LAGEOS-ETALON solutions using the Bernese Software

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Daniela Thaller, Krzysztof Sośnica, Rolf Dach, Adrian Jäggi, and Gerhard Beutler
Astronomical Institute, University of Bern (AIUB), Switzerland

INTRODUCTION

The Bernese Software (Dach et al., 2007) recently has been extended with the capabilities of analysing SLR observations to spherical satellites, e.g., the two LAGEOS and ETALON satellites.

We processed several years of SLR data to these satellites and generated weekly solutions. The estimated parameters are shown in **Table 1**. In average there are about 120 parameters per weekly solution that are estimated.

For validating the solutions we studied:

- The RMS of the observation residuals.
- The comparison of the estimated orbits with predicted orbits based on the observations of the previous week.
- The ERP differences to IERS-08-C04 and a GNSS series.

Station coordinates	estimated	7 days
Range biases	estimated for few sites	7 days
Polar motion	estimated	1 day
UT1-UTC / LOD	estimated	1 day
Osculating orbital elements	estimated	7 days
Along-track: constant acceleration	estimated	7 days
Along-track: once-per-rev acceleration	estimated	7 days
Cross-track: once-per-rev acceleration	estimated	7 days
Weighting LAGEOS	all stations	0.01 m
Weighting ETALON	all stations	0.03 m

***Table 1**: Solution characteristics concerning estimated parameters, their temporal resolution and weighting between the different satellites used.*

REFERENCES

Dach R., U. Hugentobler, P. Fridez, M. Meindl (2007): Bernese GPS Software Version 5.0. Astronomical Institute, University of Bern.

Sośnica K., D. Thaller, A. Jäggi, R. Dach, G. Beutler (2011): Validation of Earth's gravity field models using LAGEOS. Poster presented at EGU General Assembly 2011, Vienna.

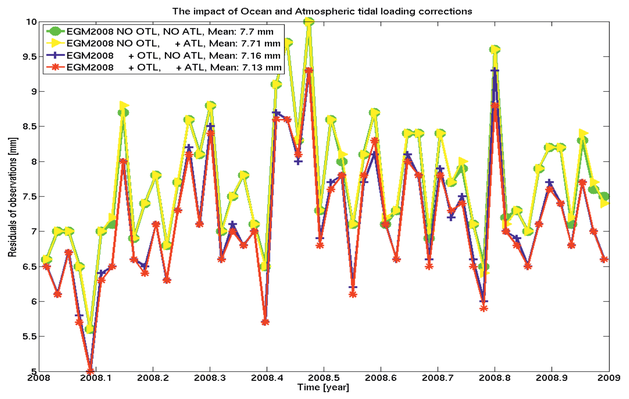

***Figure 1:** The impact of the models for ocean and atmospheric tidal loading on the solutions. **Top:** RMS of the observation residuals; **Middle:** RMS of orbit residuals between predicted and estimated orbits; **Bottom:** RMS of orbit comparison.*

PROCESSING STRATEGY

Different processing strategies have been tested and their impact on the SLR solutions has been analysed.

1. The impact of a priori models

The impact of different Earth's gravity field models on the LAGEOS solutions has been presented at EGU 2011 by Sośnica et al. (2011).

The impact of applying or ignoring ocean tidal loading (OTL) and atmospheric tidal loading (ATL) is analysed for solutions of the year 2008. The weekly RMS of the observation residuals displayed in **Fig. 1** reveals that ATL has nearly no impact on the solution, whereas omitting OTL slightly decreases the quality of the solution. **Fig. 1** also shows that both tidal loading corrections have no impact on the orbit prediction, whereas the estimated orbits show differences at the level of a few millimeters. Again, the impact of ATL is clearly smaller than the impact of OTL, i.e., about 1 mm and 4.5 mm in terms of RMS of orbit residuals, respectively (see **Table 2**).

2. The difference between LAGEOS-only solutions and combined LAGEOS+ETALON solutions

Although the number of SLR observations to ETALON satellites is clearly smaller than to LAGEOS (about 10%), we wanted to study the impact of these observations, and how the solution can benefit.

3. The impact of different ERP parameterizations

As the standard ILRS parameterization with constant ERPs causes jumps at the day boundaries, we tested a piece-wise-linear parameterization as it is used for the GNSS processing.

Type of the solution	NO OTL, + ATL	+ OTL, NO ATL	+ OTL, + ATL
NO OTL, NO ATL	1.17	4.43	4.96
NO OTL, + ATL		4.06	4.54
+ OTL, NO ATL			1.33

***Table 2**: Comparison of LAGEOS orbits by applying or ommitting OTL and ATL corrections: Median values of RMS of orbit differences shown in **Fig. 1** (given in [mm]).*

EARTH ROTATION PARAMETERS

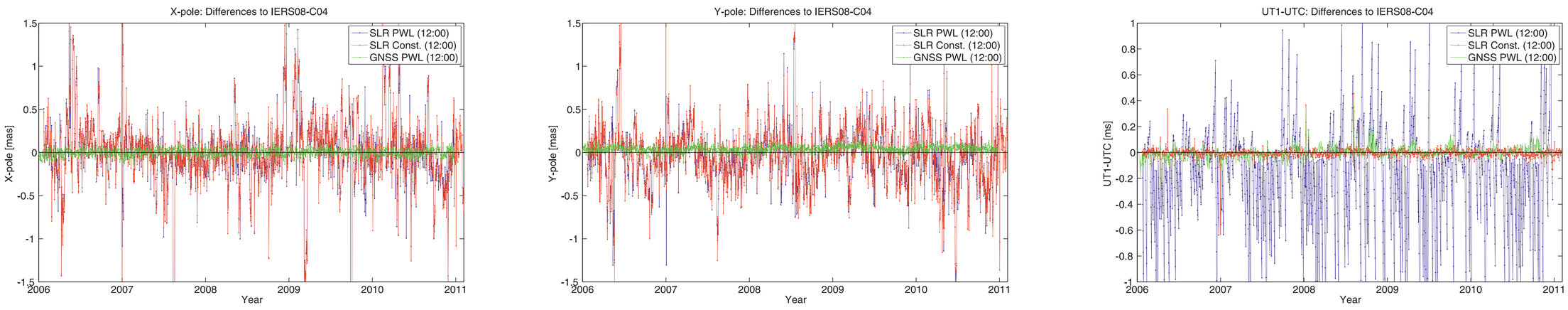

***Figure 2**: Comparison of ERP derived from SLR and GNSS solutions with the IERS-08-C04 series. **Left:** x-pole component; **Middle:** y-pole component; **Right:** UT1-UTC integrated from LOD estimates.*

		LAG+ETA constant	LAG+ETA pwl	GNSS
Mean Bias	X-pole [µas]	13.8	-4.1	-0.1
	Y-pole [µas]	-37.7	-41.4	40.5
	UT1-UTC [µs]	-5.0	-187.2	-0.9
WRMS	X-pole [µas]	459.9	428.9	41.0
	Y-pole [µas]	371.3	334.7	36.6
	UT1-UTC [µs]	38.8	436.1	42.9

***Table 3**: Comparison of ERP estimates with the IERS-08-C04 series: Mean bias and WRMS.*

We tested different parameterizations for the ERPs.

First, the standard parameterization as it is used within the ILRS Analysis Working Group (AWG) was chosen: piece-wise-constant daily polar motion, fixed UT1-UTC values and daily LOD estimates. The disadvantage of this parameterization is that the ERPs show discontiunities at the day boundaries, whereas the orbit is parameterized as continuous over the entire week.

Therefore, a second parameterization was chosen: piece-wise linear (PWL) with offset+drift parameters per day for polar motion and UT1-UTC (first value fixed) and additional continuity conditions at the day boundaries.

The comparison of both ERP series w.r.t. the IERS-08-C04 series is shown in **Fig. 2**, and the corresponding mean and RMS values are given in **Table 3**. It can be seen that the agreement with the IERS-08-C04 series is slightly better for the polar motion series using PWL parameterization. The large scatter for the UT1-UTC series using the PWL parameterization is due to the parameterization itself. It can be probably improved by fixing the value in the middle of the week instead of the value on the first day.

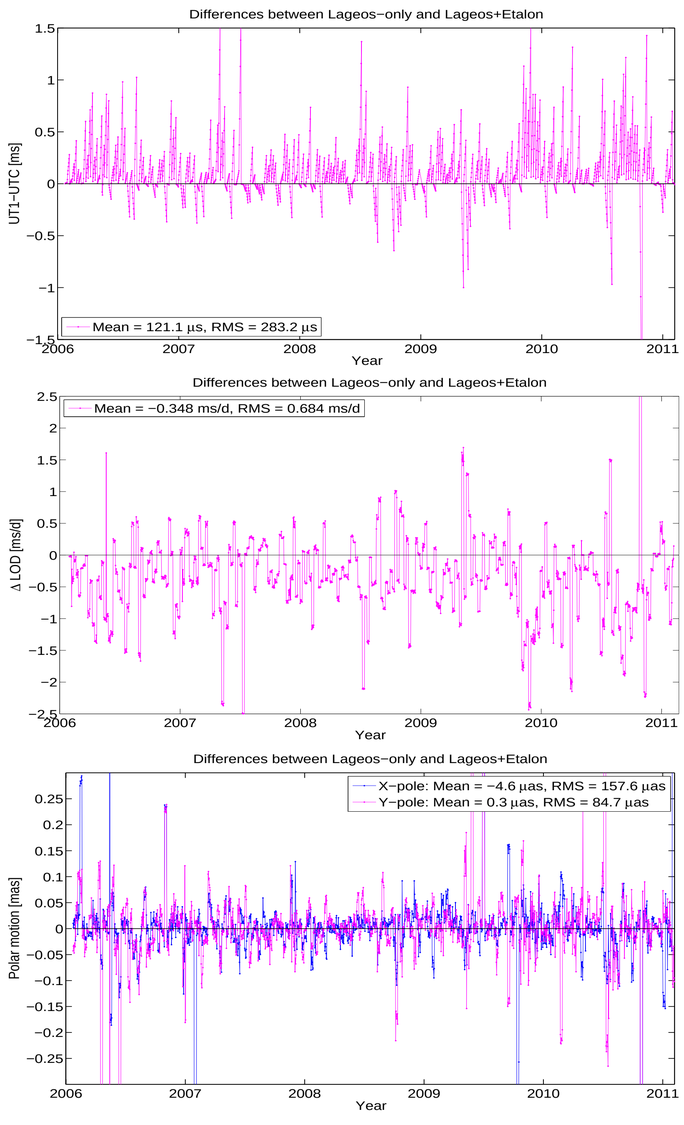

***Figure 3**: Comparison of ERP derived from LAGEOS-only solutions and combined LAGEOS+ETALON solutions.*

The impact of including SLR observations to ETALON satellites on the ERP is shown in **Fig. 3**. As expected, mainly UT/LOD shows differences to the LAGEOS-only solutions, whereas the polar motion estimates are almost identical.

When comparing the LOD estimates with a GNSS-only solution derived at the IGS Analysis Center CODE, we see that the mean bias can be reduced, although the RMS is slightly increased (see **Fig. 4**).

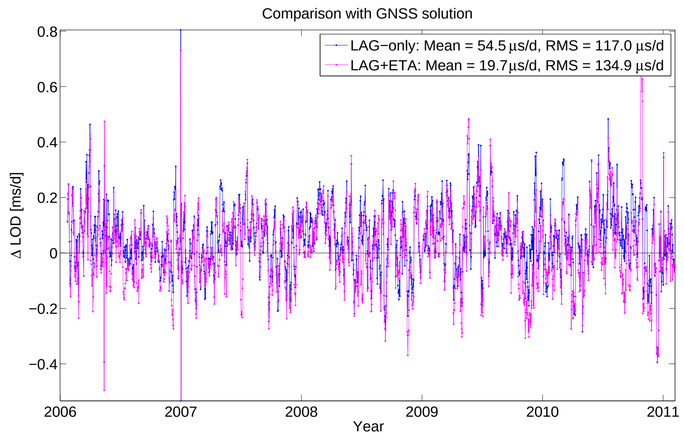

***Figure 4**: Comparison of LOD estimates from SLR solutions to GNSS-derived time series.*

CONCLUSIONS

- The impact of a priori models has been studied.
- The quality of the SLR-derived ERP series has been analysed.
- Polar motion with PWL parameterization shows a slightly better agreement with the IERS-08-C04 series.
- Including ETALON reduces the bias in LOD estimates.

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Astronomical Institute, University of Bern, Bern
daniela.thaller@aiub.unibe.ch