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Low-degree gravity field coefficients from SLR data for the new combined gravity field model GOCO02S

Andrea Maier (1), Oliver Baur (1), Walter Hausleitner (1), Eduard Höck (1), Sandro Krauss (1), Helmut Goiginger (2), Roland Pail (3), Adrian Jäggi (4), and Wolf-Dieter Schuh (5)

(1) Space Research Institute, Austrian Academy of Sciences, Schmiedlstraße 6, 8042 Graz, Austria, (2) Institute of Theoretical Geodesy and Satellite Geodesy, University of Technology Graz, , Steyrergasse 30, 8010 Graz, Austria, (3) Institute of Astronomical and Physical Geodesy, University of Technology Munich, Arcisstraße 21, 80333, (4) Astronomical Institute, University of Bern, Sidlerstrasse 5, 3012 Bern, Switzerland, (5) Institute of Geodesy and Geoinformation, University of Bonn, Nussallee 17, 53115 Bonn, Germany

Combined gravity field models benefit from the integration of complementary data sets with respect to measurement type, accuracy, etc. A new global gravity field model is to be computed by combining the recent GOCE gravity data with GRACE, CHAMP, SLR, altimetric and terrestrial data sets.

The contribution of the Space Research Institute is the determination of coefficients representing the Earth's gravity field by means of Satellite Laser Ranging (SLR) measurements. Particular consideration deserves J2, the Earth's dynamic oblateness. Its numerical value is two orders of magnitude higher than the numerical values of the other coefficients and thus requires precise determination. Typically, J2, along with further low-degree coefficients, is determined by means of SLR to high-orbiting spacecrafts.

We conducted a series of closed-loop simulation studies to demonstrate up to which degree and order the gravity field can be resolved by SLR data analysis. In this context, we performed sensitivity studies on the number of recovered coefficients, data periods (such as monthly solutions) and combinations of range measurements to several geodetic satellites. The studies are based on five years simulated SLR measurements to LAGEOS 1 and 2, Ajisai, Stella and Starlette. Spatial coverage and sampling rate influence the resulting gravity field estimate to a high extent. Thus, ranges have been simulated for those stations only that recorded measurements to the satellites in reality. The interval between successive ranges was chosen individually for each satellite so that the total number of observations reflects the real case. The ranges have been superposed with Gaussian noise with the station-specific mean value of the real measurement standard deviations serving as noise level. The five-year period was sub-divided into monthly arcs resulting in a total of 52 normal equation systems.

Our simulation studies show that SLR data provides substantial support for degree-2 coefficients recovery. It has less benefit above degree-3 terms and hardly any above degree-10 terms. This characteristic can be attributed to the sparse coverage above maritime areas, the occurrence of polar gaps and the satellites' high orbits.

The same configuration is used for real data analysis, five years of normal points to the same five satellites. In contrast to the simulation, various forces like solar radiation pressure, atmospheric drag and gravity fields of planetary bodies affect a real satellite and the existent models describing them are imperfect. Thus, the formal errors of the coefficients are larger than those computed from the simulated ranges. As the feasibility study already indicated, the contribution of SLR data to a combined high-resolution gravity field is limited to the degree-2 coefficients.