SLR data processing status of Korean SLR system

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Abstract

Korea Astronomy and Space Science Institute (KASI) installed SLR station (Daedeok) and joined the ILRS network in 2012. In addition, from early in 2013, KASI planed to prepare the SLR data processing. In this poster, we present current status and results of precise orbit determination (POD) and geodetic parameter estimations using satellite laser ranging (SLR) observations. The NASA/GSFC GEODYN II and SOLVE softwares were used for processing the normal point observation data set of LAGEOS-1, LAGEOS-2, ETALON-1 and ETALON-2. A weekly-based orbit determination strategy was employed to process SLR observations and the coordinates of ILRS sites were determined.

Precise Orbit Determination of LAGEOS-1 , 2 & ETALON -1, 2

- **LAGEOS-1,2 & ETALON-1,2 Geodetic Satellites**

Table 1

	LAGEOS-1	LAGEOS-2	ETALON-1	ETALON-2
Nationality	USA & Italy		Russia	
Launch date	May, 1976	October, 1992	January, 1989	May, 1989
Primary missions	Geodesy		Geodesy	
LRA diameter (m)	0.60		1.29	
LRA shape	Sphere		Circular	
Orbit	Circular		Circular	
Inclination (deg)	109.84	52.64	64.90	65.50
Eccentricity	0.0045	0.0135	0.0061	0.00066
Height of perigee (km)	5,860	5,620	19,120	
Period (min)	225	223	676	675
Weight (kg)	407	405	1415	

- **Precise Orbit Determination(POD) System Configuration**
  - Dynamic, measurement models/parameters, and reference frame for POD

Table 2

Model/Parameter	Description
Earth gravity	GGM02C 30X30
Planetary ephemeris	JPL DE-1403
Atmospheric density	Jacchia 1971
Station coordinates	ITRF2005 SLR rescaled
Precession/nutation	IAU2000
Tropospheric refraction	Mendes-Pavlis model
Earth tide	IERS Conventions 2003
Ocean tide	GOT99.2
Solar radiation pressure	coefficient 1.13
Numerical integration	11th Cowell's method
Editing strategy	3.5 editing
ARC	2013/01/07 – 2013/10/28 (42 weeks) / ARC length : 7days

- Measurement Data : NP data from 26 ILRS stations

Table 3

Station Number	Station Name	Station Number	Station Name
1868	Komsomolsk	7403	Arequipa
1873	Simeiz	7406	San Juan
1879	Altay	7501	Hartebeesthoek
1884	Riga	7810	Zimmerwald
1893	Katzively	7821	Shanghai
7080	Mcdonald	7824	San Fernando
7090	Yarragadee	7825	Mt Stromlo
7105	Greenbelt	7839	Graz
7110	Monument Peak	7840	Herstmonceux
7237	Changchun	7841	Potsdam
7249	Beijing	7845	Grasse
7359	Daedeok (under validation)	7941	Matera
7308	Koganei	8834	Wettzell

Precise Orbit Determination Results

- **POD result of LAGEOS-1,2 & ETALON-1, 2**
  - **Post-fit Residual for LAGEOS-1,2 & ETALON-1,2 (2013/01 – 2013/10)**

Table 4

ARCs	LAGEOS-1 (cm, Weighted RMS)	LAGEOS-2 (cm, Weighted RMS)	ETALON-1 (cm, Weighted RMS)	ETALON-2 (cm, Weighted RMS)
1	0.86	0.72	1.21	0.84
2	1.00	0.83	0.72	0.76
3	0.83	0.74	0.51	0.36
4	0.93	0.76	0.81	0.64
5	0.82	0.78	0.50	0.81
6	0.82	0.81	0.69	0.69
7	0.78	0.63	0.74	0.50
8	0.85	0.84	0.46	0.84
9	0.74	0.82	0.54	0.53
10	0.94	0.88	0.38	0.63
11	0.72	0.66	0.66	0.95
12	1.12	0.77	0.43	1.02
13	0.92	0.75	1.24	1.45
14	1.01	0.80	0.50	0.51
15	0.78	0.69	0.62	0.47
16	1.02	0.75	0.65	0.42
17	1.01	0.91	1.05	0.92
18	1.02	0.93	0.39	0.91
19	0.69	0.86	0.89	0.65
20	1.05	0.80	0.99	0.72
21	0.87	1.06	0.55	0.94

Precise Orbit Determination Results (Continued)

ARCs	LAGEOS-1 (cm, Weighted RMS)	LAGEOS-2 (cm, Weighted RMS)	ETALON-1 (cm, Weighted RMS)	ETALON-2 (cm, Weighted RMS)
22	0.83	1.16	0.56	0.50
23	0.79	0.88	0.60	1.15
24	0.76	0.78	1.07	0.71
25	0.84	1.08	1.52	0.63
26	0.68	0.83	0.62	0.62
27	0.60	0.78	0.56	1.08
28	1.21	0.71	0.56	0.98
29	0.65	0.73	0.71	0.55
30	0.63	0.62	0.53	0.49
31	0.58	0.91	0.54	1.22
32	0.64	0.68	0.42	0.52
33	1.07	0.95	0.76	0.82
34	0.69	1.09	1.39	0.45
35	1.05	0.81	0.40	0.92
36	1.10	0.63	0.88	0.42
37	0.69	0.64	0.75	0.54
38	0.96	0.58	0.36	0.62
39	0.72	0.72	0.74	0.97
40	0.71	0.72	1.58	0.54
41	0.70	0.58	0.87	0.46
42	0.85	0.68	0.64	0.47

- The weighted RMS for 4 geodetic satellites < 1 cm

Table 5

Satellite	LAGEOS-1 (cm, Weighted RMS)	LAGEOS-2 (cm, Weighted RMS)	ETALON-1 (cm, Weighted RMS)	ETALON-2 (cm, Weighted RMS)
Mean Value	0.85	0.79	0.73	0.72

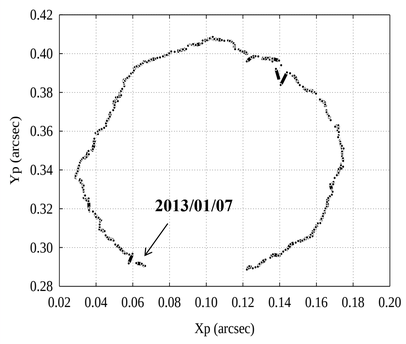
Combined Terrestrial Reference Frame(TRF) and Earth Orientation Parameters(EOP) Solution

- **Strategies for TRF & EOPs solutions**
  - Software :GEODYN II & SOLVE
  - Product : TRF(Weekly), EOPs(Daily)
  - Satellites : LAGEOS-1,2 & ETALON-1,2
  - Constraint : 1m on TRF, equivalent for EOPs
  - a priori value for stations and EOPs : ITRF2005 and IERS bulletin A respectively
  - Other configuration : Same for POD
- **TRF Results & Stability analysis**
  - TRF result for 10 ILRS core stations
  - The stability (standard deviation, STD) analysis of the station positions(X,Y,Z) (Lejba & Schillak 2011):
  - **Stability or each direction** $S_X = \sqrt{\frac{\sum_{i=1}^{N}(X_i - \bar{X})^2}{N-1}}$ **3D stability** $S = \sqrt{\frac{S_X{}^2 + S_Y{}^2 + S_Z{}^2}{3}}$
  - $\bar{X}$: Mean value of X_i direction (i = ARC #)
  - The stability analysis result of the 10 ILRS core stations

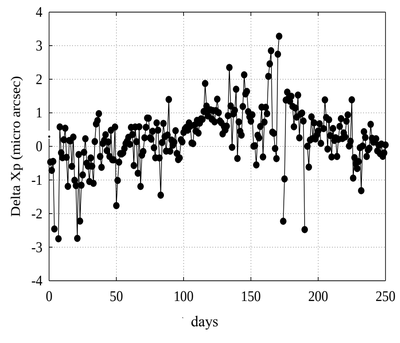
Table 6

Monument	Sx (mm)	Sy(mm)	Sz(mm)	S (mm)
7090(YARL)	6.6	7.1	8.0	7.2
7105(GODL)	4.9	3.2	5.9	4.8
7110(MONL)	4.2	4.4	7.3	5.5
7501(HARL)	10.1	11.5	11.5	11.0
7810(ZIML)	9.1	6.1	8.1	7.9
7825(STL3)	3.5	1.8	3.7	3.1
7839(GRZL)	6.2	4.3	6.1	5.6
7840(HERL)	9.8	6.3	7.4	8.0
7941(MATM)	6.1	4.6	5.7	5.5
Mean	6.1	5.5	5.9	5.8

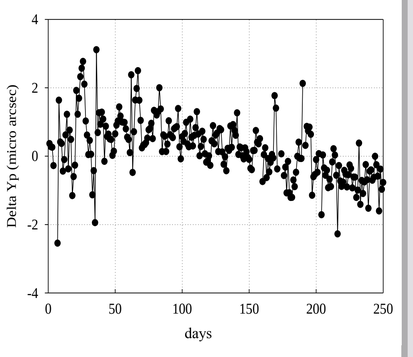
- **EOPs Results**
  - Daily polar motion



  - KASI EOPs – IERS C04 (Xp)
  - Std. Dev. : 0.87



  - KASI EOPs – IERS C04 (Yp)
  - Std. Dev. : 0.88



Summary and Future Work

- **Summary**
  - Precise Orbital and Geodetic Parameter Estimation (using GEODYN II & SOLVE S/W)
    - LAGEOS -1,2 & ETALON -1,2 POD : Weighted RMS < 1 cm (using 26 ILRS stations NP data, 42 weeks)
    - TRF solution for 10 ILRS core stations, stability analysis : 3D stability < 6mm
    - Brief comparison KASI EOPs with IERS C04
- **Future Works**
  - Try to produce ILRS AAC Products
    - Earth rotation parameters (polar motion, LOD)
    - 3-D Coordinates and velocities of global SLR tracking stations
    - Geocenter coordinates
    - High accuracy LAGEOS orbits
    - Global SLR Station Quality Assessment
  - Support Daedeok station normal operation
    - Quality check for Daedeok NP data
    - Time & Range bias information for station calibration