EARTH ROTATION AND GRAVITY FIELD PARAMETERS FROM SATELLITE LASER RANGING

K. Sośnica[1], A. Jäggi[1], D. Thaller[2], R. Dach[1]
[1]Astronomical Institute, University of Bern, Sidlerstrasse 5, 3012 Bern, Switzerland, sosnica@aiub.unibe.ch
[2]Federal Agency for Cartography and Geodesy, Frankfurt/Main, Germany

Abstract: The main 'three pillars' of satellite geodesy can be summarized as:

- precise determination of geometrical three-dimensional positions and velocities (geometry),
- modeling and observing of geodynamical phenomena including the Earth rotation parameters (ERP, rotation),
- determination of the Earth's gravity field and its temporal variations (gravity).

Even though all three pillars describe geodetic and geodynamic phenomena within the system Earth, the gravity has typically been treated separately from the geometry and rotation. Many SLR solutions comprise the estimation of SLR station coordinates, pole coordinates and the Length-of-Day (LoD) from the 7-day combined LAGEOS-Etalon solutions, whereas the gravity field parameters are not provided. On the other hand, when estimating gravity field parameters from SLR data, the parameters related to geometry and rotation have typically been fixed so far and not simultaneously estimated.

We present the results from a simultaneous estimation of the gravity field, Earth rotation parameters, and station coordinates from a combined SLR solutions incorporating spherical geodetic satellites: LAGEOS-1/2, Starlette, Stella, AJISAI, and LARES [1,2]. These solutions cover all three pillars of satellite geodesy and ensure full consistency between the Earth rotation parameters, gravity field coefficients, and geometry-related parameters [3]. We address benefits emerging from such an approach and discuss particular aspects and limitations of the gravity field recovery using SLR data.

The results of the low-degree temporal Earth gravity field determination from SLR observations will be presented, as well. We found that not only the temporal variations of low-degree zonal coefficients can be well established from SLR, but also the sectorial and, in particular, tesseral coefficients up to degree 4. The SLR-derived coefficients will be compared with the gravity field coefficients based on GRACE K-band tracking results.

We found that the simultaneous estimation of gravity field coefficients is particularly beneficial for the determination of LoD. The simultaneous estimation of the gravity field parameters along with other SLR-derived parameters: (1) reduces the offset of LoD estimates, which is mostly due to absorption of C_{20} variations by LoD estimates, (2) reduces peaks in the spectrum analysis which correspond, e.g., to orbit modeling deficiencies, (3) reduces the a posteriori error of estimated LoD values. We found that incorporating many geodetic satellites of different altitudes and inclinations and better observation geometry.

Finally, the quality of the SLR-derived pole coordinates and LoD from Starlette, Stella, and AJISAI data is by factor of two better when estimating low degree gravity field coefficients, as compared to the solution without estimating gravity field coefficients. LAGEOS satellites remarkably stabilize the ERP and station coordinate estimates in multi-SLR solutions; thus, the combined solution using SLR observations to many satellites is highly preferable.

References: [1] Sośnica K., A. Jäggi, D. Thaller, R. Dach, G. Beutler (2014): Contribution of Starlette, Stella, and AJISAI to the SLR-derived global reference frame. Journal of Geodesy, vol. 88(8), pp. 789-804. DOI 10.1007/s00190-014-0722-z

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