Can we improve LAGEOS solutions by combining with LEO satellites?

Krzysztof Sośnica, Daniela Thaller, Adrian Jäggi, Rolf Dach, Christian Baumann, Gerhard Beutler
Astronomical Institute, University of Bern, Switzerland

1. Introduction

The current analysis products of ILRS (i.e., Earth rotation parameters and SLR station coordinates) are based exclusively on the SLR observations of only four geodetic satellites: LAGEOS-1/2, and Etalon-1/2, despite long time series of precise observations of other cannonball satellites. The average number of weekly normal points to every LAGEOS amounts about 1500, whereas the average number of normal points to every Etalon is 150 – a factor of ten smaller than to LAGEOS. It raises a question: Is it possible to improve the analysis products by combining with low geodetic satellites (LEO)?

2. Starlette, Stella, AJISAI

The main advantages of combining LAGEOS with lower geodetic satellites are:

- The average number of weekly normal points is almost 9000 in a combined solution, i.e. a factor of three more than in LAGEOS-1/2 solutions
- Some of the SLR stations do not provide measurements to LAGEOS, but they observe lower satellites, e.g., Helwan in Egypt (7831), Mendeleevo in Russia (1870)
- On average 19.8 SLR stations observe LAGEOS every week, whereas 22.4 stations observe five geodetic satellites (2xLAGEOS+3xLEO).

There are, however, several problems concerning modelling of low orbits that have to be solved in order to achieve a solution of the highest precision and not to degrade the ILRS analysis products.
Precise orbit modelling of low geodetic satellites, i.e., Starlette, Stella, and AJISAI is more demanding than modelling of LAGEOS' orbits, because of:

- the high influence of the uncertainties in air drag models and variations of air density in the high atmosphere on the orbits,
- higher sensitivity to the Earth gravity field and to the temporal variations of the gravity field,
- the deficiencies in the center-of-mass corrections (CoM) for the LEO satellites compared to the well established values for LAGEOS and Etalon satellites.

In this paper we address in particular the third problem related to CoM of LEOs. We determine one CoM value for AJISAI and one CoM value for Starlette and Stella - the twin satellites.

3. Center-of-mass corrections for LEO

The station-specific CoM corrections for LEO satellites are derived from the combined LAGEOS-LEO solution, where the CoM corrections for LAGEOS satellites are well established and the range biases for LEO are estimated. Therefore, our CoM corrections for LEOs are entirely consistent with LAGEOS corrections and they do not inflict any inconsistencies onto the combined solution. The a priori CoM corrections for LAGEOS are introduced station- and time-specific following the current pilot project of the ILRS Analysis Working Group (Appleby et al., 2012). LAGEOS satellites mostly define the scale in the combined solution, because no range biases for LAGEOS are estimated for most of the SLR stations. We determine the CoM corrections for the LEOs as a difference between the a priori CoM corrections and the mean range biases for SLR stations in the period 2002.0-2012.0.

4. Results and recommendations

Figures 1 and 2 show the estimated CoM for Starlette/Stella, and AJISAI, respectively. The mean **CoM** for **Starlette and Stella** is **78 mm,** i.e., 3 mm larger than the standard ILRS value (75 mm). The standard deviation of the derived CoM is 4 mm, because of the variations between different SLR stations, amounting even 25 mm. Ries (2008) shows that the CoM corrections for Starlette should be about 78 mm and 79 mm in 1993-1999 and 2000-2008, respectively. Our results agree, thus, very well with these from Ries (2008). Therefore, the standard ILRS CoM values for Starlette and Stella should be updated in order to avoid a negative impact on the solutions, when using wrong CoM values.
The mean **CoM** for **AJISAI** for all SLR stations is **993 mm** ±12 mm. This value is 17 mm smaller than the standard ILRS CoM (1010 mm). Moreover, the variations of CoM corrections for AJISAI

reach even 45 mm for different SLR stations, and 19 mm for one station, namely Concepcion (7405) in different time spans. Our results agree quite well with the CoM values obtained by Otsubo and Appleby (2003), despite using different approaches: a method of matching full rate residual histograms with theoretical response functions versus an in-orbit analysis with the estimation of range biases. CoM for AJISAI should be, thus, considered as station- and time-specific, because using a single CoM correction for all SLR stations is not sufficient in case of this satellite.

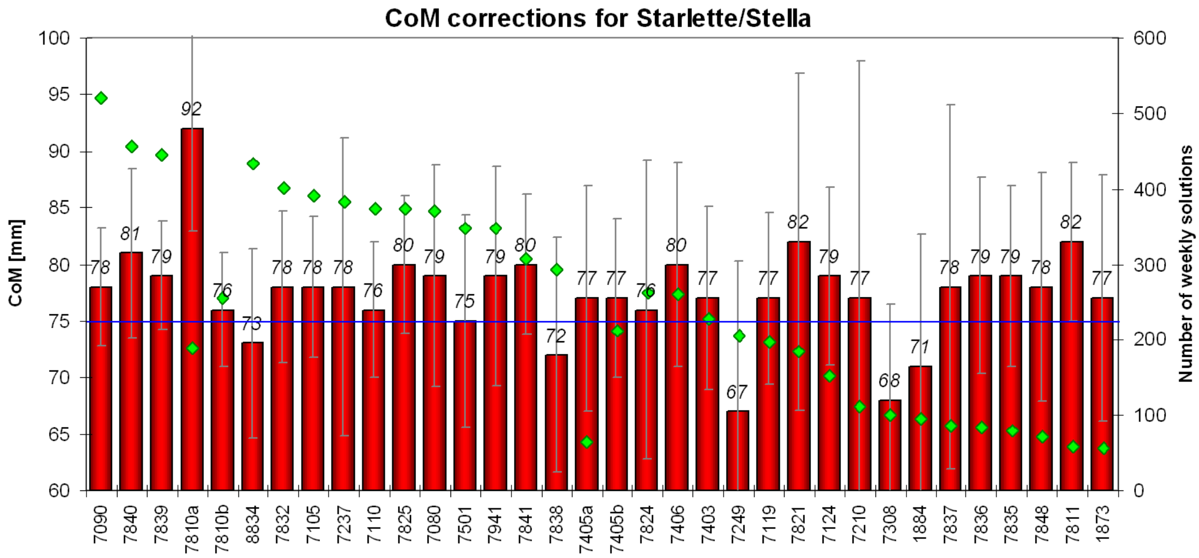

Fig. 1. Center-of-Mass corrections for Starlette/Stella with one-sigma error bars, derived from an in-orbit validation. 7810a refers to period 2002.0-2006.2, 7810b to period 2006.2-2012.0, 7405a refers to period 2002.0-2006.3, 7405b to period 2006.3-2012.0. Green diamonds denote a number of weekly solutions for SLR stations; blue line refers to the standard ILRS CoM value.

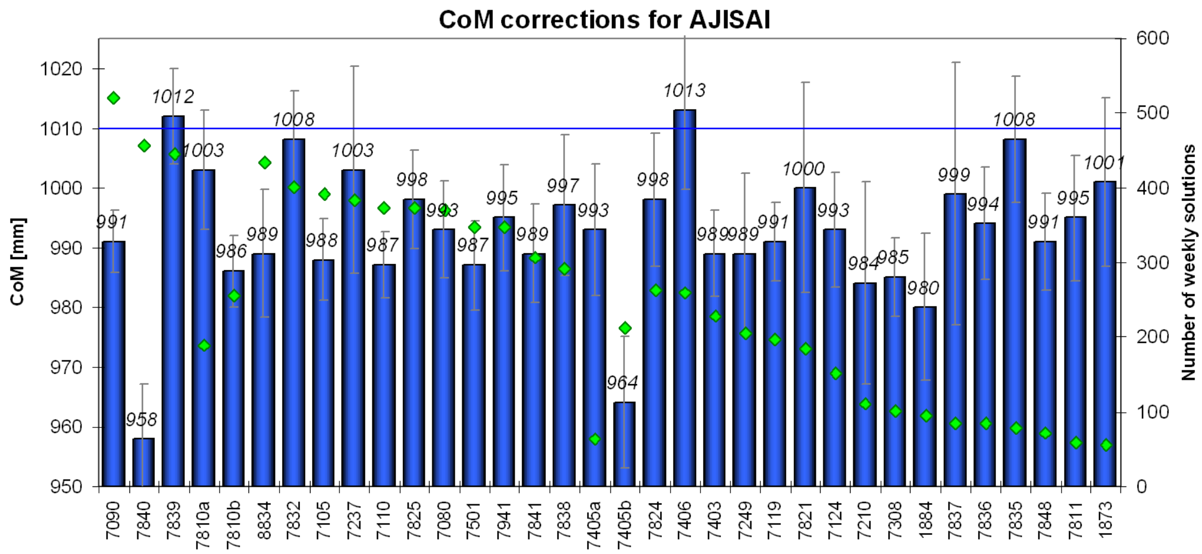

Fig. 2. Center-of-Mass corrections for AJISAI. Note a different scale w.r.t. Fig. 1.

6. References

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