Preliminary Performance Analysis for the Korean SLR station "DAEDEOK-73592601"

E. Park, Y.-R. Kim, H.-C. Lim
Korea Astronomy and Space Science Institute, Korea.
skel93@kasi.re.kr

Abstract. *Korea Astronomy and Space Science Institute (KASI) has developed two SLR systems. One of them was constructed and registered with ILRS SLR tracking station DAEDEOK(DAEK, 73592601). From August 2013, DAEK has been providing SLR Normal Point (NP) data to the ILRS Data Center. Through the ILRS evaluation and validation process, DAEK station became an active station in April 2014. KASI SLR team has performed SLR data process for LAGEOS-1/2 precise orbit determination (POD) and DAEK station performance analysis for normal operation. In this paper, the preliminarily performance analysis for the DAEK station using LAGEOS-1/2 NP data is presented in terms of the POD RMS and station bias stability results.*

Precise orbit determination configuration for geodetic satellite using SLR data

For a preliminary performance analysis of the Korean SLR station (DEAK), we processed a precise orbit determination for LAGEOS satellites using the NASA/GSFC GEODYN II software [1]. From the POD results, the normal point precision of the LAGEOS satellites and shot term bias stability information (the standard deviation about the mean of the pass-by-pass range biases), which are considered as a data quality of a SLR system, could be obtained. The basic POD configurations (dynamic, measurement models, estimation parameters, and reference frame) are summarized in the table 1. For a performance comparison with other ILRS SLR stations, 14 ILRS stations (Mcdonald(7080), Yarragadee(7090), Greenbelt(7105), Monument Peak(7110), Daedeok(7359), Zimmerwald(7810), Mount Stromlo(7825), Simosato(7838), Graz(7839), Herstmonceux(7840), Potsdam(7841), Matera(7845), Grasse(7941), Wettzell(8834)) NP data (second quarter of 2014) were used for POD

Table 1. POD configurations

ORBIT MODELS	
Geopotential	GGM02C (30 by 30) [2]
Third-body	8 planets, JPL DE403 [3]
Solar radiation Pressure	IERS Conventions 2003 direct, albedo, earth thermal radiation : applied reemitted radiation: not applied
Satellite thermal thrust	Modeled
Thermal thrust	LAGEOS: estimation of empirical
Tidal forces	solid earth tides : IERS 2003 Conventions model
	Ocean tides: Ray GOT4.7 [4]
Atmospheric gravitational attraction	not modeled/estimated
Dynamic polar motion	Applied
Relativity	point-mass accelerations, Lense-Thirring effect [5], Coriolis force
Numerical integration	Cowell 11th order predictor-corrector, integration step: LAGEOS: 150 s
MEASUREMNT MODELS	

Measurement	Satellite Laser Ranging (SLR): round-trip travel time speed of light : 299792458 m/s wavelength : 532.0, 423.0, 847.0 & 694.3 nm elevation angle cutoff : 3 degrees weighting : 1.0 m to 10 m (3 levels) range biases : est/d for some stations time biases : modeled in some stations tropospheric biases : not modeled/estimated
Data editing	3.5 sigma editing
Troposphere	Mendes - Pavlis zenith delay model [6] Mendes - Pavlis mapping function [7]
Ionosphere	not modeled/estimated
Relativity	scale: LET (TT time scale), effects: light time corrections
Satellite center of mass	LAGEOS: 0.251 m (0.245 m for 7840)
Other	Stanford ET corrections applied to 7840 ONLY
ESTIMATED PARAMETERS (APRIORI VALUES & SIGMAS)	
Adjustment	weighted least-squares adjustment
Orbital parameters	Initial position and velocity: estimated for each satellite (unconstrained), Solar radiation pressure: CR kept fixed at 1.13, Empirical accelerations (unconstrained)
Stations	a priori values: SLRF2008, a priori standard deviation: 1 m
Troposphere	not estimated
EOP	definition: x-pole, y-pole, (UT1-UTC) and LOD, epoch: at noon of each day, frequency: daily, a priori values: IERS Bulletin A, a priori standard deviation: 1 m equivalent
Range biases	for some (non-core) stations, a priori value: 0 m, a priori standard deviation: 100 m
Constraints	loose constraints (1 m, and equivalent for EOP)
REFERENCE FRAMES	
Inertial	J2000.0
Terrestrial	SLRF2008, ITRF2008[8][9], NUVEL-1A NNR (2nd source for station velocities), tidal uplift: IERS 2003 Conventions, ocean loading: GOT4.7, atmospheric pressure loading: not modeled/estimated, geocenter motion: not explicitly modeled/estimated, geocenter tidal frequencies: applied, pole tide: IERS 2003 Conventions (incl. ocean PT), origin: C(1,0) = C(1,1) = S(1,1) = 0, orientation: loose constraints (1 m equivalent)
Interconnection	Precession, Nutation : IAU 2000, Celestial pole: modeled using IERS C04 values, Relationship between UT1 and GMST: UT1-UTC estimated, Earth Orientation Parameters: estimated, Tidal variations in UT1 and PM: sub-daily not modeled

POD results – LAGEOS NP RMS

Total 26306 NP data (14 stations, second quarter of 2014) were used for LAGEOS POD. NP data quantity information of each station is summarized in the figure 1. The figure 2 shows the NP RMS results for each station. LAGEOS NP RMS results of this research were compared with

those of the ILRS Analysis or Associate Centers (Quarterly Global Report Cards) and summarized in the table 2.

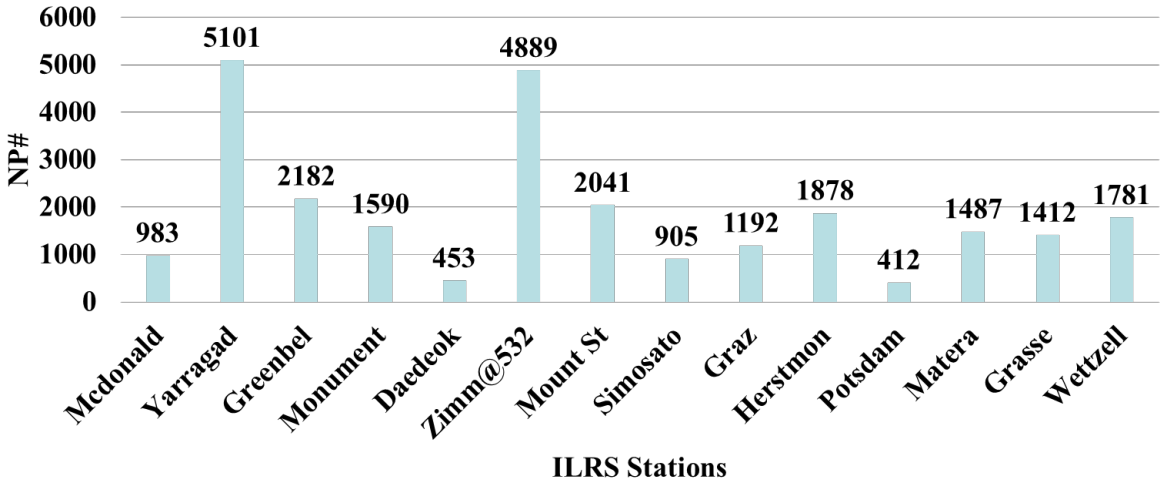

Figure 1. NP# for ILRS Stations

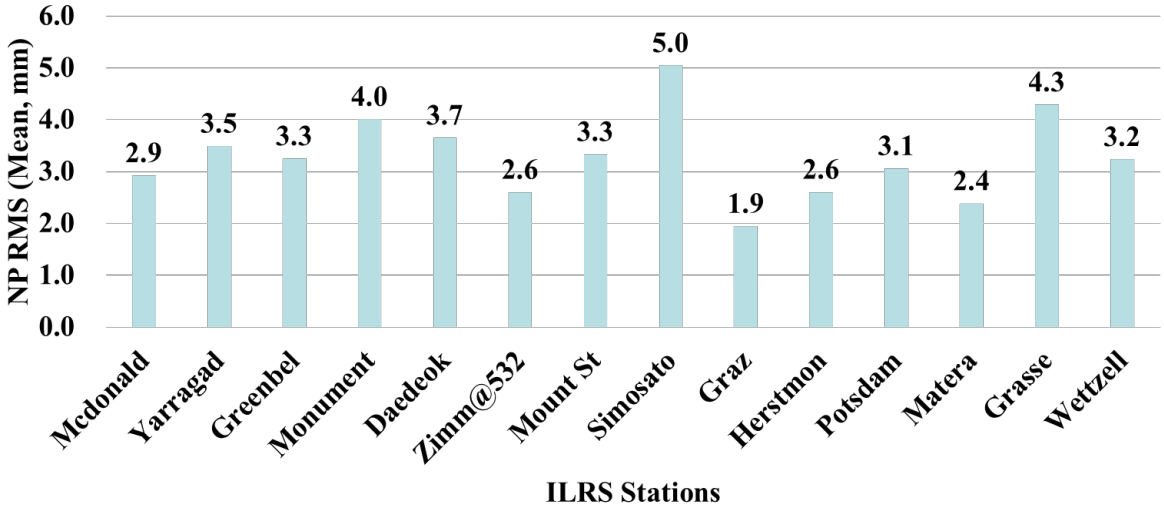

Figure 2. LAGEOS NP RMS for ILRS Stations (KASI results)

Table 2. Comparison KASI results with ILRS Global Report Card (NP RMS)

ILRS Orbit Analysis Results (Second Quarter 2014)						
Site Information	**DGFI**	**Hitotsubashi**	**JCET**	**MCC**	**SHAO**	**KASI**

			Univ.				Results
Station #	**Station Location**	**LAGEOS NP RMS (mm)**					
7080	McDonald	3.9	2.3	2.4	2.4	2.1	2.9
7090	Yarragadee	3.8	2	2.7	2.3	1.9	3.5
7105	Greenbelt	3.9	2.1	2.3	2.4	2.3	3.3
7110	Monument Peak	5.8	2.9	2.8	3.9	3	4.0
7359	Daedeok	4	4.2	1.6	3.1	-	3.7
7810	Zimmerwald	2.9	1.4	1.9	2.2	1.6	2.6
7825	Mt. Stromlo	4.6	2.7	4.7	3.6	2.1	3.3
7838	Simosato	5.5	3.1	3.8	4.3	4.3	5.0
7839	Graz	2.6	1.1	0.6	2	0.6	1.9
7840	Herstmonceux	3.3	1.7	1.4	2.6	1.2	2.6
7841	Potsdam	4.6	2.1	3.6	2.2	-	3.1
7845	Grasse	4.7	2.8	3	3	2.5	2.4
7941	Matera	2.7	0.9	1.1	1.7	1	4.3
8834	Wettzell	3	1.8	1.7	2.1	1.7	3.2
Mean		**4.0**	**2.2**	**2.4**	**2.7**	**2.0**	**3.3**

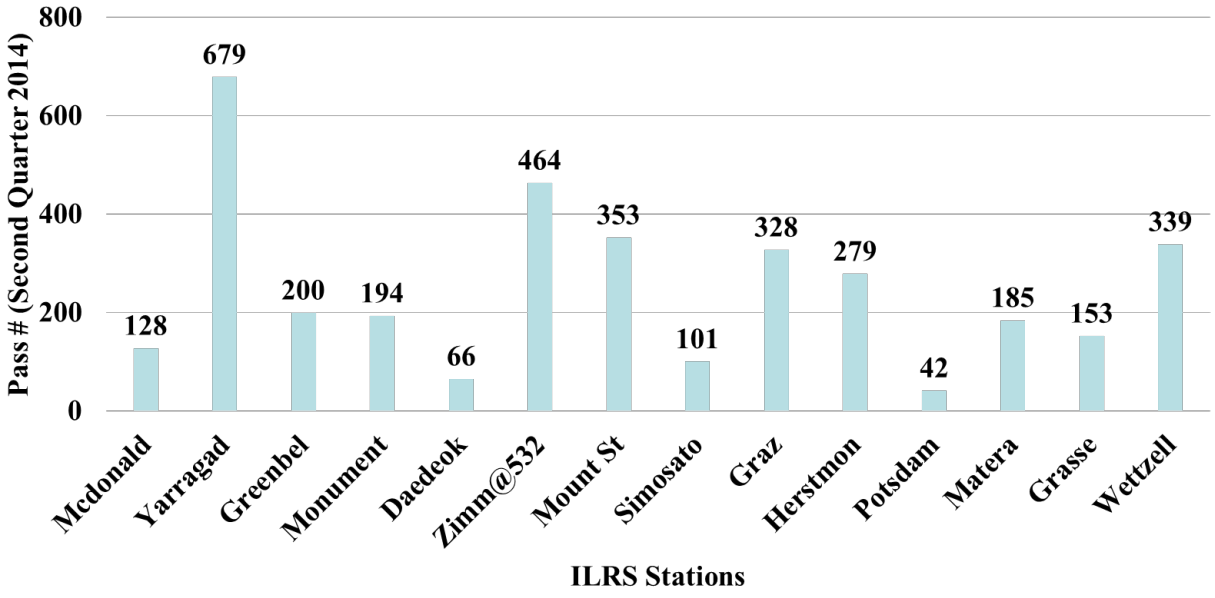

Figure 3. LAGEOS Pass # for ILRS Stations

POD results – the short term bias stability

The short term bias stability, which is defined as the standard deviation about the means of the pass-by-pass range bias, analysis was performed. Total pass number information and short term bias stability results of each station (14 stations, second quarter of 2014) are summarized in the

figure 3 and 4, respectively. The short term bias stability results of this research were compared with those of the ILRS Analysis or Associate Centers (Quarterly Global Report Cards) and summarized in the table 3.

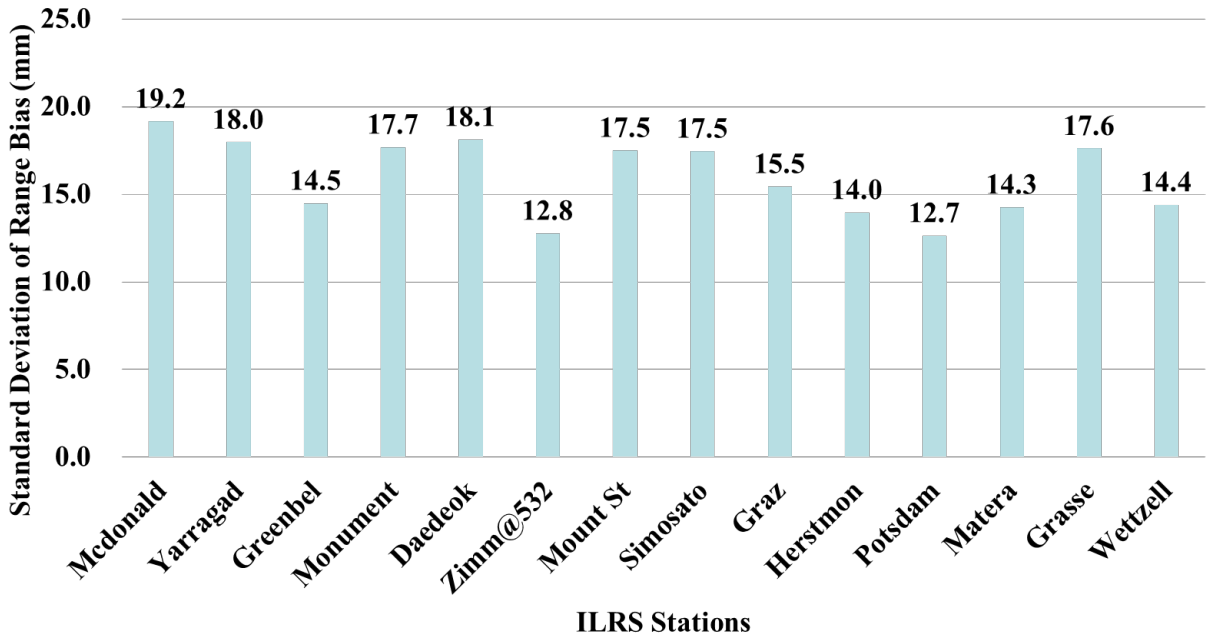

Figure 4. Short term bias stability for ILRS Stations (KASI results)

Table 3. Comparison KASI results with ILRS Global Report Card (bias stability)

ILRS Orbit Analysis Results (Second Quarter 2014)							
Site Information		**DGFI**	**Hitotsubashi Univ.**	**JCET**	**MCC**	**SHAO**	**KASI Results**
Station #	**Station Location**	**Short term bias stability (mm)**					
7080	McDonald	16	9.9	16.3	17.7	11.7	19.2
7090	Yarragadee	17	8.5	16.7	18.1	11.2	18.0
7105	Greenbelt	14.2	7.8	12.4	20.5	11.3	14.5
7110	Monument Peak	21	13	21	15.4	15.2	17.7
7359	Daedeok	12.9	15.6	15.2	24.9		18.1
7810	Zimmerwald	10.8	6	12	14.3	9.2	12.8
7825	Mt. Stromlo	14.9	10.8	15.9	20.1	10.8	17.5
7838	Simosato	13.9	10.3	9.8	18.7	11.6	17.5
7839	Graz	10.8	6.1	14.5	13.6	11.1	15.5
7840	Herstmonceux	11.1	6.6	11.1	8.6	10.4	14.0
7841	Potsdam	10.9	6.6	20.4	10.8		12.7
7845	Grasse	13.5	13.4	17.2	16.7	10.3	14.3

7941	Matera	14.2	8	22.9	12.2	31.4	17.6
8834	Wettzell	13.8	8.4	12.4	14.5	12.1	14.4
Mean		**13.9**	**9.4**	**15.6**	**16.2**	**13.0**	**16.0**

Summary and future work

In this study, we conducted the preliminary performance analysis of the Korean SLR station (DEAK). LAGEOS NP RMS, short term bias analysis of DEAK station were performed and compared with the ILRS quarterly global report card information. For future works, long term bias stability analysis and enhancing data processing procedure for large SLR data will be carried out for producing the ILRS global performance report.

References

[1] Pavlis, D.E., Luo, S., Dahiroc, P., et al., 1998. GEODYN II System Description. Hughes STX Contractor Report.

[2] Tapley, B., Ries, J., Bettadpur, S., Chambers, D., Cheng, M., Condi, F., Gunter, B., Kang, Z., Nagel, P., Pastor, R., Pekker, T., Poole, S., Wang, F., 2005. GGM02 - an improved Earth gravity field model from GRACE. J. Geod. 79 (8), 467-478.

[3] Standish, E.M., Newhall, X.X., Williams, J.G., Folkner, W.M., 1995. JPL planetary and Lunar ephemerides. DE403/LE403, JPLIOM 31410-127.

[4] Ray, R.D., 1999. A global ocean tide model from TOPEX/POSEIDON altimetry: GOT99.2. NASA Goddard Space Flight Center technical memorandum. NASA/TM-1999-209478.

[5] Lense, J., and Thirring. H., 1918. Über den Einfluss der Eigenrotation der Zentralkörper auf die Bewegung der Planeten und Monde nach der Einsteinschen Gravitationstheorie, Phys. Z., 19, 156-163, translated by Mashhoon, B., F. W. Hehl, and D. S. Theiss, 1984. On the Gravitational Effects of Rotating Masses: The Thirring-Lense Papers, Gen. Rel. Grav., 16, 711-750.

[6] Mendes, V.B., Prates, G., Pavlis, E.C., Pavlis, D.E., Langley, R.B., 2002. Improved mapping functions for atmospheric refraction correction in SLR. Geophys. Res. Lett. 29 (10), 1414.

[7] Mendes, V.B., Pavlis, E.C., 2004. High-accuracy zenith delay prediction at optical wavelengths. Geophys. Res. Lett. 31, L14602.

[8] Altamimi, Z., Collilieux, X., Legrand, J., Garayt, B., Boucher, C., 2007. ITRF2005: a new release of the International Terrestrial Reference Frame based on time series of station positions and Earth Orientation Parameters. J. Geophys. Res. 112, B09401.

[9] Altamimi, Z., Collilieux, X., Métivier, L., 2011. ITRF2008: an improved solution of the international terrestrial reference frame. J. Geod. 85 (8), 457-473.