SATELLITE LASER RANGING

EARTH ORIENTATION RESULTS FROM THE CENTER FOR SPACE RESEARCH ANALYSIS CENTER CSR 89 L 02

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Earth orientation parameters were derived from the 1989 Lageos quick-look data using the models and terrestrial reference from the previously reported series labelled EOP (CSR) 89 L 02. The results for 1989 are a continuation of the 89 L 02 series with the exception that the relative weights for some of the stations were changed and, overall, the formal uncertainties were scaled downward to better match the internal consistency of the series.

Three day intervals were used for the solutions whenever the quantity and distribution of the data were sufficient. The last two intervals of 1989 had to be combined and used as a 6-day arc. The three day intervals used are centered on dates for which the Modified Julian Date is divisible by 3. In each interval 8 parameters were adjusted, 6 orbital elements of Lageos plus the x and y component of polar motion, using the range residuals from a long arc beginning 15 Nov 1988 and ending 28 Mar 1990. The UT1R estimates are obtained from the Lageos node residuals of this long arc along with the constraint that they follow IRIS VLBI results at periods greater than about 60 days. Hence regardless of the terrestrial system's longitude origin, the origin of the UT1 series is that of IRIS VLBI.

Station positions were held fixed to the SSC (CSR) 89 L 02 values (see IERS Technical Note No 2; p. 54). This station position solution was obtained from all of the Lageos data through February 1989. The Minster-Jordan plate motion model AM1-2 was held fixed in the adjustment. To correct the EOP series to the AM0-2 plate motion model subtract linear terms with slopes of 0.50 and 0.23 milliarcsec/yr from x and y respectively. No correction to UT1 is required.

Table 1 shows the statistics for the 18 stations contributing the most observations to the solutions. The last column shows the standard deviation of the range observations that was used to derive the formal uncertainties a for the EOP values.

Table 1- STATIONS WITH MORE THAN 1000 2-MINUTE NORMAL POINTS IN THE LONG ARC USED FOR THE 1989 REPORT

STATION	#PASSES	#OBS	RMS (cm)	PREC (cm)	SIGMA
7080 MCDON4	403	4697	3.9	1.2	15
7090 YARAG	376	6256	3.6	.6	15
7097 EASTR2	102	1047	6.4	1.3	30
7105 GRF105	204	2767	3.6	.6	15
7109 QUINC2	327	5036	4.2	.5	15
7110 MNPEAK	481	7166	3.9	.7	15
7122 MAZTLN	211	2744	4.5	.6	15
7210 HOLLAS	151	1889	7.6	1.8	15
7288 MOJAV2	94	1427	3.5	.9	30
7810 ZIMMER	284	3820	7.9	3.7	30
7834 WETZEL	152	1702	7.2	2.8	30
7835 GRASSE	844	12827	6.0	1.5	15
7838 SHO	124	1745	7.7	2.8	20
7839 GRAZ	206	2728	5.2	1.1	15
7840 RGO	635	6913	5.8	2.5	15
7843 ORRLLR	299	3141	5.3	1.2	20
7907 ARELAS	245	2957	12.8	9.1	30
7939 MATERA	280	4180	10.9	7.8	30

EOP(CSR) 89 L 02 Available from 1976 to 1989

Number of measurements and RMS uncertainty per year
Units : 0.001" for X,Y,dPsi,dEps; 0.0001s for UT; ms for D

YEAR	X		Y		UT1	
	Nb	Sigma	Nb	Sigma	Nb	Sigma
1976	16	7.53	16	7.24	16	4.16
1977	24	4.31	24	3.40	24	2.55
1978	18	4.04	18	3.27	18	2.39
1979	38	2.64	38	2.28	38	1.66
1980	61	2.04	61	1.49	61	1.21
1981	62	2.55	62	1.74	62	1.24
1982	60	2.14	60	1.44	60	1.30
1983	81	1.64	81	1.84	81	1.10
1984	122	1.36	122	1.43	122	1.13
1985	121	1.37	121	1.40	121	0.98
1986	122	1.30	122	1.22	122	1.00
1987	122	1.28	122	1.25	122	1.02
1988	122	1.68	122	1.82	122	1.35
1989	120	0.95	120	0.90	120	0.75

EARTH ORIENTATION PARAMETERS AND STATION COORDINATES OF THE SOLUTION DGFII 89 L 03

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The Solution (DGFII)89L03 is a five-year LAGEOS solution as part of DGFI's reprocessing program of all LAGEOS data since 1980. It is using a carefully rescreened Full-rate ranging data set of 19708 LAGEOS passes in the period 1983 to 1987. A new model MMD2 is used, and a new set of solve-for parameters is chosen including horizontal station motions.

1.) The model

The model underlying the (DGFII)89L03 solution is the DGFI LAGEOS Model MMD2 [Reigber *et al.*, 1989] used for parameter estimation within the DGFI Orbit and Geodetic Parameter Estimation Program (DOGS). The Model MMD2 is described hereafter.

Reference Frame

CIS	: mean equator and equinox of J2000.0
Precession	: IAU 1976 (MERIT standards)
Nutation	: IAU 1980 + Herring 1987 correction
Planetary Ephemerides	: DE200/LE200 ephemerides
Initial Pole Series	: BIH87C02S homog. series (corr. to mean pole)
UT1 Parameter	: BIH87C02S homog. series
Initial Station Coordinates	: DGFI 87L03
Initial Station Velocities	: Zero
Rotation of Coordinate System	: stations 7086, 7090, 7105, 7109, 7110, 7122, 7210, 7810, 7834, 7835, 7838, 7839, 7840, 7907, 7939 [c.f. Bender/Goad, 1979]

Dynamical Model

GM	: 3.98600440 E+14 m**3 s**-2, to be solved for
Semi Major Axis of Earth	: 6378136 m
Eccentricity 1/f	: 298.257810
Rotation of Earth	: 0.7292115 E-4 rad/s
Gravity Model of Earth	: GEM-T1
C(2,1), S(2,1)	: applied, computed with respect to zero mean pole
Gravity Model of Moon	: Ferrari 77 (4*4)
Third Body	: Sun, Moon, Jupiter, Venus, Saturn, Mars, Mercury
Air Drag	: not applied
Albedo	: Heurtel analytical model
Ocean Tides	: GEM-T1 (32 waves)
Solid Earth Tides	: MERIT standards (Wahr model), with permanent tide (H-term) not removed
Relativistic Motion Equation	: harmonic isotropic

Measurement Model

Marini-Murray Refraction Model : MERIT standards
Solid Earth Tides Displacement : MERIT standards (Wahr model)
Ocean Loading Site Displacement: Schwiderski model
Pole Tide : applied
Normal point elimin. criterion : eliminated when 3 or less single shots per normal point

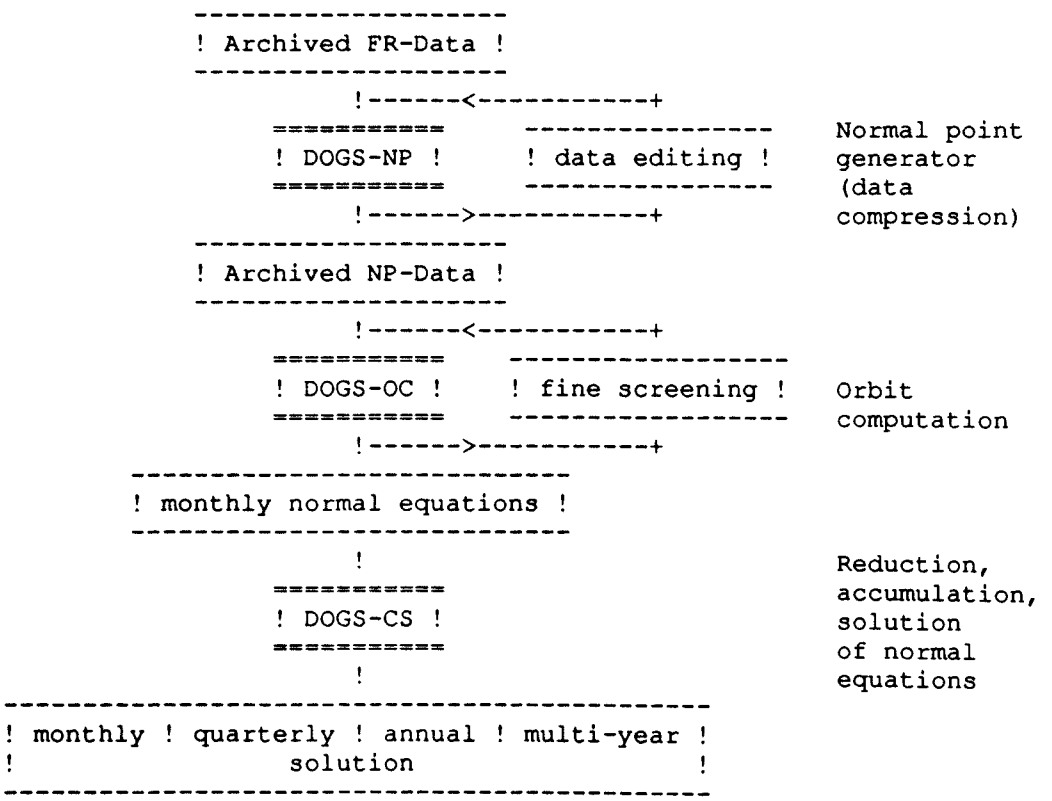
2.) The data

For the solution (DGFII)89L03 two minute normal points were generated using the module DOGS-NP. For the five years period considered here a set of 255596 normal points was generated. It has been created out of a total of 37 million LAGEOS release C full-rate data points gathered from 80 fixed and mobile sites around the world.

3.) The analysis process

The analysis was performed with the DOGS program. DOGS consists of several macro modules, those which were used for the described analysis are: the normal point generator (DOGS-NP) (see above), the orbit computation module (DOGS-OC), and the reduction, accumulation and solution module (DOGS-CS). The processing sequence is shown in table 1.

Table 1. DOGS ANALYSIS SEQUENCE



DOGS-OC is used for orbit computation, fine screening of data, and for the creation of monthly arc normal equations. DOGS-CS is firstly providing the reduced normal equations, secondly accumulating several reduced normal equations including datum contraints and eccentricity conditions, and thirdly solving the combined normal equation system.

4.) The Geodetic Datum

The solution has to be minimum constrained. Since the three translations are fixed by setting the first degree and order terms in the gravity model to zero and the scale by the velocity of light, the three rotations remain to be fixed. This is done by forcing the three rotation angles between the initial and the adjusted coordinates of a selected set of stations to become zero in the average [Bender, Goad, 1979]. In the same way the rotational drift rates around the three coordinate axes are forced to be zero with respect to a given set of horizontal station position drift rates of a geophysical plate motion model, which is in the present case the AM0-2 model [Minster, Jordan, 1978].

5.) Eccentricity conditions

In order to achieve reasonable drift rates on stations successively occupied by different systems some conditions have to be applied. First all station coordinate rates of the same site are set equal. Then eccentricity vectors between two occupations have been applied as observations only where the constraint on the solution remains reasonable small. In contrary, some occupations had to be divided into two occupations without an eccentricity vector, because a discontinuity appeared somewhere in the data.

6.) Solve-for Parameters

The solve-for parameters can be taken from table 2. Some of these parameters have been reduced in the monthly normal equations before combining the equations to a multi-year system in order to reduce the size of the system. The solution has 80 sets of X-, Y-, Z- station coordinate parameters. Only horizontal station velocities were solved for. Some of the station velocity parameters are set to the same value, so there are only 50 independent sets of N-, E- velocity parameters. All 100 velocity parameters are solved for regardless of their significance. Nevertheless, good coordinate results can only be achieved for stations having observed for a longer period of time.

Table 2. SOLVE-FOR PARAMETERS

Gravity Model Parameters	: C(0,0)
Direct Solar Radiation Param.	: CR (per 15 days)
Along Track Acceleration	: CA (per 15 days)
Orbital State Vector	: 6 parameters per monthly arc
Polar Motion	: one x and y parameter per 5 days
dLOD	: one parameter per 5 days
Station Coordinates	: geocentric coordinates X, Y, Z
Velocity of Stations	: North and East

7.) The Results

The description of the terrestrial system implementation is in appendix 1.

Station coordinates are given in appendix 2. Since horizontal station movements are also solved for, a reference epoch for the coordinates is given. The format is following the IERS rules, so column 2 to 10 contains the DOMES numbers, column 10 to 20 the CDP station number and site occupation designator, followed by x, y, z coordinates in m, the MJD of the reference epoch of the coordinates, the time span and the uncertainties of x, y, z in m. Stations with an observation period of two years or less are not included in the list since the velocity parameters are not reliably determined. The only exeption are the 5 Aegean MEDLAS sites having been occupied in 1986 as well as in 1987. All coordinates are referred to the optical axes of the ranging systems.

In appendix 3 the velocity parameters are given as follows: DOMES number, CDP station number, station motion in latitude in m/year, station motion in longitude*cosφ in m/year, uncertainties in latitude and longitude in the same dimensions. The station motions of different occupations of the same site are forced to be the same, so only one line is to be found for each site.

Earth orientation parameters for a five-year interval are given in appendix 4.

References

BENDER, P.; GOAD, C (1979): Probable LAGEOS Contributions to a Worldwide Geodynamics Control Network. In: The Use of Artificial Satellites for Geodesy and Geodynamics. Ed. by G. Veis and E. Livieratos. Athens (Greece): Publication of the National Technical University, 1979. Vol. II, pp 145-161

MINSTER, J.B.; JORDAN, T.H. (1978): Present-Day Plate Motions. Journal of Geophysical Research. Vol 83 (1978) No B11, pp 5331-5354

REIGBER, CH.; ELLMER, W.; MUELLER, H.; GEISS, E.; SCHWINTZER, P.; MASSMANN, F.H. (1989): Plate Motions Derived from the DGFI 89 L03 Solution. In: Global and Regional Geodynamics. Proceedings of the 125th Anniversary General Meeting of the International Association of Geodesy, Edinburgh, Scotland, August, 1989, Symposium 101. New York: in print by Springer, pp. 11-20.

Appendix 1:

SUMMARY SHEET FOR THE DESCRIPTION OF THE TERRESTRIAL SYSTEM ATTACHED TO A SET OF STATION COORDINATES

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1 - Technique : SLR

2 - Analysis Center : DGFI

3 - Solution identifier : SSC(DGFII)89 L 03

4 - Software used : DOGS

5 - Relativity scale : LE

6 - Permanent tidal correction on station : NO

Date sent:

7 - Tectonic plate model : AM0-2 (only for velocity datum)

8 - Velocity of light (C) = 299792458 m/sec

9 - Geogravitaional constant (GM) = parameter solved for

10 - Reference epoch = depending on the epoch of the initial values,
c.f. column 61 to 67 in the coordinate table

11 - Adjusted Parameters : GM X Y Z $\dot{\lambda}$*COS φ $\dot{\varphi}$ (for five years)
6 Keplerian elements (for each month)
CR CA (for 15 days)
PX PY LODR (for 5 days)

12 - Definition of the origin : C10=C11=S11=0.

13 - Definition of the orientation : Forcing of rotation angles between initial and adjusted coordinates of 15 stations to becomes zero in the average [Bender/Goad, 1979]

14 - Constraint for time evolution : Linear horizontal motion of each site to be solved for. Rotational drift rates around the three coordinate axes are forced to become zero with respect to a given set of AM0-2 horizontal station position drift rates.

Appendix 2: SSC (DGFII) 89 L 03

Domes Number	Network Number	X m	Y m	Z m	Epoch MJD	Data Span Days
X14106S001	1181 3901	3800620.344	882012.335	5028859.124	45704.5	1581.0
X40442S	7086ML2403	-1330121.478	-5328527.799	3236153.892	45704.5	790.5
X40442S	7086ML2404	-1330121.508	-5328527.820	3236153.853	45704.5	1030.5
X50107S	7090ML0501	-2389006.965	5043327.432	-3078534.588	45704.5	1701.0
X50107S	7090ML0506	-2389006.960	5043327.437	-3078534.608	45704.5	120.0
X40451S	7105ML0207	1130719.580	-4831347.372	3994115.452	45704.5	150.0
X40451S	7105ML0702	1130719.585	-4831347.378	3994115.448	45704.5	240.0
X40451S	7105ML0704	1130719.591	-4831347.382	3994115.460	45704.5	730.5
X40451S	7105ML0709	1130719.582	-4831347.400	3994115.442	45704.5	880.5
X40433S	7109ML0802	-2517236.655	-4198552.740	4076576.990	45704.5	1365.8
X40433S	7109ML0805	-2517236.627	-4198552.737	4076576.983	45704.5	455.3
X40497S	7110ML0301	-2386279.768	-4802352.369	3444889.449	45704.5	210.0
X40479S	7110ML0402	-2386279.661	-4802352.138	3444889.246	45704.5	1611.0
X40504S001	7122ML0601	-1660090.508	-5619099.754	2511646.600	45704.5	1826.3
X40445S001	7210 2301	-5466007.334	-2404425.420	2242190.505	45704.5	1826.3
X12612S	7510MT1501	4353446.385	2082673.276	4156503.699	46617.0	90.0
X12612S	7510MT1601	4353446.494	2082673.218	4156503.665	46617.0	90.0
X12615S	7512MT1501	4573401.414	2409328.729	3723878.234	46617.0	60.0
X12615S	7512MT1602	4573401.432	2409328.733	3723878.224	46617.0	60.0
X12602S	7515MT1501	4595217.914	2039441.848	3912626.591	46617.0	30.0
X12602S	7515MT1502	4595217.927	2039441.873	3912626.551	46617.0	90.0
X12613S	7517TL1102	4728697.099	2174379.985	3674571.715	46617.0	30.0
X12613S	7517MT1503	4728696.185	2174379.571	3674569.732	46617.0	60.0
X12613S	7517MT1601	4728696.183	2174379.646	3674569.737	46617.0	90.0
X12616S	7525TL1104	4745951.919	1905712.667	3799168.200	46617.0	90.0
X12616S	7525MT1601	4745951.155	1905712.165	3799166.279	46617.0	60.0
X14001S001	7810 4801	4331282.634	567555.964	4633140.115	45704.5	1305.8
X30101S001	7831 4601	4728284.499	2879672.547	3156890.956	45522.0	1461.0
X14201S001	7834 3001	4075529.046	931787.953	4801617.815	45704.5	1731.0
X10002S001	7835 3101	4581690.850	556165.479	4389359.630	45704.5	1185.8
X21726S001	7838 3601	-3822389.204	3699368.233	3507567.194	45704.5	1701.0
X11001S002	7839 3401	4194425.721	1162700.332	4647245.845	45704.5	1581.0
X13212S001	7840 3501	4033462.793	23669.157	4924305.890	45704.5	1551.0
X42202S001	7907 4001	1942792.500	-5804080.136	-1796910.832	45704.5	1826.3
X12734S001	7939 4101	4641964.199	1393075.683	4133261.301	45704.5	1581.0

Appendix 3: SSV (DGFII) 89 L03

Domes Number	Network Number	$\dot{\varphi}$ m/y	$\dot{\lambda}*\cos\varphi$ m/y	$\sigma_{\dot{\varphi}}$ m	$\sigma_{\dot{\lambda}}$ m
14106S001	1181 3901	.030	.026	.006	.006
40442S	7086	-.002	-.005	.001	.002
50107S	7090	.063	.031	.001	.001
40451S	7105	.006	-.010	.001	.002
40433S	7109	-.014	-.033	.001	.001
40479S	7110	.011	-.041	.001	.001
40504S001	7122ML0601	-.008	-.014	.001	.001
40445S001	7210 2301	.030	-.071	.001	.001
12612S	7510	.026	.003	.010	.010
12615S	7512	-.063	-.096	.021	.022
12602S	7515	-.055	.006	.010	.010
12613S	7517	-.037	-.002	.008	.009
12616S	7525	-.013	-.004	.013	.013
14001S001	7810 4801	.012	.027	.004	.005
30101S001	7831 4601	.103	.703	.012	.008
14201S001	7834	.013	.013	.001	.002
10002S001	7835 3101	.003	.015	.002	.002
21726S001	7838	-.009	-.008	.002	.002
11001S002	7839 3401	.015	.019	.001	.001
13212S001	7840 3501	.020	.018	.001	.001
42202S001	7907 4001	.011	.010	.001	.001
12734S001	7939	.019	.014	.001	.001

EOP(DGFII)89 L 03 Available from 1983 to 1987

Number of measurements and RMS uncertainty per year
Units : 0.001" for X,Y,dPsi,dEps; 0.0001s for UT; ms for D

YEAR	X		Y		D	
	Nb	Sigma	Nb	Sigma	Nb	Sigma
1983	73	0.80	73	0.59	73	0.011
1984	73	0.33	73	0.29	73	0.007
1985	73	0.36	73	0.27	73	0.005
1986	73	0.31	73	0.27	73	0.006
1987	73	0.29	73	0.26	73	0.006

EARTH ROTATION AND STATION COORDINATES COMPUTED FROM 4 YEARS OF LAGEOS OBSERVATIONS.

DUT 90 L 01

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A continuous series of 5-day solutions for polar motion and the A1-UT1 time difference has been computed from global laser ranging observations on the geodetic satellite LAGEOS. The time span covers a period of 4 years: 1986 through 1989. The analysis was based on full-rate data for 1986, 1987 and 1988, whereas the results for 1989 were derived from quick-look observations, i.e. sampled full-rate data.

In the analyses the observations were processed in batches of multiple contiguous 1-week data arcs, in which the orbit parameters and the earth rotation parameters are estimated simultaneously. This approach was used since the analyses were also aimed at the determination of crustal deformations, showing up in successive solutions for the positions of laser stations. Therefore, all station coordinates were adjusted simultaneously with the other parameters. The individual solutions cover data periods ranging from 8 to 19 weeks. This resulted in a total of 17 different global station coordinates solutions, together with solutions for polar motion and the A1-UT1 time difference.

The reference frame was defined with the following constraints. The longitude of Greenbelt (station id. 7105) was kept fixed at the value according to the University of Texas UT/CSR 84.02 coordinates solution. During the time-span covered by each individual solution, the stations were supposed to exhibit no motion. In addition, the average shift of the polar motion and A1-UT1 time difference with respect to the *a priori* value was defined to be zero, for each of the 17 parameter solutions. The a priori values for the earth rotation parameters were taken from the monthly IERS Bulletin B.

A summary of the computation model that was used is given in Table 1. Main elements are the NASA/GSFC GEM-T1 gravity field, the Wahr harmonic expansion model for the solid earth tides and a subset of the NASA/GSFC GEM-T1 solution for ocean tides. Here, only the constituents that are also included in the Schwiderski model were used. Table 2 provides information on the individual laser stations. The table includes the station coordinates at the reference epoch (January 1, 1986), the corresponding standard deviations, the apparent yearly motion of these stations and the corresponding standard deviations.

Both station coordinates and yearly motions were derived from a weighted least squares fit through the successive multi-week parameter solutions. The values are in m (coordinates) and in m/yr (motions). The coordinates refer to the monuments. The solution presented here may be designated as the SSC(DUT) 90 L 01 global coordinates solution. Table 3, finally, gives the raw, unsmoothed solutions for polar motion and UT1-UTC. The solution is designated EOP(DUT) 90 L 01.

Table 1- Models and constants

Dynamic model:	
Gravity field	NASA/GSFC GEM-T1 model, truncated at 20 x 20
GM	398600.4359 km3/s2
c	299792.458 km/s
ae	6378.1370 km
1/f	298.257
Solar and lunar attraction	JPL DE-118 ephemeris
Solid earth tides	Wahr model
Ocean tides	NASA/GSFC GEM-T1 model (constituents of 55 elements also in Schwiderski model only)
Solar radiation	CR adjusted occultation by earth and moon umbra and penumbra
Along-track acceleration	AT adjusted
Reference frame:	
Station coordinates	adjusted, except for longitude of Greenbelt (7105)
Earth rotation	adjusted, a priori values from IERS Bulletin B
CIS	mean equator and equinox of J1950.0
Precession	J1950 precession (JPL DE-118 ephemeris)
Nutation	Wahr series
Measurement model:	
Observations	DGFI normal points (1986, 1987) Bendix normal points (1988) Quick-look data (1989)
Tropospheric refraction	Marini-Murray model
Tidal uplift	$h_2 = 0.6090$, $l_2 = 0.0852$

Table 2: Global coordinates solution. SSC(DUT) 90 L 01

Network Number	X m	Y m	Z m	
7080	-1330021.0181	-5328401.7930	3236480.8898	
	0.0178	0.0331	0.0506	<= SX,SY,SZ (m)
	-0.0035	-0.0034	-0.0442	<= Vx,Vy,Vz (m/y)
	0.0157	0.0167	0.0202	<= SVx,SVy,SVz (m/y)
7086	-1330125.3085	-5328526.5952	3236150.1878	
	0.0076	0.0140	0.0212	
	-0.0298	-0.0128	-0.0058	
	0.0159	0.0173	0.0214	
7090	-2389006.3242	5043329.2404	-3078525.4802	
	0.0068	0.0107	0.0181	
	-0.0506	0.0219	0.0505	
	0.0217	0.0196	0.0232	
7097	-1884984.6434	-5357607.9583	-2892853.4118	
	0.0641	0.0313	0.0517	
	0.0552	-0.0447	-0.0075	
	0.0271	0.0214	0.0245	
7105	1130719.7554	-4831350.5644	3994106.3506	
	0.0161	0.0130	0.0160	
	-0.0204	0.0045	0.0008	
	0.0151	0.0134	0.0157	
7109	-2517234.7164	-4198556.1881	4076569.5619	
	0.0057	0.0154	0.0155	
	-0.0135	0.0140	0.0065	
	0.0149	0.0160	0.0160	
7110	-2386277.9083	-4802354.3574	3444881.2844	
	0.0053	0.0132	0.0165	
	-0.0326	0.0425	0.0243	
	0.0152	0.0155	0.016450	
7122	-1660089.3318	-5619100.3457	2511637.7643	
	0.0083	0.0098	0.0182	
	-0.0214	-0.0030	0.0033	
	0.0157	0.0151	0.0173	
7210	-5466006.4270	-2404427.9479	2242187.3127	
	0.0037	0.0179	0.0202	
	-0.0292	0.0584	0.0344	
	0.0163	0.0184	0.0200	
7510	4353444.9877	2082666.1575	4156506.5308	
	0.0322	0.0272	0.0273	
	-0.0173	0.0119	-0.0161	
	0.0148	0.0137	0.0139	
7512	4573400.1044	2409322.0800	3723881.6348	
	0.0384	0.0325	0.0360	
	0.0024	0.0106	-0.0194	
	0.0172	0.0156	0.0167	
7515	4595216.4742	2039435.1927	3912629.4093	
	0.0294	0.0259	0.0271	
	0.0114	0.0067	-0.0343	
	0.0158	0.0149	0.0153	
7517	4728694.7143	2174373.2173	3674572.8551	
	0.0297	0.0264	0.0291	
	0.0058	0.0170	-0.0234	
	0.0161	0.0152	0.0161	

Table 2 (cont.) : Global coordinates solution. SSC(DUT) 90 L 01

Network Number	X m	Y m	Z m	
7520	4596042.6457	1733476.6630	4055720.7169	
	0.0382	0.0347	0.0351	<= SX, SY, SZ (m)
	0.0129	-0.0171	-0.0086	<= Vx,Vy,Vz (m/y)
	0.0165	0.0157	0.0159	<= SVx,SVy,SVz (m/y)
7525	4745949.5472	1905705.8393	3799168.9351	
	0.0375	0.0347	0.0370	
	0.0294	-0.0158	-0.0226	
	0.0168	0.0162	0.0168	
7530	4443966.0578	3121945.0110	3334693.4016	
	0.0286	0.0240	0.0272	
	0.0222	0.0197	0.0469	
	0.0170	0.0173	0.0169	
7544	5072832.0075	1130886.0650	3684836.7932	
	0.0499	0.0554	0.0579	
	0.0036	0.0214	0.0097	
	0.0197	0.0214	0.0222	
7545	4893398.0739	772673.1807	4004140.8118	
	0.0559	0.0684	0.0614	
	0.0128	0.0156	-0.0055	
	0.0196	0.0256	0.0213	
7550	4336738.6126	1071271.3408	4537910.8953	
	0.0383	0.0368	0.0324	
	-0.0060	0.0190	0.0051	
	0.0164	0.0162	0.0151	
7575	3848636.1222	3251760.8491	3898909.0723	
	0.0609	0.0442	0.0491	
	-0.0249	-0.0222	0.0076	
	0.0219	0.0176	0.0191	
7580	4247620.6307	2778638.9299	3851607.3880	
	0.0568	0.0449	0.0490	
	-0.0325	-0.0355	-0.0235	
	0.0208	0.0178	0.0189	
7585	4029730.8262	2802093.2992	4062067.8480	
	0.0562	0.0451	0.0449	
	-0.0218	-0.0537	0.0008	
	0.0214	0.0182	0.0184	
7587	4117362.0770	2517076.7411	4157678.9144	
	0.0547	0.0437	0.0439	
	0.0066	-0.0168	-0.0171	
	0.0209	0.0180	0.0181	
7810	4331283.6367	567549.4329	4633139.7548	
	0.0212	0.0219	0.0183	
	0.0034	0.0141	0.0029	
	0.0125	0.0126	0.0121	
7834	4075530.0977	931781.1451	4801618.0459	
	0.0194	0.0184	0.0150	
	-0.0031	0.0146	-0.0032	
	0.0123	0.0121	0.0115	
7835	4581691.8475	556159.2622	4389359.2058	
	0.0226	0.0239	0.0219	
	-0.0195	0.0063	-0.0044	
	0.0126	0.0129	0.0128	

Table 2 (cont.) : Global coordinates solution. SSC(DUT) 90 L 01

Network Number	X m	Y m	Z m	
7838	-3822387.0181	3699362.2859	3507571.8725	
	0.0214	0.0168	0.0182	<= SX, SY, SZ (m)
	0.0251	0.0138	-0.0045	<= Vx,Vy,Vz (m/y)
	0.0168	0.0168	0.0213	<= SVx,SVy,SVz (m/y)
7839	4194426.7528	1162693.7539	4647246.3834	
	0.0190	0.0175	0.0152	
	-0.0036	0.0108	-0.0043	
	0.0123	0.0120	0.0116	
7840	4033463.8519	23662.2252	4924304.9122	
	0.0161	0.0169	0.0134	
	-0.0041	0.0079	-0.0159	
	0.0118	0.0119	0.0114	
7843	-4446476.4741	2678126.9517	-3696251.6975	
	0.0122	0.0259	0.0297	
	-0.0785	0.0606	0.0336	
	0.0223	0.0214	0.0241	
7907	1942791.8895	-5804077.6880	-1796919.3938	
	0.0212	0.0093	0.0198	
	-0.0079	0.0179	0.0071	
	0.0187	0.0180	0.0198	
7939	4641965.1080	1393069.7857	4133262.0646	
	0.0170	0.0162	0.0160	
	0.0056	0.0125	0.0064	
	0.0122	0.0122	0.0123	

EOP(DUT) 90 L 01 Available from 1986 to 1989

Number of measurements and RMS uncertainty per year
Units : 0.001" for X,Y,dPsi,dEps; 0.0001s for UT;
ms for D

YEAR	X		Y		UT1	
	Nb	Sigma	Nb	Sigma	Nb	Sigma
1986	72	1.80	72	1.80	72	13.56
1987	72	0.82	72	0.82	72	6.14
1988	73	1.14	73	1.15	73	1.62
1989	73	1.10	73	1.10	73	1.46

EARTH ROTATION PARAMETERS AND STATION COORDINATES FOR 1988 AND 1989
LAGEOS DATA GAOUA 90 L 01

V.K.TARADY, K.Kh.NURUTDINOV, V.N.SALYAMOV, M.L.TSESIS

Computer program: Kiev - Geodynamics - 3.

The force and measurement models were those of the IERS Standards with following exceptions:

- cylindrical model for the Earth shadow;
- occultation by the Moon;
- reflectance coefficient CR= 1.14 and the empirical along-track acceleration coefficient CT =-3.4 were taken fixed.

Adjusted parameters:

cartesian coordinates X,Y,Z of 41 stations, 6 orbital elements, 2 pole coordinates and excess of length of day.

Data:

106119 normal points for LAGEOS obtained by 41 stations at interval January 1988 - August 1989.

Data processing:

At the first stage station coordinates and arc- dependent LAGEOS orbital elements (5-day arcs) were solved for parameters from the normal equation system for time interval. A priori values of the Earth rotation parameters (ERP) from IERS Bulletin B and fixed longitude of Grasse station (7835) were used. At the second stage the ERP and the LAGEOS orbital elements were determined on the basis of the 5-day arcs.

Mean value of post-fit orbital residuals is 0.069 m.

The positions of station are for the reference points of the laser ranging system and include the permanent tidal deformation. Reference epoch is MJD 47161.

The ERP and station positions are presented in EOP(GAOUA) 90 L 01
and SSC(GAOUA) 90 L 01.

1 - Technique : SLR
2 - Analysis Center : GAOUA
3 - Solution identifier : SSC(GAOUA) 90 L 01
4 - Software used : KIEV-GEODYNAMICS - 3
5 - Relativity scale : LE
6 - Permanent tidal correction on station : NO
7 - Tectonic plate model : AM0-2
8 - Velocity of light (C) = 299 792 458
9 - Geogravitational constant (GM) = 3.9860 0440*10**14
10 - Reference epoch = MJD 47161
11 - Adjusted parameters : X,Y,Z
12 - Definition of the origin : C10=0, C11=0, S11=0
13 - Definition of the orientation : ERP values from IERS Bulletin B
14 - Constraint for time evolution : fixed plate motion model

EOP(GAOUA)90 L 01 Available from 1988 to 1989

Number of measurements and RMS uncertainty per year
Units : 0.001" for X,Y,dPsi,dEps; 0.0001s for UT; ms for D

YEAR	X		Y		D	
	Nb	Sigma	Nb	Sigma	Nb	Sigma
1988	73	0.21	73	0.22	73	0.011
1989	49	0.29	49	0.26	49	0.014

Domes Number	Network Number	X m	Y m	Z m	Mean MJD	Data Span Days	SX m	SY m	SZ m
X14106S001	1181S001	3800621.293	882005.259	5028859.348	47484.5	559.2	0.009	0.008	0.007
X12302S002	1884S001	3183895.941	1421496.505	5322802.929	47499.1	433.1	0.013	0.011	0.008
X	1893S001	3785945.015	2550780.471	4439461.153	47599.9	131.5	0.032	0.030	0.017
X40701S001	1953S001	1474548.313	-5811242.494	2168944.869	47486.3	471.6	0.011	0.008	0.011
X40436S	7035S001	-2428827.534	-4799756.260	3417268.415	47404.6	38.9	0.011	0.011	0.009
X40442S	7080S001	-1330021.305	-5328403.346	3236481.663	47459.3	565.4	0.004	0.003	0.005
X40442S	7086S001	-1330120.847	-5328532.251	3236146.666	47176.9	24.6	0.016	0.011	0.012
X50107S	7090S001	2389007.729	5043331.802	-3078526.845	47470.4	598.8	0.004	0.004	0.005
X40440S	7091S001	1492454.403	-4457280.159	4296819.348	47425.5	44.8	0.013	0.012	0.009
X41703S	7097S001	-1884984.878	-5357609.359	-2892854.029	47405.5	449.3	0.009	0.009	0.009
X40451S	7105S001	1130720.336	-4831352.952	3994108.400	47457.7	572.0	0.005	0.004	0.005
X40433S	7109S001	-2517235.889	-4198558.264	4076571.584	47456.5	598.2	0.004	0.003	0.005
X40497S	7110S001	-2386279.115	-4802356.760	3444883.073	47447.6	601.3	0.004	0.003	0.005
X40496S	7112S001	-1240678.817	-4720466.058	4094479.357	47414.5	49.5	0.009	0.007	0.008
X40504S	7122S001	-1660090.080	-5619103.084	2511639.024	47373.0	601.0	0.006	0.005	0.007
X92202S	7123S001	-5345868.028	-2958248.067	-1824624.657	47424.7	428.8	0.011	0.013	0.013
X40445S	7210S001	-5466006.942	-2404428.055	2242188.456	47333.1	348.6	0.004	0.005	0.007
X40405S	7288S001	-2356494.958	-4646609.537	3668428.108	47382.5	409.8	0.009	0.007	0.008
X40499S	7295S001	961319.628	-5674093.225	2740487.675	47308.3	104.9	0.014	0.009	0.012
X12613S	7517S001	4728697.975	2174374.777	3674573.436	47662.5	26.0	0.015	0.015	0.013
X12614S	7520S001	4596045.191	1733477.771	4055719.465	47728.1	34.0	0.012	0.016	0.012
X12706S	7544S001	5072834.885	1130886.605	3684835.303	47614.9	3.0	0.433	0.378	0.142
X12725S	7545S001	4893400.872	772673.714	4004139.671	47211.1	68.3	0.011	0.016	0.011
X12711S	7546S001	4461402.494	919567.274	4449509.454	47306.7	33.0	0.027	0.045	0.026
X20802S	7585S001	4029732.981	2802094.683	4062066.726	47764.8	11.6	0.016	0.016	0.013
X20804S	7587S001	4117365.093	2517078.513	4157679.881	47760.1	12.3	0.020	0.024	0.021
X14001S001	7810S001	4331283.614	567549.539	4633139.776	47495.3	538.7	0.004	0.005	0.005
X	7811S001	3738333.063	1148245.884	5021815.563	47480.6	394.9	0.013	0.014	0.012
X30101S001	7831S001	4728283.566	2879670.367	3156894.132	47723.8	75.9	0.013	0.023	0.020

SSC(GAOUA) 90 L 01

Domes Number	Network Number	X m	Y m	Z m	Mean MJD	Data Span Days	SX m	SY m	SZ m
X14201S002	7834S001	4075530.080	931781.263	4801618.061	47492.0	572.0	0.007	0.008	0.006
X10002S001	7835S001	4581691.836	556159.355	4389359.328	47445.8	513.2	0.003	0.001	0.001
X21605S001	7837S001	-2831087.691	4676203.437	3275172.937	47438.1	194.1	0.025	0.020	0.018
X21726S001	7838S001	-3822388.232	3699363.438	3507573.058	47403.1	558.1	0.006	0.007	0.007
X11001S002	7839S001	4194426.710	1162693.852	4647246.397	47469.1	562.0	0.005	0.005	0.005
X13212S001	7840S001	4033463.779	23662.311	4924304.848	47478.5	606.9	0.003	0.004	0.005
X40439S	7853S001	-2410422.387	-4477802.745	3838688.934	47459.9	30.1	0.009	0.008	0.008
X40505S	7882S001	-1997241.337	-5528044.705	2468356.197	47321.5	44.0	0.011	0.009	0.011
X	7883	-2406127.820	-4898370.330	3290337.946	47697.1	91.0	0.025	0.018	0.019
X42202S001	7907S001	1942791.936	-5804077.453	-1796919.297	47449.3	565.0	0.005	0.004	0.006
X12734S001	7939S001	4641965.038	1393069.876	4133262.074	47425.7	563.1	0.004	0.004	0.005
X13504S	8833S001	3899238.099	396769.180	5015054.992	47394.6	99.8	0.011	0.014	0.010

Notes

We have no data on the DOMES site number of the stations 1893,7811,7883
and DOMES point number of stations 1893,7035,7080,7086,7090,7091,7097,7105,
7109,7110,7112,7122,7123,7210,7288,7295,7517,7520,7544,7545,7546,7585,7587,
7811,7853,7882,7883,8833.

THE 20-MONTH EARTH ORIENTATION PARAMETERS SERIES FROM LAGEOS LASER RANGING

LPAC 90 L 01

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The solution LPAC 90 L 01 was made at the Astronomical Council (Moscow) with the use of the GEORAN-2 system of programs /1, 2/. The Lageos Laser Ranging normal point data generated at the CSR of the University of Texas at Austin were used to form this solution. There were 92 000 of normal points from January, 1988 through August, 1989.

The GEORAN-2 program consists of two main modules. The first one is for orbit computation, fine screening of data and accumulation of observation equations. The second one is the solution module. The sequence of processing is shown below (Fig. 1). A combination of normal equations can be made in "short" or "long" arcs depending on the solve-for parameters. The 5-day arc normal equations were used for estimation of EOPs. The coefficients of solar radiation reflection and along track acceleration C_R, C_T have been estimated in each of 15 and 30-day arcs. Station coordinates have been determined in the whole (20 months) arc.

The force model and constants used in the solution were taken according to the IERS Standards (1989).

Dynamical Model

- IERS constants
- Gravity Model - GEM T1 (20 x 20) with C (2,1) ans S (2,1) of IERS Standards.
- Third Body - Moon (central point mass), Sun, Jupiter, Venus, Saturn, Mars.
- Air Drag - not applied.
- Ocean Tides - Schwiderski Model, 11 Tidal waves.
- Solid Earth Tides - Wahr model.
- Relativistic correction to equations of motion.
- Solar Radiation (direct) with conical model of shadow /3/.

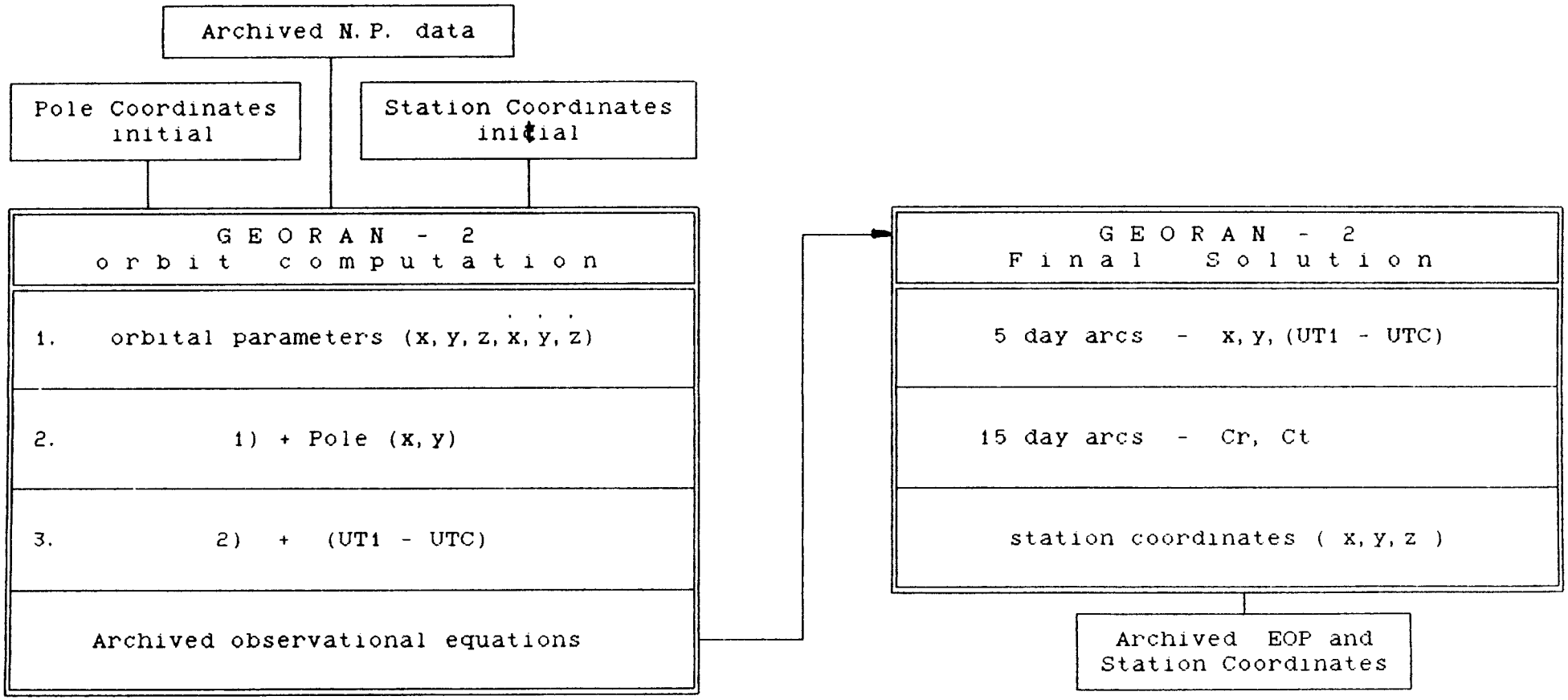
Archived N. P. data
Pole Coordinates initial
Station Coordinates initial
G E O R A N - 2
o r b i t c o m p u t a t i o n
1. orbital parameters (x, y, z, x, y, z)
2. 1) + Pole (x, y)
3. 2) + (UT1 - UTC)
Archived observational equations
G E O R A N - 2
F i n a l S o l u t i o n
5 day arcs - x, y, (UT1 - UTC)
15 day arcs - Cr, Ct
station coordinates (x, y, z)
Archived EOP and Station Coordinates

FIG. 1

Measurement Model

- Refraction - Marini-Murray Model.
- Relativistic propagation correction
- Normal points of CSR, Texas University.
- Solid Earth Tides and ocean loading site displacements.
- Pole tide.

Reference Frames

- CIS - mean equator and equinox of J 2000.0.

- Precession (IAU, 1976), Nutation (IAU, 1980). Trigonometrical series are transformed in Chebyshev polynomial series /4/.

- Planetary Ephemerides DE 200/LE2000, modified by compressing over 4-day intervals.
- Initial Pole Series - Bulletin B of IERS.

- Initial Station Coordinates - SSC (ZIPE) 89 L 01 + SSC (CSR) 89 L 02.

- The positions have an epoch of MJD=45700 and move according to the AM0-2 plate tectonic model.

- Fixed stations : 7105 (φ, λ), 7210 (φ).

EOP(LPAC) 90 L 01 Available from 1988 to 1989

Number of measurements and RMS uncertainty per year.
Units: 0.001" for X,Y, dPsi, dEps; 0.0001s for UT.

Year	X		Y		UT1	
	Nb	Sigma	Nb	Sigma	Nb	Sigma
1988	71	0.18	71	0.20	71	0.18
1989	46	0.27	46	0.25	46	0.24

References

1. Marchenko, A.N. *et al.* 1988: Proceedings of the 2nd Orlov's Conference on the investigation of the Earth by means of Geophysics, Geodesy and Astronomy (in press).

2. Abrikosov, O.A. 1986: Cinematics and Physics of Celestial Bodies, Vol. 2, No 2, Kiev.

3. Abrikosov, O.A. 1989: Observations of the Artificial Earth's Satellites, No 26, (in Russ.) Cracow.

4. Marchenko, A.N. 1988: Cinematics and Physics of Celestial Bodies, Vol. 4, No 3-4. Kiev.

SSC(LPAC) 90 L 01

NETWORK NUMBER	SITE	DOMES NUMBER	X m	Y m	Z m	SX m	SY m	SZ m	PLATE
1181S001	POTSDAM	14106S001	3800621.521	882005.206	5028859.630	0.005	0.005	0.003	EURA
1893S001	SIMEIS II	12337S006	3785945.379	2550779.969	4439461.343	0.045	0.053	0.027	EURA
1953S001	SANT. DE CUBA	40701S001	1474548.616	-5811242.586	2168945.179	0.012	0.009	0.008	NOAM
7080S001	FORT DAVIS	40442S014	-1330021.454	-5328403.303	3236481.719	0.002	0.002	0.002	NOAM
7086S004	FORT DAVIS	40442S016	-1330120.977	-5328532.255	3236146.680	0.008	0.012	0.008	NOAM
7090S002	YARRAGADEE	50107S004	-2389007.494	5043331.774	-3078527.130	0.002	0.002	0.002	INDI
7097S001	EASTER ISLAND	41703S004	-1884985.256	-5357609.275	-2892854.032	0.006	0.005	0.005	NAZC
7105S006	WASHINGTON	40451S148	1130720.343	-4831352.919	3994108.475	0.000	0.002	0.001	NOAM
7109S003	QUINCY	40433S014	-2517235.868	-4198558.242	4076571.677	0.002	0.002	0.002	NOAM
7110S003	MONUMENT PEAK	40497S006	-2386279.035	-4802356.880	3444883.105	0.002	0.002	0.002	PCFC
7112S002	PLATTEVILLE	40496S004	-1240678.351	-4720465.756	4094479.429	0.006	0.007	0.004	NOAM
7122S001	MAZATLAN	40504S001	-1660090.144	-5619103.166	2511639.151	0.003	0.003	0.003	NOAM
7210S001	MAUI I	40445S001	-5466006.786	-2404428.292	2242188.340	0.002	0.002	0.001	PCFC
7295S001	RICHMOND	40499S010	961319.304	-5674093.297	2740487.812	0.008	0.005	0.006	NOAM
7810S001	ZIMMERWALD	14001S001	4331283.628	567549.066	4633140.143	0.003	0.003	0.002	EURA
7831S001	HELWAN	30101S001	4728283.751	2879670.576	3156894.396	0.049	0.020	0.038	AFRC
7834S001	WETTZELL	14201S002	4075530.137	931781.192	4801618.143	0.004	0.004	0.003	EURA
7835S001	CERGA GRASSE	10002S001	4581691.827	556159.270	4389359.340	0.001	0.001	0.002	EURA
7837S001	SHANGHAI I	21605S001	-2831087.625	4676203.508	3275172.983	0.010	0.012	0.010	EURA
7838S001	SIMOSATO	21726S001	-3822388.244	3699363.776	3507573.391	0.003	0.004	0.004	EURA
7839S001	LUSTBUEHEL-GRAZ	11001S002	4194426.850	1162693.406	4647246.786	0.003	0.003	0.002	EURA
7840S001	HERSTMONCEUX	13212S001	4033463.860	23662.236	4924304.992	0.002	0.002	0.002	EURA
7882S001	CABO SAN LUCAS	40505S001	-1997243.133	-5528045.481	2468356.466	0.031	0.042	0.023	PCFC
7907S001	AREQUIPA	42202S001	1942791.910	-5804077.606	-1796919.343	0.002	0.002	0.003	SOAM
7939S001	MATERA	12734S001	4641965.176	1393069.825	4133262.215	0.002	0.002	0.002	EURA
8833S001	KOOTWIJK	13504S007	3899237.802	396768.664	5015055.171	0.010	0.006	0.005	EURA

Epoch MJD : 45700.

EARTH ORIENTATION FROM LAGEOS LASER RANGING SHA 90 L 01

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To determine a series of the Earth Orientation Parameters EOP(SHA) 90 L 01 and the station coordinates SSC(SHA) 90 L 01 system, the two year SLR data of LAGEOS from Jan. 1988 to Jan. 1990 have been processed with the SHORDE I program system. A "multistage-multiarc" procedure was used to estimate simultaneously satellite states, EOPs and the station coordinates in each of 60 day arcs. The station coordinates, as the global parameters, are adjusted in the whole of the 60 day arcs ; the satellite states, as the first-stage local parameters, are independently adjusted in the different subarc (10 days) ; the EOPs, as the second-stage local parameters, are independently adjusted from one sub-subarcs (5 days) to the next.

Each set of EOP solution includes three Earth Rotation Parameters Xp, Yp, DR as well as the rate of the polar motion Xp, Yp. The ability to detect the rate of polar motion with 5 day arc solution has been investigated and found to be better than 0.7 mas/day. In our solution the overall RMS fit of the laser observations to the orbits in 60-day arcs is generally about 10 cm.

The station coordinates of SSC(SHA) 90 L 01 were constrained to move according to the Minster/Jordan (1978) tectonic motion model AM0-2. The epoch of the derived SSC(SHA) 90 L 01 is MJD 47527.0. The positions of all stations are for the optical axis of the laser ranging system.

The force model and constants used in the solution adhere closely to the IERS Standards. The following is a summary of the kinematic and dynamical models used in our solutions :

Reference frame

- Mean equinox and equator of J 2000.0
- Station coordinates SSC(SHA) 90 L 01
- IAU 1976 precession
- IAU 1980 nutation
- DE200/LE200 planetary ephemerides
- TAI as the coordinate time scale of the earth-centered frame

Force model

- GEM T1 earth gravity field GM = 398600.436 km3/sec2
- Luni-Solar and planetary gravity perturbation
- Wahr solid earth tides
- Schwiderski ocean tides
- Solar radiation pressure (Cr adjusted)
- Drag-like perturbation (Cd adjusted)
- Atmospheric tide
- General relativistic perturbation (earth-centered frame)

Measurement Model

- Marini-Murray refraction model
- Solid earth tides displacement
- Ocean loading site displacement
- Relativistic correction.

EOP(SHA) 90 L 01 Available from 1988 to 1990

Number of measurements and RMS uncertainty per year
Units : 0.001" for X,Y,dPsi,dEps; 0.0001s for UT;
ms for D

YEAR	X		Y		D	
	Nb	Sigma	Nb	Sigma	Nb	Sigma
1988	73	0.79	73	0.87	73	0.038
1989	73	0.86	73	0.86	73	0.042
1990	4	0.70	4	0.79	4	0.040

Domes Number	Network Number	X m	Y m	Z m	SX m	SY m	SZ m	Epoch MJD
14106S001	1181S001	3800621.459	882005.092	5028859.473	0.066	0.056	0.034	47527.0
12302S002	1884S001	3183896.075	1421496.336	5322803.453	0.387	0.320	0.243	47527.0
40701S001	1953S001	1474548.138	-5811242.442	2168945.055	0.154	0.132	0.142	47527.0
40436S003	7035S001	-2428827.804	-4799755.994	3417268.574	0.032	0.024	0.028	47527.0
40442S006	7080S001	-1330021.544	-5328403.077	3236481.787	0.021	0.018	0.020	47527.0
40442S001	7086S001	-1330121.226	-5328532.137	3236146.821	0.024	0.021	0.028	47527.0
50107S001	7090S001	-2389007.499	5043331.918	-3078526.885	0.020	0.014	0.018	47527.0
40440S001	7091S001	1492454.186	-4457280.111	4296819.414	0.052	0.034	0.038	47527.0
40451S105	7105S001	1130720.051	-4831352.958	3994108.530	0.018	0.016	0.014	47527.0
40433S002	7109S001	-2517236.130	-4198558.076	4076571.757	0.019	0.016	0.017	47527.0
40497S002	7110S001	-2386279.421	-4802356.512	3444883.310	0.019	0.015	0.017	47527.0
40496S001	7112S001	-1240679.096	-4720465.850	4094479.526	0.023	0.019	0.021	47527.0
40504S001	7122S001	-1660090.454	-5619103.051	2511639.238	0.020	0.015	0.018	47527.0
92202S003	7123S001	-5345868.171	-2958247.730	-1824624.438	0.041	0.036	0.031	47527.0
40445S001	7210S001	-5466007.102	-2404427.654	2242188.674	0.023	0.021	0.024	47527.0
40405S013	7288S001	-2356495.242	-4646609.235	3668428.191	0.036	0.028	0.031	47527.0
40499S002	7295S001	961319.314	-5674093.183	2740487.791	0.039	0.027	0.036	47527.0
12612S001	7510S001	4353447.586	2082667.218	4156505.383	0.031	0.033	0.026	47527.0
12615S001	7512S001	4573402.589	2409323.281	3723880.234	0.042	0.031	0.031	47527.0
12602S002	7515S001	4595219.060	2039436.237	3912628.068	0.038	0.040	0.041	47527.0
12613S001	7517S001	4728698.058	2174374.470	3674573.295	0.027	0.029	0.024	47527.0
12616S001	7525S001	4745953.072	1905707.016	3799169.558	0.030	0.026	0.034	47527.0
12706S001	7544S001	5072834.726	1130886.578	3684835.442	0.024	0.034	0.026	47527.0
12725S002	7545S001	4893400.836	772673.504	4004139.557	0.026	0.036	0.031	47527.0
12711S002	7546S001	4461402.566	919567.244	4449509.356	0.124	0.086	0.110	47527.0
12718S002	7550S001	4336741.476	1071272.005	4537909.934	0.113	0.126	0.093	47527.0
20801S001	7575S001	3848638.377	3251762.297	3898907.822	0.042	0.036	0.028	47527.0
20803S001	7580S001	4247623.699	2778640.423	3851608.058	0.053	0.061	0.043	47527.0
20802S001	7585S001	4029733.158	2802094.459	4062066.758	0.051	0.038	0.036	47527.0
14001S001	7810S001	4331283.767	567549.354	4633139.848	0.023	0.016	0.017	47527.0
30301S001	7831S001	4728283.808	2879670.478	3156894.142	0.243	0.168	0.180	47527.0
14201S002	7834S001	4075530.280	931781.131	4801618.143	0.028	0.031	0.020	47527.0
10002S001	7835S001	4581691.943	556159.159	4389359.249	0.023	0.016	0.018	47527.0
21605S001	7837S001	-2831087.393	4676203.686	3275172.833	0.132	0.104	0.096	47527.0
21726S001	7838S001	-3822388.017	3699363.783	3507573.085	0.020	0.024	0.019	47527.0

SSC(SHA) 90 L 01

Domes Number	Network Number	X m	Y m	Z m	SX m	SY m	SZ m	Epoch MJD
11001S002	7839S001	4194426.907	1162693.723	4647246.432	0.026	0.020	0.023	47527.0
13212S001	7840S001	4033463.980	23662.173	4924304.952	0.024	0.018	0.017	47527.0
50103S008	7843S001	-4446476.684	2678127.259	-3696251.570	0.021	0.024	0.020	47527.0
40439S004	7853S001	-2410422.575	-4477802.436	3838689.092	0.036	0.042	0.034	47527.0
40505S001	7882S001	-1997241.667	-5528044.442	2468356.293	0.043	0.032	0.040	47527.0
42202S001	7907S001	1942791.502	-5804077.899	-1796919.262	0.021	0.015	0.024	47527.0
12734S001	7939S001	4641965.306	1393069.730	4133262.123	0.020	0.023	0.018	47527.0

EARTH ROTATION PARAMETERS AND STATION COORDINATES FROM LAGEOS LASER RANGING

ZIPE 90 L 01
ZIPE 90 L 02
ZIPE 90 L 03

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The Set of Station Coordinates (SSC) and three sets of Earth Orientation Parameters (EOP) were determined by the program package POTSDAM-5. They are based on Satellite Laser Ranging (SLR) normal points of the IERS stations for 1988 and partly 1989 (up to May). Generally, all constants and model parameters were taken from the IERS Standards (1989). As exceptions from this IERS publication the following effects were not considered :

- penumbra for the radiations pressure,
- relativistic corrections,
- tidal variations in UT1 caused by zonal tides with periods longer than 35 days and
- variations of station coordinates generated by the pole tide.

The station coordinates SSC(ZIPE) 90 L 01 were referred to the epoch 1988.0 applying the AM0-2 model for the tectonic plate motions. The origin of the reference system was defined by $C_{10} = C_{11} = S_{11} = 0$. The orientation was constrained by fixation of λ,and φ for the station 7210 and of φ for the station 7105. Additionally, no common net rotations were permitted in relation to the reference coordinate set ITRF88. Corrections due to the permanent tidal deformation of the Earth were applied. The standard deviations of the station coordinates are in the order of several millimeters for the third generation laser stations and of about two centimeters for the second generation stations. The accuracy obtained by comparison with other solutions via a seven-parameter Helmert transformation was estimated to be about or better than ± 3 cm.

For the EOP (pole coordinates and length of day-LOD) three sets with different time resolutions were determinated. The 5-days resolution set EOP(ZIPE) 90 L 01 was simultaneously estimated with the station coordinates (for the whole data interval), the 6 orbital elements and an empirical acceleration (both every 5-day interval). The average orbital fit amounts to between ±4 cm and ±5 cm.

The time resolution for the other two sets is higher, namely three days for the set EOP(ZIPE) 90 L 02 and two days for the set EOP(ZIPE) 90 L 03. In the solutions of these two sets the station coordinates were fixed to the values obtained from the processing of the mentioned 5-day values. Further, for the solutions L 02 and L 03 the seven orbit dependent parameters were estimated for 6-days intervals covering the 3- and 2-day intervals, respectively. This way a better stability could be obtained for intervals with a sparse data distribution.

While in the 5-days solutions the LOD values were directly estimated, in the L 02 and L 03 solutions UT1 values were solved for instead of LOD. These UT1 results were converted into LOD. That means that the time scales (col.1) for the ERP(ZIPE) 90 L 02 and L 03 have to be transferred for the LOD values by -1.5d and -1.0d, respectively.

Generally, the SLR data were weighted according to their estimated accuracy. In addition, several non permanent stations were provided with a smaller weight in order to reduce the influence of the change of the station distribution.

In the data processing no post-adjustment smoothing or filtering procedure was applied to the EOP series. The standard deviations of the EOP(ZIPE) 90 L 01 solution are about ±0.1 to ±0.3 mas for the pole coordinates and ±0.001 to ±0.009 ms for LOD ; the y-component of the pole is somewhat more precise than the x-component. The accuracy was estimated to be about ±0.001" (3cm) for the pole and ±0.1ms for LOD. The 3-days solutions L 02 show nearly the same precision as the 5-days solution if there are submitted at least data from 10 stations. For solutions with data from 0 to 9 stations the precision is between ±0.1 and ±0.4 mas and up to 0.4 ms, respectively. There are also several solutions on the basis of data from less than 6 stations. Here the uncertainty can rise several times. Naturally, the number of results being based on data of less than 6 stations is still higher for the EOP(ZIPE) 90 L 03 series with a time resolution of 2 days. These individual results can be at least partly worse depending on the relevance of the stations positions for the single EOP components. Therefore these individual results (7 for the L 02 and 34 for the L 03 series) were omitted. If there are measurements from at least 10 stations the precision for the L 03 series is about ±0.3 mas and ±0.02 ms, respectively. In the case of using data from 6 to 10 stations the precision of the L 03 results can be smaller by a factor up to about 2.

Domes Number	Network Number	X m	Y m	Z m	Mean MJD	Data Span Days	SX m	SY m	SZ m
X14106S001	1181S001	3800621.309	882005.330	5028859.288	47402.5	533.0	0.016	0.025	0.028
X12302S002	1884S001	3183896.121	1421496.717	5322803.158	47388.5	429.0	0.024	0.040	0.050
X	1893S001	3785945.030	2550780.532	4439461.183	47602.5	113.0	0.080	0.103	0.110
X40701S001	1953S001	1474548.281	-5811242.415	2168944.907	47407.5	353.0	0.024	0.035	0.036
X40436M003	7035M001	-2428826.567	-4799754.334	3417266.941	47404.5	39.0	0.003	0.004	0.003
X40442M006	7080M001	-1330020.927	-5328401.905	3236480.728	47439.5	473.0	0.001	0.002	0.001
X40442M001	7086M001	-1330125.280	-5328526.663	3236150.140	47162.5	53.0	0.004	0.006	0.004
X50107M001	7090M001	-2389006.546	5043329.275	-3078525.411	47403.0	534.0	0.001	0.002	0.002
X40440M001	7091M001	1492453.823	-4457278.754	4296815.770	47426.5	45.0	0.003	0.004	0.004
X41703M002	7097M001	-1884984.372	-5357608.172	-2892853.477	47376.5	477.0	0.003	0.004	0.004
X40451M105	7105M001	1130719.816	-4831350.566	3994106.386	47393.0	514.0	0.001	0.002	0.0
X40433M002	7109M001	-2517234.684	-4198556.230	4076569.579	47404.0	536.0	0.001	0.001	0.001
X40497M001	7110M001	-2386277.910	-4802354.362	3444881.316	47404.0	536.0	0.001	0.002	0.001
X40496M001	7112M001	-1240678.110	-4720463.411	4094480.509	47419.0	28.0	0.002	0.004	0.003
X40504M001	7122M001	-1660089.301	-5619100.424	2511637.746	47410.5	521.0	0.001	0.002	0.002
X92202M003	7123M001	-5345866.724	-2958247.476	-1824624.375	47337.5	131.0	0.003	0.005	0.005
X40445M001	7210M001	-5466006.555	-2404427.916	2242187.326	47324.0	372.0	0.001	0.0	0.0
X40405M013	7288M001	-2356494.020	-4646607.695	3668426.533	47429.0	410.0	0.002	0.004	0.004
X40499M002	7295M001	961319.059	-5674090.964	2740489.460	47299.0	86.0	0.003	0.006	0.005
X12613S004	7517S004	4728697.971	2174374.804	3674573.426	47403.5	533.0	0.003	0.006	0.006
X12706S002	7544S002	5072834.694	1130886.811	3684835.392	47614.5	3.0	0.623	1.432	0.962
X12725M002	7545M001	4893398.137	772673.317	4004140.826	47209.0	68.0	0.003	0.006	0.006
X12711M002	7546M001	4461399.727	919566.928	4449510.398	47300.0	30.0	0.006	0.017	0.013
X14001S001	7810S001	4331283.632	567549.568	4633139.803	47450.0	440.0	0.001	0.002	0.003
X	7811S002	3738332.756	1148246.456	5021815.906	47482.5	377.0	0.030	0.051	0.054
X14201S002	7834S001	4075530.080	931781.286	4801618.089	47405.0	536.0	0.001	0.003	0.003
X10002S001	7835S002	4581691.812	556159.389	4389359.270	47405.5	539.0	0.001	0.002	0.003
X21605S001	7837S004	-2831087.800	4676203.455	3275172.900	47389.5	241.0	0.010	0.014	0.014
X21726M001	7838M001	-3822387.085	3699362.277	3507571.862	47385.0	434.0	0.003	0.004	0.004
X11001S002	7839S001	4194426.724	1162693.894	4647246.431	47406.0	536.0	0.001	0.002	0.003
X13212S001	7840S001	4033463.854	23662.343	4924304.926	47405.5	539.0	0.001	0.002	0.002
X	7844S001	-4491072.536	3481527.827	2887391.598	47206.0	28.0	0.011	0.013	0.018
X40439M004	7853M001	-2410421.116	-4477800.438	3838690.233	47462.0	30.0	0.002	0.003	0.003
X40505M001	7882M001	-1997241.739	-5528041.299	2468355.157	47322.0	44.0	0.003	0.004	0.003
X42202S001	7907S001	1942792.047	-5804077.651	-1796919.335	47232.0	188.0	0.002	0.004	0.001
X42202S002	7907S002	1942792.019	-5804077.593	-1796919.349	47499.0	346.0	0.001	0.002	0.002
X12734S001	7939S001	4641965.116	1393069.948	4133262.148	47407.5	535.0	0.001	0.002	0.002
X13504M002	8833M001	3899237.899	396769.183	5015055.059	47412.0	14.0	0.003	0.007	0.008

EOP(ZIPE) 90 L 01 Available from 1987 to 1989

Number of measurements and RMS uncertainty per year
Units : 0.001" for X,Y,dPsi,dEps; 0.0001s for UT; ms for D

YEAR	X		Y		D	
	Nb	Sigma	Nb	Sigma	Nb	Sigma
1987	5	0.21	5	0.19	5	0.005
1988	73	0.15	73	0.14	73	0.002
1989	30	0.16	30	0.17	30	0.002

EOP(ZIPE) 90 L 02 Available from 1987 to 1989

Number of measurements and RMS uncertainty per year
Units : 0.001" for X,Y,dPsi,dEps; 0.0001s for UT; ms for D

YEAR	X		Y		D	
	Nb	Sigma	Nb	Sigma	Nb	Sigma
1987	7	0.29	7	0.24	7	0.020
1988	118	0.21	118	0.19	118	0.016
1989	49	0.22	49	0.21	49	0.017

EOP(ZIPE) 90 L 03 Available from 1987 to 1989

Number of measurements and RMS uncertainty per year
Units : 0.001" for X,Y,dPsi,dEps; 0.0001s for UT; ms for D

YEAR	X		Y		D	
	Nb	Sigma	Nb	Sigma	Nb	Sigma
1987	8	0.32	8	0.30	8	0.025
1988	157	0.23	157	0.22	157	0.017
1989	68	0.26	68	0.28	68	0.023