VERY LONG BASELINE INTERFEROMETRY

EARTH ORIENTATION PARAMETERS FROM IRIS-S VLBI MEASUREMENTS

GIUB 91 R 01

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In 1990 the VLBI group at the Geodetic Institute of the University of Bonn (GIUB) regularly correlated and analysed VLBI experiments which are observed once per month under the acronym IRIS-S (International Radio Interferometric Surveying - South). The standard configuration of the IRIS-S network consists of five stations, i.e. Westford Observatory (Massachusetts, USA), Richmond Observatory (Florida, USA), Mojave Base Station (California, USA), Wettzell Geodetic Fundamental Station (Bavaria, Federal Republic of Germany) and Hartebeesthoek Radio Astronomy Observatory (South Africa).

The data analysed so far consists of 12 sessions in monthly intervals. These datasets alone are not sufficient to determine terrestrial and celestial reference frames with adequate accuracies. Therefore, we have chosen to use the results of the global VLBI solution GLB627 (= GSFC 90 R 01) of the VLBI group at the NASA Goddard Space Flight Center which contains all Mark III S/X experiments from 1979 to December 1989 (Ma *et al.*, 1990).

The list of station positions of GLB627 included continental drift parameters dx/dt, dy/dt, dz/dt for each station which permitted the computation of station coordinates referred to selected epochs. From this data we extrapolated station coordinates for each of the IRIS-S observing dates. The station coordinates for the epochs January 1, 1990, July 1, 1990 and January 1, 1991 which reflect the coordinates used in our analyses are listed in Appendix A. The radio source positions are identical to RSC(GSFC) 90 R 01.

All sessions of the IRIS-S campaign were individually reduced using the CALC 7.0/SOLVE software system (Ryan, 1990) which is based on the MERIT standards (Melbourne *et al.*, 1983) and which is consistent with the IAU (1976) Resolution on Astronomical Constants, Time Scales and the Fundamental Reference Frame (Kaplan, 1981). The theoretical delays in the adjustment were calculated according to the Shapiro model (Ryan, 1990) and Hellings (1987) correction for relativistic bending. Horizontal and vertical ocean loading displacement effects of Goad (1980) and Scherneck (1989) were applied to the delay observables. For the tropospheric corrections we used the CfA model (Davis *et al.*, 1985) based on surface meteorological data. The ionospheric refraction is dispersive and was calibrated by dual frequency observations. Only delay observables were used in our analyses.

In the least squares adjustments the two polar motion components xp, yp, Universal time UT1 - TAI and two nutation offsets relative to the IAU 1980 Theory of Nutation (Wahr, 1981) were estimated as principal parameters. In addition, relative offsets, rates and higher order terms of the atomic clocks as well as atmospheric excess path delays in zenith direction and their rates had to be estimated. In order to best model the behaviour of the atmosphere at each station additional rate changes were introduced at epochs where the atmospheric situation as reflected by the surface weather data, i.e. temperature, pressure and relative humidity, changed significantly. Extra parameters for modeling the station clock behaviour were chosen depending on obvious deviations in the residuals.

The formal errors of the pole coordinates were based on observation weights adjusted so that the Chi-square per degree of freedom ratio was close to unity (p = observation weights, v = post fit residuals, n = number of observations, u = number of unknown parameters). These contributions to the a priori variances should account for unmodelled effects in the data reduction (Herring *et al.*, 1986).

The results of the IRIS-S analyses for the period of December 1989 to December 1990 are listed in Table 1.

References.

Davis, J.L. *et al., Radio Science,* **20**, p. 1593; 1985
Goad C.C., *JGR,* **85,** No. B5, p. 2679, 1980
Hellings, R.W., *Astron. J.*, **91**, 1446, 1986
Herring, T.A. *et al., JGR,* **91**, No. B8, p. 8341, 1986
Kaplan, G.H., *USNO Circular* **163;** Washington D.C.; 1981
Ma et al., *IERS Technical Note 5,* Paris 1990
Melbourne, W. et al., *USNO Circular* **167**, Washington D.C., 1983
Ryan J.W., *CALC-7 Release Document,* GSFC, 1989
Scherneck H.G.,

Table 1.: EOP(GIUB) 91 R 01 Available from 1989 to 1990

Number of measurements and RMS uncertainty per year
Units : 0.001" for X,Y, $d\psi$, $d\varepsilon$; 0.0001s for UT1

YEAR	X		Y		UT1		$d\psi$		$d\varepsilon$	
	Nb	Sigma	Nb	Sigma	Nb	Sigma	Nb	Sigma	Nb	Sigma
1989	1	0.33	1	0.25	1	0.20	1	0.45	1	0.20
1990	11	0.26	11	0.16	11	0.15	11	0.34	11	0.15

Appendix A

Station coordinates extracted from solution GLB627
Epoch of coordinates: 1990.0

HARTRAO	5085444.3660	2668262.6160	-2768696.7520
MOJAVE12	-2356169.2730	-4646756.7480	3668471.0490
RICHMOND	961259.7920	-5674090.8750	2740534.1560
WESTFORD	1492208.3860	-4458131.3550	4296015.9080
WETTZELL	4075541.6630	931734.3040	4801629.7230

Station coordinates extracted from solution GLB627
Epoch of coordinates: 1990.5

HARTRAO	5085444.3635	2668262.6295	-2768696.7445
MOJAVE12	-2356169.2820	-4646756.7455	3668471.0465
RICHMOND	961259.7885	-5674090.8760	2740534.1560
WESTFORD	1492208.3770	-4458131.3565	4296015.9095
WETTZELL	4075541.6540	931734.3105	4801629.7295

Station coordinates extracted from solution GLB627
Epoch of coordinates: 1991.0

HARTRAO	5085444.3610	2668262.6430	-2768696.7670
MOJAVE12	-2356169.2910	-4646756.7430	3668471.0440
RICHMOND	961259.7850	-5674090.8770	2740534.1560
WESTFORD	1492208.3680	-4458131.3580	4296015.9110
WETTZELL	4075541.6450	931734.3170	4801629.7360

EARTH ORIENTATION PARAMETERS WITH ESTIMATED SITE VELOCITIES FROM THE NASA CRUSTAL DYNAMICS PROJECT GSFC 91 R 01

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Mark III VLBI data acquired since 1979 by the NASA Crustal Dynamics Project, POLARIS/IRIS, and the USNO Navnet have been analyzed for Earth orientation parameters. The reference frame origin is defined by the a priori position of the 18-m Westford antenna on 1988 Jan. 1 and moving with AM0-2 velocity. The orientation of the frame is defined by values from EOP(IERS) 90 C 04, modified by the IERS standard UT1 tidal model, and the standard J2000.0 precession and IAU 1980 nutation models for the reference date 1986 Nov. 6 and by the direction of the WESTFORD-RICHMOND baseline, which evolves according to the AM0-2 model. Short period tidal terms in UT1 have not been removed from the tabulated values of UT1-UTC. All uncertainties are 1-sigma formal standard errors from the sequential least-squares solution GLB716 described below.

The basic models used to calculate the VLBI delays are consistent with the IERS standards and are contained in the Goddard CALC 7.3 program. These include IAU 1980 nutation with daily offsets in longitude and obliquity estimated, solid earth tides (h2 = 0.60697, l2 = 0.085) correcting the K1 term but not the zero frequency displacement, pole tide, vertical ocean loading, CfA 2.2 dry troposphere mapping, tidal variation of smoothed a priori UT1, PEP solar system ephemeris rotated to J2000.0, and a modified Hellings (1986) VLBI time delay consistent with the alternative IERS standard model at 1 ps rms. For each session a single reweighting constant computed for the particular day was added in quadrature to the data uncertainties derived strictly from SNR to reflect the actual data scatter. The dry troposphere was modeled from local meteorological data and the residual wet troposphere was estimated using a continuous piecewise-linear function with the wet Chao model. The behavior of the site clocks for each day was similarly estimated using a quadratic polynomial and a continuous piecewise-linear function. For both estimates the variation in the continuous function was constrained to physically reasonable values except in the rare instances when the data dictated otherwise. The 3-dimensional velocities of all sites with sufficient data were estimated except for RICHMOND and KAUAI. Apart from the motion of the AM0-2 model, the position of RICHMOND was constrained to change only in the a priori direction of WESTFORD. The vertical rate of Kauai was constrained to be zero to provide a more robust geometry. The adjustment of 3-dimensional velocities and the use of the wet Chao model in estimating the residual atmosphere are the major changes from our previous submission.

541 726 dual-frequency Mark III delays from 1107 sessions using fixed stations as well as several mobile sites in >3000 km networks were combined to estimate site positions and velocities, source positions, Earth orientation parameters, and troposphere and clock behavior from a least-squares solution with 548 global parameters and 215 974 arc parameters. A weak input covariance on polar motion and UT1 (X,Y - 45 mas, UT1 - 3 ms) was used so that all three components could be estimated for each session with more reliable indication of uncertainty and correlation. The weighted rms post-fit residual of the solution was 43.5 ps. The reduced chi-square was 0.99 including the constraints in the computation of the degrees of freedom (Theil, 1963).

The complete Earth orientation time series is designated EOP(GSFC)91 R 01. Other results are source positions designated RSC(GSFC)91 R 01 and site coordinates at 1979-92 Jan 1.5 designated SSC(GSFC)91 R 01.

Hellings, R. W., 1986, *Astron. J.*, **91**, 1446.
Theil, H., 1963, *Amer. Stat. Ass. J.*, **58**, 401.

SUMMARY SHEET FOR SOLUTION GSFC 91 R 01 : see p.43

VLBI Site positions at 1988 January 1.5 (see note p. 6) SSC(GSFC) 91 R 01

Monument	Name	X (m)	Y (m)	Z (m)	C. Epoch (days)	Span (days)	SX (m)	SY (m)	SZ (m)
7282 S	ALGOPARK	918034.965	-4346132.208	4561971.021	47543.4	2171.0	.001	.003	.003
7604 M	BREST	4228877.304	-333104.328	4747180.752	47771.6	6.0	.013	.003	.014
7603 M	CARNUSTY	3526416.618	-171421.247	5294098.679	47759.0	1.0	.015	.004	.021
7215 S	CHLBOLTN	4008310.276	-100650.887	4943794.556	44532.2	7.0	.009	.005	.012
7231 S	DSS15	-2353538.637	-4641649.463	3676669.933	47472.0	1.0	.003	.006	.007
1642 S	DSS45	-4460934.966	2682765.860	-3674381.708	47705.0	767.0	.016	.011	.010
1665 S	DSS65	4849336.855	-360488.968	4114748.547	47758.8	736.0	.008	.002	.009
7203 S	EFLSBERG	4033947.729	486990.360	4900430.604	44620.7	1258.0	.033	.015	.044
7225 S	GILCREEK	-2281547.001	-1453644.984	5756993.143	47434.2	2372.0	.001	.002	.003
1513 S	GOLDVENU	-2351129.012	-4655477.032	3660956.835	46881.8	3197.0	.003	.005	.005
7605 M	GRASSE	4581697.876	556125.593	4389351.207	47784.0	1.0	.017	.004	.017
7210 M	HALEAKAL	-5465998.367	-2404408.472	2242228.376	47347.2	15.0	.014	.007	.008
7232 S	HARTRAO	5085442.885	2668263.347	-2768697.318	47393.8	1783.0	.010	.007	.007
7218 S	HATCREEK	-2523969.799	-4123506.303	4147752.517	47023.6	2702.0	.001	.002	.003
7205 S	HAYSTACK	1492404.947	-4457266.485	4296881.614	46230.1	4036.0	.000	.001	.001
7242 S	HOBART26	-3950236.293	2522347.637	-4311563.001	47974.1	350.0	.011	.010	.010
7600 M	HOHENFRG	3778215.113	698644.628	5074053.392	47701.6	6.0	.010	.003	.014
7216 S	HRAS 085	-1324210.835	-5332023.087	3232118.292	46453.2	3854.0	.001	.001	.002
1857 S	KASHIM34	-3997649.063	3276690.859	3724278.889	48066.4	203.0	.006	.004	.010
1856 S	KASHIMA	-3997892.124	3276581.345	3724118.277	47010.9	2349.0	.003	.002	.006
1311 S	KAUAI	-5543845.897	-2054564.089	2387813.747	47381.7	2372.0	.002	.003	.005
7278 M	KODIAK	-3026940.001	-1575911.723	5370362.408	47630.2	730.0	.010	.006	.017
4968 S	KWAJAL26	-6143536.382	1363997.312	1034707.361	46522.1	1492.0	.010	.004	.007
7310 S	MARCUS	-5227446.712	2551379.269	2607604.704	48068.0	1.0	.016	.009	.015
7217 S	MARPOINT	1106629.502	-4882907.155	3938086.840	47009.2	2625.0	.002	.005	.004
7243 S	MATERA	4641939.113	1393002.865	4133325.336	48155.1	90.0	.008	.004	.009
7230 S	MEDICINA	4461370.277	919596.659	4449558.977	47629.3	1252.0	.004	.002	.005
7601 M	METSHOVI	2890653.027	1310295.220	5513958.533	47714.0	1.0	.020	.011	.032
7222 S	MOJAVE12	-2356170.860	-4646755.837	3668470.528	47477.8	2751.0	.001	.002	.003
7244 S	NOBEY 6M	-3871168.049	3428274.025	3723697.613	47850.0	1.0	.037	.033	.035
7279 M	NOME	-2658150.280	-693821.852	5737236.579	48062.0	3.0	.010	.005	.021
7547 S	NOTO	4934563.436	1321201.119	3806484.234	47894.1	564.0	.012	.005	.011

Monument	Name	X (m)	Y (m)	Z (m)	C. Epoch (days)	Span (days)	SX (m)	SY (m)	SZ (m)	
7204 S	NRAO 140	882880.080	-4924482.273	3944130.542	45407.1	4053.0	.001	.004	.004	
7214 S	NRAO85 3	882325.759	-4925137.936	3943397.516	47959.7	641.0	.003	.007	.006	
7213 S	ONSALA60	3370606.289	711917.368	5349830.534	46703.0	3818.0	.002	.001	.004	
7207 S	OVRO 130	-2409600.620	-4478349.493	3838603.134	45563.7	3384.0	.002	.003	.004	
7283 M	PENTICTN	-2058840.269	-3621286.351	4814420.680	46864.0	2164.0	.008	.013	.017	
7234 S	PIETOWN	-1640953.531	-5014815.985	3575411.849	47879.6	828.0	.002	.004	.004	
7258 M	PLATTVIL	-1240708.001	-4720454.309	4094481.564	47049.8	2699.0	.002	.006	.005	
7219 S	RICHMOND	961258.188	-5674090.007	2740533.648	47339.5	2561.0	.001	.002	.001	
1561 S	ROBLED32	4849245.410	-360278.301	4114884.318	45460.0	1.0	.048	.011	.040	
7229 M	SEATTLE1	-2295347.821	-3638029.371	4693408.579	48112.4	2.0	.012	.019	.024	
7227 S	SESHAN25	-2831686.496	4675733.890	3275327.760	47689.0	885.0	.007	.007	.009	
7239 S	SEST	1838237.898	-5258699.154	-3100588.997	48022.6	37.0	.010	.018	.009	
7226 S	SHANGHAI	-2847698.025	4659872.975	3283958.837	46595.0	1.0	.122	.106	.095	
7280 M	SNDPOINT	-3425461.756	-1214669.064	5223858.220	47707.5	731.0	.015	.007	.022	
7602 M	TROMSONO	2102904.341	721602.443	5958201.142	47739.0	1.0	.009	.005	.022	
7289 M	VICTORIA	-2341309.952	-3539083.805	4745768.287	48106.0	3.0	.010	.016	.020	
7223 M	VNDNBERG	-2678094.618	-4525450.774	3597410.059	46894.7	2022.0	.002	.003	.003	
7209 S	WESTFORD	1492206.806	-4458130.482	4296015.386	46994.3	3527.0	.000	.000	.000	Ref
7224 S	WETTZELL	4075540.164	931735.120	4801629.164	47161.7	2610.0	.002	.001	.004	
7284 M	WHTHORSE	-2215213.510	-2209261.591	5540292.537	47596.0	373.0	.012	.012	.029	
7285 M	YELLOWKN	-1224124.362	-2689530.637	5633555.332	46125.9	377.0	.031	.067	.139	

VLBI site velocities SSV(GSFC) 91 R 01

Station	Velocity (mm/yr) X	Y	Z	Uncertainty (mm/yr) X	Y	Z
ALGOPARK 7282	-18.7	-3.9	1.3	0.3	1.1	1.1
BREST 7604	-12.0	17.0	11.9	-	-	-
CARNUSTY 7603	-14.1	14.9	9.9	-	-	-
CHLBOLTN 7215	-13.3	16.4	11.2	-	-	-
DSS15 7231	-15.8	-1.5	-12.1	-	-	-
DSS45 1642	-36.4	-2.8	53.2	7.2	4.8	4.7
DSS65 1665	13.6	19.9	40.0	6.7	1.5	7.4
EFLSBERG 7203	-11.1	12.4	14.9	4.9	2.4	6.5
GILCREEK 7225	-24.0	-0.4	-10.4	0.5	0.8	1.2
GOLDVENU 1513	-19.3	9.4	-11.9	0.9	1.9	1.6
GRASSE 7605	-14.1	18.0	12.4	-	-	-
HALEAKAL 7120	-15.3	67.3	34.9	-	-	-
HARTRAO 7232	3.5	16.1	14.4	4.6	3.0	2.4
HATCREEK 7218	-21.3	10.0	-11.4	0.7	1.2	1.2
HAYSTACK 7205	-18.0	-2.5	3.2	0.1	0.3	0.3
HOBART26 7242	-37.8	6.7	38.5	-	-	-
HOHENFRG 7600	-16.4	15.7	10.1	-	-	-
HRAS 085 7216	-14.1	5.1	-11.6	0.1	0.7	0.5
KASHIM34 1857	-14.0	-1.2	-14.0	-	-	-
KASHIMA 1856	3.6	6.8	-11.8	1.5	0.9	2.6
KAUAI 1311	-12.9	69.6	29.9	0.4	1.1	1.0
KODIAK 7278	-31.2	2.2	10.2	6.6	3.7	11.0
KWAJAL26 4968	23.8	76.0	24.7	4.7	2.0	2.8
MARCUS 7310	43.4	65.4	23.0	-	-	-
MARPOINT 7217	-18.2	1.9	-1.5	0.5	1.8	1.5
MATERA 7243	-16.2	18.1	12.1	-	-	-
MEDICINA 7230	-15.0	15.3	16.9	2.2	1.1	2.5
METSHOVI 7601	-19.8	12.9	7.3	-	-	-
MOJAVE12 7222	-17.7	10.5	-9.4	0.2	0.8	0.6
NOBEY 6M 7244	-14.0	-1.2	-13.5	-	-	-
NOME 7279	-23.0	-2.6	-11.0	-	-	-
NOTO 7547	-32.4	7.2	8.6	6.2	2.5	5.7
NRAO 140 7204	-18.3	0.7	-1.0	0.3	0.9	0.7
NRAO85 3 7214	-13.6	-10.1	9.5	1.1	3.1	2.5
ONSALA60 7213	-13.0	11.3	10.8	1.0	0.5	1.3
OVRO 130 7207	-20.0	10.8	-10.8	0.4	1.1	0.9
PENTICTN 7283	-27.3	-13.4	9.1	3.1	5.1	6.6
PIETOWN 7234	-14.0	16.7	-20.3	0.8	2.0	1.7
PLATTVIL 7258	-20.8	-3.8	-6.9	1.1	3.4	2.9
RICHMOND 7219	-12.3	-1.7	0.7	-	0.1	0.1
ROBLED32 1561	-10.2	18.8	13.6	-	-	-
SEATTLE1 7229	-19.6	-2.1	-11.2	-	-	-
SESHAN25 7227	-18.5	-17.8	-20.2	3.6	4.0	4.3
SEST 7239	-2.2	-5.8	8.6	-	-	-
SHANGHAI 7226	-25.0	-8.0	-10.4	-	-	-
SNDPOINT 7280	-12.5	7.5	-28.5	8.7	3.8	12.6
TROMSONO 7602	-19.0	10.4	5.4	-	-	-
VICTORIA 7289	-19.8	-2.2	-11.4	-	-	-
VNDNBERG 7223	-30.8	37.5	12.6	0.9	1.4	1.3
WESTFORD 7209	-18.2	-2.9	3.4	-	-	-
WETTZELL 7224	-15.9	13.3	9.0	1.1	0.6	1.3
WHTHORSE 7284	28.1	48.1	-107.6	9.9	9.6	23.0
YELLOWKN 7285	-25.1	-24.4	40.0	11.0	24.0	50.4

Note : Parameters with very small $\sigma^2(<= 10^{-13})$ have been suppressed in the solution. This occurs for the WESTFORD position and velocity and for the velocities of sites with insufficient data.

RADIO SOURCE COORDINATES RSC(GSFC) 91 R 01

SOURCE	RIGHT ASCENSION	DECLINATION	SIGMA R.A.	SIGMA D.
	H M S	o ' "	S	"
0016+731	0 19 45.786052	73 27 30.01553	0.000093	0.00012
0048-097	0 50 41.317372	- 9 29 5.21106	0.000005	0.00014
0104-408	1 6 45.107864	-40 34 19.95632	0.000093	0.00288
0106+013	1 8 38.771043	1 35 0.31600	0.000002	0.00012
0119+041	1 21 56.861655	4 22 24.73350	0.000002	0.00012
0133+476	1 36 58.594634	47 51 29.09875	0.000018	0.00013
0201+113	2 3 46.657003	11 34 45.40884	0.000020	0.00033
0202+149	2 4 50.413834	15 14 11.04241	0.000005	0.00014
0208-512	2 10 46.200571	-51 1 1.89241	0.000054	0.00030
0212+735	2 17 30.812790	73 49 32.62073	0.000088	0.00012
0224+671	2 28 50.051089	67 21 3.02831	0.000061	0.00017
0229+131	2 31 45.893990	13 22 54.71579	0.000003	0.00012
0234+285	2 37 52.405555	28 48 8.98939	0.000005	0.00012
0235+164	2 38 38.930019	16 36 59.27412	0.000005	0.00014
0237-233	2 40 8.174435	-23 9 15.72820	0.000050	0.00158
0256+075	2 59 27.076581	7 47 39.64408	0.000030	0.00084
0300+470	3 3 35.242018	47 16 16.27490	0.000013	0.00012
0316+413	3 19 48.159911	41 30 42.10284	0.000014	0.00015
0333+321	3 36 30.107524	32 18 29.34189	0.000026	0.00032
0336-019	3 39 30.937759	- 1 46 35.80372	0.000010	0.00030
0355+508	3 59 29.747019	50 57 50.16173	0.000016	0.00012
0402-362	4 3 53.749997	-36 5 1.91193	0.000024	0.00120
0420-014	4 23 15.800686	- 1 20 33.06424	0.000002	0.00012
0430+052	4 33 11.095445	5 21 15.61925	0.000029	0.00158
0434-188	4 37 1.482707	-18 44 48.61110	0.000017	0.00067
0454-234	4 57 3.179242	-23 24 52.01827	0.000004	0.00014
0458-020	5 1 12.809861	- 1 59 14.25447	0.000009	0.00027
0528+134	5 30 56.416679	13 31 55.15101	0.000003	0.00012
0537-441	5 38 50.361797	-44 5 8.93898	0.000058	0.00052
0552+398	5 55 30.805447	39 48 49.16644	0.000008	0.00011
0637-752	6 35 46.508352	-75 16 16.81365	0.000274	0.00031
0657+172	7 0 1.525472	17 9 21.70373	0.000006	0.00017
0716+714	7 21 53.448084	71 20 36.36543	0.000100	0.00017
0727-115	7 30 19.112449	-11 41 12.59753	0.000003	0.00012
0742+103	7 45 33.059454	10 11 12.69519	0.000003	0.00012
0745+241	7 48 36.109207	24 0 24.11253	0.000009	0.00016
0814+425	8 18 15.999528	42 22 45.41760	0.000013	0.00013
0820+560	8 24 47.236144	55 52 42.67230	0.000090	0.00036
0823+033	8 25 50.338309	3 9 24.52329	0.000005	0.00014
0851+202	8 54 48.874871	20 6 30.64376	0.000003	0.00011
0859+470	9 3 3.990016	46 51 4.14011	0.000021	0.00021
0919-260	9 21 29.353817	-26 18 43.38268	0.000010	0.00029
0923+392	9 27 3.013831	39 2 20.85476	0.000008	0.00011
0925-203	9 27 51.824319	-20 34 51.23159	0.000059	0.00175
0953+254	9 56 49.875382	25 15 16.05162	0.000018	0.00057

RADIO SOURCE COORDINATES (cont.) RSC(GSFC) 91 R 01

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
0954+658	9 58 47.245059	65 33 54.82113	0.000044	0.00012
1034-293	10 37 16.079682	-29 34 2.80975	0.000007	0.00014
1055+018	10 58 29.605179	1 33 58.82690	0.000002	0.00013
1057-797	10 58 43.309610	-80 3 54.15714	0.000630	0.00029
1104-445	11 7 8.694141	-44 49 7.61621	0.000059	0.00031
1123+264	11 25 53.711899	26 10 19.98164	0.000012	0.00023
1124-186	11 27 4.392369	-18 57 17.43713	0.000015	0.00075
1144+402	11 46 58.297946	39 58 34.30719	0.000009	0.00012
1144-379	11 47 1.370602	-38 12 11.02197	0.000087	0.00250
1150+812	11 53 12.499635	80 58 29.15660	0.000504	0.00023
1156+295	11 59 31.833920	29 14 43.82951	0.000005	0.00012
1219+285	12 21 31.690581	28 13 58.50293	0.000020	0.00062
1222+037	12 24 52.421856	3 30 50.29596	0.000019	0.00058
1226+023	12 29 6.699701	2 3 8.60124	********	0.00012
1228+126	12 30 49.423377	12 23 28.04760	0.000045	0.00051
1244-255	12 46 46.801946	-25 47 49.28630	0.000025	0.00104
1253-055	12 56 11.166455	- 5 47 21.52142	0.000003	0.00015
1308+326	13 10 28.663916	32 20 43.78501	0.000006	0.00012
1313-333	13 16 7.985838	-33 38 59.16741	0.000063	0.00228
1334-127	13 37 39.782712	-12 57 24.69056	0.000003	0.00014
1354+195	13 57 4.436686	19 19 7.37395	0.000006	0.00015
1354-152	13 57 11.244884	-15 27 28.78269	0.000012	0.00059
1404+286	14 7 0.394463	28 27 14.69155	0.000005	0.00012
1418+546	14 19 46.597597	54 23 14.78849	0.000020	0.00013
1424-418	14 27 56.297311	-42 6 19.43552	0.000050	0.00033
1502+106	15 4 24.979791	10 29 39.20001	0.000002	0.00013
1510-089	15 12 50.532866	- 9 5 59.82778	0.000004	0.00018
1519-273	15 22 37.675872	-27 30 10.78290	0.000018	0.00102
1548+056	15 50 35.269237	5 27 10.44911	0.000002	0.00013
1607+268	16 9 13.321304	26 41 28.99487	0.001236	0.03144
1611+343	16 13 41.064347	34 12 47.90923	0.000006	0.00012
1610-771	16 17 49.275708	-77 17 18.46824	0.000533	0.00040
1622-253	16 25 46.891530	-25 27 38.32588	0.000005	0.00015
1633+382	16 35 15.493071	38 8 4.50054	0.000008	0.00012
1637+574	16 38 13.456548	57 20 23.97890	0.000022	0.00013
1642+690	16 42 7.848919	68 56 39.75615	0.000060	0.00013
1641+399	16 42 58.810071	39 48 36.99382	0.000008	0.00012
1730-130	17 33 2.705713	-13 4 49.54815	0.000003	0.00013
1739+522	17 40 36.978029	52 11 43.40668	0.000016	0.00012
1741-038	17 43 58.856103	- 3 50 4.61691	0.000002	0.00012
1749+701	17 48 32.840591	70 5 50.76722	0.000489	0.00077
1749+096	17 51 32.818576	9 39 0.72801	0.000003	0.00013
1803+784	18 0 45.684617	78 28 4.01730	0.000175	0.00011
1815-553	18 19 45.399361	-55 21 20.74725	0.000138	0.00050
1823+568	18 24 7.068563	56 51 1.48975	0.000031	0.00016

RADIO SOURCE COORDINATES (cont.) RSC(GSFC) 91 R 01

SOURCE	RIGHT ASCENSION			DECLINATION			SIGMA R.A.	SIGMA D.
	H	M	S	o	'	"	S	"
1831-711	18	37	28.715319	-71	8	43.55448	0.001487	0.00242
1845+797	18	42	8.990434	79	46	17.12692	0.001911	0.00089
1921-293	19	24	51.055860	-29	14	30.12158	0.000006	0.00014
1923+210	19	25	59.605397	21	6	26.16040	0.000013	0.00025
1928+738	19	27	48.495599	73	58	1.56814	0.000113	0.00013
1954+513	19	55	42.738376	51	31	48.54415	0.000038	0.00022
1958-179	20	0	57.090387	-17	48	57.67329	0.000007	0.00019
2008-159	20	11	15.710928	-15	46	40.26016	0.000087	0.00453
2037+511	20	38	37.034823	51	19	12.66046	0.000018	0.00012
2113+293	21	15	29.413451	29	33	38.36458	0.000012	0.00029
2121+053	21	23	44.517358	5	35	22.09127	0.000002	0.00012
2128-123	21	31	35.261687	-12	7	4.79778	0.000006	0.00021
2134+004	21	36	38.586285	0	41	54.21210	0.000002	0.00013
2145+067	21	48	5.458647	6	57	38.60219	0.000003	0.00012
2155-152	21	58	6.281787	-15	1	9.33032	0.000027	0.00048
2200+420	22	2	43.291357	42	16	39.97761	0.000010	0.00011
2201+315	22	3	14.975802	31	45	38.26820	0.000026	0.00057
2216-038	22	18	52.037703	- 3	35	36.88127	0.000002	0.00012
2230+114	22	32	36.408870	11	43	50.90216	0.000005	0.00015
2234+282	22	36	22.470836	28	28	57.41107	0.000005	0.00011
2243-123	22	46	18.231977	-12	6	51.27885	0.000026	0.00140
2251+158	22	53	57.747899	16	8	53.55874	0.000003	0.00012
2253+417	22	55	36.707785	42	2	52.53046	0.000029	0.00037
2255-282	22	58	5.962875	-27	58	21.25775	0.000006	0.00014
2345-167	23	48	2.608514	-16	31	12.02307	0.000006	0.00015
2355-534	23	57	53.266198	-53	11	13.69114	0.000065	0.00054
2355-106	23	58	10.882391	-10	20	8.61198	0.000008	0.00040

EOP(GSFC) 91 R 01 Available from 1979 to 1991

Number of measurements and RMS uncertainty per year

Units : 0.001" for X,Y,dψ,dε; 0.0001s for UT1

YEAR	X		Y		UT1		dψ		dε	
	Nb	Sigma	Nb	Sigma	Nb	Sigma	Nb	Sigma	Nb	Sigma
1979	2	1.43	2	2.84	2	1.04	2	1.90	2	0.67
1980	20	2.94	20	9.10	20	2.34	20	1.26	20	0.42
1981	32	11.59	32	36.50	32	9.36	32	2.84	32	1.44
1982	55	11.15	55	34.98	55	9.04	55	2.96	55	1.10
1983	65	16.02	65	31.70	65	8.16	65	2.39	65	0.76
1984	94	9.52	94	9.95	94	1.86	94	1.17	94	0.43
1985	102	5.32	102	12.92	102	1.53	102	0.86	102	0.38
1986	117	1.04	117	12.98	117	1.44	117	0.73	117	0.27
1987	130	0.69	130	0.53	130	0.28	130	0.69	130	0.25
1988	142	3.20	142	0.54	142	1.40	142	0.73	142	0.28
1989	163	0.44	163	0.49	163	0.22	163	0.55	163	0.24
1990	182	0.59	182	4.04	182	1.64	182	0.49	182	0.20
1991	3	0.30	3	0.38	3	0.18	3	0.47	3	0.18

FIXED STATION AND MOBILE SITE POSITION RESULTS WITH ESTIMATED SITE VELOCITIES FROM THE NASA CRUSTAL DYNAMICS PROJECT GSFC 91 R 02

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Mark III VLBI data acquired since 1979 by the NASA Crustal Dynamics Project, POLARIS/IRIS, the USNO Navnet, and the Geographical Survey Institute (Japan) have been analyzed for site positions. The reference frame origin is defined by the a priori position of the 18-m Westford antenna on 1988 Jan. 1 and moving with AM0-2 velocity. The orientation of the frame is defined by values from EOP(IERS) 90 C 04, modified by the IERS standard UT1 tidal model, and the standard J2000.0 precession and IAU 1980 nutation models for the reference date 1986 Nov. 6 and by the direction of the WESTFORD-RICHMOND baseline, which evolves according to the AM0-2 model. All uncertainties are 1-sigma formal standard errors from the sequential least-squares solution GLB718 described below.

132 168 dual-frequency Mark III delays from 266 mobile and local tie sessions were added to the fixed station solution designated GSFC 91 R 01 to generate a densified global terrestrial reference frame. The values and correlations of polar motion and UT1 from EOP(GSFC)91 R 01 were applied as a priori covariance information for each mobile session. Otherwise the analysis configuration was identical to solution GSFC 91 R 01. The 3-dimensional velocities of all sites with sufficient data except RICHMOND and KAUAI were estimated. The additional data increased the global parameters from 548 to 778 and the arc parameters from 215 974 to 275 098. The weighted rms post-fit residual of the mobile data was 43.9 ps. The reduced chi-square of the solution was 1.02 including the troposphere, clock and EOP constraints in the computation of the degrees of freedom.

The site coordinates at 1979-92 Jan 1.5 are designated SSC(GSFC)91 R 02.The Earth orientation series generated from the combined fixed and mobile VLBI sessions using only a weak input covariance (X,Y - 45 mas, UT1 - 3 ms) is designated EOP(GSFC)91 R 02, and the source positions are designated RSC(GSFC)91 R 02.

SUMMARY SHEET FOR SOLUTION GSFC 91 R 02 : see p.43

VLBI Site positions at 1988 January 1.5 (see note p. 16) SSC(GSFC) 91 R 02

Monument	Name	X (m)	Y (m)	Z (m)	C. Epoch (days)	Span (days)	SX (m)	SY (m)	SZ (m)
7282 S	ALGOPARK	918034.966	-4346132.208	4561971.021	47543.4	2171.0	.001	.003	.003
7271 M	AUSTINTX	-737793.687	-5459892.232	3202990.387	46988.0	1.0	.004	.016	.009
7294 M	BERMUDA	2307209.615	-4874215.817	3394317.761	47013.2	7.0	.004	.010	.006
7269 M	BLKBUTTE	-2306306.828	-4787914.372	3515736.337	46721.9	1815.0	.005	.010	.007
7291 M	BLOOMIND	302384.577	-4941699.006	4007908.372	47027.0	1.0	.010	.034	.029
7604 M	BREST	4228877.319	-333104.341	4747180.776	47771.5	6.0	.008	.002	.010
7603 M	CARNUSTY	3526416.609	-171421.243	5294098.657	47759.0	5.0	.010	.004	.014
7228 M	CARROLGA	453520.747	-5300506.735	3507207.322	46995.0	1.0	.009	.035	.021
7215 S	CHLBOLTN	4008310.270	-100650.883	4943794.550	44532.2	7.0	.008	.004	.011
7267 M	DEADMANL	-2336819.540	-4732586.925	3570329.914	46805.3	1435.0	.007	.013	.010
7231 S	DSS15	-2353538.634	-4641649.473	3676669.934	47419.8	634.0	.003	.007	.006
1642 S	DSS45	-4460934.960	2682765.863	-3674381.707	47705.0	767.0	.015	.010	.009
1665 S	DSS65	4849336.856	-360488.971	4114748.543	47758.8	736.0	.008	.002	.009
7203 S	EFLSBERG	4033947.732	486990.358	4900430.602	44620.7	1258.0	.034	.015	.044
7286 M	ELY	-2077236.178	-4486712.661	4018753.667	47214.8	2369.0	.003	.006	.005
7261 M	FLAGSTAF	-1923992.550	-4850854.472	3658589.219	47026.7	2395.0	.004	.010	.007
7266 M	FORT ORD	-2697026.639	-4354393.259	3788077.528	46696.0	1639.0	.006	.009	.008
7241 M	FORTORDS	-2699840.067	-4359126.951	3781050.807	47740.3	445.0	.030	.047	.038
7241 M	FORTORDSpq	-2699840.004	-4359126.880	3781050.802	47740.3	445.0	.050	.080	.064
7900 M	FTD 7900	-1324227.824	-5332062.993	3232022.953	47443.0	1.0	.004	.013	.007
7225 S	GILCREEK	-2281546.997	-1453644.981	5756993.142	47408.8	2372.0	.001	.001	.002
1513 S	GOLDVENU	-2351129.005	-4655477.027	3660956.830	46485.5	3197.0	.002	.004	.003
7102 M	GORF7102	1130686.711	-4831353.000	3994110.790	47734.2	136.0	.003	.010	.008
7605 M	GRASSE	4581697.908	556125.590	4389351.229	47783.6	5.0	.006	.002	.006
7210 M	HALEAKAL	-5465998.366	-2404408.466	2242228.376	47347.2	15.0	.014	.007	.007
7232 S	HARTRAO	5085442.891	2668263.340	-2768697.321	47393.8	1783.0	.009	.006	.005
7218 S	HATCREEK	-2523969.800	-4123506.299	4147752.515	47229.4	2716.0	.001	.002	.002
7205 S	HAYSTACK	1492404.947	-4457266.485	4296881.614	46248.5	4036.0	.000	.001	.001
7242 S	HOBART26	-3950236.285	2522347.638	-4311563.003	47974.1	350.0	.009	.007	.006
7600 M	HOHENFRG	3778215.125	698644.636	5074053.403	47701.8	6.0	.005	.002	.007
7216 S	HRAS 085	-1324210.835	-5332023.085	3232118.291	46501.0	3854.0	.000	.001	.001
7263 M	JPL MV1	-2493305.865	-4655197.544	3565519.255	46445.4	2213.0	.005	.009	.006
1857 S	KASHIM34	-3997649.053	3276690.864	3724278.883	48066.6	203.0	.004	.003	.006
1856 S	KASHIMA	-3997892.118	3276581.349	3724118.276	47018.3	2351.0	.003	.002	.004

Monument	Name	X (m)	Y (m)	Z (m)	C. Epoch (days)	Span (days)	SX (m)	SY (m)	SZ (m)
1311 S	KAUAI	-5543845.894	-2054564.083	2387813.746	47381.7	2372.0	.002	.002	.003
7278 M	KODIAK	-3026940.009	-1575911.727	5370362.424	47241.5	2171.0	.005	.003	.008
4968 S	KWAJAL26	-6143536.378	1363997.318	1034707.362	46522.1	1492.0	.010	.004	.005
7292 M	LEONRDOK	-522231.458	-5145676.848	3720152.262	47032.0	1.0	.004	.018	.012
7259 M	MAMMOTHL	-2448246.623	-4426738.229	3875435.786	46168.1	1212.0	.015	.027	.023
7310 S	MARCUS	-5227446.703	2551379.275	2607604.699	48068.0	1.0	.016	.009	.012
7217 S	MARPOINT	1106629.501	-4882907.161	3938086.841	47110.3	2625.0	.001	.004	.003
7243 S	MATERA	4641939.120	1393002.859	4133325.333	48155.1	90.0	.007	.003	.008
7850 M	MCD 7850	-1330008.031	-5328391.515	3236502.635	47441.0	1.0	.003	.010	.006
7230 S	MEDICIN	4461370.281	919596.657	4449558.975	47629.3	1252.0	.003	.002	.004
7601 M	METSHOVI	2890653.017	1310295.203	5513958.509	47714.9	5.0	.007	.004	.012
7038 M	MILESMON	-1204438.868	-4239211.052	4596265.977	47267.0	1.0	.009	.029	.029
7312 S	MIYAZAKI	-3582767.641	4052034.108	3369020.560	47444.1	7.0	.025	.027	.025
7288 M	MOJ 7288	-2356493.981	-4646607.630	3668426.542	47101.0	1.0	.006	.011	.008
7222 S	MOJAVE12	-2356170.860	-4646755.834	3668470.527	47350.5	2752.0	.000	.001	.001
7274 M	MON PEAK	-2386289.282	-4802346.517	3444883.889	46768.3	2949.0	.002	.005	.003
7244 S	NOBEY 6M	-3871168.040	3428274.030	3723697.609	47850.0	1.0	.037	.033	.034
7279 M	NOME	-2658150.264	-693821.841	5737236.558	46659.0	2168.0	.006	.003	.012
7547 S	NOTO	4934563.459	1321201.111	3806484.244	47859.5	564.0	.011	.004	.010
7204 S	NRAO 140	882880.080	-4924482.272	3944130.542	45407.1	4053.0	.001	.004	.004
7214 S	NRAO85 3	882325.757	-4925137.935	3943397.516	47949.8	641.0	.002	.007	.005
7270 M	OCOTILLO	-2335600.989	-4832244.191	3434392.451	46068.9	367.0	.012	.025	.018
7213 S	ONSALA60	3370606.292	711917.367	5349830.531	46727.6	3818.0	.002	.001	.003
7853 M	OVR 7853	-2410421.100	-4477800.364	3838690.246	47101.0	1.0	.004	.007	.005
7207 S	OVRO 130	-2409600.617	-4478349.489	3838603.132	45889.1	3387.0	.001	.002	.002
7254 M	PBLOSSOM	-2464070.794	-4649425.577	3593905.619	46435.5	1814.0	.007	.014	.010
7283 M	PENTICTN	-2058840.268	-3621286.347	4814420.678	46864.0	2164.0	.008	.013	.017
7234 S	PIETOWN	-1640953.526	-5014815.964	3575411.835	47849.1	828.0	.001	.003	.003
7256 M	PINFLATS	-2369635.821	-4761324.862	3511116.059	46695.2	2295.0	.003	.006	.005
7258 M	PLATTVIL	-1240708.002	-4720454.307	4094481.562	46824.5	2701.0	.001	.005	.004
7252 M	PRESIDIO	-2707704.740	-4257609.549	3888374.105	47102.2	2342.0	.004	.005	.005
7252 M	PRESIDIOpq	-2707704.718	-4257609.524	3888374.070	47102.2	2342.0	.009	.014	.012
7251 M	PT REYES	-2732332.969	-4217634.839	3914490.972	47149.0	2335.0	.003	.005	.005
7268 M	PVERDES	-2525452.671	-4670035.621	3522886.681	47221.1	2278.0	.006	.010	.008

VLBI Site positions at 1988 January 1.5 (cont.) SSC(GSFC) 91 R 02

Monument	Name	X (m)	Y (m)	Z (m)	C. Epoch (days)	Span (days)	SX (m)	SY (m)	SZ (m)	
7221 M	QUINCY	-2517230.759	-4198595.168	4076531.201	46991.3	2909.0	.003	.004	.004	
7219 S	RICHMOND	961258.188	-5674090.007	2740533.649	47339.1	2561.0	.001	.001	.001	
1561 S	ROBLED32	4849245.407	-360278.299	4114884.314	45460.0	1.0	.048	.011	.040	
7255 M	SANPAULA	-2554476.545	-4608627.330	3582138.218	47157.6	2346.0	.006	.011	.008	
7229 M	SEATTLE1	-2295347.845	-3638029.418	4693408.630	47669.4	1444.0	.011	.018	.021	
7227 S	SESHAN25	-2831686.489	4675733.893	3275327.760	47689.0	885.0	.007	.007	.007	
7239 S	SEST	1838237.901	-5258699.165	-3100588.994	48022.6	37.0	.009	.017	.009	
7226 S	SHANGHAI	-2847698.019	4659872.976	3283958.836	46595.0	1.0	.123	.106	.096	
7280 M	SNDPOINT	-3425461.741	-1214669.062	5223858.203	47385.9	2190.0	.007	.003	.011	
7281 M	SOURDOGH	-2419993.321	-1664228.685	5643538.190	46925.8	1830.0	.008	.006	.019	
7281 M	SOURDOGHpq	-2419993.309	-1664228.693	5643538.212	46925.8	1830.0	.006	.005	.014	
7844 S	TITIJIMA	-4489356.560	3482989.585	2887931.130	47307.0	742.0	.033	.027	.029	
7602 M	TROMSONO	2102904.348	721602.440	5958201.160	47739.4	4.0	.005	.003	.012	
7311 S	TSUKUBA	-3957172.748	3310238.005	3737708.949	46951.7	1900.0	.011	.009	.011	
7290 M	VERNAL	-1631473.167	-4589128.869	4106759.794	47476.9	1668.0	.003	.008	.007	
7289 M	VICTORIA	-2341309.951	-3539083.800	4745768.285	48106.0	3.0	.010	.016	.020	
7223 M	VNDNBERG	-2678094.616	-4525450.771	3597410.059	46991.7	2365.0	.001	.001	.002	
7209 S	WESTFORD	1492206.806	-4458130.482	4296015.386	47032.0	3527.0	.000	.000	.000	Ref
7224 S	WETTZELL	4075540.167	931735.118	4801629.161	47174.7	2610.0	.002	.001	.003	
7284 M	WHTHORSE	-2215213.447	-2209261.541	5540292.437	47312.5	1830.0	.005	.005	.011	
7277 M	YAKATAGA	-2529744.063	-1942091.252	5505027.906	47174.9	2141.0	.008	.006	.015	
7277 M	YAKATAGApq	-2529744.085	-1942091.200	5505027.760	47174.9	2141.0	.007	.006	.015	
7285 M	YELLOWKN	-1224124.360	-2689530.635	5633555.331	46125.9	377.0	.031	.067	.139	
7894 M	YUMA	-2196777.801	-4887337.004	3448425.155	46763.6	1815.0	.003	.006	.004	

VLBI site velocities SSV(GSFC) 91 R 02

Station	Velocity (mm/yr) X	Y	Z	Uncertainty(mm/yr) X	Y	Z
ALGOPARK 7282	-18.7	-3.6	1.1	0.3	1.1	1.1
AUSTINTX 7271	-14.1	-1.7	-6.1	-	-	-
BERMUDA 7294	-14.7	-2.5	6.4	-	-	-
BLKBUTTE 7269	-17.1	16.0	-18.0	3.4	7.0	5.0
BLOOMIND 7291	-17.2	-2.4	-1.6	-	-	-
BREST 7604	-12.0	17.0	11.9	-	-	-
CARNUSTY 7603	-14.1	14.9	9.9	-	-	-
CARROLGA 7228	-15.3	-2.1	-1.3	-	-	-
CHLBOLTN 7215	-13.3	16.4	11.2	-	-	-
DEADMANL 7267	-47.2	-43.8	27.7	9.8	19.0	13.2
DSS15 7231	-12.3	18.4	-19.9	3.8	7.3	6.6
DSS45 1642	-35.4	-3.2	51.4	7.2	4.7	4.5
DSS65 1665	17.9	18.9	44.2	6.6	1.5	7.2
EFLSBERG 7203	-9.6	11.6	15.6	4.9	2.3	6.5
ELY 7286	-20.9	4.1	-13.4	2.1	4.4	3.7
FLAGSTAF 7261	-20.7	-4.7	-6.2	2.1	5.0	3.8
FORT ORD 7266	-32.2	33.9	16.8	3.4	5.4	4.6
FORTORDS 7241	-88.6	-38.9	80.7	26.7	42.4	34.2
FORTORDS 7241	-	-	-	-	-	-
FTD 7900 7900	-14.2	-1.5	-8.4	-	-	-
GILCREEK 7225	-24.1	-0.1	-10.3	0.4	0.6	0.8
GOLDVENU 1513	-19.4	9.1	-10.1	0.6	1.2	1.1
GORF7102 7102	-17.1	-2.6	1.7	-	-	-
GRASSE 7605	-14.1	18.0	12.4	-	-	-
HALEAKAL 7120	-15.3	67.3	34.9	-	-	-
HARTRAO 7232	6.9	15.4	15.3	4.3	2.7	2.2
HATCREEK 7218	-21.9	10.0	-11.0	0.4	0.8	0.7
HAYSTACK 7205	-17.9	-2.5	3.2	0.1	0.3	0.3
HOBART26 7242	-37.8	6.7	38.5	-	-	-
HOHENFRG 7600	-16.4	15.7	10.1	-	-	-
HRAS 085 7216	-14.4	5.8	-11.9	0.1	0.6	0.4
JPL MV1 7263	-35.2	23.9	3.4	2.2	4.0	3.0
KASHIM34 1857	-14.0	-1.2	-14.0	-	-	-
KASHIMA 1856	5.1	7.3	-13.1	1.3	0.8	1.8
KAUAI 1311	-13.1	69.8	29.7	0.3	0.7	0.6
KODIAK 7278	-25.3	7.7	0.8	3.5	2.0	5.9
KWAJAL26 4968	24.8	76.4	23.6	4.7	1.6	2.3
LEONRDOK 7292	-16.1	-2.0	-5.0	-	-	-
MAMMOTHL 7259	-16.5	29.3	-20.9	5.8	10.3	8.7
MARCUS 7310	43.4	65.4	23.0	-	-	-
MARPOINT 7217	-18.5	1.2	-1.1	0.5	1.7	1.4
MATERA 7243	-16.2	18.1	12.1	-	-	-
MCD 7850 7850	-14.2	-1.5	-8.4	-	-	-
MEDICINA 7230	-13.3	14.3	17.7	2.1	1.0	2.3
METSHOVI 7601	-19.8	12.9	7.3	-	-	-
MILESMON 7038	-19.4	-2.4	-7.2	-	-	-
MIYAZAKI MIYA	-23.2	-10.5	-12.1	-	-	-
MOJ 7288 7288	-15.8	-1.5	-12.1	-	-	-
MOJAVE12 7222	-17.4	11.1	-9.9	0.2	0.6	0.5
MON PEAK 7274	-34.9	35.3	2.8	1.2	2.4	1.7
NOBEY 6M 7244	-14.0	-1.2	-13.5	-	-	-
NOME 7279	-26.1	-3.8	-6.4	2.4	1.1	5.2
NOTO 7547	-38.2	7.8	4.3	5.9	2.4	5.5
NRAO 140 7204	-18.3	0.9	-1.2	0.3	0.9	0.7
NRAO85 3 7214	-13.2	-10.0	9.6	1.0	2.9	2.4
OCOTILLO 7270	-14.9	-1.4	-12.1	-	-	-
ONSALA60 7213	-11.6	10.7	11.3	0.7	0.4	1.0

VLBI site velocities SSV(GSFC) 91 R 02

Station		Velocity (mm/yr) X	Y	Z	Uncertainty(mm/yr) X	Y	Z
OVR 7853	7853	-16.4	-1.6	-12.2	-	-	-
OVRO 130	7207	-19.5	12.2	-11.0	0.3	0.8	0.7
PBLOSSOM	7254	-22.2	28.6	-7.1	3.3	6.2	4.6
PENTICTN	7283	-27.3	-12.8	8.8	3.1	5.1	6.6
PIETOWN	7234	-16.2	8.2	-14.2	0.7	1.6	1.3
PINFLATS	7256	-25.7	23.7	-3.4	2.0	4.1	3.0
PLATTVIL	7258	-19.1	1.3	-10.5	0.8	2.5	2.2
PRESIDIO	7252	-23.8	30.0	1.8	2.5	4.0	3.6
PRESIDIO	7252	-	-	-	-	-	-
PT REYES	7251	-26.1	33.6	11.6	2.5	3.8	3.5
PVERDES	7268	-28.7	37.1	2.8	3.6	6.4	4.8
QUINCY	7221	-22.8	11.9	-11.4	1.6	2.6	2.5
RICHMOND	7219	-12.3	-1.8	0.6	-	0.1	0.1
ROBLED32	1561	-10.2	18.8	13.6	-	-	-
SANPAULA	7255	-36.3	24.2	9.3	3.5	6.3	4.7
SEATTLE1	7229	-10.4	17.2	-31.1	4.6	7.6	9.1
SESHAN25	7227	-16.8	-17.7	-22.2	3.4	4.0	3.9
SEST	7239	-2.2	-5.8	8.6	-	-	-
SHANGHAI	7226	-25.0	-8.0	-10.4	-	-	-
SNDPOINT	7280	-21.5	8.9	-16.8	4.4	1.9	6.4
SOURDOGH	7281	-28.0	1.9	-14.3	4.0	2.8	9.1
SOURDOGH	7281	-	-	-	-	-	-
TITIJIMA	TITI	-3.2	52.8	30.7	39.8	30.6	33.7
TROMSONO	7602	-19.0	10.4	5.4	-	-	-
TSUKUBA	TSUK	15.3	-5.1	-26.8	7.1	6.0	6.7
VERNAL	7290	-20.3	-5.6	-4.9	2.2	5.4	4.8
VICTORIA	7289	-19.8	-2.2	-11.4	-	-	-
VNDNBERG	7223	-32.0	35.6	14.2	0.4	0.8	0.7
WESTFORD	7209	-18.2	-2.9	3.4	-	-	-
WETTZELL	7224	-14.4	12.5	9.5	0.8	0.5	1.0
WHTHORSE	7284	-25.4	7.2	-19.7	3.7	3.6	8.8
YAKATAGA	7277	-28.1	19.6	38.4	4.3	3.4	9.0
YAKATAGA	7277	-	-	-	-	-	-
YELLOWKN	7285	-25.2	-24.1	40.1	11.0	24.0	50.4
YUMA	7894	-19.4	-3.0	-8.6	2.2	4.8	3.4

Note : Parameters with very small $\sigma^2(<= 10^{-13})$ have been suppressed in the solution. This occurs for the WESTFORD position and velocity and for the velocities of sites with insufficient data.

RADIO SOURCE COORDINATES RSC(GSFC) 91 R 02

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
0016+731	0 19 45.786061	73 27 30.01551	0.000093	0.00012
0048-097	0 50 41.317370	- 9 29 5.21113	0.000005	0.00014
0104-408	1 6 45.107861	-40 34 19.95639	0.000094	0.00289
0106+013	1 8 38.771043	1 35 0.31594	0.000002	0.00012
0119+041	1 21 56.861655	4 22 24.73344	0.000002	0.00012
0133+476	1 36 58.594638	47 51 29.09872	0.000018	0.00013
0201+113	2 3 46.657002	11 34 45.40877	0.000020	0.00032
0202+149	2 4 50.413834	15 14 11.04234	0.000005	0.00013
0208-512	2 10 46.200568	-51 1 1.89250	0.000054	0.00030
0212+735	2 17 30.812793	73 49 32.62072	0.000088	0.00011
0224+671	2 28 50.051091	67 21 3.02831	0.000059	0.00017
0229+131	2 31 45.893990	13 22 54.71573	0.000003	0.00012
0234+285	2 37 52.405556	28 48 8.98934	0.000005	0.00011
0235+164	2 38 38.930020	16 36 59.27405	0.000005	0.00014
0237-233	2 40 8.174434	-23 9 15.72825	0.000051	0.00158
0256+075	2 59 27.076580	7 47 39.64403	0.000030	0.00084
0300+470	3 3 35.242020	47 16 16.27487	0.000013	0.00011
0316+413	3 19 48.159907	41 30 42.10216	0.000012	0.00014
0333+321	3 36 30.107524	32 18 29.34185	0.000026	0.00032
0336-019	3 39 30.937758	- 1 46 35.80381	0.000010	0.00030
0355+508	3 59 29.747020	50 57 50.16172	0.000015	0.00012
0402-362	4 3 53.749994	-36 5 1.91196	0.000024	0.00120
0420-014	4 23 15.800686	- 1 20 33.06433	0.000002	0.00012
0430+052	4 33 11.095446	5 21 15.61880	0.000023	0.00079
0434-188	4 37 1.482705	-18 44 48.61120	0.000017	0.00067
0454-234	4 57 3.179241	-23 24 52.01836	0.000004	0.00014
0458-020	5 1 12.809860	- 1 59 14.25456	0.000009	0.00027
0528+134	5 30 56.416679	13 31 55.15094	0.000003	0.00012
0537-441	5 38 50.361795	-44 5 8.93910	0.000058	0.00052
0552+398	5 55 30.805448	39 48 49.16640	0.000008	0.00011
0637-752	6 35 46.508352	-75 16 16.81369	0.000274	0.00031
0657+172	7 0 1.525472	17 9 21.70366	0.000006	0.00016
0716+714	7 21 53.448083	71 20 36.36539	0.000098	0.00017
0727-115	7 30 19.112448	-11 41 12.59761	0.000003	0.00012
0733-174	7 35 45.779508	-17 35 50.85091	0.026083	1.20245
0742+103	7 45 33.059453	10 11 12.69512	0.000003	0.00012
0745+241	7 48 36.109206	24 0 24.11247	0.000008	0.00016
0814+425	8 18 15.999527	42 22 45.41755	0.000012	0.00013
0820+560	8 24 47.236147	55 52 42.67225	0.000090	0.00036
0823+033	8 25 50.338309	3 9 24.52326	0.000004	0.00014
0851+202	8 54 48.874871	20 6 30.64371	0.000003	0.00011
0859+470	9 3 3.990015	46 51 4.14008	0.000020	0.00021
0919-260	9 21 29.353816	-26 18 43.38275	0.000010	0.00029
0923+392	9 27 3.013831	39 2 20.85474	0.000008	0.00011
0925-203	9 27 51.824318	-20 34 51.23166	0.000059	0.00175
0953+254	9 56 49.875381	25 15 16.05159	0.000018	0.00057
0954+658	9 58 47.245061	65 33 54.82110	0.000042	0.00012
1034-293	10 37 16.079681	-29 34 2.80982	0.000007	0.00014
1055+018	10 58 29.605178	1 33 58.82684	0.000002	0.00013
1057-797	10 58 43.309619	-80 3 54.15716	0.000627	0.00029

RADIO SOURCE COORDINATES (cont.) RSC(GSFC) 91 R 02

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
1104-445	11 7 8.694142	-44 49 7.61631	0.000059	0.00031
1123+264	11 25 53.711899	26 10 19.98162	0.000012	0.00023
1124-186	11 27 4.392370	-18 57 17.43726	0.000015	0.00075
1127-145	11 30 7.055786	-14 49 27.36337	0.003217	0.03167
1144+402	11 46 58.297944	39 58 34.30717	0.000008	0.00012
1144-379	11 47 1.370603	-38 12 11.02202	0.000087	0.00250
1150+812	11 53 12.499629	80 58 29.15659	0.000504	0.00023
1156+295	11 59 31.833919	29 14 43.82949	0.000005	0.00012
1219+285	12 21 31.690581	28 13 58.50289	0.000020	0.00062
1222+037	12 24 52.421857	3 30 50.29588	0.000019	0.00058
1226+023	12 29 6.699701	2 3 8.60122	********	0.00012
1228+126	12 30 49.423378	12 23 28.04757	0.000045	0.00050
1244-255	12 46 46.801947	-25 47 49.28642	0.000025	0.00105
1253-055	12 56 11.166456	- 5 47 21.52162	0.000003	0.00015
1308+326	13 10 28.663915	32 20 43.78500	0.000006	0.00012
1313-333	13 16 7.985838	-33 38 59.16742	0.000063	0.00228
1334-127	13 37 39.782709	-12 57 24.69059	0.000003	0.00013
1354+195	13 57 4.436686	19 19 7.37387	0.000006	0.00014
1354-152	13 57 11.244885	-15 27 28.78280	0.000012	0.00059
1404+286	14 7 0.394462	28 27 14.69154	0.000005	0.00012
1418+546	14 19 46.597595	54 23 14.78849	0.000020	0.00013
1424-418	14 27 56.297311	-42 6 19.43560	0.000050	0.00033
1502+106	15 4 24.979790	10 29 39.19997	0.000002	0.00012
1510-089	15 12 50.532865	- 9 5 59.82787	0.000004	0.00018
1519-273	15 22 37.675872	-27 30 10.78296	0.000018	0.00103
1548+056	15 50 35.269237	5 27 10.44908	0.000002	0.00013
1607+268	16 9 13.321291	26 41 28.99422	0.001237	0.03146
1611+343	16 13 41.064346	34 12 47.90922	0.000006	0.00012
1610-771	16 17 49.275708	-77 17 18.46825	0.000531	0.00039
1622-253	16 25 46.891529	-25 27 38.32592	0.000005	0.00015
1633+382	16 35 15.493070	38 8 4.50054	0.000008	0.00012
1637+574	16 38 13.456547	57 20 23.97891	0.000022	0.00012
1642+690	16 42 7.848915	68 56 39.75617	0.000060	0.00013
1641+399	16 42 58.810070	39 48 36.99382	0.000008	0.00011
1656+053	16 58 33.447327	5 15 16.44394	0.000024	0.00043
1730-130	17 33 2.705713	-13 4 49.54819	0.000003	0.00013
1739+522	17 40 36.978029	52 11 43.40669	0.000016	0.00011
1741-038	17 43 58.856102	- 3 50 4.61694	0.000002	0.00012
1749+701	17 48 32.840584	70 5 50.76724	0.000489	0.00077
1749+096	17 51 32.818576	9 39 0.72798	0.000003	0.00012
1803+784	18 0 45.684617	78 28 4.01731	0.000176	0.00011
1815-553	18 19 45.399361	-55 21 20.74728	0.000138	0.00050
1823+568	18 24 7.068564	56 51 1.48977	0.000030	0.00016
1831-711	18 37 28.715321	-71 8 43.55448	0.001488	0.00242
1845+797	18 42 8.990419	79 46 17.12695	0.001913	0.00089
1921-293	19 24 51.055856	-29 14 30.12164	0.000005	0.00013
1923+210	19 25 59.605397	21 6 26.16040	0.000013	0.00024
1928+738	19 27 48.495602	73 58 1.56815	0.000111	0.00013
1954+513	19 55 42.738376	51 31 48.54416	0.000038	0.00022
1958-179	20 0 57.090386	-17 48 57.67334	0.000007	0.00019

RADIO SOURCE COORDINATES (cont.) RSC(GSFC) 91 R 02

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
2008-159	20 11 15.710927	-15 46 40.26018	0.000087	0.00454
2037+511	20 38 37.034823	51 19 12.66047	0.000017	0.00012
2113+293	21 15 29.413451	29 33 38.36457	0.000012	0.00029
2121+053	21 23 44.517358	5 35 22.09124	0.000002	0.00012
2128-123	21 31 35.261685	-12 7 4.79782	0.000006	0.00021
2134+004	21 36 38.586291	0 41 54.21173	0.000002	0.00013
2145+067	21 48 5.458646	6 57 38.60216	0.000003	0.00012
2155-152	21 58 6.281785	-15 1 9.33037	0.000027	0.00048
2200+420	22 2 43.291358	42 16 39.97761	0.000010	0.00011
2201+315	22 3 14.975806	31 45 38.26813	0.000026	0.00057
2216-038	22 18 52.037702	- 3 35 36.88134	0.000002	0.00012
2230+114	22 32 36.408870	11 43 50.90211	0.000005	0.00015
2234+282	22 36 22.470836	28 28 57.41106	0.000005	0.00011
2243-123	22 46 18.231976	-12 6 51.27895	0.000026	0.00140
2251+158	22 53 57.747900	16 8 53.55872	0.000004	0.00011
2253+417	22 55 36.707788	42 2 52.53042	0.000030	0.00037
2255-282	22 58 5.962872	-27 58 21.25782	0.000005	0.00014
2345-167	23 48 2.608512	-16 31 12.02314	0.000005	0.00015
2355-534	23 57 53.266196	-53 11 13.69121	0.000065	0.00054
2355-106	23 58 10.882390	-10 20 8.61206	0.000008	0.00040

EOP(GSFC) 91 R 02 Available from 1979 to 1990

Number of measurements and RMS uncertainty per year
Units : 0.001" for X,Y,dψ,dε; 0.0001s for UT1

YEAR	X		Y		UT1		dψ		dε	
	Nb	Sigma	Nb	Sigma	Nb	Sigma	Nb	Sigma	Nb	Sigma
1979	2	1.45	2	2.97	2	1.01	2	1.78	2	0.66
1980	17	0.94	17	1.35	17	0.54	17	1.13	17	0.39
1981	5	2.24	5	2.19	5	1.02	5	4.28	5	1.68
1982	11	0.82	11	0.92	11	0.41	11	1.11	11	0.36
1983	8	32.85	8	12.02	8	4.50	8	1.40	8	0.45
1984	23	17.63	23	17.09	23	2.63	23	0.99	23	0.34
1985	29	1.90	29	23.33	29	2.60	29	1.05	29	0.35
1986	39	1.66	39	22.48	39	2.47	39	0.75	39	0.28
1987	46	0.98	46	0.57	46	0.27	46	0.56	46	0.20
1988	42	5.85	42	0.59	42	2.54	42	0.55	42	0.22
1989	38	4.37	38	5.49	38	1.43	38	0.48	38	0.19
1990	37	0.60	37	0.87	37	0.41	37	0.55	37	0.22

RADIO SOURCE POSITIONS FROM NASA CRUSTAL DYNAMICS PROJECT DATA
GSFC 91 R 03

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Mark III VLBI data acquired since 1979 by the NASA Crustal Dynamics Project have been analyzed for radio source positions. The terrestrial reference frame origin is defined by the a priori position of the 18-m Westford antenna on 1988 Jan. 1 and moving with AM0-2 velocity. The orientation of the terrestrial frame is defined by values from BIH Circular D, modified by the IERS standard UT1 tidal model, and by the direction of the WESTFORD-ALGOPARK baseline, which evolves according to the AM0-2 model. The orientation of the celestial frame is defined by the standard J2000.0 precession and IAU 1980 nutation models for the reference date 1986 Nov. 6 and by the a priori right ascension of 3C273B. Short period tidal terms in UT1 have not been removed from the tabulated values of UT1-UTC. All uncertainties are 1-sigma formal standard errors from the sequential least- squares solution GLB720 described below.

The analysis configuration is identical to solution GSFC 91 R 01 except for the baseline used to constrain the orientation of the terrestrial reference frame and the a priori EOP series. 217 609 dual-frequency Mark III delays from 270 CDP geodetic sessions using fixed stations as well as several mobile sites and 13 000 delays and rates from 27 CDP astrometric/survey sessions were combined to estimate site positions and velocities, source positions, Earth orientation parameters, and troposphere and clock behavior from a least-squares solution with 702 global parameters and 77 234 arc parameters. A weak input covariance on polar motion and UT1 (X,Y - 45 mas, UT1 - 3 ms) was used so that all three components could be estimated for each session with more reliable indication of uncertainty and correlation. The weighted rms post-fit residual of the solution was 42.8 ps. The reduced chi-square was 0.96 including the constraints in the computation of the degrees of freedom.

The source positions are designated RSC(GSFC)91 R 03. Other results are the Earth orientation time series designated EOP(GSFC)91 R 03 and the site coordinates at 1988 Jan 1.5 designated SSC(GSFC)91 R 03.

SUMMARY SHEET FOR SOLUTION GSFC 91 R 03 : see p.43

VLBI Site positions at 1988 January 1.5 (see note p.23) SSC(GSFC) 91 R 03

Monument	Name	X (m)	Y (m)	Z (m)	C. Epoch (days)	Span (days)	SX (m)	SY (m)	SZ (m)	
7282 S	ALGOPARK	918034.962	-4346132.212	4561971.020	46756.9	2167.0	.001	.004	.004	
7215 S	CHLBOLTN	4008310.204	-100650.835	4943794.569	44532.2	7.0	.014	.008	.023	
7231 S	DSS15	-2353538.639	-4641649.503	3676669.938	47472.0	1.0	.003	.007	.008	
1642 S	DSS45	-4460935.078	2682765.833	-3674381.671	47705.0	767.0	.016	.014	.012	
1665 S	DSS65	4849336.793	-360488.916	4114748.539	47758.8	736.0	.011	.003	.014	
7203 S	EFLSBERG	4033947.683	486990.390	4900430.623	44620.7	1258.0	.033	.015	.043	
7225 S	GILCREEK	-2281547.036	-1453645.035	5756993.165	47252.7	2352.0	.002	.003	.004	
1513 S	GOLDVENU	-2351129.011	-4655477.074	3660956.837	46881.8	3197.0	.003	.005	.006	
7232 S	HARTRAO	5085442.699	2668263.461	-2768697.345	47240.0	1197.0	.056	.030	.018	
7218 S	HATCREEK	-2523969.805	-4123506.348	4147752.521	47023.6	2702.0	.001	.003	.004	
7205 S	HAYSTACK	1492404.947	-4457266.484	4296881.614	46277.6	4036.0	.000	.001	.001	
7242 S	HOBART26	-3950236.385	2522347.621	-4311562.947	47985.2	350.0	.012	.020	.017	
7216 S	HRAS 085	-1324210.828	-5332023.107	3232118.283	46118.3	3298.0	.001	.003	.003	
1857 S	KASHIM34	-3997649.152	3276690.800	3724278.950	48066.4	203.0	.011	.008	.018	
1856 S	KASHIMA	-3997892.226	3276581.282	3724118.324	46950.3	2349.0	.004	.003	.008	
1311 S	KAUAI	-5543845.934	-2054564.165	2387813.769	47070.8	2287.0	.002	.004	.006	
4968 S	KWAJAL26	-6143536.466	1363997.236	1034707.401	46522.1	1492.0	.010	.006	.008	
7310 S	MARCUS	-5227446.793	2551379.201	2607604.760	48068.0	1.0	.017	.012	.020	
7217 S	MARPOINT	1106629.516	-4882907.183	3938086.854	45171.4	123.0	.003	.011	.009	
7243 S	MATERA	4641939.060	1393002.899	4133325.367	48140.0	1.0	.013	.007	.020	
7230 S	MEDICINA	4461370.203	919596.702	4449558.987	47766.4	1003.0	.005	.003	.008	
7222 S	MOJAVE12	-2356170.860	-4646755.878	3668470.528	47184.9	2518.0	.001	.003	.003	
7547 S	NOTO	4934563.330	1321201.178	3806484.232	47977.9	460.0	.018	.008	.018	
7204 S	NRAO 140	882880.085	-4924482.277	3944130.538	45384.0	4053.0	.001	.004	.004	
7213 S	ONSALA60	3370606.223	711917.390	5349830.548	46424.6	3694.0	.003	.002	.006	
7207 S	OVRO 130	-2409600.622	-4478349.533	3838603.135	45519.1	3384.0	.002	.004	.004	
7283 M	PENTICTN	-2058840.281	-3621286.393	4814420.688	46864.0	2164.0	.008	.013	.017	
7234 S	PIETOWN	-1640953.526	-5014816.015	3575411.845	47887.4	828.0	.002	.004	.004	
7258 M	PLATTVIL	-1240708.000	-4720454.340	4094481.563	47049.8	2699.0	.002	.006	.005	
7219 S	RICHMOND	961258.190	-5674089.992	2740533.634	47255.7	1264.0	.008	.010	.007	
1561 S	ROBLED32	4849245.362	-360278.246	4114884.337	45460.0	1.0	.047	.012	.041	
7227 S	SESHAN25	-2831686.618	4675733.846	3275327.813	47689.0	885.0	.008	.008	.012	
7239 S	SEST	1838237.890	-5258699.097	-3100589.004	48022.6	37.0	.015	.024	.009	
7226 S	SHANGHAI	-2847698.156	4659872.931	3283958.881	46595.0	1.0	.119	.103	.093	
7223 M	VNDNBERG	-2678094.619	-4525450.819	3597410.061	46894.7	2022.0	.002	.003	.004	
7209 S	WESTFORD	1492206.806	-4458130.482	4296015.386	47093.2	3469.0	.000	.000	.000	Ref
7224 S	WETTZELL	4075540.090	931735.155	4801629.175	46969.7	2198.0	.003	.002	.006	
7285 M	YELLOWKN	-1224124.385	-2689530.667	5633555.336	46125.9	377.0	.030	.065	.136	

VLBI site velocities SSV(GSFC) 91 R 03

Station		Velocity (mm/yr) X	Y	Z	Uncertainty(mm/yr) X	Y	Z
ALGOPARK	7282	-18.9	-2.9	1.0	0.4	0.1	0.2
CHLBOLTN	7215	-13.3	16.4	11.2	-	-	-
DSS15	7231	-15.8	-1.5	-12.1	-	-	-
DSS45	1642	-27.6	-2.0	60.9	7.5	5.8	6.2
DSS65	1665	21.0	13.0	50.0	9.5	2.5	12.2
EFLSBERG	7203	-6.0	9.5	16.1	5.4	2.6	7.5
GILCREEK	7225	-21.9	-1.3	-4.9	1.8	2.0	2.3
GOLDVENU	1513	-20.2	10.0	-7.6	1.0	2.4	2.3
HARTRAO	7232	91.5	30.7	5.5	25.7	14.3	9.9
HATCREEK	7218	-21.3	9.7	-6.9	0.7	2.0	2.0
HAYSTACK	7205	-17.9	-3.4	3.4	0.2	0.4	0.4
HOBART26	7242	-37.8	6.7	38.5	-	-	-
HRAS 085	7216	-16.6	5.8	-9.4	0.8	1.6	1.7
KASHIM34	1857	-14.0	-1.2	-14.0	-	-	-
KASHIMA	1856	9.2	7.9	-6.4	3.1	2.2	5.3
KAUAI	1311	-11.7	71.6	34.5	0.5	2.9	2.8
KWAJAL26	4968	28.3	79.6	30.2	4.9	3.8	4.8
MARCUS	7310	43.4	65.4	23.0	-	-	-
MARPOINT	7217	-16.9	-2.5	1.6	-	-	-
MATERA	7243	-16.2	18.1	12.1	-	-	-
MEDICINA	7230	-8.3	10.4	21.6	3.4	1.8	5.1
MOJAVE12	7222	-18.0	10.1	-5.3	0.4	1.7	1.8
NOTO	7547	-12.7	-1.5	19.1	10.0	4.9	10.7
NRAO 140	7204	-19.0	0.8	-1.0	0.4	1.0	0.9
ONSALA60	7213	-9.8	8.4	11.7	2.5	1.1	4.0
OVRO 130	7207	-20.8	12.3	-6.7	0.4	1.9	1.9
PENTICTN	7283	-26.2	-14.1	13.1	3.1	5.3	6.8
PIETOWN	7234	-14.2	16.2	-16.9	1.0	2.4	2.3
PLATTVIL	7258	-21.2	-3.9	-4.0	1.1	3.6	3.2
RICHMOND	7219	-13.5	-5.9	5.3	6.3	10.4	6.4
ROBLED32	1561	-10.2	18.8	13.6	-	-	-
SESHAN25	7227	-11.2	-17.7	-14.7	4.9	4.3	6.5
SEST	7239	-2.2	-5.8	8.6	-	-	-
SHANGHAI	7226	-25.0	-8.0	-10.4	-	-	-
VNDNBERG	7223	-30.9	37.4	16.8	1.0	2.2	2.2
WESTFORD	7209	-18.2	-2.9	3.4	-	-	-
WETTZELL	7224	-9.2	9.0	15.1	2.5	1.2	4.4
YELLOWKN	7285	-24.3	-23.4	41.4	11.1	24.0	50.4

Note. Parameters with very small $\sigma^2(<= 10^{-13})$ have been suppressed in the solution. This occurs for the WESTFORD position and velocity and for the velocities of sites with insufficient data.

RADIO SOURCE COORDINATES RSC(GSFC) 91 R 03

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
0003-066	0 6 13.892893	- 6 23 35.33770	0.000035	0.00050
0007+106	0 10 31.005897	10 58 29.50169	0.000056	0.00128
0016+731	0 19 45.785989	73 27 30.01567	0.000097	0.00013
0026+346	0 29 14.242450	34 56 32.24526	0.000188	0.00250
0048-097	0 50 41.317376	- 9 29 5.21071	0.000005	0.00015
0056-001	0 59 5.514903	0 6 51.62179	0.000052	0.00156
0106+013	1 8 38.771041	1 35 0.31638	0.000003	0.00013
0111+021	1 13 43.144872	2 22 17.31566	0.000049	0.00142
0112-017	1 15 17.099921	- 1 27 4.57728	0.000033	0.00047
0113-118	1 16 12.520650	-11 36 15.43724	0.000420	0.00077
0119+041	1 21 56.861659	4 22 24.73389	0.000004	0.00014
0133+476	1 36 58.594625	47 51 29.09867	0.000037	0.00023
0138-097	1 41 25.832082	- 9 28 43.67428	0.000051	0.00045
0146+056	1 49 22.370848	5 55 53.56688	0.000036	0.00101
0149+218	1 52 18.058974	22 7 7.69982	0.000034	0.00050
0153+744	1 57 34.964239	74 42 43.23053	0.000707	0.00058
0201+113	2 3 46.656973	11 34 45.40902	0.000045	0.00126
0202+149	2 4 50.413883	15 14 11.04280	0.000031	0.00056
0202-172	2 4 57.674308	-17 1 19.83987	0.000075	0.00058
0202+319	2 5 4.925251	32 12 30.09443	0.000037	0.00036
0208-512	2 10 46.200593	-51 1 1.89208	0.000052	0.00030
0212+735	2 17 30.812769	73 49 32.62093	0.000088	0.00012
0224+671	2 28 50.051069	67 21 3.02877	0.000059	0.00016
0229+131	2 31 45.893992	13 22 54.71612	0.000003	0.00013
0234+285	2 37 52.405557	28 48 8.98965	0.000006	0.00012
0235+164	2 38 38.930020	16 36 59.27464	0.000008	0.00034
0238-084	2 41 4.798329	- 8 15 20.75302	0.000057	0.00081
0241+622	2 44 57.695553	62 28 6.50686	0.002102	0.00679
0300+470	3 3 35.242012	47 16 16.27521	0.000012	0.00012
0309+411	3 13 1.961958	41 20 1.18322	0.000090	0.00055
0316+413	3 19 48.159922	41 30 42.10411	0.000016	0.00018
0326+277	3 29 57.669444	27 56 15.50021	0.000097	0.00086
0333+321	3 36 30.107476	32 18 29.34209	0.000036	0.00051
0336-019	3 39 30.937774	- 1 46 35.80296	0.000010	0.00023
0338-214	3 40 35.607947	-21 19 31.16998	0.000070	0.00042
0355+508	3 59 29.747029	50 57 50.16224	0.000017	0.00013
0403-132	4 5 34.003581	-13 8 13.68945	0.000044	0.00043
0406+121	4 9 22.008640	12 17 39.84740	0.000045	0.00088
0414-189	4 16 36.544491	-18 51 8.33841	0.000045	0.00043
0420-014	4 23 15.800683	- 1 20 33.06375	0.000003	0.00013
0422+004	4 24 46.841991	0 36 6.32994	0.000040	0.00102
0430+052	4 33 11.095397	5 21 15.62125	0.000019	0.00067
0434-188	4 37 1.482719	-18 44 48.61108	0.000032	0.00033
0440-003	4 42 38.660746	- 0 17 43.41758	0.000076	0.00177
0451-282	4 53 14.646932	-28 7 37.32310	0.000097	0.00153

RADIO SOURCE COORDINATES (cont.) RSC(GSFC) 91 R 03

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
0454-234	4 57 3.179239	-23 24 52.01779	0.000006	0.00016
0458-020	5 1 12.809860	- 1 59 14.25285	0.000013	0.00069
0500+019	5 3 21.197201	2 3 4.67865	0.000040	0.00128
0454+844	5 8 42.361665	84 32 4.54402	0.003233	0.00054
0511-220	5 13 49.114600	-21 59 16.09009	0.000083	0.00229
0528+134	5 30 56.416688	13 31 55.15139	0.000003	0.00012
0529+075	5 32 38.998177	7 32 43.34251	0.000368	0.02826
0537-441	5 38 50.361787	-44 5 8.93840	0.000057	0.00051
0539-057	5 41 38.083389	- 5 41 49.42736	0.000039	0.00108
0552+398	5 55 30.805462	39 48 49.16674	0.000008	0.00012
0605-085	6 7 59.699208	- 8 34 49.97580	0.000020	0.00031
0609+607	6 14 23.865821	60 46 21.75708	0.000192	0.00060
0637-752	6 35 46.508322	-75 16 16.81341	0.000269	0.00030
0642+449	6 46 32.025860	44 51 16.59227	0.000049	0.00036
0648-165	6 50 24.581889	-16 37 39.72161	0.000025	0.00033
0707+476	7 10 46.104713	47 32 11.14598	0.000056	0.00038
0711+356	7 14 24.817496	35 34 39.79529	0.000079	0.00107
0716+714	7 21 53.448099	71 20 36.36615	0.000214	0.00041
0723-008	7 25 50.639917	- 0 54 56.54179	0.000021	0.00041
0718+792	7 26 11.734707	79 11 31.01788	0.001014	0.00051
0727-115	7 30 19.112454	-11 41 12.59708	0.000003	0.00014
0735+178	7 38 7.393700	17 42 19.00139	0.000014	0.00020
0736+017	7 39 18.033870	1 37 4.62185	0.000028	0.00034
0738+313	7 41 10.703227	31 12 0.23138	0.000021	0.00020
0742+103	7 45 33.059464	10 11 12.69557	0.000003	0.00013
0743-006	7 45 54.082278	- 0 44 17.53471	0.000031	0.00086
0748+126	7 50 52.045696	12 31 4.83240	0.000031	0.00061
0749+540	7 53 1.384487	53 52 59.64059	0.000113	0.00068
0754+100	7 57 6.642867	9 56 34.85498	0.000022	0.00038
0805-077	8 8 15.535994	- 7 51 9.88282	0.000016	0.00024
0804+499	8 8 39.666217	49 50 36.53305	0.000040	0.00023
0808+019	8 11 26.707283	1 46 52.22445	0.000034	0.00095
0812+367	8 15 25.944769	36 35 15.15096	0.000037	0.00048
0814+425	8 18 15.999563	42 22 45.41783	0.000019	0.00016
0820+560	8 24 47.236233	55 52 42.67223	0.000047	0.00019
0823+033	8 25 50.338319	3 9 24.52362	0.000005	0.00014
0823-223	8 26 1.573034	-22 30 27.20044	0.000080	0.00165
0828+493	8 32 23.216645	49 13 21.04099	0.000085	0.00046
0834-201	8 36 39.215319	-20 16 59.50070	0.000049	0.00105
0833+585	8 37 22.409512	58 25 1.84798	0.000161	0.00041
0836+710	8 41 24.365190	70 53 42.17552	0.000236	0.00037
0839+187	8 42 5.094113	18 35 40.99431	0.000041	0.00067
0851+202	8 54 48.874885	20 6 30.64401	0.000003	0.00012
0859-140	9 2 16.830925	-14 15 30.87167	0.000040	0.00044
0906+015	9 9 10.091482	1 21 35.62106	0.000080	0.00199

RADIO SOURCE COORDINATES (cont.) RSC(GSFC) 91 R 03

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
0917+449	9 20 58.458411	44 41 53.98863	0.000059	0.00067
0919-260	9 21 29.353820	-26 18 43.38237	0.000012	0.00024
0917+624	9 21 36.231076	62 15 52.18310	0.000073	0.00023
0923+392	9 27 3.013850	39 2 20.85487	0.000008	0.00011
0953+254	9 56 49.875361	25 15 16.05282	0.000011	0.00020
0955+326	9 58 20.949671	32 24 2.21274	0.000041	0.00051
0954+658	9 58 47.245095	65 33 54.82119	0.000043	0.00013
1020+400	10 23 11.565562	39 48 15.38810	0.000072	0.00060
1032-199	10 35 2.155219	-20 11 34.35400	0.000055	0.00049
1034-293	10 37 16.079687	-29 34 2.80959	0.000010	0.00017
1039+811	10 44 23.062954	80 54 39.44560	0.001021	0.00042
1045-188	10 48 6.620365	-19 9 35.72314	0.000066	0.00061
1053+815	10 58 11.535719	81 14 32.67802	0.001022	0.00037
1055+018	10 58 29.605170	1 33 58.82757	0.000006	0.00019
1057-797	10 58 43.309562	-80 3 54.15705	0.000616	0.00028
1104-445	11 7 8.694139	-44 49 7.61597	0.000057	0.00031
1111+149	11 13 58.695051	14 42 26.95457	0.000062	0.00108
1123+264	11 25 53.711926	26 10 19.98167	0.000019	0.00022
1124-186	11 27 4.392458	-18 57 17.43779	0.000030	0.00038
1128+385	11 30 53.282645	38 15 18.54918	0.000046	0.00052
1130+009	11 33 20.055717	0 40 52.84069	0.000066	0.00185
1144+402	11 46 58.297960	39 58 34.30712	0.000009	0.00013
1145-071	11 47 51.553965	- 7 24 41.13866	0.000045	0.00048
1148-001	11 50 43.870722	- 0 23 54.20107	0.000055	0.00109
1150+812	11 53 12.499803	80 58 29.15659	0.000394	0.00017
1156+295	11 59 31.833931	29 14 43.82953	0.000005	0.00012
1213-172	12 15 46.751665	-17 31 45.40077	0.000044	0.00070
1216+487	12 19 6.414831	48 29 56.16768	0.000076	0.00046
1219+285	12 21 31.690587	28 13 58.50304	0.000018	0.00060
1221+809	12 23 40.494343	80 40 4.34257	0.001125	0.00046
1222+037	12 24 52.421897	3 30 50.29663	0.000028	0.00051
1226+023	12 29 6.699701	2 3 8.60136	********	0.00013
1228+126	12 30 49.423404	12 23 28.04725	0.000023	0.00034
1243-072	12 46 4.232069	- 7 30 46.57251	0.000032	0.00037
1244-255	12 46 46.801963	-25 47 49.28537	0.000145	0.00063
1252+119	12 54 38.255590	11 41 5.89694	0.000053	0.00073
1253-055	12 56 11.166444	- 5 47 21.52238	0.000006	0.00022
1302-102	13 5 33.014948	-10 33 19.42612	0.000030	0.00039
1308+326	13 10 28.663929	32 20 43.78490	0.000006	0.00012
1323+321	13 26 16.511156	31 54 9.53464	0.000518	0.00929
1334-127	13 37 39.782714	-12 57 24.69070	0.000005	0.00015
1342+662	13 43 45.959933	66 2 25.74617	0.000327	0.00086
1342+663	13 44 8.679920	66 6 11.64564	0.000187	0.00042
1354+195	13 57 4.436695	19 19 7.37387	0.000006	0.00015
1354-152	13 57 11.244923	-15 27 28.78393	0.000042	0.00037

RADIO SOURCE COORDINATES (cont.) RSC(GSFC) 91 R 03

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
1404+286	14 7 0.394458	28 27 14.69150	0.000005	0.00012
1406-076	14 8 56.481107	- 7 52 26.66440	0.000036	0.00039
1413+135	14 15 58.817625	13 20 23.71579	0.000040	0.00091
1418+546	14 19 46.597610	54 23 14.78835	0.000027	0.00015
1424-418	14 27 56.297342	-42 6 19.43573	0.000050	0.00034
1435+638	14 36 45.802324	63 36 37.86590	0.000205	0.00058
1435-218	14 38 9.469695	-22 4 54.74436	0.000382	0.00129
1502+106	15 4 24.979803	10 29 39.20001	0.000003	0.00013
1504+377	15 6 9.530114	37 30 51.13208	0.000061	0.00068
1504-166	15 7 4.786866	-16 52 30.26436	0.000028	0.00028
1510-089	15 12 50.532873	- 9 5 59.82842	0.000023	0.00029
1511-100	15 13 44.893307	-10 12 0.26335	0.000041	0.00032
1514-241	15 17 41.813125	-24 22 19.47499	0.000129	0.00059
1519-273	15 22 37.675888	-27 30 10.78352	0.000057	0.00054
1538+149	15 40 49.491548	14 47 45.88461	0.000029	0.00083
1546+027	15 49 29.436745	2 37 1.16347	0.000039	0.00110
1548+056	15 50 35.269232	5 27 10.44923	0.000003	0.00014
1555+001	15 57 51.433952	- 0 1 50.41281	0.000028	0.00046
1606+106	16 8 46.203188	10 29 7.77493	0.000022	0.00066
1607+268	16 9 13.321256	26 41 28.99548	0.001203	0.03058
1611+343	16 13 41.064348	34 12 47.90917	0.000006	0.00012
1610-771	16 17 49.275711	-77 17 18.46790	0.000522	0.00040
1622-253	16 25 46.891550	-25 27 38.32579	0.000007	0.00018
1624+416	16 25 57.669907	41 34 40.62951	0.000059	0.00045
1622-297	16 26 6.020972	-29 51 26.97082	0.000156	0.00062
1633+382	16 35 15.493072	38 8 4.50033	0.000008	0.00012
1637+574	16 38 13.456506	57 20 23.97841	0.000038	0.00021
1638+398	16 40 29.632912	39 46 46.02777	0.000011	0.00015
1642+690	16 42 7.848911	68 56 39.75576	0.000062	0.00015
1641+399	16 42 58.810063	39 48 36.99351	0.000008	0.00012
1652+398	16 53 52.216893	39 45 36.60921	0.000037	0.00035
1656+053	16 58 33.447315	5 15 16.44439	0.000018	0.00031
1657-261	17 0 53.153974	-26 10 51.72468	0.000036	0.00030
1727+502	17 28 18.623323	50 13 10.47357	0.006900	0.04085
1730-130	17 33 2.705719	-13 4 49.54820	0.000004	0.00015
1732+389	17 34 20.578641	38 57 51.44250	0.000048	0.00044
1738+476	17 39 57.129226	47 37 58.36096	0.000064	0.00043
1739+522	17 40 36.978031	52 11 43.40657	0.000016	0.00012
1741-038	17 43 58.856103	- 3 50 4.61681	0.000003	0.00014
1743+173	17 45 35.208220	17 20 1.42256	0.000034	0.00062
1749+701	17 48 32.840625	70 5 50.76691	0.000394	0.00046
1749+096	17 51 32.818575	9 39 0.72793	0.000003	0.00013
1803+784	18 0 45.684618	78 28 4.01711	0.000174	0.00011
1807+698	18 6 50.681045	69 49 28.10727	0.000158	0.00024
1815-553	18 19 45.399387	-55 21 20.74742	0.000135	0.00049

RADIO SOURCE COORDINATES (cont.) RSC(GSFC) 91 R 03

SOURCE	RIGHT ASCENSION	DECLINATION	SIGMA R.A.	SIGMA D.
	H M S	o ' "	S	"
1826+796	18 23 14.109169	79 38 49.00045	0.001119	0.00074
1821+107	18 24 2.855189	10 44 23.77168	0.000033	0.00081
1823+568	18 24 7.068534	56 51 1.48917	0.000063	0.00031
1831-711	18 37 28.715368	-71 8 43.55468	0.001448	0.00235
1845+797	18 42 8.990739	79 46 17.12619	0.001210	0.00056
1842+681	18 42 33.641885	68 9 25.22661	0.000169	0.00032
1908-201	19 11 9.652849	-20 6 55.11175	0.000076	0.00196
1921-293	19 24 51.055866	-29 14 30.12151	0.000007	0.00015
1923+210	19 25 59.605371	21 6 26.16002	0.000017	0.00046
1928+738	19 27 48.495266	73 58 1.56784	0.000221	0.00033
1936-155	19 39 26.657619	-15 25 43.06172	0.000102	0.03467
1954+513	19 55 42.738380	51 31 48.54394	0.000029	0.00016
1958-179	20 0 57.090383	-17 48 57.67332	0.000018	0.00022
2007+777	20 5 30.998847	77 52 43.24516	0.000330	0.00022
2005+403	20 7 44.944756	40 29 48.60491	0.000201	0.00195
2008-159	20 11 15.710906	-15 46 40.25701	0.000027	0.00100
2017+743	20 17 13.079475	74 40 47.99772	0.000562	0.00047
2021+614	20 22 6.681747	61 36 58.80164	0.000090	0.00027
2021+317	20 23 19.017400	31 53 2.30365	0.000042	0.00043
2023+336	20 25 10.842072	33 43 0.21544	0.000268	0.00349
2037+511	20 38 37.034816	51 19 12.66050	0.000018	0.00013
2113+293	21 15 29.413447	29 33 38.36464	0.000011	0.00021
2121+053	21 23 44.517364	5 35 22.09143	0.000003	0.00013
2126-158	21 29 12.175843	-15 38 41.04187	0.000037	0.00110
2128+048	21 30 32.877364	5 2 17.47266	0.000134	0.00207
2128-123	21 31 35.261727	-12 7 4.79748	0.000022	0.00034
2131-021	21 34 10.309595	- 1 53 17.24067	0.000026	0.00048
2134+004	21 36 38.586269	0 41 54.21134	0.000005	0.00017
2136+141	21 39 1.309269	14 23 35.99021	0.000017	0.00025
2144+092	21 47 10.162961	9 29 46.67036	0.000016	0.00026
2145+067	21 48 5.458644	6 57 38.60233	0.000003	0.00013
2149+056	21 51 37.875551	5 52 12.95373	0.000051	0.00136
2155-152	21 58 6.281866	-15 1 9.32944	0.000024	0.00039
2200+420	22 2 43.291333	42 16 39.97751	0.000010	0.00012
2201+315	22 3 14.975764	31 45 38.26765	0.000013	0.00016
2210-257	22 13 2.497073	-25 29 30.08433	0.000514	0.00163
2216-038	22 18 52.037704	- 3 35 36.88111	0.000003	0.00014
2223-052	22 25 47.259325	- 4 57 1.39136	0.000025	0.00093
2227-088	22 29 40.084344	- 8 32 54.43691	0.000028	0.00073
2230+114	22 32 36.408959	11 43 50.90125	0.000023	0.00045
2234+282	22 36 22.470823	28 28 57.41115	0.000006	0.00012
2233-148	22 36 34.087267	-14 33 22.18972	0.000052	0.00060
2243-123	22 46 18.231960	-12 6 51.27953	0.000018	0.00031
2251+158	22 53 57.747897	16 8 53.55893	0.000004	0.00012
2254+074	22 57 17.303134	7 43 12.30177	0.000114	0.00163

RADIO SOURCE COORDINATES (cont.) RSC(GSFC) 91 R 03

SOURCE	RIGHT ASCENSION	DECLINATION	SIGMA R.A.	SIGMA D.
	H M S	o ' "	S	"
2255-282	22 58 5.962892	-27 58 21.25755	0.000007	0.00016
2318+049	23 20 44.856647	5 13 49.95092	0.000034	0.00041
2325-150	23 27 47.964167	-14 47 55.75194	0.000062	0.00072
2328+107	23 30 40.852178	11 0 18.70800	0.000028	0.00063
2329-162	23 31 38.652457	-15 56 57.01025	0.000052	0.00051
2331-240	23 33 55.238916	-23 43 40.66785	0.000743	0.00783
2344+092	23 46 36.838517	9 30 45.51283	0.000036	0.00081
2352+495	23 55 9.458015	49 50 8.33973	0.000094	0.00058
2355-534	23 57 53.266219	-53 11 13.69083	0.000063	0.00053

EOP(GSFC) 91 R 03 Available from 1979 to 1990

Number of measurements and RMS uncertainty per year
Units : 0.001" for X,Y,dψ,dε; 0.0001s for UT1.

YEAR	X		Y		UT1		dψ		dε	
	Nb	Sigma	Nb	Sigma	Nb	Sigma	Nb	Sigma	Nb	Sigma
1979	2	1.45	2	2.97	2	1.01	2	1.78	2	0.66
1980	17	0.94	17	1.35	17	0.54	17	1.13	17	0.39
1981	5	2.24	5	2.19	5	1.02	5	4.28	5	1.68
1982	11	0.82	11	0.92	11	0.41	11	1.11	11	0.36
1983	8	32.85	8	12.02	8	4.50	8	1.40	8	0.45
1984	23	17.63	23	17.09	23	2.63	23	0.99	23	0.34
1985	29	1.90	29	23.33	29	2.60	29	1.05	29	0.35
1986	39	1.66	39	22.48	39	2.47	39	0.75	39	0.28
1987	46	0.98	46	0.57	46	0.27	46	0.56	46	0.20
1988	42	5.85	42	0.59	42	2.54	42	0.55	42	0.22
1989	38	4.37	38	5.49	38	1.43	38	0.48	38	0.19
1990	37	0.60	37	0.87	37	0.41	37	0.55	37	0.22

RADIO SOURCE POSITIONS FROM THE NASA CRUSTAL DYNAMICS PROJECT

GSFC 91 R 04

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Mark III VLBI data acquired since 1979 by the NASA Crustal Dynamics Project, POLARIS/IRIS, the USNO Navnet, and the NRL reference frame program have been analyzed for radio source positions. The terrestrial reference frame origin is defined by the a priori position of the 18-m Westford antenna on 1988 Jan. 1 and moving with AM0-2 velocity. The orientation of the terrestrial frame is defined by values from EOP(IERS) 90 C 04, modified by the IERS standard UT1 tidal model, and by the direction of the WESTFORD-RICHMOND baseline, which evolves according to the AM0-2 model. The orientation of the celestial frame is defined by the standard J2000.0 precession and IAU 1980 nutation models for the reference date 1986 Nov. 6 and by the a priori right ascension of 3C273B. Short period tidal terms in UT1 have not been removed from the tabulated values of UT1-UTC. All uncertainties are 1-sigma formal standard errors from the sequential least-squares solution GLB722 described below.

The analysis configuration is identical to solution GSFC 91 R 01. In addition to the geodetic data used in solution GSFC 91 R 01, 18 066 delays and rates from 56 astrometric/survey sessions were combined to estimate site positions and velocities, source positions, Earth orientation parameters, and troposphere and clock behavior from a least-squares solution with 996 global parameters and 223 277 arc parameters. A weak input covariance on polar motion and UT1 (X,Y - 45 mas, UT1 - 3 ms) was used so that all three components could be estimated for each session with more reliable indication of uncertainty and correlation. The weighted rms post-fit residual of the solution was 43.8 ps. The reduced chi-square was 1.00 including the constraints in the computation of the degrees of freedom.

The source positions are designated RSC(GSFC)91 R 04. Other results are the Earth orientation time series designated EOP(GSFC)91 R 04 and the site coordinates at 1988 Jan 1.5 designated SSC(GSFC)91 R 04.

SUMMARY SHEET FOR SOLUTION GSFC 91 R 04 : see p.43.

VLBI Site positions at 1988 January 1.5 (see note p. 34) SSC(GSFC) 91 R 04

Monument	Name	X (m)	Y (m)	Z (m)	C. Epoch (days)	Span (days)	SX (m)	SY (m)	SZ (m)
7282 S	ALGOPARK	918034.965	-4346132.208	4561971.021	47543.4	2171.0	.001	.003	.003
7604 M	BREST	4228877.303	-333104.328	4747180.753	47771.6	6.0	.013	.003	.014
7603 M	CARNUSTY	3526416.617	-171421.247	5294098.679	47759.0	1.0	.015	.004	.021
7215 S	CHLBOLTN	4008310.277	-100650.887	4943794.555	44532.2	7.0	.009	.005	.011
7231 S	DSS15	-2353538.637	-4641649.464	3676669.934	47472.0	1.0	.003	.006	.007
1642 S	DSS45	-4460934.958	2682765.854	-3674381.704	47701.8	767.0	.016	.011	.010
1665 S	DSS65	4849336.854	-360488.967	4114748.546	47758.8	736.0	.008	.002	.009
7203 S	EFLSBERG	4033947.731	486990.360	4900430.607	44620.7	1258.0	.033	.015	.043
7225 S	GILCREEK	-2281547.001	-1453644.985	5756993.143	47434.2	2372.0	.001	.002	.003
1513 S	GOLDVENU	-2351129.012	-4655477.031	3660956.835	46881.8	3197.0	.003	.005	.005
7605 M	GRASSE	4581697.875	556125.593	4389351.207	47784.0	1.0	.017	.004	.017
7210 M	HALEAKAL	-5465998.366	-2404408.472	2242228.376	47347.2	15.0	.014	.007	.008
7232 S	HARTRAO	5085442.879	2668263.347	-2768697.318	47477.4	1783.0	.010	.007	.007
7218 S	HATCREEK	-2523969.799	-4123506.303	4147752.517	47049.8	2702.0	.001	.002	.003
7205 S	HAYSTACK	1492404.947	-4457266.485	4296881.614	46204.3	4036.0	.000	.001	.001
7242 S	HOBART26	-3950236.282	2522347.634	-4311562.997	48016.0	408.0	.010	.010	.010
7600 M	HOHENFRG	3778215.113	698644.628	5074053.393	47701.6	6.0	.010	.003	.014
7216 S	HRAS 085	-1324210.835	-5332023.087	3232118.292	46437.5	3854.0	.001	.001	.002
1857 S	KASHIM34	-3997649.062	3276690.858	3724278.891	48066.4	203.0	.006	.004	.010
1856 S	KASHIMA	-3997892.124	3276581.345	3724118.278	47022.9	2349.0	.003	.002	.006
1311 S	KAUAI	-5543845.896	-2054564.089	2387813.747	47389.4	2372.0	.002	.003	.005
7278 M	KODIAK	-3026940.001	-1575911.723	5370362.408	47630.2	730.0	.010	.006	.017
4968 S	KWAJAL26	-6143536.381	1363997.312	1034707.362	46522.1	1492.0	.010	.004	.007
7310 S	MARCUS	-5227446.710	2551379.268	2607604.704	48068.0	1.0	.016	.009	.015
7217 S	MARPOINT	1106629.501	-4882907.151	3938086.837	47057.1	2625.0	.001	.004	.004
7243 S	MATERA	4641939.111	1393002.866	4133325.338	48155.1	90.0	.008	.004	.009
7230 S	MEDICINA	4461370.276	919596.660	4449558.977	47629.3	1252.0	.004	.002	.005
7601 M	METSHOVI	2890653.026	1310295.220	5513958.534	47714.0	1.0	.020	.011	.032
7222 S	MOJAVE12	-2356170.860	-4646755.838	3668470.528	47476.2	2751.0	.001	.002	.003
7244 S	NOBEY 6M	-3871168.048	3428274.024	3723697.614	47850.0	1.0	.037	.033	.035
7279 M	NOME	-2658150.281	-693821.853	5737236.580	48062.0	3.0	.010	.005	.021
7547 S	NOTO	4934563.435	1321201.119	3806484.234	47894.1	564.0	.012	.005	.011

Monument	Name	X (m)	Y (m)	Z (m)	C. Epoch (days)	Span (days)	SX (m)	SY (m)	SZ (m)	
7204 S	NRAO 140	882880.080	-4924482.273	3944130.542	45384.0	4053.0	.001	.004	.004	
7214 S	NRAO85 3	882325.758	-4925137.934	3943397.515	47959.7	641.0	.003	.007	.006	
7213 S	ONSALA60	3370606.288	711917.368	5349830.534	46675.4	3818.0	.002	.001	.004	
7207 S	OVRO 130	-2409600.620	-4478349.493	3838603.134	45516.2	3384.0	.002	.003	.004	
7283 M	PENTICTN	-2058840.269	-3621286.351	4814420.680	46864.0	2164.0	.008	.013	.017	
7234 S	PIETOWN	-1640953.531	-5014815.986	3575411.849	47887.4	828.0	.002	.004	.004	
7258 M	PLATTVIL	-1240708.001	-4720454.309	4094481.564	47049.8	2699.0	.002	.006	.005	
7219 S	RICHMOND	961258.188	-5674090.007	2740533.647	47337.1	2561.0	.001	.002	.001	
1561 S	ROBLED32	4849245.411	-360278.302	4114884.318	45460.0	1.0	.048	.011	.040	
7229 M	SEATTLE1	-2295347.821	-3638029.372	4693408.580	48112.4	2.0	.011	.019	.024	
7227 S	SESHAN25	-2831686.494	4675733.889	3275327.760	47689.0	885.0	.007	.007	.009	
7239 S	SEST	1838237.890	-5258699.141	-3100588.997	48022.6	37.0	.010	.017	.009	
7226 S	SHANGHAI	-2847698.025	4659872.975	3283958.836	46595.0	1.0	.122	.106	.095	
7280 M	SNDPOINT	-3425461.756	-1214669.064	5223858.220	47707.5	731.0	.015	.007	.022	
7602 M	TROMSONO	2102904.340	721602.442	5958201.143	47739.0	1.0	.009	.005	.022	
7289 M	VICTORIA	-2341309.952	-3539083.806	4745768.288	48106.0	3.0	.010	.016	.020	
7223 M	VNDNBERG	-2678094.617	-4525450.774	3597410.059	46894.7	2022.0	.002	.003	.003	
7209 S	WESTFORD	1492206.806	-4458130.482	4296015.386	46987.0	3527.0	.000	.000	.000	Ref
7224 S	WETTZELL	4075540.163	931735.120	4801629.164	47160.6	2610.0	.002	.001	.004	
7284 M	WHTHORSE	-2215213.510	-2209261.591	5540292.537	47596.0	373.0	.012	.012	.029	
7285 M	YELLOWKN	-1224124.362	-2689530.637	5633555.332	46125.9	377.0	.030	.066	.139	

VLBI site velocities SSV(GSFC) 91 R 04

Station	Velocity (mm/yr) X	Y	Z	Uncertainty(mm/yr) X	Y	Z
ALGOPARK 7282	-18.6	-3.9	1.3	0.3	1.1	1.1
BREST 7604	-12.0	17.0	11.9	-	-	-
CARNUSTY 7603	-14.1	14.9	9.9	-	-	-
CHLBOLTN 7215	-13.3	16.4	11.2	-	-	-
DSS15 7231	-15.8	-1.5	-12.1	-	-	-
DSS45 1642	-36.0	-0.4	53.1	7.1	4.7	4.6
DSS65 1665	13.5	20.0	40.3	6.7	1.5	7.4
EFLSBERG 7203	-10.9	12.5	15.7	4.9	2.4	6.5
GILCREEK 7225	-24.1	-0.8	-9.9	0.5	0.7	1.2
GOLDVENU 1513	-19.3	9.2	-11.7	0.9	1.9	1.6
GRASSE 7605	-14.1	18.0	12.4	-	-	-
HALEAKAL 7120	-15.3	67.3	34.9	-	-	-
HARTRAO 7232	-0.1	15.8	16.0	4.3	2.9	2.4
HATCREEK 7218	-21.3	9.7	-11.0	0.7	1.2	1.2
HAYSTACK 7205	-17.9	-2.6	3.1	0.1	0.3	0.3
HOBART26 7242	-37.8	6.7	38.5	-	-	-
HOHENFRG 7600	-16.4	15.7	10.1	-	-	-
HRAS 085 7216	-14.2	5.1	-11.5	0.1	0.7	0.5
KASHIM34 1857	-14.0	-1.2	-14.0	-	-	-
KASHIMA 1856	3.9	6.6	-11.2	1.5	0.9	2.6
KAUAI 1311	-12.8	69.5	30.1	0.3	1.0	1.0
KODIAK 7278	-31.3	1.8	10.8	6.6	3.7	11.0
KWAJAL26 4968	24.4	75.9	25.0	4.7	1.9	2.8
MARCUS 7310	43.4	65.4	23.0	-	-	-
MARPOINT 7217	-18.3	1.9	-1.5	0.5	1.8	1.5
MATERA 7243	-16.2	18.1	12.1	-	-	-
MEDICINA 7230	-15.1	15.3	17.4	2.2	1.1	2.5
METSHOVI 7601	-19.8	12.9	7.3	-	-	-
MOJAVE12 7222	-17.7	10.4	-9.1	0.2	0.8	0.6
NOBEY 6M 7244	-14.0	-1.2	-13.5	-	-	-
NOME 7279	-23.0	-2.6	-11.0	-	-	-
NOTO 7547	-32.5	7.4	9.2	6.2	2.5	5.7
NRAO 140 7204	-18.3	0.7	-1.0	0.3	0.9	0.7
NRAO85 3 7214	-13.6	-10.6	9.7	1.1	3.1	2.5
ONSALA60 7213	-13.3	11.2	11.0	0.9	0.5	1.3
OVRO 130 7207	-20.1	10.3	-10.3	0.4	1.1	0.9
PENTICTN 7283	-27.3	-13.6	9.4	3.1	5.1	6.6
PIETOWN 7234	-14.0	16.7	-20.2	0.8	2.0	1.7
PLATTVIL 7258	-20.8	-4.0	-6.8	1.1	3.4	2.9
RICHMOND 7219	-12.3	-1.7	0.7	-	0.1	0.1
ROBLED32 1561	-10.2	18.8	13.6	-	-	-
SEATTLE1 7229	-19.6	-2.1	-11.2	-	-	-
SESHAN25 7227	-18.4	-17.8	-18.6	3.6	4.0	4.3
SEST 7239	-2.2	-5.8	8.6	-	-	-
SHANGHAI 7226	-25.0	-8.0	-10.4	-	-	-
SNDPOINT 7280	-12.6	7.1	-27.9	8.7	3.8	12.6
TROMSONO 7602	-19.0	10.4	5.4	-	-	-
VICTORIA 7289	-19.8	-2.2	-11.4	-	-	-
VNDNBERG 7223	-30.8	37.3	12.9	0.9	1.4	1.3
WESTFORD 7209	-18.2	-2.9	3.4	-	-	-
WETTZELL 7224	-16.1	13.3	9.4	1.0	0.6	1.3
WHTHORSE 7284	28.0	47.8	-107.2	9.9	9.6	23.0
YELLOWKN 7285	-25.1	-24.7	40.3	11.0	24.0	50.4

Note. Parameters with very small $\sigma^2(<= 10^{-13})$ have been suppressed in the solution. This occurs for the WESTFORD position and velocity and for the velocities of sites with insufficient data.

RADIO SOURCE COORDINATES RSC(GSFC) 91 R 04

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
0003-066	0 6 13.892887	- 6 23 35.33772	0.000035	0.00048
0007+106	0 10 31.005946	10 58 29.50235	0.000050	0.00094
0008-264	0 11 1.246583	-26 12 33.37775	0.000073	0.00038
0014+813	0 17 8.474141	81 35 8.13502	0.002915	0.00064
0016+731	0 19 45.786048	73 27 30.01551	0.000093	0.00012
0026+346	0 29 14.242668	34 56 32.24893	0.000137	0.00148
0047-579	0 49 59.473280	-57 38 27.34436	0.000190	0.00325
0048-097	0 50 41.317371	- 9 29 5.21109	0.000005	0.00014
0056-572	0 58 46.581620	-56 59 11.46782	0.000794	0.01054
0056-001	0 59 5.514930	0 6 51.62218	0.000052	0.00154
0104-408	1 6 45.107985	-40 34 19.96127	0.000040	0.00052
0106+013	1 8 38.771043	1 35 0.31600	0.000002	0.00012
0111+021	1 13 43.144881	2 22 17.31352	0.000039	0.00104
0112-017	1 15 17.099926	- 1 27 4.57766	0.000024	0.00046
0113-118	1 16 12.520721	-11 36 15.43735	0.000426	0.00078
0118-272	1 20 31.663387	-27 1 24.65329	0.000089	0.00056
0119+041	1 21 56.861656	4 22 24.73348	0.000002	0.00012
0133+476	1 36 58.594634	47 51 29.09872	0.000017	0.00013
0135-247	1 37 38.346316	-24 30 53.88554	0.000052	0.00031
0138-097	1 41 25.832065	- 9 28 43.67466	0.000052	0.00045
0146+056	1 49 22.370859	5 55 53.56700	0.000035	0.00072
0149+218	1 52 18.058977	22 7 7.69984	0.000032	0.00045
0150-334	1 53 10.121739	-33 10 25.86295	0.000092	0.00069
0153+744	1 57 34.964500	74 42 43.22918	0.000458	0.00040
0159+723	2 3 33.384515	72 32 53.66568	0.000492	0.00063
0201+113	2 3 46.657000	11 34 45.40888	0.000018	0.00032
0202+149	2 4 50.413834	15 14 11.04240	0.000005	0.00014
0202-172	2 4 57.674292	-17 1 19.84035	0.000038	0.00030
0202+319	2 5 4.925252	32 12 30.09467	0.000026	0.00030
0208-512	2 10 46.200560	-51 1 1.89254	0.000033	0.00023
0212+735	2 17 30.812790	73 49 32.62073	0.000088	0.00012
0220-349	2 22 56.401505	-34 41 28.72985	0.000067	0.00038
0224+671	2 28 50.051096	67 21 3.02831	0.000059	0.00016
0230-790	2 29 34.946796	-78 47 45.59759	0.002632	0.00467
0229+131	2 31 45.893990	13 22 54.71578	0.000003	0.00012
0234+285	2 37 52.405556	28 48 8.98938	0.000005	0.00012
0235+164	2 38 38.930020	16 36 59.27412	0.000005	0.00014
0237-233	2 40 8.174438	-23 9 15.72827	0.000050	0.00158
0238-084	2 41 4.798341	- 8 15 20.75322	0.000059	0.00081
0239+108	2 42 29.170821	11 1 0.72637	0.000048	0.00052
0241+622	2 44 57.695590	62 28 6.50657	0.002154	0.00696
0252-549	2 53 29.180487	-54 41 51.42656	0.000153	0.01152
0256+075	2 59 27.076562	7 47 39.64347	0.000025	0.00069
0300+470	3 3 35.242019	47 16 16.27490	0.000013	0.00012
0308-611	3 9 56.099401	-60 58 39.05617	0.000127	0.00037

RADIO SOURCE COORDINATES (cont.) RSC(GSFC) 91 R 04

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
0309+411	3 13 1.961963	41 20 1.18281	0.000091	0.00057
0316+413	3 19 48.159909	41 30 42.10283	0.000013	0.00015
0319+121	3 21 53.103433	12 21 13.95361	0.000035	0.00079
0326+277	3 29 57.669439	27 56 15.49977	0.000099	0.00087
0332-403	3 34 13.654494	-40 8 25.39714	0.000073	0.00044
0334-546	3 35 53.926450	-54 30 25.09600	0.001168	0.01259
0333+321	3 36 30.107509	32 18 29.34187	0.000022	0.00028
0336-019	3 39 30.937763	- 1 46 35.80361	0.000007	0.00022
0338-214	3 40 35.607942	-21 19 31.17047	0.000067	0.00041
0355+508	3 59 29.747020	50 57 50.16173	0.000015	0.00012
0400+258	4 3 5.585899	26 0 1.50265	0.000037	0.00045
0402-362	4 3 53.750008	-36 5 1.91215	0.000017	0.00041
0403-132	4 5 34.003579	-13 8 13.68985	0.000045	0.00043
0406+121	4 9 22.008636	12 17 39.84694	0.000047	0.00090
0414-189	4 16 36.544492	-18 51 8.33889	0.000043	0.00043
0420-014	4 23 15.800686	- 1 20 33.06426	0.000002	0.00012
0422+004	4 24 46.841989	0 36 6.32930	0.000041	0.00104
0426-380	4 28 40.424328	-37 56 19.57870	0.000045	0.00034
0431-512	4 32 21.177632	-51 9 25.18282	0.001314	0.00508
0430+052	4 33 11.095390	5 21 15.62070	0.000019	0.00067
0434-188	4 37 1.482719	-18 44 48.61151	0.000012	0.00023
0440-003	4 42 38.660726	- 0 17 43.41763	0.000040	0.00114
0454-810	4 50 5.440832	-81 1 2.23144	0.002454	0.00086
0451-282	4 53 14.646934	-28 7 37.32389	0.000099	0.00156
0454-234	4 57 3.179243	-23 24 52.01831	0.000004	0.00014
0457+024	4 59 52.050539	2 29 31.17665	0.000033	0.00088
0458-020	5 1 12.809863	- 1 59 14.25436	0.000007	0.00025
0500+019	5 3 21.197203	2 3 4.67811	0.000040	0.00130
0454+844	5 8 42.361587	84 32 4.54361	0.003294	0.00056
0511-220	5 13 49.114599	-21 59 16.09059	0.000085	0.00234
0522-611	5 22 34.426026	-61 7 57.13328	0.000395	0.00148
0530-727	5 29 30.042623	-72 45 28.50676	0.000282	0.00038
0528-250	5 30 7.962770	-25 3 29.89705	0.000048	0.00029
0528+134	5 30 56.416679	13 31 55.15099	0.000003	0.00012
0529+075	5 32 38.998167	7 32 43.34098	0.000377	0.02895
0537-441	5 38 50.361650	-44 5 8.93777	0.000024	0.00029
0539-057	5 41 38.083371	- 5 41 49.42747	0.000039	0.00110
0552+398	5 55 30.805448	39 48 49.16643	0.000008	0.00011
0605-085	6 7 59.699212	- 8 34 49.97626	0.000021	0.00031
0607-157	6 9 40.949561	-15 42 40.66741	0.000092	0.00174
0609+607	6 14 23.865938	60 46 21.75704	0.000091	0.00031
0615+820	6 26 3.005800	82 2 25.56856	0.002645	0.00104
0629-418	6 31 11.998105	-41 54 26.94462	0.000153	0.00074
0637-752	6 35 46.508371	-75 16 16.81391	0.000197	0.00021
0637-337	6 39 20.904714	-33 46 0.11099	0.000189	0.00060

RADIO SOURCE COORDINATES (cont.) RSC(GSFC) 91 R 04

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
0642+449	6 46 32.025817	44 51 16.59185	0.000040	0.00034
0646-306	6 48 14.096506	-30 44 19.65687	0.000044	0.00029
0648-165	6 50 24.581886	-16 37 39.72215	0.000026	0.00033
0657+172	7 0 1.525471	17 9 21.70370	0.000006	0.00017
0707+476	7 10 46.104692	47 32 11.14573	0.000056	0.00039
0711+356	7 14 24.817513	35 34 39.79535	0.000039	0.00048
0716+714	7 21 53.448083	71 20 36.36547	0.000095	0.00016
0723-008	7 25 50.639918	- 0 54 56.54218	0.000020	0.00040
0718+792	7 26 11.734680	79 11 31.01767	0.001025	0.00053
0727-115	7 30 19.112449	-11 41 12.59756	0.000003	0.00012
0735+178	7 38 7.393695	17 42 19.00101	0.000014	0.00021
0738-674	7 38 56.496415	-67 35 50.83107	0.002835	0.00947
0736+017	7 39 18.033863	1 37 4.62151	0.000025	0.00033
0738+313	7 41 10.703232	31 12 0.23118	0.000016	0.00019
0742+103	7 45 33.059454	10 11 12.69517	0.000003	0.00012
0743-006	7 45 54.082277	- 0 44 17.53532	0.000032	0.00087
0745+241	7 48 36.109207	24 0 24.11251	0.000009	0.00016
0748+126	7 50 52.045690	12 31 4.83208	0.000032	0.00061
0749+540	7 53 1.384464	53 52 59.64050	0.000114	0.00069
0754+100	7 57 6.642858	9 56 34.85458	0.000023	0.00039
0805-077	8 8 15.535987	- 7 51 9.88318	0.000016	0.00024
0804+499	8 8 39.666195	49 50 36.53289	0.000041	0.00024
0809-493	8 11 8.802866	-49 29 43.50512	0.000699	0.00343
0808+019	8 11 26.707276	1 46 52.22402	0.000035	0.00096
0812+367	8 15 25.944751	36 35 15.15077	0.000038	0.00050
0814+425	8 18 15.999531	42 22 45.41759	0.000012	0.00013
0818-128	8 20 57.447541	-12 58 59.16512	0.000048	0.00029
0820+560	8 24 47.236209	55 52 42.67210	0.000047	0.00019
0823+033	8 25 50.338310	3 9 24.52328	0.000004	0.00014
0823-223	8 26 1.573041	-22 30 27.20115	0.000081	0.00169
0826-373	8 28 4.780351	-37 31 6.27819	0.000080	0.00055
0827+243	8 30 52.086129	24 10 59.82360	0.000059	0.00105
0828+493	8 32 23.216617	49 13 21.04041	0.000081	0.00045
0834-201	8 36 39.215310	-20 16 59.50115	0.000049	0.00107
0833+585	8 37 22.409553	58 25 1.84783	0.000128	0.00034
0836+710	8 41 24.365146	70 53 42.17554	0.000209	0.00035
0839+187	8 42 5.094102	18 35 40.99400	0.000042	0.00068
0851+202	8 54 48.874871	20 6 30.64375	0.000003	0.00011
0859-140	9 2 16.830917	-14 15 30.87217	0.000040	0.00044
0859+470	9 3 3.990010	46 51 4.14005	0.000020	0.00020
0906+015	9 9 10.091415	1 21 35.61858	0.000036	0.00109
0917+449	9 20 58.458390	44 41 53.98855	0.000061	0.00068
0919-260	9 21 29.353818	-26 18 43.38271	0.000010	0.00023
0917+624	9 21 36.231038	62 15 52.18305	0.000073	0.00024
0920-397	9 22 46.418372	-39 59 35.06406	0.000094	0.00059

RADIO SOURCE COORDINATES (cont.) RSC(GSFC) 91 R 04

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
0923+392	9 27 3.013831	39 2 20.85476	0.000008	0.00011
0925-203	9 27 51.824321	-20 34 51.23165	0.000058	0.00174
0953+254	9 56 49.875355	25 15 16.05263	0.000011	0.00020
0955+326	9 58 20.949659	32 24 2.21267	0.000042	0.00053
0954+658	9 58 47.245058	65 33 54.82111	0.000042	0.00012
0959-443	10 1 59.907644	-44 38 0.59955	0.000470	0.00261
1004+141	10 7 41.498130	13 56 29.60544	0.000044	0.00092
1020+400	10 23 11.565533	39 48 15.38805	0.000073	0.00061
1030+415	10 33 3.707794	41 16 6.23527	0.000057	0.00049
1032-199	10 35 2.155223	-20 11 34.35443	0.000056	0.00050
1031+567	10 35 7.039587	56 28 46.79496	0.000283	0.00110
1034-293	10 37 16.079682	-29 34 2.80979	0.000007	0.00014
1039+811	10 44 23.062768	80 54 39.44574	0.001020	0.00039
1045-188	10 48 6.620369	-19 9 35.72350	0.000068	0.00062
1048-313	10 51 4.777611	-31 38 14.30411	0.000052	0.00039
1053+815	10 58 11.535608	81 14 32.67800	0.001039	0.00038
1055+018	10 58 29.605179	1 33 58.82690	0.000002	0.00013
1057-797	10 58 43.309706	-80 3 54.15692	0.000445	0.00021
1101-325	11 3 31.542772	-32 51 16.66106	0.066460	0.08470
1101-536	11 3 52.221433	-53 57 0.70452	0.000224	0.00464
1104-445	11 7 8.694110	-44 49 7.61607	0.000027	0.00023
1111+149	11 13 58.695048	14 42 26.95505	0.000033	0.00066
1116+128	11 18 57.301476	12 34 41.72143	0.000041	0.00073
1123+264	11 25 53.711904	26 10 19.98156	0.000010	0.00018
1124-186	11 27 4.392393	-18 57 17.43833	0.000010	0.00029
1128+385	11 30 53.282629	38 15 18.54918	0.000047	0.00054
1130+009	11 33 20.055724	0 40 52.84104	0.000049	0.00156
1143-245	11 46 8.103399	-24 47 32.89351	0.000053	0.00037
1144+402	11 46 58.297946	39 58 34.30719	0.000009	0.00012
1144-379	11 47 1.370605	-38 12 11.02207	0.000086	0.00249
1145-071	11 47 51.553954	- 7 24 41.13872	0.000047	0.00050
1148-001	11 50 43.870675	- 0 23 54.20277	0.000040	0.00092
1148-671	11 51 13.426385	-67 28 11.09129	0.001145	0.00254
1150+812	11 53 12.499701	80 58 29.15674	0.000400	0.00018
1156+295	11 59 31.833920	29 14 43.82951	0.000005	0.00012
1206-399	12 9 35.243514	-40 16 13.09812	0.000459	0.00136
1213-172	12 15 46.751667	-17 31 45.40093	0.000044	0.00071
1216+487	12 19 6.414850	48 29 56.16792	0.000059	0.00038
1219+285	12 21 31.690576	28 13 58.50307	0.000019	0.00061
1221+809	12 23 40.494263	80 40 4.34261	0.001142	0.00048
1222+037	12 24 52.421868	3 30 50.29622	0.000015	0.00040
1221-829	12 24 54.383397	-83 13 10.10582	0.016355	0.00399
1226+023	12 29 6.699701	2 3 8.60123	********	0.00012
1228+126	12 30 49.423401	12 23 28.04711	0.000024	0.00034
1236-684	12 39 46.651747	-68 45 30.89017	0.001606	0.00290

RADIO SOURCE COORDINATES (cont.) RSC(GSFC) 91 R 04

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
1243-072	12 46 4.232063	- 7 30 46.57246	0.000033	0.00037
1244-255	12 46 46.801936	-25 47 49.28572	0.000018	0.00050
1252+119	12 54 38.255528	11 41 5.89673	0.000037	0.00062
1251-713	12 54 59.921352	-71 38 18.43535	0.000554	0.00069
1253-055	12 56 11.166455	- 5 47 21.52151	0.000003	0.00015
1255-316	12 57 59.060781	-31 55 16.84873	0.000051	0.00043
1302-102	13 5 33.014944	-10 33 19.42605	0.000030	0.00040
1308+326	13 10 28.663916	32 20 43.78500	0.000006	0.00012
1313-333	13 16 7.985862	-33 38 59.16869	0.000033	0.00049
1323+321	13 26 16.511148	31 54 9.53450	0.000531	0.00952
1334-127	13 37 39.782712	-12 57 24.69061	0.000003	0.00013
1334-649	13 37 52.444493	-65 9 24.89497	0.001243	0.00238
1342+662	13 43 45.959899	66 2 25.74627	0.000335	0.00087
1342+663	13 44 8.679887	66 6 11.64577	0.000192	0.00042
1354+195	13 57 4.436689	19 19 7.37393	0.000006	0.00014
1354-152	13 57 11.244899	-15 27 28.78372	0.000010	0.00030
1357+769	13 57 55.372039	76 43 21.05283	0.000596	0.00048
1404+286	14 7 0.394463	28 27 14.69154	0.000005	0.00012
1406-076	14 8 56.481097	- 7 52 26.66418	0.000037	0.00040
1413+135	14 15 58.817629	13 20 23.71579	0.000041	0.00093
1418+546	14 19 46.597594	54 23 14.78849	0.000019	0.00013
1424-418	14 27 56.297357	-42 6 19.43572	0.000025	0.00025
1435+638	14 36 45.802444	63 36 37.86750	0.000156	0.00044
1435-218	14 38 9.469677	-22 4 54.74445	0.000391	0.00131
1442+101	14 45 16.465320	9 58 36.07443	0.000068	0.00117
1448+762	14 48 28.779107	76 1 11.59774	0.000844	0.00058
1451-375	14 54 27.409648	-37 47 33.14646	0.000270	0.00225
1451-400	14 54 32.912311	-40 12 32.51243	0.000096	0.00058
1502+106	15 4 24.979791	10 29 39.19999	0.000002	0.00013
1504+377	15 6 9.530106	37 30 51.13222	0.000063	0.00069
1504-166	15 7 4.786856	-16 52 30.26430	0.000028	0.00028
1510-089	15 12 50.532866	- 9 5 59.82794	0.000004	0.00017
1511-100	15 13 44.893298	-10 12 0.26321	0.000038	0.00031
1514-241	15 17 41.813090	-24 22 19.47499	0.000132	0.00059
1519-273	15 22 37.675873	-27 30 10.78350	0.000016	0.00037
1538+149	15 40 49.491553	14 47 45.88484	0.000030	0.00084
1547+507	15 49 17.468738	50 38 5.78818	0.000073	0.00044
1546+027	15 49 29.436774	2 37 1.16323	0.000027	0.00075
1548+056	15 50 35.269237	5 27 10.44909	0.000002	0.00013
1540-828	15 50 59.144083	-82 58 6.84234	0.024331	0.00335
1549-790	15 56 58.869125	-79 14 4.28047	0.001552	0.00067
1555+001	15 57 51.433952	- 0 1 50.41283	0.000028	0.00048
1606+106	16 8 46.203190	10 29 7.77508	0.000023	0.00067
1607+268	16 9 13.321307	26 41 28.99602	0.001233	0.03133
1611+343	16 13 41.064347	34 12 47.90922	0.000006	0.00012

RADIO SOURCE COORDINATES (cont.) RSC(GSFC) 91 R 04

SOURCE	RIGHT ASCENSION	DECLINATION	SIGMA R.A.	SIGMA D.
	H M S	o ' "	S	"
1610-771	16 17 49.275748	-77 17 18.46732	0.000314	0.00024
1619-680	16 24 18.436875	-68 9 12.50022	0.000427	0.00182
1622-253	16 25 46.891531	-25 27 38.32587	0.000005	0.00015
1624+416	16 25 57.669910	41 34 40.62982	0.000060	0.00045
1622-297	16 26 6.020800	-29 51 26.97020	0.000044	0.00029
1633+382	16 35 15.493071	38 8 4.50053	0.000007	0.00012
1637+574	16 38 13.456548	57 20 23.97889	0.000022	0.00012
1638+398	16 40 29.632920	39 46 46.02806	0.000011	0.00014
1642+690	16 42 7.848920	68 56 39.75616	0.000060	0.00013
1641+399	16 42 58.810071	39 48 36.99381	0.000008	0.00012
1652+398	16 53 52.216875	39 45 36.60952	0.000032	0.00030
1656+053	16 58 33.447314	5 15 16.44446	0.000016	0.00031
1657-261	17 0 53.153967	-26 10 51.72459	0.000021	0.00021
1717+178	17 19 13.048476	17 45 6.43614	0.000046	0.00108
1727+502	17 28 18.623305	50 13 10.47387	0.007071	0.04186
1730-130	17 33 2.705712	-13 4 49.54819	0.000003	0.00013
1732+389	17 34 20.578652	38 57 51.44287	0.000037	0.00035
1738+476	17 39 57.129240	47 37 58.36126	0.000063	0.00037
1739+522	17 40 36.978029	52 11 43.40668	0.000016	0.00012
1741-038	17 43 58.856103	- 3 50 4.61692	0.000002	0.00012
1743+173	17 45 35.208222	17 20 1.42272	0.000035	0.00063
1749+701	17 48 32.840642	70 5 50.76726	0.000404	0.00048
1749+096	17 51 32.818576	9 39 0.72798	0.000003	0.00012
1751+288	17 53 42.473670	28 48 4.93733	0.000034	0.00046
1803+784	18 0 45.684618	78 28 4.01730	0.000175	0.00011
1758-651	18 3 23.496280	-65 7 36.76034	0.001534	0.00345
1807+698	18 6 50.681071	69 49 28.10754	0.000161	0.00025
1815-553	18 19 45.399259	-55 21 20.74661	0.000047	0.00026
1826+796	18 23 14.109426	79 38 49.00153	0.000966	0.00067
1821+107	18 24 2.855216	10 44 23.77258	0.000022	0.00059
1823+568	18 24 7.068558	56 51 1.48969	0.000030	0.00015
1831-711	18 37 28.714709	-71 8 43.55499	0.000321	0.00058
1845+797	18 42 8.990874	79 46 17.12652	0.001236	0.00057
1842+681	18 42 33.641928	68 9 25.22689	0.000173	0.00033
1856+736	18 54 57.300368	73 51 19.90565	0.000445	0.00064
1908-201	19 11 9.652863	-20 6 55.11207	0.000077	0.00200
1903-802	19 12 40.018643	-80 10 5.94679	0.002619	0.00097
1921-293	19 24 51.055861	-29 14 30.12162	0.000005	0.00013
1923+210	19 25 59.605394	21 6 26.16033	0.000012	0.00023
1928+738	19 27 48.495585	73 58 1.56813	0.000113	0.00013
1925-610	19 30 6.159701	-60 56 9.18367	0.000271	0.00231
1933-400	19 37 16.217321	-39 58 1.55377	0.000076	0.00056
1936-155	19 39 26.657627	-15 25 43.06025	0.000103	0.03548
1935-692	19 40 25.527059	-69 7 56.97676	0.000741	0.00164
1947+079	19 50 5.539933	8 7 13.97687	0.000032	0.00093

RADIO SOURCE COORDINATES (cont.) RSC(GSFC) 91 R 04

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
1954+513	19 55 42.738392	51 31 48.54410	0.000029	0.00017
1958-179	20 0 57.090389	-17 48 57.67333	0.000007	0.00017
2000-330	20 3 24.116090	-32 51 45.13247	0.000247	0.00107
2007+777	20 5 30.998949	77 52 43.24534	0.000335	0.00023
2005+403	20 7 44.944765	40 29 48.60494	0.000206	0.00200
2005-489	20 9 25.390825	-48 49 53.72010	0.000419	0.00239
2008-159	20 11 15.710906	-15 46 40.25709	0.000027	0.00101
2017+743	20 17 13.079513	74 40 47.99809	0.000537	0.00041
2021+614	20 22 6.681796	61 36 58.80179	0.000091	0.00028
2021+317	20 23 19.017416	31 53 2.30359	0.000043	0.00043
2023+336	20 25 10.842076	33 43 0.21540	0.000275	0.00358
2030+547	20 31 47.958651	54 55 3.13842	0.000129	0.00060
2029+121	20 31 54.994271	12 19 41.33759	0.000030	0.00076
2037+511	20 38 37.034824	51 19 12.66045	0.000017	0.00012
2037-253	20 40 8.772854	-25 7 46.66424	0.000059	0.00042
2059-786	21 5 44.961259	-78 25 34.54565	0.005642	0.00146
2106-413	21 9 33.188282	-41 10 20.60685	0.000131	0.00070
2113+293	21 15 29.413451	29 33 38.36460	0.000011	0.00021
2109-811	21 16 30.845155	-80 53 55.22391	0.007452	0.00406
2121+053	21 23 44.517358	5 35 22.09126	0.000002	0.00012
2126-158	21 29 12.175812	-15 38 41.04214	0.000032	0.00110
2128+048	21 30 32.877393	5 2 17.47428	0.000095	0.00118
2128-123	21 31 35.261692	-12 7 4.79775	0.000006	0.00019
2131-021	21 34 10.309577	- 1 53 17.24066	0.000025	0.00043
2134+004	21 36 38.586285	0 41 54.21209	0.000002	0.00013
2136+141	21 39 1.309273	14 23 35.99011	0.000015	0.00026
2144+092	21 47 10.162963	9 29 46.67023	0.000015	0.00026
2142-758	21 47 12.729146	-75 36 13.22924	0.002298	0.00205
2145+067	21 48 5.458648	6 57 38.60219	0.000003	0.00012
2149+056	21 51 37.875509	5 52 12.95230	0.000036	0.00105
2149-307	21 51 55.523967	-30 27 53.69942	0.000047	0.00031
2146-783	21 52 3.152847	-78 7 6.64409	0.003989	0.00212
2150+173	21 52 24.819425	17 34 37.79315	0.000031	0.00059
2155-152	21 58 6.281863	-15 1 9.32872	0.000013	0.00020
2200+420	22 2 43.291358	42 16 39.97761	0.000010	0.00011
2201+315	22 3 14.975774	31 45 38.26765	0.000013	0.00017
2210-257	22 13 2.496964	-25 29 30.08474	0.000526	0.00166
2216-038	22 18 52.037703	- 3 35 36.88130	0.000002	0.00012
2223-052	22 25 47.259324	- 4 57 1.39140	0.000025	0.00088
2227-088	22 29 40.084329	- 8 32 54.43731	0.000027	0.00072
2230+114	22 32 36.408873	11 43 50.90211	0.000005	0.00015
2234+282	22 36 22.470836	28 28 57.41107	0.000005	0.00011
2233-148	22 36 34.087248	-14 33 22.18990	0.000052	0.00058
2243-123	22 46 18.231960	-12 6 51.27928	0.000012	0.00027

RADIO SOURCE COORDINATES (cont.) RSC(GSFC) 91 R 04

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
2251+158	22 53 57.747900	16 8 53.55873	0.000003	0.00012
2253+417	22 55 36.707778	42 2 52.53068	0.000025	0.00028
2254+074	22 57 17.303105	7 43 12.30140	0.000039	0.00087
2255-282	22 58 5.962876	-27 58 21.25781	0.000006	0.00014
2312-319	23 14 48.500717	-31 38 39.52925	0.000087	0.00058
2318+049	23 20 44.856630	5 13 49.95075	0.000025	0.00040
2319+272	23 21 59.862177	27 32 46.44144	0.000070	0.00062
2325-150	23 27 47.964156	-14 47 55.75212	0.000063	0.00070
2326-477	23 29 17.704391	-47 30 19.11669	0.000035	0.00050
2328+107	23 30 40.852212	11 0 18.70812	0.000022	0.00053
2329-162	23 31 38.652448	-15 56 57.01044	0.000053	0.00049
2329-384	23 31 59.476098	-38 11 47.65124	0.000086	0.00047
2331-240	23 33 55.238825	-23 43 40.66755	0.000761	0.00801
2344+092	23 46 36.838516	9 30 45.51299	0.000035	0.00065
2345-167	23 48 2.608516	-16 31 12.02307	0.000005	0.00015
2351+456	23 54 21.680171	45 53 4.23428	0.000085	0.00062
2352+495	23 55 9.458104	49 50 8.33835	0.000064	0.00040
2355-534	23 57 53.266155	-53 11 13.69093	0.000056	0.00048
2355-106	23 58 10.882392	-10 20 8.61200	0.000008	0.00040

EOP(GSFC) 91 R 04 Available from 1979 to 1991

Number of measurements and RMS uncertainty per year
Units : 0.001" for X,Y,dψ,dε; 0.0001s for UT1

YEAR	X		Y		UT1		dψ		dε	
	Nb	Sigma	Nb	Sigma	Nb	Sigma	Nb	Sigma	Nb	Sigma
1979	2	1.31	2	2.81	2	0.93	2	1.77	2	0.65
1980	20	2.94	20	9.10	20	2.34	20	1.26	20	0.42
1981	34	11.27	34	35.42	34	9.09	34	3.17	34	1.53
1982	58	10.86	58	34.07	58	8.80	58	2.91	58	1.08
1983	66	15.90	66	31.46	66	8.10	66	2.38	66	0.76
1984	96	9.43	96	9.85	96	1.84	96	1.18	96	0.43
1985	102	5.32	102	12.92	102	1.53	102	0.86	102	0.38
1986	118	1.04	118	12.93	118	1.44	118	0.73	118	0.27
1987	140	2.69	140	2.71	140	1.01	140	0.92	140	0.36
1988	155	4.36	155	0.67	155	1.84	155	0.80	155	0.30
1989	171	2.10	171	5.49	171	0.84	171	0.58	171	0.25
1990	198	0.93	198	10.88	198	2.53	198	0.63	198	0.26
1991	3	0.30	3	0.38	3	0.18	3	0.47	3	0.18

SUMMARY SHEET FOR THE 1991 GSFC SUBMISSION TO THE IERS FOR THE EOP AND THE TERRESTRIAL AND CELESTIAL FRAMES.

GSFC 91 R 01
GSFC 91 R 02
GSFC 91 R 03
GSFC 91 R 04

1) Technique: Mark III VLBI

Processed with the Mark-III Analysis System - CALC/GLOBL with the following

- Group delay observations used for geodetic data, group delays and phase delay rates used for astrometric data.

- Westford observatory's position moving according the AM0-2 plate motion model without further adjustment, the direction from Westford to Richmond evolving according to AM0-2, and the vertical rate of Kauai constrained to zero.

- A priori calibration of the 'dry' atmosphere via CfA-2.2 model atmosphere with either in situ measurements of pressure and temperature or site-dependent static values.

- No a priori calibration of the 'wet' atmosphere.

- Residual wet atmosphere modeled with the GSFC 'continuous piecewise-linear function' technique with 60 minute intervals and 50 ps/hour constraint (except for a small subset of sessions using either shorter intervals or looser constraints) and the wet Chao partial derivative.

- Hydrogen maser clock errors modeled with the GSFC 'continuous piecewise-linear function' method using unconstrained 2nd order polynomials for the gross clock performance and continuous 60-minute interval segments with a clock rate constraint of 5.e-14 for the short term clock errors (except for a small subset of sessions using either shorter intervals or weaker constraints); a small number of actual clock epoch breaks and baseline-dependent constant clock errors also modeled.

- Observation weights adjusted by session-dependent constants derived so that the chi-square per degree of freedom was unity in individual session solutions.

- Quasar source positions estimated globally except for the right ascension of the quasar 3C273B, which is used to define the origin of right ascension of the celestial reference frame.

2) Analysis Center: GSFC - the VLBI group of the Crustal Dynamics Project of the Goddard Space Space Flight Center.

3) Solution Identifier: There are 4 solutions for this submission organized as shown below:

SOLUTION CODE	PURPOSE	DATA	TABLES SUBMITTED
GLB716 (91 R 01)	EOP	fixed	sou716: source positions sit716: site positions 1979-1992 vel716: site positions, velocities eop716: UT1PM, nutation cor716: UT1PM/nutation correlations
GLB718 (91 R 02)	TRF	fixed, mobile	sou718: source positions sit718: site positions 1979-1992 vel718: site positions, velocities eop718: UT1PM, nutation cor718: UT1PM/nutation correlations cvr718: complete site position/ velocity covariance
GLB720 (91 R 03)	CRF	CDP fixed and CDP astrometric	sou720: source positions sit720: site positions for Jan 1, 1988 vel720: site positions, velocities eop720: UT1PM, nutation cor720: UT1PM/nutation correlations
GLB722 (91 R 04)	CRF	all fixed and all astrometric	sou722: source positions sit722: site positions for Jan 1, 1988 vel722: site positions, velocities eop722: UT1PM, nutation cor722: UT1PM/nutation correlations

NOTES :

Data:

fixed - data from networks having only fixed stations and some networks including mobile sites with baselines >2000 km acquired by CDP, IRIS-A/S/P, and Navnet.

mobile - data from networks including mobile sites (except as described above) acquired by CDP, NGS, and GSI.

CDP - Crustal Dynamics Project data, including 1980 MERIT.

astrometric - data from astrometric and survey sessions acquired by CDP, NRL and NGS.

Solutions:

EOP - primary EOP solution with only data useful for this purpose including POLARIS one-baseline and some 8-hr Navnet.

TRF - primary terrestrial reference frame solution including fixed and mobile data with VLBI EOP values/covariances as added a priori information for mobile data.

CRF/CDP - secondary celestial reference frame solution including only fixed and astrometric data acquired by the CDP.

CRF/ALL - primary celestial reference frame solution including all fixed and astrometric data.

4) **Software used:** CALC 7, SOLVE/GLOBL, MIT-PEP and DE200 ephemerides.

5) **Relativity Scale:** Set by the modified Hellings VLBI delay model described in the CALC 7 release documentation.

6) **Permanent tidal correction on station:** A solid earth tide model is used but the correction to remove the permanent tide (specified the IERS Standards) is not applied.

7) **Tectonic plate model:** AM0-2

8) **Velocity of light:** 2.99792458E+8 m/s

9) **Geogravitational constant:** Not applicable.

10) **Reference epoch:** 1986 November 06 for both earth rotation and nutation,1988 January 1 for site velocities. Source coordinates are J2000.0.

11) **Adjusted parameters:** Dependent on details of solution but include: earth orientation, daily nutation offsets, epoch station positions and velocities, globally estimated source positions, and session-dependent clock and atmosphere parameters.

12) **Definition of the origin:** The origin of the terrestrial reference frame is fixed by the adopted position of the Westford antenna at 1988 January 1 and the AM0-2 model. The origin is close to ITRF89 at the site velocity reference epoch.

13) **Definition of the orientation:** The orientation of the terrestrial reference frame is defined by the apriori EOP values on the reference day (1986 Nov 06) interpolated from EOP(IERS) 90 C 04 with the IERS standard tidal correction applied to UT1.The celestial reference frame is defined by the CEP pole position computed from the IAU 1980 nutation model and the J2000.0 precession model for the same reference day and the a priori right ascension of 3C273B.

14) **Evolution with time:** The stations with insufficient data are constrained to move with AM0-2 velocities. Westford's position and the direction from Westford to Richmond are constrained to evolve by the AM0-2 model. With the exception of the vertical rate at Kauai, the 3-dimensional velocities of stations with sufficient data are freely adjusted.

EARTH ROTATION PARAMETERS FROM DSN VLBI: 1991 JPL 91 R 01

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For more than a year the VLBI measurements of earth orientation conducted by the TEMPO project have been produced with typical turnaround times of one to three days.

In this report Earth Rotation Parameter (ERP) estimates have been obtained from an analysis of Deep Space Network (DSN) VLBI data that directly aligns its celestial and terrestrial reference frames with those of the International Earth Rotation Service (IERS). NASA's Deep Space Network operates radio telescopes for the primary purpose of communicating with interplanetary spacecraft. The DSN has three complexes: in California (stations DSS 12,13,14,15), in Spain (DSS 61,63,65), and in Australia (DSS 42,43,45). Two projects at JPL (called TEMPO and CAT M&E below) use these telescopes to make VLBI observations from which we have estimated earth rotation parameters. TEMPO uses the 70 meter DSN antennas (DSS 14, 43, 63) whenever possible and the 34 meter DSN antennas when the larger antennas are not available; before 1989 CAT M&E did likewise. Each observing session uses antennas in two complexes, and usually exactly one antenna in each complex. This report describes a homogeneous reduction of currently available dual frequency (S and X band) VLBI data from both projects.

The Time and Earth Motion Precision Observations (TEMPO) project makes rapid turnaround VLBI measurements of station clock synchronization and earth orientation in support of spacecraft navigation, which needs extremely timely, moderate accuracy earth rotation information. In TEMPO observations the raw bit streams recorded at the telescopes are telemetered to JPL for correlation, so that no physical transportation of magnetic tapes is involved. TEMPO uses the JPL-developed Block I VLBI system, which has a 500 000 bits/second sampling rate, with time-division multiplexing of channels. This sampling rate permits the telemetry, and thus makes rapid turnaround possible. The reduced sensitivity caused by the relatively low sampling rate in comparison to other present-day VLBI systems is largely compensated by the very large antennas and very low system noise levels of the DSN telescopes. Currently, TEMPO records 3 channels in S band (2285 MHz) and 3 channels in X band (8420 MHz) with a spanned bandwidth of 40 MHz in each band. At present the DSN nominally schedules two TEMPO observing sessions per week, one on the Spain-California (SC) baseline, and the other on the Australia-California (AC) baseline. Each session is generally 3 hours in duration (occasionally less), and records a maximum of 20 sources. TEMPO observes most sources for 3 minutes and 18 seconds, a few for 6 minutes and 36 seconds. We plan to produce an operational series of ERP estimates from TEMPO sessions during 1991 that will be a continuation of the ERP series reported here.

The Catalog Maintenance and Enhancement (CAT M&E) project determines celestial coordinates of radio sources, and baseline vectors between DSN stations, for use in spacecraft navigation. In CAT M&E observations the raw bit streams are recorded on magnetic tapes for transportation to the correlator. CAT M&E used the Mark II VLBI system from late 1978 through 1988; since June 1989 most CAT M&E observing sessions have used the Mark III VLBI system on stations DSS 15, 45, and 65, which support a 400 MHz spanned bandwidth capability. The DSN schedules CAT M&E observing sessions at irregular intervals, typically several times per year. Separate observing sessions on the SC and AC baselines are generally scheduled within a few days of each other. Each session is nominally 24 hours in duration and typically includes 100 to 270 observations of 50 to 100 radio sources.

Data from both the TEMPO and CAT M&E projects were used in the solution process for the ERP series reported here. In order that the TEMPO operational series of ERP estimates during 1991 can be an exact continuation of the ERP series reported here, the solution process consisted of two major steps. First, a "catalog solution" designated JPL 1991-1 (see below) determined radio source coordinates, station coordinates, and a parametric model for the celestial motion of the Celestial Ephemeris Pole. Then the second step, called the "ERP solution", used these results from the catalog solution to determine the earth rotation parameters in a manner that can be exactly continued in the operational series. In the ERP solution the data from each observing session were processed independently to provide an estimate of the UT0 and variation of latitude (DPHI) of the baseline VECTOR for that session. Except for the UT0 and variation of latitude, the relation between the earth-fixed reference frame and the radio-quasar reference frame was specified entirely by a priori data (which includes the results from the catalog solution). In addition to UT0 and DPHI, the other parameters estimated in the ERP solution were:

1. A first degree polynomial clock model, including a term allowing for a bias in the delay rate data, with breaks as needed. Such clock breaks are rare in TEMPO sessions but more common in the longer duration CAT M&E sessions.

2. Adjustments to the troposphere zenith delay at each station. In the CAT M&E sessions, new troposphere zenith parameters were introduced approximately every three hours. A priori estimates of the troposphere zenith delays, derived from tables of monthly average zenith delays for each station, were included in the solution with a 6 cm standard deviation.

Other properties of the ERP solution were:

1. Stations move with plate tectonic motion as specified by the Minster-Jordan AM0-2 model.

2. Ocean loading effects were calculated from the model of Pagiatakis (1982; personal communication, 1988).

3. Pole tidal effects were included (Sovers and Fanselow, 1987).

4. The Lanyi (1984) function was used for mapping zenith tropospheric delays to observed elevations.

5. The effects of charged particles in the ionosphere and solar plasma on the single-band delay and delay rate observables were removed by using the appropriate linear combination of the single-band data to form "dual frequency" delay and delay rate observables.

6. Only sessions with 5 or more acceptable delay observations were included in the solution reported here.

7. The effect on path lengths caused by moving ("slewing") the antenna subreflector, so as to maximize the antenna gain when its focal length changes as the elevation angle changes, has been modeled for the TEMPO data. No such model is needed for the CAT M&E data since CAT M&E does not slew the subreflector. (Apparent station coordinates estimated from VLBI data will be corrupted if the subreflector is slewed but the effect on path length is not modeled in the delay calculations. The station coordinates estimated by the JPL 1991-1 catalog solution and used in the ERP solution are appropriate both for the case where the subreflector is not slewed and no path length effect is modeled and also for the case where the subreflector is slewed and the resulting effect on path length is explicitly modeled in the calculations.)

We derived formal errors by adding an "additive noise" constant to the square of each raw observable error to make the Chi Square of the postfit residuals equal to the number of degrees of freedom in the solution. The delay and delay rate additive noise constants were adjusted separately for each CAT M&E observing session. For the TEMPO data, the additive noises were adjusted for each of several blocks of observing sessions.

Each Earth Rotation measurement here is a UT0-DPHI pair, and has an associated error ellipse in the UT0-DPHI plane. Each such error ellipse is completely specified by the reported standard errors and correlation coefficient between UT0 and DPHI. For single baseline VLBI measurements of ERP, such as those reported here, this error ellipse is typically quite elongated, with a ratio of major axis to minor axis of about 4:1. Therefore, for a proper interpretation of these data, it is CRUCIAL to make full use of the reported correlation coefficient.

For a single-baseline VLBI estimate of earth rotation, the orientation of the error ellipse in the UT0-DPHI plane is mostly determined by the global station geometry. The direction of the minor axis of the error ellipse in the UT0-DPHI plane as predicted by the station geometry is called the transverse rotation direction, and corresponds to the motion of the baseline in the local horizontal at each station or equivalently to a rotation about an axis through the center of the earth and the midpoint of the baseline. In addition to being relatively insensitive to random measurement errors, the transverse rotation component is also relatively free of errors introduced by tropospheric modeling errors, antenna deformations, and other sources of systematic local-vertical errors. The transverse rotation components for the DSN baselines are:

Baseline	Transverse Component
Australia-California	-1.000 DPHI + 0.00 (UT0-TAI)
Spain-California	+0.582 DPHI + 12.21 (UT0-TAI)
Spain-Australia	-0.972 DPHI + 2.77 (UT0-TAI)

These coefficients assume that UT0 and DPHI are expressed in seconds of time and in arcseconds, respectively; the units of the transverse components are arcseconds. We recommend that these linear combinations be used to take full advantage of the inherent accuracy of these data.

The ERP solution produced earth orientation results for a total of 711 observing sessions between October 28, 1978, and March 20, 1991.

During calendar year 1990, the TEMPO project produced earth rotation measurements from 94 dual frequency observing sessions, with a median standard error along the minor axis of the error ellipse of 0.6 milliarcseconds (mas), and along the major axis of 3.1 mas. During 1990 the median turnaround time for TEMPO measurements, from observation to availability of earth orientation parameters, was 2 days.

JPL 1991-1 CATALOG

The JPL 1991-1 catalog was developed specifically for use in TEMPO operational ERP solutions during 1991. Since short duration VLBI determinations of the ERP are sensitive to errors in the position of the Celestial Ephemeris Pole (CEP), and since the current IAU standards for the CEP are known to be in error by amounts significant to TEMPO, it is important that TEMPO use a CEP series that is corrected from the IAU standards and is consistent with the radio source coordinates (RSC) used. Current practicalities of TEMPO operations favor the use of a parametric model for the CEP that includes the long period motions. Therefore we have estimated such a model along with the RSC and set of station coordinates (SSC) in the JPL 1991-1 catalog solution. Although this CEP model has the form of adjustments to the coefficients of the IAU precession-nutation model, it is intended only to permit processing of TEMPO data for the ERP during the period reported here and during 1991, and will presumably need revision in 1992. In particular, it may not include all significant components and all its parameters may not be well separated, but we believe it is adequate for our purposes.

The JPL 1991-1 catalog solution had the following properties:

1. Except where otherwise noted, the catalog solution was essentially identical to the ERP solution described above.

2. All the available CAT M&E data, and most of the TEMPO data through January 12, 1991, were included.

3. Information from intra-complex radio interferometry and ground surveys was used to constrain the coordinate differences between stations within each complex (with a standard deviation of 1 cm).

4. For each pair of observing sessions that used different pairs of DSN complexes (that is, California-to-Spain and California-to-Australia) with a time separation between the midpoints of the sessions of less than 15 hours, the adjustment (dX,dY,dUT1) to the initial values of earth orientation is the same for both members of the pair. (The initial-value ERP series was a version of the SPACE90 series (Gross and Steppe, 1991) modified to not use DSN VLBI data; it is a smoothed, combination-of-techniques ERP series obtained by Kalman filtering in a manner similar to the SPACE87 system of Eubanks (1988).). This treatment of close-in-time pairs serves to determine the angle between the California-to-Spain and California-to-Australia baseline vectors. There were 65 such pairs of TEMPO sessions; there were 2 such pairs involving one TEMPO session and one CAT M&E session; and there were no such pairs involving two CAT M&E observing sessions.

5. The terrestrial frame of the JPL 1991-1 system was tied to the International Earth Rotation Service Terrestrial Reference Frame ITRF-88 (IERS, 1989, Table T-4) in the following way. The coordinates of all the DSN stations, including all those in California, were estimated in the catalog solution subject to six constraints applied to the nine coordinates of DSS 14, DSS 43, and DSS 63. These constraints are such that if a seven parameter transformation (3 translations, 3 rotations, 1 scale) between the JPL 1991-1 and ITRF-88 systems were estimated by unweighted least squares applied to the coordinates of DSS 14, 43, and 63, then the resulting 3 translation and 3 rotation parts of the transformation would be zero while the scale could be non zero and unknown in advance of computing the catalog. (When expressed as the dot product of a nine dimensional unit vector with the nine station coordinates, each constraint is assigned an a priori standard deviation of 1 cm; this does not affect the resulting coordinates but does affect the calculated formal errors, giving them a more spherical distribution than would result if either very large or very small a priori standard deviations were used.) These constraints serve to determine both the translation and the rotation of the terrestrial coordinate system. The station coordinates resulting from the solution apply at a reference time of 1988.0, in agreement with that of ITRF-88.

6. The Right Ascension and Declination of OJ 287 (0851+202) and the Declination of CTD 20 (0234+285), which are among the best observed sources in the DSN catalog and are primary sources in the IERS Celestial Reference Frame ICRF-88, were held fixed at their values in that frame as specified in the set of radio source coordinates RSC(IERS)89 C 01 (IERS, 1989, Table C-3). By this means the coordinate system of the JPL 1991-1 RSC is tied to the IERS celestial frame ICRF-88. (The Right Ascension of 3C 273 was NOT held fixed.) The formal errors of these three source coordinates are properly zero, but in order to convey the quality of determination of these two sources we have replaced these three zeros in our source list RSC(JPL)91 R 01 by the formal errors for these three coordinates from a similar solution that had three coordinates of two different well-observed sources held fixed; we have similarly replaced the two correlation coefficients between Right Ascension and Declination for these two sources.

7. The reference epoch of the JPL 1991-1 celestial system was J2000, and the definition of sidereal time was a function of the estimated precession constant.

This year we have activated the Masterfit option to perform the general relativity calculations using the Hellings correction,which has the effect of making a small change in the length scale of the Set of Station Coordinates (Hellings, 1986). As a result, the estimated Set of Station Coordinates has a scale in approximate accordance with distances that would be measured by observers in a local earth frame using conventional geodetic techniques.

The model of the celestial motion of the CEP obtained as part of the JPL 1991-1 catalog solution is presented below as adjustments to the IAU precession and nutation coefficients along with two offset parameters which represent the estimated position of the (mean) CEP at epoch J2000 as expressed in the coordinate system of the radio sources. A positive X-offset represents a displacement of the CEP toward 18 hours Right Ascension, and a positive Y-offset represents a displacement of the CEP toward 0 hours Right Ascension. Only those nutation terms listed below were adjusted in the catalog solution. Two sets of standard errors are presented; the "formal" errors are just the formal errors from the catalog solution, and the "generalized" errors are the formal errors from a similar solution which also estimated additional components with periods of 121.75, 27.55, 13.63, 9.13, and 433. days as well as both out-of-phase nutations for all ten periods, along with site velocities.

Celestial Ephemeris Pole Motion Model

Index	Period	Phase	Component	Adjustment	Formal Error	Generalized Error
	days			mas	mas	mas
precession			Longitude	- 2.76/yr	0.16/yr	0.84/yr
Y-offset			L sin eps	-16.44	0.99	5.03
X-offset			Obliquity	+ 1.05	0.30	0.34
1	6798.38	In	Longitude	- 6.67	0.70	2.65
			Obliquity	+ 1.59	0.13	0.22
		Out	Longitude	+ 2.58	0.77	3.47
			Obliquity	+ 2.48	0.08	0.27
2	3399.19	In	Longitude	+ 2.35	0.57	0.67
			Obliquity	- 0.21	0.08	0.11
10	365.26	In	Longitude	+ 4.10	0.21	0.27
			Obliquity	+ 1.99	0.07	0.13
		Out	Longitude	+ 1.49	0.18	0.31
			Obliquity	- 0.47	0.06	0.09
9	182.62	In	Longitude	+ 1.24	0.13	0.22
			Obliquity	- 0.61	0.07	0.10
		Out	Longitude	- 0.77	0.18	0.27
			Obliquity	- 0.42	0.05	0.08
31	13.66	In	Longitude	- 0.13	0.18	0.27
			Obliquity	+ 0.19	0.06	0.12

Site velocities were estimated in preliminary solutions performed to assist in selecting the final parameters of the catalog solution. The adjusted velocity parameters represented incremental velocities in addition to the velocities implied by the AM0-2 model. All stations in each DSN complex were assumed to have the same incremental site velocity. The incremental velocities were constrained so as to produce no net translation rate and no net rotation rate (relative to that implied by AM0-2) for the network composed of the three DSN complexes. Thus the estimated velocities represent the rate of deformation of the network (again relative to that implied by AM0-2); no attempt was made to estimate any net motion of the network relative to other sites in the IERS Terrestrial Reference Frame. The estimated values for the incremental velocities of the three Cartesian coordinates of each site were a few millimeters per year with formal uncertainties of a few millimeters per year. We judged these incremental velocities to be not genuinely significant, and decided not to estimate site velocities in the JPL 1991-1 catalog solution.

For accurate interpretation of the UT0 and DPHI values reported here, one should use accurate values of the latitude and longitude of the baseline vector; these can be calculated for each station pair from the SSC estimated in the JPL 1991-1 catalog solution and reported here. Approximate values are:

Baseline	Latitude (°)	Longitude (°)
Australia-California	- 43.97	+106.05
Spain-California	+ 2.99	+ 30.73
Spain-Australia	+ 38.50	- 18.10

ACKNOWLEDGEMENTS. We would like to thank each and every one of the many people who contributed to the acquisition and analysis of the DSN VLBI data. The work described in this paper was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

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SUMMARY DESCRIPTION OF TERRESTRIAL SYSTEM FOR JPL 1991-1 STATION COORDINATES.

1 - Technique	VLBI
2 - Analysis Center	JPL
3 - Solution identifier	1991-1
4 - Software used	Masterfit
5 - Relativity scale	LE
6 - Permanent tidal correction	No

7 - Tectonic plate model	AM0-2
8 - Velocity of light	299 792 458 m/s
9 - Geogravitational constant	3.9860 0448 * 10**14 m**3*S**-2
10 - Reference epoch	1 Jan 1988
11 - Adjusted parameters	X0, Y0, Z0
12 - Definition of the origin, and	
13 - Definition of the orientation	Six constraints were applied (with 1cm uncertainty) to the nine coordinates of DSS 14, DSS 43, and DSS 63, such that if a seven parameter transformation (3 translations, 3 rotations, 1 scale) between the JPL 1991-1 and ITRF-88 systems were estimated by unweighted least squares applied to the coordinates of DSS 14, 43, and 63, then the resulting 3 translation and 3 rotation parts of the transformation would be zero while the scale could be nonzero and unknown in advance of computing the catalog. See text for details.
14 - Constraint for time evolution	AM0-2 model

Domes ID	Station Name	X Meters	Y Meters	Z Meters	Mean MJD	Data Span Days	X Err	Y Err	Z Err
							Meters		
40405S003	DSS 12	-2350443.648	-4651980.875	3665630.921	45759.0	0.0	0.011	0.014	0.015
40405S014	DSS 13	-2351129.016	-4655477.113	3660956.870	45634.8	0.0	0.012	0.014	0.015
40405S001	DSS 14	-2353621.086	-4641341.572	3677052.277	46493.0	0.0	0.009	0.011	0.012
40405S019	DSS 15	-2353538.642	-4641649.547	3676669.979	47680.0	0.0	0.011	0.013	0.015
50103S005	DSS 42	-4460980.882	2682413.579	-3674582.232	46783.5	0.0	0.021	0.014	0.016
50103S001	DSS 43	-4460894.453	2682361.609	-3674748.744	46337.6	0.0	0.019	0.011	0.013
50103S010	DSS 45	-4460935.112	2682765.765	-3674381.564	48004.1	0.0	0.021	0.014	0.015
13407S003	DSS 61	4849245.283	-360278.280	4114884.305	46437.0	0.0	0.016	0.016	0.021
13407S001	DSS 63	4849092.711	-360180.683	4115108.967	46296.6	0.0	0.013	0.013	0.019
13407S010	DSS 65	4849336.796	-360488.984	4114748.636	47952.6	0.0	0.014	0.016	0.021

EOP(JPL) 91 R 01 Available from 1979 to 1991

Number of measurements and RMS uncertainty per year
Units : 0.001" for $\Delta\varphi$; 0.0001s for UT0

YEAR	$\Delta\varphi$		UT0	
	Nb	Sigma	Nb	Sigma
1979	3	0.44	3	1.48
1980	27	6.80	27	9.32
1981	17	10.26	17	12.42
1982	43	10.16	43	9.51
1983	74	5.71	74	7.18
1984	71	6.51	71	6.87
1985	19	4.87	19	4.65
1986	72	4.10	72	3.88
1987	77	3.53	77	4.13
1988	92	3.17	92	3.44
1989	92	2.28	92	2.18
1990	104	2.34	104	2.70
1991	20	1.74	20	1.80

RADIO SOURCE COORDINATES RSC(JPL) 91 R 01

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
0003-066	0 6 13.892788	- 6 23 35.31890	0.000035	0.01133
0008-264	0 11 1.246773	-26 12 33.37661	0.000060	0.00082
0013-005	0 16 11.088481	- 0 15 12.44335	0.000019	0.00049
0016+731	0 19 45.786364	73 27 30.01788	0.000076	0.00016
0019+058	0 22 32.441181	6 8 4.26979	0.000028	0.00082
0048-097	0 50 41.317325	- 9 29 5.20876	0.000016	0.00052
0104-408	1 6 45.108022	-40 34 19.95910	0.000051	0.00065
0106+013	1 8 38.771047	1 35 0.31823	0.000015	0.00033
0111+021	1 13 43.145043	2 22 17.31589	0.000099	0.00161
0112-017	1 15 17.099903	- 1 27 4.57647	0.000015	0.00039
0113-118	1 16 12.521964	-11 36 15.43350	0.000031	0.00058
0119+115	1 21 41.594956	11 49 50.41473	0.000016	0.00033
0119+041	1 21 56.861643	4 22 24.73575	0.000014	0.00045
0133+476	1 36 58.594772	47 51 29.10054	0.000031	0.00018
0146+056	1 49 22.370816	5 55 53.57039	0.000035	0.00070
0149+218	1 52 18.058994	22 7 7.70100	0.000018	0.00037
0201+113	2 3 46.656992	11 34 45.41075	0.000028	0.00053
0202+149	2 4 50.413852	15 14 11.04393	0.000015	0.00019
0202+319	2 5 4.925324	32 12 30.09568	0.000021	0.00037
0212+735	2 17 30.813306	73 49 32.62274	0.000070	0.00018
0221+067	2 24 28.428096	6 59 23.34245	0.000030	0.00043
0224+671	2 28 50.051507	67 21 3.03049	0.000056	0.00026
0229+131	2 31 45.894007	13 22 54.71673	0.000014	0.00022
0234+285	2 37 52.405637	28 48 8.99050	0.000018	0.00015
0235+164	2 38 38.930058	16 36 59.27530	0.000014	0.00015
0237-233	2 40 8.174697	-23 9 15.74098	0.000864	0.01190
0239+108	2 42 29.170834	11 1 0.72809	0.000026	0.00034
0250+178	2 53 34.882150	18 5 42.52594	0.000039	0.00105
0256+075	2 59 27.076605	7 47 39.64306	0.000038	0.00105
0259+121	3 2 30.546826	12 18 56.76671	0.000613	0.06485
0300+470	3 3 35.242190	47 16 16.27609	0.000026	0.00018
0306+102	3 9 3.623443	10 29 16.34199	0.000030	0.00044
0309+411	3 13 1.962117	41 20 1.18320	0.000040	0.00101
0316+413	3 19 48.160116	41 30 42.10592	0.000027	0.00044
0317+188	3 19 51.256678	19 1 31.29201	0.000018	0.00034
0326+277	3 29 57.669338	27 56 15.49964	0.000044	0.00062
0332-403	3 34 13.654494	-40 8 25.39690	0.000116	0.00095
0333+321	3 36 30.107616	32 18 29.34226	0.000034	0.00034
0336-019	3 39 30.937739	- 1 46 35.80280	0.000013	0.00036
0342+147	3 45 6.416473	14 53 49.55863	0.000035	0.00046
0400+258	4 3 5.586023	26 0 1.50340	0.000020	0.00045
0402-362	4 3 53.749817	-36 5 1.91228	0.000054	0.00065
0406-127	4 9 5.769635	-12 38 48.14222	0.000021	0.00054
0406+121	4 9 22.008659	12 17 39.84804	0.000029	0.00045
0409+229	4 12 43.666822	23 5 5.45430	0.000020	0.00037

RADIO SOURCE COORDINATES (cont.) RSC(JPL) 91 R 01

SOURCE	RIGHT ASCENSION			DECLINATION			SIGMA R.A.	SIGMA D.
	H	M	S	o	'	"	S	"
0420-014	4	23	15.800674	- 1	20	33.06500	0.000013	0.00026
0420+417	4	23	56.009781	41	50	2.71397	0.000032	0.00067
0423+233	4	26	55.734771	23	27	39.63476	0.000016	0.00033
0425+048	4	27	47.570306	4	57	8.32932	0.000107	0.00153
0426+273	4	29	52.960729	27	24	37.87817	0.000019	0.00044
0430+052	4	33	11.095497	5	21	15.61992	0.000058	0.00098
0434-188	4	37	1.482658	-18	44	48.61316	0.000020	0.00045
0438-436	4	40	17.179849	-43	33	8.60205	0.000112	0.00087
0440-003	4	42	38.660704	- 0	17	43.41975	0.000023	0.00069
0440+345	4	43	31.635233	34	41	6.66360	0.000038	0.00049
0446+112	4	49	7.671062	11	21	28.59691	0.000028	0.00057
0451-282	4	53	14.646570	-28	7	37.32465	0.000095	0.00118
0454-234	4	57	3.179107	-23	24	52.00601	0.000042	0.00983
0458-020	5	1	12.810213	- 1	59	14.26161	0.001040	0.01566
0458+138	5	1	45.270699	13	56	7.22264	0.000115	0.00158
0459+060	5	2	15.445876	6	9	7.49518	0.000027	0.00056
0500+019	5	3	21.197079	2	3	4.67772	0.000036	0.00055
0502+049	5	5	23.184814	4	59	42.72313	0.000101	0.00147
0454+844	5	8	42.363871	84	32	4.54438	0.000143	0.00032
0506+101	5	9	27.457052	10	11	44.60073	0.000028	0.00045
0507+179	5	10	2.369118	18	0	41.58263	0.000029	0.00051
0511-220	5	13	49.114277	-21	59	16.09167	0.000024	0.00053
0528+134	5	30	56.416706	13	31	55.15064	0.000010	0.00018
0537-441	5	38	50.361300	-44	5	8.93698	0.000082	0.00074
0537-158	5	39	32.010165	-15	50	30.32229	0.000047	0.00169
0536+145	5	39	42.365993	14	33	45.56225	0.000026	0.00039
0544+273	5	47	34.148959	27	21	56.84295	0.000046	0.00069
0552+398	5	55	30.805602	39	48	49.16572	0.000013	0.00022
0556+238	5	59	32.033111	23	53	53.92742	0.000012	0.00027
0600+177	6	3	9.130259	17	42	16.81132	0.000031	0.00045
0605-085	6	7	59.699216	- 8	34	49.97828	0.000020	0.00079
0607-157	6	9	40.949596	-15	42	40.67355	0.000196	0.00268
0611+131	6	13	57.692735	13	6	45.40218	0.000013	0.00053
0642+214	6	45	24.099519	21	21	51.20236	0.000031	0.00048
0650+371	6	53	58.283577	37	5	40.59912	0.001520	0.01542
0657+172	7	0	1.525558	17	9	21.70157	0.000043	0.00069
0710+439	7	13	38.164609	43	49	17.19507	0.001558	0.01681
0722+145	7	25	16.807802	14	25	13.74590	0.000029	0.00047
0723-008	7	25	50.639941	- 0	54	56.54466	0.000043	0.00075
0727-115	7	30	19.112466	-11	41	12.60055	0.000018	0.00035
0735+178	7	38	7.393766	17	42	18.99855	0.000007	0.00020
0736+017	7	39	18.033908	1	37	4.61794	0.000017	0.00035
0738+313	7	41	10.703572	31	12	0.22603	0.000065	0.00059
0742+103	7	45	33.059507	10	11	12.69253	0.000014	0.00028
0743+259	7	46	25.874157	25	49	2.13539	0.000033	0.00063

RADIO SOURCE COORDINATES (cont.) RSC(JPL) 91 R 01

SOURCE	RIGHT ASCENSION			DECLINATION			SIGMA R.A.	SIGMA D.
	H	M	S	o	'	"	S	"
0745+241	7	48	36.109278	24	0	24.11037	0.000031	0.00051
0748+126	7	50	52.045765	12	31	4.82762	0.000030	0.00059
0754+100	7	57	6.642949	9	56	34.85204	0.000028	0.00051
0805-077	8	8	15.536048	- 7	51	9.88650	0.000029	0.00059
0814+425	8	18	15.999670	42	22	45.41452	0.000024	0.00030
0823+033	8	25	50.338374	3	9	24.51997	0.000013	0.00028
0827+243	8	30	52.086177	24	10	59.82100	0.000038	0.00051
0836+710	8	41	24.365625	70	53	42.17165	0.000320	0.00179
0851+202	8	54	48.874933	20	6	30.64118	0.000014	0.00027
0859-140	9	2	16.831044	-14	15	30.87675	0.000120	0.00152
0859+470	9	3	3.990102	46	51	4.13736	0.000028	0.00042
0912+029	9	14	37.913505	2	45	59.24578	0.000046	0.00073
0917+449	9	20	58.458183	44	41	53.98886	0.000414	0.00339
0920-397	9	22	46.418103	-39	59	35.06621	0.000254	0.00260
0923+392	9	27	3.013907	39	2	20.85155	0.000013	0.00017
0925-203	9	27	51.824097	-20	34	51.22933	0.000154	0.00212
0952+179	9	54	56.823698	17	43	31.22631	0.000032	0.00304
1004+141	10	7	41.498024	13	56	29.60274	0.000045	0.00073
1012+232	10	14	47.065497	23	1	16.57032	0.000032	0.00045
1022+194	10	24	44.809610	19	12	20.41579	0.000022	0.00047
1034-293	10	37	16.079787	-29	34	2.81345	0.000051	0.00061
1038+064	10	41	17.162532	6	10	16.92323	0.000025	0.00061
1040+123	10	42	44.605216	12	3	31.26471	0.000022	0.00052
1042+071	10	44	55.911262	6	55	38.26336	0.000035	0.00068
1044+719	10	48	27.619683	71	43	35.93837	0.000099	0.00053
1055+018	10	58	29.605257	1	33	58.82342	0.000014	0.00032
1104-445	11	7	8.694248	-44	49	7.61898	0.000090	0.00074
1111+149	11	13	58.695075	14	42	26.95309	0.000032	0.00053
1116+128	11	18	57.301488	12	34	41.71829	0.000023	0.00047
1123+264	11	25	53.711931	26	10	19.97823	0.000013	0.00026
1127-145	11	30	7.052776	-14	49	27.39020	0.000051	0.00079
1128+385	11	30	53.282607	38	15	18.54652	0.000028	0.00055
1144+402	11	46	58.297844	39	58	34.30358	0.000088	0.00231
1144-379	11	47	1.370716	-38	12	11.02315	0.000061	0.00066
1145-071	11	47	51.554033	- 7	24	41.13966	0.000026	0.00061
1148-001	11	50	43.870871	- 0	23	54.20557	0.000041	0.00089
1150+812	11	53	12.499289	80	58	29.15342	0.000163	0.00040
1156-094	11	59	12.712055	- 9	40	52.05344	0.000478	0.00635
1156+295	11	59	31.833870	29	14	43.82480	0.000277	0.03146
1219+285	12	21	31.690498	28	13	58.50079	0.000371	0.03208
1222+037	12	24	52.421925	3	30	50.29327	0.000033	0.00068
1226+023	12	29	6.699769	2	3	8.59875	0.000016	0.00040
1228+126	12	30	49.423268	12	23	28.04538	0.000197	0.00279
1243-072	12	46	4.232137	- 7	30	46.57419	0.000026	0.00057
1244-255	12	46	46.802171	-25	47	49.28963	0.000049	0.00070

RADIO SOURCE COORDINATES (cont.) RSC(JPL) 91 R 01

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
1253-055	12 56 11.166606	- 5 47 21.52529	0.000020	0.00054
1302-102	13 5 33.015031	-10 33 19.42723	0.000027	0.00062
1308+326	13 10 28.663847	32 20 43.78223	0.000014	0.00030
1313-333	13 16 7.985933	-33 38 59.17152	0.000079	0.00089
1315+346	13 17 36.494183	34 25 15.93258	0.000030	0.00102
1334-127	13 37 39.782842	-12 57 24.69343	0.000024	0.00057
1342+662	13 43 45.959472	66 2 25.74446	0.000085	0.00055
1342+663	13 44 8.679555	66 6 11.64274	0.000053	0.00029
1349-439	13 52 56.535165	-44 12 40.38837	0.000144	0.00107
1354+195	13 57 4.436616	19 19 7.37229	0.000014	0.00040
1354-152	13 57 11.245099	-15 27 28.78763	0.000037	0.00069
1404+286	14 7 0.394394	28 27 14.69020	0.000027	0.00051
1406-076	14 8 56.481239	- 7 52 26.66562	0.000035	0.00071
1418+546	14 19 46.597353	54 23 14.78629	0.000032	0.00040
1424-418	14 27 56.302149	-42 6 19.45276	0.001536	0.00535
1430-178	14 32 57.690542	-18 1 35.24769	0.000056	0.00103
1435-218	14 38 9.469458	-22 4 54.81622	0.000119	0.04299
1443-162	14 45 53.376353	-16 29 1.61813	0.000041	0.00082
1445-161	14 48 15.054233	-16 20 24.54932	0.000042	0.00079
1502+106	15 4 24.979798	10 29 39.19827	0.000016	0.00048
1504+377	15 6 9.529309	37 30 51.13808	0.000322	0.00364
1504-166	15 7 4.787025	-16 52 30.26739	0.000033	0.00090
1510-089	15 12 50.532962	- 9 5 59.82952	0.000023	0.00062
1511-100	15 13 44.893504	-10 12 0.26397	0.000031	0.00073
1514-241	15 17 41.813294	-24 22 19.47674	0.000069	0.00097
1519-273	15 22 37.676067	-27 30 10.78549	0.000058	0.00087
1532+016	15 34 52.453664	1 31 4.20703	0.000031	0.00070
1538+149	15 40 49.491518	14 47 45.89303	0.000048	0.01115
1548+056	15 50 35.269257	5 27 10.44779	0.000023	0.00062
1555+001	15 57 51.433969	- 0 1 50.41307	0.000029	0.00069
1600+335	16 2 7.263517	33 26 53.08144	0.000086	0.00424
1606+106	16 8 46.203201	10 29 7.79569	0.000049	0.01429
1611+343	16 13 41.064203	34 12 47.90827	0.000017	0.00045
1614+051	16 16 37.556840	4 59 32.73613	0.000028	0.00066
1624+416	16 25 57.669268	41 34 40.60924	0.000323	0.01865
1622-297	16 26 6.020410	-29 51 26.96382	0.001215	0.01736
1633+382	16 35 15.492921	38 8 4.50020	0.000018	0.00045
1637+574	16 38 13.456159	57 20 23.97900	0.000044	0.00051
1638+398	16 40 29.632707	39 46 46.02843	0.000020	0.00046
1642+690	16 42 7.848275	68 56 39.75612	0.000066	0.00036
1641+399	16 42 58.809910	39 48 36.99386	0.000016	0.00042
1655+077	16 58 9.011453	7 41 27.54078	0.000032	0.00071
1656+053	16 58 33.447362	5 15 16.44392	0.000059	0.00104
1657-261	17 0 53.154182	-26 10 51.72540	0.000049	0.00093
1706-174	17 9 34.345439	-17 28 53.36418	0.000051	0.00097

RADIO SOURCE COORDINATES (cont.) RSC(JPL) 91 R 01

SOURCE	RIGHT ASCENSION	DECLINATION	SIGMA R.A.	SIGMA D.
	H M S	o ' "	S	"
1717+178	17 19 13.048475	17 45 6.43646	0.000042	0.00095
1730-130	17 33 2.705831	-13 4 49.54736	0.000025	0.00071
1738+476	17 39 57.128994	47 37 58.36212	0.000029	0.00068
1739+522	17 40 36.977755	52 11 43.40757	0.000059	0.00082
1741-038	17 43 58.856160	- 3 50 4.61635	0.000020	0.00064
1743+173	17 45 35.208169	17 20 1.41726	0.000376	0.04031
1749+701	17 48 32.840228	70 5 50.76850	0.000082	0.00051
1749+096	17 51 32.818563	9 39 0.72825	0.000020	0.00058
1751+288	17 53 42.473120	28 48 4.95093	0.000665	0.01986
1803+784	18 0 45.683436	78 28 4.01846	0.000096	0.00033
1807+698	18 6 50.680493	69 49 28.10834	0.000044	0.00034
1821+107	18 24 2.855276	10 44 23.77353	0.000036	0.00083
1845+797	18 42 8.989330	79 46 17.12850	0.000257	0.00049
1908-201	19 11 9.652928	-20 6 55.10847	0.000034	0.00081
1920-211	19 23 32.189883	-21 4 33.33308	0.000031	0.00079
1921-293	19 24 51.056113	-29 14 30.12117	0.000043	0.00081
1923+210	19 25 59.605342	21 6 26.16167	0.000021	0.00053
1928+738	19 27 48.494892	73 58 1.56958	0.000067	0.00033
1933-400	19 37 16.217626	-39 58 1.55261	0.000340	0.00294
1936-155	19 39 26.657789	-15 25 43.05819	0.000037	0.00085
1954+513	19 55 42.738238	51 31 48.54618	0.000039	0.00059
1958-179	20 0 57.090461	-17 48 57.67190	0.000028	0.00074
2008-159	20 11 15.710946	-15 46 40.25266	0.000028	0.00074
2021+614	20 22 6.681596	61 36 58.80384	0.000041	0.00034
2030+547	20 31 47.958435	54 55 3.14159	0.000060	0.00102
2029+121	20 31 54.994234	12 19 41.33981	0.000064	0.00135
2113+293	21 15 29.413433	29 33 38.36699	0.000023	0.00046
2121+053	21 23 44.517334	5 35 22.09392	0.000020	0.00054
2128+048	21 30 32.877611	5 2 17.41788	0.000254	0.06666
2128-123	21 31 35.261741	-12 7 4.79579	0.000020	0.00065
2131-021	21 34 10.309595	- 1 53 17.23817	0.000018	0.00056
2134+004	21 36 38.586377	0 41 54.21348	0.000017	0.00051
2144+092	21 47 10.162994	9 29 46.66384	0.000090	0.02693
2145+067	21 48 5.458674	6 57 38.60431	0.000017	0.00047
2149+056	21 51 37.875382	5 52 12.95594	0.000042	0.00076
2155-152	21 58 6.281979	-15 1 9.32788	0.000069	0.00104
2200+420	22 2 43.291325	42 16 39.98002	0.000027	0.00033
2201+315	22 3 14.975814	31 45 38.27411	0.000050	0.00304
2216-038	22 18 52.037718	- 3 35 36.87891	0.000024	0.00059
2223-052	22 25 47.259270	- 4 57 1.38982	0.000024	0.00058
2227-088	22 29 40.084315	- 8 32 54.43433	0.000031	0.00068
2229+695	22 30 36.469753	69 46 28.07741	0.000109	0.00049
2230+114	22 32 36.408909	11 43 50.90428	0.000017	0.00040
2234+282	22 36 22.470840	28 28 57.41358	0.000022	0.00034
2243-123	22 46 18.231948	-12 6 51.27634	0.000024	0.00060

RADIO SOURCE COORDINATES (cont.) RSC(JPL) 91 R 01

SOURCE	RIGHT ASCENSION	DECLINATION	SIGMA R.A.	SIGMA D.
	H M S	o ' "	S	"
2245-328	22 48 38.685782	-32 35 52.18675	0.000051	0.00076
2251+158	22 53 57.747920	16 8 53.56185	0.000020	0.00037
2252-090	22 55 4.237794	- 8 44 4.00822	0.002978	0.04465
2253+417	22 55 36.707742	42 2 52.53254	0.000048	0.00063
2254+074	22 57 17.303142	7 43 12.30259	0.000030	0.00065
2254+024	22 57 17.563085	2 43 17.51220	0.000036	0.00068
2318+049	23 20 44.856567	5 13 49.95367	0.000016	0.00041
2319+272	23 21 59.862230	27 32 46.44246	0.000045	0.00341
2320-035	23 23 31.953709	- 3 17 5.02267	0.000017	0.00049
2328+107	23 30 40.852194	11 0 18.70700	0.000017	0.00186
2335-027	23 37 57.339067	- 2 30 57.62939	0.000026	0.00064
2344+092	23 46 36.838486	9 30 45.51260	0.000019	0.00243
2345-167	23 48 2.608464	-16 31 12.02075	0.000038	0.00069
2351+456	23 54 21.677829	45 53 4.25047	0.001440	0.00846
2351-154	23 54 30.195138	-15 13 11.21163	0.000019	0.00059
2355-106	23 58 10.882394	-10 20 8.61071	0.000034	0.00066

EARTH ORIENTATION PARAMETERS AND CELESTIAL AND TERRESTRIAL REFERENCE FRAMES OF NAOMIZ ANALYSIS NAOMZ 91 R 01

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The VLBI analysis center at the Division of Earth Rotation of the National Astronomical Observatory has archived most of the geodetic VLBI data base covering the period from 1984. Based on these data, the Earth Orientation Parameters (EOP's: polar motion, UT1-UTC, and nutation offsets), station coordinates and their linear trends, and radio source positions were estimated by means of the NAOMIZ global solution software runnable on the main frame computer, HITAC-M680H.

The data base includes, IRIS, NASA CDP and NAVNET. However, NAVNET data are not used in this analysis due to large deviations of the results when compared with the other two data sources. IRIS and NASA CDP data are not separately analysed, but are merged. They are divided into approximately 600 data lumps, each of which covers approximately 24 hours.

EOP's are assumed to be constant within every data lump. Station coordinates are estimated for every data lump under the strong constraint that they should move linearly. In order to estimate the linear trends of the station coordinates, EOP's at two epochs are assumed fixed and IRIS-A values at 1984 January 4 and 1988 January 3 are adopted as a-priori ones. The coordinates of Westford are fixed to the IRIS-A values. AM0-2 is used as the plate motion model. The right ascension origin and the reference of the nutation offsets are defined by adjusting the mean orientation of the NAO celestial system to the mean system of RSC(IERS) 90 C 01 published in the IERS Annual Report for 1989.

All estimates which were simultaneously determined by means of the global solution software are not accompanied by nominal errors. Nominal errors are not calculable, because the system of equation to solve global solutions is too large to invert the normal matrix for error estimation.

SSC(NAOMZ) 91 R 01
SSV(NAOMZ) 91 R 01

SITE CODE	X (m)	Y (m)	Z (m)	VX (m/y)	VY (m/y)	VZ (m/y)	PLATE	EPOCH
OVRO 130	-2409600.525	-4478349.486	3838603.472	-0.00392	0.01283	0.01157	NOAM	47161
HRAS 085	-1324210.743	-5332023.024	3232118.578	-0.00511	-0.00427	0.00825	NOAM	47161
HAYSTACK	1492405.145	-4457266.361	4296881.732	-0.00000	-0.00000	-0.00000	NOAM	47161
ONSALA60	3370606.472	711917.519	5349830.459	0.00324	0.00544	-0.01546	EURA	47161
WESTFORD	1492206.996	-4458130.329	4296015.476	0.00000	-0.00000	-0.00000	NOAM	47161
MOJAVE12	-2356170.775	-4646755.819	3668470.869	-0.00448	0.00842	0.00966	NOAM	47161
WETTZELL	4075540.330	931735.258	4801629.033	0.00337	0.00516	-0.01636	EURA	47161
RICHMOND	961258.286	-5674089.938	2740533.790	-0.00387	-0.00078	0.00030	NOAM	47161
HARTRAO	5085442.567	2668263.304	-2768697.877	-0.00000	-0.00000	-0.00000	AFRC	47161
MEDICINA	4461370.461	919596.814	4449558.817	-0.00657	-0.00143	-0.01999	EURA	47161
KAUAI	-5543846.003	-2054564.625	2387813.804	-0.01284	-0.00098	0.00373	PCFC	47161
VNDNBERG	-2678097.158	-4525455.533	3597414.016	-0.02045	0.04026	0.03531	NOAM	47161
GILCREEK	-2281546.825	-1453644.827	5756993.470	-0.00153	0.00733	-0.00183	NOAM	47161
KWAJAL26	-6143536.870	1363996.760	1034707.393	-0.01357	0.00092	-0.00696	PCFC	47161
KASHIMA	-3997892.252	3276581.551	3724118.565	0.01776	0.01507	-0.01372	EURA	47161
ALGOPARK	918035.163	-4346132.079	4561971.181	0.00042	0.00457	-0.00394	NOAM	47161
HATCREEK	-2523969.677	-4123506.272	4147752.885	-0.00622	0.01156	0.00411	NOAM	47161
PLATTVIL	-1240708.690	-4720457.357	4094484.592	0.0	0.0	0.0	NOAM	47161
SESHAN25	-2831686.547	4675734.141	3275327.853	0.0	0.0	0.0	EURA	47161
DSS45	-4460935.658	2682765.442	-3674381.832	0.0	0.0	0.0	PCFC	47161
NOBEY 6M	-3871168.383	3428274.196	3723697.640	0.00000	-0.00000	-0.00000	EURA	47161
HOBART26	-3950237.106	2522347.562	-4311562.882	0.00000	-0.00000	-0.00000	INDI	47161
KASHIM34	-3997649.385	3276691.000	3724278.927	-0.00000	-0.00000	-0.00000	EURA	47161

RADIO SOURCE COORDINATES RSC(NAOMZ) 91 R 01

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
0106+013	1 8 38.771097	1 35 0.31647	********	*******
0119+041	1 21 56.861731	4 22 24.73416	********	*******
0212+735	2 17 30.813527	73 49 32.62010	********	*******
0229+131	2 31 45.894086	13 22 54.71514	********	*******
0234+285	2 37 52.405711	28 48 8.98854	********	*******
0300+470	3 3 35.242269	47 16 16.27374	********	*******
0316+413	3 19 48.160124	41 30 42.10212	********	*******
0355+508	3 59 29.747248	50 57 50.15963	********	*******
0420-014	4 23 15.800726	- 1 20 33.06632	********	*******
0454-234	4 57 3.179242	-23 24 52.02083	********	*******
0528+134	5 30 56.416756	13 31 55.14831	********	*******
0552+398	5 55 30.805560	39 48 49.16362	********	*******
0727-115	7 30 19.112505	-11 41 12.60062	********	*******
0742+103	7 45 33.059507	10 11 12.69160	********	*******
0823+033	8 25 50.338338	3 9 24.51998	********	*******
0851+202	8 54 48.874890	20 6 30.64080	********	*******
0923+392	9 27 3.013785	39 2 20.85204	********	*******
1034-293	10 37 16.079832	-29 34 2.81168	********	*******
1055+018	10 58 29.605224	1 33 58.82489	********	*******
1144+402	11 46 58.297830	39 58 34.30580	********	*******
1156+295	11 59 31.833858	29 14 43.82813	********	*******
1226+023	12 29 6.699737	2 3 8.60026	********	*******
1253-055	12 56 11.166522	- 5 47 21.52372	********	*******
1308+326	13 10 28.663832	32 20 43.78471	********	*******
1334-127	13 37 39.782800	-12 57 24.69049	********	*******
1354+195	13 57 4.436671	19 19 7.37527	********	*******
1404+286	14 7 0.394391	28 27 14.69194	********	*******
1418+546	14 19 46.595719	54 23 14.75053	********	*******
1502+106	15 4 24.979798	10 29 39.20105	********	*******
1548+056	15 50 35.269256	5 27 10.45122	********	*******
1611+343	16 13 41.064274	34 12 47.91134	********	*******
1622-253	16 25 46.891639	-25 27 38.32351	********	*******
1633+382	16 35 15.492983	38 8 4.50294	********	*******
1637+574	16 38 13.456356	57 20 23.98107	********	*******
1641+399	16 42 58.809988	39 48 36.99622	********	*******
1730-130	17 33 2.705757	-13 4 49.54491	********	*******
1739+522	17 40 36.977930	52 11 43.40959	********	*******
1741-038	17 43 58.856148	- 3 50 4.61396	********	*******
1749+096	17 51 32.818599	9 39 0.73085	********	*******
1803+784	18 0 45.684222	78 28 4.02024	********	*******
1921-293	19 24 51.055897	-29 14 30.11763	********	*******
1923+210	19 25 59.605463	21 6 26.16113	********	*******
1958-179	20 0 57.090345	-17 48 57.66981	********	*******
2113+293	21 15 29.413560	29 33 38.36778	********	*******
2121+053	21 23 44.517396	5 35 22.09450	********	*******

RADIO SOURCE COORDINATES (cont.) RSC(NAOMZ) 91 R 01

SOURCE	RIGHT ASCENSION	DECLINATION	SIGMA R.A.	SIGMA D.
	H M S	o ' "	S	"
2128-123	21 31 35.261642	-12 7 4.79450	********	*******
2134+004	21 36 38.586348	0 41 54.21502	********	*******
2145+067	21 48 5.458704	6 57 38.60503	********	*******
2200+420	22 2 43.291507	42 16 39.98023	********	*******
2216-038	22 18 52.037738	- 3 35 36.87868	********	*******
2234+282	22 36 22.470955	28 28 57.41360	********	*******
2251+158	22 53 57.747986	16 8 53.56095	********	*******
2255-282	22 58 5.962844	-27 58 21.25547	********	*******
2345-167	23 48 2.608493	-16 31 12.02169	********	*******

EOP(NAOMZ) 91 R 01 Available from 1984 to 1990

Number of measurements and RMS uncertainty per year
Units : 0.001" for X,Y,dψ,dε; 0.0001s for UT1

YEAR	X		Y		UT1		dψ		dε	
	Nb	Sigma	Nb	Sigma	Nb	Sigma	Nb	Sigma	Nb	Sigma
1984	77	****	77	****	77	****	77	****	77	****
1985	82	****	82	****	82	****	82	****	82	****
1986	88	****	88	****	88	****	88	****	88	****
1987	96	****	96	****	96	****	96	****	96	****
1988	103	****	103	****	103	****	103	****	103	****
1989	79	****	79	****	79	****	79	****	79	****
1990	70	****	70	****	70	****	70	****	70	****

POLAR MOTION AND UT1 TIME SERIES DERIVED FROM VLBI OBSERVATIONS

NGS 91 R 01
NGS 91 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), and the NASA Crustal Dynamics Project. 440,248 observations amassed during 782 observing sessions conducted between September, 1980, and February,1991, 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 a daily series of UT1 values for the period April through June, 1984, and April 1985 through March, 1990. 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 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. Shapiro's model for the relativistic corrections for signal propagation was used. This model is consistent with the corrections derived by Hellings [Hellings, 1986], with the corrections noted in Ryan's report to the IERS. Refraction in the neutral atmosphere 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. The dispersive portion of the atmospheric refraction (ionosphere) was eliminated by the use of dual frequency (X and S band) observations. Wahr's model was used for the solid Earth deformations resulting from the motion of the pole [Wahr, 1985]. Three vector components of the velocity of each station were estimated, for those stations whose data spanned more than a few months. These additional parameters introduce six new singularities into the definition of the terrestrial reference coordinate system, three for the velocity of the center of the system, and three rotation rate singularities. The velocity of the center of the system was constrained to by fixing the Westford velocity to the Minster-Jordan AM0-2 value, and the rotational singularities were removed by fixing the values of pole position and UT1 on two reference dates, rather than one as in the past. The two reference dates, 1985 Mar 24 and 1989 May 12, were selected to minimize differences with the past polar motion and UT1 series. The nutation reference date remains 1985 Oct 25. The quoted station coordinates are calculated for January 1, 1988.

Another 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].

The data were processed in a single least-squares solution in which the station and source coordinates, station velocities, polar motion and UT1 corrections, and the nutation corrections are estimated. The clock errors were treated by estimating coefficients of polynomials, usually one or two second-order polynomials per day. Atmospheric refraction modeling errors were treated by estimating the break-points of a piece-wise continuous function with break-points set every hour.

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]. Intercomparisons between the 5-day and the daily UT1 values (see below) indicates that both series 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:

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

1 - Technique:	VLBI
2 - Analysis Center:	NOAA
3 - Solution Identifier:	
4 - Software Used:	CALC
5 - Relativity Scale:	SSB
6 - Permanent Tidal Correction on Station:	Yes
7 - Tectonic Plate Model:	AM0-2, with station velocities adjusted
8 - Velocity of Light:	299792458
9 - Geogravitational Constant:	not relevant
10 - Reference Epochs:	Station Coordinates: 1/1/1988 Nutation: 10/25/85 Pole Position/UT1: 10/25/85 and 1/27/90
11 - Adjusted Parameters:	see description above
12 - Definition of the Origin:	Westford Coordinates fixed--see table
13 - Definition of the Orientation:	EOP values adopted at two epochs (see number 10)
14 - Constraint for Time Evolution:	See 10 and 13.

Table NGS-1. EOP(NGS) 91 R 01 Available from 1980 to 1991

Number of measurements and RMS uncertainty per year
Units : 0.001" for X,Y,dψ,dε; 0.0001s for UT1.

YEAR	X		Y		UT1		dψ		dε	
	Nb	Sigma	Nb	Sigma	Nb	Sigma	Nb	Sigma	Nb	Sigma
1980	16	1.03	16	1.19	16	0.56	16	1.19	16	0.41
1981	6	1.72	6	1.47	6	0.73	6	2.05	6	0.65
1982	10	1.67	10	1.98	10	0.99	10	2.16	10	0.83
1983	17	1.34	17	1.92	17	0.91	17	2.03	17	0.74
1984	70	1.04	70	1.37	70	0.68	70	1.35	70	0.47
1985	70	0.60	70	0.64	70	0.32	70	0.84	70	0.32
1986	79	0.51	79	0.53	79	0.27	79	0.77	79	0.28
1987	81	0.53	81	0.55	81	0.44	81	0.80	81	0.28
1988	77	0.42	77	0.46	77	0.25	77	0.78	77	0.28
1989	78	0.33	78	0.31	78	0.17	78	0.65	78	0.25
1990	82	0.28	82	0.28	82	0.12	83	0.58	83	0.21
1991	20	0.28	20	0.29	20	0.11	20	0.55	20	0.20

Table NGS-2. RADIO SOURCE COORDINATES RSC(NGS) 91 R 01

SOURCE	RIGHT ASCENSION	DECLINATION	SIGMA R.A.	SIGMA D.
	H M S	o ' "	S	"
0016+731	0 19 45.786040	73 27 30.01650	0.000042	0.00020
0048-097	0 50 41.317380	- 9 29 5.20980	0.000005	0.00020
0106+013	1 8 38.771050	1 35 0.31730	0.000002	0.00020
0119+041	1 21 56.861660	4 22 24.73470	0.000002	0.00020
0208-512	2 10 46.200500	-51 1 1.89150	0.000024	0.00030
0212+735	2 17 30.812900	73 49 32.62160	0.000046	0.00020
0224+671	2 28 50.051260	67 21 3.02930	0.000038	0.00020
0229+131	2 31 45.894000	13 22 54.71680	0.000004	0.00020
0234+285	2 37 52.405580	28 48 8.99040	0.000008	0.00020
0235+164	2 38 38.930040	16 36 59.27560	0.000009	0.00040
0300+470	3 3 35.242070	47 16 16.27580	0.000016	0.00020
0308-611	3 9 56.099450	-60 58 39.05480	0.000075	0.00040
0316+413	3 19 48.159880	41 30 42.10400	0.000024	0.00030
0355+508	3 59 29.747110	50 57 50.16230	0.000019	0.00020
0420-014	4 23 15.800700	- 1 20 33.06360	0.000001	0.00020
0454-234	4 57 3.179230	-23 24 52.01760	0.000005	0.00020
0530-727	5 29 30.042400	-72 45 28.50680	0.000094	0.00040
0528+134	5 30 56.416700	13 31 55.15140	0.000004	0.00020
0537-441	5 38 50.361570	-44 5 8.93800	0.000018	0.00030
0552+398	5 55 30.805510	39 48 49.16660	0 000012	0.00020
0637-752	6 35 46.508130	-75 16 16.81400	0.000062	0.00020
0727-115	7 30 19.112450	-11 41 12.59750	0.000003	0.00020
0742+103	7 45 33.059480	10 11 12.69490	0.000004	0.00020
0823+033	8 25 50.338340	3 9 24.52290	0.000005	0.00020
0851+202	8 54 48.874900	20 6 30.64330	0.000005	0.00020
0919-260	9 21 29.353800	-26 18 43.38310	0.000011	0.00030
0923+392	9 27 3.013870	39 2 20.85410	0.000009	0.00020
0954+658	9 58 47.245150	65 33 54.82030	0.000026	0.00020
1034-293	10 37 16.079680	-29 34 2.81020	0.000008	0.00020
1055+018	10 58 29.605190	1 33 58.82620	0.000002	0.00020
1057-797	10 58 43.309610	-80 3 54.15770	0.000090	0.00030
1104-445	11 7 8.694120	-44 49 7.61660	0.000020	0.00030
1144+402	11 46 58.297950	39 58 34.30610	0.000010	0.00020
1156+295	11 59 31.833930	29 14 43.82860	0.000006	0.00020
1226+023	12 29 6.699710	2 3 8.60040	0.000001	0.00020
1253-055	12 56 11.166470	- 5 47 21.52300	0.000009	0.00030
1308+326	13 10 28.663910	32 20 43.78400	0.000007	0.00020
1334-127	13 37 39.782720	-12 57 24.69130	0.000004	0.00020
1354+195	13 57 4.436680	19 19 7.37320	0.000007	0.00020
1404+286	14 7 0.394450	28 27 14.69070	0.000006	0.00020
1418+546	14 19 46.597570	54 23 14.78790	0.000023	0.00020
1424-418	14 27 56.297390	-42 6 19.43630	0.000022	0.00030
1502+106	15 4 24.979780	10 29 39.19920	0.000002	0.00020
1548+056	15 50 35.269230	5 27 10.44880	0.000003	0.00020
1611+343	16 13 41.064310	34 12 47.90870	0.000008	0.00020

Table NGS-2 RADIO SOURCE COORDINATES (cont.) RSC(NGS) 91 R 01

SOURCE	RIGHT ASCENSION	DECLINATION	SIGMA R.A.	SIGMA D.
	H M S	o ' "	S	"
1610-771	16 17 49.276030	-77 17 18.46770	0.000084	0.00030
1622-253	16 25 46.891550	-25 27 38.32610	0.000008	0.00020
1633+382	16 35 15.493020	38 8 4.50020	0.000010	0.00020
1637+574	16 38 13.456470	57 20 23.97840	0.000021	0.00020
1642+690	16 42 7.848830	68 56 39.75580	0.000038	0.00020
1641+399	16 42 58.810030	39 48 36.99350	0.000010	0.00020
1730-130	17 33 2.705740	-13 4 49.54810	0.000005	0.00020
1739+522	17 40 36.977940	52 11 43.40650	0.000016	0.00020
1741-038	17 43 58.856110	- 3 50 4.61690	0.000002	0.00020
1749+096	17 51 32.818560	9 39 0.72800	0.000003	0.00020
1803+784	18 0 45.684280	78 28 4.01720	0.000063	0.00020
1815-553	18 19 45.399370	-55 21 20.74600	0.000031	0.00030
1831-711	18 37 28.715560	-71 8 43.55490	0.000447	0.00220
1921-293	19 24 51.055880	-29 14 30.12090	0.000008	0.00020
1923+210	19 25 59.605360	21 6 26.15980	0.000026	0.00100
1928+738	19 27 48.495090	73 58 1.56860	0.000100	0.00070
1958-179	20 0 57.090410	-17 48 57.67260	0.000007	0.00020
2008-159	20 11 15.710930	-15 46 40.25840	0.000071	0.00360
2113+293	21 15 29.413420	29 33 38.36570	0.000013	0.00040
2121+053	21 23 44.517350	5 35 22.09220	0.000002	0.00020
2128-123	21 31 35.261710	-12 7 4.79680	0.000005	0.00030
2134+004	21 36 38.586280	0 41 54.21330	0.000002	0.00020
2145+067	21 48 5.458640	6 57 38.60330	0.000003	0.00020
2155-152	21 58 6.281810	-15 1 9.32920	0.000035	0.00060
2200+420	22 2 43.291320	42 16 39.97850	0.000010	0.00020
2216-038	22 18 52.037710	- 3 35 36.88010	0.000002	0.00020
2234+282	22 36 22.470820	28 28 57.41210	0.000007	0.00020
2251+158	22 53 57.747890	16 8 53.55990	0.000004	0.00020
2255-282	22 58 5.962870	-27 58 21.25650	0.000006	0.00020
2326-477	23 29 17.704380	-47 30 19.11500	0.000025	0.00060
2345-167	23 48 2.608500	-16 31 12.02200	0.000010	0.00020
2355-534	23 57 53.266130	-53 11 13.68980	0.000038	0.00050

Table NGS-3. Coordinates of the VLBI Antenna Reference Points (m). SSC(NGS) 91 R 01

Station	X	Sigma X	Y	Sigma Y	Z	Sigma Z
KAUAI	-5543845.8314	0.0039	-2054564.0685	0.0066	2387814.0981	0.0074
GILCREEK	-2281546.7849	0.0019	-1453644.8495	0.0025	5756993.3411	0.0049
HATCREEK	-2523969.6336	0.0016	-4123506.2164	0.0038	4147752.7916	0.0044
VNDNBERG	-2678094.4702	0.0016	-4525450.6962	0.0041	3597410.3441	0.0043
OVRO 130	-2409600.4676	0.0019	-4478349.4196	0.0046	3838603.4165	0.0046
MOJAVE	-2356170.7082	0.0007	-4646755.7570	0.0033	3668470.8040	0.0036
PIETOWN	-1640953.3950	0.0022	-5014815.9198	0.0053	3575412.1258	0.0048
PLATTVIL	-1240707.8262	0.0023	-4720454.1964	0.0078	4094481.7856	0.0067
HRAS	-1324210.6903	0.0008	-5332023.0047	0.0029	3232118.5365	0.0027
RICHMOND	961258.3149	0.0011	-5674089.9212	0.0019	2740533.8005	0.0014
NRAO 140	882880.2465	0.0018	-4924482.1373	0.0055	3944130.6613	0.0048
ALGOPARK	918035.1590	0.0008	-4346132.0742	0.0028	4561971.1468	0.0027
MARPOINT	1106629.6696	0.0818	-4882906.6861	0.3683	3938086.7692	0.2688
WESTFORD	1492206.9903	0.0000	-4458130.3473	0.0000	4296015.4853	0.0000
HAYSTACK	1492405.1360	0.0004	-4457266.3605	0.0009	4296881.7238	0.0008
SEST	1838237.6104	0.3784	-5258699.2466	0.0186	-3100588.2367	0.3427
DSS65	4849337.0162	0.0088	-360488.7985	0.0032	4114748.4181	0.0102
CHLBOLTN	4008310.4830	0.0132	-100650.7393	0.0095	4943794.4997	0.0210
EFLSBERG	4033947.8936	0.0151	486990.5254	0.0096	4900430.4927	0.0237
MEDICINA	4461370.4189	0.0049	919596.8330	0.0026	4449558.8114	0.0066
ONSALA60	3370606.4753	0.0032	711917.5530	0.0021	5349830.4289	0.0052
WETTZELL	4075540.3231	0.0036	931735.2983	0.0022	4801629.0201	0.0055
NOTO	4934563.5429	0.0135	1321201.2769	0.0053	3806484.0322	0.0128
HARTRAO	5085442.6962	0.0128	2668263.3569	0.0071	-2768697.5647	0.0082
SESHAN	-2831686.4572	0.0107	4675733.9731	0.0105	3275327.8308	0.0131
NOBEYAMA	-3871168.1479	0.1286	3428274.3027	0.1168	3723697.8992	0.1210
KASHIM34	-3997648.8525	0.0303	3276690.8924	0.0169	3724278.9620	0.0324
KASHIMA	-3997892.0438	0.0065	3276581.4211	0.0046	3724118.4315	0.0097
HOBART	-3950236.5546	0.0309	2522347.5325	0.0226	-4311562.8599	0.0270
DSS45	-4460935.1833	0.0199	2682765.7319	0.0155	-3674381.5210	0.0127
KWAJALEIN	-6143536.4038	0.0142	1363997.2967	0.0087	1034707.6491	0.0105

Table NGS-3 (cont.). Velocities of the VLBI Antenna Reference Points (m/yr) relative to the Minster-Jordan AM0-2 plate motion model. SSV(NGS) 91 R 01

Site	Vx	Sigma Vx	Vy	Sigma Vy	Vz	Sigma Vz
KAUAI	-0.00837	0.00189	-0.00878	0.00309	-0.01411	0.00352
GILCREEK	-0.00633	0.00088	0.00345	0.00118	-0.00887	0.00233
HATCREEK	-0.00363	0.00116	0.01350	0.00218	-0.00631	0.00244
VNDNBERG	-0.00112	0.00098	-0.00640	0.00210	-0.01319	0.00217
OVRO	-0.00685	0.00049	0.00576	0.00171	0.00190	0.00184
MOJAVE	-0.00269	0.00032	0.00823	0.00155	0.00071	0.00169
PIETOWN	0.00652	0.00109	0.01680	0.00259	-0.01791	0.00236
PLATTVIL	-0.00769	0.00214	-0.00795	0.00676	0.00011	0.00587
HRAS	-0.00103	0.00038	0.00002	0.00137	-0.00197	0.00128
RICHMOND	0.00069	0.00051	-0.00131	0.00091	0.00038	0.00063
NRAO 140	-0.00264	0.00036	0.00598	0.00112	-0.00601	0.00097
ALGOPARK	-0.00063	0.00033	0.00039	0.00110	-0.00205	0.00107
MARPOINT	-0.00307	0.01616	0.07062	0.07249	-0.03941	0.05329
WESTFORD	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
HAYSTACK	0.00022	0.00014	0.00032	0.00034	-0.00035	0.00032
SEST	0.07093	0.16020	0.00000	0.00000	-0.29060	0.14700
DSS65	-0.00197	0.00764	0.00252	0.00197	-0.00307	0.00836
CHLBOLTN	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
EFLSBERG	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MEDICINA	0.00304	0.00307	0.00210	0.00149	0.00413	0.00381
ONSALA	0.00093	0.00149	0.00194	0.00100	-0.00566	0.00247
WETTZELL	-0.00224	0.00167	0.00128	0.00102	-0.00956	0.00263
NOTO	-0.01550	0.00715	-0.00567	0.00275	-0.00616	0.00666
HARTRAO	0.00696	0.00612	-0.01606	0.00344	-0.02092	0.00390
SESHAN	0.00557	0.00538	-0.01753	0.00566	-0.03575	0.00648
NOBEYAMA	0.07280	0.06229	-0.07485	0.05655	-0.08481	0.05817
KASHIM34	-0.05626	0.01259	0.02452	0.00699	0.01286	0.01373
KASHIMA	0.01751	0.00310	0.01420	0.00217	-0.02021	0.00465
HOBART	0.00226	0.01357	-0.02954	0.01010	-0.01966	0.01190
DSS45	-0.00529	0.00931	-0.01505	0.00724	-0.01757	0.00601
KWAJALEIN	0.00102	0.00688	-0.00938	0.00409	-0.02314	0.00515

Table NGS-4. EOP(NGS) 91 R 02 Available from 1984 to 1991

Number of measurements and RMS uncertainty per year
Units : 0.0001s for UT1

YEAR	UT1 Nb	UT1 Sigma
1984	64	1.23
1985	159	0.60
1986	237	0.61
1987	246	0.63
1988	255	0.61
1989	234	0.63
1990	261	0.66
1991	75	0.61

EARTH ORIENTATION RESULTS FROM THE U.S. NAVAL OBSERVATORY VLBI PROGRAM

USNO 91 R 02

T.M. Eubanks, B.A. Archinal, M.S. Carter, F.J. Josties, D.N. Matsakis, and D. D. McCarthy, U.S. Naval Observatory, Washington, D.C., 20392-5100

As part of its participation in the National Earth Orientation Service (NEOS) the U.S. Naval Observatory (USNO) operates a program in Very Long Baseline Interferometry (VLBI) to monitor changes in the orientation of the Earth on a regular basis. NEOS is a joint cooperative effort of the USNO and the National Geodetic Survey (NGS), and this VLBI program is designed to complement the observations coordinated by the NGS as part of the International Radio Interferometric Surveying (IRIS) subcommission. The Naval Research Laboratory (NRL) and the Crustal Dynamics Project VLBI group at the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC) also assisted in the development of the program. The Navy VLBI Network (NAVNET) measures the orientation of the Earth in space from Mark III VLBI observations acquired with telescopes at Gilmore Creek, Alaska, Kokee Park, Hawaii, Richmond, Florida, Green Bank, West Virginia and, in the past, Maryland Point, Maryland. Radio telescopes at Mojave, California, Westford, Massachusetts, Algonquin Park, Canada, and Medicina and Noto, Italy, have also participated in these experiments on an occasional basis. Current NAVNET operations consist of one 24-hour duration observing session per week together with three-hour duration observing sessions on two other days of the week. These NAVNET data are used to estimate UT1, polar motion and nutation for inclusion in the International Earth Rotation Service (IERS) combined solutions. In addition, 1990 saw the commencement of a new series of experimental NAVNET measurements, known as the NAVNET Experimental (or NAVEX) series, using the Alaska, Hawaii and West Virginia stations in connection with a radio telescope in Matera, Italy. All of the currently available 24-hour-duration NAVNET and NAVEX data are provided in this report in a uniform reduction in the Navy 1991-2 reference frame, which will also be described.

The USNO VLBI program began observations in June, 1987, with a series of 8-hour GNUT (Goddard-Navy UT) experiments. These observing sessions mostly used the Maryland Point to Gilmore Creek baseline, although Kokee Park, Kauai, participated occasionally and Richmond, Florida, participated after the beginning of 1988. The GNUT experiments were under the operational control of the NRL, with assistance from the NASA-GSFC VLBI group. After a period of experimentation, routine NAVNET observations began on January 5, 1989, on a weekly basis using the Maryland, Alaska, Hawaii and Florida antennas. The Green Bank antenna provided its first VLBI data on January 25, 1989, and has participated in NAVNET observations since that time. The USNO assumed full operational control of the NAVNET experiments in April, 1989, and the use of the Maryland Point antenna was phased out in August, 1989. One 24-hour GNUT was observed in September, 1988; monthly 24-hour NAVNETs commenced in April, 1989, and all of the weekly NAVNETs have been 24 hours in duration since June 27, 1989. At present, one 24-hour NAVNET experiment is scheduled every week using at least three of the Florida, Alaska, Hawaii and West Virginia antennas. These data are reduced and released to NEOS and the IERS on a regular basis; typical processing times are now on the order of 8 to 14 days from the acquisition of data to release of the final results.

In cooperation with the Agenzia Spaziale Italizana, Centro di Geodesia Spaziale, the U.S. Naval Observatory NAVNET VLBI program has initiated a series of monthly NAVNET experimental (NAVEX) observing sessions using the new geodetic antenna in Matera, Italy, along with the Alaska, Hawaii and West Virginia NAVNET stations. This network is very well suited for the measurement of variations in the UT1, and it should be possible to routinely achieve UT1 formal errors of 10

microseconds of time or less. These errors are much less than the error caused by interpolation of the UT1, even over short durations, and these experiments are thus performed simultaneously with IRIS-A experiments conducted by the U.S. National Geodetic Survey to facilitate comparison of the NAVEX and IRIS-A data. Results from these series, although normally released separately, are included in Tables 6 and 7 with the other NAVNET Earth orientation data.This series is distinguished in Table 7 through the "I" station code (for Matera) in the station list.

The NAVNET VLBI data are acquired using Mark III VLBI data acquisition terminals with a nominal 8 X band and 6 S band channels, each with a 2 MHz bandwidth. These channels are spread across 85 MHz at S band and 350 MHz at X band, using the channel frequencies shown in Table 1, in order to improve the accuracy of the group delay estimates using the technique of band width synthesis. The NAVNET VLBI data have all been correlated at the Washington Correlator, which is located on the Naval Observatory grounds and is run by a consortium among the USNO, the NGS, the NRL, and NASA. The correlator provides estimates of the band with synthesis group delay and the phase delay rate from the radio noise recorded at the stations, together with estimates of the random (thermal) noise associated with each measurement and a quality factor describing the reliability of the measurement. Only observations with quality factors of 5 or higher are used in the USNO reduction of the NAVNET data. Observations with letter quality factors of A through F, which indicate serious problems with the correlated data, are also not used in the USNO reduction.

After correlation, fringe fitting, and the removal of any remaining bandwidth synthesis delay ambiguities, the NAVNET, NAVEX and GNUT 24-hour-duration multi-baseline data are used in a series of weighted least-squares solutions to define a USNO VLBI reference frame and to estimate the Earth orientation within that reference frame. The data are processed with IERS standard models to the maximum extent possible. The GSFC CALC 6.0 software is used in the data reduction process. The Minster and Jordan AM0-2 plate motion model is used without adjustment to describe the tectonic motions of the stations. The CFA 2.2 tropospheric mapping function is used to relate line of sight tropospheric propagation delays to the tropospheric zenith delay. Although the vertical deformations due to ocean tidal loading are modeled in the reduction process, the horizontal deformations are not, and ground deformations due to atmospheric loading are currently ignored.

Table 1 : NAVNET Channel Frequencies

Channel Number	Band	Frequency MHz
1	S	2217.99
2	S	2222.99
3	S	2237.99
4	S	2267.99
5	S	2292.99
6	S	2302.99
1	X	8210.99
2	X	8220.99
3	X	8250.99
4	X	8310.99
5	X	8420.99
6	X	8500.99
7	X	8550.99
8	X	8570.99

Unmodeled variations in the tropospheric propagation delays and the relative time offset between the station clocks are a significant source of error in geodetic VLBI. The surface pressure, temperature and relative humidity are recorded at each station and used to estimate the variations in the

hydrostatic zenith tropospheric propagation delay. Further variations in these quantities are treated by the estimation of piecewise linear models directly in the least squares solutions. A new piecewise linear function is introduced every 60 minutes for the zenith tropospheric propagation and every 90 minutes for the relative station clocks.

An attempt is made to align the NAVNET reference frame as closely as is possible with both the terrestrial and celestial reference frames maintained by the IERS, and to minimize bias offsets between the NAVNET Earth orientation parameter estimates and those of the IERS combined solutions. Due to software limitations, the NAVNET reference frame is obtained from the USNO VLBI data in a two solution process. In the first solution, the IERS Rapid Service (Bulletin A) estimates of the UT1 and polar motion are treated as a priori measurements and the nutation in longitude and obliquity is fixed at the IERS Rapid Service values, while the Right Ascension of the source 2216-038 is fixed at the value given in the IERS combined celestial reference frame for 1989 (R(IERS) 90 C 01). All other source coordinates, and all of the station coordinates except for the Richmond station, are adjusted in this solution. The purpose of this solution is to align the celestial reference frame with the celestial pole implied by the IERS Rapid Service nutation values. The coordinates of two sources, 0202+149 (in Right Ascension and Declination) and 0742+103 (in Declination only) are then fixed in a second solution to the values obtained in the first solution. This second solution globally adjusts the coordinates of all of the other sources and all of the station coordinates except for the Richmond station, together with an adjustment for UT1, Polar Motion, both components of nutation plus the piecewise linear clock and troposphere models separately for each experiment. The IERS Rapid Service estimates of the UT1 and polar motion are treated as a priori measurements in this solution. The position of the Richmond station at the epoch 1988.0 is fixed at the value given by the ITRF-89 for that epoch, and the station is allowed to move at the AM0-2 rate. Five radio sources (3C84, 3C273B, 3C345 and 3C454.3) were judged to have too much source structure to be usable for geodetic work and are no longer observed; these "deleted" sources were treated as "arc" parameters in the solution, with a separate position being estimated for each experiment in which they were observed. The USNO reference frame 1991-2 was obtained from such a solution using all of the USNO VLBI data from 1987 through February 7, 1991; this solution used a total of 39119 observation pairs (delay and delay rate) with a weighted rms residual scatter of +- 46.0 picoseconds for the delay observations and +- 99.2 femtoseconds per second for the delay rate data. Table 3 describes the stations used in NAVNET operations; the station coordinates for the NAVNET stations from the reference frame solution are given in Table 4, for the epoch 1980 October 17, while Table 5 provides the corresponding source positions. In Table 5 the Source Type (the "T" field) describes the quality of the position, with Reference ("R") and Primary ("P") sources having the most accurate positions. The Secondary ("S") sources have larger position formal errors but are still of use if no higher quality sources are available in the schedule, while the Tertiary ("T") sources are too weakly determined to be of use.

The Navy 1990-2 and 1991-2 reference frames are generally consistent except for rotational offsets. The following table gives the mean and the root mean square scatter about the mean, of the Navnet data, in the sense 1991-2 reference frame minus 1990-2 reference frame :

Table 2: Difference Between the 1990-2 and the 1991-2 weekly solutions in the sense new minus old.

I	AVG(I)	RMS (I)	RMS about Mean	Term
1	-1.0818	1.0906	0.13896	PM-X in Mas
2	-1.1887	1.2058	0.20245	PM-Y in Mas
3	-0.51385E-01	0.52117E-01	0.87020E-02	UT1 in Msec
4	-4.5814	4.5848	0.17447	PSI in MAS (unscaled)
5	0.65458	0.66024	0.86263E-01	Eps in Mas

Most of the differences are small; the biases in nutation have changed to align the Navnet data with the IERS central bureau celestial pole, rather than the internal USNO pole previously used as a reference.

The NAVNET 24-hour experiments are nominally performed on Wednesday and Thursday of each week. Earth orientation results from these data are generally available within eight to fourteen days after the end of the experiment, by the Thursday of the second week after the experiment. The NAVNET Earth orientation results in Tables 6 and 7 are obtained from the 24-hour experiments in a multi-parameter least squares adjustment for UT1, polar motion and both components of nutation, together with the piecewise linear clock and troposphere models. Additional baseline dependent clock offsets are added whenever the non-closure of the clock estimates around station triangles is judged to be significant. This solution used a total of 40368 observation pairs (delay and delay rate) and produced weighted rms residual scatters of +- 46.3 picoseconds for the delay observations and +- 98.9 femtoseconds per second for the delay rate data. (This solution included a few more recent experiments than were available for the reference frame solution.) The station coordinates and source positions are fixed at the a priori values given by the Navy 1991-2 reference frame; the positions of the tertiary sources and the deleted sources are treated as arc parameters, with a separate position being estimated for each experiment in which they were observed. The tie to the 1991-2 reference frame is thus obtained by the fixed station coordinates and source positions; this method avoids week to week variations in the reference frame used in the reduction of the NAVNET data. Although the Earth orientation parameter formal errors thus do not fully reflect errors introduced by uncertainties in the station coordinates and source positions, solutions performed without these constraints indicate that inclusion of these errors would not significantly increase the resulting Earth orientation parameter formal errors.

The errors presented in this report are formal errors obtained from the covariance matrix of the least squares adjustment. The post fit residual scatter is always larger than would be expected given the formal error estimates for the delay and delay rate observables provided by the correlator. The total residual scatter is made to agree with that expected given the observable error estimates through addition of empirically determined "noise" additive variances to the square of the correlator formal error estimates. These additive variances are determined separately for each experiment; different constants are used for the delay and delay rate data from each baseline used in an experiment. Table 7 (available on request from the Central Bureau of IERS) presents the full covariance matrix for each 24-hour experiment in the form of parameter sigmas and all ten correlation coefficients between the five Earth orientation parameters. Note that the parameter formal errors in Table 7 have all been scaled to milliseconds of arc on the ground or in the sky, so that the relative ability to determine these parameters can be ascertained easily.

Questions, comments or requests to be placed on the NAVNET distribution list should be directed to T.M. Eubanks, Code TSEO, U.S. Naval Observatory, Washington D.C. 20392-5100, by phone at (202) 653-1501, on SPAN at CDDIS::USNO or USNO01::TME, and on Internet at tme@casa.usno.navy.mil or tme@usno01.usno.navy.mil.

Table 3: Stations Participating in the U.S. Navy VLBI Program

Station	Location	Station ID Code
GILCREEK	Fairbanks, Alaska	A
KAUAI	Kokee Park, Kauai, Hawaii	K
RICHMOND	Richmond, Florida	R
NRAO85 3	Green Bank, West Virginia	W
MARPOINT	Maryland Point, Maryland	N
MOJAVE12	Mojave, California	M
WESTFORD	Westford, Massachussetts	E
ALGOPARK	Algonquin Park, Canada	G
MEDICINA	Medicina, Italy	B
NOTO	Noto, Italy	S
MATERA	Matera, Italy	I

Table 4 : NAVNET Station Locations in the 1991-2 Reference Frame. SSC(USNO) 91 R 02

Domes ID	Station Name	X Meters	Y Meters	Z Meters	Mean MJD	Data Span Days	X Err	Y Err	Z Err
							--- Meters ---		
40499S001	RICHMOND	961258.203	-5674090.097	2740533.719	47850.0	871.0	0.0	0.0	0.0
40408S002	GILCREEK	-2281546.953	-1453645.149	5756993.237	47855.0	881.0	0.002	0.003	0.003
40424S001	KAUAI	-5543845.886	-2054564.837	2387813.532	47855.0	881.0	0.002	0.004	0.004
40441S002	NRAO85 3	882325.800	-4925138.050	3943397.595	47957.5	676.0	0.001	0.002	0.001
40490S001	MARPOINT	1106629.530	-4882907.239	3938086.886	47589.0	349.0	0.002	0.006	0.005
40405S001	MOJAVE12	-2356170.818	-4646755.983	3668470.691	47924.5	416.0	0.003	0.006	0.004
72097S301	WESTFORD	1492206.836	-4458130.570	4296015.418	47957.5	15.0	0.002	0.005	0.004
12717S001	NOTO	4934563.254	1321200.858	3806484.158	47748.0	64.0	0.010	0.007	0.012
40104S001	ALGOPARK	918035.012	-4346132.312	4561971.069	48086.5	36.0	0.002	0.005	0.005
12734S005	MATERA	4641938.981	1393002.635	4133325.297	48224.0	111.0	0.010	0.007	0.011

Table 5. RADIO SOURCE COORDINATES RSC(USNO) 91 R 02

SOURCE	RIGHT ASCENSION	DECLINATION	SIGMA R.A.	SIGMA D.
	H M S	o ' "	S	"
0016+731	0 19 45.786133	73 27 30.01745	0.000032	0.00010
0048-097	0 50 41.317364	- 9 29 5.20985	0.000010	0.00039
0104-408	1 6 45.107978	-40 34 19.95812	0.000065	0.00256
0106+013	1 8 38.771090	1 35 0.31712	0.000007	0.00018
0119+041	1 21 56.861672	4 22 24.73429	0.000005	0.00010
0133+476	1 36 58.594694	47 51 29.09994	0.000011	0.00010
0201+113	2 3 46.656993	11 34 45.40954	0.000017	0.00028
0202+149	2 4 50.413860	15 14 11.04322	********	0.00000
0212+735	2 17 30.813039	73 49 32.62230	0.000041	0.00016
0229+131	2 31 45.894059	13 22 54.71721	0.000019	0.00042
0234+285	2 37 52.405603	28 48 8.99019	0.000006	0.00009
0235+164	2 38 38.930059	16 36 59.27481	0.000005	0.00009
0237-233	2 40 8.174427	-23 9 15.72847	0.000041	0.00135
0256+075	2 59 27.076590	7 47 39.64363	0.000027	0.00069
0300+470	3 3 35.242119	47 16 16.27570	0.000007	0.00010
0333+321	3 36 30.107611	32 18 29.34274	0.000021	0.00028
0336-019	3 39 30.937780	- 1 46 35.80421	0.000014	0.00044
0402-362	4 3 53.749921	-36 5 1.91100	0.000019	0.00110
0420-014	4 23 15.800710	- 1 20 33.06458	0.000005	0.00009
0434-188	4 37 1.482719	-18 44 48.61176	0.000017	0.00063
0454-234	4 57 3.179214	-23 24 52.01897	0.000007	0.00032
0458-020	5 1 12.809862	- 1 59 14.25554	0.000009	0.00021
0528+134	5 30 56.416708	13 31 55.15001	0.000005	0.00009
0552+398	5 55 30.805552	39 48 49.16579	0.000007	0.00011
0657+172	7 0 1.525513	17 9 21.70232	0.000007	0.00011
0716+714	7 21 53.448419	71 20 36.36460	0.000031	0.00018
0727-115	7 30 19.112437	-11 41 12.59945	0.000006	0.00017
0742+103	7 45 33.059477	10 11 12.69323	0.000006	1.00000
0745+241	7 48 36.109258	24 0 24.11094	0.000009	0.00011
0814+425	8 18 15.999599	42 22 45.41587	0.000012	0.00010
0851+202	8 54 48.874913	20 6 30.64161	0.000007	0.00007
0859+470	9 3 3.990116	46 51 4.13823	0.000016	0.00018
0923+392	9 27 3.013903	39 2 20.85268	0.000011	0.00007
0925-203	9 27 51.824307	-20 34 51.23359	0.000046	0.00159
1034-293	10 37 16.079650	-29 34 2.81029	0.000013	0.00057
1055+018	10 58 29.605177	1 33 58.82429	0.000009	0.00021
1123+264	11 25 53.711894	26 10 19.97898	0.000012	0.00019
1124-186	11 27 4.392344	-18 57 17.43925	0.000014	0.00067
1144+402	11 46 58.297944	39 58 34.30492	0.000019	0.00018
1144-379	11 47 1.370563	-38 12 11.01756	0.000060	0.00236
1222+037	12 24 52.421853	3 30 50.29318	0.000019	0.00058
1244-255	12 46 46.801955	-25 47 49.28871	0.000023	0.00104
1253-055	12 56 11.166449	- 5 47 21.52357	0.000007	0.00023
1308+326	13 10 28.663880	32 20 43.78284	0.000009	0.00014
1313-333	13 16 7.985865	-33 38 59.17054	0.000049	0.00201

Table 5. RADIO SOURCE COORDINATES (cont.) RSC(USNO) 91 R 02

SOURCE	RIGHT ASCENSION H M S	DECLINATION o ' "	SIGMA R.A. S	SIGMA D. "
1334-127	13 37 39.782717	-12 57 24.69273	0.000009	0.00036
1354-152	13 57 11.244884	-15 27 28.78380	0.000013	0.00057
1404+286	14 7 0.394397	28 27 14.68986	0.000009	0.00017
1418+546	14 19 46.597488	54 23 14.78676	0.000014	0.00014
1502+106	15 4 24.979772	10 29 39.19820	0.000009	0.00023
1510-089	15 12 50.532871	- 9 5 59.82951	0.000007	0.00029
1519-273	15 22 37.675895	-27 30 10.78655	0.000017	0.00101
1548+056	15 50 35.269219	5 27 10.44718	0.000007	0.00024
1611+343	16 13 41.064255	34 12 47.90825	0.000007	0.00018
1622-253	16 25 46.891598	-25 27 38.32569	0.000015	0.00061
1633+382	16 35 15.492982	38 8 4.49979	0.000009	0.00018
1637+574	16 38 13.456324	57 20 23.97857	0.000021	0.00025
1642+690	16 42 7.848641	68 56 39.75557	0.000024	0.00017
1730-130	17 33 2.705745	-13 4 49.54857	0.000009	0.00039
1739+522	17 40 36.977840	52 11 43.40640	0.000010	0.00017
1741-038	17 43 58.856100	- 3 50 4.61733	0.000006	0.00027
1749+096	17 51 32.818550	9 39 0.72756	0.000007	0.00025
1803+784	18 0 45.684036	78 28 4.01739	0.000029	0.00015
1823+568	18 24 7.068343	56 51 1.48978	0.000015	0.00018
1921-293	19 24 51.055929	-29 14 30.12151	0.000010	0.00038
1923+210	19 25 59.605366	21 6 26.16113	0.000015	0.00026
1928+738	19 27 48.495151	73 58 1.56888	0.000028	0.00014
2037+511	20 38 37.034678	51 19 12.66133	0.000011	0.00013
2121+053	21 23 44.517356	5 35 22.09261	0.000007	0.00020
2128-123	21 31 35.261705	-12 7 4.79837	0.000017	0.00086
2145+067	21 48 5.458640	6 57 38.60313	0.000005	0.00017
2200+420	22 2 43.291285	42 16 39.97897	0.000008	0.00011
2216-038	22 18 52.037705	- 3 35 36.88009	0.000006	0.00020
2230+114	22 32 36.408860	11 43 50.90358	0.000006	0.00016
2234+282	22 36 22.470823	28 28 57.41264	0.000006	0.00011
2243-123	22 46 18.231956	-12 6 51.27758	0.000019	0.00116
2253+417	22 55 36.707790	42 2 52.53184	0.000021	0.00038
2255-282	22 58 5.962940	-27 58 21.25715	0.000015	0.00054
2345-167	23 48 2.608535	-16 31 12.02116	0.000010	0.00038
2355-106	23 58 10.882394	-10 20 8.61086	0.000008	0.00036

Table 6: EOP(USNO) 91 R 02 Available from 1988 to 1991

Number of measurements and RMS uncertainty per year
Units : 0.001" for X,Y,dψ,dε; 0.0001s for UT1

YEAR	X		Y		UT1		dψ		dε	
	Nb	Sigma	Nb	Sigma	Nb	Sigma	Nb	Sigma	Nb	Sigma
1988	1	1.74	1	2.38	1	0.83	1	1.26	1	0.47
1989	28	0.63	28	0.79	28	0.35	28	0.54	28	0.24
1990	53	0.36	53	0.44	53	0.20	53	0.41	53	0.16
1991	26	0.28	26	0.27	26	0.16	26	0.39	26	0.16