

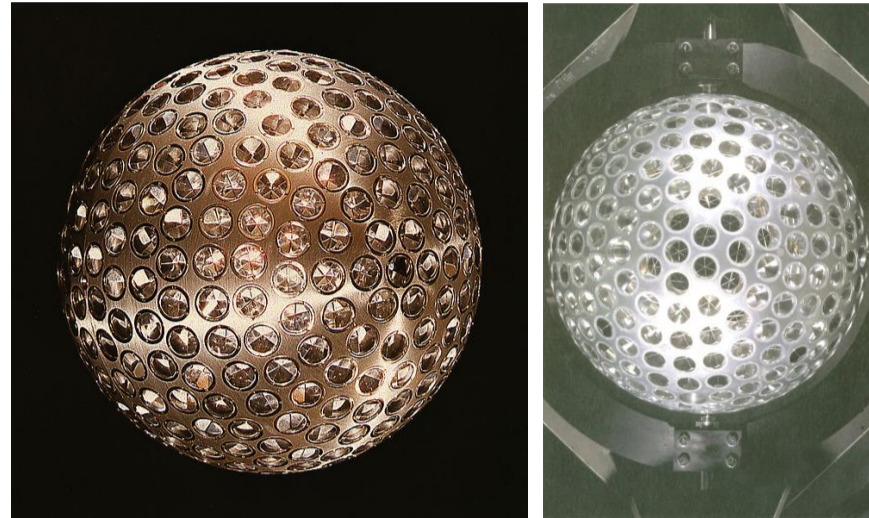
Abstract

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 preliminary 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 of LAGEOS

LAGEOS-1 Geodetic Satellite

	LAGEOS-1	LAGEOS-2
Sponsor:	United States	United States and Italy
Primary Applications:	geodesy	geodesy
COSPAR ID:	7603901	9207002
Launch Date:	May 4, 1976	October 22, 1992
RRA Diameter:	60 cm	60 cm
RRA Shape:	sphere	sphere
Reflectors:	426 corner cubes	426 corner cubes
Orbit:	circular	circular
Inclination:	109.84 degrees	52.64 degrees
Eccentricity:	0.0045	0.0135
Perigee:	5,860 km	5,620 km
Period:	225 minutes	223 minutes
Weight:	406.965 Kg	405.38 kg



Precise Orbit Determination(POD) System Configuration & Strategy

Dynamic, measurement models/parameters, and reference frame for POD

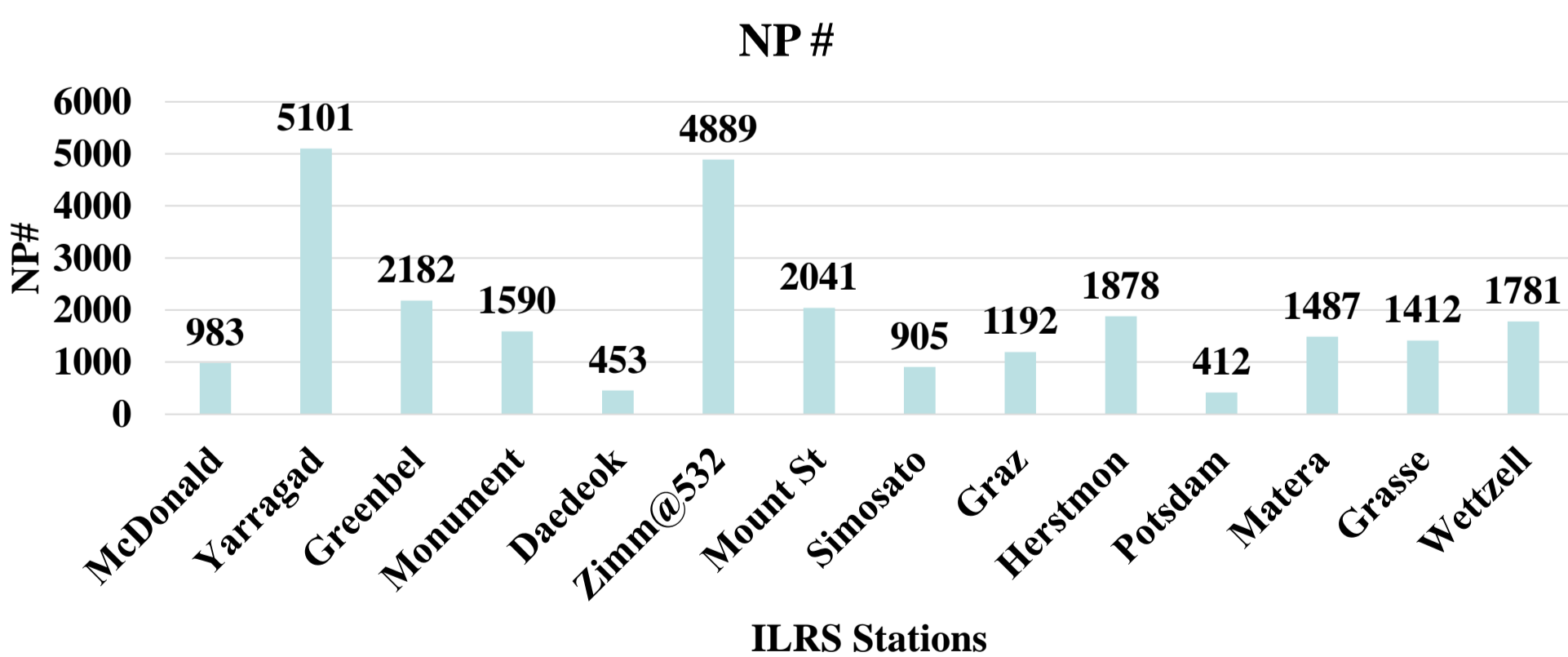
	MEASUREMENT MODELS	ESTIMATED PARAMETERS (APRIORI VALUES & SIGMAS)
Measurement	Satellite Laser Ranging (SLR): round-trip travel time speed of light : 299792458 m/s wavelength : 532.0, 423.0, 847.0 & 694.3 nm elevation angle cutoff : 3 degrees weighting : 1.0 m to 10 m (3 levels) range biases : est/d for some stations time biases : modeled in some stations tropospheric biases : not modeled/estimated 3.5 sigma editing	Adjustment Orbital parameters Stations Troposphere EOP Range biases Constraints
Data editing	Mendes - Pavlis zenith delay model Mendes - Pavlis mapping function	weighted least-squares adjustment Initial position and velocity: estimated for each satellite (unconstrained) Solar radiation pressure: CR kept fixed at 1.13 Empirical accelerations (unconstrained) a priori values: SLRF2008 a priori standard deviation: 1 m not estimated 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 for some (non-core) stations a priori value: 0 m a priori standard deviation: 100 m loose constraints (1 m, and equivalent for EOP)
Troposphere	not modeled/estimated	
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	
	ORBIT MODELS	REFERENCE FRAMES
Geopotential	GGM02C (30by30)	Inertial J2000.0
Third-body	8 planets, JPL DE403	Terrestrial SLRF2008
Solar radiation	IERS Conventions 2003	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)
Pressure	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	
Atmospheric gravitational attraction	not modeled/estimated	Interconnection Precession, Nutation : IAU 2000
Dynamic polar motion	applied	
Relativity	point-mass accelerations, Lense-Thirring effect, Coriolis force	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
Numerical integration	Cowell 11th order predictor-corrector integration step: LAGEOS: 150 s	

- NASA GSFC GEODYN II (S/W)
- Pass-by-Pass estimation using NP data(weekly based), convergence criteria for POD (< 2%)
 - Stations and EOP are fixed
 - Outlier for range bias statistics : [50mm]
- Measurement data : NP data from 14 ILRS stations
 - McDonald(7080), Yarragadee(7090), Greenbelt(7105), Monument Peak(7110), Daedeok(7359), Zimmerwald@532(7810), Mount Stromlo(7825), Simosato(7838), Graz(7839), Herstmonceux(7840), Potsdam(7841), Matera(7845), Grasse(7941), Wettzell(8834)
 - All stations are same weight for pass-by-pass estimation

Precise Orbit Determination Results

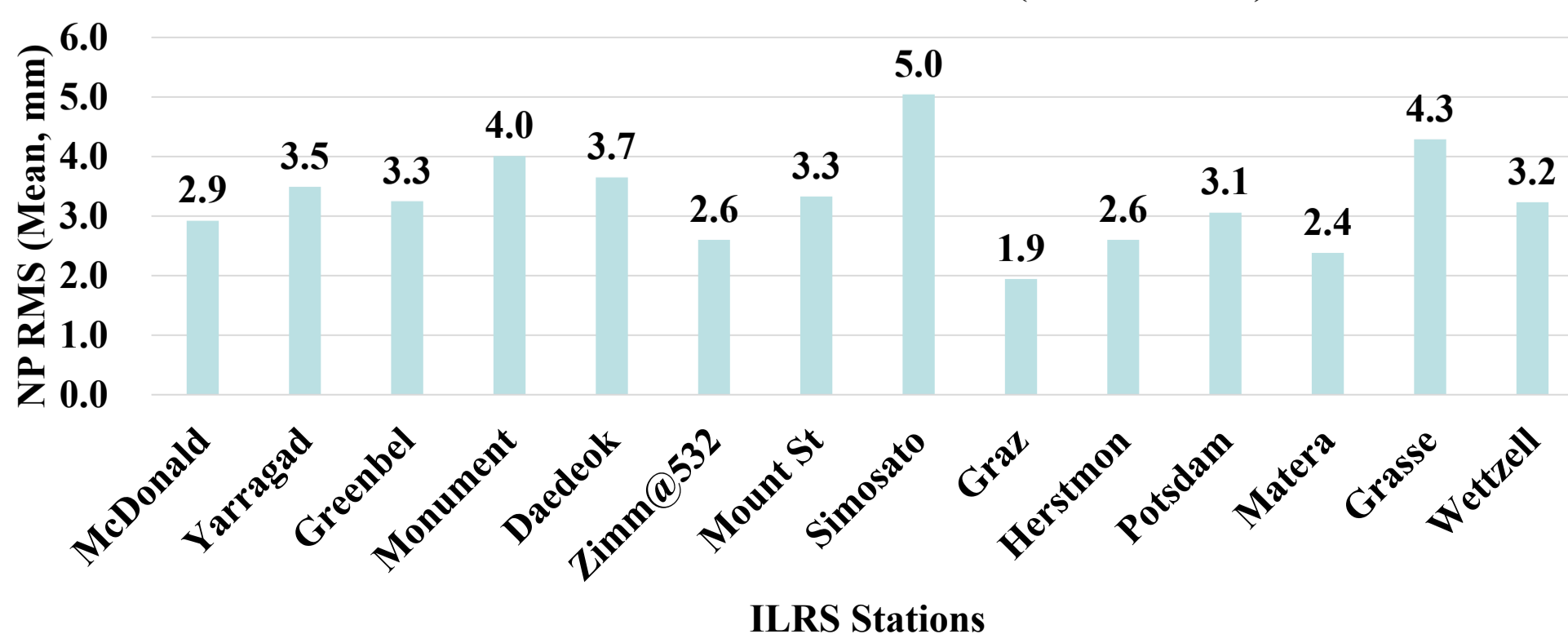
POD Results of LAGEOS

- Total 26306 NP data (14 Stations, Second Quarter 2014) used for POD
- NP# information for POD



Post-fit residual for LAGEOS, Pass-by-Pass Estimation

LAGEOS NP RMS Second Quarter 2014 (KASI Results)



Precise Orbit Determination Results (Continued)

- Comparison with ILRS Global Report Card : Orbit Analysis Results
 - KASI Results : The NP RMS(mean) of 14 ILRS stations

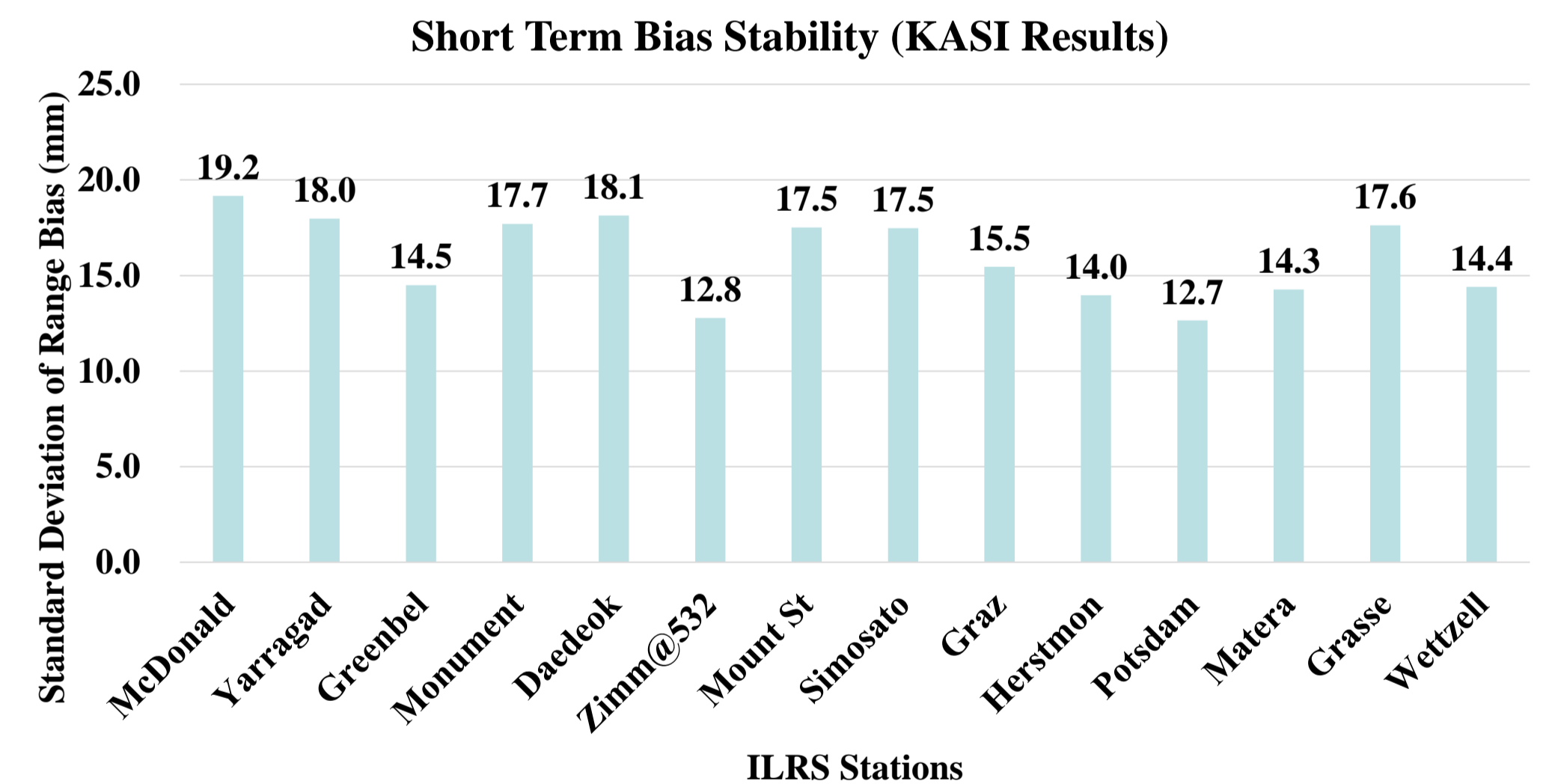
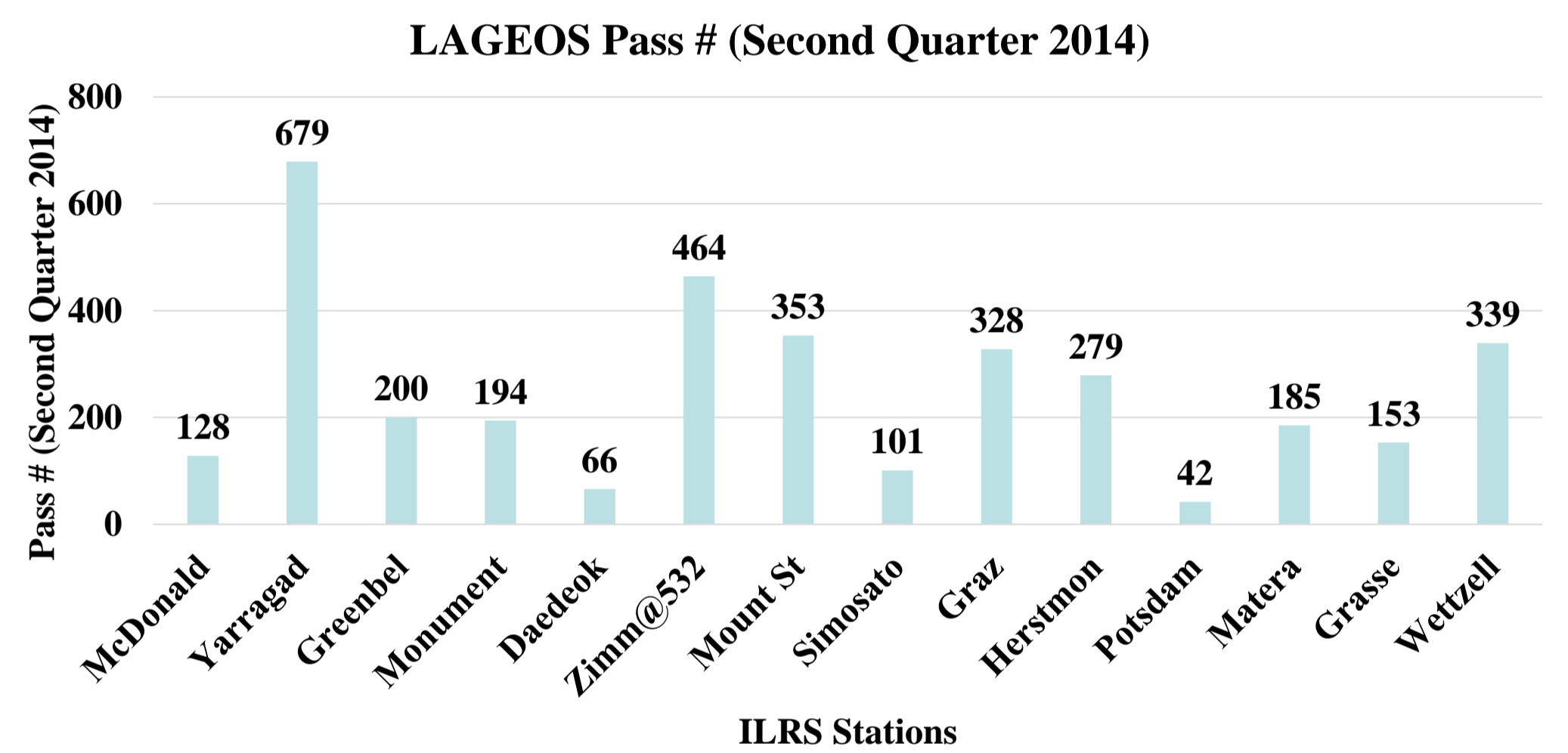
ILRS Orbit Analysis Results (Second Quarter 2014)							
Site Information	DGFI	Hitotsubashi Univ.	JCET	MCC	SHAO	KASI Results	
Station #	Station Location	LAGEOS NP RMS (mm)					
7080	McDonald	3.9	2.3	2.4	2.4	2.1	2.9
7090	Yarragadee	3.8	2	2.7	2.3	1.9	3.5
7105	Greenbelt	3.9	2.1	2.3	2.4	2.3	3.3
7110	Monument 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

* Daedeok Station(7359, Korean SLR Station) : Active-Validated ILRS Station (since 2014-04-11)

Range Bias Estimation Results

Range Bias Estimation & Stability Analysis

- Pass-by-Pass range bias estimation
 - The stability (standard deviation) analysis of the station range bias : Short term bias stability
- Range Bias Estimation Results
 - Total 3511 Pass



Comparison with ILRS Global Report Card : Short term bias stability

- KASI Results : The short term bias stability results of 14 ILRS stations

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

Summary

- Pass-by-Pass Orbit Estimation for LAGEOS-1,-2 and Range Bias Analysis for ILRS stations
 - KASI SLR data processing – 14 ILRS stations including Daedeok(Korean SLR System) NP data
 - Preliminary performance analysis for the Daedeok and ILRS stations using LAGEOS-1/2 NP data is presented in terms of the POD RMS and shot term range bias stability results.

Future Work

- Long term SLR data processing
- Considering more geodetic satellites/ILRS stations NP data
- Global SLR Station Quality Assessment