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Future SLR satellite constellations – a simulation study

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Abstract. Satellite laser ranging (SLR) is currently one of four space geodetic techniques that provide a relevant contribution to the International Terrestrial Reference Frame (ITRF) as well as to the determination of global geodetic parameters or low-degree harmonics of the Earth's gravity potential. ITRF realizations are mostly based on the observations to the two Laser GEOdynamics Satellite (LAGEOS) and two Etalon satellites, however, the impact of observations to Etalon satellites is marginal. Currently under consideration is an extension of the ITRF solution to include the LAser RElativity Satellite (LARES) and LARES-2 developed by the Italian Space Agency ASI and launched on July 13, 2022. The contribution of other satellites with retroreflectors is still being investigated.

This study aims at evaluating the contribution of the LARES-2 satellite to the realization of ITRF and deriving global geodetic parameters, such as geocenter motion, pole coordinates, length-of-day, as well as low-degree gravity field coefficients. Moreover, we consider adding subsequent satellites which supplement the existing constellation. Our research aims to investigate a positive or negative influence on the accuracy of global geodetic parameters and their correlations. We also examine various approaches to estimating geodetic parameters depending on the number of determined empirical once-per-revolution parameters of satellite orbits and different approaches of parametrization for the Earth rotation parameters, including piecewise linear and piecewise constant parametrization.

We simulate satellite orbits and SLR observations to LAGEOS-1/2 and LARES-1/2, as well as to possible pairs of LARES-3/4 and LARES-5/6. We check how the satellites at different inclination angles and heights contribute to deriving global geodetic parameters and compare the results to LAGEOS-1/2 solutions based on simulated data. We analyze the standard deviations of derived parameters, the sensitivity of particular orbits to gravity field spherical harmonics, as well as the correlations between length-of-day and Earth's oblateness term, and between the gravity field parameters of the same order and similar degree. Finally, we assess the potential improvement of estimating geocenter coordinates and Earth rotation parameters emerging from the combination of SLR observations to satellites at different inclination angles and altitudes for future geodetic missions. Having current constellations of LAGEOS and LARES satellites, we show that the highest improvements can be obtained by adding the next LARES satellite – with the same altitude as LAGEOS-2 but with a complementary inclination angle, i.e., 128 deg, thus orbiting the Earth in the opposite direction to the Earth rotation. In addition, we show that observations to the new LARES-2 satellite will especially improve determining the Z-geocenter component.