APPENDIX 3

Appendix 3

INPUT SYSTEMS (from BIH Annual Report for 1987)

EARTH ORIENTATION RESULTS FROM THE NASA CRUSTAL DYNAMICS PROJECT

ERP(GSFC)88 R 01

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Mark III VLBI data acquired since 1979 by the NASA Crustal Dynamics Project and the NGS POLARIS/IRIS programs have been analyzed for Earth orientation parameters. The reference frame is defined by the position of the Haystack 37-m antenna moving with AM0-2 velocity and its position defined on 1980 Oct. 17. The orientation of the frame is defined by values from BIH Circular D and the standard J2000.0 precession and IAU 1980 nutation models for the same date. Short period tidal terms in UT1 have not been removed from the tabulated values of UT1-UTC. All uncertainties are 1-sigma formal statistical errors from the sequential least-squares estimation described below.

The basic models used in calculating the VLBI theoreticals are described in Ma (1978), and the data analysis procedures are described in Ryan et al. (1986) and Ma et al. (1986). These models are contained in the GSFC program CALC 6.0 and are consistent with the MERIT standards with the addition of the pole tide. In the analysis which generated these results, however, the ocean loading model was not used and adjustments in longitude and obliquity were estimated for each session except the reference day. All stations move with their AM0-2 velocities on the listed tectonic plates. It should be noted that Kashima has been placed on the North American plate.

222 183 Mark III observations from 566 sessions were used to estimate station positions, source positions, Earth orientation parameters, nutation parameters and local clock and troposphere behavior from a least-squares solution with 192 global parameters and 14 246 arc, i.e., session-dependent, parameters. A weak input covariance on the Earth orientation parameters (X, Y-15 mas, UT1-1 ms) was used so that all three components could be estimated for each session with a more reliable indication of uncertainty and correlation. This affected only single baselines and nearly degenerate triangles. The overall rms fit of the solution was 83.1 ps for delay and 73.0 fs/s for rate. The reduced chi-square of the solution was .98.

The Earth orientation time series spanning nine years is given in ERP(GSFC)88 R 01. It should be noted that values from IRIS normally have X-UT correlations of 0.7 and that single baseline correlations approach unity. These correlations should be taken into account when applying the parameter uncertainties since the size of the error ellipsoid will otherwise be excessively large. Other results are source positions given in RSC(GSFC)88 R 01, station coordinates at epoch 1980 Oct. 17 given in SSC(GSFC)88 R 01, and nutation adjustments relative to 1980 Oct. 17 in NUT(GSFC)88 R 01.

References

C. Ma, NASA TM-79582, 1978.
J. Ryan et al., J. Geophys. Res. 91, 1935, 1986.
C. Ma et al., Astron. J. 92, 1020, 1986.

BIH(1988) : Annual Report for 1987.

STATION COORDINATES SSC(GSFC) 88 R 01

NETWORK NUMBER	SITE	DOMES NUMBER	X m	Y m	Z m	SX	SY	SZ	PLATE	EPOCH MJD
401S010	ALGONQUIN	40104S001	918036.723	-4346133.066	4561971.561	.002	.006	.007	NOAM	44529
106S010	CHILBOLTON	13201S002	4008312.009	-100651.879	4943794.796	.009	.005	.012	EURA	44529
101S010	EFFELSBERG	14209S001	4033949.409	486989.385	4900430.754	.008	.005	.013	EURA	44529
429S010	FAIRBANKS	40408S002	-2281545.170	-1453645.805	5756993.684	.003	.005	.010	NOAM	44529
410S030	GOLDSTONE	40405S014	-2351127.274	-4655477.930	3660957.507	.008	.015	.013	NOAM	44529
301S010	JOHANNESBURG	30302S001	5085444.328	2668262.049	-2768697.257	.026	.017	.017	AFRC	44529
407S010	HAT CREEK	40489S001	-2523968.042	-4123507.192	4147753.186	.002	.006	.008	NOAM	44529
403S010	HAYSTACK	40440S002	1492406.691	-4457267.330	4296882.102	.001	.001	.001	NOAM	44529
406S010	FORT DAVIS	40442S003	-1324209.126	-5332023.968	3232118.942	.002	.005	.005	NOAM	44529
203S010	KASHIMA	21701S001	-3997890.433	3276580.390	3724118.715	.011	.007	.020	NOAM	44529
430S010	KAUAI	40424S001	-5543844.213	-2054565.546	2387814.078	.007	.010	.015	PCFC	44529
507S010	KWAJALEIN ATOLL	50505S003	-6143534.953	1363995.752	1034707.618	.015	.013	.020	PCFC	44529
415S010	MARYLAND POINT	40490S001	1106631.226	-4882907.983	3938087.339	.004	.011	.009	NOAM	44529
112S010	BOLOGNE	12711S001	4461371.968	919595.660	4449559.136	.009	.005	.013	EURA	44529
427S010	GOLDSTONE	40405S009	-2356169.122	-4646756.731	3668471.197	.001	.005	.007	NOAM	44529
404S010	GREENBANK	40441S001	882881.815	-4924483.116	3944131.063	.001	.005	.005	NOAM	44529
103S020	ONSALA	10402S002	3370608.017	711916.419	5349830.741	.005	.004	.010	EURA	44529
405S010	OWENS VALLEY	40439S002	-2409598.868	-4478350.390	3838603.796	.001	.005	.007	NOAM	44529
402M001	PENTICTON	40105M001	-2058838.556	-3621287.265	4814421.387	.005	.010	.013	NOAM	44529
432M001	PLATTEVILLE	40496M002	-1240706.242	-4720455.146	4094482.175	.002	.008	.008	NOAM	44529
412S010	RICHMOND	40499S001	961259.855	-5674090.884	2740534.192	.002	.004	.003	NOAM	44529
108S020	MADRID	13407S003	4849247.098	-360279.338	4114884.533	.045	.014	.040	EURA	44529
201S020	SHANGHAI	21605S009	-2831684.418	4675732.822	3275327.682	.086	.083	.096	EURA	44529
201S010	SHANGHAI	21605S008	-2847695.758	4659871.645	3283958.812	.128	.110	.102	EURA	44529
428M001	SOUTH VANDENBERG	40420M002	-2678092.771	-4525451.947	3597410.498	.002	.006	.008	NOAM	44529
409S010	HAYSTACK	40440S003	1492208.546	-4458131.313	4296015.858	.001	.002	.002	NOAM	44529
115S010	WETTZELL	14201S004	4075541.876	931734.136	4801629.343	.006	.004	.011	EURA	44529
431M001	YELLOWKNIFE	40127M001	-1224122.542	-2689531.382	5633555.746	.006	.012	.025	NOAM	44529

Epoch of station positions is 1980 October 17.

POLAR MOTION AND UT1 TIME SERIES DERIVED FROM VLBI OBSERVATIONS

ERP(NGS) 88 R 01
ERP(NGS) 88 R 02

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Estimates of X, Y and UT1-UTC have been derived from a composite set of Mark III Very Long Baseline Interferometry (VLBI) observations collected under the aegis of projects MERIT (Wilkins, 1984), POLARIS and IRIS (Carter et al., 1985).More than 138 000 observations amassed during 460 observing sessions conducted between September 9, 1980, and January, 1988, were combined in a single least squares adjustment to obtain self consistent Earth orientation time series (Table NGS-1), source coordinates (Table NGS-2) (see Robertson et al., 1986) and the coordinates of the VLBI reference points of each of the radio telescopes (Table NGS-3).
Table NGS-4 contains corrections to the IAU 1980 nutation series from the IRIS 5-day observing sessions.
Table NGS-5 contains a daily series of UT1 values for the period April through June, 1984, and April 1985 through January, 1988. These UT1 values were produced from a series of special observing sessions using only the Westford-Wettzell baseline for 45 minutes each day. These restricted observing sessions are sufficient to determine only UT1. The daily values track smoothly between the regular 5-day IRIS values, and we estimate their accuracy to be 0.1 millisec (Robertson et al., 1985b).

The observations were processed at NGS using algorithms generally consistent with the MERIT standards (Melbourne et al., 1983), which include use of the IAU 1980 nutation model, an Earth tide model based on ephemeris positions for the Sun and Moon with the K1 term removed, and a model for ocean loading displacements. Hellings' model for the relativistic corrections for signal propagation was used (Hellings, 1986). Atmospheric refraction was modeled with the CFA-2.2 model (Davis et al., 1985), using meteorological data (pressure, temperature, humidity) taken at each VLBI station during each observing session. Wahr's model was used for the solid Earth deformations resulting from the motion of the pole (Wahr, 1985). Plate motions are modeled using the no-net-rotation model of Minster and Jordan (Minster and Jordan, 1978). The most significant deviation from the MERIT standards was that the IAU 1980 nutation model was corrected by estimating daily adjustments in longitude and obliquity. This deviation is necessary because the accuracy of the VLBI observations is sufficient to detect the errors in the annual, semi-annual, and fortnightly terms in the model (Herring, 1986). X and Y coordinates of the pole derived from satellite laser ranging (SLR) (Eanes et al., 1988), modified to remove a constant offset between the VLBI and SLR time series, were used in processing the single-baseline 24-hour observing sessions, to determine the Y component of the pole prior to January, 1984. After that time values interpolated from the IRIS series were used.

BIH(1988) : Annual Report for 1987.

The standard errors quoted in tables 1-4 are strictly the formal values obtained from the adjustment, and should be understood as a limit on the accuracy of the determinations, the limit that would be attained in the absence of unmodeled systematic errors. Based on intercomparisons with satellite laser ranging series we estimate that since the Wettzell observatory became operational in January 1984 the IRIS X and Y components of polar motion have accuracies no worse than 2 milliseconds of arc (Robertson et al., 1985a), and intercomparisons between these values and the daily UT1 values (see below) indicates that the UT1 values are accurate to at least ± 0.1 milliseconds of time (Robertson et al., 1985b).

On behalf of the joint International Association of Geodesy (IAG), Committee on Space Research (COSPAR) Subcommission International Radio Interferometric Surveying (IRIS) the NGS distributes the monthly IRIS Bulletin A, Earth Orientation Information, and maintains a file containing the same data on the NGS computers which can be accessed via telephone by users who would like to have the data in machine-readable form. Additional information or assistance concerning the data presented here, or the data available through the MARK 3, IRIS Bulletin A, or NGS computer system may be obtained by contacting the authors.

References:

Carter, W.E., D.S. Robertson, and J.R. MacKay, Geodetic Radio Interferometric Surveying: Applications and Results, J.Geophys. Res., 90, 4577-4587, 1985.

Davis, J.L., T.A. Herring, I.I. Shapiro, A.E.E. Rogers, and G. Elgered, Geodesy by Radio Interferometry: Effects of Atmospheric Modeling Errors on Estimates of Baseline Length, Radio Science, 20, 1593-1607, 1985.

Eanes, R.J., B.E. Schutz, and B.D. Tapley, Earth Rotation from Laser Ranging to Lageos, this volume, 1988.

Hellings, R.W., Relativistic Effects in Astronomical Timing Measurements, Astronomical Journal, 91, 650-659, 1986.

Herring, T.A., C.R. Gwinn, and I.I. Shapiro, Geodesy by Radio Interferometry: Studies of the Forced Nutations of the Earth, Part I: Data Analysis, J. Geophys. Res., 91, 4745-4754, 1986a.

Melbourne, W., R. Anderle, M. Feissel, R. King, D. McCarthy, D. Smith, B. Tapley, and R. Vicente, U.S. Naval Observatory Circular No. 167, Washington, D.C., 1983.

Robertson, D.S., W.E. Carter, B.D. Tapley, B.E. Schutz, R.J. Eanes, Polar Motion Measurements: Sub-Decimeter Accuracy Verified by Intercomparison, Science, 229, 1259-1261, 1985a.

Robertson, D.S., W.E. Carter, J.A. Campbell, and H. Schuh, Daily UT1 Determinations from IRIS Very Long Baseline Interferometry, Nature,316, 424-427,1985b.

Robertson, D.S., F.W. Fallon and W.E. Carter, Celestial Reference Coordinate Systems: Sub-millisecond of Arc Repeatability Demonstrated with VLBI Observations, Astron. J., 91, 1456-1462, 1986.

Wahr, J.M., Deformation Induced by Polar Motion, J. Geophys. Res., 90, 9363-9368, 1985.

Wilkins, G.A., (ed.), Project MERIT: Report on the second MERIT Workshop held at the Royal Greenwich Observatory on 1983 May 15-19, Herstmonceux, 74 pp., 1984.

TABLE NGS-3. Station Coordinates SSC(NGS) 88 R 01

NETWORK NUMBER	SITE	DOMES NUMBER	X m	Y m	Z m	SX m	SY m	SZ m	PLATE	MJD
405S010	OWENS VALLEY	40439S002	-2409600.583	-4478349.451	3838603.446	.003	.008	.009	NOAM	45700
427S010	GOLDSTONE	40405S009	-2356170.843	-4646755.780	3668470.833	.003	.014	.016	NOAM	45700
406S010	FORT DAVIS	40442S003	-1324210.830	-5332023.025	3232118.569	.002	.005	.006	NOAM	45700
404S010	GREENBANK	40441S001	882880.174	-4924482.166	3944130.697	.002	.007	.006	NOAM	45700
412S010	RICHMOND	40499S001	961258.209	-5674089.934	2740533.783	.002	.004	.003	NOAM	45700
415S010	MARYLAND POINT	40490S001	1106629.600	-4882907.034	3938086.959	.005	.020	.016	NOAM	45700
409S010	HAYSTACK	40440S003	1492206.923	-4458130.340	4296015.490	.010	.010	.010	NOAM	45700
403S010	HAYSTACK	40440S002	1492405.068	-4457266.374	4296881.746	.001	.003	.003	NOAM	45700
103S020	ONSALA	10402S002	3370606.448	711917.597	5349830.449	.006	.004	.010	EURA	45700
106S010	CHILBOLTON	13201S002	4008310.439	-100650.707	4943794.438	.012	.006	.016	EURA	45700
101S010	EFFELSBERG	14209S001	4033947.824	486990.561	4900430.388	.014	.008	.021	EURA	45700
115S010	WETTZELL	14201S004	4075540.310	931735.337	4801629.022	.007	.004	.011	EURA	45700
112S010	BOLOGNE	12711S001	4461370.423	919596.875	4449558.816	.011	.006	.015	EURA	45700
301S010	JOHANNESBURG	30302S001	5085442.656	2668263.457	-2768697.703	.026	.014	.017	AFRC	45700

The station coordinate epoch is January 1, 1984.

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Austin, TX 78712-1085

Telex 704265 CSRUTX UD
BITNET: SCHUTZ at UTADNX
SPAN: UTSPAN::UTADNX::SCHUTZ
GE Mark 3 AUTA

A single continuous Lageos ephemeris was fit to Lageos laser range data for the interval from May 1976 to January 1988. The data base contained about 316 000 three-minute normal points formed from over 32 000 passes collected from more than 90 sites.

The force model referred to as the CSR 8801 system. contains some departures from the MERIT Standards GM=398600.440 km**3/s**2 and the order one GEM-L2 coefficients were adjusted for consistency with the MERIT C(2,1) and S(2,1). Furthermore. some ocean tide parameters depart from the Standards.

The station coordinates were obtained simultaneously with the ephemeris and selected force model parameters. The stations were assumed to be attached to the tectonic plates noted in the following table with rates defined by the AM1-2 model of Minster and Jordan (1978). The epoch of the derived station coordinates is 1983 January 1 00:00 UTC.

The earth rotation parameters estimated simultaneously with the other parameters were three day values of pole position (x,y) and UT1. The estimated UT1 values contain Lageos node model errors which were filtered to remove periods greater than about 80 days. The reference UT1 series was the combined series of T.M. Eubanks (this volume p.D-85) from 1976 to 1986. After 1986, the reference was the monthly IRIS values reported on G.E.Mark 3.As a consequence, the long period (greater than 80 days) represents the reference UT1 series, but for periods below about 40 days, the Lageos UT1 estimates are independent of the reference series. During periods from 1976 to 1980, some three-day intervals did not have adequate tracking coverage, as reflected by larger standard errors when compared to the period from 1980 to 1988.

Note - Plate motion model : AM1-2 from Minster, J.B., and Jordan, T.H., 1978, Present-Day Plate Motions. J.Geophys.Res., 83, 5331-5354.

SSC(CSR) 88 L 01

NETWORK NUMBER	SITE	DOMES NUMBER	X	Y	Z	SX	SY	SZ	PLATE	MJD
1181S001	POTSDAM	14106S001	3800621.502	882005.190	5028859.501	.034	.034	.022	EURA	45335
1953S001	SANTIAGO DE CUBA	40701S001	1474548.542	-5811242.444	2168945.108	.155	.117	.179	NOAM	45335
7051M001	QUINCY	40433M001	-2516893.229	-4198844.933	4076411.540	.018	.016	.013	NOAM	45335
7062M001	SAN DIEGO	40436M002	-2428825.918	-4799750.460	3417272.808	.016	.014	.014	PCFC	45335
7063M001	WASHINGTON	40451M112	1130714.656	-4831367.715	3994087.426	.012	.009	.009	NOAM	45335
7064M001	WASHINGTON	40451M107	1130689.505	-4831341.933	3994123.795	1.000	1.000	1.000	NOAM	45335
7065M001	WASHINGTON	40451M108	1130692.329	-4831351.962	3994111.385	1.000	1.000	1.000	NOAM	45335
7067M001	BERMUDA	42501M001	2308538.384	-4874079.996	3393628.615	.072	.048	.073	NOAM	45335
7068M001	GRAND TURK	43602M002	1920482.507	-5619478.398	2318914.376	1.000	1.000	1.000	NOAM	45335
7069M001	PATRICK AFB	40417M002	917958.723	-5548370.183	2998776.759	1.000	1.000	1.000	NOAM	45335
7082M001	BEAR LAKE	40438M001	-1735997.267	-4425047.933	4241430.546	.026	.024	.017	NOAM	45335
7084M001	OWENS VALLEY	40439M003	-2410590.137	-4477745.038	3838648.579	.108	.096	.063	NOAM	45335
7085M001	GOLDSTONE	40405M001	-2353393.953	-4641529.064	3676899.086	.092	.100	.067	NOAM	45335
7086M001	FORT DAVIS	40442M001	-1330125.465	-5328526.469	3236150.434	.007	.004	.006	NOAM	45335
7090M001	YARRAGADEE	50107M001	-2389006.010	5043329.294	-3078525.709	.006	.004	.005	INDI	45335
7091M001	HAYSTACK	40440M001	1492453.575	-4457278.669	4296815.896	.013	.011	.010	NOAM	45335
7092M001	KWAJALEIN ATOLL	50505M001	-6143447.273	1364700.159	1034162.907	.017	.024	.024	PCFC	45335
7096M001	AMERICAN SAMOA	50503M001	-6100045.820	-996203.193	-1568976.425	.013	.020	.019	PCFC	45335
7100M001	WASHINGTON	40451M106	1131355.671	-4831168.899	3994132.165	1.000	1.000	1.000	NOAM	45335
7101M001	WASHINGTON	40451M101	1131240.446	-4831179.848	3994148.474	1.000	1.000	1.000	NOAM	45335
7102M001	WASHINGTON	40451M102	1130686.536	-4831353.013	3994110.947	.013	.011	.009	NOAM	45335
7103M001	WASHINGTON	40451M103	1130685.537	-4831348.684	3994116.392	.021	.020	.014	NOAM	45335
7104M001	WASHINGTON	40451M104	1131095.752	-4831196.858	3994170.811	.062	.052	.054	NOAM	45335
7105M001	WASHINGTON	40451M105	1130719.655	-4831350.539	3994106.549	.007	.004	.005	NOAM	45335
8213S001	WASHINGTON	40451S131	1130705.584	-4831348.397	3994117.858	.032	.026	.026	NOAM	45335

SSC(CSR) 88 L 01 (CONT.)

NETWORK NUMBER	SITE	DOMES NUMBER	X	Y	Z	SX	SY	SZ	PLATE	MJD
7106S001	WASHINGTON	40451S132	1130659.662	-4831292.885	3994173.166	1.000	1.000	1.000	NOAM	45335
7109M001	QUINCY	40433M002	-2517234.789	-4198556.005	4076569.837	.006	.005	.005	NOAM	45335
7110M001	MONUMENT PEAK	40497M001	-2386277.959	-4802354.291	3444881.457	.006	.004	.005	PCFC	45335
7112M001	PLATTEVILLE	40496M001	-1240678.317	-4720463.231	4094480.743	.009	.007	.006	NOAM	45335
7114M001	OWENS VALLEY	40439M001	-2410422.484	-4477802.514	3838686.824	.011	.010	.009	NOAM	45335
7115M001	GOLDSTONE	40405M002	-2350861.738	-4655546.142	3660998.028	.011	.010	.009	NOAM	45335
7120M001	MAUI	40445M002	-5465998.458	-2404408.509	2242228.372	.008	.011	.010	PCFC	45335
7121M001	MOTU HIUMOO	92202M002	-5345865.243	-2958246.680	-1824623.841	.011	.015	.014	PCFC	45335
7122M001	MAZATLAN	40504M001	-1660089.509	-5619100.244	2511638.033	.007	.004	.006	NOAM	45335
7123M001	MOTU HIUMOO	92202M003	-5345865.285	-2958246.677	-1824623.917	.019	.021	.022	PCFC	45335
7125M001	WASHINGTON	40451M114	1130745.769	-4831368.075	3994077.122	.021	.017	.014	NOAM	45335
7130M001	WASHINGTON	40451M116	1130735.232	-4831324.617	3994132.372	.125	.107	.084	NOAM	45335
7210M001	MAUI	40445M001	-5466006.508	-2404427.887	2242187.423	.004	.007	.006	PCFC	45335
7220M001	MONUMENT PEAK	40497M002	-2386292.284	-4802347.456	3444880.936	.015	.015	.013	PCFC	45335
7265M001	GOLDSTONE	40405M006	-2356475.780	-4646618.095	3668424.904	.019	.020	.014	NOAM	45335
7274M001	MONUMENT PEAK	40497M003	-2386289.363	-4802346.465	3444884.007	.016	.016	.014	PCFC	45335
7400M001	SANTIAGO	41705M001	1769699.470	-5044613.079	-3468260.030	.024	.017	.021	SOAM	45335
7401M001	CERRO TOLOLO	41706M001	1815516.827	-5213465.024	-3187999.357	.016	.012	.015	SOAM	45335
7510M001	ASKITES	12612M001	4353445.220	2082666.089	4156506.496	.011	.013	.010	EURA	45335
7512M001	KATAVIA	12615M001	4573400.372	2409321.969	3723881.605	.012	.015	.012	EURA	45335
7515M001	DIONYSOS	12602M002	4595216.723	2039435.100	3912629.354	.010	.012	.010	EURA	45335
7517M001	ROUMELLI	12613M001	4728694.991	2174373.131	3674572.801	.009	.012	.010	EURA	45335
7520M001	KARITSA	12614M001	4596042.880	1733476.594	4055720.703	.018	.018	.013	EURA	45335
7525M001	XRISOKALARIA	12616M001	4745949.832	1905705.702	3799168.889	.014	.015	.013	EURA	45335
7530S001	BAR GIYYORA	20702S001	4443968.823	3121946.640	3334695.252	.017	.019	.017	AFRC	45335

SSC(CSR) 88 L 01 (CONT.)

NETWORK NUMBER	SITE	DOMES NUMBER	X	Y	Z	SX	SY	SZ	PLATE	MJD
7540M001	MATERA	12734M005	4641984.804	1393057.512	4133233.313	.025	.023	.016	EURA	45335
7541M001	MATERA	12734M004	4641990.544	1393042.066	4133231.699	.015	.017	.012	EURA	45335
7544M001	LAMPEDUSA	12706M001	5072832.228	1130885.990	3684836.789	.017	.022	.015	EURA	45335
7545S001	CAGLIARI	12725S010	4893400.912	772673.560	4004139.670	.017	.023	.016	EURA	45335
7550M001	TRIESTE	12718M002	4336738.804	1071271.271	4537910.910	.027	.034	.022	EURA	45335
7575M001	DIYARBAKIR	20801M001	3848636.442	3251760.707	3898909.061	.030	.030	.023	EURA	45335
7580M001	MELENGICLICK	20803M001	4247620.925	2778638.789	3851607.309	.021	.025	.014	EURA	45335
7585M001	YOZGAT	20802M001	4029731.058	2802093.132	4062067.857	.034	.044	.019	EURA	45335
7587M001	YIGILCA	20804M001	4117362.322	2517076.651	4157678.883	.024	.019	.014	EURA	45335
7596S001	WETTZELL	14201S010	4075585.514	931837.601	4801559.120	.021	.027	.016	EURA	45335
7597S001	WETTZELL	14201S011	4075605.116	931826.877	4801546.858	1.000	1.000	1.000	EURA	45335
7599S001	WETTZELL	14201S007	4075517.644	931753.917	4801630.174	1.000	1.000	1.000	EURA	45335
7805S001	METSAHOVI	10503S001	2892596.253	1311808.420	5512610.217	.088	.080	.056	EURA	45335
7810S001	ZIMMERWALD	14001S001	4331283.806	567549.295	4633139.842	.017	.018	.011	EURA	45335
7831S001	HELWAN	30101S001	4728283.921	2879670.171	3156894.061	.092	.099	.080	AFRC	45335
7833S001	KOOTWIJK	13504S001	3899224.214	396742.740	5015073.744	.030	.031	.019	EURA	45335
8833S001	KOOTWIJK	13504S007	3899238.142	396769.020	5015055.104	.029	.030	.019	EURA	45335
7834S001	WETTZELL	14201S002	4075530.306	931781.132	4801618.123	.009	.010	.007	EURA	45335
7835S001	GRASSE	10002S001	4581692.009	556159.170	4389359.259	.008	.010	.007	EURA	45335
7837S001	SHANGHAI	21605S001	-2831087.300	4676203.670	3275172.799	.103	.088	.075	EURA	45335
7838S001	SIMOSATO	21726S001	-3822388.035	3699363.759	3507573.109	.006	.006	.006	EURA	45335
7839S001	GRAZ	11001S002	4194426.945	1162693.702	4647246.399	.007	.008	.006	EURA	45335
7840S001	HERSTMONCEUX	13212S001	4033463.991	23662.159	4924304.933	.005	.007	.005	EURA	45335
7843S001	ORRORAL	50103S008	-4446476.429	2678127.203	-3696251.875	.008	.009	.007	INDI	45335
7882M001	CABO SAN LUCAS	40505M001	-1997241.720	-5528040.936	2468355.246	1.000	1.000	1.000	PCFC	45335

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NETWORK NUMBER	SITE	DOMES NUMBER	X	Y	Z	SX	SY	SZ	PLATE	MJD
7885M001	FORT DAVIS	40442M005	-1330125.510	-5328526.416	3236150.395	.029	.031	.023	NOAM	45335
7886M001	QUINCY	40433M005	-2517242.397	-4198550.750	4076570.482	.015	.011	.008	NOAM	45335
7887M001	VANDENBERG	40420M004	-2668868.288	-4530743.159	3598684.956	1.000	1.000	1.000	NOAM	45335
7888M001	MOUNT HOPKINS	40434M002	-1936744.432	-5077638.897	3331994.034	.032	.025	.029	NOAM	45335
7891M001	FLAGSTAFF	40491M002	-1923976.799	-4850871.546	3658574.841	.032	.031	.024	NOAM	45335
7892M001	VERNAL	40492M001	-1631484.792	-4589133.647	4106749.651	.023	.025	.016	NOAM	45335
7894M001	YUMA	40493M001	-2196777.940	-4887336.898	3448425.436	.025	.024	.024	NOAM	45335
7896M001	PASADENA	40400M001	-2493211.982	-4655229.417	3565574.651	.024	.024	.019	PCFC	45335
7899M001	WASHINGTON	40451M111	1131364.615	-4831168.764	3994129.059	.036	.036	.030	NOAM	45335
7907S001	AREQUIPA	42202S001	1942791.630	-5804077.857	-1796919.262	.007	.003	.006	SOAM	45335
7918S001	WASHINGTON	40451S142	1130741.956	-4831371.376	3994079.333	1.000	1.000	1.000	NOAM	45335
7919S001	WASHINGTON	40451S145	1130705.676	-4831347.429	3994117.615	1.000	1.000	1.000	NOAM	45335
7921S001	MOUNT HOPKINS	40434S001	-1936760.322	-5077706.954	3331922.611	.016	.014	.014	NOAM	45335
7929S001	NATAL	41604S001	5186467.773	-3653856.349	-654321.819	.034	.044	.046	SOAM	45335
7939S001	MATERA	12734S001	4641965.336	1393069.698	4133262.086	.005	.006	.005	EURA	45335
7940S001	DIONYSOS	12602S001	4595217.574	2039464.233	3912612.946	1.000	1.000	1.000	EURA	45335
7943S001	ORRORAL	50103S003	-4447548.402	2677134.195	-3694996.869	.007	.008	.007	INDI	45335

AN 11.2 YEAR SLR EOP SERIES FROM LAGEOS SATELLITE LASER RANGING

SL7.1 (G14) ERP(GSFC)87 L 14

D.E. Smith, R.Kolenkiewicz and B.H. Putney,
the Geodynamics Branch, GSFC. Greenbelt. Maryland
P.J. Dunn. S.M. Klosko, E.C. Pavlis, J.R. Robbins, M.H.Torrence and
R.G. Williamson,EG&G,
Washington Analytical Services Center, Inc., Lanham, Maryland 20706
S.M. Fricke,
Republic Management System, Inc., Lanham, Maryland 20706

This solution was done by fitting 30 day (and occasionaly 35 day) day arcs of LAGEOS laser ranging normal point data from May 1976 through June 1987. There were 362 810 normal points used to form the solution, which were constructed from approximately 50 million full rate laser range observations. In each of the monthly arcs the initial state vector, two coefficients of solar radiation pressure and two coefficients of along track acceleration were estimated. The monthly arcs were combined to form a solution for earth orientation parameters and station positions. The following is a summary of the kinematic and dynamic models used for these solutions :

FORCE MODEL

- GEM-T1 Gravity model complete to degree and order 20.
- Third body perturbations: Sun, Moon, Venus, Mars, Jupiter, and Saturn (positioned with the JPL DE200 ephemeris)
- GM = 398600.4400 km3/sec2
- Tidal perturbations: Solid earth from Wahr, ocean tidal coeficients from GEM-T1
- Direct effect of solar radiation pressure adjusted twice in each monthly arc
- Along track acceleration adjusted twice in each monthly arc

MEASUREMENT MODEL

- Marini-Muray wavelength dependent refraction model with site meteorological measurements
- Velocity of light = 299792.458 km/sec
- Vertical and horizontal tide displacements: h2=0.6090, l2=0.0852
- 2 minute normal points following the Herstmonceux recommendations

BIH (1988) Annual Report for 1987.

REFERENCE FRAME

- Wahr nutation series
- J2000 precession (JPL DE200 ephemeris)
- Ae = 6378137. m
- Flattening = 1/298.257
- Apriori earth orientation (Xp Yp and A1-UT1) obtained from a weakly Vondrak smoothed earth orientation from SL7. These input values are adjusted at 5-day intervals (Xp, Yp, and A1-UT1): except that the first 5 day value of A1-UT1 in each monthly arc is fixed at the input value.
- The station positions were constrained to move according to the Minster/Jordan (1978) tectonic motion model AM0-2. The positions have an epoch of January 1983.

The Xp and Yp positions for the pole and the LOD values are in
ERP(GSFC) 87 L 14

The sigmas given are scaled formal errors from the least squares adjustment.

The station positions are presented in cartesian coordinates in
SSC(GSFC) 87 L 14.

The positions are for an epoch of January 1983, and, as for the EOP, the sigmas given are scaled formal errors from the least squares adjustment.

The positions for stations

7051, 7061, 7062, 7063, 7069, 7082, 7086, 7090, 7091, 7092, 7096, 7100, 7101, 7102, 7103, 7104, 7105, 7109, 7110, 7112, 7114, 7115, 7120, 7121, 7122, 7210, 7220, 7265, 7517, 7520, 7525, 7530, 7541, 7545, 7550, 7590, 7838, 7882, 7885, 7887, 7888, 7890, 7891, 7892, 7896. and 7899 are for the pad marker at the site.
The positions for stations

1181, 7400, 7401, 7805, 7810, 7833, 7834, 7835, 7837, 7839, 7840, 7843, 7886, 7894, 7907, 7921, 7929, 7939, and 7943 are for the optical axis of the laser ranging system.

NETWORK NUMBER	SITE	DOMES NUMBER	X m	Y m	Z m	SX	SY	SZ	PLATE	EPOCH MJD
1181S001	POTSDAM	14106S001	3800621.602	882005.144	5028859.364	.110	.108	.074	EURA	45335
7051M001	QUINCY	40433M001	-2516893.067	-4198845.021	4076411.563	.017	.016	.012	NOAM	45335
7061M001	EASTER ISLAND	41703M001	-1884984.569	-5357606.615	-2892852.514	.128	.100	.099	NAZC	45335
7062M001	SAN DIEGO	40436M002	-2428825.759	-4799750.528	3417272.733	.015	.013	.014	PCFC	45335
7063M001	WASHINGTON	40451M112	1130714.845	-4831367.722	3994087.347	.001	.006	.005	NOAM	45335
7067M001	BERMUDA	42501M001	2308538.595	-4874079.899	3393628.478	.139	.089	.129	NOAM	45335
7068M001	GRAND TURK	43602M002	1920482.742	-5619478.322	2318914.296	.450	.248	.380	NOAM	45335
7069M001	PATRICK AFB	40417M002	917959.103	-5548370.284	2998776.608	.142	.083	.110	NOAM	45335
7082M001	BEAR LAKE	40438M001	-1735997.066	-4425048.120	4241430.592	.021	.021	.015	NOAM	45335
7084M001	OWENS VALLEY	40439M003	-2410590.154	-4477745.773	3838648.330	.218	.553	.620	NOAM	45335
7085M001	GOLDSTONE	40405M001	-2353394.103	-4641529.856	3676898.746	.195	.528	.609	NOAM	45335
7086M001	FORT DAVIS	40442M001	-1330125.326	-5328526.542	3236150.388	.004	.004	.003	NOAM	45335
7090M001	YARRAGADEE	50107M001	-2389006.169	5043329.303	-3078525.572	.003	.003	.005	INDI	45335
7091M001	HAYSTACK	40440M001	1492453.734	-4457278.710	4296815.799	.013	.011	.010	NOAM	45335
7092M001	KWAJALEIN ATOLL	50505M001	-6143447.292	1364700.020	1034163.076	.017	.024	.024	PCFC	45335
7096M001	AMERICAN SAMOA	50503M001	-6100045.859	-996203.244	-1568976.317	.014	.020	.019	PCFC	45335
7100M001	WASHINGTON	40451M106	1131355.720	-4831168.684	3994132.087	.226	.180	.195	NOAM	45335
7101M001	WASHINGTON	40451M101	1131240.510	-4831179.809	3994148.458	.084	.052	.075	NOAM	45335
7102M001	WASHINGTON	40451M102	1130686.655	-4831353.070	3994110.874	.012	.010	.008	NOAM	45335
7103M001	WASHINGTON	40451M103	1130685.716	-4831348.720	3994116.296	.018	.019	.012	NOAM	45335
7104M001	WASHINGTON	40451M104	1131095.963	-4831196.830	3994170.798	.064	.054	.053	NOAM	45335
7105M001	WASHINGTON	40451M105	1130719.791	-4831350.556	3994106.469	.001	.002	.002	NOAM	45335
7109M001	QUINCY	40433M002	-2517234.651	-4198556.103	4076569.835	.003	.004	.002	NOAM	45335
7110M001	MONUMENT PEAK	40497M001	-2386277.830	-4802354.367	3444881.451	.003	.004	.003	PCFC	45335
7112M001	PLATTEVILLE	40496M001	-1240678.167	-4720463.302	4094480.711	.006	.006	.004	NOAM	45335

NETWORK NUMBER	SITE	DOMES NUMBER	X m	Y m	Z m	SX	SY	SZ	PLATE	EPOCH MJD
7114M001	OWENS VALLEY	40439M001	-2410422.346	-4477802.637	3838686.825	.010	.010	.008	NOAM	45335
7115M001	GOLDSTONE	40405M002	-2350861.583	-4655546.248	3660998.016	.010	.010	.009	NOAM	45335
7120M001	MAUI	40445M002	-5465998.367	-2404408.648	2242228.437	.007	.010	.010	PCFC	45335
7121M001	MOTU HIUMOO	92202M002	-5345865.225	-2958246.707	-1824623.797	.005	.007	.006	PCFC	45335
7122M001	MAZATLAN	40504M001	-1660089.369	-5619100.296	2511637.990	.004	.004	.003	NOAM	45335
7125M001	WASHINGTON	40451M114	1130745.851	-4831368.061	3994077.088	.013	.011	.009	NOAM	45335
7210M001	MAUI	40445M001	-5466006.420	-2404428.020	2242187.486	.003	.005	.001	PCFC	45335
7220M001	MONUMENT PEAK	40497M002	-2386292.141	-4802347.466	3444880.901	.015	.013	.011	PCFC	45335
7265M001	GOLDSTONE	40405M006	-2356475.639	-4646618.163	3668424.890	.013	.014	.010	NOAM	45335
7400S001	SANTIAGO	41705S003	1769700.127	-5044614.829	-3468263.227	.018	.012	.015	SOAM	45335
7401S001	CERRO TOLOLO	41706S001	1815517.654	-5213466.857	-3188002.492	.012	.009	.010	SOAM	45335
7517M001	ROUMELLI	12613M001	4728694.983	2174373.086	3674572.753	.013	.016	.015	EURA	45335
7520M001	KARITSA	12614M001	4596042.901	1733476.580	4055720.619	.018	.017	.013	EURA	45335
7525M001	XRISOKALARIA	12616M001	4745949.861	1905705.653	3799168.881	.021	.026	.023	EURA	45335
7530M001	BAR GIYYORA	20702M001	4443967.730	3121945.143	3334694.117	.012	.013	.013	AFRC	45335
7541M001	MATERA	12734M004	4641990.591	1393042.047	4133231.626	.017	.019	.013	EURA	45335
7545M001	CAGLIARI	12725M002	4893398.335	772673.017	4004140.721	.011	.015	.011	EURA	45335
7550M001	TRIESTE	12718M002	4336738.868	1071271.219	4537910.819	.022	.029	.019	EURA	45335
7580S001	MELENGICLICK	20803S001	4247617.879	2778638.401	3851605.518	.017	.019	.012	EURA	45335
7587S001	YIGILCA	20804S001	4117365.393	2517078.417	4157679.809	.017	.015	.012	EURA	45335
7590M001	MONTE GENEROSO	14005M002	4390310.144	696751.792	4560835.721	.009	.011	.008	EURA	45335
7596S001	WETTZELL	14201S010	4075580.206	931836.253	4801560.288	.138	.194	.130	EURA	45335
7805S001	METSAHOVI	10503S001	2892595.668	1311808.074	5512609.766	.153	.143	.096	EURA	45335
7810S001	ZIMMERWALD	14001S001	4331283.787	567549.214	4633139.808	.010	.010	.008	EURA	45335
7831S001	HELWAN	30101S001	4728284.495	2879668.706	3156893.476	.961	.586	.569	AFRC	45335

NETWORK NUMBER	SITE	DOMES NUMBER	X m	Y m	Z m	SX	SY	SZ	PLATE	EPOCH MJD
7833S001	KOOTWIJK	13504S001	3899224.448	396742.640	5015073.765	.112	.100	.060	EURA	45335
7834S001	WETTZELL	14201S002	4075530.330	931781.054	4801618.012	.005	.005	.006	EURA	45335
7835S001	GRASSE	10002S001	4581692.038	556159.120	4389359.173	.004	.005	.006	EURA	45335
7837S001	SHANGHAI	21605S001	-2831087.340	4676203.655	3275172.911	.259	.222	.185	EURA	45335
7838M001	SIMOSATO	21726M002	-3822386.775	3699362.450	3507572.076	.005	.005	.005	EURA	45335
7839S001	GRAZ	11001S002	4194426.989	1162693.663	4647246.336	.062	.006	.006	EURA	45335
7840S001	HERSTMONCEUX	13212S001	4033464.057	23662.119	4924304.856	.004	.004	.005	EURA	45335
7843S001	ORRORAL	50103S008	-4446476.623	2678127.231	-3696251.826	.008	.007	.009	INDI	45335
7882M001	CABO SAN LUCAS	40505M001	-1997241.608	-5528041.072	2468355.192	.025	.025	.022	PCFC	45335
7885M001	FORT DAVIS	40442M005	-1330125.353	-5328526.400	3236150.360	.026	.027	.021	NOAM	45335
7886S001	QUINCY	40433S010	-2517242.383	-4198554.007	4076572.330	.046	.040	.025	NOAM	45335
7887M001	SOUTH VANDENBERG	40420M004	-2668868.171	-4530743.777	3598685.125	.152	.641	.152	NOAM	45335
7888S001	MOUNT HOPKINS	40434S003	-1936744.321	-5077638.990	3331994.003	.027	.020	.024	NOAM	45335
7890M001	AUSTIN	40412M001	-754162.126	-5459061.176	3200744.117	.273	.242	.118	NOAM	45335
7891M001	FLAGSTAFF	40491M002	-1923976.590	-4850871.519	3658574.912	.030	.029	.023	NOAM	45335
7892M001	VERNAL	40492M001	-1631484.646	-4589133.808	4106749.711	.021	.023	.014	NOAM	45335
7894S001	YUMA	40493S001	-2196777.875	-4887339.166	3448428.343	.024	.023	.022	NOAM	45335
7896M001	PASADENA	40400M001	-2493211.835	-4655229.593	3565574.617	.023	.025	.019	PCFC	45335
7899M001	WASHINGTON	40451M111	1131364.780	-4831168.801	3994128.931	.036	.037	.031	NOAM	45335
7907S001	AREQUIPA	42202S001	1942791.702	-5804077.774	-1796919.376	.005	.003	.003	SOAM	45335
7921S001	MOUNT HOPKINS	40434S001	-1936760.118	-5077707.051	3331922.681	.021	.018	.020	NOAM	45335
7929S001	NATAL	41604S001	5186467.860	-3653856.360	-654322.101	.014	.019	.021	SOAM	45335
7939S001	MATERA	12734S001	4641965.355	1393069.678	4133261.996	.004	.004	.006	EURA	45335
7943S001	ORRORAL	50103S003	-4447548.622	2677134.259	-3694996.847	.008	.008	.008	INDI	45335
8833S001	KOOTWIJK	13504S007	3899238.088	396768.950	5015055.087	.032	.030	.018	EURA	45335