BOROWIEC ACTIVITY IN SATELLITE ORBIT DETERMINATION

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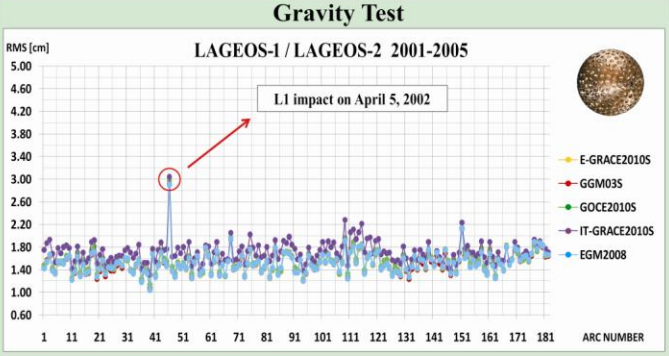
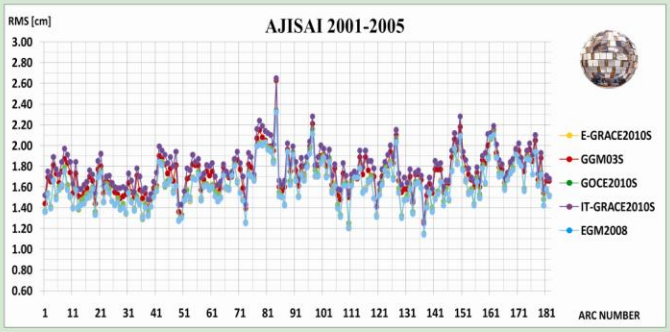
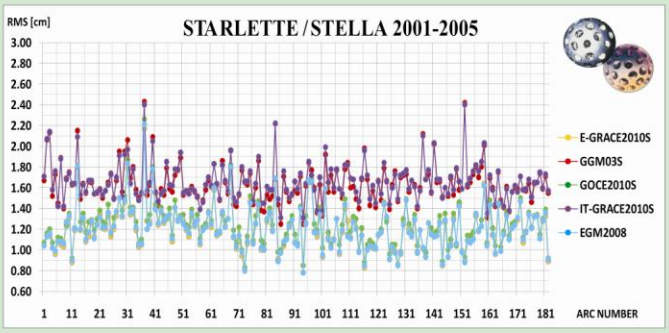
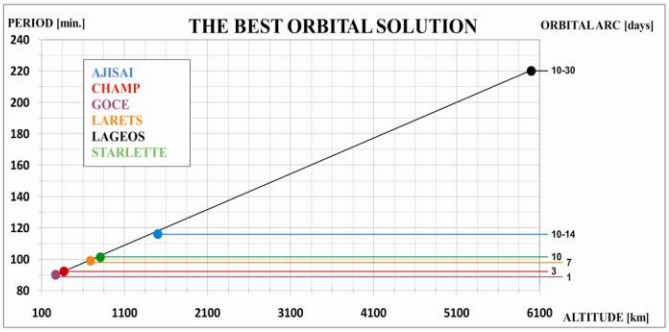
Gravity Test









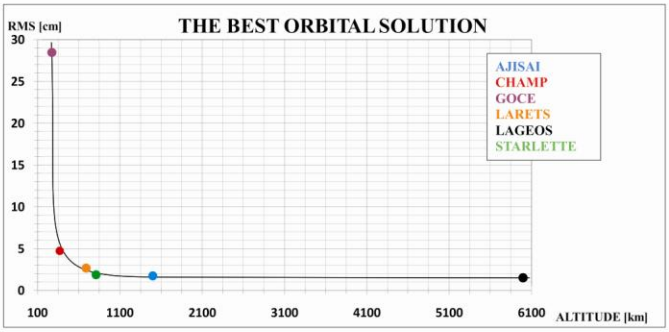


Table 1. Orbital and technical parameters of the analysed satellites.

	Ajisai	CHAMP	GOCE	LAGEOS-1	LAGEOS-2	Larets	Starlette	Stella
ID number	8606101	0003902	0901301	7603901	9207002	0304206	7501001	9306102
Launch date	August 12 1986	July 15 2000	March 17 2009	May 4 1976	October 22 1992	September 27 2003	February 6 1975	September 26 1993
Technical and physical parameters								
Number of retroreflectors	1436	4	7	426	426	60	60	60
Shape	spherical	trapezoid	octagonal	spherical	spherical	spherical	spherical	spherical
Dimensions [cm]	214	22.4 x 75 x 162.1	100	60	60	21.5	24	24
Mass [kg]	685	542	1050	407	405	23.28	47.25	48.00
CoM [mm]	1010	250	2456	251	251	56.2	75	75
Orbital parameters of the satellites								
Inclination [°]	50.0	87.2	96.6	109.8	52.6	98.2	49.8	98.6
Eccentricity	0.001	0.004	0.002	0.004	0.01	0.0002	0.02	0.002
Perigee [km]	1480	370	254	5900	5800	690	812	800
Period [min.]	116	94	90	225	222	99	104	101

Table 3. GEODYN II – Force Models and Parameters (THE BEST ORBITAL SOLUTION).

Force Models
Earth gravity field (coefficients): 20x20 (LAGEOS), 45x45 (Ajisai), 75x75 (Starlette/Stella), 80x80 (Larets), 100x100 (CHAMP), 150x150 (GOCE)
Earth gravity field (models): **EGM2008** (Pavlis et al., 2008), **EIGEN-GRACE02S** (Reigber et al., 2005), **GOCE2010s** (Pail et al., 2010) **for all satellites, GGM03S** (Tapley et al., 2007) **only for LAGEOS**
Earth tides: IERS Conventions 2003 (McCarthy and Petit, 2004)
Ocean tides: GOT99.2 (Ray, 1999)
Third body gravity: Moon, Sun and all planets – DE403 (Standish, 1995)
Solar radiation pressure: C_R coefficient 1.13 (LAGEOS, Starlette/Stella) and 1.0 (Ajisai, CHAMP, GOCE, Larets)
Earth albedo (Pavlis et al., 1998)
Dynamic polar motion (Pavlis et al., 1998)
Relativistic correction (Pavlis et al., 1998)
Atmospheric density model: MSIS86 (Hedin, 1987)
Constants
Gravitational constant times the mass of the Earth (GM): $3.986004415 \times 10^{14}$ m^3/s^2
Speed of light: 299792.458 km/s
Semi-major axis of the Earth: 6378.13630 km
Inverse of the Earth's flattening: 298.25642
Reference Frame
Inertial reference system: true of date defined at 0^h of the first day of each arc
Stations coordinates: ITRF2005 (Altamimi et al., 2007)
Precession and nutation: IAU 2000
Polar motion: C04 IERS
Tidal uplift: Love model H2 = 0.609, L2 = 0.0852
Pole tide (Pavlis et al., 1998)
Estimated parameters
Satellite state vector
Station geocentric coordinates
Atmospheric drag coefficients C_D determined every 1 hour (GOCE), 2 hours (CHAMP), 9 hours (Larets), 12 hours (Starlette/Stella), 15 hours (Ajisai), **no drag parameters for LAGEOS**
Acceleration parameters along-track, cross-track and radial at 6 hours or 12-hours intervals (Ajisai, Starlette/Stella), 24 hours (CHAMP, Larets), 5 days for LAGEOS, **no accel parameters for GOCE**
Measurement Model
Observations: 5 seconds normal points (GOCE), 15 seconds (CHAMP), 30 seconds (Ajisai, Larets, Starlette/Stella), 120 seconds (LAGEOS) from Eurolas Data Center
Laser pulse wavelength: 532 nm (Zimmerwald 423 nm)
Tropospheric refraction: Mendes-Pavlis model (Mendes et al., 2002, Mendes and Pavlis, 2004)
Editing criteria:
5σ per arc
cut-off elevation 10 degrees for all satellites
station coordinates < 50 normal points per station per arc
Numerical Integration
Integration: Cowell's method
Orbit integration step size: 20 sec (GOCE), 50 sec (CHAMP), 60 sec (Larets, Starlette/Stella), 90 sec (Ajisai), 120 sec (LAGEOS)
Arc length: 1 day (GOCE), 3 days (CHAMP), 7 days (Larets), 10 days (Starlette/Stella), 10 - 14 days (Ajisai), 10 - 30 days (LAGEOS)

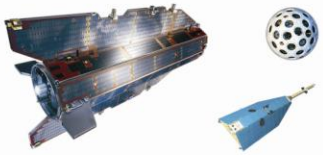


Table 2. List of the stations for orbits determination.

	Station		CDP Number
1	McDonald	(TX, USA)	70802419
2	Yarragadee	(West Australia)	70900513
3	Greenbelt	(MD, USA)	71050725
4	Monument Peak	(CA, USA)	71100411 71100412
5	Tahiti	(French Polynesia)	71240802
6	Haleakala	(HI, USA)	72102313
7	Hartebeesthoek	(RSA)	75010602
8	Zimmerwald	(Switzerland)	78106801
9	Borowiec	(Poland)	78113802
10	Mount Stromlo	(East Australia)	78259001
11	Riyadh	(Sudi Arabia)	78325501
12	Grasse SLR	(France)	78353102
13	Potsdam	(Germany)	78365801
14	Simosato	(Japan)	78383602
15	Graz	(Austria)	78393402
16	Herstmonceux	(UK)	78403501
17	Potsdam	(Germany)	78418701
18	Mount Stromlo	(East Australia)	78498001
19	Matera	(Italy)	79417701
20	Wettzell	(Germany)	88341001

Abstract

The poster presents the results of orbital analysis made for few satellites: Ajisai, CHAMP, GOCE, Larets, Lageos-1/Lageos-2 and Starlette/Stella (Table 1) based on laser data of 20 SLR stations listed in Table 2 collected during the period from 2001 to 2005 for Ajisai, CHAMP, Lageos-1/Lageos-2, Starlette/Stella, from October 1, 2009 to December 31, 2010 for GOCE and from November 6, 2003 to December 28, 2005 for Larets.
All orbital computations were performed by means of NASA Goddard's GEODYN-II program.
Table 3 contains a detailed description of force models and parameters used.
The analysis mainly concerns the tests of Earth's gravity field model for Ajisai, Lageos-1/ Lageos-2 and Starlette/Stella. The models were downloaded from http://icgem.gfz potsdam.de/ICGEM/ICGEM.html.
This poster shows which models and parameters are useful for orbital calculations and how depends the *fit* RMS on the altitude of the satellites.

Summary

1. The higher orbit of the satellite the lower *fit* RMS.
2. The results obtained for the tested Earth gravity field models shows that the best orbital solution ensure the following models:
   - ★ EGM2008, EIGEN-GRACE02S and GOCE2010S for all satellites from GOCE to LAGEOS,
   - ★ GGM03S for LAGEOS only,
   - ★ IT-GRACE2010S should not be used in calculations.
3. A substantial increase in the accuracy of laser observations, new force models and improvement in the quality of the station coordinates over the last years allows determination of station positions and velocities also from LEO satellites.

Please see (Lejba et al., 2007; Lejba et al., 2011) for more details. *

* *Lejba, P., Schillak, S., Wnuk, E. Determination of orbits and SLR stations' coordinates on the basis of laser observations of the satellites Starlette and Stella, Adv. Space Res. 40(1), 143-149, 2007.*
Lejba, P., Schillak, S., Determination of station positions and velocities from laser ranging observations to Ajisai, Starlette and Stella satellites, Adv. Space Res. 47(4), 654-662, 2011.

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