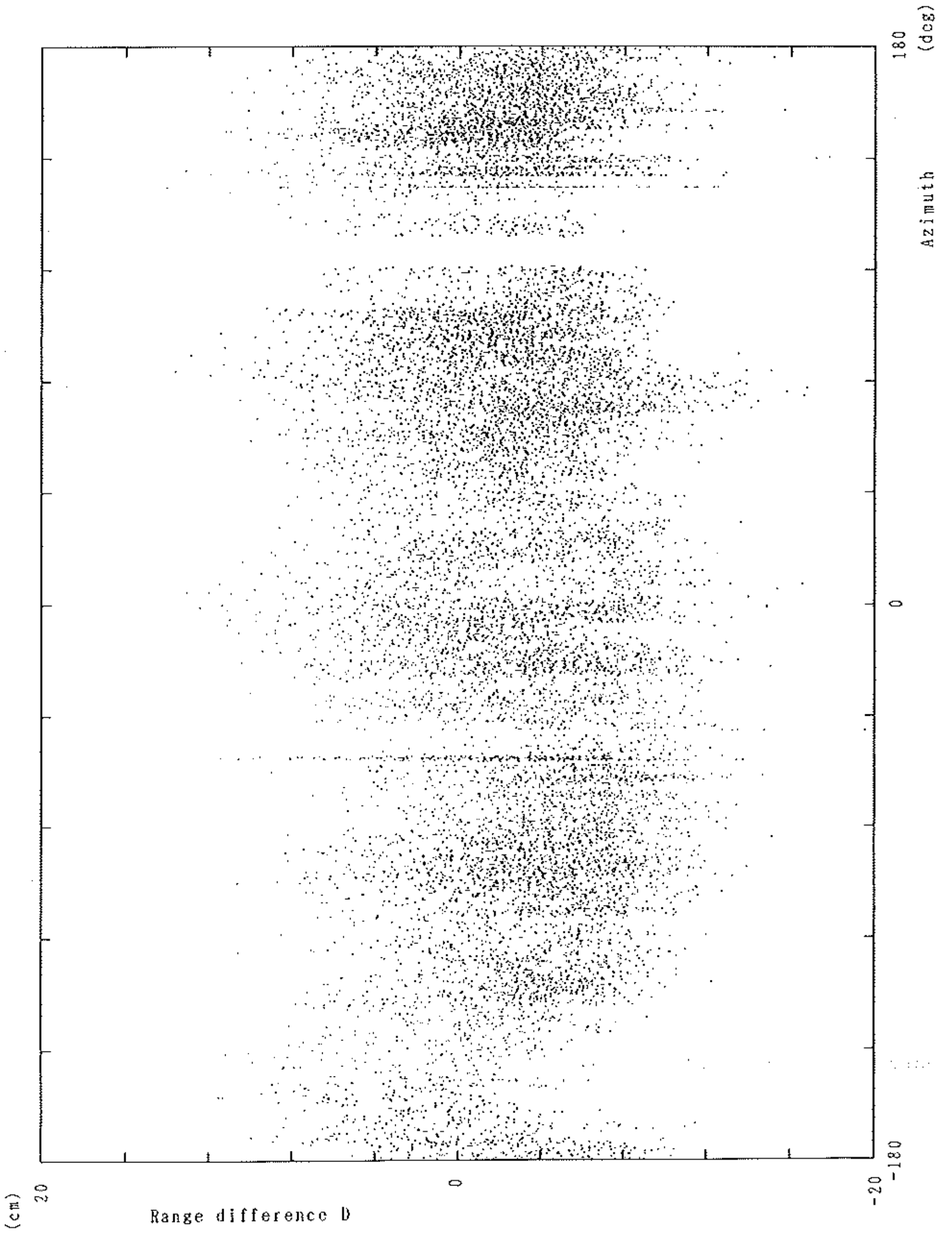


Figure 7. Azimuth dependence of D (November, 1988).

ORBITAL PREDICTION OF AJISAI IN 1988

Summary – The orbital prediction of Ajisai has been made by the orbital prediction system of the Satellite Geodesy Office. The resulting elements were sent to laser ranging observatories.

Key words: orbital prediction – Ajisai

1. Orbital prediction system

An orbital prediction system for artificial satellites was developed in the Satellite Geodesy Office (SGO) in 1986 (Sengoku, 1988). This system produces orbital elements of artificial satellites from the laser ranging data by a program named SOAP III, the Satellite Orbit Analyzer Predictor ver. III, written in a special language developed by Fukushima (1986). In SOAP III, we estimate the JHD elements by the method of least squares. The JHD elements consist of 9 parameters as follows,

n : mean motion
ξ_0 : $(e\cos\omega)_0$
η_0 : $(e\sin\omega)_0$
i : inclination
Ω : longitude of ascending node
χ_0 : $l_0 + \omega_0$
$d\omega/dt$
$d\Omega/dt$
$d(e\sin\omega)_0$

where e is the eccentricity, l is the mean anomaly and ω is the argument of perigee. The subscript 0 means the values at the epoch. The JHD elements are well-defined parameter set for a nearly circular orbit such as that of Ajisai.

The accuracy of the JHD elements created by SOAP III is checked by a rough estimation by means of an independent program.

2. Summary of quick look data of Ajisai

Quick look laser range data are sent to SGO from the Simosato Hydrographic Observatory and the Goddard Laser Tracking Network once a week via an E-mail system named G.E. Mark III. We usually produce the JHD elements from the received quick look data in the latest two or three weeks. Table 1 is the monthly statistics of the quick look data sent to our office in 1988. In total, 1348 passes and 33027 returns at 9 stations were sent to our office in 1988.

Table 1. Monthly statistics of quick look data of Ajisai

1988. Jan.			1988. Feb.			1988. Mar.		
ID	Pass	Return	ID	Pass	Return	ID	Pass	Return
1181	3	54	1181	4	92	7801	3	223
7801	12	300	7801	11	275	7838	12	526
7838	46	968	7838	64	1022	7840	13	437
7840	20	258	7840	29	465	8405	34	1866
8405	7	174	8405	17	443	8502	8	350
8502	9	225	8502	11	275	8704	8	448
8605	15	373	8605	11	270	8805	15	796
8704	1	12	8704	8	200			
8805	5	128	8805	29	710			

1988. Apr.			1988. May			1988. Jun.		
ID	Pass	Return	ID	Pass	Return	ID	Pass	Return
1181	7	186	1181	7	117	7801	10	251
7801	10	250	7801	12	300	7838	7	112
7838	7	112	7838	21	339	7840	11	128
7840	27	437	7840	30	377	8405	10	248
8405	18	447	8405	7	178	8502	15	375
8605	1	25	8502	1	24	8704	18	448
8704	17	425	8704	2	50	8805	16	397
8805	12	303	8805	8	197			

1988. Jul.			1988. Aug.			1988. Sep.		
ID	Pass	Return	ID	Pass	Return	ID	Pass	Return
1181	8	171	1181	5	111	7801	3	150
1307	6	160	7801	12	299	7838	12	394
7801	14	348	7838	20	327	7840	8	322
7838	13	208	7840	33	390	8405	5	268
7840	25	340	8405	8	185	8605	6	300
8405	38	948	8502	6	148	8704	1	50
8502	6	148	8605	2	50	8805	6	282
8704	13	322	8704	11	276			
8805	27	667	8805	16	414			

1988. Oct.			1988. Nov.			1988. Dec.		
ID	Pass	Return	ID	Pass	Return	ID	Pass	Return
1181	1	21	1181	3	89	1401	1	25
1401	1	29	1401	2	54	7801	4	100
7801	15	376	7801	4	100	7838	9	187
7838	5	79	7838	28	555	7840	17	399
7840	34	875	7840	48	1197	8405	6	148
8405	31	771	8405	14	359	8502	20	500
8502	13	320	8502	1	25	8605	9	223
8605	22	546	8605	12	291	8704	2	48
8704	28	693	8704	12	298	8805	7	177
8805	18	457	8805	8	191			

1181 : Potsdam, GDR
7801 : Haleakala, USA
7838 : Simosato, Japan
7840 : RGO, United Kingdom
8405 : Mon. Peak, USA
8502 : Yarragadee, Australia
8605 : Mazatlan, Mexico
8704 : GSFC, USA
8805 : Quincy, USA

Table 2. Accuracy of JHD elements

Sequential No.	Creation date	Period of data used	Number of data used	σ_1 (m)	σ_2 (m)
	1988	1987			
49	1/06	12/15 – 12/28	961	282	937
		1988			
51	1/18	12/30 – 1/12	529	630	604
52	1/25	1/07 – 1/20	1028	2912	3271
53	2/03	1/16 – 1/29	1174	173	2698
54	2/09	1/19 – 2/01	1472	219	191
55	2/16	2/01 – 2/14	1212	549	655
56	2/22	2/03 – 2/16	1957	314	393
57	2/29	2/10 – 2/23	2208	369	567
		2/03 – 2/23	3159	283	377
58	3/08	2/14 – 2/27	2250	269	490
		2/07 – 2/27	3172	211	365
59	3/23	2/24 – 3/08	507	544	460
61	4/01	3/09 – 3/23	763	592	416
62	4/03	3/17 – 3/31	1136	439	577
63	4/08	3/22 – 4/05	1205	541	1033
		3/14 – 4/05	1808	682	438
64	4/18	3/29 – 4/12	1564	339	691
		3/22 – 4/12	2277	326	530
65	4/22	4/05 – 4/18	1285	298	570
		3/29 – 4/18	1832	304	348
66	5/09	4/19 – 5/03	2565	124	885
		4/12 – 5/03	3504	200	521
67	5/13	4/26 – 5/10	743	87	439
		4/19 – 5/10	1285	143	219
68	5/23	5/03 – 5/18	862	153	321
		4/26 – 5/18	1227	153	161
69	5/27	5/12 – 5/26	624	211	180
		5/05 – 5/26	1009	219	101
70	6/02	5/20 – 5/31	374	208	248
		5/16 – 5/31	598	170	198
71	6/10	5/20 – 6/03	573	184	186
		5/10 – 6/03	1202	180	158
72	6/17	5/26 – 6/09	466	719	191
		5/20 – 6/09	658	186	221
73	6/23	6/01 – 6/16	547	432	186
		5/27 – 6/16	789	432	186
74	7/06	6/14 – 6/28	1135	139	262
		6/08 – 6/28	1326	156	142
75	7/07	6/22 – 7/02	1294	206	367
		6/15 – 7/02	1834	211	135
76	7/14	6/29 – 7/12	1562	183	460
		6/22 – 7/12	2185	226	218

Table 2. Accuracy of JHD elements

Sequential No.	Creation date	Period of data used	Number of data used	σ_1 (m)	σ_2 (m)
	1988	1988			
77	7/21	7/06 – 7/19	1346	413	1005
		6/29 – 7/19	2145	191	684
78	8/08	7/18 – 7/31	1068	625	1009
		7/11 – 7/31	1739	364	711
79	9/29	9/07 – 9/19	378	243	74
		9/01 – 9/19	392	216	45
80	10/06	9/13 – 9/27	379	68	648
		9/06 – 9/27	569	235	297
81	10/17	9/29 – 10/11	1287	470	848
		9/20 – 10/11	1528	206	538
82	10/24	10/01 – 10/18	2111	422	790
		9/29 – 10/18	2336	346	715
83	10/31	10/12 – 10/25	1972	556	1160
		10/05 – 10/25	2732	233	869
84	11/04	10/17 – 10/31	2267	468	1077
		10/10 – 10/31	3206	230	661
85	11/10	10/25 – 11/08	2136	409	843
		10/18 – 11/08	3115	328	645
86	11/17	11/01 – 11/15	1862	600	1216
		10/24 – 11/15	3222	297	727
87	11/24	11/08 – 11/22	1590	402	1212
		11/01 – 11/22	2661	322	874
88	12/01	11/16 – 11/29	947	321	727
		11/09 – 11/29	1800	155	451
89	12/09	11/22 – 12/05	898	652	1429
		11/15 – 12/05	1563	374	875
91	12/22	12/07 – 12/20	912	713	1482
		11/30 – 12/20	1472	428	938

The elements No.50 and 60 were not created due to errors in data.

3. The JHD elements

The JHD elements are created once a week by our orbital prediction system. Table 2 shows the accuracies of elements one week (σ_1) and two weeks (σ_2) before the period of quick look data used for the creation of elements, respectively. The averages of σ_1 and σ_2 are 364 m and 631 m, respectively.

The created JHD elements are sent to the Simosato Hydrographic Observatory, Communications Research Laboratory, Wuhan and Shanghai of the People's Republic of China, for the laser ranging observation.

These works were performed by K. Asai and K. Kawai in 1988.

We would like to thank the staff of Goddard Laser Tracking Network who have kindly sent us the quick look data of Ajisai regularly.

This report was written by A. Sengoku and S. Masai.

References

Fukushima, T., 1986: *Proc. of the 19th Symp. on Celestial Mechanics,* p.93.
Sengoku, A., 1988: *Data Report of Hydrogr. Obs., Series of Satellite Geodesy,* No. 1, p.70.
Sengoku, A., 1989: *Data Report of Hydrogr. Obs., Series of Satellite Geodesy,* No. 2, p.68.

NOTE ON THE CHARACTERISTICS OF HTLRS

Summary – Basic characteristics of the Hydrographic Transportable Laser Ranging Station (HTLRS) is reported. We performed three tests; the stability test to know the dependency on the time, the threshold test to know the dependency on the stop threshold value and the amplitude test to know the dependency on the amplitude of received pulse.

Key words: characteristics of HTLRS

This is the first report on the basic characteristics of the Hydrographic Transportable Laser Ranging Station (HTLRS).

Generally, an observed range to a satellite is a function of a group of parameters such as the amplitude of received pulse, the electric voltage of PMT, the threshold level of received signal, etc. In order to clear the dependency of observed range to these factors, we performed the following three tests; the stability test to know the dependency on the time, the threshold test to know the dependency on the stop threshold value and the amplitude test to know the dependency on the amplitude of received pulse.

Test observations were made by means of ranging to a ground target which is 1448 m apart at the Simosato Hydrographic Observatory on November 15 and November 18, 1988.

In each test, the internal time delay was measured for two sets of system parameters, for Ajisai and for Lageos, respectively.

1. Stability test

It is quite necessary for satellite laser ranging systems to be stable while they observe satellites. Especially, observed ranges to satellites should be stable. In order to check this stability for HTLRS, ranging observations to a ground target are made for about an hour on November 15, 1988. The system parameters were set for Ajisai and for Lageos, respectively.

1.1 Ajisai case

The adopted system parameters were as follows,

Ts : 50
Te : 60
Vs : 40 V
Ve : –2.30 kV
Att : 10000 (no attenuation)
Ap : 0.1 mm in diameter
Div : 0.5 mrad

where Ts is the trigger level of emitted signal in an arbitrary scale, Te the trigger level of received signal in the same scale, Vs the electric voltage of PMT to detect emitted signal, Ve the electric voltage of PMT to detect received signal, Att the indicated attenuation level, Ap the diameter of attenuation disk and Div the divergence of emitted laser pulse. The relation between Att and the transmission rate is shown in Figure 1.

The internal time delays were estimated once ten minutes as are shown in Table 1 and Figure 2, where r.m.s. means the standard deviation of residuals.

Table 1. Results of the stability test (with parameters for Ajisai, November 15, 1988)

Time (UT)	No. of return (efficient/total)	r.m.s. (cm)	Internal time delay (ns)
12:54 – 13:01	1921 / 2100	1.2	50.768
13:01 – 13:11	2819 / 3000	1.1	50.775
13:11 – 13:21	2868 / 3000	1.1	50.791
13:21 – 13:31	2871 / 3000	1.9	50.663
13:31 – 13:41	2819 / 3000	1.2	50.566
13:41 – 13:44	835 / 900	1.2	50.563

1.2 Lageos case

The adopted system parameters were as follows,

Ts : 50
Te : 20
Vs : 40 V
Ve : −3.08 kV
Att : 3800
Ap : 0.1 mm in diameter
Div : 0.5 mrad

The estimation of internal time delays was made just as the same as in the preceding subsection whose results are shown in Table 2 and Figure 3.

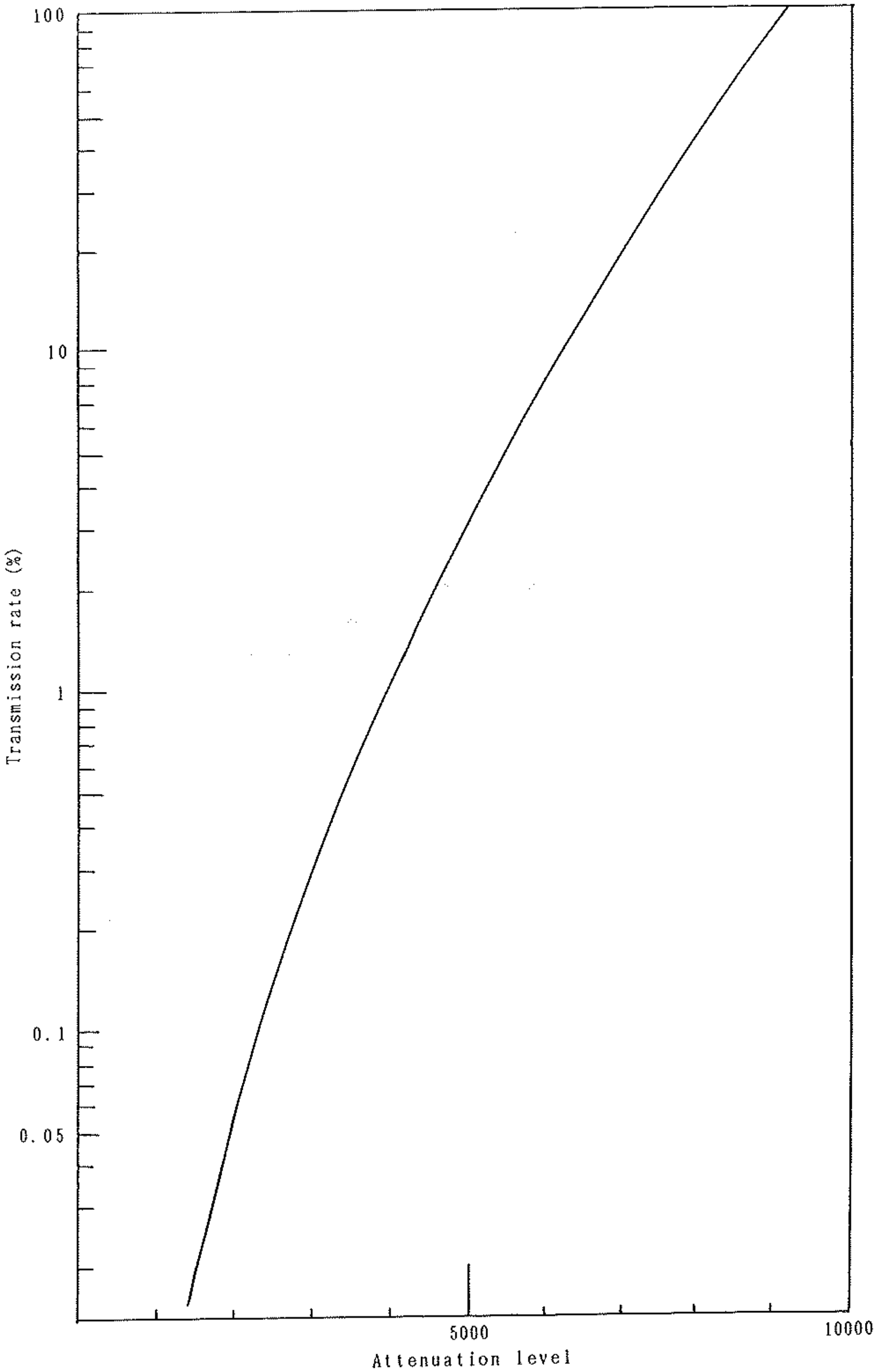


Figure 1. Transmission rate optical attenuator.

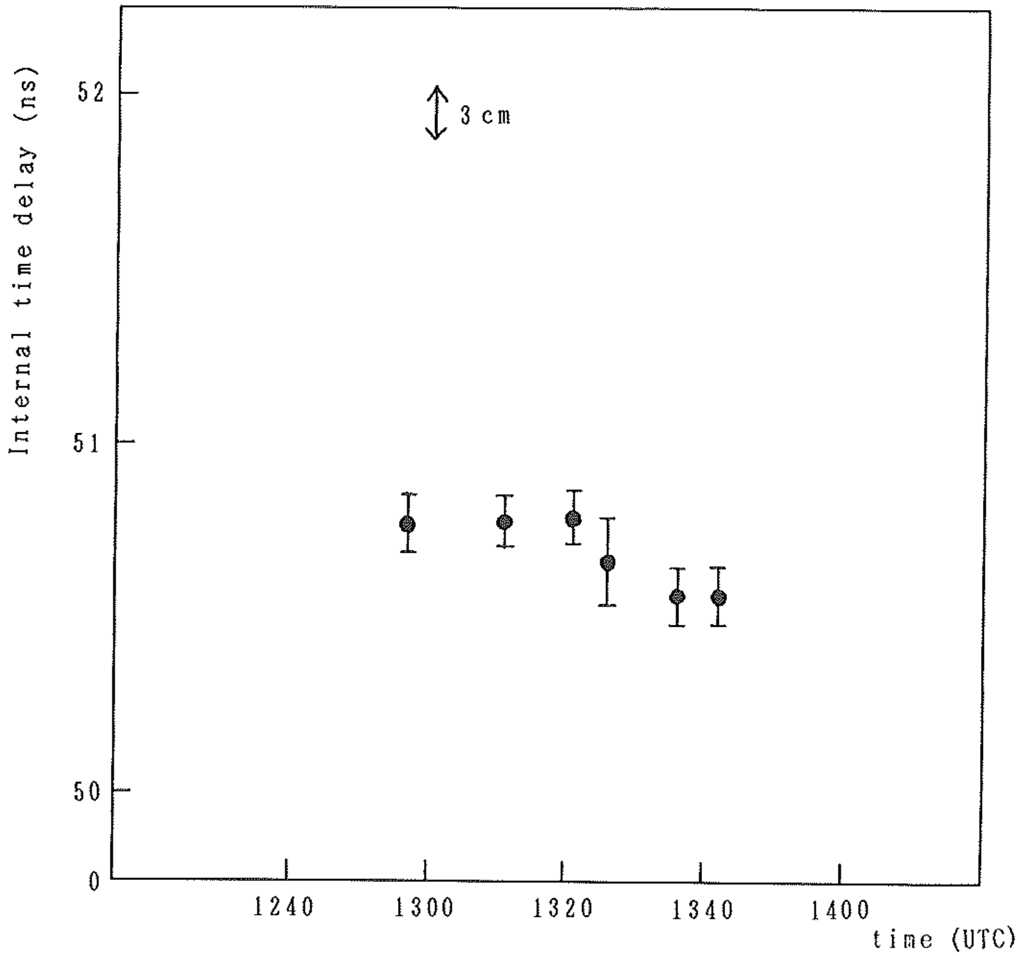


Figure 2. Results of the stability test (with parameters for Ajisai, November 15th, 1988).

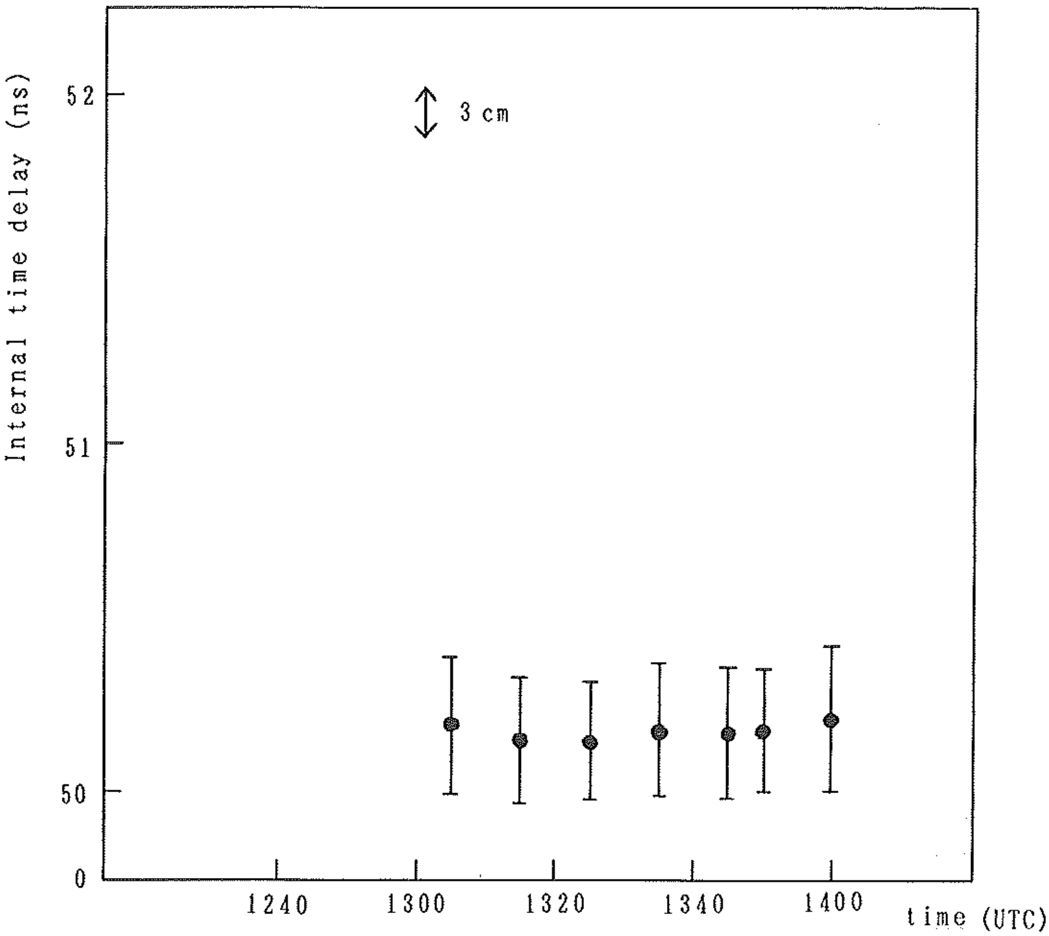


Figure 3. Results of the stability test (with parameters for Lageos, November 15th, 1988).

Table 2. Results of the stability test (with parameters for Lageos, November 15, 1988)

Time (UT)	No. of return (efficient/total)	r.m.s. (cm)	Internal time delay (ns)
13:58 – 14:00	411 / 505	3.1	50.209
14:00 – 14:10	2378 / 2816	2.9	50.192
14:10 – 14:20	2405 / 2890	2.7	50.148
14:20 – 14:30	2473 / 2908	2.5	50.146
14:30 – 14:40	2415 / 2828	2.8	50.176
14:40 – 14:50	2392 / 2831	2.8	50.168
14:50 – 14:51	183 / 222	2.6	50.175

1.3 Analysis

When the system parameters were set for Ajisai, the r.m.s. was relatively small as 1 – 2 cm while the internal time delay varied more than the r.m.s. did. It changed 0.23 ns (3.5 cm in range) in 20 minutes in the maximum case. Since the duration of Ajisai observation is as long as 12 minutes, it is recommended to make two calibration observations; before and after the satellite observation, as close to it as possible. This is because the difference between pre- and post-range offsets becomes sometimes greater than 0.1 ns.

On the other hand, when the system parameters were set for Lageos, the r.m.s. was comparatively large as about 3 cm but the internal time delay did not change significantly. The variation became 0.06 ns (0.9 cm in range) at most. Though the duration of Lageos observation is longer than that of Ajisai, the variation of range data is expected to be smaller.

In order to know the detailed features of the system stability, it is necessary to perform the stability tests further.

2. Threshold test

Generally, an observed range is also a function of the trigger level of received signal (called the stop threshold level in this report and denoted as Te). In order to check the reliability of HTLRS, we measured the dependency of the internal time delay with respect to the stop threshold level by ranging to a ground target. The observations were made on November 18, 1988.

2.1 Ajisai case

The adopted system parameters were as follows,

Ts : 50
Vs : 40 V

Ve : −2.30 kV
Att : 10000 (no attenuation)
Ap : 0.1 mm in diameter
Div : 0.5 mrad

The results are shown in Table 3 and Figure 4.

Table 3. Results of the threshold test (with parameters for Ajisai, November 18, 1988)

Stop threshold	No. of return (efficient/total)	r.m.s. (cm)	Internal time delay (ns)
20	260 / 300	1.3	50.476
40	293 / 300	1.1	50.719
60	300 / 300	1.1	50.850
80	300 / 300	1.2	50.939
100	277 / 300	1.2	50.971

2.2 Lageos case

The adopted system parameters were as follows,

Ts : 50
Vs : 40 V
Ve : −3.08 kV
Att : 3800
Ap : 0.1 mm in diameter
Div : 0.5 mrad

The results are shown in Table 4 and Figure 5.

Table 4. Results of the threshold test (with parameters for Lageos, November 18, 1988)

Stop threshold	No. of return (efficient/total)	r.m.s. (cm)	Internal time delay (ns)
10	267 / 300	2.5	50.380
20	273 / 300	2.9	50.607
30	278 / 300	2.6	50.743
40	280 / 300	2.5	50.833

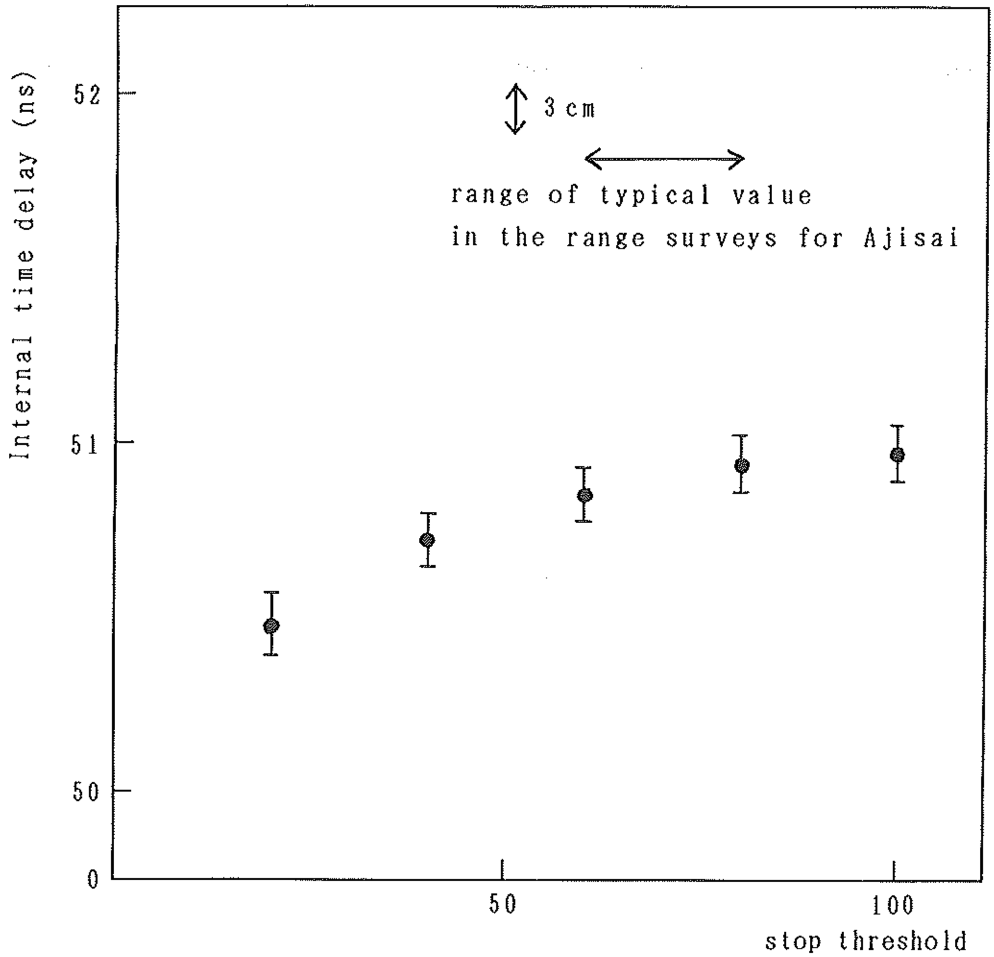


Figure 4. Results of the threshhold test (with parameters for Ajisai, November 18th, 1988).

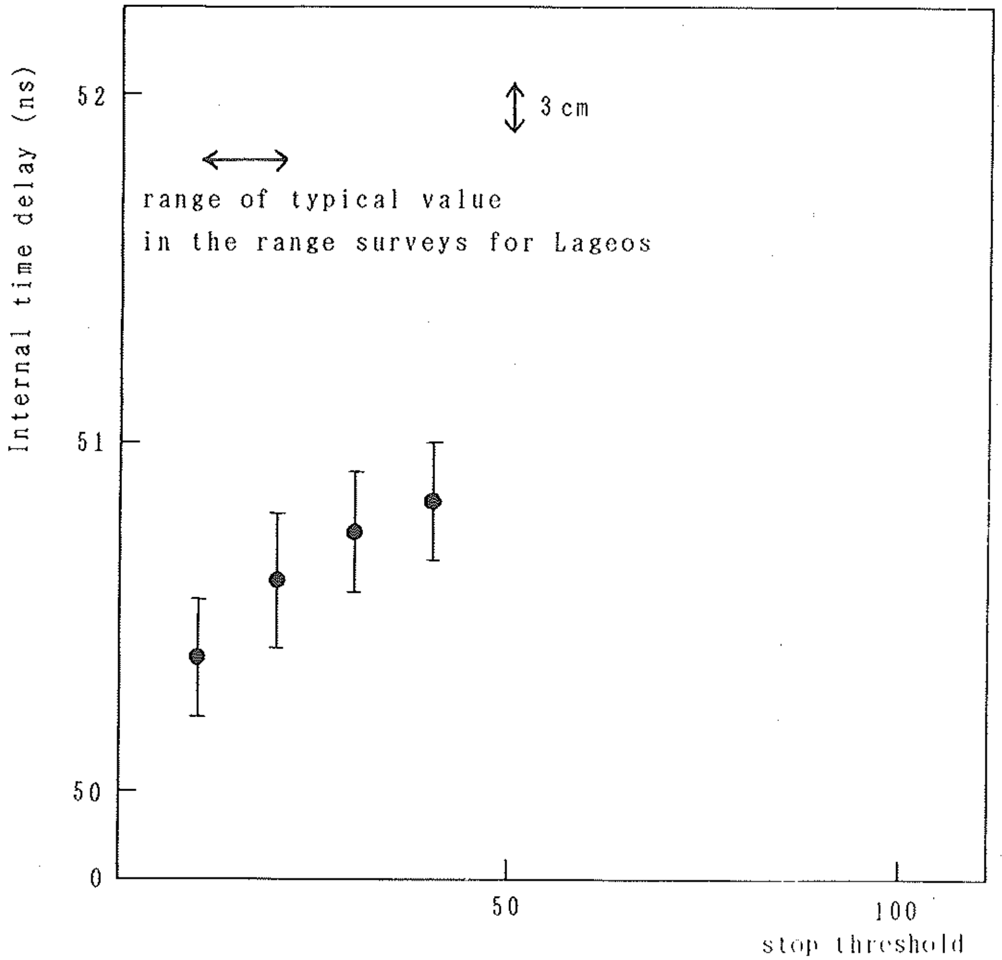


Figure 5. Results of the threshhold test (with parameters for Lageos, November 18th, 1988).

2.3 Analysis

In both cases, the internal time delay apparently depends on the stop threshold level. When the system parameters were set for Ajisai, the internal time delay changed about 0.09 ns (1.4 cm in range) within the stop threshold level 60 to 80. When the system parameters for Lageos were used, the internal time delay did about 0.23 ns (3.5 cm in range) within the stop threshold level 10 to 20. Therefore, it is desirable not to change the stop threshold level through the observation. Also the stop threshold level should be constant when receiving the laser signals of both satellites and a ground target.

3. Amplitude test

The stronger the amplitude of received pulse is, the shorter the observed range becomes. Such situation is inevitable in the ranging with a certain kind of threshold.

In this section, the dependency of the observed range with respect to the received amplitude is described. Test ranging observations to the ground target were made on November 18, 1988, while the attenuator level was changed in order to vary the amplitude of received pulse.

3.1 Ajisai case

The adopted system parameters were as follows,

Ts : 50
Te : 60
Vs : 40 V
Ve : −2.30 kV
Ap : 0.1 mm in diameter
Div : 0.5 mrad

The results are shown in Table 5, Figure 6 and Figure 8. No datum was obtained when the attenuator was set as 4000. The transmission rates in Tables 5 and 6 were directly read from Figure 1.

Table 5. Results of the amplitude test (with parameters for Ajisai, November 18, 1988)

Attenuator	Transmission rate	No. of return (efficient/total)	r.m.s. (cm)	Internal time delay (ns)
10000	99%	295 / 300	1.2	50.861
8000	47	294 / 300	1.2	50.864
6000	8.5	292 / 300	1.4	50.976
5000	3.3	253 / 300	1.8	51.144

3.2 Lageos case

The adopted system parameters were as follows,

Ts : 50
Te : 20
Vs : 40 V
Ve : −3.08 kV
Ap : 0.1 mm in diameter
Div : 0.5 mrad

The results are shown in Table 6, Figure 7 and Figure 9.

Table 6. Results of the amplitude test (with parameters for Lageos, November 18, 1988)

Attenuator	Transmission rate	No. of return (efficient/total)	r.m.s. (cm)	Internal time delay (ns)
5400	4.7%	218 / 300	1.5	50.055
4600	2.2	252 / 300	1.6	50.438
3800	.84	281 / 300	2.7	50.582
3000	.31	277 / 300	3.4	50.763
2200	.093	248 / 300	4.4	50.876

3.3 Analysis

The ratio of the distance to Ajisai at 20 degree elevation and that at the zenith is 1.96. This means that the ratio of the amplitude of received pulses becomes about 15. Then, from Figure 8, the internal time delay is estimated to change about 0.15 ns (2.3 cm in range) as the elevation of Ajisai varies from 20 degree to 90 degree. Namely, the observed range of Ajisai at the zenith will be 2.3 cm shorter than that at 20 degree elevation if the system parameters are the same. Moreover, it is said that the observed ranges in a hazy sky are longer than those in a clear sky. This is one of the limitation of HTLRS caused by having a relatively low power laser.

On the other hand, the ratio of the range to Lageos at 20 degree elevation and that at the zenith is 1.44. This means that the ratio of the amplitude of received pulses becomes 4.3. Then, from Figure 9, the internal time delay is estimated to change 0.3 ns (4.5 cm in range) as the elevation of Lageos varies from 20 degree to 90 degree. Therefore, the observed range of Lageos at the zenith will be about 4.5 cm shorter than that at 20 degree elevation if the system parameters are the same.

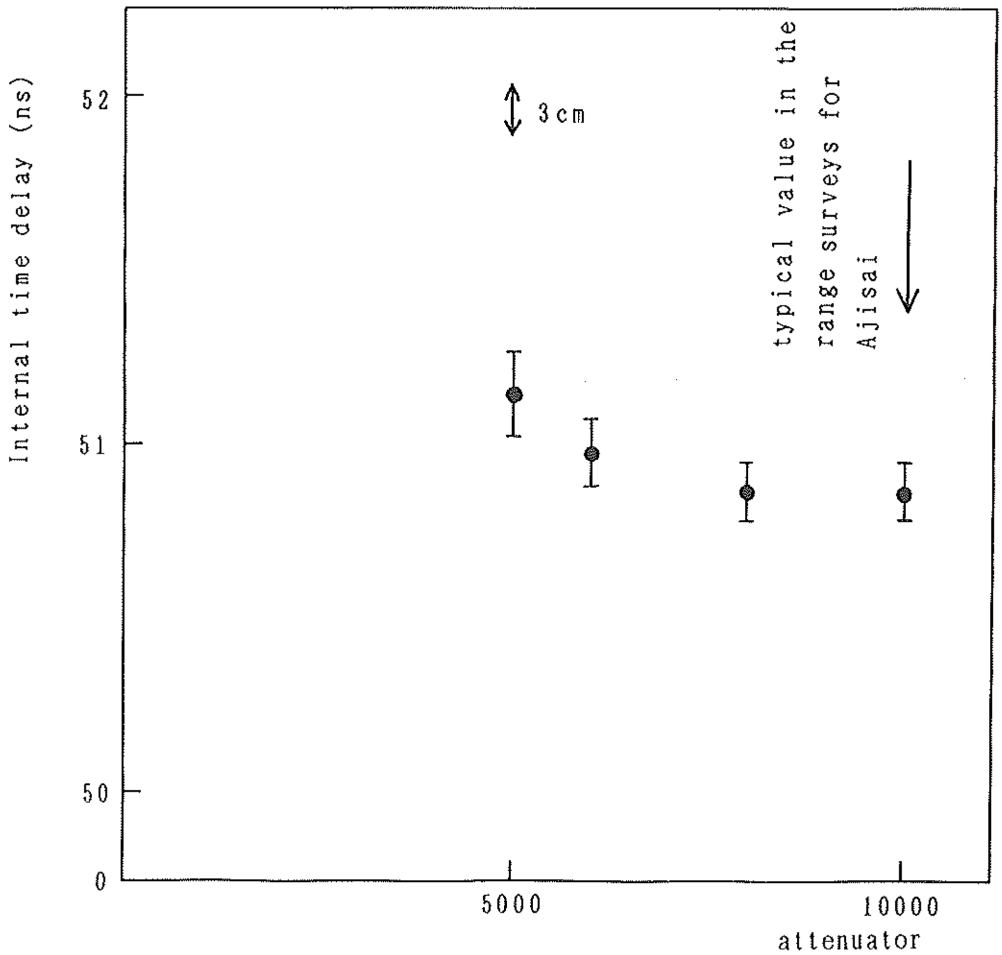


Figure 6. Results of the amplitude test (with parameters for Ajisai, November 18th, 1988).

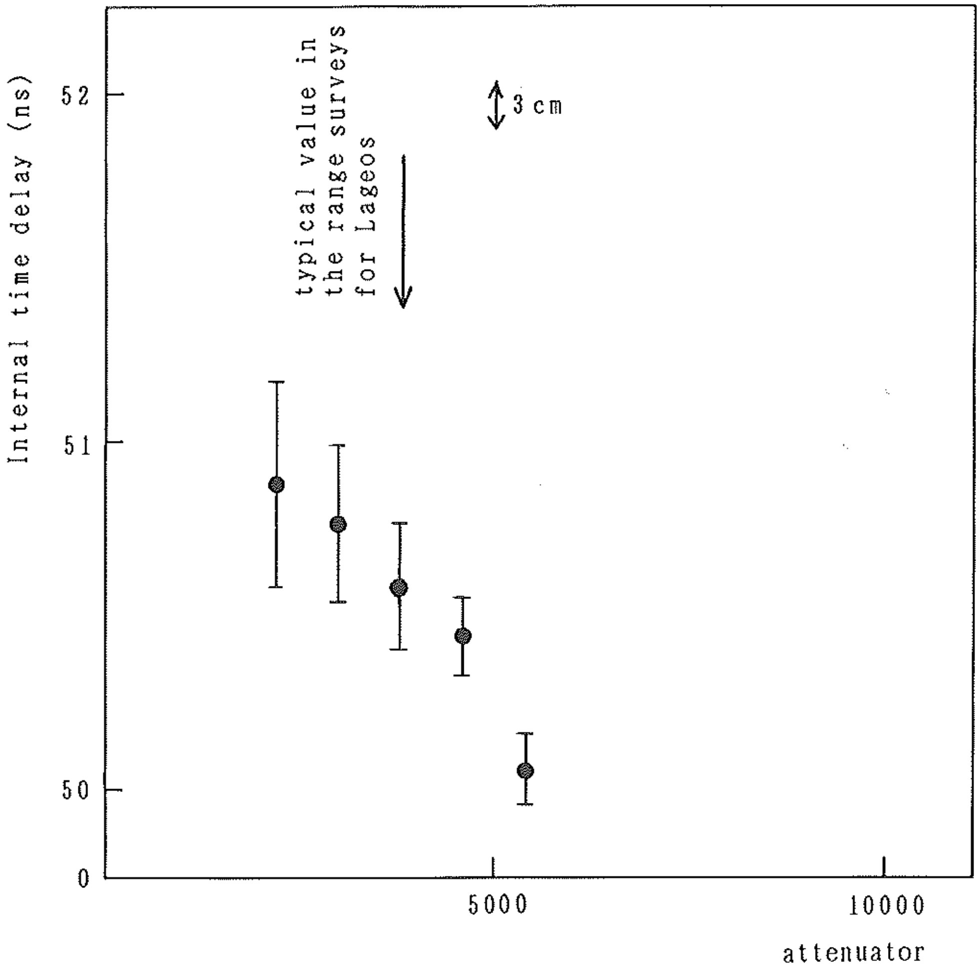


Figure 7. Results of the amplitude test (with parameters for Lageos, November 18th, 1988).

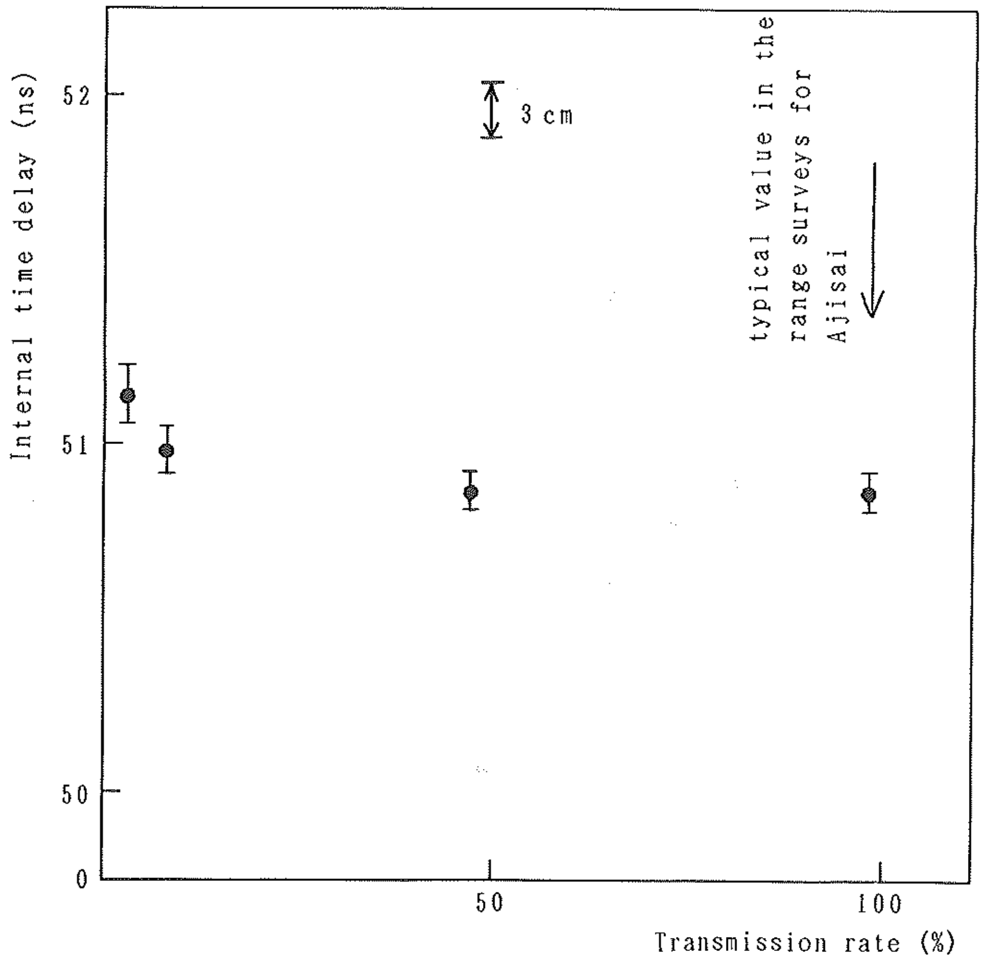


Figure 8. Transmission rate-the interval time delay (with parameters for Ajisai).

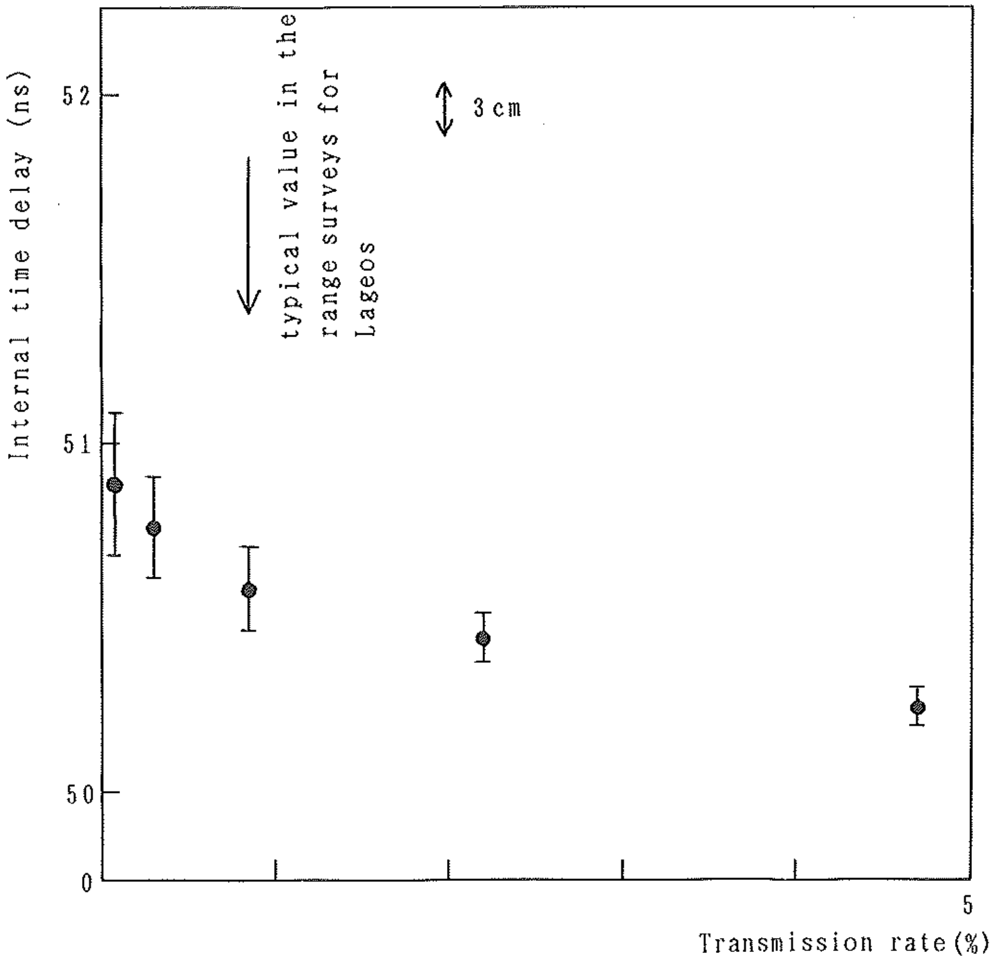


Figure 9. Transmission rate-the interval time delay (with parameters for Lageos).

Since it took a few tens of minutes to carry out the threshold test as well as the amplitude test, the results of these tests were affected by the system stability. Therefore more detailed studys are needed to clear the full capability of HTLRS.

This report was written by A. Sengoku.

References

Fukushima, T., Nisimura, E. 1988: *Data Report of Hydrogr. Obs., Series of Satellite Geodesy*, No.1, p.82.

人工衛星のドップラー観測による離島の位置決定
1988

SATELLITE DOPPLER POSITIONING OF OFF-LYING ISLANDS IN 1988

This paper is a continuation of the series of report on the satellite Doppler positioning of the off-lying islands in Japan. The provisional results of the observations made by the JHD in 1988 are given.

Key words : satellite Doppler positioning-marine geodetic controls

水路部では，1980年以降海洋測地網の整備として，人工衛星を利用して本土から遠隔地にある島嶼の経緯度の測定を行っている．本稿では，1988年に実施した米海軍航行衛星による離島の経緯度観測の暫定的な成果について報告する．観測方法，整約方法等については水路部観測報告天文測地編第17号を参照されたい（竹村・金沢，1983）．

米海軍航行衛星の観測から求めた各測点標識位置の成果をTable 1に示す．経緯度は下里の本土基準点に基づき，高さは標高でる．

Table 1. Summary of the positions of the fiducial markers expressed in the Tōkyō Datum by means of the satellite Doppler observations

Station	Marker	ϕ	λ	h
		° ′ ″	° ′ ″	m
久　米　島 (Kume sima)	G1	26 20 10.293N	126 49 38.194E	13.06
粟　国　島 (Aguni sima)	G1	26 34 34.564	127 13 12.304	95.78
那　　　覇 (Naha)	N	26 14 26.169	127 40 32.360	31.91
石　垣　島 (Isigaki sima)	G1	24 20 32.200	124 08 57.150	6.31
波照間島 (Hateruma sima)	G1	24 03 34.319	126 46 33.061	43.86
西　表　島 (Iriomote sima)	G1	24 27 59.951	123 49 17.687	31.47
仲ノ御神島 (Nakanougan sima)	H1	24 11 28.436	123 33 47.476	33.04
〃	H2	24 11 19.382	123 33 35.131	22.17
多良間島 (Tarama sima)	G1	24 40 3.815	124 41 53.739	34.44
黒　　　島 (Kuro sima)	G1	24 13 59.360	123 59 46.408	15.57

h : the height above the (local) mean sea level

1．概要

1．1　作業経過

1988年に実施した全観測地の配置をFig.1に示す．

4月中旬～4月下旬にかけて，下里・那覇・久米島・粟国島において同時観測を実施した．

5月下旬～6月中旬にかけて，那覇・石垣島・西表島・黒島・波照間島・仲ノ御神島・多良間島において同時観測を実施した．

1．2　主な作業

1．測点標識の設置

仲ノ御神島（正標・副標）

2．航行衛星の同時観測による経緯度の決定

久米島，粟国島，那覇，石垣島，西表島，黒島，波照間島，多良間島

3．経緯度測量

仲ノ御神島（副標）

1．3　使用機器等

1．航行衛星受信機　4台

機種　マグナボックス社MX-1502

機械番号　160，162，163，553（以後それぞれHD1，HD2，HD3，HD4と称する．）

2．テープ変換器　MFE5000，No. 01219

3．整約プログラム　MAGNET

2．観測

2．1　久米島，粟国島観測

本観測は，沿岸調査課が実施した離島海の基本図「鳥島」（久米鳥島）測量及び「鳥島」（久米鳥島）沿岸流観測と併行して実施した．本観測には，測量船拓洋を使用した．

観測地点と担当者

下　里	下里水路観測所庁舎屋上（Fig. 2）	小野寺　健英，増山　昭博，伊藤　秀行，森　弘和，黒川　隆司
那　覇	株式会社那覇新港冷凍屋上（Fig. 3）	竹村　武彦 第十一管区海上保安本部水路調査課職員
久米島	四等三角点奥武島（久米島）（Fig. 4）	浅井　光一
粟国島	一等三角点粟国島（粟国島）（Fig. 5）	浅井　光一

観測期間と観測数

	受信機	期　間	受信パス数
下　里	HD3	4月18日～4月27日	170
那　覇	HD2	4月18日～4月25日	139
久米島	HD4	4月19日～4月26日	114
粟国島	HD1	4月18日～4月24日	102

観測状況と地上測量

下　里：下里水路観測所庁舎屋上のNNSS受信点において観測した．

那　覇：株式会社那覇新港冷凍屋上の水路部測点標識から真方位0°0の方向，水平距離2.00mに受信アンテナを設置して観測した．受信アンテナ高は，測点標識より上方1.622mであった．

Figure 1. Doppler positioning in 1988.

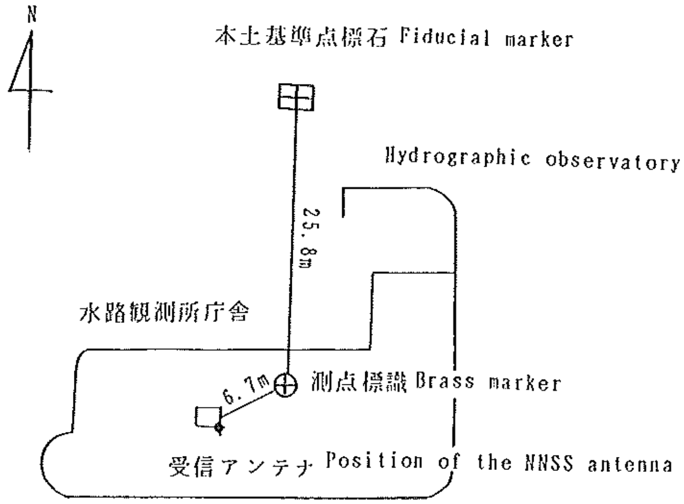


Figure 2. Site sketch for Simosato.

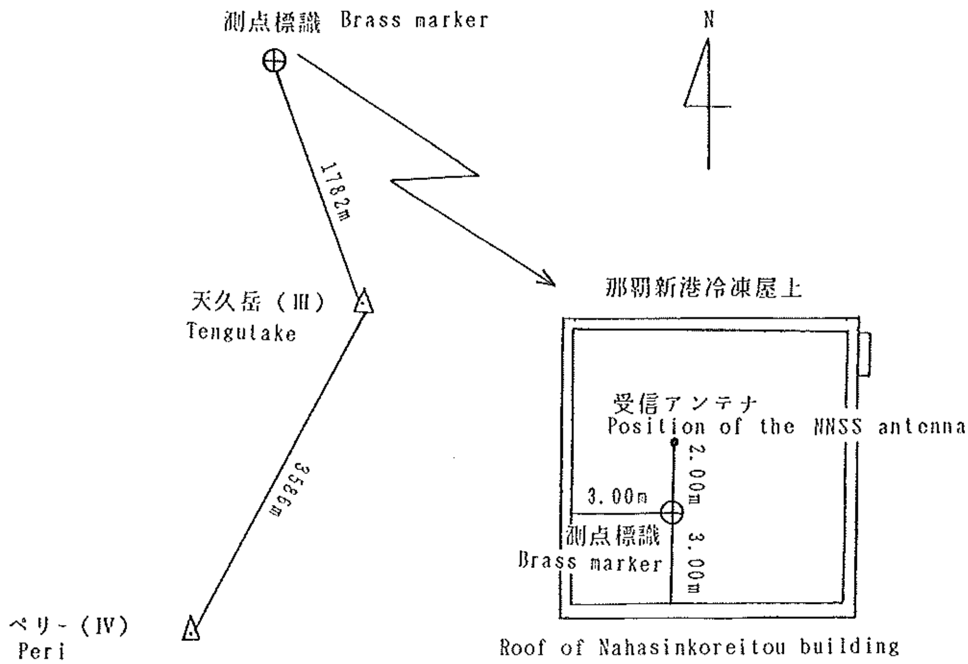


Figure 3. Site sketch for Naha, Okinawa (April session).

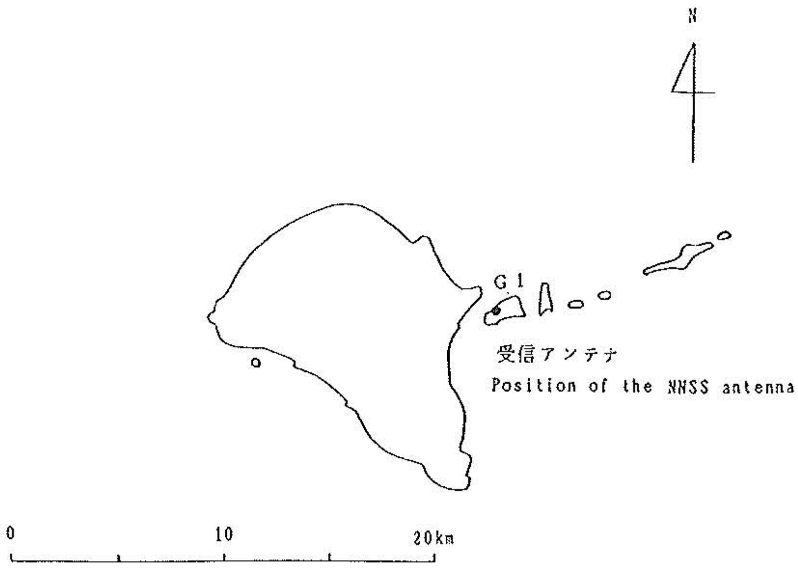


Figure 4. Site sketch for Kume Sima.

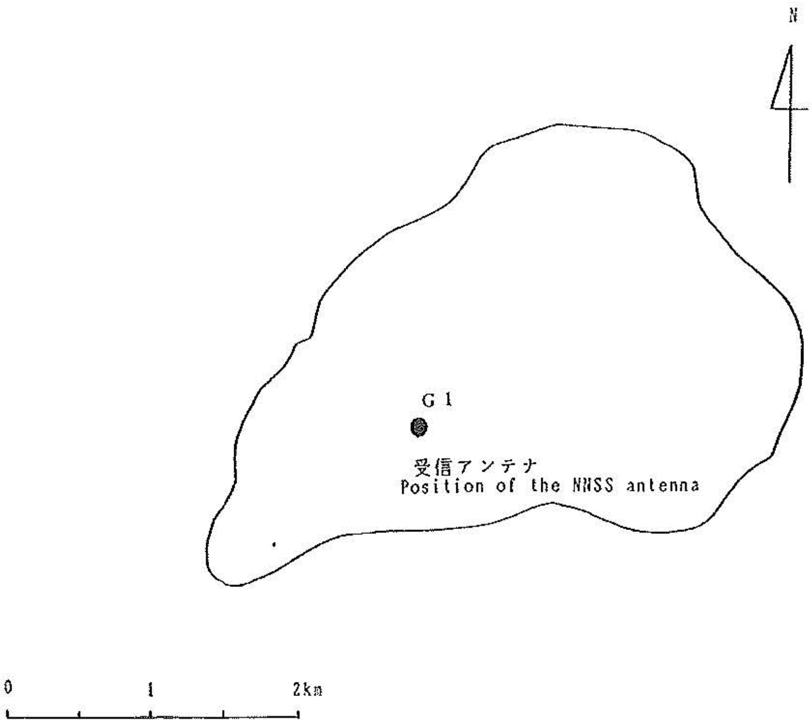


Figure 5. Site sketch for Aguni Sima.

測点標識の地上測量は1980年12月に第十一管区水路課職員が三等三角点天久岳を原点に，四等三角点ペリーを方位基準にして実施している（竹村・金沢，1983）．

久米島：四等三角点奥武島（久米島）から真方位351°.5の方向，水平距離1.387mに受信アンテナを設置して観測した．受信アンテナ高は，三角点より上方1.703mであった．

粟国島：一等三角点粟国島から真方位111°の方向，水平距離2.082mに受信アンテナを設置して観測した．受信アンテナ高は，三角点より上方1.650mであった．

2．2　西表島・黒島・波照間島・仲ノ御神島・多良間島観測

観測地点と担当者

那　　覇	株式会社那覇新港冷凍屋上（Fig. 6）	第十一管区海上保安本部水路調査課職員
石 垣 島	石垣海上保安部浮標置場工作棟屋上（Fig. 7）	内山　丈夫
西 表 島	三等三角点（鳩間）（Fig. 8）	仙石　新，長岡　継，河合　晃司
黒　　島	三等三角点（黒島）（Fig. 9）	同上
波照間島	三等三角点（波照間）（Fig.10）	同上
仲ノ御神島	主標，副標（Fig.11）	同上
多良間島	四等三角点（遠見台）（Fig.12）	同上

観測期間と観測数

	受信機	期　　間	受信パス数
那　　覇	HD 2	5月30日～6月15日	288
石 垣 島	HD 4	5月31日～6月10日	156
〃	HD 3	6月12日～6月15日	56
波照間島	HD 1	6月4日～6月5日	19
西 表 島	HD 3	6月5日～6月7日	38
仲ノ御神島	HD 1	6月8日～6月11日	58
多良間島	HD 1	6月13日～6月15日	37
黒　　島	HD 3	6月9日～6月12日	57

観測状況と地上測量

那　　覇：株式会社那覇新港冷凍屋上の水路部測点標識の真上に受信アンテナを設置して観測した．受信アンテナ高は，測点標識上1.983mであった．

石 垣 島：石垣海上保安部浮標置場工作棟屋上の測点標識から真方向114°.9，水平距離8.410mに受信アンテナを設置して観測した．受信アンテナ高は，測点標識より上方1.908mであった．

波照間島：三等三角点「波照間」から真方向35°，水平距離1.253mに受信アンテナを設置して観測した．受信アンテナ高は，三角点より上方1.312mであった．

西 表 島：三等三角点「鳩間」から真方向350°.9，水平距離8.100mに受信アンテナを設置して観測した．受信アンテナ高は，三角点より上方1.930mであった．

仲ノ御神島：水路部測点標識H 1から真方向148°.1，水平距離1.388mに受信アンテナを設置して観測した．受信アンテナ高は，三角点より上方1.176mであった．

多良間島：四等三角点「遠見台」から真方向100°.9，水平距離1.909mに受信アンテナを設置して観測した．受信アンテナ高は，三角点より上方1.380mであった．

黒　　島：三等三角点「黒島」から真方向163°.3，水平距離1.098mに受信アンテナを設置して観測した．受信アンテナ高は，三角点より上方1.519mであった．

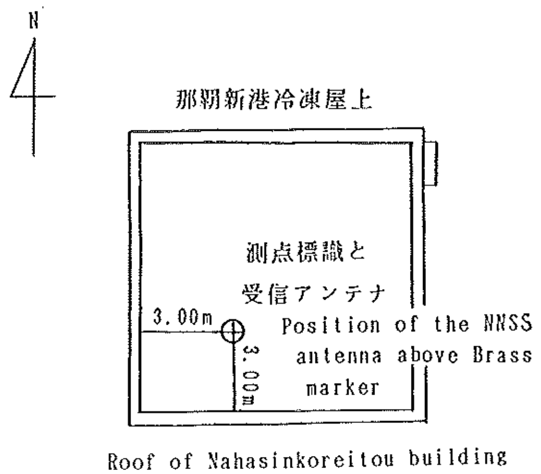


Figure 6. Site sketch for Naha, Okinawa (June session).

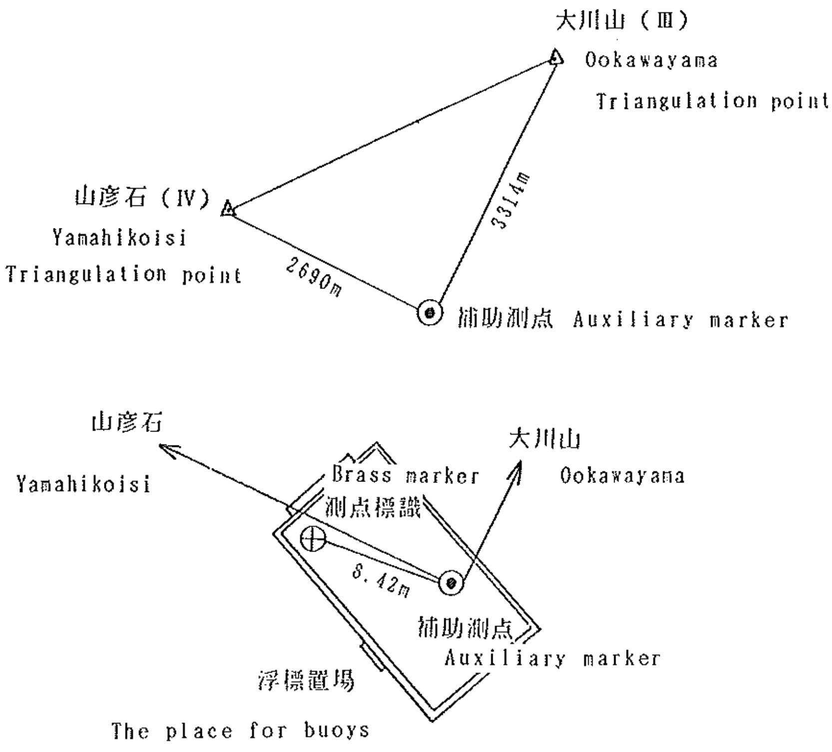


Figure 7. Site sketch for Isigaki Sima.

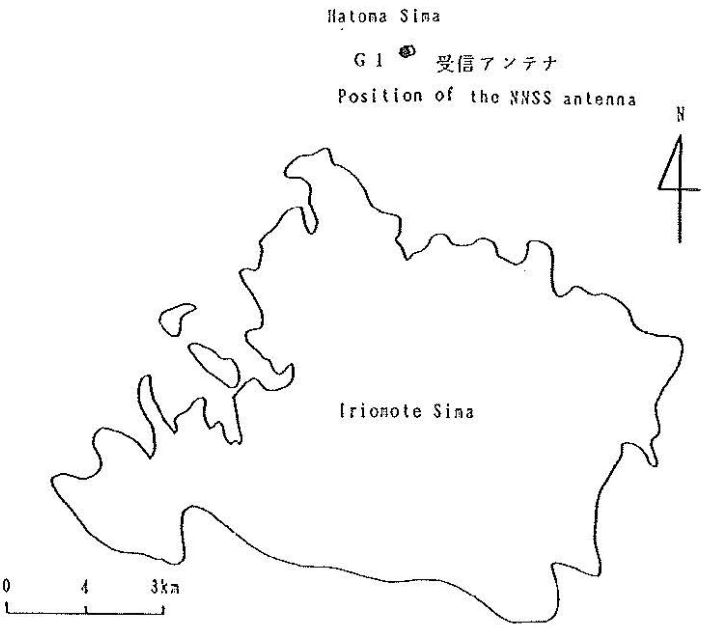


Figure 8. Site sketch for Hatoma Sima, Iriomote Sima.

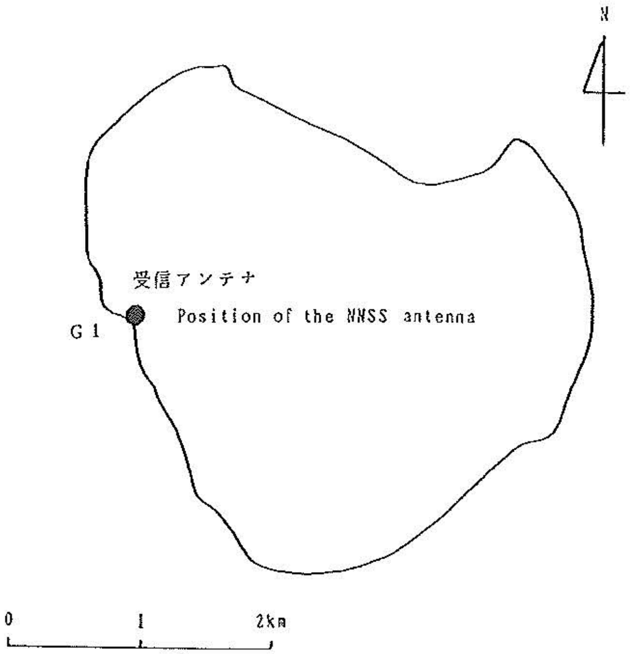


Figure 9. Site sketch for Kuro Sima.

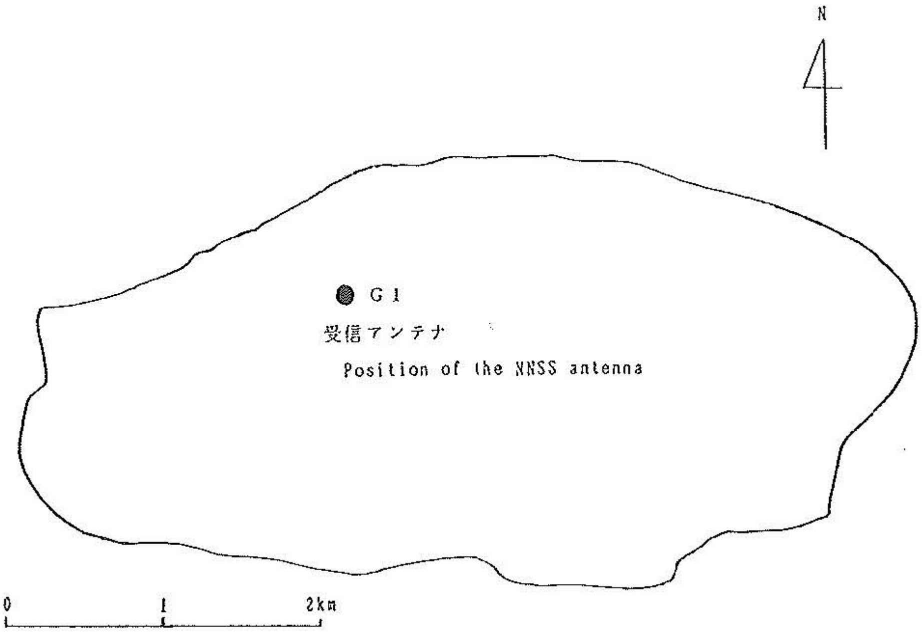


Figure 10. Site sketch for Hateruma Sima.

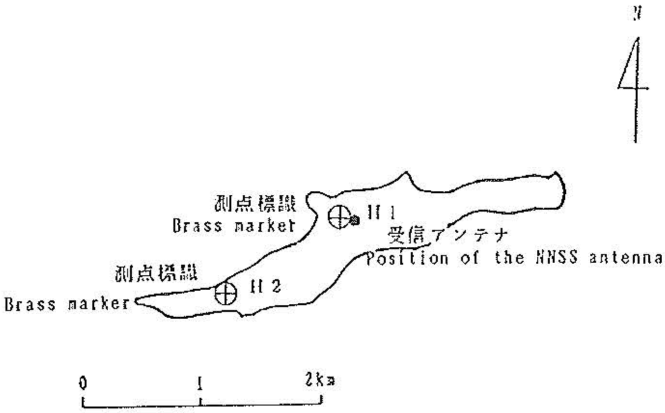


Figure 11. Site sketch for Nakanougan Sima.

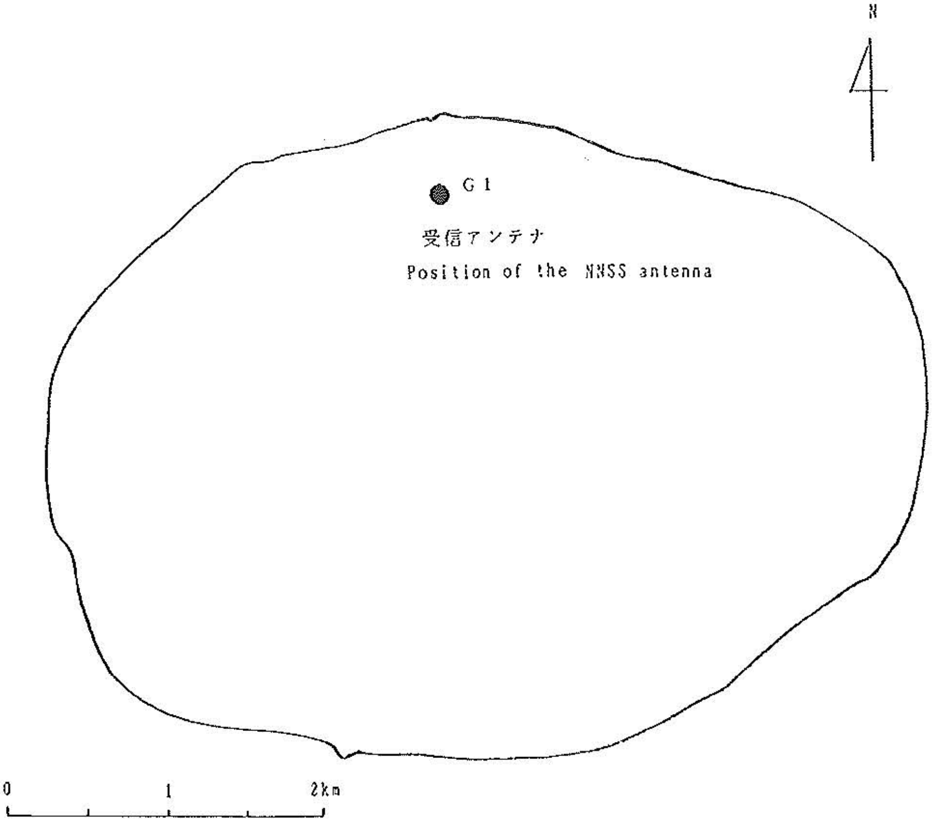


Figure 12. Site sketch for Tarama Sima.

3．成果

受信データをMAGNETプログラムにより整約し，受信アンテナ位置をWGS-72の楕円体上で求めた結果をTable 2に示す．これらの観測成果を日本測地系に変換したものがTable 3で，それぞれの同時観測結果に対し，変換に使用したパラメータの値も掲げた．いずれも高さは楕円体上の高さを表す．

Table 2. Positions of the NNSS antennas : the solutions of the translocation of the Doppler observations in the reference system of NNSS

Station	φ	λ	H	Note
	° ′ ″	° ′ ″	m	
下　　里 (Simosato)	33 34 39.069	135 56 11.860	107.070	久米島・粟国島観測
那　　覇 (Naha)	26 14 40.473	127 40 24.463	67.670	
久 米 島 (Kume sima)	26 20 24.494	126 49 30.550	49.680	
粟 国 島 (Aguni sima)	26 34 48.626	127 13 4.597	132.320	
那　　覇 (Naha)	26 14 40.587	127 40 24.449	69.120	西表島・黒島・波照間島・仲ノ御神島・多良間島観測
石 垣 島 (Isigaki sima)	24 20 47.091	124 8 50.851	39.430	
波照間島 (Hateruma sima)	24 3 49.448	123 46 26.649	71.190	
西 表 島 (Iriomote sima)	24 28 15.156	123 49 11.169	57.430	
仲ノ御神島 (Nakanougan sima)	24 11 43.435	123 33 41.126	61.710	
多良間島 (Tarama sima)	24 40 18.711	124 41 47.047	67.790	
黒　　島 (Kuro sima)	24 14 14.366	123 59 39.904	44.990	

H : the height above the WGS-72 ellipsoid(a=6378135m, f=1/298.26)

Table 3. Positions of the NNSS antennas : the transformed results of Table 2 into the Tōkyō Datum

Station	φ	λ	H	Translation parameters	Note
	° ′ ″	° ′ ″	m		
下　里 (Simosato) ☆	33 34 27.098	135 56 23.041	67.61	△U= 130.418	久米島・
那　覇 (Naha)	26 14 26.234	127 40 32.360	48.110	△V=−527.468	粟国島観測
久 米 島 (Kume sima)	26 20 10.338	126 49 38.187	26.531	△W=−675.139	
粟 国 島 (Aguni sima)	26 34 34.540	127 13 12.374	108.661		
那　覇 (Naha) ☆	26 14 26.126	127 40 32.236	47.060	△U= 132.351	西表島・
石 垣 島 (Isigaki sima)	24 20 32.085	124 8 57.420	21.223	△V=−527.984	黒島・
波 照 間 島 (Hateruma sima)	24 3 34.352	123 46 33.086	54.177	△W=−682.385	波照間島・
西 表 島 (Iriomote sima)	24 28 0.211	123 49 17.641	37.265		仲ノ御神島
仲ノ御神島 (Nakanougan sima)	24 11 28.398	123 33 47.502	43.019		・多良間島
多 良 間 島 (Tarama sima)	24 40 3.803	124 41 53.806	48.604		観測
黒　島 (Kuro sima)	24 13 59.326	123 59 46.419	27.214		

H : the height above the reference ellipsoid of the Tōkyō Datum

☆ : shows the fixed station to derive the corresponding translation parameters. The coordinates of this station were obtained by the previous Doppler observations and the ground surveys.

初めに掲げたTable 1は，Table 3に示した受信アンテナの位置に基づく測点標識等の位置である．ただし，結果が複数個ある地点については，それらの平均値を用いた．

Table 4. Positions of the NNSS antennas : the ground survey results in the Tōkyō Datum or in the local datum

Station	φ	λ	h	Note
	° ′ ″	° ′ ″	m	
下　　里 (Simosato)	33 34 27.098	135 56 23.041	67.61	久米島・粟国島観測
那　　覇 (Naha)	26 14 26.647	127 40 32.046	33.53	
久 米 島 (Kume sima)	26 20 10.801	126 49 37.925	14.76	
粟 国 島 (Aguni sima)	26 34 34.936	127 13 12.095	97.43	
石 垣 島 (Isigaki sima)	24 20 27.451	124 8 50.255	8.17	西表島・黒島・波照間島・仲ノ御神島・多良間島観測
波照間島 (Hateruma sima)	24 3 29.799	123 46 26.039	45.17	
西 表 島 (Iriomote sima)	24 27 55.497	123 49 10.456	33.40	
多良間島 (Tarama sima)	24 40 13.038	124 41 36.701	35.82	
黒　　島 (Kuro sima)	24 13 54.704	123 59 39.319	17.09	

h : the height above the (local) mean sea level

☆ : defining values of the coordinate system adopted by this series of report (expressed in the Tōkyō Datum)

Table 5. Differences between the Doppler results and the survey results : Doppler (Table 3) minus survey (Table 4)

Station	△φ	△λ	hg
	″	″	m
下　　里 (Simosato)	0.000	0.000	0.00
那　　覇 (Naha)	−0.413	+0.314	+14.58
久 米 島 (Kume sima)	−0.463	+0.262	+11.77
粟 国 島 (Aguni sima)	−0.396	+0.279	+11.23
那　　覇 (Naha)	0.000	0.000	0.00
石 垣 島 (Isigaki sima)	+4.634	+7.166	+13.05
波照間島 (Hateruma sima)	+4.553	+7.047	+9.01
西 表 島 (Iriomote sima)	+4.714	+7.185	+3.87
多良間島 (Tarama sima)	−9.235	+17.105	+12.784
黒　　島 (Kuro sima)	+4.622	+7.100	+10.12

hg : geoidal height referred to the reference ellipsoid of the Tōkyō Datum or local data

Table 6. Positions of the reference triangulation points used for the survey (expressed in the Tōkyō Datum or in the local datum)

Station	ϕ	λ	h
	° ′ ″	° ′ ″	m
下 里 高 芝 (III)	33 34 36.058N	135 54 58.502E	123.35
〃 太 地 (II)	33 34 51.295	135 56 37.380	79.57
那 覇 天久岳 (III)	26 13 37.292	127 41 05.766	45.85
〃 ペリー (IV)	26 11 46.784	127 40 24.714	48.01
久 米 島 (奥武島) (IV)	26 20 10.756	126 49 37.932	13.06
粟 国 島 (I)	26 34 34.960	127 13 12.025	95.78
波照間島 (III)	24 3 29.766	123 46 26.014	43.86
鳩 間 島 (III)	24 27 55.237	123 49 10.502	31.47
黒 島 (III)	24 13 54.738	123 59 39.308	15.57
多良間島 (遠見台) (IV)	24 40 13.050	124 41 36.634	34.44
石 垣 島 大川山 (III)	24 22 0.961	124 9 48.086	230.09
〃 山彦石 (IV)	24 21 11.032	124 7 27.438	23.00

The roman number denotes the class of the triangulation points.

本報告は，仙石　新及び浅井光一が作成し，電子計算機による観測成果の算出は浅井光一が担当した．

参 考 文 献

竹村武彦・金沢輝雄，1983：水路部観測報告天文測地編，第17号，P.61
竹村武彦，1983：水路部観測報告天文測地編，第17号，P.44
竹村武彦・監物邦男，1986：水路部観測報告天文測地編，第20号，P.68
森　巧，1976：水路部観測報告天文測地編，第10号，P.42
ドップラー観測による離島の位置決定に関する従前の報告は以下の水路部観測報告に収録してある．
竹村武彦・金沢輝雄，1983：水路部観測報告天文測地編，第17号，P.61
竹村武彦・金沢輝雄，1985：水路部観測報告天文測地編，第19号，P.85
竹村武彦，1985：水路部観測報告天文測地編，第19号，P.85
竹村武彦，1986：水路部観測報告天文測地編，第20号，P.72
竹村武彦，1988：水路部観測報告衛星測地編，第 1 号，P.46

GPSによる移動体測位実験

GPS POSITIONING EXPERIMENT FOR SURVEYING VESSELS

Hydrographic Department had been a technical consultant of "Research and Development of GPS Precise Positioning System" project of Japanese Hydrographic Association from 1986 to 1989.
In 1988, test observations of this system were made by using the survey vessels Kaiyo and Kurihama in order to estimate its performance.

Key words : GPS precise positioning

水路部は，1986年度から1988年度にかけて行われた（財）日本水路協会による移動体測位のための「GPSによる精密測位システムの研究開発」の技術指導を行った．1988年には，このシステムの性能を評価するため，測量船「海洋」及び測量艇「くりはま」に精密測位システムを搭載し，移動体測位実験を行ったので報告する．

1．観　測

移動体測位実験は，２回行った．１回目は，固定点を国立天文台(三鷹)に，移動体は相模湾で動かし，GPSの測位結果とロランCの測位結果とを比較した．２回目は，固定点を同じく国立天文台に，移動体は横須賀沖で動かし，GPSの測位結果とトライスポンダーによる電波測位の結果とを比較した．観測期間中４衛星測位はほとんどできず，３衛星による２次元測位を行った．

１．１　移動体測位実験その１（相模湾）

1988年10月20日と21日に，相模湾において１回目の移動体測位実験を行った．移動体は，測量船「海洋」で相模湾をほぼ定速で走行した．航跡をFig.1に示す．アンテナは後部甲板のてすりに固定した．海面からアンテナまでの高さは，2.59mであった．ロランCのアンテナとの相対位置関係をFig. 2に示す．固定点は国立天文台においた．国立天文台に設置したアンテナの位置は，

$\phi = 35°40'29''.952$

$\lambda = 139°32'15''.427$

$h = 107.14m$

であった．この位置は，測量によって得られた経緯度を測地系変換プログラムHENKAN84によりWGS84に変換したものである．固定点と移動体の間の距離は60～90㎞であった．

１．２　移動体測位実験その２（横須賀沖）

1988年11月21日と22日に，横須賀沖で２回目の移動体測位実験を行った．移動体は，測量艇「くりはま」で，横須賀沖を走行した．航跡をFig. 3に示す．アンテナは後部甲板に固定した．海面からアンテナまでの高さは，5.30mであった．国立天文台に設置した固定点のアンテナの経緯度は前回と同一で，高さは，h＝106.85mであった．固定点と移動体の間の距離は42㎞程度であった．

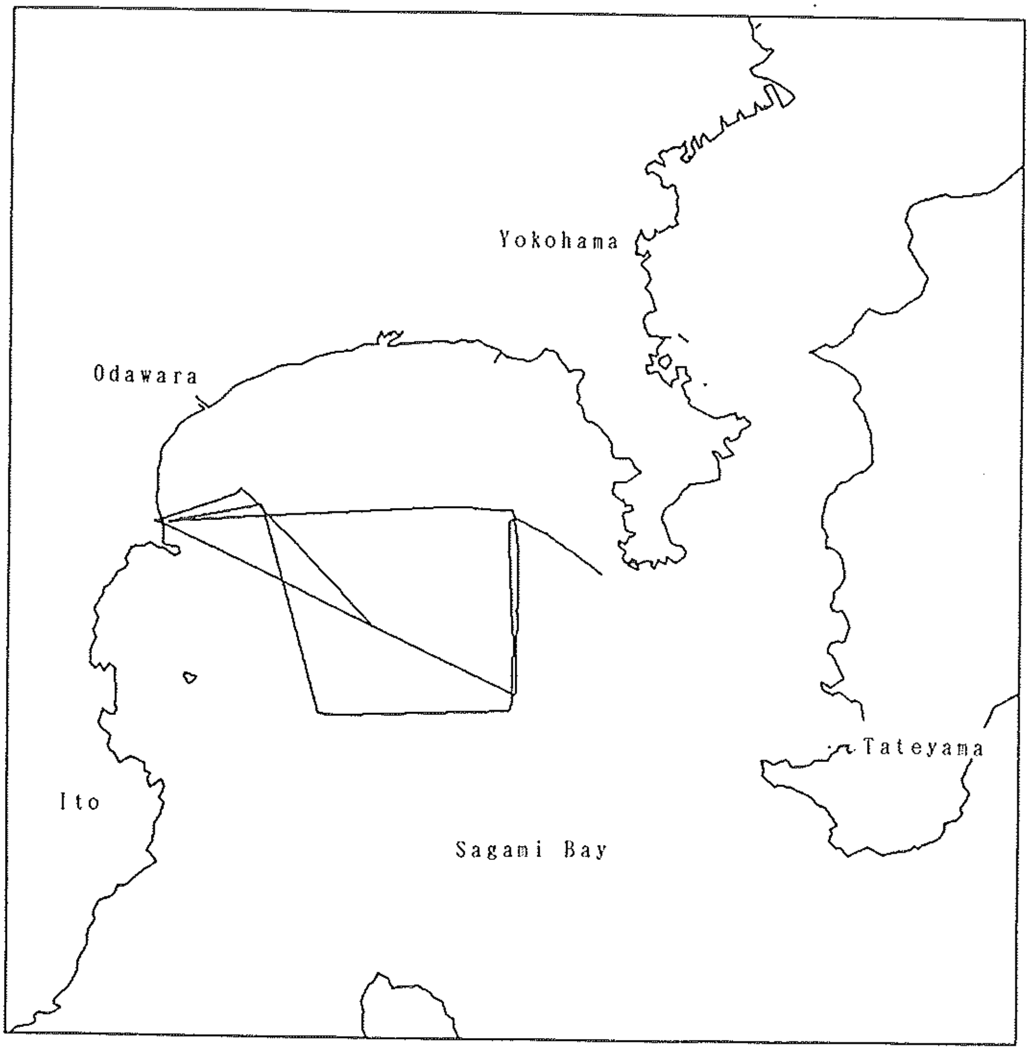


Figure 1. Trajectory of the survey vessel Kaiyo (October 20th and 21th, 1988).

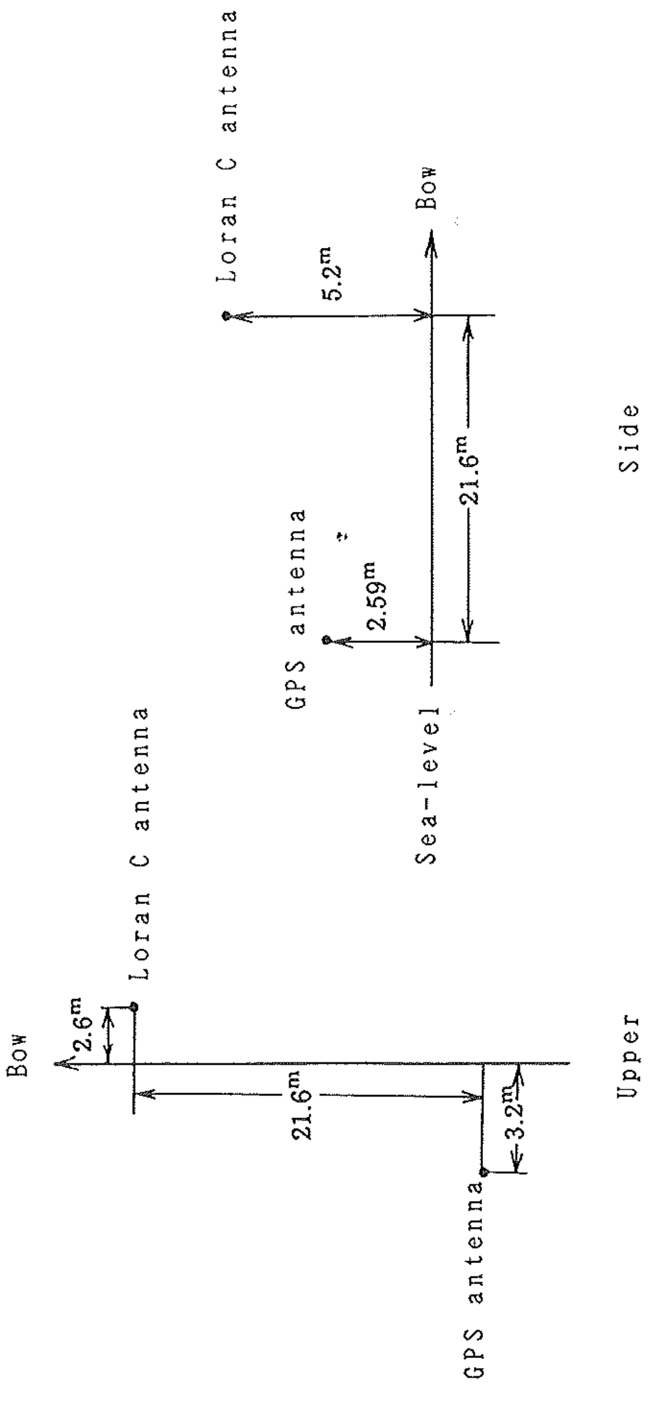


Figure 2. Configuration of two antennas at the survey vessel Kaiyo.

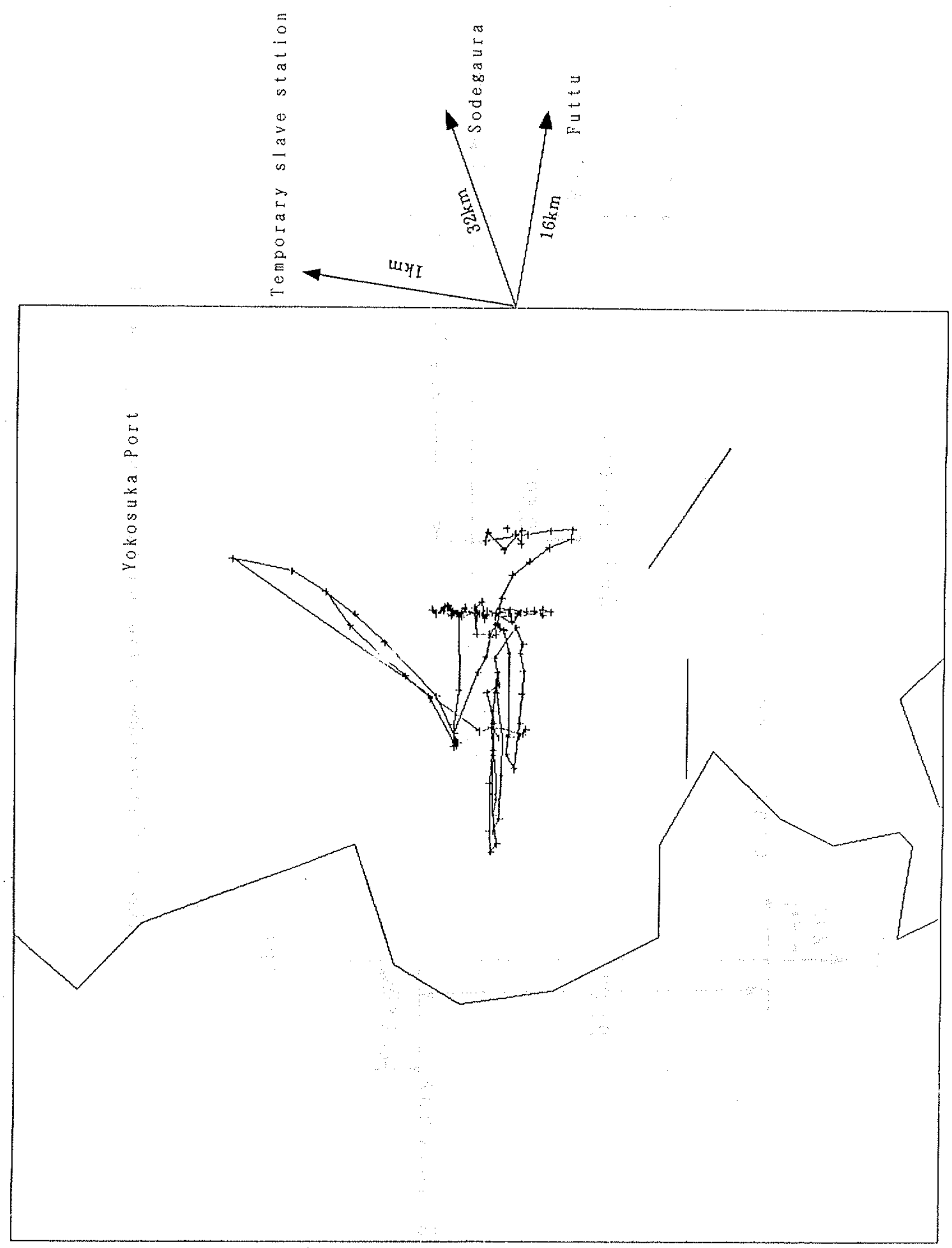


Figure 3. Trajectory of the survey vessel Kurihama (November 22th, 1988).

GPSによる測位結果を検定するため，トライスポンダー（電波測位機器）を測量艇に搭載し，同時に測位を行った．トライスポンダーのアンテナとGPSのアンテナの位置関係をFig. 4に示す．

観測期間中，衛星番号8の衛星は使用できなかったが，他の衛星については異常はなく利用できた．

2．測位解析結果

測位解析を行う前に，取得した疑似距離データを圧縮してノーマルポイントデータを生成した．2回目の移動体測位実験では，GPSの測位結果とトライスポンダーの測位結果を細かく比較するために毎秒のノーマルポイントデータを作成した．このノーマルポイントデータからトランスロケーション法により移動体の位置を求めた．位置算出法は，福島（1986），金沢他（1989）に詳しい．

衛星の軌道要素は，放送されているものを用いた．4衛星以上見える時間帯がほとんどないため，解析では楕円体高を固定した2次元測位を行った．3衛星以上が同時に見えていてGDOPが50以下の場合のみ解析を行った．

2．1　移動体測位実験その1（相模湾）

国立天文台を既知点，相模湾を移動する測量船を未知点として，トランスロケーション法により未知点の座標を求めた．位置決定は1分間隔に行い，結果をWGS84から日本測地系に変換してロランCによる測位結果と比較した（Table 1参照）．

10月21日の解析結果では，経度で約1分，緯度で約20秒の差がでた．また，10月22日の結果では，経度で6.38秒，緯度で3.01秒の差があった．各々の測位結果のばらつきはこれよりも十分小さいので，これは系統的な差であると考えられる．この原因は，次節に述べる横須賀沖における移動体測位実験の解析結果が電波測位の結果とよく一致したことから，ロランCの誤差であると考えられる．

2．2　移動体測位実験その2（横須賀沖）

2回目の移動体測位実験では，トライスポンダーによる測位結果の毎秒値が得られたので，前処理で毎秒の疑似距離のノーマルポイントデータを生成し，国立天文台を既知点，横須賀沖を移動する測量艇を未知点として，トランスロケーション法により未知点の毎秒の位置を求めた．測位結果をWGS84から日本測地系に変換して，トライスポンダーによる測位結果と比較した．

トライスポンダーは，船に主局を搭載し，陸上の既知点に固定した従局までの距離を電波により測定して測位を行う．従局の方向をFig. 3に示す．トライスポンダーは，従局の方向が直交している時が最も測位精度が高いのであるが，航跡の南西部分は従局の交角がやや小さくトライスポンダーによる測位精度が若干低い．

Fig. 5に観測中の衛星の受信状態及びGDOPを示す．GDOPは，後半に10以下となったが，前半は大きかった．

GPSによる結果とトライスポンダーによる結果とをFig. 6に示す．やや小さい黒丸がGPS，小さい点がトライスポンダーの毎秒の測位結果である．両者の違いをよりはっきりみるために，30秒おきの同時刻における測位結果を，GPSは○印で，トライスポンダーは＋印で表示している．GPSのアンテナとトライスポンダーのアンテナは2.53m離れているので，測位結果はすべてトライスポンダーのアンテナの位置にひきなおしてある．図から，2つの測位結果はほぼ10m程度であっていることがわかる．

Fig. 7は，単独測位法とトランスロケーション法の結果を同時にプロットしたものである．
トランスロケーション法の方がトライスポンダーの測位結果とよく合うことがわかる．単独測位法では数10mの誤差を生じているものと考えられる．

Fig. 8と9に11月22日のGPSとトライスポンダーの測位結果の差（前者—後者）をプロットした．GDOPが50以下の場合と10以下の場合について各々示してある．Table 2はこの差の統計である．

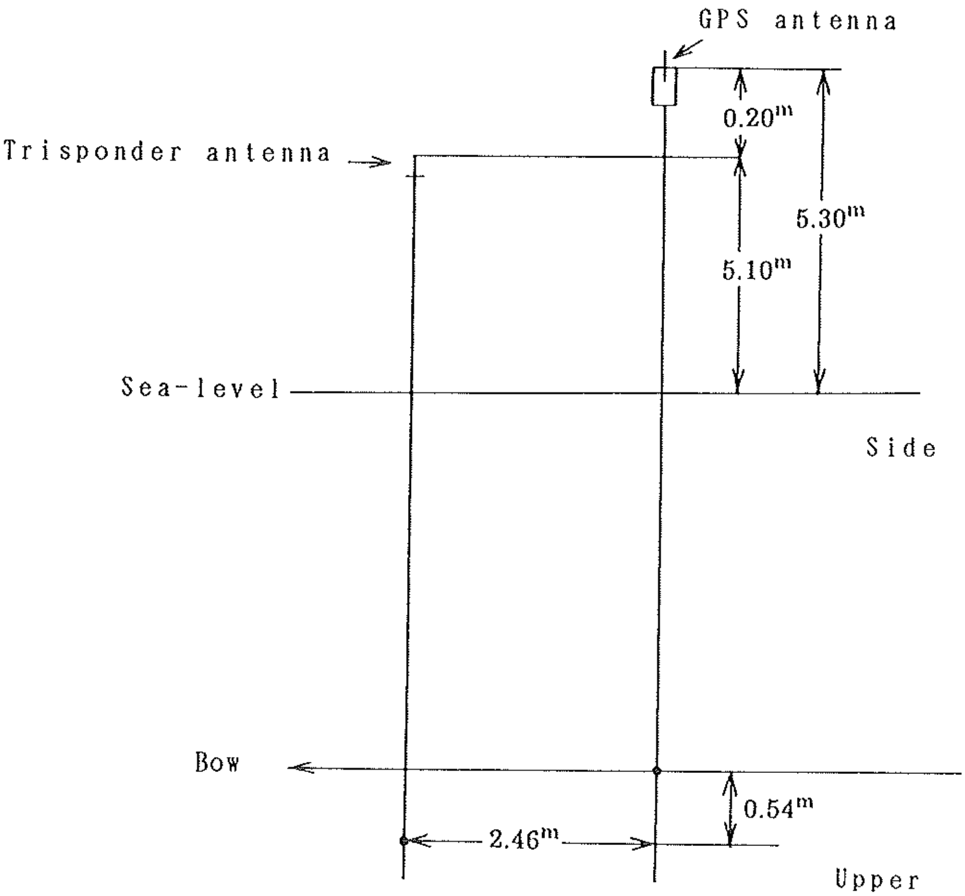


Figure 4. Configuration of two antennas at the survey vessel Kurihama.

Table 1. The positions of the survey vessel "Kaiyo"

10/21

Time (JST)	LC		GPS		LC-GPS Difference	
	Lat	Long	Lat	Long	Lat	Long
h m s	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
18 20 0	+34 59 42.72	+139 21 3.00	+35 0 4.28	+139 20 2.14	−0 0 21.60	+0 1 0.88
18 21 0	+34 59 42.84	+139 20 50.52	+35 0 4.83	+139 19 49.67	−0 0 21.99	+0 1 1.13
18 22 0	+34 59 42.66	+139 20 40.02	+35 0 5.23	+139 19 37.33	−0 0 22.59	+0 1 2.69
18 23 0	+34 59 43.32	+139 20 26.64	+35 0 5.39	+139 19 24.99	−0 0 21.95	+0 1 2.17
18 24 0	+34 59 43.68	+139 20 14.52	+35 0 5.82	+139 19 12.66	−0 0 22.22	+0 1 2.34
18 25 0	+34 59 44.58	+139 20 3.24	+35 0 6.48	+139 19 0.36	−0 0 21.90	+0 1 2.90
18 26 0	+34 59 44.58	+139 19 51.36	+35 0 6.75	+139 18 47.92	−0 0 22.25	+0 1 3.62
18 27 0	+34 59 44.34	+139 19 39.96	+35 0 7.62	+139 18 35.51	−0 0 23.28	+0 1 4.43
					Mean −22″.22 rms 0″.48	1′2″.52 1″.11

10/22

Time (JST)	LC		GPS		LC-GPS Difference	
	Lat	Long	Lat	Long	Lat	Long
h m s	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
16 9 0	+35 10 4.62	+139 25 44.04	+35 10 8.84	+139 25 38.41	−0 0 4.22	+0 0 5.41
16 10 0	+35 10 4.32	+139 25 57.00	+35 10 9.18	+139 25 51.70	−0 0 4.86	+0 0 5.30
16 11 0	+35 10 4.62	+139 26 10.02	+35 10 9.38	+139 26 4.44	−0 0 4.78	+0 0 5.42
16 12 0	+35 10 4.92	+139 26 22.14	+35 10 9.45	+139 26 17.85	−0 0 4.52	+0 0 4.14
16 13 0	+35 10 4.08	+139 26 36.24	+35 10 9.16	+139 26 31.59	−0 0 5.06	+0 0 4.49
16 14 0	+35 10 3.18	+139 26 48.96	+35 10 8.39	+139 26 44.18	−0 0 5.21	+0 0 4.78
16 15 0	+35 10 2.70	+139 27 2.82	+35 10 7.35	+139 26 55.87	−0 0 4.63	+0 0 6.73
16 16 0	+35 10 2.16	+139 27 15.48	+35 10 6.99	+139 27 9.15	−0 0 4.83	+0 0 6.17
16 18 0	+35 10 0.78	+139 27 40.62	+35 10 5.39	+139 27 33.25	−0 0 4.61	+0 0 7.22
16 19 0	+35 10 0.48	+139 27 52.86	+35 10 4.72	+139 27 46.41	−0 0 4.24	+0 0 6.45
16 20 0	+35 9 59.88	+139 28 6.24	+35 10 4.20	+139 27 59.79	−0 0 4.32	+0 0 6.45
16 21 0	+35 9 58.86	+139 28 19.14	+35 10 3.21	+139 28 12.15	−0 0 4.33	+0 0 6.79
16 22 0	+35 9 57.90	+139 28 31.38	+35 10 2.31	+139 28 24.98	−0 0 4.39	+0 0 6.25
16 23 0	+35 9 57.30	+139 28 43.62	+35 10 1.65	+139 28 37.28	−0 0 4.35	+0 0 6.14
16 24 0	+35 9 56.64	+139 28 56.34	+35 10 1.82	+139 28 50.42	−0 0 5.18	+0 0 5.72
16 25 0	+35 9 56.64	+139 29 9.48	+35 10 2.34	+139 29 4.41	−0 0 5.70	+0 0 5.07
16 27 0	+35 9 56.82	+139 29 36.00	+35 10 1.69	+139 29 28.81	−0 0 4.89	+0 0 7.01
16 28 0	+35 9 56.94	+139 29 48.84	+35 10 1.51	+139 29 41.38	−0 0 4.59	+0 0 7.28
16 29 0	+35 9 57.48	+139 30 1.80	+35 9 56.87	+139 29 48.03	+0 0 0.59	+0 0 13.55
16 42 0	+35 8 9.60	+139 30 17.46	+35 8 11.33	+139 30 8.74	−0 0 1.62	+0 0 8.69
16 43 0	+35 8 0.72	+139 30 17.76	+35 8 2.24	+139 30 9.41	−0 0 1.40	+0 0 8.35
16 44 0	+35 7 51.00	+139 30 17.82	+35 7 53.05	+139 30 9.82	−0 0 2.05	+0 0 8.00
16 51 0	+35 6 47.94	+139 30 16.56	+35 6 49.14	+139 30 10.71	−0 0 1.02	+0 0 5.83
16 52 0	+35 6 39.12	+139 30 16.20	+35 6 39.97	+139 30 11.12	−0 0 0.69	+0 0 5.12
16 53 0	+35 6 29.70	+139 30 16.38	+35 6 30.56	+139 30 10.50	−0 0 0.86	+0 0 5.88
16 54 0	+35 6 20.52	+139 30 16.74	+35 6 21.00	+139 30 10.14	−0 0 0.30	+0 0 6.60
16 55 0	+35 6 11.28	+139 30 16.50	+35 6 11.77	+139 30 9.91	−0 0 0.35	+0 0 6.60
16 56 0	+35 6 1.98	+139 30 16.68	+35 6 3.29	+139 30 11.51	−0 0 1.15	+0 0 5.15
17 1 0	+35 5 15.42	+139 30 16.20	+35 5 17.26	+139 30 11.10	−0 0 1.84	+0 0 5.10
17 2 0	+35 5 9.36	+139 30 16.68	+35 5 7.85	+139 30 10.89	+0 0 1.62	+0 0 5.77
17 3 0	+35 4 57.48	+139 30 16.62	+35 4 59.04	+139 30 11.57	−0 0 1.40	+0 0 5.05
17 4 0	+35 4 47.95	+139 30 17.58	+35 4 49.91	+139 30 11.34	−0 0 1.85	+0 0 6.21
17 5 0	+35 4 39.24	+139 30 17.58	+35 4 41.10	+139 30 12.56	−0 0 1.74	+0 0 5.02
17 12 0	+35 3 34.32	+139 30 19.14	+35 3 35.33	+139 30 11.26	−0 0 1.01	+0 0 7.88
17 16 0	+35 2 55.44	+139 30 18.42	+35 2 57.51	+139 30 11.11	−0 0 1.91	+0 0 7.33
17 17 0	+35 2 45.72	+139 30 17.52	+35 2 47.94	+139 30 10.86	−0 0 2.22	+0 0 6.66
					Mean −3″.01 rms 1″.77	6″.38 1″.62

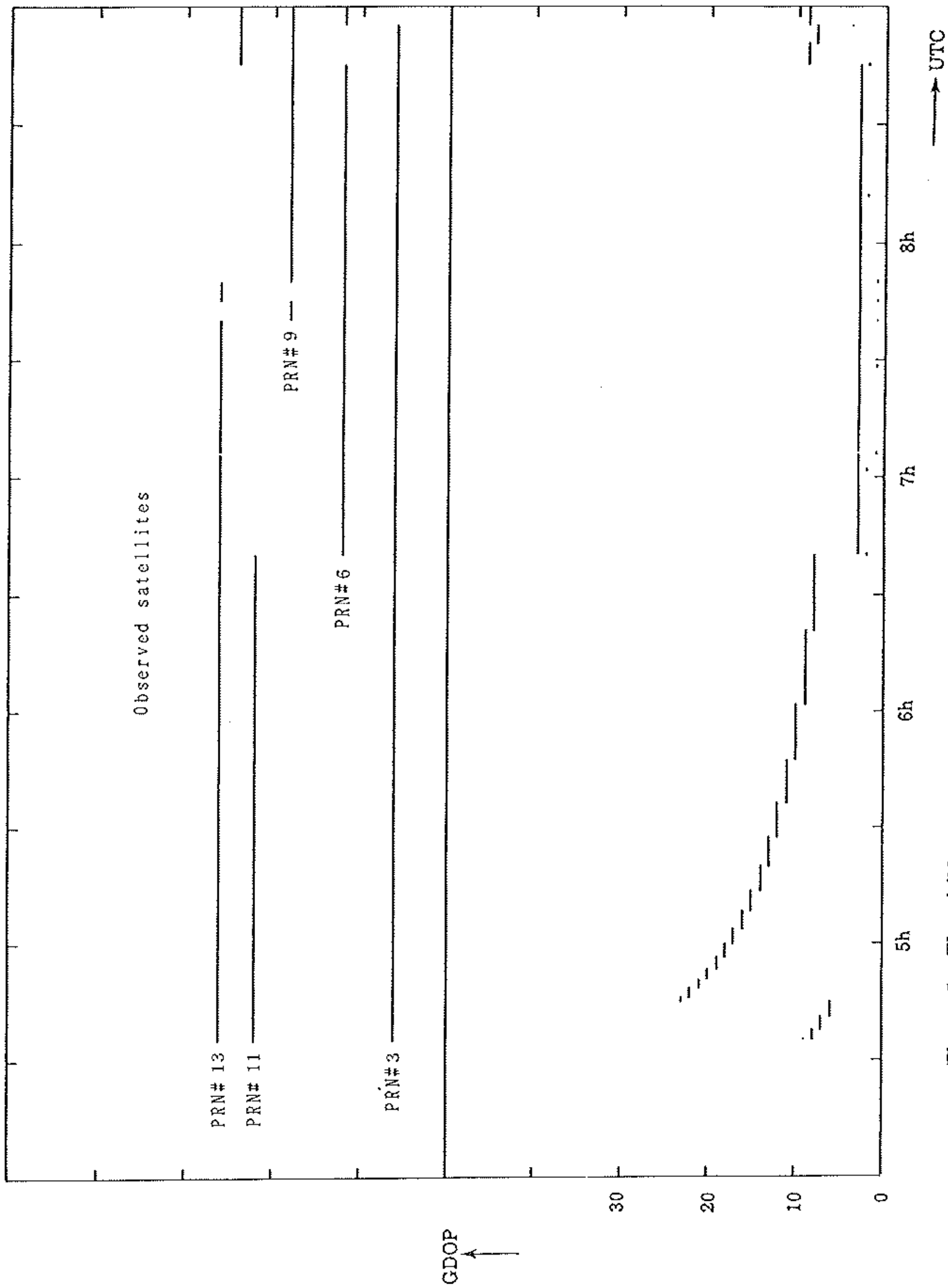


Figure 5. The visible satellites and GDOP in Sagami Bay area (October 20th and 21th. 1988).

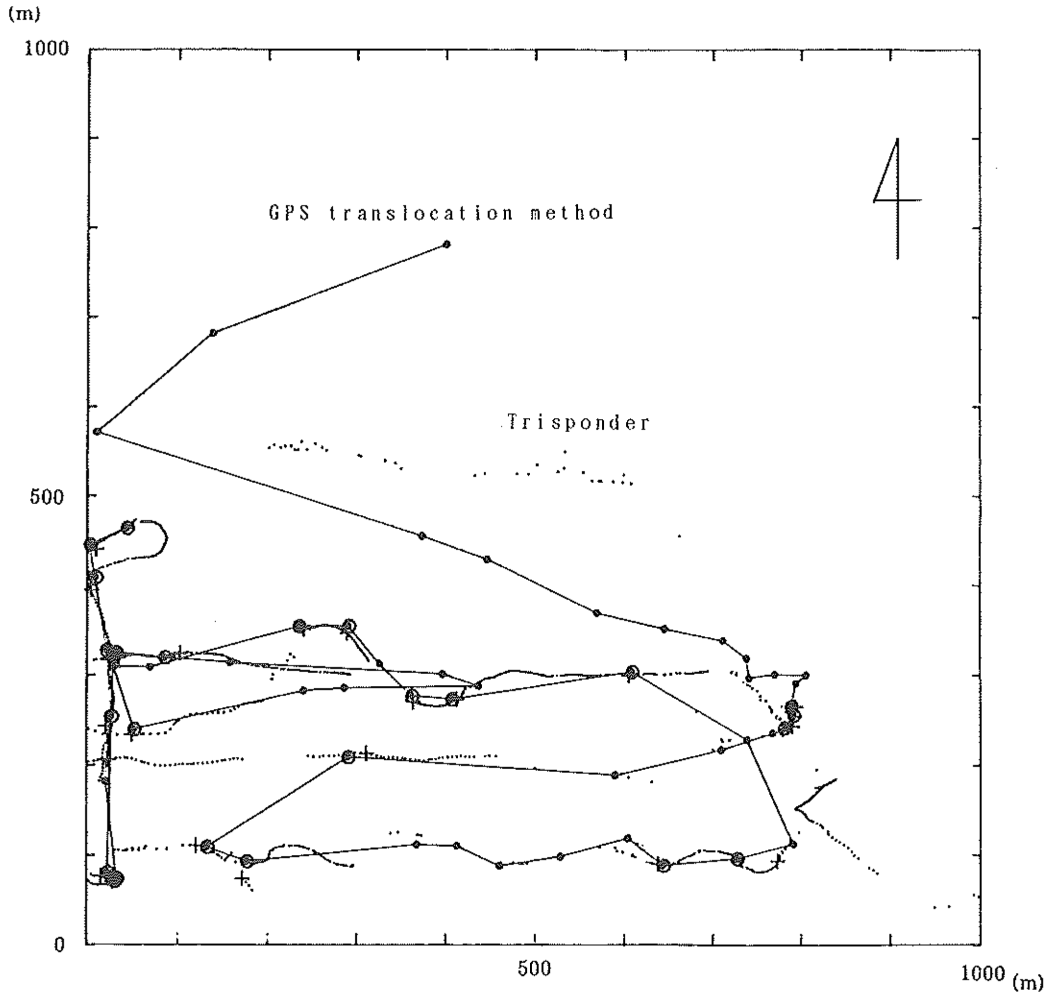


Figure 6. The positions of the survey vessel Kurihama (November 22th, 1988).

Mark ○ and + denote the determined positions by the GPS translocation technique and by the trisponder, respectively, at the same time.

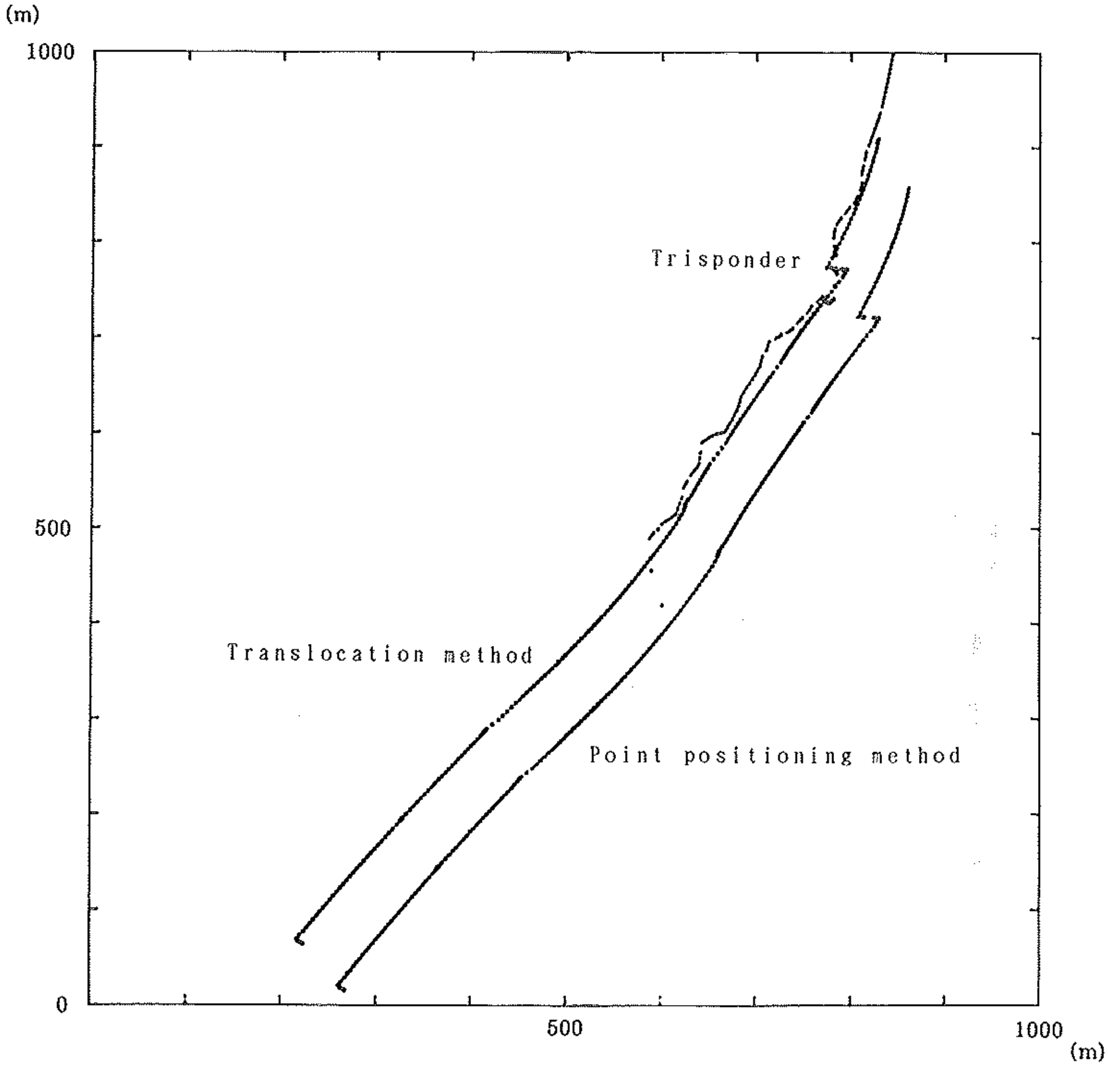


Figure 7. The positions of the survey vessel Kurihama (November 22th, 1988).
Positions determined by the GPS point positioning method, translocation technique and the trisponder.

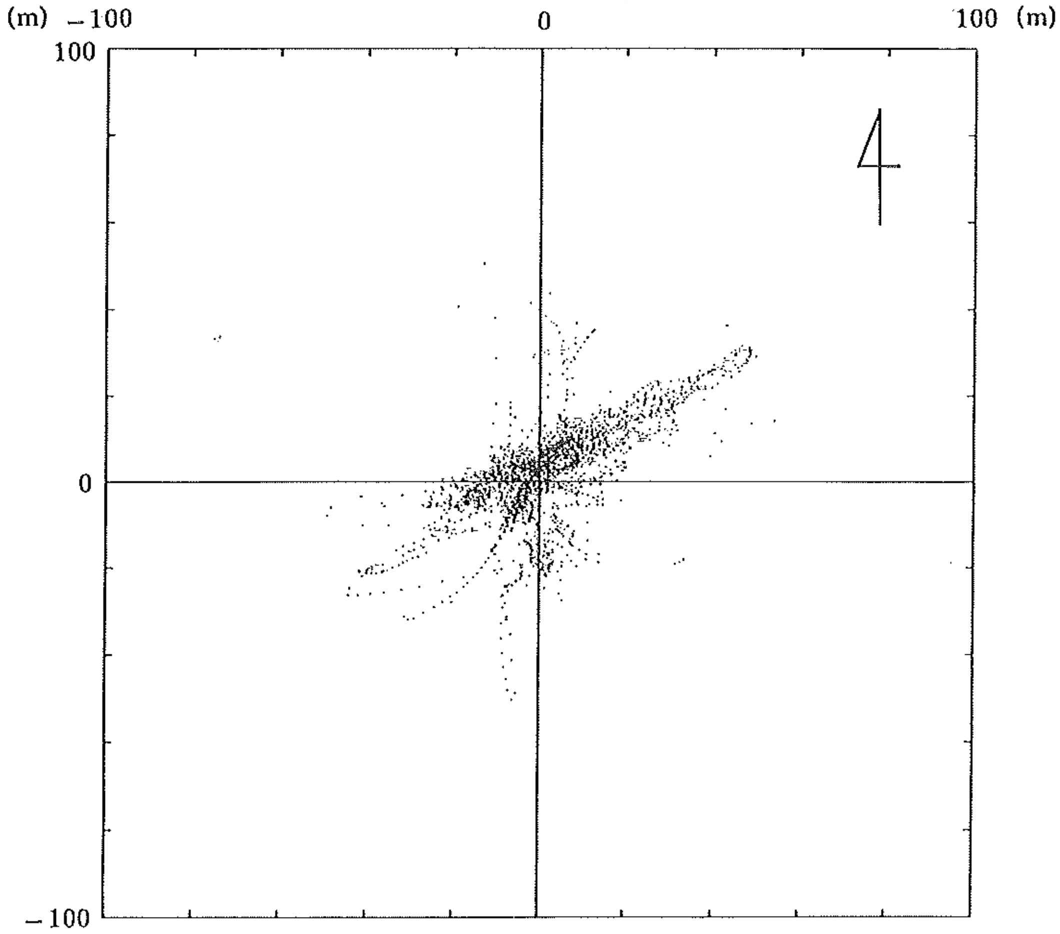


Figure 8. GPS-the trisponder (GDOP< 50, November 22th, 1988).

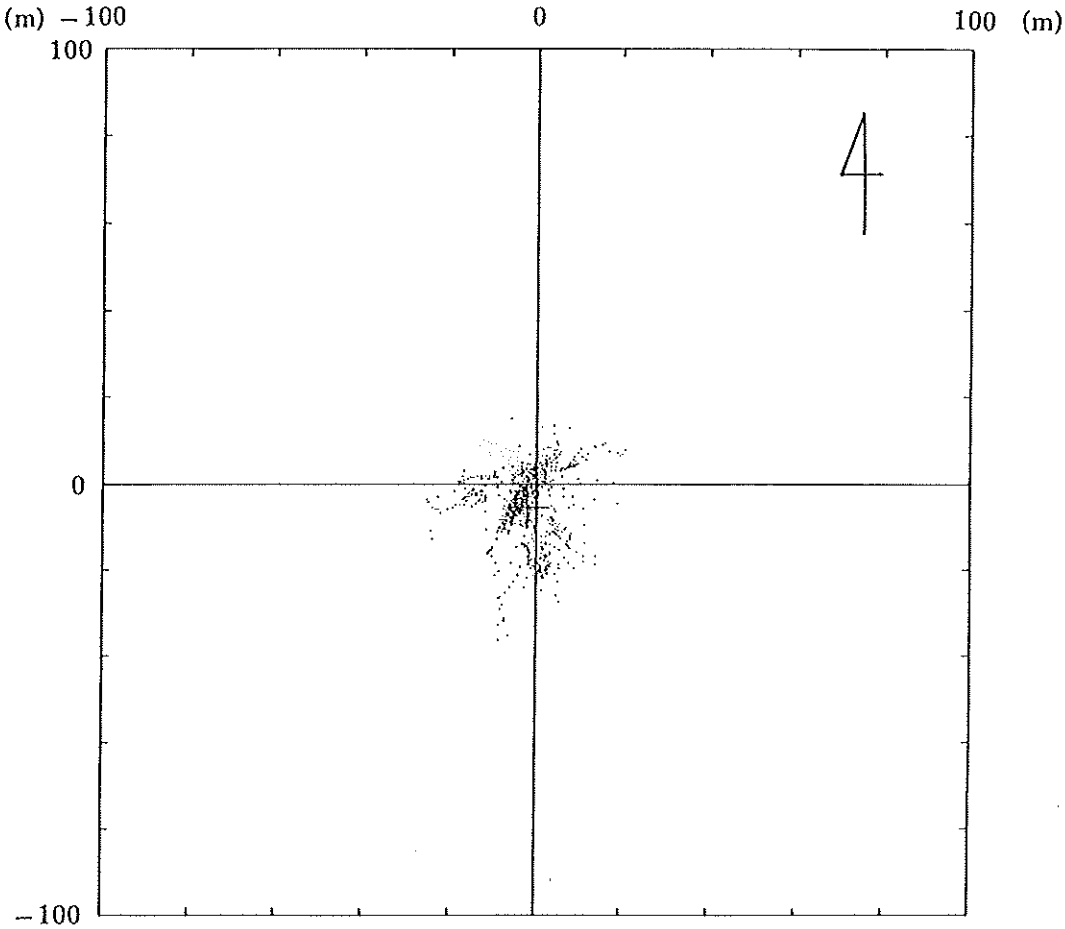


Figure 9. Site sketch for Kuro Sima.

Table 2. Statistics of GPS—trisponder

GDOP	Date	mean of GPS — trisponder north component(m)*	east component(m)*	absolute value(m)	r.m.s. (m)
50>	2894	2.58	2.06	3.30	18.2
10>	826	−5.35	−1.99	5.71	10.6

*positive in the north and east direction

GDOPが10以下の場合測位のばらつきが10m，GDOPが50のデータまで採用するとばらつきが18mとなった．差の平均値は，GDOPは10以下で5.71m，GDOPが50以下で3.30mであった．

この測位の差の平均値及びそのばらつきの原因としとは，GPSに起因するものが大部分と考えられるが，トライスポンダーの測位結果も，受信状態が良くない時は10mのオーダーでふらついており，トライスポンダーの測位誤差もその一因となっている．今回の観測では両者を分離することは事実上不可能である．

本報告は，仙石新が作成し，測位計算は淵田晃一が行い，観測は浅井光一と淵田晃一が行った．

参 考 文 献

日本水路協会（財），1989："GPS（全世界測位システム）による精密測位システムの研究開発" 報告書
福島，1986："GPS—人工衛星による精密測位システム—"，（社）日本測量協会
金沢，仙石，淵田，1989："GPSトランスロケーション法による船位の決定"，海洋調査技術第1巻第1号

「南太平洋における海洋プレート形成域（リフト系）の解明に関する研究」におけるGPS精密測位（1988）

GPS EXPERIMENT IN THE JAPAN AND FRANCE JOINT RESEARCH PROGRAM ON RIFT SYSTEM IN THE SOUTH PACIFIC OCEAN (STARMER PROJECT) IN 1988

The Hydrographic Department of Japan (JHD) has been joining the research program on rift systems in the South Pacific Ocean promoted by the Science and Technology Agency of Japan (STA) and the France Institute of Research and Exploitation of Marine (IFREMER). In this project, JHD took charge of precise positioning in the research area and analyzing the sea bottom topography of the North Fiji Basin area.

This report describes the results on the precise positioning by GPS observation during the cruise in 1988 as follows :

1) Reconstruction of the precise positioning system,
2) Research in North Fiji Basin area, and
3) Experimental observation between Simosato Hydrographic Observatory and Minami Tori sima.

Key words : GPS precise positioning-Rift System

水路部では1987年４月から1990年３月までを第Ｉ期として計画されている標記研究（科学技術振興調整費による）に参加し，海底精密地形の調査，研究を行うこととしている．本報告では，1988年に実施した作業のうち，航法測地課で担当した人工衛星を用いた精密測位観測について記述する．当課で実施した主な作業は以下のとおりである．

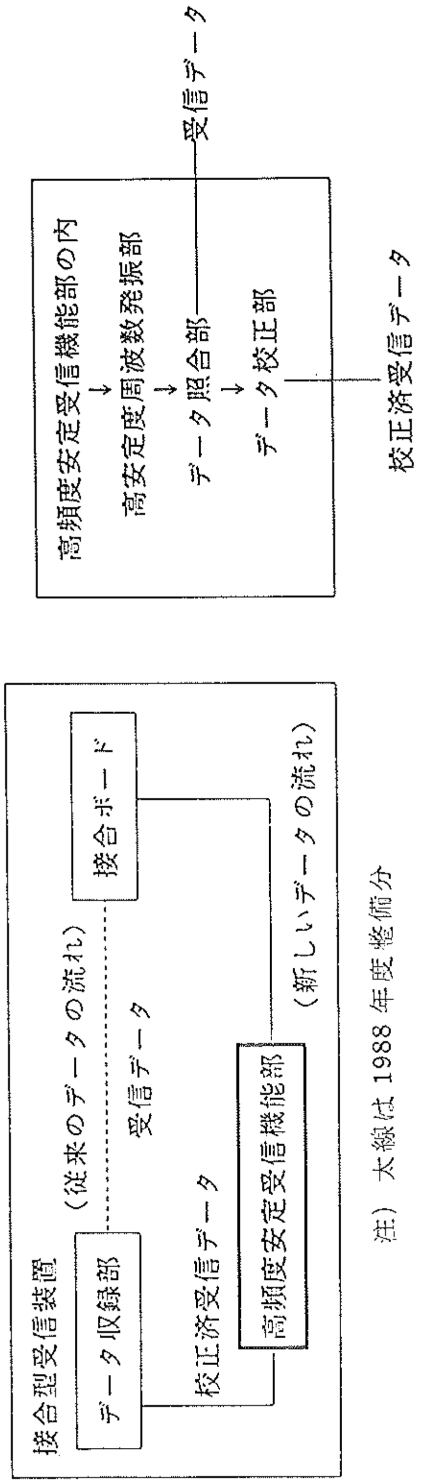
1）精密測位システムの改造．
2）南太平洋（北フィジー海盆域）における調査．
3）下里水路観測所～南鳥島試験観測．

１．精密測位システムの改造

1988年においては，1987年に整備した精密測位システム（竹村，1988）について，GPSによる測位時間帯の拡大を図るために，接合型受信装置の改造（高頻度安定受信機能部の付加）を行った（Fig. 1 参照）．

1987年に整備した接合型受信装置は，測位に必要な受信機内の周波数の安定度が低いため，移動する船の位置を高い精度で決定するには３個以上の衛星を同時に受信する必要があった．このため高い精度で測位出来る時間帯が限られており，さらに２衛星受信時の測位精度が低くかつ測位間隔が長いという欠点があった．1988年においては，接合型受信装置に主にセシウム原子時計からなる高頻度安定受信機能部を付加した．これは，高安定の周波数を発振し，接合型受信装置内の発振周波数の誤差を修正して正確な船位の測定を行うものである．この改造によって，２衛星受信時の測位精度が向上するとともに，測位頻度が上がったため，船位を常時所要の精度で把握可能となった．また測位精度評価のための試験観測を下里水路観測所～南鳥島間で実施し，単独解，トランスロケーション法による解及びNNSSによる結果の比較を行った．

接合型受信装置の改造の構成



注）太線は1988年度整備分

Figure 1. Update of GPS receiver set.

2．南太平洋（北フィジー海盆域）における調査

海洋科学技術センターの作業実験船「かいよう」によって行われた南太平洋北フィジー海盆域のリフト系の調査の概要及び同海域で実施したGPSによる精密測位観測の結果について述べる．

1）作業概要

期　間　1988年11月9日（成田発）から
1988年12月21日（成田着）まで　43日間
観測員の往復は航空機によった．

作業区域　船上班　南太平洋北フィジー海盆域（Fig.2参照）
陸上班　仏領ニューカレドニア　ヌーメア市

作業実験船　「かいよう」　2,849G/T

基地港及び寄港地　横須賀（海洋科学技術センター専用岸壁）
ニューカレドニア島（仏領）ヌーメア港
フィジー国スバ港

調査項目　「かいよう」搭載のシービーム装置による海底地形調査及び人工衛星を用いた精密測位観測

担当者　海上班　海洋調査課　岩渕　洋
陸上班　航法測地課　内山　丈夫

2）GPSを用いた精密測位観測

船上局として作業実験船「かいよう」に，また陸上局としてニューカレドニア（仏領）ヌーメアにGPS受信機を設置して，リフト系作業期間中GPS衛星の同時観測を実施した．

イ）機器設置

船上局　アンテナ：「かいよう」頂部甲板 左舷マスト上
受信機　：総合司令室
電　源　：精密電源（AC100V，60Hz）
担当者　：岩渕　洋

陸上局　アンテナ：フランス海外領土科学技術局（ORSTOM）ヌーメアセンター庁舎屋上
受信機　：庁舎2階　No.91号室内
電　源　：商用電源AC200V，50Hzを降圧トランスを用いAC100Vにして使用した．
担当者　：内山　丈夫

使用機器　GPS受信機（JLR-904A）　日本無線　（船上及び陸上局）

ロ）観　測

船上局は11月11日から12月16日まで，陸上局は11月11日から12月18日まで各々観測を実施した．

衛星モード　：2，3，4衛星モード自動選択
ディスクへの出力頻度：出力1　2秒毎　後半は3－4秒毎
出力2　5分毎
データ記録　：フルディスク（容量10メガバイト）

線の上部はDopの値を下部は受信衛星数を，各々示している．単独受信の場合Dopが小さいと位置決定精度が良い．

図中で白い部分は受信が安定していることを，黒い部分は受信が不安定なことを示している．

衛星からの電波受信状況をFig. 3に示す.

陸上局では, 11月14日から11月30日までディスプレイが故障したため, その間毎日のブルディスクの交換時に行う初期値の設定をディスプレイ無しで実施した.

ハ) 航跡図の作成

GPS衛星は全部で21個打ち上げられる予定であるが, まだ打ち上げ数が少なく, 調査期間中使用可能なGPS衛星は, PRN No.（疑似雑音番号, 以後No.と記す）で3, 6, 9, 11, 12, 13と全部で6個であった. GPS衛星の観測ができない時間帯は, NNSSと推測航法データによる測位を実施した.

ニ) データ解析

データ解析はデータ編集プログラム（淵田, 川井作成）及び解析プログラム（久保作成）により行った.

3. 下里〜南鳥島試験観測

南鳥島で実施した一次基準点観測に併行して, 1500km程離れた2地点, 下里水路観測所及び南鳥島間で, 測位精度評価のための試験観測を実施した.

観測場所, 担当者

下　里　下里水路観測所屋上（Fig. 4参照）　内山丈夫

南鳥島　滑走路脇に設置した一次基準点観測用レーザー測距装置シェルター上（Fig. 5参照）

仙石　新　　淵田晃一

観測期間

下　里　1989年3月6日15：30〜3月8日15：30

南鳥島　1989年3月5日10：50〜3月10日10：30

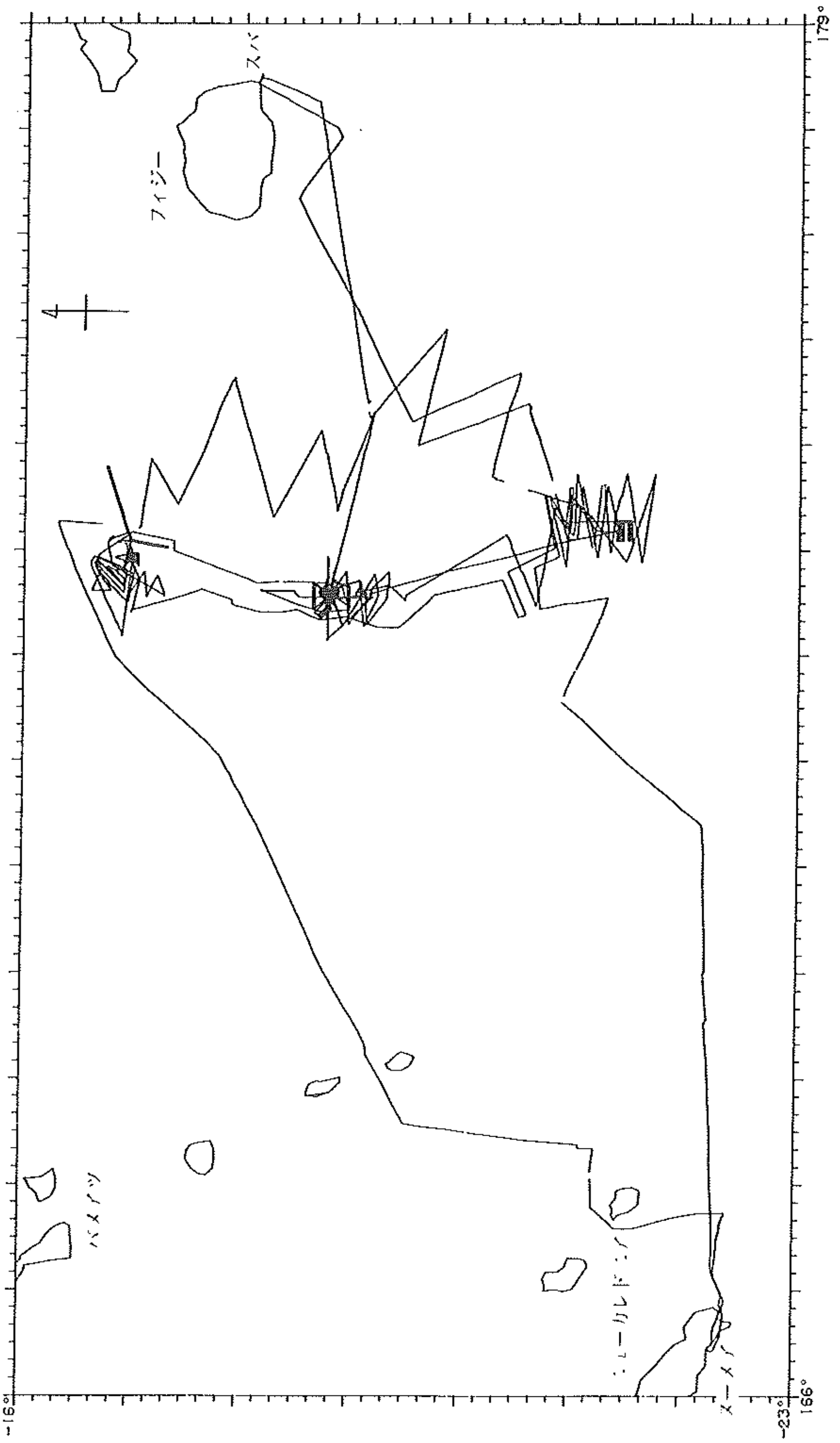


Figure 2. Track chart of Kaiyo.

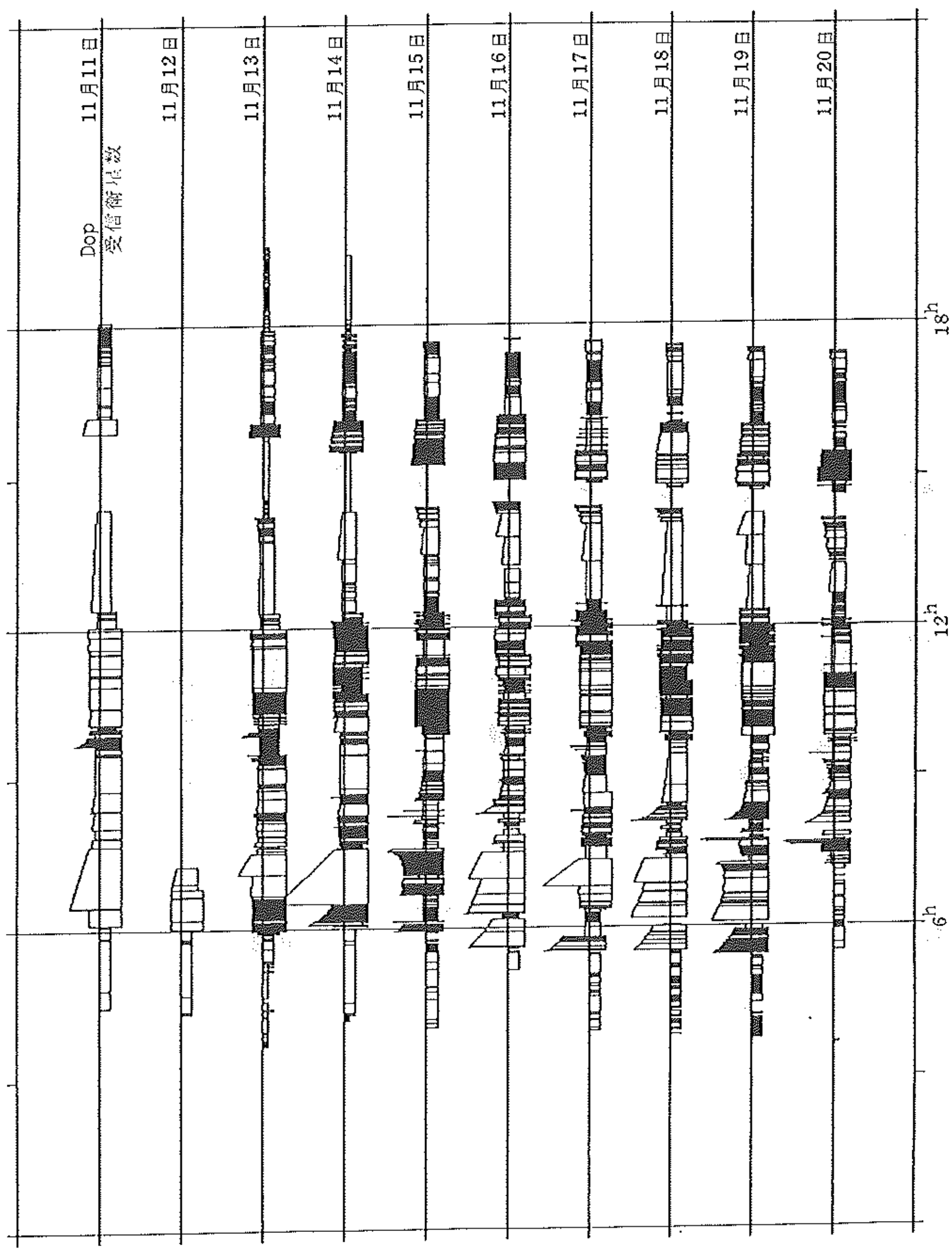


Figure 3. Satellite wave reception (Kaiyo).

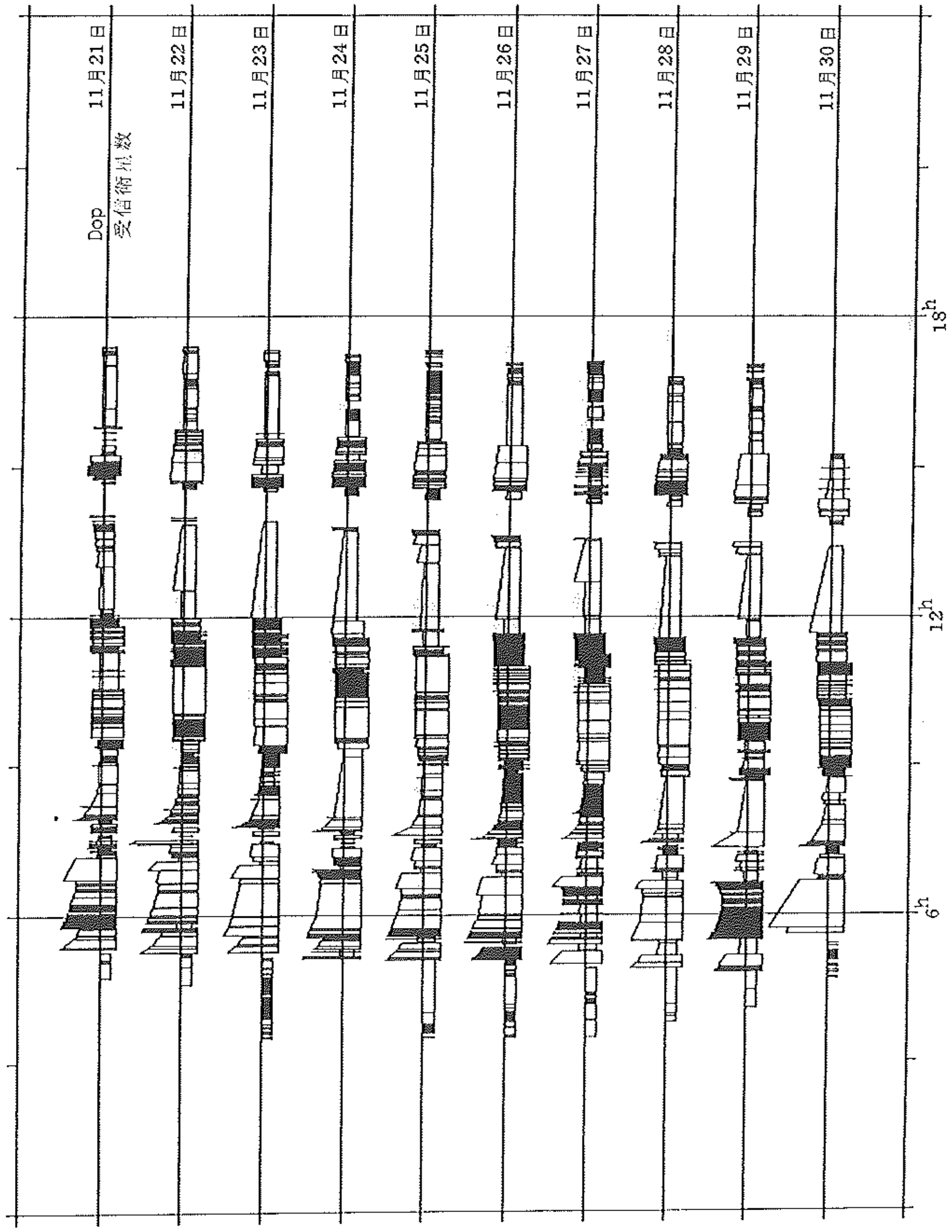


Figure 3. Satellite wave reception (Kaiyo).

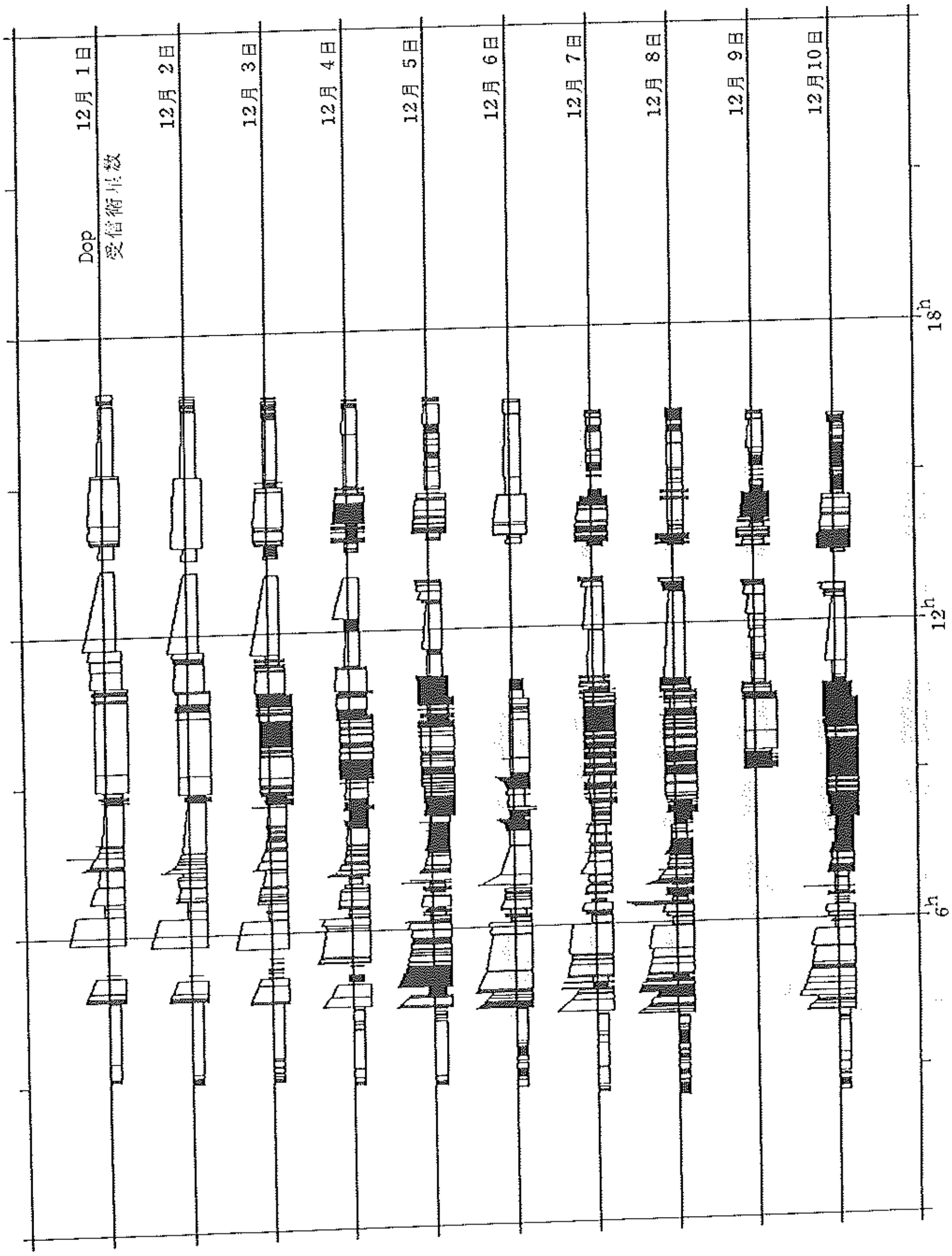


Figure 3. Satellite wave reception (Kaiyo).

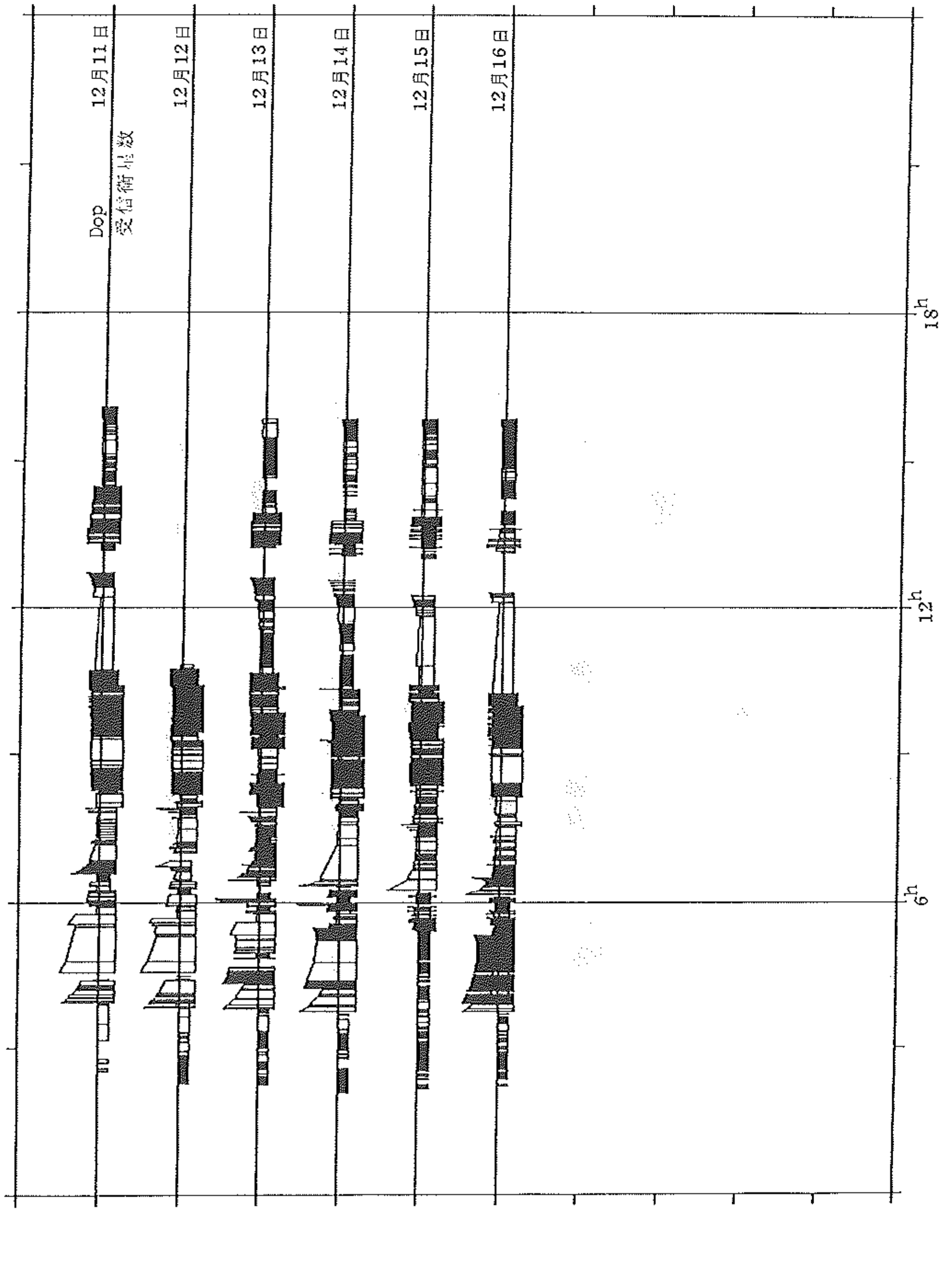


Figure 3. Satellite wave reception (Kaiyo).

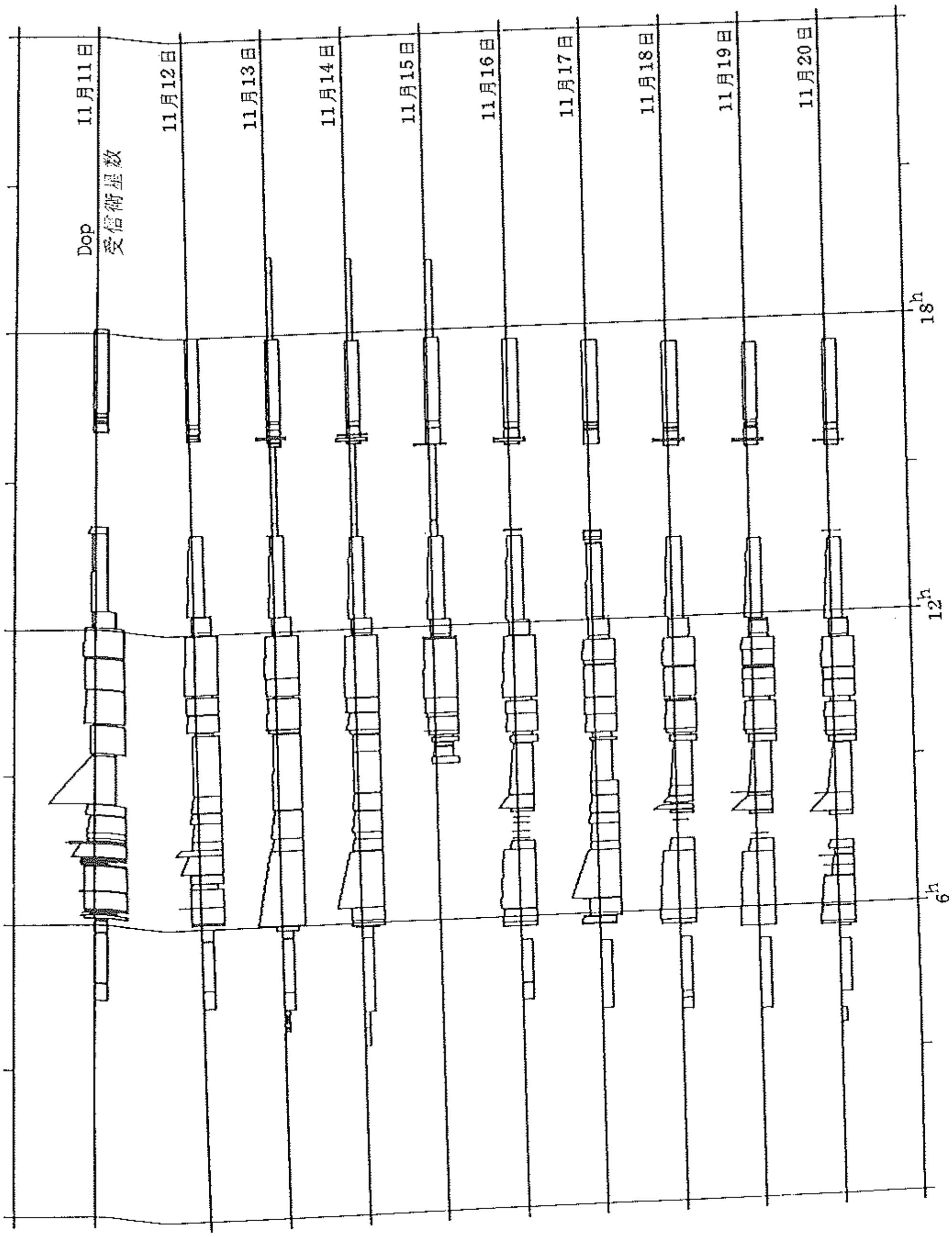


Figure 3. Satellite wave reception (Noumea).

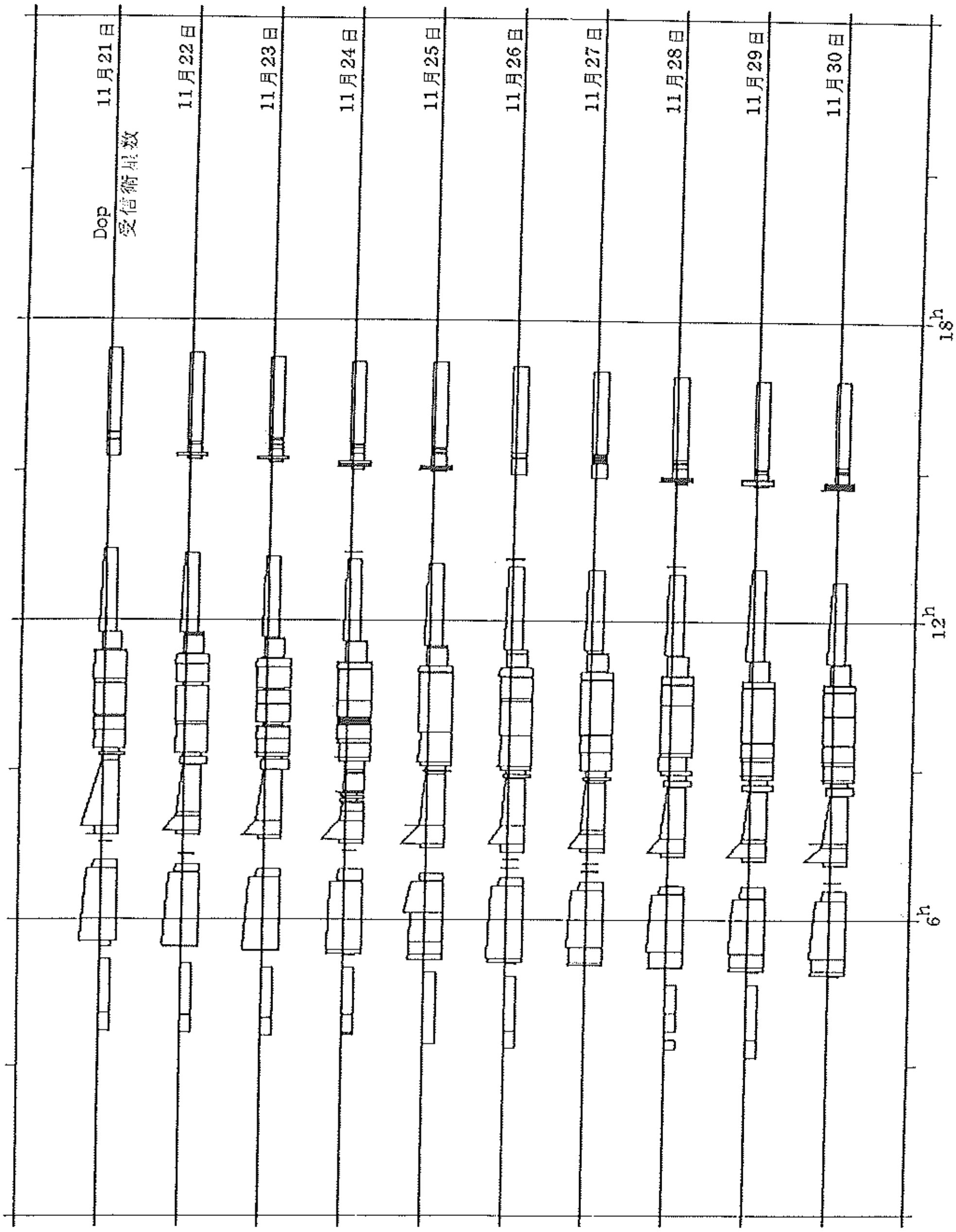


Figure 3. Satellite wave reception (Noumea).

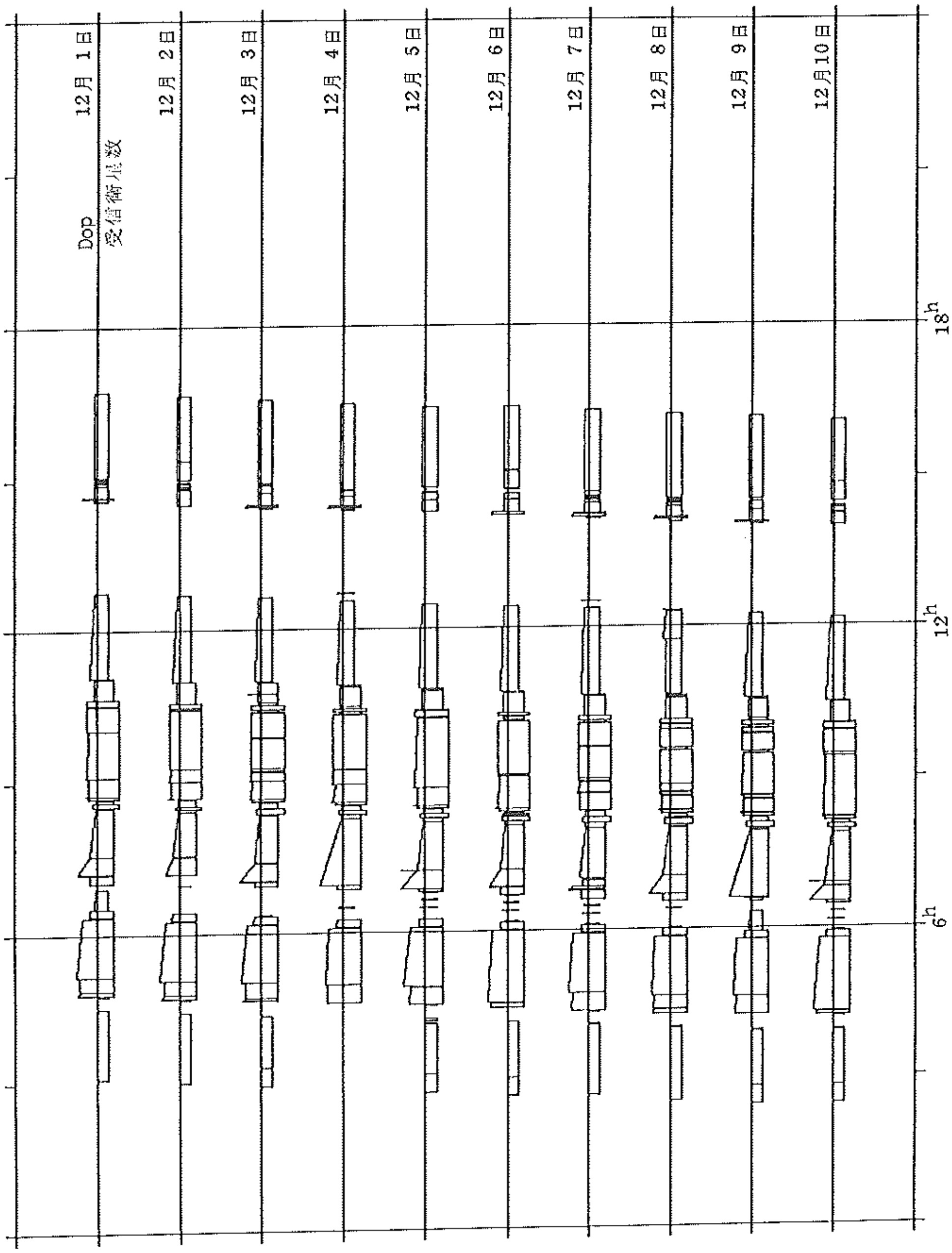


Figure 3. Satellite wave reception (Noumea).

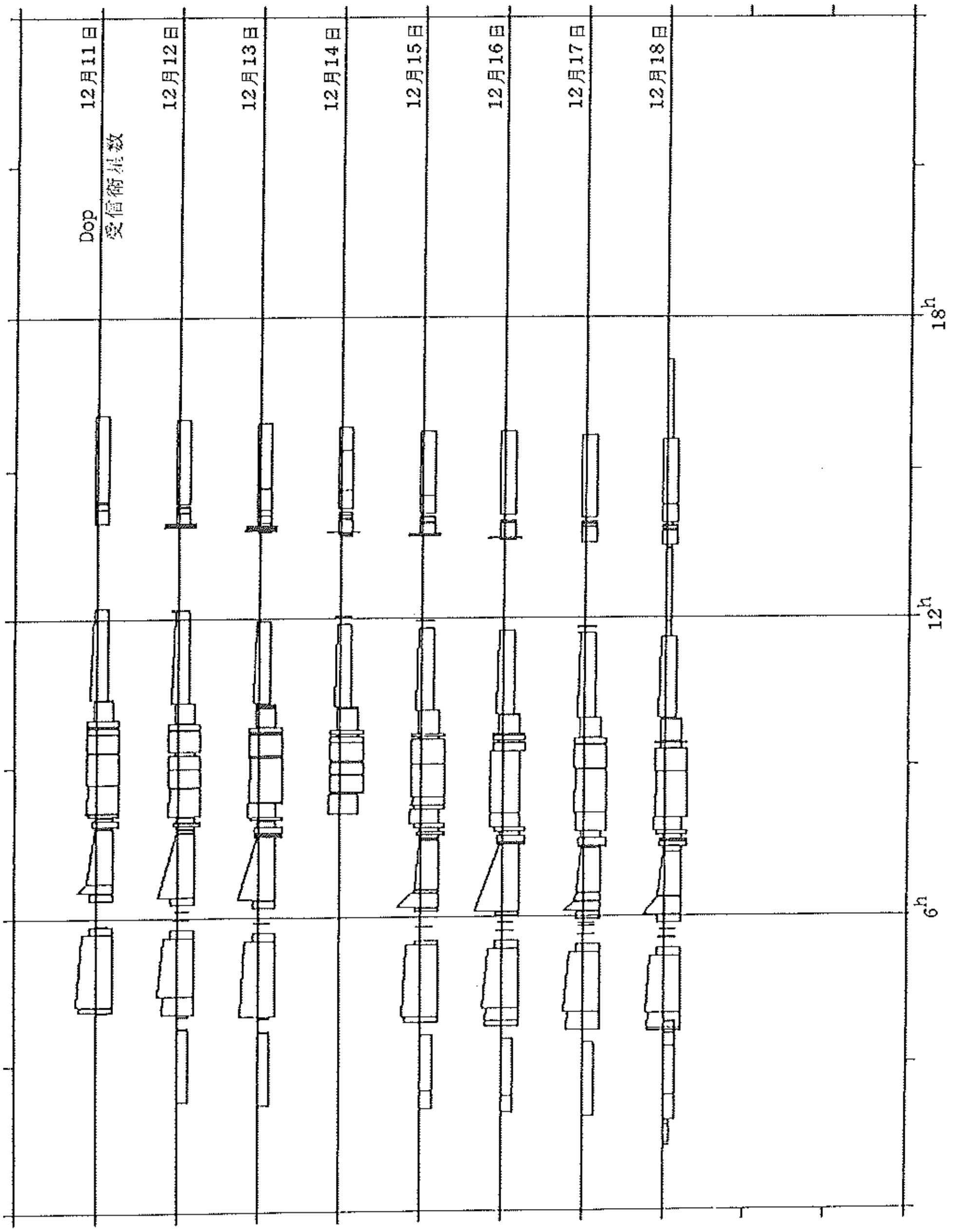


Figure 3. Satellite wave reception (Noumea).

H：基準点標石
Fiducial stone marker

A：航行衛星アンテナ
NNSS antenna

I：60cm反射赤道儀
Center of rotation of the 60cm reflector

L：レーザー測距装置，Cの2.10m上方
Center of rotation of the satellite laser ranging system, 2.10m above C

G：GPSアンテナ
GPS antenna

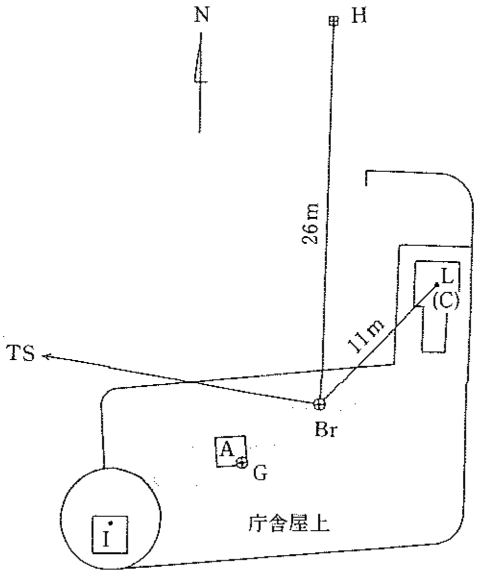


Figure 4. Simosato.

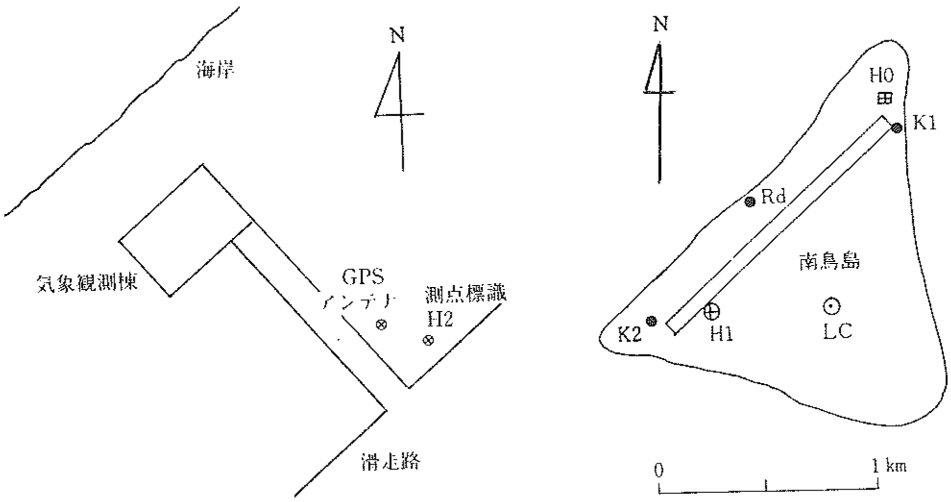


Figure 5. Minami-tori-sima.

あとがき

本報告は，内山丈夫が作成し，電子計算機による観測成果の算出は淵田晃一・川井孝之が担当した．本報告では1988年に実施した観測について記述したが，機器を一部改良し，1989年にも引続き南太平洋のリフト系の調査を実施する予定である．したがって，本報告に記述した機器の構成等に若干の変更がありうる．

最後に本研究の推進並びに現地における観測作業に協力いただいた各位に多大の感謝を捧げる次第である．

参 考 文 献

Scientific Party on Board Kaiyo, 1987 : *STARMER Cruise Report, Kaiyo 87 Cruise in the North Fiji Basin.*

竹村武彦，1983～1986：水路部観測報告天文測地編，第17～20号

竹村武彦，1988：水路部観測報告衛星測地編，第１号，P.46

竹村武彦，1989：水路部観測報告衛星測地編，第２号，P.83

平成２年３月13日印刷
平成２年３月23日発行

発　行　者	海　上　保　安　庁 東京都千代田区霞が関２丁目１番３号 （郵 便 番 号 100） 電 話　東 京（03)591－６３６１(代)
編　集　者	海 上 保 安 庁 水 路 部 東京都中央区築地５丁目３番１号 （郵 便 番 号 104） 電 話　東 京（03)541－３８１１(代)
印　刷　者	株 式 会 社 サ　ン　ワ 東京都千代田区飯田橋２丁目11番８号 平和第５ビル （郵 便 番 号 102） 電 話 東 京（03）265―1816（代）