ILRS SLR Data Analysis Standards*

*(in place today – Dec. 2009)

Erricos C. Pavlis

Goddard Earth Sciences and Technology Center and

NASA Goddard

UAW 2009, San Francisco CA

ILRS parameterization used by analysis centers for operational products	
Software	EPOS,DOGS, GEODYN, GINS, SATAN, etc.
ILRS Products	Weekly solution for coordinates of global SLR stations and daily Earth Orientation Parameters: x,y-pole, LOD, (SINEX format)
Satellites Used	LAGEOS-1, LAGEOS-2, ETALON-1, ETALON-2
speed of light (m/s)	299792458
Wavelengths (nm)	532.0, 423.0, 847.0 & 694.3 (depends on station)
Elevation cutoff (°)	3°
weighting	1.0 m/1000 m or as ACs decide (reported)
range biases	est/d according to ILRS principles (core – noncore sites)
time biases	not est/d (modeled for accepted known biases)

troposphere biases		not modeled/estimated
Data Editing		3.5 sigma editing
Troposphere		Mendes - Pavlis (IERS Conventions 2003)
Ionosphere		not modeled/estimated
Relativity	scale	LET (TT time scale)
	effects	Light-time correction
Satellite CM	Lageos	0.251 m (0.245 m for 7840)
	Etalon	0.580 m or 0.610 m
Geopotential	model	GGM02C (static terms through degree and order 30, C(2,0), C(2,1) and S(2,1) time dependent)
	GM (km^3/s^2)	398600.4415
	a_e (km)	6378.1363
	$1/f$	298.2564
Third-body		Mercury, Venus, Earth Moon, Mars, Jupiter, Saturn, Uranus, Neptune

Planetary ephemeris		JPL DE403
Solar Radiation Pressure	source	IERS Conventions 2003
	direct radiation	applied
	albedo radiation	applied
	Earth thermal radiation	applied
	Earth Shadow model	penumbra: included
	reflection radiation	
	Reemitted radiation	not applied
Satellite Thermal Thrust	LAGEOS	estimation of empirical (e.g. constant and once-per-rev) along-track and (once-per-rev) cross-track accelerations (2 sets per weekly solution)
	ETALON	estimation of empirical (constant and once-per-rev) along-track and (once-per-rev) cross-track accelerations (1 sets per weekly solution)
Tidal Forces	Solid Earth	IERS 2003 Conventions model

	Ocean	Ray GOT00.2 or GOT4.7 or FES2004, etc.
Atmospheric Gravitational Attraction		not modeled/estimated
Dynamic PM	$\Delta C_{2,1}$ and $\Delta S_{2,1}$	applied, (IERS2003)
Relativity	point-mass accelerations	yes
	Lense-Thirring effect	yes
	Corriolis force	yes
Numerical Integration		e.g. Cowell-Adams 11th order predictor-corrector
LAGEOS	integration step	L1: 150 s, L2: 60 s
	arc length	7 days
ETALON	integration step	E1 & E2: 300 s
	arc length	7 days
Orbital	initial position and	for each satellite (unconstrained)

Parameters	velocity estimated	for each satellite (unconstrained)
	Solar Radiation pressure	C_r kept fixed at 1.13 for LAGEOS, for ETALON 1.30
	Empirical accelerations	unconstrained
Stations	Defintion	SLR monument (ILRS eccentricities subtracted) at mean epoch of each arc
	a priori values	SLRF2005
	a priori standard deviation	~1 m
Tropospheric bias		not estimated
EOP	definition	x-pole, y-pole and LOD
	epoch	noon each day
	frequency	daily
	a priori values	IERS 05 C04
	a priori standard	~1 m

	deviations	
a priori range bias	value	0 m or ILRS-adopted fixed values
	standard deviation	100 m
Constraints	Stations and EOP	loose constraints ~1 m
Inertial Frame:		J2000.0
Terrestrial Frame:	station coordinates	SLRF2005
	station velocities	SLRF2005 or NUVEL-1A NNR
	tidal corrections:	
	tidal uplift	IERS 2003 Conventions
	ocean loading	GOT00.2 or GOT4.7 or FES2004, etc.
	atmospheric pressure	not modeled/estimated
	geocenter motion	not explicitly modeled
	geocenter tidal variations	IERS 2003 Conventions
	pole tide	IERS 2003 Conventions (including ocean)

	origin	$C_{1,0} = C_{1,1} = S_{1,1} = 0$
	orientation	IERS 05 C04
Precession		IERS 2003 corrections
Nutation		IAU 2000A
Celestial Pole		IERS 2003 Conventions
Relationship between UT1 and GMST		IERS 05 C04
EOP		IERS 05 C04 *a priori*
Tidal variations in COM, UT1 and PM		IERS 2003 Conventions

Stn pad ID	Name	Pulse length (ps)	Detector	Regime (single, few, multi)	Editing Level (×σ)	Calib. St. error (mm)	ETALON CoM range (mm)	ETALON CoM ADOPTED (mm)
1873	Simeiz	350	PMT	No CNTL	2.0	60	593-603	598
1879	Altay	150	PMT	No CNTL	2.5	20	600-610	605
1884	Riga	130	PMT	CNTLD s->m	2.0	10	602-612	607
7080	McDonald	200	MCP	CNTLD s->m	3.0	8.5	598-608	603
7090	Yaragadee	200	MCP	CNTLD f->m	3.0	4.5	598-608	603
7105	Greenbelt	200	MCP	CNTLD f->m	3.0	5	598-608	603
7110	Mon. Peak	200	MCP	CNTLD f->m	3.0	5	598-608	603
7119	Haleakala	200	MCP	CNTLD f->m	3	4.5	598-608	603
7124	Tahiti	200	MCP	CNTLD f->m	3.0	6	598-608	603
7237	Changchung	200	CSPAD	CNTLD s->m	2.5	10	570-580	575
7249	Beijing	200	CSPAD	No CNTL, m	2.5	8	570-580	575
7355	Urumqui	30	CSPAD	No CNTL	2.5	15	576-586	581
7358	Tanegashima	50	MCP	No CNTL	3	1.3	602-612	607
7405	Conception	200	CSPAD	CNTLD s	2.5	15	573-577	575
7406	San Juan	40	CSPAD	No CNTL	2.5	8	576-586	581
7501	Harteb.	200	PMT	CNTLD f->m	3.0	5	598-608	603
7806	Metsahovi	50	PMT	?	2.5	15	602-612	607
7810	Zimmerwald	300	CSPAD	CNTLD s->f	2.5	20	570-574	572
7811	Borowiec	40	PMT	No CNTL f	2.5	16	602-612	607
7824	San Fernando	100	CSPAD	No CNTL s->m	2.5	30	573-583	578
7825	Stromlo	10	CSPAD	CNTLD s->m	2.5	4	576-586	581
7832	Riyadh	100	CSPAD	CNTLD s->m	2.5	10	573-583	578
7835	Grasse	50	CSPAD	CNTLD s->m	2.5	6	604-613	609
7836	Potsdam	35	PMT	CNTLD s->m	2.5	10	604-613	609
7838	Simosato	100	MCP	CNTLD s->m	3.0	20	602-612	607
7839	Graz	35	CSPAD	No CNTL m	2.2	3	569-579	574
7839	Graz kHz	10	CSPAD	No CNTL s->f	2.2	3	571-577	574
7840	Herstmonceux	100	CSPAD	CNTLD s	3.0	6	563-567	565
7840	Hx kHz	10	CSPAD	CNTLD s	-1.5,+2.5	3	563-567	565
7841	Potsdam 3	50	PMT	CNTLD s->f	2.5	10	606-612	609
7941	Matera	40	MCP	No CNTL m	3.0	1	607-613	610
8834	Wettzell	80	MCP	No CNTL f->m	2.5	10	603-613	608

Stn pad ID	Name	Pulse length (ps)	Detector	Regime (single, few, multi)	Editing Level (×σ)	Calib. St. error (mm)	LAGEOS St. error (mm)	LAGEOS CoM range (mm)	LAGEOS CoM ADOPTED (mm)
1873	Simeiz	350	PMT	No CNTL	2.0	60	70	248-244	246
1879	Altay	150	PMT	No CNTL	2.5	20	36	254-248	251
1884	Riga	130	PMT	CNTLD s->m	2.0	10	15	252-248	250
7080	McDonald	200	MCP	CNTLD s->m	3.0	8.5	13	250-248	249
7090	Yaragadee	200	MCP	CNTLD f->m	3.0	4.5	10	250-248	249
7105	Greenbelt	200	MCP	CNTLD f->m	3.0	5	10	250-248	249
7110	Mon. Peak	200	MCP	CNTLD f->m	3.0	5	10	250-248	249
7119	Haleakala	200	MCP	CNTLD f->m	3	4.5	10	250-248	249
7124	Tahiti	200	MCP	CNTLD f->m	3.0	6	10	250-248	249
7237	Changchung	200	CSPAD	CNTLD s->m	2.5	10	15	250-245	248
7249	Beijing	200	CSPAD	No CNTL, m	2.5	8	15	255-247	251
7355	Urumqui	30	CSPAD	No CNTL	2.5	15	30	255-247	251
7358	Tanegashima	50	MCP	No CNTL	3	1.3	5	252-248	250
7405	Conception	200	CSPAD	CNTLD s	2.5	15	20	246-245	246
7406	San Juan	40	CSPAD	No CNTL	2.5	8	15	246-255	250
7501	Harteb.	200	PMT	CNTLD f->m	3.0	5	10	250-244	247
7806	Metsahovi	50	PMT	?	2.5	15	17	254-248	251
7810	Zimmerwald	300	CSPAD	CNTLD s->f	2.5	20	23	246-244	245
7811	Borowiec	40	PMT	No CNTL f	2.5	16	23	256-250	253
7824	San Fernando	100	CSPAD	No CNTL s->m	2.5	30	25	252-246	249
7825	Stromlo	10	CSPAD	CNTLD s->m	2.5	4	10	257-247	252
7832	Riyadh	100	CSPAD	CNTLD s->m	2.5	10	15	252-246	249
7835	Grasse	50	CSPAD	CNTLD s->m	2.5	6	15	255-246	250
7836	Potsdam	35	PMT	CNTLD s->m	2.5	10	20	256-252	254
7838	Simosato	100	MCP	CNTLD s->m	3.0	20	40	252-248	250
7839	Graz	35	CSPAD	No CNTL m	2.2	3	9	255-250	252
7839	Graz kHz	10	CSPAD	No CNTL s->f	2.2	3	9	255-250?	252
7840	Herstmonceux	100	CSPAD	CNTLD s	3.0	6	15	246-244	245
7840	Hx kHz	10	CSPAD	CNTLD s	-1.5,+2.5	3	9	245	245
7841	Potsdam 3	50	PMT	CNTLD s->f	2.5	10	18	254-248	251
7941	Matera	40	MCP	No CNTL m	3.0	1	5	252-248	250
8834	Wettzell	80	MCP	No CNTL f->m	2.5	10	20	252-248	250