LAGEOS-1 & LAGEOS-2 Quick-look Residual Analysis

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Abstract

LAGEOS-1 & LAGEOS-2 quicklook residual analysis is introduced in detail in this paper. The method for analysing the data, the force models used and the estimated parameters should be changed with the different purposes. The results obtained from several schemes were compared with each other in orbital estimate. We have analysed the stability of the results for every scheme in detail. The adopted scheme by SHAO was selected from the above schemes. In this paper, the results of LAGEOS quick-look residual analysis from Dec.31, 1998 to Jun.29, 1999 are given. The results show the rms of residuals for 3-day arc about 1cm. The SHAO has begun the service of LAGEOS-1 & LAGEOS-2 quick-look residual analysis since Oct.1, 1999, and published at the web site of Shanghai Observatory:

http://center.shao.ac.cn.

Keywords: quick-look residual analysis, satellite laser ranging.

1. Introduction

The SLR technique has been greatly developed during last 30 years. Now the precision has reached 1 cm level or better. It is very important for the observation stations acquire the feedback information of their observation results in time. The SLR quick-look residual analysis requires high accurate orbits of satellites. The rms of orbit determination must be close to the ranging precision of the global observation stations.

Shanghai Astronomical Observatory (SHAO) began the work at the end of 1997. SHAO orbit determination software was improved according to IERS conventions (1996). Now SHAO can deal with SLR quick-look residual analysis, and can satisfy the Chinese SLR network requirement. The report of SLR quick-look residual analysis of lageos-1 and lageos-2 was put on the SHAO web site biweekly last year, and it has been published weekly this year.

2. Determination of LAGEOS orbits

In the processing of the quick-look residual analysis, the force models, the measurement model, and the reference frame adopted are as follows:

Force models:

JGM3 earth gravity field; Earth rotation deformation perturbation; Moon's oblateness perturbation; Luni-solar and planetary gravity perturbations; dynamic solid earth tide model (IERS 1996); dynamic ocean tide model (UTCSR); Solar radiation pressure (Cr adjusted); Earth's radiation pressure; drag or drag-like perturbation (Cd adjusted); relativistic perturbation; empirical RTN acceleration; Lageos-1 Yarkovsky force model;

Measurement model:

Marini and Murray tropospheric refraction model; solid earth tide displacement (IERS 1996); ocean loading site displacement; permanent deformation; rotational deformation due to polar motion; short period tidal variations in the earth's rotation; relativistic correction in time and coordinate.

Reference frame:

Mean equinox and equator of J2000.0; ITRF97 station coordinates and velocities; IAU 1976 precession; IAU 1980 nutation and celestial pole offsets (IERS); DE403/LE403 planetary ephemeris; TAI as the coordinate time scale of the earth-center.

3. Choice of the estimated parameters

To obtain the orbit of LAGEOS with high precision, the estimated parameters must be considered carefully. The weighted root-mean-square residuals for the global SLR quick-look data in 3 days with respect to the LAGEOS's orbit estimated should be as small as possible. For this purpose, the following schemes are considered:

1． $\vec{r},\dot{\vec{r}}$, *C_t, C_t-dot, C_r, C_r-dot ,EOP ,diurnal and semi-diurnal EOP*；

2． $\vec{r},\dot{\vec{r}}$, *C_t, C_t-dot, C_r, C_r-dot ,diurnal EOP*；

3． $\vec{r},\dot{\vec{r}}$, *C_t, C_r, EOP, diurnal and semi-diurnal EOP*；

4． $\vec{r},\dot{\vec{r}}$, *C_t, C_t-dot, C_r, C_r-dot, EOP, diurnal and semi-diurnal EOP*，*Empirical*

RTN acceleration；

5．*the first scheme and* $\vec{R}$ 、$\vec{T}$ *components of empirical RTN acceleration*；

6．*the first scheme and* $\vec{T}$ 、$\vec{N}$ *components of empirical RTN acceleration*；

7．*the first scheme and* $\vec{R}$ 、$\vec{N}$ *components of empirical RTN acceleration*。

(above $\vec{r}, \dot{\vec{r}}$ are the satellite's position vector and velocity vector; C_t ,C_t-dot are parameter and its variation of like-drag perturbation; C_r , C_r-dot are parameter and its variation of solar radiation pressure; EOP is the earth orientation parameters.)

The result of every choice is showed in the Table 1 . The rms of the schemes is less than 2cm. According to table 1, the fifth scheme is chosen. The result of the fifth scheme is not the best but is the most stable one.

The differences from different schemes are listed in Table 2.

4. Results

The SHAO has begun the service of SLR quick-look residual analysis. The report per week is published at SHAO web site, its address is as follows:

http://center.shao.ac.cn/newsletter/ (202.127.29.4)

The results of the quick-look residual analysis in the second quarter of 1999 are listed in Table 3.

References

1. Huang Cheng, Accurately Determining the Earth Orientation Parameters with the data of LAGEOS Satellite Laser Ranging, Doctorate thesis, Shanghai Astronomical Observatory, June.1985.
2. Dennis D.McCarthy, IERS Conventions (1996), IERS TECHNICAL NOTE 21 July 1996, Central Bareau of IERS - Observatoire de Paris.
3. ZHU Sheng-yuan, et al. The Problem in ERP Determination Caused by the Variation of ERP .Acta Astronomica Sinca, Vol.26, No.4, 1985.
4. FENG Chu-gang,et al. An Analysis for LAGEOS SLR Global Normal Point Data of 1992, Annals of Shanghai Observatory, Academia Sinca, No.16, 1995.

Table 1. Residuals of Different Lageos-1 orbit Fittings (3-day arc)

(During June 30 –July 14, 1998)

Scheme No.	June 30 - July 7		July 3-5		July 6-7		July 9-11		July 12-14	
	Rms(cm) / nobs	**iteration number**	**Rms(cm) / nobs**	**iteration number**	**Rms(cm) / nobs**	**iteration number**	**Rms(cm) / nobs**	**Iteration number**	**Rms(cm) / nobs**	**iteration number**
1	0.78 /400	7	0.68 /324	3	1.01 /408	4	0.99 /518	3 Ct~Ct-dot	0.86 /496	3 Ct~Ct-dot
2	1.01 /400	5	0.96 /324	3	1.33 /412	3	1.63 /518	2	1.05 /496	3 Ct~Ct-dot
3	0.79 /400	6	0.73 /324	3	1.01 /408	3	1.00 /517	2	0.94 /496	3
4	0.63 /400	7	0.56 /324	4	0.71 /412	5 Ns~Du	0.91 /518	3 Ns~Du	0.74 /496	3 Ns~Du
5	**0.71 /400**	**6**	**0.57 /324**	**3**	**0.85 /410**	**4**	**0.92 /518**	**3**	**0.83 /496**	**3**
6	0.88 /400	Divergence, Cr~T, Tc~Ts	0.61 /324	5	0.77 /411	4 Cr~T, Tc~Ts	0.97 /518	3 Ct~Ct-dot, Ns~Du,Cr~T, Tc~Ts	0.74 /496	3 Ct~Ct-dot, Ns~Du,Cr~T, Tc~Ts
7	0.66 /400	7 Cr~R, Rc~Rs	0.60 /324	4	0.77 /411	5 Ns~Du, Cr~T, Rc~Rs,	0.91 /518	3 Ct~Ct-dot, Ns~Du,Cr~R, Rc~Rs	0.74 /496	3 Ct~Ct-dot, Ns~Du,Cr~R, Rc~Rs

(Note: the sign "~" shows that the parameters are interrelated)

Table 2. The differences of the EOP obtained from different schemes

Diff. Scheme	50995.6998 (mjd)			50998.4314(mjd)			51001.5308(mjd)			51004.3112(mjd)			51007.7189(mjd)		
	Nobs=400/nsta=13			**Nobs=324/nsta=15**			**Nobs=412/nsta=17**			**Nobs=518/nsta=14**			**Nobs=496/nsta=17**		
	dxp	**dyp**	**Dut1**	**dxp**	**dyp**	**Dut1**	**dxp**	**dyp**	**Dut1**	**dxp**	**dyp**	**Dut1**	**dxp**	**dyp**	**Dut1**
	mas		**ms**	**Mas**		**ms**	**mas**		**ms**	**mas**		**ms**	**mas**		**ms**
2-1	0.17	0.08	**-0.019**	-0.21	-0.72	**-0.023**	0.74	-3.40	**0.211**	0.03	-1.56	**0.045**	-0.07	-1.00	**-0.027**
3-1	-0.12	-0.02	**-0.002**	-0.02	0.08	**0.012**	-0.00	-0.00	**0.000**	0.06	0.07	**-0.003**	0.23	-0.26	**-0.004**
4-1	0.23	0.01	**0.304**	0.17	0.46	**-0.355**	0.30	-2.36	**5.043**	0.04	0.11	**1.995**	0.44	-0.49	**-1.177**
5-1	0.17	-0.13	**0.031**	0.16	0.37	**0.078**	-0.08	-1.15	**0.128**	0.02	0.18	**-0.006**	-0.05	-0.18	**0.012**
6-1	0.09	-0.52	**-8.345**	0.04	0.15	**-0.708**	-0.03	-1.78	**3.402**	0.06	-0.03	**-0.256**	0.50	-0.43	**-1.213**
7-1	0.15	0.04	**2.433**	0.02	0.57	**-2.421**	-0.02	-1.89	**3.856**	0.06	0.03	**2.351**	0.41	-0.51	**-0.561**
5-4	-0.06	-0.14	**-0.273**	-0.00	-0.09	**0.433**	-0.38	1.22	**-4.915**	-0.03	0.07	**-2.001**	-0.50	0.31	**1.189**
6-4	-0.14	-0.53	**-8.650**	-0.13	-0.31	**-0.353**	-0.33	0.58	**-1.641**	0.02	-0.14	**-2.251**	0.06	0.06	**-0.036**
7-4	-0.08	0.03	**2.128**	-0.15	0.12	**-2.067**	-0.33	0.47	**-1.187**	0.02	-0.08	**0.356**	-0.04	-0.02	**0.617**

Table 3. The RMS of Orbit Determination of LAGEOS-1, -2

Start time - end time	satellite	rms(cm)	satellite	rms(cm)
99/03/31/12:00-99/04/03/12:00	LAGEOS1	1.0	LAGEOS2	1.4
99/04/03/12:00-99/04/06/12:00	LAGEOS1	1.0	LAGEOS2	1.3
99/04/06/12:00-99/04/09/12:00	LAGEOS1	1.0	LAGEOS2	1.2
99/04/09/12:00-99/04/12/12:00	LAGEOS1	1.0	LAGEOS2	1.1
99/04/12/12:00-99/04/15/12:00	LAGEOS1	1.1	LAGEOS2	1.2
99/04/15/12:00-99/04/18/12:00	LAGEOS1	1.1	LAGEOS2	1.0
99/04/18/12:00-99/04/21/12:00	LAGEOS1	1.3	LAGEOS2	1.2
99/04/21/12:00-99/04/24/12:00	LAGEOS1	1.2	LAGEOS2	0.9
99/04/24/12:00-99/04/27/12:00	LAGEOS1	0.9	LAGEOS2	1.1
99/04/27/12:00-99/04/30/12:00	LAGEOS1	1.5	LAGEOS2	1.1
99/04/30/12:00-99/05/03/12:00	LAGEOS1	1.3	LAGEOS2	2.5
99/05/03/12:00-99/05/06/12:00	LAGEOS1	1.0	LAGEOS2	0.9
99/05/06/12:00-99/05/09/12:00	LAGEOS1	0.9	LAGEOS2	0.9
99/05/09/12:00-99/05/12/12:00	LAGEOS1	1.3	LAGEOS2	1.3
99/05/12/12:00-99/05/15/12:00	LAGEOS1	1.2	LAGEOS2	1.2
99/05/15/12:00-99/05/18/12:00	LAGEOS1	1.0	LAGEOS2	1.0
99/05/18/12:00-99/05/21/12:00	LAGEOS1	1.4	LAGEOS2	1.4
99/05/21/12:00-99/05/24/12:00	LAGEOS1	1.1	LAGEOS2	0.9
99/05/24/12:00-99/05/27/12:00	LAGEOS1	1.4	LAGEOS2	1.2
99/05/27/12:00-99/05/30/12:00	LAGEOS1	1.6	LAGEOS2	1.3
99/05/30/12:00-99/06/02/12:00	LAGEOS1	1.6	LAGEOS2	0.8
99/06/02/12:00-99/06/05/12:00	LAGEOS1	1.4	LAGEOS2	1.3
99/06/05/12:00-99/06/08/12:00	LAGEOS1	1.2	LAGEOS2	1.2
99/06/08/12:00-99/06/11/12:00	LAGEOS1	1.1	LAGEOS2	1.3
99/06/11/12:00-99/06/14/12:00	LAGEOS1	1.3	LAGEOS2	1.6
99/06/14/12:00-99/06/17/12:00	LAGEOS1	1.5	LAGEOS2	0.9
99/06/17/12:00-99/06/20/12:00	LAGEOS1	1.5	LAGEOS2	1.2
99/06/20/12:00-99/06/23/12:00	LAGEOS1	1.0	LAGEOS2	1.0
99/06/23/12:00-99/06/26/12:00	LAGEOS1	1.3	LAGEOS2	1.3