EARTH ROTATION (UT0-UTC AND VARIATION OF LATITUDE) BY ANALYZING LUNAR LASER RANGING

FSG 94 M 01

J.Mueller, M.Schneider, U.Schreiber
Forschungseinrichtung Satellitengeodaesie (FSG), Technical University Munich
80290 Munich, Germany

M.Soffel, H.Ruder
Theoretical Astrophysics, University Tuebingen
Auf der Morgenstelle 10, 72076 Tuebingen, Germany

We have analyzed Lunar Laser Ranging (LLR) data acquired between 1970 and early 1994. The observations are taken from the usual five sites: McDonald (three locations), Grasse and Haleakala; some normal points and quick-look returns from Wettzell are added to test their quality. All in all more than 8500 LLR measurements are used.

In a first step outliers have been eliminated. Then we performed a least-squares fit to weighted observations and determined the parameters of the Earth-Moon system.

The ephemeris of the Moon and the planets are computed with our own ephemeris program; the lunar librations were integrated simultaneously. The initial values for the integration are taken from the ephemeris DE200. A detailed description of our analysis model is given e.g. in Mueller *et al.* (1991) or Mueller *et al.* (1992).

The constants adopted for the computations are those of the IAU recommendations resp. the IERS standards (1992); however some nutation coefficients had been changed by introducing better values (e.g. for the 9-year, the annual, the half-year and the half-month coefficients).

The station coordinates have been corrected for plate motion (NUVEL NNR-1 model); the base epoch for plate motion is December 10, 1991 (MJD 48600). For some stations clock biases have been estimated.

The Earth orientation parameters are taken from a solution generated by R. Gross called SPACE93; they are introduced as a priori values in our LLR model and will be improved in a second step.

The parameters determined are station coordinates (relativistic geocentric frame), reflector coordinates (relativistic selenocentric frame), position and velocity of the Earth-Moon barycenter for one epoch, position and velocity of the lunar barycenter for an initial epoch, physical libration angles and angular velocities for this epoch, the lowest mass multipole moments of the Moon, the mass of the Earth-Moon system, the lunar Love number and one dissipation parameter, the lag angle (lunar tidal acceleration), a correction to the luni-solar precession constant and the four (two in-phase and two out-of-phase) coefficients of the 18.6 year nutation period; for them constraints indicated in Williams *et al.* (1991) have been used. Besides these parameters rates for UT1 and polar motion have been estimated.

The post-fit residuals are analyzed by the daily-decomposition method (Dickey *et al.*, 1985) to obtain improved values for UT0-UTC and variation of latitude (VOL) for each reflector station pair on every night for which sufficient data are available (at least two normal points per night are needed); the time span between the first and the last normal point has to be 1.5 hours (in some cases a coverage of only 1 hour was accepted). 1507 pairs were found. In a further step the bad ones have been eliminated and the others have been smoothed using a spline filter. The series of Earth rotation parameters (UT0-UTC and VOL) have been provided to the IERS Central bureau, designated EOP(FSG) 94 M 01.

These improved values for the Earth rotation have been used in a further iteration of the global adjustment of the LLR data. The final results for the station coordinates have been provided to the IERS Central Bureau. Its designation is SSC(FSG) 94 M 01.

Besides the parameters sent to the IERS a lot of others have been determined and are available on request. To these parameters belong the main parameter of the Earth-Moon system mentioned above and relativistic quantities like the metric parameters gamma and beta, the Nordtvedt parameter eta (strong equivalence principle), the geodetic precession of the lunar orbit, the time variation of the gravitational constant, one parameter for testing Newton's inverse square law and one parameter indicating a violation of special relativity.

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References

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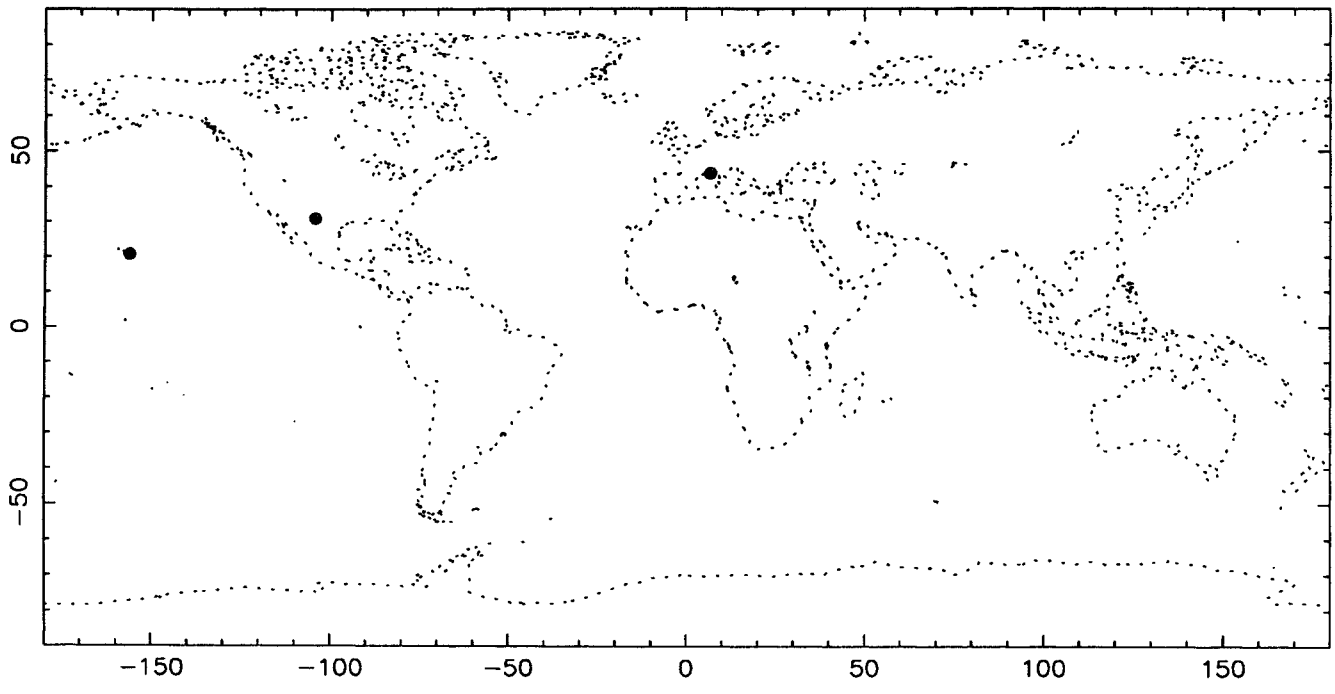
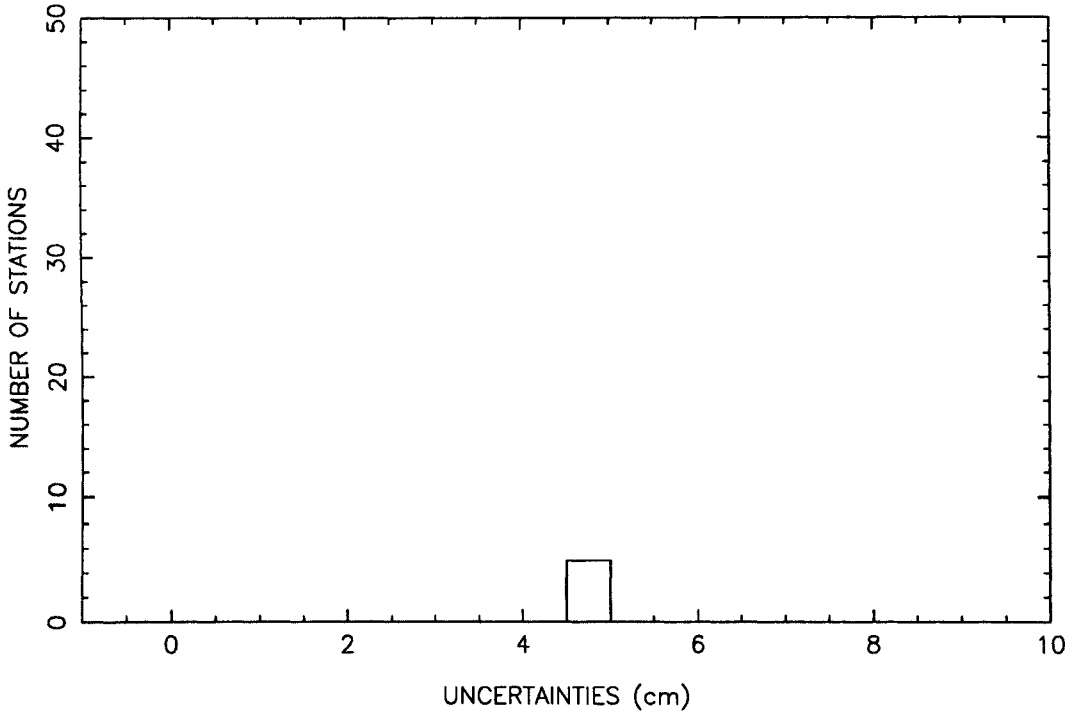
Summary description of the terrestrial system attached to the set of station coordinates SSC(FSG) 94 M 01

1 - Technique :	LLR
2 - Analysis Center :	FSG/Techn. Univ. Munich
3 - Solution Identifier :	SSC(FSG) 94 M 01
4 - Software used :	FSG LLR software
5 - Relativity scale :	Geocentric
6 - Permanent tidal correction on station :	No
7 - Tectonic plate model :	NUVEL NNR-1
8 - Velocity of light (C) :	299792.458 km/sec
9 - Geogravitational constant (GMo) :	adjusted: 398600.448 km^3/sec^2 (geocentric)
10 - Reference epoch :	December 10, 1991 (MJD 48600)
11 - Adjusted Parameters :	cartesian coordinates of stations x, y, z (rates fixed)
12 - Definition of the origin :	Geocenter (center of mass)
13 - Definition of the orientation :	EOP from 1970 to 1994 taken from SPACE93 (aligned with IERS system)
14 - Constraint for time evolution :	Constrained to NUVEL NNR-1; estimation of UT1 and polar motion rates during the global solution



Distribution of the 3 sites of the terrestrial frame SSC(FSG) 94 M 01.



Distribution of the uncertainties (quadratic mean of σ_x, σ_y, σ_z) for the 5 stations of the terrestrial frame SSC(FSG) 93 M 01.

EOP(FSG) 94 M 01 From Oct 1970 to Jan 1994

Number of measurements per year and median uncertainties
Units : 0.001" for φ; 0.0001s for UT0.

YEAR	φ		UTO	
	Nb	Sigma	Nb	Sigma
1970	7	15.00	7	10.00
1971	21	15.00	21	10.00
1972	62	10.40	62	3.92
1973	105	15.00	105	10.00
1974	68	15.00	68	10.00
1975	82	15.00	82	10.00
1976	77	15.00	77	7.02
1977	70	15.00	70	10.00
1978	58	15.00	58	10.00
1979	62	15.00	62	10.00
1980	68	15.00	67	10.00
1981	29	15.00	29	10.00
1982	3	6.84	3	3.39
1983	6	15.00	6	10.00
1984	78	7.85	78	4.96
1985	175	7.80	175	3.61
1986	42	4.00	42	1.75
1987	39	3.68	39	1.26
1988	49	1.46	49	0.94
1989	51	1.34	51	0.79
1990	98	1.47	98	0.84
1991	63	1.58	63	0.85
1992	81	1.76	81	1.30
1993	102	1.61	102	0.82